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THE APPROACH FOR ELECTRICAL NETWORK OPTIMIZATION UNDER LIBERALIZED ELECTRICITY MARKET

ELEKTRISKO TĪKLU ATTĪSTĪBAS OPTIMIZĀCIJAS KONCEPCIJA BRĪVĀ ELEKTROENERĢIJAS TIRGŪ

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Aspects of Electricity Market

Liberalized electricity market envisages the conditions when each consumer may select any the most advantageous for him generator and supplier of elelctricity. Through experience of many countries all over the world by competiting of power plants and entities running electricity trading new opportunities are created for less expensive electricity source. The practical experience maintained in the western countries demonstrates that under conditions of liberalized electricity market functioning to full extent, the price of electricity received by consumer may fell down by more than 20%.

Electricity may be considered as "current" commodity, which is characterized by feature of very restricted (non-existing) possibilities for its transportation and storage. Both these restrictions- spatiotemporal features of electricity is the basic provisions comparing with other commodities developing or forming electricity price [1].

Electricity market of the Baltic countries - that is elelctricity market stipulated by three Baltic countries attaining the utmost profit from electricity market. At present all three states with different methods are in endeavor to shape its own electricity market but it would be more feasible to create the common market as there are neither sufficient amount of power plants (energy generators) nor distribution networks (electricity suppliers) in these countries - thus it hampers competiteveness. If electricity market be common for all three states the consumers may easily select electricity generators not only in its own but in other Baltic states too.

In order to create such common market the codex for transmission networks and generators in the Baltic countries shall be established either three codexs functioning as three juridical documents but with analogous content and meaning. The above mentioned activities are in realization process but it is not clear when these will be completed.

There is a rapid development process of electricity market liberalization in the European Union (see Table 1). Now the market is fully liberalized in Austria, Finland, Germany, Norway, Sweden and Great Britain, partly liberalized in Denmark (90 %), Spain (54 %), Luxemburg (40 %), Belgium (35 %), Italy (35 %), Netherlands (33 %), France (30 %), Greece (30 %), Ireland (30 %) and Portugal (30 %).

The major benefit gained by liberalized electricity market is - an opportunity to reduce electricity annual rate escalation. The response to the question: "Whether competiteveness is ensuring the electricity price reduction in the country where electricity market exists?" is presented in the reports of the European Commission where electricity prices within the period of years 1996 to 2006 (see Table 1) - price reduction is observable in many countries but not everywhere.

Table 1.

Indicators of electricity market in different European states

State	Market availability in percentage %	Ellectricity prices deviations in industry, %
Finland	100	-19,6
Sweden	100	-17,8
Germany	100	-9,6
Great Britain	100	+8,7
Denmark	90	+0,2
Spain	45	-16,2
Belgium	35	-3,5

The Netherlands	33	-1,7
Portugal	30	-14,0
France	30	-12,7
Austria	30	-4,0
Italia	30	-2,8
Greece	30	-0,9
Ireland	30	+2,0

The electricity market of Baltic countries incorporates the following components:

- Consumption in all three countries and its future development,
- Electricity generation and supply at former time, at present and in future,
- The perspectives of the Baltic states in the frame of the European Union,
- Management operation models of electricity market,
- Analysis of electricity markets in several countries,
- Miscellaneous reasons which may influence electricity markets in Latvia, Lithuania and Estonia.

Introducing of liberalized electricity market is characterized by unbundling of transmission and distribution from generation and the opportunity offered to purchaser (customers) to select trader (or generator) of electricity. Services providing companies (distribution or transmission networks) are affected by the escalating prices and are forced to descrease both investments allocations and operation costs. The typical activities envisage: investments reduction, limitation of maintenance measures and substantial reduction of personnel. All these undertakings negatively affect quality of providing service and electricity supply reliability, as for instance, energy crisis in Europe in 2003, black-out in USA in 2003 [2], Russia in 2005 [3]. During the latest time one of the reasons of occurred failure or blackout is priority of liberalized electricity market in regard to power supply security and reliability. Gradually year by year power supply reliability has been removed by electricity business priority, as conclusions of businessmen are plain - nothing dangerous has happened.

Under the conditions of liberalized electricity market all over the world when competiteveness is fostered, the requirements for reliability and security of power supply have remained as the secondary item, which cause probability of such accidents or failures to be occured. As far power system concern is not focused anymore on maximal reliability guarantee, pre-conditions appear for emergency situations, hardly maintaining opposite interests of businessmen to achieve maximal profit and networks operator to provide reliable and secure power supply. Such situation is facing by power system in Latvia, and neighbouring power systems in Lithuania and Estonia. All power systems are interlinked with neighbouring power systems its so-called power cross-sections limited by maximal admissible power capacity in operating mode and repair scheduled schemes. Business entities trading electricity are interested in business efficiency promotion but transmission networks operators are responsible for power supply reliability and security. The more stringent are the reliability regulations for power supply the more restrictions are for liberalized electricity market. Under such situation differenet solutions are being analysed and investigated and one option may be the construction of new transmission line with more capacious power flow in electrical cross-sections where overload is anticipated under conditions of liberalized electricity market as well as construction of new generation source in regions of power deficit.

Although liberalized electricity market both in Latvia and the whole Baltic area may provide benefits as: business capabilities will be expanded of Daugavas HPP Cascade by more diversified and efficient utilization; annual Daugavas flood water utilization will be improved; opportunity will arise to use in more efficient way Daugavas HPP Cascade optimizing electricity output in public thermal power plants of Latvia and Baltic countries to reduce prime-cost.

Dynamics of Latvia's electricity import depends on the price offered by the state selling electricity. At the beginning of 90-ties electricity in Estonia was the cheapest therefore the bulk amount of electricity was passed from Estonia. In the middle of 90-ties the cheapest electricity price was in Russia and Lithuania. In 1998 Daugavas river water fall was so sufficient high during the whole year that electricity demand was covered completely by electricity generated and only tiny part was wheeled from Russia and Estonia.

Structure, Functions and Tasks of Liberalized Electricity Market

Liberalized electricity market is very sophisticated. Impossibility to store commodity (electricity) segregates electricity market from financial markets and other commodities markets, as price formation mechanism is based on balance between consumption (demand) and generation at every instant. Theoretically electricity price exists each second, but factually market is based on hour price in values of kW (kilowatt-hour). In order to transfer from monopolized electricity market to liberalized market more than several problems shall be solved [1].

Ties in liberalized electricity market are presented in Figure 1.

Liberalized electricity market comprises several components:

- Electricity generators,
- Electricity consumers,
- Supply companies (distribution and transmission networks and systems) and financial markets.

Liberalized electricity market is structured vertically: matching generation, transmission and distribution; reforming electricity utilities as separate independent entities. Electricity is delivered from generators through transmission lines, that in general establish transmission grid or system, but from supplier to consumer through distribution network or system.

Profile of electricity market components is presented in Figure 2.

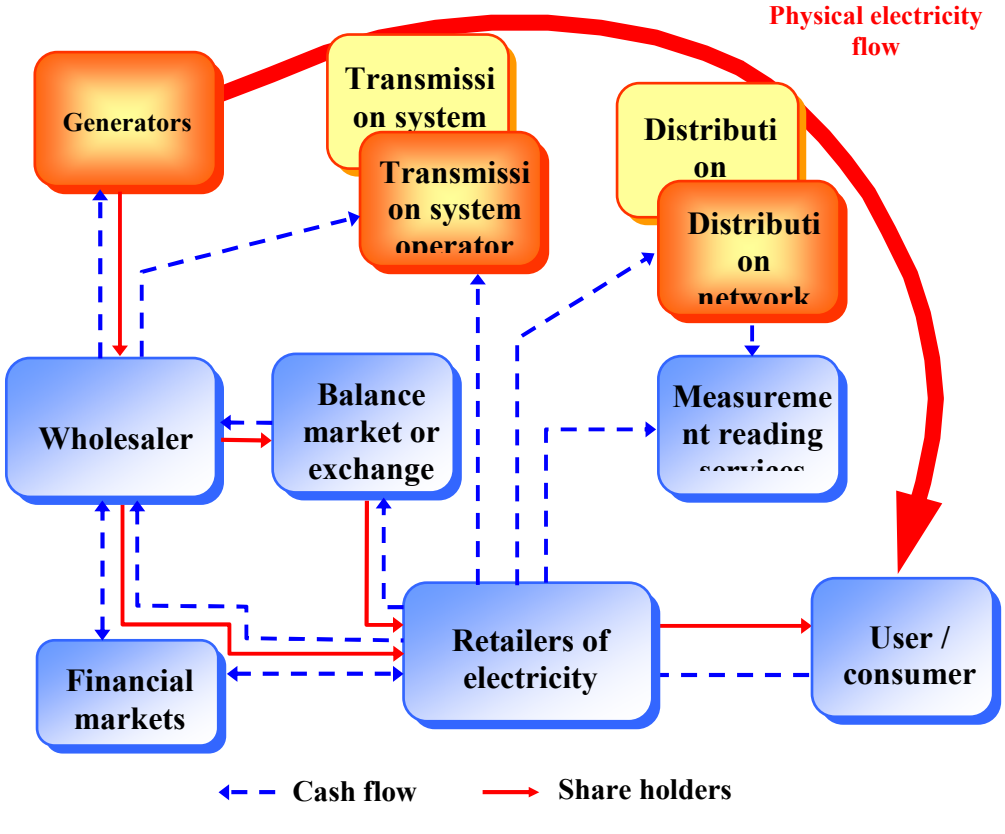

Figure 1. Liberalized electricity market

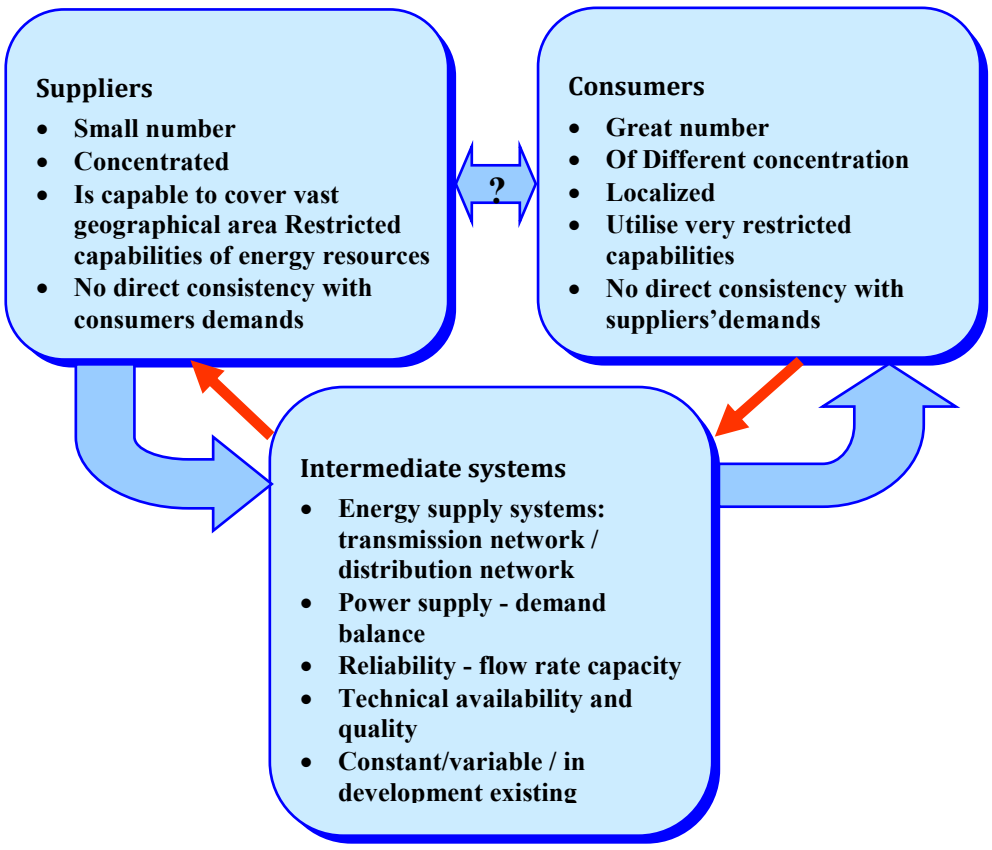

Figure 2. Components of Electricity market

In the liberalized electricity market several products are purchased and sold: energy, power, reserve, reactive power / voltage provision, cold start-up, regulation capacities: load shedding, energy quality, emergency prevention etc., where

energy - commodity, that is delivered to the consumers (end-product), is measured in kilowatt (kWh);

power - that is generated each second by generator kW; generated power within an hour is called as electricity;

reserve - power generation equipment regulation diapason in order to match demand to generation (supply) each hour;

reactive power/voltage provision - technical aspect of electricity market which assignment is to provide electricity supply to consumers with least losses in the system;

cold start-up - power, that due to consumption increment the system is capable to deliver after the certain time;

regulation capacities - market functionality elements.

The suppliers gain profit out of the mentioned products "optimal mixture trading".

External uncertain conditions create problems. Uncertainty conditions are structured to physical, financial and regulating issues (see Table 2).

Table 2.

Classification of uncertainties

Physical uncertainties	Financial uncertainties	Regulators uncertainties
Load forecaste, Weather conditions, Generators outage Other equipment outage, Other errors (human beings, dispatching personnel and relay malfunction), Equipment operable availability, Scheduling uncertainties.	Interests rates, Credits, Competiteveness, Cash flow.	Unsettled legislation, Political pressure, Influence of Interests grouping.

Identifying product costs and prices the interests of supplier and consumer shall be taken into consideration (see Table 3).

Table 3.

Factors, that stipulate product price

Interests of Suppliers	Interests of Consumers
The costs of product delivered by Supplier are determined by: Fuel costs / contracts, Operation and maintenance, Capital costs, Extra costs (of network, emergency, losses, independent system operator), Physical assets management, External conditions and uncertainties. The market determines Suppliers Prices.	Consumers charges are determined by: Local regulators approach, Consumers selected capabilities, Consumer control (switchboard) selection; Load supply to individuals: Costs - mainly capital costs - are related to distribution assets, regulation and maintenance, Prices are determined by market or Regulators.

Within no transformation period of fully regulated to liberalized market the relationship between supplier and consumer are symmetrical. Therefore creation of fully competitive market is a complicated problem.
In the liberalized (non-regulated) market risk is raised by suppliers and consumers:

- Suppliers are influenced by all risks formulated above;
- Consumers may be protected in transitional period but not all the time;
- "Regulator" may "help"or slow-down the market impact (to slow-down or mitigate risks for suppliers and consumers);
- The major conclusion: salvation generated by the result of competiteveness may be leveled by higher prices to cover risks extra-charges.
- The reviewed considerations determine the structure of general liberalized market (see Figure 3).

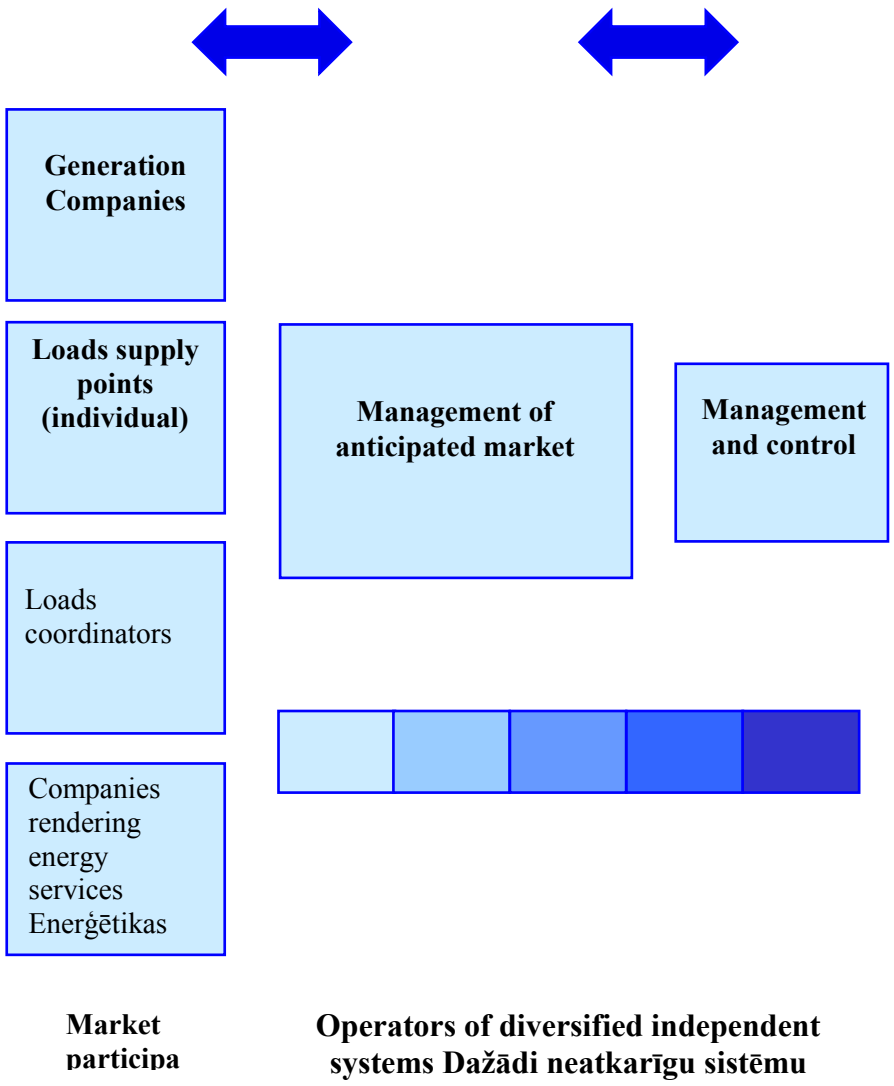

Figure 3. General structure of liberalized market

Under the liberalized market conditions the planning process of consumption and power generation shall be flexible taking into consideration interests of all participants. Load curve shall be set up in such a way that the coordinator of load (demand) may avoid adjustment and interfering to the real (instant) operation modes process.

Electrical Network Development Optimization - Significant Component of Power Engineering System Sustainability Control

The need of methods modification for electric power system development planningnow is determined by:

1) Liberalized electricity market and
2) System sustainable development.

Both criteria groups are contradictory. At present mankind is facing unique problem: the conformity of opinions is amazing that eco-system of Earth is not capable to maintain the existing economic activity level and resources utilization level: or even hardly higher, but still at the same time judging by the world gross product it will increase by 4 % per year. From ecology point of view more important is energy and raw material consumption per person [4].
The assumption that mankind should live in a fair way reasonably consuming nature resources is the substantial background for definition of sustainable development "…to satisfy the existing needs, not jeopardizing next generations power to satisfy their needs". Although despite the fact that this problem's ecological and social peculiarities are widely acknowledged, interpretation of sustainable development definition and concealed explanation are contradictious.

One of the reasons of contradictious interpretation of sustainability definition is evident - term "sustainable development" is ambigious itself, as if betraying the meaning. For many people the meaning of "sustainability" seems closer, they perceive it as challenge for ecological and social changes, for the world with stable environment where reign principles of social fair justice. Others identify themselves with "development", their interpretation means growth, *status quo* advancement.
In the article about electrical network and generation sustainability provision we consider the fact that in the preliminary stage of electrical power system design not sufficient attention is paid to the consequencies of the designed decision or solution which shall not be ignored. Taking into consideration the above mentioned we propose to apply dynamic methods in the stage of electrical power system designing that enable to observe development process and further long-term perspective.
In this article we introduce management with new, original concept of electrical power system development optimization who would be able to substantiate the decision taken, by modeling situations and its probable consequencies, thus significantly supporting selection of the optimal option.

Basic Theses of Concept on Electrical Network Development Optimisation

Basic theses of concept on electrical network development optimization are worked out, based on the analysis of major problem of liberalized electricity market, functions and components as well as on analysis results of network sustainability aspect. The first and the most essential solution obtained in the result of the analysis is - under new conditions significance of network development planning is increasing as well as optimization too. Although the existing methods shall be substantially revised and supplemented, after the desirable results of development planning may be obtained. We have elaborated seven basic theses having utilized long-term experience of network development planning, and which we recommend to use for creation of new optimization methods. Let's consider these basic theses.

1. Optimization shall be dynamic:

a) regular;
b) flexible (available for adjustment).

Usually real electrical network development is non-interruptible process which cannot be replaced by 1-3 development horizons. Such model as our researches prove distorts option of technical economic bencmarking. Under conditions of liberalized electricity market only the model of multi-step development process shall be applied. Economic analysis in compliance with methodology shall be performed in regard to economic life-cycle of the object (in electrical network that is - 20-25 years). The target function is calculated for the entire estimation period T. Under the conditions of information uncertainty the ultimate decision shall be taken only for probable near perspective 3-5 years. We designate this time interval as ***decision making period*** $t_d < T$ [5].

As far the information on development calculation period is uncertain therefore the decisions taken shall be regularly updated. The development designing process shall be taken in stages, gradually.

- Observing external information update;
- Having applied input information decisions on separate objects taken at preliminary stages;
- Utilizing updated information on preliminary system development).

2. For Optimization it is required to take into consideration sustainability of electrical power system examining long-term perspective in avoid undesirable consequencies of the decision taken.

In fact, disregarding the aspects of sustainability control of electrical network the estimation period is 20-25 years that may be modeled accurately enough with 10 development steps, thus observing sustainability aspects probably are required to analyse and predict 50 years period or 20 development steps.

3. For Optimization it is required to take into consideration power supply reliability in order to set up the rules and requirements for independent electricity producers.

The major problem of reliability estimation is such that provision and maintaining of electricity appropriate quality level costs are covered by the system's owner, but on the contrary quality unadequacy create main costs for consumer. Electricity quality - in line with price - is the most particular electricity characteristics especially in regard to industrial consumers.
From the point of view of consumer it is preferrably to select such structure where consumer may select supply quality and the respective costs. As example referred to literature [6] an option is suggested when consumers may select appropriate, corresponding to his own individual requirements reliability level, paying for connection and service as well as insurance payment for extra reliability. In Figure 4 the general principles of such approach are presented.

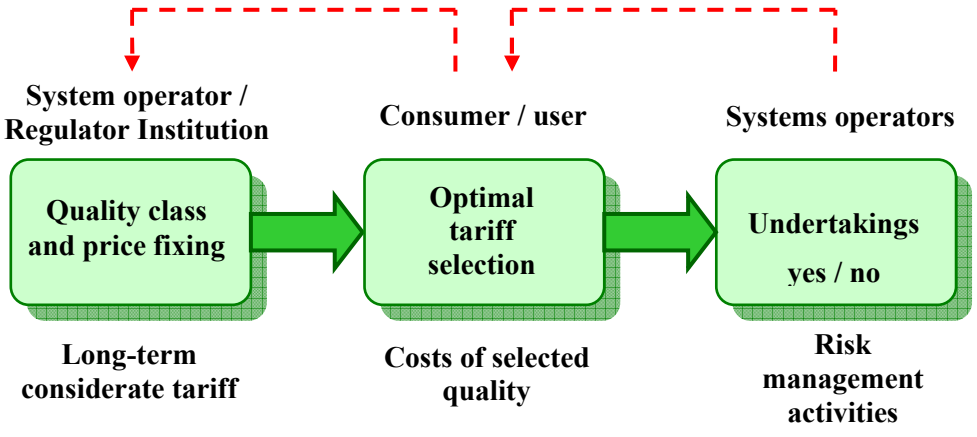

Figure 4. Quality structure tailored for consumer

4. For Optimization it is required to take into consideration information uncertainty

a) physical uncertainty;
b) financial uncertainty;
c) regulators'uncertainty.

Selecting option under uncertainty conditions: 1)information set shall be selected that represents information credibility diapason; then set i which is suggested as forecast l ; 2) options estimation criteria shall be selected; 3) select comparison (benchmarking) options; 4) selection.

5. For Optimisation Networks and generation shall be reviewed.
In order to model energy source, network model shall be supplemented by generators units and power plants links [7].
Applying electric power plants links energy saving technologies may be simulated or modeled in liberalized electricity market and in regard to electricity import from the neighbouring power systems. Executing assignments on network and generation system development together, annual loads and generation curves shall be simulated matching with harmonized operation modes.

6. Specialized information technologies shall be applied for oprimization.
Information technologies application ensures opportunity for the following:

- Promote planning efficiency, standardizing these processes and applied softwares and automate work with softwares;
- To reduce maintenance costs of information technologies systems replacing many softwares with less sets of high-tech integrated and advanced softwares.

7. In the results of Optimization the requirements and rules shall be formulated for independent electricity producers.

Conclusions

Conclusions on the concept for electrical networks optimization in liberalized electricity market:

1. The significance of Networks development optimization under the conditions of liberalized electricity market is being increased.
2. Under the conditions of liberalized electricity market it is required to use new methods for electrical network development planning.
3. The “basic principles”suggested in the Article are recommended as a basis for new methods creation.
4. The basic theses formulated in principle are related to transmission networks and electric power plants systems as well as to distribution networks and disseminated power plants.

It is predicted that liberalized electricity market is characterized by continiuos “portfolio of development cycles” of electric power plants. Sometimes these are named as investments cycles, during which the market gains both period of generation power surplus and period of generation shortage [9]. It is improper to consider that electricity market liberalization is a single event or realized undertaking - that is non-continious process demanding uniterruptible process of market development.

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Krišāns Z., Oļeiņikova I., Mutule A. Elektrisko tīklu attīstības optimizācijas koncepcija brīvajā elektroenerģijas tirgū
Rakstā piedāvāti oriģinālas elektrisko tīklu attīstības optimizācijas koncepcijas brīvā elektroenerģijas tirgus apstākļos pamatprincipi, ņemot vērā tīkla ilgtspējas vadības nepieciešamību. Rakstā apskatīti: 1) brīvā elektroenerģijas tirgus galvenie aspekti, funkcijas un uzdevumi; 2) elektrisko tīklu attīstības optimizācija kā elektroenerģētisko sistēmu ilgtspējas vadības būtiska sastāvdaļa. Piedāvāts elektrisko tīklu drošuma problēmu ilglaicīgos risinājumus izvēlēties kopējā elektrisko tīklu attīstības plānošanas procesā. Šādas attīstības optimizācijas pamatprincipi ir: 1) dinamiskums; 2) attīstības ilgtspējas nodrošināšana; 3) tīkla attīstības un apgādes drošuma problēmu kompleksa risināšana; 4) informācijas nenoteiktības ievērošana; 5) tīkla un ģenerācijas attīstības problēmu vienlaicīgs apskats; 6) specializētu informācijas tehnoloģiju izmantošana; 7) prasību neatkarīgiem elektroenerģijas ražotājiem noformulēšana. Svarīgākais secinājums, kas iegūts darbā rezultātā: jaunajos apstākļos tīklu attīstības optimizācijas un drošuma plānošanas nozīme pieaug. Tīklu attīstības optimizācija un drošums jāplāno kompleksi. Arī esošās metodes ir būtiski jāpārstrādā un jāpapildina, tikai tad elektrisko tīklu attīstības optimizācija un elektroapgādes drošuma plānošana var sniegt vēlamos rezultātus.

Krishans Z., Oleinikova I., Mutule A. The approach for electrical network optimization under liberalized electricity market
In paper are proposed the original basic principles of electric network development optimization under liberalized electric power markets. The following aspects are analyzed: 1) structure, elements and functions of liberalized electric power market; 2) electric network development optimization as element for network sustainable

development management. The paper considers in more details methods: 1) for supply reliability assessment, 2) for taking into account information uncertainty, 3) for complex optimization network and power station, 4) for application of information technology for sustainable development planning. Basic theses of concept on electrical network development optimization are worked out, based on the analysis of major problem of liberalized electricity market, functions and components as well as on analysis results of network sustainability aspect. The most essential solution obtained in the result of the analysis is - under new conditions significance of network development planning is increasing as well as optimization too. Although the existing methods shall be substantially revised and supplemented, after the desirable results of development planning may be obtained. We have elaborated seven basic theses having utilized long-term experience of network development planning, and which we recommend to use for creation of new optimization methods.

Кришан З., Олейникова И., Мутуле А. Концепция оптимизации развития электрических сетей в условиях свободного рынка электроэнергии

В статье рассмотрен ряд проблем, связанных с выбором устойчивых (долгосрочных) решений общего процесса развития надежности электрических сетей. Основнымы принципами - особенностями такой оптимизации развития являются: 1) динамичность; 2) обеспечение устойчивого (долгосрочного) развития: 3) комплексное решение проблем развития сетей и обеспечения надежности; 4) учет неоднозначности информации; 5) одновременное рассмотрение проблем развития сетей и генерации; 6) использование специальных современных информационных технологий; 7) формулировка требований к независимым производителям электроэнергии. В статье также рассмотрены основные аспекты, функции и задачи либерализованного рынка электроэнергии с учётом оптимизации развития как основной составляющей устойчивого (долгосрочного) управления электроэнергетических систем. Самый главный вывод, который получен в результате анализа - в новых условиях значение планирования развития и надёжности сети возрастает, а так же возрастает значение оптимизации. Развитие и надёжность сети следует планировать комплексно.