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Mandatory Procurement Lessons. Phenomena of External Initiator Factor

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***Abstract* – Financial support is needed in order to implement renewable resources in countries energy sector in the shortest time period. Among the most important supports for European Union Member states are feed-in tariff and feed-in tariff premiums. This research analyses one country's experience in applying subsidies of the electricity tariff that has caused public protests after 20 years. There are many reasons for this which are analysed in the paper. One of the most important reasons of high subsidies of energy tariffs – coincident mandatory procurement implementation of application of fossil fuel (imported natural gas) for cogeneration units, which has to be classified as external mover (initiator) factor. Energy sector's potential development scenarios with or without support for renewable energy resources are being analysed in the paper.**

***Keywords* – Electricity; feed in tariff; financial support; mandatory procurement; renewable energy**

1. INTRODUCTION

At present, a situation has developed in Latvia's power sector that requires solution of the problem, by transforming the support system. Transformation has to be systematic, simultaneously spanning all aspects that effect not only energy producers and users, but also the development of the national economy, including the power sector. Energy systems' development and transformation tasks are connected with the implementation of simultaneous sustainable solutions, in order to achieve a triple effect.

Transformation has to include the complex transition to a low-carbon economy, simultaneously transforming energy systems for transition to renewable energy resources and implementing a programme for increasing energy efficiency activities. The systemic approach includes different aspects, and it is a complex, socio- economic transition, that can be improved by a different support mechanism system [1].

Complex transition is illustrated by analysis of three different aspects' effect, and only an increase in the overlap area of all three development directions allows to reach triple effect of energy supply system: in order to increase the proportion of renewable energy sources and energy efficiency activities, there has also to be focus on solutions of climate change mitigation and climate change adaptation problems [2].

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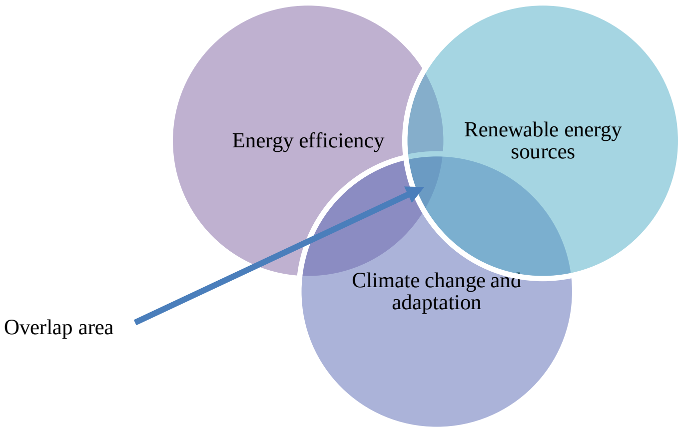

Fig. 1. Energy systems' development triple effect.

European Union (EU) legislative activities in the power sector relate to all three aspects. EU climate and energy package [3] has set a renewable energy sources proportion in year 2020. It is possible to reach it, by simultaneously increasing integration of renewable energy sources in the energy system and improving energy efficiency, especially on the side of the energy user. Two EU directives have been developed: Renewable energy sources directive [4] and Energy efficiency directive [5].

EU Renewable energy sources (RES) directive states that, at the national level, countries can develop different national support measures and cooperation mechanisms with other EU member states for the implementation of RES policies. However, EU countries efforts, when making national support mechanisms for enforcement of targets set in RES directive, show that special attention has to be brought to cost efficiency. The European Commission has stated that EU member states have to show all national support mechanisms that are based on market principles.

Latvia has chosen a renewable energy source and energy efficiency improvement support mechanism in the form of electricity mandatory procurement (MP) which presents some form of feed-in tariff. MP goal was to increase the renewable energy source share in the electricity end user balance. This can be realized comparatively simply, by financially supporting the use of local renewable energy sources, to replace fossil natural gas. This approach has several benefits: independence of the country increases, national economy develops, due to decrease of import and requirements of EU directives and country's commitment in achieving goals of the member states are executed. In the Ministry of Economics' year 2010 prediction [6] it is possible to find the hypothesis, the visual illustration of which after data processing is displayed in Fig. 2.

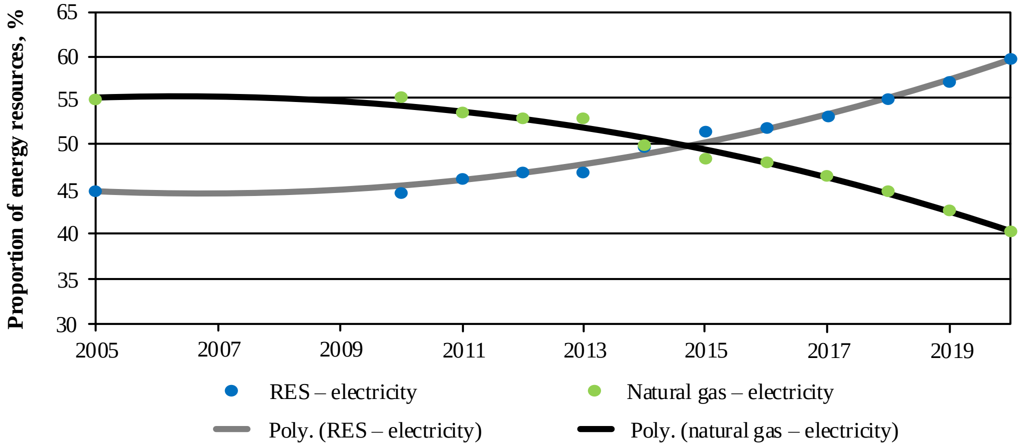

Fig. 2. Energy resources for electricity production.

It means, that with MP implementation predicted an increase in renewable energy sources share in electricity production from 45 % in year 2010 up to almost 60 % in year 2020. The plans were promising, but over the years it became evident, that the predictions of increase will not be achieved, because the number of MP recipients and paid finances increased, but the MP increase had no connection with RES use. For example, the mandatory procurement component in the electricity tariff was applied to small fossil natural gas combined heat and power plants for electricity produced in cogeneration regime and later to large electricity plants as well. This inconsistency was justified with energy resource (even fossil) support to efficient CHPs.

2. Electricity Support Tariffs

Electricity production support mechanisms in EU member states differ in terms of renewable energy source types (for biogas (BG), biomass (BM), hydropower (HY), solar energy (SO) and wind energy (WI)), in terms of support mechanisms (subsidies, grants, loans, procurement tariffs, *premium* tariffs, quota system, tax system), and financial rules (support rules and amounts). There are countries that support the use of only one of solar energy, hydropower, or wind energy, but there also are countries, that support all types of renewable energy sources [7]–[9].

Two big groups take part in the mandatory procurement system: energy producers (MP recipients) and energy users (MP payers). Both groups are displayed in Fig. 3.

Support mechanisms for biogas, biomass, hydro, solar and wind power stations in Austria, Germany, the Netherlands and Sweden are summarized in Table 1.

TABLE 1. RES ENERGY SUPPORT MECHANISMS IN AUSTRIA, GERMANY, THE NETHERLANDS AND SWEDEN [10]–[13]

Country		**AT**	**DE**	**NL**	**SE**
Subsidies	BG				
	BM				
	HY	V			
	SO	V		V	V
	WI				
Loans	BG		V		
	BM		V		
	HY		V	V	
	SO		V	V	
	WI		V	V	
Procurement tariff	BG	V	V		
	BM	V	V		
	HY	V	V		
	SO	V	V		
	WI	V	V		
Premium tariff	BG		V	V	
	BM		V	V	
	HY		V	V	
	SO		V	V	
	WI		V	V	
Quota system	BG				V
	BM				V
	HY				V
	SO				V
	WI				V
Tax regulation	BG			V	
	BM			V	
	HY			V	
	SO			V	
	WI			V	V

2.1. Electricity Procurement Tariff Determination Methodology

In Austria and Germany, the electricity feed-in tariff is based on base rate (EUR/kWh), that is set in the country’s laws and binding regulations and is dependent on the RES type and installed capacity of the equipment. Depending on technological solution, process efficiency and other criteria, a range of allowances may be applied to the base tariff. Similarly, also in the Netherlands, based on money flow calculations, an electricity procurement base rate for each RES technology is set every year. The procurement end tariff is calculated as the difference between base rate and electricity market price [14], [15].

It is remarkable that in all these mentioned countries regulatory enactments and binding documents contain the terminal values of the electricity procurement base, rather than the calculation formulas with the dependent variables. Therefore, the electricity producer receives clear information about intensity of expected support mechanism. In case of Latvia, regulatory enactments define a string of electricity procurement tariff calculation formulas with different dependent variables and values that make the support mechanism complex.

2.2. Long-Term Intensity of Electricity Procurement Tariff

In Latvia, the electricity procurement tariff is paid for 20 years, with decreasing support intensity in the last 10 years. The practices of Germany and Austria show that an annual decrease in the electricity procurement tariff with a certain percentage rate allows to decrease costs that relate to maintenance of the support mechanism and motivate producers to introduce activities for decrease of electricity production costs [16].

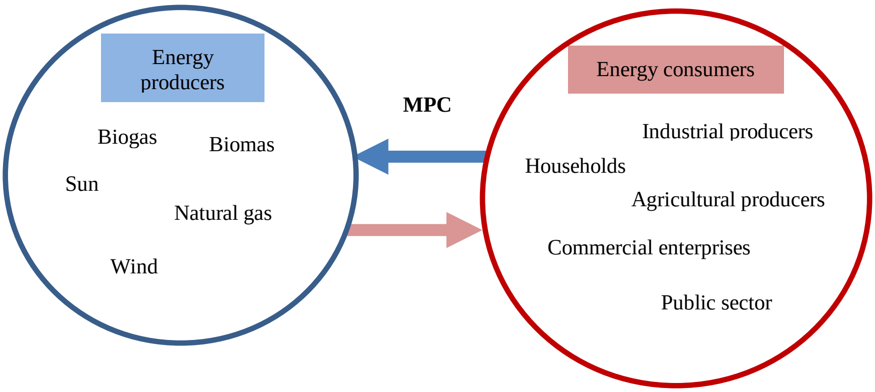

Fig. 3. Parties involved in receipt and payment of MPC.

2.3. Quota System

In Latvia, the total paid support amount in mandatory procurement tariff boundaries is limited by a quota system which, according to necessary RES part in energy end consumption, determines the number of authorisations for electricity procurement rights to be issued to operators. Despite received quotas, operators often encounter problems with starting equipment operation, therefore, the planned RES proportion increase does not appear in the balance of the country. A quota system for promotion of renewable energy production also operates in Sweden, however, there it relates to green certification market system for electricity, therefore providing, that necessary RES proportion is achieved.

In Austria, Germany and the Netherlands quota systems are not connected with electricity procurement tariff. In Austria, each RES type has a set yearly available amount of funding for maintenance of the electricity procurement tariff support mechanism. In the Netherlands, there is a common budget for all RES technology support in the framework of the support system. In Germany (for photovoltaic panels (PV)) there are set limits for installed capacity (52 W), after which, a procurement tariff for new equipment is not planned to be paid [11], [15].

2.4. Support for Electricity Production in Cogeneration

Electricity production in cogeneration in Germany and Austria is supported in the form of cogeneration additional payment, not with a separate procurement tariff, as it is done in Latvia. Investments are available for installation or modernization of cogeneration equipment. To receive support, equipment has to provide accomplishment of efficiency criteria and use of useful heat [12], [13].

3. History of Mandatory Procurement in Latvia

3.1. Development of Mandatory Procurement Component

Latvia has implemented government support mechanisms for promoting renewable energy:

– Mandatory procurement;
– Guaranteed payment for installed electric capacity (for bigger cogeneration plants).

In Latvia, costs that occur, by supporting electricity produced from RES or in high efficiency cogeneration until the mid-2017 was covered by all electricity end users in Latvia in proportion to electricity consumption and connected power, because MPC is included in electricity price. Recently, energy users' exceptions have been determined, who does not have to pay MPC [17].

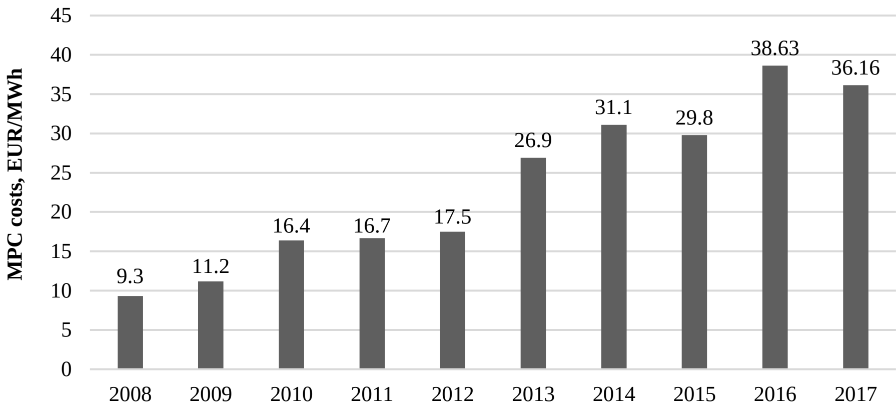

Fig. 4. MPC costs diagram.

Value of electricity mandatory procurement component changed over time (see Fig. 4), and total costs increased, drawing parallels with development of new legislation documents and provision of new possibilities for potential MPC recipients.

MPC implementation in Latvia started in the year 1995, by introduction of double tariff for electricity produced in small hydropower stations (HPS). It was followed by implementation of renewable energy sources (except electricity generated from the sun), small cogeneration stations and afterwards for big electricity stations. Then over the years, gradually, the value of electricity mandatory procurement increased (see Fig. 4). Historical events have lined up in this order:

– In 2008, the calculated MPC price was 0.93 cents/kWh;
– In 2010, MPC price calculated by Public utilities commission (PUC) was 1.64 cents/kWh;
– In 2012 MPC price increased up to 1.75 cents/kWh;
– In 2013 up to 2.69 cents/kWh. Compared to 2008, when mandatory procurement component was introduced, MPC price has increased by 1.89 cents/kWh or 3.3 times. Increase size is linked to natural gas market tariff. In comparison with neighbouring countries, in Lithuania MPC in 2013 was 2.72 cents/kWh, but in Estonia – 0.87 cents/kWh;
– In 2014, subsidised electricity tax (SET), to prevent costs increase for both electricity users and national budget that can endanger support for environmentally

friendly electricity production in existing amount. SET has three different determined rates:

- 15 % for natural gas cogeneration plants,
- 10 % for RES using plants,
- 5 % for plants, that comply with set requirements;

– For producers, that produce electricity using RES and sell in the framework of mandatory procurement, support amount above market price in 2014, compared to 2013, has increased by 12.3 % (from 73.98 mil. EUR to 83.07 mil. EUR), whereas in the first half-year of 2015, it made up 65 % from paid support amount above market price in 2014. The same was for cogeneration plants, that use fossil energy resources for energy production, paid support amount above market price, that in 2014 compared to 2013, increased by 15.9 % (from 135.92 mil. EUR to 157.50 mil. EUR), whereas in the first half-year of 2015, it made up 53 % from paid support above market price in 2014;

– In 2015 SET influenced a small MPC decrease from 31.1 cent/kWh to 29.8 cents/kWh;

– In 2016 MPC reached its highest value in MPC history and increased up to 38.63 cents/kWh, increase was observed for these energy sources:

- high efficiency natural gas cogeneration plants with electric capacity up to 4 MW or plants, that use RES without capacity limits, that provide heat for centralised heating systems,
- high efficiency cogeneration plants with electric capacity up to 4 MW, that provide at least 30 % from electricity production with animal origin by-products or their derivatives and that provide at least 70 % of raw materials themselves or buy from the producer, that owns more than 50 % from tax payer share capital, besides, produced heat is used in their own production,
- high efficiency woody biomass cogeneration plants with electric capacity up to 4 MW and at least 70 % from heat produced in cogeneration process is used in their own production,
- high efficiency natural gas cogeneration plants with electric capacity up to 4 MW or without installed electric capacity limits in RES cogeneration plants, that uses at least 70 % from produced heat for providing plant vegetation process in covered areas, whose total area is smaller than 5000 m^2.

– In 2017 first MPC payments for first natural gas small cogeneration plant owners ended, that decreased MPC value a little.

TABLE 2. SUPPORT AMOUNT ABOVE MARKET PRICE IN 2016 [18]

MPC recipients	Support, mil. EUR	Proportion, %
Mandatory procurement from RES plants	91.9	38.8
Biogas power plants	47.9	20.2
Biomass power plants	24.4	10.3
Wind power plants	8.3	3.5
Small HPS	11.3	4.8
Capacity charge (RES)	5.2	2.2
MPC for fossil cogeneration plants	34.8	14.7
Capacity charge (fossil cogeneration plants)	105.3	44.3
Total	237	100 (41 % RES + 59 % NG)

Several electricity consumer group representatives' (industrial and agricultural producers) active protests against MPC costs inclusion in electricity tariff caused development of new normative documentation and redistribution of support funding.

3.2. Main Parameters, that Directly and Indirectly Influences MPC

Mandatory procurement component value is affected by interconnected engineering-technical and economical parameters and factors. In general mathematical form, this can be illustrated with Eq. (1):

$$MPC = f(C_{\mathrm{bm}}, C_{\mathrm{ng}}, N_{\mathrm{el}}, Q_{\mathrm{th}}, B, \eta, n, \tau, z, E_{\mathrm{prod.el}}, Q_{\mathrm{prod.th}}), \tag{1}$$

where

C_{bm} Biomass fuel price;
C_{ng} Natural gas price;
N_{el} Installed electric capacity;
Q_{th} Installed thermal capacity;
B Fuel consumption;
η Equipment operation efficiency coefficient;
n Energy resource type;
τ Number of operation hours in a year;
z Taxes;
$E_{\mathrm{prod.el}}$ Total produced electricity amount;
$Q_{\mathrm{prod.th}}$ Total produced heat amount.

Support intensity for electricity production with RES technologies and natural gas cogeneration plants is determined by MC regulation No. 221 [19] and/or No. 262 [20] (further in text as MC 221 and MC 262). Support level in both regulations is defined differently, as well as different calculation formulas have been used.

Several of those are reviewed below, to accent main reasons, why MPC value increased and to illustrate, what parameters, with the help of normative documentation, are chosen for support of certain technologies. MPC value is dependent on the natural gas tariff, installed electric capacities, produced electricity, operation time and location.

3.3. Binding Formulas to Natural Gas Price (in MC 221)

Natural gas tariff, that significantly increases MPC value, if natural gas price increases rapidly, is used in support intensity calculation formula:

$$\mathrm{MPC} = f\left(\frac{T_g}{Q_z^d}\right), \quad (2)$$

where

T_g Natural gas tariff, EUR/1000 m^3;

Q_z^d 9.3, natural gas lower heating value, MWh/1000 m^3.

MPC size is dependent on natural gas tariff value inclusion in electricity tariff determination equation. For MPC size analysis, to determine fuel effect, Fig. 5 can be used.

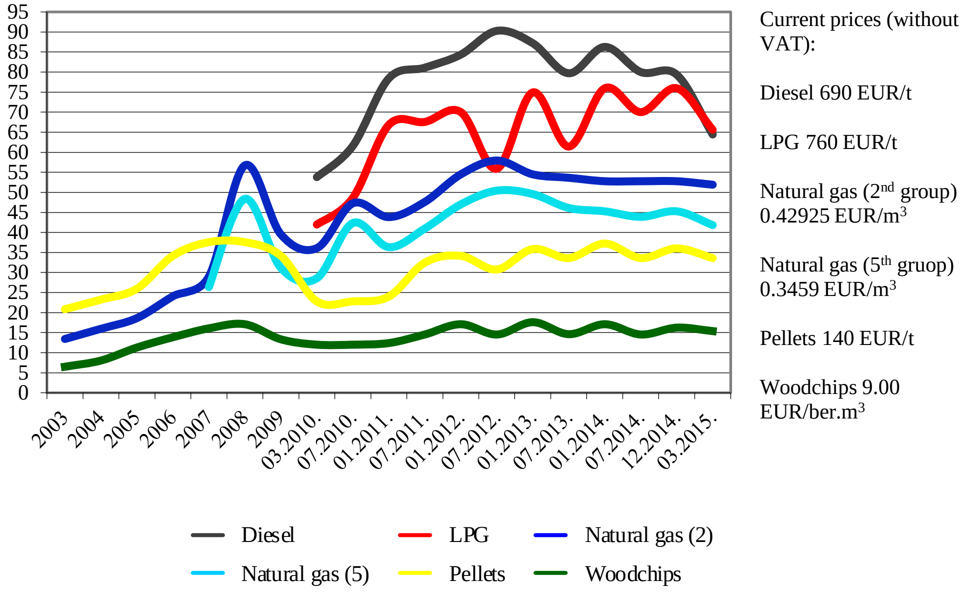

Fig. 5. Different fuel costs since 2003, taking into account efficiency coefficients of modern boiler houses.

It is important to consider, that from 2009 until 2015, as statistical data indicate, the trend in change in energy wood price can be regarded as constant, even though moments can be observed, when prices decrease or increase. Whereas the natural gas price increase during the same timeframe has almost doubled, for example, for 5th natural gas user group, it has increased from 30 EUR/MWh to 45 EUR/MWh (considering, that in both cases, natural gas is used in modern energy sources with equal efficiency coefficient).

3.4. Necessity of price differentiation coefficient (MC 221 and MC 262)

Support intensity calculation formula uses value:

$$k = f(dN), \quad (3)$$

where

k Coefficient, that is dependent on installed electric capacity;

dN Installed electric capacity range.

MC 262 coefficient is determined for 19 capacity ranges that provide more substantial support for small capacity electricity plants.

3.5. Capacity and Energy Component Distribution (MC 221)

In the support intensity calculation formula, cogeneration engineering-technical indicators are used, with the help of which, payments for capacity and energy are determined, when producing in cogeneration cycle: C – price of electricity produced in cogeneration plant for cogeneration plants until 4 MW, EUR/MWh; C_E – procurement price energy component for cogeneration plants above 4 MW, EUR/MWh; C_J – procurement price capacity component for cogeneration plants above 4 MW, EUR/MW/year.

3.6. Energy Efficiency (MC 221 and MC 262)

Efficiency coefficient 0.83 is included in support intensity calculation formula, that means the demand for cogeneration plant to use heat in heating systems (also applies to MC 262).

3.7. Operation Hours (MC 221 and MC 262)

In support intensity calculation formula directly or indirectly a value is used, for example, 3000 hours/year, which shows that using MPC, an efficient and short-term (1/3 year) operation of cogeneration plants is promoted.

3.8. Cross-Subsidies in Determination of Heat Tariff (MC 221)

Unlimited heat price is not an additional load for mandatory procurement tariff. Cross-subsidies is a financial instrument, with the help of which, cogeneration plants' profits are distributed for subsidisation of heat tariff. Tariffs, subsidised in this way, are approved by PUC.

3.9. Prevented Network Losses Coefficient (MC 221)

In the support intensity calculation formula, a correction coefficient on prevented network losses for dissipated energy production support is used.

4. MANDATORY PROCUREMENT ARRANGEMENT OPTIONS

Support mechanism for implementation of renewable energy sources is necessary due to several reasons [21]–[23]:

- Development of national economy cannot be imagined without well-considered and sustainable use of local resources:
  - to increase employment level,
  - to increase income with taxes,
  - to solve socially-economic problems, that relate to energy tariffs,
- Independence in energy relates to political independence of the country;
- Formation of business environment and promotion of innovations, by investing in innovative technologies;
- Decrease of effect on climate change;
- Climate change adaptation and increase of urban infrastructure resilience.

There are a lot of power industry regulatory documents, and they often lack succession, and it could be the main reason, why each document solves the problem as though it were a new one. In this paper, policy documents starting from 1995 are analysed.

4.1. Main Conditions of Power Industry Development

Considering an even wider integration of Latvia in European and world energy markets, it was planned to take into consideration new regional projects, that could increase security of energy supply and market liquidity, without forgetting that in wider market, there is an increase in a number of factors affecting Latvia. That is why "Power industry strategy 2030" [6] predicted flexible national and regional power industry sector policies, promoting their interaction and providing flexibility, so that, if any of the regional range projects, for which there was no confidence at the time, would be implemented or on the contrary – would not be implemented, "Power industry strategy 2030" would not lose its meaning and would still be able to effectively determine development directions of the power industry [24].

Recognizing the comparatively small energy market size of Latvia and the whole region, not only effective EU finances and support acquisition was planned, but also development of national range power industry instrument, combining loans with an effective grant system, and in its framework planning support for RES development, especially for research and development projects, for example, building insulation, as well as support for most significant national level; power industry infrastructure projects. It was planned to implement this kind of instrument in the framework of a novel Development financing institution, which was supposed to be established by the end of 2013, by uniting Guarantee agency of Latvia, Mortgage and land banks of Latvia and Land development fund. It was partially developed by making ALTUM. The united development finance institution could provide a sustainable, systematic and easily-administrated mechanism for providing financial support for business, providing support for full operation cycle of the company and situation in the market. When defining national level support instruments in RES and in the field of energy efficiency, it was planned to consider the possibility, that, in the future, at the EU level there may be an attempt to have an equal and collated approach to national support instruments of Member states.

In the informative report on power industry policy planning guidelines in a time from until year 2030, three tasks were highlighted [15]:

- Energy supply safety;
- Energy efficiency increase;
- Promotion of renewable energy sources uses.

When solving **energy supply safety questions**, it was determined, that its aspects have to be carefully evaluated both through the national and regional scope. Within the national scope, the rapid development of microgeneration should be considered, that requires a closer maintenance of the market and planning of activities, to be able to effectively integrate the energy produced in microgeneration process in the network. Whereas within the regional scope, it was predicted to consider challenges of the region, EU targets and energy policy of the neighbouring countries. "Strategy 2030" includes several preconditions and commitments on objectives and activities, in order to access to effective energy resource markets, stable and justified energy prices, as well as a safe national and regional power sector infrastructure in the long-term.

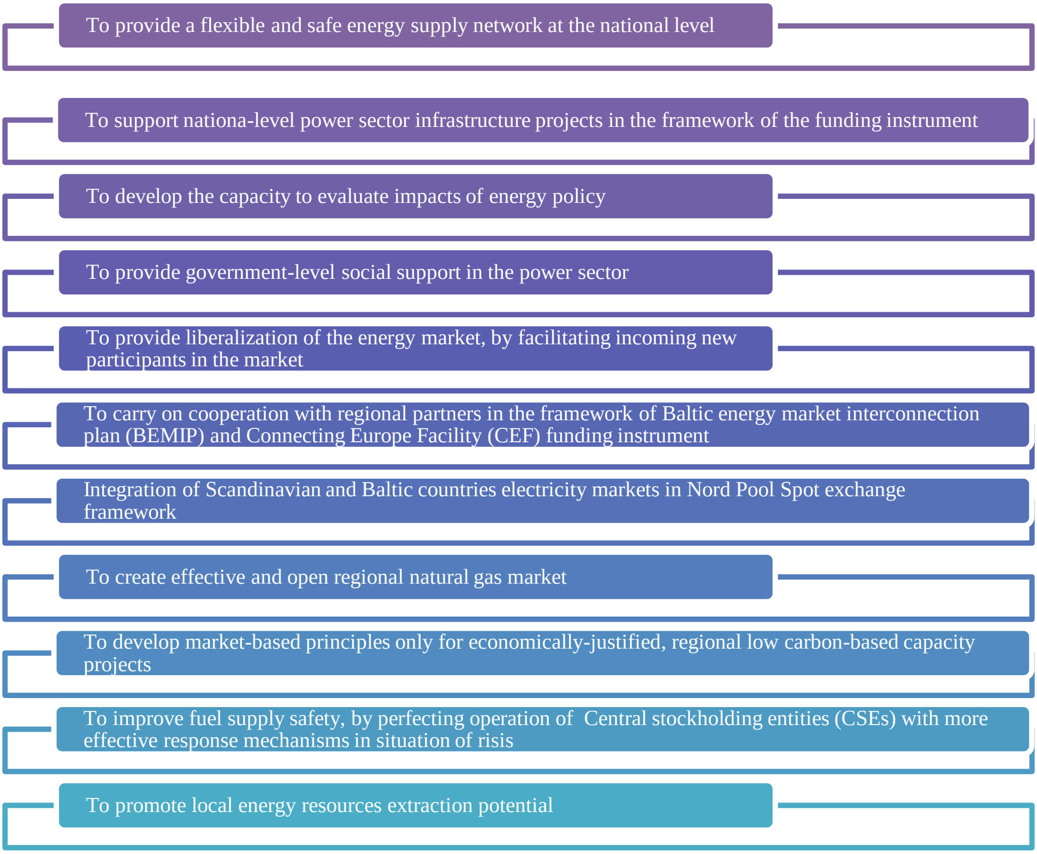

Fig. 6. Energy supply safety provision tasks.

Equally important was the prediction to plan an increase of energy efficiency which in the period of "Strategy 2030" is set as a national priority. Low energy efficiency level creates risks to energy supply safety, sustainability and competitiveness, nonetheless an increase in this level was considered the fastest and financially most effective type of risk which could be reduced, simultaneously creating additional workplaces and promoting growth. There is a significant market shortcoming in ensuring energy efficiency, especially in the building and transport sectors. To prevent these issues and promote energy efficiency across all sectors, there were several prerequisites set in "Strategy 2030".

Fig. 7. Energy efficiency increase tasks.

To decrease energy resources (for example, fossil fuel, natural gas) import and promote development of local energy production, a lot of attention in “Energy strategy 2030” is brought to promoting RES use in electricity and heat production and transport sector. Latvia’s goal until 2020 is to reach a produced energy proportion from renewable energy sources of 40 % in energy gross end consumption.

Through the implementation of support which is based on market principles and which is technologically neutral, and providing appropriate tax and emissions trade policy, until 2030 a non-binding 50 % RES threshold is achievable in energy gross end consumption, by introducing these pre-conditions.

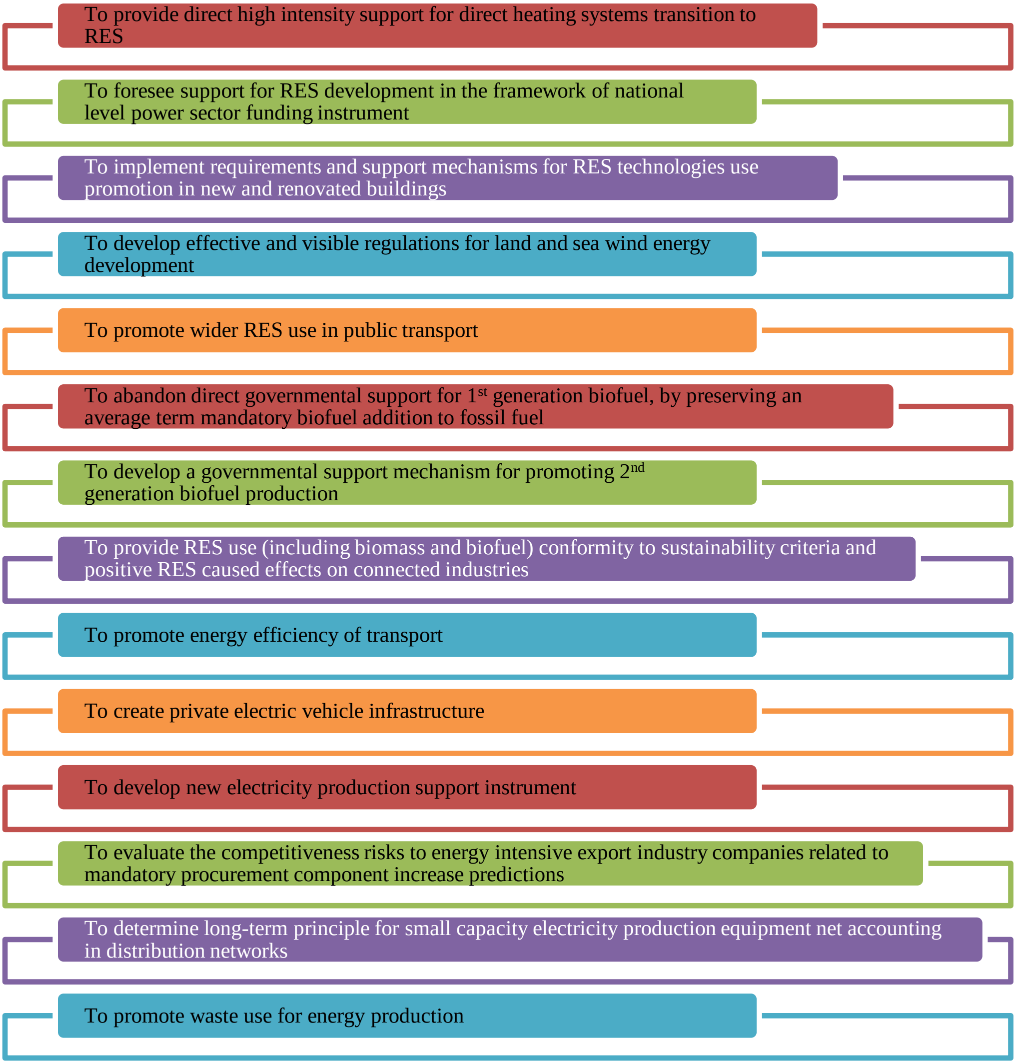

Fig. 8. Renewable energy sources use promotion tasks.

4.2. Energy Policy Objectives

Another document, looking at energy policy objectives, is Energy development guidelines for 2016–2020 [14]. Even though the document was developed three years later than “Power industry strategy 2030”, emphasis has changed a little. The main keywords are climate, renewable energy sources and energy efficiency.

Guidelines set operational directions, considering these climate and energy policy targets that EU has to reach by 2020:

- To decrease GHG emissions by 20 %, compared to the level of 1990;
- To increase renewable energy proportion in energy consumption to 20 %;
- To increase energy efficiency by 20 %.

The main target of Latvia's energy policy is to increase national economy competitiveness, by advancing safety of supply, free market and competitiveness set energy resources and energy price development, sustainable energy production and consumption together with other industries policy implementation. In order to provide a balanced energy policy for the interests of the national economy and the population, two energy policy objectives have been set [14]:

- Sustainable power industry [25]:
  - planned activities for "green energy" proportion increase, GHG emissions reduction and consumed energy effective use,
  - to provide renewable energy proportion increase in energy end consumption, planned activities are focused on fixing the support mechanism and further development, providing its operation according to market principles,
  - in energy efficiency industry legal framework will be arranged, so that Latvia could reach its set energy economy targets in the end consumer side, and by continuing started insulation programmes for apartment houses and to begin fixing governmental and municipal buildings,
  - in addition to that, it is planned to work on a more efficient heating market and development of zero emissions transport;
- Increasing security of energy supply [26], [27]:
  - it is planned to implement activities, that are focused on energy users for provision of available, stable energy supply:
    - by reducing geopolitical risks,
    - by differentiating energy resource supply sources and roads,
    - by developing interconnections and governmental inner energy supply infrastructure,
    - by implementing smart technologies in energy supply networks,
    - by creating reserves of energy resources,
    - by taking part in improvement of legal framework;
  - it is planned in the long-term to optimize energy supply safety expenses and it requires regional cooperation:
    - by promoting further integration in EU and Scandinavian countries networks,
    - by reaching price equalization in the region and differentiation of energy supply,
    - by solving both electricity and gas infrastructure questions in EU level in the framework of energy inner market.

For realisation of activities included in guidelines until 2020 there is funding from government or municipalities budget, EU funds, European infrastructure connection instrument, as well as funds from capital companies.

Energy development guidelines 2016–2020 is a policy planning document, that determines the basic principles of Latvia's government, targets and action direction in the power industry for the timeframe 2016 until 2020.

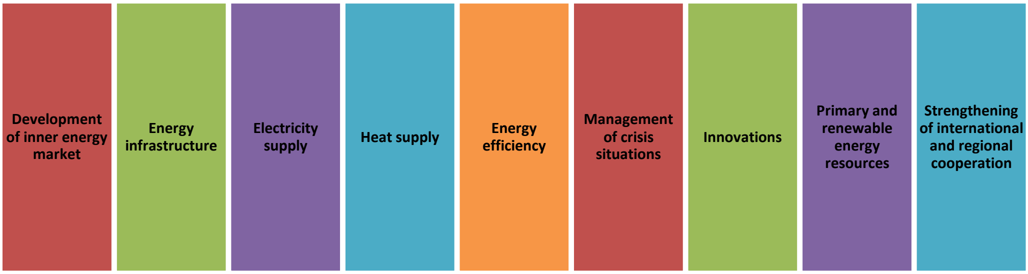

Fig. 9. Main directions of tasks to be performed in the power industry from 2016 until 2020.

5. Development Directions of Mandatory Procurement

5.1. MPC Cancellation Analysis

By cancelling MPC, an analysis should be made, to determine why electricity produced in cogeneration received support for electricity production. An important argument is primary energy (fuel energy) economy, which is an effective indicator of comparing different energy production types. Comparison is made between electricity and heat production in two diametrically opposed cases:

– Both energy types are produced in cogeneration simultaneously;
– Both energy types are produced separately in boiler house and power plant.

Both electricity and heat production technological solutions from the point of energy resource economy are compared in Fig. 10.

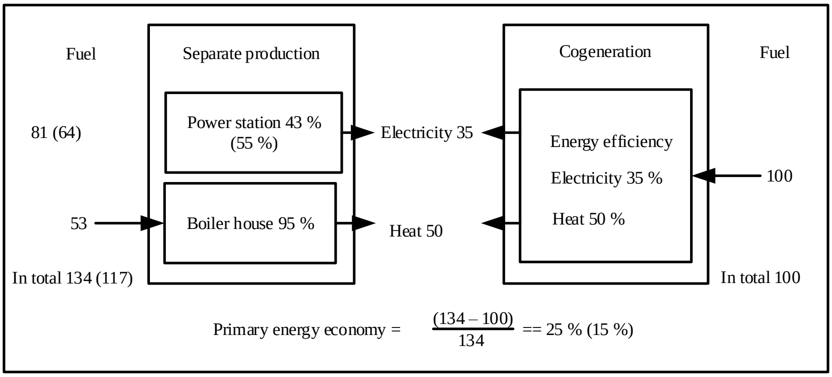

Fig. 10. Comparison of cogeneration and separate energy production.

As can be seen from analysis in Fig. 10, in order to reach equal amounts in separate heat and electricity production, a larger amount of fuel is necessary. The energy efficiency indicators of cogeneration electricity and heat production are 35 % and 50 %, respectively. They correspond to real values, using internal combustion engines. Primary energy economy is affected by the energy efficiency of separate energy production– the higher is the energy efficiency; the smaller the economy. Fig. 10 displays a case, where electricity is produced in a power station with the efficiency of 43 % and heat – in a boiler house with an efficiency 95 %. In the figure, for the sake of comparison, the values in brackets are provided when electricity is produced in a modern, combined cycle natural gas power station. As can be seen from the picture, in case of cogeneration, the primary energy economy is between 15 % and 25 %.

5.2. Evaluation Methodology

The evaluation methodology includes analyses of profits and losses on two levels.

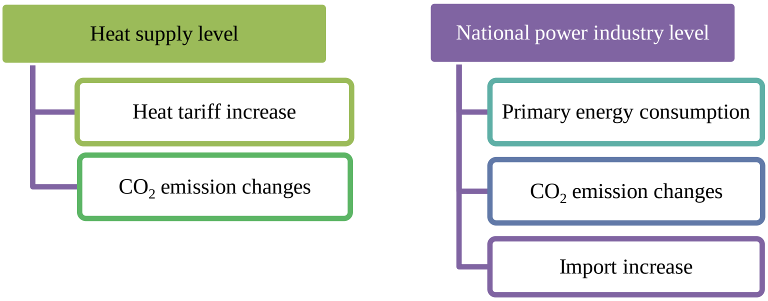

Fig. 11. Influence evaluation levels in case of MPC cancellation.

Influence evaluation methodology has to include two different levels. The heating company level has to be analysed from the perspective of electricity support and heat cross-subsidy. At the national power industry level, it is important not only to consider primary energy consumption and imported energy increase, but also increase of effects on climate change.

When determining heat tariff, a heating company has the option to use cross-subsidies, because there is no partial coverage of plant costs included in the calculations (MC 221) and a proportional allocation of costs for heat production is not provided for (MC 262). Consequently, by cancelling MPC for electricity, the cross-subsidy component in the heat tariff will disappear, which will lead to an increase in heat tariff from 10 % to 30 %.

The heating company's impact evaluation methodology also includes an energy resource consumption nomogram, the example of which has been produced for a specific company (Rezekne heat networks) below.

Greenhouse gas (GHG) emission increase is evaluated depending on energy resource type. If the heating company of a plant replaces fossil fuel cogeneration with a biomass boiler, CO_2 emissions reduction is obtained using equation:

$$\mathrm{CO_2} = B_2 \cdot R,\ \mathrm{t_{CO2}/year}, \tag{4}$$

where

R Fossil fuel emission factor, $\mathrm{t_{CO2}/MWh}$.

Primary energy economy reduction in the national power industry is determined by calculating fuel consumption in cogeneration and, separately, in boiler house and power plant:

- Energy resource consumption at the energy source with cogeneration equipment (before MPC cancellation) is obtained using the following equation:

$$B_1 = (N_{\mathrm{el}} + Q_{\mathrm{th}}) \cdot \tau / \eta_{\mathrm{kog}},\ \mathrm{MWh/year}, \tag{5}$$

where N_{el} – installed electric capacity in cogeneration plant, MW; Q_{th} – installed thermal capacity in cogeneration plant, MW; τ – *c*ogeneration station's operation hours in a year, h/year; η_{kog} – efficiency coefficient of cogeneration plant.

– Energy resource consumption in boiler houses for replacement of cogeneration equipment with boiler houses (after MPC cancellation) is calculated in accordance with the equation:

$$B_2 = Q_{th} \cdot \tau / \eta_{bh}, \text{ MWh/year,} \tag{6}$$

where
η_{bh} Efficiency coefficient of boiler house.

– Energy resource consumption for electricity production in a power plant is determined using equation:

$$B_3 = N_{el} \cdot \tau / \eta_{elst}, \text{ MWh/year,} \tag{7}$$

where
η_{elst} Efficiency coefficient of boiler house.

– Energy resource consumption increase in the national power industry after MPC cancellation during the period, when heating company's cogeneration plants stop production, is calculated using the equation:

$$B_4 = B_2 + B_3 - B_1, \text{ MWh/year.} \tag{8}$$

GHG emissions increase is evaluated depending on energy resource type. In case of fossil fuel use, CO_2 emissions addition in national GHG account is determined with the equation:

$$CO_2 = B_4 \cdot R, \text{ t}_{CO2}\text{/year,} \tag{9}$$

where
R Fossil fuel emission factor, t_{CO2}/MWh.

An increase in energy resources import negatively affects not only the power industry, but also the national economy overall. The decrease in economy of primary energy resources after MPC cancellation makes it possible to determine national financial losses from imported fossil energy resources:

$$I = C \cdot B_4, \text{ EUR/year,} \tag{10}$$

where
C Fuel price, EUR/MWh.

5.3. An Example of Analysis. City of Rezekne

In Rezekne in 2008, a reconstruction of energy sources began, by replacing the technological equipment for heat production (replacing steam boilers with water heating boilers). Two cogeneration plants were developed. During reconstruction, the use of heavy fuel oil was fully abandoned, replacing it with natural gas, and planning diesel as back-up fuel. The total JSC "Rezekne heat networks" heat capacity makes up 86.83 MW, but electric capacity – 5.57 MW [16].

TABLE 3. ENGINEERING-TECHNICAL DESCRIPTION OF ENERGY SOURCES IN REZEKNE

Heat source	Heat source address	Energy production equipment	Number	Capacity, MW	
				Thermal	Electric
Cogeneration plant	Riga iela 1	Boilers:			
	N. Rancana iela 5	*Logano* SB 825 M-16400	3	49.2	
		Cogeneration equipment:			
		TCG 2020 V20	2	3.9	3.9
		Sub-total:		53.1	3.9
Cogeneration plant	Atbrivosanas aleja 155a	Boilers:			
		Logano SB 825 M-12600	2	25.2	
		Vitomax 100	1	2.9	
		Cogeneration equipment:			
		TCG 2020 V12	1	1.11	1.07
		TCG 2016 V12C	1	0.62	0.6
		Sub-total:		29.83	1.67
Boiler house	Meza iela 1	Boilers:			
		Vitoplex 200	1	1.3	
		Vitoplex 200	1	1.3	
		Vitoplex 200	1	1.3	
		Sub-total:		3.9	
Total				86.83	5.57

The events in Rezekne in the time period after reconstruction, were illustrated by articles in central and local newspapers.

In 2012, the national newspaper *"Neatkariga Rita Avize"* informed about 5.35 million EUR total investments in reconstruction of boiler houses in Rezekne with 0.74 million EUR EU Cohesion fund co-funding. By selling electricity in the common "Latvenergo" market, "Rezekne heat networks" gained funding, that offer an opportunity to reduce production costs [28].

In April of 2013 in the paper "Dienas Bizness" [29], it was reported that Rezekne began to use cogeneration equipment that, together with reconstruction of three boiler houses, made it possible to improve efficiency of heat production. PUC confirmed heat tariff reduction by almost 20 %. The heat tariff in February 2013 in Rezekne was 74.47 EUR/MWh, but in April

– 61.75 EUR/MWh. At the time, it was one of the lowest heating tariffs among Latvia's largest cities.

In January 2018, the PUC decided to reduce Rezekne's heat end tariff. Currently, the end tariff that corresponds to the latest natural gas price published (on 1 April 2017) is 184.97 EUR/thsd. nm^3, namely, 52.42 EUR/MWh is applied in Rezekne. The new fixed end tariff since 1st March 2018 is 52.14 EUR/MWh that in relation to current valid end tariff, is a decrease by 0.5 % [30].

In order to analyse the operational indicators of Rezekne's cogeneration energy sources, a natural gas consumption nomogram depending on efficiency coefficient has been developed and is illustrated in Fig. 12.

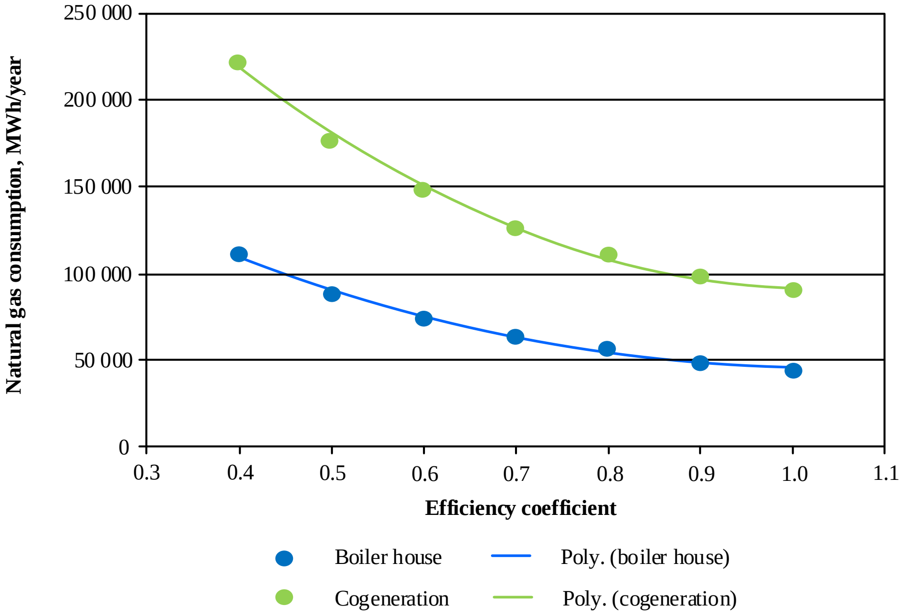

Fig. 12. Natural gas consumption nomogram.

If cogeneration equipment is used for simultaneous production of heat and electricity at the energy source, the natural gas consumption curve is mathematically described by the equation:

$$B = 322075 \cdot \eta^2 - 663979 \cdot \eta + 433576, \text{ MWh/year.} \tag{11}$$

If thermal energy generation equipment is used for production of heat at the energy source, natural gas consumption curve is mathematically described by equation:

$$B = 161037 \cdot \eta^2 - 331990 \cdot \eta + 216788, \text{ MWh/year.} \tag{12}$$

If MPC is cancelled, then:

– Heat tariff T_{th} in Rezekne will increase by 20 %:

$$T_{\text{th}} = 52.14 \cdot 1.2 = 62.57\ \text{EUR/MWh},$$

– Natural gas imports in boiler houses for cogeneration equipment in Rezekne before MPC cancellation:

$$B_1 = 5.57 \cdot 2 \cdot 8000/0.8 = 111400\ \text{MWh/year},$$

– Natural gas imports in boiler houses in Rezekne for cogeneration equipment replacement with boilers after MPC cancellation:

$$B_2 = 5.57 \cdot 8000/0.9 = 49511\ \text{MWh/year},$$

– Natural gas consumption for electricity production in CHP plants in condensation mode in Riga, to provide electricity deficit during the period, when cogeneration plants in Rezekne stop production:

$$B_3 = 5.57 \cdot 8000/0.5 = 89120\ \text{MWh/year},$$

– Natural gas import increase in Latvia after MPC cancellation during the period, when cogeneration plants in Rezekne stop production:

$$B_4 = 89120 + 49511 - 111400 = 27231\ \text{MWh/year},$$

– If natural gas price is low 20 EUR/MWh, Latvia's national economy financial losses of natural gas import after MPC cancellation, if cogeneration plants in Rezekne stop production and electricity deficit is covered by heat-electric generating plant in Riga, would be bigger than 0.5 million EUR each year:

$$I = 20 \cdot 27231 = 544662\ \text{EUR/year},$$

– Greenhouse gas emissions increase is evaluated depending on the energy resource type. In case of fossil fuel use, it is determined by the equation:

$$\text{CO}_2 = 27231 \cdot 0.201 = 5446\ \text{t}_{\text{CO2}}/\text{year}.$$

Prior analysis shows, that MPC has been disproportionately large, but in case of its cancellation, the national power industry will increase fossil fuel consumption in power plants. This is due to several reasons: the development policy of the power industry in terms of technological solutions for electricity production has been focused on support for natural gas cogeneration plants and has not been sustainable in terms of renewable energy sources. A paradoxical situation has evolved, whereby the recipients of MPC legal protected and it is not possible to cease MPC to and at the same time, if country would decide to pay compensation to MPC recipients, natural gas consumption in Latvia will increase, because a divided heat and electricity production would begin and primary energy resource consumption would increase.

5.4. Development Vision of the Power Industry

Financial support for new technological solutions for electricity production is applied in many European Union member states. Support forms and methods can change and differ [17].

However, electricity mandatory procurement is a kind of guarantee for sustainable development of national economy in the country which is why it is important to analyse and evaluate possibilities and their use.

Recently several development trends of energy systems have emerged. Electricity supply and heating becomes closer connected due to different reasons. Smart power industry offers to change flexibility of capacities, new innovative technological solutions, energy management and behaviour of energy consumer. Therefore, it is important to predict energy supply that includes energy system groups, their interconnectivity, evaluating them in accordance with engineering-technical, economic, socio-economic, environmental and climate-related aspect.

Energy production and energy source choice is dependent on not only consumer load, but also on development level of technologies, on innovation implementation speed and other factors, that influence economic and climate change indicators. Electricity production will be even closer connected with heating system's development and cooperation with industry, diversification of energy resources and especially heat and electricity production from the Sun.

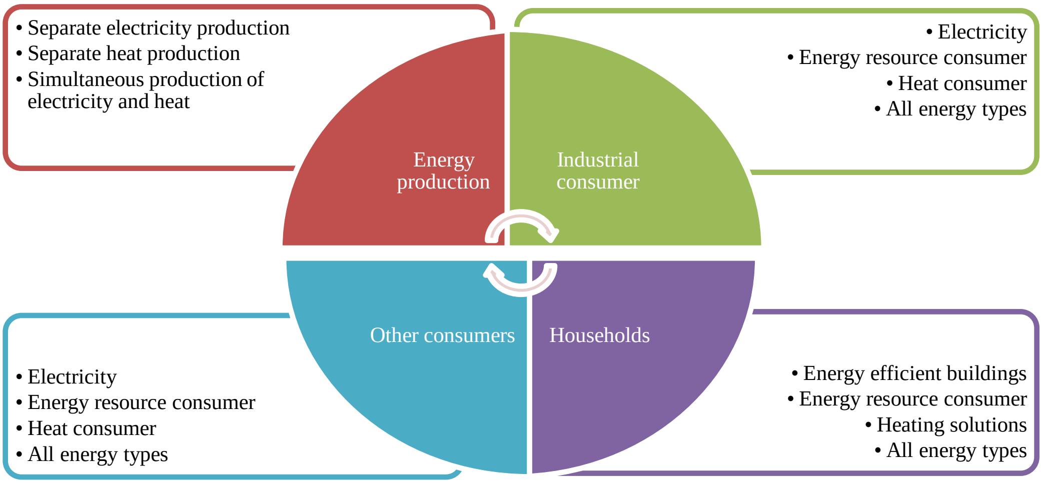

Fig. 13. Energy systems groups and current problems.

Development of biotechonomy or bioeconomy will bring significant changes to the national economy, including the power industry. National economy structure and resource use will change [31]:

– Due to circular economy development, currently widely available fuel will be used for manufacturing of products with a high added value. Competitiveness between resource use increase will create constructive competition among producers, and the power industry will remain with low quality biomass (forestry residue, straw and other agricultural residues);
– Solar panel role in power supply and heating will grow, because:
  - innovations in electric technology solutions are developing rapidly and solar panel prices decrease: during the last 5 years they have decreased by 75 % [32],
  - energy accumulation technological solutions for both heat and electricity storage and improvement of bioenergy quality are developing rapidly [32];

- Energy supply structure will change, because:
  - small and medium electricity and heat consumers will become energy producers to provide their own energy supply capacities and sellers of produced energy residue [33],
  - due to increase of energy consumers' energy efficiency, demand after installed capacities will decrease and necessity to reorganize components of the energy system will present itself, for example, to the decentralize part of heating system [34],
  - due to the development of energy consumers' elasticity potential evaluation, the demand for installed capacities will decrease [35],
  - the role of industrial companies in energy supply will grow, because not only industrial by-products will become raw materials for neighbouring companies, but also residual heat will become heat addition in district heating systems [36].
- Low energy consumption building construction requirements are already included in normative documentation. The introduction of low energy buildings in the urban environment will lead to significant changes in the perceptions of heat supply in municipalities. With a decrease in the load on the heating system, it will be important to decide how to create the heating supply system. Currently, there are 3 alternative solutions which are topical in Scandinavian countries, but in the Baltic countries there still are four solution groups [13]:
  - big heating systems with cogeneration plants at the source and with long heating networks,
  - small individual heating systems for densely inhabited building groups,
  - energy source for a single building, that can be a boiler, small cogeneration plant, or a combined system with a boiler and/or solar collectors or solar panels,
  - energy source in each apartment or room, ranging from a small boiler and chimney in the building wall, to a furnace in each room.
- The development of electricity supply system is dependent on future development direction of energy systems. The role of cogeneration stations will decrease proportionally to heating system changes and biotechonomy development [37], [38]:
  - renewable and fossil fuel for simultaneous electricity and heat production will compete with other solutions and more often there will be situations, when use of cogeneration plants will not be economically feasible,
  - fossil fuel cogeneration plants influence climate change and their sustainability will not be able to be justified in terms of the increase of negative impacts on the environment. In this case, it should be considered, that big cogeneration plants are participants of emissions trade scheme (ETS) and electricity producers in EU ETS scheme have to buy CO_2 quotas, with which to pay for their GHG emissions to the air,
  - the implementation of innovative technologies and replacement of big electricity production sources with alternative electricity supply solutions will become more and more popular:
    - with small dissipated renewable energy source electricity sources,
    - with individual electricity sources, for example, solar panels,
    - households have other problems and solutions, that are connected with changes in energy consumption, energy supply safety and energy efficiency of the consumer;

- The opportunities available to industrial companies are even wider, because manufacturers always have heat leftover from their processes which can be entered in district heating systems. Four different energy supply solution groups are possible:
  - industrial companies invest funding and install an energy source, the operation of which is only dependent on the availability and prices of energy resources,
  - manufacturers connect to an independent energy source,
  - industrial companies take part in industrial symbiosis and give all electricity and residual heat to nearby companies, including the heating supply system,
  - combined energy supply system with partial energy demand provision at the company's source and partial energy (mostly electricity) supply from the system;
- Households have other problems and solutions, that are connected with changes in energy consumption, energy supply safety and energy efficiency of the consumer [22]:
  - buildings will increase energy efficiency, and heating and electricity supply systems will have to adapt to new conditions. By evaluating energy consumption of households, it has to be taken into account, that engineering-technical and financial help of energy service companies (ESKO) will increase and by increasing their energy efficiency, energy consumption in buildings will decrease,
  - in order to capture the future vision, an indicator should be used, that characterizes low energy consumption building groups. Scandinavian countries use construction density ratio:

$$PR = \frac{F_{\mathrm{ap}}}{F_{\mathrm{ter}}}, \mathrm{m^2/m^2}, \quad (13)$$

where
F_{ap} Living space, m^2;
F_{ter} Construction area, m^2.

Heat users in this case can be divided in three groups:
- PR = 0.1–0.3 – single family buildings construction area;
- PR = 0.6–1 – multi-family buildings residential areas, for example, row houses;
- PR > 1 – residential neighbourhoods of multi-story buildings.

This indicator is one of the most important, that affects future energy supply development and planning.

The future challenges described in this chapter will affect the development of energy systems and the necessity to apply support mechanisms for different components of energy systems. Mandatory procurement is only a political instrument that can influence the development of the power sector both positively and negatively: by implementing MPC and other subsidies, it is possible to develop, stop or destroy the sustainability of a country's national economy. Therefore, the challenge of the country is to identify sustainable development directions and to support them.

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