Regional Energy Saving Program Development: Comprehensive Approach
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Terms and Definitions

Efficient use of energy resources (energy efficiency) – achievement of economically sound efficiency of use of energy resources in the context of the current level of engineering and technology development and in compliance with environment protection requirements.

Energy certificate (passport) – a document reflecting the energy resource consumption balance, efficiency parameters in terms of energy resource use within the framework of various activities of an entity, energy saving potential as well as data on energy saving activities.

Energy consumption – consumption of energy resources by consumers, individual entrepreneurs, and legal entities for their internal needs independent of their form of incorporation.

Energy efficiency indicator – an absolute or specific value of consumption or loss of energy resources for any purpose products set by national standards, entities’ standards, and voluntary certification systems.

Energy resource – an energy carrier which is being currently used or may be used beneficially in the future.

Energy carrier – a set of works and (or) services which performance would enable savings of monetary funds via efficient use of energy resources.

Energy saving project – a set of works and (or) services which performance would enable savings of monetary funds via efficient use of energy resources.

Energy saving company – a legal entity providing services and (or) performing works on the basis of contracts for implementation of energy saving project.

Energy supply company – an entity which self-generated or procured electric and (or) thermal energy to consumers.

Energy survey – a survey of consumers and producers of energy resources with the purpose of establishing efficiency parameters of energy resource generation, distribution and use as well as energy saving potential and development of economically sound measures aimed at their improvement.

Financial and economic mechanisms – in this methodology the term means proven patterns of attracting and repaying financial resources for implementation of energy saving programs.

Fuel and energy balance (FEB) – a system of indicators reflecting a qualitative ratio between generation (supply) and consumption of energy resources in the country, region, area.

Heating degree-days (HDD) – a universal indicator which determines the climate severity level; it is a basic calculation value to identify heat transfer resistance of facilities, indirectly characterizes the energy consumption level required for maintenance of comfort parameters.

Region – in this methodology the term means a part of a territory of the country within the borders set in compliance with a dominant feature; most often, jurisdiction of regional or local authorities is accepted as such a feature (the administrative-territorial border).

RES – renewable energy sources.

State energy saving policy – legal, organizational, financial and economic regulation of activities in the field of energy saving.
Main Conclusions

Comprehensive regional energy saving and energy efficiency improvement program is a basis for the regional energy long-term security and is a platform for an energy efficient regional development strategy.

This practical methodology is the outcome of several years of work by a handful of experts in the development of regional and municipal energy saving programs. This document presents the principles and methods for the development of regional energy efficiency programs within various sectors based on Russian economy examples. In addition, the methodology offers the principles and experiences of similar programs from other countries.

One of the key advantages of a comprehensive regional energy saving and energy efficiency improvement program is that such programs offer a platform for an energy efficient regional development strategy. Further, the combination of these regional strategies helps form an overall state strategy and improved energy efficiency boosts economic development in each region and, consequently, across the country as a whole.

The presented methodology is one of many possible options for program development, and should by no means be treated as the only one.

Program Types

The following types of programs may be singled out depending on issues with regional energy supply and energy saving potential:

1. Programs required by federal or local legislation.
2. Investment programs with limitations, based on priority and availability of financial resources.
3. Programs focused on certain areas, such as coordination of energy savings by end consumers.
4. Programs addressing specific issues, targeting key regional goals such as energy security, abandoning expensive fuels, or increasing use of renewable and local energy sources.

In practice, the programs may be combined and integrated. The main objective is to ensure the program reflects the overall energy strategy. Thus, program type should be chosen as early as possible.

Energy saving is not an isolated process; it should be viewed only in connection with other processes involved in the development of cities, regions and countries.
The energy saving and energy efficiency improvement program development process has six main stages:

Stage 1. Collect initial data, define a program format. Review and compare identified regional specifics and define the program type: the first stage enables developers to create an accurate picture of issues related to regional energy supply and energy efficiency.

Stage 2. Develop a regional fuel and energy balance, define energy saving potential and energy reserves across the economy. Prepare a regional fuel and energy balance and evaluate energy saving potential in all sectors of the regional economy.

Stage 3. Select priority areas of energy saving, develop a program structure. Develop an energy saving program concept (i.e., devising a program structure on the basis of priority energy saving and energy efficiency improvement choices).

Stage 4. Select main program activities to achieve priorities, select most efficient activities and align them with each other. Choose the most efficient and fast-track activities among all program actions.

Stage 5. Select motivation mechanisms to help implement technical measures. Develop the final, comprehensive regional energy saving program, which will define required motivational mechanisms depending on regional specifics.

Stage 6. Monitor energy saving and energy efficiency improvement programs during their development and implementation. Within the framework of the regional energy saving program, monitor energy consumption parameters. Thus, an efficient comprehensive energy saving program enables:

- a comprehensive picture of energy saving potential in the region, costs for fulfillment of this potential and expected monetary savings as a result;
- comprehensive monitoring of energy consumption in the region, control of fulfillment of this potential and expected monetary savings as a result.

The implementation of a comprehensive energy saving and energy efficiency improvement program will primarily enable:

- improvement of energy security, a decrease in energy intensity of GDP, avoidance of additional costs and the saving of regional internal and borrowed funds.

The state energy saving policy, which involves a balanced system of measures, is implemented in several stages – during which a set of motivational mechanisms is introduced and gradually introduced.

The creation of an efficient regional energy infrastructure that supports sustainable regional changes (for example, the construction and demolition of housing, industrial plants, etc.) is crucial, and requires an efficient system of regional energy management. Such a system should be the result of a comprehensive energy saving policy that complements with the regional energy saving program.

The presented methodology attempts to combine international best practices and Russian experience with energy saving programs and provides a framework for the development of regional energy saving programs.
The era of inexpensive hydrocarbons has passed; for many countries it ended with the global energy crises of the 1970’s. In recent decades many developed countries – which import the bulk of natural fuels – launched energy efficiency improvement activities in various sectors of their economies as well as measures aimed at energy and resource saving at the regional and national levels. Most such programs continue to this day.

What is the purpose of a comprehensive energy saving and energy efficiency improvement program? First of all, it seeks to establish an accurate picture of the situation in regards to energy consumption – without any distortion. Further, it provides a summary of the territory’s current consumption of fuel, thermal power, electricity and water in various sectors, which gives policy-makers a clear understanding of the situation and enables easy identification of priorities.

However, the implementation of such a program requires a significant financial investment as well as commitment from the state, which would in the end be compensated via the program results. As a rule, the higher the price of fuel and energy resources in the region, the shorter the payback period of an energy saving activity. Therefore, energy saving is often the cheapest energy resource in energy dependent countries. For instance, Russia, taking into account its reserves of primary fuel resources, is a striking example of a country for which energy dependency will never be a problem. But at the same time energy saving and energy efficiency improvement issues remain an urgent and critical need.

The experience of Russia and a number of other countries shows that actions and objectives should be specific to each region and priorities should be determined by local specifics. Energy saving may be viewed as a means to improve reliability of energy supply, especially in large cities that experience energy capacity problems during peak periods. Energy saving is not an isolated process; it should be viewed only in connection with other processes involved in the development of cities, regions and countries. The great diversity of regions and situations in the world requires the use of a review methods and specifically adapted models during the development of energy saving programs. Regions, both in Russia and in other countries, are characterized by not only quantitative parameters (population, territory, consumption of fuel and energy resources, industrial production structure), but also by qualitative characteristics. Recognizing the need for implementation of comprehensive energy saving and energy efficiency improvement programs, regions today often encounter problems related to their practical development and (and this is characteristic for Russia) the lack of an effective methodology.

The objective of this methodology is to present such a practical-level methodology.
Energy Saving Programs as Basis for Regional Energy Efficiency

Energy saving is often seen as independent from main regional development programs, but in reality it is an integral part, and often a basic element, of regional development as a whole. The integration of energy saving within the general regional development policy should be carried out as follows (Figure 1):

- develop an energy saving program aligned in terms of its objectives and tasks with the general regional development context;
- perform design activities to support the implementation of the developed set of program activities and mechanisms;
- implement technical solutions stimulating regulatory, financial and economic mechanisms;
- monitor energy efficiency outcomes;
- review the obtained results and adjust the program based on the review.

The recent energy efficiency policies of Sweden and Canada are good examples of consistent energy efficiency improvements.

The current energy policy of Canada is based on market principles. It is focused on the sustainable development and not limited (as in the past) to energy generation and consumption. Rather, energy saving in Canada is considered in two interrelated spheres: conservation of mineral energy resources and efficient use of energy.

Officials developed and adopted several special federal regulatory acts aimed at conserving mineral energy resources. In addition to federal laws, local officials adopted energy efficiency legislation at the regional and provincial levels.

In 2005, the Swedish Government set a new program objective: to eliminate the country’s dependence on carbon-based fuels by 2020. A national program to overcome oil dependence was presented by the Swedish Government in October 2005. It focuses on RES, transport and centralized heat supply, and includes:

- Tax benefits for industry in case of replacement of oil with other types of fuel to encourage conversion from oil heating to RES-based heating;
- Increase in the volume of RES, to ensure renewable fuels become the basis of the entire energy supply;
- Activities aimed at using RES in the transport sector;
- Scientific research in RES;
- Continuous investment in centralized heat supply and clear financial stimuli for the use of biofuel and environmentally friendly heating in cases when they are economically sound.
The specific strategic objectives and tasks of regional development and the challenges of each unique energy system determine the actions, goals and correspondingly the type of energy saving program to be used. Several types of energy saving programs may be singled out (Figure 2):

- Programs required by federal or local legislation.
- Investment programs with limitations, based on priority and availability of financial resources.
- Programs focused on certain areas, such as coordination of energy savings by end consumers.
- Programs addressing specific issues, targeting key regional goals such as energy security, abandoning expensive fuels, and increased use of renewable and local energy sources.

In practice, the programs may be combined and integrated. The main objective is to ensure the program is effective in the overall energy strategy. Thus, program type should be chosen as early as possible.

As of 2010, over 600 energy saving programs have been developed in 78 regions of the Russian Federation, including: 50 regional programs, 93 programs for individual sectors of the economy (fuel and energy complex, housing and utility sector, education, etc.) and 462 municipal and city programs. However, some of these achievements were overshadowed during a comprehensive evaluation of the reduction in energy intensity of the Regional Domestic Product and Russia’s GDP. One of the reasons for this is that a systematic, comprehensive approach was not applied when developing these programs. Such an approach would provide a complete picture of the regional energy efficiency and energy saving potential.
The energy saving program development process includes several key aspects that determine program structure: program objectives and tasks, regional specifics, the development history of the region’s energy infrastructure, and the region’s energy challenges and strategic objectives.

The energy saving and energy efficiency improvement program is implemented in six major stages (Figure 3):

1. Collect initial data, define a program format.
2. Develop a regional fuel and energy balance, define energy saving potential and energy reserves across the economy.
3. Select priority areas of energy saving, develop a program structure.
4. Select efficient technical solutions aimed at energy saving and energy efficiency improvement and align them with each other.
5. Select motivation mechanisms to implement technical measures in the field of energy saving and energy efficiency improvement.
6. Monitor energy saving and energy efficiency improvement programs during their development and implementation.

Each stage should result in a specific outcome, but the stages can occur simultaneously and can overlap. For example, when the first stage is half completed, providing an initial understanding of the region, the identification of energy saving potential – stage 2 – can begin.
A clarified or more detailed algorithm of energy saving program development (ref., inter alia, Appendix A) may correspond with the following (based on an example of a large megalopolis):

1. Regional thermal energy and electricity consumption balances (as well as a summary fuel and energy balance) should be developed on the basis of statistical information and other data taken from the reports of state statistical agencies and the reference notes of energy firms.

2. Total values of energy consumption (thermal energy and electricity consumption) should be determined by main structural sub-divisions of the city economy within the regional fuel and energy balance (industry, public sector, transport, housing and utility sector, construction, trade, population, other consumers).

3. Relative consumption percentages should be identified based on aggregate energy consumption data (thermal energy and electricity). These proportions provide guidelines for the creation of saving assignments for consumers.

4. Annual fuel and energy savings (thermal resources and electricity) should be identified based on general recommendations. Thermal energy and electricity saving assignments should be distributed in proportion to general consumption within the fuel and energy balance structure.

5. Energy consumption (thermal energy and electricity) by the social sphere (education, public health, culture, social protection, sport) should be divided into regional and municipal. Fuel and energy resource saving assignments for municipal facilities (education, public health, culture, social protection, sport) should be re-assigned to municipalities.

6. General thermal energy and electricity saving assignments for the population should be distributed between municipalities in proportion to population. Municipalities’ responsibilities should also encompass energy saving in trade, the municipal level social sphere, industry and population.

7. Required activities should take into account current and future energy saving programs (covering fuel and energy complex facilities, transport, housing and utility sector, recommended lists of activities and databases on advanced technologies) in order to best implement energy and resource saving recommendations.

8. The most advantageous actions should be selected for inclusion in the program. Mainly, technologies characterized by three- to five-year payback are accepted for the purpose of implementation within the framework of the targeted city energy saving program.

9. The success, or profitability, of program activities should be defined based on cost parameters, taking into account expected energy resource savings.

10. Consolidated profitability parameters of the program are determined by summing up all program costs and savings.

11. Motivational mechanisms (staff incentives, energy saving outreach, regulatory and legal documents, standards) should be developed.

12. Regional and municipal level program control and monitoring mechanisms should be identified.

**Stage 1. Collect Initial Data, Define a Program Format**

The main objective at this stage is to identify regional characteristics that most influence energy cost and consumption. Regions in various countries may differ significantly regarding the number of quantitative and qualitative parameters. For all, the following should be included (Figure 4):

- **Regional energy supply and infrastructure (energy sources and networks, peak electricity output);**
- **Dynamics of energy consumption by sector and sub-sector;**
- **Miscellaneous factors such as industrial base and Regional Domestic Product.**

**Figure 4. Key regional characteristics**
Norwegian households are characterized by high electricity consumption, mainly for heating and household appliances. In 2006, Norway’s energy consumption per house exceeded 16,000 kWh/year – more than four times the European average of 4,000 kWh/year. Yet from 1997 to 2007 Norway managed to reduce its energy consumption relative to other countries that participated in the ODYSSEE/MURE project (the project for setting energy efficiency indicators in European countries), dropping from second to fourth highest per household consumption.

The difference in levels of energy consumption by households in various countries may be explained by several factors, including climate, average home size, family income, and relative energy efficiency (according to ADEME, 2009).

The main outcome of the first stage of the regional energy saving program development is a set of identified regional specifics as well as a review of those characteristics and a preliminary definition of the program type. This stage provides a snapshot of current regional energy supply and efficiency issues.

In addition to the primary specifics there are other important regional parameters that influence energy saving program format:
- geographical specifics (landscape, coastal or continental location);
- area of the region;
- population density, share of urban population;
- consumption of fuel and energy resources, structure of industrial production and Regional Domestic Product.

Reliable data may be taken from various sources (Table 1):
- geographical and climatic maps;
- government statistics and reports;
- surveys and questionnaires;
- reports issued by organizations, institutions, think tanks;
- other sources of information.

The main outcome of the first stage of the regional energy saving program development should be a set of identified regional specifics as well as a review of those characteristics and a preliminary definition of the program type.

Note, the program type (see above) may change significantly in the process of the program’s development. For example, during the development of Moscow’s energy saving program, the program type was changed from “program focused on certain areas” to “investment program with limitations” because of the global financial crisis. Therefore, this stage provides a snapshot of current regional energy supply and efficiency issues, which may change over time.

<table>
<thead>
<tr>
<th>Table 1. Main regional parameters and their sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regional parameter</strong></td>
</tr>
<tr>
<td>Natural and climatic specifics</td>
</tr>
<tr>
<td>Geographic location</td>
</tr>
<tr>
<td>General climatic characteristic</td>
</tr>
<tr>
<td>HDD</td>
</tr>
<tr>
<td>Total area of the region</td>
</tr>
<tr>
<td>Population</td>
</tr>
<tr>
<td>Density of the population</td>
</tr>
<tr>
<td>Structure of urban centers</td>
</tr>
<tr>
<td>Regional energy resources and infrastructure</td>
</tr>
<tr>
<td>Aggregate capacity of energy sources. Reserves of thermal energy and electricity capacities</td>
</tr>
<tr>
<td>Length of networks. Equipment wear and tear</td>
</tr>
<tr>
<td>Quantity of imported energy resources (gas, oil products, electricity)</td>
</tr>
<tr>
<td><strong>Dynamics of consumption</strong></td>
</tr>
<tr>
<td>Consumption schedules, load peaks</td>
</tr>
<tr>
<td>Other important factors (industrial structure, Regional Domestic Product level)</td>
</tr>
<tr>
<td>Industrial structure</td>
</tr>
<tr>
<td>Regional Domestic Product structure, Regional Domestic Product level</td>
</tr>
<tr>
<td><strong>Environmental specifics</strong></td>
</tr>
<tr>
<td>Data on the structure and quantity of emissions</td>
</tr>
<tr>
<td>Area designation (forest areas, share of the special protected natural area, etc.)</td>
</tr>
</tbody>
</table>

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Stage 2. Define Balance, Energy Saving Potential

Each region has its own energy saving potential. The term itself reflects the difference between the current level of energy efficiency and results demonstrated by optimal practices and standards. There are two main groups of energy saving potentials:

1) improvement of efficiency of non-renewable fuels usage via energy saving technologies and activities.
2) decreased usage of non-renewable fuels via an increase in the share of renewable energy usage.

The two groups are represented schematically in Figure 5.

The contribution of the first and second groups to overall energy saving potential differs depending on regional specifics. In the majority of cases the value of the first group significantly exceeds that of the second group. In the experience of developed countries, the first group potential is accomplished first, and only then do renewable energy sources (sequentially or concurrently) begin to replace traditional types of fuel.

The optimization of the fuel balance in Sweden from 1980 to 2003 (Figure 6) is one of the most successful examples of fulfillment of combined potentials of the first and second groups.

Over the last twenty years Sweden has successfully moved away from dependence on its primary fossil fuel, oil. Today its electricity and thermal energy are generated via the use of biomass, industrial wastes, thermal pumps and secondary energy.

Energy saving potential may be evaluated with the use of gross parameters (for example, the aggregate volume of savings of energy resources consumption: electricity (MWh/annum), thermal energy (Gcal/annum), water (m³/annum)), and specific parameters (ref. Table 2).

It is necessary to use current levels stipulated by standards as well as the best available global practices to accurately evaluate the regional potential. The energy saving potential should be determined on the basis of the data collected during the previous stage.

The aggregate regional energy saving potential and its structure should be determined following the definition of efficiency parameters (specific values) along the entire chain – from production/generation to consumption.

Note: indicators based on the energy efficiency of best available practices in the same sphere may differ significantly in different regions. Territorial specifics of the region, climate, regulatory and legal framework and a number of other aspects can have a significant impact. For example, consumption of six tons of fuel per person is acceptable for northern regions with mining industry, but is absolutely unacceptable for southern regions with tourism as a primary activity.
Economic potential is a part of the technical potential fulfillment, which is economically sound if the main economic efficiency criteria are applied: discounting rates, opportunity cost (export price of natural gas), environmental and other indirect effects and external factors.

Financial potential is a part of the economic potential that should be fulfilled within the framework of the current market conditions, prices and limitations if the investment decision criteria are used.

Structuring the energy saving potential per the above classification enables an optimal organization during the implementation, fulfills available reserves and ensures their ability to roll out the energy saving policy in the region.

The main outcomes of the second stage of the regional energy saving program development should be the development of the integrated regional fuel and energy balance and evaluation of energy saving potentials in various sectors of the economy and within the region as a whole.

Baseline values of energy efficiency improvement reserves are identified. The energy saving potential structure is classified at the level of the consolidated fuel and energy balance on the basis of the review of energy efficiency in major sectors.

For example, for a megalopolis like Moscow, which is an individual region of the Russian Federation, the energy saving potential structure was distributed in such a way (Figure 7) that the bulk of it (approximately 63%) fell on ultimate consumption (34%) taking into account the energy saving outturn among the population (29%).

When developing a set and sequence of program activities it is necessary to remember the following classification of potentials:

- Technical (technological) potential is evaluated proceeding from an assumption that all obsolete and inefficient equipment will be replaced immediately with the best in class available alternatives, reducing energy consumption from the average regional level to a near-minimum level. Costs and limitations with respect to its implementation are not taken into account during the calculation of this potential.

The consolidated regional fuel and energy balance is the basic document for determining energy saving potential. Its main task is to show total availability and use of energy sources in the region. It may also be developed at the country, region, city or personal level. Primary information needed to build the balance includes energy audits, energy supply data, energy firms’ outputs, reports from local authorities and other statistics. The fuel and energy balance development should result in data on generation and consumption of energy resources, losses, energy saving potential and spare capacities.

The fuel balance may be compiled both for the entire energy complex of the region and for its individual components – production, generation, processing, conversion, transportation, storage and use of all types of energy. Thermal energy balances, electricity balances, gas fuel balances, liquid fuel balances, solid fuel balances, renewable and secondary energy source balances and solid domestic waste balances should all be compiled within the framework of a consolidated fuel and energy balance.

The consolidated regional fuel and energy balance is a balanced system of indicators representing the make-up of the energy complex at a certain point in time. Recommendations regarding efficient use of individual energy resources, the replacement of energy carriers, electrification and fuel supply specifics and the location of energy intensive industries should be developed on the basis of the fuel and energy balance review.

The fuel and energy balance is the basic document for determining energy saving potential. Its main task is to show total availability and use of energy resources in the region. It may also be developed at the country, region, city or personal level. Primary information needed to build the balance includes energy audits, energy supply data, energy firms’ outputs, reports from local authorities and other statistics. The fuel and energy balance development should result in data on generation and consumption of energy resources, losses, energy saving potential and spare capacities.

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Table 2. Evaluation of energy saving potential

<table>
<thead>
<tr>
<th>Energy sources</th>
<th>Total generation of thermal energy and electricity</th>
<th>Difference between actual and regulatory values (for each sector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating network</td>
<td>Thermal energy and heat carrier losses</td>
<td>Difference between actual and regulatory values</td>
</tr>
<tr>
<td>Electric grid</td>
<td>Electricity losses</td>
<td>Difference between actual and regulatory values</td>
</tr>
<tr>
<td>Industry</td>
<td>Specific consumption of fuel and energy resources for manufacturing of products</td>
<td>Difference between actual values and best sectoral indicators</td>
</tr>
<tr>
<td>Public sector</td>
<td>Specific consumption of thermal energy and electricity per person (per year)</td>
<td>Difference between actual and regulatory values (for these types of buildings)</td>
</tr>
<tr>
<td>Transport</td>
<td>Specific fuel and electricity consumption per ton-kilometer</td>
<td>Difference between actual and best sectoral values</td>
</tr>
<tr>
<td>Housing sector</td>
<td>Specific thermal power consumption per person, electricity and water consumption per person per annum</td>
<td>Difference between actual and regulatory values (for these types of buildings)</td>
</tr>
<tr>
<td>Service sector, trade</td>
<td>Specific thermal energy and electricity consumption per person, per year</td>
<td>Difference between actual and required values (by sector for the region)</td>
</tr>
<tr>
<td>System-wide indicators</td>
<td>Specific consumption of fuel and energy resources (in relative terms) per person per annum</td>
<td>Difference between actual and required values (by sector for the region)</td>
</tr>
</tbody>
</table>

- When evaluating population’s needs for electricity, both country differences in electricity consumption and availability of electric household appliances in households shall be taken into consideration.

![Figure 7. Energy saving potential structure in Moscow](image-url)
A set of priority areas of energy efficiency improvements should be developed based on the region’s potential. When developing the set it is necessary to take into account the potential of system solutions. In many cases, implementing system measures may have a much greater impact than individual optimization solutions.

The implementation of comprehensive solutions at a higher system level may impose certain limitations, both on the consumers’ operation regime (energy sources) and on their composition and structure. Indeed, when an excess of potential comprehensive solutions are available they should be prioritized, while individual potentials of optimization should be considered on a secondary basis.

The implementation of comprehensive solutions aligned with optimization at the sector level supplements and strengthens their impact and can in ideal cases lead to synergetic, cumulative solutions. To a large extent the ultimate type of the regional energy saving program is determined at this stage as a result of accurate highlighting of energy efficiency improvement priorities for the region.

Regional energy saving programs should include target energy saving and energy efficiency improvement indicators:

a) efficiency of energy resource use in the housing sector and in utility infrastructure systems;

b) reduction in energy losses when transmitting energy, use of equipment with energy resources consumption metering and regulation devices;

c) increase in the number of high-level energy efficiency facilities;

d) increase in the number of facilities using local types of fuel, secondary and renewable energy sources;

e) increased use of fuel-efficient transport vehicles (natural gas and hybrid);

f) decreased budget for energy supply to public sector organizations and increased funds to complete program activities.

As noted above, the diversity of regions limits universal solutions: each case requires a unique set of measures. For example, let us look at the two Russian regions of Vorkuta, in the north, and Krasnodar, a southern region.

The review carried out in Vorkuta defined a set of sufficiently simple and understandable technical solutions (Figure 8): flushing and retrofit of intra-building utility systems, adjustment of networks, installation of variable speed drive pumps at central heat supply stations, and thermal insulation of building envelopes, which is aimed at making the energy inefficient hot water boiler obsolete. In the case of Vorkuta, where the population is dwindling and is concentrated, the high energy saving potential is represented by the rebuild of energy sources (Vorkuta CHPP-1 and CHPP-2) and by implementation of circuit designs related to loading of CHPP turbines.
For the dispersed population of Krasnodar region (Figure 9), most energy saving potential is in the improvement of efficiency of gas use for domestic purposes and pro-active development of RES.

Target indicators of aggregate energy consumption are set by all EU member states within the framework of their national energy efficiency action plans. At least three countries (Denmark, Romania and Latvia) set target indicators at the level of the proposed annual target (energy consumption reduced by 1.5%; the general EU objective is 20% reduction by 2020). The Latvian energy efficiency strategy of 2000 includes a target indicator of 25% reduction in consumption of primary energy resources per one unit of GDP by 2010. In Russia the target indicator of GDP energy intensity reduction is 40% by 2020 (from 2007 level).

The main outcome of the third stage of the regional energy saving program preparation shall be the development of the energy saving program concept, i.e. the development of the program structure on the basis of selection of priority areas and main regional energy saving and energy efficiency improvement indicators.

To a large extent the ultimate type of the regional energy saving program is determined at this stage as a result of accurate highlighting of energy efficiency improvement priorities for the region.
### Stage 4. Select Efficient Technical Solutions

Determining the most efficient set of measures and activities for regional energy saving programs requires two main tasks:

- Select technical and organizational measures for staged implementation;
- Create a favorable motivational environment for implementing these measures (regulatory and legal framework, economic stimuli, bans, etc.).

Some technical solutions can increase the level of energy efficiency of facilities in different sectors of the economy, but they must be chosen according to the characteristics of the project and the region. The following criteria are used to select technical solutions:

- Outcomes of pilot projects;
- Sectoral catalogues;
- Information materials provided by fabricators of energy efficient equipment proven by experience of its application;
- Documents from specialists exhibitions, workshops, conferences and other relevant events;
- Sectoral and general reference guides on best available energy efficient technologies – BREF (ref. Appendix B);
- Proposals from experts.

At this point, the most appealing activities (from the point of view of payback timeframe, process feasibility, environmental requirements, other preset parameters and limitations) should be chosen. The main technical activities broken down by energy saving areas are represented in Table 3.

Preliminary technical and economic evaluations focused on the feasibility of implementing selected activities within the framework of the regional regulatory environment should be carried out at this stage. Then the selected activities should be aligned with facilities, sub-programs, implementation timeframes, and resources, taking into account the investment attractiveness. The impact of each program task should be paramount when aligning, planning and interfacing the activities.

One of the main tasks of the program preparation is the development of an activities implementation structure that incorporates the following criteria:

- Structure and extent of the energy efficiency improvement reserve;
- Amount of attracted financing;
- Payback period;
- Favorable environment for implementation of energy saving activities under the program.

The main outcome of the fourth stage of the regional energy saving projects program development should be the selection (from the entire set of the earlier identified measures and based on the specific regional needs) of the most efficient and effective (producing the most energy and monetary savings and having the most political support), fast realizable (based on the prioritized needs, the implementation time, available or attractable financing and having the optimal payback period) and the realistically most implementable measures.

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The City of Moscow lacks adequate energy for its development and has chosen a new energy strategy based on the use of energy saving technologies. This strategy includes a set of sub-programs that are inter-aligned in terms of timeframes, resources and target indicators. Implementation has demonstrated that only a set of activities aimed at energy efficiency improvement at sources, in heat networks and electric grids, and at ultimate consumption is capable of achieving the desired results in terms of fuel consumption and ensuring a 40% decrease in energy intensity of the Regional Domestic Product by 2020.

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### Table 3. Basic areas of technical energy saving and energy efficiency improvement activities

<table>
<thead>
<tr>
<th>Sector</th>
<th>Technical activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel production and transportation</td>
<td>Introduction of technologies for saving primary energy resources during production and transportation (for example, gas flaring)</td>
</tr>
<tr>
<td>Generation of energy carriers</td>
<td>Improvement of efficiency of operating power stations; installation of gas turbine plants at operating power generation units; of digi heat utilization; introduction of new technologies aimed at improving plant and equipment efficiency; introduction of circuit designs aimed at optimizing the energy sources structure, including maximum loading of the most efficient combined heat and power plants and transfer of boilers to the peak operation regime or the spinning reserve (medallions); introduction of co-generation and tri-generation technologies; use of RES: replacement of power installations using traditional fossil fuels with RES.</td>
</tr>
<tr>
<td>Heat networks</td>
<td>Reduction in thermal losses via the use of efficient thermal insulation technologies; use of measures aimed at improving heat network life (diagnostics, preventive repairs, introduction of an end-to-end quality assurance system, development of controlled heat networks).</td>
</tr>
<tr>
<td>Electric grids</td>
<td>Reconstruction of transformer sub-stations; reconstructions of overhead networks and cable lines; creation of a system of electric grids aimed at optimizing sub-station loading and grid throughput capacity; introduction of harmonics filtering devices; activities aimed at reducing dependence of electric consumption on the air temperature – for example, the use of heat accumulators instead of simple electric heaters.</td>
</tr>
<tr>
<td>Water supply and disposal systems</td>
<td>Reconstruction and substitution of worn portions of the water-supply system; development of closed water recycling systems; optimization of the pressure levels in all elements of the system; use of variable speed drives in all pumping equipment.</td>
</tr>
<tr>
<td>Residential and public buildings</td>
<td>Thermal insulation of building envelopes; installation of plastic double-glazed windows; installation of water, heat, electricity and gas metering devices; installation of energy-saving equipment in premises and regulation systems at building inlets; efficiency improvements of the internal (building inlets) and premises lighting systems.</td>
</tr>
<tr>
<td>Industry</td>
<td>Use of technologies aimed at reducing energy intensity of manufactured products; application of the efficient industrial lighting systems; use of secondary energy resources of plants.</td>
</tr>
</tbody>
</table>

3. The table represents only a part of technical measures aimed at energy efficiency improvements.
Stage 5. Select Motivation Mechanisms

The implementation of a number of technical measures necessary for the regional energy system development and energy efficiency improvement requires regulatory and legal framework improvement and the creation of a positive, motivating environment. Some motivational mechanisms include:

- Financial and economic mechanisms;
- Regulatory and legal framework, regulations and standards;
- Information and outreach measures;
- Incentives for tariff stimulation and other types of encouragement.

Full-fledged and full-scale energy saving activities require an entire system of financial and economic mechanisms based on a comprehensive approach to regional energy saving. Such mechanisms require significant investments from various sources of financing.

A number of parameters shall be taken into account when developing the financial and economic mechanisms:

1. Type of works performed (design and survey works, construction and installation, monitoring, analytical reviews);
2. Form of ownership of the facility where an energy saving activity is being performed (private, municipal, state), and availability of state budget financial support;
3. Source of financing (internal, attracted, borrowed funds);
4. Energy supply process area where the energy saving activity is carried out (generation, networks, ultimate consumption);
5. Energy supply system (centralized or decentralized).

Financial and economic mechanisms should be developed based on the above parameters. At the same time, it is important to develop mechanisms that not only incentivize implementation of energy saving activities within the framework of the energy saving program, but also create the necessary prerequisites for regional development.

Recommended stages of development and introduction of the financial and economic mechanisms:

1. Carry out a preliminary evaluation of possible financial resources – sources and totals – resulting from implementation of technical and organizational measures.
2. Establish the following patterns of interaction between all process participants:
   a. Natural flows (of energy carriers);
   b. Cash flows;
   c. Document turnover (including document formatting and compilation);
3. Compile a legal profile (review legal support for the existing patterns):
   a. Federal legislation;
   b. Regional legislation;
   c. Regulations and standards;
4. Devise amendments and addenda to fix any problems in the implemented development;
5. Agree to the prepared amendments;
6. Introduce the mechanism;
7. Monitor.

The main financial and economic mechanisms in the region include:

- Internal funds of consumers of energy resources;
- Borrowed funds in the form of short-term and long-term credits and credit facilities, leasing schemes;
- Depreciation and investment components of the tariff;
- Grants provided by foundations (state budget funds, funds provided by national and international foundations);
- Budget support in the form of co-financing, subsidizing, and benefits;
- Revolving mechanisms.

For example, for the last ten years over 60 projects have been developed and implemented in various spheres in Russia’s Arkhangelsk region, including: residential buildings, public entities, energy sources and heat networks. Entities’ own funds (45%), state budget funds (2%) and foreign investment (53%) financed the implementation of these projects.

It is advisable to review the existing financial motivation measures in the region together with the financial and economic mechanisms. Such motivation measures (tax and tariff benefits, customs privileges, etc.) should be treated cautiously and their likely outcomes must be thoroughly calculated in advance.

Serious attention must be given to the project payback. For fast-payback projects, no economic stimulation is required. Rather, support is required for projects that are crucial for the regional development and would be unlikely to payback under current conditions. In such cases, consolidation of all economic by-effects (reduction in budget costs, re-use of released capacities, prevention of hazardous overloading of energy system elements, environmental effect) is required. That consolidation should be converted into economically attractive conditions for project implementation.

Integrating and comprehensive use of various sources of financing should be accompanied by the improved efficiency of the regulatory and legal environment of energy saving in the region.
When developing a set of motivation mechanisms it is possible to adjust measures selected at the previous stages. Such a necessity may arise as a result of tariff regulation, outreach, or approval of balanced legislative documents at the regional and federal levels.

For example, data obtained as a result of expert-level assessments demonstrated that contradictions in Russia’s current regulatory and legal documents have curbed their motivational impact. Only 36% of business entities are interested in implementation of energy saving activities (energy end users), while 18% of entities are neither interested nor disinterested (public sector); and “the motivation” of the remaining 46% contradicts to the logic of energy saving activities implementation (energy supplying organizations).

On the whole, a wide range of mechanisms aimed at fostering energy and resource saving motivation is necessary for the full-scale development of an effective program. For example, in 2009, specialists of the Russian R&D Power Industry Institute carried out a review of mechanisms aimed at supporting energy saving policy introduction. Over one hundred such mechanisms were proposed and divided into five main groups below (Figure 10).

Clearly, under current Russian conditions bans and strict controls are the key “motivation” mechanisms. There is no optimum or universal mechanism structure, however. Each region, by virtue of its characteristics and specific needs, must determine its own set of most effective and efficient mechanisms. Without such motivation mechanisms in place, a lack of compliance would result, dooming the entire program.

After identifying the necessary mechanisms, the regional program should be approved as per the established state procedure and a system for activities management and the implementation structure should be established (Figure 11).

The main outcome of the fifth stage should be a developed comprehensive regional energy saving program that prioritizes the implementation activities and identifies necessary motivation mechanisms. Such a program will foster the establishment of an integrated understanding of energy saving in the region, attract costs for fulfillment of this potential and recoup expected savings following the program’s completion.

The implementation of the comprehensive energy saving and energy efficiency program will first of all enable:

- Improvement of the energy supply security of the region;
- Reduction in energy intensity of the Regional Domestic Product;
- Avoidance of additional short- and long-term costs in various sectors of the economy;
- Savings on internal and borrowed funds.
STAGE 6. Monitor Program during Development and Implementation

Any regional energy saving program should include a comprehensive monitoring system of the regional energy consumption and a system for evaluating the efficiency of various measures and activities. Specific consumption of energy resources at energy sources, losses during transportation/transmission of energy carriers, and specific indicators in different sectors of consumption (ref. above) may be used as parameters reflecting the success of the program’s activities. Monitoring energy efficiency indicators (most of which are listed in Table 4 below, including the data spread) is an important component of the energy saving program, as it enables objective judgments about outcomes.

The data included in the Table 4 show that program implementation and its monitoring are aimed at ensuring minimum energy consumption and loss. At the same time, the objective should be an increase in the share (up to 30%) of equipment with metering facilities.

The above range of data was obtained in the course of developing and implementing several energy saving programs in Russia. Values of the above indicators may differ, one way or the other, depending on regional specifics.

Note, neither of the existing regional activities data collection systems (for example, state statistics, technical inventory bureaus (BTI), energy servicing companies and energy consumption audit companies) is satisfactory for thorough energy efficiency monitoring. A better system should be created as a part of an organizational mechanism for regional energy efficiency management.

Establishing a strong management system is one of the key tasks of program implementation, and it entails certain costs. The next section includes a detailed description of the elements of such functioning system.

The main outcome of the sixth stage should be comprehensive, continuous monitoring within the framework of the developed regional energy saving program, starting with the energy consumption indicators.

Table 4. Range of main indicator values by sectors of the regional economy

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Indicator value range</th>
<th>from</th>
<th>to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific consumption of fuel for generation of thermal energy, tons of equivalent fuel/Gcal</td>
<td>0.01</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Specific consumption of fuel for generation of electricity, tons of equivalent fuel/kWh</td>
<td>250</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>Consumption of energy resources for internal needs: thermal energy, electricity, water, %</td>
<td>5</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Thermal energy losses in networks, %</td>
<td>5</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Electricity losses in grids, %</td>
<td>10</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Specific consumption of electricity for water supply (production and transportation of water), kWh/m³</td>
<td>0.17</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Water losses in networks, %</td>
<td>8</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Specific consumption of thermal energy for heating of residential and public buildings, Gcal/m²</td>
<td>0.11</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Specific electricity consumption by the population, kWh/person</td>
<td>550</td>
<td>1,200</td>
<td></td>
</tr>
<tr>
<td>Specific water consumption by the population, m³/person</td>
<td>95</td>
<td>170</td>
<td></td>
</tr>
</tbody>
</table>

Share of consumers who have energy metering devices installed (for water, thermal energy, electricity, gas), % | 0 | 100 |
Monitoring as the Basis of Energy Management

One of the goals of the regional energy saving program’s implementation is to build up a comprehensive energy management system.

Energy Management and Monitoring Data

Proceeding from the international practice of entities that have faced problems implementing energy policies, the management cycle based on Plan-Do-Check-Act enables continuous improvement and the introduction of energy management fundamentals into day-to-day practices.

The principle may be presented in the form of a diagram (ref. Figure 12):

- **Plan**: set targets, define processes required for distribution of outcomes in compliance with opportunities in the field (select priority activities);
- **Do**: introduce processes, implement activities;
- **Check**: monitor and measure energy processes and products in terms of their compliance with the energy policy, set targets, key characteristics of these processes;
- **Act**: develop activities for further improvement of energy efficiency and energy saving.

Monitoring, measurement and review are the first steps in further development of the regional energy saving program (prior to commencement of this work it is necessary to find out the starting point to plan the route). It is necessary to monitor all key characteristics of regional processes impacting energy efficiency. It means that they shall be monitored, measured and reviewed from time to time.

The key characteristics should include at least:

- energy consumption and energy efficiency review data (by facilities, groups of facilities);
- list of facilities, groups of facilities characterized by significant energy consumption;
- interconnection between significant energy consumption and other characteristics of facilities (for example, the extent of thermal insulation of building windows);
- energy efficiency indicators;
- activity efficiency indicators in terms of performance of objectives and tasks set.
It is necessary to regularly identify and revise the requirements for statistical data to ensure they objectively reflect the energy status of the region. Regional-level activities must guarantee that all equipment used for monitoring and measurements (not only equipment owned by the region), as well as regulations for collection of data at the regional level, provide reliable, newly obtained data. All significant energy consumption must be examined in order to respond accordingly.

The system designation:

- a) accumulate information about activities of economic entities in the field of energy saving;
- b) track changes in planned indicators within the framework of the regional energy policy;
- c) when errors in the energy policy;
- d) identify technical, economic and financial potentials and their realization (or lack of realization).

### Common Principles of Data Collection and Review

Data collection shall be organized as follows:

1. Identify the minimum required level of detail that ensures completeness and integrity within the boundaries of time and funding.

   **Level of detail:**
   - “territorial”: region on the whole; individual sectors; groups of economic entities within sectors; individual economic entities.
   - “time-based”: year, six months, quarter, month, etc.

   A rapid increase in input information quantity should be taken into account when shifting to the next detail level. At the same time, the shift to the next level may prove to be inadvisable due to a lack of time, funds or reliable information. It is possible to apply different levels of detail to the review of sufficiently large economic entities that significantly influence regional energy indicators.

2. Jointly with regional officials and independent experts, prepare a list of parameters and clarify the level of detail of their values in terms of time. These parameters should be formulated on the basis of input data processing and reflect outcomes of program implementation.

3. Ensure (with the use of organizational mechanisms) thorough, accurate and timely collection of data, which should be reviewed as it is received.

4. If it is impossible to ensure thorough, accurate and timely data, make a decision either to correct the list of parameters and levels of detail or to add measures to resolve the identified problem.

5. As program is being implemented, evaluate the possibility to take steps 1-4 with a higher level of detail when necessary.

Data input into the monitoring system may be automated or performed manually, or both. Manual input is applied when the data require preliminary cleaning, agreement, or clarification – i.e., when direct human participation is necessary. This method is mostly used either at the first stage (collection of initial data) of the program development or in the process of program monitoring before the development of regulations.

Under “energy management” the management cycle based on “Plan-Do-Check-Act” best practices is understood. This cycle enables continuous improvement and the introduction of energy management fundamentals into day-to-day practices of a region.
**Software Systems for Collection and Review of Data and Their Selection**

Based on time and cost, Business Intelligence (BI) software is most suitable for monitoring system development. The market is developed and its specialists are highly skilled and available. The list of suppliers includes well-known international companies (Microsoft, Oracle, IBM, SAP, etc.) as well as companies involved in BI at the local level.

The Total Cost of Ownership (TCO) methodology may be used to make a decision on a specific software system. The essence of TCO is in consideration of all costs (for procurement of software and hardware, operation, etc.) during the entire life cycle of the information system. Both commercial and publicly-accessible software solutions are available for calculation of TCO (see an example of the publicly-accessible software at: http://www.tcotool.org/index_en.html).

**Example of a Simple Computer Program**

In 2010, specialists at Russian firm TEK developed the Region-2010 software to demonstrate basic elements of the methodology related to the energy consumption monitoring.

Software designation:
- demonstrate the operation of the methodology using limited initial data;
- fine-tune elementary collection of required information, which helps determine, in area, which data can be collected quickly and which data are missing;
- demonstrate expected outcomes for the pre-set period (for example, for three years);
- evaluate the expected volume of energy resource savings in kind and in USD depending on selected activities, prices for resources;
- produce a tentative evaluation of the possibility of pay-back of costs for energy saving via saved energy resources.

The software comprises:

A. Tools to develop:
   - a list of facilities by levels of detail (for example: sectors, groups of consumers);
   - a list of parameters to be monitored (for example, electricity consumption, electricity costs, costs for manufacturing of products, etc.);
   - a list of data collection time periods (quarter, year);
   - other service information;

B. Formats for input of planned and actual information on the status of facilities’ parameters in time;

C. Summary tables and reports for review of input data.

Thus, the systematic and functioning energy management system, connecting the dots, is the minimum key condition for the long-term success of the developed regional energy saving program.
According to recent practices, the development of regional energy saving programs in current conditions is a process aimed at understanding the most important regional energy problems, defining improvement potential and strengthening economically sustainable development by establishing an efficient monitoring and management system of energy and resources supply across all sectors and sub-sectors of the economy.

Developing the state energy saving policy in different regions takes place in several stages (Table 5), and each region will maintain its own rate of development depending on its own characteristics. As the national system of management and energy infrastructure evolves, different sets of regulatory and legal mechanisms will be used.

Rigid prohibitive mechanisms prevail in the first stages (requirements, standards, rules (Figure 10)), while as a new institutional environment (Figure 14) is created, less rigid, more attractive mechanisms (privileges, outreach activities, etc.) may be added.

The various characteristics of regions mean that a simple set of individual solutions will not always lead to efficiency improvement. Certainly, there is no uniform universal set of energy and resources saving measures and technologies. At any point in time, key regional specifics determine the common vector, direction of modernization, and the establishment of a certain set of measures – as well as the sequence of their implementation.

Table 6 and Appendix C include basic mechanisms for implementing energy saving measures, including examples from various countries. The motivation mechanisms demonstrate how the motivation of entities may be improved and how barriers to pro-active implementation may be overcome.

Figure 14: Correlation of prohibitive and motivation measures

Not all successful cases of one country may be applied effectively in other countries, because of the varying stages of the energy efficiency improvement process. Nevertheless, the majority of cases convincingly prove the workability of motivation measures.
Despite the variety of approaches, on the whole, comprehensive energy saving programs allow regions to optimise operating capacities and create required reserves. Regional energy saving programs shall become the basis for comprehensive energy resources and reduction in energy intensity of the Regional Domestic Product.

4 Program indicators are monitored and the program is adapted if necessary

Energy management is fully integrated into the regional management structure, delineating planning and implementation responsibilities and reduction in energy intensity of the Regional Domestic Product.

Multi-level system for encouraging reduced energy consumption for all groups of consumers based on actual savings of fuel and energy resources

Consumption energy and energy resources are monitored, errors are identified

"Green" energy saving plans and renewable energy sources and local types of fuel evaluated, embraced; payoff indicators reflect regional policy

Table 5. Levels of development of the regional energy saving management policy

<table>
<thead>
<tr>
<th>Level</th>
<th>Energy saving policy</th>
<th>Organizational structure</th>
<th>Motivation to save energy</th>
<th>Information systems</th>
<th>Investments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No explicit energy management policy is in place</td>
<td>No energy management structure or energy saving subvision is in place</td>
<td>The majority of consumers haven’t motivation to save energy</td>
<td>No information system in place; no energy consumption reporting is in place</td>
<td>No investments into energy efficiency improvement</td>
</tr>
<tr>
<td>1</td>
<td>No regional-level energy policy has been developed</td>
<td>A regional energy saving agency (or a regional level unit responsible for energy saving) is under establishment</td>
<td>Only energy consumption audits of individual facilities and implementation of low-cost measures are possible</td>
<td>Partial implementation of individual energy saving activities has begun</td>
<td>Only short-term, 1-3 year payback investments</td>
</tr>
<tr>
<td>2</td>
<td>The energy saving policy is being implemented in the region on the basis of current federal legislation</td>
<td>Energy management is not included in the list of top-priority activities</td>
<td>No encouragement of personnel and top managers to reduce energy consumption, no system for evaluating savings</td>
<td>Reports on consumption by sectors of the economy are prepared; partial metering of energy resources has begun</td>
<td>Only expensive energy saving activities are financed</td>
</tr>
<tr>
<td>3</td>
<td>A comprehensive energy saving program is in place, serves as basis for development of the official energy policy</td>
<td>Officials at the regional/municipal level report to their management on the program and results obtained</td>
<td>Motivation to implement energy saving activities for various categories of consumers is fixed in legislation (federal, regional)</td>
<td>An automated system for collection and review of energy consumption data is being implemented</td>
<td>Funds repayment criteria are the same as for all other investments; use of investments with 5-4 year payback</td>
</tr>
</tbody>
</table>

Table 6. Examples of introduction of state and regional energy saving policy mechanisms

<table>
<thead>
<tr>
<th>State policy mechanisms</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of unified methodological bases for preparation of current, retrospective and prospective fuel and energy balances as well as main indicators of usage efficiency for fuel and energy resources.</td>
<td></td>
</tr>
<tr>
<td>In 1996 Denmark approved a Program for Conversion of Combined Heat and Power Plants; in compliance with the Program all medium and small heat generators are to be rehabilitated to become low output combined heat and powerplants or biofuel plants.</td>
<td></td>
</tr>
<tr>
<td>The efficiency of Belarus’ state policy in the field of energy saving is confirmed by the following outcomes:</td>
<td></td>
</tr>
<tr>
<td>- 2.9% increase in GDP from 1995 to 2008, while gross consumption of fuel and energy resources increased by 17%;</td>
<td></td>
</tr>
<tr>
<td>- Belarus’ economy’s energy intensity dropped 25% from 2005 to 2008, and from 0.276 t of oil equivalent per 1 USD of GDP based on the 1995 purchasing power parity to 0.234 t of oil equivalent per 1 USD of GDP in 2008 (for reference, energy intensity in Russia in 2005 equalled 0.432 t of oil equivalent per 1 USD of GDP).</td>
<td></td>
</tr>
<tr>
<td>Development of regulatory and technical documents which regulate the preparation, execution and review of regional fuel and energy balances.</td>
<td></td>
</tr>
<tr>
<td>Development of municipal information systems including indicators of sources, networks and consumers of energy resources.</td>
<td></td>
</tr>
<tr>
<td>In 2009, China’s energy consumption for the production of ten thousand tons of GDP equalled 1.2 tons of coal equivalent. This number represented the first decrease since 2005. In compliance with the ninth Five-year Plan for Economic and Social Development for 2006-2010, energy consumption per one unit of GDP is set to decrease by 20% over the period.</td>
<td></td>
</tr>
</tbody>
</table>

Not all successful cases (ref. Appendices C and D) may be applied effectively in other countries, because of the varying stages of the energy efficiency improvement process. Nevertheless, the majority of cases convincingly prove the workability of motivation measures in case of staged and consistent implementation of the energy saving policy both at the regional and country levels in various sectors of the economy.

Suitable mechanisms are selected based on the specifics of the relevant region. At the same time, ongoing changes in the regional configuration (commissioning and decommissioning of residential buildings, regional infrastructure facilities, industrial entities, etc.) necessitate an efficient regional energy supply and energy management system.

Despite the variety of approaches, on the whole, comprehensive energy saving programs allow regions to optimise operating capacities and create required reserves. Regional energy saving programs shall become the basis for comprehensive regional development programs - to improve efficiency of existing sources, utilise reserves for future development and proactively use secondary and non-traditional energy sources rather than construct new energy-generating facilities.

The development of such programs is a crucial step in building an efficient life support system and the establishment of a robust platform for regional and national development. Staged implementation of a set of activities fosters understanding of the current situation in the region, identifies critical problems and defines methods of energy efficiency improvement.
Appendices

APPENDIX A. PRACTICAL, DETAILED ALGORITHM FOR DEVELOPING A COMPREHENSIVE REGIONAL ENERGY SAVING PROGRAM

### Description of work stages

1. Make a decision on development of a city (region, municipality) energy saving program (concept). Clarify battery limits (composition) of the object (municipality), develop terms of reference.

2. Clarify initial data, develop (correct) questionnaires with respect to the housing sector, public sector facilities, municipal entities.

3. Correct questionnaires on energy sources and additional data formats. Request information on outcomes of energy surveys and entities’ energy saving programs under implementation.

4. Disseminate questionnaires, collect statistical forms and obtain data from other sources.

5. Obtain initial data, carry out initial processing. Use and compare data from websites, public domain databases, sectoral reports, regional development programs, city and municipality general plans.

6. Clarify requirements stipulated by federal and regional legislation with regard to development and approval of programs, clarify required indicators, identify regional priorities.

7. Structure the regional program concept, energy and resource saving development strategy, define objectives and tasks.

8. Approve the regional program concept and start developing a targeted comprehensive program.

9. Compile an individual (thermal energy, electricity, water, fuel) and a consolidated regional fuel and energy balance.

10. Review energy resource loss at all stages: generation, transport/transmission and distribution of fuel and energy resources, as well as consumption. Identify basic problems in the field of energy resources production/generation and consumption, evaluate the energy saving potential.

11. Develop a program structure as per the identified hierarchy of problems, define the energy saving rate (reduction in energy resource losses), fuel and energy resource saving assignments by sectors and consumption groups.

12. Identify issues by sector (sub-program). Select required energy saving measures and activities by sub-programs.

### Description of work stages

13. Use activities, parameters and indicators of existing (and future) energy saving programs of city (regional) entities within the framework of sub-programs.

14. Select additional objects for implementation of activities, calculate expected energy resource saving indicators, economic effect, profitability, payback.

15. Use programs and plans for major overhauls of residential buildings and public sector facilities to achieve the set fuel and energy resources saving parameters.

16. Distribute the set of measures and activities by type (organizational, technical, informational), payback period, other indicators.

17. Align the set of activities by timeframes (stages), areas, resources - in order to achieve the targets and indicators, set program parameters and define the set objectives and tasks.

18. Review the situation with energy resources metering, develop programs for implementation of regulations for various groups of consumers (metering, energy surveys, certification of buildings).

19. Develop (create) a system for energy saving management in the region and municipalities.

20. Develop an information support and outreach plan, train human resource officers in energy saving.

21. Use opportunities provided by federal (with regard to a regional program) and regional (with respect to municipalities) targeted programs to implement the consistent energy saving policy.

22. Use related programs and mechanisms for implementation of the comprehensive energy saving policy (labeling programs, energy efficient construction, Kyoto Protocol mechanisms, environmental insurance, etc.).

23. Clarify consolidated indicators of the program (values of fuel and energy resource savings, reduction in consumption, emissions, financial indicators).

24. Develop additional investment mechanisms and levers for implementation of proposed program measures and activities.
### Appendix B. Example of a Best Available Technology Reference Document (BREF)

- Energy efficiency management system
- Planning and identification of objectives and tasks
- Energy efficient design
- Improvement of the level of process integration
- Maintenance of motivation in the process of energy efficiency initiative implementation
- Maintenance of skills of human resources
- Information exchange
- Energy efficient design
- Improvement of the level of process integration
- Maintenance of motivation in the process of energy efficiency initiative implementation
- Maintenance of skills of human resources
- Information exchange
- Efficient control of production processes
- Monitoring and measurements
- Energy consumption audit and energy diagnostics
- Thermo-economics
- Energy models, databases and balances
- Optimization of parameters of energy resources use

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### Appendix C. Mechanisms for Energy Saving Measures Implementation

#### Activities and support mechanisms

<table>
<thead>
<tr>
<th>Energy Consumption Audit and Energy Diagnostics</th>
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<td>Enthalpy and Exergy Review (Pinch analysis)</td>
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#### Examples

- **Retirement options**: installation of gas turbine plants at operating power generation units; off-gas heat utilization; introduction of new technologies; development of replicable projects
  - Development of design documentation on modern energy efficient gas turbine plants for the purpose of their large-scale fabrication by local manufacturers (if relevant; conditions are in place).
  - Development of standard solutions for retrofit or replacement of uniform equipment at existing energy sources, development of design documentation on modern condensing boilers for the purpose of their large-scale fabrication by local manufacturers (if relevant; conditions are in place), development of standard solutions for installation of gas turbine plants (GTPs) and gas piston units (GPPs) at existing boilers.
- **Development of circuit solutions to coordinate operation regimes of small cogeneration sources with existing regional energy systems.**

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In Russia, two companies, Bankhinenge and Tateneng, were among the first energy companies to introduce gas turbine plants and gas piston units fabricated by Russian and foreign manufacturers. For example, in 2002 to 2004 specialists of OMO Bankhinenge commissioned gas piston units at five facilities, with a total installed electric capacity of 32.15 MW and 30% Coal/ hour thermal capacity.

In 2003, a GTP-ChPP complex (the first complex of this type in the Republic of Tatarstan, Russia) was erected at Kazan CHPP-1 (MO Tateneng), the aggregate capacity of the complex is 50 MW (2 units 25 MW each) on the basis of modern gas turbine technologies, utilizing off-gas heat in heat recovery boilers. Individual components of plants fabricated by foreign manufacturers failed in the course of operation, and in combination with a lack of well-organized and service maintenance, these failures meant unprotected equipment downtime.

**Optimization of the structure of energy sources**
- The need to develop heat supply options (this need should be approved at the legislative level or in the form of obligatory requirements, national standards).
- Maximum loading of most efficient combined heat and power plants, transfer of boilers to peak load operation regime.
- Development and implementation of comprehensive projects for improvement of the structure of energy sources based on an energy system efficiency indicator rather than simple evaluation of an individual project payback/identification of required purchases of electricity and gas from external networks; optimization of the structure of energy resources in a settlement, including general-use CHPPs and boilers, sectoral CHPPs and boilers, peak load energy sources, small-scale energy generation facilities.
- Replacement of boilers with combined heat and power plants, introduction of approaches for distribution of heat loads in favor of more energy efficient sources of combined generation.
- Ban on construction of condensing power plants in cities, requirements to use electric boilers only in areas characterized by excess electricity capacity or low cost electricity.
- Creation of a regulatory and legal framework to set requirements for newly constructed and retrofitted energy sources, appropriate energy efficiency requirements in technical regulations.

- **Maintenance**
- **Monitoring and measurements**
- **Energy consumption audit and energy diagnostics**
- **Enthalpy and exergy review (Pinch analysis)**
- **Thermo-economics**
- **Energy models, databases and balances**
- **Optimization of parameters of energy resources use**

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There is a National Heat Supply Planning System in Denmark. Municipalities are obliged to plan heat supply system development (however they are not obliged to create these systems). Danish energy saving policy reduces the emphasis on conversion of heat supply systems towards centralization around combined heat and power plants (including 50 MW mini-ChPPs).

Within the centralized heat supply system of Copenhagen, approximately 90% of annual demand for thermal energy is covered by energy generated in the course of waste processing biomass as the main source of fuel (50%). Coal is used for generation of up to 8% of thermal energy. Natural gas and oil account for an insignificant share in the thermal balance (of note, in Denmark the price of natural gas is the highest in Europe, 1.09€/kW-in 2010/11). All energy sources contribute to the common system; all waste burning sources and sources utilizing thermal energy of industrial wastes are loaded first of all, then centralized heat supply systems are loaded, and finally peak-load boilers.

Electric heating in Denmark is strictly prohibited (though several residential buildings are still heated with the use of electric boilers).

In France, first waste burning sources are loaded, then coal and natural gas sources are loaded, and only then - fuel oil sources are loaded when generating thermal energy.

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*The document is in public domain on http://www.14000.ru*
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In Japan, the two main types of energy efficiency are: (1) improving energy efficiency in existing buildings, and (2) building new, more energy-efficient buildings. The former includes improving energy efficiency by using energy-efficient materials and designs, while the latter involves designing and building new buildings that are more energy-efficient than existing ones.
APPENDIX D: REGIONAL ENERGY EFFICIENCY IMPROVEMENT PROGRAMS, BEST PRACTICES

ENERGY TARIFFS AND VULNERABLE GROUPS OF CONSUMERS

Since July 2007, electricity and gas markets in EU Member States have been fully opened for all customers. According to the European Regulation* Group for Electricity and Gas (ERGEG, 2007), end-user price regulation distorts the market. ERGEG thus recommends end-user price regulation be abolished or brought into line with market conditions.

Case: Reducing fuel poverty by increasing energy efficiency

An approach providing assistance to low-income households in order to implement energy efficiency measures has proved to be a success in the UK. It is used to reduce fuel poverty in the longer term.

What: Warm Front scheme to tackle fuel poverty and improve energy efficiency

Why: In the United Kingdom (UK), reducing and addressing fuel poverty is one of the main objectives of energy policy. Fuel poverty occurs due to a combination of poorly insulated, energy inefficient houses and low income. In these households, financial barriers to energy efficiency measures are high.

According to the UK definition, a household is in fuel poverty if it needs to spend more than 10% of its income on a satisfactory heating regime. In 2004, about 2 million households were in fuel poverty in the UK (OECD/IEA, 2008).

How: In England, the Warm Front Scheme provides energy efficiency grants to households that receive some form of social benefit, such as households with dependent children, the elderly, the long-term sick and the disabled. The public grant is funded by DEFRA (Department for Environment, Food and Rural Affairs) and managed by Eaga, one of the UK’s largest suppliers of heating and renewable energy.

In the Warm Front Scheme, central heating is offered to all eligible households. Other energy efficiency measures may also be offered, subject to maximum grant amounts.

Outcome: Between the introduction of the scheme in June 2000 and the end of 2007, nearly 1.5 million households received assistance. The average grant investment was GBP 839 in 2004-2005 and GBP 1436 in 2006-2007. The average payback time was 5 years in 2004-2005 and 7 years in 2006-2007.

As a result of the investments, the CO2 emissions of the households fell an average of 24% in 2004-2005 and 13% in 2006-2007. Other benefits were improved air quality and energy security (OECD/IEA, 2008).

Similar regional energy efficiency programs targeted to households in fuel poverty are in place in Northern Ireland, Wales and Scotland.

INTERACTION BETWEEN PRODUCERS AND CONSUMERS TO MOTIVATE ENERGY SAVINGS AND EFFICIENCY

Case: Energy Efficiency Commitment for electricity and gas suppliers


Why: To improve energy efficiency of households through obligations to energy suppliers.

How: The Electricity and Gas Order requires electricity or gas suppliers who supply at least 50,000 domestic customers to achieve energy saving targets in the households. The overall target for the 2005-2008 period was a savings of 130 TWh, of which at least half had to be met in low-income households. Failure to comply with the requirements led to financial penalties. Flexibility is allowed through trading suppliers could buy or sell energy savings, or their obligations, to other suppliers.

Outcome: In the 2005-2008 period, the suppliers delivered savings of 187 TWh, nearly 50% more than the target. And at least half of the savings were made in low-income households (Ofgem, 2008).

Case: Energy saving obligation to electricity distribution system operators

What: Obligate electricity distribution system operators to achieve energy savings in household and non-household sectors in the Flemish region in Belgium.

Why: To improve energy efficiency in household and non-household sectors.

How: In the Flemish region, electricity distributors must achieve an annual energy saving target of 2% of electricity supplied to house-holds and 1.5% of electricity supplied to non-household customers. The target is based on the amount of electricity supplied in two previous years. Operators that fail to achieve the target must pay a financial penalty.

The distributors can decide which energy saving measures to promote to achieve the target. The measure must consist of financial (for example grant on low-cost loan) and awareness-raising elements (i.e. consumers’ awareness). In addition, the system operators were required to carry out two energy scans for every 100 household connections between 2007 and 2009. Where advisable, energy saving light bulbs, water-saving showerheads, pipe insulation and radiation foil are installed to the scanned households. The electricity distributors are also obliged to offer energy accounting for schools and health and welfare facilities and support local authorities in their energy policy (Flemish energy efficiency action plan 2008-2010).

Outcome: The most common measures have been super-insulated glazing; condensing boilers and high-efficiency boilers; roof insulation in existing buildings; thermostatic valves; and solar boilers (Flemish energy efficiency action plan 2008-2010). The realized primary energy savings have varied between 600 and 1000 GWt/year in 2003-2006 (Cornells, 2009).

Case: CO2 Building Rehabilitation program in Germany

What: An approach providing assistance to low income households to improve energy efficiency in existing residential buildings.

Why: To improve energy efficiency in existing residential buildings.

How: In Germany, subsidies combined with low interest loans are granted for the renovation of buildings that require substantial energy saving investments. For a building completed before 1984, for example, a subsidy of 17.5% of renovation costs (up to 8750 euro per dwelling) may be granted if the building’s energy consumption is at least 30% higher than required by the current building code. Alternatively, a low-interest loan may be granted to cover the investment costs. The length of the time within which the loan has to be paid is limited to 20 years, but the period of repayment can be delayed for a maximum of three years. If the renovated house (built before 1984) achieves the energy efficiency grants to households that receive some form of social benefit, such as households with dependent children, the elderly, the long-term sick and the disabled. The public grant is funded by DEFRA (Department for Environment, Food and Rural Affairs) and managed by Eaga, one of the UK’s largest suppliers of heating and renewable energy.

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performance standard for new buildings, 9% of the loan is forgiven. If energy consumption goes 30% beyond the standard, the relief is 12.5%.

The loans are managed by KfW, a non-profit public banking group. Lower interest rates than most commercial loans result in average savings of about 7-12% per loan.

Outcome: From 1996 to 2004, the CO2 Building Rehabilitation Program approved loans for about 16.3 million m² for 96,000 dwellings. Between 2001 and 2005, the estimated annual energy saving was 20 PJ (OECD/IEA, 2008).

Case: Energy certificates of buildings

What: Energy certificate of buildings.

Why: To inform buyers and tenants, and prospective tenants, of a building’s energy performance.

How: The EU directive on Energy Performance of Buildings (2002/91/EC) requires Member States to ensure that when buildings are constructed, sold or rented out, an energy certificate is available to the prospective buyer or tenant. The certificate presents the energy consumption of the building for space and hot water heating, cooling, ventilation and lighting. In addition, the certificate shows the reference values such as current legal standards, and gives recommendations for cost-effective improvement of energy performance.

Outcome: In Germany, there are about 500 ESCO companies and an estimated 50,000 projects. The average investment payback time is 5 to 15 years, and the average saving in energy varies between 10% and 38% of energy consumption before the investment. The most common technologies delivered in ESCO projects are heating, insulation and CHP (Bertoldi et al., 2007).

References to Useful Documents:


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