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Bratanova, Alexandra and Robinson, Jacqueline and Wagner, Liam and Kolegov, Vitaly and Nikitchenko, Aleksey and Nikitchenko, Anna

School of Economics, University of Queensland, School of Economics, University of Queensland, Economics, Griffith Business School, Griffith University, IESE Business School, National Institute for System Studies of Entrepreneurship, National Institute for System Studies of Entrepreneurship

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Alexandra Bratanova[a,c], Jacqueline Robinson[a] , Liam Wagner [b], Vitaly Kolegov[d], Aleksey Nikitchenko[e] and Anna Nikitchenko[f]

[a] School of Economics, University of Queensland, St Lucia, Queensland, 4067, Australia

[b] Economics, Griffith Business School, Griffith University, 170 Kessels Road, Nathan, Queensland, 4111, Australia

[c] Corresponding author: email – a.bratanova@uq.edu.au; phone: +61 421 138 919

[d] IESE Business School, Avenguda Pearson 21, Barcelona, Spain

[e,f] National Institute for System Studies of Entrepreneurship (NISSE), 13 Rusakovskaya street, Moscow, Russia

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Abstract

Russia set an ambitious energy efficiency goal requiring involvement of all sectors of the economy. It requires specific and efficient public policies at all levels of governance. However, decision making in the energy sector in Russia is complex and characterized by multiple policy objectives, conflicting interest groups and a lack of available quantitative data. This study investigates the decision problem of energy efficiency improvements in the industrial sector – a policy proposed by the Moscow City Government. Multiple criteria analysis (MCA) is tendered as an appropriate evaluation tool. As limited studies exist of the application of MCA in Russia, none – for regional energy systems development, this paper provides a novel solution for regional public management. We adapted the MCA PROMETHEE method and undertook an expert survey to evaluate the policy proposal and develop recommendations. This paper describes the adjustment of the evaluation tool to the existing institutional structure and decision making procedures in Russia. It provides a discussion about the participation of stakeholder groups and determination of policy objectives, options and criteria. The analysis leads to a ranking of preferred policy alternatives to assist policy selection and energy efficiency program development. From this, we recommend partial subsidization of the costs of industrial organisations to implement contracts with energy service companies as the best performing option. More importantly we demonstrate the applicability and usefulness of MCA as a decision support tool for Russian public decision-making. Its wide application is expected to improve public management at both regional and federal levels.

Key words: multiple criteria analysis, energy, industry, developing country, Russian regions

Highilghts:

- Energy efficiency improvement in industry is analysed as a decision problem
- Multiple criteria analysis undertaken for Russian regional case study based on expert survey
- Adjustment of the tool is described to the existing institutional structure
- Policies are ranked, subsidization of energy service contracts costs is recommended
- We demonstrate usefulness of decision support tool for Russian public management

1. Introduction

Russia is one of the most energy intensive economies among the former USSR republics (WB and IFC 2008) with the highest energy intensity ratio value (0.42 kgoe[1] per USD dollar of GDP) of ten of the highest energy consuming countries in the World. At the same time Russia has outstanding national energy efficiency potential of nearly half primary energy use (Trudeau and Murray 2011). To realise its potential, Russia introduced a national energy efficiency goal. It initially targeted a 40% decrease in energy intensity by 2020 in comparison with 2007 across all sectors in the national economy (GRF 2010), although, by 2014, the target was reduced to 13.5% (GRF 2014).

The national energy efficiency target requires modernisation of the whole energy system in the country which can only be achieved with active participation, both administrative and financial, of Russian regions and business organisations (Kiseleva, Rafikova et al. 2012). The ambitious national goal was taken up by Russian regions, which were required to achieve it by establishing regional energy efficiency targets, programs and policies (RF 2009, GRF 2014). Regional governments face a complex problem of allocating limited public resources to improve energy efficiency across sectors and across possible policies and programs within the economy.

Moscow was one of the first regions in the country to initiate the efficiency program (MCG 2011) addressing the goal by means of regulatory and financial stimulation of energy efficiency across all sectors of the regional economy (DFERM 2011). A comprehensive regional program has been made one of 15 prioritised public programs for the region which became a part of the public program targeting improvement in engineering and utilities infrastructure and energy conservation (MCG 2014). The proposed funding of the program over 2014-2018 exceeds 787 billion RUR with over 70% of the expense to be covered by private enterprise and investors (MCG 2014).

Of particular importance for the success of the efficiency initiative in Russia is industry. Manufacturing, for example, is responsible for approximately 25% of total energy consumption in the country. Energy efficiency potential in manufacturing is estimated at 5% of the national final energy use (WB and IFC 2008).

The Moscow regional government recognised the need for a strong policy to realise energy efficiency potential in the industrial sector. Therefore in 2012 the regional government declared a need to develop a public policy to stimulate efficiency improvement in industry. This initiative was assessed as a pilot project of implementation of regulatory impact assessment in the Moscow City Government (Kolegov 2013).This paper presents economic evaluation of this policy proposal as a complex decision problem.

[1] Kgoe - kilograms of oil equivalent.

Decision making in the energy sector in Russia in general is characterized by multiple policy objectives and criteria, conflicting interest groups and lack of quantitative data for analysis. Economic literature demonstrates the ability of economic evaluation tools and specifically multiple criteria analysis (MCA) to assist decision making in the search for compromise solutions for the complex problems associated with the energy sector (Diakoulaki and Karangelis 2007, Tsoutsos, Drandaki et al. 2009, Wang, Jing et al. 2009, San Cristóbal Mateo 2012).

At the same time economic evaluation is rarely used to support decision making at the regional level in Russia (Kolegov 2008, Kolegov 2009, Bratanova 2012a, Bratanova 2013, Bratanova and Belyaev 2013). A review of the literature demonstrates a gap in the adoption of economic evaluation in the former USSR countries (Furubo, Rist et al. 2002).

Few studies have applied MCA to the Russian energy sector. One exception is a study by Voropai and Ivanova (2002) who develop an MCA approach to address a complex problem of electric power system expansion. They provide a case study for the Russian United Electric Power System (UEPS). However, their study is focused on a theoretical MCA model for an energy system planning problem not addressed in this research. Their analysis is based on simulated rather than empirical results and generic expert preferences. To date no empirical studies have been found with MCA undertaken for the regional energy sector in Russia. The objective of this paper is therefore to undertake an economic evaluation and develop recommendations for the regional government on the preferred policy to stimulate energy efficiency in industry. For this purpose, the paper proposes MCA as a well-developed and internationally widely used economic evaluation tool, but which is novel for decision making in Russia. The study also aims to test the tolerance of MCA to the current institutional system in Russia and provide recommendations on the integration of MCA into current public program development in Russia for evaluation of energy projects to facilitate decision making. We, therefore, contribute to the body of the literature by providing an empirical application of MCA to real life Russian regional conditions to address an important decision problem.

This paper is comprised of five sections. The next section provides background information on the decision problem under consideration and industry sector problems and operations under Russian regional conditions. Section 3 establishes the research methodology including the major components for the MCA adopted for the case study. This section also describes the application of the research methodology to the regional case study. The results of this application, together with a discussion and acknowledgement of the limitations of the study are provided in section 4. The final section provides conclusions and discusses policy implications.

2. Background: energy efficiency in regional industrial sector - problems and potential

Energy efficiency improvement potential in Russian industry is estimated at 38% of current energy use (WB and IFC 2008). Although, in Moscow over the last two decades, industrial production has been reallocated from the central business area to the outer suburbs (Erin and Bratanova 2012), industry use of energy in the region remains substantial. Improvement in efficiency in industry plays an important role to achieve the regional energy efficiency goal (MCG 2011; MCG 2011).

The complexity of energy efficiency as a decision problem in Russia and Moscow is reflected in the multiple barriers to efficiency in the industry sector (NISSE 2012) including the following.

- Lack of energy management systems in most large and medium-sized industrial enterprises;
- Lack of financial resources for industrial enterprises to implement energy efficiency projects;
- High degree of depletion of equipment and infrastructure in industry, low level of innovative decisions and projects in the sector;
- Lack of awareness by market participants of existing opportunities for energy efficiency improvements in industry; and
- Lack of a clear policy mechanism to stimulate the energy efficiency of enterprises and lack of effective control over execution of the legislation.

There are other factors contributing also to energy efficiency in industry as a problem for regional public management in Russia. Electricity price liberalisation for industrial consumers implemented as a part of the Russian power sector reform (IEA and OECD 2005, OAO RAO "UES of Russia" 2011) created a situation of “cross-subsidization” where industrial organisations partly bear the energy costs of households. At the Moscow regional level the cross-subsidization problem has been addressed by direct financial support provided by the regional government to industry (MSD 2009, MSD 2011). Although these measures were expected to help industry organizations meet energy costs and continue production, realistically, they have failed to create incentives to improve energy efficiency in the production process or to stimulate technological development.

The described issues for energy efficiency identify a need to develop a specific regional policy for the industrial sector which would complement the existing legislation and would help to achieve state goals in energy intensity improvement (MCG 2011, MCG 2011, CCAM 2012). This paper further demonstrates how MCA was applied to assist the regional government in the development of this regional policy to stimulate energy efficiency in industry.

3. Material and methods

The family of decision support techniques based on MCA principles has grown substantially since the 1960s and has become widely used to support decision making for international, national and regional projects (El-Swaify and Yakowitz 1996, Prabhu, Colfer et al. 1999, DCLG 2009, Wang, Jing et al. 2009, Zopounidis, Galariotis et al. 2015) including those in the fields of energy and environmental modelling (Huang, Poh et al. 1995, Kowalski, Stagl et al. 2009, Bottero, Ferretti et al. 2015, Zopounidis, Galariotis et al. 2015). Zhou et al. (2006) showed that the number of studies has doubled every ten years since 1975.

Methodologically, MCA accommodates a comparison of policy alternatives by their performance against multiple criteria and taking into account the relative importance of the criteria. Methods developed within the MCA family vary significantly in terms of analytical purpose, use of underlying models and software utilisation (DCLG 2009).

A review of the literature indicates that no single MCA approach has yet been suggested as offering a uniform solution suitable for application for all situations. Each approach has limitations and perspectives (Ishizaka and Nemery 2013). The specific features which influence the choice include data availability, analysis objectives, personnel skills and availability, financial and time constraints of decision makers and analysts, and field of its application (Guitouni, Martel et al. 1999, Ishizaka and Nemery 2013). Although the literature shows no general preference toward application of particular MCA approaches to studies in the energy sector, Munier (2011), based on a survey of 66 projects evaluated using MCA, demonstrates that there was an abundance of cases which used analytic hierarchy process (AHP) and outranking methods for environmental projects. The same conclusion is reached in the review of MCA studies in energy planning by Pohekar and Ramachandran (2004).

This study applies PROMETHEE ('Preference Ranking Organization METHod for Enriched Evaluation') which is believed to match the properties of the case study under consideration and provide an analysis of results satisfying transparency, consistency as well as ease to use requirements. The method also allowed for communication between decision maker and the model during the construction of the performance matrix (DCLG 2009) which was important for the Russian regional case study.

The underlying principles of the PROMETHEE method is elimination of policy options dominated by others according to their performance against the criteria, taking into account the relative weights of the criteria (DCLG 2009). The outranking approach is based on pair wise comparison of options against criteria and can be described as follows.

Given options a and b, the difference between scores $f_j(a)$ and $f_j(b)$ against criterion j is $d_j(a,b)$:

$$d_j(a,b) = f_j(a) - f_j(b). \quad (1)$$

The obtained value for this difference is processed with a preference function P_j to obtain a multi-criteria preference index $\pi(a,b)$ such that the following holds:

$$0 \le P_j(d_j(a,b)) \le 1, \quad (2)$$

$$\pi(a,b) = \sum_{j=1}^{k} w_j \times P_j(d_j(a,b)). \quad (3)$$

Where $P_j(d_j(a,b))$ is a preference function value obtained when option a is compared with option b against criterion j; and, w_j is the weight applied to criterion j. When $\pi(a,b) = 0$, option a is not preferred to option b on any criteria. On the contrary, when $\pi(a,b) = 1$, option a is preferred to option b on all criteria (Mareschal 2013):

The weights are normalised such that the following holds:

$$\sum_{j=1}^{k} w_j = 1, \quad 0 \le w_j \le 1. \quad (4)$$

The ranking of options is executed in PROMETHEE with the help of two indexes also referred to as "preference flows", positive $\phi^+(a)$ and negative $\phi^-(a)$, and a resulting net flow index $\phi(a)$. The indexes are outlined in table 1.

Table 1 PROMETHEE preference flow description

Preference flow	Description	Function
Positive	Measures relative preference of one option (a) to all others	$\phi^+(a) = \frac{1}{n-1}\sum_{a \ne b} \pi(a,b)$ $a,b \in A,\ a \ne b$
Negative	Measures relative preference of all other options to the one option (a)	$\phi^-(a) = \frac{1}{n-1}\sum_{a \ne b} \pi(b,a)$ $a,b \in A,\ a \ne b$
Net	Aggregated value of flows	$\phi(a) = \phi^+(a) - \phi^-(a)$

Source: (Mareschal 2013)

The preference indexes are used to construct two types of ranking in the PROMETHEE framework: partial and complete ranking as defined in table 2.

Table 2 PROMETHEE partial and complete ranking

Ranking	Function
Partial	*a* is preferred to *b* iff $\phi^+(a) \geq \phi^+(b)$ *and* $\phi^-(a) < \phi^-(b)$ *or* $\phi^+(a) > \phi^+(b)$ *and* $\phi^-(a) \leq \phi^-(b)$
Complete	*a* is preferred to *b* iff $\phi(a) > \phi(b)$

Source: (Mareschal 2013)

Preference functions are utilised to reflect decision makers' perception about the scaling used for criteria (Mareschal 2013). Although the preference functions help to fully define decision makers' preferences, their selection is associated with some level of subjectivity. The assumptions for the choice of a preference functions for each of the criteria in this study are discussed in section 3.2.

Having outlined the research methodology, the next section describes features of the MCA developed for the case study. The data collection has been organised to mimic the decision making process in the regional government and government procedures currently in place in Moscow to ensure the evaluation tool can be integrated and effectively used to support decision making in Russian regions.

4. Calculation: Moscow regional case study

4.1 Determination of state policy objectives

Establishment of clear objectives for the policy is an essential part of the decision making process using MCA (DCLG 2009). Difficulties in objective determination are frequently associated with the need to incorporate political, economic and social aims of the policy as well as to ensure that the interests of all stakeholder groups are accommodated.

For the Russian regional case study multiple iterations and broad discussion with government representatives facilitated an agreement on the following objectives for the proposed policy:

- Create incentives for the regional industry organisations to improve energy efficiency;
- Stimulate industry development in Moscow;
- Stimulate growth of investment and technological development in the regional industrial sector;
- Improve ecological situation in the region.

Discussion with the stakeholder groups showed that the ecological objectives were mostly treated as complimentary to the other objectives. Investment growth in the industry and technological development were also declared to be secondary with respect to the stimulation of energy efficiency improvement. These objectives were removed from the front line, such that industry support targeting energy efficiency improvements was made the most important objective for the policy.

4.2 Stakeholder and expert groups: data collection

A wide representation of stakeholders was required to undertake the MCA. Five stakeholder groups were identified whose interests are potentially impacted by the proposed regulation as described in table 3. Equal weights (20%) were assigned to each stakeholder group.

Table 3 Stakeholder groups, description and representation

<table>
<tr><th colspan="2">Stakeholder group</th><th>Description</th></tr>
<tr><td>1</td><td>Regional and municipal governments, other authorities</td><td>Government departments, municipal authorities</td></tr>
<tr><td>2</td><td>Energy generating companies</td><td>Companies operating in the electricity and heat generation industry</td></tr>
<tr><td>3</td><td>Energy management and energy service companies</td><td>Firms operating in the emerging market of energy management and energy service for industry, business and residential construction management</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Social development and environment protection groups</td><td>Organizations working with international, national and regional programs and initiatives for social-economic development of Russia and regions, community support and social security</td></tr>
<tr><td>Environment management companies, independent experts (environmental engineers) qualified and experienced in energy management and pollution control in industry</td></tr>
<tr><td>5</td><td>Industrial production companies</td><td>National and regional associations of business organizations and producers. Small and medium sized companies operating in the production sector in Moscow</td></tr>
</table>

Source: Expert survey results

Self-assessment was used to analyze the aptitude of each expert to represent the stakeholder group interests. The analysis revealed no contradictions between the self-reported field of expertise and the area of interest of the expert and stakeholder group represented. Therefore none of the surveys from experts were excluded from the analysis.

The experts representing ecological funds, environment protection organisations, industrial ecologists and other organisations in this field were combined into one stakeholder group with representatives of social development and protection organisations. Although they could have been separated, experts from each field of interest ranked themselves as representing both positions sharing the interests of environmental protection and social security and development. Therefore a single stakeholder group, group 4, was formed for the analysis.

4.3 Determination of policy options

MCA as a decision support tool is frequently used to provide a structured and systematic approach for the identification of policy options or alternatives (Haldi, Frei et al. 2002, DCLG 2009). Determination of the policy options for this study required several stages with a number of iterations. At the first stage, the initial set of options with broad definitions was developed based on the policy proposal and objectives. However, as a result of the focus group discussion some of the shortlisted options were considered unfeasible and removed from the option list. The final list of options is defined in table 4 and illustrated in a decision tree (figure 1).

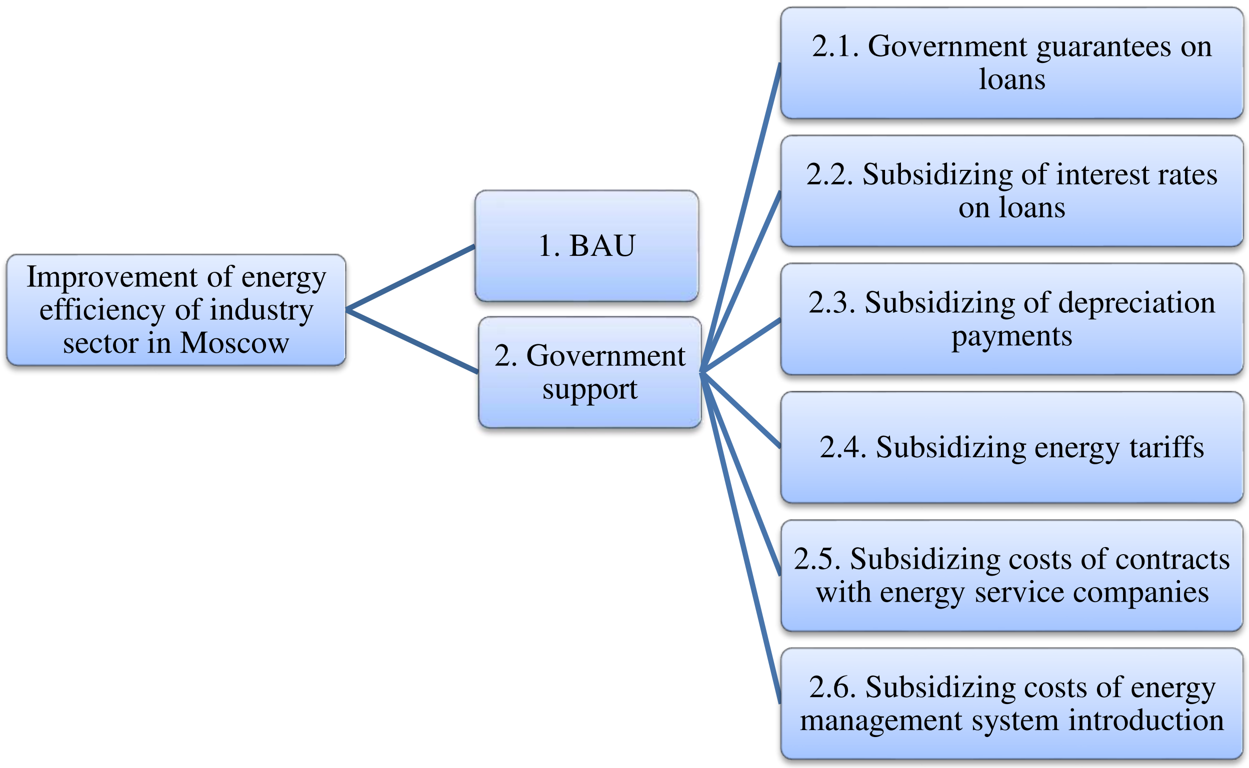

Figure 1 Decision tree for the final set of policy options

Source: Focus group discussion outcomes

Table 4 Policy options

Options		Description
1	BAU	Maintain business as usual, regulation and policy are unchanged
2	Provision of government support	Government providing support to the industrial organisations to improve energy efficiency in one of the following forms:
2.1	Government guarantees on loans	Government guarantees are to be provided to eligible industrial organisations to support their applications for bank loans to undertake energy efficiency improvement projects
2.2	Subsidizing of interest rates on loans	Partial subsidizing interest rates on loans to undertake industrial programs of modernization for energy efficiency improvement (including generating capacity and transmission lines modernisation)
2.3	Subsidizing of depreciation payments	Partial subsidizing of depreciation payments for assets purchased, renewed or repaired for the purposes of energy efficiency improvement or/and as a part of energy efficiency projects
2.4	Subsidizing energy tariffs	Partial subsidizing of energy tariffs for organisations in case they undertake modernization programs for energy efficiency improvement
2.5	Subsidizing costs of contracts with energy service companies	Partial subsidizing costs for industrial companies entering into contracts with energy service companies. Eligible companies will be allowed to apply together with eligible energy service companies
2.6	Subsidizing costs of energy management system introduction	Provision of subsidies to partly cover costs of energy management system development and implementation including educational and training activities in energy efficiency and energy conservation

Source: Focus group discussion

4.4 Determination of criteria for analysis

Criteria play a crucial role in MCA application since they are the parameters against which the options' performance are measured (Janssen 1991, El-Swaify and Yakowitz 1996, DCLG 2009). Systematic determination of criteria therefore is especially important for the analysis.

An initial broad set of criteria was developed to reflect the policy objectives, however as a result of a discussion with stakeholder representatives a few criteria were excluded as being redundant. After several iterations, a final set of criteria was formed as provided in table 5 and in the criteria tree (figure 2).

Interestingly, the criterion 4.2 "Propensity for corruption" was added to the criteria set as it was suggested that the preferred policy option should have minimal opportunity to create a corruption situation. Since corruption reduction is one of the major national goals (MFRF 2012, President of the Russian Federation 2012), current legislation sets procedures for anti-corruption evaluation of proposed regulation, anti-corruption measures are required to be undertaken by all federal and regional authorities. The criterion was added to the investment group of criteria to reflect the position expressed by the experts, who identified corruption as one of the major barriers for an increase in external investment inflow to the industrial sector of Moscow.

Table 5 MCA criteria

Criterion		Qualitative/ quantitative	Description of the criteria or question to be asked to measure the performance of options
1.1.	Budget expenditure	Quantitative	Amount of budget funds required to implement the option, counted per one company over five year period
1.2.	Costs for Moscow industrial organisations		A period of time required to recover costs of the energy efficiency project implementation for a company given it obtains the government support
2.1.	Energy efficiency improvement	Qualitative	Will the implementation of the option reduce energy use per unit of production or result in improvement of energy efficiency?
2.2.	Decrease of emissions level		Will the implementation of the option result in improvement in the environmental situation in the region by reducing emissions by industrial enterprises?
3.1.	Decrease of production costs and goods prices		Will the implementation of the option result in reduction of production costs of goods produced by regional industrial enterprises?
3.2.	Creation of jobs in industry sector		Will the implementation of the option generate new jobs for the residents of the region?
4.1.	Increase of investments into assets renovation		Will the implementation of the option increase investment activity of enterprises and use of funds for replacement, renovation or modernization of fixed assets?
4.2.	Propensity for corruption		Will the implementation of the option lead to an emergence of a corruption situation?

Source: Focus group discussion

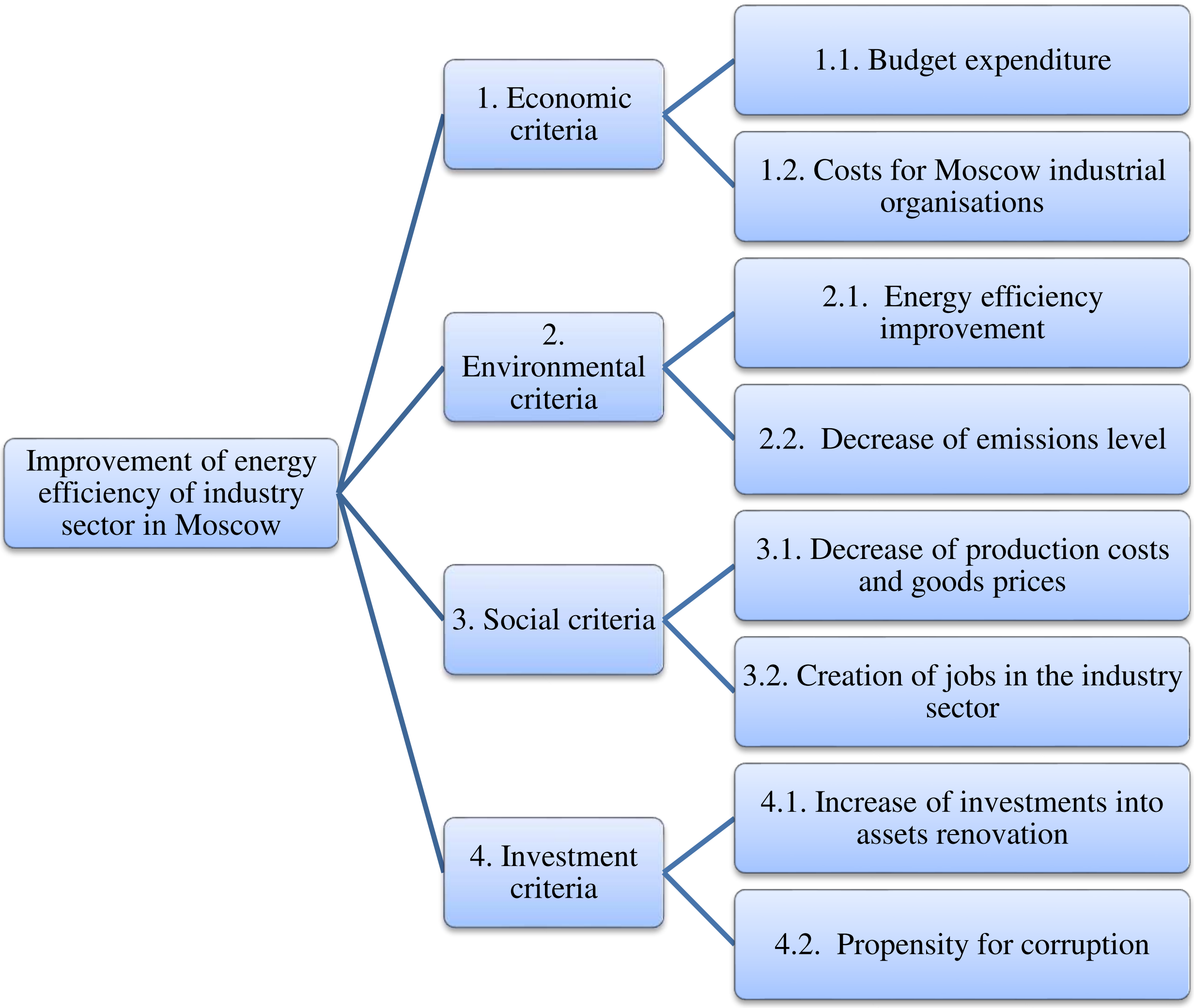

Figure 2 Decision tree for the MCA criteria

Source: Focus group discussion

The listed criteria and options formed the performance matrices which were distributed to stakeholder representatives to collect qualitative data to score the performance of options against criteria. Experts were asked to estimate options' performance against criteria based on a scale of one to five. The interpretation of the scale is presented in table 6.

Another important step for the MCA is criteria weighting. To ensure transparency of the analysis, a simple way to allocate weights was applied - experts were asked to attach a percentage weight to each criterion reflecting its importance for the policy such that the sum of the weights equals 100%.

Table 6 Interpretation of scores for qualitative criteria

Score	Interpretation	Answer to the associated questions
1	no performance against a criterion, no change from the existing situation is expected	"no, will not result in change"
2	low performance against a criterion, existing situation is expected to be changed slightly	"will result in slight change"
3	medium performance against a criterion, existing situation is expected to be changed to a medium scale	"will result in change to a moderate extent"
4	good performance against a criterion, existing situation is expected to be changed	"yes, will result in change to a substantial extent"
5	excellent or outstanding performance against a criterion, existing situation is expected to be substantially changed	"yes, will change to a large extent"

As discussed in section 3.1, the PROMETHEE approach requires specification of the preference function for every criterion. A trade-off exists between complexity of the preference function which is expected to reflect the performance of the option against the criteria and transparency of the analysis. As transparency is a high priority in the analysis undertaken for this regional case study, simple preference functions are applied for the analysis. Specifically, a "usual" preference function (Munier 2011) is applied to all qualitative criteria since they were evaluated on a five scale qualitative basis (table 6) and it is believed that the difference between the qualitative scores (for example, between "good" and "very good"; "bad" and "good") is consistent for application to all qualitative criteria. A linear preference function is utilised for quantitative criteria namely costs to the budget and business (criteria 1.1 and 1.2).

5. Results and discussion

This section first discusses the weights applied to the criteria by the survey respondents. We continue with a discussion about the MCA results from an overall perspective.

5.1 Weights allocation to MCA criteria

The weights assigned by stakeholder groups are illustrated in figure 3.

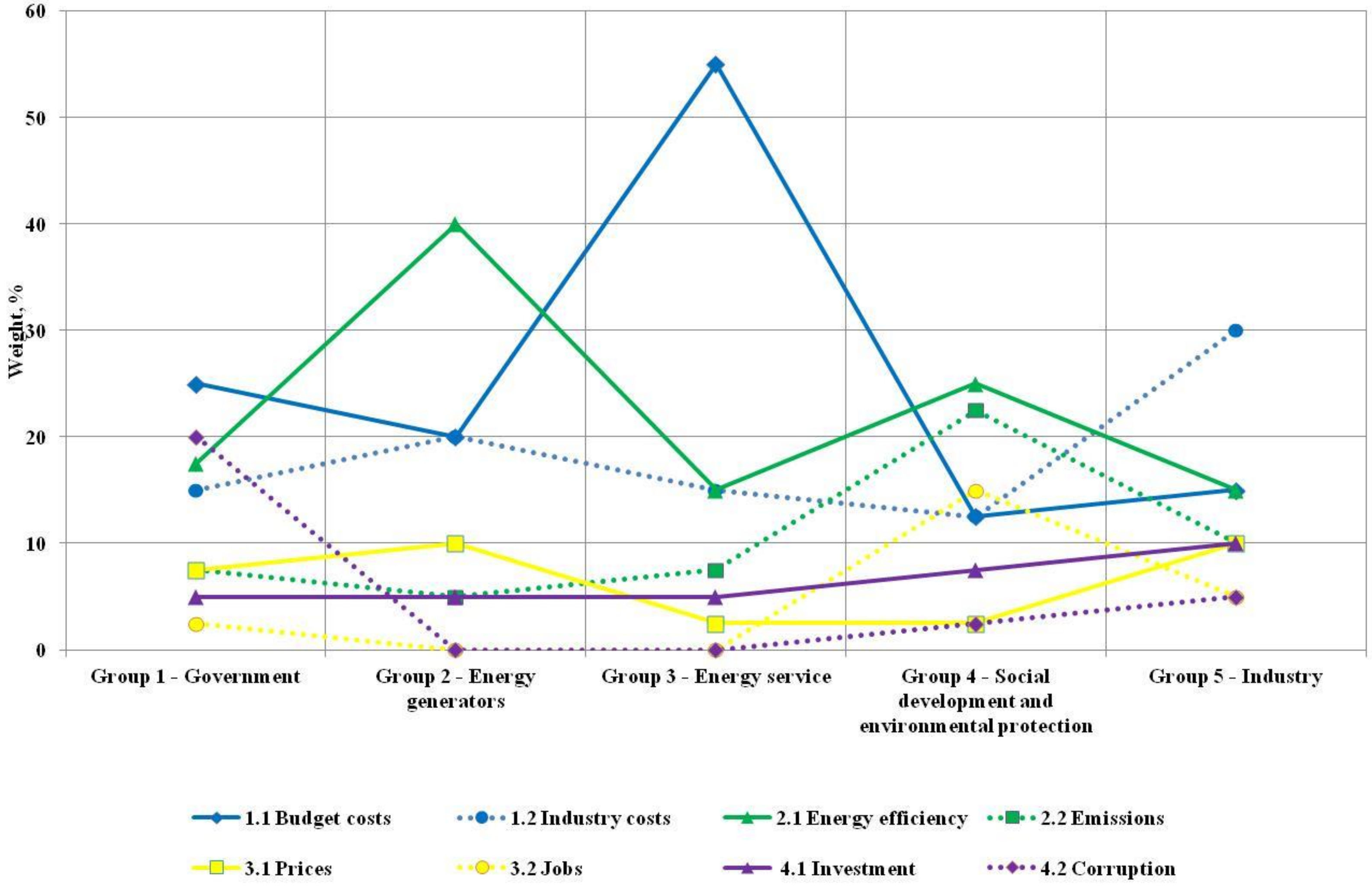

Figure 3 Weights allocated by stakeholder groups

Source: Survey results

The analysis shows that the criteria weighting reflects the positions and interests of the stakeholder groups. Specifically, group 5, representing the industry stakeholder group, stresses the importance of criterion 1.2 (costs to business) above any other criteria. The social and environmental group (group 4) ranks the criterion of jobs creation (criterion 3.2) higher than representatives of other stakeholder groups. They also emphasize the importance of emissions reduction as the policy objective by assigning a weight of 22.5% to criterion 2.2.

Interestingly, the criterion of increasing investment activity of industrial enterprises (criterion 4.1), designed to reflect the regional policy objective to stimulate modernization and renewal of assets and production technology in the industry, is estimated as marginally significant by the survey respondents with an assigned weight of 5-10%. At the same time criterion 4.2 "Propensity for corruption" is ranked very low by all the stakeholder groups except from the representatives of public authorities who assigned it a weight of 20%.

Analysis of the weighs assigned to criteria by the experts allows us to comment on important differences in policy preferences across stakeholder groups. In many cases the weights show clear bias towards the interests of individual groups suggesting strategic behavior. Analysis of the performance matrices of individual stakeholder groups confirms this conclusion.

5.2 MCA results

Integration of the stakeholder groups' positions has been facilitated by the embedded *Visual PROMETHEE* scenario analysis tool - *Balance of Power* analysis. The resulting ranking for policy options is presented in table 7 and figure 4.

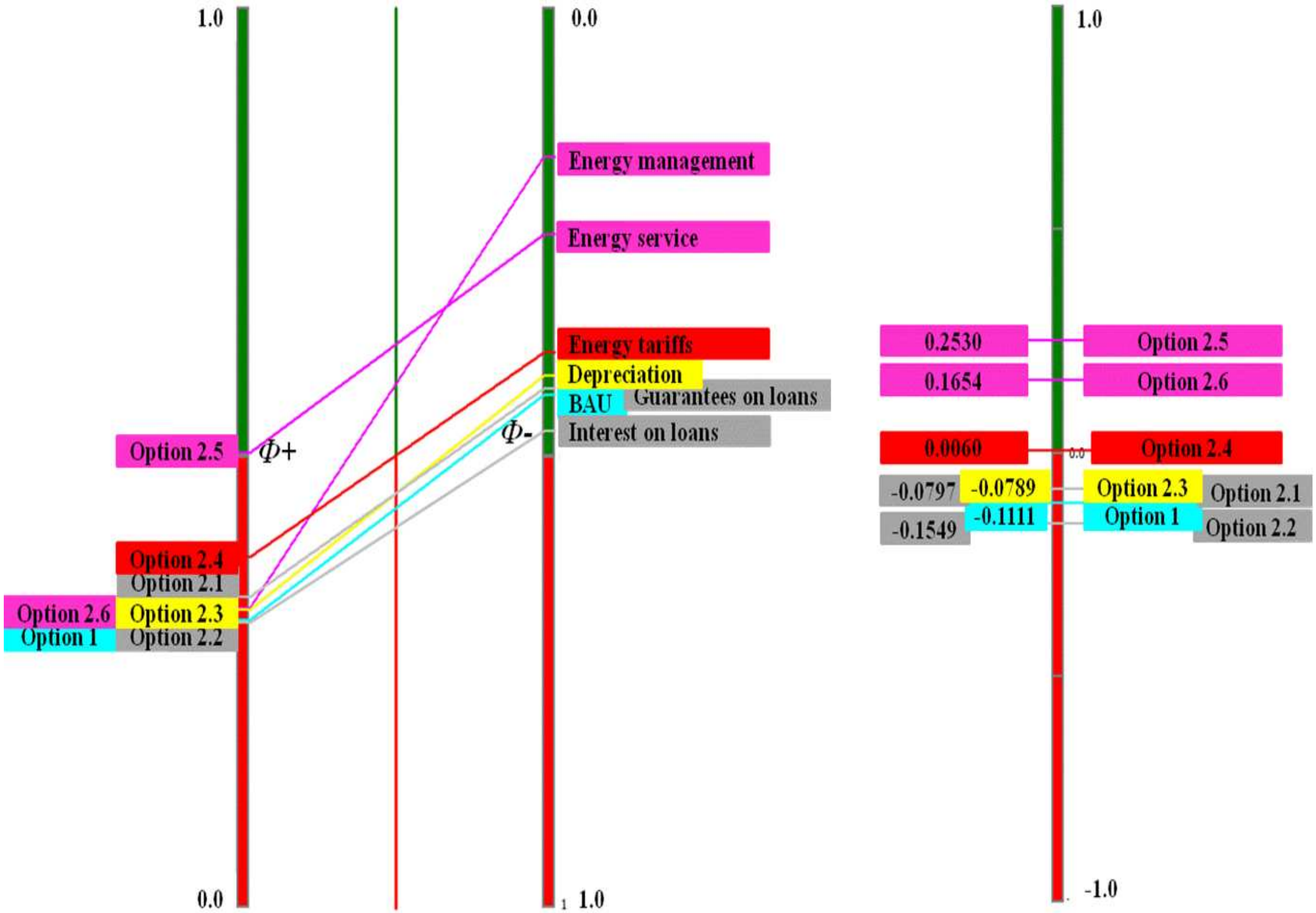

Figure 4 MCA partial (left) and complete (right) ranking results

Source: PROMETHEE analysis

The analysis of stakeholder groups' responses doesn't identify a unique solution for the decision maker. It shows that no option is preferred to all others in absolute terms. However, the complete ranking results (figure 4) allow us to separate several groups of policy alternatives. The leading options are 2.5 and 2.6 which represent energy management and energy service development policy alternatives. The next best option in the ranking is option 2.4 - tariff subsidizing, which obtained a positive overall ϕ score of 0.006 (table 7).

Partial ranking of the aggregated data (figure 4) shows that only option 2.5 (subsidizing costs of energy service companies) shows positive values for both parameters under consideration – ϕ^{+} and ϕ^{-}. Consequently, option 2.5 outperforms the others with the given performance matrix scores and criteria weights. However, performance of option 2.6 (subsidizing costs of energy management system introduction) is close to the highest ranked option.

The remainder of the policy alternatives obtained negative ϕ values and are located in the negative part of the ϕ column (figure 4). The worst ranked option is option 2.2. (interest rate subsidizing), which was slightly outperformed by the BAU (option 1).

Table 7 MCA policy options ranking

Rank	Policy option		Score		
			ϕ	ϕ^{-}	ϕ^{+}
1	2.5	Subsidizing costs of contracts with energy service companies	0.2530	0.2525	0.5055
2	2.6	Subsidizing costs of energy management system introduction	0.1654	0.1663	0.3317
3	2.4	Subsidizing energy tariffs	0.0060	0.3832	0.3893
4	2.3	Subsidizing of depreciation payments	-0.0789	0.4088	0.3299
5	2.1	Government guarantees on loans	-0.0797	0.4239	0.3442
6	1	BAU	-0.1111	0.4303	0.3193
7	2.2	Subsidizing of interest rates on loans	-0.1549	0.4713	0.3164

Source: PROMETHEE analysis

It is noted that the BAU option, which assumes continuation of the current situation in the industry with no government support to be provided, falls in the negative range of the results. This can be interpreted as a recognition of the need for change in the functioning of the current system.

Overall, the MCA analysis revealed the following results;

- The policy alternative ranked highest is option 2.5 "Subsidizing costs of energy service companies".

- The second ranked alternative is option 2.6 "Subsidizing costs of energy management system introduction", although it is not clearly compatible to most of the other policy options.
- Tariff subsidizing (option 2.4) is marginally positively scored and ranked the third best policy alternative.

These results are further discussed from the perspective of policy implications in section 5.

5.3 Sensitivity analysis

A sensitivity analysis of the results determined the robustness of the model and the responsiveness of the rankings to change in the weights assigned to the criteria and stakeholder groups.

The sensitivity analysis demonstrates that the two highest ranked options, 2.5 and 2.6, do not change their rank as a result of the change in weights. The three options with the worst performance also remain poorly ranked for all the sensitivity scenarios. This supports the conclusion that the MCA provides a robust ranking of the options. Importantly, MCA as an evaluation tool is frequently criticized in the literature for subjectivity of the results which in turn is attributed to the weighting of criteria. The case study shows that the ranking of the policy options and hence the recommendations provided to decision makers can be regarded as robust with respect to the criteria weighting. The outcome of the sensitivity analysis is provided in more detail in the Appendix.

5.4 Limitations of the analysis

There are a number of limitations of the analysis. These are discussed below.

- *The options are assumed not to be implemented simultaneously.*

This assumption was crucial to collate qualitative data, complete the performance matrix and was a limiting factor of the software. However, it can be argued that a combination of options could be expected to produce a synergic effect and overall better results than any single option.

- *Limited communication with experts.*

Focus group meetings took place in December, 2012 – January, 2013 in Moscow. No opportunities were available for further meetings with the participants. This limited communication opportunities. Follow-up interviews would have been valuable for discussion about the results, for testing the robustness of the results and to receive and provide feedback to participants. At the same time it limited the transparency of the analysis since it has not been possible to determine if all the experts fully understood all the options and criteria.

However, taking into account that the objective of the research is to develop a practical tool for analysis and decision making which can be integrated into the current decision making procedures, this approach is acceptable given that written communication is prescribed in government communication and all the acceptance procedures for government papers assume written comments and communication.

- *Identification of options and criteria*

The identification of options and criteria was undertaken with limited specification of their scope or detail. Although this limits the transparency and objectivity of the analysis, this approach reflects the objective of the policy proposal which required evaluation. MCA has played an important role in the identification of options considered by experts as worth further development and exclusion of options which are not expected to meet the strategic objectives for improving energy efficiency.

- *Sticks and carrots in the stimulation of energy efficiency improvement*

The listed policy options clearly represent only incentive-based mechanisms for government intervention. It can be argued that introduction of energy saving norms or energy efficiency requirements for equipment in the industry might result in better outcomes for the region as a whole targeting energy efficiency improvement. However, it needs to be acknowledged that Russian regional authorities have limited jurisdiction in regulation of industry operations. Industry regulation development and enforcement is mostly under the jurisdiction of the Federal Government and the State Duma of the Russian Federation. This limits the policy options available for regional governments.

- *Timeframe for the analysis*

A five year period was selected as a timeframe to consider the effects of the options. This appears reasonable as it matches the regional budgetary arrangements. However, it needs to be acknowledged that the flow-on consequences from energy efficiency improvements would be expected to exceed the selected timeframe.

- *Subjectivity*

Criteria weighting is often associated with subjectivity which is the main argument of MCA opponents. However, for the purposes of this research subjectivity in the weighting of the identified criteria reflects the strategic behaviour of stakeholder groups and is considered a positive feature in the analysis, rather than a disadvantage. Strategic behaviour of stakeholders is a characteristic of public decision making and public management. Decision making in the energy sector in Russia is complex and involves multiple parties with potentially conflicting interests, consequently strategic behaviour is anticipated. Therefore MCA as an evaluation technique should acknowledge, consider, and be capable of including and managing the strategic behaviour of involved parties.

At the same time it is necessary to acknowledge that the selected way of assigning weights across stakeholder groups also limits the research results.

- *Business as usual option*

The BAU option assumes nothing changes over the period from when the proposed policy is put in place. However, changes might be expected to occur in the energy efficiency of industrial organisations regardless of the proposed policy. However, these changes are independent of the decision to be made regarding the selection of the regulatory option for the regional government and cannot be reasonably predicted and incorporated into the analysis. Consequently it has been assumed that any change to the current situation, beyond the scope of the potential effect of the proposed policy, will affect all the options. This allows us to define the BAU option as the scenario with no foreseeable changes in the future with respect to the current situation.

6. Conclusions

Based on this analysis, it is recommended that the regional government develop a policy for partial subsidization of the costs of industrial organisations to implement contracts with energy service companies. This policy alternative appears to provide the best performance against the identified criteria describing the objectives of the policy – namely, energy efficiency improvement in industry in the Moscow region.

By partially subsidizing the costs of energy management in industry regional authorities can utilize the potential of the next highest ranked option to facilitate achievement of the policy objectives.

Subsidizing energy tariffs, although ranked closely behind the two highest ranked options, is not recommended to the government. Subsidizing depreciation payments cannot be recommended for implementation either, as it showed a poor performance against the criteria and is not expected to facilitate improvement in the existing regional energy efficiency.

An important result of the analysis is the ranking of the BAU policy option. The result shows that the BAU option is ranked among the two least preferred options. This suggests that overall, stakeholders share a positive expectation of a change to the existing situation which could result from implementation of the proposed policy. Hence if the regional government develops and implements the policy under consideration, it is expected to go some way towards improving energy efficiency in industry, stimulating technological development in Moscow and investment inflow in industry as well as facilitating an improvement in the ecological situation in the region.

However, analysis of the ranking for each of the stakeholder groups also identified important differences across the groups which can be partly explained by the strategic behavior of respondents. In the situation under investigation strategic behavior is important to identify and acknowledge. Identification of strategic behavior by stakeholder groups in the weighting of criteria and scoring the performance matrix helps to understand the positions and interests of each of the stakeholder groups. It is a valuable outcome from the analysis – the decision maker needs to be aware of the stakeholder group interests when formulating and implementing the energy efficiency policy. Specifically, budget cost and achieving energy efficiency were priority criteria for the energy services and energy generators respectively.

As discussed in section 1, MCA, despite being a well-established and widely used evaluation technique, has rarely been applied in Russia. No studies have been found to date with MCA being used to facilitate decision making for regional governments in the energy sector in Russia. At the same time MCA has been identified as capable of addressing public policy development needs, data limitations and multiple stakeholder requirements which characterise decision making in the energy sector in Russia.

The results from the analysis lead to the conclusion that MCA can be recommended as a decision support tool along with the development of relevant databases to be incorporated into policy and program development procedures at the regional level in Russia. It should be used at the level of strategic planning and to facilitate policy option development and selection for the energy sector. MCA facilitates the inclusion of a broad range of stakeholder representatives into development and discussion about policy alternatives and represents an improvement from the qualitative and descriptive practice which is currently in place to undertake analysis with pre-defined policy options. Consequently, this study contributes to filling this gap by establishing an MCA framework which has demonstrated its capability of integration into current decision making procedures in Russia.

However, it is acknowledged that the efficacy of implementation of each policy option under consideration will, to a great extent, depend on the way the option is implemented, managed and monitored. There are other options, not considered in this analysis, which might perform an important role for improving energy efficiency. For example, education can be effective if educational programs are properly designed, planned, implemented and monitored. On the other hand, options with a high ranking as a result of the analysis but poorly implemented, could be ineffective. A good example of this situation is government subsidies to install energy measuring devices. If the subsidy targets installation of devices only there is a risk that the devices will not be used, monitored and supported after the subsidy is received. A similar situation was widely discussed in the literature when federal legislation introduced a requirement for industrial organisations to undertake an energy assessment and to submit energy efficiency passports (GRF 2011, MCG 2011). Audits were undertaken and passports submitted by the majority of large enterprises to avoid fines, but the recommended measures for energy efficiency improvements were mostly not implemented (CCAM 2012). Consequently it is reasonable to assume that any option requires suitable implementation, monitoring and control and sufficient resources to achieve the policy objectives.

Given the concluding comments from this study, MCA, as an evaluation tool with a demonstrated applicability to support decision making in the Russian regional energy sector, can also be adapted to a broad range of decision problems in energy management and other public utilities. The potential of MCA as a decision aid tool therefore spans all Russian regions and public policies.

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Appendix

Sensitivity analysis of the MCA results

Sensitivity analysis to change in criteria weights

For the purposes of the sensitivity analysis to the change of criteria weights each of the weights is changed by 5% at a time. An increase of 5% for one of the criteria resulted in a subsequent proportional decrease of weights assigned to other criteria. For illustrative purposes a case of equal weights for all criteria was also considered. Consequently, ten scenarios of weights allocation (WS) were developed for sensitivity analysis:

- WS1: initial weights for MCA;
- WS2: equal weights assigned to every criterion (approximately 12%);
- WS3 – WS10: weights increased by 5% for individual criteria with a subsequent proportional decrease of weight for all other criteria.

The scenarios of weights allocation and the MCA ranking of policy options for every scenario are provided in table 8. The plus and minus signs in the table represent positive and negative positions of options on the ϕ scale.

Table 8 Sensitivity of MCA results to the change of criteria weights

Parameter		Scenarios of weights allocation									
		WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9	WS10
Criteria	1.1	25	12	30	24	23	24	24	24	24	24
	1.2	16	12	15	21	15	16	16	16	16	16
	2.1	24	12	22	22	29	22	22	22	22	22
	2.2	11	12	11	11	11	16	11	11	11	11
	3.1	6	12	6	6	6	6	11	6	6	6
	3.2	7	12	6	6	6	6	6	12	6	6
	4.1	6	12	6	6	6	6	6	6	11	6
	4.2	5	12	5	5	5	5	5	5	5	10
		Option / ϕ parameter range									
Rank	1	2.5/+	2.5/+	2.5+	2.5/+	2.5+	2.5/+	2.5/+	2.5/+	2.5/+	2.5/+
	2	2.6/+	2.6/+	2.6/+	2.6/+	2.6+	2.6/+	2.6/+	2.6/+	2.6/+	2.6/+
	3	2.4/+	2.3/+	2.4/-	2.4/+	2.4+	2.4/+	2.4/+	2.4/+	2.4/+	2.4/-
	4	2.1/-	2.4/+	2.1/-	1/-	2.3-	2.3/-	2.3/-	2.3/-	2.1/-	1/-
	5	2.3/-	2.2/-	1/-	2.3/-	2.1-	2.1/-	2.1/-	2.1/-	2.3/-	2.3/-
	6	1/-	2.1/-	2.3/-	2.1/-	2.2-	2.2/-	2.2/-	2.2/-	2.2/-	2.1/-
	7	2.2/-	1	2.2/-	2.2/-	1-	1/-	1/-	1/-	1/-	2.2/-

Source: PROMETHEE analysis

The sensitivity analysis shows that the MCA results are robust and consistent in the ranking of the best performing policy alternatives. Across all of the scenarios tested, policy options 2.5 and 2.6 remain the two highest ranked options.

Option 2.4 (tariff subsidizing) showed only minimal sensitivity to the change in weights and retained the third highest rank in almost all the cases of weighting change. However, the ranking changed from a positive to negative sign for the net flow (ϕ) parameter and hence from positive flow to negative ranges for ϕ score.

Option 2.3 (depreciation subsidizing) retain fourth and fifth position in the overall ranking remaining in the negative part of the ϕ range (with the exception of the WS2 and WS3 cases). Although option 2.3 shows sensitivity to the weighting, it remains within the middle range of the ranking across scenarios, not improving better than third position in the ranking, but not falling below sixth position.

Options 2.1 and 2.2 remain at the end of the ranking for all the weighting scenarios. Option 2.1 outperformed option 2.2 in all but one weighting scenarios. However, both options remain in the negative range according to the ϕ parameter. This observation confirms the robustness of the MCA results and hence ranking of options.

Important variability of ranking position with respect to change in weight is shown by the BAU option. It fluctuates from fourth to last position in the ranking across scenarios. However, as it mostly remains at the end of the ranking list, it supports the robustness of the earlier findings and the recommendation to reject this option is robust.

Sensitivity analysis to change in the weights for expert groups

The analysis has been undertaken assuming all the stakeholder groups have equal importance in this decision making process. The importance is reflected by the weights assigned to every expert group within stakeholder groups and used to weight each criterion in the construction of the aggregated performance matrix. The equal allocation of weights, however, can be questioned. Sensitivity analysis has been undertaken to test the responsiveness of the MCA ranking results to the change in weights allocation among expert groups. As before, the *Balance of Power* tool embedded in the *VP* software has been applied to test the sensitivity of MCA results. Nine scenarios (WS11-WS19) have been developed accordingly for the changed weights.

The results from the sensitivity analysis are presented in table 9 for the weighting scenarios WS11-WS19. It shows that variation of weight for each of the expert groups in the allocation has not substantially changed the MCA ranking. Option 2.5 preserves the highest rank across all the weighting scenarios followed by option 2.6. Option 2.4 remains third ranked, but changes ϕ score from positive to negative values. Option 2.2 shows the worst performance across the scenarios. It is outperformed by the BAU option, and options 2.3 and 2.1. The latter share fourth and fifth positions in the ranking.

Table 9 Sensitivity of MCA results to the change of weights for expert groups

Parameter		Weighting scenario								
		WS11	WS12	WS13	WS14	WS15	WS16	WS17	WS18	WS19
Expert group	1	10	15	9	10	9	9	9	9	10
	2	10	10	15	9	9	9	10	9	9
	3	10	9	10	15	10	9	9	9	9
	4	10	9	10	9	15	9	9	10	9
	5	20	19	19	20	19	25	19	20	19
	6	10	9	9	9	10	9	15	9	10
	7	10	9	9	9	9	10	10	15	9
	8	20	20	19	19	19	20	19	19	25
		Option / ϕ parameter range								
Rank	1	2.5/+	2.5+	2.5+	2.5/+	2.5/+	2.5/+	2.5/+	2.5/+	2.5/+
	2	2.6/+	2.6/+	2.6/+	2.6/+	2.6/+	2.6/+	2.6/+	2.6/+	2.6/+
	3	2.4/+	2.4/-	2.4/-	2.4/-	2.4/-	2.4/+	2.4/+	2.4/+	2.4/+
	4	2.1/-	2.1/-	2.1/-	2.1/-	2.1/-	2.1/-	2.3/-	2.1/-	2.1/-
	5	2.3/-	1/-	1/-	2.3/-	2.3/-	2.3/-	2.1/-	2.3/-	2.3/-
	6	1/-	2.3/-	2.3/-	1/-	1/-	1/-	1/-	1/-	1/-
	7	2.2/-	2.2/-	2.2/-	2.2/-	2.2/-	2.2/-	2.2/-	2.2/-	2.2/-

Source: PROMETHEE analysis results

In conclusion, the MCA ranking shows little sensitivity to the weights allocated across expert and stakeholder groups. It confirms that the final ranking of options to be recommended to decision makers is robust.

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