Socio-economic Indicators Influence in Terms of Natural Gas Supply Policy and Decision Making - Macedonian Case

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Abstract – Sustainable energy planning is very important in creating energy policies that underpin reliable energy systems. Macedonia has mainly coal based energy production, implying significant air pollution. Thus, natural gas is pointed out as a solid substitute. In order to analyze the combined implications of economic and social aspects when assessing six natural gas supply options vs. a set of selected relevant indicators, the Multi Criteria Decision Making (MCDM) and Analytic Hierarchy Process (AHP) technique were applied. The purpose of this paper is to address the combined effects of economic and social indicators affecting natural gas supply policy and decision making.

Keywords – natural gas, economic aspects, social aspects, MCDM, AHP.

1. Introduction

Decision- and policy-makers are continuously faced with increasing demands and constrains in the processes of conceptualizing, assessing and designing a sustainable energy system. Despite the traditional analyses of an energy system in terms of direct or explicit cost of energy produced [1],[2], one of the contemporary approaches is denoted as societal and includes both explicit (private) and external (hidden) costs. [3] Explicit costs relate to clear and obvious cash outflows concerning the actual investment, while an external cost, also known as an externality, arises when social or economic activities of a particular group of persons (authors note: and/or processes) have an impact on another group and when that impact is not fully accounted or compensated for by the first group.[4] Externalities are those which implicitly embed social and environmental aspects, additionally burdening the explicit (economic) costs. An example of this would be a power plant generating SO 2 emissions, causing damage to human health, thereby imposing considerable external costs that in turn aggravate the social impact. Contemporary developments in terms of sustainable energy policies, lead to a global movement resulting in cleaner and more socially benign energy regime as an antipode of the “quantity-based logic of modern technology and economics (i.e. more, faster and bigger are better).” [4], [5]. In [6], the relation between explicit costs and externalities is clearly identified (Fig.1).

Figure 1. Relation between explicit (private) and external (hidden) costs [6]

Materializing the sustainable energy policies in everyday life require recognizing the social value of
an energy system. There are a number of definitions for social value, while the forms it has taken so far in public policy are also quite different. [7] The search for better quality of life, under the circumstances of increasing energy demands, implies the creation of energy policies in which social values are sublimated by the objective norms of technical success (e.g., the celebration of efficiency in all things). [4] Such an understanding in terms of social value is a concept that has gained importance over the past decade. [7]. Efficiency evaluations of energy systems were usually made by energy analyses supplemented by cost analyses. However, system ecologists found the results of these analyses misleading, and promoted a new approach, i.e. the so-called *emergy* (i.e. embodied energy) evaluation. [8] *Emergy* is a measure of quality differences between various forms of energy. Each form is generated by transformation processes in nature and each has a different ability to support work in natural and in human systems. The recognition of these quality differences is a key concept. In *emergy* evaluation, nature and human economy are viewed as parts of an interconnected system, where both work of nature and human labor in generating products and services are measured in terms of *emergy*. [9]

Modern movements in energy sector engineering and the related policy driven decision making, promote and foster the so-called “greening” the exploitation of fossil fuels, that encompasses substituting natural gas, implementing “clean coal” technologies, introducing “ecologically sustainable” mining, etc. [4] Having in consideration that natural gas is the “greenest” among fossil fuels with two times lower CO₂ emission compared to oil, and three times lower CO₂ emission than coal, it could be a feasible bridge towards a low carbon economy. [10] Numerous aspects affect the current situation with the natural gas supply in Macedonia. Many of them are interrelated and in order to facilitate defining proper and comprehensive policies, any related assessment should take such interrelations in consideration. A stable, reliable and diversified natural gas supply is an important driver of economic development in any country. Therefore, one of the main objectives of any Macedonian energy strategy is to increase natural gas utilization by constructing new connections and harmonizing relevant legislation with the existing EU *acquis communautaire* for energy, environment and competition. Currently, the largest consumer of natural gas is the steel industry, as well as district heating utility companies. For household heating, it is necessary to provide more significant penetration of natural gas through enabling and diversifying supply from various different sources. This would stimulate greater reliability and market competitiveness. Nevertheless, a high share of natural gas in this sector could not be expected, due to the lack of infrastructure and habits to use natural gas. Furthermore, when it comes to transportation sector, the use of natural gas in the country is only symbolic. Currently, the only registered activity in terms of natural gas consumption is in the public transportation company under the authorities of the city of Skopje. This company adapted 30 buses with diesel engines for combined use of natural gas and diesel. In conclusion, the overall picture regarding natural gas utilization in this sector is quite disappointing. The usage of diesel prevails – in the period from 1990 till 2006, the share of diesel vehicles has increased from 33% to 60%. [11] In general, the increased consumption of natural gas leads towards decreased carbon intensity. This paper deals with both economic and social aspects of natural gas supply chain in Macedonia, through identification of relevant indicators, assessment of their relative importance and their impact/influence versus different supply alternatives.

2. Problem definition, background and methodology

2.1 General description and background

The management of supply of any goods or commodities is adopted and applied in different industries to varying levels. Regardless of industry type, the core role of supply chain management is to align procurement and delivery with the strategic goals, and to ensure that these goals are achieved with optimal efficiency. Oil, gas and power generation industries are challenged with the continuous demand for streamlined processes, easier collaboration, and in time decisions and solutions. The imperatives of the competitive electricity market, both in terms of explicit and external cost amplify the importance of the low carbon technologies. Acknowledged as a less carbon intensive fuel, natural gas has a potential to contribute towards a more sustainable energy future. In the final energy project investment value, external costs originating from, and related to, environmental hazards and/or e.g. the turmoil in the quality of life often prevail over economic costs. The results of a number of independent economic studies confirm that these external costs make coal-fired power one of the most expensive forms of electricity generation. As Grausz (2011) elaborates [12], the external costs of power generation represent the costs not paid by the owner of the generation facility but by society. The share of the external vs. explicit costs for several different electricity generation technology types is shown on Fig. 2.
A comprehensive multi-criteria model to rank electric energy production technologies, according to multiple criteria categorized in the following groups: (O&M) costs, investment costs, technical aspects are included. Demirtas (2013) [14], an energy system an additional, fourth pillar, i.e. reliability, when it comes to sustainable planning of the emerging importance of energy security and economic, social and environmental. As a result of sustainable development contains of three pillars: strategies). Traditionally, the concept of (vulnerabilities of the adopted solutions and enabling the analysis of the decision robustness (explicit cost (traditional approach), the aim is to identify solutions that better correspond to preferences stated by decision maker(s). A carefully chosen method can also include the treatment of the uncertainty of data, enabling the analysis of the decision robustness (vulnerabilities of the adopted solutions and strategies). [13] Traditionally, the concept of sustainable development contains of three pillars: economic, social and environmental. As a result of the emerging importance of energy security and reliability, when it comes to sustainable planning of an energy system an additional, fourth pillar, i.e. technical aspects are included. Demirtas (2013) [14], performed an evaluation of renewable energy technology for sustainable energy planning by using the above mentioned four groups of indicators. In terms of economic indicators identified are: investment costs, operational and maintenance (O&M) costs, service life and payback period; while as social indicators recognized are: social benefits and social acceptability. Stein (2013) [15] developed a comprehensive multi-criteria model to rank electric energy production technologies, according to multiple criteria categorized in the following groups:

![Figure 2. Social costs of electricity generation (2010$/MWh)](12)

Making sound decisions related to assessing natural gas supply options has often shown to be difficult. This is due to the fact that explicit and external costs cannot always be made clear. Without access to complete and transparent information regarding real costs of any natural gas source, policymakers do not have solid tools to decide among the best choices from an economical and a social welfare point of view. This approach considers models and methods that explicitly describe the multiple dimension reality. Instead of looking at an “optimal” solution based on the explicit cost (traditional approach), the aim is to identify solutions that better correspond to preferences stated by decision maker(s). A carefully chosen method can also include the treatment of the uncertainty of data, enabling the analysis of the decision robustness (vulnerabilities of the adopted solutions and strategies). [13] Traditionally, the concept of sustainable development contains of three pillars: economic, social and environmental. As a result of the emerging importance of energy security and reliability, when it comes to sustainable planning of an energy system an additional, fourth pillar, i.e. technical aspects are included. Demirtas (2013) [14], performed an evaluation of renewable energy technology for sustainable energy planning by using the above mentioned four groups of indicators. In terms of economic indicators identified are: investment costs, operational and maintenance (O&M) costs, service life and payback period; while as social indicators recognized are: social benefits and social acceptability. Stein (2013) [15] developed a comprehensive multi-criteria model to rank electric energy production technologies, according to multiple criteria categorized in the following groups:

1. All currencies are converted into 2010 US dollars equivalents using historical inflation rates for from the International Monetary Fund (IMF), World Economic Outlook Database (IMF 2011).

Financial, technical, environmental and finally social/economic/political as a fourth aggregated group. Tsoutos et al. (2009) [16] created multi-criteria methodology for sustainable energy planning on the island of Crete by means of combining indicators into two groups: technical – economic (investments, O&M costs, conventional fuel savings, maturity of technology and safety of supply) and social – environmental (CO2 emissions reduction, contribution to local development and welfare, social acceptance and viability of the remaining environmental effects).

With this perspective in mind, and taking into account the new realities in terms of environmental protection, energy markets and human development, there is a need for a substantially more complex view of the problem. Hence, the main purpose of this study is to contribute towards advanced approaches in assessing natural gas supply options for Macedonia based on a paradigm different from traditional cost-benefit analysis (explicit costs analysis). Such a framework - both complex and comprehensive - combines all important aspects required to attain an optimal solution under the case-specific circumstances.

2.2 Methodology

Considering the complexity of the problem analyzed in the multidimensional environment, the optimal solution is enabled by means of complex mathematical models, methods and techniques that use a quantitative or qualitative approach. MCDM is a quantitative approach used to assess and select a suitable course of action/choice/strategy/policy among several available options. [17] The primary components of the MCDM are the attributes, criteria (and their corresponding indicators) and alternatives, noted as resources. These resources are the basis for reaching the final state (e.g. decision/problem solution) by using the transformation process (operators, mapping). In the context of policy making processes, indicators represent key signals for the necessary legislation improvements. Indicators serve four main functions: simplification, quantification, standardization and communication, and usually contain assessments and analyses in the context of the defined goals. Alternatives represent decision makers’ possible choices. When alternatives are identified, initial ideas usually derive from a brainstorming session performed among a selected relevant poll of stakeholders (e.g. the poll of decision maker(s)). These ideas must then be enriched to arrive at a respectable choice set. This enrichment is twofold: firstly, the list of alternatives has to be enlarged, and secondly each alternative must be clothed with information. [18] The decision matrix,
\( \mathbf{X}_{M\times N} \), aggregates the complete problem related information and is a basis for the problem solution. Further, it incorporates the subjective mapping of the attributes’ set \((X)\) onto the criteria set \((S)\). \( N \) is the number of the mapped criteria relevant for the calculation of weights, hence relevant for the decision making. That is:

\[
\mathbf{X} = \{ x_{ij} = f_j(A_i) \}_{M \times N}, i = 1, M, j = 1, N
\] (1)

where, \( M \) and \( N \) are the number of alternatives and criteria (indicators), respectively, while \( x_{ij} = f_j(A_i) \) indicate the value of the \( x_j \) criterion with respect to the alternative \( A_i \). \( S = \{ f_1, f_2, \ldots, f_N \} \) is the set of the identified feasible alternatives. A weighting factor, \( w_j \), can be connected to each criterion indicating its importance. Then, the “best” solution to a MCDM problem can be defined as:

\[
(\forall x \in X) (\exists f(x) \in S): X \mapsto S = \{ f(x) | x \in X \} \] (2)

where \( X = \{ x | g(x) \leq 0 \} \) and \( g(x) \leq 0 \) are the problem related set of attributes and the corresponding vector of constraints, respectively. \( A = \{ A_1, A_2, \ldots, A_M \} \) is the set of the identified feasible alternatives. A weighting factor, \( w_j \), can be connected to each criterion indicating its importance. Then, the “best” solution to a MCDM problem can be defined as:

\[
\max_{j=1,M} \text{max} \left( U_j(f) \right) = \sum_{j=1}^{N} w_j \cdot u_j(f_{ij}(x_{ij}))
\] (3)

where, \( U_j(f) \) is the overall utility function calculated for the alternative \( A_i \), while \( w_j \) and \( u_j \) are the weighting factor and the utility related to a particular criteria and the corresponding alternative \( A_i \). [19]

AHP [18] is one of the techniques utilized by the MCDM based on the priority theory, and it is used in this survey. In the literature a variety of techniques are available, with the most notable and frequently applied being the Rating Method, Entropy Method, etc. [17] AHP simultaneously analyzes complex problems that involve multiple attributes, criteria and alternatives. Thus, AHP [18] is a systematic procedure for representing elements of any problem by, first, breaking it down into its smaller constituent parts. These parts are then sorted into a hierarchical order and assigned are numerical values from 1 to 9, concordantly to subjective judgments. It enables performing simple pair-wise comparison judgments to develop priorities in each hierarchy and to calculate weights relating to stakeholders’ preferences. Saaty (1990) [19] recommends that the number of levels in the problem hierarchy should be limited to six, and the number of items per each level should not exceed nine. After the identification of relevant indicators per hierarchy level, the next step is to determine corresponding weights related to the selected indicators. The relative importance of an indicator denotes the priority assigned to the indicator by the decision–maker in a MCDM environment. Decision makers’ preferences often prevail for indicators related to their professional occupation or position [17]. The selection of the poll of experts and stakeholders in the MCDM process is therefore considered crucial. The calculated weights correspond to the elements of the normalized principle eigenvector of a decision matrix \( A_i \), derived by aggregating stakeholders opinions/judgments, in accordance to eq. (4):

\[
A_i = \begin{bmatrix}
1 & \ldots & a_{1n} \\
\vdots & \ddots & \vdots \\
1 & \ldots & 1
\end{bmatrix}, i = 0, l - 1, l = \sum_{L=1}^{n}l_L \] (4)

where \( L \) denotes the number of hierarchy levels. The sum of weights per hierarchy level must be equal to 1, as it is presented in the following eq. (6):

\[
\sum_{j=1}^{n} W_j = 1
\] (5)

AHP enables inconsistency check of the obtained preferences. Saaty [18, 19] uses the largest eigenvalue \( \lambda_{\text{max}} \), to define a consistency index \( CI \) defined by the following expression (7):

\[
CI = \frac{\lambda_{\text{max}} - N}{N - 1}
\] (6)

where \( N \) is the number of criteria. The consistency index is divided by the random index of the order of the matrix considered to compute the final inconsistency measure referred to as consistency ratio. A consistency ratio of 0.1 or less is considered acceptable. [18, 19].

3. Case study: Relative importance of social and economic set of indicators for natural gas supply chain in Macedonia

3.1 Natural gas supply challenges in Macedonia

Electricity production in Macedonia is dominantly coal based with more than 78% of the annual
produced electricity\textsuperscript{2}, originating from Pulverized-Coal (PC)-fired Thermal Power Plants (TPP). This significantly contributes to the pollution of all three environmental media: air, soil and water. Moreover, the Macedonian energy sector contributes with 74% of the total greenhouse gases (GHG) emissions in the country. [20] According to the Health and Environment Alliance (HEAL) [21], “existing coal plants in Macedonia create a total of between 109 and 297 EUR million per year in health costs to people and governments in the region.”

An energy transition shift towards sustainable energy production is an urgent need for the Macedonian economy. As noted in Fig. 3., in terms of reduced environmental impact (mainly air pollution) and social cost, nuclear and wind technologies often prove to be more favorable. [5]

Macedonia does not have a nuclear program. Bosevski and Causevski (1998) [22], pointed out that due to the depletion of domestic coal reserves, nuclear power plant is the only option for long-term stable electricity production. The country has recently started to analyze the development of nuclear energy as a feasible option. Participating experts are aware that its realization is a long term endeavor that is both expensive and resource demanding. Such a process is not in compliance with the current situation of the Macedonian electricity market which is characterized by high import dependence, and lack of domestic generation capacities. On the other hand, in terms of wind energy, due to the stochastic nature of the wind, installed wind capacity capabilities should readily be compensated by other sources, whereby hydro and gas fired power plants could be pointed out as more convenient and more environmentally-friendly solutions. [11]

Having the afore mentioned aspects in perspective, natural gas has proved to be accepted as a reliable energy source to accelerate the energy transition of any country, not only in terms of lower emissions and good operational flexibility in electricity production, but as well, as an important energy source for final consumption, especially in the residential sector. Macedonia has no domestic natural gas production. Furthermore, its gas supply is fully sourced from Russia. This makes the country’s position regarding security of supply highly vulnerable to external factors. Developing a concept to facilitate natural gas supply diversification is a critically important issue for decision makers in the country. As pointed out by Mladenovska and Kochov (2015) [23], since 1997, when Macedonia started to use natural gas, the progress in developing the gas infrastructure and increasing the consumption is negligible, especially in the households. One of the main reasons for this status-quo is that only two municipalities in the country have developed gas distribution infrastructure. Investment and operational costs (i.e. economic costs) are definitely among the most important issues in creating policies related to domestic natural gas supply chain. However, there are significant external costs (externalities), related to the social environment (quality of life, prices of energy sources (fuels), air pollution, health system’s expenditure, etc.) that must be taken in consideration. Enabling a comprehensive and integrated approach to defining energy and development strategies, based on sustainability principles, is therefore of crucial importance. With these principles in mind, in this paper are described and analyzed several potential natural gas supply options (alternatives), alongside corresponding economic and social indicators relevant for the decision making assessment.

3.2. Problem hierarchy, indicators and alternatives

Through the use of AHP, supported by brainstorming sessions, the problem hierarchy with relevant indicators is constructed. The main (four) sets of indicators are in accordance with the extended sustainability paradigm, since the main goal of the research is to facilitate sustainable policy making in terms of natural gas supply chains in Macedonia. The problem hierarchy is presented in Fig. 4. Based on the prepared questionnaire and the carefully selected 34 experts, the preferences resulting from the pairwise comparison of the indicators are obtained. By aggregation of the preferences, as well as the performed consistency check, the weighting factors

\textsuperscript{2} JSC MEPSO (2015). Dispatch report on electricity production. JSC MEPSO
Figure 4. Identified indicators and their corresponding weights in terms of creating policies in natural gas supply chain in Macedonia [24], adapted for the herein analyzed social and economic issues.)
of the indicators are calculated. The values of the weighting factors (importance) of the indicators are presented in Fig. 4. [24]

Further, a set of 6 alternatives in terms of possible and feasible natural gas supply options are identified: [25]

- (1) Existing pipeline (status-quo),
- (2) South Stream,
- (3) Energy Community (EC) Gas Ring,
- (4) Trans Adriatic pipeline (TAP)
- (5) Liquefied Natural Gas (LNG) and
- (6) Gas Storage.

Fig. 5. [25], clearly exhibits the two extremes, i.e. the set of economic factors (indicators) as the most important, and the set of social factors (indicators) as least important factors for the natural gas supply. Among the assessed natural gas supply options, EC Gas Ring which as a project significantly contributes to diversification, regional development and social welfare of the country and the region as a whole, is the first ranked.

This research is focused solely on the economic and social groups of indicators. This is due to their identified significance as the two clearly identified extremes, as well as the previously elaborated interdependence and correlations between them. [24]

The economic indicators considered in this paper are categorized in five subgroups: energy mix, economy’s energy intensity, natural gas consumption, carbon intensity and new investments in energy and gas infrastructure. [24, 25] A short description of these indicators is given as follows:

- The energy mix has an influence on the so-called Energy Trilemma Index [26], as a benchmark for sustainability of national energy systems, which in case of Macedonia shows low ranking especially in terms of environmental sustainability.
- Defined as energy consumption per unit of Gross Domestic Product (GDP), economy’s energy intensity has significantly higher values in Macedonia compared to European Union members (EU28), predominantly due to energy intensive industry and low efficiency of energy production technologies.
- Natural gas consumption has a significant impact on economic growth. This indicator is in correlation with the quality of life indicator as well as with the prices of other competitive energy sources. Natural gas consumption is important indicator regarding socio-economic and environmental aspects, having in consideration that the consumption of energy per unit of product or service shows tremendous changes through different phases of industrial development. [27]
- Dominantly coal based electricity production, followed by a minor usage of natural gas, contributes to high values of carbon intensity, i.e. high values of GHG emissions per unit GDP. [24]
- According to the results from the survey, the most important (as per the highest weighting factor) among the economic indicators is the indicator highlighted as new investments in energy and gas infrastructure. The existence of reliable and developed energy and gas infrastructure is an important precondition for new investments, and by extension one of the main drivers of economic growth. It implies higher consumption of natural gas and contributes to natural gas market competitiveness especially in residential sector, thereby affecting the social group of indicators. Therefore, the correlation between economic and social indicators should be emphasized as a critically important issue.[24, 25]

In terms of social aspects, Spreng and Wils, (1996) [28] pointed out that in past decades, measurement and quantification of the corresponding indicators was more difficult and complex compared to the ones used in engineering science. A real “revolution” in the development of social indicators appeared in the 1970s. The Organization for Economic Cooperation and Development (OECD), the Economic and Social Council of the United Nations (UN), and the Conference of European Statisticians (CES) initiated a number of activities for a “more adequate monitoring of the social conditions and processes”. [29] Three main social factors are identified. i.e. the quality of life, the ambient air quality and the prices of other competitive fuels (households) (€/kWh). [24] In this study, the latter is associated with the highest weighting factor. This is

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no accident, having in consideration that the breakdown of Macedonia’s final energy consumption indicates significant usage of electricity for heating purposes. Unfortunately, currently no policies and/or measures exist to overcome this situation (e.g. block tariffs etc.). Moreover, the treatment of electricity as a social category, thus a commodity that should be affordable at low prices, actively contributes for the current situation. Conversely, domestic usage of heat supplied to district heating systems is limited to only 10% of the population (only in the capital4). Pricing of energy for households – especially natural gas –, is a serious concern in almost all SEE countries [30], since for large percentage of the population the prices are too high and burdensome.

The six defined natural gas supply options (alternatives) set out above were assessed versus social and economic indicators from the second hierarchy level (8 indicators in total), resulted in ranking of the alternatives and selecting the best option. The normalized values of the preferences in assessment of the alternatives are presented in Table 1. The assessment is performed by using decision making software, with defining tree levels of priority: high (0.5), medium (0.35) and low (0.15).

Table 1. Assessment of the alternatives (supply options) versus social and economic indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Existing pipeline</th>
<th>South Stream</th>
<th>EC Gas Ring</th>
<th>TAP</th>
<th>LNG</th>
<th>Gas Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>New investments in gas and energy infrastructure</td>
<td>0.344</td>
<td>0.212</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.212</td>
</tr>
<tr>
<td>Economy’s energy intensity</td>
<td>0.194</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
</tr>
<tr>
<td>Natural gas consumption</td>
<td>0.189</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
</tr>
<tr>
<td>Energy mix</td>
<td>0.166</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
</tr>
<tr>
<td>Carbon intensity</td>
<td>0.107</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
</tr>
<tr>
<td>Quality of life</td>
<td>0.201</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
</tr>
</tbody>
</table>

4 Energy Community Secretariat. (2012). Annual report on the implementation of the aquis under the Treaty establishing the Energy Community. ECn Secretariat.

4. Results and discussion

The ranking of the alternatives based on the preferences from Table 1., is presented in Table 2. Table 2. indicates that LNG is the most preferred option regarding social and economic indicators (taking into consideration their corresponding weights). The higher ranking of the LNG-option is mainly due to the following indicators: quality of life and prices of other competitive fuels. Moreover, the SEE region has exhibited a strong initiative to develop LNG import and regasification capacities, as a response to any failures in its pipeline gas supplies. However, this infrastructure investment requires significant costs. As second ranked, the TAP option offers a theoretical opportunity for additional interconnections with Balkan neighbors, particularly through Ionian – Adriatic Pipeline (IAP), planned as a 400km link from Fieri in Albania to Ploče in Croatia. [31] Such an interconnection will enrich diversification and increase price competitiveness, resulting in overall improvement in economic and social welfare in the country.

Table 2. Ranking of the alternatives

<table>
<thead>
<tr>
<th>Rank</th>
<th>Alternative</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LNG</td>
<td>0.212</td>
</tr>
<tr>
<td>2</td>
<td>TAP</td>
<td>0.190</td>
</tr>
<tr>
<td>3</td>
<td>EC Gas Ring</td>
<td>0.173</td>
</tr>
<tr>
<td>4</td>
<td>Gas Storage</td>
<td>0.159</td>
</tr>
<tr>
<td>5</td>
<td>Existing pipeline</td>
<td>0.150</td>
</tr>
<tr>
<td>6</td>
<td>South Stream</td>
<td>0.116</td>
</tr>
</tbody>
</table>

The interdependence among the social and economic sets of indicators attributed to each of the analyzed alternatives is illustrated in Figure 6.
As exhibited in Figure 6., the alternative Gas storage – located in the middle of the quadrant – has equal importance in terms of social and economic indicators. Despite this outcome, while having the greatest social and economic benefits, options EC Ring and LNG can be argued as viable and even recommended solutions, because they offer natural gas supply diversification. Moreover, when it comes to diversification of supply, taking into account its geographic position, Macedonia possesses an advantage and can benefit from different gas interconnections. Although gasification is consistently declared among the priorities of all Macedonian governments, Macedonia has not made significant progress in terms of interconnections. Furthermore, as a participant at the Central and South-Eastern European Gas Connectivity (CESEC) initiative, whose main objective is commitment of the parties (countries) for providing gas supply from at least three independent sources [32], Macedonia is obliged to achieve gas supply diversification. A good example of diversification efforts can be pointed out in terms of the municipality of Strumica, which implemented a project with introducing Compressed Natural Gas (CNG) for supplying the city-gas distribution system. In contrast and in keeping with the conclusions stated in the study on preferable heating options for the city of Skopje [33], generally, gasification should not be recommended as an option in areas where district heating network already exists. Therefore, a sound approach would be that prior to any policy interventions, the research concept and scope of this study should be extended to the entire country. As a positive practice, similar research in Serbia was performed by Brkić (2008) [34], in terms of the preferences between gas usage and district heating in urban areas. Notwithstanding the aforementioned, in 2014, the government of Macedonia made it mandatory to install natural gas utilization infrastructure in every new building\(^5\). An additional incentive for natural gas consumption could be found in introducing new electricity tariffs for households that will prevent usage of electricity for heating purposes. The tariff system in Croatia, where there are four different consumption scales (tariff models) and corresponding prices\(^6\), could be a good example. However, it must be emphasized that increasing the consumption of natural gas in the households is not a sufficient factor for enabling better environmental quality. Such an example is evident in the city of Kumanovo which is one of the two cities in Macedonia with developed gas distribution grid even since 2011\(^7\). During the last five years, Kumanovo was identified as one of the most polluted cities in the country. Air pollution was so high during December 2016 and January 2017, as well as in December 2017 and January 2018\(^8\), that Skopje and Kumanovo were ranked as the most polluted cities in Europe. This suggests there are many other threatening sources of air pollution besides households and traffic. With regards to Skopje’s pollution problems, the main contributor of PM\(_{10}\) and PM\(_{2.5}\) is biomass burning (mostly from heating and/or illegal smelting purposes). The share of PM\(_{10}\) and PM\(_{2.5}\) deriving from biomass burning is almost two times bigger than the share of PM\(_{10}\) and PM\(_{2.5}\) deriving from traffic. [35] Such conditions arguably reinforced the importance of a comprehensive and integrated approach towards sustainable energy policy, implying that social and economic indicators should be treated in accordance with their interdependencies and correlations therein. The importance of diversification, in particular as it relates to economic and social indicators, is confirmed during this research by the first three ranked options (LNG, TAP and EC Ring) which provide supply from different sources. Unfortunately, instead of prioritizing investments that provide diversification of supply, policy makers in the country invest in construction of gas transmission pipelines throughout the country’s regions. Commitment to diversify natural gas supply remains notably absent. Nevertheless, it should be pointed out that on 14\(^{th}\) of October 2016, a Memorandum for Understanding for the construction of gas interconnection corridor between Shtip (Macedonia) and Nea Mesemvria (Greece), was signed by

\(^8\) http://air.moepp.gov.mk/ (accessed 04.02.2018)
Macedonian Energy Resources (MER) and Hellenic Gas Transmission System Operator S.A. (DESFA)°. This should be pointed out as the country’s first step towards diversification of gas supply, and will be an opportunity not only for utilizing LNG from Revithoussa LNG terminal in Greece, but moreover, it shall make the connection with TAP more feasible. An additional benefit for the region where Macedonia can obtain an enhanced interconnectivity role is the existing gas pipeline connecting Skopje (Macedonia) and Kosovo (TPP Kosovo A). Whilst not operational since the 1980s, with severe damage in certain sections, its overall state is assessed to be solid°. Prior to reactivation, a thorough investigation shall be required. The existence of the pipeline Skopje – TPP Kosovo A represents a significant opportunity for the both countries, especially since Kosovo remains without any gas supply and gas market. It would also contribute significantly towards the EC Gas ring project. A further benefit for Macedonia could be the income derived from transit taxes. From a Kosovo’s perspective, this project would contribute to an increased resource independency, security and resource diversification of its energy sector. Finally, such a project would contribute to regional development and political stability as it would be eligible for the Instrument for Pre-Accession Assistance Cross-border Cooperation’s (IPA CBC) funding.

5. Conclusion

When it comes to detailed analyzes of an energy investment project from a project-life-cycle point of view, external costs related to environmental risks and quality of life, can often prevail over economic costs. As such, policy and decision makers are confronted with the challenging task of energy policy creation and energy projects development that should not only generate profit for the owner, but at a national level, should contribute towards improving the country’s social welfare. This paper combines the influence of the social and the economic indicators in assessing and selecting optimal natural gas supply options for Macedonia under the described current market, reliability, geostrategic and policy circumstances set out in detail throughout this paper. It should be emphasized that supply diversification strongly correlates to improved quality of life due to higher competition in terms of prices of other competitive fuels. In turn, this leads to substitution of electrical energy use (coal based production of electricity) and finally resulting in lower GHG emissions, contributing to overall improved quality of air. As an alternative (described at length in this paper), LNG is ranked first in terms of economic and social impact, and represents a solid policy option for distant regions without access to main gas pipelines and with insignificant consumption levels or demand. In addition, the EU prefers financing and supporting energy projects that are of interest to at least two member states. Alternatively, gas diversification and gas interconnections requirements, regarded as a regional project, place the option of an EC Gas Ring concept higher. Although an expensive project, it could significantly drive and improve regional economies as well as the social welfare. In parallel, Macedonia should work on serious penetration of natural gas within the electricity and thermal energy production sector as well as on the popularization of natural gas among households. It could be achieved firstly via implementing a new energy price paradigm that promotes preferential gas prices for energy producers (electricity and thermal energy), and secondly via introducing block tariff system for households electricity bills. The latter would prevent and discourage electricity usage for household heating. Namely, in 2014, with a share of 38.10%, electricity was the most used energy for household heating in Skopje. Closely behind, was the firing wood consisting 32.32%. Only 28.79% from the households were connected to the district heating, while 100 MWth are non active users. Most of the non active users are switched either to electricity or to firing wood. [33] Moreover, there are two other municipalities in the country (Bitola and Makedonska Kamenica) with developed district heating infrastructure, which more than 10 years have been out of operation. Unfortunately, currently due to inexistence of gas supply infrastructure, natural gas is not a fuel switching option in either of the described cases.

Finally, one of the most explicit conclusions to be derived from the alternatives’ ranking, is that diversification of natural gas supply is one of the critical drivers of economic and social welfare in the country. Moreover, natural gas supply diversification could be a significant driver towards wider natural gas penetration across various sectors. However, residential sector gasification and district heating are competitive and the former excludes the latter or vice versa. Thus, gas supply projects should be based on detailed studies and analyzes, and should be deployed only in areas where gas has shown to be a more advantageous option versus district heating. Proposing new legal instruments is a sound

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opportunity to address this challenge, e.g. usage of solid fuels for heating should be recommended to be forbidden by law. In addition, in specific areas where connection to the district heating network exists, it should be obligatory for every household/company. Although consumer choice is thus removed, overall costs to consumers are reduced. Conversely, for areas without access to district heating infrastructure, natural gas should be promoted as the best option (both with restrictive measures in terms of solid fuels and incentives for using natural gas). The so called “virtual gas supply concept” applied in Strumica, should be replicated in other cities where pipeline gas is not available.

In the transportation sector, the usage of natural gas, CNG and LNG can contribute towards better urban air quality. The correspondent legislation must be oriented towards environmental/air quality protection, following the principle “polluter pays”. Through this approach, not only in terms of pricing of diesel fuel, but as well in terms of additional eco-taxes, emissions from obsolete and old vehicle fleet in Macedonia shall be reduced.

Hence, Macedonia needs a new energy transition and a fundamentally new energy and environmental paradigm. Otherwise, the inevitable consequences of inaction will strongly affect the national economy and the social welfare, which at present are extremely fragile. The case study reviewed within this paper, and the applied methodology has shown to be a useful tool for policy makers, since it deals with aggregated indicators in order to prepare a solid base for obtaining strategic decisions in a limited period of time.

Nomenclature

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AHP</td>
<td>Analytical Hierarchy Process</td>
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<tr>
<td>CES</td>
<td>Conference of European Statisticians</td>
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<td>CESEC</td>
<td>Central and South European Gas Connectivity</td>
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<td>CNG</td>
<td>Compressed Natural Gas</td>
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<td>EC</td>
<td>European Commission</td>
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<td>EU</td>
<td>European Union</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GHG</td>
<td>Greenhouse gasses</td>
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<td>GNI</td>
<td>Gross National Income</td>
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<td>HEAL</td>
<td>Health and Environment Alliance</td>
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<td>IAP</td>
<td>Ionian – Adriatic Pipeline</td>
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<td>IMF</td>
<td>International Monetary Fund</td>
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<tr>
<td>IPA CBC</td>
<td>Instrument for Pre-Accession Assistance Cross-border Cooperation</td>
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<td>LNG</td>
<td>Liquefied Natural Gas</td>
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<tr>
<td>MCDM</td>
<td>Multi Criteria Decision Making</td>
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<tr>
<td>OECD</td>
<td>Organization for Economic Cooperation and Development</td>
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<td>PC</td>
<td>Pulverized Coal</td>
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<td>SEE</td>
<td>South Eastern Europe</td>
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<td>TAP</td>
<td>Trans Adriatic Pipeline</td>
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<td>TPP</td>
<td>Thermal Power Plant</td>
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<td>UN</td>
<td>United Nations</td>
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[33]. Faculty of Mechanical Engineering Skopje, MACEF. (2017). Defining of techno-economic optimal and environmentally sustainable heating structure and implementation of the centralized supply of sanitary hot water for the city of Skopje. Balkan Energy Group.
