

Methodological concept of decision making support tool for the purpose of long-term energy planning

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Formulation of long-term energy strategies and policies is a complex task. It needs to consider number of aspects i.a. forecast of energy and fuel demand, possible supply paths, expected impact on environment, as well as public consultation process. There are number of formal methods that aim supporting decision making for the long-term energy planning. They help understanding complexity of problem, finding the best compromise solution and allow public participation. In the following paper methodological concept of combining energy scenarios and multi-criteria analysis (MCA) will be introduced. Energy scenarios are tools that help to explore and understand the future energy system. MCA provides assessment of different policy option in respect to multiple criteria. Moreover it allows public participation in decision making process. Combined method is promising tool for energy planning and decision.

Keywords and phrases: scenario planning, participatory multi-criteria analysis, sustainable energy development.

Introduction

In September 2009, Polish government introduced *Energy Policy for Poland till 2030* [1]. Besides the main document, which indicates the priorities and objectives for the future energy development, there are several appendix attached, e.g. *Projections of the fuel and energy demand* [2], *Strategic Environment Assessment report* [3], *results of the public consultation processes* [4] and many other.

Formulation of long-term energy strategies and policies is a complex and demanding process. It needs to consider number of aspect, such as: forecast of energy and fuel demand, possible supply paths, expected impact on environment, as well as public consultation process (see Fig. 1).

Political decision taken today, have a key importance for the future. They influence energy system development, which have a further impact of economy, society and environmental. Political priorities and objectives are the basis for the legislation, financing and investments. Energy market is good self-regulated by market conditions and competition, but there are energy options that need supportive incentives to be realised [5]. Selection

of the energy development path, should consider multi-objective perspective and assure public participation in the process.

There are number of formal methods of decision making support, inc. strategic energy decision. In the following paper methodological concept of combining energy scenario and multi-criteria analysis will be introduced. Concept is a promising tool for strategic decision support, as well Sustainability Impact Assessment.

Article is organised as following. In Section 2 and 3 introduces the methodology of scenario planning and multi-criteria analysis with examples of use in energy project. In Section 4 innovative concept of decision making support for the purpose of energy planning is presented. Its advantages and possible application areas are indicated.

Scenario analysis

One of the key element of energy policy formulation is prognosis of energy and fuel demand in the long-term perspective. Energy forecasts are most often made on historical trends (e.g. technology patterns, consumer behaviour) and take into consideration assumption of

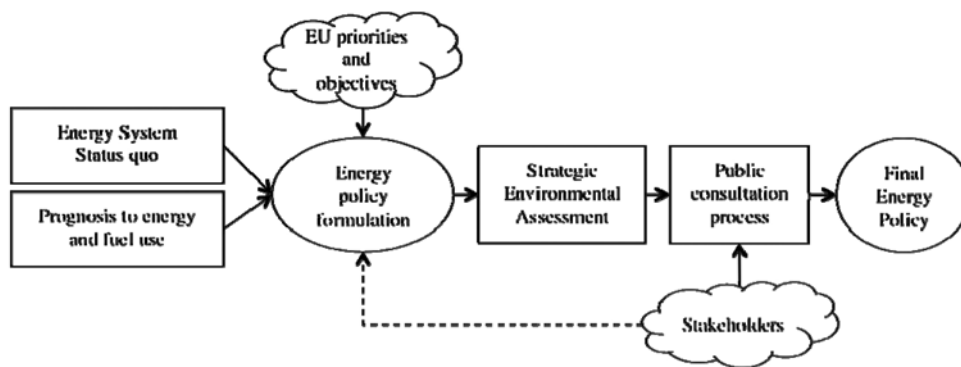


Fig. 1. Scheme for energy policy formulation process e.g. Poland.

future trends (e.g. population and GDP growth, structural changes, technology diffusion). There are number of forecasting methodologies that help to explore future demand, e.g. *trend extrapolation*, *consensus methods*, *simulation methods*, *scenario analysis* and many others [6].

Scenario analysis remains to be nowadays most commonly used tool for exploring of the possible energy development. Energy scenarios present possible development in the future energy system, both on the demand and supply side. Nest to reference scenario, alternative paths of development are introduced (e.g. optimistic, pessimistic, ambitious and non-active). Analysis of different energy scenarios help decision maker in understanding actions and measures needed to achieve targets and goals [7].

There are different types of energy scenarios; *Nominative scenarios* developed on the basis of wishful future norms and *explorative* that mapping possible future developments; *Quantitative* described as storylines and *qualitative* calculated on the basis of mathematical models. Scenarios can vary also because of the its time frame e.g. *short-, mid-or long-term*, as well as its range e.g. *global, country, regional* (see Table 1 that presents the examples of studies on energy scenario).

Even the nature of scenarios remains to be speculative, their role shouldn't be diminished. Scenarios can be a useful tools of strategic planning support by offering the possibility of identifying problems, barriers and challenges. Throughout analysing the trends and present actions, they allow: better assessment of the of different

Table 1. Examples of the energy scenarios (on basis of [8]).

Developer	Time horizon	Type	Model used	Purpose	Source
Global scenarios					
Intergovernmental Panel for Climate Change	2100	Narrative and quantified	3–6 models: AIM, ASF, IMAGE, MARIA, MES-SAGE, MINICAM	Explorative	[9]
Shell International	2050	Mostly narrative	–	Explorative and narrative	[10]
Stockholm Environmental Institute	2050	Narrative and quantified	PoleStar	Explorative	[11]
Scenarios for Europe					
Institute Computers Communications Systems of National Technical University Athens	2030	Quantified	PRIMES	Explorative	[12]
Stockholm Environmental Institute	2020	Quantified	LEAP	Normative	[13]
German Aerospace Centre	2050	Quantified	MESAP	Explorative	[14]
Scenarios for Poland					
Institute for Renewable Energies & Greenpeace Poland	2030	Narrative and quantified	MESAP	Explorative	[15]
Institute for Sustainable Development	2050	Narrative and quantified	Excel simulation	Normative	[16]
Central Mining Institute	2030	Narrative	–	Explorative	[17]
Wuppertal Institute for Climate, Energy and Environment	2050	Narrative	–	Explorative	[18]

policies alternatives, identifying the main dimensions and drivers for future development, understanding dynamic links among the main drivers and assessing relative importance and sources of uncertainties in analysis [8].

Multi-criteria analysis

Multi-Criteria Analysis (MCA) is decision-making support tool, as well as a form of integrated sustainability assessment. It allows measuring impact and comparison between alternatives according to multiple criteria. MCA helps decision maker understanding the problem in order to select best compromise solution regarding his/her preferences. Moreover, it allows public participation and may be a platform to communication between decision-makers and stakeholders [19, 20].

Multi-criteria methods become increasingly popular in development of long-term policies that target at sustainable development. There are widely applied for decision aid in the energy contexts, inc. energy planning, energy resource allocation, energy exploitation, energy policy formulation and many others (see Table 2).

There are numerous MCA methods introduced in literature. In the general classification they divided into: *Multi-Objective Decision-Making*, which involve design of alternatives that optimises the objectives of decision making, and *Multi-Attribute Decision-Making* that considers the selection of the “best” alternative in terms of their attributes. Common characterises of methods (i.e. MADM) includes [21]:

- *Decision problem formulation.* Decision problem consist of set of alternatives and set of assessment criteria (attributes). It is represented with the form of matrix, where the values for each alternative according to each criterion are given. MCA facilitate the use of both quantitative and qualitative measurement scales.
- *Building decision maker preference model,* in which different stakeholders (e.g. representatives of trade unions, public administration, industrial organisations, non-governmental organisation, business) are giving the information about the relative importance of the criteria. Each member enters his or her own judgements, and makes a distinct, identifiable contribution to a jointly reached conclusion.
- *Solving decision problem.* In order to solve problem, decision matrix is aggregated according to decision maker’s preference model. According to general

classification MCA methods can be categorised as: *the utility theory methods* (e.g. MAUT), *the outranking methods* (e.g. ELECTRE, PROMTHEE), *mixed methods* (e.g. AHP) and others.

Multi-criteria methods is a promising tool complex decision problems with high conflict potential. It allows taking different alternatives and criteria and different interest of stakeholders groups that are essential for sustainable planning (inc. energy planning). Moreover they help to structures and facilitates stakeholders’ involvement in the decision processes, which increases the quality of decisions.

Decision making support for the purpose of energy planning

In the following paper methodology of combined energy scenario and multi-criteria analysis is presented (see Fig. 2). In scenario analysis possible energy development path are explored and introduced; While in multi-criteria analysis alternatives are evaluated according to multiple criteria and decision maker preference model, in order to provide a recommendation of best compromise solution to decision maker.

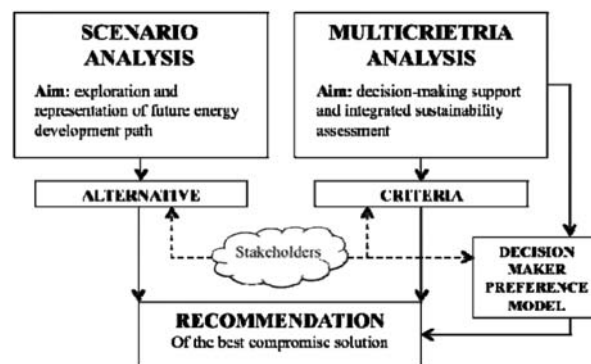


Fig. 2. Scheme of combined energy scenario and multi-criteria analysis.

Numerous advantages of this combined method have been recognised. Energy scenarios allow detail representation of the future energy system, both on demand and supply side. They help decision maker to structures information about possible energy development and understand the actions needed to achieve target and

Table 2. Examples of the energy scenarios (on the basis of [19]).

Focus	Scope	Method	Source
Regional energy planning	Renewable energy technology plan for Sardinia island	ELECTRE III	[22]
Energy resources allocation	Energy resource allocation for households sector of Madras city	AHP	[23]
Electric utility generation	Electric power system expansion planning	MAUT	[24]
Energy strategy	RES energy scenario assessment and ranking for case study of Austria	PROMTHEE	[25]

goals. MCA compliments scenario analysis by offering energy evaluation according to multidimensional criteria, e.g. sustainability dimensions. It help to reduce scenario information complexity in organised and transparent way. It provides necessary information in order to select the “best” future energy development path.

There are number of challenges for the strategic decision making for the energy future, such as dealing with high complexity of socio-economic features, involving multidimensionality and different opinion of stakeholders, assuring transparency and objectivity of the decision process. Combined scenario analysis and multi-criteria analysis address those challenges.

Additionally, the potential o the method is seen in the area of Integrated Sustainability Assessment. Sustainability assessment can be described as “a systematic and iterative process for the ex-ante assessment of the likely economic, social and environmental impacts of policies, plans, programmes and strategic projects, which is undertaken during the preparation of them and where the stakeholders concerned participate pro-actively” [26]. The main aim of SIA, as well as the method presented in the following paper is to improve the performance of the long term strategies, policies and plans. The other similarity lies in *interactivity* of the process.

Combined energy scenario and multi-criteria analysis is a promising tool of supporting strategic decisions in energy context. It has been successfully implemented for the purpose of energy strategy formulation i.a. for Austria [25] and Belgium [27].

Conclusions

Formulation of long-term energy strategies and polices is a complex tasks that compound with high degree of complexity and allocation of often conflicting interests. It needs to consider number of aspects, such as: forecast of energy and fuel demand, possible supply paths, expected impact on environment, as well as public consultation process. In order to assure quality consensus the process must be transparent and objective. There are number of formal methods that aim supporting decision making for the long-term energy planning. In the following paper methodological concept of combining energy scenarios and multi-criteria analysis have been introduced. It is a promising tool of decision making, as well as of Integrated Sustainability Assessment.

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