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COMPLEX ASSESSMENT MODEL FOR ADVANCED TECHNOLOGY DEPLOYMENT

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Abstract. The construction sector constantly offers new products, more effective technologies and novel solutions aimed at improvement of the quality of human habitats and wider distribution of technologies. Currently, effective technologies that require less time and costs for production, installation and use are gaining greater significance. Among them are construction materials and technologies with increasingly popular sustainability features. Considering the above, the article offers a complex algorithm for assessing the deployment and distribution potential of a new technology/product. For this purpose, a multi-stage model of alternatives and criteria was suggested and an analytical multi-stage evaluation model has been designed. The practical example illustrates the assessment of micro environment using a combination of AHP (Analytic Hierarchy Process) and Permutation methods. The designed multi-criteria assessment model promotes accessibility of users to a technology, new product, a part of the product and a technological process.

Keywords: technology, multi-stage, model, AHP, permutation method, MCDM, implementation, development.

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Introduction

As suggested by experience of some successful countries, economic growth based on traditional factors of production is inevitably transient; meanwhile, long-lasting high productivity of a national system can be guaranteed by operation of innovation-based enterprises. Innovation in businesses is based on the development of technologies/products (Oliveira, Lino 2013). Technological development – innovation activities based on adoption of technologies and innovations designed in other enterprises, usually by way of procuring technological lines or production know-how licences, etc. (Skibniewski, Zavadskas 2013). The technology adoption lifecycle describes how a market develops for a new product category (Moore 1991).

Shift in the production and business paradigm, development of new materials and emerging new needs of the public can generate an immense innovation potential in any industrial or business area (Testa *et al.* 2011). Most scientific researches underline that in terms of construction firms, the technological progress not only requires the development of new technologies and solutions but also their implementation as well as diffusion of technological advancements in products and production processes (Akadiri *et al.* 2013; Cavico *et al.* 2013; Håkansson, Ingemansson 2013; Tamošaitienė, Zavadskas 2013).

Uptake of new technologies and products by construction firms is a complex process (Mazurkiewicz, Poteralska 2012). First, it is related to great risk and reorganisation of existing production processes and organisational systems (Dunović *et al.* 2013). Criteria pertaining to the process of new technology uptake should be analysed assessing internal financial criteria of a company as well as aspects related to the external business environment and development of the technology market. This means a complex assessment of the effects brought by micro, meso and macro environments (Kaklauskas *et al.* 2012).

The likelihood that construction firms adopt or generate innovations is affected by firm specific as well as market related criteria. On the one hand, firm characteristics as firm size, type of activity, location and managers' quality (including age and education) indeed affect innovation and technology adoption. On the other hand, very important are market-related features as market growth, profit margins, price of financing, risk, intellectual property rights (IPR), market structure, codification patterns, regulations, and type of clients – high-end versus low-end (Blackley, Shepard III 1996). The fragmented structure of the sector contributes to deter diffusion (von Hippel

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1988), as does the complex and network-like structure of the construction production process. As the end-product is the outcome of the coordinated inputs of different subcontractors the transfer of ideas – and even more the R&D process itself – may become difficult and expensive. In any case, and regardless of firm size, enterprises' success in implementing project-based innovations depends on firms' capabilities, the environment in which they operate, and the characteristics of the innovation itself (Manley 2008). Firm capabilities include core competences and the methods used to build and exploit them (Montalvo, van der Giessen 2012).

No decision to invest into new technologies is made quickly. Mostly decision-making is affected by uncertainty brought by new technologies and their developmental trends. Uncertainty of newly implemented technologies encompass unknown future market conditions, internal capacity of the company (accurate investment costs for acquisition of a new technology, requirement for new specialists for work with the new technology) and many other factors

The importance to assess technological uncertainty becomes even more obvious as a company strives for competitive advantage and successful continuation of its activities. This process is inseparable from technology uptake solutions as it considers future change of the technology over a certain period of time. In sectors that encounter especially rapid technologic change, firms rarely receive full return on investments; in any case, new technologies are unavoidable in such business structure. Not only does importance of such strategic decisions arise from substantial investment costs but also from their impact on the future operations of the firm. Investments into a new technology not only result in acquisition of a certain piece of equipment that enables a new process or provides an opportunity to improve existing or create new products or services; in addition, they shape competence and intellectual potential, which in time contributes to competitive edge of the company (Vasauskaitė *et al.* 2011). This necessitates models for assessment of new technology integration and adjustment in the market that would facilitate corporate decision-making related to market demand for a new technology, product or service.

1. Complex model of technology deployment in construction

Aiming to satisfy standards for sustainable construction sector products, processes and works; apply strategies for efficient use of energy in buildings; observe requirements on energy performance of buildings; and use certification of energy performance of buildings, sustainable technologies must be integrated into the construction sector.

Technology integration is inseparable from the corporate strategy (Fig. 1). The strategy becomes especially relevant under current market economy conditions, as companies need to project their business development trends and service demand as well as survive on markets and make a profit (Teece 2010). The corporate strategy accurately defines the niche and trend selected by the firm. Assessment of a corporate strategic decision to invest into a new technology requires forecasting the growth strategy adopted by the company.

In a construction firm, the following strategic fields of activity could be underlined: construction technology and product, model-laboratory conditions, model-simulation of an operating environment, prototype, final product, manufacture preparation, and construction technology process. Based on previous research results (Shadiya, High 2012; Green *et al.* 2012; Schiederig *et al.* 2012; Kim *et al.* 2011; Mat, Razak 2011; Kanapeckiene *et al.* 2010; Ghassan *et al.* 2010), authors of the article offered a new assessment model for companies that want to introduce a sustainable technology, product or material to a market. The model comprises three complex basic environments on the macro, meso and micro levels and four most important advanced technology development levels: ecological, sustainable, environmental and green (Kaklauskas *et al.* 2012; Tamošaitienė *et al.* 2013).

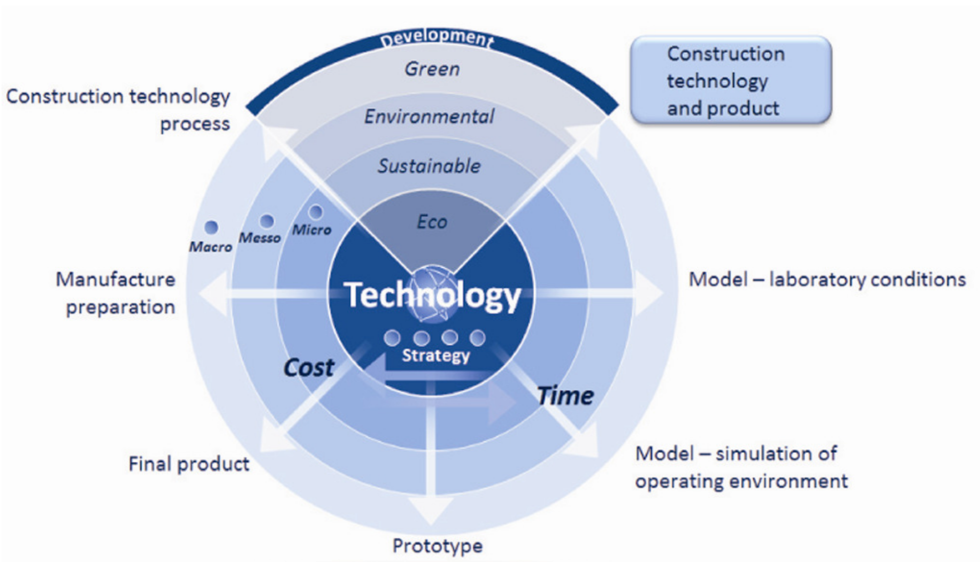

Fig. 1. Advanced technology development concept

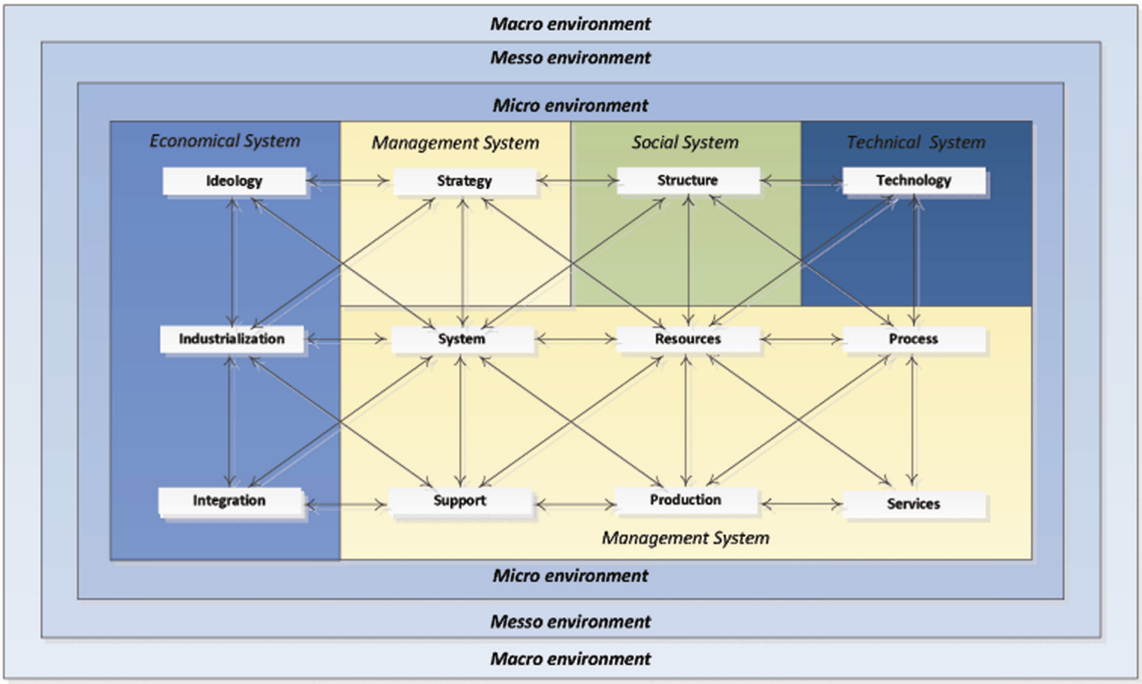

Fig. 2. The general complex assessment model for new technology development

These days, to stay competitive, many organisations have shifted their focus to becoming socially and environmentally responsible as more and more consumers demand and support only environmentally friendly products and services (Cavico *et al.* 2013; Bakar *et al.* 2011). According to Akadiri *et al.* (2013), current building technology selection methods fail to provide adequate solutions for two major issues: assessment based on sustainability principles, and the process of prioritizing and assigning weights to relevant assessment criteria. For these reasons, the article authors suggest the complex assessment model for new technology development genered (Fig. 2 and Fig. 3).

The suggested model is focused on sustainable technologies and comprises environmental issues, technical efficiency, functional requirements and social aspects as well as satisfies existing needs of the public aiming to:

- Create conditions conducive to sustainable development of entrepreneurship and business;
- Create sustainable and effective economic infrastructure;
- Promote sustainable use of resources;
- Ensure stability of ecosystems;
- Ensure that regulatory environment is conducive to business growth;
- Promote entrepreneurship and business development including direct foreign investments;
- Implement sustainable development principles in business;
- Use natural resources sustainably, preserve biodiversity and landscape.

The model created by the article authors may be described as a systematic data processing aimed at assessment of adjustment of an innovative technology in construction market. The procedures of model are presented in Figure 4.

2. Empirical case study for advanced technology deployment

Decision-making is the process of defining the decision goals, gathering relevant criteria and possible alternatives, evaluating the alternatives for advantages and disadvantages and selecting the optimal alternatives (Wu *et al.* 2008). Finding the right decision for a complicated problem is one of the most important tasks of today. Consequently, it is crucial to develop a multi-stage decision-making system that would consider multiple efficiency criteria and enable solving complicated problems. Such problems can hardly be solved with the help of decision aiding methods based on a single criterion. Figure 3 presents the created multi-stage MCDM application model, which is suitable for solving a wide range of complicated problems in macro-, meso- and micro-environment stages (Tamošaitienė, Gaudutis 2013).

As authors or earlier articles focused on the effect of macro- and meso-levels (Brauers *et al.* 2012; Kildiene 2013), this case study demonstrates the model on the micro level.

The suggested model is used for a small or medium construction company that aims to introduce innovative sustainable technologies/products to the market. Next, a real example on the use of the model in the Lithuanian market is presented.

A small and medium enterprise (SME), mainly operating in sale, rent and maintenance of construction machinery, vehicles and construction materials. The company follows the product development strategy that is aimed at business growth within the existing market by developing new advanced areas of activity. These areas require the use of effective materials, new production methods, advance technologies, etc. The SME has regular suppliers but also

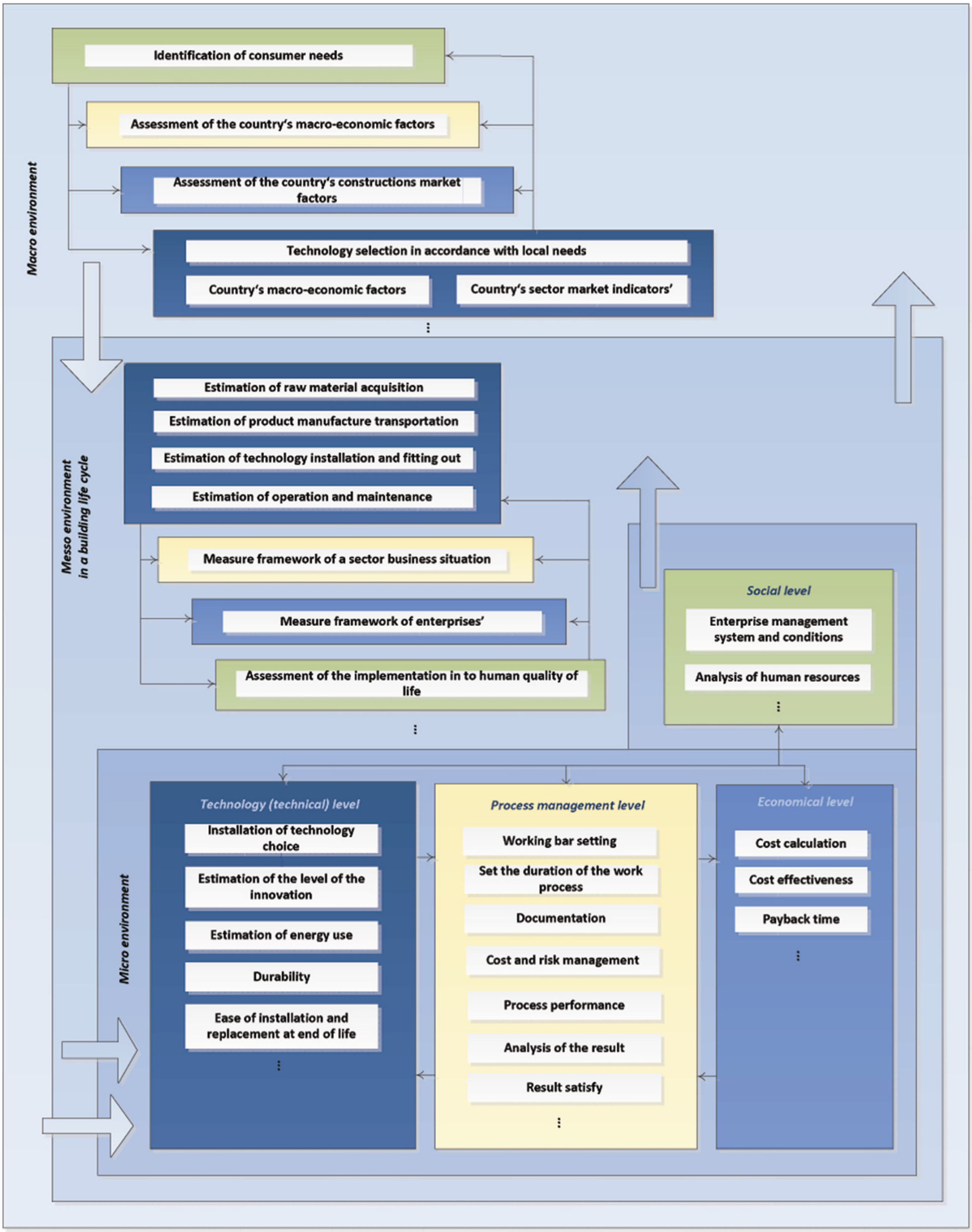

Fig. 3. Detail complex assessment model for advanced technology development

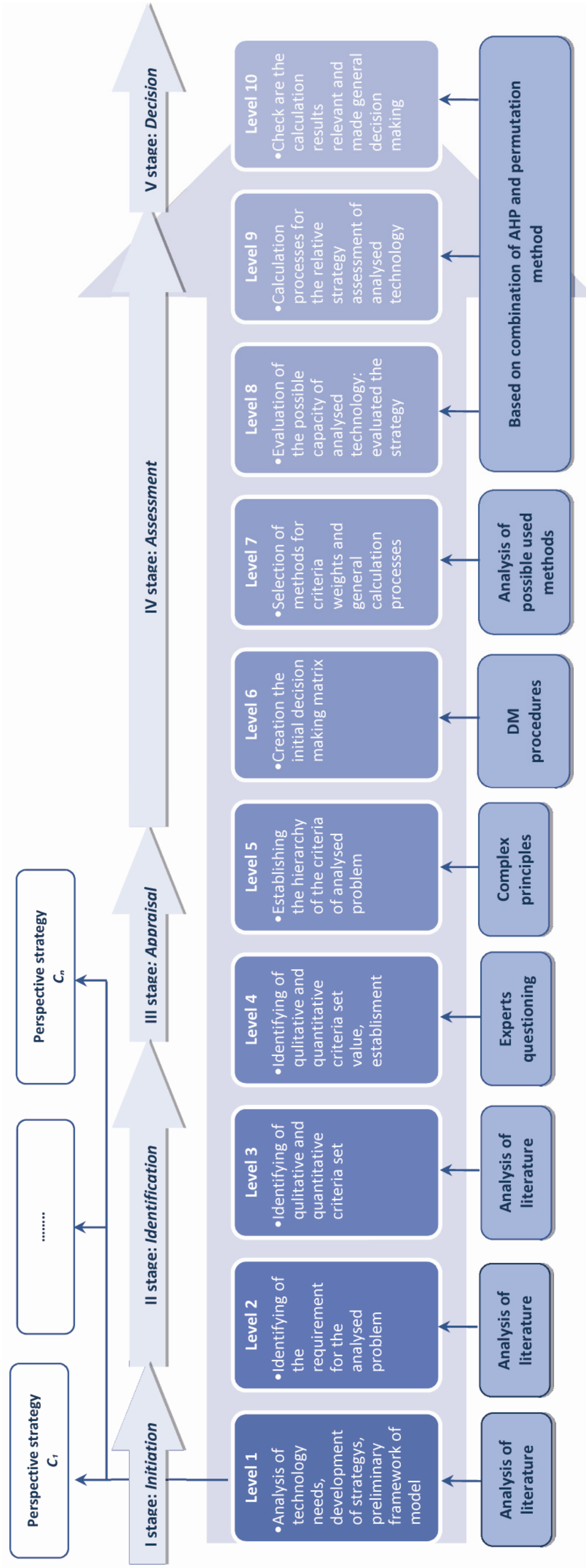

Fig. 4. Main steps for the application of combined methods for technology complex assessment

seeks for new attractive offers for machinery or products to be sold on the local market. For the empirical case study, three technological alternatives were selected: innovation for facade insulation; building environment innovation; and innovative building structures and technology design.

Management of the company is considering an offer to distribute the products on Lithuanian market. Therefore, the most important criteria need to be assessed to take a rational decision. The suggested technology deployment model is used for multi-stage assessment.

3. Determination of criteria and alternatives

Summary of earlier research results suggests that numerous factors determine the suitability of a technology/product. Some of them are directly related to technological features, others have more to do with the company, and some – with a user or other environmental conditions. A technology is selected objectively only provided it is assessed considering various aspects as a complex, using a set of criteria. Usually, such complex assessment based on a set of criteria produces suitability results for each technology alternative that differ according to various criteria, which does not allow ranking, i.e. selecting the best alternative in terms of various aspects. It is exactly the need to compare technology alternatives that determines treatment of the search for a solution as a multi-criteria assessment task.

Differentiation of criteria for assessment of sustainable technologies serves a certain purpose – to determine the most important, essential criteria and define their limit values. Any criterion that loses at least one technological feature is treated as unsuitable.

Comparison of three different technologies is only effective if the designed system of criteria can be used to define all alternatives. The assessment focused on three different innovative technologies:

Alternative a_1 – innovation for facade insulation;

Alternative a_2 – building environment innovation;

Alternative a_3 – and innovative building structures and technology design.

It aimed to determine possible distribution of the alternatives on Lithuanian market, for which general assessment criteria were selected.

The literature review indicated the lack of a uniform system of criteria that could be used for assessment of innovative technologies. Various literature sources on assessment of construction technologies suggest different criteria. Based on criteria selection system by Akadiri *et al.* (2013), the article authors selected the following criteria:

(1) *Comprehensiveness*. The chosen criteria should cover four categories – economic, environmental, social and technical – in order to ensure that account is being taken of progress towards sustainability objectives. The criteria need to have the ability to demonstrate movement towards or away from sustainability according to these objectives.

(2) *Applicability.* The chosen criteria should be applicable across the range of options under consideration. This is needed to ensure the comparability of the options.

(3) *Transparency*. The criteria should be chosen in a transparent way, so as to help stakeholders to identify which criteria are being considered, to understand the criteria used and to propose any other criteria for consideration.

(4) *Practicability*. The set of chosen criteria must form a practicable set for the decision to be assessed, the tools to be used and the time and resources available for analysis and assessment.

Considering these four rules, 12 criteria were selected (Table 1).

The expert method is suggested for definition of the significance of assessment criteria on the micro level, as the majority of criteria on this level depend on views of a stakeholder or capabilities of the company.

4. Methodology

One of the most important steps for multi-criteria decision-making is to identify the weight for each criterion. It was carried out with the help of AHP, which in concisely can be expressed as the relative values of a set of criteria.

Using the AHP method (Saaty 1980; Wu *et al.* 2008; Maskeliūnaitė, Sivilevičius 2012), expert evaluations are expressed in numerical values according to the assessment scale (Table 2), which is the equivalent of abstract linguistic assessment sets and the set of integers.

Although reliability of qualitative criteria is lower than that of qualitative criteria, usually the selection of multi-criteria decision-making analysis cannot be successful without qualitative criteria. Consequently, there is a need to ensure logical and reliable assessment involving

Table 1. Objectives used to assess the micro environment for technology deployment

Characteristics of criteria set		Measurement units	Description
TECHNICAL ASSESSMENT CRITERIA – X_1			
X_{11}	Novelty of the product/process in the sector	(score) Saaty scale (1980)	Assessment focuses on novelty of the product/technology, which by certain features or purpose greatly differs from goods or services earlier offered on the market (or by a certain company). An innovative product can be of two types: technologically novel or technologically advanced.
X_{12}	Ecology	(score) Saaty scale (1980)	A product made following EU and national legislation regulating eco-production. Those wanting to label their products as organic must correspond to requirements that apply to the entire production process, which is assessed by an independent controlling institution.

Continued Table 1

Characteristics of criteria set		Measurement units	Description
X_{13}	Recycling	(score) Saaty scale (1980)	Is a process to change (waste) materials into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to plastic production.
X_{14}	Longevity compared to analogues	(score) Saaty scale (1980)	Product longevity is its ability to keep the required features of a set period of time or a long time under expected impact. Maintained normally and used in an appropriately design and constructed building must correspond to requirements of the building for an economically sound period of time.
X_{15}	Criterion indicating the quality of use	(score) Saaty scale (1980)	Design and user interface.
ASSESSMENT CRITERIA FOR INNOVATION IMPLEMENTATION PROCESS – X_2			
X_{21}	Production differentiation	(score) Saaty scale (1980)	Production and sale of similar but different products in the same branch of economy. It is particular to monopolistic competition. It allows reducing competition and increasing prices.
X_{22}	Period of warranty	(score) Saaty scale (1980)	Period of warranties in comparison to analogues offered on the market.
X_{23}	Labour costs	Person/hour	Labour costs per one unit of production shows changes in wages and salaries paid by the company.
CRITERIA FOR ECONOMIC ASSESSMENT OF THE INNOVATION – X_3			
X_{31}	Direct costs	EU/m^2	Costs, which according to general principles pertaining to eligibility of costs could be perceived as specific costs that are directly related to implementation of the project. These costs are listed in the detailed budget of the project.
X_{32}	Indirect costs	EU/month	These costs are not regarded as directly related to the project. Indirect costs are listed in the detailed budget of the project.
X_{33}	Expected profit	%	Expected profit is gross profit less alternative (direct and expected) costs.
X_{34}	Technology effectiveness compared to analogues	(score) Saaty scale (1980)	Quality in general and compared to analogues. Possibilities of technological development. Reliability of equipment.

Table 2. AHP method: scale for assessment of qualitative criteria (Saaty 1980)

Importance level	Linguistic importance level	Description of importance
1	Alternatives are equal	Both alternatives are equal in terms of a criterion.
3	Weakly superior alternative	Based on experience and opinion of an expert (in respect of the assessed alternative), the alternative is weakly superior compared to another alternative.
5	Important superiority of the alternative	Based on experience and opinion of an expert (in respect of the assessed alternative), the alternative has an important superiority compared to another alternative.
7	Obviously superior alternative	The alternative has an obvious superiority (in respect of the assessed alternative) and the superiority has been proved in practice.
9	Absolutely superior alternative	The alternative has an absolute superiority (in respect of the assessed alternative).
2,4,6,8	Interim values	When a compromise among previously named assessment is required.
1/3, 1/5, 1/7, 1/9	If alternatives are assessed according to criterion x, and alternative A has one of above-stated result, compare it to alternative B (R^xAB), then alternative B will have an inverse result compared to the alternative A (R^xBA or 1 / R^xAB).	

Table 3. Significance of the criteria matrix

	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{21}	X_{22}	X_{23}	X_{31}	X_{32}	X_{33}	X_{34}
X_{11}	1	2	2	2	1	1	3	3	1/5	1	1/5	5
X_{12}	1/2	1	1	1	1/3	1/3	3	1	1/6	1/2	1/7	1/6
X_{13}	1/2	1	1	1	1/3	1/3	3	3	1/7	1/2	1/7	1/8
X_{14}	1/2	1	1	1	1/3	1/3	2	2	1/7	1/2	1/7	1/6
X_{15}	1	3	3	3	1	1	3	2	1/6	1	1/5	1/5
X_{21}	1	3	3	3	1	1	3	3	1/6	1/2	1/5	1/5
X_{22}	1/3	1/3	1/3	1/2	1/3	1/3	1	1	1/7	1/2	1/7	1/7
X_{23}	1/3	1	1/3	1/2	1/2	1/3	1	1	1/7	1/2	1/7	1/7
X_{31}	5	6	7	7	6	6	7	7	1	5	1	2
X_{32}	1	2	2	2	1	2	2	2	1/5	1	1/4	1/4
X_{33}	5	7	7	7	5	5	7	7	1	4	1	2
X_{34}	1/5	6	8	6	5	5	7	7	0.5	4	1/2	1

qualitative criteria. For this reason, consistency ration CR is calculated for each pairwise comparison. If CR is less or equals 10%, the pairwise comparison is regarded appropriate. If CR is more than 10%, the pairwise comparison needs to be repeated to reduce the inconsistency of the evaluation.

For the solution of the problem, the permutation method was selected. The method was developed by Paelnick (1976). The permutation method uses Jaquet-Lagreze's successive permutations of all possible rankings and alternatives (Hwang, Yoon 1981). When applying this MCDM method, all permutations of alternatives according to their preferability are checked and compared among themselves (Turskis 2008). With *m* alternatives, *m!* permutations are available. Let's suppose that the number of alternatives (a_i, $i = 1, 2\ldots, m$) should be assessed according to the criterion (x_j, $j = 1, 2 \ldots, n$). As the best alternative from among the three available should be selected, there are $m = 3!$ alternatives, for which $m = 3 \cdot 2 \cdot 1 = 6$ combinations are made.

$$\pi_1 = a_1 \succ a_2 \succ a_3;\ \pi_2 = a_1 \succ a_3 \succ a_2;\ \pi_3 = a_2 \succ a_1 \succ a_3;$$
$$\pi_4 = a_2 \succ a_3 \succ a_1;\ \pi_5 = a_3 \succ a_1 \succ a_2;\ \pi_6 = a_3 \succ a_2 \succ a_1.$$

The method allows defining the best priority ranking for the use of alternatives. It can be used with cardinal and ordinal indicators (Zavadskas *et al.* 2011).

5. Practical application

During the first stage, an expert evaluates the importance of criteria using pairwise comparison. Technology alternatives are assessed according to selected criteria and their significance as defined by experts (Table 3).

During the second stage, the matrix for assessment of technology alternatives is designed based on selected criteria and their significance as defined by experts (Table 4).

During the third stage, the permutation method is used to compare combinations of alternatives, which defines the priority ranking of best alternatives. The best permutation has the greatest a β_g value, i.e. the permutation π_5. The evaluation of ordering of the alternatives evaluation

Table 4. Initial decision-making matrix

Criteria	Weight	Alternatives		
		a_1	a_2	a_3
Optimum – maximum				
X_{11}	0.073	7	7	8
X_{12}	0.030	6	10	5
X_{13}	0.031	10	10	10
X_{14}	0.030	7	2	7
X_{21}	0.059	5	5	5
X_{22}	0.057	7	9	9
X_{33}	0.020	3	4	4
X_{34}	0.023	3	5	5
Optimum – minimum				
X_{15}	0.241	268.8	72.9	1.43
X_{23}	0.057	235.36	477.97	98.26
X_{31}	0.233	26.37	122.32	7.25
X_{32}	0.147	12.46	4.93	17

criterion $\beta_g (g = \overline{1, m!})$, is carried out in the following way: suppose there is the g^{th} permutation $\pi_g = \{\ldots, a_k \ldots, a_e\} \forall g, g = \overline{1, m!}$ where a_k is preferable to a_e. Then, to this permutation the following estimate β_g is assigned is given as Eqn (1):

$$\beta_g = \sum_{k,e=1}^{m} \sum_{j \in C_{ke}} q_j - \sum_{\substack{k,e=1 \\ k \neq e}}^{m} \sum_{j \notin H_{ke}} q_j, \forall g;\ q = \overline{1, m!}, \quad (1)$$

where: $C_{ke} \left\{ j / x_{kj} \geq x_{ej} \right\}, k, e = \overline{1, m}; k \neq e;$

$$H_{ke} = \left\{ j / x_{kj} < x_{ej} \right\}, k, e = \overline{1, m};\quad k \neq e.$$

Then the following evaluation criterion is given to the permutation. In this case, the alternative a_3 is the most suitable according to selected criteria, as $\pi_5 = a_3 \succ a_1 \succ a_2$ (Table 5).

Table 5. Permutations and calculations of evaluation criteria

$\pi_1 = a_1 \succ a_2 \succ a_3$			
	a_1	a_2	a_3
a_1	0	**0.073 + 0.031 + 0.030 + 0.059 + 0.020 + 0.023 + 0.057 + 0.233 = 0.525**	**0.057 + 0.147 = 0.204**
a_2	0.030 + 0.057 + 0.020 + 0.023 + 0.241 + 0.147 = 0.518	0	**0.147**
a_3	0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 = 0.796	0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 + 0.241 + 0.057 + 0.233 = 0.853	0
Evaluation criterion β_1		**0.525 + 0.204 + 0.147**	0.518 + 0.796 + 0.853
$\pi_2 = a_1 \succ a_3 \succ a_2$			
	a_1	a_3	a_2
a_1	0	**0.057 + 0.147 = 0.204**	**0.073 + 0.031 + 0.030 + 0.059 + 0.020 + 0.023 + 0.057 + 0.233 = 0.525**
a_3	0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 = 0.796	0	**0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 + 0.241 + 0.057 + 0.233 = 0.853**
a_2	0.030 + 0.057 + 0.020 + 0.023 + 0.241 + 0.147 = 0.518	0.147	0
Evaluation criterion β_2		**0.204 + 0.525 + 0.853**	0.796 + 0.518 + 0.147
$\pi_3 = a_2 \succ a_1 \succ a_3$			
	a_2	a_1	a_3
a_2	**0**	**0.030 + 0.057 + 0.020 + 0.023 + 0.241 + 0.147 = 0.518**	**0.147**
a_1	0.073 + 0.031 + 0.030 + 0.059 + 0.020 + 0.023 + 0.057 + 0.233 = 0.525	**0**	**0.057 + 0.147 = 0.204**
a_3	0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 + 0.241 + 0.057 + 0.233 = 0.853	0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 = 0.796	**0**
Evaluation criterion β_3		**0.518 + 0.147 + 0.204**	0.525 + 0.853 + 0.796
$\pi_4 = a_2 \succ a_3 \succ a_1$			
	a_2	a_3	a_1
a_2	**0**	**0.147**	**0.030 + 0.057 + 0.020 + 0.023 + 0.241 + 0.147 = 0.518**
a_3	0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 + 0.241 + 0.057 + 0.233 = 0.853	**0**	**0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 = 0.796**
a_1	0.073 + 0.031 + 0.030 + 0.059 + 0.020 + 0.023 + 0.057 + 0.233 = 0.525	0.057 + 0.147 = 0.204	**0**
Evaluation criterion β_4		**0.147 + 0.518 + 0.796**	0.853 + 0.525 + 0.204
$\pi_5 = a_3 \succ a_1 \succ a_2$			
	a_3	a_1	a_2
a_3	**0**	**0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 = 0.796**	**0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 + 0.241 + 0.057 + 0.233 = 0.853**
a_1	0.057 + 0.147 = 0.204	**0**	**0.073 + 0.031 + 0.030 + 0.059 + 0.020 + 0.023 + 0.057 + 0.233 = 0.525**
a_2	0.147	0.030 + 0.057 + 0.020 + 0.023 + 0.241 + 0.147 = 0.518	**0**
Evaluation criterion β_5		**0.796 + 0.853 + 0.525**	0.204 + 0.147 + 0.518
$\pi_6 = a_3 \succ a_2 \succ a_1$			
	a_3	a_2	a_1
a_3	**0**	**0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 + 0.241 + 0.057 + 0.233 = 0.853**	**0.073 + 0.030 + 0.031 + 0.030 + 0.059 + 0.057 + 0.020 + 0.023 = 0.796**
a_2	0.147	**0**	**0.030 + 0.057 + 0.020 + 0.023 + 0.241+ 0.147 = 0.518**
a_1	0.057 + 0.147 = 0.204	0.073 + 0.031 + 0.030 + 0.059 + 0.020 + 0.023 + 0.057 + 0.233 = 0.525	**0**
Evaluation criterion β_6		**0.853 + 0.796 + 0.518**	0.147 + 0.204 + 0.525

Regular font – concordance values; Bold font – non-concordance values

The suggested algorithm may be used as means for a decision-maker aiding the selection of the best alternative from among their number described using quantitative and qualitative criteria.

Conclusions

The methodology suggested by the article authors allows combining components of the processes for technology implementation in the construction market: assessment of the external market, assessment of the internal market, state of the company and technology solutions into one complex solution. This complex assessment methodology corresponds to the concept of sustainable construction.

The multi-stage model demonstrates that effective decisions can be made only subsequent to complex analysis and assessment of relations between criteria that belong to all – macro, meso and micro – environments.

The offered case study and algorithm for assessment of the situation on the micro level formulate a new complex view to effective implementation of new technologies/products in the construction sector.

The suggested multi-stage system may be effectively used in operation of construction companies.

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