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Combined methodology to evaluate transition to low carbon society

Silvija Nora Kalnins*, Dagnija Blumberga, Julija Gusca

Riga Technical University, Institute of Energy Systems and Environment, Azenes iela 12/1, Riga, LV 1048, Latvia

Abstract

The research proposes an innovative, structured sustainability methodology for environmental management, the main element of which is an evaluation system to make it possible to advance and improve the transition of society to low carbon generation. A three-dimensional methodology model is established through which a results-based indicator evaluation method is integrated together with a multi-criteria analysis method and the indicator based screening method for the evaluation of the selected projects, programmes, strategies and educational processes. Methodology testing is performed for Latvia's case.

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Keywords: low carbon society; monitoring and evaluation; multi-criteria analysis; result-based indicators

1. Introduction

A low carbon society (LCS) is a term in sustainable development of a community which develops or adapts its behaviour and economy to be less dependent on carbon emitting activities [1]. The improvement of resource productivity, increasing the capacities to use fewer natural resources and to emit less pollution during all manners of production will lead to a society with a higher standard of living and a cleaner and healthier environment [2]. LCS aims to lower its emissions without causing a significant effect on economic growth [3] Within this society, there are three key components: the environment itself and the effects which are caused through carbon emissions (climate change, increased extreme and unpredictable conditions, biodiversity loss); policy making in different sectors (energy, transport, waste management and agriculture, etc.) with the ability to reduce the effects of carbon emissions on the environment; and low carbon generation with a change in thinking with behaviour shifting towards

* Corresponding author. Tel.: + 371 67089908
E-mail address: silvija-nora.kalnins@rtu.lv

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renewable energy use, technology transfer to low carbon and green technology, lower-carbon emissions in transport and energy-saving practices [2]. Low emission measures are frequently reviewed in terms of their technological characteristics: transfer to renewable energy sources, introduction of low emission fossil fuel technologies, integration of new biofuels in heating systems and transportation [4–6]. Nonetheless, the difference between the impact assessment of these measures at the development phase and at implementation are often very different and frequently, in the latter case (implementation and post-implementation phase), there is no adequate assessment of the actual results and their impact on transition to a low carbon society. It is evident through the publications included within this review that there is a general consensus of the need to increase collaboration among the various stakeholders in society to improve the environmental performance and the pace of transition to a low carbon society.

In order to deduce what lifestyle changes would have the potential to impact transition to a low carbon society, Neuvonen et al. [7] applied a backcasting scenario approach whereby first criteria are defined for the desirable future and then a series of feasible and logical steps are constructed that need to be followed from the present to that desirable future. Within their study, lifestyle backcasting made it possible to identify key actors and diverse lifestyles that support sustainability. The authors saw the communication of alternatives in lifestyles allowed those, dedicated to sustainable ways of living, to expand their practices to create change on a wider scale. Similar testing to the backcasting scenario approach by Kok et al. [8], Robinson et al. [9], Vergragt & Quist [10] and others [11–13] not only explore the challenges in involving participants but also the valuable role such an approach has. The need to have a broader look at the diversity of actors and governance in the backcasting approach which is so important in the complexity of reaching a resilient low carbon state, is noted by researches [10],[14,15]–[16].

Struggles to provide accurate models which include climate policy development are discussed in many papers [17–19]. The low carbon society methodology used by Kainuma et al. [4] reviews potential at the country level which explores the links between policy development, and modelling the possibility to introduce reductions in emissions in critical sections of the economy, such as transportation. LCS modeling proves to be a highly integrated process which is challenging to apply due to the various actors, not always comparable data sets, and the necessity to illustrate both national-level and municipal-level contributions.

The goal of the work is to create an innovative, structured sustainability methodology for environmental management, the main element of which is an evaluation system to make it possible to advance and improve the transition of society to low carbon generation and to demonstrate the success of such an instrument by testing it on the selected projects, programmes, strategies and educational processes. Methodology testing is performed for Latvia's case.

2. Materials and methods

2.1. Evaluation methodology

The methodology developed and presented in the paper for establishing a low carbon society allows us to progress towards this goal by applying evaluation techniques. The combined methodology is illustrated with the aid of an algorithm (see Fig. 1.) which contains 12 modules (separated methodologies were already tested and the results presented [19–22]).

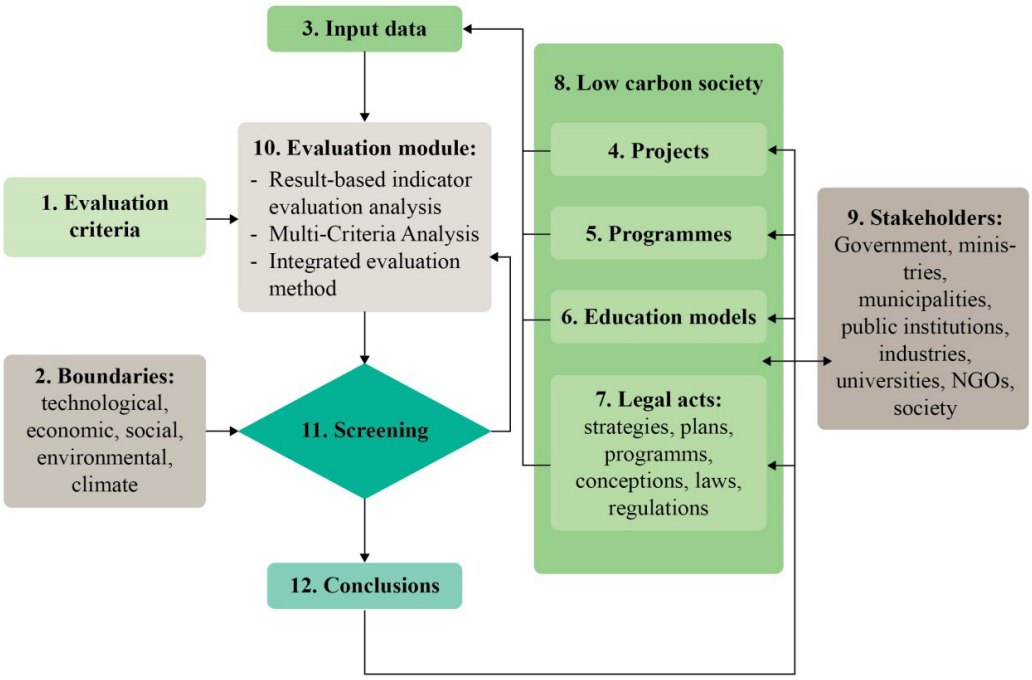

Fig. 1. Algorithm for evaluation of transition to a low carbon society [22].

'Evaluation criteria' module includes three-dimensional indicators which help to evaluate members of a low carbon society, activities of a low carbon society and the evaluation of low carbon measures, comparison of results and conclusions, proposals, recommendations. 'Boundaries' include technological, economic, social, environmental and climate restrictions for the development of a low carbon society. 'Input data' describes the current situation through information on taxes and policy (including fiscal) instruments, empirical models, data values. 'Low carbon society' is a cumulative module that combines modules "Projects", "Programmes", "Legal acts" un "Education", and shows how the mutual implementation of the activities contributes to Latvia's transition to a low carbon society. 'Stakeholders' include all involved parties which can implement low carbon measures. Each of these interested parties has their own specific goals or objectives which produce their motivation on the individual-level, although the overall goal for the society. The 'Evaluation module' includes three evaluation methods: (1) multi-criteria analysis TOPSIS method, (2) results-based evaluation indicator method; and (3) integrated evaluation method. The comparative module ('Screening') is necessary in order to compare the results produced from the evaluation module to the border restrictions. The 'Conclusions' include essential parts for developing a low carbon society which is diverse and multi-layered.

2.2. Description of case-study: framework for Latvia's transition to a low carbon society

The main responsible bodies for the development and implementation of policy related to the transition to a low carbon society in Latvia are the Ministry of Environmental Protection and Regional Development, Ministry of Finance, Ministry of Economics, Ministry of Transport, Ministry of Agriculture and institutions supervised by these ministries.

Latvia's placement and contribution to the regional and global framework for addressing challenges in transition to a low carbon society is focused on Latvia's need to maximize its efficiency in achieving advancements in policy, project/programme results and raising educational and research capacities.

The policy environment in Latvia's transition to a low carbon society consists of:

- Latvia's Sustainable Development Strategy until 2030 [23] which contains the objectives to: a) ensure energy independence of Latvia by increasing the provision of energy resources and integrating in EU energy networks (includes energy efficiency, increasing the proportion of renewables in the energy and transport sector); and b) become a EU leader in the preservation, increase and sustainable use of natural capital (includes the effective management of natural resources and the promotion of a sustainable lifestyle).
- National Development Plan (2014−2020) [24] integrates sustainable transport, productivity in the use of natural resources energy, energy efficiency issues, air quality within its cross-sectoral strategic objectives on economic growth, productive manufacturing (limiting GHG emissions), energy efficiency & energy production, and sustainable management of natural capital & cultural capital (increasing the share of processed waste, increase of forest coverage).
- Environment Policy Strategy (2014−2020) [25] lists many policy goals relevant to transition to LCS including: good environmental communication and the facilitation of public involvement in resolving environment in environment issues; improved waste management; reduction of air pollution and contributions to reducing climate change.
- Sectoral policy documents such as Energy Development Guidelines 2007−2016 [26], Transport Development Strategy 2007−2013 [27], Latvian First Energy Efficiency Action Plan 2008−2010 [28], Renewable Energy Resource Implementation Strategy 2006−2013 [29], etc.
- Supporting regulatory framework covering various issues.

The comparative analysis shows several issues that do not necessarily indicate positive advancements in policy development in Latvia's transition to a low carbon society:

- problems identified in the policy area do not have appropriate results indicators designed to ensure that the policy addresses these problems within its allotted timeframe. Thus, for instance, although the Environment Policy Strategy (2009−2015) lists lack of long-term, systematic research, insufficient level of introduction of low GHG emission technologies and lack of interest among consumers to change their consumption patterns among the essential barriers for development in the sphere of climate change, there are no results indicators to permit the clear measurement of specific accomplishments in overcoming these barriers.
- weak indicators from the 2005−2010 Climate Change Mitigation Programme [30] such as number of campaigns and number of research which are indications of processes and financial disbursement are eliminated in the environment policy strategies that follow in 2009 and 2014, however there are no results indicators to replace the measurement of the policy's success in reaching any goals besides GHG emissions.
- The language in the policy documents is process-oriented applying such terms as 'coordinate', 'facilitate' and 'improve' showing no improvement in the accountability for results.
- There is evidence of a decrease in developing strategies or appropriate actions for collaborating with interested stakeholders or target groups within the policy documents examined.

3. Results and discussion

In order to provide an overall assessment of Latvia's progress to a low carbon society, 9 development scenarios are developed:

1. Latvia's "business as usual" scenario – no results-based evaluations, lack of coherence between policy level indicators and expected results, minimal involvement of stakeholders in implementation
2. Latvia's optimistic scenario – results-based evaluations conducted and policy improvements made in conformity with lessons learned, complete coherence between indicators and results, involvement of all key stakeholders in implementation of measures
3. Latvia's pessimistic scenario – reporting on results ceases entirely, policy documents are generalized, stakeholder involvement reduces to a minimum
4. European Union's "business as usual" scenario – ex-ante evaluations on the programme level, financial allotments continue on project level with minimal dissemination of best practices

5. European Union's optimistic scenario – results-based evaluations introduced, inter-country cooperation improved through dissemination of lessons learned, replication of successful projects in other countries
6. European Union's pessimistic scenario – financial accountability ceases, programme design becomes superficial
7. United Nations' (based on Millennium Development 7th goal) "business as usual" scenario – slow progress to reach goals, evaluation of overall indicators
8. United Nations' (based on Millennium Development 7th goal) optimistic scenario – close to reaching global goal, improved environmental governance worldwide
9. United Nations' (based on Millennium Development 7th goal) pessimistic scenario – GHG emissions target eliminated from global targets

Criteria weights within TOPSIS method are defined by 48 experts (MSc level environmental science students) using the expected value method. Survey participants were asked to rate given measures (education, legislation, projects and programs), by their efficiency for achieving low carbon society, on a scale from 1 to 10, where 10 means the most effective and, therefore, more important and 1 the least effective (see Table 1).

Table 1. Decision matrix for evaluation of transfer to low carbon society.

Scenario	Education module	Projects	Programmes	Legal acts
Latvia's "business as usual" scenario	3	3	5	4
Latvia's optimistic scenario	8	8	8	9
Latvia's pessimistic scenario	6	7	7	6
European Union's "business as usual" scenario	5	5	7	4
European Union's optimistic scenario	9	7	8	7
European Union's pessimistic scenario	4	5	6	3
United Nations' (based on Millennium Development 7th goal) "business as usual"	5	4	5	2
United Nations' (based on Millennium Development 7th goal) optimistic scenario	8	6	7	6
United Nations' (based on Millennium Development 7th goal) pessimistic scenario	6	5	5	4

Survey results showed that education is the most effective, in respondents' opinion, with the average rating 7.91, legislation was a close second with the average rating 7.90. Project and programme importance were rated as less influential at 7.00 and 6.92, respectively. Criterions were ordered by their importance (Education>Legislation>Projects>Programmes), which was obtained as a mean average of ratings given by the experts.

If *k* criterion is listed in ascending order of importance criteria weights are calculated using following formulas:

$$E(w_1) = \frac{1}{k^2}$$

$$E(w_2) = \frac{1}{k^2} + \frac{1}{k(k-1)}$$

$$\vdots \qquad (1)$$

$$E(w_{k-1}) = \frac{1}{k^2} + \frac{1}{k(k-1)} + \cdots + \frac{1}{k \cdot 2}$$

$$E(w_k) = \frac{1}{k^2} + \frac{1}{k(k-1)} + \cdots + \frac{1}{k \cdot 2} + \frac{1}{k \cdot 1}$$

where:
$E(w_j)$ – expected value of the criterion j and is used as the weight for that criterion,
k – number of criterion.[42]

If two criterions are ranked as equal, their weight is determined by subtracting the weight from all other criteria from 1 and dividing that by 2. Criteria weights are showed in Table 2.

Table 2. Criterions weights.

Criterion	Average rating (from survey)	Weight
Programs	7.91	0.0625
Projects	7.90	0.1459
Legislation	7.00	0.2708
Education	6.92	0.5208

Results of the cumulative evaluation are given in Fig. 2.

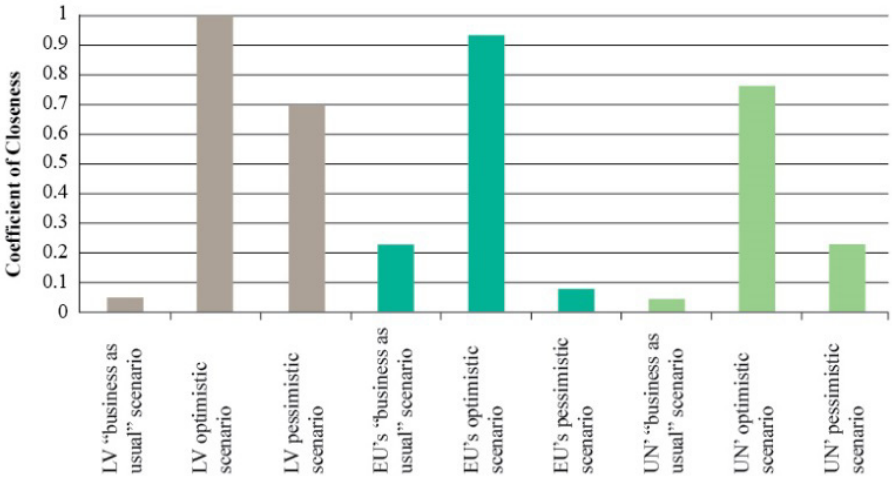

Fig. 2. Results of the cumulative evaluation of the module 'Low carbon society'.

As reflected in Figure 2, under the optimistic scenario, the transfer to a low carbon society shows good results. At the global level (in the framework of the United Nations and achievement of the Millennium Development Goals) results are expected to be the least successful of the three – Latvia the most successful at almost completely achieving the ideal. This is primarily due to the lower rate of impact which projects and legal acts can achieve on reaching results. The limits at the global level will always be restricted by the sum of the varying efforts of the countries upon which the global efforts depend.

At the national level – in case of Latvia – the optimistic scenario, whereby results-based evaluations are conducted, policy improvements made and there is full involvement of stakeholders in the implementation of measures, shows to be able to achieve excellent advancement to a low carbon society. A high level of coherence and coordination among the various sectors, decision-makers and society produces high capacity for transition to a low carbon society. Interestingly, the pessimistic scenario in this case is also high. This seems to indicate that, if left to their own devices, the performance of education, projects and programmes would still be greater than in the current situation. This may be partially explained by the mismanagement of indicators in the 'business as usual' scenario.

Currently, there are many indicators selected to measure progress in Latvia which target processes (number of seminars organised, number of research conducted), rather than results (knowledge increased among x target groups as a result of seminars, types of behavioural changes made as a result of training, number of policy-decisions made based on qualitative research). Thereby, in the pessimistic scenario, by merely adapting our method from looking at processes to considering results, the national level analysis will show to achieve much more than "business as usual". For the opposite reason, the EU level shows the worst results in the pessimistic scenario. The European Union, in its transition to a low carbon society at the "business as usual" level shows the best result – there is a fairly good, basic framework of evaluating program-level results, efforts are coordinated and managed through cooperation projects among countries and between research institutions and the public and private sector. Stripped of this 'business as usual' approach, the European Union will reduce drastically in its delivery at the pessimistic scenario. The coordination and coherence achieved through the business as usual at this level is that which currently helps the differing stakeholders and various initiatives steer results to the obtainable target of a low carbon economy. In this case, the pessimistic scenario shows true regression from the 'business as usual' approach.

4. Conclusions

A combined methodology for evaluation of transition to a low carbon society has been developed which includes the main drivers of sustainability and a low carbon society – legislation, education and research, projects and programmes, as well as interest groups (stakeholders which include decision-makers, the industrial sector, educators, NGOs and society). The methodology has been tested to see the relevance of its application and its effectiveness in evaluating the sustainability of processes on the national, municipal and institutional levels. The results of the comprehensive evaluation provides points from which development activities can be launched in order to form a resilient, low carbon future. Such evaluations should be conducted ex-ante and ex-post in processes such as the development of country action plans (including in budget allocations) and strategic documents at the national level (both in sector and cross-sector strategies).

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