

# Application of Transition Engineering Methodology to Energy Efficiency Development in the Brewery Company

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**Abstract.** Most companies aimed at long-term sustainable development take full responsibility to reduce the environmental risks in order to guarantee environmental safety and social justice of the planet's population. In accordance with circular economy principles, energy efficiency and energy saving are currently among the most important strategic directions for technological development of many enterprises. For transition to «low carbon» development scenario, companies are setting priorities and goals, taking into account the concept of sustainable development, considering the energy consumption index or energy usage ratio as one of the key business indicators. An analysis of existing methods and approaches in companies' energy management show a low level of strategic planning and management. To improve energy efficiency and implementation of energy policy, as well as to create conditions for company's sustainable development in long term, it is necessary to apply innovative management methods. Such approaches as transition engineering and participatory backcasting will allow companies to determine the main directions of strategic business development in the field of energy efficiency. The need to improve methodological approaches to managing the energy sector of the enterprise's economy determines the relevance of the chosen research topic. The aim of this paper is to present the results of CREA-RE-RU project, which deals with circular economy and resource efficiency development. The project investigated following key points: existing methods and approaches for managing energy resources of an enterprise; a review of innovation management methods for improving the energy efficiency of companies; application of the «transition engineering» approach to the formation of the company's energy development strategy; the results of application of the «transition engineering» approach for developing an energy efficiency strategy for the brewery company.

## 1. Introduction

Rapid urbanization and industrialization have led to the fact that most countries in the world face various social and environmental problems, which include depletion of natural resources, global warming and environmental pollution. Companies try to find such business models that could reduce the environmental pressure. Such model can be considered a circular economy, which is a new model of using resources, in which production waste can become valuable resource for another production process. The circular economy model has been developed since the late 1980s, and it is considered as transition from traditional linear economic model based on a «take-make-consume-throw away» pattern to a circular model related with reduce, reuse and recycle principles. The goal of circular

economy is production of goods and services with restriction of primary raw materials consumption, also with reduction of losses of natural resources and non-renewable energy.

The importance of circular economy and resource efficiency has increased also in the Baltic Sea Region. The unique features of the Baltic Sea, and its environmental pressures, demand the latest scientific knowledge and innovative management approaches into strategic policy implementation. This fact is acknowledged through a joint action in HELCOM, dedicated to ensuring that environmental standards are fully implemented by all parties throughout the Baltic Sea Region [1].

In the frame of the international project «Preparing Learning about Resource Efficiency Leading into Circular Economy», a survey was conducted in order to evaluate the current knowledge and performance on resource efficiency and circular economy of companies in the Baltic Sea region countries. A study indicated that about 78% of the respondents chose sustainability in general (including concepts such as social/environmental/economic sustainability, corporate social responsibility, fair trade etc.) as the most important concepts leading to circular economy. These were followed by the resource efficiency concept: (waste minimization, energy efficiency, material efficiency etc.) [2].

Resource efficiency development and circular economy implementation in companies in the Baltic Sea Region—in Finland, Sweden, Latvia and St. Petersburg Region, Russia – was in focus in the two parallel twinning international projects "CREA-RE" (Creating aligned studies in Resource Efficiency) and "CREA-RE-RU" (Creating aligned studies in Resource Efficiency in Sweden and Russia), which has been realizing since 2018. The projects received funding from the Interreg Baltic Sea Region program of the European Union and the Swedish Institute, respectively. Project partners included four universities: Lahti University of Applied Sciences (Finland), University of Gävle (Sweden), University of Latvia (Latvia) and ITMO University (Russia).

In accordance with objectives of the project four international teams worked on case-studies, which were offered by the Latvian enterprises. One of them was carried out with Valmiermuižas Brewery Company about their resource efficiency and circular economy issues. The main goal was promotion of resource efficiency concept and activity development into direction of sustainable business.

The working group had the following objectives such identification and analyzing of significant environmental aspects; developing and offering of concrete proposals to increase energy efficiency; suggestion of energy efficiency development strategy for Valmiermuižas Company.

## 2. Method

For innovative progress in energy efficiency development transition to a qualitatively new level of management is required. Transition represents scientifically based synthesis, which includes forecasting, planning and implementation of strategic goals and objectives. The authors analyzed the application of transition engineering approach for managing energy efficiency development.

In accordance with [3] Transition Engineering, which is an emerging field whose practitioners design and carry out the projects of change. Transition Engineering requires a systems perspective for planned changes to current engineered systems. Transition involves the whole of society, economy, ecology, infrastructure and energy and material supply chains. The Interdisciplinary Transition, Innovation, Management and Engineering methodology generates new opportunities through disruptive ideas. These new ideas are developed into shift projects with the mission of long-term engineering and management of the 80% fossil fuel production decline. Transition Engineering achieves energy transition, one project at a time [4].

The current challenges on improving energy efficiency suggests that transition engineering approach is the most suitable for managing long-term corporate strategy based on voluntary initiatives. The development of scenarios, the approval of backcasting results and actions for further implementation, and the interaction between the participants lead to a deeper understanding of environmental values and contribute to their achievement [5, 6].

Krumdieck has proposed a Transition Engineering process distinguished in different steps. Transition engineering steps involve different kind of processes [7]. The first steps are an analysis

process, consisting of learning past and current situation, significant environmental, social and economic aspects, interests and needs of stakeholders. Then a strategic process is proposed, consisting of scenario development and resulting in the generation of path-break system concepts and trigger events modelling. The next step concerns a tactical process, where a backcasting process is required in order to identify the essential phases and to achieve the desirable future vision.

Cappellaro [8] set the correspondences between Transition Engineering and Transition Management. The author argues that «both transition engineering and transition management processes deal with managing societal change toward sustainability and achieving a strict connection between technical solutions and successful practices» [8]. The study offers 4 phases of transition process (strategic, tactical, operational and reflexive) and number of methods and tools which can be applied in the implementation of sustainability transition process.

According to authors it is necessary to split the reflexive phase into two parts: analytical phase, which is concerned to learning of past trends and current situation, and reflexive phase based on analysis of the results of the transition process and further review and revision. As outlined in Table 1 each phase of transition process can be presented by transition engineering steps and the numbers of methods and tools which support to achieve the desirable future vision.

**Table 1.** Transition Engineering tools and methods contributing to transition process [8 with review by authors].

<b>Transition process phase</b>	<b>Transition Engineering steps</b>	<b>Transition Engineering methods</b>
Analytical phase	1. Study of the past trends and current situation 2. Stakeholder analysis and engagement 3. Formulating the vision of the future	Analytical methods (SWOT, PEST-analysis, stakeholder analysis)
Strategic phase	4. Backcasting and scenario development	Design methods (Co-design, Ecodesign, Design for sustainability)
Tactical phase	5. Path-break concepts 6. Trigger events modelling	Planning Tools (Sustainability Report, EMAS, ISO 14001)
Operational phase	7. Transition Change Project 8. Implementation and monitoring	Technologies (Appropriate, Smart, Net-zero technologies)
Reflexive phase	9. Review and revision	Sustainability Assessment (Sustainability indicators, LCA)

Thus, in the authors' view, the transition engineering is appropriate approach to develop energy efficiency strategy for brewery company as framework of corporate environmental responsibility and sustainability of the business.

### **3. Energy efficiency development in the brewery company**

#### *3.1. Analytical phase*

When analyzing company's external environment, it is important to identify the factors that are likely to influence the organization's sustainable development and energy efficiency particularly. To conduct the past trends and current situation analysis of energy efficiency development it is necessary to apply environmental aspects analysis and stakeholder analysis.

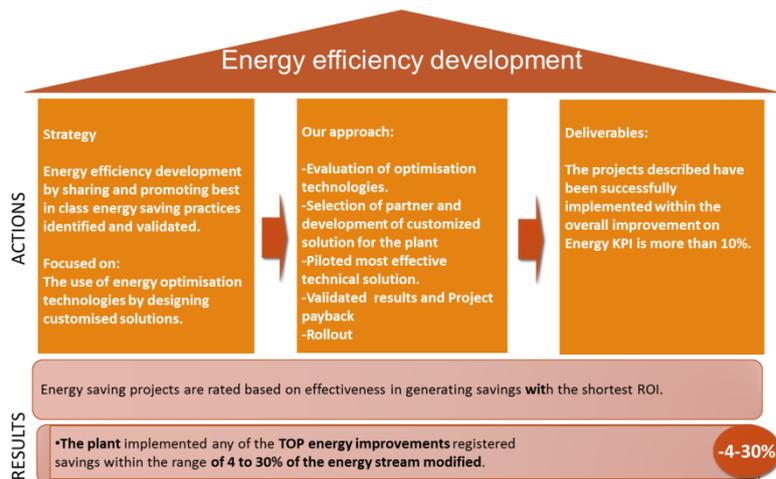
In Valmiermuižas Brewery Company a large amount of heat is required for the process; consequently large oil fed boilers are usually in operation on site to meet the demand. There is a need

for cooling, particularly after fermentation and in the storage areas. Presently this is often supplied via electrical air conditioning units and chillers. This equipment is not particularly energy efficient and is heavily reliant upon fossil fuels for operation [9, 10]. The energy demand can be divided into thermal energy needed for heating and cooling on one hand and electrical energy on the other. In general the greatest users of electricity within a brewery are electrical motors and refrigeration. The amount used for heating, ventilation and air conditioning (HVAC) and lighting will depend on the design and size of the facility but it is generally considered to be a minimal proportion of the total consumption [9, 10].

Beer manufacturing consists of multiple phases: malting, mashing, boiling, fermentation, bottling and ageing [9, 10]. The energy audit, conducted by authors, showed, that the average energy demand per brew is 160 kWh for heating the hot liquor from 70°C to 80°C, 270 kWh for boiling and roughly 200 kWh for cleaning purposes. Roughly 7% of the wort is boiled off. On a Monday the energy demand for heating the hot liquor in the morning is significantly higher than the average as the hot liquor cools significantly over the weekend and sums up to approximately 500 kWh. The energy consumption in breweries is often expressed in terms of their specific energy consumption. This is defined as the amount of energy required per unit of finished product (MJ per hectolitre or kWh per hectolitre) [9, 10], which in Valmiermuižas brewery makes 1.06 kWh/hl in average.

### 3.2. Strategic phase

Strategy development constitutes a cornerstone of energy efficiency of the Company. The central step was to develop the desirable future vision through the construction of a model of energy efficient and energy independent company in a final future state followed by developing a scenario corresponding to the results of the model [11]. As Vergragt and van der Wel emphasise «Future visions alone are not enough: backcasting implies an operational plan for the present that is designed to move toward anticipated future states» [12] According with Robinson «the purpose of backcasting was not to produce blueprints, but to indicate relative feasibility and implications of different energy futures (including social, environmental and political implications) on the assumption of a clear relationship between goal setting and policy planning» [13]. Figure 1 shows the result of strategy and key actions development to achieve desirable future vision, designed by authors.



**Figure 1.** Strategy of energy efficiency development.

### 3.3. Tactical phase

Learning of the current situation, setting specific goals, formulation of desirable future vision of the energy efficiency development allow to develop scenarios for achieving this picture of success. All scenarios could be classified in three groups: inertial, strategic and innovative. Inertial scenario is

based on the prevailing trends, which are accepted as dominant [14, 15]. Strategic scenario includes the several transformations like implementation of technical solutions, creation and development of environmental management system, changing the manager's mindset, formation of culture and environmental friendly behaviour. The innovative scenario should be completed by implementing innovative technologies and best available techniques, which can give quick and effective results. Transition engineering approach requires innovative scenario development and implementation [14, 15].

### 3.4. Operational phase

For informed decision-making related to the development and implementation of scenarios, with selection of the most effective environmental investment projects and management approaches, the "cost-benefit analysis" method is recommended to use [16, 17, 18]. The method is based on comparison of costs for environmental protection measures, implementation of design decisions, etc. and the results of the implementation of these activities. All energy saving projects can be categorized by type: steam, electrical, heat recovery and energy efficiency lighting. Below the main energy efficiency projects are presented. The economic indicators of proposed projects are presented in the Table 2.

**Table 2.** Economic indicators of energy efficiency projects.

<b>Energy efficiency projects</b>	<b>Energy Saving, [kWh]</b>	<b>Net Growth Savings, [€]</b>	<b>Project Cost, [€]</b>	<b>Return On Investment, [month]</b>
Insulation of steam pipe work	21 960	3 279	250	1
Optimization of electrical power distribution	34 270	4 817	12 000	30
Heat recovery from LP compressor	18 970	2 736	4 750	21
Energy efficiency lighting	24 500	3 562	13 590	46

### 3.5. Reflexive phase

The future vision alone is not enough for the successful implementation of the strategic scenario, the backcasting method requires to answer the question: «What do I do today to achieve the future vision». Operational plan for the present should be designed to move toward anticipated future states. Backcasting, then, is not based on the extrapolation of the present into the future —rather; it involves the extrapolation of desired or inevitable futures back into the present [19, 20]. Based on the performed study, the following tasks of the stage can be formulated: 1) Discuss and assess the viability of scenarios, identify their weaknesses and strengths; 2) Develop short-term and medium-term activities, identify the necessary resources and means for their implementation; 3) Assign responsible persons for action plan implementation; 4) Identify opportunities, barriers and implementation conditions (technological, socio-economic and cultural); 5) Set the control points and list of indicators for continuous monitoring.

## 4. Results and discussions

As a tool for managing the energy efficiency development, the transition engineering approach was applied. According with the methodology, the image of an energy efficient company was formulated; the significant environmental aspects was identified, developed and analyzed scenarios for the development of energy efficiency; economic criteria were proposed to justify the effectiveness of measures. Developed methodological and practical recommendations for managing the energy

efficiency development in the form of a procedure that includes five phases: analytical, strategic, tactical, operational and reflexive

## 5. Conclusion

The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used. A circular economy can not only replace a linear economy, but also solve complex environmental and social problems. The circular economy model is significantly dependent on managers' mindset and commitment, investments from stakeholders, on legislation, on cooperation between business and consumers, on the development of new technologies and new ways of industrial production. The results of case study presented in this paper can be used wider then application in the brewery company. The results will promote the sharing and spreading of knowledge about circular economy and resource efficiency, offer valuable information about transition engineering approach to energy efficiency strategy development. CREA-RE-RU project demonstrated the efficient academia-industry cooperation to promote the circular economy principles in the business sector of the countries of Baltic Sea Region.

## References

- [1] HELCOM Baltic Sea Action Plan adopted on 15 November 2007 in Krakow Poland by the HELCOM Extraordinary Ministerial Meeting. Link to the internet [http://www.helcom.fi/Documents/Baltic%20sea%20action%20plan/BSAP\\_Final.pdf](http://www.helcom.fi/Documents/Baltic%20sea%20action%20plan/BSAP_Final.pdf)
- [2] Sergienko O, Pavlova A, Savoskula V, Karvinen M, Sorvari J, Obuka V, Klavins M, Hillman K, Autio S 2018 A circular economy: an analysis of the businesses awareness level in the Baltic Sea Region countries *Electronic Scientific Journal of NIU ITMO, Series "Economics and Environmental Management"* **4** pp 124-138 DOI: 10.17586/2310-1172-2018-11-4-125-138
- [3] Global Association for Transition Engineering Link to the internet <https://www.transitionengineering.org/>
- [4] Pakhomova N V, Richter K K, Vetrova M A 2017 Transition to circular economy and closed loop supply chains as driver of sustainable development (St. Petersburg: Vestnik of St. Petersburg University) *Economics T/33* **2** pp 244- 268
- [5] Pishchulov G V, Richter K K, Pakhomova N V, Tsenzharik M K 2018 A circular economy perspective on sustainable supply chain management: an updated survey (St Petersburg) *University Journal of Economic Studies* vol 34 issue 2 pp 267–297 <https://doi.org/10.21638/11701/spbu05.2018.204>
- [6] Nikki Svensson, Elin K Funck 2019 Management control in circular economy Exploring and theorizing the adaptation of management control to circular business models *Journal of Cleaner Production* vol 233 1 October 2019 pp 390-398
- [7] Krumdieck S 2013 Transition Engineering: adaptation of complex systems for survival *International Journal of Sustainable Development* **16(3/4)** 310-321
- [8] Cappellaro F 2015 Engineering in Transition Approaches, strategies and technologies for implementing system innovation towards sustainability University of Bologna, PhD thesis 371 p
- [9] Sturm B, Butcher M, Wang Y, Huang Y, Roskilly T 2012 The feasibility of the sustainable energy supply from bio wastes for a small scale brewery A case study *Applied Thermal Engineering* **39** 45-52
- [10] Valmiermuiza Brewery Company Link to the internet <<https://www.valmiermuiza.lv/>>
- [11] Jansen L 2003 The challenge of sustainable development *Journal of Cleaner Production* **11** pp 231–245
- [12] Vergragt P, van der Wel M 1998 Back-casting: an example of sustainable washing in: N Roome (Ed.) *Sustainable Strategies for Industry* (Washington DC: Island Press) pp 171–184
- [13] Robinson J 1982 Energy backcasting: a proposed method of policy analysis *Energy Policy* **10** pp 337-344

- [14] Dobrynina V K, Pavlova A S 2018 Innovative approaches to energy efficiency management of enterprises Proceedings: Social and Humanitarian and Economic Sciences: Actual Problems, Achievements and Innovations Collection of scientific papers based on the materials of the International Scientific and Practical Conference Edited by E P Tkacheva pp 132-135
- [15] Yusuke Kishita, Benjamin C McLellan, Damien Giurco, Kazumasu Aoki, Itsuki C Handoh 2017 Designing backcasting scenarios for resilient energy futures Technological Forecasting and Social Change vol 124 pp 114-125
- [16] Sergienko O I 2017 Initiatives of companies to introduce cost-effective and sustainable energy alternatives based on the BAT principle *Efficiency of the economy, environmental innovations, climate and energy policy* pp 145-158
- [17] Alisa Yushchenko, Martin Kumar Patel 2017 Cost-effectiveness of energy efficiency programs: How to better understand and improve from multiple stakeholder perspectives? *Energy Policy* vol 108 pp 538-550
- [18] Manavalan E, Jayakrishna K 2019 An Analysis on Sustainable Supply Chain for Circular Economy *Procedia Manufacturing* vol 33 pp 477-484
- [19] George Goddard, Megan A Farrelly 2018 Just transition management: Balancing just outcomes with just processes in Australian renewable energy transitions *Applied Energy* vol 225 1 pp 110-123
- [20] Kwok L Shum 2017 Renewable energy deployment policy: A transition management perspective *Renewable and Sustainable Energy Reviews* vol 73 pp 1380-1388