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Framework for Sustainability Assessment of Small and Medium-Sized Enterprises

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Regions of Central Europe are characterised by the economic activity mainly performed by micro companies and small and medium sized enterprises (SMEs). In accordance with the sustainable economic development of the Central Europe SMEs, key objectives have been recognised to tackle the challenge, namely: implementation of energy efficient and environmentally friendly technologies in production process, promotion of economic and social benefits of sustainability and achieving positive changes in behaviour of employees. This paper presents a novel approach (3EMT tool) for sustainability assessment of SMEs together with resulting normalized quantitative indicators, statistical benchmark indicators and SME energy consumption profiles. The 3EMT tool enables the evaluation of energy and environmental performance of SMEs and provides ranking useful for benchmarking and supports regional sustainability evaluation.

1. Introduction

The Small and Medium-sized Enterprises (SMEs) are the most vital part of Europe's economy. They are Europe’s biggest net job creators, employing more than 100 million employees firmly anchored in their local and regional communities, producing 60 % of European GDP and are a guarantee of social cohesion and stability (European Commission, 2009). Furthermore, SMEs are responsible for significant amount of industrial innovations as reported by Sungjoo et al. (2010) in terms of networking and by Van de Vrande et al. (2009) in terms of trends. They are thus a major element for a knowledge-based economy (Narula, 2004).

However, almost 65 % of the industrial environmental impact in EU relates to SMEs as stated in (European Commission, 2010). Despite huge policy efforts, the EU is still far from reaching its 2020 energy savings target. According to (Önüt and Soner, 2007), it is important to take preventive measures to reduce energy costs and increase efficiency in industry and consequently in SMEs. As shown in (Thollander et al., 2007), the largest barrier found in the studied SMEs was the low priority of energy related issues, and to reduce this barrier there is a need for a strong public policy, targeting these types of companies. Also, according to (Trianni and Cagno, 2012), the recognised major barriers are represented by the access to capital, lack or imperfect information on cost-efficient energy efficiency interventions and the form of available information.

The environmental impact of the SMEs can be assessed through various comprehensive sustainable approaches in industrial production, as presented in (Cucek et al., 2013) using multiobjective optimisation and in (Chew et al., 2013) focusing on process modification potentials, as well as holistic approaches presented by (Mooney et al., 2013) and (Timmerman et al., 2013). The red line connecting all these approaches is the use of ICT technologies. As reported by (Côté et al., 2011), there is a need to develop appropriate ICT tools for assessing energy efficiency in SMEs that can be more widely used, an interesting example is presented by (Merchan et al., 2013).

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As a respond on the above mentioned challenges, Partners of Central Europe regions are involved in the CEEM (Central Environmental and Energy Management as a Kit for Survival) project, designing a common tool 3EMT to evaluate the energy and environmental performance of SMEs to get ranking useful for benchmarking regions and to increase the energy efficiency in the addressed enterprises. The main goal of the 3EMT tool is to help companies to implement new, green technologies and to actively support more sustainable approaches in the industrial production. This paper presents the framework for the sustainability assessment of SMEs elaborating scoring technique, resulting normalised quantitative indicators, statistical benchmark indicators and SME energy profiles for the selected industrial branches.

2. Methodology

Sustainability of each particular company can be analysed in different forms. Being inspired by the energy certification in buildings and energy audits in industry a conglomerate of quantitative and qualitative methods for assessing sustainability in SMEs has been proposed for the 3EMT tool.

2.1 Structure of the 3EMT tool

The 3EMT tool has been developed in a form of web based self-assessment questionnaire. A division into questions related to five sustainability categories has been done, as presented in Figure 1. Each category is given a sub-score using performance indicators (PI), as a core 3EMT tool methodology for performance and scoring, resulting in the overall score definition.

Energy Efficiency category is addressed through various questions related to the energy consumption of the assessed company with selected indicators such as energy intensity, energy productivity and the share of renewable energy sources in the final energy use.

Future and Innovation category is addressed through questions related to attitude towards green issues, climate friendly investments, awareness of related obstacles and the future outlook.

Environment category is addressed through indicators such as SME footprint, CO_2 emissions, and attitude toward recycling and ecology.

Quality and Management (Q&M) category is addressed through the questions related to quality control, maintenance, management and internal structure of the addressed company.

The final category is Horizontal Issues, which is a category important for assessing the self-image perception of the company. It addresses questions related to the adhesion of the policies, awareness and relevance of EU future programs, and as already mentioned self-image perception.

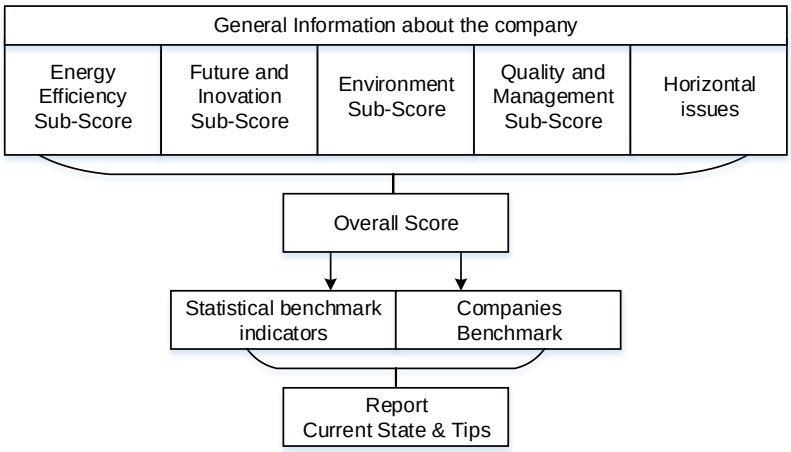

Figure 1: Structure and categories of the 3EMT tool

2.2 Selected Quantities and Normalization

For the purpose of SME sustainability performance evaluation, a set of quantities to be monitored has been proposed. Namely, energy use, installed power and related costs. Each of these quantities is subdivided by energy source and in principle also by typology of use. For SMEs in some branches it is important whether the energy use occurred in the office environment, manufacturing hall or in the construction site. Since many companies are typically not able to measure or distinct the typology of energy use, a smaller subset of quantities, namely eight, has been chosen by relevance and data availability as presented in Table 1. The first 5 quantities are used generally for all SMEs, whilst indicators 6, 7 and 8 are relevant for companies owning RES power plants. Quantities related to renewable energy

can be expressed in percentage with respect to the total energy consumption. Hence, in contrast to quantities 1-5, no further normalization with respect to company size is needed for quantities 6-8.

Table 1: Selected quantities for SME energy efficiency performance evaluation

Number	Quantities	Description
1	E_{tot}	Total energy consumption - division by fuels
2	C_{tot}	Total energy cost - division by fuels
3	E_{el}	Electricity consumption
4	C_{el}	Electricity costs
5	P_{el}	Available electrical power
6	$E_{ren\text{-}el}$	Total amount of renewable electricity production
7	$E_{ren\text{-}th}$	Total amount of renewable thermal energy production
8	$\varepsilon_{ren\text{-}el}$	Share of on-site renewable electricity consumption

In order to allow the comparison of addressed SMEs which can differ in sector and size, a normalisation has been done. Enterprises are grouped in different ways, for example by type of activity (NACE code) or by country or region. Moreover, different "size" aspects can be distinguished, in terms of economic, geometric and time quantities. In Table 2, selected normalisation factors for the SME sustainability performance evaluation are presented.

Table 2: Selected normalisation factors for SME sustainability performance evaluation

Normalisation factor	Description	Abbreviation	Unit
Economic size	In terms of Turnover	TO	€/y
	In terms of Number of Employees	NoE	Integer
Geometric size	In terms of Volume (Net volume)	NV	m^3
Time aspects	Working hours	h	h/y

However, it is impractical to manage all possible combinations of the quantities and normalisation factors. By having this in mind, a restricted selection of quantitative indicators that meet a "necessary and sufficient" criterion, is proposed and presented in the results and discussion section.

2.3 Statistical Benchmark

For the statistical benchmark used in the 3EMT tool, two main country/region specific indicators have been proposed. Namely Energy Productivity (EP) and Total Energy Use per type of SME disaggregated by fuel, where Energy Productivity is defined as branch specific value added per branch specific total energy used.

2.4 Performance and Scoring

Analysed features of SMEs can provide quantitative information (i.e. energy consumption and costs), while other yield qualitative information (i.e. policies, awareness and perception). To obtain the scores required for the 3EMT tool SME benchmark the scoring technique based on the performance indicators has been used, both for qualitative and quantitative analysis. For each indicator and each company subset (i.e., NACE code) a Performance Indicator (PI) is calculated in the range from 1 to 5 according to the following rule: PI = n if up to the n × 20 % of the benchmark companies have a worse indicator score than the considered company. The benchmark values are therefore dynamic, since with each new addressed company the benchmark data pool is larger. With economy progressing towards sustainability the benchmark values are automatically adapted through the PI rule and SMEs that do not consider such transition will receive lower scores.

For the quantitative analysis, different predefined sub-category weights are assigned to the performance indicators $w_{ij}^{(qt)} = w\left(PI, c_j\right)$, where *PI* is the PI associated with the indicator I_i and c_j is the addressed sub-category. Overall sub-category quantitative Performance Indicator $PI^{(qt)}(c_j)$ is defined by Eq.1, where $w_{ij}^{(qt)}$ is the predefined weight (value) corresponding to the i-th indicator and j-th sub-category.

$$PI^{(qt)}\left(c_j\right) = \frac{\sum_i w_{ij}^{(qt)} PI\left(I_i\right)}{\sum_i w_{ij}^{(qt)}} \tag{1}$$

For the qualitative analysis, different predefined weights are assigned to the qualitative scores, $w_{ij}^{(qt)} = w\left(s_i, c_j\right)$, where s_i is the score (value) associated with the i-th answer and c_j is the addressed sub-category. The sub-category qualitative score is given by the Eq.2.

$$S_j = \left(\frac{\sum_i w_{ij}^{(ql)} s_i}{w_{ij}^{(ql)}} \right) \quad (2)$$

The fore mentioned PI definition rule is also applied here, as the conversion of the scores appears to be problematic, due to the possibly narrow distribution of only a few integer numbers. An overall sub-category qualitative Performance Indicator $PI^{(ql)}(c_j)$ is therefore defined by Eq(3), where $w_{ij}^{(ql)}$ is the predefined weight corresponding to the i-th answer and j-th sub-category.

$$PI^{(ql)}(c_j) = PI(S_j) = PI\left(\frac{\sum_i w_{ij}^{(ql)} s_i}{\sum_i w_{ij}^{(ql)}} \right) \quad (3)$$

However, in both cases the final output is a PI that is a relative value based on the benchmark comparison of the companies. These relative values are then combined in the calculation of the final sub-category PIs, where different weights are assigned to the quantitative and qualitative contribution.

3. Results and Discussion

Resulting indicators and energy profiles elaborated in this chapter represent the methodological basis of 3EMT tool for the SME sustainability performance assessment. Each company receives a benchmark score through the 3EMT performance scoring process and is presented with an average country and branch specific SME energy profile, according to the type of SME for the comparison.

3.1 3.1 Resulting Normalized Quantitative Indicators

As presented in chapter 2.2 Selected Quantities and Normalization, eight quantities and four normalisation factors were selected to form the quantitative framework for the sustainability assessment of the SMEs with 3EMT tool. Consequently a total of nine quantitative indicators (densities), which are of real interest for the companies, were defined to represent the normalized metrics for the energy efficiency performance evaluation. The resulting Quantitative Indicators are given by the equations in Table 3.

Table 3: Resulting quantitative indicators

	Quantitative indicators	Unit	Description
1	C_{tot}/TO	%	index estimates the relative weight of energy costs with respect to the turnover
2	C_{el}/TO	%	Similar to index 1, but restricted to electricity
3	E_{tot}/NoE	kWh	Total energy consumption per employee
4	E_{el}/NoE	kWh	Similar to index 3, but restricted to electricity
5	$E_{tot}/(NV \times h)$	kW/m^3	Total energy consumption per cubic meter per working hour
6	$E_{el}/(NV \times h)$	kW/m^3	Similar to index 5, but restricted to electricity
7	$E_{el}/(P_{el} \times h)$	%	Ratio between the equivalent number of hours at peak power ($Hrs_{peak} = E_{el}/P_{el}$), useful to verify the contract volume of peak electricity
8	$(E_{ren\text{-}el}+E_{ren\text{-}th})/E_{tot}$	%	Ratio between total renewable energy production and total energy consumption
9	$E_{ren\text{-}el}/E_{el}$	%	Similar to index 8, but restricted to electricity, share of on-site renewable electricity consumption

Using the information obtained through the 3EMT self-assessment process, quantitative indicators are calculated. Indicators from 1 to 7 are general quantitative indicators (relevant for all SMEs), whilst indicators (8 and 9) are used to assess the SMEs with the RES power plants.

3.2 3.2 Resulting Statistical Benchmark Indicators and SME Energy Consumption Profile

For the purpose of developing a branch and country/region specific reference SME, statistical data on energy consumption desegregated by fuels and SMEs value added was obtained in correspondence with the regional/national statistical authorities.

For the Slovenian case, the SMEs value added and the total energy use are reported on a yearly basis to the national statistics authority. Based on collected data, country and branch specific energy productivity has been defined for each SME type, as presented in Table 4. Due to the variations and complexity of statistical data obtained from the Slovenian national statistics authority, only a selection of five industrial branches is presented in the paper.

Table 4: Energy productivity for selected branches per type of SME in €/GJ

NACE code	Small (10-49 employees)	Medium (50-249 employees)
C10 - Manufacture of food products	155 €/GJ	110 €/GJ
C22 - Mfr. of rubber and plastic products	307 €/GJ	185 €/GJ
C25 - Mfr. of fabricated metal products	329 €/GJ	151 €/GJ
C28 - Mfr. of machinery and equipment n.e.c.	420 €/GJ	451 €/GJ
F - Construction	116 €/GJ	75 €/GJ

Furthermore, the final energy consumption profile per type of SME has been modelled, using NACE classification and the statistical data on fuel disaggregation. In Figure 2 and Figure 3 a graphical representation of the final energy use (energy consumption profile) in Slovenian reference small SME (10-49 employees) and reference medium SME (50-249 employees) for the selected branches is presented. Model is based on data from 351 small SMEs and 276 medium SMEs from the selected branches in Slovenia. The companies that have less than 10 employees (micro companies) are not included in this category, due to not being obligated to report the energy consumption to the national statistics authority.

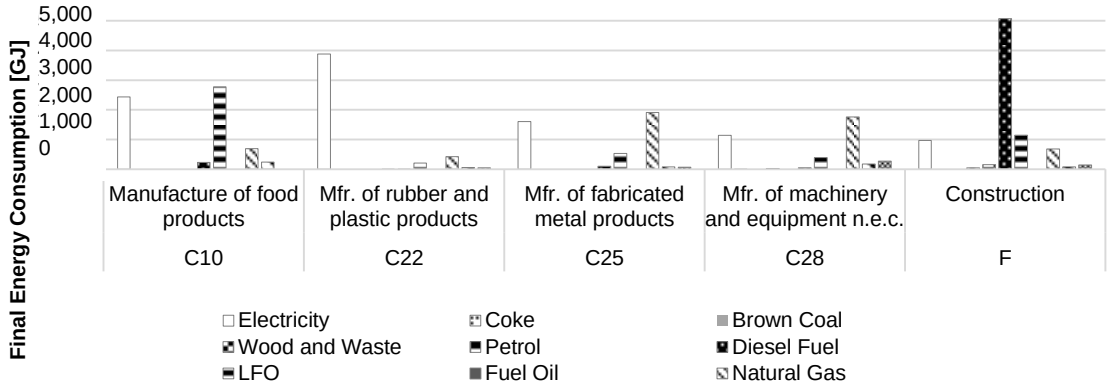

Figure 2: Energy Consumption Profile for reference small SME for branches C10, C22, C25, C28 and F

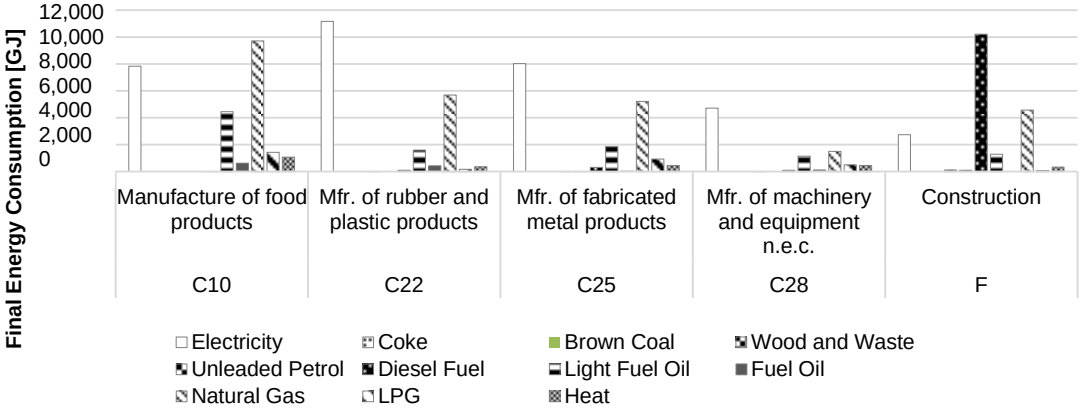

Figure 3: Energy Consumption Profile for reference medium SME for branches C10, C22, C25, C28 and F

Statistical benchmark indicators were used in the process of developing a prototype of the 3EMT tool providing a structure for comparing the sustainability performance of SMEs by branch through indicators that are supported by the national or local statistical data.

4. Conclusion

This contribution presents the structure and the methodology of 3EMT tool, developed for the sustainability assessment of SMEs. The 3EMT tool prototype has been developed taking into account the importance of resource, environmental and economic activities of SMEs. A set of normalised quantitative indicators has been proposed, having in mind the availability of energy related data within SMEs and the significance of the represented information. By using the normalised quantitative indicators, national/regional statistical benchmark indicators, corresponding SME energy consumption profiles and innovative scoring techniques presented in this paper, assessment of different sustainability levels of Central Europe SMEs is enabled. Data collected through the 3EMT tool can be used by policy makers to tune existing and develop new policies, incentive schemes and regulations in order to favour cleaner consumption and production patterns at the national and local level. By increasing responsible energy use and addressing overall efficiency on the company level with the 3EMT tool the SMEs environmental and competiveness potential can be fully reached, paving the way for achieving the EU "20-20-20" targets. Future research challenges are related with the generalisation of national and regional statistical data related to energy use in SMEs. Also, further work in order to improve and fine tune the 3EMT tool is recognised as an area for future research. Prototype testing and validation has already started on the targeted 500 SMEs from Central Europe countries, namely Slovenia, Austria, Italy, Hungary and Czech Republic. However, the success of the follow-up and fine tuning process largely depends on dedication and commitment of the SMEs and their willingness to sustainably change established patterns of energy consumption.

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