Sustainability Criteria for standardisation of noise reducing devices

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Invited Paper

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ABSTRACT

This paper presents an overview of generic database of sustainability criteria values for a range of noise reducing devices (NRDs) for surface transport developed as part of the research carried out in the EU project "Quietening the Environment for a Sustainable Surface Transport" (QUIESST) (1) and how these criteria can be used for sustainability assessment of noise barriers standards.

The NRD Industry has been involved in this research and NRD's manufacturers have always shown a great interest in sustainability assessment. This is coupled with the new Construction Product Regulation (305/2011/EU -CPR) (2) that came into force in July 2013 that promotes a new approach in products qualification based on the declaration of performance against seven essential requirements.

Sustainability has been specifically addressed with the new 7th basic requirement, '*sustainable usage of natural resources'*. The method developed within this research is used to define evaluation procedures to meet sustainability as the 7th basic requirement as part of new standards.

Keywords: Noise barriers, sustainability, standards.

1. INTRODUCTION

There is a recognised need to move towards more sustainable usage of natural resources to address issues such as resource availability and management, climate change and resilience. The use of resources will be determined by the availability of such resources into the intended environment along with the approach taken towards sustainability, which may itself depend on a number of factors, as seen from the range and variety of definitions that have been deployed over time. Decisions may then be based around a range of knowledge-based parameters such as the availability of a resource or the priority of any desired action as well as overarching requirements, as for instance to minimise costs or environmental impact.

NRD are a growing part of Europe's transport infrastructure: a key objective of the Commission of the European Communities' White Paper on European transport policy (COM (2001)370) (3,4) was to promote the sustainability of surface transport and its respective Infrastructure. It is important to consider the sustainability of noise reducing devices for use at the road or track side at all stages of the products useful life from design to decommissioning and disposal. This consideration requires to define what sustainability means and how can it be assessed. One approach to expressing sustainability is that of the triple bottom line (TBL) approach, also known as "*people, planet, profit*", which seeks to encapsulate an expanded spectrum of values and criteria for measuring organizational (and societal) success: economic, ecological and social. With the ratification of the United Nations and ICLEI TBL standard for urban and community accounting in early 2007, this became the dominant approach to public sector full cost accounting. Similar UN standards apply to natural capital and human capital measurement to assist in measurements required by TBL, e.g. the ecoBudget standard for reporting ecological footprint. The ratification mentioned above underlines the importance of embedding sustainability in the standardization process.

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The definition that was used in this research is the following: **'The optimal consideration of technical, environmental, economic and social factors during the design, construction, maintenance and repair, and removal/demolition stages of NRD projects'** (Oltean- Dumbrava et al, 2012) (5). The problem is not a minor one when one considers the size of typical projects which have to incorporate the complexities of the designing task, the enormity of construction work, as well as the resources required to maintain and eventually remove NRD once they have reached the end of their life cycle. NRD can use as much resources and have as much of an impact on the built environment as many other large built structures and can run into millions of Euro in costs.

The main sustainability factors to be evaluated in this case can be grouped under social, technical, environmental and economic. Under each factor there are a number of key sustainability criteria for which information need to be collected.

2. DETERMINING THE SUSTAINABILITY CRITERIA FOR NRDs

2.1 Research Methods - Criteria

A number of approaches were employed to gather information on relevant criteria values. In addition to carrying out a review of the literature, a mixture of discussion meetings, semi-structured interviews, circulation of the database, and exchange of emails with key players in the NRDs industry, were carried out by the authors to ensure scientific rigor when consulting with the industry (6 to 9).

2.2 Social Criteria

There was little published information on the social criteria values. A survey questionnaire was developed to aid the process of collecting 'opinion based' data on each type of NRD. The questionnaire was specifically sent to selected respondents, a total of 30, which included: leading design engineers/consultants, academics, public authorities, contractors, authors of EN standards and design guides/ books related to NRDs, asset managers involved with NRDs, and selected QUIESST partners. Despite the relatively small number, the group of respondents can be viewed as a multi-disciplinary group of high level experts involved with all the main NRD types. Therefore, the opinion of this group is given a high weighting in comparison to gaining a large number of responses from non-key players who may well lack the necessary specialist knowledge to provide informed opinions. However manufacturers and suppliers of a particular NRD type were purposefully omitted from consideration. A potential conflict of interests and major bias was foreseen with this particular stakeholder group in providing qualitative judgment for each main NRD type, which could skew the results obtained. This approach necessarily reduced the pool of respondents but was justified by the aim for a high quality and reliable data set.

2.3 Technical Criteria

The defined technical sustainability related indicators refer mainly to the material properties and technical performance of the main NRD types over their whole life. The acoustical/technical performance is the most widely researched aspect of NRDs, and so much disjointed and disparate data exists on the various types of NRD. In conjunction to carrying out a review of the literature, a mixture of: discussion meetings, semi-structured interviews, circulation of the database, and exchange of emails with key players in the NRDs industry, were carried out by the authors to ensure scientific rigor via consulting with the industry. Manufacturers, specialist contractors and suppliers of the main NRD types were specifically targeted as they were considered most likely to have the relevant data. Additionally, records of compliance to the relevant EN standards related to NRDs (EN 1794 parts 1 and 2, for example (16,17)) were also considered to be major sources of technical data for the main NRD types.

2.4 Environmental Criteria

The methodology as set by the French Standard NF P01-010 (20) about life cycle analysis of building products was carried out. Semi structured interviews, discussion meetings, telephone interviews, and exchanges of emails with the relevant stakeholders and QUIESST partners were carried out, and the relevant literature was consulted to determine the necessary generic boundaries and assumptions for the Environmental Life Cycle Analysis (ELCA) for each main NRD type. The method has been implemented however a number of assumptions were made in order to feasibly conduct the ELCA study.

These are:

- The ELCA is only a part of a 'cradle-to-grave' assessment
- Results of the ELCA relate only to the production stage and give the masses of materials used for the construction of each type of NRD
- From generic cases (and specific examples for noise barriers), the masses necessary to conduct an ELCA have been calculated per square meter of the NRD
- Volumes of materials used for the production of each NRD types were provided by a noise barrier consultant who was a partner in QUIESST
- Production of each material needed for the NRDs assembly was assessed however processes to manufacture the NRD and to assemble the materials together are not fully considered
- Transport values are calculated for an average lorry of 20-28 tones capacity
- Installation processes have not been taken into account in this modeling
- Maintenance has also been neglected
- Timber has been considered as a dangerous waste due to its treatment for decay and fungi.
- The end of life waste treatment of the main NRD types has been considered to evaluate its disposal
- Materials for energy recovery, recyclability potential and re-use potential have been roughly calculated as a proportion of materials within the NRD

Note that despite the gaps in including certain processes and life cycle stages, the set of assumptions were developed in consultation with a multi-disciplinary team of experts involved in the QUIESST project and so are sufficiently robust to indicate the likely environmental impacts.

2.5 Economic Criteria

There was no research into the whole life costs of all the main NRD types carried out before. After categorising the economical criteria into either what is possible to provide on a per NRD type basis or is site/system specific (for example the reduction in property prices due to the placement of the NRD is clearly only assessable at the site level), it is evident that many of the criteria align with the typical criteria considered in conducting a Life Cycle Cost Analysis (LCCA). Indeed, many of the economical criteria defined for assessing the economic sustainability of NRDs aims to assess the economical performance of NRDs across its whole life. Therefore, it was decided that the best and most efficient method to generate the necessary generic information for the planned database was to conduct a LCCA per main NRD type. The LCCA method provided a structured means to assess the costs of products and projects over the whole life cycle. Incidentally, the results also provided the basis for a tentative comparison, given that the assumptions are similar. The method involved a simplified LCCA approach which considered the following primary criteria: capital costs, operation, maintenance, and demolition/removal costs. Semi-structured interviews, discussion meeting, telephone interviews, and exchanges of emails with the relevant stakeholder and QUIESST partners were carried out, and the relevant literature was consulted to determine the necessary generic boundaries and assumptions for the LCCA per main NRD type. The method has been implemented and consequently a number of criteria were concurred in order to feasibly conduct the LCCA study, given below:

- Cost of land per unit is the same for all NRD types
- Design costs per unit is the same for all NRD types
- Length of all NRD types = 500m
- Barrier height = 4m
- Module length (distance between posts) = 3m
- For tunnels, cover road width = 21m

A detailed overview of the various construction, maintenance, and removal related processes and costs considered per NRD type and additional information relating the generation of income was also carried out. Table 1 shows the resulting 22 sustainability primary criteria defined for NRD. These '22 primary criteria' respectively highlight all the major issues to consider, and so assess, across each sustainability factor. In total, 141 criteria form the complete sustainability hierarchy for NRD, of which, 92 are directly measurable. The TDBU research results highlighted a general consensus amongst the stakeholders in supporting the initial set of sustainability criteria, whereby 93% of the total proposed criteria were rated as 'moderately important-very important' by the stakeholders.

Table 1 - Summary of sustainability factors and primary criteria ranked in order of importance

Sustainability Factor	Primary Criteria
Technical	Material selection
	Buildability/constructability
	Flexibility and adaptability
Environmental	Energy
	Land use
	Air quality and climate change
	Flora and fauna
	Water
	Waste
Economic	Life cycle cost
	Green value
	Financial sources
	Compensation cost
	Effect on local residential/commercial property prices
	Contractual and procurement type
Social	Safety and security
	Health and well-being
	Severance/separation
	Social acceptance
	Architectural design and local context
	Community engagement
	Local employment and engagement with local business

However, it should be noted that **optimising a particular criterion in isolation, e.g. cost and technical performance, does not necessary increase the sustainability of NRD projects**. Indeed, it is the combination of the outcome of *all* measured criteria in relation to each other in an equitable way within the defined sustainability framework which shows the relative sustainability of the project as a whole. Multi Criteria Decision Making (MCDM) tools offer one viable approach to assessing multiple NRD sustainability criteria in conjunction with each other in an unbiased way to generate an index value to denote overall sustainability performance.

3. BENEFITS OF NRD SUSTAINABILITY ASSESSMENT: THE STANDARDISATION PROCESS

3.1 Overall Benefits of the NRD Sustainability Research

NRD manufacturers have always shown a great interest in sustainability assessment (8,10). As a consequence a "green" approach is often present in procurement and installation of solutions and products to fit an environmental need. **Asking for sustainable products without a common and reliable method for sustainability assessment, may lead to confusion on the market and distortions in competition**. A harmonised and reliable method in product sustainability evaluation is then the first benefit expected by NRD Industry.The implementation of product and systems for noise reduction always implies a complex and long process involving all major sustainability aspects. Various social implications clearly emerge in the early design phase; technical aspects and the whole life cycle costs are to be considered during design, procurement and installation activities and environmental friendly materials are always preferred.

A second important benefit for the market is represented by the possible enlargement of similar approach to the NRD related industrial sectors. The lack of a common assessment methodology has been the reason for a different concept of sustainability across Europe.

In northern Europe, **social** and **environmental** aspects are always dominating factors in NRD choice: NRDs may even been rejected if they do not properly address issues such as respect of the environment or acceptance from the residents. On the other way, in southern Europe, design and construction phases have often been driven by **technical** and **economic** matters.

That is why all four factors will have to be considered throughout the whole lifecycle of NRD. It is to be remarked that common methods and approaches do not necessarily sacrifice needs emerging from different cultural and social backgrounds in various European countries. Criteria have been defined through a data collection performed in different counties. They are likely to cover the full range of criteria being used in decision making process. Weighting factors introduction allows for a flexible approach in sustainability evaluation.

At present, **industry training is required to promote the message of developing and implementing low carbon and sustainable strategies for NRD projects, and also for sustainability assessment using selected NRD sustainability criteria**. As such, there is scope to create jobs by providing this training to close this existing gap in the knowledge base for the NRD industry.

The NRD Industry has been asked to face new challenges regarding product qualification and testing against legislation and standards. The new Construction Product Regulation (305/2011/EU -CPR) that is in force since the second half of 2013 is promoting a new approach in products qualification based on the declaration of performance against seven essential requirements. With respect to the previous Construction Product Directive (89/106/EEC - CPD) some relevant new challenging requirements have been included. Sustainability has been specifically addressed with the new 7th basic requirement (Table 2).

Table 2 – New requirements of the Construction Product Regulation (CPR) 305/2011/EU

CPD	CPR
1- Mechanical resistance and stability	1- Mechanical resistance and stability
2- Safety in case of fire	2- Safety in case of fire
3- Hygiene, health and the environment	3- Hygiene, health and the environment ***throughout the life cycle + safety of workers***
4- Safety in use	4- Safety and **accessibility** in use
5- Protection against noise	5- Protection against noise
6-Energy economy and heat retention	6-Energy economy and heat retention **Energy efficiency of construction work during construction and dismantling**
	7-Sustainable use of natural resources

3.2 Standardisation

A lot of work is needed to define common harmonised standards for all products in different fields of construction activities. Given that (road) NRDs are considered as "road equipment" (while railway noise barriers are considered as part of "track equipment"), they are already covered by approved harmonised standards as the product standard EN14388 (15) and the supporting standards as EN14389-1 and EN14388-2 (16,17) (new standards are also on the way for railways). Updating of the existing standards is then foreseen and the method developed within the QUIESST research project will be an essential aid to define evaluation procedures to meet sustainability as the 7th basic requirement. The NRD industry will benefit for coming first on the market with a full set of standards. A similar approach can then be propagated to railway noise barriers.

The development of standards for the sustainability assessment of products introduced into the market not only will help the NRD Industry, but will also be a an essential tool for Public Authorities and Road Managers when implementing Public Procurement techniques.

Overall, the work presented will allow for a universal approach to assessing the sustainability of NRD projects that will be consistent with the overall global transport sustainability agenda. Within the targets and the scope of the Industrial Associations involved in the present standardisation work, the implementation and dissemination of sustainability assessment methods is a priority. The NRD market is expected to strongly increase in Eastern European Countries and outside Europe where transport infrastructures projects are being developed. In western part of the continent NRD will represent an important item in existing infrastructure, e.g.: for refurbishment plans.

CEN/TC 226 ("Road Equipment" Technical Committee) recently decided to include it in its Working Plan. The first author of this paper was appointed Liaison Officer with CEN/TC 350, (Sustainability of construction works), to advise how sustainability aspects can be included in road circulation products standardisations.

CEN/TC 226 WG6 (working group on NRD) is the first TC 226 working group that has created a specific task group (TG4) entirely dedicated to Sustainability. This group recently started a preEN standard that will look at the general aspects of sustainability assessment for NRD: papers will be published in scientific reports as soon as relevant progress will be available.

4. CONCLUSIONS

In order to assess the sustainability performance of NRD, this paper presented relevant sustainability factors and primary criteria. Broadly speaking, the criteria can be rated from "moderately important" to "very important". These rankings will inform, but not constrain the assessment of the overall sustainability of NRD projects.

For assessing the overall sustainability of NRD project options, a clear multi-criteria decision making system (MCDM) for comparing all criteria in relationship to each other is required.

Work has now started to move from criteria and indicators to standardisation of sustainability aspects. This is task will require substantial collaboration with the industry and manufacturers.

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