CHEMICAL ENGINEERING TRANSACTIONS
VOL. 89, 2021
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.cetjournal.it
Guest Editors: Jeng Shiun Lim, Nor Alafiza Yunus, Jiří Jaromír Klemeš

ISBN 978-88-95608-87-7; **ISSN** 2283-9216
DOI: 10.3303/CET2189040

Review of Eco-friendly Guidance of Transport Infrastructure: Korea and the World

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Korea had a big ambition to be one of the most sustainable cities, so the government is paying more attention to environmental impacts as a key element in evaluating any transportation project, such as subway construction and extension. Compared to other transportation modes, the railway system provides significant environmental, economic, and social benefits, and it is considered a key factor to attain the 2050 vision of 'European Green Deal', which targets cutting the greenhouse gases' net emission, achieving social equity, and ensuring the separation of economic growth from resource usage. Australia has enforced the 'Environment Protection licenses' in railway using special authorities that impose the respect of all environment licenses during both construction and operation stages. In Korea, despite the enforcement of environmental protection, regulations are lacking at the construction stage, where a qualitative approach is adopted to measure the environmental impacts. During the feasibility study, the Korean guideline adopts a quantitative approach and focuses on the measurement of air and noise pollution and accident reduction. Developed countries insist on considering other environmental impacts related to health, biodiversity, and wildlife (Europe, United Kingdom, and Australia).

1. Introduction

Transportation's sustainability becomes the worldwide target, especially with the recent sharp increase in urban population and trip activities, and with the transportation sector being one of the most contributors to environmental pollution. US Environmental Protection Agency (US EPA) (2019) that transportation is the highest contributor to greenhouse gases with a percentage of 29 %, followed by electricity with 25 %. To mitigate this issue, cities have been trying to encourage sustainable mobility and limit private vehicles, through several policies such as Transportation Demand Management (TDM), and environmental regulations. Railway proved significant environmental and social benefits, as it provides fast, reliable, and comfortable service, and contributes to relieving road congestion and traffic emission. European Commission assumes that the railway systems play a key role in achieving its 2050 vision of 'European Green Deal' (EuC, 2019), to eliminate the net emission of greenhouse gases, to realize social equity, and to ensure the separation of the economic growth and resource use. Abbasi et al. (2013) confirmed that the rail emissions are much less than the road, air, and sea transportation, but insisted on the presence of toxic effects within the rail traffic environment. Cities, worldwide, are tempting to provide guidance and orientation bases for railway project construction and operation. The Korean guideline enforces the consideration of environmental costs at feasibility studies (KDI, 2017). Kim et al. (2018) studied the feasibility of these guideline. This guideline has been developed by Korea Development Institute (KDI), which plays a key role in developing and setting Korea's long term economic plans, while collaborating with both public and private sectors. Developed countries consider health, biodiversity, and wildlife impacts consideration in infrastructure projects studies, railway systems included, through different regulations and policies, such as the Environmental Impact Assessments (EIA). Transportation infrastructure projects, such as railways, contribute to social and economic growth and prosperity (Eddington, 2006). Kennedy et al. (2005) provided four conditions to attain sustainability in transportation: good management of transportation and land use, fair and efficient financing system, infrastructure strategic investment, and good management for neighborhood projects.

Paper Received: 1 July 2021; Revised: 7 August 2021; Accepted: 5 November 2021
Please cite this article as: Bencekri M., Ku D., Kwak J., Kim J., Lee S., 2021, Review of Eco-friendly Guidance of Transport Infrastructure: Korea and the World, Chemical Engineering Transactions, 89, 235-240 DOI:10.3303/CET2189040

2. Eco-friendly guidance

Recently, and due to the increase in travel demand, as well as the global warming threats, transportation policy should emphasis on the environmental aspects of transport infrastructure. The development of a sustainable transportation system is the key solution. This study investigated the practices and procedures introduced around the world regarding the enhancement of the sustainability of transportation infrastructure projects, such as the railway system. The railway system has proved its ability to enhance the city's economic and social development, by increasing accessibility and connecting (Zhang et al., 2014).

In Europe, the European Commission (EuC) strengthened the environmental assessment with the important environmental effects since 1998 (Hoyos and Bueno, 2016). The EuC represents the organisation responsible for executing European Union's vision and goals, as well as proposing adequate recommendations and policies. The EuC has put a target of reaching 10 % of renewable energy sources in transport by 2020. Most European countries could not achieve the set target, and for this reason, the railway projects were given priority in transport infrastructure. The Organisation for Economic Co-operation and Development (OECD) incite countries at considering both the direct and the indirect impacts of the environment and wellbeing and stressed the need to ensure the social benefits of infrastructure projects.

2.1 Eco-friendly guidelines in Korea

The Korean Ministry of Strategy and Finance's Preliminary Feasibility Study of Public Enterprises and Quasi-government Agencies (2020.04.29) established an environmental feasibility procedure of public projects. The concept of sustainable development, which has recently become important, is largely attributable to the recognition of the environmental impacts of development projects. Environmental sustainability has been suggested in the need to promote a balance between the development benefits and the impacts resulting from the environmental damage.

In Korea, even though the social awareness of environmental problems did not get equal attention as in Europe or Australia, the importance of environmental preservation is rising both at the individual and public levels. From this perspective, the government environmental review is recommended to outline the environmental impact, and investigate and analyze the natural environment, living environment, and socioeconomic environment of the projects' surrounding area. The focus of the environmental assessment is to determine whether to implement the project in advance by recognizing the possible environmental problems after the feasibility study. It is also intended to encourage in-depth analysis by examining the possibility of post-environmental problems. Generally, projects inevitably cause environmental problems such as air and noise pollution, water and soil pollution. The environmental damage during the construction stage is not included in the Korean guideline quantitative analysis, Korea adopts a qualitative approach instead. The environmental damage assessment includes the cost of the scattered dust, equipment noise, water and soil pollution, and construction waste. Both the measurement and mitigation of construction environmental damage follow a qualitative approach, based on the subjective procedure. To minimize these damages, the following policies are adopted: installation of wheel and car washing facilities, implementation of spray, installation of dust-proof facilities, installation of sediment and drainage channels, proper disposal of generated waste, and reduction of noise and vibration.

For the feasibility stage, the Korean guideline includes both air and noise pollution is considered in cost-benefit analysis. Korean guidelines provide units for different emitted gases: carbon monoxide (CO), nitrogen oxide (NOx), particulate matter (PM), volatile organic compounds (VOC), and carbon dioxide (CO_2), based on the EuC standardization, and recommended applying the basic units differentially according to the population density and the regional characteristics. The guideline specified that in the case of the railway system, where a significant number of short-distance conversions can occur, the generated emissions, when a vehicle's temperature is below 70 °C, must be considered in the analysis, in railway projects additional cold start emissions reduction should be reflected.

The following Eq(1) to Eq(8) are the adopted quantitative methods to calculate air pollution and noise pollution for transportation projects. To calculate the air pollution reduction benefits of the project, the following Eq(1) and (2) have been considered:

$$VOPCS = VOPC_{Before} - VOPC_{After} \quad (1)$$

$$VOPC = \sum_l \sum_{k=1}^{3} (D_{lk} * VT_k * 365) \quad (2)$$

In Eq(2), k is vehicle type (auto, bus, freight). D_{lk} is traffic volume by link(l), by vehicle type(k). VT_k is Air pollution cost per km of the link speed by vehicle type(k).

For the calculation of the noise pollution reduction benefits of a project, the guideline first, distinguished the noise level of several types of infrastructure projects.

First, for the areas over 10 m from the road edge, the noise pollution calculation; the Eq(3) has been considered:

$$L_{eq} = 8.55 \log\left(\frac{QV}{l}\right) + 36.3 - 14.1 \log(\gamma_a) + C \quad (3)$$

In Eq(3), Q is equivalent traffic for 1 h. V is average speed. l is the distance from the virtual driving centerline to the end of the road. γa is Distance ratio (the ratio of the distance to the predicted point 10 m or more away from the road edge to the standard 10 m distance). C is a constant.
Second, on the highspeed national highways, the noise pollution could calculated following the Eq(4) and (5):

$$L_{eq} = PWL + 10 \log\left(\frac{1}{4*d*s}\right) + \Delta L_i + a_i + ad \quad (4)$$

$$PWL = 73.4 + [20\log(V) = 10\log(\mathrm{a1} + 3.8 * \mathrm{a2})] \quad (5)$$

In Eq(5), a1 is a small car incorporate rate and a2 is a big car incorporate rate. The sum of a1 and a2 is 1. ΔL_i, a_i and ad are correction value of road traffic noise
Finally, on railroads, for the noise pollution calculation, the following Eq(6) has been considered:

$$L_{eq} = \overline{L_{max}} + 10 \log\left(\frac{n*T_e}{T}\right) - 15 \log(r_s) \quad (6)$$

In Eq(6), $\overline{L_{max}}$ is the average power of the highest noise level on the passage of an individual train. *n* is the number of trains per operation time. T_e is the maximum noise duration per train per second. *T* is operation time per second. R_s is the ratio of the predicted distance on the reference distance.
Accordingly, the noise cost savings are calculated using the following Eq(7) and (8):

$$VONCS = VONC_{Before} - VONC_{After} \quad (7)$$

$$VONC = \sum_i \sum_j P * l_{ij} * L_{ij} \quad (8)$$

In Eq(8), *P* is the basic unit of noise cost. L_{ij} is the target route extension length. L_{ij} is the predicted noise level for the target route extension length. *i* is the Classification of roads and railways (general road, high-speed national highway, general railway, high-speed railway, etc.). *j* is the link length within the area of influence.
Korea has introduced the Environmental Impact Assessment (EIA) intending to review, predict, and assessing the environmental impacts of a project, to design adequate measures to limit or relieve the adverse effects introduced by that project. The Korean government has established a dedicated organization for the EIA studies the K-eco specialized agency, which conducts EIA investigations.
The EIA studies are mainly used for creating comprehensive management of the post-implementation impacts of a project on the environment. The EIA is forced by Korean law, and it should be conducted according to the following principles (Article4, Environmental Impact Assessment Act): ensuring the achievement of the sustainable development; measuring the economic impact within the extent economically and technically practicable, based on scientific surveys and forecasts; informing the concerned residents of the project plan, and including them in the assessment process; facilitating the EIA investigation results to residents and decision makers.
The following Figure1 describes the whole process of the Korean social care and environmental impact, which shows a rigorous follow-up and control prior and during the project to monitor the social and environment impacts. Although the Korean EIA is enforced by law (the Environmental Impact Assessment ACT), it is not applied for all projects, as it is mainly for city development, industrial complexes, energy projects, and waste management facilities.
Moreover, in the Korean context, wider impacts are not considered in the feasibility study of projects. The wider impacts include social and health impacts, the impact on economy (consumption, economic activities, etc.), and biodiversity impacts. Wider impacts consideration during project appraisal was debatable topic, but it gains an increasing popularity within developed countries such as Australia (Australian Transport Assessment and Planning, ATAP), New Zealand (Economic Evaluation Manual, EEM), and the UK (Web-based Transport Analysis Guidance, WebTAG). The two guidelines WebTAG and EEM are considering the wider economic benefits as additional benefits to the benefit cost analysis (BCA). In particular, WebTAG includes noise, air quality, urban landscape, physical health and reliability. The ATAP guideline do not include wider impacts in the BCA, but they are accorded key importance in decision making process. The OECD analyses the benefits in various aspects by reflecting the benefit of passenger and environmental benefits. Also, to calculate the health benefits, The World Health Organization (WHO) uses HEAT (Health Economic Assessment Tool), and the Transport for London (TfL) uses SART (The Sickness Absence Reduction Tool). Both methods analyze the effect of increased physical activity. HEAT measures the effect of reducing mortality (Kahlmeier et al., 2017) and SART measures the effect of reducing the number of days of absence (Transport for London, 2015).

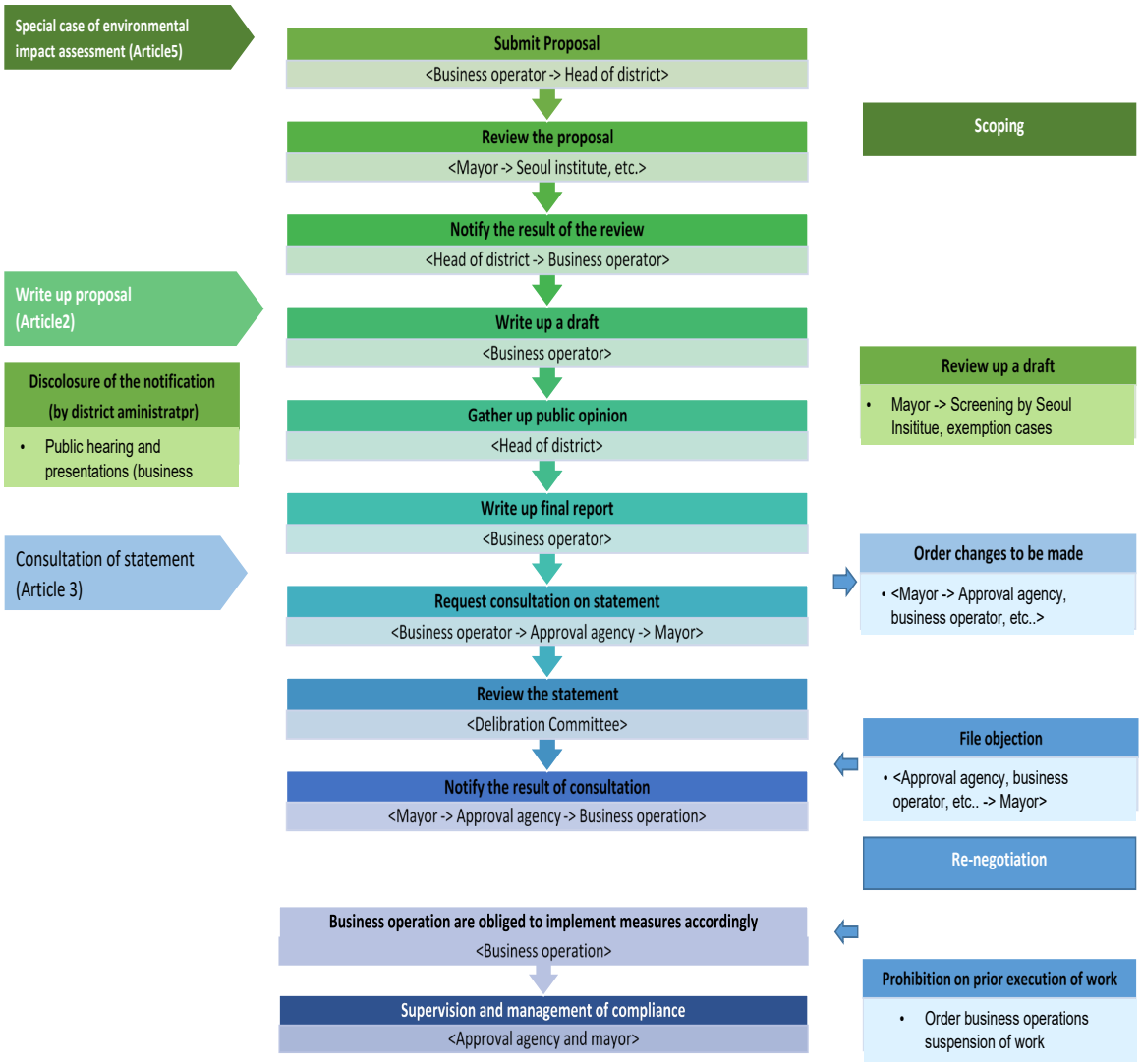

Figure 1: Korea Environmental Impact Assessment Process (Seoul Solution, 2015)

2.2 Eco-friendly guidelines globally

All countries' infrastructure projects are first authorized base on an appraisal study. An appraisal study is a tool given to decision-makers, which is often based on a cost-benefit analysis (CBA) or multi-criteria decision analysis (MCDA). With the rising issue of climate change, many countries include environmental consideration tools, but the tools are not mandatory and not well developed. European Commission strengthened the implementation of a Life Cycle Assessment (LCA) for evaluation green-product, transportation-related are included (Zampori et al., 2016), and for extracting useful recommendations and conclusions on projects.

The LCA is not only applicable in Europe but many other countries around the world. In transportation, the LCA identifies the direct and indirect effects, in term of energy use and traffic emissions, set goals, and form policies to achieve these goals (Regional et al., 2014). The LCA is considered a developed version of the EIA, by not only considering emissions from the construction and operation stage but also include a comprehensive list of impacts associated with a prospective or past project, considering the life cycle process as a whole (Regional et al., 2014)

Wider Economic Impacts (WEI) benefits have gained immense popularity recently, especially with the rise of active mobility modes, such as cycling, where the cost-benefit analysis is seen as bias against them (Sellittoa et al., 2013). The WEI is an important element to be considered in addition to the traditional CBA, as it is considered as the change of impact that is supplementary to the user benefits or an induced effect that shapes economic performance (Oxera, 2014). The WEI measure reflects the impacts on the economy that arise because of market failures or imperfections, additionally to traditional user benefits.

Countries such as New Zealand, Australia, and the UK include the WEI benefits in their project appraisal, so active mobility projects could raise in competitive to traditional road infrastructure, and environmental benefits are strongly reflected and considered in the decision-making process. Douglas and Brooker (2013) showed that Australia's larger transport projects factor traditional benefits raised by 10 % to 20 % while including the WEI benefits. UK's WebTAG (the web-based transport appraisal guidance for England) is an evaluation procedure in form of a software and policy guideline for any infrastructure project. It covers both business case development and investment decision. WebTAG considers the landscape while measuring the environmental impacts in infrastructure projects. The Australian Transport Assessment and Planning (ATAP) Guidelines are presented as an infrastructure planning tool and decision support framework. It is also a web-based guideline and outlines the best practice. In Australia, a project proposal should reach its jurisdictional objectives, and has to prove that the project's value for money is beneficial to the community. Although the guideline presents a powerful decision-making tool, it focuses mainly on transport planning and assessment, while neglecting the operational aspect of transport such as traffic management. The ATAP considers energy conservation in addition to pollution reduction for environmental analysis. In New Zealand, the Economic Evaluation Manual is implemented, where benefits are divided into market goods and non-market goods. The environmental benefit is included in the benefits of the non-market good, as profit items that can be evaluated relatively are classified according to cultural, visual, and ecological influences. Health benefits or external effects that were reflected as Wider Benefit in the UK and Australia are classified as individual benefit items, but in New Zealand, the benefits are reflected according to the type of transportation infrastructure project.

2.3 Comparison summary

By comparing Korea measures and legislation with the rest of the world in term of environmental assessment policies, this research provided a summary table that compare the environmental assessment methods at the construction stage as well as at the feasibility study stage between Korea and other developed countries (Table1). Then, the research highlighted the advantages and disadvantages of Korean eco-friendly measures provided in KDI guideline (Table 2).

Table 1: Project environmental assessment (Korea and the world)

Project Stage	Korea	Some Other Countries
Construction stage	Qualitative approach to measure environmental damage - The construction period is long (5-7 y), and the environmental treatment measures that occur during this period are to simplify the evaluation. - A subjective treatment plan that could not represent the real costs - Only assessing dust, noise, soil, and water pollution, as well as construction waste	The Environmental Life Cycle Analysis (ELCA) is adopted for transport projects and includes the environmental assessment during the construction stage. The ELCA adopts a quantitative approach to measure. Example of adopting countries: UK, Australia, Europe
Feasibility Study	Considers air pollution costs (greenhouse gases: CO, NOx, PM, CO_2), and noise costs	Wider Impacts are considered, such as health, biodiversity, and wildlife impacts of the total project (Europe, Australia, New Zealand, UK)

Table 2: Advantages and disadvantages of Korea eco-friendly guideline

Category	Elements
Advantages	- The detailed quantitative calculation method to measure the environmental impacts in terms of greenhouse gases and noise pollution during the feasibility study. - Consider environmental damage during the construction period. - Differentiate between projects type (rail, road, intersection, etc.) in the calculation method.
Disadvantages	- Qualitative method for the construction environmental damage => subjective and easy to mislead decision makers. - The nonenforcement of the EIA for transportation projects. - The non-consideration of the wider impacts during the feasibility study. - The nonenforcement of the ELCA for transportation projects.

3. Conclusions

The Korean government has enforced a strict policy to reflect environmental impacts during the feasibility study and the construction stage. The adopted approach during the construction stage is the qualitative method, which results in the lack of accuracy of the provided measurements. The feasibility study adopts a detailed highly accurate quantitative method to calculate noise and air pollution, as well as accidents cost, but the Korean guideline does not include the wider impacts, such as health, biodiversity, and wildlife impacts, which have huge and significant impacts on the environment. The introduction of the Korean Environmental Impact Assessment (EIA) Act could a little compensation for the absence of wider impact, but this act is mainly a post-implementation evaluation procedure.

Acknowledgments

This study was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2017R1D1A1B06032857).

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