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Knowledge-based minimization of railway infrastructures environmental impact

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Abstract

Life Cycle Assessment (LCA) and intelligent data analysis can help in reducing carbon and water footprints of rail infrastructure construction projects. The goal is to improve the railway construction processes with regard to their environmental impact, mainly in those aspects related to climate change such as carbon and water footprints.

Based on a set of 27 indicators of every task in the construction process, a comprehensive compilation of basic information was performed, where the main project units and their sub-tasks were reviewed and analyzed.

Afterwards, focus was on analyzing the transformation from environmental impact to carbon and water footprints, by means of the development of a consolidated evaluation methodology. A tool is being developed based on data mining and computational intelligence approaches. It will allow knowledge-based alternative project units scheduling, conditioned to previously selected specific footprint values and environmental indicators. This decision support system (DSS), based on multi-criteria and multi-objective intelligent optimization algorithms, will help to reduce carbon and water footprints of rail infrastructure construction projects by around 10% and 5%, respectively.

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Tests are going to be performed on two real high speed railway construction projects. That way, a global search procedure provides an analysis of the best alternatives in the scheduling and execution of the project units and their environmental impact offering a front of solutions displaying different trade-off amongst several 'footprints'.

Results will allow the development of a series of environmental impact indicators, which will support rail infrastructure construction companies becoming more sustainable and efficient by minimizing their environmental impact.

1. Introduction

Life Cycle Assessment (LCA) techniques, combined with intelligent analysis of data coming from rail infrastructure works, is helping to reduce their carbon and water footprints. The goal is to improve the rail infrastructure construction processes with regard to their environmental impact, mainly in those aspects related to climate change like carbon and water footprints and other environmental indicators. This is a rising trend, as illustrated by Botniabanan AB (2010) environmental product declarations (EPD) of railway infrastructures.

At a fast pace, water footprint of a process or infrastructure is getting relevant, due to scarcity of this natural resource. This paper presents a pioneer study on this matter, because no other reference about water footprint of rail infrastructures has been found on the specialized literature. The study here described is aligned with the European Water Initiative, EUWI (2002), fostering a correct water resources management. Also social impact estimation of rail infrastructures is a novel approach.

A threefold (environmental, economic and social) in-depth analysis has been performed on railway infrastructure project units. A multi-objective optimization has been performed on these three values, in order to find a trade-off solution for project units scheduling.

This paper is organized as follows: Section 2 describes the problem related to environmental and social impact of rail infrastructures' construction. Section 3 explains the proposed methodology. The analysis of some preliminary results is shown in Section 4. Finally, the main conclusions and further work and research are outlined in Section 5.

Table 1. Kilometers of high speed lines in Europe, source UIC (2011).

Country	In operation	Under construction	Planned	Total country
Belgium	209	0	0	209
France	1,896	210	2,616	4,722
Germany	1,285	378	670	2,333
Italy	923	0	395	1,318
The Netherlands	120	0	0	120
Poland	0	0	712	712
Portugal	0	0	1,006	1,006
Spain	2,056	1,767	1,702	5,525
Sweden	0	0	750	750
Switzerland	35	72	0	107
United Kingdom	113	0	204	317
Total	**6,637**	**2,427**	**8,705**	**17,119**