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Evaluating the environmental performance of the high speed rail project in the Basque Country, Spain

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A B S T R A C T

This paper analyses the contribution of the high speed rail project in the Basque Country, Spain, to energy consumption reduction and to climate change mitigation by means of a simplified Life Cycle Assessment. The calculation of CO_2 emissions and energy consumption reductions over the service lifetime of the infrastructure (60 years) shows that, even in the most optimistic scenarios considered, it would neither compensate the CO_2 emissions linked to its construction and maintenance (2,71 $MtCO_2$), nor would it contribute to net energy savings before 55 years of service. Robustness of these results leads us to conclude that GHG emissions reduction and energy savings should not be used as a general argument in favour of investing in high-speed rail infrastructure.

1. Introduction

Transport policy faces, at the beginning of the twenty-first century, an unresolved dilemma: how to reconcile an apparently unstoppable growth of passenger and freight traffic with its undesirable social and environmentally harmful effects. Transport currently accounts for about a third of EU's energy consumption (European Commission, 2015a) and a fifth of greenhouse gas (GHG) emissions (European Commission, 2015b), and whereas in other sectors GHG emissions have been decreasing, in transport they have grown by 29% between 1990 and 2009. Moreover, transport activity is expected to double by 2050 (European Commission, 2011a, 2013). Thus, the development of sustainable forms of transport has been one of the key priorities of the transport policy all around Europe. The European Commission, for instance, has repeatedly stressed the need to pursue a series of measures to limit the contribution of transport activity to climate change, calling to strengthen the environmental assessments of policy initiatives with important environmental effects (European Commission, 2011b, 1998).

In this context, high speed rail (HSR) is sometimes proposed as sustainable mode of transport, i.e. as a means to reconcile the dilemma between transport growth and sustainability (see e.g. Jehanno, Palmer, & James, 2011). However, while few countries have embarked in HSR technology, the environmental arguments favouring investments in HSR are far from clear. Railway transport on HSR lines has been acknowledged by the AR5-III (Sims et al., 2014) as an alternative with potential for the reduction of GHG emissions. However, the report highlights that not only the operation, but also the HSR infrastructure construction, maintenance and dismantling produces emissions and other environmental impacts should be considered from an integral perspective of its life-cycle.

The question is, therefore, whether HSR lines can lead to a net reduction of environmental impacts considering their entire life-cycle. Different studies indicate that HSR investments may compensate infrastructure construction burdens and mitigate CO_2 emissions (Akerman, 2011; Chang & Kendall, 2011; Chester &

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Horvath, 2010). However, these reports also underline the high sensitivity of the results to certain variables, such as passengers' demand, traffic diverted and induced and construction burdens. Westin and Kågeson (2012) find that, in order to balance the annual emissions from the railway construction, traffic volumes of over 10 million passengers are needed annually; most of the traffic diverted from other modes must come from aviation, and the lines cannot involve an extensive use of tunnels. Chester and Horvath (2010) estimate that the Californian HSR line (CAHSR, 1100 km) might take 6–8 years to balance the carbon footprint of construction, provided HSR vehicle occupation is kept higher than for the other transport modes. Chang and Kendall (2011) analyzed the San Francisco-Anaheim line (CAHSR, 725 km) balance, concluding that the GHG emissions footprint could be balanced in 6 years' service, although low occupation might delay the process to over 20 years; and on a line where tunnels and viaducts are only 15% of the layout. Akerman (2011) likewise defends a net savings on GHG emissions on the Europabanan line (Sweden, 740 km). The UIC also claims that the HSR offers tangible advantages over other transport modes (Jehanno et al., 2011).

Furthermore, if the environmental performance of HSR investments is to be evaluated under current European environmental policies (especially regarding climate change and energy consumption), reduction of environmental impacts should not only be undoubted after the infrastructure's lifetime but in a rather shorter period of time. In its Roadmap to a low carbon economy to 2050, the EU has committed to reduce its emissions to at least 80% below 1990 levels (40% by 2030 and 60% by 2040), in order to be consistent with a +2 °C temperature stabilisation in comparison to pre-industrial levels (European Commission, 2011a). These targets have been accompanied by others such as reducing European energy dependency and reducing the use of critical resources like energy, raw materials, soil and water (European Commission, 2011c, 2010).

In this context, the Spanish and Basque Governments projected a 180 km length star-shaped HSR network – commonly known as the Basque Y due to its "Y" shape linking the three Basque capitals– that will also be connected to the French and Spanish HSR lines. The Basque Climate Change Strategy 2050 argues that the construction of this new HSR line would shift transport from other modes and be essential in the reduction of emissions exceeding 80% on the 2050 horizon.[1] Strategy Action Line 4 from this Strategy contemplates boosting intermodality and transport means with lower GHG emissions, including a new Basque Railway Network action (#12) for freight and passenger transport (Basque Government, 2015a).[2] Actually, the budget of the Basque Government for 2016 allocated the equivalent to over 50% of the Environment and Territorial Policy Department budget to the HSR construction (Basque Government, 2015b). However, LCA studies of the Spanish HSR network in general (García Álvarez, 2010) and the studies for the Basque Y (Basque Government, 2012) fail to consider the emissions and energy embodied in the construction of the infrastructure, despite the scientific consensus on its importance (Baron, Martinetti, & Pépion, 2011; Cour des; Comptes, 2014; Sims et al., 2014). In fact, while the Basque Government (2012) reports an emission savings potential of 425 tonnes of CO_2 daily for the Basque Y, an assessment of the whole infrastructure life-cycle is still pending.

This paper aims to perform an environmental assessment of the Basque Y HSR project by means of a simplified LCA, in order to specifically analyse its potential contribution to climate change mitigation and energy savings.[3] The environmental performance of HSR technology is evaluated under two important assumptions: (1) a proper evaluation of the environmental performance of HSR requires considering its entire life-cycle; and (2) the environmental performance in terms of GHG emissions and energy savings should be assessed under current national and European strategies and commitments. In the European context, this means: (1) that GHG emissions should be reduced by 80% in 2050 as compared to emissions' levels in 1990 (European Commission, 2011a); (2) reducing the use and dependence of energy (European Commission, 2011c, 2010).

The rest of the paper is structured as follows: Section 2 explains the methodology and data used for the simplified life-cycle assessment. Section 3 provides with the results in our baseline scenario and alternative sensitivity scenarios. Section 4 discusses the main findings in the context of the current European transport policy. Finally, Section 5 provides with the main conclusions and policy implications.

2. Simplified life cycle assessment of the Basque Y

This section documents the methods and materials to perform a simplified life-cycle assessment (simplified LCA) on the Basque Y HSR infrastructure. Since our aim is to assess its potential contribution to GHG emissions reductions and energy savings in the context of climate change mitigation and energy security, we focus on calculating the carbon and energy footprint, measured in tonnes of CO_2 (tCO_2) and tonnes of oil equivalent (toe), respectively.

After a brief description of the project background in section 2.1, the steps applied to perform the simplified LCA of the Basque Y in this work are the following: (1) calculation of the carbon and energy footprints associated with the construction and maintenance of the infrastructure (section 2.2.1); (2) calculation of the net carbon and energy footprints associated with operation based on project estimations, considering passengers and freight traffic under a baseline scenario (section 2.2.2); and (3) consideration of four other alternative scenarios for sensitivity analysis (section 2.3).

Any new transportation infrastructure starts from a situation of environmental deficit due to its construction burdens. Thus, a new HSR line may lead to net environmental impact reductions only when the initial deficit is compensated after some years of operation. Since the new infrastructure absorbs demand from other existing transportation modes, the net environmental balance for the new infrastructure is derived from the comparison of environmental impacts from all existing transportation modes in two alternative scenarios, one without the HSR, and the other one with the HSR line in service. Thus, the net environmental impact (EI) of

[1] The Basque Climate Change Strategy 2050 partially includes the objectives set by the EU. It proposes reducing GHG emissions at least 40% by 2030 and 80% by 2050 in relation to 2005. Furthermore, it proposes achieving 40% renewable energy contribution in final consumption by 2050. As for the transport sector, the Strategy proposes a reduction in emissions of almost 85% by 2050.

[2] More specifically, the Basque Climate Change Strategy considers that mobility in the Basque Country will undergo a notable transformation, "firstly, a gradual change from oil derivatives to alternative fuels combined with a drive towards intermodality, fostering modes with lower GHG emissions and boosting pedestrianism in town centres. Subsequently, in the latter decades of the period, where mobility needs will have reduced due to the new territorial and urban planning layout, transport modes like railway and electric cars linked to electricity generation schemes with lower GHG emissions will become consolidated. This transformation will enable transport emissions reductions exceeding 80% by 2050" (Basque Government, 2015a).

[3] This analysis focuses on the GHG emissions and energy consumption balance; however the reader should bear in mind that other environmental dimensions are also affected by the HSR construction and operation such as: habitat fragmentation, impacts on flora and fauna (affecting biodiversity), occupation of fertile land, landscape and visual impact, noise and vibrations, etc. In fact, impacts are generally similar along road and railways (Cour des Comptes, 2014; Dorsey, Olsson, & Rew, 2015; Jehanno et al., 2011).