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The potential mitigation of CO_2 emissions via modal substitution of high-speed rail for short-haul air travel from a life cycle perspective – An Australian case study

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ABSTRACT

The objective of this study is to provide a strategic evaluation of the mitigation of CO_2 emissions via modal substitution of high-speed rail for short-haul air travel on the Sydney–Melbourne, Australia city-pair from a life cycle perspective. It has been demonstrated that when considering CO_2 emissions from vehicle operations, the modal shift from air to high-speed rail on this city-pair has the potential to provide a means of CO_2 mitigation. However, uncertainty exists with regard to level of mitigation potential when considering the whole-of-life performance of the systems. Given the significant difference in the infrastructure requirements between the air mode and the high-speed rail mode, this study quantifies the life cycle CO_2 load attributable to each system and examines the effect on CO_2 mitigation potential. The study concluded that while the inclusion of the linehaul infrastructure did increase the CO_2 load associated with high-speed rail mode, it did not equate to or exceed the CO_2 load per trip as experienced by the air mode. The avoided annual life cycle CO_2 emission in the target year 2056 was 0.37 Mt representing an 18% reduction when compared to the air mode only on the city pair. In fact, the scenario comparison indicated that the substitution of high-speed rail for short-haul air travel on the city pair resulted in CO_2 emissions avoidance throughout the longitudinal period.

Introduction

In recent decades, society has become 'accustomed to travelling further, faster and more frequently' (Kenworthy et al., 2005, p. 371). However, the dominance of carbon intensive transportation systems and the human desire for unfettered high-speed mobility are at variance with the principles of sustainable development (Black, 2010). Given that the projected growth in global demand for air services will negate any fuel efficiency gains per passenger unit of distance travelled, alternative mitigation approaches must be implemented as a means of augmenting the current strategy for CO_2 emission reduction from the aviation sector. Due to the inability of the current suite of mitigation strategies to curb air transport emissions growth, the concept of a technological transition to less carbon intensive modes of transportation has been advanced as being a means of reducing the climate change impacts associated with air travel. This is most notably the case with regard to high-speed rail (HSR) modal substitution for short-haul air travel (Givoni and Banister, 2006).

The objective of this study is to provide a strategic evaluation of the mitigation of CO_2 emissions via modal substitution of HSR for short-haul air travel on the Sydney (SY)–Melbourne (ML) city pair from a life cycle perspective. While Robertson

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(2013) demonstrated a variable degree of CO_2 emission mitigation potential via such modal substitution on the SY–ML city pair, the study considered only CO_2 emissions associated with operations. It is now recognised that, in the case of transportation systems, CO_2 emissions generated by the provision of the transport services should not only account for vehicle travel but should also include pre-combustion, vehicle supply (manufacturing, maintenance and disposal of vehicles), and transport infrastructure supply (construction, maintenance, operation and disposal) (Spielmann and Scholz, 2005). Robertson (2013) concluded that further research into the life cycle CO_2 of these two modes of high-speed transportation would provide greater resolution to the formulation of future transport policy pertaining to such modal substitution in Australia. This paper builds upon the study of Robertson (2013) through the addition of a life cycle perspective.

The structure of the paper is as follows: Section 'Research background' provides an up-to-date background to the research problem. Section 'Methodology' details the adopted methodology for the assessment. Please note that the accompanying supplementary data to this study provides a detailed description of life cycle inventory components for both systems. Sec tion 'Results' details the results of the longitudinal assessment. The results will be presented as two scenarios. Scenario 1 will consider only the air mode, while Scenario 2 will consider an assumed modal shift. Sections 'Discussion' and 'Conclusion' provide a discussion and a summary of the results and the principal findings of the study.

Research background

In November 2012, the Australian Department of Infrastructure and Transport (DIT), in response to the International Civil Aviation Organisation 2010 Assembly Resolution A37-19, published the report: *Managing the Carbon Footprint of Australian Aviation* (DIT, 2012). This report presented an overview of the initiatives, undertaken and proposed, to manage the carbon footprint of Australian aviation, both international and domestic, by air transport actors such as airline operators, the aerospace industry and the Australian Government.

The DIT report stipulated a like commitment to that of the International Air Transport Association's goals for the reduction of emissions from international aviation, however it failed to specify a domestic aviation reduction target. Based upon the continuation of current trends, the report concluded that under such a projection scenario, Australia's domestic CO_2 emission would reach 21.8 Mt in year 2050 (DIT, 2012). Furthermore, the DIT report made the observation with regard to aviation emissions, that, '[t]he net carbon footprint continues to grow' and that as annual improvements in aerospace technology diminish, greater savings would be required in order to reach 'more stringent environmental targets' (DIT, 2012, p. iii).

While the report documented various options available to the Australian air transport sector for reducing its emissions, the report critically failed to examine the potential of a technological transition from short-haul air travel to HSR on the proposed east coast corridor. On the other hand, the UK's Committee on Climate Change, an independent statutory body, examined this issue of a transition from short-haul air travel to HSR in a regional context and found that by such a transition there was indeed scope for a useful contribution towards achieving the UK's 2050 aviation emissions targets (CCC, 2009).

Over the past decade the intensification of polemical discourse pertaining to political pressure and public opinion surrounding climate change has led to anthropogenic climate change mitigation becoming a central issue within the policy arena. The inclusion of the issue of anthropogenic climate change mitigation as a key policy was nowhere more evident than in the 2010 Federal election campaign. In addition to pricing carbon pollution, the then Labor Government announced that it would initiate a feasibility study for a high-speed rail network linking Brisbane, Sydney, Canberra and Melbourne. In a campaign press release, Labor argued that the reason why HSR should be considered was that it was the '. . .Labor Government's vision for moving the nation and economy into the future, increasing productivity, supporting a sustainable population and tackling climate change' (Hawker-Britton, 2011, p. 4).

The Labor Government's decision to revisit the proposal for the development of HSR on the east coast was aligned with The Greens party's long held position for the development of a HSR link between east coast capital cities. The HSR study was commissioned as part of the Labor Government's 'bargaining process' with The Greens in return for political support thereby allowing for the formation of a Labor minority government. In accord with the Labor and The Greens position, the Liberal/National coalition opposition during the election campaign intimated that if elected it would also commission a HSR feasibility study (Hawker-Britton, 2011). With the provision of more environmentally benign and less carbon-intensive modes of long distance passenger transport gaining political prominence, in association with the prospect of job creation during a period of global economic uncertainty, rail infrastructure was now very much back on the domestic political agenda (von der Heidt et al., 2009).

Managed by the Department of Infrastructure, Transport, Regional Development and Local Government, a consortium led by leading global consultancy firm AECOM Australia and including KPMG, Sinclair Knight Merz and Grimshaw Architects was appointed to undertake the initial part of the HSR feasibility study. The objective of the study was to identify corridors, estimate construction costs, and to undertake preliminary geotechnical investigations and the financial and economic modelling necessary to determine the project's viability. The study commenced in February 2011 and was completed in April 2013. Phase 1 of the HSR study was released in July 2011 (AECOM, 2011). Included in Appendix C of Phase 1 of the study was the assessment of environmental externalities. The externalities for GHG emissions due to operation were estimated (AECOM, 2011).

Phase 2 of the HSR study was released in April 2013 to much debate primarily concerning the economics of the project and the interminable timeframe proposed for planning and construction phases. The report estimated that the SY–ML