Life-cycle assessment of high-speed rail: the case of California

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Abstract

The state of California is expected to have significant population growth in the next half-century resulting in additional passenger transportation demand. Planning for a high-speed rail system connecting San Diego, Los Angeles, San Francisco, and Sacramento as well as many population centers between is now underway. The considerable investment in California high-speed rail has been debated for some time and now includes the energy and environmental tradeoffs. The per-trip energy consumption, greenhouse gas emissions, and other emissions are often compared against the alternatives (automobiles, heavy rail, and aircraft), but typically only considering vehicle operation. An environmental life-cycle assessment of the four modes was created to compare both direct effects of vehicle operation and indirect effects from vehicle, infrastructure, and fuel components. Energy consumption, greenhouse gas emissions, and SO_2, CO, NO_X, VOC, and PM_{10} emissions were evaluated. The energy and emission intensities of each mode were normalized per passenger kilometer traveled by using high and low occupancies to illustrate the range in modal environmental performance at potential ridership levels. While high-speed rail has the potential to be the lowest energy consumer and greenhouse gas emitter, appropriate planning and continued investment would be needed to ensure sustained high occupancy. The time to environmental payback is discussed highlighting the ridership conditions where high-speed rail will or will not produce fewer environmental burdens than existing modes. Furthermore, environmental tradeoffs may occur. High-speed rail may lower energy consumption and greenhouse gas emissions per trip but can create more SO_2 emissions (given the current electricity mix) leading to environmental acidification and human health issues. The significance of life-cycle inventorying is discussed as well as the potential of increasing occupancy on mass transit modes.

Keywords: passenger transportation, life-cycle assessment, California, high-speed rail, trains, cars, autos, aircraft, planes, energy, fuel, emissions, greenhouse gas, criteria air pollutants