Analyzing the Potential of Hybrid and Electric Off-Road Equipment in Reducing Carbon Emissions from Construction Industries

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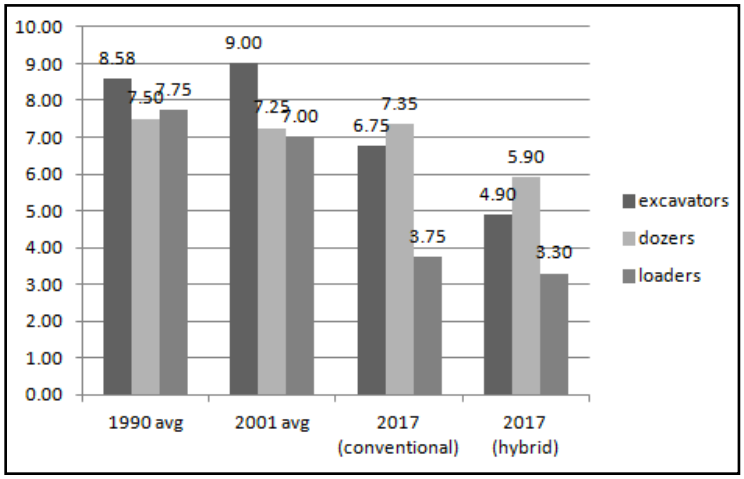
Over the last 25 years, technological innovation in the heavy construction equipment industry has led to dramatic reductions in criteria air pollutants such as particulate matter (PM). However much less is known about how advances in construction equipment technology have impacted Greenhouse Gas (GHG) emissions from the construction industry.

Study Methods

This report surveys the construction and equipment manufacturing industries, describes the latest and emerging technologies, and presents an updated GHG emissions inventory for the construction industry which for the first time presents emissions estimates at both the state and subsector level. It then utilizes a scale-composition-technique model, which accounts for the size of the equipment fleet, as well as the fuel economy and hours of operation of individual machines, to estimate the impact of the greening of the construction equipment fleet on GHG emissions.



The available evidence suggests that replacing diesel with electric equipment holds potential to reduce GHG emissions much more sharply than hybrid technologies, which themselves are associated with relatively modest—though non-trivial—reductions in GHG emissions.

Findings

With regard to hybrid equipment, this study documents improvements in fuel efficiency in several types of heavy construction equipment, including excavators, bull dozers and wheel loaders. Figure 1 reports fuel use factors, which along with activity load are the prime determinant of both fuel consumed and GHG emitted by construction equipment. The fuel use factors shown there for hybrid excavators, dozers and loaders are 27%, 20% and 12% lower than the contemporaneous conventional equipment. These figures are broadly in line with the findings from the study's review of twelve specific models, from ten different manufacturers, which revealed fuel use reductions of 10-45%, with an average of 28%, attributable to hybrid equipment.

In addition to hybrid heavy equipment, this rport also examines the nascent battery-electric construction equipment industry. Although electric equipment has long been in use in, for example, certain mining applications, innovations in battery technology have only recently enabled the commercial availability of small to medium-sized battery excavators. The available evidence suggests that replacing diesel with electric equipment holds potential to reduce GHG emissions much more sharply than hybrid technologies, which themselves are associated with relatively modest—though non-trivial—reductions in GHG emissions. Using the energy consumption estimates from one experiment involving diesel and electric mini-excavators, this report documents that this technology could enable emissions to fall in each of the 50 states. When substituting battery electric for diesel excavators, GHG emissions from excavation are 59% lower on average, and this figure ranges from 79% in the state with the greenest electricity grid (New York) to a still-large 34% in Colorado, where more electricity is generated using high-emissions fuels like coal.

Among the results of the scale-composition-technique analysis, the study estimates that in a counterfactual world where excavator technology failed to advance since 2001, CO2 emissions would be 335 million pounds higher each year; this is comparable with two years of emissions that result from the entire construction sector in the District of Columbia, or with six months of emissions that result from the entire construction sector in Alaska.

Policy Recommendations

The large emissions reductions shown to result from improved technology speak for a policy focus on innovation. This report surveys the following policy options: green performance contracting for highway construction, regulating new engine technology, equipment use, and regional air quality; raising fuel taxes, and subsidizing the development and use of off-road clean tech.

About the Authors

Matthew J. Holian is a professor in the Economics Department at SJSU. Dr. Holian received his doctoral degree in Economics from the Ohio State University. He currently teaches courses in Cost-Benefit Analysis, Econometrics, Industrial Organization and Regional Economics. His research focuses on environmental, public, urban and transportation topics, and his writing has appeared in scholarly journals such as the Journal of the Association of Environmental and Resource Economists, Ecological Economics, Public Choice, Environment and Urbanization Asia and the Journal of Housing Economics.

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To Learn More

For more details about the study, download the full report at ***transweb.sjsu.edu/project/1533.html***

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