PE-2 Estimates Hig

New Web-based tool aids in modeling life-cycle greenhouse gases generated in road building

By Amlan Mukherjee

Pavement-Neutral Life-Cycle Analysis Software

Over the last 10 or 20 years, the asphalt pavement industry has taken specific steps to promote technologies that reduce an already low pavement carbon footprint. Recently, there has been some confusion and uncertainty in the pavement and construction industry about how to recognize and measure the environmental impacts associated with all facets of pavement construction activities.

Michigan Technological University (MTU) recently released software, PE-2, that does just that — it quantifies one of the more common metrics of environmental impact, carbon footprint. The software was developed by MTU through a Michigan Department of Transportation (MDOT) sponsored research project.

Curtis Bleech, P.E., MDOT Pavement Operations Engineer, coordinated the two-year environmental life-cycle analysis (LCA) project with MTU. Recognizing an increased awareness of the importance of sustainability, Bleech stated that "Although MDOT envisions this LCA software as material neutral, it is useful to understand the impact of different pavement and construction practices on the overall carbon footprint."

Dr. Howard Marks, NAPA Director of Environmental Affairs, said: "Finally, the pavement construction industry now has an unbiased, pavement-neutral LCA software that can make comparisons between pavement technologies, types, and construction activities. While asphalt pavements already have a very low carbon footprint compared to other pavement materials, something this software reflects, the asphalt pavement industry and its agency partners will continue to push technologies that can reduce it even further — higher RAP in pavements, lower mix temperatures, and designing longer-lasting Perpetual Pavements."

Across the country, departments of transportation are looking to reduce the environmental impact of highways. A new Web-based measurement tool called the Project Emission Estimator (PE-2) offers a way to benchmark life-cycle greenhouse gas emissions for highway projects. The PE-2 can account for construction, maintenance, rehabilitation, and the cumulative vehicular emissions during the service life of the pavement.

In 2006, a legislative mandate in California required a reduction in emissions, and Michigan and Washington are also investigating ways to reduce greenhouse gas emissions in highway construction. At the federal level, similar efforts have been made through the Federal Highway Administration's (FHWA) Sustainable Pavements Program.

While an increased emphasis on sustainability is likely to have a direct impact on the economic bottom line, it also presents an opportunity for innovation in alternative low-impact materials, the use of recycled materials, and improved construction processes.

hway Construction Emissions

In this regulatory environment, a tool like the Project Emission Estimator (PE-2) can be valuable for its ability to estimate project emissions and support sustainable practices when decisions are being made. Contractors and state agencies can use these metrics to benchmark and monitor the life-cycle emissions of products and processes associated with highway construction.

In the long run, it is expected that these estimated project emissions will provide the necessary justification for the use of alternative technologies and have the potential for supporting decision-making at all levels.

The PE-2 is a Web-based tool designed to benchmark life-cycle greenhouse gas emissions for highway construction, rehabilitation, and preventive maintenance projects. The goal of the PE-2 platform is to support a decision-making method that accounts for the project-specific context and conditions with the goal of reducing greenhouse gas emissions of the products, processes and services that define the pavement life cycle. It does not compare and contrast alternative pavement materials, but instead promotes improved decision-making, recognizing that the solutions for one project may not apply to another.

Background

The PE-2 applies a project-based approach toward environmental life-cycle assessment (LCA), focusing primarily on estimating emissions associated with highway transportation projects. In an LCA study, all the energy and material inputs for a project are inventoried, along with the associated environmental outputs and emissions and the relative impact of specific materials and/or processes.

The life of a pavement section is defined as the interval between consecutive major pavement reconstruction projects. This interval is usually punctuated by a few maintenance and rehabilitation projects.

The project-based approach estimates the life-cycle emissions of the pavement section by summing the emissions for each of the construction, maintenance, and reconstruction projects, along with the cumulative vehicular emissions during the service life of the pavement. The life-cycle emissions of all products, processes and services involved in the construction project are considered.

The PE-2 tool — accessible at *www.construction.mtu.edu:8000/cass_reports/webpage/* — was developed using on-site construction product and project data collected

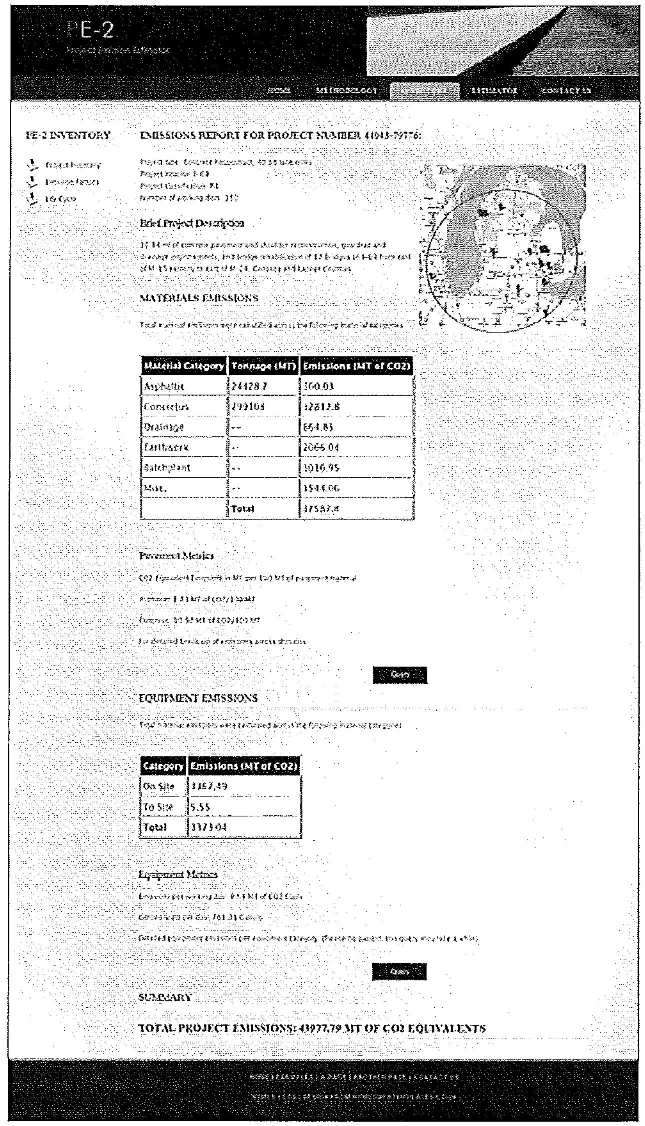

Fig. 1: The Project Inventory Screen

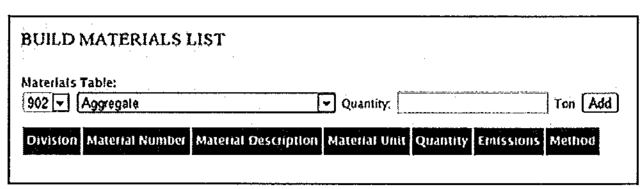

Fig. 2: The Materials Estimator Function

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from 14 construction, maintenance and rehabilitation projects from across the state of Michigan. A list of current life-cycle emission factors for construction materials and equipment was then drawn from leading life-cycle inventories and other related emission calculation methods.

Next, a project emissions inventory was developed, organizing the site data and using the estimated emission factors to calculate life-cycle emissions of products and processes associated with the highway construction. And finally, a Web-based interface for the inventory was developed to simplify project emission estimation and benchmarking.

The data collection process relied on FieldManager construction management software, which Michigan Department of Transportation (MDOT) inspectors use for reporting on general site conditions, contractor personnel, equipment, and quantities of different materials consumed on site.

Highway construction emissions were computed by multiplying the emission factors by the relevant units of material and equipment used in a project. All emission factors are expressed as equivalents of CO_2 emissions per unit, for example metric tonnes of CO_2 emissions per cubic yard. This includes carbon equivalents of SO_x,

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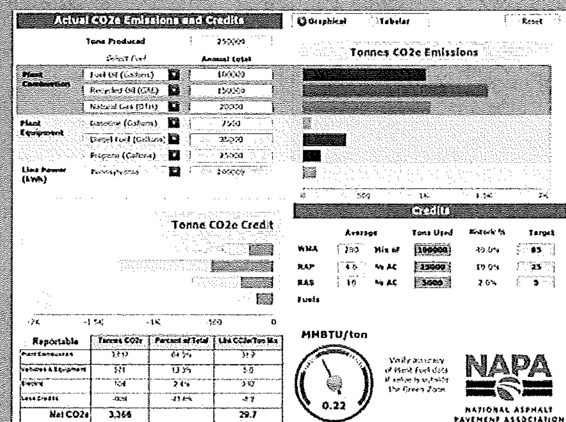
NAPA Expands Online Greenhouse Gas Calculator

The latest version of NAPA's Greenhouse Gas Calculator now includes CO_2 credits for the use of RAP, RAS, and warm mix. The Greenhouse Gas Calculator also allows numerous inputs with graphical outputs. To access the calculator, visit *www.asphaltpavement.org/ghgc.*



Putting PE-2 Into Action

Construction activities can be carbon intensive. A sample 2-mile surface street reconstruction with improvements can have 3,100 tons carbon dioxide equivalent (CO_2e) emissions, which is comparable to vehicles combusting about 350,000 gallons of gasoline.

It certainly makes environmental sense to seek activities and technologies that lower the construction carbon footprint.

The asphalt pavement industry continually looks for ways to reduce its pavements' carbon footprint. Construction practices such as increasing RAP content, use of RAS, and optimizing pavement mixing temperature can all substantially reduce asphalt's already small carbon footprint. As illustrated in the following walkthrough, the PE-2 software makes these types of project-based comparisons of CO_2e emissions easy and intuitive, and can help illustrate the environmental impacts associated with different choices in roadway construction activities.

A Project Walkthrough

Embedded in the PE-2 software are several projects completed under Michigan Department of Transportation (MDOT) contracts. The software can be used to review emissions associated with a completed road reconstruction project, illustrating the impact that choices in equipment and materials might have for future projects.

From the PE-2 homepage, *www.construction.mtu.edu:8000/cass_reports/webpage/*, the user can view more than a dozen completed MDOT projects and their emissions estimates via the Inventory tab. Choosing "US-41: Road Reconstruction HMA and Concrete" and clicking the query button calls up details associated with project emissions.

Shown is a description of the project, along with emissions associated with its materials, such as asphalt, concrete, drainage materials, earthwork, etc. (see Fig. 1).

For a 2.02-mile surface street reconstruction with improvements, the US 41 project utilized approximately 14,000 tons of asphalt mix and 5,000 tons of concrete. The PE-2 software identifies all material amounts and emissions in the units of metric tonnes, which are referred to here simply as "tons."

Looking at the materials side of the project, the drainage materials (e.g., metal and corrugated poly piping, sewer, and culvert materials, including PVC) have the greatest carbon intensities. These carbon-intense materials are followed closely by concrete.

Specific materials for each Material Category are outlined in the Material Estimator Tool under the Estimator tab.

Asphalt pavement materials, according to the software and as shown in Fig. 1, have one-tenth the carbon intensity of concrete materials; for example, 1.2 tons of CO_2e per 100 tons of asphalt pavement vs. 10.8 tons of CO_2e per 100 tons of concrete materials.

The listed values are the carbon intensities of the combined raw materials themselves. Emissions associated with producing a pavement mix — asphalt or concrete — are identified separately in the Batchplant material category.

Similarly, energy and emissions associated with application of pavement material, including transportation of finished materials to the project site, are accounted for in the Equipment Emissions section with details visible through the query function (see Fig. 2). Separate emissions estimates are provided for both asphalt and concrete paving equipment.

When all the inputs are considered, PE-2 finds that the US 41 project had a total project emissions of 3,094.64 CO_2e.

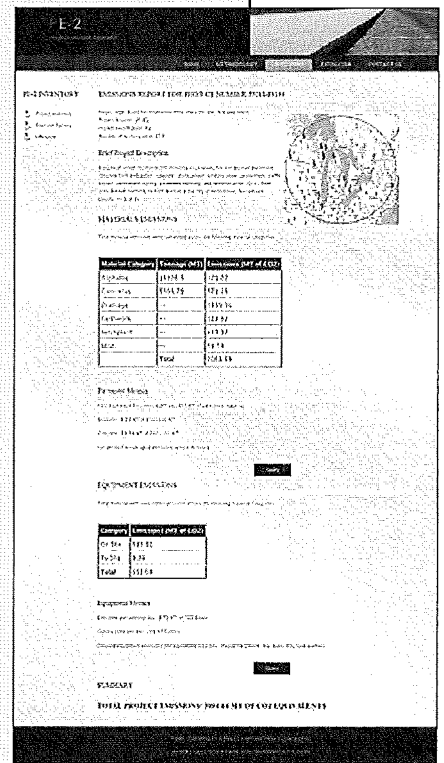


Fig. 1: Project emissions report for reconstruction of US 41 using asphalt and concrete

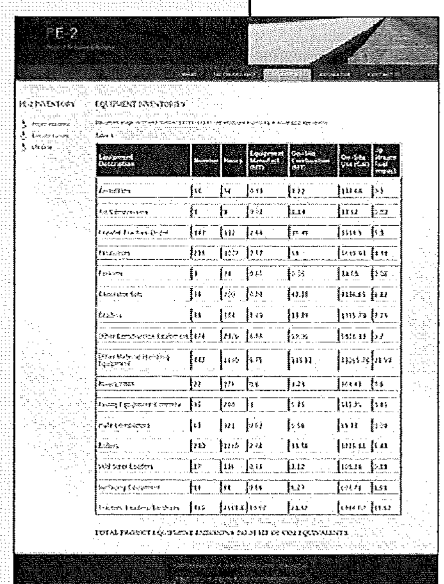


Fig. 2: Expanded equipment emissions report for the project

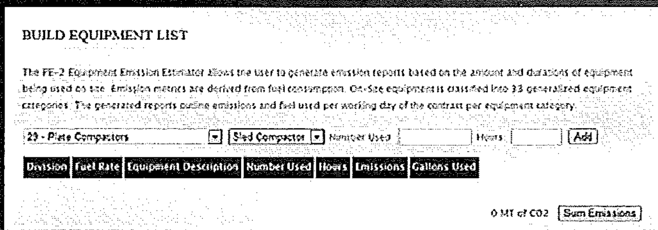


Fig. 3: The Equipment Estimator Function

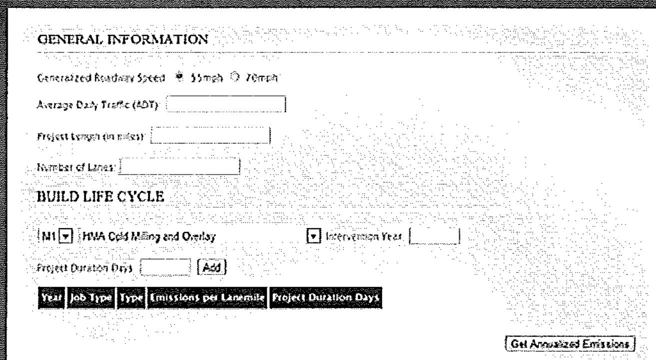


Fig. 4: The Life-Cycle Estimator Function

NO_x, CH_4 and other greenhouse gas emissions.

The emissions associated with the service life of pavements were calculated by multiplying the emission factors estimated from the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) by the total vehicle miles traveled on the section for each year of life (accounting for growth in traffic). Pavement/vehicle interaction was not accounted for. Traffic emissions due to construction delays were estimated by accounting for the extra emissions due to reduced speed on a pavement section for the total number of hours of the construction schedule.

The calculated emissions were validated by comparing them with peer studies that were conducted independently, including a recent study by ICF International Inc. (Gallivan 2010), as part of an investigation of greenhouse gas mitigation measures in highway construction. A detailed discussion is in Mukherjee et al. (2011).

With the PE-2 Web interface, all relevant product and process data collected for a project is organized into an inventory report for the particular project. (See Fig. 1.)

The estimator tool can help decision-makers and contractors in benchmarking their projects. The respective material and equipment quantities, type, number and hours of estimated equipment usage (product and process) are added. Users can also benchmark equivalent annualized emissions for a project by providing traffic characteristics and an expected maintenance schedule.

The PE-2 Web interface has four main tabs: Home, which introduces the tool and its purpose; Methodology, which outlines the underlying methodology; Inventory, which summarizes project reports; and Estimator, which is used to benchmark projects.

There are three subsections to the Estimator section: the Materials Estimator, the Equipment Estimator, and the Life-Cycle Estimator.

In the Materials Estimator (Fig. 2), users can add materials using drop-down menus classified by pay-item divisions specified by MDOT. As the list builds, the summation button at the bottom of the page adds up the total emissions.

Similarly, with the Equipment Estimator (Fig. 3) users can project equipment and number of hours of estimated usage from drop-down menus classified by the activities the

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items are typically associated with. Again, the summation button at the bottom of the page adds up the total emissions.

The Life-Cycle Estimator (Fig. 4) allows users to input project traffic characteristics and progressively build a construction and maintenance schedule to estimate the expected life-cycle emissions.

PE-2 Use

At the project level, the PE-2 tool can be used on future projects to estimate and benchmark emissions. The first step would be to use the list of materials and their estimated use to benchmark expected project emissions before a project starts.

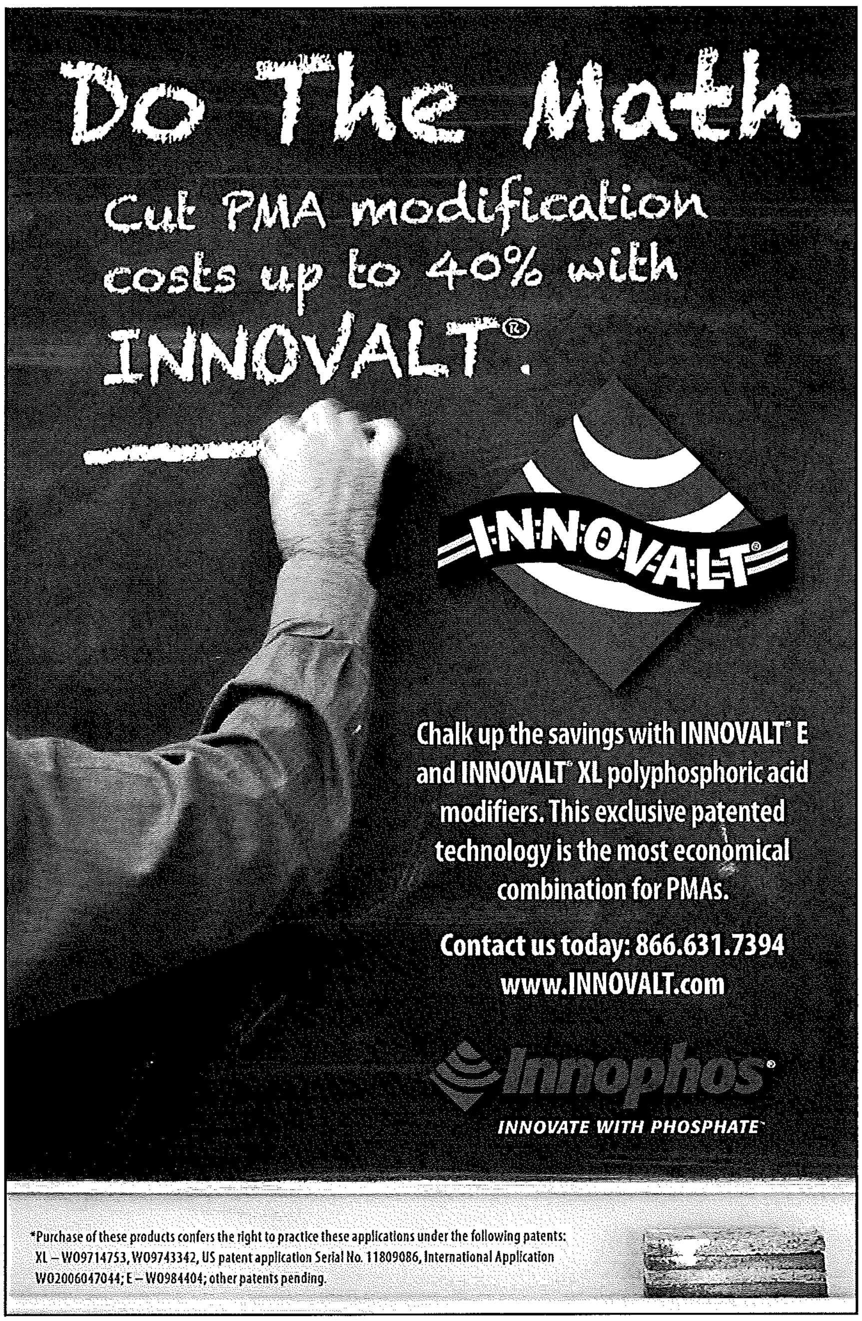
At the end of the project, PE-2 can be used to generate an emissions report using the actual data collected using FieldManager or equivalent reporting software. Agencies should encourage contractors (through direct economic or equivalent incentive) to reduce the actual project emissions when compared to the benchmark for the project.

In addition, contractors' efforts at reducing greenhouse gas emissions during the project construction process — as measured by the difference between the estimated and actual emissions — can be recognized through an incentive program. Contractors can beat their benchmarks through more efficient project site design and schedule planning or by using alternative materials during the construction process.

When considering emissions-reduction strategies, agencies must recognize that emissions reduction is part of a broader goal of building more sustainable pavements. Therefore, all measures should consider long-term socioeconomic outcomes as well.

In the view of this author, reduction strategies should emphasize incentive-based individual adoption ensuring win–win premises for all stakeholders, rather than top-down enforced standards that may disproportionately disadvantage certain stakeholders. AP

Amlan Mukherjee, Ph.D., is an associate professor in the Department of Civil & Environmental Engineering at Michigan Technological University in Houghton, Mich.



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