MIT energy experts explore life 'beyond carbon'

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If all nations burned gasoline for transportation at the same rate as the United States, world gasoline consumption would rise nearly ten-fold, with a corresponding hike in the concentration of greenhouse gases.

That's just one reason why it is imperative that nations work to create a more sustainable transportation system, says John Heywood, director of MIT's Sloan Automotive Lab and the Sun Jae Professor of Mechanical Engineering.

"As the countries in the developing world rapidly motorize, the increasing global demand for fuel will pose one of the biggest challenges to controlling the concentration of greenhouse gases in the atmosphere," Heywood writes in "Fueling Our Transportation Future," an article he wrote for the September issue of Scientific American.

Heywood is one of three MIT professors who tackle energy in the magazine's September issue, whose cover proclaims the theme "Energy's Future: Beyond Carbon."

While Heywood's article focuses on improving transportation efficiency, MIT Professors John Deutch and Ernest Moniz explore the possibilities of expanding nuclear power to reduce emissions of greenhouse gases.

All three professors are members of MIT's Energy Research Council, which issued a report in May exploring how MIT can help solve the global energy crisis.

Improving transportation efficiency will be a critical part of any energy strategy, says Heywood, because transportation accounts for 25 percent of worldwide greenhouse gas emissions. Greenhouse gases such as carbon dioxide are emitted when fossil fuels like gasoline and coal are burned. The gases trap heat within Earth's atmosphere, raising global temperatures and altering weather patterns.

In his piece, Heywood outlines four options for improving transportation sustainability: "We could improve or change vehicle technology; we could change how we use our vehicles; we could reduce the size of our vehicles; we could use different fuels. We will likely have to do all of these to drastically reduce energy consumption and greenhouse gas emissions."

U.S. petroleum consumption has been steadily growing by about two percent per year. It will take quite some time to reverse that trend, according to Heywood. By reducing the weight and size of vehicles and "step(ping) off the ever increasing horsepower/performance path," developed nations may be able to level off petroleum demand in 15 to 20 years and start a slow downward path, he writes.

In the longer term, new technologies could further reduce fuel consumption. Heywood estimates that within five years, new technologies such as gasoline hybrids, turbocharged gasoline engines and low-emissions diesel could produce market-competitive vehicles. Hydrogen fuel cell technology will take longer to reach consumers.

However, it will take 20 to 30 years for any of these engine technologies to reach "major fleet penetration," meaning, the point at which they account for more than one-third of mileage driven, according to Heywood. It may take some 50 years for fuel cells and hydrogen to reach that state, he noted.

Other alternative fuels, including biomass-based fuels such as ethanol and biodiesel, are already being produced but have not made much of an impact in the United States yet.

"It is likely that the use of biomass-based fuels will steadily grow," Heywood writes. "But given the uncertainty about the environmental impacts of large-scale conversion of biomass crops to fuel (on soil quality, water resources and overall greenhouse gas emissions), this source will contribute but is unlikely to dominate the future fuel supply anytime soon."

Heywood suggests that new regulatory and tax policies will be needed to realize the fuel-reduction benefits as new technologies come into the market. Raising fuel-efficiency requirements, charging a fee to consumers who purchase high-fuel-consumption cars and offering rebates to those who buy efficient models could all help achieve a more sustainable transportation system.

Another promising way to cut carbon emissions is to rely more heavily on nuclear power, according to Moniz and Deutch.

Moniz, co-director of MIT's Laboratory for Energy and the Environment and Cecil and Ida Green Professor of Physics, co-chairs MIT's Energy Research Council. Deutch, also a member of the energy council, is an Institute Professor at MIT.

Nuclear power now supplies about one-sixth of the world's electricity, making it the largest "carbon-free" energy source in the world. Only a handful of new plants are now planned in the United States, but nuclear power is drawing renewed attention, spurred by concerns over global warming and new advances in nuclear plant technology and safety.

"With growing worries about global warming and the associated

likelihood that greenhouse gas emissions will be regulated in some fashion, it is not surprising that governments and power providers in the U.S. and elsewhere are increasingly considering building a substantial number of additional nuclear power plants," Deutch and Moniz write in their Scientific American article, titled "The Nuclear Option."

Global electricity consumption is expected to grow 160 percent by 2050. A tripling of the world's nuclear capacity by that year could help meet that electricity need without large new emissions of carbon, according to a 2003 MIT study, "The Future of Nuclear Power," which Deutch and Moniz co-chaired.

That study proposed that if worldwide nuclear power generation tripled to one million megawatts by the year 2050, it would save between 0.8 billion and 1.8 billion tons of carbon emissions per year, depending on whether gas- or coal-powered plants were displaced.

"At this scale, nuclear power would significantly contribute to the stabilization of greenhouse gas emissions, which requires about seven billion tons of carbon to be averted annually by 2050," Deutch and Moniz wrote.

To reach that level of nuclear energy production, a few obstacles must be overcome, according to Deutch and Moniz. Major obstacles are the high costs of nuclear power plant construction, uncertainty over nuclear waste management and concerns about nuclear proliferation.

Deutch and Moniz suggest that a government-imposed "carbon tax" could raise the cost of generating electricity from coal or natural gas, making nuclear energy more attractive to power companies. Reducing construction costs and time would also make nuclear power more economical.

They also propose that the federal government establish consolidated interim storage as part of the nation's nuclear waste management strategy.

Threats of nuclear proliferation could be countered by establishing relationships in which countries such as the United States, Russia and France would lease nuclear fuel to countries that want to develop nuclear power plants. The United States would then reclaim the spent fuel and dispose of it, eliminating the risk that countries could secretly develop weapons programs under the guise of generating nuclear power.

Although the challenge is great, Deutch and Moniz believe success is attainable. Since 2000, more than 20,000 megawatts of nuclear capacity have come online, mostly in the Far East.

"Reaching a terawatt of nuclear power by 2050 is certainly challenging, requiring deployment of about 2,000 megawatts a month," they write. "A capital investment of $2 trillion over several decades is called for, and power plant cost reduction, nuclear waste management and a proliferation-resistant international fuel cycle regime must all be addressed aggressively over the next decade or so."

Source: MIT