HARVARD-CHINA PROJECT
on Energy, Economy and Environment

HARVARD-CHINA PROJECT NEWSLETTER

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Cover Image: "Jade Dragon Snow Mountain" by Jiayin Lu, SEAS Ph.D. G2, a Harvard-China Project photo contest winner

The Harvard-China Project is based at the Harvard John A. Paulson School of Engineering and Applied Sciences and receives major support from the Harvard Global Institute on the theme of "China 2030/2050: Energy and Environmental Challenges for the Future."

CCICED MEETING '19

In early June, Professor Michael McElroy, chair of the Harvard-China Project, attended the annual general meeting of the China Council for International Cooperation on Environment and Development (CCICED) in Hangzhou with Project Executive Director Chris Nielsen. Co-chaired by Li Ganjie, China's Minister of Ecology and Environment, Xie Zhenhua, its Special Representative for Climate Change, and international counterparts from western governments and UN Agencies, CCICED is the highest international advisory body providing policy recommendations on environment and development to Vice Premier Han Zheng and China's State Council.

Among topics discussed at the annual meeting were the need to raise national goals and accelerate timelines (known formally as "Nationally Determined Contributions") under the Paris Agreement of the

UN Framework Convention on Climate Change, the need to make investments under the Belt and Road Initiative compatible with global deep decarbonization objectives, and China's hosting of the next Conference of the Parties to the UN Convention on Biological Diversity in 2020. Participation in CCICED provides the Harvard-China Project with an opportunity to introduce its research findings directly into discussions informing Chinese policy-making and to emphasize the role of independent research in understanding and addressing China's environmental and climate risks. It also strengthens Harvard-China Project relationships with leading decision makers on environment and development from across China and around the world.

Image by CCICED

James Hammitt by Claudio Cambon, HUCE // City image by Adobe Stock Photo

RESEARCH HIGHLIGHT

Professor James Hammitt's Research on Valuing Environmental Health Risk

Every society faces a challenge of deciding how much pollution control, and avoidance of associated health risks, is the right amount. The answer is certainly not 100% control—at least over policy-relevant timeframes, acknowledging limits of current technologies—because the marginal costs of abatement rise as pollution levels decline and become exorbitant as they approach zero. At some point it becomes wiser for society to shift limited public resources into other policies that offer comparable health or other benefits at lower costs.

One standard tool to help guide such decisions is benefit-cost analysis, in which all of the positive effects of pollution control (e.g., health benefits) and negative ones (e.g., control costs) are placed in common (monetary) units and compared. To complete such an analysis, the money value of reducing mortality risk—generally expressed in the value per statistical life, or VSL—is a crucial input.

James Hammitt, Professor of Economics and Decision Sciences at the Harvard T.H. Chan School of Public Health and Director of the Harvard Center for Risk Analysis, has been leading studies of environmental health risks and their value in Chinese society as part of the Harvard-China Project for more than 15 years.

Hammitt's latest research on VSL in China, co-authored by past or current Project affiliates Fangli Geng, Xiaoqi Guo, and Chris Nielsen, was published earlier this year in the *Journal of Risk and Uncertainty*. It takes advantage of rigorously sampled, interdisciplinary household surveys conducted by the Harvard-China Project with collaborators at Peking University in the city of Chengdu in both 2005 and 2016.

VSL is expected to increase with rising per capita income, but at what rate? The new Hammitt et al. study is close to unique in the international literature in estimating VSL in the same population, using the same methods, at two dates between which the local economy grew swiftly. It found rates of growth with respect to income substantially higher than most earlier studies; in economics lingo, it estimated an income elasticity for VSL

approaching 3.

In fact, the reasons for the rapid VSL increase are not resolved by the study, and could include other social changes in addition to a rise in income. In any case it suggests that Chinese policy-makers considering new investments or rules to reduce pollution should recognize that the value of health and safety in the eyes of citizens is likely to continue to increase rapidly. Any new policy interventions should prioritize public health more than if this trend were otherwise.

"At some point it becomes wiser for society to shift limited public resources into other policies that offer comparable health or other benefits at lower costs."

A second major finding concerns methodology. A problem with such survey-based "stated preference" studies is that respondents have limited understanding of small probability changes and can have a hard time determining their value. By eliciting values from each respondent for two different risk reductions, the study poses a test for internal consistency and identifies respondents whose answers indicate a clearer understanding of the premise. Limiting analysis to this sizable sub-sample results in a doubled VSL estimate, which implies that other VSL estimates based on full survey samples (as in most literature) might be biased downward by 50%.

The study, freely downloadable at the Harvard-China Project website, is: Hammitt, James K., Fangli Geng, Xiaoqi Guo, and Chris P. Nielsen. 2019. "Valuing mortality risk in China: Comparing stated-preference estimates from 2005 and 2016." Journal of Risk & Uncertainty 58 (2-3): 167–186.

FALL EVENTS RECAP

The Harvard-China Project hosted a number of Research Seminars and co-sponsored events this fall semester.

In September, **Yingying Lu**, a Harvard Graduate School of Design (GSD) doctoral candidate and incoming researcher of the Harvard-China Project, kicked off the fall semester events with her Ph.D. defense at GSD. Her talk, "Walking Culture in China," explored how walking contributes to the urban environment by reducing transportation energy consumption and emissions.

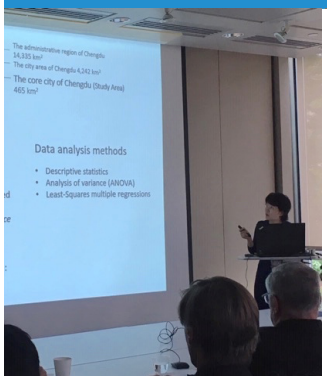
In October, **Siqi Zheng**, the Samuel Tak Lee Associate Professor of Real Estate Development and Entrepreneurship in the MIT Department of Urban Studies and Planning, delivered a talk on "Social Costs of Air Pollution in China." She contemplated the broader social costs of air pollution in Chinese cities by examining the negative effects of air pollution on social activities in cities, the social interactions embodied in such activities, and urbanites' subjective well-being.

Fengkui Duan, Associate Professor, School of Environment, Tsinghua University, China, presented on "Characteristics and Mixing State of Haze Pollution in China," which explored the chemical composition of PM2.5 during severe haze episodes in wintertime Beijing, which continue despite a decrease in annual average ambient $PM_{2.5}$ since 2013.

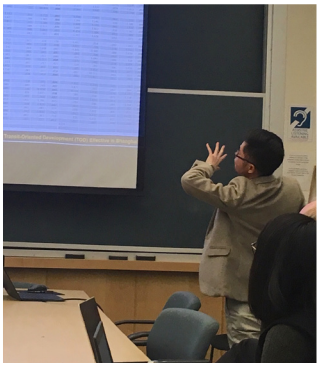
In November, **Faan Chen**, Postdoctoral Fellow in the Harvard-China Project, presented "Driving and the Built Environment: Is Transit-Oriented Development Effective in Shanghai?," which tested whether travel behavior is affected more by transit-oriented development or residential self-selection.

Cecilia Han Springer, Postdoctoral Research Fellow in the Harvard Kennedy School (HKS) concluded the fall semester with a December talk co-sponsored by the HKS Environment and Natural Resources Program on "Opportunities and Challenges in China's Carbon Market: From Model to Reality." She explored whether China's carbon market can be effective based on both modeling analyses and fieldwork on the operational challenges of the policies.

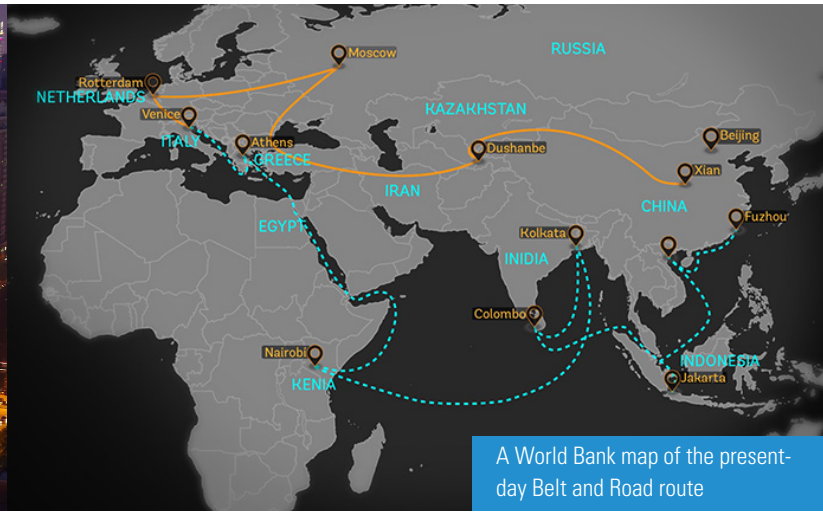
The Harvard-China Project also co-sponsored a September workshop organized by the Harvard Center for Risk Analysis to honor Prof. John S. Evans of the Harvard T.H. Chan School of Public Health. The two-day workshop, **"Risk Assessment, Economic Evaluation, and Decisions Workshop,"** explored the intersection of risk assessment and economics and featured papers from leading experts, including **seven Harvard-China Project affiliates or alumni** including Prof. Evans himself.






Xi'an, Shaanxi Province, marks the Eastern end of the Belt and Road



A World Bank map of the present-day Belt and Road route

RESEARCH HIGHLIGHT

Solar Energy Could Turn the Belt and Road Initiative Green

Researchers quantify the region's renewable energy potential

The region covered by the Belt and Road Initiative (BRI) has significant potential to be powered by solar energy, according to a recent study in the journal *Joule*. Less than 4 percent of the maximum solar potential of the region could meet the BRI's electricity demand for 2030. The research suggests a possible solution to reduce BRI countries' need for fossil fuels as they develop. This is the first time the renewable energy potential of the region is quantified.

The Chinese government launched the BRI in 2013, aiming to promote regional development and connectivity. "Belt" represents the Silk Road Economic Belt that echoes the ancient Silk Road, which linked Asia to Europe. "Road" refers to the 21st Century Maritime Silk Road that connects China to South East Asia, South Asia, and North Africa. So far, more than 120 countries in Asia, Europe, Africa, North America, South America, and Oceania are involved.

Constructing hard infrastructure, such as railways, buildings, and power plants, is a main focus of the initiative. However, most of the projects use large amounts of energy, resulting in high emissions. In addition, most countries involved in the BRI are developing countries. A proportion of their population doesn't have access to electricity. As the region develops under the initiative, the need for power is projected to increase.

"If we continue to rely on fossil fuels for energy, it can add significantly more CO_2 to the atmosphere, not just this year, but for the next few decades," says co-author Xi Lu at Tsinghua University. "This is not sustainable. If we want to achieve the emission reduction goal set by the Paris Agreement, we need renewable energy."

"The solar potential and cooperation opportunities revealed in this analysis is a chance for the BRI countries to leapfrog from their carbon-intensive trajectories to low-carbon futures"

Many BRI countries, especially those in West and South Asia, have high sun exposure, so Lu and his colleagues decided to assess the region's solar resource. The team selected 66 BRI countries that are connected geographically and built an integrative spatial model to calculate their solar power potential with high-resolution data.

The team first identified areas suitable for building solar farms. These areas would receive suffcient solar radiation and have lower land value otherwise--places like forests and agriculture land are excluded. Then they computed the spacing and packing density of solar panels, which absorb sunlight and generate energy, that would maximize power yield for each area. Finally, they calculated the areas' energy outputs in each hour after considering limiting factors like shading and temperature, which affects the performance of solar panels.

"Our model provides a comprehensive analysis of the region's solar energy potential by taking into account many influencing factors," Lu says. "We also calculated the solar energy outputs on an hourly basis, which is more accurate than previous estimates that use monthly data."

The team found that these countries can generate as much as 448.9 petawatt hour of energy, which is about 41 times the demand for electricity in these countries in 2016. Their 2030 electricity need could be satisfied by converting only 3.7 percent of the region's solar energy. To achieve this, it would require an investment of

$11.2 trillion and a land area of 88,426 square kilometers.

"If you make that commitment, the energy is free."

"The money is very large," says co-author Michael McElroy, the Gilbert Butler Professor of Environmental Studies at the Harvard John A. Paulson School of Engineering and Applied Sciences. "But if you make that commitment, the energy is free. Plus, the cost of building solar farms is coming down very dramatically because of the technological advances. We project it to become similar to fossil fuels within a decade."

The analysis also reveals a mismatch between the energy potential and the electricity demand. Countries with 70.7% of the potential consume only 30.1% of regional electricity. Therefore, cross-border power transmission grids can be utilized to maximize the benefits from solar energy through exporting surpluses of solar electricity to meet shortages in supplies of electricity elsewhere. To put such a project in action, international cooperation is essential.

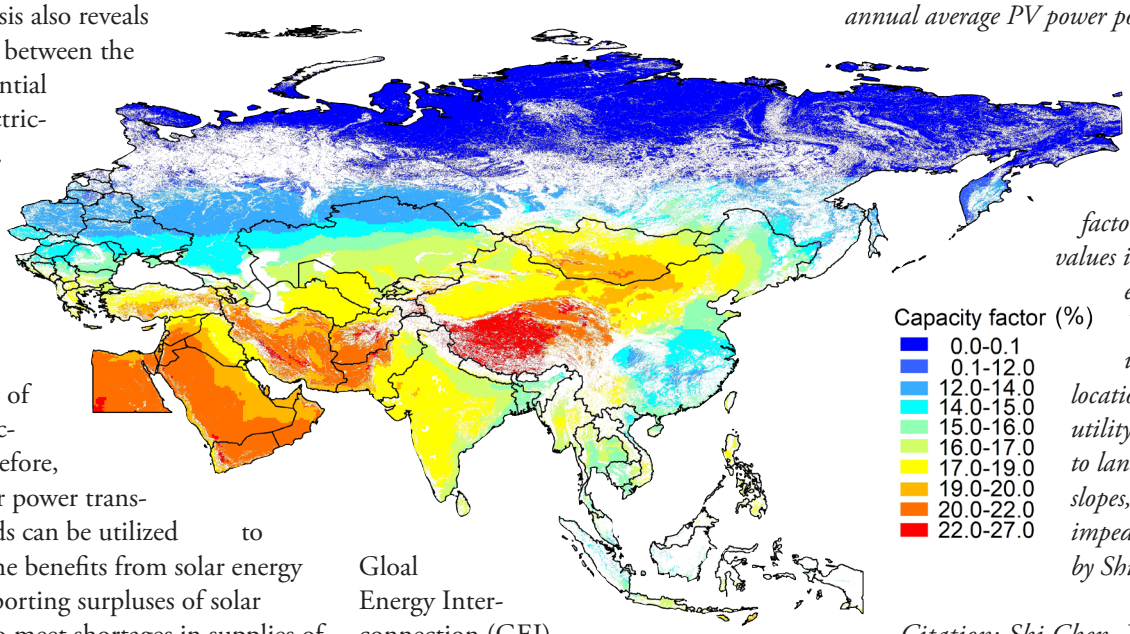
"It would be challenging, because different countries have different priorities when it comes to development," Lu says. "But the BRI is an opportunity as it sets up a framework for collaborations between countries, associations, and industries to happen. There are also funds and banks committed to promoting green development of the BRI, which provides financial support."

Because BRI countries span multiple time zones and various climate conditions, such cross-border grids would also help reduce the impact when sunlight isn't available in certain areas.

"This advantage coincides with the 'Facilities Connectivity' concept, which is one of the five cooperation priorities of the BRI," says the first author Shi Chen at Tsinghua University. "In the context of Gloal Energy Interconnection (GEI), solar power generation is bound to usher in a new development opportunity in the wave of trans-national and even trans-regional power interconnection."

"The solar potential and cooperation opportunities revealed in this analysis is a chance for the BRI countries to leapfrog from their carbon-intensive trajectories to low-carbon futures," says co-author Jiming Hao at Tsinghua University. "The opportunity to decouple future economic growth from increasing carbon emissions does exist."

"Our hope here is that this paper can influence the greening of BRI, so we can try to do the initiative in a better way," says McElroy. "And I'm optimistic about that."



Caption for Figure:

Distribution of Solar Capacity Factors across the BRI Region. Capacity factor reflects the annual average PV power potential given limits of technologies, strength of solar radiation, and other factors, with higher values indicating greater potentials. White areas are unsuitable locations for utility-scale PV due to land use, terrain slopes, and other impediments. Figure by Shi Chen.

Citation: Shi Chen, Xi Lu, Yufei Miao, Yu Deng, Chris P. Nielsen, Noah Elbot, Yuanchen Wang, Kathryn G. Logan, Michael B. McElroy, and Jiming Hao. 2019. "The potential of photovoltaics to power the Belt and Road Initiative." Joule, 3, Pp. 1-18.

By Yvaine Ye, Cell Press

INAUGURAL PHOTO CONTEST

This fall the Harvard-China Project launched an inaugural Photo Contest, which drew nearly 60 submissions for prizes in three separate categories: Natural Landscape of China; Energy and Environment in China; Urban Landscape and Cities of China. Submissions were received from University members across the Harvard John A. Paulson School of Engineering and Applied Sciences; Harvard College; Harvard Medical School; Harvard Graduate School of Design; Harvard T.H. Chan School of Public Health; and the Harvard Kennedy School. The cover image; photo at left (by Philip Milana, Harvard College 2021, Economics/EAS); and other images can be found on our website.

NEW PUBLICATIONS

Hammitt, James K., Fangli Geng, Xiaoqi Guo, and Chris P. Nielsen. 2019. **"Valuing mortality risk in China: Comparing stated-preference estimates from 2005 and 2016."** *Journal of Risk & Uncertainty* 58 (2-3): 167–186.

Gao, Meng, Peter Sherman, Shaojie Song, Yueyue Yu, Zhiwei Wu, and Michael B. McElroy. 2019. **"Seasonal prediction of Indian wintertime aerosol pollution using the Ocean Memory Effect."** *Science Advances* 5 (7): eaav4157.

Chen, Shi, Xi Lu, Yufei Miao, Yu Deng, Chris P. Nielsen, Noah Elbot, Yuanchen Wang, Kathryn G. Logan, Michael B. McElroy, and Jiming Hao. 2019. **"The potential of photovoltaics to power the Belt and Road Initiative."** *Joule* 3: 1-18. *Cover article of August edition of Joule.*

Cao, Jing, Mun S. Ho, Dale W. Jorgenson, and Chris P. Nielsen. 2019. **"China's emissions trading system and an ETS-carbon tax hybrid."** *Energy Economics* 81: 741-753.

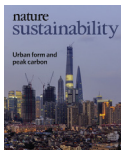
Sherman, Peter, Meng Gao, Shaojie Song, Patrick Ohiomoba, Alex Archibald, and Michael B. McElroy. 2019. **"The influence of dynamics and emissions changes on China's wintertime haze."** *Journal of Applied Meteorology and Climatology.*

Cao, Jing, Mun S Ho, and Wenhao Hu. 2019. **"Energy consumption of urban households in China."** *China Economic Review* 58.

Srinivasan, Sumeeta, Chenghe Guan, and Chris P. Nielsen. 2019. **"Built environment, income and travel behavior: Change in the city of Chengdu 2005-2016."** I*nternational Journal of Sustainable Transportation.*

Cao, Jing, Mun Sing Ho, Yating Li, Richard G. Newell, and William A. Pizer. 2019. **"Chinese residential electricity consumption estimation and forecast using micro-data."** *Resource and Energy Economics* 56: 6-27.

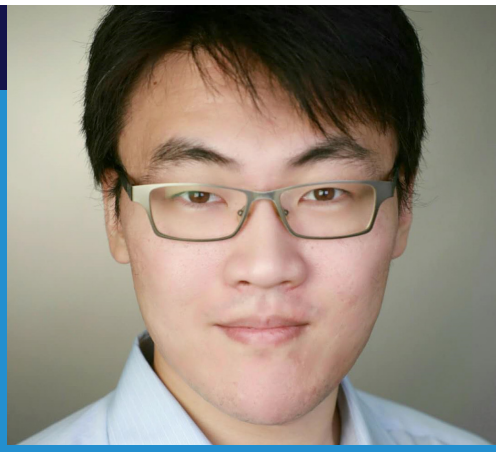
Guan, Chenghe. 2019. **"Spatial distribution of high-rise buildings and its relationship to public transit development in Shanghai."** *Transport Policy* 81: 371-380.



Wang, Haikun, Xi Lu, Yu Deng, Yaoguang Sun, Chris P. Nielsen, Yifan Liu, Ge Zhu, Maoliang Bu, Jun Bi, and Michael B. McElroy. 2019. **"China's CO2 peak before 2030 implied from diverse characteristics and growth of cities."** *Nature Sustainability* 2: 748–754. *Cover article of August edition of Nature Sustainability.*

RESEARCHER SPOTLIGHT

Tianguang Lu
Postdoctoral Fellow



As a young boy, Tianguang Lu idolized his electrical engineer father, and his career path commenced accordingly. "I was deeply influenced by him," says Lu, a postdoctoral fellow at the Harvard-China Project. "In the beginning, I hoped to follow in my father's footsteps to make my contribution to the electric power industry."

But as Lu progressed in his graduate studies, he fell in love with research. "Although sometimes there was pressure when I ran into a bottleneck," he says, "after I solved the problem, I felt a great sense of accomplishment." As his work advanced to the study of regional energy systems, he began to realize that he could also incorporate fields beyond electrical engineering, employing elements of data mining methods such as machine learning to better divine critical information as well as economic methods like game theory to help explore operation and market interactions between different regional energy systems.

He sees this same kind of interdisciplinary approach at work at Harvard-China Project. "Here, you can collaborate with scholars from many fields—including economics, environment, and energy," he says. Which helps, he notes, because so much of these topics are inherently intertwined. He offers the example of his current research, which is focused on the integration of low-carbon, low-emission power generation into India's power systems, and conducted under the leadership of HCP Chair Michael McElroy, who has expertise in air pollution, greenhouse gases, and climate, and in collaboration with current Ph.D. student Peter Sherman and HCP associate Xinyu Chen, both of whom focus on climate and energy.

Specifically, Lu says, his work on India seeks to better understand "how the combination of wind and solar can meet the future power demand, because India's population will grow very fast in the future." Lu's analysis has found that while some studies on Indian energy systems conclude that solar power will dominate the future of renewable energy in the country—mostly due to the existing rich solar resources—the reality is more complex. "Yes, at a lower level of renewable penetration, the power sector did favor solar investment," Lu says of his research findings. "But a higher penetration of renewables will favor wind power, because there is less variability from wind power, and wind will have a greater capacity factor"—the ratio of energy produced by a system relevant to its theoretical maximum.

This kind of state-level renewable integration that the India project is attempting, Lu says, is a monumental challenge with an equally monumental potential payoff. "It offers a big opportunity to solve various problems like greenhouse gas emissions and pollution," he says. "The goal of my work is to understand how energy systems can integrate more renewables to let the world be more green."

Lu's career has taken a more academic path than his father's, he notes. But he and his father still talk shop. Lu has his analytical perspective of engineering. "And I often speak to him about the practical aspect," he says.

By Dan Morrell