Summer/Fall 2022

HARVARD-CHINA PROJECT on Energy, Economy and Environment

HARVARD-CHINA PROJECT

NEWSLETTER

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The Harvard-China Project, based at the Harvard Paulson School of Engineering and Applied Sciences, receives support from the Energy Foundation China, Sze Family Charitable Foundation, Ningxia Yanbao Charitable Foundation, Harvard Global Institute, President's Office, and Climate Change Solutions Fund.

LETTER FROM THE EXECUTIVE DIRECTOR

Diversifying the Harvard-China Project's Geographic Research Scope

Chris P. Nielsen (above) is the Executive Director of the Harvard-China Project. Michael B. McElroy, Gilbert Butler Professor of Environmental Studies, is the Faculty Chair.

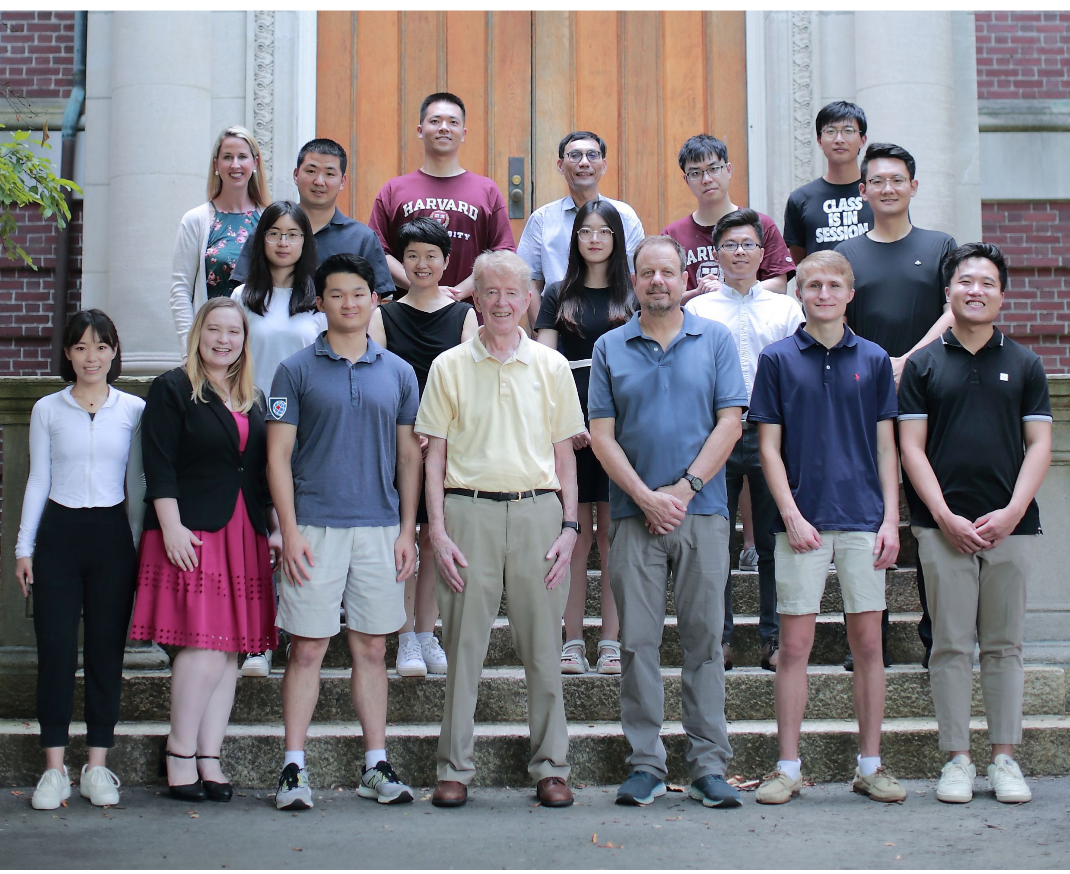
It's been another eventful half-year for the Harvard-China Project. We happily completed our rebound from the pandemic effects on our local community. Over the summer our offices were buzzing with activity, with fully 24 researchers (including seven undergraduate RAs) working on topics ranging from decarbonizing "hard-to-abate" heavy industries to opportunities for green ammonia to effects of carbon border tariffs. And our pace of peer-reviewed publication and external engagement has remained robust, as reported throughout this newsletter.

More concerning is the effect of strains in U.S.-China relations on our research exchanges. Most problematic has been a sudden spate of visa rejections for Chinese scholars invited for the current year, including ones in hardly sensitive fields like architecture, economics, and the health impacts of air pollution. We hope this impediment to collaboration proves temporary.

Helping us to adapt to unpredictable political developments is a broadening of our geographical scope, building on recent studies of energy decarbonization, climate impacts and air quality in India led by Project Chair Prof. Michael McElroy. Our research has already begun to touch on additional parts of Asia, and the Project is working with the Ash Center at the Harvard Kennedy School to develop a joint initiative in this direction.

More broadly, an emerging new ambition of the Project is to cultivate a scholarly community in which lessons and questions from decades of research on energy, economy and environment in China and the U.S. are extended to other high-emitting economies, conducted by teams drawn from across Harvard, partner universities in China, and those of other nations.

For the world to meet the challenges of climate change successfully, we firmly believe that cross-fertilization of ideas of independent scholars from diverse national contexts and experiences—motivated foremost by the urgency of shared planetary risks—will be essential. Global universities like Harvard are uniquely well-placed to bring curious minds together across both disciplines and borders, and the times clearly demand that we deliver.



HCP Summer Update: A Beehive of Activity

With the COVID pandemic restrictions mostly lifted across campus, the Harvard-China Project was able to resume many pre-pandemic activities. This past academic year we welcomed seven new visiting fellows who bring expertise in such fields as carbon markets, renewable energy, and offshore wind (page 7). We also were able to run an in-person Summer Undergraduate Research Assistantship program, which paired our researchers with Harvard students for eight weeks of summer research projects (page 9). We also hosted a month-long visit from **Meng Gao**, a Project alumnus and Assistant Professor at Hong Kong Baptist University. And we bid fond farewells to our long-term Postdoctoral Associates in Urban Planning and Transportation Studies, Drs. **Yingying Lyu** and **Faan Chen**.

NEW HCP RESEARCH

Clean Hydrogen: A Long-Awaited Solution for Hard-to Abate Sectors?

Modeling the value of clean hydrogen in decarbonizing heavy industries/transport

One of the world's biggest climate challenges is decarbonizing fossil energy uses that cannot be directly electrified using renewable power. Among so-called “hard-to-abate” (HTA) sectors are major industries that rely on fossil fuels, either for high-temperature energy or for chemical feedstocks. These include iron and steel, cement, chemicals, and building materials, together responsible for approximately 30% of the world’s annual CO_2 emissions.

Another HTA sector is heavy-duty transportation such as trucking and shipping, which is harder to electrify than passenger transport because it would require enormous batteries that add to vehicle weight and take a long time to charge.

As countries examine pathways towards decarbonization, relatively wealthy ones like the U.S. and much of Europe are pursuing strategies focused on renewable power generation and electric vehicles. China faces significantly different challenges due to a distinctive carbon emission profile resulting from the much larger roles that HTA heavy industries play in its economy.

New research published in *Nature Energy* examines how China—by far the largest producer of iron, steel, cement, and building materials—can potentially utilize clean hydrogen (“green” and “blue” hydrogen) to decarbonize HTA sectors, and aid in achieving its 2030 and 2060 decarbonization pledges. Green hydrogen is made by splitting water molecules—H_2O—using renewable electricity, while blue hydrogen is produced conventionally, from fossil fuels, but combined with carbon capture and storage.

The new paper from the Harvard-China Project is the first study to date that uses an integrated modeling approach to evaluate the potential use of clean hydrogen across China’s energy system and economy, in order to meet its 2060 net-zero target.

“Filling this research gap will help draw a clearer roadmap for China’s CO_2 emission reductions,” explains lead author of the paper **Xi Yang**, a researcher at the Harvard-China Project. “Our goal with this study was to envision a role for clean hydrogen in China’s energy economy, which can then provide a reference for other developing economies with large heavy industrial and transportation sectors.”

Clean hydrogen in HTA sectors can help China save $1.72 trillion in investment costs and avoid a 0.13% loss in aggregate GDP.

The study evaluated three questions: What are the key challenges of decarbonizing HTA sectors? What are the prospective roles for clean hydrogen as both an energy carrier and feedstock in HTA sectors? And would widespread application of clean hydrogen in HTA sectors be cost-effective compared to other options?

To analyze the cost-effectiveness and role of clean hydrogen across China’s entire economy—with an emphasis on the under-researched HTA sectors—the team built a model of an integrated energy system that includes supply and demand across sectors. Results show that a widespread application of clean hydrogen in HTA sectors can help China achieve carbon neutrality cost-effectively compared to a scenario without clean hydrogen production and use. Clean hydrogen can save $1.72 trillion in investment costs and avoid a 0.13% loss in the aggregate GDP (2020-2060) compared to a pathway without it.

The researchers also examined the type of clean hydrogen—green or blue—that would be most cost effective. Their study indicates that the average cost of China’s green hydrogen can be reduced to $2/kg of hydrogen by 2037 and $1.2/kg by 2050, when it will be much more cost-effective than blue hydrogen ($1.9/kg).

“China has rich untapped resources of solar and wind energy, both onshore and offshore,” explains **Chris P. Nielsen**, co-author of the paper and Executive Director of the Harvard-China Project. “These resources give China advantages towards developing green hydrogen for use in its industrial and transportation sectors.”

And while decarbonizing such hard-to-abate sectors is critical to climate action, it may have additional benefits. New markets for green hydrogen could also help the power system transition to renewable sources. Nielsen explains that green hydrogen production would do this by providing a comparatively flexible form of electricity demand that need not be met instantaneously, like most electricity loads. Instead it can often be scheduled, at least within short time frames. Such demand flexibility is valuable to grid managers, helping them to accommodate the inherent variability of renewable power sources as they are affected by changing meteorological conditions.

Research Cited: Xi Yang, Chris P. Nielsen, Shaojie Song, and Michael B. McElroy. 2022. “Breaking the “hard-to-abate” bottleneck in China’s path to carbon neutrality with clean hydrogen.” *Nature Energy*.

SEAS FOCUS ON HCP RESEARCH

In a Hotter World, Air Conditioning isn't a Luxury, it's a Lifesaver

By Leah Burrows, SEAS Communications

As extreme heatwaves ravage the United States, Europe and Africa, killing thousands, scientists warn that the worst is still to come. With countries continuing to pump greenhouse gases into the atmosphere, this summer's sweltering temperatures may seem mild in 30 years.

This summer, many witnessed the deadly impact extreme heat can have in a country ill-prepared for scorching temperatures. In the U.K., where air conditioning is rare, public transportation shut down, schools and offices closed, and hospitals cancelled non-emergency procedures.

Air conditioning, a technology many take for granted in the world's wealthiest nations, is a life-saving tool during extreme heat waves. However, only about 8% of the 2.8 billion people living in the hottest—and often poorest—parts of the world currently have AC in their homes.

In a recent paper, a team of researchers from the Harvard China Project, housed at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS), modeled the future demand for air conditioning as days with extreme heat increase globally. The team found a massive gap between current AC capacity and what will be needed by 2050 to save lives, especially in low-income and developing countries.

The team found a massive gap between current AC capacity and what will be needed by 2050 to save lives.

The researchers estimated that, on average, at least 70% of the population in several countries will require air conditioning by 2050 if the rate of emissions continues to increase, with that number even higher in low-latitude countries like India and Indonesia. Even if the world meets the emissions thresholds laid out in the Paris Climate Accords—which it's not on track to do—an average of 40% to 50% of the population in many of the world's warmest countries will still require AC.

"Regardless of the emission trajectories, there needs to be a massive scale-up of air conditioning or other space cooling options for billions of people so that they're not subject to these extreme temperatures throughout the rest of their lives," said **Peter Sherman**, a postdoctoral fellow at the Harvard China Project and first author of the recent paper.

Sherman, with postdoctoral fellow **Haiyang Lin**, and **Michael McElroy**, the Gilbert Butler Professor of Environmental Studies at SEAS, looked specifically at days when the combination of heat and humidity, measured by the so-called simplified wet-bulb temperature, could kill even young, healthy people in a matter of hours. These extreme events can occur when the temperatures are sufficiently

HCP & THE MITTAL SOUTH ASIA INSTITUTE EVENT RECAP

Decarbonizing India's Energy Economy

India, the second most populous country on the planet, has enormous energy demands. It is investing billions in renewable power, with the goal of generating 50 percent of its energy requirement from renewables by 2030. Professor **Michael B. McElroy** explored India's path to a decarbonized power system during a Harvard-China Project seminar, co-sponsored by Harvard's Mittal South Asia Institute. In a pre-event interview, Professor McElroy focused on the interdisciplinary need of climate change research, saying, "We have a number of papers trying to address the prospects for more renewable energy in India. One of the things I am particularly proud of is that we have been able to engage our Chinese visitors in thinking about India and other nations, as well as thinking about China, and hope to encourage the reverse, meaning Indian scholars thinking not only about India but the rest of the world. I would like to believe that we're promoting a more significant international research engagement on critical issues, where our scholars have a more global perspective." To watch the event video, visit https://bit.ly/3QuFGEV.

high or when humidity is high enough to prevent perspiration from cooling the body.

"While we focused on days when the simplified wet-bulb temperature exceeded a threshold beyond which temperatures are life-threatening to most people, wet-bulb temperatures below that threshold may still be really uncomfortable and dangerous enough to require AC, especially for vulnerable populations," said Sherman. "So, this is likely an underestimation of how much AC people will need in the future."

The team looked at two futures—one in which the emission of greenhouse gases significantly increases from today's average and a middle-of-the-road future where emissions are scaled back but not cut completely.

In the high-emissions future, the research team estimated that 99% of the urban population in India and Indonesia will require air conditioning. In Germany, a country with a historically temperate climate, the researchers estimated that as much as 92% of the population will require AC for extreme heat events. In the U.S., about 96% of the population will need AC.

High-income countries like the U.S. are better prepared for even the direst future. Currently, some 90% of the population in the U.S. has access to AC, compared to 9% in Indonesia and just 5% in India.

Even if emissions are scaled back, India and Indonesia will still need to deploy air conditioning for 92% and 96% of their urban populations, respectively.

More AC will require more power. Extreme heat waves are already straining electrical grids across the globe and the massive increased demand for AC could push current systems to the breaking point. In the U.S., for example, air conditioning already accounts for more than 70% of the peak residential electricity demand on extremely hot days in some states.

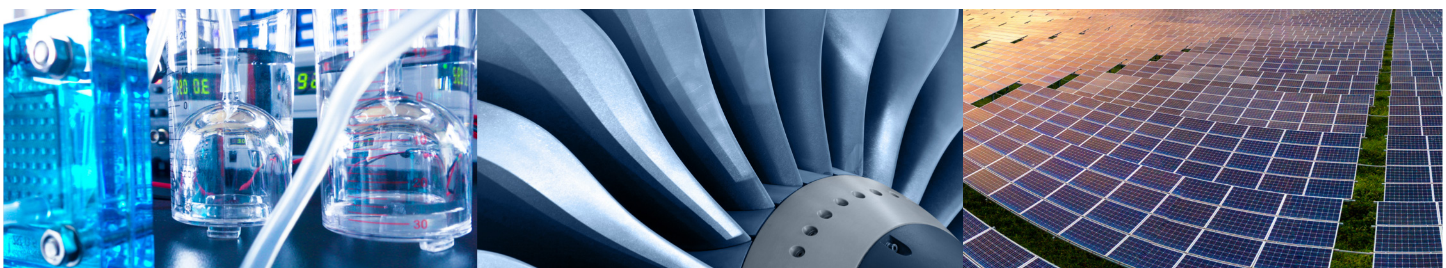
"If you increase AC demand, that has a major impact on the electricity grid as well," said Sherman. "It puts strain on the grid because everyone is going to use AC at the same time, affecting the peak electricity demand."

"When planning for future power systems, it's clear that you can't simply scale up of present-day demand, especially for countries such as India and Indonesia," said McElroy. "Technologies such as solar power could be particularly useful for handling these challenges, as the corresponding supply curve should correlate well with these summertime peak demand periods."

Other strategies to moderate increased electricity demand include dehumidifiers, which use significantly less power than air conditioning. Whatever the solution, it's clear that extreme heat isn't just an issue for future generations.

"This is a problem for right now," said Sherman.

Research Cited: Peter Sherman, Haiyang Lin, and Michael B. McElroy. 2022. "Projected global demand for air conditioning associated with extreme heat and implications for electricity grids in poorer countries." *Energy and Buildings*, 268, August, 112198.



NEW HCP RESEARCH

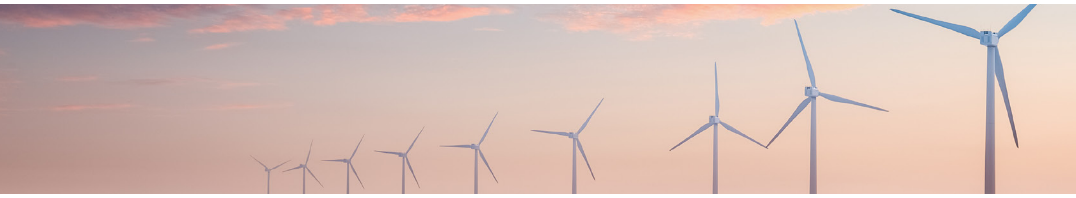
The Harvard-China Project is diversifying its geographic scope (read the Director's Letter on page 2). In addition to the air conditioning study above, two recent papers demonstrate this commitment. The first, "**Deep decarbonization of the Indian economy: 2050 prospects for wind, solar, and green hydrogen**," published in *iScience*, explores pathways for a carbon free India by 2050. Researchers envision a major role for the use of "green hydrogen" in decarbonization, produced by electrolysis of water powered by renewables. Green hydrogen's benefits are wide ranging: it offers an efficient means to decarbonize many hard-to-abate sectors; it accommodates the variability of wind and solar power as a storage medium; it can be used as a feedstock for the production of ammonia and other chemicals; and it can be an energy source for fuel cell vehicles, which have significant applications for India's future long-distance road transport.

In the second paper, "**Production of hydrogen from offshore wind in China and cost-competitive supply to Japan**," published in *Nature Communications*, a team of researchers from Harvard University, Shandong University, China University of Petroleum Beijing and Huazhong University of Science and Technology has explored the possibility of producing hydrogen via electrolysis using power generated from offshore wind in China. The team analyzed the potential for a green hydrogen supply chain to Japan delivered from offshore wind produced in China on an hourly basis from every Chinese coastal province. The researchers determined that offshore wind power from China could provide potentially as much as 12 petawatt-hours of electricity annually. The team found that Chinese-produced hydrogen can be delivered in a volume that can help Japan meet its future net-zero emissions projections, in a cost-effective way.

COMMUNITY UPDATES

Michael B. McElroy Reappointed to Five Year Term with International Environmental Advisory Council

Michael McElroy, Chair of the Harvard-China Project, was invited to an additional five-year term with the China Council for International Cooperation on Environment and Development (CCICED). This appointment follows 13 prior years of participation on the Council, an international body that advises the Government of China on environmental and development issues in China and beyond. Founded in 1992, CCICED members represents experts from the highest level of international governments, business, research and social organizations. The executive body is comprised of half Chinese and half international partners, chaired by Han Zheng, the Vice Premier of China and executive vice chairs Huang Runqiu, China's Minister of Ecology and Environment, and Steven Guilbeault, Canadian Minister of Environment and Climate Change. The group's exchange of ideas and innovations are mobilized by annual meetings and working groups.



NEW HCP RESEARCH

Cost of Renewable Intermittency: Research from the HCP Economics Group

The great challenge of increasing renewables is their intermittent nature: when the wind does not blow or the sun does not shine, we need a backup source of electricity. While future storage technologies will hopefully be more affordable, current grid operators must either run fossil-fueled plants or ask users to reduce their demand to compensate. In the U.S. and Europe, this job mostly falls on gas-fired plants, as they are most flexible—they can be "ramped up" or down at lower costs.

China, however, has few gas-fired units due to the high cost of gas, and the fact that more than 40 percent of natural gas used is imported. The task of compensating renewables falls on coal, which leads to indirect costs of wind and solar that are often overlooked; namely, the frequent ramping up and down leads to higher fuel use, with plants operating for fewer hours per year at lower rates. That is, instead of running at rated capacity (say, 600 MW) they run at lower-than-optimum rates, resulting in higher fuel use per kilowatt hour. While data exists on actual operating hours, one cannot easily estimate how much of the observed decline in average annual hours is a result of compensating for wind and solar.

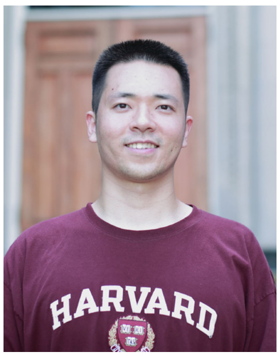
In a paper recently published in *Energy Economics,* Harvard-China Project researchers from Xian Jiaotong University and Harvard estimate this indirect cost of incorporating intermittent energy. They studied monthly operating hours of coal units at the provincial level and related them to coal used, per kWh generated. This linkage, however, cannot be directly made, since dispatch decisions are related to the energy efficiency of generating plants; that is, the number of hours that a plant operates depends on the dispatcher who is tasked with promoting energy efficiency while meeting electricity demand. From the statistical point of view, the choice of hours is not a randomly chosen variable. The authors exploit how hydropower affects the hours of coal plants –power that is determined by water levels, which are randomly generated by nature. Using this variation in hydropower across time and space, the authors estimate that a 100-hour reduction in annual hours lead to a 3% increase in coal use per kWh. Given the estimated reduction in average coal hours due to higher renewables, they estimate that the lower thermal efficiency cost is about US $4.8 billion in 2019. This cost doubles if one values the social cost of the extra carbon emitted at $50/ton.

The task of compensating for renewables falls on coal, which leads to indirect costs of wind and solar that are often overlooked.

Research Cited: Jianglong Li and Mun Ho. 2022. "Indirect cost of renewable energy: Insights from dispatching," *Energy Economics*, 105, January.

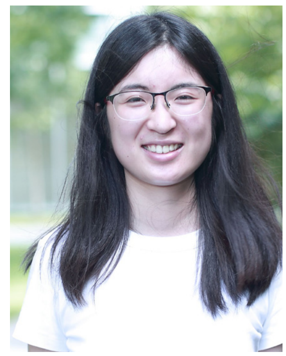
MEET HCP'S NEWEST RESEARCHERS

Yiliang Jiang, a Ph.D candidate in Tsinghua University's School of Environment, first became aware of the Harvard-China Project during a seminar led by Professor Michael B. McElroy in 2020. "I was so impressed by Dr. McElroy's professionalism and his perspectives on the future transportation transition, and that led me to apply to join the Harvard-China Project." Yiliang's research explores a techno-economic sensible decarbonization transition ally of China's on-road transportation sector in order to meet China's 2030 carbon peak and 2060 carbon neutrality climate targets. For Yiliang, the best part of his time at Harvard is the interdisciplinary research. "I really found the 'Aha!' moments come very quickly when well-trained researchers sit together in the conference room. I have learned a lot along the way."

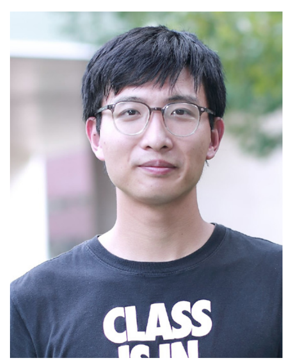


Hu Xian, an economics Ph.D candidate from Tsinghua University, works with Mun S. Ho, Harvard-China Project Research Associate, and Jing Cao, a Tsinghua University professor and Associate of the Harvard-China Project. She explains her research, saying, "Right now I am working on computable general equilibrium models of the global economy-energy-environment, focusing on carbon pricing policies of different regions and their effects on the economy, welfare, and climate. I will also explore interdisciplinary research like the integration of economic and environmental models." For Xian, the best part of the experience has been the community. "Harvard provides us with a good research environment and many academic resources such as talented scholars with different backgrounds, interesting seminars, and rich library resources."

Yu Zhang, another Tsinghua University economics Ph.D candidate who also works with Jing Cao and Mun S. Ho, applies a general equilibrium model and microdata to explore the impact of policy reforms in China's power sector. Eventually, Yu aims to work in a university or research institution, and says her time at the Harvard-China Project has benefited this aspiration. "As an economics student, studying electricity was a big challenge for me because of its multidisciplinary background. The Harvard-China Project has provided me with a platform for interdisciplinary research, which has given me a deeper understanding of my research topic."



Haiyang Jiang, a Tsinghua University Ph.D candidate in the Department of Electrical Engineering, focuses on decarbonizing China's power system with Power-to-X technologies and analyzes their economic benefits. He says he made great progress in his research, which he would like to expand upon with a career in academia. Above all, "I want to acknowledge Mike McElroy, Chris Nielsen and Haiyang Lin for their patient and professional guidance in advancing my research work."

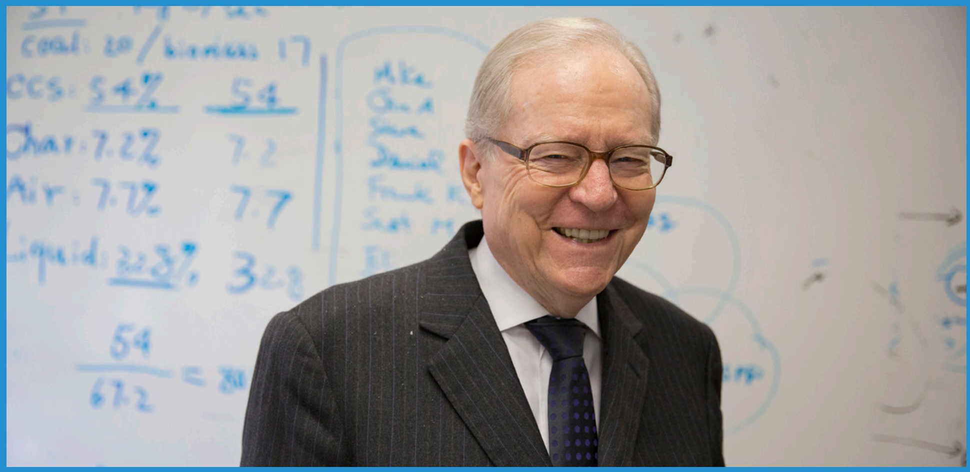


JOIN THE HARVARD-CHINA PROJECT AS A RESEARCHER

We invite current Harvard students of any academic level (bachelor's, master's, or Ph.D. students) in any Harvard school to contact us about research opportunities at the Harvard-China Project - email us at harvardchinaproject@harvard.edu. Each year we also appoint a number of visiting researchers from other universities (ranging from Ph.D. students to junior and tenured faculty members) and several postdoctoral fellows. We encourage those who have strong academic and research records related to our current research areas to apply for these opportunities. This year we are accepting applications on a rolling basis, to join us during the second semester of this academic year, or for next fall 2023. To apply for a position, visit our website: www.www.chinaproject.harvard.edu/visiting-researcher

HCP COMMUNITY NEWS

IN MEMORIAM: DALE W. JORGENSON (MAY 7, 1933 – JUNE 8, 2022)



Dale W. Jorgenson, one of the founding faculty leaders of what is now the Harvard-China Project on Energy, Economy, and Environment, passed away June 8, 2022, aged 89. As a Harvard Professor of Economics and University Professor, he continued to be one of the China Project's most active faculty participants throughout its history. Two weeks before he died, he hosted a welcome dinner for the Project's two newest visiting Ph.D. students, from Tsinghua University. He died of respiratory complications and is survived by his wife Linda, two children, and three grandchildren.

Jorgenson was a pioneer in multiple areas of economics. These included information technology and economic growth, tax policy and investment behavior, applied econometrics and, most relevant here, energy economics and analysis of environmental policy, including in China.

As the world's foremost scholar of productivity measurement, he had written about energy productivity and econometric analysis of energy inputs since the 1970s. His 1974 model of U.S. economic growth was one of the earliest inter-industry models with an econometric treatment of energy inputs. He led a team of collaborators to develop the model and use it for analyzing energy shocks, environmental policies, tax reforms, and carbon pricing. A book distilling this research is *Double Dividend: Environmental Taxes and Fiscal Reform in the United States*, with three co-authors including Mun Ho, his long-time associate and co-leader of the China Project's economics research. Jorgenson employed these tools in statutory assessments of environmental policies for the U.S. Environmental Protection Agency, notably of the Clean Air Act.

Jorgenson's research on productivity and economic growth spanned the globe. As Michael McElroy started development in 1993 of a multi-disciplinary research program on China under Harvard's University Committee on the Environment, Jorgenson and Dwight Perkins initiated an economics component by constructing a simple model of China's economic growth and energy demand. This was published in the China Project's first book, *Energizing China: Reconciling Environmental Protection and Economic Growth*, and set the basis for Jorgenson's decades of partnership with McElroy leading the Project's economics research. He began travelling to China to work with collaborators and attend conferences and workshops, including a number organized by the Project. He supervised the Harvard Ph.D. dissertation of Jing Cao, who as a Tsinghua University professor continued to collaborate closely with Jorgenson and today remains one of the Project's lead economists.

Jorgenson later advised and contributed to broadly interdisciplinary studies led by Chris Nielsen and Ho that integrated atmospheric sciences, engineering, environmental health, and economics, published in the 2007 volume, *Clearing the Air: The Health and Economic Damages of Air Pollution in China*, and the more advanced 2013 sequel, *Clearer Skies Over China: Reconciling Air Quality, Climate, and Economic Goals*. In these book-length assessments bridging schools of Harvard and those of Chinese universities, Jorgenson, Ho, and later Cao used results from modeling air pollution emissions and concentrations, human and crop exposures, and health and agricultural impacts to allocate pollution damages to different sectors and fuels. They then applied an energy-environmental-economic model of China to simulate the impact of policies, such as carbon taxes, on air pollution damages and economic growth.

More recently, Jorgenson guided a new cohort of students from China to use household survey data to study energy consumption behavior and to use firm data to study their energy-output relationships. His most recent paper is "Urban Household Consumption in China: Price, Income, and Demographic Effects," published in 2020 when he was aged 87. Another notable paper in his last years is "China's Emissions Trading System and an ETS-Carbon Tax Hybrid," published in 2019.

Most researchers of the China Project, in all fields, knew Jorgenson from his regular presence in the Project's Pierce Hall conference room, mainly to meet with research fellows but also to strategize with Ho, Nielsen, and McElroy. Some knew him better than others, but the entire Harvard-China Project community mourns the sudden loss. He has left a void that will be hard to fill, not just in the work of the Harvard-China Project but also in its atmosphere of active and supportive mentorship from its most distinguished senior leaders. Yet he has also left a worldwide network of students and collaborators who have learned much from him and will surely extend the work he pioneered, as well as the spirit of generous shared inquiry with which he pursued it.

UNDERGRADUATE SUMMER RESEARCHERS

Student Researchers Grapple with Decarbonizing China + Asia

This summer, through the generous continued support of the Harvard Office of Career Services, the Harvard-China Project coordinated its fourth summer of undergraduate research. This year, seven students were paired with Harvard-China Project researchers for the "Decarbonization in China and Asia" summer research assistantships.

Eddie Dai '25 and **Genevieve Raushenbush** '24 worked with Harvard Graduate School of Design Professor Ann Forsyth and Harvard-China Project Associate Yingying Lyu for the "STGA Lishui Community Study." They constructed a database detailing the geographical layout and features in the community of Lishui in Nanjing, China. They pinpointed key variables (recreational facilities, public transit stops, health clinics, and more) to help construct the map to better understand the context Lishui's aging population lives in, to help the team devise digital technologies to improve peoples' ability to age in place.

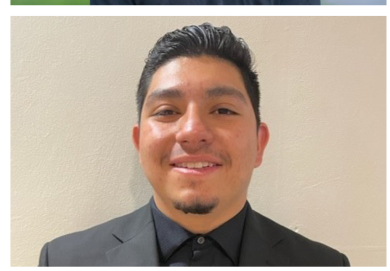
Jack Walker '24 continued his research on air quality and climate benefits of decarbonizing the shipping industry. Says Jack, "After previously working with postdoctoral fellow Peter Sherman during the past academic year, our focus this summer was to examine the air quality impacts of three main emissions pathways for the shipping industry: business-as-usual, 50% emissions reduction, and 100% emissions reduction. Peter was essential to the success of the project, always ready to help explain something that may not make sense."

Blake Chen '25 also worked with Dr. Sherman, but on an "Analysis of the Indirect Impacts of Methane on Global Chemistry and Climate Models." They explored the secondary effects of methane and how methane-related processes are represented by climate models. Using the Harvard supercomputer, they ran simulations for different climate models based on varying methane emissions levels, and analyzed the effect these changes had on other atmospheric gases.

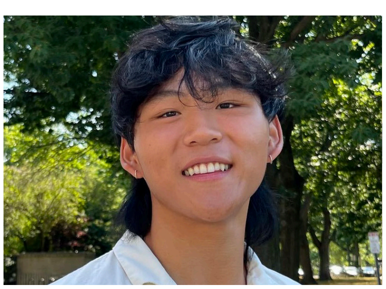
Andres Hernandez Gonzalez '24 worked with Haiyang Lin, postdoctoral fellow, on "Green Hydrogen and Green Ammonia as Energy Carriers." They used the relative costs of today's technology to define parameters that can be optimized to provide the least cost of hydrogen given localized production. He says, "Dr. Lin has inspired me to do my best by offering his wisdom and making this assistantship fun. My passion for this work comes from my ultimate goal to work in the hydrogen economy, perhaps working for or running my own green energy start up."

Joshua Cai '24 worked with Mun S. Ho, Research Associate, for "Economics of Electricity System Reform and Household Demand." He explains, "my research project studied the issues of the Chinese electricity system, and how issues, such as coal overcapacity, affected the efficiency of overall electricity generation. Ever since the world has been moving towards a carbon-neutral future, China has been attempting to move towards a greater reliance on renewable energy, but this has economic implications on China's existing coal industry."

Rachel Seevers '23 investigated the "Global Policy and Technology Surrounding Steel Sector Decarbonization" with Xi Yang, Research Associate. Says Rachel, "My job was to investigate the standing governmental policies (both restrictions and incentives) of the steel sector, to determine gaps and trends that need to be addressed. I identified key drivers like time, money, and governmental structure and was able to complete a cross comparison between countries. With my work, researchers are able to have a clearer picture of the policy world their technologies would be implemented into and the gaps that need to be addressed."



Photos, clockwise from top: Rachel Seevers, Joshua Cai, Andres Hernandez Gonzalez, Blake Chen, Jack Walker, Genevieve Raushenbush, Eddie Dai.



CAMPUS NEWS

New Harvard Institute to Unite, Advance Efforts to Stem Tide of Climate Crisis

In June, Harvard University announced the creation of the **Salata Institute for Climate and Sustainability**, a groundbreaking new entity that will advance and catalyze research programs across all of Harvard's schools and enable comprehensive cross-university education in climate and the environment.

The Salata Institute will launch in fall 2022 and be led by Vice Provost for Climate and Sustainability Jim Stock. The Institute is made possible by a $200 million gift to Harvard from Melanie and Jean Eric Salata. Jean Salata is the chief executive and founding partner of Baring Private Equity Asia.

The Institute will pursue a pathbreaking approach to the climate challenge—one that aims to grow and galvanize the network of climate-focused scholars across Harvard, create new pathways for student education and participation in the development of climate and sustainability solutions, and add critical focus on significant, real-world progress with near- and long-term impact. It will also act as a hub and connection point for the many existing climate-related programs and initiatives across the University.

"Climate change is one of the most pressing issues of our time. It is a crisis whose impact will affect our children and many generations to come, and we have a responsibility to them to do everything we can to address it," the Salatas said. "Through initiatives like the one we are announcing today, and many others like it globally, we can harness the power of the world's best researchers and most talented policy and business leaders to create a more sustainable future for all of us."

Adapted from a Harvard Gazette article.

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