Summer/Fall 2022

HARVARD-CHINA PROJECT on Energy, Economy and Environment

HARVARD-CHINA PROJECT NEWSLETTER

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Cover Image: Windmill on Hailing Island, Yangjiang City, Guangdong Province, China | Adobe.

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

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.

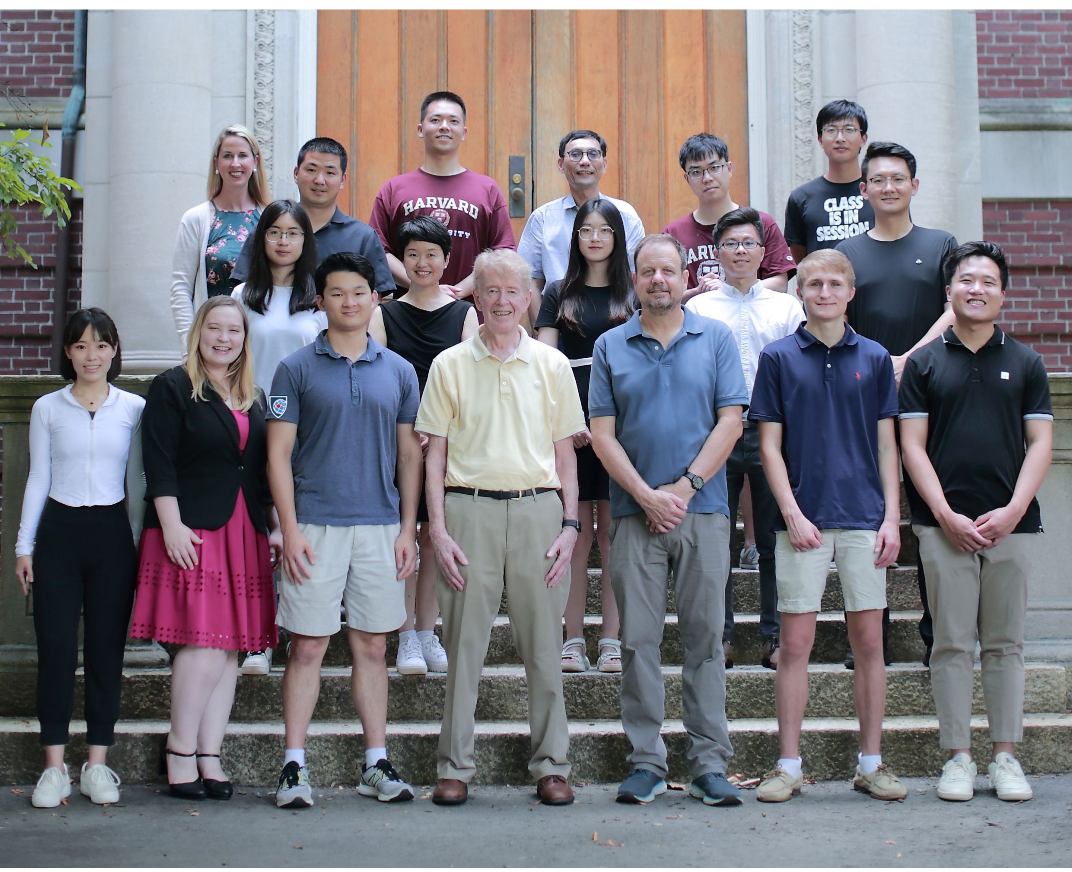
More concerning is the effect of strains in U.S.-China relations on our research exchanges. Most problematic has been a sudden spate of visa rejections for Chinese scholars invited for the current year, including ones in hardly sensitive fields like architecture, economics, and the health impacts of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

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.



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.

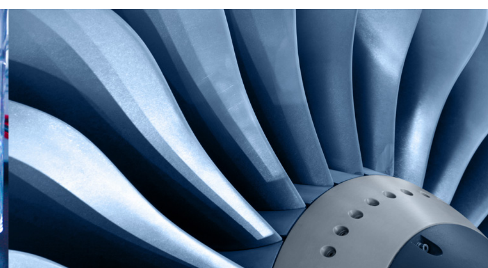
"If you increase AC demand, that has a major impact on the electricity grid as well," said Sherman. "It puts strain on the grid because everyone is going to use AC at the same time, affecting the peak electricity demand."

"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

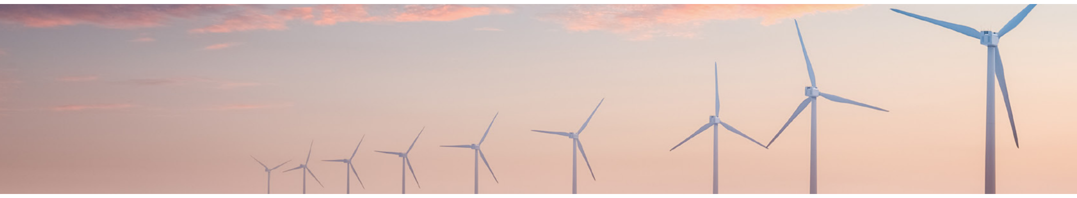
The Harvard-China Project is diversifying its geographic scope (read the Director's Letter on page 2). In addition to the air conditioning study above, two recent papers demonstrate this commitment. The first, "**Deep decarbonization of the Indian economy: 2050 prospects for wind, solar, and green hydrogen**," 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.

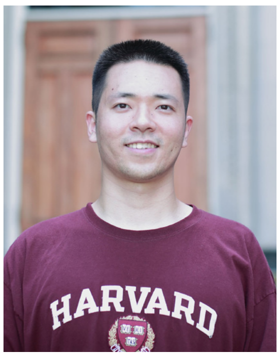
In a paper recently published in *Energy Economics,* Harvard-China Project researchers from Xian Jiaotong University and Harvard estimate this indirect cost of incorporating intermittent energy. They studied monthly operating hours of coal units at the provincial level and related them to coal used, 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.

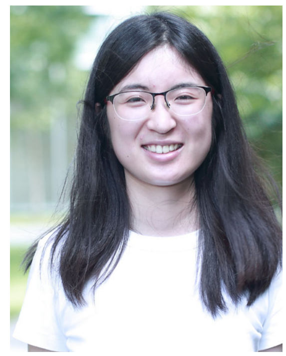
MEET HCP'S NEWEST RESEARCHERS

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."

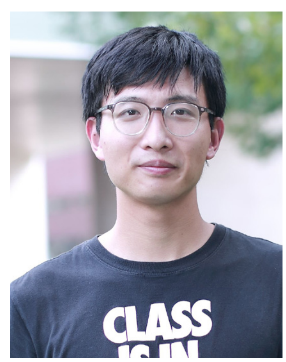


Hu Xian, an economics Ph.D candidate from Tsinghua University, works with Mun S. Ho, Harvard-China Project Research Associate, and Jing Cao, a Tsinghua University professor and Associate of the Harvard-China Project. She explains her research, saying, "Right now I am working on computable general equilibrium 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."

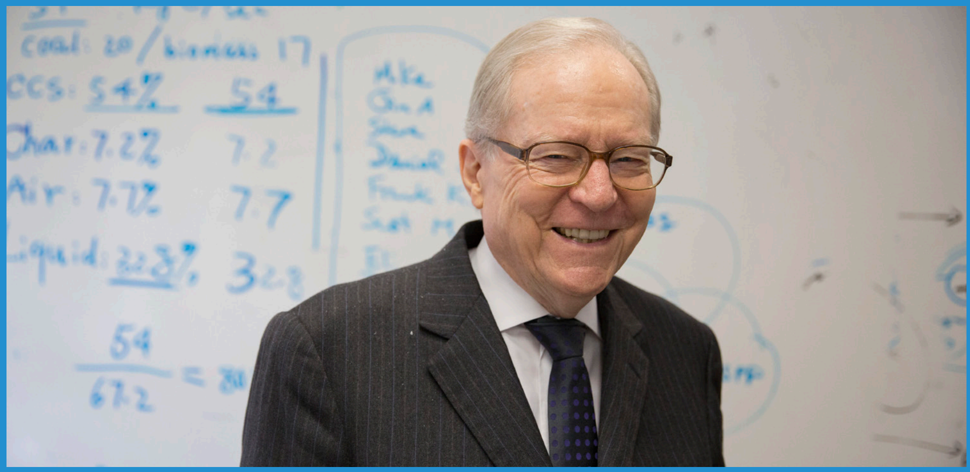


JOIN THE HARVARD-CHINA PROJECT AS A RESEARCHER

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.

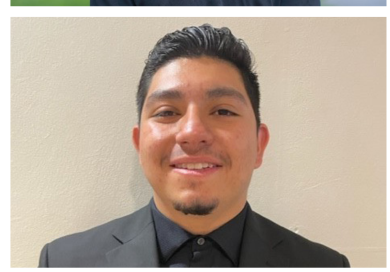
Jack Walker '24 continued his research on air quality and climate benefits of decarbonizing the shipping industry. Says Jack, "After previously working with postdoctoral fellow Peter Sherman during the past academic year, our focus this summer was to examine the air quality impacts of three main emissions 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.

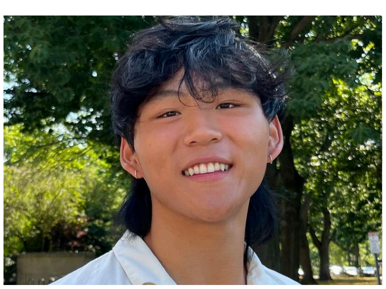
Andres Hernandez Gonzalez '24 worked with Haiyang Lin, postdoctoral fellow, on "Green Hydrogen and Green Ammonia as Energy Carriers." They used the relative costs of today's technology to define parameters that can be optimized to provide the least cost of hydrogen given localized production. He says, "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.

RECENT PUBLICATIONS: MARCH TO AUGUST

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*.

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.

Shaojie Song, Haiyang Lin, Peter Sherman, Xi Yang, Shi Chen, Xi Lu, Tianguang Lu, Xinyu Chen, and Michael B. McElroy. 2022. **"Deep decarbonization of the Indian economy: 2050 prospects for wind, solar, and green hydrogen."** *iScience*, 25, 6, 104399.

Shi Chen, Xi Lu, Chris P. Nielsen, Guannan Geng, Michael B. McElroy, Shuxiao Wang, and Jiming Hao. 2022. **"Improved air quality in China can enhance solar power performance and accelerate carbon neutrality targets."** *One Earth*, 5, 5, 550-562.

Rong Tang, Jing Zhao, Yifan Liu, Xin Huang, Yanxu Zhang, Derong Zhou, Aijun Ding, Chris Nielsen, and Haikun Wang. 2022. **"Air quality and health co-benefits of China's carbon dioxide emissions peaking before 2030."** *Nature Communications*, 13, 1008.

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Yingying Lyu and Ann Forsyth. 2022. **"Technological devices to help older people beyond the home: An inventory and assessment focusing on the neighborhood and city scales."** *Cities & Health*.

Faan Chen, Yilin Zhu, Jiacheng Zu, Jingyang Lyu, and Junfeng Yang. 2022. **"Appraising road safety attainment by CRITIC-ELECTRE-FCM: A policymaking support for Southeast Asia."** *Transport Policy*, 112, 104-118.

Faan Chen, Lin Shi, Yaxin Li, Qilin Wang, Haosen Sun, Xinyu Tang, Jiacheng Zu, and Zhenwei Sun. 2022. **"Measuring road safety achievement based on EWM-GRA-SVD: A decision-making support system for APEC countries."** *Knowledge-Based Systems*, 25, 109373.

HARVARD-CHINA PROJECT
on Energy, Economy and Environment

HARVARD-CHINA PROJECT NEWSLETTER
哈佛大学中国项目新闻通讯

本期内容

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哈佛中国项目隶属于哈佛大学保尔森工程与应用科学学院，项目获得中国能源基金会、施家慈善基金会、宁夏彦宝慈善基金会、哈佛全球研究所、校长办公室以及气候变化解决方案基金的支持 。

执行主任的信

多元化哈佛-中国项目的地理研究范围

哈佛中国项目又是一个丰富多彩的半年。我们很高兴在大流行对当地社区的影响背景下实现逆转。整个夏天，我们的办公室热闹非凡，整整 24 名研究人员（包括 7 名本科生助研）研究的主题从“难以减排”的重工业脱碳到绿色氨的机会，再到碳边界关税的影响。正如本时事通讯中所报道的那样，我们的同行评审出版物和外部参与的步伐一直保持强劲。

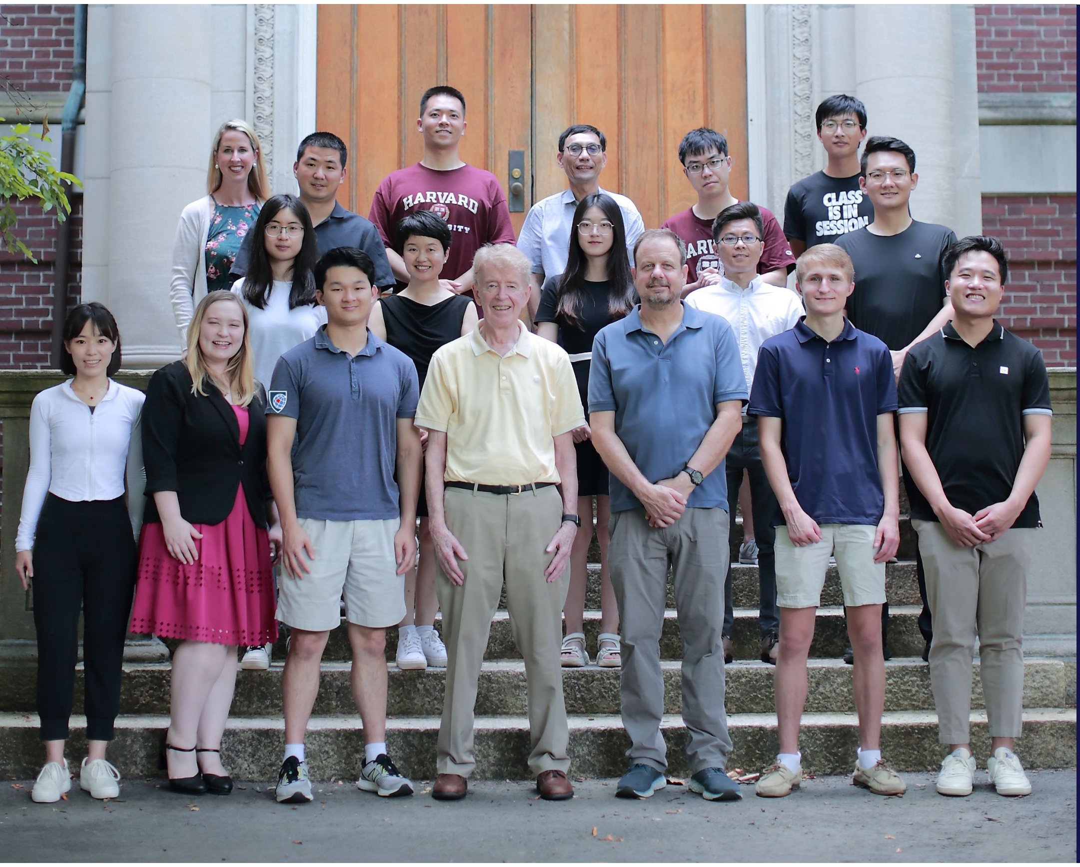
更令人担忧的是中美关系紧张对我们研究交流的影响。最大的问题是今年邀请的中国学者的签证突然被拒，其中包括建筑、经济学和空气污染对健康影响等几乎不敏感领域的学者。我们希望这种合作障碍是暂时的。

帮助我们适应不可预测的政治发展扩大了我们的地理范围，建立在项目主席 Michael McElroy 教授领导的印度最近对能源脱碳、气候影响和空气质量的研究的基础上。我们的研究已经开始触及亚洲的其他地区，该项目正在与哈佛肯尼迪学院的 Ash 中心合作，在这个方向上制定一项联合倡议。

更广泛地说，该项目的一个新目标是建立一个学术社区，将数十年来中国和美国关于能源、经济和环境研究的经验和问题扩展到其他高排放经济体，由来自在哈佛、中国的合作大学和其他国家的大学进行研究。

为了让世界成功应对气候变化的挑战，我们坚信，来自不同国家背景和经验的独立学者的思想的交叉融合——首先是出于对共同的地球风险的紧迫性的考虑——将是至关重要的。像哈佛这样的全球性大学拥有得天独厚的优势，可以将跨学科和跨国界的好奇心聚集在一起，而时代显然要求我们这样做。

Chris P. Nielsen（上图）是哈佛中国项目的执行主任。*Michael B. McElroy*，吉尔伯特·巴特勒环境研究教授，是项目教职主席。



HCP 夏季更新：活动蜂巢

随着COVID 大流行的限制在校园内基本解除，哈佛中国项目得以恢复许多大流行前的活动。在过去的一学年中，我们迎来了七位新的访问学者，他们带来了碳市场、可再生能源和海上风电等领域的专业知识（第 7 页）。我们还能够亲自运行暑期本科生研究助理计划，该计划将我们的研究人员与哈佛学生配对，进行为期八周的暑期研究项目（第 9 页）。我们还接待了香港浸会大学项目校友和助理教授高蒙为期一个月的访问。我们向长期从事城市规划和交通研究的博士后研究员吕瑛英和陈法安博士道别。

新的 HCP 研究

清洁氢：难以减排的行业期待已久的解决方案？

模拟清洁氢在重工业/运输脱碳中的价值

世界上最大的气候挑战之一是使那些不能直接使用可再生能源实现电气化的化石能源使用脱碳。在所谓的“难以减排”（HTA）行业中，有一些主要依赖化石燃料的行业，无论是高温能源还是化学原料。这些包括钢铁、水泥、化学品和建筑材料，它们共同造成了全球约 30% 的二氧化碳年排放量。

另一个 HTA 领域是重型运输，如卡车运输和航运，它们比客运更难实现电气化，因为需要巨大的电池，这会增加车辆的重量并且需要很长时间来充电。

随着各国研究脱碳途径，美国和欧洲大部分地区等相对富裕的国家正在推行专注于可再生能源发电和电动汽车的战略。由于 HTA 重工业在其经济中发挥的更大作用，中国面临着截然不同的挑战，因为其碳排放特征独特。

发表在《自然能源》上的新研究探讨了中国——迄今为止最大的钢铁、水泥和建筑材料生产国——如何潜在地利用清洁氢（“绿色”和“蓝色”氢）使 HTA 部门脱碳，并帮助实现其 2030 年和 2060 年的脱碳承诺。绿色氢是通过使用可再生电力分解水分子（H_2O）制成的，而蓝色氢则是通过传统的化石燃料生产的，但与碳捕获和储存相结合。

哈佛中国项目的新论文是迄今为止第一项使用综合建模方法评估清洁氢在中国能源系统和经济中的潜在用途的研究，以实现其 2060 年净零排放目标。

“填补这一研究空白将有助于为中国的二氧化碳减排绘制更清晰的路线图，”该论文的主要作者、哈佛中国项目研究员杨曦解释道。“我们这项研究的目标是设想清洁氢在中国能源经济中的作用，然后可以为其他拥有大型重工业和运输部门的发展中经济体提供参考。”

HTA 领域的清洁氢可以帮助中国节省 1.72 万亿美元的投资成本，避免 0.13% 的GDP 总量损失。

该研究评估了三个问题：HTA 部门脱碳的主要挑战是什么？清洁氢作为 HTA 领域的能源载体和原料的预期作用是什么？与其他选择相比，清洁氢在 HTA 领域的广泛应用是否具有成本效益？

为了分析清洁氢在中国整个经济中的成本效益和作用——重点关注研究不足的 HTA 行业——该团队建立了一个综合能源系统模型，其中包括各部门的供应和需求。结果表明，与没有清洁氢气生产和使用的情景相比，清洁氢气在 HTA 领域的广泛应用可以帮助中国经济高效地实现碳中和。与没有清洁氢的途径相比，清洁氢可以节省 1.72 万亿美元的投资成本，并避免0.13%的总 GDP（2020-2060 年）损失。

研究人员还检查了最具成本效益的清洁氢气类型——绿色或蓝色。他们的研究表明，到 2037 年，中国绿色氢的平均成本可以降至 2 美元/千克，到 2050 年可以降低到 1.2 美元/千克，届时它将比蓝色氢（1.9 美元/千克）更具成本效益。

“中国拥有丰富的陆上和海上未开发的太阳能和风能资源，”该论文的合著者兼哈佛中国项目执行主任克里斯·尼尔森解释道。“这些资源使中国在开发用于工业和交通运输领域的绿色氢方面具有优势。”

对这些难以减排行业进行脱碳对气候行动至关重要，而且可能带来额外的好处。绿色氢的新市场也可以帮助电力系统向可再生能源过渡。尼尔森解释说，绿色氢气生产将通过提供一种相对灵活的电力需求形式来做到这一点，这种电力需求不需要像大多数电力负荷那样立即得到满足。相反，它通常可以被安排，至少在很短的时间内。这种需求灵活性对电网管理者来说很有价值，可以帮助他们适应可再生能源的固有可变性，因为它们受到不断变化的气象条件的影响。

最新研究：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 专注于 HCP 研究

在更热的世界里，空调不是奢侈品，而是救生员

来自 SEAS Communications 的 Leah Burrows

随着极端热浪肆虐美国、欧洲和非洲，造成数千人死亡，科学家们警告说，情况还会更糟糕。随着各国继续将温室气体排放到大气中，今年夏天闷热的气温在 30 年内可能看起来显得温和。

今年夏天，许多人目睹了极端高温对一个对高温准备不足的国家可能产生的致命影响。在空调很少见的英国，公共交通关闭，学校和办公室关闭，医院取消了非紧急程序。

在世界上最富裕国家，空调是许多人认为理所当然的技术，在极端热浪中是一种拯救生命的工具。然而，目前生活在世界上最热（往往也是最贫穷）地区的 28 亿人中，只有大约 8% 的人家中有空调。

在最近的一篇论文中，来自哈佛约翰·保尔森工程与应用科学学院 (SEAS) 的哈佛中国项目的一组研究人员模拟了随着全球极端高温天数的增加，未来对空调的需求。该研究团队发现，目前的空调容量与到 2050 年挽救生命所需的容量之间存在巨大差距，尤其是在低收入和发展中国家。

该研究团队发现，目前的空调容量与到 2050 年挽救生命所需的容量之间存在巨大差距。

研究人员估计，如果排放率继续增加，到 2050 年，平均而言，几个国家至少 70% 的人口将需要空调，而在印度和印度尼西亚等低纬度国家，这一数字甚至更高。即使世界达到了《巴黎气候协定》中规定的排放阈值——它没有按计划进行——在世界上许多最温暖的国家，平均 40% 到 50% 的人口仍然需要空调。

"无论排放轨迹如何，都需要为数十亿人大规模扩大空调或其他空间冷却选择，以便他们在余生中不会受到这些极端温度的影响，"哈佛中国项目的博士后研究员和最近论文的第一作者，彼得谢尔曼说。

Sherman 与博士后研究员蔺海洋和 SEAS 环境研究的吉尔伯特·巴特勒教授迈克尔·麦克尔罗伊 (Michael McElroy) 专门研究了用所谓的简化

HCP 和米塔尔南亚学院活动回顾

印度能源经济脱碳

印度是地球上人口第二多的国家，能源需求巨大。它正在投资数十亿美元用于可再生能源，目标是到 2030 年实现其 50% 的能源需求来自可再生能源。Michael B. McElroy 教授在哈佛-中国项目由哈佛大学联合米塔尔南亚研究所主办的研讨会上探讨了印度通往脱碳电力系统的道路。在活动前的采访中，McElroy 教授着重强调了气候变化研究的跨学科需求，他说："我们有很多论文试图解决印度更多可再生能源的前景。我特别自豪的一件事是我们已经能够让我们的中国访客思考印度和其他国家以及中国，并希望鼓励相反的情况，这意味着印度学者不仅要思考印度，还要思考世界其他地区。我愿意相信我们正在促进对关键问题的更重要的国际研究参与，我们的学者在这些问题上拥有更全球化的视角。"要观看活动视频，请访问 https://bit.ly/3QuFGEV.

湿球温度测量的热量和湿度的结合甚至可以在几个小时内杀死年轻，健康的人的时期。当温度足够高或湿度高到足以防止汗液冷却身体时，就会发生这些极端事件。

“虽然我们关注简化的湿球温度超过阈值的时期，超过该阈值温度对大多数人来说会危及生命，但低于该阈值的湿球温度可能仍然非常不舒服和危险到需要空调，特别是对于弱势群体，”谢尔曼说。“因此，这可能低估了人们未来对 空调的需求量。”

该团队研究了两种未来——一种是温室气体排放量比今天的平均水平显著增加，另一种是排放量减少但未完全减少的中间道路。

在高排放的未来，研究小组估计印度和印度尼西亚 99% 的城市人口将需要空调。在德国，一个在历史上气候温和的国家，研究人员估计多达 92% 的人口将需要空调来应对极端高温事件。在美国，大约 96% 的人口将需要空调。

像美国这样的高收入国家甚至为最可怕的未来做好了更好的准备。目前，美国约 90% 的人口可以使用空调，而印度尼西亚为 9%，印度仅为 5%。

即使排放量减少，印度和印度尼西亚仍需要分别为其 92% 和 96% 的城市人口安装空调。

更多的空调将需要更多的电力。极端热浪已经给全球电网带来压力，对空调需求的大量增加可能会使当前系统达到崩溃的边缘。以美国为例，在一些州的极端炎热的日子里，空调已经占到了居民用电高峰的70%以上。

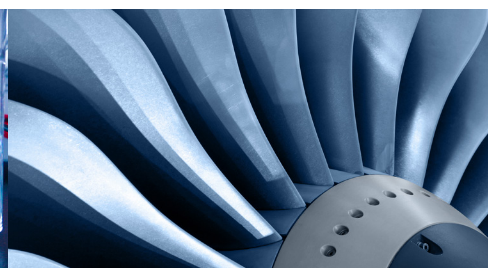
“如果你增加空调需求，那也会对电网产生重大影响，”谢尔曼说。“这给电网带来了压力，因为每个人都会在同一时间使用交流电，从而影响了高峰用电需求。”

“在规划未来的电力系统时，很明显，你不能简单地扩大当前的需求，尤其是对于印度和印度尼西亚等国家而言，”McElroy 说。“太阳能等技术对于应对这些挑战可能特别有用，因为相应的供应曲线应该与这些夏季高峰需求期密切相关。”

缓解电力需求增加的其他策略包括除湿机，其耗电量明显低于空调。无论解决方案如何，很明显极端高温不仅仅是未来一代的问题。

“这是目前的一个问题，”谢尔曼说。

最新研究：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.



新的 HCP 研究

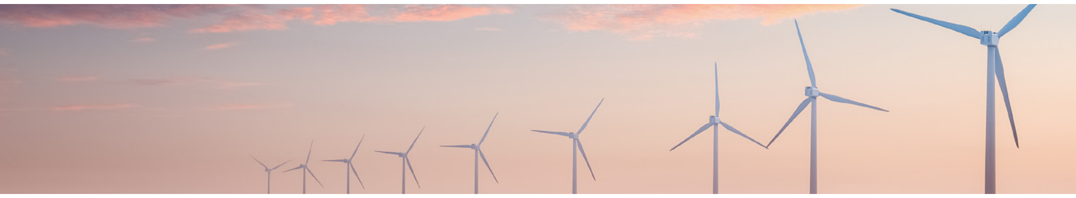
哈佛中国项目正在扩大其地理范围（请阅读第 2 页的主任信函）。除了上面的空调研究，最近的两篇论文也证明了这一承诺。第一篇，“印度经济的深度脱碳：2050 年风能、太阳能和绿色氢的前景”，发表在 iScience 上，探索了到 2050 年印度实现无碳的途径。研究人员设想在脱碳方面使用“绿色氢”将发挥重要作用，它由可再生能源驱动的水电解产生。绿色氢的好处是广泛的：它为许多难以减排的部门提供了一种有效的脱碳方法；它适应风能和太阳能作为存储介质的可变性；它可以作为生产氨和其他化学品的原料；它可以作为燃料电池汽车的能源，这对印度未来的长途公路运输中具有重要应用。

发表在《自然通讯》上的第二篇论文“中国海上风能生产氢气和向日本提供具有成本竞争力的供应”中，哈佛大学、山东大学、中国石油大学、北京大学和华中科技大学的研究团队探索了利用中国海上风电发电通过电解制氢的可能性。该团队分析了中国沿海各省每小时从中国生产的海上风电向日本输送绿色氢气供应链的潜力。研究人员确定，来自中国的海上风电每年可提供多达 12 帕瓦时的电力。研究小组发现，中国生产的氢气可以以一种具有成本效益的方式提供，输送的数量可以帮助日本实现其未来的净零排放预测。

社区更新

Michael B. McElroy 再次被任命为国际环境咨询委员会委员，任期五年

哈佛中国项目主席迈克尔·麦克尔罗伊（Michael McElroy）受邀在中国环境与发展国际合作委员会（CCICED）中再任职五年。此前，麦克尔罗伊已在该委员会工作了13年，该委员会是一个为中国政府提供有关中国和其他地区环境和发展问题建议的国际机构。CCICED成立于 1992 年，其成员代表了来自国际政府、企业、研究和社会组织的最高水平专家。执行机构由一半中国人和一半国际合作伙伴组成，由中国国务院副总理韩正担任主席，中国生态与环境部部长黄润秋和加拿大环境与气候变化部部长史蒂文·吉尔博担任常务副主席。该小组的思想交流和创新由年度会议和工作组调动。



新的 HCP 研究

可再生能源间歇性成本：HCP经济学小组的研究

增加可再生能源的巨大挑战是其间歇性：当风不吹或太阳不照时，我们需要一个备用电力来源。虽然未来的存储技术有望更加经济实惠，但当前的电网运营商必须要么运行化石燃料发电厂，要么要求用户减少需求以进行补偿。在美国和欧洲，这项工作主要落在燃气电厂上，因为它们最灵活——它们可以以较低的成本"增加"或减少。

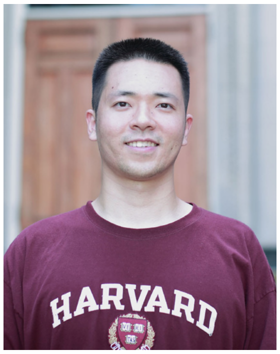
然而，由于天然气成本高，以及使用的天然气有 40% 以上是进口的，中国的燃气机组很少。补偿可再生能源的任务落在了煤炭身上，这导致风能和太阳能的间接成本经常被忽视；也就是说，频繁的上升和下降导致燃料使用量增加，工厂每年以较低的速度运行的小时数减少。也就是说，它们不是以额定容量（例如 600 兆瓦）运行，而是以低于最佳速率运行，从而导致每千瓦时的燃料使用量增加。虽然存在实际运行小时数的数据，但人们无法轻易估计观察到的年平均小时数下降有多少是风能和太阳能补偿的结果。

> **补偿可再生能源的任务落在了煤炭身上，这导致了经常被忽视的风能和太阳能的间接成本。**

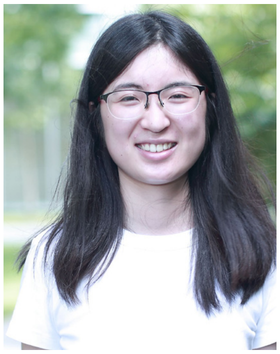
在最近发表在《能源经济学》上的一篇论文中，来自西安交通大学和哈佛大学的哈佛中国项目研究人员估计了纳入间歇性能源的间接成本。他们研究了省级燃煤机组的每月运行小时数，并将其与每千瓦时所用煤炭相关联。然而，这种联系不能直接建立，因为调度决策与发电厂的能源效率有关；也就是说，工厂运行的小时数取决于负责在满足电力需求的同时提高能源效率的调度员。从统计的角度来看，小时数的选择并不是一个随机选择的变量。作者研究水力发电如何影响燃煤电厂的运行时间——由水位决定的电力，水位是大自然随机产生的。利用水电在时间和空间上的这种变化，作者估计每年减少 100 小时会导致每千瓦时的煤炭使用量增加 3%。鉴于可再生能源增加导致平均燃煤小时数减少，他们估计 2019 年较低的热效率成本约为 48 亿美元。如果将额外碳排放的社会成本估计为 50 美元/吨，这一成本将翻倍。

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

认识 HCP 的最新研究人员

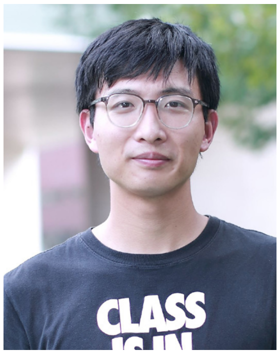


2020年，清华大学环境学院博士生姜怡梁在Michael B. McElroy教授主持的研讨会上第一次了解到哈佛-中国项目。关于未来的交通转型，这促使我申请加入哈佛中国项目。”怡梁的研究探索了中国公路运输行业技术和经济耦合的低碳转型路径，以实现中国 2030 年的碳峰值和 2060 年的碳中和气候目标。对于怡梁来说，他在哈佛最好的时光是跨学科研究。当训练有素的研究人员坐在会议室里时，“啊哈”的时刻来的非常快。我在此过程中学到了很多东西。



清华大学经济学博士研究生胡弦与哈佛中国项目研究员何文胜、清华大学教授、哈佛中国项目客座研究员曹静合作。她解释了她的研究，说：“现在我正在研究全球经济-能源-环境的可计算一般均衡模型，重点关注不同地区的碳定价政策及其对经济、福利和气候的影响。我还将探索跨学科研究，例如经济和环境模型的整合。”对于弦来说，体验中最好的部分是社区。“哈佛为我们提供了良好的研究环境和丰富的学术资源，如不同背景的优秀学者、有趣的研讨会、丰富的图书馆资源等。”

另一位清华大学经济学博士生张瑜也与曹静和 何文胜合作，应用一般均衡模型和微观数据来探索政策改革对中国电力行业的影响。最终，瑜的目标是在一所大学或研究机构工作，并表示她在哈佛中国项目的时间使这一愿望受益匪浅。“作为一名经济学专业的学生，由于其多学科背景，学习电学对我来说是一个很大的挑战。哈佛-中国项目为我提供了一个跨学科研究的平台，让我对自己的研究课题有了更深入的了解。”



清华大学电机系博士生姜海洋专注于用Power-to-X技术实现中国电力系统的脱碳并分析其经济效益。他说他在研究方面取得了很大进展，他希望在学术界进一步发展。最重要的是，“我要感谢 Mike McElroy、Chris Nielsen 和 Haiyang Lin 在推进我的研究工作方面提供的耐心和专业指导。”

作为研究员加入哈佛中国项目

我们邀请哈佛大学任何学院的任何学术水平的在校学生（学士、硕士或博士生）与我们联系，了解哈佛中国项目的研究机会 - 发送电子邮件至 harvardchinaproject@harvard.edu。 每年我们还任命一些来自其他大学的访问研究人员（从博士生到初级和终身教职员工）和一些博士后。 我们鼓励那些拥有与我们当前研究领域相关的强大学术和研究记录的人申请这些机会。 今年我们以滚动方式接受申请，在本学年的第二学期或明年秋季 2023 加入我们。要申请职位，请访问我们的网站：www.www.chinaproject.harvard.edu/visiting-researcher

HCP 社区新闻

纪念：DALE W. JORGENSON（1933 年 5 月 7 日 - 2022 年 6 月 8 日）

Dale W. Jorgenson 是现在哈佛-中国能源、经济和环境项目的创始人之一，于 2022 年 6 月 8 日去世，享年 89 岁。作为哈佛经济学教授和大学教授，他是中国项目历史上最活跃的教师参与者之一。在他去世前两周，他为该项目的最新来访的两名清华大学的博士生举办了欢迎晚宴。他死于呼吸系统并发症，留下妻子琳达、两个孩子和三个孙子。

Jorgenson 是多个经济学领域的先驱。其中包括信息技术和经济增长、税收政策和投资行为、应用计量经济学，以及与此最相关的能源经济学和环境政策分析，包括中国的研究。

作为世界上最重要的生产力测量学者，他自 1970 年代以来就撰写了有关能源生产力和能源投入计量经济分析的文章。他 1974 年的美国经济增长模型是最早对能源投入进行计量经济学处理的跨行业模型之一。他带领一个合作者团队开发了该模型，并将其用于分析能源冲击、环境政策、税收改革和碳定价。提炼这项研究的一本书是《双重红利：美国的环境税和财政改革》，三位合著者包括他的长期合作伙伴和中国项目经济学研究的共同负责人何文胜。Jorgenson 在美国环境保护署环境政策的法定评估中使用了这些工具，尤其是对《清洁空气法》的评估。

Jorgenson对生产力和经济增长的研究遍及全球。1993 年，迈克尔·麦克尔罗伊 (Michael McElroy) 开始在哈佛大学环境委员会下开展一项针对中国的多学科研究项目，Jorgenson 和德怀特·珀金斯 (Dwight Perkins) 通过构建中国经济增长和能源需求的简单模型，开始了经济学部分的研究。这发表在中国项目的第一本书《为中国注入活力：协调环境保护与经济增长》中，并为 Jorgenson 与 McElroy 领导该项目的经济学研究的数十年合作奠定了基础。他开始前往中国与合作者一起工作并参加会议和研讨会，其中包括该项目组织的一些会议和研讨会。他指导曹静的哈佛大学博士论文。作为清华大学教授，曹静继续与 Jorgenson 密切合作，如今仍然是该项目的首席经济学家之一。

Jorgenson 后来为 Chris Nielsen 和 Ho 领导的广泛的跨学科研究提供建议并做出贡献，该研究将大气科学、工程、环境健康和经济学结合起来，发表在 2007 年的《净化空气：中国空气污染的健康和经济损害》中，以及更先进的 2013 年续集，更清晰的中国天空：协调空气质量、气候和经济目标。在这些连接哈佛大学和中国大学的长篇评估报告中，Jorgenson、Ho 和后来的曹静使用模拟空气污染排放和浓度、人类和作物暴露以及健康和农业影响的结果来分配不同部门的污染损害和燃料。然后，他们应用中国的能源-环境-经济模型来模拟碳税等政策对空气污染损害和经济增长的影响。

最近，Jorgenson 指导了新一批来自中国的学生使用家庭调查数据来研究能源消费行为，并使用公司数据来研究其能源产出关系。他最近的论文是“中国的城市家庭消费：价格、收入和人口效应”，发表于 2020 年，他那时已经 87 岁。他晚年的另一篇引人注目的论文是“中国的排放交易体系和 ETS-碳税混合体，”于 2019 年出版。

哈佛中国项目所有领域的大多数研究人员都认识Jorgenson，因为他经常出现在项目的Pierce会议室，主要是与研究人员会面，同时也与何、尼尔森和麦克尔罗伊制定战略。有些人比其他人更了解他，但整个哈佛中国项目社区都在为他的突然离去而悲痛。他留下了一个难以填补的空白，不仅在哈佛中国项目的工作中，而且在其最杰出的高级领导人积极和支持的指导氛围中。然而，他也留下了一个由学生和合作者组成的全球网络，他们从他身上学到了很多东西，并且肯定会扩展他开创的工作，以及他所追求的慷慨共享探究的精神。

本科暑期研究员

学生研究人员努力实现中国+亚洲的脱碳

今年夏天，在哈佛职业服务办公室的持续慷慨支持下，哈佛-中国项目协调了其第四个暑期本科生研究。今年，七名学生与哈佛-中国项目的研究人员配对参加"中国和亚洲的脱碳"暑期研究助理。

Eddie Dai '25 和 Genevieve Raushenbush '24 与哈佛大学设计学院教授 Ann Forsyth 和哈佛中国项目助理 吕瑛英 一起进行了"STGA 丽水社区研究"。他们构建了一个数据库，详细介绍了中国南京丽水社区的地理布局和特征。他们确定了关键变量（娱乐设施、公共交通站点、健康诊所等），以帮助构建地图，以更好地了解丽水人口老龄化的背景，帮助团队设计数字技术来提高人们就地养老的能力.

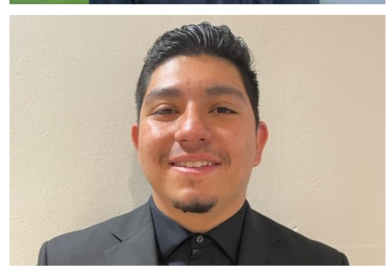
Jack Walker '24 继续研究航运业脱碳的空气质量和气候效益。 Jack 说："在上一学年与博士后研究员 Peter Sherman 合作之后，我们今年夏天的重点是研究航运业三种主要排放途径对空气质量的影响：一切照旧、减排 50%、和减排100%。彼得对项目的成功至关重要，他随时准备帮助解释一些可能没有意义的事情。"

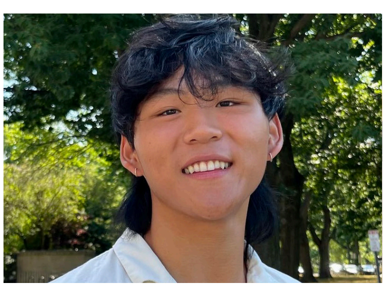
Blake Chen '25 也与 Sherman 博士合作，但研究的是"甲烷对全球化学和气候模型的间接影响分析"。他们探索了甲烷的次要影响以及气候模型如何代表甲烷相关过程。使用哈佛超级计算机，他们根据不同的甲烷排放水平对不同的气候模型进行了模拟，并分析了这些变化对其他大气气体的影响。

Andres Hernandez Gonzalez '24 与博士后蔺海洋合作，研究"绿色氢和绿色氨作为能源载体"。他们使用当今技术的相对成本来定义可以优化的参数，以在本地化生产的情况下提供最低的氢气成本。他说："蔺博士通过提供他的智慧和幽默来激励我做到最好。我对这项工作的热情来自于我在氢经济领域工作的最终目标，也许是为自己的绿色能源工作或经营自己的绿色能源初创公司。"

Joshua Cai '24 与研究员 Mun S. Ho 合作，研究"电力系统改革和家庭需求经济学"。他解释说："我的项目研究了中国电力系统的问题，以及煤炭产能过剩等问题如何影响整体发电效率。自从世界朝着碳中和的未来迈进以来，中国一直试图转向更多地依赖可再生能源，但这对中国现有的煤炭工业产生了经济影响。"

Rachel Seevers '23 与研究员 杨曦 一起研究了"围绕钢铁行业脱碳的全球政策和技术"。 Rachel 说："我的工作是调查钢铁行业的现行政府政策（包括限制和激励措施），以确定需要解决的差距和趋势。我确定了时间、金钱和政府结构等关键驱动因素，并且能够完成国家之间的交叉比较。通过我的工作，研究人员能够更清楚地了解他们的技术将实施到的政策世界以及需要解决的差距。





照片，从顶部顺时针方向： *Rachel Seevers, Joshua Cai, Andres Hernandez Gonzalez, Blake Chen, Jack Walker, Genevieve Raushenbush, Eddie Dai.*

校园新闻

新哈佛学院联合起来，推进遏制气候危机浪潮的努力

6 月，哈佛大学宣布成立萨拉塔气候与可持续发展研究所，这是一个开创性的新实体，将推动和促进哈佛大学所有学院的研究计划，并实现气候和环境方面的全面跨大学教育。

萨拉塔研究所将于 2022 年秋季成立，由负责气候和可持续发展的副教务长 Jim Stock 领导。 Melanie 和 Jean Eric Salata 向哈佛捐赠了 2 亿美元的资金，使该研究所成为可能。Jean Salata 是霸菱亚洲私募股权基金的首席执行官和创始合伙人。

该研究所将寻求一种开创性的方法来应对气候挑战——旨在发展和激励整个哈佛以气候为重点的学者网络，为学生教育和参与制定气候和可持续发展解决方案创造新途径，并增加对具有近期和长期影响的重大现实进展的关注。它还将作为整个大学许多现有的气候相关计划和倡议的枢纽和连接点。

“气候变化是我们这个时代最紧迫的问题之一。这是一场危机，其影响将波及我们的子孙后代，我们对他们有责任尽我们所能解决它，”萨拉塔斯夫妇说。“通过像我们今天宣布的倡议以及全球其他许多类似举措，我们可以利用世界上最优秀的研究人员和最有才华的政策和商业领袖的力量，为我们所有人创造一个更可持续的未来。”

改编自哈佛公报文章。

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