LEARNING FOR THE CLIMATE:

Exchanging Best Practices for U.S. & Chinese Cities on Climate Change and the Green Transition

A Report from the 2023 Heartland Mayors' Delegation to China

Part of the U.S. Heartland China Association's Yangtze-Mississippi Municipality Energy Transition Exchange Project

Edmund Downie | February 2024

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Nanjing Yangtze River Bridge. IMAGE SOURCE: 钉钉, CC BY-SA 4.0 , via Wikimedia Commons

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FOREWORD: ABOUT THE 2023 HEARTLAND MAYORS DELEGATION TO CHINA

In the first such visit since the pandemic; the U.S. Heartland China Association (USHCA) led a bipartisan delegation of six U.S. mayors representing communities along the Mississippi River Basin to visit their counterparts in the People's Republic of China. This Mayors' delegation visit took place in the context of recent visits by Senator Chuck Schumer and a **bi-partisan delegation of six U.S. Senators, California Governor Gavin Newsom's recent trip** to China, and the **meeting in San Francisco between President Biden and President Xi**.

The delegation included Mayor Jim Brainard of Carmel, Indiana; Mayor Barbara Buffaloe of Columbia, Missouri; Mayor Lee Harris of Shelby County, Tennessee; Mayor Chokwe Lumumba of Jackson, Mississippi; Mayor Kim Norton of Rochester, Minnesota; and Mayor Robyn Tannehill of Oxford, Mississippi. These leaders were selected for this sponsored trip based on their demonstrated thought leadership to represent municipalities of different sizes from the Mississippi River Basin in America's Heartland. Two science advisors and one expert – Dr. Gabriel M. Filippelli and Dr. Lixin Wang from Indiana University, and Edmund Downie from Princeton University – provided support that ensured successful bilateral engagements.

Over a ten-day period, just as the U.S.-China bilateral working group under the leadership of U.S. Special Envoy for Climate John Kerry and his Chinese counterpart Xie Zhenhua strived to complete the **Sunnylands Statement on Enhancing Cooperation** to Address the Climate Crisis in California, the Heartland mayors delegation visited five Chinese communities to put the bilateral cooperative framework into action at the local level.

This visit kicked off a historic two-way exchange as part of USHCA's Yangtze-Mississippi Municipality Energy Transition Exchange project. This project aims to promote city-to-city best practice sharing between the communities along these two major rivers around energy transition, climate mitigation, and green economy.

The report below summarizes takeaways from this visit for U.S.-China bilateral cooperation on climate and energy. Edmund Downie offers examples of fruitful policy areas for exchange highlighted during our visit as well as broader principles to guide further such initiatives. Its insights can support U.S.-China cooperation under the Yangtze-Mississippi Municipality Energy Transition Exchange project and other subnational initiatives that will drive forward energy and climate partnerships between the two countries in the years to come.

Min Fan
Executive Director, U.S. Heartland China Association

IMAGE SOURCE: Kevin Drew Davis, stock.adobe.com (modified)


IMAGE SOURCE: Dragon Claws, stock.adobe.com (modified)

EXECUTIVE SUMMARY

In fall 2023, the U.S. Heartland China Association (USHCA) brought six mayors from five U.S. states along the Mississippi River to visit five Chinese cities along the Yangtze River for exchanges on energy transition, climate mitigation, and green economy. The nine-day visit, funded by U.S. private foundations and facilitated by the U.S. State Department, took place at a unique window of collaborative reprieve amid ongoing tension U.S.-China relations. The results demonstrate the enduring value of subnational exchange. Participants came back with new relationships as well as policy strategies that they can adapt to tackle their communities' energy and climate challenges.

This report shares insights from the delegation for successful U.S.-China subnational exchange. First, it highlights three policy areas for learning that attracted the U.S. mayors' interest:

Transit bus electrification: U.S. cities are increasingly interested in cutting emissions and air pollution with battery-electric buses (BEBs). More than 95% of transit BEBs operating worldwide today are in China. China's experiences offer operational and financial models for BEB adoption and suggest a broader whole-ecosystem model to develop BEB manufacturing and make transit fleet electrification affordable.

Street design: U.S. and Chinese cities feature lots of broad, multi-lane "arterial" roads that suit vehicle traffic better than pedestrians and two-wheelers. Both countries are trying to change that. The wide protected bike lanes on many Chinese arterial roads can provide inspiration for similar efforts in the U.S.

Economies of scale in heating, cooling, and wastewater: U.S. cities generally use decentralized infrastructure for heating and cooling and large-scale centralized infrastructure for wastewater treatment. The delegation saw alternative models in China: district energy systems, widely used for heating Chinese cities, and newer "clustered" wastewater treatment mini-plant pilots. U.S. officials can learn from China's policy tools for enabling district energy buildouts, while similar "clustered" system projects in the U.S. suggest an emerging area for exchange.

Subnational exchanges can build on lessons in these and so many more policy areas. Promisingly, both countries are pushing to expand exchanges as part of last November's bilateral Sunnylands Statement. How can we make these exchanges effective? The USHCA delegation suggests two models of engagement.

First, the two sides should set up subnational technical dialogues on climate and energy. They can road-test a mix of topics – such as those in this report – with focus sessions at this year's U.S.-China subnational climate summit. Sessions with strong engagement can be launching pads for sustained dialogues with country visits.

Second, the countries could also sponsor business and technology showcases or pilots around climate change and energy transition issues that affect subnational policy, focusing on non-sensitive sectors like climate-smart agriculture or waste management.

Successful exchanges require careful match-making to connect communities facing similar challenges. They also benefit from incorporating a mix of participants – city leaders as well as policy specialists or department heads – to enable informed and meaningful discussions.

INTRODUCTION

From October 29, 2023 to November 7, 2023, the U.S. Heartland China Association (USHCA) led a delegation of six mayors to China for exchanges with Chinese counterparts on climate and energy. The mayors, hailing from six Heartland cities, visited Hong Kong as well as four cities along the Yangtze River: Wuhan, Nanjing, Suzhou, and Shanghai (Figures 1 & 2). Events included a meetings, conferences, and roundtables with local officials (Hubei-U.S. Heartland Mayors Roundtable, Nanjing-U.S. Heartland Cities Business Forum, China-U.S. Sister Cities Conference, and Yangtze-Mississippi Regional Forum) as well as site visits to universities, businesses, communities, and industrial zones.

> **"Collaboration between U.S. and Chinese mayors not only benefits the hundreds of millions of people living in our two countries, but the on-going joint work will lead to best practices that can be applied around the world."**
>
> *Mayor Jim Brainard, Carmel, Indiana, delegation leader*

The USHCA Mayors' Delegation took place amidst a tense period for U.S.-China relations. China's rise, and the weakening of U.S. primacy in global order, means that competition increasingly defines this bilateral relationship across economic, military, and political domains. Citizens' views of each other have become increasingly negative, particularly in the U.S. Gallup polling finds that the share of Americans viewing China favorably fell from 53% in 2018 to just 15% in 2023.[1] COVID-19 dampened exchange channels like education: U.S. students in China fell from around 12,000 in 2018-19 to just 211 in 2021-22 amidst the country's severe lockdowns, while Chinese students in the U.S. dropped more modestly from 375,000 to 290,000.[2]

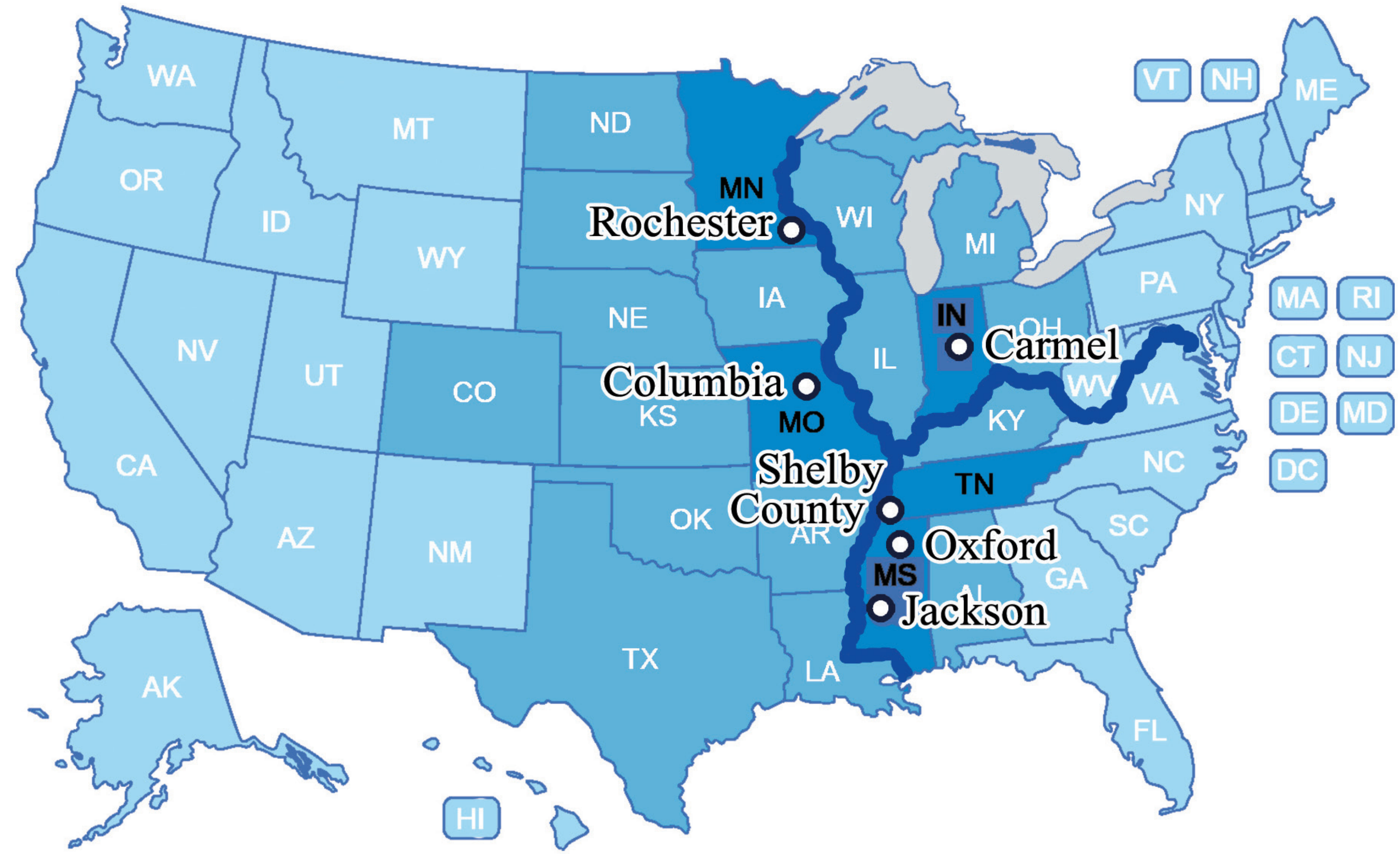
Against this backdrop, what is the value – if any – of subnational exchanges on climate and energy? The USHCA Heartland Mayors' Delegation exemplifies their benefits. Part of their value is at the level of high politics. The USHCA delegation was the third delegation of U.S. elected officials to China since COVID-19, following visits by a bipartisan group of Senators as well as Governor Gavin Newsom from California. Organizing such exchanges can give U.S. and Chinese diplomats opportunities to strengthen their working relationships for managing more complex or divisive engagements. Mayors and other subnational officials can also be messengers for national priorities on issues that directly affect theircommunities.

But subnational exchanges like the Mayors' Delegation are also a boon for the states, provinces, and cities that participate in them. For one, they build relationships that can open up channels for people-to-people exchange. Such exchanges help American and Chinese communities develop international mindsets and deepen their understanding of each other's societies – two societies that will, in many ways, define the century to come. Exchange can also generate economic opportunities as part of our $750 billion bilateral trading relationship, the world's biggest.[3]

1 Megan Brennan, "Record-Low 15% of Americans View China Favorably," Gallup, March 7, 2023, https://news.gallup.com/poll/471551/record-low-americans-view-china-favorably.aspx.

2 Institute of International Education, "Host Regions and Destinations of U.S. Study Abroad Students, 1999/00-2021/22," accessed February 13, 2024, https://opendoorsdata.org/data/us-study-abroad/all-destinations/.

3 United States Trade Representative, "The People's Republic of China," accessed February 13, 2024, https://ustr.gov/countries-regions/china-mongolia-taiwan/peoples-republic-china.



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美国中部美中协会

Figure 1. Map of the six U.S. communities whose mayors participated in the USHCA Mayors' Delegation, as well as the greater Heartland region (shaded) and its key rivers, the Mississippi and the Ohio. (U.S. Heartland China Association)

Figure 2. Chinese host cities along the Yangtze River / IMAGE SOURCE: Peter Hermes Furian, stock.adobe.com (modified)

These exchanges can also generate concrete policy lessons and ideas for subnational participants. Many of the basic tasks that subnational governments handle – economic development, environmental protection, public service provision – are the same in both countries. Authorities can learn from each other on how to achieve them. Chinese city officials have long studied their U.S. counterparts closely to guide their push for growth and modernization – a push whose achievements have helped transform China into a competitor. U.S. officials can benefit in turn from studying those achievements, particularly in areas where China is a global leader like green industry and renewable energy. Global warming hurts U.S. and Chinese communities alike; studying each other's strategies to accelerate the energy transition and adapt to climate change can help communities manage this threat.

This report draws on the USHCA delegation's experiences to highlight three examples where U.S. cities can benefit from seeing climate and energy policy strategies in the Chinese cities visited:

- Transit bus electrification
- Multi-modal streets
- Economies of scale for heating, cooling, and wastewater infrastructure

Chinese cities' policy packages on these issues do not lend themselves to "copy-and-paste" or "plug-and-play" adoption in the U.S. Our governing systems differ in fundamental ways, from institutions and values to economic and social structures. Yet U.S. and Chinese cities, as noted above, are driving towards many shared goals. Seeing Chinese cities' achievements and shortcomings in managing climate change and the energy transition can expose U.S. cities to new policy strategies to consider adapting for adoption at home. They can also set benchmarks for ambition in areas like transit bus electrification, where Chinese cities lead the world.

Both the U.S. and China want subnational governments to play a central role in their climate cooperation this decade. Their bilateral Sunnylands statement on climate cooperation, from November 2023, devoted a standalone section to subnational cooperation and pledged a U.S.-China subnational summit for the first half of 2024. The USHCA exchange indicates several promising ways to take this exchange forward. One is technical dialogues and exchanges at this year's summit and beyond that bring together subnational officials and policy experts. Focus areas from this report like transport electrification and street design would work well, as would a host of other topics – flood and heat resilience, say, or building materials efficiency. Meanwhile, the countries could also sponsor business and technology showcases or pilots around climate change and energy transition issues that affect subnational policy, focusing on non-sensitive sectors like climate-smart agriculture or waste management. In organizing these exchanges, both sides should focus on bringing together communities facing similar challenges and incorporating a broad mix of participants – city leaders as well as policy specialists or science advisors.

IMAGE SOURCE: Maxim Chuev, stock.adobe.com

TRANSIT BUS ELECTRIFICATION

The low-carbon transition requires replacing fossil fuels with clean sources of power across our economy – including our transportation systems, responsible for around one-fifth of global CO_2 emissions.[4] Buses alone contribute around 1.5% of global CO_2 emissions and 0.5% of U.S. greenhouse gas emissions, mostly from diesel combustion.[5] Battery-electric buses (BEBs) have become the dominant low-carbon alternative; they comprised more than 90% of sales of "alternatively-fueled" buses in 2022, with the balance made up by hybrid and fuel-cell buses.[6] BEBs in the U.S. can cut carbon emissions by 1.5 to 8 times against their diesel counterparts, while also reducing local urban air pollution.[7]

China is far and away the world leader in bus electrification. Its public transit bus fleet is 65% electric, and its BEBs accounted for a staggering 96% of all such buses worldwide.[8] The cities that hosted the USHCA delegation included enthusiastic electrifiers like Nanjing, whose fleet is 87% electric.[9]

Figure 3. EV Bus Charging Station in Nanjing (Katherine Newton-Henry / USHCA)

4 Hannah Ritchie and Max Roser, "Cars, Planes, Trains: Where Do CO2 Emissions from Transport Come From?," Our World in Data, December 28, 2023, https://ourworldindata.org/co2-emissions-from-transport.

5 International figures calculated from International Energy Agency, "Trucks & Buses," IEA, accessed January 17, 2024, https://www.iea.org/energy-system/transport/trucks-and-buses; International Energy Agency, "Greenhouse Gas Emissions from Energy Highlights," August 2023, https://www.iea.org/data-and-statistics/data-product/greenhouse-gas-emissions-from-energy-highlights. U.S. figures calculated from U.S. Environmental Protection Agency, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021," 2023, https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf.

6 International Energy Agency, "Trucks & Buses."

7 For the carbon emissions impact, see Jimmy O'Dea, "Electric vs. Diesel vs. Natural Gas: Which Bus Is Best for the Climate?," Union of Concerned Scientists, July 19, 2018, https://blog.ucsusa.org/jimmy-odea/electric-vs-diesel-vs-natural-gas-which-bus-is-best-for-the-climate/. John Carey, "The Other Benefit of Electric Vehicles," Proceedings of the National Academy of Sciences, January 17, 2023, https://www.pnas.org/doi/10.1073/pnas.2220923120.

8 刁静严 [Diao Jingyan], "15城启动首批公共领域车辆电动化试点 [15 Cities Launch Their First Pilots for Public Sector Vehicle Electrification]," November 27, 2023, 中国城市报, accessed January 17, 2024, http://paper.people.com.cn/zgcsb/html/2023-11/27/content_26029059.htm; International Energy Agency, "Global EV Data Explorer," IEA, April 26, 2023, https://www.iea.org/data-and-statistics/data-tools/global-ev-data-explorer.

9 南京公共交通（集团）有限公司 [Nanjing Public Transportation (Group) Co Ltd], "改革创新赋能高质量发展——南京公交集团荣获'江苏省五一劳动奖状'荣誉称号 [Reform and Innovation Enables High-Quality Development -- Nanjing Public Transportation Group Honored with the Title of Jiangsu Province May Day Labor Award]," April 23, 2023, http://www.njgongjiao.com/zhxw/5632.

IMAGE SOURCE: Dirk, Generated with AI, stock.adobe.com

These achievements followed from a strong national policy commitment to developing a full ecosystem for bus electrification. Chinese authorities launched a series of city-level transport electrification pilots among public-use vehicles (buses, taxis, and various public-sector vehicles) in 2009.[10] They built on these pilots with expanded purchasing mandates as well as ample procurement and operational subsidies during the 2010s. The national government offered transit system operators up to 500,000RMB/bus (around $75,000) for transit bus purchases through 2016, for instance, in addition to further local government subsidies.[11] Combined subsidies covered 60% of procurement costs between 2015-17 for one transit operator in the southern megacity of Shenzhen, the fastest electrifier; Shenzhen's fleet was 90% electric by 2017.[12] These demand-side policies supported a host of entrants to the BEB manufacturing sector – both existing bus manufacturers like Yutong as well as new EV specialists like BYD. (More than one-third of Yutong's 70,000 buses sold in 2015 were battery-electric and plug-in hybrid, and that share held constant even as its sales dropped from the late 2010s.[13]) Subsidies in the late 2010s shifted to supporting charging infrastructure to enable more effective BEB operations.[14]

The past decade of experience with bus electrification has produced plenty of lessons for Chinese cities around incor-

10 财政部 [Ministry of Finance], "关于开展节能与新能源汽车示范推广试点工作的通知 [Notice on Launching Work Pilots for Demonstration and Promotion of Energy-Saving and New-Energy Vehicles]," January 23, 2009, https://www.gov.cn/zwgk/2009-02/05/content_1222338.htm.

11 Institute for Transportation and Development Policy, "E-Bus Experiences from China," November 2020, https://cff-prod.s3.amazonaws.com/storage/files/OjhAMaEIF-NtixRKSEPINvzRj9fKpm8J5OOsFIHdP.pdf.

12 World Bank, "Electrification of Public Transport: A Case Study of Shenzhen Bus Group," 2021, 14, https://documents1.worldbank.org/curated/en/708531625052490238/pdf/Electrification-of-Public-Transport-A-Case-Study-of-the-Shenzhen-Bus-Group.pdf; 薛露露 [Xue Lulu] et al., "中国纯电动公交车运营现状分析与改善对策 [Overcoming the Operational Challenges of Electric Buses: Lessons from China]" (World Resources Institute, September 2019), https://wri.org.cn/sites/default/files/2021-12/overcoming-operational-challenges-electric-buses.pdf.

13 郑州宇通客车股份有限公司 [Yutong Bus Co. Ltd.], "2015年度报告 [2015 Annual Report]," April 4, 2016, 16–17; 郑州宇通客车股份有限公司 [Yutong Bus Co. Ltd.], "2017年度报告 [2017 Annual Report]," April 2, 2018, 17; 郑州宇通客车股份有限公司 [Yutong Bus Co. Ltd.], "2019年度报告 [2019 Annual Report]," March 30, 2020, 17–18; 郑州宇通客车股份有限公司 [Yutong Bus Co. Ltd.], "2021年度报告 [2021 Annual Report]," March 28, 2022, 19–20.

14 Institute for Transportation and Development Policy, "E-Bus Experiences from China."

porating BEBs into transit systems. Strategies like leasing buses and entrusting charging infrastructure to standalone service providers helped transit operators manage the high capital costs of electrification.[15] Range and charging speed challenges among early generations of BEBs also prompted operational adjustments: new scheduling patterns, for instance, as well as additional BEB procurements to maintain full service coverage.[16]

Technology improvements since then are alleviating some of these challenges. Average nominal driving ranges of new BEBs rose 47% from 2015-2019, from around 275km to more than 400km.[17] Battery capacity decays with use, but newer batteries enjoy longer lifetimes; decay rates in Shenzhen have slowed from 20% every 2.5 years to every 4 years among newly-procured buses, with battery replacements covered under manufacturer warranties.[18] Chinese transit systems can also choose between mixtures of fast-charging and slow-charging batteries and stations; fast-charge systems deliver full charges within 20 minutes or less, though battery ranges can be 40-60% lower.[19]

China's experiences show that BEBs can serve as a mainstay of a bus transit system. The world is starting to follow. Bloomberg New Energy Finance projects that 50% of global buses will be electric by 2032, up from 21% today (almost all in China).[20] The U.S. is far from this benchmark, though cities are looking to change that.

15 World Bank, "Electrification of Public Transport: A Case Study of Shenzhen Bus Group."

16 薛露露 [Xue Lulu] et al., "中国纯电动公交车运营现状分析与改善对策 [Overcoming the Operational Challenges of Electric Buses: Lessons from China]"; Cheng Li et al., "Research on Technical Systems of Battery Electric Buses in China," Sino-German Cooperaton on Low-Carbon Transport (LCT) (Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and China Academy of Transportation Sciences, December 2022), https://transition-china.org/wp-content/uploads/2022/12/Research-on-Technical-Systems-of-Battery-Electric-Buses-in-China-4.pdf.

17 Cheng Li et al., "Research on Technical Systems of Battery Electric Buses in China," 33.

18 World Bank, "Electrification of Public Transport: A Case Study of Shenzhen Bus Group," 60; Cheng Li et al., "Research on Technical Systems of Battery Electric Buses in China," 67.

19 Cheng Li et al., "Research on Technical Systems of Battery Electric Buses in China," 42.

20 Kyle Stock, "Buses Are Going Electric Faster Than Passenger Cars," Bloomberg, June 9, 2023, https://www.bloomberg.com/news/articles/2023-06-09/buses-are-going-electric-faster-than-passenger-cars.

BEBs in service, awarded, or on order as of 2022 were up 66% on 2021, but they remain well under 10% of national operating fleet.[21]

> **"As mayor of a city with a major university, I was encouraged to see the potential and desire for two-way education exchanges with both scholarly and cultural benefits."**
>
> *– Mayor Robyn Tannehill, Oxford, Mississippi*

Chinese cities' experiences present a range of financing and operational models for U.S. cities in BEB adoption.[22] These include, for instance, the wide range of leasing practices that Chinese cities have used in BEB procurement, from buying buses while leasing batteries (Chengdu) to leasing buses and charging infrastructure as a package (Shenzhen). U.S. cities have also experimented with leasing batteries for their BEBs; at least 13 agencies executed battery leases as part of procurements with federal grant support between 2016-21.[23] Chinese cities have also developed dispatch models for buses with shorter ranges, using them for purposes from augmenting rush-hour capacity to serving as emergency backups.

Chinese experiences also underscore how mainstreaming BEBs in U.S. cities requires a whole-ecosystem approach, with state and federal support to procure buses and build a competitive supply chain. Lifetime ownership costs for BEBs can be competitive with or even less than diesel buses, because of low fueling and operational costs. But capital costs remain a hurdle; BEB purchase costs can be significantly higher, while charging infrastructure is an additional upfront cost.[24] Federal funding lags demand. The Federal Transit Administration's Low or No Emissions Vehicle program in 2022 covered only 21% of transit agency funding applications to the program for zero-emissions vehicles and supporting infrastructure.[25] These purchase costs are particularly significant where range and charging infrastructure limitations encourage agencies to buy more BEBs than the diesel buses they wish to replace, as Chinese cities initially did.[26] States, meanwhile, can also help cities manage these costs by sponsoring cooperative procurements; states like Iowa and Minnesota have used these tools for general bus procurement beyond BEBs.[27]

Meanwhile, U.S. cities would benefit from a more competitive market when procuring BEBs. Chinese cities have had a range of domestic options for BEBs; in 2019, only one manufacturer (Yutong) enjoyed a market share above 10%,[28] U.S. cities have fewer choices. Buy American requirements generally require transit agencies to purchase U.S.-made BEBs to access federal funding.[29] But manufacturer bankruptcies (Proterra) and market exits (Nova), as well as bans on federal funding for Chinese manufacturers (BYD), have left only a handful of manufacturers still operating in the U.S. market (Gilling, New Flyer).[30] Limited supply and weak competition has lengthened procurement timelines, forcing agencies to replace planned BEB with diesel orders (Milwaukee) or maintain long-term purchase options in current diesel procurements (New Jersey).[31] To be sure, the U.S. market is much smaller than China's: around 5,000-6,000 buses purchased per year, as against around 40,000 in China in 2022.[32] Belgian producer Van Hool is building a battery-electric transit bus plant in Tennessee, but federal authorities should be actively engaging with companies like Solaris, Europe's largest BEB manufacturer, to figure out how to draw them into the U.S. market.[33]

> **"The visit was important and informative ... and opened the lines of communication for potential city-to-city alliances that could help lift the economy of Memphis and Shelby County."**
>
> *– Mayor Lee Harris, Shelby County, Tennessee*

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21 This estimate is for full-size buses. It is based on the most recent available data -- 2022 for BEBs (CALSTART) and 2020 for the national operating fleet of buses and commuter buses (American Public Transportation Association). in Rachel Chard et al., "Zeroing in on ZEBs:" (CALSTART, February 2023), 5, https://calstart.org/wp-content/uploads/2023/02/Zeroing-in-on-ZEBs-February-2023_Final.pdf; American Public Transportation Association, "2022 Public Transportation Fact Book," January 2023, 4, https://www.apta.com/wp-content/uploads/APTA-2022-Public-Transportation-Fact-Book.pdf.

22 For studies, see World Bank, "Electrification of Public Transport: A Case Study of Shenzhen Bus Group"; Cheng Li et al., "Research on Technical Systems of Battery Electric Buses in China"; 薛露露 [Xue Lulu] et al., "中国纯电动公交车运营现状分析与改善对策 [Overcoming the Operational Challenges of Electric Buses: Lessons from China]."

23 Federal Transit Administration, "Annual Report on Leasing Arrangements," December 2021, https://www.transit.dot.gov/sites/fta.dot.gov/files/2021-10/FY2021-Annual-Report-on-Leasing-Arrangements.pdf.

24 For lifetime bus cost estimates, see International Finance Corporation, "E-Bus Economics: Fuzzy Math?," January 2020, https://www.ifc.org/content/dam/ifc/doc/mgrt/ifc-transportnotes-fuzzymath-final.pdf; Vishnu Nair et al., "Technical Review of: Medium and Heavy-Duty Electrification Costs for MY 2027- 2030," February 2, 2022, https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files/2022/02/EDF-MDHD-Electrification-v1.6_20220209.pdf; Caley Johnson et al., "Financial Analysis of Battery Electric Transit Buses" (National Renewable Energy Laboratory, June 1, 2020), https://doi.org/10.2172/1659784; International Finance Corporation, "E-Bus Economics: Fuzzy Math?"; Vishnu Nair et al., "Technical Review of: Medium and Heavy-Duty Electrification Costs for MY 2027- 2030."

25 Calculated based on data in Transportation for America, "Greener Fleets: Meeting the Demand for Clean Transit," May 2023, https://t4america.org/wp-content/uploads/2023/05/Greener-Fleets-2-1.pdf.

26 Christof Spieler, "Electric Buses Are the Future. Agencies Are Still Right to Be Cautious.," TransitCenter, April 25, 2023, https://transitcenter.org/electric-buses-are-the-future-agencies-are-still-right-to-be-cautious/.

27 Sarah Plotnick and Sean Peirce, "Creative Procurements to Improve Transit Cost and Effectiveness" (Federal Transit Administration, February 2021), 34–36, https://rosap.ntl.bts.gov/view/dot/55464; Minnesota Office of State Procurement, "Contract B-347(5)," September 27, 2023, https://osp.admin.mn.gov/sites/osp/files/pdf/b-347%285%29.pdf.

28 Cheng Li et al., "Research on Technical Systems of Battery Electric Buses in China," 36. That fragmentation may have partly reflected local industrial policy, as governments used BEB purchase subsidies to fund procurements of buses from local manufacturers. A World Resources Institute shows market shares for five major bus manufacturers in different cities; the largest market shares for each are in their home provinces. 薛露露 [Xue Lulu] et al., "中国纯电动公交车运营现状分析与改善对策 [Overcoming the Operational Challenges of Electric Buses: Lessons from China]," 13.

29 Gordon Feller, "What the Electric Bus Industry Could Do with a Multibillion-Dollar Federal Investment," *Association of Metropolitan Planning Organizations* (blog), June 7, 2021, https://ampo.org/what-the-electric-bus-industry-could-do-with-a-multibillion-dollar-federal-investment/.

30 Ian Duncan, "U.S. Funding Ban for Chinese Buses Arrives, Disrupting Transition to Electric," *Washington Post*, December 17, 2021, https://www.washingtonpost.com/transportation/2021/12/17/electric-buses-federal-funding/; Ian Duncan, "Electric Buses Get Billions in Federal Aid. A Top Maker Just Went Bankrupt.," *Washington Post*, August 13, 2023, https://www.washingtonpost.com/transportation/2023/08/12/proterra-bankruptcy-electric-buses/; AB Volvo, "Nova Bus Ends Bus Production in the US," June 21, 2023, https://www.volvogroup.com/en/news-and-media/news/2023/jun/news-4571491.html.

31 Graham Kilmer, "Transportation: Is It the End of Battery Electric Buses for Milwaukee?," Urban Milwaukee, November 7, 2023, https://urbanmilwaukee.com/2023/11/07/transportation-is-it-the-end-of-battery-electric-buses-for-milwaukee/; Colleen Wilson, "NJ Transit Electric Bus Project Zips along. But Huge Hurdles Remain to Expand It Statewide," Bergen Record, November 21, 2023, https://www.northjersey.com/story/news/transportation/2023/11/21/nj-transit-faces-huge-hurdles-to-expand-electric-bus-program/71658076007/.

32 Government Accountability Office, "Public Transit: Updated Guidance and Expanded Federal Authority Could Facilitate Bus Procurement," September 10, 2015, 9, https://www.gao.gov/assets/gao-15-676.pdf; Bill Canis and William J. Mallett, "Buy America and the Electric Bus Market" (Congressional Research Service, August 6, 2018), 2, https://sgp.fas.org/crs/misc/IF10941.pdf; ; 郑州宇通客车股份有限公司 [Yutong Bus Co. Ltd.], "2022年度报告[2022 Annual Report]," March 27, 2023.

33 Solaris, "Solaris Is the Leader of the European Electric Bus Market after First Half of 2023," September 1, 2023, https://www.solarisbus.com/en/press/solaris-is-the-leader-of-the-european-electric-bus-market-after-first-half-of-2023-2012; Solaris, "Tests of the Solaris Trollino Trolleybus in Canada," September 15, 2023, https://www.solarisbus.com/en/press/tests-of-the-solaris-trollino-trolleybus-in-canada-2033.

MULTI-MODAL STREETS: REDESIGNING ARTERIAL ROADS

Transportation is the U.S.'s largest emissions source, and more than half of those transportation emissions come from personal vehicles.[34] Offering safe ways to get around on bikes and on foot can cut down on those emissions. They promote health by preventing air pollution from road travel and lowering barriers to active lifestyles. Street redesigns can also reduce car accidents, especially on "arterial" roads; these multi-lane, car-focused roads are just 15% of U.S. urban streets, but 67% of pedestrian deaths take place on them.[35] Both pedestrian deaths and poor air quality affect low-income communities and communities of color most severely.[36]

The streets of the cities of the Yangtze River Delta – and of many other Chinese cities -- offer useful examples of design footprints for U.S. urban planners to consider as they try to incorporate more multi-modal elements in their street design. Examples on arterial roads are especially useful. Chinese city planning during the 20th century emphasized broad arterial roads bounding dense "superblocks," large residential tracts accommodating thousands of people in mid- and high-rise apartments.[37] Planning guidelines through at least the 2010s required roads of eight or more lanes every kilometer across a city grid.[38] These arterial

Figure 4. Median-Protected Lane for two-wheelers on arterial road in Suzhou, Jiangsu Province, China (Charles O. Cecil / Alamy Stock Photo)

34 Congressional Budget Office, "Emissions of Carbon Dioxide in the Transportation Sector," December 13, 2022, https://www.cbo.gov/publication/58861.

35 Smart Growth America, "Dangerous by Design 2022," 2022, 20, https://smartgrowthamerica.org/dangerous-by-design/.

36 Smart Growth America, "Dangerous by Design 2022"; American Lung Association, "Disparities in the Impact of Air Pollution," November 2, 2023, https://www.lung.org/clean-air/outdoors/who-is-at-risk/disparities.

37 Har Ye Kan, Ann Forsyth, and Peter Rowe, "Redesigning China's Superblock Neighbourhoods: Policies, Opportunities and Challenges," *Journal of Urban Design* 22, no. 6 (November 2, 2017): 757–77, https://doi.org/10.1080/13574809.2017.1337493.

38 World Bank and Development Research Center of the People's Republic of China State Council, *Urban China: Toward Efficient, Inclusive, and Sustainable Urbanization* (The World Bank, 2014), 142, https://doi.org/10.1596/978-1-4648-0206-5.

IMAGE SOURCE: Taweechai, stock.adobe.com roads were dominated historically by buses and bicycles, the latter of which covered as much as two-thirds of trips in some cities in the 1980s.[39] But growing affluence in China prompted the expansion of motorbikes and private automobiles alongside street redesigns to accommodate them. Bicycle mode shares fell under 5% in some cities by the mid-2010s.[40] The resulting network of car-dominated wide roads is one of several contributors to traffic fatality rates in China, which were seven times higher than the United States as of the mid-2010s.[41]

China's road network – including its arterial roads – nonetheless often maintains the multi-modal bones of its historic focus: road-side lanes for two-wheelers, separated from car traffic by broad medians (Figure 4). Bike lane networks have been reinforced over the past 10-15 years from a resurgence in interest in multi-modal planning. This shift reflects several intertwined trends – growing concern about air pollution and traffic congestion, as well as the expansion of e-bikes and bike share networks.[42] Planners have brought bike lanes to arterial roads that either never had them or had demolished them in prior road-widening waves (Figure 5)

China's urban arterials tend to be far broader than the United States; the high-volume roads classified as arterials by many local U.S. governments are more often around four to six lanes.[43] But the multi-modal elements of China's arte-

Figure 5. Protected lane for two-wheelers on arterial road in Zhengzhou, Henan Province, China IMAGE SOURCE: Windmemories, CC BY-SA 4.0, via Wikimedia Commons

39 Based on data for specific years in individual cities from Hua Zhang, Susan A. Shaheen, and Xingpeng Chen, "Bicycle Evolution in China: From the 1900s to the Present," *International Journal of Sustainable Transportation* 8, no. 5 (September 3, 2014): 317–35, https://doi.org/10.1080/15568318.2012.699999.

40 Tianqi Gu, Inhi Kim, and Graham Currie, "To Be or Not to Be Dockless: Empirical Analysis of Dockless Bikeshare Development in China," *Transportation Research Part A: Policy and Practice* 119 (January 2019): tbl. 12, https://doi.org/10.1016/j.tra.2018.11.007; Tianqi Gu, Inhi Kim, and Graham Currie, "The Two-Wheeled Renaissance in China—an Empirical Review of Bicycle, E-Bike, and Motorbike Development," *International Journal of Sustainable Transportation* 15, no. 4 (February 1, 2021): 239–58, https://doi.org/10.1080/15568318.2020.1737277.

41 Estimated fatalities in China from the World Health Organization for 2016 indicate 86.9 deaths per 100,000 registered vehicles, as against 12.5 reported deaths for every 100,000 vehicles in the U.S. in 2015. World Health Organization, "Global Status Report on Road Safety 2018," June 17, 2018, https://www.who.int/publications-detail-redirect/9789241565684. A study of car accident rates in the Chinese city Chengdu by Qiao et al. finds arterial road density as one of several statistically significant predictors. Si Qiao et al., "Effects of State-Led Suburbanization on Traffic Crash Density in China: Evidence from the Chengdu City Proper," *Accident Analysis & Prevention* 148 (December 1, 2020): 105775, https://doi.org/10.1016/j.aap.2020.105775.neighborhood-level crash incidence in Chinese cities has not been sufficiently analyzed. This study fills this gap by quantifying the effects of built environment factors on neighborhood-level automobile-involved crash density (NACD

42 Gu, Kim, and Currie, "The Two-Wheeled Renaissance in China—an Empirical Review of Bicycle, E-Bike, and Motorbike Development."

43 See, for instance, City of Eugene Public Works, "Street Repair Terminology," November 17, 2016, https://www.eugene-or.gov/DocumentCenter/View/56293/Street-Repair-Terminology-PDF?bidId=; City of Round Rock, "Transportation Criteria," February 2021, https://www.roundrocktexas.gov/wp-content/uploads/2021/02/Sec-1-Street-Design-Criteria.pdf.

rial roads align nicely with the growing interest among U.S. street planners in redesigning their own arterials. Protected road-side bike lanes make two-wheeler trips much safer and more comfortable for riders than paint-only lanes and using concrete curbs or broad medians to provide that protection can reinforce those (Figure 6). These features can also be part of "road diets" that discourage dangerous driving speeds by cutting down on the number and width of lanes in a road. They can be even more effective when paired with center-running medians that reduce the length of road crossings for pedestrians (Figure 7).

Figure 6. Protected bike lane on arterial road in Boulder, Colorado (image courtesy of City of Boulder)

Figure 7: protected bike lane on Bluff Springs Road with center-running crosswalk island in Austin, Texas (image courtesy of the City of Austin)


IMAGE SOURCE: by Tom Fisk, Pexels.com

ECONOMIES OF SCALE FOR HEATING, COOLING, AND WASTEWATER

In designing infrastructure for basic services like heating, cooling, and wastewater, planners can opt for varying degrees of centralization. Decisions here reflect, among other factors, economies of scale. Most U.S. cities provide heating and cooling via decentralized equipment. Buildings generally have their own heating and cooling units that run on fuel or power provided from a centralized grid network. (Examples include boilers or air conditioners in houses or commercial buildings, for instance, which run on natural gas or electricity supplied by centralized networks of pipelines or power lines). By contrast, cities tend to process wastewater in large, centralized plants that collect sewage from a broad territory. On-site septic tanks – the most common decentralized processing technology – manage wastewater for 4% of households in large metropolitan areas (50,000+ residents) and 9% in small metropolitan areas (2,500-50,000 residents).[44]

> **"Our Chinese colleagues clearly wanted to share and learn. I was impressed with their eagerness to enter a dialogue."**
>
> *– Mayor Barbara Buffaloe, Columbia, Missouri*

These approaches are not the only options available. District energy networks heat or cool water and circulate it through distribution pipelines to provide heating or cooling to connected buildings. These systems can reduce system costs as against decentralized alternatives because of the economies of scale in centralized plants, which can heat or chill water more efficiently. District cooling, for instance, can consume 20-30% less power than the most efficient conventional cooling systems across a network while reducing its peak power demand by 30% or more.[45]

Of course, centralized infrastructure can lose its cost-effectiveness in low-density communities that require larger networks to serve. More than half of rural households in the U.S., for instance, process wastewater with on-site septic tanks rather than public sewers.[46] Clustered wastewater treatment systems offer an intermediate solution, collecting wastewater from a small number of buildings (tens or hundreds of dwellings, for instance) and processing it in a single system or facility.[47]

The USHCA delegation to China included exposure to both district heating and clustered wastewater treatment systems. The mayors visited an example of the latter in rural villages on Chongming Island in the megacity of Shanghai (Figure 8). These systems process wastewater using membrane biofilm-based technology to

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44 United States Census Bureau, "American Housing Survey -- 2021 National -- Plumbing, Water and Sewage Disposal -- All Occupied Units -- Geography Filters: Urbanized Area, Urban Cluster," accessed January 27, 2024, https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html.

45 Strategy&, "Increased Adoption of District Cooling Could Save US$1 Trillion in Energy Costs Worldwide," July 22, 2019, https://www.strategyand.pwc.com/m1/en/press-releases/2019/increased-adoption-of-district-cooling.html.

46 United States Census Bureau, "American Housing Survey -- 2021 National -- Plumbing, Water and Sewage Disposal -- All Occupied Units -- Geography Filters: Rural," accessed January 27, 2024, https://www.census.gov/programs-surveys/ahs/data/interactive/ahstablecreator.html.

47 For case studies of communities that have adopted clustered wastewater treatment systems, see Environmental Protection Agency, "Case Studies of Individual and Clustered (Decentralized) Wastewater Management Programs," June 2012, https://www.epa.gov/sites/default/files/2015-06/documents/decentralized-case-studies-2012.pdf.

Figure 8. USHCA Delegation Visit to Clustered Wastewater Treatment Facility in Shanghai (Huapiao Village, Chenjia Town, Chongming District) (Katherine Newton-Henry / USHCA)

preserve water quality on an island whose nature reserves include important habitats for migratory birds.[48] Officials cited savings on connecting to centralized sewer systems among their merits for these villages.

China's population density is more than four times the United States', and so Chinese rural communities like those on Chongming Island actually have comparable densities to many U.S. cities.[49] The population density of Chenjia Town, whose constituent villages received some of the island's first clustered systems, is comparable to Houston (around 1300 people per square mile).[50] U.S. cities are exploring clustered wastewater systems to serve their more suburban fringes, but also to reinforce aging centralized sewer systems amidst growing strains from climate change and water scarcity.[51] Case studies from cities like Mobile, Alabama, and El Paso and Austin in Texas offer examples of these applications.[52] Their appeal will grow with emerging membrane-based treatment technologies like those used on Chongming Island that expand the array of uses the processed wastewater can serve.[53]

48 Jonathan Browning, "A Tour of Chongming Dongtan Nature Reserve," Pacific Standard, June 14, 2017, https://psmag.com/news/a-tour-of-chongming-dongtan-nature-reserve.

49 World Bank, "Population Density (People per Square Kilometer of Land Area)" (World Development Indicators, 2021), https://data.worldbank.org.

50 上海市崇明区人民政府 [People's Government of Chongming District, Shanghai], "陈家镇概况 [Situation of Chenjia Town]," January 10, 2023, https://www.shcm.gov.cn/jzpd/014003/014003001/20210107/0e1c5161-327c-4db5-8a28-31bac41940ee.html; US Census Bureau, "2020 Census Urban Areas Facts," Census.gov, June 2023, https://www.census.gov/programs-surveys/geography/guidance/geo-areas/urban-rural/2020-ua-facts.html.

51 Kara Nelson, "Small and Decentralized Systems for Wastewater Treatment and Reuse," in Water Conservation, Reuse, and Recycling: Proceedings of an Iranian-American Workshop, by National Research Council (The National Academies Press, 2005), https://doi.org/10.17226/11241; Lu Liu, "How to Provide Reliable Water in a Warming World – These Cities Are Testing Small-Scale Treatment Systems and Wastewater Recycling," The Conversation, December 15, 2023, http://theconversation.com/how-to-provide-reliable-water-in-a-warming-world-these-cities-are-testing-small-scale-treatment-systems-and-wastewater-recycling-215753.

52 Liu, "How to Provide Reliable Water in a Warming World – These Cities Are Testing Small-Scale Treatment Systems and Wastewater Recycling"; Community Environmental Services, "Preferred Wastewater Systems for the Texas Hill Country and Over the Edwards Aquifer: Economic and Environmental Considerations" (The Meadows Center for Water and the Environment, March 2019), 27–31, https://hillcountryalliance.org/wp-content/uploads/2019/10/Preferred-Wastewater-Systems-for-the-Texas-Hill-Country-and-Over-the-Edwards-Aquifer-MCWE-Susan-Parten-Study.pdf.

53 On the promise of membrane-based treatment processes, see Liu, "How to Provide Reliable Water in a Warming World – These Cities Are Testing Small-Scale Treatment Systems and Wastewater Recycling."

Chongming Island's wastewater system is unusual in China, but district heating is not. It covers space heating for two-thirds of total urban heated floor area in northern China, the country's main heating demand region and it dominates heating provision in buildings in this region constructed since the mid-2000s.[54] Energy for district heating is produced almost entirely from fossil fuels – coal (around 80-90%) and some natural gas.[55] Half comes from highly efficient combined heat and power (CHP) plants that capture excess heat from fuel combustion for electricity generation. Such excess heat can contain more than half of the stored energy in coal or natural gas inputs to power plants.[56] The Suzhou High-Speed Rail New Town (Figure 9), a high-tech industrial district, heats 200 million square feet of floor area using large, centralized natural-gas boilers (70%) as well as waste-heat pipelines from a nearby thermal power plant (30%).[57] (The pipelines had previously supplied waste heat to manufacturing operations that formerly occupied the site.) The centralized boilers deliver heat at least 30% more efficiently than a distributed system could, even beyond the systemic efficiency gains from waste heat capture.[58]

Figure 9. Mayors' Delegation Visit to Energy Management Center at the Suzhou High-Speed Rail New Town (Katherine Newton-Henry / USHCA)

54 Yichi Zhang et al., "Clean Heating in Northern China: Regional Investigations and Roadmap Studies for Urban Area towards 2050," Journal of Cleaner Production 334 (February 1, 2022): 130233, https://doi.org/10.1016/j.jclepro.2021.130233; International Energy Agency and Tsinghua University Building Energy Research Center, "District Energy Systems in China: Options for Optimisation and Diversification," 2017, 17, https://iea.blob.core.windows.net/assets/590cc681-349a-4a55-9d3f-609eff6cde0b/DistrictEnergySystemsinChina.pdf.

55 A 2017 report from the International Energy Agency and the Tsinghua University Building Energy Research Center cites coal as providing 81% of district heating energy supply and natural gas as providing 15%. A more recent study from Zhang et al. reports coal as providing 90% of "overall primary energy consumption." Zhang et al., "Clean Heating in Northern China"; International Energy Agency and Tsinghua University Building Energy Research Center, "District Energy Systems in China: Options for Optimisation and Diversification," 15.

56 The most efficient coal-combustion technologies, for instance, capture up to around 45% of the stored energy in the coal used as fuel, with the remaining 55% released as excess heat. International Energy Agency and Tsinghua University Building Energy Research Center, "District Energy Systems in China: Options for Optimisation and Diversification," 34.

57 Floor area taken from 江苏苏州市相城区新闻中心 [News Center of Xiancheng District, Suzhou City, Jiangsu], "100万平方米，开启集中供暖！[Starting Up District Heating across 1 Million Square Meters!]," November 25, 2023, https://new.qq.com/rain/a/20231125A0690H00.

58 江苏苏州市相城区新闻中心 [News Center of Xiancheng District, Suzhou City, Jiangsu], "100万平方米，开启集中供暖！[Starting Up District Heating across 1 Million Square Meters!]."

District energy networks can reduce emissions against decentralized alternatives through the efficiency gains they offer. Still, they are not inherently zero-carbon. China's district heating systems used 185 million tons of coal in 2015, around 2.4% of all global coal consumption.[59] Building district energy infrastructure around existing or new fossil-fueled power plants can mean years or decades of carbon-emitting operations to recover the capital costs of investment. But there are many cleaner alternatives for district heating and cooling. District cooling systems are powered by electricity, so supplying these with low-carbon electricity – solar, wind, hydropower, or any other emissions-free source – allows for low-carbon cooling. For heating, cities across the world – including China and the United States – have adopted a host of other low-carbon alternatives:

> **"Both countries have a lot to learn from each other about topics that affect our cities every day, from new technologies on climate change to innovations in health care."**
>
> *– Mayor Kim Norton, Rochester, Minnesota*

- Biomass, biofuels, and renewable sources of waste. District heating supplied around 11% of total space and water heating for European Union members in 2017; around 30% of that energy came from biomass or biofuels (22%) or renewable waste sources (7%) such as municipal waste.[60] Shenyang, the capital of China's Liaoning Province, captures heat from sewage wastewater to heat a 280,000 square foot residential block as a (small) part of its district heating system.[61]
- Geothermal energy. Major networks like that of Xianyang, Shaanxi Province (70 million square feet of heated floor space as of 2018) make China the world's largest operator of geothermal district heating.[62] The U.S.'s largest network is in Boise, Idaho (6 million square feet).[63] USHCA delegation participant (and sister city of Xianyang) Rochester, Minnesota is installing a 1 million square-foot network.[64]
  - Geothermal systems can also provide cooling, as done in systems under construction on Princeton University's campus and in an affordable housing development outside Boston.[65]
- Waste heat from data centers, as done to heat several million square feet in Amazon's Seattle campus.[66]

59 Calculated from International Energy Agency and Tsinghua University Building Energy Research Center, "District Energy Systems in China: Options for Optimisation and Diversification," 11; International Energy Agency, "Global Coal Consumption, 2000-2025," December 16, 2022, https://www.iea.org/data-and-statistics/charts/global-coal-consumption-2000-2025.

60 European Commission Directorate-General for Energy et al., "Renewable Space Heating under the Revised Renewable Energy Directive: ENER/C1/2018 494 : Description of the Heat Supply Sectors of EU Member States Space Heating Market Summary 2017" (LU: Publications Office of the European Union, 2022), 7–8, https://data.europa.eu/doi/10.2833/256437.

61 International Energy Agency and Tsinghua University Building Energy Research Center, "District Energy Systems in China: Options for Optimisation and Diversification," 31–32.

62 张会民 [Zhang Huimin], "咸阳市发展'地热能'科技优势已形成 [Xianyang City's Technological Advantages in Developing Geothermal Energy Are Already Formed]," 咸阳日报 [Xianyang Daily], March 20, 2018, http://www.xianyang.gov.cn/xyxw/jjms/201803/t20180320_502348.html; 廖睿灵 [Liao Ruiling], "中国地热直接利用规模连续多年居世界首位——向大地要热能 [The Scale of Direct Utilization of Geothermal Heating in China Has Been First in the World for Years on End——Getting Heating from the Ground]," 人民日报（海外版）[People's Daily (Overseas Edition)], August 3, 2023, http://www.news.cn/politics/2023-08/03/c_1129783523.htm.

63 City of Boise, "Geothermal," accessed January 28, 2024, https://www.cityofboise.org/departments/public-works/geothermal/.

64 Catherine Richert, "Rochester Bets on Geothermal to Power a Green Future," MPR News, September 5, 2023, https://www.mprnews.org/story/2023/09/05/rochester-bets-on-geothermal-to-power-a-green-future; Thorkell Erlingsson et al., "Geothermal District Heating System in Xianyang, Shaanxi, China" (World Geothermal Congress, Bali, Indonesia, 2010), https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2010/3412.pdf.

65 Princeton University Facilities, "What Is Geo-Exchange?," May 2021, https://facilities.princeton.edu/news/what-geo-exchange; Miriam Wasser, "The Country's First Gas Utility-Run Networked Geothermal Heating and Cooling System Breaks Ground in Mass.," WBUR, June 13, 2023, https://www.wbur.org/news/2023/06/13/net-worked-geothermal-eversource-heat-pump-gas-utility.

66 David Roberts, "Amazon's Seattle Campus Is Using a Data Center next Door as a Furnace. It's Pretty Neat.," Vox, November 22, 2017, https://www.vox.com/energy-and-environment/2017/11/22/16684102/amazon-data-center-district-heating.

- Solar thermal energy, which involves capturing the sun's energy to provide heat. St. Paul, Minnesota has integrated solar thermal collectors to supply 23,000 square feet in its district heating system, while communities in the sunny and cold Tibetan Plateau have also adopted this technology.[67]
- Deep water source cooling, which involves chilling water by circulating it at significant depths in natural bodies of water. Cornell University's $58.5mn lake-source cooling project, built during the 1990s, cut its campus cooling energy demands by 85%.[68]

Limited density in U.S. cities can hamper the cost-effectiveness of district energy systems. But introducing district energy systems to downtowns and denser neighborhoods or developments also requires large-scale upfront capital investments. These costs require a collective investment decision covering a large swathe of buildings as opposed to the separate decisions by individual building owners that decentralized energy systems allow. This challenge explains why large institutions like campuses and airports have been some of the U.S.'s biggest growth markets for district energy systems in recent decades.[69] They involve single actors meeting large energy demands in a fixed location for decades, where high lifetime savings can compensate for longer payback periods.

Federal funding can make district energy more appealing for communities by lowering the upfront costs. The Department of Energy's Geothermal Technologies Office, for instance, announced $13 million in grants in April 2023 to help 11 communities design geothermal heating and cooling systems.[70] Some tax credits can also help communities and institutions in adopting district energy from sources such as geothermal, solar thermal, and biogas.[71] Rochester, for instance, is funding around half of its $34mn geothermal project using federal investment tax credits for geothermal as well as other grant funding sources.[72]

> **"Our Chinese hosts showed great interest, a desire to work together ... and incredible hospitality. I'm looking forward to hosting and showing off our U.S. cities to a Chinese delegation next year."**
>
> *– Mayor Chokwe Lumumba, Jackson, Mississippi*

67 国家太阳能光热产业技术创新战略联盟 [China Solar Thermal Alliance], 中国可再生能源学会太阳能热发电专业委员会 [Solar Thermal Power Generation Specialized Committee of the China Renewable Energy Society], and 中关村新源太阳能热利用技术服务中心 [Zhongguancun Xinyuan Solar Thermal Technology Service Center], 中国太阳能热发电及采暖行业蓝皮书 2020 (2020 Blue Book of Concentrating Solar Power and Solar Heating Industry), 2020, http://www.cnste.org/uploads/soft/230128/1_1803034811.pdf.

68 Cornell University, "Lake Source Cooling," accessed January 28, 2024, https://fcs.cornell.edu/departments/energy-sustainability/utilities/cooling-home/cooling-production-home/lake-source-cooling.

69 ICF and International District Energy Association, "U.S. District Energy Services Market Characterization" (U.S. Energy Information Administration, February 2018), 32, 51–56, https://www.eia.gov/analysis/studies/buildings/districtservices/pdf/districtservices.pdf.

70 Department of Energy, "DOE Announces $13 Million to Support Community Geothermal Heating and Cooling Solutions," April 25, 2023, https://www.energy.gov/articles/doe-announces-13-million-support-community-geothermal-heating-and-cooling-solutions.

71 Michael Bernier et al., "The Inflation Reduction Act's Energy- and Climate-Related Tax Provisions," The Tax Adviser, January 1, 2023, https://www.thetaxadviser.com/issues/2023/jan/the-inflation-reduction-acts-energy-and-climate-related-tax-provisions.html; Carrier, "A Guide to Federal Tax Incentives for Commercial Geothermal Heat Pumps," 2023, https://www.shareddocs.com/hvac/docs/1001/Public/07/HEAT_PUMP_TAX_INCENTIVES_2022.pdf; Department of Energy, "Federal Solar Tax Credits for Businesses," August 2023, https://www.energy.gov/eere/solar/federal-solar-tax-credits-businesses; Michael Bernier et al., "The Inflation Reduction Act's Energy- and Climate-Related Tax Provisions"; Carrier, "A Guide to Federal Tax Incentives for Commercial Geothermal Heat Pumps."

72 Richert, "Rochester Bets on Geothermal to Power a Green Future."

DEEPENING SUBNATIONAL ENGAGEMENT ON CLIMATE & ENERGY

Subnational governments in China and the United States can learn from each other on climate and energy issues. The USHCA Heartland Mayors delegation highlighted insights for U.S. cities on topics from bus electrification and street design to district energy and wastewater treatment. Many other areas deserve similar exchanges. U.S. cities and states have developed innovative policy strategies across a host of climate policy domains. These include setting up dedicated financing vehicles or tax streams for climate action; embracing nature-based solutions to boost resilience against flooding and sea level rise; and using public procurement mandates to create markets for low-carbon building materials.[73] These strategies tackle some of the same challenges that Chinese cities and provinces face in greening their economies and building resilient communities.

From left to right: Mayor Jim Brainard of Carmel, Indiana; Mayor Barbara Buffaloe of Columbia, Missouri; Mayor Chokwe Lumumba of Jackson, Mississippi; Mayor Robyn Tannehill of Oxford, Mississippi; Mayor Kim Norton of Rochester, Minnesota; Mayor Lee Harris of Shelby County, Tennessee

The U.S. and China are embracing subnational engagement in bilateral climate diplomacy. The two countries have dedicated a sub-group to subnational engagement as part of the bilateral working group on climate change that emerged from their November 2023 Sunnylands statement, mentioned above. They plan to host a U.S.-China subnational summit on climate and energy this year.

The fruits of the USHCA delegation suggest several ways to make expanded subnational engagement effective. For one, the countries can sponsor technical dialogues and study visits for subnational officials

73 Joseph B. Keller, Manann Donoghoe, and Andre M. Perry, "How US Cities Are Finding Creative Ways to Fund Climate Progress," Brookings, accessed January 29, 2024, https://www.brookings.edu/articles/how-us-cities-are-finding-creative-ways-to-fund-climate-progress/; Peyton Siler Jones, "Harnessing the Power of Nature-Based Solutions," National League of Cities, April 20, 2023, https://www.nlc.org/article/2023/04/20/harnessing-the-power-of-nature-based-solutions/; Christina Theodoridi and Jaden Kielty, "California Can Pave the Way on Decarbonizing Cement," Natural Resources Defense Council, December 14, 2022, https://www.nrdc.org/bio/christina-theodoridi/california-can-pave-way-decarbonizing-cement.

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IMAGE SOURCE: Summit Art Creations, stock.adobe.com

and policy experts. The summit, for instance, could host special focus sessions as launching pads for sustained engagements on specific topics. This report has highlighted promising topics for exchange like transport electrification, street design, and district energy. There are so many more, from flood and heat resilience to distributed solar and building materials efficiency. Organizing online dialogues and thematic study tours after the summit can allow participants to build upon these engagements while also bringing new communities into the fold. The U.S. and China could also explore technology or business showcases around climate change and energy transition issues that affect subnational policy. These activities could focus on less politically sensitive sectors. Growing official and industry interest in both countries around clustered wastewater treatment solutions, for instance, suggests that this field could suit a showcase well; other options include climate-smart agriculture or municipal waste management.

Capturing the potential of subnational summits and exchanges requires good planning. U.S. and Chinese officials operate in very different institutional contexts and bureaucratic cultures. Organizers can support participants in building the cultural literacy needed to bridge these gaps. They can deepen the policy gains from exchange by connecting cities and states with similar challenges: building flood resilience, say, or diversifying economies beyond fossil-fuel extraction. Where funding allows, organizers should also ensure that delegations include not just political leaders, but also policy specialists who can dive into the technical questions that determine how new strategies in one country translate to the other. More broadly, subnational governments need the political space to maintain effective exchanges even amidst the ups and downs of bilateral affairs. The U.S.'s federal system makes this easier for U.S. participants than Chinese ones, as does the greater support within American government institutions for frank and open exchange.

U.S.-China subnational engagement on climate and energy needs commitment and planning – but its benefits are clear. The two governments are laying a foundation for expanding it this decade. They must work with cities, states, and funders to make it deliver.

IMAGE SOURCE: Daniel Schwen, CC BY-SA 4.0 , via Wikimedia Commons (modified)

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AUTHOR BIO

Edmund Downie is a PhD candidate in Public Affairs in the Science, Technology, and Environmental Policy program at the Princeton School of Public and International Affairs. He studies how to build realistic and durable pathways for deep decarbonization in China, India, and the Global South. He is a co-author of the ***Guide to Chinese Climate Policy 2022*** (Oxford Institute for Energy Studies), and his writings have appeared in the ***Washington Post***, ***Foreign Policy***, ***Barron's***, ***The Wire China***, and ***chinadialogue***.

Before joining SPIA, Edmund was a non-resident fellow at the Columbia University SIPA Center on Global Energy Policy (CGEP); a senior analyst at Analysis Group in Boston; and a Fulbright Scholar at Yunnan University in China. He received an MPhil in International Relations at Nuffield College, Oxford as a Marshall Scholar (2017) and a B.A. in Ethics, Politics, and Economics from Yale University (2014).

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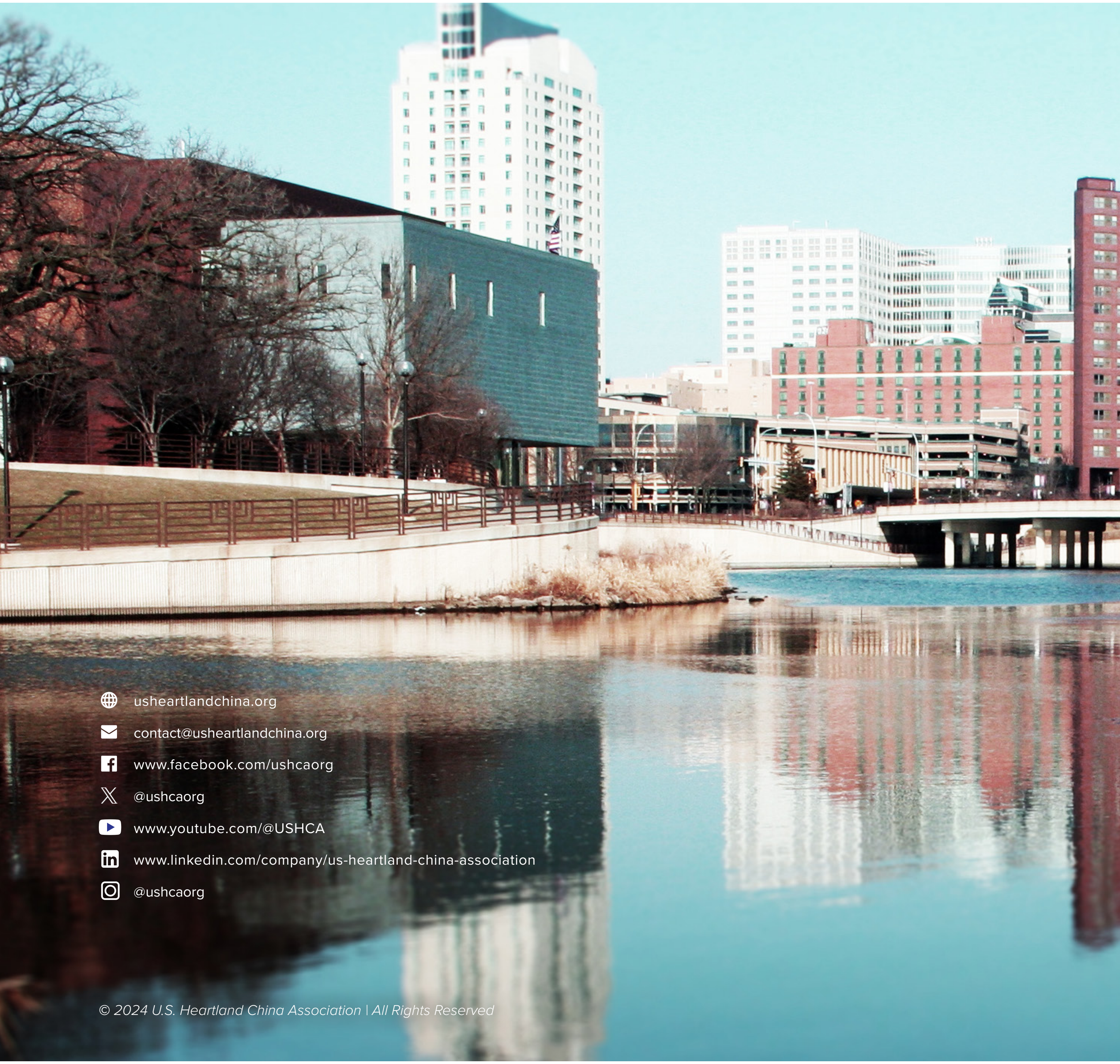

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