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Title: Capturing the Legacy of the U.S.-China EcoPartnerships Program

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Introduction

Transitioning innovations from the laboratories and research institutes into the marketplace can be a significant challenge. For more than a decade, operating under the auspices of the *U.S.-China Ten Year Framework for Cooperation on Energy and Environment*, a select group U.S. and Chinese actors from the public, private, and civic sectors have joined together in the U.S.-China EcoPartnerships program to conduct activities at the subnational level, such as research and demonstration, to accelerate the development, commercialization, and deployment of promising energy and environmental technologies and solutions. These subnational partnerships have delivered approximately \$733 million in U.S. economic benefit, through commercialization and deployment of patented technologies, generated more than \$603 million in U.S. technology sales to China, and created nearly 100 new U.S. jobs (U.S. EcoPartnerships Secretariat, unpublished data, April 2020). The article that follows provides insights into the purpose, principles, structure, and implementation framework of this impressive program; the diverse set of projects that comprised U.S.-China EcoPartnerships between 2008 and 2020; the commercial and environmental impacts of the program; and lessons learned for potential future bilateral subnational programs.

Purpose, Principles, and Structure of the U.S.-China EcoPartnerships

In June 2008, at the fourth meeting of the Strategic Economic Dialogue (SED) in Annapolis, Maryland, the United States and China signed the *U.S.-China Ten Year Framework (TYF) for Cooperation on Energy and Environment*. The TYF called for Action Plans to enable U.S.-China

collaboration in seven priority areas: clean air; clean and efficient transportation; clean, efficient, and secure electricity; clean water; energy efficiency; protected areas and nature reserves; and wetlands conservation.¹ Later that year, during the fifth SED in Beijing, the United States and China signed the *Framework for EcoPartnerships* which set forth the objectives, principles, and structure of the U.S.-China EcoPartnerships program; launched the first EcoPartnerships; and established the U.S. Department of State and China National Development and Reform Commission (NDRC) as the bodies expected to guide and facilitate the implementation of the EcoPartnerships.

Purpose

According to the *Framework for EcoPartnerships*, and subsequent evolutions of the program, the purpose of U.S.-China EcoPartnerships is to support U.S. and Chinese participants from the public, private, and civic sectors to grow mutually beneficial voluntary partnerships in clean air, clean water, and waste reduction that advance energy security, economic growth, and use of environmental technologies in China, while promoting and protecting U.S. interests, including creating overseas market opportunities for U.S. firms and encouraging U.S. innovations, such as development, commercialization, and deployment of energy and environmental technologies.

Principles

Core operating principles include: (1) partnerships must rely on the voluntary, active, and sustained commitments of participating entities; (2) each country is to establish its own process for eliciting participation, with projects selected to become EcoPartnerships by a Joint Secretariat; (3) initiatives may involve individual sectors (e.g., clean water) or be cross-sectoral; (4) the partnership is not an exclusive cooperation mechanism, but intended to work in concert

with all efforts that advance goals of energy security and economic growth; and (5)

EcoPartnerships are encouraged to adopt new principles and practices to help achieve their goals, such as new collaborative research methods that accelerate the timeline for moving a promising technology from lab-scale demonstration to pilot-scale demonstration to production.

Framework

Finally, the *Framework for EcoPartnerships* sets forth a structure whereby a Joint Working Group oversees implementation of the U.S.-China EcoPartnerships program, and each individual U.S.-China EcoPartnership establishes a Task Force, composed of members from each country, to develop details of partnership cooperation in a signed Statement of Intent (SOI) and Implementation Plan that specifies the partnership's tasks, milestones, and deliverables; expected outcomes; outreach plan; and staffing and resource plans (U.S. EcoPartnership Secretariat, unpublished data, December 2008).

Implementation of the Framework for U.S.-China EcoPartnerships

Building upon the *Framework for EcoPartnerships*, at the second Strategic and Economic Dialogue (S&ED) in Beijing in May 2010, the *Implementation of the Framework for EcoPartnerships* was signed. This document further defined key procedures for implementation of the U.S.-China EcoPartnerships program, including the management structure, selection standards for new U.S.-China EcoPartnerships, public outreach, and reporting mechanisms for the program. This document identified the U.S. Department of State, with participation by U.S. Department of Energy, U.S. Department of Commerce, and the U.S. Embassy Beijing's Environment, Science, Technology, and Health (ESTH) section, and NDRC, with participation

of the Chinese Embassy in the United States' economic section, as co-chairs of a Joint Secretariat, to facilitate oversight of the initiative at a senior level and set the overall strategic direction. The document also delineated an Advisory Committee, comprised of relevant experts, to provide recommendations to the Joint Secretariat on selecting U.S.-China EcoPartnerships. In general, selection to the U.S.-China EcoPartnerships program is highly competitive. On average, approximately 15 percent of applications are selected for the EcoPartnerships recognition. Projects are selected based on their ability to demonstrate: an innovative energy or environmental concept; a tangible output; a viable work plan for a three-year term; a large potential impact through research, development, commercialization, and/or deployment; that designation as a U.S.-China EcoPartnership will increase the project's likelihood of success; a qualified team from each country; and adequate financial resources (U.S. EcoPartnership Secretariat, unpublished data, August 2020).

Since 2014, Lawrence Berkeley National Laboratory (LBNL) has supported the U.S. Department of State in implementing the work of the Joint Secretariat for EcoPartnerships in the United States (i.e., the U.S. Secretariat). The primary functions and objectives of the U.S. Secretariat are twofold: (1) to coordinate all communications related to current or potential U.S.-China EcoPartnerships; and (2) to reach out to the broader stakeholder base (which is the field or industry in which the EcoPartnership is functioning) to help raise the profiles of U.S.-China EcoPartnerships and promote innovative breakthroughs that advance energy security and economic growth and enhance the use of environmental technologies in China, while promoting and protecting U.S. interests. Major activities of the U.S. Secretariat include: (1) new U.S.-China

EcoPartnerships recruitment and onboarding; (2) existing U.S.-China EcoPartnerships technical assistance, including helping to address technical challenges that may have arisen, identifying emerging opportunities that may be conducive to the success of the partnership, capturing lessons that may be informative for their peers, and identifying and preparing designated U.S.-China EcoPartnerships for graduation; and (3) outreach and communication, involving fostering regular interaction across U.S.-China EcoPartnerships and with the external stakeholder community by planning and executing an annual meeting to induct new U.S.-China EcoPartnerships and graduate partnerships that have completed their Implementation Plans, circulating a regular newsletter, managing a program website (<https://ecopartnerships.lbl.gov/>), and developing public relations materials (e.g., fact sheets, videos) on an as-needed basis (U.S. EcoPartnerships Secretariat, unpublished data, August 2020). Special volume journals, including the 2015 *Journal of Renewable and Sustainable Energy* which featured 15 articles by U.S.-China EcoPartnerships and was circulated to 35,000 subscribers, is one example of the U.S. Secretariat's outreach and communications efforts.² This 2020 *Journal of Environmental Progress and Sustainable Energy (JEPS)*, which profiles 14 articles by U.S.-China EcoPartnerships and captures the impact and legacy of the program, is another example.

The U.S.-China EcoPartnerships: Past and Present

Since the U.S.-China EcoPartnerships program was launched in 2008, a total of 45 U.S.-China subnational projects have been inducted into the program across at least 20 U.S. states and 15 Chinese provinces. Of these, 15 partnerships are active in 2020 and 22 have “graduated” after successfully demonstrating their EcoPartnership concept and completing their Implementation

Plans. All graduates are honored in Annual Signing/Graduation Ceremonies which are held in Beijing and Washington, D.C. on alternating years.

The list of current and graduated U.S.-China EcoPartnerships includes³:

- 1. Capstone Turbine – BROAD Air Conditioning** – Develop combined cooling-heating power (CCHP) systems to improve energy efficiency in buildings (joined 2018).
- 2. Louisiana State University – Chinese Academy of Sciences** – Conserve wetlands through joint data collection and analysis (joined 2018).
- 3. Natural Resources Defense Council – Shenzhen Power Supply Bureau** – Establish market mechanisms for demand response (DR) and integration of renewable energy into power grids (joined 2018).
- 4. Chemical and Metal Technologies (CMT) – CPI Yuanda Environmental-protection Engineering Co. Ltd.** – Demonstrate and evaluate CMT’s patented sorbent that treats flue gas and wastewater from coal-burning power plants for the removal of mercury, heavy metals, selenium, and nitrates/nitrites (joined 2016).
- 5. Minerals Technologies, Inc. – Sun Paper** – Repurpose 100% of the lime mud produced in the paper-making process and thereby eliminate it as a waste product from the paper-making process (joined 2016).
- 6. UniEnergy Technologies – Rongke Power** – Deliver large-scale flow battery-based energy storage solutions to enable increasing penetration of renewables and to advance grid modernization in both the United States and China, and around the globe (joined 2016).

7. **University of Southern California – Bayeco** – Develop transient plasma technology in coal-fired combustion devices to reduce air pollution in the next 5-10 years (joined 2016).
8. **U.S. Geological Survey (USGS) Wetland and Aquatic Research Center – Beijing Forestry University** – Assessment of vegetation, sediment and water dynamics floodplains of major rivers (joined 2016).
9. **Boeing – Commercial Aircraft Corporation of China (COMAC)** – Produce and thoroughly test aviation biofuels, enhance air-traffic management procedures, and promote lean aircraft manufacturing and recycling (joined 2015).
10. **Columbia University – Baotou Steel** – Separate iron oxide and rare earth minerals from steel slag for use as new feedstocks; sequester sulphur oxides (SO_x), nitrogen oxides (NO_x), and carbon dioxide (CO₂) from ironmaking flue gas; and produce highly pure calcium carbonate (CaCO₃) (joined 2015).
11. **Ramboll Environ – Jiangsu China-U.S. Environmental Monitoring Company (EMCUS)** – Install emissions monitoring equipment at chemical-industrial parks; issue safety alerts; inform new standards (joined 2015).
12. **Sea Turtles 911 - Hainan Normal University** – Foster conservation research, sustainable seafood practices, ecotourism, and student exchanges that empower local communities to safeguard the health of the ocean by saving sea turtles from extinction (joined 2015).
13. **University of Kentucky Center for Applied Energy Research – Jiangsu Wisdom Engineering Technology Co., Ltd.** – Pilot a 1 MW facility that captures volatile organic compounds (VOC) prior to combustion in energy-intensive industrial plants (joined 2015).

- 14. Wilson Solar Power – Shenzhen Enesoon Science & Technology Co.** – Pilot a 20 megawatt (MW) concentrating solar power plant using innovative Brayton Air Cycle technology that operates 24/7; build 1000 MW plant by 2020 (joined 2015).
- 15. Coca-Cola Company – Yangtze River Delta Circular Economy Institute of Technology** – Develop and commercialize bio-plastics suitable for beverage containers and other packaging applications from agricultural residues (joined 2013).
- 16. Environmental Defense Fund – Shenzhen Low Carbon Development Foundation** – Integrate mobile emissions into Shenzhen’s landmark emissions trading system (transportation emits 30 % of its greenhouse gases) (joined 2014).
- 17. General Electric (GE) – Harbin Electric Company** – Develop and deploy the top-performing gas-turbine-combined-cycle power plant that reduces emissions without compromising output (joined 2014).
- 18. Greater Philadelphia – Tianjin Economic Development Authority (TEDA)** – Showcase advanced building technologies, district level energy performance monitoring, and industrial waste water treatment solutions (joined 2014).
- 19. LBNL – Shandong Academy of Sciences** – Equip city officials with training, tools, and methodologies to create aggressive and viable low-carbon development plans (joined 2014).
- 20. Port of Los Angeles (POLA) – Shanghai Municipal Transportation Commission (SMTC)** – Deploy shore-based power systems (joined 2014).
- 21. Institute for Sustainable Communities (ISC) – National Center for Climate Change Strategy and International Cooperation (NCSC)** – Champion sustainable development initiatives at the local level (joined 2013).

- 22. Natural Resources Defense Council – Beijing Energy Conservation and Environmental Protection Center** – Demand side management to cut energy use in Beijing's buildings (joined 2013).
- 23. New York Institute of Technology – Peking University** – advancing innovative water quality models; real-time water monitoring tools and information systems; water scarcity and hydrologic simulations; and techniques for water management during hydraulic fracturing (joined 2013).
- 24. Raven Ridge Resources, Inc. – Guizhou Intl Cooperation Center for Environmental Protection** – Capture and utilize coal-bed methane (joined 2013).
- 25. Stony Brook University – Tongji University** – Capture and utilize methane from municipal solid waste for cost-effective conversion into transportation and power-generation fuels (joined 2013).
- 26. Columbus – Franklin County, Ohio / Ohio State University – Hefei, Anhui / Hefei University of Technology** – Enhance water quality and resilience; to collaborate in developing new electrified vehicle (EV) products to meet new fuel economy standards in China; to explore, develop and demonstrate advanced building systems and construction techniques (joined 2012).
- 27. International City/County Management Association (ICMA) China Center – China University of Political Science and Law (CUPL)** – promotes good governance and environmental sustainability at the sub-national level via city-to-city cooperation (joined 2012).
- 28. Nature Conservancy's Great River Partnership - The Chinese Yangtze River Fishery Administration** – Experience sharing, technique exchange, and demonstration projects in the areas of fisheries monitoring and habitat conservation (joined 2012).
- 29. Portland, Oregon – Kunming, Yunnan Province** – Transit-oriented planning, bicycle networks, green buildings and growth boundaries (joined 2012).

30. **University of California, Los Angeles (UCLA) – Peking University** – Conduct joint research on smart grids, intelligent vehicles, and electric vehicles (joined 2012).
31. **Center for Climate Strategies (CCS) – Global Environmental Institute (GEI)** – equip provincial officials with training, tools, and methodologies for low-carbon planning (joined 2011).
32. **Duke Energy / Charlotte, North Carolina – ENN Ecological Holdings Co. Ltd. / Langfang, Hebei** – technology exchange and demonstrations on clean and secure energy (joined 2011).
33. **Purdue University – Chinese National Academy of Sciences** – Assess degradation of terrestrial natural resources due to land use changes and population growth (joined 2011).
34. **U.S. Business Council for Sustainable Development - China Business Council for Sustainable Development** – Link manufacturers so waste streams from one can serve as feed stocks for another (joined 2011).
35. **Utah – Qinghai Industrial Technology Strategic Alliance** – National park development and protection (joined 2011).
36. **Tulane University – East China Normal University** – Develop a global model for the sustainability of coastal cities (joined 2008).
37. **Wichita – Wuxi** – Exchange best practices regarding clean air and clean water on a municipal and industrial level (joined 2008).

Over the past 12 years, a total of eight U.S.-China EcoPartnerships have been dismissed from the program for one or more of the following reasons: (1) the participating organizations decided that they no longer wished to continue; (2) the Joint Secretariat determined that the participating organizations failed to remain sufficiently active, including failing to submit a satisfactory

Implementation Plan, maintain adequate engagement with the Secretariat, and share insights on progress with peers (via the website, annual workshop, or through other venues); or (3) the Joint Secretariat determined that the maximum time limit for participating in the program had been reached (normally three years, though an additional extension of up to two years may be considered on a case-by-case basis).

The Impact of the U.S.-China EcoPartnerships

According to reports by U.S.-China EcoPartnerships to the U.S. Secretariat between October 1, 2015 and March 31, 2020, the program has helped to advance U.S. innovation, energy security, economic growth, and use of environmental technologies in China in the following ways:

- Demonstrating and accelerating commercialization of 13 innovative technologies. For example, under the UniEnergy Technologies and Rongke Power EcoPartnership, the China National Energy Administration (NEA) approved the construction of a 200-megawatt (MW) / 800-megawatt hour (MWh) flow-battery peak-load-shifting power station in Dalian China and listed the project as a demonstration of a national chemical energy storage peak-load shifting power station. The national demonstration project is the largest chemical energy storage power station in the world.⁴
- Achieving 3 new patents. For instance, CMT developed a patented sorbent that treats flue gas and wastewater from coal-burning power plants under the CMT – CPI Yuanda Environmental-protection Engineering Co. Ltd. EcoPartnership. (U.S. EcoPartnership Secretariat, unpublished data, February 2019).

- Establishing 1 new startup company. This includes GreenOre CleanTech L.L.C., which was established in 2016 through Columbia Technology Ventures and designed the first commercial iron and steel slag reutilization pilot plant in Inner Mongolia, China under the Columbia University – Baotou Steel EcoPartnership project.⁵

Establishing 2 new joint ventures (JV). For instance, Baotou Steel Group and GreenOre CleanTech L.L.C. officially registered as a JV at the Chinese local Department of Commerce in January 2018.⁶

- Establishing 8 scientific research collaborations, such as that between the LBNL – SDAS EcoPartnership on low-emissions development planning for cities. LBNL and SDAS completed an analysis of Shandong’s energy demand and energy cap utilizing the Green Resources & Energy Analysis Tool (GREAT) developed by LBNL. This analysis served as the scientific basis for energy policies adopted under the 13th Five Year Plan by Shandong's Development and Reform Commission.⁷
- Facilitating an estimated \$603 million of U.S. technology sales and \$733 million in economic benefit to the United States, such as through the GreenOre CleanTech L.L.C., which is building ten copies of its steel slag treatment plant through 2028 for an estimated U.S. economic benefit of \$200 million, including an estimated U.S. export value of \$65 to \$75 million.
- Contributing to the development of 6 new industries and nearly 100 new U.S. jobs. For instance, the Boeing – COMAC EcoPartnership promotes cleaner aerospace manufacturing operations including among original equipment manufacturers and

suppliers in the United States and new job opportunities and emerging industries around aviation sustainability in the United States and globally (U.S. EcoPartnership Secretariat, unpublished data, February 2019).

- Facilitating formal proposal, adoption, or implementation of 29 new laws, policies, regulations, standards, or strategies addressing clean energy, such as the Asian Carp Reduction in the Mississippi Basin Strategy, developed by the Yangtze River Basin Fisheries Resource Management Commission and The Nature Conservancy Great Rivers Program, which has resulted in the United States drawing on the Chinese Unified Catch Method to enhance the effectiveness of fishing out of invasive Asian Carp in the Illinois River (U.S. EcoPartnership Secretariat, unpublished data, April 2017).
- Building capacity at 89 institutions to address clean energy issues, including training more than 1,600 individuals and delivering 772 days of technical assistance on a wide range of topics related to clean air; clean and efficient transportation; clean, efficient, and secure electricity; clean water; energy efficiency; protected areas and nature reserves; and wetlands conservation. As an example, the Sea Turtles 911- Hainan Normal University EcoPartnership trained 15 college students to be volunteer educators for sea turtle conservation. These students then taught sea turtle conservation to about 800 elementary, middle, and high school students in rural areas of Hainan, China (U.S. EcoPartnership Secretariat, unpublished data, April 2017).
- Releasing 4 new publications to address clean energy issues. For instance, the March 2020 *Environmental Science: Processes and Impacts* journal article, “Spatial Distribution

of Heavy Metals in the West Dongting Lake Floodplain, China,” published by the USGS Wetland and Aquatic Research Center – Beijing Forestry University EcoPartnership.⁸

Participants in U.S.-China EcoPartnerships indicate that these outcomes can be attributed to a program model that covers a broad range of important environmental technologies and solutions; facilitates strong internal coordination and communication among U.S.-China EcoPartnerships; and provides access to higher-profile recognition and audiences than subnational organizations would be able to access independently. For future potential subnational efforts modeled on U.S.-China EcoPartnerships, participants suggested replicating the program between different countries (e.g., U.S.-India) or expanding it to cover more countries or regions (e.g., Association of Southeast Asian Nations); considering region-to-region initiatives (e.g., Greater Philadelphia to the Jin-Jing-Ji region); providing greater support to access additional funding (e.g., through linkages to foundations or competitive grants); and selecting more projects that demonstrate promising business models and commercial outcomes.

Conclusion

As demonstrated by the achievements described above, U.S.-China EcoPartnerships – through a subnational program model with a set of carefully defined goals, principles, and flexible framework for implementation – have done an exceptional job of accelerating the development, commercialization, and deployment of promising energy and environmental technologies and solutions for benefit to the United States. The subsequent pages of this journal are dedicated to describing the projects that contributed to many of these impressive outcomes in more detail,

including information on project design, activities, achievements, and lessons learned that can be utilized to foster future successful subnational collaborations.

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