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Joining China to Provide Global Leadership

Recognizing the strategic importance of China for future energy and climate change initiatives, and the vital role that Washington State plays in commerce with China, Pacific Northwest National Laboratory (PNNL) has invested considerable time and effort to form institutional agreements with Chinese entities, to engage key public and private technology and trade stakeholders in the United States, and to pursue collaborative research and development between institutions. Working with the U.S. Department of Energy (DOE) and the departments of State and Commerce, PNNL is ideally positioned to support a bilateral effort to dramatically accelerate technology development and deployment, improve the outlook for mitigation of climate change, and catalyze new global markets for advanced energy systems.

PNNL's science base, resources, and relationships will contribute to all facets of a DOE-China clean energy program, including net-zero emissions communities, infrastructure-ready biofuels, energy storage technology, and proliferation-resistant nuclear power. In particular, PNNL is uniquely able to deliver rapid progress in two key areas:

- ▶ **Integrated emissions capture and storage.** PNNL is pursuing integrated capture of criteria pollutants and CO₂, and use of geological co-sequestration, to achieve high efficiencies and lower costs for post-combustion emissions management. Teaming with China in such an effort could significantly accelerate scientific discovery, technological innovation, and ultimately, technology implementation in both the U.S. and China, a critical element of achieving global reduction in greenhouse gas emissions. PNNL has been advancing this approach within the Chinese Academy of Sciences (CAS) and the National Development and Reform Commission, and has established an agreement with and support from the National Institute of Clean-and-Low-Carbon Energy (NICE).
- ▶ **Transforming the electric grid.** PNNL is applying high-performance computing, advanced mathematical analytics, and world-leading information visualization to provide new tools that will enable use of real-time monitoring data to transform planning and operation of the electric grid. China has more phasor measurement units (PMUs) installed than the U.S. and has sought PNNL's expertise as they face a unique opportunity to manage their electric infrastructure as a national asset. Expanding ongoing work with Chinese power operators would accelerate progress in both nations.

Seeking to maximize contributions in these areas, PNNL has established collaborations and partnerships with various academic, laboratory and business institutions. These engagements include:

- ▶ **International Consortium for Clean Energy (ICCE):** In 2006, PNNL joined with the CAS Dalian Institute of Chemical Physics and Institute of Coal Chemistry to form the International Consortium for Clean Energy. Supported by an investment of more than \$300,000 from PNNL and strong support from the CAS president, Dr. Lu Yongxiang, this mechanism has brought more than 25 senior U.S. and Chinese scientists together to conduct more than \$1.3 million in research.
- ▶ **Memorandum of Understanding (MOU) with CAS:** In forming the ICCE, Dr. Lu Yongxiang challenged CAS, PNNL and the National Energy Technology Laboratory (NETL) to develop an even more extensive effort to address fossil energy conversion and emissions capture and sequestration. As a result, PNNL and NETL directors signed an MOU with the CAS Research Center for Energy and Power (CEP) in May 2009, and initiated the first joint projects in June 2010, with the aim of significantly reducing environmental emissions and improving efficiency of fossil fuel conversion. The CEP coordinates the R&D activities of the six energy-related institutes within CAS¹.

- ▶ **MOU with NICE:** Established by China's central government and funded by Shenhua Group—the largest state-owned energy company in China—NICE is a national-level industrial R&D institute. In May 2010, PNNL and NICE signed a MOU to develop clean energy technologies in areas such as carbon capture and storage (CCS), direct coal to liquids, coal gasification, and renewable energy and chemicals.
- ▶ **Engaging China Power Grid Operators:** PNNL is working with the State Grid, Southern Grid, and the Northern China Electric Power University to identify testing, demonstration, and deployment opportunities for advanced transmission and distribution system planning, measurement, and system operation, all based upon near real-time data supplied by a nationwide network of PMUs. PNNL also is training China grid personnel to use this real-time measurement data for grid operation and emergency management response.
- ▶ **U.S.-China Clean Energy Research Center (CERC):** PNNL led development of a proposed CERC consortium that joins 14 world-class institutions from the U.S. and 15 from China, spanning fundamental science to commercial deployment. Consortium members bring more than \$100 million of ongoing RD&D, with a commitment to leverage the existing research programs in the U.S. and China and accelerate the innovation cycle for clean coal including emissions capture and disposition or storage. The consortium proposes five collaborative technical projects with \$14.1 million cost share over five years, covering conversion, capture, storage, system integration and analysis.

PNNL HAS AN ESTABLISHED TRACK RECORD IN CHINA

PNNL is proud of nearly two decades of activity in China serving the varied missions of the DOE offices of Science, Fossil Energy, Energy Efficiency and Renewable Energy, and the National Nuclear Security Administration, as well as other federal agencies. These

engagements have established a base of technical credibility in China. Our most prominent activities are summarized below.

- ▶ **Sequestration of Fossil Fuel Emissions:** PNNL led the only nationwide assessment of geologic sequestration capacity and economics in China, working in collaboration with the CAS Institute of Rock and Soil Mechanics. This work provides a critical first step toward establishing the potential for CCS technologies to offer meaningful and cost-effective CO₂ reductions in China. Its scope includes identifying key geologic storage formations; completing first-order assessments of capacity in each formation; identifying over 1,600 large, industrial sources of CO₂ in China; and completing the very first cost curve for CCS across China via source-sink matching and least-cost optimization. This work has received international recognition.
- ▶ **Advanced Fossil Energy Conversion with Integrated Emissions Capture and Storage:** For many years, staff at PNNL have supported the Office of Fossil Energy and the FutureGen Industrial Alliance and have been instrumental in securing the participation of the China Huaneng Group in that alliance. The FutureGen effort, while facing challenges in the United States, provided the model for the Chinese GreenGen effort, which is on track to be the first integrated, commercial-scale power plant with CCS.
- ▶ **Electric Infrastructure:** PNNL is collaborating with China grid operators on tools for system operational reliability and expansion planning. China is rapidly developing its national grids, with urgent requirements for improved capacity, ability to transmit and integrate renewable energy from remote locales, and system monitoring and control using phasor technologies. These issues align with the infrastructure transformation priorities of DOE's Office of Electricity Delivery and Energy Reliability.

- ▶ **Building Energy Efficiency:** A decade ago, PNNL established the Beijing Energy Efficiency Center, which still operates independently to advance Chinese building efficiency codes. Most recently, with funding from the Department of State Asia Pacific Partnership program and DOE, PNNL assessed building energy codes in six nations, including China, identifying international best practices and energy-efficient technologies. This led to an evaluation of building code enforcement in two Chinese cities that, when complete, will provide an enforcement model that will vastly increase the impact of Chinese energy building codes.
- ▶ **Climate Change Research:** Since 1996, PNNL has led the tasks of Regional Climate Modeling and Climate Change Impacts in the agreement between DOE and the China Meteorological Administration (CMA). The agreement is now part of a bilateral pact between DOE and the Chinese Ministry of Science and Technology on Global and Regional Climate Change. Joint research with CMA has used historical climate data from China and advanced climate models at PNNL to significantly improve understanding of the role of aerosol and land use on regional climate change in China.

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[†]The six institutes are: Institute of Coal Chemistry (ICC), Dalian Institute of Chemical Physics, Institute of Process Engineering, Institute of Engineering Thermophysics, Institute of Chemistry, and the Institute of Rock and Soil Mechanics.