U.S.–China Clean Energy Research Center
中美清洁能源联合研究中心

WATER-ENERGY TECHNOLOGIES (CERC-WET)

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WATER-ENERGY TECHNOLOGIES (CERC-WET)

VISION: To build and transfer a foundation of knowledge, technologies, human capabilities, and relationships that position the United States, in particular with relevant industries, non-profits, and our research peers in China, to thrive in a future with constrained energy and water resources in a changing global climate.

Scope of Work

CERC-WET will implement the following four approaches to achieve our objectives:

- Build a team of the best researchers.
- Implement active project management.
- Strongly connect to end-users of our products and outputs.
- Leave space for Unexpected Innovation.

U.S. Research Team Members

Total US Budget: $39M over 5 years, of which $12.5M is from DOE

U.S. Team

UC Berkeley (UCB)
UC Davis (UCD)
UC Irvine (UCI)
UC Los Angels (UCLA)
UC Merced (UCM)
Lawrence Berkeley National Laboratory (LBNL)
The Stockholm Environmental Institute (SEI)

China Research Team Members

Total China Budget: $30M over 5 years, of which $12.5M is from MOST

China Team

Research Institute of Petroleum Exploration & Development (RIPED)
China Institute of Water Resources and Hydropower Research (IWHR)
Guodian New Energy Technology Research Institute (GNETI)
Institute of Engineering Thermophysics, Chinese Academy of Sciences (CAS)
Institute of Seawater Desalination and Multipurpose Utilization, State Oceanic Administration (SOA)
National Climate Centre (NCC), China Meteorological Administration (CMA)
Energy Research Institute, National Development and Reform Commission (NDRC)
Institute of Atmospheric Physics, CAS
Chinese Academy of Meteorological Sciences (CAMS)
Wuhan Regional Climate Center(WRCC), CMA
International Applied Energy Technology Innovation Institute
Tsinghua University
Beijing Normal University
Northeast Petroleum University
Peking University

U.S.: Funding and Consortium Members

SoCalGas

Southern California Edison

Energy Foundation
building a new energy future

California Energy Commission

Disney Research

Glacier Technologies
A wholly owned subsidiary of BBNC

Duke Energy

University of California
Office of the President

China: Funding and Consortium Members

中国石油

雅砻江流域水电开发有限公司
YALONG RIVER HYDROPOWER DEVELOPMENT COMPANY, LTD.

中国国电
CHINA GUODIAN

中国长江三峡工程开发总公司
CHINA THREE GORGES PROJECT CORPORATION

丹诺（北京）石油技术服务有限公司
Dano(Beijing)Oilfield Services Co.,Ltd

中国石油吉林油田公司
PETROCHINA JILIN OILFIELD COMPANY

5 Topic Areas in CERC-WET

- **Topic Area 1** Water Use Reduction at Thermo-electric Plants
  U.S. Lead: Per Peterson, (UC Berkeley) / China Lead: GUO Hua (CGDG GNETI)

- **Topic Area 2** Treatment & Management of Non-Traditional Waters
  U.S. Lead: David Sedlak, (UC Berkeley) / China Lead: YANG Qinghai (RIPED)

- **Topic Area 3** Improving Sustainable Hydropower Design & Operation
  U.S. Lead: Soroosh Sorooshian, (UC Irvine) / China Lead: WANG Dongsheng (NRCSHD)

- **Topic Area 4** Climate Impact Modeling, Methods, Science for E-W Systems
  U.S. Lead: Alan DiVittorio, (LBNL) / China Lead: XIAO Chan (NMC)

- **Topic Area 5** Data/Analysis to Inform Planning, Policy, and Other Decisions
  U.S. Lead: Nan Zhou, (LBNL) / China Lead: WANG Jianhua (IWHR)

CERC-WET Partners

U.S. Partners

California Energy Commission

Energy Foundation

Duke Energy

SoCal Gas

SoCal Edison

Glacier Technologies

Disney Imagineering R&D

UC Office of the President

China Partners

China National Petroleum Corporation

China Guodian Corporation

Yalong River Hydropower Development Company, Ltd.

Jilin Oilfield

Dano (Beijing) Oilfield Services

China Three Gorges Corporation

Topic Area 1 Objectives

Topic 1 Objectives

To address electricity needs, particularly in water-scarce regions, by creating technological breakthroughs in the areas of dry cooling, non conventional power conversion, dry carbon-capture methods and reduced fuel consumption

Topic Area 1 U.S. Projects

U.S. Projects

- 1.1 **Dry CO2 capture based upon nanoscale framework materials** (Jeffrey Long, UC Berkeley)
- 1.2 **Reheat air combined cycles (RACC)** (Per Peterson, UC Berkeley)
- 1.3 **Integrated Gasification Fuel Cell power plants** (Scott Samuelsen, UC Irvine)
- 1.4 **Dry cooling for steam condensation** (Yanbao Ma, UC Merced)
- 1.5 **Synthesis of flexible, low-temperature thermoelectrics and heat exchangers** (Jeffrey Urban, LBNL)
- 1.6 **Nanostructured Surface Enhancement of Spray Cooling Water Vaporization Processes** (Van Carey, UC Berkeley)

Doctoral student James Kendrick and Professor Per Peterson with test equipment to study heat transfer in molten salts.
Photo: Peg Skorpinski

Topic Area 1 China Projects

China Projects

- **1.1 A complete set of efficient and low-cost desulfurization wastewater treatment process and materials** (GUO Hua, GNETI)
- **1.2 Technology and application of unidirectional water withdrawal of brown coals** (GUO Hua, GNETI)
- **1.3 Synergetic technologies of water recycling, waste heat utilization, gypsum rain management at thermoelectric plants** (GUO Hua, GNETI; LU Yuan, CEP-CAS)
- **1.4 Efficient and Water-saving IGCC/IGFC Power Generation System** (ZHAO Lifeng, CEP-CAS)

Pilot plant of desulfurization wastewater treatment system in one of the CGDC's thermoelectric plants in Sichuan.

Topic Area 1 Project Examples

U.S. Project Example

1.2: Reheat air combined cycles for 280 MW gas turbines. Increase power conversion thermal efficiency and reduce water consumption. Heat sources can include high-temperature reactors and concentrating solar.

GE 7FB gas turbine modified for external heating via non-fossil sources

China Project Example

1.1: Develop technologies to achieve zero wastewater discharge and reduce the water consumption at thermoelectric plants of generating units over 600 MW.

Two Industrial test systems with different technical routes of Flue Gas Desulfurization wastewater treatment（6-8 tonnes/hour）

Topic Area 2 Objectives

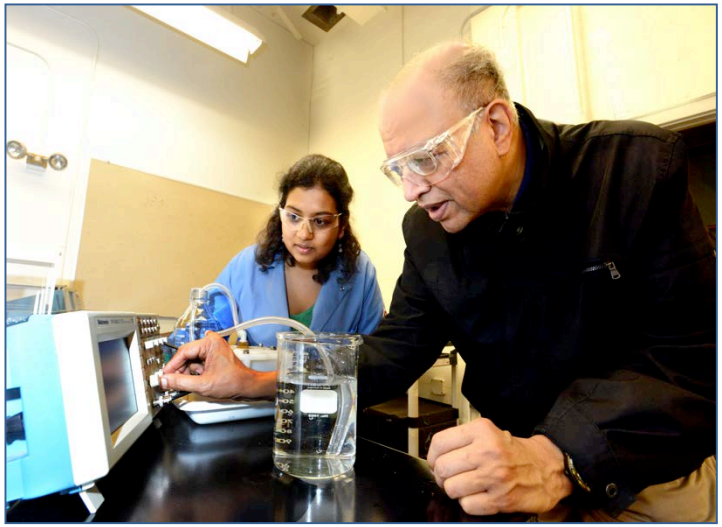
Topic 2 Objectives

- Treat and make useful non-traditional waters for societal use
- Create new technologies to address brine management and to protect the environment
- Create technologies to treat wastewater from oil and gas production

Topic Area 2 U.S. Projects

U.S. Projects

- **2.1 Capacitive Deionization of Brackish Waters** Ashok Gadgil, (UC Berkeley/LBNL)
- **2.2 Selective Removal of Divalent Cations with Graphene Oxide Membranes** (Baoxia Mi, UC Berkeley)
- **2.3 Forward Osmosis with Ionic Liquids** (Robert Kostecki, LBNL)
- **2.4 Enhanced Treatment of Desalination Brines** (David Sedlak, UC Berkeley)
- **2.5 A Systems-Level Analysis of Non-Traditional Water Management (**Diego Rosso, UC Irvine)
- **2.6 Geochemical Approaches for Managing of Non-Traditional Waters** (William Stringfellow, LBNL)
- **2.7 High Water Recovery Desalination of Non-Traditional Water** (Eric Hoek and Richard Kaner, UCLA)
- **2.8 Waterless Dry CO2 Fracking (Special affiliated project)** (George Moridis, LBNL)



Professor Ashok Gadgil and postdoctoral researcher Chinmayee Subban test a capacitive deionization (CDI) unit in order to evaluate their novel technology to desalinate brackish water. *Photo: Peg Skorpinski*

Topic Area 2 China Projects

China Projects

- **2.1 Waterless Dry CO_2 Fracturing**
  Meng Siwei, RIPED, CNPC
  Xu Jianguo, Jilin Oilfield, CNPC

- **2.2 Advanced treatment technologies and materials**
  Zhang Yushan, Institute of Seawater Desalination and Multipurpose Utilization, SOA(Tianjin)

- **2.3 Evaluation and optimal scheduling technologies for oilfield water system**
  Yang Qinghai, RIPED, CNPC
  Jia Deli, RIPED, CNPC
  Jiang Minzheng, Northeast Petroleum University

Prof. LIU He is discussing waterless dry CO2 fracturing tools with his colleagues in topic area 2.
photo : Duan Yongwei

Topic Area 2 Project Examples

U.S. Project Example

2.1 Capacitive De-Ionization of Brackish Waters

Capacitive deionization (CDI) deploys an electric field to move and trap ions at charged electrode surfaces, removing them from water. There are no membranes to foul, and technology operates at ambient pressure and temperature. We are working on next generation CDI technology.

China Project Example

2.1 Waterless Dry CO2 Fracturing

Waterless dry CO2 fracturing uses liquid CO2 (LCO2) to crack open the formation, providing highly conductive paths for hydrocarbons. The project aims to improve stimulation mechanism, technologies, LCO2 thickening and equipment to enhance the technology of LCO2 fracturing.

Topic Area 3 Objectives

Topic 3 Objectives

- Optimize hydropower operations by including environmental objectives and extend research to demonstrations

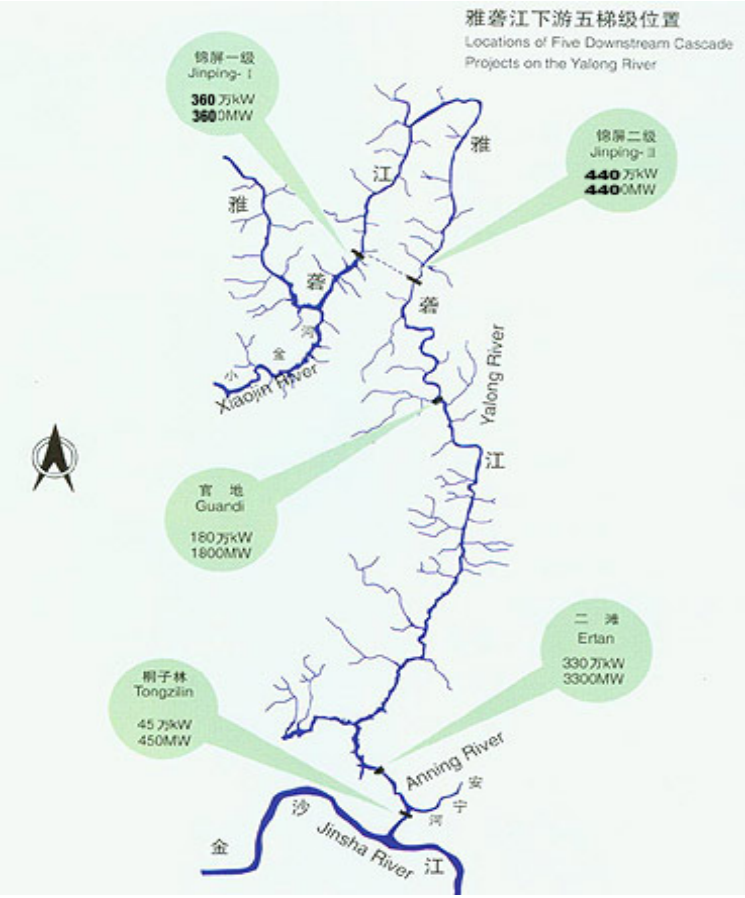
- Assess climate change impacts on optimal hydropower designs and high precision of short term precipitation forecasts data

- Develop hydrometeorology and climate forecasts to support hydro-facility optimal operations

Topic Area 3 China Projects

China Projects

- **3.1 Development of models for assessing the effect of hydropower construction on reservoir water temperature** (Peng Qidong, IWHR)
- **3.2 Evaluation of the effectiveness of eco-system protection measures during hydropower operations** (Wang Dongsheng, IWHR)
- **3.3 Reservoir inflow forecasting incorporating precipitation forecasting** (Bao Shujun, IWHR) (Miao Chiyuan, BNU)



Sketch map of planned research area: locations of five downstream cascade projects on the Yalong River

Topic Area 3 U.S. Projects

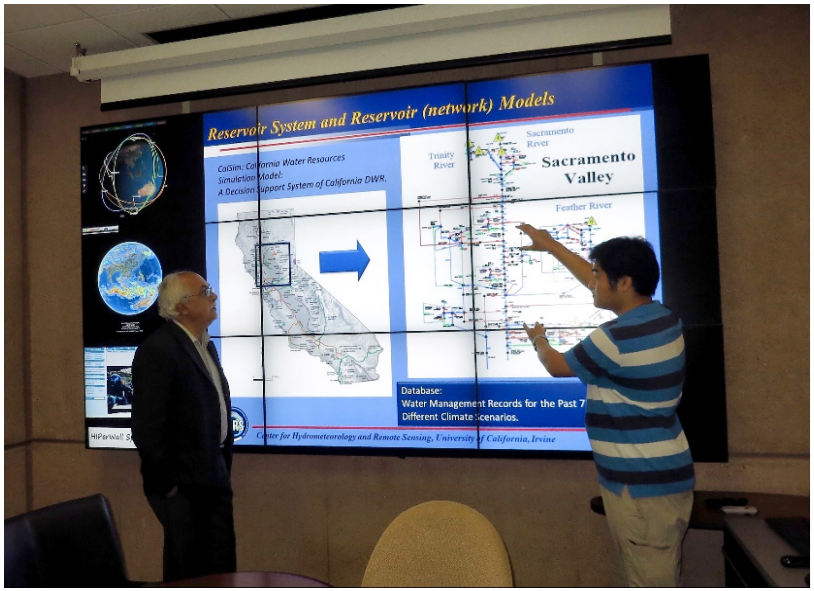
U.S. Projects

- **3.1 Optimizing Hydropower Operations While Sustaining Temperatures and Ecosystem Functions** (Joshua Viers, UC Merced); (Jay Lund, UC Davis)

- **3.2 Assessing Climate Change Impacts on Optimal Hydropower Design and Investment Strategies** (Soroosh Sorooshian, UC Irvine); (Jay Lund, UC Davis)

- **3.3 Developing Hydrometeorology and Climate Forecasts to Support Short-Term Hydropower Operation (**Soroosh Sorooshian, Koulin Hsu, Xiaogang Gao and Amiir Aghakouchak, UC Irvine)

- **3.4 Electric Grid Reliability and Greenhouse Gas Implications of Climate Change-Impacted Hydropower Resources** (Scott Samuelsen, UC Irvine)



Prof. Soroosh Sorooshian (left) and a postdoctoral researcher Dr. Tiantian Yang (right) are discussing the complexity of reservoir system in the northern California, where most of the hydropower generation plants are located. *Photo: Dr. Hao Liu*

Topic Area 4 Objectives

Topic 4 Objectives

- Recommendations from climate models based on predicted changes in hydrological cycle, for regional policy makers and industry
- Development of decadal prediction and long term projections of extreme events in U.S. and China regions
- Determining impacts of changing hydrological inputs on power and water

Topic Area 4 China Projects

China Projects

4.1 Regional hydrological simulation based on climate system model with refined resolution hydrological model; (Rong Xinyao, CAMS)

4.2 Future projection of climate change with climate models; (Xin Xiaoge, NCC)

4.3 Climate Change Impacts on Water Resources, hydropower production, and energy consumption; (Xiao Weihua, IWHR)

4.4 Integrated impact assessment of main high impact climate events in key areas on the water resources and hydropower; (Xiao Chan, Xu Hongmei, NCC)

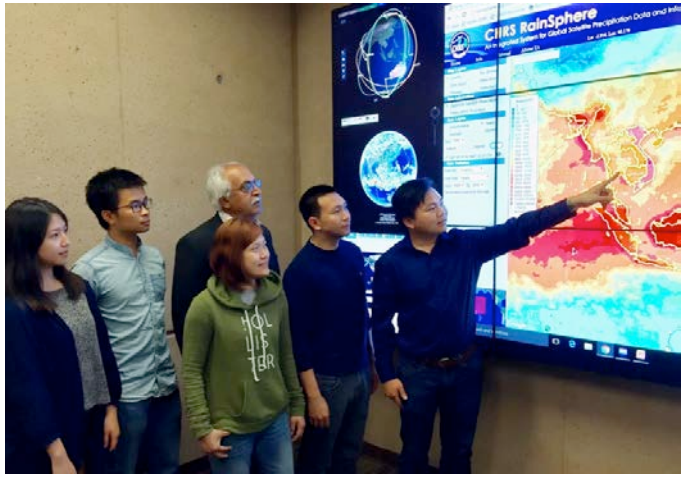
4.5 Assessment of climate change impact on groundwater (Xiao Weihua, IWHR)

Members of NCC CERC-WET team visited Huaihe river flood control project for a field trip

Topic Area 4 U.S. Projects

U.S. Projects

- **4.1 Telescopic Techniqes for Multi-Scale Prediction of Regional Hydrology** (Alan DiVittorio, LBNL)
- **4.2 Climate change impact sensitivity of electric grid resource availability** (Jack Brouwer, UC Irvine)
- **4.3 Characterization, visualization, and communication of parametric sensitivities** (Soroosh Sorooshian, Xiaogong Gao, UC Irvine)
- **4.4 Modeling and Analysis of Extreme Events** (Kuolin Hsu, Soroosh Sorooshian, UC Irvine)
- **4.5 Energy Consequences of Ongoing Conversion of Groundwater Systems into Closed Hydrologic Basins due to Overdraft** (Graham Fogg, UC Davis)
- **4.6 Improving the Characterization of California's Snowpack for Water and Energy Resource Management** (Steve Margulis, UCLA)



Dr. Phu Nguyen (right), a postdoctoral researcher, illustrates an extreme precipitation event based on a newly developed data-base visualization platform termed CHRS RainSphere to Prof. Sorooshian and students.
Photo: Dr. Tiantian Yang

Topic Area 5 Objectives

Topic 5 Objectives

- Identify effective water and energy technologies that minimize costs and maximize water/energy efficiency and GHG reduction
- Highlight climate impacts on future energy development paths and water limits in key regions of China and the American West
- Innovate the technology for evaluation and simulation of energy and water life cycles
- Conduct policy analysis to provide insights and recommendations for future energy-water nexus management decisions and optimal co-control of energy and water

Topic Area 5 China Projects

China Projects

5.1 National scale water resources and energy system simulation and policy analysis (Wang Jianhua, IWHR)

5.2 Coupling simulation of regional water resources and energy and its decision support
- Southwest China application
(Hong Yang,Tsinghua University)
- Northwest China application (Zhao Yong, IWHR)

5.3 Management and technology integration of water resources and energy systems in typical areas
- Urban application (Liu Jie, Peking Univ.)
- Technology integration for water and energy efficiency (Wu Yongzhong, IWHR)

Professor Wang Jianhua attends the Global human settlements forum. IWHR in cooperation with AEii received the 2014 Global Human Settlements Award of Green Technology.

Topic Area 5 U.S. Projects

U.S. Projects

- **5.1 Life-cycle systems analyses of the water-energy processes and technologies (**Arpad Horvath, UC Berkeley)
- **5.2 Water impact of long-term energy development at national and regional scales (**Nan Zhou, LBNL)
- **5.3 Modeling complex water-energy systems (**Annette Huber-Lee, Stockholm Environment Institute)
- **5.4 Recycled water scenarios for electricity generation (**JR Deshazo, UCLA)
- **5.5 Market characterization of Non-Traditional Waters in California (**Arpad Horvarth, David Sedlak, UC Berkeley)

David Sedlack and postdoctoral students use liquid chromatography as one of their tools to track chemical contaminants in water supplies.
Photo: Peg Skorpinski

CERC-WET