Final Progress Report
Sustainability Science Program
Term: September 1, 2013 – August 1, 2014

Name:
Chao Zhang

Your fields:
Energy and environmental policy assessment
Environmental system analysis

Your degree program, institution and graduation date:
PhD, Division of Environmental System Analysis, School of Environment, Tsinghua University, 2012

Faculty host at Harvard name and department:
Henry Lee, Harvard Kennedy School of Government

Description of SSP-related research activity, including a title:
Case study on water-energy nexus in Chins: Water-carbon trade-off for China's thermal power industry.

Abstract:
The energy sector is increasingly facing water scarcity constraints in many regions around the globe, especially in China, where the unprecedented large-scale construction of coal-fired thermal power plants is taking place in its extremely arid northwest regions. As a response to water scarcity, air-cooled coal power plants have experienced dramatic diffusion in China since middle 2000s. By the end of 2012, air-cooled coal-fired thermal power plants in China amounted to 114 GW, making up 14% of China's coal-fired power generation capacity. But the water conservation benefit of air-cooled units is achieved at the cost of lower thermal efficiency and consequently higher carbon emissions intensity. My study reveals that in 2012 the deployment of air-cooled units contributed an additional 24.0-31.6 million tonnes of CO_2 emissions (equivalent to 0.7-1.0% of the total CO_2 emissions by China's electric power sector), while they saved 841-953 million m^3 of consumptive water use (about 60% of the total annual water consumption of Beijing) when compared to a scenario with water-cooled plants. This water-carbon trade-off is poised to become even more significant by 2020, as air-cooled units are expected to grow by a factor of two to 260 GW, accounting for 22% of China's total coal-fired power capacity.

Identification of the problem you address:
Thermal power production in northwest China is facing a severe water scarcity problem. As a response to water shortage, air-cooling technology has been widely adopted in newly built thermal power plants in northwest China. While bringing water conservation benefits, this technological choice also incurs energy efficiency penalty and therefore additional CO_2 emissions for per unit net electricity output. This research aims to reveal the scale of this water-carbon tradeoff.

Key question asked about the problem:
How large are the water-saving benefits and the associated additional carbon emssions incurred by deployment of air-cooling technology in China's thermal power industry?

The methods by which you answered that question:
I gathered facility-level data of water and energy consumption in thermal power plants with different cooling technologies in China. Regression models for water consumption and energy

consumption were established to estimate water saving effect and additional carbon emission associated with using air-cooling technology.

Principle literature upon which the research drew:
This research was mainly drew on literature about water-energy nexus. It is also an extension of my previouse research on the life cycle water use of China's energy sector conducted in my first year of SSP fellowship.

Empirical data acquisition description:
Facility-level data on water and energy consumption of thermal power plants provided by China Electricity Council were collected.

Geographical region studied:
China

Recommendations that might be relevant for your problem:
The construction of air-cooled coal fired power plants in the water scarce north and northwest regions of China and the resulting increase in CO_2 emissions is a striking and telling example of the growing tradeoffs involved in dealing with energy provision. The water saving benefit is significant compared with moderate incremental CO_2 emissions. But with a growing number of thermal power plants with air-cooling technology to be built in China's northwest region in the future, such trade-off will continue to grow. Policy makers should take both positive and negative effects of water-saving technologies in energy sector into consideration.

A description of the final product(s) you have/are aiming to produce:
A paper titled "The Water-Carbon Trade-off for Thermal Power Industry in China" co-authored with Professor Laura Diaz Anadon and other Chinese colleagues has been submitted to Environmental Science & Technology.

Description of major other intellectual or professional advancement activity(ies) over the past academic year:
I have been working as an assistant professor in School of Economics and Management, Tongji University, China since September, 2013.

Please list citations for reports, papers, publications and presentations that built on your fellowship research (please list full citations here, paragraph length abstracts, and attach copies of URLs if possible):
1. Zhang, C., Anadon, L.D., A multi-regional input-output analysis of domestic virtual water trade and provincial water footprint in China. ***Ecological Economics***. 2014, 100: 159-172.

2. Zhang, C., Anadon, L.D., Life cycle water use of energy production and its environmental impacts in China. ***Environmental Science & Technology***. 2013, 47: 14459-14467.

Principal collaborators outside Harvard:
NA

List any awards or grants that you have received this year for the current or coming year. Please provide details regarding title of award, financial amount, and date of award:
None.

If you are moving to a new position, please list your contact information there:

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