China Energy Group

Lawrence Berkeley National Laboratory

Expertise Related to Assessment of

and Recommendations for China’s Five-Year Plans

Since its establishment in 1988, Lawrence Berkeley National Laboratory’s China Energy Group has performed many research projects directly related to and having influence on the development of China’s Five-Year Plans, as follows:

# 13th Five Year Plan (2016-2020)

## Project: Reinventing Fire: China

*Description:*

Three-year collaborative project with China’s Energy Research Institute, Lawrence Berkeley National Laboratory’s China Energy Group, and Rocky Mountain Institute. Findings were used to brief both the U.S. and Chinese governments in advance of the 2014 U.S.-China Joint Announcement on Climate Change and the 2015 Paris Agreement. ERI won awards from the Chinese government for the advice provided by this project for the 13th Five-Year Plan.

*Key Findings:*

As part of its Paris Agreement commitment, China pledged to peak carbon dioxide (CO2) emissions around 2030, striving to peak earlier, and to increase the non-fossil share of primary energy to 20% by 2030. Yet by the end of 2017, China emitted 28% of the world’s energy-related CO2 emissions, 76% of which were from coal use. How China can reinvent its energy economy cost-effectively while still achieving its commitments was the focus of a three-year joint research project completed in September 2016. Overall, this analysis found that if China follows a pathway in which it aggressively adopts all cost-effective energy efficiency and CO2 emission reduction technologies while also aggressively moving away from fossil fuels to renewable and other non-fossil resources, it is possible to not only meet its Paris Agreement Nationally Determined Contribution (NDC) commitments, but also to reduce its 2050 CO2 emissions to a level that is 42% below the country’s 2010 CO2 emissions. While numerous barriers exist that will need to be addressed through effective policies and programs in order to realize these potential energy use and emissions reductions, there are also significant local environmental (e.g., air quality), national and global environmental (e.g., mitigation of climate change), human health, and other unquantified benefits that will be realized if this pathway is pursued in China.

*Publications:*

Zhou, N., Price, L., Yande, D., Creyts, J., Khanna, N., Fridley, D., Lu, H., Feng, W., Liu, X., Hasanbeigi, A., Tian, Z., Yang, H., Bai, Q., Zhu, Y., Xiong, H., Zhang, J., Chrisman, K., Agenbroad, J., Ke, Y., McIntosh, R., Mullaney, D., Stranger, C., Wanless, E., Wetzel, D., Yee, C., and Franconi, E., 2019. “A roadmap for China to peak carbon dioxide emissions and achieve a 20% share of non-fossil fuels in primary energy by 2030,” *Applied Energy* 239: 793-819. <https://doi.org/10.1016/j.apenergy.2019.01.154>

Rocky Mountain Institute, Energy Research Institute, Lawrence Berkeley National Laboratory, 2018. *Reinventing Fire: China Executive Summary*. <https://rmi.org/insight/reinventing-fire-china/>

## Project: Evaluating China’s Low Carbon City Program

*Description:*

In 2009, China committed to reducing its carbon dioxide intensity (CO2/unit of gross domestic product, GDP) by 40–45% by 2020 from a 2005 baseline and in March 2011, China’s 12th Five-Year Plan established a carbon intensity reduction goal of 17% between 2011 and 2015. The National Development and Reform Commission (NDRC) of China then established a Low Carbon City policy and announced the selection of 5 provinces and 8 cities to pilot the low carbon development work. LBNL’s China Energy Group was invited by NDRC to be the sole international expert to provide technical assistance including scientific methodologies and analyses of best practice policies and programs from cities around the world. LBNL’s China Energy Group partnered with China’s Innovative Green Development Program (IGDP) on this work to assist with implementation of the program during the 12th Five-Year Plan period and to make recommendations for improvements that cities could implement during the 13th Five-Year Plan period.

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*Key Findings:*

Macro-level indicators of low carbon development, such as energy use or CO2 emissions per unit of GDP or per capita may be too aggregated to be meaningful measurements of whether a city or province is truly “low carbon”. Instead, indicators based on energy end-use sectors (industry, residential, commercial, transport, electric power) offer a better approach for defining “low carbon” and for taking action to reduce energy-related CO2 emissions. The China Energy Groups review of the historical development and context for low-carbon urban development in China and its ex-ante comparative assessment of the low-carbon development plans and supporting measures formulated for each of China's 8 pilot low-carbon cities found that while the 8 pilot cities have made progress in establishing low-carbon plans, key barriers such as a lack of explicit definition for low-carbon city, complexity and confusion resulting from several parallel programs, and insufficient supporting policies and market-based instruments may hinder urban development that is truly low carbon.

*Publications:*

Ohshita, S., Zhang, J., Yang, L., Hu, M., Khanna, N., Fridley, D., Liu, S., Li, A., Sun, M., and Zhou, N. 2017. *China Green Low-Carbon City Index*.

<http://eta-publications.lbl.gov/sites/default/files/chinacityindex052017_en.pdf>

Khanna N.Z., Fridley D. and L. Hong. 2014. “China's pilot low-carbon city initiative: A comparative assessment of national goals and local plans.” *Sustainable Cities and Society* 12: 110-121.

Price, L., N. Zhou, D. Fridley, H.Y. Lu, L. Hong, C. Fino-Chen, J. Ke, S. Ohshita, M. Hu, Y. Zhou, S. Hammer, and X. Hu. 2014. “Energy-Efficiency and Greenhouse Gas Mitigation Policy Options: Assisting Chinese Cities in Prioritizing and Choosing Strategies to Implement to Become a Sustainable Community,” *Proceedings of the American Council for An Energy-Efficient Economy 2014 Summer Study on Energy Efficiency*. Washington DC: ACEEE.

Price L., Zhou N., Fridley D., Ohshita S., Lu H., Zheng N. and C. Fino-Chen. 2013. “Development of a Low-Carbon Indicator System for China.” *Habitat International* 37: 4-21. <http://eta-publications.lbl.gov/sites/default/files/lbl-5739e-lowcarbon-habitatjune-2012.pdf>

Zhou, N., Ohshita, S., Price, L., and Zheng, N. 2011. “A Low Carbon Development Guide for Local Government Actions in China,” *Carbon Management*. Volume 2 (4): 455‐469.

## Project: Net Zero energy buildings in China: policies, standards and pathway

*Description:*

We provided a variety of technical supports for building energy efficiency during China’s 13th FYP. We conducted net zero energy building research comparisons on standards and demonstration case studies. The first study analyzes net zero energy buildings in the hot and tropic climate regions. The on-going study is collecting case studies, standards and technology adoption in cold climate zones. The study was done in collaboration with researchers in China through the U.S.-China Clean Energy Research Center, Building Energy Efficiency project.

*Publication:*

Wei Feng, Qianning Zhang, Hui Ji, Ran Wang, Nan Zhou, Qing Ye, Bin Hao, Yutong Li, Duo Luo, Stephen Siu Yu Lau. 2019. “A review of net zero energy buildings in hot and humid climates: Experience learned from 34 case study buildings.” *Renewable and Sustainable Energy Reviews* [Volume 114](https://www.sciencedirect.com/science/journal/13640321/114/supp/C), 109303.

## Project: City level building energy efficiency and low carbon emission pathway

*Description:*

Two projects are conducted in the 13th FYP, to model building sector energy use in China from the 13th FYP to 2030 and 2050. LBNL worked closely with City of Wuhan, and Qingdao to develop a long-term building sector energy use pathway. Several policy scenarios were also developed to capture policy’s contribution to carbon emission in residential and commercial buildings. Finally, the modeling results were reported to Wuhan and Qingdao local MOHURD to provide solid data supports on their 14th FYP building energy efficiency policy decision making.

*Publication:*

Ding C., Feng W., Li X., Zhou N. 2019. “Urban-scale building energy consumption database: A case study for Wuhan, China.” *Energy Procedia* 158, 6152-6157.

## Project: Policy Recommendations for China’s Building Sector during the 13th Five-Year Plan

*Description:*

The project reviewed four Chinese cities (Beijing, Fuzhou, Qingdao, and Shanghai Changning) policies and experience on energy efficiency and renewable energy utilization in buildings. Different aspects of policies in Chinese cities are discussed, including: existing building retrofit, ultra-low energy buildings, and renewable energy application. To contrast with the Chinese cities’ policies, several international cities building energy efficiency policies are reviewed and compared. International cities' policy best practices in the similar areas with Chinese are illustrated. Finally, recommendations for Chinese cities to further develop building energy efficiency policies are discussed.

*Publications:*

Feng, W., H.Y. Lu, L. Xu, N. Zhou, L. Sherlock, J. Hou, and X. Wang. 2019. “Building energy efficiency policy in Chinese cities and comparison with international cities”, *Proceedings of the 2019 European Council for An Energy-Efficient Economy*. Hyeres, France, June 3 - 8, 2019. <https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2019/3-policy-and-governance/building-energy-efficiency-policy-in-chinese-cities-and-comparison-with-international-cities/>

Wang, Xia, Wei Feng, Weiguang Cai, Hong Ren, Chao Ding, and Nan Zhou. "Do residential building energy efficiency standards reduce energy consumption in China? – A data-driven method to validate the actual performance of building energy efficiency standards." *Energy Policy 131* (2019) 82 – 98. <https://china.lbl.gov/publications?f%5Bauthor%5D=139>

Ge, Jing, Wei Feng, Nan Zhou, Mark D Levine, and Carolyn Szum, 2017. *Accelerating Energy Efficiency in China’s Existing Commercial Buildings Part 2: Solutions and Policy Recommendations*. <https://eta-publications.lbl.gov/sites/default/files/accelerating_energy_efficiency_in_chinas_existing_commercial_buildings_-_part_2_02262018.pdf>

Ge, Jing, Wei Feng, Nan Zhou, Mark D Levine, and Carolyn Szum, 2017. *Accelerating Energy Efficiency in China's Existing Commercial Buildings, Part 1: Barrier Analysis.* LBNL-2001078. <https://eta-publications.lbl.gov/sites/default/files/accelerating_energy_efficiency_in_chinas_existing_commercial_buildings_-_part_1_02262018_1.pdf>

## Project: Transport Sector 12th and 13th FYP Policies Assessment

*Description:*

We evaluated the latest developments in China’s transport sector, including the latest policies in the related 12th FYPs for oil and natural gas industry, and evaluated potential future oil and natural gas supply-demand and infrastructure gaps given recent trends of sectoral developments. In support of future planning and modeling efforts at Sinopec during the 13th FYP period, we also reviewed the latest developments in international policies and trends to reduce oil consumption.

*Publications:*

Khanna, N.Z. and Fridley, D., 2015. “Mind the Gap: New Developments and Outlook for China’s Transport Sector to 2030.” *Proceedings of the 2015 ECEEE Summer Study on Energy Efficiency*. Toulon, France: 1 – 6 June 2015.

Khanna, N., Fridley, D., Zhou, N., Zhu, L., 2019. *Review of International Oil Consumption Trends, Policies, and Outlooks.* Berkeley, CA: Lawrence Berkeley National Laboratory.

## Project: Assessment of Coal Use in China during the 13th Five-Year Plan

*Description:*

Some analysts have declared that China’s coal consumption may have peaked, but preliminary data indicate that coal consumption increased in 2017. This recent growth, combined with our analysis of projected increases in electricity demand that cannot be met by other fossil-fuel or non-fossil-fuel electricity sources, along with projected increases in coal use in light manufacturing, other non-industrial sectors, as well as in coal use for transformation, indicates potential future growth of China’s coal use to levels of 2,908 Mtce to 3,060 Mtce in 2020, with associated increases in energy-related CO2 emissions.

*Publications:*

Lin, J., D. Fridley, H.Y. Lu, L. Price, and N. Zhou. 2018. “Has Coal Use Peaked in China: Near-Term Trends in China's Coal Consumption”, *Energy Policy*, 208-214. <https://doi.org/10.1016/j.enpol.2018.08.058>

Liu, X., J. Lin, J. Hu, H.Y. Lu, and J. Cai. 2019. “Economic Transition, Technology Change, and Energy Consumption in China: A Provincial-Level Analysis”. *Energies*, 12, 2581; doi:10.3390/en12132581

## Project: Techno-economic Assessment of Measures for Phasing-out Dispersed Coal Use in Northern China

*Description:*

We conducted an in-depth techno-economic assessment of technologies for replacing dispersed coal use in the residential, commercial and industrial sectors in Northern China . We used bottom-up energy end-use modeling and scenario analysis to analyze technical options described in 13th FYP policies including the Greenhouse Gas Control Work Plan, 13th FYP for Environmental Protection and Jing-Jin-Ji Air Pollution Prevention Plan, and the Winter Heating Plan of the Northern Region and assessed their impact on reducing dispersed coal use. We found that current policies can reduce existing dispersed coal use in North China by about half, but more aggressive technical measures and expansion of existing policies to cover all of North China are needed to come close to phase-out dispersed coal use by the early 2020s.

*Publication:*

Khanna N, Liu X, Fridley D, Ge J., Zhou N. 2019. “Technical Roadmap to Phasing Out Dispersed Coal Use in North China.” Berkeley, CA: Lawrence Berkeley National Laboratory.

## Project: Techno-Economic Assessment of Industrial Boiler Systems in China

*Description:*

For this assessment, we conducted a comprehensive techno-economic analysis to evaluate various strategies for improving efficiency and maximize fuel-switching of industrial boilers. The analysis focused on three options: (1) fuel switching to replace coal with alternative fuels for small size of boilers; (2) retrofitting boilers through a series of efficiency improvement measures; (3) developing community-scale, distributed systems to replace otherwise scattered boilers operated by individual industrial facilities. Key barriers that prevent these solutions from being fully captured are discussed and policy recommendations to tackle these barriers are provided.

*Publications:*

Shen, B., Y. Han, L. Price, H.Y. Lu, and M. Liu. 2017. “Techno-economic evaluation of strategies for addressing energy and environmental challenges of industrial boilers in China”, *Energy*, Volume 118. <http://dx.doi.org/10.1016/j.energy.2016.10.083>

Zhang, Q., X. Zhao, H.Y. Lu, T. Ni, and Y. Li. 2017. “Waste energy recovery and energy efficiency improvement in China’s iron and steel industry”, *Applied Energy*, Volume 191. <http://dx.doi.org/10.1016/j.apenergy.2017.01.072>

Lu, H.Y., L. Price, Q. Zhang. 2015. “Capturing the Invisible Resource: Analysis of Waste Heat Potential in Chinese Industry”, *Applied Energy*, Volume 161. doi:10.1016/j.apenergy.2015.10.060.

Liu, M., Shen B., Han Y., Price L., Xu M. 2015. “Cost‐Effectiveness Analysis on Measures to Improve China’s Coal‐fired Industrial Boiler,” *Energy Procedia* 75: 1549 – 1554, doi: 10.1016/j.egypro.2015.07.330.

## Project: Understanding Key Features of China’s Carbon Trading Pilots and Insights from California

*Description:*

By examining China’s allowance mechanism from two aspects-allowance allocation and allowance distribution, this paper compares China’s carbon trading pilots with the EU Emissions Trading Scheme and California Cap-and-Trade Program. The comparison identifies the unique features in allowance mechanism and particular issues that affect the efficiency of the pilots. The paper also recommends courses of action to strengthen China’s existing pilots and to build valuable experiences for the establishment of the national cap-and-trade system in China.

*Publications:*

Xiong, L., Shen, B., Qi, SZ., Price, L., Ye, B. 2017. “Comparative Analysis on Allowance Mechanism of China’s Carbon Trading Pilots”, *Applied Energy*, Volume 185: 1849-1859. <http://dx.doi.org/10.1016/j.apenergy.2016.01.064>.

Shen, B., Dai, F., Price, L., and Lu, H., 2014. “California’s Cap‐and‐Trade Program and Insights for China’s Pilots,” *Energy and Environment*, Volume 25 (3 & 4): 551‐575.

# 12th Five Year Plan (2011-2015)

## Project: Evaluating the Impact of Appliance Standards During the 12th Five Year Plan

*Description:*

In collaboration with the China National Institute of Standardization (CNIS) and based on the latest market data, LBNL’s China Energy Group used bottom-up stock turnover analysis to conduct both prospective and retrospective impact evaluation of the energy and CO2 emission reductions from appliance standards programs during the 12th FYP period. The project findings helped quantify the significant overall savings from the appliance standards program, and identified products that were outdated and in urgent need of energy efficiency standard updates.

*Publications:*

Khanna, N., Zhou, N., Fridley, D., and M. McNeil, M., 2016. *Prospective Evaluation of the Energy and CO2 Emissions Impact of China’s 2010 – 2013 Efficiency Standards for Products*. Berkeley, CA: Lawrence Berkeley National Laboratory.

Zhou, N. Khanna, N., Fridley, D., and Romankiewicz, J. 2013. *Development and Implementation of Energy Efficiency Standards and Labeling Programs in China: Progress and Challenges*. Berkeley, CA: Lawrence Berkeley National Laboratory.

Khanna, N., Zhou, N., Fridley, D., and Fino-Chen, C. 2013. "Evaluation of China's local enforcement of energy efficiency standards and labeling programs for appliances and equipment." *Energy Policy,* 63:646-655. <https://doi.org/10.1016/j.enpol.2013.09.035>

Khanna N.Z.,Guo J. andY. Zheng. 2016. “Effects of Demand-side Management on Chinese Household Electricity Consumption: Empirical Findings from Chinese Household Survey.” *Energy Policy* 95: 113-125.

## Project: China’s Pathways to 2020 and 2030

*Description:*

This study uses a bottom-up, end-use model and two scenarios -- an enhanced energy efficiency (E3) scenario and an alternative maximum technically feasible energy efficiency improvement (Max Tech) scenario – to evaluate what policies and technical improvements are needed to achieve the 2020 carbon intensity reduction target. The findings from this study show that a determined approach by China can lead to the achievement of its 2020 goal.

*Publications:*

Zheng, N., Fridley, D., Zhou, N., Levine, M., Price, L., and J. Ke. 2011. “China’s Pathways to Achieving 40% ‐ 45% Reduction in CO2 Emissions per Unit of GDP in 2020: Sectoral Outlook and Assessment of Savings Potential.” *Proceedings of the 7th Session of the 13th Annual Meeting of the China Association of Science and Technology*. Tianjin, China: 22 September 2011. (LBNL‐5257E)

Fridley, D., Zheng, N., Zhou, N., Ke, J., Hasanbeigi, A., Price, L., 2011. *China Energy and Emission Paths to 2030*. Berkeley, CA: Lawrence Berkeley National Laboratory.

## Project: Evaluating China’s Non-Fossil Targets

*Description:*

More than 130 countries have targets for increasing their share of renewable or non-fossil energy. These shares and targets are often reported without clear articulation of which energy accounting method was used to convert non-fossil electricity into units that allow comparison with other energy sources. Three commonly used conversion methods are well documented by organizations dealing in energy statistics, but often, the method is not clearly stated when countries translate national targets into international pledges or when organizations track and compare targets across nations. China—the world's largest energy producer, energy consumer, and emitter of energy-related carbon dioxide (CO2)—uses a distinct fourth method that is unique, not well documented in the literature, and not transparent in policy documents. A single, standardized, and transparent methodology for any targets that are pledged as part of an international agreement is essential.

*Publication:*

Lewis, J., D. Fridley, L. Price, H.Y. Lu, and J. Romankiewicz. 2015. “Understanding China’s non-fossil energy targets”, *Science*, November 27. <http://science.sciencemag.org/content/350/6264/1034>

## Project: Evaluating Energy Performance Contracts in China and the United States

*Description:*

Energy performance contracting (EPC) is a mechanism that uses private sector investment and expertise to deploy energy efficiency retrofits in buildings, industries, and other types of facilities. China and the United States both have large, growing EPC markets. This project shared key insights on each market, including strengths and barriers inherent to these markets, compares the two markets, and sets forth options for enhancing EPC markets in each country. The project concluded with recommendations structured around common goals of both countries.

*Publication:*

Evans, M., Yu, S., Roshchanka, V., Haverson, M., Shen B., Price, L., Liu, MZ, Meng, L., Miao, P., Dai, F., in collaboration with the ESCO Committee of the China Energy Conservation Association (EMCA), 2015. *White Paper: Unleashing Energy Efficiency Retrofits Through Energy Performance Contracts in China and the United States*, LBNL‐190662, Richland, WA: Pacific Northwest National Laboratory and Berkeley, CA: Lawrence Berkeley National Laboratory.

## Project: Evaluating Best Practices and Lessons Learned for China

*Description:*

There are many energy efficiency policies in China, but the motivation and willingness of enterprises to improve energy efficiency has weakened. This project first identifies barriers that enterprises face to be self‐motivated to implement energy efficiency measures and then categorizes these barriers into four categories: awareness, information, technical capacity, and financial availability. It then reviews international policies and programs to improve energy efficiency, and evaluates how these policies have helped to address the barriers identified. We found that policies and programs in energy efficiency and carbon reduction need to go hand in hand to incentivize companies, and that those policies and programs send clearer signals and help change enterprises' decisions when they are persistent but dynamic. Our specific policy recommendations to China fall under three key categories: identification of energy efficiency potential, workforce development, and market channels for energy efficiency financing.

*Publications:*

Liu, X., B. Shen, L. Price, A. Hasanbeigi, H.Y. Lu, C. Yu, and G. Fu. 2019. “A Review of International Practices for Energy Efficiency and Carbon Emissions Reduction and Lessons Learned for China”, *Wiley Interdisciplinary Reviews: Energy and Environment*. DOI: 10.1002/wene.342

Ohshita, S. and Price, L., 2010. “Lessons for Industrial Energy Efficiency Cooperation with China,” *China Environment Series 11*. Washington, DC: Woodrow Wilson International Center for Scholars.

## Project: Evaluating Chinese Energy Audit Practices during the 12th FYP

*Description*

This project combined a review of China’s national policies and programs on energy auditing with information collected from surveying a variety of Chinese institutions involved in energy audits. A key goal of the project is to conduct a gap analysis to identify how current practices in China related to energy auditing differ from energy auditing practices found around the world. This project report presented our findings on the study of China’s energy auditing practices at the national and provincial levels. It discussed key issues related to the energy audits conducted in China and offers policy recommendations that draw upon international best practices.

*Publications*

Shen, B., Price, L, and Lu, H., 2012. “Energy Audit Practices in China: National and Local Experiences and Issues,” *Energy Policy* Volume 46 (2012): 346‐358.

Price, L. and Lu, H., 2011. “Industrial Energy Auditing and Assessments: A Survey of Programs Around the World,” *Proceedings of the European Council for an Energy‐Efficient Economy’s 2011 Summer Study*. Stockholm: ECEEE.

## Project: Quantitative Analysis and Evaluation of China’s Energy Efficiency in the Industrial Sector

*Description:*

Evaluated the energy trends of China’s industrial sector in terms of energy efficiency, compared China’s energy efficiency levels in iron and steel sector to other countries, and conducted co-benefit analysis of China’s cement industry.

Publications:

Shen, B., H.Y. Lu, and L. Price. 2014. “U.S. Experience Addressing Energy and Environmental Challenges of Industrial Boiler Systems: Insights for China”, *Conference proceedings of 2014 CCEEE Fall Study on Industrial Energy Efficiency*, Beijing, China. October 24 – October 26, 2014.

Lu, H.Y., L. Price, A. Thekdi, S. Nimbalkar, M. DeGroot, and J. Shi. 2014. “Conducting Process Heating Energy Efficiency Assessments in Chinese Industrial Plants – Case Studies based on Assessments Conducted at Two Steel Plants,” *Proceedings of the 2014 European Council for An Energy-Efficient Economy’s Industrial Summer Study*. Arnhem, The Netherlands, June 2-5, 2014.

Hasanbeigi, A., Jiang, Z., Price, L., 2014. “Retrospective and Prospective Analysis of the Trends of Energy Use in Chinese Iron and Steel Industry,” *Journal of Cleaner Production*, Volume 74: 105‐188.

Hasanbeigi, A. Price, L., Zhang, C., Aden, N., Li, X., and Shangguan, F., 2014. “Comparison of Iron and Steel Production Energy Use and Energy Intensity in China and the U.S.,” *Journal of Cleaner Production*, Volume 65: 108‐199.

Hasanbeigi, A., A. Lobscheid, H. Y. Lu, L. Price, and Y. Dai. 2013. “Quantifying the Co-benefits of Energy-Efficiency Programs: A Case-study for the Cement Industry in Shandong Province, China,” *Science of the Total Environment*, Volumes 458–460: 624-636.

Hasanbeigi, A., Price, L., Fino‐Chen, C., Lu, H., Ke, J. 2013. “Retrospective and Prospective Decomposition Analysis of Chinese Manufacturing Energy Use and Policy Implications.” *Energy Policy*, Volume 63: 562–574.

Ke, J., Price, L., McNeil, M., Khanna, N., and Zhou, N. 2013. “Analysis and Practices of Energy Benchmarking for Industry from the Perspective of Systems Engineering,” *Energy* Volume 54 (2013) 32‐44.

Hasanbeigi, A., L. Price, H.Y. Lu, L. Wang. 2010. “Analysis of Energy-Efficiency Opportunities for the Cement Industry in Shandong Province, China: A Case-Study of Sixteen Cement Plants,” *Energy* Volume 35: 3461-3473.

# 11th Five Year Plan (2006-2010)

## Project: Assessment of China’s Energy-Saving and Emission-Reduction Accomplishments and Opportunities During the 11th Five Year Plan

*Description:*

The project provided an assessment of selected 11th Five-Year Plan policies and programs that China has instituted in its quest to fulfill the national goal of a 20% reduction in energy intensity by 2010. The report finds that China has made substantial progress toward its goal of achieving 20% energy intensity reduction from 2006 to 2010 and that many of the energy-efficiency programs implemented during the 11th FYP in support of China's 20% energy/GDP reduction goal appear to be on track to meet – or in some cases even exceed – their energy-saving targets.

*Publications:*

Price, L., Levine, M.D., Zhou, N., Fridley, D., Aden, N., Lu, H., McNeil, M., Zheng, N., and Qin, Y. 2011. “Assessment of China’s Energy-Saving and Emission-Reduction Accomplishments and Opportunities During the 11th Five Year Plan”*. Energy Policy* 39 (4): 2165 – 2178.

Zhou, N., McNeil, M., Fridley, D., Lin, J., Price, L., de la Rue du Can, S., Sathaye, J., Levine, M., 2007. *Energy Use in China: Sectoral Trends and Future Outlook*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL‐61904).

## Project: Evaluating Industrial Energy Policies during China’s 11th Five-Year Plan

*Description:*

This study analyzes China's industrial energy consumption trends from 1996 to 2010 with a focus on the impact of the Top-1000 Enterprises Energy-Saving Program and the Ten Key Energy-Saving Projects.

*Publications:*

Ke J., Price L., Ohshita S., Fridley D., Khanna N.Z., Zhou N. and M. Levine. 2012. “China’s Industrial Energy Consumption Trends and Impacts of the Top-1000 Enterprises Energy-Saving Program and the Ten Key Energy-Saving Projects.” *Energy Policy* 50: 562-569.

Price, L., Xuejun Wang, Jiang Yun, 2010. "The Challenge of Reducing Energy Consumption of the Top-1000 Largest Industrial Enterprises in China", *Energy Policy*, Volume 38 (11).

Price, L., Wang, X., Jiang, Y., 2008. *China’s Top‐1000 Energy‐Consuming Enterprise Program: Reducing Energy Consumption of the 1000 Largest Industrial Enterprises in China*. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL‐519E).

## Project: Evaluating the impact of energy efficiency and low carbon policies during the 11th Five Year Plan

*Description:*

The project conducted quantitative analysis to understand the trend in energy intensity in China during the 11th Five-Year Plan and to explore a variety of options toward meeting the 20 % target using a detailed end-use energy model. In addition, the project presented a prospective analysis of policy-specific energy savings and emissions reductions through 2030 for key existing policies and new policies likely to be implemented in the buildings, industry and transport sectors.

*Publications:*

N. Zhou, D. Fridley, M. McNeil, N. Khanna, W. Feng, and J. Ke. 2013. "Quantifying the potential impact of energy efficiency and low carbon policies for China." *European Council for an Energy-Efficient Economy’s 2013 Summer Study on Energy Efficiency.* LBNL-6161E

Lin, Jiang, Nan Zhou, Mark D Levine, and David Fridley. 2007. *Taking out One Billion Tons of CO2: The Magic of China’s 11th Five Year Plan?* Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-757E. [*https://eta-publications.lbl.gov/sites/default/files/lbl-757e-11th-fypjune-2007.pdf*](https://eta-publications.lbl.gov/sites/default/files/lbl-757e-11th-fypjune-2007.pdf)

Zhou, N., Levine, M.D., and Price, L., 2010. “Overview of Current Energy‐Efficiency Policies in China.” *Energy Policy*, Volume 38 (11).

Lin, Jiang, Nan Zhou, Mark D Levine, and David Fridley. 2006 *Achieving China’s Target for Energy Intensity Reduction in 2010: An exploration of recent trends and possible future scenarios*. Berkeley, CA: Lawrence Berkeley National Laboratory, 2006. LBNL-61800.

[*https://eta-publications.lbl.gov/sites/default/files/lbl-61800-2010-energy-reductiondec-2006.pdf*](https://eta-publications.lbl.gov/sites/default/files/lbl-61800-2010-energy-reductiondec-2006.pdf)

# 10th Five Year Plan (2001-2005)

## Project: China’s Sustainable Energy Future

*Description:*

In collaboration with the Beijing Energy Efficiency Center and other US national laboratories, this project developed models and provided analysis to assist in formulating recommended policies and support those policies throughout the discussions and debates that will produce the final 10th Five-Year Plan.

*Publications:*

Sinton, J. E., Stem, R.E., Aden, N.T., Levine, M.D., Dillavou, T.J., Fridley, D., Huang, J., Lewis, J.I., [Lin](https://china.lbl.gov/publications?page=15&f%5Bauthor%5D=8), J., McKane, A.T., Price, L.K., Wiser, R.H., Zhou, N., and [Ku](https://china.lbl.gov/publications?page=15&f%5Bauthor%5D=101), J.Y., 2005. *Evaluation of China's Energy Strategy Options.* Berkeley, CA: Lawrence Berkeley National Laboratory; National Renewable Energy Laboratory. <https://eta-publications.lbl.gov/sites/default/files/lbl-56609-china-energy-strategiesmay-2005.pdf>

Price, L., Sinton, J., Worrell, E., Phylipsen, D., Hu, X., and Li, J., 2002. “Energy Use and Carbon Dioxide Emissions from Steel Production in China,” *Energy*, The International Journal Volume 27(2002): 429‐446.

Lamont, A., Sinton, J.E., and Yuan, G., 2000. *End-Use Energy Modeling for China’s 10th Five-Year Plan.* Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, Beijing Energy Efficiency Center. <http://eta-publications.lbl.gov/sites/default/files/lbl-48044-energy-modeling-10fyp2000.pdf>

## Project: Designing and Development of Voluntary Agreements in China

*Description:*

The use of Voluntary Agreements as a policy for increasing energy-efficiency in industry, which has been a popular approach in many industrialized countries since the early 1990s, is being tested for use in China through a pilot project with two steel mills in Shandong Province. The pilot project was developed through international collaboration with experts in China, the Netherlands, and the U.S. Designing the pilot project involved development of approaches for energy-efficiency potential assessments for the steel mills, target-setting to establish the Voluntary Agreement energy-efficiency goals, preparing energy-efficiency plans for implementation of energy-saving technologies and measures, and monitoring and evaluating the project's energy savings.

*Publications:*

Price, L., Worrell, E., and Sinton, J., 2004. “Designing Energy Conservation Voluntary Agreements for the Industrial Sector in China: Experience from a Pilot Project with Two Steel Mills in Shandong Province,” in T*he Handbook of Environmental Voluntary Agreements*, E. Croci, ed., Kluwer Academic Publishers.

Price, L. Jiang, Y., Worrell, E., Du, W., Sinton, J.E, 2003. *Development of an Energy Conservation Voluntary Agreement Pilot Project in the Steel Sector in Shandong Province:* Report to the State Economic and Trade Commission, People’s Republic of China. Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL‐51608).

# 9th Five Year Plan (1996-2000)

## Project: Understanding the Energy-Saving Potential of China’s Industrial Sector

*Description:*

In China, about 80% of the energy used in the industrial sector is consumed by heavy industry. Of this, the largest energy-consuming industries are chemicals, ferrous metals, and building materials. This paper presented the results of international comparisons of production levels and energy use in six energy-intensive subsectors: iron and steel, aluminum, cement, petroleum refining, ammonia, and ethylene. The sectoral analysis results indicated that energy requirements to produce a unit of raw material in China are often higher than industrialized countries for most of the products analyzed in this paper, reflecting a significant potential to continue to improve energy efficiency in heavy industry.

*Publications:*

Price, L., Worrell, E., Martin, N., Lehman, B., and Sinton, J., 2000. “China’s Industrial Sector in an International Context,” *Proceedings of the Workshop on Learning from International Best Practice Energy Policies in the Industrial Sector*, May 22‐23, 2000, Beijing.

# 8th Five Year Plan (1991-1995)

## Project: A Review of China’s Energy Policy

*Description:* Evaluated China’s energy policies from the central planning period (1952-1979), and energy policies during the transitional period (1979-1994). The project also provided an outlook for China’s energy system.

*Publications:*

F. Yang, N. Duan, Z, Huan, M. Levine, N.C. Martin, J.E. Sinton, Q. Wang, D.Zhou, F. Zhou, and C. Zhu. 1994. *A review of China’s Energy Policy*. LBL-35336. Berkeley, CA. [https://digital.library.unt.edu/ark:/67531/metadc623906/m2/1/high\_res\_d/104450.pdf](https://digital.library.unt.edu/ark%3A/67531/metadc623906/m2/1/high_res_d/104450.pdf)

# 7th Five Year Plan (1986-1990)

## Project: Industry Sector Programs for Seventh Five Year Plan

*Description:*

Analyzed China’s four largest energy-consuming industries and associated energy-conservation programs during China’s 7th Five-Year Plan.

Publications:

Liu, Zhiping, Jonathan E Sinton, Fuqiang Yang, Mark D Levine, and Michael K Ting. *Industrial Sector Energy Conservation Programs in the People's Republic of China during the Seventh Five-Year Plan (1986-1990)*. Berkeley, CA, 1994. LBNL-36395. <http://eta-publications.lbl.gov/sites/default/files/lbnl-36395e.pdf>