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The political economy of electricity dispatch reform in China

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HIGHLIGHTS

- Savings from China's energy efficient dispatch (EED) policy are at best relatively small.
- EED exacerbates imbalances and center-provincial tensions in China's current power system.
- Incentive-based dispatch reform is likely to produce better outcomes than EED.
- Keys to reform are independent regulation and a formal, transparent ratemaking process.
- Transition to cleaner, cost-efficient electricity system in China is political-economic as well as technological.

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ABSTRACT

The transition to a cleaner and more cost-efficient electricity system in China is political-economic as well as technological. An example is the reform of China's method of dispatching power plants, which potentially affects the economic relationships between consumers and producers, between grid and generating companies, and between central and provincial governments. Historically, coal-fired power plants in China all received roughly the same number of operating hours, regardless of efficiency or cost. In 2007, Chinese government agencies began to pilot "energy efficient dispatch," which requires that generators be dispatched on the basis of thermal efficiency. Using a case study of Guangxi Zhuang Autonomous Region in southern China, we evaluated potential energy and cost savings from a change to energy efficient dispatch. We found that the savings are at best relatively small, because large, efficient generators already account for a significant share of total generation. Moreover, as an administrative policy that does not change economic incentives, energy efficient dispatch exacerbates imbalances and center-provincial tensions in the current system. We argue that incentive-based dispatch reform is likely to produce better outcomes, and that the keys to this reform are empowering an independent regulator with pricing authority and establishing a formal, transparent ratemaking process.

1. Introduction

China's electricity system, the world's second largest after the U.S.,[1] is the engine of its economy and the world's largest single source of CO_2 emissions (Kahrl et al., 2011). Chinese government agencies face the extraordinary challenge of meeting rapidly growing electricity demand reliably and inexpensively while reducing its environmental footprint (Williams and Kahrl, 2008). In practice, addressing this challenge means replacing or reducing the use of coal, China's most abundant and least expensive fuel, while keeping costs under control. This can be achieved by changing the physical infrastructure of generators and wires, or by changing how the system is operated. Such changes, in turn, depend on changing the rules and institutions governing power system operations and investment. China's electricity governance has been undergoing halting institutional reform for more than a decade (Xu, 2002; Zhang and Heller, 2004; International Energy Agency (IEA), 2006; Xu and Chen, 2006; Ma and He, 2008), and further reforms are being contemplated at high levels in China's leadership.

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[1] "Electricity system" here refers to installed generation capacity. Based on data from the U.S. Energy Information Administration and the China Electricity Council, it is likely that China eclipsed the U.S. in terms of gross electricity generation in 2011.

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Table 1
Historical synopsis of industrial structure, ownership, dispatch, and wholesale generation pricing in the Chinese power sector.[a]

	1980–1984	1985–2001	2002-present
Industrial structure	Vertical integration	Vertical integration	Unbundled generation and transmission & distribution (2002)
Ownership	Predominantly central government owned	Central and provincial government ownership, increasing private investment in generation	Central and provincial government ownership, declining share of private investment
Dispatch	Economic dispatch based on total embedded cost	Equal shares dispatch	Equal shares dispatch; pilot projects for energy efficient dispatch (2007)
Wholesale generation pricing	Internal transfer prices	Investment recovery based on financial lifetime (1985) Investment recovery based on operational lifetime (2001)	Benchmark price (2004) Fuel price-wholesale price co-movement (2004)

[a] For more detail on the institutional history and evolution of China's electricity sector, see Johnson (1992), Shao et al. (1997), Andrews Speed and Dow (2000), Zhang and Heller (2004), Xu and Chen (2006), International Energy Agency (IEA) (2006), Ma and He (2008), and Williams and Kahrl (2008).

The policy questions of concern are what reforms are required to achieve economic and environmental goals for the sector, and what their prospects are for being implemented successfully, given the large political and economic interests tied up in this industry. Here, we explore these questions in the case of a specific initiative to change the way the electricity system is operated, known as energy efficient dispatch.

In power systems, grid operators *dispatch* generators – that is, increase or decrease their output – as needed to meet electricity demand as it rises and falls over the course of a day. In most of the world, the principle guiding generator dispatch is the same, namely that generators are dispatched in order of increasing variable cost of operation (Steinberg and Smith, 1943). In general, variable costs are dominated by the cost of fuel, so that for a given fuel type (i.e., coal, natural gas, or oil) more fuel efficient generators will be dispatched before, and will operate for more hours than, less efficient ones. However, this "merit order" approach to dispatch has never been used in China.

Instead, operators in China have historically allocated operating hours equally among the coal-fired generators that constitute the bulk of China's generating capacity. This "equal shares" system is inherently inefficient, as it does not dispatch generators in economic merit order; it is also more polluting, since less fuel-efficient, higher-emissions generators are operated more than they would be otherwise. To reduce the energy inefficiency of the equal shares approach, government agencies recently began to pilot an alternative "energy efficient" dispatch system based on generator heat rates (fuel efficiency) and emission rates.

In this paper, we analyze the proposed energy efficient dispatch policy in the context of the political economy of China's power sector, via a case study of Guangxi Zhuang Autonomous Region. Drawing on a basic dispatch model and historical load and generator data, our analysis addresses four main questions:

(1) What is the potential magnitude of cost, energy, and emissions savings from changing from the existing dispatch system to energy efficient dispatch?
(2) What are the economic and political challenges associated with implementing energy efficient dispatch?
(3) Does energy efficient dispatch provide the incentive framework needed for a more energy and cost efficient electricity sector in China?
(4) If not, what changes are required to provide the necessary incentive framework, and what is the political economy of those changes?

The paper is organized as follows. Section 2 provides a historical overview of electricity dispatch in China, focusing on why the government adopted dispatch rules that are inefficient from a power system perspective. Section 3 describes the power sector in Guangxi, which provides the paper's empirical foundation. Section 4 uses monthly generation data to examine how the equal shares dispatch system has been implemented, and assesses the potential benefits and costs of implementing energy efficient dispatch in Guangxi. Section 5 examines energy efficient dispatch in the broader context of changes in incentives needed for least cost dispatch and efficient capacity investment in China. Section 6 offers concluding thoughts. Further methodological details of our analysis are found in the Supporting Material.

2. Historical overview of dispatch in the Chinese power system

This section provides a brief historical overview of how China's power dispatch institutions have evolved in industrial structure, ownership arrangements, and wholesale generation pricing since the advent of economic reforms in the late 1970s. This history, summarized in Table 1, is essential context for understanding the questions posed in this paper.

As China's economic reforms gathered steam in the early 1980s, surging electricity demand combined with limited state capital resulted in inadequate generating capacity and power shortages. To encourage investment in power generation, in 1985 central planners took two primary actions: (1) opening up investment to local governments, the domestic private sector, and foreign investors, and (2) restructuring wholesale generation rates to improve terms for investors. Wholesale generation rates were calculated based on a levelized cost of electricity (LCOE) formula with a fixed number of annual operating hours Eq. (1), with specific costs and technical parameters negotiated between government planners and individual power plants on a case-by-case basis. The amortization period (t) used in calculating the *LCOE* was based on the financial lifetime of the unit.

$$LCOE = \frac{CC \times r/(1-(1+r)^{-t}) + FOM}{AOH} + FC + VOM \quad (1)$$

- *LCOE* is the levelized cost of electricity
- *CC* is an overnight capital cost (yuan/kW)
- r is the average cost of capital
- t is the amortization period
- *FOM* is fixed operations and maintenance costs
- *AOH* is annual operating hours
- *FC* is fuel costs
- *VOM* is variable operations and maintenance costs

This approach to wholesale pricing required that generators produced enough electricity to achieve their negotiated rate