REGULATORY FRAMEWORK AND SUSTAINABLE DEVELOPMENT OF THE ELECTRICITY SECTOR: THE CASE OF CHINA

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Abstract

Both supply- and demand-oriented solutions are important in cleaning up the electricity sector. However, their successful deployment requires elimination of various barriers. This paper looks at China's electricity industry, one of the world's largest emitters of greenhouse gases, by relating the regulatory framework to sustainable development of the sector. Under the regulatory framework featured by competing and un-coordinated authorities and conflicts between central and local governments, regulatory policies/instruments have not been conducive to remove the barriers to effective deployment of supply- and demand-side solutions. Consequently, the potential gains of pollution-control measures adopted in China have not been fully realized.

Key Words: electricity sector, environmental issues, sustainable development, regulatory framework, China, Asia

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1. INTRODUCTION

Driven by industrialisation and urbanisation, large quantities of fossil fuels have been burned to meet people's energy needs, resulting in global warming and environmental degradation that are posing an unprecedented threat to all human beings. How to balance the need for energy against the environmental impact of producing and consuming enegy presents a big policy dilemma. As a rising economic power and currently the world's second largest economy, China's role in the international battle against climate change could not be overstated.

China has relied on dirty energy to fuel economic growth over the last 30 years, giving rise to environmental problems which have been felt across the country and abroad (Auffhammer and Carson, 2008). There is increasing concern about whether and how the economy can make a transition toward more sustainable development. Nowhere does such a transition pose a greater challenge than in the electricity sector, where coal is the dominant fuel in electricity generation, accounting for over 70% of the country's generation capacity and 80% of the electricity supply (ChinaFAQs, 2013). The sector is responsible for 40% of China's sulfur dioxide (SO_2) emissions and about half of energy-related carbon dioxide (CO_2) emissions (Williams and Kahrl, 2008). The key challenge is how to supply adequate and reliable power by a clean and environmentally benign electricity sector.

It is widely recognised that both supply- and demand-side solutions are important in achieving sustainable development of the electricity industry (IEA, 2006; 2007). Most of the solutions involve the adoption of off-the-shelf technologies. However, the promise of technology is insufficient to ensure their successful deployment, because of problems arising from potential conflicts between environmental and sectoral objectives (Collier, 1997). Additional complexity may arise in countries where the sector has undergone structural changes and regulatory reform, driven primarily by economic arguments (Vine, *et al*, 2003). As electricity production and consumption is one of the main contributory factors in many environmental problems, the environmental ramifications of a changing electricity sector are important for policy analysis (Collier, 1998). A vast body of literature has emerged, modelling the design of regulation in which environmental concerns are considered against a background of sectoral, economic policies (e.g. Baron, 1985; Fullerton, *et al*, 1997; Acutt and Elliott, 1999). Empirical literature on how environmental concerns are addressed in the energy sector is growing, but most on developed countries.[1] This paper attempts to fill in the gap in literature by looking at the case of China, a growing economic power and now likely the world's largest emitter of greenhouse gases.

China's electricity industry has undergone changes and reforms over the last three decades. Although literature on China's electricity reform is increasing, not many have related the resultant regulatory framework to environmental concerns in the sector.[2] This is another gap in literature the paper attempts to fill, by examining the problems and challenges arising from the regulatory framework to the sustainable development of China's electricity sector. To do so, an analytical framework is developed, drawn upon literature on the deployment of supply- and demand-side

solutions, regulatory governance, and environmental policy integration. It is then applied to the case of China's electricity sector.

The paper is structured as follows. The next section provides an overview of China's electricity industry, followed by literature review which leads to an analytical framework. The following sections relate the current regulatory framework of the sector to the deployment of supply- and demand-side solutions in China. The last section contains discussion and conclusions.

2. INSTITUTIONAL LANDSCAPE IN CHINA'S ELECTRICITY SECTOR

Throughout the pre-1979 period, the sector was state-owned, vertical integrated, and headed by the industry ministry. While such an industrial management system remained in place until 1997, changes were allowed at local levels from the mid 1980s. Spurred by supply shortages, a policy was issued and implemented in 1985, in which provincial governments were granted the authority to approve investment projects with the capacity at or below 50MW, and electricity generation was opened to private investors. Consequently, there has been a proliferation of locally based, small-scale power plants (Wirtshafter, 1990).

In 1997, the industry ministry was dissolved. The State Power Corporation (SPC) was established to take over the business operations of the sector while the ministry's policymaking and administrative functions were transferred to the State Economic and Trade Commission and later to the now called National Development and Reform Commission (NDRC). In 2002, the SPC was unbundled into five generating

companies and two grid companies.[3] The five national state-owned generating companies (the Big Five thereafter), which controlled just below 50% of China's total generation capacity in 2010 (SERC, 2011), have been expected to compete with one another and with other power producers. The two grid companies own over 90% of transmission and distribution assets, acting as regional monopolies. In March 2003, a new regulatory body - the State Electricity Regulatory Commission (SERC) - was created as a signal of China's commitment to establish independent regulation.

However, the sector does not yet have a recognisable independent regulator. Authorities for policy and regulation are shared by several agencies. The SERC is mandated with wide-ranging statutory powers but has lacked effective regulatory authorities because the NDRC, the *de facto* chief regulator of the sector, still takes the lead in two important policy areas – pricing and investment project approval. The Price Bureau of the NDRC and its local offices set electricity tariffs, and NDRC's Energy Bureau and its provincial presence issue investment permits. In 2008, the Energy Bureau was reformed into the National Energy Administration (NEA), which remains under the jurisdiction of the NDRC. [4] The SERC was folded into the NEA in 2011. Other government agencies in play include the Finance Ministry which sets the rule for cost and accounting standards, the State Administration of Taxation which collects taxes, and the State-owned Asset Supervision and Administration Commission (SASAC) which is responsible for managing state-owned assets and in charge of senior management appointment in state-owned electricity companies. When it comes to renewable energy and environmental issues, the Environmental Protection Ministry, the Ministry of Land Resources, and the Ministry of Water Resources are also involved in the regulatory process because of their responsibilities.

The regulatory framework has been further complicated by the traditional quasi-federalist structure of government administration in China. There has been a great degree of decentralisation in decision-making and enforcement, and the central government only has limited control over provincial governments (Blanchard and Shleifer, 2001). In protection of local interests and in promotion of local development, governments at sub-national levels may ignore or bypass regulations and rules issued by the central government, or not to enforce them fully or in prescribed ways (Xu, 2011). When it comes to the electricity sector, the role of local governments has been increasing since the delegation of decision-making in the mid 1980s. Provincial governments approve small-scale power projects, as well as serve as conduits for submitting applications for bigger projects which are subject to central government's approval (Wirtshafter, 1990). Provincial governments also involve in setting local electricity tariffs by influencing local Price Offices.

3. ANALYTICAL FRAMEWORK

This section develops an analytical framework to relate the regulatory framework to environmental issues in the electricity sector, based on which problems and challenges to China's transition towards an environmentally benign electricity system are examined. It is also hoped that the analytical framework will hold a degree of general applicability - useful for understanding the experience of other countries in tackling environmental issues in the sector. It draws upon the literature on the deployment of supply- and demand-side solutions and that on regulatory governance.

The two blocks of literature are then bridged by literature on environmental policy integration.

(a) Deployment of supply- and demand-side solutions

Guidelines on how to achieve a clean electricity sector have been posited in publications of energy organisations or associations,[5] based on decades-long discussion of different models adopted in the sector and the experience of various countries (mainly developed ones). Although there is no 'one size fits all' policy route to lower emissions, it is widely agreed that both the supply- and demand-side solutions are important (WEC, 2007; IEA, 2004).

On the supply side, improvement in environmental performance arises from three main sources. First, emissions from coal-fired generation can be reduced through closing down smaller, inefficient generating units and replacing them with bigger, more efficient ones; using cleaner coal; and retrofitting coal-fired units with pollutant-capture equipment (IEA, 1999). Second, environmental gains can be obtained through switching from coal to less polluting fuels and, preferably, to renewable sources. Third, pollution can be reduced by improving generation efficiency,[6] because a given energy output could be produced by using a smaller amount of fuels. Solutions on the demand side aim to contain electricity demand (IEA, 2003). Reduction in the growth of electricity demand comes from energy saving and energy efficiency by end users. A more generic name for demand-oriented policies is demand-side management (DSM), which can be defined as 'a structured means of promoting end-user energy efficiency (EE) and energy savings' (IEA, 2006, p107).

The potential benefits from supply- and demand-side solutions may not be fully realized because of various barriers. In the paper three types of barrier are identified: economic, institutional and structural.[7] [8] Economic barriers are related to high costs and/or insufficient revenues that prevent investment in the deployment of the solutions, and market distortions or market failures caused by externalities. On the one hand, replacing old, inefficient coal-fired units with new, efficient ones, fitting pollutant-capture equipment, and adopting less-polluting generation technologies (e.g. renewables) require substantial upfront investment and continuing injection of capital to cover operating costs, thus making related solutions less cost-competitive (Garcia, 2013). On the other hand, cleaner plants or/and technologies carry substantial positive externalities – less pollution. The cost disadvantages combined with environmental benefits of the supply-side solutions present a potential market failure, calling for policies to create conditions that level the playing ground for plants using different technologies. A level playing ground is needed both within the coal-fired sub-sector, and between coal-generated electricity and renewables. In addition to financial supports, appropriate investment planning methodologies and licensing rules, price regulation, and dispatch arrangements are all essential for overcoming economic barriers.

Investment planning methodologies and project approval rules will affect the type of plant to be built. To lend support to cleaner plants/technologies, it is important for environmental costs and benefits to be integrated appropriately into the planning process for investment in generation capacity, and for environmental standards to be considered as one of the main criteria used in project approval (IEA, 2006). On-grid

electricity tariffs need to be set to allow for the recovery of the up-front investment and to compensate for the environmental benefits of cleaner plants or/and technologies. Carbon taxes (also known as emission charges, pollution taxes or levies) can also be used as a cost adder or price adjustment, internalizing pollution damage that is not fully reflected in electricity prices (Green, 2008). Appropriate pricing (probably in combination with the use of price adjustment mechanisms) could be expected to incentivize power generation and dispatch from cleaner plants. This may be particularly important in an unbundled electricity industry where profit-driven companies in the generation sub-sector would otherwise make dispatch decisions based purely on the principle of cost efficiency: plants with low operating costs (but tend to be dirtier) will run more and those with high operating costs run less. To promote the development of renewables, price-based schemes are usually combined with quantity-based measures such as renewable portfolio standards, together with actions which ensure grid access and institute purchase obligations (Garcia, 2013; World Bank, 2008).

When it comes to generation efficiency, it is crucial there are provisions in on-grid tariffs which incentivize power producers to adopt efficient practices (Liston, 1993; Beesley and Littlechild, 1989).[9] Competition may also come in play in that it compels incumbents to use inputs more efficiently.

On the demand side, bringing end-user electricity prices closer to the cost level would give consumers economic incentive to save energy and improve EE.[10] However, EE technologies often require high up-front capital and additional costs, while savings accrue over time and carry positive externalities (World Bank, 2008). To overcome

the economic barrier associated with the public goods nature of EE technologies, the international practice is to direct EE/DSM incentives to households and firms through DSM programs which are usually provided by grid companies (ibid). In turn, economic incentive is needed for grid companies to invest in DSM programs. It could be done through appropriate price and revenue regulation which allows the recovery of the costs (Vine, *et al*, 2003).

Structural barriers are the obstacles related to the structural features of the industry. In the generation sub-sector of an unbundled electricity industry, lowering entry barriers and allowing independent power producers (IPPs) have at least two environmental gains. Firstly, it would put incumbents under competitive pressure and thus induce them to improve generation efficiency. Secondly, it may promote the development of renewables because, according to World Bank (2008), IPPs are the main developers of renewable energy projects. Thus, the dominance of incumbents in plant development and in generation can be seen as a structural barrier in that it may boost potential for abuse of dominant position (GWEC, 2005) and deter potential entrants. Another structural barrier in an unbundled electricity system is related to grid access. For the purpose of encouraging the development of renewables and IPPs, it is necessary to reduce/eliminate the discretion of grid companies over grid access, by putting them under the authority of the sector regulator (ibid). Subjecting grid companies to regulatory authority is also important for the deployment of demand-side solutions in that it is a prerequisite for imposing incentive-based regulation and mandatory requirements on the companies for investing in DSM programs.

Institutional barriers are the features of the institutional framework that hinder the deployment of the solutions. Their elimination is required in order to overcome the structural and in turn economic barriers (IEA, 2008). In general, transparency, consistency and predictability in rule-making and enforcement are among the principles of good governance (Jacobs, 2003; Zhang, 2010). When it comes to sustainable development in the electricity industry, it is important to have in place the institutional arrangements through which the policies/instruments needed to overcome the aforementioned economic and structural barriers could be made and enforced. In other words, there is a need to improve institutions in such a way that transparent and clear price structures that reflect full costs (including those associated with externalities) across the whole production chain could be set and enforced; investment projects be approved according to well-defined, fair procedures in which environmental concerns are incorporated; and incumbents (in particularly grid companies) be effectively regulated. Because tackling environmental issues in the electricity sector involves diverse policy arenas, coordination mechanisms are needed for joint policy-making and priority setting among various entities, agencies and government departments (IEA, 2007; 2008).

The policy prescriptions discussed above are normative at large. Practices and policies adopted in the real world will unsurprisingly deviate from the ‘best-practice’ model. To bring in some elements that help explain real-world practices as they occur, the analytical framework draws on literature on regulatory governance and environmental policy integration, which are detailed in the next two sub-sections, respectively.

(b) Regulatory framework: an institutional perspective

While the public interest theory of regulation and the Chicago School focus heavily on the demand side of regulation, the institutional perspective places emphasis on the institutional determinants of regulatory policy (Spiller and Tommasi, 2005). Seeing regulation as a design problem, Levy and Spiller (1994) distinguish between two components of a regulatory design – regulatory governance and regulatory incentives. The governance structure of a regulatory system involves 'the mechanisms that societies use to constrain regulatory discretion and to resolve conflicts that arise in relation to these constraints' (Levy and Spiller, 1994, p205). Regulatory incentives are the rules applied to the regulated. While incentives from regulatory policies and instruments may affect regulatory outcomes, the impact of regulatory incentives depends on the governance structure for regulation and the institutional determinants of regulatory governance (Spiller and Tommasi, 2005).

In general, a primary function of regulation in public utilities such as electricity is to address issues arising from the specific features of the industries – large sunk investment, economies of scale, and mass consumption of the products/services. It seeks to allocate costs across producers and consumers in a way that maintains investors' willingness to invest while attempting to minimize the cost of service provision (Bonbright, 1961; Littlechild, 1983). Regulation also seeks to achieve social objectives such as universal service which emphasizes access to the services at affordable prices, an issue more pronounced in developing countries (Kirkpatrick and Parker, 2004). Regulatory outcomes – how well the sectoral economic and social objectives are served - depend, to a great extent, on the incentives from regulatory

policies/instruments, which are in turn determined by the governance structure and process of rule making and enforcement and their link to the underpinning institutional environment. In regulated network industries such as electricity, various actors relate to one another within the broad institutional framework, with the dominant ones as governments (national and sub-national governments, and/or government departments), regulatory agencies, regulated firms (incumbents and entrants), and other interest groups (Maegli and Jaag, 2009). Regulatory regimes differ in the degree to which regulatory agencies are related upwardly to the governments, horizontally to other agencies, and downwardly to regulated firms and interest groups (Maegli, et al, 2012). It is also worthwhile looking at how close regulatees are situated in the structure (Hood *et al*, 1999). In analysis of the institutional determinants of regulation, attention should be put not only to the formal attributes of the actors and their relations, but also to their attitudes and behavior as well as the informal distribution of power among them (Thelen and Steinmo, 1992). In other words, regulation can be analyzed as the outcome of complex exchanges among the actors (Spiller and Tommasi, 2005).

The theories on regulation and regulatory governance in public utilities are concerned mainly with the regulatory design through which the sectoral economic (and social) objectives are addressed. However, there is another market failure in the electricity sector - environmental externalities, which calls for regulatory intervention. Although environmental issues are traditionally dealt with by environmental policy, there is a recognition that the environmental sector alone cannot secure environmental objectives and that non-environmental policy areas need to consider environmental effects (Lafferty and Hovden, 2003).

(c) Sustainable development and environmental policy integration

The idea of non-environmental sectors taking on board environmental policy objectives is a central element of the environmental dimension of sustainable development (Persson, 2004). The integration of environmental concerns into other policy areas has been referred to as environmental policy integration (EPI). There is no agreement on the definition of EPI and how much weight environmental objectives should receive. A ‘strong’ definition is given by Lafferty and Hovden (2003), which stresses the importance of incorporating environmental objectives into all stages of policymaking in non-environmental policy sectors, with a view that principle priority should be given to environmental policies. A less ‘stronger’ view can be found in Collier (1997), which emphasizes removal of contradictions between policies and a balanced approach towards environmental, enegy-centred, and economic objectives. Further down the spectrum is ‘weak’ EPI, which argues for simply taking environmental concerns into consideration in policy formulation and enforcement in other sectors (Jordan and Lenschow, 2008)

Given the normative nature of the conceptions, there is a need to derive from EPI literature the elements which help understand and explain various practices observed in different countries. To this end, it is useful to see EPI as not just a state of affairs which is the aim of policymaking, but also the process necessary for achieving change (Lafferty and Hovden, 2003). There are two factors which are important for understanding the process and outcomes of policy integration: functional overlap between environmental and other goals – whether they are synergistic or conflictive;

and political commitment to environmental objectives (Dupont and Oberthür, 2012; Lafferty and Knudsen, 2007). Together they will determine the position of environmental considerations in relation to sectoral and other objectives in the process of policy integration. Seeing EPI as a process is to take an institutional perspective and place emphasis on the institutional and policy context of EPI (Pollack, 2009). Treating EPI as a process means turning analysis to the governing structure and process that take place inside political systems in which different actors interact and employ different combinations of policy instruments (Schout and Jordan, 2005).

(d) Towards an analytical framework for empirical analysis

This subsection lays out an analytical framework by bringing together the three blocks of literature discussed above. Both supply- and demand-side solutions are important for achieving environmental goals in the electricity sector. Successful deployment of the solutions requires removal of economic barriers, which in turn calls for elimination of structural and institutional barriers. However useful, the guidelines prescribed by international energy organizations on how to overcome the barriers are normative, describing essentially the desirable attributes of policies and institutions. In order to add positive elements to the analytical framework, the institutional perspective of regulatory governance is brought in. By linking regulatory outcomes with the institutional determinants of regulatory policy, this perspective brings the regulatory framework into the discussion and highlights its role in determining regulatory incentives.

At this stage, the explanatory framework isn't yet complete, in that the discourse on regulation and regulatory governance in public utilities is centered traditionally on the regulatory design for achieving economic (and some social) objectives of the sectors. Literature on EPI is then drawn upon to bridge the regulatory framework with the environmental dimension of sustainable electricity development. When examining the outcomes of integrating environmental with sectoral policies, it is useful to analyze the functional overlap among various objectives and the political commitment to environmental considerations. The electricity sector is associated with multiple objectives, including economic (e.g. bringing in investment to ensure adequate and reliable supply of electricity; safeguarding consumers from monopolistic pricing; etc), social (accessibility and affordability) and environmental ones. In addition, the industry may carry development goals due to its key role in promoting economic growth in developing countries like China (Kirkpatrick and Parker, 2004). Given the mass consumption nature of electricity and the obligation of universal service, governments (and/or politicians) may intervene in the sector in such a way as to win political support (Spiller and Tommasi, 2005). It should be noted that what is referred to as governments in the analysis includes not only the central but also sub-national ones, if the latter play an important role in the game, like the case in China. Therefore, misalignment in interest and priority between governments at different levels needs to be incorporated into analysis. As what has been said, the extent to which different objectives are functionally synergistic or conflictive, together with governments' commitment to environmental considerations, will decide the priority order of the objectives in policy making and enforcement, and may affect the power distribution among various actors and the ways in which the actors relate to and interact with one another. In turn, this can impact on what regulatory policies and instruments are

adopted and how they are enforced in the sector. Deployment of supply- and demand-side solutions will be facilitated if the regulatory incentives from the policies/ instruments are conducive to eliminating related structural and economic barriers.

The rest of the paper applies the analytical framework to the case of China's electricity sector, by analysing data collected from various sources. Second-hand data were collected from three sources: 1) websites and publications of regulatory agencies, government departments and China Electric Power Information Centre; 2) reports on Chinese media such as newspapers and magazines; and 3) publications of international organisations and academic literature on China's electricity industry. They were supplemented by data collected from individual interviews with officials at regulatory agencies and government departments and researchers who had conducted extensive research in related areas (see the Appendix for more details on the informants and the nature of the interviews). It was intended that data triangulation would provide cross-validity and help rule out potential bias in individual data sources or/and informants. Based on information cross-checked across data sources, the rest of the paper relates the regulatory framework to the deployment of supply- and demand-side solutions in China's electricity sector.

4. REGULATORY FRAMEWORK OF CHINA'S ELECTRICITY SECTOR AND BARRIERS TO SUPPLY- AND DEMAND-SIDE SOLUTIONS

This section examines whether the current regulatory framework facilitates the elimination of the barriers to the deployment of supply- and demand-side solutions.

As the reduction of economic barriers may require removal of institutional and structural ones, the section looks firstly at institutional, then structural, and finally economic barriers.

(a) Regulatory framework in electricity and institutional barriers

The electricity industry has been considered strategically important for the national economy and therefore tightly controlled by the Chinese government. Before 1997, the sector was a vertically integrated state-owned monopoly headed by the industrial minister. Different from most other industries and ministries, this sector has been a political base for China's bureaucracies (Chen, 2010). Many Party and government leaders had their root in the industry.[11] This connection had ensured the sector's position in centrally made policies; conversely, it also made it easier for the government to maintain control over the industry (Yeh and Lewis, 2004). After the industry ministry was dissolved in 1997, authority for making sectoral policies remained in the hand of state commissions. The situation has not been fundamentally changed even after the establishment of the 'independent' regulator - the SERC, as the NDRC has maintained control over what really matters in the sector – pricing and investment approval. As the key bureaucratic arm of the Communist Party, the NDRC is responsible for formulating and implementing strategies of national economic development and putting forward polices of macroeconomic management (NDRC, 2013). As commented by one of the interviewees, electricity policies made by the NDRC have been very important part of the strategies and plans of economic development. Ensuring adequate supply of electricity has been the primary guideline for policymaking (author's interviews). Policies regarding end-user prices made by

the Price Bureau need to serve the NDRC's function of overseeing general price stability and managing inflation (ibid.). It should be noted that such electricity policies may ultimately be intended to maintain political legitimacy, as inadequate energy supply and social stability are now seen as serious threats to the economic interests of the country and therefore the survival of the Party state (Andrews-Speed, 2010).

The establishment of the SERC can be seen as one of the reform moves following the standard practice in other countries (Victor and Heller, 2007). Created as an autonomous regulatory body, the SERC has the nominal mandate to oversee competition in the generation sub-sector, prevent market domination, and mediate and adjudicate disputes between power plants and the grids in relation to grid connection and access (Yu, 2005). However, its status as the sector regulator has not been supported by law and, having no real say in investment approval and electricity tariffs, it lacks necessary regulatory power to unfold its mandates (Qiu and Li, 2012). Despite being called an 'independent' regulator, its independence is questionable due to its industrial and political ties. When abolished in 1997, the industry ministry transferred its staff to the SPC (which were later unbundled into the Big Five and the two grid companies), NDRC's Energy Bureau, and late the SERC (Cheng and Tsai, 2009). There has been continuing personnel interflow among the companies and regulatory agencies (ibid.).[12] In addition, its effectiveness as a sector regulator has been challenged by its resource and capacity constraints (Andrews-Speed, 2010). Local branches of the SERC are particularly weak, given their dependence on local labour markets for staffing and sometimes local governments for information (Tsai, 2011).

When it comes to environment issues, the State Environmental Protection Ministry (SEPM) appears to be important. It is responsible for environmental governance in the country and takes part in the formulation of plans associated with trans-boundary environmental problems (Chang and Wang, 2010). According to Article 26 of the Environmental Protection Law effective from 1989, environmental protection facilities must be concurrently designed, constructed and operated with power plant projects; and the SEPM has the authority of not endorsing any projects which fail to respect the requirement and suspending the ones in the course of construction if non-compliance is found (Zhang, 2007). However, as reported in Cheng and Tsai (2009) and commented by one of the interviewees, the NDRC can approve power projects that do not meet the environmental standards, for the purpose of alleviating power shortages.

The governing agencies for the electricity sector have been competing for rule ownership and policy formulation (Lema and Ruby, 2007; Lin and Purra, 2010). The NDRC has seemed dominant in the game. Nevertheless, there lacks coordination among different policy areas. According to the Supervision and Administration of the Power Industry Directives enacted in 2005, it is the SERC that is mandated to cooperate with the SEPM to supervise the implementation of environmental regulations and standards in the sector. However, with no authority over investment approval and tariff setting, the SERC has no means to materialize the coordination (author's interviews). The situation has not been improved despite attempts to increase communication through the establishment of such entities as the National Energy Commission and the NEA (Andrews-Speed, 2010; Downs, 2008).

In addition to fragmentation and lack of coordination among the central agencies, the regulatory framework in the electricity sector has been shaped by the conflicts between central and local governments. Decentralization of decision making to the provincial level in the mid 1980s has unwittingly increased local control over the electricity system. Divergence in interests and incentives between central and local governments and difficulty in reconciling long-term national goals with short-term local priorities have led to the emergence of parallel policy agendas, creating problems in enforcement (Williams and Kahrl, 2008).

The most striking jurisdictional conflict between the central and local governments lies in ratemaking and investment planning, two of the most important regulatory areas into which environmental concerns can be integrated (author's interviews; Kahrl, *et al*, 2011). Small-scale power projects are now approved by provincial governments. Applications for bigger projects are submitted to NDRC's Energy Bureau through its local branches. Final local tariffs for both power generation and consumption are decided by local Price Offices, subject to NDRC's scrutiny. However powerful, the NDRC at the central level is understaffed (Cheng and Tsai, 2009). Limited capacity, together with information asymmetry, makes it difficult for the state commission to carefully review and investigate all proposed projects and prices submitted by its local units (Sun, *et al*, 2012). In fact, central agencies often have very modest authority over their local branches even though the latter are formally part of the former's vertical chain of command (Ma and Ortolano, 2000; Andrews-Speed, 2004). Local offices of the NDRC and SEPM need to report to and are paid by local governments, which also have full discretion over appointing senior managers of local state-owned power companies (Cheng and Tsai, 2009). Collusion is

pervasive among local governments, local state-owned power companies and local branches of central agencies, which advances local interests but impedes the implementation of national policies (Andrews-Speed, 2010). As they have historically been evaluated according to economic growth, local governments tend to de-prioritize compliance with environmental targets and related policy initiatives set by the central government.

In summary, there has been fragmentation and lack of coordination among conflicting and competing regulatory agencies. As the key bureaucratic arm of the Communist Party, the NDRC seems the most powerful, with its priorities overriding those of the other agencies in policymaking. As a result, electricity regulation and administration is still highly politicalized. Such a regulatory framework lends no assistance to transparency, consistency and predictability in rule making and enforcement. A general observation across the agencies is their small staff size, limited capacity and weak control over their local branches, all impeding regulatory effectiveness. Divergence in interests and incentives between central and local governments has given rise to further enforcement and compliance problems at local levels where environmental concerns have given way to short-term local interests.

(b) Regulatory framework in electricity and structural barriers

Unbundling created two grid companies and the Big Five, alongside local-based power producers. The national companies have close political connections through the membership of their key executives in the Central Committee of the Chinese Communist Party and because of the sector’s importance as the political base for

government's top leadership (Chen, 2010). They also have close ties with the NDRC's Energy Bureau and the SERC through the 'old-boy networks' of ex-industry-ministry staff and continuing personnel interflow between them and the agencies. Therefore, they have become too powerful to be subject fully to the regulatory authority of the agencies. Their stronghold is particularly obvious against the SERC, given the latter' precarious institutional standing in the midst of fragmented bureaucratic politics and the fact that its Chairman has an administrative rank no higher than those of the companies' top managers (Sun, *et al*, 2012).

The Big Five are expected to compete with one another and other power producers. To promote competition in generation, the government has put a 20% limit on the share of any single firm in any single region. However, the Big Five have seemed to less abide by it. For instance, China Power Investment Corporation (one of the Big Five) is allowed to get away with owning more than 20% share in both the northeastern and northwestern markets (ibid.). The reason, to much extent, lies in the slacks in the regulatory framework –fragmented authority and conflicting agendas among governing bodies. The SASAC, which is mandated to supervise state assets in state-owned companies, has actively promoted the expansion of the Big Five in all segments of the generation sub-sector (Luo, *et al*, 2012). In face of rising coal prices, for instance, the Big Five have integrated upwards to own or/and open their own coal mines, with the encouragement and endorsement from the SASAC and the NDRC (Zhang and Chen, 2011). They have also gained the franchise of the development of all Chinese major rivers, leaving no room for private participation in big scale hydro power stations (Sun, *et al*, 2012). Three of the five companies have been the leading players in other renewables (ibid.). Despite its mandated responsibility over

competition in the generation sub-sector, the SERC has been unable to stop the expansion of the companies (Zhang and Chen, 2011; author's interviews). As a result, the Big Five's dominance has even slightly increased, with their share in installed capacity rising from around 40% in 2002 at the time of unbundling to 49% in 2010 (SERC, 2011).

Unchecked entrenchment of state-owned companies has squeezed out IPPs in all segments of electricity generation (Sun, *et al*, 2012; Garcia, 2013). Their upward integration and continued dominance have served as entry barriers to private investors, even though legal barriers to entry have long been removed since the mid 1980s. Constrained by access to finance, private investors tend to be developers of small power projects (Pittman and Zhang, 2010). Approval of projects involving small-scale generation capacity falls in the authority of provincial governments. However, private investors may be disadvantaged if lacking local connections (Sun, *et al*, 2012). Various restrictions are imposed on private-invested projects, in addition to technical and environmental standards; while approval of local state-owned projects is usually subject to less scrutiny (ibid.). The consequence has been a proliferation of small-scale, less efficient (more polluting) power plants at local levels, accompanied by a general withdrawal of private investment.

Owning over 90% of transmission and distribution assets, the two grid companies act as regional monopolies and monopsonies. When grid companies are the sole buyer for generating firms, the sector regulator should play a crucial role in ensuring that power producers have equal and fair access to the transmission wires. However, given the SERC's weak authority, the grid companies in China have got great discretion over

grid access. In their decisions, they have favoured their affiliated generating plants and other state-owned generators against IPPs (Zhang and Heller, 2004). They've also biased towards coal-fired plants against renewables because they suffer losses from purchasing renewable power which they can not pass onto consumers (this will be discussed in more details later on). Their stronghold against the SERC also implies difficulty in imposing regulation and mandatory requirements on the companies for investing in DSM programs.

In short, industry concentration in electricity generation is still high and the dominance of the Big Five has continued, due to the conflicts among governing agencies and the weak authority of the SERC. Facing various entry barriers, there has been limited private investment in the generation subsector in general and in renewables in particular. Too powerful to be regulated by the SERC, the grid companies stand as a big obstacle for the development of renewables and IPPs, and for the deployment of DSM.

(c) Regulatory framework in electricity and economic barriers

As discussed earlier, removal of economic barriers is crucial for the successful deployment of supply- and demand-side solutions. On the supply side, the key is to create the market conditions that level the playing ground for plants using different technologies and compensate for the cost disadvantages and positive externalities of cleaner plants or/and technologies. Pricing, investment planning, and dispatch arrangements can exert great influence on investment decisions, technology choices, the efficiency of resource utilization, and plant dispatch. Pricing is also important for demand-side solutions because of its role in incentivizing end users to save energy

and participate in DSM programmes, and grid companies to invest in DSM programs. In China, there are two sets of electricity prices, namely the on-grid tariffs - the wholesale prices paid by grid companies to generators, and the catalogue prices - the prices paid by end-users to grid companies, both of which are set by the NDRC and its local offices.

As the economic planning body, the NDRC sets on-grid tariffs in such a way that capacity expansion could keep up with China's fast economic growth (Kahrl, *et al*, 2011). A model of 'cost repayment plus return' has been adopted to provide adequate incentive for capacity expansion, in which both prices and volume quotas are predefined in power purchase contracts to allow the recovery of investment costs and reasonable profits (Gao and Li, 2010; Kahrl, *et al*, 2013). Under the quota-based dispatch system, annual operating hours are allocated to individual power producers according to their capacity size.[13] In price setting, NDRC's Price Bureau issues a guidance price for each region and then allows its local Price Offices to make adjustments and decide on the price at which an individual power producer can sell electricity (Ma, 2011). Due to collusion between local governments and local Price Offices, local tariffs tend to be much higher than regional guidance prices, and tariffs received by well-connected power producers - mostly local state-owned – are usually more favorable than those for IPPs (Sun, *et al*, 2012).

Prices for renewables vary according to technologies and the nature of projects. A bidding-based concession scheme was introduced in 2002 for large national renewable projects. Tariffs for such projects are the winning prices. Tariffs for other projects are set on the basis of 'cost-repayment plus return'. Recently, feed-in tariffs

(FIT) have been introduced to incentivize the installation of renewable capacity through a premium added on top of the average wholesale prices for coal-fired power plants.[14] Like price-setting for coal-fired electricity, the NDRC issues guidance FITs and final tariffs are decided through negotiations of various stakeholders.[15] The prices set under the FIT scheme and those negotiated locally are usually higher than the tariffs resulted from concessions (Ma, 2011). Nonetheless, it is commented that the price difference between coal-generated power and renewables is insufficient in compensating for the positive externalities of the latter (e.g. Liao, *et al*, 2010; Garcia, 2013).

Efforts have been made to introduce emission charges, but encountered difficulties, due to the conflicts among government agencies. At least five agencies are involved, namely the SERC, NDRC, SEPM, the Ministry of Finance, and the State Tax Administration. Conflicts and competition among them have been revolved around the levels of the charges, how to track emissions and who pays for the cost of installing pollution tracking system, who collects the taxes, and how the collected levies are used (Zhang and Xi, 2010; author's interviews). At local levels, the implementation of pollution charges has faced resistance because of the divergence in priorities between central and local governments (Williams and Kahrl, 2008). Problems with using the price adjustment mechanism have hindered a level playing field being created for different generating technologies. Under the current dispatch system, they have discouraged power generation and dispatch from cleaner plants or/and technologies in that they have failed to improve the cost-competitiveness of 'greener' generating units against dirtier ones.

Setting end-user prices is in the authority of the NDRC, whose Price Bureau issues guidance prices and local Price Offices decide final rates. In general, prices are set to achieve political and social objectives (Kahrl, *et al*, 2011) and discriminated according to the types of user, namely industrial, commercial, residential and agricultural.[16] In desire for promoting economic growth, electricity prices for industries have been set lower than both residential and commercial consumers, providing little incentive for industrial users to improve energy efficiency and adopt EE technologies. For the purpose of maintaining social stability and containing inflation, electricity prices for households have been kept at below-cost levels and differentiated according to affordability. Such prices may be conducive to meeting the obligation of universal service, but less able to induce rational electricity consumption and the adoption of energy-saving appliances.

There is no separate price for the use of the grid network, partly because of the traditional thinking of Chinese Socialist ideology that pricing based on economic principles is irrelevant or inappropriate for firms like grid companies whose assets are funded by state investment (author's interviews). The revenues of grid companies therefore depend on the discrepancy between on-grid and end-user prices. This has given rise to adverse effects on both supply- and demand-side solutions. Due to difficulty in approving increases in end-user prices, the price premiums for renewables have squeezed grid companies' revenues, making them resistant to any increase in FITs that would bring renewables to market competitiveness. The companies have been unwilling to connect renewable power plants and buy their electricity, even though they are obliged to do so under the power purchase agreements (Garcia, 2013; author's interviews). Grid companies also face little

incentive to invest in DSM programs because the costs cannot be recovered through their revenues.

In summary, electricity pricing and the dispatch arrangement in China's electricity sector have been driven by a need for rapid capacity expansion, with little consideration of environmental concerns. Investment planning has been guided by the overriding principle of ensuring adequate electricity at the central level, and leaned toward the promotion of local interests at the provincial level. Grid companies face no economic incentive to purchase renewable energy as well as invest in DSM programs. The way end-user rates are set gives little, if any, incentive for saving electricity and improving EE. These economic barriers and difficulty in removing them are associated with the problems of the current regulatory framework and the resultant institutional and structural barriers.

5. SUPPLY- AND DEMAND-SIDE MEASURES ADOPTED IN CHINA

In view of the above-discussed difficulties in eliminating the barriers, this section evaluates the major supply- and demand-side measures adopted in China.

(a) Supply-side measures

Given coal's dominance in electricity generation, pollution from coal-fired power plants has been one of the biggest concerns in China's transition towards sustainable development. Various measures have been adopted to control pollution in the sub-sector. Effort has been made to replace small, inefficient generating units with new,

bigger ones, through the so-called ‘big up and small down’ strategy. Given presently limited feasibility in switching to low sulfur coal in the country (Eliasson and Lee, 2003), the main approach for reducing SO_2 emissions from thermal power plants has been retrofitting generating units with flue gas desulfurisation (FGD) equipment. Commitment has also been made to reduce coal’s dominance by switching to alternative energy, in particular renewables.

The ‘big up and small down’ scheme was introduced in 2007, in which the central government required that all new generating units be at least 600MW and that small, old generating units be phased out. To back the policy with economic incentives, the NDRC introduced an initiative which lowered the feed-in tariffs for small units. The results were immediate, with 553 units totaling 14.4 GW capacity being shut down in 2007, 43% above the official target for that year (SERC, 2007). An interesting but unsurprising observation is that most of the closed units were owned by the Big Five and almost all the orders for new supercritical units were also made by them (ibid.). With access to finance which is usually unavailable to non-national firms, the Big Five are able to afford the high upfront investment in setting up new, large-scale units with more advanced power cycles. In fact, they have strong incentive to replace small, inefficient units with bigger ones under the cost-plus pricing regime and the current dispatch arrangement in which the allocation of operating hours is based on the size of installed capacity. It should be noted that, once the increased number of operating hours and the relatively higher prices are secured in the power purchase agreements, the generator may run advanced, clean, efficient plants less often than its less efficient ones, given the difficulties in implementing pollution charges (Gao and Li, 2010; author’s interviews).

Enforcement of the scheme has seemed poorer at local levels, where small, old, inefficient coal-fired units concentrate. The aforementioned incentives are less relevant to locally based generators because their main concern is about the up-front investment. Even the incentivizing effects of lowering tariffs for small units would be much diluted because of local governments' influence over and collusion with local Price Offices in setting final on-grid prices for individual generators. Given the fact that many local state-owned power plants are constructed with local government finance either through the banking system or/and indirectly through fiscal allocations, closing of small units would generate a significant strain on provincial banks, as well as leave thousands of people unemployed (Williams and Kahrl, 2008).

Installing pollution abatement equipment has been used in China as the main approach to reduce SO_2 emissions from thermal power plants. In 2003, the SEPM mandated the installation of FGD equipment for all new, expanded or retrofitted coal-fired units, and started pollution levies on SO_2 emissions (Rosen and Houser, 2007). Due to the conflicts and lack of cooperation among the NDRC, SERC and SEPM, the mandate and the emission levies were not well enforced (author's own interviews). In 2005, the NDRC introduced a feed-in tariff adder for generators with FGD-equipped units. Progress has followed. It is reported that FGD-equipped units accounted for more than three-quarter of all thermal-based capacity in China by the end of 2010 (IEA, 2012). Again, local power plants have been much less compliant than the Big Five (SERC, 2007). The reason lies in the former's difficulty in meeting the high initial capital requirement and the fact that the involvement of local governments in tariff setting loosens the incentive from the tariff adder. It should be noted that the

tariff adder is granted to companies with FGD equipped units rather than electricity generated from such units. It has been widely reported that many such units do not use the equipment in power generation because of high operating costs (Liu, 2006; Li and Fu, 2008). The tariff adder may have encouraged installation; but there is insufficient incentive for switching on the equipment because power producers face low or nonexistent penalties for not running the scrubbers, given the difficulty in enforcing the emission charges.

China has committed to develop renewable energy as the major strategy for reducing coal's dominance in power generation. Renewable electricity standard (RES) has been implemented whereby all generators with 5GW or more capacity are mandated to have at least 8% of their capacity from non-hydro renewables by 2020 (NDRC, 2007). Under power purchase agreements (PPAs), grid companies are obliged to grant grid access to every renewable unit at the connect point closest to the generator, and purchase all renewable electricity generated.

National renewable projects are granted through the bidding-based concession scheme. In order to meet the requirement of the RES and enjoy financial supports for capacity installation which are usually attached to such projects, national state-owned generators bid aggressively and undercut their rivals by low bid prices, resulting in tariffs (the winning prices) too low to make the projects economically viable (Sun, *et al*, 2012; Garcia, 2013). Renewable projects granted through the concession scheme account only for a small part of installed capacity.[17] All the other projects have been approved through the normal process, most of them at the provincial level, where specific criteria for licensing are set locally (Sun, 2006). With the involvement of

local governments, tariffs set for local-based projects are generally higher, which have been further raised under the FIT scheme. However, they are still considered insufficient in compensating for the environmental benefits of renewables (Garcia, 2013).

Following the price- and quantity-based schemes, a rapid growth in installed renewable capacity has been observed. However, it has not been matched by a correspondent growth in actual power generation and dispatch from renewable sources. It is estimated that around 30% of the installed capacity has been dormant, and the other 70% operate far below their nameplate capacity (Williams and Kahrl, 2008; Garcia, 2013). The RES, the tendering system, and the FIT scheme have all focused on investment-based incentives. Incentives for generating electricity from installed capacity have been weak, due to the problems with introducing and implementing emission charges and insufficient price premiums for internalising externalities. Grid companies' refusal to respect their connection and purchase obligations specified in the PPAs stands as another big obstacle for renewable energy developers. It's reported that a significant portion of installed capacity has not been connected to the grid (Garcia, 2013). The lack of economic incentives, accompanied by the weak authority of the SERC, has led to poor enforcement of the PPAs, leaving a lot of installed capacity lying idle.

Improvement in generation efficiency can reduce pollution, especially for coal-fired plants. The 'big up and small down' scheme has attempted to improve thermal efficiency by replacing inefficient units with more efficient ones. However, under the current pricing and dispatch arrangements, power generation and dispatch from

efficient plants is not guaranteed because power producers tend to make dispatch decisions according to cost- rather than technical-efficiency of their generating units. Market competition can compel generators to improve efficiency. However, various entry barriers for private investors and continued dominance of the Big five mean that incumbents face little competitive pressure. The 'cost-plus-return' model for pricing has no provision for tariff reduction over time, providing no incentive for efficiency enhancement. The involvement of local governments in setting local tariffs serves as a further shield for local power producers from pressure to improve efficiency.

Demand-side measures

In China, demand-side solutions have received less attention, although rising system costs on the supply side and continued growth of electricity demand have increased the cost-effectiveness of EE and DSM. Enjoying prices long subsidised by residential and commercial users, industries have been China's largest electricity consumer, with energy-intensive heavy industries being the main driving force for rising electricity consumption per unit GDP over recent years (Williams and Kahrl, 2008). In an attempt to control electricity consumption from industries, a recent move from the central government is to use price discrimination against selected energy-hungry heavy industries (Yu, 2012). However, intervention by local governments in setting local end-user rates has made enforcement difficult in provinces where discriminated industries are their economic lifeline (author's interviews). Ignoring the call from the central government, some of the provinces have continued to issue preferential tariffs to enterprises in black-listed industries, in order to promote local industrial development (Rosen and Houser, 2007; Yu, 2012).

Residential electricity prices have been kept at lower-than-cost levels in order to maintain social stability and contain inflation. Given the complex political economy and the contestation and resistance encountered at local levels,[18] raising residential prices has been a sensitive issue in China. Over the last two decades, the country has witnessed a rapid growth of electricity consumption by households and commercial users. This has flattened system load factors and increased peak demand (Hu, *et al*, 2005),[19] which has to be met by keeping reserve coal-fired generating units running because China lacks natural gas peak plants (William and Kahrl, 2008). Consequent environmental cost is likely to be high.

DSM has so far been deployed in China mainly as a load management tool to deal with power shortages. Even so, its electricity saving and peak-load reducing effects have been evident (Hu, *et al*, 2005).[20] In general, low end-user prices have effectively undervalued the systematic use of EE/DSM as a solution to reduce energy consumption. Furthermore, grid companies face no economic incentive to invest in DSM programs because the investment cannot be recovered through their revenues. By all accounts, EE/DSM lacks economic and institutional footholds in China.

6. DISCUSSION AND CONCLUSIONS

Discussion above indicates that, despite observable progress, the potential gains of the supply- and demand-side measures adopted in China have not been fully realized, due to the presence of various barriers and difficulty in removing them under the current regulatory framework. Explanation to this can be made based on the analytical

framework, which emphasizes the institutional determinants of regulation and the factors which determine the position of environmental considerations in relation to other objectives in policymaking and enforcement.

China's electricity sector is associated with various objectives. There are sectoral objectives, namely economic objectives – aiming mainly to maintain and expand provisions of services; and social objectives –universality of service. Increasingly important are the goals of environmental protection. The sector also carries diverse development goals, among which increasing electricity production to meet the requirement of current and future economic growth is still the dominant one (Yeh and Lewis, 2004). The government has intervened in the sector for political objectives – preserving political legitimacy and the rule of the party-state - by pursuing the development goals and maintaining social stability (Garcia, 2011; Lin and Purra, 2010). Another dimension of political objectives relates to the party-state's intention to maintain control over the economy through keeping a firm hand on strategically important industries such as electricity. In regard to the development and political objectives, it is necessary to bring into the discussion the complex relations between the central and local governments. While the central government puts emphasis on the role of the sector in overall economic planning and lessening regional and rural-urban inequality, local governments are more interested in developing local industry, maintaining employment, and promoting other local interests (Martinot and Li, 2007). Given the history of the sector as a political base for Party and government leaders and the strong political ties of national power companies, the goals of the companies also come in play. These powerful state-owned or controlled companies thrive to expand as so to maintain and enhance their dominance or monopoly.

There is complex functional overlap among the various objectives. Above all, the objective of maintaining political legitimacy is ultimate. It overlaps in a highly synergistic way with sectoral economic objectives and the development goals, in that economic policy of the sector serves development goals and development is deemed as necessary for political legitimacy. Stressing accessibility and affordability, the obligation of universal service is functionally in line with the government's social-related development goals, ultimately serving the political objective of maintaining social stability. As public ownership has traditionally been used as a means of maintaining economic control, the preservation of the party-state's control over the sector and in turn the economy hinges upon the expansion of state-owned or controlled power companies. Dominance of public ownership in the sector is also conducive to achieving other development/political objectives, in that it is easier for the government to promote the development of particular industries by issuing preferential electricity prices and to maintain social stability and harmony by keeping residential electricity prices low, if power companies are state owned. Objectives of the central and local governments are partly synergistic and partly conflictive. On the one hand, the pursuit of central government's development goals depends, to a great extent, on the development of individual provinces. Evaluating local government officials according to economic growth may have strengthened the functional synergy between the development goals pursued by governments at different levels. On the other hand, local-oriented and protectionist policies adopted by individual provinces may have negative externalities on other provinces and on the economy as a whole. This is one of the areas where national and local goals are functionally conflictive. The central government tends to be more tolerant towards local policies that conflict

with the center's goals when having adequate electricity or/and promoting economic growth becomes most pressing.

There is substantial conflictive overlap between the goal of tackling pollution and the sector's economic policy, given the country's abundance of coal and irreplaceability of coal-fired plants in serving peak loads in current China. In turn, there lacks functional synergy between environmental objectives and the development goal of supplying adequate and reliable electricity for economic growth. Despite increasing attention received from the central government, environmental issues have not been considered ultimately vital for political legitimacy and stability, and therefore received political commitment far less than the goal of ensuring electricity supply. Commitment from local governments may be even lower, given the dominant criterion used for evaluating local officials' performance and high conflictive overlap between environmental objectives and local governments' priorities.

Thus, environmental considerations have become subordinate to the economic and development goals in policymaking and enforcement. The importance order of the various policies and the nature of functional overlap among them explain the allocation of policy responsibilities among governing bodies and their position in the power structure. Given the importance of sectoral economic policy/regulation to the development and political goals, the NDRC - the key bureaucratic arm of the Chinese Communist Party – has had an overarching control over pricing and investment approval. It has also been dominant in the competition among governing agencies and has overriding power over the SEPM on issues in which economic concerns conflict with environmental considerations. It's no surprise that the SERC was folded into the

NEA in 2011 and thereby made subordinate to the NDRC. When it comes to the relation between the central and local governments, delegation of decision-making has seemed to prevail because of cyclic power shortages.

As a result, the regulatory framework of the sector has two features. The first is the dominance of the NDRC among competing and uncoordinated governing bodies. The second is substantial autonomy of local governments in making and enforcing policies, which gives rise to conflicts between short-term local priorities and long-term national goals. Under such a regulatory framework, electricity regulation and administration has been politicalized; and regulatory policies/instruments have been designed and implemented primarily to expand generation capacity on the supply side, and facilitate industrial development and maintain social stability on the demand side. Measures which cater to preserve public ownership have been favored, for the purpose of control and for the ease in advancing the goals of governments, central or/and local. Such policies/instruments give rise to structural and economic barriers to the deployment of supply- and demand-side solutions, or/and make their removal difficult. This explains why the potential gains of the supply- and demand-side measures adopted in China have not been fully realized.

It should be noted that development goals are diverse and emphasis has shifted over time, from an overarching focus on growth targets in the 1990s to, in the current century, the pursuit of a broad concept of development in which social and environmental parameters are included (Garcia, 2011). This gives a glimpse of hope: environmental considerations are moving upward on the central government's agenda; increasing political commitment may follow. In fact, public anger about dirty

air and water has been rising in recent years, and pollution has become one of the top reasons for social unrest in China (Shen, 2013). Environmental problems have therefore become an increasing, although not the most serious, threat to the political legitimacy. This can be expected to increase synergetic overlap between environmental objectives and development/political goals, and in turn change the position of environmental considerations in relation to other concerns in the policy process. Given local governments' importance in making local polices and enforcing national ones, it may prove crucial to integrate explicit environmental targets in the evaluation of local officials, in order to align local priorities with the center's environmental objectives.

References

Acutt, M. & Elliott, C. (1999). Regulatory Conflict? Environmental and Economic Regulation of Electricity Generation. *European Environment, 9*(4), 135-141.

Andrews-Speed, P. (2004). *Energy Policy and Regulation in the People's Republic of China*, London: Kluwer Law.

Andrews-Speed, P. (2010). The Institutions of Energy Governance in China. *Centre for Energy, Petroleum and Mineral Law and Policy*, 1-49.

Andrews-Speed, P. (2012). *The governance of Energy in China: Transition to a Low-Carbon Economy*. Palgrave MacMillan,

Auffhammer, M. & Carson, R.T. (2008). Forecasting the Path of China's CO2 Emissions Using Province-level Information. *Journal of Environmental Economics and Management*, *55*(3), 229-247.

Baron, D. P. (1985). Non-cooperative Regulation of A Nonlocalized Externality. *RAND Journal of Economics*, *16*, 553-568.

Beesley, M. E. & Littlechild, S.C. (1989). The Regulation of Privatised Monopolies in the United Kingdom. *Rand Journal of Economics*, *20*, 54-72.

Blanchard, O. & Shleifer, A. (2001). Federalism with and without Political Centralization: China versus Russia. *IMF Staff Papers*, *48*, 171–79.

Bonbright, J.C. (1961). *Principles of Public Utility Rates*. New York: Columbia University Press.

Chang, Y. & Wang, N. (2010). Environmental Regulations and Emissions trading in China. *Energy Policy*, *38*, 3356-3364.

Chen, L.(2010). Playing the Market Reform Card: the Changing Patterns of Political Struggle in China's Electric Power Sector. *The China Journal*, 64, 69-95.

Cheng, T. & Tsai, C. (2009). Powering Rent Seeking in the Electricity Industry. in R.Ngo & Y. Wu (Ed.), *Rent Seeking in China*. London: Routledge.

China FAQs (2013).The network for Climate and Energy Information: Coal for Electricity. http://www.chinafaqs.org/issue/coal-electricity (accessed on April 23rd, 2013).

Collier, U. (1997). *Energy and Environment in the European Union: the Challenge of Integration*. Aldershot: Avebury.

Collier, U. (1998). Liberalisation in the Energy Sector: Environmental Threat or Opportunity? *Deregulation in the European Union: Environmental Perspectives*, *1*, 93-113.

Dupont, C. & Oberthür, S. (2012). Insufficient Climate Policy Integration in EU Energy Policy: the Importance of the Long-term Perspective. *Journal of Contemporary European Research*, *8*(2), 228-247.

Downs, E.S. (2008). China's "New" Energy Administration'. *China Business Review*, November–December.

Eliasson, B. & Lee, Y. Y. (2003). *Integrated Assessment of Sustainable Energy Systems in China: The China Energy Technology Program: a Framework for Decision Support in the Electric Sector of Shandong Province* . Dordrecht: Kluwer Academic Publishers.

Fullerton, D., McDermott, S. P. & Caulkins, J. P. (1997). Sulfur Dioxide Compliance of A Regulated Utility. *Journal of Environmental Economics and Management*, *34*(1), 32-53.

Gao, C. & Li, Y. (2010) Evolution of China's Power Dispatch Principle and the New Energy Saving Power Dispatch Policy. *Energy Policy, 38*, 7346-7357.

Garcia, C. (2011). Grid-connected Renewable Energy in China: Policies and Institutions under Gradualism, Developmentalism, and Socialism. *Energy Policy*, *39*, 8046-8050.

Garcia, C. (2013) Policies and Institutions for Grid - Connected Renewable Energy: 'Best Practice' and The Case of China. *Governance, 26*(1), 119-146.

Green, R. (2008) Carbon Tax and Carbon Permits: The Impact on Generators' Risks. *The Energy Journal, 29*(3), 67–90.

Global World Energy Council (GWEC) (2005). Wind Force 12: A Blueprint to Achieve 12% of the World's Electricity from Wind Power by 2020. *Report*, GWEC and Greenpeace.

Hemphill, R. C., Cave, M. E. & Schoech, P. E. (2003). Incentive Regulation in Network Industries: Experience and Prospects in the U.S. Telecommunications, Electricity, and Natural Gas Industries. *Review of Network Economics, 2*, 316-337.

Hood, C., Scott, C., James, O., Jones, G. & Travers, T. (1999). *Regulation Inside Government: Waste-Watchers, Quality Police, and Sleaze-Busters*. Oxford: Oxford University Press.

Hu, Z.G., Moskovitz, D. & Zhao, J.P. (2005). *Demand-Side Management in China's Restructured Power Industry: How Regulation and Policy Can Deliver Demand-Side Management Benefits to a Growing Economy and a Changing Power System*, Washington, DC: World Bank.

International Energy Agency (IEA) (1999). Retrofit of Power Stations for Green House Gas Abatement: Case Studies. *IEA Greenhouse Gas Programme*, report no. Ph3/18, October 1999.

International Energy Agency (IEA) (2003). *The Power to Choose – Demand Response in Liberalised Electricity Markets*. Paris :IEA/OECD.

International Energy Agency (IEA) (2004). *World Energy Outlook*. Paris: IEA/OECD.

International Energy Agency (IEA) (2006). *China's Power Sector Reforms: Where to Next?* Paris :IEA/OECD.

International Energy Agency (IEA) (2007). *World Energy Outlook*. Paris: IEA/OECD.

International Energy Agency (IEA) (2008). *Deploying Renewables: Principles for Effective Policies*. Paris :IEA/OECD.

International Energy Agency (IEA) (2012). Non-greenhouse Gas Emission from Coal-fired Power Plants in China. *Profile,* No. 12/4. IEA Clean Coal Centre.

Jacobs, S. (2003). Assisting Economic Transition: An RIA Strategy for Developing Countries. paper presented at the Conference on Regulatory Impact Assessment: Strengthening Regulation Policy and Practice, Centre on Regulation and Competition, University of Manchester, UK.

Jordan, A. & Lenschow, A. (2008). Environmental Policy Integration: An Innovation in Environmental Policy? in A. Jordan & A. Lenschow (ed.), *Innovation in*

Environmental Policy? Integrating the Environment for Sustainability, 313-341, Cheltenham: Edward Elgar Publishing Ltd.

Kahrl, F., Williams, J., Ding, J. & Hu, J. (2011). Challenges to China's Transition to A Low Carbon Electricity System. *Energy Policy, 39***,** 4032-4041.

Kahrl, F., Williams, & Hu, J. (2013). The Political Economy of Electricity Dispatch Reform in China. *Energy Journal*, *53*, 361-369.

Kirkpatrick, C. H. & Parker, D. (2004). Infrastructure Regulation: Models for Developing Asia. *ADB Institute Discussion Papers 6*, Asian Development Bank Institute.

Knudsen, J.K. (2010). Integration of Environmental Concerns in A Trans-Atlantic Perspective: the Case of Renewable Electricity. *Review of Policy Research*, *27*(2), 127-146.

Lafferty, W. & Hovden, E. (2003). Environmental Policy Integration: towards An Analytical Framework. *Environmental politics*, *12*(3), 1-22.

Lafferty, W. M. & Knudsen, J. (2007). The Issue of Balance and Trade-offs in Environmental Policy Integration: How Will We Know EPI When We See It?. *EPIGOV Paper no. 11*, Institute for International and European Environmental Policy.

Lema, A., & Ruby, K. (2007). Between Fragmented Authoritarianism and Policy Coordination: Creating a Chinese Market for Wind Energ. *Energy Policy,* 35(7), 3879-3890.

Levy, B. & Spiller, P. (1994). The Institutional Foundation of Regulatory Commitment: A Comparative Analysis of Telecommunications Regulation. *Journal of Law, Economics and Organization, 10*(2), 201-246.

Li, J. & Fu, J. (2008). Thermal Plants Encouraged to Increase Desulfurization Efforts. *China Daily,* January 19th, 2008 (in Chinese).

Liao, C., Jochem, E., Zhang, Y. & Farid, N.R. (2010). Wind Power Development and Policies in China. *Renewable Energy*, *35*, 1879-1886.

Lin, K-C & Purra, M.M. (2010). Transforming China's Industrial Sectors: Institutional Change and Regulation of the Power Sector in the Reform Era. Working Paper no. SPP10-12, Lee Kuan Yew School of Public Policy, National University of Singapore

Liston, C. (1993). Price-cap versus Rate-of-return Regulation. *Journal of Regulatory Economics*, *5*, 25-48.

Littlechild, S. (1983). *Regulation of British Telecommunications' profitability: report to the Secretary of State,* London: Department of Industry.

Liu, S.X. (2006). The Electric Tiger Drags Its Feet: SEPA Gives Six Electricity Producers A Timetable. *China Youth Daily,* August 8th, 2006 (in Chinese).

Liu, W., Lin, G., and Zhang, X. (2002). Cost-Competitive Incentives for Wind Energy Development in China: Institutional Dynamics and Policy Changes. *Energy Policy, 30,* 753–765.

Luo, G., Zhi, F. & Zhang, X. (2012). Inconsistencies between China's Wind Power Development and Grid Planning: An Institutional Perspective. *Renewable Energy*, *48*(1), 52-56.

Ma, J. (2011). On-grid Electricity Tariffs in China: Development, Reform, and Prospects. *Energy Journal, 39*, 2633-2645.

Ma, X. & Ortolano, L. (2000). *Environmental Regulation in China: Institutions, Enforcement and Compliance.* Lanham: Rowman & Littlefield.

Maegli, M. & Jaag, C. (2009). Regulatory Governance Costs in Network Industries: Implications for Postal Regulation. *MPRA Working Paper*, No. 15309.

Maegli, M., Jaag, C. & Finger, M. (2010). Regulatory Governance Costs in Network Industries: Observations in Postal Regulation. *Competition and Regulation in Network Industries, 11*(2), 207-237.

Martinot, E. & Li, J. (2007). Powering China's Development: the Role of Renewable Energy. Special Report, WorldWatch.

National Development and Reform Commission (NDRC) (2007). *Medium- and Long-Term Plan for Renewable Energy Development.* China: NDRC.

National Development and Reform Commission (NDRC) (2013). Main Functions of the NDRC. http://en.ndrc.gov.cn/mfndrc/default.htm (accessed on July 19th, 2013)

Nilsson, M. & Persson, Å. (2003). Framework for Analysing Environmental Policy Integration. *Journal of Environmental Policy and Planning, 5*(4), 333-359.

Persson, A. (2004). Environmental Policy Integration: An Introduction. *Policy Integration for Sustainability Background Paper,* Stockholm Environment Institute.

Peterson, T. D. & Rose, A.Z. (2006). Reducing Conflicts between Climate Policy and Energy Policy in the US: the Important Role of the States. *Energy Policy*, *34*(5), 619-631.

Pittman, R., & Zhang, V. Y. (2010). Electricity Restructuring In China: How Competitive Will Generation Markets Be? *The Singapore Economic Review*, *55*(02), 377-400.

Pollack, M. A. (2009). The New Institutionalisms and European Integration. in A. Wiener and T. Diez (ed.), *European Integration Theory* (pp125-143). Oxford: Oxford University Press.

Qiu, X. & Li, H. (2012). Energy Regulation and Legislation in China. Working Paper, Environmental Law Institute, Washington DC.

Rosen, D.H. & Houser, T. (2007). *China Energy: A Guide for the Perplexed*, Peterson Institute for International Economics, Washington, DC.

Schout, A, & Jordan, A. (2005). Coordinated European governance: Self Organizing or Centrally Steered? *Public Administration*, *83*(1), 201–220.

Shen, F. (2013). China Air Pollution Triple WHO Recommended Levels in First Half. *Bloomberg News*, July 31th, 2013.

Spiller, P. T. & Tommasi, M. (2005). The Institutions of Regulation: An Application to Public Utilities. in *Handbook of New Institutional Economics* (pp515-543), Springer US.

State Electricity Regulatory Council (SERC) (2007). Report on the Electricity Sector Efficiency and Emissions Reductions. http://www.serc.gov.cn/jgyj/ztbg/200804/t20080415 8883.htm (accessed in April 2010)

State Electricity Regulatory Council (SERC) (2011). *Electricity Regulatory Annual Report 2010* (State Electricity Regulatory Commission PR China, Beijing)

Sun, X. (2006). Policy Takes the Wind out of Investors' Sails. *China Daily*, December 27th, 2006.

Sun, X., Guo, L. & Zeng, Z. (2012). Market Entry Barriers for FDI and Private Investors: Lessons from China's Electricity Market. in Y. Wu, X. Shi & F. Kimura (ed.) *Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies* (pp83-102). Jakarta: ERIA.

Thelen, K.D. & Steinmo, S. (1992). Historical Institutionalism in Comparative Politics. in K.D. Thelen, S. Steinmo, & F. Longstreth (ed.), *Structuring Politics: Historical Institutionalism in Comparative Analysis*, Cambridge: Cambridge University Press.

Tsai, C. (2011). The Reform Paradox and Regulatory Dilemma in China's Electricity Industry. *Asian Survey*, *51*(3), 520-539.

Victor, D. & Heller, T. (2007). Introduction and Overview. in D. Victor & T. Heller (ed.), *The Political Economy of Power Sector Reform: The Experiences of Five Major Developing Countries*, Cambridge: Cambridge University Press.

Vine, E., Hamrin, J., Eyer, N., Crossley, D., Maloney, M. & Watt, G. (2003. Public Policy Analysis of Energy Efficiency and Load Management in Changing Electricity Business. *Energy Policy ,31,* 405-430

World Energy Council (WEC) (2007). *Energy & Climate Change*. London: WEC.

Williams, J. H. & Kahrl, F. (2008). Electricity Reform and Sustainable Development in China" *Environmental Research Letters, 3*(4), http://www.iop.org/EJ/article/1748-9326/3/4/044009/erl8_4_044009.html

Wirtshafter R. M. (1990). Decentralization of China's Electricity Sector: Is small beautiful? *World Development*, *18*(4), 505–512.

World Bank (2008). *Financing Energy Efficiency: Lessons from Brazil, China, India, and Beyond* , World Bank, Washington, DC

Xu, C. (2011). The Fundamental Institutions of China's Reforms and Development. *Journal of Economic Literature*, *49*(4), 1076-1151.

Yeh, E.T. & Lewis, J.I. (2004). State Power and the Logic of Reform in China's Electricity Sector. *Pacific Affairs*, *77*(3), 437-466.

Yu, Q. (2005). Strengthening the State Electricity Regulatory Commission. *China Law & Practice,* April 2005,

http://www.chinalawandpractice.com/Article/1692525/Issue/8508/Strengthening-the-State-Electricity-Regulatory-Commission.html (accessed in July 2013).

Yu, Y. (2012). How to Fit Demand Side Management (DSM) into Current Chinese Electricity System Reform? *Energy Economics*, *34*, 549-557.

Zhang, C. & Heller, T.C. (2004). Reform of the Chinese Electric Power Market: Economics and Institutions. *Stanford Program on Energy and Sustainable Development Working Paper*, no. 4.

Zhang, V. Y. & Chen, Y. (2011).Vertical Relationship in China's Electricity Industry: the Quest for Competition? *Utilities Policy, 19*, 142-151

Zhang, Z.X. (2007). China's Reds Embrace Green. *Far Eastern Economic Review*, *170*, 33-37.

Zhang, Z. & Xi, S. (2010). Environmental Tax Delayed. *Economic Observer On-Line*, http://www.eeo.com.cn/ens/Politics/2010/03/29/166354.shtml (accessed in April 2012).

Zhang, Y-F. (2010). Towards Better Regulatory Governance? Regulatory Reform in Selected Developing Countries, 2003-2007. *Public Management Review, 12*(6), 873-891

Endnotes

[1] e.g. Collier (1998); Peterson and Rose (2006); Knudsen (2010).

[2]Williams and Kahrl (2008), Kahrl, *et al*, (2011), and Lema and Ruby (2007) are among the few studies which relate electricity reform to environmental issues. Andrews-Speed (2010, 2012) examines the governance and sustainable development of the energy sector as a whole.

[3] The five generating firms are China Huaneng Corporation, China Datang Corporation, China Guodian Corporation, China Huadian Corporation, and China Power Investment Corporation. The two grid companies are the State Grid Corporation and the South China State Grid Corporation.

[4] The Energy Bureau is referred to throughout the paper when discussing project approval, for the sake of consistency.

[5] Such organisations include the World Energy Council, International Energy Agency, Global World Energy Council, World Bank, etc.

[6] The technical definition of energy efficiency on the supply side is thermal efficiency. The term of generation efficiency is used in the paper to cover thermal plants as well non-thermal ones.

[7] It should be noted that technology has an important role to play in cleaning up the electricity sector. However, technological barriers are not addressed separately in the paper because it is less relevant to the main theme of the paper. In addition, where necessary, certain aspects of technological obstacles are integrated into the discussion of the three barriers.

[8] It should be noted that the categorization of the three barriers are conceptual. In the real world, the difference between them is not always clear-cut and policies to overcome them are often intertwined.

[9] For a review of the theory and practice of incentive regulation, see Hemphill, *et al* (2003).

[10] In practice, it may prove sensitive and difficult to raise end-user prices, in particular to residential users, because of the issue of accessible and universal service. Such social objectives will be discussed later in the paper.

[11] Such leaders include LI Peng - former Premier, and JIANG Zemin – former General Secretary of the Communist Party of China and President of the People's Republic of China, to mention just a few.

[12] For instance, the first Chairman of the SERC, Mr. Chai Songyue, was a long-time supporter of Li Peng, the former Premier whose family controls the power sector both before and after the unbundling of the industry (Yeh and Lewis, 2004).

[13] Pilot projects for 'energy efficient dispatch' have been implemented in selected provinces in 2007. Nation-wide implementation was planned but has not started (Kahrl, *et al*, 2013)

[14] The price premiums vary according to energy technologies, geographic locations and availability of renewable resources.

[15] The pricing arrangement results in different prices for different projects. An extreme case is Xinjiang Dabancheng No. 1 and No. 2 wind farms. The tariffs of the two neighbouring wind farms are different because one of them is subordinate to the Department of Water Conservancy of Xinjiang and the other to the Xinjiang Electricity Utility (Liu, *et al*, 2012).

[16] Since the 1990s, price adjustments such as interruptible and time-of-use pricing have been introduced in many provinces. However, none are cost-based (Kahrl, *et al*, 2011).

[17] For instance, installed wind capacity through competitive tendering constituted only 13% of all newly installed capacity in 2008 (Garcia, 2013).

[18] There have been many reports about cases in which proposals of raising local residential prices were blocked at public hearings (William and Kahrl, 2008).

[19] For instance, due to the increasing use of air conditioning, system load factors, which are traditionally high in China because of the large industrial share in electricity consumption, have begun falling (Hu, *et al*, 2005).

[20] Hu, *et al* (2005) estimate that a reduction of peak load by 15 GW was achieved through DSM measures in 2003 and 2004. Beijing was one of the provinces/municipalities showing promising results, where DSM measures helped maintain a constant load factor from 1997 to 2003 (ibid.).