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Solar photovoltaic projects in China: High investment risks and the need for institutional response

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HIGHLIGHTS

- China-specific risk factors for photovoltaic project development are identified.
- High cash flow risk and lack of legal recourse inhibit private sector investment.
- Opaque public tenders and rent-seeking lead to low field performance.
- High-level reform attempts fail to gain traction due to vested interests.

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ABSTRACT

The Chinese government identifies the renewable energy sector as a core strategic industry. Since 2009, China is the country with the highest annual investment into renewable energy, predominantly wind and solar photovoltaic projects. Due to rapid cost decline, industrial transformation, and policy support, the relative share of solar project investment is growing at a disproportionate rate. However, there is no systematic analysis of how efficiently these investments are allocated; or the underlying risk and return characteristics. Based on structured interviews with 69 market participants, this paper identifies severe cash-flow uncertainty, unreliable supply chains and a weak regulatory environment as most prominent risk factors that currently inhibit sustainable and demand-driven market development. Expanding on the interview results, this study discusses the origins of risk in China and how the institutional response to investment risk currently fails to address the core problems.

1. Introduction

Energy consumption and a society's economic development are closely related [1]. Since the beginning of China's rise from an agricultural society to a global center of manufacturing, abundant and reliable energy supply is and will remain a main driver for economic growth [2]. At the same time, the social development that results from economic growth feeds back into the energy sector through increased household consumption.

This paper focuses on a subsector of the energy supply: The electricity sector. In 2014, China's annual total electricity generation grew by 3.8% to 5523 TWh [3]. To match projected consumption, growth will remain around 4% annually until 2020 [4] before flattening towards 2.3–3.1% annually until 2035 [5]. To give a perspective: The growth of approximately 200 TWh is slightly below Turkey's total net electricity generation of 228 TWh [6]. This means that every year, China is adding the equivalent of Turkey's entire electricity production to itself.

The installed – but not necessarily connected – capacity grew by 102 GW to 1360 GW [3]. The 102 GW of newly added capacity in China approximately equals Spain's total installed generation capacity as of 2012, which is 105 GW [6]. This means that every year, China adds an entire Spain's worth of power plants to itself.

To create a new electricity infrastructure at the scale of a major European economy every year is a challenging endeavor in itself. Chinese policy makers habitually manage this complexity by focusing the expansion process on a very narrow set of target variables: Cost, speed, and fuel supply. This focus ensured that economic growth was not hampered by a lack of electricity supply in the recent past. But it also entails several negative consequences, of which two are most relevant to this work:

- An electricity sector dominated by inefficient thermal power plant designs that burn low-grade coal, emitting large amounts of ashes, particulates, and greenhouse gasses.

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- Limited opportunities for the deployment of new technologies due to cost pressure; and a lack of competitive market forces that could induce industrial modernization.

Growing environmental and competitive concerns incited the government to revise its approach. Additionally, other countries spearheaded deployment of renewable energy technologies, which led to rapid cost decline of renewable electricity generation. This opened up wind and solar project development as feasible alternative for Chinese planning bodies. Eventually, China promoted its renewable energy sector to a core strategic industry in 2010 [7]. This entails favorable public support and access to funding.

Table 1.1 shows the results of this strategic shift. Wind energy already has an established capacity base, in part catalyzed by the European Union's clean development mechanism. Solar energy project development in China is still in its primary growth phase. The year 2012 marks the first year of China's strong scale-up of solar energy capacity.

Environmental constraints, the cost decline of solar technologies, and the need to create demand for China's struggling photovoltaic equipment manufacturing industry are now increasingly reflected in its overall electricity sector strategy. The result is that Chinese government agencies have to adapt to a more complex environment, with a higher number of target variables to consider, as compared to a scenario where coal use would continue to dominate.

Photovoltaic projects are exposed to a wide array of risk factors over their life-span [9]. Risk factors originate at different stages of a project's implementation, from planning to engineering to operation. Factors vary in their significance along local conditions such as climate, technology [10,11], regulatory policies [12], energy market design [13,14], legal recourse, logistics and skilled labor [15]. Stakeholders have to identify and specify risk factors that are relevant for a specific project at a specific location [16,17] according to the stakeholders' business model [18]. Investors need to develop risk frameworks that allow for an accurate estimation of a risk-adjusted required rate of return for their investment [19–22]. Insurance firms need tools to evaluate the likelihood of risk events causing liability cases [23]. Project developers and engineering firms have to analyze project risk for their resource management, bidding and design considerations.

A number of studies discuss risk characteristics across the Chinese photovoltaic manufacturing value chain [24–31]. These studies contribute to the scientific body of knowledge by providing an overall analysis of the sector's growth barriers. They do not discuss or identify individual risk factors on the project level for the Chinese market.

On the project level, existing studies identify risk factors for distributed, small-scale photovoltaic applications [18,32–35]. Distributed generation is a special case of photovoltaic project development, officially accounting for 17% of installed capacity as of 2014. This deployment form differs in several relevant characteristics from the large-scale photovoltaic projects discussed in this paper. They represent 83% of installed capacity in 2014 [36]. The relevant differences for this work are financial models, geographic project location, intended life-span, grid connection and mounting technology. These characteristics significantly change the underlying risk factors that project participants in into their decision making. From the perspective of investment risk as borne by institutional investors [37], large-scale photovoltaic projects remain the primary form of risk exposure in China [30].

China-specific project-level risk factors for large-scale photovoltaic projects are not sufficiently discussed and systematized in the current body of knowledge. Given the size, speed and growth perspective [31,38] of photovoltaic project development in China, an analysis of risk factors and their implications is a timely and important issue. The timeliness is emphasized by current regional developments. Neighboring countries such as India [39] and Pakistan [40] increasingly mirror the Chinese photovoltaic scale-up strategy, implying similar risk characteristics. Only with a detailed risk analysis of the status quo in China can these countries develop appropriate risk management systems to avoid some of the shortfalls of the existing approach, which are identified in this paper.

This study aims to answer the question: To which degree is the increasing complexity of electricity sector development reflected by institutional modernization and adequate regulation, and how does this translate into risk factor perception among private-sector market participants. How well are regulators, standardization institutions, and local governments developing the new skill-sets, policies, and processes needed to effectively manage fast solar scale-up and provide a functioning market environment?

2. Evidence of high investment risk in Chinese photovoltaic project development

In this paper, investment risk is the likelihood that a Photovoltaic project will fail to generate revenues sufficient for an economically sustainable operation, contrary to prior estimates by the investors. Investment risk is the sum of a project's underlying risk factors.

In China, investment risk originates from several country-specific factors that together result in a risk level that is exceptionally high in comparison to other countries that also have ambitious renewable energy expansion policies.

Three factors provide evidence of high investment risk:

(1) Sources of financing

One indicator of high country-specific risk is the origin of project funding. China became the country with the highest total renewable energy investment in 2009 [41]. The country maintained this position through the end of 2014, as Fig. 2.1 shows.

The total investment given in Fig. 2.1 is composed of four sources of funding: (1) Asset finance encompasses both private and public sector lending and direct equity investments in large-scale projects. (2) Small distributed capacity (SDC) refers to small projects financed through consumer loans, and secured through feed-in tariffs, net metering or other policies. (3) Public market finance is equity investment in publicly-traded firms that develop renewable energy projects. (4) Venture Capital or Private Equity (VC/PE) is funding from closed funds in technology companies [43].

Table 1.1
Growth of wind and solar power in China: capacity and generation. *Source:* electricity council [8], NEA [3].

	Total capacity (GW_{AC})				Annual generation (TWh_{AC})			
	2014	2013	2012	2012–2014 (%)	2014	2013	2012	2012–2013 (%)
Wind	95.81	76.52	61.42	56	n/a	138.26	103.05	34
Solar[a]	26.52	15.89	3.41	678	n/a	8.37	3.59	133

[a] Includes small number of experimental demonstration projects using alternative technologies.