RENEWABLE POWER GENERATION SUBSIDIES IN CHINA: AN ECONOMIC FEASIBILITY ANALYSIS AND POLICY RECOMMENDATIONS

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Abstract

China is the world's largest renewable energy producer by installed capacity and electricity generation from renewables. Renewable power producers in China have long been supported by the feed-in-tariff (FIT) scheme. However, following exponential growth in renewable energy and an expanding deficit in FIT funding, China has been reducing FIT subsidy rates and transitioning towards a multilayered supportive scheme for renewable energy power production. In particular, China has introduced the trading of Green Power Certificate in 2017 and implemented the Renewable Portfolio Standards in 2020. This thesis studies the economic feasibility of a centralized and grid-connected solar PV power plant under the FIT scheme and proposes policy recommendations based on the discounted cash flow model results for the improvement of the current subsidy scheme.

Keywords: Renewable energy power generation; subsidies; Feed-in-Tariff; Green Power Certificate; Renewable Portfolio Standards; economic feasibility; discounted cash flow model; China.

Acknowledgments

This thesis is dedicated to my grandfather, who fought and won the battle against cancer. He showed me how to triumph over fear and taught me the true meaning of audacity.

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Abbreviations

BNEF	Bloomberg New Energy Finance
CAPEX	Capital Expenditure
CREST	China Renewable Energy Subsidy Tool
DCF	Discounted Cash Flow
DSCR	Debt Service Coverage Ratio
ETS	Emission Trading System
FIT	Feed-in-Tariff
GHG	Greenhouse Gas
GPC	Green Power Certificate
ICT	Information and Communications Technology
ITC	Investment Tax Credit
IEA	International Energy Agency
IMF	International Monetary Fund
IRENA	International Renewable Energy Agency
IRR	Internal Rate of Return
MOF	Ministry of Finance
MSW	Municipal Solid Waste
NDRC	National Development and Reform Commission
NEA	National Energy Administration
NOLC	Net Operating Loss Carryforward

NPV	Net Present Value
O&M	Operating and Maintenance
OPEX	Operating Expense
PBP	Payback Period
PTC	Production Tax Credit
REC	Renewable Energy Certificate
REDF	Renewable Energy Development Fund
REL	Renewable Energy Law
RPS	Renewable Portfolio Standard
VAT	Value-added Tax

1 Introduction

China's renewable energy sector is expanding exponentially. According to IRENA (*Country Rankings*, 2020), by 2020, China had a total installed capacity of renewable energy at 925 GW, nearly triple the size of that in the United States, which ranked the second in the world, at 311 GW. The same dataset also suggests that, back in 2005, the total installed capacity of renewable energy in China was only 121 GW; the number doubled in 5 years to 250 GW in 2010 and doubled again to 502 GW in 2015.

Apart from overall installed capacity, China also ranks the first in electricity generation from renewable energy. According to the statistics of IRENA (*Country Rankings*, 2020), total renewable power generation is over two times larger than that in the United States, which ranks second place. However, within the country itself, renewable energy is not the dominant energy source. According to the National Bureau of Statistics (2021), by the end of 2020, thermal power accounted for 77.6% of total electricity generation in China, while hydropower, wind, nuclear, and solar took up 10.5%, 5.6%, 4.8%, and 1.4%, respectively. Based on data from the IEA (2020c), China remains an economy primarily driven by coal, with 64% of electricity generated from coal by March 2020. When we compare the electricity mix in China with that in the EU and United States, we can see a significant difference.

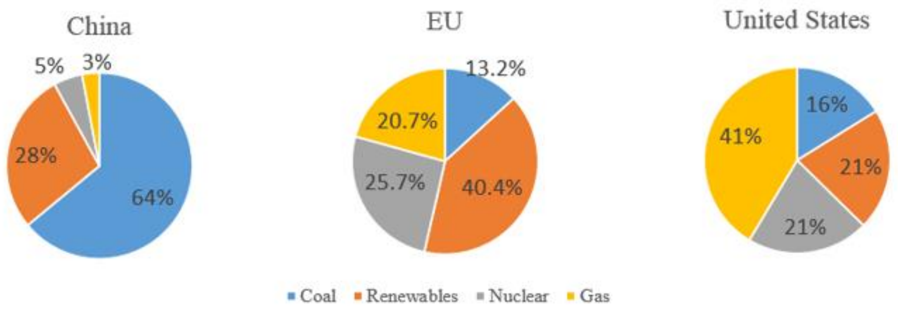

Figure 1: Electricity mix of three countries by March 2020[1]

The largest coal producer in the world, China is also the largest emitter of greenhouse gases (GHGs). According to Climate Watch (2018), 24% of the world's GHGs were emitted in China, exceeding the second-largest emitter by a wide margin. The report also shows that in cumulative terms, the country has surpassed the United States as the largest cumulative GHGs emitter in 2014, contributing 18% of the world's cumulative emissions by 2018. By per-capita GHG emissions, China registered 8.4 tCO2e per capita in 2018, falling behind the top 10 countries, which all stood at over 22 tCO2e per capita in the same year (Climate Watch, 2018). However, the country as a whole is releasing more GHGs into the atmosphere than the developed world combined (*Report: China Emissions Exceed All Developed Nations Combined*, 2021).

Resolute to shoulder more responsibility in combating climate change, China has pledged to peak CO2 emissions before 2030 and achieve carbon neutrality by 2060

[1] The charts here are compiled using data from IEA. The author referred to three charted created by the IEA: Electricity mix in the United States (January to December 2020); Electricity mix in China (Q1 2020); Electricity mix in the European Union (January to September 2020).

(*The Race to Zero Emissions, and Why the World Depends on It*, 2020). To achieve this ambitious goal, China would need to make every effort in reforming its current energy mix. Based on a research of Xiliang Zhang, the Director of the Institute of Energy, Environment and Economy at Tsinghua University, if China will increase photovoltaic power generation by 16 times, wind power generation by 9 times, nuclear power generation by 6 times, and double its hydropower generation, its carbon emissions will increase to 10.3 billion tons in 2025 and will begin to decline in 2035 after plateauing for 5 to 10 years.[2] With that in mind, there remains much to be done if China still wants to achieve the 30-60 goal.

During the 2010s, the rapid growth of renewable power generation could be attributed largely to the introduction of supportive schemes by the government and an increasingly accommodative environment for renewable investments. But recently, China's government has reduced the feed-in-tariff (FIT) rates for wind and solar power production due to a growing funding deficit under the FIT scheme. The government is proactively seeking alternative supportive schemes and encouraging renewable power producers to achieve grid-parity. In this context, it is worthwhile to study the impact of shrinking subsidies on the economic feasibility of renewable power plants and propose alternative policy schemes for promoting the development of renewables.

This paper aims to study the economic feasibility of centralized solar PV plants as China's government lowers feed-in-tariff rates and cut subsidies for renewable

[2] Retrieved from *Carbon Neutrality: Paths and Options for Energy Transition (Translated)*, 2021.

electricity generation. The author also proposes policy recommendations for the more efficient administration of the current subsidy schemes, as well as suggests alternative policy solutions for the government to promote renewable power generation. The structure of this paper is divided into eight chapters. Chapters one through three serves as an introduction to the more substantive discussion: the first chapter of this thesis is a prelude to further discussion; the second chapter summarizes previous studies and the main references of this thesis; the third chapter constructs the economic framework of this study. Chapters four through seven develops policy recommendations based on quantitative and qualitative analysis of China's subsidy schemes: Chapter 4 discusses extensively the current policies on renewable power generation and identifies drawbacks of the current schemes; Chapter 5 constructs a financial model and compares the changes in key financial measurements under different policy assumptions; Chapter 6 presents the results and implications of the financial model; Chapter 7 develops policy recommendations in accordance with the model outputs. Lastly, Chapter 8 concludes the entire study, identifies the limitations of this paper and encourages further research.

2 Literature Review

The subsidy schemes for renewable power production in China have raised academic interest due to their complex administration and recent reforms of improvement. This study is unique in that the author performs economic feasibility analysis of a proposed centralized and grid-connected solar power plant in the context of the current subsidy scheme and goes on to develop a set of policy recommendations based on the results of the model. Having said that, this thesis would not have been materialized without previous studies and numerous documents offering explanations and political context of the subsidy schemes in China.

For the background research on China's subsidy policies, the author mainly referred to the original texts published on the state government's website. There are three governmental bodies involved with the supervision and guidance of the subsidy schemes for renewable power production: National Energy Administration (NEA), Ministry of Finance (MOF), and National Development and Reform Commission (NDRC). From conducting the research, the author possesses the impression that the NEA is responsible for the overall administration of the subsidy schemes, and the MOF is in charge of the management of the FIT budget, while the NDRC is responsible for setting national targets for energy transformation. Apart from that, the author also referred to the policy interpretation published by the State Power Grid Company (*Policy Graph*, 2021) on the administrative and legal aspects of the subsidy schemes.

The discussion on the taxonomy of renewable power production subsidies is based on a technical paper published by Taylor (2020) on the global energy subsidy transformation to 2050. It also draws on the analysis of Sovacool (2017), who provides an overarching review of global energy subsidies, their types and scope, strengths and limitations, and provides insights on reforming the current energy subsidy systems. For the estimations of China’s current subsidy amount, the author referred to multiple reports issued by IRENA, IEA, and IMF, which offered differentiated calculation methods and definitions of subsidies for fossil fuels as well as renewable energy.

The analytical method of this thesis and many key assumptions therein are built upon previous studies on the economics of solar PV projects. In particular, Yuan et al. (2014) applied the analytical framework of Levelized Cost of Electricity (LCOE) to assess the economic feasibility of distributed PV in China and concluded that, at the condition of 100% own consumption, only projects deployed in most resource-abundant regions could earn economic profits. Cucchiella et al. (2017) constructed a discounted cash flow model on photovoltaic systems in the residential sector based on key financial indicators such as net present value (NPV), discounted payback time (DPBT), and LCOE. They showed in their study that financial indicators for solar PV projects are lower when subsidies are reduced or deleted, and presented Italy as an example where solar PV installation is lower after the end of the subsidy period. (Dusonchet & Telaretti, 2015) studied different support schemes for solar PV projects in various European countries, and presented the economic impact of government support on the IRR and NPV of proposed projects. Although results vary among countries due to distinctive support schemes, they concluded that the model demonstrates the highest profitability in countries where the electricity compensation scheme is active. F. Zhang et al. (2015) applied the cash flow model on distributed-generation PV (DGPV) systems in China and identified the difficulty in securing project financing as the major barrier in the development of DGPV systems.

The author cites multiple sources as the foundation of model assumptions in this thesis. For the average cost structure of a grid-connected, centralized solar PV project in China, the author refers to the 2019 National Survey Report of PV Power Applications by IEA (2020b). In addition, the assumptions on the subsidy payout ratio are based on the China Renewable Energy Subsidy Tool and the Energy Project Valuation Model created by BNEF. Other online data sources include the website of State Power Grid Company, the official trading platform of Green Power Certificate, and databases of international organizations.

For the proposal of policy recommendation, the author should credit several previous studies on the RPS system, wind and solar abandonment, and clean energy subsidy swap. In particular, Dong et al. (2019) studied the characteristics and efficiency of China's RPS system and proposed the implementation of an incremental electricity price to complement the RPS system. Barbose (2019) looked at the historical impact of the RPS system in the United States and offered insight into future policy trends. He concluded that roughly 6 GW of installed capacity was newly added every year to serve RPS compliance needs, totaling half of all renewable energy capacity additions in the past decade. Moreover, S. Li et al. (2017) analyzed the current trends of wind and solar abandonment in China and stated that efficient power peak regulation and transmission could be the key to reduce curtailment rates. In addition, Bridle et al. (2019) reviewed 4 cases of countries shifting public resources from fossil fuels to clean energy and proposed other countries follow suit by redirecting government support to large-scale on-grid renewables.

3 Theoretical Framework

3.1 Economics of subsidy

A subsidy is a form of financial benefit, usually given by the government, to remove some type of burden from a business or institution ("Subsidy," 2021). In the context of this study. it is given by the Chinese government to promote the production or the sales of renewable power. In a perfectly competitive market, the supply curve of the producer and the demand curve of the consumer should intersect at the market equilibrium point, at which the quantity of goods produced is also at its optimal. Any form of subsidy will shift the supply curve while altering the quantity of goods transacted, resulting in inefficiency in the market. As demonstrated in the graph below, when a per-unit subsidy is granted, both the consumer surplus and the producer surplus are higher than in a perfectly competitive market. The deadweight loss in the market after the imposition of a unit subsidy represents an inefficient transfer of public resources, as marked by the triangular area.

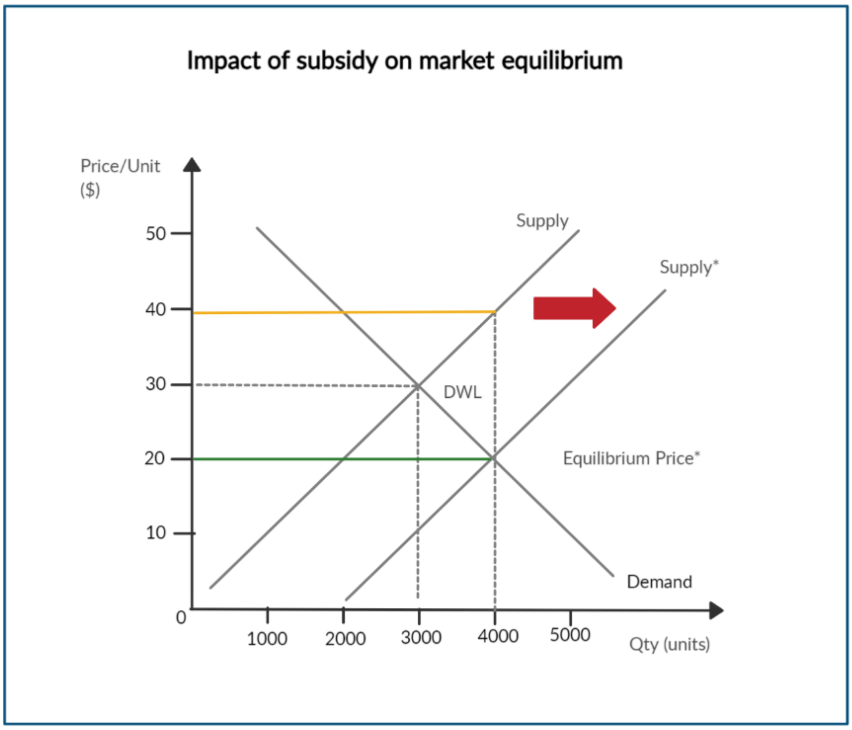

Figure 2: Impact of unit subsidy on market equilibrium

As proven by economic theory, a subsidy transfers public resources to producers and consumers, and thereby increases the quantity of goods transacted. A unit subsidy for renewable energy power generation functions in a similar manner with an aim to promote the share of electricity generated from renewables. Subsidies in other shapes – as will be discussed in the following section – are not necessarily depicted by the same economic theory and lie beyond the scope of this study.

3.2 Taxonomy of subsidies

Subsidies can take many forms, and it is imperative that we first elucidate the types of subsidies under discussion in this study. The IMF categorizes subsidies into two general groups: producer subsidy and consumer subsidy. Producer subsidy arises when the price received by the producer is higher than the equilibrium price in the free market. Consumer subsidy, conversely, arises when the price paid by the consumers is lower than the equilibrium price, or a benchmark price (IMF, 2013). It is not hard to understand, though, if we refer to the figure on a unit subsidy granted by the government. Both producer surplus and consumer surplus increase by a portion of the subsidy in total, and the portion enjoyed by either the producer or the consumer, is their relative share of the subsidy.

To break it down further, Sovacool (2017) provides a taxonomy of energy subsidies consisting of 5 groups: 1) direct financial transfer, such as government grants and low-interest loans; 2) preferential tax treatment, such as the Investment Tax Credits and Production Tax Credits in the United States; 3) trade restrictions, such as import quotas and tariffs, which are not relevant in the context of renewable energy, since renewables are more domestic compared to fossil fuels; 4) energy-related services provided by the government at less than full cost, for example, government direct investment in energy infrastructure, etc.; and 5) regulation of the energy sector that includes market accessibility and price controls. In this study, the author will discuss easy-to-access debt instruments and preferential tax policies as alternatives to China's current subsidy scheme. In the meantime, the author will also explore other policy channels that could potentially unleash a spurt of renewable installations.

The main pricing scheme in China for renewable energy power generation is the FIT scheme. In other countries where the FIT schemes have started earlier and matured farther, the higher prices of renewable power are guaranteed by collecting electricity surcharges from consumers. Therefore, technically speaking, conventional FIT shall not fall under the umbrella of subsidies, since these are capital resources reallocated from consumers to producers with the government acting as a pass-through entity. In China, however, the central government plays a larger role than merely passing through the capital stream. It assumes an administrative duty, granting approval for renewable projects to receive the FIT revenue and making decisions on how to allocate collected electricity surcharges to those approved projects. As a result, the FIT system in China is more comparable to an indirect financial transfer, as a subcategory of government subsidies, than to a capital reallocation program that channels consumer surplus into the producer's pockets, as epitomized by the FIT schemes in other countries.

3.3 Externalities

As positioned by Taylor (2020), environmentally friendly subsidies can help to improve the efficiency of capital allocation across the energy sector. It is for this reason when evaluating subsidies for fossil fuels, we not only include direct or indirect transfers from the government but should also take into account inefficient taxation on negative externalities. The consumption of fossil fuels could induce tremendous costs to society, and inefficient taxation on such costs – most frequently in the forms of climate change and air pollution – will result in a higher quantity of goods transacted and an equilibrium price that is too low. As shown in the graph below, the supply curve will shift to the left if the government imposes a full pricing mechanism for fossil fuels that efficiently captures the associated social costs. In such circumstances, the producer faces higher generation costs and will therefore reduce production for the benefit of the overall society.

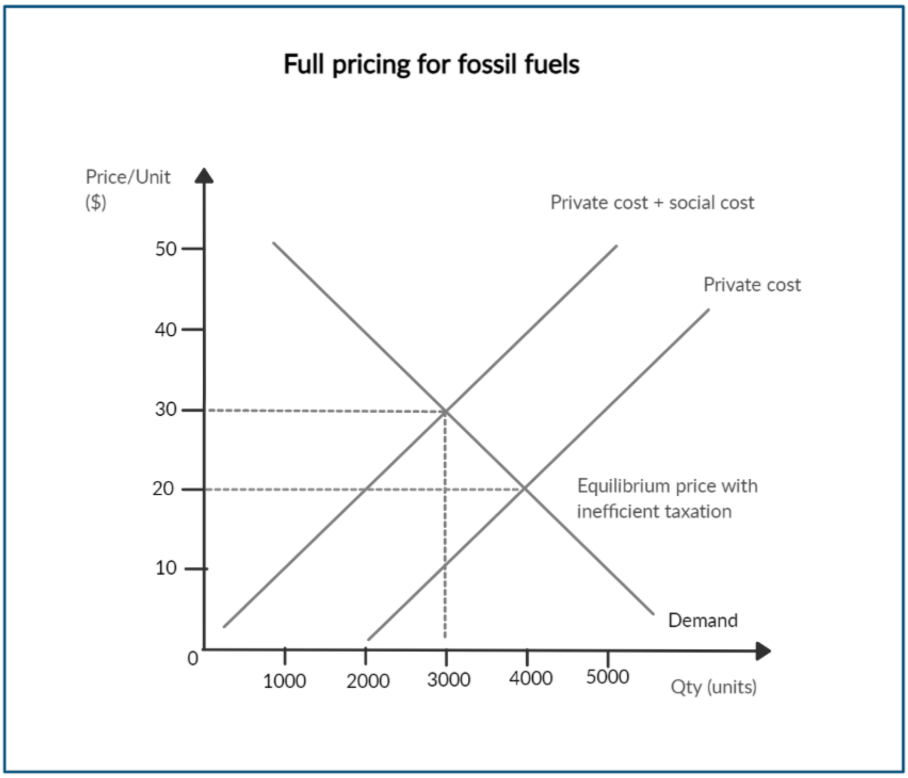

Figure 3: Full pricing for fossil fuels vs. inefficient taxation

On the other hand, renewable energy could potentially bring three types of positive externalities to society: social benefits, health benefits, and economic benefits.

Firstly, renewables could bring social benefits by the promotion of renewable jobs and adherence to a sustainable economy. Since resources such as wind and solar are carbon-free and regenerable, they are more environmentally friendly compared to conventional energy sources. Secondly, renewable energies do not produce as serious health repercussions as burning fossil fuels. Switching to renewables will result in less pollution from coal-fired power plants and improved air quality. And thirdly, certain uses of renewables can bring economic benefits to individuals and nations as a whole. For example, landowners could earn an income from hosting renewable energy power plants. And electricity prosumers, or end-users who provide electricity for their own needs through distributed electricity generation systems, could enjoy economic gains by producing electricity and connecting excess electricity to the grid. Apart from individual gains, countries as a whole can also gain economic benefits from renewable energy. Nations like Japan that depend heavily on oil imports might be severely impacted when oil prices fluctuate. In such a sense, renewable energy can be deployed independently and shows a much more stable price trend.

4 Renewable Energy Subsidies in China

In this chapter, the author intends to provide a holistic and overarching description of China's current subsidy schemes for renewable power production. This chapter will serve as the bedrock of the subsequent sections, where the author delves deeper into the economic impact of those subsidy schemes. To briefly summarize, there are overall two supportive schemes for renewable power generation in China: a long-running feed-in-tariff (FIT) scheme and an immature Renewable Portfolio Standard (RPS) policy that is loosely connected to the Green Power Certificate (GPC) system. As familiar as those might sound, these subsidy structures are distinctive from those implemented in other countries. The FIT scheme in China, although with similar functions and economic implications as those in countries such as Japan and Germany, differs from its foreign counterparts due to a more complex administrative structure and heavy government oversight. The RPS policy, on the other hand, has only been recently implemented as a trial run and has thus far remained with no significant legal or regulatory power. China's GPC system, which originates from the Renewable Electricity Certificate (REC) system in the United States, predates the RPS policy and was originally implemented separately from the RPS policy as an alternative to the FIT scheme. Hence, to understand the subsidy systems in China, we should first take a closer look at their respective characteristics.

4.1 China's current subsidies for renewable power production

Although China's subsidy schemes for renewable power production were implemented in reference to those enforced in developed countries such as European countries, Japan, and the United States, it still lags behind in administration and the level of support. According to the research by Taylor (2020), China circulated 15.6 billion USD of renewable subsidies in 2017, accounting for 9% of the world. The same report states that the EU, the United States, and Japan recorded 90 billion USD, 23.7 billion USD, and 19 billion USD, respectively, accounting for 54%, 14%, and 11% of total renewable subsidies in 2017. Taylor (2020) also estimates that, of the 15.6 billion USD of subsidies provided, 97% goes to renewable power generation, and that makes China the third-largest supporter for renewable power generation in 2017, taking up 12% of total subsidies for renewable power generation in the world.

The FIT scheme is the main subsidy scheme for renewable energy power production in China. Over the years since its initiation, it has stimulated the deployment of renewable power and encouraged technology advancement and cost reduction. However, the support under the FIT scheme has been declining in recent years due to a growing funding deficit. According to the Ministry of Finance, subsidies provided under the FIT scheme were 8.1 billion CNY (1.3 billion USD) in 2019.[3] The amount subsequently declined to 5.67 billion CNY (0.89 billion USD) in 2020[4], and rebounded slightly to 5.95 billion CNY (0.93 billion USD) in 2021[5].

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[3] The budget for FIT subsidy in 2018 is determined by the Ministry of Finance in a published document titled *Notice of the Ministry of Finance on Issuing the Budget of Additional Subsidy*

4.1.1 Renewable Energy Law

The government's official support for renewable energy development began with the enactment of the Renewable Energy Law (REL). In 2005, China's then-president Hu Jintao signed the first version of REL, which entered into force in January 2006. As stated in the first article of the 2006 REL, the law proclaims the government's support of the development and utilization of renewable energy in the forms of wind, solar, hydro, biomass, geothermal, ocean, etc. The 2006 REL was a meaningful step towards a sustainable future. Not only did the passage of the law prompted subsequent policies, but it also signals a recognition within the ruling party of the need to transform the current energy mix.

The 2006 REL was brought into effect against the backdrop of an economy driven entirely by coal. Before the passage of the law, electricity generation from renewable energy was markedly minimal compared to that from conventional energy sources. According to the IEA, in 2005, China's electricity generation from solar PV only registered 84 GWh, accounting for 0.003% of total electricity generation. With

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Funds for Renewable Energy Electricity Prices (Translated). The author retrieved this information from a news article published at:
http://www.xinhuanet.com/power/2019-06/21/c_1210165971.htm

[4] The budget for FIT subsidy in 2019 is determined by the Ministry of Finance in a published document titled *Notice of the Ministry of Finance on Issuing the Budget of Additional Subsidy Funds for Renewable Energy Electricity Prices in Advance for 2020 (Translated)*. The author retrieved this information from a news article published at:
http://www.tanjiaoyi.com/article-29515-1.html

[5] The budget information is retrieved from the news article published by the National Demand Side Management Platform.

government stimulus and expanding business investment, electricity generation from solar PV skyrocketed to 224,000 GWh in 2019, representing roughly 3% of total electricity generation (IEA, n.d.). Likewise, electricity generation from wind recorded 2028 GWh in 2005, accounting for 0.081% of total electricity generation, and climbed to 406,000 GWh (5.4%) in 2019 (IEA, n.d.). Although the share of solar PV in China was still below the level in developed countries by the end of 2019, the growth was still visibly exponential. Statistically, the proportion of electricity that is produced from solar PV rose over 800 times during the period from 2005 to 2019. Similar growth was also witnessed in wind development, although to a lesser extent, with the share of wind energy increased 66 times during the same period. This eye-catching growth can be attributed largely to the favorable business environment at the time, which was partly the outcome of the government's supportive policies to promote renewable energy, especially marked by the REL that came into force in 2006.

4.1.2 Feed-in-tariff Scheme and Renewable Energy Development Fund

One of the most significant contributions of the 2006 REL is that the law describes vaguely a cost-sharing mechanism for renewable energy power generation that resembles a feed-in-tariff scheme. According to Chapter V of the 2006 REL, on-grid electricity prices for renewable energy are determined by the relevant State Council department based on different local conditions, in particular, the technology levels of different geographic areas. In the case where the price of renewable power exceeds the price of electricity generated from conventional energy sources due to higher generation costs associated with renewables, the State Council demands that the premium over the conventional electricity prices to be borne by electricity end-users. Other costs associated with renewable energy power generation, such as grid-connection cost and power transmission cost, can also be reasonably calculated in the sales price of electricity and levied on consumers. This cost-sharing mechanism is the prototype of the government-controlled FIT scheme that was later established in 2012.

Although the cost-sharing system might sound identical to a foreign FIT scheme, the main distinction is the role of the Chinese government. According to the 2006 REL, a special-purpose fiscal budget is set aside for the promotion of renewable energy development. The fiscal budget can be used in support of the research and development, power system construction, and information technology system building of renewable energy. By the 2009 amendment of the REL, a Renewable Energy Development Fund (REDF) was established to incorporate the special-purpose fiscal budget. The REDF, administered by the Ministry of Finance, later became the central piece of China's FIT scheme and retained significant oversight power over the approval and allocation of the FIT subsidy.

The REDF is essentially a fund administered by the Ministry of Finance, that collects renewable energy electricity surcharge from electricity consumers, and allocates subsidies to renewable power plants eligible for FIT subsidy. When the collection of RE surcharge is insufficient, the Ministry of Finance will withdraw money from the afore-mentioned special-purpose fiscal budget to meet the high demand for FIT subsidy. And when the RE surcharge is abundant, the MOF will refund the fiscal budget using the RE surcharge. In reality, only in later years when the REDF became significantly underfunded, the fiscal special-purpose budget was drawn on to cover the deficit.

There are two types of subsidy under the FIT scheme: a per-unit subsidy and a lump-sum subsidy, the calculation methods of which are slightly different (*Measures for the Administration of Renewable Energy Electricity Surcharge Subsidy Funds*, 2020). For projects that receive a per-unit subsidy, the FIT price is determined based on the price gap between generation cost and electricity grid-connection price. The grid-connection price differs from region to region but is always equal to the desulfurized coal power price within the region. This is because China has long remained an economy powered mainly by coal, and the coal power price is set as the benchmark electricity price. Although less popular, a lump-sum subsidy is sometimes granted for projects eligible for the FIT scheme. In that case, the subsidy price is independent of elements such as generation costs and provincial-specific coal power prices. It is worth noting, however, that both types of subsidy are subjected to a value-added tax.

$$(1)\ Per-unit\ subsidy = \frac{generation\ cost - desulfurized\ coal\ power\ price}{1+VAT}$$

$$(2)\ Lump - sum\ subsidy = \frac{lump - sum\ subsidy}{1 + VAT}$$

$Where$:

$VAT = value - added\ tax\ rate$

To sum up, the flowchart below illustrates the characteristics of the FIT scheme in China. The key players are the electricity consumers, power grid companies, renewable power producers, and on top of that, the REDF administered by relevant governmental authorities. Just as how any FIT scheme functions in foreign countries, the electricity consumers pay a per-unit renewable energy surcharge to the power grid companies. However, what is unique to China’s FIT system is that the RE surcharge is then passed on to the REDF, which falls under the supervision of the Ministry of Finance. On the other side of the equation, renewable energy power producers that wish to be included under the FIT scheme should submit applications to the National Energy Administration, which verifies project-related information and grants approval for FIT inclusion. To do so, the NEA manages a catalog system and periodically publishes the name of newly eligible projects. The power grid companies, following the directions from the government, subsequently dispatch FIT subsidies to renewable power producers.

With government oversight, the FIT scheme in China operates with a significant delay in payment and curtailment in subsidies. Firstly, the RE electricity surcharge has experienced a relatively low collection rate that led to an enlarging funding deficit in the REDF. Secondly, although the REDF was established with the sole purpose of promoting renewable energy development, the fund has been exploited to support initiatives other than the FIT scheme. Thirdly, since renewable power producers have to submit applications to the NEA for inclusion under the FIT scheme, the benefits of the FIT are not guaranteed and are most often granted with significant delays in payment. And lastly, as the government retains control over the reallocation of FIT subsidies, the subsidy payout ratio is also manipulated by the state government. The later sections of this chapter will analyze with greater detail the deficiency of the FIT scheme. And in Chapter 7, the author will delve deeper into the shortcomings of the FIT scheme with an emphasis on the administrative inefficiency of the REDF, and offer policy recommendations for improvement.

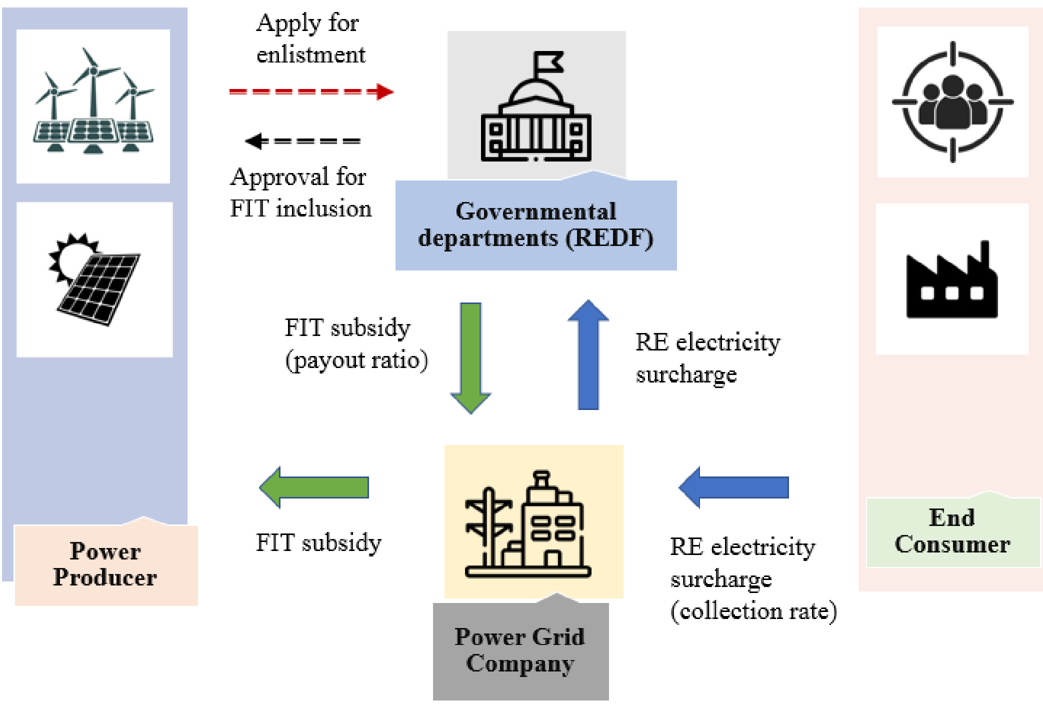

Figure 4: Administrative flowchart of China’s feed-in-tariff scheme

4.1.3 Feed-in Tariff Scheme for Solar Project

The subsidy scheme for solar projects has experienced three phases before a fully-fledged FIT scheme was introduced. In the first phase, the Chinese government stipulated a pro-rata subsidy for solar power generation projects. Qualified projects can receive a lump-sum subsidy equal to 50% of the total initial investment, while those located in remote areas can receive a subsidy of up to 70% of the total investment outlay (*Notice on the Implementation of the Golden Sun Demonstration Project (Translated)*, 2009). According to Fan et al. (2021), the subsidy was in effect usually granted ex-ante, before the actual grid-connection of the project. This resulted in a potential loophole where project owners swindle the subsidy but refuse to achieve the final completion of the project. In turn, loose oversight over subsidy allocation also promoted the fast growth of photovoltaic power generation. It is estimated that over 9,000 solar projects were listed under the Golden Sun Demonstration Project plan within three years since its implementation (Fan et al., 2021).

The first reform for solar power generation subsidy took place in 2013 when the National Development and Reform Commission (NDRC) announced its plan to prescribe benchmark electricity prices for solar PV power generation. The policy marks the inception of China's feed-in-tariff scheme for solar projects, and more importantly, it set up a differentiated pricing system under the FIT scheme based on the location of the project. For centralized solar power plants, the NDRC divided all China into three regions by the abundance of solar energy and the level of construction cost. Region I includes most northern and northwestern China, where solar energy is abundant, and the feed-in-tariff rate for that is set at 0.9 CNY/kWh.[6] Region II covers the vast midland and the FIT rate is 0.95 CNY/kWh. Region III includes the rest of China (excluding Tibet), or more specifically the rainy eastern part of China and the humid south, with a tariff rate of 1.0 CNY/kWh (NDRC, 2013). For distributed photovoltaic power generation, the electricity price is set at 0.42 CNY/kWh without geographical differentiation. The feed-in-tariff rates were subsequently reduced for the first time in 2016, and then for a second time in 2017, when the rate for Region I was 0.65 CNY/kWh, for Region II, 0.75 CNY/kWh, and for Region III, 0.85 CNY/kWh (NDRC, 2016a). The Tibetan area was first included under the FIT scheme in 2017, with a rate of 1.05 CNY/kWh for a centralized solar plant.

Figure 5: Geographical categorization for solar projects under the FIT scheme

Source: China Land, 2015

[6] All feed-in-tariff rates shown here are VAT-included.

The second reform to the FIT scheme for solar projects happened in 2019 when the NDRC changed the benchmark price system to a guide price system. Before the reform, the FIT rates were fixed and guaranteed for power producers, although distinction existed for different geographical regions. After the reform, however, the FIT rates were no longer serving as a fixed benchmark, but rather a maximum price cap for power producers. For newly built solar projects, the actual FIT prices are determined through market-based competitive bidding, but the resulting prices shall not exceed the guide price. The policy also lowered the benchmark FIT rates for existing projects, to 0.4 CNY/kWh, 0.45 CNY/kWh, and 0.55 CNY/kWh, respectively, for Region I to III (NDRC, 2019a). In the meantime, the subsidy rate for distributed solar plants was also reduced. And for the first time, the NDRC also stipulated a 0.18 CNY/kWh per-unit subsidy for stand-alone household solar systems.

The current solar FIT rates were determined in 2020 when the Chinese government further reduced the guide prices to 0.35 CNY/kWh, 0.4 CNY/kWh, and 0.49 CNY/kWh for Region I through III, respectively. The progressive reduction signals the government’s acknowledgment that market competition should orientate grid-connection prices for solar projects, and that government policies only provide guidance. Under the guide price system, solar power producers compete for a stronger business presence and are willing to swallow a narrower profit margin. The policy also incentivizes the industry to proactively upgrade technology and invest in research and development.

Region	Benchmark price (CNY/kWh)			Guide price (CNY/kWh)	
	2014	*2016*	*2017*	*2019*	*2020*
I	0.90	0.80	0.65	0.40	0.35
II	0.95	0.88	0.75	0.45	0.40
III	1.00	0.90	0.85	0.55	0.49
Tibet	-	-	1.05	-	-

Table 1: Summary of FIT rates for solar projects in China

4.1.4 Feed-in Tariffs Scheme for Wind Project

Similar to the solar FIT scheme, the FIT scheme for wind development also experienced three phases. Before 2003, wind development in China was minimal due to high equipment costs and less available technology. From 2003 to 2007, the government organized five concession bidding rounds for wind project development to promote the deployment of wind farms. The grid-connection prices of those projects were determined by bidding and varied by the project. Altogether 15 onshore wind projects were approved in those five rounds of concession bidding, adding 3,000 MW of installed capacity to China's wind profile (China Everbright Securities, 2019). The majority of the projects registered a grid-connection price from 0.4 CNY/kWh to 0.5 CNY/kWh, which in retrospect, is significantly lower than the first feed-in tariff rates introduced for wind projects in 2009.

The concession bidding scheme was followed by a reform to set up benchmark electricity prices for wind projects in 2009. Similarly, as the solar FIT scheme, the NDRC divided China into four regions based on the average capital expenditure, abundance of wind resources, among other relevant factors. Region I consists of cities of Xinjiang and Inner Mongolia, with a FIT price set at 0.51 CNY/kWh. Region II and III cover the vast northern and northwestern China, with FIT prices of 0.54 CNY/kWh and 0.58 CNY/kWh. The rest part of China is included in region IV with the highest FIT rate at 0.61 CNY/kWh. The FIT prices for wind projects set in 2009 were also progressively reduced several times. In 2019, the government introduced the guide price mechanism for wind projects. Under such a mechanism, the officially announced FIT rates will only act as s maximum cap for newly added wind projects, while the actual FIT price is determined by competitive bidding (China Everbright Securities, 2019).

Region	Benchmark price (CNY/kWh)				Guide price (CNY/kWh)	
	2009	*2015*	*2016*	*2018*	*2019*	*2020*
I	0.51	0.49	0.47	0.40	0.34	0.29
II	0.54	0.52	0.50	0.45	0.39	0.34
III	0.58	0.56	0.54	0.49	0.43	0.38
IV	0.61	0.61	0.60	0.57	0.52	0.47

Table 2: Summary of FIT rates for wind projects in China

Figure 6: Geographical categorization for wind project under the FIT scheme

Source: Wu, 2009

4.1.5 Renewable Energy Electricity Surcharge

The RE electricity surcharge is levied on electricity consumers in the form of a surcharge over the usual electricity tariffs. The surcharge is collected by power grid companies and then passed on to the REDF before reallocation to eligible renewable energy power plants under the FIT scheme. A simplified version of the calculation formula of the RE surcharge is demonstrated in a government announcement (NDRC, 2006):

$$RE\ surcharge$$

$$= (RE\ generation\ cost - desulfurized\ coal\ power\ price)$$

$$* RE\ generation\ volume$$

$$+ excess\ of\ \text{O\&M costs for public RE stand alone power systems}$$

$$+ other\ reasonable\ costs$$

$Where$:

$(1)\ Excess\ of\ O\&M\ costs\ for\ public\ RE\ standalone\ power\ systems$

$= \text{O\&M costs for public renewable energy stand alone electric power system}$

$- \text{average sales price for local provincial level grid connected power} * (1 + \text{VAT})$

$(2)\ Other\ reasonable\ costs$

$= \text{Renewable energy power generation project grid access expenses}$

$+ \text{other reasonable costs}$

To conclude, the RE electricity surcharge covers three types of RE costs above prices for conventional energy sources. According to a translation of the document issued by NDRC (2007), the first type is the amount to which grid-connected power prices for renewable energy exceeds the local power price benchmark for desulfurized coal grid-connected electricity; the second portion covers the amount to which operation and maintenance costs for public renewable energy stand-alone power systems are higher than the average sales price for local provincial-level grid-connected power; the last portion, or other reasonable costs, includes grid-access expenses for renewable energy power generation projects and other relevant expenses.

The RE surcharge is levied on end-consumers that can be divided into two types. The first type includes industrial and commercial users of electricity, and the other includes agricultural and residential users of electricity. The RE surcharge rate levied on the second type of consumer – agricultural and residential users – has remained at the level of 0.001 CNY/kWh since the inception of the policy. The RE surcharge rate on industrial and commercial consumers, however, has been adjusted upwards many times to cover the growing funding deficit of the REDF. When first introduced in 2006, the surcharge rate for industrial and commercial consumers was set at 0.002 CNY/kWh, which was then increased to 0.004 CNY/kWh in 2009 (Zhao & Lin, 2016). During the years, the cost of renewable energy power generation has been declining. As a result, the industry opened up huge opportunities for investment and the number of newly added renewable power plants soared. As more power plants had been constructed, the demand for FIT subsidies also significantly increased. The REDF has been running a growing deficit, and in response, the government hiked the surcharge rate for industrial and commercial consumers of electricity to 0.008 CNY/kWh in 2012, and again to 0.015 CNY/kWh in 2013. In 2016, the RE surcharge rate for industrial and commercial users has hiked again, in all regions except for Xinjiang and Tibet, to 0.019 CNY/kWh (Han, 2020). The surcharge rate has remained at the 2016 level till today, despite the cry-out of the renewable industry for the government to further hike the rate due to the expanding deficit in REDF.

Category	Year	RE surcharge (CNY/kWh)
Industrial and Commercial	2006	0.002
	2009	0.004
	2012	0.008
	2013	0.015
	2016	0.019
Agricultural and Residential	-	0.001

Table 3: Summary of renewable energy electricity surcharge rates

Although experts have endorsed further raising the RE surcharge rates to cover the funding deficit in the REDF, the government has circumvented such possibility in its response to the request (Chen, 2019). It has been avoiding further spikes in the RE surcharge rates and has been exploring alternative approaches to fill in the gap. In such a sense, the Chinese government decided that instead of increasing the burden on end-users, it is better off to minimize the subsidy given out in the first place. A policy announcement in 2020 states that all newly commissioned projects will receive subsidies on a cost-revenue balance basis (*Measures for the Administration of Renewable Energy Electricity Surcharge Subsidy Funds (Translated)*, 2020). This means that the amount of RE surcharge collected from electricity consumers, or the inflow of funding to REDF each year, will determine how much subsidy can be given away to power producers under the FIT scheme. This additional clause was included mainly due to the insufficient funding to the REDF. By the end of 2018, the accumulated deficit of the REDF has grown to 233.1 billion CNY (B. Li, 2019). The widening gap in funding is due to many reasons. Partly this is because more renewable power plants have been deployed as a result of government support. But on the other side of the coin, the lack of oversight and regulation over the collection of RE surcharge is also a major reason behind the REDF being significantly underfunded.

4.1.6 Green Power Certificate

China introduced the GPC system in February 2017, more than two years before the enforcement of the RPS policy in May 2019. The three major government bodies in charge of the FIT scheme – NDRC, NEA, and the MOF – conjointly published a notice on the issuance and purchase mechanism of the Green Power Certificate, announcing the first alternative subsidy scheme to the FIT scheme in China. As the REC in the United States, the GPC in China is an electronic certificate issued by the central government for every 1 MWh of renewable electricity (excluding electricity generated by hydropower) produced by power generation companies (International Institute of Green Finance, CUFE, 2019). However, the GPC in China differs from its foreign counterpart in that it was originally introduced with an aim to substitute the FIT scheme, and therefore is only loosely linked to the RPS policy.

Since the GPC system was only recently implemented in China, first as a trial run, the trading has thus far remained inactive. The trading system is a two-way and voluntary process. The producer can choose whether to apply for a GPC, and on the other side, the consumer can voluntarily choose to purchase from a pool of products differentiated by the project site, certified date, price, and etc. On the supply side, power generation companies that choose to apply for a GPC need to log onto an online platform managed by the NEA[7], register the construction and commission information of the project, and provide electricity bills or transaction account to prove that 1MWh of electricity has been sold to a regional power-grid company. The NEA will then go on to verify the information and issue the GPC to eligible power generation companies. The certified GPC will be traded on a separate trading platform where relevant information associated with the project is disclosed along with the price.[8] Each GPC has an individual registry, which will be canceled once sold, and reselling is not allowed. On the demand side, any public institutions, enterprises, and natural persons can purchase the GPC traded on the platform, and choose among differentiated GPC projects at a price determined through seller-buyer negotiation.

In economic terms, the GPC is a tradable commodity but it does not directly affect the generation of renewable electricity. Once the power producer has fed the energy into the grid, electricity from renewables and conventional sources is confluent and cannot be separated. On that account, the GPC does not directly inject more electricity from renewables into the power grid. In fact, from the power producer's perspective, the GPC does not carry more economic value than the FIT subsidy, in view of the fact that the price of GPC cannot exceed the FIT guide price, and that

[7] Renewable energy information management platform (Translated). Accessible at: http://djfj.renewable.org.cn/default/coframe/auth/login/login.jsp

[8] The GPC trading platform is accessible at: http://www.greenenergy.org.cn/

once the GPC is sold, the corresponding amount of electricity generation is no longer eligible for FIT subsidy.

4.1.7 Renewable Portfolio Standards

The Renewable Portfolio Standards policy in China still lags behind its foreign counterparts in design, enforcement, and administration. The 2006 REL provided a legal context for the RPS policy in stipulating that the State Council will release national targets for renewable energy and design policy guidelines for the local governments. In 2010, the government briefly mentioned its plan to progressively roll out the RPS policy in an announcement to promote the development of strategic and emerging industries (State Council, 2010). However, the narrative was buried among other grandiose topics and no concrete measures were proposed in the document. Almost a decade later, the NEA published a draft version of the RPS policy in March 2018, calling for public opinions and suggestions (NEA, 2018). In May 2019, the NEA issued the final policy decision in a document titled "Notice on the Establishment of the Consumption Guarantee Mechanism on Renewable Energy Electricity (translated)"; the policy became known as China's Renewable Portfolio Standards. This policy prescribes province-specific goals for renewable power consumption during 2018 and 2020. Each province is assigned with two targets: a mandatory and enforceable minimum quota and a non-binding target that the provincial government is encouraged to achieve. It is worth noting that the state government has two measurements for renewable power consumption: one stipulates the power consumption target for all renewable energies including hydropower, and another stipulates power consumption only from wind and solar energy. Since this paper is focused on power generation from wind and solar, the targets described below are also consistent with the second measurement that excludes hydropower.

Among the administrative regions, Qinghai province, where both solar and wind resources are abundant, is mandated the highest mandatory quotas at 19% in 2018 and 25% in 2020. The lowest minimum quotas, on the other hand, are set for Shanghai municipality at 2.5% in 2018 and 3% in 2020 (NDRC, 2019c). Since the policy was published in May 2019, the targets for 2018 were only retrospective, and the targets for 2019 were also non-binding. In fact, this policy was implemented as a practice test in 2019, giving ample time for provincial governments and regional power grid companies to adjust their renewable power portfolio. According to the policy, the quota targets will be binding and the RPS system will start to possess punitive power from the beginning of 2020.

In May 2020, the NEA and the NDRC revisited the targets set in 2019 and published another policy with revised quotas for 2020 (NDRC, 2020). The minimum consumption quota for Shanghai municipality, for example, was raised to 4% in the May 2020 policy from 3% as stipulated in the May 2019 policy. The minimum quota for Hebei Province, conversely, was revised downwards from 15% to 12.5%. For Shandong Province, the non-binding target of 11% stipulated in the 2019 document was set as the minimum quota in the 2020 document, while the non-binding target was raised to 12.1%.

Although the RPS guidelines were stipulated by the state government in 2019, the enforcement at the provincial level progressed slowly. After the release of the guiding policy, multiple provincial governments successively announced the locally adapted version of the RPS system. Shandong Province was quick to respond and drafted a local interpretation of the guiding policy by the end of 2019 in accordance with the first state announcement, in which the minimum provincial target was set at 11%. Shanghai municipality, on the other hand, implemented the RPS system in February 2021 and claims compliance with the revised quota of 4% (Shanghai Development and Reform Commission, 2021). Guangdong Province also made a public announcement in March 2021, setting provincial guidelines effective on April 1, 2021, and valid for 3 years (Guangdong Provincial Development and Reform Commission, 2021).

According to the state policy guidelines, the responsible parties for renewable power consumption are two types of entities (NDRC, 2019c). The first type is power grid companies at provincial and local levels. The second type is large electricity consumers that directly purchase electricity in the wholesale market or electricity prosumers that equip power plants for self-production. Both parties are responsible for the provincially designated renewable power quota, but electricity for agricultural and heating uses is exempted from compliance with the RPS.

As the RPS policy was implemented after the GPC system, the two schemes are largely misaligned. The main approach for compliance with the RPS policy is increasing the purchase or consumption of electricity generated from renewable sources. Electricity consumers with compliance obligations can choose to consume or self-produce more electricity from renewable sources. In the meantime, electricity suppliers can fulfill compliance responsibility by inter-provincial trade of electricity, purchase of ownership for distributed renewable energy plants, and etc. (Shanghai Development and Reform Commission, 2021). The complementary approaches may vary among provinces but fall within the following two categories. The first one is through the trading of GPC, which certifies that 1MWh of electricity is generated from renewable energy. The second approach is by trading excess units of electricity consumed or generated above the provincial mandatory quotas.

The trading system of excess RE generation differs from the GPC system in that the former has multiple markets at the municipality, provincial, and regional levels, and that the amount of RE traded in the market must be in excess of the entity's compliance obligation. Beijing municipality was the first to introduce an excess RE generation trading market. In January 2021, Beijing Power Exchange Center published a manual, in which the Center describes the excess RE generation trading system as the principal platform for RPS administration and compliance assessment. China Southern Power Grid also announced in April 2021 that 5 provinces under its jurisdiction will trade in a common market for excess RE generation (H. Wang & Lan, 2021). In the announcement, China Southern Power Grid also claims that 2,716 certificates of unit excess RE generation have been verified and registered. The excess RE generation trading system as well as the RPS scheme itself is still incubating and evolving, and the implementation progress so far varies among provinces; therefore, it is difficult to presume the future role of the excess RE generation trading system.

4.1.8 Monitoring and Evaluation System of Wind and Solar Investment

In January 2019, before the RPS policy was implemented nationwide, the NDRC issued a notice on promoting the grid parity of solar and wind power generation (NDRC, 2019b). The notice stipulates that to satisfy the RPS goals for each province, solar plants and wind farms that can achieve grid parity or grid connection at low generation cost will be prioritized over other similar power generation projects. The government encourages renewable energy power producers to compete with each other to eventually achieve technological breakthroughs and reach grid parity. In fact, the notice also emphasizes the importance of a monitoring and evaluation system that assigns ratings to provinces on the capacity of new solar and wind projects. A red zone is a region with substantial renewable energy production and will not be allowed to build new solar and wind projects unless the project does not require subsidy or is categorized as an anti-poverty or demonstration project. In addition, an orange zone will be encouraged to progress towards grid parity with some limitations on new installations, and a green zone where renewable energy power production is still in high demand should strive to meet the minimum RPS goals for renewable energy consumption (NEA, 2020a). As shown in the graphs below, in 2019, Tibet was marked as a solar PV installation red zone (Tibet also enjoys the highest FIT rate). The vast midland including Xinjiang was marked as the orange zone. For wind development in 2019, Xinjiang and Gansu provinces were marked as the red zone but were later downgraded to the orange zone in 2020. The Inner Mongolia province and some municipalities of the neighboring provinces were marked as orange for limited construction of wind projects.

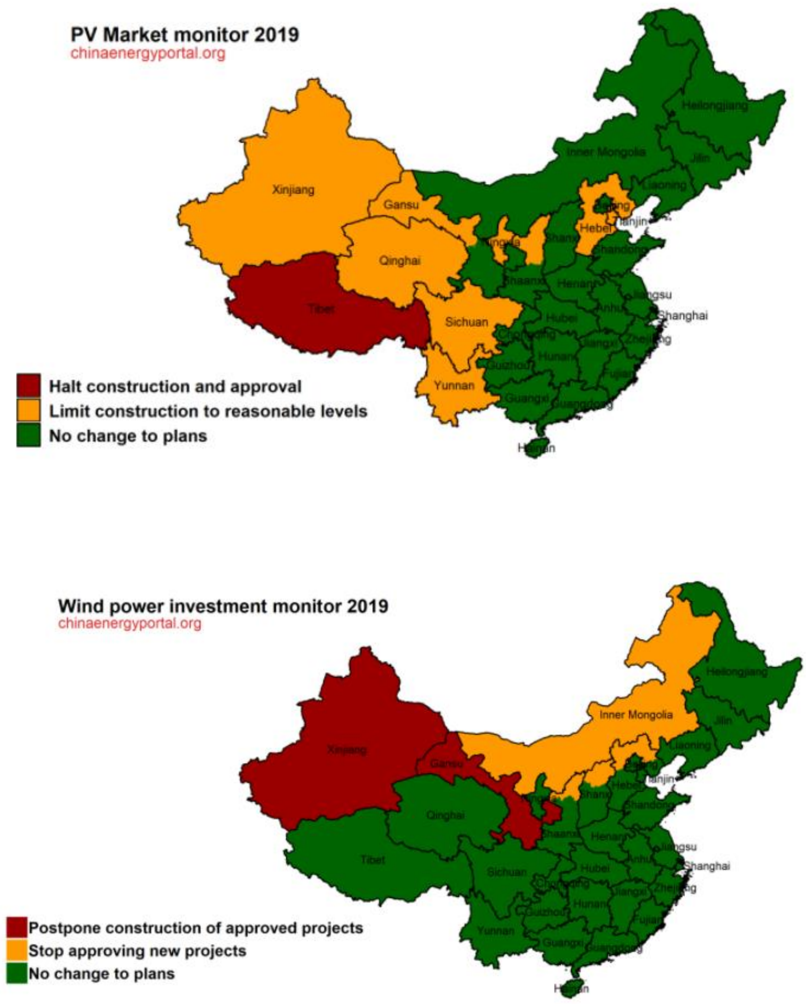

Figure 7: Solar and wind power capacity monitor map 2019

Source: China Energy Portal, 2020

4.2 Existing issues with China's current subsidy schemes

4.2.1 Funding deficit of the REDF

The REDF, the major source of funding for renewable energy subsidies under the FIT scheme, has been running a large deficit. According to the Ministry of Finance (2020e), there are three main reasons behind the REDF being underfunded. Firstly, the RE electricity surcharge has not been adjusted after 2016 to reflect the growing deficit of the REDF. Secondly, the Ministry of Finance states that in many cases, the RE surcharge that is payable to the REDF was not collected on time or even left uncollected, especially from self-prosuming power companies and local power grid companies. According to Junfeng Li, the Director of National Center for Climate Change Strategy and International Cooperation (NCSC), who also participated in the drafting of the 2006 Renewable Energy Law, 35% to 40% of the RE surcharge was left uncollected due to the lack of supervision and enforcement (Zheng, 2019). Li says this is because the relevant department of the government failed to effectively collect surcharges from household electricity usage, and estimates this gap to be a staggering 19 billion CNY. On the other hand, the self-produced electricity by power suppliers was also left well-hidden and largely unregulated. Li states that the total uncollected surcharge from household and self-produced electricity usage amounts to 40 billion CNY, almost one-third of the accumulated deficit of the REDF by the time. According to an industry research report issued by a Chinese securities company, from 2012 to 2018, only around 60% of the collectible RE surcharge was actually paid to the REDF. The numbers varied across the years, with 2012 registering the lowest collection rate at 56.74% and 2017 recording a higher collection rate at 69.17% (China Everbright Securities, 2019).

Year	Surcharge rate (CNY/kWh)		Electricity consumption (100 million kWh)		Collectible surcharge	Collected surcharge	Collection rate
	Industrial and commercial	Residential	Industrial and commercial	Residential			
2012	0.008	0.001	42,426.32	6,227.70	345.64	196.11	56.74%
2013	0.010	0.001	45,452.32	6,776.15	449.94	297.98	66.23%
2014	0.015	0.001	47,288.23	6,929.46	716.25	491.38	68.60%
2015	0.015	0.001	47,203.35	7,276.10	715.33	444.87	62.19%
2016	0.019	0.001	50,069.45	8,054.04	959.37	557.84	58.15%
2017	0.019	0.001	53,226.66	8,694.77	1,020.00	705.50	69.17%
2018	0.019	0.001	58,036.00	9,685.00	1,112.37	691.10	62.13%
Total					**5,318.90**	**3,384.78**	

Table 4: RE surcharge payable to and collected for the REDF

Source: China Everbright Securities, 2019

And thirdly, in some regions, the renewable energy installed capacity has exceeded the level determined by the national plan due to the lack of scale control. Recalling the monitoring and evaluation system implemented by the central government of China, Xinjiang and Gansu province were marked as investment red zone for wind development in 2019, falling under the category of excessive growth in renewable energy power plant installation. Likewise, Tibet was marked red for solar development in 2019, along with the other provinces in central China being marked orange for a halt in new installation of solar plants.

With the REDF running a significant budget deficit, only a selected pool of newly installed renewable power plants can be enlisted under the FIT subsidy scheme. The verification process usually takes many months or even years. And even though approval to enlistment is granted, most of the projects receive only a slice of the promised subsidy and even that small portion is usually given out in delays. Acknowledging the delay in subsidy allocation, the Ministry of Finance issued a notice to provide guidance for the prioritization of certain projects (Ministry of Finance, 2020a). According to the notice, the FIT subsidy allocation should prioritize and given in full to distributed solar PV projects under 50kW of installed capacity, and then to solar PV projects whose grid-connection prices are determined through competitive bidding. Projects newly enlisted under the FIT scheme will also be prioritized before those enlisted before. The next in line are PV “leader” projects announced by the state; for such projects, the state will guarantee the allocation of 50% of the FIT subsidy payable. For all other projects, the FIT subsidy will be allocated by an equal proportion but with no guarantee of the amount. It is estimated by industry experts that renewable power projects that are enlisted only receive 25 to 30% of the subsidy payable and that a 100% subsidy payment ratio will only be reached until around 2040 (CPNN, 2020).

4.2.2 Waste-to-energy eligibility under the FIT subsidy scheme

There are three subcategories of renewable power projects that have been included in the FIT subsidy list: wind, solar, and biomass. While the bulk of subsidy funding flows to wind and solar projects, biomass still receives roughly 5% of the total subsidy, and most projects that were approved under the biomass category are in reality waste-to-energy incineration projects. Traditional sources of biomass energy, according to the definition by the U.S. Energy Information Administration, include wood processing waste, agricultural crops, animal manure and human sewage, and biogenic materials in municipal solid waste (MSW) (U.S. Energy Information Administration, 2021). Most power plants included under the FIT subsidy list are waste incineration projects that generate electricity from MSW, or better known as garbage. In some developed countries, where an advanced waste recycling system has been operating for decades, the garbage is usually well-sorted for MSW electricity generation to properly achieve its goal of environmental protection. For China, however, a country where a nationwide municipal waste recycling campaign started only in 2019, the composition of MSW is far less optimal for electricity generation.

MSW incineration has been proven to be a more environmentally friendly waste management process than landfills. It is, however, not anywhere close to being considered a renewable energy source for power generation. According to the analysis of L. Wang & Li (2017) on the greenhouse gas emissions of a waste incineration project in Beijing, the net CO2 emissions per unit of waste is 0.165 t, and the electricity generated per unit of waste is 298.27 kWh. We can do a simple calculation here to derive the CO2 emissions per kWh of electricity generated from a sample waste incineration project and arrive at 553.19 g/kWh. This is lower than the predicted CO2 emissions from coal-fired power plants at 796.7 g/kWh but is almost 20 times higher than the average per unit electricity CO2 emissions of solar PV projects, which is predicted at 33-50 g/kWh (Y. Li, n.d.).

If waste-to-energy incineration plants are emitting far more greenhouse gases than clean energy sources, the current approach to subsidize MSW power generation projects under the REDF should be reevaluated for maximum efficiency in resource allocation. According to Luan (2021), by 2021, a cumulative capacity totaling 28 GW of biomass power generation projects have been approved to receive FIT subsidy under the REDF, amounting to a cumulative 99 billion CNY under the subsidy scheme. In reality, the Chinese government has also realized this issue and announced to enforce stricter supervision on emission standards of MSW plants. We can expect the country to cut subsidies for waste-to-energy incineration projects and redirect the resources to wind and solar projects in the future.

4.2.3 Delay in the approval process for FIT enlistment

The red tape in the FIT approval process caused significant delays in subsidy payment to eligible projects. Before 2020, the Chinese central government managed the FIT subsidy list using a catalog system. For inclusion under the FIT scheme, power producers submit an application to the NEA, which verifies the project's status and grants approval. All approved projects within a certain time will be compiled into a catalog and will be publicly notified. It is after the notification when the project will finally start to receive FIT subsidies, or at least, become eligible for FIT subsidies. From 2012 to 2019, a total of seven catalogs were announced by the NEA, covering a cumulative installed capacity of 167 GW. The first four batches of catalogs were announced within a year, while the sixth and seventh catalogs were announced almost two years apart. Taking projects approved during the seventh cycle as an example. The public notification of the seventh catalog was announced on June 11, 2018; however, to meet the application deadline for the seventh cycle, the projects needed to be fully commissioned before March 2016. This means that by the time the project is approved to receive FIT subsidies, it has already been running without financial support for over two years.

Sequence	Added capacity (GW)	Cumulative capacity (GW)	Announcement date
1	0.10	0.10	2012-06-12
2	0.16	0.26	2012-10-15
3	23.53	23.79	2012-12-20
4	23.20	46.98	2013-02-26
5	13.64	60.62	2014-08-21
6	53.75	114.37	2016-08-24
7	53.10	167.46	2018-06-11

Table 5: Renewable energy FIT subsidy catalogs before 2020[9]

[9] Compiled from policy announcements published by the Ministry of Finance.

Acknowledging the delay in the approval process, the Chinese government underwent a reform in 2020 to streamline the administration of the FIT scheme. The catalogs previously controlled by the NEA are replaced by lists of renewable energy projects managed by the provincial grid companies (Ministry of Finance, 2020). Instead of a top-down approach where the central government directly oversees and verifies the projects, the new subsidy management system revolves around provincial power grid companies, leaving the central government with only supervision duties. The new system is also based entirely on an online platform, where power producers register project information, and power grid companies verify project status before submitting the request to provincial and then central governments for final approval. With a more efficient subsidy management system in place, in 2020 alone, ten batches of renewable power projects were approved and included under the FIT scheme. It is estimated by BNEF that by April 2021, a total installed capacity of 566 GW (including the projects previously approved under the catalog system) has been included in the FIT scheme, nearly three times as much as the total installed capacity approved under the catalog system.

The majority of deployed renewable power projects, however, remain untapped by the FIT subsidy. Based on the statistics published by the NEA, by 2020, the cumulative installed capacity of renewable energy has reached 934 GW in China. In contrast, by the end of 2020, only 310 GW of that has been included under the FIT subsidy system (Luan, 2021). The first four months of 2021 have seen a large increase in the capacity of projects approved for FIT subsidy, totaling 256 GW (Luan, 2021).

These newly approved projects, however, are mainly projects commissioned before 2020 but were put on the waitlist for FIT inclusion. As the Chinese government continues to reduce FIT rates for newly approved renewable energy projects, we can expect to see a shrinking number of projects approved for FIT subsidy in the near future. In fact, the Ministry of Finance already issued a notice in 2020 stating that offshore wind and solar thermal projects commissioned after the end of 2021 will no longer be included under the FIT scheme (Ministry of Finance, 2020).

4.2.4 Abandonment of wind and solar resources

Abandonment of wind and solar resources in regions with high generation but low consumption capacity has been a disturbing issue for the government. In 2018, the NDRC issued a document addressing the resource abandonment issue and set annual targets for improvement (NDRC, 2018). The targets for 2018 were to keep wind abandonment rate below 12% and solar abandonment rate below 5%. Both wind and solar abandonment rates should be controlled at below 5% by 2020. By the government's effort, the wind abandonment rate decreased gradually from 17.1% in 2012 to 3.4% in 2020 while solar abandonment rate decreased from 10.3% in 2015 to 2% in 2020 (State Grid New Energy Cloud, 2021). According to a study by Qi et al. (2018), roughly 16% of overall wind generation was abandoned from 2010 to 2016, resulting in an estimated loss of 1.2 billion USD in the opportunity cost of wind generation.

There are four reasons behind wind and solar abandonment, according to the study of S. Li et al. (2017). Firstly, the curtailment can be attributed to the fast-growing development of renewable energy in China. Secondly, S. Li et al. (2017) argue that the deployment of renewable energy power outpaced the construction of grid transmission lines. The other two factors are identified as the incompatibility of renewable energy with the power peak system and the underdeveloped market for renewable energy consumption.

The hyper-development of renewable energy power generation in China during the 2010s could be the leading reason behind the curtailment. In 2012, the cumulative installed capacity of photovoltaics was 4.2 GW. The number skyrocketed to 204.7 GW in 2019, almost increased by 50% in merely 7 years ("Solar Power in China," 2021). Wind power also experienced a high-speed growth during the same period, tripling the cumulative capacity of 75 GW in 2012 to 210 GW in 2019 ("Wind Power in China," 2021). Many power producers went into the business searching for profits and taking advantage of the FIT subsidy scheme, without possessing the key technologies of efficient power transmission or meteorological forecast. In addition, the underdeveloped inter-provincial electricity transmission system could also be an impediment. Since many renewable energy power plants were located in remote areas such as Xinjiang and Gansu Province, without efficient transmission systems, the power either has to be consumed locally or abandoned. Even with solid government support, without a ravenous market to consume, the supply of renewable energy power will eventually exceed the demand and result in overcapacity. The abundance of newly installed power plants widened the gap of deficit in the FIT subsidy scheme and eventually took a toll on the end-users from whom the REDF collected RE electricity surcharge. In light of that, from a perspective of efficient resource allocation, the government should not continue to fund projects which are no longer operative or register an irregularly high abandonment rate. Funding for a project with high curtailment is highly inefficient and wasteful, especially when there are other projects in need of such funding.

4.2.5 Poor Sales Performance of the Green Power Certificates

The GPC has recorded poor sales performance since its first appearance. Inasmuch as the misalignment between the GPC system and the RPS system, as well as the fact that the current RPS system is still in a trial run, sales of GPC depend solely on voluntary action. Although the government intended to brand GPC as an alternative for the FIT scheme, the sales record of GPC has been a complete fiasco. By June 2021, the total number of tradable GPC (wind and solar) approved by the government was 32 million; in other words, 32 million MWh of electricity generated from renewable energy seeks the sales of GPC as an alternative for the FIT subsidy. In contrast, the total number of GPC sold up to date was merely 76 thousand, accounting for 0.24% of the total tradable GPC in the market. Out of the 76 thousand GPC, only 172 were solar GPC. This is because the price of GPC is marked to the cost of power production, and solar power generation is usually more expensive than wind.

Judging from the sales data, whether the sales of GPC can alleviate the financial burden of the FIT scheme is highly doubtful. In fact, some provinces introduced a trading system of excess RE generation to complement the RPS policy in 2021. Although compared to the heterogenous trading markets for excess RE generation, the GPC system has a longer history and better uniformity, it is difficult to judge whether the GPC system possesses a competitive edge due to its poor sales record. It is possible that once a standardized trading system for excess RE generation is introduced nationwide, the GPC system will be forced out of the market and into non-existence.

5 Methods of analysis

5.1 Analytical framework

In this chapter, the author intends to model the economic feasibility of a solar PV project under China's current subsidy policy. There are various methods of analysis to evaluate the revenue and cost balance of a project, for example, LCOE, net present value, and internal rate of return, among many others. In this study, the author will focus on the key financial measurements of the hypothetical project. By using financial models to predict the cash inflows and outflows during the project's life span, the analysis will serve two purposes: 1) provide insights for power suppliers with regards to production optimization; and 2) evaluate the effectiveness of various government policies combining subsidy and alternative incentives with an aim for maximizing the efficiency of public resource allocation.

The author performs an economic analysis using a discounted cash flow (DCF) model, with key model indicators being the net present value (NPV), the internal rate of return (IRR), and the payback period (PBP). The hypothetical project is assumed to be a grid-connected, centralized solar photovoltaic project located in Zhejiang Province of China. As the bedrock of this analysis, the baseline model is established upon the assumptions that no subsidy or any varieties of financial incentives will be granted to the project, nor will the project employ debt financing instruments. Thus, the baseline model forecasts the economic feasibility of the project in the worst-case scenario. When conducting further analysis, additional inputs, such as the subsidy payout ratio and the debt-to-equity ratio, will be annexed to the baseline case to reflect the impact of such parameters on the cost-benefit balance of the project. The implications of changes in key financial measurements will serve to justify the policy recommendations proposed in the later chapters of this thesis. Among many assumptions made in this chapter, the main focus of this model is to evaluate the impact of subsidies under the feed-in-tariffs scheme and propose possible routes of improvements to the administration of that scheme.

The DCF model evaluates the economic feasibility of the project by discounting every future cash flow into the present period, at an interest rate that equates to the time value of money. Then by subtracting the initial cash outflow, which in the case of a power generation project, is equivalent to the initial capital expenditure, the key result is indicated as the net present value of the project. Meanwhile, the internal rate of return is the interest rate at which the net present value of the project is equal to zero, or in other words, the discounted cost and benefit of the project offsets each other and the project yields zero profit. The payback period is the number of years required to recover an initial investment outlay without discounting. Generally speaking, a project with higher NPV and IRR, or lower PBP is more desirable for the investors. The key outputs of this model are based on the following mathematic equations:

$$(1)\quad DCF = \frac{CF_1}{1+r} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n}$$

$Where$:

$DCF = discounted\ cash\ flow$

$CF_n = net\ cash\ flow\ in\ the\ nth\ period$

$r = interest\ rate$

$$(2)\quad NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - initial\ investment$$

$$(3)\quad 0 = CF_0 + \frac{CF_1}{(1+IRR)} + \frac{CF_2}{(1+IRR)^2} + \cdots + \frac{CF_n}{(1+IRR)^n}$$

$Where$:

$CF_0 = initial\ investment\ outlay$

$$(4)\quad PBP = full\ years\ until\ recovery + \frac{uncovered\ cost\ in\ the\ last\ year}{cash\ flow\ during\ the\ last\ year}$$

5.2 Baseline model specifications

To assist the evaluation of the effects of various policy channels, the baseline model removes all policy incentives and financing means, leaving the model to show the cost-revenue balance of the project in the worst-case scenario. It is worth noting that the baseline model is constructed upon certain assumptions that only serve as a foundation for further analysis; it carries no significance in reference to the revenue and cost structure of a project on the ground. Moreover, the assumptions are overgeneralized in order to provide the metrics of an average solar PV project in China. The costs in initial installation, for example, should be adjusted for a real-life project based on the actual development plan.

In the calculations of the baseline model, the following key assumptions are made:

1. The project is a 20 MW grid-connected, ground-mounted, and centralized solar PV plant located in Zhejiang Province;
2. The construction period of the project is one year starting from the beginning of 2019, during which period the total amount of initial investment outlay is expensed and no revenue is generated through the project;
3. The operation period is 30 years starting from the beginning of 2020;
4. The baseline project is financed 100% by equity, and therefore no debt interest payment is expensed;
5. The corporate tax rate is 25%, without taking into account tax deductions for renewable energy power producers;
6. Referring to the CPI index of China by the end of 2019, the inflation rate is assumed to be constant at 3%, applicable to the costs of the project;
7. No subsidy under the FIT scheme is granted to the project during its entire life span; only the revenue from selling electricity is considered
8. The quantitative effects of net-metering and renewable portfolio standards are also not considered.

5.2.1 Generation

To calculate the annual cash inflow of the project, we should first estimate the annual electricity generation of the project. The nameplate capacity, as the name itself suggests, does not equate to the actual generation output of the project. Due to the varying technologies of the solar panels – for example, whether the panels track the sun or not (the tracking feature), or whether there are batteries installed in the system (the energy storage feature) – and other meteorological factors, the actual generation of the project is usually below the maximum output. It is estimated that the capacity factor for an average solar power plant in China is relatively low at 17% ("Solar Power in China," 2021), which will be used as our assumption. The degradation rate translates into less power produced as the system ages. Performance of the panels declines, resulting in a year-on-year reduction in generation level of the modules, due to unavoidable circumstances such as UV exposure and weather cycles (Pickerel, 2017). According to Dhimish & Alrashidi (2020), the degradation rate of photovoltaics is equal to 1.15% a year in Japan, 1.3% a year in the Republic of Korea, and ranges from 0.8% to 1.25% per year in the USA. Since the latitude of Beijing is similar to that of Japan, ROK, and the USA, we will assume that the degradation rate of photovoltaics in China is equal to 1%/year. In addition, we will assume that the total operational days of the project in a year be 360 days, taking into account the days when the solar plant is shut down for annual maintenance or experience irregular power outages.

Based on the aforementioned assumptions, the total generation of the project in the first year of its operation is equal to 20 MW * 17% * 360 * 24 = 29,376 MWh. The generation in the following years will start to take a degradation rate of 1% per annum.

Nameplate capacity	20	*MW*
Capacity factor	17	*%*
Degradation rate	1	*%*
Operational days	360	*days*
First-year generation	29,376	*MWh*

Year	**Period**	**Discount factor (degradation = 1%)**	**Total generation (MWh)**
2019	Construction	-	-
2020	Operation	1.000	29,376.00
2021	Operation	0.990	29,082.24
2022	Operation	0.980	28,791.42
2023	Operation	0.970	28,503.50
2024	Operation	0.961	28,218.47
2025	Operation	0.951	27,936.28

Table 6: Example of total generation in the initial years

5.2.2 Revenue

China implements a FIT scheme for wind and solar power generation, though the administration of which is somewhat different from that in other countries. Under the FIT scheme, the revenue of a solar PV project in China consists of two parts: 1) the revenue received from power-grid companies at a per-unit price equal to that of desulfurized coal power; and 2) the subsidy provided by the REDF that is equivalent to the difference between the benchmark price (or the guide price after 2019) under the FIT scheme and the desulfurized coal power price. As demonstrated in the first equation below, the subsidy amount under the FIT scheme is equal to the FIT price, subtracted by the desulfurized coal power price, which is unique for each province. Since we hypothesize that the baseline project does not receive any subsidy under the FIT scheme during its life span, the revenue of the project is equivalent to the revenue received from power grid companies at the benchmark coal power price. The second formula below shows the discounted total revenue during the base-case project's life cycle.

(1) $P_{FIT} = P_c + P_s$

$Where$:

$P_{FIT} = total\ price\ under\ FIT\ scheme$

$P_c = desulfurized\ coal\ power\ price$

$P_s = subsidy\ under\ FIT\ scheme$

(2) $\Pi = \sum_{t=1}^{n} \frac{Q_t \cdot P_{c,t}}{(1+VAT)\cdot(1+r)^t}$

$Q_t = Q_{t-1} \cdot (1-d)$

$Where$:

$\Pi = total\ revenue$

$Q_t = total\ electricity\ generation\ in\ period\ t$

$P_{c,t} = desulfurized\ coal\ power\ price\ in\ period\ t$

$VAT = value - added\ tax\ rate$

$r = discount\ rate$

$d = degradation\ rate$

For the baseline model, since the project is a 20 MW grid-connected, centralized solar PV plant, 100% of the electricity generated will be sold to the power grid companies at the benchmark on-grid electricity price for desulfurized coal power generation. Zhejiang province, in which the hypothetical project is located, was selected as the demonstration province for a trial run of a pilot policy, which replaces the current standardized coal-fired benchmark electricity price with a floating price consisting of a base price and a margin. The desulfurized coal-power base price, including value-added tax and net of any subsidy, is set by the Zhejiang Provincial Development and Reform Commission at 415.3 CNY/MWh for power generation after 2015.

In July 2019, a new policy was implemented to reduce the rate of value-added tax for the power generation industry from 16% to 13% (Great Wall Securities, 2019).

Theoretically, the value-added tax rate is borne by the consumers who purchase the final product. A change in the VAT rate will affect both revenue and cost of the power producer proportionally, and therefore should be a straight pass-through with no impact on the profitability of the project. On the revenue side, this new policy reduces the first portion of the revenue received by power producers, to an extent that can be calculated as 415.3 CNY/MWh - 415.3 CNY/MWh * (1 + 13%) / (1 + 16%) = 10.7 CNY/MWh. The updated coal-power base price, including VAT, should be 415.3 – 10.7 = 404.6 CNY/MWh.

Pursuant to a policy announced by the Zhejiang Provincial Development and Reform Commission in December 2019 to further reduce the base price of desulfurized coal, another 3.4 CNY/MWh should be subtracted. Unlike other provinces in China, where a unified coal-fired electricity benchmark price is stipulated for any project connected to the grid, Zhejiang province allows a 10% premium above the base price and a 15% discount below the base price. It is for that reason, each coal-fired power plant has a different on-grid electricity price, but within the range of the prescribed cap and floor. For the simplicity of the analysis here, the author will subtract another 3.4 CNY/MWh from the coal-power base price after the reduction in the VAT rate, rendering a current base price of 404.6 – 3.4 = 401.2 CNY/MWh. The baseline model refers to this rate as the current desulfurized coal power price, ignoring the effect of the floating price mechanism. Since the revenue gained by power producers through selling electricity to power grid companies is net of value-added tax, the actual per-unit gain on electricity sales, without the FIT subsidy, is 401.2 CNY/MWh / (1 + 13%) = 355.04 CNY/MWh.

The discount rate, or the required rate of return, is another key assumption in the DCF model that could significantly inflate the project NPV. It is referenced as the minimum rate of return that the investor would accept based on the particular risk profile of the project. Based on prior research, the discount rate of solar PV projects in European countries usually takes 5% (Cucchiella et al., 2017); the rate in China, however, should be higher considering the lower bankability of projects in a developing economy. Yuan et al. (2014) stated in their research that, according to the Beijing Municipal Commission of Development and Reform, the benchmark required rate of return for a traditional power production project in China was 8%; nonetheless, in light of a higher risk associated with the development of a solar PV project, they have adjusted the required rate of return for a solar plant to 10%. Given that the benchmark interest rate of commercial long-term loans in China is around 5% (China Construction Bank, 2015), and that the required rate of return should exceed the cost of financing, the author verifies that 10% is plausible and will use the number as the hypothetical discount rate in the baseline model.

5.2.3 Capital costs

Capital cost is an item of one-time initial capital expenditure on the planning, construction, and development of the project. In project finance, it is usually termed

CAPEX, or initial capital expenditure. CAPEX is the largest cash outflow in the project's life cycle; it usually can take up over 50% of the total expenditure. The CAPEX of a photovoltaic project consists of two major categories: the hard costs and the soft costs. In the hardware cost category, the cost of solar modules is usually the largest bulk of costs for a project. Other hardware may include the inverter, mounting materials – or solar module racking that is used to fix solar panels on surfaces – and other electronics such as cables, ICT devices, and compact substations. The soft costs of developing a project can come from designing and planning, installation cost, shipping equipment, grid connection work, securing permits for land, headcount costs, and etc.

The table below provides an estimated breakdown of the average capital expenditure of a >10 MW grid-connected, ground-mounted, centralized photovoltaic project commissioned by the end of 2019. The costs are estimated on a per watt nameplate capacity basis, and the impact of value-added tax is assessed at the bottom. It is also worth noting that the types of hardware, such as module and inverter, vary significantly across manufacturers; therefore, the table can do no better than provide a generalized view of the project's costs. The costs of hardware for solar PV plants have also declined drastically during the past decade and are continuing to drop as technology improves. The author will use the 2019 national average estimated by the IEA for the cost of modules to represent the largest expenditure in CAPEX. Since Zhejiang province falls under the third resource category of solar development, which receives the highest feed-in-tariff rate among all three regions on account of higher costs on average, the actual cost structure of a project located in Zhejiang should fall on the higher end of the spectrum. With that said, the author will not adjust the costs for the proposed project upwards due to the absence of a reasonable basis, but it is worth emphasizing that, on average, the economic feasibility of an actual project should seem less propitious than the one proposed in this study.

Cost category		Average (CNY/W)	Share in total investment (%)
A	**Construction and equipment**		
1	Module	1.681	40.55%
2	Inverter	0.177	4.27%
3	Mounting material	0.265	6.39%
4	Other electronics (cables, etc.)	0.885	21.35%
Subtotal		**3.008**	**72.55%**
B	**Soft costs**		
1	Planning and design	0.047	1.13%
2	Installation work	0.367	8.85%
3	Shipping expenses	0.018	0.43%
4	Permits and commission	0.046	1.11%
5	Project margin	0.183	4.41%
Subtotal		**0.661**	**15.94%**
Total (excl. VAT)		**3.669**	**88.50%**
Average VAT	(equal to 13% of total cost excl. VAT)	0.477	11.50%
Total (incl. VAT)		**4.146**	**100.00%**

Table 7: Initial cost structure

Source: 1) IEA, 2020b; 2) the average VAT is calculated based on the 2019 policy in Zhejiang Province to reduce the rate of VAT down to 13% for the power generation industry.

For our baseline model of a 20 MW centralized PV system, the CAPEX of the project is estimated to be 3.669 CNY/W * 20 MW = 73.38 million CNY. It is worth noting that in reality, the VAT is levied on the initial investment outlay and reimbursed by the consumers when the project starts operation. Since the construction period of the proposed project only takes one year, the time value of money will not have a material impact on the project's profitability, and therefore we will exclude VAT in both cost and revenue calculations. Since we ignore the effect of debt financing in the baseline model, we will assume that the total CAPEX of 73.38 million CNY is drawn down in the first year, financed 100% by equity.

5.2.4 Operational expenditure

The operation and maintenance cost, or better known as OPEX in project finance, is an annual expenditure during the operation period of the project. It is a key component of a solar plant, as ensuring the quality of operation and maintenance serves is essential to mitigate potential risks of the project (IRENA, 2019). It consists of annual maintenance of equipment and facilities, cleaning fees, insurance, and etc. Based on a previous study by Yuan et al. (2014), the OPEX in the first year after project commission will be set to equal 1% of the total initial investment. In the following years during the project's life span, annual inflation will be added to the OPEX cost to adjust for changes in the price level. In this study, the author will use China's CPI index for the year 2019, which rose 2.9% compared to the previous year, as a proxy for the inflation rate (Xinhua News, 2020a). In conclusion, the annual inflation is assumed to remain constant at 3% during the project operation cycle.

Year	Period	Discount factor	OPEX
2019	Construction	-	-
2020	Operation	1.00	733,800.00
2021	Operation	1.03	755,814.00
2022	Operation	1.06	778,488.42
2023	Operation	1.09	801,843.07
2024	Operation	1.13	825,898.36
2025	Operation	1.16	850,675.32

Table 8: OPEX for the initial years since project operation

5.3 Debt financing

For the next steps, we will start to insert key inputs to analyze the impact of various policies on the economic feasibility of the project. As discussed above, debt financing is an integral part of developing a solar PV project. Utilizing debt can lower the cost of capital, boost the IRR to equity, and shorten the payback period of the project. More debt equates to lower cost and higher profitability to the equity investor, but the lenders usually demand a certain ratio of equity investment because that way, their interests are better protected in an event of business decline. The Chinese government stipulates that for a fixed asset investment project in the power sector, at least 20% of the initial investment should be funded by equity (State Council, 2015). Such a ratio, however, is unlikely to be achieved by private-owned enterprises due to their insufficient credit history compared to state-owned enterprises; a minimum equity ratio of 30% is usually demanded by lenders for private-owned enterprises (CPIA, 2020). Taking heed of the minimum equity ratio, the author created four scenarios to be compared with the baseline model. The selected equity ratio ranges from 20% (the lower bound as prescribed by the Chinese government) to 100% (the assumption in the baseline case). In addition, all other hypotheses, such as no FIT subsidy during the project's life span and no tax break for renewable energy power producers, remain the same as the baseline model.

There are different types of debt depending on the format of repayment. Here we will assume the debt is mortgage type, which means a fixed amount of annuity that includes both interest expense and principal repayment is made each year. The other type of debt that is very often used for renewable energy projects is debt sculpting. In debt sculpting, the principal and interest obligations are calculated to match the strength of net operating income in each year. In such a case, a fixed debt service coverage ratio (DSCR) – the ratio of net operating income in each period over total debt service in the same period – is given throughout the debt tenor. It is difficult, however, to find an industry average DSCR ratio for the power generation sector. On the other hand, the mortgage type of debt is contingent only on two assumptions: debt tenor and the cost of debt. Since both have readily available industry average data, here the author will structure the debt using the mortgage type.

According to industry information, the standard tenor of debt for solar projects is within 15 years (CPIA, 2020). Since we make no assumptions on the creditworthiness of the producer, we will use the standard 15 years as the tenor of debt in our model. The cost of debt, conversely, can be very different depending on project specifics. According to the Industrial and Commercial Bank of China, one of the major commercial banks in China, the interest rate of long-term commercial loans over 5 years is set at 4.9% (Industrial and Commercial Bank of China, 2015). Based on previous studies and taking into account the associated risks of a 15-year loan for a solar PV plant, we will adjust the standard long-term interest rate upwards to 6% as the hypothesis in this study.

5.4 Preferential tax policy

Based on enterprise income tax law effective from January 2008, renewable energy project developers enjoy income tax exemption for the first three years of project operation, followed by another 3 years with a preferential tax rate of 12.5%, compared to the benchmark tax rate of 25% (BNEF, 2021).

The preferential tax policy, coupled with the standard accounting treatment for net operating loss carryforward (NOLC), however, only plays a minor role in assessing the profitability of the project. Net operating loss carryforward is a beneficial policy that exempts a company from corporate income tax burdens if the entity had experienced a substantial net operating deficit in the previous fiscal year. The net income loss can be carried forward into the subsequent periods to offset the company's taxable income, but the NOLs usually cannot be extended indefinitely into the future. According to Article 18 of the Enterprise Income Tax Law of the People's Republic of China amended in 2018, the Chinese government allows a maximum of 5 years for NOLC. The project in this model renders an NOL in the construction period due to the initial investment expenditure, which can be carried forward for 5 years, deducting the taxable income in the first 5 years of the project's operation. Consequently, the preferential tax policy for renewable power producers is, in effect, inefficacious to the project during the first 5 operational years. With that said, the 12.5% preferential tax treatment is applicable on the 6^{th} year of the project's operation, when the project is no longer qualified for NOLCs.

In this analysis, the preferential tax policy is applied to the project after factoring in debt financing. With a comparative analysis, the author intends to discover the impact of a tax holiday on projects with different debt structures, namely, on the baseline model and 4 other scenarios in the previous analysis, with a debt ratio of 30%, 50%, 70%, and 80%, respectively.

5.5 Subsidy under the FIT scheme

The per-unit price of electricity under the FIT scheme consists of two parts: the benchmark price of desulfurized coal power and the price-gap subsidy that is equal to the difference between total FIT price and the benchmark coal price. The second portion is paid through the REDF and allocated by the Ministry of Finance. The NEA maintains a list of approved projects for FIT subsidies, and adds new projects into the list periodically after verification. Only those projects approved by the NEA to receive the FIT subsidy are eligible for the second portion of revenue, whereas those not enlisted or those experiencing a delay in FIT subsidy payment only receive the first portion of revenue equivalent to the benchmark coal power price. The FIT subsidy is paid out to power producers annually via the REDF for a maximum of 20 years since grid connection (Ministry of Finance, 2020e).

The approval and maintenance of the list of eligible projects by the NEA were redundant and inefficient, frequently resulting in delays in the approval process and in subsidy payments. With an aim to streamline the process, China's Ministry of Finance released a document in 2020 changing the previous catalog system to a list system for the management of eligible projects (Ministry of Finance, 2020b). The document, however, not only benefited renewable power producers by rationalizing the list management but also enforced a stricter rule on the criteria of solar projects for approval under the FIT scheme. The document states that, in order to qualify for FIT subsidies, conventional centralized solar projects should have been fully connected to the grid before July 2017, but the deadline for photovoltaic leader projects and other solar projects whose prices are determined through bidding can be extended to the end of 2019 (Ministry of Finance, 2020b). Likewise, it also sets a due date for conventional wind projects by the end of 2019. With a sunset clause under which centralized renewable energy projects will not receive FIT subsidy starting from 2020, this policy announcement calls a halt to the universal FIT scheme and ushers in the era of competitive bidding and grid-parity for renewables. Nevertheless, this does not intend to forbid all newly commissioned renewable energy plants from accessing FIT subsidies. In fact, although the document raised an outcry among the industry, especially among those who only just entered the market expecting the business to be lucrative, the true purpose of this policy is to foster a healthy market competition in light of the decreasing costs for renewable power generation and reward producers who can achieve near grid-parity.

Against the backdrop of a gradually reducing total price of FIT, in the first half of 2020, 295 newly commissioned centralized solar PV projects out of 346 applicants were approved for inclusion under the REDF subsidy list, with the total FIT price determined through a bidding process (NEA, 2020b). The lowest price among approved solar PV projects is 242.7 CNY/MWh and the average year-on-year reduction in bidding price is 78.5 CNY/MWh. However, the approved projects are geographically concentrated in 15 provinces and municipalities, channeling funds into only half of China’s administrative regions. Zhejiang province registered 25 approved projects in 2020, totaling an installed capacity of 2.5 GW. On top of that, the highest bidding price among projects approved in Zhejiang Province is 449.3 CNY/MWh – well below the official FIT for the third resource region at 490 CNY/MWh.

5.5.1 Basic assumptions

The operation of the project, as stated, is assumed to start at the beginning of 2020, following a one-year construction period in 2019. This assumption is made in line with the sunset clause on the phaseout of renewable energy FIT subsidy that precludes centralized PV projects commissioned after the end of 2019 from the FIT scheme. The author hypothesizes that the project is enlisted at the beginning of the first operational year, without any delay in the application and approval process.

Given the fact that the total FIT price was determined through bidding after 2019, and that the actual bidding prices for solar PV projects approved in 2020 are poles apart, to pose a one-fit-for-all assumption on the amount of FIT subsidy is a great challenge. Since the main emphasis of this paper rests in assessing the impact of a subsidy payment delay on the economic feasibility of renewable power projects, the author will refer to the highest approved tender price in 2020 so as to display the impact in the most conspicuous way. As the highest tender in 2020 was priced at 449.3 CNY/MWh, the author will assume the total FIT price to be its approximate, 450 CNY/MWh. We have seen in Chapter 4 that the FIT subsidy paid to power producers is net of value-added tax, or subsidy paid = subsidy payable / (1 +

value-added tax). Therefore, the final FIT subsidy received by the power producer should be (450 – 401.2) / (1 + 13%) = 43.19 CNY/MWh.

In the assessment of the impact of FIT subsidy, the author will assume that the proposed project is funded 30% by equity and 70% by debt, which is allegedly the standard capital structure for a renewable energy plant owned by private developers. The repayment of debt is also assumed to be the mortgage type. In addition, all assumptions with regards to corporate income tax, such as NOLC and preferential tax policy for renewable energy projects, still hold for the analysis here.

5.5.2 Subsidy payout ratio

Owing to the inefficient administration of the REDF, the subsidy payment under the FIT scheme has been most often delayed and curtailed. Although the REDF was established with an aim to stimulate renewable energy production, in practice, the REDF has been channeled into causes other than providing funding for the FIT scheme. In this section, the author intends to assess the extent to which a delay in FIT subsidy payment damages the economic feasibility of a centralized solar PV project located in Zhejiang Province. Two cases are created to contrast the key financial measurements of the project with full FIT subsidies paid in time and with curtailed and delayed subsidy payments.

Under the first scenario, the full FIT subsidy payments are granted in a timely fashion throughout the project’s life span. In this case, the project should be able to reap the benefits of the FIT scheme to its utmost. The annual subsidy under the FIT scheme paid to the project owner for a maximum of 20 years, net of value-added tax, should be constant at 43.19 CNY/MWh. In contrast, the second scenario models a curtailed payment under the FIT scheme due to the enlarging deficit in the REDF. Moreover, the curtailment in subsidy amount will also render a prolonged payment schedule, whereby the overdue subsidy payment will be remunerated to the power producer beyond the 20-year time frame.

To improve the accuracy of the analysis here, instead of hypothesizing a constant subsidy payout ratio throughout the project's operational years, the author will use the CREST model generated by Luan (2021) to provide a more dynamic view of the subsidy payment schedule. The model is based on a 2020 national policy, which prescribes that any payment from the REDF will be determined on a cost-revenue balance basis (Ministry of Finance, 2020a). In other words, the subsidy payout ratio is proportionate to the income from renewable energy electricity surcharge collected from electricity consumers.

The CREST model provides the historical trend and a forecast of both the yearly supply and demand of the FIT subsidy for renewable energy from 2012 to 2050. On the supply side, the REDF is funded by the RE electricity surcharge collected by two types of power consumers: commercial and industrial consumers, and agricultural and residential consumers. The RE surcharge rate on the former type of consumers was hiked four times from 2006 to 2016 and has remained at 19 CNY/MWh since the last upward adjustment in 2016. The RE surcharge rate on the second type of consumption, contrarily, has remained constant at 1 CNY/MWh. Based on actual electricity consumption data by segment, and with a forecast of power demand growth going forward into 2050, the CREST model configures an estimate of annual subsidy supply from 2012 to 2050. In the meantime, the annual demand of subsidy is contingent on the number of projects approved each year, and the capacity thereof. Dividing the total yearly demand by the total supply, the FIT subsidy payout ratio is then calculated in accordance with the cost-revenue balance principle prescribed by the state government.

As stipulated by the Chinese government, renewable energy projects will be eligible for FIT subsidies for a maximum of 20 years since grid connection. However, since the REDF is currently experiencing a widening gap in funding, projects enlisted after 2019 might experience significant delays in FIT subsidy payment in the initial years of operation. In addition, the payout percentage should register a j-curve that bottoms out in two to three years following the first subsidy payment and gradually increase in the subsequent years, in view of the fact that over 60% of projects by capacity currently under the subsidy list were enlisted between 2020 and the first half of 2021. The demand for subsidy should peak by around the end of 2021, as a result of the subsidy phaseout for centralized PV projects. On this account, the following table presents a j-shaped curve of payout percentage as discussed. Although in an ideal scenario, the full amount of subsidy is paid within a maximum of 20 years, the model allocates delayed subsidy payment into later years and thereby smooths capital inflow during the project’s full life cycle.

Times	Operation	Payout ratio
2020	Op Yr 1	47%
2021	Op Yr 2	17%
2022	Op Yr 3	18%
2023	Op Yr 4	23%
2024	Op Yr 5	25%
2025	Op Yr 6	31%
2026	Op Yr 7	34%
2027	Op Yr 8	36%
2028	Op Yr 9	39%
2029	Op Yr 10	42%
2030	Op Yr 11	44%
2031	Op Yr 12	46%
2032	Op Yr 13	50%
2033	Op Yr 14	53%
2034	Op Yr 15	59%
2035	Op Yr 16	66%
2036	Op Yr 17	79%
2037	Op Yr 18	86%
2038	Op Yr 19	97%
2039	Op Yr 20	114%
2040	Op Yr 21	126%
2041	Op Yr 22	138%
2042	Op Yr 23	138%
2043	Op Yr 24	139%
2044	Op Yr 25	139%
2045	Op Yr 26	139%
2046	Op Yr 27	138%
2047	Op Yr 28	38%
2048	Op Yr 29	0%
2049	Op Yr 30	0%

Table 9: Subsidy payout ratio by year

Source: Luan (2021)

6 Results and Conclusion

6.1 Baseline model results

Assumptions

η	Capacity factor	17	*%*
E_{cap}	Nameplate capacity	20	*MW*
$Days$	Operational days	360	*days*
d	Degradation factor	1	*% p.a.*
P_c	Desulfurized coal power price	401.2	*CNY/MWh*
$CAPEX$	Initial capital outlay	73,380,000	*CNY*
$OPEX$	Annual operational outlay	733,800	*CNY*
π	Inflation rate	3	*%*
r	Discount rate	10	*%*
VAT	Value-added tax rate	13	*%*
r_{tax}	Corporate income tax rate	25	*%*

Output

IRR	Internal rate of return	9.40	*%*
NPV	Net present value	(3,078,120.10)	*CNY*
PBP	Payback period	9.93	*Years*

In the baseline model, the corporate income tax rate is assumed to be 25%, without considering the impact of a tax break for renewable energy power producers. The effect of net operating loss carryforward (NOLC) is also taken into account, consistent with China's income tax law. NOLC is a policy that allows negative income in the previous fiscal year to offset any taxable income in future periods. China's corporate tax code allows a maximum of 5 years for NOLC, which means the deferred tax asset can be carried forward to offset a positive net income in the nearest 5 future periods. When we factor in the effect of NOLC, the result of the baseline model shows an IRR of 9.40%, lower than the required rate of return at 10%. Therefore, the NPV for this project is also negative, totaling a 3.1 million CNY deficit.

Both IRR and NPV are useful measurements of investment return, but the two methods focus on different aspects of the project. The NPV method is biased towards cash flows in the nearer time periods, whereas the IRR method presents a more holistic view of the project's profitability during its entire life cycle. Since the project in question incurs a large investment outlay in the first period, the NPV is naturally biased towards the initial cash outflow. In addition, the undiscounted payback period for this project is 9.93 years, which means it will take almost 10 years to repay the initial investment outlay.[10] It is worth noting, however, that a solar PV project financed 100% by equity is nearly impossible in practice. Since a photovoltaic project requires a large sum of initial capital expenditure and the payback period is extended, debt financing is very often utilized to lower the cost of investment. The project will demonstrate more a promising financial position when lenders contribute to the project because debt is usually cheaper than equity.

[10] The payback period takes into account the construction period. In other words, the calculation starts from the year the loan is drawn down.

6.2 Debt financing results

Assumptions

r	Interest rate	6	%
T	Tenor	15	Years
$\frac{D}{D+E}$	Debt ratio	Various	%

Output

Case		Output				
number	name	Debt ratio (%)	Equity ratio (%)	IRR (%)	NPV (CNY)	PBP (yrs)
1	Baseline	0%	100%	9.40%	(3,078,120.10)	9.93
2	V1	30%	70%	11.00%	3,857,727.47	9.09
3	V2	50%	50%	12.86%	8,481,625.85	8.14
4	V3	70%	30%	16.63%	13,105,524.23	6.44
5	V4	80%	20%	20.45%	14,928,718.24	5.35

The debt financing analysis depicts the impact of the debt ratio. As expected, the four sensitivity scenarios, where varying ratios of debt are used to fund the project, show a higher equity IRR and higher NPV than the baseline model. As the result indicates, when the project is funded 13% by debt, the NPV is calculated as zero. This means that for the project to generate a positive return to the equity investors, at least 13% of the initial investment outlay should be financed by debt. It is also obvious that as the debt ratio increases, the equity IRR increases along with the project NPV, whereas the PBP decreases. This is because the lenders usually expect a lower return than equity investors, in exchange for more protection under uncertain circumstances. By utilizing debt financing effectively, the project owner can generate a higher return.

Although a higher debt ratio translates into higher profitability for the project owner, a minimum equity share is usually required by national law. The Chinese government stipulates a minimum of 20% equity investment for renewable energy power projects. However, due to credit constraints, private-owned projects are usually subjected to a minimum of 30% equity investment. The difference between an equity ratio of 20% and 30% renders a gap between the IRR of 20.45% and 16.63%.

6.3 Preferential tax policy results

Assumptions

r_{tax_nor}	Normal tax rate	25	%
r_{tax_red}	Reduced tax rate (4th-6th year of project operation)	12.5	%
r_{tax_null}	Tax exemption (1st-3rd year of project operation)	0	%

Output

Case	Debt ratio	Original IRR	IRR + tax break	Increase
1	0%	9.40%	9.52%	1.32%
2	50%	12.86%	12.99%	1.03%
3	70%	16.63%	16.78%	0.91%
4	80%	20.45%	20.85%	1.98%

The tax holiday policy, surprisingly, does not have a significant impact on the profitability of the project. According to the state government, a tax break should ideally serve as an alternative stimulus for the development of renewable energy production. However, due to the treatment of NOLC, the benefit of a tax break is trivialized. The above output table presents a comparison of equity IRR before and after the introduction of a tax break for two otherwise identical scenarios. As can be seen from the table, the benefit of a tax break on the equity IRR is marginal. The increase in IRR after the application of the preferential tax policy is around 1% for projects with various debt structures. This is because large infrastructure projects require a large sum of cash outflow in the construction period. The NOL in the construction year usually carries into the operational years. In reference to an upper limit on NOLC, the proposed project can still benefit from the tax holiday in its 6th year of operation. However, since the reduction in corporate income tax rate is only 12.5% in the 6th period, the impact of the tax holiday policy on the project's economic feasibility is minimal.

In addition, projects with a higher debt ratio generally benefit less from the tax holiday. This is because a project financed with more debt generates less gross income during the operational years, in return for a lower initial investment outlay for equity investors. As the size of taxable income decreases, the reduction in tax expense also decreases, resulting in a less significant impact of the tax holiday on projects with a higher debt ratio. However, when the project is financed 80% by debt, it starts to generate positive net income in the 5th operational period, and therefore the tax holiday policy demonstrates the highest impact on the project with an 80% debt ratio.

6.4 FIT subsidy results

Assumptions

P_c	Coal power price	404.6	*CNY/MWh*
$P_s{}'$	FIT subsidy (incl. VAT)	48.8	*CNY/MWh*
P_s	FIT subsidy (excl. VAT)	43.19	*CNY/MWh*
VAT	Value-added tax rate	13%	*%*
$\frac{D}{D+E}$	Debt ratio	70	*%*

Output

	Total	Actual	Change
Equity IRR	21.91%	18.40%	-16.05%
NPV	22,523,477.45	17,096,005.45	-24.10%
PBP	5.03	6.04	1.01

The analysis of subsidy payment under the FIT scheme, as anticipated, depicts a significant adverse effect of delayed subsidies on the project's economic feasibility. The output table compares the key financial indicators of the two scenarios – full and timely subsidy payments in each period and curtailed payment with a prolonged timeline due to the delay. As evidenced in the output table, the equity IRR of the project when the FIT subsidy is granted in a timely manner is recorded as 21.91%. In contrast, when the project is subsidized with only a curtailed amount, the equity IRR is 18.4%, with a 16.05% decrease from the upper-case scenario. The NPV of the project is also considerably larger if the project could receive the promised amount of subsidy when the payment is due. If the subsidy payout ratio is contingent on the cost-revenue balance principle, the NPV of the project will record a 24.1% reduction than in the ideal situation. In addition, if the payment is delayed, the undiscounted payback period will be extended by 1.01 years, which means the project will continue to register a cumulative income loss for an additional year.

In light of the above discussion, we can safely conclude that the delay in subsidy payment under the FIT scheme and a reduction in payout ratio will substantially injure the financials of the project. Although the decline in equity IRR might seem to be within the comfort zone in absolute terms, one cannot neglect a reduction in NPV that is over 24%. On top of that, extending the payback period for another year will no doubt hurt the bankability of the project. On one hand, a prolonged payback period means the project owner will have to wait longer to achieve the break-even point of their investment and have to survive the cumulative operating loss for an additional year. On the other hand, a longer payback period may discourage investors who have liquidity concerns. Since a renewable energy plant requires a large amount of capital expenditure, many things could potentially go wrong and result in an unrecoverable investment.

There are many key assumptions that could potentially change the magnitude of the worsened profitability here. For example, the NPV method is very sensitive to the assumption of the discount rate. Since a large bulk of the delayed subsidy payment is recovered during the later years of the project's operation cycle, a higher discount rate could lead to a smaller present value of the subsidy revenue, and thereby a wider gap in NPV calculation. Moreover, the per-unit price of FIT subsidies also plays an important role. By imposing competitive bidding on newly commissioned projects, the Chinese government is fostering a market-oriented pricing mechanism for renewable power plants. The subsidy portion under the FIT scheme, in excess of the benchmark coal power price, has been decreasing against the backdrop of the government's endorsement for RE grid-parity. In light of a decreasing FIT subsidy, the adverse effect of a reduced payout ratio could be shrinking as well.

7 Policy Recommendation

In the previous chapters, the author modeled the impact of various government policies on the economic feasibility of a centralized solar PV project located in Zhejiang Province, China. Such analysis outperforms descriptive analysis of policy interventions and strives to provide quantitative reasoning in favor of or against China's various state policies on the FIT scheme. By comparing the variations in a set of profitability measurements, the effects of different policy channels can be visibly demonstrated and contrasted on an equal footing with one other.

In reference to the output results of the model, the author concludes with four policy recommendations to complement the current policy on renewable energy power generation: 1) bridge the gap between the supply and demand for subsidy under the FIT scheme by improving the economic and operational efficiency of the REDF; 2) generate more revenue streams into the REDF by reallocating public resources from fossil fuel subsidies; 3) supplement the phaseout of the FIT scheme with the introduction of effective alternatives, and 4) renewable projects should be closely monitored for the abandonment rate of resources. All such policy recommendations as mentioned are built upon the Chinese government's resolution to transform the energy mix and promote the share of renewables in the energy mix. In 2019, the top 10 countries with the highest share of renewables in the primary energy mix registered a percentage of renewables from 16.98% to 9.98%. China, on the other hand, recorded the renewable energy share as 4.68% of the primary energy mix in the same year (Y. H. Zhang, 2021). To achieve a transformation in the energy consumption structure, interaction of multiple policy channels is required.

7.1 Improve the efficiency of the REDF

The REDF, being the main source of supply for renewable energy subsidy under the FIT scheme, has been running a deficit that continues to expand. The deficit, on one hand, signals a growing demand for FIT subsidies resulted from the exponential development of renewable energy power production. But more importantly, on the other hand, the growing deficit discourages further development by squeezing the profit margin for power producers. As it has been pointed out, the NPV for a project that satisfies all assumptions made in this analysis only becomes positive when the project can secure over 13% of debt in the initial investment outlay. Such requirement on the financing structure presumes certain history of credibility demonstrated by the project owner and therefore precludes newcomers from making profits in the industry.

In light of the principle set by the government that the subsidy payout ratio is determined on a cost-revenue balance basis, or more specifically, by the collection rate of the RE electricity surcharge, the key issue here boils down to how to improve the administrative process of the REDF. The author proposes several refinements to the functionality of the REDF. Firstly, since the FIT subsidy is, in effect, borne by electricity end-users in the form of a per-unit RE electricity surcharge, the collection rate of such surcharge should be raised through more effective enforcement and heavier regulations. Secondly, the verification and approval process of enlisting power generation projects for subsidy should be streamlined to ensure payment in a timely fashion. Thirdly, as the RE electricity surcharge in China only accounts for a minimal percentage of total electricity bill compared to other industrial economies, the Chinese government should consider raising the surcharge rate again. Last but not the least, the use of REDF should be subject to public scrutiny to make sure every penny is spent on the promotion of renewable energy development, as is suggested to be the sole purpose of the fund.

To start off, a more effective regulatory and enforcement mechanism is required to increase the collection rate of RE electricity surcharge. Although the surcharge rate on agricultural and residential use of electricity has remained at 0.001 CNY/kWh, the surcharge rate on commercial and industrial electricity use has been raised several times from 0.008 CNY/kWh to 0.019 CNY/kWh during 2006 and 2016. The rise in RE surcharge rate was enforced to remedy the REDF's growing deficit, which was registered at 55 billion CNY in the first half of 2016 (Reuters, 2016). While the surcharge rate has not been further raised, the deficit in the REDF continued to grow and reached 233.1 billion CNY by the end of 2018 (B. Li, 2019). Although industry experts have researched the possibility of further hiking the premium rate to 0.029 CNY/kWh, the NDRC circumvented the idea in its reply to the proposal (Chen, 2019).

As has been discussed in the previous chapters, the main reason behind the widening budget deficit is the inadequate collection rate of RE electricity surcharge –

only around 60% of the surcharge payable has been effectively collected during 2012 and 2018 (China Everbright Securities, 2019). Based on a tripartite government document, there are four channels of electricity sales on which a RE surcharge is levied: direct sales of electricity from power generators to large consumers, sales through independent local power grid companies, self-consumption of electricity prosumers, and other sales through regional power grid companies (Ministry of Finance, 2011). The second and the third channels are often loosely regulated, leading to a low collection rate of RE electricity surcharge. Due to the particular characteristics of off-grid electricity prosumers, it is difficult for the government to regulate their use of electricity. The oversight responsibility of collecting such RE surcharge, therefore, should be shared among the government, relevant stakeholders, and the public.

Secondly, the government should make every effort to guarantee timely payment to projects qualified for receipt of FIT subsidies. Prompt payment to the project, as has been demonstrated in the model, translates into significantly higher NPV and a shorter payback period. Delay in payment, in contrast, can have an adverse effect on the profitability of the project, resulting in a 24.1% decrease in the NPV of the proposed project. In consideration of such consequences, it is necessary that the government further streamline the verification and approval process for project enlistment under the REDF to ensure prompt payment of FIT subsidies.

Recognizing the delay in the approval process, the government took the first step to streamline the bureaucracy. The Chinese central government announced in January

2020 that the catalog system for managing renewable energy subsidy list will be changed to a list system (Ministry of Finance, 2020c). Under the old catalog system, the project owners directly submit applications to the NEA website, with the central government performing the majority of verification duties. Newly approved projects within a certain period, expanding from months to even years, are compiled into a catalog. Once the catalog is made public, the projects are officially included under the FIT scheme. From 2012 to 2018, a total of 7 catalogs were published, covering an installed capacity of 167 GW (China Everbright Securities, 2019). Those catalogs were approved with a large time gap between one another, the farthest being 22 months apart (China Everbright Securities, 2019). What that means is, once a project misses the submission deadline for the last catalog, it will have to wait for another 22 months before it could be officially included under the subsidy list.

The new list system reduces the burden on the central government by assigning most verification duties to the regional power grid companies and provincial energy departments. The power producers submit applications to the regional power grid company for the first round of screening, which is then passed on to the provincial energy department for a re-examination. After two rounds of initial screening, the application will be eventually presented to the central government for final confirmation (*Policy Graph*, 2021). At the time of writing, there have been 10 lists approved in 2020 and 9 lists approved in 2021 (*Policy Graph*, 2021). Before the list system was introduced in 2020, solar projects included under the subsidy list only account for 24.6% of all commissioned solar projects by total installed capacity

(China Electricity Council, 2020). Similarly, for wind, the capacity that is covered by subsidy makes up only a portion of the total installed capacity by the end of 2019, at 66% (China Electricity Council, 2020). In 2020 and 2021, the new list system prompted a surge in the number of newly approved projects; many eligible projects in stock that were waitlisted finally received approval for enlistment. By the end of the first quarter in 2021, the proportion of renewable energy projects included under the subsidy accounts for 59.7% of total renewable projects by installed capacity.[11]

Although the reform in the subsidy list management has allowed more projects to enjoy the benefit of the FIT scheme, there is still room for policy improvement. The 19 lists published after the initiation of the new list system are not exhaustive; there are eligible projects in stock that have been waiting in line but yet to receive the first payment of promised subsidy. In addition, viewing from a different angle, as more projects in stock are approved for receipt of subsidy, more pressure is put on the government to effectively manage the widening funding gap in the REDF. If the government fails to inject fresh revenue streams into the REDF, the loss will be eventually borne and shared by each project owner in the form of a shrunken subsidy payout ratio.

Thirdly, the government should consider hiking the RE electricity surcharge rate to fill the funding gap in the REDF. The current RE surcharge rate on industrial and commercial consumption has not been raised since 2016, while the current rate on residential use has remained at 0.001 CNY/kWh since initiation. The graph below

[11] The data on the total installed capacity of renewable energy is from NEA (2021). The data on capacity included under FIT is extracted from Luan (2021).

demonstrates the per-unit RE surcharge as a percentage of total electricity tariffs in three administrative regions of China. Although the electricity pricing system varies among different regions, some more complex than others, the graph provides a general depiction of the burden of RE surcharge on end consumers. In the above-mentioned three administrative regions, residential RE surcharge takes up less than 0.2 percent of the total per-unit electricity price, whereas industrial RE surcharge accounts for roughly 3% of the total electricity tariffs.

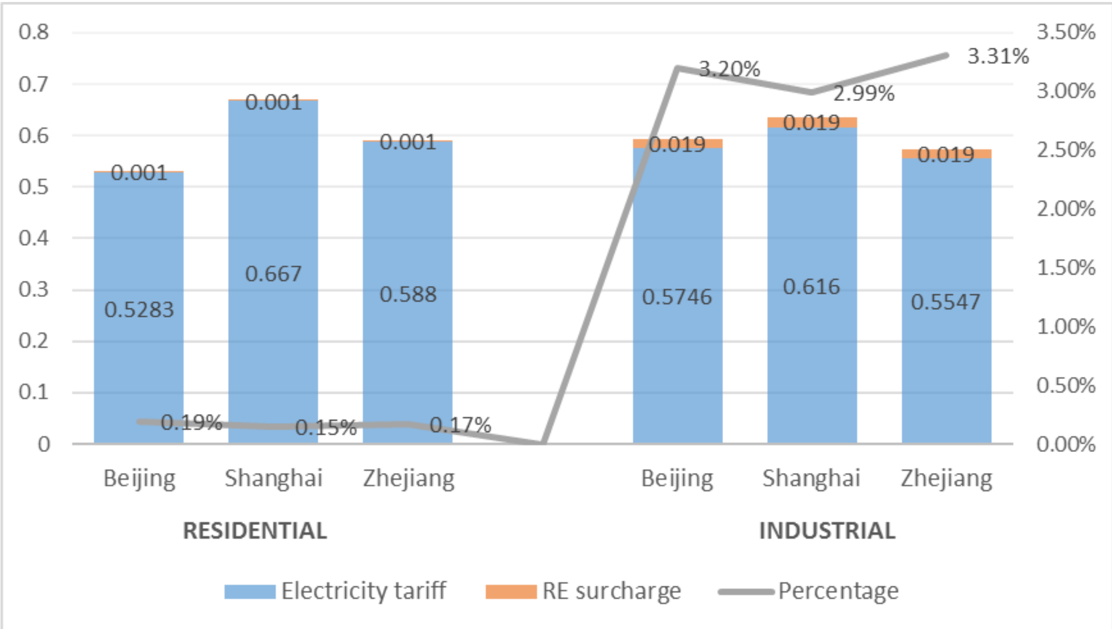

Figure 8: RE surcharge as a percentage of electricity tariffs in three municipalities (province) in 2020[12]

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[12] Each province or municipality in China enforces a unique electricity pricing system. The rate structures and the tariffs therein are very distinctive across regions. The electricity tariffs for the above-mentioned 3 regions refer to a specific rate in a tiered pricing structure, instead of the average within the same structure. For example, if the pricing system is seasonal, the author refers to the non-summer rate. If the structure is based on time of use, the author selects the non-peak and non-trough hour rate. If the pricing system is based on peak demand,

Some developed economies that administer a similar pricing structure record a substantially higher RE surcharge rate. In Germany, for example, the RE electricity surcharge, or the EEG (Erneuerbare-Energien-Gesetz) rate accounted for 23% of electricity price for private households consuming between 2,500 and 5,000 kWh in 2017 (Federal Ministry of Economic Affairs and Energy, 2021b). The BMWI, Germany's Ministry of Economic Affairs and Energy, reduced the EEG rate for two consecutive years from 6.880 ct/kWh in 2017 to 6.405 ct/kWh in 2019 (Federal Ministry of Economic Affairs and Energy, 2021a), yet the rate remains considerably higher than that in China. Japan, on the other hand, also registers a higher share of RE surcharge in the total electricity tariff than China. According to Japan's Ministry of Economy, Trade and Industry (2020), the percentage of RE surcharge in total electricity bills for industrial and commercial use was 15%, while that for residential electricity use was 11% in 2019. The unit price of RE surcharge has also increased after the FIT scheme was implemented in Japan in 2012. The surcharge rate in 2012 was 0.22 JPY/kWh but substantially increased to 2.95 JPY/kWh in 2019 and 2.98 JPY/kWh in 2020 (Tokyo Electric Power Company Holdings, 2019).

An increase in the electricity bill, no matter how minimal, might significantly impact China's poorest households. Premier Li Keqiang stated at the third press conference of the 13th National People's Congress that 600 million Chinese were living on a monthly income of 1,000 CNY (150 USD) (Xinhua News, 2020b). Hiking the RE surcharge on residential consumption would greatly affect those living under

the author refers to the middle-level demand for residential use and the highest level of demand for industrial use.

the minimum wage line. With that said, a raise in the RE surcharge on industrial end-users might serve as a reasonable starting point in order to narrow the funding gap in the REDF. For the next steps, the government can also consider a combination of increasing the RE surcharge rate for residential electricity consumers and a direct transfer program targeted towards the poorest households. By targeted transfer, the government could alleviate the financial burden on the poor and allow the recipients to pay for electricity bills.

Fourthly, although the REDF was erected for the sole benefit of renewable energy development, a portion of the fund has been exploited to support the development of non-renewable energy. The fund has been struggling to feed the hungry mouths of renewable energy producers, and the gap between the supply and demand of FIT subsidies has been widening since the fund's inception. However, the government has allocated a portion of the REDF to support the growth of non-clean energy. According to a 2019 government document, the funding from REDF has been used to support the exploitation and utilization of unconventional natural gas such as coalbed methane, shale gas, and tight gas (Ministry of Finance, 2019). The subsidy standard in 2018 was fixed at 0.3 CNY/cubic meter, which was then changed to a progressive scheme in 2019.

Additionally, since the announcement of the first subsidy catalog in 2012, multiple waste incineration projects were enlisted under the REDF subsidy list, exploiting the revenue from RE electricity surcharge (Ministry of Finance, 2012). To begin with, municipal solid waste is sourced from everyday items we use and then throw away, and therefore, it is non-renewable in a technical point of view. Moreover, the sustainability of waste-to-energy technology is highly debatable. In a study of the environmental impact of municipal solid waste incineration projects in France, Beylot & Villeneuve (2013) highlighted the large variability among waste-to-energy technology, depending on the incinerator technical characteristics. Indeed, even though the potential adverse effects of waste-to-energy projects on the climate and environment might be varied, the possibility of tremendous environmental burdens cannot be overlooked. The director of NCSC, Li Junfeng, opposes the inclusion of waste-to-energy projects under the REDF, saying that incineration is a measure to treat urban and rural waste, and should not compete with wind and solar projects for the limited funding resource under the FIT scheme (Zheng, 2019).

7.2 Reallocate public resources from fossil fuel subsidy

A subsidy swap – reallocation of the savings from reducing fossil fuel subsidy to fund the clean energy transition – could magnify the contributions to long-term emissions reduction (Bridle et al., 2019). Indeed, the provision of subsidies for fossil fuels not only drains limited public resources but also impedes the development of sustainable technologies. A clean energy subsidy swap could free up resources for more pressing priorities and address the widening funding gap for renewables under the FIT scheme. The Global Subsidies Initiative refers to subsidy swap as a redirection of government resources with two key elements that can take place independently: 1) fossil fuel subsidies are reduced and; 2) measures are taken to increase the deployment of sustainable energy (Bridle et al., 2019). Since the paper has already discussed extensively how to stimulate renewable energy deployment from the perspective of policy-makers, this section will be mainly centered upon the current status of fossil fuel subsidies in China and the possibility to reallocate such resources to renewables.

There is no consensus over the current volume of fossil fuel subsidies in China due to the various measurements among different institutions. The IMF uses the broader definition based on post-tax consumer subsidies, as opposed to pre-tax consumer subsidies that are more widely adopted. The difference between the two concepts is that post-tax consumer subsidies give full consideration to two forms of taxation – both a general excise tax and a levy on negative externalities such as local pollution, traffic congestion, and global warming (IMF, 2021). The IMF includes the hidden effects of these externality costs, which represent another form of subsidy to fossil fuels. According to the IMF estimates, the total post-tax subsidies for fossil fuels in China have reached 1791.8 billion USD in 2017, the largest component being the externalities on local air pollution at 1093.6 billion USD (IMF, 2021). The IEA, on the other hand, uses the measurement of pre-tax consumer subsidies. The fossil fuel subsidies in the IEA standards are broken down by energy source, including subsidies for oil, electricity, and gas. As shown in the graph below, the total amount of subsidies given out to fossil fuels in China was estimated by the IEA at roughly 51 billion USD in 2018 and 30 billion USD in 2019.

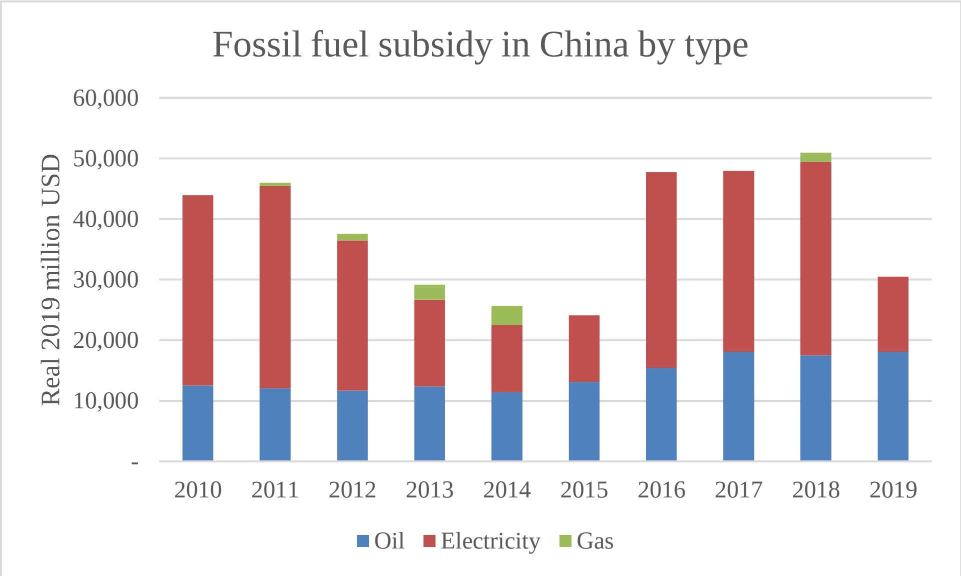

Figure 9: Fossil fuel subsidy in China from 2010 to 2019

Source: IEA, 2019

A reallocation of fossil fuel subsidies to renewable energy would largely fill the gap of the REDF. It is estimated by China Electricity Council (2020) that the funding gap for enlisted renewable energy projects and eligible projects on the waitlist had reached 327.3 billion CNY by the end of 2019. A complete phaseout of fossil fuel subsidies and a proportional increase in spending on renewable energy could introduce 208.8 billion CNY of capital (1 USD = 6.96 CNY on Dec 30, 2019[13]) and close the deficit in the REDF by over 60%. Although the reality is not as simple as the math here, we can still expect a sizeable gain on the renewable side.

[13] *US Dollar to Chinese Yuan Spot Exchange Rates for 2019*. (2021, June 15). Exchange Rates UK. https://www.exchangerates.org.uk/USD-CNY-spot-exchange-rates-history-2019.html

The logic behind a reduction in subsidy for fossil fuels is to increase the price of the commodity over the cost. The IMF (2021) recommended several approaches based on country experiences. Firstly, there should be gradual step-by-step price increases for fossil fuels. Since a subsidy reimburses the producer for the cost in excess of the price accepted by the consumer, a gradual increase in the commodity price will rebalance the equilibrium and reduce subsidy expenses for the government. In addition, the IMF also suggests targeted programs or cash transfers in the protection of the poor against the adverse impact of a price spike in fossil fuel commodities. A comprehensive energy sector reform plan is also mentioned as a key ingredient to a successful subsidy swap program. As an important component of the reform plan, an efficient carbon pricing system is highly demanded. By putting a halt to the current emission trajectory, a nationwide carbon market could potentially discourage further investment into fossil fuels and thereby redirecting more funding resources into the renewable sector. Moreover, since fossil fuels and renewables are substitutes in the power market, by enforcing an emissions trading system, the Chinese government could galvanize more demands for renewables and eventually seal the price gap in renewable power production. In fact, the country has already begun pilot emission trading schemes (ETS) in 7 provinces and municipalities since 2011 (Tan Jiao Yi, 2021). In 2017, China decided to implement the ETS nationwide, initially covering the power generation sector and later expanding to seven other sectors (IEA, 2020d). The Ministry of Ecology and Environment (2021) issued the official policy announcement by the end of 2020 and scheduled the measures to come into effect in February 2021.

7.3 Provide alternatives to the FIT subsidy

In light of the Chinese government's resolution to gradually phase out subsidy under the FIT scheme, it is imperative to develop other market-based funding mechanisms for renewable energy power producers as alternatives to the current subsidy system. Although as the results demonstrate, the withdrawal of FIT subsidy will do nothing but hurt the development of renewable energy by squeezing the already thin profit margin, the government's intention to cut down FIT subsidy is unquivering. In response to the trend of a decreasing FIT subsidy, the author here proposes three measures as alternatives: 1) encourage public and private financial institutions to provide easy-to-access debt capital to renewable energy projects; 2) an effective taxation system that delivers tangible benefits to renewable power producers; 3) expand the market for Green Power Certificates;

Firstly, the government should encourage low-cost and easily accessible term loans to renewable energy power producers as an alternative source of financing. Qin (2020) suggests that the most plausible means to narrow the funding gap in the REDF is to issue the so-called government-based agency bonds. He recommends that the first round of agency bonds total 300 billion CNY with a tenor of 20 years, which would fully cover the accumulated deficit of the REDF by the end of 2020. The interest rate, Qin estimates, could be as low as 3%, or even 2%, assuming equal credibility as a government bond in the same time. As promising as it might sound, the author posits that an interest rate on a loan to renewable energy projects cannot be held as equivalent to a government bond with the same maturity, considering the business risk and project-specific risk associated with renewable energy projects. On top of that, assuming the obligations of a 300 billion CNY debt instrument that is correlated to a single industry, if managed poorly, might have a ripple effect on the agency's balance sheet, and therefore could be very risky for the issuer.

A fully-fledged financing mechanism for renewable projects requires interaction of multiple policy channels and the consorted efforts of all stakeholders and the general public. Although this paper is confined to discuss the actions of the government, we should also highlight the indispensable role of the private sector. To the benefit of the renewable sector, the public now has a growing appetite for green investing and the financial institutions are increasingly lenient on lending to renewable projects. Needless to say, the government should also assume its duty to create a favorable financing environment for the borrowers. To begin with, the government should establish a set of reporting metrics to be routinely disclosed to the investors. Such transparency can mitigate investors' concerns over project-specific risks and reduce borrowing costs for power producers arising from information asymmetry. Since the repayment of debt is contingent on the performance of the power plant, or more specifically, on uncontrollable factors such as the intensity of natural resources, there is also a fundamental need to enhance the credibility of the project and lower payment default risk. In that regard, the government could encourage the use of credit enhancement facilities such as guarantees provided by the government, or first-loss provisions supported by major banks.

Secondly, the current taxation landscape on renewable power projects could be improved to deliver more tangible benefits to power producers. The government should extend the corporate income tax exemption policy to cover a longer period of the project’s operation. As have been demonstrated with the model, the tax break prescribed by the Chinese government – zero rates during the first 3 years of operation and halved rate in the subsequent 3 years of operation – overlaps with the accounting treatment of net operating loss carryforwards and therefore only has a marginal impact on the project. With consideration for the NOLC treatment, only a corporate income tax reduction in the years after the fifth period of operation would bring concrete profit to the project. In response to a decreasing FIT price, the government could revise the current corporate income tax exemption program to stimulate the development of renewable energy power production. In fact, the tax exemption policies could replace the FIT scheme as the major supportive program for renewable power generation. As has been discussed before, the administration of the FIT scheme in China is overcomplicated and inefficient. Conversely, tax exemption policies directly benefit power producers by changing their accounting treatment and thereby, their tax expenses and overall profitability.

On the other hand, a reduction in the VAT rate would directly benefit the end consumers with no material impact on power producers. This is because a shrinking

VAT rate reduces the revenue and the cost of the project simultaneously and proportionally. On that account, a reduction in the VAT rate would transfer the economic value equivalent to the VAT to the end consumers, by-passing the power producers. However, a decrease in the VAT rate could invigorate the consumption of renewables and thereby incentivize the deployment of renewable power.

In addition to the current corporate tax break and a reduced VAT rate, the Chinese government could also resort to other preferential tax policies to lure in investors. The PTC and ITC structures in the U.S. might serve as a valuable reference. The Production Tax Credit (PTC) is a dollar-for-dollar offset of taxes due, contingent on the total electricity generation output of the renewable power plant. The PTC rate for wind projects is equal to 2.5 US cents per kWh of generation, and the claim of such credits is based on the year the project starts construction (Thomson Reuters, 2021). In comparison, the Investment Tax Credit (ITC) offsets taxes due based on the capital investment value of the project, or more specifically, the CAPEX of the project. Solar project owners are eligible for claiming 26% of the project's capital costs if they start construction between 2021 and 2022 (Thomson Reuters, 2021). The unused ITC amount can be carried backward for 1 year and forward for 20 years, after which half of the unused ITC amount will expire while the other half remains deductible (U.S. Department of Energy, 2021). The PTC is paid out in 10 years and any unused amount can also be carried forward into future fiscal years, although the PTC scheme has been phased out for projects commencing construction after 2020 (Congressional Research Service, 2020). Two key characteristics of the PTC and ITC schemes in the U.S. could offer some insight for China. Firstly, under both PTC and ITC structures, the amount of tax credits is dependent on the specifics of the project, either capital costs or total electricity generation. Such structures might deliver higher economic value to certain projects than corporate tax rate reduction. Secondly, PTC and ITC can be carried forward to offset taxes payable in future periods. Hence, tax credit structures, by design, have a larger impact on a project's profitability and can ensure tangible benefits to power producers.

Thirdly, the government should stimulate the demand for Green Power Certificates as an alternative to FIT subsidies. The subsidy under the FIT scheme takes two forms: a per-unit subsidy that is equal to the difference between grid-connection price and generation cost, and a lump-sum subsidy that disregards the price gap. The Chinese government stipulates that the sales price of GPC shall not exceed the amount of subsidy under the FIT scheme, and the amount of power generation renumerated by GPC will no longer be eligible for FIT subsidy (Han, 2020). Since the GPC is traded in an open market based on the demand-and-supply balance, the price of GPC in a perfectly competitive market should equate to the difference between generation cost and sales price. Therefore, regardless of the payment schedule, the GPC brings the same economic value as the per-unit subsidy under the FIT scheme.

With consideration for the delay in FIT subsidy payment, a fully functional GPC trading system can outperform the FIT scheme with its timely payment schedule. The GPC is traded in an open market in real-time, which means that buying and selling have no apparent delay. According to the transaction manual of GPC, sales revenue will be transferred to the seller in the next business day after the transaction (National Renewable Energy Information Management Center, 2017). In conclusion, an efficient GPC system with sufficient trading volume will benefit the power producers, and in the meantime, lessen the financing burdens of the REDF by reducing the demand for FIT subsidies.

Nevertheless, the current GPC system still awaits reform. As of now, the GPC system in China has remained a trial run and only demonstrated limited effect. To start with, the pricing mechanism of GPC is defective due to significantly off-balance demand and supply. The number of registered GPC exceeds 31 million, while the number of GPC sold only totals 70 thousand, and that leaves over 31 million of GPC available for sale in the market (*GPC Trading Platform*, n.d.). Currently, the price of GPC is settled through negotiation between the seller and the buyer. Once sold, the corresponding GPC will be unregistered on the platform and cannot be repurchased by another entity (National Renewable Energy Information Management Center, 2017). Moreover, since the GPC scheme was introduced before and independently from the RPS scheme in China, the two schemes had remained unattached under most circumstances. The main purpose of the GPC, as stated by the government, has been to provide alternative funding to the FIT subsidy, and the enforcement of the scheme has been based on voluntary commitment of individuals, companies, and public entities.

Conversely, in the U.S., where the REC system has been operating for decades, the pricing mechanism functions with a higher level of economic efficiency. The REC system in the U.S. operates in conjunction with the RPS program, which has been enacted as a mandatory renewable energy policy in 29 states and the District of Columbia (U.S. Energy Information Administration, 2019). To fulfill the enforceable renewable energy consumption goals under the RPS scheme, utilities that fall short of the mandated requirements purchase RECs from other power suppliers with excess renewable power generation. Since there exists ample demand and supply, the price of such RECs is determined in a competitive environment with sufficient consideration for factors such as the vintage year, type of technology, project location, and whether the RECs were generated for RPS compliance ("Renewable Energy Certificate (United States)," 2021).

The amalgamation of RPS and REC in the United States offers some valuable lessons to be learned. Until today, China has mainly relied on the FIT scheme for the promotion of renewable energy electricity. The FIT scheme has undoubtedly led to an initial expansion in renewable deployment and thereby resulting in further technology improvement and cost reduction. However, it can only go thus far by itself. After the initial stage, it is time for China to introduce a complementary mechanism that is more market-oriented and cost-effective for the state government. A reform of the current RPS scheme could address the growing funding deficit under the FIT scheme and possibly invigorate further development in renewables. The NEA published a draft policy in April 2021, proposing to raise the share of electricity generated from wind and solar to 11% by the end of 2021, followed by a year-on-year increase that would eventually lead to 16.5% of total electricity from wind and solar by 2025 (Credit Energy, 2021). A complementary RPS scheme could set a consumption target that approximates 16.5% with a certain degree of differentiation among provinces.

7.4 Reduce the abandonment rate of wind and solar power plants

Efficient use of public resources is attained only when the abandonment rates of wind and solar projects are minimized. When the installed capacity exceeds the absorptive capacity of the region, the excess will either have to be transmitted to another region for consumption or abandoned. The overall abandonment rate of renewable energy has fallen from 16% in 2012 to 3.6% in 2021 (State Grid New Energy Cloud, 2021). However, the abandonment rate is still higher in certain regions. The main reason behind the abandonment of resources is the underdevelopment of inter-provincial transmission networks. To address the root of the issue, the government could explore a mixture of policies. For a starter, the government can introduce energy storage technology to renewable power generation; this could mitigate the intermittency of renewable electricity as well as reduce the abandonment of extra capacity. Meanwhile, demand-side management could be employed to contract consumer demand during peak hours and thereby reducing the need for installing excess capacity.

Aside from immature transmission networks, another reason for the abandonment of renewable energy in certain areas arises from illegal action of solar plant owners, who secretly install additional photovoltaic panels in an attempt to inveigle more subsidy from the public pocket (Hou & Lu, 2020). Since the subsidy payment under the FIT scheme is contingent on the actual output of the power plant, once the project is enlisted for FIT subsidies, some solar plant operators covertly install more solar modules so that the total electricity generation would be higher. In response, the government can put a cap on the abandonment rate for eligible projects and retract FIT subsidies once the maximum threshold is breached. Such a policy will encourage government oversight on project specifics and guarantee an efficient allocation of public goods, such as land, to the most trustworthy. Moreover, a maximum abandonment rate would also pressure individual power producers to make sure their plant is performing to its utmost. If regulations punish power producers who arbitrarily abandon excess capacity, those deceivers would be deterred from deploying extra units in the first place.

8 Conclusion

The economic feasibility of a ground-mounted, grid-connected, and centralized solar PV project located in Zhejiang Province is assessed. With the discounted cash flow model as a foundation, the author performed a sensitivity analysis to study the impact of different policy schemes on the profitability of the proposed project. The results show that the project will only have a positive NPV when funded 13% or more by debt. In addition, the model demonstrates that the curtailment in the FIT subsidy payout ratio will reduce project NPV by 24.1%. Moreover, the current preferential tax policy for renewable power producers delivers only minimal benefit to power producers, increasing the equity IRR of projects with distinctive debt ratios by approximately 1%.

This thesis constructs policy recommendations in accordance with the outputs of the discounted cash flow model. By performing a sensitivity analysis, the impact of a change in key assumptions is visibly displayed in the key financial measurements. Based on the changes in project NPV, IRR, and PBP, the following conclusions are drawn:

(1) Delayed or curtailed subsidy payment under the FIT scheme can materially impact the economic feasibility of renewable power generation projects. The main reason behind the growing deficit in FIT funding is the inefficient administration of the REDF. To address this issue, the government should first make every effort to

raise the collection rate of RE electricity surcharge. Secondly, to ensure timely payment of FIT subsidies to power suppliers, the government could further streamline the application and verification process for renewable projects to be included under the FIT scheme. Additionally, the government could consider hiking the RE surcharge rate for industrial and commercial users. Last but not the least, the government should stop funding non-renewable projects with the REDF.

(2) China still heavily subsidizes fossil fuels. An efficient and fully functioning emissions trading system at the national level that covers all sectors could put a price tag on the negative externalities associated with the use of fossil fuels, and facilitate the reallocation of capital resources to renewable energy.

(3) In the context of a fading FIT scheme, the government could rely on alternative support schemes that are more cost-efficient and market-oriented. Firstly, the availability of accessible and cost-efficient financing is key to the survival of a renewable power plant. Given that the FIT payment is most often delayed and curtailed, the government could encourage private sector involvement in renewable investments by creating a favorable business environment. Secondly, the government could consider reform to the current preferential tax policy to deliver more tangible benefits to the power producers. The tax break does not impose a financial burden on electricity consumers and requires less government administration. Thirdly, the market for GPC could be expanded by imposing mandatory but differentiated RPS targets for each province.

(4) The abandonment rate of wind and solar resources could be further decreased by implementing technologies such as efficient transmission networks and demand-side management.

The paper adopts both quantitative and qualitative approaches to analyze the policy impact of China's current subsidy schemes on renewable power production. The uniqueness of this paper is that it extensively discusses the evolution of China's subsidy schemes, and proposes policy recommendations based on an economic feasibility analysis. However, the paper is not without flaws. The author wants to direct readers' attention to the following limitations:

(1) The financial model in this study is constructed using generalized assumptions. The economic feasibility of the proposed project might not truly reflect the cost structure, financing needs, and policy context of a renewable energy power generation project in reality. In addition, since the electricity pricing system in China is differentiated among provinces, the author chose her hometown, Zhejiang Province, as the location for the hypothetical project due to limited time and resources. The conclusions of this thesis should be applied with caution on projects located in other provinces in China.
(2) The paper is written during the transitional period for the RPS and ETS schemes in China, and therefore the author cannot discuss the policy implications of the RPS and ETS schemes extensively. The RPS scheme has started a trial run in

2019 and was scheduled to become legally binding in 2020. On the other hand, a nationwide ETS scheme was announced by the end of 2020; the efficacy of such a scheme has not been reported.

(3) Each policy recommendation for reform in the current subsidy scheme in China was proposed under separation frames. In other words, the author has not considered the sum of the individual impacts of the policy mechanisms proposed in this thesis.

Due to limited time and resources, the research as presented is not all-encompassing. Therefore, the author would also like to stimulate future research in the areas below:

(1) The author identified the low collection rate of RE electricity surcharge as a key reason behind the REDF being underfunded. Further research could focus on the policy and regulatory solutions to a low RE surcharge collection rate.

(2) The author proposed raising the RE surcharge rate as a last resort if the REDF still runs a deficit at a 100% RE surcharge collection rate. However, the scope (raising surcharge rate for industrial or residential use, or both?), the potential impact (does a rate hike adversely impact electricity end-users?), and the scale (by how much should the rate be further increased?) of such a hike remain topics for future research.

(3) The author also proposed reform in current preferential tax policies. In particular, the author referred to the PTC and ITC in the United States, claiming that the eligibility for tax credits to be carry forward could deliver tangible benefits to power producers if the tax scheme is implemented in China. However, the author acknowledges that the taxation systems in China and the United States are vastly different and it requires further research to prove the tax credits system applicable to China.

(4) Lastly, the author draws on the experience of foreign countries in claiming that a fully-developed RPS system would expand the GPC market in China. However, the GPC system was introduced earlier and separately from the RPS scheme in China. Therefore, further research is recommended to study the stimulus effect of the RPS scheme on the GPC system in China.

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