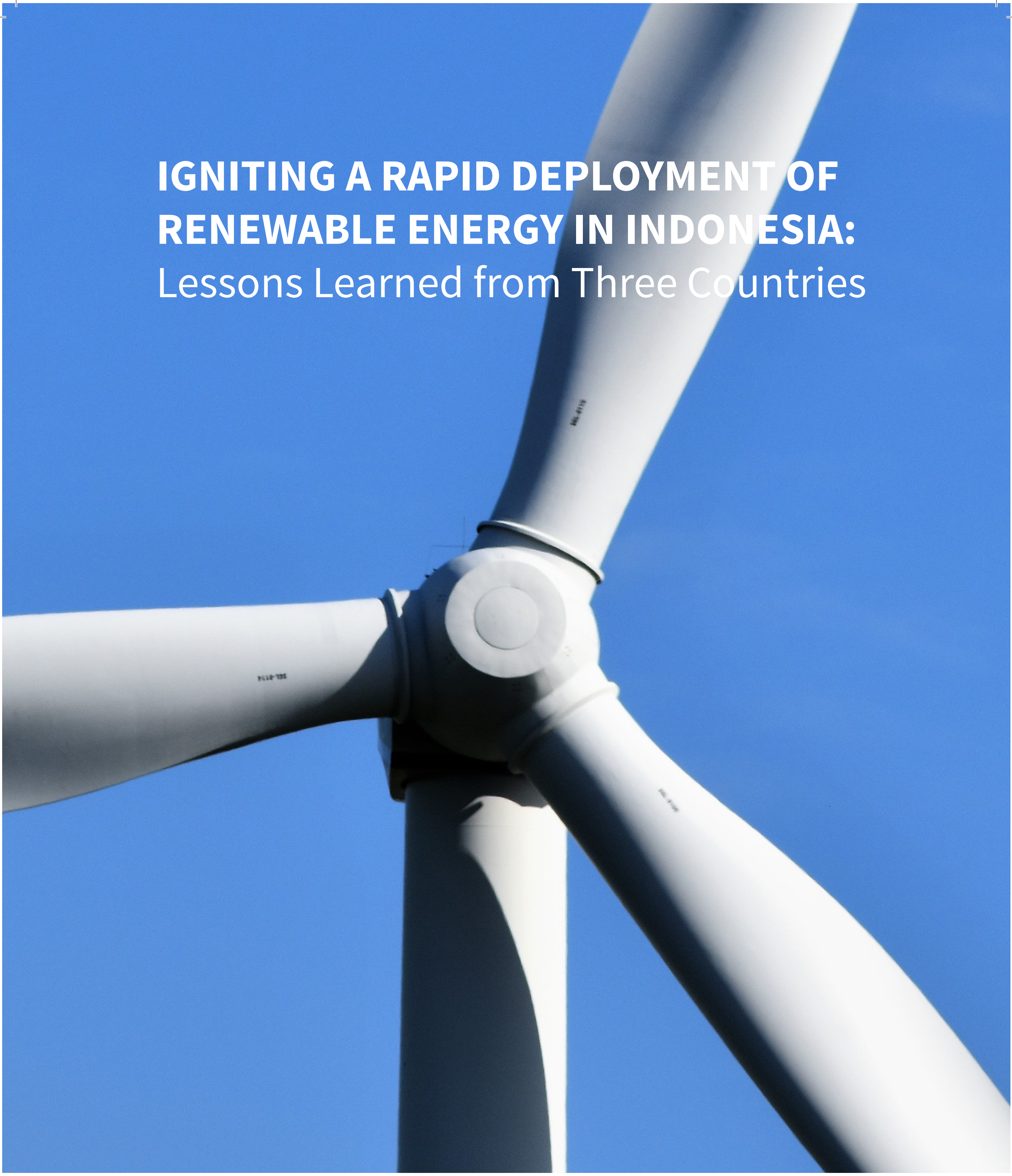
IGNITING A RAPID DEPLOYMENT OF RENEWABLE ENERGY IN INDONESIA:
Lessons Learned from Three Countries



IESR
Institute for Essential Services Reform

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Contents

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Preface

"Limiting warming to 1.5°C is possible within the laws of chemistry and physics, but doing so would require unprecedented changes" - Jim Skea, Co-Chair of Intergovernmental Panel on Climate Change Working Group III

The Special Report on Global Warming of 1.5°C was just launched on Monday, 8 October 2018. This report highlights that limiting global warming to 1.5°C above the pre-industrial level could ensure a more sustainable and equitable society. This means that major reductions in greenhouse gas emissions in all sectors (including the energy) and immediate transformation are needed.

Most of the countries are now moving towards ambitious mitigation goals to meet the 1.5-degree pathway. International Renewable Energy Agency (IRENA) argues that the rapid deployment of renewable energy (to increase from around 15% of the primary energy supply in 2015 to 65% in 2050) is one of the essential measures to tackle the challenge. In addition, International Energy Agency (IEA) also mentioned that the share of fossil fuels in primary energy demand should be cut by 50% between 2014 and 2050. This massive energy transition must be supported by well-designed policy framework, especially in developing countries.

In the Indonesian context, the country has set goals of increasing the share of renewables as one of the decarbonization processes. As laid out in Indonesia's National Energy Plan, the share of renewables are aimed to increase from 7% today to 23% in the country's energy mix by 2025, and 31% by 2050. However, the complete supporting policy and programs to facilitate clean energy development are still lacking.

The Institute for Essential Services Reform (IESR) has performed extensive research on clean energy policy. The main research question of the study is what kind of coherent policy framework Indonesia needed to have rapid deployment of renewable energy? Thus, we designed the research into four main objectives:

1. Review the clean energy policy framework and summarize the lessons learned from three reference countries: Germany, China, and India.
2. Synthesize the clean energy best practices, e.g. long-term national target, policy framework and support, power sector regulatory, market development, governance/institutional setting, and financial mechanism.
3. Review Indonesia's national circumstances on clean energy policy.
4. Identify the gaps between the existing condition and the clean energy best practices, as well as develop the recommendations on how to close the gaps.

Germany, China, and India are countries that have success stories of renewable energy development. For this reason, we decided to focus on these three countries and extracted lessons learned for Indonesia.

We hope that this report will ignite the rapid development of renewable energy in Indonesia by taking into account some international experiences and know-how.

November 2018

Fabby Tumiwa
Executive Director

Executive Summary

Indonesia has huge potential of renewable energy which the Indonesian power sector still underutilizes. The long reliance on fossil fuels, particularly coal, has proven difficult to break as perception of coal as cheap energy and renewables as costly technologies remains. Although some measures to develop renewables have been introduced since early 2000, the Indonesian renewables sector has yet to take off. Some challenges such as policy uncertainty, market barriers, financing barriers, and low renewables manufacturing capacity have been contributing to the sluggish development of renewables in Indonesia.

As more countries transition towards renewable energy, Indonesia may benefit from the experiences of countries that have successfully developed renewables. Lessons learned from Germany, China, and India provide valuable insights into the ways of those countries advance on renewables markets.

Renewables in Indonesia

Targeting to reach 23% of renewables share in primary energy mix by 2025 and 31% by 2050, Indonesia has been struggling to meet the targets. By 2017, renewables only accounted for 8% of primary energy mix in the country while the other 92% fulfilled by fossil fuels. The same trend can be seen in the Indonesian power sector where renewables share only reached 12% in 2017 while fossil fuels remained dominating the sector by generating 88% of electricity in the country.

In terms of capacity, the renewables also only enjoy modest if not worrying growth. The year-on-year capacity addition of renewables in Indonesia has been declining since 2013. In 2017, Indonesia only added 242 MW of renewable energy, the lowest since 2011. Renewables investment in Indonesia was $1.3 billion in 2017, decreasing by 17% compared to the $1.57 billion in the previous year.

The slowing development of renewables in Indonesia has been caused by several factors such as regulatory and policy uncertainty, market barriers, financing barriers, and undeveloped local renewables industry. The regulatory uncertainty has increased the perceived risk to investors, urging investors to wait and see until the next regulations on renewables provide better investment climate to them. The last pricing structure which caps the renewables prices at 85% of BPP is deemed as the main market barrier to obtain funding for new projects. The disregard of subsidies, price interventions, and externalities of coal also creates unlevel playing field for renewables. The increasing demand from multinational companies to use renewables-based electricity in Indonesia most of the time has to compete with PLN's interest to keep the national grid under its sole control.

The absence of financing instruments such as surcharge and coal levies further discourages PLN to purchase renewables as the utility sees renewables as burden to its budget when the electricity tariffs remain flat and the electricity subsidies have been reduced. In addition, the lack of local renewables manufacturers also contributes to the less-competitiveness of renewables technologies in the country.

Renewables in Germany

Energiewende, a German energy transition program, is a continuous and gradual process of energy transition based on four main drivers: climate change (reducing CO2 emissions), nuclear phase-out, energy security (reducing fossil-fuel dependence), and competitiveness and growth (industrial policies).

In 1990, German parliamentary adopted its emission reduction target: 25 percent lower CO2 emissions by 2005 compared to 1990 levels. Also, in the same year, Germany planned to double its renewable sources in primary energy consumption from 2.4 to 5 percent and in electricity generation from 5 to 10 percent by 2010. To fully support these goals, Electricity Feed-in Law was authorized in 1991 which introduced Feed-in Tariffs (FITs) for renewable energy. However, these tariffs were not high enough to make renewable energy competitive against conventional energy.

In 1998 the European Union released several directives to encourage competition by breaking up monopolies in the energy production and distribution. Two years later, German electricity market was fully liberalized. In the same year, Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz/EEG) was also introduced to boost the uptake of renewable electricity as well as to facilitate renewable electricity in entering electricity market.

The Renewable Energy Sources Act had undergone several amendments from 2004 to 2017 in order to support innovation and technological development as well as enabling the integration of renewables into the power market. With the latest amendment of EEG (amendment 2017), payment to renewables installation shall be determined in a competitive process (auctions) instead of being set by the governments (FITs). This reform is hoped to align the renewables development with grid expansion, to reveal the true cost of renewable generation, and to align with the European Commission's goal of having a market-based renewables instrument.

The EEG has become a key driving force of renewable energy expansion in Germany. In the period of 2002-2017, the share of renewable energy in Germany had increased more than four times both in primary energy consumption and in gross electricity consumption. Moreover, the installed capacity for renewables also rose more than six times from 18 GW in 2002 to 111 GW in 2017 with an annual growth of 12.9% in the last 15 years. On the contrary, conventional energy installed capacity has declined, from 97 GW in 2002 to 90 GW in 2017.

Renewables in China

China has been growing rapidly in the past three decades, largely supported by the manufacturing and heavy industries. China consumes far more energy, mostly from coal, that has caused some serious environmental issues such as air pollution. To overcome this, China has to shift away from coal to renewable energy in its power sector.

China has ratified the Paris Agreement and committed to reducing its carbon intensity by 60% to 65% below 2005 level by 2030, raising the share of non-fossil energy in the primary energy mix to 20% by 2030, and peaking its CO2 emissions by 2030. These commitments were then translated into Energy Five Year Plans (FYP) and Renewable Energy FYP, which set strategies for the development of energy and renewable energy sector in China.

In 2017, the renewables accounted for 650 GW or 37% of Chinese total installed capacity. Almost two-thirds of 125 GW additional capacity installed in 2017 came from the renewables. On average, from 2007 to 2017 China added 49.5 GW of renewables per year. This growth has driven a high employment in Chinese renewable energy sector. In terms of investment, the country has seen an accelerating trend in the past decade.

China has been shutting down many of its older coal power plants and installing supercritical and ultra-supercritical coal power plants which has higher efficiency and produce lower emission. At the end of 2016, China's national electricity was oversupplied with $237 billion potential stranded assets of coal power plants, caused by slowing electricity demand growth. On the other side, China's renewable sector has been facing severe curtailment, caused by several factors: limited flexibility in the thermal power plants, inadequate transmission grid planning and operation, long-term physical contracts, interprovincial trading inflexibility, and provincial authority that favors coal.

Since 2002, the Chinese power market is split into two main sectors, generation and transmission & distribution. Both wholesale and retail electricity price are subject to NDRC approval. The generation dispatch orders are determined at the beginning of each year by local governments by balancing supply and demand. A minimum dispatch is granted to coal plants to ensure their profitability.

The rapid growth of renewable energy in China in the past decade is associated with a strong incentive policy implemented in the country. R&D institutions and R&D fund were established to support the renewables industrialization. The renewables industry also enjoyed tax reduction, direct financial subsidy, Feed in Tariff scheme, and guaranteed power purchase by the grid companies. Since December 2017, China started implementing a national carbon market. If implemented effectively, this market will further increase the uptake of renewables in China and bring market incentives to coal generators to shift to cleaner energy.

Renewables in India

As the second most populated country in the world, India is projected to be one of the countries with most extensive energy demand in the upcoming decades. To meet the high projected demand, India has already started to transition their energy infrastructure from fossil fuel into renewable energy. Securing energy supply (energy security), providing universal energy access, and achieving climate change targets are the key drivers of energy transition in India. The government also has committed into this plan by establishing several key policies and measures which help building an attractive environment for investor to join in developing the renewables-based power plants.

In 2015, the Government of India (GoI) set a target of reaching 175 GW renewable installed capacity, consisting of 100 GW from solar power, 60 GW from wind power, 10 GW from biomass power and 5 GW from small hydropower by 2022. The target is seen to be an ambitious one, as India's renewable energy installed capacity in 2015 was only 38 GW and development trajectory that was far below the set target. After setting out the ambitious target, the renewable energy installed capacity in India has taken off ever since. In fact, in June 2018, GoI increased the renewable target into 227 GW with additional 52 GW comes from a raise in each individual target as well as a new scheme such as offshore wind.

The strong growth of renewable energy in India has been supported by integrated policy established over the years. With Electricity Act 2003, GoI stipulated the unbundling of the electricity market structure and the preparation of national electricity plan that envisages India's electricity sector development for the next fifteen years. Furthermore, through National Electricity Policy (2005) GoI guarantees private participation in renewable power generation and with the National Tariff Policy (2006), the renewable energy tariffs and RPO portfolio will be regulated by each state taking into account stakeholders' interests.

To support their ambitious renewable programs and targets, India has prepared a renewable energy fund by putting a levy on coal produced and imported in India since 2010 and pooled the fund into the National Clean Energy & Environment Fund (NCEEF). The levy on coal has increased from Rs. 50/tons in 2010 into Rs. 400/tons in 2016 and total fund accumulated reached Rs. 86,440.21 or equal to $ 11.4 billion US. The fund has been used to finance government programs as well as other eligible renewable energy projects.

Some other instruments/policy support used in India are Feed-In-Tariff, Renewable Energy Certificate, Viability Gap Fund, and tax/fiscal incentive. These policy supports are provided through combination of Central and State Government instruments which can evolve on regular basis. The changes in the policy in each state are still monitored regularly by India's Ministry of New and Renewable Energy.

Lessons Learned

Germany, China and India face different barriers in developing their renewable energy. To overcome it, they each introduces different policies. Some of these policies are country specific, but some are also applicable for all three. From the policies used to tackle the barriers and its implementation process, there are major findings that can be derived as lessons learned for Indonesia.

- **Consistent national leaderships that show a strong political will to support and promote renewable energy**

  Removing barriers and establish enabling environment to attract and mobilize investment in clean energy requires a long process. Deploying renewables require prioritization over other type of energy, particularly fossil, that might need support or consensus from various political power in the country constantly. A change in political leadership should not interrupt the process by any means to maintain the momentum which has been established.

- **Integrated renewable policies and government's responsive actions**

  Integrated or coordinated policy strategies are needed to ensure consistent and coherent policy goals across sectors and institutions, which are directly and indirectly involved in the renewables industry. The various ministries or government agencies must also be responsive in improving the market instruments necessary in increasing renewables investments.

- **Adaptive renewable policies that respond to the latest development stage and trends**

  Since renewables are emerging technologies and the market developments differ for each country, the policy adopted must consider these factors and exhibit the optimum instruments to support renewable energy technology deployment.

- **Grid management**

  The integration of renewables into the power grid is challenging. Lessons from China indicate that the failure to manage the grid will lead to high renewables curtailment. Grid planning, sufficient investment and improving grid operation are important to avoid curtailment, maximizing the benefits of clean electricity from renewable sources, and strengthen energy security.

- **Strong focus on research & development (R&D)**

  The R&D activities have proven effective in bringing the renewables costs down, increasing technological capabilities of local renewables manufacturers, and enhancing the competitiveness of renewable technologies in global and local markets.

- **An effective renewable pricing policy**

  In the early implementation phase, all countries set Feed in Tariff (FiT) policy that favors renewable energy. FiT should be calculated based on levelized cost of electricity (LCOE) produced from renewable energy. FiT provides security for renewable IPPs and gives predicted electricity supply from the generators into the system. To be effective, the FiT policy needs to be supported with conducive institutional and regulatory environment and also able to adapt to changes in technology and market conditions.

- **Policy cost**

The cost of policy implementation must be identified and calculated both monetary and non-monetary terms, and the government has to bear this cost or reduce it using instruments at their disposal.

Recommendation

- **Financing instruments for renewable energy development**

  The trends show that the progress in renewable energy development in Indonesia has been sluggish in the past decade. This slow progress is largely due to the lack of financing instruments available for funding renewables projects in Indonesia. The creation of financing instruments is needed to ensure a low-cost financing for renewables projects in Indonesia. This low-cost financing system would help lower the cost of renewables generation in the country. The financing instruments would also help create access to finance for small-scale renewables projects in eastern Indonesia, where the electricity demand is low and hence most banks do not find those projects attractive to finance. The funding for renewable can sourced for levy on coal production and fuel consumption, and electricity surcharge.

- **Formation of Renewable Energy Fund**

  A special fund needs to be allocated for renewables development in Indonesia. This special fund can be used for various financial support such as equity investment, low interest loan, guarantee, and project grant.

- **Establishing an Independent regulator**

  An independent regulator can help ensure that private electricity generators have access to PLN's power grid and get fair tariffs when they sell directly electricity to the industrial consumers. It will also promote transparency, minimize political interests, and prevent regulatory uncertainty.

- **Creating priced-based policy instruments**

  Feed-in Tariffs (FITs), Feed-in Premium, and auction system are some of policy instruments that could help Indonesia boost its renewables development. To reveal the real cost of renewables, Indonesia could use the reverse auction system to set FIT for utility-scale projects. A well-designed auction system has to ensure that sufficient competition and transparency are present. Meanwhile, the small-scale renewables projects could remain using the FIT system with pricing varies according to the technology type.

1. Introduction

Indonesia has abundant renewable energy resources. Despite having huge potential, Indonesia is lagging behind other countries in the development of renewable energy. By 2017, the total installed capacity of renewable energy in the country only reached approximately 9 GW (EBTKE ESDM, 2018)

The government of Indonesia has been aware of the importance of renewable energy for the country. Through the National Energy Policy (KEN) stipulated in 2014, Indonesia aims to increase the New and Renewable Energy (NRE) share in the primary energy mix to 23% by 2025. This policy is crucial to help ensure energy security and meet Indonesia's pledge to curb the greenhouse gas emissions by 26% by 2020 or by 41% with international help.

To meet the target set in KEN, the central government of Indonesia issued the General Planning for National Energy (RUEN) in 2017. The plan sets out specific targets for each type of energy sources and strategies to achieve the targets. Realizing that oil imports have been increasing over the years and renewable energy is still underutilized, the central government aspires to reduce oil and increase renewables in the primary energy mix.

While the plan is in existence, the implementation appears to be challenging. The government has been struggling to find the best way to ensure the energy security while keeping the environmental impacts low and electricity prices affordable (energy trilemma). The good intention to develop renewables has not been accompanied with policy instruments to turn the plan into a reality. In fact, the perception of investment climate in the Indonesian renewables sector seems deteriorating as MEMR keeps changing the regulations related to renewable energy development in the country.

One of ways to bring changes in the sector is learn from other countries which have been successful in developing their renewables markets. A team of IESR researchers has conducted desk research on renewable energy policies in three countries, namely, Germany, China, and India and analyzed key lessons that might be pertinent to the Indonesian context. The three countries were chosen as many see them as global leaders in the renewable energy development.

This report starts with a detailed account of the Indonesian renewables sector before exploring the experiences from the three countries in fulfilling their renewables targets. The last part of this paper presents key takeaways from those experiences and best practices for policy makers to ignite the rapid development of renewable energy in Indonesia.

2. Renewable Energy in Indonesia

A country with more than 260 million inhabitants, Indonesia is the fourth most populous country in the world and the largest economy in Southeast Asia. Coal is the primary energy source used to generate electricity in the country. Indonesia is also the world's largest coal exporter despite its lower coal reserve compared to other countries like Australia and China. This condition makes it harder for Indonesia to shift away from coal to renewables as the government itself tries to protect the coal industry by increasing the uptake of coal domestically (for electricity) when the global coal demand is declining.

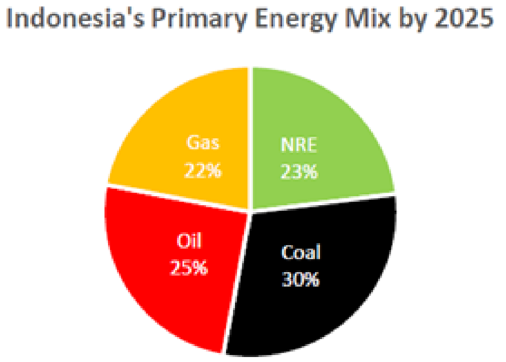
With more than 17,000 islands spread across the archipelago, it is also challenging for Indonesia to fully integrate its transmission and transportation infrastructure needed to distribute fuels for power plants. This has been the cause of low electrification rates in some regions in Indonesia. The country has increased its effort to boost the electrification ratio through a program called as the 35,000 MW program. This program however offers a bigger portion to coal-fired power plants than renewables, raising questions about Indonesia's commitment to renewable energy.

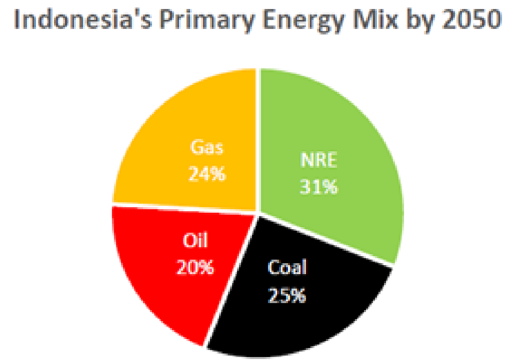
The following parts review the Indonesian renewables target and programs, latest development, electricity market, regulatory and institutional frameworks, financial incentives, and overall challenges in the development of renewable energy in Indonesia.

2.1. National Targets and Programs

Indonesia, under Paris Agreement, has pledged to lower its greenhouse gas emissions by 26% by 2020 or 41% with international support. To lower emissions in its power sector, the government of Indonesia stipulated the National Energy Policy (KEN) in 2014, setting out targets to increase the New and Renewable Energy (NRE) share in the primary energy mix to 23% by 2025 and 31% by 2050. The renewable energy referred in KEN includes geothermal, hydro, wind, solar, tidal, and biomass energy. Meanwhile the "new energy" includes nuclear, hydrogen, coal bed methane, liquefied coal, and gasified coal energy.

Figure 1.
Indonesia's Primary Energy Mix by 2025 and 2050 as set in KEN, Gov. Reg. No. 79/2014.





Note: Primary energy mix includes energy for electricity and direct use (transportation).

As there are no specific proportions determined for the renewables and "new energy", this report assumes that the target will be fully met with the renewables. This report will then use the renewables, instead of NRE, as the terminology referred to renewable energy.

In the 2015 – 2019 National Medium-Term Development Plan (RPJMN), Indonesia puts targets to achieve 10% to 16% share of renewables in primary energy mix by 2019, increase the renewables installed capacity (geothermal, hydro, and micro-hydro power) to 7.5 GW, and start pilot-projects of tidal power with capacity at least 1 MW. The other plan for the Indonesian power sector called as the General Planning for National Electricity (RUKN) was published by the MEMR since 2008 with renewal for every two years. The plan provides guidelines for long-term (20 years) development of power sector in Indonesia. The RUKN is used by PLN to make its ten-year Electricity Supply Business Plan (RUPTL).

Table 1.
Indonesia's Electricity Generation Mix by 2025 as set in RUKN and RUPTL

	2015 - 2034 RUKN (draft)	2018 - 2027 RUPTL
NRE	25%	23%
Coal	50%	54.4%
Gas	24%	22.2%
Diesel	1%	0.4%

The Indonesian government through the Presidential Regulation No.22/2017 on the General Planning for National Energy (RUEN) carries out a roadmap to achieve the national targets set in KEN. This RUEN was prepared by using computer modeling to project the 2015 to 2050 energy demand in Indonesia and in effort to meet the objectives of KEN. To meet the targeted NRE shares, Indonesia must install at least 45.2 GW of renewables by 2025 or 33.3% of targeted total installed capacity of 135.5 GW and 167.7 GW of renewables by 2050 or 37.8% of targeted total installed capacity of 443.1 GW in that year. Moreover, the biofuel, biomass, and biogas shall be utilized for direct use (e.g. transportation).

The RUEN also specifically sets out installed capacity targets for each type of renewable energy, as demonstrated in Figure 3. The targets referred in the Figure 3 are a mix of committed and potential projects in Indonesia. The committed projects will be developed by central government while potential projects are expected to be developed by provincial governments with the plan will be further detailed in the General Planning for Regional Energy (RUED). In addition to the national renewables targets, RUEN also puts targets to fully electrify the whole country by 2020. However, there are no specific targets for renewables-based power generation (GWh).

The Indonesian government through the MEMR Regulation No. 12/2015 sets out targets to increase the biodiesel utilization in the country (see Table 2). This program is commonly known as the B20 program. Although the program was initially intended for both Public Service Obligation (PSO - subsidized) and non-PSO, only PSO received subsidies from the government to use biodiesel. As the result, the non-PSO sectors such as industry and commercial were reluctant to comply with the regulation.

Figure 2.
NRE targets for electricity and direct use in 2025 and 2050 according to RUEN 2017

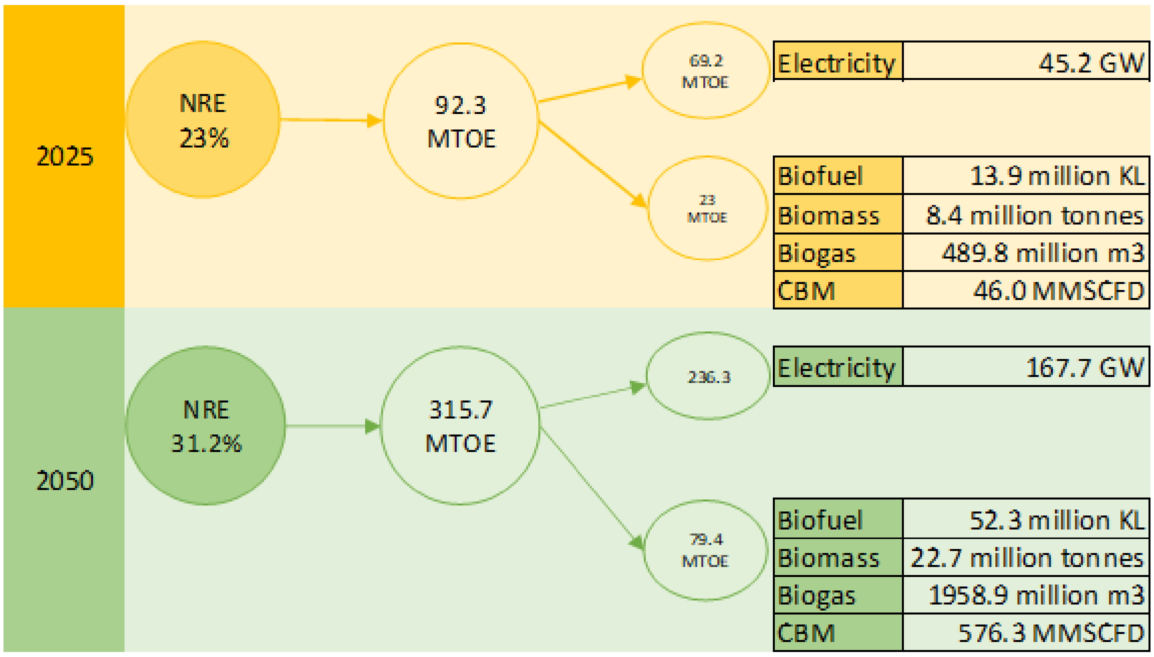
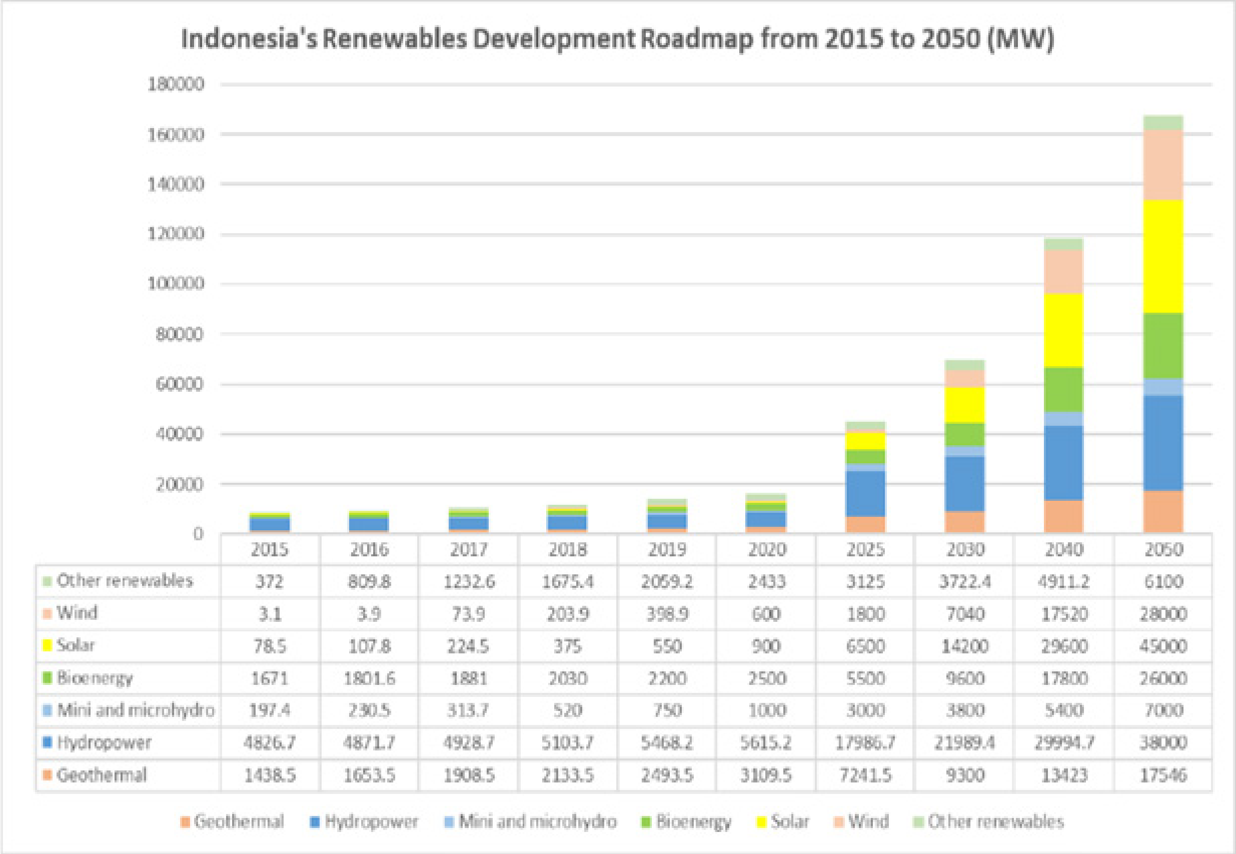


Figure 3. Indonesia's Renewables Development Roadmap from 2015 to 2050 according to RUEN 2017



	2015	2016	2017	2018	2019	2020	2025	2030	2040	2050
Other renewables	372	809.8	1232.6	1675.4	2059.2	2433	3125	3722.4	4911.2	6100
Wind	3.1	3.9	73.9	203.9	398.9	600	1800	7040	17520	28000
Solar	78.5	107.8	224.5	375	550	900	6500	14200	29600	45000
Bioenergy	1671	1801.6	1881	2030	2200	2500	5500	9600	17800	26000
Mini and microhydro	197.4	230.5	313.7	520	750	1000	3000	3800	5400	7000
Hydropower	4826.7	4871.7	4928.7	5103.7	5468.2	5615.2	17986.7	21989.4	29994.7	38000
Geothermal	1438.5	1653.5	1908.5	2133.5	2493.5	3109.5	7241.5	9300	13423	17546

The recent Presidential Regulation (PR) No. 66/2018, which is the second revision of PR No. 61/2015 on CPO Fund, then ensures that both the PSO and non-PSO will get subsidies for biodiesel. The biodiesel subsidies come from CPO Fund which is collected from levy on Crude Palm Oil (CPO) and CPO derivatives exports. With these subsidies, the non-PSO is required to use B20 starting from September 2018. The B20 mandatory program is expected to help Indonesia reduce its oil imports (which have continuously increased and burdened the state budget), decrease CO2 emissions, and protect local biodiesel industry from EU's antidumping duties.

The Indonesian government has also initiated some programs to achieve both the electrification ratio and renewables targets, including the five-year program (2014 – 2019) to build 35,000 MW of power plants across Indonesia with 25% or 8800 MW of it coming from renewables, the Bright Indonesia program (PIT) to electrify 12,695 villages in eastern Indonesia by 2019 mainly with the renewables sources, and the energy-saving solar-powered

Table 2.
Biodiesel Mandate in Indonesia (percent of blending) according to MEMR Regulation No. 12/2015

Sector	April 2015	January 2016	January 2020	January 2025
Microbusiness, fisheries, agriculture, transportation, and PSO	15%	20%	30%	30%
Non-PSO transportation	15%	20%	30%	30%
Industry and commercial	15%	20%	30%	30%
Electricity	25%	30%	30%	30%

lights (LTSHE) program to provide basic electricity to 2,519 villages in the most remote and outermost areas in Indonesia by 2019. The 35,000 MW program is an on-grid program aimed at increasing power in already-electrified areas, the PIT program is an off-grid program targeting areas that have not been electrified by PLN, and the LTSHE program is part of the PIT program that aimed at villages that have no electricity access at all. The PIT program will account for 1,000 MW of the 35,000 MW program.

2.2. Current Status

Indonesia still puts its focus on electrifiying the whole country by 2020. Data from the MEMR shows that by the end of 2017 Indonesia had a national electrification ratio of 95.35%, with the East Nusa Tenggara and Papua had the lowest electrification ratios of 61.02% and 62.10% respectively. To electrify the country, the government of Indonesia prefers coal to renewables. This is reflected in the 2017 electricity mix, with coal still dominated the power sector, accounting for more than 50% of electricity generation. Meanwhile, the renewables only shared 12.15% of total electricity mix in 2017. The same trends can be seen in the 2017 energy mix which was still dominated by fossil fuels, accounting for 91.6% of its primary energy mix.

The historical data on electricity generation also appears to contradict the target of 23% renewable energy by 2025. As Indonesia keeps rising its electricity generation to meet the increasing demand, the coal generation has also increased from 61 TWh in 2009 to 146 TWh in 2017. In terms of share, the decreased share of diesel in the generation mix has been predominantly replaced by coal. As seen in the Table 3, the share of diesel has been decreasing from 25% in 2009 to 5.8% in 2017 (decreased by 19.2%) while the share of coal has been increasing from 39% in 2009 to 57.22% in 2017 (increased by 18.22%). At the same period, the renewables have only seen an insignificant growth from 11% to 12.15%, an increase of 1.15%.

In addition, from 2011 to 2017, the share of renewables in generation mix had been locked in the range of 10% to 13%, showing stagnation of renewables deployment in Indonesia. The decreased share of renewables from 12.46 % in 2016 to 12.15% in 2017 is also aligned with the decrease of renewables generation from 30977 GWh in 2016 to 30920 GWh in 2017. Moreover, this small share of renewables has been primarily contributed by hydropower, leaving other types of renewables underutilized.

Since 2007, the cumulative renewables installed capacity has grown by 95%, from 4.67 GW to 9.1 GW in 2017 (preliminary data, including off-grid bioenergy). This growth equals to an average of 444 MW installed capacity addition per year and a 6.9% compound annual growth rate (CAGR). This growth is considered small compared to what the country wants to achieve by 2025. Unless the country annually adds 4500 MW of renewables until 2025, Indonesia is set to miss its 2025 renewables target.

The actual trends, however, are alarming. As demonstrated in the Figure 6, the year-on-year capacity addition of renewables in Indonesia has been declining since 2013. In 2017, Indonesia only added 242 MW of renewables (including off-grid

Figure 4. Indonesia's Energy Mix and Electricity Mix in 2017. Data from DJK ESDM (2018)

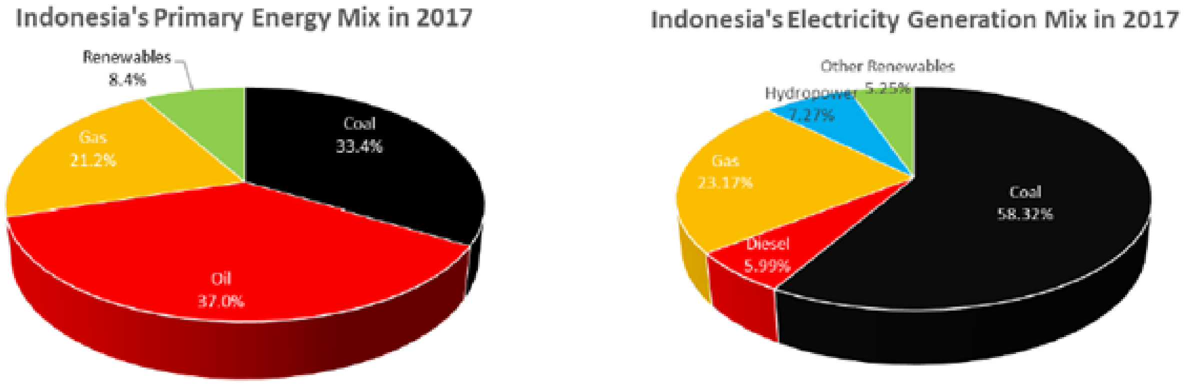


Table 3.
Indonesian Electricity Generation by Source from 2009 to 2017. Data from DJK ESDM (2017, 2018). Note. Grid connected only, 2017 data is preliminary.

Year	Coal	Diesel	Gas	Hydropower	Other renewables	Total Renewables	Total Generation (GWh)
2009	39.00%	25.00%	25.00%	8.00%	3.00%	11.00%	156797.20
2010	38.00%	22.00%	25.00%	12.00%	3.00%	15.00%	169786.22
2011	44.06%	22.95%	21.00%	6.80%	5.20%	12.00%	183420.93
2012	50.27%	14.97%	23.41%	6.39%	4.96%	11.35%	200317.56
2013	51.58%	12.54%	23.56%	7.73%	4.58%	12.31%	216188.53
2014	52.87%	11.81%	24.07%	6.70%	4.55%	11.25%	228554.90
2015	56.06%	8.58%	24.89%	5.93%	4.54%	10.47%	233981.98
2016	54.70%	6.96%	25.88%	7.88%	4.58%	12.46%	248610.52
2017	57.22%	5.81%	24.82%	7.06%	5.09%	12.15%	254487.66

bioenergy), hitting its lowest since 2011. In fact, the growth of renewables in the past decade has been modest compared to the gigantic growth of thermal power plants in Indonesia. The trends also imply plummeting overall capacity additions in recent years due to slowing electricity demand growth in Indonesia.

In terms of investment, data from DGNREEC shows that renewables investment in Indonesia reached $1.3 billion in 2017, decreasing by 17% compared to the $1.57 billion investment in 2016. The Indonesian government targeted to reach at least $2 billion investment in 2018. This target is considered small compared to IRENA's estimate at $7.9 billion of annual investment needed by Indonesia from 2015 to 2030 to meet the 23% renewables targets (IRENA, 2017). The decreased investment in 2017 also coincides with EY's 2017 Renewable Energy Country Attractiveness Index (RECAI) that tossed Indonesia out of top 40 countries with high attractiveness in renewables investment opportunities. Indonesia was ranked 38th in 2015 and 2016.

In contrast, the coal-fired power plants seem more favorable to the Indonesian government as the country keeps increasing its investments in coal-fired power plants. The heavy reliance on coal,

Figure 5.
Required Annual Capacity Addition to Meet the 23% Renewables Target in MW. Data for 2017 from EBTKE ESDM (2018), for 2025 Targets from RUEN 2017. The 2017 data is preliminary, data is patchy.

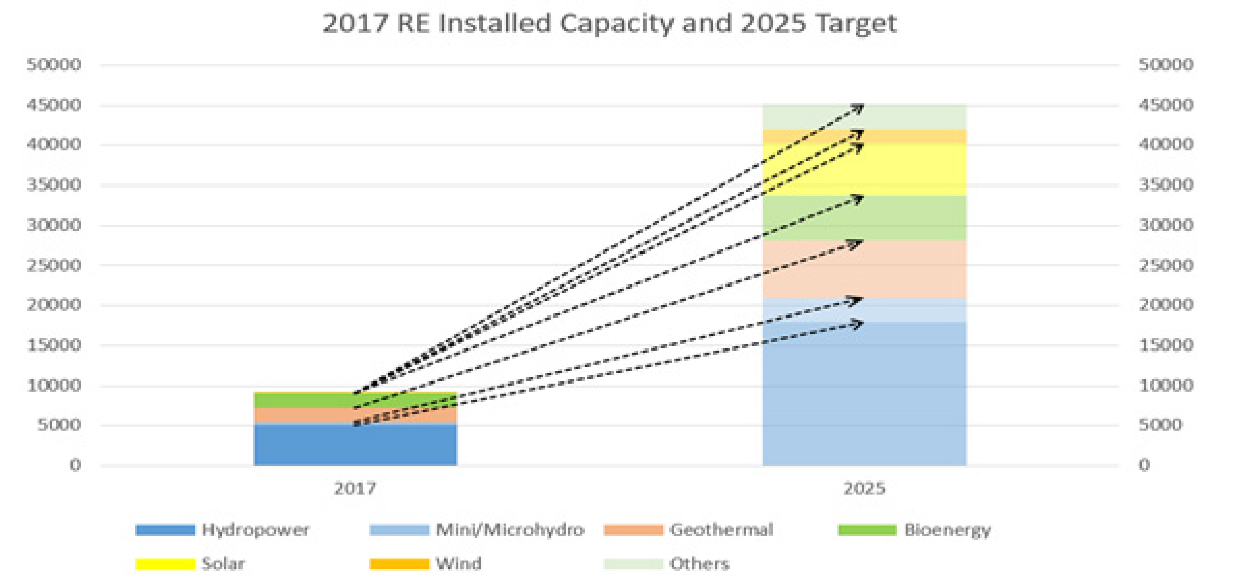
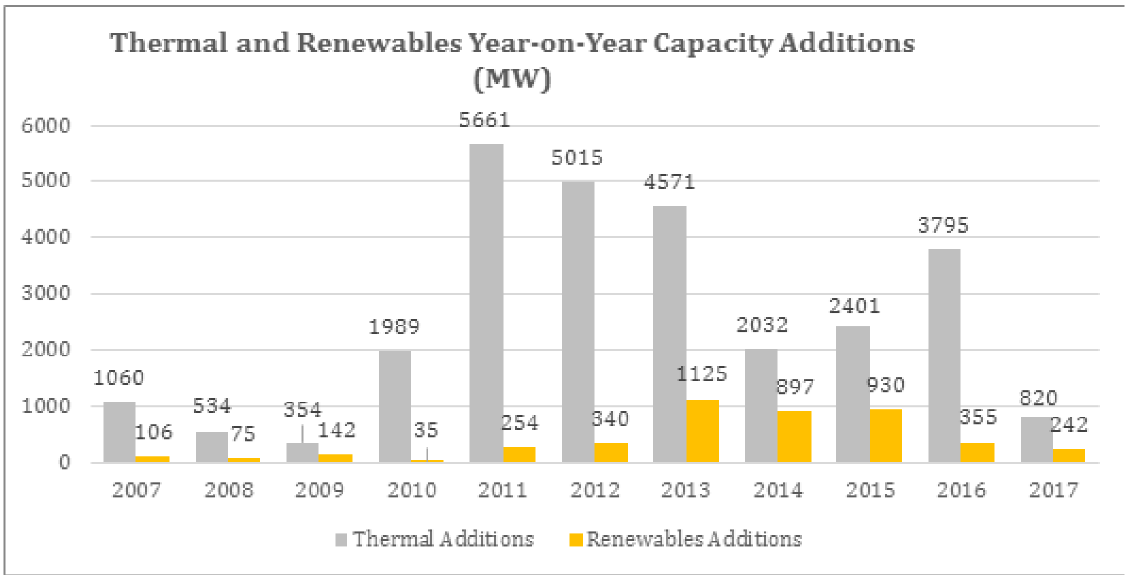


Figure 6.
Indonesia's year-on-year thermal and renewables installed capacity addition. Data for 2017 renewables from EBTKE ESDM (2018), for 2017 thermal data from DJK ESDM (2018), for bioenergy from Indonesia Energy Roadmap 2017-2025, and for others from DJK ESDM (2017).
Note: on-grid data except for bioenergy, the 2017 data is preliminary.



however, is posing a risk of stranded assets to Indonesia. As Indonesia is enforcing the capacity payment mechanism to secure the investment in its power sector, the IPPs will be paid for the power they can produce rather than the power they dispatch into the grid. IEEFA in its 2017 report calculates that current utilization rate of coal-fired power plants in Indonesia is 57.3%. Therefore, if PLN was to proceed its 2017 RUPTL to build 12,845 MW of coal-fired power plants in Java-Bali system from 2017 to 2026, Java-Bali would have more than 40% or 5138 MW of idle capacity over 25 years. This would translate into PLN's obligations to pay $16.2 billion for electricity the end-users would not use (Chung, 2017).

At the same time, the implementation of biodiesel policy in Indonesia has also been ineffective. As seen in the Figure 8 below, the biodiesel targets have never been met over the years. In 2016, the consumption only reached around 3 billion liters (Wright & Rahmanulloh, 2017), much lower than target at around 6 billion liters. Value chain and unsustainable supply are some of barriers to meet the biodiesel targets (Purwanto & Pratama, 2017). It is also worth noting that most of biodiesel is used for transportation and only less than one percent of electricity is utilizing biodiesel (Wright & Rahmanulloh, 2017).

Figure 7.
Year-on-year renewables investment in Indonesia. Data for actual investment from EBTKE ESDM (2018) and for investment needs from IRENA (2017).

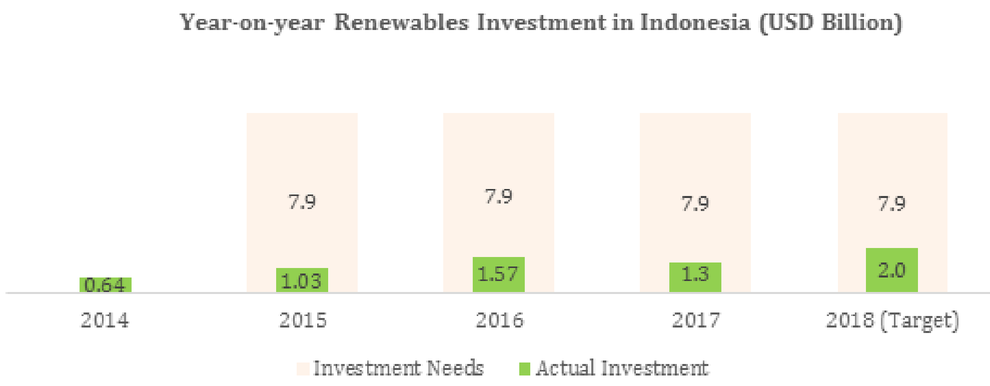
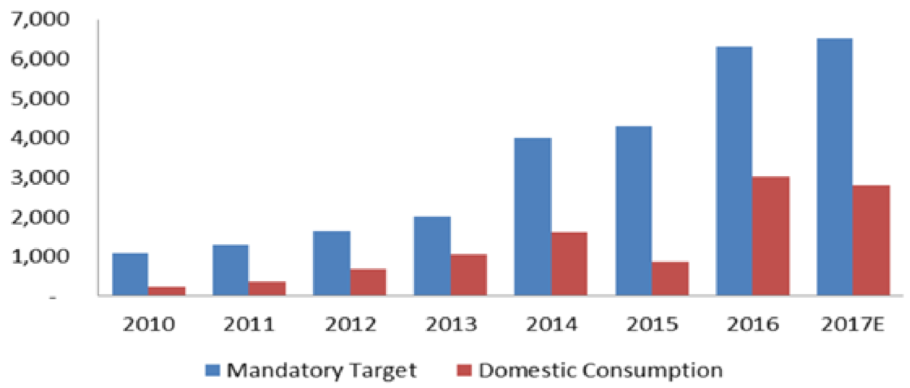


Figure 8.
Biodiesel Mandatory Target and Domestic Consumption in Indonesia (Million Liters).
Source: Wright & Rahmanulloh, 2017. Note: 2017E is first quarter of 2017.



2.3. Electricity Market

The Indonesian power market consists of two main sectors, generation and transmission & distribution. In the generation sector, there are the state-owned utility (PLN) which generates most of electricity in Indonesia, Independent Power Producers (IPPs), and Private Power Utilities (PPUs). The transmission, distribution, and retailing are not separated and fully controlled by PLN. PLN acts as a single buyer which procures electricity generated by IPPs under a Power Purchase Agreement (PPA) in accordance to its procurement and business plan.

The PPA system might become a barrier to the development of renewables in Indonesia. As the renewables prices keep declining, the power market is expected to use more renewables. However, with PPA, PLN will be locked in two to three-decade contracts of coal generation. Even if the renewables prices are already competitive, these long-term contracts will prevent PLN from rapid deployment of renewables as PLN would likely avoid its coal-fired power plants becoming stranded assets.

The Electricity Law No. 30 of 2009, which replaced the annulled 2002 Electricity Law, legitimates the state as the controller of power market and PLN as a vertically integrated utility which acts as the main player in generation sector and sole player in transmission and distribution sectors in Indonesia. Although the law allows region-owned enterprises, private companies, cooperatives, and community initiatives to participate in distribution sector, PLN still holds the right of first-priority to distribute the electricity to end customers.

As the market is regulated and an independent regulator is absent, the electricity tariffs are controlled by the government. The absence of independent regulator might have created loopholes that allow the government to misuse its authority to regulate the electricity tariffs to maintain political support from the public. The trends seem consistent with this assertion as the previous and current governments have always decided not to increase the electricity tariffs as the presidential elections approach. The objective to maintain low electricity tariffs to retain political position has sacrificed the development of renewables in Indonesia. With this objective in mind, the government naturally prefers coal to renewables to produce cheap electricity.

The PPUs are private companies whose captive power plants to provide a localized source of power to their customers (usually industrial complexes) or for their own use. These captive power plants may operate off-grid or be connected to power grid to sell the excess power to PLN or purchase power from PLN as a backup/parallel system. By the end of 2016, all PPUs in Indonesia still used fossil fuels to generate the electricity (DJK ESDM, 2017).

The captive power can help increase the uptake of renewables if power wheeling is allowed. With power wheeling, the PPUs have an option to generate the electricity from renewable sources located in areas away from the industrial complexes they serve and transmit it to their customers by using the power grid owned by PLN. This idea has been accommodated in the Government Regulation No. 14/2012 (amended by Government Regulation No. 23/2014) and the MEMR Regulation No. 1/2015 which offer an opportunity for private companies to participate in the provision of electricity for public use and allow them to access the transmission and distribution network owned by PLN.

These regulations, however, lack details of technical procedures and transmission fees charged to private companies when using PLN's network. As the result, the power wheeling is not effectively implemented yet. PLN, as the sole owner of power grid in Indonesia, retains its position as the only company involved in the transmission and distribution sector (Kamarudin & Boothman, 2017).

The slow adoption of power wheeling triggers many multinational companies operated in Indonesia which have committed to becoming 100% renewable (RE100) to question the support the country provides to them in fulfilling their commitments. This may become a threat for the country as these companies might choose to move their operation to other countries where the utilities can provide them with 100% renewables-based electricity or where power wheeling is well-implemented.

2.4. Regulatory and Institutional Frameworks

Regulatory Framework:

Institutional Framework:

Table 4. Regulatory framework in the Indonesian renewables market

Regulation	Description
Law No. 30/2007 on Energy	• Prioritizing the energy access to underdeveloped, remote, and rural areas by utilizing local energy sources, particularly renewable energy sources • Business entities and individuals that use renewables may obtain incentives from government and/or regional government until the renewable energy reaches its economic value • Government and regional government shall increase the utilization of renewable energy • The R&D on energy shall be focused on NRE to stimulate the domestic energy industry • Commercialization of NRE research outcomes must be funded by the state revenues coming from non-renewable energy
Law No. 30/2009 on Electricity	• Prioritizing NRE to ensure the sustainability of electricity supply • NRE is used in accordance with its economic value
Law No. 21/2014 on Geothermal	• Enacted as the replacement of 2003 Geothermal Law, the 2014 Geothermal Law redefines the geothermal exploitation activities as non-mining activities and thus allows such activities to be conducted in protected and conservation forest areas, where around 42% of Indonesian geothermal resources are found (PwC, 2017) • Provision of direct and indirect utilization of geothermal. Direct utilization is defined as any non-electricity purposes while indirect utilization is for electricity generation purposes • Provision of pricing for geothermal power which should reflect the economic feasibility of geothermal development • Provision of production bonus, which is a certain percentage of the gross revenue from the commercial operation date of the first unit, to be provided by the Geothermal Permit holders to local government whose authority over permit holder's working area

Regulation	Description
National Medium-Term Development Plan (RPJMN)	• The 2015 – 2019 RPJMN puts targets to achieve 10% to 16% share of renewables in primary energy mix by 2019, increase the renewables installed capacity (geothermal, hydro, and micro-hydro power) to 7.5 GW, and start pilot-projects of tidal power with capacity at least 1 MW
National Energy Policy (KEN) or Government Regulation No. 79/2014	• Setting out plan to increase the New and Renewable Energy (NRE) share in the primary energy mix to 23% by 2025 and 31% by 2050
General Planning for National Energy (RUEN)	• Formulated by the National Energy Council, RUEN sets out a roadmap to achieve the national targets set in KEN. To meet the targeted NRE shares, Indonesia must install at least 45.2 GW of renewables by 2025 or 33.3% of targeted total installed capacity of 135.5 GW and 167.7 GW of renewables by 2050 or 37.8% of targeted total installed capacity of 443.1 GW in that year
General Planning for National Electricity (RUKN)	• Prepared by the MEMR and approved by the House of Representatives, RUKN provides guidelines for long-term (20 years) development of power sector in Indonesia. It is used in developing PLN's Electricity Procurement Business Plan (RUPTL). The draft of 2015 - 2034 RUKN (the latest version of RUKN) sets out target to increase the share of NRE to 25% by 2025
RUPTL	• Issued by the PLN, RUPTL sets out PLN's ten-year plan to develop the Indonesian power sector. The 2018 RUPTL aims to reach 23% of NRE share in electricity generation mix by 2025, by adding 15 GW of renewables onto the grid.
Ministerial Regulations	• MEMR Regulation No. 33/2017 on Procedure for provision of energy-saving solar-powered lights for communities that do not have access to electricity yet • MEMR Regulation No. 41/2017 on Electricity Tariffs • MEMR Regulation No. 49/2017 on Power Purchase Agreement Principles • MEMR Regulation No. 50/2017 on Utilization of Renewable Energy Sources for Electricity Supply • MEMR Regulation No. 32/2008 on Biofuels Production, Trade, and Use

The role of government is dominant in the Indonesian power market. The government is regulating the sector through the MEMR, facilitating the allocation of state budget for electricity subsidy, operating the power market through the state-owned utility (PLN) and supervising and controlling the overall power market. PLN as the sole power utility in Indonesia is the main provider of the electricity and infrastructure to generate, transmit, distribute, and retail electricity. Meanwhile the local companies, cooperatives, and communities can get involved in the electricity provision in Indonesia and act as complementary electricity providers when electrical service from PLN is not available.

The MEMR is the primary regulator governing the Indonesian power market. It consists of several directorates that have separate responsibilities. The DGNREEC has the responsibility to formulate and issue regulations related to renewable energy and energy conservation and while the DGE for general electricity provision, including tariff setting. The licensing of renewables projects is given by the local government while the licensing of electricity projects (generation, transmission, and distribution) is provided by the local government and DGE.

The policy making process in the Indonesian power sector involves ministries and national council.

The MOF is in charge of the formulation of budget allocations, electricity tariffs, and subsidies. The BAPPENAS is responsible for setting out national development planning, including the electricity infrastructure. The DEN has the authority to design and formulate the national energy policy to ensure energy security. The MOEF is in charge of issuing forest use permits for power generation projects in forest areas and formulating environmental standards for power plants. In addition, the CMEA, MOI, MOPWH, MOT, and MSOE also have roles, although limited, in the making of renewables and electricity policies. The summary of institutions which get involved in the Indonesian power sector can be seen in the Table 5 below.

Table 5.
Institutions in Indonesian renewables and power sectors. Adapted from Tharakan (2015)

	New and Renewable Energy	Electricity
Policy Making	DEN, BAPPENAS, MOF, MOEF, CMEA, MOI, MOPWH	DEN, BAPPENAS, MOF, MOEF, CMEA, MOI, MOT, MSOE
Licensing	Local government	DGE, Local government
Regulator	DGE, DGNREEC	DGE
Operation	Local companies, cooperatives, communities	State-owned utility (PLN), captive power, cooperatives, communities
DEN: National Energy Council, BAPPENAS: Ministry of National Development Planning, MOF: Ministry of Finance, MOEF: Ministry of Environment and Forestry, CMEA: Coordinating Ministry of Economic Affairs, MOI: Ministry of Industry, MOPW: Ministry of Public Works and Housing, MOT: Ministry of Trade, MSOE: Ministry of State-Owned Enterprises, DGE: Directorate General of Electricity, DGNREEC: Directorate General of New and Renewable Energy and Energy Conservation.		

The decentralized political system in Indonesia makes a transition toward clean energy more challenging as conflicts and miscoordination between different actors in charge in the policy making might arise. Oftentimes the local governments have low capacity to formulate robust local energy policies and lack comprehensive understanding of national goals. On the other hand, the central government usually has limited understanding of local circumstances and lacks coordination with local policy makers in policy making process (Marquardt, 2014).

2.5. Financial Instruments and Incentives

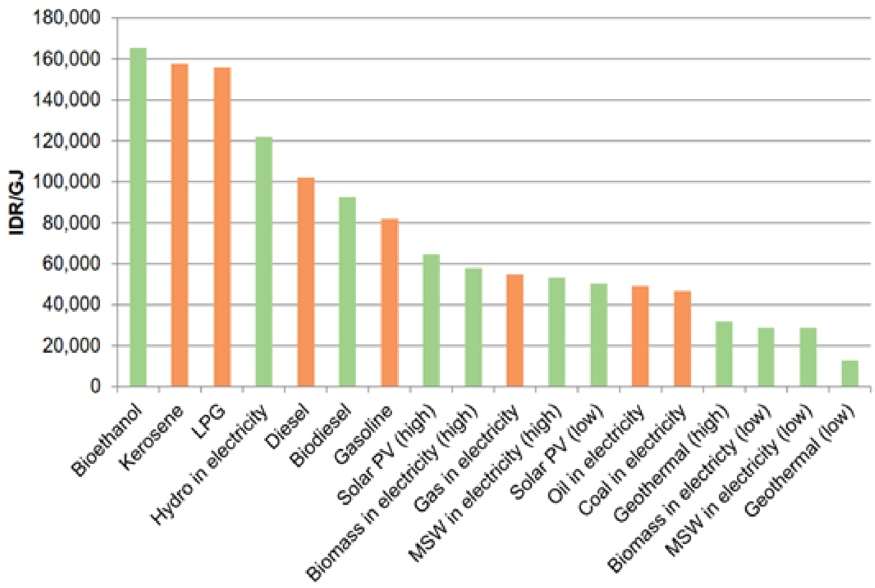
As the renewable energy industry is still emerging in Indonesia, the country needs to incentivize the development of renewables projects. Some incentives available in the renewables sector in Indonesia can be seen below.

1. Fiscal and Financial Incentives

Table 6.
Fiscal incentives for renewable energy projects in Indonesia

Item	Description
VAT (MOF Reg. No. 21/2010)	Exemption from VAT for imported strategic taxable goods of machinery and equipment, excluding spare parts, used in renewables projects
Income tax (MOF Reg. No. 21/2010)	The net income tax reduction by 30% of the investment value, accelerated depreciation and amortization, reduced dividends for foreign investors, and compensation for losses for renewables projects
Import duty (MOF Reg. No. 21/2010)	Exemption from import duty for equipment and capital used in renewables projects

Figure 9.
Subsidies per GJ of energy for renewables and fossil fuel sources.
Source: Vivid Economics as cited in (Ward et al., 2015).
Note: Renewables subsidies in green, fossil fuel subsidies in orange.



- **Fiscal Incentives**

The government of Indonesia has provided both fiscal and financial incentives for renewables projects in the country since 2010. These incentives include value-added tax (VAT) exemption, income tax reduction, import duty exemption, and tax holiday.

By providing these incentives, the government intends to not only attract investors in renewables projects but also stimulate growth in local renewables-equipment manufacturing industries. The absence of specific criteria of machinery and equipment that can be exempted from import duty might increase reliance on imported equipment and thus reducing the effectiveness of Ministry of Finance Regulation No. 35/PMK.010/2018 which aims to develop domestic power generating (including renewables) industries.

The incentives given to renewable energy, however, are small compared to subsidies for fossil fuels. In 2015, the United Kingdom Low Carbon Support Programme in its report concluded that Indonesia provided less

Table 7.
Financial incentives for renewables projects in Indonesia

Item	Description
Geothermal Fund (MOF Reg. No. 62/PMK.08/2017)	The Indonesian government appointed PT Sarana Multi Infrastruktur (SMI) to manage IDR 3.7 trillion to be used in the exploration and exploitation activities of geothermal energy in Indonesia. The fund will be disbursed through lending activities, equity participation, and/or geothermal data and information supply.
Special Allocation Fund (DAK) of rural energy sector (MEMR Reg. No. 3/2013)	Fund allocated in state budget for specific regions to help finance renewable energy development activities in areas where electricity from PLN is not available.
Credit program from food and energy security (KKP-E)	Financing incentives in the form of interest subsidies for renewables developers. These incentives are disbursed by the MOF to implementing banks to cover the excess of the interest reduction borne by the banks.

subsidies per GJ of energy for renewable energy technologies than for most of fossil fuel sources (see Figure 9). As PLN mainly uses coal, gas, and oil to generate electricity, those sources more benefited from electricity subsidies than FIT-priced renewables sources (Ward, Marijs, Tumiwa, & Salim, 2015).

- **Financial Incentives**

  While the financial incentives are available, most of developers do not make use of it. The renewables developers perceive that the process to claim the incentives oftentimes is complicated. It also appears that the interest subsidies provided by the government are unhelpful in lowering the interest rates for renewables developers in Indonesia. The interest rates which local banks charge to the renewables developers more than 10% much higher than 3% of interest rate foreign banks usually charge to developers. In addition, unlike banks in other countries, the local banks in Indonesia do not provide project financing scheme to fund renewables projects.

2. Grid Connection and Tariff Incentives

- **Feed-in-Tariffs (FIT)**

  The FIT scheme implemented in Indonesia has been ineffective in boosting the deployment of renewables in the country. This has been caused by several factors which will be discussed in the later part of this section. The latest FIT for each type of renewables is outlined in the Table 8 below.

Under the MEMR Regulation No. 50/2017, the IPPs will be paid according to tariffs which are benchmarked against the cost of electricity generation or "Biaya Pokok Pembangkitan (BPP)" or based on business-to-business (B2B) negotiation between PLN and IPP, as described in the Table 8 above. If the local BPP is higher than the national BPP, the offtake prices must not exceed 85% of local BPP. An exception applies to hydro, municipal waste, and geothermal power, where the maximum offtake prices are 100% of local BPP. Meanwhile, when the local BPP is lower than the national BPP, the offtake price can be negotiated between the PLN and IPP.

With these new tariffs, the opportunity to develop renewables projects is higher in remote areas, which mainly use high-cost diesel generators to generate electricity, than in Java and Bali, where the BPP is low as coal is primarily used to generate electricity. However, as the electricity demand in remote areas is relatively low (80% of electricity demand in Indonesia is in Java-Bali) and the grid infrastructure in those areas is also lacking, the development of renewables in remote areas would be limited. Therefore, this new tariff scheme would be inadequate to help the country meet its 23% renewables goal.

The B2B negotiation mechanism may bring a chance for IPPs which operate in regions where the local BPP is less than the national BPP to negotiate a higher price with PLN. On the flip side, this mechanism might also discourage investors to invest as they perceive making an investment in a project with no fixed offtake price as risky.

Table 8.
Renewables Tariffs based on MEMR Regulation No. 50/2017

Renewable Energy Source	Procurement Method	Tariff Mechanism	
		Local BPP>National BPP	Local BPP≤National BPP
Solar PV	Direct selection based on capacity quaota	Maximum 85% of local BPP	Mutual agreement between PLN and IPP
Wind			
Biomass	Direct selection		
Biogas			
Tidal			
Hydro		Maximum 100% of local BPP	
Municipal waste-to-energy	Based on laws and regulations		
Geothermal			

The risk perception might even be higher as the negotiated price agreed by PLN and IPP is subject to MEMR approval, lengthening the bureaucracy of renewables projects in Indonesia. The use of BPP instead of the marginal economic value of the project also gives increased risk to investors as the offtake price will change due to BPP updates (PwC, 2017).

The Indonesian government also applies the Build, Own, Operate, and Transfer (BOOT) scheme to all renewables but the municipal waste-to-energy. This scheme requires the IPPs to transfer their power plant assets to PLN once their PPAs expire, meaning that there is no contract renewal for IPPs. The scheme has raised objections from developers as the costs associated with asset transfer (e.g. land acquisition) cannot be covered by current renewables tariffs of 85% of BPP. Under the new PPA scheme (85% of BPP), most of developers find difficulties in finding funding for renewables projects (PwC & APLSI, 2018).

The regulation of renewable energy tariffs itself has been established in Indonesia since 2002. Before 2015, the tariff regulations of bioenergy and municipal waste to energy were only for small-scale projects (less than 10 MW), making the development of large projects impossible. The renewables tariffs had been differentiated based on grid interconnection (low, medium, and high voltage) and project location. Each project location or region had a different incentive factor called as "F" factor, with "F" factor for Java equaled to one and other regions bigger than one. While using location as a factor in determining FIT is a good approach, Indonesia seemed not to consider the available renewables resources in each region in determining the "F" factor.

It also appears that Indonesia has been decreasing the FIT over the years. Unlike other countries which decrease the FIT as the renewables penetration in the power system increases, Indonesia rushed to reduce the FIT before the renewables market takes off in the country.

The renewables tariffs under older regulations were higher than current tariffs. The higher tariffs, however, were ineffective in boosting the renewables investments in Indonesia. The PLN saw renewables as burdens to its budget as it had to pay extra costs to renewables developers when the electricity tariffs remained flat and the electricity subsidies for the company have been reduced. The FIT mechanism that had been used in Indonesia lacked details of instruments (e.g. surcharge and coal levies) that could be used by PLN to fund the renewables development.

The implementation of surcharge - the extra costs of renewable generation passed onto consumers - might be difficult as the issue of electricity tariffs in Indonesia is political. A regulation to increase electricity tariffs is usually unpopular in the public. Meanwhile, imposing levies or taxes on coal would also be challenging as many political interests are involved in the industry. The policy innovation and boldness of policy makers are therefore necessary to secure funding for developing the renewables in the country.

The use of BPP as a benchmark to set renewables tariffs is in line with the government's intent not to increase the electricity prices until 2019 (when the presidential election will be held) and reduce the electricity subsidies. However, this new tariff scheme is deterring as it takes away incentives for renewables developers, hence discouraging renewables investments in Indonesia. The government therefore contradicts the 2007 Energy Law which encourages the government to provide incentives to business entities and individuals that utilize the renewables until the renewables reach its economic value (Article 20).

At the same time the Indonesian coal industry has received subsidies from the government which indirectly help lower the costs of coal purchased by the PLN. The industry received at least USD 946.1 million and USD 644.8 million of subsidies in 2014 and 2015 respectively (Attwood et al., 2017). The recent Domestic Market Obligation (DMO) policy which caps the coal price sold to PLN to USD 70 per metric ton (much lower than the market price) further helps the PLN secure cheap coal for its generation. The PLN also obtains lower-price diesel from the state-owned oil and gas company, Pertamina (Eichelbroenner & Schweneke, 2018). The subsidies along with the price interventions and externalities are not taken into account in the BPP. Therefore, the BPP is not reflecting the true costs of generation and the benchmarking of renewables against BPP is thus not ideal.

- **Prioritized grid access for renewables-based generators**

  Under MEMR Reg. No. 50/2017, PLN is only obliged to run the renewables-based power plants with capacity less than 10 MW (must-run), while the large renewables plants must compete with thermal plants. As most thermal power plants are not flexible (difficult to ramp up/down instantly), PLN might prefer to curtail renewables generation when demand is lower than supply of electricity. This situation could discourage the development of renewable energy in Indonesia. Like other countries, the Renewable Energy Law might be much needed to guarantee the grid access and prioritized dispatch for renewable energy in Indonesia.

2.6. Challenges of Renewables Development in Indonesia

IEA in its 2011 report classifies renewables barriers in two categories, economic and non-economic barriers. The economic barriers consist the direct costs of renewables technologies relative to other energy technologies. The non-economic barriers include regulatory uncertainty, institutional, market, financial, infrastructure, awareness, skilled workers, and public acceptance. While the economic barriers would be likely more complex to overcome, the Indonesian government can focus on reducing the non-economic barriers of renewables development in Indonesia. Some of those non-economic barriers are described as following:

- **Regulatory and policy uncertainty**

  The trends show that different leadership at MEMR has different appetite towards renewables, causing frequent changes in renewables regulations in Indonesia. The lack of consistent commitment to renewables has cost the development of renewables market in Indonesia. The constantly changing regulations increase the perceived risk and uncertainty for investors and developers, reducing the attractiveness of Indonesian renewables market to investors. A survey conducted by PwC in 2018 concludes that investors see regulatory uncertainty as the top barrier to large-scale power plant investments in Indonesia (PwC & APLSI, 2018).

  Furthermore, even though the country has a number of development plans for the renewables sector (e.g. RUEN, RUKN, RUPTL), most of the plans are inconsistent with one another. The inconsistency has been caused by different approaches used in each plan (e.g. bottom-up approach in RUPTL and top-down approach in other plans) and different assumptions (e.g. economic and demand growths) fed into the modellings.

  The top-down approach oftentimes applies overoptimistic economic growth, creating an overestimated demand growth and capacity additions. The RUEN, therefore, might need to be revisited as it was prepared under an overoptimistic condition which led to large required capacity additions of coal. On the other hand, the bottom-up approach used in RUPTL is insufficient to make the plan as a firm and legitimate planning in the Indonesian power sector because the plan is changing annually. The policy makers might also need to alter the parameters used in developing these plans as most of the time the plans give a large proportion of development to coal.

- **Market barriers**

  The Indonesian government failed to establish support policy that is able to adapt to changes in market conditions. The rush on FIT reduction before the Indonesian renewables market take off proves this assertion. The pricing structures of renewables in Indonesia have also been through some major changes since its first introduction in 2006. The inconsistent pricing structures have made it hard for investors to predict the investment climate in the Indonesian renewables sector. Furthermore, the last pricing structure which caps the renewables prices at 85% of BPP is deemed as a barrier to obtain funding for new projects.

The Indonesian coal industry has received a significant number of subsidies from the government which indirectly help lower the costs of coal purchased by PLN. The recent regulation to cap the coal price sold to PLN to USD 70 per metric ton (much lower than the market price) also distorts the price signal from market which should have become a push to shift away from fluctuated-price coal to declining-price renewables. In addition, PLN has long enjoyed lower-price diesel from Pertamina. As the subsidies, price interventions, and externalities are not taken into account in the BPP, many see the benchmarking of renewables against BPP as discriminatory.

Moreover, the incentives given to renewable energy are small compared to subsidies for fossil fuels. By 2015, Indonesia provided less subsidies per GJ of energy for renewable energy technologies than for most of fossil fuel sources.

The absence of an independent regulator makes the determination of electricity tariffs political. The decision not to increase the electricity tariffs until 2019 by current government, which led to the stipulation to cap renewables tariffs to 85% of BPP, is deemed as means to retain public support for current government. This cap, however, is detrimental to renewables development in Indonesia as the tariffs are deemed insufficient to make the renewables projects attractive to investors.

PPA system for coal plants and short-term goal to keep electricity prices low might cost Indonesia in the future as coal plants will become stranded assets once the renewables reach grid parity. The PLN's hesitation to allow IPPs to use its grid to sell power directly to end-consumers (power wheeling) is not only impeding the renewables development for industries but also exposing the country to the risk of losing investments from multinational companies which join the RE100 movement. This PLN-centric market structure shows that in many cases renewables development has to compete with PLN's interests.

- **Financing barriers**

Indonesia has been struggling to set financing instruments that can help capture the opportunity that renewables bring to the country. The PLN see renewables as burdens to its budget as it has to pay extra costs to renewables developers when the electricity tariffs remain flat and the electricity subsidies for the company have been reduced. No financing instruments such as surcharge and coal levies are available to help PLN fund the renewables development. Although the implementation of such instruments might be challenging in Indonesia as the issue of electricity tariffs is political and many political interests are involved in the coal industry, the financing products would help the country meet its 23% renewables target.

In addition, the government needs to find ways to lower the financing costs of renewables projects in Indonesia. The local banks still discern renewables projects as high-risk projects and hence charge renewables developers with high interest rates (more than 10%). With the high interest rates and 85% BPP pricing structure, only few projects can be developed.

- **Undeveloped local renewables manufacturing industry**

The renewables manufacturing industry in Indonesia is still far below its potential capacity. By 2016, Indonesia only produced 445 MWp of solar modules domestically (Julianto, 2016). No data on wind turbine industry is available, however, the Sidrap project which is the largest wind mill project in Indonesia (75 MW) uses wind turbines imported from Spain (Simorangkir, 2017). The absence of local renewables manufacturing industry contributes to the higher costs of renewables technologies than in other countries.

To increase technological capabilities of local renewables manufacturers and to bring costs down, the Indonesian government has to put more focus on the Research and Development (R&D) of renewables. At this stage, there are no specific plans that show the amount of fund available for universities, research institutes, and private companies to undertake renewables R&D activities. The strategies to develop key renewables technologies and move the technologies from laboratory to market are also absent. The government also has yet to see the potential of creating new jobs in the country if establishing the local renewables industry in the country.

To conclude, the government of Indonesia has failed to address the non-economic barriers in renewables development in Indonesia. The support policy is difficult to predict as it has been changing constantly. The incentives provided to developers are also not matched with the development phase and maturity of renewables technologies. The transparency, longevity, and certainty needed in the making of attractive renewables market are lacking and hence hamper rapid development of renewable energy in Indonesia.

3. International Experience in the Development of Renewable Energy

This study undertakes a comparison study that aims to explore a range of experience from three countries, namely Germany, China, and India, to extract the lessons learned from them, and to prescribe best practices that can be used to help the government of Indonesia discover the best ways to prepare the Indonesian renewables market for takeoff. These three countries were chosen as many see them as global leaders in the development of renewable energy.

3.1. Case Study 1: Renewable Energy Development in Germany

As the world's fourth biggest economy, Germany has demonstrated to the world that a persistent commitment by government, industry and society to change can set an energy transition in motion: shifting from conventional energy, e.g. thermal (coal, oil, and gas) and nuclear power to renewables and lowering energy consumption (energy efficiency). "Energiewende", as the German energy transition has been labelled, is among the most successful energy transition programs globally.

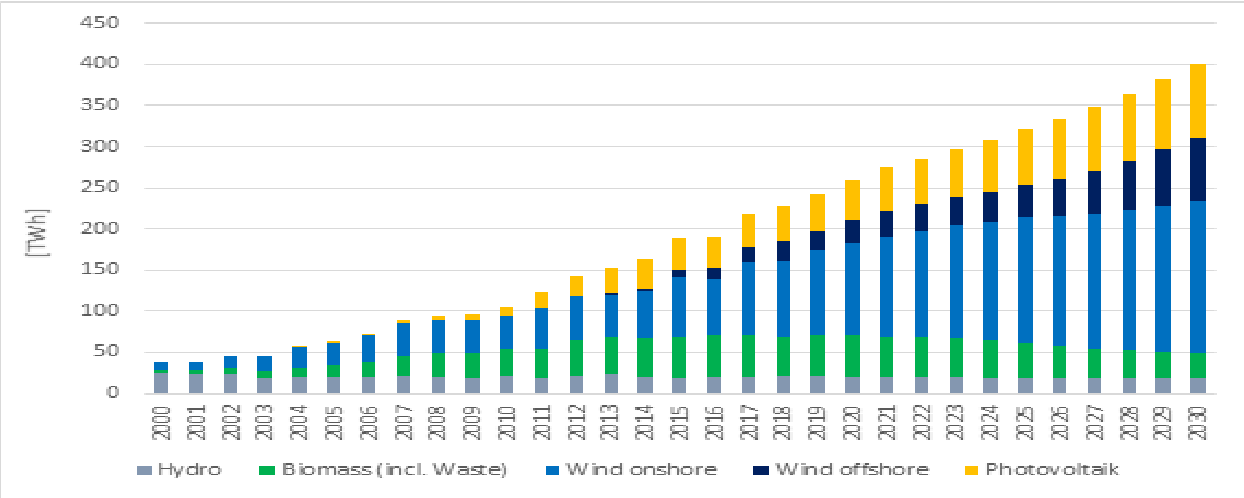
The energy transition program that leads to a high progressive development of renewable energy in Germany is basically a continuous process up to now. It rooted back in the 1970s, with air pollution and then the anti-nuclear movement, which was sparked by Chernobyl Disaster in 1986. After Chernobyl, a wider debate on the risk of nuclear intensified and it ended the nuclear consensus among the four established parties (CDU, CSU, SPD and FDP) that had shaped German energy policy over the previous decades. However, the real start implementation of the energy transition started with the Renewable Energy Sources Act /EEG and associated policies.

Table 9.
Key German Energiewende Targets. Data from Agora Energiewende (2018).

		Status Quo	2020	2022	2025	2030	2035	2040	2050
Reduction of GHG emissions	Reducing CO2 emissions in all sectors compared to 1990 levels	-27.6% (2017)*	-40%			-55%		-70%	-80 — 95%
Phasing out nuclear power	Gradual shut down of all nuclear power plants by 2022	11 units shut down (2015)	Gradual shut down of remaining 8 reactors						
Renewable energy contribution	In final energy consumption	13.1% (2017)	18%			30%		45%	Min. 60%
	In gross electricity consumption	36.1% (2017)*		40-45%		55-60%		Min. 80%	
Increase of energy efficiency	Reducing primary energy consumption compared to 2008 levels	-5.9% (2017)*	-20%						-50%
	Reducing gross electricity consumption compared to 2008 levels	-2.9% (2017)*	-10%						-25%

Note. * preliminary

Figure 10.
Germany's annual gross renewable electricity generation targets in 2000 – 2035. Source: Agora Energiewende (2015b)



The following section will detail how Germany is transitioning from risky and polluting conventional energy sources to sustainable and clean renewable energy sources. In the last twenty years, Germany has significantly diversified its electricity mix toward renewable sources (the share of which increased from 4% of total power demand in 1990 to 36% in 2017).

3.1.1. National Targets and Programs

The German Energiewende is the country's well-planned transition program that aims to provide a long-term strategy towards a future energy system: developing renewable energy and improving energy efficiency. It encompasses a comprehensive and integrated policy covering all sectors of the economy, that is accompanied by civil society engagement and has brought forward a sizeable energy transition industry. There are four main drivers behind the Energiewende, avoiding/ tackling climate change (reducing CO2 emissions), phasing out nuclear power, maintaining and strengthening energy security (reducing fossil-fuel dependence), and ensuring competitiveness and growth (industrial policies). These main drivers are then translated into the targets with their associated timeline (Table 9).

With the technological development of renewables and falling technology cost, the government, during the last 20 years, has consistently raised the level of ambition in its targets. Most recently, the newly formed government, and its coalition agreement, has agreed to further raise the Renewables target to 65% by 2030 (Figure 10). Wind (both on and offshore) and solar are the main pillars; solar is expected to see larger shares than in this graph now, since generation cost of ground mounted solar has fallen below wind generation cost most recently (auction results 2018).

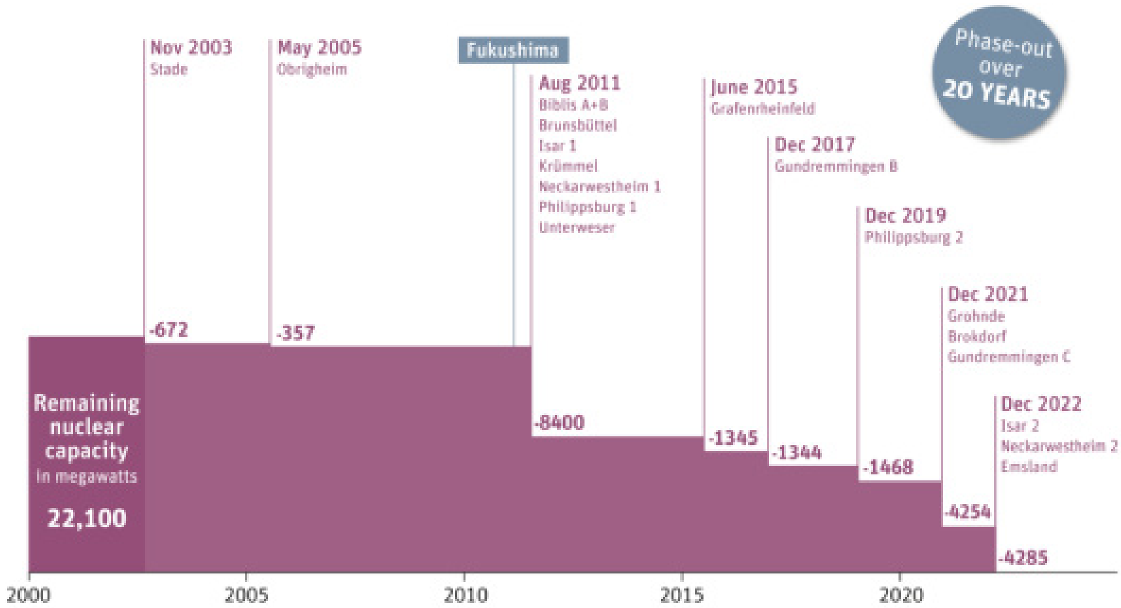
3.1.2. Current Status

3.1.2.1. Nuclear Phasing-out

Following two decades of increasing public protests against the use of nuclear power due to concerns about safety and nuclear waste, a consensus between the German government and the country's nuclear power plant operators on a nuclear phasing-out was achieved in 2000. Germany aimed to gradually shut down all nuclear power plants by 2022 (Figure 11). This agreement had been temporarily suspended by a conservative government in 2009, but then reintroduced after the Fukushima nuclear accident in 2011. Nuclear power plant operators can transfer the electricity generated from one plant to another plant which is located at a point more critical to the grid. This may shift some of the dates listed below but will not affect the overall schedule (Heinrich Böll Stiftung, 2016 [1]). As of 2018, more than 12 GW of originally 22 GW have been closed down.

[1] This had been lifted by conservative government in 2009, but the reintroduced after Fukushima in 2011.

Figure 11.
Nuclear Phase-out Schedule in Germany. (Source: Heinrich Böll Stiftung, 2016)



3.1.2.2.Renewable Energy

The generation mix in Germany is mainly made up of conventional and renewable energy sources. In regard to conventional energy sources, Germany utilizes coal (both local brown coal and (mainly imported) hard coal), mineral oil, natural gas, and nuclear. Biomass (including municipal waste), solar (from the sun), wind (both onshore and offshore), and hydro are categorized as renewables.

At the end of 2017, Germany's total installed capacity reached 202 GW with an increase of 5 GW from the previous year (AGEE, BMWi, Bundesnetzagentur in Fraunhofer, 2018). The additional renewable capacity amounted to 9 GW whilst conventional power capacity declined by 4 GW leading to a net increase of 5 GW.

Wind power dominated the share of additional installed renewable capacity in Germany, representing 74% of the 9 GW i.e. 7 GW, then followed by solar power (25.5%). The biomass addition was the lowest, with approximately 0.5%. Furthermore, wind power outpaced all other energy sources in 2017 with the growth of 13% from 2016

Figure 12.
Germany's installed capacity in 2016 and additions in 2017. Data from Fraunhofer (2018).

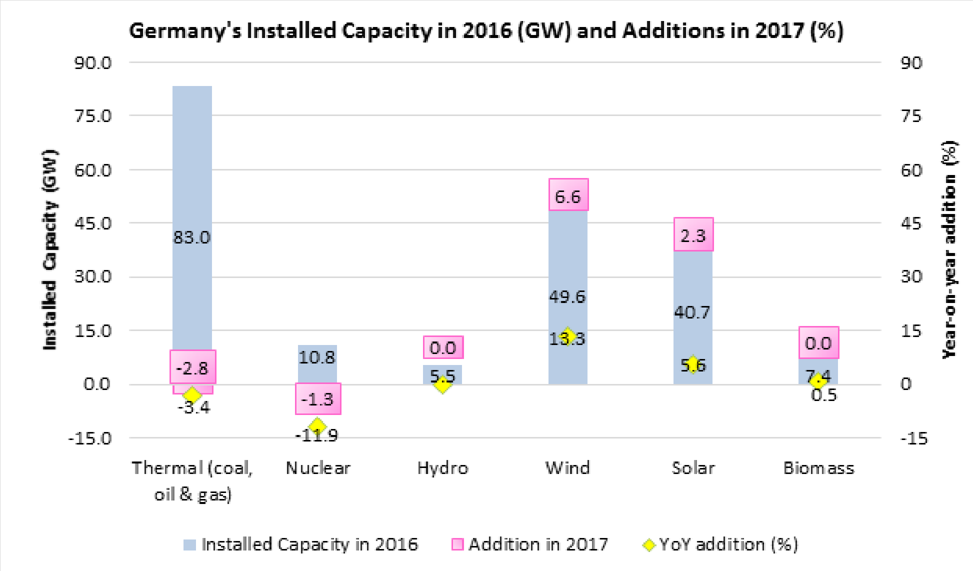
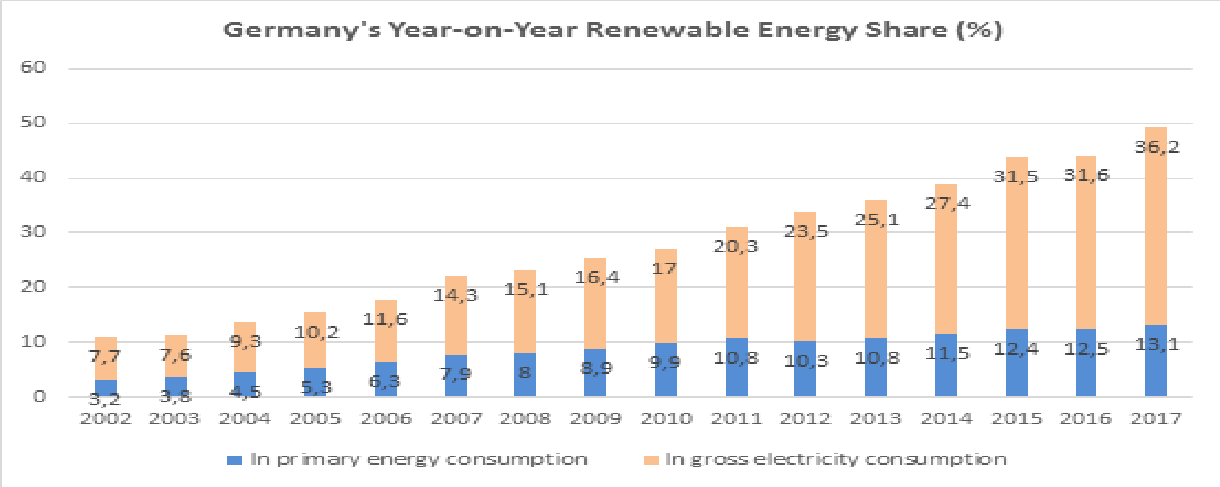


Figure 13.
Germany's Year-on-Year Renewable Energy Share (%). Data from Federal Ministry for Economic Affairs and Energy (2018)



while solar grew at almost 6%. Whereas hydro and biomass were stagnant from 2016 to 2017, the installed capacity of conventional energy sources was decreasing (Figure 12).

The Renewable Energy Sources Act which introduced a feed-in-tariff, and, in 2017 added tenders for medium and large scale projcets has enabled the increasing year-on-year share of renewables. In the period of 2002-2017, the share of renewable energy in Germany increased more than four times both in primary energy consumption and in gross electricity consumption (Figure 13). Moreover, the installed capacity for renewables also rose more than six times from 18 GW in 2002 to 111 GW in 2017 (Figure 14) with an annual growth of 12.9% every year for the last 15 years. On the other hand, conventional energy installed capacity has declined, from 97 GW in 2002 to 90 GW in 2017.

Overall, the gross electricity generation development in Germany was relatively steady with the total increasing by 2.2% during the period of 2002-2017, growing from 587 TWh to 600 TWh. However, there was a shifting of generation mix in the country from conventional energy sources to renewable energy sources throughout the period (Figure 15). The conventional electricity share was decreased from 89% to 63%.

During the period of 2002-2017 the energy sources in Germany have been changed: nuclear and hard coal were considerably going down, while lignite (brown coal) remained mostly stable (Figure 16). On the other side, the share of renewable sources in total generation increased from 8% in 2002 to 33% in 2017. Wind contributed to around 16% of generated electricity in 2017, increasing significantly from 3% in 2002. Meanwhile solar PV, which, initially, was much more expensive than

Figure 14.
Germany's Year-on-Year Renewables Installed Capacities (GW). Data from Fraunhofer (2018).

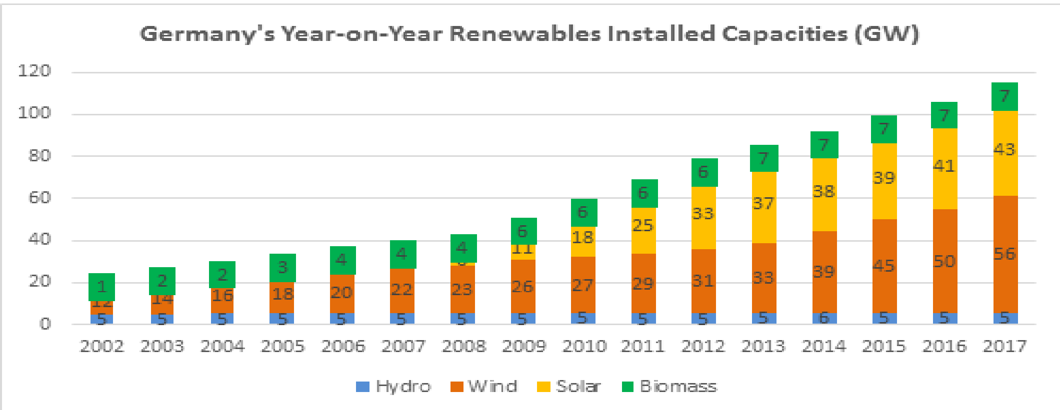
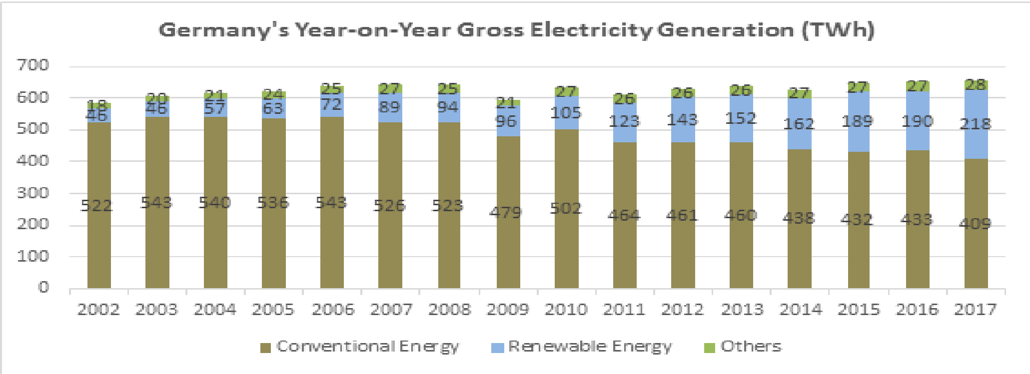


Figure 15.
Germany's Year-on-Year Gross Electricity Generation (TWh). Data from AG Energiebilanzen (2018). Note: Gross electricity generation is defined as total electricity generated. Thus, electricity losses, electricity for own-consumption, and electricity for captive market are included here.



wind power, increased slowly from 0.03% in 2002 to 1.1% in 2009 and went up steeply to 6% in 2017.

Figure 17 shows that in 2017, the renewables alone accounted for around 33% of the electricity generation mix. However, the country still needs to generate an additional 7-12% to reach its 2025 target. In 2017, hydropower generated 20.2 TWh, decreasing by 15% compared to 2002. Wind power generated 106.6 TWh with an average annual growth of 13% in the last 15 years. Solar power generated 39.9 TWh, increasing by 42.3% yoy. Lastly, biomass power generated 51.4 TWh, an increase of 14.9%. In total the renewables generated 654.6 TWh in 2017, growing by 0.7% yoy (AG Energiebilanzen, 2018).

There was a large solar PV boom from 2009 until 2012 that was caused by high feed in tariffs and falling technology cost, which provided, in combination, high rates of return to the investors during this period. However, feed in tariffs have been following the learning rate of PV technology more closely, and PV growth was slower since then (Figure 18). Yet, with the ambitious 65% target for 2030, higher investment rates of 4 GW of PV annually will be needed.

3.1.2.2.1. Renewable Energy Curtailment

By definition of Renewables legislation, wind and solar enjoy priority feed-in: whenever wind plants and solar PV produce electricity, they are entitled to feed in the power into the grid. This makes sense from an economic perspective, as- unlike thermal power plants that have fuel costs), wind and solar have zero marginal cost. The residual load is covered by other generation, when needed. German system has shown remarkable ability to flexibly deal with the variability of wind and solar (11-87% RE feed-in in specific hours in 2016) and it is one of the securest in the world, with record low interruption numbers.

Figure 16.
Germany's Year-on-Year Gross Electricity Generation by Energy Sources Type (TWh). Data from AG Energiebilanzen (2018).

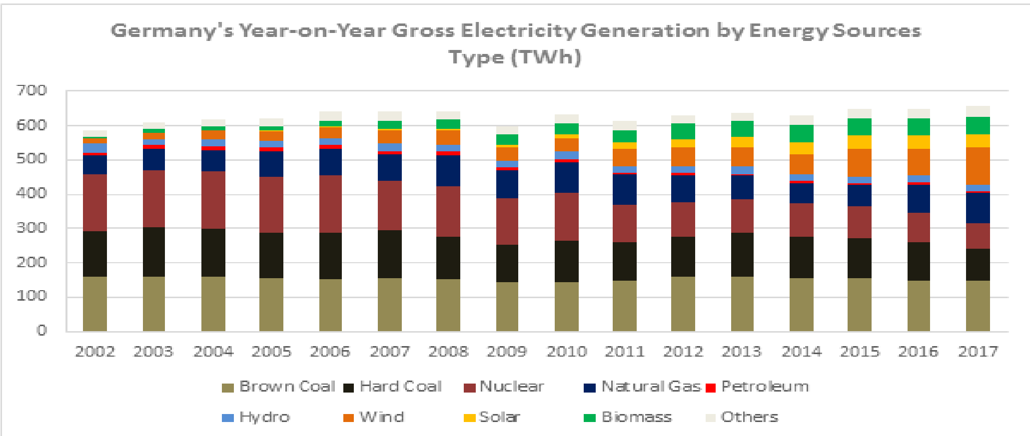
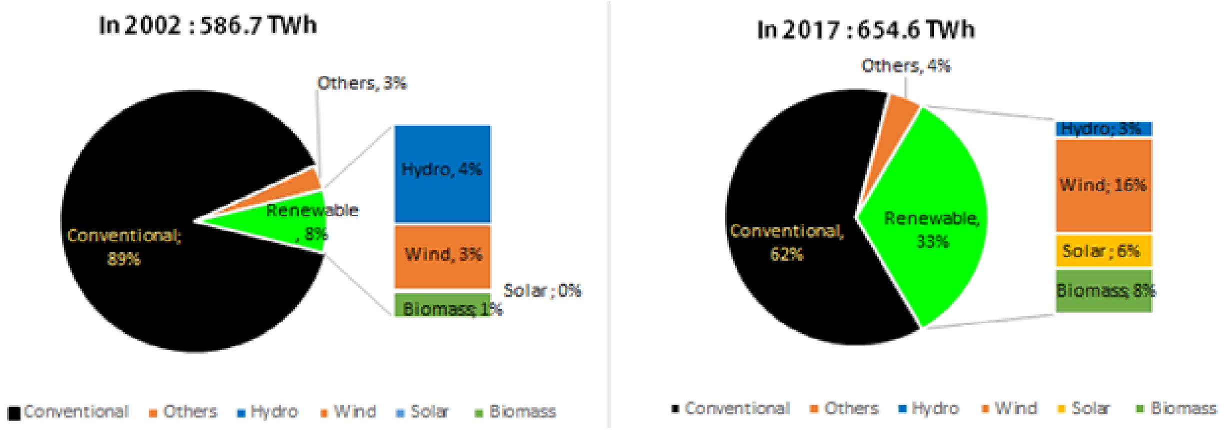


Figure 17.
Germany's Electricity Generation Mix In 2002 and 2017. Data from AG Energiebilanzen (2018).



However, there are times of high Renewables, in particular wind generation, when the system is not able to fully absorb all the generated energy. Some of the wind power is then curtailed by the system operator.

Curtailment is a situation where the output of a generator is reduced from what it could otherwise produce given available sources (e.g., wind or sunlight), typically on an involuntary basis. Investors are compensated for the curtailed energy, which, therefore, needs to be paid by the consumers. It is still assumed to be the most economical way of dealing with curtailment, as, otherwise investors would price the curtailment risk in their cost calculation, resulting in higher generation cost due to the curtailment risk.

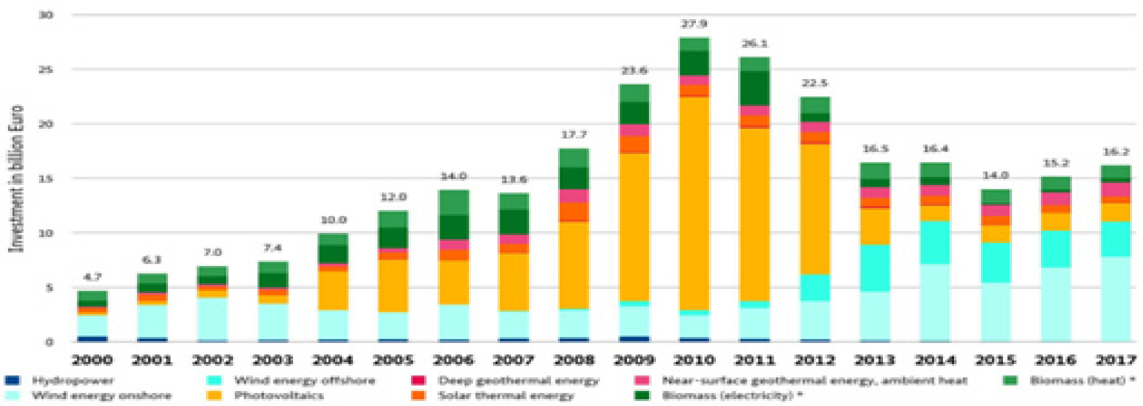
Reasons what it occurs in Germany are:

a) Partly still inflexible thermal generation (must run combined power and heat plants), partly high minimum technical load of older coal and nuclear power plants, which prevents these plans from reducing their output below a certain level;

b) Little demand response potential activated, meaning there is not enough potential to "store" excess energy"; this is foreseen to be changing through price signals (low or even negative cost of energy, which incentivize demand response), one important example: electric car batteries, also electric heat pumps (also works with electric cooling);

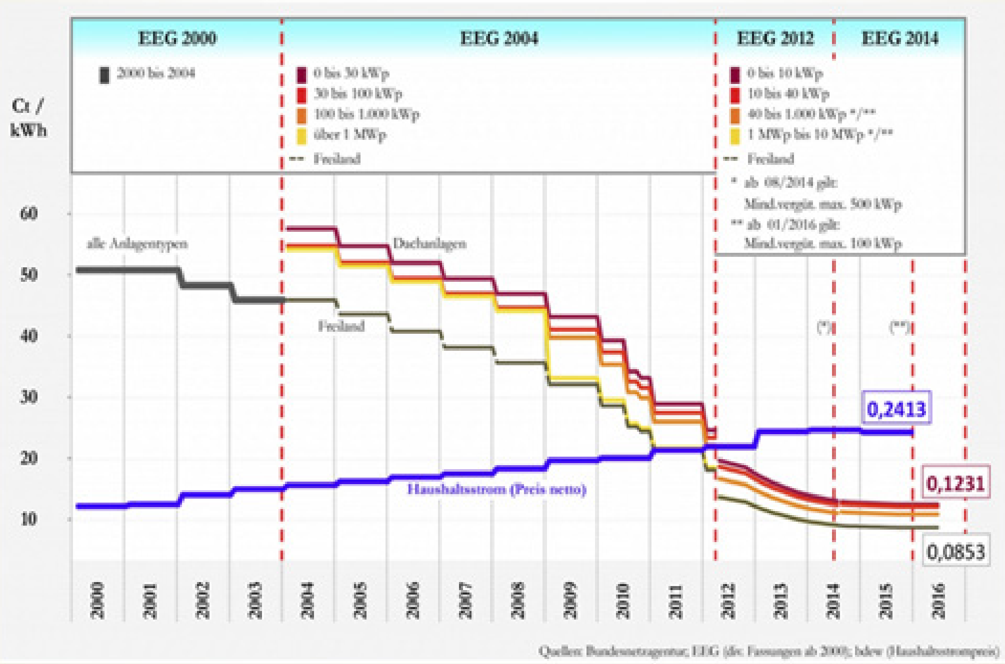
c) Congestion, since grid has not been built up fast enough; in particular to evacuate wind power regionally through the 110kV high voltage distribution grid in the North, and then, on high voltage lines, from the North to demand centres in the South of Germany.

Figure 18.
Germany's Year-on-Year Renewables Investment (Billion Euro). Source: AGEE in Federal Ministry for Economic Affairs and Energy (2018)



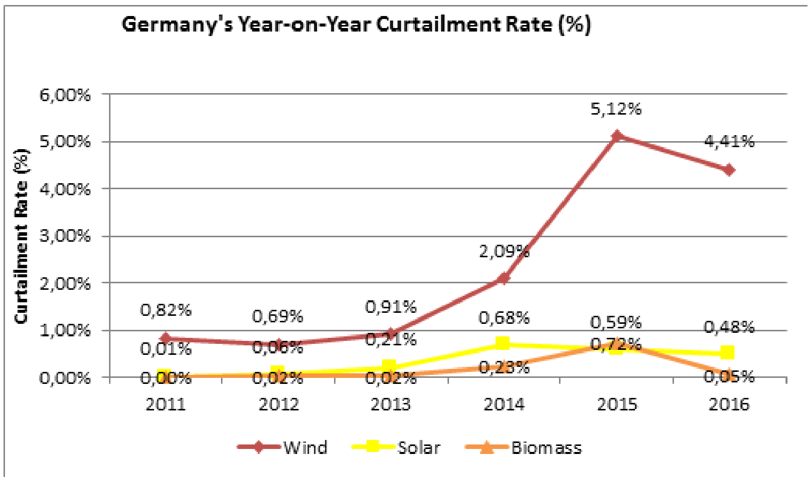
Feed-in Tariff changed as EEG being amended

The figure below shows how Feed-in Tariff (FiT) for photovoltaic power as a function of commissioning date changed as the EEG being amended. EEG 2000 stated that all photovoltaics installed and operational in 2001 (including old photovoltaics) will receive FiT as high as 50.6 Cent/kWh and photovoltaics starting operation in 2002 as high as 48.1 Cent/kWh. This EEG also dictated a decrease of 5% FiT for photovoltaics every year from 2002. In 2004 the EEG was amended and photovoltaics installed on roof received higher FiT, depending on its capacity. However these new FiTs are still subject to 5% depression as stated in EEG 2000. The feed in tariffs generally followed the impressive trend of falling technology cost of PV, decreasing from more than 50ct/kWh to about 8 ct/kWh in just 12 years.



The latter is expected to be resolved in some years, when large North-South transmission lines will be in operational; however, building new transmission ines through densely populated Germany has proven challenging; therefore, some of these lines will be built as underground cables. For the reason of congestion, there is also redispatch of power plants (usually meaning (more expensive gas) power plants in the South, where electricity is needed, are turned on, while other, cheaper ones,

Figure 19.
Germany's Year-on-Year Curtailment Rate (%). Data from Bundesnetzagentur (2017)



in the North, are turned off). However, it should also be noted that a certain level of curtailment does make sense economically, rather than building extra transmission lines, which are only needed during a few very-high-renewables feed in hours a year. Therefore, the adopted German planning regime foresees a rate of 3% of annual wind and solar production to be curtailed as an efficient planning provision.

3.1.3. Electricity Market

The German electricity market was liberalized in 1998 (Deloitte, 2015). Before the liberalization, the electricity supply chain was vertically integrated. It has since been unbundled, i.e. subdivided into generation, transmission, distribution, and retail suppliers (Table 10). The electricity market liberalization benefits Germany as it creates a level playing field for new market entrants that wish to compete with the established former utilities both on the generation and retail side. Unbundling seeks to overcome a situation where:

- vertically integrated firms that generate, transport, and sell electricity can discriminate against competing firms, which do not have their own transport capacity and

- vertically integrated grid operators have no interest in extending the grid and facilitating grid access to new market players, which would enhance competition

The German regulation has enforced legal and organizational unbundling. This means that entities that generate power or are retailers, are still allowed to own and operate transmission and distribution networks, but need to put up "Chinese walls" between these activities. Transmission and distribution investment and operation are strictly controlled by the regulatory authority. On the transmission side, three of the four former utilities, E.ON, RWE, and Vattenfall have sold majority or all shares of their former transmission business, so the largest part of the transmission system is actually ownership unbundled and thus immune against any bias on the generation/retail side.

In addition, to unbundling the monopoly, this new liberalized electricity market also introduced a new

Table 10.
Market Share of German Electricity Companies. Source: Agora Energiewende (2015a).

Sector	Leading Companies	Market Share	Total Number of Providers
Transmission	Amprion Transnet BW TenneT 50Hertz Transmission	100% Combined	4
Distribution	EnBW E.ON RWE Vattenfall	The big 4 distribution companies own and operate a significant portion of the distribution system, though the exact level is not clear	Approximately 890 distribution system operators, about 700 of which are municipally owned Stadtwerke
Generation	EnBW E.ON RWE Vattenfall	56% installed capacity (June 2014) ~70% of electricity generated (2016)	Over 1000 producers (not including individuals)
Retail Suppliers	EnBW E.ON RWE Vattenfall	45.5% of total electricity offtake (TWh)	Over 900 suppliers

[2] More than a million rooftop solar installations exist and many wind farms were developed and are owned by citizen cooperatives.

Brief summary of energy market liberalization

First Package: Directive 96/92/EC in 1996
Contributes to the creation of internal market for electricity.

Second Package: Directive 2003/54/EC in 2003
Energy markets should be completely open for competition.

Third Package: Directive 2009/72/EC in 2009
Provisions regarding grid access and cross-border trading.

concept named as Energy-only Market (EOM). This EOM rewards electricity that has been produced by selling it at free markets, such as European energy exchange (EEX), making the market more efficient, reduce overcapacity, and encourages flexibility in power production (power production will be adjusted on a quarter-hourly basis to match the demand changes).

As a commodity, electricity will be traded in wholesale electricity market and retail electricity market. Electricity generators compete in wholesale electricity markets to sell electricity to large industrial consumers and electricity suppliers. Suppliers compete in the retail electricity market to sell electricity to the final consumer (TenneT, 2017). Selling price for the electricity is based on the marginal costs of producing it. Given the fact that marginal costs consist of fuel costs, costs for CO2 emission certificates, and variable operating costs, electricity from renewables will always be the cheapest and placed first in the Merit Order (a method to rank available sources of energy based on ascending order of price together with the generated electricity capacity).

Although there are currently over 800 individual providers, the majority of the country's electricity is still produced by four (five in 2016) big energy companies: E.ON, RWE, Vattenfall, EnBW, and LEAG (Figure 20) (Deloitte, 2015). However, these big companies only own about 5.4% of renewable resources, meanwhile private individuals and farmers own 42% of it, followed by investors (project developers, industry, banks), regional/municipal utilities, and others (Figure 21).

Figure 20.
Shares of big companies in Germany's produced electricitity (Data Source : Bundesnetzagentur, 2017)

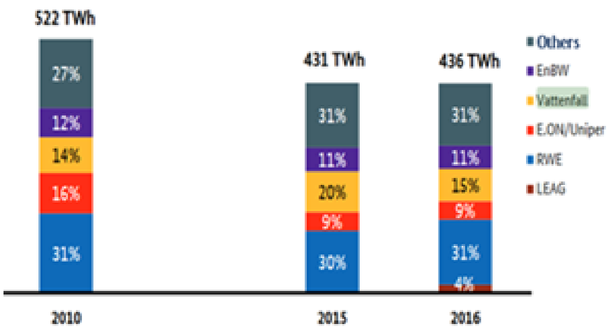


Figure 21.
Ownership of renewable generation in Germany in 2017 (Source : Agentur für Erneuerbare Energien 2017)

In order to ensure security of supply at any time, sufficient capacity must always be available. With ever increasing amounts of renewable energy, Germany is developing a more flexible power system. This includes a strong and well interconnected grid, increasingly flexible demand and flexible fossil fuel and bioenergy power plants, to react to fastly changing supply of wind and solar as well as cover low-wind and sun-deficient hours (for example, during winters). These flexible thermal power plants are being utilized at less hours then in the past. There has been a long debate in Germany (and elsewhere in Europe) as to whether the energy-only market would provide sufficient incentives (through very high prices during hours when supply is low) for peak power plants, that are dispatched during few hours of the year. Finally, the electricity market in Germany has been developed in to an "electricity market 2.0", which is capable of delivering energy security even in a system that is based on a majority share of intermittent power from renewables (Federal Ministry for Economic Affairs and Energy, 2015a). For more details, see section 3.1.4.4 below.

3.1.4. Regulatory and Institutional Frameworks

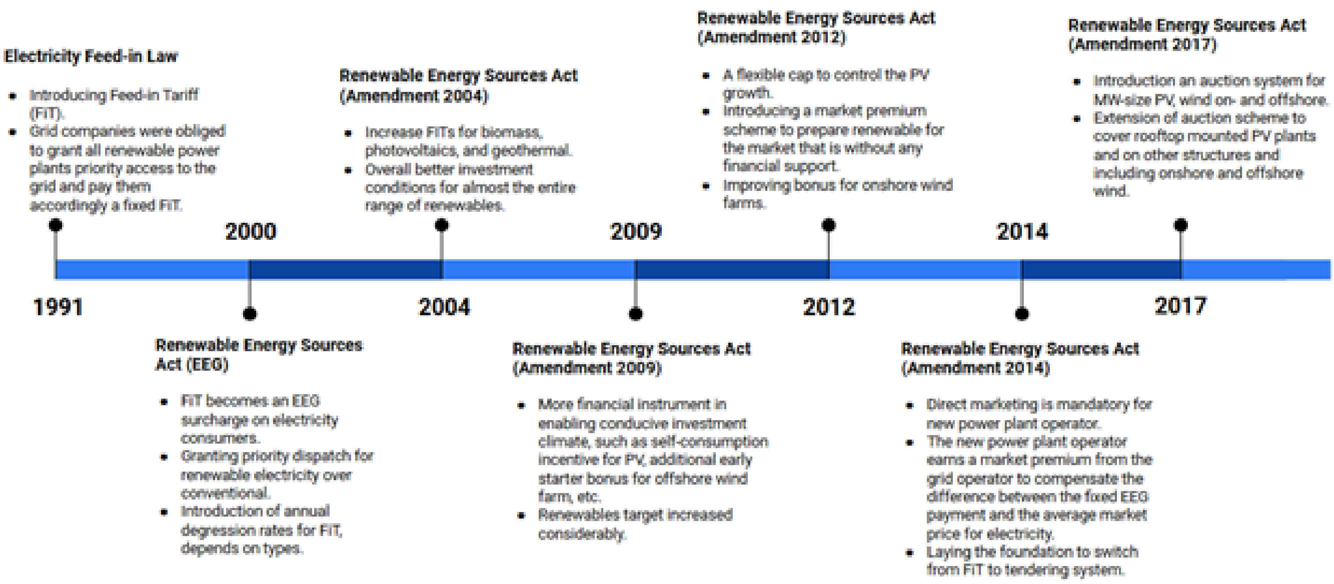
3.1.4.1 Action Plan on Climate Change

While phasing out nuclear has been the key driver for developing renewables in Germany, climate change mitigation has also been a powerful additional reason for renewables support. In 1990, an expert commission set up by the German parliament suggested that Germany cut its

Table 11.
Action Plan on Climate Change

Year	Subject	Description
1990	First GHG emissions reduction target approved by Parliamentary	80% GHG emissions reduction from 1990 levels by 2050
2005	Amendment of 2000 National Climate Protection Program	25% CO^2 emissions reduction from 1990 levels by 2005 with an ambitious strategy to increase energy efficiency and the further expansion of renewable energy
2010	Energy Strategy (Energiekonzept) as Energy Transition Policy (Energiewende)	• GHG emissions reduction from 1990 levels: 40% by 2020 and 80-95% by 2050 • Renewable energy in gross final energy consumption from 1990 levels: 18% by 2020 and 60% by 2050 • Renewable energy in gross electricity consumption from 1990 levels: 35% by 2020 and 80% by 2050
2014	Climate Action Program 2020 (Aktionsprogramm Klimaschutz 2020)	• Electricity sector emission reduction: 22 million tCO2e between 2016 and 2020 • Renewable electricity supply: 40-45% by 2025; 55-60% by 2030 (as stipulated in 2014 Renewable Energy Sources Act) • A competitive tendering system will be conducted to control quantity and to ensure adherence to the target set • Upgrading the electricity grids will be conducted to ensure the successful integration of renewable into the grid
2016	Climate Action Plan 2050 (Klimaschutzplan 2050)	• GHG emissions reduction from 1990 levels: 40% by 2020 and 80-95% by 2050 (as stipulated in 2010 Energiewende) • Energy sector emission reduction from 1990 levels: 61-62% by 2030 • The plan is mainly about restructuring the energy sector • Renewable energy sources will be providing energy supply dominantly in a way of phasing out conventional fuels.

Figure 22.
Renewable Energy Sources Act



emissions 30% by 2005 compared to 1987 levels. In 1990, the consensus on GHG emissions reduction target was achieved by the Parliament; which was being adapted and updated since then (Table 12).

In the beginning, measures to achieve the climate change target focused on energy efficiency and/or optimizing Combined Heat and Power (CHP) plants. Only later, in particular since the Green party joined the federal government coalition in 1998, did the expansion of renewable energy become an important element. Thus, renewable energy utilization played an increasingly important role in Germany's energy development, particularly in the electricity sector.

3.1.4.2 Renewable Energy Sources Act

The Renewable Energy Sources Act (Erneuerbare-Energien Gesetz/EEG) promotes the generation of electricity using renewable energy sources. This Act, preceded by the Electricity Feed-In-Law in 1991, has been amended several times during the period of 2000 to 2017 in order to support innovation, technological development and incentivize cost decrease and renewable electricity market integration (Figure 22).

The difference between the wholesale market price and the guaranteed FIT or FIP is financed through the EEG surcharge (surcharge is largely

Incentivizing Renewables in Germany: From feed-in tariffs (FIT) to premiums and auction systems

Feed-in Tariffs (FIT) was introduced in Germany to incentivize the use of and accelerate investment in renewable energy sources such as wind, biomass, hydropower, geothermal, and solar photovoltaics by providing fixed remuneration (tariff) above retail or wholeshale prices for 15 years following start of operation. This tariff is differentiated between technologies and system sizes to ensure economic viability of the various applications, thereby preventing windfall profits for large projects or technologies that are already more mature than others.

The FIT is set to gradually decrease for new systems with the expectation that the technologies become more efficient and affordable by the time. Initially this *degression* was a fixed percentage per year. However, as PV system's cost declined faster than FITs, the PV systems were over subsidized and the FITs were adjusted more rapidly.

In addition, since 2012, FiT were gradually superseded by feed in premiums, which oblige investors to market the electricity from Renewables at the wholesale market, providing some incentive to produce, where feasible, electricity according to market needs. This mainly concerns biomass, but can also be relevant for PV and wind, when it comes to technological specifications such as rotor blade configuration or orientation of solar panels (East or West rather than South only).

From 2000 until now, Germany's FITs have gone through three phases of existance.

2000-2009

- Focused on scaling up domestic renewable energy generation
- FIT policy design was established that provided Transparency, Longevity, and Certainty (TLC) to investors
- FIT rates degression were modest & EEG was adjusted at a regular intervals.

2009-2011

- Photovoltaic (PV) FIT is actively adjusted to manage the volume of annual PV installation due to the rapid decline in solar PV modules cost.
- PV policies were reviewed more frequently.

2012-present

- Reduce in FIT payments due to continued cost declines for solar PV, wind, and biomass.
- Introduction of market premium option.
- A 90% cap on FIT-eligible PV electricity
- Addition of a 52 GW PV capacity threshold

By 2017, Germany is to phase out FITs for large systems and switch to auctions, in which the buyer receives bids from sellers. It is expected, that the determination of tariffs via competitive auction, instead being fixed by the government, will drive renewable energy subsidies down or eliminate them completely. The result of the first one and a half year shown, that the auctions have indeed led to further cost reductions for renewables.

financed by smaller and residential consumers, while large energy intensive industries are exempt). This surcharge has risen from 1.32 ct./kWh in 2009 to 5.28 ct./kWh in 2014, when 10.57 GW of the still expensive PV generation came online. This capacity is receiving the guaranteed FIT from start of the operation onwards for 15 years and therefore increasing the household prices. However, the surcharge has risen more modestly during the past five years, to 6.9 €ct/kWh in 2018. With expensive solar and wind generation leaving the system from the early 2020s, the surcharge is expected to shrink from about 2022 onwards (Agora Energiewende, 2018).

3.1.4.3 Energy Industry Act

Energy Industry Act *(Energiewirtschaftsgesetz/ EnWG)* is a Federal Law that contains basic regulations on grid-based energy. This law first came into force in 1935 and was last revised in 2011.

In general, the Energy Industry Act was enacted to enhance competition, security of supply and sustainable energy production. This Act also requires electricity labelling according to type energy source, providing greater information on electricity sources to allow consumers to make informed decision about their supplier. Additionally, this Act sets rules for the planning and construction

Table 12.
Energy Industry Act

Year	Subject	Description
1935	Energy Industry Act *(Das Energiewirtschaftsgesetz)* of 1935	• Provided regulatory structure for electricity • Cooperation among electric utilities were encouraged to prevent economic harm due to competition. • There was no separation between generation, distribution and sales • No competition due to demarcation agreements, which means a particular area is secured to single energy provider

Year	Subject	Description
1998	The Act to Amend the Energy Industry Act *(Das Gesetz zur Neuregelung des Energiewirtschaftsrechts)*	• Liberalization and deregulation of the German electricity and gas markets with the intention to lower prices for electricity and gas to a competitive level within in the European common market
2003	Changes through the First Amendment *(Änderungen durch die erste Novelle)*	• Adoption of European Union (EU) Directives on electricity and gas to further progress toward electricity and gas market liberalization • Partial legalization of Associations' Agreements on third-party access for electricity and natural gas network
2005	Changes through the Second Amendment *(Änderungen durch die zweite Novelle)*	• Regulated third party access (regulatory authorities monitor the network operators) • Larger utilities (> 100,000 connected customers) must separate their grid area from all other economic activities within the company • Provided a special regulation for the injection of biogas into the gas grid
2008	Changes through the Amendment on year 2008 *(Änderungen durch die Novelle von 2008)*	• Liberalisation of meter reading and meter operators • Connection user may choose their meter operators • Installation of smart metering (meter reading) at new electricity users or at users that undergo big renovation
2011	Changes through the Amendment on year 2011 *(Änderungen durch die Novelle von 2011)*	• Further unbundling of transmission, transmission and distribution system operators • The regulation of gas storage facilities and on measuring equipment and measuring systems • Introduction of further consumer protection rights and • Regulatory authorities become more independent

of grids. Since it first came into force in 1935, this Act has gone through several amendments from 2003 to 2011 (Table 12), with the aim of allowing new entrants to enter into competition with the large, formerly state-owned utilities by increasing the level of competition among suppliers and retailers of energy, in order to supply electricity in the most cost-efficient manner.

3.1.4.4 Electricity Market Act

The German – and European – electricity market organises dispatch of power on a merit-order base: Suppliers of electricity bid at the energy exchange based on their short-term marginal costs (SRMC) of producing electricity. These SRMC are determined mainly by the fuel cost of the power plant, i.e. coal or gas prices. Increasing forward wholesale market prices are also supposed to provide investment signals for new investment, in case additional generation is needed. With the growing shares of variable renewable power from wind and solar, which do not have fuel costs and almost zero marginal cost, discussions emerged on the potential need of adopting the price formation regime, in order to ensure efficient markets that ensure adequate capacity at times when many thermal power plants have lower operating hours. The Electricity Market Act aims to make electricity market fit for higher shares of renewables- whilst securing a high level of security of supply that follows European orientation. The Act also intends to optimize the integration of the various elements of the electricity system. The draft Electricity Market Act and the Capacity Reserve Ordinance were adopted by the Federal Cabinet on November 4th, 2015.

Important measures in this Electricity Market Act include (Federal Ministry for Economic Affairs and Energy, 2015b):

- Guaranteeing free and competition-based price formation and permit price peaks to occur on the electricity markets (thus providing adequate investment signals).
- Improving transparency on the electricity market to promote efficient generation, consumption and trading decision.
- Monitoring security of supply, not only on national output levels, but also to the European internal market of electricity.
- Upholding balancing group (electricity providers and traders) commitments to secure power supply for their clients.
- Introducing a capacity reserve outside of the electricity market to ensure security of supply in the face of unforeseeable events. Both capacity and grid reserve (see below) are determined by the federal regulatory authority.
- Prolonging incentives to older thermal power plants to avoid these are being dismantled (so called "grid reserve") beyond 31 December 2017 until key grid expansion projects are completed to ensure secure grid operation in times of grid congestions caused by temporarily insufficient North-South high voltage connections.
- Reducing and sharing more fairly the costs of grid expansion.

3.1.4.5 Regulations on Grid Expansion

In 2017, around 33 percent of German power production was from renewable sources, where more than 15 percent are onshore and offshore wind. Over two thirds of Germany's onshore wind capacity is installed in the north and north east of the country. Meanwhile, large metropolitan areas and large power consuming industries are largely located in the south and west of the country. Therefore, grid upgrades are needed to deliver electricity cost-efficiently. To ensure adequate planning for grid development, the four German transmission operators set up ten-year network

Table 13.
Regulations on Grid Expansion

Year	Subject	Description
2009	Power Grid Expansion Act *(Energieleitungs-ausbaugesetz/ EnLAG)*	• This act lists priority projects which are exclusively the responsibility of the federal states.
2011	Grid Expansion Acceleration Act (*Netzausbaubeschleu-nigungsgesetz Übertragungsnetz/ NABEG)*	• Simplify the planning of grid expansion projects which involve several federal states or cross-national boundaries. • Power line routes are centrally planned and approved by the Federal Network Agency *(Bundesnetzagentur/ BNetzA)*, while involving public participation. • Ultra-high voltage lines will be reviewed by Germany's Network Agency. • Enactment of underground cable installation for high-voltage (110 kV) lines. • Existing grids should also be upgraded and optimized, for example by using special temperature-resistant power lines to transport greater amount of electricity.
2013	Federal Requirement Plant Act *(Bundersbedarfsplan-gesetz/ BBPIG)*	• Become the central instrument for the expansion of the transmission grids. • This Act identifies the priority expansion projects, national and cross-border, on the basis of the Grid Development Plan and the Offshore Grid Development Plan.

development plans. These consider a range of possible supply and demand developments, in order to be approved by the regulatory agency. During the last decade, a number of new regulations were introduced that are to provide for adequate planning procedures and timely project implementation. They are to reflect power sector needs, cost-efficient technological options and environmental and social impact of high voltage transmission lines in the densely populated country. More recently, focus was put on methods of increasing transmission capacity of existing infrastructure, for example by adding additional conductors on towers where this is feasible, using temperature monitoring to allow higher power flows on overhead lines when weather permits (for example during strong wind periods, where transmission capacity needs are increased, but wind helps cool the lines) or testing novel security concepts.

3.1.4.6 The Act on the Digitization of the Energy Transition (*Gesetz zur Digitalisierung der Energiewende)*

In a power system with shares of 50% and more variable Renewables, the ability of the system to flexibly adopt supply and demand is of utmost importance. Traditionally, high voltage transmission grids are operated smartly, i.e. control centres measure and calculate loads at many locations in the system in order to safely operate it. Large industrial consumers have time of use tariffs that consider the wholesale market prices of electricity generation at specific time intervals. Consequently, they pay less at times of low demand or high feed-in of wind or solar power. To make the whole system more flexible, incentives to adopt use of electricity to its availability, are gradually expanded to other consumer groups such as commercial customers or households with high electricity consumption. A precondition for the application of such pricing schemes is the ability to link consumption (as well as generation, in the case of e.g. households that feed electricity generated from rooftop solar panels to the grid) to the time it is being used. Therefore, more advanced "smart" meters that record and communicate time of use to the electricity provider are needed. These smart meters capable of two-way communication between power producers and consumers, provide the technical backbone for time of use tariffs and are the basis for "smart grids," which can detect and instantly react to local changes in generation and demand, increasing efficiency and flexibility of the system.

The Act on the Digitization of the Energy Transition (Gesetz zur Digitalisierung der Energiewende) is a cornerstone for the development of smart meters, enabling smart grids, and smart homes in Germany. Beginning in 2017, on top of large-scale, medium scale consumers and generators of electricity will also be fitted with smart metering systems. As of 2020, these systems will be rolled out to private households consuming more than 6,000 kWh of electricity per year.

Central aspect of the act (Federal Ministry for Economic Affairs and Energy, 2015c):

- **The legislation strikes a balance between costs and benefits:**

  The new rules balance the relationship between the costs and benefits of installing and operating smart meters. This ensures that the costs do not exceed the expected benefits – which might be the case for smaller household consumers. Additionally, smart meters will be phased in gradually. Large-scale consumers and generating installations will take on a pioneering role in the use of modern metering and control technology. Smaller users are to follow later.

- **Minimum technical requirements ensure data protection and security:**

  The act establishes new, binding protection profiles and technical guidelines to ensure data protection, data security and interoperability. The act also contains precise rules governing who can access what data and when. This ensures both that the data will be protected, and that use can be made of all the data needed for the energy supply by the parties entitled to use that data.

3.1.5. Financial Instruments and Incentives

For the business case of both renewable energy and energy efficiency investments, financing cost play an essential role, as the largest share of the investment

Table 14.
Incentives for renewable energy in Germany (Source: RES LEGAL Europe, 2017)

Incentive	Description
The KfW Renewable Energy Programme–Standard	Provides low-interest loans with a fixed interest period of 10 years including a repayment-free start-up period for investments in installations for electricity production
The KfW Programme offshore wind energy	Provides loans and financing packages to support companies wanting to invest in offshore wind farms in the German Exclusive Economic Zone or in 12 nautical-mile zone of the North and Baltic Sea.
The KfW Consortium Loan Energy and Environment Programme	Provides a consortium loan between up to EUR 4 billion for on-shore wind farms and photo-voltaic installations
The KfW Renewable Energy Programme Premium	Provides amongst others low interest loans and grant repayment support (Tilgungszuschuss) for electricity generation in deep geothermal installations.
The KfW Renewable Energy Programme "Storage"	Supports the usage of stationary battery storage systems, related to a PV installation, which is connected to the electricity grid.
The KfW Renewable Environmental Programme	Provides amongst others low interest loans for commercial purchases of electric, plug-in and hydrogen vehicles.
The Environment Bonus	Regulates buyer's premium for the purchase of electric, plug-in and hydrogen vehicles
Market premium	Plant operators of RES plants exceeding an installed capacity of 100 kW which are not obliged to take part in the tendering procedures are supported by a market premium for electricity they sell directly. The amount of the market premium shall be calculated each month.
Tenant electricity surcharge	PV-plants up to 100 kW on residential buildings are supported through the Tenant electricity surcharge, if the electricity is supplied and consumed within the building itself without using the grid. Electricity exported to the grid is supported by the Feed-in tariff.
Feed-in tariff	For power plants up 100 kW the support system is based on a feed-in tariff, which the grid operator pays to the plant operators. The amount of tariff is set by law and is usually paid over a period of 20 years. The plant operators can also opt for the market premium. Plants with a capacity higher than 100 kW can be supported through the feed-in tariff in exceptional cases.
Tendering	Onshore and offshore wind projects starting from 750 kW, solar projects starting from 750 kW biomass plants starting from 150 kW and already existing biomass plants must be awarded in a tendering procedure. The tendering procedure will also set the level of this support.
Flexibility surcharge	The operators of new biogas plants may claim additional support for providing capacity for on-demand use.
Flexibility premium	The operators of biogas plants that have been commissioned before 1.8.2014 may claim additional support for providing additionally installed capacity for on-demand use.

needs to be undertaken up front. In particular when technologies are relatively new, investors and banks tend to apply high risk factors, making these kinds of investments relatively expensive. There are three groups of financing instruments that can help to reduce financial barriers for renewable energy technologies (RETs): those used to overcome financing barriers, those used to address the specific risks of RET investments, and those that address both simultaneously (as, for example, where financial markets lack the sophistication to offer risk management instruments suitable for RETs).

Based on products from the German-speaking area, the solution packages from German Investment and Development Company (Deutsche Investitions- und Entwicklungsgesellschaft/DEG) offer opportunities to partially reduce the predominant lack of capital funding in foreign markets. Additionally, to the long-term loans of between four and ten years, which are also offered in local currency, the German government-owned development bank (Kreditanstalt für Wiederaufbau/KfW) subsidiary offers various support programs (Rödl and Partner, 2016):

- **Climate partnerships with business**

  This program supports climate protection measures of German, European and local companies by assuming 50 percent of the costs, e.g. for the introduction of innovative climate protection technologies.

- **Develop Public Private Partnership**

  The co-financing instrument for projects with a special development and economic value added is aimed at German and European companies and covers 50 per cent of the costs.

- **Up-Scaling**

  The program promotes innovative pioneering investments by German, European and local Small and Medium Companies in developing countries that are about to be commercialized (for example solar home systems). Up-scaling takes over up to 500,000 euros of the total investment, which are repayable in case of success.

- **Subsidies for feasibility studies**

  The German Investment Corporation (Deutsche Investitions- und Entwicklungsgesellschaft/DEG) take over 50 percent of the cost for feasibility and market studies as part of the preparation of further investment measures, such as wind measurements for wind farms.

Furthermore, there are incentives in Germany to promote renewable energy as follows (RES LEGAL Europe, 2017):

3.1.6. Key Lessons

Every country does have its specific political and economic framework conditions, different resource potential and demand pattern and development. On the other hand, the physical and energy economic fundamentals are not that different across the globe. Therefore, looking at the experience of other countries, help in designing our own energy transition. Against this background, some important key lessons from energy transition in Germany are:

- **Electricity market liberalization**

  Opening up monopoly markets has allowed new actors to come with competing investments (and investment strategies) as compared to the incumbent utilities, which were mainly interested in protecting their nuclear and fossil investment of the past.

  Then, secondly, short term and balancing market have helped system operator to safely and efficiently integrate renewables, as imbalances were reduced to ever lower levels, despite increase in renewables. The bulk of imbalances is balanced through the market, where investors that could provide short term additional (or reduced) supply would benefit from high or low (negative) price signals. This market regime has contributed for example to thermal power plant retrofitting's or the use of hydro/pumped hydro, demand response, or, in the coming years, small scale battery investment. As a result, Germany's power system continues to be among the safest around the globe. From Agora report in 2018 "Electricity system in Germany – understanding the current situation", SAIDI in Germany in 2016 is only around 13 minutes.

- **Consistency of favourable framework conditions for renewable energies**

  1. Long and medium-term targets for CO2 reduction and renewable shares, that have been adopted to more ambitious level over time;
  2. Renewable Energy Act (EEG) as main policy instrument, that has provided priority grid access to Renewables and technology specific 15-20 years tariffs based on technology cost at respective points in time;
  3. Introduction of a mechanism that adjust tariffs with technology learning;
  4. Transition from Feed in tariffs (FITs) to Feed in Premium (FiP), that move renewables closer to markets. This forces investors to market their energy at the wholesale market, which provides additional benefits for precise forecasting and good market integration;
  5. Priority grid connection and grid access that takes away risk to not being able to feed in electricity due to network constraints. In terms of curtailment, this will mean compensation to investors;
  6. Auctions for larger power plants that further drove down cost for electricity from wind and solar, on the basis of a well-established regulatory system; FiT for small scale investment (e.g. roof top), as risk and up-front investment for small scale investment otherwise too high; and
  7. Grid expansion: necessity to integrate planning of generation and demand, while also taking into account integrated point of view (value of electricity at some remote location may be lower than equivalent electricity close to actual demand centre).

- **Establishment of a state-owned bank designated for renewable energy's financing**

  Germany has KfW (Kreditanstalt für Wiederaufbau) that provides loans and supports for various renewable energy projects with lower interest rate.

- **Private sector involvement**

  Private investment and involvement in renewable energies are considered as an important stimulant for energy sector transformation in a country. Their involvement will allow competition with incumbent utilities and force them to also adapt.

- **Social acceptance and support for renewable energies**

  German population has a high acceptance and support for renewable energies and energy transition in addition to all politics, economics, and technological factors. Solar rooftop is considered as an investment by private households. Meanwhile wind projects are developed by cooperatives formed by groups of citizens. Conclusively, due to the EEG, energy consumers in Germany can develop themselves to become energy producers.

3.2. Case Study 2: Renewable Energy Development in China

China, a country of roughly 1.4 billion people, has been growing at an unprecedented pace in the past three decades. The rapid economic growth has been mainly propelled by the economic liberalization since 1978, reforming the centrally planned economy used in 1949 until late 1978 to a market-oriented economy that reflects on investment and export-led growth.

The manufacturing and heavy industries have largely contributed to China's remarkable growth, putting the country as the second largest economy in the world and the largest goods exporter in the world. The growth, however, comes at a price. China consumes far more energy than any other countries in the world and has become the largest greenhouse gasses (GHG) emitter in the world as it has mainly generated electricity from coal. The excessive use of coal has caused some serious environmental issues such as air pollution. To overcome this, the

Chinese government has committed to gradually shifting away from coal and increasing the uptake of renewable energy in its power sector.

China has taken some important actions to develop its renewable energy sector, making it as a country with the largest renewables installed capacity and largest renewables electricity generation in the world. The following part will specifically explore how China navigates its renewable energy sector, the targets set nationally, the latest progress, the electricity market and regulatory frameworks, financial incentives, and lessons learned from Chinese renewables development.

3.2.1. National Targets and Programs

China has ratified the Paris Agreement and committed to reducing its carbon intensity by 60% to 65% below 2005 level by 2030, raising the share of non-fossil energy in the primary energy mix to 20% by 2030, and peaking its CO2 emissions by 2030.

These commitments would later be translated into China's Energy Five Year Plans (FYP), which set strategies for the development of energy sector in China. The 13th Energy Five Year Plan (2016-2020) sets targets to reduce coal share in the primary energy mix to below 58% in 2020 from 64% in 2015. Furthermore, the 13th Renewable Energy Five-Year Plan puts in place targets for the total renewable energy installed capacity to reach 680 GW by 2020, generating 1900 TWh of electricity or 27% of total power generation.

The plan also specifically defines targets for hydropower, wind, solar, and biomass power to reach 340, 210, 110, and 15 GW of installed capacities and 1250, 420, 150, and 90 TWh of power generation respectively by 2020. In addition to the specific installed capacity and generation targets, the plan also stipulates the amount of money that will be invested in the renewable energy sector in China from 2016 until 2020. Total investment for new renewable energy plants allocated in the 13th FYP is $373.1 billion (RMB 2.5 trillion), with 40% of it or $149.3 billion (RMB 1 trillion) goes to solar power, $104.5 billion (RMB 700 billion) to wind, $74.6 billion (RMB 500 billion) to hydropower, and the remaining to other types of energy (Koleski, 2017). The FYP is subject to constant review and revision over its five-year period.

3.2.2. Current Status

Data from China Electricity Council (CEC) shows that in 2017, China reached 1777 GW of total installed capacity in its power sector, achieving an increase of 125 GW compared to 2016. Out of 125 GW, almost two-thirds of it came from the renewables. In total, the renewables accounted for 650 GW or 37% of Chinese total installed capacity in 2017. Growing 68% from what was achieved in 2016, the capacity

Figure 23.
China's Installed Capacity in 2016 and additions in 2017. Data from National Energy Administration (NEA) as presented in China Energy Portal (2018b) for biomass and CEC as presented in China Energy Portal (2018a) for others.

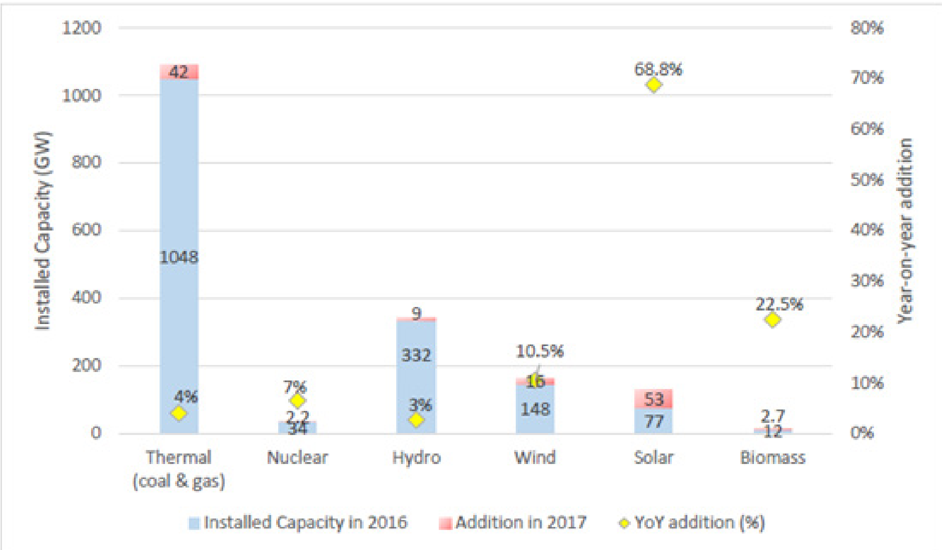
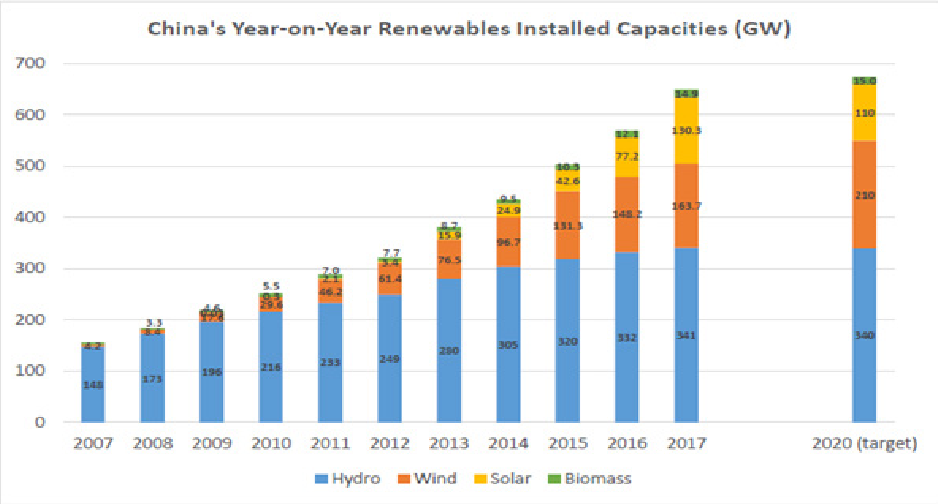


Figure 24.
China's Year-on-Year Renewables Installed Capacities. Data from Dongming (2017) and NEA as presented in China Energy Portal (2018b) for biomass, and CEC as presented in China Energy Portal (2018a) for others. Note: The 2020 targets are subject to future review and revision given that hydro and solar targets have already been surpassed in 2017.



addition of solar power in 2017 outpaced all other power resources as shown in the Figure 23.

The increasing year-on-year installed capacity of renewables as seen in the Figure 24 below also represents a strong commitment of Chinese government to shifting away from coal to cleaner energy resources. On average, from 2007 to 2017 China added 49.5 GW of renewables per annum. With current trajectory, China is expected to reach or even surpass its 2020 targets stipulated in the 13th Renewable Five Year Plan (FYP). This growth has driven a high number of employment in Chinese renewable energy sector. Data from IRENA shows that by 2016 China has created 3.64 million jobs from the renewable energy industries, in which 1.96 million jobs come from solar PV industry, 509000 from wind, 690000 from solar water heating, and 95000 from small hydropower (IRENA, 2017).

In terms of power generation, China hit the mark by producing more than 6000 TWh in 2017. The generation mix, however, was still dominated by thermal generation (mainly coal) with 4472 TWh, increasing by 5.2% compared to 2016. The renewables itself accounted for more than 26% of

Figure 25.
China's Year-on-Year Renewables Power Generation. Data from Dongming (2017) and NEA as presented in China Energy Portal (2018b) for biomass, CEC as presented in China Energy Portal (2018a) for others.

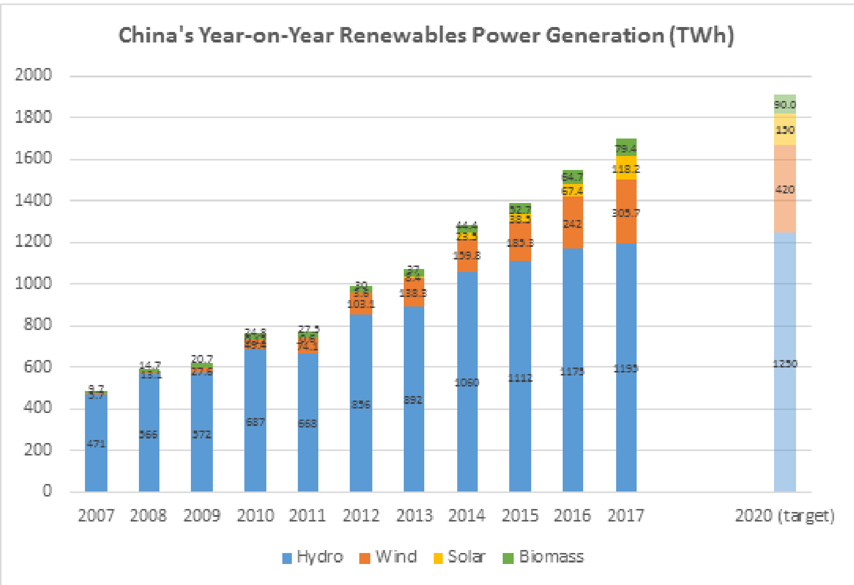
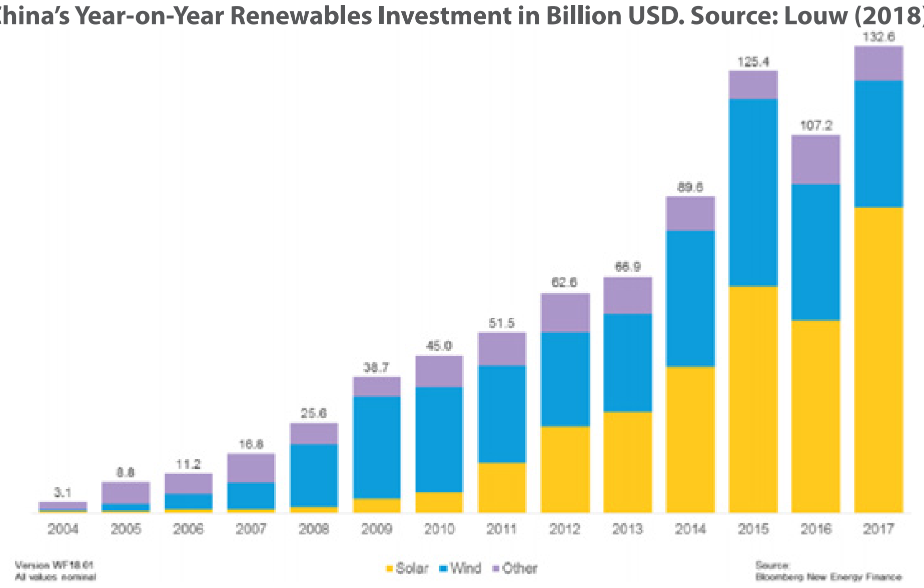


Figure 26.
China's Year-on-Year Renewables Investment in Billion USD. Source: Louw (2018).



power generation mix, closing the gap with the 27% share target in 2020. In 2017, the hydropower generated 1195 TWh, increasing 1.7% from 2016. Wind power generated 306 TWh, an increase of 26% year-on-year (yoy). Solar power generated 118 TWh, increasing by 79% yoy. Lastly, biomass power generated 79 TWh, a 22.7% increase yoy (China Energy Portal, 2018b). In total the renewables generated 1698 TWh in 2017, growing by 9.6% yoy.

In terms of investment, the country has seen an accelerating trend in the past decade. China only saw $3.1 billion of renewables investment in 2004. This number then soared in 2017 as Chinese investment made a new high record of renewables investment by reaching $132.6 billion, accounting for 40% of `world's renewable energy investment in that year (Louw, 2018).

The progress China has achieved in its renewables sector is rapid. Between 2012 and 2017, China managed to increase by more than 6 percentage points or 705 TWh of renewables generation as Figure 27 demonstrates below. Wind power generation increased by 2.7 percentage points, the largest among renewables, followed by solar, hydro, and biomass power that grew by 1.7, 1.4, and 0.6 percentage points respectively. The share of thermal generation, on the contrary, had seen a decrease of 8 percentage points in five years.

Figure 27.
Power Generation in China. Data from Dongming (2017) and NEA as presented in China Energy Portal (2018b) for biomass, CEC as presented in China Energy Portal (2018a) for others. Note: Thermal includes coal and gas.

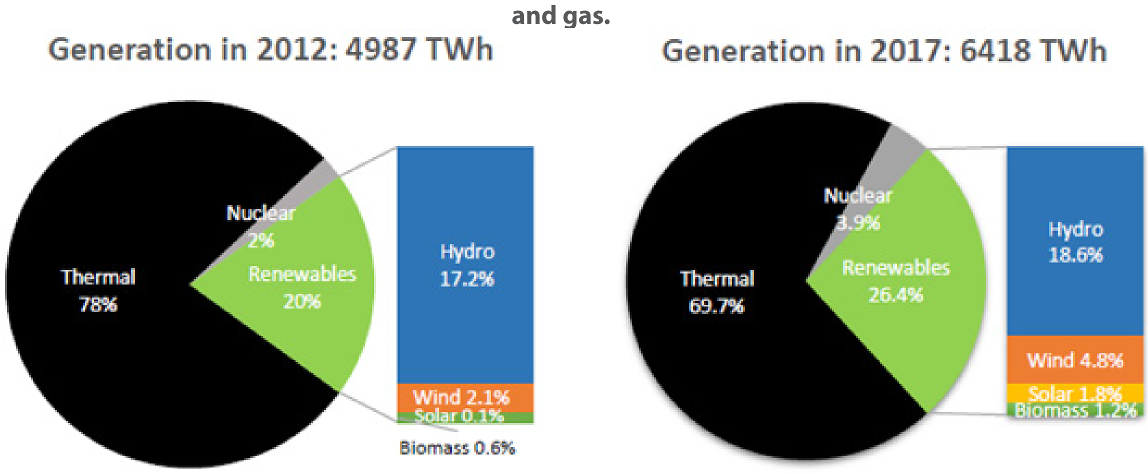
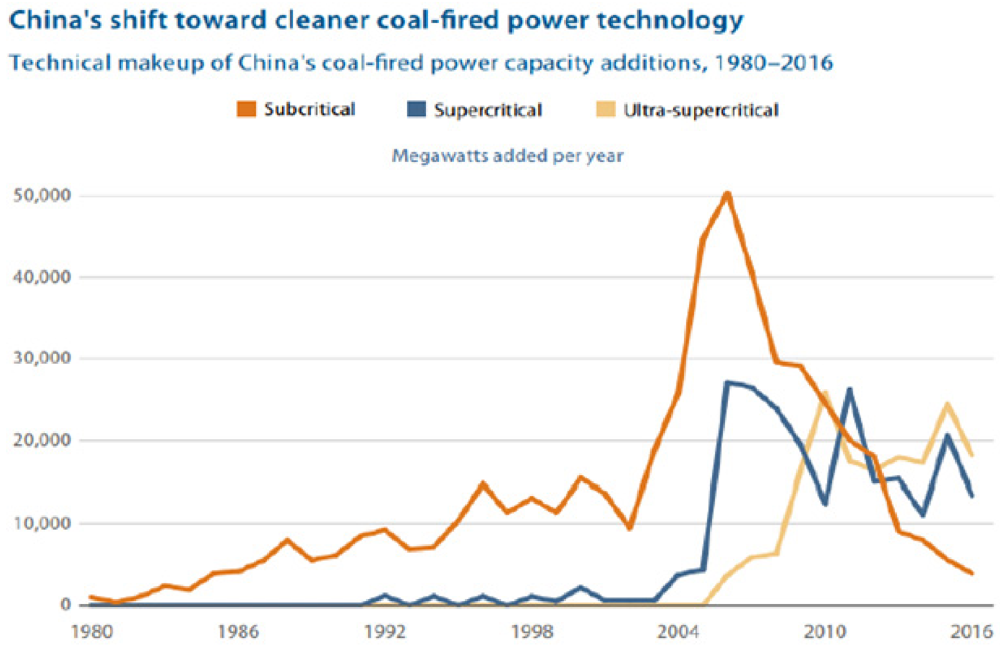


Figure 28.
China's coal-fired power technology (Hart, Bassett, & Johnson, 2017)



It is also important to note that China has been shutting down many of its older coal power plants and installing supercritical and ultra-supercritical technologies in newer coal power plants to increase efficiency and reduce levels of carbon dioxide and other pollutants. Figure 28 shows how the share of subcritical (less-efficient) plants in newly installed coal-fired power plants has been plummeting while the share of ultra-supercritical plants has been increasing over the years.

Despite having the highest renewables generation in the world, China has been facing severe curtailment – an output reduction of a renewable energy producer below what it could have generated – in recent years. In 2016, the national average curtailment rates of wind and solar power reached 17% and 19.8% respectively, making China as a country with the highest curtailment rates in the world (Louw, 2018). The curtailment accounted for 56.2 TWh of generation or more than Singapore's power consumption in 2016. The provincial curtailment rates varied from 4% to 43% for wind and 7% to 32% for solar power. Rigid quota setting, including of generation within and trade across provinces in China, is not compatible with the short-term flexibility required to efficiently integrate variable renewables such as wind power (Davidson, 2018).

In general, the main factors causing curtailment in China can be classified as following.

In winter, the heat supply demand in the northeast China increases significantly. The district heating in this region is usually supplied by Combined Heat and Power (CHP) plants. Since there is an intrinsic coupling between the heat supply and power output, these must-run CHP units have limited flexibility to adjust its power output. The minimum generation level of these CHP units is set above 60% (IEA, 2018). This leads to high renewables curtailment in the northeast China over winter. Moreover, most of the coal-fired power plants in China operate as base-load power plants with a high load rate, ranging from 50% to 100% (Clean Energy Ministerial, 2018), hence restricting the integration of more renewables into the network.

The Chinese government also arranges fixed schedules for interprovincial and interregional power transfer or exchange (Danish Energy Agency, 2015) under long-term contracts at fixed rates set by the government (Louw, 2018). This affects the flexibility of the whole power system to address the intermittency of renewables as the lack of interprovincial or interregional dispatch limits grid operators' access to available demand and capacity reserve (Ye, Jiaqi, & Mengye, 2018). The monthly or annually must-meet energy totals of coal-fired

Table 15.
Causes of renewables curtailment in China (Davidson, 2018; Li, et al., 2014)

Technical constraints	Institutional constraints
Limited flexibility in the thermal power plants: (see #245) • Coal power plant inflexibility: coal plants have high minimum generation levels and long minimum up/down time (#220, 247) • Must-run Combined Heat and Power (CHP) plants: run in winter with high minimum electricity outputs • Regional shortage of more flexible generation such as gas, pumped hydro, and reservoir hydropower plants	**Long-term physical contracts**, which set high minimum outputs and long-interval (weekly to monthly) commitment schedules for coal power plants limit short-term balancing efforts
Inadequate transmission grid planning and operation: • No integrated transmission grid and resource planning that ensure the renewables generation can be transferred to load centers • Absence of adequate grid codes that help ensure a secure and reliable integration of renewables into the network • Concerns about stability and reliability due to lack of knowhow in control centers and inadequate or no-integration of mid- and short-term wind forecasts in dispatch schedules	**Interprovincial trading inflexibility**: pre-scheduled interprovincial flows set annually with fixed quantity and price and different trading rules across provinces and regions impede short-term trading and power exchange across regions
	Provincial authority: local governments prioritize coal in their planning, operation, and market authority and set high annual generation quotas for coal plants

power plants and long-term coal commitment scheduling further limit the integration of renewables into the power grid (Davidson, 2018).

Although high curtailment rates are closely tied to technical factors, the institutional constraints play a bigger role in this issue (Davidson, 2018). In some provinces, the grid congestion may require grid expansion to accommodate more power to flow, but most of the time it is more an issue of flexibility (scheduling and interprovincial trading) than sufficient capacity.

Some measures taken by the Chinese government to overcome the technical problems of integrating renewables into the grid are slowing down renewables investment in provinces where curtailment rates are high, constructing ultra-high-voltage (UHV) transmission lines to connect renewables generation sites with demand centers, and starting coal plant flexibility and wind-to-heat (to reduce CHP minimum outputs) pilot projects (Davidson, 2018).

Some measures taken to address the institutional problems are overturning the coal monthly allowances, introducing a down-regulation market, and piloting wholesale spot-market projects in some provinces in China. The down-regulation market was introduced in 2014 in northeast region to provide financial incentive for flexible thermal power plants. In this market, the power plants which operate above the baseline (50% in northeast China) have to compensate power plants which operate under the baseline (Clean Energy Ministerial, 2018), hence minimizing the financial losses caused by reduced operating hours. This mechanism has significantly increased the coal plant flexibility.

Furthermore, China has also piloted wholesale spot-market projects in some provinces, with eight provinces are planned to fully operate a spot market by late 2018 or early 2019 (IEA, 2018). The transition from a down-regulation market to a wholesale spot market in China is necessary as the current down-regulation market only runs day-ahead trading, a longer time resolution compared to real-time or intraday trading that wholesale spot markets have (Clean Energy Ministerial, 2018). These wholesale spot markets will be the foundation of the merit order dispatch (important in reducing curtailment), increasing participation of renewables in the network, and advancing the just-implemented carbon trading in China.

In addition to curtailment issue, China also faces stranded asset issue. At the end of 2016, China's national electricity oversupply was 35% with potential stranded assets of coal power plants were valued at $237 billion (Zhou & Lu, 2017). The generation oversupply has been driven by expansive development of power plants in the last decade and low electricity consumption growth in China in recent years. In 2015 alone, the country added 130 GW of newly installed capacity when the electricity consumption growth only reached 0.96% (China Energy Portal, 2016). The full load hours of thermal power plants in that year fell to 4364 hours (a 50% capacity factor), hitting the lowest utilization level since 1969 (Lin, Kahrl, & Liu, 2017). The utilization level dropped deeper in 2016 to 4165 hours before rebounding slightly to 4209 hours in 2017. The slowing electricity demand growth has been caused by the success of energy efficiency measures in China and the decelerating manufacturing activities in recent years due to the transition of this country toward a service economy.

3.2.3. Electricity Market

The Chinese power market is split into two main sectors, generation and transmission & distribution. In the power generation sector, there are state-owned and private generation companies (IPPs), which compete with each other to produce electricity. Meanwhile the transmission, distribution and retailing are not separated and fully controlled by the State Grid Corporation of China (State Grid) and China Southern Power Grid (South Grid) owned by the government. These two power grid operators also have their regional and provincial subsidiaries.

Generators receive regulated tariffs which are based on operating costs plus its return on investment. For coal power plants, coal prices are a key input in generation costs. As coal market is deregulated while the power market is regulated, a decline in coal prices cannot be immediately passed on to the electricity tariffs. Therefore, increasing the profit margin of coal power plants. This situation has encouraged more investment in coal-fired power plants in the past years despite the overcapacity (Spencer, Berghmans, & Sartor, 2017).

The generation dispatch orders are determined at the beginning of each year by local governments by balancing supply and demand. A minimum dispatch is granted to coal plants to ensure their profitability. The wholesale power prices imposed by generators to grid companies and retail prices charged by grid companies to customers are subject to NDRC approval.

The electricity market in China has been through some changes since 1985. In general, there are three stages of electricity market reform in China, as outlined in Table 16.

Table 16. Power Sector Reform in China (Kahrl, Williams, & Hu, 2012)

In the first stage period, between 1980 and 1984, the majority of electricity generation was owned by the central government. Some changes occurred in 1985 to 2001 period, where the government started opening-up the power generation market to the private investors and applying equal shares dispatch mechanism which allocates equal generation hours to generators. Notable transformation took place in 2002, when China unbundled its generation and transmission sectors after the State Council issued the Proposal for Power Sector Structural Reform. The proposal sets out the objective to split power generation and transmission and to gradually separate transmission and distribution services and to initiate competition in electricity retailing sector (Wilson, Yang, & Kuang, 2015).

The reform process itself never really progressed beyond the stage of unbundling the power generation and transmission sectors. China had continued to impose regulated prices to power

Table 16.
Power Sector Reform in China (Kahrl, Williams, & Hu, 2012)

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

generators and the transmission tariffs had not been separately determined. The sales of electricity were controlled by local transmission and distribution monopoly, making the transmission, distribution, and retail remained fully vertically integrated (Pollitt, Yang, & Chen, 2017).

However, since the issuance of Document No. 9, Opinions on Deeping Power Sector Reform, in March 2015 by the State Council, more progressive power market reforms have been pursued. Every province in China, except Tibet, has been piloting the retail liberalization and wholesale electricity market since 2015. Regulators have also started formulating transmission fees and piloting more transparent tariffs in several Chinese regions.

Under this new round of reforms, a portion of renewables and nuclear generation will be dispatched and priced by regulators and directly sold to consumers. While the rest of generation coming from thermal, nuclear, and renewables power plants will be traded in the markets. The existing coal plants will also get lower guaranteed generation hours as the regulators intend to annually reduce the quotas. Meanwhile all new coal plants that have been approved after March 15, 2015, will not get a minimum dispatch and must compete to get 100% generation dispatch (Zhou & Lu, 2017).

The benefits of these pilot projects have been enjoyed by some provinces that experience coal generation oversupply. Compared to benchmark pricing mechanism, the wholesale market has caused significant electricity tariff reduction, thus increasing the economic activities in those provinces (Zhao, et al., 2017).

Parallel to the power market reforms, on December 19, 2017, China started implementing a national carbon market. This carbon market is the largest carbon market in the world, by involving 1700 emitters in China's power sector and accounting for a third of its total emissions (Harvey & Min, 2017). This will significantly affect the dispatch order by lowering the operating hours and therefore profitability of less efficient coal plants while prioritizing the more efficient coal plants and renewables-based power plants to produce electricity.

The benefits brought by carbon market, however, can only be gained if China is opening up its wholesale and retail markets and embraces merit order dispatch, which assigns dispatch order based on the marginal costs of production. Carbon pricing is also expected to increase generation costs of thermal plants. When oversupply occurs, it would be even more difficult to pass on the extra costs to consumers (Spencer et al., 2017). Therefore, if implemented effectively, this market will further increase the uptake of renewables in China and bring market incentives to coal generators to shift to cleaner energy.

3.2.4. Regulatory and Institutional Frameworks

Regulatory Framework:

1. The Renewable Energy Law

Enacted as a law in 2005, implemented effectively in 2006, and amended in 2009, the renewable energy law aims at promoting renewable energy, diversifying energy mix, ensuring energy security, and protecting the environment (Article 1). China is the first developing country to have such a law (Hagaan, 2015).

The law sets five key mechanisms to develop renewable energy (Zang et al., as cited in Hagaan, 2015), including setting national targets for renewable energy, mandating grid connection and purchase policy of renewables, introducing a national feed-in-tariff system, setting a cost-sharing mechanism that allows utilities to share the renewables generation costs with the electricity end-users, and lastly establishing the Renewable Energy Development Fund which delivers financial support for renewable R&D, pilot projects, standard setting, rural renewable projects, renewable resource assessments, local renewable manufacturers, and grid companies.

The Renewable Energy Law has proven effective in sending positive signals to market. Since the implementation of this law, China has seen increased investments in the renewables sector. Many big global wind-turbine manufacturers built factories in China and more power generators also enter the market (Hagaan, 2015), creating new jobs and strengthening China's renewables manufacturing industry.

2. Medium and Long-Term Development Plan for Renewable Energy

Established in 2007, this plan puts in place medium (by 2010) and long-term (by 2020) targets for each renewable energy type and the share of renewable energy in total energy consumption. The plan aims to achieve 190 GW of hydro, 5 GW of wind, 300 MW of solar, and 5.5 GW of biomass installed capacities by 2010 and 300 GW of hydro, 30 GW of wind, 1.8 GW, and 30 GW of biomass installed capacities by 2020. These targets then translate into 10% share of renewables in total primary energy consumption by 2010 and 15% by 2020.

3. Renewable Energy Five Year Plans

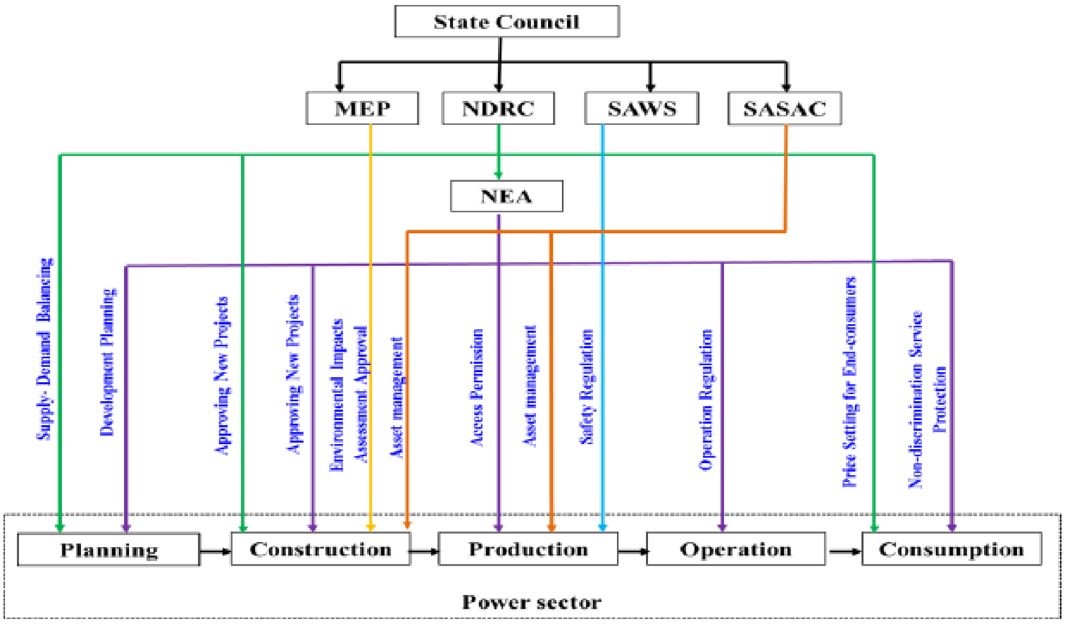
A derivative of China's Energy FYP, the Renewable Energy FYP is a framework legislation stipulating Chinese plans and strategies for developing the renewable energy in China in five-year period. In addition to the Renewable Energy FYP, China has other supporting FYPs, including the Electricity FYP, Wind FYP, Solar FYP, etc., that usually released in parallel. The Renewable FYP sets specific targets for each of renewable energy type in terms of the installed capacity, electricity generation, and investment as explained in part 3.2.1.

Institutional Framework:

China has a complex governing institution network in its power sector, constituting several layers with, sometimes, overlapping functions (Menezes & Zheng, 2018). At the top of the layer, there is the State Council, which acts as the top administrative authority in China's economy. The State Council sets responsibilities to the National Development and Reform Commission (NDRC), State Owned Assets Supervision and Administration Commission (SASAC), Ministry of Environmental Protection (MEP) which in 2018 replaced with the Ministry of Ecology and Environment (MEE), and State Administration of Work Safety (SAWS) for overseeing the power sector in China.

NDRC is responsible for controlling prices and investment in the power sector. The national NDRC is authorized to approve new large-scale projects, while the small projects go to the provincial-

Figure 29.
Regulatory Institutions in China's Power Sector
(Source: Tan and Zhao, as cited in Pollitt et al., 2017). Note: MEP was superseded by MEE in 2018.



level NDRC. The National Energy Administration (NEA), under the NDRC, is in charge of preparing and executing development planning, strategies, policies, and regulations, and counseling on power sector reform.

SASAC takes responsibility to supervise and manage assets possessed by the state-owned enterprises. MEP (replaced by MEE in 2018) formulates the environmental policies and evaluates the environmental impacts of projects and pollution coming from the power plants. Meanwhile SAWS issues safety regulations of electricity production. The whole flow of command in the Chinese power sector can be seen in the Figure 29 below.

The drawback of this network is the difficulty in coordinating the actions taken by different government agencies as no institutions act as a coordinator that rules the policy making process and none want to be ruled by others (Pollitt et al., 2017).

3.2.5. Financial Instruments and Incentives

The rapid growth of renewable energy in China in the past decade is associated with a strong incentive policy implemented in the country. Some major incentives available in the Chinese renewables sector are explained below.

1. Research and Development (R&D) Incentives

- **Establishment of R&D institutions**

China, as enacted in the Renewable Energy Law, sets to push the R&D and industrialization of renewable energy. One of ways to do that is establish the R&D centers dedicated for each type of renewables. Some of the research centers that have been established between 2005 and 2016 are shown in Table 17.

These R&D centers have been successfully improving the Chinese renewables technological capabilities. For instance, China is now advanced in core wind energy technologies, including large-scale wind turbine, wind turbine blade airfoil, and offshore wind farm design and construction. China's capability to manufacture low-cost solar cell and polysilicon is also associated with the success of its R&D institutions in making technological breakthroughs (Zhao et al., 2016), benefiting not only the country but also the rest of the world.

The Chinese manufacturers have then become the global market leaders in the solar PV and wind turbine manufacturing industries. In 2015, by market share, five of the top six global solar PV

Table 17.
The R&D institutions for renewable energy established from 2005 to 2016.
Adapted from Zhao, Chen, & Chang (2016)

No.	Name of the institution (established year)	Main works
1.	National Engineering Research Center-Hydropower Equipment (2005)	Aims to facilitate the development and application of new technologies and products in hydropower generation.
2.	Testing Station of National Engineering Research Center for Wind Power Generation (2006)	Aims to track new technologies of wind power generation globally and provide testing service of wind turbines and components for investors of wind power generation projects and equipment suppliers around the world.
3.	Research Center for Solar Power Generation of Chinese Academy of Sciences (2009)	Aims to study on technologies of testing solar PV modules and solar thermal power generation.
4.	Engineering Research Center of Ministry of Education for Renewable Energy Power Generation (2009)	Aims to research and develop small hydraulic turbine of high efficiency.
5.	National Engineering Laboratory of Biomass Power Generation Equipment (2010)	Aims to manufacture new types of power equipment for biomass power generation, and contribute to the R&D of wear and corrosion resistance new materials.
6.	National Engineering Research Center for Offshore Wind Power (2010)	Aims to design and manufacture offshore wind power equipment and study on maritime anti-corrosion technology, as well as technologies for wind turbines with the generation capacity of no less than 2.5 MW.
7.	National Development and Technology Popularizing Center for Geothermal Energy (2013)	Aims to study on development strategies, policies and key technologies of geothermal energy.

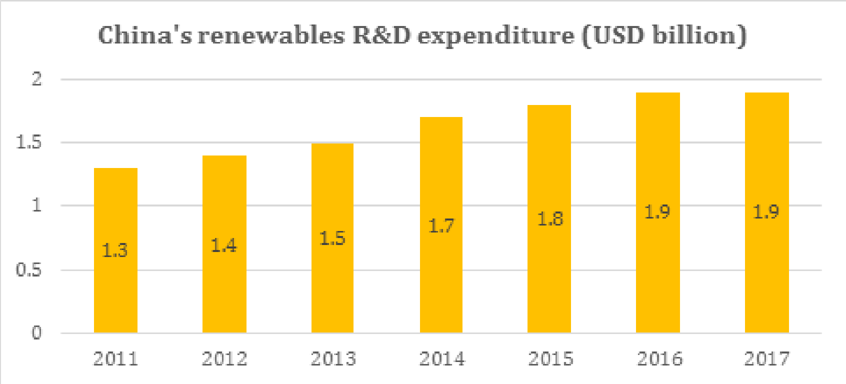
manufacturers and five of the top ten wind turbine suppliers in the world were Chinese (Buckley & Nicholas, 2017). The Chinese companies have also been expanding its renewables investments to other countries, such as Brazil, Australia, Canada, and the United States to gain more opportunities to grow.

- **R&D fund**

The renewables-R&D activities are expensive and risky, and therefore need financial support from the government to move the technologies from laboratories to market. Some funding sources available for the universities, research institutions, and companies to conduct R&D and industrialization of key renewables technologies are the Renewable Energy Development Fund, National High Technology R&D (863) Program, National Basic Research (973) Program, State Key Lab (SKL) and State Engineering and Technology Research Center (SETRC) Programs, National Science and Technology Infrastructure Program, China Torch Program, Five-Year-Plans, and National Natural Science Fund (Ball, Reicher, Sun, & Pollock, 2017).

As seen in the Figure 30, the Chinese government has kept increasing its spending on renewable energy R&D from USD 1.3 billion in 2011 to USD 1.9 billion in 2017. This confirms China's strong commitment in the development of renewable energy in the country as R&D is key to bring the renewables costs down. The lower costs will also increase the competitiveness of Chinese renewables

Figure 30.
Year-on-year China's renewables R&D expenditure.
Data from Frankfurt School-UNEP Centre/BNEF (2018)



technologies and help maintain China's position as one of renewables market leaders in the world.

2. Fiscal and Tax Incentives

- **Tax support**

The hydro, wind, solar, biomass, and geothermal power generation projects in China have long enjoyed some kinds of tax support given by the government to increase the renewables competitiveness. The so-called preferential tax policy includes value-added tax (VAT), income tax, and import duty incentives.

Through these relaxed taxes, the government intends to reduce tax burden and increase profit margins of renewables companies. As a result, more companies enter the market which would increase the competition and lower the overall costs of renewables projects. In order to prevent over reliance on imported equipment and boost the R&D activities of local equipment manufacturers, China has set criteria of wind power equipment that can be exempted from the import duties and VAT.

Table 18.
Tax support for renewables projects in China (Source: Zhao et al., 2016)

Tax items	Regulation contents (Preferential tariff)	Non-preferential tariff
VAT	(1) Municipal solid waste incineration power projects shall be exempted from VAT, if the solid waste accounts for no less than 80% of the power generation fuel, and the projects meet the emission standard. The VAT rate for methane biomass, small hydro and wind power projects is 13%, 6% and 8.5% respectively. (2) From October 1, 2013 to December 31, 2015, the VAT for solar energy power products can enjoy a tax refund of 50%.	17%
Income tax	The newly built hydropower projects on main rivers approved by the NDRC and the installed capacity of a project is no less than 250 MW, together with the wind power, solar power and geothermal power projects can enjoy an income tax concession, which consists of income tax exemption in the first 3 years and a 50% reduction of the income tax from the 4th to the 6th year, starting from the year when the projects firstly obtained income.	25%
Import duty	Since January 1, 2008, the import duty and import VAT of imported key components and raw materials for domestic enterprises manufacturing wind turbines of large capacity can be refunded. The refund tax shall be used for R&D of new wind power products.	Varied

Table 19.
Tax exemption catalog for wind power equipment since 2012 (Source: Zhao et al., 2016)

Items	Specification requirements
Wind turbine generator unit	Generator capacity shall be over 2 MW
Blade, gearbox, generator	Generator capacity shall be over 2 MW
Offshore and intertidal wind turbine installation vessel	Lifting capacity shall not be less than 500t, which can install offshore wind generator over 5 MW

- **Financial subsidy**

Some of financial subsidies available for renewables projects are shown in the Table 20 below.

The financial subsidy granted for renewables projects in 2012 reached ¥8.6 billion ($1.36 billion), which subsidized 496 renewables projects in China. This number increased by 3300% compared to 2006's subsidy of ¥251 million ($39.55 million), which was used to support 38 renewables projects (Zhao et al., 2016).

3. Grid connection and Tariff Incentives

- **Feed-in-Tariffs (FiT)**

The FIT scheme has been very effective in attracting investors and developers to invest in the Chinese renewables sector. The FIT has been reduced several times to reflect the decreasing cost of renewables-based generation. The latest FIT for each renewable energy type can be seen in the Table 21 below.

Data from IRENA below shows the evolution of tariff mechanism in China. In its early stage of renewables development, China used auctions to determine the price level of FIT. In 2003, the first renewables auctions were conducted for onshore wind projects. The prices revealed in these auctions were used to set a fixed FIT introduced in 2009. The utility-scale solar PV projects were then auctioned in 2009 and 2010 before China established a unified FIT in 2011. China provided a Feed-in-Premium (FIP) for biomass projects from 2005 to 2009 before setting out a unified FIT for agriculture and forestry-based biomass power in 2010 and waste-based biomass power in 2012. Hydropower projects have used project-by-project-based regulated prices.

The costs associated with FIT have been funded through a national surcharge passed onto electricity consumers and subsidies from the central government, which are together kept in the Renewable Energy Development Fund. However,

Table 20.
Subsidy standards for renewables (Source: Zhao et al., 2016)

Items	Subsidy Standard
Wind power equipment manufacturers	The first 50 wind power units of MW-scale could be rewarded at the standard of ¥600/kW.
Grid-connected solar PV power projects	The subsidy standard is 50% of the total investment of solar PV power generation system and the associated transmission and distribution systems. This standard can be raised to 70% in remote regions with no power supply.
Solar PV power demonstration buildings	For building attached PV projects, i.e. the building plays as a supporter of the PV components, the subsidy standard in 2013 is ¥5.5/W. For building integrated PV projects, i,e, the PV panels are encapsulated into building materials, the 2013 subsidy standard is ¥7/W.
User-side solar PV power projects	The subsidy standard in 2012 is ¥7/W, which can be appropriately increased if the project is combined with smart grid or micro grid.
Biomass power generation projects	The biomass power generation projects can enjoy a subsidy of ¥0.25/kWh for 15 years after commercial operation. Since 2010, the subsidy of newly approved projects dwindles by 2% per year.

Table 21.
Stipulation of FIT for renewable energy
(Source: Zhao et al., 2016 with update for solar PV and on-shore wind power from NDRC)

Type	Stipulation Content
Wind power	(1) China's territory is divided into four types of wind resource regions where different feed-in tariffs are defined. The benchmark tariffs are ¥0.40, 0.45, 0.49 and 0.57/kWh respectively. (2) Offshore wind power is divided into coastal and intertidal wind power. The feed-in tariff of coastal and intertidal wind power projects is ¥0.85/kWh and ¥0.75/kWh respectively before 2017.
Biomass power	(1) Agriculture and forestry biomass power projects follow both benchmark tariff policy and bidding price policy. If the investor of a new project is selected by bidding, the feed-in tariff of the project will be determined by the bidding price; otherwise the benchmark tariff will be ¥0.75/kWh. (2) The feed-in tariff of waste incineration power projects is ¥0.65/kWh.
Small hydropower	(1) The feed-in tariff of inter-provincial hydropower stations is determined by negotiation between the electricity supplier and buyer; Other hydropower stations follow benchmark tariff policy, and the price is formulated by taking into consideration the hydropower exploitation cost, the provincial average electricity purchase price, and the demand and supply of the market. (2) Provinces with large amount of hydropower adopt time-of-use electricity price, which varies according to three different periods of electricity supply: flow period, wet period and dry period.
Solar PV	According to the availability of solar energy, China's territory is divided into three types of solar resource regions where different feed-in tariffs are defined. The benchmark tariffs are ¥0.55, 0.65 and 0.75/kWh respectively.
Geothermal power	The feed-in tariff of geothermal power projects is determined considering their actual construction and operation costs as well as reasonable profits.

the growth rate of renewables generation has been higher than of the electricity surcharge paid by consumers (Ming, Ximei, Na, & Song, 2013), making the subsidy gap widen over the years. By the end of 2017, the outstanding payments of FIT had soared to RMB 100 billion or approximately USD 15.6 billion (Green Tech Media, 2018).

To balance its subsidy deficit, in June 2018, the government of China announced that it had halted the allocation of quotas for utility-scale solar PV projects until further notice and reduced FIT for the projects by 0.05 yuan per kWh (National Development and Reform Commission (NDRC), 2018). This new move is following the change in

Figure 31.
Evolution of Chinese tariff mechanism for renewables generation (IRENA, 2013)

the Chinese wind sector which will abandon the FIT scheme and shift to auction mechanism in the beginning of 2019 (MAKE Consulting, 2018).

The subsidy system used in China to finance its renewables projects has long been perceived as unsustainable. The two to three-year delay in subsidy payments has put a strain on developers' cash flow. Meanwhile, the rapid development of renewables has burdened the state budget. Wood Mackenzie estimated that if China continues to provide subsidies to renewables developers, it could cost the country RMB 250 billion (about USD 39 billion) by 2020.

To replace the subsidy scheme, China launched a voluntary trading scheme of green electricity certificates (GEC) in July 2017. Under this new system, the renewables generators can trade their GEC to coal-fired power generators as well as companies which have their own renewables goals. In addition, in March 2018, NEA issued a draft of Renewable Electricity Quota and Assessment Method which sets out a mandatory Renewable Portfolio Standard (RPS) target for each province for 2018 and 2020 (IEA, 2018). This system obligates grid companies, power retail companies, and large end-users to participate and help provinces meet their renewables quotas. The GEC can be purchased to meet the obligations.

The power market reforms and carbon markets are perceived as key to develop the GEC scheme. If the markets are not liberalized and thus the electricity prices are determined by the government, there will be no difference between coal and solar power as neither the cost fluctuations of coal power nor the declining renewable costs are fully reflected in electricity tariffs (Chinadialogue, 2017). With market reforms, the renewables can compete squarely with coal power, providing renewables a competitive advantage. While the carbon markets might be used as a platform to trade the GEC.

Table 22.
Incentives policies on setting market regulation (Source: Zhao et al., 2016)

Policy (established year)	Implication
Related regulations on renewable energy power generation, NDRC (2006)	Standardize the approval process of REPG project. The newly built hydropower projects on main rivers as well as the hydropower and wind power projects the total installed capacity of which are no less than 250MW and 50MW respectively should be approved by NDRC. The biomass power, geothermal power and solar power projects which need national subsidy support should also be approved by NDRC.
Guiding opinions on tax distribution of inter-provincial hydropower project, Ministry of Finance (2008)	Standardize tax distribution of inter-provincial hydropower project. Reasonable tax distribution weight is formulated based on the contribution that related provinces made in the construction and operation stage of the project.
Notice on cancelling domestic rate requirement for equipment procurement of wind power generating project, NDRC (2009)	Regularize competition in the wind power industry. The provision that the wind farms the domestic equipment rate of which doesn't reach 70% and above should not be built has been abolished since November, 2009.
Notice on strengthening wind power grid-connection and market consumption for 2013, NEA (2013)	Standardize wind power grid-connection and market consumption. The wind power utilization rate should be regarded as an important indicator for scheduling its future development scale in the region.
Notice on adjusting the standard of renewable energy tariff surcharge and environmental protection price, NDRC (2013)	Standardize renewable energy tariff surcharge. The standard of renewable energy tariff surcharge has been raised from 0.008 Yuan to 0.015 Yuan since September, 2013.

- **Full-purchase of power generated**

Under the Renewable Energy Law, the power grid companies in China are obliged to fully purchase power generated by licensed renewable-based power plants. During the early stages of renewables industry in China, when the share of renewables was still low and so was its impact on the grid stability, this policy had been effective in stimulating the development of renewables. However, as the industry increases rapidly, the power grid companies are not willingly accepting the renewables-based power generation, blaming its impact on grid stability and safety due to its intermittency (Zhao et al., 2016).

The full-purchase policy has not been accompanied with appropriate grid-connection standards or grid codes that are important to safely and reliably interconnect intermittent renewables into the grid. Some technical aspects that need to be addressed in the grid codes are power quality, active and reactive power control, low voltage ride through (LVRT), high voltage ride through (HVRT), frequency range, voltage control, and solar and wind power forecasting. China, however, has committed to continually updating and optimizing its grid-connection standards aligned with the penetration levels of renewables, local power system, and climate conditions.

4. Market Development Incentives

- **Market regulation**

Ensuring a fair competition environment in the renewables industry, China has set several policies and provisions to restrict the behavior of the actors in the industry, as explained below.

Table 22. Incentives policies on setting market regulation (Source: Zhao et al., 2016)

3.2.6. Key Lessons

From the analyses made in the previous parts, there are several key lessons that can be learned from China's renewable energy development.

Clear regulatory framework and rule of law	The Renewable Energy Law, Medium and Long-Term Development Plan for Renewable Energy, and Energy Five Year Plan have sent positive signal to investors by ensuring the government commitments to developing the renewable energy in China in the long run.
Explicit renewables targets	China has committed to installing 680 GW of renewables and generating 1900 TWh of renewables-based electricity by 2020. The clear-cut targets are important to express the political commitments from the government to develop its renewable energy sector and send positive signal to investors to attract more investments in China.
Renewable Energy Law and Renewable Energy Development Fund	China is the first developing country to have a Renewable Energy Law. The Law has proven effective in sending positive signals to investors interested in investing in the Chinese renewables market. Since the implementation of this law in 2005, the renewables investments in China has been increasing, creating new jobs for the country and strengthening its renewables manufacturing industry. The Renewable Energy Development Fund accelerates the development of renewables in China by delivering financial support for R&D, pilot projects, standard setting, rural renewables projects, local renewables manufacturers, and grid companies.
Pilot and demonstration projects of wholesale market	To accommodate transition toward a liberalized market, China has been piloting the retail liberalization and wholesale electricity market since 2015. The pilot projects have benefited the provinces where the projects taken place by reducing the local electricity tariffs and helped the government establish the most ideal power market in China. The pilot projects also push the regulators to use more transparent transmission fees to let the renewables be sold directly from generators to end-users. The wholesale markets will provide renewables a competitive advantage over fossil fuels.

Strong support for renewable energy research and development (R&D) activities	As China sees the R&D as the national importance to increase the Chinese competitiveness in the 21st century's science and technology, the country has kept increasing its spending on renewables R&D. The renewables R&D fund can be accessed by the universities, research institutions, and companies which conduct R&D and industrialization of key renewables technologies. The R&D has helped bring the renewables costs down, increase technological capabilities of local renewables manufacturers, and increase the competitiveness of Chinese renewables technologies in global market. China's capabilities in cutting-edge renewables technologies have helped the Chinese companies become global market leaders in solar PV and wind turbine manufacturing industries.
Development of renewable energy equipment manufacturing industry	The domestically manufactured renewables equipment has proven more cost-effective than imported equipment, reducing the renewable project costs and thus increasing the deployment of renewable energy. China also perceives the renewables industry as its economic backbone in the future as it continues to win more market share in global renewables equipment market. By developing this industry, China has succeeded to create more than 3 million jobs by 2016.
Various financial incentives	The Chinese government offers varied types of financial incentives, including R&D, fiscal & tax, grid-connection and tariff, and market development incentives used to increase the attractiveness and competitiveness of renewables in China.
Grid connection and integration issues	China has the highest curtailment rates of wind and solar power in the world. Rigid quota setting, including of generation within and trade across provinces in China, is not compatible with the short-term flexibility required to efficiently integrate variable renewables such as wind power. Some measures taken by the Chinese government to address curtailment issue are overturning the coal monthly allowances, introducing a down-regulation market, and piloting wholesale spot-markets which will enable intraday or real-time trading. The down-regulation market has significantly increased the flexibility of coal power plants in China.
Unsustainable subsidies	The FIT system in China has helped boost the renewables generation in China. As the growth rate of renewables generation has been higher than of the electricity surcharge paid by consumers, the subsidy gap has widened over the years. The two to three-year delay in subsidy payments has put a strain on developers' cash flow. Meanwhile, the rapid development of renewables has burdened the state budget. The subsidy system therefore is unsustainable to be used to finance the renewables projects. To replace the subsidy scheme, China launched a voluntary trading scheme of green electricity certificates (GEC) and has drafted a mandatory Renewable Portfolio Standard (RPS) for each province. The power market reforms and carbon markets are perceived as key to develop the GEC scheme.

3.3. Case Study 3: Renewable Energy Development in India

India is the world's third-largest economy (by PPP) and energy consumer. In 2015, India accounted for total final consumption (TFC) of 577.68 Million tonnes of oil equivalent (Mtoe), represents 6% of the total global TFC (International Energy Agency (IEA), 2017). The electricity plants consumed most of the country's TFC with a total of 34% TFC.

In the same year (2015), the country shared 18% of the world's population and projected to be one of the world's most extensive energy demand in the upcoming decades (World Bank, 2018). In a study, International Renewable Energy Agency - IRENA

(2017) estimates that the growing energy demand in the country is projected to grow faster than Brazil, US, and even China due to the rapid growth of its population, income level and urbanization rates.

To meet the future demand, India has started to build their energy infrastructure by transitioning a highly reliant on fossil fuel into renewable energy. The country already set and promote the development of renewable energy through various policies and measures. With a consistent and conducive environment of the energy transition, the country would be the third largest renewable energy usage in 2030 after China and the US (IRENA, 2017).

In this subchapter, how India drives its renewable energy development will be discussed. It includes the national renewable energy targets and progress, the electricity market and regulatory frameworks, financial incentives, as well as lessons learned from Indian renewables development.

3.3.1. National Targets and Programs

India is responsible for about 6.7% of global GHG emissions after China, the US, and the EU (World Resources Institute (WRI), 2017). However, India is taking actions to mitigate their emission by ratifying the ambitious Paris Agreement. As of October 2016, the country is officially pledged its commitment to reduce the emissions intensity of its GDP by 33-35% from 2005 levels as well as achieving 40% cumulative electric power installed capacity from new and renewable energy resources by 2030.

To achieve the energy sector targets, India aims to achieve arguably the world's most ambitious renewable energy capacity expansion programs. In 2015, the Government of India has set a target to install a total of 175 GW renewable energy capacity by 2022. The target includes 100 GW from solar energy, 60 GW from wind power, 10 GW from biomass energy, as well as 5 GW of small hydropower. Moreover, in June 2018 the New and Renewable Energy Minister announced the additional target of 52 GW (up to 227 GW in total by 2022) from new schemes like offshore wind and solar.

The Jawaharlal Nehru National Solar Mission (JNNSM) or often referred as the National Solar Mission (NSM), was one of the foundations of renewable energy target of solar in India which launched in January 2010. Initially, the mission aims to achieve a target of 20 GW by 2022 in three phases: the first phase (up to 2012-2013), second phase (from 2013 to 2017) and the third phase (from 2017 to 2022). However, considering the rapid deployment of solar energy from the first and second-half phase, in July 2015 the government ramped up the target from 20 GW to 100 GW by 2022 (Ministry of New and Renewable Energy (MNRE), 2015).

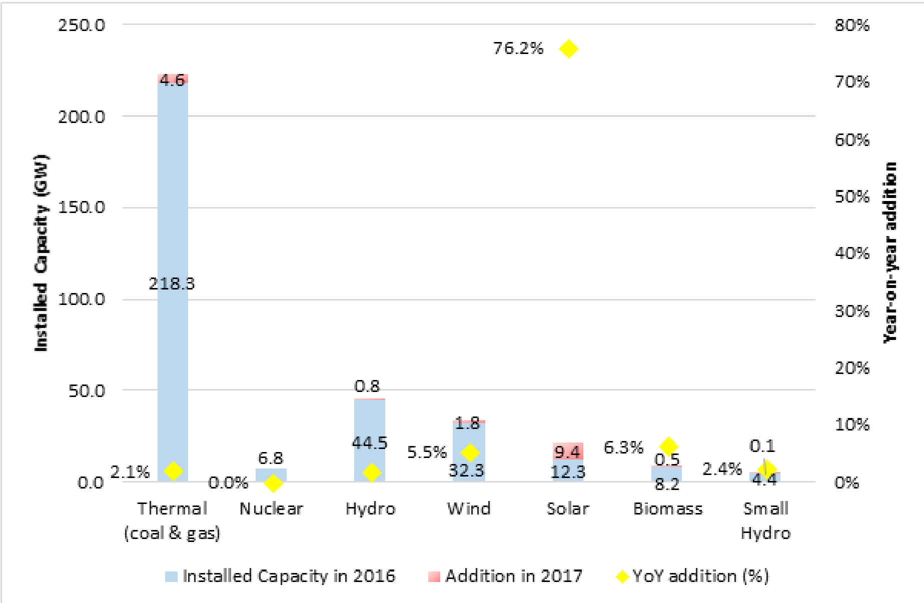
As for the wind energy target, unlike solar, the program is not initiated under a specific national mission. It is only translated into wind power program under the Ministry of New and Renewable Energy (MNRE) which covers the resource and potential assessment as well as projects development through fiscal and promotional policies. In addition to the program, a similar approach is conducted by the MNRE for the development of biomass energy and small hydropower in India.

Moreover, the country also has a program to envisaged renewable capacity addition into the

Table 23.
India's renewable energy target for 2022 (Adapted from Saluja & Singh, 2018)

Renewable Technologies	Commissioned/ pipeline (GW)	FY19 (GW)	FY20 (GW)	Total (GW)
Solar	49.5	34	30	113.5
Wind	46.6	10	10	66.6
Small Hydro	5.0	0.5	0.5	6
Biomass	9.5	0.5	0.5	10.5
Floating Solar & Offshore Wind	0	16	15	31
Total	110.6	61	56	227.6

Figure 32.
India's installed capacity in 2016 and additions in 2017. Data from Central Electricity Authority (CEA), 2018a)



electricity grid: green energy corridor project. The project initiated in 2012 and aims to integrate and synchronize the electricity produced from renewables and thermal energy in the main grid.

3.3.2. Current Status

At the end of 2017, India reached 344 GW of the total installed capacity, achieving an increase of 17 GW from the previous year (Central Electricity Authority, 2018a). Renewables contribute to almost three-quarter (12.6 GW out of 17 GW) of the total additional installed capacity. Furthermore, hydropower dominates the share of total installed renewable capacity in India for about 43%, followed by wind power (almost 30%) and solar energy (almost 19%). The biomass energy shares the lowest installed capacity - as opposed to other renewable energy shares, with approximately 7%.

Similar to China, solar energy in India also outpaced all other power sources in 2017 with the growth

Figure 33.
Year-on-year renewables installed capacity in India. Data from CEA (2018a) and Ministry of Statistic and Programme Implementation (MoSPI), 2018.

Figure 34.
Quarterly trends of India's new investment in clean energy.
Source: Bloomberg New Energy Finance (2018).

of 76% from 2016 (see Figure 32). Having the circumstances, the country ranked in the world top 10 total installed renewable power generation capacity in 2017 after China, the US, Germany, Spain and Italy (IRENA, 2017).

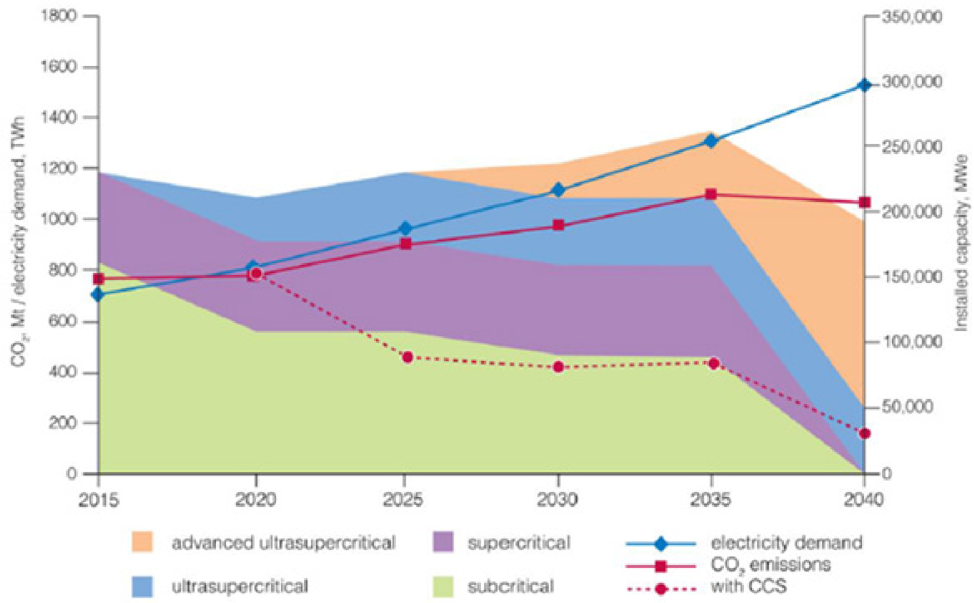
However, the average year-on-year additional renewables growth rate in the last decade was at 9% - or 6.7 GW of renewables per annum. Nevertheless, in the last two years, the growth rate was at 12.8 GW per annum. Most of the target comes from the solar parks and rooftop PVs. Thus, the installation of the rooftop PV needs to be doubled annually to meet the target despite the solar rooftop market is not conducive. Bloomberg New Energy Finance - BNEF (2017) argues that the bottlenecks of the rooftop market are due to mainly driven by industrial and commercial self-consumption (need an uptake from residential PV), as well as funded by the rooftop owner (need financial improvement for developers or customers). The annual trend in renewables installed capacity in India from 2007 to 2017 is shown in Figure 33.

The increasing year-on-year (yoy) additional installed capacity of renewables in 2017, however, do not be reflected in the investment of clean energy in the country. Referring to the data from BNEF (2018), the Indian investment in clean energy had been decreasing from the fourth quarter of 2016 to the third quarter of 2017 (see Figure 34). In other words, there was a depression of investment of US$ 2.7 billion between 2016 to 2017. In a report, BNEF (2017) mentioned that the investment fall was due to cancelled auctions and power contract renegotiations. Nevertheless, the investment in the years ahead is still favorable for investors considering the ambitious target of 227 GW total installed capacity from renewables by 2022.

As for the power generation, India produced more than 1300 TWh in 2017 (CEA, 2018a). Most of the electricity (for about 1000 TWh or almost 80%), was still generated from the thermal power plants (mainly powered by coal) yet aimed to reduce the share down to 30% (from 40% of renewables installed capacity) by 2030 under India's intended nationally determined contribution - INDC (Chawla, 2018).

To follow the clean energy development plan, the Government of India is promoting the supercritical technology as well as retiring some of the coal-fired power plant fleets. The country plans to retire a total of 48.3 GW of coal-based capacity throughout its two five-year plans (FYPs) cycles. During the 13th FYP (2017-2022), the first 22.7 GW of coal power plants are considered for retirement. Additionally, during the 14th YFP (2022-2027), a coal-based capacity of 25.6 GW will be completing their 25 years of operation by March 2027 (CEA, 2018b). The new planned coal power plants throughout the FYPs will be built by using at least a supercritical technology. In a study, Barnes (2014) projects that by 2040 the subcritical and supercritical technology will be retiring entirely and replaced by ultra-supercritical (with about 50 GW) and advance ultra-supercritical (with almost 150 GW) technology (see Figure 35).

Figure 35.
Indian coal power plant clean coal technologies and retirement scenario.
Source: Barnes (2014)



In 2017, renewables accounted for only 17% of the total power generation mix (more than 220 TWh). Hydropower dominates the share with almost 10%, followed by wind (4%), solar (2%), biomass (around 1%) and small hydro (0.6%). The shares do not much change as opposed to the share in 2014 - except for the share of solar power which only accounted for 0.4%. Figure 36 compares the power generation by fuel in India between 2017 and 2014.

The electricity produced from the renewables is increasing with an average rate of 177 TWh per annum (or almost 5 percent a year) over a decade. Similar to China, most of the renewable electricity in India is produced from hydropower. Furthermore, having the most significant additional installed capacity between 2017 and 2016, solar power plants in the country marked as the most increased electricity feed in 2017 - with almost doubled (an increase of 92% or equal to 12.4 TWh) from the previous year (CEA, 2018a).

Following the solar power, in 2017 wind power generated 53 TWh, increasing 14% from 2016. Electricity generation from biomass become the third with an increase of 8% yoy - equal to about 1 TWh. The hydropower generated 126 TWh in 2017, increasing by 3.1% yoy. A full spectrum of the renewable energy generation by technologies were only available until the year 2014. Thus, from 2014

Figure 36.
Power generation by fuel in India. Data from Central Electricity Authority (CEA) (2018a).

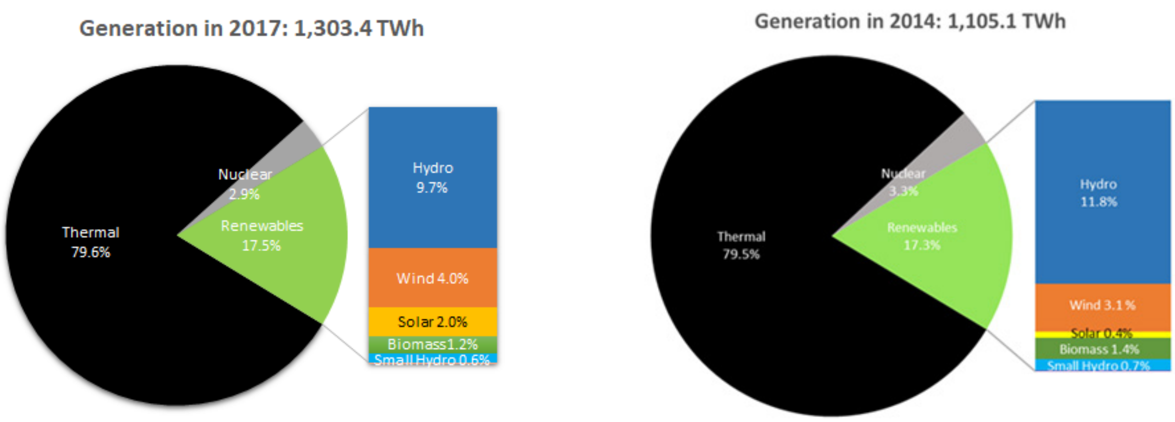
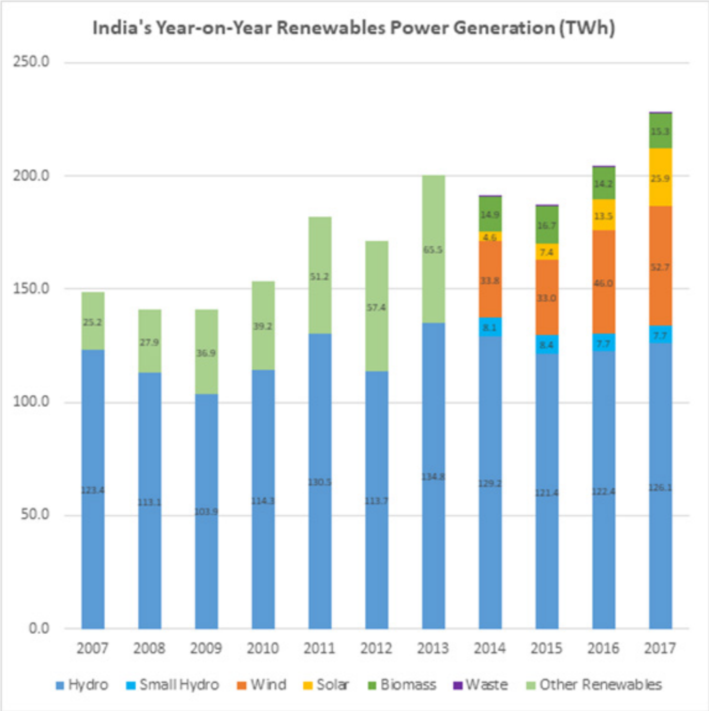


Figure 37.
India year-on-year renewables power generation.
Data from Central Electricity Authority (CEA) (2018a).



backwards, the renewable energy sources can be distinguished from hydro or other renewables only (see Figure 37 below).

3.3.3. Electricity Market

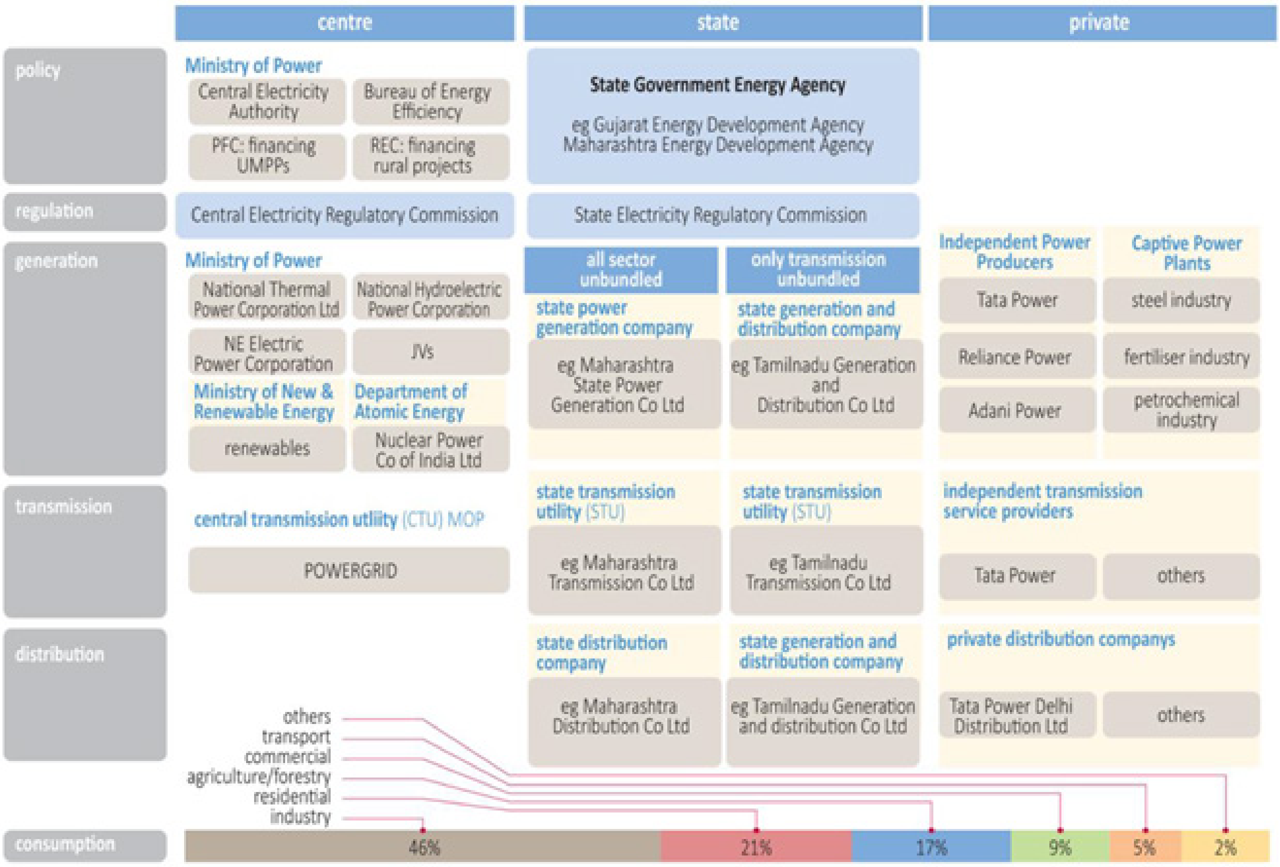
Under the Indian Constitution, power is one of the concurrent subjects in India in which both Central and State governments are responsible for the development of the sector. The Central government has several generation utilities (e.g. National Thermal Power Corporation, National Hydroelectric Power Corporation, North Eastern Electric Power Corporation), yet has only one central transmission utility (i.e. Power Grid Corporation). In the other hands, the State governments have its own generation company(s), transmission company(s), as well as distribution company(s). Hence, the three primary segments in the Indian power market are the generation, transmission, and distribution. Figure 38 depicts the key stakeholders and its roles in the power sector in the country.

As implied in Figure 38, electricity market in India can be categorized as an unbundling, competitive market in which utility partially broken up and/or partially divested. The Electricity Act of 2003 (EA 2003) mandates State Electricity Boards (SEBs) to divide the previously integrated power utilities into separate entities for handling the generation (generation companies - Gencos), transmission (transmission companies - Transco), distribution (distribution companies - Discoms) and trading functions. Thus, the EA enables the development of a competitive market in the country's electricity sector.

In the generation sector, any entity (e.g. individual, group, public, private) could set up a power plant subject to environmental clearances. The only exception is for hydropower plants above a specific amount of capital investment, regulated by central government on a case-by-case basis (Sen & Jamasb, 2013). Gencos are allowed to sell electricity to any distribution licensee, and even directly to consumers with permission from State Electricity Regulatory Commissions (SERCs).

The transmission sector can only be handled by a State-funded entity in which neutral to all players in the power field. The Central Transmission Utility (CTU), in this case, the Power Grid Corporation, interconnects the SEBs and various Gencos, as well as performed as a bulk electricity supplier (Sen & Jamasb, 2013). Independent transmission

Figure 38.
India's key stakeholders and roles in the power sector. Source: Barnes (2014)



service providers are also allowed to obtain power transmission licenses. Together with Load Dispatch Centers (LDCs), scheduling and dispatch of the electricity is part of the Transco's day-to-day job.

Power distribution is the final and most crucial link in the entire electricity market chain in India. Through Discoms, the sector has an immediate influence on the sector's commercial viability as well as the consumers who pay for power services. Since there is no distinction between distribution and retail supply under EA 2003, Discoms could use one license to engage in distribution, trading and retail supply (Sen & Jamasb, 2013). Furthermore, the open

Table 24.
Four phases of electricity market reforms in India. Adapted from Sen & Jamasb (2013)

	1948 - 1991	1991 - 1996	1996 - 2003	2003 - present
Market Structure	• Vertical integration	• Unbundled generation; • Single-buyer	• Unbundled generation, transmission and distribution; • Non- competitive; • Single-buyer	• Unbundled generation, transmission and distribution; • Competitive; • Multiple-buyer
Ownership	• State Electricity Boards; • Centrally-owned Generation Companies (1970)	• State Electricity Boards; • Centrally-owned Generation Companies • Independent Power Producers (1996)	• State Electricity Boards; • Centrally-owned Generation Companies • Independent Power Producers	• State Electricity Boards; • Centrally-owned Generation Companies • Independent Power Producers

access scheme to intrastate network infrastructure, imposed by a cross-subsidy surcharge for low-income consumer groups, namely agriculture.

The Indian electricity market has been evolving since 1948. The Electricity (Supply) Act in 1948 signified the formation of State Electricity Boards (SEBs) with full powers controlling the generation, transmission, distribution and utilization of electricity within respective states. The Central Electricity Authority (CEA) was responsible for planning and development of the power system. In 1991, the Act was amended to introduce private generating companies and allowed 100% foreign investment. The electricity reforms in the country can be summarized into four periods, as outlined in Table 24.

Electricity provision in the country's prominent cities began in 1899, supplied by profit-oriented firms (Sen & Jamasb, 2013). The system was metered with prices set at similar standard with London. The system persevered until India's independence in 1947. A year after the independence (in 1948), India's first Electricity Supply Act was enacted and marked as the first stage of electricity in India.

Modelled on the United Kingdom's (UK) Electricity Supply Act, the Indian Electricity Supply Act ascertaining vertically integrated public sector companies, called State Electricity Boards (SEBs) to take on the generation, transmission and distribution of the electricity in every state. The SEBs took over most of the private electricity companies between 1948 to 1956. Until the 1990s, there were no new private licenses granted to supply electricity.

The first reform took place with the enactment of the Electricity Laws (Amendment) Act in 1991. The Act unbundled the generation sector with a single-buyer market model to the private participation. In a study, Sen & Jamasb (2013) argued that the reformation be done to bring foreign investment as Independent Power Producers (IPPs) as the government made a Structural Adjustment Program in the liberalisation of the Indian economy. The history showed that the IPP reform in the country failed due to economic and political factors.

Having the circumstances, some of the states - Orissa in 1996, Haryana in 1997, and Andhra Pradesh in 1998, decided to completely unbundle their SEBs into generation, transmission, and distribution companies as well as setting up the State Electricity Regulatory Commissions (Sen & Jamasb, 2013). Following the electricity market structure reformations, the Central government passing the Electricity Regulatory Commissions (ERC) Act in 1998 to encourage states to establish their regulation regarding deregulation of the market.

The last and most recent power reform in the country occurred in 2003 by the introduction of the latest Electricity Act. The stipulation of the Act is aimed to reform the market structure from a non-competitive and single-buyer model to a multiple-buyer model with a more competitive market in the generation, transmission, and distribution sector. In addition to the market structure reform, the Central government also introduced the wholesale power trading and power exchanges in 2007.

3.3.4. Regulatory and Institutional Frameworks

India has been exposed to widespread energy scarcity since the first oil crisis in 1973. After since then, the country set up a long history of initiatives to promote renewable energy in the pursuit of energy security. The Solar Energy Society of India made the first appearance in 1976 as the country's first institutional framework in renewable energy. In 1982, India already had established a dedicated renewable and new energy sources in a department level - Department of Non-conventional Energy Sources (DNES). A decade later, the department transformed into the world's first ministry which exclusively dedicated to managing the renewable energy, the Ministry of New and Renewable Energy (MNRE).

Following the establishment of DNES, many supporting bodies and associations are also established. The identified supporting bodies and associations of renewable energy in India is summarized in Table 25. As a result, wind and solar technologies already being promoted through various policies and measures over the last three decades.

The significant development of renewable energy in India took off, arguably, with the coming into force

Table 25.
Supporting bodies and associations of renewable energy in India. Adapted from IRENA (2017)

Renewable energy	• Department of Non-Conventional Energy Sources (1982) • India Renewable Energy Development Agency (1987) • Ministry of Non-Conventional Energy Sources (1992) • Ministry of New and Renewable Energy (2006) • National Clean Energy Fund (2011)
Solar energy	• Solar Energy Centre (1982) • Solar Energy Corporation of India (2011) • Indian Solar Manufacturers Association (2011) • National Institute of Solar Energy (2013)
Wind energy	• Indian Wind Power Association (1996) • Indian Wind Turbine Manufacturers Association (1997) • National Institute of Wind Energy (1998) • Indian Wind Energy Association (2002) • Wind Independent Power Producers Association (2013)

of the country's Electricity Act in 2003 (EA 2003). The Act (EA 2003) provides the regulatory interventions to optimize the utilization of the resource, including renewable energy. It promotes the renewable energy through tariff determination, renewable purchase obligation (RPO) specification, grid connectivity facilitation, and marked development promotion. Furthermore, the Act also stipulated India's Central Electricity Authority (CEA) to prepare a national electricity plan in five years planning with a 15-year perspective.

In 2005, the National Electricity Policy (NEP) was enacted to promote and accommodate private participation in renewable energy. Under the policy, the capital cost of renewable energy is being reduced through competition. However, the specific renewable energy tariff has not regulated yet.

The tariff then was regulated further under the National Tariff Policy (NTP) in 2006 (and amended in 2011). The policy oversees the role of the State Electricity Regulatory Commissions (SERCs) and mandates the SERCs to set a minimum percentage of RPO and preferential tariffs. The RPO percentage and tariffs should consider the availability of the resources as well as its impact on retail tariffs from distribution companies. The NTP also has a further role in overseeing the mechanism for promoting the renewable energy and timeframe for implementation.

Following the establishment of NTP, the government start to set the renewable energy target under the National Action Plan on Climate Change (NAPCC) in 2008. The plan identifies eight cores of national missions running through 2017, including the national solar mission. The national solar mission is later on recognized as the Jawaharlal Nehru National Solar Mission (JNNSM). The national wind energy target also pledged by the government after the substantial progress of the JNNSM.

The Indian Electricity Grid Code (IEGC) is another decisive policy framework established by the government to ensure the absorption of electricity from renewables into the grid. The Code was developed by the Central Electricity Regulatory Commision (CERC) in 2010 which provide the methodology for renewable energy scheduling as well as the incentive mechanism for the states who absorb the significant degree of renewable generation. Thus, the power system operators shall make all efforts to evacuate the available power from renewables.

In summary, the existing renewable energy regulatory framework in India can be identified in the form of renewable energy policy, RPOs, renewable energy certificate (REC) mechanism, grid connectivity, forecasting provisions. These frameworks are often evolving in all major States on a regular basis. As such, India's Ministry of New and Renewable Energy has initiated a monitoring exercise on a monthly basis to track and record the evolving renewable power regulatory framework.

3.3.5. Financial Instruments and Incentives

Policy support for renewable energy sector in India are currently provided through combination of Central and State government financial instruments and incentives. The Central government provides policy support under the Ministry of New Renewable Energy. The financial instruments and incentives provided under the policy measures and relevant legislation include:

- **Feed-in Tariffs (FiTs)**

  In the national level, the levelized tariff for renewable powers is issued by the CERC as FiTs. At the states level, the preferential tariffs for procurement by distribution companies of power generated from renewables.

  Most Electricity Regulatory Commissions (ERCs) have put in place technology specific FiTs for their states as is mandated by the EA 2003. These tariffs are developed in a public consultative process after giving due consideration to views from all stakeholders. After considering all relevant fixed, operating & fuel costs and the normative generation from each resource, a levelized tariff is formulated with due consideration for return on equity, generally in the range of 16%. Such tariffs once decided hold over the length of the PPA (~ 20 years). Tariffs are revised each year for new upcoming projects.

- **Renewable Purchase Obligation (RPO)**

  SERCs are required to set RE targets for obligated entities in their states through the instrument of RPOs as mandated by section 86 (1) (e) of EA 2003. Such RPO targets should be gradually increasing and be applicable not only to Utilities but also to Captive (CPP) and Open Access (OA) consumers. Largely based on these principles, most states (28 out of 29 states in the country) have RPO regulations in place which vary widely from 1% to slightly over 10%. All these states also have a RPO compliance and verification mechanism coupled with penal provisions in place.

- **Renewable Energy Certificates (RECs)**

  The RECs mechanism was instituted to overcome the geographical resource variation as a way towards RPO compliance. There are presently two types of RECs namely, non-solar and solar RECs. The renewable electricity generated under this mechanism is split into two parts: the grey electricity and the green environmental attribute (REC). The mechanism essentially involves issuance of RECs by a central agency (based on actual generation) to registered RE generators who can trade these certificates to obligated entities (utilities/CPP/OA) who need to fulfill their RPO. The grey electricity is treated as the same way as conventional power and the generator is assumed to be compensated at the pooled cost of power purchase (APPC) of the buying utility. The RECs are to be compensated at a market determined price by trading these on the power exchanges within a price band (a floor and forbearance price) determined by the CERC which ensures sufficient compensation to the generator.

  Pooled Cost of Purchase means the weighted average pooled price at which the distribution licensee has purchased the electricity including cost of self-generation, if any, in the previous year from all the energy suppliers long-term and short-term, but excluding those based on renewable energy sources, as the case may be.

- **Accelerated depreciation**

  Renewable energy developers can avail of accelerated depreciation to reduce taxable profits. Accelerated depreciation for wind and solar projects (80% p.a. on the written down value) allow companies with a large adjustable income to save on tax whilst acquiring a valuable asset. These incentives were phase out in 2017 and, until that time, offer a strong financial incentive. However, this incentive cannot be used if the generators avail the Generation-based incentives (GBI).

- **Generation-based Incentives (GBI)**

  The GBI introduced in 2009 offers wind power generators at 0.50 INR per kWh, supplied subject to a cap of 10 million INR per MW. This benefits the IPPs who have no use for tax credit in the initial years. The output-oriented incentives are also given by the government which allow the tariff be paid more than tariff approved by SERC.

- **Foreign Direct Investment (FDI)**

  The growth of the clean energy sector in India has been impressive. India permits FDI up to 100 percent in the sector under the automatic route in renewable energy generation and distribution projects that are subject to the provisions of the EA 2003.

- **Customs and excise duty exemption.**

  The exemption covers both customs and excise for importing specific equipment for the initial setting of renewable projects. A power generating company is granted income-tax exemption for 10 consecutive years of its initial 15 years of operation.

- **Tax and fiscal incentives**

  Tax cost forms a substantial part of engineering, procurement, and construction (EPC) project costs, which can range from 10 percent to 20 percent of the total renewable energy project cost. Considering the special focus on renewable energy, the Central Government has offered various incentives for developing renewable energy power projects, including exemption from customs and excise duties on specific goods required for setting up these projects. However, these exemptions are subject to the fulfillment of prescribed conditions and compliances to be undertaken by the EPC contractor or IPP. Furthermore, some of the state governments have provided the incentives in the form of a VAT at 5 percent, a significant reduction over the 15 percent VAT rate levied by some other states.

- **Tax holiday**

  The tax holiday is regulated under the domestic income tax law. Undertakings engaged in the generation or generation and distribution of power have been offered a 10-year tax holiday for renewable energy plants if power generation begins before 31 March 2017. However, the plants have to pay a minimum alternative tax at the rate of approximately 20.4 to 21.4 percent (based on the income), which can be offset over the next 10 years.

3.3.6. Key Lessons

India's renewable energy development has demonstrated the massive deployment over the last five years, with the growth from 12 to 17.5 percent of installed national capacity. It is driven mainly by the bold and specific government's renewable energy target arguably. Beyond the target, the government also support the development of various supporting regulatory, institutional, as well as the financial framework for renewable energy in a holistic approach. The key lessons from India can be summarized as follows:

- **Strong and bold renewable energy target**

  As India has been highly depended on overseas energy sources (i.e. oil and coal) to power it is economy, the government pledged to safeguard the national interests by significantly adopt and deploy the renewables at a scale that could transcend the fossil fuels. Thus, the country aims to achieve the additional installed capacity from renewables up to 227 GW by 2022.

- **Well established institutional framework**

  India has a long history building the institutional backbone to promote the renewable energy development. The country's first dedicated new and renewable energy sources department (Department of Non-conventional Energy Sources) was established in 1982. Following the establishment of DNES, many supporting bodies and associations of renewable energy are also established.

- **Paving the development from extensive research and development**

  During the first phase of renewable energy development in India (from the 1980s to 1990s), renewables (primarily solar and wind) were developed from a lab-based technology. It was then tested through some pilot projects which funded mainly from the country's public money as well as conducted as part of technical cooperation project with partner countries. Subsequently, the technology progresses along the way.

- **Integrated, stable and consistent energy policy apparatus**

  India has put into action a comprehensive policy and regulatory apparatus to make the renewable energy development, coordination, and cooperation between the central and states governments run arguably smooth. Deregulating the energy market, combined with the supportive political consideration on the energy planning and tariff regulation, distort efficient market operations.

- **Prioritizing the energy strategies into country's foreign policy**

  To further accelerate the pace of renewable energy development, India has made new partnerships (bilateral, plurilateral and multilateral) to access the foreign investments. Furthermore, the country also established and implement a single window clearance to ease the land acquisition for renewables. As a result, the risks for power producer are lowered, and the flow of foreign capital and companies are increased.

  To conclude, the aggressive renewable energy development in India's clean energy transition is a combination of three main drivers, in which securing the energy supply, providing universal energy access, and achieving the climate change target.

4. Lessons Learned and Recommendation

Germany, China and India face different barriers in developing their renewable energy. To overcome it, they each introduces different policies. Some of these policies are country specific, but some are also applicable for all three. From the policies used to tackle the barriers and its implementation process, there are major finding that can be derived as lesson learned for Indonesia.

Lesson Learned

- **Consistent Leadership That Shows A Strong Political Will to Promote Renewable Energy**

Energy transition is a long process that requires consistent policies and support for renewable energy development. A change in political leadership should not interrupt the process by any means to maintain the momentum which has been established.

Lessons from India demonstrate how renewable energy issues stand above political interests. In 2003, India, under PM Atal from Bharatiya Janata Party, legislated the Electricity Act, which stipulates the mandatory usage of renewables through the Renewable Purchase Obligation (RPO). The next PM, Manmohan Singh from Indian National Congress party, then continued to promote renewable energy through national program such as JNNSM for solar and wind programme for wind power. The current PM of India, Narendra Modi from BJP party, then takes the renewable development in India into the next level by setting a massive target of renewable installed capacity by 2022 (see Figure 39).

- **Integrated Renewable Policies and Government's Responsive Actions**

Integrated or coordinated policy strategies are needed to ensure consistent and coherent policy goals across sectors and institutions, which are directly and indirectly involved in the renewables industry. The government must also be responsive in improving the market instruments necessary in increasing renewables investments.

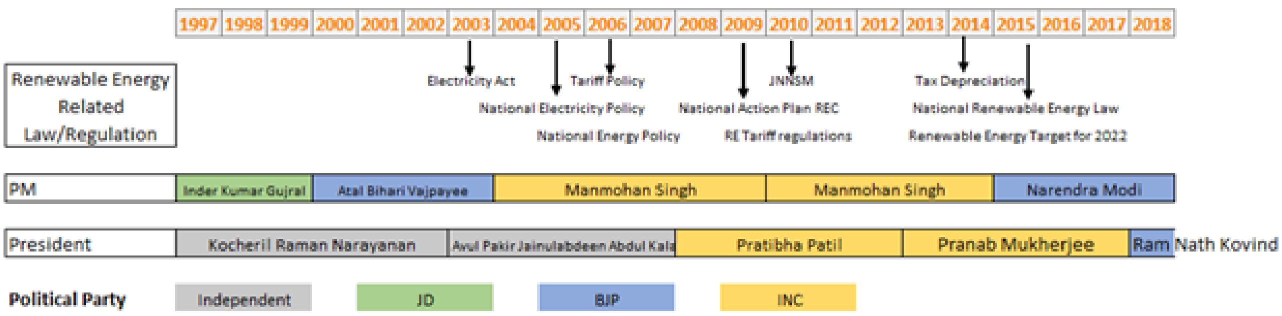
India, for instance, sets out regulation that allows 100% Foreign Direct Investment (FDI) for renewables projects. To support this regulation, the Indian government also established a Foreign Exchange Rate Hedging Facility (FXHF) which protects the developers or off-takers from currency risks.

- **Adaptive Renewable Policies That Respond to the Latest Development Stage and Trends**

Policy has to be updated in response to market development.

Germany, for example, started with fixed price incentives determined by the government, known as FIT. As the installed PV capacity exceeded the initial plan, the FIT is reduced accordingly. In 2017, the EEG - the main regulation that governs FIT - was amended. With this new amendment, the FIT scheme is changed into an auction system as the renewables prices have become more competitive.

Figure 39.
India's consistent, integrated and comprehensive Policy



- **Grid Management**

  The integration of renewables into the power grid is challenging. Lessons from China indicate that the failure to manage the grid will lead to high renewables curtailment.

  To prevent the same problem from happening in Indonesia, PLN needs to increase its know-how in transmission and resource planning, flexible thermal power plants, and integrating medium- and short-term variable renewable forecasts into dispatch system.

- **Strong Focus on Research & Development (R&D)**

  The R&D activities have proven effective in bringing the renewables costs down, increasing technological capabilities of local renewables manufacturers, and enhancing the competitiveness of Chinese renewables technologies in global market.

  The Indonesian government should take the similar steps by providing funding that can be accessed by the universities, research institutions, and companies to conduct R&D and industrialization of key renewables technologies.

- **An Effective Renewable Pricing Policy**

  In the early implementation phase, all countries set FiT policy that favours renewable energy. To be effective, the FiT policy need to be supported with conducive institutional and regulatory environment and also able to adapt to changes in market.

  In Germany, the FiT policy started with fixed tariff that was decreasing annually and eventually substituted with tariff from auction. In China, a combination of tariff with subsidy support and auctioned tariff are used. Meanwhile, FiT in India is set by a commission using a formula that can accommodate all stakeholder interests. Renewable energy portfolio is also targeted for each state using Renewable Purchase Obligation (RPO) policy.

  Considering the Indonesian geographical conditions and infrastructural development, the renewable costs vary across regions. If the country implements an auction system, the system will give tariffs that reflect these challenges.

- **Policy Cost**

  Based on example countries, there are three sources of funding for renewable energy:

  ▷ Electricity surcharge, where the cost is passed onto electricity consumers (Germany)

  ▷ Subsidies, where the cost is charged onto subsidies (China)

  ▷ Levy/Tax, where the cost comes from tax on coal (India)

Recommendations

- ## Financing Instruments for Renewable Energy Development

  The trends show that the progress in renewable energy development in Indonesia has been sluggish in the past decade. This slow progress is largely due to the lack of financing instruments available for funding renewables projects in Indonesia. The creation of financing instruments is needed to ensure a low-cost financing for renewables projects in Indonesia. This low-cost financing system would help lower the cost of renewables generation in the country. As the result, more renewables will be purchased or developed by PLN. In addition, the financing instruments would also help create access to finance for small-scale renewables projects in eastern Indonesia, where the electricity demand is low and hence most banks do not find those projects attractive to finance.

  Lessons learned from Germany, China, and India help shed some light on how the three countries fund the renewables projects and drive the rapid development of renewables in their power markets. While Germany and China use surcharge to fund the renewables, India came out with an idea to impose tax on its coal production and import to support renewables. The subsidies, although important in the early stage of renewables development, prove unsustainable in the long-term. China started to

Table 26.
Three scenarios of coal taxes in Indonesia

Coal Tax	Scenario 1	Scenario 2	Scenario 3
Low CV	1%	3%	5%
Medium CV	2%	3%	5%
High CV	3%	3%	5%
Very High CV	4%	3%	5%

abandon its subsidy scheme to fund renewables as the high penetration of renewables means more burden on its state budget.

To see significant growth in the renewables, Indonesia must then try new approaches to help stimulate the market. The following are some funding sources which would help the country reach its 23% renewables target. The idea is to collect these funding sources into the Renewable Energy Fund (REF) which will be used to support the development of renewables in Indonesia.

1. Tax on Coal Production

   There are four types of coal produced in Indonesia, low, medium, high, and very high calorific value coal. While most of coal produced in Indonesia contains low and medium calorific value, the other types also have a significant share in the market. The following are three scenarios that Indonesia could use to collect taxes on coal production:

- Scenario-1 : imposing a progressive tax rate on coal production, ranging from 1% to 4% of coal reference price (Harga Batubara Acuan/HBA in USD per metric ton). The tax rate increases as the calorific value of coal increases
- Scenario-2 : imposing a fixed tax rate at 3% of coal reference price regardless the calorific value of coal
- Scenario 3 : imposing a fixed tax rate at 5% of coal reference price regardless the calorific value of coal

Implementing the above scenarios into RUEN projection of coal production, Indonesia will have approximately USD 525-572 million (scenario 1) or USD 881-966 million (scenario 2) or USD 1,468-1,610 million (scenario 3) available for its renewables development between 2018 to 2050.

By applying tax on coal, the price of coal-based electricity will increase. This will

Figure 40.
Potential fund from coal taxes to support renewables development in Indonesia

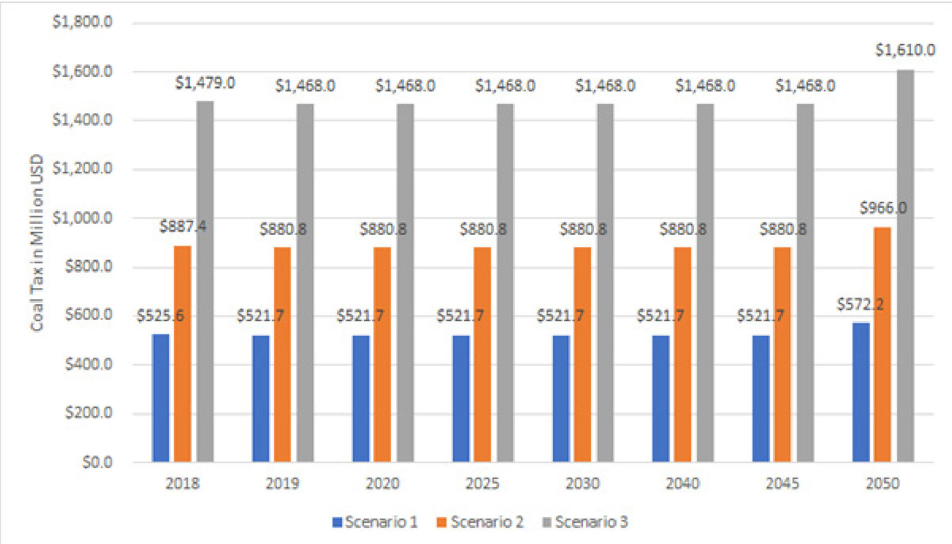
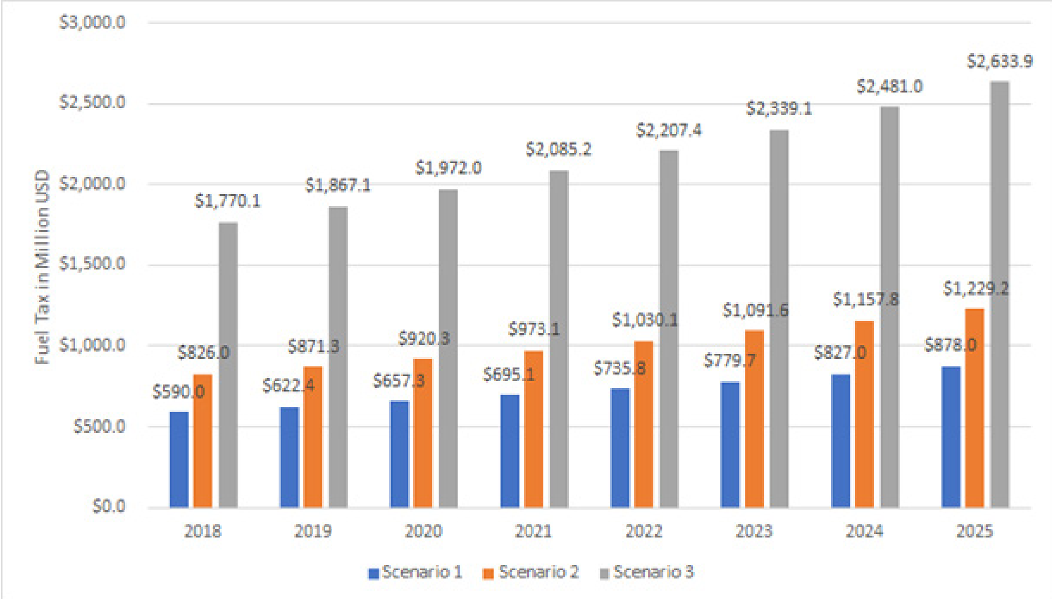


Figure 41.
Potential fund from fuel oil taxes to support renewables development in Indonesia



create a level playing field for renewables to compete with fossil fuels.

2. Tax on Fuel Oil

   The following are three scenarios on fuel taxes that Indonesia can execute:

   - Scenario 1: charging a flat tax rate at 2.5% on fuel oil
   - Scenario 2: charging a flat tax rate at 3.5% on fuel oil
   - Scenario 3: charging a flat tax rate at 7.5% on fuel oil

   Implementing the above scenarios into fuel consumption projection from ministry of energy and mineral resources planning bureau, the collected fuel tax can reach approximately USD 622 million (scenario 1) or USD 871 million (scenario 2) or USD 1770 million (scenario 3). As the fuel consumption is projected to increase, the tax figures will also raise into USD 878 million (scenario 1)

Figure 42.
Potential fund from electricity surcharge to support renewables development in Indonesia

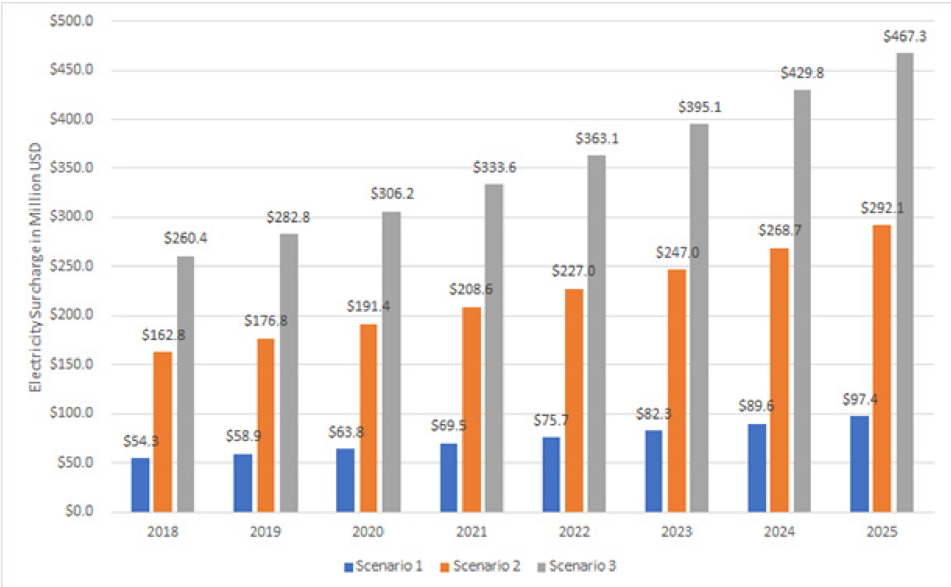
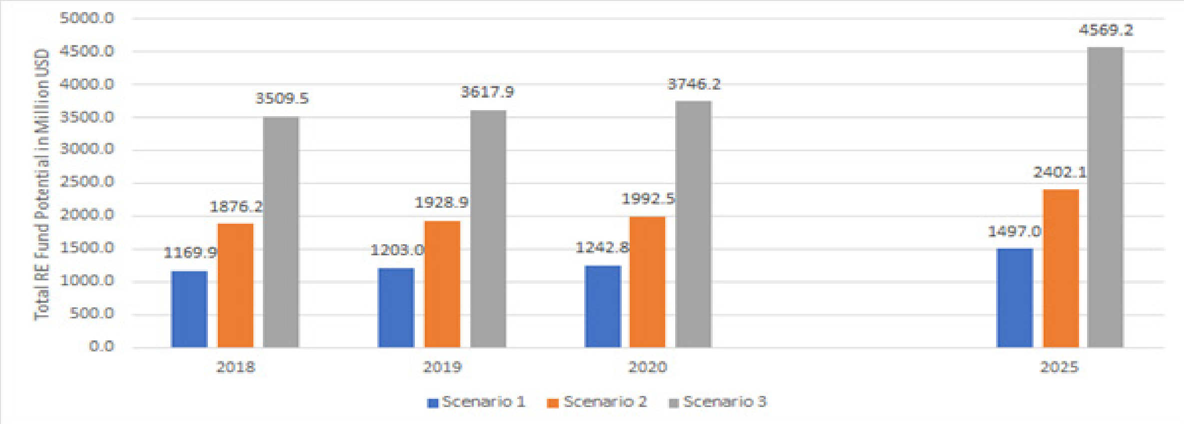


Figure 43.
Total RE fund potential for Indonesia



or USD 1229 million (scenario 2) or USD 2633 million (scenario 3) by 2025.

In addition to increasing the share of renewables in the power market, the fuel tax will also help Indonesia curb oil imports (and hence fuel oil subsidies), trigger people to use oil more efficiently, stimulate the automakers to develop fuel-efficient vehicles, and encourage people to use more public transportation.

3. Electricity Surcharge

The state-owned utility, PLN, classifies residential customers into three categories, R1 (450 - 2200 VA), R2 (3500 - 5500 VA), and R3 (>6600 VA). With 4.1 millions of 900 VA customers and 23.2 millions of 450 VA customers obtain subsidized electricity, Indonesia has over 35 millions of non-subsidized customers. This non-subsidized customers could be charged with surcharge that will be used for renewables development. The industrial and commercial consumers are not charged with the surcharge to keep the competitiveness of Indonesia against other countries.

The following are three scenarios to impose the electricity surcharge in Indonesia:

- Scenario 1: 5% for R2 and R3 consumers
- Scenario 2: 15% for R2 and R3 consumers
- Scenario 3: 2% for non-subsidized R1 and 15% for R2 and R3 consumers

If this surcharge was implemented in 2017, Indonesia would have had at least USD 49 million (scenario 1), USD 147 million (scenario 2), or USD 235 million (scenario 3) in 2017 to fund the renewables projects in the country. Assuming 2% of annual electricity price hikes and following electricity sales projection in RUPTL 2018-2027, the fund obtained in 2025 will reach USD 467 million (scenario 3).

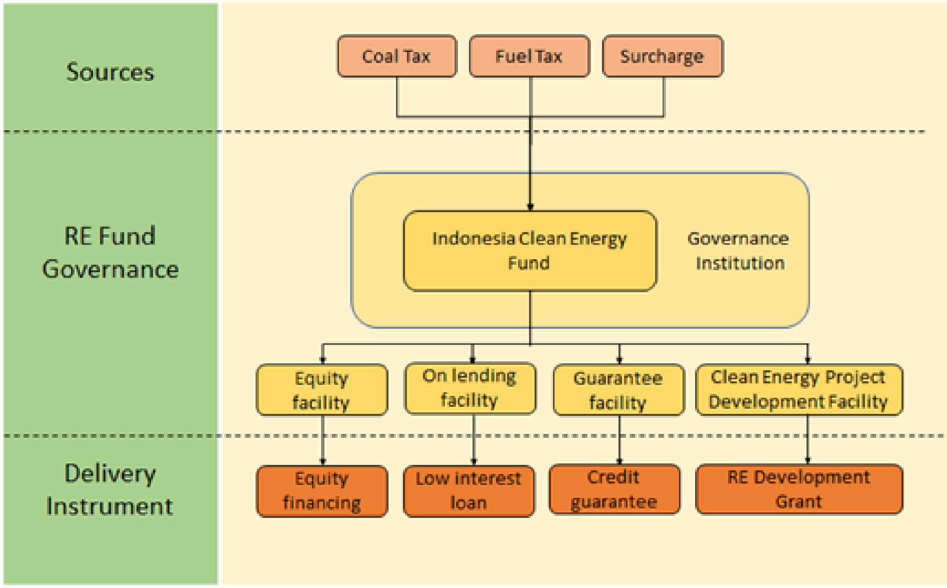
If combined and implemented in 2017, the taxes and surcharge would have provided Indonesia with a range of funding as shown in the Figure 43 below. Under scenario 1, Indonesia will have a total RE Fund of USD 1.1-1.5 billion, scenario 2 at around USD 1.9-2.4 billion, and scenario 3 at USD 3.5-4.6 billion between 2018 to 2025. This RE Fund will be key to stimulate the renewables market in Indonesia and help the country meet its 2025 renewables target.

• Formation of Renewable Energy Fund

A special fund for renewables is needed to guarantee the continuity of renewables development in Indonesia. The establishment of such funding might need to be stipulated in a Renewable Energy Law to legalize its implementation. The processes of collecting, managing, and disbursing the funding are shown in the Figure 44 below.

The funding from coal tax, fuel tax, and surcharge will be collected into a funding pool called as Renewable Energy Fund (REF). This REF will be controlled by a governance institution which also governs the equity, on lending, guarantee, and clean energy project development facilities. The

Figure 44.
Architecture of Indonesia Renewable Energy Fund



governance institution will determine how much fund each facility will obtain.

The equity facility aims to help IPPs which do not have adequate equity to lend capital from banks. The on-lending facility will subsidize local banks to provide low interest loans to renewables developers. The guarantee facility is responsible in providing credit guarantee to local banks in behalf of renewables developers. Lastly, the clean energy development facility will disburse grants directly to strategic renewables projects in Indonesia. The REF would help Indonesia solve most of problems the developers face currently in developing renewables in the country.

• Establishing an Independent Regulator

Lessons learned from the three countries show that each of them implements or starts to implement a liberalized power market. When the market-based system is not in place, an independent regulator can help ensure that the open access to power grid and fair tariffs are imposed when private companies need PLN's network to sell directly the electricity to the industrial consumers. The power wheeling would not only help Indonesia retain investments from committed-to be 100% renewables-multinational companies but also free the state budget from power infrastructure spending as more power plants will be built by private companies.

In addition, the independent regulator will also increase the level of transparency in the Indonesian power market, minimize political interests in the power market, and prevent frequent regulatory changes. These will eventually lead to increased attractiveness of the market to investors. At the same time, the independent regulator would ensure the cost of generation is calculated fairly, creating a level playing field for renewables.

• Creating priced-based policy instruments

The three countries use several instruments to increase renewables investments, namely the Feed-in-Tariff, Feed-in-Premium, and auction system. The FIT system proves effective in boosting renewables development in Germany. The auction system which has been effectively implemented since 2017 has helped further reduce the renewables generation costs in Germany. The Feed-in-Premium which is added on top of market prices also provides incentives for investors to develop renewables projects in Germany.

While current renewables tariffs (85% of BPP) in Indonesia are deemed insufficient to develop new renewables projects and hence unattractive for investors and developers. To reveal the real cost of renewables, Indonesia could use the reverse auction system to set FIT for utility-scale projects. The same mechanism had been successfully implemented by China in the past. A well-designed auction system has to ensure that sufficient competition and transparency are present. The auctions should be conducted by an independent regulator explained above. Meanwhile, the small-scale renewables projects could remain using the FIT system with pricing varies according to the technology type.

References

CHAPTER 1 AND CHAPTER 2

Attwood, C., Bridle, R., Gass, P., Halimanjaya, A. S., Laan, T., Lontoh, L., … Toft, L. (2017). Financial Supports for Coal and Renewables in Indonesia. The International Institute for Sustainable Development.

Chung, Y. (2017). Overpaid and Underutilized: How Capacity Payments to Coal-Fired Power Plants Could Lock Indonesia into a High-Cost Electricity Future. Institute for Energy Economics and Financial Analysis (IEEFA).

DJK ESDM. (2017). Statistik Ketenagalistrikan 2016.

DJK ESDM. (2018). Laporan Kinerja Tahun 2017.

EBTKE ESDM. (2018). Capaian EBTKE Triwulan I 2018.

Eichelbroenner, M., & Schweneke, M. (2018). Study on Fundamentals for a Successful Renewable Energy Deployment in Headline Indonesia. GIZ GmbH LCORE-INDO.

IRENA. (2017). Renewable Energy Prospects: Indonesia. Abu Dhabi: International Renewable Energy Agency (IRENA). Retrieved from http://www.irena.org/DocumentDownloads/Publications/IRENA_REmap_Mexico_report_2015.pdf

Julianto, P. A. (2016, November 25). Pemerintah Pacu Industri Panel Surya. Kompas. Retrieved from https://ekonomi.kompas.com/read/2016/11/25/162207726/pemerintah.pacu.industri.panel.surya

Kamarudin, Y., & Boothman, T. (2017). Powering the Nation : Indonesian Power Industry Survey 2017. PwC Indonesia. Retrieved from https://www.pwc.com/id/en/energy-utilities-mining/assets/power/power-survey-2017.pdf

Marquardt, J. (2014). A Struggle of Multi-level Governance: Promoting Renewable Energy in Indonesia. Energy Procedia (Vol. 58). Elsevier B.V. https://doi.org/10.1016/j.egypro.2014.10.413

Purwanto, W. W., & Pratama, Y. W. (2017). Analysis of Indonesia's Renewable Energy Policy: Status, Barriers, & Opportunities. Jakarta: Penerbit Universitas Indonesia (UI-Press).

PwC. (2017). Power in Indonesia: Investment and Taxation Guide November 2017 5th Edition (Vol. 9th).

PwC, & APLSI. (2018). Alternating Currents: Indonesian Power Industry Survey 2018. Retrieved from https://www.pwc.com/id/en/publications/assets/eumpublications/utilities/power-survey-2018.pdf

Simorangkir, E. (2017, September 14). Baling-baling "Kebun Angin" Pertama RI Datang dari Spanyol. Detik.Com. Retrieved from https://finance.detik.com/energi/d-3643372/baling-baling-kebun-angin-pertama-ri-datang-dari-spanyol

Tharakan, P. (2015). Summary of Indonesia's Energy Sector Assessment. Metro Manila: Asian Development Bank.

Ward, J., Marijs, C., Tumiwa, F., & Salim, E. (2015). A Coherent Fiscal Policy Framework for Promoting Renewable Energies and Energy Efficiency in Indonesia.

Wright, T., & Rahmanulloh, A. (2017). Indonesia Biofuels Annual Report 2017. Jakarta: USDA Foreign Agricultural Service.

CHAPTER 3

GERMANY

AG Energiebilanzen. (2018). Strommix [Online image]. Retrieved from https://ag-energiebilanzen.de/index.php?article_id=29&fileName=20171221_brd_stromerzeugung1990-2017.pdf

Agora Energiewende. (2015a). Report on the German Power System: Version 1.2. Retrieved from https://www.agora-energiewende.de/fileadmin/Projekte/2014/CP-Deutschland/

CP_Germany_update_1015_web.pdf

Agora Energiewende. (2015b). Understanding the Energiewende: FAQ on the Ongoing Transition of the German Power System. Berlin, Germany: Author.

Agora Energiewende. (2018). Die Energiewende im Stromsektor: Stand der Dinge 2017. Rückblick auf die wesentlichen Entwicklungen sowie Ausblick auf 2018. Berlin, Germany: Author. Retrieved from https://www.agora-energiewende.de/fileadmin/Projekte/2018/Jahresauswertung_2017/Agora_Jahresauswertung-2017.pdf

Batstrom. (2016). Loans and Repayment Subsidies for Energy Storage Batteries in Grid-Connected Solar PV Systems in Germany. Retrieved from http://www.batstorm-project.eu/loans-and-repayment-subsidies-energy-storage-batteries-grid-connected-solar-pv-systems-germany

Bundesnetzagentur (BnetzA). 2017. Monitoringbericht 2017. Retrieved from: https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Bundesnetzagentur/Publikationen/Berichte/2017/Monitoringbericht_2017.pdf?__blob=publicationFile&v=4

Deloitte. (2015). European Energy Market Reform. Country profile : Germany. Retrieved from: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Energy-and-Resources/gx-er-market-reform-germany.pdf

Federal Ministry for Economic Affairs and Energy. (2015a). Electricity Market 2.0. Berlin. Retrieved from https://www.bmwi.de/Redaktion/EN/Artikel/Energy/electricity-market-2-0.html

Federal Ministry for Economic Affairs and Energy. (2015b). An Electricity Market for Germany's Energy Transition. Berlin. Retrieved from https://www.bmwi.de/Redaktion/EN/Publikationen/whitepaper-electricity-market.pdf?__blob=publicationFile&v=9

Federal Ministry for Economic Affairs and Energy. (2015c). The digitization of the energy transition. Berlin. Retrieved from https://www.bmwi.de/Redaktion/EN/Artikel/Energy/digitisation-of-the-energy-transition.html

Federal Ministry for Economic Affairs and Energy. (2018). Development of Renewable Energy Sources in Germany 2017. Retrieved from https://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/development-of-renewable-energy-sources-in-germany-2017.pdf?__blob=publicationFile&v=17

Fraunhofer. (2018). Net installed electricity generation capacity in Germany. Retrieved from https://www.energy-charts.de/power_inst.htm

Heinrich Böll Stiftung. (2016). Energy Transition: The German Energiewende. Berlin. Retrieved from https://book.energytransition.org/sites/default/files/downloads-2016/book/German-Energy-Transition_en.pdf

PV-Magazine. (2018). Germany's Brandenburg Launches Home Storage Incentive Program. Retrieved from https://www.pv-magazine.com/2018/07/30/germany-brandenburg-launches-home-storage-incentive-program/

RES LEGAL Europe. (2017). Promotion in Germany. Retrieved from http://www.res-legal.eu/search-by-country/germany/tools-list/c/germany/s/res-e/t/promotion/sum/136/lpid/135/

Rödl and Partner. (2016). Wege zur Finanzierung von Erneuerbare-Energien-Projekten in Schwellen- und Entwicklungsländern. Nürnberg. Retrieved from https://www.roedl.de/themen/erneuerbare-energien/2016-10/finanzierung-erneuerbarer-energien-projekten-in-entwicklungslaendern

TenneT. (2017). Market Review 2017. Electricity market insights. Retrieved from: https://www.ensoc.nl/files/20180405-market-review-2017-bron-tennet.pdf

CHINA

Ball, J., Reicher, D., Sun, X., & Pollock, C. (2017). The New Solar System China's Evolving Solar Industry and Its Implications for Competitive Solar Power in The United States and The World. Stanford Steyer-Taylor Center for Energy Policy and Finance.

Buckley, T., & Nicholas, S. (2017). China's Global Renewable Energy Expansion How the World's Second-Biggest National Economy Is Positioned to Lead the World in Clean-Energy Investment. Institute for Energy Economics and Financial Analysis.

China Energy Portal. (2015). 2015 detailed electricity statistics. China Electricity Council. Retrieved October 15, 2018, from https://chinaenergyportal.org/en/2015-detailed-electricity-statistics/

China Energy Portal. (2018a). 2017 Electricity & other energy statistics. Retrieved October 15, 2018, from https://chinaenergyportal.org/en/2017-electricity-energy-statistics/

China Energy Portal. (2018b). 2017 Summary operating stats for hydro, wind, PV, and biomass power. Retrieved October 15, 2018, from https://chinaenergyportal.org/en/2017-summary-operating-stats-hydro-wind-pv-biomass-power/

Chinadialogue. (2017, May 22). Green Certificates to Bolster Market for Renewables. Retrieved from: https://www.chinadialogue.net/article/show/single/en/9805-Green-certificates-to-bolster-market-for-renewables

Clean Energy Ministerial. (2018). Thermal Power Plant Flexibility, a publication under the Clean Energy Ministerial campaign. CEM.

Danish Energy Agency. (2015). Power markets and power sector planning in Europe - Lessons learnt for China. Danish Energy Agency.

Davidson, M. R. (2018). Creating Markets for Wind Electricity in China: Case Studies in Energy Policy and Regulation. Massachusetts Institute of Technology.

Dongming, R. (2017). Development status of renewable energy in China - Industries, Goals, and Policies. Energy Research Institute, NDRC. Retrieved from http://www.keei.re.kr/keei/download/seminar/170911/II170911_b02.pdf

Frankfurt School-UNEP Centre/BNEF. (2018). Global Trends in Renewable Energy Investment 2018. Frankfurt am Main. Retrieved from http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-report-2018

Green Tech Media. (2018, June 12). China Takes a Step Closer to Grid Parity With the Introduction of Wind Auctions. Retrieved from Green Tech Media: https://www.greentechmedia.com/articles/read/china-takes-a-step-closer-to-grid-parity-with-the-introduction-of-wind-auct#gs.QA9jKiU

Hagaan, E. (2015). Renewable Energy Policy Review, Identification of Gaps and Solutions in Ghana. UNDP.

Hart, M., Bassett, L., & Johnson, B. (2017). Everything You Think You Know About Coal in China Is Wrong. Center for American Progress.

Harvey, H., & Min, H. (2017, December 19). The China Carbon Market Just Launched, And It's The World's Largest. Here's How It Can Succeed. Retrieved from Forbes: https://www.forbes.com/sites/energyinnovation/2017/12/19/the-china-carbon-market-just-launched-and-its-the-worlds-largest-heres-how-it-can-succeed/#62c9a0fd7ce6

IEA. (2018, March 23). Renewable Electricity Quota and Assessment Method (Draft for Opinions). Retrieved from IEA: http://zfxxgk.nea.gov.cn/auto87/201803/t20180323_3131.htm

IEA. (2018). Status of Power System Transformation 2018. OECD/IEA.

IRENA. (2013). Renewable Energy Auctions in Developing Countries. IRENA.

IRENA. (2017). Renewable Energy and Jobs Annual Review 2017. IRENA.

Kahrl, F., Williams, J., & Hu, J. (2012). The political economy of electricity dispatch reform in China. Energy Policy.

Koleski, K. (2017). The 13th Five-Year Plan. US-China Economic and Security Review Commission Staff Research Report.

Li, C., Shi, H., Cao, Y., Wang, J., Kuang, Y., Tan, Y., & Wei, J. (2014). Comprehensive review of renewable energy curtailment and avoidance: A specific example in China. Renewable and Sustainable Energy Reviews.

Lin, J., Kahrl, F., & Liu, X. (2017). A regional analysis of excess capacity in China's power systems. Resources, Conservation & Recycling.

Louw, A. (2018). Clean Energy Investment Trends, 2017. Bloomberg New Energy Finance.

MAKE Consulting. (2018). China Takes a Step Closer to Grid Parity with the Introduction of Wind Auctions. MAKE Consulting.

Menezes, F., & Zheng, X. (2018). Regulatory incentives for a low-carbon electricity sector in China. Cleaner Production, 919-931.

Ming, Z., Ximei, L., Na, L., & Song, X. (2013). Overall review of renewable energy tariff policy in China: Evolution, implementation, problems and countermeasures. Renewable and Sustainable Energy Reviews, 260-271.

National Development and Reform Commission (NDRC). (2018). [National Development and Reform Commission, Ministry of Finance, National Energy Administration Notice on matters related to photovoltaic power generation in 2018]. NDRC.

Pollitt, M., Yang, C.-H., & Chen, H. (2017). Reforming the Chinese Electricity Supply Sector: Lessons from International Experience. EPRG Working Paper.

Spencer, T., Berghmans, N., & Sartor, O. (2017). Coal transitions in China's power sector: A plant-level assessment of stranded assets and retirement pathways. Institut du développement durable et des relations internationales (IDDRI).

Wilson, S., Yang, Y., & Kuang, J. (2015). Powering growth, keeping the lights on and prices down. In R. Garnaut, L. Song, C. Fang, & L. Johnston, China's domestic transformation in a global context (p. 187). Acton, A.C.T : ANU Press.

Ye, Q., Jiaqi, L., & Mengye, Z. (2018). Wind Curtailment in China and Lessons from the United States. Brookings-Tsinghua Center for Public Policy.

Zhao, C., Zhang, W., Wang, Y., Liu, Q., Guo, J., Xiong, M., & Yuan, J. (2017). The economics of coal power generation in China. Energy Policy.

Zhao, Z.-Y., Chen, Y.-L., & Chang, R.-D. (2016). How to stimulate renewable energy power generation effectively? - China's incentive approaches and lessons. Renewable Energy, 147-156.

Zhou, Y., & Lu, S. (2017). China's Renewables Curtailment and Coal Assets Risk Map. Bloomberg New Energy Finance.

INDIA

Barnes, I. (2014). Upgrading the efficiency of the world's coal fleet to reduce CO2 emissions. (CCC/23). London: IEA Clean Coal Centre. Retrieved from https://www.usea.org/sites/default/files/072014_Upgrading%20the%20efficiency%20of%20the%20world%27s%20coal%20fleet%20to%20reduce%20co2%20emissions_ccc237.pdf

Bloomberg New Energy Finance (BNEF). (2017). Accelerating India's Clean Energy Transition. Retrieved from https://data.bloomberglp.com/bnef/sites/14/2017/11/BNEF_Accelerating-Indias-Clean-Energy-Transition_Nov-2017.pdf

Bloomberg New Energy Finance (BNEF). (2018). Clean Energy Investment Trends, 2017. Retrieved from https://data.bloomberglp.com/bnef/sites/14/2018/01/BNEF-Clean-Energy-Investment-Investment-Trends-2017.pdf

Chawla, K. (2018). Drivers, apparatus, and implications of India's renewable energy ambitions. In D. Scholten (Ed.), The geopolitics of renewables (pp. 203-227). Cham: Springer International Publishing. doi:10.1007/978-3-319-67855-9_8

Central Electricity Authority (CEA). (2018a). Monthly Reports of All India Installed Capacity. Retrieved from http://www.cea.nic.in/monthlyinstalledcapacity.html

Central Electricity Authority (CEA). (2018b). National Electricity Plan. Retrieved from http://www.cea.nic.in/reports/committee/nep/nep_jan_2018.pdf

International Energy Agency (IEA). (2017). World Energy Balances: Overview (2017 edition). Paris: International Energy Agency. Retrieved from: https://www.iea.org/publications/freepublications/publication/world-energy-balances---2017-edition---overview.html

IRENA. (2017). Renewable Energy Prospect for India, a working paper based on REmap. Abu Dhabi: International Renewable Energy Agency. Retrieved from http://www.irena.org/publications/2017/May/Renewable-Energy-Prospects-for-India

IRENA. (2016). Renewable Energy Capacity - Statistic Time Series [Interactive Data Set]. Retrieved from http://resourceirena.irena.org/gateway/dashboard/?topic=4&subTopic=16

India's Ministry of New and Renewable Energy (MNRE). (2015). Ministry of New and Renewable Energy's Resolution on Scaling up of Grid Connected Solar Power Project under National Solar Mission. Retrieved from https://mnre.gov.in/file-manager/grid-solar/100000MW-Grid-Connected-Solar-Power-Projects-by-2021-22.pdf

Ministry of Statistic and Programme Implementation (MoSPI). (2018). Energy Statistics 2018. Retrieved from http://mospi.nic.in/sites/default/files/publication_reports/Energy_Statistics_2018.pdf

Sen, A. & Jamasb, T. (2013). Chapter 17 - not seeing the wood for the trees? electricity market reform in india. In F. P. Sioshansi (Ed.), Evolution of global electricity markets (pp. 497-530). Boston: Academic Press. https://doi.org/10.1016/B978-0-12-397891-2.00017-1

Shrimali, G. & Reicher, D. (2017). Instruments to Mitigate Financial Risk in Indian Renewable Energy Investments. Stanford: Stanford Precourt Institute for Energy. Retrieved from https://energy.stanford.edu/sites/default/files/bofa_india_project_paper_4pub_0.pdf

World Bank. (2018). World Bank Open Data [Population Data Set]. Retrieved from https://data.worldbank.org

World Resources Institute (WRI). (2017). CAIT emissions data Climate Watch. Washington, DC: World Resources Institute. Retrieved at www.climatewatchdata.org

Appendix

Appendix A – History of Energiewende

History of Energiewende

Year	Summary
1973-1975	Germany's anti-nuclear movement was born. Farmers and activists protested the construction of a planned nuclear reactor in Wyhl, close to Germany's border with France and Switzerland. This movement grew bigger and was supported by allies in the peace, women's and environmental movement, also addressing topics like pollution, energy savings and environmental protection.
1979-1980	Green Party is established, with the core purpose of of phasing out nuclear energy in West Germany. Moreover, activists and politicians started to use the term, *Energiewende* after the book: *Energie-Wende – Wachstum und Wohlstand ohne Erdöl und Uran* (Energy transition: Growth and Prosperity Without Oil and Uranium) was published in 1980.
1986	Chernobyl Disater occured in Ukraine. The accident strengthened German's resistance to nuclear energy and ignited smaller anti-nuclear movement in East Germany. In the same year, the weekly magazine *Spiegel* published a cover story on global warming, motivating parliament to establish a commission to address concerns about climate change.
1990	During the reunification, the only two nuclear power plants in East Germany were switched-off initiating the nuclear phase-out. Additionally, parliament adopted its first emissions reduction target: 25 to 30 percent fewer CO_2 emissions by 2005, compared to 1987 levels. The consensus in 1990 eventually agreed to adopt Germany's first emissions goal which is to reduce greenhouse gas emissions by 80 percent by 2050
1991	New legislation is introduced. In particular, feed-in tariffs for renewable energy that required utilities to purchase renewable energy from third-party producers at a fixed price. However, these tariffs were not high enough to incentivize larger investment in renewable generation.
1997	New international agreement, known as the Kyoto Protocol, sees Germany commit to cutting its CO_2 emissions, as Germany at that time was the sixth biggest emitter.
1998	EU passed several directives to encourage competition by breaking up monopolies in energy production and distribution. In the same year, Germany's Social Democrats and Greens (Red-Green Coalition) replaced the conservative government and pledged to phase out nuclear by around 2022, cut carbon emissions, and transitions to renewable energy.
2000	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz/EEG) was introduced guaranteeing new fixed feed-in tariffs and priority grid access for renewables. The Act aimed to increase the production of renewable electricity (comes from wind, solar photovoltaics, biomass, hydropower, geothermal)
2000-2012	There were several amendments to the Renewable Energy Sources Act in order to support innovation and technological development by reducing the feed in tariffs as well as to enable renewable electricity market integration. The regulations eventually grew from 11 articles in the 2000 version to 88 articles and five appendices in the 2012 version.
2010	The vote in the German parliament in 2010, eventually, reached the agreement of a grand transformation to get away from fossil fuel towards a future based on renewable energies.
2011	Fukushima Daichi disaster encouraged chancellor Merkel to announce new nuclear phase out by 2022, with backing of large parliamentary and public majority. Only two years before, the same coalition ha abandoned the phase out compromise struck by the former government.
2014	The amendment of the Renewable Energy Sources Act that provided a trail for a sustainable growth of renewable energy.

Appendix B – Renewable Energy Sources Act

Year	Summary
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Appendix C – Subsidy and Incentive for Energy Storage (Battery) in Grid-Connected Solar PV System

KfW Bankengruppe and the Federal Ministry for the Environment (BMWi) are supporting the increased use of battery system as an energy storage in conjunction with solar photovoltaic systems linked to the electricity grid through a program named "KfW-Programm Erneuerbare Energien Speicher" (KfW- Renewable Energy Storage Program). This program aims to encourage further market and technical development of storage battery systems for solar PV installations and to increase their market penetration (Batstrom, 2016).

This program, which started in 2013, provides low-interest loan and repayment subsidies for new battery system together with grid connected photovoltaic. Finance is available up to 100 percent of eligible net investment costs and the subsidy amounts to a maximum of 30 percent of the investment cost for the energy storage system. This funding is only available for high quality products and for the system that helps reducing congestion on the local grid: peak production from the solar PV installation at midday is not fed into the grid, but is stored in batteries for use later in the home.

The program was initially started in May 2013 and ran until the end of 2015. It was then relaunched on March 1st, 2016 and will now run until the end of 2018.

In the German region of Brandenburg, an incentive program named "1000-Speicher-Förderprogramm" has also been launched in March 2018 to support private individuals in increasing own consumption from solar, which at the same time reducing the burden on the power grid (PV-Magazine, 2018). This incentive is given by the Landesbank Investitionsbank (ILB) to solar PV home storage systems, with a capacity of 2 kWh. The subsidy consists of a non-repayable loan covering up to 50 percent of the investment, for a maximum of Euro 7000. The program runs until December 31st, 2022.

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