CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF ELECTRICAL ENGINEERING

Department of Economics, Management and Humanities

MASTER'S THESIS

Study Program: Electrical Engineering, Power Engineering and Management

Field of Study: Economy and Management of Power Engineering

Scientific Advisor: Ing. Julius Bemš, Ph.D

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Prague 2020

MASTER'S THESIS ASSIGNMENT

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II. Master's thesis details

Master's thesis title in English:

Development of a government support for renewables in Russia

Master's thesis title in Czech:

Development of a government support for renewables in Russia

Guidelines:

1. Examine governmental support programs for selected renewables in different countries.
2. Identify main parameters of current support schemes.
3. Identify specific conditions for investing in renewable power sources in Russia.
4. Propose governmental support scheme for renewables installation in Russia.

Bibliography / sources:

1. Subhes C. - Energy Economics: Concepts, Issues, Markets and Governance, Springer, 2011, ISBN: 0857292676.
2. R. A. Brealey, S. C. Myers, and F. Allen, Principles of Corporate Finance, 10th ed. McGraw-Hill/Irwin, 2010.

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Date of master's thesis assignment: **31.01.2019** Deadline for master's thesis submission: ________

Assignment valid until: **20.09.2020**

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III. Assignment receipt

The student acknowledges that the master's thesis is an individual work. The student must produce his thesis without the assistance of others, with the exception of provided consultations. Within the master's thesis, the author must state the names of consultants and include a list of references.

Date of assignment receipt

Student's signature

Declaration:

I hereby declare that this master's thesis is the product of own independent work and that i have clearly all information sources used in the thesis according to Methodology Instruction No. 1/2009 - "On maintaining ethical principles when working on a university final project, CTU in Prague".

Date Signature

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List of abbreviations

FIT – Feed-in tariff

PV – photovoltaic

LEC (LCOE) – Levelized cost of electricity

IEA – International Energy Agency

IRENA – International Renewable Energy Agency

RF – Russian Federation

NPV – Net Present Value

Contents

Abstract

The following work is designed to present a governmental support scheme for renewables installation in Russia according to the current strategy in the sphere of the Russian government.

In order to do that I will firstly examine the main kinds of measures a government can take in order to support renewables installation, then I will consider some actual cases from different countries: their goals, laws and measures taken and results as well as considering how these measures can be applicable in Russia.

In the third part I will take into consideration the specific conditions in Russia, such as current infrastructure condition, pointing isolated systems that have to be operated by very expensive and highly pollutant diesel stations; the natural renewable potential of different areas of Russia and how the renewables could improve the conditions of life and decrease expenditures; the current political situation and legislative base already introduced in Russia in order to support the renewables. Also the current financial situation and energy forecast for Russia and the world will be taken into consideration. In the final part I will consider the currently declared energy goals till 2035 and propose a support scheme for renewables installation.

In the end the support scheme summary and conclusion are presented.

Introduction

Every year more and more countries engage in supporting renewable energy. It is not only a case of climate change mitigation or reducing CO_2 emissions though. It is also a great way to obtain energy independence, create a source of income and workplaces.

But while many countries have already made considerable progress on this way, Russia is currently lagging behind without a powerful renewable industry, or a clear and diverse support scheme that would facilitate the emergence of such industry. It is largely dictated by the fact that Russia is a big fossil fuel producer and exporter and by big influence of the companies of this sphere in the country matters. However it doesn't mean that there is no place for renewables in Russia and that a potential support scheme would be a luxury that is not really needed for any reasons other than keeping up-to-date with the current energy trends.

With help of renewables Russia can solve many of its today's problems, many of which were already tackled by other countries and it is only necessary to make use of their experience. Some of the problems are also largely a problem of Russia alone, such as big amounts of polar settlements not connected to the grid. On the other hand, this issue was also tackled by other countries on a smaller scale.

In this work I will address and offer solutions to the crucial issues of today's Russia , such as:

- Secluded settlements relying on costly and pollutant diesel energy;
- Big amounts of agricultural waste in the country that are neither used nor utilized;
- Not enough certainty in current renewable course and legislation, creating obstacles for renewable industry emergence;
- Energy production deficit in some regions of Russia.

In this work I analyzed different kinds of renewable support mechanisms and schemes, why do countries use them and how they facilitate reaching their goals, as well as how they can be used in Russia's case.

After that, the issues of Russia are considered in more detail and current legislative base as well as government strategy in the sphere are taken into consideration. Finally a project of renewable support scheme for Russia is offered and its costs are estimated as well the means for its funding.

1. Renewable support types

Recently the issue of renewable energy sources introduction has become crucial in many countries around the world. Various reasons and explanations to that can be listed, but among others the necessity of reducing the CO2 emissions and saving resources stand out, as well as the inability to provide relatively cheap electricity using conventional methods in some secluded or hard-to-reach places.

Due to higher cost of installation and production, renewable energy is generally only attractive in a market driven by policy support. Moreover, many people still have largely no understanding of this industry and avoid investing into renewables, preferring something more conventional and understandable. In this way the government should play a key role. On one hand, governments may fund basic and applied technology research and development, as well as some proof-of concept activities for demonstration. On the other hand, governments may enact legislations which indirectly increase the market value of carbon mitigation technologies, such as through cap-and-trade arrangements or carbon taxes. Different forms of fiscal support mechanisms or subsidies focusing on increasing returns from investment in RE projects emerge to make them more commercially attractive. Examples include feed-in tariffs, renewable obligation on suppliers, Renewable Portfolio Standards, tradable renewable energy certificates, and taxbased incentives. Public policies have a significant influence on the development of new technologies in the RE sector.

According to [2], the renewable incentives can be generally divided into three categories:

- Financial subsidies
- Research and development funding
- External costs of energy production not accounted for in pricing systems

The category of financial subsidies is very vast, and the same source offers such classification:

- Direct subsidies and rebates
- Favourable tax treatment
- Provision of infrastructure and public agency services below cost
- Provision of capital at less than market rates
- Failure of government-owned entities to achieve normal rates of return
- Trade policies, such as import and export tariffs and non-tariff barriers

In the first part I will list and characterize the main types of subsidies a government can introduce in order to incentivize the renewable deployment in the country, their advantages and weaknesses.

1.1 Direct subsidies and rebates

Definitions and explanations of such a broad term as subsidy vary a lot. Here are some variants offered:

- A subsidy is a benefit given to an individual, business, or institution, usually by the government. It is usually in the form of a cash payment or a tax reduction. The subsidy is typically given to remove some type of burden, and it is often considered to be in the overall interest of the public, given to promote a social good or an economic policy, encourage new developments by providing financial support for the endeavors. [1]
- Subsidies comprise all measures that keep prices for consumers below market level or keep prices for producers above market level or that reduce costs for consumers and producers by giving direct or indirect support. [2]

Generally subsidies are classified as direct and indirect.

- Direct subsidies are generally the ones that imply an actual payment of funds toward a particular individual, group or industry.
- Indirect subsidies are those that do not hold a predetermined monetary value or involve actual cash outlays. They can include activities such as price reductions for required goods or services that can be government-supported. This allows the needed items to be purchased below the current market rate, resulting in a savings for those the subsidy is designed to help. [1]

1.2 Feed-in tariffs

A feed-in tariff (FIT) is a system where a renewable energy source owner receives a fixed or variable payment according to long-term purchase agreements for selling electricity generated by renewable sources. The contracts are usually ranging from 10-25 years.

Feed-in tariffs are designed in order to allow the renewable plant holders make money on the energy surplus they are getting. As the production of solar and wind and other kinds of renewable energy is not very reliable throughout the time and usually happens in different time period regarding its consumption, much of the energy would be thrown away or a significant amount of storage would be necessary.

Considering this and the fact that the purchase and installation of renewable sources of energy is a quite costly activity by itself, the transition to renewables does not bring any real benefit to its potential users as the price of a kWh produced and used could be much higher than the one consumed directly from the grid.

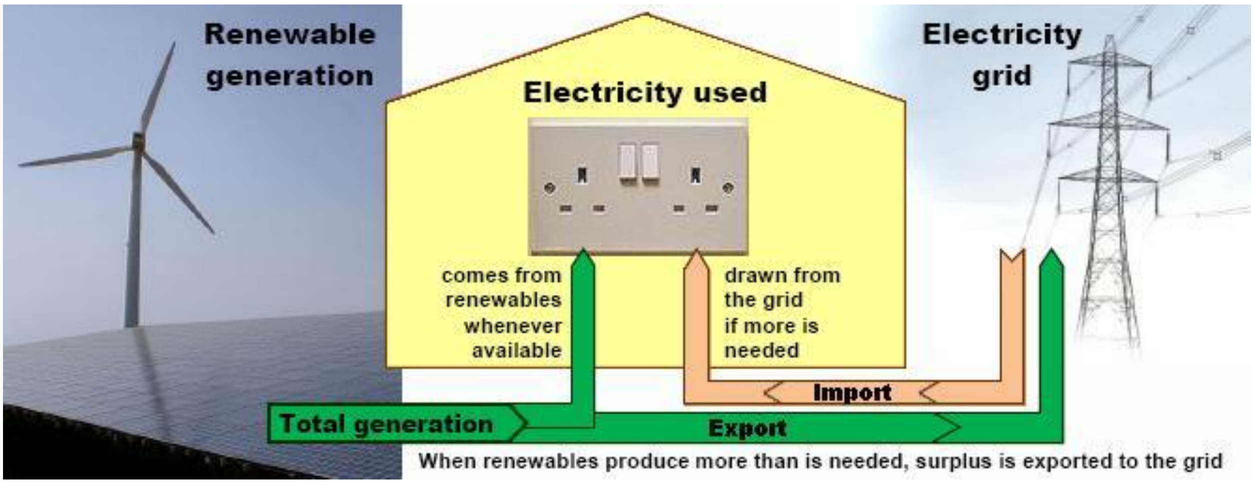


Figure 1 – Feed-in tariff structure [3]

Thus, it is necessary to create circumstances where the customers can actually benefit from installing solar panels or wind plants, one of the ways to do that is to allow them to sell the unused electricity back to the grid. In that case the government takes on the responsibility to pay to the producer for such returned energy for a particular lengthy period of time (up to 20-25 years), determining the tariffs for such a purchase depending on the type of renewable source, its installed capacity, in some cases time of production and period of the plant installation.

Classification of feed-in tariffs

There is a lot of difference between different types of feed-in tariffs and they can serve a lot of goals depending on how they were designed. Firstly, there is a general division on whether the renewable energy producer receives payment for all his production or only for a part of it.

According to this feature the feed-in payment are divided on:

- Payment for all generation – the owner receives a certain amount of money for every kWh generated;
- Payment for electricity exported – the owner receives money only for the amount of energy that gets sold back to the grid.

In the past, most of the countries paid the renewables' owners just for the fact of generating, without making them sell their electricity – so they could both put it in their own use and receive money for it. But in the recent years more and more countries stop using the all generation tariff. In the EU this process has been sped up by European Commission guidance for the design of renewables support schemes for the period of 2014-2020, which has obliged the countries to change the so-called generation-based tariffs for export ones. [4] This has already been implemented, for example, in the UK, with the abortion of their generation tariff program on April 1st, 2019 and in Germany according to the amendment of the German Renewable Energy Sources Act. [5]

Mainly, there is two types of feed-in tariffs – a fixed feed-in tariff and a premium-based feed-in tariff. The difference between them lies in price formation. Fixed feed-in tariff is designed so that the renewable supplier receives the same amount of money for every kWh bought from him, thus the tariff is independent from the electricity market price; the graph can be seen below.

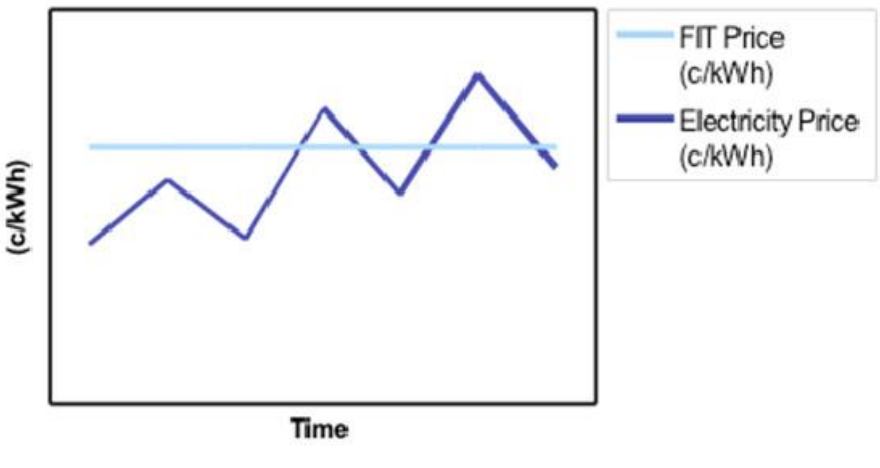


Figure 2 – Fixed FIT price model [6]

The premium tariff payment amount works on the basis of the market electricity prices by adding an additional amount of money for the tariff over the market price for electricity.

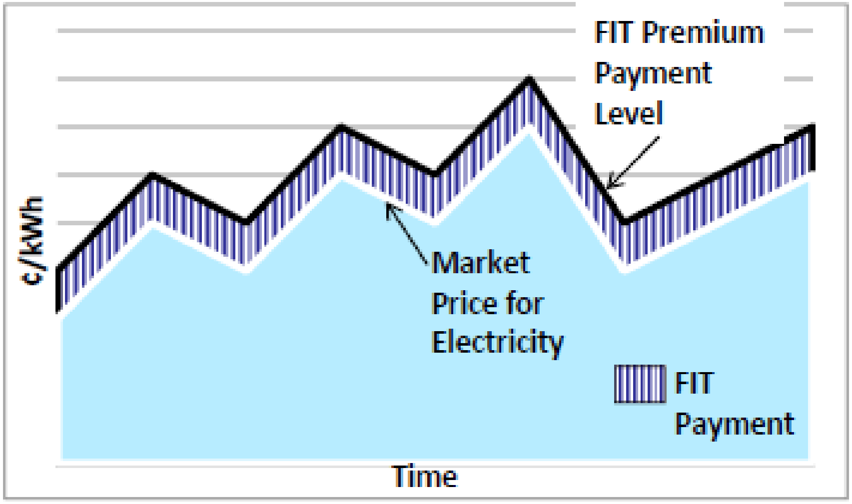


Figure 3 – Premium FIT price model [6]

There are also schemes, where the premium rule works another way, for example in Market Premium Scheme in Germany, according to the formula:

$$MP = AW - MW; \ (1)$$

Where:

MP – level of the market premium; [EUR/kWh]

AW – value applied for consideration; [EUR/kWh]

MW – respective monthly market value; [EUR/kWh]

Advantages of premium FIT in comparison with fixed FIT

- Premium tariff is better for optimizing market participation, because the FIT payments are dependent on the prevailing electricity price. As a consequence, this structure can create incentives to produce electricity in times of high demand and to install new generation in areas with higher average market prices because of locational pricing structures
- Premium-price FIT policies arguably demonstrate a higher degree of compatibility with deregulated (or liberalized) electricity generation markets, by allowing both renewable and conventional generation to be sold directly on the spot market
- Premium FIT encourages competition between new generation. Generators are typically required to market their electricity on the spot market under premium-price FIT policies, so that RE generators compete with one another and with conventional generators. Therefore, it is also argued that premium-price FIT frameworks are more likely to encourage competition among electricity producers. [6]

Drawbacks of premium FIT

- Higher average payments per kWh. Premium-price FIT policies have demonstrated a lower degree of cost efficiency than fixed-price FITs, which results in higher average payments per kilowatt-hour. This is primarily because the premium price option requires greater risks due to the less-predictable revenue streams. These increased risks are likely to lead to higher required returns and result in greater costs per kWh for society, if the same levels of RE deployment are to be reached.
- Premium-price FIT policies do not typically include a purchase guarantee. Those participating in the premium option sell their electricity on the spot market and receive the corresponding market price, with an added FIT premium. Investors see the absence of a purchase guarantee as an added risk in the premium option, which will increase their required returns. [6]

Premium feed-in tariff can also be floating, meaning that the market obtained revenue from sales will be added by by a constantly fluctuating premium amount, thus summing up in fixed payment for the customer.

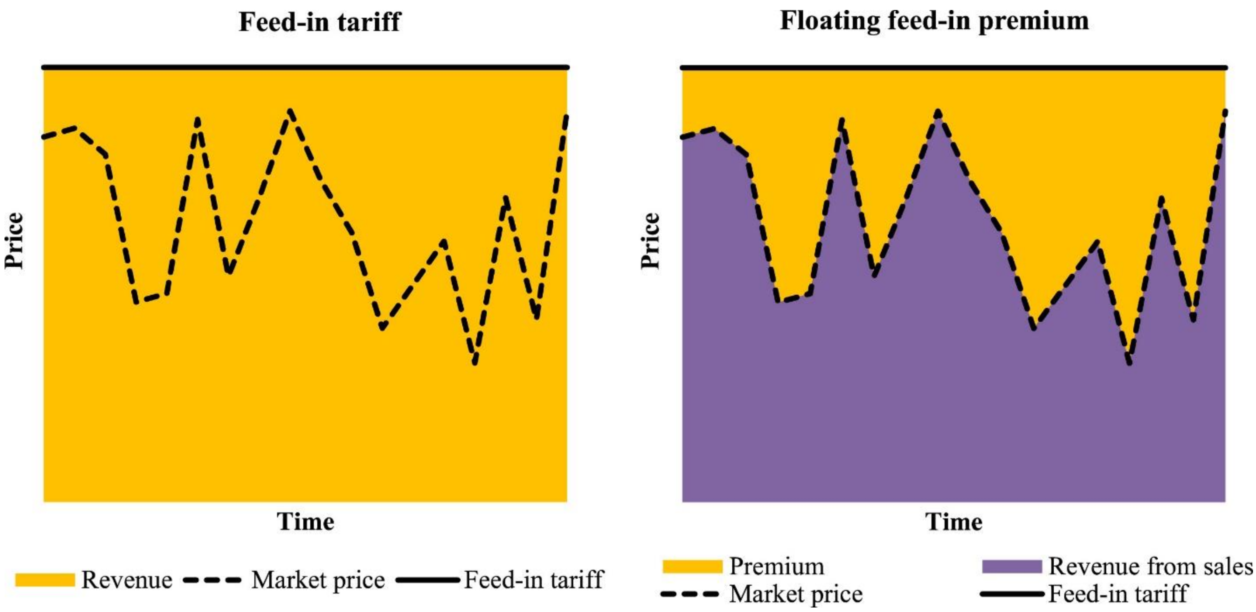


Figure 4 – Floating feed-in premium [7]

A feed-in tariff is a system where a renewable source holder receives a fixed or variable payment according to long-term purchase agreements for the sale of electricity generated from RE sources. These purchase agreements, which aim to be both effective and cost-efficient, typically offer a specified price for every kilowatt-hour (kWh) of electricity produced and are structured with contracts ranging from 10-25 years. In order to tailor FITs to a range of policy goals, the payment level can be differentiated by

- technology type,
- project size,
- resource quality
- project location [6]

There are many approaches to establishing the amount of FIT payment. They can be based on:

- Levelized cost (LEC), (which is a concept of average calculated production cost of the plant for its whole life span), of RE generation, plus a targeted return set by policymakers or regulators;

$$LEC = \frac{\sum_{t=1}^{n} \frac{I_t + M_t - F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \quad (2), \qquad [8]$$

Where
I_t – investment in year t;
M_t – Operational and maintenance costs in year t;
F_t – Fuel costs in year t;
E_t – Amount of electricity produced in year t;
r – discount rate;
n – system's life span

This allows to compare different means of energy production in [Currency/kWh] manner. Subsidizing allows producers or customers to save up on any of these costs, usually on investment ones, which reduces the final value of LEC, thus achieving a more competitive energy.

- Based on the value either to society or to the utility (which can include climate change mitigation, health impacts, energy security, electricity price decrease and other);
- Cost-based payment levels are designed to provide sufficient revenues to make projects profitable, while also limiting over-payment.

Feed-in tariff can also be classified according to how their amount is adapted in time:

- Inflation adjustment – adaptive approach, which protects the real amount of renewable projects;
- Pre-established tariff degression – generally set to track (or help) cost reduction;
- Responsible tariff degression – the rate of the market growth determines the future rate of degression and, consequently, FIT tariff level;
- Time of delivery – tier-based payment organization, which depends on the amount of demand

Feed-in tariff degression calculation

As the feed-in tariff value is generally calculated as to fully or partly compensate the costs, it should adapt to the changes of such costs, mainly such of initial investment. In order to introduce such changes in a way that is just and understable for a possible renewable producer, most of the countries with feed-in tariffs introduce degression coefficient.

Its value varies between countries and types and tariffs and is set by law, but is generally designed in accordance with price forecasts. For example, the general value of degression coefficient for solar plants can be connected to Swanson's law, which states that the solar panels price decreases by approximately 20% every time the cumulative installed PV panels capacity is doubled. The empirical graph is depicted below:

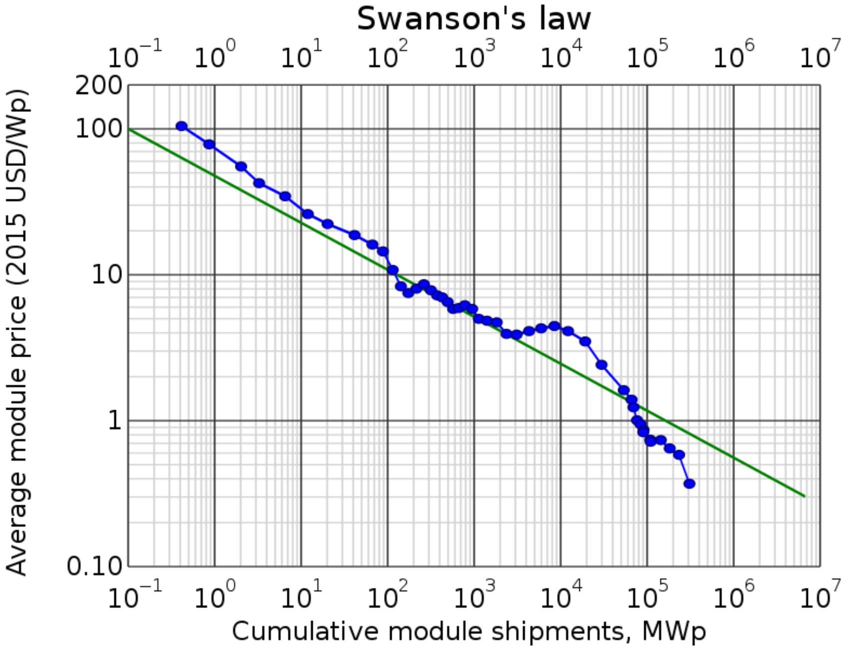


Figure 5 – Swanson's law graph [9]

The amount of cumulative solar PV capacity is forecasted to increase every year by 16% by the International Energy Agency (IEA); the forecast is performed till the year 2030, which makes the first 10 years of the 30-year solar panel life span and potential program period.

1.3 Renewable auctions

In renewable energy auctions, the government issues a call for tenders to install a certain capacity of renewable energy-based electricity. Project developers who participate in the auction submit a bid with a price per unit of electricity at which they are able to realize the project. The government evaluates the offers on the basis of the price and other criteria and signs a power purchasing agreement with the successful bidder. [10]

Renewable energy auctions, despite some difficulties in implementation in the past, have become a popular policy tool in recent years. The number of countries that adopted renewable energy auctions increased from 9 in 2009 to at least 44 by early 2013, out of which 30 were developing countries. Auctions let the governments achieve deployment in a cost-efficient and regulated manner. Auction schemes have benefited from the rapidly decreasing costs of renewable energy technologies, the increased number of project developers, their international exposure and know-how, and the considerable policy-design experience acquired over the last decade.

Well-designed auctions avoiding potential windfall profits and underpayments. While auctions have become very attractive, they only benefit the successful bidders and tend to favour large players that are able to afford the associated administrative and transaction costs.

Based on national energy plans as well as the size and maturity of the renewable energy market, the design of auction schemes will reflect each country's priorities in terms of technology, volume and location. Technology-specific auctions allow for the promotion of certain technologies and diversification of the portfolio. In addition to selecting the technology, auctions can be site-specific. The identification of sites with ideal resources and secured grid connection potentially reduces risks to investors. [10]

The most common type of auction is the sealed-bid auction, where project developers simultaneously submit their bids with an undisclosed offer of the price at which the electricity would be sold under a power purchase agreement. An auctioneer ranks and awards projects until the sum of the quantities that they offer covers the volume of energy being auctioned.

Another type of auction is the multi-round descending-clock auction, where in an initial round, the auctioneer offers a price, and developers bid with offers of the quantity they would be willing to provide at that price. The auctioneer then progressively lowers the offered price in successive rounds until the quantity in a bid matches the quantity to be procured. Hybrid models are possible, using both the descending clock auction in a first phase and the sealed-bid auction in a second phase.

Strict requirements are a necessity in a successful auction project (financial, environmental, grid connection, etc.) as well as strong compliance rules (penalties, bid bonds, project completion guarantees, etc.) that reduce the risk of underbidding, project delays and project failure. As with other deployment policies and support mechanisms, the successful implementation of auctions relies on an appropriate regulatory and institutional framework, relevant skills and adequate infrastructure to attract investors. [10]

Advantages and drawbacks of auctions

Advantages

Auctions limit the risks for investors because they offer guaranteed revenue over a period of time.

- With auctions, generators are guaranteed the purchase of their RE-based electricity at a fixed price as well as guaranteed access to the grid as per the signed PPA. Under these circumstances, the project developers are assured a market for the electricity they produce, which reduces the risk of investment.
- The longevity of the PPA (often between 15 and 20 years) constitutes another element of security. This stability of long-term fixed payments involves lower risks for RE project developers and investors and is therefore likely to lower the costs of financing. [10]

Auctions lead to cost efficiency due to price competition.

- Auction schemes establish a competitive bidding situation and put downward pressure on prices. The prices and overall costs of the auction can be controlled by setting a maximum price over which bids will not be selected (ceiling price).

Auctions are useful for volume and budget control.

- Auctions are useful for controlling capacity installed, because they set a targeted or capped volume as a key element of their design. They are also useful to control the budget, especially when a ceiling price is used.
- Auctions can provide a clear schedule for the new power capacity to be procured, provided the problems of underbidding and non-performance are addressed. [10]

Selection of the preferred bidder on criteria other than price allows for the achievement of multiple policy objectives.

- While auctions typically select the winning bids on the basis of price, they are often used to achieve other policy objectives using additional evaluation criteria (e.g. local employment, local environment, industrial development, etc.). Projects could be scored higher, for example, if they are located in high-load areas or in areas that currently lack electricity access, thereby engendering additional economic benefits to the jurisdiction. [10]

Drawbacks

Auctions can lead to discontinuous market development (stop-and-go cycles).

- Unless auction schemes are linked to a fixed schedule of auctions at regular intervals (e.g., more than once per year), they may lead to a stop-and-go pattern of deployment. These conditions prevent investment in local manufacturing facilities and the development of a robust supply chain.

Participating in auctions requires resources that small-scale or new project developers may not have.

- The risk for bidders that their project will not finally receive a contract is relatively high, especially in very competitive auctions. To win the auction, bidders must present feasibility studies and land use permits, adding layers of transaction costs with little assurance that this risk will be rewarded with an actual contract.

Competitive bidding can lead to underbidding.

- Under an auction scheme, an incentive is created for bidders to bid as low as possible in order to increase their chances of securing a contract. This creates a risk of underbidding - developers bid too low to actually be able to realize the project. [10]

1.4 Quota system

An incentive system where the government sets the percentage or an amount of energy, usually annually, that comes from renewable sources and then allows the market place to determine the cost. The idea is that a certain amount of energy from RE is mandated, but how this is done and at what cost is left to the market to decide. The energy mandate may be fulfilled through actual energy production, or the purchase of renewable energy credits, depending on the design of the incentive. The underlying theory is that competition in this market place will drive down the costs of supplying renewable electricity and thus minimize the costs to the consumer of meeting renewable energy targets. Given the focus on market action, quota systems fit the more developed economies better than transitional or developing economies where energy markets, to the extent they exist, are less mature. [11]

Advantages of quota and certificate schemes

The main advantage of RES quota and certificate systems is that RES policy targets can be achieved in a very cost-efficient way because the certificate prices are determined by market forces. Utilities that have to fulfil a RES quota have a strong incentive of doing this in the most cost-efficient way possible. This minimizes the overall costs of the support scheme for electricity consumers. There is also a high probability that RES policy targets will be met if there are sufficiently high penalties for non-achievement of quota obligations. At the same time, there is no risk of an uncontrolled growth of RES installations because there is no incentive to produce additional RES electricity once the quota has been met. [12]

Disadvantages of quota and certificate schemes

Experiences of several countries have shown that the supposed cost-efficiency of RES quota and certificate schemes often does not correspond to the reality and that overall costs are often higher compared to alternative RES support schemes such as FIT (Feed-in Tariff). This is mainly due to the risks that are related to RES investments under a Green Certificate scheme which include not only the electricity price risk but also the green certificate price risk. In some cases, RES operators attempt to hedge against these risks by concluding long-term power purchase agreements (PPA) with utilities but also in these agreements, the risks will have to be priced into some degree. RES quota and certificate schemes are less suited for promoting a diversified energy mix as well as technological development and innovation as they tend to discourage investment in more expensive RES technologies. [12]

RES quota and certificate schemes also tend to favour large RES producers that can generate least-cost electricity and shoulder the costs related to the marketing of RES electricity and green certificates. In some cases, this issue is solved by specific Green Certificate markets for small-scale RES projects.

2. Country cases

2.1 Germany

Why is it relevant? Germany is one of the pioneering countries in the renewable sphere, making its experience of renewable law introduction and correction when necessary much more thorough than ones of other countries, that have also massively based their program on the German experience of renewable incentives creation. Though it would be not wise to copy the laws of a well-developed renewable country when creating a support scheme for Russia, Germany's case can clearly show which law projects have proved to be working over time.

Germany is one of the world leaders in terms of installed renewable capacity (its amount is about 117 GW) and production share, which sometimes reaches up to 40-50%. [13] The data on installed capacity is pictured below.

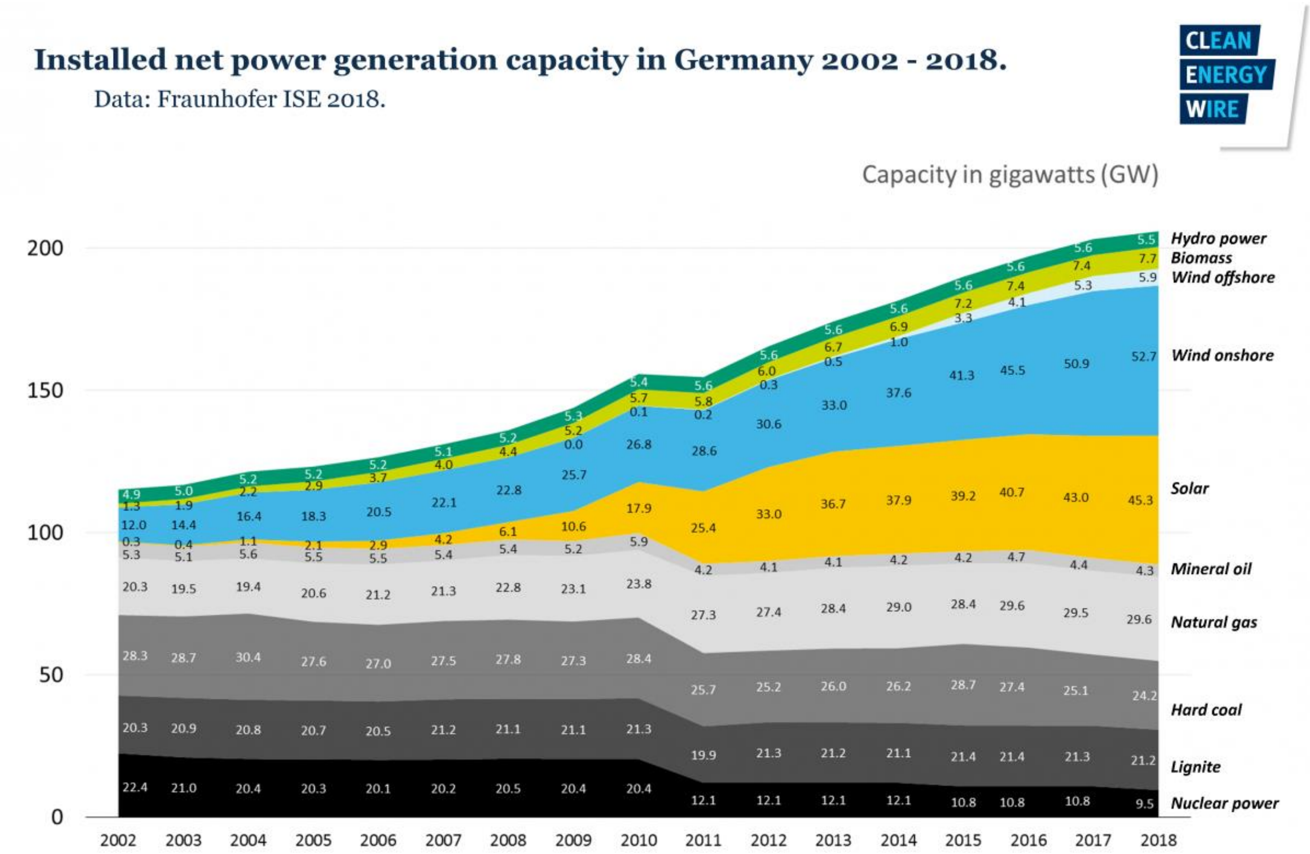


Figure 6 – Installed net power generation capacity in Germany 2002-2018 [13]

It can be seen that just within several years the amount of renewable installations has increased by multiple times. How did they achieve that and what stands behind this politics?

Strategy

Energiewende – the goals of the energy concept were introduced in 2010, they are as follows:

- Reducing CO2 emissions 40% below 1990 levels by 2020 and 80% below 1990 levels by 2050
- Increasing the relative share of renewable energy in gross energy consumption to 18% by 2020, 30% by 2030 and 60% by 2050
- Increasing the relative share of renewable energy in gross electrical consumption to 35% by 2020 and 80% by 2050
- Increasing the national energy efficiency by cutting electrical consumption 50% below 2008 levels by 2050
- Phasing out all nuclear plants by 2022 [14]

The main factors driving the energy transition are considered to be:

- Environment. The risks related to nuclear energy and nuclear waste storage after Chernobyl and Fukushima disasters - after the 2011 nuclear accident in Fukushima, excluding Japan itself, Germany was the center of political action regarding the transition towards denuclearization. The German government has agreed on a set of new policy measures to achieve the Energiewende (or energy transition), which includes targets to produce at least 35 percent of Germany's electricity with renewable resources by 2020 and 80 percent by 2050. As of mid-2011, Germany generated 20 percent of its electricity from renewable resources. [15]

- Economic Motives:
    - Jobs. A major driver for alternative energy in Germany today is the perception that renewable energies are an engine for economic growth and job creation, but this was not initially the case. The impact of energy transition on employment is positive, with a yearly net increase of 18 000 jobs up to 2020, when compared to a scenario without the Energiewende. Currently, the German renewable energy sector comprises 334 000 jobs.
    - Export. Renewable energy and energy efficiency have created attractive business opportunities for companies that produce equipment for renewable generation. For example, in 2011 Siemens generated more than 40 percent of its entire sales revenue with its "Environmental Portfolio", which consists mainly of renewable energy and energy-efficient technologies. Renewable energy technologies are now among Germany's fastest growing export segments. In 2015 the export ratios reached 70% for PV; 66% for wind, 50% of biodiesel and 66% of heat pumps produced in Germany were consigned for export. [16]
    - In addition, the policies have created opportunities domestically for companies that install renewable energy technologies, ranging from large industrial players that install offshore wind turbines to small-scale installers of solar panels on rooftops. The policies have also benefited farmers using residual biomass to produce electricity as well as farmers who provide land for solar panels and wind turbines.
- Resource Endowment. Germany is not considered to have abundant renewable resources. Given existing technologies and energy demand, Germany could technically cover 128 percent of its electricity consumption with renewables with renewable energy potential for electricity is around 9.7 MWh/capita/year. Germany has virtually no oil reserves and only small proven natural gas reserves, but it has 4.7 percent of global proven reserves of coal. Germany's high dependence on

foreign gas resources has sped up policy creation to support renewable energy for electricity. But given that coal reserves are readily available, dependence on foreign gas cannot fully explain Germany's enthusiasm for renewables. [15]

- Political System. The Green Party plays an important role in shaping German energy and environmental policy. Over the years of winning considerable amount of seats in Bundestag it has motivated established parties to adopt more environmentally friendly positions in order not to lose their voters.
- Cultural Factors. Renewable energy is widely supported by the German population. When Energiewende was approved in 2011, 90 percent of Germans supported rapid increase of renewable energy share, with 73 percent in favor of renewables even if it meant increased electricity costs. Wind energy is widely accepted, but solar photovoltaic energy is more controversial because some Germans believe that they should not subsidize a technology that is not well suited to Germany, which has poor solar insolation. Generally German population is evaluated to be tolerant for policy measures that lead to higher levels of government intervention, such as taxes on energy and subsidies for renewable energies. This factor makes it easier for the German government to introduce new renewable support measures than it would in, for example, the US. [15]

History of renewable acts in Germany

As one of the pioneering nations Germany has a rich history of important reforms that set its role as one of the leaders in renewables:

- First percentage-based feed-in tariff introduction in 1991;
- Introducing Renewable Energy Act (EEG) in 2000 – a series of German laws governing the renewable production;
- First nuclear phase-out law (Atomgesetz) (2002) – banning all new nuclear power construction
- Energy concept introduction, setting the todays goals for CO_2 reduction and renewable share increase stated above (2010);
- Second nuclear phase-out law – permanently shutting down 17 reactors with the intention to close all of till the end 2022;
- Renewable Energy Act 2.0 Introduction (2014) – incurring changes into renewable incentives, thus, for example introducing the use of market premiums.

Below you can see how these incentives have changed the share of nuclear and renewable production over the years.

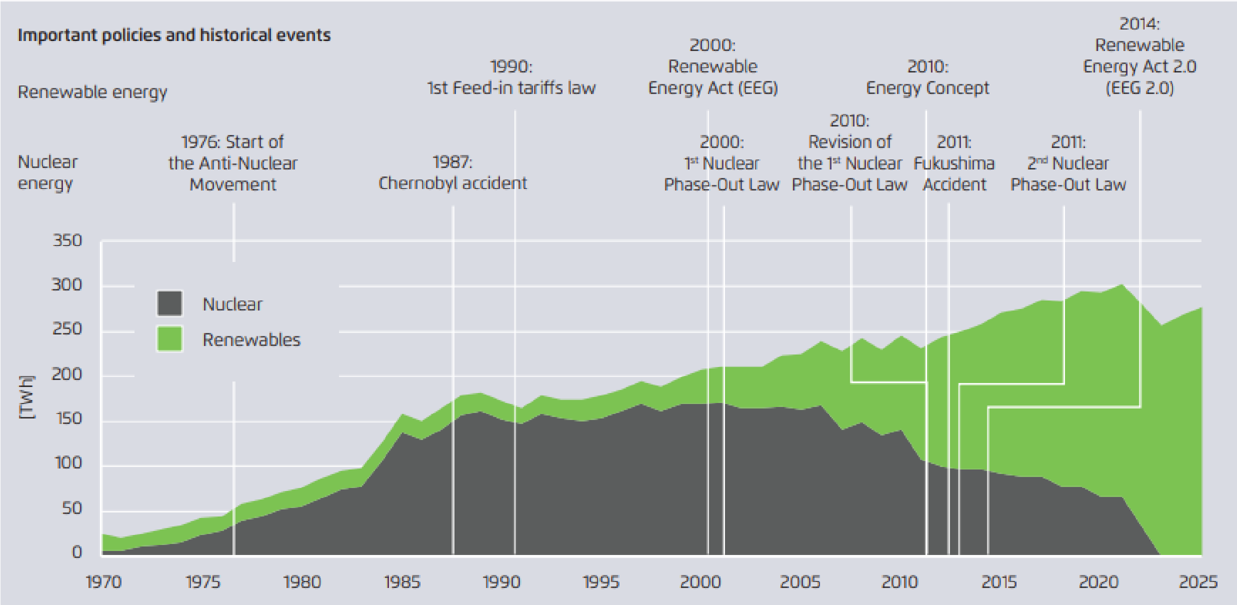


Figure 7 – Important laws and events over the years and their impact on the share of renewables in Germany [17]

What kind of subsidies does Germany offer today for the investors?

Currently Germany offers a big variety of support measures for renewable energy with a high level of detail for individual cases.

They include:

- Different kinds of loans for specific types of renewables with options of repayment free period of up to 3 years and constant interest rate up to 20 years
    - Standard loan – all technologies except for offshore wind, up to 50 million EUR per project, interest rate of 1.05%, repayment period of up to 20 years, possible repayment-free startup period; [3]
    - Premium loan – geothermal drilling of over 400 m, up to 80% of investment and 975000 EUR limit, interest rate depending on capital market, repayment period of up to 20 years, startup non-repayment period of up to 3 years; [3]
    - Storage loan – for solar installations up to 30 kWp, fixed interest rate, repayment period of up to 20 years, startup non-repayment period of up to 3 years; [3]
    - Offshore wind loan – installation in German exclusive Economic Zone or in 12-nautical mile zone of North and Baltic sea, up to 50% of investment capped by 400 million EUR, up to 70% of investment capped by 700 million EUR, fixed interest rate, repayment up to 20 years, non-repayment startup period of up to 3 years; [3]
    - Innovation loan – all technologies, up to 70% of investment, fixed interest rate, repayment up to 30 years, non-repayment startup period up to 5 years; [3]

- Feed-in tariff
    - Fixed feed-in tariff for small-scale installations – payment amount depending on technology, duration of payment, size of the plant; degression coefficient is set individually for each kind of technology, duration – up to 20 years; [3]
    - Premium feed-in tariff: determined by a tender – payment amount depending on technology, plant size and date of commissioning, degression coefficient is set individually for each kind of technology, duration – up to 20 years; [3]
- Flexibility subsidy
    - Flexibility suncharge – biogas plants can receive additional support for providing capacity for on-demand use, 40 EUR per kW installed per year; [3]
    - Flexibility premium – support for additionally installed capacity of biogas plants, 130 EUR per additionally installed kW per year for 10 years; [3]
- Tenant electricity suncharge – solar installations up to 100 kW not using the grid, the amount is lower than feed-in tariff but the network charges and taxes are avoided; the residential use of the building must be over 40%, degression of 0.5% per month which will be increased to 2.8% if the yearly installation cap of 500 MW is reached, period – 20 years. [3]

Introduction of auctions in Germany with 2017 Renewable Energy Sources Act has also shown one of the many cases of a phenomena noted recently in many countries, the significant decrease in support necessary due to increase in competitiveness:

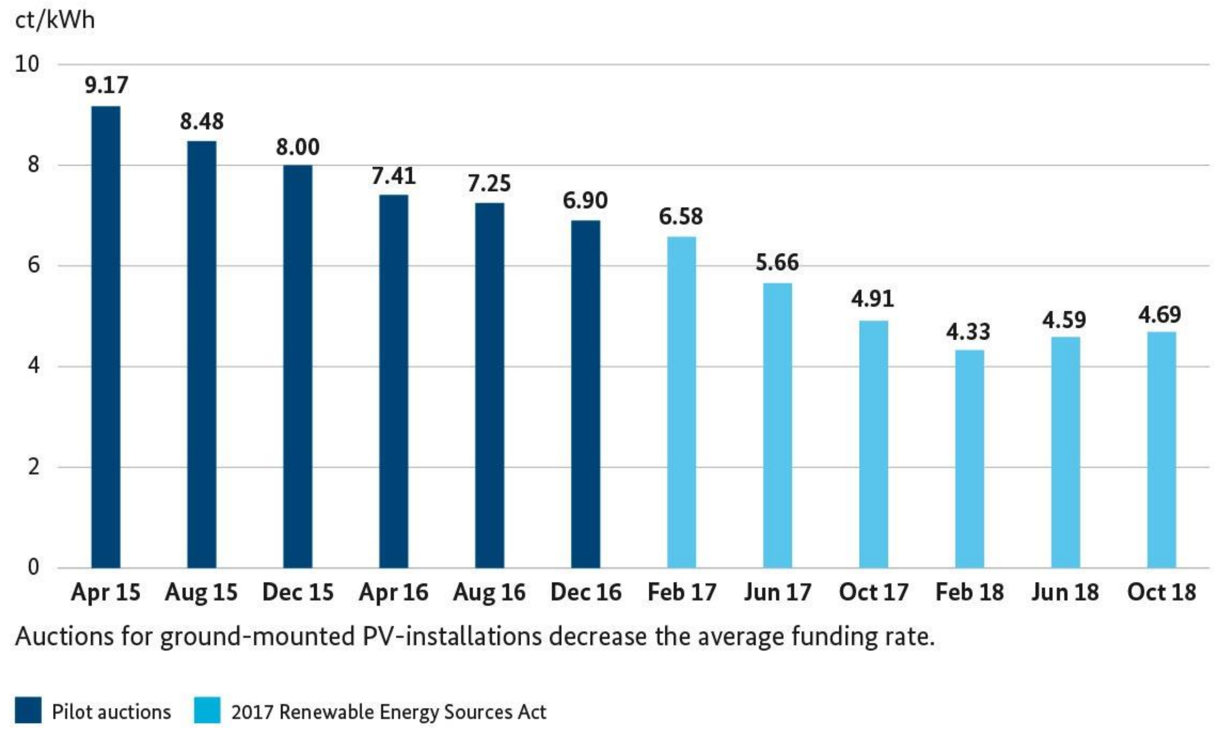


Figure 8 – Influence of auction introduction in Germany on the feed-in amount [18]

As you can see on the figure above, the introduction of auctions has decreased the amount of support necessary two times in just 3.5 years, which is a significant increase in speed and big step towards self-sustainability of renewables in the country.

Calculation methodology

Germany uses LCOE principle for calculation, as you can see on the figure below, representing the evolution of German feed-in tariff level for PV panels.

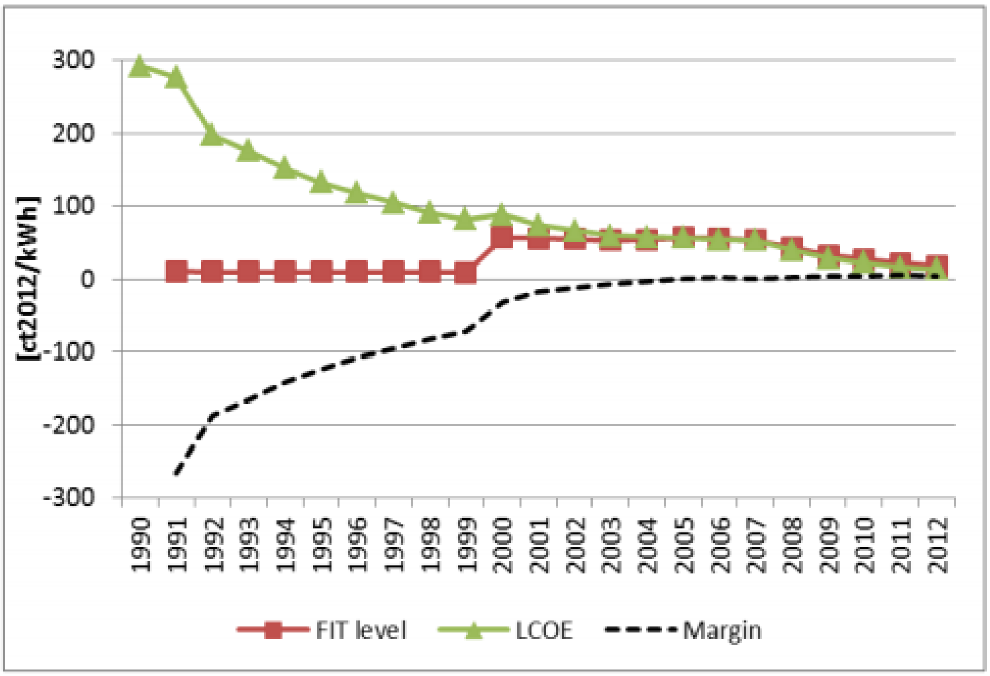


Figure 9 – Comparison of FIT and LCOE levels for PV panels in Germany [19]

Additional impact:

Energiewende has also set the goal of reducing CO2 emissions by 40% till 2020, which is in accordance with the provisions set by Kyoto protocol, but the final goal has not been met in time, with the result of 27.34% emission decrease at 01.01.2020 according to information from International Energy Agency (IEA):

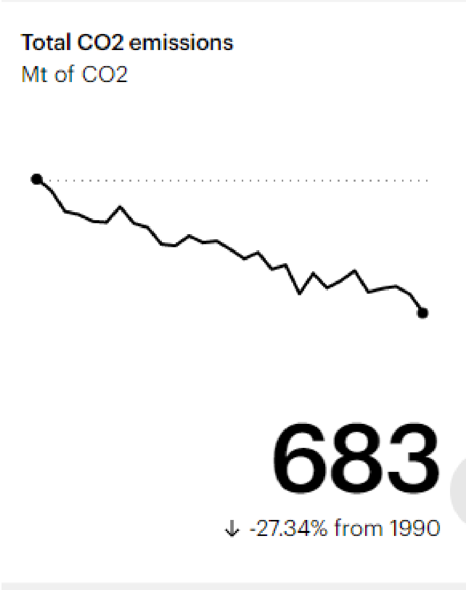


Figure 10 – Influence of German renewable programs on CO2 emissions 1990-2020 [20]

2.2 United Kingdom

Why is it relevant? United Kingdom has one of the simplest, yet effective scheme of energy transition with one of the earliest to start, concise but well-developed auction-type “Contract for Difference” scheme for different types of renewable projects among European countries with clear and explained of initial implementation and on-the-go corrections, which makes it a great foundation for auction-type scheme creation.

Reasons:

- The United Kingdom ratified the Kyoto agreement on decreasing the CO_2 emissions and has set it as a primary goal for its renewable program;
- Usage of the renewables is widely supported in Britain with polls showing over 70% of population supporting an increase in renewable generation share; [21]
- Facilitating energy production for distant islands of the United Kingdom with no local energy production and high and economically unfeasible transmission costs from the main island of the United Kingdom.

Energy goals of the United Kingdom are:

- Energy security – priority of secure supply for the customers
- Energy efficiency – improving energy efficiency by decarbonizing
- Decarbonization – reducing CO_2 emissions by at least 80% till 2050 in comparison with 1990 [22]

Types of incentives in the UK

Carbon price floor – an incentive of implying cost on CO_2 emission, thus increasing the fossil fuels production cost.

Feed-in tariff

The feed-in tariff structure in the UK was simpler than in Germany, that is why it can be comprised in a relatively small table, which is depicted below. The payment was dispatched according to the amount generated, not the one returned to the grid. The amount of payment depended on the type of technology, plant size, date of commissioning and rate. A person or an entity having less than 25 different installations certified to receive the state support were entitled for a higher tariff. The ones having more than 25 installation were entitled to a middle tariff – a measure designed so that the state support would not be abused just for additional profit without the real need for them.

Table 1 – Feed-in tariff scheme in the UK [23]

Type	Amount	Feed-in tariff terms Higher rate	Middle rate
Solar	<10 kW 10-50 kW 50-250 kW 250-1000 kW 1000-5000 kW	3.79 p/kWh 4.03 p/kWh 1.69 p/kWh 1.33 p/kWh 0.15 p/kWh	3.41 p/kWh 3.63 p/kWh 1.52 p/kWh 1.33 p/kWh 0.15 p/kWh
Wind	0-50 kW 50-100 kW 100-1500 kW 1500-5000 kW	8.24 p/kWh 4.87 p/kWh 1.55 p/kWh 0.47 p/kWh	
Hydro	0-100 kW 100-500 kW 500-2000 kW 2000-5000 kW	8.03 p/kWh 6.46 p/kWh 6.46 p/kWh 4.73 p/kWh	
Anaerobic Digestion	0-250 kW 250-500 kW 500-5000 kW	4.50 p/kWh 4.27 p/kWh 1.54 p/kWh	

There was also an additional tariff for the energy exported to the grid in the amount of 5.38 p/kWh. It had to be measured by a specially installed smart meter, otherwise the export share of the total generation was estimated as 50%.

With the development of renewable generation, the UK government decided the generation feed-in tariff to be no longer needed and a burden to the budget. It was abolished on the 1st of April 2019 with all the payments for installations commissioned before that day staying in place. Nowadays only export tariff is in force for British installations.

Contracts of difference

Contracts of difference (CfDs) are the kinds of auctions – for every unit of energy produced the government is bound by the contact to give a certain amount of money to the producer, decided by the result of a auction-based competition, which defines the so-called strike price.

The concept of a strike price in such a contract should be understood as a certain value of wholesale spot electricity price. If the electricity prices fall below the necessary strike price level, the enterprise receives money from a government-founded LCCC (Low Carbon Contracts Company), a special entity created to be a counterparty in CfDs. It is made in order to ensure the competitiveness of renewable plants to their conventional counterparts. Vice versa if the spot price rises above the strike price level, the low-carbon producer is obliged to pay to LCCC. The scheme is demonstrated on figure 11.

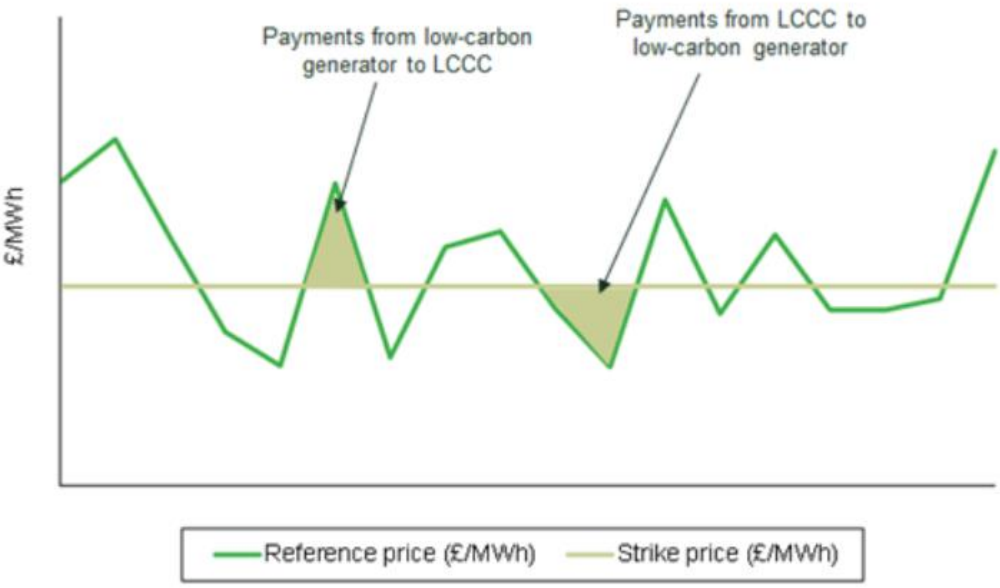


Figure 11 – Contract for difference payments [24]

Judging by the figure above, it is obvious that the strike price is crucial in the issue of how much money will the producer receive from the government. So why doesn't he just put it as high as possible and reap maximum profits at the expense of the government?

The strike price of the contract is decided as a result of an auction, where many companies compete for the right to receive the government subsidies. So, how is it decided on who will receive them? First of all, as it is told about the UK in this example, the UK government lists the possible contestants. For example, in the last allocation round to date (round 3) which took part in May 2019 it was opened to so-called Pot 2 renewable technologies. In contrast with previously talked upon solar panels and on-shore wind farms, which has been part of people's lives for 20-30 years now, this time the auction has been held among the less established renewable technologies, such as Advanced Conversion Technology and Remote Island Wind farms and Offshore Wind Farms.

The auction was also held for such means of obtaining energy as dedicated biomass with combined heat and power, anaerobic digestion plants of installed capacity exceeding 5 MW, geothermal energy, tidal stream energy and wave energy. [25]

But how can these so different kinds of renewable plants be compared in order to understand which project is the most deserving? There are multiple steps to it. First of all, the government sets the entrance threshold for the bidders – it is called the administrative strike prices. It means that the LCCC on the behalf of the UK government is not willing to set the strike price for the applicants higher than the set value.

For the 3rd round of subsidies allocation the prices were listed as follows:

Table 2 – Administrative Strike Prices (ASP) according to technology types [26]

Technology Type	Delivery Year	
	2023/24	2024/25
Advanced Conversion Technologies	113	111
Anaerobic Digestion (>5MW)	122	121
Dedicated Biomass with CHP	121	121
Geothermal	129	127
Offshore Wind	56	53
Remote Island Wind (>5MW)	82	82
Tidal Stream	225	217
Wave	281	268

But where did the LCCC take these values from? And why do they differ so much? There is a special technology for setting these values. Below are the main principles set by the government in order to carry out a fair competition between the projects:

Table 3 – Objectives of ASP setting and the implications behind them [26]

	Objective	Implications for setting ASPs
1	**Based on robust cost information**	
	ASPs should draw on the latest generation cost data, while also considering market conditions, policy considerations and other technology-specific factors to ensure value-for-money for consumers.	Use latest evidence on renewable electricity generation costs to produce a supply curve for each technology in each year.
2	**Set to encourage participation in the allocation round**	
	ASPs should be set at the minimum level necessary to encourage new investment from a significant proportion of the supply curve.	Target 25% of the supply curve when setting reserve prices.
3	**Set using a consistent approach across technologies**	
	The methodology for ASPs should take a consistent approach across all technologies.	Target the same proportion of the supply curve (25%) for each technology.

It is written that the calculation is set to target 25% of the supply curve for the price setting. But what exactly does it mean in this case? Let's assume that there is a set of sites available and potentially good for a certain renewable energy installation from the list, let it be offshore wind farms. Some of them may already exist, that's even better for the calculations. All these real and theoretical projects comprise the whole 100% of the supply curve. As a result it looks like this:

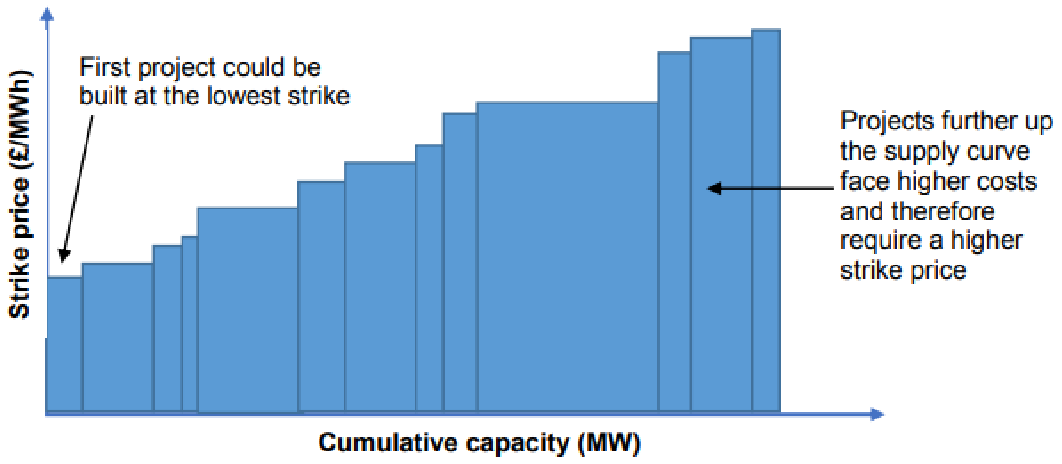


Figure 12 – The renewable projects supply curve [26]

As it can be seen from the graph, each project has its own potential installed capacity, meaning that some of them, even if highly profitable, are bound to stay small for different reasons mainly lack of usable continental shelf or lack of wind strong enough to make the plant project viable. For each of these projects the cash flow calculation has been carried out. It can be based as on the theoretical data used by the LCCC or available data from active projects. Setting the NPV of the investment equal to zero for the 15 years life span (the actual life span of the project can be longer, but the subsidies will be discontinued in 15 years since the project start) the calculation is set to find the most expensive one within the most prospective 25% of installed capacity. The strike price of this project will be set as the threshold, or better say ceiling for possible subsidy applicants.

The value of 25%, by the way, is not just taken arbitrary. Or, better say, to some extent it is, but there is a reason behind it. For the previous two rounds of allocation, the supply line value was set as 19%, but it was decided, that it doesn't allow enough contestants to pass, thus having not enough bidders in the end, not so much competition and in the end, less alternatives and higher strike prices for the auction winners.

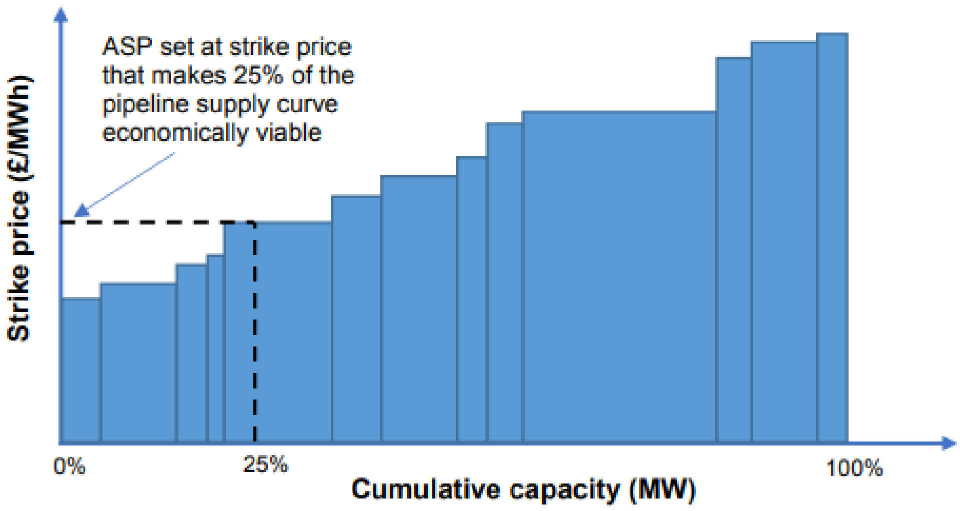


Figure 13 – Choosing the ASP according to the supply line [26]

From the official document, explaining the objectives and methodology of ASP calculation, the influencing factors are listed as follows:

" • Technology specific factors such as capital and operating costs, financing costs as well as any build constraints.

• Market conditions such as wholesale electricity prices and the discount which generators may face when signing a Power Purchase Agreement (PPA).

• Policy considerations such as the need to drive technology cost reductions and increase value for money for consumers; allowing generators to bid on a non-discriminatory basis and thus targeting the same proportion of the supply curve across technologies. ASPs have also been set to encourage a significant proportion of potential projects to come forward and compete in the allocation round – this level has been set at 25% of the modelled supply curve for each technology.

These factors mean that an ASP for a particular technology is different to the 'levelised cost' – the average cost over the lifetime of the plant per MWh generated. Relative to this levelised cost, an equivalent strike price could be higher or lower for a number of different reasons, all of which are taken into account in the setting of these ASPs.

For each project the following data is taken into account:

Table 4 – Costs taken into account for projects used for ASP calculation [26]

Capex costs	Opex costs and revenues	Decommissioning costs	Generation and other key data
Pre-development costs	Fixed opex	Financial security costs	Capacity of plant
Construction costs	Variable opex	Cost of decommissioning	Availability
Infrastructure costs	Insurance		Efficiency
	Connection costs		Load factor
	Heat revenues		Hurdle rate
	Fuel costs/gate fees		
	Strike price revenue (determined in Step 3)		

Expenditures and revenues are set throughout the period of subsidizing and life span of the project as it shown on the figure below:

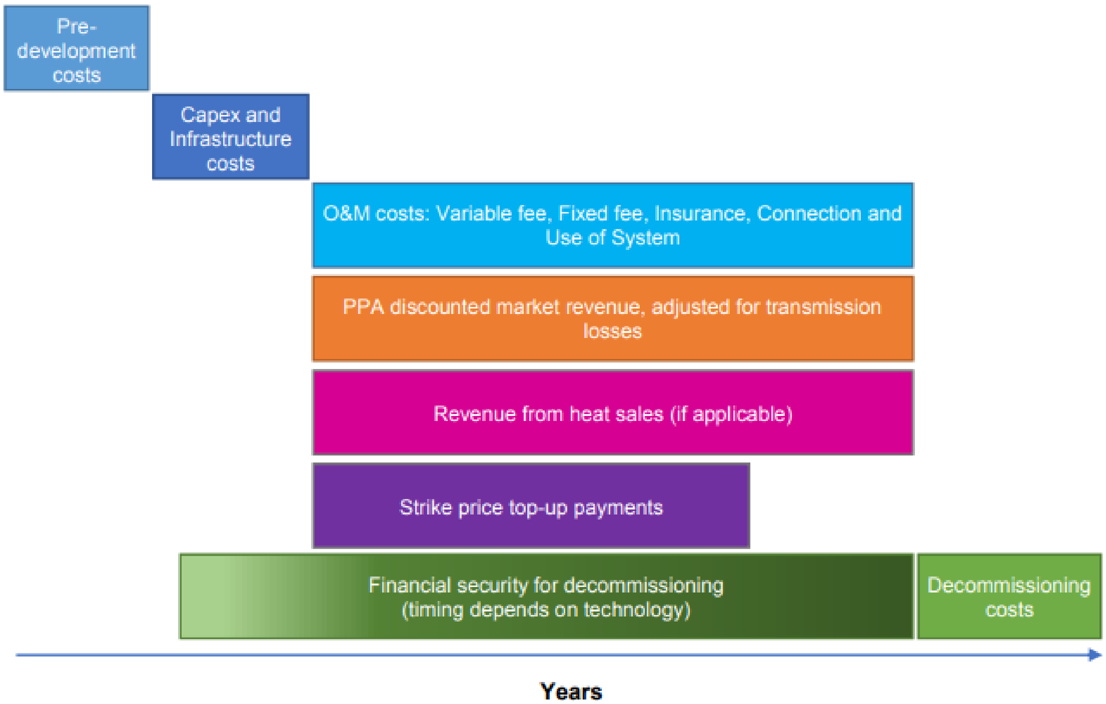


Figure 14 – Time scheme of expenditures and revenues of a CfD applicant project [26]

The values for such calculations are based on the Electricity Generation Costs Report 2016 of the government of the United Kingdom [25]. This includes assumptions on pre-development costs, construction costs, operating and maintenance costs, connection and use of system charges, load factors and efficiencies, and project timings.

According to the information from [24], revenues for the production were estimated according to market price assumptions, where the baseload technologies (such as Advanced Conversion Technology) were assumed to the valued differently from intermittent technologies (such as Offshore Wind).

But when the ASP is set, how does the competition continue? When the ineligible projects are ruled out, the applicants are free to set whatever strike price they want (below the cap). In theory, anybody can just bid a low strike price and win the competition, but that will make the bidder lose money in case it will be accepted. So the concept of CfDs encourages the companies to reveal their true costs, on the other hands looking to decrease them in order for their project to be preferred over other projects.

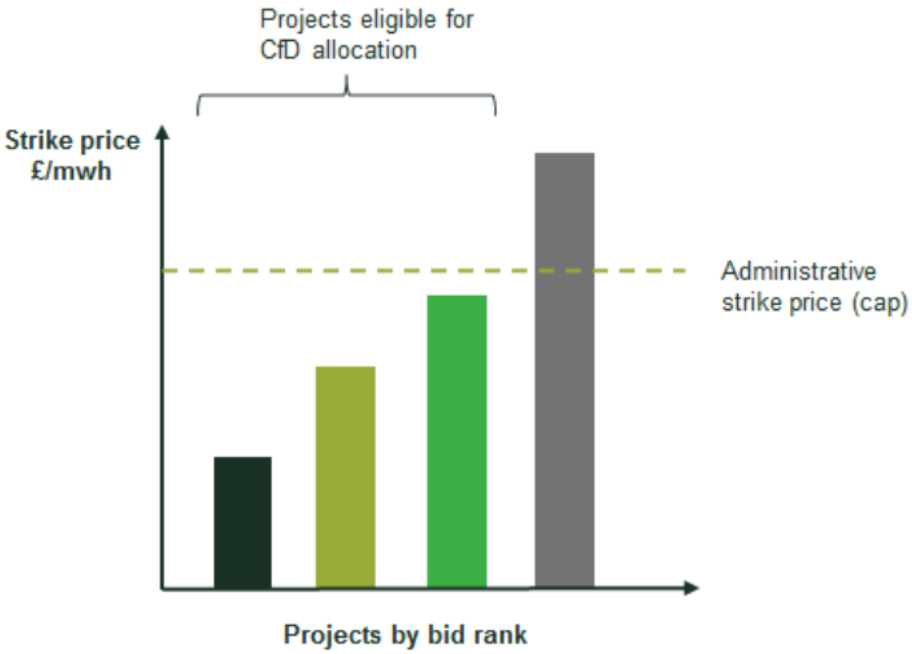


Figure 15 – Eligibility criterion of CfD applicants' projects [24]

Even the first auction held back in 2014 showed that there is a lot of improvement potential regarding costs reduction in comparison with the ASPs. The lowest bid for onshore wind was £79.23/MWh, which is around 17% lower than the set ASP of £95/MWh, the project to be delivered by 2016/17 and the lowest bid for offshore wind projects with the ASP of £140/MWh was at the value of £119.89/MWh, which is around 18% lower. And this was achieved when the ASPs were initially set relatively low, because as it is said above the ceiling project was considered the one situated on the 19% of the supply line instead of today's 25%.

But where are these reductions taken from? How much does a change of 1 or 2 per cent of a strike price shows in the investment and operating costs or in capacity factor? Let's depict this as an imaginary project, which is initially exactly good enough to pass the ASP requirements. The project is conducted by [22] relying on prices from Electricity Generation Costs 2013 [27], valid as of date of the auction of October 1, 2014. Its properties are:

	Onshore wind farm commissioned in 2016	Offshore wind farm commissioned in 2016
Pre-tax rate of return under RO	7.91%	9.76%
Hurdle rate adjustment under CfD (relative to RO scheme)	-0.4%	-0.6%
Capacity factor	28%	38%
Predevelopment costs	£0.1m/MW	£0.07m/MW
CAPEX	£1.5m/MW	£2.5m/MW
Fixed OPEX	£37.1/kW/year	£62.9/kW/year
Variable OPEX	£5/MWh	£2/MWh

Figure 16 – Assumptions for an ASP strike price project [24]

Now let’s consider that we have managed the reduce the costs or increase the capacity factor or lowered IRR we are looking for, thus creating space for the strike price reduction. These changes affect the reduction for the project using onshore wind as it shown on the figure below:

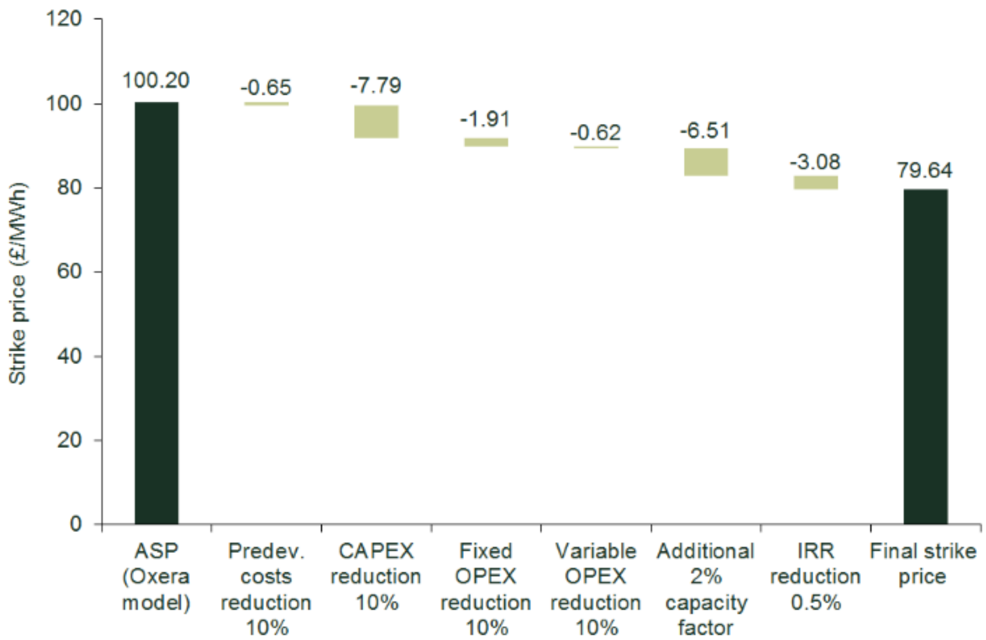


Figure 17 – How changes in the project properties affect its strike price – onshore wind [24]

The same procedure was carried out for the project using offshore wind:

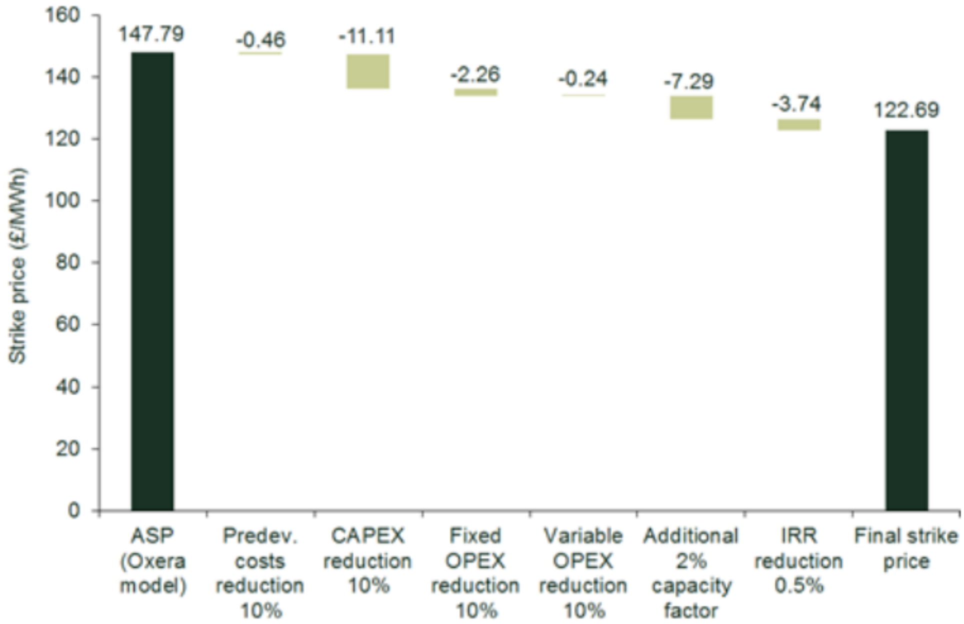


Figure 18 – How changes in the project properties affect its strike price – offshore wind [24]

Here you can see that the sequence of small changes and improvements in the technology leading to better performance or decreased costs can significantly influence the final strike price of the bidder. Ensuring clear and fair competition between bidders has proven to achieve immense progress on the goal of decreasing renewable costs and increasing their competitiveness.

Even though the UK government sets the primary goal as to decrease the CO_2 emission, the current measures taken can be considered insufficient and the British policymakers are not estimating the impact of the subsidies and meeting final goals very positively:

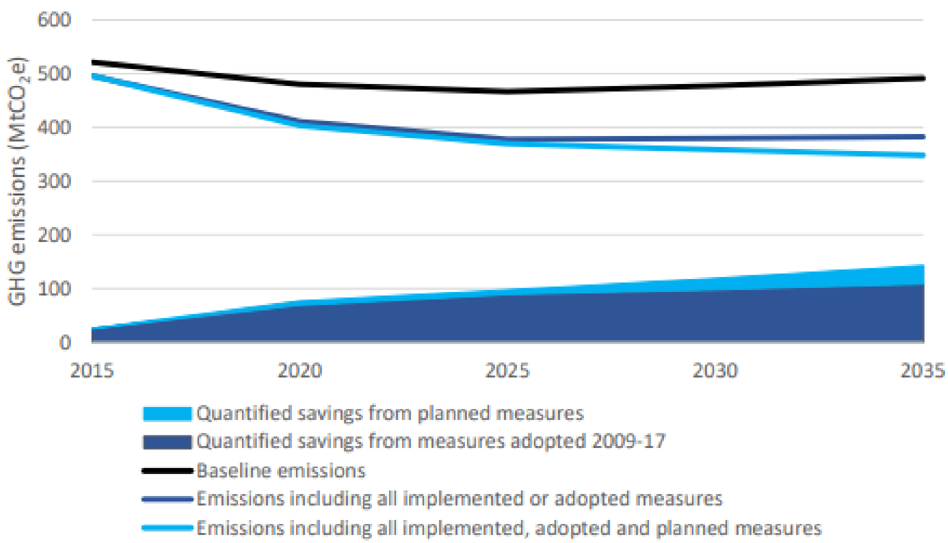


Figure 19 – Forecast on CO2 emission reduction till year 2035 according to British policymakers [22]

As you can see on the graph on CO_2 Forecasted outcome of the UK policy – the final impact of the measures taken is considered insufficient and is forecasted to bring only partial decrease of what was planned with a decrease by about a third in 20 years in the very best case. Still it can be considered a very good result, though not reaching the very ambitious goals of British environmental policy.

2.3 France

Why is it relevant? France relies for the most part on nuclear energy, thus not forced to undergo a fast transition to renewables in order to become less dependent on import, like it is the case with Germany or Denmark – the pioneers of renewable transition. Thus, it is another kind of transition scheme, which is more relevant for Russia as it is not forced by economic circumstances to undertake a rapid transition scheme.

Reasons:

- France has declared its will to decrease the share of nuclear-based energy by increasing the share of renewable production and shut down 15 nuclear reactors till 2030.
- Closure of coal-based power plants in 5 years
- Decrease of CO2 emission amounts according to the Kyoto protocol [27]

Objectives:

- Achieving no coal-based power incentives:
    - Ban on shale gas explorations and no new license for hydrocarbons explorations delivered.
    - Integration of the ecological cost in the price of carbon by
    - increasing the carbon tax (to reach €100/tCO2 in 2030) [27]
- Accelerate the changes toward well-balanced energy production, carbon free
    - Objective of 32% of renewable energy in 2030 (energy transition law).
    - Objective of 50% of nuclear energy in 2025.
    - RE financing: objective to doubling the wind and photovoltaic energy capacity by 2022.
    - Favour private investment: shorten and simplify the procedures for RE deployment.
    - Focus on research, development and investment efforts on storage operators and smart grids. [27]
- Circular economy and recycling: a new economic model
    - Divide by two the dumped household waste by 2025.
- Support the transitions
    - Attributions of funds to the regions in return of their commitment to reduce their environmental footprint (by the production of local RE), to protect biodiversity and to create jobs.
- Increase the use of Renewable Energy
    - Possibility for citizens and local authorities to receive funding for renewable energy projects.
    - Widespread use of the single permit for wind energy, biogas and hydroelectricity.
    - Obligatory power purchase rates will finance self-generated renewable electricity consumed by private individuals and businesses: a call for projects for commercial and industrial buildings will be launched before summer.
    - Objective of financing 1 500 methanation projects in France [27]
- Smart Grid
    - 35 million Linky smart meters (electricity)

France is in the leading position in the European Union regarding renewable energy development and utilization.

- The 2005 Energy Law established the guidelines for energy policy and required that the proportion of renewable energy in the energy consumption structure reach 10% in 2010.
- Introduced a wind energy development zone, with the pricing mechanism set by the government
- In the 2008 Renewable Energy Development Plan, it was regulated that solar panels of less than 30 m2 are free of duty
- The 2014 Energy Transition for Green Growth Bill set a target to increase the fraction of renewables in final energy consumption to 32% by 2030 [27]

Objectives in numbers:

- 30% less fossil fuel consumption in 2030, compared to 2012
- Increase the share of renewable energy to 32% of final energy consumption by 2030 and to 40% of electricity production
- Reduce final energy consumption by 50% in 2050 compared to 2012
- 50% less waste in landfill by 2050
- 40% less greenhouse gas emissions in 2030 compared to 1990
- Diversify electricity production and reduce the share of nuclear energy to 50% by 2025 [27]

Support incentives for renewables in France:

Electricity:

- Feed-in tariff – wind, solar, biogas and hydropower installations are eligible, capacity up to 100 kW for solar, 500 kW for biogas and hydropower, wind projects selected separately from a number of applicants, annual capacity cap, contract period 15-20 years; [3]
- Premium tariff – wind, geothermal, biomass, hydropower and household waste biomass are eligible, capacity up to 1 MW for hydropower, 12 MW for biogas, 6 MW for wind, geothermal and biomass projects are selected specifically from applications, amount is calculated according to a formula agreed upon for a specific technology by the French renewable law; annual capacity cap, contract period 20 years; [3]
- Tax regulation mechanisms – electricity generated from renewable energy sources is promoted through several tax incentives. Persons investing in renewable energy plants are eligible for an income tax credit. Furthermore, persons that install photovoltaic installations on buildings are eligible for a reduced VAT rate. [3]
- Tenders – solar, wind, biomass and biogas plants are eligible for a tender procedure, targeted capacities for the tenders are set each year, penalties and conditions set differently and specifically in the tender invitation. [3]

Heat:

- Loans – biomass and solar thermal energy are eligible, up to 30000 EUR with repayment period up to 15 years; [3]
- Thermal renovation subsidy – low income households can receive thermal renovation support to decrease energy losses, all thermal technologies eligible, up to 2000 EUR and up to 70% granted at the start of work, low income level specifically defined for different regions of France; [3]

- Biomass plants tender subsidy – biomass plants with heat production over 1000 toe used in industrial, agricultural and service sectors are eligible, amount to be calculated according to the tender's winner financial plan; [3]
- Tax regulation mechanisms – persons investing in renewable energy plants are eligible for an income tax credit. Furthermore, persons that install certain heat production installations in buildings are eligible for a reduced VAT rate. [3]

Transport:

- Biofuels quota – producers of fuel are subject to higher tax by the amount 7.5-7.7% if their fuel does not comply with legal requirements for share of bioethanol or biodiesel. [3]

Impact and forecast

According to the objectives set, France is set to decrease its CO_2 emissions by 40% till 2030. However as of 2020, the goal is far from being met, according to the data from IEA. Below you can see the graph of CO_2 emission change in France compared to 1990 with the total decrease of 15.32%:

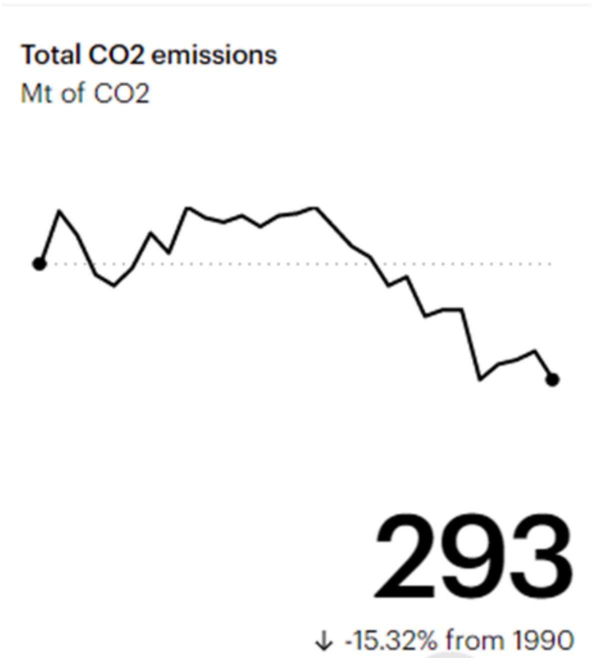


Figure 20 – Graph of CO_2 emission change in France 1990-2020 [20]

France also sets to significantly increase its renewable production share by 2030 from 19.1% in 2015 to 49% in 2030, the main task being reducing the dependence of the country from nuclear energy and achieving the goal value of 50%. The major factor in that change should be wind-based power, generated in the specific wind energy development zone, delineated by the Ministry of Energy of France, as well as significant increase in solar production. The comparison of 2015 electric production pie chart with the forecasted one in 2030 is depicted below:

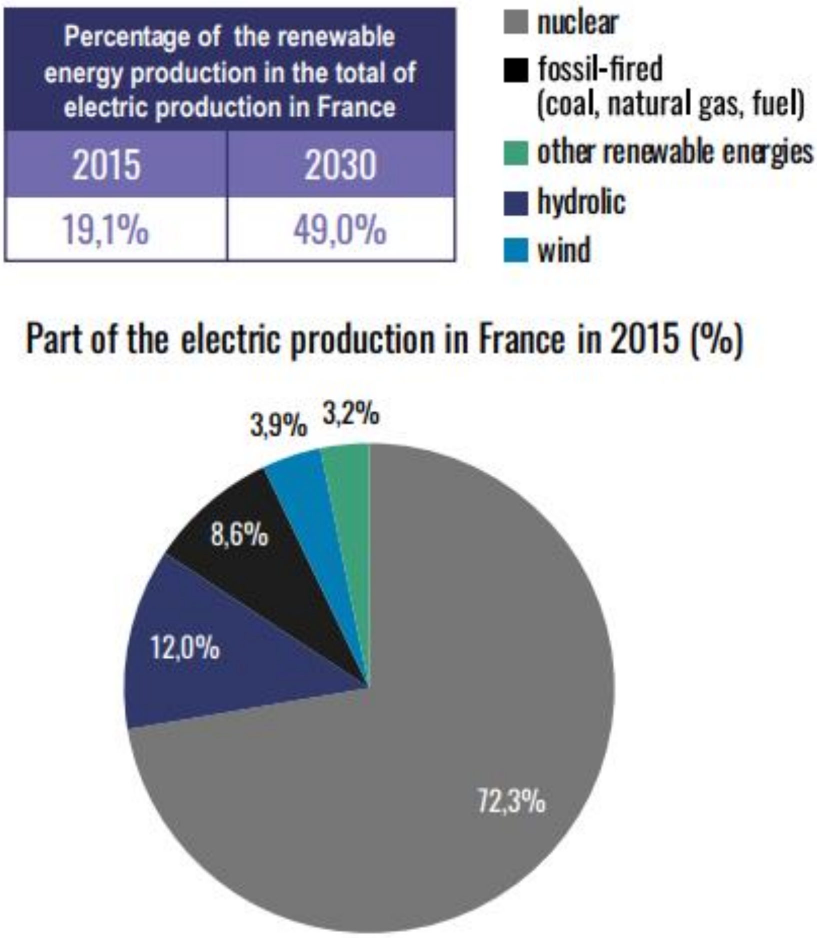


Figure 21 – Electricity production shares in France as of 2015 and the goal for 2030 [27]

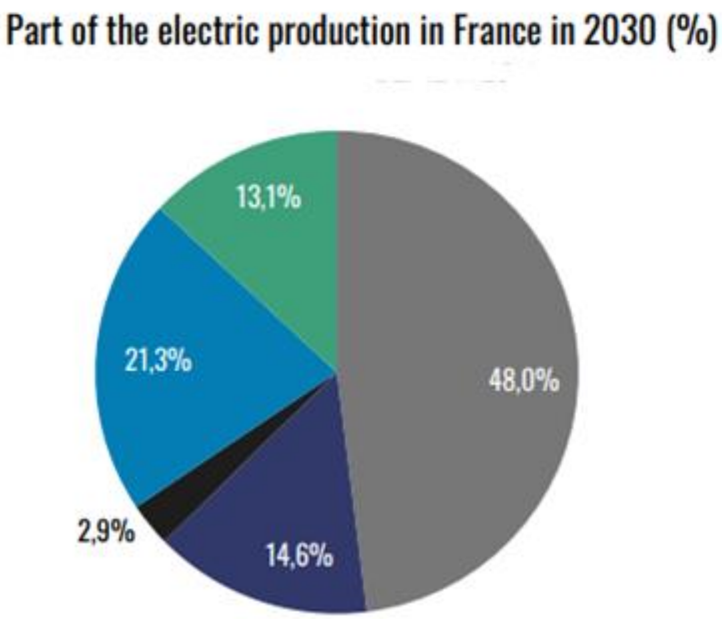


Figure 22 – France energy goal for 2030 by source [27]

Among renewable sources France already relies a lot on wind power, due to the project of Wind Power Development Zone by French Ministry of Energy and the country's geographical position with a lot of oceanic coastline. According to the France's plan, its transition towards renewable energy by 2030 will majorly be influenced by wind energy, which can clearly be seen on the figures below:

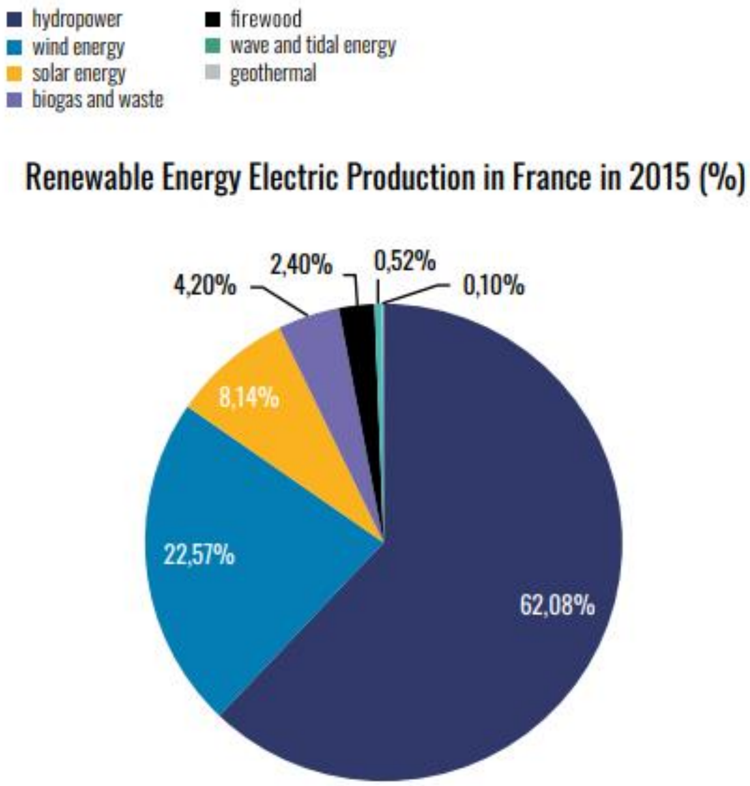


Figure 23 – France renewable energy production by source as of 2015 [27]

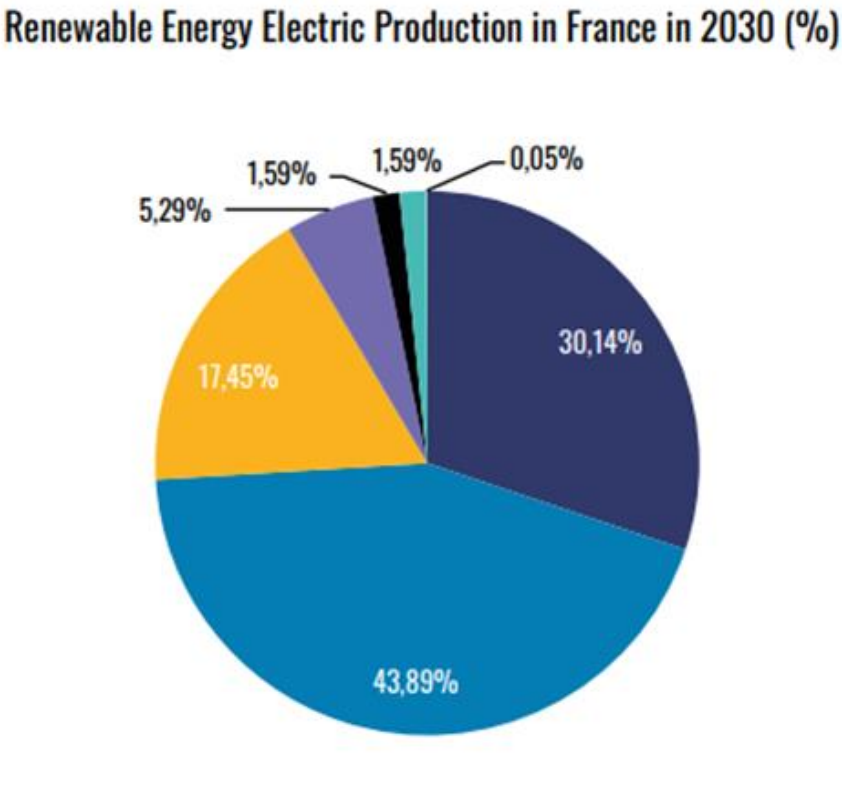


Figure 24 – France renewable energy production by source as of 2030 [27]

2.4 China

China has no goal to cut their fossil fuel production while developing renewable industry in the country. As Russia plans to continue to rely on fossil fuel while it is available in the country, the Chinese experience on the issue will be useful. Moreover, it is also generally the case of China that most of the innovative programs are planned, driven and financed by the government itself, not by attracting investors from the outside. This subchapter is devoted to showing the advantages and drawbacks of such policy regarding renewable energy introduction.

Reasons:

Economic Motives. The Chinese Party has declared in 2012, that they see renewable energy as an essential source of growth for the Chinese economy and are going to finance it in sustainable matter. Four of the ten largest manufacturers of wind turbines are Chinese companies. Similarly, five of the top ten manufacturers of solar PV cells are headquartered in China. The wind generation industry alone in China is estimated to have generated an average of 30.000 direct jobs annually between 2006 and 2020. As a global renewable leader China has reached level such level of impact on it when they majorly influence the price decrease in the field, thus further incentivizing domestic deployment of renewable energy. [15]

Resource Amount. China has a moderate amount of renewable energy resources, mostly in the form of wind energy and large hydropower. Its renewable electricity potential is up to 6.1 MWh/capita/year, which is significantly lower than the one of the countries pioneering the renewable change, such as Denmark, but still enough to potentially meet its entire domestic energy demand with renewables. China also has large amounts of non-renewable resources, for example, the Chinese share of coal reserves is estimated to be 13.3 of global. However, at the current speed of its utilization, China is expected to run out of coal in less than 30 years, meaning that China either needs to find alternatives to coal or be prepared to become a massive coal importer in future. China is not blessed with high amounts of oil and gas, so it relies on their import, being the second largest oil importer in the world after the United States. [15]

Political System. China has a single-party system and in the system of the so-called socialist market economy, the installation and realization of projects according to five-year plans have greatly facilitated the rapid buildup of its solar PV and wind energy industries. The one-party system makes it easier to implement changes, but the key challenge in Chinese energy policy has not been in the passing of laws and regulations but rather in their implementation, due to extensive amount of local laws and objections of local governments. [15]

Cultural Factors. The Chinese mentality is generally oriented towards long-term impact, so renewable energy plan is warmly welcome in the country, especially due to fact that it will facilitate the decrease of pollution in the cities. Pollution is by far the main reason for possible social unrest in China according to social polls, so the Communist Party generously introduces more and more renewable programs and projects, seeing them as the ground for stability in the country. [15]

According to current estimates, 7 out of 10 most polluted cities are situated in China and it leads to yearly 1.6 million of deaths – 17% of the average annual rate of deaths in the country. The yearly financial losses are estimated as more than 500 billion USD yearly and decrease in life expectancy by 5 years.

Objectives:

13th Five Year Plan for Electricity (2016-2020) set the following objective:

- Raise non-fossil fuel’s share of total electricity production from 35 to 39 percent by 2020. [28]

Instruments and laws:

Four key mechanisms to promote the growth of renewable energy are established in China:

- a national renewable energy target and central and local renewable energy development and utilization planning;
- a mandatory connection and purchase policy by which grid companies are required to sign an agreement with renewable electricity generators in their jurisdiction to purchase all of the electricity generated from the generators, and provide grid connection services;
- an on-grid electricity price for renewables, akin to a national feed-in tariff system, which pays renewable electricity generators a fixed, additional amount for each kilo-watt hour of electricity generated, above the wholesale electricity price for desulfurized coal-fired power; and
- a cost-sharing mechanism, funded by a surcharge on electricity sales, to pay for feed-in tariffs, grid connection projects, and independent, public renewable energy grids, as well as a Renewable Energy Development Special Fund to cover activities such as science and technology research for renewables, standard setting, pilot projects, rural utilization of renewables, and renewables resource assessments. [28]

Problems of Chinese approach

China has faced the problem of lower performance of their wind projects compared to the ones in other countries. It generally happens because of:

- long delays in connecting wind farms to the grid, due to a lack of coordination between wind farm and grid development planning, as well as a lack of incentives for grid companies to connect to renewables generators (about 25–30% of China's erected wind turbines are not connected to the grid at any one time, although most eventually are connected);
- the lower conversion efficiency of domestic turbines compared to international manufacturers;
- poor integration of wind farms with the grid and grid company reduction of wind-generated electricity due to concerns that wind-generated electricity might destabilize the grid.
- Large numbers of policies and laws that regulate renewable energy, including central level and local level laws, general laws and specialized laws. [29]

All renewable energies are generally under the uniform management of the National Energy Commission, whereas water, ocean, and geothermal energies are respectively in the charge of the Ministry of Water Resources, the State Oceanic Administration and the Ministry of Land and Resources. This leads to renewable energy programs having to pass multiple examinations and approvals of different departments with mutually inconsistent rules.

- No special administrative rules and local regulations regarding the development and utilization of renewable energy, except for the provisions of Renewable Energy Law, which are set in the form of principles rather than laws.
- Vague formulations without clear requirements for specific matters, such as failing the obligations, amount of time for dealing with requests or amount of time prescribed for connecting the renewable generation facility into the power grid.
- Unclear setting of objectives and the ones responsible for them, as well as target achievement evaluation procedure;
- Traditional energy-related industries have great influence on local policies and are in the form of local or state-level monopolies, hindering the development of renewables;
- Financial subsidies for renewables end up being much more limited than planned, traditional energy companies avoid paying renewable tax, the total underfinancing reaching 200 billion Yuan throughout the years
- Abandonment of functioning renewable installations due to incapability with local power grids because of fluctuations in production level, most of them being built as manifestation of Chinese political achievements without the real need [28]

Impact, forecast and budget

- Renewable budget in 2016-2020 in China is estimated about 360 billion USD
- Job creation plan is 13 million workplaces till the end of 13th Five-year plan in 2020
- By 2030, one-fifth of the country’s electricity consumption is forecasted to come from non-fossil fuel sources
- According to the IEA, 36 percent and 40 percent of the world’s growth in solar and wind energy in the next five years will come from China [20]

2.5 USA (Alaska)

Why is it relevant for the work? Russia has a vast amount of polar, mountain and hard-to-reach settlements, which is economically unfeasible or technologically impossible to connect to the grid. It significantly increases the power costs in these villages, making it necessary for the government to provide the citizens with costly power subsidies. It also creates complicated logistics for delivering diesel fuel which in turn deals a great amount of damage to the environment. Although, Russia is quite the only country to deal with such issue on a state level, some territories in USA and Canada have already tried and implemented renewable support schemes for such cases. Alaska is an example of such a case.

Alaska in 2003 has introduced a law, considering grant funding for households with high energy costs (amounting at least in 275 percent of average national value).

The applier is eligible to be funded:

- Electric generation, transmission and distribution facilities, including:
    - Equipment, materials and activities
    - Land or right-of-way acquisition, professional expenses, engineering and permitting costs
- Natural gas distribution and storage facilities, including equipment, materials and activities
- Petroleum product storage and handling facilities, including equipment, materials and activities
- Renewable energy facilities, including solar, wind, hydropower or biomass technologies used for on- or off-grid:

- electric power generation
- water or space heating
- process heating and power

- Backup or emergency power generation or energy storage technology, including generation equipment installed on consumer premises; [30]

The fund implements such program as:

- Energy efficiency improvements and conservation measures, i.e. weatherization of residences and community facilities
- Programs encouraging the use of energy-saving appliances and devices
- Programs aimed at improving the quality and cost of energy service [30]

Alaska renewable grant fund is an example of financing the projects which were unlikely to receive private investment, in a country where no federal renewable program exists up to date. Being financed straight from the budget by the means of taxpayers, it allowed the household with high bills relieve the financial burden. Such a measure must be implemented in Russia, as even if investments will be drawn into the Russian Arctic, some of the settlements are less financially attractive even though they need sustainable electricity just as much. For financing these projects, an Arctic Fund must be established, as well as the means of its financing.

2.6 Global renewable energy development

International agreements on emissions and climate change

The Kyoto Protocol

The start of the world-scale efforts against climate change and decrease in CO_2 emissions is generally connected with the enactment of the Kyoto protocol on December 11th, 1997. Its idea lied in the agreement between industrialized nations to overtake a yearly plan on decrease of CO_2 emission by an average between nations of 5.2% till 2012, thus decreasing the all-world amount of CO_2 emissions by 2012 by 29%. [1]

The particular goals of decrease, though, were different between the countries – EU countries were set a goal of 8% decrease, US and Canada – 7% and 6% respectively.

Countries that ratified the Kyoto Protocol were assigned maximum carbon emission levels for specific periods and participated in carbon credit trading. If a country emitted more than its assigned limit, then it would be penalized by receiving a lower emissions limit in the following period. [31]

The protocol placed a heavier burden on developed nations than less-developed nations. The Kyoto Protocol mandated that 37 industrialized nations plus the EU cut their GHG emissions. Developing nations were asked to comply voluntarily, and more than 100 developing countries, including China and India, were exempted from the Kyoto agreement altogether. [31]

The developing nations participated by investing in projects designed to lower emissions in their countries. For these projects, developing countries earned carbon credits, which they could trade or sell to developed countries, allowing the developed nations a higher level of maximum carbon emissions for that period. In effect, this function helped the developed countries to continue emitting GHG. [31]

The United States, which had ratified the original Kyoto agreement, dropped out of the Protocol in 2001. The U.S. believed that the agreement was unfair because it called for industrialized nations only to limit emissions reductions, and it felt that doing so would hurt the U.S. economy. Without their participation, it was deemed debatable whether the Kyoto protocol can and will reach its initial goal. [31]

The Paris Agreement

The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework. [32]

Even with the increasing role of renewables, the role of coal, gas and fossil fuels in general is still going to be significant in the next 20 years. Major energy forecasters such as International Energy Agency (IEA) and Organization for Economic Co-operation and Development (OECD) agree that in 20 years the world will still rely mostly on fossil fuels, with the amount of electricity produced with its means will only grow, as is depicted in figures and tables below:

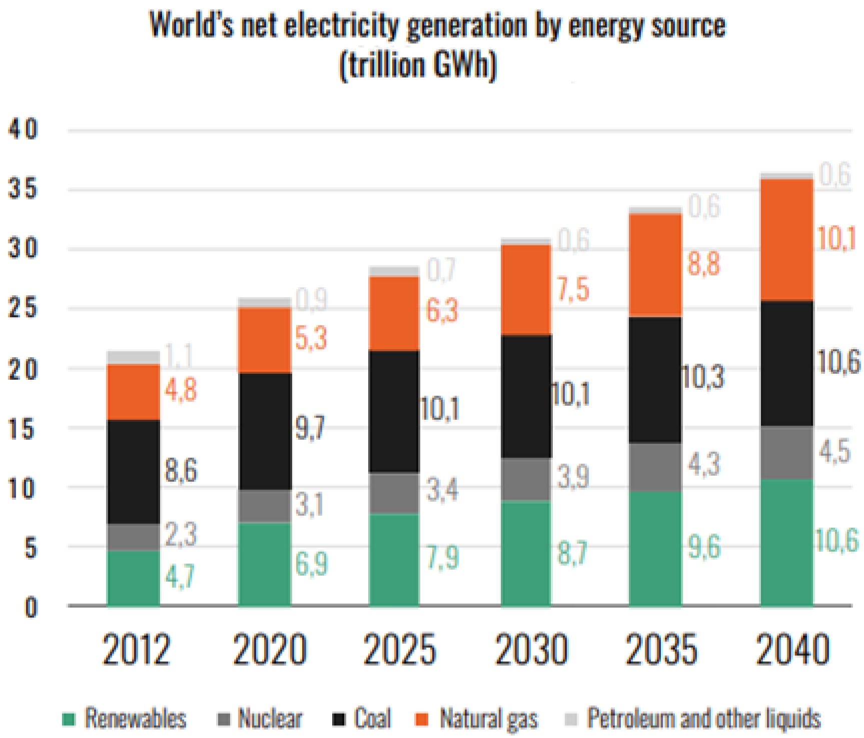


Figure 25 – Electricity production by energy source forecast till 2040 by OECD [27]

IEA considers the future of renewable energy via three scenarios – New Policies, Current Policies and Sustainable Development.

The New Policies Scenario provides a measured assessment of where today's policy frameworks and ambitions, together with the continued evolution of known technologies, might take the energy sector in the coming decades. The policy ambitions include those that have been announced as of 2018 and incorporates the commitments made in the Nationally Determined Contributions under the Paris Agreement, but does not speculate as to further evolution of these positions. [33]

The Current Policies Scenario is based solely on existing laws and regulations as of 2018, and therefore excludes the ambitions and targets that have been declared by governments around the world.[33]

The Sustainable Development Scenario, starts from selected key outcomes and then works back to the present to see how they might be achieved. The outcomes in question are the main energy-related components of the Sustainable Development Goals, agreed by 193 countries in 2015:

- Delivering on the Paris Agreement. The Sustainable Development Scenario is fully aligned with the Paris Agreement's goal of holding the increase in the global average temperature to "well below 2 °C".

- Achieving universal access to modern energy by 2030.
- Reducing dramatically the premature deaths due to energy-related air pollution. [33]

Table 5 – Electricity production by energy source forecast till 2040 by IEA [33]

World primary energy demand by fuel and scenario (Mtoe)

			New Policies		Current Policies		Sustainable Development	
	2000	2017	2025	2040	2025	2040	2025	2040
Coal	2 308	3 750	3 768	3 809	3 998	4 769	3 045	1 597
Oil	3 665	4 435	4 754	4 894	4 902	5 570	4 334	3 156
Gas	2 071	3 107	3 539	4 436	3 616	4 804	3 454	3 433
Nuclear	675	688	805	971	803	951	861	1 293
Renewables	662	1 334	1 855	3 014	1 798	2 642	2 056	4 159
Hydro	225	353	415	531	413	514	431	601
Modern bioenergy	377	727	924	1 260	906	1 181	976	1 427
Other	60	254	516	1 223	479	948	648	2 132
Solid biomass	646	658	666	591	666	591	396	77
Total	10 027	13 972	15 388	17 715	15 782	19 328	14 146	13 715
Fossil fuel share	*80%*	*81%*	*78%*	*74%*	*79%*	*78%*	*77%*	*60%*
CO_2 emissions (Gt)	23.1	32.6	33.9	35.9	35.5	42.5	29.5	17.6

Notes: Mtoe = million tonnes of oil equivalent; Gt = gigatonnes. Solid biomass includes its traditional use in three-stone fires and in improved cookstoves.

Out of the three, the New Policies Scenario is generally considered the main for the estimations and it shows the preserving primary role of fossil fuels in the next 20 years, as well as increase in CO_2 emissions of the world, generally caused by increasing role of developing economies in the world.

Out of the whole picture, each of the renewable kinds of energy is important to look at in terms of amount of increase or decrease in their spread – the level of introduction of the renewables is greatly connected to their affordability for customers and attractiveness for investors as well amount of competition in the field.

According to empirical laws of price changes, such as Swanson's law for solar panels mentioned in Chapter 1, it is possible to estimate the future price of solar panels based on the forecast of their amount in 2040.

The forecast of renewable energy production by type performed by OECD is depicted below:

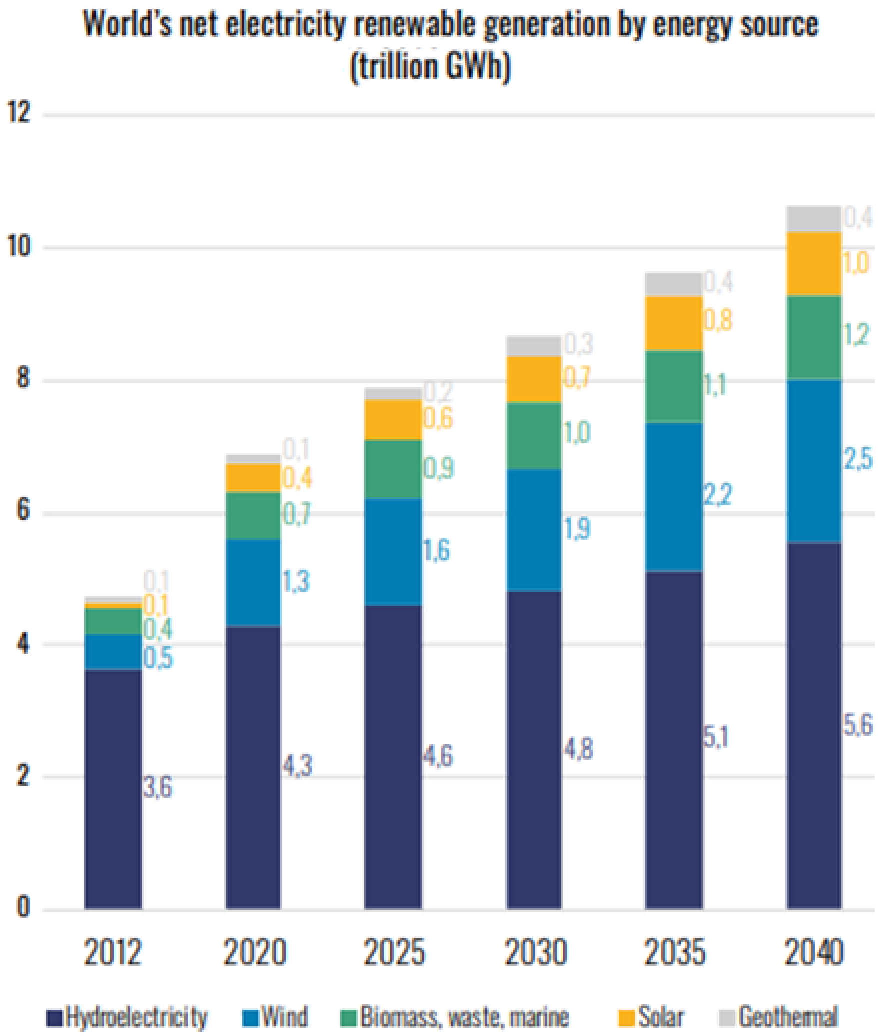


Figure 26 – Renewable energy produced by source forecast till 2040 by OECD [27]

From this graph it can be seen that the role of renewables in the world's energy production will continue to rise steadily and, for example, it can be drawn from this forecast that, according to the Swanson's law, solar panels can be estimated to decrease in cost by about 25% by 2040 compared with today's value. However, such assumptions are rather broad and generally several scenarios are to be considered. For example, like in this research on the future price of solar panels [34], several scenarios of amount growth speed is correlated with the capital expenditures forecast for the same scenarios:

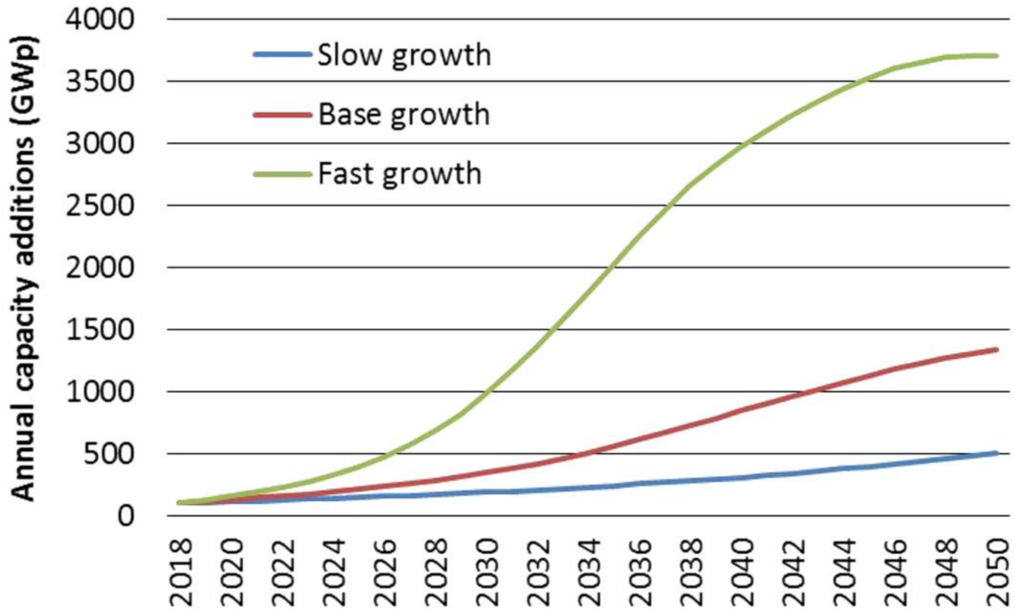


Figure 27 – Solar annual capacity additions forecast till 2050 [34]

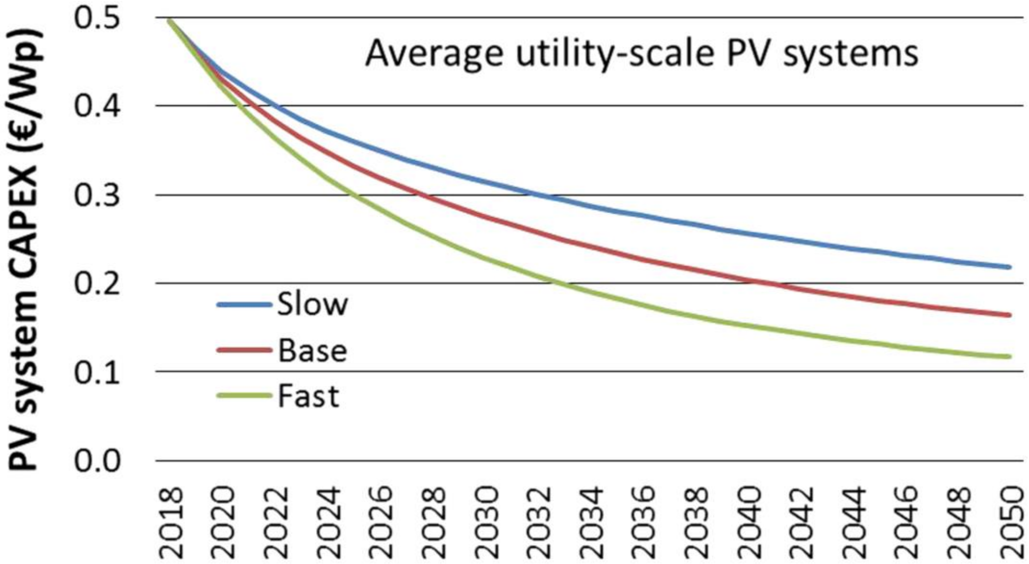


Figure 28 – Solar panels capital expenditures forecast till 2050 [34]

In the next chapter I will identify the constituents for investing in renewables in Russia, consider its main energy problems and how the examples from other countries can be used to solve them, what factors make Russia lag behind the world leaders in the clean energy transition and how they be dealt with, as well as what measures has the Russian government already undertaken in order to incentivize the introduction of renewables in Russia.

3 Specific conditions of investing in renewables in Russia

I identify four main constituents to be considered for investing in renewables in Russia:

- Infrastructural problems
- Renewable potential
- Legislative base
- Financial situation and situation in the energy field

3.1 Infrastructure

Russia has a large territory, most of which is poorly populated. Under such conditions, most regions of Siberia and the Far East are cut off from the country's main energy system. In addition, there are also infrastructural problems - in particular, many regions of the north of Russia are extremely inaccessible by land, and in winter by river and sea. In this regard, in Russia there is a system by which the northern regions purchase a certain list of products regulated by the state and fuel in advance, while fleet or aviation forces are often used, since land communication is extremely difficult. This puts an additional burden on the budgets of these regions and as a whole, is quite expensive for the state.

In addition, in the conditions of the north of Russia, a situation often arises in which the settlements are quite far from each other, their population is small, and the area in which this settlement is located is difficult to access. In this regard, the conduct of electrical communications in these settlements is expensive and impractical. Therefore, diesel power plants often become a source of energy in the north. The positioning and production of diesel power stations is presented on the map below:

Figure 29 – Map of Russian electricity grid with information on amount and production of local municipal diesel power stations [35]

Table 6 – Data from figure 29

Region	Amount of municipal DPS	Yearly production [MWh]
Arkhangelsk region	58	85467
Nenets AO	36	Approx. 25000
Komi Republic	27	14561
Yamalo-Nenets AO	41	1524335
Khanty-Mansi AO	37	34900
Tomsk region	22	14689
Krasnoyarskiy kray	70	98806
Tuva Republic	12	9970
Sakha Republic	166	325315
Chukotskiy AO	46	97352
Kamchatskiy kray	181	151568
Irkutsk region	57	68312
Zabaikalskiy kray	20	7103
Khabarovskiy kray	64	19297
Primorskiy kray	28	28790
Sakhalin region	24	50500
	889	2555965

As you can see from the map, most of Russia (65%) is not electrified, though it is not entirely desolate in the parts which are not electrified. Generally, the case is that towns and villages are so far from the main grid, that it is economically unfeasible to build transmission lines and include them in the so-called centralized grid.

The secluded towns and villages are also not necessarily situated in Arctic where there is also little to no sun and sometimes not strong enough wind. For example, as you can see on the map extract below, the Russian region on the coast of the Japanese sea, most of the cities and towns are situated in the south or west, and the north-east part has a lot of hills and mountains, where there are 28 villages with no connection to the centralized grid.

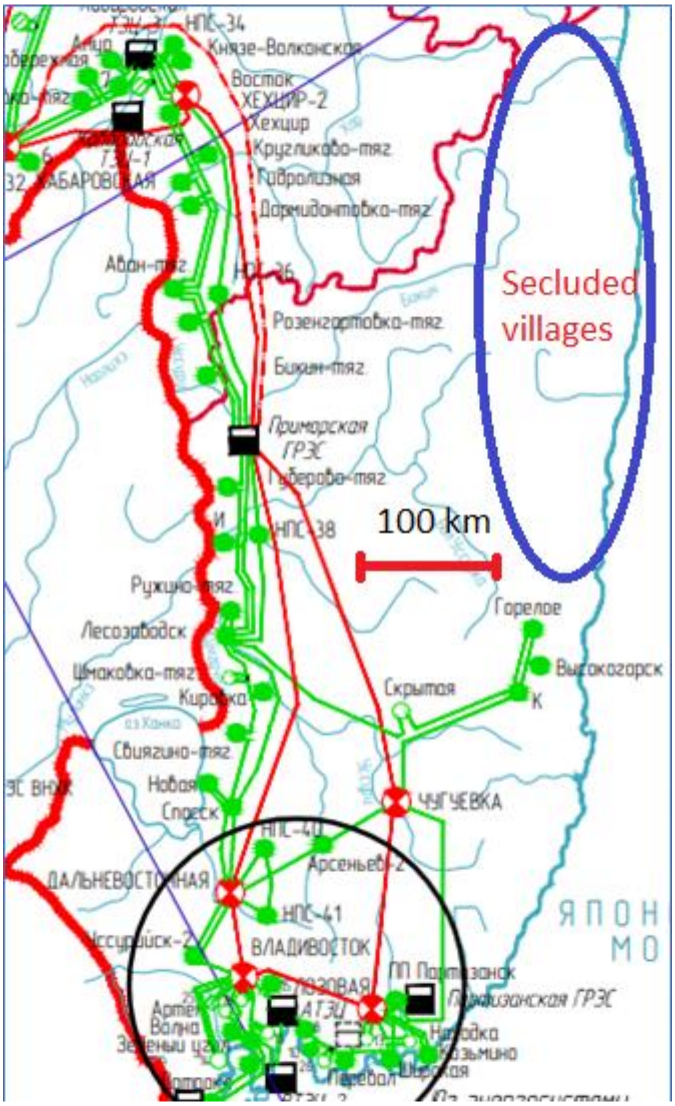


Figure 30 – Diesel-electrified villages of Primorskiy Kray

They are generally reached by the sea and are interconnected by roads, though these villages have a joint population of several thousand people and it is economically unfeasible to connect them to the grid, as well as technologically complicated due to mountain landscape. These days they get their power supply by the means of diesel delivered from the mainland. But at the same time these villages experience a vast amount of solar energy as well as strong coastal wind, so renewable energy is a perfect solution for them. Though it can be said with almost 100% certainty that the initial costs will be an extremely hard burden for local villagers, thus it is on the government to incentivize the deployment for such issues. In the long run, using renewable energy proves to be far less costly, especially when it concerns the region on the south of Russia located exactly on the seacoast.

The same situation can be seen in Eastern Siberia, south to the lake Baikal. Due to mountain landscape, many villages on the border with Mongolia are situated very far from the main grid. The south of Buryatia and Chita region, that are pictured on the map below, are not only subject to big amounts of solar radiation and high wind speeds, the renewable resources there are also very consistent. Both Ulan-ude, the main city of Buryatia and Chita, the main city of Chita region, generally experience more than 300 sunny days per year and consistent wind speeds of 4-5 m/s.

The map showing the location of secluded villages in South-east Siberia is pictured below:

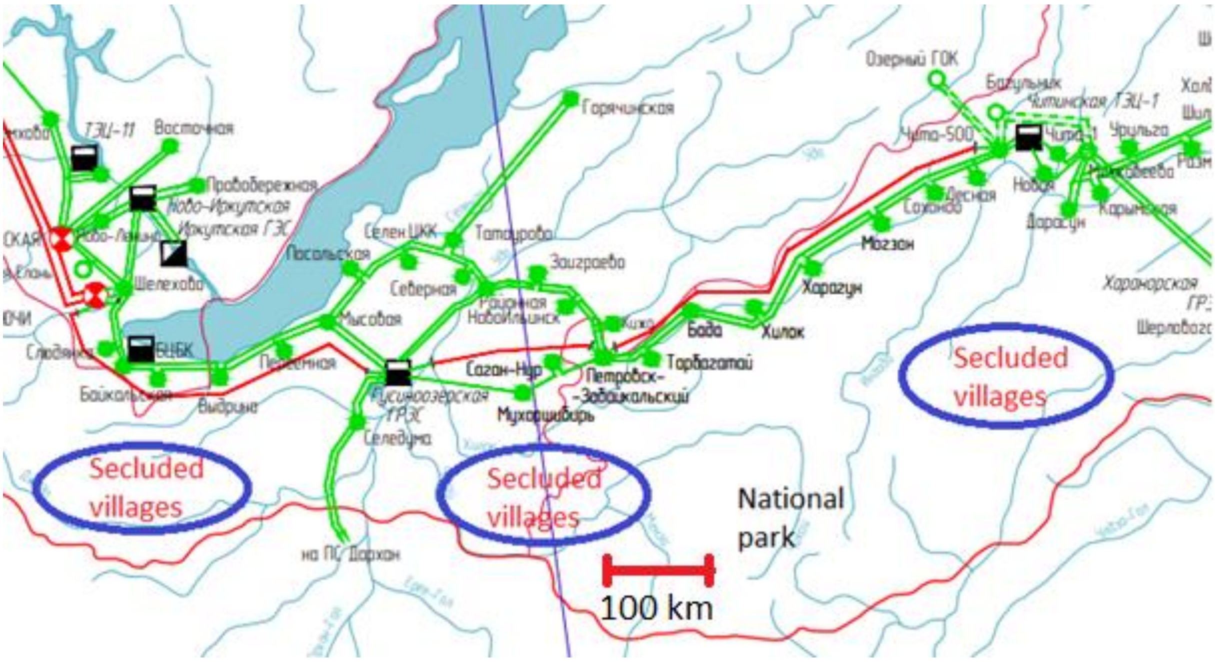


Figure 31 – Diesel-electrified villages zones in Eastern Siberia

They receive subsidies for electricity prices and are located within regions with tariff regulation, meaning that the electricity price is set and not market regulated.

Figure 32 – Electricity price zones in Russia [36]

The specific cost of electricity produced at a diesel power plant is, in principle, quite high due to the price of diesel fuel - the retail price of diesel fuel for generators is approximately 45 rubles per liter. In the case of the northern regions of Russia, the price increases significantly due to transportation costs.

On average, according to the Nordic Ecobusiness Center, the cost of diesel for the northern regions is at least 70 RUB / kg. These data are confirmed when recalculating large-scale purchases of diesel fuel, for example, in table 3.1, for example, the Khabarovsk Territory Administration, for example, in 2019 reported that diesel purchases were made at a cost of 71500 RUB (per 1 ton, but basically, you can find out about procurement prices only by checking the register of public procurements of an enterprise that enters into supply contracts, so, according to such data, the Nenets Autonomous District purchased diesel fuel at a price of 80,131 RUB per 1 ton. [37]

In general, the list of examples of diesel purchases with transportation by northern and secluded regions for year 2019 according to the information I found in the government procurement registry looks like this:

Table 7 – Diesel fuel purchase examples from Russian State Purchase Register [37]

Region	Diesel fuel amount, [t]	Price, [RUB]	Specific price [RUB/t]
Chukotsky AR	-	245219983.92	-
	4600	386124000	83940
Yamalo-Nenets AR	880	62837839.68(*)	71447
Nenets AR	11510	922313189.05	80131
Kamchatsky kray	-	346929218.16	-
Khabarovsky kray [ ]	-	-	71500
Arkhangelsk region	2000	105762000	52881

Often it is not possible to track down the specific price of diesel fuel in such contracts, because diesel fuel, gas, machine oil etc. are generally bought together and go under the name of “oil products”.

Unfortunately, the regional and federal budgets in their financial reports do not separate subsidies to energy producers in the northern regions in separate sections from other municipal organizations, therefore it is easier to establish the amount of subsidies for fuel according to a comparison of data on the cost of its purchase and transportation and compare it with the cost of electricity generated , taking into account that these cost items are almost 100% of the cost of production. The information from the map is comprised in the table below it.

Generally, there is no register on installed capacity and power production this map is the only source on full amount Russian Arctic production. That is why I have no reason not to trust it. All these regions are estimated to consume about 1 million tons of diesel fuel.

At the same time a significant part of that energy doesn’t reach the customer due to bad condition of transmission lines. According to the electricity consumption report from Amderma village in Nenets AO, the average yearly energy losses on the way from production to the customer are 18,2% [ ]. In the lack of other comprehensive data on losses by electricity production In polar and secluded areas, I assume that value to be pretty much universal across the Russian Arctic with diesel production.

This means that basically the local governments subsidy the fuel even more than they could and according to the report of Amderma village the specific diesel fuel consumption estimate per 1 kWh delivered to the customer is roughly equal to:

$$g_{cons} = 0.269 \left[\frac{kg}{kWh}\right]$$

Taking into consideration the price of fuel for the Nenets AO which is 80131 RUB/t, which makes it 80.131 RUB/kg, I estimate that the cost of 1 kWh of electricity delivered currently is approximately:

$$Price = g_{cons} * \ Fuel\, price\, per\, kg = 0.269 * 80.131 = 21.56 \left[\frac{RUB}{kWh}\right] \quad (3)$$

But these regions have governmentally regulated tariffs, which are set at much lower levels, here is the table of electricity prices for the regions that receive their energy from diesel. It means that the operator of the so-called "Severny Zavoz" (Северный завоз), which is the program according to which the fuel and products are shipped to these regions, do not receive enough compensation for their expenses, thus they need to be subsidized.

This results in yearly expenses of about 80 billion roubles. But not only diesel costs a lot of money, it emits a lot of CO_2 and creates a significant basis for climate change. For example, according to the IMF report from 2015,

The general production in Russia has practically not been connected to renewables in the time most of the countries were rapidly installing it and only recently the Russian government has started to show interest in renewable investments. But the production share scheme for Russia, pictured below, shows that there still is a lot to be done to even reach a couple percent of production.

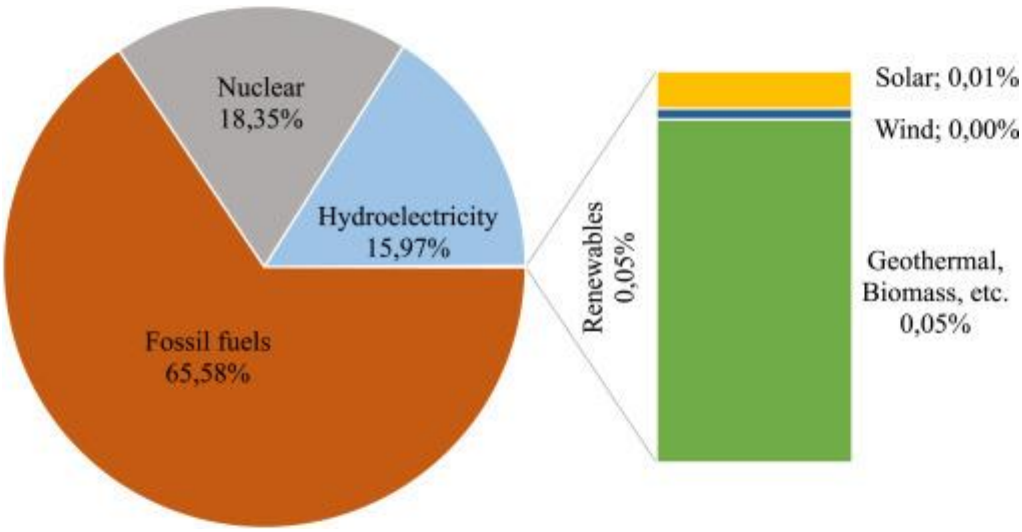


Figure 34 – Production share diagram in Russia by source [36]

Russia also faces a problem with a big percentage of power stations in cities being too old and either needing renovation or complete rebuilding. For example, the wear of power stations and boiler houses in Western Siberia reaches up to 80% and the situation in European part of Russia is not much better – the average wear of power stations equipment is estimated at a level of 65%. Even though the government introduces modernization programs with yearly quotas for renovation amount which must be met and are met, this program is receiving heavy critique in the field because it generally ends in renovation of those power stations that need the lowest amount of investment, thus the oldest and most worn out stations become the last in the renovation queue. For example, none of the power stations in Murmansk and Tver regions, which are more than 50 years old, is going to be renovated at least till 2024, the same goes for stations in Saratov region (45 years old) and Republic of Tatarstan (43 years old). Moreover, it is open to discussion whether some of the objects needed an urgent renovation at all, as 5.5

GW out of 8.6 GW to be modernized by 2024 are younger than an average power station in Russia (33 years) and with the overall budget of 1.9 trillion rubles till 2025 and the yet unknown sum for the second stage of the program it may prove to be an immensely big sum of money not very well spent.

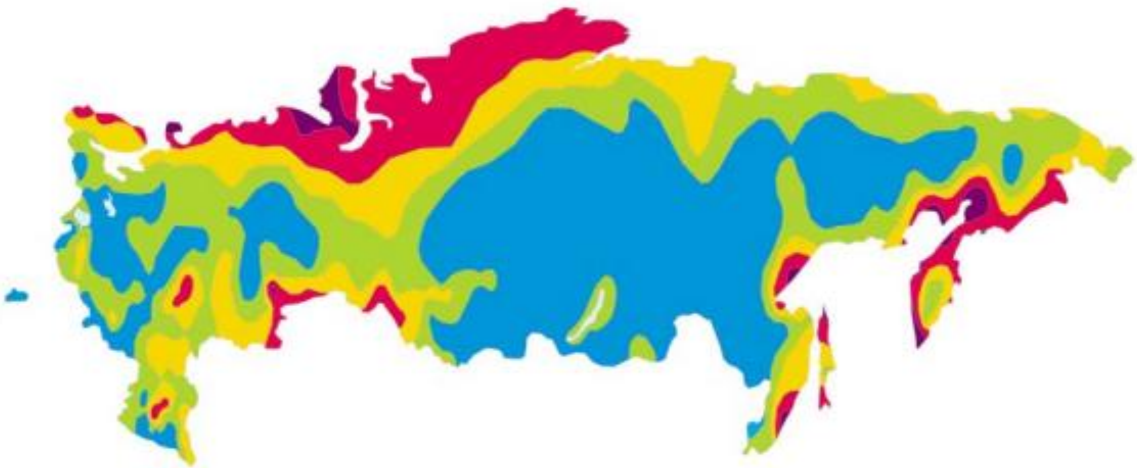
At the same time most of these regions have big prospects for usage of renewable energy. For example, the majority of European Russia, especially the southern part of it, produces a lot of biowaste, which can be used for biomass or biogas power stations, which can massively decrease the production burden for power stations using fossil fuels in these regions; as well as coastal cities like Murmansk have a big wind usage potential and such cities as Kazan located relatively to the south of Russia may benefit from solar energy.

It has also become a trend recently that many Russians move to live to the south to cities on the coast of Black Sea or nearby, such as Krasnodar, Sochi or Rostov-on-Don; as well as to Moscow and its suburbs, meaning that demand for utilities in these cities increases every year; these regions already have to import energy from the neighboring regions and the situation will only worsen, for example the forecast for Krasnodar is that the energy consumption in the city will increase by more than 12% by as soon as 2023. It has also faced the decrease in energy production in 2019 compared with 2018, which makes the situation even graver. Ironically, the south of Russia is in a perfect position when it comes to renewable sources, not only it has a lot of sun and sufficient amount of wind energy from the coast of Black Sea, but also these regions are highly agricultural which creates a lot of prospects for biomass and biogas power production.

3.2 Renewable potential

At the same time Russia has a lot of renewable potential, which just needs to be unleashed and, more importantly, in some cases as with diesel plants in the North, it will make the government save money.

In this part I want to discuss the potential of renewable sources of energy, especially in the non-electrified areas, as they will be of biggest importance in my proposed program.



	Sheltered terrain m/s	Sheltered terrain W/m²	Open terrain m/s	Open terrain W/m²	Sea coast m/s	Sea coast W/m²	Open sea m/s	Open sea W/m²	Hills and ridges m/s	Hills and ridges W/m²
■ (purple)	>6.0	>250	>7.5	>500	>8.5	>700	>9.0	>800	>11.5	>1800
■ (red)	5.0 6.0	150 - 250	6.5 7.5	300 - 500	7.0 8.5	400 - 700	8.0 9.0	600 - 800	10 11.5	1200 - 1800
■ (yellow)	4.5 5.0	100 - 150	5.5 6.5	200 - 300	6.0 7.0	250 - 400	7.0 8.0	400 600	8.5 10.0	700 1200
■ (green)	3.5 4.5	50 - 100	4.5 5.5	100 - 200	5.0 6.0	150 - 250	5.5 7.0	200 - 400	7.0 8.5	400 700
■ (blue)	<3.5	<50	<4.5	<100	<5.0	<150	<5.5	<200	<7.0	<400

Figure 35 – Wind potential of Russia [38]

Wind potential may be one of the most important mediators on the way to investing in Russia's energy resources. The north coast is largely not connected to the grid and is a subject to diesel subsidies, which put an enormous burden on local and sometimes, consecutively, federal budgets.

Source: http://ecoclub.nsu.ru/altenergy/images/karta2.gif

Figure 36 – Solar potential of Russia [38]

Russia has a lot of solar resource, especially in the south which is not surprising, but at the same time the middle part of Russia can also benefit quite highly from solar installation, because, for example, of cold, which affects the solar performance well. A lot of good solar sites are also situated in remote Siberian sites, which creates possibility for off-grid installations and thus savings on diesel fuel. The southern parts of Russia can produce about 1300 kWh year 1 kWp in the south and about 1000 kWh per 1 kWp in middle Russia. Northern Russia is generally subject to polar nights and irradiation levels there are quite low.

Figure 37 - Russia geothermal resources [38]

Russia has considerable geothermal resources, which are mostly situated on Kamchatka peninsula, Kuril islands and Sakhalin island at the east of Russia, the potential of the cites are up to 9 MW per site and in case of enough to supply themselves only by using geothermal energy.

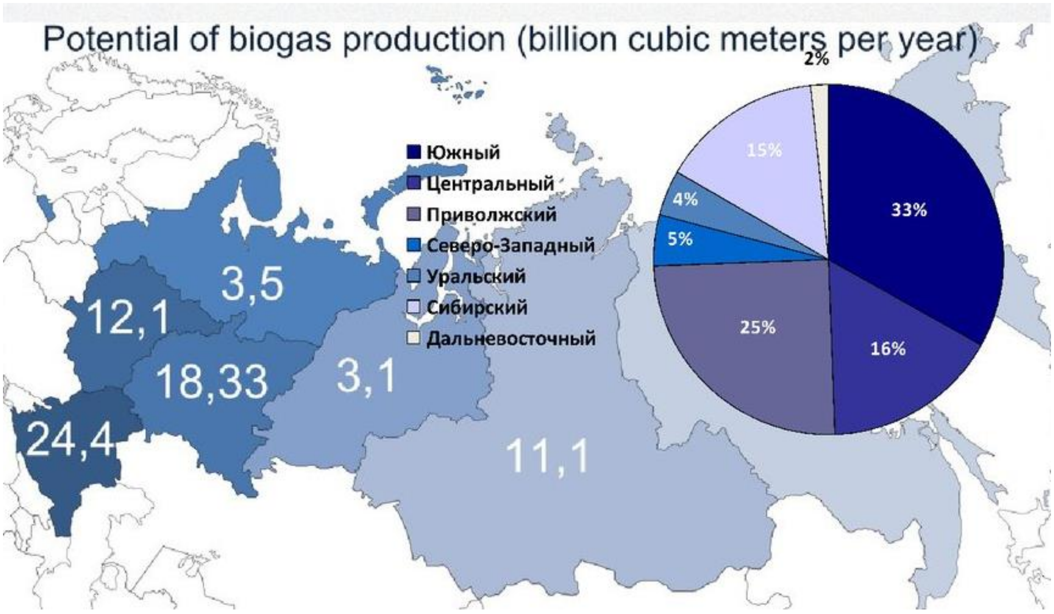


Figure 38 – Biogas potential in Russia [39]

Russian Western and South-Western regions are highly agricultural and industrial, which creates a lot of possibilities for biogas and biomass usage for energy production. Moreover, due to cross-subsidizing of electricity tariffs in Russia, the low tariffs for the population are provided by the higher tariffs for enterprises which pay 2-3 more than the population for the same amount of electricity. This has led to precedents where enterprises, especially the ones of the agricultural sector decided that loaning money to transition to biomass or biogas energy would cost them less without any government support than continuing to pay for the bills, even though all the equipment has to be imported.

3.3 Current legislative base

Currently there are two decrees in Russia implying support for renewable investments, Decree 449 from as support for investors who will take part in wholesale market, and Decree 47 from 23.01.2015 for private investments.

Analysis and main provisions of Decree 449

The Decree No. 449 establishes the support mechanism for renewable electricity deployment through capacity markets. Selected renewable power projects receive capacity payments for a period of 15 years for maintaining readiness to generate electricity on demand. In the case when power plants will not be able to meet previously agreed availability requirements, their capacity remuneration levels will be reduced accordingly.

Auctions are being held on an annual basis to award these capacity remuneration contracts. For now, only wind, solar PV and small hydropower plants are eligible to participate and biomass is excluded from the support.

In order to be eligible to participate in the auctions, proposed projects must be equal to or exceed 5 MW; hydropower plants cannot be larger than 25 MW. [20]

Contracts are awarded to projects with the lowest capital costs. Eligible proposals also have to comply with high local content requirements:

How is it calculated:

Every year, the commercial operator of the wholesale market, taking into account the features provided for by the agreement on joining the wholesale market's trading system, calculates the rate of return on capital invested in the generating facility for the i-th year (NDi) according to the formula:

$$R_i = (1 + R_b) * \frac{1 + RI_{gi}}{1 + RI_o} - 1, \ (4) \ [40]$$

Where:

R_i - the basic level of the rate of return on capital invested in a generating facility, set at:

14 percent - for generating facilities, investment projects for the construction of which were selected during the competitive selection of investment projects for the construction of generating facilities, operating on the basis of the use of renewable energy sources, carried out before January 1, 2016; [40]

12 percent - for generating facilities, investment projects for the construction of which were selected during the competitive selection of investment projects for the construction of generating facilities operating on the basis of the use of renewable energy sources, conducted after January 1, 2016; [40]

RI_{gi} - the average profitability of long-term government obligations used in calculating the price of capacity for capacity suppliers, determined for the i-year in the manner established by the federal executive body, which carries out the functions of developing state policy and legal regulation in the field of analysis and social economic development; [40]

RI_o - the basic level of profitability of long-term government obligations, set at 8.5 percent. [40]

The calculation of the component price for the capacity of generating facilities, ensuring the return of capital and operating costs in the i-th year (KEi), is determined by the commercial operator of the wholesale market in accordance with the features stipulated by the agreement on joining the trading system of the wholesale market, according to the formula:

$$KE_i = \left(\frac{R_i * ND_{i-1}}{1 - NP} + r_i\right) : 12 + ER_i \ \ (5) \ [40]$$

Where:

R_i is the amount of invested capital at the beginning of the i-year; [40]

ND_{i-1} - rate of return invested in a generating facility, operating on the basis of the use of renewable energy sources, capital for the year preceding the i-th year; [40]

NP - the calculated value determined in accordance with the agreement on joining the trading system of the wholesale market, taking into account the corporate income tax rate used to calculate the amount of corporate income tax to be credited to the federal budget, and the corporate income tax rate used to calculate the amount of corporate income tax payable to the budget of the respective constituent entity of the Russian Federation; [40]

r_i is the amount of return on invested capital in the i-th year; [40]

ER_i - the product of the operating costs determined for the corresponding type of generating facilities and the i-th year in accordance with paragraph 7 of the Rules for determining the price of power, and the share of costs compensated by the payment for the capacity of generating facilities, determined in relation to this generating facility and in relation to the i-year in the manner prescribed by Appendix N 1 to the Rules for determining the price of capacity. [40]

In order to receive the full payment for energy provided, the tender applicant has to ensure the following share of the local equipment requirement. Appendices of Decree 449 specify which parts correlate with what percentage of the whole installation, thus creating no ambiguity for the calculations. Failing to do so will lead to non-admittance to the tender or cancellation of the contract. The requirements table varied from year to year to ensure that the companies taking part in the tender have time to adapt to the final requirements. [40]

Table 8 – Minimum local content requirement according to Decree 449 [20]

Minimum local content requirement	Year
Wind farms over 5 MW:	
35%	2014
55%	2015
65%	2016-2020
Solar PV over 5 MW:	
50%	2014 to 2015
70%	2016 -2020
Small hydro over 5 MW:	
20%	2014 to 2015
45%	2016-2017
65%	2018-2020

Projects selected through the auction system are to sign “Agreements for the Supply of Capacity” where the price level of RES capacity and the duration of capacity supply are specified. As mentioned above, the price for the RES capacity can be lowered in cases when the plant is unable to provide agreed power capacity.

The Decree No. 449 and the Art. 32 of the Federal Electricity Law guarantee priority purchase for the renewable power. [40]

In order to control the increase of newly added renewable generation capacities, and thus the mechanism’s impact on electricity prices and the costs of the mechanism, the Resolution No. 861 of May 2013 has been adopted. The Resolution established yearly limits for new renewable generation capacity up to 2020 (expressed in MW):

Table 9 – Installation amount per year in MW according to Decree 449 [20]

	2014	2015	2016	2017	2018	2019	2020	2014 - 2020
Wind	100	250	250	500	750	750	1 000	3600
Solar	120	140	200	250	270	270	270	1520
Small hydro	18	26	124	124	141	159	159	751
Total	238	416	574	874	1 161	1 179	1 429	5 871

The installations have not been yet put into work, so it is hard to determine whether the decree is going to successful, however, it is criticized now for it is encouraging building renewable plants in the places where they are not especially needed, but it is easier to fill the necessary requirements for capacity factor thus ensuring the payment for the bidder even if the energy produced is not needed by the local energy operator. Moreover, the formulation of the decree makes it impossible to install the plants in the government-regulated price zone thus making 65% of the country unsuitable for installation.

Government Decree 47

Since 2015, decree no. 47 prescribes that five percent of the energy compensation should come from renewable energy sources. Although the localization requirements for the generation of renewable energy for this purpose are not formally applicable, the price for energy is significantly higher if the requirements are met.

- Sphere of regulation: RES facilities on retail electricity markets (<25 MW) [41]
- Technology: Wind – Solar – Small Hydro – Biomass – Biogas – Landfill gas
- Who will benefit: Winner(s) of the annual competitive tenders of RE investment projects to be included into the regional electricity master plans
- Basis of payment: Electricity production (kWh)
- Terms of payment: Tariff for electricity produced (RUB/kWh)
- Limits of final payment: CapEx – OpEx – Capacity Factor – Local content – Qualification – Certification – 5% of network losses
- Payback period: 15 years
- Projects are tendered on the regional level (regional master plan)
- Regional authorities must adopt master plans before May 1 on an annual basis.
- General principles for the competitive selection:
    - End user tariff growth reduction
    - Volume of RE electricity produced is below 5% of network losses
    - Minimization of environmental damage
    - Solving of social problems in the region
- Public disclosure and transparency [41]

Restrictions:

- CapEx – not higher than the limit set by Decree 47
- From January 1, 2017 the facility must meet local content requirements. [41]

Decree 47 for isolated zones

Differences in government support:

- No limitation to 5% of losses
- No limitation in CapEx and OpEx
- No local content requirements
- The RE electricity is purchased by the last resort supplier [41]

Unlike Decree 449, that has not yet received a final verdict, mainly due to the fact that the plants are not yet built and receives mixed reviews from the analysts noticing how some issues are tackled well and others not so much, the Decree 47 is generally declared as unsuccessful and not reaching its goal. Among the main problems are listed the need for certification in the region main city or Moscow which makes it hard for remote sites to participate, vague requirements that inflict uncertainty of the application approval, no help with initial investments that is important in Russia as the incomes of households and enterprises are not big, especially in regard with imported goods as ruble has been significantly devaluated over the last years. Moreover, in the atmosphere of uncertainty about the future of their businesses and incomes, owners and people generally do not wish to invest in renewables. The requirement for the local content also hinders the renewable development as the Russian-made renewable equipment is considerably more expensive.

3.4 Financial situation

Income level is viewed as an essential factor to look at when considering the future success of renewables in a country. Renewable energy can not be considered a part of essential needs, therefore whether the population and enterprises will support and use renewables for electricity production highly depends on the income level and the living standard.

The average monthly salary in Russia is estimated as 37900 rubles after tax as of 2019, which is 465 EUR as of 2020. Such a salary is certainly insufficient to expect that the population will invest into renewables without help for initial investment. For example, the Russian-based local content requirement fitting HEVEL Group smallest grid connected 1.12 kWp package costs 94190 RUB (1155 EUR) [42], which is more than twice over the salary amount and the one of 15.12 kWp costs 844790 RUB (10361 EUR). These prices are not affordable for an average Russian and there are currently no incentives to help that.

Moreover, many renewable technologies are very scarcely represented on the Russian market, thus making it hard for purchasers to fulfill the local content requirement and significantly increasing the prices not only because of shipping but because local producers don’t have enough competition.

Current situation in Russian energy sector, forecast and its impact on renewables

But not only low salaries, incomes and uncertainty hinder the introduction of renewables. Renewable energy sphere is a subject to a so-called "lobby effect" [43], where the countries with influential fossil fuel producers lag behind in the transition towards the cleaner energy not only because they don't need it in the short run, but for another reason. Mainly, fossil fuel producers in such countries are major taxpayers and policy influencers; they also have impact on many industries in the country. Fossil fuel can also be a great source of influence for a country in the world, when exported to other countries. Easily obtained source of money also creates an atmosphere where the government does not to modernize their economy and energy sector in particular, because they have a steady income of money already. In Russia fossil fuel producers are very influential and close to the government thus making it harder to promote and implement renewable energy support schemes.

All the main fossil fuels (oil, gas and coal) are produced in Russia today and regarding the position of the fossil fuel in the means of production as a commodity and usage for electricity production not much is going to change at least until 2040, both according to the forecast for countries by British Petroleum and recently published Russian Energy Strategy – 2035. The main outline of the Russian position on fossil fuels is to capitalize on them as much as possible while they are still relevant, so the plan is to even increase the production and direct additional financing on new oil and gas fields development as the country is running out of the old ones, mostly discovered in the times of the Soviet Union.

Below you can see the forecast of production as a commodity and energy production by source in Russia till 2040 performed by British Petroleum:

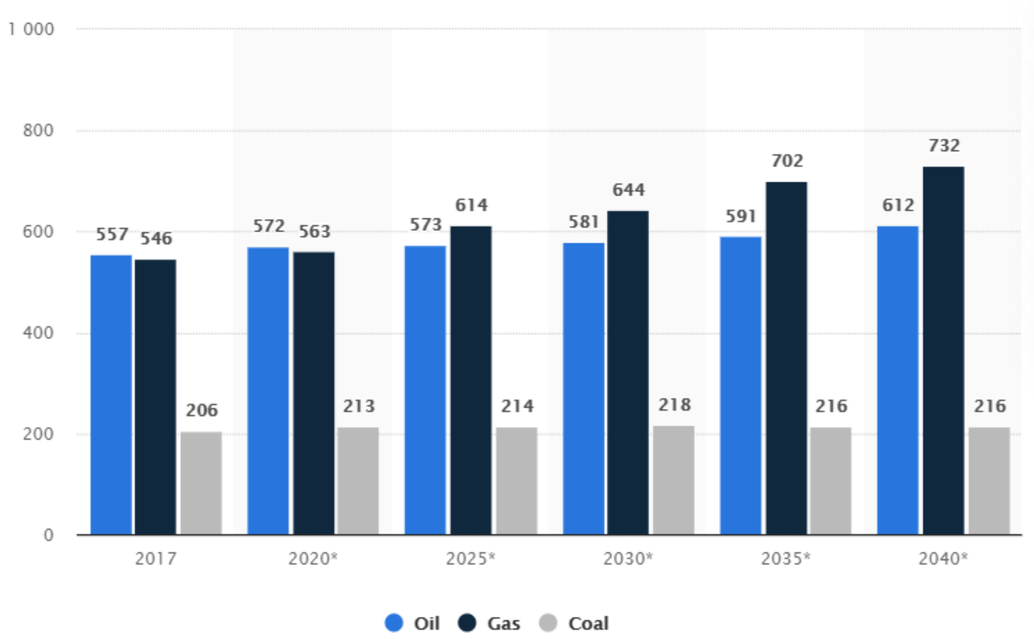


Figure 39 – Production by source in Russia till 2040 in million metric tons of oil equivalent [44]

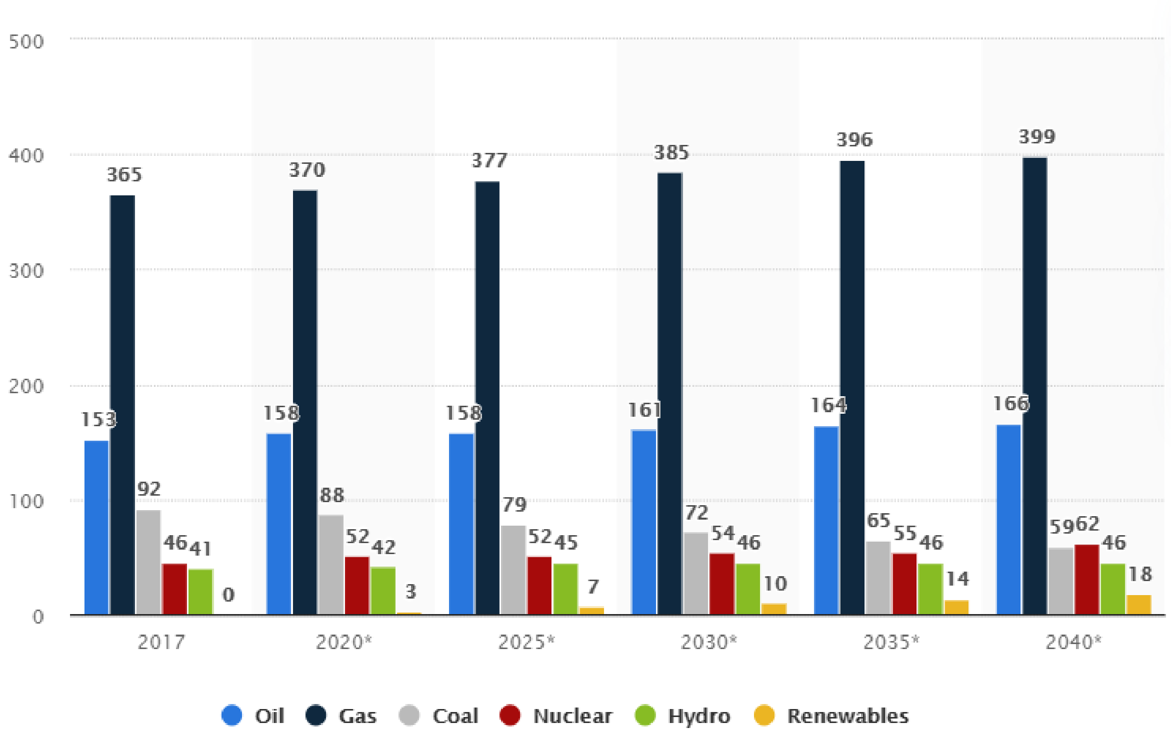


Figure 40 - Energy production volume forecast in Russia till 2040 by fuel in million metric tons of oil equivalent [44]

Generally the current and future situation with fossil fuels in Russia means, that the main priority in renewable energy introduction in the country must be started in the applications where industrial-sized fossil fuel energy production can't really compete with renewable energy. Mainly these are:

- Usage of diesel fuel in polar and secluded settlements – costly, incredibly bad for the environment, needs complicated logistics and is unreliable and hard to fix in case of force-majeure such as early icing of rivers or generator breakdown. It also urges people to use electricity very rarely and hinders the development of the Russian Arctic in general
- Small-scale residential and commercial use – with a bit of initial help, solar panels and wind installations can be less costly than grid electricity, especially in the case of commercial users as their tariffs are significantly higher in Russia
- Self-sustaining production – enterprises in particular spheres such as agriculture are able to supply their own energy at smaller prices than it would be if they used grid electricity
- Help decreasing the burden in energy deficit regions where the situation is not expected to become better in the nearest future, such as Russian Black Sea coast

Using the best practices from the other countries I have examined in the Chapter 2 and setting the main problems to solve as well as currently present development-hindering factors, I proceed with proposing the support scheme for renewables in the Russian Federation in the Chapter 4.

4 Proposing governmental support scheme for renewables installation in Russia

The main reason why a government introduces a renewable support scheme is the will to fulfill its strategy goal, thus it should be outlined in the very beginning of the government support scheme.

Unfortunately, the Energy Strategy – 2035 is still in development and the previous energy strategy will be not valid for the upcoming period. Though the latest variant issued on 18.12.2019 does not cover any specific renewable production goals, it declares the will of the government to decrease the cost of the energy for decentralized regions by 17% by introducing more renewable capacities in the field. [45]

The version issued in October outlines the goal on renewables at 28,7 TWh, which is 2,7% of today's production of 1049 TWh and is going to comprise 2,07% of production according to plan of the energy ministry. [45]

I am going to complete both of the tasks, so here is the outline of the strategy.

Table 10 – Russian Energy Strategy 2035 Renewable Objectives [45]

Year	Total Electricity Production [TWh/year]	Renewable Electricity Production [TWh/year]	Decrease of energy production cost for state-regulated tariff regions [regarding the level of 2019]
2019	1049	2 (+ approx. 13.3 according to Decree 449 results allocation by 2025)	-
2035	1380	28.7	17%

4.1 Proposal of government support program plan

The main problems of Russia energy sector and subsidy priorities:

1. Decrease the dependence of polar and secluded regions from extremely expensive diesel fuel usually delivered in summer by sea or rivers.
2. Introduce a diversified support scheme for grid-connected installations of different scale.
3. Support scheme should be clear and transparent in the long term, to ensure confidence of investors and facilitate the emergence of renewable industry.
4. Incentivize the biogas and biomass production and address the issue of agricultural waste in Russia.
5. Introduce an auction scheme facilitating solution of energy challenges in Russia as an alternative to Decree 449 scheme.

According to my proposition, the funds of the governmental support should be allocated between these points according to their priorities. Firstly, they are designed to ensure that everybody gets a stable electricity supply, which should always be a number one priority and secondly, the government energy strategy 2035 states that one of the criteria for renewables is to decrease the production cost of electricity by 17% till 2035.

Funding

The government of Russia has declared their plans to allocate 400 billion rubles in current prices into renewable energy till 2035 with exception of financing the renewable installation, which are already being built according to the Government Decree 449. [40] This roughly means a yearly budget of 26.67 billion rubles. As the government of Russia has no goals to decrease gas, oil and coal production – and the latter will even increase and has no goal of CO_2 emission reduction in the current version of their strategy, implementation of additional funding via CO_2 allowances is not realistic. Moreover, the payments for reducing CO_2 emissions are currently not recognized by Russian tariff law. [46]

Another variant of additional funding is introducing a renewable tax into electricity bills. A significant change though could create protests as it happened with a recent pension age increase in Russia, because general situation stability and low electricity and gas prices are a crucial pillar of today's Russian government rating in the situation after ruble exchange rate plunge.

However even the smallest of renewable taxes will create a lot of funding and not aggravate the people. Today 146,5 TWh is consumed yearly in Russia for residential use. [45] Current tariffs are 3-8 RUB per kWh and increasing them by 0.1 RUB per kWh would result in additional 14.65 billion rubles yearly, thus increasing yearly incentive budget by 54,9% and increase electricity tariffs by only 3,3% at the biggest.

I consider establishing renewable tax at the level of 0.2 RUB/kWh in case the current budget will not be enough, as it would unlikely to be viewed as a big change and at the same time increase the renewable budget more than twice.

4.2 Polar diesel production

The program summary presented in the end of the part.

The first part of the program is designed to provide renewable energy to polar and secluded areas of Russia, which are generally supplied by diesel fuel. The cost of diesel for electricity production is quite high by itself and due to long and complex shipping mechanism called "Severny Zavoz", which can be translated as "Northern Delivery", it increases by 50-80%, according to fuel contracts from these regions according to Russian purchase register and generally reaches prices up to 90000 RUB/t. In addition to that diesel fuel is very harmful for the environment.

There have been many discussions about the incentive methodology for secluded regions, the main idea being incentives based on payment according to cost saved by not using diesel fuel, the so-called "avoided costs". [46] The idea Is that the funds allocated for diesel fuel could be transferred to finance the renewable incentives in case of diesel consumption reduction. This would need no additional funds allocation to the ones that are already there.

The avoided cost incentive can be provided in different ways and will have different issues:

- Full or partial compensation to the investor for avoided diesel cost – can vary greatly according to changes in yearly transportation services, location or efficiency of both renewable source and diesel generator (meaning older and used generators may consume more diesel, thus creating a possibility of bigger incomes for the same value)
- A compensation too big can create a problem of not very effective allocations
- Payments for avoiding environmental damage are not recognized by Russian tariff law and are emission decrease is not included in Russian energy strategy; these payments can also be very variable

The fluctuations in payment levels can be significant, especially the ones concerning transportation, for example the local government of Khabarovskiy kray has announced that their new transportation contracts have decreased its costs by 23%. This can induce additional risks for the investors and scare them away.

This issue can be resolved by introducing Energy Performance Contracts between the investor and an energy service company, which can mitigate the risks according to:

- Full or partial savings amount paid to the investor till payback, then the service company takes over the responsibilities over the place;
- Ensuring the minimum level of compensation that the investor will receive in a certain period of time [46]

On one hand, these incentive design can ensure significant and fast profits for investors and no money loss for the government and local governments as they would end up paying the same amount of money, but on the other – create a very massive and rapid inflow of not very cost-effective decisions, which will result in more expenses after the service company will take it over. For this reason, it would make sense to not set a compensation amount too high so that it only pays back in the case of a good investment, but depending on the place the necessary amount will always be different and will depend on various circumstances, thus difficult to estimate correctly. This can also create a very bulky system where every tariff has to be calculated distinctively and recalculated every year which is difficult to keep track of and hard to maintain.

Another way is to improve this scheme by adding both place-specified and not-specified auctions with setting the maximum compensation ceiling for the saved diesel amount; with the offer to set the compensation for a kWh produced. This can be considered a safer version of the incentive, as with sufficient offer and installation capacity cap set it will ensure that only the most cost-efficient projects will be installed, and the incentive realization will generally be more controllable and driven. On the other hand, it will likely draw less investments.

In both of the cases, the money saved on diesel purchase shall be allocated to the grant fund, designed to run the whole program, help maintaining the installations and also fund other necessary projects in the secluded areas of Russia, which are of no great interest to investors, such as local transmission lines renovation or very remote villages.

As a kind of combination between the approaches, I would like to implement a combined scheme. In a matter of one project per locality, the investment projects shall be submitted to the regional department of the grant fund which will be responsible for maintaining the program in the

Russian Arctic. On the previously agreed upon date the best project is chosen and given 36 months to be implemented.

These projects will also be exempt from tax and be eligible for government supported 0% interest loan with no upfront cost. But it is also set with some responsibilities – the installation shall be made no longer than in 36 months after loan allocation date (or equipment purchase if the loan will not be used), otherwise a system of fines is prescribed in the total value of:

- 1% of the project cost (not included in the payback calculation) in case of delay from 2 weeks to 3 months
- 3% of the project cost in case of delay from 3 up to 6 months;
- 5% of the project cost in case of delay from 6 to 12 months;
- Discontinuation of the contract for installation after 12 months will all loan responsibilities switched to the investor.

Grant fund and its responsibilities

Grant fund will need personnel responsible for each region where the program takes place, that will be 16 regions. They will be responsible for:

- maintaining full database for the program and providing it to investors when necessary;
- providing training and education on installation and maintenance of the equipment;
- repair and maintenance;
- provide certification of projects before installation and systems after installation;
- responsible for selection of investors;
- in the end of the program the grant fund will have all the sites under its control and will be responsible for recycling or repowering.

Grant fund will be mostly funded through the amount of money otherwise spent on diesel fuel, where half of the sum goes to the investor till payback is reached and half goes to the grant fund. At the same time, organizational costs and employee salaries will appear before the investments and working projects and continue throughout the whole program, therefore the grant fund will also receive a particular sum from the whole renewable program budget yearly.

Polar program estimation on examples

Wind case

I have chosen a Condor Air 380/50-50 wind turbine of 50 kW installed power with the cost of 3289000 RUB [48] the output characteristics of the wind turbine is depicted below:

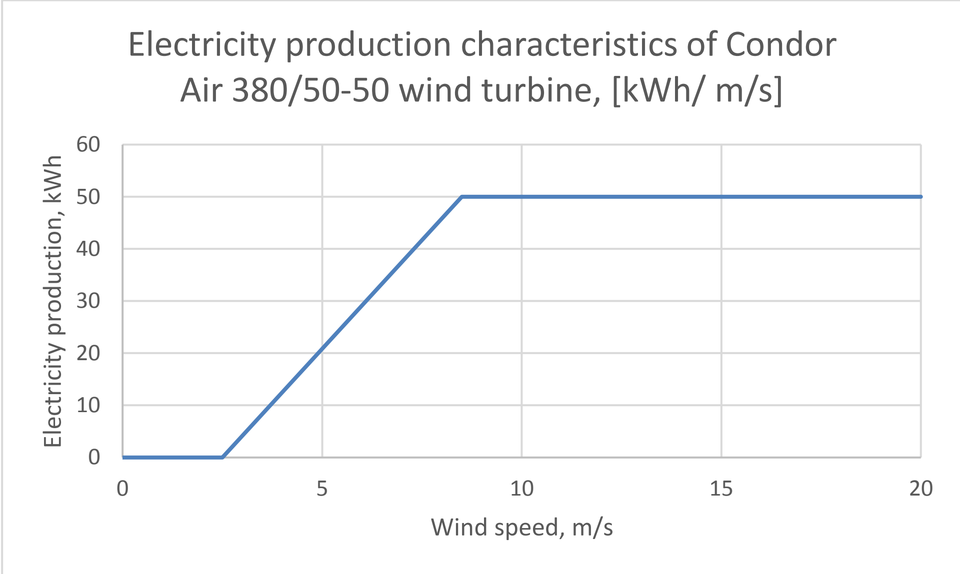


Figure 41 – Electricity production characteristics of Condor Air 380/50-50 wind turbine [47]

Estimated monthly electricity production is set according to evaluation of wind level by HOMER:

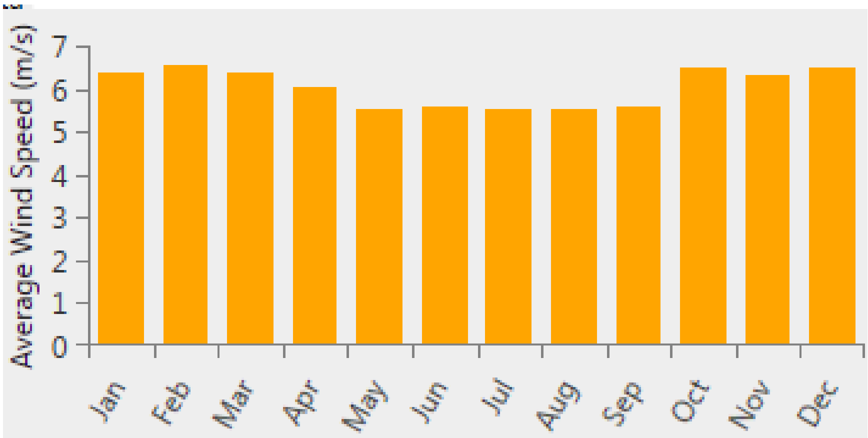


Figure 42 – Estimate of a monthly wind speed [48]

Estimated data inputs are contained below. I have included obligatory storage batteries installation in the plan, in order to prevent local diesel installation from working at below 30% load thus decreasing its life span and increasing specific diesel consumption. The minimum regulated amount of storage will have to be able to store an amount of energy produced by the renewable installation at nominal power for 2 hours, and I have chosen Delta GX12-200 lead-acid batteries of 200 Ah and 12 V, thus for this project it will amount in storage equivalent to 25 kWh according to the formula:

$$E_{storage} = \frac{W_{storage}}{U_{storage}} = \frac{100 * 10^3}{12} = 8333.33\ [Ah] \quad (6)$$

Where $E_{storage}$ – total capacity of the storage;

$W_{storage}$ – amount of energy necessary to store;

$U_{storage}$ – voltage of batteries.

The amount of batteries will then equal:

$$n_{storage} = \frac{E_{storage}}{E_1} = \frac{2083.33}{200} = 41.67 \approx 42 \quad (7)$$

Table 11 – Equipment for wind case

Equipment	Amount	Lifespan	Price, RUB	Total price, RUB
Wind turbine Condor Air 380/50-50, 50 kW [47]	1	20	3289000	**3289000**
Installation costs			+20%	**657800**
Lead-acid storage batteries Delta, 12 V 200 Ah [49]	42	12	42400	**1780800**
Additionals for correct work of diesel generator (Control box, ATS, charge controller) [50]	1	20	1300000	**1300000**
Total shipping cost			+40%	**2557360**
Total investment cost				**9608560**

As the payback period is designed to finish before it will be necessary to install new accumulators, the grant fund will take on responsibility to change them.

Operating expenditures:

Table 12 – Operating expenditures

Parameters	Value
Repair and maintenance	2% of investment excl. shipping and installation
Grant fund repair and maintenance program financing	3% of investment excl. shipping and installation

This will be set as a compulsory monthly amount of payment to the grant fund, the personnel of which will provide the repair of the installation if necessary.

Solar case

Decree 449 specifies the capacity factor for solar installations in Russia as 0,14. However, within the polar program it can be the case where solar panels will be installed in the place where it will be much lower, however the installation will still be necessary because no other kind of renewable source can provide electricity in the village. In order to simulate this, I will also consider a case where solar capacity factor is 0.085.

Table 13 – Equipment for solar case

Equipment	Amount	Lifespan	Price, RUB	Total price, RUB
Solar panel Seraphim Solar Eclipse WT Mono [51]	50	20	10000	**500000**
Installation costs			+20%	**100000**
Lead-acid storage batteries Delta, 12 V 200 Ah [49]	13	12	42400	**551200**
Additionals for correct work of diesel generator (Control box, ATS, charge controller) [50]	1	20	400000	**400000**
Total shipping cost			+40%	**580480**
Total investment cost				**2131680**

Economic parameters

Inflation value

Inflation value will be taken as the value forecasted for 2016-2030 by Ministry of Economic Development of Russia. It has taken into consideration three types of forecasts – pessimistic, neutral and optimistic, the values for inflation are 3.6%, 3.7% and 3.8% respectively. [52] I will use a neutral variant.

Thus, inflation value is 3,7%.

Tax

Tax rate in Russia is equal to 20%. [53]

Discount rate

Investor point of view

I will be calculating from the investor point of view, so the calculation for the discount rate will be done according to capital asset pricing model. The formula is as follows:

$$r = r_f + \beta * (r_m - r_f) \quad (8)$$

where r_f – risk free rate

r_m – market return

β – coefficient of sensitivity toward market movements.

According to Central Bank of Russia [54], the yield of 20 year maturity bonds is 6.67%. I will take this percentage as risk-free rate:

$$r_f = 6.67\% \quad (9)$$

According to the site [55], equity risk premium for Russia currently is:

$$r_m - r_f = 9{,}43\% \quad (10)$$

Average levered beta for green and renewable energy is:

$$\beta = 0.8 \quad (11)$$

Putting all these values into formula (8), I receive a discount rate of:

$$r = 6.67 + 0.8 * (9.43) = 14.21\% \quad (12)$$

Owner point of view

According to Decree 1470 of Russian Federation [56] the discount rate is calculated according to the formula:

$$d = d_i + \frac{P}{100}, \quad (13) \ [56]$$

where:

d_i – risk-free discount rate;

$\frac{P}{100}$ – risk adjustment.

The discount rate without taking the risk into consideration is calculated using the formula [56]:

$$d_i = \frac{1 + \frac{r}{100}}{1 + \frac{i}{100}} - 1, \quad (14) \ [57]$$

where:

r – refinancing rate;

I – inflation rate.

The key rate of Bank of Russia is 5.50% as of 2020. According to this data, the risk-free discount rate is:

$$d_i = \frac{1 + \frac{5.5}{100}}{1 + \frac{3.7}{100}} - 1 = 1.7\% \quad (15)$$

Risk adjustment for existing technology is set to 5% according to Decree 1470 [ ], so the total discount rate is equal to:

$$d = 1.7 + 5 = 6.7\% \quad (16)$$

Based on the taken data and diesel price of 80.131 RUB/t, I estimate the payback period for investment into polar program.

Table 14 – Estimation of payback time for polar investment

Case	Production amount based on	Payback time, [years]
Wind	Wind speed graph	5
	Capacity factor (0.34)	8
Solar	Capacity factor (0.085)	

As it can be seen from the table, wind projects are paid back within the program timeline.

Table 15 - Remote and isolated villages support scheme summary

Criteria	Values and conditions
Small villages investment support	• Payment till payback policy • The investor will receive compensation yearly according to diesel fuel savings • Grant fund takes over the responsibilities over the site afterwards
Eligibility	• Eligibility of all renewable kinds
Additional support eligibility	• Payments are exempt from tax • State supported renewable loan with (0% of interest) o In order to be approved for the subsidized loan, investor needs to present the estimated amount of expenditures; o Information about local consumption and electricity production shall be collected by grant fund personnel o Loan payments will be deducted from yearly payments to investor in the minimum amount of 10% yearly
Obligations	• Establishing a minimum storage amount (2 hours of installed power level production) • Establishing a minimum diesel fuel saving rate as 30% • Installations must be put into operation no longer than 36 months after obligation taken, unless force majeure happens, such as: o Impossible to deliver equipment to the site for the reasons, not dependent from an investor, such as rivers freezing
Fines	• Delay of installation will be fined as: o Up to 3 months: 1% of the project cost o Up to 6 months: 3% of the project cost o Up to 9 months: 5% of the project cost o 1 year and more: contract termination – the loan repayment becomes the responsibility of the investor, fine in the value of the project
Funding	• Grant fund will be allocated 2 billion RUB yearly. • The rest will come from avoided costs from not consuming diesel fuel – the rest of the funds will be used on financing building of other sites

4.3 Feed-in tariff

The general trend in renewable support is moving away from fixed feed-in tariffs, because this system can not quickly adapt to changes in the renewable industry and it does not encourage increase in renewable energy competitiveness in sufficient manner. Therefore, it is advised by international organizations on renewable energy that countries adopt auction-based support schemes and, for example, European Commission guidance for the design of renewables for EU countries prescribed all European Union countries to transition to auction schemes.

However, many countries have preserved feed-in tariffs for smaller scale renewable installations, as it would be an unnecessary sophistication for domestic-scale and generally small-scale allocation. Auction participation can be quite costly and small systems can't compare with bigger ones in bid values. Thus, I will start with fixed feed-in tariffs.

Program for grid-connected renewable installations

In 2017 the government of Russia has first declared that they will introduce a feed-in tariff law and in 2020 it has presented a preliminary project of a feed-in tariff law. The law has not been passed yet and has been sent for revision, but the conditions of this edition were:

- Feed-in tariff amount is based on electricity sales to the grid according to the weighted average wholesale electricity price in the region (are in the gap from 1.5 to 3.5 RUB)
- Tax exemption for 3 years
- Only for installations up to 15 kW
- Grid priority principle
- Only private houses are eligible, no flats [57]

In order to evaluate the incentive provided by the government, I have created a standard estimate case of a solar installation in Moscow, Krasnodar and Saint-Petersburg, where I am going to export all the electricity produced into the grid. Discount rate is 6.7% and inflation is 3.7%.

Table 16 – Solar equipment for feed-in tariff evaluation

Eqiupment	Price, RUB	Amount	Total
Solar panel Seraphim Solar Eclipse WT Mono 300W [52]	10000	50	500000
Cables, connectors, additionals [50]	5% of solar panels cost = 25000		
Inverter GW-5000 DT 380V 3-phase 5 kW (15 kW) Solar [50]	134500	1	134500
Total			659500
Repair and maintenance	2% of investment cost = 13190		

The weighted average wholesale price for the region in Moscow currently is 2.65 RUB. The same kind of price in Krasnodar is 3.14 RUB. Case length is 20 years. The results are as follows:

Table 17 – NPV analysis of introduced feed-in tariffs

Parameter	Moscow	Krasnodar	Saint-Petersburg
Weighted average wholesale electricity price [RUB/kWh]	2.65	3.14	2.35
Yearly solar output [kWh]	921.39	1229.49	856.12
NPV	-504000	-295000	-567000

It can be seen that this design creates an insufficient compensation, which also varies a lot throughout the country and creates uneven profits distribution – for example, in the sunny regions of Northern Caucasus and Black Sea the weighted average wholesale electricity price for the region is higher than in Moscow and generally the level of payouts throughout the country would be very different, bearing risks of windfall profits in some regions and creating a big burden for the budget and not being able to incentivize solar panels installation in other.

It is also necessary to mention that one-technology support projects are not welcome in the analyses of renewable programs, because technological distribution is one of the pillars of green energy transition and competitiveness of the industry in the country.

Therefore, I would like to introduce my scheme for small-scale renewable installations of different technologies.

I will base the feed-in values on the concept of LCOE (Levelized Cost of Electricity). Feed-in tariff is not taxed in my project, and it should ensure faster introduction of the renewable technology in Russia. The same equipment as in the previous case will be used for solar calculations, as it represents the estimate of an average package offered on the Russian renewable market for households.

Solar feed-in tariff with zonal division

The Russian government declared that they will prefer supporting only small-scale renewable installations, ideally only up to 15 kW of installed capacity. I have introduced the 0-100 kW installed capacity so they can opt for a fixed feed-in tariff instead of participating in the auction.

I offer introducing a feed-in tariff system according to pricing zones, which I have delineated on the figure below. They are made in accordance with data from PVgis [58] on solar panels yearly electricity production for European part of Russia, Western and Eastern Siberia, and insolation maps as well as insolation data from cities in the Russian Far East.

I picked fixed feed-in tariff instead of premium one, because it eliminates the element of uncertainty in the compensation amount for the customer and makes it possible to implement the program as in the parts of the Russian grid which both belong to the two price zones and not.

Figure 43 – Solar feed-in tariff zonal division

I opted for simple transparent scheme of compensation based on geographical position and based on single value for one zone, because I wanted the scheme for domestic-scale systems to be easy-to-understand for customers and fair. I have additionally introduced bonus zones which are designed to additionally induce renewable investment in regions with energy production deficit.

As was stated in the previous part, many Russians would consider investing into renewables too expensive for them, because the sums exceed the average salary by a considerable amount. I offer introducing a subsidized loan scheme for domestic-scale solar and wind installations of up to 100 kW installed capacity with the interest rate of 3% (compared with the actual rates offered by banks of around 6%).

Calculation assumptions:

- Decommissioning cost assumed as 5% of CAPEX [59]
- Loan for 15 years, interest is 3%.

Table 18 – Solar feed-in according to zone division

Zone	Up to 100 kWp [RUB/kWh]
1	3.57
2	3.87
3	4.22
4	4.64
Bonus	0.5

Degression coefficient is set according to Swanson's law (Chapter 1) and IRENA estimation on solar investment price changes and amount of new solar installations – the value is -0.5% monthly.

Wind

Feed-in tariff for wind is calculated based on the equipment representing the estimate of an average offer on the Russian renewable market, LCOE is determined according to wind installation capacity factor of 0.28. [40]

- Capacity factor assumed as 0.28.
- Loan for 15 years, interest is 3%.

Equipment	Amount	Lifespan	Price, RUB	Total price, RUB
Wind turbine Condor Air 380/50-50, 50 kW [47]	1	20	3289000	**3289000**
Invertor 50 kW Huawei SUN 2000-50KTL-M0 [50]	1	20	267000	**267000**
Cables, connectors, additionals	2% of wind investment cost = **71120**			
Maintenance	2% of wind investment cost = **71120**			
Total investment cost				**3627120**

Table 19 – Wind feed-in tariff

Type of payment	Feed-in tariff amount [RUB/kWh]
General tariff	3.13
Bonus	0.5

It is also necessary to make the policy support scheme diverse and include many types of renewable technologies, as experience of other countries shows that more diverse support schemes are increasing the likelihood of better renewable energy introduction in the country. [6]

LCOE for further types of renewable energy will be made based on costs estimations provided by IRENA [61] for renewable development in Russia and costs estimations for different kinds of renewable energy as a whole.

Hydroenergy

Small hydroenergy is not as competitive in Russia as solar or wind power and has much lower demand, as can be clearly seen from the results of capacity allocation in accordance with Decree 449 – out of 751 MW of volume offered only 160 MW were allocated over several years.

In this regard I consider it necessary to establish the fixed and clear rules and compensation amounts for small hydroenergy of any size (size of up to 10 MW will be accepted as small) and exempt it from the necessity to participate in tenders as it is done, for example, in Germany. [18]

Calculation assumptions:

- Capacity factor assumed as 0,44. [60]
- CAPEX estimated as 200000 RUB/kW for 0-0.2 MW; [60]
- CAPEX estimated as 180000 RUB/kW for 0.2-1 MW; [60]
- CAPEX estimated as 154000 RUB/kW for 1-10 MW; [60]
- OPEX estimated as 2% of CAPEX. [60]

Table 20 – Feed-in tariff value for hydropower:

Size [MW]	Feed-in tariff value [RUB/kWh]
0-0.2	8.24
0.2-1	7.41
1-10	6.34

Hydropower prices are estimated as stable, so no degression coefficient is included.

Biomass

The Russian government declared the will to decrease the share of fossil fuel based incomes by increasing production amounts in other spheres. One of these spheres is agriculture. It generally plays a big role in the Russian economy and its significance and size in Russia is expected to grow more.

However, there is a considerable problem in Russia with agricultural waste. Yearly waste amount which is not utilized or used is estimated to be around 800 million tons of organic waste and the damage is estimated as around 450 billion RUB.

Support for electricity production from biomass and biogas could not only help the country transition towards the green energy, but also take part in solving this issue. Even though the goals for electricity production till 2035 in Russia are not very ambitious and the budget is also small, it can help bring live into industry and help it take off.

The biomass and biogas production will also be subject to technology-specific sectioned auctions, however for smaller installations (up to 500 kW installed capacity), a constant feed-in rate is offered, as it would be hard for smaller bids to compete in the auction and afford participation fees and securities.

Calculation assumptions:

- CAPEX estimated as 278000 RUB/kW [60]
- OPEX estimated as 4% of CAPEX [60]
- Capacity factor is 65%. [59]
- Fuel cost is 218 RUB/GJ [60]

Table 21 – Feed-in tariff level for biomass

Size	Feed-in tariff value [RUB/kWh]
0-500 kW	10.37

According to IRENA estimation, biomass production costs are decreasing at the speed of -0.6% yearly. [60]

Biogas CHP

For the biogas plants, also small-scale plants (0-500 kW) are subject for a fixed feed-in amount.

Calculation assumptions:

- CAPEX for manure estimated as 385000 RUB/kW; [60]
- OPEX for manure estimated as 4% of CAPEX/year; [8]
- Fuel (manure) cost estimated as 168 RUB/GJ; [60]
- Theoretical energy potential of biogas containing 50% methane is 5 kWh/m^3 and technical energy potential of electricity is 42% of the theoretical energy potential; [59]
- To simplify the calculation, only electricity and no heat were assumed to be produced, but the technical capacity is about 80% for simultaneous production of heat and electricity. [59]

- Landfill gas CAPEX is estimated as 91500 RUB/kW; [60]
- Landfill gas cost is estimated as 84 RUB/GJ; [60]

Table 22 – Feed-in tariff for biogas

Size	Type	Feed-in tariff value [RUB/kWh]
0-500 kW	Biogas	14.02
	Landfill gas	5.31

According to IRENA estimation, biogas costs are decreasing with the speed of -0.6% yearly.

Geothermal energy

According to IRENA estimations, the following calculation assumptions are taken:

- CAPEX estimated as 105000 RUB/kW; [61]
- OPEX estimated as 2700 RUB/kW/year; [61]
- Capacity factor is 0.55 [61]
- Support period is 20 years

Table 23 – Feed-in tariff for geothermal energy

Size/Technology	Feed-in tariff value [RUB/kWh]
Geothermal	3.62

As most of small villages in Kamchatka currently have diesel-based energy, the Arctic Fund from the polar part of my support program will be responsible for financing those projects. As Kamchatka peninsula is a part of Severny Zavoz program, the measures taken for the towns and villages suitable for the polar incentive program are valid for geothermal sources of energy in Kamchatka, too.

Allocation amount

Due to small budget I consider it necessary to introduce yearly allocation caps. For installations exceeding the cap in the corresponding year, no feed-in tariff will be introduced. Yearly allocation amount for fixed feed-in tariff throughout all technologies will be set as 150 MW. This will help better organize the budget and ensure that introduction of renewables is uniform.

There is now a general prescription by European Commission guidance for the design of renewables for EU countries to switch the renewable support schemes into the form of renewable auctions. Though it has no force outside the EU, the overwhelming majority of other countries around the world started using auction schemes for renewable support and it is showing great results regarding fairness of compensation and adaptation to renewable industry development in the country, unlike the previously undertaken and somewhat rigid feed-in tariff technologies.

4.4 Auction schemes

As a part of my renewable program I have dedicated a significant part of the allocation to auctions. Regular auctions help reduce the technology price in the country quite fast and ensure the long-term stability for investors and industry.

Technology-neutral wind and solar multi-criterion auction

Currently there is already an auction scheme in the Russian renewable sphere – a capacity payment based Decree 449 auction, the objects of which have not been put in use yet. However, it has already been criticized for its strictness in such criteria as local content and availability.

But it was designed for relatively big scale competitors of over 25 MW, who can compete in such circumstances. On the other hand, the local content requirement for smaller scale retail bidders who are subject to Decree 47, this is a much more complicated task and the Decree has almost completely failed to incentivize the smaller scale installation.

Russian government is very much interested that the competitors comply with this rule, but the multi-criteria auction makes it possible to implement it without completely scaring away the investors.

The auction has three criteria with weights:

- Lowest cost (0.7) – it is calculated according to the difference between the highest bid to win and the lowest, the lowest bid having the coefficient of 0.7;
- Built in the energy deficit zone (0.1) – yes or no criterion, it should encourage bidders to make installations where it is the most needed;
- Local content requirement (0.2) – calculated according to the difference between the goal local content requirement and zero. It can also have values between 0.2 and 0.3 if the value is exceeded, calculated by taking the difference between the bidder's value and 1.

As the auctions are known to discriminate against small bidders, who can not compete with their bigger counterparts and can often not afford paying participation fees having big risks of not winning in the end.

That is why there is also an auction dedicated for participants of installed capacity of less than 500 kW. However, as the allocation amount is rather small, it is also necessary to ensure that one bidder does not dominate the bidding process setting the price. That is why the upper constraint for a bid should be also set. It will be 20 MW.

Due to small budget and generally unambitious renewable goal, the installation amounts are very small – in this case 125 MW yearly. It is arguable whether such an amount of installation can really incentivize the renewable industry in the country, however, a small but consistent amount of yearly installations can achieve trust towards the sphere from investors and general population and so it could be considered a starting point for full-scale renewable introduction in the country.

Table 24 – Technology-neutral wind and solar multi-criteria auction

Criteria	Values and conditions
Installed capacity	• Over 500 kW • Not more than 20 MW per one bid
Qualification	• Price ceiling will be set as 4.5 RUB/kWh and undisclosed • Recalculated according to 50% percentile if it is below 7 RUB/kWh for the next year
Winner selection	• Winner is selected based on multi-criteria decision with weights: ○ Lowest cost (0.7) ○ Built in energy deficit zone (0.1) ○ Fulfills the local content regulations (0.2)
Responsibilities	• Participation bonds (500 RUB/kW) of installed capacity of the project or (250 RUB/kW) if the project already has a building permit • Installation should be completed in 36 months for wind and 24 months for solar • Delay of installation will be fined as: ○ From 1 month up to 3 months: 1000×kW of installed capacity ○ Up to 6 months: 3000×kW of installed capacity ○ Up to 9 months: 5000×kW of installed capacity ○ More than 1 year: contract termination, fine in the amount of project cost but no less than 10 million RUB, participation ban for 3 years • Location constraints
Allocation amount	• Fixed as 125 MW yearly

Small-scale installations

A specific auction for smaller installations has much milder requirements and smaller payment regulations.

Table 25 – Small scale installations auction

Criteria	Values and conditions
Installed capacity	• 0-500 kW
Qualification	• Ceiling price set as 5.5 RUB/kWh and undisclosed • Renumerated according to 50% percentile next year if the value is lower
Winner selection	• Lowest cost
Responsibilities	• No participation bonds • Permit acquisition expenses are compensated for projects who won a bid • Installation should be completed in 36 months for wind and 24 months for solar and biomass • Delay of installation will be fined as: o From 1 month up to 3 months: 1000×kW of installed capacity o Up to 6 months: 3000×kW of installed capacity o Up to 9 months: 5000×kW of installed capacity o More than 1 year: contract termination, fine in the amount of project cost but no less than 1 million RUB, participation ban for 3 years
Allocation amount	• Fixed at 50 MW yearly

A special auction for biomass should be also implemented, as decreasing amount of agricultural waste was one of the main goals.

Biomass auction

Table 26 – Biomass auction

Criteria	Values and conditions
Installed capacity	• Over 500 kW • Up to 10 MW per bidder
Qualification	• Ceiling price set as current biomass LCOE + 20% and undisclosed • Renumerated according to 50% percentile next year if the value is lower
Winner selection	• Lowest cost
Responsibilities	• Participation bonds (500 RUB/kW) of installed capacity of the project or (250 RUB/kW) if the project already has a building permit • Installation should be completed in 24 months • Delay of installation will be fined as: o From 1 month up to 3 months: 1000×kW of installed capacity o Up to 6 months: 3000×kW of installed capacity o Up to 9 months: 5000×kW of installed capacity o More than 1 year: contract termination, fine in the amount of project cost but no less than 10 million RUB, participation ban for 3 years
Allocation amount	• Fixed at 50 MW yearly

4.5 Adaptability of the program

According to European Commission guidance for the design of renewables support [3], auctions are considered the type of renewable support scheme most adaptable for the future changes. Due to the market-oriented structure of the incentive, the auction program pricing is transparent and flexibility is considered high.

Fixed feed-in tariff part is equipped with technology-based degression coefficients, which are designed in order to adapt the compensation amount with the changes in renewable energy costs in a transparent and predictable manner. On the other hand, they can be revisited if the tariffs do not provide adequate compensation level anymore.

4.6 Objective completion

There were two main goals in Russia Energy Strategy 2035 concerning renewables – price reduction for polar settlements and installation plans.

I consider diesel fuel price to be 38.30 RUB/kWh as it was calculated in Chapter 3. The total amount of energy produced yearly in polar settlements is 2555965 MWh. The average price per kWh produced by renewable sources of energy is estimated as 10 RUB/kWh. This way I can estimate how much energy should renewables produce yearly in order to achieve an overall 17% decrease price as it was stated in the goal. Capacity factor of installations is estimated as 0.2. The amount of energy to be produced by renewable sources in order to meet the goal in this case is:

$$Q_{RE} = \frac{Q_{total} * Price_{diesel} * Reduction\ goal}{Capacity\ factor * T_{year} * Price_{RE}} = \frac{2555965 * 1000 * 38.30 * 0.17}{0.2 * 8760 * 10} = 0.943\ TWh \quad (17)$$

According to allocation amounts in other parts of the program, I can estimate the amount of energy produced by installations contracted by 2035.

Table 27 – Amount of electricity produced in 2035 according to the plan

Part of the program	Capacity factor	Allocated amount, [MW]	Electricity produced in 2035, [TWh]
Fixed feed-in tariff	0.25	150	4.927
Multi-criteria auction	0.2	150	3.942
Small scale auction	0.2	50	1.315
Biomass auction	0.6	50	3.942
Total			14.126

Fully allocated, along with polar program these projects will increase electricity production by at least 14.248 TWh, which fulfills the goal of 13.4 TWh. If some of these amounts fail to be allocated in some years, the allocation amounts can be changed in the following years.

4.7 Costs

In this part I estimate the amount of expenditures it will take to teach the goals listed in the Energy Strategy 2035.

The support program cost is estimated according to assumption that all renewable auctions will allocate all capacity offered at a maximum possible price; the price change over years is adapted according to forecasts of IRENA.

Everybody entitled for a subsidized loan will use this possibility, the proportion of solar installations per each solar zone is taken corresponding to proportion of population in these zones.

Amount of capacity installed yearly is estimated according to the installation cap until the energy strategy goal is reached.

Costs are estimated according to three scenarios: pessimistic, normal and optimistic. In the pessimistic scenario, the renewable energy LCOE levels will stay the same till 2035, in normal they are assumed to decrease gradually and reach the total decrease of 20% by 2035, in positive – the decrease is 40%.

Table 28 – Costs estimation of support program

Type of support	Estimated cost till 2035 [billion RUB]		
	No price change scenario	-20% price scenario	-40% price scenario
Grant fund/polar project	30 + self-funding	30 billion RUB + self-funding	30 billion RUB + self-funding
Loan subsidy polar	188	169	148
Loan subsidy domestic	95	85	74
Fixed feed-in	178	139	122
Solar/wind auction	110	86	75
Small scale auction	37	29	25
Biomass auction	327	257	225
	965	795	699

In any case, the basic budget of 400 billion RUB is insufficient, additional funding will be made in form of renewable payments incorporated either into a base rate or energy bill, the total amount of subsidy will be:

Table 29 – Amount of payment for renewable energy subsidy

Payers for renewable energy	Negative scenario payments [RUB/kWh]	Normal scenario payments [RUB/kWh]	Positive scenario [RUB/kWh]
Industrial and residential	0.054	0.037	0.028
Residential only	0.387	0.270	0.204

Conclusion and policy summary

Table 30 – Support program summary

<table>
<tr><th>Type of support</th><th>Conditions</th></tr>
<tr><td>Avoided costs polar program</td><td>Compensation based on amount of diesel fuel saved according to payment till payback policy, up to 20 years</td></tr>
<tr><td>Polar grant fund</td><td>Financing renewables in off-grid sites with diesel generation, financed by avoided costs polar program</td></tr>
<tr><td>Loan for polar installations</td><td>0% interest loan with 2 years repayment-free period, to be repaid till the end of polar program contract</td></tr>
<tr><td colspan="2">Fixed feed-in tariff</td></tr>
<tr><td>Solar zonal division +
Location bonus</td><td><table><tr><th>Zone</th><th>Up to 100 kWp [RUB/kWh]</th></tr><tr><td>1</td><td>3.57</td></tr><tr><td>2</td><td>3.87</td></tr><tr><td>3</td><td>4.22</td></tr><tr><td>4</td><td>4.64</td></tr><tr><td>Bonus</td><td>0.5</td></tr></table></td></tr>
<tr><td>Wind + Location bonus</td><td><table><tr><th>Type of payment</th><th>Feed-in tariff amount [RUB/kWh]</th></tr><tr><td>General tariff</td><td>3.13</td></tr><tr><td>Bonus</td><td>0.5</td></tr></table></td></tr>
<tr><td>Hydropower</td><td><table><tr><th>Size [MW]</th><th>Feed-in tariff value [RUB/kWh]</th></tr><tr><td>0-0.2</td><td>8.24</td></tr><tr><td>0.2-1</td><td>7.41</td></tr><tr><td>1-10</td><td>6.34</td></tr></table></td></tr>
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Continuing Table 30 – Support program summary

Auctions	

Technology-neutral wind and solar multi-criterion auction	• Wind and solar bids compete with each other within the same yearly auction
	• Winner is selected based on multi-criteria decision with weights:
	    o Lowest cost (0.7)
	    o Built in energy deficit zone (0.1)
	    o Fulfills the local content regulations (0.2)
	• Allocation amount – 125 MW yearly

Small-scale auction	• Separate auction for solar and wind installations up to 500 kW installed capacity • Lower participation payments and fines in comparison with other auctions, cost is the only criteria • Allocation amount – 50 MW yearly
Biomass auction	• Technology-specific biomass auction • Allocation amount – 50 MW yearly

In this work an analysis of different kinds of renewable support schemes were analyzed, first as standalone measures and their advantages and disadvantages taken into consideration, as well as how and when they are best to be implemented.

Then these measures were analyzed as a part of renewable schemes of different countries, what are they meant to achieve, what are strategies of different countries investing in renewable energy and how successful these schemes are regarding renewable goals. I have also taken into consideration the potential of their implementation in Russia and how these measures can help in solving the current issues in renewable energy sphere. Then I outlined the main issues that need solving by the means of renewable energy in Russia and the main obstacles – the vast resource potential is scarcely used due to powerful fossil fuel producers lobby, small amount of support as well as controversial legislation and low income levels of the population.

I have set my first priority at tackling the issue of secluded villages that are not connected to the grid – they depend on highly pollutant and expensive diesel fuel and the government spends considerable sums on subsidies, so that the electricity price for the locals is affordable. I offer introducing the avoided costs compensation scheme for investors, which means that the amount paid to the investor depends on the amount of diesel fuel not used, thus saving money and the environment. The compensation would be based on "payment till payback" scheme, where the investor is paid money until he gets his money back with reasonable profit. After that the renewable installation would be taken over by the Arctic Fund, which would also be partly funded from the avoided costs of not using diesel fuel.

I also introduced a diverse feed-in tariff scheme for different kinds of renewable installations connected to the grid based on the LCOE principle – some of them needed decisions suitable specifically for Russia, such as zonal solar feed-in tariff, which is introduced due to high variety of insolation throughout the country. Also a system of yearly renewable auctions was introduced – it is designed to ensure competitive and diverse development of renewable industry in Russia, which will tackle important local issues, such as big amounts of agricultural waste in the country. Also a multicriteria auction is designed, so that installations having higher share of local content and the ones installed in problematic zones would be preferred. A separate auction for smaller installations is designed to ensure competitiveness for smaller projects that would not be able to compete otherwise and would have hard time fulfilling the criteria. Lastly, the possible costs of the measures undertaken are estimated and variants of additional funding are offered since the current budget is not sufficient to tackle all the crucial issues that can be solved in Russia with help of renewable energy sources.

It can be summed up that in many cases mentioned in this work, renewable energy sources introduction would not only facilitate the environment, but also significantly decrease energy production costs.

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