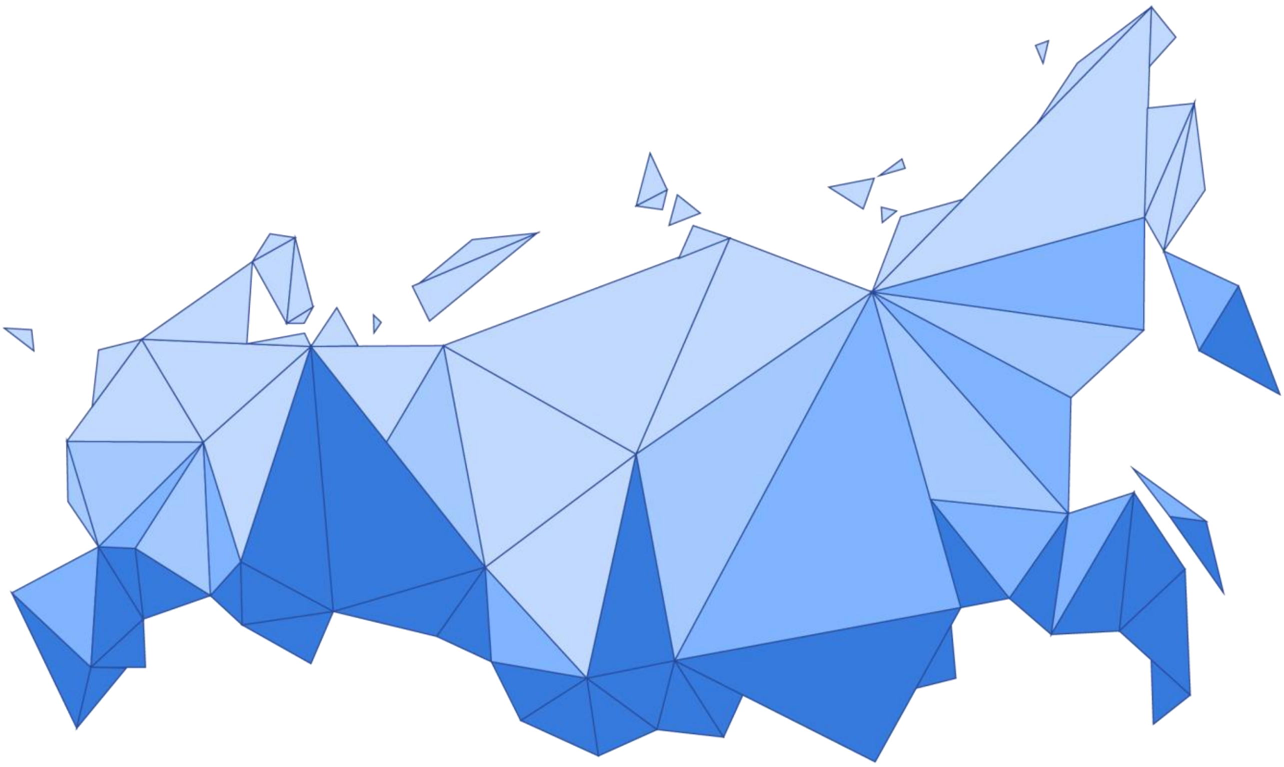
ENABLING PV in Russia



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List of Acronyms

Acronym	Definition
“a”	Per Annum
ATS	Administrator of the Trade System
BM	Balancing Market
BRELL	Belorussia, Russia, Estonia, Latvia and Lithuania
BSW	Bundesverband Solarwirtschaft (German Solar Industry Association)
CAPEX	Capital Expenditures
CFR	Financial Settlement Centre
CHP	Combined Heat Plant
CHPP	Combined Heat and Power Plant
CIS	Commonwealth of Independent States
DAM	Day-Ahead Market
DC	Direct Current
DCode	Distribution Code
DFC	Discounted Cash Flow Analysis
DSCR	Debt Service Coverage Ratio
EEG	Emeuerbare Energien Gesetz (Renewable Energy Source Act, Germany)
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EPC	Engineering, Procurement and Construction
ESIA	Environmental and Social Impact Assessment
EU	European Union
FCM	Free Contracts Market
FIT	Feed-in Tariff
FOREX	Foreign Exchange
FSA	Fuel Supply Agreement
FSK UPS	Federal Grid Operator
FX	Foreign Exchange
GDP	Gross Domestic Product
GHG	Green House Gas
GIZ	Gesellschaft für Internationale Zusammenarbeit
GOST	Gosstandard (*National Standard*)
GWh	Gigawatt hours
GW(p)	Gigawatt peak
HPP	Hydropower Plant

Acronym	Definition
HV	High Voltage
ICT	Information and Communication Technology
IDGC	Interregional Distribution Grid Companies
IEA	International Energy Agency
IES	Integrated Power Systems of UPS
IEMS	Intelligent Energy Management System
IFC	International Finance Corporation
IMF	International Monetary Fund
IPP	Independent Power Project
IRR	Internal Rate of Return
I_{SC}	Short Circuit Current
JSC	Joint Stock Company
KPI	Key Performance Indicators
kV	Kilovolt
kWh	Kilowatt hours
kW(p)	Kilowatt (peak)
LCOE	Levelized Costs of Electricity
LLCR	Loan Life Cycle Coverage Ratio
LTD	Limited Company
LV	Low Voltage
m^2	Square Meters
MDG	Millennium Development Goals
MTS	Mobile TeleSystems
MWh	Megawatt hours
MW(p)	Megawatt (peak)
NGO	Non-Governmental Organization
NP	Non-commercial Partnership
NPV	Net Present Value
NRP	Non-Regulated Prices Market
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
OPEX	Operational Expenditure
PJSC	Public Joint Stock Company
PP	Power Plant
PPA	Power Purchase Agreement
PPP	Private Power Project

Acronym	Definition
PV	Photovoltaic
PVPS	Photovoltaic Power Systems Program
R&D	Research and Development
RC	Regulated Contracts Market
RE	Renewable Energy
RES	Renewable Energy Source
ROE	Return on Equity
ROEK	Ryazan Oblast Electricity grid Company
ROI	Return on Investment
RP	Regulated Prices Market
RUB	Russian Ruble
SHS	Smart Home Systems
SME	Small and Medium-Sized Enterprise
SO UPS	Company Supervising the UPS
SPP	Solar Power Plant
SPV	Special Purpose Vehicle
SRS	Solar Residential Systems
TWh	TeraWatt Hour
UN	United Nations
UPS	Unified Power System of Russia (Unified National Power Grid)
USD	United States Dollar
USSR	Union of Soviet Socialist Republics
VAT	Value Added Tax
WACC	Weighted Average Cost of Capital

Objectives of the ENABLING PV project

The market for solar PV installations has become more and more international over the last decade. While the first solar boom was mainly restricted to developed countries who decided to support renewable energies with often similar support schemes mainly based on feed in tariffs, the landscape today for solar energy is different and much more diverse. Having already reached or being on the verge of reaching cost competitiveness with conventional energy sources in many countries, the number of markets and of business models that work in those markets have multiplied in the last years. And just as every project is different so are the framework conditions in every country.

It is in this context of a more and more international PV market that the German solar association BSW-Solar together with the consulting firm eclareon have started in 2013 to investigate business models and the business environment for PV in different countries under the label "ENABLING PV". The first study was published in 2014 and the series covers today countries such as for example Tunisia, Jordan, Brazil, Argentina, Nigeria, Angola, Iran, Pakistan and Afghanistan.

The label also stands for the intention of this report: enabling the growth of solar, PV based energy around the globe. In order to achieve this, projects need to be realized and the first step towards this may be the generation, distribution and also discussion of country specific knowledge. **ENABLING PV reports shall provide a starting point for those investors and solar entrepreneurs who have a specific interest to expand their business in new markets.**

This report on the potential for PV in Russia is embedded in further activities implemented by eclareon together with the association EUROSOLAR Russia in the second half of 2018 in Russia. With **Kaliningrad and Krasnodar**, two pilot regions were selected, and meetings and workshops were organized to discuss with the administration, companies, institutes, universities and potential investors about possible applications of PV systems and to identify pilot projects. Therefore, these two regions are presented in this report as example regions for the diffusion of photovoltaic solutions in Russia.

In the search for pilot projects, the focus has quickly expanded to include solar energy solutions for heat supply, be it for hot water, space heating or process heat. Several pilot projects in both regions are currently being further developed with German and Russian companies and investors.

For 2019 it is planned to implement the successful approach in two other Russian regions. In the course of this, this report will be expanded to include two additional regions as well as solar thermal solutions for heat generation.

Задачи проекта ENABLING PV

В течение последних десятилетий, рынок солнечных фотоэлектрических установок становится все более интернациональным. Первый солнечный бум случился в основном в развитых странах, которые решили поддержать возобновляемые источники энергии используя зачастую аналогичные схемы поддержки, основанные главным образом на льготных тарифах. Сегодня ситуация в области солнечной энергетики уже иная и схемы стали разнообразнее. В последние годы, ВИЭ во многих странах уже стали конкурентоспособными или находятся на грани конкурирования с традиционными источниками энергии с точки зрения капитальных затрат, число рынков и бизнес-моделей, работающих на этих рынках, увеличилось в несколько раз. И, как различны между собой разные проекты, так и рамочные условия в каждой стране отличаются друг от друга.

Именно в этом контексте глобализации рынка солнечной энергетики в 2013 году Немецкая Ассоциация Солнечной Энергетики BSW-Solar совместно с консалтинговой фирмой eclareon приступила к изучению бизнес-моделей и бизнес-среды солнечной энергетики в разных странах. Этот масштабный и многогранный проект получил международное название, своеобразный узнаваемый лейбл "ENABLING PV". Первое исследование было опубликовано в 2014 году, и, на сегодняшний день, серия исследований охватывает такие страны, как Тунис, Иордания, Бразилия, Аргентина, Нигерия, Ангола, Иран, Пакистан и Афганистан.

Этот лейбл также отражает посыл данного отчета к способствованию росту солнечной, фотоэлектрической энергетики, по всему миру. Для этого необходима реализация проектов солнечной энергетики, и первым шагом на пути к этому может стать генерирование, распространение, а также обсуждение знаний и данных, специфичных для каждой конкретной страны. **Отчеты ENABLING PV станут отправной точкой для тех инвесторов и предпринимателей в области солнечной энергетики, которые заинтересованы в расширении своего бизнеса на новых рынках.**

Данный отчет о потенциале и перспективах фотоэлектричества в России является частью масштабных мероприятий, реализованных компанией eclareon совместно с ассоциацией «ЕВРОСОЛАР Россия» во второй половине 2018 года в России. При участии **Калининградской Области и Краснодарского Края,** были выбраны два пилотных региона. Наряду с этим, в целях обсуждения различных вопросов и определения пилотных проектов, были организованы встречи и семинары с представителями администрации регионов, компаниями, ВУЗами и потенциальными инвесторами, заинтересованными в развитии и применении фотоэлектрических систем. По этой причине, эти два региона представлены в данном отчете в качестве примеров применения и распространения фотоэлектрических решений в России.

В процессе поиска пилотных проектов, фокус исследования быстро расширился и теперь также включает в себя решения в области солнечной энергии для теплоснабжения, будь то горячая вода, отопление помещений или технологическое тепло. Несколько пилотных проектов в обоих регионах в настоящее время находятся на стадии обсуждений и разработки при активном участии немецких и российских компаний и инвесторов.

В 2019 году планируется проведение подобной работы еще в двух регионах России. В ходе этой работы, данный отчет будет расширен за счет включения в него двух дополнительных регионов, а также солнечных тепловых решений для производства тепла.

Executive Summary

Until recently, renewable energies (other than large hydro) did not play a big role in the energy supply in the Russian Federation, despite the huge potential it has in the country. Simply put, the primary reasons have been the large national oil and gas reserves, which have led to low electricity prices and the lack of experience with using renewable technologies. However, recent market figures show that the wind energy and photovoltaics (PV) sectors are expanding, indicating that these technologies may play a more important and prevalent role in Russia in the future.

The question now is: where can projects be realized and which obstacles need to be removed to grow the solar PV market, despite low electricity prices? To answer this, it is important to highlight business models that can work. Standardising PV business models that create win-win situations for all parties involved in a solar PV project is always challenging. It is particularly so in emerging PV markets like Russia, where "more" standardized models that can easily be reproduced still need to be developed and information on prices is fuzzier than in established PV markets with more experience. This ENABLING PV report presents different business models that each give direction as to how PV can be exploited in different segments and installation sizes.

It is in this context, that the international consulting company eclareon GmbH, specialised in the sector of renewable energy and energy efficiency, supported by the Russian partner EUROSOLAR Russia has analysed the procedures and barriers of the Russian PV sector, both on a national level and in two Russian regions: Kaliningrad Oblast and Krasnodar Krai. Moreover, profitability analyses for three different PV business models were prepared to assess the economic viability of these models.

The objective of the report is to provide practical information about the current status of the Russian PV market in general and more specifically in the two regions. The information in this report will support the German and Russian solar industry as well as interested companies in the energy industry, regional economic development institutions and scientific institutions to further develop the Russian PV market. To achieve this the following activities were annexed to the Enabling PV project, going beyond the report:

- Presentation of the legal, regulatory and electricity market framework conditions for the development of grid-connected and off-grid solar PV systems in Russia
- Description and profitability analysis from the investor point of view for three different business models for PV in Russia
    - ✓ Large grid connected photovoltaic power plants (PV parks) with a capacity up to 25 megawatts; such installations are running on regulative-driven business models based on tenders in the wholesale market or the retail market.
    - ✓ Diesel PV hybrid systems with a capacity starting with several kilowatts up to a maximum of several megawatts; such installations provide power supply off-grid in remote and isolated areas or function as back-up systems in weak grid areas.
    - ✓ Grid-connected residential photovoltaic rooftop systems of up to 15 KW capacity, which may be operated in the near future based on a drafted law on microgeneration including a net metering scheme which currently to Russian Duma for further approval and discussion.
- Roundtables in Germany, in Moscow and in the two regions to present the project and to discuss interim results and to identify pilot PV projects

The conclusions drawn from the roundtables in Kaliningrad Oblast and Krasnodar Krai have shown that the conditions for the development of PV are in particular favourable in Krasnodar. This is because the region is lacking in its own generation capacities, has high solar irradiation, PV is already installed and the overall environment favours the development of solar energy.

The situation in Kaliningrad is different: not only does Kaliningrad have less natural solar irradiation than Krasnodar but the region is also unique due to its geographic seclusion from the Russian mainland meaning that energy security is the focus of the regional energy policy. This has led to vast generation capacity being installed in the region. Application options have been identified for some off-grid and weak-grid applications, for which diesel generators have hitherto been used. And there is is a vital interest in initiating exemplary flagship projects to demonstrate technical solutions and for offering education like trainings for planners and installers. In addition, one would like to consider solar energy in the hot water and space heating supply for building.

In Krasnodar Krai all market segments of the business model have the potential to yield positive results due to the payback potential during the lifetime of the PV projects and their internal rate of return. And yet, the attractiveness of the three types of installations has varied and depends on many factors that may also go beyond pure economic considerations.

Diesel PV hybrid installations have yielded the most promising calculated results. Use cases for such applications were identified in both Krasnodar Krai and Kaliningrad Oblast. Large solar parks are much more likely to appear soon in Krasnodar given the higher irradiation levels. Such parks are either built based on the federal wholesale market, using Decree 449, which has been a defining factor for the recent growth in RES in Russia, or on the retail market, using Decree 47 that aims to compensate grid losses with RES. Provisions in both decrees are challenging because of local content rules and transparency. In regards to payment calculations, the rules are complicated and leave room for interpretation.

Finally, the analyzed business model in the residential sector shows that it is still too early to draw final conclusions as the law on microgeneration ("15 kW decree") has not yet been finally enacted and details of how residential customers can become PV prosumers have not yet been detailed. For solar PV to be successful in Russia investment prices have to be low, otherwise residential solar installations will largely be installed by wealthy enthusiasts only, for whom the installation of a PV system goes beyond economic considerations.

Сводное Резюме (Executive Summary)

До недавнего времени возобновляемые источники энергии (за исключением крупных гидроэлектростанций) не играли большой роли в энергоснабжении Российской Федерации, несмотря на их теоретически хороший потенциал. Основными причинами такого положения вещей являются имеющиеся большие национальные запасы нефти и газа, которые приводят к низким ценам на электроэнергию, и отсутствие опыта использования возобновляемых технологий. Однако последние рыночные данные свидетельствуют о расширении применения ветровой энергетики и фотоэлектричества (PV) и указывают на то, что эти технологии могут также играть более важную роль в России в будущем.

На данный момент, вопрос таков: где, несмотря на низкие цены на электроэнергию, можно реализовать мощности и какие препятствия существуют на пути развития солнечной электроэнергетики? Поэтому, важным этапом является определение бизнес-моделей, которые могут наиболее успешно работать в России. Стандартизация PV бизнес-моделей, которые создают беспроигрышные ситуации для всех участников проекта по солнечной энергетике, всегда является проблемой. Особенно проблематична такая стандартизация на развивающихся рынках солнечной энергетики, таких как Россия, где еще только предстоит разработать "более" стандартные модели, которые можно было бы легко воспроизвести снова. В данном отчете ENABLING PV представлены различные бизнес-модели, каждая из которых дает направление, как солнечная энергетика может быть использована в различных сегментах рынка и какого размера могут быть установки.

Именно в этом контексте международная консалтинговая компания eclareon GmbH, специализирующаяся в области возобновляемой энергетики и энергоэффективности, при поддержке НП «ЕВРОСОЛАР Россия» провела анализ процессов и актуальных барьеров, происходящих и существующих в российском фотоэлектрическом секторе как на национальном уровне, так и в двух конкретных российских регионах - Калининградской Области и Краснодарском Крае. Кроме того, был подготовлен анализ рентабельности и экономической жизнеспособности различных фотоэлектрических бизнес-моделей, чтобы дать возможность провести первую оценку экономической жизнеспособности этих моделей.

Основной целью проекта является предоставление практической информации о текущем состоянии российского фотоэлектрического рынка в целом, и в особенности, в этих двух регионах. Информация, содержащаяся в настоящем докладе, поможет немецкой и российской солнечной промышленности, а также заинтересованным компаниям энергетической отрасли, региональным институтам экономического развития и научным учреждениям обеих стран в дальнейшем развитии российского рынка фото энергетики. Для достижения этой цели в рамках проекта ENABLING PV, который выходит за рамки данного отчета, были проведены следующие мероприятия:

- Презентация правовых, регуляторных и рыночных условий для развития в России солнечных фотоэлектрических систем, как подключенных к электрическим сетям, так и не подключенных к электрическим сетям.
- Описание и анализ рентабельности с точки зрения инвестора для трех различных бизнес-моделей фотоэлектрических модулей в России
  - ✓ Крупносетевые фотоэлектрические электростанции (фотогальванические парки) мощностью до 25 мегаватт, работающие по регулируемым бизнес-моделям на тендерной основе на оптовом или розничном рынке.
  - ✓ Дизельные PV гибридные системы мощностью от нескольких киловатт до нескольких мегаватт; такие установки обеспечивают автономное электроснабжение в отдаленных и изолированных районах или выполняют функцию резервных систем в слабых районах электросетей.

- ✓ Фотоэлектрические системы на крышах зданий, подключенные к электрическим сетям, мощностью до 15 кВт, которые могут быть использованы в ближайшем будущем на основе проекта закона о микрогенерации, включая схему сетевого учета, который в настоящее время представлен на утверждение и обсуждение в Государственную Думу РФ.

- Круглые столы и встречи в Германии, Москве и двух регионах с целью презентации проекта и обсуждения промежуточных результатов

Относительно выводов, которые можно сделать по итогам этих мероприятий для Калининградской Области и Краснодарского Края, можно сказать, что в Краснодарском Крае условия для развития фотогальваники особенно благоприятны Это связано с тем, что регион не имеет собственных генерирующих мощностей, имеет высокий уровень солнечного излучения, PV уже установлен, и общая окружающая среда благоприятствует развитию солнечной энергетики. Ситуация в Калининграде иная: в Калининграде не только меньше естественного солнечного излучения, чем в Краснодаре, но и уникальность региона обусловлена географической удаленностью от материковой части России, что делает энергетическую безопасность одним из основных направлений региональной энергетической политики. Это привело к установке в регионе огромных генерирующих мощностей. Были определены варианты применения для некоторых автономных и слабо сетевых систем, для которых до сих пор использовались дизель-генераторы. ВИЭ, безусловно, представляют интерес, но условия для развития фотоэлектрических модулей в целом менее благоприятны, чем в Краснодаре, где все три рассмотренные бизнес-модели скорее всего появятся и/или будут расти. В Калининграде, однако, существует жизненно важный интерес к инициированию образцовых флагманских проектов, чтобы продемонстрировать технические решения для всей России и предложить обучение, такое как обучение проектировщиков и монтажников. Кроме того, хотелось бы рассмотреть возможность использования солнечной энергии в горячем водоснабжении и отоплении зданий.

В Краснодарском крае все сегменты рынка бизнес-модели имеют потенциал для получения положительных результатов за счет окупаемости в течение всего срока реализации фотоэлектрических проектов и внутренней нормы доходности. И все же привлекательность этих трех типов установок варьируется и зависит от многих факторов, которые могут выходить за рамки чисто экономических соображений.

Гибридные установки дизель-солнце дали наиболее многообещающие расчетные результаты. Случаи использования таких систем были выявлены как в Краснодарском крае, так и в Калининградской области. Большие солнечные электростанции в Краснодаре, скорее всего, появятся в ближайшее время, учитывая более высокий уровень облучения. Такие парки строятся либо на базе федерального оптового рынка с использованием Постановления № 449, что явилось определяющим фактором роста ВИЭ в России в последнее время, либо на розничном рынке с использованием Постановления № 47, целью которого является компенсация потерь в сетях за счет ВИЭ. Положения обоих указов являются сложными из-за правил местного содержания и прозрачности. Что касается расчетов по платежам, то правила сложны и оставляют возможность для интерпретации.

Наконец, проанализированная бизнес-модель в жилищном секторе показывает, что еще слишком рано делать окончательные выводы, поскольку закон о микрогенерации ("Постановление о 15 кВт") еще не принят окончательно, а подробности о том, как бытовые потребители могут стать PV-потребителями, еще не определены. Для того, чтобы системы, работающие на солнечных фотоэлектрических батареях, были успешными в России, стоимость инвестиций должна быть низкой, иначе бытовые солнечные установки будут устанавливаться в основном только богатыми энтузиастами, для которых установка фотоэлектрических систем выходит за рамки экономических соображений.

1. Introduction to the Russian Power Sector

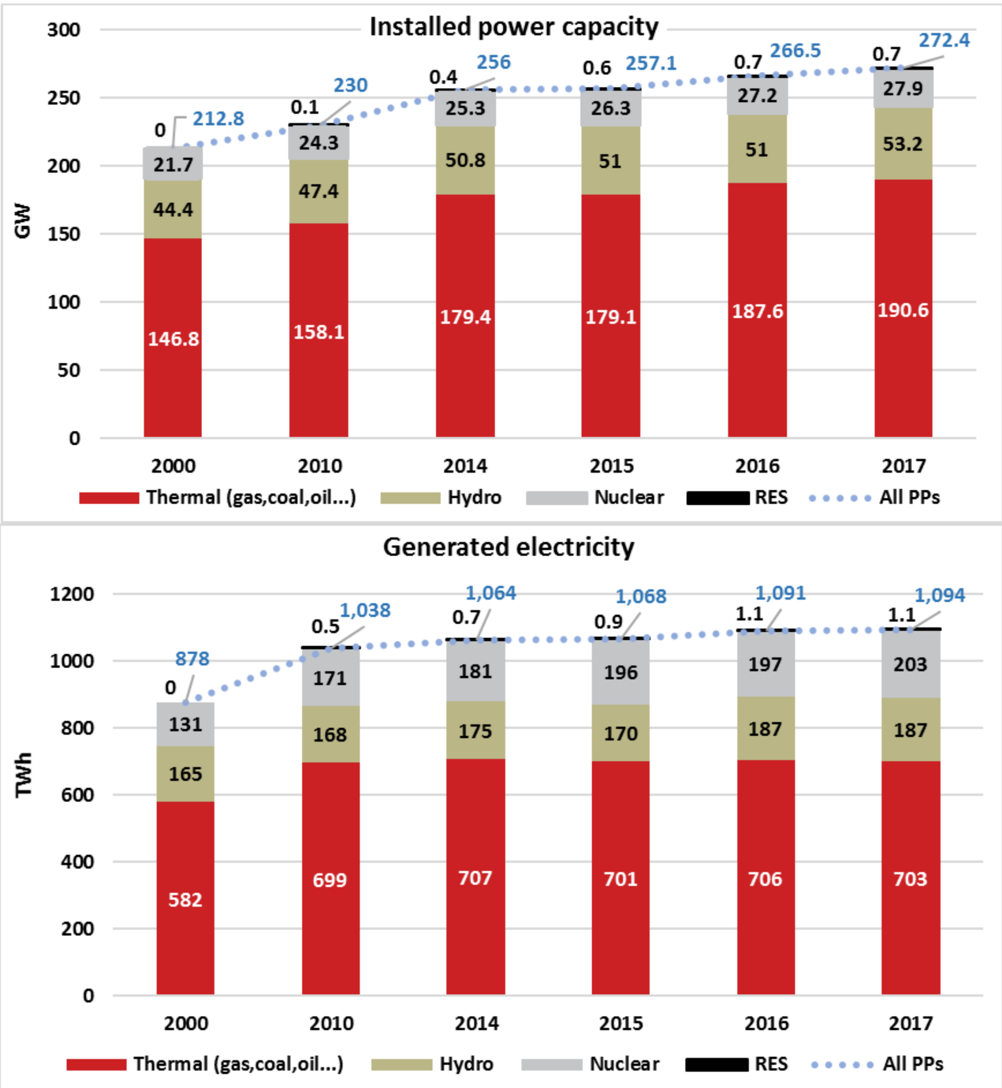
In order to be able to understand the role of renewable energy, in particular of solar PV, in the Russian Federation it is important to have a basic understanding of the framework in which renewables have to find their place.

1.1 Sector Infrastructure

1.1.1 Power Sector

The Russian power sector has several interconnected levels and the electricity system is complicated to understand. Russia is the world's leading primary energy exporter [1] and among the largest world energy producers. **The installed capacity for power generation in Russia is growing steadily**. Between 2000 and 2017, the total installed power capacity grew by 28% from 212.8 GW to 272.4 GW (see Figure 1). The power generation capacity has also grown since 2000, gained one forth in capacity in 17 years.

Figure 1 Total installed power capacity and total annual electricity generation for some years in Russia by type of power plant (including but not limited to UPS)



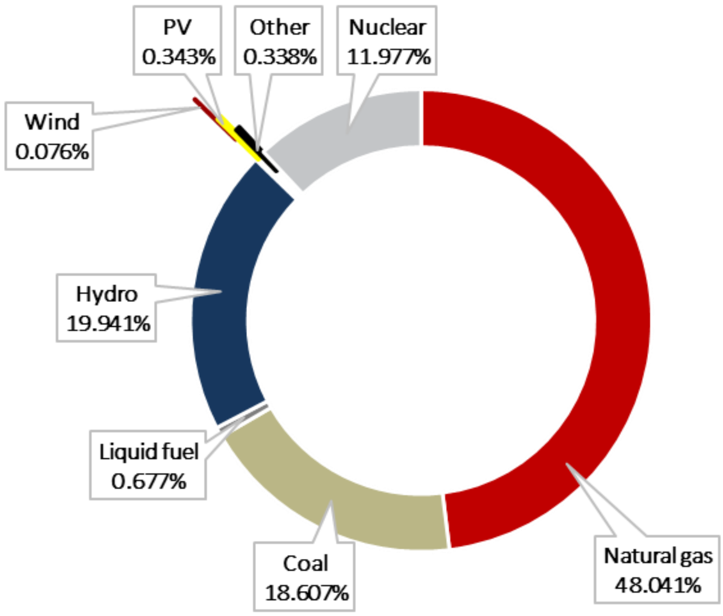
Source: Annual reports of the State Statistics Service of Russia, 2017 and 2018 [6]

The per capita electricity consumption in Russia in the year 2015 was 6.59 MWh/capita. That was the result of a slow but stable growth of electricity consumption in the country since the fall of the USSR. In comparison, in Germany this index was 7.01 MWh/capita for the same year, in the USA it was 12.83 MWh/capita and 4.05 MWh/capita in China [2].

The central grid is the Unified Power System of Russia (UPS, also called United National Power Grid). The UPS unites all the power plants, power grids and transformer substations. The UPS network covers practically all of the country except some remote and isolated areas mainly in the Far East and Siberia. Therefore, official data on power generation and installed capacity only includes the regions covered by the UPS. **The total installed capacity of the power plants of the UPS as for December 2018 amounted to 243.3GW of which PV's installed capacity was 0,34%[131].** In 2018, Russian power plants united by the UPS**,** generated 1,070 TWh [4] of which 758.4 GWh were generated by solar power plants (SPPs) [131]. According to the Ministry of Energy, the overall electricity generation (including but not limited to the UPS) was 1,091 TWh.

Russia has enough installed capacity and generated electricity to cover its electricity needs. In 2017, the surplus generation was 13.327,3 million kWh [7]. In the last few years renewable energy generation (except hydro) has expanded, however RES still only make up under 1% of electricity generated [8] (see Figure 2) and nearly 50% of electricity is generated by the combustion of natural gas at fossil-fuelled power plants.

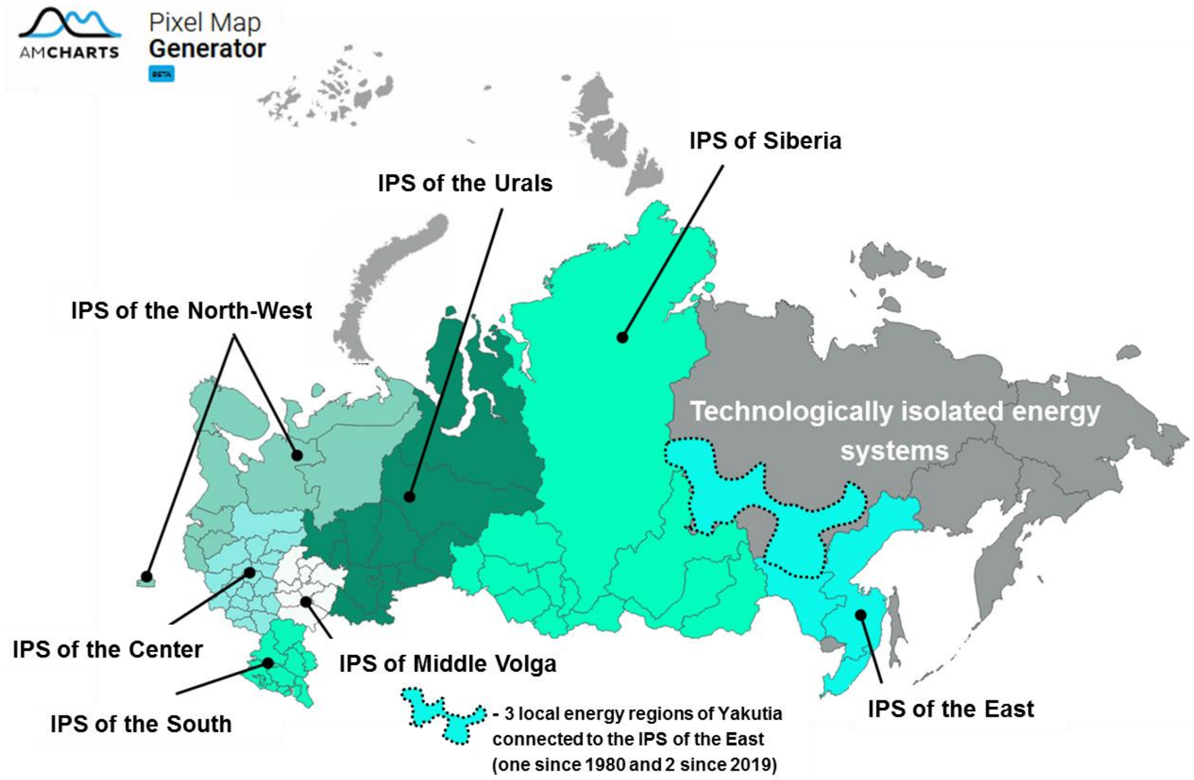
Figure 2 Installed electricity generating capacity in Russia in 2018 by technology



Source: based on: SO UPS, "Informative Overview of the Unified Power System of Russia: the Subtotals", 2019[131] and Ministry of Energy of Russian Federation, 2018 [9]

The UPS is divided into seven sub-regional systems, the so-called Integrated Power Systems (IPS) of the UPS (see Figure 3), representing a total of **71 regional power systems** and different owner structures [10]. An IPS is a set of several regional power systems united by a common mode of operation, having a common dispatch control as the highest level of control in relation to the dispatching controls of its power systems. Along with them, there are isolated energy systems, not connected to the UPS and therefore not related to any of IPS. A regional power (energy) system is a combination of related energy resources, methods of electricity production, conversion, distribution and use, and supply of energy to consumers through grids [133]. Each energy system includes different participants, like grid companies, energy suppliers, energy generating companies and their interaction.

Figure 3 The seven IPSs of the Russian UPS

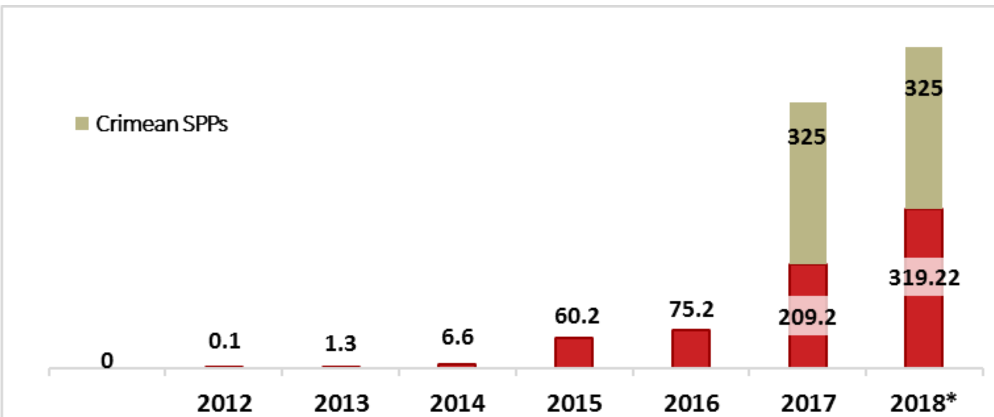


Source: eclareon, 2019, based on SO UPS[10], generated with amCharts Pixel Map

1.1.2 Solar PV Sector

Solar PV has until now not played an important role in the electricity mix of the Russian Federation. The first PV power plants appeared on the Russian market in 2012 and have become more frequent based on changes in RES legislation. In 2017, roughly 130MW of PV capacity were installed in Russia, and additional 325MW of Crimean SPPs. According to preliminary estimations, in 2018, new PV installations had a capacity of 110MW. With the Crimean SPPs, which are included in Russian databases, the installed PV capacity in 2018 was over 600 MW (see Figure 4).

Figure 4 Installed PV capacity in Russia 2012-2018, MW



Source: based on SO UPS, "Informative Overview of the Energy System of Russia: the Subtotals", 2017 [8],2018; and a personal contact with specialists of SO UPS; **data as December 1st 2018, total numbers for 2018 might be slightly bigger*

Although this is fairly small with regards to overall installed generation capacity in Russia, time series data show the positive development over recent years. The most important change being the introduction of the tender-based scheme for the promotion of RE which became effective in 2013 (Decree 449, please refer to chapter 2.1.1.).

When looking at the capacity figures it is important to note, that the real volume of installed PV capacity is slightly larger due to the fact, that not all off-grid and private PV power generating facilities are registered and included in overall statistics.

When it comes to estimating the potential of small-scale installations, assumptions vary. According to estimations of an article in Forbes.ru, the potential future cumulative integration of grid connected small scale PV (small private PV installations of 5-10 kWp) may be between 14 and 17GW [11], while, according to estimations of the Moscow School of Management Skolkovo, already installed RES based microgeneration capacity in Russia for October 2018 was around 11 GW [132].

1.2 Electricity Market Stakeholders

The Russian electricity market is the result of a vast and long-lasting reformation process, including the liberalization of the power market and the creation of wholesale and retail electricity markets [12] both of which differ between regions. There is a variety of state- and private-owned companies active in the Russian energy market permitting the government to control the strategically important market from one side and leaving a window open for private capital inflows from the other side.

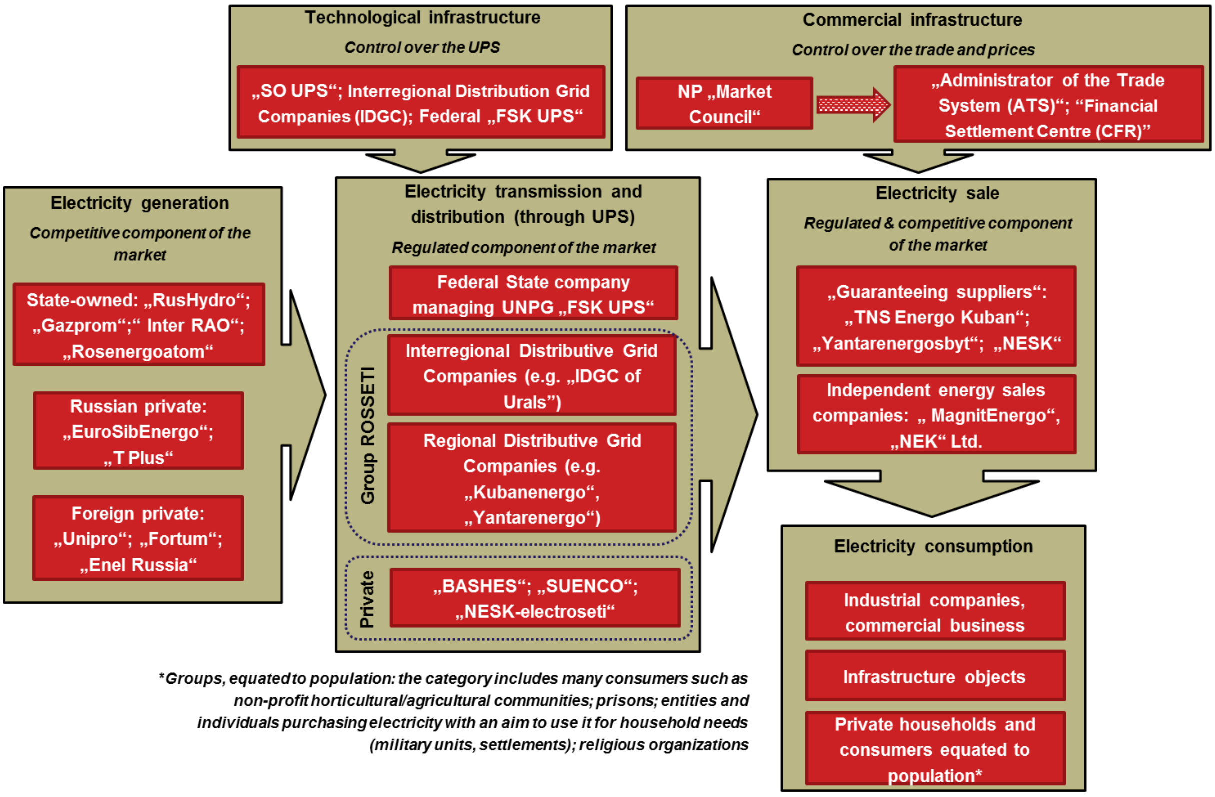
1.2.1 National Stakeholders

The stakeholders of the electricity market can be divided into the following categories:

- organizations of technical infrastructure (federal transmission grid operator “FSK of UPS“, a company supervising the UPS SO UPS and Interregional Distribution Grid Companies (IDGC) controlling regional parts of the UPS (IPSs));
- organizations of commercial infrastructure (such as “Administrator of the Trade System (ATS)”, organizing capacity and energy trade on the wholesale market; “Financial Settlement Centre (CFR)”, controlling financial relationship on the wholesale electricity market and NP “Market Council” created to ensure the balance between the participants of the energy and capacity markets and create a unite trade zone for them);
- power generating companies;
- regional power grid companies (there may be more than one such company in a region, some of them may be state-owned, while others may be private),
- distribution companies and
- consumers [13]

The schematic illustration of the relationships between the different stakeholders and the names of some of the most important actors is presented in Figure 5
:

Figure 5 Relations between the main stakeholders of the Russian electricity market



Source: Based on Ernst & Young Global Limited, "Overview of the electricity and power industry in Russia", 2018 0

Some of the most important companies and their roles within these stakeholder groups are the following:

- Commercial infrastructure: Association Non-profit partnership "**Market Council**" unites producers and buyers of the wholesale and retail electricity markets, ensuring the unity of commercial infrastructure, and owns two further organizations managing the wholesale electricity and capacity markets. Both technological and commercial infrastructures of the Russian electricity market fall under the government control. "Administrator of the Trade System (ATS)" (100% owned by "Market Council") – organizes the trade of electricity and capacity on the wholesale market.

- Power generating companies: power producers generate and sell electricity to the distributing companies on the wholesale and retail markets. **There are both state- and private-owned power generating companies in Russia.** The largest state-owned companies are "Inter RAO" (the only company in Russia which exports and imports electricity[15]); "RusHydro", "Rosenergoatom", and "Gasprom Energoholding". The largest private companies that are active nationally are "EuroSibEnergo" PLC, "T Plus"; the largest foreign private companies are Unipro PJSC (E.ON Russia JSC until June 2016), PJSC "Enel Russia" and Fortum[16]. The top 10 largest generating companies own about 80% of all the generating capacity of the UPS of Russia and produce more than 85% of electricity, see Table 1 [17].

Table 1 Top 10 largest power generating companies of Russia

Company	Total installed power generating capacity, GW	Average annual power generation, thousand GWh
RusHydro	39	104.3
Gasprom Energoholding	39	150.8
Inter RAO	28.5	122.1
Rosenergoatom	27.9	202.9
EuroSibEnergo	19.5	67.6
Unipro	11.2	48.2
Siberian Generating Company	10.9	36
Enel Russia	9.4	42
Fortum	4.8	28.1
Quadra	2.9	9.5

Source: Ministry of Energy of Russian Federation, 2018 [17]

- Transmission companies: **Most of the Russian grids (including regional grids) are owned and controlled by the state-owned JSC "ROSSETI"**, which is one of the largest grid companies of the world. The centralized dispatching control of the UPS and its infrastructure and control of all IES is committed by the 100% state-owned "System Operator of the United Power System" (SO UPS, JSC); general management of the UPS is under the leadership of the Federal Grid Company of the United Power Grid (FSK UPS, a subsidiary of „ROSSETI");
- Transregional distribution grid companies: These companies manage regional parts of UPS. **Most of them are owned by ROSSETI** (like "Yantarenergo" in Kaliningrad or "Kubanenergo" in Krasnodar and a larger companies like PJSC "IDGC of the South"); simultaneously, there are other similar grid companies, not owned by "ROSSETI", such as the private companies JSC "BASHES"[18], "NESK-electroseti" and "SUENCO" [19] owning the remaining small part of Russian grids.
- Distribution companies/energy sales companies: **these include numerous so-called "guaranteeing suppliers" and "independent distribution companies", which are, basically, utility companies.** "Guaranteeing suppliers" are energy sales companies and are the result of the reorganization of large regional power companies and wholesale resellers; these companies are obliged to sign a contract with consumers in its area of activity and sell the electricity under the state-regulated prices. "Independent distribution companies" have the right to refuse to enter into a contract with a consumer and electricity prices because they are not under the jurisdiction of the government.
- Electricity consumers: These are described in chapter 1.2.4.

There are also pioneers in the **Russian solar PV sector** who have put their efforts to propel solar energy forward together by found the non-profit, "Association of the Solar Energy Enterprises of Russia". Today, the association includes the following eight companies [20]:

1. AltEnergo: founded in 2009, the Belgorod based company is active in system integration and project development for innovative biogas, wind and solar PV energy solutions.
2. Wlibor Systems: founded in 1999 and specializing in anti-terrorist activities and infrastructure security; they have licenses from the Federal Security Service (FSB) of Russia.
3. aleo solar: German PV module manufacturer, established in 2001, and producing monocrystalline solar panels.

4. Helios Resource: founded in 2010, Helios Resource is a producer of multi-crystalline silicon wafers; in 2017 they had a wafer production of 99 MW; their wafers are used for cell and module manufacturing in China and finally supplied to Russian "Avelar Solar Technology" for the fulfillment of local content requirement rules
5. R&D Center TFTE: The Research and Development Center for "thin-film technologies in energetics (TFTE) is an R&D unit of Hevel Solar. It was founded in 2010 with the objective to develop a PV industry in Russia. R&D Center TFTE designs and produces PV modules and is also active in the field of PV system integration and operation.
6. Svjaz Engineering: Founded in 1997, they are a power electronics solution provider active in different industries (e.g. railway). They also do research in the field of converter technology for difficult climatic conditions
7. Hevel Solar (Hevel Group; owned by "Rosnano" and "Renova"): Hevel is the largest and probably most renowned PV company in Russia. They were founded in 2009 and are a vertically integrated solar company that integrates module manufacturing based on hetero-junction technology, project financing and development as well as plant operation. They have completed a total of 16 projects in Russia with an overall capacity of approx. 189 MW, nearly all of them are ground-mounted. In October 2018, 9 more PV parks with a combined capacity of 25 MW were under construction. SPPs have been constructed in Astrakhan Oblast, Saratov Oblast and the Republic of Altay. After having sold 3 SPPs to the Finish company "Fortum" and 1 SPP to "Lukoil" Hevel manages 12 grid-connected SPPs with an overall capacity of 129 MW.
8. Solar Systems Ltd., founded in 2014 by Chinese company "Amur Sirius Power Equipment" LTD is a PV installer; in 2017 their installed capacity reached 30 MW, a plan is to launch 365 MW of PV power until 2020.

1.2.2 On-grid Power Generation

As mentioned above most of the Russian electricity grid is the property of the state-controlled company "ROSSETI". In 2017, **the company managed 2.3 million kilometres of power lines and 496 thousand transformer substations with an overall capacity of 773,000 MVA** [21]. The company delivers energy to over 70% of the Russian population and to a range of industrial sites which together form more than 60% of the Russian GDP [22].

The UPS works with the "**BRELL ring**" (including energy systems of Belorussia, Russia, Estonia, Latvia and Lithuania) which was left after the fall of the USSR and with energy systems of Azerbaijan, Georgia, Kazakhstan, Mongolia and Ukraine [23]. The UPS in Russia includes more than 10,700 power lines most of which are overhead with the voltages between 110 and 1,150kV [23][24]. Practically all electricity generated in the country is grid-connected as the official statistical data normally does not consider off-grid generation. The image below (Figure 6) presents the power grids stretching throughout the Russian territory. The European territory and Southern Russian borders have a well-developed grid, whereas major part of Siberia and the East of Russia are lacking it. There are some local large grids (in green) to be seen in different parts of the map, e.g. close to Norilsk city (upper part of Siberian federal district) in Yakutia (upper part of the Far Eastern federal district), Magadan Oblast (Eastern part, on the shore of the Okhotsk Sea), grids of Kamchatka. These grids are disconnected from the UPS and depend on the local power generating facilities and locally extracted and/or imported fuel.

Figure 6 Map of the modern electrification and power grids of Russia

Source: SO UPS, 2017 [128]

The table below contains information about electricity generation and consumption in Russia between 2010 and 2017. Adding-up energy consumption and energy losses may not equal 100% because of electricity imports and exports. As shown in Table 2, electricity generation in Russia has been growing while the total energy consumption has remained stable at around 98% of the produced energy. The peak consumption usually occurs on days with the lowest average temperature due to increased electricity usage. **Electricity losses account for > 2% of total production** and are due to old generation, transmission and distribution equipment, the imperfection of energy metering and simple theft of electricity.

Measures to prevent the losses are always planned for the year ahead and include energy efficiency measures, the installation of the energy saving equipment, and the renovation of the existing transformer stations etc. According to the calculations of "FSK UPS", in 2017 these measures helped to avoid the loss of 56,000 MW.

Table 2 Electricity Generation Profile in the UPS, years 2010-2017)

Year	Total electricity generated (thousand GWh)	Total energy consumption (% from total electricity generation)	Total energy losses (% from total electricity generation)	Total PV electricity generation (% from total electricity generation)	Maximum peak consumption (GWh)	Per capita electricity generation (kWh per capita)
2017	1,053.90	98.7	2.3	0.053	151.2	7.5
2016	1,048.50	97.9	2.4	0.007	151.1	7.4
2015	1,026.80	98.2	2.3	0.001	147.4	7.3
2014	1,024.90	98.9	2.1	_	154.7	7.3
2013	1,023.50	98.7	2.2	_	147	7.4
2012	1,032.30	98.5	2.1	_	157.4	7.5
2011	1,019.40	98.1	2.2	_	147.8	7.4
2010	1,004.70	98.4	n.d.	_	149.1	7.3

Source: SO UPS, "Report on the functioning of the UPS of Russia" (years 2010-2017); Annual report "FSK UPS" for 2015 "Illuminate the present – create the future", 2016 [125]; Annual report "FSK UPS" for 2017 "On the way towards the digital energy sector", 2018 0; Federal State Statistics Service of the Russian Federation, "Electricity generation per capita", 2018 [127]

Grid-connected energy generation from renewables in Russia is also growing quickly. Until 2014, there was no sign of grid generation for PV, and in the years since then its share of the overall electricity generation has risen to half a percent. In 2015, more solar power plants began to be constructed and connected to the UPS. In 2015, newly installed SPPs reached a capacity of 53.6MW; in 2017, the newly installed capacity reached 150MW (according to the data, published on the official web site of government of Russia [25] and an article published by the Ministry of Energy of Russia)[26] [27].

Table 3 Installed RES-based electricity generating capacity, MW

Year, as for January 1st of the following year	Hydropower	Wind	PV	Biomass
2018	48,506.3	183.9	834.2	n.d.
2017	48,449.6	134.4	534.2	
2016	48,085.9	10.9	75.2	
2015	47,855.2	10.9	60.2	
2014	47,712.4	-	-	
2013	46,654.4	-	-	
2012	45,976.8	-	-	
2011	44,569.2	-	-	
2010	44,262.9	-	-	
2009	46,040.7	-	-	

Source: Annual reports of SO UPS, 2019 [129]

1.2.3 Off-Grid Power Generation

According to some expert estimations, 60% to 70% of Russian territory is not covered by the centralized power grid [28]. However, it is important to notice, that around 85% of Russian territory is not livable and 60% of its territory is covered by permafrost. **The largest part of Russia (3/4 of the territory) is Siberia and the Far East which together have around 13% of the Russian population which is around 20 million people** [28]). Hence, the overall electricity consumption in these regions is very low in comparison to the overall consumption in Russia.

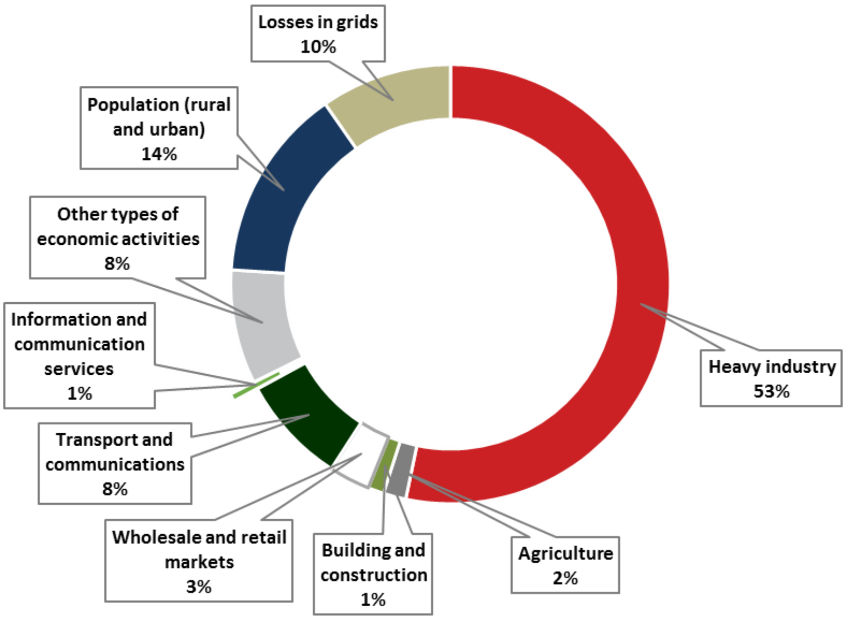
Exact data about off-grid installed power capacity, generation and consumption is not available in open sources. According to our assumptions, based on the estimated number of people living off-grid and an average electricity consumption per capita, **the off-grid electricity generation in Russia could be roughly 100GWh annually**, which is around 9% of the total power generation (generation, including but not limited to UPS, data from Ministry of Energy of Russia).

This off-grid electricity is generated by a number of power stations of different sizes and ages. **Most of these decentralized power stations are diesel generators** but some power stations work on gas, coal and renewables [132] (incl. some hybrid PV-diesel PPs). There is also a small number of independent private power generation facilities (e.g. own generation of industries, which they build to satisfy their own needs) that are not integrated into regional power systems and not included in official statistics.

1.2.4 Electricity Consumption and Demand

As already mentioned, the total amount of the energy consumed accounts for 98-99% of the energy produced (based on [29]). **The largest share of generated electricity in Russia is consumed by the industrial sector.** Figure 7 below illustrates electricity consumption in Russia (incl. UPS) in 2017 by sector 0. Heavy industries include mining and manufacturing industry (e.g. steel production), production and distribution of natural gas, electricity and water.

Figure 7 Electricity consumption by sector in Russia in 2017



Source: Federal State Statistics service of the Russian Federation, 2018 0

Electricity demand in the country has stagnated for several years and no drastic growth in demand is expected in the near future. In 2016, the demand increased by 1.7% because of the additional day of the leap year, colder than usual winter and warmer than usual summer [31]. In 2017, the demand growth increased by 0.5% due to lower temperatures in February and from April to August in some regions [31].

1.2.5 Electricity Markets, Prices, Tariffs and Costs

In Russia one needs to distinguish, as in many other countries, between **wholesale and retail markets** for electricity, and regarding pricing mechanism between **price zones, non-price zones and technologically isolated areas.**

1.2.5.1 Wholesale and retail markets

The Russian **wholesale electricity market** is divided into several segments [34]:

- The day-ahead market (DAM): covers distribution of 75% of all electricity generated in the country.
- Regulated contracts market (RC): covers some 14% of electricity sold. Prices (tariffs) are calculated in accordance with formulas established by the federal executive bodies.
- Balancing market (BM): covers around 4% of electricity being sold in the country.
- Free contracts market (FCM): also covers around 4% of electricity sales in the country. Participants negotiate about the price, electricity volume and counteragents individually 0.

Generating facilities with a capacity below 5 MW are not permitted to be active on the wholesale market [32].

Table 4 Possibilities of participation on different types of market depending on the installed power capacity

Installed capacity, MW	Wholesale electricity market	Retail electricity market
≤5 MW		✓
5-25 MW	✓	✓
≥25 MW	✓	

Source: eclareon 2019

The Russian **retail electricity market** has two segments (based on 0):

- Regulated prices market (RP) for private residential energy consumers (also referred to as population or households) where the price is established by the executive authority of state tariff regulations in each region/oblast. Prices are set for the year ahead and are based on the analytical data and prognoses of the electricity market development. Prices, as well as minimal and maximal tariffs may vary depending on the season and the region of the country and taking into consideration peculiarities of the energy system of each concrete region. The ceiling price is controlled by the Federal Antimonopoly Service of Russia.
- Non-regulated prices market (NRP) for all non-residential energy consumers including commercial SMEs, larger industries, agricultural sector and public services (hospitals, administration, schools etc.) NRP exists only in the price zones of the retail electricity market.

Since 2018, the term “electricity tariffs” for non-residential consumers is no longer used. Instead, there are now “electricity prices”. The term “electricity tariffs” is still used to designate electricity prices [40] of private households. Electricity price for large industrial consumers is established on a case by case basis, based on hourly consumption.

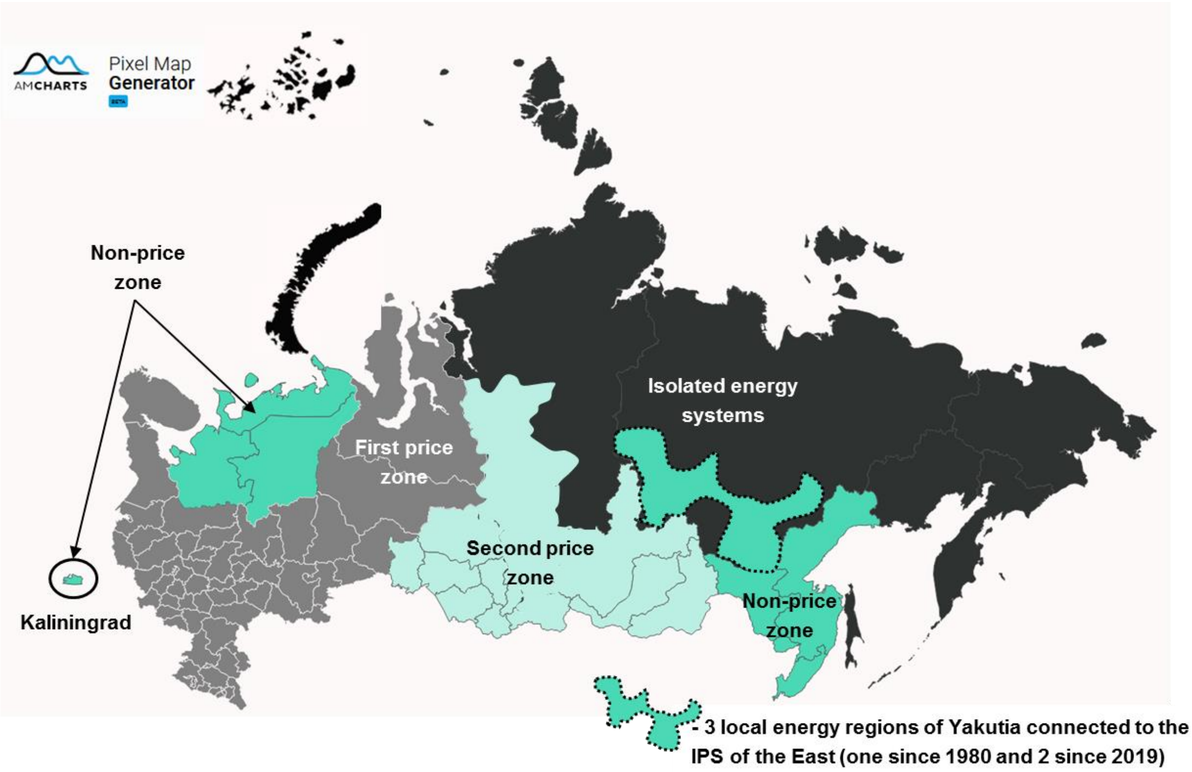
1.2.5.2 Price and non-price zones

The territory of Russia is split between 4 zones (see Figure 8):

- Price zones (first and second): prices for the consumers on the wholesale market and the retail market (**except for residential consumers**) are non-regulated
- Non-price zone (covering different territories of Russia but having the same rules): prices and tariffs for **all** consumers are regulated
- Isolated energy systems: prices and tariffs for all consumers are regulated

Electricity tariffs for residential consumers and groups equated to population are always regulated, regardless of which zone they belong to. Groups, equated to population includes many consumers such as non-profit horticultural/agricultural communities, prisons, entities and individuals purchasing electricity with an aim to use it for household needs (military units, settlements), and religious organizations.

Figure 8 Geography of the Russian electricity market



Source: eclareon 2019, based on E&Y, "Overview of the electricity and power industry in Russia", 2018 0, generated with amCharts Pixel Map

The **two price zones** are located in the Russian federal districts **(partly) Northwestern, Central, Southern, North Caucasian, Ural and Volga region** and are characterized by a large number of suppliers and purchasers of electricity, as well as well-developed network infrastructure availability that enables a competitive electricity market. In these two zones, price formation on the wholesale market is mostly free as long as it remains below a ceiling price defined by the "Administrator of the Trade System (ATS)" and except for the regulated contracts, see further explanation below.

The **non-price zone** is located in the federal districts **Northwestern (its larger part), part of Siberia, small part of Far Eastern region and Kaliningrad Oblast.** In these zones, electricity tariffs both on the wholesale and retail electricity markets are established by the "Administrator of the Trade System" in accordance to the Decree № 1172 of December 26th 2010 and Decree № 1178 of December 29th 2011 and by the Federal Executive Authorities based on the corresponding legal framework, the Tariffs Regulation.

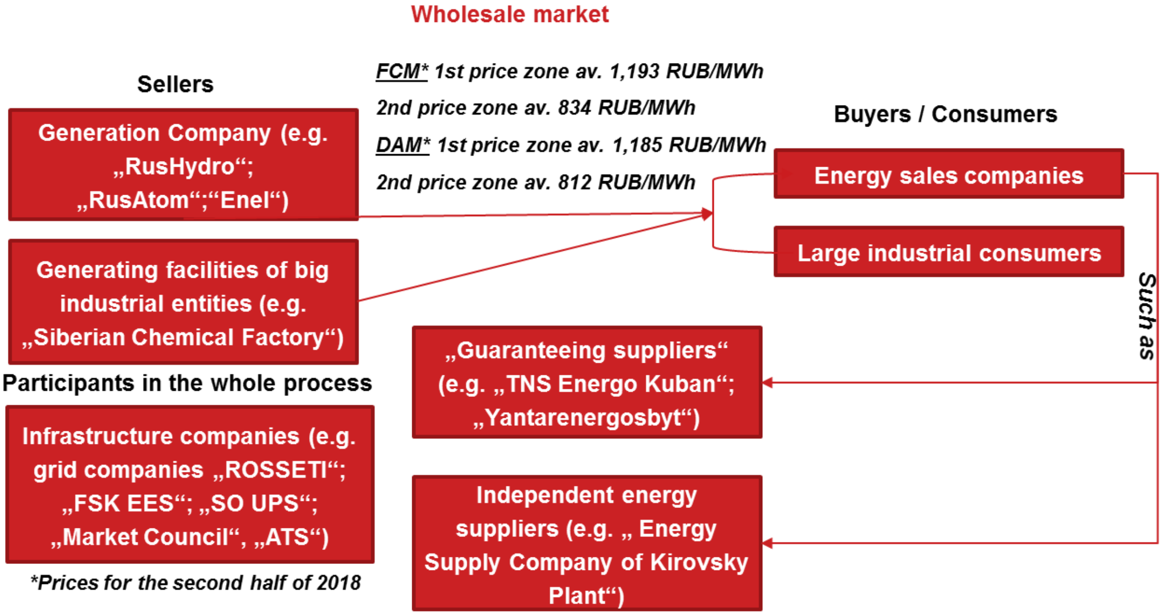
Regarding our two example regions described in the following chapters, Kaliningrad Oblast is included in the non-price zone, while Krasnodar Krai is in the first price zone. All in all, there are three main price categories on the electricity market:

1. Electricity prices for consumers on the wholesale market: price formation is defined in non-price zones and technologically isolated areas or generally free in price zones but a ceiling price is fixed by "ATS"
2. Electricity prices for industrial consumers on the retail market: this price can be freely negotiated in price zones as a general rule but there are price ceilings defined by "ATS".
3. Electricity tariffs for private residential customers (retail market): their electricity price is always established by the local executive body in the field of the state tariffs regulation in accordance to the ceiling tariffs published by the "Federal Tariff Service of Russia".

1.2.5.3 Development of electricity prices

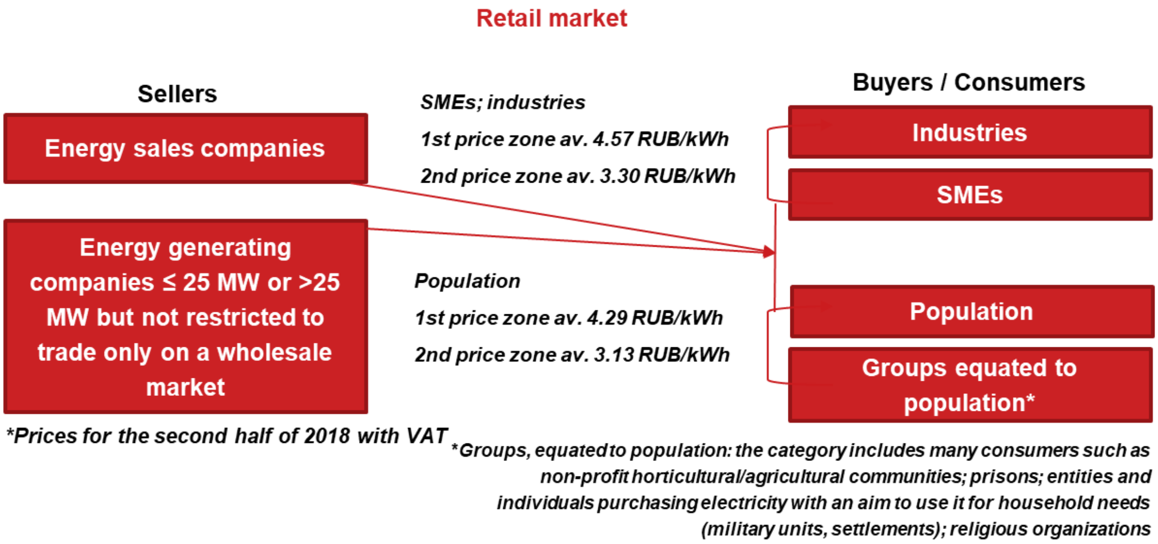
Figure 9 and Figure 10 illustrate the schematic functioning of the both wholesale and retail markets and mention the resulting electricity prices for the 1st and 2nd price zones in second half of 2018.

Figure 9 Scheme of the functioning of the wholesale electricity market with prices for 2018



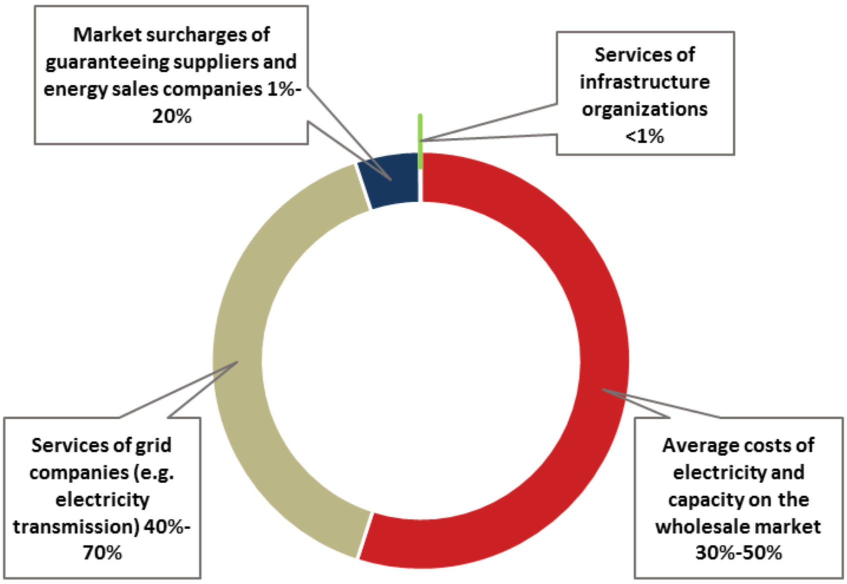
Source: "ATS", "Prognose of the free (non-regulated) electricity (capacity) prices by region for 2018 and initial data for prognoses"[32], August 2018

Figure 10 Scheme of the functioning of the retail electricity market with prices for 2018



Source: "ATS", "Prognose of the electricity price for the end consumers 2018", 2018 [32]

Figure 11 Scheme of the electricity price formation for the industrial consumers on the retail market (for first and second price zones)

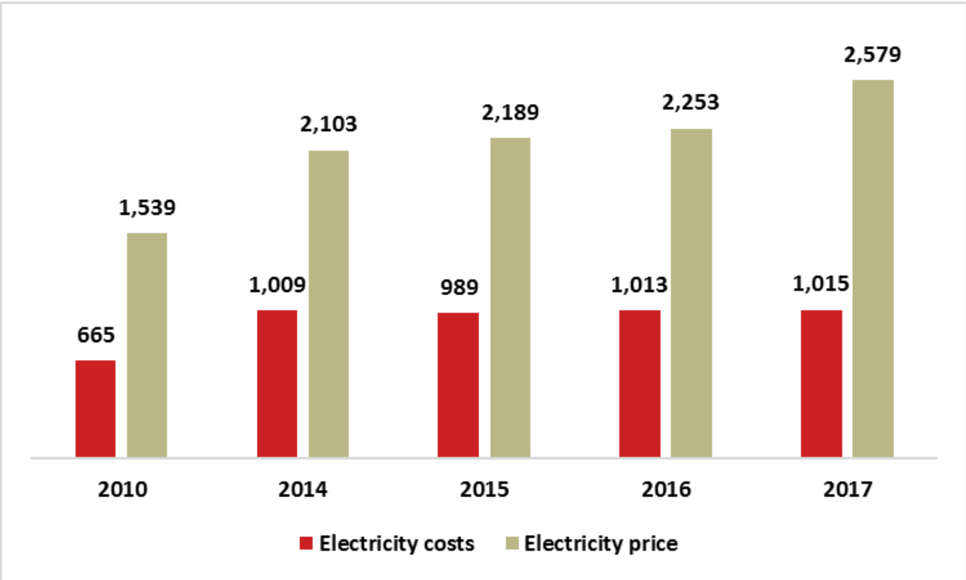


Source: En-Mart "Costs of electricity for industries", 2018 [40]

The average electricity price for the non-residential entities[1] in the retail market in the first price zone in the second half of 2018 was 5.15 RUB/kWh (0.07 EUR/kWh) including national VAT of 18%; in the second price zone it was 3.64 RUB/kWh (0.05 EUR/kWh) [41].

Looking at the evolution of prices in recent years, **companies pay more and more for electricity each year**. In 2017, the average price for 1MW of power in Russia cost 67% more than in 2010, while energy generation costs increased by 52% within the same period. Figure 12 illustrates, how average electricity costs and prices have changed in the last 7 years.

Figure 12 Average in Russia electricity generation costs and electricity consumer prices, RUB/MWh, 1 RUB=0.013 EUR



Source: Federal State Statistics Service of Russia, annual reports, 2017 & 2018 [6]

[1] Entities" is a term used for non-residential consumers and include commercial SMEs (offices, hair salons, shops, cafes), industries (like farms, caning factories, cement factories etc.)) and public services (hospitals, administration, schools etc

According to Ministry of Energy of the Russian Federation, the increase of electricity prices for non-residential consumers is also due to the fact that **more and more industry consumers prefer to switch to their own electricity generation or direct connection to the state grids regulated by the "FSK UPS"**, and thereby avoid local transmission companies and power sales companies. Independent generation permits companies to avoid costs of electricity transmission (collected by grid operators) and premiums from energy sales companies. And large companies and dominant industries have the capacity to invest time and money in a direct connection to these high-voltage grids. Both options create the possibility to avoid cross-subsidization (see 1.2.5.4) and stop spending money on supporting the population [37] [132].

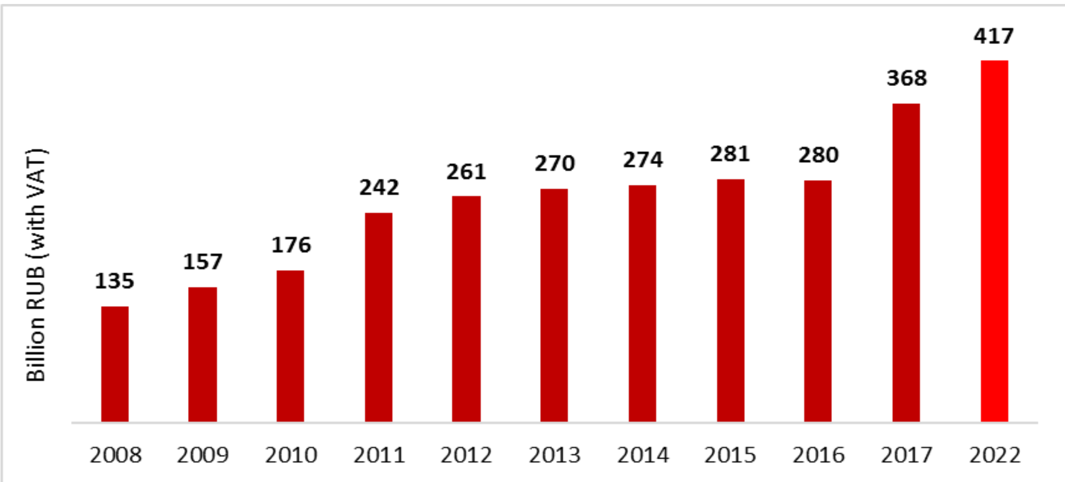
In the period between 2009 and 2017, about 7GW of generating capacity was installed by industrial consumers trying to avoid participation in cross-subsidization [38]. Usually, independent generation of industries is based on gas (gas turbines) [39] due its low price (4-6 RUB per cubic meter (5 – 8 €ct)). As a result**, SMEs are left alone in a battle against rising electricity prices**.

1.2.5.4 Electricity tariffs for residential energy consumers

Tariffs for the population differ drastically depending on the region, tariffs for Krasnodar Krai and Kaliningrad Oblast are mentioned in the chapters 3 and 4. **But basically, retail market tariffs for private residential customers are kept low with subsidization.** On average, these prices are 30% lower than the prices paid by so-called entities on the retail market who cross-subsidize (cross-subsidization) the electricity prices of private households. This is very untypical in Germany but is widespread in CIS (Commonwealth of Independent States) countries. To keep household prices low, there are **two main types of subsidization** of energy sector in Russia.

- The first is a **direct subsidization**, which includes the allocation of money from the federal budget to local budgets to partly cover the costs of coal, diesel and other fuel types used for energy generation targets. In other words, these subsidies finance operational costs of energy generation. The strongest support is given to the Far East and, according to government plans, subsidization of the regions will continue.
- The second is more widespread and developed, it is **cross-subsidization** [35]

Figure 13 Dynamics of cross subsidization of energy sector in Russia between 2008-2017 and a prognosis for 2022



Source: Government of Russian Federation, "Cross Subsidization in electricity sector: Problems and solutions", 2017 [35]

The volume of cross-subsidizing has increased drastically in the last 5 years. This is due to different factors, including the overall imperfection of the subsidization system, the historic of cross-subsidization and the absence of an alternative variant of consumers' support. These costs have to be paid by large, small and medium industrial consumers, budget organizations, housing and communal services organizations [36]. By 2022 the sum of cross-subsidization may reach 417 billion RUB (5,611 billion EUR based on OANDA exchange rate February 13th 2019 here and further in the document).

1.2.5.5 LCOE of PV electricity

For some companies, PV generation or hybrid PV-diesel/gas/petrol generation can become a reasonable solution too especially in sunny regions such as Krasnodar Krai. **Regarding costs of PV based electricity, there are a number of different estimations of Russian energy market experts**, based on different assumptions and the fact that there is no mass market in which past costs of similar projects could be taken as a more reliable basis for cost assumptions.

For instance, an analyst of "VTB Capital" [42], Vladimir Sklyar, stated that LCOE for "green" (renewable energy based) energy in Russia is currently 3-6 times higher than wholesale prices of traditional electricity [43]. According to "Market Council", in 2018, LCOE for PV in Russia was the highest and fluctuated between a range of 24 - 26.5 RUB/kWh (32 – 36 €ct /kWh) and is supposed to decrease to 20 RUB/kWh (27 €ct /kWh) by 2020 0. However, should loan rates by the Central Bank decrease for RES projects with a simultaneous drop of CAPEX for PV equipment, then, large scale PV may become competitive with traditional energy sources (oil, gas, nuclear) by 2030.

There are some stakeholders in Russia that argue that the situation with residential PV generation is different, assuming that costs for residential solar energy sometimes do not exceed 9 RUB/kWh (12 €ct /kWh). This difference is explained by a lower CAPEX assumption (e.g. absence of land costs, as a stakeholder simply uses an own roof/land for PV modules; absence of grid connection costs), shorter construction periods and no tax implications in that PV application segment [45].

A study of the Russian Presidential Academy of National Economy and Public Administration published in 2018 calculated LCOEs for different installation sizes and under varying financing conditions. This study illustrates the huge bandwidth of possible costs of PV depending on the underlying assumptions of the calculations: using a WACC of 17.5% for discounting project cashflows, LCOEs vary between approx. ~11 €ct/kWh as a minimum for large scale PV and approx. 76 €ct for residential PV. Reducing the WACC to 7.7% brings down these values to 6 €ct/kWh and 43€ct/kWh respectively. The high end LCOE values in this study account for carbon capture and compression without costs of storage and transportation.

The base case scenarios of the profitability analysis calculations undertaken by the authors in chapter 5 of this report resulted in LCOEs between 9 RUB/kWh (12 €ct/kWh.) and 14 RUB/kWh (19 €ct/kWh). However, depending on the variation of key assumptions such as installation costs and solar irradiation, very different LCOE levels can be calculated. For instance, as PV is becoming more prevalent in a region, competition among suppliers increases and turnkey installation prices continue to decline, including the LCOE for PV power.

What remains true, regardless of the underlying calculation, is that low electricity prices in Russia remain a challenge for the cost competitiveness of solar PV and other RES. A diligent planning process and good site selection (high irradiation, relatively high electricity prices of consumers, bad or no grid connection), or a personal interest/motivation in trying out renewable energy sources is important to be successful in the nascent Russian PV market.

1.3 Russian Business Models for Solar PV

Business models on the Russian PV market can be divided into the following two categories:

1. **Regulative-driven business models** that are directly defined by an energy specific law and can profit from support mechanisms. The following business models belong into this category:

   - **Wholesale market projects**, including those participating in the contract competition of the long-term capacity delivery agreements under the Decree 449 managed by "ATS". These projects are normally ground mounted PV parks with several megawatts of installed capacity, but not less than 5 MW. Afterwards they are connected to the grid (UPS) - this market segment is dominated by multinational companies such as Fortum, Enel and Hevel. According to "ATS", there have not been any PV projects in Krasnodar Krai or Kaliningrad Oblast under the power delivery agreements competition since its introduction in 2013. The main reasons for this are: high costs of PV equipment and CAPEX, too long payback periods in comparison with other investment options (5-10 years [45]) and the lack of local government support for both producers (potential generators, PV-based) and consumers of PV-based energy. For Kaliningrad Oblast an additional reason is the limited sunny days in comparison to Krasnodar. An additional important challenge for building large scale projects under Decree 449 is the fulfilment of a high local content quota of 70%. Further details are given in chapter 2.1.1.

   - **Retail markets projects**: Such groupings occurred after the Decree 47 entered into force in 2015. They have minor differences from the projects in the wholesale market. For example, the contract competition for PV power plants of the retail market is held by local federal units and "SO UPS" is excluded from the management of the SPP. Additionally, the installed capacity of such power plants cannot exceed 25MW, otherwise such plant can become part of the wholesale market. An important note is that Decree 47 should be adapted to regional conditions and be legalized in each region separately. That is done through additional decrees and local laws, created by regional legislative bodies, which are aimed at enforcing Decree 47. Further details are given in chapter 2.1.2.

   - **Micro-generation (residential) up to 15 kW as part of the retail market:** This group will develop and become part of the grid as soon as the law on micro generation enters into force. Here private "prosumers" will be able to generate electricity with the aim of covering their demand as well as officially having the right to sell the surpluses/send them into the grid. Currently, micro-generation exists but is reduced to rooftop PV panels etc. that are disconnected from the grid and not registered or included in official energy statistics. Further details are given in chapter 2.1.3.

   - **Projects for the isolated energy system**: Various RES power plants of different capacities have already been built in Kamchatka, Yakutia and Chukotka. These SPPs are local, are cut from the UPS and usually have small capacities aimed at providing energy for a chosen area or settlement. Not mainly based on a specific law, but because of the obligation of a guaranteeing, usually the state-owned, supplier to ensure electricity supply in these regions.

2. **Self-supporting** business models that are not directly defined in an energy specific law but come from private initiatives of individuals and companies: Installed capacity of such projects may vary from kilowatts to several megawatts. Examples of these projects are installations initiated by industrial consumers who want to reduce their exposure to rising electricity prices from the above-mentioned cross-subsidization of electricity prices of private households. Such PPs are constructed either by entities or by third parties with the aim of generating electricity for the own needs.

This report will examine the profitability of three of the aforementioned business models in detail and in specific application for power generation (see chapter 5). We have selected those that are currently the most interesting for Russian and German SMEs who want to become active together in the Russian solar PV market. These three segments are:

1. **Ground-mounted grid-connected photovoltaic power plants (PV parks)** with a capacity of up to 25MW; such installations are built using tenders in the wholesale market or the retail market, whereas this report focuses on retail market installations.
2. **Diesel-PV hybrid systems** with a capacity between approx. 50 kW and a maximum of several MW; these installations supply power in off-grid areas (remote or isolated territories) or function as back-up systems in weak grid areas.
3. **Grid-connected residential photovoltaic rooftop systems** of up to 15 KW capacity, operated based on a net-metering scheme in the near future.

These three business models cover a wide range of PV system configurations (grid-connected and off grid) and system sizes. Moreover, the three business cases address different customer groups (grid operators, commercial and residential) and their economic availability is based on different business models. While large MW systems under law 449 and 47 receive beneficial tariffs, the profitability of diesel PV hybrid installations is mainly determined by diesel savings and the profitability of the residential model come from savings in the electricity bill. The profitability calculations, investment assumptions and sensitivities for the attainable profitability are presented in detail in section 5 of this report.

2. Regulatory and Business Framework

2.1 PV Regulations and Support Schemes

There are currently two support schemes in Russia that support the generation of electricity from renewable energy sources in the wholesale and retail market, including PV. The regulations for PV installations differ depending on the respective market.

2.1.1 Capacity Supply Tender (Wholesale Market)

2.1.1.1 Introduction

The perhaps most visible support of renewable energy development and electricity generation from RES in Russia began in 2013 with the **Decree № 449** that was drafted by the Ministry of Energy of the Russian Federation and adopted by the government on 28 May 2013. This decree established a mechanism for encouraging RES use in both the wholesale electricity and the capacity markets. The adopted resolution became the first stage of development of RE in Russia.

The main idea of the mechanism, that supports RE on the wholesale market, is that renewable electricity suppliers (investors), both Russian or foreign, **get long-term agreements for the supply of operating PV capacity** after their projects are selected in a competitive tender process for RE installations. The scheme offers the awarded bidders – contrary to other European tender schemes – payment per capacity (MW) instead of per electricity output (MWh). According to the capacity supply agreements, wholesale market consumers (large electricity consumers) are obliged to remunerate the supplied capacity by paying beneficial tariffs over the course of 15 years (duration of agreements).

It should be noted that **supporting renewable energies through capacity contracts (MW) is a unique concept**, opposed to remuneration based on electricity supplied (MWh).

Such capacity tenders (covering solar power, wind power, small-sized hydropower and waste-to-energy) **have been organized every year since 2013** by the regulatory body "Market Council" [46] and every year several projects have been selected. In 2018 there were two winning parties (Fortum, a Finish power utility, and Avelar Solar Technology which is the subsidiary of Russian company Hevel) [47]. Both taken together they will realize 10 PV projects with a total capacity of 148.5 MW. The seven projects proposed by Fortum company, with a total planned capacity of 110 MW, have a proposed CAPEX which is almost half of the CAPEX proposed by the Avelar Solar Technology.

2.1.1.2 Process Steps

As mentioned above, the regulatory body "Market Council" invites potential suppliers of electricity generated from renewable energy sources to participate in the capacity tender, which occurs annually.

The project **selection procedure comprises of two rounds:**

1) In the first selection round, it is determined whether the project meets all the requirements for participating in the scheme such as:
   - maximum capital costs per 1kW
   - local content requirements etc.
2) In the second selection round, the winning projects are selected based on a single parameter, which is the capital costs of the project.

Once the project is selected, **the investor will be remunerated on a monthly basis depending on the plant's capacity.** The remuneration is calculated for each plant, and is based on the capital costs indicated in the bid submitted by the investor during the tender. The tender winners sign an agreement for the supply of capacity with the wholesale market consumers through the intermediary, the JSC "Financial Settlement Center (CFR)" [48]. The winning party receives guarantees of stable profitability and beneficial tariffs for electricity but is obliged to complete the construction of the RE installation and to ensure that local content requirements are fulfilled (see chapter 2.1.1.4).

To be eligible for support under the capacity supply tender scheme, RES installations need to be qualified as generating facilities operating on renewable energy (or certified) by the regulatory body "Market Council", in line with the government Decree № 426 'On the Qualification of RES Installations' and has to be included in the official version of the regional "Scheme and Programme of the Perspective Development of the Regional Energy Sector" (a document prepared by each region individually and on an annual basis, also mentioned in section 3.3 "Region-specific regulatory & legal framework" for Krasnodar Krai), approved by the executive authority of the regional subject of Russia (there are different types of regions in Russia, including republics, krai, oblast, autonomous oblast, and cities of the Federal importance).

Moreover, to calculate the capacity price, the **expected revenue from selling electricity on the wholesale market is taken into consideration**. Thus, the investor has two revenue streams which combined should ensure a return of the capital investments of a project by 12% for the 15-year payback time.

2.1.1.3 Support Scheme Requirements

As mentioned in the previous section, **RE installations have to be approved by the regulatory body "Market Council"** and given the status "generating facility operating on renewable energy" to receive support under the capacity supply tender scheme. This status can only be given when the installation has been constructed, connected to the grid and commissioned.

Moreover, the capacity supply tender scheme is eligible for **RE installations with at least 5MW** of installed capacity [12], i.e. wholesale market participants. To participate in the capacity tender, an investor needs to be registered as a provisional supplier on the wholesale market [31].

A further important requirement of this support scheme is that the **RE plant has to meet certain availability criteria**, such as the minimum capacity factor over a year which should be 0.14 for PV plants. The capacity factor is reflected in the amount of electricity that the RE producers sell for a year. If the capacity factor of the plant is lower than 0.14, the capacity remuneration will be respectively reduced.

Moreover, the **maximum capital investments of the project** (expressed in RUB/kW) **as well as the O&M costs** (expressed in RUB/kW per year) **are fixed** and specified by the government Executive Order № 1472-r. For example, the maximum allowed capital expenditure for plants commissioned in 2019 is 105,262 RUB/kW (approx. 1,416 EUR/kW), whereas for the plants commissioned in 2020 the limit will decrease to 103,157 RUB/kW (approx. 1,388 EUR/kW). The maximum allowed O&M costs for the year 2019 are 2,777 RUB/kW (approx. 37 EUR/kW per year), and in the year 2020 the value will increase to 2,880 RUB/kW (approx. 38.7 EUR/kW per year).

The **capacity supply tenders** for selecting the power plants operating on renewable energy sources **are organized only for the 1st and 2nd price zones** (see section 1.2.5 Electricity Markets, Prices, Tariffs and Costs), i.e. Decree № 449, regulating capacity tenders, is not applicable to RE installations in isolated regions and non-price zones.

2.1.1.4 Local Content Rule

Another important factor for PV investors is the local content rule, which stipulates that **70% of the equipment used for the construction of the PV plants, as well as project development work, needs to originate from Russia** (used to be 50% in 2014-2015 and increased to 70% for the period 2016-2024) [50]. The determination of the localisation coefficient is described in chapter 2.3.4.

If PV investors fail to fulfil the local content requirement of 70%, they are subject to a significant penalty coefficient that amounts to 0.35 (for wind power plants the penalty coefficient is 0.45). Respectively, if the PV plant developer does not satisfy the minimum localisation of 70%, it will only receive 35% of the calculated tariff (65% lower than the corresponded tariff). These issues/risks have the potential to adversely impact the projects [52].

This rule is a barrier for raising the RES share because the Russian manufacturing industry for RE equipment and technologies is still small. Hence, it is more difficult and expensive to supply the equipment needed to comply with that local content rule. Moreover, it is questionable to what extent it will be possible to scale up capacities in order to achieve the RES targets in the timeframe put forward by the government - a 4.5% RES share by 2024 [51].

2.1.2 Electricity Supply Tender (Retail Market)

2.1.2.1 Introduction

In January 2015, the **Decree № 47** "On Amending Certain Acts of the Government of the Russian Federation on Promoting the Use of Renewable Energy Sources in Retail Electricity Markets" was adopted. The decree introduced a **support mechanism for renewable electricity generating facilities with an installed capacity of up to 25 MW in the retail electricity market**.

The decree contains common directives which are not specified for individual regions. Thus, **all regions in Russia enforce Decree 47 separately** through the implementation of respective legislative acts, decrees and laws. Bashkortostan has implemented such laws, while Kaliningrad Oblast has not. The decree obliges regions to enforce these laws, but does not specify when and lacks non-compliance measures.

According to the scheme, **local grid operators in respective regions are obliged to purchase electricity generated by RE facilities to compensate their projected grid losses**. **However, the purchase is limited to 5% of the projected grid losses in the region.**

Projects which qualify as "renewable" by the regulatory body "Market Council" enjoy long-term tariffs for the period of 15 years (same as in the wholesale market) [53]. To get this compensation, RE generating facility operators need to participate in the competitive selection procedure - electricity supply tenders, organized in each of the regional subjects of the Russian Federation (see chapter 2.1.2.4).

According to Decree № 47, the inclusion of a generating facility operating on renewable energy in the price and non-price retail market and in isolated regions should occur according to the following principles:

- Minimization of the increase of prices (tariffs) for electricity (power) for the end-consumers in the retail market
- For non-price and price zones, the amount of electricity purchased from RE facilities should not exceed 5% of the projected losses of electricity by the grid companies
- For isolated areas, the project implementation should result in the price reduction of electricity in the respective region
- Minimization of environmental damage
- Addressing social problems in the area where the project is implemented
- Transparency.

It is estimated that the **total capacity of RE facilities that could be installed based on this support mechanism is approximately 3,000 MW** with a total required investment of 8 billion dollars (approx. 7 billion EUR) [54].

2.1.2.2 Responsibilities

In contrast to the capacity supply tender scheme (Decree № 449), regional and non-federal authorities [55] have an important role in the development of renewable energy projects in the retail market. **It is up to the regions to choose between organising tenders for specific RE technologies or technology neutral ones**.

Federal authorities are not entirely excluded, however, because **regional authorities can only define preferential tariffs for RE installations for a maximum of 5 years**. Tariffs for longer periods need to be approved by federal authorities. Moreover, it is a federal authority, namely the regulatory body "Market Council", which has to formally approve an installation being "renewable" (qualification).

2.1.2.3 Tariff Calculation

The preferential tariff for RE facilities is calculated using the methodology approved by Order № 900/15 of the Federal Antimonopoly Service on "The approval of the methodology for the establishment of the tariffs and (or) extreme (minimum and (or) maximum) levels of tariffs for electricity (power) from renewable energy facility in order to compensate for losses in grid" from 30 September 2015.

According to this methodology, **preferential tariffs are calculated so that the basic level of the return on investment capital (ROIC) is 12%** (for the projects commissioned since January 2017). These tariffs are usually several times higher compared to the tariffs for conventional electricity used for the same purposes.

The retail market, like the wholesale market, a **PV project has to satisfy localisation requirements of at least 70%,** otherwise the preferential tariff is decreased by 65% (see Section 2.1.1.4)

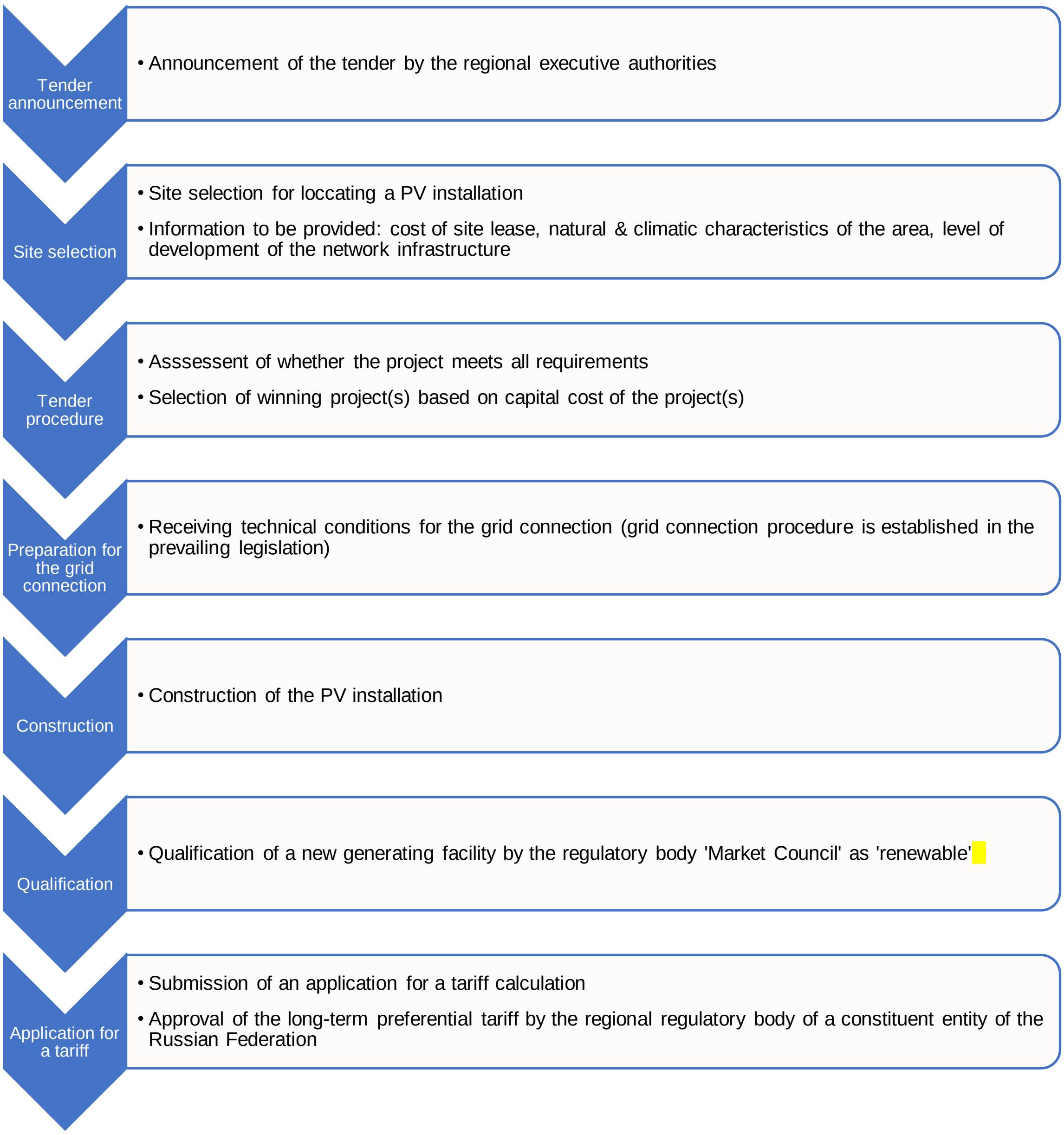
A major difference between the support scheme for RE projects in the retail market and the one applied to the wholesale market is that the **preferential tariff in the retail market is calculated per MWh**, while in the wholesale market the tariff is paid for the capacity (capacity price) expressed per MW (Decree № 449) 0. It means that there is no need to make any adjustments of the preferential tariff when the electricity market price changes [57].

The Order № 900/15 was amended on 15 March 2018 when the Order № 317/18 entered into force, introducing the tariff calculation methodology for power plants installed in isolated regions; an important part which was previously missed.

2.1.2.4 Process Steps

According to the Decree № 47, there are **seven stages to receive support** (preferential tariff) under the electricity supply tender scheme, including PV projects [58] (see Figure 14).

Figure 14 Process steps for obtaining support for a RE project in the retail market



Source: eclareon & EUROSOLAR Russia, 2019

RE projects that are supported by the electricity supply tender scheme are selected in a **competitive selection procedure** (tender), which is held by regional executive authorities. Decree № 47 does not determine how often these tenders have to be organized, meaning that regional executive authorities are free to decide on their own. Selected RE projects are then included in the regional electricity sector development schemes and programmes. Only with the inclusion in the regional “Scheme and Program of the Perspective Development of Energy Sector…”, can RE installations be certified as renewable by the regulatory body Market Council (similar to the wholesale market). Qualification is carried out in accordance with the “Procedure for the qualification of the generating facility operating on renewable energy sources”, approved in June 2008 by the Decree № 426.

Based on the qualification certificate, the **regional regulatory authority sets the preferential tariff for the capacity and for the electricity generated from renewable energy sources for the grid loss compensations purpose, which is paid for 15 years.** When a RE facility starts generating electricity, the generated volume of electricity is certified by the regulatory “Market Council” and, based on these certificates, the grid operator remunerates for the supplied renewable electricity and capacity [59].

2.1.2.5 Effectiveness of the Support Scheme

At the current stage it is difficult to evaluate the effectiveness of the support mechanism defined by the Decree № 47 (Electricity Supply Tender) since it is still relatively new. **So far, there are no statistics regarding the selected projects for each region.** Moreover, it is highly probable that there were no commissioned power plants given the fact that it takes 2-4 years to construct a plant once it was selected by the regional commission. In Krasnodar Krai a single tender with total capacity of 90MW was organized in 2018. Only one party participated in this tender and the realization of the 90MW is not yet certain because of open questions regarding the construction of the plants. The tendered capacity is not included in the Scheme and Programme of Development of Energy Sphere of Krasnodar Krai 2019-2023.

The following four observable features of the support scheme might limit its effectiveness:

1. Preferential tariffs are only determined once the project is qualified as “renewable” by the regulatory body “Market Council”. RE installations can only qualify when constructed, meaning that project developers/investors are only eligible for preferential tariffs after the investment is done, so there is of uncertainty regarding the project revenues.
2. The limitation of the renewable power purchase in the retail market of up to 5% of total transmission grid losses, resulting in limited purchases of renewable electricity by the transmission grid operator [60]. The total transmission grid losses in Kaliningrad in 2017 amounted to 762.6 GWh. This implies that through the support scheme for the retail market a maximum of 3,100MWh of energy can be sold a month, which corresponds roughly to the production of 30MW solar PV plants in Kaliningrad. In Krasnodar Krai, the total losses in 2017 were 3,980GWh, where 5% is equivalent to 199,020MWh of renewable electricity that can benefit from the support scheme in a month, corresponding to the production of a 174MW solar PV plants in the region.
3. Moreover, according to the tariff regulation, preferential tariffs that last for more than 5 years need approval from the federal authorities, raising uncertainty further about whether long-term tariffs will be granted.
4. As mentioned above, the tariffs are calculated using the methodology approved by Order № 900/15, both for the installed capacity and for the electricity sold on the retail market [61]. When developing the methodology, officials did not take into account that, according to Decree № 442 (retail market rules) the amount of electricity that can be sold to a grid company to compensate for 5% of its losses, must be confirmed by a special certificate which is issued by the regulatory “Market Council”. In Decree № 442, however, there is no reference to the capacity as a commodity. Respectively, a situation in which plant operator cannot sell capacity because certificates were not issued is possible [59].

2.1.3 Microgeneration

Currently, a new “action plan aiming to support the development of generating facilities based on renewable energy sources with an installed capacity of up to 15 kW” is being revised and is awaiting governmental approval. The draft was signed by the Deputy Prime Minister Arkady Dvorkovich on 19 June 2017[62].

On November 7th 2018, the draft law passed to Russian Duma (the lower house of the Federal Assembly of Russia) for further approval and discussion. In early February 2019, Russia’s lower house approved the draft law for the introduction of net metering for solar and other renewable energy generators with a capacity <15 kW [63] after its first reading - three readings are required before the law can be enacted. According to government officials this will happen by the end of 2019.

Upon final approval, the country's main law on electricity generation will be amended, introducing the concept of 'microgeneration from RES' and defining the main rules for selling the excess electricity for the wholesale market price (which fluctuates around 1RUB/kWh (approx. 1 €ct/kWh)) from small RE generating facilities on the retail market [64].

The drafted law establishes the following principles:

- RE generating facility shall be owned by a user or belong to the owner by other legal bases.
- Installed capacity of a facility must not exceed 15 kWp.
- The generation object shall aim to fulfil its own energy demand for households or supply its own production needs.
- Installed capacity is used on the retail energy market only.
- The drafted law is only for private stand-alone houses, apartment houses are excluded from the list of potential users.

The scheme is reported to be a net-metering scheme allowing private prosumers to sell energy surpluses to the grid without being considered companies. They need to sign a purchase agreement with a guaranteeing supplier, which is obliged to accept and sign these contracts.

The process for the valuation of the electricity saved/sold is still unclear, but will depend on the price zone of the energy market. It is likely, that in price zones 1 and 2, the price will be calculated as a weighted average and unregulated energy price that is calculated by established procedures. In the non-price zones, like Kaliningrad Oblast, this will be a regulated price. For isolated energy systems in Siberia and Far Eastern, energy will be sold at the minimum production price established by the authorized executive body.

2.1.4 Further Support Mechanisms

Decree № 850 from 20 October 2010 defined the criteria for subsidizing technical RE connections of up to 25 MW from the federal budget to the electricity grid. According to those criteria

- the electricity has to be generated from RES.
- the installed capacity of the RES facility cannot exceed 25 MW.
- the owner of the generating facility does not have tax arrears, is not bankrupt etc.

In 2016, the Decree № 961 from 23 September 2016 complemented Decree № 850; the later one being a part of the government program 'Energy Efficiency and Development of the Power Sector'. Decree № 961 established certain rules and procedural steps for receiving federal subsidies for the connection of RE generating facilities of up to 25 MW to the electricity grid.

The decree envisages that the decision on providing the subsidy is made by a special commission created by the Ministry of Energy. **Subsidy cannot exceed 70% of the overall costs of the connection of the RE facility to the grid and cannot cost more than 15 million RUB (approx. 202 thousand EUR).** Finally, technical grid connection costs are defined as the actual cost of the grid connection, determined in accordance with the legislation of the Russian Federation on electricity [65].

2.2 Codes and Standards

2.2.1 Transmission Rules and Grid Connection

The most important legislation that governs transmission operations is **Governmental Resolution № 861** "On the Approval of the Rules for Non-Discriminatory Access to Electricity Transmission Services and the Provision of these Services, of the Rules for Non-Discriminatory Access to Dispatch Management Services in the Electric Power Industry and the Provision of these Services, of the Rules for Non-Discriminatory Access to the Services of the Trading System Administrator and the Provision of these Services and the Rules for Technological Connection of Power Receivers (Power Units) of Legal and Natural Persons to Power Networks".

As the name indicates, **the resolution establishes four sets of rules**: the first three provide equal rights to all electricity consumers to access the electric power transmission and its related services, while the fourth is meant to provide guidance and set technical requirements for the connection of a generating object to the grid [66].

2.2.2 National Standards for Solar Energy

The executive body responsible for standards in Russia is the Fed**eral Agency for Technical Regulation and Metrology** (*Росстандарт*, in engl. Rosstandart). From 2013-2018 the body approved a series of GOST (abbreviation from "*государственный стандарт*" or in engl. "Gosstandard", i.e. national standard) standards in the energy field.

In the field of solar power engineering specifically, including PV systems, there are 69 national standards, most of which were approved between 2013-2016 [67]. The fact that most of the standards were approved in such a short time indicates that the country wants to push ahead with the development of its PV industry.

A GOST certificate is a document attesting that the product conforms to the Russian national GOST standards. This certificate may be required to import, manufacture or sell products in the Russian Federation. In 2009, the Russian government adopted Resolution № 982 (adopted on 1 December 2009 and entered into force on 15 February 2010), containing **the list of products that are subject to mandatory certification** [68]. If the product is part of that list, it has to be certified before it can be sold in the market. **PV modules and PV inverters are not included in the list.** The only current GOST for PV modules is GOST P 51597-2000 "Nontraditional power engineering. This certification is too old and is not suitable anymore for actual materials and technologies. Nevertheless, some other components needed for the construction of the PV plant (i.e. transformers) can be a part of the list and thus subject to mandatory certification 0.

2.3 Trade, Investment and Import Conditions

2.3.1 Trade and Investment

Russian support mechanisms for renewable electricity generation have the potential to minimize some risks and aim at securing investments as well as protecting the investment profitability from changing market conditions [70]. This can be specifically inferred by the support mechanism for the wholesale market, which has proven to work well for several years.

From the tender results it can be observed that most of the project winners are big companies either from Russia or in collaboration with Russian companies with experience in PV manufacturing or PV project development.

However, when it comes to the support mechanism for the retail market, Decree № 47, it is not clear to what extent it will offer sufficient support in increasing the share of RE technology. One important drawback of the support scheme is its complexity and the high number of institutions that are involved in the process of selecting and qualifying the project, both on a regional and federal level.

One of the most stringent requirements that is seen as an impediment for increasing foreign investment is the strict local content requirement of 70% for PV projects (see Section 2.1.1.4). Under these conditions, the easiest and most secure way to profit from the support mechanisms is to partner with companies located in Russia.

2.3.2 Inflation and Interest Rates

As of February 2019, the Bank of Russia has forecasted that **the range for annual inflation will vary between 5.0 and 5.5% by the end of 2019.** It is expected to be 1.5% lower, at 4% at the beginning of 2020.

The **baseline interest rates** at which banks can lend money from the central bank is based on the so-called key rate which is currently (02/2019) kept at **7.75%.**

2.3.3 Import Conditions for PV

The main countries from which Russia imports PV modules are the US, China and Germany [71]. However, in recent years PV modules imports have decreased as a result of EU and US sanctions in conjunction with the significant effort the country has made to increase its local production of PV components.

As already described in section 2.1.1.4, for PV installations to qualify for support in both for the wholesale and retail market, it has to comply with the rules laid down in the Government Decree № 426 "On the Qualification of a Generating Object Operating Using Renewable Energy Sources" [72]. One important criterion for project selection is the local content rule that requires that more than 70% of the PV equipment as we all project development work has to be located in Russia, according to the Decree № 1472-r of 28 July 2015 [73].

The decision about whether the project/installation meets these criteria is made by the regulatory body "Market Council". To determine the localisation level of the power plant, the origin of all of its constituent components has to be confirmed. Moreover, the localisation level also takes into consideration the origin of the project development work. If 70% is not achieved, the project does not qualify or the preferential tariffs for selling the produced renewable electricity are significantly reduced, by applying a coefficient of 0.35 (for the retail projects), the business case would deteriorate. As a result of the local content requirements, a PV manufacturing and construction industry has developed in Russia, ranging from research and development (R&D) to the production of PV modules and the construction of PV plants [74]. The other result is that imports of PV modules to Russia have decreased.

Nevertheless, **foreign PV equipment is still available on the Russian market. However, this equipment cannot be used for tendered projects, but only for private electricity generation where local content rules are not applicable.**

2.3.4 Determination of the Localisation Coefficient

One of the most important criteria determining to what extent specific RE power plants can benefit from the capacity supply tender scheme and the electricity supply tender scheme (Decrees № 449 and № 47) is its localisation coefficient. The localisation coefficient indicates how many of the components comes from Russia. The localisation coefficient is determined according by Decree № 426 "On the Qualification of a Generating Object Operating Using Renewable Energy Sources". Each component of the PV installation or project development work has a specific percentage weight (see Table 5).

Regarding PV, the **calculation of the localisation coefficient depends on the type of PV installation used: crystallin silicon or thin-film.** The overall localisation coefficient for the plant is determined as the sum of its components, grouped in the categories indicated in the Table 5 (refers to silicon PV). It is important to note that the percentage set in Decree № 426 for each category cannot deviate from the value specified in Table 5 (i.e. it is either zero or the value specified per category). For example, if in Category 4, the electrical connections between cells and modules are produced in Russia but the encapsulation material for the PV module is imported, the overall percentage for this category will be zero. Moreover, in the case when the origin of the constituent element of the power plant or work cannot be proved, the respective category will be assigned a zero-percentage level [75].

Table 5 List of conditions for determining the localization of the generating facility operating on the basis of photoelectric conversion of solar energy using crystalline silicon technology

Category		Percentage
1.	Silicon (including recycled) and silicon ingots used in photocells produced in Russia	20%
2.	Silicon wafer (silicon cell) produced in Russia	15%
3.	Crystalline silicon solar cells produced in Russia, including the processing of the silicon wafer, the additional structure for electricity flow as well as the final surface treatment	25%
4.	Electrical connection between the solar cells and modules as well the encapsulation materials for the PV modules produced in Russia	5%
5.	Assembly, final connection of wiring elements and inverter testing performed in Russia	12%
6.	Details and components of the supporting structures is produced in Russia, the needed metal is produced in Russia, as well as assembly of the supporting structure in completed in Russia	5%
7.	The wiring and electrical equipment not listed above is provided by a supplier from Russia	3%
8.	Site survey as well as the design of the power plant, including the drawings, is produced in Russia	5%
9.	Assembly, inverter connections as well as other electrical installation work on the power plant site, except the work related to the connection to the grid, is performed in Russia	5%
10.	Mounting on the power plant site for the construction of the foundation, assembly and installation of supporting structures, auxiliary elements and their components are produced in Russia	5%

Source: Decree № 426, 2017 [75]

As previously mentioned, since 2016 the localisation coefficient for PV plants has been 70% to fully benefit from the support schemes in the wholesale as well as the retail market. This might seem to be a high percentage requirement for a country only starting to develop its renewable energy sector, however, it has been reported that power plants with a localisation coefficient of even 100% are already being constructed in Russia [76].

2.4 Financing of PV Power Plants

Bank loans and credits to investors usually have an average interest rate of 10%-11%. One possible measure to bring the installed RE capacity to the planned level and attract more investors would be to bring down the loan rate to an estimated level of around 8%-9%. This would mean subsidizing from the state budget [77]. Currently, these measures are being discussed in the government, as such a decision could cost the state an additional 27 billion RUB (approx. 364 million EUR) [77].

As project financing, understood as non-recourse finance where the payback of loans is secured by project cashflows only, is restricted to large PV plants with an investment volume of several million EUR, **credits will likely be granted as private or corporate loans**, depending on the type of PV investor (private or corporate). The creditworthiness and the risk profile of the individual investor and only to a lesser extent the project itself will determine the interest rate and whether the loan will be granted at all.

2.5 Legal Framework Analysis

A legal framework for **regulative-driven PV investments** that include support schemes for PV investments is an important first step for the ignition of the Russian PV market. However, the **current support system entails a number of risks for PV investors** they should bear in mind and that can substantially reduce the interest for PV investments both in the retail and the wholesale market.

The identified risks are structured according to their appearance:

- In the framework of the implementation of the support scheme.
- Within the legal framework governing the support scheme.
- In the financial framework as a consequence of the support scheme and other factors.

2.5.1 Risks Concerning Implementation of the Support Scheme

During the implementation of the support scheme, PV investors face several risks that could impede their projects. A group of risks for investors result from the dependency from activities on a large number of authorities selecting and qualifying projects, be it at the regional or federal level.

The most telling example for this risk is that **the federal authorities have to formally approve an installation as being 'renewable' to benefit from the support scheme**. This is a requirement for investments in both the retail and the wholesale market. The decisive point is, however, **that this approval can be only issued after the installation has been built.** As a consequence, investors have to build the PV installations before knowing whether or not their investment is eligible. Russian experts report that this risk is realistically quite low because a PV system is a PV system and that is difficult dispute. Still, qualification and hence 100% certainty of benefits being paid is only achieved after the installation has been built.

Another example is that **the amount of the financial support installation get is calculated only when the construction phase is finalized** and the objects are connected to the grid and qualified as "renewable" generating facilities. Experience from other European PV markets shows that such fundamental decisions at the very end of a project process have a very negative impact on planning security and therefore the investment security of PV projects.

For the retail market, another risk, besides the above mentioned one, is the **inconsistency in the legislative acts.** The investor has to present a special certificate which is required for the successful transaction of the generated power and to receive the remuneration for the energy as well as for the capacity. However, the capacity is not considered a commodity in retail market rules and thus it is not clear how a certificate can be issued. Plant operators can end up in a situation where they are not able to sell their capacity because the respective certificates are not be issued.

Another risk is that PV plants that receive support under the capacity supply tender scheme in the wholesale market have to **fulfil certain availability criteria expressed in the capacity factor** of the installation. If they fail to meet that criteria, the remuneration will be reduced.

Since the sun, the source for PV plants, is intermittent, it is possible that plant operators suffer from reduced income for reasons that are out of their control. This requirement is an additional risk from the perspective of investors.

The **local content regulation** in Russia constitutes an additional risk for project developers because of the development of costs, the installation and the O&M. This depends on to what extent the Russian PV market develops in general. If there is a sufficient market and enough producers for components to create competition, this risk should be relatively low. However, if the market stays small, these risks will increase.

2.5.2 Risks Concerning the Framework Governing the Support Schemes

With regard to the legal framework that governs the support schemes, a major risk is **the lack of transparency when assessing the funding of PV projects**. Financing RE projects that are part of regional programs is carried out in a manner established by the budget legislation of Russian Federation. The distribution of these budgets is not published. For that reason, it is not clear whether or not the foreseen budget is sufficient to cover the costs of the support schemes, which increases the risks for investors even further.

Another risk is related to the **complex structure and wording of the legal texts** on which the support schemes for RE are based. This point was illustrated by the law firm Rödl & Partner in 2017 with regards to Decree 449: “it is questionable how much legal certainty Decree No. 449 actually offers, since the calculation of capacity prices is based on an extremely complex form, which for many is still rather opaque” [78]. The authors of this study, having discussed this topic with Russian stakeholders, believe that this comment is still true today and could also be extended to other legal documents and acts.

Seeking early legal advice with regards to the relevant national laws and their “correct” interpretation is an important step for business development activities in every new target market and Russia is certainly no exception to this rule.

2.5.3 Risks Concerning Financial Framework

The risks described above have a negative impact on the bankability of projects. These risks are also reflected in risk premiums that lead to significantly higher cost of debt from banks: Investors have to deal with interest rates of 10%-11% for their debts which are 5 to 10 times higher than current interest rates for PV projects in Germany. In addition, investors may ask for higher returns because of a higher perceived risk, which has to be generated by project revenues.

This, in turn, **leads to higher macroeconomic costs for the deployment of PV**, which again leads to higher insecurity that the support scheme will be amended. Therefore, the high interest rates are both a consequence of risks and are a risk in themselves.

3. PV Market and Potentials in Krasnodar Krai

In the following section, general information about the power sector in Krasnodar Krai and the specific data concerning the local PV market are described and relevant PV business models in Krasnodar Krai are introduced. The regionally-specific regulatory framework for renewable energy development is also discussed.

3.1 Energy Market of Krasnodar Krai

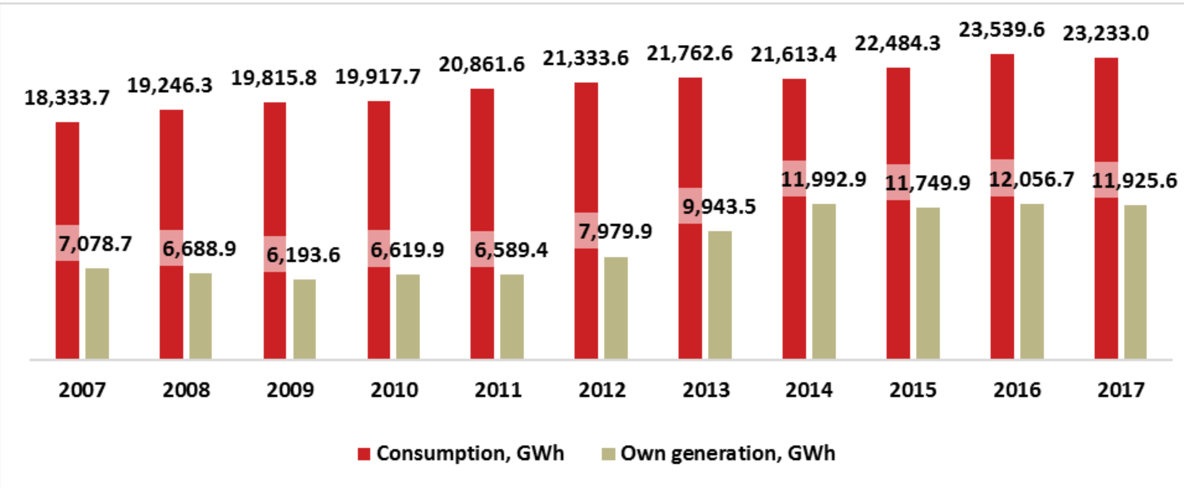
3.1.1 Electricity Generation, Consumption and Demand

Krasnodar Krai is one of the **fastest growing and simultaneously most energy deficient regions of Russia.** Unlike most other Russian regions, the peak electricity consumption in Krasnodar Krai occurs during summer due to the climate condition of having relatively mild winters and hot summers with temperatures beyond 35°C in the summer. Industrial buildings, offices and private households widely use air conditioning systems to cool the air during the hot summer temperatures [79]. Energy consumption has increased by 26.7% from 18,333 GWh in 2007 to 23,233 GWh in 2017.

The annexation of the Crimean Peninsula put additional pressure on the regional power system: after the Ukrainian power system stopped supplying the peninsula with electricity, the region has become fully dependent on the UPS and the power system in Krasnodar Krai was forced to become a bridge between Crimea and the Russian mainland to “share” its energy with its neighbor.

As a result of rising pressure on the grid and power generating facilities, **blackouts happen on a regular basis and disturb businesses and the population**. Figure 15 illustrates, how regional electricity consumption has been developing throughout the years and compares energy consumption and domestic energy generation in Krasnodar Krai.

Figure 15 Energy consumption and domestic energy generation in Krasnodar Krai within latest 10 years, GWh



Source: Federal State Statistics service of the Russian Federation, 2018 0

On August 8th 2018, regional electricity consumption broke a historical record and reached a load of 5.03 GW which was 433 MW higher than the previous peak consumption of July 2016 [80].

Currently, the region produces up to 40% of the electricity it consumes annually. The remainder is imported from the neighboring regions and purchased on the wholesale market. In 2017, regional electricity generation in Krasnodar was only 11.9 GWh [81] while electricity consumption amounted to 23.2 GWh [82].

Further drastic growth in the power consumption of the region is forecasted by experts due to the expansion of industries, further development of seaports and intensive housing construction. The annual growth of electricity consumption is assumed to reach 1.7% which may result in an overall increase 12.4% for the period 2016-2023 [83].

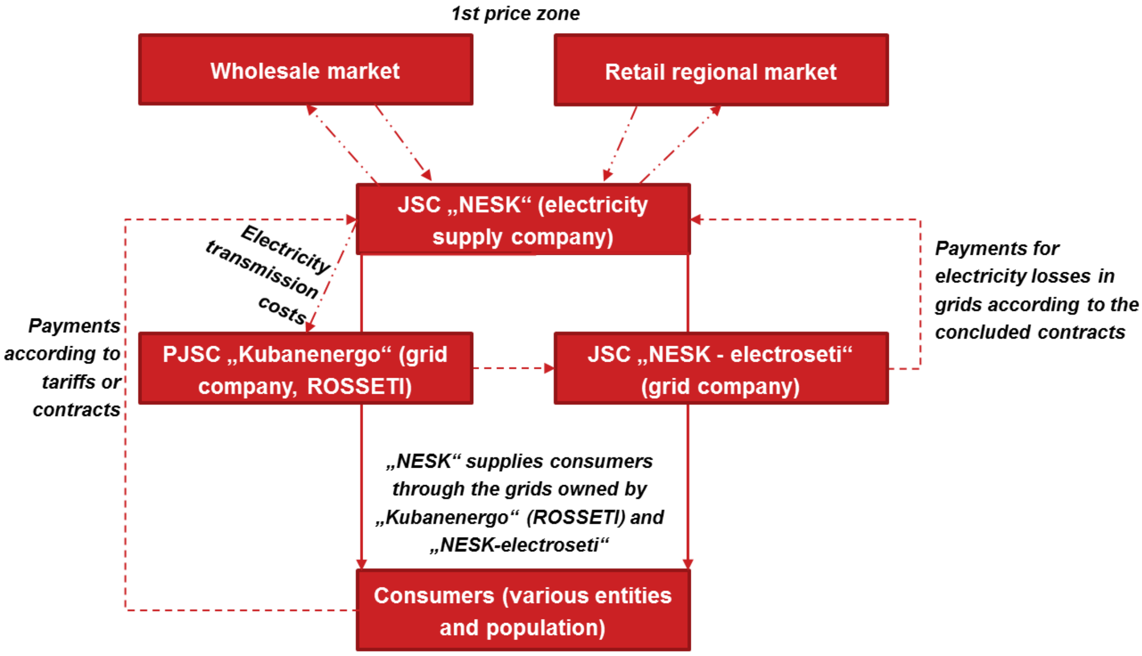
3.1.2 Regional Electricity Market Stakeholders

The electricity market in the region has several stakeholders:

- Two main electricity retailing companies (guaranteeing suppliers): "TNS Energo Kuban" and "NESK"
- Electricity transmission companies: two majors are "Kubanenergo (ROSSETI)" and "NESK-electroseti" (independent); other private small grid operators
- Eight major electricity generating facilities (including Krasnodar CHPP; Krasnopolyansk HPP, Sochi and Dzhubga fossil fueled power plans, Adler fossil fueled power plant
- Some energy blocks (power units) of industries and own generation facilities (entities and private) – in total 303.7 MW installed capacity [84].

Altogether, the power plants belonging to different electricity generation companies have a **capacity of 23,322.57 MW**, the largest generating object is the "Krasnodar CHPP" owned by "Lukoil-Kubanenergo" [82].

Figure 16 Scheme of functioning of the electricity markets in Krasnodar Krai



Source: eclareon 2019

The **electricity retailing companies** are also called "guaranteeing suppliers", the first "TNS Energo Kuban" PJSC, which is the main electricity retailer in the region, covers about 55% of the territory. The second, "NESK" JSC, was created in 2003 with the aim to form a natural competitor for the "TNS Energo Kuban" and avoid a monopoly in the market. "NESK" manages about 30% of the territory of Krasnodar Krai.

Both companies purchase electricity from the wholesale and retail markets and sell it to consumers in the retail market (population, industries) and to consumers in the wholesale market 0. Other energy retailers generate the remaining 15% electricity for the territory.

The **electricity distribution and transmission companies** (grid companies) present in the region are: “Kubanenergo” owned by ROSSETI (responsible for the grid 0,4-110 kV), JSC “NESK electricity grids” owned by “NESK - electroseti”, two grid companies owned by “FSK UPS” and some small private grid operators. “Kubanenergo” and “NESK - electroseti” manage a major part of the grids. “Kubanenergo” is responsible for rural and high-voltage grids in the region, while “NESK - electroseti” manages urban grids.

As electricity prices in the region grow, electricity sales companies are raising sales surcharges and grid companies are increasing the costs of transmission, and **more industry consumers are switching to the self-generation**. Examples are the butter factory “Krasnodarsky”, “Verhebakansky Cement Plant”, wine factory “Fanagoria”, winery “Abrau-Durso”, a retail food supermarket chain “Magnit” [86]. The majority of these private plants are powered by natural gas. Examples include:

- The winery “Abrau-Durso” has installed gas turbines with a capacity of about 500 kW;
- The “Krasnaja Poljana” ski resort near Sochi has 10 MW of gas generation turbine;
- The Guest house “Mys Vidny” in Sochi has installed 1.8 MW of gas turbine in addition to the existing grid [87].

One of the reasons for the rise in electricity prices in Russia is that a heft of power is being generated with the help of natural gas, whereas in Krasnodar, the **price for gas on the wholesale market is 7-10% higher than average gas prices in central Russian regions** [88]. In 2017, electricity generation in the part of UPS of Krasnodar Krai dropped by 2.5% (see Table 6), whereas in-house generation grew by 10% to 275 GWh. **Construction energy generating facilities fueled by gas is more profitable than purchasing the same electricity volume from the grid.** According to calculations made by Andrej Smirnov, the analyst of “Energo Capital”, a self-owned 2 MW power plant will have a payback period of 5 years, whereas the annual electricity demand volume generated by it will cost 58% less than if purchased from the grid [88].

The energy retailing and generating company “Magnit Energo” (a subsidiary of the “Magnit” supermarket chain), has costs of 1 kWh of electricity for their own needs resulting in 1.5 RUB (approx. 2 €ct), which is cheaper than residential tariffs for private households [89]. “Magnit Energo” use mostly gas turbines to generate electricity. Simultaneously, the company may sell the surpluses to other consumers on the retail market for ≈3.48 RUB/kWh (5 €ct/kWh) [89] which is cheaper than the prices for entities on the same retail market (see information on prices in Table 7). “Magnit Energo” has 33.6 MW of installed energy generating capacity in Krasnodar Krai and more in other Russian regions [90].

Figure 11 in the previous chapter illustrated a relation of different parts of electricity prices. It clearly shows that **40 to 70% of the end energy price which consumers pay are services of grid operators**, basically, fees for energy transportation and market surcharges of energy sales companies. In cases of independently owned in-house generation, these parts of the end price are abolished or minimized due to various factors which include: shorter distances for electricity transportation; own grids; no distributors (energy producer = energy sales company).

3.1.3 On-Grid Generation

In Krasnodar Krai, **more than 90% of the electricity is produced by energy generating facilities connected to the grid.** These grids are also a part of the UPS of Russia. As it has already been mentioned in the text above, Krasnodar Krai is an energy deficient region, with more than 50% of consumed electricity being imported.

Table 6 below includes information about privately owned in-house electricity generation in the region, imported energy and per capita generation.

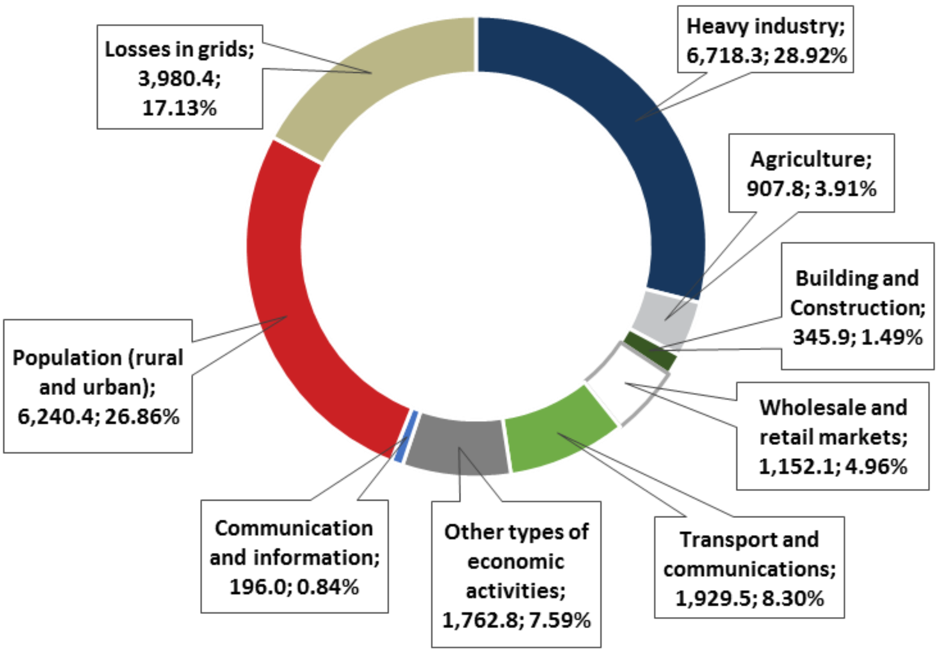
The table shows that in-house electricity generation is increasing and that Krasnodar Krai is one of the most energy deficient regions in the country.

Table 6 Electricity Generation Profile in Krasnodar Krai, years 2010-2017

Year	Total electricity generated (thousand GWh)	Total energy consumption (% from electricity generation)	Total electricity import (% of consumption)	Per capita electricity generation (kWh per capita)
2017	11.93	194.8	48.7	2.1
2016	12.06	195.2	48.8	2.1
2015	11.75	191.4	47.7	2.1
2014	11.99	180.2	44.5	2.2
2013	9.94	218.9	54.3	1.8
2012	7.98	267.4	62.6	1.5
2011	6.59	316.6	68.4	1.2
2010	6.62	300.9	66.8	1.2

Source: Based on Federal State Statistics Service of the Russian Federation, "Electricity Balances 2017" 0; Federal State Statistics Service of the Russian Federation, "Electricity generation per capita", 2018 [127]; Ministry of Economy of Krasnodar Krai, monitoring of social and economic development of Krasnodar Krai, "About the results of the social and economic development of the region in 2010…2017", 2018 [106]

Figure 17 Electricity consumption by sector in Krasnodar Krai, 2017, million kWh and %



Source: Federal State Statistics Service of the Russian Federation, "Electricity Balances 2017", 2018 0

3.1.4 Off-Grid Generation

There is little data on off-grid generation in Krasnodar Krai. According to media sources, there are examples of private gas, diesel, hybrid and PV generating facilities which are not connected to the grid and are not part of UPS. It is hard to estimate the volume of such electricity generation, due to the fact that most of it is not registered and/or published. Generating facilities owned and built by entities (see chapter 3.1) may be also sometimes seen as off-grid generation.

3.2 Investment Framework for PV

3.2.1 Solar Irradiation

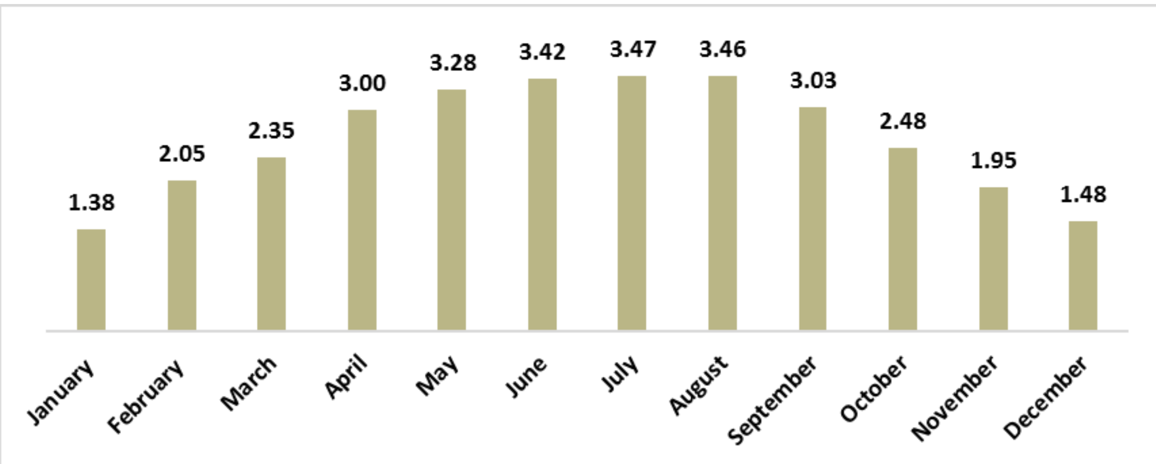
Krasnodar Krai is one of the Russian regions with the highest solar irradiation. The map of the region (Figure 18) gives an overview of the solar radiation intensity, which is highest in the coastal area close to Anapa and the Kerch Strait and lowest in the south-western mountainous areas.

Figure 18 Annual Global Tilted Irradiation (GTI) Krasnodar Krai

Source: Global Solar Atlas [130]

The region gets over 2,000 hours of sun annually, which is around 280 days per year. In comparison, Moscow get 10 times less sun. The average yield on the horizontal surface reaches 1,400-1,700 kWh/m^2/year [92]. Figure 19 presents information on how much energy a 1 kW PV system generates on average.

Figure 19 Average hourly generation by 1 kWp PV system in Krasnodar city, kWh

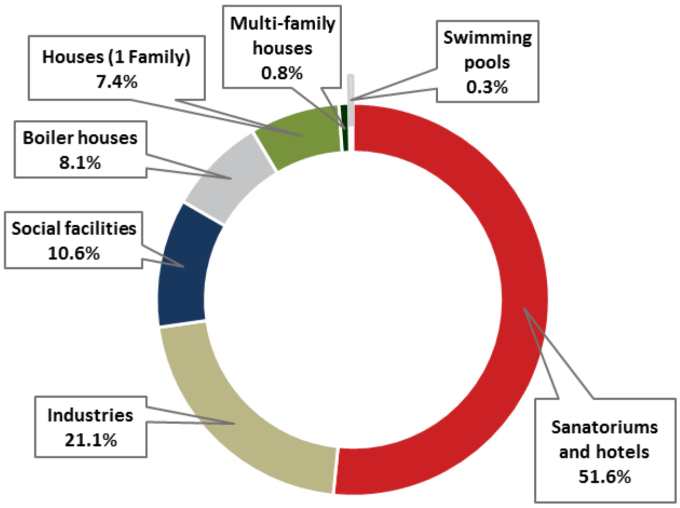


Source: "NSiA" PV installing company, Krasnodar, "Characteristics of a complex 1 kWp PV system "Datscha", 2018 [93]

3.2.2 Target Customers

Although there is no official data different sources say that in 2013, there were **151 known PV and solar thermal systems in Krasnodar Krai with a total estimated capacity of 5.3 MW**. Most of this capacity (over 2.5 MW) served the needs of sanatoriums and hotels in electricity and heat [105], only some more than 8% of PV systems were used by residential customers. Figure 20 shows the structure of the known PV systems in Krasnodar Krai in 2016 by type of consumer [104].

Figure 20 Structure of PV systems by type of user in Krasnodar Krai



Source: Based on "Sustainable Building Technologies", 2016 [105]

According to research done by eclareon, the overall installed PV capacity will most likely be higher and reach up to 10 MW by the end of 2018. There are currently no large-scale solar power plants in the region but **solar energy is used locally in small projects**. Until 2018, there have been no projects under the long-term power delivery agreement (see 2.1) [94]. The price for electricity generated by PV systems is estimated to be competitive with the price of energy from the grid, this is discussed further in section 3.4.3. Electricity prices and tariffs are presented in Table 7.

Table 7 Some electricity prices in Krasnodar Krai

	Time period			
	2018 2/2	2018 1/2	2017 2/2	2017 1/2
	Retail market, RUB/kWh (EUR/kWh) with VAT 18% (since 2019, VAT is 20%)			
Urban population with gas stoves and groups equated to them (single rate tariff only)	4.61 (0.062)	4.44 (0.059)	4.44 (0.059)	4.28 (0.057)
Urban population with electric stoves and rural population, (single rate tariff only)	3.23 (0.043)	3.11 (0.041)	3.11 (0.041)	3 (0.04)
Average entity	6.13 (0.082)	5.92 (0.079)	5.49 (0.074)	5.39 (0.072)
Other entities, RUB/MWh (EUR/MWh) with VAT 18% (since 2019, VAT is 20%)				
Constructing and building companies, average price	–	–	6,911* (92.99)	–
Agricultural consumers (e.g. farms, canneries, etc), average price	–	–	7,314* (98.42)	–

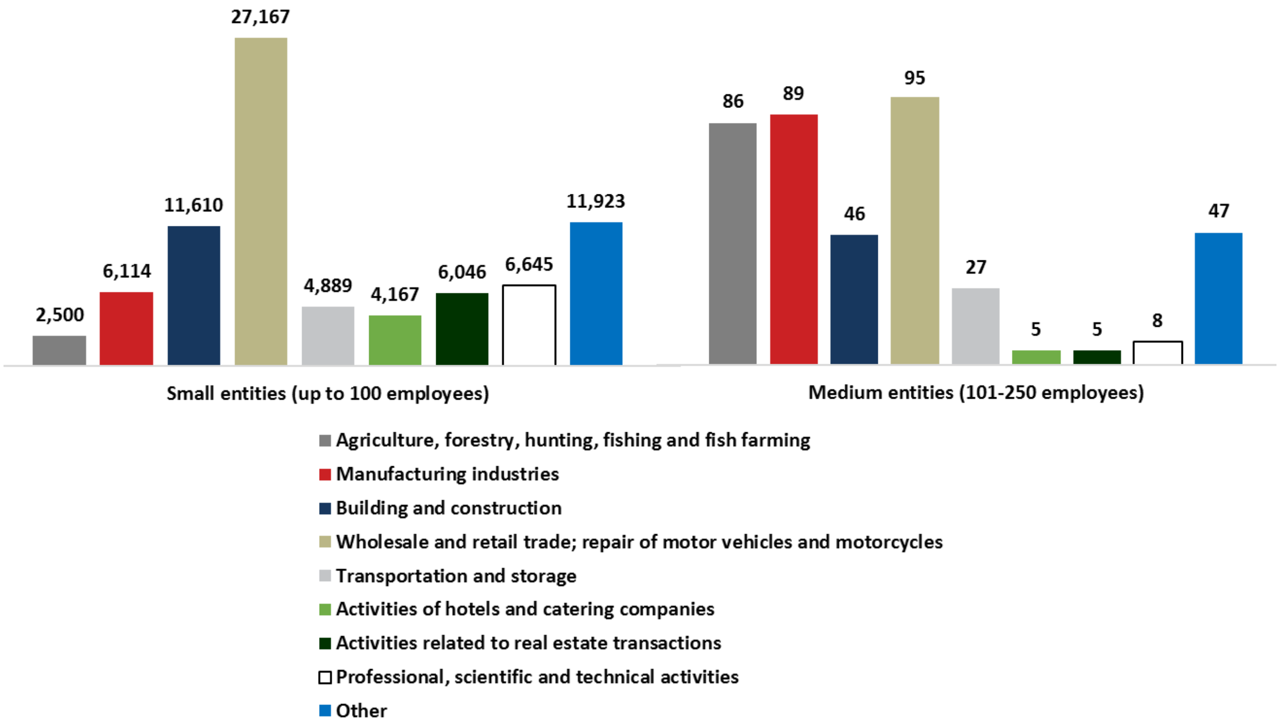
	Time period			
	2018 2/2	2018 1/2	2017 2/2	2017 1/2
	Other entities, RUB/MWh (EUR/MWh) with VAT 18% (since 2019, VAT is 20%)			
SMEs, purchased capacity (load) less than 150 kW/month & 150-670 kW/month differs depending on the voltage and type of contract and guaranteeing supplier	3,829.02 – 9,156.13** (51.52 – 123.21)	–	–	–
Large industrial consumers, purchased capacity (load) 10 and more MW/month (depending on the type of contract, price category, guaranteeing supplier, voltage, etc.)	2,124 – 7,906** (28.58 – 106.39)	–	–	–

Source: *Federal State Statistics Service, Krasnodar Krai department, "Krasnodar Krai in Numbers, 2017", 2018 [96], ** Time2Save, "Base of electricity tariffs for enterprises", 2019 [97]

The price for entities is often much higher than the average in Russia and in Krasnodar Krai in 2018 it reached 9 RUB/kWh (12 €ct/kWh). The load ranges are as follows: SMEs have loads up to 670 kW per month and rarely more, while large entities and industries consume up to 10 and more MW each month.

In 2017, there were 408 small and 81,061 medium size entities in Krasnodar Krai, Figure 21 below illustrates major representatives of small and medium entities of Krasnodar Krai in 2017.

Figure 21 Quantitative and qualitative composition of medium and small enterprises in Krasnodar Krai, 2017



Source: Federal State Statistics Service, Krasnodar Krai department, 2019 [98]

3.2.3 General Perception and Acceptance of PV.

In Krasnodar Krai, there is increasing interest in deploying renewable energy to increase electricity generation. The **municipalities and administration are aware of the possibilities and generally have a positive attitude towards solar power**, as statements from the vice mayor of Krasnodar, Sergey Altukhov [99], vice-mayor of Krasnodar Krai, Vasiliy Shvetz 0 and other policy makers indicate. However, the big leap towards PV development in the region has not happened due to the lack of regional regulatory support and high local turn key system costs leading to long payback times for PV installations 0.

At the same time, there is **growing interest in application of solar PV from SMEs and industries**. There are examples of companies in agriculture, tourism and other sectors in the region that are eager to decrease their operational expenditures and use PV or hybrid PV-diesel/gas energy generating facilities. These solutions lead to a decrease in fuel costs and allow them to build agricultural or commercial sites independently from grids. Companies become interested in PV and other sustainable power technologies and energy efficiency solutions when they get more information about them. Hence, one of the push-factors for such technologies is capacity building to increase the awareness and spread knowledge about renewable energy and energy efficiency technologies.

Different from the SMEs knowledge about PV solutions is limited among ordinary citizens. Addressing renewable energy use should be addressed in conjunction with global climate change which are usually discussed by a rather narrow circle of NGOs and scientists in Russia. Ordinary people hardly think about the alternative variant of electricity production, especially as long as the "15 kW Law" has not come into force (see section 2.1). Some do not care about PV development, others do not see the necessity in PV and think that a new coal or gas power plant would be the best solution.

3.3 Region-specific regulatory & legal framework

Federal support schemes for renewable power generation are also applicable to Krasnodar Krai. The support scheme for the wholesale market – capacity supply tender (see Section 2.1.1), defined in Decree № 449, is not Oblast specific and therefore projects from all regions, including the Krasnodar Krai can participate in the tender.

In the **retail market**, as defined by the Decree № 47 (see chapter 2.1.2), electricity supply tenders are organized at the regional level following the rules stipulated by decree and its related regulations. On 30 August 2016, the Ministry of Fuel and Energy Complex and Housing and Communal Services of Krasnodar Krai approved the Order № 289.1 "On Approving the procedure and conditions for the competitive selection of generating facilities that operate on the basis of renewable energy sources, for which the sale of electricity is planned for the retail market, in the scheme of development of the power of Krasnodar region, requirements for appropriate investment projects and the criteria for their selection" [101].

The first tender for the selection of projects for electricity generation for the retail market that will compensate for the transmission grid losses in Krasnodar Krai took place at the beginning of 2018 [101].[102] The call for applications was announced by the Ministry of Fuel and Energy Complex and Housing and Communal Services of Krasnodar Krai. After the application period closed on 25 January 2018, there was only one single application. The project envisaged the construction of 18 PV power generating facilities with individual capacities up to 5 MW that in sum will have 90 MW.

According to the decisions published on 20 February 2018 by the commission for project selection, the bid was evaluated based on the following criteria:

- Capital expenditure for the construction of 1kW of power generation
- Payback time
- Planned operation and maintenance (O&M) expenditure for 1 kW installed capacity
- Expected variable cost for the production of 1 MWh
- The number of previously implemented projects
- The local content coefficient

Each criterion was evaluated on a 10-point scale. The bidding project accumulated 40 points and was selected as the winning project. However, the project is still not launched and has not been included in the official “Scheme and Programme of the Development of the Energy sector of Krasnodar Krai for the period 2019-2023”, which is an annual report describing the current regional energy sector and major plans of its development. Similar documents are published every year for each region.

The company which won the tender (“Renewable Energy Sources” Ltd.) was given directions to design a process of technological connection of the planned SPP to the power grids, which is currently lacking, otherwise, it is impossible to calculate energy costs and end electricity tariff which is to be paid to the company [103]. The tariff will be calculated once the construction phase is finalized and the objects are connected to the grid and qualified as generating facility operating on renewable sources in accordance with Decree № 426. The qualification is done by the regulatory body NP “Market Council”.

Besides the federal laws promoting renewable energy sources, **Krasnodar Krai also has regional specific regulations**. The law № 723-K3 ‘On the use of renewable energy resources in Krasnodar Krai was adopted on 7 June 2004 establishing the following main principles for the use of RE sources:

- The economic profitability of using RES instead of conventional ones
- Advantages in terms of energy savings
- The environmental advantages of using RES instead of conventional ones
- Legal support and economic incentives from the authorities of the Krasnodar Krai to support the RES use.
- Priority of construction of RES generating facilities is given to areas that are remote or have a low-quality electricity grid; tourism areas with high population density and polluted air; for natural reserves and specially protected natural areas in ecologically clean areas, places of mass recreation and treatment of the population RES are the most preferable sources of energy supply

The financing of renewable energy (RE) projects is not described and explained in detail in the law and leaves room for interpretation: It is simply stated that financing projects that are part of the regional programs is carried out in a manner established by the budget legislation of the Russian Federation. For other RE projects, that are not part of the regional program, financing can be obtained from the regional budget on the condition that the money be returned. Additionally, investment can be obtained from Russian or foreign investments or other sources stipulated by the country’s legislation. The tariffs for the electricity generated from the RE sources are calculated in line with federal laws for tariff calculation.

The current RES share in the region is 2.6%. In order to increase this share, **Krasnodar Krai adopted three programs to promote RES use for the period of four, five and ten years** respectively. According to the ten years’ program, namely the ‘Energy saving and increasing the energy efficiency of Krasnodar Region for the period 2011-2020’, by exploiting the RES potential of the region, the electricity generated could be increased by 1,300 MW replacing the conventional power facilities. At the same time this will result in increasing the energy supply for households, the public sector, tourist and recreational objects from renewable and environmentally friendly sources [104].

3.4 Regional PV business models

Following the classifications of business models, chosen for this report and described in section 1.3, the situation pertaining to these 3 business models in Krasnodar Krai is described in the following subsections.

3.4.1 Model 1: PV parks

There are no large MW SPPs in Krasnodar Krai so far, a first project is in preparation (see chapter 3.3). And there are examples of enterprises and budget organizations that get electricity from PV modules. As mentioned in chapter 3.1, for entities (commercial companies, industrial consumers, various registered businesses incl. offices) it is often cheaper to construct an independent energy generating facility rather than invest time and money in the grid connection process or buy electricity from an energy sales company. Some examples:

- In Timaschowski (Krasnodar Krai) an autonomous 4.5 kW PV power plant serves the needs of an agricultural entity Premix (producer of compound feedstuff)
- Rooftop PV water heating system in a state hospital of Anapa city (solar thermal)
- 5.4 kW PV power station at the Ust-Labinsk city hospital
- 70 kW rooftop PV system on the railway station in Anapa (yearly generation exceeds 84,000 kWh), installed by German “Viessmann”[107]
- 30 kWp (120 solar modules 270 W each) rooftop PV system in Krasnodar, on the roof of “Aloe Center”, a local spa-center. The existing PV system covers most of energy consumption at daytime, the remainder is automatically taken from the grid. For example, first registered after installation maximal generation happened in September, when peak daily generation reached 186 kWh. Generation for the whole month resulted in 3,323 kWh. A managing director initiated this project and was willing to comply with the brand of environmentally friendly enterprise (basically, marketing reasons). The secondary reason was a desire to save energy costs because a spa center consumes much electricity - a PV system helped them to reduce their usual electricity bills by 30%.

Figure 22 Hybrid PV-grid system; rooftop 30 kW PV solution on the roof of "Aloe Spa" Center in Krasnodar

Source: eclareon 2018

3.4.2 Model 2: Off-grid PV &Hybrid Systems

Diesel (or petrol) generators are the most well-known solutions for remote areas with no grid connection or with regular blackouts. In Krasnodar Krai, many households and entities also use gas generators, especially during summer. In 2018, the price for 1 l diesel reached 43.4 RUB (58 €ct), 1 m^3 natural gas cost 6.22 RUB (8 €ct).

Southern Krasnodar Krai has mountainous regions where **resorts, sanatoriums and camp sites** are situated. Examples are: the ski resorts and sanatoriums of Lago-Naki, mountainous part of Mostovsky district, areas of the Malaya Laba river with their developing tourism industry, coastal areas of the Black and the Azov seas, hotels on the banks of lakes rich in fish. There are around 20 registered large sanatoriums in mountainous areas and some small private hotels and camps (approx.15-20), which are not often mentioned in official statistics.

Additionally, **about 4 to 10 settlements still have no connection to the electricity grid** due to hilly terrain. Furthermore, off grid areas exist on flatland, for example, **new settlements or newly built districts of existing settlements, where grid and gas pipes have not been connected to houses during construction**. Very often, services for connection to the grid and gas pipes are expensive, therefore consumers need to search for other solutions, such as diesel generation. For example, for a private household (gas consumption less than 5 cubic meters/hour), connection to a gas pipeline in 2017 could reach 100,000 RUB (1,345 EUR), while for an entity consuming up to 15 cubic meters/hour, the technical connection could overstep 10 million RUB (134,567 EUR) [109]. Along with the development of technologies and growth of the popularity of RES, PV generation enters the market as well and hybrid PV-diesel systems gain popularity.

One of the industrial sites producing particleboards, installed a 27-kW rooftop PV system to supply itself with electricity [110]. The building was constructed in Krasnodar Krai in an area far from the grid and was firstly equipped with a 30-kW diesel generator. Later, the PV system was built and afterwards the building was connected to the grid. Now the PV system produces enough electricity to feed the working process, air-condition during summer and heat in winter. The automatic controlling system switches on the diesel generator when there is no sun, the battery levels are low and there is a blackout in the grid. In April 2018, independent power generation reached 3.5 MWh, while the peak generation is supposed to reach 5 MWh/month. The payback period of the PV system was estimated to be 4 years under current conditions. Such autonomous solar systems do not need certifications as long as the energy generated by them is used exclusively by the owner and is not fed into the power grid.

Solar energy is also popular among mobile network operators. In Krasnodar Krai, many mountainous regions are cut from the grid and from the radio signal due to its terrain. Mobile operators “Beeline” and “MTS” were the pioneers in using PV for such case. As early as 2004, “Beeline” used a PV powered station to transmit a mobile signal and internet to the remote settlements. The solution is 5 times cheaper than stretching the electricity grid and cables through mountains and relic forest [99]. Similar story happened with “MTS” in 2007, PV stations made it possible to provide remote villages (Guzeripl’, Tyumenskiy, 3-Ya Rota) in mountainous areas with speed mobile internet and communications [108]. During sunny days in summer the PV stations generate up to 70 kWh/day.

Figure 23 Autonomous 10.8 kW PV system, "MTS" mobile phone station for signal transmission, Lago-Naki, Krasnodar Krai

Source: "Igor Samorodov, "Solar Center" PV company, Krasnodar Krai, 2007

3.4.3 Model 3: Residential PV Systems

Until the microgeneration law enters into force (see chapter 2.1.3), **the electricity produced by households is used for own needs and consumed by other sources (incl. grid) in case of low sun irradiation levels.** One of the most relevant examples is the Autonomous House, designed and owned by Nikolay Driga: the combination of PV panels, a wind turbine and a water heating system fueled by wood pellets makes the household fully independent from the grid, with energy and heat costs 4 times lower than if the power came from the grid 0. More than 50 households have been inspired by this example and equipped houses with RES including PV. No special certification or permission is needed for similar small-scale private power generation. This may change once residential installations are allowed to be connected to the grid after the approval of the respective law on microgeneration (please refer to section 2.1.3.).

The construction of a PV system is characterized by a combination of relatively high upfront investments and relatively low operational expenses. According to our own estimations, based on analyses of realized projects on websites of PV installing companies in Krasnodar Krai, like "Solar Center" "Ecoproject Energo", "NSiA", "Clever Energy" and others, **the current number of private households in Krasnodar Krai owning an autonomous PV/hybrid PV diesel/wind/gas/ system is between 170 and 300**. It is hard to estimate an exact number of such households due to the absence of a centralized statistical database and there is no obligation to register such systems.

One can find various offers from numerous companies; the price range differs depending on the installed capacity and origin of the equipment. The "Clever Energy" company working together with Nikolay Driga, the creator of the "Autonomous House" in Krasnodar Krai and the CEO of "Svoya Energiya Ltd.", lists a range of implemented projects on their website with sizes between 3 and 120 kW. As does the local PV installer "Solar Center" who has realized projects for both industrial consumers and private households.

Often, PV systems which are not grid connected usually combined a grid connection and/or other generation technologies such as wind or diesel. On average, a household needs to invest about 250,000-350,000 RUB (ca. 3,360 to 4,700 EUR) to equip private households with a hybrid system including solar PV suitable to more or less cover the energy demand (which is on average 4 kW).

After analysis of prices for various PV solutions for private households, offered by different PV installing companies in Krasnodar Krai we found an **average price** for 1 kW installed PV capacity, including price of hardware, mounting equipment and installation services for a hybrid PV-grid solution, that varies **between 65,000 and 87,500 RUB/kWp (874-1,177 EUR/kWp)**, while a price for 1 kW installed capacity for an autonomous standalone PV system (including storage, other hardware and services) can reach up to 142,000 RUB (about 1,900 EUR) mainly due to additional costs of a storage system [111].

This pricing information given by local stakeholders has been acknowledged by the authors of this report and been taken into account in the profitability analysis presented in chapter 5. Especially the lower ends of the prices mentioned seem to be rather optimistic. However, taking into account lower labor costs it cannot be excluded that prices are as low as stated. The base price chosen for the profitability analysis of residential systems, which are grid connected and only include the PV system costs of the energy system was 100,000 RUB/kWp (approx. 1,340EUR/kWp). Lower prices were included in the sensitivity analysis.

Figure 24 Autonomous rooftop PV system in Nikitino, an off-grid village in mountainous areas of Krasnodar Krai

Source: Igor Samorodov, "Solar Center" PV company, Krasnodar Krai, 2015

According to the estimations of Nikolay Driga, in Krasnodar Krai, the cost of 1 kWh of PV based electricity could eventually be as low as:

- 2.5-3 RUB/kWh (3 – 4 €ct/kWh) for systems combined with the grid and without batteries
- 3.5-4 RUB/kWh (4 – 5 €ct/kWh) for hybrid PV systems with batteries
- 7 RUB/kWh (9 €ct/kWh) and more for autonomous systems

All his calculations were said to include CAPEX, costs of transportation, mounting equipment, manpower, OPEX (for 25 years).

PV based electricity costs of around 4 RUB/kWh (5 €ct/kWh) would be lower than electricity purchased from the grid [112] (also see Table 7Table 7 Some electricity prices in Krasnodar Krai). It needs to be added that the calculations undertaken for this report did not match these estimations but resulted in higher LCOEs which, of course, could be decreased further by assuming lower system prices.

3.4.4 Conclusions and Perspectives

Krasnodar Krai is a promising region for PV development for the following reasons:

1. it is one of the sunniest areas in Russia;
2. generation capacity is missing and;
3. electricity tariffs for private households as well as electricity prices on the retail and wholesale market will definitely increase in the future.

However, because most of the region is connected to UPS's power grid and **electricity tariffs for residential customers are subsidized and kept artificially low**, investments in residential PV systems by grid connected households is uncommon, and will remain so while PV installations cannot be connected to the grid and expensive battery storage is used.

This may change with the **microgeneration law** which is planned for the end of 2019. Additional motivations need to complement or substitute economic considerations to motivate private households to invest in private PV installations. These motivations could be technical curiosity, the desire to increase energy independence or the desire to do good for the environment. However, while these motivating factors exist only few are concerned with them. Economic reasons are by far the most important driver for investing in PV, taking into consideration that the average Russian household income is > 50% lower than in Germany, limiting private investments [114]. Key target PV customer groups could be described as follows:

Private households:

- Residential users **in newly built or remote/mountainous areas** can be targeted: These households need to pay for the connection to the grid and sometimes to gas pipelines before they get access to the low electricity tariffs. Often the connection is costly and takes a long time, so investing in PV and/or hybrid system is attractive.
- The microgeneration law could also make solar PV installations more attractive for **people living in cities and have a holiday house** which they visit in summer and on weekends. Electricity produced by the PV system during the remaining time could be sold in the grid and become a source of an additional small but regular income for a household. However, it remains to be seen how electricity sales will be compensated under the law. As it looks today, excess electricity will most likely be valued with the wholesale price of electricity which fluctuates around 1RUB/ kWh (1 €ct/kWh).

The **peninsula Taman** in Krasnodar Krai may be especially attractive for solar PV for the following reasons: Taman is vulnerable to regular blackouts which have already caused serious discontent amongst households because, for instance, food was spoiled because of unpowered fridges. As a consequence, people often think about alternative energy solutions. Secondly, the construction of a big port and new industrial zones that also need to be powered has already started and shall be completed by 2021.

Industrial, commercial and public consumers (entities):

- Both entities connected to the grid and those located in remote areas have to pay higher grid electricity prices and also have to bear higher grid connection costs than private consumers. Moreover, their power consumption peaks during the day and rises in the summer when air conditioning systems are on. Therefore, in-house PV or PV hybrid systems can be a viable alternative to the grid.
- **Industrial consumers, farms and fisheries and supermarket chains** have started to construct their own generating facilities and have even founded their own power production companies (as in the case of "Magnit Energo") to decrease the expenditures on electricity and heat or even profit from electricity trade in case of surpluses. The installation of PV systems is sometimes perceived as a good combination between saving money for fuel/grid electricity and get a better image of an environmentally friendly company.

4. PV Market and Potentials in Kaliningrad Oblast.

In the following section, the general information about the power sector of Kaliningrad Oblast and the specific data concerning PV market are described. The importance of two selected PV business models in Kaliningrad Oblast are described. The regionally-specific regulatory framework for renewable energy development is also discussed.

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4.1 Power Sector of Kaliningrad Oblast

4.1.1 Electricity Generation, Consumption and Demand

Kaliningrad Oblast is a region with an interesting and rich history, located outside the main Russian borders. The region is included in the UPS of Russia ("United Power Grids of the North-East" part of UPS), however grids of UPS and Kaliningrad Oblast are interconnected through the BRELL (Belorussia, Russia, Estonia, Latvia and Lithuania) ring, in particular, its Latvian and Belorussian parts.

The region produces enough electricity to supply its needs, while demand has grown slowly and steadily. Surpluses of generated electricity are sent to neighbouring electricity grids of 110 kV and 330 kV [115]. In 2017, the region's supply in electricity, heat, steam and gas together reached 106%. However, the region is currently facing a problem of dependence from the BRELL ring and is realizing the necessity of having enough generating capacity to fully supply itself should they ever be disconnected from BRELL and UPS. **Thus, the fuel and power sector of the region is developing quickly and is getting legislative and economic support from the federal government.**

The Table 8 below includes information about the regional generation, imported energy and per capita generation. Until 2010, the region had problems with electricity generation and the majority of energy was imported. Starting in 2011, regional generation was stable with slight fluctuations.

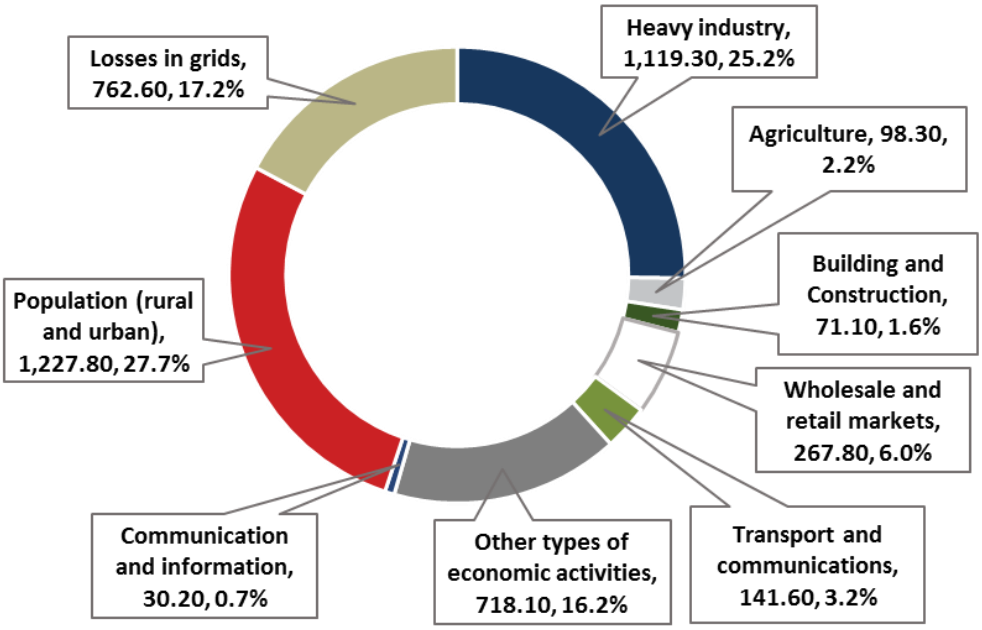
Table 8 Electricity Generation Profile in Kaliningrad Oblast, years 2010-2017

Year	Total electricity generated (MWh)	Total energy consumption (% from electricity generation)	Total electricity export (% of generation)	Per capita electricity generation (kWh per capita)
2017	7,10	62,0	38,0	7,2
2016	6,73	66,3	33,7	6,8
2015	6,22	71,2	28,8	6,4
2014	6,46	70,1	29,9	6,7
2013	6,39	69,5	30,5	6,6
2012	6,85	62,2	37,8	7,2
2011	6,45	63,6	36,4	6,8
2010	3,14	127,8	-27,8	3,3

Source: Based on Federal State Statistics Service of the Russian Federation, "Electricity Balances 2017"0; Federal State Statistics Service of the Russian Federation, "Electricity generation per capita", 2018 [127]

Unlike in Krasnodar Krai, the **largest electricity consumers in Kaliningrad oblast are private households** (population, 28%). Industrial companies account for around 25% of electricity consumption.

Figure 25 Electricity consumption by sector in Kaliningrad Oblast, 2017, million kWh and %



Source: Federal State Statistics Service of the Russian Federation, 2018 0

4.1.2 Regional Stakeholders

The regional electricity market in the region has several stakeholders:

- there is one main electricity sales company “Yantarenergosbyt” and 11 additional electricity retailers,
- 11 grid companies, including the major one, “Yantarenergo” (subsidiary of “ROSSETI”)
- one main, belonging to “Inter RAO EES” combined heat and power plant and several additional energy generating facilities

The overall installed generating capacity by the end of 2017 was 1,176.4 MW, of which 900 MW belonged to the by far largest CHPP power plant “Kaliningrad CHP-2” (belongs to “Inter RAO”) [116]. In 2017, one new CHPP and a new generating block of another older CHPP were launched in the region, adding 237.1 MW of newly installed capacity [116]. **Over 90% of electricity in the region is generated with the help of natural gas**, which is also the main fuel for boiler houses and heat generation at CHPPs.

The largest electricity retailer is the regional guaranteeing supplier JSC “Yantarenergosbyt” created in 2011 by JSC “Yantarenergo” to split electricity transmission and electricity retail functions between the two companies. The largest grid company is JSC “Yantarenergo”, a subsidiary of “ROSSETI”. Other energy retailers include JSC “Oboronenergosbyt” owned by the Ministry of Defence of the Russian Federation and “Rusenergosbyt”.

4.1.3 On-Grid Generation

As already stated above, local energy production is larger than consumption: in 2017, own generation in the region amounted into 7,116.8 GWh, 99% of which was generated by “Kaliningrad CHP-2”.

Power plants owned by “Yantarenergo” all work on hydropower and they generated 10.2 GWh. 99.4% of the capacity installed in the region refers to CHPPs that are fuelled by natural gas, 0.14% are hydro power plants and 0.43% - wind power installations [116]. **Close to 100% of electricity produced in the region is on-grid generation**.

4.1.4 Off-Grid Generation

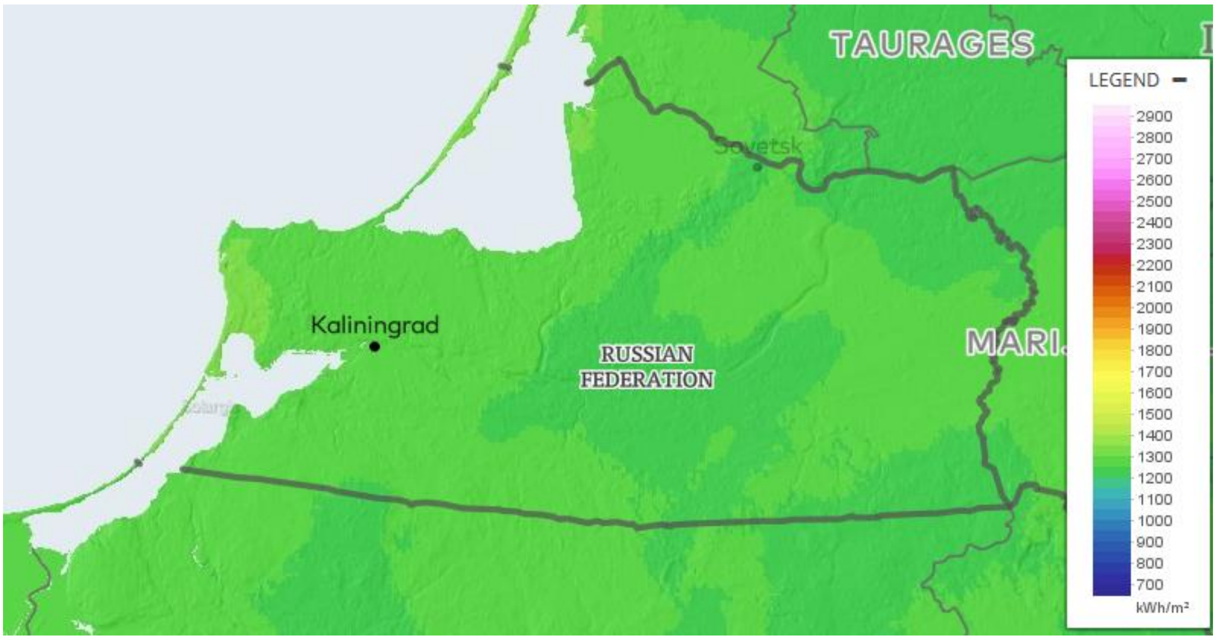
Off-grid generation in Kaliningrad Oblast consist of some isolated examples of mainly residential PV. Although this region is well-developed, there are settlements without grid connection or with bad connection resulting in frequent power cuts. One of the examples is Orlovka village, where inhabitants frequently suffer from blackouts for various reasons, including outdated transformer stations and storm warnings followed by planned power outages. In this village, most of the houses use diesel generators for backup [122].

4.2 Investment Framework for PV

4.2.1 Solar Irradiation

Kaliningrad oblast has about 180 sunny days per year, **with an average yield of 1,100-1,250 kWh/m²/year**[118], one of the highest for the north-western Russian territories. There are no large solar projects and no SPPs in the region, all PV systems existing the region are presented by small PV projects such as street lighting and private PV systems in residential sector.

Figure 26 Annual Global Tilted Irradiation (GTI) Kaliningrad Oblast



Source: Global Solar Atlas [130]

4.2.2 Target Customers

Kaliningrad Oblast is included in the first non-price zone, which means there is no free price formation on the wholesale electricity market in the region, **prices on the retail market are also strictly controlled and pre-established.** The core electricity prices and tariffs are presented in
Table 9.

Table 9 Electricity prices in Kaliningrad Oblast

	Time period			
	2018 2/2	2018 1/2	2017 2/2	2017 1/2
	Retail market, RUB/kWh (EUR/kWh) with VAT 18% (since 2019, VAT is 20%)			
Urban population with gas stoves and groups equated to them (single rate tariff only)	4.05 (0.19)	3.92 (0.05)	3.92 (0.05)	3.79 (0.05)
Urban population with electric stoves and rural population (single rate tariff only)	2.84 (0.05)	2.74 (0.04)	2.74 (0.04)	2.65 (0.03)
Entities, RUB/MWh (EUR/MWh) with VAT 18% (since 2019, VAT is 20%)				
SMEs, purchased capacity (load) less than 150 kW/month & 150-670 kW/month differs depending on the voltage and type of contract and guaranteeing supplier	3,828.75 – 6,240.06 (51.56 – 84.03)	–	–	–
Large industrial consumers, purchased capacity (load) 10 and more MW/month (depending on the type of contract, price category, guaranteeing supplier, voltage, etc)	2,832 – 5,975.49 (38.14 – 68.14)	–	–	–

Source: Energo 24, Residential Electricity Tariffs in Kaliningrad Oblast, 2018 [119], “Yantarenergosbyt”, 2019 [121]

4.2.3 General Perception and Acceptance of PV

The **general attitude towards renewable energy is positive in Kaliningrad Oblast**. Wind energy projects are developing in the region, reflecting a willingness to “go green”: In 2018, a new 6.9 MW wind power plant was installed near the Ushakovo settlement. It replaced an old wind park in Kulikovo and was a project of “ROSSETI”, more precisely, its regional subsidiary “Yantarenergo”.

With regards to PV, the number of enthusiasts may be in the hundreds [120]. A variety of PV systems are offered online, with people sharing their ideas and experiences in forums and blogs and sharing examples of private houses equipped with solar panels being evidence of the rising popularity of this technology among ordinary people. However, there is not specific information about realized PV projects: Due to the limited number of sunny days the development of electricity generation based on PV in the area is not regarded as a priority by the local administration. Moreover, the relatively low irradiation in combination with low, regulated electricity prices does not promote the use of PV, especially when there are no PV specific support schemes.

In the past, the development of renewable energy sources in the region has been supported by the energy retailer and distributor “Yantarenergo”. For instance, **the company was the first in Russia to allow a household connect a private PV system to the grid**. This system was built by a private businessman who was not interested in saving money but who installed the PV installation because of technological curiosity and to become electricity independent.

After long negotiations, the company accepted to install a bidirectional electricity meter which allowed to feed electricity produced by his PV system into the grid and save electricity costs. However, this installation is an individual case rather than a representative business model that will be copied by other citizens

4.3 Region-specific regulatory & legal framework

The federal support schemes for renewable power generation are applicable to Kaliningrad Oblast. The support scheme for the wholesale market – contract supplied capacity (see Section 2.1.1), defined in Decree № 449, is not oblast specific and therefore projects from all regions, including the Kaliningrad Oblast can participate in the tender. In the retail market, as defined by the Decree № 47, the electricity supply tenders (see Section 2.1.2) are to be organized at the regional level following the rules stipulated by the decree and its related regulations.

Until now, no projects chosen under the conditions of the contract supplied capacity were in Kaliningrad. **Decree 47 has not been implemented in Kaliningrad Oblast** and not adapted to the region through local legislative acts and enforcing decrees.

Currently, there are no specific regulative or legislative acts targeting the support of RES in Kaliningrad Oblast. Energy independency from neighbouring countries is the centre of regional energy politics: The “Scheme and programme of the development of energy sector of Kaliningrad Oblast 2018-2022” targets the independence of the regional energy system from foreign countries, especially from Lithuania, as the main gas pipeline delivering gas to the CHPPs in Kaliningrad Oblast stretches through Lithuanian territory. The question of energy security became even more important after economic sanctions were enforced between Russia and European countries. According to this document, Kaliningrad Oblast shall pay more attention to the development of RES in the region, particularly hydropower, bioenergy (including waste) and wind energy due to its potential in the region. The document refers to national normative legal acts and a Russian Energy Roadmap 2030 but does not mention any concrete local legislative acts which may help the RES development in the region.

4.4 Business Models for Solar PV

As per the classification of business models chosen for this report and were described in chapter 1.3, the situation pertaining to the three business models in Kaliningrad oblast are described in the following subsections.

4.4.1 Model 1: PV parks

There are no large PV power plants in Kaliningrad Oblast and currently **there are no plans to develop such projects or support them in this region**. Nevertheless, there are opportunities to use PV to supply socially important facilities with energy. In Kaliningrad Oblast there is already a case of Lugowoje village where a rooftop PV system generates up to 50 kW daily for a street lighting [123]. The PV power station was a pilot project financed by the European Union under a project of energy efficiency development and costed 40,000 EUR. Currently this PV system permits Lugowoje to save some 100 thousand RUB annually (approx. 1,340 EUR).

4.4.2 Model 2: Off-Grid PV & Hybrid Systems

Having a **country/holiday house** is usual in Russia and so more new houses are being built in rural areas, which are not connected to the grid. If there is a grid close to a house the connection costs are often high, even comparable with the cost of a rooftop PV system.

In 2014, a family from Tscherepanowo village invested about 160,000 RUB (2,153 EUR) in 6 PV modules and a battery which now fully supplies their house, while “Yantarenergo” offered a grid connection for 150,000 RUB (2,018 EUR) [123]. Tscherepanowo is still disconnected from the power grid and everybody except for this family uses diesel generators.

According to some estimations, there are **about 250 small residential PV systems in Kaliningrad Oblast which function autonomously** and usually in combination with diesel or petrol gensets [124]. The average payback period for a residential PV system (as for 2016) is assumed to be 5-8 years. The calculations undertaken in this report suggest, that the payback periods for hybrid PV systems will most likely be longer, even in areas with a higher solar irradiation than Kaliningrad.

4.4.3 Model 3: Residential PV systems

There is no official statistical data giving an exact number or installed capacity of residential PV systems in Kaliningrad Oblast.

In 2014, a precedent was set when an official connection between a PV system and grid was set up in Kaliningrad. A local businessman, Mr. Rigikov, installed 5.4 kW with a peak production of 35 kWh on a sunny day. After negotiations with “Yantarenergo”, the pioneer got permission to feed the city’s power grid with electricity on days when his system generates more energy than the household consumes and rotate the electricity meter backwards which, turning a profit for the owner. This story was a first example of a “prosumer” in Russia but has no analogies.

Another similar case happened in Orlovka, a village close to Kaliningrad. The settlement is connected to the power grid, **but blackouts happen so frequently that practically all households have diesel generators**. One family decided to invest money in a rooftop PV system combined with batteries, permitting the house to be fully autonomous for up to two days [122]. The household is mainly supplied by PV modules which simultaneously charge the batteries. During the night and on cloudy days the batteries switch on and in case of a discharge of power, is taken from the grid. The main argument against diesel generators was noise and questions about stocking the required fuel supplies.

4.4.4 Conclusions and Perspectives

Kaliningrad Oblast has less solar irradiation than other Russian regions, its electricity prices are fully regulated and low and its electricity consumers are connected to the grid, although some exceptions exist. Kaliningrad Oblast has no concrete regional support scheme for the development of RES, however there have been some examples of successful PV use. The most promising directions for enabling PV in this region are:

- **Development of residential PV hybrid systems in areas with no or weak grids**. Such areas are newly built settlements, where connection to the grid is expensive or takes a lot of time. As described above, there are villages where the existing grid cannot provide stable electricity supply. Furthermore, after enforcement of the Law on 15 kW, private households could shorten the payback period for their PV systems and this may encourage more private persons to install PV or hybrid solutions.

- **Pilot projects**. Because Kaliningrad Oblast is an enclave, it is relatively easy to try out modern technical solutions in the region. Both the administration of the region and local energy companies are open to new technologies and experiments and are in a tight cooperation with “Skolkovo”, a Russian analog to “Silicon Valley” – a modern scientific complex near Moscow intended to develop, support and commercialize new technologies, R&Ds, ideas in whatever sphere. For example, there is a project of “ROSSETI”, which aims to test grid digitalization in the region, which will become the first Russian experience. Same for RES source: Kaliningrad Oblast was the first to connect a residential PV system to the state power grid and wants to hold the status of an innovative test area, and a Russian frontrunner and pathfinder.
- **PV & heat pump water and space heating systems**. Such combined solutions are mainly connected with the construction of energy efficient houses. Such systems are already used in Kaliningrad and may become more popular over the time.

5. Selected PV Business Cases

This section is dedicated to the profitability analysis of three selected PV business cases. Sample calculations of typical projects include: cash-flow modelling and sensitivity analyses to provide an outlook of profitability changes related to changes in system prices, energy yield and remuneration.

For the three business cases we have used the best possible solar radiation values of Krasnodar Krai. This solar radiation corresponds to approx. 1,600 kWh / m^2 / a (global tilted irradiation, GTI). After applying a performance ratio of 0.82 to this irradiation, the specific yield used (and shown in the graphs and figures) is 1,312 kWh / kWp / a. For Kaliningrad, these values are lower: GTI is approx. 1,300 kWh / m^2 / a which results into a specific yield of 1,066 kWh / kWp / a. The corresponding results for Kaliningrad are described in the sensitivity analysis of the yield.

5.1 Methodology of profitability analysis

An excel based discounted cash flow analysis (DCF) was used for profitability analysis in this report. The DCF methodology evaluates a project using the concept of the time value of money.

All future cash flows are estimated and discounted to give their present values. The **net present value** (NPV) is the sum of all positive and negative cash flows' present values including the initial investment. The NPV allows for the comparison of investments with different durations and cash flow profiles over their lifetime at the present point in time. Besides NPV, the **internal rate of return** (IRR) for both the equity and the entire project were calculated as well as the **amortization period** (payback time) for the invested capital. These parameters give investors an indication of the attractiveness of an investment.

Another key parameter calculated is the **levelized cost of electricity** (LCOE) which makes it possible to compare power plants of different generation and cost structures.

Finally, ratios such as the **debt service coverage ratio** (DSCR) and **loan life cycle coverage ratio** (LLCR) provide information about whether the project cash flows suffice to reimburse the debt invested in a project.

5.2 PV Parks

Large scale photovoltaic systems , also known as **solar PV parks are usually designed to supply power to the electricity grid**. They are differentiated from most roof-mounted and other decentralized solar power applications because they supply bulk power at the utility level, rather than to a local user. Large scale PV plants are generally the type of projects most institutional investors and developers invest in.

As described in previous chapters **ground-mounted PV parks are currently built in Russia either on the provisions of Decree 449** (wholesale market, federal auctions) **or Decree 47** (retail market, regional auctions). Regarding support payments the Federal Decree 449 and Decree 47 differ mainly on the basis of the support payments: While Decree 449 foresees to pay a beneficial tariff based on installed capacity (MW), Decree 47 does so based on electricity generation (in MWh). **The calculations for solar parks in this report were made under the assumption that they are built under the provisions of the regional retail market Decree 47** which aims at compensating 5% of grid losses by RES.

Still, both regulations also have similar provisions: projects are awarded based on tenders with the investment costs (CAPEX) playing a key role in the assessment of the bids and the calculation of the support granted. Moreover, both regulations share important local content provisions (70%), minimum capacity factor requirements (14%), a payment period for the beneficial tariff of 15 years and a targeted return for the investor of 12%.

Given these similarities it should be possible to draw conclusions for projects built on the grounds of Decree 449 which does not aim at compensating grid losses but may be seen as the main instrument to create a national PV industry and increase the RES share. In order to do so we have also calculated an annual capacity premium that would correspond to the beneficial tariff paid under Decree 47.

Profitability Analysis (Inputs, Outputs, Scenarios, Sensitivities)

A profitability analysis for a large-scale PV project (10 MW) is presented below.

Figure 27 Project Overview - Large Scale PV

PV Project			
PV System Size		kWp	10.000
Specific System Cost		RUB/kWp	75.000
Investment Subsidy		RUB	-
Total System Cost		RUB	750.000.000
Fixed Operation Costs		RUB p.a.	15.000.000
Variable Operation Costs		RUB/kWh	-

PV Generation		
Yield	kWh/qm/a	1.600
Performance Factor	%	82%
Specific Yield	kWh/kWp/a	1.312
Degradation	% p.a.	0,70%

Investment			
Project Duration		Years	25
Beneficial tariff payments		Years	15
Equity		RUB	185.001.222
Debt (Gearing)	80%	RUB	600.000.000
Loan Tenor		Years	10
Interest Rate		%	10,00%
Discount Rate		%	12,00%
Inflation Rate		%	5%

PV Business Model			
Beneficial tariff	100%	RUB/kWh	6,50
Targeted capacity factor		%	14,00%
Avg. capacity factor achieved		%	14,17%
Fees		RUB/kWh	-
Retail electricity market price		RUB/kWh	4,00
Undersupply Penalty		RUB/kWh	-
Inflation Adjustment		%	-
Calculatory average capacity premium		RUB/kWp/a	8.009

Results		
Net-Present Value	RUB	28.311.814
Project IRR	%	11,00%
Equity IRR	%	13,71%
Payback Period	Years	13,30
LCOE (no subsidy)	RUB/kWh	8,96
Min DSCR**	x	1,09 x
Min LLCR***	x	1,09 x

* LCOE: Levelized Cost of Electricity

** DSCR: Debt Service Coverage Ratio

*** LLCR: Loan Life Coverage Ratio

Source: eclareon, 2019

About the assumptions for this PV Business Case

The site selection is based on many considerations, such as whether the PV plant is close to the grid, and whether the process for obtaining a grid connection agreement is transparent and predictable. The assumed solar radiation is reached in Krasnodar Krai.

The analysis of the solar resource and projected energy yield are critical inputs for the financial analysis. The energy yield is a critical parameter that determines (along with the capital costs and the tariff) the financial viability of the project. Probability based energy yield are modelled over the operating life of the PV system. The total system costs reflect the current favorable world market prices for PV components. Large-scale PV power plants are designed with **decentralized or centralized PV inverter** technology.

The central inverter configuration remains the first choice for many medium- and large-scale solar PV plants. A large number of modules are connected in a series to form a high voltage (HV) string. Strings are then connected in parallel to the inverter.

Central inverters offer high reliability and simplicity of installation. Central inverters are usually three-phase and can include grid frequency transformers.

In contrast, the string inverter concept uses multiple inverters for multiple strings of modules. String inverters provide MPPT on a string level with all strings being independent of each other. This is useful in cases where modules cannot be installed with the same orientation or where modules of different specifications are used or when there are shading issues.

String inverters, which are usually used in single or three phases, can be serviced and replaced by non-specialist personnel and it is practical to keep spare string inverters on site. This makes it easy to handle unforeseen circumstances, as in the case of an inverter failure. In comparison, the failure of a large central inverter, with a long lead time for repair, can lead to significant yield loss before it can be replaced.

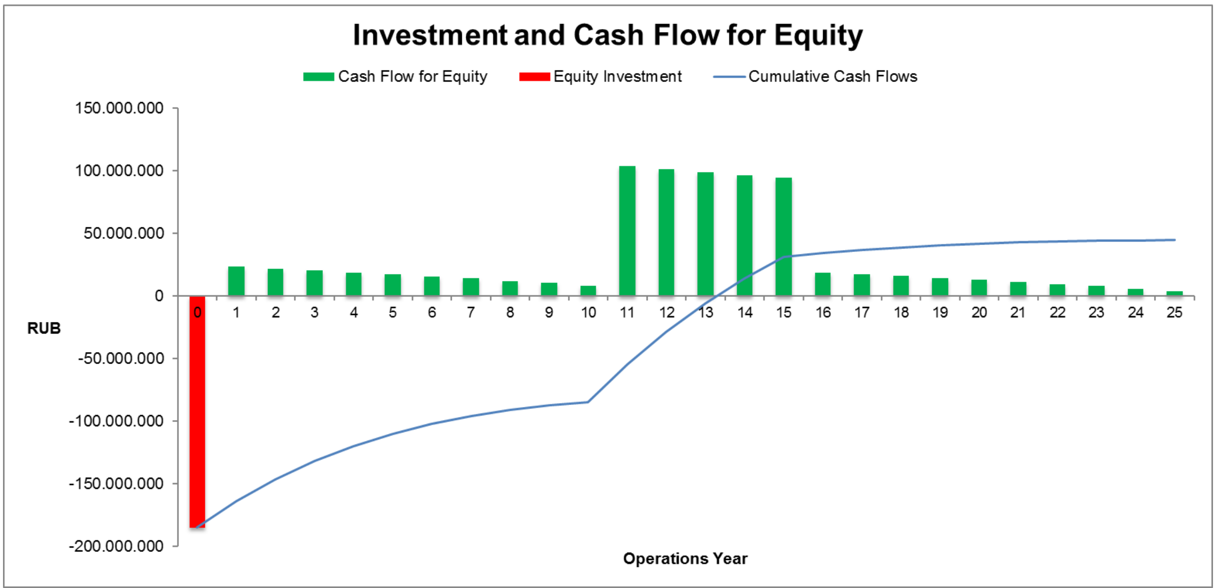
The assumptions regarding the financing conditions correspond to the possible terms and conditions of February 2019. The lifetime of the system is set to 25 years and is based on the lifetime of the PV modules. All cash flows including financing for this first case are in RUB and interest rates and inflation rate are also RUB based. For the underlying beneficial tariff to be paid please see chapter 2.1.2.3 of this study.

Financial results for this PV Business Case

As Figure 27 shows the **payback period** is **13 years,** the **equity IRR** is **13,71% and the project IRR is 11%.** Notice that both values represent approximations to the target values set in the provisions of Decrees 47 and 449: projects shall be paid back in accordance with the payment duration of the beneficial tariff. Moreover, the return for the investor is targeted at approx. 12%. IRR are not in the strict sense, measures of project return but rather a calculated theoretic interest rate that would bring discounted cashflows to 0.

Still, given that based on the provisions on the law itself it is not clear what kind of investor return is meant (return on investment, return on equity, real rates of return or nominal ones), the IRR seems a good enough approximation for the purpose of this report. The input parameter into the model that decisively determines the payback period is the beneficial tariff that is paid on a monthly basis. Taking into consideration electricity sales on the retail market and keeping other input variables stable, the beneficial tariff corresponds to 6.5 RUB/kWh paid over 15 years. **If the project were built under the provisions of Decree 449, the calculated capacity tariff would correspond to approx. 8,000 RUB/kWp/ year (107.6 EUR/kWp/year)** or, as tariffs are in reality paid per month and per MW, to approx. 667,500 RUB/MWp/month (8,982 EUR/MWp/month). The cash flow for the case is as follows:

Figure 28 Equity Cash Flow - Large Scale PV

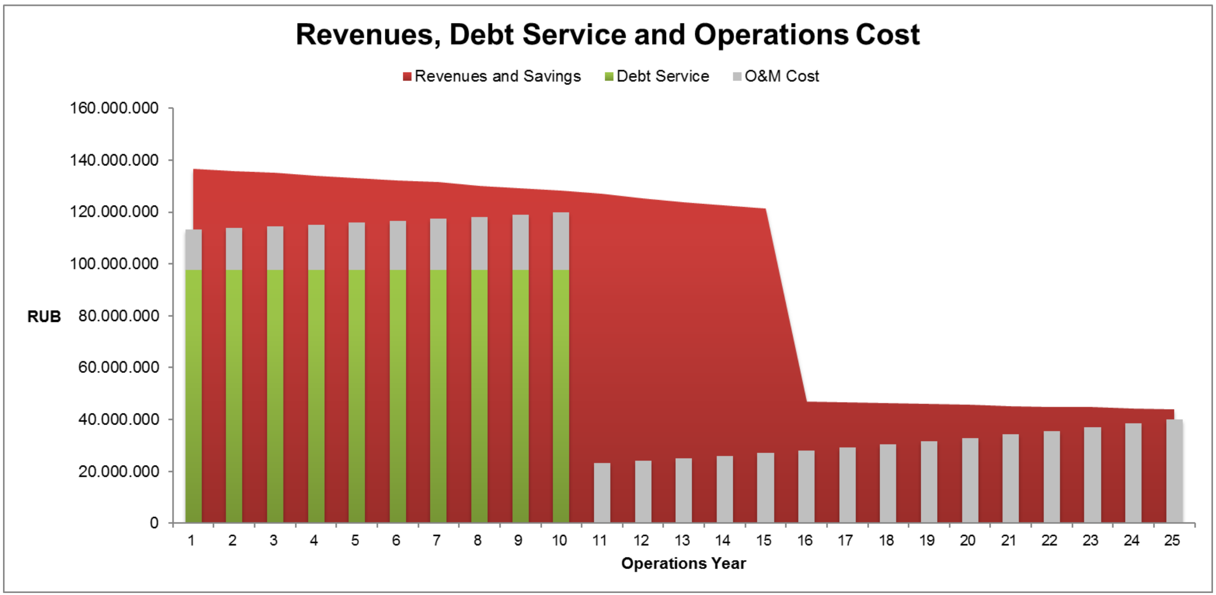


Source: eclareon, 2019

Due to module degradation and missing inflation adjustment for the beneficial tariff, the yearly cash flows for equity are gradually reduced. The sudden increase after year 10 is caused by the end of the debt tenor and the full reimbursement of the loan. The decrease in year 16 is explained by the end of the payment period of the beneficial tariff: After 15 years the project continues to generate revenues but purely based on electricity sales on the retail market. For this calculation the, compared to German electricity prices, fairly low retail market price chosen was 4RUB/kWh for the whole life of the project. Depending on the region and the consumer group, this price may vary but it needs be taken into account that the provisions of Decree 47 state that solar PV installations shall, after payments of beneficial tariffs will have ceased, lead to reduced retail market prices.

The sudden reduction of revenues after year 15 is also shown in the next graph which, in addition, also shows decreasing real revenues because OPEX costs are escalated based on the inflation while revenues are based on a stable electricity sales price and plant performance is naturally decreasing over time as the equipment ages and the plant performance goes down (0.7% per year).

Figure 29 Project Cash Flows - Large Scale PV



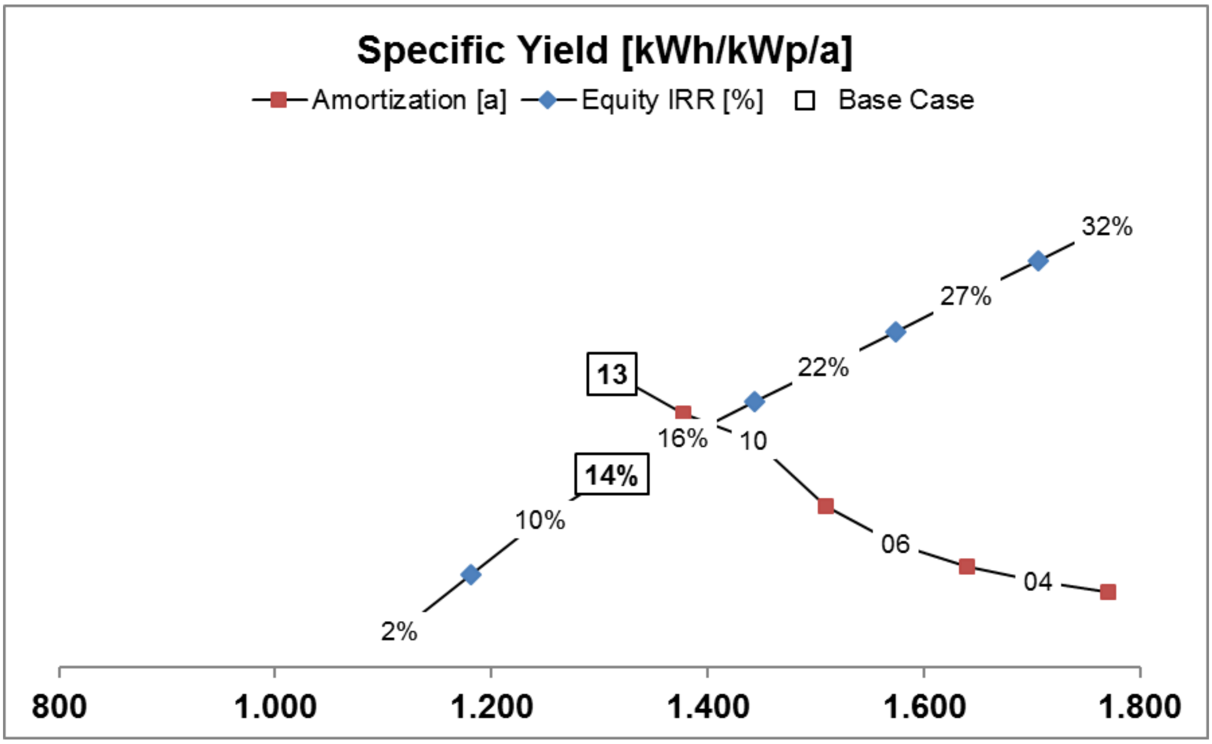
Source: eclareon, 2019

Sensitivity of results for this PV Business Case

The following figures show how the two key economic performance indicators for the investment, payback period (Amortization) and return on equity (Equity IRR) change when certain assumptions about the investment framework conditions are modified. The figures show which modification in individual assumptions influence the profitability of the investment particularly strongly (→ high sensitivity). This needs to be carefully observed when making investments.

The specific yield shown below are the kilowatt hours produced by the PV system per kWp capacity and per year. It is calculated on the basis of the solar radiation multiplied by the performance factor of the PV system. This factor, which is always less than 1, includes the technical conditions for the efficiency of the PV system, the efficiency, orientation and inclination of PV modules, possible shadowing, etc.

Figure 30 Specific Yield Sensitivity - Large Scale PV



Source: eclareon, 2019

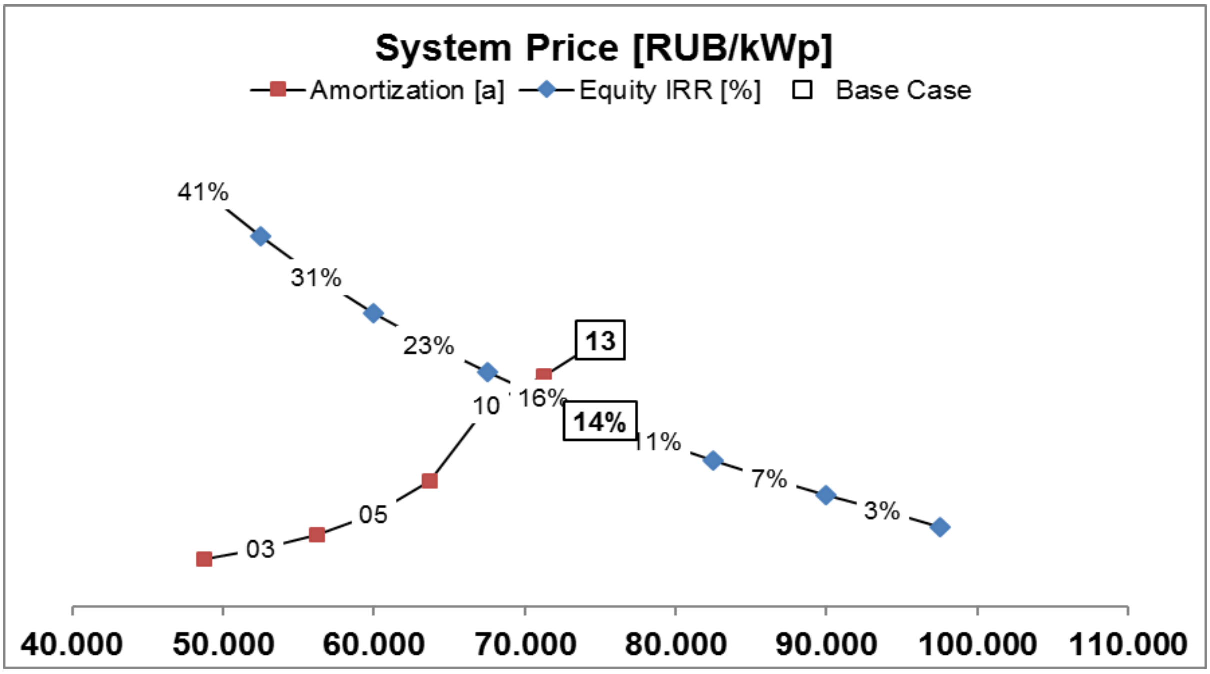
The **same plant in Kaliningrad would lead to the following results**:

Scenarios	Specific Yield	Payback	NPV (RUB)
Kaliningrad	**1.066**	**N/A**	**(199.603.136)**

Everything else kept equal, the net present value (NPV) **for the same installation in Kaliningrad would be negative and it could not be paid back given the lower irradiation**. If similar results in terms of payback period and IRR were to be achieved in Kaliningrad, the beneficial tariff would have to be increased to about 11RUB/kWh (14 €ct/kWh) and/or combined with lower investment costs (CAPEX) which could be achieved, for example, by providing direct regional subsidies. However, as stated before, there are no hints at the moment that such support for PV plants is discussed in Kaliningrad.

Going back to using the more favorable solar irradiation at Krasnodar Krai, the following figures show the influence of changing other key input parameters on the equity IRR and the payback period:

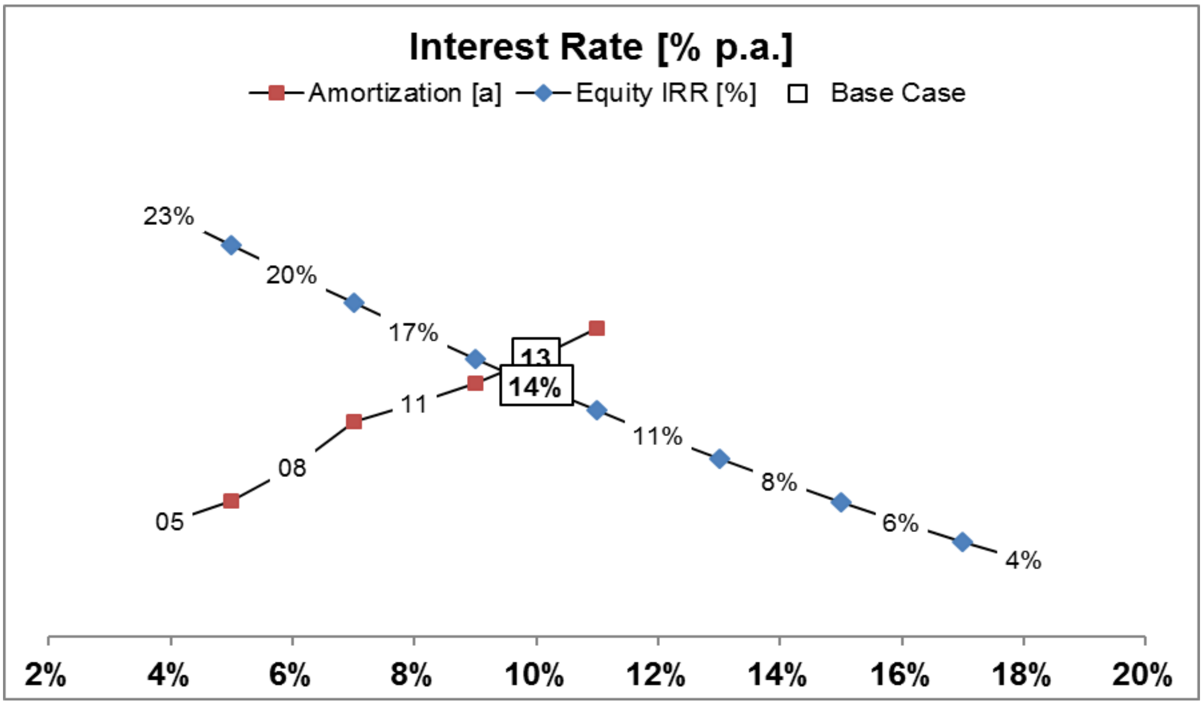
Figure 31 System Price Sensitivity - Large Scale PV



Source: eclareon, 2019

The profitability of projects is strongly influenced by the yield, the beneficial tariff and the system price because of their strong impact on revenues and overall costs.

Figure 32 Interest Rate Sensitivity - Large Scale PV



Source: eclareon, 2019

Compared with other examples, the debt leverage of 80% is quite high and the debt tenor is 10 years, so we see a strong impact of the interest rate as well. The interest rate for debt in the base case is assumed to be at 10%. From the sensitivity analysis we can see that the project does not sustain much higher interests if the other input parameters are kept as is.

5.3 PV-Diesel hybrid System

A solar-PV diesel hybrid system combines the power output of PV arrays and diesel generators. The control system draws power in such a way that it maximizes the load contribution of PV and minimizes diesel generators. If there are multiple generators and there is sufficient power from PV, the control system will shut off some of the generators completely to minimize fuel consumption.

Most electricity consumers in Russia are connected to the grid and pay relatively low electricity prices. **Still, diesel solutions can be found in many remote areas and isolated territories and in new settlements without a grid connection. Moreover, diesel gensets are used as a backup solution in those areas where the grid is rather weak and hence prone to blackouts.**

PV-diesel solutions are a convincing alternative for existing diesel powered grids. Today, a cost advantage of PV-diesel hybrid systems compared to conventional stand-alone diesel gensets can be achieved.

In principle two main basic system solutions are suitable and commercially available on the market.

- **Hybridization without storage technology**
- **Hybridization with storage technology**

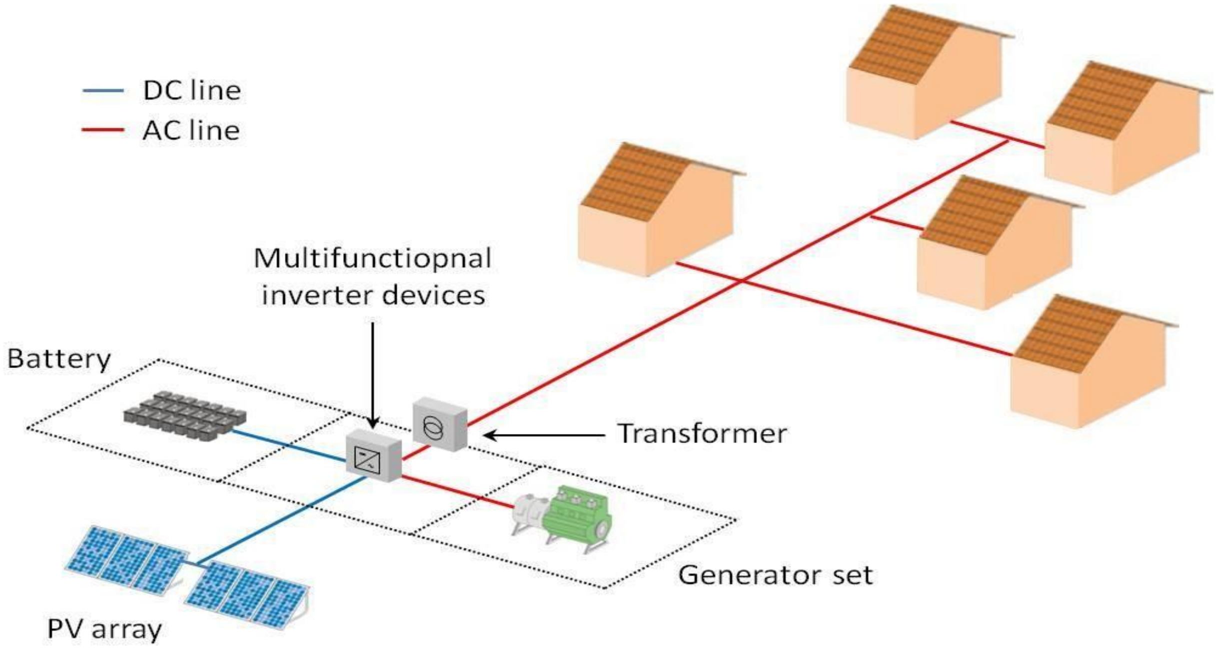
The integration of a PV plant with a high PV penetration rate (ratio between PV peak power and genset nominal power) is only possible with an additional intelligent control unit. A so-called fuel save controller unit can be integrated into both new and existing power supply systems. The integration of a fuel save controller unit allows a significantly higher PV penetration level up to 60% (ratio between PV peak power and genset nominal power).For each MW installed genset capacity, a photovoltaic plant with 600 kWp can be added to the genset power supply system. The fuel save controller manages the feed-in of PV and the diesel genset remains unaffected.

The additional integration of battery storage power can compensate for the fluctuations in load and irradiation to further increase the overall system efficiency by providing spinning reserves and facilitating optimized genset operation.

Ancillary services include frequency-dependent control of active power feed-in, voltage stability, black start capability after a grid failure and grid congestion management. These services provide renewable energy with the same grid-stabilizing characteristics as conventional power plants. Thus, storage systems enable the provision of high-quality energy at any time and balance the fluctuations caused by the rapid rise in solar energy use. The same storage system can also be used for other purposes, such as an uninterruptible power supply. As generators become more adjustable and controllable, the number of conventional units can be significantly reduced while future grid requirements can still be met, and supply reliability can be guaranteed at any time. Depending on the storage size a diesel off-mode is applicable.

Figure 30 below indicates the setup of a PV-diesel hybrid system for rural grid electrification.

Figure 33 Schematic view of a PV / diesel hybrid system for rural electrification



Source: IEA-PVPS T9, 2013

Profitability Analysis (Inputs, Outputs, Scenarios, Sensitivities)

Option 1: PV-Diesel-PV hybrid system without storage

A profitability analysis for a PV-Diesel hybrid system without storage and based on diesel savings is presented below.

Figure 34 Project Overview - Captive PV without storage

PV Project			
PV System Size		kWp	250
Specific System Cost		RUB/kWp	90.000
PV Battery Size		kWh	-
Specific Battery Costs		RUB/kWh	-
Total System Cost		RUB	22.500.000
Fixed Operation Costs		RUB p.a.	450.000
Variable Operation Costs		RUB/kWh	-
PV Generation			
Global Tilted Irradiation (GTI)		kWh/qm/a	1600
Performance Factor		%	82%
Specific Yield		kWh/kWp/a	1.312
Degradation		% p.a.	0,70%
Investment			
Project Duration		Years	25
Equity		RUB	7.624.536
Debt (Gearing)	70%	RUB	15.750.000
Loan Tenor		Years	10
Interest Rate		%	10,50%
Discount Rate		%	12,00%
Inflation Rate		%	5%

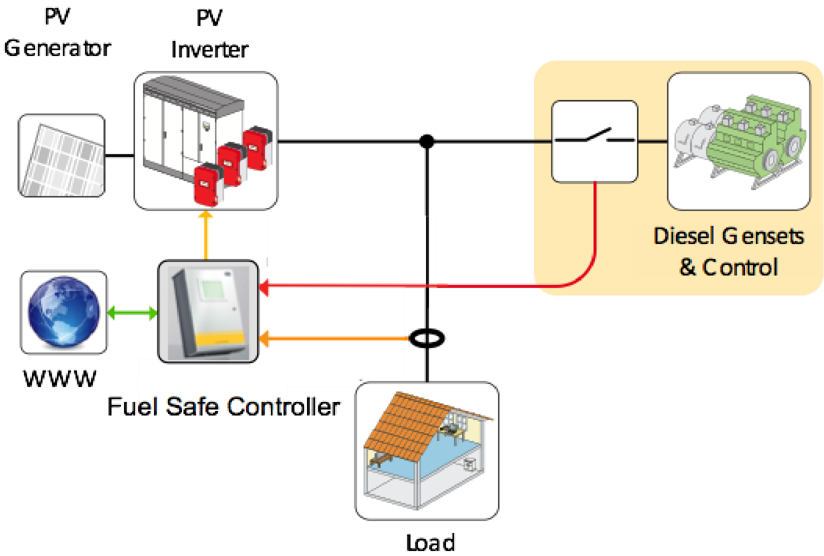
PV Business Model		
Direct PV Consumption	%	100%
PV Consumption via Battery	%	-
Battery Losses	%	-
Effective fuel costs	RUB/ liter	45
Diesel Generation Costs	RUB/kWh	15
Fuel cost escalation	% p.a.	5%
Results		
Net-Present Value	RUB	27.221.239
Project IRR	%	23%
Equity IRR	%	33%
Payback Period	Years	4,51
LCOE (no subsidy)	RUB/kWh	11
Min DSCR**	x	1,37 x
Min LLCR***	x	2,13 x

* LCOE: Levelized Cost of Electricity
** DSCR: Debt Service Coverage Ratio
*** LLCR: Loan Life Coverage Ratio

Source: eclareon, 2019

About the assumptions for this PV Business Case

Figure 35 Intelligent and fast interfacing between load, genset and PV inverter, Fuel Save Controller



Source: SMA Solar Technology

The diesel genset together with the connected load is the overlaid system and builds the electrical network. That is still valid even if the PV supplies energy into this grid. The PV can be seen as a negative load. The fuel save controller unit does not control the genset, it controls the PV power system to keep the genset within allowed operation conditions.

Diesel generators have to operate at at least 30% of installed capacity in order to avoid inefficient operation. 24h/7days genset operation is required. An adequate load profile during the day (sunshine) to reduce fuel consumption is assumed. In general, a share of 60% PV with fuel save controller without storage is advised.

As in the other cases, the assumptions regarding the financing conditions correspond to the possible terms and conditions of February 2019. Both captive diesel projects (without and with storage) are also calculated in RUB since the revenues are generated from diesel savings which are assumed to be paid in RUB.

The lifetime of the system is set at 25 years and is based on the lifetime of the PV modules. Again, the solar radiation is set to 1,600 kWh / m^2 / a which represent irradiation levels in Krasnodar Krai.

After analyzing the diesel prices for the target customer groups of this business case we have assumed a price of about 45 RUB per liter. This amounts to about 15 RUB (0.20 EUR) per kWh generation costs with common diesel generators under the assumption that the genset eficiency is at 3 kWh/ liter. Fuel cost escalation is 5%.

For this case and also for the captive case with storage, no additional savings of maintenance costs for the on-going diesel generators were taken into account for the lifetime of the PV investment. Operation costs used are restricted to the PV system (inlcuding storage) itself but does not extend to the diesel genset. This is, however, a simplification since one could also consider savings in the maintenace costs for the diesel in favor of the profitability of the PV investment, because some of the generators can be switched off after installation of the PV and thus reduce the maintenance costs and create additional savings.

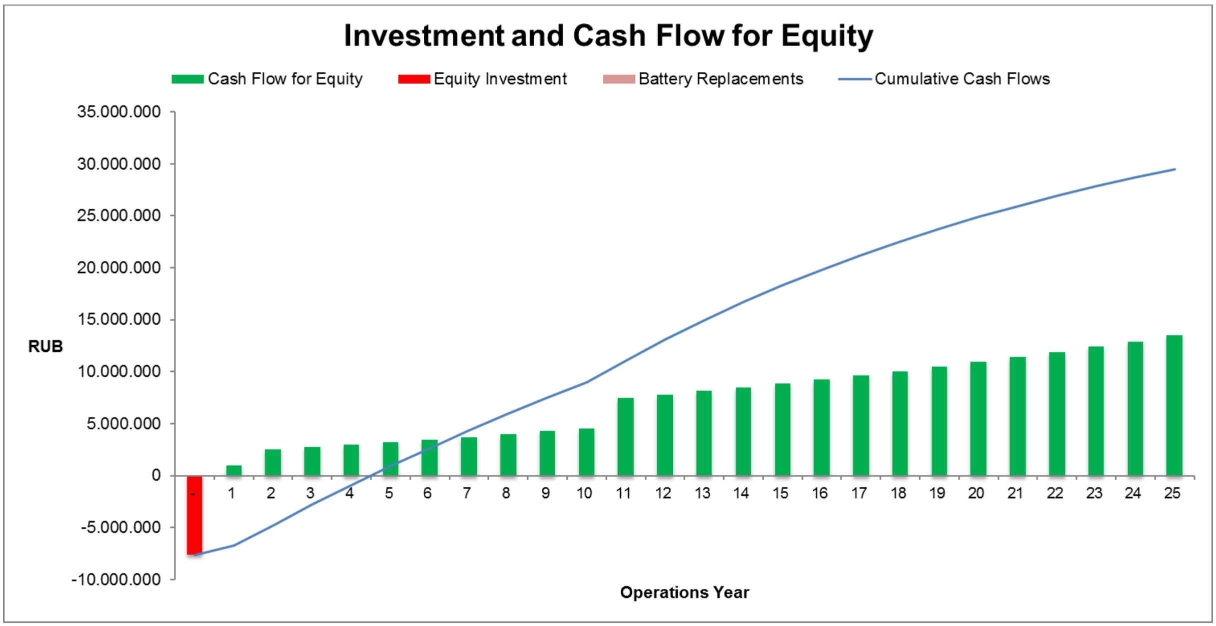
These diesel genset maintenace cost savings are more important the longer the diesel genset can be switched off completely. This would be the case for an installation with storage, because such a system configuration would allow the PV system to cover up to 100% of the load. Moreover, another simplicfication is the assumption that both cases were calculated for a 250kWp system in order to compare both cases as much as possible.

Howver, given a specific project with an individual load and consumption profile, an installtion with storage technology could integrate a larger share of PV and cover up to 100% of consumption. Hence, an instllation with a battery would be larger which could consequently also lead to economies of scale which could reduce system costs / kWp.

Financial results for this PV Business Case

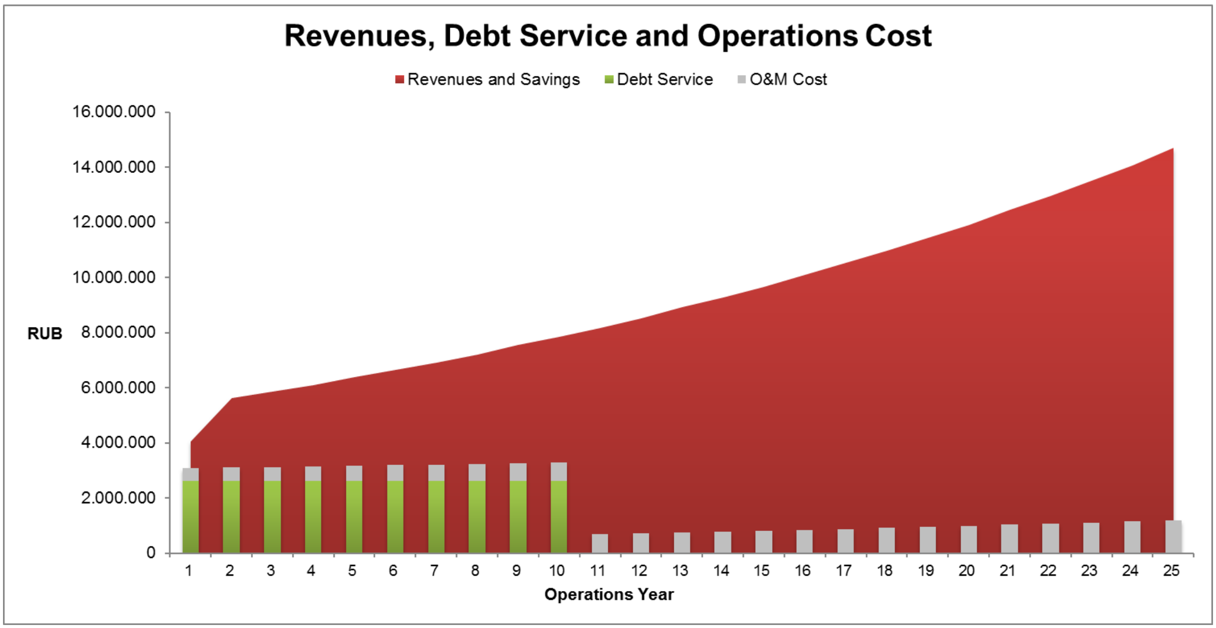
As can be seen from Figure 34, with best possible solar irradiation conditions in Krasnodar Krai the **payback period is 4.51 years** only and the **equity IRR** is **33%.** The cash flow for the case is as follows:

Figure 36 Equity Cash Flows - Captive PV without storage



Source: eclareon, 2019

Figure 37 Project Cash Flows - Captive PV without storage

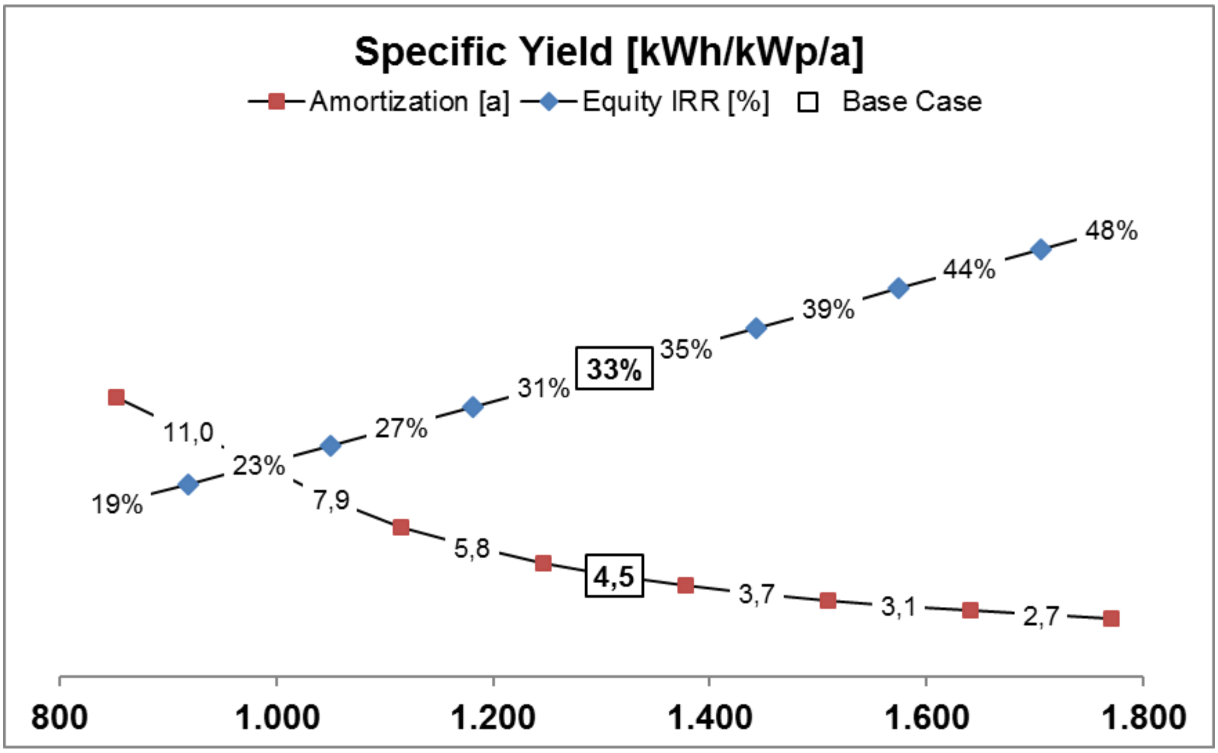


Source: eclareon, 2019

Sensitivity of results for this PV Business Case

The following figures show how the two key economic performance indicators for the investment, payback period (amortization) and return on equity (equity IRR) change when certain assumptions about the investment framework conditions are modified. The figures show which alterations of the individual assumptions influence the profitability of the investment particularly strongly (→ high sensitivity). This needs to be carefully observed when making the investment.

Figure 38 Specific Yield Sensitivity - Captive PV without storage



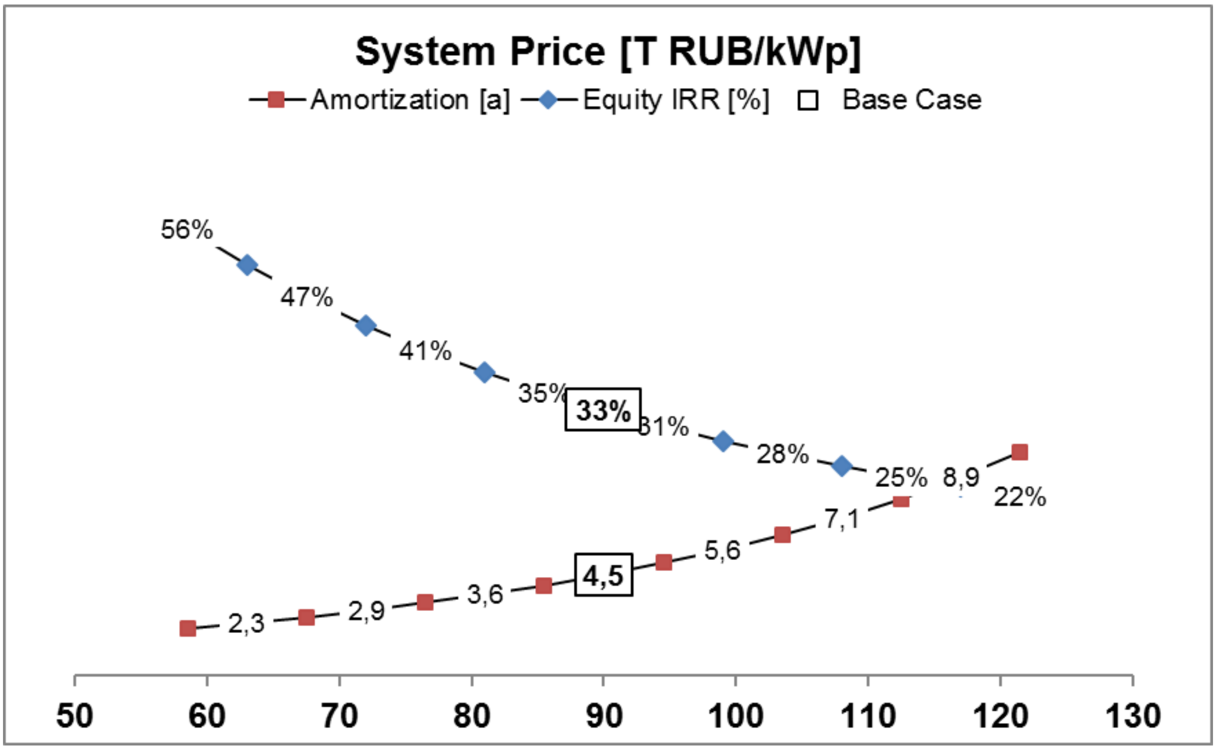
Source: eclareon, 2019

As before, it was also looked at the results or an identical installation in Kaliningrad where the irradiation (specific yield) would be lower. The results show that an investment in a diesel PV hybrid system, everything else being equal, would also be repaid in a less sunny region albeit the payback period would increase to 7.57 years.

Scenarios	Specific Yield	Payback	NPV (RUB)
Kaliningrad	**1.066**	**7,57**	**17.253.491**

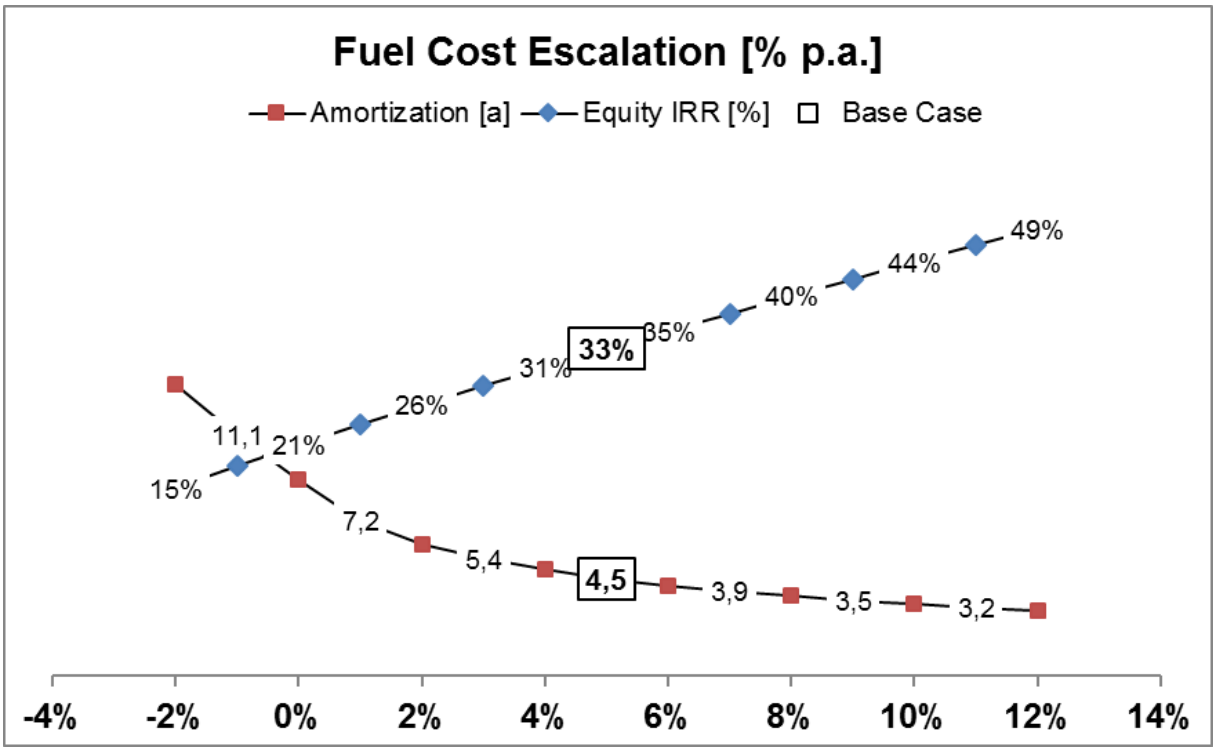
Going back to using the more favorable solar irradiation at Krasnodar Krai, the following figures show the influence of changing other key input parameters on the equity IRR and the payback period:

Figure 39 System Price Sensitivity - Captive PV without storage



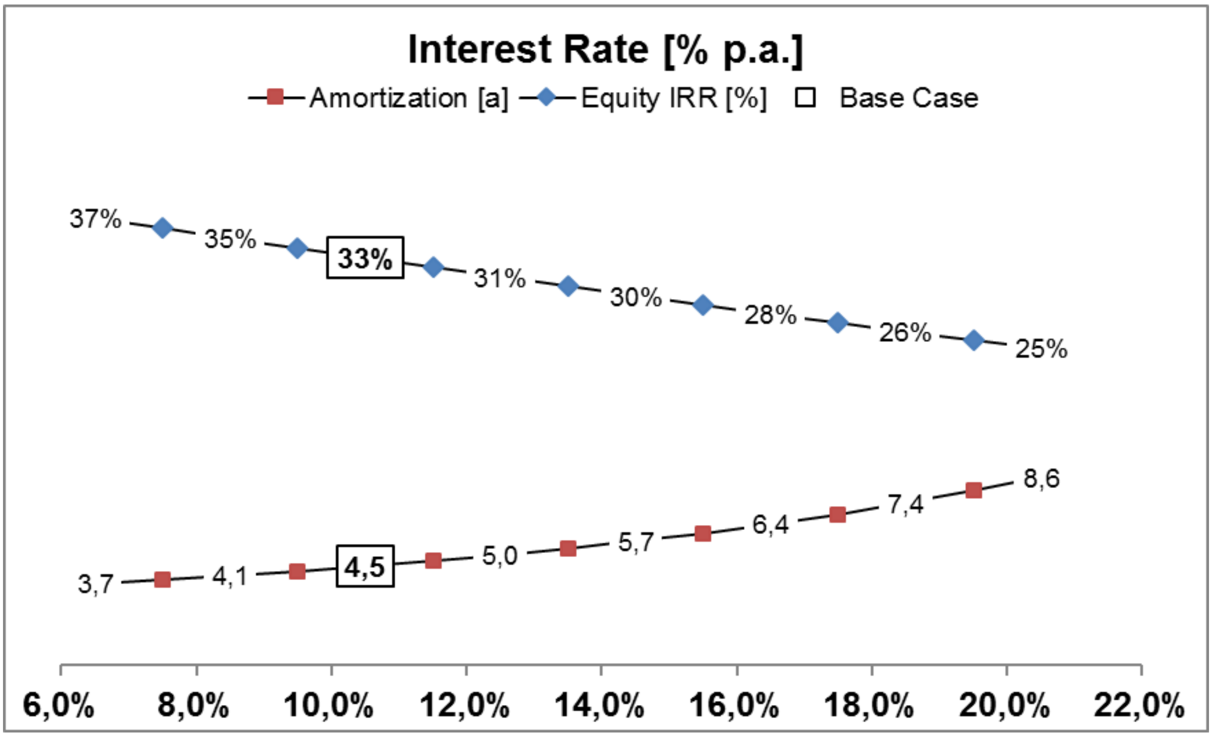
Source: eclareon, 2019

Figure 40 Fuel Cost Escalation Sensitivity - Captive PV without storage



Source: eclareon, 2019

Figure 41 Interest Rate Sensitivity - Captive PV without storage



Source: eclareon, 2019

Option 2: Captive Diesel-PV hybrid with storage

Below an exemplary profitability analysis for a PV-Diesel hybrid project with storage and based on diesel savings is presented.

Figure 42 Project Overview - Captive PV with storage

PV Project			
PV System Size		kWp	250
Specific System Cost		RUB/kWp	90.000
PV Battery Size		kWh	270
Specific Battery Costs		RUB/kWh	15.000
Total System Cost		RUB	26.543.836
Fixed Operation Costs		RUB p.a.	530.877
Variable Operation Costs		RUB/kWh	-

PV Generation			
Global Tilted Irradiation (GTI)		kWh/qm/a	1600
Performance Factor		%	82%
Specific Yield		kWh/kWp/a	1.312
Degradation		% p.a.	0,70%

Investment			
Project Duration		Years	25
Equity		RUB	8.994.863
Debt (Gearing)	70%	RUB	18.580.685
Loan Tenor		Years	10
Interest Rate		%	10,50%
Discount Rate		%	12,00%
Inflation Rate		%	5%

PV Business Model		
Direct PV Consumption	%	60%
PV Consumption via Battery	%	30%
Battery Losses	%	20%
Effective fuel costs	RUB/ltr	45
Diesel Generation Costs	RUB/kWh	15
Fuel cost escalation	% p.a.	5%

Results		
Net-Present Value	RUB	12.720.095
Project IRR	%	17%
Equity IRR	%	20%
Payback Period	Years	11,27
LCOE (no subsidy)	RUB/kWh	14
Min DSCR**	x	0,68 x
Min LLCR***	x	1,40 x

* LCOE: Levelized Cost of Electricity
** DSCR: Debt Service Coverage Ratio
*** LLCR: Loan Life Coverage Ratio

Source: eclareon, 2019

About the assumptions for this PV Business Case

The integration of a storage system reduces the operating time of the diesel genset and the fuel consumption. The storage ensures power quality and grid stability (voltage, frequency, reactive power) and can substitute spinning reserve and idle genset operation.

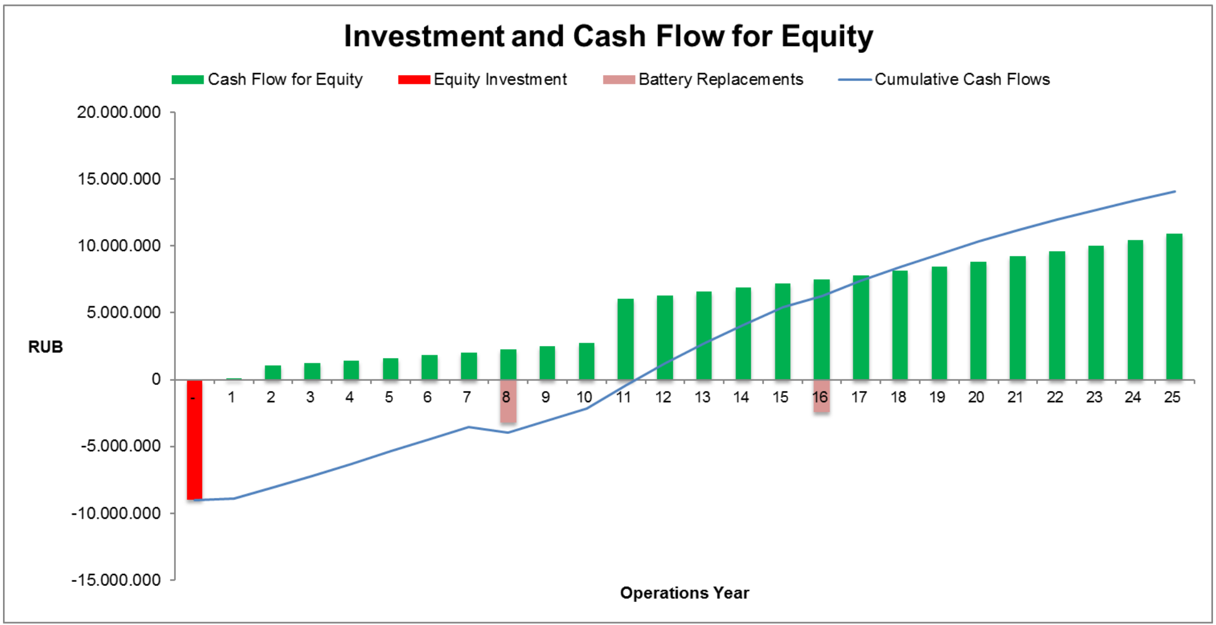
The PV penetration and storage capacity can be extended to the economic optimum and a diesel off-mode can be supported. Power sharing among generation units may help to meet the load demand in the most economical way. An additional control unit is needed.

The above calculation for the PV project is done with a lead acid storage technology with lower specific battery costs than lithium based technologies. This case assumes two battery replacements in years 8 and 16, with decreasing costs because the present value of this investment is considered and future cost reduction is very likely.

Financial results for this PV Business Case

As can be seen from Figure 42, the **payback period** is **11.27 years** and the **equity IRR** is **20%.** The cash flow for the case is as follows:

Figure 43 Equity Cash Flows - Captive PV with storage



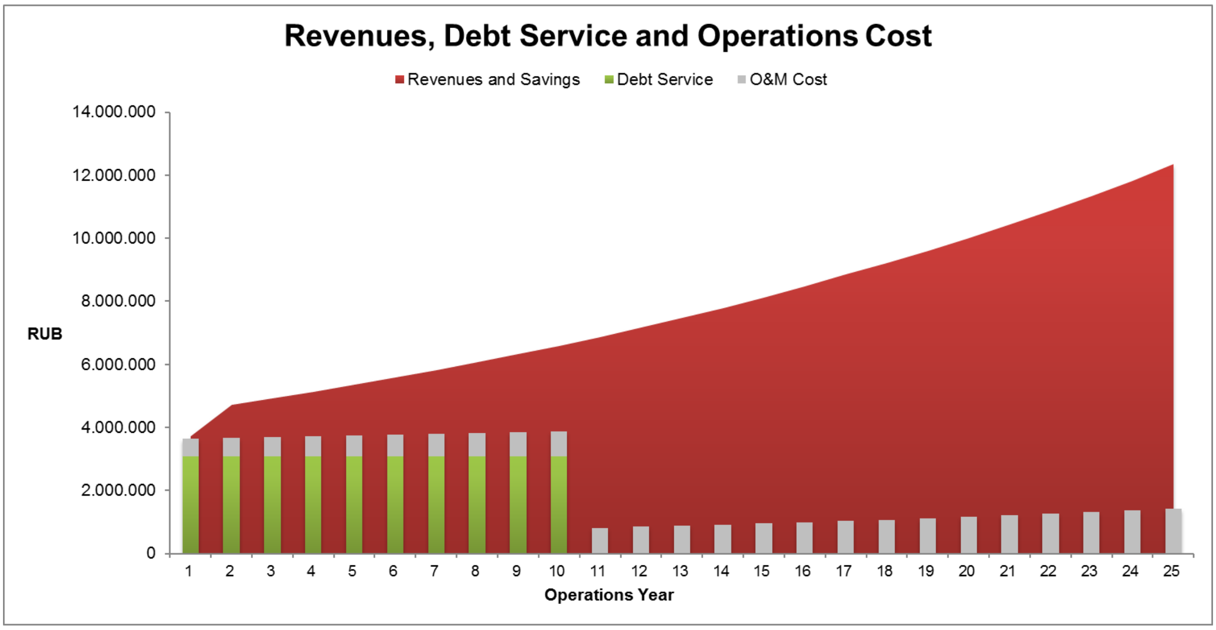
Source: eclareon, 2019

As described in the assumptions, the captive diesel-PV case with storage assumes two battery replacements in years 8 and 16. In this case the long-term inflation rate (5% in the first year but 4% for the following years) applied to the O&M costs is lower than the fuel cost escalation (5%) that drives the increased savings over time. Thus, towards the end of the project the absolute O&M costs increase less than the revenues/savings.

It can also be argued that a 3rd battery replacement would be needed in year 24 to stay in line with an 8-year replacement cycle. However, this was not done since it was judged unlikely that 1 year before the end of the project the battery would be exchanged. Moreover, it can be assumed that the battery technology in 16 year when the battery is replaced for the second time is so advanced that replacement intervals can be reduced further.

Scenarios	Specific Yield	Payback	NPV (RUB)
Kalingrad	**1.066**	**15,84**	**5.471.311**

Figure 44 Project Cash Flows - Captive PV with storage

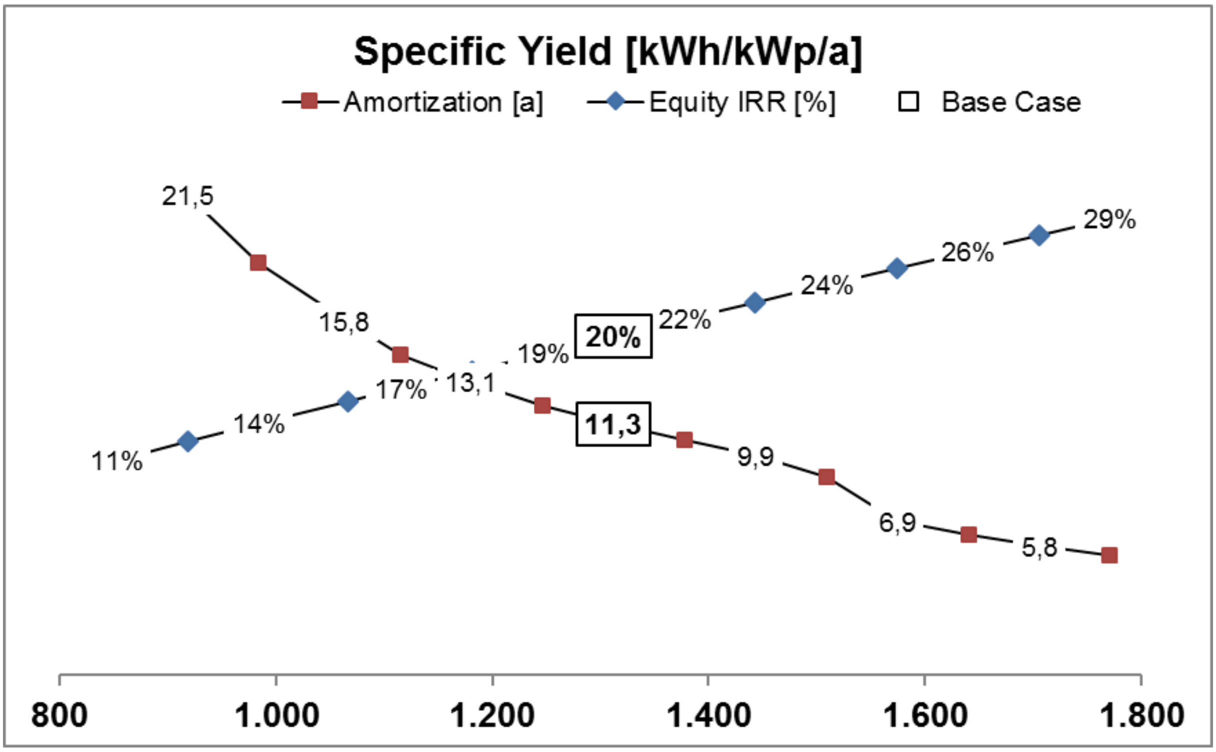


Source: eclareon, 2019

Sensitivity of results for this PV Business Case

The following figures show how the two key economic performance indicators for the investment, payback period (amortization) and return on equity (equity IRR) change when certain assumptions about the investment framework conditions are altered.

Figure 45 Specific Yield Sensitivity - Captive PV with storage

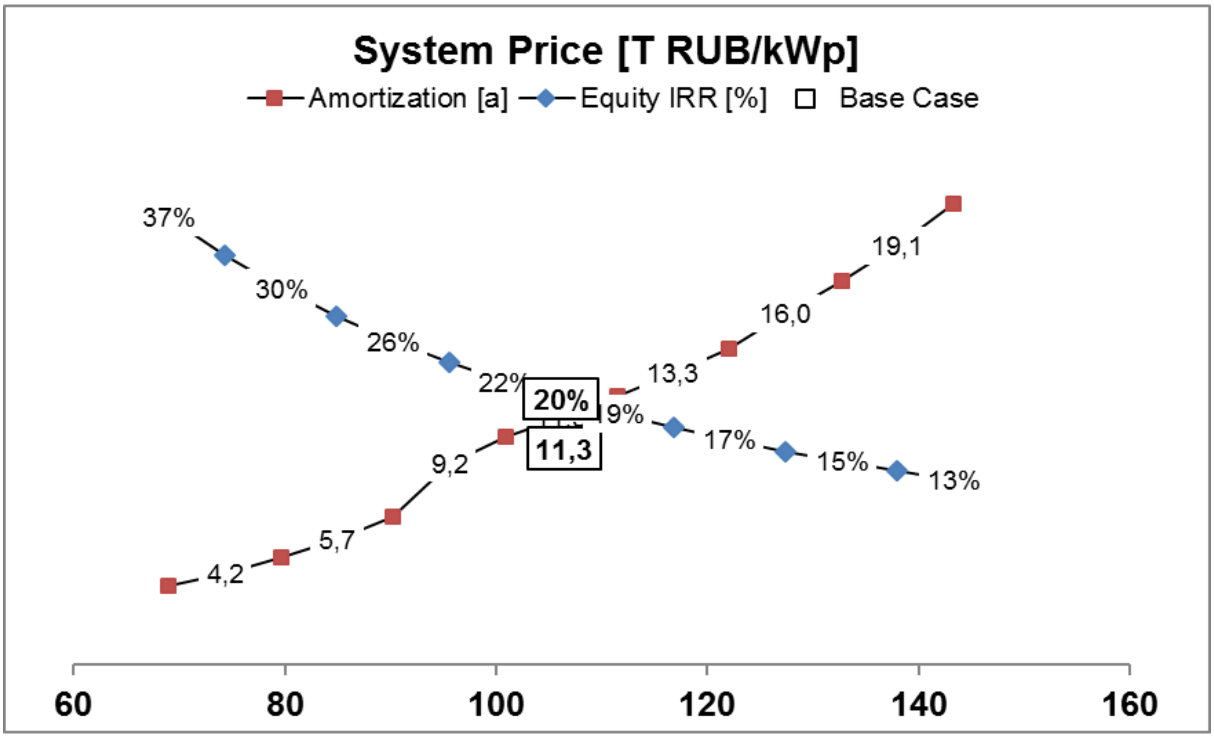


Source: eclareon, 2019

As before, looking at the results for an identical system in Kaliningrad it can be acknowledged that a PV diesel hybrid installation with lead acid storage would also be paid back in less sunnier regions, albeit this period would be longer at 15.84 years.

Going back to using the more favorable solar irradiation at Krasnodar Krai, the following figures show the influence of changing other key input parameters on the equity IRR and the payback period:

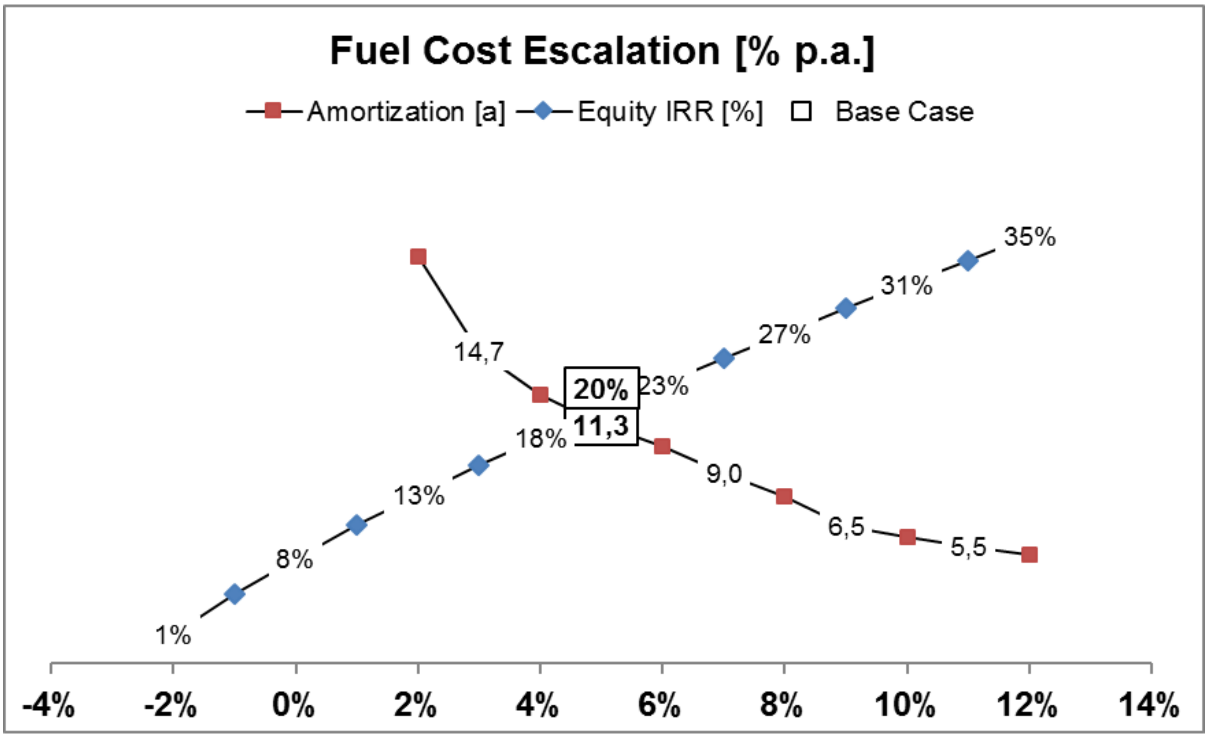
Figure 46 System Price Sensitivity - Captive PV with storage



Source: eclareon, 2019

The yield and the system price have a strong impact on the profitability of a project.

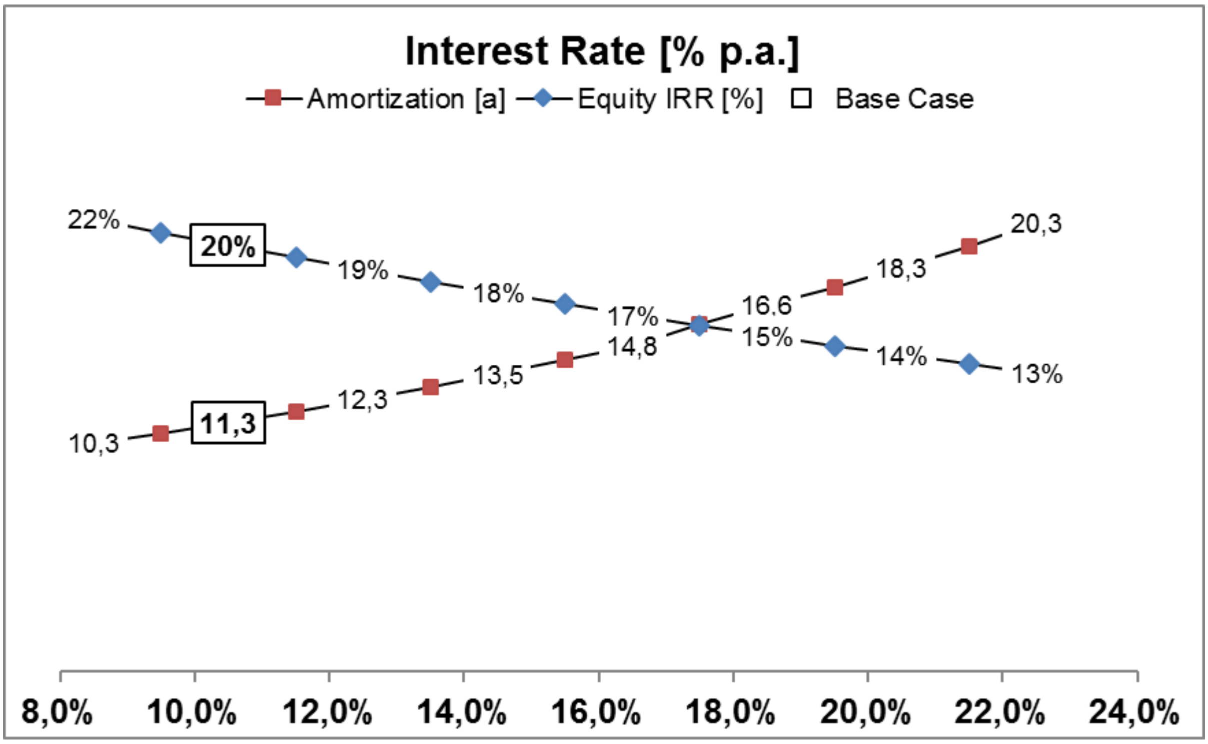
Figure 47 Fuel Cost Escalation Sensitivity - Captive PV with storage



Source: eclareon, 2019

The rate at which the fuel costs are escalated over the project period has a strong impact on the profitability of the project.

Figure 48 Interest Rate Sensitivity - Captive PV with storage



Source: eclareon, 2019

5.4 Residential PV systems

A grid connected residential solar PV system combines the power output of PV arrays with a grid connection. As of today, the legislation in Russia to allow private households to connect their PV installation to the grid has not been finally enacted (microgeneration law see previous sections on this topic). It is expected that the law will finally be passed by the end of 2019 so that grid connected residential systems could appear in 2020.

Implementation details on the law are not yet known but **grid connection will most likely be implemented as a net metering model that would allow owners of private PV systems to combine their self-consumption with net metering credits that are created when a bi-directional electricity meter turn backwards when surplus electricity is fed into the grid.**

Such net metering credits could lead to savings on the electricity bill but there may be a limitation of how many kWh can be used / month/ year etc. to reduce the electricity purchased from the grid at retail market prices. As a consequence, there may be the possibility to sell excess electricity fed into the grid. Today, it is reported that the prices for selling excess electricity would be wholesale electricity prices which fluctuate around 1RUB/kWh (1 €ct/kWh) today. If this scheme is confirmed by and large, excess electricity sales would be limited because savings of (higher) retail electricity prices would be more attractive.

Profitability Analysis (Inputs, Outputs, Scenarios, Sensitivities)

A profitability analysis for a residential PV system based on a net metering scheme is presented below.

Figure 49 Project Overview – Residential PV

PV Project			
PV System Size		kWp	15,00
Specific System Cost		RUB/kWp	100.000
Investment Subsidy		%	-
Total System Cost		RUB	1.500.000
Fixed Operation Costs		RUB p.a.	15.000
Variable Operation Costs		RUB/kWh	-
Additional CapEx (e.g. Batterie)		RUB	-
PV Generation			
Specific Yield		kWh/qm/a	1600
Performance Factor		%	82%
Specific System Performance		kWh/kWp/a	1.312
Degradation		% p.a.	0,70%
Investment			
Project Duration		Years	25
Equity		RUB	1.200.000
Debt (Gearing)	-	RUB	-
Loan Tenor		Years	10
Interest Rate		%	11,3%
Discount Rate		%	10,0%

PV Business Model				
Category		**Share**	**Unit**	**Price**
Feed-in Tariff		-	RUB/kWh	-
Self-consumption		-	RUB/kWh	-
	Fees		RUB/kWh	-
Net-metering		100%	RUB/kWh	5,15
	Fees		RUB/kWh	-
	Excess Electricty		RUB/kWh	1,00
PPA Tariff		-	RUB/kWh	-
	Fees		RUB/kWh	-

Results		
Net-Present Value	RUB	189.084
Project IRR	%	11,48%
Equity IRR	%	11,48%
Payback Period	Years	20,39
LCOE* (w/o subsidy)	RUB/kWh	8,42
LCOE (w subsidy)	RUB/kWh	8,42
Electricity Price Escalation	% p.a.	7,00%

* LCOE: Levelized Cost of Electricity

Source: eclareon, 2019

About the assumptions for this PV Business Case

As in the previous cases, the solar irradiation for Krasnodar Krai was applied in the base case. It was assumed that **a residential household under the microgeneration law will become a prosumer who has three options** regarding what he can do with his generated electrcity under a net metering scheme:

1. Direct (self) consumption
2. Collecting net metering credits to reduce his electrcity bill and
3. Sell exces electricty to the grid

Options 1 and 2 were both evaluated equally with a rather high residential tariff of 5.15 RUB/kWh (retail market price) that can be found in Krasnodar Krai. The annual increase of electrcity prices is set at 7%. Excess electrcity could only be sold at the wholesale market price which is evaluated at 1 RUB/kWh. Under these assumptions, it was calculated that direct consumption and net metering credits will be as high as possible (in the model account for 95% of generated eelctrcity) and sales of excess electricity only account for 5%.

The assumptions regarding the financing conditions asume that these installations attract rather wealthy individuals who can afford the investment and will buy the system based on their own funds alone. As mentionned before the average disposable income of Russian households is less than 50% of the household income in Germany which means that many households will not be able to afford the upfront investment and, given the rather low economic returns and long payback time due to low grid electricity prices it is not likely that banks will finance such installations for low-income households.

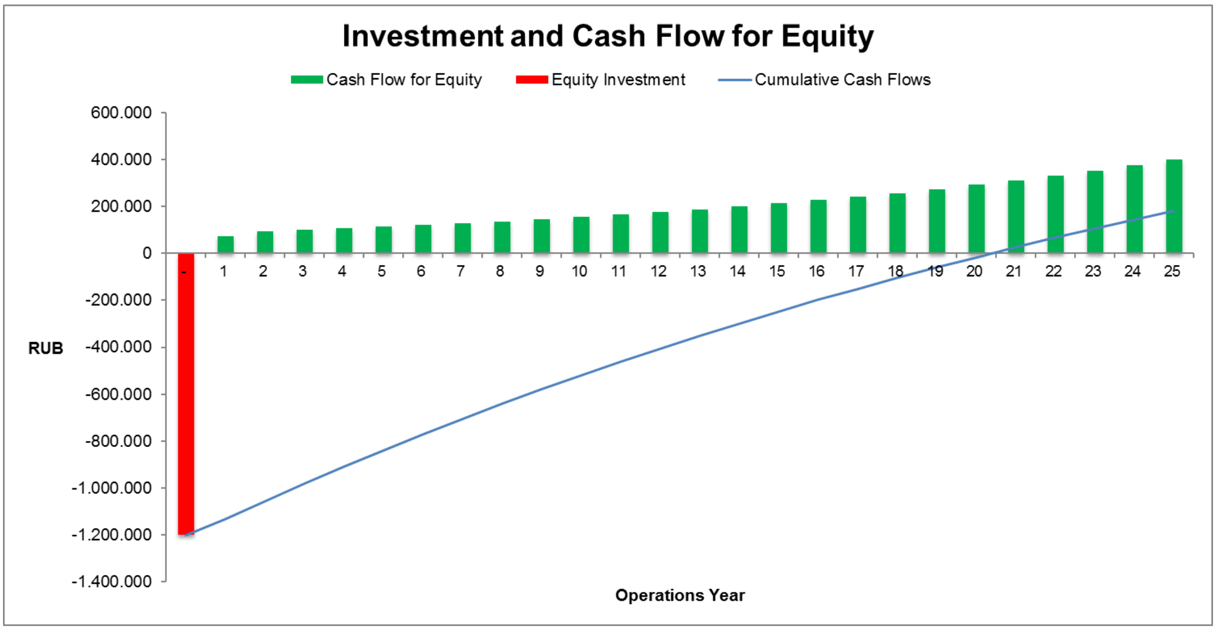
Still, based on some of the pricing information received in Krasnodar, the system costs may in fact be lower than the 100,000 RUB/kWp used in the base case calaculation which would positively impact the IRR and shorten the payback period. This effect is shwon in the sensitivity analysis pertaining to system prices.

The lifetime of the system is set to 25 years and is based on the lifetime of the PV modules. Again, the solar radiation is set to 1,600 kWh / m^2 / a.

Financial results for this PV Business Case

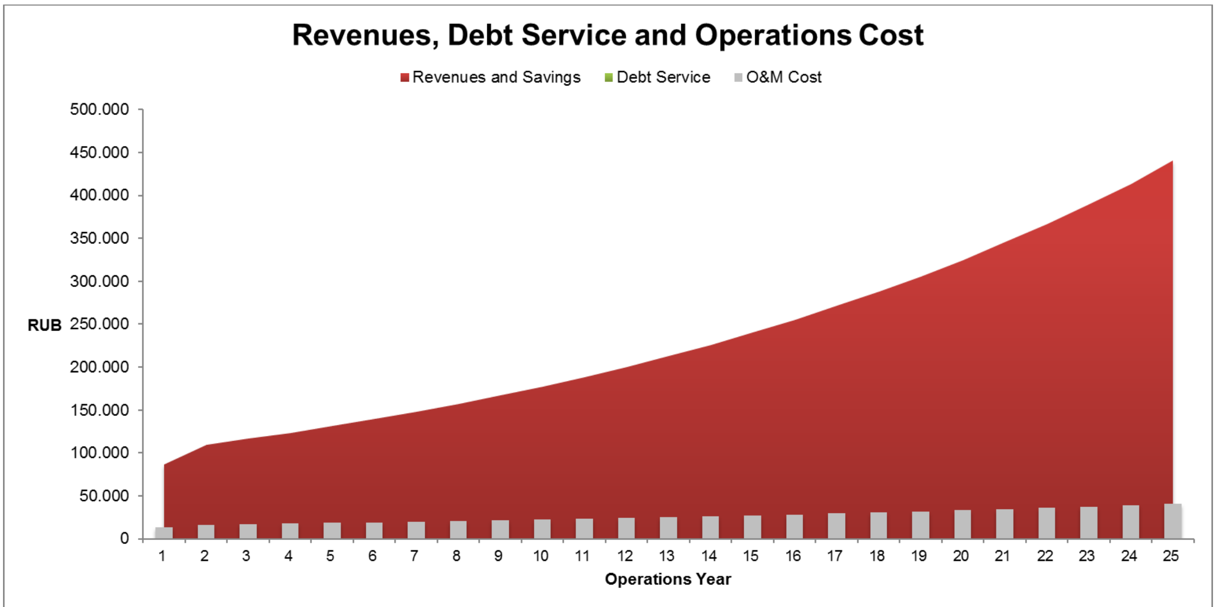
As can be seen from Figure 49, with best possible solar irradiation conditions in Krasnodar Krai the **payback period is 20.39 years** and the **equity IRR** is **11.48%.** The cash flow for the case is as follows:

Figure 50 Equity Cash Flows - Residential PV



Source: eclareon, 2019

Figure 51 Project Cash Flows - Residential PV

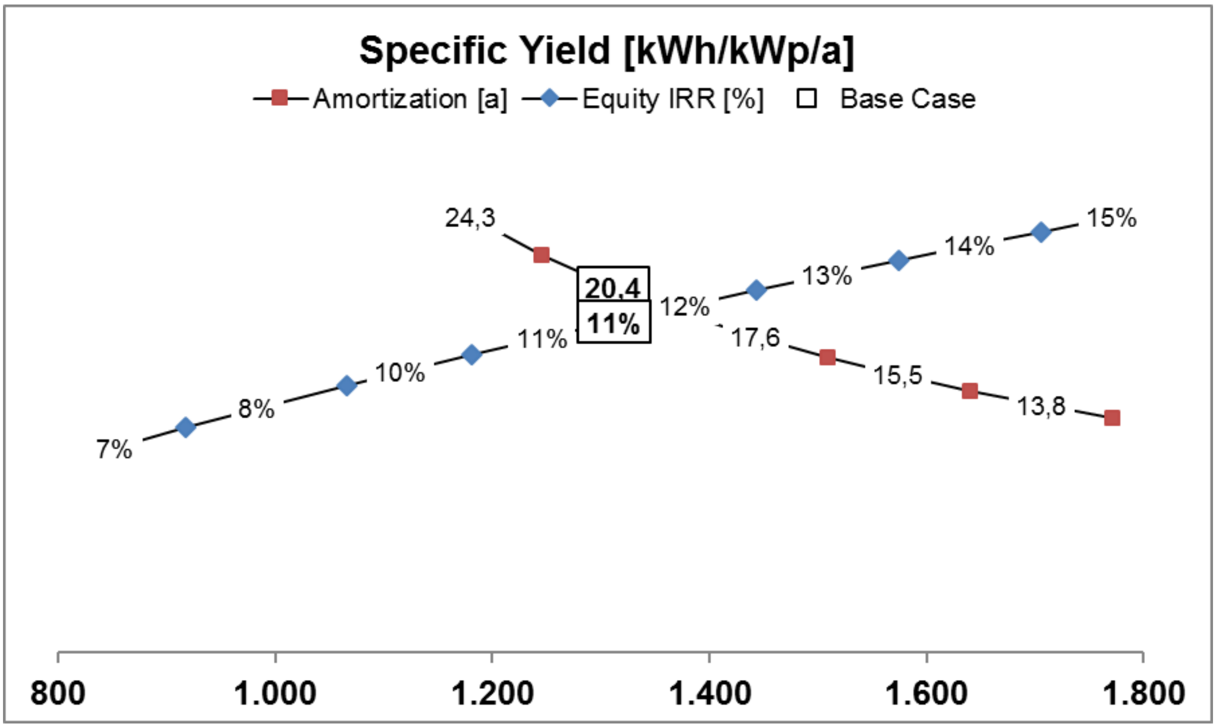


Source: eclareon, 2019

Sensitivity of results for this PV Business Case

Again, the following figures show how the two key economic performance indicators for the investment, payback period (amortization) and return on equity (equity IRR) change when certain assumptions about the investment framework conditions are modified. The figures show which alterations of the individual assumptions influence the profitability of the investment particularly strongly (→ high sensitivity). This needs to be carefully observed when making the investment.

Figure 52 Specific Yield Sensitivity - Residential PV



Source: eclareon, 2019

Looking at Kaliningrad it becomes instinctively clear that installations built in areas with lower solar irradiation will have a hard time to compete with low grid electricity prices.

Under the same conditions, such installations could not be paid back in Kaliningrad over the lifetime of 25 years.

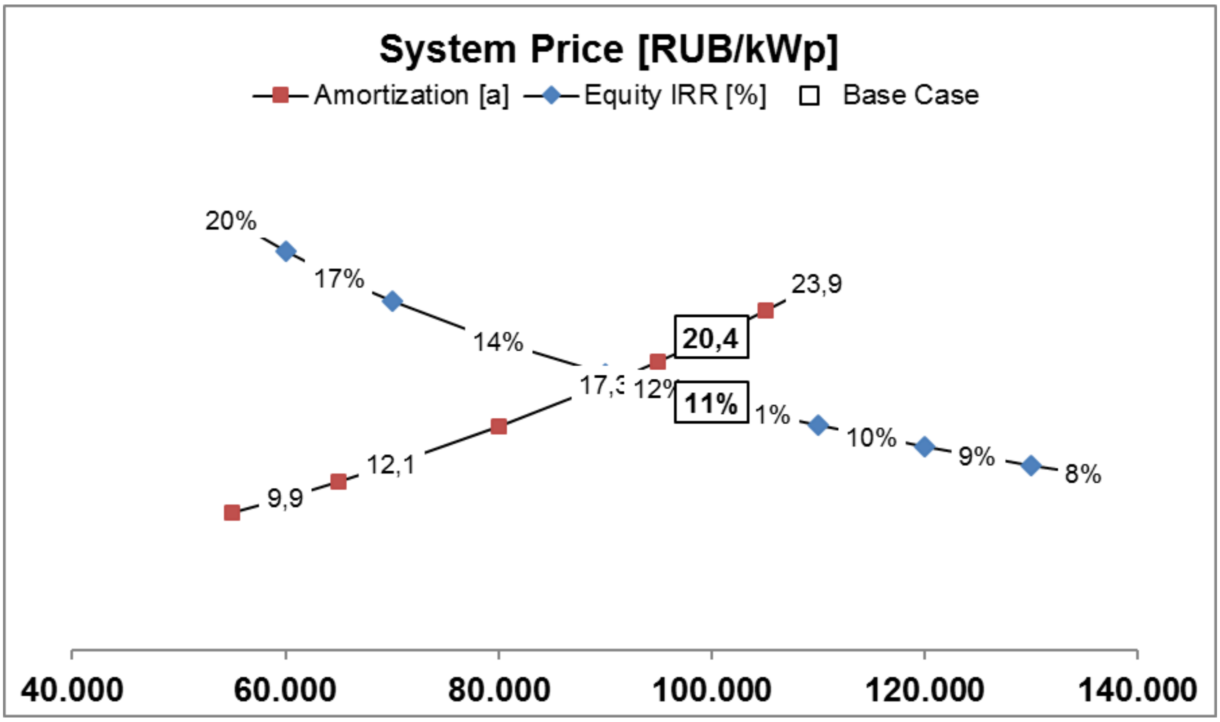
Scenarios	Specific Yield	Payback	NPV (RUB)
Kaliningrad	**1.066**	**#NV**	**(106.291)**

If the system costs were around 20% lower the system payback time would be around 20 years. As mentioned before, prices may be lower than the 100,000 RUB/ kWp assumed in the base case.

Taking again the irradiation levels in Krasnodar, the effects of lower (but also higher) overall system prices can be seen in Figure 53

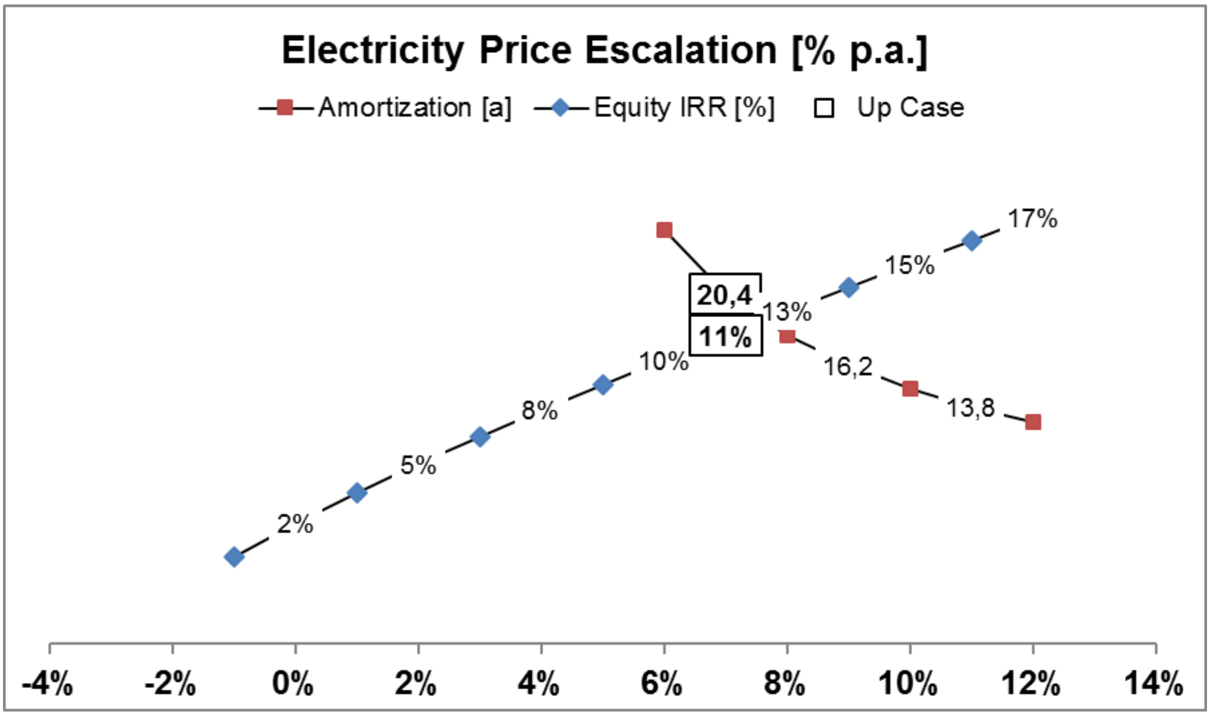
:

Figure 53 System Price Sensitivity - Residential PV



Source: eclareon, 2019

Figure 54 Electricity Cost Escalation Sensitivity - Residential PV



Source: eclareon, 2019

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