# ENABLING PV in Uzbekistan

**Project partners**

eclareon

BSW GERMAN SOLAR ASSOCIATION

**Funded by**

Federal Foreign Office

Published by:

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Funding by: Federal Foreign Office (German: Auswärtiges Amt), abbreviated AA

Project Number (funding code-FKZ): AZ45220010

Editing date of publication: Berlin, 14.12.2022

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We thank AHK Central Asia (AHK Zentralasien – GIC Usbekistan) for the support in creating the study.

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## List of Acronyms

| Acronym | Definition |
|---|---|
| “a” | Per Annum |
| BSW | Bundesverband Solarwirtschaft (German Solar Industry Association) |
| CAPEX | Capital Expenditures |
| CHP | Combined Heat Plant |
| CIS | Commonwealth of Independent States |
| DCF | Discounted Cash Flow Analysis |
| DSCR | Debt Service Coverage Ratio |
| GDP | Gross Domestic Product |
| GW | Gigawatt |
| GWh | Gigawatt hours |
| HPP | Hydropower Plant |
| HV | High Voltage |
| IPP | Independent Power Project |
| IRR | Internal Rate of Return |
| JSC | Joint Stock Company |
| kV | Kilovolt |
| kWp | Kilowatt peak |
| kWh | Kilowatt hours |
| LCOE | Levelized Costs of Electricity |
| LLCR | Loan Life Cycle Coverage Ratio |
| LLP | Limited Liability Partnership |
| LTD | Limited Company |
| $m^2$ | Square Meters |
| $m^3$ | Cubic Meters |
| MW | Megawatt |
| MWh | Megawatt hours |
| NEP | National Power Grids of Uzbekistan |
| NPV | Net Present Value |
| O&M | Operation and Maintenance |
| PES | Grid operator |
| PP | Power Plant |
| PPA | Power Purchase Agreement |
| PV | Photovoltaic |
| RE | Renewable Energy |
| REG | JSC “Regional Electric Grids” |

| Acronym | Definition |
|---|---|
| RES | Renewable Energy Source |
| RESE | Regional Electric Supply Enterprise |
| RFP | Request for Proposals |
| RFQ | Request for Qualification |
| SPP | Solar (PV) Power Plant |
| SSR | Soviet Socialist Republic |
| TPP | Thermal Power Plant |
| TPP JSC | JSC "Thermal Power Plants" |
| UES | United Energy System of Uzbekistan |
| UES CA | United Energy System of Central Asia |
| USD | United States Dollar |
| USSR | Union of Soviet Socialist Republics |
| UZS | Uzbek Soums |

# 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 in the 2000s and 2010s was mainly restricted to developed countries, who decided to support renewable energies in most cases with similar support schemes mainly based on preferential 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 intensely growing international PV markets that the consulting company eclareon and the German Solar Association BSW-Solar have started in 2013 to jointly investigate business models and the business environment for PV in different countries under the name of “ENABLING PV”. The first study was published in 2014 and studies have covered countries such as Tunisia, Jordan, Kazakhstan, Brazil, Argentina, Nigeria, Angola, Iran, Pakistan, Afghanistan and Azerbaijan.

The name of the project itself “ENABLING PV” demonstrates the objective of this report: enabling the growth and development of solar 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 entrepreneurs who have a specific interest in solar energy and are willing to expand their business into new markets.

This report on the potential of the Uzbek PV market was accompanied and informed by activities implemented by eclareon in 2020, 2021 and 2022 in Uzbekistan, including PV installations, workshops and educational projects in the renewable energy sector.

When searching for areas of application where pilot projects could most quickly be installed, the focus was directed to applications for irrigation solutions in agriculture, so-called "solar pumping systems" or "solar powered irrigation systems" (SPIS). This field of application is very promising since there is a large demand for such solutions in Uzbekistan and at the same time medium-sized solar and water companies from Germany have extensive know-how that can be shared with Uzbek companies and experts. As a result of this combination, several pilot projects are currently discussed and developed by German and Uzbek companies as well as by the Uzbek government.

Moreover, a workshop in Uzbekistan was held in the second half of 2020 to present the results of the first edition of this report and to discuss SPIS pilot projects in the country.

Also, an online roundtable was organised in 2021 to make stakeholders discuss concrete business opportunities and the general development of the renewable energy sector. In 2022, concrete discussions targeted a pilot project in the area of solar powered irrigation systems which will enable local farmers to optimise their production and increase their income with the help of clean and sustainable solar energy. One of the main focus areas of this study is to assess the business potential for the application of solar-powered irrigation systems in Uzbekistan.

Berlin, December 7th, 2022

Julian Scheider

Project Manager, “ENABLING PV in Uzbekistan“

# Задачи проекта ENABLING PV

В течение последнего десятилетия, 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 растущего международного рынка фотоэлектрической энергии немецкая солнечная ассоциация BSW-Solar совместно с консалтинговой фирмой eclareon в 2013 году приступили к изучению бизнес-моделей и бизнес-среды для фотоэлектрической промышленности в разных странах под маркой проекта «ENABLING PV». Первое исследование было опубликовано в 2014 году, и, на сегодняшний день, серия исследований охватывает такие страны, как Россия, Казахстан, Тунис, Иордания, Бразилия, Аргентина, Нигерия, Ангола, Иран, Пакистан и Афганистан.

Название «ENABLING PV» демонстрирует намерение этого отчета: способствовать росту и развитию солнечной энергетики по всему миру. Для этого необходимо реализовывать проекты, основой которых является сбор, распространение и обсуждение знаний, специфичных для данной страны. **Отчеты «ENABLING PV» должны стать отправной точкой для тех инвесторов и предпринимателей в области солнечной энергетики, которые заинтересованы в расширении своего бизнеса на новые рынки.**

Данный отчет о потенциале фотоэлектрической энергии в Узбекистане является частью дальнейшей деятельности, осуществляемой компанией eclareon в 2020 и 2021 годах в Узбекистане. В феврале 2020 года консультанты eclareon посетили страну и провели встречи с местными заинтересованными сторонами и организациями, ответственными и заинтересованными в развитии фотоэлектричества в стране.

В процессе поиска пилотных проектов все большее внимание уделялось применению решений для ирригации в сельском хозяйстве, так называемых «солнечных насосных систем» или «солнечная насосная ирригационная система». Причиной тому является огромный спрос на эти решения в Узбекистане, и в то же время средние компании по производству солнечной энергии и воды в Германии обладают большим количеством ноу-хау, которыми они могут поделиться с узбекскими компаниями и специалистами. В результате в настоящее время обсуждается и разрабатывается несколько пилотных проектов при активном участии немецких и узбекских компаний и правительства.

Во второй половине 2020 года был проведен семинар в Узбекистане. Целью семинара было представить результаты данного исследования и обсудить пилотные проекты по «солнечным насосным системам» в стране.

# Executive Summary

After the services sector, Uzbekistan's heavy industry, including mining and hydrocarbon production is the 2nd largest contributor to the country's GDP. Also, the agricultural sector plays an important role in the country: most of the labor force works in this sector and Uzbekistan is one of the main exporters of agricultural products to neighboring CIS countries.

Until recently, the energy sector in the country was completely controlled by the state and state-owned companies. It was only in early 2020 that small changes were introduced and the process of reforming the sector started. Today, foreign companies are present only in the solar sector, while the traditional power generation, distribution and sales sector is still monopolized, despite numerous declarations by government officials to transition to a liberalized market model. The energy sector in Uzbekistan relies mainly on locally produced natural gas. About 88% of the country's thermal power plants are gas-fired, about 4% are coal-fired, and about 7.5% of the installed capacity is hydropower. Uzbekistan suffers from a serious energy deficit due to a growing demand for energy and a large number of settlements (about 1,500, or about 20-30% of the population of the country) and agricultural regions which are not connected to the electricity grid. Diesel power generation is still widespread in such regions.

Despite the favorable conditions for the development of solar generation in the country, the development of photovoltaic power in particular and RES in general has only started. To date, large tenders for solar power plants with a capacity of 100 MW or more are being held and a number of investment agreements on the construction of large PV parks have already been concluded. However, as of early 2022, only two projects with a total capacity of 200 MW have been finalized. The remaining projects are under construction or at earlier development stages. The private renewable energy sector only became active at the end of 2022, when the Government created an online platform for the purchase of small PV systems for which private and legal entities (SMEs) could benefit from state subsidies.

In order to develop the local PV market, questions regarding use cases, profitability and potential customer groups need to be addressed by identifying business models that can work successfully in Uzbekistan today. Standardization of such business models is important but also difficult in young markets in general. Also in Uzbekistan, the process of forming effective and more standardized business models will take some time.

This ENABLING PV report presents different business models, and each of them demonstrates how solar power can be used in different market segments and what system size/ capacity is typically associated with such business models.

The main goal of the study is to provide practical information on the current state of the photovoltaic market in the Republic of Uzbekistan. This information shall then help the German and Uzbek solar and general renewable energy industry, as well as interested energy industry companies, regional economic development institutes and scientific institutions in both countries to further develop the solar energy market in the country. To achieve this, legal, regulatory and market conditions for the development of photovoltaic systems in Uzbekistan are presented and cost-benefit analysis from the investor's point of view are described for three different PV business models in Uzbekistan.

The economic analysis of the business models in this study has shown that all segments of the PV market have high economic potential, evidenced by parameters such as a low payback period and a high internal rate of return. Yet the attractiveness of these three types of installations varies and depends on many factors that may go beyond purely economic considerations.

The usage of solar energy with battery storage by private consumers in remote areas has yielded the most promising design results in terms of system profitability. Mainly due to the savings on diesel fuel and a high insolation, it is possible to pay back the initial PV investment in a short period and to increase the access to electricity in remote Uzbek areas at the same time.

Large grid-connected PV power plants and their economic attractiveness in the current conditions in Uzbekistan can be assessed based on the currently existing public support schemes for such projects and the declared tariffs for the purchase of solar energy from such power plants. However, the access to this information is limited and other considerations going beyond the price per kWh may play a role for the realization of such industrial PV projects as well. At the moment, the existing investment projects claim a rather low cost for 1 kWh EUR (on average 0.023 EUR) generated by such power plants, negatively impacting the period of return on investment for such projects.

# Qisqacha xulosa (Executive Summary)

O'zbekiston Respublikasi og'ir sanoatning, shu jumladan foydali qazilmalarni (shu jumladan uglevodorodlarni) qazib chiqarishni YaIM tarkibidagi ulkan o'rni bo'lgan mamlakatdir. Shu bilan birga, qishloq xo'jaligi muhim rol o'ynaydi, o'z aholining ko'p qismini ish bilan ta'minlaydi va O'zbekistonni qo'shni MDH davlatlariga qishloq xo'jaligi mahsulotlarini eksport qiluvchi mamlakatlardan biriga aylantiradi.

Yaqin vaqtgacha mamlakat energetika sohasi to'liq davlat va davlat kompaniyalari nazorati ostida edi va faqat 2020 yilda o'zgarishlar va sohani isloh qilish jarayoni boshlandi. O'zbekiston energetika sektori asosan mahalliy tabiiy gazga asoslangan bo'lib, mamlakatimiz issiqlik elektr stantsiyalarining yarmidan ko'pi gaz bilan, 4% ga yaqini ko'mir bilan, o'rnatilgan quvvatning 7.5% gidroelektr stantsiyalarida ishlaydi.

Shu bilan birga, O'zbekistonda energiyaga bo'lgan talabning ortishi bilan bir qatorda jiddiy energiya tanqisligi, shuningdek ko'plab aholi punktlari (1500 ga yaqin yoki mamlakat aholisining taxminan 20-30%) va qishloq xo'jaligi mintaqalari mavjud. elektr tarmoqlariga ulanmagan. Bunday mintaqalarda dizel quvvati hali ham keng tarqalgan.

Mamlakatda quyosh energiyasini ishlab chiqarishni rivojlantirish uchun qulay sharoitlarga qaramay, fotoelektrik energetika va umuman qayta tiklanadigan energetika sohasi O'zbekistonda rivojlanishining boshida turibdi. Bugungi kunda mamlakatda 100 MVt va undan ortiq quvvatga ega quyosh elektr stantsiyalari uchun katta tanlovlar o'tkazilmoqda, shuningdek, yirik fotoelektrik parklarni qurish bo'yicha bir qator investitsiya shartnomalari o'tkazilmoqda. Ammo shu kungacha ushbu loyihalar hali amalga oshirilmagan. Shu munosabat bilan, hozirgi paytda O'zbekistonda quyosh energiyasi qaysi sohalardan samarali foydalanishi mumkin, u qayerda foydali bo'ladi va undan kim foyda ko'radi degan savol tug'iladi.

Bu savolga javob berish uchun bugungi O'zbekistonda muvaffaqiyatli ishlashi mumkin bo'lgan biznes modellarini aniqlash juda muhimdir. Bunday yechimlarni standartlashtirish odatda yosh bozorlarga taalluqli emas va O'zbekiston misolida samarali va yanada standartlashtirilgan biznes modellarini ishlab chiqish uchun biroz vaqt kerak bo'ladi.

Ushbu ENABLING PV hisoboti turli xil biznes modellarini taqdim etadi, ularning har biri quyosh energiyasini turli xil bozor segmentlarida qanday ishlatish va qanday quvvat tizimlarini o'rnatish mumkinligi haqida ma'lumot beradi.

Aynan shu nuqtai nazardan, Germaniyaning Quyosh sanoati assotsiatsiyasi (BSW-Solar) ko'magi bilan qayta tiklanadigan energiya va energiya samaradorligini oshirishga ixtisoslashgan eclareon GmbH xalqaro konsalting kompaniyasi jarayonlarni tahlil qildi va o'zbek fotoelektr sektorida yuzaga keladigan va mavjud bo'lgan to'siqlar. Ushbu tadqiqotda umuman O'zbekiston Respublikasida elektr energiyasi bozoridagi vaziyat to'g'risidagi ma'lumotlar, shuningdek, mamlakat uchun aniqlangan potentsial jozibador ish holatlari tahlili mavjud.

Loyihaning asosiy maqsadi - O'zbekiston Respublikasida fotoelektr bozorining hozirgi holati to'g'risida amaliy ma'lumot berish. Ushbu hisobotda keltirilgan ma'lumotlar Germaniya va O'zbekistondagi quyosh va umumiy qayta tiklanadigan energetikaga, shuningdek, manfaatdor energetika kompaniyalari, mintaqaviy iqtisodiy rivojlanish institutlari va ikki mamlakatning ilmiy muassasalariga mamlakatda quyosh energiyasi bozorini yanada rivojlantirishda yordam beradi. Ushbu maqsadga erishish uchun O'zbekiston Respublikasida fotoelektrik tizimlarini rivojlantirishning huquqiy, me'yoriy va bozor sharoitlari hamda fotoelektrik tizimlarning uch xil biznes modellari uchun investorlar nuqtai nazaridan xarajatlar va foyda tahlili keltirilgan.

O'zbekiston Respublikasida fotoelektr energiya bozorining barcha segmentlari fotoelektr loyihasini qoplash muddatlari va ichki rentabellik darajasi tufayli ijobiy natijalarga erishish imkoniyatiga ega, ammo ushbu uch turdagi qurilmalarning jozibadorligi o'zgarib turadi va faqat iqtisodiy jihatlar doirasidan tashqariga chiqishi mumkin bo'lgan ko'plab omillarga bog'liq.

Tizimga energiya zaxirasi (akkumulyator) qo'shilishi bilan chekka hududlardagi xususiy iste'molchilar uchun quyosh energiyasidan foydalanish dizayndagi eng istiqbolli natijalarni berdi. Dizel yoqilg'isidagi mablag'larni tejash va yaxshi insolatsiya darajasi tufayli bunday

loyihalarni tezda qoplashga va O'zbekistondagi hududlarni elektrlashtirish darajasini sezilarli darajada oshirishga imkon beradi.

O'zbekistondagi yirik elektr tarmoqlari elektr stansiyalari va ularning zamonaviy jozibadorligini iqtisodiy jihatdan jozibadorligini hali ham nazariy jihatdan va davlat tomonidan hozirda mavjud loyihalarni qo'llab-quvvatlash sxemalari va shu kabi quyosh elektr stansiyalardan quyosh energiyasini sotib olish uchun e'lon qilingan tariflar asosida baholash mumkin. Ayni paytda, mavjud investitsiya loyihalari bunday elektrostantsiyalar tomonidan ishlab chiqarilgan 1 kVt / soatiga ancha past narxini e'lon qildi va bu ham ushbu loyihalar uchun sarmoyalar rentabelligiga ta'sir qiladi.

# 1. Introduction to the power sector of Uzbekistan

## 1.1 Common information about the country

The Republic of Uzbekistan is located in Central Asia. The country with its 33 million inhabitants became independent in 1991 after the fall of the Soviet Union and is today a member of the Commonwealth of Independent States (CIS), a regional intergovernmental organization that was formed following the dissolution of the USSR [1]. **Uzbekistan's major economic activities are industrial production (including mining activities) (26.7% of GDP) and services (41.5% of GDP), followed by agriculture, forestry and fishing (25.1% of GDP) and construction (6.7% of GDP).** The country's economy has steadily grown in the past decade. For instance, until 2021 the GDP quintupled compared to 2005 and reached 69.24 billion USD [3]. Uzbekistan's GDP has increased continuously during the presidency of Islam Karimov. After Shavkat Mirziyoyev became President of Uzbekistan, the country undertook extensive economic reforms which had a short-term negative impact on GDP growth. However, after 2018 the economy re-started to grow as shown by an increasing GDP.

Uzbekistan is a member state of the CIS but foreign trade relations are not limited to neighbouring countries (Kazakhstan, Kyrgyzstan, Russia, Belarus) but also include other regions. In 2022, Uzbekistan's foreign trade volume totalled USD 50 billion. That's an increase of 18.7% over 2021. The most important trading partners in 2022 were Russia (18.6%) and China (17.8%). Kazakhstan accounted for 9.2% of the trade volume, Turkey for 6.4%, the Republic of Korea for 4.7% and Germany for 2.3%.

With regards to international policies, Uzbekistan tries to remain neutral and focuses on the development of its economy through international trade. Since the start of Russia's military aggression in Ukraine in 2022, Uzbekistan has refrained from making official statements on the situation and has increased its foreign trade cooperation with both Western countries and Russia. For example, in September 2022, Shavkat Mirziyoyev and Vladimir Putin signed a declaration on a comprehensive strategic partnership between the two countries, and in late November 2022 the Uzbek president signed a 6 billion EUR trade agreement with French President Emmanuel Macron.

**Natural resources have played a key role in the economic development of Uzbekistan**. **In 2021 Uzbekistan was among the world's 16 major natural gas producers, and the 19th largest producer of natural gas in the world in terms of proven reserves** [4]. In terms of explored oil reserves, Uzbekistan ranks 43$^{rd}$ and its share of total primary energy supply in 2019 stood at 5.5%. In terms of oil production, Uzbekistan ranks 48$^{th}$ in the world, producing about 2.7 million tonnes of oil annually.

**Another important economic sector of Uzbekistan is agriculture, which accounted for 25% of the country's GDP in 2021.** The domestic agricultural sector formed during Soviet times was restructured in the late 1990s, and the large state holdings typical of post-Soviet countries have disappeared and been replaced by more than 80,000 private companies and farms producing more than 90% of the country's total agricultural output. This output includes a wide range of different products from vegetables and fruits to dairy products and cotton [6][7]. The largest importer of agricultural products from Uzbekistan is Russia but official data on Uzbek trade volumes need to be interpreted with care: 67% of agricultural products are exported to Kazakhstan and only 17% to Russia but these statistics do not include re-exports of a majority of the goods from Kazakhstan to Russia [8][9]. Such re-exports take place for geographical and logistic reasons. After international sanctions were imposed on Russia, Uzbekistan's foreign trade with Russia increased by 20% in 2022, driven by Russia's need to substitute the products and services previously imported from Western countries [80].

**Figure 1 Uzbekistan on the world map**

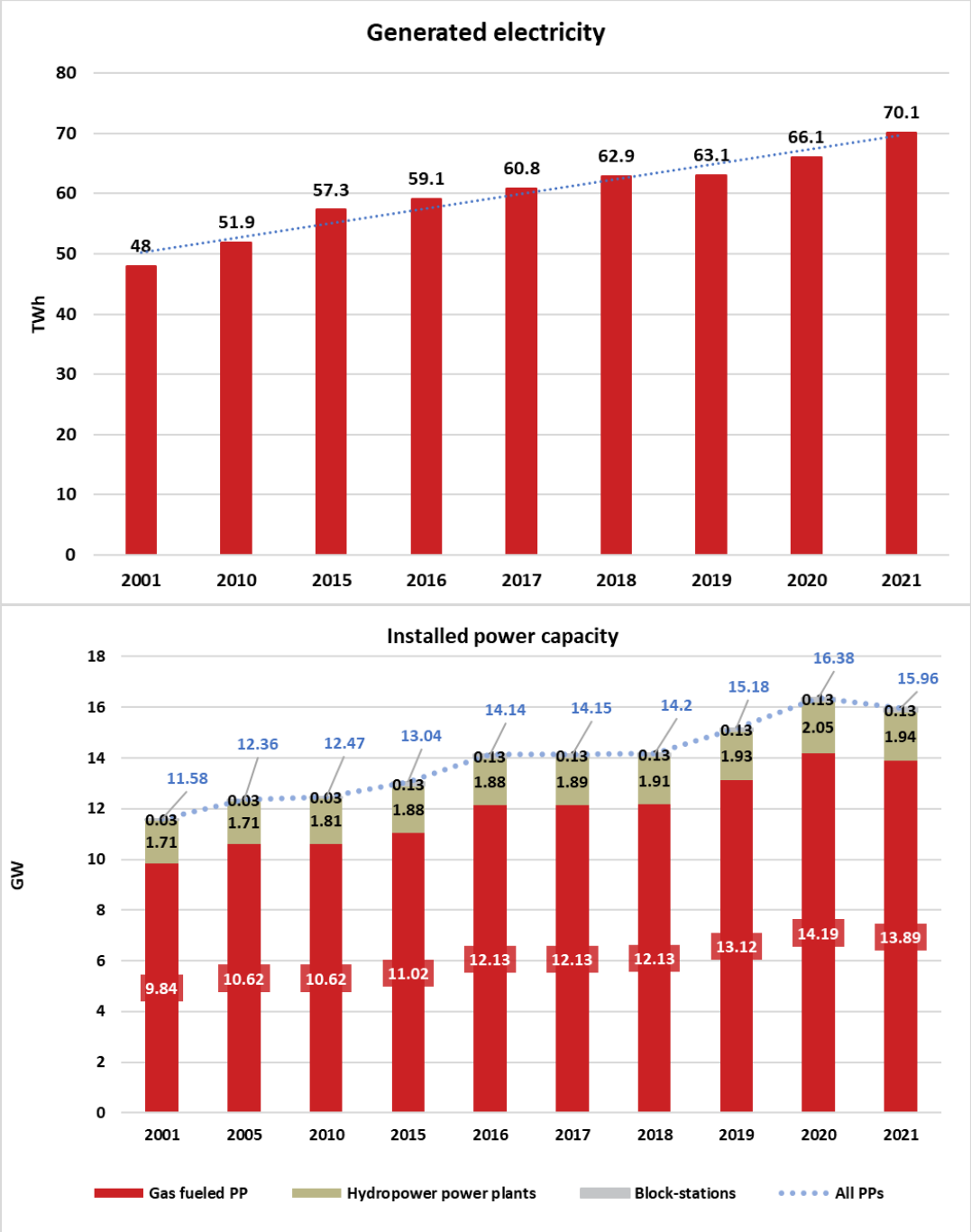
**Source: eclareon 2022, map generated by Pixel Map Generator, amCharts**

## 1.2 Electricity generation, consumption and demand

Uzbekistan's energy sector is mainly characterized by the exploitation and subsequent use of natural gas. In 2021 the country produced about 51 billion $m^3$ of natural gas, of which 15 billion $m^3$ (25%) were exported [25]. Despite the large amounts of gas exploited, there are occasional shortages in the internal market of Uzbekistan which leads to the occasional suspension of gas exports. For instance, in late 2022 and early 2023, Uzbek consumers across the country faced disruptions in gas, electricity and heat supply due to very low temperatures [80]. State monopolization, lack of private investment, corruption, and lack of proper gas sector optimization measures are key to the problem of the national gas industry. However, the Government of Uzbekistan plans to discontinue natural gas exports by 2025 for the benefit of gas-deficient regions and to increase overall power generation by 2030. At the end of January 2023, Uzbekistan signed a road map for Russian gas imports to Uzbekistan but does not intend to join the gas union proposed by Moscow with Russia and Kazakhstan [81].

Thermal, mainly gas-powered power plants, have been the main source of electricity in Uzbekistan. As of 2022, 90% of Uzbekistan's generating capacity was generated by such power plants. **According to Uzbekistan's Prime Minister Abdulla Aripov, electricity production is to nearly double by 2030 and amount to 120 thousand GWh, compared to 66.3 thousand GWh in 2020 [24][26][24].** To implement this, the "Concept of Providing Uzbekistan with Electricity for 2020-2030" was adopted by the Government of Uzbekistan with assistance of the World Bank and the Asian Development Bank. This concept emphasizes the modernization of power plants and the development of the RES sector [25]. The government's planned capacity increase is motivated by the need to provide electricity to Uzbekistan's growing population and developing economy. Most of the thermal power plants have an efficiency factor of 25% which is low compared to an efficiency factor of around 60% of modern combined-cycle units. The long service life of thermal power plants of more than 25 years and obsolete technology which leads to a very high fuel consumption are among the main reasons for the inefficiency of the country's electricity sector.

**Figure 2 Total installed capacity of power generation facilities by type of power plants and total annual power generation in Uzbekistan for the past 20 years**




**Source: eclareon 2022 based on: BP Statistical Review of World Energy 2000 – 2022 and data from Ministry of Energy of the Republic of Uzbekistan [52]**

Within the last 20 years, total generation capacity in Uzbekistan has increased by more than 40%. Despite a relatively low per capita electricity consumption of **2.4 MWh/year** in **2020 electricity consumption in Uzbekistan has been continuously growing since the fall of the Soviet Union.** In the same year electricity consumption per person in neighboring Kazakhstan was 5.4 MWh, in Russia 7.3 MWh and about 6.67 MWh in Germany [27]. In 2020, Uzbek electricity consumption amounted to 69 TWh**.** As electricity consumption continues to increase, the pressure to increase energy generation increases as well.

## 1.3 Electric power sector of Uzbekistan

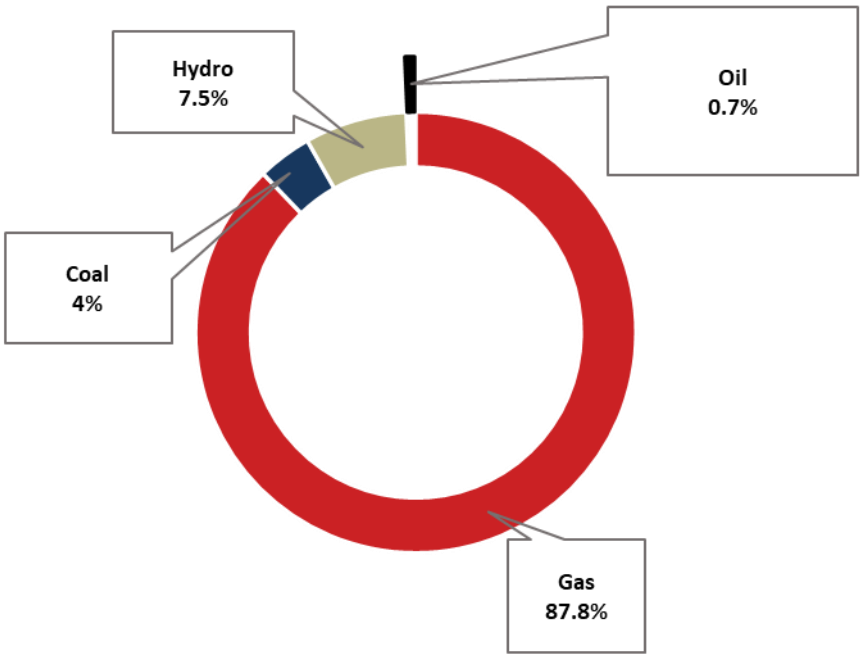
The electric power sector of Uzbekistan has its origins in Uzbek SSR and the subsequent merger of the energy sectors into the **United Energy System of Uzbekistan (UES)**. The UES is today part of the United Energy System of Central Asia (UES CA).

The electrification of Uzbek regions is and has been a priority of the government already since Soviet times. Electrification was of utmost importance for the development of agriculture, an important economic sector [29]. Today, Uzbekistan has enough generation capacity to cover the country's energy needs in spite of increasing demand for electricity. **The UES unites all electricity generating facilities of the country and, as of 2021, the installed capacity of all power plants in UES amounts to around 16 GW. However, only about 13 GW are operational.**

**There are 52 operational power plants in Uzbekistan** that use various energy sources, including natural gas, coal and hydro power. Taking into account that equipment of many electric thermal power plants in Uzbekistan has been in use since Soviet times, the obsolescence of the equipment is high. **On average, 62% of thermal power plants are considered obsolete since they have been operational for more than their originally intended lifespan of 30 years** [37]. It should be noted that the digitization of the oil and gas industry in Uzbekistan is only in its early stage of development. Therefore, data on the energy structure is either scarce or only published for the very first time and needs hence to be interpreted with care.

Uzbekistan’s power generation capacity is planned to be increased as well with the help of new nuclear power capacities. The Russian corporation “Rosatom” plans to build a nuclear power plant (NPP) with an installed capacity of 2.4 GW in Jizzak Oblast by 2028. After the NPP is launched, it will account for approx. 15% of the total installed power capacity of the country. This new power plant is supposed to use domestically-mined uranium. Currently, the country ranks 7$^{th}$ among the largest uranium extractors in the world and 10$^{th}$-largest in terms of uranium reserves. Notably, France is also interested in Uzbekistan's nuclear sector and signed a memorandum in the autumn of 2022.

**Figure 3 Proportion of different energy sources in total installed capacity in Uzbekistan in 2021**




**Source: eclareon 2022 on materials: International Energy Agency – Energy policy review Uzbekistan 2022 [83]**

In addition to the capacities shown-above, Uzbekistan makes use of so-called "block stations", small power plants, owned by private consumers/entities and connected to the UES. In 2019

such power plants produced around 1% of the total electricity in the country or 603 GWh [53]. Block stations can include power plants of any type (PV, hydro power, bio gas, natural gas etc.). Energy is fed into the UES on the basis of annual contracts concluded with the organization of commercial infrastructure of the energy sector (see 1.4.2 for more details on the commercial infrastructure in Uzbekistan) [54]. The largest block-stations are Uz-Kor Gas Chemical (96.8 MW) and Almalyk CHP (36 MW), working for the internal needs of major industries - the Ustyurt Gas Chemical Complex and the Almalyk Mining and Metallurgical Plant respectively.

**Since 2001, the state-owned company "Uzbekenergo" is the largest utility of the country. The company was established by the Ministry of Energy and, as of 2020, owns 85.7% of Uzbekistan's installed power generation capacity which amounted to 12.13 GW.** In 2017, all hydropower plants (HPPs) of the Republic of Uzbekistan were transferred from "Uzbekenergo" and "Uzsuvenergo" to the newly formed JSC "Uzbekhydroenergo", which in turn in 2021 had 1.94 GW of installed capacity, or 12.2% of the total installed capacity in the country. **Thus, in 2019, 99% of the energy sector and infrastructure in Uzbekistan was publicly owned and had a monopolistic structure.** In the same year, enterprises belonging to **"Uzbekenergo" generated 56,300 GWh which** represents around 90% of the country's total electricity production of 62,800 GWh [36]. The remaining 10%, not counting the above-mentioned private block stations, were generated by Uzbekhydroenergo's power plants.

Outside the RES sector, there is only one example of electricity generation by a private company in Uzbekistan. In 2020 management rights of two thermal power plants in the city of Angren, which is located in the Tashkent region near the capital city, were transferred to a foreign company, the Kazakh private company LLP "Mining Works". By January 2023, one of these two power plants had already been re-integrated into the public sector due to large incurred losses.

**The still small RES sector could become an example of a competitive private market.** As of January 2023, 200 MW of solar power were built in Uzbekistan following public tenders. The two installations are owned by French and Emirati companies. Given that renewable energy is currently at a very early development stage in Uzbekistan (see section 2.1 for details), hydro generation accounts by far for the largest share of RES in the energy sector, representing around 7.5% of the installed capacity of power plants in Uzbekistan.

There is no official data on electricity grid losses. However, according to World Bank estimates**, the average annual losses in electric power transmission and distribution amount to around 20%. Around 25% of these grid losses occur in the high voltage (HV) grid and 75% in the distribution grids [10].** In order to minimize those grid losses, the government set-up the "Modernization and Reconstruction of Main Power Substations" -project. Its aim is to improve stability, efficiency and reliability of the grid but after many years of modernization there are still regions that are poorly electrified and consumers in these regions often face power outages caused by accidents and repair work.

## 1.4 Electricity market stakeholders

Uzbekistan's electricity market was for many years a public monopoly and **"Uzbekenergo" was a vertically integrated organization, which included all main stages from electricity production to its delivery to end users [42].**

A first step towards a competitive market was to place HPPs under the management of "Uzbekhydroenergo" and later completely reorganize "Uzbekenergo". The reorganization of "Uzhydroenergo" created three new actors in the energy sector: JSC "Heat Power Plants", JSC "National Electric Grids of Uzbekistan" and JSC "Regional Electric Grids" [31]. **However, still almost all energy stakeholders in Uzbekistan are state-owned or controlled.**

The main law governing relations in the electric power sector is the Law on the Electric Power Industry, which came into force in 2009. Together with the Asian Development Bank and the

World Bank, the government currently revises this law to reflect a policy change from energy-intensive to energy-efficient equipment (see 1.6.1 more details).

**Electricity market entities in Uzbekistan can be divided as follows:**

- Supervising body of the electricity sector (Cabinet of Ministers, Ministry of Energy, “Uzbekenergo” JSC)
- Commercial infrastructure organizations of the energy sector (JSC “National Electric Grids of Uzbekistan”)
- Organization of technological infrastructure of the energy sector (JSC "Uzenergoinspection", JSC "National Electric Grids of Uzbekistan", JSC "Uzenergoengineering")
- Electricity producers (JSC "Heat power plants", JSC "Uzbekhydroenergo")
- Electricity network infrastructure (JSC “National Power Grids of Uzbekistan” (NEP))
- Energy sales companies (JSC “Regional Electric Grids”)

### 1.4.1 Energy sector regulator

**The Cabinet of Ministers of the Republic of Uzbekistan (henceforth Cabinet of Ministers) is the governing body** in the electric power sector**.** The Cabinet of Ministers establishes the general strategy for the industry development, balances production and consumption, and is in charge of financing as well as of the procedures for withdrawal and commissioning of electric power facilities [12]. **The tariff policy of the renewable energy market is also one of the responsibilities of the Cabinet of Ministers.**

The **Ministry of Energy of the Republic of Uzbekistan (henceforth Ministry of Energy)** issues licenses for certain types of activities, approves standard contracts for electric power supply and implements investment projects in the electric power sector. RES policy development as well as construction of RES objects is also coordinated by the Ministry of Energy.

In 2010 “Uzbekenergo” was defined as a specially authorized body of the electric power industry [13] whose roles and responsibilities go beyond those of a mere infrastructure organization. Together with the Cabinet of Ministers, “Uzbekenergo” draws up a balance of production and consumption of electric energy and makes proposals on setting tariffs. Uzbekenergo has a wide range of powers, including for example the development of guiding documents, technical control over the operation of energy infrastructure and the management of main power networks [12].

### 1.4.2 Commercial infrastructure organizations

**“Uzbekenergo” was defined as the Unified Purchaser of Electric Power Produced by Electricity Generating Companies based on the 2009 Law on Electric Power Industry.** "Uzbekenergo”, enters into agreements with power generating companies, buys electricity and subsequently sells it to the organizations of the territorial grid operators. **Following the reorganization of “Uzbekenergo”, NEP took over the function of a single electricity purchaser and from 2019 sold electricity purchased from its producers to regional power grid companies.**

It was planned to transfer the functions of the Single Purchaser from the NEP of Uzbekistan to the state trading company already by 2021. This transfer would allow to move away from the monopoly of NEP and create a more competitive market in the energy sector. However, as of January 2023, this transfer of functions had still not taken place.

### 1.4.3 Technology infrastructure organizations

**"Uzenergoinspection", a government body of the Ministry of Energy, participates in the development of regulatory and legal acts in the field of technical regulation regarding production, transmission, distribution and consumption of electrical energy. "**Uzenergoinspection" controls all technical aspects in the energy sector, from electricity generation to its delivery to the final consumer. Operative and dispatching management of power generation is done by NEP.

The task of JSC "Uzenergoengineering" is designing electrical networks of all voltage types [47].

### 1.4.4 Energy producers

There are several large public companies that own almost all power generation facilities in Uzbekistan. Among these companies are: JSC "Therma Power Plants" ("TPP" JSC), which owns more than 85% of the power capacity, and JSC "Uzbekhydroenergo", which owns about 13% of the total installed capacity. "TPP" JSC operates all thermal power plants in Uzbekistan, of which the largest are: Syrdarya TPP (3 GW), Tashkent TPP (1.86 GW), Novo-Angren TPP (2.1 GW) and Navoi TPP (1.72 GW).

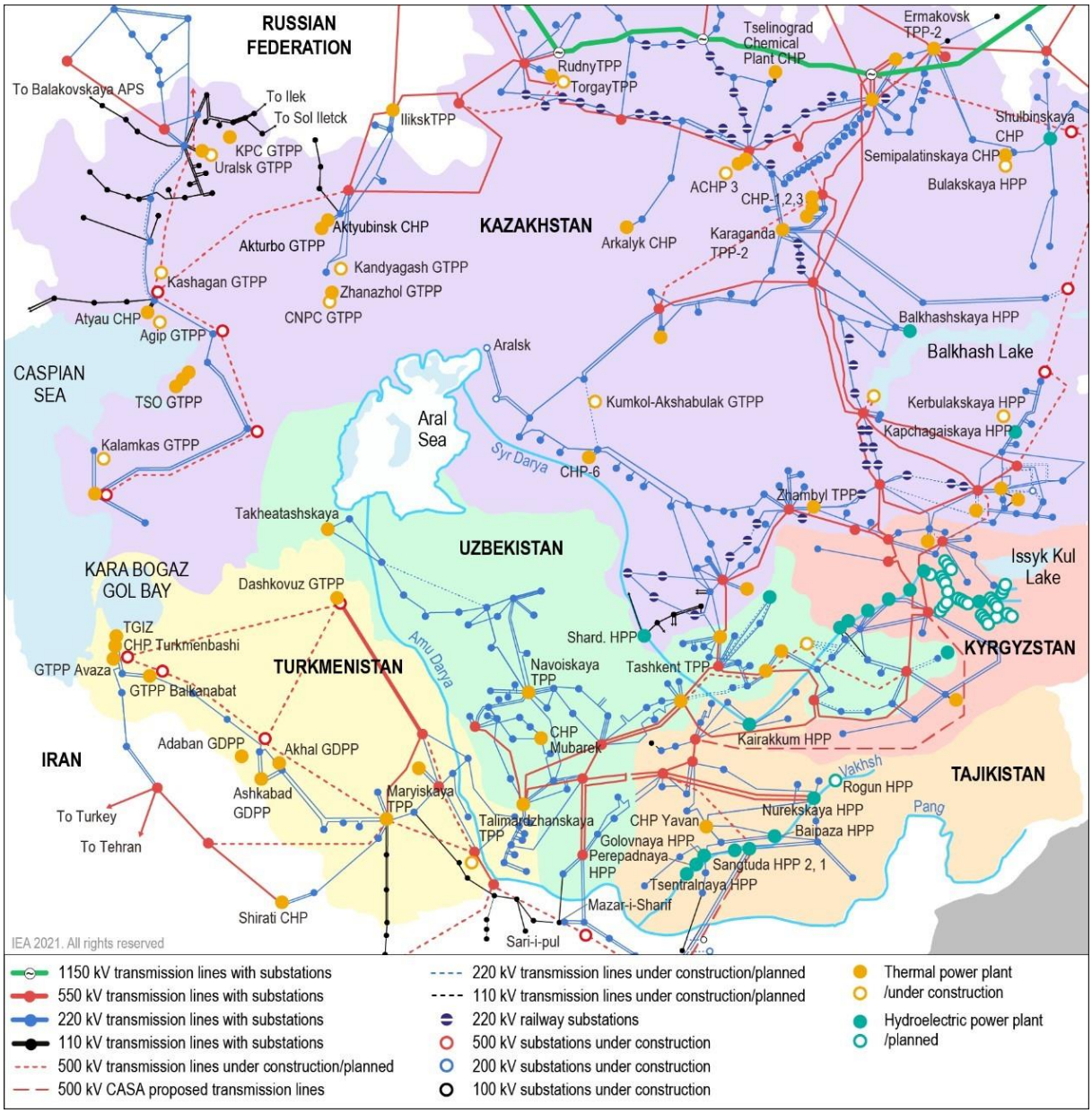
"Uzbekhydroenergo" manages all hydropower plants in the country with a total installed capacity of 1.85 GW [35]. The largest HPP plants are**:** Charvakskaya HPP (666 MW), Khodjikent HPP (165 MW), Tuyamuyunskaya HPP (150 MW) and Andijan HPP (140 MW) [34].

As of early 2023, mainly two companies are active in the renewable energy sector - Total Eren (France) and Masdar (UAE). Each company owns a 100 MW power plant and they are located in the cities of Samarkand and Navoi.

### 1.4.5 Grid infrastructure

**All electric grids in Uzbekistan are connected to transformer substations of the "National Energy Grids of Uzbekistan"**. In 2019, NEP consisted of 14 regional high-volage (HV) power grids, a national dispatchment center and other departments that shall ensure the uninterrupted operation of the grid. In total, there are 77 substations with 220-500 kV voltage and 9,700 km of overhead power lines of the same voltage pass [11].

**Figure 4 Electric grids in Uzbekistan**




**Source: International Energy Agency – Energy policy review Uzbekistan 2022 on materials of USAID (2015), Central Asia Electric Grid [83]**

### 1.4.6 Energy suppliers

**JSC "Regional Electric Grids" (henceforth REG) is a distribution and sales organization that sells electric energy generated by power producers through NEP.** REG has 16 subordinate regional organizations (the largest are Tashkent City PES (grid operator), Samarkand PES, Tashkent PES and Kashkadarya PES), which sell electric energy to the Regional Electric Supply Enterprises (RESE). A total of 209 District Electricity Supply Enterprises (RESEs) sell electricity to end consumers across all of Uzbekistan. The RESEs operate grids with voltages ranging from 0.4 to 110 kV.

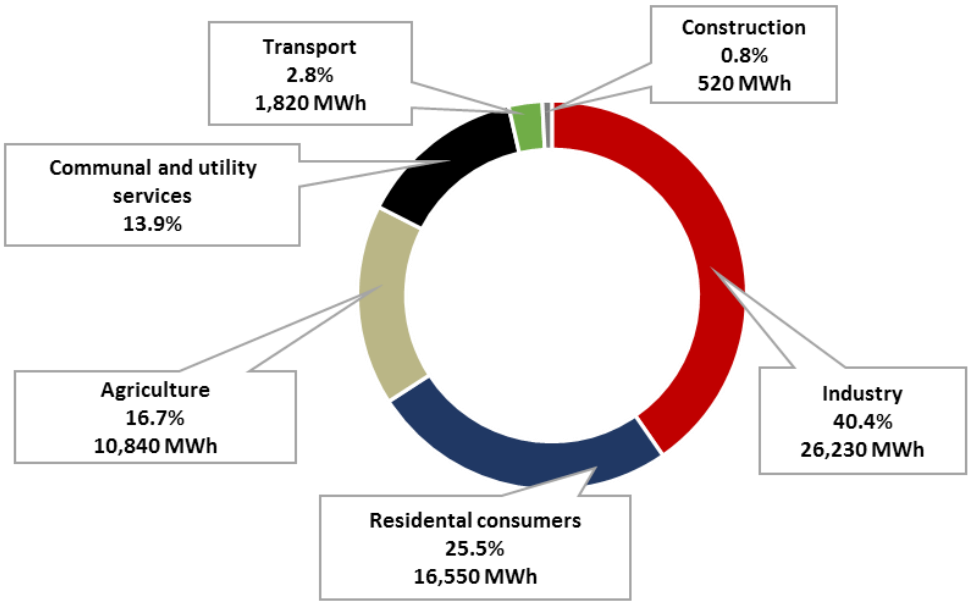
## 1.5 Electricity consumption and demand

The demand for electricity in Uzbekistan has grown constantly. As mentioned earlier, the per capita consumption in the region is still relatively low (1.89 MWh/year per person), but energy consumption is increasing year by year. In 20 years, electricity consumption has increased

from 16.7 TWh in 2000 to 69 TWh in 2020. According to the "Concept of Electricity Supply to Uzbekistan until 2030", consumption growth of up to 120,800 GWh can be satisfied by increasing energy capacity [26].

**According to "Uzbekenergo", the major consumers of electric energy in Uzbekistan are the industrial sector (40%), households (25%) and the agricultural sector (16%).**

**Figure 5 Electricity consumption by sectors in 2020 in % and MWh**




**Source: eclareon 2022 based on information of JSC "Regional Electric Networks" [50]**

### 1.5.1 On-Grid power generation

The United Energy System (UES) was created during the Soviet times and included the power generating capacities of Uzbekistan, Kazakhstan, Turkmenistan and Kyrgyzstan. After the collapse of the Soviet Union, the UES of Uzbekistan began operating independently [48]. Today, the UES is one integrated system, whose dispatch control is executed by the "National Electric Grids of Uzbekistan". The Uzbek energy infrastructure works in parallel with the energy systems of neighboring countries, providing access to electricity throughout the year. The central position of Uzbekistan's energy system in the "United Energy System of Central Asia" (UES of CA) allows the country to trade electricity with other CIS states on favorable terms [49].

Electricity supply is often interrupted in Uzbekistan's regions and consumers are frequently left without energy for several hours per day. This is mainly for the following reasons: insufficient generation capacity, malfunctions of power plants, frequent accidents at electrical installations and damage to power grids [38][39]. Electricity outages are also caused by fuel shortages that prevent power plants from operating at their full capacity. [79].

### 1.5.2 Off-Grid power generation

Despite the official 100% electrification rate of Uzbekistan, there are remote areas with no grid electricity supply. **More than 60% of Uzbekistan's population lives in such areas, which include at least 1,500 rural settlements, each inhabited by between 500 and 10,000 people [59]**. The lack of electricity in remote areas and interruptions in gas supply have led to problems with drinking water and telecommunications services. Moreover, the lack of electricity has also a negative impact on agricultural productivity. **Autonomous diesel power generation is often used to overcome the problem of missing of bad grid electricity supply**. **However, this causes other problems. For example, residents of many remote regions, such as the inaccessible rural areas of the Jizzak region, have to deal with fuel**

**shortages in the winter because strong winds and snowfalls can make the access to the region very difficult.** Not only sparsely populated areas in Uzbekistan face such problems but also the autonomous Republic of Karakalpakstan [23].

## 1.6 Electricity markets, prices, tariffs and costs

### 1.6.1 Wholesale and retail markets

**At present, there is no wholesale electricity market in Uzbekistan.** The retail market is represented only by the structure of “Uzbekenergo” and its subdivisions.

The Decree of the President of the Republic of Uzbekistan from April 6th, 2020 "On Priority Measures to Increase the Financial Stability of the Oil and Gas Industry", however, proposes the **development of a stock wholesale electricity and natural gas market [41].**

On the basis of the above-mentioned new edition of the law "On Electric Power Industry", the electricity market shall be re-structured to become more competitive. This restructuring will entail further reorganization of institutions and a transition to the implementation of the private sector. Despite public discussions on this initiative, the integration of a wholesale electricity market model that would include for example "day-ahead bidding" and similar market mechanisms has not yet been implemented. This model could enable wholesale purchases and sale of electricity on a monthly contract basis and the implementation of a balancing electricity market model.

**The transition to a wholesale electricity market has been announced many times. As of January 2023, free price formation shall be implemented by 2026 with the introduction of the wholesale market.**

### 1.6.2 Formation of electricity prices

Electricity prices in Uzbekistan are among the lowest in the world and amount to EUR 0.027 per kWh for households. The tariff policy fixing the prices is the responsibility of the Cabinet of Ministers. After the implementation of the law "On the Use of Renewable Energy Sources", tariffs for end users are formed based on the purchase costs of electricity from all energy sources, including renewable energy installations [33]. At the moment, there is no clear scheme and openly accessible information on the tariff formation in Uzbekistan.

**Four main tariff groups of electric energy consumers exist in Uzbekistan.**

Enterprises of large and heavy industries belong to Group 1 (see Table 1). This tariff requires payment for each kWh needed in advance.

The second group includes all remaining consumers who pay for electricity at a single rate. This tariff requires payment for each kWh of electricity supplied.

In Uzbekistan, as in other Central Asian countries, there are two types of domestic consumers: Consumers with electric stoves and consumers using gas. Gas is a cheaper source of energy for cooking purposes, so the difference in costs that users have to pay for household needs is offset by the difference in tariffication. Thus, consumers with electric stoves (Group 3.2) pay a lower tariff due to their high electricity consumption [70].

**It should be noted that electricity tariffs have not changed for the last four years since 2019.**

**Table 1 Electricity consumption by sectors in 2022**

| Group | Group | Tariff in UZS per kWh | Tariff in Euros per kWh |
|---|---|---|---|
| 1 | **Consumers with connected capacity over 750 kVA, differential tariff calculation** | 450 | 0.041 |
| 2 | **All consumers, except households, single rate calculation** | 450 | 0.041 |
| 3.1 | **Households not using electric stoves** | 295 | 0.027 |
| 3.2 | **Households equipped with electric stoves** | 147.5 | 0.013 |
| 4 | **Consumers in groups 1 and 2 using electricity for heating, hot water and cooking purposes** | 450 | 0.041 |

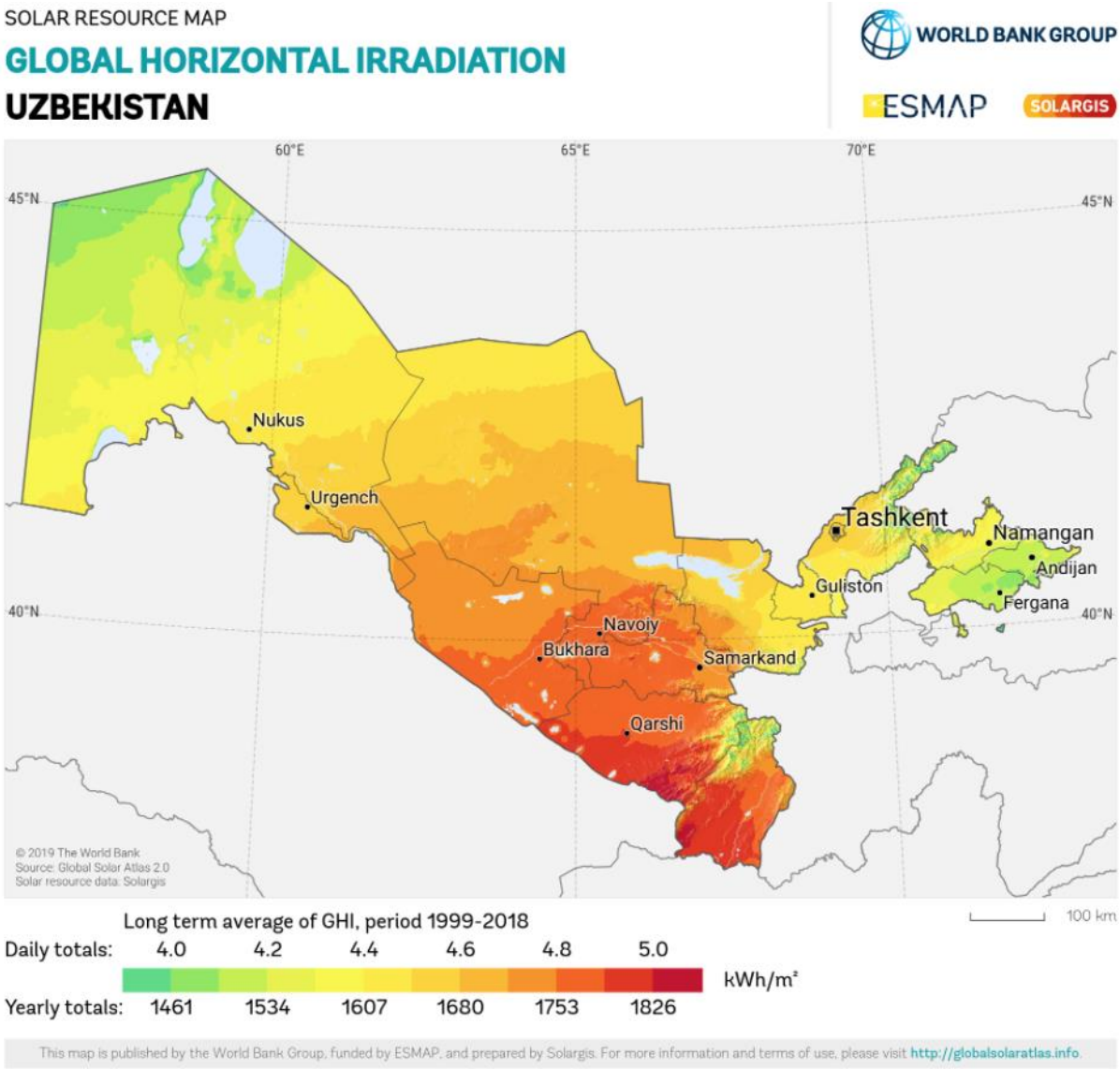
**Source: eclareon 2022 on materials of JSC "Regional Electric Networks" [51]**

# 2. Investment framework for PV

## 2.1 Solar Irradiation and state of the solar energy market in Uzbekistan

Uzbekistan's solar potential is impressive. Therefore, the introduction of renewable energy is one of the priorities in the energy sector. **Uzbekistan has 320 sunny days per year and the potential for solar energy production is estimated to be around 50.9 billion tons of oil equivalent. The country's total PV potential varies mostly between 1,400 and 2,000 kWh/m$^2$ per year [14][15][72]. The Republic of Karakalpakstan and the regions of Navoi, Kashkadarya, Surkhandarya and Namangan** are most promising for the development of solar energy [18][19].

**Figure 6 Annual global horizontal irradiation (GHI) of Uzbekistan**




**Source: Global Solar Atlas [71]**

The commissioning of the first 135-kW-solar-power-plant (SPP) in the Namangan region in 2015 can be seen as the starting point for the development of the PV sector in Uzbekistan. One year later, in 2016, the Uzbek company ERIELL and ENESOL from the UAE built the largest mobile solar power plant in the CIS with a capacity of 1.2 MW. The plant was designed to cover the electricity needs of Lukoil's Kandym gas field [55].

In the following years, no more solar power plants or other large RES facilities were built mainly because a regulatory framework for RE projects was still missing. Although the former Uzbek President Islam Karimov stated in 2013 that Uzbekistan should seriously focus on the development of solar energy no significant change occurred. After Shavkat Mirziyoyev came into power the new government decided to develop a more energy-efficient economy and also to diversify the Uzbek energy mix mainly by increasing the share of hydropower and other RES [15].

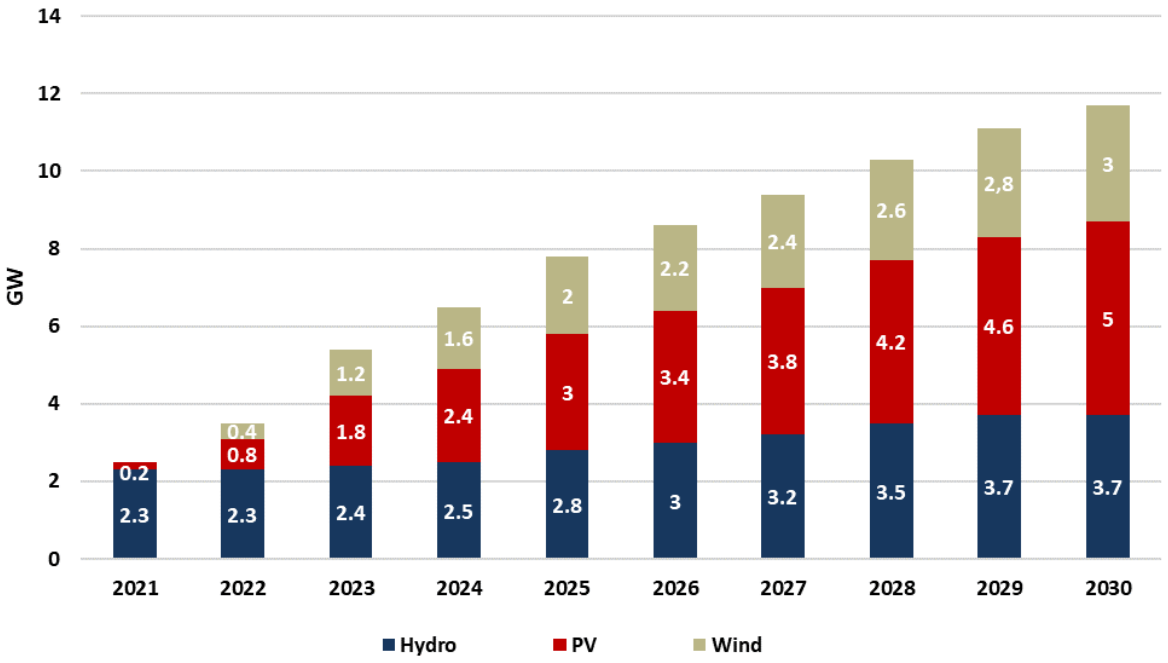
The renewable energy development program was launched in 2017. Until 2019, the country has mostly defined the policy for the RES sector and enacted the necessary legal framework. Today, the country mainly focuses on attracting investments into the RES sector.

**The Government of Uzbekistan has adopted a tendering scheme for the construction of large RES projects**. This scheme allows the state both to control the volume of new RES capacity and to make the investor selection process more transparent. Primarily, solar and wind projects are tendered.

**The first tenders for the construction of solar power plants with a total capacity of 200 MW were launched in 2019**. The Ministry of Energy organized these tenders which included the design, the construction, the commissioning and the operation of solar power plants in Samarkand and Navoi for a period of 25 years. The projects were to be built as public-private partnerships, whereby the tariff offered by each company would remain fixed for 25 years and the state would be obliged to buy the electricity until the end of the contract.

**As part of the new electricity sector strategy, the Government has also set quantitative targets for the development of the RES generation capacity between 2021 to 2030:**

**Figure 7 Projection of generation capacity increase in Uzbekistan for 2021-2030 (in GW)**




**Source: eclareon 2022, based on Ministry of Energy of the Republic of Uzbekistan [61]**

**Uzbekistan intends to install photovoltaic power plants with a total installed capacity of 5 GW over a period of 10 years.**

As of early 2023, tenders were held for 4 solar parks and 3 wind farms and the winners of the tenders were announced (see Table 2).

**Commercialisation of photovoltaic components also exists in Uzbekistan. It is estimated that up to 20 companies sale solar systems**. An example of such a company is All Solar which has installed more than private 1,000 PV systems [56]. Most of the PV manufacturing or installation companies are members of the Uzeltekhsanoat Association. Membership in this association gives the right to offer services and products on the state

platform "energymarket.uz" which also features PV subsidies (see section 3.2). The following firms are members of the above-mentioned association and can be seen as **the main photovoltaic companies in Uzbekistan: Modern Power Sytems LLC, All Solar LLC, Solar Nature LLC, Mir Solar LLC, Quyosh Issiqlik Energiyasi JV LLC, Solar City Solutions JV LLC, Nukuselectroapparat JV LLC, Sun Hightech LLC, Texnopark LLC, Nura Group LLC, Energy production technologies LLC and Solara LLC**. Most of these firms import equipment from China and Europe, but there are also firms that offer locally manufactured photovoltaic modules.

**The Masdar company from the United Arab Emirates (UAE) is the main foreign investor in the Uzbek renewable energy market**. The close political ties between the UAE and Uzbekistan exist since Shavkat Mirziyoyev came into power. Masdar was awarded the projects for electricity sales prices as low as 0.03 EUR per kWh.

**In the next 10 years, Uzbekistan intends to connect large PV projects with a total installed capacity of 5 GW to the grid. The new installations shall be mainly built in the Republic of Karakalpakstan and the regions of Navoi, Kashkadarya, Surkhandarya and Namangan.**

**Table 2 PV power plants in Uzbekistan**

| № | Location | Capacity | Year | Investor | Auction Price |
|---|---|---|---|---|---|
| 1 | **Samarkand** | 100 | 2021 | Total Eren (France) | 327 UZS/KWh **(0.027 EUR/KWh)** |
| 2 | **Navoi** | 100 | 2021 | Masdar (UAE) | 222 UZS/KWh **(0.018 EUR/KWh)** |
| 3 | **Navoi** | 200 | 2023 | Phanes Group (Netherlands) | 327 UZS/KWh **(0.027 EUR/KWh)** |
| 4 | **Samarkand** | 220 | 2023 | Masdar (UAE) | 219 UZS/KWh **(0.018 EUR/KWh)** |
| 5 | **Jizzakh** | 220 | 2023 | Masdar (UAE) | 372 UZS/KWh **(0.03 EUR/KWh)** |
| 6 | **Surkhandarya** | 457 | 2023 | Masdar (UAE) | 205 UZS/KWh **(0.017 EUR/KWh)** |

**Source: eclareon 2022, based on Ministry of Energy of the Republic of Uzbekistan [61]**

Other, non-RES related foreign investments into the power sector are constrained because the market is not yet liberalized.

## 2.2 PV module manufacturing in Uzbekistan

Given the difficult economic situation of the country, Uzbekistan currently does not have sufficient resources to substantially support the growth of the RES market. Moreover, low grid electricity prices hamper the development of RES in the country**. In 2022, Uzbekistan was among the 15 countries in the world with the cheapest grid electricity price for the end user which stood only at 0.026 Euros per 1 kWh** [72]. These low prices do not incentivize the purchase of solar systems. **Local production of PV modules could potentially become more important for Uzbekistan's RES sector.** PV manufacturing could allow to locally build up technical experience, potentially with the help of foreign knowhow. Moreover, local manufacturing could also create jobs [73] albeit the direct employment potential of modern, fully or half-automated manufacturing sites is limited. As described above, several small companies manufacture solar panels in Uzbekistan. These companies are mostly also active across other segments of the PV value chain: most small manufacturers are also installers and wholesalers of PV systems [56]. In case the growth of the Uzbek PV market picks-up these small companies will likely be unable to meet a growing demand for solar modules. Large-scale production could bring down costs and allow to cover the demand from all potential user

groups of solar power generation, from farmers to mining enterprises (see section 2.4 for details). Both Uzbek and Kazakh silicon can be used to create Uzbek photovoltaic panels.

## 2.3 Use of solar energy in the agricultural sector

Given the importance of the agricultural sector and its share in the Uzbek economy, the Government of Uzbekistan promotes the introduction of energy efficient technologies in this sector. Solar pumps allow to extract water from wells at sites with no access to grid electricity. The installation includes a traditional electric pump, which is operated by a photovoltaic system. This solution has been implemented successfully in many agricultural Uzbek regions with no connection to the electricity grid. Pilot projects for water supply systems using systems exist already. In total, over 2,200 kW of PV has been installed. The largest of these projects are:

- "Samarkand Experimental Farming of the Scientific Research Institute of Horticulture, Viticulture and Winemaking named after academician M. Mirzaev" (13.5 kW),
- "Samarkand Scientific Experimental Station of Scientific and Research Institute of Vegetable Crops and Potatoes " (15 kW) and
- "Scientific Research and Training Station" (18.5 kW).

Various projects such as “Support to Agricultural Enterprises” financed by the International Bank for Reconstruction and Development or Agroinnovation projects support the development of solar powered irrigation systems. These and similar projects have led to the installation of more than 2,200 kW of PV. Taking into that the agricultural sector represents 33% of Uzbekistan’s GDP, this market has great potential in Uzbekistan, provided that available water resources can be exploited sustainably without risking the over-exploitation of water resources.

**As described in section 3.2.1, farms are eligible for government subsidies if they use photovoltaic systems > 5 kW to power a water pump.** This support mechanism offers an opportunity to address problems in both the energy and water sector in rural areas.

## 2.4 PV business models in Uzbekistan

**Until now, the main solar electricity consumers have been the following:**

1. Farmers
2. Mining companies
3. Private households
4. Residents of remote settlements
5. Urban infrastructure

**In the following paragraphs business models for each of these consumer groups are presented.**

### 2.4.1 Model 1: PV systems for agricultural consumers, up to 100 kW

Many farms lack access to electricity. For farmers, renewable energy sources are in most cases the only option to gain access to electricity, especially in remote region. SPPs, when used on farmland, allow for crop irrigation with the help of solar powered pumps. The source of electricity can also be a hybrid unit including more than one generation technology such as solar-wind diesel units. This can reduce electricity production costs [58]. **Special government subsidies are available for the purchase of PV systems with a capacity of up to 100 kW:**

**an individual or corporation can receive government support of up to 1,500 EUR (for more details see section 3.2.1).**

Also, starting January 1st, 2022, farmers who implement water-saving technologies (which in the end of 2019 had already been 2% of the farmers in the country) are granted state subsidies for the cost of electricity consumed by pumping units for cotton and cereal production [65]. Full coverage of the cost of electricity in this case will allow some group of farmers to install hybrid-PV systems at almost no costs.

**Besides using solar energy on farms, PV electricity can be used to power greenhouses**. Energy for greenhouses can be provided by means of photovoltaic systems, which radically reduces energy bills, currently accounting for more than 50% of production costs [67].

### 2.4.2 Model 2: Photovoltaic parks for mining operations, 100 kW to 100 MW

Mining enterprises are an important group among potential users of solar energy. An example of a successful PV project in this sector is a natural gas extraction site of the Russian company “Lukoil”. Mining sites are often remote and do not have access to the centralized electricity supply and UES zones and they therefore have to use RES or generators. While generators require the constant procurement and supply of fuel, photovoltaic systems can efficiently supply power to drilling units and other equipment, saving up to 60% of the energy consumed from other sources [60].

Competition in this type of project is high. Projects are awarded by tenders. Participants need to comply with all rules and regulations and are selected on the lowest price bis which is usually below 0.03 EUR/ kWh.

### 2.4.3 Model 3: PV parks in centralized and decentralized areas, ≥100 MW

The Government of Uzbekistan, while developing the RES sector, puts its emphasis on supplying electricity to the remote regions and settlements. Sustainable centralized electricity supply with RES can be achieved by constructing PV parks with an installed capacity of more than 100 MW. These parks may supply electricity to remote rural communities. In Uzbekistan there are **approximately 1,500 of such settlements with up to 7,500,000 Uzbeks**. Today, residents of unelectrified areas are forced to use other types of offgrid electricity generation such as fuel powered generators. Supplying fuel for the operation of these gensets can be a challenge [58]. Large PV parks, tendered by the government, allow to generate electricity to meet the needs of settlements as well as nearby industry. The government plans to equip the central and southern regions - Jizzakh, Samarkand, Bukhara, Kashkadarya and Surkhandarya - with 100-500 MW of solar power capacity by 2030. Regions where ecotourism is to be developed shall also be equipped with solar power facilities. These regions are not necessarily located in remote areas but photovoltaic power generation will have, according to the government, a positive impact on the attractiveness for ecological prone tourists.

### 2.4.4 Model 4: PV systems for private use, 1.5 kW to 100 kW

This group can be divided into decentralized and grid-connected use. According to official data **around 20 million** residents live in rural settlements. **These settlements** are more likely to experience interruptions in electricity supply than those of other regions. Thanks to the benefits provided by the government, **private consumers in decentralized off-grid regions are entitled to a 30 percent state subsidy for the purchase of PV systems with a size of up to 100 kW** (for more details see section 3.1).

A small number of companies already operates in this market segment by selling turnkey photovoltaic systems to both grid-connected and off-grid households. Due to legislative changes introduced in 2019, individuals using solar energy for self-consumption do no longer need any official permits and are also subject to additional tax benefits.

A procedure for the purchase of surplus electricity from private RES facilities was established in 2021. This possibility makes the installation of yet-very expensive batteries obsolete and

creates the possibility to use the PV-generated electricity more efficiently. As a result, the payback period for a PV investment can be reduced which increases the economic attractiveness of this business model.

### 2.4.5 Model 5: PV systems for administrative and urban buildings

Uzbekistan's transition towards an energy efficient economy entails a number of measures, including equipping urban infrastructure with SPPs for self-consumption (for more details see section 3.1). This may include both small and medium-sized PV systems, depending on the technical requirements of buildings. At present, the government has neither developed a specific support scheme for implementing RES projects in this market segment nor defined the size for a small or a medium system. Therefore, investors interested in this model need to find their own way to turn this market segment into an economically viable business case.

# 3. Regulatory and business framework

## 3.1 Regulation and support schemes for solar energy and RES projects

**The main law in Uzbekistan regulating the electric power sector is the law "On Electric Power", adopted in 2009.**

This law regulates the main relations in the electricity sector, assigning rights and obligations to each participant of the electricity sector. The law allows for the sale of electricity produced for own use, including the possibility for private owners of renewable energy facilities to sell their surplus on a contractual basis through the UES to the Single Purchaser - NEP of Uzbekistan. As noted earlier, despite the fact that there is legal basis to sell this electricity, the respective executive order is still discussed and the publication of tariffs is scheduled for 2023.

**In spring 2019, Uzbekistan adopted a "Law on the Use of Renewable Energy Sources".** This law regulates renewable energy projects. The state reserves the right to determine the policy in the RES sector. The main regulatory body in the country in the area of RES use is the Cabinet of Ministers with the Ministry of Energy having a special authority. All power producers are to comply with technical regulations, norms and rules.

**This law has for the first time formalized the state incentives for RE production. Companies that produce renewable energy may claim the following tax incentives:**

- Exemption from property tax for 10 years
- Exemption from land tax on land plots occupied by RES facilities with a capacity of more than 0.1 MW each for a period of 10 years
- Exemption from mandatory contributions for a period of 10 years. These contributions include contributions to the Republican Road Fund and contributions to the non-budgetary Reconstruction Fund

**The law also describes state incentives for manufacturers of renewable energy equipment who are exempt of the following taxes:**

- All taxes for a period of 5 years
- Mandatory contributions for a period of 5 years. These contributions include contributions to the Republican Road Fund and contributions to the extrabudgetary Reconstruction Fund [33]

However, the enactment of this law did not lead to an immediate increase in interest in the country's RES sector. Therefore, the President of Uzbekistan Shavkat Mirziyoyev adopted the decree **"On accelerated measures to improve energy efficiency of economic sectors and social sphere, introduction of energy-saving technologies and development of renewable energy sources"** by mid-2019 in order to accelerate the development of the RES sector. This decree aimed to increase the attractiveness of RES for both major corporations and for private individuals by introducing the following incentives:

- Not only the construction and commissioning of RES projects are supported but also their operation. For example, RES-based electricity, was given priority in the dispatch schedule of the UES operator over electricity generated from traditional energy sources.
- Costs related to grid connection are paid by the energy producer.
- If expansion or reconstruction of the grid is necessary for the connection of RES units, the costs are borne by the grid owner.

Uzbekistan is also planning to supply different buildings with electricity generated by renewable energy installations. These buildings include:

- State administrative buildings of the Republic of Uzbekistan
- State administrative buildings of the Republic of Karakalpakstan
- Shopping malls, parks, restaurants
- Supermarkets, shops, markets and warehouses
- Gas stations
- Medical facilities
- Airports, railway and bus stations
- Hotels and service facilities
- Commercial banks and their branches
- Telecommunications companies

For projects equipping such buildings with RES, it was planned that investors shall receive subsidies which will be determined for each project individually, but there are special types of subsidies that apply to all projects. As this procedure is not transparent and given the lack of examples for obtaining such subsidies, its implementation has not yet been confirmed and needs to be detailed further.

**Based on a presidential decree, from May 1st, 2023 at least 50% of the free space of the roofs of multi-storey buildings must be equipped with PV with a capacity of up to 100 kW.** The subsidies within the framework of this initiative are not significant and are calculated for 3 years, namely exemption from payment of property, land and income tax. With the additional installation of energy storage systems with a capacity of at least 25% of the plant's capacity, the benefits will be valid for up to 10 years. In addition to the aforementioned subsidies, if the necessary requirements are met, the investor can count on additional subsidies, which will be discussed below.

## 3.2 Support schemes for PV projects

Solar energy projects in Uzbekistan can be divided by their size and owner structure into small-scale private photovoltaic installations (including solar collectors) and large-scale RES projects. For the development of these two project types different support schemes and mechanisms exist and will be discussed below.

### 3.2.1 Rules and support schemes for small-scale PV projects

The first state support scheme for small-scale photovoltaic facilities entailed a compensation of 30% of the investment cost up to a maximum of 3 million UZS (273 EUR) in total.

This compensation scheme did not work well and did not encourage individuals to invest into solar energy because the subsidy was perceived as too low and did therefore not enable most potential customers to pay for the remainder of the costs.

**A new set of measures was adopted in autumn 2022, which aims to financially stimulate the use of renewable energy by private and legal persons. Under this new subsidy**

**package, 2 types of state support become available - a one-time payment for the purchase costs and the provision of an interest-free loan.**

- **The amount of the one-time payment for the purchase costs** depends on the capacity of the photovoltaic system. There are 5 main groups, which are shown in the table below. Consumers who use PV systems with a capacity of 5 kW or more to power pumps are provided with the highest level of compensation. The payments are financed by the Extrabudgetary Inter-sectoral Energy Saving Fund which is governed by the Uzbek Ministry of Energy.

**Table 3 Compensation for small-scale power plants for renewable energy facilities**

| № | Source type | Capacity in kW | Compensation |
|---|---|---|---|
| 1 | PV | 0.5-1 | 2,100,000 UZS **173 EUR** |
| 2 | | 1-1.5 | 3,000,000 UZS **247 EUR** |
| 3 | | 1.5-2 | 4,500,000 UZS **371 EUR** |
| 4 | | > 2 | 6,000,000 UZS **495 EUR** |
| 5 | PV with solar pump | > 5 | 15,000,000 UZS **1,237 EUR** |
| | **Source type** | **Capacity in litre** | **Compensation** |
| 1 | PV collector | 100 (4 kW/day) | 1,500,000 UZS **124 EUR** |
| 2 | | 200 (7 kW/day) | 2,100,000 UZS **173 EUR** |

**Source: eclareon 2022, based on Ministry of Energy of the Republic of Uzbekistan [61]**

- **The interest-free loan** is granted for a period 36 months and covers, on average, 25% of the solar system costs.

This state support has been implemented not only to increase the installed solar capacity, but also to stimulate the domestic market for the production of photovoltaic systems. For this purpose, an internet portal (energymarket.uz) was created. Local photovoltaic system manufacturers have the right to place their offers on this portal which also grants access to the subsidies. The interest-free instalment plan and applies to locally produced photovoltaic panels, wind turbines and solar water heaters. This support scheme is available to the purchaser of the system, but only if the equipment is manufactured in Uzbekistan. The platform presents systems up to 20 kW peak and their prices. The prices are quite high and in most cases are above market prices. This means that even though the purchaser receives a discount or interest-free loan to purchase the equipment, the final price does not differ significantly from the market price.

**According to Uzbek legislation, surplus energy that has been produced by RES facilities can be sold. The only authority that has the right to buy electricity from RES is the Regional Electricity Networks JSC. The minimum contract period is 10 years and the price is 80% of the basic consumer tariff for households and for power plants up to 1 MW is 360 UZS/kWh (0.03 EUR/kWh) for businesses.**

**The tariff for private individuals is contracted directly with the authorized regional network (Regional Electricity Networks JSC).** It is reported that several of such contracts have been signed but the transaction amounts have not been disclosed.

### 3.2.2 Rules and support schemes for large RES projects

**Large RES projects can only be realized in Uzbekistan through a public tendering scheme.** The Ministry of Energy of Uzbekistan publishes tenders on its official website. These tenders will then be implemented as public-private partnerships (PPA). The tender documents provide basic information on the economic and technical part of the future project. **Winners are selected in 2 phases – Request for Qualification (RFQ) and Request for Proposals (RFP) from pre-qualified bidders.** In the pre-qualification round, the bidder gets acquainted with the basic requirements for the project. The technical and economic regulations are described in the pre-qualification request, allowing participants to immediately assess their ability to participate in the tender.

- **The Request for Qualification round involves the submission of a Request for pre-qualification, which includes 4 main sections:**
  - **Technical qualification:** evidence that the potential tenderer meets the applicable technical criteria
  - **Financial qualification:** confirmation that the potential tenderer meets applicable financial criteria
  - **Legal qualification:** confirmation that the potential tenderer has satisfied all legal criteria
  - **Pre-qualification form and other documents or information**
- The participants who successfully passed the first phase of the tender process must submit a Request for Proposal, RFP and their names are published on the website of the Ministry of Energy. After the first stage, the participants are given access to an online platform (virtual data room), where they will have to upload and submit their RFPs. The RFP must include a technical and financial proposal for the project.

**The tender is awarded to the bidder who presented the best technical solution and offered the cheapest price per kWh.**

**As mentioned earlier, large PV projects are implemented as public-private partnerships, whereby, upon conclusion of the contract, the government buys electricity at a fixed tariff for a fixed period, in most cases for 25 years.**

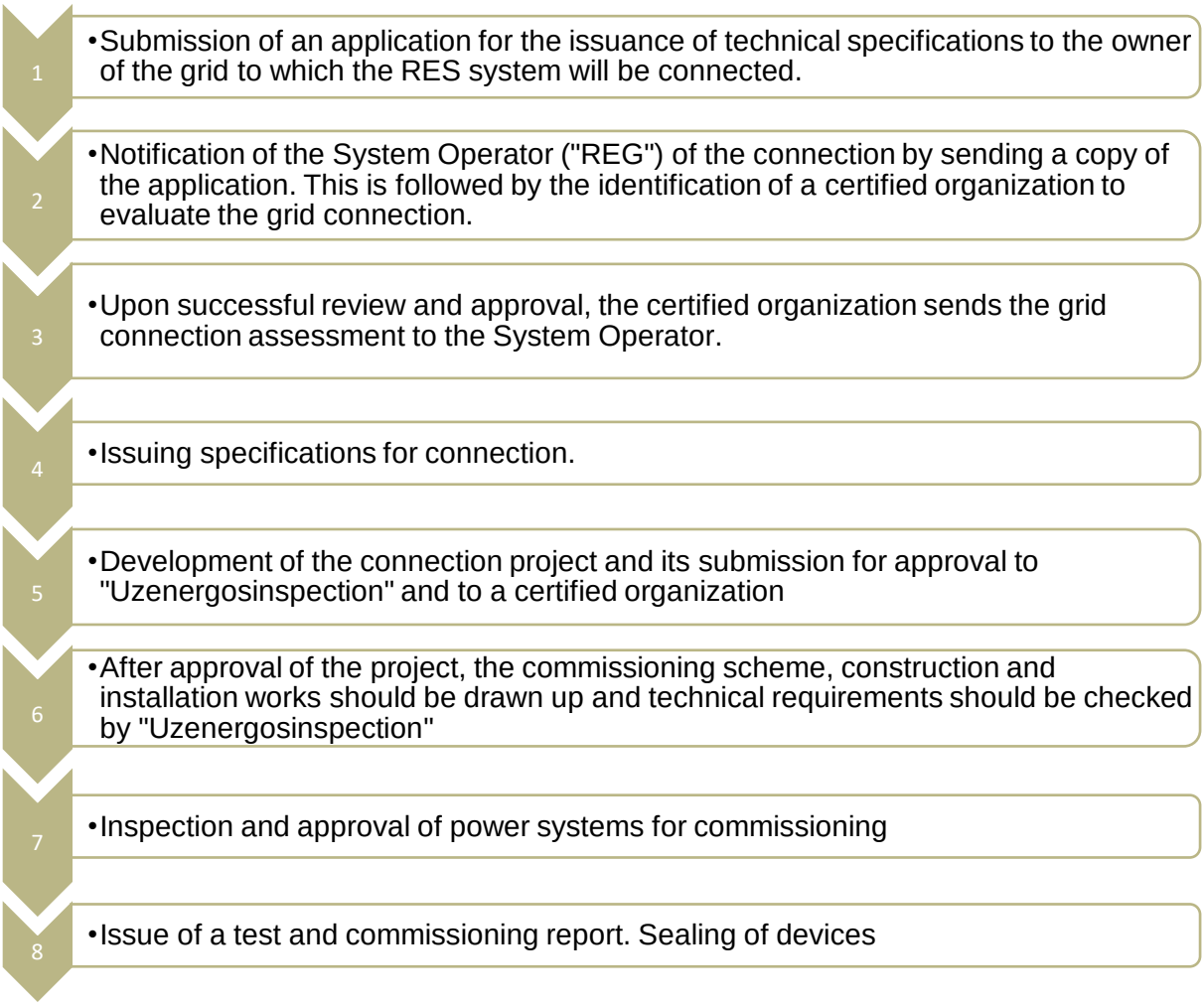
Not only the construction and commissioning of RES power plants RES are supported not only but also their further operation. The dispatchment of electricity generated from RES is prioritized over the dispatchment of electricity generated by conventional sources. The costs of connecting RES installations to the UES are borne by the electricity producer. However, if it is necessary to reconstruct or expand the existing electricity network to enable the grid connection of RES installations, the financial costs are borne by the network operator.

## 3.3 Codes, standards and tariffs

### 3.3.1 Electricity transmission rules and technological grid connection

PV systems of different capacities can be connected to the power grids. The regulation for connecting RES power generating facilities to the UES are presented below:

**Figure 8 Rules for connection of RES facilities to UES in Uzbekistan**




**Source: eclareon 2022, based on the Annex to the Resolution of the Cabinet of Ministers of July 22, 2019 [68]**

**With regards to electricity sales prices, it can be said that there are no fixed RES tariffs for large RES installations in Uzbekistan. These tariffs are established based on public tenders. The Ministry of Energy defines capacities for RES projects and announces tenders on its website for necessary types of generation and the desired location of the facility.**

**In 2021, Uzbekistan approved tariffs for the purchase of electricity from small RES facilities that can supply surplus to the general electricity grid. The tariff for power plants is 80% of the basic consumer tariff and amounts to 360 UZS/kWh (0.03 EUR/kWh).**

The Government is currently developing a programme to purchase electricity from individuals and legal entities at a rate of 1,000 UZS/kWh, which is three times higher than the regular tariff. This programme is designed exclusively for Tashkent city and is to be implemented for commercial entities in 2023 and for private consumers from the beginning of 2024.

## 3.4 Terms of trade and investment

### 3.4.1 Trade and investments

In the early 2000s after the fall of the Soviet Union and during the presidency of Islam Karimov, Uzbekistan isolated itself internationally. The country-imposed currency controls and economic growth stagnated. Due to these controls, a black currency market formed. Until 2017, Uzbekistan was one of three countries worldwide with such a market and essentially two

exchange rates. The black-market currency exchange rate was on average twice as high as the official one. This allowed the elected representatives to use both currency exchange markets for their own profit until 2017 [75]. During this period, the population still exchanged currencies at the official market rate. This worsened the situation with the shadow economy that accounted for about 40-50% of the country's GDP in 2019 [76]. The situation changed after Shavkat Mirziyoyev came into power and introduced large-scale reforms. **The devaluation of the national currency in 2017 was followed by the introduction of free conversion rates, which ended the above-described black-market situation. The new government also liberalized customs and the tariff policy which reduced import customs rates [77].** Thanks to these reforms, foreign investments in Uzbekistan have by now become more attractive although serious economic problems still exist.

### 3.4.2 Inflation and interest rates

After the end of the black-market-economy following the introduction of a convertible currency, price liberalization and other major reforms, the country's inflation increased substantially until 2019. Since then, the inflation in Uzbekistan is, relative to other countries in the region, relatively moderate. In 2022, the inflation rate in was at 12.25%, 3% lower than in 2019 [62]. As of January 1st, 2023, Uzbekistan's main interbank interest rate from is 15%, which is 1% lower than the rate since 2019.

## 3.5 Financing of PV power plants

Measures developed to support the development of the RES sector also include certain incentives affecting the financing of RES facilities. In the case of debt financing of RES installations, lenders provide a green loan with a tenor of 5 years.

As of early 2023, the following five banks in Uzbekistan are financing "green" projects for interest rates that are close to the interbank rate of the central bank:

- AKIB Ipoteka Bank (14% per annum),
- Asakabank (15% per annum),
- JSC Halk Bank (15% per annum),
- JSCB Uzpromstroybank (15% per annum), and
- JSCB Kishlokkurilishbank (17% per annum).

The financed projects include many different RES technologies and products such as photovoltaic plants, solar water heaters, wind generators, micro and small hydro power plants up to 1 MW, biogas production equipment, biogas plants, other renewable energy devices and energy storage systems.

# 4. Selected business models

This section is dedicated to the profitability analysis of solar powered water pump projects in Uzbekistan. The calculations include cash-flow modelling and sensitivity analyses to assess the impact on profitability related to changes of key input parameters such as the system price, energy yield or electricity savings.

For the business case calculations we have used the solar radiation values of Samarkand in the south-eastern part of the country. According to data taken from the Global Solar Atlas , a tool freely provided by the World Bank and International Finance Corporation to provide easy access to data on solar resource and photovoltaic power potential, the solar irradiation in the region corresponds to 1,753 kWh/m$^2$ (global horizontal irradiation (GHI)). After applying a performance ratio of 0.80 to this irradiation, the specific yield used (and shown in the graphs and figures) is 1,609 kWh/kWp/a. Please note, that the specific annual PV yield in Samarkand depends heavily on the specific location of the project. The solar irradiation (again GTI at optimum angles) varies in Uzbekistan between approx. 1,650 kWh/kWp/a in the east to 2,100 kWh/kWp/a in the south.

The farming segment seems ideal for the introduction of photovoltaic energy in the country not at least because farmers can benefit from the most important government subsidies which makes the . Therefore, the economic performance of this business model the most efficient in the region's ability to integrate solar power.

## 4.1 Methodology of profitability analysis

**An Excel based discounted cash flow analysis (DCF) was used for the profitability analysis.** The DCF methodology evaluates a project using the concept of the time value of money. The analysis is based on monetary values only and does not consider other positive impacts of PV such as environmental or health effects.

All future cash flows are estimated and discounted to their present values. The **net present value** (NPV) is the sum of all positive and negative cash flows 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 an indication of the attractiveness of a PV investment. Please note that we have used discounted cashflows for the calculation of the amortization period, but that we also show an undiscounted payback period in the project overview charts. By definition, these undiscounted payback periods are always shorter than the discounted payback periods because the time value of money concept is ignored which basically means that 1 UZS today will still be worth 1 UZS at any time in the future.

Another key parameter calculated is the **levelized cost of electricity** (LCOE) which makes it possible to compare power plants of different generation technologies 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. These values should be at least > 1 which would mean that free project cash flows would suffice to pay back debt.

## 4.2 20 kWp Solar water pump

A 20 kWp PV system provides the electricity needed to operate a solar water pump. With the extracted water the owner of the system can irrigate agriculturally used land. The amount of water that will be pumped depends on a number of parameters such as for example the water resources in the area (groundwater or surface water), the crops to be irrigated and the efficiency of the pump. This business case assumes that the water pump is already in place, but is operated by a privately owned diesel genset. The PV system substitutes the genset, therefore, the revenues are based on fuel savings. A chemical battery is not part of the PV system configuration but a physical storage unit like a water tank is already in place. Like this, the fields can also be irrigated during the night to decrease evaporation losses and the overall efficiency of the PV system is increased, because it is able to operate in periods where no irrigation is needed. In addition, it must be pointed out, that a water pump can only be installed in areas with sufficient and sustainable water resources, as the system calculated here does not include water resources monitoring. The potential problem of overextraction of groundwater needs to be closely monitored.

Solar water pump systems can range from 5 kWp to several 100 kWp, but systems around 20 kWp are common and are considered sufficient for many situations. Compared to the residential business case, the PV system price per kWp is lower due to a larger system size and since the installation is ground mounted and hence less expensive than rooftop mounted systems. The irradiation values used are 2,011 kWh/m$^2$ GTIopta and 1,609 kWh/kW PVout).

The applied direct PV consumption, that determines which share of the solar irradiation can effectively be converted into “useable” electricity, was set to 60%, due to the system supplying electricity to one single appliance. This value can be increased by increasing the storage capacity or other efficiency-oriented measures. The PV system performance was assumed to decrease by 0.7% per year accounting for the wear and tear of the system.

The lifetime of the system was set rather conservatively to 20 years. An increase based on the lifetime of the PV modules to 25 and even 30 years would be reasonable as well provided that the system is installed professionally and with “high enough” quality.

Total turnkey PV system costs (capital expenditure, Capex) for the PV system were reported to be around 12,000,000 UZS/kWp. Moreover, an investment subsidy of 15,000,000 UZS for solar pumping installations > 5 kWp was taken into account. In sum, total system costs amount to 225,000,000 UZS. The operation costs were reported to account for about 2% of the system costs which is a rather high value.

The PV system in the business case was financed with 30% equity provided by the owners of the PV system. The other 70% are financed with debt. The loan tenor is 10 years. The debt interest rate is 16%, in line with the interest rates for green loans. An interest free loan accounting for 25% of the purchase costs was not taken into account for this business case calculation but could improve the results of the calculation further. The equity was discounted with a rate of 15% which is 3% higher than the inflation rate. This is a rather low rate and reflects that the customer’s primary objective is not to earn money from fuel savings but to be able to irrigate his fields and increase his crop quality and yield which is the more important source of revenue for him. The farmer does not want to lose money either, therefore the discount rate for his equity investment was higher than the long-term inflation rate. If this were a pure “project finance” investment case it would be illogic that debt is more expensive than equity that carries a larger share of the investment risk. In this case, this assumption was made nevertheless given that the bank would provide a loan for such a system not primarily or solely based on the expected cashflows of the project (as is the case in pure project finance transactions) but rather based on the creditworthiness of the borrower, the farmer in this case. Therefore, the bank’s loan would be reimbursed even if the financed PV system generated less savings than planned provided that the farmer’s creditworthiness proves to be sustainable. The motivation for the farmer to still take out a loan could be a lack of equity in combination with the possibility to deduct loan interest payments from his taxable income. In

addition, the farmer can count on green credit, which is represented in Uzbekistan by five banks.

**Figure 9 Project Overview – 20 kWp solar water pump**

| PV System | | |
|---|---|---|
| Project Duration | Years | 20 |
| PV System Size | kWp | 20.0 |
| Nominal storage capacity | kWh | - |
| Total PV system costs /kWp | UZS/kWp | 12,000,000 |
| Investment Subsidy-PV | UZS | 15,000,000 |
| Total PV System Cost (after subsidies) | UZS | 225,000,000 |
| Performance Factor | % | 80% |
| Degradation | % p.a. | 0.70% |
| Applied Solar Yield | kWh/kWp/a | 1,609 |
| Average Yearly Generation | kWh/a | 29,933 |
| Fixed Operation Costs PV | % p.a. | 2.00% |
| Battery Replacement Interval | Years | - |

| Financing | | | |
|---|---|---|---|
| Debt (Gearing) | 70% | UZS | 157,500,000 |
| Loan Tenor | | Years | 10 |
| Debt Interest Rate | | % | 16% |
| Initial Equity | | UZS | 69,895,942 |
| Additional Equity | | UZS | - |
| Discount Rate | | % | 15.0% |
| Longterm Inflation Rate | | % | 12.0% |

| System Operation - Savings | | |
|---|---|---|
| Applied Direct PV Consumption | % | 60.00% |
| Applied Battery PV Consumption | % | - |
| Genset Efficiency | kWh/ltr | 3.0 |
| Average Replaced Fuel Consumption p.a. | ltr/year | 5,987 |
| Fuel Price (1st Ops Year) | UZS/ltr | 12,623.00 |
| Oil costs as % of fuel costs | % | 10.00% |
| Fuel Price Escalation | % p.a. | 12.00% |
| Genset CAPEX fee saved | UZS p.a. | - |
| Genset OPEX fee saved | UZS p.a. | - |
| Generator related savings (average) | UZS/kWh | 10,932.37 |

| Results | | |
|---|---|---|
| Net-Present Value | UZS | 967,302,251 |
| Equity IRR | % | 105% |
| Project IRR | % | 53% |
| Amortization - discounted payback period | Years | 1.30 |
| Undiscounted payback period | Years | 1.11 |
| LCOE (no subsidy) | UZS/kWh | 1,655.42 |
| Min DSCR** | x | 2.89 x |
| Min LLCR*** | x | 4.30 x |

* LCOE: Levelized Cost of Electricity

** DSCR: Debt Service Coverage Ratio

*** LLCR: Loan Life Coverage Ratio

**Source: eclareon, 2022**

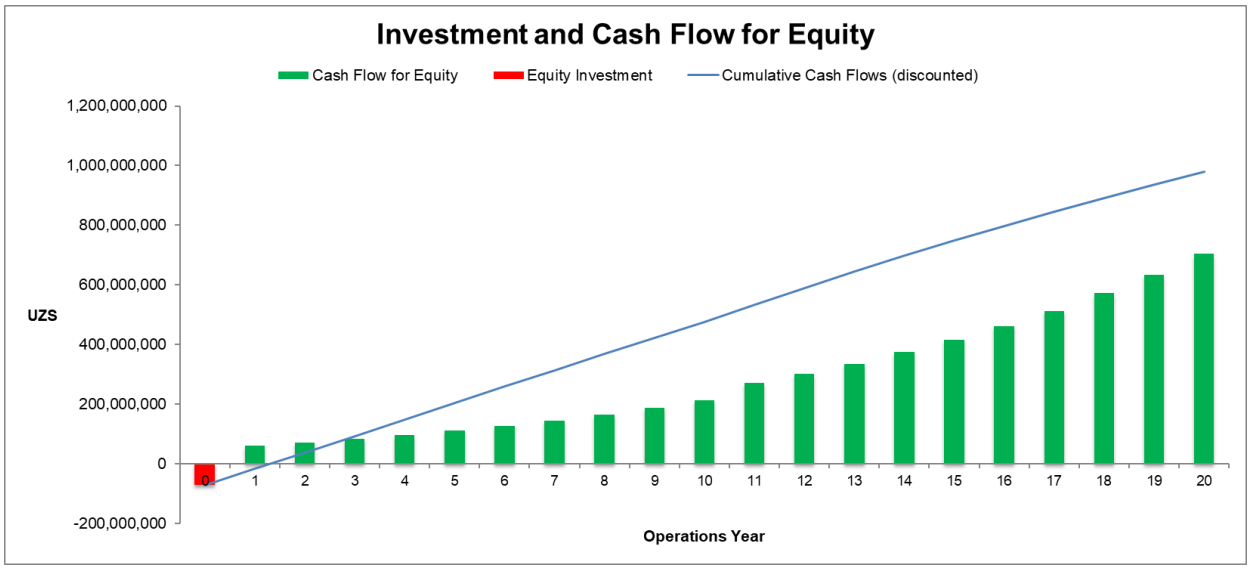
It was assumed that the generator needs 1 liter of fuel to produce 3 kWh of electricity. The fuel is purchased for 12,623 UZS/liter and 10% for lubrication oil that regularly needs to be exchanged was added. The fuel price is increased annually “only” by a long-term inflation rate of 12% although the price of fuel has increased by about 200% in the past two years. Given that the customer already owns a generator and also wants to keep it as a backup system neither generator purchase or replacement costs nor other O&M costs were taken into account for the generator in this business case.

## Financial results for the solar water pump

The results for this business case are a positive net present value of 967,302,251 UZS and an internal rate of return for the equity invested of 105% which means that the PV system is an economically very viable investment under the assumptions described above. The equity investment is paid back after approx. 1.3 years, longer using discounted cash flows, shorter if cash flows are not discounted. This payback period is already extremely short and could be even shorter with a project lifetime of 25 years. During interviews the feasibility of such short payback times were confirmed, market actors mentioned payback times of around 18 months what is in the range of the calculated 1.3 years.

Looking at more detail at the business case, the equity cash flow looks as follows:

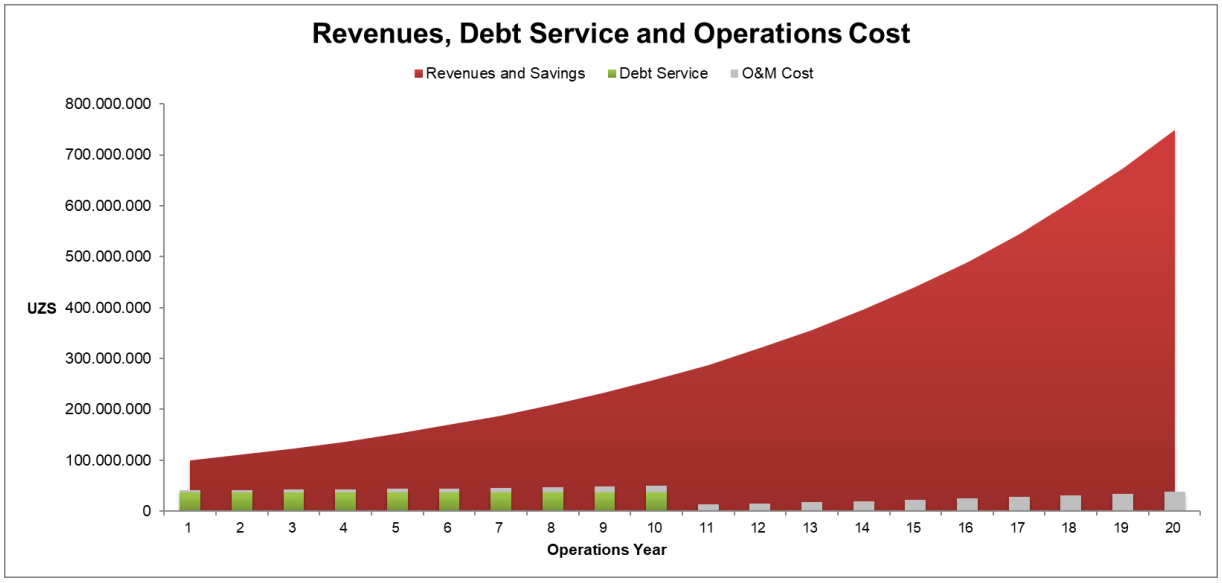
**Figure 10 Equity Cash Flow - 20 kWp solar water pump**




**Source: eclareon, 2022**

As can be seen, the equity cash flow increases year by year because fuel prices were escalated in line with the inflation rate. The loan is paid back after 10 years, hence the equity cash flow increases a little more in year 11. The point where the cumulated cash flows cross the x- axis shows the discounted payback period of 1.3 years.

**Figure 11 Revenues, Debt Service and Operations Cost - 20 kWp solar water pump**




**Source: eclareon, 2022**

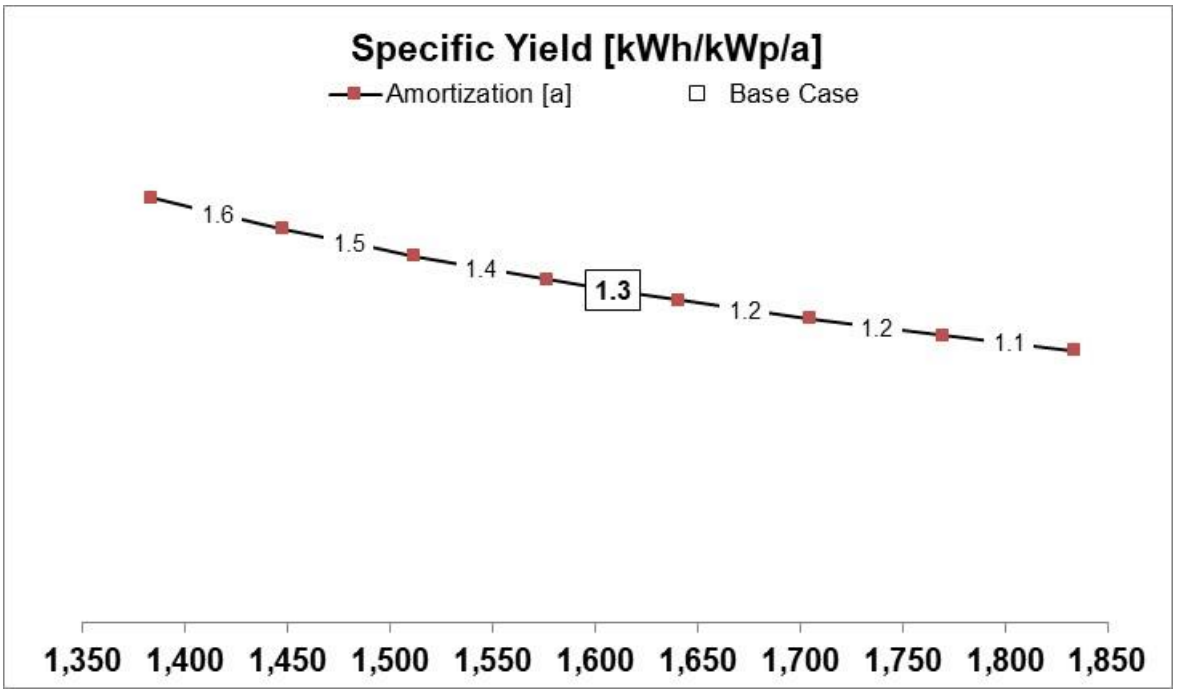
## Sensitivity of results for the solar water pump

The following figures show how the key economic performance indicator of the investment, the discounted payback period (amortization), change when certain of the assumptions described above are modified.

The specific yield shows the kilowatt hours produced by a PV system per kWp of 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 includes the technical conditions for the efficiency of the PV system, the efficiency, orientation and inclination of PV modules, possible shadowing, etc.

It can be seen that the financial results for the PV installation improve when the system would be built at a site with higher irradiation: the payback period decreases when more electricity can be harvested.

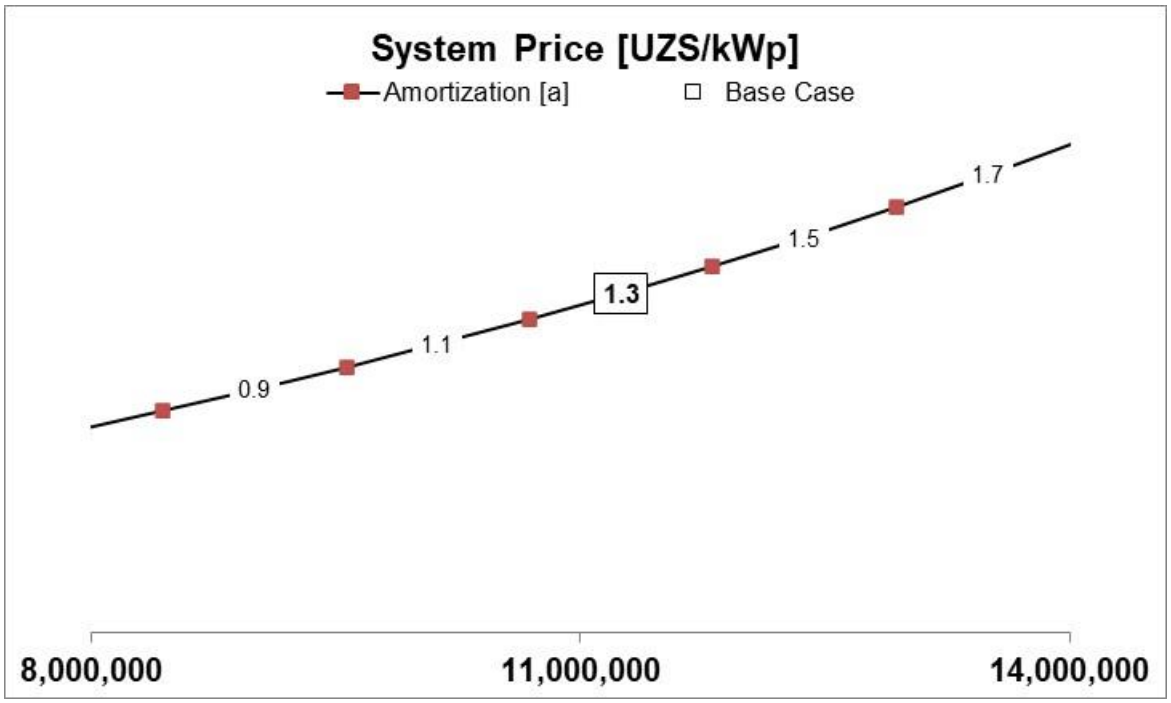
**Figure 12 Specific Yield Sensitivity - 20 kWp solar water pump**




**Source: eclareon, 2022**

Another important factor to assess the economic viability of a PV system are the system costs: The higher these costs are, the less attractive becomes the investment.

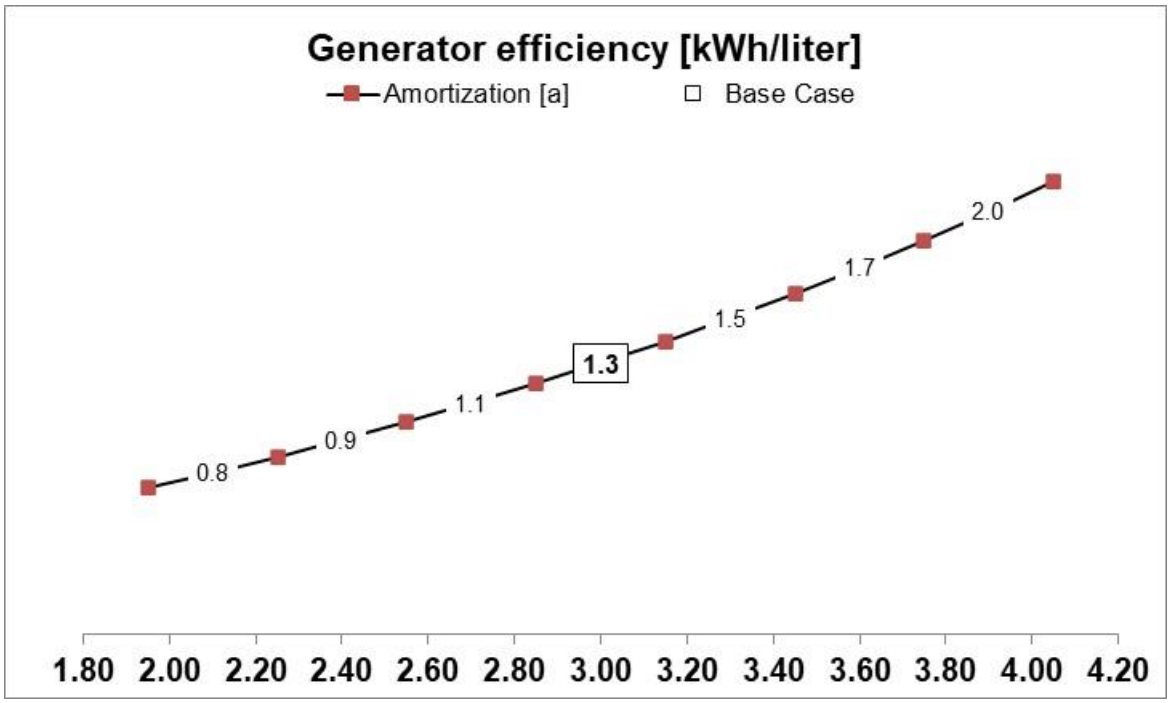
**Figure 13 System Price Sensitivity - 20 kWp solar water pump**




**Source: eclareon, 2022**

Another parameter that has an impact is the generator efficiency. The more kWh can be generated with one liter of fuel, the more efficient the generator is and the less attractive becomes the PV investment. Inversely, if less kWh can be generated with a liter of fuel, the shorter the payback for the PV system will be. As can be seen in the graph below, a kWh/liter ratio of 2 instead of 3 as in the base case, would result in a discounted payback period of only around 0.8 years. Inversely, if 1 liter of fuel generates 4 kWh of electricity the payback period would be around 2 years.

**Figure 14 Generator efficiency Sensitivity - 20 kWp solar water pump**




**Source: eclareon, 2022**

# 5. Conclusion

**Uzbekistan's energy sector is characterized by the exploitation of domestic fossil fuel resources and a partially obsolete and inefficient energy infrastructure inherited from the Soviet past of the country.** Despite the government's intentions to reform and liberalize the energy sector, the Uzbek energy market is today still organized as a public monopoly without a liberalized wholesale and retail electricity market. The public monopoly enables the government to fix low electricity tariffs for consumers who welcome such low prices. However, these low prices hinder foreign investments into the energy sector. It needs to be seen which impact the planned implementation of liberalized retail and wholesale markets will have on consumer prices and foreign investment.

**The region has an enormous potential for the deployment of solar energy – irradiation values range between 1,800 and 2,000 kWh/m$^2$ per year for most areas of the country. However, as of 2023, the current cost of electricity is too low, preventing the large-scale deployment of solar energy in the short-term.** Large reserves of natural gas, which are used to generate more than 85% of the country's electricity, as well as the large generation still built during Soviet times have allowed the government to keep electricity tariffs at very low levels. These low prices and the country's focus on conventional sources of energy have also impeded the development of a large market for RES installations. However, the (investment) environment has started to improve, albeit slowly. This recent improvement in market environment is mainly based on policy changes undertaken during the last 10 years. For example, **the government has announced to install a total cumulative PV capacity of 5 GW by 2030. This objective seems however challenging taking into account that as of early 2023 only 0.2 GW were installed.** Most of the installed PV capacity is based on a public tendering scheme which awarded 75% of all tendered volumes to the company Masdar from the UAE.

**Given the low grid electricity prices, PV solutions for off-grid or remote regions with a weak grid, and in particular agricultural regions, seem to be a promising market segment.** Green loans introduced at the end of 2022 allow farmers to finance their photovoltaic systems. Moreover, agricultural enterprises have the possibility to sell surplus PV electricity for 80% of the basic tariff when feeding it into the grid.

**In addition, Uzbekistan's regulatory framework targets other private PV consumers as well but the cheap grid electricity combined with a still underdeveloped climate consciousness in the region have hindered the market growth of PV in this segment.** In most cases, households are interested in having uninterrupted electricity supply but due to the missing awareness for environmental and climate related topics of the majority of the population, the transition to renewable energies is not a priority for most. Instead, households rather continue to rely on grid electricity supply in centralised regions or on fuel-powered generators in decentralised regions without access to the electricity grid. Work in educational institutions can inform and increase the awareness about RES and green topics in general and also trigger policy action for the transition towards a more sustainable energy generation with the help of renewable energy sources.

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