BUSINESS MODEL
for a Solar PV project in Kazakhstan's metallurgical sector

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Capacity Development for Climate Policy in the Countries of Southeastern and Eastern Europe, Southern Caucasus and Central Asia

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On behalf of
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Kazakhstan 2024

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EXECUTIVE SUMMARY

Kazakhstan's growing economy is characterized by inefficient, unsustainable consumption of fossil fuels and natural resources. The country is also vulnerable to climate change impacts and is subject to natural disasters. Climate trends are expected to exacerbate these impacts, including droughts, heat waves, floods, mudflows, and landslides that are already responsible for land degradation, infrastructure damage, and loss of life. As a response to this, the Republic of Kazakhstan has elaborated a national long-term low emission development strategy (CNS) according to the Paris Agreement's Article 4.19.

The CNS economic modelling revealed that additionally needed investments for reaching carbon neutrality is estimated for the 40-year period from 2021 to 2060 at a total of around USD 666.5 billion. By far the largest investment for carbon neutrality is needed in power and heat generation with 46% of the total investment. Regulated and low prices and tariffs in several sectors, which are relevant for tackling climate change, such as in power generation, transmission and distribution, however, hinder investments in decarbonization.

One of the major bottlenecks for effective decarbonization policies and actions in Kazakhstan is the resistance from industries that are trying to protect their existing business models. Private investments in low-carbon solutions and the shift towards renewable energy sources are hindered by highly regulated tariffs and low prices in the energy sector.

Solidcore[1] is one of the leaders in the recovery of precious metals in Kazakhstan with a portfolio of two producing gold mines and an impressive growth project for the new full-cycle pressure oxidation plant. Solidcore's shares are traded on the Astana International Exchange (Kazakhstan).

In order to solve the task of developing RES, the gold mining company Solidcore plan to implement a comprehensive project involving the construction of two solar power plants with a total installed capacity of 40 MW and one gas engine mobile station with an installed capacity of 40 MW to cover the unstable generation of solar stations (according to information presented by Company, 20 MW of CGU units will be under external electrical grid operator control – independent start/stop engine operation for balancing purposes). The project will be implemented in the Abay and Kostanay regions within five years: 2023 – 2027. The total investment will be around $70 million.

Within the framework of this business model, numerical modeling of the integration of two photovoltaic parks and a park of cogeneration plants into the current technological process of the Solidcore company was performed.

[1] In June 2024, Polymetal International has changed its name to Solidcore Resources following the sale of its Russian business Polymetal JSC.

Calculations were performed for the Kostanay and Abay regions. Calculations were carried out for the period 2025 - 2038.

As a result of numerical modeling of the integration of renewable energy sources into the technological process, the following calculations were performed:

- calculation of the amount of green energy generated by two photovoltaic parks
- calculation of the reduction of CO_2 emissions due to the generation and consumption of the renewable energy
- modeling of the operation of cogeneration plants, calculation of CO_2 emissions from the natural gas burning process
- reduction of electricity consumption from the grid due to the generation of its own electric energy (PV plus CGU units)
- reduction of CO_2 emissions for two branches: Abay and Kostanay
- payback period of investments in photovoltaic parks and CGU units.

1. GOLD MINING INDUSTRY CURRENT STATE AND SOLIDCORE COMPANY PLANS

The industry faces significant challenges, including the depletion of the mineral resource base, which is seen as a fundamental issue[2]. Gold mining companies are increasing production rates annually, but the real growth in reserves is slow, with exploration and preparation of deposits taking seven to eight years on average. No major gold deposits have been discovered since independence, and many operations rely on Soviet-era discoveries. Some enterprises consider short-term extraction of off-balance ores, and some plants continuously seek external raw materials.

Two primary reasons for these challenges are the low investment attractiveness of geological exploration, especially greenfield, and the bureaucratic process of obtaining permits for sample export for research. Investment incentives, such as real VAT exemptions for both subsoil users and service companies, are seen as effective tools. A significant issue for the entire mining sector is the non-return of payable VAT, which deters investors.

Another major challenge is the low intensity of geological exploration. A bureaucratic process hampers the export of samples for analysis, with delays due to local accreditation requirements. The only internationally accredited laboratory, ALS Kazgeokhimia, is overloaded, with standard analyses taking 45 to 60 days, which is too long given the short field season in many regions. Accelerating exploration would benefit from the launch of a digital geological information database, which would facilitate AI implementation, expedite site selection, and increase the chances of discovering good deposits.

To replenish the mineral resource base, Solidcore Eurasia actively collaborates with junior companies. The 2017 Subsoil Code simplified exploration rights acquisition, boosting domestic junior business and improving geological study quality. The company has about 20 exploration licenses and several for geological study, covering over 70,000 square kilometers.

Following the sale of Russian assets and the company's rebranding to Solidcore Resources plc, the Company's focus has shifted to prioritizing Kazakhstan. The strategy involves developing processing hubs in eastern and northern Kazakhstan and pursuing greenfield projects to establish new hubs. Long-term growth involves acquiring new deposits with assessed or ready-for-final-evaluation reserves, with domestic junior companies being key partners in this endeavor.

Solidcore plans to invest approximately $1 billion, primarily in building a metallurgical plant in Pavlodar (Ertis POX) and expanding the company's asset portfolio, including exploration and M&A activities.

[2] Kazakhstan's Gold Mining Industry Faces Challenges and Opportunities – MINEX Forum

2. AVAILABILITY AND FEASIBILITY OF INTEGRATING RENEWABLE ENERGY SOURCES

According to Article 1 of the Law of the Republic of Kazakhstan on Support for the Use of RES, renewable energy sources are those that are continually replenished due to natural processes, including the energy of sunlight, wind energy, hydrodynamic energy of water, geothermal energy (heat of the ground, ground water, rivers, and basins), and anthropogenic sources of primary energy (biomass, biogas and other fuels derived from organic waste) used for the production of electric and/or thermal energy[3]. RE Resource Potential in Kazakhstan: Wind: 1,820 billion kWh/year, Hydro: 62 billion kWh/year, Solar: 2.5 billion kWh/year, Geothermal: 4.3 GWt

The wind potential at various sites across the country was studied in accordance with the methodology for estimation of wind potential, in particular annual dynamics of wind characteristics was determined for 15 sites. Based on this work, a Wind Atlas of Kazakhstan and pre-investment studies for these sites were developed. A solar atlas of Kazakhstan was developed in 2017, too.

Wind Energy

Wind energy has the greatest potential among all RES in Kazakhstan. Around half of its territory has an average wind speed of about 4 to 5 m/sec at a height of 30m. The greatest wind potentials are in the Atyrau and Mangystau regions in the Caspian Sea area, and northern and southern Kazakhstan. According to the Republic of Kazakhstan 2030 Concept of the Fuel and Energy Complex Development, the country's wind potential is 1,820 billion kWh per year.

Hydro Energy

Hydropower is the second-largest RES in Kazakhstan. Kazakhstan has an estimated potential of 170 billion kWh per year, of which about 62 billion kWh are technically feasible. The annual hydropower potential of medium and large rivers is 55 billion kWh, and 7.6 billion kWh from small rivers. About 8 billion kWh from small hydropower plants are estimated to be technically feasible. Hydro energy resources are well distributed throughout the country.

Solar Energy

Solar energy has an enormous potential in Kazakhstan. Solar energy can produce about 2.5 billion kWh per year, with 2,200- 3,000 hours of solar per year (2,500-3,000 hours per year in the southern regions) out of 8760 hours.

Geothermal Energy

Kazakhstan is also potentially rich in geothermal resources. Its hydro geothermal resources with temperatures of 40°C to more than 100°C are estimated at 10,275 billion m3 by water rate and 680 billion

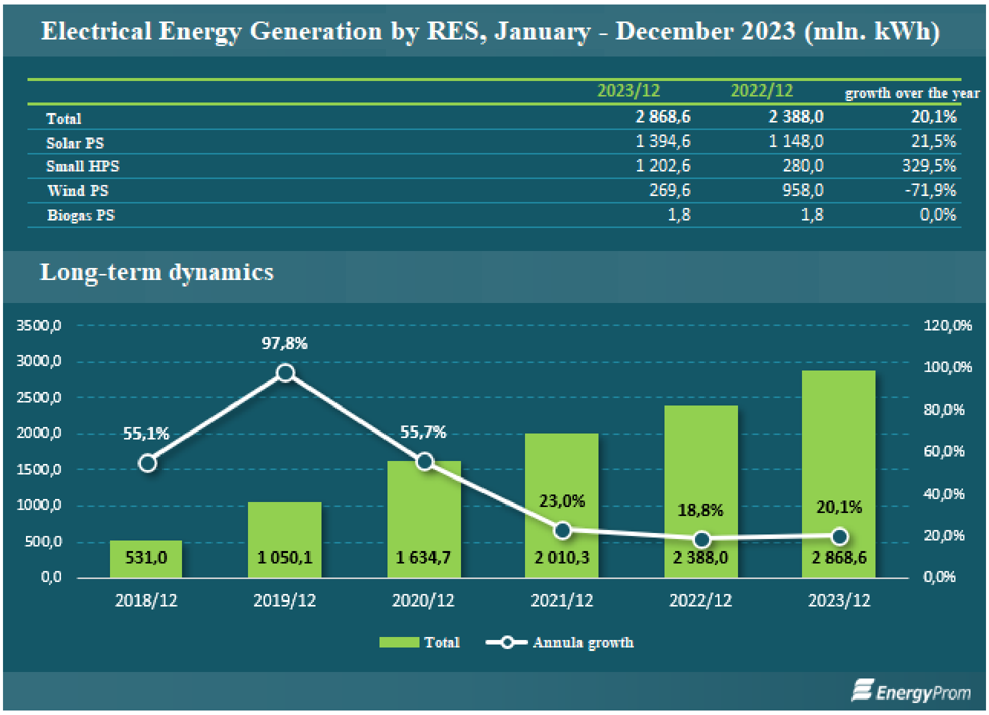
[3] Investors guide to renewable energy projects in Kazakhstan 2022 - USAID (korem.kz)

Gcal by heat rate, which is equivalent to 97 billion toe (ton of oil equivalent) or 2.8 billion TJ, equivalent to the country's estimated fossil fuel reserves. Kazakhstan has estimated hydrocarbon reserves of 12 billion tons of oil and condensate (17.2 billion toe) and about 6-8 trillion cubic meters of gas (7-9.2 billion toe). Its coal reserves are estimated at 150 billion tons (101.0 billion toe). Geothermal sources are located primarily in western Kazakhstan (75.9%), southern Kazakhstan (15.6%) and central Kazakhstan (5.3%).

Biogas Energy

Kazakhstan is a major producer of grain and other agricultural products, which produce a significant amount of waste from crops and manure. The largest volumes of mixed agricultural wastes are available in the Almaty, East Kazakhstan, Zhambyl, Kostanay, Akmola and Karaganda regions.

The Ministry of Energy of Kazakhstan has recently released data on renewable energy sources (RES) electricity generation in 2023[4]. In 2023, the total electricity produced by RES facilities amounted to 6,675.5 million kWh, marking a 30% increase compared to the same period in 2022. Among the various RES sources, wind power plants (WPPs) contributed the largest share with 3,824.99 million kWh, while biopower plants generated the smallest amount at 2.71 million kWh. Additionally, solar power plants accounted for 1,853.95 million kWh, and small hydropower plants (HPPs) generated 993/87 million kWh.



Electrical Energy Generation by RES, January - December 2023 (mln. kWh)

	2023/12	2022/12	growth over the year
Total	2 868,6	2 388,0	20,1%
Solar PS	1 394,6	1 148,0	21,5%
Small HPS	1 202,6	280,0	329,5%
Wind PS	269,6	958,0	-71,9%
Biogas PS	1,8	1,8	0,0%

Figure 1: Electrical Energy Generation by RES (January – December 2023, mln. kWh)

[4] QazaqGreen | News Kazakhstan | Renewable energy accounted for 5.92% of electricity generation in Kazakhstan in 2023

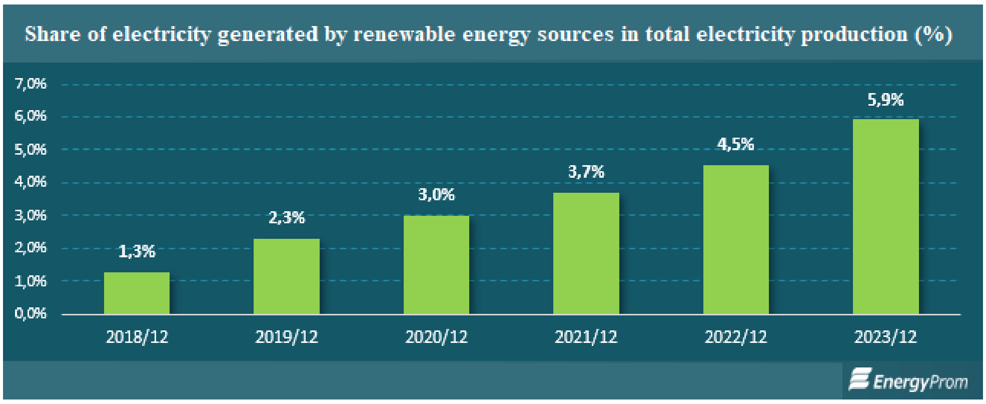


Figure 2: Share of Electricity Generated by RES in total electricity production (%)

Most of the installed capacity came from:

- solar power plants: 1.4 thousand MW, plus 21.5% for the year.
- small hydroelectric power plants: 1.2 billion tenge, annual growth by 4.3 times.
- wind power plants had a capacity of 269.6 MW (minus 71.9%),
- bioelectric power stations - 1.8 MW (the same as a year earlier).

3. CHOOSING APPROPRIATE RENEWABLE ENERGY TECHNOLOGIES BASED ON THE ENERGY DEMAND AND RESOURCE AVAILABILITY

There are objective problems in the development of the renewable energy industry[5].'

First, the amount of electricity generated by RES facilities depends on weather conditions: solar power plants (SPP) - on the intensity of solar radiation, wind power plants (WPP) - on the presence of wind speed. Therefore, in order to include new RES facilities in the energy system, it must be adapted. How? By introducing changes to the regulatory mechanisms for priority dispatch of RES facilities, so that the system operator can regulate - by reducing - the supply of electricity to the grid from RES facilities during a decrease in demand from consumers.

The second is the instability of electricity generation by renewable energy sources. This problem can be solved by the development and implementation of energy storage systems that could store excess electricity and release it into the network during peak demand hours from consumers. At the moment, this industry of energy accumulation and storage is actively developing and it is necessary to introduce appropriate regulatory mechanisms that would establish the obligation to use energy storage systems for new renewable energy facilities. All this will allow balancing the energy system during peak load hours and reducing energy consumption, reducing imbalances in the electricity market from renewable energy sources and increasing the reliability of the energy system in Kazakhstan.

Third, the main problem of Kazakhstan's energy sector is that a large percentage of the installed generation capacity consists of morally and physically obsolete coal power plants dating back to the Soviet era. For the production of electricity from renewable energy sources, the country has "raw materials": wind and solar radiation as natural energy carriers. But there is no mass production of means of generating electricity from them. In order for wind energy and renewable energy sources to become a competitively dominant sector of the economy, not only conditions are needed in the form of raw materials and sales markets, but also industries related to the generation, transport and sale of electricity, many enterprises united in clusters and creating an added value chain from design to final product and even environmentally friendly processing of exhausted RES elements. With this approach, the price of components for

[5] https://kapital.kz/economic/123504/kak-razvivayet-sya-rynok-vozobnovlyayemykh-istochnikov-energii

renewable energy facilities can be reduced due to the effect of scaling production. Insufficient development of the mechanical engineering and electrical engineering industries related to renewable energy sources may become an obstacle to the effective development of the RE industry.

It must also be said that since the amount of electricity sent from renewable energy sources to the power grid over a period of time depends on weather conditions, it is necessary to provide for the presence of additional traditional generating capacities. They operate on traditional fuels, which can be stored and used in the required volume to generate the required amount of electricity. These are the so-called shunting capacities that can balance the country's energy system.

During periods of increased demand for electricity from consumers, when weather conditions do not allow renewable energy facilities to generate more energy - this is evening time for solar plants or calm periods for wind farms. Taking into account the unresolved technical problems for energy storage systems that could balance the energy received from renewable energy sources over time, there will be a need for traditional generating capacities as shunting facilities.

Currently, 147 renewable energy facilities (with a capacity of over 100 kW) with a total installed capacity of 2,903.54 MW are operating in the Republic of Kazakhstan6:

- 59 wind power plants with a total capacity of 1,409.55 MW;
- 46 solar power plants with a total capacity of 1,222.61 MW;
- 39 hydroelectric power plants with a total capacity of 269,605 MW;
- 3 biogas power plants with a total capacity of 1.77 MW.

In 2023, 16 RE facilities with the total installed capacity of 495.57 MW were put into operation:

- 12 wind power plants with a total capacity of 437.1 MW in the Akmola region and the Zhetisu region,
- 2 hydroelectric power plants with a total capacity of 3.7 MW in the Almaty and Turkestan regions and
- 2 solar power plants with a total capacity of 54.77 MW in the Turkestan region.

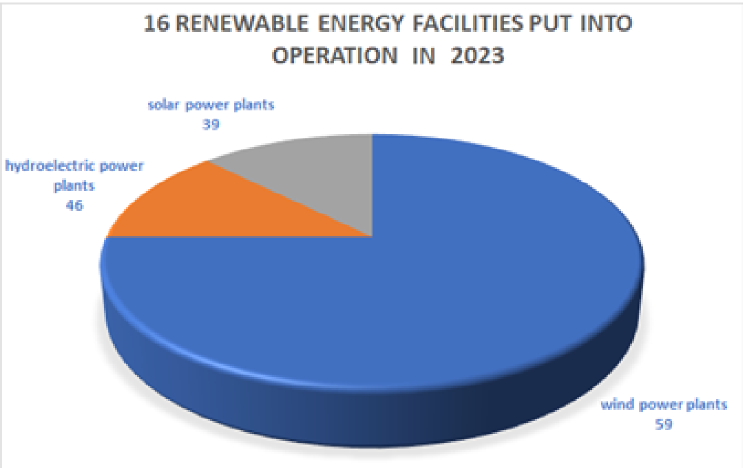


Figure 3 Renewable Energy Facilities Put into Operation in 2023

[6] [Объем электроэнергии, произведенной с использованием возобновляемых источников энергии (ВИЭ), достиг 5,92 % - Svetland-oil.kz]

According to consultant approach, the most popular RES technologies in the Kazakhstan metallurgical industry, are:

- PV plants and Natural Gas Cogeneration Units (like shunting capacities) installation with the partial usage of the generated hot water.
- Wind Power Plants

By 2027, it is planned to commission 25 renewable energy projects with a capacity of 599.85 MW.

4. GLOBAL SOLAR PV GROWTH AND PRICES OVERVIEW

Global annual solar PV installation volumes are scaling up fast, doubling from 2019-2227. Despite high project costs, 35% year-on-year growth is reached from 2022-23. The acceleration is largely driven by the renewable energy installation targets set by many governments to improve energy security and accelerate the transition to clean fuels. South America installed the bulk of new solar PV in 2022 at 88%, followed by Africa with 58%, the Middle East with 41%, Asia with 38%, North America with 37%, and Europe with 28%.

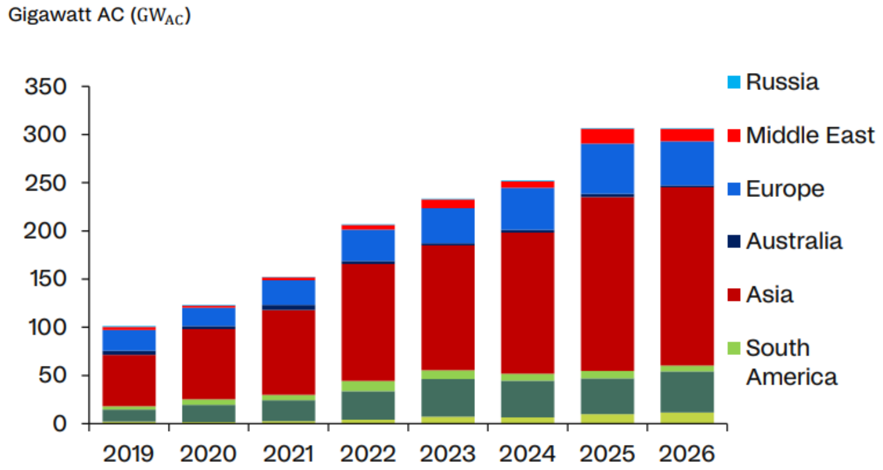


Figure 4: Global solar PV installation by construction year, 2019-2026

Europe was the second-largest region for newly installed capacity last year, after Asia. A total 32 gigawatts (GW) of new solar PV capacity was installed in Europe in 2022, lifting cumulative installed capacity over 200 GW. This represents a 28% increase over 2021 (25 GW) and was a record level. This underscores the solar sector's resilience in the face of ongoing challenges, and Europe's growing reliance on renewables to achieve energy security and decarbonization plans. The new commissioning records were mostly driven by Germany (7 GW), Spain (5.7 GW), Poland (4 GW), and the Netherlands (3.3 GW). In 2023, 36 GW of new solar capacity come online, too. Up to 2030, the EU utility solar PV pipeline totals 104 GW.

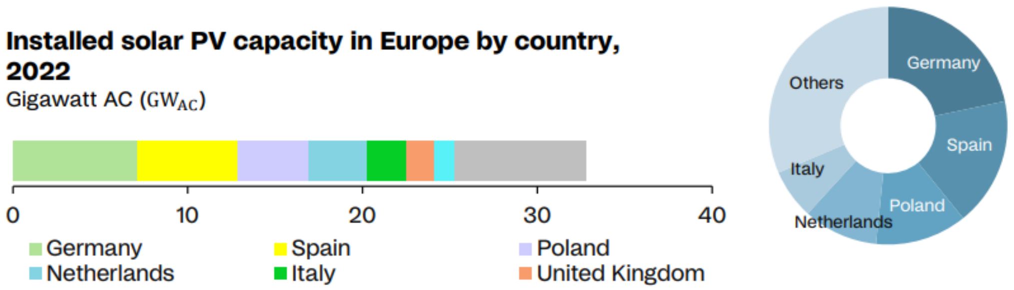


Figure 5: Installed solar PV capacity in Europe by country

[7] [Solar Market Whitepaper 2023 (3e-news.net)]

The EU's Green Deal Industrial Plan aims to boost the competitiveness of Europe's net-zero industry, providing a supportive environment for scaling up solar PV manufacturing. Current goals include ensuring that 40% of solar panels are made within the EU by 2030. While Europe currently has manufacturing capacity across all aspects of the solar panel value chain, these will need to be scaled up. While manufacturing capacity for wafers, cells and modules is set to expand significantly in the coming few years, Europe is the only region without polysilicon manufacturing capacity following the closure of the REC production plant in Norway last year.

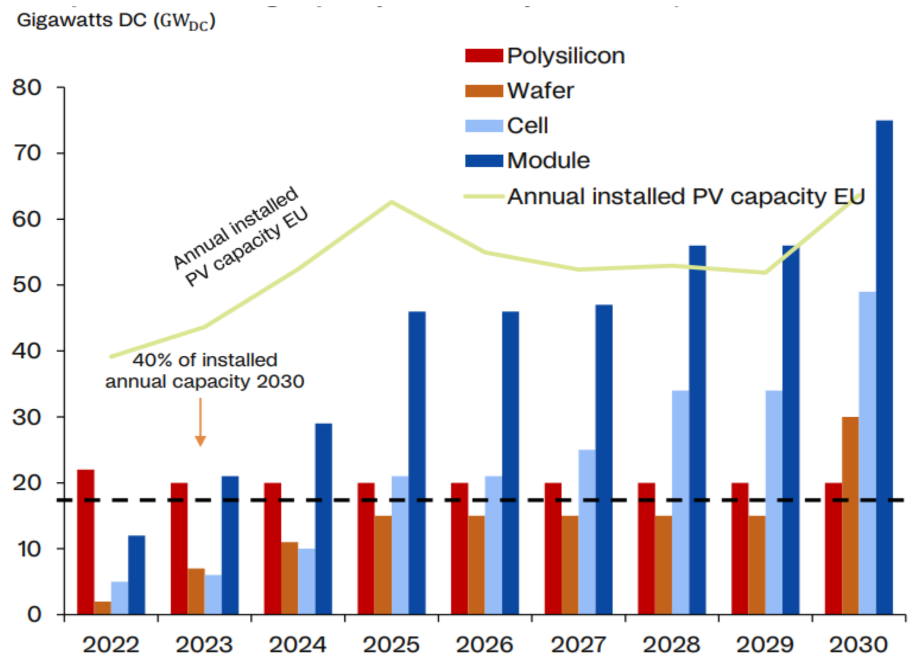


Figure 6: Europe manufacturing capacity: commodity vs demand, 2022-2030

Polysilicon prices hit a turning point in 4Q22 with supply catching up to demand. Other commodities along the value chain followed suit in the beginning of 2023 with module prices in the Chinese market stabilizing around $0.22/watt after the Lunar New Year. Module prices are expected to continue falling as polysilicon prices approach pre-pandemic levels.

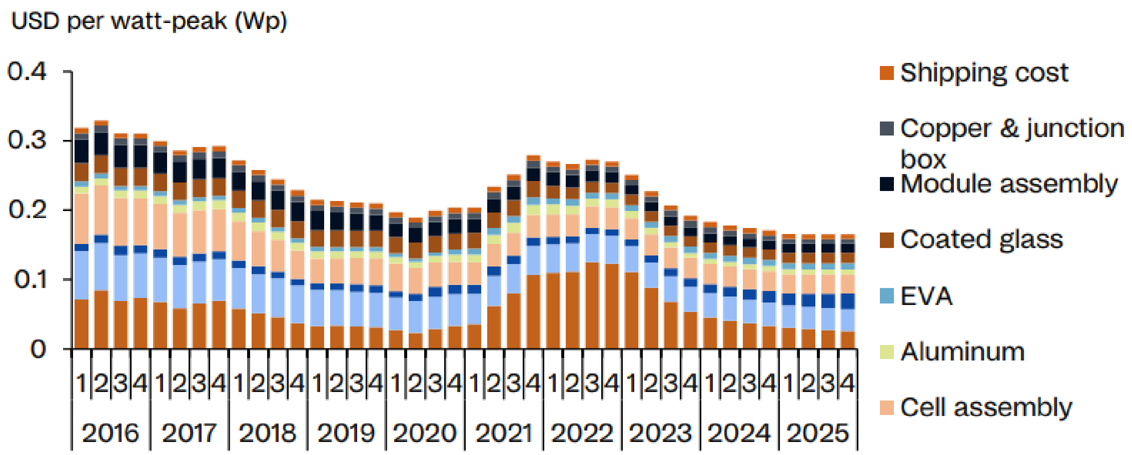


Figure 7: Module manufacturing costs in China

The cost of European solar PV projects significantly increased between 2019 and 2023. This was largely due to the cost of modules, balance-of system components and labor which contributed to a 15% increase as service price inflation rose in most segments. Although module prices have stabilized near 2019 levels, other costs related to balance of system and engineering procurement and construction (EPC) have increased.

Markets that rely heavily on imports from China, such as Europe and Australia, saw elevated module prices fall in late-2022. Module prices in the US and India remain high as supply backlog issues and commodity tariffs persist.

Larger project sizes can, however, benefit from certain economies of scale associated with system installation. On a per watt-peak (Wp) basis, cost reductions can be expected from standardized set-ups of racking and mounting systems, as well as fixed costs such as installation equipment and permitting distributed over larger system sizes.

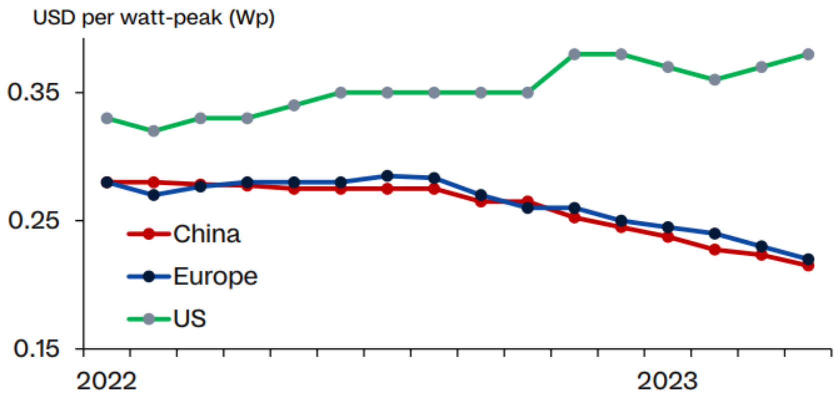


Figure 8 Module spot prices in the US, Europe and China, 2022-2023

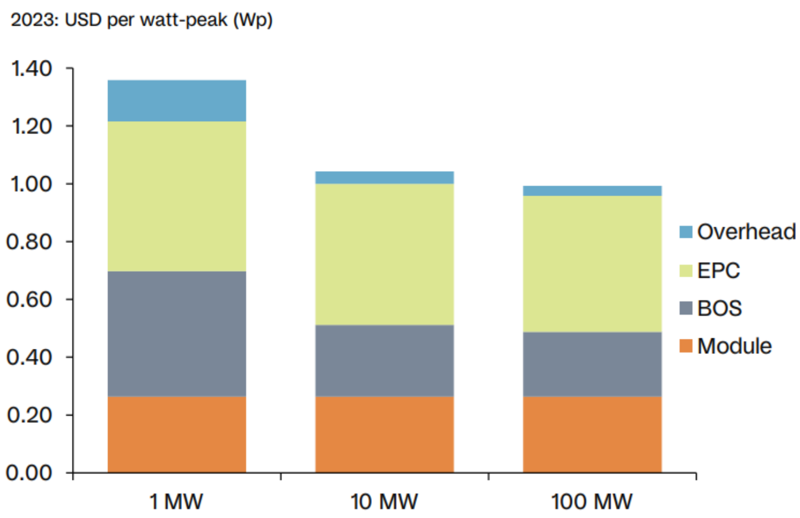
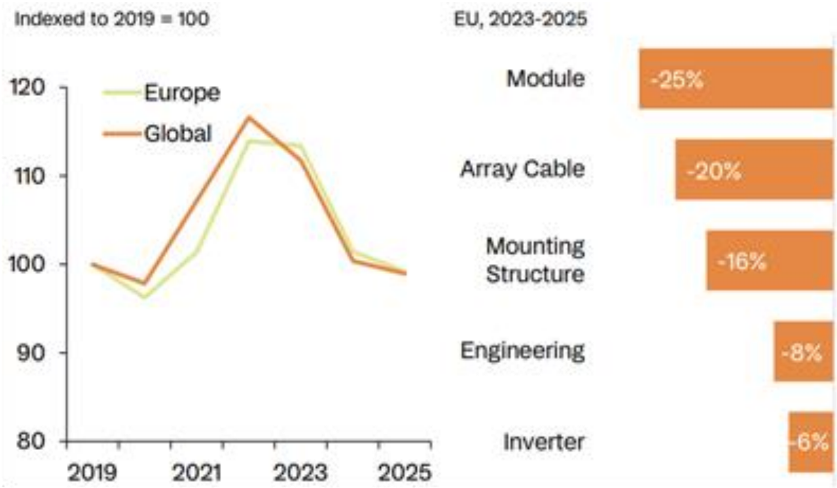


Figure 9: European project costs by system size

Other balance-of-system costs can expect reductions as different types of equipment are chosen. Price of balance-of-system components such as inverters will reduce as central inverters are chosen over string inverters. Lastly, as system set-ups become increasingly simplified with larger project sizes, installation costs are expected to decrease as the difficulty of installation reduces.



Up to 2025, European solar projects are likely to see reduced costs as service price inflation decreases towards 2019 levels. As more Chinese polysilicon, cell and wafer supply is onshore, module prices are likely to fall by at least 25% with Europe expected to continue depending on Chinese module imports.

Figure 10: Solar PV price inflation

Prices for key raw materials such as aluminum, steel and copper are expected to decrease, which may help stabilize prices for key balance of-system components such as mounting structures and cables. Supply chain bottlenecks associated with increasing lead times for inverters are also expected to ease, leading to inverter prices lowering from 2023 onwards as more supply is onshore. Lastly, increased average project sizes will contribute to boost economies of scale, helping reduce the costs of labor-intensive segments as ease of installation increases with more standardized systems.

Operating costs

Operating costs per year needed in order to keep the photovoltaic system working (e.g. cleaning, insurance, new inverter after ~10 years, electricity for inverter, ...). According to average rating, the operating costs can be assumed by between 1.5 to 2.0 percent of the acquisition cost of the solar panel system, annually.

PV and potential savings

The highest solar potential is estimated in Kazakhstan at 3.76 TW of solar photovoltaic energy[8]. According to the Central Asia Data-Gathering and Analysis Team (CADGAT), the potential is 6684 TWh/year.

With 2200–3000 hours of sunlight per year, solar radiation is 1200–1700 kW/m² or, according to another source, 1300–1800 kW/m². The gross, technical and economic potential of solar energy in Kazakhstan is estimated at 1 billion GWh, 1 million GWh and 10 GWh, respectively. Another source estimates the total annual solar energy generation potential in Kazakhstan to be between 3.9 and 5.4 billion kWh.

[8] : https://www.c-o-k.ru/articles/perspektivy-vozobnovlyaemoy-energetiki-v-respublike-kazakhstan

5. SOLIDCORE COMPANY AND PLANNED RE PROJECT

Kazakhstan has embarked on the development of renewable and alternative energy. The President of the Republic of Kazakhstan stated that the RES ratio in the total electricity generation in the country by 2030 must be at least 15%. For these purposes, the Government of the Republic of Kazakhstan has developed the Energy Balance until 2035; and it is also developing a Strategy to achieve net-zero emissions by the Republic of Kazakhstan by 2060. Today, 139 renewable energy facilities with an installed capacity of 2,180 MW operate in the republic, which generate 3.69% of the country's electricity.

Solidcore is one of the leaders in the recovery of precious metals in Kazakhstan with a portfolio of two producing gold mines and an impressive growth project for the new full-cycle pressure oxidation plant. Solidcore's shares are traded on the Astana International Exchange (Kazakhstan).

In order to solve the task of developing RES, the gold mining company Solidcore and the Qazaq Green RES Associations will implement a comprehensive project involving the construction of two solar power plants with a total installed capacity of 40 MW and one gas engine mobile station with an installed capacity of 40 MW to cover the unstable generation of solar stations (according to information presented by Company, 20 MW will be under external electrical grid operator control – independent start/stop engine operation for balancing purposes). The project will be implemented in the Abay and Kostanay regions within five years: 2023 – 2027. The total investment will be around $70 million.

It should be mentioned that the initial project will be divided in to 2 sub-projects:

- In the Abay region compay will construct a 17 MWe (installed capacity) PV park. Company plan to procure PV panels direct from China. Planned panels capacity 700 Wt. The estimative distance between PV park and consumer is around 2 km.
- In the Kostanay region company will install a 23 MWe (installed capacity) PV park plus balancing capacities on Natural Gas. The estimative distance between cogeneration units (CGU) and consumer is around 500 m. According to information provided by the Company, they are involved in the CGU equipment supplier selection process. According to preliminary information, company is in negotiation process with Jenbacher and Caterpillar companies. As for the number of cogeneration units: or 9 units with he installed capacity 4.5 MW or 12 units with the installed capacity 3.3 MW.

The projects location map is presented below:

Figure 11: Solidcore - PV projects location map

As was mentioned earlier, the total project CAPEX is around $70 million, from which:

- Natural gas pipelines, gas distribution system, automation control, CGU units, etc: around $30 million
- PV park in the Abay region around $17.5 million
- PV park in the Kostanay region around $14.5 million[9].

As for the estimative electrical energy tariffs, company presented the following information:

- For Abay region: 30 - 31 KZT/1 kWh
- For Kostanay region: 20 – 21 KZT/1 kWh

Regarding Current annual consumption of the Solidcore company in 2 branches, was presented the following information:

- Abay region - 115 mln. kWh / an
- Kostanay region - 160 mln. kWh/an

Operating costs per year needed in order to keep the photovoltaic system working. According to average rating, the operating costs were assumed 2.0 % of the solar park, annually.

System losses, due to transformer station, inverters, connections and interconnections were assumed at 4.5%.

All earlier presented information is summarized in the figure, below:

Abay region		
Solidcore Resources - Annual Electrical Energy Consumption	115 000.00	MWh/an
Planned installed capasity of the PV park	17.00	MW
Estimated cost of the planned PV park	13.34	mln. Euro
Estimated reduction of the annual electrical energy consumption for the period 2024 - 2035	0.0%	
Green Electrical Energy cost (tariff)	0.051	Eur/kWh

Kostanay region		
Solidcore Resources - Annual Electrical Energy Consumption	160 000.00	MWh/an
Planned installed capasity of the PV park	23.00	MW
Estimated cost of the planned PV park	16.10	mln. Euro
Estimated cost of the planned CGU park	20.10	mln. Euro
Estimated reduction of the annual electrical energy consumption for the period 2024 - 2035	0.0%	
Green Electrical Energy tariff	0.051	Eur/kWh
Natural gas cost (tariff)	7.00	Eur for 1000 nm^3
Electrical energy cost, produced from naturl gas (tariff)	0.037	Eur/kWh

Figure 12: Summary information presented by Solidcore staff and assumed by the expert team

[9] Given information was presented by company staff during MS Teams call, meetings in the ECOJER office and official e-mails exchange.

Having the Kazakhstan solar atlas, projects locations, planned capacities, information regarding the weather condition and already collected data on solar radiation during the previous years, expert team calculated solar radiation and photovoltaic system performance for the Abay and Kostanay regions. It should be mentioned that the PV panels degradation coefficient (decrease in productivity) was considered, too.

According to Solidcore company request, expert team considered the period 2025 – 2038.

5.1 Modeling for Abay region

The following values were calculated for the annual green electrical energy generation by the PV park with the planned installed capacity of 17.00 MW.

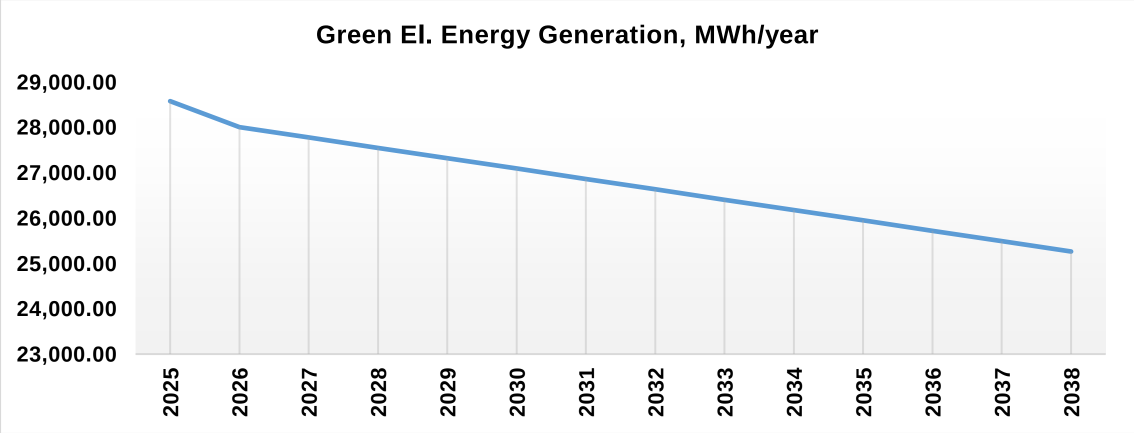


Figure 13: Green El. Energy Generation by PV park, MWh/year

Without the implementation of this solar power plant construction project, electricity for industrial enterprises of Solidcore will continue to be consumed from the power grid with a high Grid Emission Factor. According to the international methodology of the UNFCCC CDM ACM 0002 "Grid-connected electricity production from renewable sources", CO_2 emissions were calculated by multiplying the annual planned electricity generation according to the scenario and the grid emission factor (0.84 tCO_2/MWh).

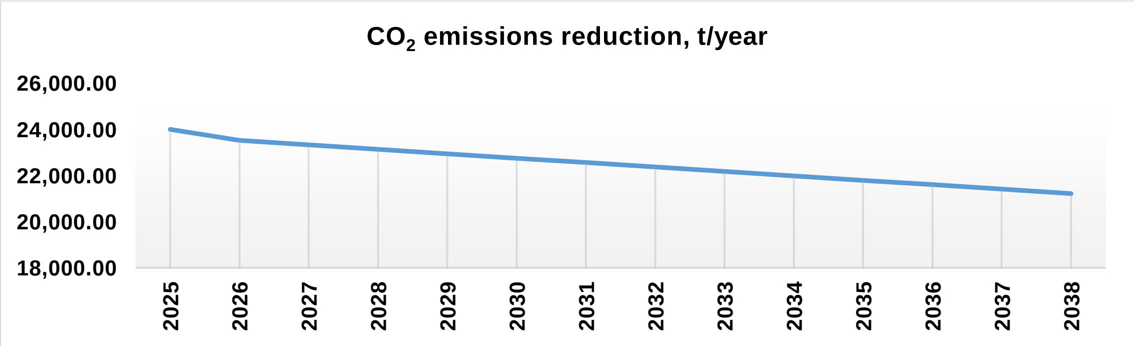


Figure 14: CO_2 emissions reduction due to PV park, t/year

As was mentioned earlier, PV degradation coefficient (decrease in productivity) was considered. This explains the slight decrease in the productivity of photovoltaic panels with each passing year.

The photovoltaic park generates green electricity every year, thus it is possible to determine the amount of green electricity (accumulative value) that the photovoltaic park will produce for the period 2025 - 2038. This information is presented below:

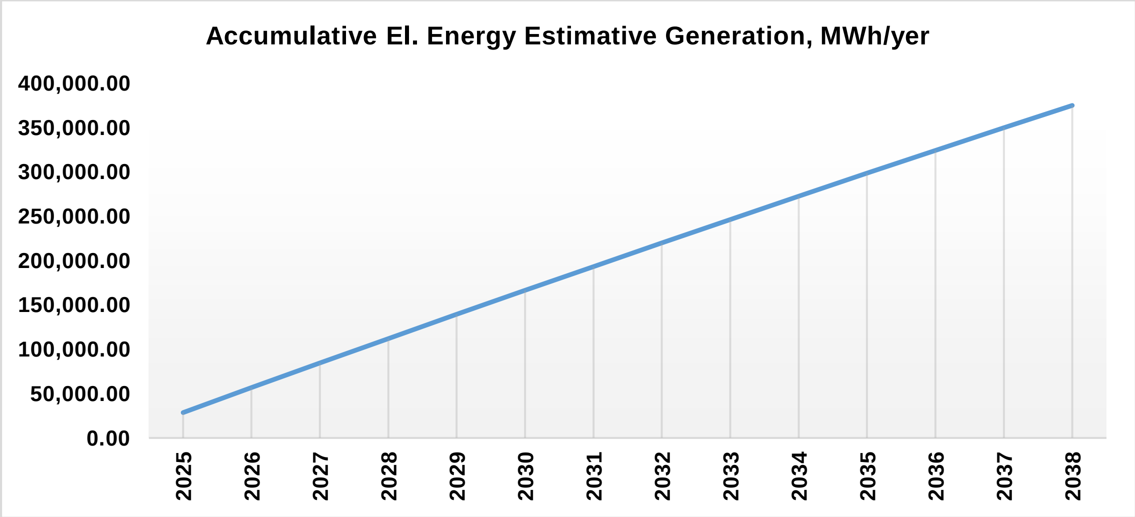


Figure 15: Accumulative El. Energy Estimative Generation by PV park, MWh/yer

At the same time, the accumulative values for the CO_2 emissions, during the period 2025 – 2038, could be calculated, too. This information is presented in the figure, below:

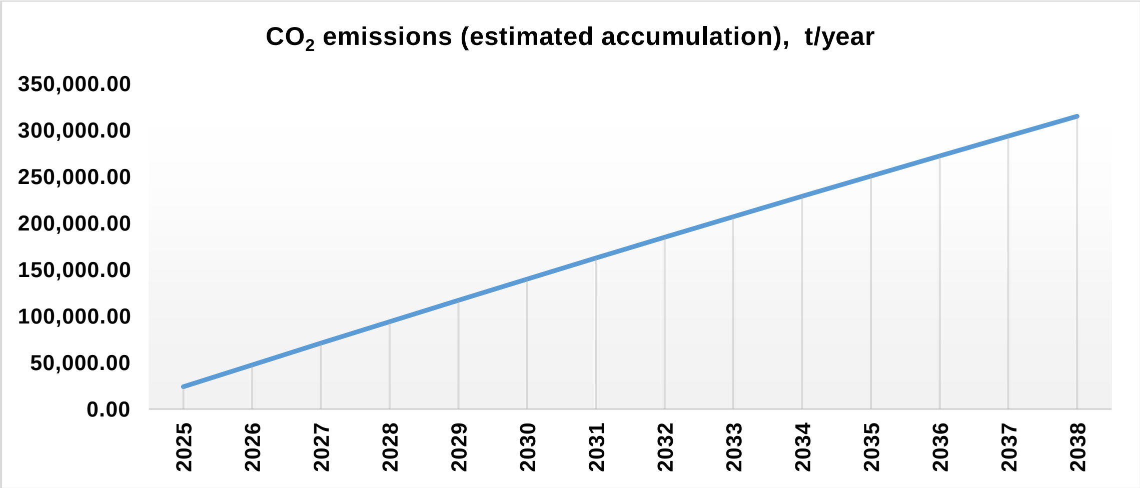


Figure 16: CO_2 Emissions (estimated accumulation) due to PV park, t/year

Considering all earlier presented Input data and respective experts' assumption, the payback period for the PV park was calculated. This is presented in the following figure.

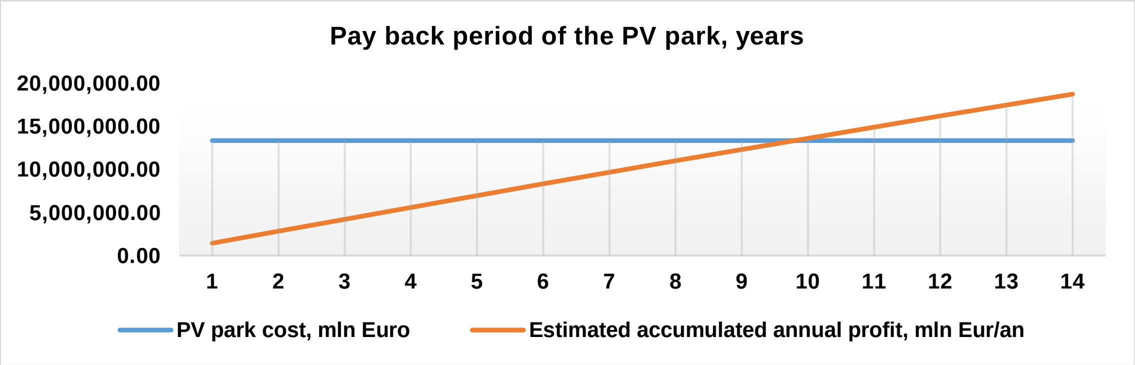


Figure 17: Payback period of the PV park in Abay region, years

5.2 Modeling for Kostanay region

As was mentioned earlier, in the Kostanay region Solidcore company will construct a PV park with the installed capacity of 23 MW and additionally some Cogeneration Units (CGU) will be installed like balancing capacities. The total installed capacity of the CGU park will be 40 MW. It is necessary to cover the unstable generation of solar stations (according to information presented by Company, 20 MW will be under external electrical grid operator control – independent start/stop engine operation for balancing purposes). The following values were calculated for the annual green electrical energy generation by the PV park with the planned installed capacity of 23.00 MW.

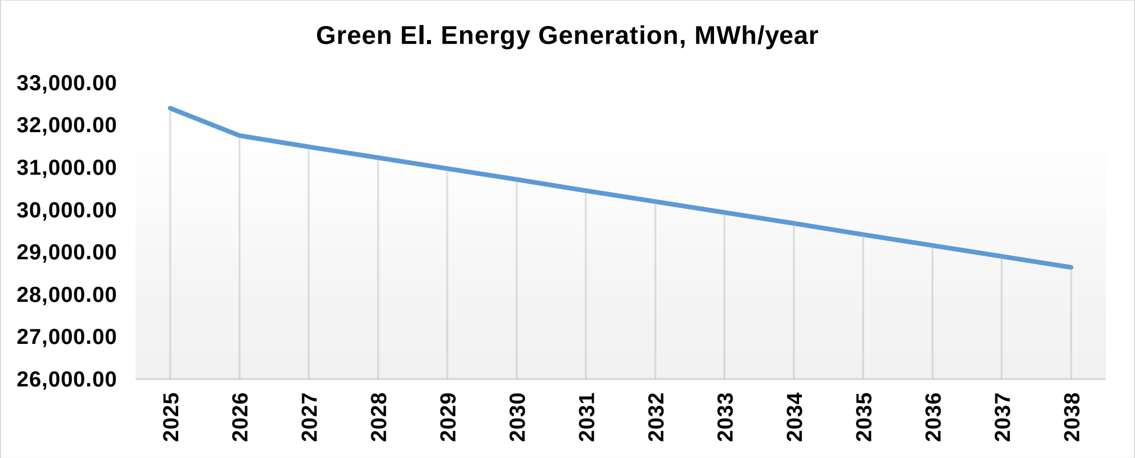


Figure 18: Green El. Energy Generation by PV park, MWh/year

As was mentioned earlier, PV panels degradation coefficient (decrease in productivity) was considered. This explains the slight decrease in the productivity of photovoltaic panels with each passing year.

The same grid emission factor (0.84 tCO_2/MWh) was used.

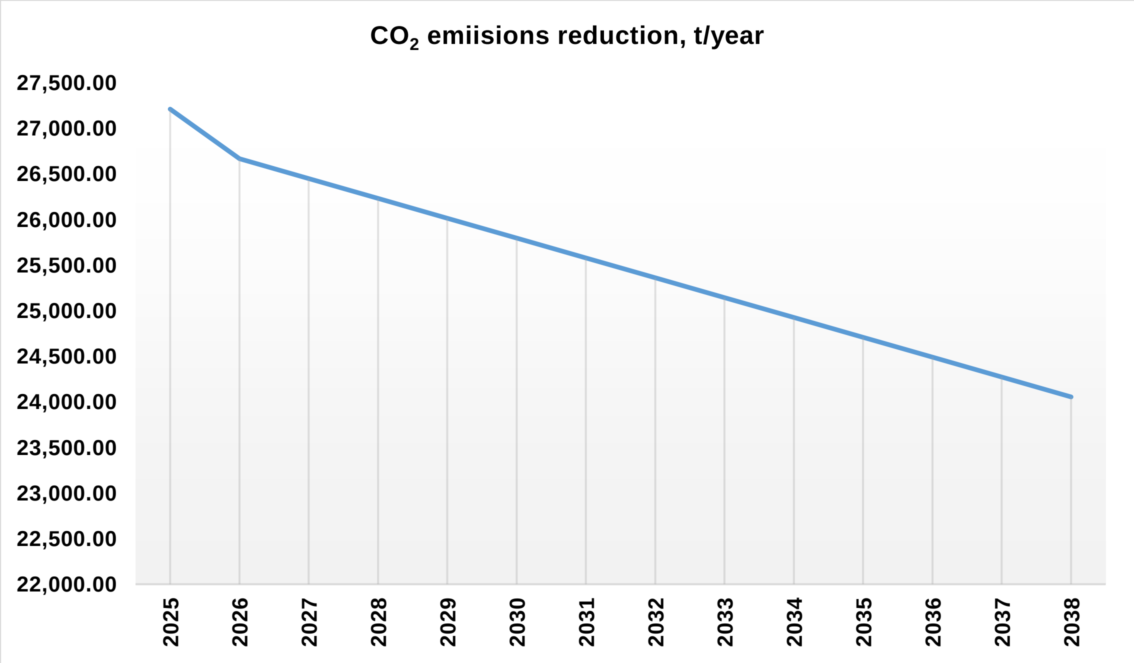


Figure 19: CO_2 emissions reduction due to PV park, t/year

According to provided information, CGU units will operate in parallel with the PV park. In case of CGU units the main fuel will be natural gas. In the modeling process was assumed that Cogeneration Units will operate a certain number of hours per day to compensate the amount of energy generated by the photovoltaic park. For each operational year these hours have been calculated. As a result of the operation of cogeneration units and the combustion of natural gas, company will use own electrical energy (produced from natural gas) and will replace the certain amount of electrical energy (from external electrical grid), produced from coal. As a result of the partial transition to natural gas, the company will significantly reduce CO_2 emissions into the atmosphere. Given CO_2 reduction is presented in the figure below:

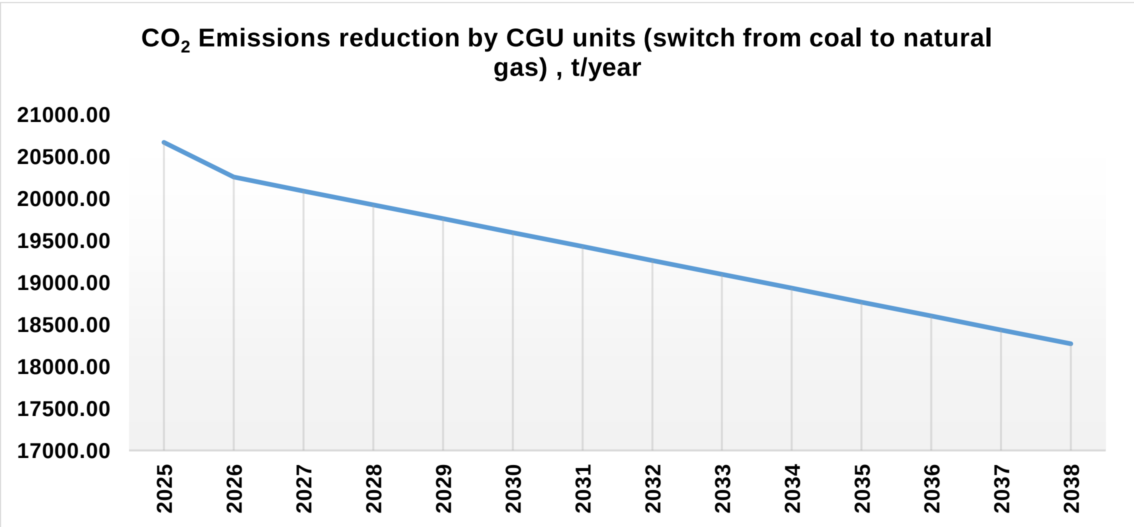


Figure 20: CO_2 emissions reduction by CGU units, t/year (fuel switch)

The resulting emissions (PV park and CGU emissions) are presented in the following figure:

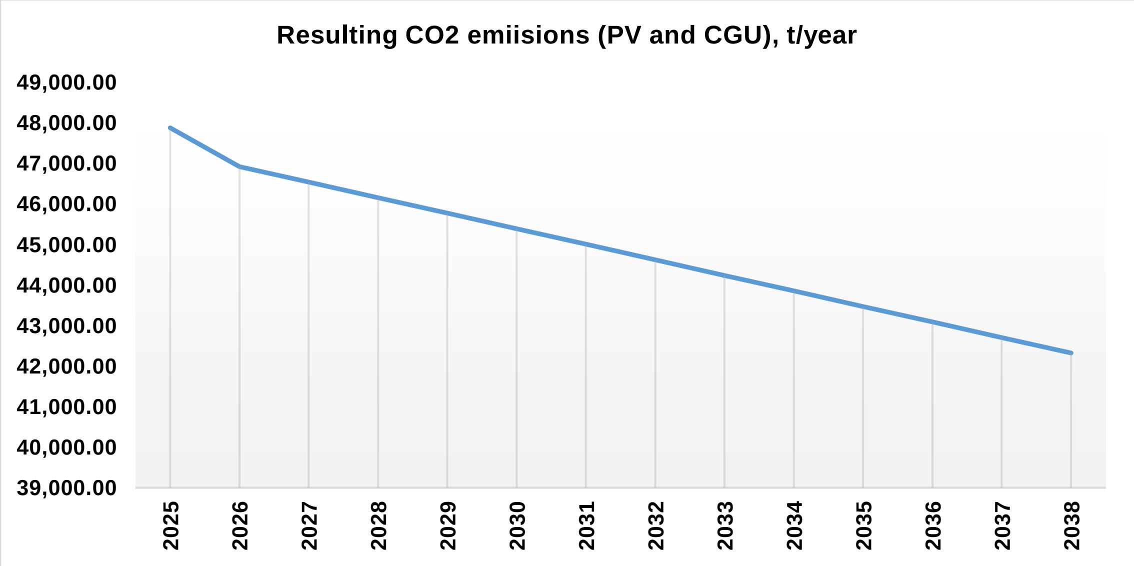


Figure 21: Resulting CO_2 emissions (PV minus CGU), t/year

Considering all earlier presented Input data and respective experts' assumption, the payback period for the PV and CGU units were calculated. This is presented in the following figure.

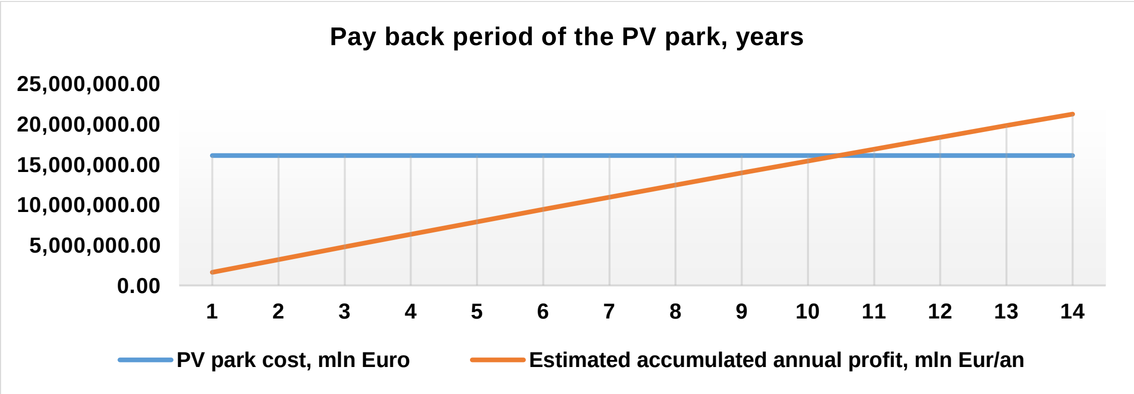


Figure 22: Payback period of the PV park in Kostanay region, years

The estimative payback period for the CGU units makes around 13.9 years.

5.3 Common modeling results for PV parks and CGU units for Abay and Kostanay regions

Regarding Current annual consumption of the Solidcore company in 2 branches, was presented the following information:

- Abay region - 115 mln. kWh / an
- Kostanay region - 160 mln. kWh/an

Summary results for Abay region:

The share of the green electrical energy, generated by the planned PV park, is presented below:

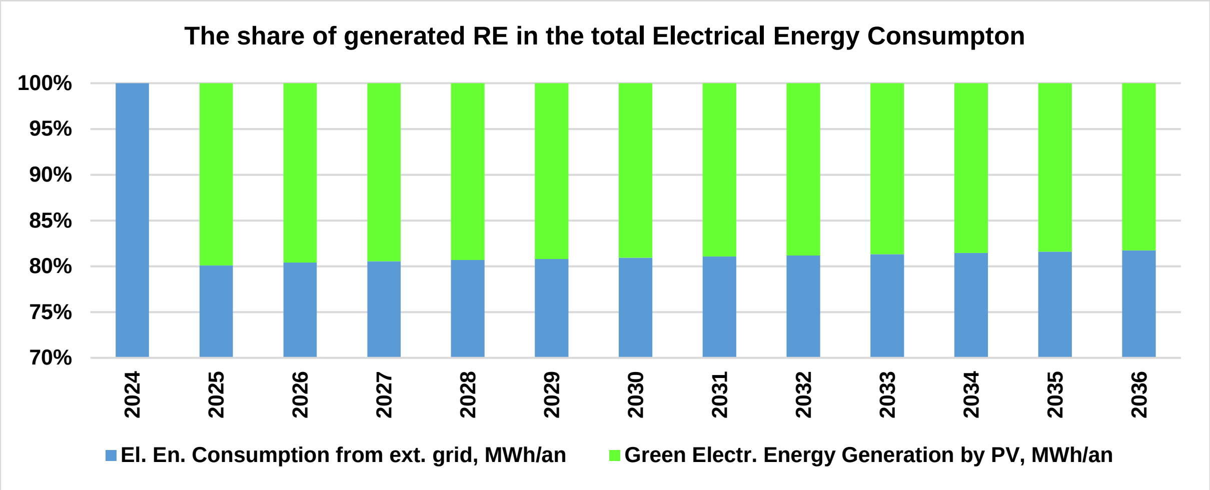


Figure 23: The share of generated RE in the total Electrical Energy Consumption in Abay region

Summary results for Kostanay region:

The share of the green electrical energy, generated by the planned PV park, is presented below:

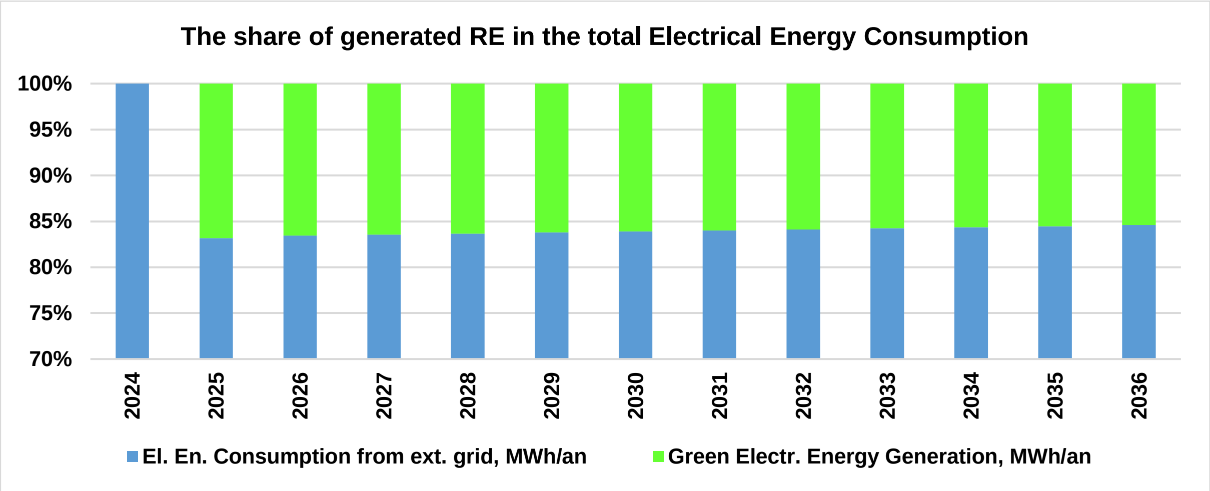


Figure 24: The share of generated RE in the total Electrical Energy Consumption in Kostanay region

6. SUMMARY RESULTS FOR BOTH BRANCHES: ABAY AND KOSTANAY

Information about current electrical energy consumption (Abay and Kostanay branches) and respective consumption reduction after PV and CGU units installation is presented below.

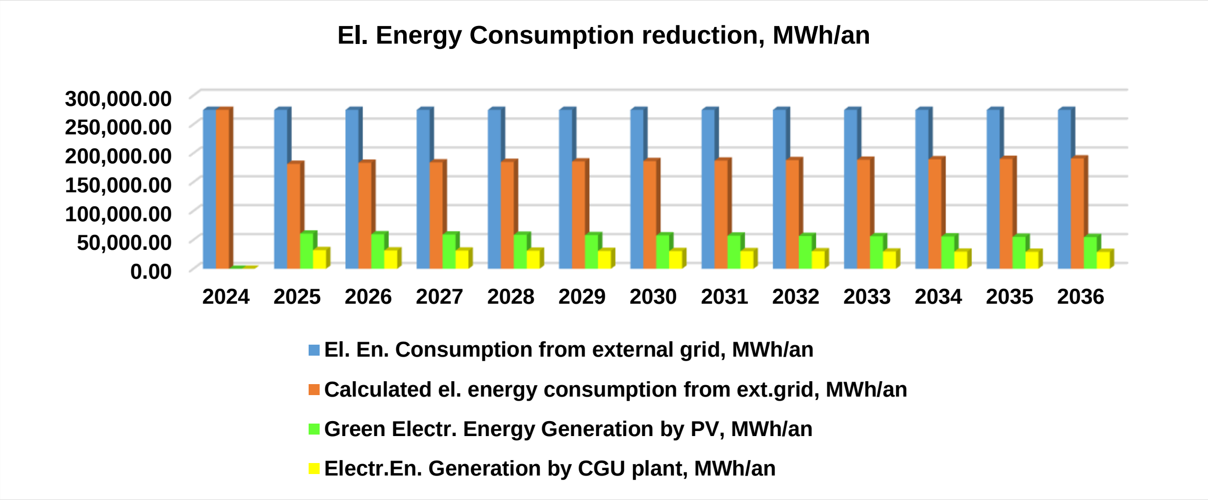


Figure 25: Electrical energy consumption reduction for Abay and Kostanay branches

On figure 27 the electrical energy consumption from external electrical grid by two branches (Abay and Kostanay) are marked with the blue color. Due to installation of the PV parks and CGU units, the electrical energy consumption from external electrical grid will be reduced – red color. The green electrical energy generation by PV parks is marked green and contribution of CGU units is marked yellow. An average calculated electrical energy consumption reduction from external electrical grid makes 32.1 %.

Information about current CO_2 emissions (Abay and Kostanay branches) and respective CO_2 emissions reduction after PV projects implementation, is presented in the figure below.

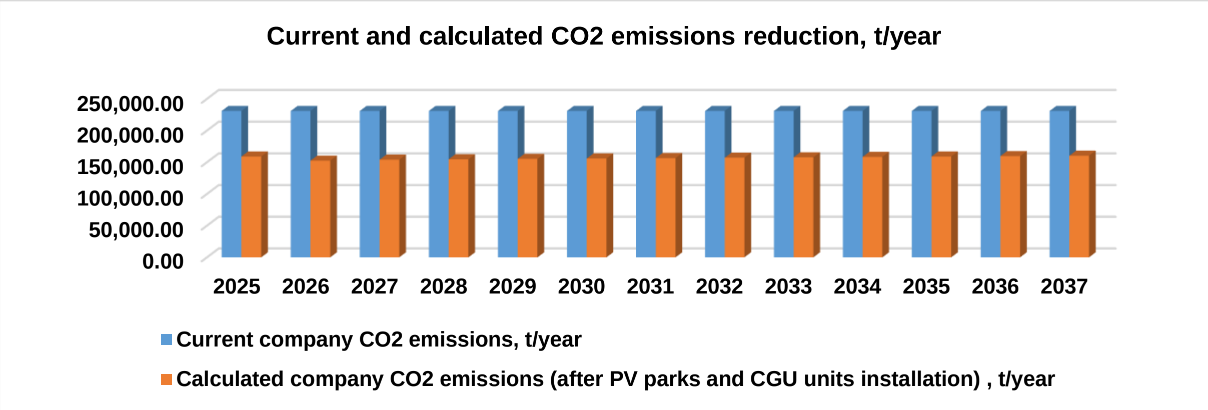


Figure 26: CO_2 emissions reduction for Abay and Kostanay branches

The combined reduction of CO_2 emissions (photovoltaic park plus the transition from coal to natural gas in the CGU units) will be reduced by the amount of emissions into the atmosphere from the combustion of natural gas during the operation of the CGU. The average calculated CO_2 emissions reduction makes 29.3 %.

ANNEX

Provided and assumed information for the business model

Information provided by company:

- The initial project will be divided in to 2 sub-projects:
  - In order to solve the task of developing RES, the gold mining company plan to implement a comprehensive project involving the construction of two solar power plants with a total installed capacity of 40.0 MW and one gas engine mobile station with an installed capacity of 40 MW (in Kostanay region) to cover the unstable generation of solar stations (according to information presented by Company, 20 MW of CGU units will be under external electrical grid operator control – independent start/stop engine operation for balancing purposes). The project will be implemented in the Abay and Kostanay regions within five years: 2025 – 2030. The total investment will be around $70 million.
  - In the Abay region company will construct a 17 MWe (installed capacity) PV park. Company plan to procure PV panels direct from China. Planned panels capacity 650/680 Wt. The estimative distance between PV park and consumer is around 2 km.
  - In the Kostanay region company will install a 23 MWe (installed capacity) PV park plus balancing capacities on Natural Gas. The estimative distance between cogeneration units (CGU) and consumer is around 500 m. According to information provided by company, they are involved in the CGU equipment supplier selection process. According to preliminary information, company is in negotiation process with the Jenbacher representative and Caterpillar companies. As for the number of cogeneration units: or 9 units with he installed capacity 4.5 MW or 12 units with the installed capacity 3.3 MW.
- As was mentioned earlier, the total project CAPEX is around $70 million, from which:
  - Natural gas pipelines, gas distribution system, automation control, CGU units, etc: around $38 million
  - PV park cost in the Abay region around $17.5 million
  - PV park cost in the Kostanay region around $14.5 million.
- As for the estimative electrical energy tariffs, company presented the following information:
  - For Abay region: 30 - 31 KZT/1 kWh
  - For Kostanay region: 20 – 21 KZT/1 kWh
- Regarding Current annual consumption of the Solidcore company in 2 branches, was presented the following information:
  - Abay region - 115 mln. kWh / an
  - Kostanay region - 160 mln. kWh/an
- According to the international methodology of the UNFCCC CDM ACM 0002 "Grid-connected electricity production from renewable sources", CO_2 emissions were calculated by multiplying the annual planned electricity generation and the grid emission factor (0.84 tCO_2/MWh).

Assumptions:

- Operating costs per year needed in order to keep the photovoltaic system working. According to average rating, the operating costs were assumed 2.0 % of the solar park, annually.
- The PV panels degradation coefficient (decrease in productivity) was considered, too.
- System losses, due to transformer station, inverters, connections and interconnections were assumed at 4.5%.
- Grid emission factor for natural gas: 0.202 tCO_2/MWh. This emission factor is used by EBRD in different calculation tools (emission factor for natural gas in case of cogeneration technologies)
- Hot water utilization (from CGU units) in the technological process/own necessities: 20%