KfW Development Bank

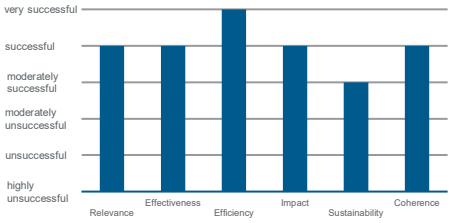
Ex post evaluation
Electricity supply Zaatari Camp, Jordan

Title	Electricity supply for host communities and Syrian refugees, Zaatari Camp, in Jordan		
Sector and CRS code	Energy, 23		
Project number	2015 40 665		
Commissioned by	Federal Ministry for Economic Cooperation and Development (BMZ)		
Recipient/Project-executing agency	Ministry of Design and International Cooperation/Ministry of Energy and Mineral Resources		
Project volume/ Financing instrument	*EUR 15.0 million/SI refugees grant*		
Project duration	*December 2015 – June 2019*		
Year of report	2022	**Year of random sample**	2022

Objectives and project outline

The objective at outcome level was to help secure the electricity supply for the refugees at Zaatari Camp and stabilise the grid for the host communities. At impact level, the project contributed to reducing the economic and social consequences of the Syrian war in Jordan by supplying Jordan with an ecologically more sustainable electricity supply. The construction of a photovoltaic system exploited the great potential for solar energy in Jordan.

Overall rating:
successful



Key findings

The project had a high developmental relevance due to the significant improvement of the electricity supply in the Zaatari Camp and made a contribution to reducing the economic and social consequences of the Syrian war in Jordan. It is the largest photovoltaic system in refugee camps in the world and is considered a leading example of clean, affordable and more sustainable access to energy in refugee camps, thus contributing to Jordan's ecologically more sustainable and cost-efficient electricity supply. Overall, the project is rated as successful:

– The most important reason for the successful assessment of relevance is the role of electricity supply as a basic need and an important prerequisite for a dignified life for refugees.

– The hours of electricity supply were increased from just 6 hours per day to 11.5 hours per day. At the same time, annual electricity costs fell from around USD 4.3 million to around USD 360,000 in the first three years after the plant was commissioned.

– 99% of households in the Zaatari Camp have electronic household appliances. With average electricity consumption of 2.6 kWh per household per day, Zaatari performs significantly better than other refugee camps around the world. This is also due to the cost-efficient provision of electricity by the solar power system.

– Only in terms of sustainability is it unclear to what extent a structure with the Ministry as the executing agency on the one hand and UNHCR as the operator on the other is organisationally sustainable in the long term.

Conclusions

– The lack of prequalifications enabled rapid implementation in favour of improving living conditions for the target group.

– Due to capacity constraints, the electricity supply cannot increase indefinitely and measures are needed in the future to keep electricity consumption under control while satisfying the basic needs of all refugees.

– The project shows that photovoltaic systems are also suitable as clean, affordable and cost-efficient electricity generation solutions in refugee camps.

Rating according to DAC criteria

Overall rating: 2

Relevance

Jordan has taken in many refugees as a result of the conflict in Syria. At the time of the EPE, almost 750,000 refugees lived in Jordan. This is close to one in every fifteen inhabitants of the country. Around 650,000 of the refugees currently living in Jordan come from Syria. The integration of refugees poses major challenges for the country. One of the two most important refugee camps in Jordan is the Zaatari refugee camp, which was built in 2012. It was originally intended to serve as a stop-off point for accommodating refugees in the Azraq Camp (about 80 km away, in central-east Jordan). However, the refugees already settled in Zaatari refused to switch. Since the camp was founded, more than 400,000 Syrian refugees have lived in Zaatari. At the time of the project appraisal, there were around 80,000 refugees. This figure was constant at the time of the EPE at 80,970 refugees. Meeting the basic needs of refugees at Zaatari Camp is an important prerequisite for living as dignified a life as possible. Access to sustainable energy should serve as a bridge between emergency aid and development, facilitate refugees' educational opportunities, support entrepreneurship and innovation, and promote the well-being of people and communities (IRENA & UNHCR, 2019). According to the Moving Energy Initiative (Global Plan of Action for Sustainable Energy), around 97% of people living in refugee camps have limited or no access to energy. However, many of the fundamental rights, such as the right to social security or to a dignified standard of living (Article 22 and Article 25 of the UN Declaration on Human Rights, respectively), can only be ensured if there is a sufficient supply of energy. The UNHCR recognises the importance of energy access for well-being and aims to electrify refugee camps based on sustainable solutions and the integration of renewable energies.

Jordan's energy sector is highly dependent on imports. At the same time, Jordan has a very high potential for solar energy with an estimated solar radiation of approx. 2,085 kWh/m². Nevertheless, the share of renewables in Jordan's electricity generation was only 0.7% at the time of the appraisal. Jordan is one of the 20 countries in the world with the least amount of water, while at the same time having high solar and wind potential. In this context, expanding photovoltaics based on minimal water use is particularly advantageous (Tianyi Luo, 2018). The reception and care of over 650,000 refugees presented Jordan with considerable economic and social challenges. In particular, the northern region of Jordan bordering Syria, in which Syrian refugees are predominantly based, is poorer than the national average and is therefore more susceptible to potentially negative economic and social consequences of immigration. The project was therefore in line with Jordan's strategies for tackling the refugee crisis and developing a sustainable energy supply.

The impact chain was as follows: With the expansion of a PV system in the Zaatari refugee camp -> the demand for energy in the camp from energy sources outside the camp decreases -> this relieves the power grid of the host communities -> ultimately there is a higher acceptance of the refugees by host communities -> and within the refugee camp the energy is used for productive use. At national level, the role of renewable energies should be strengthened. The impact chain is still plausible today.

Supporting the Zaatari refugee camp and relieving the burden on host communities while promoting the expansion of renewable energies in Jordan is still highly relevant. The impact chain/project concept is relevant from the perspective of the time and the present. The relevance of the project is rated as good.

Relevance rating: 2

Coherence

The project complemented the German government's support for refugees and host communities in northern Jordan in a targeted manner in the transition from emergency aid to resilience-building measures. As part of its financial cooperation, the Federal Government financed projects in Jordan in the water supply, sanitation and education sectors, among others. Ensuring electricity supply through the photovoltaic system in Zaatari Camp complements the Stabilisation of Neighbouring Countries Syria Crisis project, in

particular, which provided complete piped water supply and sanitation systems in Zaatari Camp. As a result, electricity, water supply and waste water disposal are available throughout the entire refugee camp. Furthermore, the project fits well into the follow-up phase, in which a clearer focus was placed on the communities and supply facilities affected by the refugee flow. Through solar power generation, the project also contributes to the implementation of Agenda 2030 goals, to which the German Federal Government has committed itself (SDG 7: Affordable and clean energy). The photovoltaic system provides clean, cost-efficient and more reliable access to energy for refugees at Zaatari Camp. By replacing cost-intensive electricity from the grid and making significant savings on the part of UNHCR, the project meets a prerequisite for alleviating poverty (SDG 1) and boosting socio-economic development. Finally, SDG 7 is closely linked and indispensable for the achievement of further SDG objectives such as SDGs 2, 3, 8 and 10.

UNHCR collaborated very well in the implementation of the project and coordinated the measures. UNHCR also made its own contribution in this sense, as it expanded and upgraded the initially rudimentary network infrastructure at Zaatari Camp. This is also currently being operated with the help of an external company. Due to the urgency of the project, the project-executing agency MEMR built on an existing list of prequalified companies in previous photovoltaic projects when awarding contracts for supplies and services. The executing agency currently plays no active role in the project. As the owner of the facility, the project-executing agency ensures operation and maintenance of the facility after a possible closing of the camp/withdrawal of UHNCR. UNHCR acted as coordinator for donor activities. In the energy infrastructure department, Zaatari Camp received support from Japanese DC in addition to FC. This financed a 33 kV line to which the FC-financed photovoltaic system was connected. UNHCR has also trained around 150 electricians with financial support from Japanese DC. Two trained/experienced electricians are working on the operation of the photovoltaic system.

In summary, it can be said that the measure was well embedded in the German contribution in Jordan and was implemented together with other donors. Overall, the coherence criterion is therefore rated as good.

Coherence rating: 2

Effectiveness

The objective at outcome level was to help secure the electricity supply for the refugees at Zaatari Camp and stabilise the grid for the host communities. The following indicators are used to assess target achievement:

Indicator	Target value	Actual value at EPE
(1) Coverage of electricity demand in the refugee camp by PV system	75% (15 GWh)	113% (22.7 GWh)
(2) Reducing the congestion of the electricity grid in northern Jordan (host communities)	N/A	N/A
(3) Contractually guaranteed energy quantity/per year	24.4 GWh	22.3 GWh

Indicator (1): The PV system met or significantly exceeded the project's objective of meeting the demand for electricity at Zaatari Camp. However, it is important to mention that the plant has been expanded by 1 MW. In 2021, the output of the PV system was 22.7 GWh, which represents 113% of the electricity supply for the residents of the camp compared with the target value of 75% (project appraisal). At the same time, the number of hours of electricity supply per day was increased from just 6 hours at the time of the evaluation to 11.5 hours at the time of the EPE. According to UNHCR and focus groups with refugees, 100% of containers/households in the camp are illuminated.

Indicator (2): The achievement of the programme objective in terms of reducing congestion on the electricity grid for the host communities could not be assessed in the EPE. Due to a lack of available data, no indicator was assigned at the time of the appraisal. In addition, no retrospective quantification could be carried out as part of the EPE due to a lack of network modelling scenarios. Qualitatively, based on discussions with representatives of the host communities and the mayor of the municipality of Zaatari, it can be said that electricity supply is one of the few services in northern Jordan that runs trouble-free. The region's grid operator also confirmed that, in spite of the doubling of electricity connections in the wake of the Syrian crisis, the electricity supply in northern Jordan functions 24 hours a day. However, these positive statements cannot be quantified as the project-executing agency did not share the data.

Indicator (3): The plant's average annual electricity production from January 2018 to December 2021 was 22.3 GWh. However, an energy volume of 24.7 GWh in the first year was contractually agreed, with an average of 24.4 GWh guaranteed in the first four years of operation. This means that the previous output of the system is approximately 8% below the contractually guaranteed energy quantity. At the time of the assessment, an annual energy output of about 20 GWh was approximated based on the estimated solar irradiation of the region. The quantity guaranteed by the general contractor was initially set at 21.6 GWh and subsequently increased by a further 1 MW to 24.7 GWh when the plant was increased. This is significantly more optimistic than the initially guaranteed quantity, which may explain the lower production. With the advancing technical degradation of solar modules, electricity production will fall by around 0.5% per year in the future. Significant effects on the quality of service for residents are not to be expected as a result.

No unintended negative impacts of the project were identified.

Overall, the objectives at outcome level were largely achieved or more than achieved, insofar as data is available. The effectiveness of the project is therefore rated as good.

Effectiveness rating: 2

Efficiency

In the invitation to tender of the general contractor for the supplies and services contract as well as the initial operation of the plant, it was possible to make use of existing lists of prequalified companies. They were invited to submit a tender. As these were the beginnings of renewable energy projects in Jordan, the interest of companies to gain a foothold in the sector was high. Furthermore, the project was the first to make use of the previously adopted regulatory framework of a net metering scheme.

The high number of bidders reduced the originally planned costs so that the planned capacity of the PV system could be increased from 10 MWp to 12.9 MWp. In addition to the construction of the 12.9 MWp photovoltaic system, the FC funds were also used to fund three years of operation and maintenance services by the general contractor, as well as spare parts and special tools for five years of operation. In addition to project implementation, the implementation consultant's services also included monitoring plant operation for a period of three years. Production efficiency is reasonable and in line with market rates.

The current operator has experience in operating PV systems. The deficiencies identified during the final inspection, such as inadequate storage of the replacement modules, glass breakage of the modules and shadow and fire hazards due to vegetation, have been remedied or were not present at the time of the EPE. After expiry of the contract with the general contractor, UNHCR outsourced maintenance and operation of the system to a Jordanian company and for the handover and transfer of knowledge between general contractor and successor operator. The annual operating and maintenance costs are USD 725,735 and are 100% borne by UNHCR. Compared with the operating and maintenance costs of the first three years (average EUR 360,238), these are significantly higher. At the time of the EPE, the total annual expenditures account for only a quarter of the electricity costs before the project was implemented. In the first year after commissioning the PV system, UNHCR's annual electricity costs fell from around USD 4,325,136 to just USD 373,183. With the exception of 2021, where the increase in the electricity supply to 16 hours/day was accompanied by annual electricity costs of USD 2,182,498, these remained low or at a fraction of the costs before the plant was put into operation for the entire period since the plant was put into operation. These savings are a significant relief for UNHCR's financial burden, especially in the

context of the continued existence of the Zaatari Camp and the tight budget allocations. The allocation efficiency is therefore rated as very good.

The measure had a very high allocation efficiency and freed up resources that can be used elsewhere. Production efficiency also performed very well, as a larger capacity was financed with the same funds. Overall, the efficiency criterion is rated as very good.

Efficiency rating: 1

Overarching developmental impact

The objective at impact level was to contribute to reducing the economic and social consequences of the Syrian war on Jordan by supplying Jordan with an ecologically more sustainable electricity supply.

The following indicators are used to assess target achievement:

Indicator	PA status	Ex post evaluation
(1) Access to lighting for learning	2–3 hrs/day	6–8 hrs/day
(2) Possession of electrical household goods such as refrigerators, washing machines and televisions	N/A	99%
(3) Share of renewable energies in electricity generation in Jordan	0.7%	26%
(4) CO2 savings	-	15,600 t/p.a

With the help of the project, the hours of electricity supply in the Zaatari Camp were increased from just 6 hours a day (PA) to 11.5 hours per day (EPE). According to the refugees surveyed and UNHCR, this is a significant improvement in the electricity supply in the refugee camp.

This development is noticeable in several areas of refugees' lives:

1) Education: Access to lighting in the evening hours enables reading and social activities in the households and community centres in the camp. Especially as more than half of the residents of the refugee camp are children, lighting for learning and doing homework in the evening hours is of great importance. Lighting as an important driver of the academic performance of children is proven in various studies (Lekan-Kehinde and Asojo, 2021; Esper, London and Kanchwala, 2013). Around 32 schools are run in Zaatari and lessons are given in shifts (girls and boys in separate groups). During the pandemic, the electricity supply was increased to 16 hours a day to enable remote learning without disruption. Adults also benefit from this by having easier access to online courses.

2) Residents in the Zaatari refugee camp have also used the improved electricity supply to purchase household electrical goods such as refrigerators, washing machines and television sets. According to UNHCR, 99% of households use this equipment. But heaters that are not supposed to be operated with electricity are also used in winter, as well as air conditioners in summer. This leads to potentially negative effects and can result in network failures (see also Sustainability indicator). Food and medicine storage is much easier with refrigerators, which has prevented food waste and increased food supply in stores. The contribution of the electricity supply to food and drug safety (refrigerators in households and healthcare facilities) was also underlined by information from UNHCR and random interviews with refugees. Surveys on the shopping street in Zaatari's refugee camp revealed that food retail operators in particular (fruit and vegetables, dairy products) require an uninterrupted power supply. To bridge the time without electricity from the solar power system, they have various solutions in their stores. Most people use used car batteries and diesel generators, while few who have been able to raise the investment funds have installed

small photovoltaic systems on their roofs. Around 60% of households have purchased washing machines based on improved electricity and water supply. This benefits women and girls through less physically demanding work for hand washing and gives them more free time for other activities. UNHCR (2018) estimates the time gained in this way to be approx. 2–3 hours per day. The average electricity consumption per household and day is 2.6 kWh. With this consumption, Zaatari refugee camps are between Tier 3–4 in terms of energy access. Access to energy is measured by ranking from 0 to 5 (Bhatia and Angelou, 2015). While energy access under Tier 0 is limited to kerosene lamps and candles, Tier 5 includes modern household goods (Irena and UNHCR, 2019). The Zaatari refugee camp performs significantly better than other refugee camps worldwide.

3) The share of renewable energies in electricity generation in Jordan recorded a rapid increase from just 0.7% (PP) to the current 26% at the time of the EPE. The photovoltaic system in Zaatari was the first project to use the net metering method. Subsequent projects in the renewable energies area (in northern Jordan) were based on a different method. Accordingly, it cannot be determined whether the photovoltaic plant had structural effects for similar projects in Jordan and thus contributed to increasing the share of renewable energy in Jordan beyond its own installed capacity. However, it is considered a leading example of clean, affordable and more sustainable access to energy in refugee camps and is, for example, the largest photovoltaic system in refugee camps worldwide. According to UNHCR employees at Zaatari Camp, UNHCR uses the experience gained with the PV plant in Zaatari to exchange experiences internally with UNHCR teams in other countries planning similar projects. The UNHCR Strategy for Sustainable Energy 2019–2025 also aims to electrify refugee camps based on sustainable solutions and the integration of renewable energies.

4) Before the photovoltaic system was put into operation, UNHCR and Zaatari Camp were the biggest buyers and end customers in northern Jordan with annual electricity costs of USD 4.4 million on average. The electricity supply was predominantly based on gas and oil as well as high imports. With the commissioning of the photovoltaic system, an average of 22.3 GWh of clean solar power is fed in per year. This is an important component in the development of an ecological energy sector in Jordan that is less dependent on imports. The CO2 savings from the photovoltaic system are estimated at 15,600 t/p.a. Over the technical service life of 20 years, around 312,000 t of CO2 emissions can be prevented.

In summary, it can be said that the project achieved very good impacts within the Zaatari Camp. However, the effects on the expansion of renewable energy in Jordan seem negligible. The project is rated as good overall under the indicator “Overarching developmental impacts”.

Impact rating: 2

Sustainability

The project has taken place in the context of refugees and crises. For the first three years after commissioning of the plant, the general contractor covered the operation of the plant as well as spare parts. To further ensure the long-term operation of the plant, UNHCR has subsequently awarded operation and maintenance to a private company. An operating concept for this was drawn up together with the executing agency. One risk to the sustainable operation of the plant is the outsourcing of spare parts procurement from the maintenance and operation of the plant. In the course of the evaluation, it was found that the parties involved may not have been aware of the contractually agreed spare parts procurement/delivery with the general contractor of five years. As a result, UNHCR only outsourced maintenance and operation of the plant at the end of 2020 after the contract with the general contractor expired, while it procured spare parts directly and funded them from its own budget. This type of contractual structure (operation and maintenance of the plant does not include spare parts) carries the risk that, in the worst case, the operator of the plant will evade responsibility. In addition, problems with the performance of all inverters occurred almost simultaneously with the change in operation and maintenance. The resulting high demand for spare parts was funded from UNHCR’s own budget. The inverters continued to overheat at the time of the evaluation. UNHCR commissioned an external expert opinion to determine the causes of overheating of the inverters and to identify targeted measures. Among other things, the expert report is said to have referred to deficiencies in the manufacture or low performance of the cooling systems. A solution to this was to be found between the executing agency as the client of the supplies and services and

the general contractor at the time. According to UNHCR, any adaptations must be covered under manufacturer's warranty and at no extra cost to the executing agency and/or UNHCR.

The free electricity supply in the refugee camp has an adverse impact on the project's impacts and tends to have a negative impact on its sustainability. The continuous high power consumption leads to load on the grid and interruptions in supply. According to the grid operator, the transformers in the camp are running at 120% of their load, which is said to have serious effects on their service life and performance. For example, many households use electricity for heating in the winter at the expense of the electricity grid, despite the fact that UNHCR distributes vouchers for gas for winter heating. The vouchers are redeemed for other purposes. Similarly, some households use air-conditioning systems during the summer. The use of heating and air-conditioning systems exceeds the basic consumption of households and thus UNHCR's ability to increase the hours of electricity supply beyond 11.5 hours.

The executing agency plays hardly any role in the project, which also explains the difficulties described above with regard to procuring spare parts. As the executing agency and owner of the plant, MEMR is obliged to guarantee the operation of the plant in the event of the closure of the camp or withdrawal of the UNHCR. During the EPE, the executing agency confirmed its readiness and the stock of available resources in order to take over operation of the plant if necessary, the service life of which is estimated to be 20 years. UNHCR has demonstrated a high degree of own responsibility in maintaining the technical and economic performance of the plant. In addition to covering maintenance and operating costs, UNHCR is also actively working on solutions to reduce demand and optimise the load in the camp. In addition to its own analyses, UNHCR is also in close contact with the administration of the refugee camp in Azraq, where a small pilot project with smart controllers was recently introduced. According to UNHCR estimates, a budget of USD 6–8 million is required to implement such measures. The Norwegian Refugee Council, which supported the above-mentioned pilot project in Azraq, indicated in a discussion during the EPE that it was ready to extend smart controllers to Zaatari, provided that this pilot project proves to be suitable. Measures to keep power consumption at the camp under control are necessary in order to cover the basic needs of the refugee camp's residents as demand increases and to maintain a reliable service if necessary. During interviews with entrepreneurs in the camp, a very clear willingness to pay electricity bills was signalled, who hoped for a continuous supply of electricity in return. However, the introduction of electricity bills/payments by entrepreneurs is currently hindered by legal and administrative obstacles such as registration in the Jordanian company register.

The plant was built in desert areas without any significant vegetation. No relocations were necessary. The modules are only partially cleaned with robots that do not require water. The plant operator has complained about the functional capability of the robots and has replaced them at least temporarily with rotating brushes. Nevertheless, they consume comparatively more water than cleaning robots, which can put a strain on scarce water resources, especially in view of the water shortages in Jordan.

Another potential short-term risk for maintaining the project's beneficial effects is the recent changes in electricity tariffs in Jordan. As part of efforts to mitigate the coronavirus crisis, the Jordanian government has reduced electricity tariffs for the highest tariff group such as hotels and industry. Electricity tariffs for households, on the other hand, have been increased since April. However, Jordanian citizens are spared from the tariff increase by being able to apply for subsidised tariff of 7 cents/kWh. Syrian refugees, on the other hand, cannot claim the subsidised tariff or afford the high tariff (16 cent/kWh). As a result, there is a risk that refugees living outside the refugee camps will end up in energy poverty and move to Zaatari Camp, as energy is available there free of charge. According to UNHCR, Zaatari would be a preferable alternative to Azraq, as the latter is remote and has fewer employment opportunities in the area. In the event of an increase in the residents of the camp, the PV system would not be sufficient to maintain the current electricity supply (11.5 hours/day).

The sustainability of the plant per se should be ensured for the coming years in spite of ambiguities in the procurement of spare parts. At the same time, there is a risk that the expansion of electricity demand will put even more strain on transformers that are already under strain. This could greatly reduce the service life. The sustainability is therefore rated as satisfactory overall.

Sustainability rating: 3

Notes on the methods used to evaluate project success (project rating)

Projects are evaluated on a six-point scale, the criteria being **relevance**, **coherence**, **effectiveness**, **efficiency**, **overarching developmental impact and sustainability** and the final **overall rating** of developmental effectiveness. The scale is as follows:

Level 1	Very good result that clearly exceeds expectations
Level 2	Good result, fully in line with expectations and without any significant shortcomings
Level 3	Satisfactory result – project falls short of expectations but the positive results dominate
Level 4	Unsatisfactory result – significantly below expectations, with negative results dominating despite discernible positive results
Level 5	Clearly inadequate result – despite some positive partial results, the negative results clearly dominate
Level 6	The project has no impact or the situation has actually deteriorated

Rating levels 1-3 denote a positive assessment or successful project while rating levels 4-6 denote a negative assessment.

The **overall rating** on the six-point scale is compiled from a weighting of all six individual criteria as appropriate to the project in question. Levels 1–3 of the overall rating indicate a "successful" project, levels 4–6 an "unsuccessful" project. It should be noted that a project can generally be considered developmentally "successful" only if the achievement of the project objective ("effectiveness"), the impact on the overall objective ("overarching developmental impact") **and** the sustainability are rated at least "satisfactory" (level 3).