الجامعة الهاشمية
The Hashemite University

The Hashemite University's Grid-Connected Project with 4,016 kWp Solar Farm

Executive Summary:

The Hashemite University's (HU) Grid-Connected Project with 4,016 kWp Solar Farm is part of the Hashemite University's Renewable Energy and Energy Efficiency (RE&EE) strategy, launched in 2012. The project is part of a 5 MWp project that achieved 100% energy independence for the university. This contributes to HU role and ethical commitment towards its community and stakeholders in environmental sustainability

The project aims provide the energy independence of the university, by constructing a grid-connected fixed-tilt PV farm in an area on the campus ground that not design for any urban expansion. The design followed industry standards for optimum energy generation in the Zarqa, Jordan region, with panels tilted at 26° and facing south. Rows were separated by a distance that will assure the elimination of shading effect year-round.

The design used string inverters, which are used to maximize energy output, and minimize downtime. The different systems were separated into four zones, with each zone having 1 MWp capacity. Each zone had a low-voltage to a medium voltage transformer, which were all connected to a newly built feeder switch gear room. The whole farm has an supervisory and control and data acquisition system that follows the daily operations.

The plant implementation on a 70,000 m_2 area, with more than 26,000 m_2 of actual panels surface area, allows it for rain water collection and water reuse. Water trenches were installed around the zones, and are collected in a water tank.

The project's tender documents, evaluation, and supervision were done through committees of expert from the Hashemite University's faculty and staff. The implementation of the design commenced in November 2015. Commissioning and final connection to the grid was in June 5th, 2016. The implementation was done through a Contractor of a local and an international joint venture, with more than 90% of the engineers and staff of Jordanian nationality, many of whom were graduates of HU.

The project provides 7.23 GWh of electricity annually, covering about 81.2 % of the power needs of the campus. This is the equivalent of completely powering 1,414 homes, each requiring 426 kWh monthly.

The project achieves long-term economic and environmental sustainability for the campus. The project's total cost was 4.5 million Jordanian Dinars (US$6.35m). Assuming the current electricity tariff is fixed over the next 20 years (US$0.376/kWh), the project has a payback period of 2 years and 4 months, with an internal interest rate (IRR) of 40.8%. The 20-year net present value (NPV) of the project is JD14.74 million (US$20.82m) after inflation, system depreciation, and operation and maintenance are accounted for. The project reduces the campus carbon footprint, by reducing its annual CO_2 emissions by more than 3,615 metric tons, and reducing the need to import, transfer, refine, and burn oil by more than 20,510 barrels of oil, annually.

Eligibility Criteria:

- Project implemented in a Public University, located in Zarqa, Jordan (MENA Region)
- Commencement of Project Construction: November 2015 > 1 year
- Initial Capital Investment US$6.35m > US$3m
- Project Operating Continuously since June 5, 2015 for 10+ Months > 6 months
- Project completely funded by HU, with 2 years and 4 months payback period

June 5th, 2016: Opening Ceremony of the Project under the Patronage of HRH Prince Hasan Bin Talal **Project Overview**

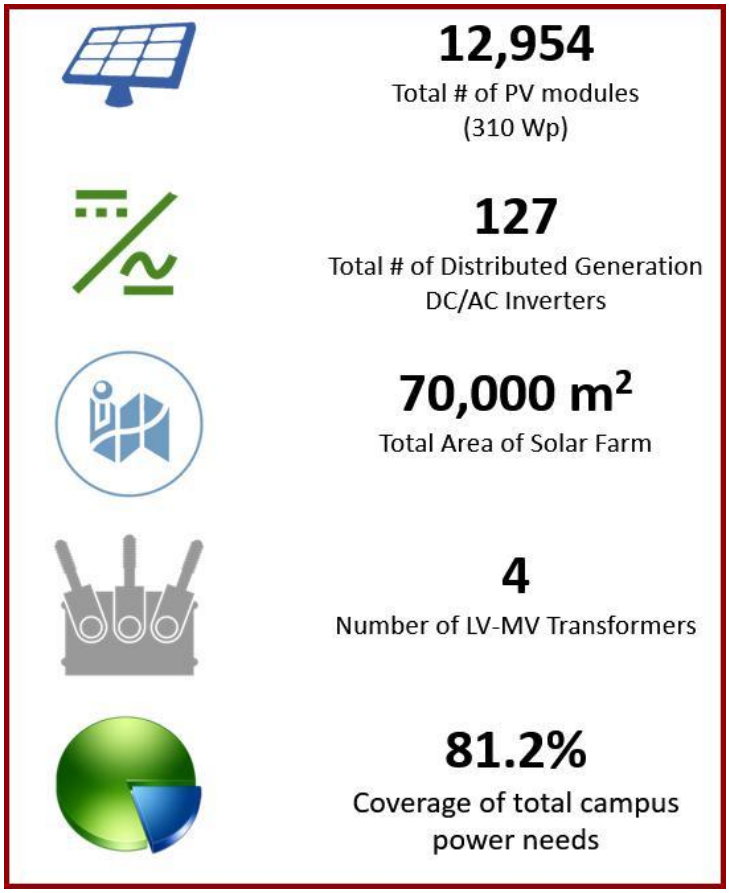
The Hashemite University (HU) is named after the Jordanian Royal family — the Hashemites — and was established by a Royal Decree in June of 1991, and accepted its first students in 1995. Over the last 20 years, HU has expanded its academic and research profile to reach thirteen (15) faculties and one institute with more than 225 laboratory in different colleges, all equipped with the latest technological equipment. Even more impressive is the university's increase in the number of admitted students, which has exceeds 26,000 students enrolled in 53 undergraduate programs and 27 Master programs at the beginning of the academic year 2016/2017.

The Hashemite University's current administration, headed by Professor Kamal Eddin Bani-Hani, has adopted Renewable Energy and Energy Efficiency (RE & EE) as one of its strategic objectives for the decade. This strategy includes expanding the campus area with new energy-saving buildings, relying on green building technologies, retrofitting older buildings with energy efficient systems and lighting fixtures, employing solar systems on all new buildings on campus, and setting a goal to achieve 100% energy independence, relying completely on renewable solar energy using photovoltaic (PV) panels.

HU was successful in constructing and commissioning a 5 MWp PV project that covers all its power needs, making it one of the first energy-independent campuses in the world.

Project Description:

The Hashemite University's (HU) Grid-Connected Project with 4,016 kWp Solar Farm is part of the 5 MWp project implemented in the campus to cover the 100% of the university's electrical needs.



Due to the location of the university at a semi-arid region in Jordan, the area receives more than 330 of sunny days, making photovoltaics one of the major technologies to be employed in the region. With the introduction of net-metering regulations in Jordan in 2012, the construction of the project became economically feasible.

The project was constructed in an 70,000 m_2 area east of the campus main area, which is not designed for future buildings or expansion. It is part of the university's Science Zone, in which the Structural Systems Laboratory (SSL) and the Hashemite University Free Trade Zone are being developed.

The farm was divided into four similar capacity zones, with 1 MWp for each zone. The structures used for the plants are heavy-duty galvanized steel structure imported from Germany, with ability to withstand external elements and strong winds. Piling was used to anchor the structures, which greatly reduced the overall cost of the project. Trenches were constructed to capture and reuse the rain and cleaning water, increasing the environmental efficiency of the project.

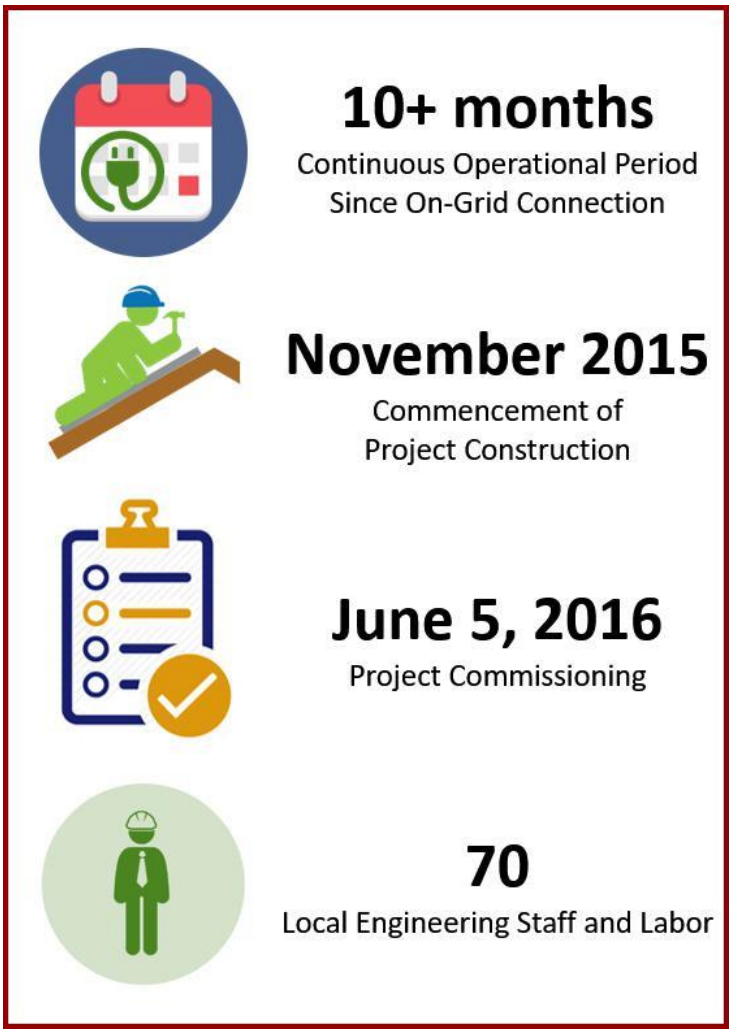
A total of 12,954 panels (poly-crystalline type, 310 Wp, 16% efficiency, with positive tolerance only) was the number of PV panels used in this project. One hundred and twenty seven (127) 27.6 kWp DC/AC inverters (outdoor type, 2 MPPTs, 98% efficiency) were used, which were connected to 4 main low-voltage to medium-voltage transformers. This has resulted in covering 81.2% of HU campus total electrical needs.

The whole farm has an supervisory and control and data acquisition system that follows the daily operations. It has an advanced weather station connected to it, transforming the plant to become a cutting-edge research facility.

All project components were exposed, with all safety precautions taken into account. The objective was to allow campus users and visitors to appreciate the ease and safety of this technology implementation, transferability, and appreciate the positive impact it will have on the environment.

Project Construction Details

The work started on the project in late 2012, with a Core Team in the Faculty of Engineering at HU taking the first steps to seeing this project from "conception to completion." The team worked to develop world-class tendering documents detailing the scope, deliverables, and technical specifications of the project.



The team built on the its expertise in this multi-disciplinary project. It constructed two PV pilot projects implemented in campus with 3 kWp and 30 kWp capacities. One was to test the capability of employing solar canopies for cars as a proof of concept. The other was to test the efficiency and economic feasibility of tracking versus fixed PV systems.

Through several expanded committees, the tendering stage, evaluation stage, and awarding stage were completed at the end of 2014. After all the licensure and permits were completed, construction of the project started in November 2015.

The core team, along with several experts from the university and Jordan's technology centers (Royal Scientific Society, Ministry of Energy and Mineral Resources, Energy Regulatory Commission, and Jordan Electrical Power Company), supervised the construction of the project. The supervision of the project through local experts saved the university more than JD 400,000 in supervision costs compared to the case if handled by an external firm.

The construction was through a consortium of a Jordanian firm and an Italian firm. More than 90% of the team working on the project were Jordanians (more than 70 Jordanian engineers and labor). Many of the engineers employed by the contractor were graduates of the Hashemite University.

The construction methodology was centered around noise mitigation and zero interruptions to the daily activities on campus. All heavy work was done after work hours and during weekends and holidays. Each work zone was closed off during the constructions to maximize the safety for the students. Moreover, a clear construction plan and labor division were used to complete the project on-time and with no financial overruns.

The project was commissioned on June 5, 2016, and has been in continuous operation for more than ten months. There were no interruptions of operations for the project since its on-grid connection. Also, there were no injuries reported during its construction.

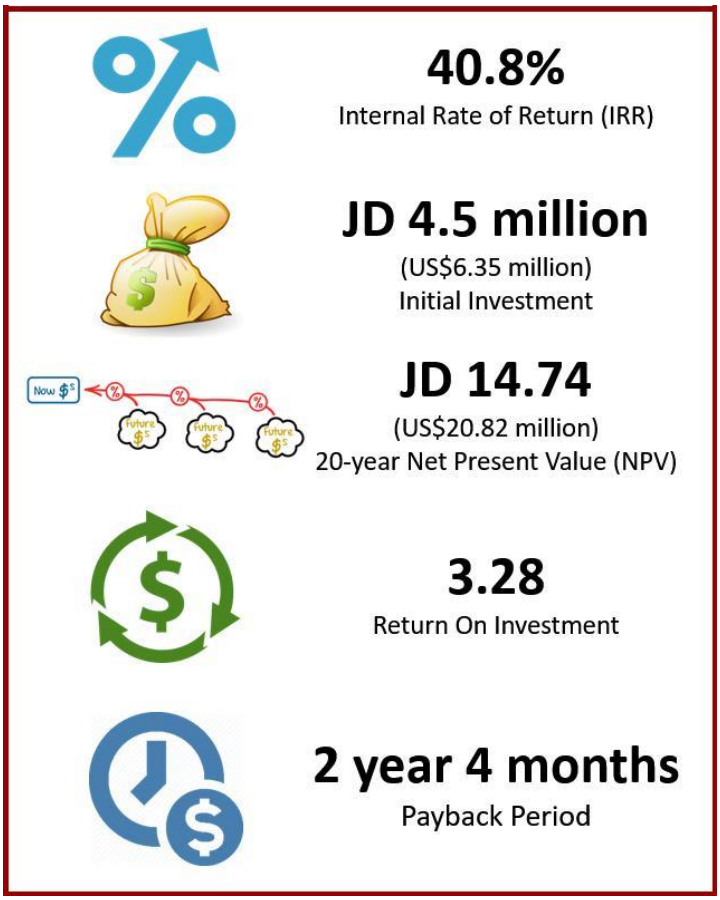
Economic Analysis

The project's total initial cost is 4.5 Million Jordanian Dinars (U$ 6.35m). The current electricity tariff is JD 0.266 (US$0.376). A conservative assumption of fixed electricity tariff is used for the lifetime of the project.

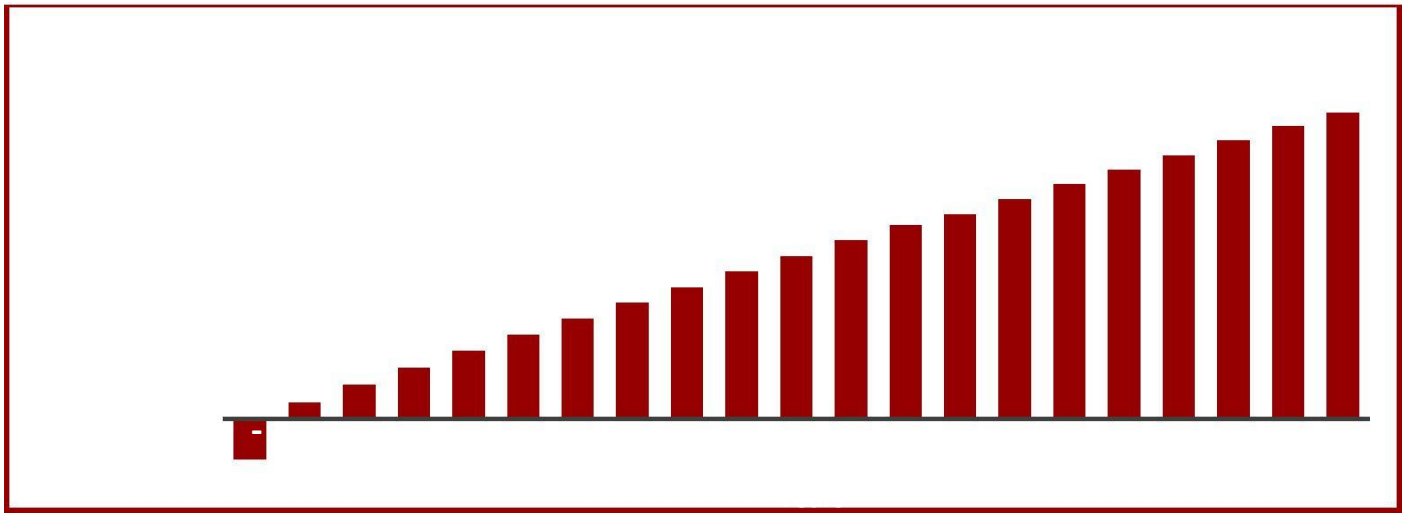
The project was completely funded by HU using Engineering, Contracting, and Procurement (EPC) methodology. Hence, no loans were used to cover its cost. The average annual inflation rate in Jordan (6.27% per year, over the last 40 years) was used to estimate the interest rate and economic feasibility of the project.

Based on these economic variables, the 20-year net present value (NPV) of the project was found to be JD 14.74 Million, with a 328% 20-year return on investment (ROI), and a 40.8% 20-year internal rate of return (IRR).

These calculations took into account the operations and maintenance (O&M) costs of the project, exchange of all inverters at the 13-year mark, and the annual depreciation in PV system performance. The following graph shows the accumulative annual cash flow over 20-years.



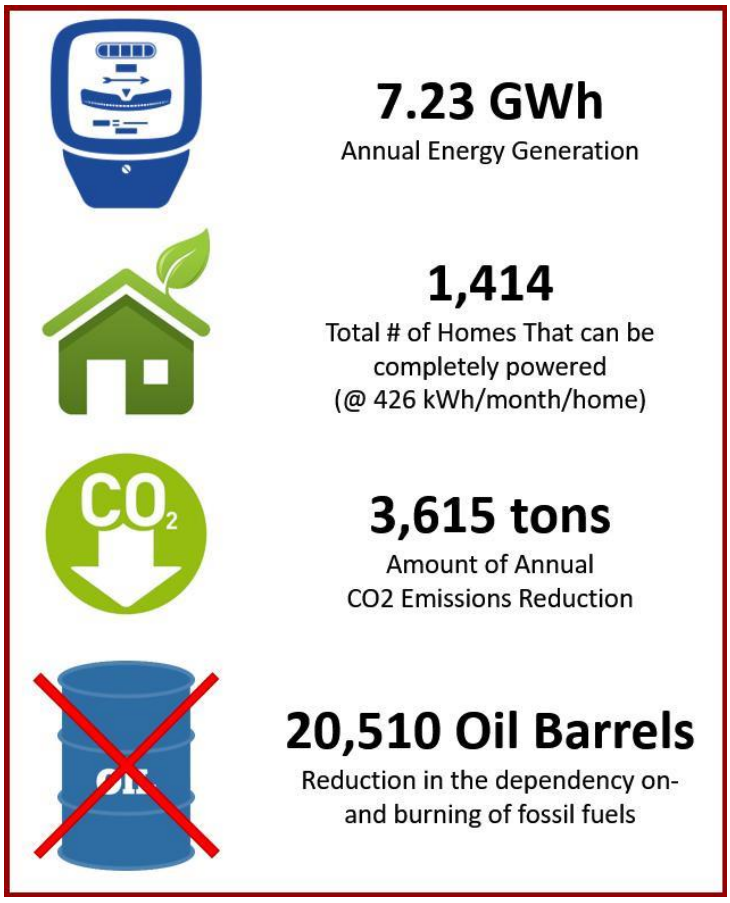
With the distributed generation of the project generating around 7.23 GWh annually, and considering a 0.8% depreciation in the system's performance, the payback period (PBP) of the project was calculated to be 2 years and 4 months. This takes into account that the first 3 years of O&M are the responsibility of the Contractor, at no extra cost incurred by the university.



Sustainability and Environmental Impact

The design and implementation of the project called for an optimum power generation, with the systems facing south, and at a 26° fixed-tilt angle. The distance between rows was made to assure elimination of shade losses year round.

With that in mind, the total generated energy per kWp is 1,800 kWh annually, which is around the highest power generation in Jordan. Furthermore, the annual electrical power generation of the systems is 7.23 GWh. This comes to about 81.2% of the total electricity needs of the entire campus (the remaining electricity needs are provided through a 1 MWp distributed generation system installed in the campus as solar walkways and carpark solar canopies).



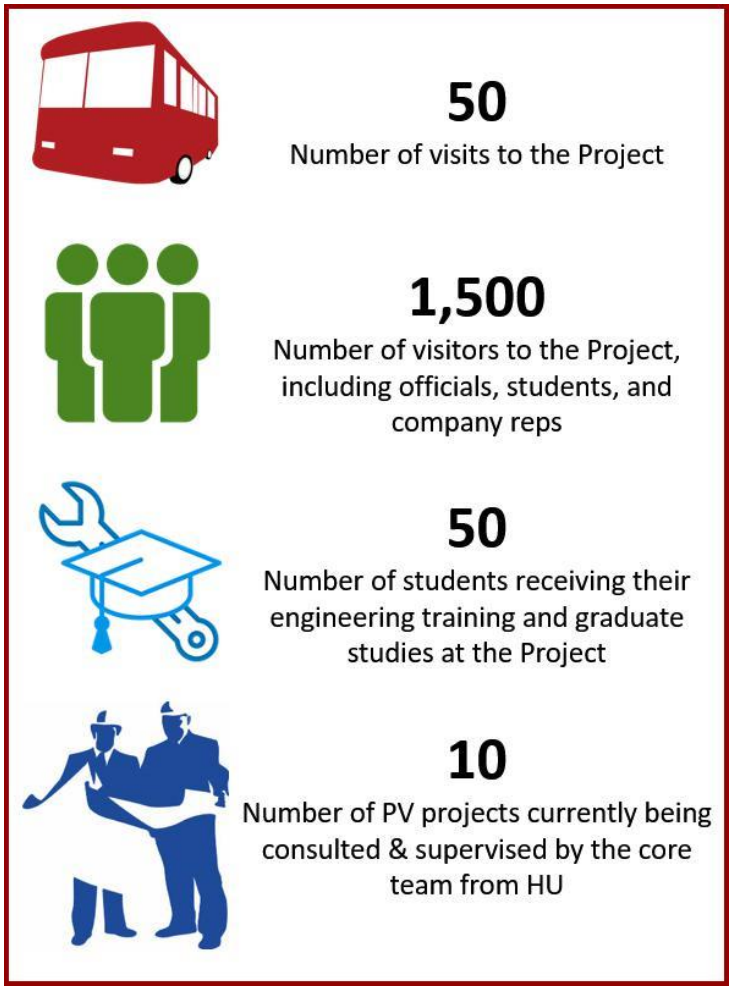
Taking into account the total population in Jordan is 6.5 million and an average of 4.8 citizens per family (as per 2015 census data), and the electrical demand for residential sector of 6,938 GWh annually (based on the 2015 data provided by the Ministry of Energy and Mineral Resources), the average Jordanian residential home consumes around 426 kWh/month. Hence, the project is estimated to provide 100% of the electrical needs for 1,414 Jordanian homes with renewable energy.

Extra care was put to minimize the effect on the local environment, where the area dedicated for the project was not used for olive tree farms. All construction waste was disposed of in an environmentally-friendly manner, where container boxes and wood were sent for recycling. This project also increases the overall share of renewable energy sources, as one of the major objectives of Jordan's National Strategy is to increase its renewable energy mix to 10% by the year 2020.

Following the 2015 EPA guidelines, each kWh of electricity produces an average of 0.5 kilogram of CO_2, which would be released in the air and increases the greenhouse gas effect. This project helps in mitigating this environmental effect, by eliminating 3,615 tons annually of CO_2 from being released into the air. Furthermore, the project eliminates the need to import, transfer, refine, and burn 20,510 oil barrels annually, which has a compounded positive effect: decreasing the reliance on fossil fuels, decreasing Jordan's dependence on imported fuel (and help in mitigating the annual deficit), and decreasing the amount of fuel toxic byproducts which negatively affect the environment.

Capacity Building and Social Impact

Since the commencement of works, and through commissioning and operation of the projects, it has had a strong social impact on the campus, and has positively impacted the perceived image of the university as a whole.



The project has received more than 1,500 visitors from outside the university in 50 visits, including official visits by the ambassadors of USA, Sweden, and the Netherland. Students from public and private universities, elementary and secondary schools visited the project to learn about its importance, environmental impact, and the ease, safety and transferability of renewable energy technologies.

The core team, represented by:

- Prof. Shaher Rababeh, Vice President for Engineering and Administrative Affairs
- Prof. Ahmad Al-Ghandoor, Director of the Energy Center
- Dr. Mohammad Al-Abed, Faculty of Engineering
- Dr. Bashar Hammad, Faculty of Engineering

have met with many local community delegates, and representatives of different energy and industry sectors. This has fascinated mutual agreements for the university to provide consultation and supervision to more than ten projects in Jordan, representing a direct indicator of capacity building and transfer of knowledge in renewable energy mega projects. These projects include University of Jordan's 16 MW PV project, Zarqa Free Zone 1.5 MW PV Project, Prince Mohammad Sports Complex 1MW project, and Jordan University of Science and Technology 20 MW PV project.

The project has been covered by numerous national and international news outlets, including Al Jazeera, France 24 Arabic, Jordan TV, PV Magazine, and local news papers.

More than 50 undergraduate and graduate students received their technical field training and research during the commencement and operation of the project. This is in addition to more than 60 faculty and staff members who worked directly in the committees, supervision, and training on the project.

Several campus-wide compulsory student courses have added to their curriculum field visits, report writing, presentations, or technical and feasibility analysis of the project. This have been introduced to more than 1,500 students on campus, with this number expected to rise as more students are introduced to these courses.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اسم المشترك	الجامعه الهاشميه		
رقم و نوع الاشتراك	05/3 3 07 16/002600		
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تفاصيل الشهر السابقة

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