The Hashemite University
Renewable Energy Center

Renewable Energy Report

2021/2022

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Introduction:

The Hashemite University is committed to driving sustainable energy initiatives and reducing its environmental impact, positioning itself as a national research and development hub for cutting-edge innovations in the field of renewable energy. As part of our comprehensive approach to becoming more energy self-sufficient and achieving increased carbon savings, we are actively collaborating with businesses, graduates, and academics to explore and develop smart energy solutions. These endeavors encompass a wide array of technologies, updated approaches to demand-side management, and behavioral interventions aimed at enhancing energy efficiency and sustainability. Our vision extends beyond just academic excellence; we are resolute in our pursuit of 100% energy independence. To materialize this vision, Hashemite University has successfully implemented 5 MW photovoltaic (PV) systems on campus, generating approximately 8.5 GWh of renewable energy annually. The integration of these PV systems has had a significant impact on our carbon footprint, leading to a reduction of over 4455 metric tonnes of CO2 emissions annually. Additionally, it has significantly diminished our reliance on imported, transferred, refined, and burned oil, saving more than 25275 barrels of oil every year.

Despite our progress, we recognize that growth and expansion bring new challenges. With the completion and full equipping of three new buildings in 2019, the university experienced a surge in energy demand, around 15% higher than before. To address this surge and fortify our commitment to energy efficiency, we have undertaken strategic upgrades to our existing buildings.

- ✓ Improving the energy efficiency of existing buildings, minimizing energy wastage and optimizing consumption by 2023.
- ✓ Increasing the energy efficacy in the campus by having Smart Energy Meter and Management System (AMI).
- ✓ Improving the renewable energy generation by 2024.

Renewable Energy Center:

Vision:

The renewable energy center aims to be an accredited research center in the fields of renewable energy research in Jordan and the Arab region.

Mission:

Renewable energy center provides the necessary support research and studies in the fields of renewable energy by providing equipment, devices, trained staff and raise awareness of the importance of renewable energy projects

Center instructions

Sustainability is a priority at the Hashemite University. Through the actions that it is taking, the University aims to become more energy self-sufficient with increasing the carbon saving. The Hashemite University aims to have Smart Grid's and Campus with ability to dynamically manage all sources of power on the grid means that more distributed generation can be integrated within it. The sustainability policy at the Hashemite University is focused on improving energy efficiency and moving towards a sustainable energy future in HU through energy saving practices and approaches, new energy building saving techniques, and renewable energy sources.

Center tasks

The main tasks, services and consultation

- ✓ Maintaining the productivity of the university's solar energy system and working to maintain it.
- ✓ Perform energy auditing for local industry and corporations
- ✓ Training students to design monitor and maintain solar energy systems and increase their efficiency.
- ✓ Helping students with projects related to renewable energy.
- ✓ Supporting scientific research in the field of renewable energy.
- ✓ Provide laboratory and consultancy services in energy impact assessment and auditing.
- ✓ Work to coordinate training courses, seminars, workshops & public lectures and field visits in the field of energy.

Renewable energy and smart grid project

Completed Projects

- ✓ The Hashemite University's (HU) Grid-Connected Project with 4,016 kWp Solar Farm: The project provides 7.23 GWh of electricity annually, covering about 81.2 % of the power needs of the campus. 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 CO2 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.
- ✓ The Hashemite University's (HU) Building-Integrated Photovoltaic (BIPV) Grid-Connected Project with 1,018 kWp Implemented as Pedestrian Walkways and Carparks Project: The project provides 1.68 GWh of electricity annually, covering about 18.8 % of the power needs of the campus. This is the equivalent of completely powering 328 homes, each requiring 426 kWh monthly. This has resulted in covering 18.8% of HU campus total electrical needs. This project aims to help the university to achieve 100% energy independence for the university with the 4 MWp PV farm which covered 81.2% of the university electricity bill. 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. The project already commissioned and has been in continuous operation for more than three years. There were no interruptions of operations for the project since its on-grid connection.

Current Projects

In order to help the university to achieve 100% energy independence, the university has implemented PV systems and upgraded the existing buildings to higher energy efficiency by:

- ✓ Increasing the energy efficacy in the campus by having Smart Energy Meter and Management System (AMI). Smart meter system based IoT technology for all the HU building is our new project. In 2021, we issued the project tender and started the

implantation of it which will be completed by 2023. This project aims to remotely monitor and control building energy consumption and improve energy efficiency from heating and air conditioning, to lighting and security systems.

- ✓ Improving the renewable energy generation by 2024 (SCADA system for the PV projects in HU): The systems shall include monitoring and control systems to measures and records systems performance parameters. In 2021, we issued a new tender to upgrade the current PV project and developed a SCADA system. In the project, SCADA system will perform all data acquisition, monitoring and control functions of the PV system. In order to improve the energy efficiency, all necessary information concerning process behavior, instrument and integrity controller, sequential control and alarm function shall be immediately available at the operation consoles.
- ✓ Lighting: we replaced the building lights (fluorescent) with LED lights, which consumes less than 25% of the energy required by other fluorescent based light systems.
- ✓ Implementation of fully smart grid lab with real handwear in the loop for training and research purposes.
- ✓ Adding a new PV system (60 KW) to the campus power grid by 2024.

Energy Data and Comparative Analysis

Data Sources:

Data for this report is sourced from various departments and facilities within the university, including energy consumption records.

Energy results Analysis

As part of our ongoing commitment to sustainability and environmental accountability, Hashemite University diligently monitors and reports its energy consumption and renewable energy generations. This yearly reporting, we present up to data for the 2021 and 2022 in the following table:

	Energy consumption (GWh)	Renewable energy generations (GWh)	Net energy generation (GWh)
2021	7.8	8.1	+0.3
2022	8.2	8.4	+0.2
Total	16	16.5	+0.5

In the first half of 2021, The Hashemite University's campus was not fully equipped due to COVID-19 restrictions; however, it still managed to surpass its energy consumption through impressive renewable energy generation, producing 8.1 GWh of renewable energy compared to 7.8 GWh consumed, resulting in a positive net energy generation of +0.3 GWh. As COVID-19 restrictions were lifted in the second half of 2021, the campus likely experienced increased activities, potentially leading to higher energy consumption. Nevertheless, over the entire period of 2021-2022, the university continued its commitment to sustainability, generating 16.5 GWh of renewable energy compared to 16 GWh of energy consumed, achieving a positive net energy generation of +0.5 GWh and showcasing its dedication to promoting cleaner energy sources.

Research Sustainability.

One of the main aims for the Hashemite University is to encourage and improve scientific research and projects to serve local community and industry and to elevate research quality and educational outcomes. The following list of recent publication (2021-2023) and project at the Renewable energy center:

Book

- Holderbaum, W.; Alasali, F.; Sinha, A. Energy Forecasting and Control Methods for Energy Storage Systems in Distribution Networks. *Springer Cham, Switzerland,* Edition 1, 2023, p. XVI- 204*,* https://doi.org/10.1007/978-3-030-82848-6.

Journal

- Alasali, F.; Saidi, A.S.; El-Naily, N.; Smadi, O.; Khaleel, M.; Ghirani, I. Assessment of the impact of a 10-MW grid-tied solar system on the Libyan grid in terms of the power protection system stability. *Clean Energy* 2023, 7 (2), 389-407, (open access).
- Alasali, F.; Saidi, A.S.; El-Naily, N.; Smadi, M.A.; Holderbaum, W. Hybrid Tripping Characteristic-Based Protection Coordination Scheme for Photovoltaic Power Systems. *Sustainability* 2023, 15, 1540. https://doi.org/10.3390/su15021540, (open access).
- Alasali, F.; Saidi, A.; El-Naily, N.; Alnaser,S.; Holderbaum, W.; Saad, S.; Gamaledin, M. Advanced Coordination Method for Overcurrent Protection Relays Using New Hybrid and Dynamic Tripping Characteristics for Microgrid. IEEE Access 2022, 10.1109/ACCESS.2022.3226688, (open access).
- Zarour, E.; Alasali, F.; Alsmadi, O.; El-Naily, N. A new adaptive protection approach for overcurrent relays using novel nonstandard current-voltage characteristics. *Electric Power Systems Research* 2023, 216, 109083.
- Alasali, F.; Zarour, E.; Holderbaum, W.; Nusair, K. Highly Fast Innovative Overcurrent Protection Scheme for Microgrid Using Metaheuristic Optimization Algorithms and Nonstandard Tripping Characteristics. IEEE Access,2022, 10.1109/ACCESS.2022.3168158, (open access).
- Alasali, F.; Salameh, M.; Semrin, A.; Nusair, K.; El-Naily, N.; Holderbaum, W. Optimal Controllers and Configurations of 100% PV and Energy Storage Systems for a Microgrid: The Case Study of a Small Town in Jordan. *Sustainability* 2022, *14*, 8124. https://doi.org/10.3390/su14138124, (open access).
- Abeid, S.; Hu, Y.; Alasali, F.; El-Naily, N. Innovative Optimal Nonstandard Tripping Protection Scheme for Radial and Meshed Microgrid Systems. *Energies* 2022, *15*, 4980. https://doi.org/10.3390/en15144980, (open access).
- El-Naily, N.; Saad, S.; Elhaffar, A.; Zarour, E, Alasali, F. Innovative Adaptive Protection Approach to Maximize the Security and Performance of Phase/Earth Overcurrent Relay for Microgrid Considering Earth Fault Scenarios. *Electric Power Systems Research*,2022, 206,107844.
- Waleed Hammad, Thaer Sweidan, Mohammed I. Abuashour, Haris M. Khalid, SM Muyeen,"Thermal Management of Grid-Tied PV System: A Novel Active and Passive Cooling Design-Based Approach" IET Renewable Power Generation Vol. 15, No. 12, pp. 2715-2725, 2021.
- Aljdaeh, E., Kamwa, I., Hammad, W., Mohammed I. Abuashour; Sweidan, T., Khalid, H.M., Muyeen, S.M, "Performance Enhancement of Self-Cleaning Hydrophobic Nanocoated Photovoltaic Panel in Dusty Environment". Energies Vol. 14, No. 02, pp. 1-18, 2021.
- Nagy Osman, Haris M. Khalid, Tha'er O. Sweidan, Mohammed I. Abuashour, S.M. Muyeen, "A PV Powered DC Shunt Motor: Study of Dynamic Analysis Using Maximum Power Point-Based Fuzzy Logic Controller", Energy Conversion and Management: X, Vol.

15, August, 2022.

- Derar Al Momani, Yousef Al Turk, Mohammed I. Abuashour, Haris M. Khalid, S.M. Muyeen, Tha'er O. Sweidan, Zafar Said, M. Hasanuzzaman, " Energy saving potential analysis applying factory scale energy audit – A case study of food production", Heliyon, Volume 9, Issue 3,2023.
- Mohamed R. Gomaa a,b , Waleed Hammad c, Mujahed Al-Dhaifallah d, Hegazy Rezk e,f,* "Performance enhancement of grid-tied PV system through proposed design cooling techniques: An experimental study and comparative analysis" in Solar Energy, Vol. 211, DOI: 10.1016/j.solener.2020.10.062,Pp: 1110-1127.

Conferences

- Aldalahmeh, S.; Hayajneh, A.; Alasali, F. Power Load Estimation in Smart Grids via k-Means Clustering using Sensor Networks. IEEE Jordan International Joint Conference on Electrical Engineering and Information Technology (JEEIT), Amman, Jordan, 2023.
- Alasali, F.; Zarour, E.; AL-Hayajneh, A.; Alsamadi, O. Optimal Protection Coordination Scheme of Overcurrent Relays for Microgrid System. IEEE International Conference on Renewable Energy Research and Application, Turkey, 2021.
- Saad, S.; Alasali, F.; El-Naily, N.; Elhaffar, A.; Hussein, T.; Mohamed, F. Coordination of Mixed Overcurrent and voltage-Restrained Overcurrent Relays to Avoid Miscoordination Problems Considering IEC time-Current Curve Limitations. IEEE International Renewable Energy Congress, Tunisia, 2021.
- Tha'er O. Sweidan, Mohammed I. Abuashour, Nagy Osman, "Transient Analysis of DC Shunt Motor Supplied by Stand-alone PV System Employing FOCV for MPPT", 2020 Advances in Science and Engineering Technology (ASET) International Conferences. IEEE Xplore.

Funded Projects

- **Project title**: Analyzing Smart Grid Resilience Under Cyber-Physical Threats**, January 2023-January 2025**
  - **Project group**: Dr. Feras Alasali (**investigator**), Dr. Anas Almajali, Dr. Ali Hayajneh, Prof. Awni Itradat
  - **Source:** Ministry of Higher Education and Scientific Research - Jordan, Scientific Research and Innovation Support Fund**, Budget:** 132000 USD.
  - **Abstract**: Our initiative is centered on assessing the resilience of smart grids to a variety of cyber-physical threats at High Voltage (HV), Medium Voltage (MV), and Low Voltage (LV) levels. We are using simulations to study different threat scenarios and their impacts on the power protection system, particularly at HV/MV levels, while also addressing the often underappreciated threats on LV networks. The ultimate goal is to enhance the power grid's resilience at all voltage levels, leading to the development of a more robust cybersecurity strategy for the energy sector. Further information is available at https://cyberssgridhu.github.io/

Training Courses and Community service:

- Free activities:
  - ✓ 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.
  - ✓ HU 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.
  - ✓ More than 70 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 75 faculty and staff members who worked directly in the committees, supervision, and training on the project.
  - ✓ Free renewable energy training course for the students and local community
- Paid activities:
  - ✓ Renewable energy training course the students and local community.

Student Experience and Scientific Trips

Within the context of the Climate Policy at Hashemite University, our paramount focus is to enhance the student experience by fostering a learning environment that emphasizes sustainability. To achieve this goal, the following priority actions have been identified:

- ✓ All projects in the campus have a direct positive capacity building and social impact.
- ✓ We are committed to empowering our students to become responsible and active participants in the local community, engaging in initiatives that promote sustainability and contribute positively to the environment.
- ✓ Through diverse opportunities, we promote student engagement in sustainability-related initiatives, enabling them to develop a comprehensive understanding and practical skills in this critical field.

- ✓ Active collaboration with student clubs and organizations fosters a strong network of sustainability advocates, amplifying our collective impact and driving meaningful change.
- ✓ Ensuring our campus is accessible and safe for individuals with disabilities or special needs reflects our commitment to inclusivity, ensuring everyone can actively participate in sustainability efforts.

Since the commencement of PV projects at HU, 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 PV project has received more than 2000 visitors from outside the university in 75 visits, including official visits by the ambassadors of USA, Sweden, and the Netherland. Students from universities, 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. In 2022/2023, the renewable energy center and PV project has received more than 300 visitors from outside the university in 40 visits. The center also holds a free two weeks training for the university student about designing and implementation PV system. Here are some of the photos from the training sessions and site visits: