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EDAMA
Energy, Water & Environment

الشراكة الأردنية الألمانية
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Solar Energy in Jordan - Innovations: Digitalization, Storage and Mobility

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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The Jordanian - German Energy Partnership

This work has been supported by the Jordanian-German Energy Partnership through Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The project helps to share experiences of Germany's energy transition in Jordan. In this way, Jordanian experts from the energy sector, administration, academia, and education can be made aware of the challenges of the energy transition. The Energy Partnership combines exchange between high-ranking government representatives with expert advice from industry, science and academia and other relevant stakeholders. Regular intergovernmental meetings enable an intensive political and technical exchange between German and Jordanian decision-makers on the energy transition. The Jordanian-German Energy Partnership is led by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) and the Jordanian Ministry of Energy and Mineral Resources (MEMR). GIZ facilitates the work of the partnership with secretariats in Amman and Berlin.

SolarPower Europe

SolarPower Europe is the award-winning link between policymakers and the solar PV value chain. Our mission is to ensure solar becomes Europe's leading energy source by 2030. As the member-led association for the European solar PV sector, SolarPower Europe represents over 250 organisations across the entire solar sector. With solar sitting on the horizon of unprecedented expansion, we work together with our members to create the necessary regulatory and business environment to take solar to the next level.

EDAMA

Is a Jordanian business association that was founded in 2009. The word EDAMA was derived from the Arabic word, which means sustainability. The association envisions Jordan as the regional hub and successful model for green growth, furthermore, it's a non-govermental organization (NGO) recognized for creating a thriving green economy. EDAMA empowers businesses to play a leadership role in transforming Jordan's energy, water, and environment sectors.

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Project Information

This report is part of the “Boosting Renewable Energy Build Up as contributor to Jordan’s post COVID-19 Recovery” project that EDAMA and SolarPower Europe are implementing. The project is supported by the Jordanian-German Energy Partnership through Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, which supports innovation in the solar energy sector. Disseminating best practices and recommendations will accelerate the energy transition, help Jordan reach its climate goals and support a green recovery.

The project consists of three work packages:

» Work Package 1: Jordanian EPC and O&M Best Practice Guidelines.
» Work Package 2: Report on Innovations: Digitalization, Storage and Mobility.
» Work Package 3: Post-COVID 19: Addressing a clean and sustainable recovery in Jordan.

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Foreword

The global energy sector was severely affected by the COVID-19 pandemic, disrupting supply chains and thus economic activity across the world. In Jordan, lockdowns impacted the renewable energy sector, exposing an over-reliance on imported energy sources to meet demand and slowing renewable source adoption. Despite the need to improve energy autonomy, increasing the share of renewable sources in the electricity mix faces integration barriers. Therefore, Jordan needs to adopt new technologies to enhance grid flexibility and efficiency. In doing so, the country will show that renewables are a cost-effective alternative to imported energy sources, further accelerating its energy transition.

This report has been developed by EDAMA Association, and SolarPower Europe, with the support of stakeholders across the Jordanian solar industry. It identifies challenges facing renewables integration into the grid and explores how new technologies and innovations can solve these challenges.

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List of Abbreviations

AI	Artificial Intelligence
BEMS	Building Energy Management System
BIPV	Building-Integrated Photovoltaics
CCTV	Closed-Circuit Television
COC	Central Operation Center
DC	Direct Current
EMRC	Energy and Minerals Regulatory Commission
EV	Electric Vehicle
GHG	Greenhouse Gas Emissions
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOs	Guarantees of Origins
ICE	Internal Combustion Engine
IoT	Internet of Things
IRENA	International Renewable Energy Agency
kW	kiloWatt
kWh	kiloWatt Hour
kWp	kiloWatt Peak
LIDAR	Light Detection and Ranging
LPWAN	Low-Power Wide-Area Networks
MEMR	Ministry Of Energy and Mineral Resources
MENA	Middle East and North Africa
MW	MegaWatt
NDC	Nationally Determined Contribution
NEPCO	National Electric Power Company
O&M	Operations & Maintenance
P2P	Peer-To-Peer
POI	Point of Interconnection
PPA	Power Purchase Agreements
PPC	Power Plant Controller
PV	Photovoltaic
R&D	Research and Development
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
V2bV2B	Vehicle to Building
V2G	Vehicle to Grid
V2H	Vehicle to Home
VIPV	Vehicle-Integrated Photovoltaics

1. Introduction

Key questions on digitalization:
How could Jordan make the most of the energy market opportunities of digitalization?
Could digitalization improve and tackle challenges and technical barriers in the Jordanian energy sector?

Jordan has limited indigenous conventional energy resources and is heavily dependent on energy imports to meet its growing energy demand. However, the country has enormous renewable energy potential, particularly when it comes to solar. Recently, increased deployment of this has begun to make a dent in Jordan's dependency on energy imports, which answered 88% of the country's energy demand in 2021, down from 97% in 2014. By providing support for renewable energy projects, the share of renewable energy in electricity generation increased from 10.8% in 2018 to 21% in 2021[1]. As a result, Jordan leads the Middle East and North Africa region in the adoption of renewable energy, setting ambitious targets for its green transition.

However, the significant increase in the share of renewable energy sources in a relatively short time presents technical and financial challenges. Namely, the higher share of renewable energy resources requires structural changes in the planning and operation of the electricity grid since Jordan's grid infrastructure has not kept up with the developments on the supply side of the energy mix. Power system flexibility is a core component of operational and planning practices at the transmission and distribution levels. Market structure, grid codes and the regulatory framework should evolve to facilitate the adoption of digital technologies and to ensure that the challenge of integrating higher shares of renewables into the grid is successfully tackled without prejudicing any transformation plans.

The digitalization of the energy sector in Jordan is critical to the country's current and future economic development. Currently, it is dealing with existing challenges whilst simultaneously pursuing ambitious plans toward self-reliance, in line with the goals set in the Energy Sector Strategy 2020-2030, published by the Ministry of Energy and Mineral Resources (MEMR) (14% share of renewable energy in the primary energy mix by 2030, and a 31% share of renewables in the electricity mix by 2030), and an ambitious greenhouse gas (GHG) emission reduction target of 31% by 2030, compared to the Business-as-Usual (BAU) scenario in 2012 as in Jordan's Updated Submission of 1st Nationally Determined Contribution (NDC)[2].

The Jordanian government has launched several important initiatives to promote digitalization and the adoption of energy storage systems (ESS), addressing the challenge of integrating an increasing share of renewables into the country's electricity mix. More than ever, this has highlighted the need for innovative digital and storage solutions in energy-intensive industries, including mobility.

Jordan can take advantage of different digital technologies and business models that are transforming the energy landscape worldwide, and promote them to improve grid operations and efficiency, enabling the energy transition, in addition to creating local job opportunities. Figure 1 shows multiple core technologies and business models applicable to various sectors in Jordan and long-term transition applications.

Core Technologies and Business Model

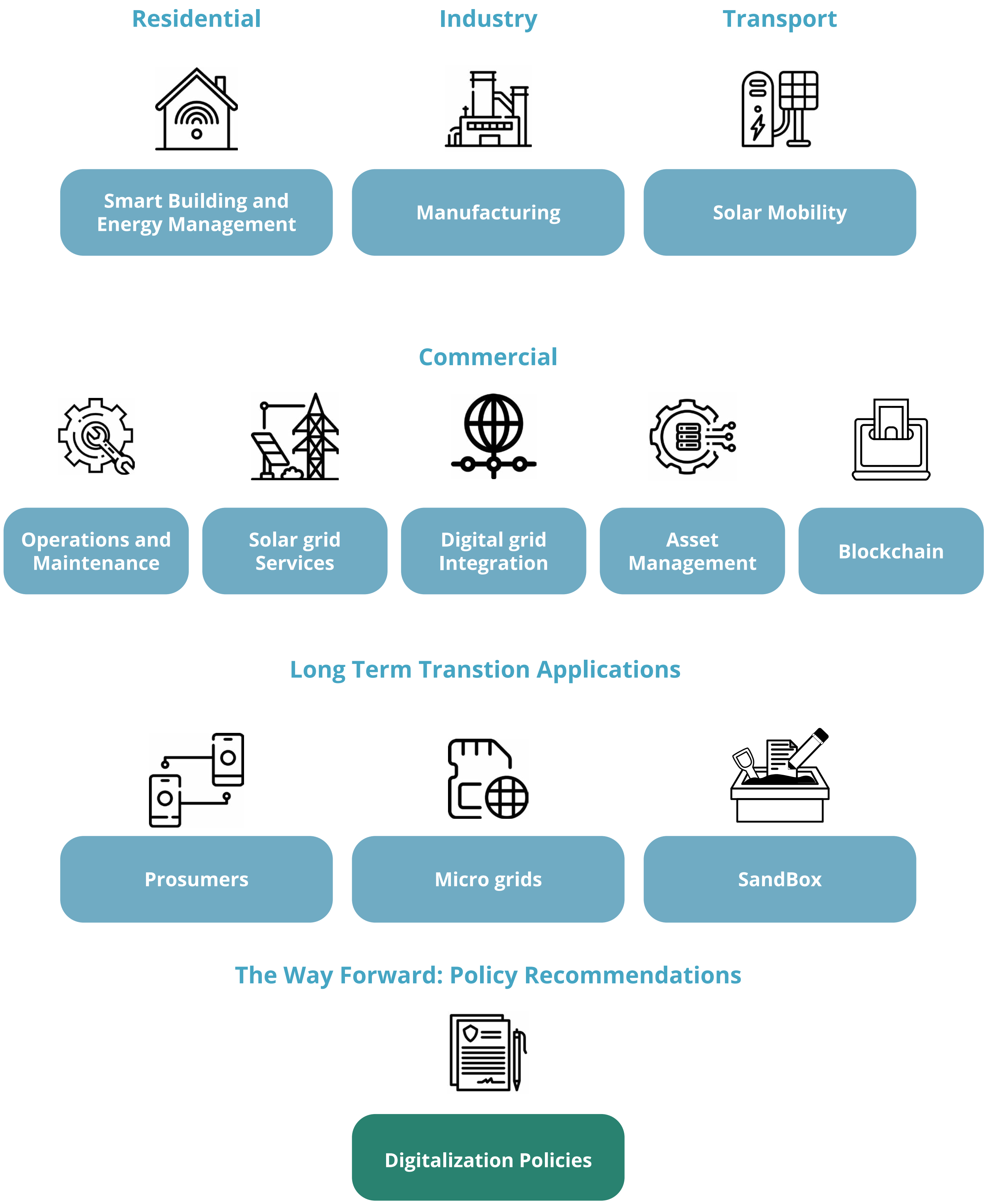


Figure 1: Core technologies and business model.

The report was prepared by a joint national and international task force from EDAMA's members and key national and international stakeholders, including policymakers and energy regulators. It provides an overview of innovative transformation solutions, supporting the transition towards renewable energy and contributing to a green economy.

Figure 2 shows multiple key technologies, connected to digitalization, which will be discussed in this report. In addition, it showcases examples and case studies of system strengthening from different stakeholders in the Jordanian industry that have improved performance, reliability, and adaptation to shocks like COVID-19. The report also discusses ideas for reforming existing systems and infrastructure as well as policy recommendations.

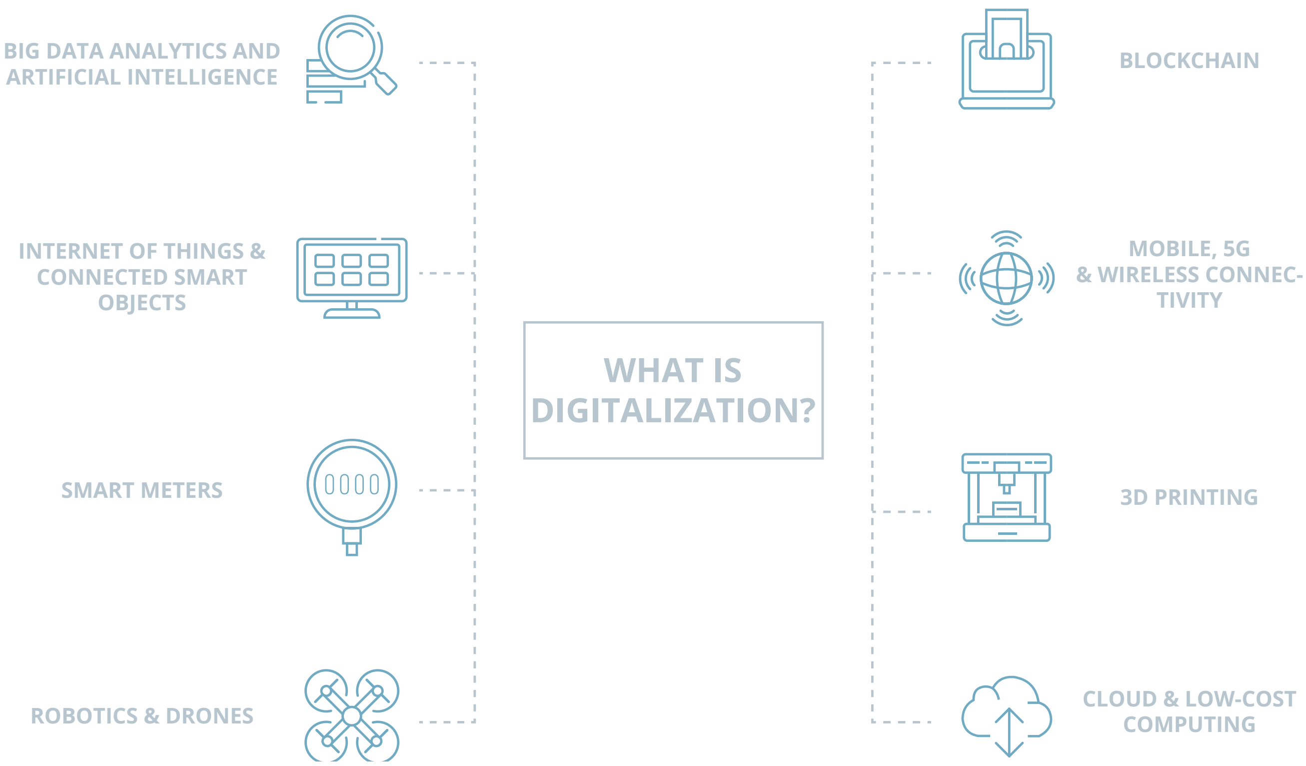


Figure 2: What is digitalization?

2. Digital Solar Business Models

The advent of new technologies such as big data analytics, the internet of things (IoT), robotics, and blockchain allows for the emergence of entirely new solar business models and the improvement of existing models, making them more profitable.

2.1 Smart Buildings

Artificial intelligence (AI) is intelligence demonstrated by computers and machines. It performs tasks usually accomplished by humans. AI platforms have the potential to enhance the energy sector by lowering energy costs, facilitating, and accelerating the adoption of renewable energy in electrical grids.

It is possible to install Smart Building technologies in both residential and commercial buildings. The integration of AI and devices with IoT technology into buildings has the potential to improve operational efficiency and optimize space, and asset utilization. A library of benchmark data is formed and analyzed to identify potential operational improvements by collecting data on occupant behavior and consumption portfolio. Using this technology, building owners will be able to cut energy consumption significantly and achieve ambitious cost-saving targets. Photovoltaic (PV) and building energy management systems, storage, EV charging stations and smart appliances are all part of the smart building package. Installing solar PV systems and energy storage increases self-consumption rates. A diagram of the components of smart buildings is shown in Figure 3.

Self-consumption of a PV solar system is defined as the economic model in which the building utilizes electricity generated by PV to satisfy its own electrical demand. Self-consumption provides greater independence from the grid. Thus, self-consumption combines producers and consumers, turning them into *prosumers*.

» **Smart Building Energy Management Systems,** which provide energy monitoring, are possible with wireless communications, advanced data analytics, and IoT technology.

A Building Energy Management System (**BEMS**) is the software, hardware, and services associated with the intelligent monitoring, management, and control of different energy types.

» **Battery Storage** is a mutually reinforcing technology when combined with solar PV. Residential storage can increase solar PV self-consumption rates from approximately 30% to 70%, potentially lowering the electricity bill, with additional system benefits of reducing network expansion and system costs.

» **Demand Response** provides an opportunity for consumers to play an essential role in the operation of the grid by lowering or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. Energy demand in the building can also increase at times of high solar generation and increase self-consumption rates.

» **Heat Pumps, heat storage batteries, and air conditioning units** could be optimized with solar generation, and use excess solar electricity as heat.

» **Smart Thermostats** are connected to the internet and combined with electric heating or cooling. Solar providers in the US are already offering customers free smart thermostats.

- **Smart Automated Building Appliances** such as fridges, tumble dryers, washing machines, dishwashers, motion-sensor lighting, and blinds. Digital technology can remotely control and communicate with these appliances to adapt to on-site demand.

- **Smart Electric Vehicle (EV)** Charging in car parks could significantly increase self-consumption for households and businesses, especially when combined with storage.

- **Smart Meter Data** can also help identify the customers most likely to have the highest shares of self-consumption.

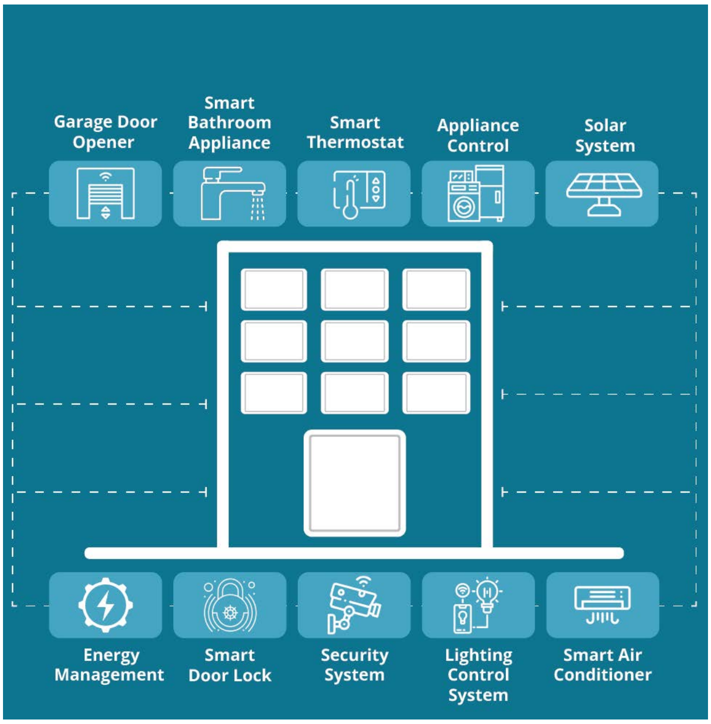


Figure 3: The Intelligent Building Package.

Smart Building Energy Management Systems are the key digital technology to increase self-consumption. Deep machine learning and AI are integrated within these systems to help forecast and manage generation and consumption, and voice activation technology to make systems more user-friendly. Some energy management systems can optimize electricity flows and heat and electric mobility, achieving sector coupling and full electrification. At present, few energy management systems are advertising the ability to integrate with, and optimize solar PV. Those that can integrate, will take a share in the solar market. The ideal scenario would be for these systems to integrate with other facility management functions in commercial buildings.

As a demand response, aggregators that use remote control technology can also reduce on-site demand and increase grid feed-in at times of high electricity prices, thereby increasing the revenues of PV with implicit demand response. Explicit demand response also generates additional revenue by selling flexible services within wider demand response markets. An estimated peak load reduction for demand response in Jordanian households is 3.5 kWh on average per day[3].

Suppose smart EV charging is to be used to increase self-consumption rates. In that case, the PV installation size needs to be improved and sized according to the vehicle's forecast power demand for optimum profitability. Intelligent solar charging leads to long-term cost stability for the vehicle user. Likewise, electric vehicles (EVs) are a way for the solar owner to use excess electricity. A vehicle-to-home and vehicle-to-grid integration strategy could also provide valuable grid services and revenue.

Finally, Smart Meter Data could make the identification of potential solar customers much more efficient. In the past five to ten years of solar development, door-to-door salespeople often knocked on the doors of suitable-looking homes. Companies could use anonymized consumption data from smart meters and statistical patterns to identify which customers' demand profiles are the best match for solar PV. If a business customer has high electricity consumption levels between 11am and 3pm or has demand that could easily be shifted to that time; they are ideal for solar-powered consumers.

A key question is whether these Smart Building technologies are self-sustaining. Do they now increase or decrease the return on investment on an installation when combined with solar? If not yet, when will they? Compared to the total cost of a PV installation, many of these add-on technologies are relatively low cost. Smart thermostats are already advertising paybacks of less than two years on their own, which could be reduced further when combined with solar and electric heat. Pilot projects have shown that the payback period on an energy management system is less than two years for modern single-family homes with controllable loads in the medium term.

However, at present, adding one of these items to a PV system can, in many countries, reduce the payback period on the package. has shown that solar-only systems often provide higher rates of return under current conditions than solar-plus-storage systems[4]. As storage and smart technology costs decrease, the business case for combining solar with this new technology will be more apparent.

Case study: The Impact of “Artificial Intelligence” in Monitoring

It is possible to integrate AI with energy system monitoring applications. In that context, a Jordanian hypermarket, which relied on a 132kWp on-grid PV system to lower electricity costs, used the TaQTaK application to analyze energy data with AI. It allows users to integrate their energy systems into the pp and receive notifications that forecast energy consumption and warn of potential faults that could occur soon. The application finds problems and gaps in the system and increases staff’s awareness of energy consumption and efficiency.

The TaQTaK application reduced the hypermarket’s total energy consumption, from 888.53 kWh to 795.09 kWh. This resulted a drop of 12% in the hypermarket’s electricity bill. Moreover, it increased the PV system contribution by 20%, from 57% to 77% of the total energy consumption. Using the application, the hypermarket improved its electricity consumption and became more efficient.

2.2 Increasing Efficiency of Design and Performance of Solar Plants.

Digitalization could reduce costs in the solar industry using satellite imaging, 3D Light Detection and Ranging (LIDAR) technology, and remote design software. These technologies support developer efforts to - accurately and quickly - estimate power output, and energy savings. In addition, the developer saves cost of in-person site inspection.

Design software increases the quality of systems design and installation. The ease with which systems are being designed and installed accelerated the adoption of rooftop PV systems and improved the accuracy of information provided to the customer. Moreover, using design software in combination with smart meter data can optimize module orientation (south or east-west) and tilt to maximize output and fit the demand profile of a building, or make the most of patterns in electricity prices.

Remote design software could support municipalities in identifying suitable roofs and plan a street-by-street solar PV deployment program. Also, satellite technology combined with climate data adapts the design to local climates, e.g., snow or wind load or dust.

Case Study: Drones Using Intelligent Analytics

Wind turbine inspection, solar plant inspection, solar plant layout, de-icing wind turbine blades, aerial visual inspections & analytics, construction verification, topography surveying, rooftop surveying, mapping, and asset digitalization & management; are all possible with drones. These drones can also be equipped with high-resolution infrared thermal imaging cameras to take images and videos of solar and wind farms, with a 90% reduction in mission planning time, 40% reduction in coordination time, 98% reduction in data collection errors, and 45% reduction in cost.

Drones are an important tool that has advanced PV performance and reliability monitoring. Drones combine thermal imaging and software to identify and report PV module anomalies. Sager Space uses drones in Jordan to collect, process, and analyze data through an AI engine and provide the asset owners with actionable insights on which to base their data-driven decisions.

Sager Space used drones equipped with thermal imaging cameras to conduct thermal inspections of Baynouna Solar Energy Project. The results showed that 0.473% of the total modules installed (3281 out of 693,216 modules) were affected by thermal defects. Major anomalies that could have affected the plant's performance accounted for approximately 0.344% (2384 modules) of the total.

Figure 4: Inspection using drones.

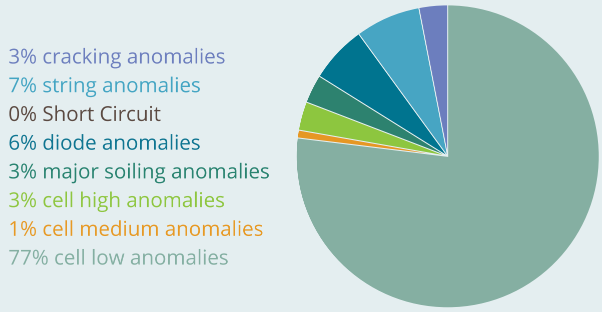


Figure 5: Anomalies Breakdown.

Using drones, Sager Space significantly reduced the amount of time taken to conduct thermal imaging of all the modules in the plant. In the end, they had the results in 14 days, minimizing time lost for replacing damaged modules and plant downtime. The analysis findings of the collected data are shown in Figure 5.

2.3 Increasing Digital Operations and Maintenance and Asset Management of Solar Plants

Digital technologies have reduced operation and maintenance (O&M) costs and increased asset performance, particularly in large-scale ground-mounted PV plants. Digitalization of the solar sector is evolving; with each new digital technology, the market increases efficiency and lowers costs.

Currently, Monitoring systems collect and process huge amounts of data from large-scale PV plants such as energy data, weather data, and electric currents. Data collection and processing develop with technology advances, resulting in cost optimization of data collection and efficient processing.

- Technologies

The below technologies could be utilized in increasing the O&M asset performance

» **Reliable predictive and preventative maintenance** are essential techniques to assure the lifetime of efficiency in service. Preventative maintenance includes physical inspections scheduled at varying time intervals, whereas predictive maintenance is condition-based maintenance being carried out after deep analysis and monitoring of the degradation of main parameters of equipment. Engaging in data processing will improve these maintenance techniques and management of operational data, which will avoid future damage, equipment loss, and plant outages. This is done using

» **Remote Sensing and Control that** enables remote troubleshooting and faults diagnosis. Communications infrastructure, embedded test electronics, and data analysis support the Remote Sensing and Control. The current communication infrastructure (i.e., GPRS, DSL, and LAN) limits the full potential of remote sensing and control. However, promising advances in communication such as Low-power Wide-Area Networks (LPWAN) and 5G networks will enhance remote sensing and control and permit future IoT applications.

» **Cloud Computing** is the on-demand access to computing resources over the internet. The advantages of cloud computing are cost-saving, security, increased collaboration, quality control, and disaster recovery. These advantages, coupled with the prospects of remote sensing and control, will revolutionize the industry and current practices. Consequently, standards are yet to be developed, and research is still needed in this new domain.

» **Digital Field Workers** use mobile technology to do field operations efficiently. Furthermore, control centers can track teams and assign tasks in an optimized manner. The field workers' input will verify information in real-time, thus increasing reporting quality and shortening response times.

» **Advanced software analysis** is another tool that could be used in the management of operational data, such as interventions, reaction and resolution times, event types, final diagnosis of cause and cost of interventions. Such data could be utilized to optimize and enhance assets and resources at a lower cost.

» **Drones** are used to visualize modules, wiring, other plant components, and infrared thermal imaging monitoring. Drones could have onboard data analytics capabilities to detect patterns and changes.

» **Satellite Forecasting** for irradiance measurements and remote sensing is now considered best practice. Forecasting also allows for better-timed maintenance visits and compared with actual measurement data to improve accuracy further. Satellite-based data services are accurate across the year and are less prone to systemic errors. Looking ahead, we are likely to see more and more granularity in satellite data, at 15-minute intervals, for example. Similar technology can also track dust, pollution, and particulate matter that impacts yield.

» **3D Printing** could reduce spare parts management costs by reducing the number of spare parts in storage, decreasing lead times, and manufacturing spare parts closer to the site.

Those technologies enhance Asset Lifecycle Management using industrial connectivity platforms to leverage big data and increase efficiency. Data are analyzed, modeled, and simulated at all levels (portfolio, plant, inverter, and module-level) by digital engineering.

Figure 6: PV system in Jordan.

Case Study: Solar PV Control Center

Kawar Energy operates more than 120 PV power plants with a total installed capacity of more than 180 MW distributed across the country with an estimated yearly reduction of more than 10k metric tons of CO2. These projects include different types of installation, including ground -mounted, roof, and parking lot canopies, either fixed or tracker. The grid interconnection type of these plants is either net-metering or wheeling arrangements or off-grid, with different types of clients/loads, including developers, commercial, banks, hospitality, educational, governmental, and residential.

With this number of plants and the diversity they compromise, maintaining and operating them might prove to be a difficult task, which created the need to have a Central Operation Center (COC), where all these plants are monitored, controlled and their performance analyzed using:

1. Big data analytics and AI
2. Dedicated Leased Line, 3G/4G or wireless connectivity
3. Cloud-based monitoring tools and platforms
4. Smart meters

The central operation center sees through the SCADA systems and different monitoring platforms. It provides many services, including live monitoring, events tracking, predictive maintenance, and an advanced analytics tool. Such services help guarantee achieving power plant KPIs, remote site monitoring using live, closed-circuit television (CCTV) cameras, and better overall control over the plants. These capabilities depend mainly on cloud services and internet connections that could be wired or wireless.

This system improves the response time to types of events, reduces energy losses caused by component failures, helps predict component failures, and improves the overall efficiency of operating and

maintaining solar PV power plants. Still, work is to be done along the road to connect these plants to one platform that aggregates all data from all plants and leverages big data analysis and AI to benefit from reduced costs and improved efficiency.

Figure 7: Solar PV Power Plant (Source Kawar Energy Company - Orange Project).

Wheeling systems are defined as the transfer of electricity through transmission and distribution lines from off-site generation to area of use for self-consumption.

2.4 Upsell Solar with Additional Services

Solar PV systems are integrated with smart building technology such as building energy management systems, storage EVs, smart appliances, electric heating and cooling systems, and smart learning thermostats as described in section 2.1.

Providers can also give customers extra value from their PV installations with cryptocurrencies based on blockchain technology. The service provider can provide the customer with cryptocurrencies that offer additional value to solar or renewable electricity, such as SolarCoin, GENERcoin, and EnergyCoin. These cryptocurrencies are usually allocated per MWh of solar electricity produced and can later be converted into Bitcoin and hard currency.

A lack of understanding remains amongst many energy industry players about what blockchain technology is and the value it can provide. In the context of energy, leading consultants define blockchain as follows:
A blockchain is a digital ledger that permits direct transaction conduction and billing with another party or the so-called peer-to-peer trading concept. This concept means that all transaction data are stored in a chain, with each block reinforcing the previous one. A bank or exchange, or any traditional intermediary, is no longer required, as the chain of blocks acts as witnesses to each transaction carried out between a customer and a provider. The blockchains cannot be modified without retroactively altering the preceding blocks[5].

» Opinion is divided within the solar PV industry as to whether blockchain technology will have a lasting impact on the electricity sector or as they are relatively new technologies.

Case Study: SolarCoin: A Digital Asset to Initiate the Global Energy Transition

SolarCoin is an international and community-based initiative promoting the development of solar energy and self-consumption using one of the most disruptive technologies to have emerged in recent years: blockchain. SolarCoin is like an air mile program. Any solar power producer can connect their solar panels to the SolarCoin network by registering their solar installation to the Solar Coin website and receiving 1 Slr (i.e., Solar Coin, §) for each MWh of solar energy produced.

SolarCoin uses blockchain technology to generate a decentralized, incorruptible, and auditable record of solar energy produced by any solar owner and comes in addition to government- backed subsidies. SolarCoin is already present in 46 countries and has been rewarded to over 2,130,000 MWh of solar power production on a test-basis, using the SolarCoin API and SolarCoin raspberry Pi3 scripts available to all monitoring platforms, EPCs, inverter, and datalogger companies.

SOLARCOIN GRANT PROCESS

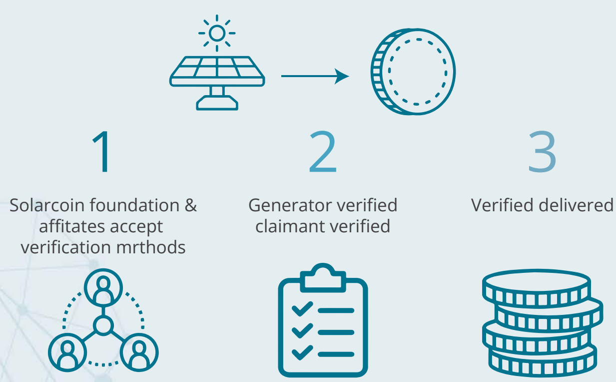


Figure 8: Solarcoin grant process.

2.5 Improve Integration of Renewable Energy into The Grid

Through intelligent plant controls paired with solution-oriented plant sizing and layout, solar energy can create cost-effective, flexible capacity that supports supply and demand balancing. This prospect is increasingly interesting in markets with less stable or saturated grid infrastructure.

With decreasing energy storage costs, solar energy is becoming more cost-effective in compared to conventional plants, even when the sun is not shining, which enables the integration of even more clean energy on the grid.

Case Study: Al Badiya Storage Expansion Project (23MWp/12.6 MWh):

Al Badiya's second phase expansion project is the first utility-scale storage project in the MENA Region combined with an energy storage system in Al-Mafraq - Jordan, with a capacity of 23 MWp/12.6 MWh.

The project includes an expansion of 11 MWp, consisting of approximately 34,350 solar PV panels (320 Wp each), a locally made tracking system, and a 12.6 MWh lithium-ion energy storage system (Tesla Powerpack).

The total size of the storage power plant combined with the first phase is 23 MWp. The new power plant's purpose is to enhance the grid by power peak shaving and power shifting to increase the grid's stability and support the grid at peak load hours. Additionally, it also improves the availability of energy during night- time hours.

Tesla was selected to provide a 3 MW/12.6 MWh powerpack system paired with the 11 MW second phase of the solar park. The powerpack will perform multiple functions, including renewable firming, ramp rate control, and reducing curtailment.

Philadelphia Solar
Delivering Clean Energy Solutions

Digital technology used

Figure 9: Al Badiya Storage Expansion project (23MWp/12.6 MWh).

2.6 Solar Grid Services

Utility-scale solar plants are controllable and can provide flexible grid services, like frequency regulation, allowing system operators to respond quickly and strategically to changing conditions. A vital component of these types of PV power plant controller (PPC) is the plant-level controller. It is intended to regulate the real and reactive power output from the PV power plant to behave as a single large generator.

The PPC can provide the following plant- level control functions:

» Dynamic voltage and power factor regulation and closed-loop VAR control of the solar power plant at the point of interconnection (POI).
» Real power output curtailment of the solar power plant when required so that it does not exceed an operator-specified limit.
» Ramp-rate controls to ensure that the plant output does not ramp up or down faster than a specified ramp-rate limit, to the extent possible.
» Frequency control (governor-type response) to lower plant output in case of an over- frequency situation or increase plant output (if possible) in case of an under-frequency problem, and Start-up and shutdown control.

The PPC implements plant-level logic and closed-loop control schemes with real-time inverters to achieve fast and reliable active and reactive power regulation. The commands to the PPC are provided through the SCADA human-machine interference or even through other interface equipment, such as a substation remote terminal unit.

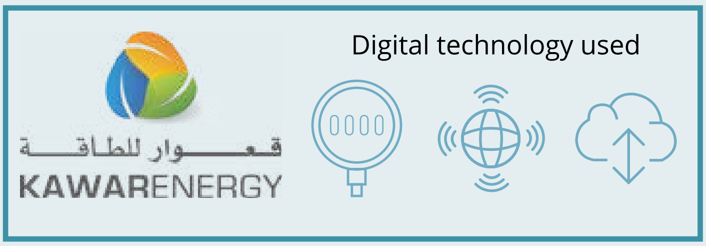
Many operational challenges are addressed by making utility-scale solar dispatchable by enabling grid operations flexibility. For example, some ramping demands on conventional generation resources are reduced if solar plants can control ramp rates during morning and evening hours. Thereby providing the means to operate the grid even in the presence of high solar penetration.

Case Study: Grid Intelligent Solar

For Solar PV Power Plants connected on a Wheeling Scheme, the Power Plant Controller (PPC) and Remote Terminal Unit (RTU) add an automatic/ manual function on ABB Scada sys600 system. The function gives the operator the option to put the inverters in manual mode, excluding the inverters from participating in the PPC regulation. In addition, the operator will be able to write the following parameters into the inverter directly:

» Power factor
» Reactive Power
» Active Power

The system also supports primary frequency response to maintain grid stability. Therefore, Grid operators and utilities could model variable renewable energy sources as controllable and dispatchable in their integrated resources planning processes.



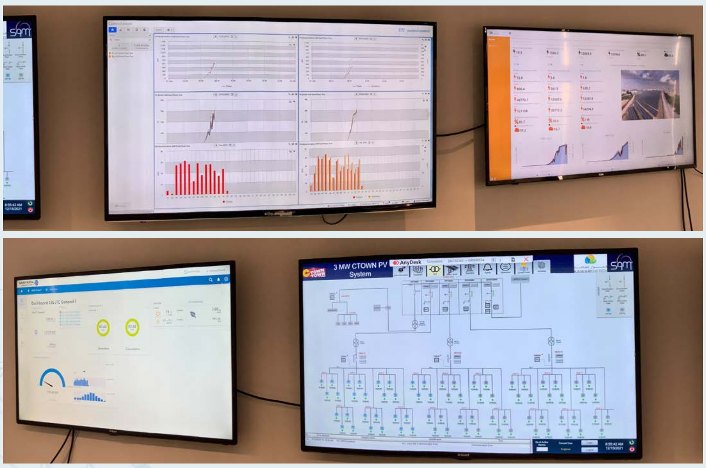


Figure 10: Scada control center.

Case Study: Battery Storage Integrated Solar PV Plant

The station was built through Belectric gulf with a capacity of 46.33MWp integrated with a Behind-the-meter (BTM) pilot battery storage project with a total capacity of 2.6MWh on behalf of the MEMR.

BELECTRIC gulf

Digital technology used

The Project was built in the National Electric Power Company (NEPCO) substation and connected to the 33kV feeder with its meter. The battery helped the PV plant to have two modes of operation: Peak shaving and PV smoothing. The PV smoothing feature can keep the battery available for smoothing both up and down ramps in PV output. Moreover, the battery assisted in supporting the grid with the reactive power support and voltage regulations and primary frequency response to maintain grid stability.

Figure 11: South Amman Solar Power Plant.

2.7 Transport Sector Switch to Solar Mobility

Jordan is considered one of the pioneering countries in the electrification of the transport sector in the Middle East. However, the infrastructure required to serve the increasing number of EVs is still being developed.

With the high fossil fuel prices in Jordan, the operating cost of gasoline-powered vehicles has been steadily rising in recent years. In addition, electricity prices are comparatively lower and more stable compared gasoline prices. On the other hand, EV's operating expenses do not increase at the same rate due to the stability in the electricity prices. Therefore, the number of Jordanians switching to electrical vehicles is increasing. EVs currently number around 30,000 cars across the kingdom and are expected to make up 35% of all vehicles in Jordan by 2025 due to their sustainability and economic feasibility[6]. The Energy and Minerals Regulatory Commission (EMRC) has granted 48 licenses for charging stations in private and public facilities, while as of March 2022, 68 stations are still in the process of obtaining the license. Few, however, exist at tourist sites and vital locations such as airports. The reasons of the slow progress in installing changing points across the kingdom are the prolonged process of acquiring the permit from the EMRC, strict safety regulations and requirements, and long commissioning processes.

In 2015, EVs were exempted from customs, registration fees, and sales tax for the first time to enhance the trend towards the use of environmentally friendly vehicles. In 2015, the government replaced 300 Internal Combustion Engines (ICE) with EVs, the first project of its kind in the Middle East region. In addition, the Greater Amman Municipality bought 100 EVs and 30 taxi EVs as a pilot phase.

Unfortunately, in 2018, the government increased the customs tax on electric cars from 0% to 25%[7]. In 2019, the government reduced the taxes on EVs for the category of 250 kilowatts and less from 25% to 10%, and for the category of 251 kilowatts and above from 25% to 15%[8] .

As seen in the graph below, the number of electric cars imported to Jordan depends on the percentage of customs and tax exemptions. In 2016, the total number of EVs that had customs duties imposed on them was 853. The number increased dramatically by 2800% in 2017 and 2018, reaching 9478 after the customs exemption decision. However, this number decreased by 57% due to the cancellation of the exemption in 2019[9]. Figure 12 shows the number of EVs imported to Jordan in the last 5 years (not accumulated).

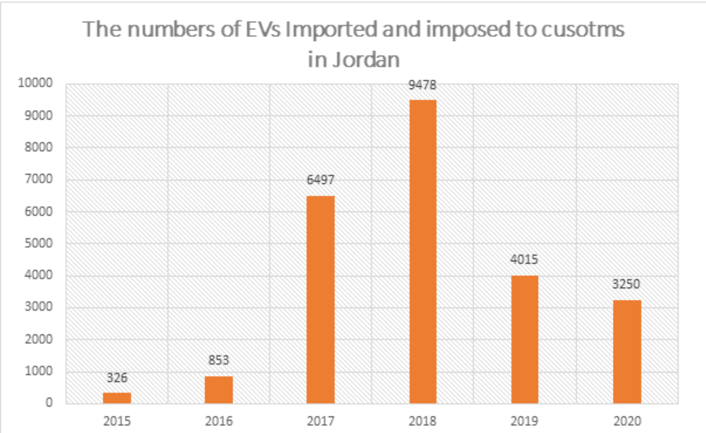


Figure 12: The number of EVs Imported & imposed to customs in Jordan.

Granting charging stations licenses is a burdensome process to ensure that they are safe for operation. However, some service providers have complained of unnecessary delays when the same charging infrastructure was installed in different sites. The decarbonization of the transport sector is high on national political agendas around the world because transportation is responsible for roughly a quarter of global CO_2 emissions and significant air and noise pollution in cities worldwide. A profound transformation of the transport sector is urgently needed to achieve Jordan's climate ambitions. Electrification – direct and indirect – appears to be the most effective and efficient solution to clean transport[10].

Therefore, it must go hand in hand with the deployment of renewables in the electricity mix and should not lead to a growth in the share of CO_2-intensive fuels. As the global market for EVs has experienced rapid growth in the past few years, and falling costs of PV, the penetration of renewable in the transport sector continues to be a vital issue for policymakers and consumers who are increasingly sensitive to sustainable sourcing of their electricity. According to a recent study, the transportation sector consumes 49% of Jordan's national energy[11]. Implementing a transportation model that incorporates the electrification of transportation sector, energy generated from renewable energy plants, and enhancing the electric mobility infrastructure should be considered through the following:

2.7.1 Solar-Powered Mobility

Solar-powered mobility refers to models where solar electricity is used directly or indirectly to 'fuel' clean mobility. Various models exist and offer different options for transport cases.

» **On-site Solar charging**

For direct electrification of transport, on-site solar supply solutions imply a direct connection of a solar system to the charging point, following the logic of self-consumption. This model allows for savings on the energy bill, including grid tariffs and taxes, by covering part of the energy consumption with self-generated electricity, which is particularly attractive in countries with high electricity costs, such as Jordan.

Smart management of the charging process maximizes the penetration of solar energy. It can allow for peak-shaving (i.e., reducing the peak loads of charging stations), reducing the necessary grid connection capacity and the associated costs. This solution is particularly appropriate during the day – slow to fast charging where vehicles are parked for several hours, such as public parking spaces or workplaces. Coupling with battery storage is promising for ultra-fast charging stations and storing the excess PV generation.

» **Off-Site Solar Sourcing**

Models offer an alternative to on-site charging, especially with no available space. Solar electricity is not produced at the charging point. Still, it is supplied commercially to the electromobility consumer through innovative supply contracts, in which the energy production is traced from generation to consumption through Guarantees of Origin (GOs). Purchasing unbundled GOs or Utility Green Procurement products is an easy solution for smaller consumers or consumers unwilling to invest in a solar system. In parallel, PPAs offer the opportunity for consumers to invest in additional solar capacities. Consumers directly benefit from the power generated by the plant at a competitive and stable price agreed on over a 10-to-25-year period. This option is thus desirable for large electricity consumers such as trains, metros, or trams.

2.7.2 Vehicle-Integrated Photovoltaics

Vehicle-Integrated Photovoltaics (VIPV) are solutions where a vehicle is equipped with integrated solar PV cells. The term and the technologies come from Building-Integrated Photovoltaics (BIPV); a group of solar technologies where solar PV cells replace conventional building materials. In recent years, thanks to the falling cost of solar cells and improvement in cell integration, VIPV vehicles have been deployed in the market, offering a clean and affordable alternative.

VIPV solutions have been developed in all transport sectors – passenger cars, trucks, buses, boats, trains, aviation – and offer specific benefits in each case. The PV cells can provide a simple power source for auxiliary services depending on the models. In most advanced cases, they provide additional power to the EV battery and extend its driving range, saving fuel costs. It can also power specific applications, such as the liftgate systems of trucks or refrigerated trailers.

2.7.3 Smart Solar Charging

Solar mobility is also smart mobility, with smart charging technologies playing a central role. At the charging station level, smart charging can help to optimize the solar self-consumption ratio. It also has relevant applications at the system level. By unlocking the flexibility of EV batteries, smart charging can support the grid integration of solar and contribute to 'greening' the electricity system and the power used by EVs. International Renewable Energy Agency (IRENA) has modeled that in 2050, a global fleet of more than 1 billion EVs could provide approximately 14 TWh of batteries, compared to the 9 TWh estimated capacity of stationary batteries[12].

Case Study: Free Public Charging Station - Ajloun EV Rapid Charging Station

An EV charging station powered by an on-grid 35 kW PV system has been installed in Ajloun, Jordan. The station aims to encourage utilization of EVs in the area; initiate Green Tourism by providing a solution for tourists who may be using electric cars to travel to Ajloun; and increase awareness among the local community of new technologies while integrating them with bright and clean energy sources.

The design was assessed based on a daily charge for six cars, each for 20 min to charge up to 80% of battery capacity from 0% charge. The charging will be free of charge, and information of how much energy was used and equivalent costing will be provided to beneficiaries as part of the awareness part of the project. The on-grid PV system is expected to cover all the charging station's designed demands, including additional lighting loads and the operator's room. Surplus energy will be fed to the grid and rounded for the allocated utility meter.

SEED

Cowater International

Digital technology used

Figure 13: Ajloun EV rapid charging station.

Case Study: Mobile charging through "Ma3aak" Application

The "Ma3aak" mobile application, launched in 2018, offers various services to cars, including changing flat tires, spark plug and battery replacement, and even towing. It works in a similar way to ride-hailing apps, in which the user pinpoints his/her location on a map and waits for the required service to be provided on site. Due to the scarcity of charging stations in the capital Amman, and the low ranges of EVs, "Ma3aak" application has provided EV owners with the possibility of charging their vehicles for up to an hour, a time enough for the EVs to charge enough energy to reach their destination. However, this service is only available in Amman for the time being.

A very convenient concept, especially in emergency situations. The services, which are licensed by EMRC, are completely digitalized, from ordering the service to its payment, which has multiple benefits, including better time management and convenience of payment. The company is facing challenges regarding user awareness but asserts that the service has been successful so far.

معاك
MA3AAK

Digital technology used

Figure 14: An EV during the charging process by the Ma3aak application.

2.8 Manufacturing

Equipment and module manufacturers have long used robotics and other digital technologies to increase accuracy and reduce costs in solar manufacturing. Robotization is relevant for the wider digitalization of the sector as it allows the collection of data on processes and efficiencies. In the future, there is potential for connected machines and advanced data analytics to further reduce the cost of solar PV value chain manufacturing.

Advanced monitoring technology also helps reduce the risk of exposure to raw materials and chemicals used in PV manufacturing processes and enables

far higher quality control standards. Further down the production process, automation has allowed in-depth quality checks of individual cells and modules. Many equipment manufacturers already have advanced systems for monitoring the performance and efficiency of individual cell and module production lines. Other players are seeing more and more demand from clients for equipment to communicate with other machines and components in the factory and with a central SCADA communications system. This could allow for the application of predictive maintenance to solar manufacturing equipment. Clients also want equipment to be more flexible and future-ready, adapting to future digital innovations in manufacturing processes.

In the same way solar digital O&M is seeing the emergence of digital field workers, some product manufacturers are providing digital factory and workers with information systems that allow staff to improve their work accuracy and quality.

There is a specific potential for more mass personalization in solar manufacturing in specific niche solar PV markets, where wholesalers, end-users, or architects could order custom-made parts from manufacturers. This would mean that manufacturers could provide a more specialized service, leading to more choice for consumers and greater potential growth of digital market, which would be an example of digital technology permitting the consumerization of business-to-business activity. It could involve specific requirements in module shape, bifacial features, or materials adapted to low irradiance or high-temperature conditions. It also could be applied to integrated, organic, glass, and transparent PV buildings. In glass- based PV modules, customers are already ordering products to spec.

In the future, it is also possible that 3D printing could be used to manufacture both whole modules and spare parts in a cheaper and quicker manner, and closer to the site. Some manufacturers are investing R&D into 3D printing, although many commentators believe this is still a long way off. This is particularly relevant to spare parts for discontinued models and production lines.

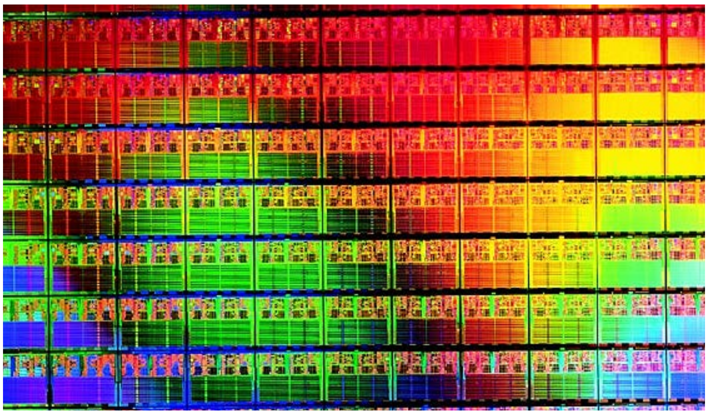


Figure 15: Silicon Wafer Photovoltaic.

3. Long Term Transition Technologies

Jordan can benefit from different experiences worldwide to apply different transition applications in the long run. The long-term transition technologies will create new opportunities in the energy sector, and assist in reducing energy costs, however it will require an advanced upgrade on the infrastructure. Below are examples of long-term Transition applications.

3.1 Consumers to Prosumers

The digitalization of the energy sector will create opportunities for consumers to generate revenue by trading energy. The grid interconnection types of solar PV plants in Jordan are either net-metering or wheeling connection agreements. A digital platform for electricity trading would empower the consumer to become a prosumer, shifting the energy sector towards a peer-to-peer energy trading (P2P) model. P2P energy trading allows the end-users to become distributors by selling the electricity at a desired price to others using a P2P platform without any intermediary. P2P also aids the prosumer community resilience to outages in emergencies and increases the renewable deployment and flexibility of the grid.

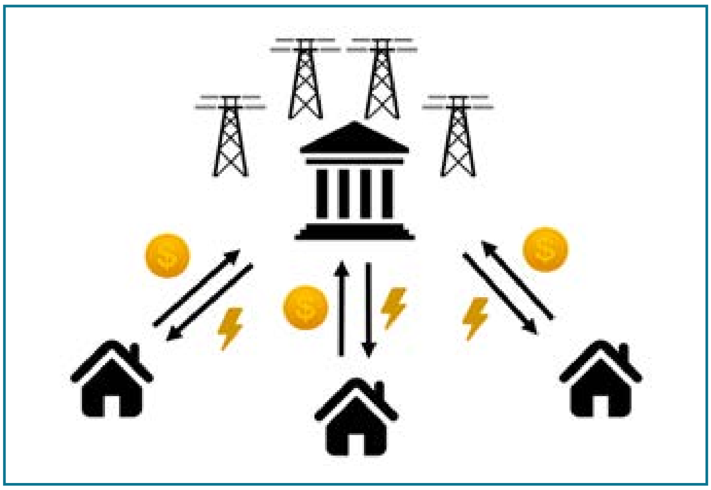


Figure 16: Traditional electricity trading system.

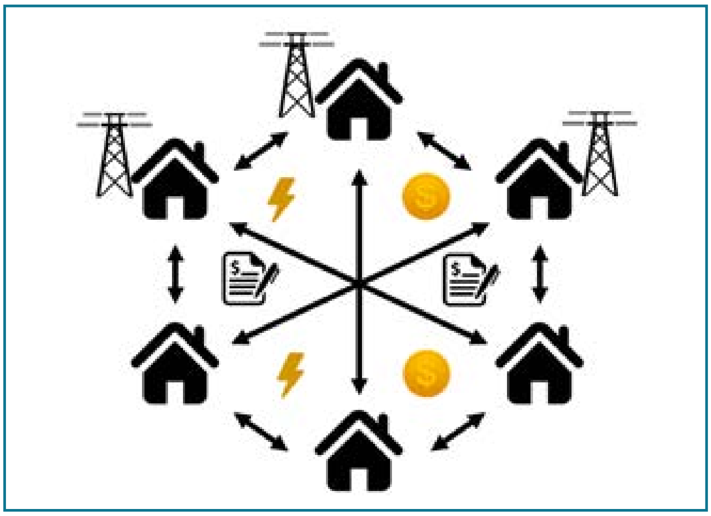


Figure 17: P2P electricity trading system.

Examples of P2P energy trading schemes

A P2P energy trading scheme was trialed in the UK in 2018, led by London-based energy start-up "Very" on a social housing estate in Hackney, London. In April 2018, "Very" successfully facilitated the UK's first-ever physical energy trade using blockchain technology, in which one kWh of electricity was sent from a rooftop solar PV array on one of the estate's buildings to a resident's home in another building, using "Very's" peer-to-peer energy trading software platform. The ongoing trial of the platform is supported by repowering London (a community organization), Innovate UK (a national government funding program to help business R&D), and the utility British Gas, owned by parent company Centrica. Utilizing Artificial Intelligence-based "smart hubs" in tenants' homes to calculate their energy demand profiles and Power Vault batteries to store power allows "Very" to test practical applications of their technology, including how consumers respond to it.

The goal is ultimately to test whether AI and peer-to-peer trading can optimize the use of electricity generated on a community-owned PV site, reducing residents' bills, and increasing energy independence. Jordanian policy makers could use the 'sandboxing' practice in the UK and allow innovative start-ups and social entrepreneurs to experiment with new technology when it is shown there is a clear consumer benefit.

3.2 Grid-Connected Microgrids

Grid-connected microgrids are used to provide a backup or uninterruptible power supply source through advanced microgrid management software platforms that optimize the different generation sources within the microgrid.

There is considerable overlap between large (and primarily commercial and industrial) self-consumption and the use of grid-connected microgrids, with the significant difference being that grid-connected microgrids are also engineered to be able to provide back-up and operate in island mode if market conditions make this favourable. This prospect often involves the use of battery storage, gas, or diesel generators. The two primary business opportunities for solar- based grid-connected microgrids are industrial sites and municipalities.

A grid-connected microgrid can be defined as: "A group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity concerning the grid. A microgrid can operate remotely or connect and disconnect from the grid to enable it to operate in both grid-connected and island mode.[13]"

Blockchain technology is well suited to managing flows within a grid-connected solar microgrid, determining when generation assets within the asset should be powered up or down. This technology can also, if applicable, govern transactions within the microgrid.

4. The Way Forward: Policy Recommendations

To increase access to clean, sustainable, and reliable electricity for all sectors in Jordan, expanding the existing grid infrastructure and enhancing the integration of new digital technologies in the energy system are essential. The following subsections discuss the way forward for each applicable technology highlighting the opportunities, limitations, and the policy recommendations.

4.1 Solar Powered Smart Buildings

Smart buildings are a vital element to the future development of smart cities. Smart buildings can make cities become safe, smart, and sustainable. Also, this technology will assist owners in harnessing and controlling their energy use.

Integrating solar-powered buildings with smart technologies will open an opportunity for advanced energy management and provide the consumer with the ability to control and monitor the demand and supply of energy. Solar-powered smart buildings can reduce the payback period of the solar PV system by providing higher rates of return compared to solar-plus-storage systems only. Moreover, the adaptation of the prosumer model will lead to open a new market of hybrid PV systems with battery storage.

The lack of understanding of the benefits of smart building by the owners and developers, and the unavailability of specific building codes and standards to integrate this technology in buildings hinder the adaptation of smart buildings technology in the kingdom. Effort is required to flourish smart building technology in the country such as **developing training sessions for professionals, raising awareness of the importance of smart buildings and setting standards to integrate the technology into new and existing buildings**. Moreover, incentives for consumers should be provided to accelerate and develop such models in Jordan.

4.2 Grid Services and Smart Grid Integration

Utility-scale solar resources with SCADA systems are now an important tool to help operators meet the flexibility needs of the grid. However, grid distribution utilities are facing many hurdles such as the lack of regulations for most grid-connected distributed generation energy plants, and unavailability of large battery storage connected to utility-scale PV plants on the distribution grids, which leads to energy curtailment.

Developing competitive and open energy markets with related economic frameworks and regulations will accelerate integration of renewables and batteries to the grid (either by DC-Coupling, AC-Coupling or hybrid coupling with batteries) which will make the market more competitive.

4.3 Digital O&M and Asset Management of Solar Plants

Implementing new technologies in the Jordanian market would enhance the plants' performance ratios, and more renewable electricity could be injected into the grid with implementing innovation technologies such as cloud computing, satellite forecasting, drones, etc. Cloud computing and satellite forecasting services could be used in PV power plants to maintain data records. A network infrastructure should be created for cloud computing services. A database of maintenance activities is essential for operators to develop annual maintenance schedules and a better prediction of the frequency of maintenance. **Drones could also be used during construction phase and asset management of plants and robotics**. However, it is very hard to get a permit to use drones in Jordan. Obtaining such permits should be easier for developers or O&M service providers. **With such new technologies and information, technicians will need to get training on using mobile technologies for the maintenance activities.**

4.4 E-Mobility

The energy capacity of EV batteries and charging/discharging flexibility of EVs can introduce different business models such as vehicle to grid (V2G), vehicle to home (V2H), and vehicle to building (V2B). Since no additional investments are required to use as energy storage, these batteries will provide an efficient form of energy storage. On the other hand, there are many factors limiting the usage of EVs and the electrification of the transportation sector in Jordan, such as underdeveloped infrastructure in Jordan, lack of awareness of the impact of E-mobility on the environment, and limited number of public charging stations on highways and inside cities. More efforts are needed to extend charging infrastructure in public and private spaces. Overcoming those challenges and limitations could be through:

» **Reducing the taxes and simplifying the procedures to obtain the necessary permits** to encourage investments in developing charging stations and infrastructure.

» **Introducing carbon-taxing regulations**, which means vehicles pay their annual registration fees based on their carbon emissions.

» **Encouraging the private sector to invest in EV charging stations**, and to simplify the regulations, and reduce permit procedures.

» **Developing new regulations that address the overlap between the EMRC and electricity distribution companies**, which causes a delay in the installation and operation of charging stations and their integration with renewable energy sources.

4.5 Blockchain in Energy Sector

Blockchain is a decentralized technology; it can lead to a reduction of central authorities' control. Therefore, it is necessary to have a clear framework that benefits all parties, including society, public sector, economy, and investors. The blockchain application in Jordan is deficient. Various key challenges slow the adoption of blockchain technology, such as the absence of proper laws and regulations. The energy infrastructure and the single buyer model adopted in Jordan are the main challenge towards moving to the open market and applications of blockchain.

Blockchain technology could replace many current services provided by energy distributors, especially in billing and metering services. Relying on the new digital infrastructure may weaken the role of the distribution company as a provider of such services. The blockchain market could be started with pilot projects **by introducing and developing platforms that transform passive consumers into active consumers (prosumers)**.

4.6 Energy Microgrids

Microgrids have not been implemented in Jordan yet; However, the technology could be highly applicable in rural areas, especially in the southern part of Jordan. The closest applications are the hybrid off-grid systems that depend on diesel generators and solar energy. The roles of grid operators and microgrid participants should be identified to facilitate the adoption of microgrids.

Microgrids may be applied at commercial, industrial, and residential sites. However, Microgrids cannot be applied at this moment in Jordan since they rely on other undeveloped technologies such as batteries, blockchain, and peer-to-peer energy trading models. There is a need for the Jordanian government to **increase awareness of business models for investment in microgrid installation, maintenance, monitoring and operating**. The public is still not aware of microgrids and their advantages. Furthermore, implementing microgrids will require financial feasibility studies, impact studies on the grid security and stability.

4.7 Peer-to-Peer Energy Trading

Peer to Peer energy trading is one of many concepts that are still new and can have a positive impact in the Jordanian market. Peer-to-Peer energy trading can provide ancillary services and positive impact on grid resiliency, increase penetration of renewable energy, and dispatch cost-effective services. They have also the potential to convert cities and villages to be more environmentally friendly, acting as alternative to extra cost of the electrical grid infrastructure. The government could fully exploit such technologies by **having a clear plan and vision on the national level towards energy digitalization**. The plan should involve developing the grid infrastructure and infrastructure for smart EV charging stations to ease the adaptation. The government should also **provide more awareness campaigns (both public and private sectors), trainings of the benefits of these technologies**. All stakeholders in the energy sector should be part of the transition to **ensure proper setup, configuration, and commissioning of integrated smart systems instead of relying on a single buyer business model**.

5. Appendices

5.1 Annex 1 - Policy Makers and Regulatory

Entity	Name / Position
Energy and Mineral Regulatory Commission (EMRC)	Amaal Al-khatatbeh / Renewable Energy Engineer
	Mamoun Abdelrazaq / Engineer at Energy Conservation section
	Muna Al-Musa / Energy Conservation Head Section
Ministry of Energy and Mineral Resources (MEMR)	Abdallah Aldweik / Energy Expert / Jordan Renewable Energy and Energy Efficiency Fund (JREEEF)
	Alaa Al-Hadidi / Associated Engineer, Renewable Energy and Energy Efficiency Department
	Arwa Abukashef / Associated Engineer, Renewable Energy and Energy Efficiency Department
	Baraah Alsurdi / Planning Engineer at Planning and Organizational Development Directorate.
	Helda Khader / Energy Engineer Intern / Jordan Renewable Energy and Energy Efficiency Fund (JREEEF)
	Omar Mus'ab Alrosan / Assistant Engineer at Renewable Energy and Energy Efficiency Directorate- Studies section

5.2 Annex 2- National Task Force Members

Company	Name / Position
Associated Transtech Contracting Co (ASTRACO)	Amer Kattan / Manager Renewable EnergyDepartment
Catalyst group	Firas Rimawi / Consultant
Darb Company	Hana Ziyad / Business Development Engineer
Firas Balasmeh Group	Firas Balasmeh / CEO
Jinko Solar Company	Waleed Al-hallaj / Business Development Manger
Kawar Energy	Azzah Al-Khalailah / Senior Performance & Operation Analysis
	Hanna Zaghloul / CEO
	Mahmoud Slameh / Head of O&M
	Malik Momani / Operations & PerformanceAnalysis Engineer
Mitsubishi Corporation	Mohamed Zawaideh / Manager, BusinessDevelopment
Modern Arabia for Solar Energy	Tariq Khalifeh / General Manager
	Haya Shahitit / Operations Coordinator
Mustakbal Clean Technology	Shukri Alhalabi / Chief Operating Officer
Optimiza Solution Company	Omar Halaseh / Chief Technology Officer
	Samer Khouri
Orange Telecommunications Company	Hashem Al-Azheri / Renewable energy manager
	Rana Abulouha / Office Manager
	Raslan Deiranieh / CFO
Sagerdrone	Mohanad Al-ashhab/ Sales & Technical Engineer
Yellow Door Energy Company	Josephine Pham / Marketing manager

5.3 Annex 3- List of Interviews

Company	Name / Position
Al-Manaseer Group	Mohanad Halawani / Renewable & Biofuel Energy Consultant
	Ramez Khoury / General manager
	Yasser Manaseer / Partner
Algebra Intelligence	Ahmad Altawafsheh / CEO & founder
Associated TransTech Contracting Co ASTRACO	Amer Kattan / Manager renewable energy department
Belectric	Mouath Odetallah / Testing and Commissioning Manager / O&M Jordan Manager
Catalyst group	Firas Khilafat / Investment Executive
	Firas Rimawi / Technical Director
	Tamara Otoum / Business Development Executive
Darb Company	Hana Ziyad / Business Development Manager
EV King	Ahmad Abu Raddad / Chief Executive Officer
FB group	Firas Balasmeh / CEO
Izzat Marji group	Shifaa Khatatbeh / Energy Efficiency Manager
Kawar Energy	Azzah Al-Khalailah / Senior Performance & Operation Analysis
	Hanna Zaghloul / CEO
	Mahmoud Slameh / Head of O&M
	Malik Momani / Operations & Performance Analysis Engineer
Ma3aak Application	Emad Bader / General Manager
Mustakbal Clean Technology	Shukri Alhalabi / Chief Operating Officer
Optimized Solution Company	Saif Khouri / Chief Operations Officer
Philadelphia Solar	Mohammad Zitawi / Design & Application Manager
Sager drone	Mohanad Alashab / Technical Sales Engineer

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