

Best Practice Fundamentals in Smart Grids For a Modern Energy System Development in Jordan

Faisal Y. Alzyoud, NesreenAlsharman, and ALMofleh Anwar

Abstract: The incoming technologies and the fifth generation in telecommunication systems are characterized by the spread of IoT sensors and the application of IPv6, as internet will be everywhere with zero cost. But, unfortunately the proliferation of IoT devices will consume a lot of energy, and embrace toxic pollution and E-waste. To utilize the benefits of smart devices and reduce the harmful of their applications, there is a tendency to apply green IoT devices and green energy aspects. Smart grid starts to arise in the horizon and a plenty of researches are done to utilize the use of energy, so smart grids technology is considered an important and dominant factor for modern community to achieve several objectives like energy security, cost reduction, and economic factors that mitigate climate changes by reducing the emission of CO₂. Smart grids can adapt to the proliferation of energy consumption resources by integrating different renewable energy resources and applying recharging systems like electric vehicle in transportation, so smart grid is considered a good solution in countries development through applying technology regulations and rules. Jordan is one of growing countries in developing green energy resources, it starts to use different green energy resources like sun and wind, so Jordan substantially begins to utilize the smart grids practices, reduce energy costs and mitigate the environmental pollutions.

Key words: IoT, JNES, PV, RES, SGNs

Introduction

Electricity is considered as one of the vital aspects for human life, since every part of our life style will need energy source and electricity. The demand for electricity will rise for the incoming years; due to the increase of Internet of Thing (IoT) devices and sensors which depend on electricity [1]. To fulfill with the energy sources shortage and the increase in energy cost, there is an important need for a smarter approach to increase and utilize the energy efficiency, these needs develop smarter energy

management solutions to adapt the development of technologies like smart grids. Smart Grid Networks (SGNs) will be a good alternative for the transmission systems in new century; since SGNs depend mainly on renewable energy resources such as wind and sun. SGNs optimize the use of electricity generation and search for solutions to reduce the cost of power in kilowatts, also SGNs try to engage the consumer with electricity generation process. Smart meters are used as electronic devices to record energy consumption, and establish a communication with electricity suppliers for monitoring and billing purposes. The number of smart meters in the grid is expected to reach around 240 million in Europe, 150 million in North Africa, and about 400 million in China by year 2020 [2].

Electricity was often generated by plants are laid far away from urban and industrial communities; as electric plants require special environmental conditions such as: production facilities, places for water dams, etc. Initially, electric power was generated by medium voltage range, then this voltage can be raised to high voltage by voltage lifting transformers in order to move it over long distances range from hundreds to thousands kilometers, after electricity moved to the target position, it is then reduced to medium used voltage using voltage reduction transformers to fulfill different requirements in both nomadic and industrial demand limits [3]. Due to the promising aspects of implementing IoT, and smart cities concepts; There is a crucial need to develop green IoT and low-carbon emission technologies to handle different aspects related to energy such as energy security, adapting to climate changes and the growth in economy [4]. Smart grids are considered one of the important technologies including low-carbon energy technologies and renewable energy sources such as Electric Vehicles (EV). Smart grid uses different digital technologies to manage and control electric generation, transportation, and use as smart grid uses the

following techniques to enhance energy efficiency used and apply greenIoT features such as [5]:

- Smart power transmission systems.
- Implementing efficient distribution protocols.
- Implementing efficient computing techniques.
- Nodes scheduling
- Nodes switching from sleeping mode to active mode.
- Adapting energy efficiency techniques.
- Utilizing CR techniques in energy harvesting [6].
- Adapting new renewable energy sources [16].

Intelligent Networks (INs) play as coordinator to handle and utilize the capabilities of INs's generators, INs's operators, INs' send users and INs's stakeholders in the electricity market to achieve costs reduction, reliability, stability and reduce the environmental impacts. Power grids deploy massive Advanced Metering Infrastructure (AMI) to measure power consumption techniques such as smart meters which collect and gather electrical measurements [7]. AMI collected electrical data combined with other non-electrical data sources such as weather see Figure 1.

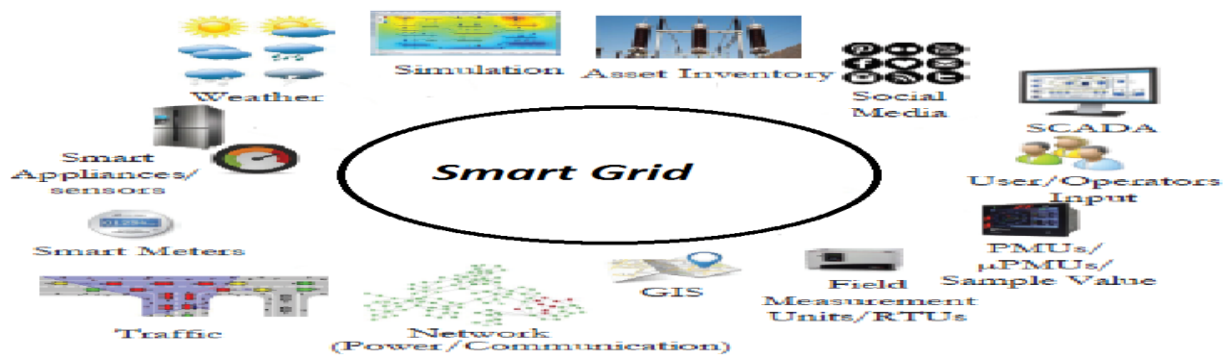


Figure 1: Smart Grid electric and non-Electric Sources

Jordan as most of the world countries starts to plan and add further investment in smart grid; since adapting and implementing smart grids will have a set of technologies that will be used in different environments fields around the world including: local

business, adapting strategies compatible with existing infrastructures, regulations rules developments, and increase investment in smart grid as depicted in Figure 2, which represents the evolutionary nature of elegant smarter grids.

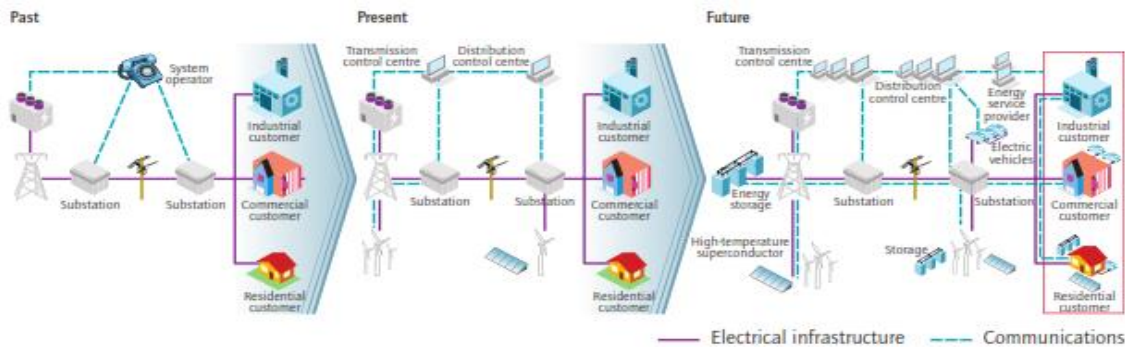


Figure 2: Smart Electricity Systems Evolution

The evolution in electric system grids are addressed by many challenges related to technical, financial and the regulations for each region. Smart grids are characterized by high data volume reaching terabytes

or more (Big Data) with a valuable values [8]. Smart grid are characterized by several features shown in Table 1.

Table 1: Smart Grids Features

<i>Smart Grids Feature</i>	<i>Details of Smart Grids Feature</i>
Customers Participation	- Smart grids systems enable their consumers to modify and adapt their requirement according to balance supply and demand intervals. Smart grids develop new technologies to produce information about consumers electricity utilize, and supply users by new forms of and cost price and electricity pricing reduction incentives.
Scalability and Efficiency	- Smart grids are able to support the developing set of customer sited energy distributed resources. Also, to centralized power plants. Smart grids have different energy power consumption sources like small-scale combined power and heat, renewals, and they contain energy storage devices that will rapidly growth during the value chain of smart grids starting from energy suppliers to marketers and customers.
Flexibility and Management	- Smart grids are designed to operate with markets efficiently, and to generate an opportunity for their consumers for selecting the best service among different competing services. Energy source, capacity, location, time, and quality are some of the smart grids variables that should be managed efficiently, so markets play main factor in smart grids variables management. Flexibility is needed for smart grids owners, operators, regulators, and consumers to enhance the rules and regulations of business suitable to market conditions.
Quality and Customer Satisfactions	- Smart grids support different prices and grades of power because the cost of premium power-quality features is augmented with the electrical service agreement, so advanced new control methods are needed to monitor necessary components, and to enable rapidly diagnosis solutions which will impact power quality like: switching surges, lightning, harmonic sources and line faults.
Optimize and Utilization	- Smart grids use the modern techniques to utilize their assets. Such energy utilization that can be attained by dynamic ratings, and sensing loads increase rate Smart grids maintenance can be improved efficiently with condition-based maintenance through performing equipment maintenance at regular time.

However, the new trends in smart grid development are to replace carbon-based generators by renewable energy from sun and wind that are characterized by: intermittent, uncontrollable uncertainty, as they have virtually no marginal costs [9].

Jordanian Scenarios for smart Grids

Smart grids technologies implementation generate several benefits relating to operation, security and adapting new renewable energy policies in many fields such as solar energy marketing, but unfortunately, bulk smart grids may face drawbacks such as complexity in monitoring, operations and control of combined set of power grids planets. In general, the

cost of energy production, and electric energy in specific are growing rapidly; due to the reduce in fossil fuel world resources, the rise demand for energy in the world, the price cost per kWh, so energy production from traditional resources becomes more expensive because their scarcity. Jordan as a part of the world, its demand for energy increases rapidly. It is anticipated that the annual development rate of the electrical loads will reach (3.7%) in average by the year 2040 as depicted in Figure 3.

The maximum demand is expected at summer season; since in this interval the electric consumption is increased due to the use of air conditions and other electric devices [10].

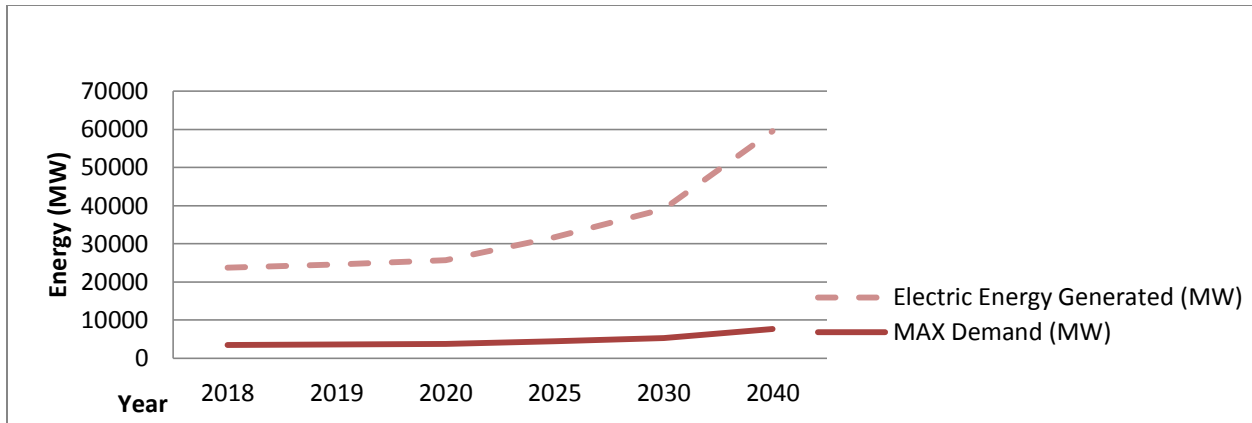


Figure 3: Jordan Electricity Demand Forecast

Jordan plans to reduce its dependence on natural energy fuel supply (Diesel, N.Gas, and Heavy Fuel Oil) which is estimated to exceed 90% before 2016 [18] see Figure 4. Jordan adapted several strategies to reduce its dependency on energy imported resources by applying a strategies plans to use renewable energy sources. Jordan government started to implement its energy strategy, so it applied several steps to increase its renewable energy electricity production sources using wind and solar

energy[17]. Jordan government signed many agreements to encourage the use of renewable energy by developing many projects to produce electric energy with capacity of about (418) MW, in addition many projects are assigned to utilize Jordan natural sources of energy like oil shale, sooil shale can anticipate in covering about (30%) of the all energy generation by the year 2025 in Jordan[10] [19].

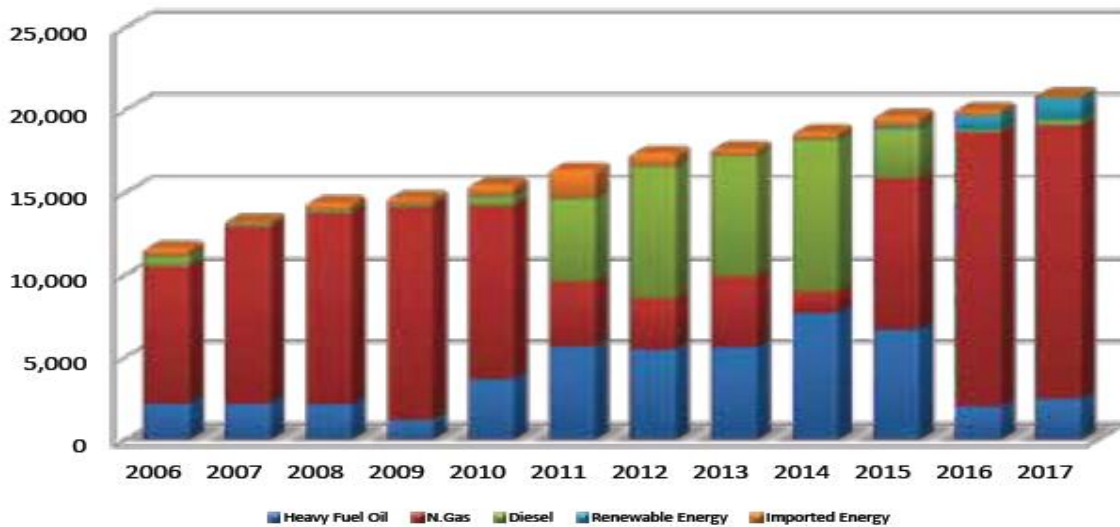


Figure 4: Jordan Electrical Energy Resource Types from 2006-2017

Jordan National Energy Strategy (JNES)

The energy costs consume about 52.8% of Jordan's economic revenue as it is shown from Jordan Ministry of Energy and Mineral Resources annual report in the year 2015. This report shows that most of energy cost comes from the country's imports, so Jordan adopted a strategy that depends on using its green natural resources such as its sunny weather and wind swept

laying on eastern and northern areas in Jordan; these weather conditions are considered as best solutions for photovoltaic (PV) and wind turbine solar projects [11]. The basic goals for Jordan plan are to reduce using imported oil, reduce energy waste, and develop renewable energy sources to reach 10% as energy production source by 2020, and enhance energy efficiency to reach 20% in 2020 [12]. Jordan National Energy Strategy (JNES) is built on the following steps [13]:

- Increase the security for sustainable supply of petroleum products and enhance the competition in energy commercial sector.
- Achieve the security of electric power supply.
- Achieve security of natural gas supply and diversify the resources for importing.
- Utilize the renewable energy sources.
- Exploit the oil shale to generate electricity
- Introduce nuclear energy to generate electricity
- Raise the energy efficiency.

Jordan is considered as one of the most discriminator countries in Middle East which invests in Green Financing. Green financing means using all the financial products and services like insurance, loans, bonds in green projects, stocks, and private equity. JNES concentrates on improving energy performance, consumption reduction, and improving the participation of renewable energy sources to the total used energy resources.

Smart Grid Sustainable Development in Jordan

Pricing is an important incentive factor in renewable energy promotion policies. China is the fastest growing country that invests in renewable energy resources in the world [20], so it reduced electric grid prices; to promote its electric grid renewable energy resources, so the promoted pricing models which are suitable for renewable energy can be adapted to renewable energy sources [14].

Sustainable energy depends on natural sources that replenish themselves rapidly, while Renewable or green energy can support electricity consumers with low costs. Electricity pricing or tariff includes marginal cost, load pattern, and social criteria [15]. Green powers are deliberate environmentally as they are socially and friendly acceptable; renewable energy sources include: biomass, wind, sun, Geo – thermal and hydro. Renewable power sources can support smart grid with the following features:

- Utilization the storage of RER resource output remotely
- Renewable Energy Systems (RES) functionality improvement facilitated
- Energy Provision facilitation and classification
- Redistribution of grid energy
- Facilitating storage of electric grid energy

- Functionality enhancement for electric vehicles with plugging hybrid systems

Renewable Energy Projects in Jordan

Energy sector in Jordan occupies important part in economic and renewable energy starts to play a significant progress since 2017; the basic sources of renewable energy in Jordan are Wind and solar energies. Jordan started to put new strategies mitigated with the new plans developed from the long term comprehensive national strategy for the sector of energy during the years (2016 - 2025), as it is depicted by applying different renewable and green energy projects to be an alternative solutions for natural gas, heavy fuel and diesel oil as shown in table 2 [13].

It is noted from these projects the implementation of renewable energy sources is auspicious and can be a good alternative to support Jordan with its energy requirement. These new projects are compatible with the context issues permanent law for renewable energy No.(13) for the year 2012, which promotes incentives for investment in the infrastructure of renewable energy projects, in addition the government force the electricity companies to buy all the generated electrical energy from these. The aim of these incentives is to speed up the growth of renewable energy sector as it is shown in table 3. It is noted that the energy mix in Jordan will occupy about (20%) of energy.

Table 2: Jordan Performed Renewable Energy Projects during(2015-2018) [19]

	Project name	Capacity (MW)	Operation Date	
Wind Energy Projects	Tafilawind project	117	Sep/2015	
	Al-Hussein wind project	88	First Quarter/2016	
Solar Energy Projects	First round of the direct offers,(12)PV projects.	200	First Quarter/2016	
	Second round of the direct offers,(4)PV projects: -Mafraq development projects(150)MW	200	Mid/2018	
	Quwireh PV Project	103	First Quarter/2018	
	Large Industries	Al-Rashadih	17	Third Quarter/2017
		Al-PotashCo.	33	First Quarter/2018
	Small Solar Systems(<5MW)	Net Metering	154	--
Welling		49	--	

Table 3:Jordan Future Renewable Energy Projects (2019–2021) [19]

	Project name	Capacity(MW)	Operation Date
Wind Energy Projects	First round of the direct offers,(6)PV projects: - Al-Rajafproject	82	
	- Shobakproject	45	
	- Al-Fajeejproject	89	
	Third round of the direct offers	100	2020/2021
Solar Energy Projects	Baynouna Project	200	Mid/2019
	Third round of the direct offers,(4)PVprojects	200	End/2020
	Al-Risha PV Project	50	Mid/2019
	East Amman Project	40	2019
	Al-Qatranna PV Project	30	--
	Philadelphia PV Project	50	Mid/2020
	Universities Projects	40	
	Welling Projects/NEPCO,sTransmission Lines	393	
	Small Solar Systems(<5MW)	Net Metering Projects	116
Welling Projects		128	--

Conclusion and Future Work

The solar PV system is considered as an optimistic renewable energy system solution for the generation of electricity as it has a resource with clean energy and no CO₂ emission. However, there is a severe

problem of applying the resources of the renewable energy into the current grids of the power system. It was noticed that the generation and consumption of energy in Jordan reached a peak due to the critical increment in the amount of population in addition to the political matter in the region. Jordan has concerns as what other countries in the world have,

especially those related to the climate changes that are affected with the increment levels of CO₂ and other gasses. Hence, Jordan has begun to replace its dependence on fossil fuels to renewable energy fashion. Due to the limitation of energy resources in Jordan and the poor energy infrastructure, Smart Grid technology is considered as a convenient solution to overcome the current grid technology. In addition to that, smart grid reduces line losses and this would help to: (1) avoid the shortage of prevailing power (2) improve the reliability of supply (3) the enhancement of energy quality and its management, and finally (4) protecting revenues and preventing theft. Hence, it is possible to implement global smart grid system in away that exploits financial and technical resources of neighbor countries, in addition to the variation of their renewable energy sources. In the future a further analysis using various simulation tools and mathematical models to investigate the advantages of applying smart grid techniques is required.

References

[1] V. der Hoeven and M. .Biro, " World energy outlook 2012 presentation," in International Energy Agency - World Energy Outlook, 2012.

[2] C. S. Lai and L. L. Lai, "Application of big data in smart grid," in IEEE International Conference on Systems, Man, and Cybernetics, Kowloon. Academic Press, 2015, pp.665-670.

[3] A. R. Khan, A. Mahmood, A. Safdar, Z. A. Khan, and N. A. Khan, "Load forecasting, dynamic pricing and dsm in smart grid: A review," in Renewable and Sustainable Energy Reviews, 2016, pp. 1311-1322.

[4] X. Yang, X. He, W. Yu, J. Lin, R. Li, Q. Yang, H. Song, "Towards a low-cost remote memory attestation for the smart grid," Sensors, 15 (2015), pp. 20799-20824.

[5] C. Zhu, V.C. Leung, L. Shu, E.C.-H. Ngai, "Green Internet of Things for the smart world," IEEE Access, 3 (2015), pp. 2151-2162.

[6] Faisal Y. Alzyoud, Wa'el Jum'ah Al Zyadat, Fadi Hamed, Fayez Shrouf, "A Proposed Hybrid Approach Combined Qos with CR System in Smart City ", Eurasian Journal of Analytical Chemistry ISSN: 1306-3057 OPEN ACCESS 2018 13 (6), pp. 178-185.

[7] A. Bose, "Smart transmission grid applications and their supporting infrastructure," IEEE Transactions on Smart Grid, vol. 1, no. 1, pp. 11-19, June 2010.

[8] O. Zinaman, M. Miller, A. Adil, D. Arent, J. Cochran, R. Vora, S. Aggarwal, M. Bipath, C. Linnvill, A. David et al., "Power systems of the future," The Electricity Journal, vol. 28, no. 2, pp. 113-126, 2015.

[9] Rens Philipsen, German Morales-Espana, Mathijs de Weerd, and Laurens de Vries (2016). Imperfect Unit Commitment Decisions with Perfect Information: a Real-time Comparison of Energy versus Power. In Proc. of the Power Systems and Computation Conference.

[10] The Hashemite Kingdom of Jordan, National Electric Power Company Report, 2017.

[11] Renewable Energy Perspectives in Jordan / Suhil Kiwan Professor of Mechanical Engineering at Jordan University of Science and Technology Irbid-Jordan. February 2016.

[12] The National Energy Efficiency Action Plan of Jordan / RCREEE - http://www.rcreee.org/sites/default/files/plans_jordanian_neeap_summery_2013.pdf.

[13] Jordan 2025 Overview/<http://www.jorelaunched.jo/jordan-2025/#2025overview>.

[14] Iskin I, Daim T, Kayakutlu G, Altuntas M. " Exploring renewable energy pricing with analytic network process - Comparing a developed and a developing economy. " Energy Economics 2012;34 (4):pp.882-91.

[15] N. Phuangpompitak, and S. Tia, "Opportunities and Challenges of Integrating Renewable Energy in Smart Grid System ", Energy Procedia 34 (2013), pp. 282 – 290.

[16] Alonso M, Amaris H, Alvarez-Ortega C., " Integration of renewable energy sources in smart grids by means of evolutionary optimization algorithms". Expert Systems with Applications 2012;39 (5):pp.5513-5522.

[17] Article - Jordan takes part in ceremony to sign Paris climate agreement/<http://www.jordantimes.com/news/local/jordan-takes-part-ceremony-sign-paris-climate-agreement>

[18] Mahasneh, Mohammad & Alsafasfeh, Qais. (2014). "Smart Grid Law and Regulation—Case Study of Tafila Smart Grid". Beijing Law Review. 05. pp.102-106. 10.4236/blr.2014.51009.

[19] www.nepco.com.jo

[20] Sun Peng, Liu Ling, and Lou Runping. 2016, "Feed in Tariff Regulation Policy of Renewable Energy Industry-Based on the comparison of Fixed Price, Constant-premium Price, Variable-premium Price[J] ". Systems Engineering, (5), pp. 82-89.



Faisal Yousef Alzyoud received his Ph.D. with honor in Computer Networks from Universiti Sains Malaysia on June 2011, Faisal research interests are in the field of wireless networks, Ad hoc networks, AI, and logic fields.

Nesreen Alsharman was PHD Student at New Mexico State University and she is interested in network, AI, and logic fields.