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A Survey About the Relationship Between Renewable Energy, and Artificial Intelligence

Mamdoh Bacor T Barnawi
Engineering and Works Department of the Land Forces, Ministry of Defence, Saudi Arabia
daybyday9090@hotmail.com

Abstract

This essay will discuss renewable energy. It discusses the various forms of renewable energy, the intricacy of a power grid that incorporates RE, the connection between artificial intelligence and limited energy, and, to a lesser extent, optimisation methods based on AI for the sizing of integrated renewable energy systems in smart cities. The Integrated Renewable Energy System (IRES) is a key component of the Smart City. Issues relating to energy supply and demand can be resolved by integrating the available renewable energy sources. Their appropriate size is required to adjust to future integrated renewable energy sources in order to maintain a stable state of energy supply and demand. Various writers have proposed different methods to implement the integrated renewable energy system in order to meet technological, economic, and size issues. This study offers a thorough analysis of a number of subjects pertaining to integrated renewable energy systems (IRES)-based power generation for smart cities. The integration of various energy sources, the use of smart grids for integration, and techniques for IRES sizing using software and artificial intelligence algorithms are all covered in detail. The scaling of integrated renewable energy systems in smart cities is the subject of this article's review of several AI algorithms.

Keywords: Renewable Energy, Smart Cities, Power Grids, Solar energy, Geothermal Energy, AI

Introduction

A multifaceted understanding of computational, economic, and social issues is necessary to address the challenges associated with integrating advanced artificial intelligence technology into Smart Energy systems and grids. An initial domain description and a well-defined research topic specification are necessary for this type of socio-technical platform and integration. Beyond the post-industrial society and its ramifications, the pursuit of sustainable development has engaged industry, academia, and society in the search for concrete answers for global development. As a result, both the literature outlining the difficulties that resulted and the new procedures connected to the adjustments were enhanced. Multidisciplinary contributions are integrated into the development of smart city research. New Problems for the study of sustainable forms of economic development were brought about by advanced disruptive technology. Through efficient resource management, residents of a smart city will lead high-quality lives if renewable energy is available. To meet energy demand, smart cities must advance their complete renewable energy policies using alternative energy sources as geothermal, biomass, wind, thermal collectors, and solar panels [7, 8]. One of the main application areas for both smart city research and the deployment of disruptive technologies is the study of energy management. This investigation is one of the main goals of our study. Important changes in energy generation, distribution, storage, and sales methods are being recorded by the global energy business as a result of the challenge to enhance energy's flexibility and lower costs and pressure on the environment (resource consumption and decrease in CO2 emissions. During the energy crisis of the mid-1970s, when it became clear that conventional fuels were in risk of running out, renewable energy (RE) gained popularity and natural resource conservation became a priority. Questions about the necessity of preventing or correcting environmental harm were highlighted in the 1980s by pollution, global warming, and resource depletion [9]. Energy use in recent years has drawn attention to low-carbon renewable energy sources and the necessity of ongoing environmental and human health protection [10], [11]. Reducing greenhouse gas emissions and reliance on imports are two key benefits of integrating renewables into the energy system. Since renewable energy can naturally recreate itself more easily than fossil fuels, efforts are being made to make it as real as possible.

Methodology

Our research paradigm is justified as a result of the critical literature evaluation in the preceding section. The main components of our research technique are as follows, considering the multidisciplinary character of this study and our primary goal of combining cutting-edge computer science research with economics and smart city research:

1) The understanding of sources of renewable energy.
2) The understanding of AI and how we can integrate with RE.
3) The understanding of the macro-economic contribution to the debate on Smart Girds and Renewable Energy domain.
4) The integration of advanced Artificial Intelligence components to the research model, recognizing AI as a research domain with a key impact on efficiency and performance on Smart grids and RE.
5) The combined impact of Macro-Economic factors and AI value propositions to resilient Smart Cities research.

Type of renewable Energy.

1- Solar energy

Of all the energy sources, solar energy is the most plentiful and may even be used when the weather is overcast. The Earth absorbs solar energy at a rate that is roughly 10,000 times faster than the rate at which people use energy. For a variety of uses, solar technologies can provide fuels, power, natural lighting, heating, and cooling. Photovoltaic panels or mirrors that focus sunlight are two ways that solar technologies turn sunlight into electrical energy. Even while not every nation has the same amount of solar energy, each one can use direct solar energy to contribute significantly to its energy mix. In the past ten years, the cost of producing solar panels has drastically decreased, making them not only accessible but frequently the least expensive source of electricity. Depending on the kind of material used in production, solar panels can have a range of colors and a lifespan of about 30 years [12].

Fig.1 Solar energy

2- WIND ENERGY

Utilising massive wind turbines situated on land (onshore) or in freshwater or the ocean (offshore), wind energy captures the kinetic energy of flowing air. Although wind energy has been utilised for thousands of years, in recent years, onshore and offshore wind energy technology have advanced to create more power by using bigger rotor diameters and higher turbines. Though average wind speeds differ greatly depending on the locality, but the technical potential of wind energy is greater than that of electricity generation worldwide, and most parts of the world have enough room to support a sizable wind energy deployment. Although wind speeds are high in many regions of the world, distant areas might occasionally be the ideal places to generate wind power. The potential for offshore wind generation is enormous [13].

Fig. 2 Wind energy

3- **GEOTHERMAL ENERGY**

4- Geothermal energy makes use of the thermal energy that is readily available from the Earth's interior. Wells or other methods are used to harvest heat from geothermal sources.
Hydrothermal reservoirs are naturally sufficiently hot and permeable, whereas enhanced geothermal systems are suitably hot reservoirs that have been boosted by hydraulic stimulation. The most valuable geothermal resources are found at temperatures higher than 100°C and contain steam and/or pressurised hot water [14] [16] [17]. Electricity may be produced from fluids of different temperatures once they reach the surface. With almost a century of operation, the technique for producing power from hydrothermal reservoirs is dependable and well-established [18].

5-

Fig. 3 Wind energy

6- **HYDROPOWER**

Hydropower harnesses the energy of water moving from higher to lower elevations. It can be generated from reservoirs and rivers. Reservoir hydropower plants rely on stored water in a reservoir, while run-of-river hydropower plants harness energy from the available flow of the river.

Reservoirs for hydropower frequently serve several purposes, including electricity production, flood and drought management, irrigation water, drinking water, and navigation. The biggest renewable energy source for the electrical industry at the moment is hydropower. It depends on largely consistent rainfall patterns, and droughts brought on by climate change or alterations to ecosystems that affect rainfall patterns may have a detrimental effect. Additionally, the infrastructure required to generate hydropower may have negative effects on ecosystems. Because of this, many people believe that small-scale hydro is a more ecologically benign choice, and it's particularly appropriate for communities in isolated areas.

Artificial Intelligence is currently playing a key role in the transformation of the energy model. It allows us to do something that we are not capable of doing: to handle large amounts of data, which must also be processed in a logical and reasonable way. And in the field of energy in particular?

We are currently in the midst of a transition to a sustainable energy system. Most countries are not reducing their emissions fast enough, so the integration between renewables and smart grids is essential.

How AI is affecting renewable energy

When we are talking about the effect that means the relation that makes renewable energy work with a good performance more than alone.

Complexity of a power grid with RE.

Renewable energies such as wind and photovoltaic will become much more efficient in the future with the application of Artificial Intelligence (AI). Many energy companies are already starting to apply Artificial Intelligence and Machine Learning to control the demand and production of renewable energies.

Solar and wind energy are linked to climatic factors to generate renewable energy, which conditions energy productivity. This conditions the productivity of energy, but with AI we can anticipate a drop in electricity production with the demand for consumption to stabilize the amount of energy available in the system [27]. That will Avoid outages or shortages of electricity supply at specific times and places where it is not possible to cover everything with renewable energies alone. These two types of energy will benefit the most from the use of AI in the management of the energy production grid.

generally classified into two types [8], conventional energy sources (CES) and renewable energy sources (RES) [28], to share it, large grids have been built, which connect the production points and the places that require energy, such as cities and industry. The many levels of complexity displayed by power networks are depicted in Figure 1, which also shows the various node sizes where power generation and consumption take place, Figure 4, the various

For instance, RES like wind, solar, and biomass power [19, 30] account for little more than 20% of the electricity demand in European power supply networks. Europe plans to raise this percentage to 75% [21] of all electricity generated and supplied. Investments in renewable energy technologies [32] in the USA have increased dramatically over the last ten years [22], from USD 11.4 billion in 2005 to around

USD 46.5 billion in 2018, propelling the industry for renewable energy in a "green" path across the nation [23]. We must bring out certain recent events in the United States, such as the Inflection Reduction Act [24], which also heavily favours renewable energy [26,25] sources, and the disparities in the weights of its lines.

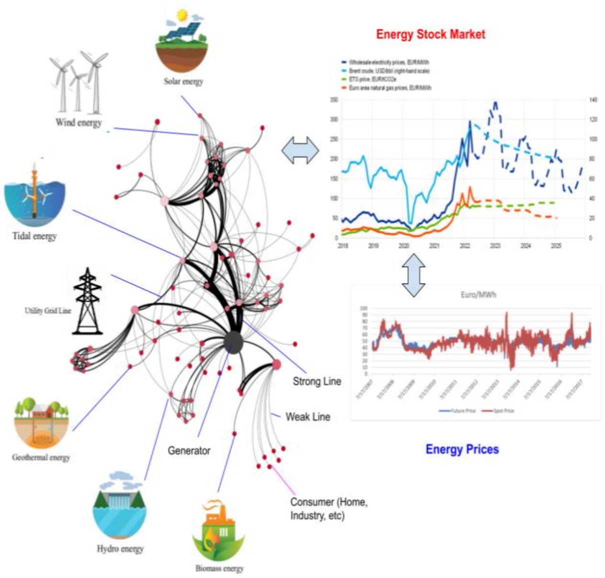


Fig. 4 Complexity of a power grid

Simulating the Dynamics and Operation of the Power Grid uses the data types mentioned in this section. Figure 5 (top panel) provides a summary of the different models, including a quick statistical analysis of the power grid models overall and for each of the primary subjects. In accordance with our previous discussion, we divide the models into two groups: models influenced by mathematics and models inspired by artificial intelligence (AI). We classify the publications on mathematically inspired models into three categories, namely.

Models based on dynamical systems and equations, as well as nonlinear methods.

• Models based on stochastic differential equations.

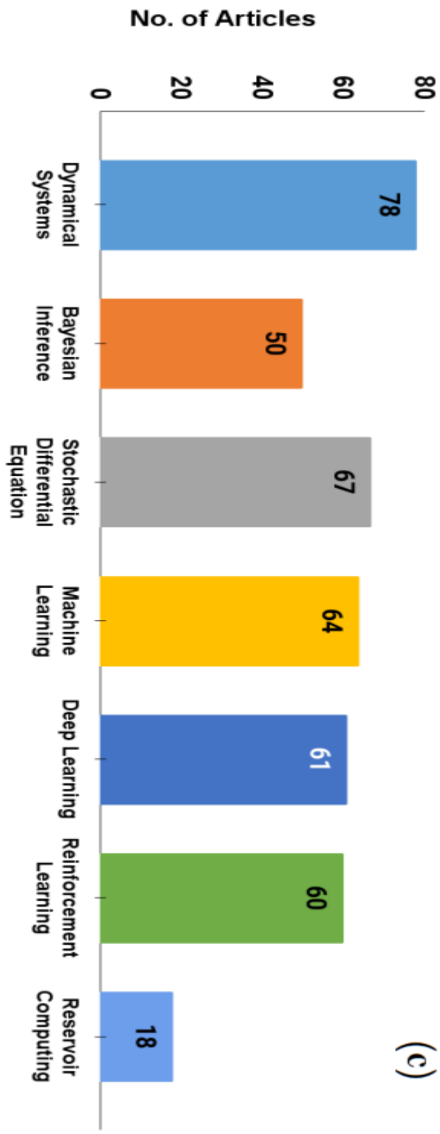
• Models based on Bayesian inference.

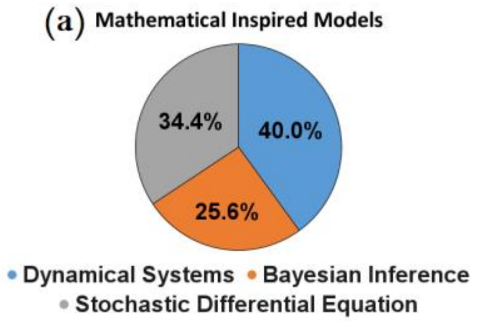
Dynamical system techniques use the assumption that the system under consideration is in a state that is represented by a collection of variables that satisfy a time-evolution (differential) equation and are functions of time [41, 39]. A stochastic differential equation, like the model [43,42], is created when this equation has stochastic terms that describe probabilistic aspects of the variables' temporal development. The statistical characteristics of the many data sets taken from the power grid system that may be inferred are the main emphasis of Bayesian inference, rather than the time development of the pertinent variables [149,150]. Power grids are modelled mathematically through the use of stability (synchronization) regimes, performance analysis, and optimization strategies. Regarding algorithms influenced by AI, we categorize them into• Machine learning algorithms.

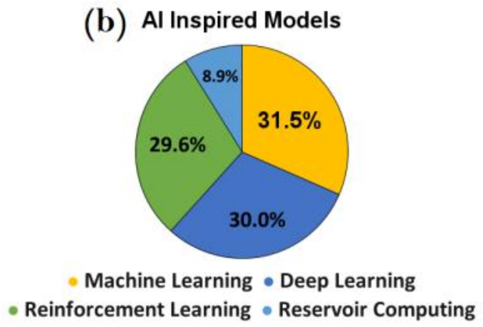
Deep learning algorithms.

Reinforcement learning algorithms.

Reservoir computing algorithms.







The area of machine learning (ML) [151–153] is concerned with creating data-driven, computational techniques that can model or forecast a system's behaviour by learning how it operates through data sampling. The goal of deep learning (DL) [45,44], a field distinct from machine learning (ML), is to increase the intricacy of learning architectures to a level that is beyond human comprehension. This can occasionally lead to new scientific problems, such as the need to explain the underlying mechanisms that support or explain a particular prediction's outcome.

Figure 5. Statistics of the literature survey in this paper with respect to the modeling approaches, namely (a) mathematically inspired models and (b) AI-inspired models. In (c) we plot the statistics for each of the modeling approaches, and in (d) the statistics of each modeling approach with respect to the different topics related to power grid research.

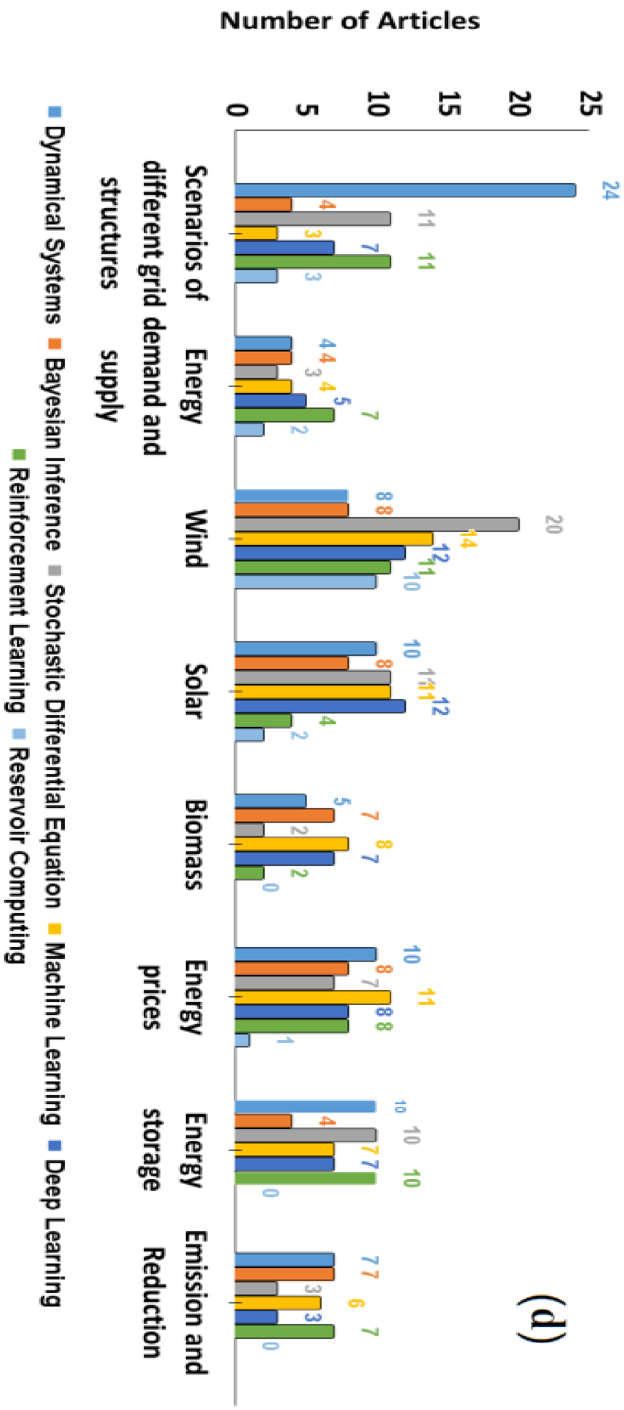


fig.5 Static of the literature survey

AI & RE Smart city integration.

first, will show this diagram to be the idea clearer.

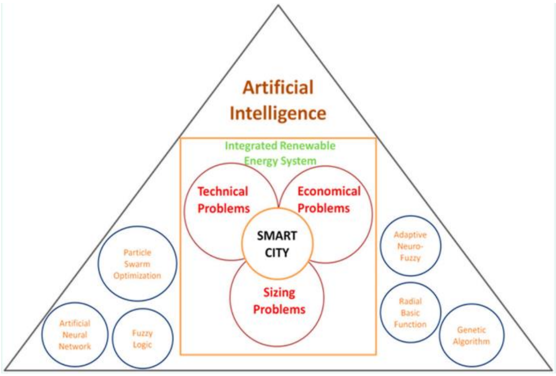


Fig. 6 Complexity of a power grid

Renewable energy in Smart City

Making effective use of renewable energy is a challenging problem for researchers working on smart city energy management. [47] has examined the effective use of renewable energy for construction and transportation. He asserts that in order to address issues like energy efficiency and the interplay between components of smart city systems, the development of smart cities should be given top priority. To choose the PV energy source, the components of the dispersion city and compact city scenarios have been taken into account. Economic and environmental elements have been considered to implement the concept of a Smart Energy Network (SEN). This concept of SEN is simulated by Chai et al. [48], When it is determined that the overall efficiency of a cogeneration system is greater than the effective efficiency of a city's independent power and heat generation. Through heat and power generators, SEN can offer a viable alternative for effectively supplying customers with electricity in urban settings. Certain techniques, certain aspects of elements, and various approach tactics are needed when planning renewable energy solutions in a smart city. Motion et al. have established these suitable planning techniques [20]. It is made up of matrices. Based integration model for the development of different characteristics of Smart City. The matrices-based model decides the weights and priorities of action for a multidisc plenary action chain. A smart city renewable energy management technique has been applied at an estimate configuration in [46]. In this work, the basic control method measures the MPP of the wind and is calculated without calculating the PV wind speed or the solar distortion, which is really useful for real small-scale wind turbines and PV systems. FC is regulated to supply power shortages if the main grid PV and wind power supply are not sufficient for the net grid or load capacity requirements.

integration of renewable energy system (IRES)

IRES takes demand response, energy storage, distributed generation, and renewable energy into account while distributing and communicating energy. Economic, technological, and regulatory issues are resolved through the integration, demonstration, and development of IRES [49]. IRES's shortcomings stem from their unpredictability, the changing environment, and the fact that changes in solar and wind energy do not align with the load demand's temporal distribution. This malfunction causes the battery to deplete quickly in addition to affecting the system's energy output. In general, any energy source used separately will result in a considerable amount of oversizing, which effectively raises the design's cost. [50] has stated the consequence of IRES for distributed sites in a city using the smart grid system. IRES installation in a large scale is more affordable than per-house installation [51,52]. Furthermore, Figueiredo and Martins [15] have done an investigation in the field of IRES management of buildings. Wind generators, PV generator, biomass generator, and oil/thermal generators are integrated for building energy requirements. A sensor has been used to collect information about voltage, position, and fuel cell power generation in IRES

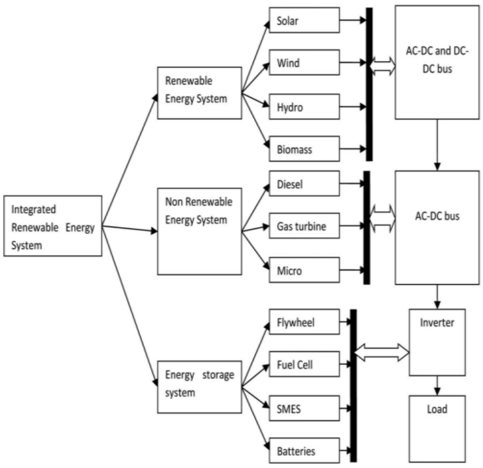


Fig. 7 IRES system

AI based on the IRES system

AI techniques are helpful as an extra way to combat traditional tactics or IRES system elements.

They are getting more and more popular these days and have been employed to address challenging real-world issues in a variety of sectors. Fuzzy logic (FL), artificial neural networks (ANN), genetic algorithms (GA), and other hybrid systems—combinations of two or more algorithms—are among the algorithms that make up artificial intelligence (AI). When the necessary environmental information and the location of the IRES system are available, traditional methods for determining IRES size are frequently employed. However, if enough information

Ref	Software	Analysis	Highlights	Advantages
[15,54,57]	MATLAB	• Implementing various AI algorithms	• Optimal configuration is expressed in terms of minimum cost of electricity	• Functions and data can be easily plotted. • Different prediction algorithms are easily implemented. • Can create user interface for monitoring.
[29]	HOGA	• Genetic algorithm used for optimization.	• Optimization of dissimilar load profiles has been done in hybrid renewable systems. • Photovoltaic has been found as the essential component for hybrid systems	• Short computational take time. • Multi- or mono-objective optimization and sensitivity analysis performed. • Net metering system available
[32,58]	HOMER	• Technical analysis • Economical analysis • Emission analysis	• System sizing and optimization • COE of hybrid system found • Estimate energy production, • Estimate life-cycle costs	• Easy to understand and user-friendly. • Data handling capacity • Presents an efficient graphical demonstration of the results.
[59]	RETScreen	• Environmental, Financial analysis	• Off grid system feasibility analysis is carried out • Prediction of annual green house gas emission.	• EXCEL base software • Financial analysis is a strong point • Product record and meteorological database were taken from NASA.

Table Comparison of software used for IRES system sizing.

Conclusion

This is a thorough overview article that covers every facet of IRES, including the various sizing techniques employed by smart city researchers. It has been noted that the best system configuration for scaling IRES is determined using artificial intelligence (AI) technology. The optimal size of the IRES system is currently determined using algorithms like the Adaptive NeuroFuzzy-Based System (ANFBS), Genetic algorithm (GA), Radial Basis Function Network (RBFN), Particle Swarm Optimisation (PSO), Artificial Neural Network (ANN), and Simulated Annealing (SA). The benefits of various AI algorithms vary; for example, PSO performs the optimisation more quickly and precisely, whereas swarm optimisation offers superior performance. Similarly, some algorithms have drawbacks. For example, the GA method requires additional computations since each iteration yields a different answer. Many researchers have worked in the topic of IRES size, as has been noted below; nevertheless, more study is required to determine how to improve battery efficiency and longevity by concentrating more on lowering the cost of IRES sizing.

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