Amirkabir Journal of Mechanical Engineering

Amirkabir J. Mech. Eng., 55(1) (2023) 3-6
DOI: 10.22060/mej.2023.20755.7346

Energy Management Model for a Standalone Hybrid Microgrid Using a Dynamic Decision-Making Algorithm

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ABSTRACT: Renewable energy is vital for the future of the energy supply because of its properties, which include sustainability, affordability, and environmental friendliness. The low dependability of these sources is a disadvantage due to their nondeterministic and unpredictable production patterns. Utilizing several energy production sources in conjunction with energy storage and backup sources could relieve the problem of system dependability. This study recommends a hybrid microgrid that is independent of the grid and consists of primary sources of wind and solar energy production in addition to a battery and generator backup system. This is achieved through the use of dynamic decision-making algorithms, modeling, construction, and assessment, as well as thirteen distinct strategies for the electrical supply of residential units. Under the scenario to use 24% renewable energies, the consumption of fossil fuel is 1,1 liters per day, and the yearly production energy of the total renewable energy conversion system is comparable to 1,697 kWh with a net present value of $553.68. By increasing the renewable energy factor to 54 percent, the consumption of fossil fuel is reduced to 0.69 liters, and the annual production energy is increased to 1,652 kWh. Consumer energy management with a renewable energy factor of 100 percent, an annual energy usage of 1,933 kWh, and a net present value of -$379.

Review History:

Received: Jan. 05, 2022
Revised: Oct. 01, 2022
Accepted: Oct. 17, 2022
Available Online: Feb. 08, 2023

Keywords:

Renewable energy
Sustainability
Energy storage
Microgrid
Strategies

1- Introduction

Due to the increase in energy demand and the depletion of fossil fuels, concerns regarding the security of the primary energy source have already been expressed. The negative environmental repercussions of power generation from fossil fuels have also spurred the focus on renewable energy. The diesel generator-based backup system serves as a guarantee of energy supply capabilities. As a result of the extensive usage of renewable energy sources, the future electrical network will face considerable uncertainties that may affect its performance [1]. The World Energy Organization anticipates that fossil fuel reserves, which account for more than 79 percent of the world's primary energy and are mostly utilized in the transportation industry (57.7 percent), will steadily diminish [2]. As a result of environmental concerns, reserves of fossil fuels such as coal, oil, and gas are finite; as energy consumption increases and these reserves diminish, national budgets will become unsustainable [3]. Due to its reliance on a network of diesel generators, it has become incredibly expensive and harmful to the environment. Renewable energy appears to be a viable option for generating electricity, despite being intermittent and unpredictable. In multigenerational and hybrid systems, energy storage is one of the major solutions [4]. As renewable energy sources increase in popularity, power systems will transition from their existing structure to ones with a large proportion of renewable energy (wind energy, solar energy, etc.) [5].

2- Methodology

This investigation was conducted using a quantitative approach. Using Proteus software, the control system's design was synthesized. The decision-making algorithm was created using C programming and the PCWH CCS C compiler and was then installed on the microcontroller. The development circuit for the PIC16F18877 microcontroller was built to combine all electronic circuits controlled by the loaded program. Relay switching circuits consist of two components:

1- Switching and relay control modules which are used to adjust the output voltages of solar and wind renewable energy sources.

2- Charging or discharging switching circuits that are used for charging or discharging. These basic relay circuits are used through the program loaded in the PIC16F18877 microcontroller.

3- Results and Discussion

Based on the use of battery backup, diesel generator, and the combination of solar and wind energy, thirteen logical subsystem configuration variants have been determined. A

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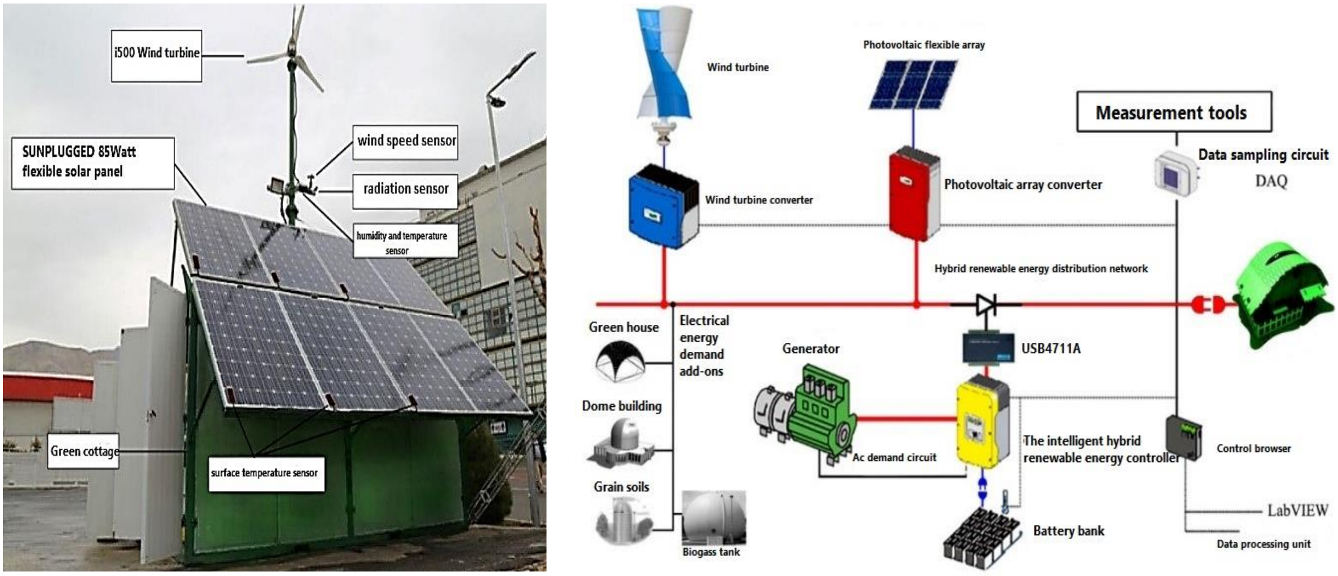

a. The exterior view of the system.   b. System connection schematic

Fig. 1. Schematic of The Combined Renewable System and Control Equipment.

Table 1. Optimal Hybrid Renewable Energy Conversion System Configurations.

Model	Fuel (l)	Initial cost ($)	COE ($)	Battery (100Ah)	TG2500 (kW)	Wind (i500)	Solar (kW)
1	407	1222	0.379	2	1	0	0.368
2	253	1888	0.381	2	1	1	0.205
3	359	1579	0.402	3	1	1	0
4	585	695.6	0.407	4	1	0	0
5	0	3378	0.446	4	0	2	0.396
6	0	3800	0.510	5	0	3	0
7	0	4130	0.547	11	0	0	1.42
8	1080	285.46	0.636	0	1	0	0
9	1080	289.83	0.637	0	1	0	0.00651
10	1011	1278	0.721	0	1	1	0
11	1017	1325	0.717	0	1	1	0.00348
12	0	14083	1.8	0	0	14	0.0397
13	0	15000	1.91	0	0	15	0

combination with a Cost Of Electricity (COE) of $0.381 per kW consists of a solar subsystem with a cost of $0.205 (with an initial cost of $410), a wind turbine with an initial cost of $1000, a diesel generator (electric motor) model TG2500DC, and two batteries with a capacity of 100 amp hours. This system utilizes 54% renewable energy and requires 253 liters of fuel per year. In addition, after 1345 hours of operation, the electric motor generated 675 kilowatt-hours of electricity.

4- Conclusion

In light of the research findings, the following recommendations are provided for approaching the sustainable development model of managing energy expenses and energy consumption.

1- Small wind turbines work best in winds over 4 meters per second (less than 400 Watts).

2- The ideal layout for harvesting renewable energy is a roof slope angle of 30.2 degrees and the city's azimuth at 195 degrees.

3- Eliminate environmental effects.

4-Guaranteed household renewable electricity purchases should cost more. The critical feed-in tariff limit is $0.06.

Politically, the most crucial component in the economic efficiency of the scenarios is the growth in the sale price of energy from renewable sources, followed by the decrease in operational costs, according to a sensitivity analysis of the scenarios. The impact of increasing fixed assets is minimal. The environmental damage caused by the implementation of the first scenario is equivalent to 1065 kg of carbon dioxide produced per year, whereas the adoption of the second scenario results in the production of 633 kg of carbon dioxide annually.

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HOW TO CITE THIS ARTICLE

M. Esmaeili Shayan, G. Najafi, S. Esmaeili Shayan, Energy Management Model for a Standalone Hybrid Microgrid Using a Dynamic Decision-Making Algorithm, Amirkabir J. Mech Eng., 55(1) (2023) 3-6.

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