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# Micro-grids and Their Impact as a Smart Grid

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## Abstract

Smart grid (micro-grid) technology is a rapidly evolving area of power system management that is changing the way to generate, distribute, and consume electricity. At the heart of the smart grid are the sources of energy that power it. Ideal sources of energy for smart grid systems and their impact on the overall efficiency and effectiveness of the smart grid are explained in order to clearly understand their effects. Micro grids are a type of distributed generation since the energy (power and heat) is produced nearby where it is needed. A two-terminal element that has the feature that the voltage between the terminals is known at all times is an ideal voltage source. The current flowing from the source has no bearing on this voltage. This means that any current might conceivably pass through the source in any direction, and this is called a micro-grid.

**Keywords:** Inverter, Battery, Smart grid.

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## 1. Introduction

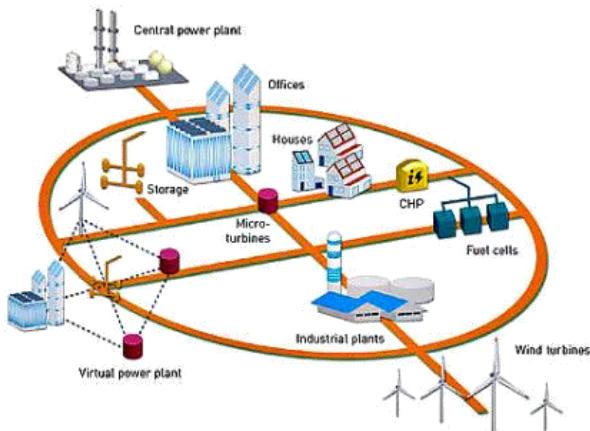
Nowadays, people often think that microgrids are a small version of the smart grid system: it functions independently from the main grid and has its own secondary distribution grid. it also doubles up as 1 station (metaphorically) upon which the reliability and power output of a large national ac-power stations can be modeled. In this not-built-yet-are not-power supply community of a similar nature, street lights bill its own. Now microgrid as energy-saving technology which is safe and reliable and friendly to the environment has emerged in recent years. The smart grid is a modern power distribution system



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that uses advanced communication and information technology. It is more effective and reliable than systems of power supply conducted on the traditional a.c. cycle frequency basis, moreover it balances power fluctuations at each place where there is load demand. Now this allows real-time control and monitoring. We can not only set the electricity supply price using the Non-Grid with more microgrids, but also avoid wasting any surplus energy. Microgrid of TV-Grid. The first benefit microgrids can bring is to break from the grid. This makes them more reliable and resilient. Through microgrids, we can integrate renewable energies into the grid. The building of microgrids can also mean reductions in greenhouse gas emissions and the establishment or encouragement of sustainable power practices. Microgrids can combine renewable energy with storage methods to balance the supply and demand for electricity. Thus they are not only good for individual buildings, but quite Honestly. Microgrids through localized power generation and distribution can help reduce the burden on the main grid. This can further reduce its pressure. Moreover, microgrids can lead to a smaller demand for new transmission and distribution infrastructure. And that is costly to make, time-consuming plan and requires a large amount of capital. However, integration of microgrids into the power system also presents technical problems. One of the major ones is how multiple microgrids can actually be coordinated with the Grid. The complex series of individual grids that constitutes the network of smart grid demands its own method of coMpetent coordination; the addition of several small grids only complicates matters further. Moreover, there are technical problems concerning the integration of various energy storage technologies and microgrid systems. [2,4].

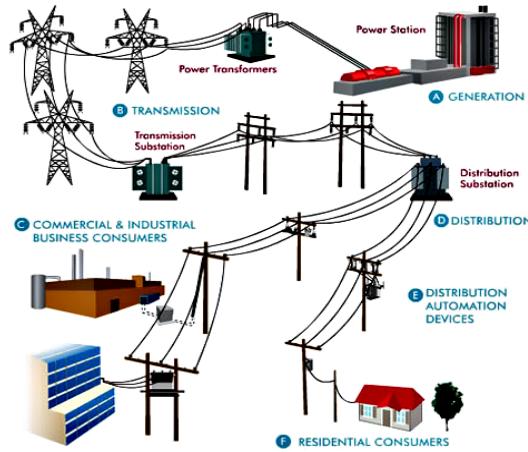


**Fig. 1:** modern micro-grid [1]

## 2. Electrical Grid

### 2.1 Electrical grid properties

- 1- Reliance on large-scale fossil fuel powered generators.
- 2- Rising carbon dioxide emissions.
- 3- Concentrating a lot of power in one area.
- 4- Supplying power over a lengthy transmission line.
- 5- Has a low dependability against unexpected defects and is not economical.



**Fig. 1:** normal electrical grid [1]

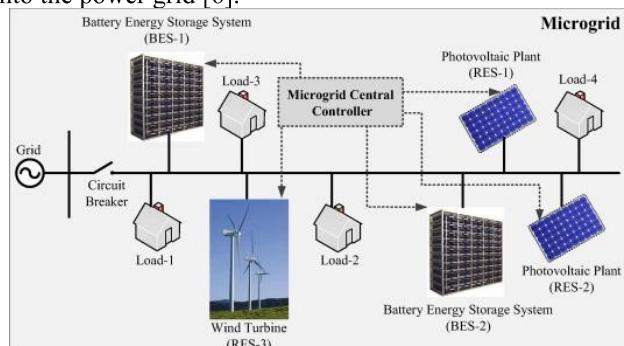
## 2.2 Operation and Characteristics of Micro-grid

- 1- Integrate renewable resources.
- 2- Control the flow of power.
- 3- Reduce Carbon emissions.
- 4- Reduce losses.
- 5- Reliable against sudden faults.
- 6- Customer is a part of the grid.

### 2.2.1 Micro-grid (Battery)

Battery grid is one of the modern concepts that has gained popularity in the field related to the energy industry. It is a system that combines energy storage technology beside main power grid, allowing for greater efficiency, reliability, and sustainability. The battery grid is a system that utilizes energy storage technologies, such as batteries, to store excess energy generated by renewable sources, such as solar and wind, and distribute it back to the grid when needed. This allows for more efficient use of renewable energy sources, which are often intermittent and unpredictable. By storing excess energy, the battery grid can help to make balance of the demand and the supply of electricity, reduce the need for fossil fuels, and improve the overall reliability of the grid [5].

One of the key benefits of the battery grid is its ability to provide backup power during outages or emergencies. In traditional power grids, outages can occur due to a variety of reasons, such as extreme weather conditions or equipment failures. The battery grid can provide backup power during these events, reducing the impact of outages on businesses and households. This can also help to reduce the need for expensive backup generators, which are often powered by fossil fuels. The battery grid can also help to reduce the cost of energy. By storing excess energy by using renewable energy sources and the battery grid can reduce the need for expensive fossil fuels, which are subject to price fluctuations. In addition, the battery grid can help to reduce the need for expensive upgrades to the power grid infrastructure, such as new transmission lines and transformers. However, there are also challenges associated with the battery grid. One of the main challenges is the cost of energy storage technologies, such as batteries. While the cost of batteries has decreased in recent years, it is still a significant expense for many homeowners and businesses. In addition, there are also technical challenges associated with the integration of energy storage technologies into the power grid [6].

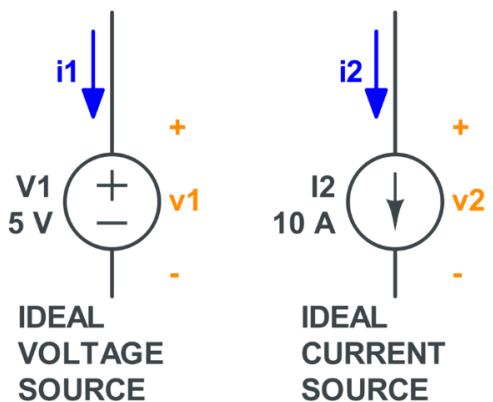


**Fig. 2:** Micro-grid (Battery) [6]

## 2.2.2 Electrical ideal sources

An electrical ideal source is a device that has the ability to provide a constant voltage or current output regardless of the load placed on it. Electrical ideal sources are theoretical constructs used in electrical engineering to model the behavior of real-world electrical sources. An electrical ideal source is an abstraction that is used to simplify the analysis of electrical circuits. It is an idealized model of a real-world electrical source, such as a battery or a generator. The primary characteristics of an electrical ideal source are that it can provide a constant voltage or current output regardless of the load placed on it. This means that the output of an electrical ideal source is not affected by the resistance of the load, and it can deliver power to the load at maximum efficiency [7].

There are two types of electrical ideal sources: voltage sources and current sources. A voltage source is a device that can provide a constant voltage output regardless of the load placed on it. Similarly, a current source is a device that can provide a constant current output regardless of the load placed on it. These sources are used in a wide range of applications, including power supplies, electronic circuits, and electrical systems. One of the primary advantages of electrical ideal sources is that they simplify the analysis of electrical circuits. By using these theoretical constructs, engineers can model the behavior of real-world electrical sources and predict how they will behave under different conditions. This makes it easier to design and optimize electrical systems, which can save time and money in the development process. However, it is important to note that electrical ideal sources have limitations. In the real world, no electrical source is truly ideal, and there will always be some variation in the output voltage or current. Additionally, electrical ideal sources do not take into account the effects of temperature, aging, and other factors that can affect the performance of real-world electrical sources [8].



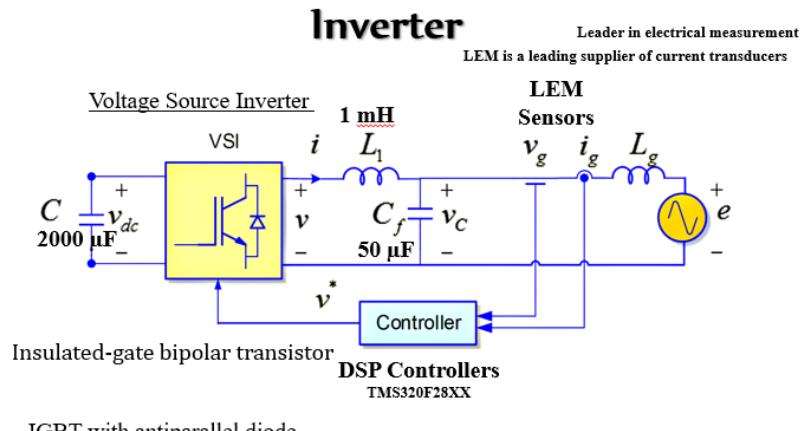
**Fig. 3:** Ideal sources [8]

## 2.3 Micro-grid (Inverters)

The inverter grid is a critical component of modern renewable energy systems. It is a device that converts direct current (DC) electricity generated by solar panels or wind turbines into alternating current (AC) electricity that can be used to power homes, businesses, and the electric grid. The inverter grid is a key technology in the transition to renewable energy sources. As solar panels and wind turbines generate DC electricity, the inverter grid is used to convert that energy into AC electricity that can be used by the electric grid. This conversion process is essential because the majority of energy consumers use AC electricity. The inverter grid allows for the seamless integration of renewable energy sources into the existing power grid infrastructure [8].

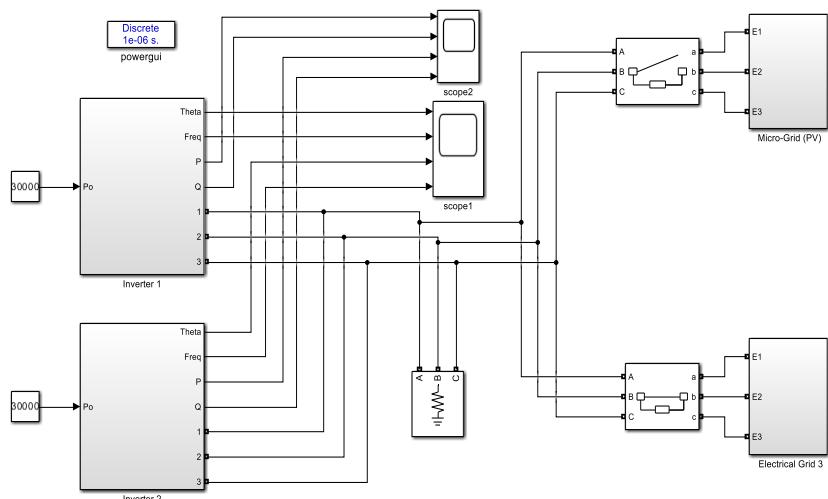
One of the key benefits of the inverter grid is its ability to improve the efficiency of renewable energy systems. As solar panels and wind turbines generate DC electricity, the inverter grid can convert that energy into AC electricity with minimal energy losses. This allows for more efficient use of renewable energy sources and can help to reduce the overall cost of energy. In addition to improving the efficiency of renewable energy systems, the inverter grid can also help to improve the reliability of the electric grid. As more renewable energy sources are integrated into the grid, the inverter grid can help to balance the supply and demand of electricity. This can help to prevent blackouts and other power outages that can be caused by fluctuations in energy supply and demand. However, there are also challenges associated with the inverter grid. One of the main challenges is the cost of the technology. While the cost of inverters has decreased in recent years, it is still a significant expense for many homeowners and businesses. In addition, there are also technical challenges associated

with the integration of inverters into the power grid, such as the need for grid-interactive inverters that can communicate with the electric grid.



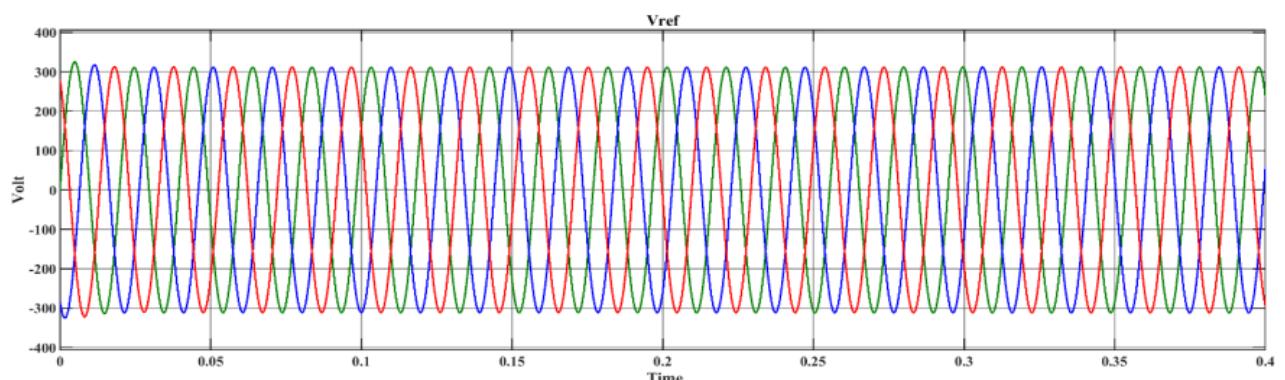
**Fig. 4:** Inverter diagram

### 3. Matlab Model and discussion` the Results



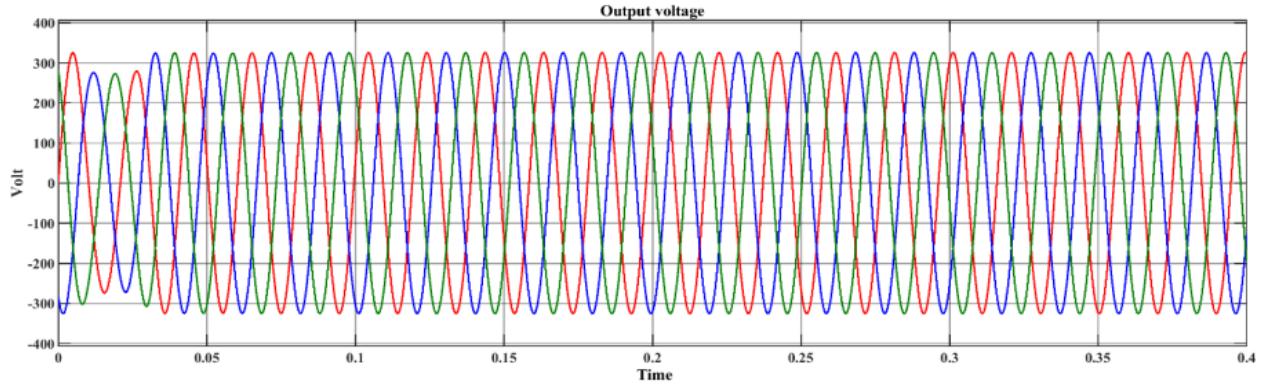
**Fig. 5:** Matlab Model

#### 3.1 Output results off-Grid



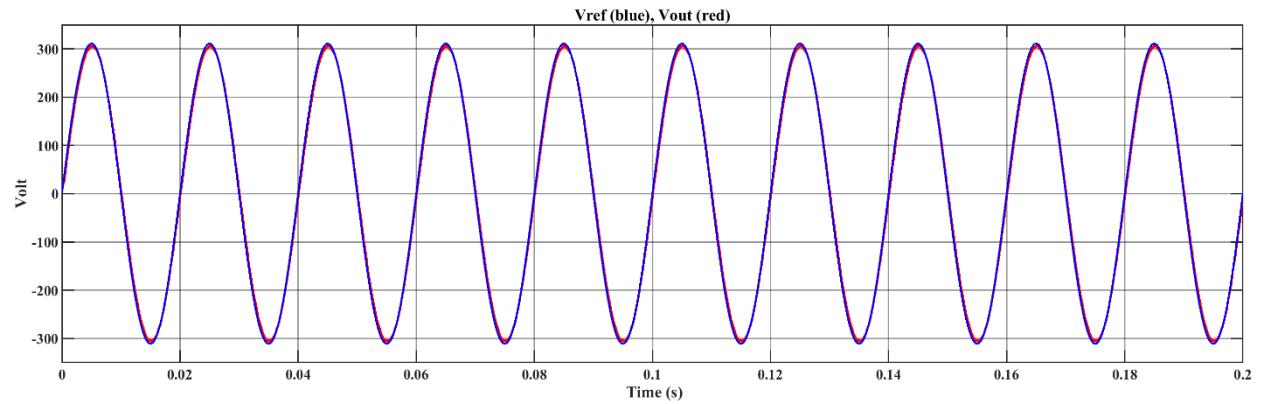
**Fig. 6:**  $V_{ref}$

As can be seen from the figure of voltage below, the voltage wave has a little bit of a difference from the reference voltage at the beginning of the wave, but it returns to the same level as the reference voltage (equal 311 v).



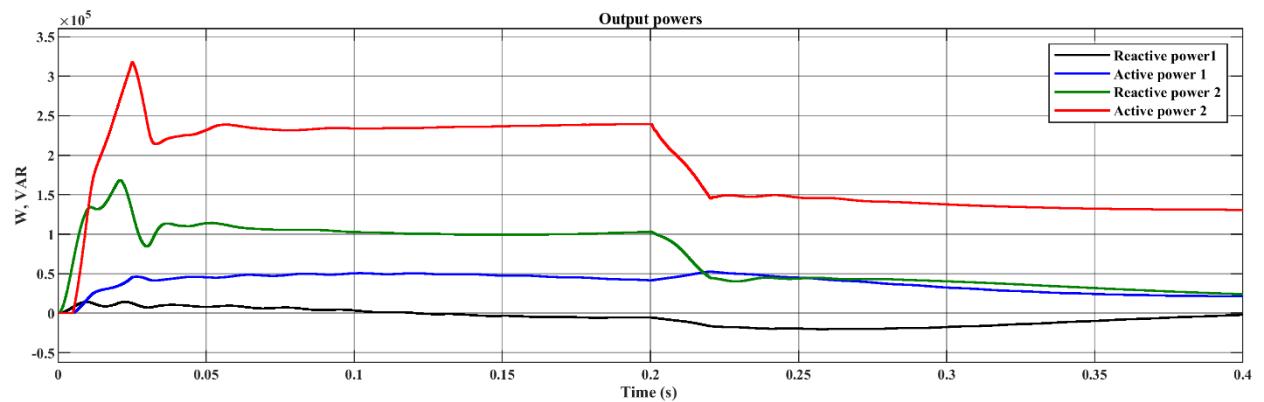
**Fig. 7:** output voltage

### 3.3 Output result of single inverter



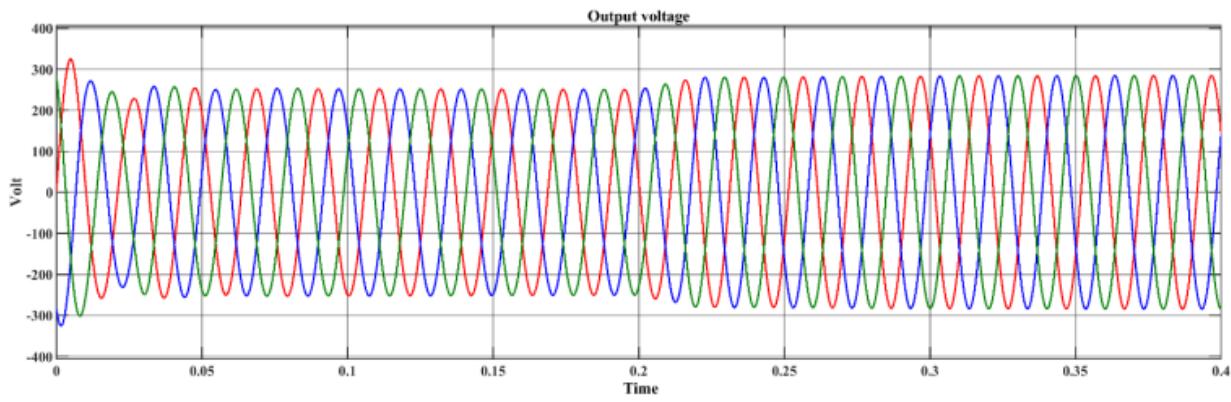
**Fig. 8:** Output voltage of the inverter with reference signal

It can be seen that the output of the inverter is near the input voltage that is generated using an AC source.



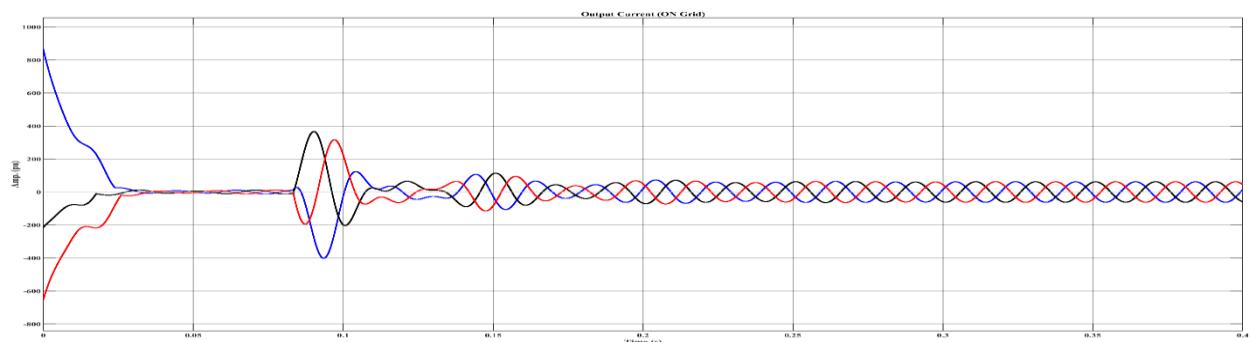
**Fig. 9:** Output powers

As we observe the output active power of inverter 2, it has the stability and highest value of about 1250 MW, whereas the output active power of inverter 1 reaches 450 MW in 0.4s. On the other side, the reactive power of inverter 2 goes down and reaches about 450 MVAR after 0.22s, while the reactive power of inverter 1 slows down near 50 MVAR.



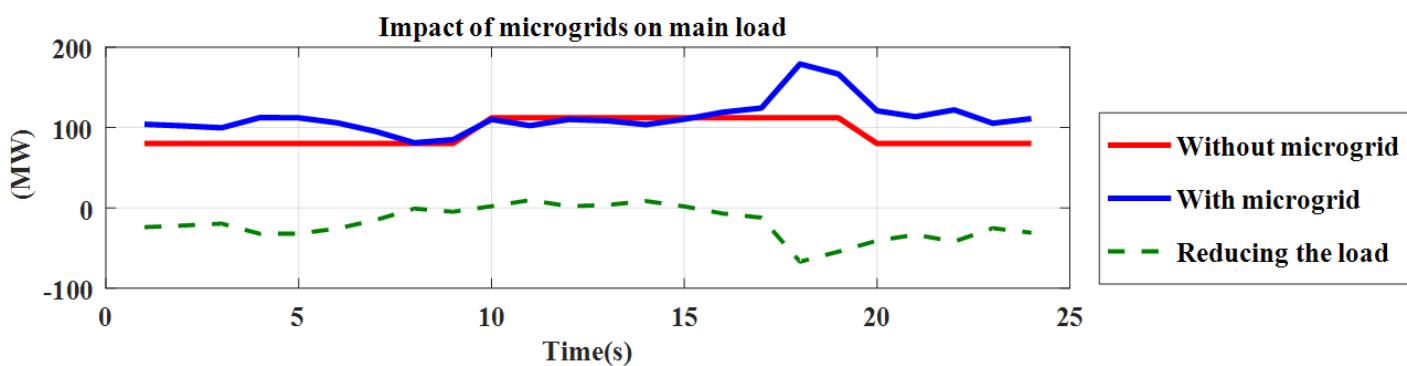
**Fig. 10:** Output voltage

It's very clear from the above figure that the shape of the three phase goes to stability near 280 -volt in 0.4s. The output voltage reaches stability quickly, from 0.2 to 0.4 s.



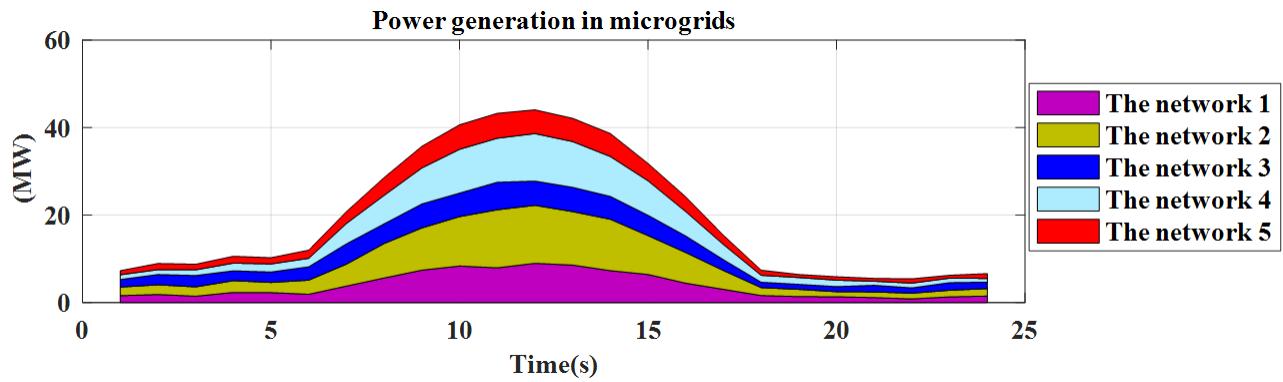
**Fig. 11:** output current on-grid

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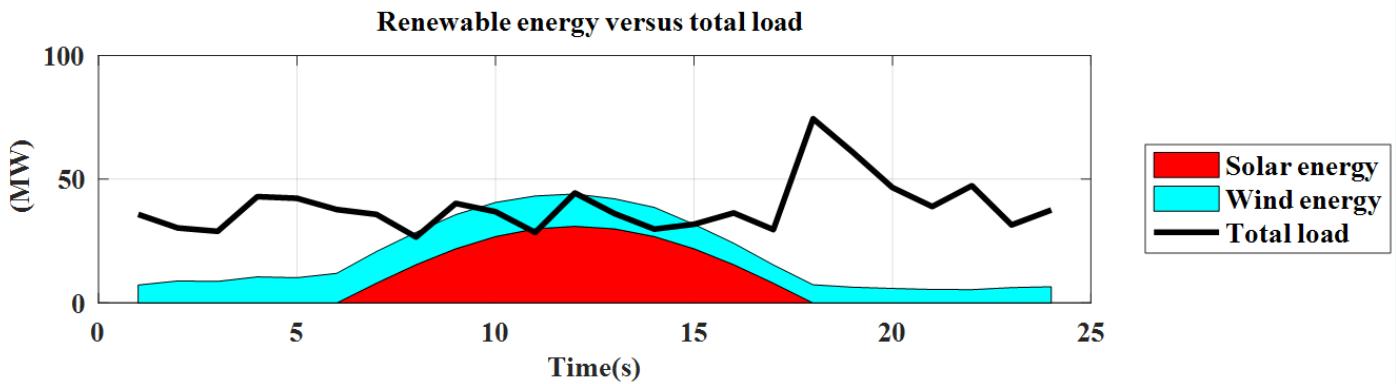
**Fig. 12:** Impact of micro grids

When using micro grids, the output power increase the average value of power about 20 % comparing with the second case study (without micro grids).



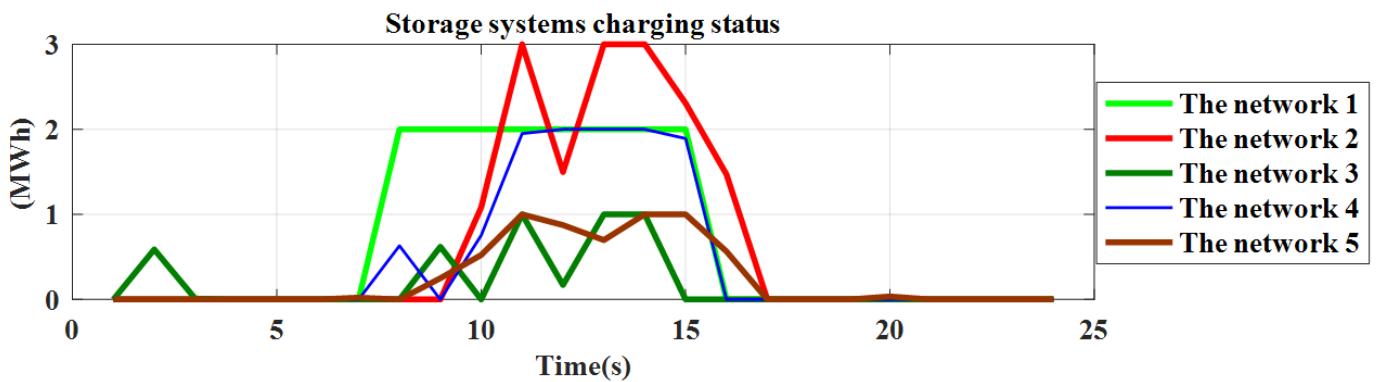
**Fig. 12:** Micro grids power generation

In average we can illustrate that the micro grid will increase the output power about 50 MW.



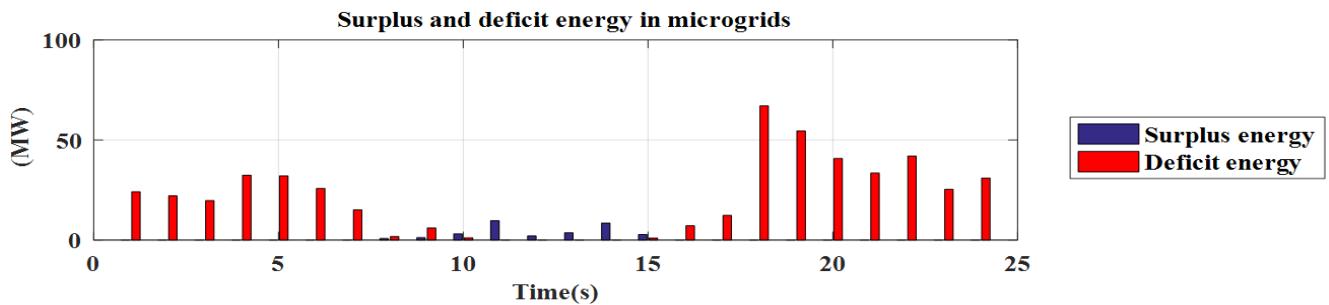
**Fig. 13:** renewable energy

The figure above show the total energy if we compare between two energies wind energy and solar energy. The output power reaches 80 MW approximately.



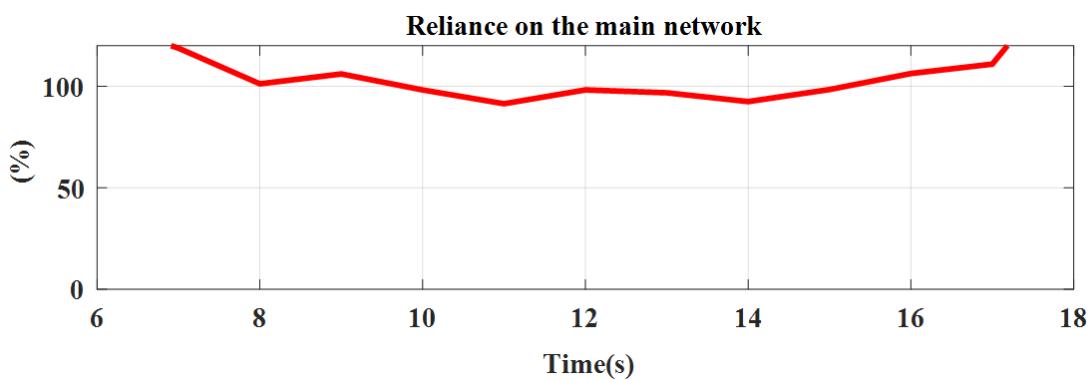
**Fig. 14:** Storege systems

Micro grid 1: Capacity 10.0 MW, Renewable Energy about 60.0%, Micro grid 2: Capacity 15.0 MW, Renewable Energy about 80.0% ,Micro grid 3: Capacity 8.0 MW, Renewable Energy about 40.0%, Micro grid 4: Capacity 12.0 MW, Renewable Energy about 70.0% , Micro grid 5: Capacity 7.0 MW, Renewable Energy about 50.0% .



**Fig. 15:** Surplus and energy in micro grids

It can be observed that the deficit rate when using partial networks is almost insignificant and to a small degree compared to the surplus of energy that reaches a level of 70 megawatts. This increase encourages the development of this industry and increases its growth.



**Fig. 16:** Reliance on the main network

We observe that the reliability using micro grids is high, ranging between 90% and 120%, which is an excellent percentage and confirms that adopting micro grids leads to increased reliability by utilizing this technology due to its positive and guaranteed impact.

**Table 1:** Impact of using micro grid on output load in day

Load reduction	Grid load with Micro grid	Grid load without micro grid	Hour
-24.03540732	104.0354073	80	1
-22.04097528	102.0409753	80	2
-19.64509037	99.64509037	80	3
-32.39512951	112.3951295	80	4
-32.05829401	112.0582942	80	5
-25.78111737	105.7811174	80	6
-15.02529944	95.02529944	80	7
-0.974834456	80.97483446	80	8
-4.862627455	84.86262746	80	9
2.008548069	109.9914519	112	10
9.628309776	102.3716902	112	11
1.993116026	110.0068844	112	12
3.581582107	108.4184179	112	13

8.437352775	103.5626472	112	14
1.775496162	110.2245038	112	15
-7.064258181	119.0642582	112	16
-12.23708312	124.2370831	112	17
-67.04994142	179.0499414	112	18
-54.49193503	166.4919354	112	19
-40.77128934	120.7712893	80	20
-33.42567475	113.4256748	80	21
-41.96006307	121.9600631	80	22
-25.31431321	105.3143132	80	23
-30.96733553	110.9673357	80	24

## 4. Conclusion

The micro grid is a new concept that has the potential to revolutionize the energy industry. It can provide backup power during outages, reduce the cost of energy, and improve the overall efficiency, reliability, and sustainability of the power grid. However, there are also challenges associated with the battery grid, such as the cost of energy storage technologies and technical challenges. As the demand for energy continues to grow, the battery grid will play an increasingly important role in our energy infrastructure. Micro grids can have a significant impact on the smart grid by providing localized power generation and distribution, promoting renewable energy integration, and increasing the reliability and resiliency of the grid. However, there are also challenges associated with the integration of microgrids into the smart grid, such as coordination and technical challenges. As the demand for electricity continues to grow, the integration of microgrids into the smart grid will play an increasingly important role in our energy infrastructure. The inverter grid is a critical component of modern renewable energy systems. It allows for the seamless integration of renewable energy sources into the existing power grid infrastructure and can help to improve the efficiency and reliability of the electric grid.

## Acknowledgement

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## References

- [1] Irmak, Erdal, Ersan Kabalci, and Yasin Kabalci. "Digital Transformation of Microgrids: A Review of Design, Operation, Optimization, and Cybersecurity." *Energies* 16.12 (2023): 459
- [2] Babu, K., et al. "Intelligent Energy Management System for Smart Grids Using Machine Learning Algorithms." *E3S Web of Conferences*. Vol. 387. EDP Sciences, 2023.
- [3] Misra, Sudheeksha, et al. "Optimal Control Strategies for Mitigating Frequency Deviation in Microgrid-Based Smart Village Systems." *Smart Village Infrastructure and Sustainable Rural Communities*. IGI Global, 2023. 269-282.
- [4] Hossain, Md Alamgir, et al. "Overview of AC microgrid controls with inverter-interfaced generations." *Energies* 10.9 (2017).
- [5] Bauer, Michaela, et al. "Power flow in heterogeneous battery systems." *Journal of Energy Storage* 25 (2019).
- [6] Hosseiniemehr, Tahoura, Arindam Ghosh, and Farhad Shahnia. " Cooperative control of battery energy storage systems in microgrids" *International Journal of Electrical Power& Energy Systems* 87(2017): 109-120.
- [7] Runge, Jason. *Design and control of resilient micro-inverter system*. . Diss. 2016.
- [8] Hu, Haibing, et al. "Efficiency improvement of grid-tied inverters at low input power using pulse-skipping control strategy." *IEEE Transactions on Power electronics* 25.12 (2010): 3129-3138.