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Introduction

To

Microgrid

Report

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Introduction To Microgrid

The Problem:

1- Centralized generation is often dirty, costs are increasing and T&D (transmission and distribution) is vulnerable to natural and man-made interruption.

2- Distributed renewables are expensive and CHP (Combined heat and power) is rarely optimized for grid support robust market participation.

Microgrids that integrate renewables and CHP are the answer:

1- The blended kWh rate of CHP and renewables delivers cost-effective energy.

2- Balancing the technologies improves energy reliability.

3- Can improve grid efficiency and reliability via ancillary services.

4- Microgrid could be the answer to our energy crisis.

5- Transmission losses gets highly reduced.

6- Microgrid results in substantial savings and cuts emissions without major changes to lifestyles.

7- Provide high quality and reliable energy supply to critical loads

What is Microgrid?

- It is a small-scale power supply network that is designed to provide power for a small community.
- It enables local power generation for local loads.
- It comprises of various small power generating sources that makes it highly flexible and efficient.
- It is connected to both the local generating units and the utility grid thus preventing power outages.
- Excess power can be sold to the utility grid.
- Size of the Microgrid may range from housing estate to municipal regions.

Microgrid Components:

1. Distributed Generation.
2. Loads.
3. Immediate storage.
4. Controller.
5. Point of Common Coupling.

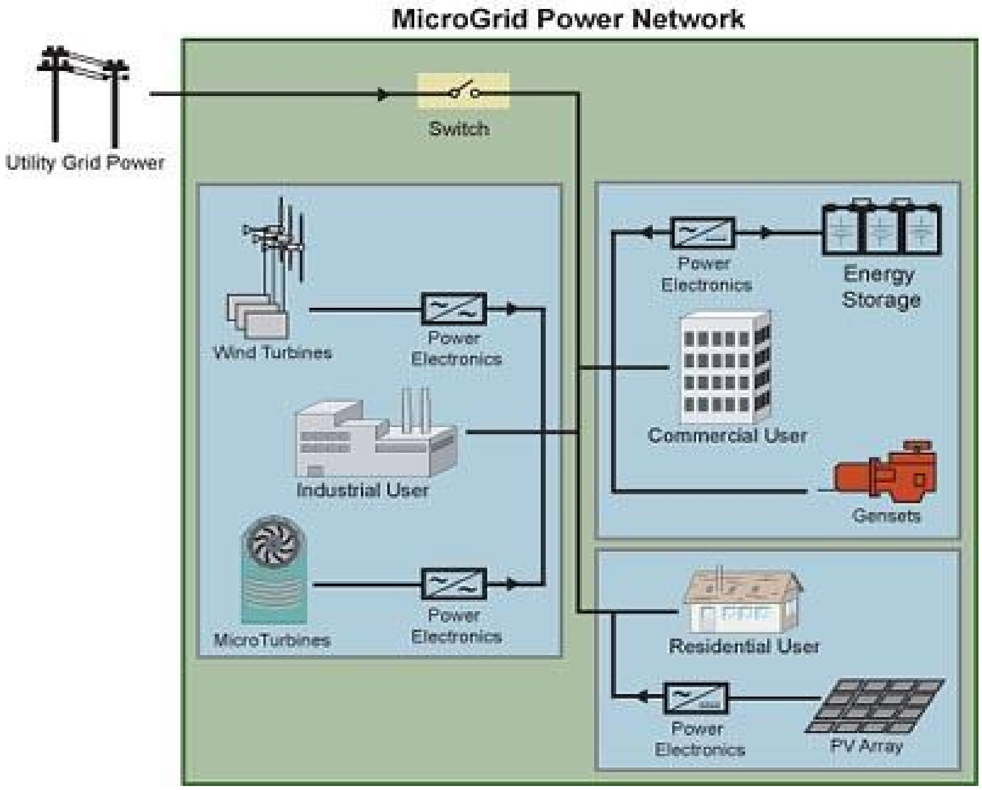

Fig.1 Microgrid power network with utility.

Typical Microgrid is shown below:

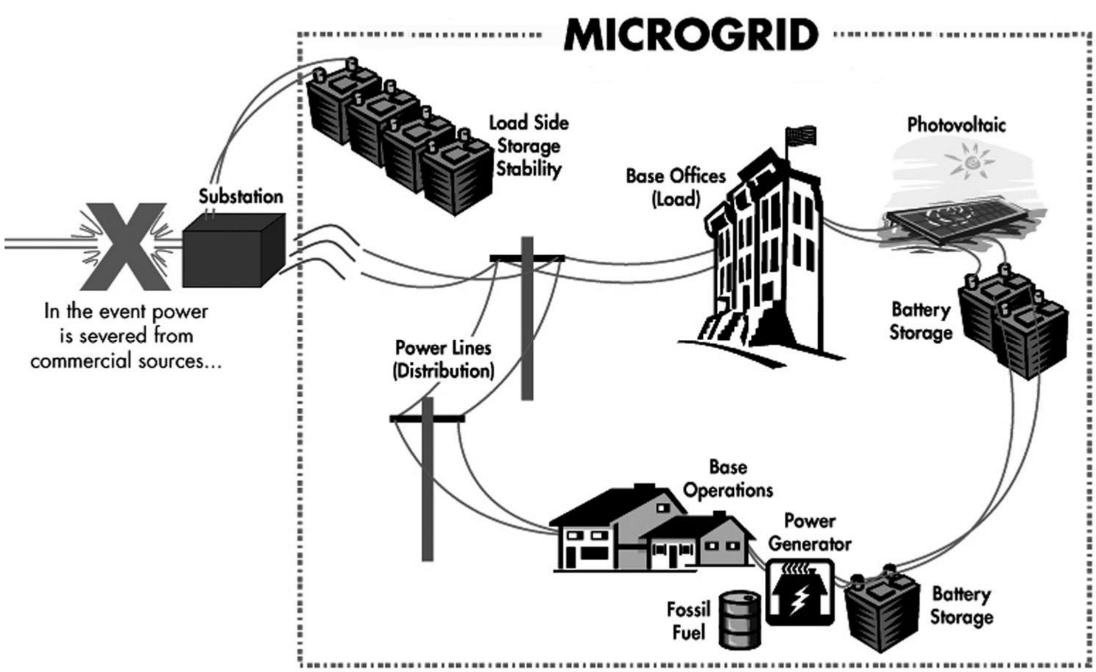

Fig.2 Typical microgrid.

Anatomy of a Microgrid:

- Generation
  - Reliable and cost effective renewables
  - CCHP & Fuels cells with waste heat recovery and optimization
- Bi-directional inverters
- Software
  - Sophisticated local management and integration with building automation
  - Grid aggregation and dispatch
- Energy Storage
- Fleet Electrification & Vehicle-to-Grid (V2G)
- Project finance and execution
- Operation and maintenance

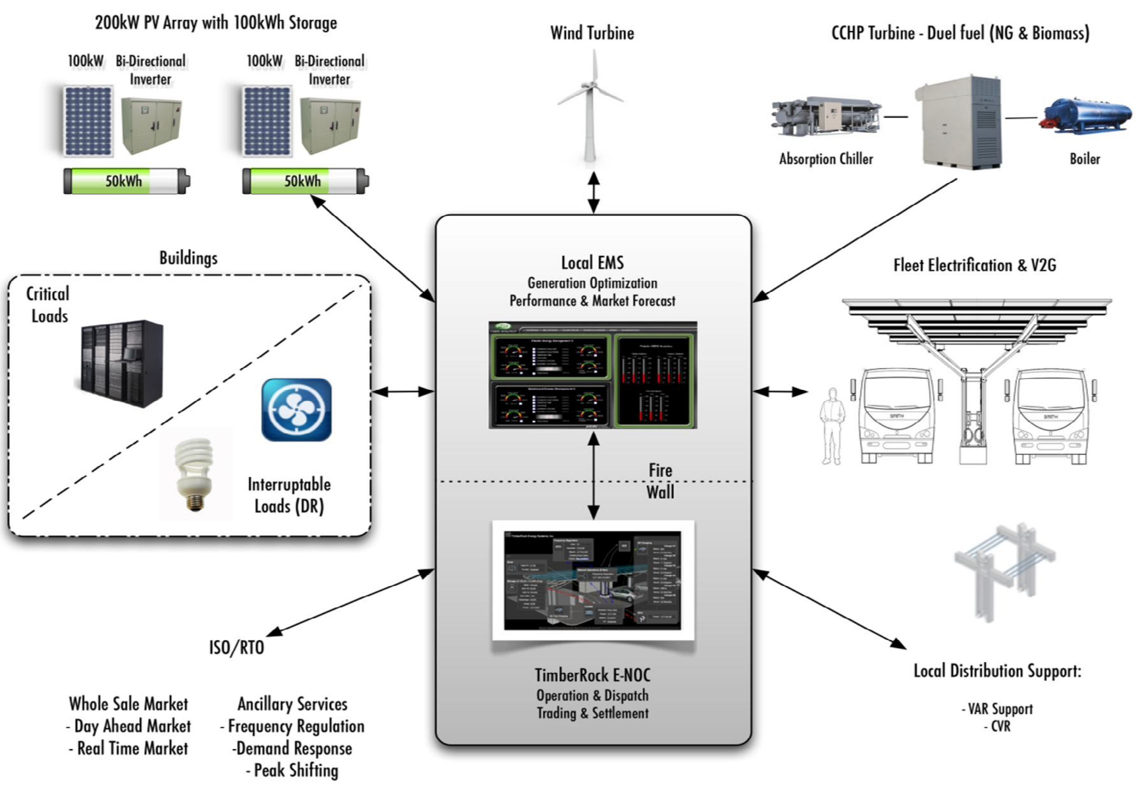

Fig.3 Anatomy of a microgrid.

Legacy Bulk Electrical System That Was Then:

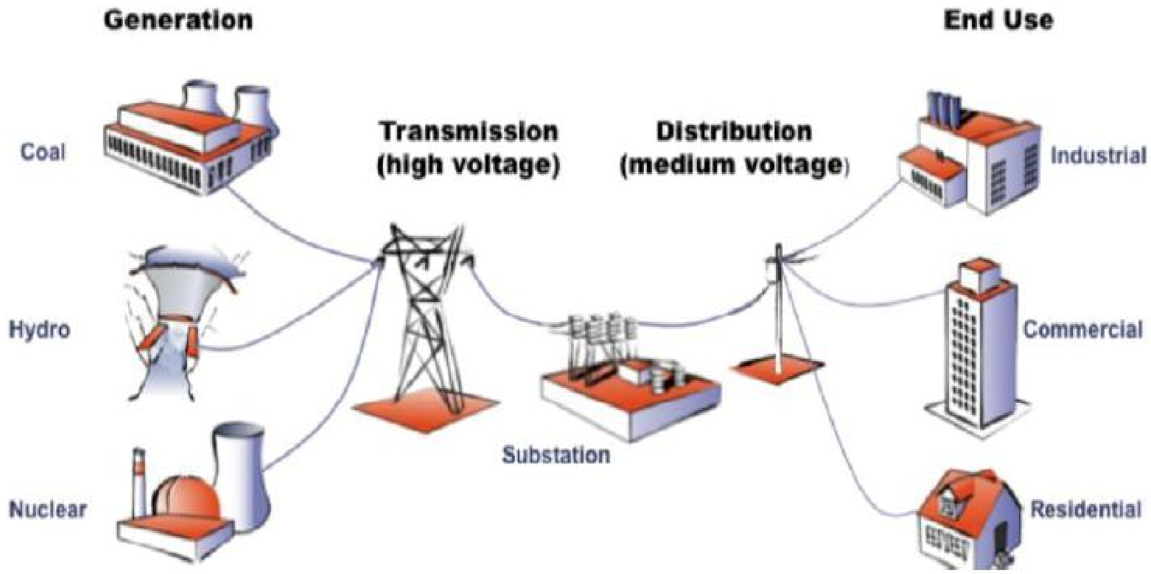

Fig.4 Legacy Bulk Electrical System.

Microgrids This is Now:

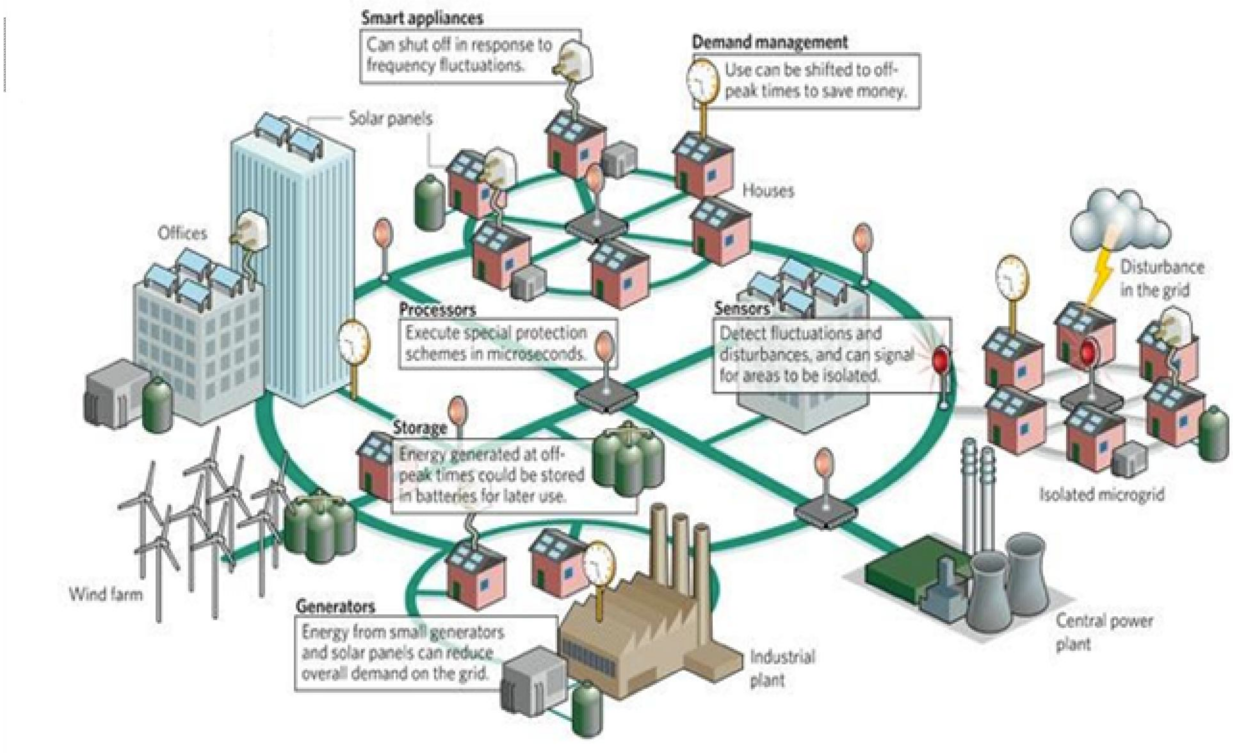

Fig.5 Microgrids now.

Value Proposition of Microgrids:

- Building Own/Operator
  - Improved energy reliability during natural or man-made grid interruptions
  - Cleaner electricity and reduced emissions
  - Reduction of demand and time-of-use charges
- Grid Operators
  - Renewables peak shifting & firming
  - Ancillary services
    - Frequency regulation
    - Demand response
    - Spinning Reserve
- Distribution Utility
  - Reduced congestion on transmission and distribution infrastructure
  - Power factor correction
  - Voltage support
- When these benefits are fully monetized, the economic performance of Microgrids can increase by 10%+**.**

Microgrid Operating Modes:

1- Grid Connected Mode:

- Utility grid is active.
- Static switch is closed**.**
- All the feeders are being supplied by utility grid.

2- Island Mode:

- Utility grid is not supplying power
- Static switch is open.
- Feeder A, B, C are being supplied by Micro sources.
- Feeder D (not sensitive) is dead.

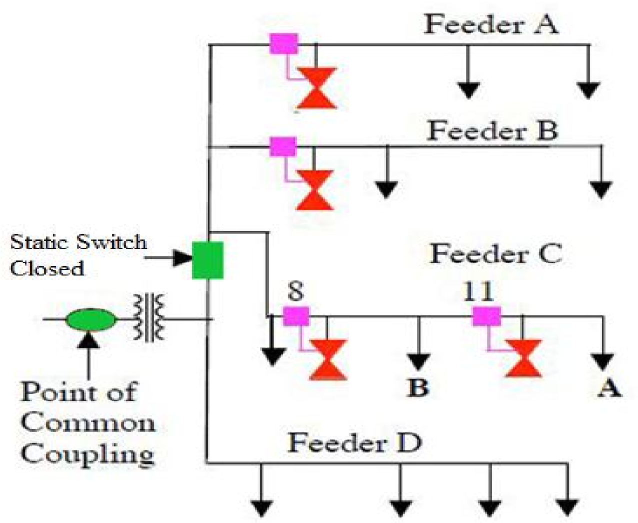

Fig.6 Grid Connected Mode.

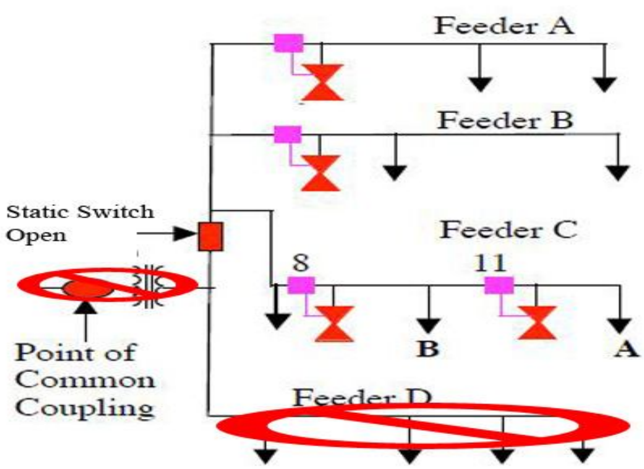

Fig.7 Island Mode.

Interconnected Microgrids (Power Parks):

- Practical size of Microgrids is limited to a few MVA.
- For larger loads, it is desirable to interconnect many Microgrids to form a larger Microgrid network called **Power Parks**.
- The advantages of this Microgrid structure insures greater stability and controllability for the **Power Parks**.

Environmental Aspects:

- Microgrid encourages the use of the renewable energy sources.
- Large land use impacts are avoided.
- CO2 Emissions are reduced.

Conventional Grid vs. Microgrid:

- Efficiency of conventional grid is very low as compared to Microgrid.
- Large amount of energy in the form of heat is wasted in conventional grid.
- Power sources in case of Microgrid (often referred to as Microsources) are small and are located in close proximity to load.

Advantages & Disadvantages:

Microgrid Advantages:

1. A major advantage of a Microgrid, is its ability, during a utility grid disturbance, to separate and isolate itself from the utility seamlessly with little or no disruption to the loads within the Microgrid.
2. In peak load periods it prevents utility grid failure by reducing the load on the grid.
3. Significant environmental benefits made possible by the use of low or zero emission generators.
4. The use of both electricity and heat permitted by the close proximity of the generator to the user, thereby increasing the overall energy efficiency.
5. Microgrid can act to mitigate the electricity costs to its users by generating some or all of its electricity needs.

Microgrid Disadvantages

1. Voltage, frequency and power quality are three main parameters that must be considered and controlled to acceptable standards whilst the power and energy balance is maintained.
2. Electrical energy needs to be stored in battery banks thus requiring more space and maintenance.
3. Resynchronization with the utility grid is difficult.
4. Microgrid protection is one of the most important challenges facing the implementation of Microgrids.
5. Issues such as standby charges and net metering may pose obstacles for Microgrid.
6. Interconnection standard needs to be developed to ensure consistency. IEEE P1547, a standard proposed by Institute of Electrical and Electronics Engineers may end up filling the void.

The Future of Microgrids:

For some, microgrids hold the promise of becoming a basic “building block” in the implementation of the next generation smart grid infrastructure. However, as is the case with most new technology, there will be significant implementation challenges to overcome.

In many respects, microgrids are smaller versions of electrical grids. Like electrical grids, they consist of power generation, distribution, and controls such as voltage regulation and switch gears. However, they differ from electrical grids by providing a closer proximity between power generation and power use, resulting in efficiency increases and transmission reductions. Microgrids can also be integrated with renewable energy sources such as solar and wind power. The use of renewable energy introduces the need for energy storage and/or off-peak energy source integration, something modern microgrids are designed to manage.

Security and independence from potential grid interruptions such as blackouts and brownouts are also considered microgrid benefits, especially for critical applications running at hospitals and military bases. This benefit is illustrated by the performance of the Sendai microgrid at Tohoku Fukushi University. While the overall electrical grid was compromised during the devastating 2011 earthquake and tsunami, the microgrid, using distributed generators and batteries, continued to provide power to a variety of facilities.

Microgrids can meet the needs of a wide range of applications in commercial, industrial, and institutional settings. Larger microgrid applications include communities ranging from neighborhoods to small towns to military bases. Another largely untapped application is the “offgrid” area of the world where one billion-plus people live without regular access to electricity. These “off-grid” areas are currently served (if at all) by diesel generators or similar small scale electricity generating equipment.

Overall, the microgrid's structure makes it a viable platform for large entities to reduce energy costs and generate revenue through the sale of energy during periods of peak demand. Additionally, microgrids can efficiently and effectively provide "off-grid" areas with regular access to electricity as well as "keep the lights on" in times of crisis for critical applications like a hospital.

Challenges to Microgrid Adoption:

Utilities have been reluctant to endorse microgrids. The valid historical argument has been the safety concern of unintentional "islanding", that is, a part of the grid that has become separated from the grid but not shut down during a black out. The safety concern is that unintentional islanding can be dangerous to utility workers, who may not be aware that a circuit within the "island" still has power. Secondly, islanding may prevent automatic reconnection of devices into the grid. Existing grid protocols address this concern in that they dictate that all distributed power generation must shutdown during power outages. To address these concerns, new inverter technologies are designed to integrate renewable energy sources such as solar and wind while allowing safe operation in island mode.

Another challenge has been the lack of established standards for microgrids. A positive step in addressing this was the 2011 adoption of the Institute of Electrical and Electronics Engineers (IEEE) standard P1547.4, "Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems". The standard provides best practice guidelines for implementing different ways a microgrid can island and reconnect, all while seamlessly providing power to users of the microgrid.

Another step in creating standards is the establishment of the Consortium for Electric Reliability Technology Solutions (CERTS) in 1999. This group consists of national laboratories, industry, and universities that collaborate on research and develop technologies to protect and enhance the reliability of the U.S. electric power system, including furthering the development of microgrid designs.

CERTS is investigating optimal microgrid design and have field tests in operation. For example, CERTS established the Microgrid Test Bed Demonstration with American Electric Power to demonstrate the integration of small energy sources into a microgrid. The project included three advanced techniques, collectively referred to as the CERTS Microgrid concept, which has reduced the need for custom field engineering solutions needed to operate microgrids.

Perhaps the key 'tipping point" for the adoption of microgrids into the overall smart grid architecture is cost. As costs for key microgrid elements such as renewable energy sources (e.g., solar), energy storage (e.g., batteries, supercapacitors), advanced load generation controls, and smart switches continue to decline, the economics for microgrids for specific applications will become cost competitive compared to traditional power sources.

Microgrids –What's Next?

Although the technical immaturity, utility reluctance, and current cost structure of microgrids will limit their application to niche markets in the short term, the future for microgrids is promising. Power equipment companies now investing in pilot microgrid projects and currently available market opportunities will be well positioned for market leadership as the demand for microgrids increases over time. However, perhaps the largest benefactors of microgrids will be foresighted utilities, communities, industrial parks and the like, that will leverage microgrids to optimize their energy costs with the added bonus of generating revenue opportunities by selling energy back to the grid during periods of peak demand.

Future Directions on Microgrid Research:

- To investigate full-scale development, field demonstration, experimental performance evaluation of frequency and voltage control methods under various operation modes.
- Transition between grid connected and islanded modes on interaction phenomena between distribution generation and high penetration of distributed generation.
- Transformation of Microgrid system today into the intelligent, robust energy delivery system in the future by providing significant reliability and security benefits.

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