# Comprehensive Review on Controlling Power Flow in Distribution System By Using UPFC

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**Abstract:** *Over time, renewable energy will gradually displace coal, oil, and gas from our energy consumption patterns. Pairing renewable energy systems has the potential to improve economics or performance over what could be achieved by each system working in isolation. Distributed generation system is used to improve the operations of electricity delivery systems at or near the end user. DG also has an effect on system losses. In many cases, the effect of DG on losses is positive, as DG is often located close to the demands where the energy is consumed. Generators and loads are generally connected to the busbar in the electric power network, and different busbars are connected with transmission lines or distribution lines. The unified power flow controller (UPFC) realizes real-time control over power flow in transmission lines by adjusting the line parameters, including node voltages, phase angle, and line impedance, which cover all adjustable parameters of other FACTS. This paper reviews the work done by different scholars in controlling the flow of power by using FACTs, or UPFC .*

***Keywords:*** *. Renewable energy, Hybrid energy systems, Distribution Grid, UPFC, FACT,*

## I. Introduction

The global need for energy has been rising rapidly. Coal, oil, and gas are a few and finite examples of traditional energy sources. As a result, it is crucial that we conserve our current energy supplies and look into new ones. The two most promising forms of renewable energy for humanity are solar and wind energy [1]. The future energy system will be based primarily on renewable energy sources due to the abundance of these resources [2]. Coal, oil, and gas will eventually be replaced by renewable energy in our energy consumption patterns. It is necessary to reorganize the current energy systems in order to integrate a significant proportion of renewable energies into the power system. This transition depends on the intelligent electricity grid, also known as the smart grid (SG).

When renewable energy systems are combined, it may be possible to obtain better economics or performance than if the systems were used separately. For instance, combining solar and wind power systems can lower transmission costs overall because of their complementary peak output during the day and night, which could ease grid congestion and enable the use of shorter transmission lines.

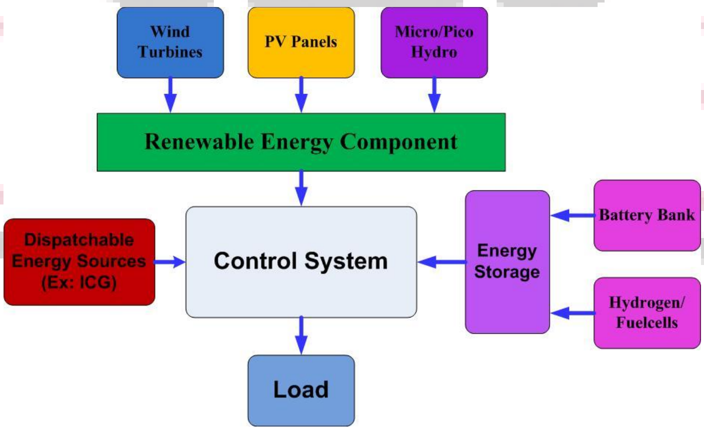


**Figure 1 Hybrid Energy Systems**

One of the most potential alternatives to conventional fossil fuels, which have had detrimental effects on the environment, is renewable energy. In order to address the unpredictable nature of renewable energy resources, provide dependable electricity, and lessen their dependence on fossil fuels, hybrid renewable energy systems (HRESs) interconnected with multiple renewable and nonrenewable energy sources and storage devices have sparked widespread concerns. This is illustrated in Figure 1. The optimal planning and operation of HRESs depend significantly on optimization techniques. Traditional deterministic optimization techniques, on the other hand, run into problems because of systematic uncertainties that may be present in environmental, economic, technical, and political issues. Such problems call for integrated, imprecise optimization techniques that most effectively scale the components of hybrid systems under various uncertainties.

## II. DISTRIBUTED GENERATION SYSTEMS

LV grid nearby, multigenerational systems for integrated gradient utilization (including wind, solar, and other distributed renewable power generation), residual heat, residual pressure, and residual gas generation equipment, and small natural gas-fired systems with combined cooling and heating capabilities are all examples of distributed generation technology. It functions essentially as a small-capacity generating unit for construction, grid integration, and energy consumption[3].

The construction and use of compact, modular power generation equipment that can be coupled with energy storage and management systems is another definition of distributed generation. It is utilized to enhance how electricity distribution systems function at or close to the end customer. The electric grid may or may not be linked to these systems. Distributed generation occurs when electricity is produced at or close to the load center, where it will be needed. Distributed generation utilizes renewable energy sources like solar and wind as well as non-renewable ones like diesel generators.

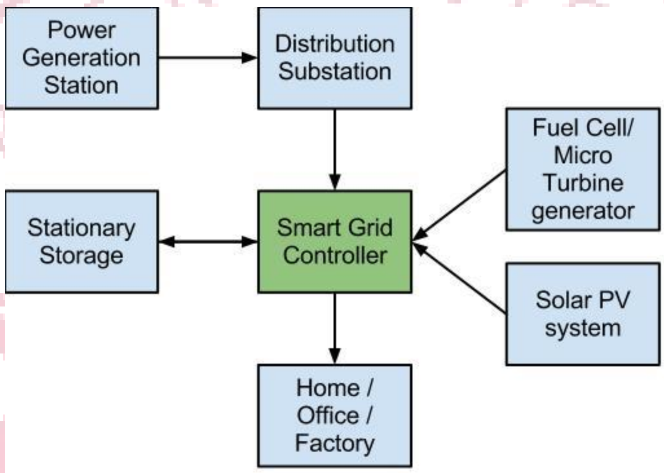


**Figure 2 Distributed Generation Systems (DES)**

System losses are impacted by DG, as well. Since DG is frequently situated close to where energy is utilized, it frequently has a positive impact on losses. As a result, the amount of energy that needs to be transferred over a given distance is decreased, lowering losses. The quality and dependability of the power supply in the electrical system can also be impacted by DG. DG could benefit the electrical market by reducing load and serving as a demand response. Electric utilities can employ DG to lower peak loads, offer ancillary services like reactive power and voltage support, and enhance power quality, especially on a local level.

## III. MICROGRID

Small independent power systems known as microgrids (MGs) can function while the larger grid is down, promoting resilience and supplying energy to rural areas and places hit by natural catastrophes. The deployment of distributed energy resources (DER) and the communication integration of these resources with the MG management system or an MG controller were the main foci of the majority of MG demonstration projects around the world.

Microgrids are becoming more common in order to reduce load increase, incorporate intermittent renewable energy sources, and avoid lengthy power outages. A single-owned building or campus and a community microgrid that serves a number of buildings with numerous owners are both categories of microgrids. The owner/operator, referred to as the aggregator, who is in charge of the best planning and effective operation of these microgrids, finds the community microgrid to be more difficult. Microgrids should therefore be able to monitor and manage the loads and distributed energy resources (DERs) that are located inside each building. When residential structures are integrated into a community microgrid, this problem is even more difficult. The aggregator in the community microgrid needs to be able to see residential loads and DERs well in order to monitor and manage this sector's loads.

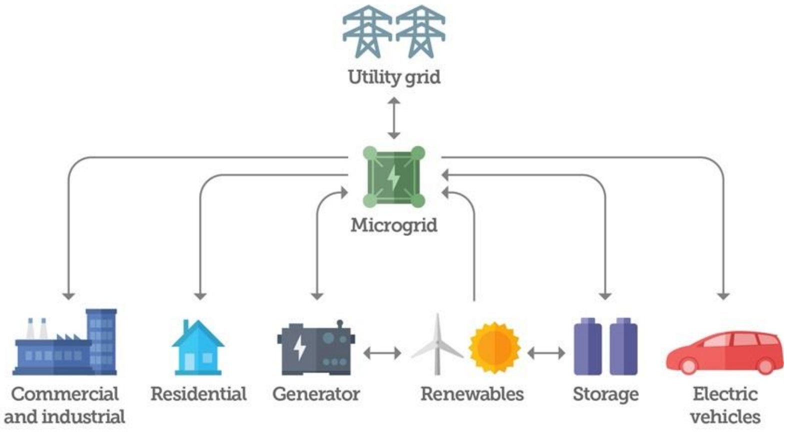


**Figure 3 Microgrid Technology**

The electrical features of MGs, such as whether they are set up as a direct current (DC), alternating current (AC), or hybrid system, can be used to classify them. In DC MGs, converters are used to connect generators, storage devices, and loads to the shared DC bus. An inverter is utilized if there are AC loads. In AC MGs, converters connect generation units and loads to the shared AC bus. According to function demand, microgrids are divided into three categories: simple microgrid, multi-DG microgrid, and utility microgrid.

- Simple microgrid

A simple microgrid is one that uses only one type of DG, has basic functionalities, and is designed to provide continuous power to key loads.

- Multi-DG microgrid

A multi-DG microgrid is made up of numerous simple microgrids or other kinds of coordinated, complementing DGs. The construction and management of such a grid are far more difficult than those of a straightforward microgrid. To ensure power balance during islanded operation, some loads must be designated as sheddable loads.

- Utility microgrid

A utility microgrid can be interconnected with any DG or microgrid that satisfies certain technical requirements. In such a microgrid, loads are ranked according to consumers' expectations for reliability, and in an emergency, high-priority loads will receive preferential power.

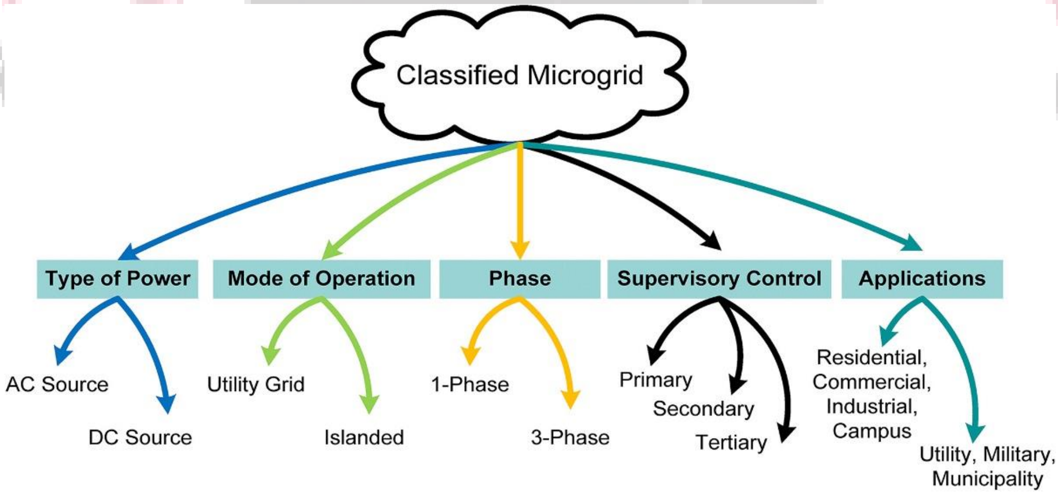


**Figure 4 Classification of Microgrid**

To fulfill the additional requirements of microgrid monitoring, microgrid data can be transferred to any location with a covered network. Due to the volume and complexity of the data in the microgrid, special attention should be paid to the data structure and interface of the entire database while communicating with the outside world. The client-server model is always used for communication between the microgrid and the outside world, allowing visitors to view all the data in web pages. Additionally, as microgrid communication data is updated in real-time, it is important to keep the data current for academics to analyze.

## IV. POWER FLOW

In power system analysis, power flow is a fundamental notion. The steady-state power flow across the whole electric power network is determined by power flow calculations. In the electrical power network, busbars are typically used to connect generators and loads, while transmission lines or distribution lines connect several busbars. In fact, each line has reactance and resistance, which causes both active and reactive power loss. Each bus has active power (P), reactive power (Q), voltage angle (), and voltage magnitude as its four parameters or variables (V). Nonlinear using complex numbers is the first mathematical model of power flow for AC systems. The original nonlinear equations are approximated by linearized DC power flow to make the power flow calculation simpler.

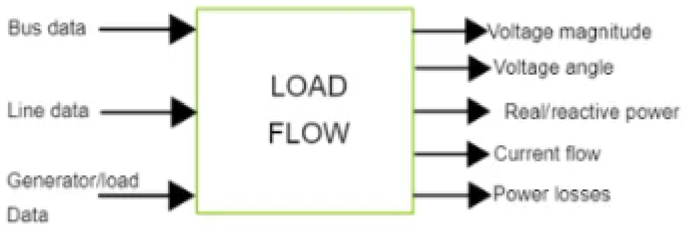


**Figure 5 Representation of Power Flow**

In power system studies like contingency analyses and reliability assessments, especially for large-scale systems, linearized power flow models are of great relevance. The classical DC power flow (DCPF) model, one of the most extensively used models, is praised for its state independence, resilience, and computational effectiveness. Despite its benefits, the DCPF model does not take into account reactive power or bus voltage magnitude.

## V. RELATED WORK IN CONTROLLING POWER FLOW BY USING UPFC

The universal power flow controller (UPFC), which covers all adjustable parameters of other FACTS, achieves real-time control over power flow in transmission lines by modifying the line characteristics, including node voltages, phase angles, and line impedance. As technology advances, phase shifters, thyristor controlled series compensation (TCSC), static synchronous compensator (STATCOM), static var compensator (SVC), short-circuit current limiter (UPFC), and static var compensator (SVC) change line characteristics to control power flow.

From the conventional amplitude and phase control to the contemporary control based on a synchronous rotating coordinate system, UPFC control approaches have evolved. Additionally, the structure of the control system evolved from the traditional linear PI (Proportion Integration) or PID (Proportion Integration Differentiation) to neural network, fuzzy, and nonlinear control, which are based on adaptive theory, decoupling control, cross-coupling control, and coordinated control. We have covered several researchers' assessments utilizing UPFC in Table 1 below.

| AUTHOR/ REFERENCES | TITTLE | RESULT | CONCLUSION | LIMITATION |
|---|---|---|---|---|
| R VENKATA KRISHNA [4] | DISTRIBUTED POWER FLOW CONTROLLER FOR ENHANCING POWER SYSTEM STABILITY R | effectiveness of DPFC in voltage profile improvement | Improve Voltage Profile by DPFC | UPFC is the most power full FACTS device currently. |
| S. Rangu [5] | Recent trends in power management strategies for optimal operation of distributed energy resources in | detailed review of distributed and decentralised approaches for economical operation | beneficial to the scientific community for developing further investigations in the related research field | Risk limiting dispatch models need to be developed for future energy communities like Virtual Power plants |

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|---|---|---|---|---|
| | microgrids: A comprehensive review | | | and Resilient-Microgrids |
| Bindeshwar Singh [6] | A comprehensive survey on enhancement of system performances by using different types of FACTS controllers in power systems with static and realistic load models | power system reliability and security enhanced | enhancement of system performances such as load-ability, real and reactive power losses, voltage profiles, power system stability, bandwidth of operations | FACTS controllers in multi-machines power systems |
| Pavlos S. Georgilakis [7] | Unified Power Flow Controllers in Smart Power Systems: Models, Methods, and Future Research | methods for the control of UPFC are intelligent control schemes as well as various advanced control techniques | heuristic algorithms are best for UPFC allocation problem | Need of cost reduction |
| Yasir Muhammad [8] | Solution of optimal reactive power dispatch with FACTS devices: A survey | ➢ Minimize the slack bus power<br>➢ Maximize voltage stability margin<br>➢ Minimize voltage deviation.<br>➢ Minimize volt–ampere compensation prices | key challenges faced by these techniques in solving ORPD problems are highlighted | optimization problems in reactive power planning (RPP) |

## IV. CONCLUSION

Coal, oil, and gas will eventually be replaced by renewable energy in our energy consumption patterns. When renewable energy systems are combined, it may be possible to obtain better economics or performance than if the systems were used separately. Electricity delivery systems at or close to the end consumer can operate more efficiently thanks to distributed generation systems. System losses are impacted by DG, as well. Since DG is frequently situated close to where energy is utilized, it frequently has a positive impact on losses. In the electrical power network, busbars are typically used to connect generators and loads, while transmission lines or distribution lines connect several busbars. The universal power flow controller (UPFC), which covers all adjustable parameters of other FACTS, achieves real-time control over power flow in transmission lines by modifying the line characteristics, including node voltages, phase angles, and line impedance. This essay examines research on employing FACTs or UPFC to manage the flow of electricity done by various academics.

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