EVALUATING THE EVOLVING DISTRIBUTION SYSTEM

Ulteig

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Distribution Planning and Analysis

Over recent years, the electrical distribution system in the U.S. has evolved significantly from the electrical distribution system of the past. Traditionally, the power flow has started at large scale, centralized generation connected at high voltage, transferred through the transmission system, then the distribution system to deliver power to the loads.

There has been a shift from traditional large-scale generation to the addition of large-scale renewable plants, and now to small scale distribution connected, distributed energy resources (DER). Today's distribution system often includes small-scale wind and solar generation from communities, houses and businesses and is operated and maintained through smart devices – things which were unheard of in the distribution system just a few short years ago. The growing penetration and number of DER has reversed the direction of the traditional power flow and introduced new unexpected challenges on the distribution system, resulting in the need for new distribution regulations and detailed planning studies.

Pair this evolutionary nature of the distribution system with the aging workforce of those in the electric utility industry, and it's easy to see how it could be hard to keep up!

There are various aspects that need to be studied on the distribution system; the required studies fall into the following categories: power flow studies, power quality studies, and dynamic studies.

1 **POWER FLOW STUDIES**

2 **POWER QUALITY STUDIES**

3 **DYNAMIC STUDIES**

POWER FLOW STUDIES

A power flow analysis considers the steady state conditions of a distribution feeder. Limitations based on thermal and voltage constraints are identified with these types of studies, and system upgrades can be recommended based on the results of the studies. [3]

Power flow studies can include:

- Capacity planning
- Voltage drop calculations
- Ampacity
- Contingency analysis
- Time-series power flow analysis
- Volt/Var Studies

POWER QUALITY STUDIES

Power quality analyses ensure that the voltage and frequency waveforms comply with standards for distribution systems. This type of analysis could look at evaluating the operating conditions that lead to power quality disturbances, equipment affected by disturbances, voltage sag and swells and how to mitigate these disturbances.

Harmonics, another power quality consideration, are also necessary to study on the distribution system, especially with the growing number of non-linear loads and harmonic sources, such as converters and arc furnaces. [3]

DYNAMIC STUDIES

Dynamic studies are used to evaluate the dynamic interaction between DER and the distribution system as well as the transient response of the distribution system to switching events or faults. Dynamic studies will become increasingly important with higher levels of DER to investigate whether control systems can maintain voltage and frequency when subjected to disturbances.

Optimization and model validation are also important aspects to consider during the dynamic study process. Planning needs a validated model baseline to forward plan to system for years to come. It needs to start from a relatively accurate point, while operations need a validated model to respond to outages and day-to-day conditions.

Ulteig has been providing services and solutions supporting power delivery since 1944. Ulteig's study services team with over 40 years of combined transmission and distribution planning experience, both on the utility side as well as renewables, has the knowledge and background to assist with the growing demands for distribution planning and analysis.

Below are a few ways Ulteig can help with your distribution studies:

1 FEASIBILITY STUDIES OF DISTRIBUTED ENERGY RESOURCES

CHALLENGE:

With the ever-decreasing cost of microgrid, small-scale renewable energy projects, like rooftop solar and small wind turbines, are becoming more popular at the distribution level. These projects may introduce issues onto the distribution system and need to be evaluated for compliance with applicable design and interconnection standards but finding the resources and expertise necessary to properly evaluate their potential impact can be challenging. If studies are not done pre-interconnection, there may be expensive changes required to the system to mitigate issues which occur post-interconnection.

SOLUTION:

Feasibility studies should be performed on these projects prior to interconnection to ensure that no issues will be introduced onto the distribution system. Key items a feasibility study may review are the system load flow, short circuit contribution, harmonic distortion, coordination, and system grounding. Additionally, an overall review of the proposed project design can be done to verify compliance with distributed generation standards such as IEEE 1547 or verification that the project meets specific requirements of the interconnecting utility.

ULTEIG SUPPORT:

Ulteig has performed many feasibility studies for small-scale wind and solar projects and has an extensive background in utility-scale renewable project design and interconnection studies. These two levels of experience combine to give Ulteig a unique ability to identify potential issues which should be reviewed and resolved prior to interconnection. A thorough review of any potential generation project, no matter how small, will help ensure the distribution system of the future maintains reliability. A pre-interconnection feasibility study will help keep much more costly potential issues post-interconnection **to a minimum.**

2 POWER QUALITY STUDIES

CHALLENGE:

Wind and solar generators interconnecting at a distribution level often have limited information available on the expected harmonic voltage and current distortion of the generator. Thus power quality issues may not be realized until the project is interconnected and system issues due to harmonics start to appear, such as equipment overheating or failure.

SOLUTION:

Temporary power quality meters can be used to evaluate the distribution system at key points at the time the new generator is energized and after to identify these potential harmonic issues and determine solutions for mitigation as necessary. Power quality analysis can also be completed in a distribution system without the introduction of a wind/solar project, if there are simply issues which may seem to point toward issues related to power quality. Issues related to power quality in a distribution system can be hard to both discover and find the root cause, but solutions are often inexpensive and easy to implement. Ulteig has the equipment and experience to complete a harmonic evaluation on your system.

ULTEIG SUPPORT:

Ulteig has temporary harmonic meters available which are suitable for power quality metering on distribution systems. We have performed harmonic analysis in a wide range of applications, from utilizing meters to identify the root cause of issues thought to be related to harmonics in an industrial facility to analyzing and mitigating the cause of excessive harmonic current distortion of a multi-phase utility-scale wind project in Texas. Ulteig can utilize modeling software as needed to supplement the review of data recorded by power quality meters to provide detailed recommendations such as installation of harmonic filters or operating configurations to avoid power quality problems.

3 VOLT/VAR COMPENSATION ANALYSIS

CHALLENGE:

As interest in the green lifestyle increases, combined with incentives and accessibility to install renewable resources, the amount of DER on the distribution system has grown. As a result, the challenges that DER poses to the distribution grid have also grown. Small-scale renewable resources introduce the same issues of intermittency and reliability challenges due to the nature of the wind and solar that are faced on the transmission level. These challenges, which have led system operators and regulatory commissions to enforce interconnection requirements at the transmission level, are also posing issues on the distribution level.

Much of the DER being installed on the distribution system is PV technology. The real power rise and fall during sunrise and sunset is predictable, however the power fluctuations due to cloud cover throughout the day are drastic and sudden. Cloud cover can cause a PV plant to drop from its full rating to 0 MW output. These real power fluctuations can result in voltage fluctuations on the system, larger than the criteria that a utility will typically allow on their system. Wind generation has similar issues, although the variation in generation is not as instantaneous as observed with solar.

The constant variation in voltage and power can lead to violations in the utility flicker criteria, power quality concerns, continuous operation of the existing voltage regulation equipment on the system and eventually leading to maintenance concerns.

These concerns could potentially lead to limiting the amount of DER that is allowed on the system.

SOLUTION:

Rather than limiting DER on the system to prevent these problems, the issues above can be mitigated through reactive compensation support. Various distribution class voltage solution options which allow for manipulating voltage and power factor as needed are available in various forms, including:

1. *Voltage regulators*
2. *Load tap changing transformers*
3. *Switched shunt devices and smart switching technology*
4. *Medium/Low Voltage STATCOM devices*

ULTEIG SUPPORT:

Through steady state and dynamic simulations, Ulteig can demonstrate the effect of the real power fluctuations on the voltage, and study various options for mitigation. The studies involve finding the optimal location of the reactive compensation, as well as evaluate the benefits of one solution over another to assist with cost benefit analyses. Some solutions offer significant benefits in performance over others, such as reduced operation of mechanical devices or reduced capacitor switching or assistance with conservation voltage reduction, however they do come at a higher price point. The results of the study can assist in the evaluation of the best solution.

These types of studies also demonstrate how the proposed solution allows for increased DER penetration, demonstrate the voltage flicker mitigation and improved power quality (power factor).

Ulteig can also make recommendations on control operation and best solution options to minimize operation of devices which can lead to mechanical failure.

CONCLUSION

Today's distribution system requires detailed analysis and considerations, including various types of power flow, power quality, dynamic, optimization, and model validation type analyses. These studies help ensure the reliability and robustness of the distribution system, given the growth that can be expected in the future. These studies can also help ensure that the optimum approach is taken to utilizing various resources, to take full advantage of the capacity of the system while still remaining cost effective.

Ulteig, with over 40 years of transmission and distribution planning experience and well versed in various typical transmission and distribution planning software packages, can assist with the management and execution of these studies, including the following:

- Power Quality
- Load Flow
- Volt/Var Compensation
- Arc Flash
- Renewable Energy Interconnections
- Coordination Studies
- Rate Studies
- Injection Studies
- Loss Reduction Studies

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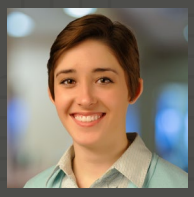

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SOURCE LINKS

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2. Martini. Integrated Distribution Planning (2016).
3. Homer, Stewart & Coddington. Distribution Planning Modeling Tools (2017).
4. Diaz de Leon, Reddy & Managoli. Minimizing Impacts of PV Solar Generation in Distribution Grids.