Study Committee C6

Active Distribution Systems and Distributed Energy Resources

Paper ID_508

Analysis and a Conceptual Framework of Short-Term Planning Operation of South American Active Distribution Systems

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Summary

- A massive increase in distributed energy resources (DER) within distribution networks is foreseen.
- Main challenges to be considered within the new distribution operation planning (DOP) frameworks focused on South American systems are shown.
- A comprehensive methodological framework of day-ahead DOP was conceptually proposed to estimate, evaluate, and manage the possible operative states.
- Traditionally solutions (such as on-load tap changer (OLTC), capacitor banks and network reconfiguration) and modern alternatives (i.e., demand response and energy storage systems) are considered.

Motivation

- DER involves changes in electric power systems, foreseeing that the distribution sector will be the most affected.
- Networks will be starting a transition towards active distribution networks (ADN).
- It involves technical and operational challenges due to greater uncertainties in operation, risks of contingencies, and degradation in supply quality.
- New planning tools will be the core of ADN operation, integrating DER functioning models to define strategies and efficient solutions, resulting in technical, economic, and environmental benefits.
- It can be said that the massive penetration of DER is not only a challenge but also an opportunity.
- Observability, control, and automation should be enough to know the whole state of the system and actively manage all participants based on scheduling.
- These resources are absent or scarce in South American distribution systems, so it is crucial to find compromise solutions that fulfil the observability requirements.

Planning Context

- Active Network Management (ANM) systems appear as one of the main facilitators to ensure an ordered competence in the electric market at the time that they allow reaching a series of objectives.
- These ANM can be grouped into direct and indirect control methods.
- Indirect control strategies are related to those market methods that use price signals or contracts to influence users' consumption (such as day-ahead dynamic prices).
- Direct control methods rely on direct control signals over resources (e.g., remotely controlled switches). These methods are: network reconfiguration and active and reactive power control. A combination of both control methods is commonly used to obtain better solutions for DOP.
- The coordination and integration of numerous resources, together with the fact that some of them have stochastic behavior, brings about challenges.
- Neglect the inherent random behavior of DER and demands, assuming negligible forecasting errors, results in less realistic future estimations and sub-optimal solutions for DOP.
- Forecasting future system states will allow identifying potential security problems (congestions and/or voltage violations) to prioritize or select objectives and control strategies that provide more appropriate solutions. Contrary to methodologies that establish fixed strategies for all operative conditions, which may result in unacceptable computing times or have no solution at all.
- Finally, one of the most widely used solutions to improve system observability is using state estimation (DSSE), which use a reduced number but appropriately located network measurements to obtain a complete, coherent, and reliable data of the network state.

Traditional and modern solutions to tackle technical issues

Issue	Traditional solutions	Modern solutions
Voltage drop/rise	Capacitor Banks	Coordinated Volt/VAR control
	Generation tripping	Coordinated DER management
	Limits for demand and generation	On-line reconfiguration
Hosting Capacity	Network reinforcement	Coordinated DER management
	Limits for generation	On-line reconfiguration
Reactive Power Support	Transmission network	Coordinated Volt/VAR control
	Capacitor Banks	Coordinated reactive power DER management
	Limits for demand and generation	
Equipment overload	Network reinforcement	Coordinated DER management
	Limits for demand	Coordinated Volt/VAR control
		On-line reconfiguration

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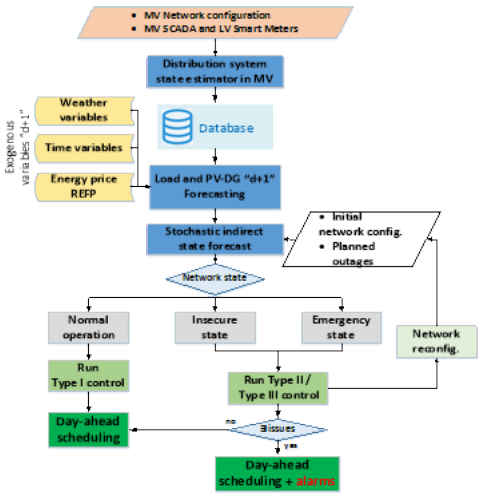
continued

Proposed Framework

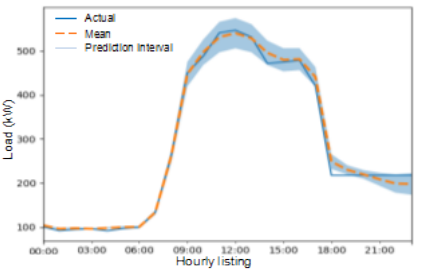
- The aims are both technical and economic ones, and they look to increase the benefits not only for users but also for the distribution utility.
- Photovoltaic distributed generation (DG-PV) considered is of small scale for self-consumption with possible delivery of the surplus to the network. So it is not considered as a control variable within the optimization process.
- Demand response program (DR) tries to take advantage of the users´ rationality to modifications in the energy price. Thus, a mechanism based on price signals (dynamic price) is proposed.
- Electrochemical batteries for distribution system applications (BESS) are considered.
- The main steps of the proposed framework for the DOP are:



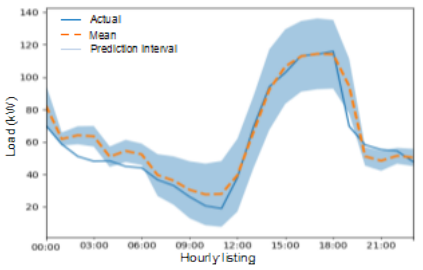
Case Study – Partial Results

- Within the activities considered in the proposed framework. To deal with uncertainty: A new probabilistic net load forecasting model has been developed based on an effective combination of deep learning techniques and Monte Carlo Dropout.
- The historical observations are smart meter records taken from the dataset of the project "Caucete Smart Grid," located in the Province of San Juan – Argentina.
- Results have been evaluated through metrics widely considered in load forecasting. For this, the root mean square error (RMSE) and the Winkler score (WS) were adopted.
- In the case of the distribution transformer (120 consumers, mainly residential, with 28% of PV-DG) RMSE are 8.32 and WS of 35.59, for a prediction interval of 68.3%.
- For industrial consumer, resulting metrics provided by the model are 11.70 and 39.37 for RMSE and WS, respectively.

Probabilistic Net Load Forecasting for MV Industrial Consumer



Probabilistic Net Load Forecasting for MV Distrib. Transformer



Conclusion

- Massive increase in DER is foreseen within the distribution networks. As a result, the role of the distribution system operators will be widely increased, and they will carry out similar management to what happens upwards in transmission systems.
- A new comprehensive methodological framework of day-ahead DOP was conceptually proposed to provide an efficient scheduling that supports the real-time operative decision-making.
- According to the results, it can be said that the proposed load forecasting model with MC Dropout has the capability of generating accurate predictions and capturing the uncertainty present in the load or net load forecasting. Thus, this forecasting algorithm results appropriate as background information for the proposed operation planning tool.