An Overview of the Research on Power System Challenges and Issues

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Abstract-
The power business is seeing a quick pace of technological advancements, which has led to the publication of new technical papers and research projects addressing the growing problems associated with power system restoration and repair. A thorough evaluation of methodologies and procedures is required in light of the current concentration of research efforts on the problems of power system restoration and repair and restoration, as well as the multiplicity of strategies employed by these fields. This article analyses the work on the restoration problem and the repair and restoration problem of the power system in a methodical and thorough manner.
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INTRODUCTION

For many years, the safe and efficient design and management of electric power systems has revolved around computational techniques and information systems. These days, there are a lot more complex computational issues due to transformative factors including renewable energy, distributed resources, energy storage, large-scale sensing, customer-owned resources, environmental regulations, and much more. The conventional grid economics and reliability goals have been combined with sustainability objectives, which has led to an increase in unpredictability and complexity and is probably going to make a large percentage of the computational techniques and information systems in use today outdated. This paper Thrust Area 5 looks at these computational difficulties. The new operational and planning decision-making tools that are required must be based on computational techniques that can handle more complex issues and take into consideration unpredictable conditions, the impact of non-dispatchable resources, and customer involvement. However, the accessibility of vast amounts of more precise data from intelligent electronic devices (IEDs), phasor measuring units (PMUs), and Advanced metering infrastructure (AMI) offers tremendous potential for enhanced grid operation, control, and planning; however, methods for gathering, organising, and securing this data must be discovered in order to use it to enhance, expand, and replace current modelling, computation, control, and decision-making instruments. Figure 1 illustrates the following aspects of the future grid's significance for computational systems: a developing grid, vast amounts of fresh data, sophisticated computing, and decision-making (automated or human). In the current market climate, the contemporary power system is pushed very near to its critical functioning limitations. Long transmission networks with high capacity are frequently employed to fulfil the modern society's need for power supplies. Although solar and wind energy are widely used as clean, renewable energy sources, their inherent volatility, unpredictability, and irregularity make them unstable. Consequently, mishandling certain partial failures can easily result in mishaps and dangerous domino effects, which might ultimately result in a widespread or large-scale blackout. Worldwide, there have been a lot of widespread blackouts in recent years. For instance, the August 14, 2003, North American blackout resulted in massive losses, and it took over two weeks for the electricity to be restored. On November 4, 2006, there was a power outage in Europe that lasted up to two hours and affected 15 million people. On November 10, 2009, there was a widespread blackout across Brazil and Paraguay. Following the March 11, 2011, earthquake and tsunami, the Fukushima nuclear power plant was forced to close in an emergency because its emergency power and external power were insufficient to sustain the cooling system, which resulted in radiation leakage and other disastrous consequences. The worst power outage in northern India occurred on July 30-31, 2012, affecting 670 million people, and involved 50 GW of load. While much work has been done to make power systems robust to outages, large-scale blackout hazards still exist and are unavoidable. The detrimental effects on the general population, the economy, and the power system itself may be successfully mitigated with the right restoration strategy. It is crucial to do research on the fastest and most efficient ways to restore the electrical grid following blackouts.

OPPORTUNITY AND THE CHALLENGE

(i) Decision Making Framework for the Future Grid- The ability to make decisions, whether automatically or by humans, is essential to any sector or business's success. A large percentage of the industry's current decision-making procedures are now or soon will become outdated due to the new objectives, stricter control requirements, and higher unpredictability and complexity of the future grid. In contrast to the components of existing grids, every smart device, technical subsystem, and economic agent found in emerging grids will make decisions based on achieving both the grid's overall aims and their own personal aspirations Therefore, the grid's ability to make decisions and achieve its goals securely depends on its ability to answer issues like: can operational problems be identified and resolved; are pertinent models accurate; are analytical tools powerful enough; can all important decisions be made in a timely and satisfactory manner; and how far ahead can stakeholders plan.

(ii) Computational Issues of Optimization for Planning- The degree of uncertainty in long-term resource planning issue formulations must rise with the incorporation of renewable energy and demand's increased price sensitivity. Decisions are split into two groups and uncertainties are described in terms of probabilistic scenarios in stochastic programming models. Prior to knowing the scenario realisation, first stage investment decisions must be made; nevertheless, depending on whatever scenario materialises, second or later stage operational decisions may be made. Numerous possibilities and computational intractability arise from a comprehensive depiction of multidimensional uncertainty. Simultaneously, taking into account the effects of planning choices on the market necessitates a bi-level framework in which upper-level planning decisions predict lower-level equilibrium responses from market actors. These issues also provide computational difficulties.

(iii) Hierarchical Probabilistic Coordination and Optimization of DERs and Smart Appliances- The opportunity to turn the distribution system into an active and controllable resource with a dramatic impact on system economics, primary energy source utilisation (including shifts in fuel usage from petroleum to natural gas, nuclear, etc. and associated shifts in greenhouse gas emissions), ancillary services, and system security enhancements is provided by renewables and other distributed energy resources (DER), including storage, smart appliances, plug-in hybrid electric vehicles (PHEVs). It is evident that these advantages need the efficient and well-coordinated use of these resources in order to be achieved. A significant and difficult probabilistic coordination and optimisation challenge is created by the expected enormous number of these tiny resources, their unpredictability, and their mobility (PHEVs).

RESEARCH ISSUES

(i) Decision Making Framework for the Future Grid- A greater degree of complexity and unpredictability characterises the change of the power sector. To really accomplish its goals and guarantee a secure industrial transition, the future grid must be able to use vast amounts of data, sophisticated computation techniques, and analytical tools, which will need an evolution of the current decision and business processes. The first task in this thrust area looks at issues like how new decisions will impact current ones, what decisions need to be automated, who will make them, how, and how the technologies being used now will support these decisions. It also asks if there will be a single emerging paradigm for decision making in the future industry. The emerging concept of prosumers economically motivated entities (homes, buildings, microgrids, etc.) that can produce or store energy in addition to consuming it is central to the framework for making decisions. These entities are outfitted with enabling technologies that enable them to become strategic and optimised decision-makers. Additionally, consumers display a variety of values, such as their beliefs about what is proper for society and what they stand for in terms of societal values. When discussing the consequences of sustainability responses at the individual level, this is very pertinent. There are several forms of qualitative analysis frameworks that cover held values in addition to sold or assigned values.

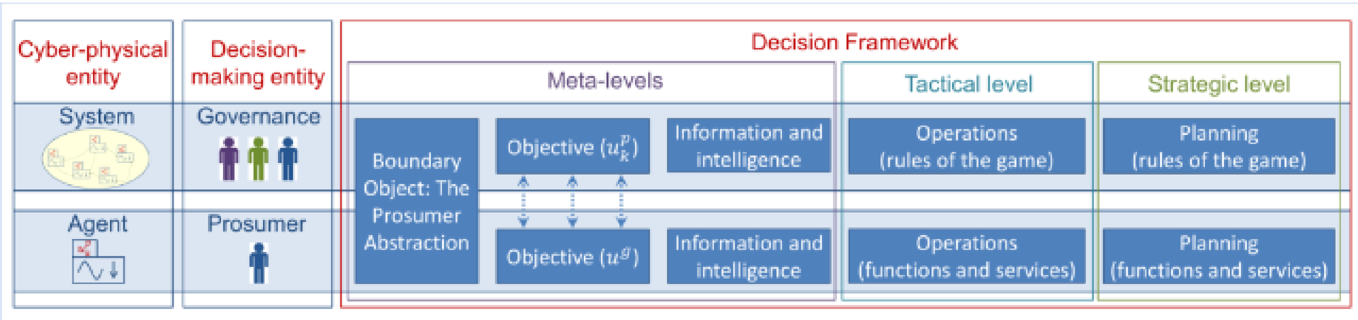

Figure 1- Principal Actors in the Decision Making Framework

(ii) Computational Issues of Optimization for Planning- Planning for generation expansion is the main emphasis of this activity (GEP). Creating stochastic models for continuous variables like fuel prices and future loads is the first step towards incorporating uncertainty into the form of scenarios for a stochastic programming model. In order to estimate potential future evolution routes, scenario trees with discrete nodes that each reflect a possible combination of values of the unknown quantities at a future point in time together with conditional branching probabilities, must then be built. The resultant tree can become quite huge over a multi-period time horizon with even a relatively modest number of branches from each node. Because each path from a potential expansion plan requires the simulation of its results, either explicitly or indirectly, created to roughly represent potential future evolutionary routes. The resultant tree can become quite huge over a multi-period time horizon with even a relatively modest number of branches from each node. The computing task can become unmanageable since every path from the tree's root to a leaf node at the end of the time horizon requires the outcomes of a candidate expansion plan to be simulated, either explicitly or implicitly. Deriving a more manageable collection of scenarios that accurately capture the effects of unknown variables on the best investment choices is, thus, the primary research question. The goal of this job is to refine, put into practice, and evaluate a technique for lowering the total number of scenarios taken into account in a GEP stochastic programming model. In our two-stage model, energy production by both new and existing units in each period is represented by the second stage, while choices to invest in additional capacity of various types of generating units across the planning horizon are represented by the first stage. Forward Selection in Wait-and-See Clusters (FSWC) is a scenario reduction technique that was created in the past for medium-term fuel and generation planning issues.

CONTROL APPROACHES BASED ON MPC

The fundamental concepts of Receding Horizon Control (RHC), also known as model predictive control, were first presented in industrial control applications in the 1960s and 1970s, particularly in the chemical sector. Subsequently, this control strategy was accepted by researchers when it reached the academic and research sphere. The sorts of predictive controllers have been well-described and contrasted in a number of studies. MPC is a logical approach for systems with limitations. This fact illustrates why, in comparison to other controller types, predictive controllers are so widely used. Generally speaking, the predictive controller minimises the cost function that ensures the system operates as it should in order to provide the converter the necessary control signal. Microgrid control systems have been the subject of extensive research in recent times. While optimal performance is needed in other structures, achieving dependable performance balancing supply and demand is the most crucial factor in small-scale microgrids. The hysteresis band control approach has been applied to energy management in a variety of research projects because of its straightforward structure and ease of use. Predictive controllers, on the other hand, offer a wide variety of uses in the fields of drives and power electronics and minimise the cost function by resolving optimisation issues while taking technological limitations into account. Numerous industrial applications employ the model predictive control approach in contemporary industrial control. Two categories can be used to group these techniques: 1. Continuous control set MPC (CCS-MPC), which necessitates a modulator to create switching pulses in accordance with the control system settings. 2. Finite control set MPC (FCS-MPC), which leverages the benefit of limiting the number of switching possibilities to optimise the problem. It is common knowledge that a converter has two states in which the switches may be turned on and off, and that the number of states that can be created by combining these states is finite. Because of this built-in feature, the converter switching model is simple to explain, and the forecast can simply be summed up in the few scenarios that are listed.

(i) MPC-Based Primary Control- To manage the voltage in PCC (in island mode) and the output power of each DG (in grid-connected mode), the FCS-MPC technique is suggested as the major control layer. The Voltage Model Predictive Control (VMPC) approach is offered as a droop control and secondary to adjust the output voltage of DGs in the island mode. In the grid-connected mode, the Direct Power Model Predictive Control approach (DPMPC) is applied to manage the power sharing between each DG and the grid. A study on the development of a predictive controller for voltage regulation in island microgrids using a discrete time model is provided in. In this study, a microgrid is constructed by connecting many distributed generating units in parallel. The controller design's objective is to regulate the mains voltage for various loads. This controller is for a single-phase microgrid architecture and is designed utilising a discrete-time function that offers substantial microgrid tracking functionality. There have been several methods used to test this controller's performance. This controller exhibits higher tracking performance and provides microgrids with adequate performance against the dynamics of various loads.

(ii) MPC-Based Secondary Control- For both grid-connected and island mode, a unified model predictive voltage and current control (UMPVIC) method is described in. This technique may be employed flexibly in the main control layer for appropriate load sharing and in the tertiary layer for power flow. To lessen the voltage and frequency variations brought on by the primary droop layer, a fuzzy control approach is suggested. To enhance voltage quality, this fuzzy controller may optimise secondary layer coefficients. Converters respond dynamically far more quickly than the frequency load does. Droop control is typically employed to distribute microgrids' reactive and active electricity. This method's drawbacks include voltage and frequency variations from their nominal values in a steady condition. For the purpose of returning the microgrids' voltage and frequency, a distributed secondary controller based on the prediction model using a state space method is suggested. In order to avoid voltage and frequency variations, a secondary controller is thus supplied. The suggested method's effectiveness is assessed by subjecting it to a feeder impedance that is incompatible with both balanced and unbalanced linear load circumstances. For many energy storage systems, a voltage observer-based distributed model predictive control approach is suggested. An enhanced distributed predictive control technique is suggested in order to lessen the impact of communication latency on the voltage observer. The delayed system is strengthened by this proposed plan. To analyse the dynamic performance, a predictive controller is included into a small-signal dynamic model.

CONCLUSION

The power grid faces significant risks and problems as a result of new and highly unpredictable renewable energy sources, as well as opportunities brought about by smart and controlled appliances and better, less expensive communications. In order to use the controllability of these resources to create a system that will enhance economics, the environment, and system dependability, the research community should adapt by creating new methodologies and paradigms. Through a coordinated (hierarchical) optimisation and control strategy, we have been creating a novel method for monitoring and managing the abundance of minor resources in this research paper. Uncertainty has always made long-term planning difficult, but the degrees, complexity, and volatility of the uncertainties affecting generation expansion planning are rising. By concentrating on how these scenarios impact the planning decisions that need to be made right away, we are narrowing down the number of potential future scenario routes that need to be taken into account in this research. Additionally, we are looking at how supplier rivalry, transmission limitations, and demand response affect each provider's individual investment choices.

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