CHAPTER 1
INTRODUCTION

The growing industrialization and improved life-style of peoples has increased
energy demands and this trend is bound to continue further at different pace and
needs. Today, generation of power is witnessing a paradigm shift from
conventional centralized generation. Hybrid generation is being adopted engaging
both centralized and distributed generation capacities. Multiplicity of vendors
(sources) and varying cost of energy generation has today qualified energy as a
tradable commodity. Consequently establishments like Power Trading
Corporation, Power Grid Corporation etc. are established for trading and
transportation of power. These corporations manage their operations economically
using advance and specific management tools, for generation, transmission and
trading of power. The key indices namely system efficiency, economy and
resource utilization (optimal control of delivery) influence the business and are of
vital importance to the respective management teams. In this research work, the
author analyzes power system, its management and presents a combined influence
of management and technological drivers on defined key indices, as against
isolated impacts published and reported by management and engineering scholars.

Energy management, for its multiplicity of resources (Generation: conventional
and distributed) mode of transport (Transmission: by HVAC and HVDC) and the
end user (Distribution companies: state owned and private) today presents a
complex case, for management teams. The complexity further enhances for
multiple generation source both in conventional (Nuclear, Thermal, Hydro) and
distributed (Thermal, Gas or Diesel, Hydro, Solar and renewable) sectors. The
power transmission has both HVAC and HVDC distribution of power and is handled by corporation of different nature (public and private).

The author presents a techno management approach to the technological aspects of the power grid networks where the economics and efficiency is gained by utilizing technological devices.

Models simulating power system, with scaled down parameters of generators, transmission lines and loads, have been constructed by the author for studying power flow networks during this research. Relevant features simulating faults and failures are added to the models to relate with modern power utility systems and to facilitate simulation and study of energy management and maximum power utilization under specific network conditions, of demand and supply. The study includes simulation of concepts like: Unified Power Flow Control (UPFC), Supervisory Control and Data Acquisition (SCADA) and Digital Numerical Distance Relay (DNDR) in the network to study the impact on power delivery and optimization of operational efficiency. A combined techno-managerial model is thus presented by the author in this work.

**RESEARCH METHODOLOGY**

**Type of Research:** As the topic of the research is “Economic and Efficient Management of Transmission and Control of Electrical Power” it was considered to take up experimental work and investigate first-hand how efficiency and economics can be introduced in power transmission using the new technological devices. For this reason suitable models were designed and constructed to simulate the real system.

The hardware models constructed were:

1. **AC Network Analyzer:** This model was developed to conduct experiments for different Power Grid configurations and to study economics and efficiency by using UPFC device (Unified Power Flow Controller). The model also enabled study of issues encountered in the management of operational power flow in
networks and methods to resolve operational issues to improve reliability of networks.

(2) Power System Model: This model was designed to study high voltage overhead transmission lines. The dynamic model had elements to simulate transmission lines up to 400kV and provided with:
a. Supervisory Control and Data Acquisition (SCADA)
b. Digital Numerical Distance Relay (DNDR)

(3) Cable Fault Locator: This model was built for locating different types of faults in underground cables accurately and efficiently for the maintenance of the power network.

**Need for the study:** Operational economy and efficiency are related to each other and closely influence sustenance of any technology. For trading energy profitably it is important that the trading operations are managed efficiently. To manage the operations of an energy corporation the corporation has to study and identify the efficiency impediments and their direct/indirect influence on operations. It is also important for the utility to have the latest updates on technologies to remain competitive. This multi-disciplinary study is an attempt in this direction and provides an analysis of efficiency impediments and advance power transmission technologies.

**Significance of the study:** On the basis of the objectives stated above the research was conducted to suggest measures for economic and efficient transmission of power from the viewpoint of techno-management. The study on a larger perspective would be of huge national importance as improved efficiency of operations improves availability and cuts down on capital costs making electrical energy more affordable.

**Objective of the study:** The main objective of the research here is:
(1) To investigate through simulation, the management aspects of the complex electrical power networks
(2) To study through practical implementation the key
issues on a dynamic model (3) To study the performance of UPFC device and DNDR (4) To implement SCADA automation architecture on the model (5) To study “Maintenance management” of underground cables by locating the faults quickly and accurately (6) To suggest efficiency and economy measures in power transmission over long distances.

Research design: The methodology proposed primarily involves visits to the electrical power networks and substations for topology of the network and system operating parameters followed by construction of dynamic model and simulation of the networks. In secondary stage, simulated networks to be interfaced with new technological concepts like UPFC Device, SCADA automation and Digital Numerical Distance Relay (DNDR) to investigate system improvements and to find solutions for the following:

1. Efficient and economic management of power transmission, control and utilization of the generated power from existing resources and eliminating wastage of power by incorporating automation
2. Maximizing power flow in an interconnected grid network
3. Protection of the grid network under conditions of different faults

Source of data: The Sources of data in this research work has been taken from both primary and secondary data sources. As there is lot of experimental study involved in the research to study economic and efficient management of transmission system and control of electrical power, the author had to design a model which would give practical results and data. Before building the models the author carried out literature survey in depth to understand the existing and future scope of the research work.

a) Primary source: The primary sources of data are the results obtained from the experiments conducted on various model developed as discussed in the chapters. The models are flexible in nature which can simulate different power system grid to understand through experiments how the economics and efficiency in
transmission system is affected during power flow and faults and to study the control devices in the system.

b) Secondary sources: The secondary sources of data are obtained by reviewing papers published on similar research work, their findings, conclusions, approaches and limitations. This research work was done after the survey of literature which forms the basis of development of models where power system network problems can be simulated and the hurdles in economics and efficiency in managing can be analyzed.

Chapter Scheme:

A brief on the contents of chapters is given below:

Chapter two, “Review of Literature on Management of Automation in Energy Systems” comprises reviews on the subject with special attention to the developments in SCADA automation. Advance SCADA devices, techniques and network security is discussed based on available literature from various international journals and proceedings of National and International seminars. A paper titled, “SCADA Automation in Energy Management Systems” has been contributed by the author and has been published in IJREAT (International Journal of Research in Engineering & Advanced Technology) in their June-July 2014 issue (Volume 2, Issue 3).

Chapter three “Economic Management of Transmission of Power — An Experimental Study on AC Network Analyzer” discusses about constructing a dynamic model of an “AC Network Analyzer” for study of a simulated power grid network. The chapter details out key features of the AC Network Analyzer and highlights its ability of simulating interconnected power grid network of different configurations. The flexibility of configuration, measurement and analysis is documented in the chapter along with experiments on the model.

Paper titled, “AC Network Analyzer, A Dynamic Benchmark For Power System Study” has been published in IJREAT (International Journal of Research in Engineering & Advanced Technology) in their Oct-Nov 2014 issue (Volume 2, Issue 5) and another paper titled, “Economic and Efficient Management of Transmission and Control of
Chapter four “A Power System Model – To Study SCADA Automation and Digital Numerical Distance Relay”. The author presents a dynamic model for study of protection of transmission lines. The protection device, a Digital Numerical Distance Relay, is a plug-in to the Benchmark Power System Simulator which is utilized in the study to simulate the impact of line faults (Line-Ground, Double Line to Ground, Three Phase fault and Three-Phase to Ground faults). The chapter discusses overall impact on efficiency and economy of the system, by addition of Digital Numerical Distance Relays (DNDR) as early identification, isolation and rectification would improve transmission line performance. This chapter also discusses about SCADA automation. The author has published a paper titled, “Dynamic Model of 400 kV Line with Numerical Distance Relay” in IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 2, Issue 3, June-July, 2014

Chapter five on “Management of High Voltage DC Power and its Economics” analyzes HVDC Transmission and its impact on economy and efficiency of power transmission. The author in this chapter compares and projects HVDC and HVAC economics. In the present time of power crisis of high demand supply gap, it would be helpful to implement efficient and reliable technologies to peak power utilization. A paper titled, “Management of High Voltage DC Power”, has been published by the author in International Journal of Contemporary Technology & Management, IJCTM, Volume-II, Issue-VI, July 2013, ISSN 2278-8034.

Chapter six “Maintenance Management of Underground Cables for Reliable System Operation” analyzes management and maintenance of the underground transmission systems/cables, associated monitoring and maintenance techniques. Equipments for detection of faults, procedure for fault rectification etc. is discussed ensuring post fault continuity of power, new techniques and equipment available with emphasis on management and efficiency. The chapter highlights

Chapter seven “Technological Innovation and its Entrepreneurial Management” analyzes management of key technological innovations related to the field of electrical systems along with a case study from industry. As the broad area of the present research is techno management, this chapter has been added recognizing the crucial role of innovations in various technological fields which can be related to this study.

Case study of technological innovation by an Indian company has been studied in detail to visualize the process of innovation (conceptualization, development and launching), process of industry (product life cycle, and business management) and the critical parameters for successful innovation. New saleable product establishes a new industry in a short time. The case history discussed here confirms this that if the innovation is managed well it can cause phenomenal growth of an enterprise resulting into an organization. A paper titled, “Technological Innovation and its Management”, has been published by the author in IJREAT International Journal of Research in Engineering & Advanced Technology, Vol.-2, Issue-3, June-July, 2014 and another paper titled, “Automation of Water Distribution Plant” in IJREAT International Journal of Research in Engineering & Advanced Technology, ISSN: 2320 – 8791, Volume 2, Issue 1, Feb-Mar, 2014.

Chapter eight “Discussions and Conclusions” is on overall study of the research project. While every chapter of this thesis is self-contained with specific abstracts, experiments and conclusions, this chapter highlights the original contributions made by the author and the research publications in the international journals and summarized in a paper titled, “Dynamic Models for Teaching and Research in Electrical Engineering and Management of Power” has been published in International