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Identifying the reason for Energy Wastage & Suggesting a Tool to reduce it

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Declaration

This is to certify that the Mr. Ankur Sharma, a student of MBA in Power Management, SAP ID-500066292 of UPES has successfully completed this dissertation report on "Identifying the reason for Energy Wastage & Suggesting a Tool to reduce it" under my supervision.

Further, I certify that the work is based on the investigation made, data collected and analysed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfilment for the award of degree of MBA.

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Table of Contents

Abbreviations

DER	Distributed Energy Resources
DR	Demand Response
DSO	Distribution System Operator
EEPOS	Energy management and decision support systems for Energy POSitive neighborhoods
I&C	Instrumentation & Control
SCADA	Supervisory Control And Data Acquisition
VEST	Virginia Embeded System Toolkit
PLC	Programmable Logic Control
PV	Photovoltaic
BDA	Big Data Analytics
AI	Artificial Intelligence
CHP	Combined Heat and Power

IED	Intelligent Electronic Devices

List of Tables

List of Figures

Abstract

One fundamental objective of automation systems is to control appliances remotely. In this paper, we present how we control and monitor a power management system (a vital part of most industrial as well as domestic automation systems) from virtually anywhere using a central cloud based service. The design, implementation and operation of the centralised cloud connected ad-hoc wireless automation system are conferred and the benefits of cloud based automation systems compared to mere Internet based automation systems are also cited.

The increasing capacity of distributed electricity generation brings new challenges in maintaining a high security and quality of electricity supply. New techniques are required for grid support and power balance. The highest potential for these techniques is to be found on the part of the electricity distribution grid.

This article addresses this potential and presents the EEPOS project's approach to the automated management of flexible electrical loads in neighbourhoods. The management goals are :

(i) maximum utilization of distributed generation in the local grid,

(ii) peak load saving/congestion management, and

(iii) reduction of electricity distribution losses.

Contribution to the power balance is considered by applying two-tariff pricing for electricity.

The presented approach to energy management is tested in a hypothetical sensitivity analysis of a distribution feeder with 10 households and 10 photovoltaic (PV) plants with an average daily consumption of electricity of 4.54 kWh per household and a peak PV panel output of 0.38 kW per plant. Energy management shows efficient performance at relatively low capacities of flexible load. At a flexible load capacity of 2.5% (of the average daily electricity consumption), PV generation surplus is compensated by 34–100% depending on solar irradiance. Peak load is reduced by 30% on average. The article also presents the load shifting effect on electricity distribution losses and electricity costs for the grid user.

CHAPTER ONE: INTRODUCTION

1.1 Overview

Power providers constantly deal with demands to increase productivity and reduce costs. This translates into the need for administrators, engineers, operators, planners, field crews, and others to collect and act on decision-making information. Power system vendors are following a trend to make devices smarter so they can create and communicate this information. The term "power system" describes the collection of devices that make up the physical systems that generate, transmit, and distribute power. The term "instrumentation and control (I&C) system" refers to the collection of devices that monitor, control, and protect the power system.

Power system automation refers to using I&C devices to perform automatic decision making and control of the power system.

Data Acquisition

Data acquisition refers to acquiring, or collecting, data. This data is collected in the form of measured analogue current or voltage values or the open or closed status of contact points. Acquired data can be used locally within the device collecting it, sent to another device in a substation, or sent from the substation to one or several databases for use by operators, engineers, planners, and administration.

Power System Supervision

Computer processes and personnel supervise, or monitor, the conditions and status of the power system using this acquired data. Operators and engineers monitor the information remotely on computer displays and graphical wall displays or locally, at the device, on front-panel displays and laptop computers.

Power System Control

Control refers to sending command messages to a device to operate the I&C and power system devices. Traditional supervisory control and data acquisition (SCADA) systems rely on operators to supervise the system and initiate commands from an operator console on the master computer. Field personnel can also control devices using front-panel push buttons or a laptop computer.

Power System Automation

System automation is the act of automatically controlling the power system via automated processes within computers and intelligent I&C devices. The processes rely on data acquisition, power system supervision, and power system control all working together in a coordinated auto- 2 matic fashion. The commands are generated automatically and then transmitted in the same fashion as operator initiated commands.

I&C System IEDs

I&C devices built using microprocessors are commonly referred to as intelligent electronic devices (IEDs). Microprocessors are single chip computers that allow the devices into which they are built to process data, accept commands, and communicate information like a computer. Automatic processes can be run in the IEDs, and communications are handled through a serial port like the communications ports on a computer. IEDs are found in the substation and on the pole-top.

1.2 Background of the Study

Automation of electricity distribution grids is one of the steps toward Smart Grids and the successful integration of distributed energy resources (DER, referring to electricity generation). Automation opens various ways for "smart" energy management, which is the subject of many techno-economic studies.

The most common subject of distribution grid studies is feasibility, which analyzes the most cost-effective methods of grid development). Such methods are related mainly to the maximum utilization (and optimal dispatch) of DER. In some studies, optimal control of the distribution grid is combined with load shifting.

It is analyzed that the optimal sizing of electrochemical storage systems in distribution grids. Optimal storage capacity depends on the DER penetration level and load characteristics. In general, increase in storage capacity reduces peak load in to the local grid. However, storage installation may turn out to be unprofitable due to the high ratio of installation costs to the life cycle. This ratio is currently the main focus of battery research for Smart Grid applications. The payback period of electrochemical storage systems at different electricity prices and different system installation costs.

The literature review by Basak et al. (2012) concluded that the feasibility of distribution grid automation depends on many factors, which should be simultaneously implemented through efficient energy management. These factors imply high utilization of DER and local electricity grid support – in particular, peak shaving/congestion management. In addition to the active power management, reactive power control could further increase the utilization of the distribution grid, keeping the power quality within the required limits.

Furthermore, energy management in distribution grids could contribute to the power balance on a country level. This could be of interest to countries with a high deployment of wind farms, the majority of which are connected to a power transmission grid.

Knowing the importance of automation in distributed energy systems at a high level of DER deployment and the feasible development of Smart Grids in general, the present article provides a contribution to and presents a methodology for centralized energy management in distribution grids. This management applies to flexible electrical loads and generators with the possibility to fully or partly control and automate their operation pattern.

The proposed energy management is a part of the EEPOS energy system. EEPOS, Energy management and decision support systems for Energy Positive neighbourhoods, is an FP7 project supported by the European Union (http://eepos-project.eu/). The implementation of the proposed energy management within the EEPOS energy system has been described in the publication by Klebow et al. (2013).

1.3 Purpose of the Study

Process automation is a technology that may be viewed as a two-edged sword. On the one hand it can be viewed as a productivity and quality enhancer, while on the other hand, it can be viewed as a mechanism to control, routinize, and de-skill work. These views both have elements of truth, but with appropriate design and adoption considerations, we believe that it is possible to enhance the positive elements while reducing the negative ones.

This report looks at the issues that have arisen for the early adopters of process automation. These people are the innovators, the ones who have been through the "school of hard knocks," taken the brunt of an immature technology, and suffered from the fact that there are few experienced people to guide them. Some of the projects we saw succeeded, some failed, but few found the going easy. This technology is not for the feint of heart—at least not yet. However, we hope, through this report, to document experiences and lessons learned. We hope that we have extracted practical insights to provide insights to the developers of process automation tools and guidance to those who wish to automate their processes.

As described by Christie, the specific objectives of the study are to

• Identify the technical, social, and organizational inhibitors to the adoption of process automation:

– Assess the prevalence and scope of software process automation.

– Categorize the technologies and practices that are currently being used.

– Identify effective and ineffective technologies and practices.

– Develop guidelines for process automation implementers.

• Support vendors and researchers in developing products more in tune with end-user needs:

– Develop guidelines for researchers and vendors to improve product effectiveness.

– Foster effective communications between researchers, vendors, developers and end users.

These general objectives have been met through a series of activities that include in-depth interviews followed by a questionnaire survey and a workshop. The specific objectives of these activities are as follows:

• The interviews are aimed at gathering practitioner experiences in a relatively unstructured way, to identify what individuals believe are the important issues in the adoption of software process automation, and to establish a basis for the more structured questionnaire survey. Some of the interviewees were contacted about a year after the initial interviews. This allowed us to estimate what progress (or lack thereof) organizations had made over an extended period of time, and to identify why some projects had been successful and others failed.

• The questionnaire survey assesses a wider cross-section of those involved with process automation and includes individuals outside the software community. Because the questionnaire respondents are following a standard format, the data in this phase of the study will be analyzed in a more quantitative fashion.

• Finally, the workshop was aimed at identifying success strategies for the introduction of software automation. The workshop brought together a widely diverse group of individuals with experience in research and development, adoption, management and end use of process automation, and to raise awareness of critical issues across these communities.

Objectives

I. Identify the reason of energy wastage.

II. Identify tool to reduce energy wastage.

Objective is to maintain equilibrium between renewable and non-renewable resources, so as to conserve our natural resources for future generation. Power System automation can bring a positive outcome from the same.

Nowadays, water is a big issues like water pollution is the contamination of water bodies, usually as a result of human activities. Water bodies include for example lakes, rivers, oceans, aquifers and groundwater. Water pollution results when contaminants are introduced into the natural environment. For this we required automation in Effluent Treatment Plant(ETP) & Sewage Treatment Plant(STP) which is mandatory in manufacturing process industries as per the government norms.

Also the air pollution is a mixture of solid particles and gases in the air. Car emissions, chemicals from factories, dust, pollen and mold spores may be suspended as particles. Ozone, a gas, is a major part of air pollution in cities. For this Power system automation plays a very vital role as data acquisition, monitoring & its control by the means of instrumentation which is the integral part of the automation. As an example it is been observed near diwali in New Delhi the air quality index reach to 1000 ppm which is to lie in between 30-80 ppm. For this Ambient Air Quality Monitoring Systems or AAQMS monitors the level of pollutants.

In the context of Diwali many power plants & industries are shutdown to maintain this air quality.

For energy conservation is the effort made to reduce the consumption of energy by using less of an energy service. This can be achieved either by using energy more efficiently or by reducing the amount of service used and by the means of automation . Energy conservation is a part of the concept of Eco-sufficiency.

Data acquisition refers to collecting data in the form of measured analog current or voltages values or the open or closed status of contact points. **Power system supervision** is carried out by operators and maintenance engineers through this acquired data either at a remote site represented by computer displays and graphical wall displays or locally, at the device site, in the form of front-panel displays and laptop computers. **Control** refers to sending command messages to a device to operate I&C (a collect of devices that monitor, control and protect the system is referred as I&C system) and power system devices.

The use of automation is to monitor, control and manage power system to facilitate a reduction in activities and the need for staffs to make long journey to survey the power network and its systems saving staffs time and transport costs. Furthermore, failure/faults can be observed timely to facilitate timely corrective action. This problem is in the entire distribution (medium and low voltages including consumers) network which is extensive. Therefore, this is a realistic challenge since it is the largest network which is growing very fast and affects directly customers connected to the network.

Hence the objective of **Power System Automation, allows automatic, computerized control of utility power network facilities**. Automation system allows power generation, transmission systems and distribution system to be monitored and controlled from a remote location, even if they were far away from the systems location.

1.4 Research Hypothesis

The proposed energy management of electrical loads applies to distributed energy systems with a high deployment of DER. The management goals can be summarized as follows:

1. Maximum utilization of DER in the local grid (local consumption of generation surplus)
2. Local grid support: peak load saving/congestion management
3. Local grid support: reduction of electricity distribution losses
4. Cost-effective load shifting following the electricity price

The management is performed centrally at the neighbourhood level. Neighbourhood, for example, could comprise all grid users connected to the low-voltage side of a medium- to low-voltage substation. The instrument for the energy management is the controllable electrical load.

Centralized energy management could be provided by an electricity retailer or a demand-side aggregator who could (i) participate in the electricity exchange market with power demand bids, and (ii) offer load shifting-based grid support services to the local Distribution System Operator (DSO).

Based on the energy situation in the neighbourhood, the central management system will inform the grid users on the optimal shifting of electrical loads. The final load shifting is performed by the grid users following the suggestions from the central management system. Thus, the management decision is performed centrally and applied by decentralized energy management systems of individual grid users. Decentralized management systems have direct access to the controllable loads of grid users. This ensures a high utilization of flexible load resources in the neighbourhood. Such management provides efficient performance of load shifting taking into account not only the interests of individual grid users but also the techno-economic interests of the whole neighbourhood as well as the electricity distribution grid. Thus, the proposed management serves all involved grid users, and it is up to the grid users themselves whether to apply the suggested management efficiently. As concluded, such a combination of centralized and decentralized energy management systems may increase the performance of the Smart Grid.

The proposed energy management is developed for the automated management of controllable electrical loads. Such management can be applied not only to electrical loads but also to controllable electric generators. Good examples here are electric motors or generators in electro thermal systems – combined heat and power (CHP) plants and heat pumps (e.g., in solar thermal systems, air conditioners, geothermal heat pumps). The methodology can also be applied to storage systems with electricity as input and/or output energy type (e.g., electrochemical secondary batteries). The above-mentioned electro thermal systems are good candidates for automated electricity management since they include thermal energy storage. Thermal storage provides the energy system with flexibility in operation: the operation of electric motors may be shifted in time (e.g., 20 min later or earlier) without affecting the normal operation of the system. Normal operation is the operation of the thermoelectric system, which ensures that heating or cooling characteristics (e.g., temperature in a room, hot water temperature) are in an acceptable range.

In order to discuss the methodology, let's be mindful of the fact that automation in power management can provide controls for a variety of environmental, mechanical, and security systems, because each of these systems can separately or together form a power management system (PMS). The approach for developing the automation performance index (API) has purposefully stayed generic and does not get involved with any of the specific systems that may be controlled. In addition to the above listed Decision Criteria, ten tasks which are illustrated and referenced by numbers shows the research work task in the methodology. These tasks are fundamental steps in the API model development:

- Task #1: Establishing decision criteria for each step.
- Task #2: Conducting comprehensive literature research.
- Task #3: Forming the expert panel.
- Task #4: Designing the questionnaire for the panel.
- Task #5: Identifying, Organizing, Classifying and the major automation parameters.
- Task #6: Selecting the significant parameters.
- Task #7: Developing the API model.
- Task #8: Testing and validating the model.

Establishing Decision Criteria

This research work was divided into eight major tasks, allowing extensive investigation of each research part, and integration of them to accomplish the goal of this research. Although, some of the titles are similar, however, a research task is defined as a research work for a specific part of the whole research study such as conducting Literature Search, when criteria is defined as a set of standards and policies for selection of parameters and modelling techniques. It acts as a filter that justifies a decision such as Criteria for Literature Search. The major tasks were:

Conducting Comprehensive Literature Research:

The research extensively utilized engineering and automation journals and Internet resources, as well as a comprehensive literature search of related subjects. This task should exhaust search of referee journals, trade publications, conference proceedings, and any other related publications. The most-significant parameters were identified using the input from the practicing facility managers through a number of communications and meetings using a Delphi method of reaching consensus. This effort, combined with information obtained through literature research, was used to screen the most-significant parameters for defining the API model.

Forming the Expert Panel:

To establish a basic understanding for the state of the industry and also to meet experts in the subject, information from following relevant seminars were used: Performance Based Procurement, International Council of Research and Innovation in Industrial Automation. From the above seminars, and also from the list of building automation professional contacts, qualified experts in assisting with the research were identified. The preliminary research was done in two stages. Stage one was completed as an independent study titled: "A Step towards Development of Industrial Automation System Performance Indicators.

Designing the Questionnaire for the Panel:

A questionnaire was designed and developed to capture the expert knowledge from expert panel's input. The questions were designed to be relevant to this research, short and precise without leading the experts in any direction. A total of three questions were sent by e-mail. The first question was intended to get an overall view for the current trends in the industrial automation. The response to this question did not affect the process of forming the API model, but helped in validating it. Questions 2 and 3 were the key questions for the model.

Organizing, Classifying and Identifying the Major Industrial Automation Parameters:

Information from literature and online research, and feedback from the expert panel was tabulated and organized separately into similar categories for the parameters cited, and the most significant parameters were chosen. Parameters cited most often were given more priority in the selection process.

Selecting the Significant Parameters:

Parameters were selected based on the frequencies of their citations in literature search and expert opinions from survey. Some of the parameters were not directly scalable. In order to define scalable parameters for the model, logical correlations between the parameters that identified by this research and other quantifiable parameters were established.

Developing the API Model:

API is defined as an index representing the expected performance levels of Industrial Automation. This index, in general form, is the weighted average of the normalized significant automation performance parameters. Models chosen for API were further refined by industry design guidelines. A quantitative model to evaluate the performance of industrial automation helped to assess the existing state of system in comparison with its desirable mode. Any inferior deviations were then addressed. Structuring a decision-support system to routinely monitor and reduce deviations from set objectives which improved the system performance.

Testing and Validating the Models:

Verification shall be done to ensure that the model is defined correctly, the algorithms have been implemented properly, and the model does not contain errors or oversights. No computational model will ever be fully verified, guaranteeing error-free implementation. A high degree of statistical certainty is all that can be realized for any model as more cases are tested. A set of sensitivity analysis shall be conducted for observing the range of API and validation of its estimates and trends predicted by the numerical model.

Advantages of Industrial Automation:

We have carried out numerous energy projects for retail and other commercial properties. In many cases, the projects have helped customers **to halve their consumption of energy**. For industrial properties, automation system improvements and modernisation of technology will enhance operations. The projects bring about savings and improve operating conditions in production plants.

Good maintenance can also bring savings in industries. Some of the savings can be achieved by modernising the technology. The savings achieved will pay for the investment made. We will give a savings guarantee for the project and, if required. Smart automation systems in industries help achieve high-quality product and enhance operational conditions.

With a new centralised automation system, one can have all the control functions on one display: ventilation machine and heat distribution timings, settings, control curves and alarms. The system can also be remote controlled. Subsystems can be driven through variable frequency drives on a per need basis. A centralised automation system can provide more accurate information about the indoor environmental conditions in the shop floor.

CHAPTER 2: Literature Review

2.1 Review Area Broad

A literature review is necessary to know about the research area and what problem in that area has been solved and need to be solved in future. This review process approach was divided into five stages in order to make the process simple and adaptable. The stages were:-

Stage 0: Get a "feel"

This stage provides the details to be checked while starting literature survey with a broader domain and classifying them according to requirements.

Stage 1: Get the "big picture"

The groups of research papers are prepared according to common issues & application sub areas. It is necessary to find out the answers to certain questions by reading the Title, Abstract, introduction, conclusion and section and sub section headings.

Stage 2: Get the "details"

Stage 2 deals with going in depth of each research paper and understand the details of methodology used to justify the problem, justification to significance & novelty of the solution approach, precise question addressed, major contribution, scope & limitations of the work presented.

Stage 3: "Evaluate the details"

This stage evaluates the details in relation to significance of the problem, Novelty of the problem, significance of the solution, novelty in approach, validity of claims etc.

Stage 4: "Synthesize the detail"

Stage 3+ deals with evaluation of the details presented and generalization to some extent. This stage deals with synthesis of the data, concept & the results presented by the authors.

Controlling method of injection molding machine for new technologies

Controlling method of injection molding machine for new technologies is one of the issue, some approaches were used for this issue which is injection molding machine controlling process very hard with relay logic, so embedded system controlling process (logic) used for injection molding machine, this process is better than the relay logic & it provides an effective & easy way to control the hydraulic system. The increasing complexity of automation applications needs new framework architecture to development automation control system.

By using automation components like that component oriented design, reusability & picture structure is better way for reduces increasing complexity of automation. This approach reduces valuable development time because the component can be tested with their internal test functionality. By using hardware structure, system software architecture & experimental plate form give a better approach to development of a distributed control system for PLC based applications. PLC based applications & technology is very effective and useful technique to improve product quantity & quality.

New trends in industrial Automation

New trends in industrial Automation is second issue, some approaches were used for this issue which is simulation approach for speed control of Induction motor using Lab view software. It claims that choosing Lab View as the human machine interface for the implementation is a proper decision as it has various types of application s and functions that are easy to understand and use, secondly this approach is more economical as the objectives and system defects can be identified without the implementation of the circuit.

2.2 Review Area Narrow

Energy Storage in co-generation power plant

Energy Storage in co-generation power plant is third issue, some approaches were used for this issue which is comparison of two methods of electrical power storage. One of them is conventional method on other side another is modern system. In conventional power storage method has taken the battery storage method and

Wireless Data Transmission

Wireless Data Transmission is fourth issue, some approaches were used for this issue which is Engineering Approach for Secure and Safe Wireless Sensor and Actuator Networks for Industrial Automation Systems which includes the security concept in context of industrial automation and It gives an introduction of a holistic networks but still easy to implement approach for automation networks. Justification of problem illustrated through the holistic approaches including security protocols and also works on VEST (Virginia Embedded Systems Toolkit) focuses on the development of effective composition. But a gap is that a security solution must ensure that the cost of an attacker to break the security solution is higher than his/her potential benefit.

2.3 Factors critical to success of study

The eight points below highlight key characteristics to pay attention to and are derived from real-world experiences of managing complex automation projects and identify key attributes to help manage the experience.

1. Don't underestimate the demands

To ensure project demands can be met, it is recommended to evaluate the workload requirements for all stakeholders prior to the execution of a large project. If the company does not have large project execution experience, it is highly recommended to discuss with knowledgeable professionals to define the requirements. One common misconception is that the current work responsibilities can be maintained while taking on additional project loading activities as well. Another common oversight is underestimating the detailed knowledge required to provide accurate data or review/approvals required. These oversights can be detrimental to success and all work loading should be properly planned and staffed for success.

2. Engage with stakeholders early

It is important to have a solid working relationship between all stakeholders. It is recommended to dedicate time of the front-end of the project to establish a solid foundation based on ethical business practices. Face-to-face meetings are always recommended over video or conference calls. It is important to discuss the interactions between groups and define scope boundaries. Define the expectations of how requests, submittals, deadlines, and out of scope requests will be handled. Doing business is easy when the project is within schedule and budget. However, when deadlines are looming and stakes are high, it is always better to understand how to work together to address issues and concerns prior to a high-stress situation. Over communicate the expectation from all stakeholders to ensure everyone understands.

3. Request feedback often

Embracing the aspect of continual improvement. Meaning, all stakeholders should check their ego in at the door, humble themselves, and ask for direct honest feedback. Positive feedback is great but the only way to improve is to define the negative aspects. This is a two-way street for all stakeholders. Both customer and contractor should have an open discussion because we all have responsibilities to deliver. Depending on the project size, milestone reviews can be performed on a periodic basis. All issues and actions should be published and follow-up on for each feedback session.

4. Get management involved

Involving upper management on a periodic basis shows a commitment to the responsibilities. This cultivates an open door policy to help clarify current issues at hand and provide primary decision makers with first-hand information. These meetings should be more strategic than tactical. Identify all roadblocks or critical path items but keep the topics at a level that everyone can follow and do not allow conversations to get into the weeds, which might lose the interest of the management team. Review meetings should not be the standard weekly or bi-weekly meeting attendees. Identify a separate time to review the key issues to keep management aware of the project status.

5. Hold stakeholders accountable

All stakeholders should be held accountable to deliver the associated data and/or information needed to move the project forward. Always assign specific deadlines for delivery and do not allow generic time frames to be assigned. If items are delayed then the following predecessor items will be delayed as well. All deliverables and deadlines should be reviewed at every meeting to ensure everyone fully understands and accepts the responsibilities. Collective synergy and commitment from all stakeholders will result in project success.

6. Follow the process

Partnering with a professional group with a defined and qualified process of implementation can be the difference between success and failure. Do not allow a custom approach or non-proven strategies to creep into the project. Cutting a new path or re-inventing the wheel only invokes a level of uncertainty to the outcome. The only way to predict the future is to understand the past. When schedules become tight, most people search for ways to cut corners. Be sure to fully evaluate the impact or potential impact of all actions and trust the proven process to lead to success.

7. Do the right thing

Mistakes will happen, but what is important is, to be honest, and admit the mistake, identify how to correct the situation, and provide a solution to prevent that mistake from happening again. To provide honest, fair, and open communications with all stakeholders is always the best policy. Always act in the best interest of the customer and lead by example.

8. Remain persistent and open

Common attributes of successful projects are acceptance and upholding responsibilities from all stakeholders. All successful projects have hardships throughout the project life cycle. However, persistence to work through those issues establishes a level of trust and understanding that builds healthy relationships. An open culture of continuous improvement and dedication to success are critical to forming a bonding partnership. Partnerships are a deeper commitment by a stakeholder to provide long-term engagement.

2.4 Summary

Power providers constantly deal with demands to increase productivity and reduce costs. This translates into the need for administrators, engineers, operators, planners, field crews, and others to collect and act on decision-making information. Power system vendors are following a trend to make devices smarter so they can create and communicate this information. The term "power system" describes the collection of devices that make up the physical systems that generate, transmit, and distribute power. The term "instrumentation and control (I&C) system" refers to the collection of devices that monitor, control, and protect the power system.

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Power system automation is an act of controlling the power system automatically by deploying appropriate instrumentation and control in the system. Power system automation includes monitoring, evaluation, analysis, and control of processes associated with generation and of delivery systems of power from power stations to customers. Further, power system automation consists of three major processes, namely, **data acquisition, power system supervision** and **power system control** all working in a coordinated automatic fashion.

Data acquisition refers to collecting data in the form of measured analog current or voltages values or the open or closed status of contact points. **Power system supervision** is carried out by operators and maintenance engineers through this acquired data either at a remote site represented by computer displays and graphical wall displays or locally, at the device site, in the form of front-panel displays and laptop computers. **Control** refers to sending command messages to a device to operate I&C (a collect of devices that monitor, control and protect the system is referred as I&C system) and power system devices.

CHAPTER 3: Research Design, Methodology & Plan

8.1 Data sources

Data collection is the cornerstone of spend analysis. It provides the evidence firms need to scrutinise their expenditure and build up some sort of a picture of their spend profile. Various factors come into play in data collection for spend analysis. For a start, the amount and quality of data collected depends on the accounts payable systems the firm has in place. Some IT systems are better than others in what they will allow firms to do with data. Of course, this assumes that all purchasing is done is accordance with company procedures.

It is the specific procedures or techniques used to identify, select, process, and analyze information about a topic. In a **research** paper, the **methodology** section allows the reader to critically evaluate a **study's** overall validity and reliability.

In order to get detailed information about the problems responsible for the energy wastages we concentrated on an industry named **"Merino Panel Products Ltd."** the data has been collected by two methods:

1. Primary data collection method.
2. Secondary data collection method.

Primary data collection method:

We personally visited the consumer i.e. the above mentioned industry and tried to know the factors responsible for any kind of energy wastage. For this we carried out five step process which is mentioned below:

1. Interviews
2. Questionnaires and surveys
3. Observations
4. Documents and records
5. Oral histories

Secondary data collection method:

Since the secondary data is the information that is already been collected & used by any other person other than the user itself for a purpose, so we collected the data from other sources as well, so as to avoid some points of energy wastage that might not have been covered through primary data.

The sources we utilised for the secondary data collection are censuses, government publications, internal records of the organisation, reports, books, journal articles and websites.

The detail of the same has been mentioned in the bibliography.

Mostly, primary data has been collected for the study. This is raw data which is collected from employees who make automation applications on their day to day activities. This type of data is more relevant and reliable than secondary data since it is from the source. Primary data also provides first-hand information.

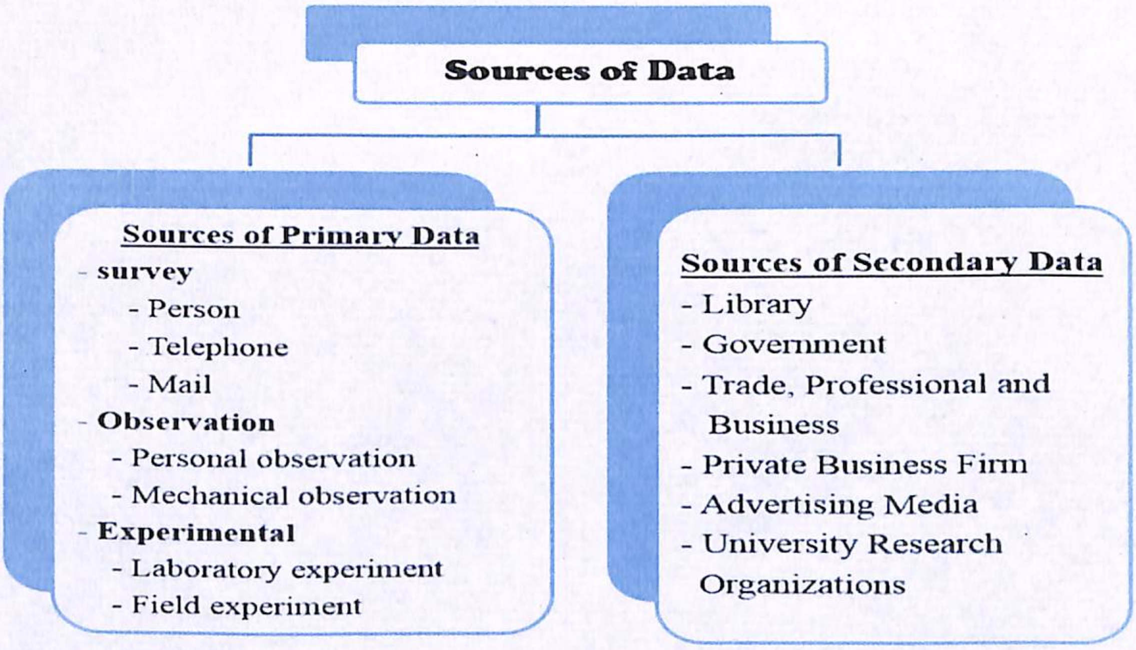

Figure 1: Source of Data.

3.2 Research Design & Methodology

Automation technologies and solutions are developing rapidly and with these new solutions buildings and industries can be affected significantly.

Energy efficiency and cost savings by automation:

Automation has great importance for energy efficiency, since it makes it possible to control the property and the conditions prevailing in industrial plants. Automation is the brain that controls and regulates all the circumstances.

The most critical automation decisions are made at the design phase, including in there modernization and repair phase, in which automation should be focused on as it has great importance for energy efficiency, cost savings and firewall & data safety solutions.

By the help of an automation system, we can manage, for example, HVAC control systems, energy consumption control, access control and fire alarm systems via a single integrated interface. We utilize open solutions which allow for system independence and, therefore, support common communication interfaces such as KNX, LON, MODBUS, M-Bus, DALI, and BACnet.

The automation system is in use in many towns and cities, which have integrated to the system number of real estate and water supply facilities. Small individual facilities as well as large buildings and industrial plants can be monitored by the system.

The most modern control room and energy management services are also available. The up-to-date information collected from the property and data stored in the history of the property can be used to analyze and predict the performance of maintenance.

In property development and modernisation, there are several criteria that influence decision-making, and energy efficiency and life cycle costs are two of them. A modern centralised automation system can be used to manage the energy efficiency of buildings and processes, to ensure the correct use of systems, to control environmental parameters—in short, to 'run' the building.

Best way to save:

We have carried out numerous energy projects for retail and other commercial properties. In many cases, the projects have helped customers **to halve their consumption of energy**. For industrial properties, automation system improvements and modernisation of technology will enhance operations. The projects bring about savings and improve operating conditions in production plants.

Good maintenance can also bring savings in public buildings. Some of the savings can be achieved by modernising the technology. The savings achieved will pay for the investment made. We will give a savings guarantee for the project and, if required. Smart automation systems in residential buildings help achieve high-quality housing and enhance living conditions.

Improved manageability:

With a new centralised building automation system, one can have all the control functions on one display: ventilation machine and heat distribution timings, settings, control curves and alarms. The system can also be remote controlled. Subsystems can be driven through variable frequency drives on a per need basis. A centralised automation system can provide more accurate information about the indoor environmental conditions in the building.

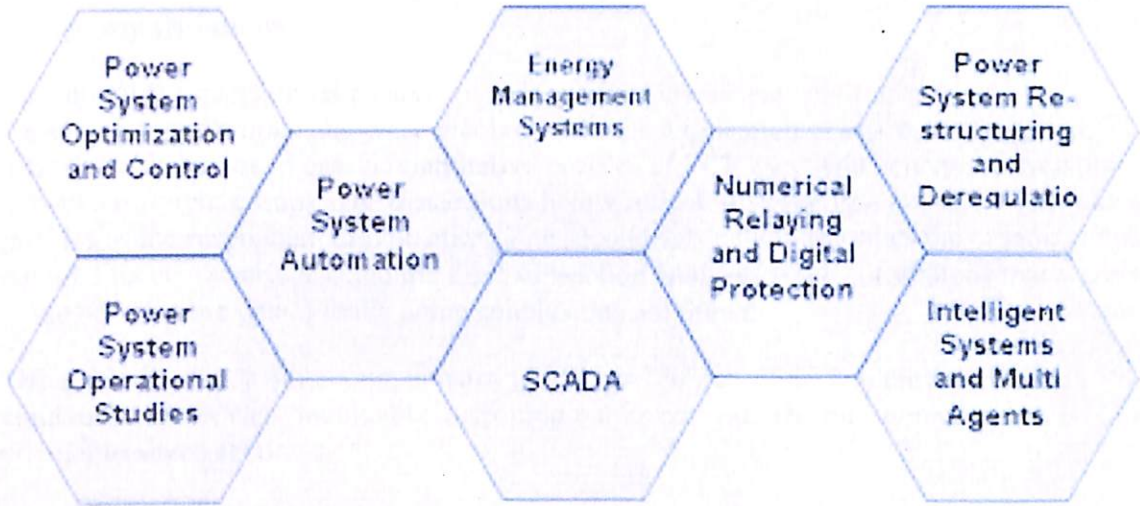

Figure 2: Automation functional block.

The technical focus of energy - saving design in the process of electrical automation under the new situation

The premise of electrical automation is the high efficiency of energy, low pollution transmission, and according to the laws of physics, energy in the transmission process will be due to resistance, distance and other factors to produce a certain loss in the construction of electrical automation should be Control the transmission loss as a key technical aspects, by reducing the transmission loss and improve the efficiency of power transmission, reduce transmission costs, control the possible pollution and hazards. On the one hand, the electrical automation process to use benign alloy material as a wire material, which can reduce the power transmission and use of the process of loss, control the entire electrical automation system resistance loss.

On the other hand, the process of electrical automation to optimize the wiring of the wire form, by reducing the length of the wire, optimize the power supply distance, change the load distribution form and other technical means to control the power in the electrical automation system in the loss and waste. In addition, according to the physical formula, you can increase the electrical cross-section of the electrical equipment to reduce the resistance of the entire system, and thus achieve the effective control of energy consumption during transmission.

The process of electrical automation requires the application of a large number of different types of transformers, and the realization of electrical automation energy-saving targets also need to scientifically set, select and apply the transformer. On the one hand, in the construction of electrical automation to energy-saving transformers as the preferred target, in order to reduce the active loss from the transformer to achieve energy-saving electrical automation development goals.

3.3 Survey Questions

The aim of the questionnaire survey was to gather a consistent set of data from a wide variety of organizations that were involved with the application of process automation. This data allowed us to obtain quantitative profiles of PCE users and generate correlations between different groups. The discussions below reflect this: The first subsection provides profiles of the respondent organizations, the second subsection describes the organizations' automation characteristics, and the third subsection analyzes some correlations that were made between the data. Finally some conclusions are drawn.

The questionnaire is quite long, consisting of over 120 questions, and the interviews conducted earlier were invaluable in scoping out its content. The questionnaire was broken down into seven sections:

- business/product characteristics
- implementation team characteristics
- application focus
- process characteristics
- the development technology
- transition and adoption
- impacts and insights

Questionnaire:

1. How much thought do you give to saving energy in your industry?
2. How often do you turn the heating down or off when you go out for a few hours or when you go to bed at night?
3. How concerned are you about the expected future price rises in energy?
4. How concerned are you about climate change?
5. Who is your current electricity supplier?
6. Who is your current gas supplier?
7. How do you pay your energy bills?
8. How many low energy light bulbs do you have in your home?
9. What heating types do you have in your home?
10. What heating controls do you have at home?
11. Which improvements would you ideally need to make your home more energy efficient?

The questionnaire was distributed to a large number of organizations (approximately 150), but, despite follow-up letters, the return rate was somewhat disappointing; we received only 35. Part of this we believe is due to the size of the questionnaire, and part of it may be due to the fact that many questions dealt with issues of adoption and use that respondents had not yet had much experience with. In analyzing the results, there are two kinds of bias with which we have to deal. The first relates to the population to whom the questionnaire was distributed. Because of the relatively specialized area and widely varying organizational cultures, it would be close to impossible to select a controlled population for the study.

The second type of bias is introduced as a result of who, among the first population, returns the completed questionnaire. Because of the low return rate, there is always a question of bias (e.g., were successful groups more motivated that unsuccessful groups to return their responses?). Bias may also have been introduced by the fact that the large majority of respondents were managers and analysts, and not those who were directly supported by the automation (i.e., end users). Thus, when interpreting the results, the exploratory nature of this study should be kept in mind.

The following are 10 of the biggest energy-wasting oversights people make at home and how to adjust to more eco-friendly practices.

1. Leaving the Lights On

One of the most obvious energy-wasting habits is leaving the lights on, and it's also one of the easiest habits to fix. By simply turning off the lights when you leave a room or your home, you will save electricity and help your light bulbs last longer. If you think you might forget, use a smart home system to remotely monitor your lighting from your smart phone.

2. Using Incandescent Bulbs

Incandescent lights consume an exorbitant amount of energy. A quick way to reduce energy use is to switch to energy-efficient bulbs. ENERGY STAR certified bulbs — such as halogen incandescent, compact fluorescent lamps (CFLs) and light-emitting diodes (LEDs) — use 25–80 percent less energy than traditional incandescent bulbs and last up to 25 times longer.

3. Leaving Electronics Plugged In

Appliances and electronics use energy even when they're turned off. One tip to help save on utility bills is to unplug all electronics — including TVs, computers, and phone chargers — when they aren't in use. Connecting multiple electronics to a power strip makes it easier to switch off unused devices all at once.

4. Powering an Empty Chest Freezer

Having an extra freezer in the garage is great for storing food, but does more harm than good when it is empty. A running chest freezer consumes around 103 kWh and costs an average of $14 per month. When your chest freezer is empty, unplug it to save energy and money.

5. Browsing Your Refrigerator

Those few seconds staring into the refrigerator add up. Every year, people spend around 10 hours looking at an open fridge or freezer, accounting for 7 percent of the appliance's total energy use. Another helpful tip is to open the fridge and freezer only when necessary and save your browsing for the pantry.

6. Running the Dishwasher Half-Full

The average dishwasher requires around 1,800 watts of electricity to run — running it daily would cost $66 per year. You can cut down on energy use by running the dishwasher only when full. You can also save around 15 percent of the dishwasher's total energy use by switching its setting from heat dry to air dry.

7. Washing Clothes in Hot Water

Almost 90 percent of a washing machine's energy is spent heating water. You can cut energy use in half by switching from hot to warm water, and reduce it even further by using cold water. Unless you are trying to remove oil or grease, cold water sufficiently cleans clothing, towels and sheets.

8. Setting the Thermostat Too High

In many households, water heater temperatures are set too high. Even though many water heaters are set at 140 degrees by default, the Department of Energy recommends 120 degrees for energy efficiency. Cut your energy bill by 3–5 percent for every 10 degrees you lower the thermostat.

9. Not Programming Your Thermostat

Heating and cooling consume nearly half of a home's energy. A programmable thermostat helps cut down on unnecessary heating or cooling when you aren't home. Smart thermostats are even more energy efficient — they are remote controlled, can "learn" your preferred temperature, and default to energy-saving mode when no one is home.

10. Forgetting to Change Air Filters

Any home with an HVAC unit has air filters that need to be regularly cleaned for the HVAC to function effectively. As your HVAC runs, the air filter traps air particles. Once the air filter clogs, the HVAC expends more energy pulling in air. To reduce an HVAC system's energy use, replace its air filters every three months. For the more forgetful among us, a simple phone notification can keep you up to date and breathing cleaner air.

Electricity is essential for living comfortably, but there are simple ways you can reduce your energy use, save money, and improve your home's sustainability without hindering your daily life. Try an idea or two from the above list– or even better, all of them – and see the savings pile up.

1. Shutdown your computer

Computers are some of the biggest energy users in office buildings. Turn your monitor off at night and ditch the screensaver. Today's computers can be turned on and off over 40,000 times. Opting to shut down over using a screensaver does not affect your computer's lifespan. (Energy Star). So power down!

2. Choose the efficient lighting system

LED bulbs are the most energy efficient lighting option. LED bulbs use 75% less electricity than incandescent bulbs (Energy Star). The also have no mercury, and last about 25 times longer than traditional incandescent bulbs (DoE).

3. Eliminate vampire power: unplug idle electronics.

Devices like televisions, microwaves, scanners, and printers use standby power, even when off. Some chargers continue to pull small amounts of energy, even when plugged in (a good judge of this is if a charger feels warm to the touch). In the US, the total electricity consumed by idle electronics equals the annual output of 12 power plants (EPA).

4. Use a power strip to reduce your plug load.

To avoid paying for this "vampire power," use a power strip to turn all devices off at once. Flipping the switch on your power strip has the same effect as unplugging each socket from the wall, preventing phantom energy loss.

5. Turn off the lights

Just one switch and you're done!

3.4 Interview Procedures

Case studies can be conducted using a number of approaches, and as suggested by Hartley, they may be seen as a research *strategy* which uses both quantitative and qualitative data. In this initial study, observation of auction events and interviews were used to obtain participants' perceptions of the phenomenon. In later studies, interviews were supported by additional data collection methods such as Likert surveys, were supported by additional data collection methods such as Likert surveys, response counting, access to company performance data and presentations, or observation through company training or communication sessions.

Interviews can be structured, semi-structured or open in form according to the objectives of the researcher. The approach in this research was to use semi-structured interviews, to enable a focus on specific issues, but allowing the respondents to talk around the subjects, and to create rich data on their experiences. This follows from Kvale (1996) who proposes that information from interviews need to capture interpretations of events or phenomena, reflecting the worldview of the informant. In approaching interviews, Jones (1985) suggests that researchers will prepare some key questions, which are likely to change and develop as the research moves on, and as new themes are revealed. This reflects my own approach, where each study created greater understanding of the topic and subsequently allowed a more focussed discussion with respondents on core issues.

Interviews may produce problems of analysis, as the interview transcripts may be lengthy. These data need to be subject to careful scrutiny and interpretation, which is largely achieved through the coding process. The approach to cases and interview content was as follows:

1) after completing the relevant interviews, to write up a short case summary, to capture important points and initial insights;

2) once the interviews had been coded in detail, the case would be expanded around the findings from the coding process;

3) these case reports were then refined or edited, in accordance with the focus of each paper;

4) relevant data would be extracted from the cases, according to the research questions or objectives of the specific article.

3.5 Data Analysis Procedures

Started in the information technology (IT), Big Data Analytics (BDA) has now found extensive applications in many areas of technology and business intelligence (Chen et al., 2012). Those serving mass consumers are particularly interested in using such tools to understand the current state of their business and track the still-evolving aspects. The electric power industry, interacting with one of the largest customer-serving critical networks is going through some drastic, rapid changes in both business and technical paradigms Bui et al. (2012), Jaradat et al. (2015), Aiello and Pagani (2014). Thus, naturally it is presenting limitless opportunities for BDA. Power system Big Data (BD) brings new opportunities such as providing an otherwise non-existing feedback loop, taking actions to correct and enhance planning, and enabling accurate realization of the system states, leading to more informed operations.

In this we aim to overview some fundamental concepts and characterizations of BD and BDA, in the domain of power systems. We address questions such as: What are the attributes of energy data and whether they constitute BD? What are the distinct concepts in BDA related to power systems? What are the challenges in generation, communications, management and analysis of BD? What are the new core theories that furnish BDA in power system domain? What are the barriers to adopt the existing generic BDA tools and platforms for BDA in power systems?

Energy big data characterization

Although the term "Big Data" is self-explanatory, it still can be a source of confusion or controversy. For example, what an electric utility may consider BD could be seen as moderate size data for data-centric enterprises. The relativity of BD to the systems that operate based on those data is recognized even within the IT community Chen et al. (2012), Russom et al. (2011). Nevertheless, a definition often used for BD is a "high-volume, high-velocity and high-variety information asset that requires and demands cost-effective, innovative forms of information collection, storage, and processing for enhanced insight and decision making" (De Mauro et al., 2016). From this definition, the volume, i.e., size of data is not the only factor, as there are other factors too. The so called "three Vs" of BD, see Fig. 1, are described as follows:

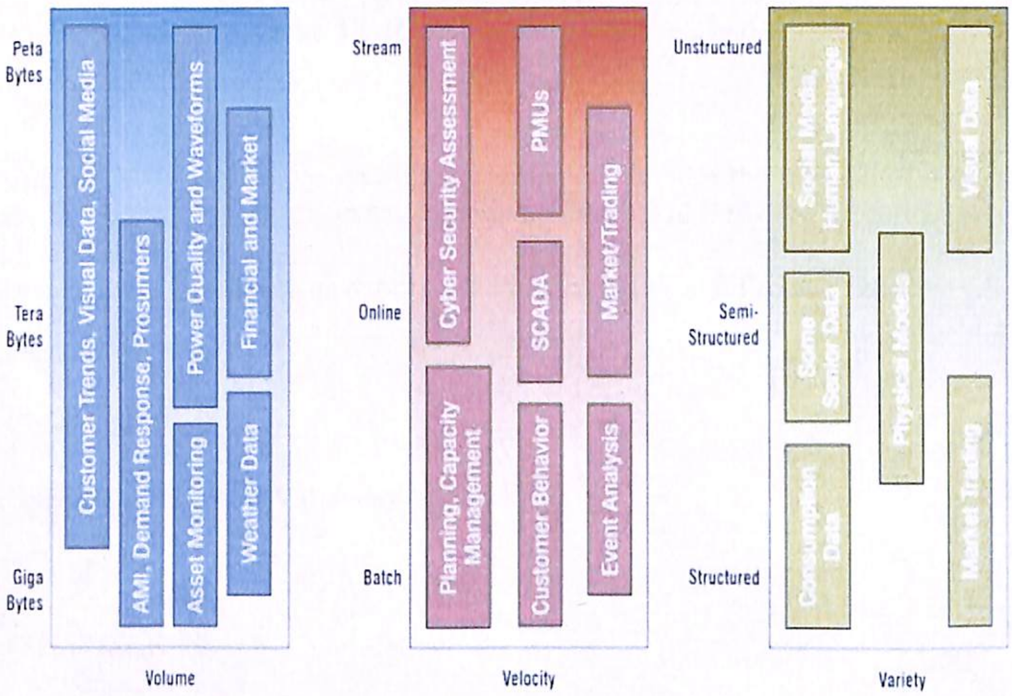

Figure 3: The 3 V attributes of BD and some examples in the context of power systems .

CHAPTER 4: Findings & Analysis

In this chapter, we used to carry out different statistical tests for the purpose of data analysis. Data were first coded in excel sheet and exported to Statistical Software for further analysis.

The following Statistical Tools have been used in the Analysis of Primary Data:

- Descriptive Statistics
- Chi-Square Test
- One-way analysis of Variance (ANOVA)
- Test of Mean differences
- Factor Analysis
- Reliability Test
- Correlations analysis
- Regression analysis

The data analysis in the present chapter has been divided into two main heads:

(1) Descriptive Analysis: Statistical tools used in the present research study pertaining to descriptive analysis: Frequency Distributions and Cross Tabulation

(2) Inferential Analysis: Statistical tools used in the present research study pertaining to the inferential analysis: Correlation/ Regression Analysis.

4.1 Descriptive Statistics

Descriptive analysis or statistics does exactly what the name implies: they "describe", or summarize, raw data and make it something that is interpretable by humans. They are analytics that describe the past. The past refers to any point of time that an event has occurred, whether it is one minute ago, or one year ago. Descriptive analytics are useful because they allow us to learn from past behaviours, and understand how they might influence future outcomes.

The vast majority of the statistics we use fall into this category. (Think basic arithmetic like sums, averages, percent changes.) Usually, the underlying data is a count, or aggregate of a filtered column of data to which basic math is applied. For all practical purposes, there are an infinite number of these statistics. Descriptive statistics are useful to show things like total stock in inventory, average dollars spent per customer and year-over-year change in sales.

The road to scaling intelligent automation

Learning from the best practices followed by high-performing 'Automation Frontrunners', we have developed five recommendations for scaling intelligent automation:

- Take a pragmatic approach when evaluating and choosing use cases:

Finding and developing viable intelligent automation use cases gives energy and utilities leadership a clear understanding of how they fit in with business strategy, competencies and capabilities.

- Optimize the right processes before trying for scale:

It is essential that organizations have a strong grasp of the process re-engineering and workforce impact before proceeding to try and scale. Force-fitting solutions to existing structures will lead to undesirable consequences and/or suboptimal gains.

- Put emphasis on breakthrough technology and ensure sufficient resources in place:

By focusing on technologies such as advanced analytics and deep learning in core functions, you can deliver outsized benefits.

- Centralize execution, governance and leadership:

Using a dedicated team, along with staff rotated from application areas, can allow you to create and sustain "lighthouse projects".

- Upskill the existing workforce ensuring change management:

A comprehensive upskilling program will not only give you the viable talent pool you need for execution, it will also help with one of the most challenging areas for any digital transformation – culture. The change management practices will help individuals, teams and overall organizations to scale up and benefit from the intelligent automation.

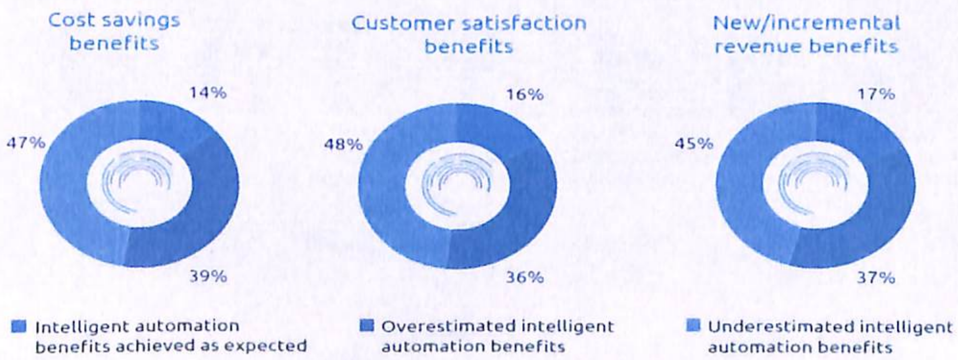

Figure 4: Intelligent automation benefits – expected against actual achieved.

The sector is driving significant value from intelligent automation compared to other industries

Boosting operations

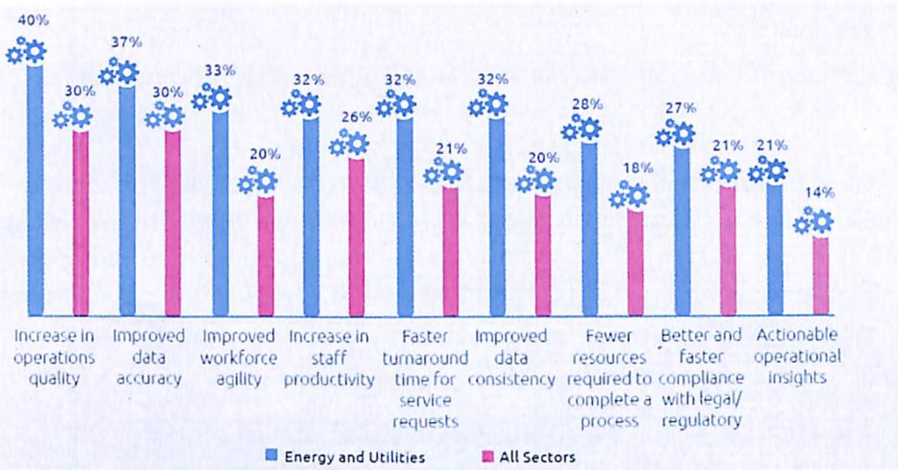

Table 1: Percentage of executives saying that they achieved operational benefits from their intelligent

Top line growth

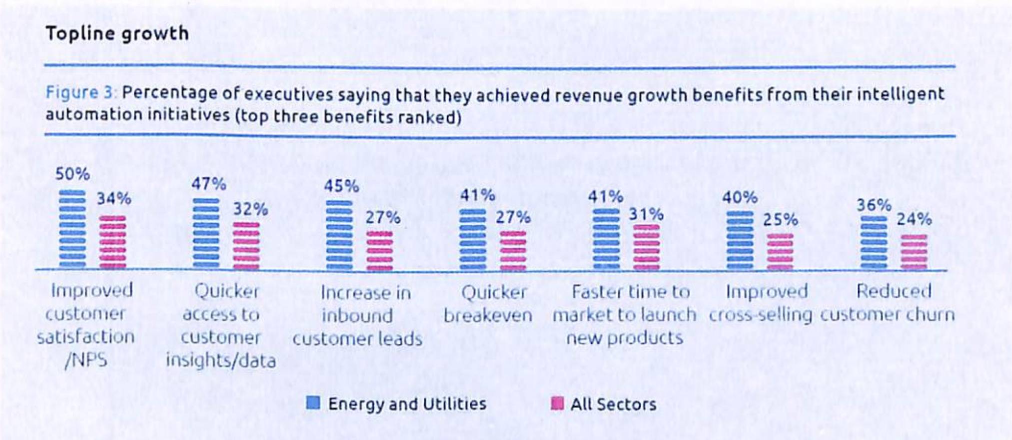

Table 2: Percentage of executives saying that they achieved revenue growth benefits from their intelligent (top line growth)

4.2 Regression Analysis/ Correlation Analysis

Regression analysis was performed in order to test the relationships of the dependent variables and independent variables. In this study, simple linear regression and multiple linear regressions with stepwise method was used. Pearson correlation was used to evaluate the linear relationship between two variables. In addition, multiple linear regressions were used to explore the relationship between one dependent variable and a number of independent variables.

Intelligent automation can drive significant cost savings across the energy and utilities sector

The energy and utilities sector could realize cost savings from $237 billion to $813 billion if it were to implement intelligent automation in its target processes at scale. To demonstrate the cost efficiencies that intelligent automation can deliver in the sector, we built a model using industry benchmarks and our survey data. (see Figure 5).

	A. Projected market size (in $ billion)*	B. Operating expenses as a % of revenue** (in %)	C. Projected operating expenses for the sector (in $ billion) (A*B)
Oil and gas	11,564.2	54%	6,243.5
Electricity utilities	2,840.4	53%	1,493.9
Water networks	181.9	60%	108.6
Electricity and gas utilities	1,471.1	55%	815.5
Energy services	705.2	54%	379.5

Table 3: Cost savings that could be realized across energy and utilities by implementing intelligent automation.

Conservative benefits estimate			
	D1. Target processes to be automated (in %)***	E1. Average cost savings from intelligent automation (in %)***	F1. Potential cost savings from intelligent automation (in $ billion) (C*D1*E1)
Oil and gas	16%	15%	149.8
Electricity utilities	14%	20%	41.8
Water networks	15%	20%	3.3
Electricity and gas utilities	14%	30%	34.3
Energy services	14%	15%	8.0
G1. Total projected cost savings from intelligent automation (in $ billion)			237.2

Table 4: Total projected cost savings from intelligent automation (conservative benefits estimate).

Optimistic benefits estimate			
	D2. Target processes to be automated (in %)***	B. Operating expenses as a % of revenue** (in %)	E2. Average cost savings from intelligent automation (in %)***
Oil and gas	22%	42%	576.9
Electricity utilities	20%	43%	128.5
Water networks	21%	48%	10.9
Electricity and gas utilities	19%	44%	68.2
Energy services	20%	38%	28.8
G2. Total projected cost savings from intelligent automation (in $ billion)			813.3

Table 5: Total projected cost savings from intelligent automation (optimistic benefits estimate)

Artificial intelligence is on the rise, though critical challenges remain in achieving scale

Only a minority are able to scale up their intelligent automation initiatives

We define "scaled adoption" as deployments that go beyond pilot and test projects and are adopted to a significant degree across business units, functions, or geographies. However, scaled adoption in the sector is rare. As Figure 5 shows, this is true at both a global cross-sector level (where in 2018 we found that 16% have reached scale) as well as for energy and utilities specifically.

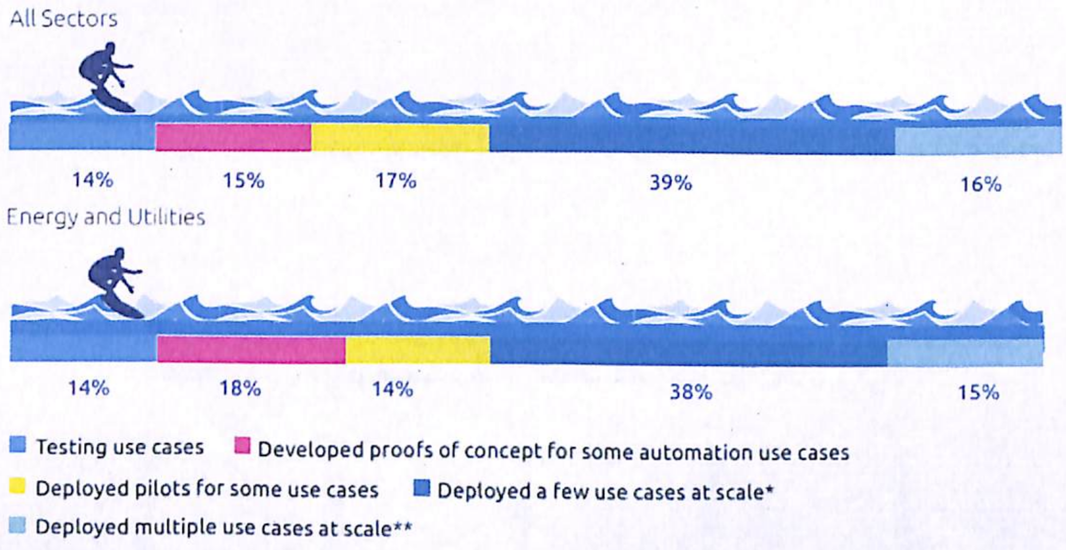

Figure 5: Global cross-sector level (where in 2018 we found that 16% have reached scale) as well as for energy and utilities specifically.

Intelligent automation maturity in energy and utilities – a national, sub-sector and value-chain perspective

As Table 7 shows, the oil and gas segment leads in the deployment of scaled intelligent automation initiatives. The sector has faced significant challenges: the need to cut costs to maintain margins, ensuring safety and reliability in its processes, fluctuating commodity prices, changing regulatory policies and changing demand. These factors have been a catalyst for deploying automation and enhancing efficiency across supply chain processes. Water utilities, on the other hand, lag behind in scaled adoption. However, within that segment, processes such as water purification have considerable automation deployments.

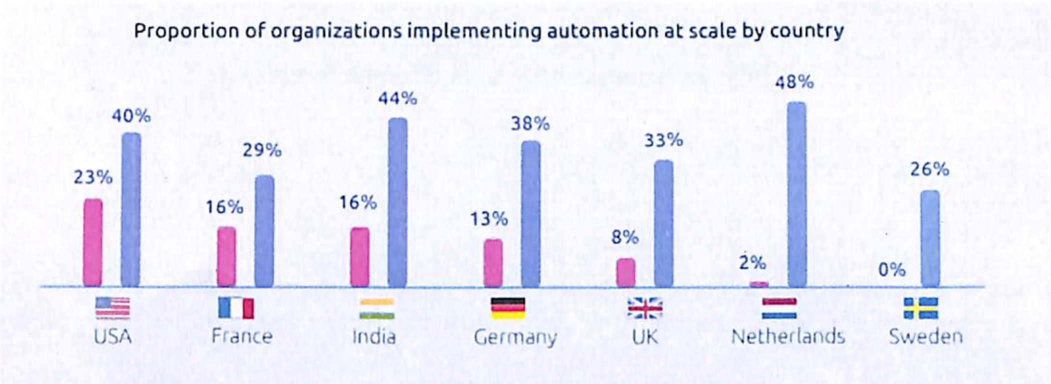

Table 6: Proportion of organization implementing automation at scale by country.

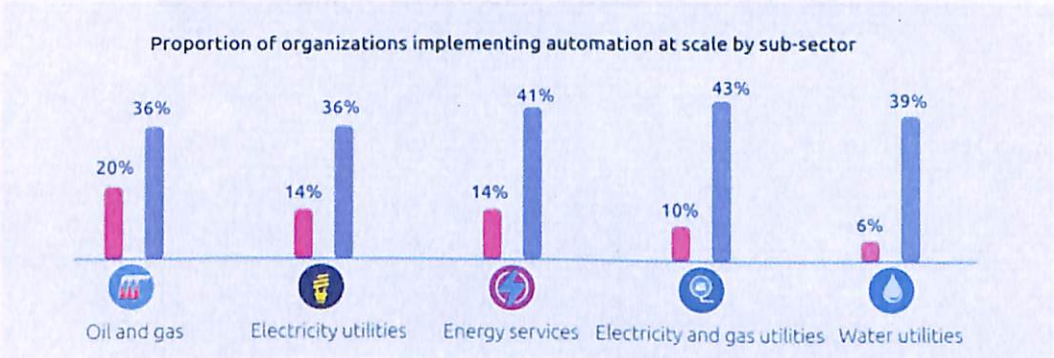

Table 7: Proportion of organization implementing automation at scale by sub-sector.

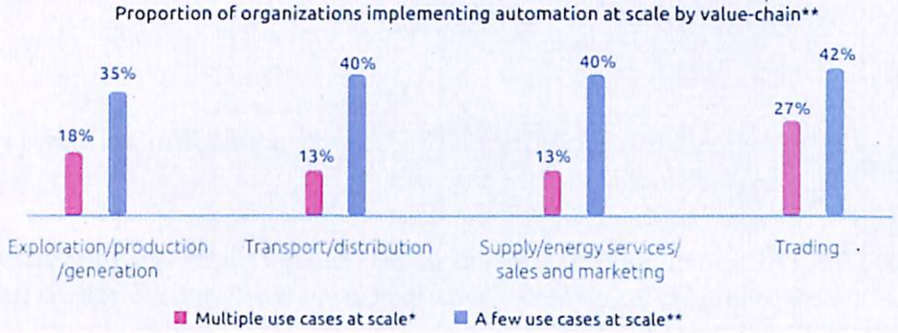

Table 8: Energy and utilities organizations implementing intelligent automation at scale (as a percentage of organizations experimenting with or implementing intelligent automation).

CHAPTER 5: Interpretation of Results

5.1 Interpretation of Results

Energy efficiency is a major concern for sustainable development activities, because increasing energy consumption implies usually increasing CO2 emissions and a long lasting impact on global warming. The energy demand has been constantly growing over the last few years, partly because of the emergence of new electrical applications, such as new services and new technologies for transportation, requiring increasing investments in the energy producing sector.

Furthermore, during some specific periods, the electricity distribution network can be under stress, because of high power demand. In order to face the rising electricity demand, a number of solutions for efficient energy consumption can be found. Indeed, energy management entails all the actions that could influence the demand for energy, such as actions to suppress ineffective energy consumption and actions to dim energy consumption at a large or medium scale. Energy generation from renewable sources and new power distribution business models for active energy control have been promoted and sometimes have been even legitimized via regulations at the national and European level. Besides, it is often mentioned that energy efficiency and renewable energy are the so-called "twin pillar" of sustainable development. These are fundamental to slow the increasing demand of energy.

In this meaning, the energy management analysis main goals are:

1. To understand the environmental benefits of energy management through connected household appliances with clear figures—the analysis should take stand-by consumption into account, as well as the fact that it avoids demand peaks, reduces energy losses;

2. To quantify the reduction in CO2 emission enabled by a better consumption and load management;

3. To perform a cost benefit analysis of a house energy management system.

The energy management analysis work approach is presented in Figure 1 in which it is easy to understand that all of the electricity value chain has to be considered.

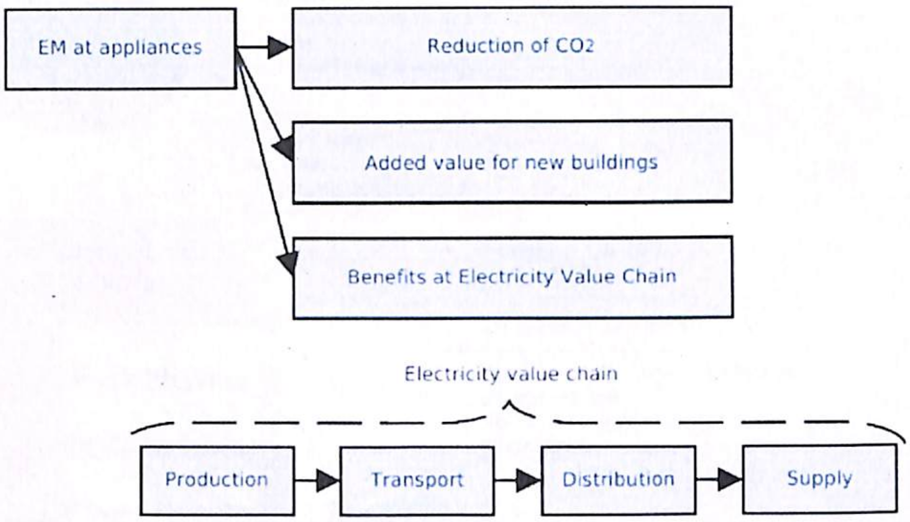

Figure 6: Energy management analysis work approach.

The Demand Side Management is gaining, today, more and more attention from technicians and investors. The Figure 3 shows the recent investment amount by the main energy companies in the USA in millions of US dollars.

Each of the these objectives can be fulfilled by using two control strategies:

• Intelligent on/off control;

• Advanced control.

These considerations and the resulting scenario are summarized in Figure 4. It is important to have a global overview of energy management actions inside apartments. In Figure 5, this overview is reported, while in Table 1, the load shifting actions (see also Figure 6) are explained in detail.

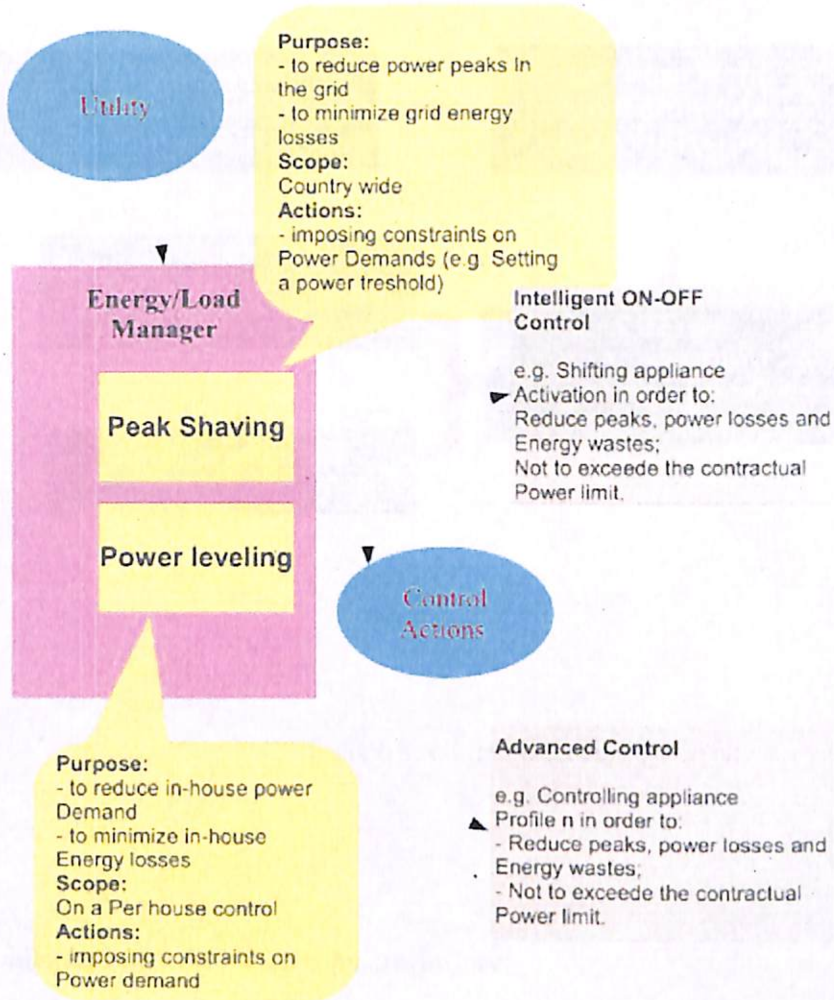

Figure 7: DSM function block diagram.

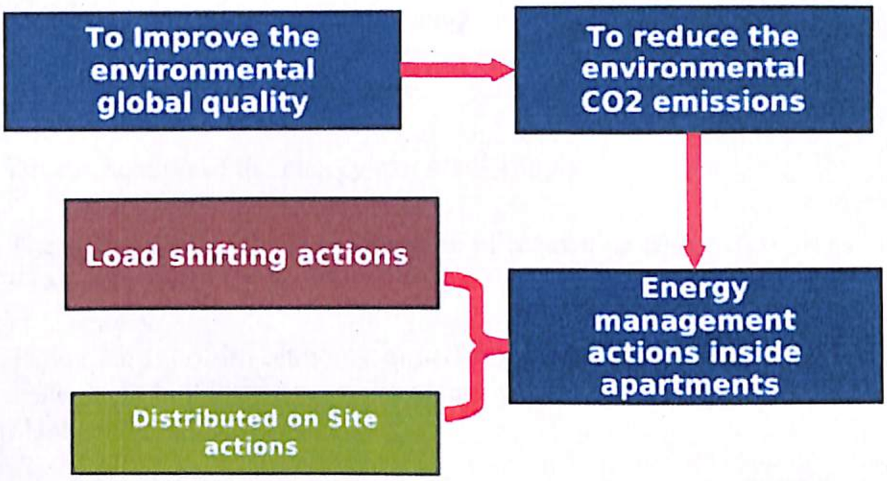

Figure 8: Global overview.

5.2 Comparisons of Results with Assumptions

Actually, the electrical distribution systems, overall medium voltage (MV) ones, and their design and operation criteria are subjected to deep changes, due to different factors. Among these, the main ones concern: the energy market liberalization, the new and complex energy governance policies, the environmental pollution reduction and sustainable development, the renewable development, the increase of energy efficiency, the costs reduction and the growth of the penetration of the so-called distributed generation (DG).

In particular, the forthcoming presence of DG in electrical distribution systems has strongly modified the nature of such systems; these systems, in fact, having today a radial topology and managed in a passive way (supplying energy from electrical power plants to end users), are destined to reach an active role by means of the implementation of the typical functions of load management, demand side management, demand response and generation curtailment. However, the DG penetration determines some technical problems in electrical systems that must be faced and solved rapidly to enjoy the potential benefits of DG and to really start the revision process aiming at the implementation of the so-called smart grids. The smart electrical distribution grids represent the needed evolution of the actual networks by means of a deeper implementation of automation functions, with high a level of information and communication technology (ICT) applications in order to increase the power quality and ancillary services guaranteeing the security and economic/energetic efficiency in electric energy supplying.

The distributed generation can introduce some potential benefits in electrical distribution systems, such as:

- Flexibility and electrical load management;
- Coverage of the local load peaks;
- Diversification of the energy resources supply;
-
- The larger possibility of exploitation of renewable energy resources in favorable locations;
-
- Time deferral of investments, aimed at the adaptation of transmission and distribution systems, at building new power plants and at the reinforcement of existing power plants and electrical systems;
- Electrical energy loss reduction.

However, the DG presence causes some technical problems that must be rapidly faced and solved, like:

- Increase of short circuit currents;
- Increased complexity of automation and protection systems;
- Increased complexity of voltage regulation, due to a modification of power flows;
- Unwanted possible MV system islanding.

Chapter 6: Future & Expected outcome of the study

Demand for technological, social and emotional, and higher cognitive skills will rise by 2030.

Skill Shift shave accompanied the introduction of new technologies in the workplace since at least the Industrial Revolution, but adoption of automation and artificial intelligence (AI) will mark an acceleration over the shifts of even the recent past. The need for some skills, such as technological as well as social and emotional skills, will rise, even as the demand for others, including physical and manual skills, will fall. These changes will require workers everywhere to deepen their existing skill sets or acquire new ones. Companies, too, will need to rethink how work is organized within their organizations.

This briefing, part of our ongoing research on the impact of technology on the economy, business, and society, quantifies time spent on 25 core workplace skills today and in the future for five European countries—France, Germany, Italy, Spain, and the United Kingdom—and the United States and examines the implications of those shifts.

6.1 Conclusion

The power grid is experiencing significant changes since an increasing number of variable renewable energy sources (VR) takes the place of more conventional forms of generation. This change is occurring together with increased production of energy in the distribution network. Simultaneously, consumers have started to become active participants in the electricity market, in the role of producer, consumer or both (prosumer). All these trends are constantly changing and therefore require interaction between TSO and DSO.

Consumers are at the heart of this change. The TSOs and DSOs should encourage this development by improving and reforming the way they interact and how they define their roles and their responsibilities.

To achieve these objectives, the network operators must make possible the access to all types of market (energy, system services, balancing) but always keeping sufficient reliability.

It is therefore increasingly important to take advantage of the opportunity to exploit and control the large and constantly rising numbers of energy resources placed at the distribution level (solar panels, wind turbines, energy storage systems) to offer services at system level.

The agreements for the operational management and planning between the TSOs and DSOs need to be reviewed and improved to support a market structure which would allow harvesting the potential improvements to the consumer.

The JWG has investigated the current level of automation at DSO level and provided technical guidelines of the future DSO automation requirements.

As identified in the survey, short-term forecasting of demand and DER is expected to be the most beneficial to all identified TSO/DSO functions.

Improved situational awareness through the application of advanced monitoring (AMI, etc.) and state estimation at the distribution level will improve overall system visibility; however, the main benefit to the TSO/DSO interface will be through more accurate short-term forecasts of net active and reactive power at defined interfaces. Topology recognition, through SCADA systems and advanced distribution management systems (ADMS), can be used to improve distribution state estimations as well as provide information on the DER connected to interfaces during normal conditions and during reconfigured system states. Additionally, the enhanced system observability can potentially provide advanced assessment of flexibility is especially relevant for the real-time operation of active network management.

The ability to schedule or dispatch active power production of DER or demand-side participation, by the DSO or other parties, is necessary to achieve many of the operational and market functionalities, but is expected to only have an indirect relationship with operational planning.

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Appendices