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FUTURE ENERGY SYSTEM INTEGRATING RENEWABLE ENERGY SOURCES INTO THE SMART GRID THROUGH INDUSTRIAL ELECTRONICS

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ABSTRACT

Future of any country rely on the energy system of that country, how optimistically energy generated to fulfill the responsive demand and supply of the countryman with high efficiency, reliability and flexibility. This paper is aiming at the idea of making renewable energy sources (RESs) compatible with the smart grids (SGs) operation through industrial electronics. The integration of RESs in SGs is a challenging task, mainly due to the intermittent and unpredictable nature of the sources, typically wind or sun. Another issue concerns the way to support the consumers' participation in the electricity market aiming at minimizing the costs of the global energy consumption.

Index Terms: Renewable energy, Renewable energy systems (RESs), smart grids (SGs), automated meter reading (AMR), advanced metering infrastructure (AMI).

I. INTRODUCTION

The utility industry across the world is trying to numerous challenges, including generation variegation, optimal deployment of expensive assets, demand response, energy conservation, and reduction of the industry's overall carbon footprint. It is evident that such critical issues cannot be addressed within the confines of the existing electricity grid [1]. The existing energy grids are unidirectional in nature where as the smart grids are bi-directional, which convey reliability to consumers for taking decisions about their amount of energy used and how to use further energy with efficiency and also give a perfect image of how much they have to pay for their consumptions.

Networking between all smart grid devices and systems is a key supporting component of grid systems. The smart grid demonstration help to find out the concept of the virtual top node (VTN) and virtual end node (VEN), where standardized protocols link key components of the grid architecture together and allow them to communicate [2].

II. SMART GRIDS

Traditional power grid converts only one-third of fuel energy into electricity, without recovering the waste heat. Almost 8% of its output is lost along its transmission lines, while 20% of its generation capacity exists to meet peak demand only (i.e., it is in use only 5% of the time). In addition to that, due to the hierarchical topology of its assets, the existing electricity grid suffers from domino- effect failures. The next-generation electricity grid, known as the "smart grid" or "intelligent grid," is expected to address the major shortcomings of the existing grid. In essence, the smart grid needs to provide the utility companies with full visibility and pervasive control over their assets and services. The smart grid is required to be self-healing and resilient to system anomalies. And last but not least, the smart grid needs to empower its stakeholders to define and realize new ways of engaging with each other and performing energy transactions across the system [1].

III. EVOLUTION OF SMART GRID

The initiative taken in the fostering of the smart grid is automated meter reading (AMR). AMR is the foundation scheme to the smart grid which is also called as the intelligent grid. AMR is the real-time measurement of the how much electricity has been utilized by the consumer. For example: the energy meters used for domestic purposes. The advantages of this kind of meters are:

- Accurate meter reading, less estimations.
- Billings get improved.
- Transparency between consumer and service provider.

There are some disfavors of it like: Utility can remotely shut off users [3], privacy level of consumer get reduced because details of use reveal information about user activities.

Although, AMR cover some issues but the main issue of getting rid of demand-supply management was not overlaid by this initiatory technique. So due to its' one-way communication system, it's overtaken by a new technology advanced metering infrastructure (AMI) or smart meters. Smart meters enable two-way communication between the meter and the central system. Unlike home energy monitors, smart meters can gather data for remote reporting. Such an advanced metering infrastructure (AMI) differs from traditional automatic meter reading (AMR) in that it enables two-way communications with the meter. Smart meters are fundamentally electronic device which records consumption of the electric energy periodically in intervals of an hour, more or less. It also modify customers service level parameters. Though, it reaches to the basic targets for load management and revenue protection. Smart meters are capable of measuring a multitude of consumption parameters (e.g., active power, reactive power, voltage, current, demand, and so on) with acceptable precision and accuracy. It appears to users in the form of energy management applications that allow command and control on all nodes of the network.

Development of smart meters are blow up in another form which give wide variety of generation options, e.g. central, distributed, intermittent, and mobile. It's esteemed as smart grid. The pervasive control and intelligence that embodies the smart grid has to reside across all geographies, components, and functions of the system, to superimpose itself using communication technologies.

The return and capabilities get increase while investing on smart grid, it can be seen in Fig. 1.

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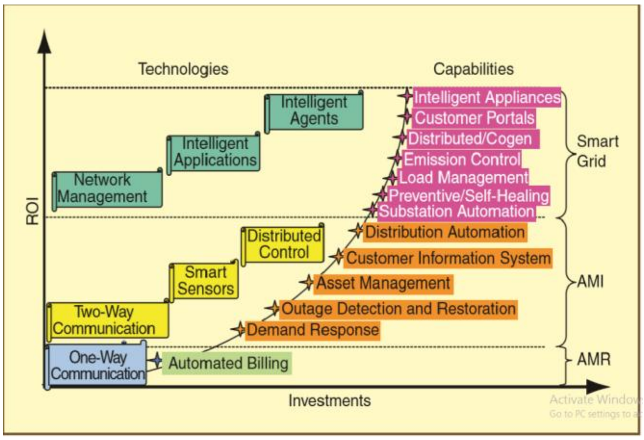

Fig. 1. Smart grid return on investments

IV. RENEWABLE ENERGY

Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and bio fuels and hydrogen derived from renewable resources [4].

Different sources like photovoltaic and wind are in different development stages and they have different levels of penetration in actual energy scenario, all the renewable energies share common problems. This is related to the fact that the power system is evolving towards active distribution grids with a significant amount of medium-scale and small-scale generators (ranging from hundreds of kW to tens of MW), involving both conventional and renewable technologies, together with storage systems (which importance in the overall scenario) and flexible high-voltage transportation systems connecting those grids with lower ROW (Right Of Way) restrictions. Within active grids, generators and loads can both play a role as operators in electricity markets. Furthermore, distribution grids have to be equipped with protection systems and real-time control systems leading to smart micro-grids (SMG) usually operated in connection to distribution grids but with the capability of automatically switching to a stand-alone operation if faults occur in the main distribution grid, and then re-connected to the grid. The safe operation in any condition (grid-connected or stand-alone) relies also on good simulation tools to predict the behavior of the overall system considering the specific operation of the renewable energy sources. The operation of a SMG can result in higher availability and quality compared with strictly hierarchical management of power generation and distribution. The security of the system can be improved by the ability of feeding final users, reacting to demand variations in a short time by redispatching energy thanks to smart systems. This allows to reduce risks and consequences of black-outs, avoiding the increase of the global production. These goals can be fulfilled only thanks to efficient networking of the distributed sources [5].

A. PV Energy Conversion

Sun is the eternal source of energy. So PV installation is increasing rapidly in emerging countries. This turn out to be eminent source of the energy without causing any impairment effect on the environment.

The most relevant goals of PV energy include 40% cost reduction of PV panels and of the power-converter stage within five years, increased efficiency of both panels and converters and considerable improvement in converter reliability. These goals are driving the research toward several directions [1]:

- Increase efficiency of power converters (using less transformers and resistive devices and converters based on silicon carbide (SiC) devices).
- Reducing the losses during transmission of power (using wireless transmission system to trifling the power loss).
- Making compatible panels (so that faults can be detected easily).
- Highest power extraction algorithms.
- Integrating the power generated (with suitable mechanisms and communication technologies).

B. Wind Energy Conversion

Accumulation of energy from the sun can be taken by natural means also because the earth and whole environment get heated from the sun unevenly and from this wind are created which blows all the time in the atmosphere. From this perpetual wind, energy can be generated. The power available from the wind is a function of the cube of the wind speed, so as wind speed increases, power output increases dramatically up to the maximum output. The goal of research for now is to produce high power production from each of the wind turbine. To make this possible a few steps are required:

- The area should be increased for installation of the wind turbines.
- Wind turbines should be planted near the off-shores because winds blowing there are stronger and more constant as compared to commercial areas.
- The wind turbines can be installed at the high altitude sites, so as to increase the power output.
- The power gained by the wind turbine should be integrated to stimulate more amount of power.

V. POWER ELECTRONICS: HANDLING ENERGY FLOW BETWEEN PLAYERS

To establish an interconnection between different players: manufacturers or producers, energy repository systems and loads, power convertor technology can enable this interconnection. All players can contribute to provide protection to the smart grid and might have the potentiality to work in different functional modes such as stand alone, micro grid, or cluster. In the stand-alone case, the power producer is disconnected from the grid and supplies merely a single load.

In the case of micro grids, several manufacturers, energy repository systems, and loads are connected together and try to operate in a controlled manner, by this they may interact with the central electrical grid and with other islands.

In the cluster scenario, various producers distributed across the main or central electric grid try to operate together, forming a virtual producer with high cumulative power that can accept supervisory signals from the utility system operator. Then again, energy consumers may come forward to accept their duties and responsibility to modulate their own power to contribute to the stability of the grid or to provide indirect storage. Indirect storage examples are as follows:

1. Molten salts can be used as energy storage system.
2. Cold/ hot elements of refrigeration systems can be used for Heat energy storage.
3. Energy stored in the batteries of hybrid electric vehicles.

Consumers may accommodate their power environment, even to the point of operation in stand-alone mode, when it becomes difficult to operate a controlled island. Another case would be in emergency response (for example, in the case of any natural disaster or in a hospital emergency), which requires an uninterruptible power system capability.

VI. COMMUNICATION SYSTEMS: HANDLING INFORMATION FLOW BETWEEN PLAYERS

In smart grid all elements and devices are interconnected, most of them have wireless interconnections. All the distributed element networks get operated by a central or head part of the grid, for handling this a communication network is required by which all the devices(which are entirely acting as a grid), operated exquisitely without creating any wire bumble. As it is a bi-directional way of communication system, it provides interface between energy management system and consumer, so that interaction established, that interface work as a full information interchanging path, by this way consumers get all details about their usage and with help of it they can reduce their energy cost.

Smart grids are self healing grids. If any kind of looming failure occurs, then the smart grid predict it and take a corrective action itself, which helps in damage or sudden breakages of the system.

VII. COMMUNICATION SYSTEMS: HANDLING INFORMATION FLOW BETWEEN PLAYERS

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VIII. CONCLUSION

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IX. ACKNOWLEDGMENT

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