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AN OVERVIEW OF SMART GRID

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Abstract:—Increasing complexity of power grid and its management, growing demand and service quality expectations such as greater grid reliability, efficiency and security as well as environmental and energy sustain ability concerns have triggered the next major step in the evolution of the power grid towards a "Smart Grid". It is an expected result of implementing new technologies in power systems, including renewable energy resources, distributed generation and latest information and communication technologies. In this paper a overview of smart grid system is given and technological advancements made to normal power grid to make it "Smart Grid" are discussed.

Keywords:— Distribution Generation, Renewable energy Sources, Smart Grid.

I. INTRODUCTION

Most of the world's electricity delivery system or "grid" was built when energy was relatively inexpensive. While minor upgrades have been made to meet increasing demand, the grid still operates the way it did almost 100 years ago energy flows over the grid from central power plants to consumers, and reliability is ensured by maintaining excess capacity. The result is an inefficient and environmentally wasteful system that is a major emitter of greenhouse gases, consumer of fossil fuels, and not well suited to distributed, renewable solar and wind energy sources. In addition, the grid may not have sufficient capacity to meet future demand. Several trends have combined to increase awareness of these problems, including greater recognition of climate change, commitments to reduce carbon emissions, rising fuel costs, and technology innovation. In addition, recent studies support a call for change:

- Power generation causes 25.9 percent of global carbon (CO2) emissions.
- CO2 emissions from electricity use will grow faster than those from all other sectors through 2050.
- Forecast demand for electricity may exceed projected available capacity in the United States by 2015.

Governments and regulators, utility companies, and technology firms are rethinking how the electricity grid should look. Already, utility companies and governments around the world are launching efforts to:

- Increase distributed solar and wind power generation to increase the electrical supply without additional greenhouse gas emissions.
- Use Plug-In Hybrid Electric Vehicles (PHEVs) to generate and consume electric power intelligently.
- Sequester (scrub and store) the carbon from coal plant emissions.
- Use demand management to improve energy efficiency and reduce overall electricity consumption.
- Monitor and control the energy grid in near-real time to improve reliability and utilization, reduce blackouts, and postpone costly new upgrades.

For all of these efforts—solar and wind plants, PHEVs, active home-energy management, and grid monitoring—to work together in one integrated system, a new level of intelligence and communication will be required. For example:

- Rooftop solar panels need to notify backup power generators within seconds that approaching clouds will reduce output.
- The grid needs to notify PHEVs about the best time to recharge their batteries.
- Utility companies need to communicate with and control appliances such as refrigerators and air conditioners during periods of peak electricity demand.
- Factory operators must know the cost of electric power every few minutes to manage their energy use economically.
- Homeowners need to become smart buyers and consumers of electricity by knowing when to adjust thermostats to optimize energy costs.

Unfortunately, these activities cannot be achieved with the current energy grid. Today's electric infrastructure simply cannot coordinate and control all the systems that will be attached to it.

A new, more intelligent electric system, or "Smart Grid" is required that combines information technology (IT) with renewable energy to significantly improve how electricity is generated, delivered, and consumed. A Smart Grid provides utility companies with near-real-time information to manage the entire electrical grid as an integrated system, actively sensing and responding to changes in power demand, supply, costs, and emissions from rooftop solar panels on homes, to remote, unmanned wind farms, to energy-intensive factories [1].

II. DIFFERENT TECHNIQUES USED TO CONVERT NORMAL POWER GRID TO SMART GRID

1. DESIGN OF GREEN BUILDING ENERGY SYSTEMS:

The green building energy system is a digitally monitored and controlled energy system that is composed of locally generated electricity and collected thermal power, a power and thermal distribution network and a service-oriented structure that reliably and efficiently manages high-quality power, cooling and heating services. While this system has potential to be energy independent, it can also be operated in parallel with the utility grid, either drawing power from or supplying power to the grid. The green building energy system has four essential components, as illustrated in Fig. 1:

- A Thermal Power Network
- A DC Electric Power Network
- A AC Electric Power Network
- A Smart Energy Management Network

This design architecture cost-effectively provides a greater degree of reliability, efficiency, and sustainability. The four components are described as follows.

1.1 Thermal Power Network:

Heating (including hot water and space heating) and cooling (including refrigeration and air conditioning) represent at least 50% of the energy load and 75% of the peak power load in a typical building. The approach shifts a significant portion of the energy requirements from electricity (kilowatt hours) to a range of thermal technologies that might include solar thermal collector, thermal storage and heat recovery from energy conversion processes.

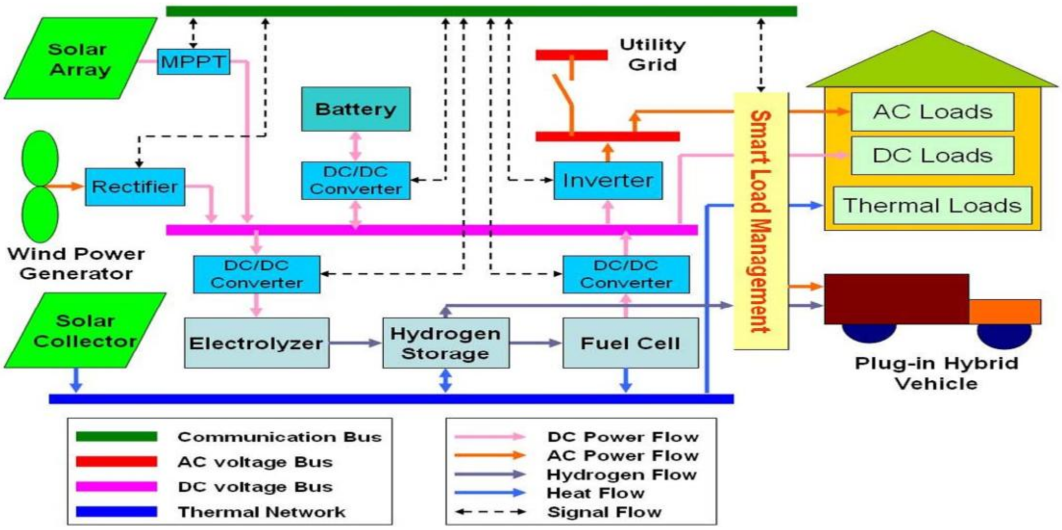

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Fig. 1. Schematic of the green building energy system

1.2 DC Electric Power Network:

The DC voltage bus bar links different sources of energy including solar panels, wind-turbine generators, fuel cells, and batteries. The wind generator produces varying-frequency or fixed-frequency AC power, depending on the machine technology it uses. The output AC voltage is converted to a DC voltage through a rectifier. The output power from solar panels varies with the solar irradiance, depending on the weather. To achieve highest efficiency and match the solar panel voltage with the DC bus voltage, a maximum power point tracker (MPPT) is needed [2]-[8], which consists of a DC/DC power converter and a controller. The fuel cell system uses the hydrogen that is produced by the excess energy to generate electric power. The battery is connected to the DC voltage bus through a bi-directional DC/DC converter. By controlling this converter, the power from or to the battery can be managed. The output of the battery is dependent on the load demand, taking the optimization into account.

The electrolyzer, which can split water to produce hydrogen and oxygen, is powered by the DC voltage bus. It is a load or energy sink from the energy perspective. The hydrogen can be stored for future use. The DC electric power can typically used to run LED lighting devices, power DC electronic devices and charge the batteries in the Plug-In Hybrid Electric Vehicle (PHEV), all of which might be common in the future. The produced hydrogen can also fuel the plug-in hybrid electric vehicle.

1.3 AC Electric Power Network:

Since a vast majority of the existing electric equipment and appliances are operated from AC power, the DC voltage has to be converted to a single-phase or three-phase AC voltage. This power conversion is performed by high-efficiency voltage source inverters. Since all energy sources are aggregated on the DC electric power network instead of the AC network, the control of inverters is relatively simple, either regulating the output voltage or controlling the output power. To achieve high energy efficiency, the load consumption of the AC power has also to be controlled, which is managed by the smart energy management network.

1.4 Smart Energy Management Network:

The green building energy system forms a microgrid, which is a collection of small-size power generators and local loads. In this design, a multi agent based control approach is used to manage the energy flows. In the multi agent framework, each energy resource and load in the microgrid is represented by an autonomous agent, or a reactive agent. These reactive agents are then connected to other agents in the multi agent system. The multi agent system provides a common communication interface for all the different agents in the system, making agent interaction possible. The communication can be implemented by a Home Area Network (HAN). The control strategy for the represented energy resource or load is completely incorporated in the software port of the agent, so it is also called “control agent”. With each control agent running on a separate processor or computer, the control system is distributed. The functions of the agents may be different depending on the characteristics of the represented devices. Based on the agent technology, a smart energy management network can be developed that is able to enhance reliability and efficiency of energy supply by intelligently managing a variety of renewable and distributed generation assets and load shifting and shedding in periods of high demand or during an emergency. The dynamic allocation of energy resources is based upon availability, expected demand, and customer-set criteria for energy efficiency, reliability, resiliency, and environmental commitments.

2. ADVANCED DISTRIBUTION AUTOMATION (ADA) APPLICATIONS AND POWER QUALITY IN SMART GRIDS:

A successful power grid management activity such as Distribution Automation (DA) hinges on the information collected from the network itself using an integrated monitoring system. It enables real-time monitoring of grid conditions for the distribution system operators and allows automatic reconfiguration of the network to optimize the power delivery efficiency and/or reduce the impact and duration of outages.

By definition, an ADA is a "set of technologies that enable an electric utility to remotely monitor, coordinate, and operate distribution components in a real time mode from remote locations".

2.1 Hydro-Quebec and Smart Grid:

Hydro-Quebec is showing leadership In this field with its road map towards a smart grid, which should include (see Figure 2):

- Grid monitoring (to improve reliability)
- Equipment monitoring (to improve maintenance)
- Product monitoring (to improve power quality)

The utility has ambitious programs. To achieve its energy efficiency program, HQ has focused on two targets:

- Capacitor banks installation
- Volt control

To reduce the outage duration, HQ has focused on fault location Pilot projects have been conducted to demonstrate the efficiency of two ADA systems such as:

- Volt & VAR Control (VVC) system
- Fault Location (FL) system

The impact of these systems on distribution grid and customers is permanently evaluated.

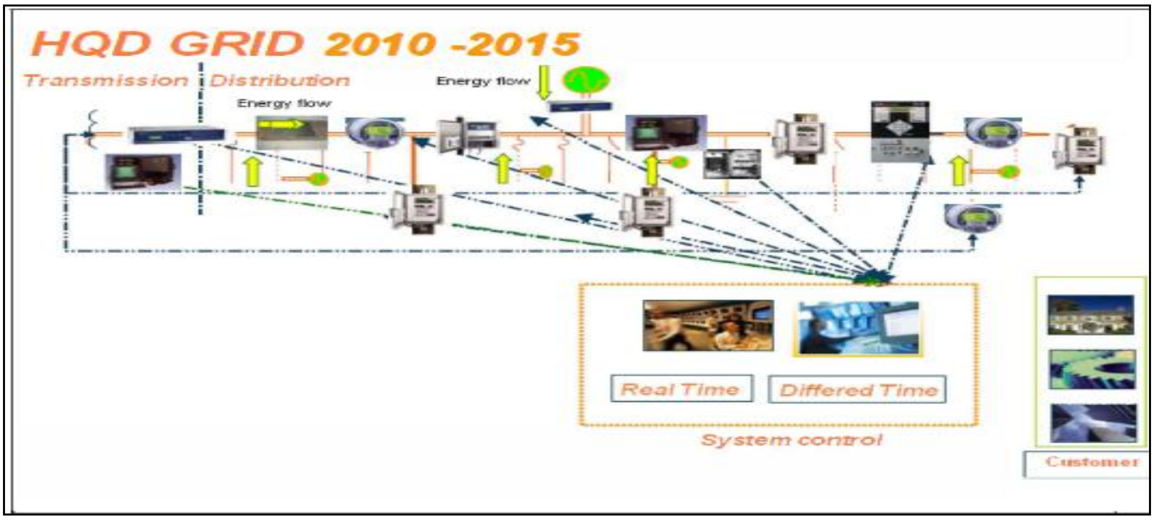

Fig 2: Grid, equipment and product monitoring

2.2 Volt and VAR control (VVC)

The VVC application is based on the CVR (Conservation Voltage Reduction) concept, which is associated with having the customer's voltage at the lowest level consistent with proper operation of equipment and within levels set by regulatory agencies and standards setting organizations. Hydro-Quebec aims saving energy by controlling the voltage level and by managing the reactive power (VAR) in the distribution network.

To fulfill this goal, the utility decided to use a VVC system, which requires a permanent surveillance of the voltage level at the end of the distribution feeder and the installation of switching shunt capacitor banks along the feeders Figure-3a.

In 2005 and 2006, Hydro-Quebec has done some experiments at Pierre-Boucher (PBR) substation (in suburban Montreal) to find the effectiveness of the conservation voltage reduction for energy saving and to evaluate the economic feasibility of the concept [9].

In the fall of 2008, Hydro-Quebec Distribution (HQD) commissioned a voltage and VAR control system named CATVAR at PBR substation to reduce energy consumption and distribution system losses. Basically, the voltage regulation system at the substation was replaced with an intelligent system that uses network measurements to maintain a stable voltage level at the end of the feeder that is close to the lower limit specified by Standard CSA-235. The CATVAR system also analyzes the network's VAR requirements and orders the switching on and off of shunt capacitor banks when required.

Fig 3: (a) Capacitor bank (b) Voltage monitoring device

3. INTELLIGENT TERMINAL UNIT (ITU) FOR SMART DISTRIBUTION GRID:

3.1 Structure of ITU:

The primary functions of ITU are status monitoring, fault detection, fault location, fault diagnosis, information interaction and switching control. Through detecting the loss of voltage, the over current and the transient and steady current and voltage of feeders, it determines the position of faults and operates the corresponding switching, isolates faults and restores power supply. The model of ITU is shown as figure5.

3.2 Characteristics of ITU

The ITU for smart distribution grid compared with the traditional FTU has the following characteristics:

3.2.1 Realization of complete information interaction:

Through the distributed control network based on fiber optic Ethernet and supplemented by microwave and power line carrier, one ITU exchanges the complete information with other ITUs and control master. The information includes not only node voltage, current, active power, reactive power, apparent power, power factor, frequency, harmonics, voltage fluctuation, voltage flicker, switch position signal, breaker failure signal , all the more off-limit signal, reclosing signal and fault recording signal, but also protection and fault isolation output signal, network reconfiguration and fault diagnosis decision-making signals, etc. Using the extensive interactive information, the ITU can improve the protection action speed and fault location accuracy, avoid the false-operation of protective relays.

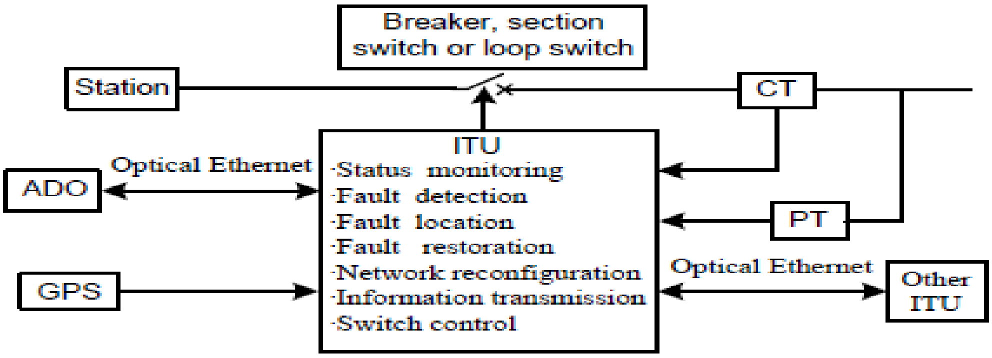

Fig 4 Structure of ITU

3.2.2 Realization of distributed control:

The ITU performs the orders of protection tripping, fault location, restoration of power and fault diagnosis decision. The remote control and remote modulation order of the control master only plays a supporting role. This not only improves the control of real-time, but also improves the distribution network reliability to avoid the control failure of the whole network as a result of the control master fault.

3.2.3 Self-healing function:

The ITU's diagnosis functions not only conclude the ITU's self-healing function, but also conclude the self-healing function of the distributed control network. When a failure ITU is diagnosed, the ITU is out of the network and its works are taken over by nearby ITU. When the distribution network is failure, the ITU can automatically isolate faults and restore power supply of the non-fault region to achieve the self-healing function of the distribution network. Meanwhile, the ITU can diagnose the devices of the local node. According to the real-time information of the feeder and the devices, the ITU predicts the weak links or the possible fault links to warn in time and take appropriate defensive measure for the link [10].

4. ENHANCED WIDE AREA MONITORING SYSTEM (EWAMS):

Fig 5 shows a block diagram of the EWAMS applied to a two-area four-machine power grid. It uses CI techniques to more accurately predict the state of the system in advance. It consists of different components such as The Missing Sensor Restoration (MSR) module, Local Area Monitor (LAM) module, Wide Area Monitor (WAM) module and the Integrity Check (IC) module. These modules use different technologies for reliable performance of the system.

The terminal voltage and speed deviation signal from each of the generators in the power system is received at the MSR module of the EWAMS. The MSR monitors the inputs for missing or faulty signal and triggers a CI based algorithm that restores the missing sensor input for a short period of time. This ensures reliability of the system. Since the auto encoder used in the MSR module computes the correlation between the input signals to produce 'healthy' signal outputs, missing or 'unhealthy' inputs are immediately detected, thus also adding a level of security. The output of the MSR goes into the WAM module which predicts step-ahead values of the speed and voltage deviations of the generators. Delays over communication channels can be overcome by these step-ahead predictions. The signals from the generators are also predicted using an LAM in each area which is assumed to have a more reliable and secured communication channel to the IC module. The output from the LAM and the WAM are then used by the IC module to compare between the predicted signals of each generator. Since the signals coming from the LAM are assumed to be more reliable, any discrepancy between the LAM and the WAM output during integrity check implies faulty or compromised signals coming from the generators. This will be treated as integrity fail and will raise different alarms. This added redundancy in the system will make it more secured and reliable. The IC module thus helps to identify the healthy, faulty or compromised state of the system. Thus by compensating for communication delays, predicting one or more steps ahead for control decision-making and with added redundancy, the EWAMS has enhanced features of reliability, integrity and security. The design of IC module, however, is not a part of this paper.

4.1 Reliability:

A reliable system is one that functions the way its users expect it to. In this case, this means that the end result of the WAMs function should be a step-ahead prediction of the states of all generators in all areas of the multi-area system. Communication delays, congestion and security breach are some of the obstacles to reliable performance of a WAM. The MSR and the WAM modules help to ensure reliability in the EWAMS. MSR module helps by identifying the missing sensor signal and using a CI technique, such as Particle Swarm Optimization (PSO), to restore the missing sensor. The Multiple-Inputs Multiple-Outputs (MIMO) SRN predicts future outputs of the system ahead of time. This ability of the system to predict the output well in advance makes it more reliable. Wide Area Controllers (WACs) can use this reliable information from the WAM to take proper control actions in real time.

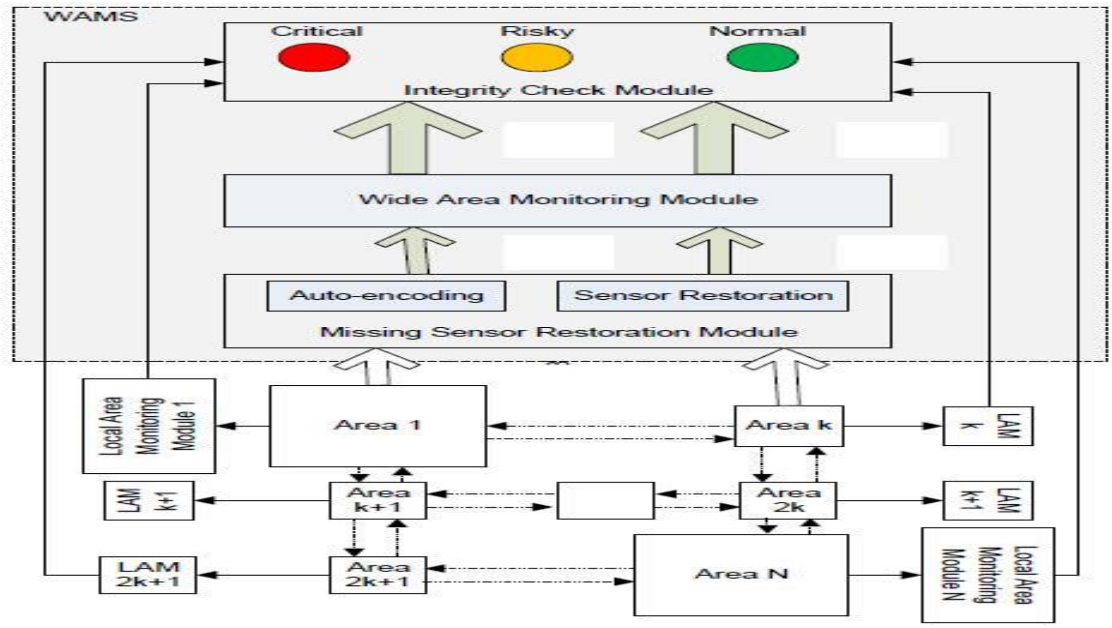

Fig.5. design of a EWAMS

4.2 Integrity

Integrity is trustworthiness. In order for a controller to make good decisions, it must have accurate, fault-free data with which to generate its choices. Real-world devices, however, are not always perfectly reliable. Sensors can malfunction, signals can become delayed due to congestion, and electromagnetic noise can cause glitches in communication. Missing-sensor fault tolerance [11] utilizes neural networks as auto-encoders to correlate interdependencies in data and detect inaccuracies in the reported data. The auto-encoder in the MSR module allows for the detection of faulty signals that is, signals that do not reflect the true state of the system and the PSO compensator uses the mutual information in the healthy signals to estimate the true value of the missing signal for brief periods, allowing for excessive lag or even sensor failure without sacrificing the integrity of the overall system. This is further enhanced by having LAMs in different areas for reporting the state of the signal through a more secured channel for the integrity check which is performed by the IC module and informed to the user in some ways.

4.3 Security

One of the dangers of separating monitoring and control from the system to be managed is that it becomes more vulnerable to remote interference by malicious entities. A secure system can detect such intrusions and compensate for them, not permitting them to interfere with proper function of the system as whole and alerting human operators to the problem if such persists. The MSR module adds inherent security to the system by restoring faulty signal to real values, thus making any unhealthy or compromised signals useless. Also, the redundant information from the LAM over a secured channel provides additional security feature. The IC module uses this reliable information to alert the user about the state of the system thus making it secured [12].

5. SMART ELECTRICAL ENERGY STORAGE SYSTEM FOR SMALL POWER WIND TURBINES:

5.1 SYSTEM DESCRIPTION:

The general block diagram of the SSMS for a small wind farm is presented in Fig. 6. As results from the figure, the SSMS consists in the following main four modules:

- Stochastic Source Module (SSM) which comprises the renewable energy source (wind) with stochastic output
- Short Term Storage Module (STSM) based on a flywheel with Induction Motor (IM)
- Medium/Long Term Storage Module (MLTSM) based on a Vanadium Redox flow Battery (VRB)
- Medium Term Storage Module (MTSM) based on a Lead Acid Battery (LAB)

An auxiliary module (Converter 5 + Filter + Transformer) is represented by the Grid Interface Module (GIM) and provides connections with the main network and the insulated loads. It allows in addition both the active power transfer and the reactive power generation. The whole SSMS is managed by a Global System Control (GSC) which automatically controls all the modules through local control units (LCU) and is based on fuzzy logic algorithms. All the modules are interconnected through a dc bus.

The active power and reactive power outputs to the grid are adjusted by the GIM. The GSC is hierarchically structured being associated with the LCU controllers. The GSC and LCU maintain by control the desired value of the dc bus voltage across the capacitor in order to obtain the desired output power value. The designed SSMS includes the following desirable features: based on renewable energy, active & reactive power deterministic generation, clean energy, good controllability and efficient maintenance costs. The cost and maintenance efficiency of SSMS is promoted by the design into modules with well defined interfaces and control units.

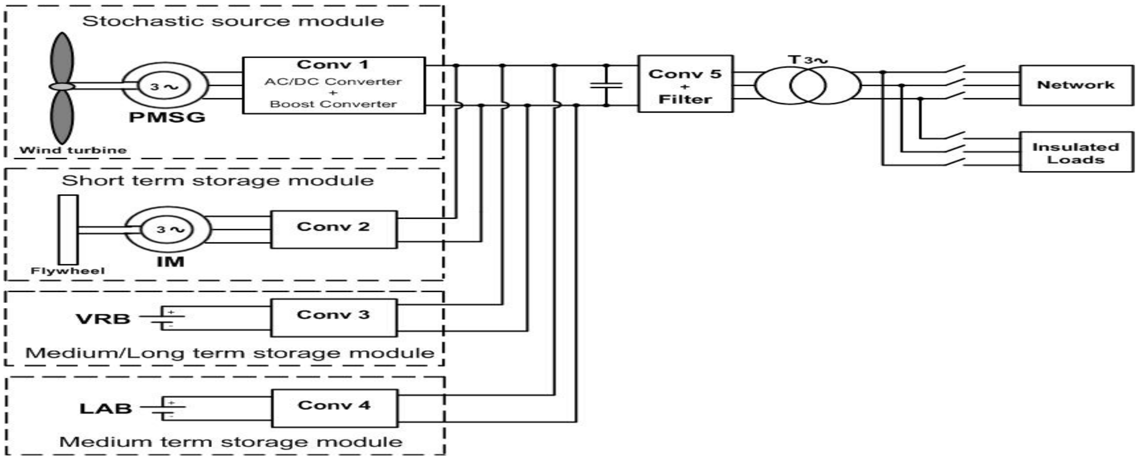

Fig. 6. Block diagram of the SSMS for wind systems

5.2. Stochastic Source Module

The SSM comprises the following parts: a) the wind energy source with stochastic output; b) the Permanent Magnet Synchronous Generator (PMSG) and c) the power Converter 1. To describe the wind energy source with stochastic output is considered an aerodynamic wind mathematical analysis based on the following main parameters:
Aerodynamic wind power:

$$P_W = \frac{1}{2}\rho\pi R^3 v_{wind}^3 C_p(\lambda,\beta). \quad (1)$$

Aerodynamic torque:

$$T_W = \frac{1}{2}\rho\pi R^3 v_{wind}^2 C_p(\lambda,\beta)/\lambda \quad (2)$$

Tip speed ratio:

$$\lambda = \frac{\omega_{WTR}.R}{v_{wind}} \quad (3)$$

Where: ρ is the air density, R the rotor blades length, v wind is the equivalent wind speed, λ is the tip speed ratio, Cp (λ, β) is the power coefficient, β is tilting angle of wind turbine rotor and ω WTR is the angular velocity of the rotor blades. The wind generator rotates with a variable speed and generates a variable power which strictly depends on the wind speed. In Fig. 8 is depicted the speed/time characteristic of the wind generator, for a short time and in the absence of storage system. Taking into account this characteristic, and the wind mathematical model Kaimal [13], [14] it was depicted the aerodynamic model in Matlab/Simulink,]. It was used the Kaimal mathematical model because it is in accordance with the Danish Standards. Another important parameter for the wind turbine is the power curve as relationship of Cp and λ.

6. SMART STORAGE SYSTEM FOR SEAMLESS TRANSITION OF CUSTOMERS WITH INTERMITTENT RENEWABLE ENERGY SOURCES INTO MICROGRID:

6.1 SMART STORAGE SYSTEM

6.1.1. Overview

In order to make the aforementioned solutions, this paper proposes the smart storage system. The smart storage system provides the references for rated voltage and frequency near during islanded microgrid and adopts the battery for energy storage of which fast response is possible to solve the energy balance problem when the microgrid is changed to islanded operation.

In order for the smart storage system to solve the resynchronization with the upstream network, it is geographically located at the PCC. Thereby, the smart storage system is able to directly measure a magnitude and phase angle of the voltage of the upstream network and resynchronize with the upstream network. In the customers considered in this paper, since there is no DER providing the references for voltage and frequency, the smart storage system can control the references for voltage and frequency of the microgrid and carry out the resynchronization. Also, the smart storage system physically comprises the STS and has thus a structure which is able to directly control the STS to minimize the transients when microgrid is reconnected to the upstream network after resynchronization is completed.

The geographical location of the smart storage system enables it to immediately confirm the operation mode of the microgrid. Thereby, the smart storage system has its various control modes to accomplish the specific goals according to the operation mode of the microgrid. Each control mode of the smart storage system can be properly selected according to an operation mode of the microgrid and certain control mode can be selected according to the necessary. The structure of the smart storage system which is explained before is shown in Fig.7

6.1.2 Control system of the smart storage system

In the most previous research work relevant to the microgrid, in order for the DERs to provide the references for voltage and frequency when the microgrid is changed to islanded operation mode, they adopt only the droop control method without the fast communication [15]-[20]. In the grid connected operation mode, the droop control method can regulate the real power, but not regulate the reactive power.

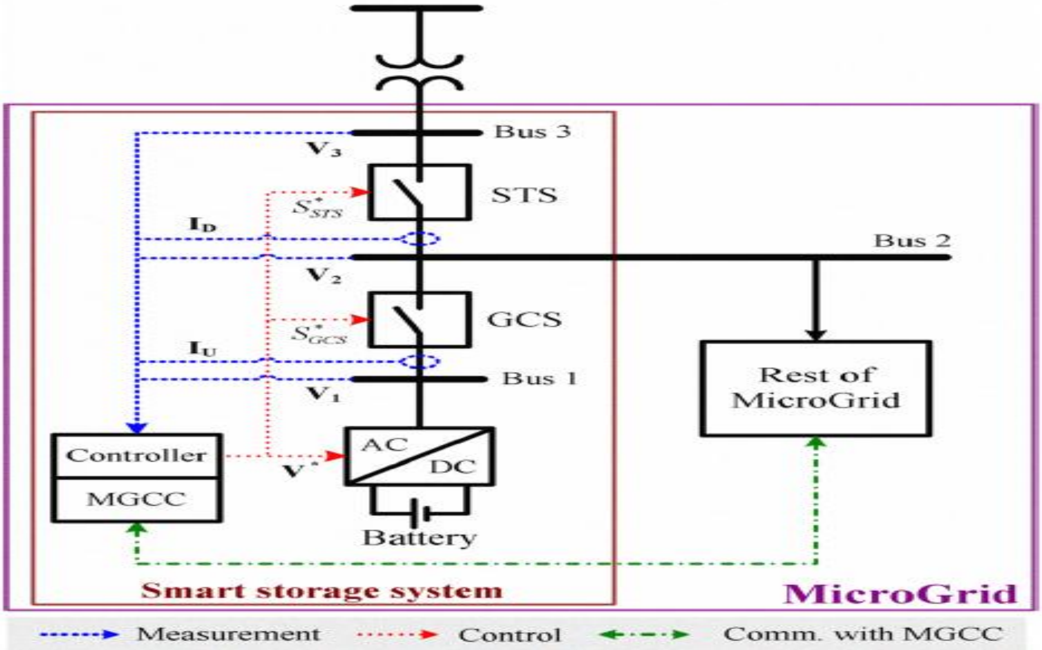

Fig7. Structure of smart storage system

There are the unit power flow control and feeder power flow control [20] using the real power control by the droop control method. Conventional DERs adopt only one of them. In [21], to regulate the reactive power in the grid-connected mode, two control modes according to the operation mode of the microgrid are presented. However, the geographical location of the DERs and fast communication between the DERs and the STS are not considered. Therefore, accurately deciding the time to change the control mode could not be easy in contrast with the smart storage system presented in this paper. Accordingly, it is not practical. The control modes of the smart storage system are given in Table I according to each operation mode of the microgrid and real and reactive power control.

In Table I, the microgrid dispatch control (MDC), unit dispatch control (UDC) and voltage control (YC) are control modes where the microgrid is operated with a grid-connected mode, and the droop control and re-synchronization control are control modes where the microgrid is operated with a islanded operation mode. The MDC is a control mode regulating the real and reactive power of the smart storage system so that the upstream network can exchange the constant real and reactive power with the microgrid even though the outputs of the DER with the intermittent RESs and certain loads within the microgrid are frequently fluctuated. In [21], a feeder power flow control is; however, it is that a certain DER regulates the only real power of one of the feeders within the microgrid, which is unlike the MDC regulating the real and reactive power exchanged with the upstream network. The UDC is another control mode regulating the real and reactive power of the smart storage system to accomplish the specific goals such as a battery management and frequency and voltage restoration. The YC is another control mode regulating the terminal voltage of the smart storage system using the droop concept.

In Table I, the droop control is another control mode providing the references for voltage and frequency using the droop concept. The re-synchronization is the other control mode synchronizing the voltage magnitude and phase angle of the microgrid with those of the upstream network to reconnect the microgrid to the upstream network. In order to minimize the transients during the change between the control modes by a transition of the operation mode of the microgrid, the time that control mode is changed must be synchronized with STS operation. Therefore, as depicted in Fig. 13, the smart storage system has to comprise the STS. If not, these are interfaced by the fast communication, nearly locating each other.

TABLE I
CONTROL MODES OF THE SMART STORAGE SYSTEM

Operation mode of microgrid	Real power control	Reactive power control
Grid-connected operation mode	MDC	MDC
		UDC
	UDC	
		VC
Islanded operation mode	Droop control	
	Re-synchronization control	

7. SUPER CONDUCTING MAGNETIC ENERGY STORAGE

A Superconducting Magnetic Energy Store is an energy storage device that stores electrical energy in a magnet field without conversion to chemical or mechanical forms. In SMES, a coil of superconducting wire allows a direct electrical current to flow through it with virtually no loss. This current creates the magnetic field that stores the energy. On discharge, switches tap the circulating current and release it to serve a load. To remain superconductive, the SMES coil must operate at cryogenic temperatures. Therefore, SMES devices require cryogenic refrigerators and related subsystems in addition to the solid-state power conditioning devices, monitors, controls, climate controls, utility and user interface equipment, safety devices and transportation features.

SMES systems for power quality applications are available from two vendors in the United States: American Superconductor Corporation (ASC) and lntermagnetics General Corporation (IGC). Both systems, as shown in Figure 2a consist of Low Temperature Superconducting coils that operate in liquid helium at a temperature of 4K(269OC). The devices use High Temperature Superconducting leads as an interface to copper conductors that are used outside of the cryostat of the SMES. Because the HTS leads operate at higher temperature than LTS materials, they improve system thermal efficiency and electrical performance at the cryogenic/ambient interface. Figure 2b illustrates a SMES unit connected in series with the electric grid and an AC load[22].

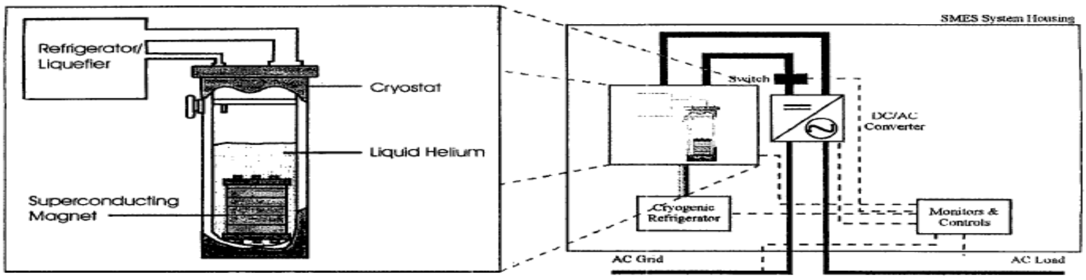

Fig8. Blowup of SMES Cryostat and Coil and SMES System in Series Grid-Connected Configuration.

Most SMES units fielded to date provide IMW for 1 second and can be paralleled for more power. These early units have been used in power quality applications to correct voltage sags and dips at industrial facilities in the US and Africa. A new application is being installed by a US utility to stabi1ize a large, ring transmission network. Six units, each capable of' providing 2MW, will be installed at substations to stabilize oscillations in the transmission network.

SMES systems have several advantages. A SMES coil has the ability to release large quantities of power within a fraction of a cycle, and then fully recharge in just minutes. This quick, high-power response is very efficient and economical. SMES manufacturers cite controllability and reliability and no degradation in performance over the life of the system as prime advantages of SMES systems. SMES systems are compact, self-contained, an highly mobile; a single semitrailer or equivalent space can deliver megawatts of power. It can be kept at remote locations. Also, SMES units contain no hazardous chemicals and produce no flammable gases. The estimated life of a typical system is at least 20 years.

The technical challenges to SMES include: SMES devices produce large magnetic fields requiring stay out zones and careful component design; they have the potential to rapidly pressurize their cryostats if their coils go normal (become non-superconducting). These issues are well understood and managed safely. For small SMES systems, the issues are designing the conductor to minimize parasitic losses from the air conditioning and refrigeration (including HTS leads and coil) systems, and designing the PCS to minimize costs. Because coil characteristics drive PCS requirements, coil and PCS advances will greatly affect each other. The main business challenge for this new technology lies in the enhancement and full commercialization of smaller systems and the development of systems with greater energy capacity at affordable cost.

III. CONCLUSION

Growing power consumption and increasing complexity in the power grids encouraged to built new grids which are smarter than normal grids these normal grids are made smarter using different modifications and techniques. The techniques used not only meeting the power requirement but also making the grid versatile, stable and smarter. These smart grids are future of power management which eliminate the disadvantages of normal power grid and make grids to meet future demand and ensure continuous supply of power.

Smart grids can make environment cleaner by using eco friendly technologies to generate and distribute energy.

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