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Perspective Approach to Smart Grid Technologies : A Review

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Abstract— Smart Grid is a modernized grid to maintain a reliable and secure transmission and distribution of electricity. It is laced with use of information communication technology (ICT) and advanced control mechanisms with full cyber-security aimed at improving reliability, security, and efficiency of the electric grid. In a traditional electric grid electricity transfer is from grid to consumer, while in the new smart grid the energy flow is bidirectional because of the integration of renewable energy sources like photo voltaic, wind, fuel cell, bio gas, geothermal and so on. Consumers are also producer of electricity which is going to change the economics of electricity sector: buyers are now sellers. The changed topology of electric power network demands deployment of 'smart' technologies that are automated and interactive for metering, communications concerning grid operations and automation. Use of 'smart' appliances, consumer devices and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles requires provision of timely information and control options. Fast system response resulting from integration of renewables, advanced power convertors, smart appliances etc. demands a stat of art technology for the protection of smart grid.

Keywords-*ICT, Cyber-security, renewable integration.*

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I. INTRODUCTION

The term "smart grid" can be described as the quick foundation substitution of the electrical wiring framework. At the point when the propelled framework is totally executed, it will take into consideration correspondence includes over the networks that are not presently accessible - thus the expression "smart"[3]. A "smart grid" is essentially a progressed electrical conveyance framework that has the ability to adjust electrical loads from differing, and frequently discontinuous, elective energy creation sources. One key part of the "smart grid" is the ability to store electrical energy [4].

Electric power frameworks overall face radical change with the need to decarbonise power supply, supplant maturing resources and tackle new data and correspondence advances (ICT). The Smart Grid utilizes progressed ICT to control cutting edge control frameworks dependably and effectively [2].

As advancement has an immediate connection with time so for a productive usefulness of network, computerized innovation has been presented in framework. This new advanced innovation empowers two way correspondences which ensures the immediate connection among utilities and all customers.

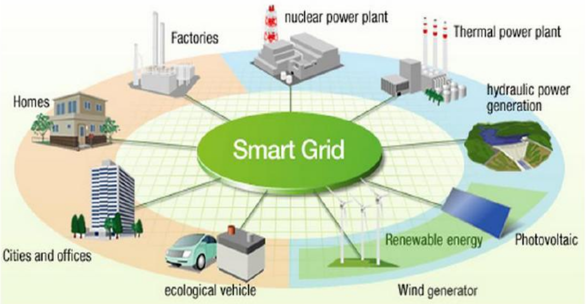

Figure 1: smart grid

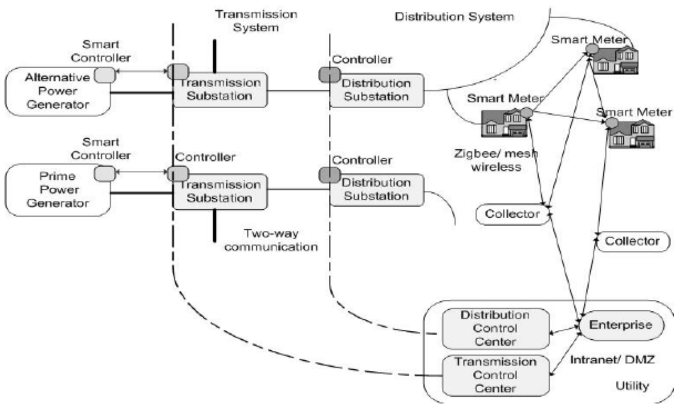

Figure 2: Typical smart grid components and connections block diagram [10]

II. LITERATURE REVIEW

Since the beginning, various unmistakable occasions have changed the course of our reality: in 1439, Johannes Gutenberg built up the printing press; in 1712, the primary financially effective steam motor was presented; in 1886, Karl Benz protected the gas-controlled vehicle; and in the twentieth century, the Internet rose and perpetually changed the manner in which we convey and trade data.

In the mid 1900s, when Henry Ford initially began to utilize mechanical production system strategies to mass produce vehicles, there was next to no in the method for instrumentation. Gradually, as the vehicle advanced, consistently expanding measures of operational data were made accessible to the driver.

Studies on Smart lattice (SG) were done in [20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31]. Chen et al. [23], Yu et al. [31], and Hassan and Radman [26] quickly audited the fundamental ideas of SG and a few advances that could be utilized in SG. The creators of [27, 28] looked into the current SG institutionalizations and gave solid suggestions for future SG benchmarks. Vasconcelos [29] laid out the potential advantages of savvy meters, and gave a short outline of the lawful structure administering metering exercises and arrangements in Europe. Dark colored and Suryanarayanan [22] decided an industry point of view for the shrewd appropriation framework and distinguished those innovations which could be connected later on research in the keen dissemination framework. Baumeister [21] displayed a survey of the business related to SG digital security. Chen [24] investigated the security and protection issues in SG and related these issues to digital security in the Internet. Gungor and Lambert [25] investigated correspondence systems for electric framework computerization and endeavored to give a superior comprehension of the cross breed arrange design that can give heterogeneous electric framework mechanization application prerequisites. Akyol et al. [20] examined how, where, and what sorts of remote correspondences are reasonable for organization in the electric power framework. Wang et al. [30] gave a review on the correspondence designs in the power frameworks, including the correspondence organize structures, innovations, capacities, prerequisites, and research difficulties. They additionally talked about the system usage contemplations and difficulties in the power framework settings.

III. THE SCOPE OF A SMART GRID

To improve the unwavering quality, security, and productivity of the electric system from large generation a smart grid uses digital technology, through the conveyance frameworks to power purchasers and a developing number of circulated age and capacity assets (DOE/OEDER 2008a [11]). The data arranges that are changing our economy in different zones are likewise being connected to applications for dynamic improvement of electric framework tasks, support, and arranging. Assets and administrations that were independently overseen are presently being incorporated and rebundled as we address conventional issues in new ways, adjust the framework to handle new difficulties, and find new advantages that have transformational potential.

Territories of the electric framework that spread the extent of a smart grid incorporate the accompanying:

- The conveyance foundation (e.g., transmission and appropriation lines, transformers, switches),
- The related dispersed vitality assets and the end-use frameworks,
- Management of the conveyance foundation and creation at the different dimensions of framework coordination (e.g., transmission and dissemination control focuses, local unwavering quality coordination focuses, national crisis reaction focuses),
- The data systems themselves (e.g., remote estimation and control interchanges systems, between and intra-undertaking correspondences, open Internet), and
- the regulatory environment and monetary that powers venture and propels leaders to obtain, execute, and keep up all parts of the framework (e.g., stock and security markets, government motivating forces, controlled or non-managed rate-of-degree of profitability) [12].

IV. CHARACTERISTICS OF SMART GRID

The primary qualities of smart grid are clarified underneath:

Empowers educated interest by clients

Buyers help balance free market activity, and guarantee dependability by changing the manner in which they use and buy electricity. These changes come because of shoppers having options that propel diverse buying examples and conduct. These decisions include new advances, new data about their power use, and new types of power valuing and motivators.

Suits all generation and capacity choices

A smart grid suits substantial, brought together power plants, yet additionally the developing exhibit of client sited circulated vitality assets. Mix of these assets – including renewable, little scale joined warmth and power, and vitality stockpiling – will increment quickly up and down the value chain, from providers to advertisers to clients

Empowers new items, administrations and market

Effectively planned and worked advertises productively make an open door for shoppers to pick among contending administrations. A portion of the free network factors that must be unequivocally overseen are vitality, limit, area, time, rate of progress and quality. Markets can assume a noteworthy job in the administration of these factors. Controllers, proprietors/administrators and shoppers need the adaptability to alter the tenets of business to suit working and economic situations.

Gives the power quality to the scope of requirements

Not every business undertaking, and surely not every single private client, needs a similar nature of intensity. A brilliant lattice supplies changing evaluations (and costs) of intensity. The expense of premium power-quality highlights can be incorporated into the electrical administration contract. Propelled control strategies screen fundamental parts, empowering fast determination and answers for occasions that sway control quality, for example, lightning, exchanging floods, line deficiencies and harmonic sources.

Advances resource use and working productivity

A smart grid applies the most recent advances to improve the utilization of its advantages. For instance, advanced limit can be achievable with dynamic appraisals, which enable advantages for be utilized at more noteworthy loads by ceaselessly detecting and rating their abilities. Upkeep effectiveness can be improved with condition-based support, which flags the requirement for gear support at unequivocally the opportune time.

Framework controls gadgets can be changed in accordance with diminish misfortunes and wipe out blockage. Working proficiency increments while choosing the least-cost vitality conveyance framework accessible through these kinds of framework control gadgets. [13].

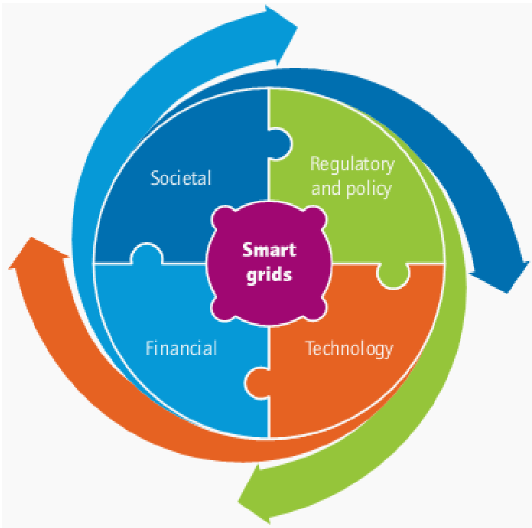

Figure 3: Smart grids can link electricity system stakeholder objectives

V. Smart Grid Framework

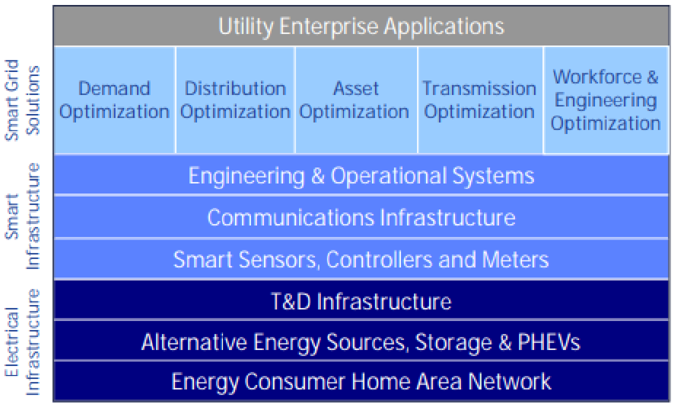

Figure 4: Framework of smart grid [14]

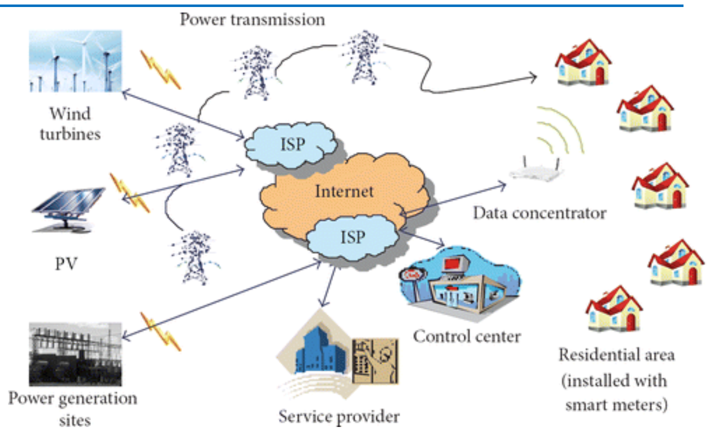

Figure 5: An example of communication architecture in smart grid [15].

VI. Components of a Smart Grid System [7]

Smart Substations:

Smart substations incorporate the observing and control of basic and non-basic operational information, for example, control factor execution, transformer and battery status, security and breaker.

Smart Power Meters:

Smart Power meters incorporate a tow path correspondence among shoppers and power suppliers. These are utilized for charging information gathering, recognize blackouts and dispatch fix groups to address area quicker. Keen power meters regularly hold a nearby connection between shrewd substation and smart appropriation.

Smart generation:

Smart Grid encourages power creation assets to advance energy generation, and to consequently look after voltage, recurrence and power factor guidelines dependent on input from different focuses in the lattice. Brilliant network gives widespread access to moderate, lowcarbon electrical power creation and capacity.

Smart distribution:

Smart grid is self-recuperating, self-adjusting and self-enhancing. It incorporates superconducting links for long-separate transmission, and robotized observing and examination instruments fit for distinguishing or notwithstanding foreseeing link and different disappointments dependent on continuous information on climate [7].

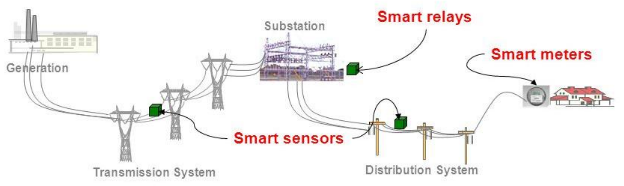

Figure 6: smart meater and sensor

VII. The Key Challenges for Smart Grids

 strengthening the grid—guaranteeing that there is adequate transmission ability to interconnect energy assets, particularly sustainable assets

 moving seaward—building up the most productive associations for seaward wind ranches and for other marine advances

 developing decentralized models—empowering smalller scale power supply frameworks to work agreeably with the all out framework

 Communications—conveying the correspondences framework to enable possibly a large number of gatherings to work and exchange the single market

 Active interest side—empowering all purchasers, with or without their own age, to assume a functioning job in the task of the framework

 integrating discontinuous creation—finding the most ideal methods for coordinating irregular age including private microgeneration

 Enhanced insight of generation, request and most outstandingly in the smart grid

 Preparing for electric vehicles—while Smart Grids

Must suit the necessities everything being equal, electric vehicles are especially stressed because of their portable and very scattered character and conceivable huge sending in the following years, what might yield a noteworthy test for the future power systems [9].

VIII. Smart Grid Advantage

Following are the benefits or advantages of Smart Grid:

- It lessens electricity theft.
- It lessens electricity losses (transmission, conveyance and so forth.)
- It lessens electricity cost, meter perusing cost, T&M tasks and upkeep costs and so on.
- It diminishes hardware failures because of programmed activity dependent on shifting burden conditions. Request Response decreases weight on resources of smart grid amid pinnacle conditions which lessens their likelihood of failure.
- It diminishes supported blackouts and lessens sequentially related reclamation cost.
- It diminishes air emanations of CO_2, SO_x, NO_x and PM-2.5. Thus shrewd matrix adds to keep condition green.
- It diminishes oil use and wide scale power outages. Thus smart grid gives security to the general population by giving consistent power.
- Smart grid is fit for satisfying expanded shopper need without including foundation [16].

IX. MODERN HARDWARE AND CONTROL FOR SMART GRID

Modern Hardware for Smart Grids	Modern Control Methods for Smart Grids
1 Power Electronic Devices • Unified Power Flow Controller (UPFC) • DVAR or DSTATCOM • Static Voltage Regulator (SVR) • Static VAR Compensator (SVC) • Solid State Transfer Switch • Dynamic Brake • AC/DC inverter 2 Superconductivity • First Generation wire • HTS cable • Second Generation wire 3 Distributed Generation • Microturbine • Fuel Cell • PV • Wind Turbine 4 Distributed Storage • Nas battery • Vanadium Redox Battery (VRB) • Ultra capacitors • Superconducting Magnetic Energy Storage (SMES) 5 Composite Conductors • Aluminium Conductor Composite Core Cable (ACCC Cable) • Aluminium Conductor Composite Reinforced Cable (ACCR Cable) • Annealed aluminium, steel supported (ACSS)	1 Distributed Intelligent Agents • Digital Relays • Intelligent tap changer • Energy management system • Grid friendly appliance controller • Dynamic distributed power control 2 Analytic Tools • System performance monitoring and control • Phasor measurement analysis • Weather prediction • Fast load flow analysis • Market system simulation • Distribution fault location • High speed commutating 3 Operational Application • SCADA • Substation Automation • Transmission Automation • Distribution Automation • Demand Response • Outage management • Asset optimization

Table 1 : Modern Hardware control table of Smart Grid[5]

X. Smart Grid Applications

There are different examples of smart grid applications including:

- Automatically closing down gear that isn't fundamental for brief timeframes to diminish control request. For instance refrigerators [16] can be incidentally turned off without influencing the sustenance contained inside at peak times.

- Programming gear to turn on when there is a respite in power request and abundance sustainable generation. Envision its evening and the power request is at its most reduced yet it is an especially blustery night and all the breeze turbines are creating at greatest yield. Rather than detaching this power or decrease yield at other power stations which can be costly and wasteful, the Grid could turn on clothes washer or dishwasher which has been stacked that night prepared
- Using the battery stockpiling limit of associated Electric Vehicles amid times of peak control request. As opposed to requiring extra power from costly momentary power plants, a smart grid could permit vehicle proprietors who wish to utilize their power put away in their vehicles batteries. When the power request decreases, the batteries would then be revived [19].

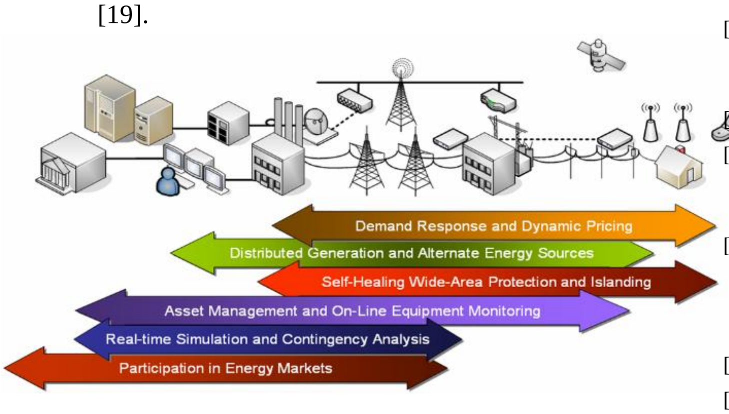

Figure 7: smart grid applications [18]

Figure 8: smart grid applications

XI. CONCLUSION

Smart grid, IntelliGrid, and secure smart grid terms are being utilized now in these days to depict advancements that consequently and quickly seclude issues, reestablish control, screen request, and keep up and reestablish solidness for increasingly dependable generation, transmission, and conveyance of electric power [6].

A smart grid is an umbrella term that covers modernization of both the transmission and conveyance frameworks. The idea of a smart grid is that of a "computerized overhaul" of dispersion and long separation transmission frameworks to both streamline current activities by lessening the losses, just as open up new markets for elective vitality creation [8].

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Benefit Category	Benefit Sub-category	Benefit
	Market Revenue	Energy Revenue
		Capacity Revenue
		Ancillary Services Revenue
Economic	Improved Asset Utilization	Optimized Generator Operation
		Deferred Generation Capacity Investments
		Reduced Ancillary Service Cost
		Reduced Congestion Cost
	T&D Capital Savings	Deferred Transmission Capacity Investments
		Deferred Distribution Capacity Investments
		Reduced Equipment Failures
	T&D O&M Savings	Reduced T&D Equipment Maintenance Cost
		Reduced T&D Operations Cost
		Reduced Meter Reading Cost
	Theft Reduction	Reduced Electricity Theft
	Energy Efficiency	Reduced Electricity Losses
	Electricity Cost Savings	Reduced Electricity Cost
Reliability	Power Interruptions	Reduced Sustained Outages
		Reduced Major Outages
		Reduced Restoration Cost
	Power Quality	Reduced Momentary Outages
		Reduced Sags and Swells
Environmental	Air Emissions	Reduced CO2 Emissions
		Reduced SOX, NOX, and PM-2.5 Emissions
Security	Energy Security	Reduced Oil Usage
		Reduced Wide-Scale Blackouts

Table 2: smart grid benefits [17]