# Innovation of Power System in India

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**ABSTRACT**
*Power system has significant growth in interest and investment in the India. All activities have led to innovations and developments that simultaneously give power system engineers different challenges and oppurnities.The aim this paper to focus on recent innovations and future outlook of the Indian power systems. Such innovation include: Husk power system, Smart Grid and Renewable energy resources.*

***Keywords:*** Husk power system, Power system, Smart Grid, Renewable Energy.

## I INTRODUCTION

India is currently one of the world's fastest growing economies with the interest from investors across the globe. At the same time the appetite for energy has left the country hard pressed. Many part of the country still face blackouts and in same villages there is no experience of power. The Indian Government does recognize the impending Energy-Crisis that the Country's growth can faced.

According to International Energy Agency, India relies on coal for about 40% of its total energy consumption, oil for about 24%, and natural gas for 6%, according to the International Energy Agency.

But the country is looking beyond fossil fuels; at nuclear energy and renewable energy in a big way. At the same time, India is looking at the "Smart Grid" also. So what is Smart Grid?

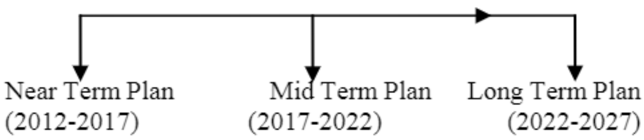
Smart Grid is an automated widely distributed energy delivery network characterized by a two-way flow of electricity and information, capable of monitoring and responding to changes in everything from power plants to customer preferences to individual appliances [1].We can also define Smart Grid as: Electricity delivery system (from the point of production to the point of consumption); integrated with communication and information technology. To better understand smart grids, we can look at the features:

(a) Fully automated power delivery network for monitors and controls electricity flows.
(b) Two-way flows of electricity and information between the power plant and the point consumption.
(c) Lowered carbon footprint and reduced emissions; increased access to renewable energy resources (like solar and wind).
(d) Use of digital technology to save energy, reduce cost and increase reliability.
(e) Improved power quality as per the need of 21st century economy.
(f) Reduced disruptions, improved efficiency and better asset utilization.

Individual categories of innovation discussed in this paper will include Husk power system, renewable energy particularly wind energy – and plug-in hybrid electric vehicles (PHEV) along with electric vehicles (EV). Another key component of the Smart Grid-related innovations is the recent developments in communication that enables intelligent components of the power system to work together to achieve system-wide intelligence.

## II DRIVERS OF INNOVATIONS IN POWER SYSTEMS

The effect of Smart Grid towards Indian power sector is promising and fore sighting to transform and develop secure, adaptive, efficient and sustainable system by 2027 to provide the citizens with reliable and competitive energy by usage of innovative technologies and policies to fulfill the needs and aspirations of all by active participation of stake-holders. Smart Grid has a very wide view towards the future and is passionately progressing to achieve the targets and goals propagated in the five year plans [1]. These five year plans are divided as:




**(a) The focus of the "Near Term plan" (2012-2017) is :**
(i) Renewable integration.
(ii) Wide Area Monitoring.
(iii) Reduction in Power Cuts.
(iv) Efficient Power Exchanges.
(v) Access to "electricity for all".
(vi) Improvement in Power Quality.
(vii) Increase in inter-regional power exchange capacity.
(viii) Reduction of Transmission & Distribution (T&D) losses below 15% in all utilities.
(ix) Standards for smart appliances- energy efficient and Disaster Recovery (DR) ready.
(x) Training and capacity building in utilities and in the industry to build operate and maintain smart grid systems and application. This time period will see some smart grid pilot projects, low cost smart meter specifications finalization and testing: 2012-13, Verification of technology trials in terms of scalability, sustainability and rollout of smart grid projects in major metros.

**(b) The goal of the "Mid Term" plan (2017-2022) is:**

(i) End of load-shedding.
(ii) Improvement in power quality.
(iii) 1200kV AC system in operation.
(iv) Infrastructure and standards for Electric Vehicles.
(v) Efficient forecasting and dispatching of renewable.
(vi) Reduction of T&D losses to below 10%in all utilities.
(vii) Mandatory standards for appliances regarding readiness, energy efficiency and emission.
(viii) Export of Smart Grid products to overseas. This time period will see Smart Meters for all new connections all across the country, Demand Response for peak load management to avoid power cuts, systems for load forecasting and generation forecasting integrated with weather forecasting, Outage Management Systems and Mobile Crew Management systems, Utility wide smart grid roll-outs in select utilities– metros and large urban areas and Smart (Green) Buildings integration with utilities.

**(c) The "Long Term" plan (2022-2027) will look at :**

(i) Economically viable utilities,
(ii) Stable 24x7 power supply to all,
(iii) 33% or more renewable in power system,
(iv) EV infrastructure leveraged as Virtual Power Plant (VPP),
(v) Export of Smart Grid products, solutions and services overseas.
(vi) IT network and CRM system for electric utilities provided to other service providers such as water and gas distribution, land revenue collection, etc.During this time period, the industry will experience utility wide smart grid rollout in all major utilities, Real time pricing- price signals and choice of tariff plans to all categories of customers, Smarter Cities– Utility Corridors that can leverage common field infrastructure for automation and control of electricity, water, gas an district cooling/heating networks; common control and command centers, automated mobile crew systems etc, Robotics for live-line maintenance and Trials of superconductivity (HTSS).The plans for beyond 2027 include:
(vii) Smart utilities managing other pieces of vital infrastructure sector. For example, water and gas distribution and surface transport, etc.
(viii) Electrify almost all economic activates including transport and much of agricultural process and decarbonizes the power sector through dramatic increase in renewable and nuclear carbon capture and storage technologies. While India is trying to take its first steps in the Smart Grid area, Ontario State in Canada has already managed to go through the learning cycle of the initiative [1] .

**(d) Plans of HPS in India**

Husk Power Systems is a rural empowerment enterprise. It focuses on inclusive rural development on the backbone of electric power. Unlike any other effort in the world, it creates a self-sustaining ecosystem in the villages it serves, enabling economic development along with environmental protection, physical well-being and strengthening. .

A humble effort spearheaded by locals from the communities served, HPS strives to touch more than 10 million lives over the next five years, in rural areas across the world, often at the bottom of society's priorities. A business of rural electrification that transcends the conventional ideas around delivery of electrical energy to masses, HPS has created unique models of decentralized electricity generation and distribution that can be well managed by the locals using local resources, thereby bringing the age old wisdom of self-sufficiency.

HPS is a revolution in progress that attempts to channelize the largely dissociated efforts of various stakeholders - communities, investors, entrepreneurs, businesses, government and the society at large - to bring the worldwide impoverished and under-served rural population from the bottom to the top of the list of priorities.

**(e) Plans for Renewable energy resources in India**

"Promoting freedom from Fossil Fuels…but the time is running out…soon, there will be nothing left to burn on the earth but earth itself".

This is the new take on freedom and green activism for energy consumers and policymakers in India, courtesy the Indian Renewable Development Agency (IREDA), whose website forecasts a fiery death for planet earth. IREDA is merely following the enduring fashion of modern times, one of global green activism and a strongly held belief in the coming era of a new energy revolution. In this twenty-first century coup, clean and green renewable energy sources will soon banish dirty and polluting fossil fuels into the trashcan of history. Some are even convinced that a new messiah will do to renewable energy what John. Rockefeller did to oil and Bill Gates is doing to computers! This global fever is now entrenched firmly in the Indian policy-making establishment.

By the time the Y2K virus slipped into oblivion in 2000, renewable energy sources accounted for 2,000MW of installed capacity in India's power generation sector. This works out to about two percent of the total electric power generation capacity in the country. The Ministry of Power has now set very ambitious targets for the renewable sector; the capacity is slated to go close to 11,000 MW, or, more than five percent of the total electric power generating capacity in India. Look at the renewable ambitions from another angle. During the 1990s, the average annual addition to capacity was about 150MW. In the next ten years the average annual addition to capacity is slated to leapfrog five times to about 750MW [3]. India has abundant untapped renewable energy resources. Abundant access to solar energy that can be harnessed, an expansive coastline and numerous rivers and waterways position the country as an ideal marketplace for renewable energy technologies. These conditions are amply supported by excellent R&D capabilities and policies designed to accelerate the development of renewable energy technologies [4].

## III SMART GRID AND ITS MAIN COMPONENTS

**(a) Task performed by Smart Grid :**

The Smart Grid is defined by [1] as an electrical grid that can perform the following tasks:

(i) Integration of ''smart'' appliances and consumer devices.
(ii) Provision to consumers of timely information and control options.
(iii) Dynamic optimization of grid operations and resources
with full cyber-security.
(iv) Deployment and integration of distributed resources and generation, including renewable resources.
(v) Development and incorporation of demand response, demand-side resources, and energy-efficiency resources.
(vi) Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.
(vii) Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.
(viii) Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning.
(ix) Deployment of ''smart'' technologies (real-time, automated, interactive technologies that optimize the physical operation of appliances and consumer devices) for metering, communications concerning grid operations and status, and distribution automation.
(x) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services. This means that several fields of technology and engineering can validly claim to be part of the Smart Grid, including power systems analysis, telecommunications, control systems, artificial intelligence, etc. In its current state, the Indian power system requires upgrades and careful implementation at all its main components in order to meet the Smart Grid qualifications above.

**(b) Distribution and Substation Automation**

The distribution system is the part of the power system that most directly affects the customer's experience, as well as being the level Figure 1. Distribution and Automation of electricity where most of the small-scale disturbances occur. Figure 1. shows Distribution automation schemes have been proposed, simulated, and in some cases implemented in order to improve reliability and optimize system operations. The long-term goal for distribution automation includes self-healing systems, optimized operating conditions, and reduced customer disruptions in fault conditions. A sample of published research on distribution automation systems can be found in references Substation automation is a sub-area that allows for reliable communications and operation of substation equipment. Since all distribution systems originate at substations, a reliable [6-9].

Substation system is essential. Current applications of substation automations rely on a normalized set of communication standards such as IEC 61850, GOOSE message formats, DNP3 protocols, etc., to ensure that automation projects can work with multiple vendors and successfully integrate into the overall power system. An example of visions for the automated distribution system can be seen in reference [10].

**(c) Advanced Metering and Metering Communications**

The term "Advanced Metering" refers primarily to demand meters that have two-way communication capabilities, which allows for greater load control by the utilities and cost control by the customers. Newer meters going to be installed in the India have some communication capabilities already, thanks to automatic meter reading (AMR) implementations in the past decade. Advanced metering infrastructure (AMI) is a to pick that includes studying communication schemes and standards in order to avoid data congestion and increases reliability [11].Figure 2 shows.

**(d) Plug-In Hybrid Electric Vehicles (PHEV) and Electric Vehicles (EV)**

Plug-in vehicles – both PHEV and EV constitute an interesting challenge and opportunity for power systems studies in the India. It is expected that electric vehicles will grow over the next decades, and that the growth will place a great strain on the power system due to the increased charging demands. There are currently very few plug-in vehicles on the road in the India, but that will soon change with the debuts of mass-production models from several manufacturers. There have been several predictive and simulation-based studies on the topic of PHEV and EV penetration into the market, and the next few years will provide opportunities to test those hypotheses. The key to integrating PHEV and EV into the system is controlled charging, and to a lesser extent, Vehicle to-Grid (V2G) potentials.

**(e) Renewable Energy Resources**

Renewable energy resources are possibly the most important aspect of Smart Grid. The most popular – and cost-effective –type of renewable energy in use today is wind energy. (This does not include hydroelectric and nuclear generation in the renewable category).Wind and Solar energies are the most commonly used renewable resources, and each of them exhibit unique dynamic properties that affect the power system in different ways as seen in [12] and [13].Figure 3 shows renewable energy resource.

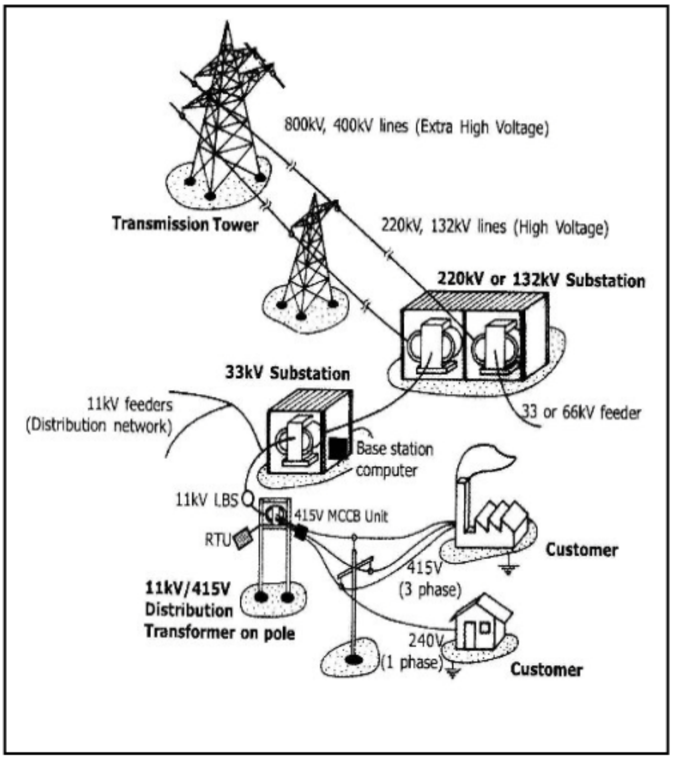



Fig 1

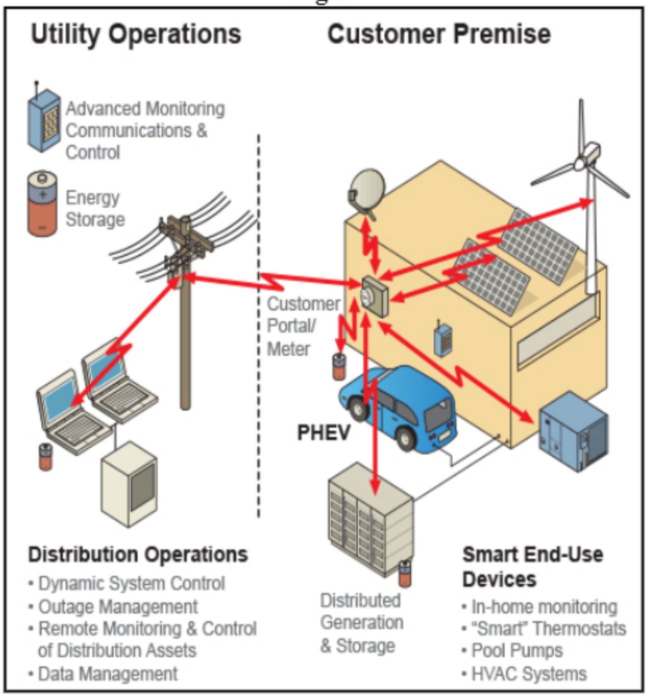



**Fig 2 : Advanced Metering and Metering Communications and Plug-In Hybrid Electric Vehicles and Electric Vehicles.**

## IV HUSK POWER SYSTEM AND ITS APPLICATION

Husk Power Systems designs, installs and operates biomass-based power plants. Each plant uses proprietary gasification technology to convert abundant agricultural residue (procured from local farmers) into electricity, which is then distributed to rural households and micro-enterprises through a micro-grid system – providing a better quality, cheaper way to meet their need for energy.HPS creates an ecosystem around each plant by providing income generation opportunities to local farmers and entrepreneurs. Additionally, it creates employment through its livelihood programmes such as the incense stick manufacturing program which largely employs women.

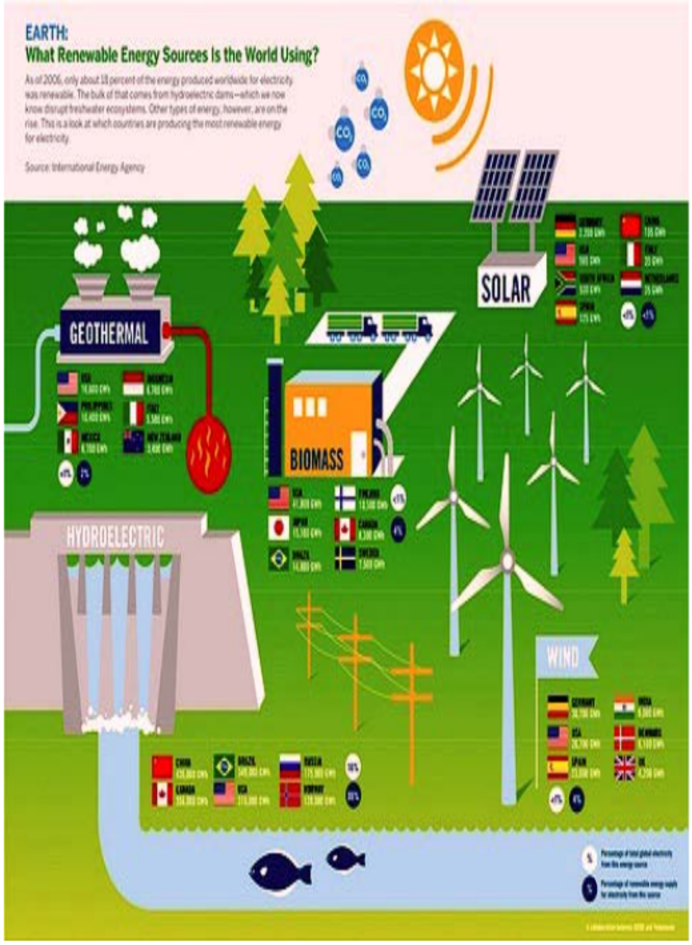



**Fig 3 : Renewable energy resources (solar, wind, geothermal, biomass).**

This enables sustainable development within the communities HPS serves. Since 2008, HPS has successfully installed more than 80 plants in Bihar, providing electricity to over 200,000 people across 300 villages and hamlets.HPS provides end-to-end renewable energy solutions by installing 25-kW to 100-kW 'mini power plants' and then wiring villages and hamlets of up to 4000 inhabitants to deliver electricity on a pay-for-use basis. It uses a biomass gasification based proprietary electricity generation process, that generates electricity using 100% producer gas based system ("single fuel mode") and distributes electricity directly to households and small businesses while keeping costs low by running insulated wires along bamboo poles to subscribing households, businesses and farms. Its Total Landed Cost of Installation < $1,300 per kW and Operational Cost is < $0.15/kWh

In just four years HPS has installed 84 mini-power plants, providing electricity to over 200,000 people spread across 300 villages, and employing 350 people operating across the state of Bihar.

Each plant serves around 400 households, saving approximately 42,000 litres of kerosene and 18,000 litres of diesel per year, significantly reducing indoor air pollution and improving health conditions in rural areas. By extending village life beyond day light hours, HPS promotes economic development by enabling businesses to stay open after dark and allowing children to study at night. HPS creates an ecosystem around each plant by providing income generation opportunities to local farmers and entrepreneurs. Additionally, it creates employment through its livelihood programmes such as the incense stick manufacturing program which largely employs women. This enables sustainable development within the communities HPS serves.

## V CONCLUSION

As seen in various references for this paper, there are several Smart Grid and other power systems projects funded by the Indian Government. The largest implication is that in a few years there will be an infrastructure that provides measurements, data, and communication paths. The next step would be to find applications that use these infrastructures to achieve the stated goals for Smart Grid. The future developments that are of interest to the authors include PHEV/EV integration, renewable energy integration, the impact of Smart Grid on power systems education, and the development of new schemes to utilize HPS.The applications of recent innovations have already begun to bear fruit in terms of existing projects meeting their stated goals. Each area in the Indian power system is incrementally improving reliability and customer experience thanks to the additions of new technologies. Some technologies are: a transmission corridor improves its voltage profile and increases its capacity. These innovations are tools that provide power system engineers with the ability to solve problems in different ways and increase the efficiency of the power system. It is the collective responsibility of engineers, educators, and policy makers to create an environment where future innovations can grow around the infrastructures that are being put in place.

## VI FUTURE OUTLOOK

India's transmission grid is in urgent need of expansion and improvement. According to industry sources, utilities worldwide will spend US$ 378 Billion in Smart Grid technologies by 2030 and India, the third largest smart grid investment market, is set to install 130 million Smart Meters by 2021. At present, the market in India is nascent with only few smart meters roll outs so far. But this situation is expected to change and gather pace from 2012 onwards. Apart from smart meters, the investment will be geared towards grid automation, communication infrastructure, IT systems and hardware; home area network, and system integration. India Smart Grid spending is likely to touch about Rs. 9,500 crore by 2015 from the current level of Rs. 5,500 crore. However, investors in India are deterred by the sector's financial weakness, public ownership of utilities and bureaucratic delays [15]. The PHEV/EV integration holds promises and challenges to power systems operations. They represent potentially large and unpredictable loads to the power system if they're added to the system in an uncontrolled manner. [16] A utility that is equipped with advanced metering capabilities can reduce the impact of PHEV/EV and even turn it into a scheduling asset. This can be done by communicating charging availability between vehicles and the grid, thus ensuring that the charging is minimal during peak load conditions and the base load units have better utilization during low load periods. [17] In addition to peak load management, PHEV/EV can act as small-scale energy storage units with vehicle-to-grid (V2G)schemes [18].Renewable energy integration is of interest for the fact that renewable energy resources are not easily controllable. Wind and sunlight do not operate on a schedule. This presents challenges in addition to the dynamic and static performances of generators using these resources. Several other factors are involved in the future of renewable energy as well. The Indian wind energy sector has an installed capacity of 17,365.03 MW (as on March 31, 2012). In terms of wind power installed capacity, India is ranked 5th in the World. Today India is a major player in the global wind energy market. The potential is far from exhausted. Indian Wind Energy Association has estimated that with the current level of technology, the 'on-shore' potential for utilization of wind energy for electricity generation is of the order of 102 GW. The unexploited resource availability has the potential to sustain the growth of wind energy sector in India in the years to come [19].The impact on power systems education is not immediately clear. It is obvious that the coursework has to keep pace with the new technological advances and prepare the students for a changing industry. This may also mean a greater cooperation and integration with experts in other fields such as intelligent controls, automotive engineering, transportation engineering and mechanical engineering. In the India, there is a projected shortage in the power systems workforce due to upcoming retirements and low enrollment in previous years. This problem has been momentarily delayed due to the economic downturn keeping many engineers and researchers from retiring early, as well as forcing companies and universities to freeze hiring. This has a potential to become a large problem because each person who currently works in power systems has to learn new job functions and work on integrating new technologies, making training and replacement more difficult. At this time, there are ongoing projects at a few utilities that are attempting to use HPS, Renewable energy resource like solar, wind and hydro. Other special protection schemes and remedial action schemes are also being investigated. The regional independent system operators –companies that manage transactions and transmissions in areas with many utilities – are requiring more HPS to be installed by the local utilities, which reinforces the point about the growth of an infrastructure waiting for applications to catch up.

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