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Transforming Power Distribution Systems in J&K State

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***Abstract*—**With the emergence of new technologies in distribution systemsandadvancementsin computational techniques/algorithms to ascertain optimal size and position of the distributed generation systems using renewable energy resources for their integration with the grid, the power distribution systems may be completely transformed to meet the 21st Century needs.Accordingly, to improve the power delivery system with minimum losses , in this paper, a 'Model Distribution System' has been proposed for a pilot town in J&K State after carrying out a detailed system study and evaluation of latest technological advancements worldwide.The said system incorporates the advanced smart grid technologies along with inclusion of renewable whose penetration level has been computed/ derived through simulationstudiesusing heuristic approach. Further, the pilot area considered in this paper being a major tourist destination, other electrical works which improve the aesthetic view of the area are also part of the proposed distribution system.

***Keywords*—**AMI; AT&C loss; Automation; Distributed generation; optimal penetration; PLM; smart metering

Introduction

One of the major issues of Power generation in J&K State is its sole dependence on Hydel power plants whose generation drastically reduces in winters due to lean discharge in the rivers and precisely during the same period the power demand surges high. Thus, the State becomes perpetually energy deficient during winters, compelled to import power from the thermal generators situated in the neighboring states. With the vision to improve the power scenario in the State, a holistic view of all the entities of power sector viz. Generation, Transmission and Distribution was taken under joint initiative of Government of India and Govt. of J&K State in the year 2015 to formulate a roadmap for making 24x7 Power For All (PFA) available for the consumers of the state. The system study revealed that besides generation, there are constraints in transmission network as well, which is inadequate to evacuate power from generating stations. Consequently, the State has to surrender power in peak seasons when the hydel generators produce to their full potential. Likewise, in the power distribution sector, the underlying network is highly obsolete and has surpassed its life, leading to system outages and forced curtailments on frequent basis. The State has although undertaken massive capacity addition works in all segments under different flagship schemes in line with the said roadmap yet non-reduction of AggregateTechnical &Commercial (AT&C) losses, as expected has been the matter of serious concern. TheAT&C losses in the State were of the order of 64% at the time when the roadmap was prepared [1], a level far higher than the National average, which has marginally been reduced to 61.34 % this year.It was therefore inferred that unless the loss levels are contained within acceptable limits, system additions alone are worthless, therebynecessitating the need of exploring other measures[2]. Further, it was found out that the losses at transmission level formed only 4.12% of the total loss figures while the remaining 57.22% were being incurred in power distribution system. To determine the exact reason for the same, details of distribution system in one of the commercial towns of the State was taken as a sample. The data revealed that out of the total AT&C loss of 53% in the aforesaid sample town, losses of 24% were attributed to technical losses &remaining 29% were the commercial losses. This clearly implies that besides technical inadequacies due to long LT lines, obsolete and undersized infrastructure, high value of commercial loss forms a major role in increasing the overall loss, which is largely accredited to power pilferage in the State. This also leads to significant wastage of power as 'Free Power is never conserved'. Thus, the weakest link in the entire value chain of power supply is the distribution network,

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which makes it imperative to implement both technical interventions as well as structural reforms.

It is worth mentioning that steps are being taken to improve the distribution sector from the last decade. Administrative measures like formation of a definitive regulatory framework were taken by GoIalongside enactment of Electricity Act 2003, National Electricity Policy 2005 and National Tariff Policy 2006 and other important regulations. On the lines of the said regulations, Electricity Act 2010 was launched by J&K State, which governs the power sector in the State today. Besides structural reforms, the Govt. has also taken technical measures with the launch of APDRP scheme (Accelerated Power Development and Reforms Programme) specifically focusing on bringing down the AT&C losses by improving the HT/LT ratio, replacement of electro-mechanical meters with tamper proof electronic meters and strengthening the distribution network. Soon after, another initiative, named Restructured Accelerated Power Development and Reforms Programme (R-APDRP) was launched with inclusion of IT initiatives for the first time. The scheme is in implementation phase in the State and measures like High Voltage Distribution System (HVDS) to eliminate LT lines, Aerial Bunched Cables to make the conductors pilferage free, metering at all levels from feeders, DTs to consumers and establishment of Data Centers have been taken. The scheme however caters to the towns with population more than 10000. In the remaining towns, Integrated Power Development Scheme (IPDS) has been launched in urban areas on the same lines and DeenDayalUpadhyayaGrameenJyotiYojana (DDUGJY) in rural areas which also includes feeder separation for agricultural consumers. Recently, a special package, namely 'Prime Minister's Development Package' has been granted to J&K State in Transmission as well as Distribution sector.

However, with the emergence of latest and more sophisticated technologies, a lot more is required to be done in respect of system automation as the present system is still the conventional one with minimal communication. The dire need at present is to replace the metering infrastructure to bring the unaccounted energy into use with effective communication capability. The communication network ensures a stable supply of electricity. Particularly, for J&K State, which has a long history of natural disasters; and is still a multi hazard prone region susceptible to earthquakes, floods, landslides, avalanches, high velocity winds, snow storms, terrorist acts etc., a secure communication network is essential for speedy power restoration. The need of a reliable communication network in power systems was felt when the power supply in the State, specifically in Kashmir valley was severely disrupted due to floods in September 2014, the absence of communication systems between the sub-stations and the control center delayed the restoration of power supply. Likewise, in the month of January 2013, heavy snow-fall in Kashmir resulted in snapping of 400 kV & 220 kV transmission lines, which caused complete black-out in valley for two days. The absence of a strong communication system at the sub-stations prolonged the restoration of power supply to important installations of Kashmir. An effective communication is also essential to integrate the Renewable energy resources with the existing Grid. Since the consumers have now started to incline towards the renewable energy resources. The number of customers installing rooftop solar generation or owning plug-in hybrid or electric vehicles is gradually increasing. However, the high penetration of such devices creates new dynamics for which the current equipment in distribution systems is inadequate. Rapid fluctuations of power output from distributed renewable resources causes severe voltage control problems [3]. Therefore, it is essential to integrate these generators with the existing Grid, which is possible only through the adoption of Smart Grid technologies. As such, in this paper, a 'Model Distribution Network' is proposed which encompasses these system inadequacies.

Proposed 'Model Distribution System': Case Study

Smart Grid technologies are surely the answer to our traditional and ill-equipped electrical systems which have declining reliability. However, the implementation of smart grid technologies shall be far more effective/ successful if we are able to motivate and attract the consumers by showcasing consumer-centric benefits rather than utility centric benefits.

As a case study, Katra town in J&K State has been taken in this paper wherein a Model Distribution system has been designed to ensure reliability of power by adopting Smart Grid technologies including Renewables as well as beautification of town through electrical infrastructure.

Katra is one of the busiest towns in Jammu and Kashmir State and holds strategic importance for its National and international tourism as it serves as the base camp for pilgrims visiting the holy shrine of 'Vaishno Devi'. The town is dotted with plenty of hotels, guest houses, and restaurants, various socio-cultural centres, commercial centres etc. owing to its thriving tourism. The town, because of its dense population and massive number of tourists, faces challenges to provide reliable electricity supply.

Current Scenario of Katra:

Presently, Katra town is fed from two 33/11 kV sub-stations, namely Tarakote Substation (near Banganga Check post) having (2X6.3+1X3.15) MVAcapacity andKatra Substation (on Domel- Katra Road) having 2X10 MVA capacity. A total of two 11 kV feeders emanating from Tarakote Sub-station feed Katra town and eight 11 kV feeders emanate from Katra Receiving Station.

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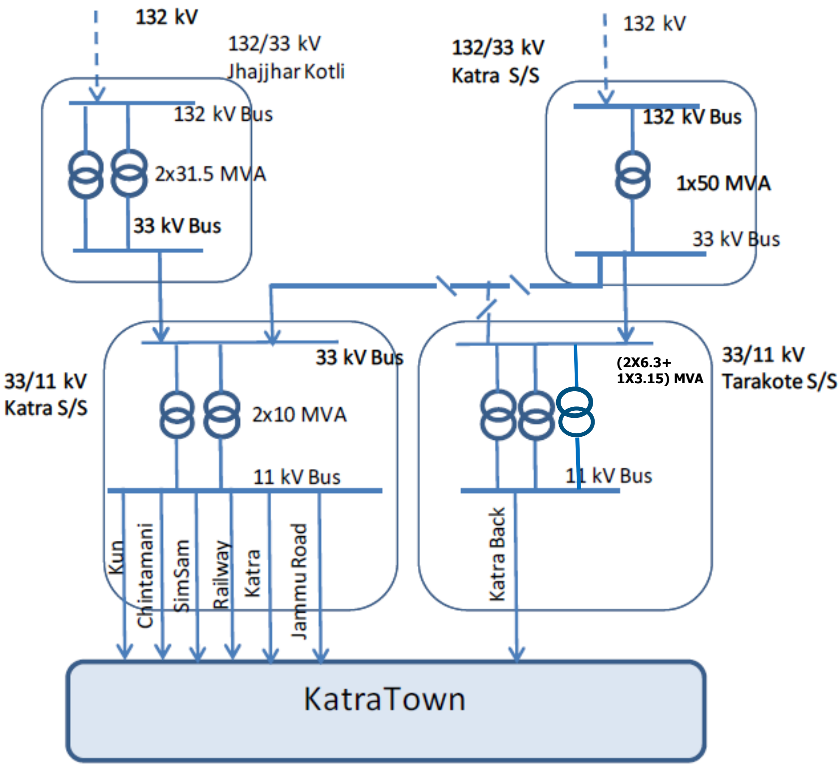

Fig 1. Schematic Diagram of Katra

The total number of consumers in the town is 4916.The consumer profile of the town in tabulated below:

Table 1: Consumer Profile of Katra town

11 KV Feeder	Domestic	Commercial	State/Center	Industry	PHE	Street Light	Bulk	Grand Total
Katra	245	406	13	1	0	-	5	670
Jammu Road	205	392	0	0	1	-	7	605
Kun	901	650	9	5	0	4	1	1570
Chintamani	748	484	9	3	0	-	-	1244
New VD	5	53	1	0	0	1	4	64
Old VD	156	522	1	0	0	1	1	681
PHE Shrine Board	10	0	0	0	5	-	-	15
Katra Back	18	42	2	0	0	-	2	64
PHE Dhansar	0	0	0	0	1	-	-	1
SimmSamm	0	0	0	0	0	-	2	2
Total:	2288	2549	35	9	7	6	22	4916

It is worth noting that 51.85% of the consumers are from Commercial Category.

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Key findings:

Going by the present parameters, Katra has an annual load growth of 5% and incurs high AT&C losses to the tune of 53%, which is far higher than the National Average of 22%. The present Peak Demand is 24.6 MVA whilst the average DT failure rate is as high as 8.67% per annum. The distribution infrastructure is in poor condition and has exceeded its life. The metering system in the town is also obsolete and Revenue Collection system is typically old. Moreover, the present distribution system is critically loaded and is unable to sustain the growth in demand expected in near future. Overloaded system is resulting into frequent interruption of supply, poor voltage profile & high technical losses. The associated communication systems to ensure system reliability and management are also minimal.

As such, establishing a robust, highly reliable, automated power distribution systemwhich will be self-sufficient as well as self-healing while preserving the aesthetic aspect of the town in order to make it a world class tourist venue is absolutely essential.

Proposed System components:

The Power Distribution system designed herein is a hybrid one with integration of Renewables:

1. System Strengthening:

a) Capacity addition at 33/11 kV Katra Sub-Station is required. Additional Power Transformer of 10 MVA capacity is being proposed to meet the load requirements.

b) **Ring Main Units for feeders:** Ring Main Units (RMUs) are being proposed for easy location of faults and their re-configuration with minimum downtime & without manual intervention as the RMUs will provide the control and monitoring of networks from remote central point. In case of failure of main feeder, the power supply to the town will not stopped but will flow from another source and this switchover will be made within a moment. The RMUs will also protect the transformers and cables from over voltages, short circuits, earth fault conditions etc. through automatic Isolators & circuit breakers, thereby reducing power outages and improving power delivery mechanisms.A total of 11 Ring main units (RMU) 3 way are being proposed for fast and safe feeder interchange from Grid S/stn, 18 Ring main units (RMU) 3 way are also being proposed along 11 KV feeder length from Katra Sub-station, 25 Ring main units (RMU) 3 way and 6 Ring main units (RMU) 4 way are also being proposed at along 11 KV feeder length from Tarakote s/stn.

c) **LT side Protection:** LT distribution box with MCBBs of suitable ratings may be provided for all DTsunder 400 KVA rating (173 in this case) for DT protection and control of outgoing LT circuit.

2. System automation through Smart Grid Technologies [5]:

a) **Advanced Metering Infrastructure (AMI):** Most of the consumers in Katra town are either un-metered or have defective energy meters. Billing is therefore done on assessment basis, thereby leading to the misuse of electricity. A smart metering mechanism is essential to bring this unaccounted energy into the system [6]. The Smart meters completely eliminate manual interface and facilitate two-way communication which will help the consumers to manage their load resulting in reduction of their electricity bills and long-term cost savings. In addition, the energy consumption data from DTs and Consumers is sent to control centre which may be audited to control theft. The control centres established at Jammu (DRC) and Srinagar (DC) cities under R-APDRP scheme may be utilized. A total of 4916 smart meters are required for the existing consumers. In addition, 420 AMR meters are required to be installed on Distribution Transformers (410) and 11 kV feeders (10).

b) **Smart Collection Mechanism:** The present collection efficiency is poor due to unavailability of consumer-centric billing and collection systems. With establishment of Smart collection mechanism, the collection efficiency will increase in a comprehensive manner by implementation ofe-payment centre, e-mail/SMS based billing, and drop box based collection facility, online payment and other innovative means.

c) **Outage Management System:** Presently, the fault locating methodology is conventional and results into prolonged outages/ power interruptions. Creation of outage management system which incorporates sensors to detect outages, devices to allow parts of the grid to make automated repairs to itself will drastically reduce the restoration time rather minimize it to the level of several seconds. Thus, a more reliable distribution system by way of faster and more accurate response times to power system outages will be established in the town.

d) **Peak Load Management System (PLM):** The management of peak demand may be done using Smart meters, which have been proposed as a part of advanced metering infrastructure. During peak load conditions, two-way communication facility available with smart meters will send alters to consumers for reducing load and also send a variable price signal (intra-day variable tariff) to consumers to encourage them to use power during non-peak hours (low price of power). Consequently, load curtailment will reduce the power consumption by users. Users below the load allowed at that time shall remain connected and if their consumption exceeds the allowed level, they will be disconnected after due warning. This technique will also help in reduction of the loads in the

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form of inverters and batteries, which has a big share in total load in the town.

3. Improvement of Aesthetic view of town:

a) **Converting the overhead network with underground cables:** The 11 kV and LT lines being overhead often get snapped due to the damage caused by monkeys and also due to extreme weather conditions such as high wind, thunderstorms, heavy snow etc. owing to mountainous topography of the town. As such, underground cabling will make the Power lines less susceptible to outages, thereby providing quality power supply throughout the year, under all weather conditions. Moreover, the underground wiring will also preserve the aesthetic view of the town. In addition, a provision for ducting may also be kept so as to accommodate future modifications and for laying works by other agencies.

b) **Packaged Sub-stations:** Packaged Sub-stations may be installed in place of the conventional / existing Distribution Transformers along the main road since they are compact, easy to install and maintenance free, thereby ensuring trouble-free operation while preserving the beauty of the area.

c) **PAD mounted Distribution sub-stations:** PAD mounted distribution transformers are being proposed in the lanes/ sub-lanes.

d) **Installation of Ornamental/ Decorative poles for Street Lighting:** To present a picturesque view to the tourists visiting the town, external illumination in the town roads as well as the important places may be given prime importance. Therefore, ornamental poles for street lighting are being proposed herein.

4. Inclusion of Renewable Energy Resources: Renewable energy/ Green energy can be a key factor/ trump card to lure the consumers to adopt and contribute to smart grid technologies. Frequency Support Ancillary Service (FSAS) can be used to complement the daily changes in the renewable generation [6].The details of Renewable Energy Resources being deployed along with their location and size as derived through simulation studies are given in Table 2.

Table 2. Detail of Planned RE penetration

	Solar PV1 MW Plant	1 LS
	Solar PV of 3 kWp for distributed generation	185
	Wind Energy Plant 1MW	1 LS
	Bio Gas Plant	1 Number

a) **Solar PV Plant:** 1 MW Solar Plant may be set-up near Banganga.

b) **Solar Roof Tops:** Encouraging solar roof-tops, especially in Katra town which has hilly terrain, may bring about a big share of un-used solar power to our existing available energy. Installation of 3kWp Solar PV rooftops on all Government buildings, a total of 185 units will be required. Thus, additional 185 smart meters will also be required.

c) **Wind Energy Plant:** Harnessing the wind is one of the cleanest, most sustainable ways to generate electricity as wind power produces no toxic emissions and none of the heat-trapping emissions that contribute to global warming. High winds often blow (ranging up to 7 mph) in Katra town making it convenient to use this abundant energy resource. As such, Wind Energy Plant of 1MW may be set-up. The Wind energy plant may be set-up near Railway Station of Katra.

d) **Bio-Mass:** With majority of consumers being from commercial category, additional energy may also be generated by converting waste to power by utilizing the 'horse dung' as the town has numerous ponies for transporting materials uphill and also pilgrims often ride / hire ponies to complete the holy trek. This will contribute to environmental improvements as well by cleaning the town. There is ample space near the new yatra track for establishment of Bio-Mass plant.

Table 3. Quantum of Wastes for Bio-Mass Plant

Food / Kitchen Waste	50 tons/day
Horse/Mule excreta	45 tons/day
Total Waste	95 tons/day

The estimated Biogas generated with the available 95 tons/day organic waste is 11,400 m^3/day and equivalent to 11 MWh/day or 4.0 MU per year.

5. Micro SCADA System: Substation and Distribution Automation through SCADA system.

6. Electric Vehicles: Battery operated vehicles are already in use in small stretch of the yatra trek in shrine area. Use of similar plug-in Electric vehicles in the town area will reduce consumption of petro fuels and make environment clean. In addition, batteries installed in Vehicles may be used for storing energy during non-peak hours for utilization during peak hours.

7. DSM Measures: By converting the rate structures with higher billing/ tariff rates for electricity usage during peak hours, load shift to non-peak hours may be achieved. The consumers may be made aware that they can easily lower their electricity bills if they shift their usage to off peak hours and to reward consumers for this shift.

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Present vis-à-vis proposed System:

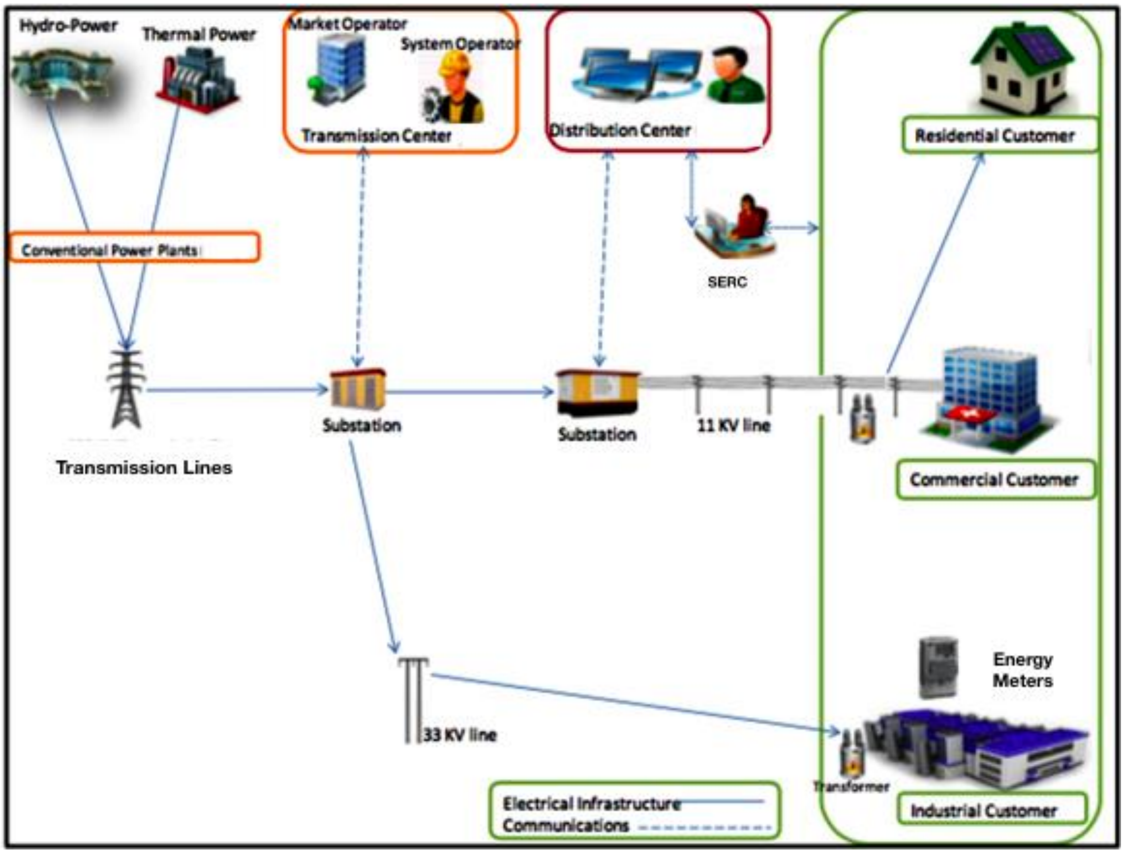

Fig. 2 Schematic diagram of the present system

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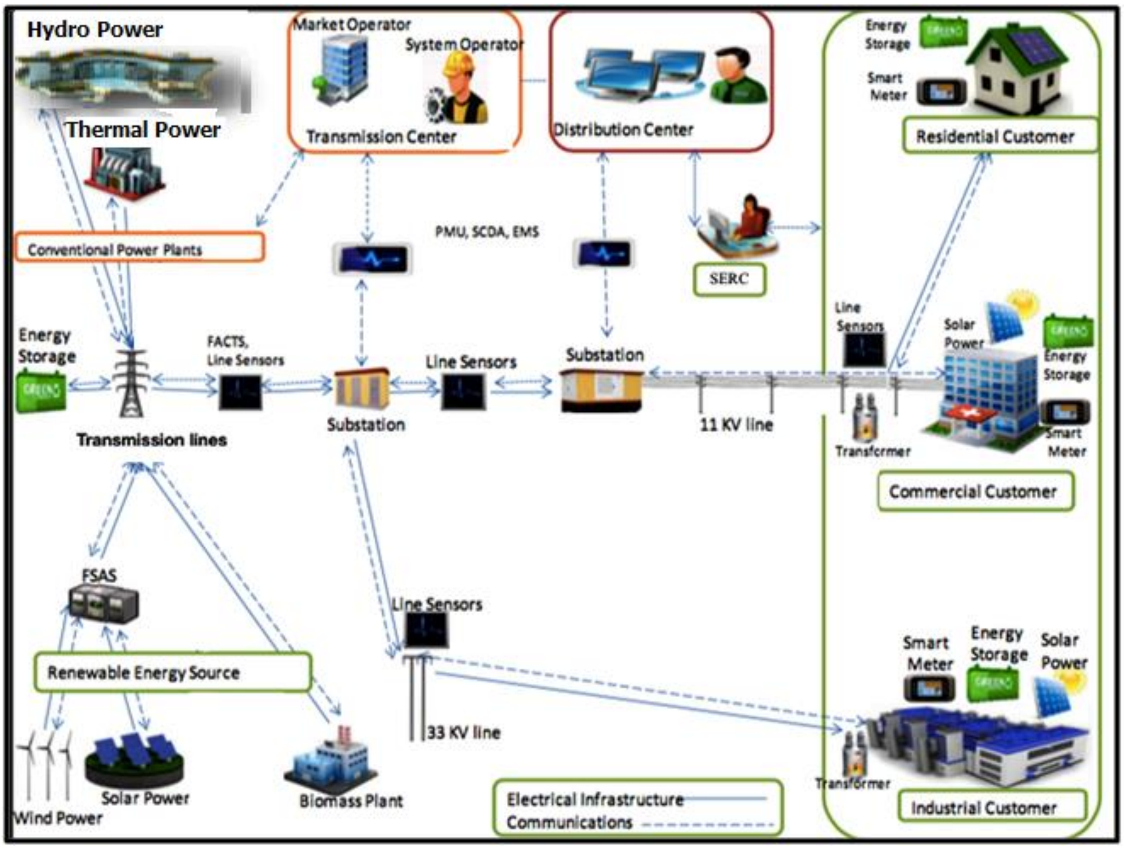

Fig. 3 Schematic diagram of Proposed Distribution System

Conclusion:

The proposed distribution system will bring down the loss levels from 53% (present) to less than 10%. Current distribution issues of unstable and unreliable power supply will be resolved with development of a more responsive and self-healing network, which will also facilitate active participation of consumers thereby achieving greater consumer satisfaction. Performance statistics System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), Customer Average Interruption Frequency Index (CAIFI), and Mean Time to Repair (MTTR) etc. will improve significantly.

Cost analysis is not a part of this paper, it may however be said that with the immense benefits of Smart Grid technologies, the investment required for implementing this system may be recovered within 36 months. The speculated investment for improving the aesthetic view of the town may be non-recoverable for the power utility point of view, but it will definitely boost tourism in the town thereby generating revenue for the State.

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