Automated H.R. System

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Abstract*— Manual recording and tracking of attendance and calculation of salary of employees is a very tedious task. Proposed system offers a cheap alternative to that with minimal cost of installation. Further, continuously tracking the location of employees during the office hours with the help of their device location can prove inefficient due to the enormous consumption of device battery. The proposed system offers an alternative to this problem as well. Location of device is updated periodically, thus both, conserving battery of the device as well as removing redundant entries. The system also offers offline storage of data to be uploaded by field workers in case of absence of internet connection. Main advantages of this system is its minimal cost of deployment, low cost of maintenance and efficient battery conservation.

Index Terms—*attendance management system, cloud computing, HR automation, geotracking.*

I. INTRODUCTION

Attendance tracking of the employees of an organization manually is a time and labour consuming task.

The Inora HR System is a software developed for daily staff attendance, customer service and reporting for Inora. The information is sorted date-wise and employee-wise and a report is generated. It facilitates to access the attendance information of a particular employee via the computer admin interface[1]. The system detects false attendance using the Geo Fencing feature and also a photo is taken during marking of the attendance[4][5]. The manager will receive an alert if attendance is marked beyond the boundary. This system will also help in evaluating the payroll of employees[3].

The system will provide an interface for the employees to mark their attendance and also track it efficiently. Also, false absent markings can be reported to the manager[1]. The manager will be able to track their employees when on a field visit. As continuous location updates will heavily tax the battery, we have decided to update the location on hourly basis. Data will be processed with the help of data aggregation techniques to help store and retrieve it efficiently. The entire system will be hosted on AWS cloud so there will be the flexibility of storage and computational capability[6]. Also, AWS has built world class, highly secure infrastructure, both physically and over the internet[6].

Initially, the system will be deployed for use in only Android OS, with the only functionalities being implemented being Attendance tracking[1] and payroll calculation[3].

The system will be implemented on A.W.S cloud server for ease of maintenance and flexibility of use of resources[6].

II. HARDWARE AND SOFTWARE COMPONETS

Only one hardware component is involved in the system on deployment/customer end, smart-phone owned by the employee.

Initially, the system is targeted for an android only audience, and hence, the smart-phone devices should have a minimum of the following version of android operating system installed in them:

- Android Lollipop (5.0)

The smart phone has to have a minimum of the following requirements along with permissions as required to access the modules:

- Camera (5.0 MP or more)
- Location module
- Storage (100 MB or more)

The system shall also comprise of a website which can be accessed by the managers to view reports, approve/ reject requests, etc.

The minimum hardware requirements for a PC to access the website are as follows:

- Intel i3 (5th Gen) or AMD A10 or above Processor, 2 GB or more R.A.M., 200 GB HDD.
- Internet access to the system(1.0 Mbps or higher)
- There is no need to install any special software as the website can be accessed from any supported browser.

III. INITIAL SYSTEM

The initial features offered in the system are the attendance recording and tracking system along with the employee payroll calculation system based on their attendance.

The attendance recording is aimed to be made proxy-proof by taking into consideration the following three parameters[5]:

1) *Photo*
2) *Location*

3) Time

The photo is to make sure that it is the employee themselves, the location to make sure that the employee marks their attendance within the Geo-fence and the time to record the time of attendance record.

The system architecture for the proposed system is as follows:

The architecture comprises of two external entities, which are the employee and the manager or the admin, two access devices, which are the mobile and personal computer (P.C.), along with two storage modes which are the offline device storage and the online cloud storage.

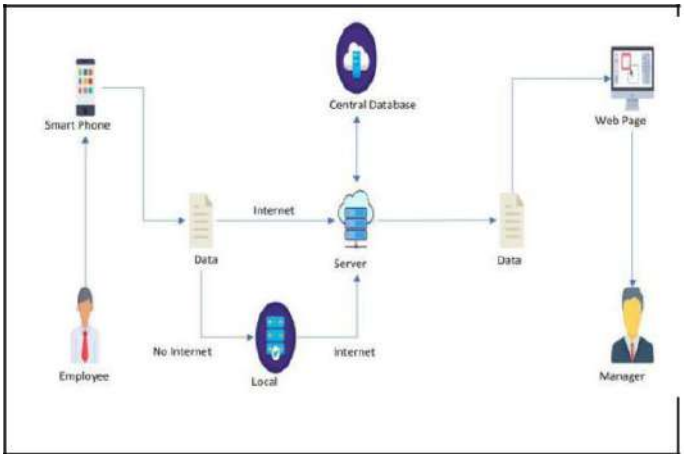


Fig. 1: Architecture of proposed system

Initially, the user (employee) enters the data (attendance data, field reports, etc.) from their mobile device. If the mobile device has a connection to the internet, the data is directly uploaded to the cloud server. In case of absence of internet connection, the data is stored in the mobile device. When the deice regains access to the internet, the data is automatically uploaded to the cloud storage server. This data can be accessed by the manager/admin via a website which is linked to the cloud server.

IV. ALGORITHM

Process flow of the above system can be given as follows:

Algorithm: New user registration

Inputs: User details

Output: Account with user credentials

1. START
2. User (employee) downloads the application.
3. Go to the sign-up page.
4. Enter the details asked for user registration.
5. Click on submit button.
6. END

Algorithm: Attendance Marking

Input: Selfie image, time-stamp and location.

Output: -

1. START
2. Enter the credentials to log in.
3. Go to the attendance module.
4. Click on mark attendance.
5. Take a selfie image.
6. The application captures the image and associates the location and time of the image capture.
7. The data is verified for time and location.
8. The data is stored on the cloud server.
9. END

Algorithm: Location Tracking

Input: Location of mobile device.

Output: -

1. START
2. A notification is sent to the mobile device for the employee to update their location details.
3. The location of the device is then verified against Geo-fence boundary.
4. If the device is not present with the boundary, a notification is sent to both, the employee device, as well as the manager's device.
5. The location details are stored on the cloud server.
6. END

Algorithm: Leave request

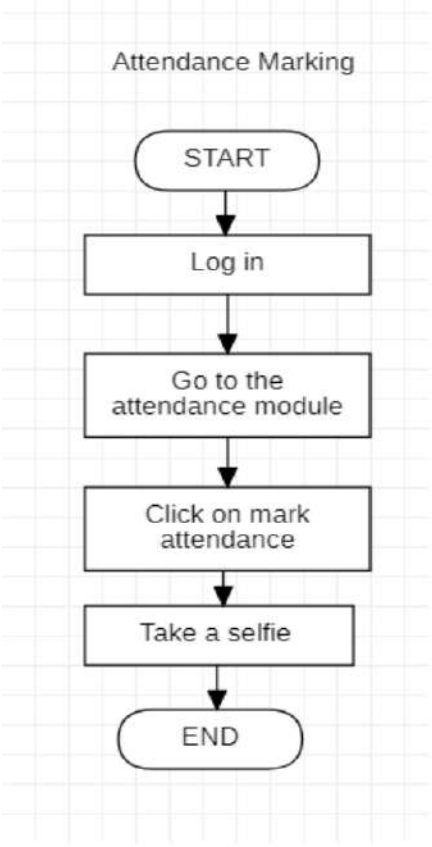
Input: Date and duration of leave

Output: request status update notification

1. START
2. Login.
3. Employee requests for a full/half day leave.
4. The request is stored on the cloud.
5. A notification is sent to the manager.
6. Manager checks for available leave.
7. Manager approves/rejects leave request.
8. Status is updated on the server.
9. Employee is sent notification of the status update.
10. END

Flowcharts:

1.



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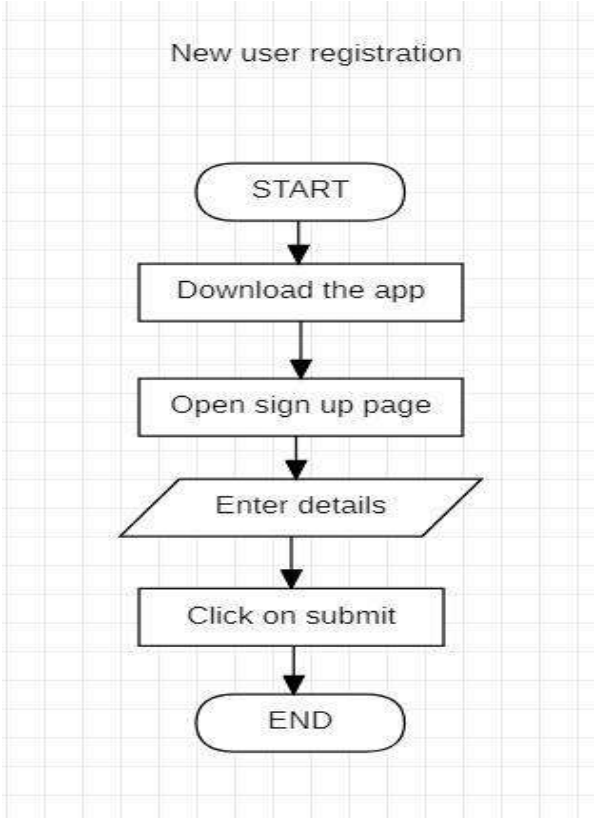

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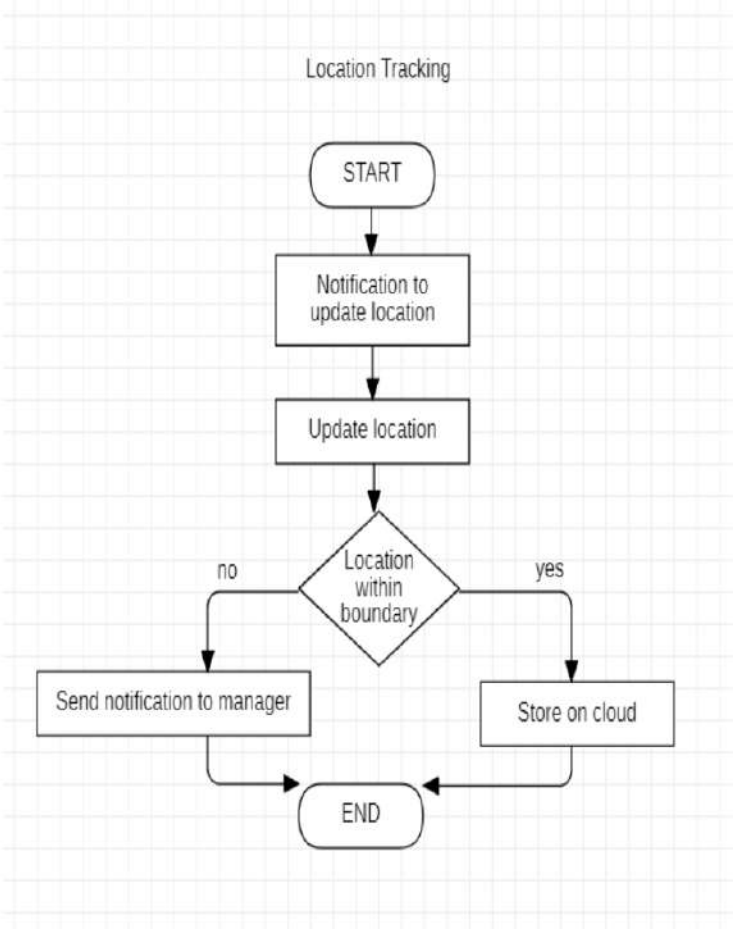

V. SYSTEM FEATURES

The proposed system has the following extra features:

1) Efficient employee location tracking.
2) Notification updates to authorities.
3) Change of record in case of incorrect entry by appropriate authority.
4) Leave request by employees.

4.1 *Efficient employee location tracking:*

Earlier systems used to track the location of targeted devices continuously. The problem with this mechanism is that it generates a lot of redundant data besides draining the target device's battery drastically.

To counter this problem, our system only generates a location access request periodically, preferably once every hour. This helps in saving of battery as well as preventing generation of redundant data.

4.2 *Notification updates to authorities:*

Authorities in the upper levels of management hierarchy will be notified in case of the following scenarios:

- An employee is absent.

- An employee is late for work.
- An employee has not marked their attendance.
- An employee requests for a change in attendance record.
- An employee is not within the Geo-fence.
- An employee requests for half day/ full day leave.

The employees shall also be sent notification in the following cases:

- They haven't marked the day's attendance.
- There is a status update in their request for change in attendance record or leave.

4.3 *Change of records in case of incorrect entries:*

The employees can sometimes forge to mark their attendance. This may lead to unwanted miscalculations on their behalf for generation of salary payroll.

In order to avoid this, the employees can request a change in the attendance record from the storage after providing sufficient proof for their mistake to the management. The management shall be provided with a module to help correct the attendance record as required.

This, however, shall be allowed only a predetermined number of times, exhausting which, the employee shall not be allowed to make request for a change again until the next cycle.

4.4 *Leave request by employees:*

Employees can request for Half day/ full day paid/unpaid leaves as per availability and business model of the organization from their portal itself. Upon doing so, a request notification will be sent to the manager who can then accept or reject the request as required. The employee shall then be sent a notification of the update of their request on their device.

CONCLUSION

The main advantage of this system is that the maintenance for this system will cost very less as it is deployed on the cloud. It will also minimise any initial cost of deployment. The system also eliminates redundant location records and also helps in conserving device battery. Employees as well as the managers get notification for any requests or update on requests. Future works on this system include a customer feedback or query system integrated into this system as well as an e-commerce platform for organizations to sell their products. The system can be used by any organization deploying modules as per their needs.

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A supervised scheme for aspect extraction in sentiment analysis using the hybrid feature set of word dependency relations and lemmas

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ABSTRACT

Due to the massive progression of the Web, people post their reviews for any product, movies and places they visit on social media. The reviews available on social media are helpful to customers as well as the product owners to evaluate their products based on different reviews. Analyzing structured data is easy as compared to unstructured data. The reviews are available in an unstructured format. Aspect-Based Sentiment Analysis mines the aspects of a product from the reviews and further determines sentiment for each aspect. In this work, two methods for aspect extraction are proposed. The datasets used for this work are SemEval restaurant review dataset, Yelp and Kaggle datasets. In the first method a multivariate filter-based approach for feature selection is proposed. This method support to select significant features and reduces redundancy among selected features. It shows improvement in *F*1-score compared to a method that uses only relevant features selected using Term Frequency weight. In another method, selective dependency relations are used to extract features. This is done using Stanford NLP parser. The results gained using features extracted by selective dependency rules are better as compared to features extracted by using all dependency rules. In the hybrid approach, both lemma features and selective dependency relation based features are extracted. Using the hybrid feature set, 94.78% accuracy and 85.24% *F*1-score is achieved in the aspect category prediction task.

Subjects Artificial Intelligence, Data Mining and Machine Learning
Keywords Feature extraction, Aspect based sentiment analysis, Machine learning, Natural language processing, Support vector machine

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INTRODUCTION

Quick improvements in e-commerce websites lead customers to purchase and analyze products online. Also, it allows end-users to express their views/opinions related to an item and services by means of reviews. These opinions are useful for other users to decide about the purchase of a product. These are also helpful to manufacturers to enhance the quality of their items and services and they may know what exactly customers want. In any case, it is hard for an individual to analyze a large number of reviews and rate them

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Automated Generation of Medical Reports Using Deep Learning Techniques

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Abstract

Medical Imaging, being in the vanguard of technological transformation, aids in renovating the field of radiology. It is widely used in the diagnosis and treatment of various diseases. Such is done using the radiographs, commonly known as X-Rays. Automation of the diagnostics using radiographs for medical report generation will be beneficial to the field of radiology. It will accelerate the diagnosis as well as aid in the triaging of the report. This paper proposes a system that focuses on chest disease and hence will make use of chest X-Rays for diagnosis. The solution proposed is a method to automate medical report generation, by using Deep Learning Techniques. A system that uses Convolutional Neural Networks (CNNs) along with Long Short-Term Memory Networks (LSTMs) makes this possible.

Keywords*-Chest Radiographs; Convolutional Neural Network; Long Short-Term Memory; Medical Reports; Chest Diseases*

I. INTRODUCTION

Artificial Intelligence and Machine Learning have influenced medicine in myriad ways, and medical imaging is at the forefront of technological transformation. Such technologies being an interdisciplinary pathway have the capability to alter the medical field. When applied to the field of diagnostic radiology, these technologies aid in quickening as well as accurizing the existing process. To address the afore mentioned goals, this paper proposes a system to automate the generation of medical reports. The system proposed focuses on chest diseases, hence chest radiographs are used. It aims at using a chest radiograph as an input and generating a medical report as an output.

For the system to be accurate in the diagnosis of chest diseases, it is essential that the X-Ray must present an Anteroposterior Projection. Furthermore, the system must take the complete Chest Projection as an input. For this the Chest X-Ray must show superiorly 5 cm above the shoulder joint, for proper visualization of airways and inferior to the lower border of the 12th rib. The level of the acromioclavicular joints must be in the lateral position. Other than this, the Chest X-Ray is evaluated on the basis of the following areas:

The Airway, Bones, Cardiac Silhouette, Diaphragm, Edge of the Heart, Field of Lungs, the Gastric Bubble, and Hila. Fig. 1 illustrated below shows a normal chest X-Ray, which projects the above-mentioned areas.

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The paper proposes to achieve the objectives by using deep learning technologies such as Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) units. Furthermore, it describes how the technology is put to use in reference with our objective.
The system aims to detect the abnormality in the chest X-ray, and generate a report based on the abnormality. The system focuses on distinguishing the following abnormalities: Pleurisy, Effusion, Pneumonia, Bronchitis, Infiltration, Nodule, Atelectasis, Pericarditis, Cardiomegaly, Pneumothorax, Fractures, Mass, Edema, Pleural Thickening, Consolidation, Epyphysema, Fibrosis, Hernia, and more. The respective medical report will be generated, by using the LSTM units. This report will contain the impressions, findings, and MTI tags.

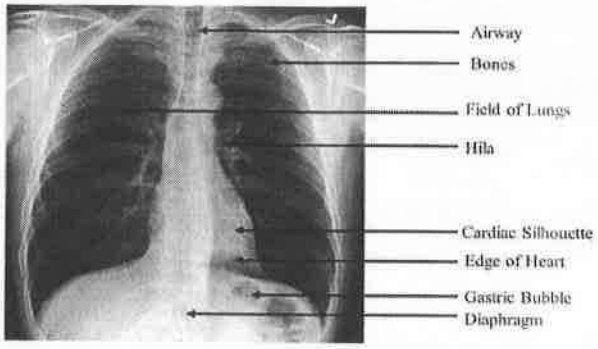

Fig. 1: Illustration of a Normal Chest X-Ray. The Markers associated project the areas that are considered while evaluating the Chest X-Ray.

II. DATASET

The model was trained using the NICXR (7,470 chest X-Ray images with multiple annotations) dataset which provided the X-ray images as well as the reports along with it.

III. OBJECTIVES

The project aspires to revolutionize the medical field by automating report generation based on radiographs. The manual procedure of scrutinizing the X-Ray by a medical professional and then generating a report is time consuming. The proposed system intends to eliminate the need for a radiologist and aims at enhancing automatic diagnosis. Additionally, it aims at reducing the criticality period and aid towards an early diagnosis. The system simplifies the process of diagnosis as, the user will only have to upload an X-Ray to the system, and a medical report containing the diagnosed results of the X-Ray will be presented in it.

The aims and objectives of this work are:

A. To generate a precise CNN-based model that aids in extracting necessary features required for diagnosis.
B. Develop a Report Generation module that is based on Language Model which uses LSTM units.

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IV. PROPOSED METHOD

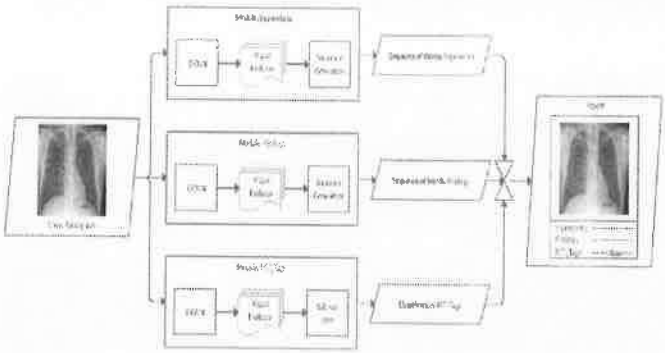

Fig. 2: Proposed System Architecture

The final medical report is designed to print the Impressions, Findings and the MTI Tags. Hence the proposed system was individually trained for each of the contents.

The system contains following major procedures:

A. Feature Extraction

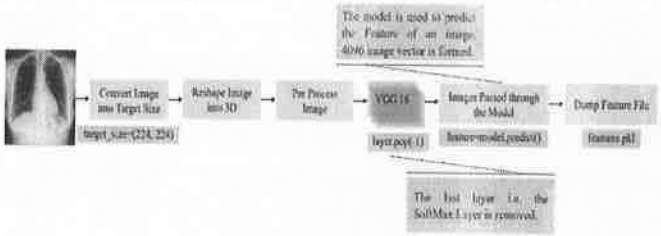

Fig. 3: Feature Extraction

To create an efficient and highly functioning system, the VGG16-like model is used in the proposed system, since it is the finest in regards of accuracy and efficiency. The VGG16-like model is used to construe the contents of the input, which is the Chest X-Ray. The last layer of the VGG16-like model is for the purpose of the classification of the images into various labels. However, in the system proposed, this layer is discarded for the impressions and findings module, as this layer emphasizes on the internal representation of the images, and the main objective of the system is to generate reports. The MTI Tags module does use this last layer for classification of labels, where these labels themselves are the MTI Tags which are printed. The VGG16-like model has been used in the system to extract the features required for the appropriate medical report generation. The proposed model extracts 1-D 4096 element vectors for the sake of the text data preparation. These vectors are saved in a .pkl file for further use.

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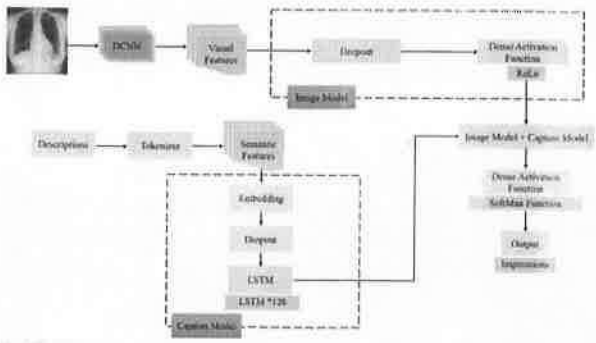

Fig.4: Structure of the Impressions Module

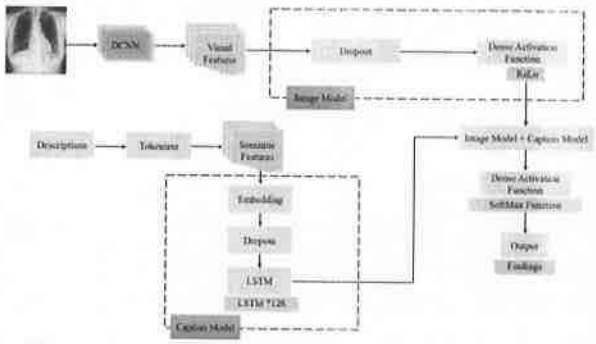

Fig. 5: Structure of the Findings Module

Algorithm for Feature Extraction (for Impressions and Findings):

1. Re-Structure the Model. Discard the Last Layer as Classification is not Required.
2. Extract Features from Each Photo.
3. For Each Photo in the Dictionary perform:
   i. Load an Image from File.
   ii. Convert the Image Pixels to an Array
   iii. Re-shape Data.
   iv. Prepare Image for VGG Model.
   v. Get Features.
   vi. Store the Features acquired.

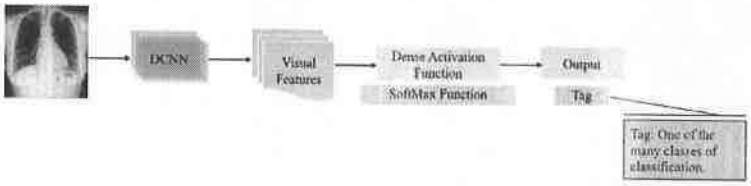

Fig. 6: Structure of the MTI Tags Module

Algorithm for Feature Extraction (for MTI Tags):

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1. Extract Features from Each Photo.
2. For Each Photo in the Dictionary perform:
   i. Load an Image from File
   ii. Convert the Image Pixels to an Array
   iii. Re-shape Data
   iv. Prepare Image for VGG Model
   v. Get Features
   vi. Predict Class

B. Text Data Preparation

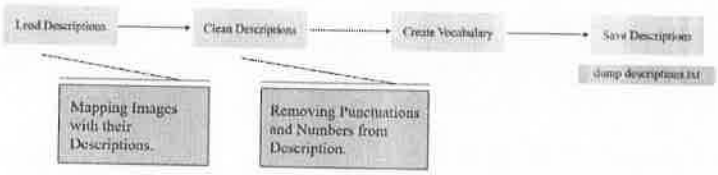

Fig. 7: Text Data Preparation

The principal objective of the proposed system is to generate a medical report. In simpler terms, every Chest X-Ray has to be associated with a caption. Therefore, to associate every image with a caption, the description texts available in the dataset have to be cleaned. The process of cleaning the description texts has to be done in order to reduce the size of the vocabulary of words, which will be used to automatically generate a caption.

The process of cleaning consists of the following steps:

2. Conversion of the word strings into lowercase.
3. Discarding the punctuation marks out of the sentences.
4. Discarding all the words which are one character or less in length.

On completing the above-mentioned steps, the text data can be considered as clean, and ready to use for the training of the system model. Consequently, a file which contains the Chest X-Ray, along with the caption (report) associated with it; in front of it, is generated for the training of the report generation model.

Algorithm for Text Data Preparation:

1. Load Descriptions: (For Each Line)
   i. Split Line by Whitespace
   ii. Take the first token as the Image ID and the rest as the description.
   iii. Convert description tokens back to string.
   iv. If the Image ID is not mapped then perform mapping.
   v. Store Description.
2. Clean Descriptions: (For Each Line)
   i. Tokenize
   ii. Convert to Lowercase.
   iii. Remove Punctuation from Each Token.
   iv. Remove Hanging 's' and 'a'.
   v. Remove Tokens with Numbers in them.
   vi. Store as a String.

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C. Report Development

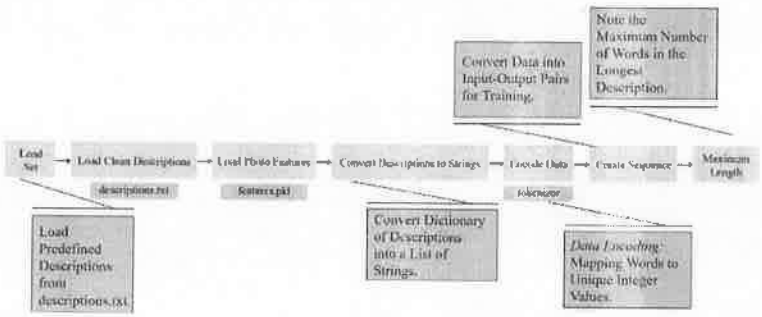

Fig. 8: Report Development

The Medical Report Generation Module can be implemented by defining and training it using the file prepared in the previous module. The model will be trained on the images and the associated captions within the file. The file contains the training data, in which the captions associated with each image are the reports, which are the intended outcome. The supposedly associated captions are in fact the Findings present in the Chest X-Ray. Furthermore, the module uses a Sequence Processor, which is intended to be used as a word embedding layer. This word embedding layer is used for handling the text input which is followed by the LSTM layers. The proposed system uses 64 LSTM layers. A decoder is used to make the final prediction. This is done by implementing the dense layer, which is used to merge together and process the fixed length vectors generated by both, VGG16 and Sequence Processor.
On implementing all the modules in the sequential process, the model successfully generates a caption for the given Chest X-Ray. The caption is generated consecutively, one word at a time. Hence, the photo features for the dataset are loaded and the description text gets encoded. Encoding is the process of converting description text to numbers. It is done before it is presented as an input to the model. Encoding is a necessary process as it creates a consistent map from word to a unique integer value. Each description is hence split into words, and the model can be trained with any image. Finally, the model is fitted.

Algorithm for Model Development:

1. Prepare Tokenizer.
2. Create Sequences of Images, Input Sequences and Output Words for an Image.
3. Walk through each Image ID and each Description for an Image.
   i. Encode the Sequence.
   ii. Split one Sequence into Multiple x,y Pairs:
      a. Split into Input and Output Pair
      b. Pad Input Sequence
      c. Encode Output Sequence.
      d. Store Sequences
4. Calculate the Length of the Description with the Most Words.
5. Feature Extraction Model.
   i. Sequence Model.
   ii. Decoder Model.
   iii. Tie Image ID, Sequence, and Word together.
   iv. Summarize Model.

Algorithm for Sequence Generation:

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Generate Descriptions

1. Seed the Generation Process.
2. Iterate over the Whole Length of the Sequence.
   i. Integer Encode Input Sequence.
   ii. Pad Input.
   iii. Predict Next Word.
   iv. Convert Probability to Integer.
   v. Map Integer to Word.
   vi. Stop if we Cannot Map the Word.
   vii. Append as Input for Generating the Next Word.
   viii. Stop if we Predict the End of the Sequence.

Algorithm for Model Fitting:

1. Define Checkpoint Call back.
2. Fit Model.

V. RESULTS

The proposed modules for impressions, findings and MTI Tags show accuracies 73.89%, 74.80%, and 82.31% respectively. Following are the plots representing the same.

Fig. 9: Epoch vs. Accuracy Plot (Impressions)

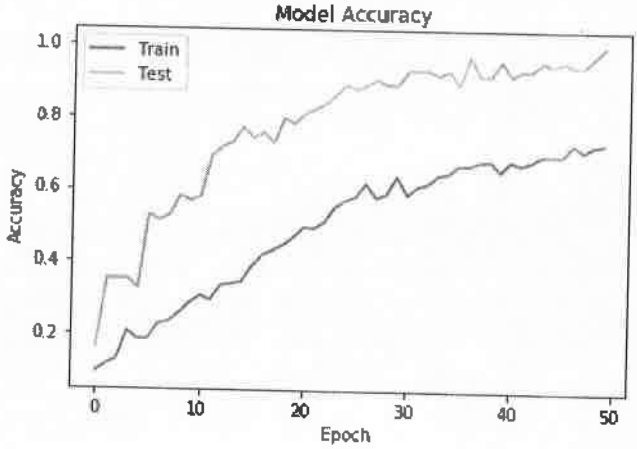

Fig. 10: Epoch vs. Loss Plot (Impressions)

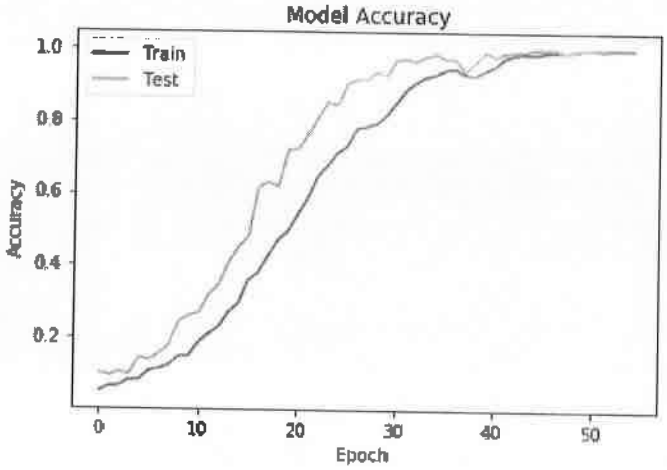

Fig. 11: Epoch vs. Accuracy Plot (Findings)

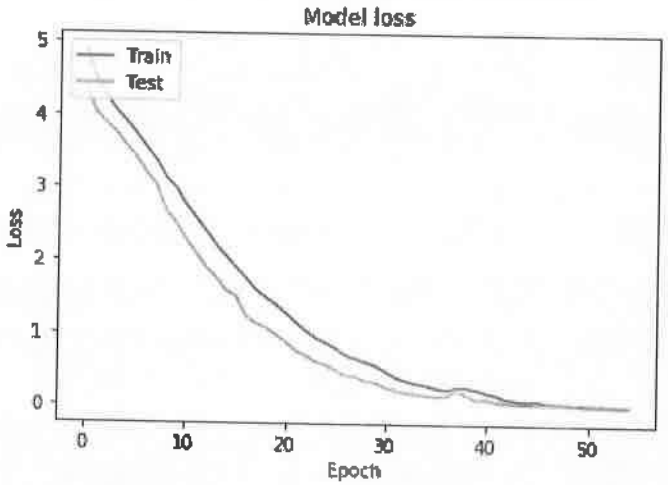

Fig 12: Epoch vs. Loss Plot (Findings)

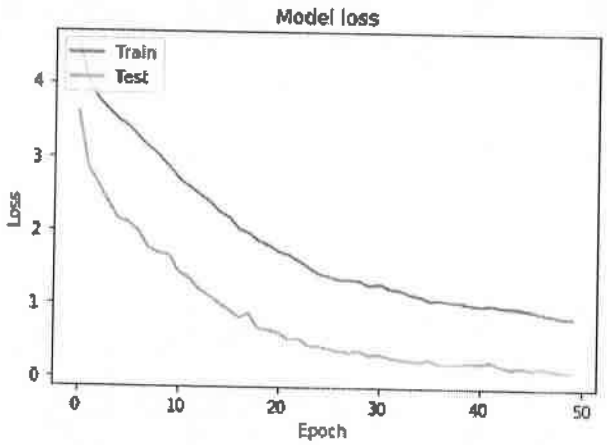

Fig. 13: Epoch vs. Accuracy Plot (MTI Tags)

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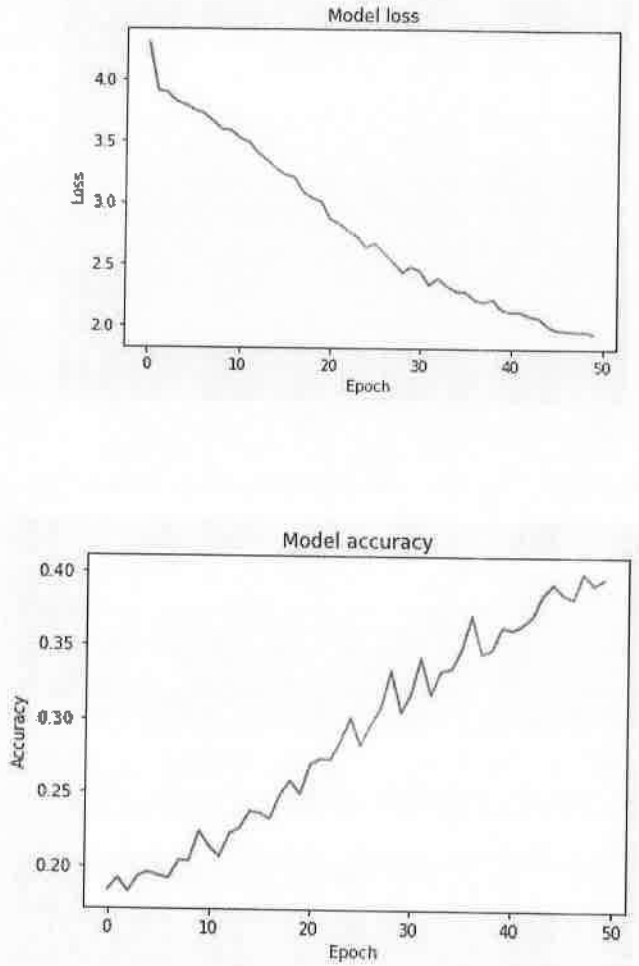

Fig 14: Epoch vs. Loss Plot (MTI Tags)

The Image Captioning Model has the following BLEU Scores associated to it:

BLEU-1	0.782051
BLEU-2	0.732300
BLEU-3	0.710488
BLEU-4	0.643870

Table 1: BLEU Scores for Image Captioning Model

VI. CONCLUSION

Automatic Medical Report generating system was successfully developed. A CNN-based model for feature extraction and LSTM units for language development. Such Neural Network algorithms enabled an accurate report generation and diagnosis.

Such a system aids in quick diagnosis, which can be distributed in rural areas, and to clinics which lack in medical experience. The automatization of this process eradicates the exhaustive amounts waiting period required for the generation of reports, hence enhancing the triaging of the further treatment procedure.

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TEC Response and Subsequent GPS Error Caused by the Most severe Geomagnetic Storm of Solar Cycle 24 at India

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This paper presents the response of low-latitude and mid-latitude ionosphere to a severe geomagnetic storm that occurred on 17 March 2015 at 0445 UT, and the subsequent effect of this storm on GPS error in the East-West (E-W) and North-South (N-S) directions. The Vertical Total Electron Content (VTEC) data has been analysed from three dual frequency GPS receivers, which were installed under the framework of the International GNSS Service (IGS). For each day of the year, the data is downloadable as a single file in the Receiver Independent Exchange Format (RINEX) from the IGS data portal. The VTEC values from the IGS are obtained at one minute intervals. Results show the variations in GPS derived VTEC during the severe geomagnetic storm. Negative ionospheric storms caused by composition changes are observed at mid-latitude region of Lucknow, while positive ionospheric storms caused by magnetospheric convection and Equatorial Ionospheric Anomaly (EIA) are prominent at low-latitude regions of Bangalore and Hyderabad. The maximum depletion in VTEC peak at mid-latitude region of Lucknow when compared to the quiet day mean VTEC was 61 percent during a negative ionospheric storm that occurred on 18 March 2015, and maximum enhancement in VTEC peak at low-latitude region of Bangalore and Hyderabad when compared to the quiet day mean VTEC was 26 percent and 21 percent respectively during an early positive ionospheric storm on 18 March 2015. Positive ionospheric storms caused by enhanced EIA and Prompt Penetration Electric Fields (PPEF) are prominent at low-latitudes. The highest GPS error during storm time was +7.2m and +11.3m in E-W and N-S directions respectively at Lucknow. The average GPS error in E-W and N-S directions during storm time was higher at the mid-latitude station of Lucknow.

Keywords: GNSS, Vertical Total Electron Content (VTEC), IGS, Geomagnetic storms, Storm day, Quiet Day

1Introduction

Ionospheric disturbance caused by the sun's electromagnetic radiation has been an important area of research since the discovery of theory of ionization of an atmospheric layer by Sydney Chapman in 1931. There has been much advancement in ionospheric research and space technology since then. Particularly, the invention of Global Navigation Satellite Systems (GNSS) has increased our dependence on navigation tools. Today, in the 21st century, all forms of navigation use GNSS services for guidance. There are several other GNSS-reliant systems like precision agriculture, surveying, communication, and internet and most importantly power grids. Strong ionospheric storms or disturbances pose a threat of disrupting the functioning of GNSS-reliant systems that are primary for many human activities today. Furthermore, ample research has been done on seismo-ionospheric anomalies, which are disturbances in the ionosphere that appear around the time of natural disasters like earthquakes[1]. It is therefore of utmost importance to understand the regional and global behavior of ionosphere with respect to the sun's electromagnetic radiation on a diurnal, monthly, seasonal and yearly basis. Such spatial and temporal observations will lay the foundation for generating now casting and forecasting models of ionospheric parameters, which can later be used to mitigate errors caused in GNSS-reliant systems[2]. In the last decade, many researchers have studied on the diurnal, monthly, seasonal and annual variations of ionospheric parameters in low-latitude and mid-latitude regions[3-10]. Many others offered comparison results of the measured data obtained from different resources at various geographic locations with various models, such as IRI and NeQuick[11-15].

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In this paper, ionospheric behavior will be discussed in detail with regard to mostly one parameter i.e. Total Electron Content (TEC). TEC is defined as the total number of electrons in a vertical column of one square meter, a parameter that would allow us to assess and visualize ionospheric behavior conveniently[16]. It is mathematically expressed as an integral of the entire ionospheric electron density profile. The unit of measurement for TEC is TEC Units (TECU = 10^{16} m^{-2}) [17]. In the past, TEC was measured using various techniques, but with developments in space technology and radio diagnostics, it is now mostly measured by Global Positioning System (GPS) or other GNSS services. With increasing GNSS networks and faster internet capabilities, the spatial and temporal extent of TEC data today is large. Furthermore, the Very High Frequency (VHF) and Ultra High Frequency (UHF) radio waves that carry such data do not undergo severe degradation during ionospheric storms[2]. These characteristics of present-day TEC data make it an appropriate parameter to analyze and visualize ionospheric behavior. It is also important to note that most communication and navigation errors caused by phase advance and Doppler shift of carrier, time delay of modulation, Faraday rotation of polarization, *etc.* are predominantly related to TEC[17].

The aim of this study is to analyze variations in TEC over the Indian subcontinent in response to the strongest geomagnetic storm of solar cycle 24, and further analyze the subsequent positioning error caused in GPS by such TEC variations. 2015 is the year that witnessed the most geomagnetic activity in solar cycle 24 (2008 to 2020). There were up to three severe ionospheric storms in 2015 with the strongest storm of the solar cycle occurring on 17 March 2015 at 2200 UT. The study is part of a larger research project, which is working on hostingreal-time ionospheric data on an open access Web-platform

2 Literature

2.1. TEC derived from GNSS

GNSS is an effective tool for measuring TEC along the ray path of a satellite and receiver. Moreover, dual-frequency GNSS allows for estimation of TEC more accurately by eliminating ionospheric errors as opposed to single-frequency GNSS stations where the main source of error is ionospheric delay[18]. Dual-frequency GNSS receivers use pseudo-range and carrier phase measurements to compute Slant TEC (STEC)[19]. The formula for STEC as a function of pseudo-range (P), which is the pseudo distance between satellite and receiver at the time of receiving the signal, is given by[16]

$$STEC_P = \frac{2}{k}\left[\frac{{f_1}^2 {f_2}^2}{{f_1}^2 - {f_2}^2}\right](P_2 - P_1) + \tau^r + \tau^s + I + T + mpp \quad \text{... (1)}$$

where, k is a constant whose value is 80.62 (m^3/s^2); f_1 and f_2 are frequencies of pseudo-ranges P_1 and P_2; τ^r and τ^s are the differential code bias and inter-frequency bias corresponding to P_1 and P_2; I is ionospheric induced error; T is tropospheric induced error; mpp is multipath error.

Similarly, the formula for STEC as a function of carrier phase, which is the pseudo-range expressed in units of cycles of carrier frequency is given by

$$STEC_C = \frac{2}{k}\left[\frac{{f_1}^2 {f_2}^2}{{f_1}^2 - {f_2}^2}\right](L_1\lambda_1 - L_2\lambda_2) + \varepsilon^r + \varepsilon^s - I + T + \lambda N \quad \text{... (2)}$$

where, λ_1 and λ_2 are the wavelengths of carrier phases L_1 and L_2; ε^r and ε^s are the differential code bias and inter-frequency bias corresponding to L_1 and L_2; I is ionospheric induced error; T is tropospheric induced error; N is integer ambiguity.

$STEC_P$ has high noise and low ambiguity whereas $STEC_C$ has low noise and high ambiguity. Therefore, by combining both, accuracy of data can be improved[19]. By further converting STEC to Vertical TEC (VTEC), effects of increased path distance caused due to the oblique path travelled by GNSS signal between receiver and satellite are removed[18]. The relationship between STEC and VTEC is expressed as[16]

$$VTEC = (STEC - b_s - b_r)\, cos\chi' \quad \text{... (3)}$$

where, b_s and b_r are satellite bias and receiver bias respectively; χ' is the zenith angle at the Ionospheric Piercing Point (IPP). IPP is expressed as[19]

$$\chi' = arcsin\left[\frac{R_e}{R_e + h_m}\, sin\chi\right] \quad \text{... (4)}$$

where χ is the zenith angle at receiver position, R_e is the mean radius of the earth and h_m is the height of ionospheric layer. By substituting equation 4 in equation 3, we get

$$VTEC = STEC\left\{cos\left[arcsin\left(\frac{R_e}{R_e + h_m} sin\chi\right)\right]\right\} \quad \text{... (5)}$$

IPP refers to the region of ionosphere where the GPS signal passes through maximum electron density. Mean IPP is 350 kilometers[18].

2.2. International GNSS Service (IGS)

IGS is a collaborative effort by more than 200 self-funded organisations across the world (mostly universities, research centers and space agencies). The aim of the service is to provide GNSS products with high accuracy, spatial and temporal coverage. Dual-frequency and more recently triple-frequency GNSS stations are used by IGS to gather data from more than a hundred countries[20-21]. The data is free for public use and therefore can be downloaded from the IGS data portal. However, a few countries exercise restriction in data sharing.

IGS currently distributes data collected and archived from two GNSS services: GPS and GLONASS; each of which are the satellite-based navigation systems of the United States of America (USA) and Russia. IGS initially relied only on data gathered from GPS satellite constellation. But in 2005, data from GLONASS was integrated into the IGS data flow after continuous efforts to do so since 200[20]. The combined use of both satellite navigation systems has increased the overall accuracy.

IGS products fundamentally measure two atmospheric parameters: Tropospheric Zenith Path Delay (ZPD) and Ionospheric TEC. This is done by combining pseudo-range measurements of GNSS with IGS precise clocks and orbits. For this study, ionospheric TEC values are extracted from five IGS stations each of which are listed along with their latitude, longitude and station code in Table 1.

Data in the IGS portal is downloadable in Receiver Independent Exchange Format (RINEX). The RINEX format allows for easy exchange of data and was first presented and accepted in 1989. Since then there have been upgrades and minor changes to the format. For the purpose of this study, RINEX Version 2.11 observation (.o) files are used. The observation files are used to extract TEC values.

IGS products are maintained by a Central Bureau located at NASA's (National Aeronautics and Space Administration) Jet Propulsion Laboratory (JPL). IGS products are a service of the International Association of Geodesy (IAG) and are recognized by the Federation of Astronomical and Geophysical Data Analysis Services (FAGS)[16].

Table 1 — List of IGS stations used for study
(Source :http://www.igs.org/network.html)

IGS Station Code	City	G. Lat	G. Long
IISC	Bangalore	13.02	77.57
HYDE	Hyderabad	17.42	78.55
LCK3	Lucknow	26.91	80.96
SGOC	Colombo	6.89	79.87
LHAZ	Lhasa	29.66	91.10

G. Lat' and 'G. Long' denote 'Geographic Latitude' and 'geographic Longitude' respectively.

2.3. Interplanetary Magnetic Field (IMF)

The sun has a complex magnetic field with distributed magnetic field lines of varying intensities. This magnetic field is not restricted to its immediate vicinity. It is carried through interplanetary space by solar wind. When the path of such solar wind is directed towards earth, geomagnetic storms can be expected as a result of interaction between IMF and earth's dipole-like magnetic field. B_t is a vector that denotes the overall IMF carried by solar wind while B_x, B_y and B_z denote its components in X, Y and Z axes. B_x and B_y are parallel to the ecliptic while B_z is perpendicular to the ecliptic. When B_z is oriented southward, it connects strongly with the earth's magnetic field which is oriented northward. The two opposite charges attract, causing disruption in the magnetosphere. Furthermore, when B_z turns southward and increases in intensity, interplanetary electric field (IEF) penetrates to low-latitude ionosphere leading to abnormal increases in ionospheric TEC[22]. The unit of measurement for IMF is nano-Tesla (nT). B_z values of -10 nT or lower are an indication of geomagnetic disturbances.

2.4. Disturbance storm time (Dst) and Planetary K (K_p) indices

The earth's magnetic field behaves like a dipole with equipotential lines that are closed on the day side and open towards the night side. This phenomenon is caused by electro-magnetic fields of varying magnitudes formed around the earth as a result of ionosphere-atmosphere interaction and magnetospheric convection[23]. Charged particles from the ionosphere or those carried by IMF's are constantly trapped on magnetic field lines. These generate an electric field known as ring current that is oriented towards the west. During geomagnetic storm period, ring current increases due to higher injection of charged particles into the magnetosphere and ionosphere by IMF. The vice-versa is true for quiet periods. Given the direct correlation between ring current and storm behavior, it is widely accepted as a storm-time indicator[24]. Ring current is measured by a parameter called Disturbance Storm Time Index or Dst. The unit of measurement is nano-Tesla (nT).

Another index that is a good measure of magnetospheric convection is the Planetary K or K_p

index. It is derived by measuring horizontal variations in the magnetic field at thirteen sub-auroral locations using a magnetometer. Based on the amplitude of magnetic variation at each location, standardized K values are estimated in the range of 0 to 9 using a quasi-logarithmic function. The standardized values are corrected for daily and annual variations that differ with location of observatory. Finally, all thirteen corrected K values are averaged to obtain the final K_p index[24]. K_p is a dimensionless parameter.

3 Method of Analysis

Solar and geomagnetic indices have been used to identify space weather events caused by the interaction of magnetosphere and solar flares. Hourly averaged values of B_z, Dst and K_p for 2015 are downloaded from NASA's OMNIWeb service (https://omniweb.gsfc.nasa.gov/form/dx1.html). These indices have been used to extract the strongest geomagnetic storm that has occurred in solar cycle 24. The duration of the geomagnetic storm is known as 'storm time', and the days such durations of time have occurred in are known as 'event days'. The indices were further used to extract five consecutive 'quiet days' which experienced least geomagnetic activity in the month of March, 2015. The VTEC measured on 'quiet days' is averaged to provide 'quiet day mean VTEC'. Later, these hourly averaged indices were plotted for 'event days' with respect to 'Universal Time (UT)', and compared with overlaid plots of 'quiet day mean VTEC' and 'event day VTEC' in order to explain fluctuations in ionospheric TEC as a result of increasing or decreasing solar and geomagnetic activity.

In this study, TEC data for 2015 over the Indian subcontinent has been extracted from RINEX observation (.o) files that are downloadable from the IGS data service portal hosted by NASA: ftp://cddis.gsfc.nasa.gov/gnss/data/daily/2015/. RINEX .o files are extracted using an open-source software designed by Dr. Gopi Seemala of the Indian Institute of Geomagnetism (IIG). Once extracted, each observation file provides magnitude of VTEC in the ionospheric region over the respective IGS station for the respective day of year with a temporal resolution of one minute. Apart from plotting these VTEC values for each location with respect to 'UT' to observe variation of ionospheric TEC on 'event days' and 'quiet days', this data was further used to generate a contour plot for mapping 'Mean Annual VTEC' with respect to 'UT' and 'Geographic Latitude' for the year of 2015.

Finally, GPS error during 'event days' and 'quiet days' has been calculated using the RINEX .o files and RINEX navigation (.n) files that are downloadable from the above mentioned IGS data portal. The .n file contains ephemeris data (precise clock and orbit measurements) that is transmitted by the GPS satellite. The RINEX .o and .n files were processed in 'RTKLib' software to obtain solution files (.pos). 'RTKLib' is an open source program package for GNSS positioning. Comparing the positioning obtained from the RTKLib solution files with the actual position of the station (geographic latitude and geographic longitude), GPS error in North-South (N-S) and East-West (E-W) direction was calculated. The GPS error is so calculated and plotted for 'event days', and is overlaid with 'quiet day mean GPS error' that is calculated by averaging GPS error recorded on the five quietest days of March 2015.

4 Results

4.1. Observations of VTEC from three stations across India between 16 March 2015 and 20 March 2015

From Fig. 1 it can be observed that, the first solar event occurred on 17 March 2015, with the Sudden Storm Commencement (SSC) occurring at 0445 UT. After SSC, the initial fast decay lasted till 0700 UT. Subsequently the Main Phase (MP) of the storm started at 0800 UT and ended at 2200 UT, when the Dst value reached its lowest at -223 nT. The Recovery Phase (RP) of the storm started at 2200 UT on 17 March 2015, and the Dst continued to be lower than -50 nT until 1000 UT on 20 March 2015.

An IMF with southward B_z of magnitude -16 nT came into interaction with the magnetosphere at 0800 UT on 17 March 2015. As a result, the Dst decreased to -73 nT and K_p measured 7.7 at 1200 UT, indicating a severe geomagnetic storm. On the same day, an IMF with a southward B_z of -18 nT came into interaction with the magnetosphere at 1400 UT. Immediately after this, the Dst dropped to extreme negative values on 17 March 2015, reaching -223 nT at 2200 UT. The K_p index remained higher than 7 until the midnight (0000 UT) of 18 March 2015, indicating severe storm conditions throughout the afternoon and evening of 17 March 2015. The average Dstand K_p before the storm, on the quiet days of 14, 15 and 16 March 2015 are 11 nT and 1.8 respectively.

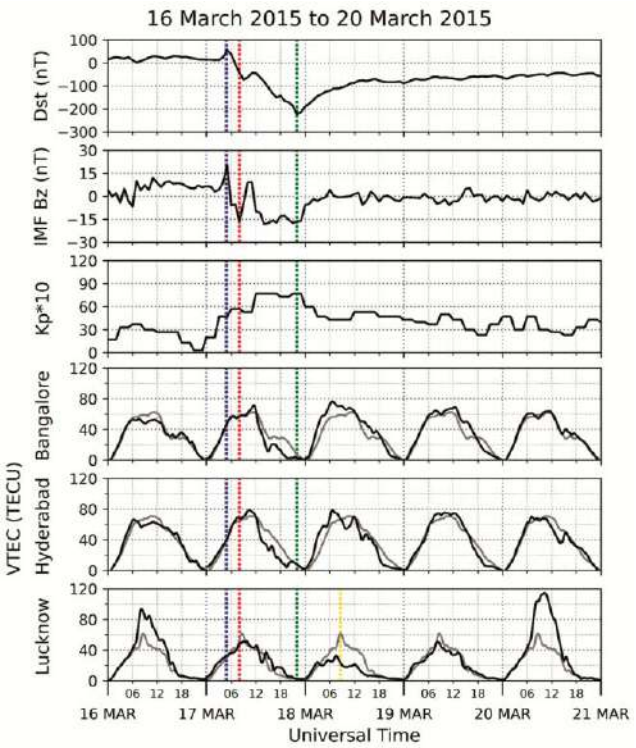

Fig. 1 — A graphical representation of Dst, IMF Bz, K_p index, VTEC and quiet day mean VTEC between 16-20 March 2015 at Bangalore, Hyderabad and Lucknow. The Sudden Storm Commencement time (SSC~0445 UT on 17 March) is shown by the blue dotted line; the Major Phase Commencement time (MPO~0800 UT on 17 March) is shown by the red dotted line; the Recovery Phase Commencement time (RPO~2200 UT on 17 March) is shown by the green dotted line; The peak hours of ionization on 18 march 2015 at Lucknow is shown by the yellow dotted line; VTEC variation is illustrated by the black solid line; Quiet day mean VTEC variation is illustrated by the grey solid line.

The average Dst and K_p after the storm subsided, on the quiet days of 18, 19 and 20 March 2015 are -76 nT and 4.1 respectively.

Figure 1 further illustrates VTEC observations from three stations across India plotted for event days. VTEC at Lucknow on quiet days of March reaches its highest values at approximately 0830 UT, and VTEC starts depleting slowly from the very next hour till it reaches its lowest values at approximately 1600 UT. However, after SSC, electron content depletions trigger an immediate negative ionospheric storm in Lucknow on 17 March 2015. VTEC during the peak hours of ionization (0830 UT) of 17 March 2015 depleted by 19 percent, when compared to the quiet day mean VTEC value at the same time. After the Main Phase (MP) of the storm ended at 2200 UT on 17 March 2015, a delayed and more intense negative ionospheric storm was observed at Lucknow on 18 March 2015. VTEC during the peak hours of ionization of 18 March 2015 depleted by 61 percent, when compared to the quiet day mean VTEC value at the same time. A negative ionospheric storm was observed again on 19 March 2015 at Lucknow, and it was similar to that observed after SSC on 17 March 2015. This meant, the VTEC during peak hours of ionization of 19 March 2015 decreased by 19 percent, when compared to quiet day mean VTEC value at the same time. VTEC at Lucknow recovered exponentially on the final event day, reaching its maximum value of 113 TECU at 1000 UT on 20 March 2015. This is the highest recorded VTEC value at Lucknow in all five days encompassing event 1. This meant a phenomenal 70 percent increase in VTEC during peak hours of ionization of 20 March 2015, when compared to quiet day mean VTEC value at the same time.

At Hyderabad and Bangalore, the quiet days and storm days show very similar TEC patterns and behaviors. VTEC at Hyderabad and Bangalore on quiet days of March reaches its highest values at 1030 and 1130 UT respectively, and continues to be high until 1200 UT. VTEC starts slowly depleting after 1200 UT, till it reaches its lowest values at 2000 UT and 2100 UT respectively. After SSC, enhancements in electron content trigger an immediate positive ionospheric storm in Hyderabad and Bangalore on 17 March 2015. The VTEC during peak hours of ionization (1030 UT and 1130 UT respectively) of 17 March 2015 increased by 10 percent in Hyderabad and 13 percent in Bangalore, when compared to quiet day mean VTEC value at the same time at the respective locations. After the Main Phase (MP) of the storm ended at 2200 UT on 17 March 2015, an early positive ionospheric storm was observed at Hyderabad and Bangalore on 18 March 2015 at 0640 UT. VTEC at 0640 UT on 18 March 2015 increased by 21 percent in Hyderabad and 26.5 percent in Bangalore, when compared to quiet day mean VTEC value at the same time at the respective locations. On 18 March 2015, VTEC reached its highest value at 0640 UT in Hyderabad and Bangalore. This implies that the VTEC peak after storm day shifted to earlier UT at both locations, when compared to VTEC peak on the quiet days at the respective locations. The positive ionospheric storm triggered in Hyderabad and Bangalore on 17 March 2015 subsides on 19 March 2015, when magnitude of VTEC slowly decreases to normal quiet

day values and TEC behavior resembled that of the quiet days.

4.2. Effect on GPS measurements at Bangalore between 16 March 2015 and 20 March 2015

Form Fig. 2 it can be observed that, at Bangalore, the highest GPS error on 17 March 2015 in the East-West (E-W) direction is +5 m at 1530 UT. The average GPS error in the E-W direction between 1530 and 1600 UT on 17 March 2015 was +3 m. This can be attributed to the sudden increase and decrease in VTEC between 1500 and 1800 UT on 17 March 2015 at Bangalore, which can be observed as a small secondary peak in Fig. 1 reaching 21 TECU at 1610 UT. An average GPS error of -3 m was recorded between 0730 and 0800 UT on 17 March 2015 in the North-South (N-S) direction at Bangalore, following the Sudden Storm Commencement (SSC) at 0445 UT. An average error of -3 m was recorded again between 1000 and 1100 UT in the N-S direction on 17 March 2015, following the commencement of the Main Phase (MP) of the storm at 0800 UT. Finally, an average GPS error of -4 m was recorded in the N-S direction between 1500 and 1600 UT on 17 March 2015 at Bangalore. The high GPS error in N-S directions between 1500 and 1600 UT can be attributed to the small secondary peak in Bangalore between 1500 and 1800 UT on 17 March 2015. On 18 March 2015, at Bangalore, the highest GPS error in the N-S direction was +6 m at 0520 UT. This can be attributed to the early positive ionospheric storm that occurred in Bangalore on 18 March 2015. On the same day and location, average GPS error in the N-S direction was +4 m between 1800 and 1840 UT.

4.3. Effect on GPS measurements at Hyderabad between 16 March 2015 and 20 March 2015

From Fig. 3 it can be observed that, at Hyderabad, the highest GPS error on 17 March 2015 in the East-West (E-W) direction is +6.8 and +6.3 m at 1500 and 1630 UT respectively. This can be attributed to the sudden increase and decrease in VTEC between 1500 and 1630 UT on 17 March 2015 at Hyderabad, which can be observed as a small secondary peak reaching 32 TECU at approximately 1600 UT in Fig. 1. While the average GPS error in the E-W

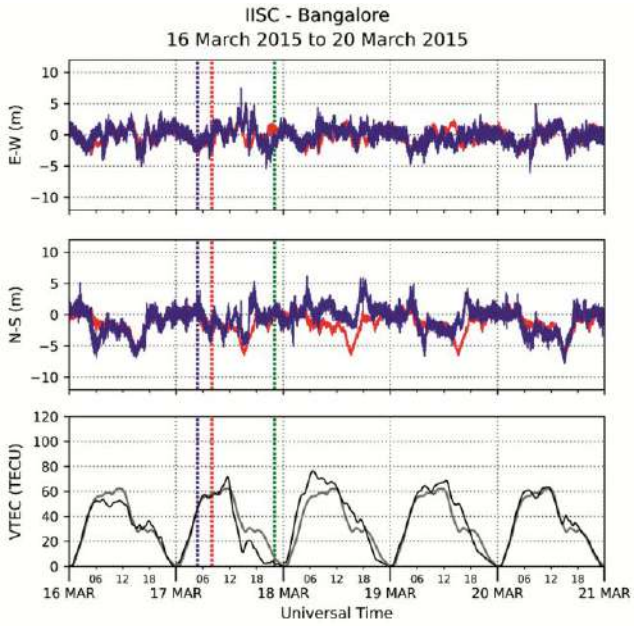

Fig. 2 — GPS error in East-West (E-W) and North-South (N-S) directions along with VTEC and quiet day mean VTEC,between 16 and 21 March 2015 at Bangalore. The solid blue line denotes measured GPS error during storm days; the solid red line denotes quiet day mean GPS error; the Sudden Storm Commencement time (SSC~0445 UT on 17 March) is denoted by the blue dotted line; the MajorPhase Commencement time (MPO~0800 UT on 17 March) is denoted by the red dotted line; the Recovery Phase Commencement time (RPO~2200 UT on 17 March) is denoted by the green dotted line.

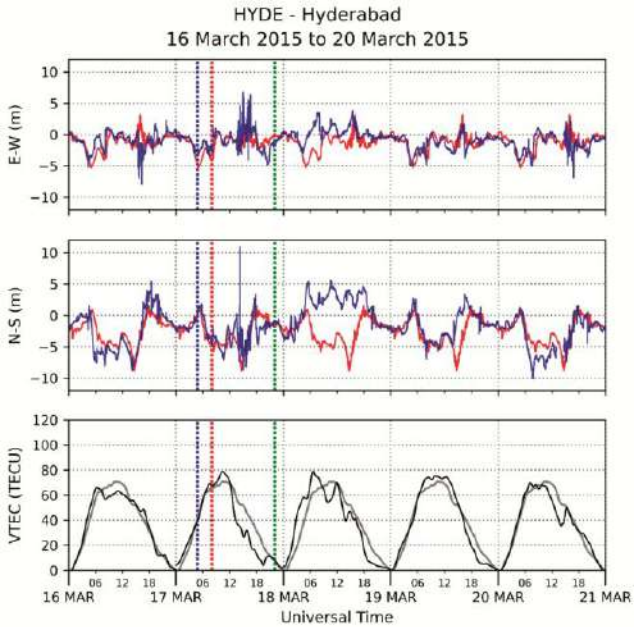

Fig. 3 — GPS error in East-West (E-W) and North-South (N-S) directions along with VTEC and quiet day mean VTEC,between 16 and 21 March 2015 at Hyderabad. The solid blue line denotes measured GPS error during storm days; the solid red line denotes quiet day mean GPS error; the Sudden Storm Commencement time (SSC~0445 UT on 17 March) is denoted by the blue dotted line; the Major Phase Commencement time (MPO~0800 UT on 17 March) is denoted by the red dotted line; the Recovery Phase Commencement time (RPO~2200 UT on 17 March) is denoted by the green dotted line.

direction between 1500 and 1630 UT on 17 March 2015 is +2 m only, the error during this timeframe constantly fluctuates to +4 m and +5 m. An average GPS error of +3.2 m was recorded between 0730 and 0800 UT in the E-W direction on 18 March 2015. This can be attributed to the early positive ionospheric storm that occurred on 18 March 2015 at 0640 UT in Hyderabad. At Hyderabad, on the quiet days of March, mean GPS error in the North-South (N-S) direction between 0700 and 1130 UT is -4.6 m. This can be attributed to the increasing electron content due to ionization in the atmosphere during sunlit hours of the day. The comparison between N-S GPS error during storm days and mean N-S GPS error during quite days that is illustrated in Fig. 2, clearly shows that measured GPS error deviates significantly from quiet day mean GPS error at 0545, 1040 and 1745 UT on 18 March 2015. The GPS error in N-S direction at the aforementioned durations of time is +5 m at Hyderabad. While the GPS error in N-S direction at 0545 UT can be attributed to the early positive ionospheric storm that occurred on 18 March 2015 at 0640 UT in Hyderabad, the GPS-error in N-S direction at 1040 UT can be attributed to the sudden increase in VTEC between 1000 and 1200 UT. In Fig. 1, this can be observed as a secondary peak at 1200 UT on 18 March 2015 at Hyderabad.

4.4. Effect on GPS measurements at Lucknow between 16 March 2015 and 20 March 2015

From Fig. 4 it can be observed that, at Lucknow, the highest GPS error on 17 March 2015 in the East-West (E-W) direction is +7.2 m at 1620 UT. The average GPS error in the E-W direction between 1520 and 1620 UT is +4.4 m. This can be attributed to the sudden increase and decrease in VTEC on 17 March 2015 at Lucknow at two instances: between 1345 and 1545 UT, and between 1615 and 1850 UT. These instances can be observed in Fig. 1 at Lucknow as a small secondary peak reaching 37 TECU at approximately 1430 UT, and another smaller tertiary peak reaching 18 TECU at 1710 UT. An average GPS error of +3.7 mwas recorded between 0210 and 0340 UT in the E-W direction on 18 March 2015 at Lucknow. This can be attributed to the sudden increase and decrease in VTEC between

0220 and 0400 UT on 18 March 2015 at Lucknow, which can be observed as a small peak in Fig. 1 reaching 24 TECU at 0300 UT. Similarly, an average GPS error of +3.5 m was recorded between 0700 and 0740 UT in the E-W direction on 18 March 2015 at Lucknow. This can be attributed to the sudden increase and decrease in VTEC between 0430 and 0900 UT on 18 March 2015 at Lucknow, which can be observed as a sharp secondary peak in Fig. 1 reaching 33 TECU at 0730 UT. The average GPS error in the North-South (N-S) direction between 0600 and 0740 UT on 18 March 2015 at Lucknow is +7.8 m. The highest GPS error of +11.3 m in the N-S direction was recorded at Lucknow during this time at approximately 0615 UT. This can be attributed to the sharp secondary peak between 0430 and 0900 UT at Lucknow on 18 March 2015.

5 Discussions

5.1 VTEC response to geomagnetic storm on 17 March 2015 at Bangalore, Hyderabad and Lucknow

At the low-latitude stations of Bangalore and Hyderabad, VTEC on quiet days generally reaches its peak values between 1100 UT. During the geomagnetic storm on 17 March 2015, positive ionospheric storms are observed at both locations on 17 March 2015 and 18 March 2015. After the commencement of Main

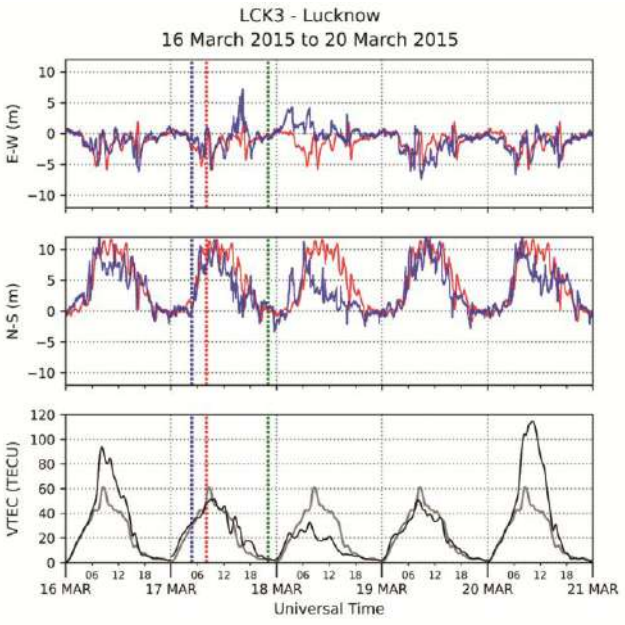

Fig. 4 — GPS error in East-West (E-W) and North-South (N-S) directions along with VTEC and quiet day mean VTEC,between 16 and 21 March 2015 at Lucknow. The solid blue line denotes measured GPS error during storm days; the solid red line denotes quiet day mean GPS error; the Sudden Storm Commencement time (SSC~0445 UT on 17 March) is denoted by the blue dotted line; the Major Phase Commencement time (MPO~0800 UT on 17 March) is denoted by the red dotted line; the Recovery Phase Commencement time (RPO~2200 UT on 17 March) is denoted by the green dotted line.

Phase (MP) on the early hours of 17 March 2015, the VTEC peak on that day shifted to later UT at low-latitudes. An early positive ionospheric storm occurred again on the early hours of 18 March 2015 at both locations. Both positive ionospheric storms can be attributed to enhanced Equatorial Ionospheric Anomaly (EIA) or "Fountain Effect". The thermospheric winds present in the E-region laying over the equator causes the ions to travel across the magnetic field lines. The moving ions create an eastward electric field (E), whose electric field lines are mapped along the northward magnetic field (B) lines. This creates an upward (E x B) plasma drift resulting in the fountain effect, which is responsible for enhanced TEC in the equatorial and low-latitude regions [25]. Furthermore, a twin-peak is observed at Hyderabad on 18 March 2015 where VTEC reaches peak values at 0640 (79 TECU) and 1200 UT (70 TECU). While the enhancement in VTEC on the early hours of 18 March 2015 at Hyderabad can be attributed to storm induced effects on ionosphere, the delayed enhancement at 1200 UT can be attributed to EIA. A possible cause for decrease in VTEC between 0700 and 1200 UT on 18 March 2015 could be an increase in recombination rates due to changing ionospheric chemistry and/or temperature at this time. This temporary E x B plasma drift produces a peak of ionization at 1200 UT on 18 March 2015 at Hyderabad, which subsequently decreasesduring the night. Another possible cause for this second VTEC peak at 1200 UT could be Prompt Penetration Electric Fields (PPEF), which are driven by the leakage of high-latitude convection electric fields to low-latitudes. The intense turbulence of the electric fields resulting from the magnetosphere–ionosphere interactions could be responsible for dramatic changes in VTEC.

At the mid-latitude station of Lucknow, VTEC on quiet days of March generally reaches its peak values between 0800 and 0900 UT. This duration is known as the 'peak hours of ionization'. At Lucknow, ionospheric storm occurred immediately after SSC on 17 March 2015, and following the termination of Main Phase (MP), when geomagnetic disturbance is at its maximum. Since the termination of Main Phase (MP) occurs late at night, an early negative ionospheric storm is witnessed on 18 March 2015, with VTEC reaching its peak values during the day at earlier UT. The negative ionospheric storm conditions at Lucknow can be attributed to enhanced electron content losses due to composition changes in the ionosphere. According to Mendillo[2], composition changes that influence negative storm conditions are a result of storm induced modifications to thermospheric convection. On the quiet days following a geomagnetic storm, the VTEC increases abnormally as observed on 20 March 2015, where VTEC increases after three consecutive days that saw TEC depletions induced by an extremely strong geomagnetic storm. This VTEC enhancement on 20 March 2015 at Lucknow can be attributed to electron content added into the region's ionosphere through convection from higher latitudes.

Furthermore, smaller VTEC peaks illustrating sudden enhancements in VTEC are observed on 17 and 18 March 2015 at all three locations between 1200 UT and 1800 UT. Such delayed electrodynamics can arise from winds generated by auroral heating that reach low latitudes. This is also known as the "Disturbance Dynamo" mechanism. The delayed electric field produced by the disturbance dynamo is driven by joule heating due to storm energy input[4,26-28]. Depending on the polarity and duration of these electric fields, they can either cause large uplifts or downdrafts of the ionospheric plasma leading to enhancement or depletion of VTEC. However, an analysis of the mechanisms leading to TEC enhancement and depletion is beyond the scope of this paper.

5.2 GPS error caused by variations in ionospheric VTEC during storm time at Bangalore, Hyderabad and Lucknow:

At low-latitude regions of Bangalore and Hyderabad, the highest error in E-W direction on 17 March 2015 was observed between 1500 and 1630 UT. In both regions, this can be attributed to the secondary VTEC peak between 1500 and 1600 UT as observed in Fig. 1. The cause of such enhancement in VTEC in the post-afternoon duration of the day could be due to delayed electrodynamics induced by the geomagnetic storm that occurred on the early hours of 17 March 2015. While GPS error in the E-W direction on 18 March 2015 at Bangalore did not deviate much from the respective quiet day mean GPS error, an average GPS error of -3.2 m was recorded in the E-W direction on 18 March 2015 at Hyderabad. This could be attributed to VTEC enhancements caused by magnetospheric and ionospheric convection processes during the early positive ionospheric storm that occurred in Hyderabad at 0645 UT on 18 March 2015. Furthermore, while the GPS error in N-S direction on 17 March 2015 at Hyderabad did not deviate much from the respective quiet day mean GPS error, an average GPS error of -3 m was recorded in the N-S direction on 17 March 2015 in Bangalore between 0700 to 0800UT, and 1000 and 1100 UT. VTEC enhancements triggered after Sudden Storm

Commencement (SSC) and during the Main Phase (MP) of the storm could be the cause of GPS error in the N-S direction at Bangalore on the morning hours of 17 March 2015. At both Bangalore and Hyderabad, the GPS error in the N-S direction on 18 March 2015 was recorded at +5-6 m between 0500 and 0600 UT. This could be attributed to VTEC enhancements caused by the early positive ionospheric storm that occurred between 0600 and 0700 UT on 18 March 2015 at both locations. A GPS error of +5 m was recorded in the N-S direction on 18 March 2015 at Hyderabad at 1040 UT. This could be attributed to VTEC enhancement between 1000 UT and 1200 UT in Hyderabad on 18 March 2015 that can be observed as a clear secondary peak in Fig. 1.

At the mid-latitude region of Lucknow, high GPS error was recorded in both E-W and N-S directions during storm days. While the highest GPS error of +7.2 m was recorded at Lucknow in the E-W direction on the evening (1620 UT) of 17 March 2015, the highest GPS error of +11.3 m was recorded at Lucknow in the N-S direction on the morning (0615 UT) of 18 March 2015. In almost all instances where a GPS error of +3 m was exceeded in the E-W and N-S directions at Lucknow on 17 and 18 March 2015, the cause seems to be sudden depletions in VTEC governed by recombination chemistry that is followed by an immediate enhancement in VTEC due to magnetospheric convection processes at mid-latitudes.

5.3. Contour plot depicting 'Mean Annual VTEC' with respect to 'UT' and 'Geographic Latitude' for the year of 2015

From Fig. 5, it can be observed that, the EIA region lies between 10 N and 20 N latitudinal regions.

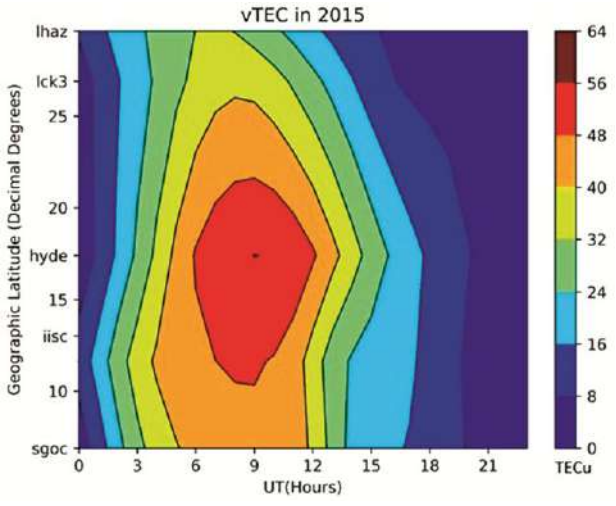

Fig. 5 — Contour plot showing diurnal variation of Mean Annual VTEC with respect to Geographic Latitude for the year 2015.

Further, the Mean Annual VTEC values observed at Lucknow are lower than those at low-latitude regions of Hyderabad and Bangalore. However, on certain quiet days of the year, VTEC at Lucknow reaches values that largely exceed those at the low-latitude stations. This can be observed in Fig. 1 on the quiet days of 16 and 20 March 2015.

6 Conclusions

Ionospheric disturbances caused by severe geomagnetic storms at low-latitude and mid-latitudes regions of India accurately coincide with previous observational studies on storm-time VTEC variations at similar latitudinal regions around the globe. For instance, while a negative ionospheric storm was witnessed at the mid-latitude region of Lucknow in response to the geomagnetic storm that occurred on 17 March 2015, positive ionospheric storms occurred in the low-latitude regions of Bangalore and Hyderabad where ionospheric VTEC is governed by electrodynamic mechanisms such as the EIA. Furthermore, storm induced effects on ionosphere are first felt at mid-latitude regions, and these effects last longer for negative ionospheric storms. While enhanced EIA plays a prominent role in positive storm phases, the delayed and prolonged storm effects play an equally important part in determining the duration and magnitude of VTEC enhancements. At low-latitude and mid-latitude regions, if the termination of Main Phase (MP) occurs in the evening, the VTEC peak increases in magnitude and shifts to earlier UT the following day. Further, quiet day mean VTEC values observed at Lucknow are lower than those at low-latitude regions of Hyderabad and Bangalore. This is due to the increased intensity and duration of solar radiation at low-latitude regions. However, on certain quiet days of the year, VTEC at Lucknow reaches values that largely exceed those at the low-latitude stations. This can be observed in figure 1 on the quiet days of 16 and 20 March 2015. This study strongly recommends further inquiry into the thermospheric and magnetospheric convection processes, which govern such VTEC enhancements at mid-latitude region of Lucknow on quiet days.

GPS error in E-W and N-S directions is higher at the mid-latitude region of Lucknow than at the low-latitude regions of Bangalore and Hyderabad. While GPS error at Lucknow during storm time could be attributed to sudden increases and decreases in VTEC that are governed by recombination chemistry and magnetospheric convection processes at mid-

latitudes, GPS error at Bangalore and Hyderabad are caused by increased VTEC during positive ionospheric storm durations that are governed by magnetospheric and ionospheric convection processes at low-latitudes. At the low-latitude regions of Bangalore and Hyderabad, fluctuations in VTEC caused by delayed electrodynamics contribute to GPS error in the post afternoon durations of the storm days (17 and 18 March 2015), especially between 1400 and 1800 UT.

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Comparison and Validation of VTEC Derived from GPS, IRI-Plas and NeQuick-2 During 2015 and 2019 in India

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Abstract
The paper compares Vertical Total Electron Content (VTEC) values extracted from IGS's distributed network of dual-frequency GPS stations in India, and the VTEC values extracted through IRI-Plas-2017 and NeQuick-2.0.2 models at the same locations and the same durations of time. Diurnal variation and relative deviation of modelled and measured VTEC of IGS reference stations at Lucknow (LCK3, Latitude: 26.91218, Longitude: 80.95564) and Hyderabad (HYDE, Latitude: 17.41728, Longitude: 78.55088) are visualized through graphical representation, during 2015 and 2019. Further, statistical analysis was performed on both datasets. The outputs of this project revealed that, the magnitude of maximum relative deviation of modelled VTEC from measured VTEC was high while using IRI-Plas model at Lucknow and Hyderabad in each month of solar maximum and solar minimum. Furthermore, during solar minimum, VTEC is highly overestimated by both models during peak hours of ionization and the magnitude of overestimation at these hours is higher while using IRI-Plas model for both regions. Finally, the highest coefficient of determination value was recorded at Hyderabad during 2019 while using IRI-plas model. The R^2 analysis shows that IRI-Plas model produces a more accurate representation of VTEC during solar minimum and maximum at both regions.

1. Introduction

Total Electron Content (TEC) has been an important parameter to study disturbances in the ionosphere that are caused by variations in intensity of solar radiation. While comprehensive analysis on TEC derived from trans-ionospheric radar instruments started as early as 1957 (Evans, 1957 and Bauer and Daniels, 1959), with the advent of artificial satellites, TEC derived from Global Navigation Satellite Systems (GNSS) is currently the most preferred data source for observing ionospheric behaviour (Mendillo, 2005). Over the last 20 years, while several researchers offered successful insight on the diurnal, monthly, seasonal and annual variations in TEC at various latitudinal regions (Bhattacharya et al., 2009, Unnikrishnan et al., 2002 and D'ujanga et al., 2012), several others offered an insight into the electromagnetic phenomena responsible for short-term and long-term impacts of solar radiation on ionospheric TEC (Chauhan and Singh, 2010, Anderson et al., 2006 and Appleton, 1946).

Based on years of research on ionospheric plasma, a data-based empirical model named International Reference Ionosphere (IRI) was first launched in 1978, as a standard for ionospheric parameters. Over time, with the emergence of better modelling techniques and newer datasets, updated versions of IRI such as: IRI-1985, IRI-1990, IRI-2000, IRI-2007, IRI-2016 and most recently IRI-Plas, were launched (Bilitza, 1990, Bilitza et al., 2000 and Bilitza and Reinisch, 2008). TEC, is one amongst the thirty-seven other ionospheric parameters that are calculated by IRI. Similarly, NeQuick is another prominent ionospheric model that is developed by the International Centre for Theoretical Physics (ICTP) in Italy, along with the University of Graz in Austria. It is a three-dimensional and time-dependent empirical model of the ionosphere's electron density profile. Unlike the IRI-model, TEC and electron density are the only two parameters calculated by NeQuick. The latest version of this model is NeQuick-2.

In this study, Vertical Total Electron Content (VTEC) extracted from GPS, IRI-Plas and NeQuick-2 are compared at two regions in India during 2015 and 2019. The comparative and correlation analysis aims to quantify deviation of modelled TEC data from measured TEC data, at a mid-latitude region and a low-latitude region of India, during the solar maximum (2015) and solar minimum (2019).

2. Literature

2.1 Total Electron Content (TEC)

TEC is a parameter widely used to depict the effect of solar radiation on the ionosphere. TEC can be defined as the total number of electrons that are present in an area enclosed by a tube with an arbitrary cross-section of 1 square meter laid over the entire length between the satellite and receiver (Okoh et al., 2015). TEC values will be high during the daytime due to ionization by X-rays and UV-rays, and low during night-time due to the recombination process. Further, when Interplanetary Magnetic Fields (IMF) directed towards earth interact with the magnetosphere, electromagnetic processes govern TEC enhancements and depletions in the ionosphere. Also, TEC is directly proportional to signal delay because the increase in free electrons in the ionosphere creates a highly dispersive medium through which GPS signals must travel.

2.2 Solar Cycle

The intensity of solar activity increases and decreases in an 11-year cycle. This solar cycle dictates the extremity of X-rays and UV-rays emitted by the sun. Therefore, the solar cycle has dramatic implications on the electromagnetic mechanisms of the Earth's upper atmosphere (David, 2015). In a typical solar cycle, intensity of solar activity increases through the first five or six years until it reaches a maximum, and then decreases through the remainder of the 11-year cycle until it reaches a minimum. The current solar cycle i.e. solar cycle 24 is predicted to end in 2020. The cycle's solar maximum was reached in 2014-15.

2.3 International GNSS Service (IGS)

IGS provides highly precise navigation information through over 400 global permanent GNSS stations and close to 200 organizations spread over 100 countries are responsible for contributing towards the establishment of this organization (source: www.igs.org). The accuracy and precision of GNSS measurements is very high. GNSS data derived from the IGS network fundamentally measures two atmospheric parameters: The Tropospheric Zenith Path Delay (ZPD) and Ionospheric TEC. This is done by combining pseudo-range measurements of GNSS with IGS precise clocks and orbits (Kouba, 2009). IGS hosts data obtained predominantly from a single satellite navigation system i.e., Global Positioning System (GPS). More recently, data from Russia's GLObal NAvigation Satellite System (GLONASS) has been incorporated into the IGS workflow. The data is available for download from the IGS data portal, which is hosted by National Aeronautics and Space Administration (NASA). IGS station in Lucknow (LCK3) is located at 26.91218 N and 80.95564 E, and IGS station in Hyderabad (HYDE) is located at 17.41728 N and 78.55088 E.

2.4 TEC Derived from Dual-Frequency GPS

In a GNSS network such as the GPS, for the 'navigation message' to travel from the satellite to the receiver, a 'carrier wave' is required. In case of a dual-frequency GPS design, two carrier waves are used: L1 at 1575.42 MHz and L2 at 1227.60 MHz. Pseudo-range estimations from 'L1' and 'L2' are used to calculate Slant TEC (STEC) at a station. The empirical formula for calculating STEC from pseudo-range measurements is given below:

$$STEC = \frac{2}{k}\left[\frac{{f_1}^2 {f_2}^2}{{f_1}^2 - {f_2}^2}\right](P_2 - P_1) + \tau^r + \tau^s$$

Equation 1

Where, 'k' is a constant whose value is 80.62 (m3/s2); 'f_1' and 'f_2' are frequencies of pseudo-ranges 'P_1' and 'P_1'; 'τ_r' and 'τ_s' are the differential code bias and inter-frequency bias corresponding to 'P_1' and 'P_2' (Kenpankho et al., 2011). Once STEC is corrected for the 'satellite bias and 'receiver bias', VTEC is calculated using the following formula:

$$VTEC = STEC\left\{cos\left[arcsin\left(\frac{R_e}{R_e + h_m} sin\chi\right)\right]\right\}$$

Equation 2

Where, χ is the zenith angle at receiver position, R_e is the mean radius of the earth and h_m is the height of ionospheric layer (Tariku, 2015).

2.5 International Reference Ionosphere (IRI)

IRI is an empirical model developed by the Committee on Space Research (COSPAR) and International Union of Radio Science (URSI) to provide standardized measurements of ionospheric parameters. A team of 60+ ionospheric experts from different parts of the world are responsible for generating the model, and introducing corrections or modifications for enhancing model accuracy. The inputs for this model are provided from a variety of instruments such as: a worldwide network of ionosondes, incoherent scatter radars, topside sounder satellites, and in-situ satellite measurements (Dieter et al., 2011). IRI was standardized by International Standardization Organization (ISO) in 2014. The model is developed based on experimental evidence rather than our evolving theoretical understanding of ionospheric plasma and its behaviour. Theoretical observations are only

used to bridge whatever gaps are encountered in the development of this model. Therefore, if certain geographical areas and time periods do not have an underlying database of ionospheric research, then the ionospheric parameters estimated by IRI for that spatial and temporal extent have a risk of being mildly unreliable. For a given date, time and location, the IRI model estimates ion composition, electron density, VTEC, height of ionospheric layers, vertical ion drift and ion temperatures at various temporal resolutions.

2.6 Nequick-2 Model

NeQuick is based on the DGR profiler model, which was originally proposed by G. Di Giovanni and S. M. Radicella in 1990. The model empirically reproduces electron density profile of the ionosphere using the sum of Epstein layers (Sandro, 2009). The DGR model was designed to fulfil, to a reasonable extent, the basic criteria used to judge an empirical model of the ionosphere's electron density profile w.r.t. height. These criteria were first defined by Dudeney and Kressman in 1986, which state that mathematical formulations of ionospheric parameters should be simpler than traditional ionogram inversion techniques. In 1995, improvements to the original DGR model made by Radicella and Zhang allowed for estimation of VTEC (Sandro and Man-Lian, 1995). Further improvements and modifications were made to the original model in 2001, 2005 and 2006. These additions are reflected in the latest version of this model i.e. NeQuick-2. The NeQuick model has been particularly successful in estimating electron density of ionosphere above 100 km. The model is currently adopted by the European satellite navigation system (GALILEO) for ionospheric corrections of its single frequency GNSS operation. Further, the NeQuick model is adopted by International Telecommunication Union (ITU) as a suitable model for estimating ionospheric parameters (Ezquer et al., 2017). For a given date, time and location, the NeQuick model estimates electron density and VTEC at various temporal resolutions.

3. Method of Analysis

3.1 Data Download

GPS data was downloaded from the IGS data portal hosted by NASA at: ftp://cddis.nasa.gov/gnss/data/-daily/. From the data portal, 'observation files' with '.o' file extension can be downloaded for each day of the year. This data is available since 1992 for more than 300 geographic locations. To achieve the objectives of this study, '.o' files from GPS stations located at Lucknow and Hyderabad are downloaded for all days of 2015 and 2019. Download of '.o' files from IGS data portal was automated using Python script. Navigation message files, or '.n' files, which contain ephemeris for all the GPS satellites, were also downloaded from IGS data portal using a Python script. The hourly VTEC data from IRI-Plas and NeQuick 2 models can be obtained for a specific geographic location and hour. The IRI-Plas data was obtained by compiling and running the IRI-Plas source code, written in FORTRAN, which is available at ftp://ftp.izmiran.ru/pub/izmiran/SP-IM/ (Gulyaeva, 2020). The default values for all the parameters were used while running the IRI-Plas program. Similarly, the NeQuick-2 data was obtained by compiling and running the NeQuick-2 source code, written in FORTRAN, which is available at https://t-ict4d.ictp.it/nequick2/source-code (Zhang et al., 2010). Lower endpoint value of 0km, higher endpoint value of 20200km, and the daily solar index F10.7 values obtained from NASA OMNIWeb Data Explorer available at https://omniweb.gsfc.nasa.gov/form/dx1.html were used as parameters for running the NeQuick-2 program. The hourly VTEC data from both the models for Lucknow and Hyderabad for all days of 2015 and 2019 was thus obtained, and processed into a .csv (comma-separated values) file in our desired format.

3.2 Data Pre-Processing

GPS data downloaded from IGS data portal requires further pre-processing in order to extract VTEC values. Since each observation file represents data of one single day and one single station, around 1,460 observation files need to be downloaded for Lucknow and Hyderabad during 2015 and 2019. However, given that some data is missing, a total of 1179 observation files are downloaded using python script. TEC and satellite ephemeris data is compressed in observation and navigation files respectively in a Receiver Independent Exchange (RINEX) format. To extract this data, each RINEX observation and respective navigation file is provided as an input to the GPS-TEC software, designed by Dr. Gopi Seemala of the Indian Institute of Geomagnetism (https://seemala.blogsp-ot.com/). The output is a text file in standard text format, which provides in a column, VTEC values measured at one-minute intervals, for that day and location. A Python program was used to read data from the output files, which was processed to obtain hourly averaged VTEC values for all days of 2015 and 2019, at Lucknow and Hyderabad.

3.3 Data Processing

Once the data files with hourly-VTEC values from all three data sources are ready, they are used as an

input to two python scripts: the first script is used to graphically represent diurnal variation of VTEC at Lucknow and Hyderabad during 2015 and 2019, using all three data sources; while the second script is used to generate a plot to represent relative deviation between modelled VTEC prediction and measured VTEC. The relative deviation (D) is calculated using the following formula:

$$D = \left[\frac{(Modelled\ VTEC - Measured\ VTEC)}{Measured\ VTEC}\right] \quad \text{Equation 3}$$

A third Python script is used to generate a scatter plot for the measured VTEC on X-axis, and modelled VTEC on Y-axis from IRI-Plas and NeQuick-2 in their respective plots. Linear regression analysis was performed on the data to determine the capability of both models in accurately producing VTEC data for the specific geographic locations during 2015 and 2019.

4. Results

4.1 Diurnal Variation and Relative Deviation (D) of Modelled and Measured VTEC at Lucknow During 2015

From Figure 1 and Figure 2 it can be observed that, at Lucknow, the relative deviation of modelled VTEC from measured VTEC is mostly positive throughout the year at all durations of the day. This indicates that, both IRI-Plas and NeQuick-2 models overestimate VTEC throughout the day at Lucknow during 2015. From Table 1 it can be observed that, at Lucknow, during 2015, the maximum relative deviation of modelled VTEC from measured VTEC was observed between 2100 UT and 2300 UT from February to October while using the IRI-Plas model. Similarly, while using the NeQuick-2 model, the maximum relative deviation was observed between 2100 UT and 2300 UT from February to August. However, during the remaining months of the year, the NeQuick-2 model shows maximum relative deviation from measured VTEC between 1300 UT and 1600 UT. In the month of November, both models show maximum relative deviation from measured VTEC at 1300 UT. Finally, the maximum relative deviation from measured VTEC for the entire year was observed in April at 2300 UT for both models.

From Table 1 it can further be observed that, at Lucknow, during 2015, the maximum relative deviation of modelled VTEC from measured VTEC during peak hours of ionization was observed in September (81.94%) while using IRI-Plas model; and in November (55.38%) while using NeQuick-2 model. Negative relative deviation from measured data was observed at peak hours of ionization in the months of March and July while using the NeQuick-2 model.

4.2 Diurnal Variation and Relative Deviation (D) of Modelled and Measured VTEC at Hyderabad During 2015

From Figure 3 and Figure 4 it can be observed that, at Hyderabad, during 2015, the relative deviation of modelled VTEC from measured VTEC is both positive and negative, depending on the duration of day and month. Throughout the year, the positive relative deviation or overestimation by modelled data is observed in the post-afternoon durations of the day. Low and negative relative deviation is observed predominantly in the sun-lit hours of the day. During certain months, the negative relative deviation or underestimation by modelled data extends to later UT. From Table 2 it can be observed that, at Hyderabad, during 2015, the maximum relative deviation of modelled VTEC from measured VTEC was observed between 2100 UT and 2300 UT, or 0000 UT, throughout the year while using IRI-Plas model.

Similarly, while using the NeQuick-2 model, the maximum relative deviation was observed between 2000 UT and 2300 UT, or 0000 UT, throughout the year. Finally, the maximum relative deviation from measured VTEC for the entire year was observed in March at 0000 UT for both models.

From Table 2 it can further be observed that, at Hyderabad, during 2015, the maximum relative deviation of modelled VTEC from measured VTEC during peak hours of ionization was observed in September (34.25%) while using IRI-Plas model; and in February (-22.96%) while using the NeQuick-2 model. Negative relative deviation from measured data was observed at peak hours of ionization in certain months while using both models. While negative relative deviation at peak hours of ionization was observed only in the months of February and March while using the IRI-Plas model, negative relative deviation at peak hours of ionization was observed almost throughout the year while using NeQuick-2 model.

4.3 Diurnal Variation and Relative Deviation (D) of Modelled and Measured VTEC at Lucknow During 2019

From Figure 5 and Figure 6 it can be observed that, at Lucknow, during 2019, the relative deviation of modelled VTEC from measured VTEC is both positive and negative during most months, with the exception of a few months (April, May, June and August) where positive relative deviation was observed at all durations of the day.

Table 1: Maximum relative deviation and relative deviation at peak hours of ionization between modelled and measured VTEC during 2015 at Lucknow

Month	Maximum relative deviation while using IRI-Plas model (%)	Maximum relative deviation while using NeQuick-2 model (%)	Peak hours of ionization as observed from measured data	Relative deviation during peak hours of ionization while using IRI-Plas model	Relative deviation during peak hours of ionization while using NeQuick-2 model
January	195.35 at 0000 UT	182.59 at 1600 UT	0700 UT	35.41 %	49.22 %
February	187.40 at 2100 UT	101.99 at 2100 UT	1000 UT	12.81 %	12.32 %
March	293.32 at 2300 UT	207.36 at 2000 UT	0800 UT	9.88 %	-4.62 %
April	426.71 at 2300 UT	392.92 at 2300 UT	0900 UT	22.94 %	17.21 %
May	385.35 at 2300 UT	351.19 at 2300 UT	0900 UT	20.90 %	11.94 %
June	380.13 at 2200 UT	362.13 at 2200 UT	0800 UT	20.65 %	11.96 %
July	319.40 at 2200 UT	210.44 at 2200 UT	0800 UT	17.83 %	-3.21 %
August	308.50 at 2300 UT	190.46 at 2300 UT	0700 UT	47.89 %	16.60 %
September	215.46 at 2300 UT	108.59 at 1400 UT	0900 UT	81.94 %	48.12 %
October	202.01 at 2100 UT	172.49 at 1400 UT	0700 UT	60.50 %	32.05 %
November	180.13 at 1300 UT	177.72 at 1300 UT	0600 UT	72.67 %	55.38 %
December	134.35 at 2000 UT	112.90 at 1500 UT	0900 UT	64.02 %	52.12 %

Table 2: Maximum relative deviation and relative deviation at peak hours of ionization between modelled and measured VTEC during 2015 at Hyderabad

Month	Maximum relative deviation while using IRI-Plas model (%)	Maximum relative deviation while using NeQuick-2 model (%)	Peak hours of ionization as observed from measured data	Relative deviation during peak hours of ionization while using IRI-Plas model	Relative deviation during peak hours of ionization while using NeQuick-2 model
January	196.21 at 2300 UT	140.36 at 2200 UT	0800 UT	14.20 %	6.70 %
February	188.08 at 2200 UT	132.34 at 2200 UT	1000 UT	-11.44 %	-22.96 %
March	1239.1 at 0000 UT	846.86 at 0000 UT	1000 UT	-3.66 %	-17.97 %
April	758.12 at 0000 UT	681.46 at 0000 UT	1000 UT	0.95 %	-13.32 %
May	217.41 at 2300 UT	178.66 at 2300 UT	0900 UT	20.11 %	-2.73 %
June	182.76 at 2100 UT	167.84 at 2100 UT	0800 UT	21.81 %	-0.44 %
July	261.62 at 2200 UT	158.72 at 2200 UT	0900 UT	26.11 %	-7.86 %
August	132.07 at 2100 UT	88.29 at 2000 UT	0900 UT	28.26 %	-7.29 %
September	234.94 at 2200 UT	121.11 at 2100 UT	1000 UT	34.25 %	1.82 %
October	247.29 at 2300 UT	119.87 at 2100 UT	0900 UT	28.88 %	-0.31 %
November	243.84 at 2200 UT	148.22 at 2100 UT	0900 UT	25.16 %	2.47 %
December	303.40 at 0000 UT	166.53 at 2000 UT	0900 UT	28.57 %	11.06 %

Table 3: Maximum relative deviation and relative deviation at peak hours of ionization between modelled and measured VTEC during 2019 at Lucknow

Month	Maximum relative deviation while using IRI-Plas model (%)	Maximum relative deviation while using NeQuick-2 model (%)	Peak hours of ionization as observed from measured data	Relative deviation during peak hours of ionization while using IRI-Plas model	Relative deviation during peak hours of ionization while using NeQuick-2 model
January	161.05 at 0600 UT	114.98 at 0600 UT	0800 UT	122.29 %	82.41 %
February	175.29 at 0700 UT	119.35 at 0700 UT	0900 UT	108.57 %	72.74 %
March	144.63 at 0600 UT	112.49 at 0600 UT	0800 UT	131.81 %	100.95 %
April	780.58 at 0000 UT	492.83 at 0000 UT	0800 UT	119.25 %	91.40 %
May	135.37 at 1000 UT	116.39 at 1000 UT	0900 UT	123.36 %	97 %
June	159.83 at 2100 UT	93.28 at 1900 UT	0700 UT	83.07 %	44.65 %
July	N.A.	N.A.	N.A.	N.A.	N.A.
August	135.97 at 0700 UT	91.13 at 0900 UT	0800 UT	129.53 %	82.76 %
September	145.25 at 0300 UT	92.57 at 0300 UT	0700 UT	91.93 %	54.45 %
October	174.80 at 0200 UT	128.13 at 1200 UT	0800 UT	95.85 %	72.10 %
November	N.A.	N.A.	N.A.	N.A.	N.A.
December	193.52 at 0700 UT	142.48 at 0700 UT	0900 UT	130.38 %	95.16 %

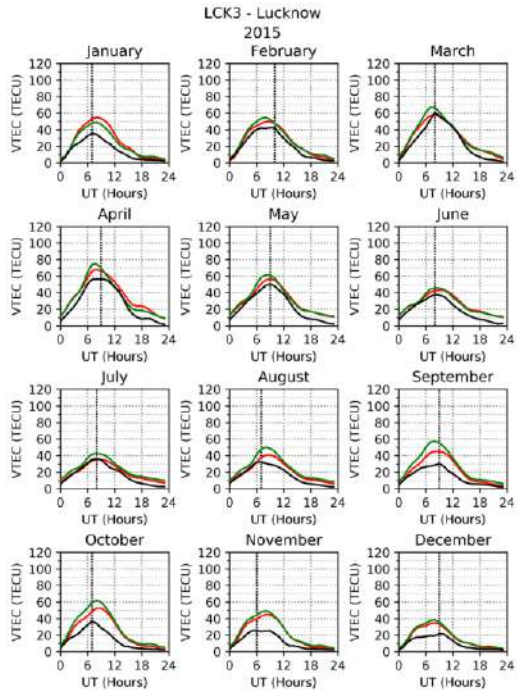

Figure 1: Diurnal variation of modelled and measured VTEC at Lucknow during 2015. The black, green and red solid lines denote VTEC derived from GPS, IRI-Plas and NeQuick-2 respectively. The vertical black dashed line denotes the peak hour of ionization as observed from measured data

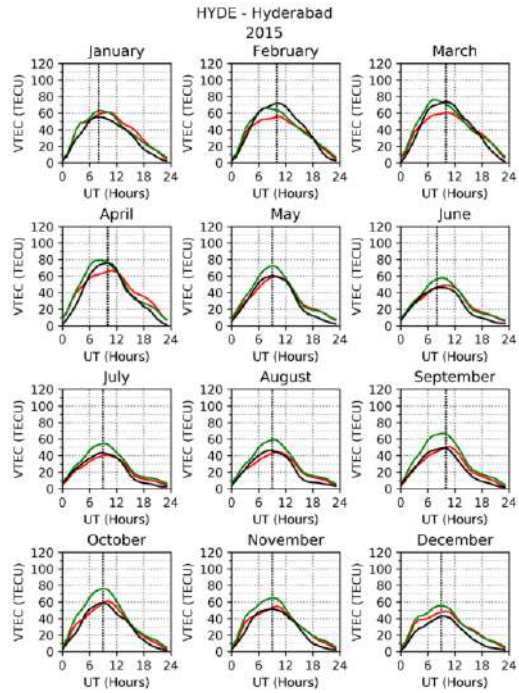

Figure 3: Diurnal variation of modelled and measured VTEC at Hyderabad during 2015. The black, green and red solid lines denote VTEC derived from GPS, IRI-Plas and NeQuick-2 respectively. The vertical black dashed line denotes the peak hour of ionization as observed from measured data.

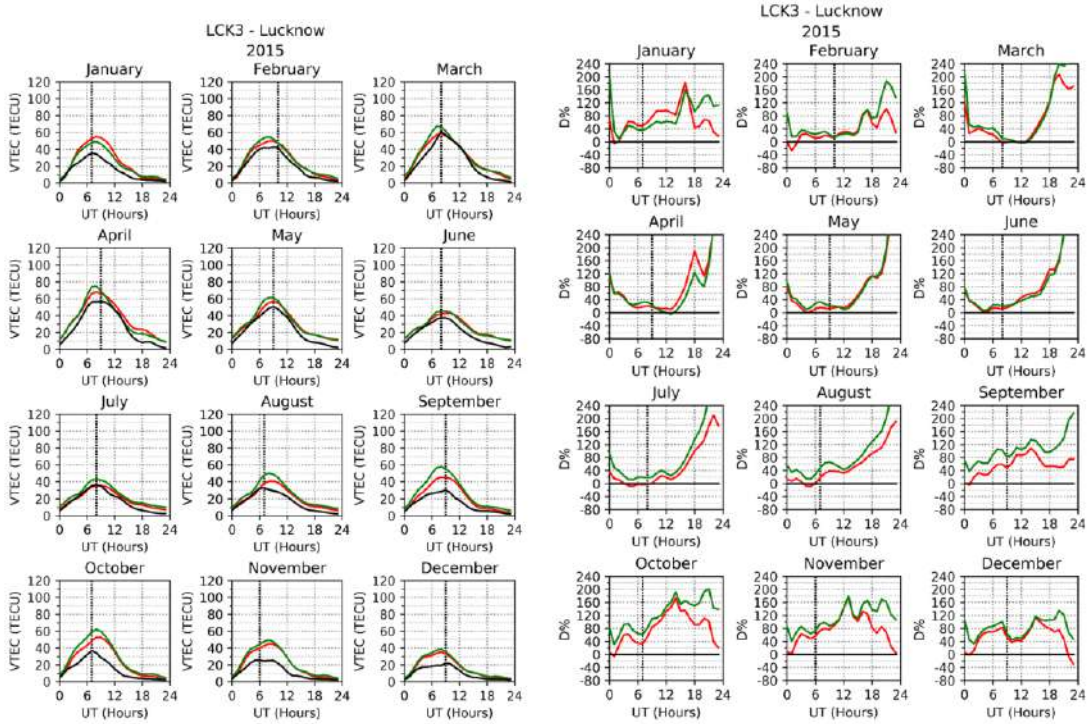

Figure 2: Relative deviation of modelled and measured VTEC at Lucknow during 2015. The green and red solid lines denote relative deviation from the measured data while using IRI-plas and NeQuick-2 respectively. The vertical black dashed line denotes the peak hour of ionization as observed from measured data

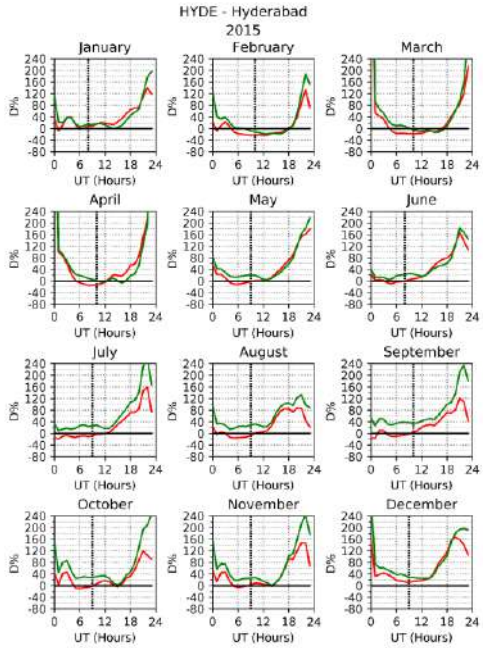

Figure 4: Relative deviation of modelled and measured VTEC at Hyderabad during 2015. The green and red solid lines denote relative deviation from the measured data while using IRI-plas and NeQuick-2 respectively. The vertical black dashed line denotes the peak hour of ionization as observed from measured data

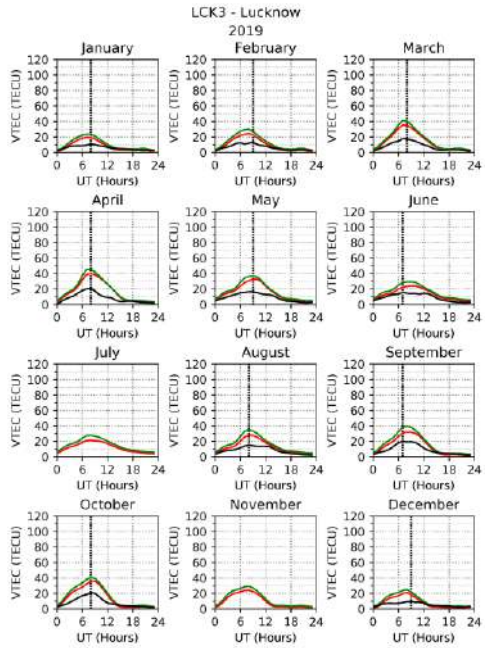

Figure 5: Diurnal variation of modelled and measured VTEC at Lucknow during 2019. The black, green and red solid lines denote VTEC derived from GPS, IRI-Plas and NeQuick-2 respectively. The vertical black dashed line denotes the peak hour of ionization as observed from measured data

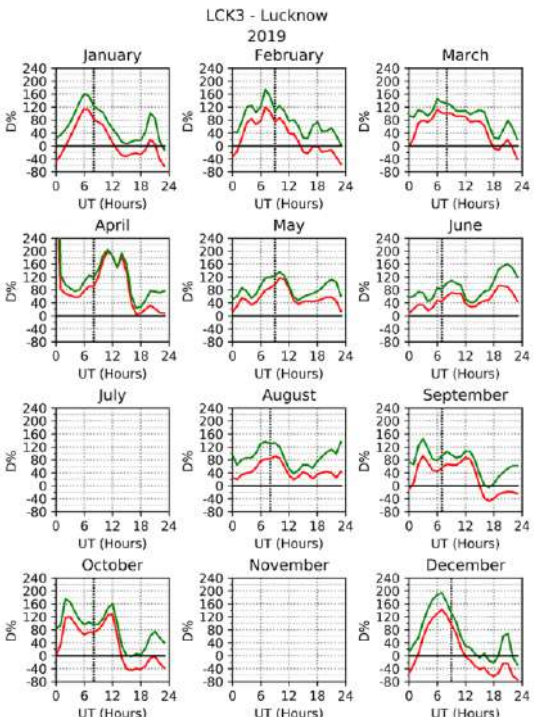

Figure 6: Relative deviation of modelled and measured VTEC at Lucknow during 2019. The green and red solid lines denote relative deviation from the measured data while using IRI-plas and NeQuick-2 respectively. The vertical black dashed line denotes the peak hour of ionization as observed from measured data

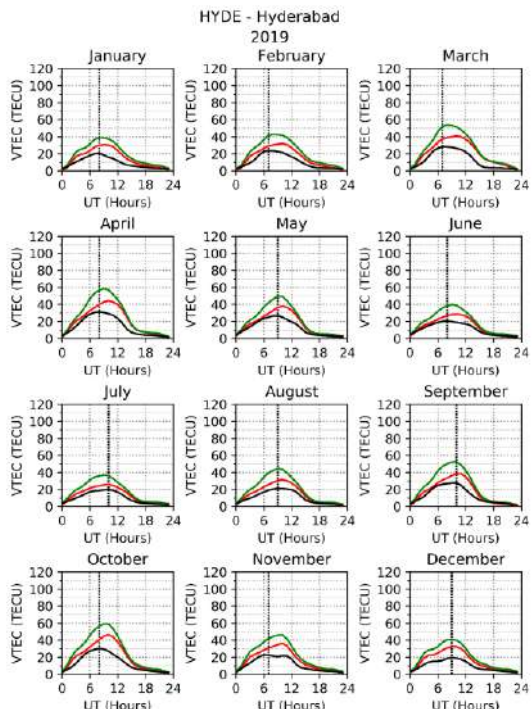

Figure 7: Diurnal variation of modelled and measured VTEC at Hyderabad during 2019. The black, green and red solid lines denote VTEC derived from GPS, IRI-Plas and NeQuick-2 respectively. The vertical black dashed line denotes the peak hour of ionization as observed from measured data

Table 4: Maximum relative deviation and relative deviation at peak hours of ionization between modelled and measured VTEC during 2019 at Hyderabad

Month	Maximum relative deviation while using IRI-Plas model (%)	Maximum relative deviation while using NeQuick-2 model (%)	Peak hours of ionization as observed from measured data	Relative deviation during peak hours of ionization while using IRI-Plas model	Relative deviation during peak hours of ionization while using NeQuick-2 model
January	163.74 at 1300 UT	109.24 at 1300 UT	0800 UT	89.71 %	45.29 %
February	186.54 at 1800 UT	102.80 at 1800 UT	0700 UT	76.46 %	23.71 %
March	248.94 at 1600 UT	237.81 at 1600 UT	0700 UT	85.48 %	32.24 %
April	144.41 at 1400 UT	123.04 at 1400 UT	0800 UT	81.23 %	26.77 %
May	99.32 at 1100 UT	69.19 at 1200 UT	0900 UT	85.72 %	36.58 %
June	104.87 at 1000 UT	55.10 at 1100 UT	0800 UT	86.94 %	30.61 %
July	98.77 at 2100 UT	60.89 at 1400 UT	1000 UT	82.52 %	30.44 %
August	108.83 at 0900 UT	55.16 at 1500 UT	0900 UT	108.83 %	43.29 %
September	127.26 at 1300 UT	89.46 at 1300 UT	1000 UT	89.50 %	39.8 %
October	146.16 at 0200 UT	89.82 at 0200 UT	0800 UT	86.57 %	34.17 %
November	134.05 at 1400 UT	86.38 at 1400 UT	0700 UT	83.48 %	34.73 %
December	129.31 at 0700 UT	73.43 at 1500 UT	0900 UT	109.20 %	65.08 %

The negative relative deviation from measured data is mostly observed in the post-afternoon durations of the day, and in some months (January, February and December) it is observed between 0000 UT and 0300 UT. Furthermore, GPS data from the IGS portal is unavailable for the months of July and November.

From Table 3 it can be observed that, at Lucknow, during 2019, the maximum relative deviation of modelled VTEC from measured VTEC was observed at different durations of time at different months of the year. However, in all months of the year except June, August and October, both models show maximum relative deviations from measured VTEC at the same UT. Finally, the maximum relative deviation from measured VTEC for the entire year was observed in April at 0000 UT for both models. From Table 3 it can further be observed that, at Lucknow, during 2019, the maximum relative deviation of modelled VTEC from measured VTEC during peak hours of ionization was observed in March while using IRI-Plas (131.81%) and NeQuick-2 (100.95%) models. Negative relative deviation from measured data was not observed at peak hours of ionization at Lucknow during 2019.

4.4 Diurnal Variation and Relative Deviation (D) of Modelled and Measured VTEC at Hyderabad During 2019

From Figure 7 and Figure 8 it can be observed that, at Hyderabad, during 2019, the relative deviation of modelled VTEC from measured VTEC is both positive and negative, depending on the duration of day. Throughout the year, positive relative deviation is observed in the earliest hours of the day, and throughout the sunlit hours of the day. Furthermore, throughout the year, negative relative deviation is mostly observed in the post-sunset duration of the day. Negative relative deviation is also observed between 0000 UT and 0200 UT throughout the year.

From Table 4 it can be observed that, at Hyderabad, during 2019, the maximum relative deviation of modelled VTEC from measured VTEC was observed at different durations of time at different months of the year. However, in all months of the year except July, August and December, both models show maximum relative deviations from measured VTEC at approximately the same UT. Finally, the maximum relative deviation from measured VTEC for the entire year was observed in March at 1600 UT for both models. From Table 4 it can further be observed that, at Hyderabad, during 2019, the maximum relative deviation of modelled VTEC from measured VTEC during peak hours of ionization was observed in December while using IRI-Plas (109.2%) and NeQuick-2 (65.08%) models. Negative relative deviation from measured data was not observed at peak hours of ionization at Hyderabad during 2019.

5. Discussions

At the mid-latitude region of Lucknow and the low-latitude region of Hyderabad, the maximum relative deviation of modelled VTEC from measured VTEC has a higher magnitude while using IRI-Plas model for all months of 2015 and 2019. While the maximum relative deviation for the entire year at Lucknow was observed in April for both years, the same was observed in March at Hyderabad during 2015 and 2019. During the peak hours of ionization, when electron content in the ionosphere is at its highest due to increased solar radiation, the magnitude of relative deviation of modelled VTEC from measured VTEC is higher while using IRI-Plas model at both regions during 2019.

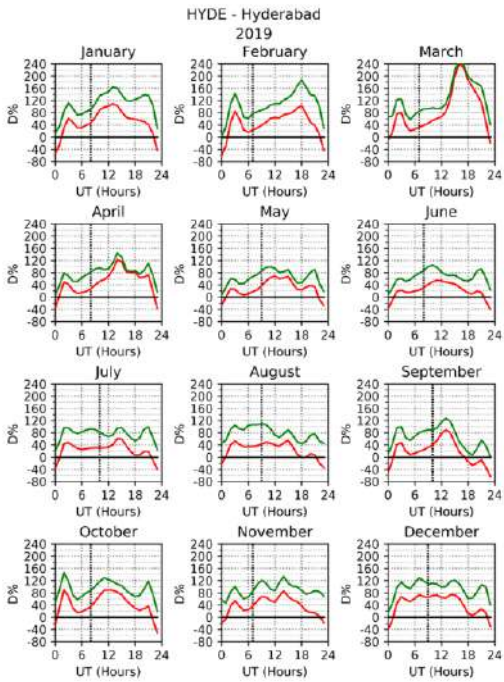

Figure 8: Relative deviation of modelled and measured VTEC at Hyderabad during 2019. The green and red solid lines denote relative deviation from the measured data while using IRI-plas and NeQuick-2 respectively. The vertical black dashed line denotes the peak hour of ionization as observed from measured data

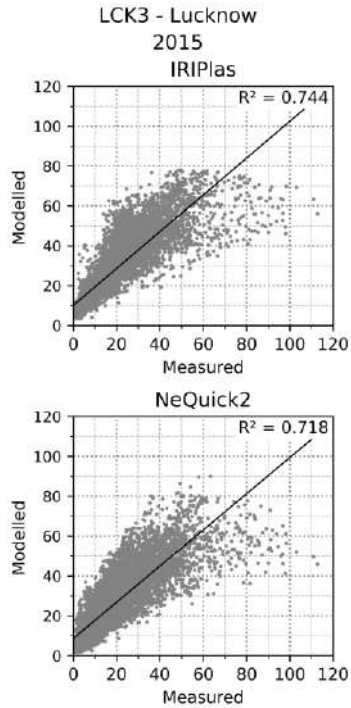

Figure 9: Scatter plot of modelled vs measured VTEC at Lucknow during 2015

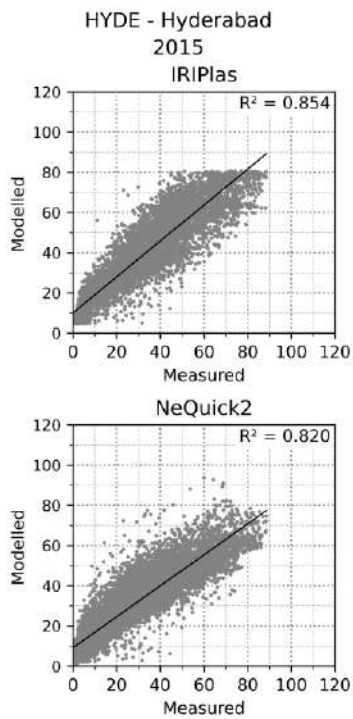

Figure 10: Scatter plot of modelled vs measured VTEC at Hyderabad during 2015

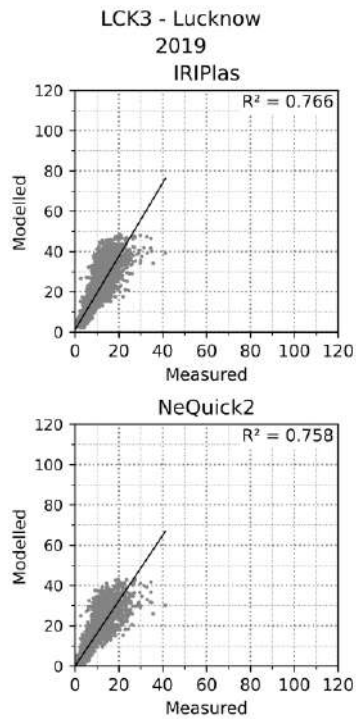

Figure 11: Scatter plot of modelled vs measured VTEC at Lucknow during 2019

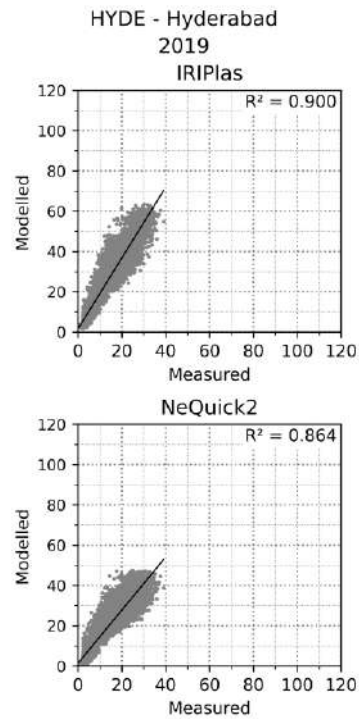

Figure 12: Scatter plot of modelled vs measured VTEC at Hyderabad during 2019

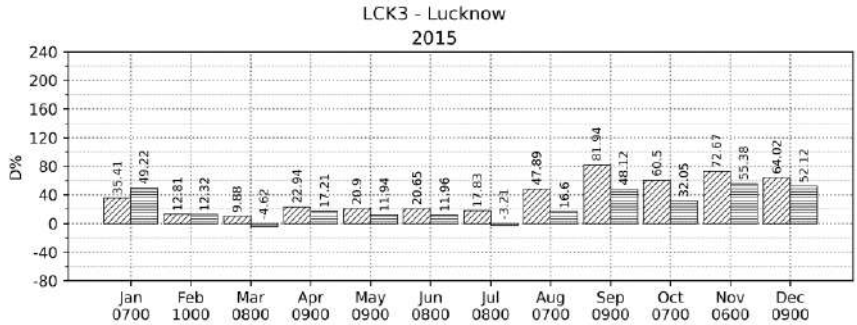

Figure 13: %D at peak hours of ionization for all months of 2015 at Lucknow. Relative deviation of IRI-Plas and NeQuick-2 data from measured VTEC is denoted by diagonally-hatched and horizontally-hatched bar plots respectively

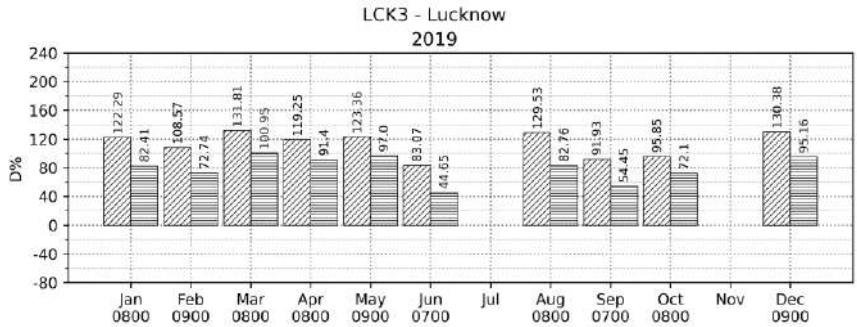

Figure 14: %D at peak hours of ionization for all months of 2019 at Lucknow. Relative deviation of IRI-Plas and NeQuick-2 data from measured VTEC is denoted by diagonally-hatched and horizontally-hatched bar plots respectively

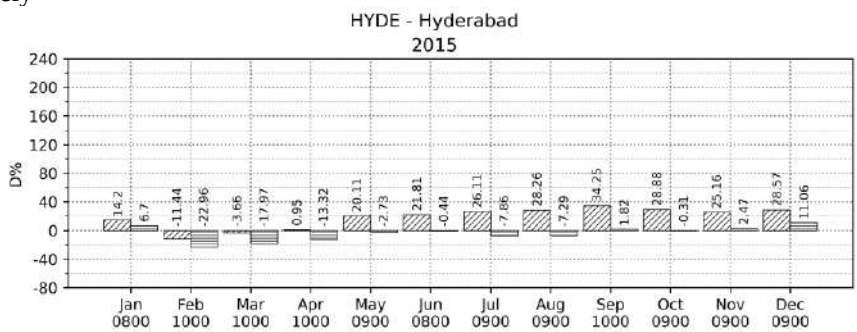

Figure 15: %D at peak hours of ionization for all months of 2015 at Hyderabad. Relative deviation of IRI-Plas and NeQuick-2 data from measured VTEC is denoted by diagonally-hatched and horizontally-hatched bar plots respectively

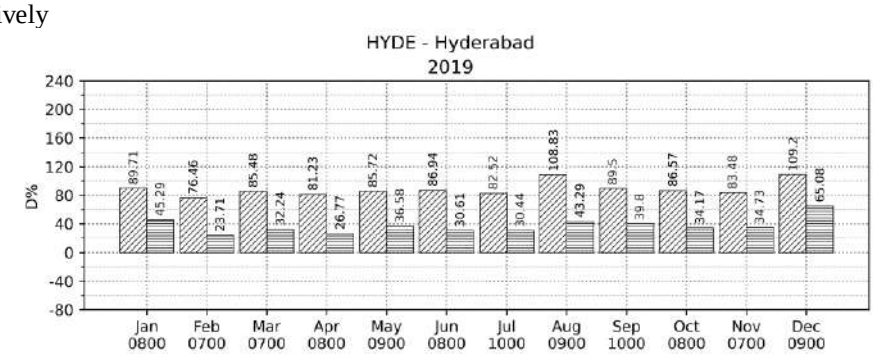

Figure 16: %D at peak hours of ionization for all months of 2019 at Hyderabad. Relative deviation of IRI-Plas and NeQuick-2 data from measured VTEC is denoted by diagonally-hatched and horizontally-hatched bar plots respectively

While the same observation holds true at Lucknow during 2015, the magnitude of relative deviation from measured data has a higher magnitude while using the NeQuick-2 model at Hyderabad in the months of February, March and April of 2015. Furthermore, during peak hours of ionization at both regions, negative relative deviation was not observed in any month of 2019. Considerable negative relative deviation during peak hours of ionization was only observed in Hyderabad during 2015 while using the NeQuick-2 model. Also, the magnitude of relative deviation at peak hours of ionization is higher during 2019 in both regions for both models, when compared to relative deviation of modelled data at peak hours of ionization during 2015 for the respective regions.

Finally, from Figures 9, 10, 11 and 12 it can be observed that the IRI-Plas data shows higher R^2 value when compared to NeQuick-2 data for both years and at both regions. Furthermore, at both regions, R^2 value is higher during 2019.

6. Conclusions

From the above study the following conclusions are made:

- The magnitude of maximum relative deviation of modelled VTEC from measured VTEC was higher while using IRI-Plas model at Lucknow and Hyderabad during all months solar maximum and solar minimum. At Lucknow, the maximum relative deviation for the entire year was recorded in April during solar minimum and maximum. However, at Hyderabad, the same result was recorded in March during solar minimum and maximum. The above-mentioned characteristics of maximum relative deviation at both geographic locations seem to be unaltered by the effects of solar maxima and minima.
- From Figures 13, 14, 15 and 16 it can be summarized that, during the peak hours of ionization, magnitude of relative deviation of modelled VTEC from measured VTEC was higher while using IRI-Plas model for both years at both regions, except for three months of 2015 at Hyderabad. The above-mentioned characteristics of relative deviation during peak hours of ionization at both geographic locations seem to be unchanged by the effects of solar maxima and minima. Negative relative deviation of modelled data during peak hours of ionization is observed only during solar maximum at certain months. Considerable underestimation of VTEC during peak hours of ionization was only observed in Hyderabad during the solar maximum while using the NeQuick-2 model. Furthermore, the magnitude of relative deviation of modelled data during peak hours of ionization is higher during solar minimum at both regions for both models. Therefore, it can be concluded that, during solar minimum, VTEC is highly overestimated by both models during peak hours of ionization, and the magnitude of overestimation at these hours is higher while using IRI-Plas model for both regions. During the solar maximum, VTEC at the mid-latitude region of Lucknow during peak hours of ionization showed maximum relative deviation during the September Equinox and December Solstice seasons, while using both models (Figure 13). However, during the same year, while VTEC at the low-latitude region of Hyderabad during peak hours of ionization showed maximum deviation during June Solstice, September Equinox and December Solstice seasons when using IRI-Plas model, the same was observed while using NeQuick-2 model in the March Equinox season (Figure 15). Finally, during solar minimum, At Lucknow and Hyderabad, VTEC is highly overestimated by both models throughout the year. However, NeQuick-2 model was more accurate in predicting VTEC during peak hours of ionisation of solar minimum, especially at the low-latitude region of Hyderabad (Figure 15 and Figure 16).
- The coefficient of determination (R^2) values were high during solar minimum while using both models at both regions. This implies that both models show smaller differences when compared to measured VTEC at both geographic locations during solar minimum. Furthermore, the IRI-Plas model produces a more accurate representation of VTEC when compared to NeQuick-2 model during solar minimum and maximum. Finally, R^2 value at Hyderabad is higher than that at Lucknow during solar minimum and maximum. This indicates that, both models produce electron content at a low-latitude region more accurately, than at a mid-latitude region in India.

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Current Situation of Education field due to Corona Virus Disease 19

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Abstract- **The spread of corona virus disease 19 has drastically disrupted each aspects of human life including education. It has created an unprecedented test on education. In many educational institutions around the world, campuses are closed and teaching-learning has moved online. Internationalization has slowed down considerably. In India, about 32 crore learners clogged to go to schools/colleges & all learning actions brought to an end. Despite of all these challenges, the Higher Education Institutions (HEIs) have reacted positively and managed to ensure the continuity of teaching-learning, research and service to the society with some tools and techniques during the pandemic. This article highlights on major impacts of COVID 19 on HEIs in India. Some measures taken by HEIs and educational authorities of India to provide seamless educational services during the crisis are discussed. Due to COVID 19 pandemic, many new modes of learning, new perspectives, new trends are emerged and the same may continue as we go ahead to a new tomorrow. So, some of the post COVID 19 trends which may allow imagining new ways of teaching learning of higher education in India are outlined. Some fruitful suggestions are also pointed to carry out educational activities during the pandemic situation.**

Keywords: *COVID 19* , higher education, impact, India, post *COVID 19*
Abbreviations- COVID 19-Corona Virus Disease, WHO- World Health Organization, ODL- Open & Distance Learning

1. Introduction

The COVID-19 as a pandemic was declared by the WHO [1] on 11 March 2020 which has overstated more than 4.5 million peoples worldwide. In India, the 1st affected patient of *COVID 19* was detected on 30 January 2020 in the state of Kerala & the pretentious had a travel history from Wuhan, China (Wikipedia)[2]. In India, the 1st death was reported on March 12, 2020 and the nation observed Janta Curfew for a day on March 22, 2020. This outbreak pandemic was evolved in Wuhan city of China and has affected many countries.[3]

The pandemic has significantly disrupted the growth of countries where the cases of novel coronavirus are reported. In order to reduce the crowd, countries are taking various measures such as lockdown, workplace non attendance, school closure, suspension of transport facilities etc. For controlling the spread of the COVID-19 pandemic, educational institutions have been temporarily closed by most of the countries around the world. Over 90 per cent student population of the world are affected by this closure nationwide. India is also suffering from the pandemic. In order to control the infection of COVID-19, Indian government has taken various measures such as on 22 March 2020, first Janta Curfew was announced by the Prime minister of India. Later on 21 days lockdown was announced by the prime minister of India to control the cases of COVID-19. On 14 April 2020, further the lockdown was extended by the Indian government till 3 may 2020. This decision is affecting the various sectors in the country. The education sector is also affected by the lockdown which is a critical determinant of the economic future of the country. As per the directives of the government, all schools, institutes & universities are closed. Whole education system is disrupted by the pandemic COVID-19.[4][5]

On 16 March, the government proclaimed a countrywide lock-down of schools and colleges. On 18 March, CBSE delivered modified rules for assessment centres. This incorporates keeping up a separation of in any event 1 meter between the understudies taking the test with a class not having in excess of 24 understudies. In the event that the rooms of the assessment communities are little, separate the understudies and cause them to sit in various rooms. On 19 March, CBSE and JEE primary assessments were delayed till 31 March. On 20 March, Maharashtra government dropped assessments for class 1 to 8 and elevated the understudies to the following classes, while assessments for class 9 and 11 were delayed till 15 April Madhya Pradesh Board of Secondary Education deferred board tests for class 10 and 12 and asked school chiefs to advance or keep understudies of class 5 to 8 dependent on

Problem of Indian Democracy and its solution

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Abstract

Indian democratic structure is the largest democracy of the world. Indian democracy is achieved good level during last 65 years after republic country. People are getting the right and duties to participate in government directly or indirectly. In democracy it is rule by the people where every citizen participate in the process of decision making through elected representative.in modern India it has to face many obstacles and challenges to improve true democracy. The challenges are social and economic inequalities, unemployment, poverty, casteism, communication, population explosion etc. Indian law system plays an important role in political reformation to avoid wrong practices and motivate good practices. Indian democracy has been working successfully for the last 6 and half decades continuously in the multi-cultural and multi-racial society.in this regard if decentralization process would take place properly the goal of good governance could be achieved.

Keywords:- democracy, Indian constitution, education, social

Introduction:- All Indians are proud that we are the largest democracy in the world more than sixty-five years. We have already read that democracy means government of the people, for the people, and by the people. That is democracy means not only process of election but social and economic development of the people. People getting experience of freedom of expression, freedom of movement and religion. Our country has seen developing and transforming socially and economically. Democracy is not only for election but also fulfil social and economic aspiration of society. The word democracy get from the Greek word " deokratia' which means rule of the people. Demo means people and kratos means power. It means that democracy is the power rest with the people. Democracy is defined as a form of government where supreme power is vested in the people and it is exercised directly or indirectly by a system of representation with election.in this way democracy is a form of government which is run by elected representative. Democracy is not limited to political democracy. It means a form of government, type of state, pattern of social system, design of economic order, a way of life and culture. When we say that India is a democracy that means not only political institution but also Indian society and every Indian is democratic showing basic democratic value of equality, liberty, fraternity, secularism, and justice in the social environment and personal behaviour.

Conditions for democracy:-the condition for democracy is it should fulfil both political and social economic aspect of people's participation and satisfaction. There is two major categories that is Political condition and social and economic condition. The essential condition is we must adopt and accept laws and constitution which gives supreme power to the people. The fundamental right such as equality, liberty of thought, freedom of expression, movement, and communication must be protected by constitution. The opportunities for participation in politics for all citizens not only in election but also in other aspect of political process has to be made available. There should be responsible government where the executive is answerable

to the legislature and the legislature to the people and judiciary. Political institution like political parties and different pressure group should be functional for expressing essential needs and demands. A democratic system is powerful if it maintains strong public opinion in various forms through media or other communication process democratic system ensures that the social development should go hand in hand with democratic values which shows equality of social status and opportunities for development, social welfare, and security. Every citizen should know opportunities of compulsory education and economic development of people. The benefit of economic development must spread to poor and deprived section of society. The social and economic development of people also gives power to strengthen social development.

Challenges to Indian Democracy

India has been working as a responsible democracy since independence. It is appreciated by international community. The election has been conducted periodically for all political parties from panchayat to presidents. There is a smooth transfer of power from political parties at national and state level. The judicial organ, executive, legislative are functioning in their way. The parliament and state legislative control the executive by keeping question hours. The important act like right to information (RTI 2005), Right to information (RTE 2009) have given power to people. The mass media like print and electronic is having freedom and playing important role making public opinion. The important social change has been initiated almost in every walk of life and development is taking place in social and economic field. India is a country of full of diversity like language, culture, religion etc. When India got dependence it was economically underdeveloped, there was various religion disparities, widespread poverty, illiteracy, unemployment, and public welfare shortage. All Indian people have much more expectation from independence. These challenges were discussed below.

Illiteracy: - The major challenges among the people was illiteracy which was a matter of grave for the successful functioning of democracy in India. The education of people was important for good working of democracy and socio economic development of country.it is important for human dignity.

When India achieved independence the literacy was almost less. The rate of literacy in 1951 was 18.33 percent and female literacy rate was negligible with 8.9 percent so it was fear that people would not be able to play their role effectively and exercise their right to vote to right candidates which is individual expression for democracy.

Literacy is essential for enabling people to participate in election process and casting their valuable vote effectively. Literacy gives awareness of various issues, problems, demands, and interest in the country.it also make them aware about equality, fraternity of Indian democracy. According to 2011 census the literacy rate has increased to 74.04 percent, the female literacy rate is lagging at 65.46 percentage that means ¼ of country's population is still illiterate. Now a day's right to education is fundamental right and we hope that it will help to increase percentage of education.

Poverty: - The maximum proportion of Indian population lives below poverty line, called as BPL. The poverty line is defined as an income level below which human being cannot provide for their basic necessities for cloth and shelter. Poverty is related with deprivation of right and also associated with human development Index (HDI).The poverty also depends social

economical political if we viewed from HDI perspective. The poverty is attributed with many factors one of which is unemployment and under employment. Many people in village area do not have sufficient work to earn. In city area the number of educated unemployed is very high .This is due to poverty In short, the process of economic development has not been able to ensure social justice to society and gap between poor and rich. Therefore poverty will remain a challenge to Indian Democracy.

Gender Discrimination;- male and female discrimination exists in everywhere in the country. Everybody must have had such a experience of gender inequality in our society. But Indian constitution has given equal opportunity to both male and female and it is a basic principle of Indian constitution. The Indian constitution said that men and women are equal and there is no discrimination against women. In Indian constitution the fundamental right and duties are given and it has made clear policy about gender equality. But the fact of life is different and discrimination against female is continue everywhere. There is a sex ratio, child sex ratio, maternal mortality rate where it can understand how there is discrimination against female. The number of female has been declining since 1901.in 1901 the sex ratio was 972 female per 1000 male.it came down to 927 female per 1000 males in 1991.as per 2011 census it was 90 female per 1000 ,also which is not satisfactory. The child sex ration is also a serious matter of concern. As per 2011 census the child sex ratio (0-6 years)in India is only 914 female children per 1000 male children. There are several factors for declining this ratio like preference is given for male child Discrimination treatment given to girl child and incident like female foeticides .There is a another use of technology to identify foetus of child and abortion. The maternal mortality ratio is 254 per lakh as per 2004-06 record.so considering all the data gender discrimination is high in the context of social and economic development. The female literacy rate in India is 65.46 percentage in 2011 where as the male literacy rate is 82.14 percent .female are given discrimination in employment and in public life also. Therefore the 73 and 73 constitutional amendment , 1993 providing 33 percent reservation of seta in every walk of life like panchayat raj, municipal corporation, for political empowerment of women. The women reservation bill is submitted in parliament to increase the proportion of women and provide opportunities for equal participation.

Casteism, communalism, religious fundamentalism

The Indian democracy have serious challenge from caste system, community system, and religion system.in the ancient India it was division of labour and has become more rigid group classification. The most inhuman aspect of caste system is practise of untouchability. This type of practise are maintained in various villages in spite of constitutional ban imposed on it.Therefore segregation takes place for so called low caste and depriving from social benefit. These low caste people performing menial labour and hardest physical work in society. Caste system is playing negative role in democracy in India. Caste system is becoming notorious as a tool of exploitation for narrow political gain. The caste system is working against the root of democracy. For maintaining caste mentality the democratic facilities like right of equality, freedom of speech, freedom of expression, free media press etc. are misusing by different power in society. The caste system also contributing the continuation of social and economic inequalities. in India it is happening from than 5000 years about inequalities in society .The scheduled caste (SC) and scheduled tribes (ST) and backward classes are suffering from the ages about social and economic deprivation. Due to this inequality there is a serious challenges

to Indian democracy. In the era of globalisation, liberalization, caste has not been eradicated from our society but it is increasing for vote bank politics.

Corruption: - in India it is a major concern about corruption in public life. India was ranked 95th of 183 countries defined as corrupt in transparency as per international corruption perception index (CPI). Corruption is present in every walk of life like land and property, health, education, commerce and industry, agricultural, transport, police, armed forces even religion places. Corruption is continue in all political, bureaucratic, and corporate sector. Now it become a common practice about corruption in electoral process and bribing of voters in election process.in short corruption is a sign of political instability and institutional decay which is challenging to good goverence.as a citizen we should take vow not to take part in corrupt practice at any level and make contribution to eliminate corruption from our country.

Criminalization of politics:-In recent year's criminalization has entered into politics and it became debatable issue. There are some antisocial element who do not keep faith on democratic principles and values. They are busy in violence and other undemocratic method to success in election process. This is not a good practise and there should be urgent need to apply serious solution to improve such a tendency. Criminalization has no value and place in democratic set up. Democracy can be improved by applying and promoting democratic value and ban on criminal activities. Judiciary also taking a serious note of criminal tendencies in politics and apply serious action to ban such a criminal activities. The government is also taking some effective step to solve these issues. This is a good indication for successful functioning of democracy. We as a awakened citizen and voters of the largest democracy should contribute by not electing such a person who have criminal background.

Corrective measures: - The democracy in India is facing serious challenges. The prominent leaders of freedom movement and makers of Indian constitution were very much aware of these social and economic problem so they have made a lot of provision to solve these issues. There is a necessity of dialog between government agencies, political parties, civil society and people. There should be some corrective measure as follows.

Education for all; - The framers of Indian constitution has identified the significance and necessity of education for all for smooth functioning of democracy. Therefore free and compulsory education to all children up to 14 years of age provision is made in constitution. All state government are making effort to complete this goal of free education for all. National literacy mission was set up in 1988 for removal of illiteracy under the platform of sarva shiksha abhiyan.Now a days nationwide program known sakshar bharat is being implemented. The main purpose to develop functional literacy and numeracy in the age group of fifteen and above. The sarva shiksha abhiyan is a flagship program of central government for children between 6-14 years .Now the Indian government has passed the Right to education act where education has become a fundamental right for all children of age group 6-14 years.

Poverty eradication: - in India various program have been implemented for eradication of poverty in India. There are two categories a) To lift beneficiaries above poverty line by helping them with some asset or skill or both so that they can employ themselves to earn income. b) To provide temporary wage employment for landless and poor.at the same time Jawahar gram sammrudhi yojana (JGSY) is a program for employment generation in rural area. This program is being implemented by the village panchayat. The employment assurance scheme (EAS) covers 1778 drought prone desert and hill area block. The main purpose of the program is to

provide employment is manual work in agricultural season. The Mahatma Gandhi Rural Employment Guarantee Act (MNREGA) is being implemented to improve livelihood security of people in rural area by giving guarantee of 100 days wage employment.

Elimination of gender discrimination:- the goal of democracy cannot fully released if the female percentage are not included in the process of social, economic, and political development. Therefore various types of laws have been included in the constituent provision for the development of women. The 73rd and 74th amendment of Indian constitution in 1993 are the main points in the process of political empowerment of women. These amendment have given 1/3 of seat in panchayat raj institution, Municipal Corporation, also there is adoption of national policy for empowerment of women in 2001. The main objective of national policy is to create environment by economic and social policies for development of women. Also to give equal access for participation and decision making process of women in social, political, and economic life. To strengthen legal system to eliminate all forms of discrimination against women.

Judicial reforms:- the success of all corrective measures depends on efficient functioning of administration of judicial system.in last few years the performance of public administration come under close scrutiny. The corruption, irresponsibility, inefficiencies are common problems which affect the administration. There are some serious issues like slow disposal of cases and low rate of prosecution in criminal cases. There are some recommendation of various committees focus to make administration accountable and people friendly. There should be building of capacity for quality governance and orientation of administration to promote people for participation, decentralization. There must be transparent decision making process and also it should improve the performance and integrity of public services. The ethics should be maintained in administration. The major issue which needs concern are that simplification in rue s and procedure. There should be updating of outdated laws and number of judiciary staff should increase as per pending cases.

Role of people in democracy:- As a people of India do we really know the role of citizen in a democracy? Generally it is assumed that government rules the people and people have to respect them. But this is not expected in democracy. The people of democratic country should be active and not passive.in short democracy can be successful only when people are awakened and gives reaction in thinking and behaviour. People have to appreciate the opportunities for their required rile and play a proactive role to fulfil the goal of democracy. The democracy system in India started after independence in1947.the socio cultural setting still are not in tune with the democratic culture. India is multi-cultural, multi-lingual, and carries the characteristics of traditionalism and at the same time it is trying to get the values of modern democracy. Now everybody is thinking that government should do this and that.if things are not happening in an expected manner then everybody gives the blame to government. As we are aware that the democratic government in our country is handled and run by the representative elected by us.in that matters every citizen should take responsibility about functioning of government at state and national level.so every citizen has to participate and play important role.

The important role of citizen in a democracy is to mix and participate in public life. The most important opportunity is exercising the right to vote during election. To cast our valuable vote we should know the agenda of different political parties and nature of candidates. In our country

there is low percentage of voting in election process. The election commission is trying their best to aware and educate people about importance of participation in election process.

Simply to participate in election process is not sufficient to strengthen the democracy. The true form of participation comes through membership of political parties. Those who are not interested to join political parties they ca join active membership of independent non-governmental organisation that is known as civil society organisation. Theses organisation represent different group such as women, farmers, doctor, engineers, workers, business owners, human activist etc. These type of organisation and their movement put pressure and bring political awareness about different issues of people in society.

The people of India has to make democratic system responsive and responsible. The Indian constitution makes the responsible to the executive and legislative but citizen should know that parliament and Municipal Corporation and panchayat raj are accountable. The effective instrument created by Indian constitution is right to information (RTE Act 2005).the awakened citizen can take objection to become informed about public issue that is how elected political leaders or representative were using their power for public interest. When people come to know that government is not keeping their promises the people organisation can raise their issue through mass media. They can make recommendation and demand accountability from the government. If the government fail to fulfil promises the group of people may protest or carry peaceful agitation to make government accountable. The people should realize that citizenship is more important than voting. People assume that democracy is a system where everything is allowed because it is by the people and for the people. Due to this there is a complete chaos that devastate structure of society.it gives opposite effect of democracy.it should understand that if we have right to do certain thing then we have also responsibility that our action do not disturb the right of others.

Conclusion:- The success of democracy is depend upon participation of citizen. When citizen will play proactive role the challenges will be minimized against democracy. All the people should respect the law and avoid violence. All people should keep respect the right of their fellow and dignity as a human being. If the person or group os holding different view nobody should denounce a political person or group as an evil. People can raise issue and ask question to government but not challenge its authority. Everybody has the right to practise its own culture but should accept that it is a part of plural society and democratic state. When you express your thought you should also give response to hear to other even if you disagree with them

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Abstract- **The spread of corona virus disease 19 has drastically disrupted each aspects of human life including education. It has created an unprecedented test on education. In many educational institutions around the world, campuses are closed and teaching-learning has moved online. Internationalization has slowed down considerably. In India, about 32 crore learners clogged to go to schools/colleges & all learning actions brought to an end. Despite of all these challenges, the Higher Education Institutions (HEIs) have reacted positively and managed to ensure the continuity of teaching-learning, research and service to the society with some tools and techniques during the pandemic. This article highlights on major impacts of COVID 19 on HEIs in India. Some measures taken by HEIs and educational authorities of India to provide seamless educational services during the crisis are discussed. Due to COVID 19 pandemic, many new modes of learning, new perspectives, new trends are emerged and the same may continue as we go ahead to a new tomorrow. So, some of the post COVID 19 trends which may allow imagining new ways of teaching learning of higher education in India are outlined. Some fruitful suggestions are also pointed to carry out educational activities during the pandemic situation.**

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1. Introduction

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their exhibition in past terms. Board tests of class 10 and 12 were deferred in Kerala Assam government dropped all tests till 31 March. The Union Public Service Commission likewise deferred the meeting for the Civil Services Examination 2019 to be held from 23 March to 3 April. The SSC tests in Tamil Nadu and Pondicherry were deferred to 15 April.[6]

The purpose of this paper is to state the effects of lockdown on schools, universities, teachers and parents.

- Highlight the impact of COVID 19 on higher education sector.
- Enlighten various emerging approaches of India for higher education
- Enlist post COVID 19 trends of HEIs
- Put few suggestions for continuing educational activities of HEIs facing the challenges created by *COVID 19* .

Methodology

Various reports of national and international agencies on COVID 19 pandemic are searched to collect data for current study. As it is not possible to go outside for data collection due to lockdown, information are collected from different authentic websites, journals and e-contents relating effect of corona on higher educational system of India.

2. Impact of COVID-19 on Higher Educational Sector:

The shutdown of universities has also affected the student's learning in universities. In order to ensure the continuity in institutes and universities, one immediate measure is essential. To conduct the class smoothly, online teaching methodology is adopted. Learning management software and open-source digital learning solutions are adopted by the universities to run online classes. Higher education is a critical determinant of the economic future of the country and higher education sector has significantly affected by the pandemic as well. Many students from India enroll in universities abroad. Due to the global closure of the institutes and universities, it is expected that it will reduce the demand for the international higher education.

The main concern which is coming in the mind of everyone is the effect of the pandemic on the rate of employment. Because of the current situation, graduates who have recently completed their graduation fear from the withdrawal of job offers from corporate. Teaching methodology in institutes and universities has also transformed due to the lockdown in India. It has been replaced the old chalk-talk model with the new technology. E-learning solutions are making teaching and learning possible in this situation but engagement is a big problem attached with the e-learning. The policy makers are trying to solve the problem of engagement of students and tackling the digital divide .In order to manage the crisis in Indian education section, a multi-pronged strategy is necessary in the long term.

An effective education and well rounded practices are needed in India to build the capacity of young minds in this time of crisis. To ensure the overall progress in India, It will drive employability, well-being, health[12] and productivity through the development of skills. Pandemic *COVID 19* has severely affected the total educational system of India as well as the globe but some of the most impacted areas of higher education of India are as pointed below.

Destabilized all educational activities: Outbreak of *COVID 19* has compelled lockdown in every sector including education. The institutions got closed with cease of educational activities and created many challenges for the stake holders [7] (Pravat, 2020a). So, the various activities like admission, examinations, entrance tests, competitive examinations conducted by various boards/schools/colleges/ universities are postponed. Many entrance tests for higher study got cancelled which created a great challenge in the life of a student of higher education**.** The primary challenge was to continue teaching learning process when students, faculties and staff could no longer be physically present on the campuses. The obvious solution for the institutions was to depend online teaching learning. However, within a relatively short time, HEIs have been able to provide support to the students through online modes. *COVID 19* has accelerated adoption of digital technologies to deliver education. It encouraged all teachers and students to become more technology savvy. The HEIs have started conducting orientation programmes, induction meetings and counselling classes with the help of different e-conferencing tools like Google Meet, Skype, Youtube live, Facebook

live, WebEx etc. to provide support services to the students. This initiative has taken to create an effective virtual environment of teaching learning and to create motivation among students for online activities. The teachers and students improved the use of electronic media for sharing information by making use of WhatsApp, Google drive, Telegram, Twitter etc.[8] (Pravat, 2020b). They have been sharing important documents with the group members and creating online local repository also. Students are advised to submit the scanned copies of the assignments to the institution through email. Institutions have also started receiving internship reports and projects through email during the lockdown for COVID 19.

Mixed impact on Academic research & Professional Development: COVID 19 has both negative and positive impacts on research. If we take the negative side, it has made impossible for researchers to travel and work together with others nationally and internationally. Some joint research work or project work are made complicated to complete. Some scientific laboratory testing/research work could not be conducted. If we look at the positive side, academicians got much time to improve their theoretical research work. Academicians got acquainted with technological methods and improved their research. Webinars and e-conferences became normal methods for sharing expertise among students and academicians around the globe with similar issues. They could get much time to concentrate on professional development by doing research and to improve knowledge by sharing ideas through webinars and e-conferences. They enhanced their technical skill and could get the scope for publishing articles in journals, publishing books in this free time.

Severely affected the educational assessment system: Most of the external examinations have been delayed & almost every inner evaluations have been suspended which has pessimistic effect on students' learning. Many institutions have been managing the internal assessments through online mode using different digital tools but the postponement of the external assessments, has a direct effect on the education. This uncertainty has created anxiety among students as they are blocked in the same grade/class without promotion. Similarly, many students who had appeared final/board examinations would suffer a lot as by the time they get their certificates, it might be too late for them to apply for the forthcoming academic year in another nations due to lockdown.[9]

Reduced employment opportunities: Many entrance tests job recruitments got cancelled which created negative impact with a great challenge in the life of a student of higher education. The Indians who have been doing their jobs abroad became upset of their job withdrawal also. In India, there is no recruitment in Govt. sector and fresh graduates are in pressure of fearing of unemployment from corporate sectors due to pandemic condition. Many students may lose their jobs from India and overseas. The pass out students may not get their job outside India due to various restrictions caused by COVID 19 . All these facts imply towards increase of unemployment rate due to this pandemic. With increase of unemployment situation, the interest for education may gradually decrease as people struggle for food rather than education [8]

3. Emerging approaches of India for Higher Education during COVID 19

Many challenges are created by COVID 19 . The HEIs have responded positively and adopted various strategies to face the crisis during the pandemic. The Government of India has also taken number of preventive measures to prevent spread of pandemic COVID 19. [10][11] The MHRD and University Grants Commission (UGC) have made several arrangements by lunching of many virtual platforms with online depositories, e-books and other online teaching/learning materials, educational channels through Direct to Home TV, Radios for students to continue their learning. During lockdown, students are using popular social media tools like WhatsApp, Zoom, Google meet, Telegram, Youtube live, Facebook live etc. for online teaching learning system. ICT initiative of MHRD (e-Broucher- https://mhrd.gov.in/ict-initiatives) is also a unique platform which combines all digital resources for online education [7]. UGC has released Guidelines on Examinations and Academic calendar in view of COVID-l9 pandemic and subsequent lockdown on 29th April, 2020 (UGC notice). [12] All terminal examinations have been postponed and shifted to July 2020 and suggested commencement of classes from August 2020.[10] UGC has also prepared complete calendar for the academic session 2020-2021with new dates keeping in view of the lockdown. Some of the digital initiatives of UGC & MHRD for higher education during COVID 19 are pointed as below[18]:

e-GyanKosh (http://egyankosh.ac.in/) is a National Digital Repository to store & offer the digital learning assets which is created by the Open & Distance Learning Institutions of our nation. The things in eGyanKosh are secured by copyright, with all rights held by Indira Gandhi National Open University (IGNOU).

Gyandarshan (http://www.ignouonline.ac.in/gyandarshan/) is a web-based TV channel devoted to educational and developmental needs for Open and Distance Learner. A web-based TV channel devoted to educational and developmental needs of the society

Gyandhara (http://ignouonline.ac.in/Gyandhara/) is an internet audio counseling service offered by IGNOU [7][16]. It is a web radio where students can listen to the live discussions by the teachers and experts on the topic of the day and interact with them through telephone, e-mail (gyandhara@ignou.ac.in) and through chat mode.[9]

Swayam provides Massive Open Online Courses (MOOCs) with 140 universities approved credit transfer feature. Swayam Prabha provides high quality educational programs through 32 DTH channels transmitting educational contents. e-PG Pathshala (https://epgp.inflibnet.ac.in/) is for postgraduate students. Postgraduate students can access this platform for e-books, online courses and study materials. The details of these three digital plat forms are described by the author in the previous paper [8]

e-Adhyayan (e-Books) is a platform that provides 700+ e-Books for the Post-Graduate courses. All the e-Books are derived from e-PG Pathshala courses. It also facilitates play-list of video content.

e-Pathya. (Offline Access) is one the verticals of e-PG Pathshala which is programming driven course/content bundle that encourages understudies seeking after advanced education (PG level) in distance learning just as grounds learning mode. It additionally encourages disconnected admittance.

National Digital Library of India (NDLI) (https://ndl.iitkgp.ac.in/) is an archive of e-content on numerous controls for a wide range of clients like understudies (all things considered), educators, analysts, curators, library clients, experts, in an unexpected way abled clients and all other deep rooted students. It is being created at Indian Institute of Technology Kharagpur. It is intended to assist understudies with getting ready for entrance and serious assessments, to empower individuals to take in and plan from best practices from everywhere the world and to encourage analysts to perform between connected investigation from various sources. It is a virtual vault of learning assets with a solitary window search office. It is also available to access through mobile apps.

e-Yantra (https://www.e-yantra.org/) provides hands on experience on embedded systems. It has about 380 Lab and made 2300+ colleges benefited.

FOSSEE (https://fossee.in/) is short form for Free/Libre and Open Source Software for Education, which is developed to promote open source software for education as well as professional use.

Virtual Labs (http://www.vlab.co.in/) has created web-empowered educational plan based tests intended for far off activity. It has more than 100 Virtual Labs comprising of around 700+ web-empowered tests which are intended for distant activity. It gives far off admittance to Labs in different orders of Science & Engineering. These Virtual Labs takes into account understudies at the undergrad level, post graduate level just as to explore researchers.

e-ShodhSindhu (https://ess.inflibnet.ac.in/) is an assortment of e-diaries, e-diary files and digital books on long haul access premise. It has 10,000+ e-diaries, 31,35,000+ digital books. It gives admittance to subjective electronic assets including full-text, bibliographic & real information bases to scholastic organizations at a lower pace of membership.

Shodhganga (https://ess.inflibnet.ac.in/) is a phase for research understudies to store their Ph.D. speculations & make it available to the entire scholastic organization in open access framework. The scientists can get, list, store, spread and protect Electronic Theses and Dissertations introduced by the analysts.

VIDWAN(https://vidwan.inflibnet.ac.in/) is a head information base & public examination network which has profiles of researchers/analysts and other employees working at driving scholarly establishments and other Research and Development associations in India

National Educational Alliance for Technology (NEAT)(https://neat.aicte-india.org/) is an initiative for skilling of learners in latest technologies through a Public-Private partnership model between the Government (through its implementing agency AICTE) and the Education Technology companies of India. It brings the best technological products in education pedagogy on a single platform for the convenience of learners.

SAKSHAT (https://sakshat.ac.in/) is one Stop Educational gateway for communicating all the education & knowledge associated requirements of students, scholars, teachers & lifelong pupils. The gateway provides the latest news, press releases, achievements etc related to Ministry of HRD[10]. So one can visit SAKSHAT to know the world of online learning.

4. Post COVID 19 Trends of Higher Education

Change is inevitable which has been forced upon the society due to COVID 19. The opportunities created by the pandemic COVID 19 will lead towards a better tomorrow. Tomorrow will be a new morning which will entirely be in our own hands. New technologies will certainly challenge the traditional paradigms such as classroom lectures, modes of learning and modes of assessment. The new trends will allow the education sector to imagine new ways of teaching learning and some trends may be pointed as below.[18]

1. **May encourage personalised learning:** Learning may not be confined to classes or to any specific boundaries. Students may be the virtual learners with one teacher leading dozens of students in the new age. The learning modules may be modified to suit different learning styles and the learning contents may come from different sources to meet the learners' aspirations and needs. Students may pursue their learning in the new paradigm as per their choice.

2. **Student Attendance may slow down:** Many parents may be reluctant to send back their children to schools/colleges suddenly after the end of lockdown. Some poor family parents who have lost their livelihood during the pandemic may not be able to afford the expenditure to send their children to institutions. This may lead to home education for another few months.

3. **National and International student mobility for higher study may be reduced:** Student safety and well-being issues are important deciding factors for students and their parents for movement to international institutions for higher study. The fresh method of social distancing will carry on for quite some time & can affect on-campus one on one teaching learning. The majority of the parents will choose to find workable options closer to their home and may restrict for less movement within the country due to the pandemic. The international education has also been affected by the crisis. Many international universities have been closed and are delivering all educational activities online. Many international conferences in higher education have been cancelled or turned into a series of webinars. So, the national and international student movement may be diminished.
4. **Learning with social distancing may continue.** All will maintain social distancing and avoid warm handshake, hug, personal greeting, and intimacy for a long time. Invisible restrictions may constraint the fun & joy of campus life. Sports, Gyms, tournaments may be in low gear for a longer period resulting less physical activities of students.

5. **Educational institutions may run with different shifts per day.** The necessitate for societal distancing may imply less students in every division. So, most of the educational institutions may work in different shifts per day which may put further pressure on the teaching & organizational employees of the institution to manage.

6. **May raise the gap between privileged and unprivileged students** and required technical gadgets for online learning. It will widen the gap between privileged and unprivileged learners creating inequality.

7. **Teaching learning may run with technology.** More and more students will depend on technology and digital solutions for teaching learning, entertainment and connecting themselves with the outside world. Students will aid internet facility to communicate virtually with their teachers & fellow learners through E-mail, WhatsApp, Videoconference, Instant message, webinar or any other tool.

8. **Assessment system may be changed to new shape.** Artificial Intelligence (AI) may help teachers to deal with assessment, evaluation, preparing score cards & monitoring the performance of each student easily. AI may use digital platform extensively to reduce burden of examiner in handling examination and evaluation systems. If these activities are made simpler, the academicians would be able to concentrate more on course development, qualitative teaching-learning and skill development.

9. **Demand for Open & Distance Learning (ODL) and online learning may grow.** COVID 19 has enforced the human being society to preserve social distancing. It has produced more summons to carry on teaching learning by preserving social distancing. To meet these summons there is more demand for ODL & online method of education & the same trend may continue in future also.

10. **Blended learning may take the leading role.** Blended learning combines both face to face and online learning modes. COVID 19 has accelerated adoption of digital technologies to deliver education and encouraged the educational institutions to move towards blended mode of learning. All teachers and students became more technology savvy. The traditional face to face mode with post COVID 19 technology mode will lead the education towards blended mode of teaching learning and it may transform the structure of the education system.

11. **Student debt crisis may rise.** In India, lots of students or their parents take education loans for higher education. If the employment market does not pick up, student debt crises may rise and create serious issue. Students may face increased stress, anxiety and depression due to their student loans.

12. **Unemployment rate is expected to be increased.** There is no recruitment in Govt. sector and fresh graduates fear withdrawal of their job offers from private sectors due to the pandemic COVID 19 [8] (Pravat, 2020b). Many Indians might have returned home after losing their jobs overseas due to COVID 19. Hence, the fresh students who are likely to enter the job market shortly may face difficulty in getting suitable employment.

5. Impact of COVID-19 on Education System

In order to control the spread of the novel coronavirus, state governments started the closure of schools and colleges across the country. It was somewhere announced in the second week of March as a temporary measure to avoid the crowd. Initially, for a month closure of schools was announced by the government but gradually the time of closure was extended and it is uncertain when they will reopen. During this period, there are various activities take place which are very crucial such as competitive exams and entrance tests of various universities, board examination and semester examinations in universities, nursery school admissions as well as admission process in universities. In order to stop the outbreak of COVID-19, no immediate solution is found out.In India, the closure of school and university will not only have a short-term impact on the continuity of learning of young learners but it will have a large effect on the economic growth of the country as well as having large effect on the society[17].

6. Impact of COVID-19 on Schools

In order to raise the skills, best public policy tool available is going to school.School is a place where children can have fun and raise social awareness and social skills. The main motive of going school or being in school is that it enhances the ability of the child. Spending a relatively short period of time in school increases skills and ability. On the other side missing the school or not attending the school will have negative effect on the skill growth The closure of the schools has affected the structure of learning and schooling. Firstly, it affected the teaching and assessment methodologies.Online teaching methods are adopted by the few private schools that are handful in taking online classes. In those schools children are taking classes online. On the other side low-income private and government schools have complete closure and not having the access to e-learning solution. It is disrupting the learning of students. Parents are facing various issues because of the change in teaching methodology[17].

7. Impacts COVID-19 on online classes on Parents

In order to maintain the attendance or not missing out too much, children are forced to continue their education at home and generally have not been sent out from the home to play.[13]Bjorklund and Salvanes (2011) described that major inputs into a child's learning is provided by the families as these are treated as a central to education. Parents

are facing issues in understanding the new methodology of teaching. Some parents are not very techno friendly. Thus, they are not able to guide their ward to take classes online. Connectivity of internet is also a big challenge in front of all teachers, students and parents. Many disturbances have to face due to the poor connectivity[13][17].

8. Assessments

The teaching for students is not only interrupted by the closure of schools, colleges and universities. Lockdown also affected the assessment of the students all around the world. Many exams and assessments have been cancelled or postponed because of the closure of educational institutions. For both students and teachers, this is a new era of the education. Many colleges and universities have shifted their traditional classes system to the online classes as well as the examination system also has been shifted from offline to online. They are using online assessment tools for evaluation. Online assessment tools are not free from the limitations. There are various errors related to the measurement are reported in online assessment tools in comparison to the usual measurement.[14]Piopiunik et al. (2020) showed in their research thateducational credentials are used by the employers to assess the applicants such as grade point averages and degree classifications to sort applicants. Thus, the lockdown is also affecting the placement of the new graduates on labour market. Matching efficiency of the new graduates is reducing due to the increment in the disruptions in the signals of the applicants which is leading higher job separation rates and slower earning growth.According to [15] Fredriksson and Ihlen (2018), this is costly both to the individual and also to society as a whole.[17]

9. Conclusion

The closure of schools, colleges and universities is interrupting the learning of students and also disrupting the internal assessment and public assessments for qualifications. The traditional method of teaching has been replaced by the online teaching. One side online teaching is providing opportunity to the students for learning another side there are various issues are attached with the new methodology of teaching. Education institutions are searching the ways to solve the issues which arose due to the lockdown and putting their efforts to fill the loss of learning. In order to rebuild the loss in learning at the time when they will be reopened, schools need resources. There are many questions in front of the schools such as how to target the children and how to utilize these resources etc. need to be solved. The internal assessment of the students related to the learning should not be skipped. It should be postponed. In order to avoid the longer unemployment period for new graduates, new policies should be formed to support them in their entry to the labour market [17]. Virtual education is the most preferred mode of education at this time of crisis due to the outbreak of COVID 19. The post COVID 19 education seems to be an education with widely accepted online/virtual education which may perhaps be a parallel system of education. This paper has not covered any statistical analysis on higher education however further in-depth study with statistical research may also be undertaken.

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PERFORMANCE ANALYSIS OF 8KW GRID TIED ROOFTOP SOLAR SYSTEM IN HINJAWADI, PUNE

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Abstract- **India has enormous sunlight based energy potential. Each quarter-hour the measure of energy from the sun that strikes the earth is sufficiently adequate to flexibly the energy necessity of the entire world for one year. To create efficient power energy from normal assets and cycles that are recharged continually in its different structure which are viewed as condition neighborly, non dirtying and assists with diminishing the effects of customary power age subsequently expanding the country's energy autonomy. Photovoltaic power generation framework has been expanding in term of introduced limit over the most recent couple of decades. An investigational study of 8 kW grid-Tied PV systems which is installed on Rooftop of Library building at International Institute of Information Technology, Hinjawadi, Pune (Latitude 18°31'10" N, Longitude 73°51'19"E, Altitude 554m from sea level) is presented. This study consists of the quality of the electric energy produced & inserted into the network. This Solar system includes of 25 × 320 Wp polycrystalline PV modules (Waree Company) , Grid Tie Solar String Inverter of 10Kw (Delta Company) & mobile GPRS for Data manager for data acquisition & distant monitoring. The Solar plant has been Commissioned on 16 February 2018 & Integrated on 22 February 2018 & generated total Electrical energy 30.37 MWh & 24.29 Ton till 28 February 2021. The Generated electrical energy is injected directly into the grid without any storage apparatus[8]. This paper presents the analysis of the performance of the system & calaculate payback period of investment cost.**

Keywords – Grid Tied PV system, Rooftop solar, Solar Panel, Inverter

1. Introduction

Electricity is an integral part of the human being in this modern lifestyle. We are completely dependent on uninterrupted power supply to power our gadgets, appliances, healthcare, education, you name it and that requires electricity [1]. Solar Energy is one of the solution to give uninterrupted supply. Renewable energy has become an alluring energy source in the most recent decade because of bringing worry up in energy & natural issue. With current worldwide economy development, energy utilization rate in numerous nations have been quickly rising and petroleum product cause nursery impact and a dangerous atmospheric deviation. To decrease utilization of non-renewable energy source & illuminating condition issue numerous administrations are develop strategy furthermore, methodology intend to build extent power producing from renewable energy source. Sun powered housetop framework is one of the renewable energy source that as of late increment in term of infiltration level.

Solar based energy is power from the sun which is converted into electric energy. Sun oriented energy is the dirt free & most plentiful sustainable power supply reachable. Sunlight based advances can outfit this energy for an variety of employments, including creating electricity, generous light & warming water for homegrown, commerce, or modern utilize. The rising power demand in most recent couple of years and the wide contrast among generation and burden, prompted uphold the public lattice with extra generations, sun based power is getting generally mainstream in generation area since it is spotless, endless, trustworthy and accessible in all sizes furthermore of its capital expense is persistently diminishes. It has likewise gotten more proficient since the power transformation efficiency of converters gadgets & photovoltaic sun oriented cells has expanded. It has additionally gotten more effective since the power transformation efficiency of converters gadgets & photovoltaic sunlight based cells has expanded.

The Renewable energy (RE) sources are generally excellent answer for give elective energy to conquer the worldwide energy issue, and it's accepted to have the option to address the energy difficulties that can't be comprehended by conventional concentrated power plants [2]. The Grid associated PV systems on the planet represent about 99% of the introduced limit of sun powered energy contrasted with remain solitary systems, which use batteries. The battery-less grid associated Photovoltaic network are savvy & need a smaller amount support [3]. The sun oriented PV innovation has now reached to its business acknowledgment and requires an insignificant

consideration of manpower for its activity [4]. Grid-associated PV systems have numerous specialized points of interest, for example, adaptability, non-contaminating, emanating no clamor, requiring little upkeep and straightforwardness to introduce in any territory where the sun oriented light is accessible, in this manner, numerous nations are urging clients to introduce PV systems so as to help the customary energy sources & to expand the commitment of sustainable power source to restrict carbon dioxide (CO2) discharges. Commonplace megawatt scale grid-associated sun oriented PV power plant principle parts are: sun based PV panels, module mounting (or global positioning frameworks, Step-up transformers ,Inverters & grid association interface, [2] & the net valuable energy yield of any sunlight based energy transformation structure relies upon different ecological factors, for example, surrounding temperature, sun based illumination force, the pace of residue settlement on the nearby planetary group upper surface and wind speed at establishment locales [3]. Available annual average solar insolation in a day is 5.44 kWh/m^2 per day.

Month	Air Temperature °C	Daily Solar Radiation kWh/$\boldsymbol{m^2/d}$
January	20.5	6.74
February	22.0	7.22
March	25.6	6.50
April	28.8	6.39
May	29.7	7.04
June	27.4	3.70
July	25.3	2.14
August	24.5	2.15
September	25.1	4.19
October	25.0	6.036.03
November	22.3	6.50
December	20.2	6.75
Annual	24.7	5.44

Table1-Annual Average Solar Insolation (*Source:* Feasibility Report of Board of Energy Studies)

Grid-associated PV systems have numerous specialized focal points, for example, adaptability, non-contaminating, transmitting no commotion, requiring little support and straightforwardness to introduce in any region where the sun based illumination is accessible, hence, numerous nations are urging clients to introduce PV systems so as to help the conventional energy sources and to expand the commitment of renewable energy to restrict carbon dioxide (CO2) emanations.A grid-associated PV system comprises of sun based boards, one or a few inverters,a power molding unit and grid association equipment[4].

II. Grid Tied PV system details

A 8.00 kW peak (KWp) rooftop grid-tied PV system was installed under **Quality Improvement Programme (QIP)** of **Savitribai Phule Pune University in February 2018** on the rooftop of cafeteria/Library building. The DC-side of 3Ph, 8 kW grid connected inverter is connected to the PV array. The system is installed to insert the produced energy directly into the existing electrical network. It includes of 3 major components that are Solar Panels, Grid-connected Inverter & Energy Monitoring solution.

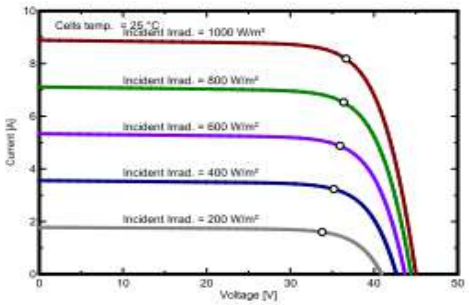
1. Solar Modules

The grid-tied Solar PV module consist of 25 Crystalline Silicon Solar cell modules with each capacity of 320Wp, with RFID tag & as per IEC 61215/IS 14286 standards with installed capacity of 8.00 kWp. The module mounting structure on RCC rooftops- Hot Dip Galvanized (80 micron) is used. The panels are arranged in three rows , nine panels is arranged in series in first row, nine panels is arranged in series in second row & seven panels is arranged in series in last row. The actual photograph of Solar module arrangement is shown in figure.

Fig.1-Actual Photograph of Solar Module arrangement

Solar Module	Polycrystalline Silicon Solar Cell as per IEC 61215/ IS 14286 standards
No. of Modules	25
SPV Module Capacity in (Wp)	320
RFID tag	Yes
Avarage Height	3.3^0
Tilt Angle	19^0
Azimuth	True south
Model	WS 320
P_{max}	320Wp
System capacity	8 Kwp
Voltage@ Max. Power (Vmpp)	36.80
Current @Max. Power (Impp)	8.70
Open Circuit Voltage (Voc)	45.30
Short Circuit Current (Isc)	9.42
Efficiency of Panel (%)	16.50
Cell Type	Poly-crystalline Silicon
panel dimension (mm)	1960*990*40
panel weight (Kg)	22.50KG ± 5%
Cable	$4\ mm^2$cross section, 1200 mm long

Table 2- Specification of Solar Panels



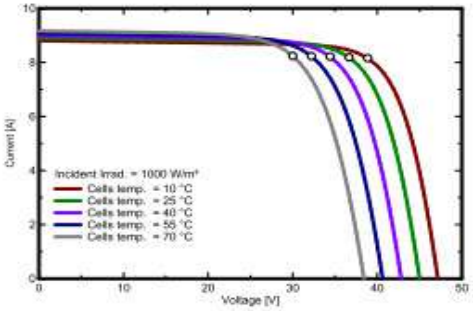


Fig2.a) I-V Curve Variation with Irradia **Fig.2.b) I-V Curve Variation with Temparature**

2. Inverter

It is the vital part of any grid tied system. The output of the PV modules are linked to Delta RPI M10A, 3Ph Grid Tied Solar Inverter which convert DC energy into AC & directly connected to utility system. The Inverter is switched ON all day & synchronized to the electric grid automatically. The Inverter stops its service for operator protection if grid faces issues such as shut down or irregular issues. [6] This Inverter have dual MPP tracker, wide voltage range (200-1000V DC), Transformer less, reactive power manage, Ergonomic grip devise, Ultra compressed volume, Build in power logger, IP65 security point, Build in AC/DC Switch & Peak efficacy up to 98.3%.

3. Monitoring & data acquisition system

The Generation data monitoring system DelREMO with web based server & access of user id & password is used.The DelREMO is the interface between your RPI Solar Inverter and the DelREMO Web Portal. DelREMO stands for Delta Remort Monitoring Solution.

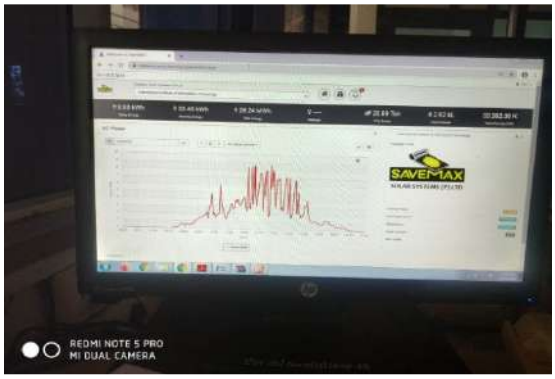


Fig.3- Solar Inverter with ACBB& DCDB **Fig.4 Monitoring System**

details of Inverter is shown in table 2

The data in the portal can be accessed via the internet on any browser from anywhere. Integrating weather sensor is also possible. The advantages of Monitoring system are Server Based Remote Monitoring, Connects up to 60 Inverters, GPRS Modem in Built, 8 Nos. of Analog/Digital Inputs, Power Management Feature, Weather Monitoring, External Energy Meter can be Monitored Inbuilt Memory of 4 GB, Custom Reports and Graphs. It is predominantly used to screen the exhibition of the Inverter, energy yield, etc. At discretionary cost the system gives an amazingly adaptable interface to encourage PC-based inverter observing and control through Ethernet, or Internet associations.

Specification of Inverter	
Brand	DELTA
Model Name	RPI-M10A
Model number	RPI103FA0E1000
Serial Number	O1M17901272WR
MPP Tracker Test	415-800 V
Max AC current	15.15-16.2 A
Input DC voltage	550-650V

Output AC Power	9.5-10.5 kVA
AC voltage range	200-1000
Input DC current	15-17A
Efficiency (%)	> 97%
No. of inverter per project site	1

Table 3- Specification of Inverter

4. Single line diagram

The single line diagram for 8 kw solar plant is as follows.

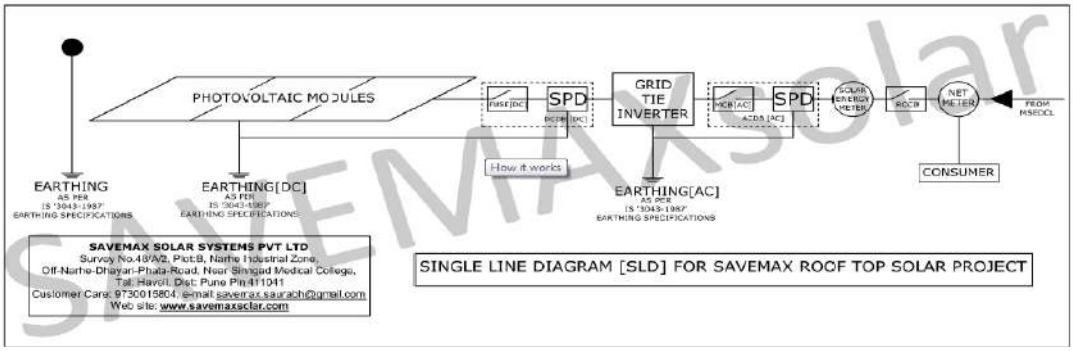


Fig.5- Single Line Diagram

Electricity Meter is connected to measure the generated electricity.

- **Earthing:** The Earthing system is used for array, distribution system & SPV power plant. Each array structure is grounded properly as per IS: 30431987. The GI strip of 25*3 mm is utilized for earthing.
- **Lightning:** The Lightning arrester with conventional type earth pit is provided for the protection against lightning as per IEC 62305 standards.

Fig.6-Lightning Arrester

Fig.7- Solar Energy Meter

- **Cables-**
  - Single core,Multistrand, 4sq.mm TUV approved solar cable for DC side
  - Multi strand cable for AC side
  - MC4 connectors suitable for 4 sq.mm cable
  - UV protected cable ties for solar cables

Fig.8.Satellite view of International Institute of Information Technology,Hinjawadi, Pune

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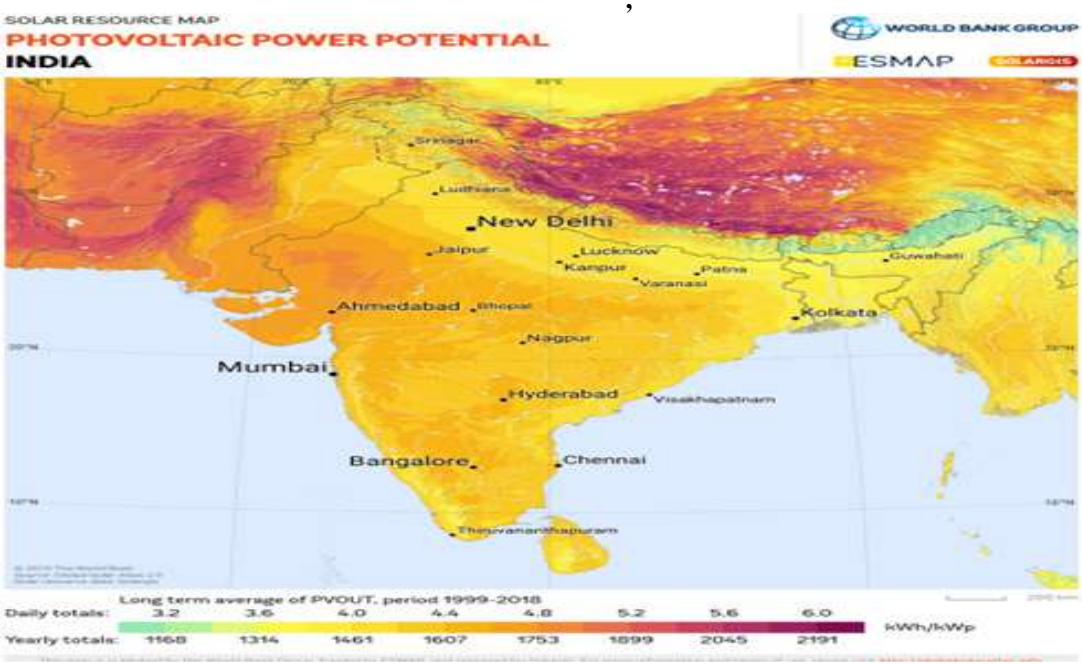

Fig.9. India Solar Energy Map (https://globalsolaratlas.info/download/india)[7]

III. Plant Performance parameters

The following parameters we can record through our DelREMO monitoring system.

AC Power	AC Voltage & Current	DC Voltage & Current
Yield	User Graph	Technical report
Plant Report	Communication Trend	

Here for understanding the data of all above parameters of 26th August, 2020 are shown below

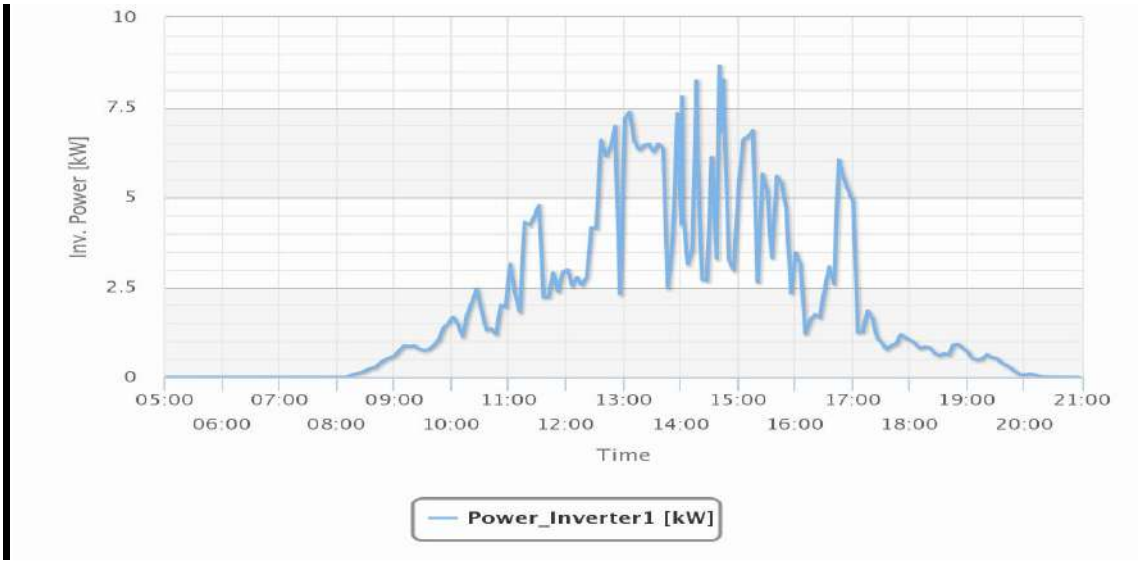

Fig.10. AC POWER

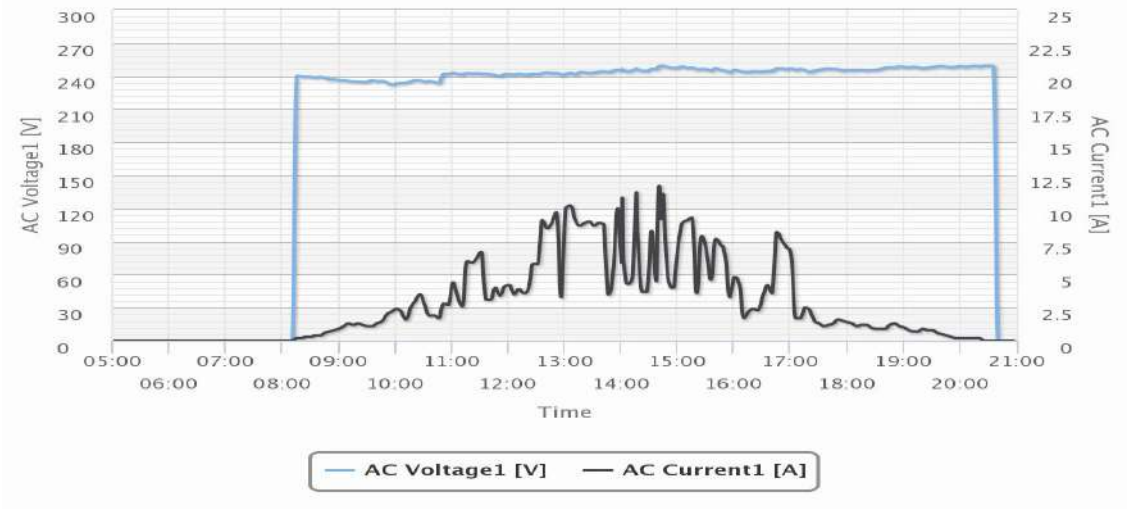

Fig.11. AC Voltage & Current

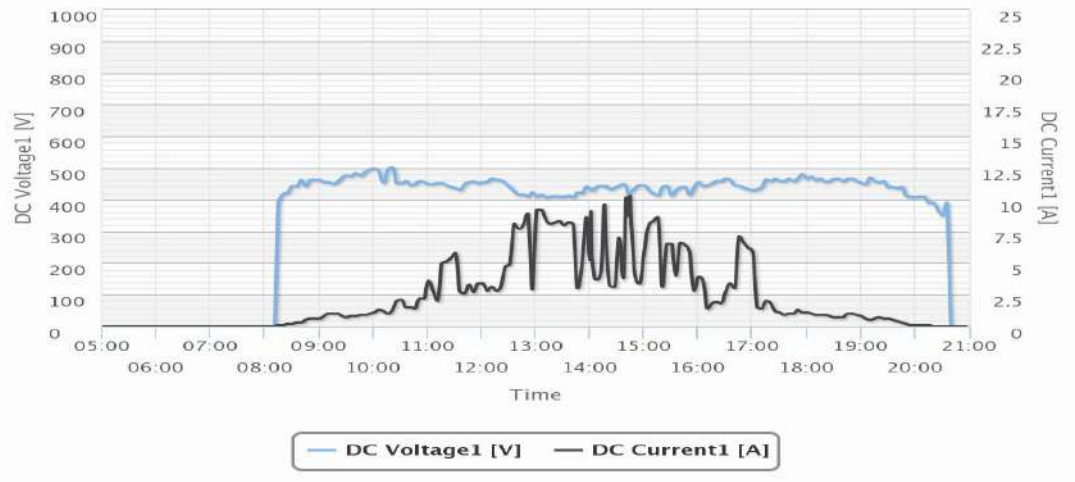

Fig.12. DC Voltage & Current

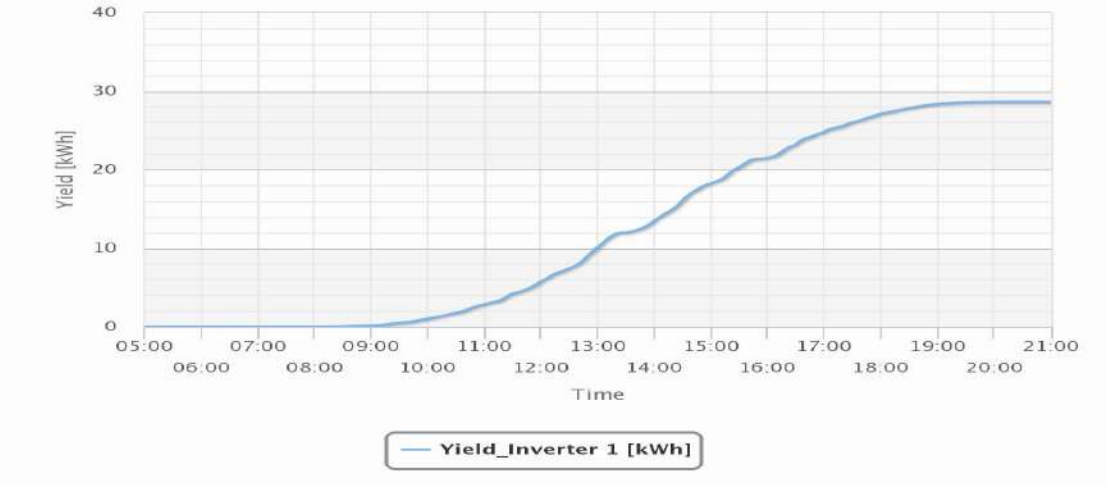

Fig.13. Yield Inverter operation

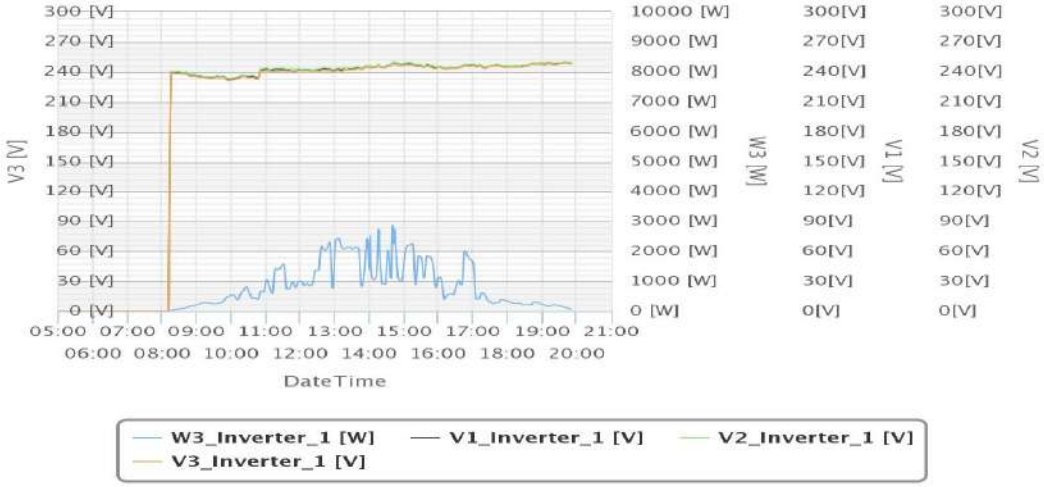

Fig.14. User Graph- Ac power 3, AC Voltage phase 1,2,3

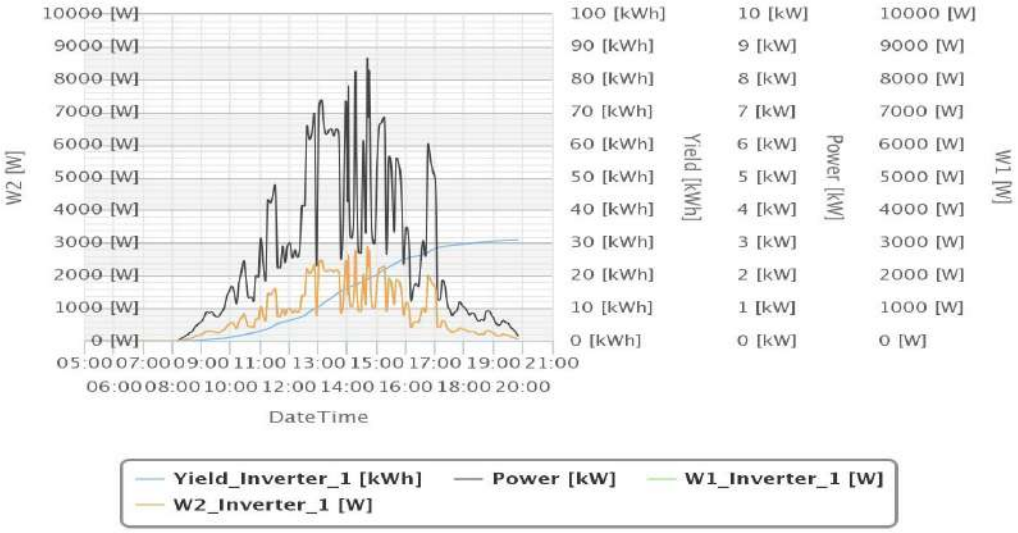

Fig.15. User Graph Energy Total Power, Ac Power1, Ac power2

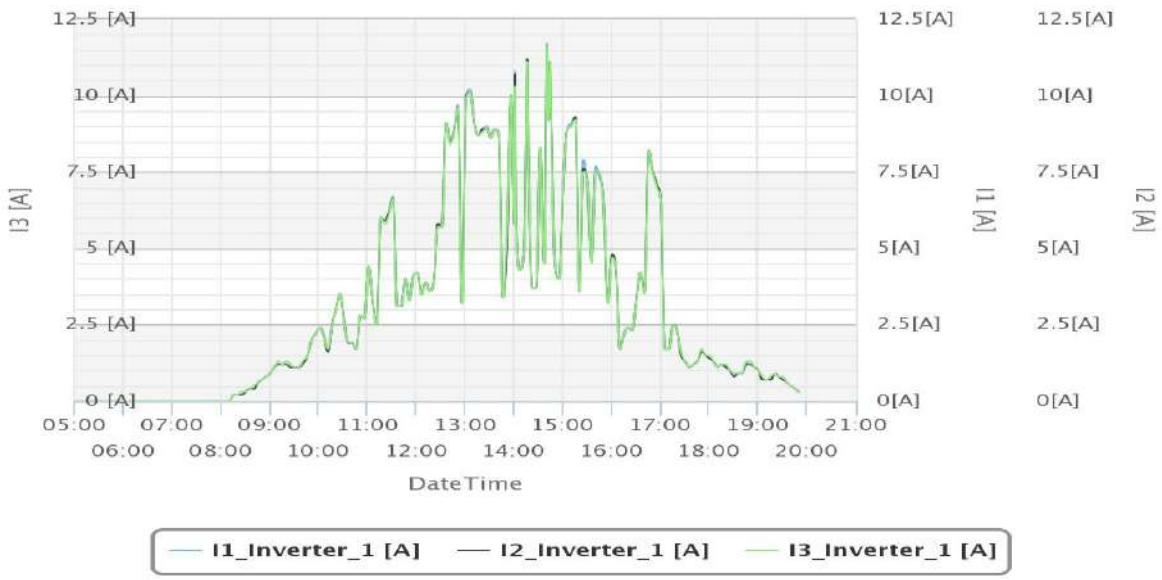

Fig.16. AC Current Phase 1,2,3

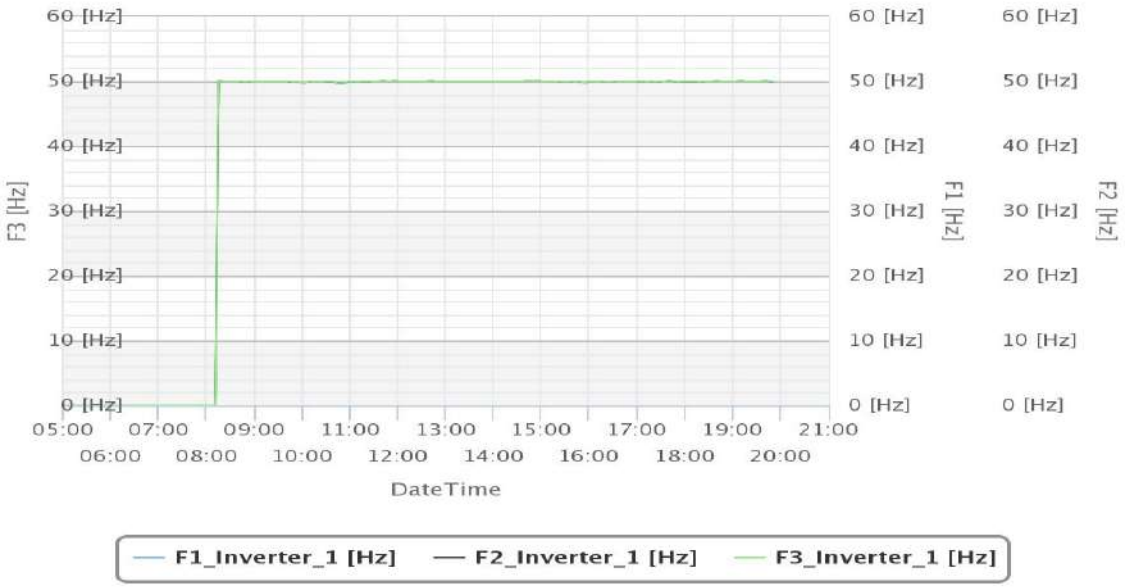

Fig.17. AC Frequency Phase 1,2,3

Plant Yearly Report

Client Name- Savemax Solar Systems Pvt Ltd

Plant Name- International Institute of Information Technology,Hinjawadi Pune

The detailed generation report till February 2021 since plant installation in February 2018 are given below.

	2018		**2019**		**Jan 2020 to Jan 21**	
Plant Capacity (DC):	8.00	kWp	8.00	kWp	8.00	kWp
Plant Capacity (AC):	10	kW	10	kW	10	kW
Total Energy Generated:	**9558.14**	kWh	**10290.59**	kWh	**9629.05**	kWh
Specific Yield Energy:	3.22	kWh/kWp	3.47	kWh/kWp	2.97	kWh/kWp
Performance Ratio:	0	%	0	%	0	%
CUF:	10.91	%	11.75	%	7.29	%
	Jan-18	------	Jan-19	807.69	Jan-20	867.88
	Feb-18	219.49	Feb-19	974.36	Feb-20	728.92
	Mar-18	1,113.45	Mar-19	1071.52	Mar-20	1083.28
	Apr-18	1,086.20	Apr-19	1126.52	Apr-20	1126.14
	May-18	1,133.29	May-19	1064.93	May-20	1059.63
	Jun-18	838.51	Jun-19	742.76	Jun-20	144.87
	Jul-18	531.37	Jul-19	641.98	Jul-20	772.48
	Aug-18	644.21	Aug-19	682.46	Aug-20	570.55
	Sep-18	948.65	Sep-19	662.01	Sep-20	479.07
	Oct-18	1,072.04	Oct-19	859.16	Oct-20	146.99
	Nov-18	1,013.69	Nov-19	911.19	Nov-20	920.39
	Dec-18	957.35	Dec- 19	746.01	Dec- 20	839.35
					Jan- 21	886.5
					Feb- 21	924.69

Table 4- Total Generation since plant Installation

Currently Institute has sanctioned load capacity is 732 kVA & taking electricity from Maharashtra State Electricity Distrubution Co. Ltd. The Institute are paying per unit cost of electrical energy consumed is around 10 rupees. The Total fund sanctioned for this project is 500000 from Savitribai Phule Pune Universty under QIP scheme. & Our own contribution is 98500. So the total cost of the project is 598500/-.

The Total Electricity generated by this project since February 2018(actual date of Installation) to 31st January 2021 is 29474.78Kwh.If per unit energy cost is 10 rupees, then (**30399.47*10= 303944.7 rupees**) we have saved **Three Lacs Three Thousand Nine Hundred & Forty Four rupees Seventy paise.**

IV. Conclusion

The performance parameters of 8KW grid tied Solar plant installed on roof top of library building of International Institute of Information Technology is presented here. All the parameters like AC power, AC Voltage & Current, DC Voltage & Current, Yearly plant report, phase frequencies are shown here. The plant is installed in February28, 2018 to till January 2021, we have saved **303944.7** rupees. Means in last 36 months, we have saved 8444.30 rupees/ month. So if we consider the same rate of generation, the payback period of our investment is 70.87 months(5 Years, 11 Months) from date of installation.

Acknoweledge

I would like to thanks to Board of Energy Studies, SPPU Pune, the management & Principal of International Institute of Information Technology,Pune for giving me opportunity to work on this project.

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Recent Trends in Electrical Power System by using Computational Intelligence Techniques

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Abstract— The energy sector around the world is facing increasing difficulties due to increased energy requirement, efficiency, changes in demand & supply design & be short of analysis necessary for best possible administration. These difficulties are greatest in growing markets. This makes the electrical network multipart, highly stressed & therefore subject to subsequent failures. The efficiency problems are mainly problematical because the proliferation of informal grid connections means that a large amount of electricity is not metered or billed, leading to losses and increased CO2 emissions. Traditional methods of solving network design, problems of scheduling, processing & managing have been widely designed for various supplications, however these techniques suffer from various complexities because of the need for inferred existence, provision of non-optimal solutions, etc. These difficulties can be overcome by transmitting knowledge of the energy sector on to CI software suppliers. With careful development, artificial intelligence systems can be particularly helpful for automating structured and routine tasks and giving people the ability to tackle the problem of energy challenges in future. Computational Intelligence (CI) can provide a better solution under different circumstances & are broadly used in electric engineering applications. Almost all developed nations are using computational intelligence techniques which enable communication amongst IOT devices, smart meters & smart grid network. These advances can help improve power supply administration, efficiency, clarity, and increment the utilization of sustainable power sources. The utilization of computational intelligence techniques in electricity network wherever it can have serious effects as clean, low-priced & consistent power is essential for improvement. his article focuses the use of computer-assisted intelligence techniques in PS issues. Different types of intelligent techniques which are widely used in the electrical network explained in details.

Keywords- *Electrical Power System, Computational Intelligence techniques, Artificial Intelligence Techniques*

I. INTRODUCTION

Improved interconnection & load on the electricity grid along with noninterference & ecological concerns have brought latest perspectives summons for the process, organize & computerization of the electrical network. The control & operation of electrical network become complicated because of difficulty of designing & unpredictability's. PSs models for process & control are very much depending on the intention of the activity. In the eminently ruthless electricity market through computerization, CI techniques are extremely useful. As a utility try to offer smart solutions technical (security, stability and high energy quality)

& ecological objectives, there are numerous complex problems in the Smart Grid(SG) solutions like forecasting freight, prices and ancillary services, among others; penetration of new & renewable energies Inflate; offer affiliate strategies; planning & control of the energy system; operational decisions with missing information; Increase of distributed generations & response to demand on the electricity market; parameterization of the controller in variable operational situations, etc. Risk & economical adjustment in the electricity sector aim to find an ideal compromise among maximizing the estimated return & minimizing the risks related with these investments. The CI techniques are latest tools to solve complicated issues which were difficult to solve by using traditional methods. Heuristic optimization procedures are broadly useful techniques that are entirely flexible & may be utilized to numerous kinds of target capacities & imperatives. As of late, these latest heuristic devices have been consolidated between themselves what's more, latest strategies have developed that consolidate components of nature based techniques. Creating arrangements with these apparatuses offers 2 significant points of interest: advancement time is a lot shorter than when utilizing more conventional approaches, & the systems are hearty, being moderately unfeeling toward loud as well as absent information/data known as vulnerability. Because of ecological, option to proceed & cost issues, there is an expanded enthusiasm for better usage of accessible power network capacities in both packaged & unbundled PS. Examples of generation that outcomes in substantial streams, will in general acquire more prominent losses, & to undermine stability & security, eventually make certain generation designs monetarily unwanted. Consequently, new gadgets & assets, for example, flexible ac transmission systems, distributed generations, the smart grid technologies (SGT) are used. In the developing territory of PS, The CI techniques plays imperative job in giving better arrangements of the current & latest issues. This paper records different expected territories of PS & gives the jobs of CI in the rising PS. A short survey of CI techniques is likewise introduced.

All inclusive access to moderate, solid, and sustainable current energy is one of the Sustainable Development Goals (SDGs). However it will stay only that—an objective—except if creative arrangements and present day innovations can survive the numerous energy-related deterrents that plague rising markets, from an absence of adequate power generation, to insufficient transmission & distribution framework, to reasonableness & atmosphere concerns. What's more, the expansion &decentralization of energy creation, alongside the approach of new innovations & evolving request designs, make complex difficulties for power generation, transmission, distribution, & utilization in all countries. Computational intelligence (CI) can possibly cut energy squander, lower energy costs, and encourage and quicken the utilization of clean sustainable power sources in power frameworks around the world. Man-made intelligence can likewise improve the planning, operation, and control of power frameworks. In this way, AI innovations are intently attached to the capacity to give perfect and modest energy that is fundamental to development.

II. SIGNIFICANCE OF ELECTRICAL POWER NETWORK DEVELOPMENT

From the last couple of years, the tremendous development has been done in different eras of electrical engineering. Various optimization techniques are adopted in PS planning & operation. Due to this optimization techniques substantial amount of money saved in large power network in terms of the fuel cost, the improved operational dependability & PSS [1,2]. Now a day's PS becoming more & more complex due to continuous increasing in electrical demand, increasing fossil fuel requirement in power plants which leads to increase in cost & emission in the atmosphere. Hence optimization is necessary for safe action of PS network [3].Minimizing the cost of generating electricity with regulated energy may be a challenge which satisfies the system or maximizes the social well-being of an unregulated energy system various operational restrictions. The optimization issues are generally nonlinear which includes nonlinear object function & nonlinear

equalities & inequalities. In addition, as fossil fuel funds like oil & coal are decreasing, wide-ranging renewable energy source expansion & contentious nuclear power concern regarding indefensible level of energy and ecological emission, optimization is becoming further significant in the operation of power systems economic and environmental reasons [4,5,8].

There were many ways, including traditional and artificial intelligent method used to resolve energy structure optimization issues. [7-18]. These techniques are constantly being enhanced & advanced to solve larger and more interconnected systems. Optimization problem are complicated by many restrictions. So find the best solution. The purpose of these methods is to reduce the calculation time. The investigators have projected numerous latest and enhanced techniques for this purpose [8]. Some optimization problems are taken into account in the operation of the electrical network. Economic distribution, unit contract, hydrothermal planning, maintenance schedule, optimization, Power flow, etc

2.1. Economic Dispatch [1,4] By bringing the energy generation unit online, you can reduce the fuel expenditure of the power generation unit while unit & network working restrictions are met. The emissions can be included to the impartial function of this issue. The financially viable distribution point of view, the fuel unit price of production function is a nonlinear curve; the solution is that the total production of power generation online, the unit will respond to the total load demand in the most appropriate way. The fuel price capability of producing units in the financial dispatch distribution point of view, can be approximated by second order function. On the other hand, another functions of the actual price of fuel, like advanced categorize, You can add numerous fuel category & control device effects. Also generation units face practical restrictions on prohibited areas of operation considering this approach.

Due to all these problems, optimization problem under nonlinear constraint. Thus find a practical, cheap & quick resolution to this difficulty. In the cost-effective distribution approach, all power generation units go online to fulfill the upload request. Offline program planning, creation Units turn on / off every hour according to the load predict for a designed point in time, which is known as unit commitment (UC) [1,2]. The UC issue is to plan generators with the end goal that the all out creation cost of the framework is limited while the necessary turning hold is kept up & all another generator & framework imperatives are fulfilled over a booked time skyline, going from 1 day to multi week. The unit commitment planning is usually a great combination crisis. The best solution for this can be achieved with complete numbering from combinations of possible production units which is not realistic. In addition, the operation of the electrical network in irregular environments. Centralized optimization based on price or profit instead of cost. Therefore, the purpose of the unit's commitment plan based on irregular electricity prices, the system aims to maximize the total benefit of the public service regardless of the task. To meet the demand for cargo and the return reservation. Therefore, a more complete solution. You need to find a unitary commitment based on price. Most power generation systems have thermal plants as well as also hydroelectric power plant. The best possible planning of energy production for an electrical network with together Thermal & Hydroelectric plants known as hydrothermal planning [1, 4]. The hydraulic restrictions & other additional restrictions for systems with pumped storage systems or a stepped hydraulic unit. Hydrothermal planning methods are generally reduces the total fuel price of a thermal unit by ignoring the subsidiary price of hydropower A unit that has been restricted by the generator, structure & hydraulic power for a time. In the small hydrothermal planning approach, planning time is usually varies from 1 day to 1 week.

2.2. Optimum power flow [1, 8] is also significant concern in the energy system development. Of course, this is a non-linear programming strategy. Specific target functions, such as production costs and transmission outages Satisfaction of gender equality and inequality between generators and the operating system limited

due to capability limits & safety necessities. The ideal electric current function is formulated scientifically as an expansion the ideal power flow strategy for economic transmission issues bus voltage, bus angle and transformer taps are considered. From other people FACTS units and units Phase change. Optimizing and analyzing energy flows is necessary to overcome this problem. Ideal energy flow has turn into a great instrument for offline & online planning czech.

One more significant optimization method in the energy system, optimal reactive power dispatch (ORPD) [19]. ORPD appointment. Control variables, such as the size of the transmitter voltage and the VAR variable Configure transformer and compensation conversion to minimize target function It also meets device and system limits. ORPD goal, Prevent total energy loss or deviation from load voltage to voltage configuration Higher stability or tension index to increase tension stability. ORPD is a composite wide-range optimization issues with non-linear goals. It relates to operational limitations. Depending on the electrical system, ORPD keeps bus loads within permitted limits customer service quality. In the highly competitive electricity market, electric services must operate more closely, this can cause overload & problems with voltage stability. Available bandwidth (ATC) [20] is a measure of bandwidth on the physical bus network, about that use is perfect. ATC is designed & recorded for each control area public communiqué structure for open access through transmission networks power distribution. Finding ATC is a challenge. The Total Transfer Capacity (TTC) & the 2 transmission ranges are designed, "Transmission Reliability Margin (TRM) & the Capacity Benefit Margin (CBM)". First an precise ATC solution is critical to maximizing the use of ATC today while transmission network maintenance. An under-estimated ATC may cause under-utilization of communication, whereas associate degree over-estimated ATC can bring down the system dependability.

III. COMPUTATIONAL INTELLIGENCE TECHNIQUES IN POWER SECTOR

The need of CI techniques in PS because the Power system investigation by ordinary strategies turns out to be more troublesome as a result of: (I) Complex, flexible and huge measure of data which is utilized in estimation, finding and learning. (ii) Increase in the computational timeframe and precision because of broad and huge system information dealing with.In the recent times, AI-base methods have been broadly utilized to solve optimization issues. These techniques comprise advantages that may be addressed composite issues may not be resolved by traditional techniques.

Fig.1.CI in Power System Area

Furthermore, these techniques are straightforward to relate due to their simple & direct arithmetic arrangement. Combined with other methods, the system improves the strengths of every single technique. AI techniques often replicate natural phenomenon or the societal activities of animals & humans.

3.1. The Expert system (ES) [21], as well identified like the information system, is a computer based programs which combines knowledge acquired by experts in a particular topic & gives problem evaluation to customers. The regular type of ES is a computer program containing the principles for examination & proposals for clients who possess a smaller amount involvement with tackling a particular issue. ES were created through the 1960s & 1970s & economically functional all through the 1980s. The procedures of ESs may be arranged into the classifications of rule based, information based, neural systems, object-situated technique, case based thinking, framework design, clever operator systems, database approach, demonstrating, and philosophy. ESs are additionally joined with Fuzzy System (FS) to Fuzzy Expert System (FES) or joined with Neural System (NSs) to Neural Expert System (NESs). As of late, with the improvement of computer procedures, ESs are relevant to online supplications. They are known as artificial intelligence programs that, by providing knowledge about specific tasks, acquire problem-solving skills at the expert level. The ES first introduced in beginning of 1970s by Feigenbaum (Feigenbaum et al.1971). It is a rule or knowledge based network that utilizes interface knowledge & procedures to resolve issues. They are hard an adequate amount to be resolved by human experience. Several advantages like:stable and reliable, canbe effortlessly broadcast, canbe effortlessly recognized.

Primary impediment of ES is that it experiences a knowledge bottleneck by having failure to learn or adjust to new circumstances. The knowledge designing procedures began with straightforward guideline based method & stretched out to further developed strategies such as item situated plan, subjective thinking, check & approval strategies, characteristic dialects, & multi-specialist systems. For as far back as quite a long while, a lot of ES applications has been created to get ready arrangement, break down, oversee, control & work different parts of electricity production, transmission & the distribution system.

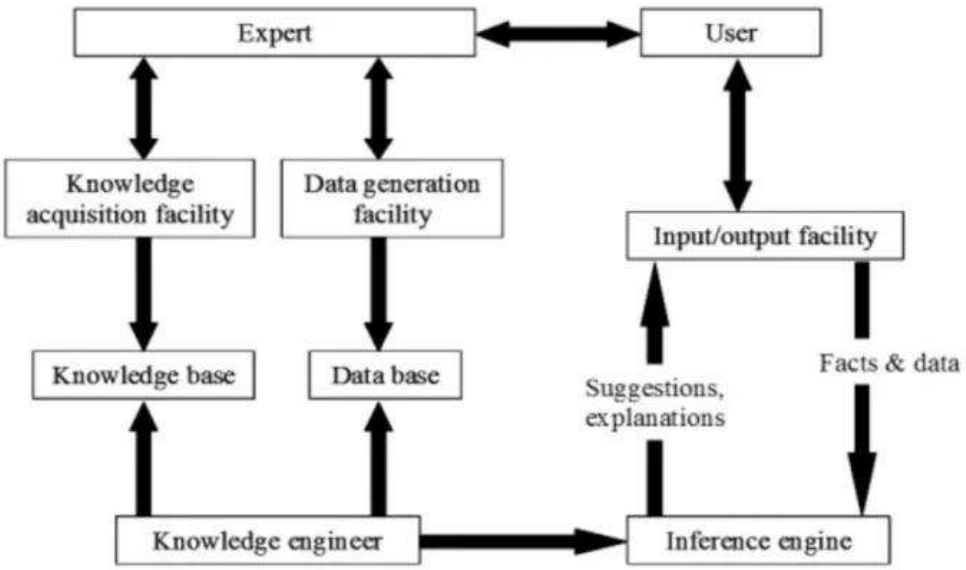

Fig.2. Structure of Expert System

3.2. Fuzzy systems (FS) [12, 14, 31, 36] are method of arithmetical description ambiguous in linguistic terms rather than exact mathematical explanations. They are suitable for managing vulnerabilities & estimated thinking. In a FS, the participation capacities are dubiously defined to speak to the level of reality of certain

occasions or circumstances. The estimations of participation capacities run from zero to one in their semantic structure related with loose ideas. FSs were created in 1965 & have gotten well known in specialized critical thinking.

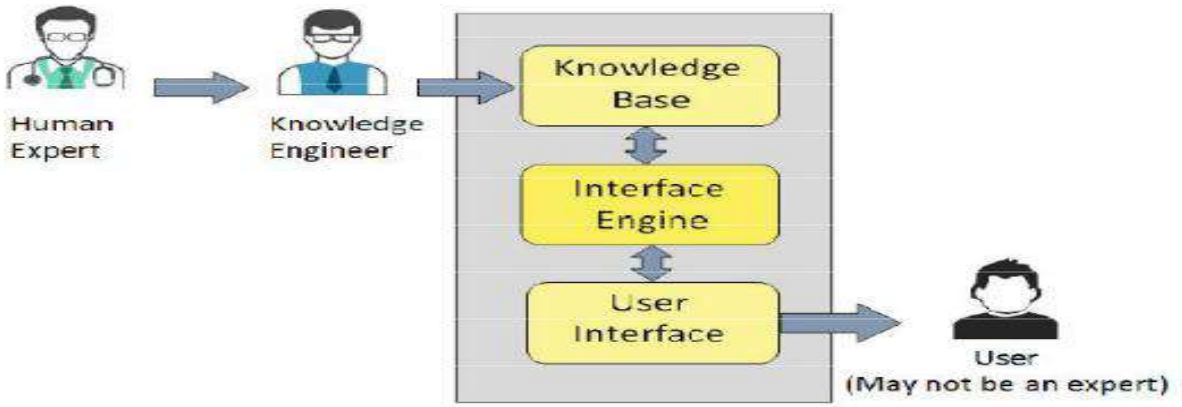

Fig.3. Components of Expert system

Fuzzy system can be utilized for planning the substantial parts of power networks. It can be utilized in whatever thing from little circuits to huge centralized computers, build the effectiveness of the parts utilized in power networks. As the vast majority of the information utilized in power network investigation are inexact qualities and presumptions, fuzzy system can be of extraordinary use to determine a steady, definite & vagueness open yield.

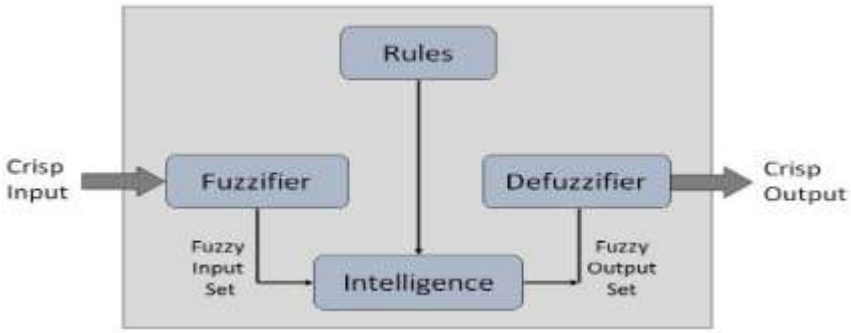

Fig.4. Fuzzy System

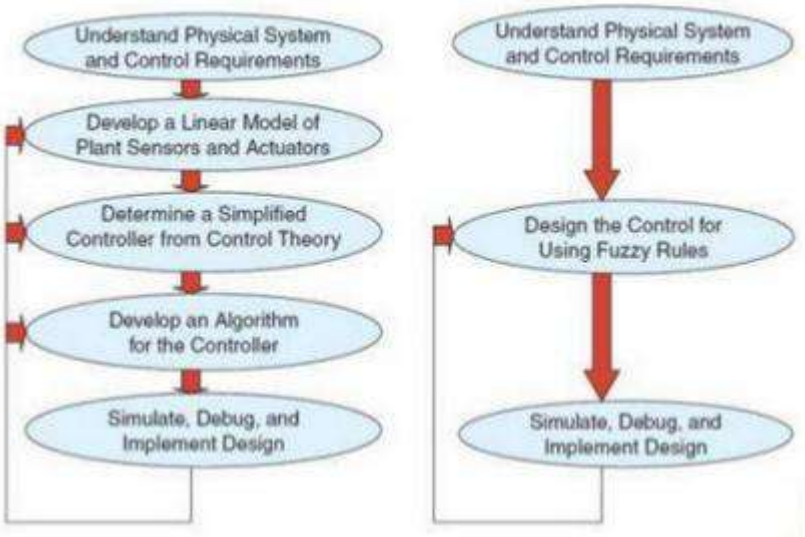

Fig.5. Benefits of using Fuzz logic

3.3.Artificial Neural Networks (ANN) [6,33] are numerical models reproducing the human organic neural system for handling data. A neural system comprises of a small number of layers of neurons connected by weight connections. There are a few sorts of neural networks characterized by their configuration, for example, feed forward, Radial basis function, back propagation, recurrent networks, & so forth. Each sort of neural organize is prepared to do some particular work subsequent to being prepared. Neural networks can deduce a capacity from perceptions which is especially valuable for applications with the unpredictable undertakings looked, in actuality, similar to work estimation, grouping, information handling, and so forth. The essential favorable position of NNs is the capacity to study calculations, the online adaptation of dynamic network, speedy equal calculation & smart introduction of information. ANN is an information dispensation paradigm motivated by the organic nervous system. How the brain processes data [29]. A key component of this worldview is the new data structure handling system comprising of an enormous number of exceptionally interconnected preparing components (neurons) that collaborate and tackle explicit issue. ANN learns like people through examples. The initial point for the ANN claim was the training algorithm projected by Heb in the year of 1949, he showed how networks of neurons can demonstrate learning behavior. For the duration of training in the second phase, the neuron is affected by a set of finite samples called the training set, which in turn adjusts the neuron's weights. for specific learning rules, ANN is not planned in the traditional logic, but we learn to resolve problems connection with the environment. Very few calculations are performed at the location of a single node (neuron) not exist. However, the explicit memory or processing location of the NN is included in the connection between the nodes. Not all input sources feeding a node are equally important. It all depending on -ve or +ve weight. Entry incoming at node is converted as per the node's activation function. The major advantages of ANN are[29]:

- It is fault tolerant, capable of handling situations where information is incomplete and data is corrupted.
- The astonishing parallelism supplied by the huge number of neurons & the associations among them have been distributed representation.
- ANN with the correct representation is very useful for solving nonlinear problems because it can model all degrees of nonlinearity problem.
- No prior knowledge of system model is required.
- It is prompt & robust. Has knowledge skills & adapts to the information.

Although NN training is normally computationally exhaustive, it takes very little time to properly assess accurate results come out as soon as the network is trained. Regardless of the advantages, some drawbacks of ANN are: (a) The dimension is large,(b) Optimal configuration selection, (c) Training method selection, (d) ANN "black box" representation. The fact that there is a lack of explanatory power and (e) results are always produced when the input data is incorrect. Other disadvantage of NN systems is that they are not scalable. That is, once the ANN is skilled to perform a particular job, it becomes hard to do so. Expand the NN to other responsibilities with no retraining. ANN are the most capable technique for lots of feeding networks. There is a problem and it is being used in various applications. ANNs are primarily classified according to their structural design (number of levels) & geology (connection model, feed forward or iteration) & knowledge system. Depending on the structural design, the ANN model can be a 1 layer ANN containing a perceptron model (Proposed by Rosenblot in the year of 1959) & ADALINE (Proposed by Widlow & Hoff in the year of 1960).

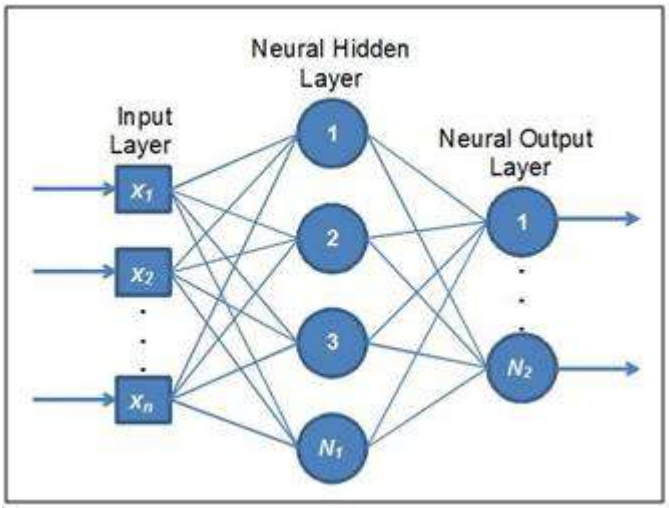

Fig.6. ANN model

ANN models can be more classify Feed forward NN & feed backward NN depending on neural interaction. ANN learning is Supervised, Unsupervised & Reinforcement learning. Depending on the construction of neurons, ANN models can be classify as multi-layer, perceptron model, Boltzmann m/c, Cauchy m/c, self-organized Kohonen card, correlative interactive memory, Adaptive Resonance Theory I(ART-I) & Adaptive Resonance Theory II (ART-II) for ANN propagation.

3.4. Simulated Annealing [8, 34] is a highly-rated search algorithm optimization problem; identify high-quality estimation at international optimization level points for specific functions in the research space. This method simulates the incubation process. Metallurgical plants are used to heat and cool controlled metals to resize crystals & reduces efficiency. Incubation simulation was developed to solve in the 1980s.The optimization problem in another search space proved to be more effective method of listing research spaces. The precedence of SA are its common relevancy to work with any network & expenditure function; its capability to improve optimally Decision; & its easy execution even for complicated issues. The major drawback of SA is multiple annealing. The technique cannot enlighten either or not it has create the best possible resolution. Several another techniques are needed (such as branching and linking). SA has been utilized in variety PS supplications like transmission development scheduling, unit commitment, maintenance planning, etc.

3.5. Taboo Search (TS) [8] is also Meta Heuristic search to solve harmonics development issues in industrial engineering, management science, economics & information technology. This strategy has a place with neighborhood search innovation; use memory structures to improve the performance of local research methods combine them first with the local minimum. When a potential arrangement has been acquired, it is set apart as taboo, in this manner the algorithm doesn't visit that chance over & over throughout the investigate procedure. TS were created during 1970s & as of late has been broadly utilized for its powerful search abilities.

Taboo Search (TS) is essentially a memory gradient descent search. The memory contains a series of earlier visited visitor's conditions as well as a number of conditions that may be assumed unwanted. This data is reserved in the taboo list. The condition, surrounding territory, & length of the taboo list are serious design variables. Additionally to these taboo parameters, 2 extra variables like aspiration & diversity are often used. Aspiration is utilized when each and every adjacent states, the present state is also incorporated in the listing of taboos. In this case, the taboo obstruction is ignored by choosing a fresh state. Diversification add up unpredictability to this deterministic investigate. If the investigate in Taboo does not converge the investigate is restored arbitrarily. TS is an iterative enhancement process that begins with an early resolution & attempts

to find the best solution by most tumble vicinity investigate algorithm. The main components of ST are movement, taboo list and suction level. TS is used in a variety of power system applications, such as transmission planning, optimal placement of capacitors, commitments, hydrothermal planning, fault diagnosis / alarm management, reactive power planning, etc.

3.5. "Ant Colony Optimization Algorithm (ACOA) [22] is a probabilistic strategy to tackle optimization issues. It tends to be decreased to the issue of discovering the briefest ways through diagrams dependent on the conduct of ants in discovering nourishment for their colony by denoting their path with pheromones. The briefest way is the path with the most pheromone marks which the ants will use to convey their food reverse to homes. The 1st algorithm was created in year of 1991 & from that point forward, numerous variants of this rule have been created"[27].

"Dorigo first introduced the Ant Colony Detection System (ACS) in 1992 [30]. ACS procedures are propelled by conduct of real ant colonies and are utilized to take care of useful or combinatorial issues. ACS algorithms somewhat emulates the conduct of real ants. The fundamental highlights of ACS are the positive input for the recuperation of good distributed arrangements calculation, which evades untimely convergence, and the utilization of productive heuristics to discover satisfactory arrangements at the beginning phases of the examination procedure. The primary disadvantage of the ACS method is the shortcoming of computational usefulness. The ACS method was fundamentally used to locate the most brief way in the transmission network"[26].

3.6. Genetic Algorithm (GA) - It is related to evolutionary computing using technology inspired by evolution Inheritance biology, mutation, selection & crossover. GA was partially inaugurated from the 1950s and is one of the most popular. Computer science strain, Bioinformatics, chemistry, economics, engineering, manufacturing and mathematics, Physics and other fields. Using this technique, the search may get some time to calculate best solution.

3.7. Evolutionary programming (EP)[6, 35] also obeys evolutionary computation paradigm for discovering the optimal universal resolution for an optimization issue. Scalable programming was developed in 1960, Connect actions between parents and offspring instead of trying mimics a particular genetic operator observed in nature. Main operator Evolutionary planning includes mutation, evaluation and selection. Is Because of its power, this method is also widely used in various optimization techniques research skills.

3.8. Particle Swarm Optimization (PSO) [8, 33] is one of the most heuristic algorithms which is invented under the emulation of simplified social behavior of animals in herds, For example. With a flock of fish and a flock of birds. This is a scalable population-based algorithm. It is effective for solving nonlinear continuous optimization issues. PSO gives a population-based investigate process. Individually (particles) vary position (state) over time. Use speed Vectors depending on societal manners of individuals in the updating population. The present location of every element in the swarm as it flies multi-dimensional looking for space for a issue. Throughout flight, every element with a definite velocity energetically adapt based on your flight experience and the experience of your neighbors Particle finds the most excellent place for himself among his neighbors. PSO technology can provide high quality solutions with shorter calculations time with further stable convergene property than another stochastic techniques. PSO, invented since 1995, many areas of research & application, like engineering, management finance. A system, and one of the most broadly utilized optimization techniques today. Differential evolution belonging to the class of evolution strategies [23] Optimizer is a technique of arithmetic optimization of multidimensional functions .Discover the universal

smallest amount of multidimensional multimodal functions reasonably fast and robust. Differentiate advancement advanced middle of 90's A random function minimizer based on a simple population and a. It will be one of the most used by researchers. Core ideas for This technique is a plan for adding weights to generate a test parameter vector. Difference between two third population vectors It is completely self-organizing. Test vectors are used in the next generation when: The value of the objective function decreases.

IV. APPLICATION COMPUTATIONAL INTELLIGENCE TECHNIQUES IN POWER SECTOR

For the past 20 years, the method has been based on artificial intelligence, common in solving various energy system problems like scheduling, control, forecasting, planning, etc. these methods can handle the difficult tasks you face through the application of large modern power system with more interconnection It is established to congregate the growing demand. The utilization of these strategies has been effective in numerous regions of PS designing. Some serious issues of PS that AI strategies have been applied to, incorporate arranging, activity and demonstrating investigation.

4.1. Power System Expansion Planning (PSEP) [24]: The arrangement of a commonplace EPS is enormous & complex together with essential segments as AC-DC transmission system, generators, load, distribution system & FACT devices. The fundamental goal of smallest amount of price system expansion planning is to advance the segments important to give a satisfactory vitality gracefully at least expense. PSEP, numerous components have to be contemplated, for example, demand, line and FACTS situation, ecological impacts, and so on. This incorporates the planning of any extension Generation, Transmission & Distribution. Additional problems likewise considered in this undertaking are receptive power planning, unwavering quality examination and system structure among others.

4.2. Power System Operation (PSON) [8]: In real-time PSON, the online power generation must meet full load & transmission losses safely & securely. With this approach, working power station& transmission system is considered. Related questions Includes power generation schedule, economic schedule, optimal power flow, hydrothermal scheduling, UC, voltage monitoring, reactive power discharge, load frequency adjustment, static & dynamic safety evaluation, contract management, contract management, service plan, equipment monitoring, fuel plan & dynamic reprogramming the generator. For monitoring purposes data collection & energy management system (SCADA/EMS), service restoration , load prediction & control, alarm processing, failure analysis, service recovery, network/substation switching, state estimation & finest energy flow are incorporated in plan.

4.3. Electrical Network Modelling/Analysis [11] Electrical Network Modeling problems/ Analysis include analysis of power flow, harmonics, transient stability, simulation, control design, dynamic stability, protection & detection. Most as of late, AI based techniques have been applied to issues in deregulated situation supporting clogging managing, enhancement of offering procedures & age booking [25].On the other hand, many challenges remain. Hence, these techniques constantly developed & enhanced to cope with the growing complexity of power systems with increasing restrictions on conventional electricity energy industry and competitive environment of the electricity market.

V. TOWARDS A SMART ENERGY DIVISION

The energy division has a splendid future with the appearance of arrangements, for example, smart grids oversaw by AI. These are electrical systems that permit two-path correspondence among Suppliers and

purchasers: [2] coordinated smart grids a layer of data that permits correspondence between its different parts with the goal that they can react better quick changes in energy needs or earnest circumstances. IS Level of data made by an overall establishment of smart meters and sensors, permits data obtaining, Archiving and analysis [3] Phasor Measurement Units (PMU) or synchrophasors, They are another fundamental component of the advanced smart network. Empower continuous data arrangement and measurement from various far off purposes of the system. This makes a refreshed, exact and incorporated perspective on all administrations System that takes into account better system the executives. Along with powerful data analytics, these give smart grids The articles added to the unwavering quality, wellbeing, and efficiency of power transmission and distribution Networks.[4,5] Given the enormous volume and the various structures from such data artificial intelligence procedures, for example, AI are the best for examination and use[6]. These data examination can be utilized for an assortment of purposes, including Error recognition, prescient support, energy quality observing and guaging of sustainable power sources [7]. Development in data and correspondence Technologies (ICT), Cloud Computing, Big Data Analytics, and artificial intelligence helped spread it Smart measurement. The broad utilization of smart meters and propelled sensor innovation has made gigantic amounts of data that is produced rapidly. These dates require new ones Methods of capacity, transmission and examination. As a representation Sake, with an inspecting pace of multiple times 60 minutes, once a great many smart meters introduced in a smart framework create in excess of 35 billion records[8].

Deep learning techniques, a subset of AI, can help recognize examples and abnormalities across huge datasets—both on the force request and force gracefully sides—that in any case would be almost difficult to accomplish. This has brought about improved frameworks, quicker critical thinking, and better performance.Advanced economies are driving the route in the use of AI in the force division. For instance, DeepMind, an auxiliary of Google, has been applying AI calculations to 700 megawatts of wind power in the focal United States to foresee power yield 36 hours in front of genuine age utilizing neural systems prepared on climate conjectures and authentic breeze turbine data[9]. Deep learning calculations are additionally ready to learn all alone. At the point when applied to vitality information designs, the calculations learn by experimentation. For instance, in Norway, Agder Energi joined forces with the University of Agder to build up a calculation to streamline water use in hydropower plants[10].Water may seem, by all accounts, to be an apparently perpetual wellspring of vitality, anyway just a restricted measure of it is accessible to deliver hydroelectricity, so it must be utilized ideally.

Artificial intelligence can likewise help with prescient issues in hydroelectricity Production. When all is said in done, most nations have done this hydrological data gathered over a time of 40 years, e at times longer, which makes it simpler to foresee of hydrology utilizing the demonstrated stochastic twofold elements Programming instruments. In the most recent year, be that as it may, environmental change has halted such gauges. Right now arithmetic The models behind the power generation operation are around 30 years and as a rule are not perfect with the flow realities of the hydroelectric division [12].The expanding vulnerability of boundaries, for example, future precipitation levels or estimating are among the numerous difficulties to improving production and profit.

VI. USES OF AI IN THE ENERGY DIVISION

Foreseeing disappointments was one of the primary employments of AI in the energy area just as in real time maintenance and recognizable proof of the perfect upkeep time plans. In a part where gear disappointments happen regularly with possibly noteworthy outcomes, Artificial intelligence joined with the correct sensors can help Monitor gadgets and recognize mistakes before they happen Save assets, cash, time and life Geothermal energy, which guarantees consistent energy production, is viewed as a likely wellspring of

essential power (The base measure of power that must be provided power grid at some random time) on the side of Expansion of less dependable renewable energies. Toshiba ESS has become Investigate the utilization of IoT and AI to improve efficiency and dependability of geothermal power plants [27]. For instance, advanced prescient diagnostics The data is utilized to anticipate what issues may emerge. Mood killer the plants. Preventive estimates, for example, synthetic concoctions Active fixing showers are streamlined to maintain a strategic distance from turbine personal time (Quantity, sythesis and time) with IoT and AI. Like what Innovations are significant in a nation like Japan has the third biggest geothermal asset on the planet, particularly considering the serious cost drop renewable sources, for example, solar energy. Upkeep encouraged by picture handling. He The British national system became drones Screen links and arches that convey electricity.Power stations for homes and organizations. Outfitted with Infrared and top notch cameras, these automatons They were especially helpful because of their inability to distinguish blunders. Capacity to cover huge geographic regions and troublesome territory. They were utilized to cover 7,200 air miles in England and Wales. Artificial intelligence is then used to screen them State of electrical frameworks and assurance of when to utilize them. must be supplanted or fixed [28] Decision making on energy efficiency. Smart gadgets like the most effective method to enact Amazon Alexa, Google Home and Google Nest Customers communicate with their indoor regulators and more Control frameworks to screen your energy utilization. The computerized change of home energy the board and consumer gadgets additionally permit programmed counters Use artificial intelligence to enhance energy use and capacity. To For instance, this can make gadgets turn off when Electricity is costly or power must be led by the vehicle and put away different batteries when power is modest or solar energy on the rooftop it is plentiful. With populace development and urbanization developing markets and the subsequent rambling artificial urban areas Intelligence will assume a key job in this exertion Data, including system data, smart meter data, climate Data and data on energy utilization - to consider and improve Constructive execution, enhancement of asset utilization and Greater accommodation and profitability for inhabitants [29]

Additionally, in deregulated markets like the United States where consumers can pick their energy suppliers, Artificial intelligence empowers consumers by empowering them to run the show your provider dependent on your power source inclinations, your family financial plan or your utilization propensities. Scientists at Carnegie Mellon University have advanced an AI framework called Lumator that consolidates client inclinations and utilization data Information on the distinctive rate plans, restricted in time extraordinary costs and other item offers so as to give suggestions to the most reasonable current gracefully movement. At the point when you become more acquainted with the client Custom, the framework is modified to switch consequently Power plans when better arrangements are accessible, all without gracefully disruption.[30]. These arrangements can likewise add to expanded the contribution of renewable energy helping consumers make the progress their inclination for renewable energies in the demand made for them, and can be utilized to flag consumer level to makers demand for renewable energy.

Artificial intelligence can help improve electricity demand predictions generation, improving production decision making. This is particularly important in the transition to renewable energy, because they are often inconsistent due to their addiction climate, wind and water flows and their dependence on fossils emergency fuels. AI-based predictions combined with energy The storage infrastructure can reduce the need for such backup systems [31]. Finally, the spread of distributed production means this consumers will now contribute to electricity generation, effectively as producers. How are you prosumers become more important players in the system. Artificial intelligence will facilitate decision making at optimal times for distributed production to contribute to the network, rather than draw from him. Artificial intelligence can also help

traditional manufacturers as well network administrators who will now have to balance intermittent renewables, distributed generation, included prosumer and new trends on the demand side, like increase in electric vehicles (EVs).

Prevention of losses due to informal connections.Losses due to informal connections are another challenge for the electricity sector. Artificial intelligence could be used to detect deviations in usage patterns, payment history & other consumption data to detect them connections. Also, when combined with automation meters, you can improve your tracking. It can also help optimize costly and time-consuming physical inspections.

VII. CONCLUSION

The reliability of planning & design is the major feature of the power system. Conventional strategies doesn't satisfy the probabilistic quintessence of power systems which may increment in operational & security costs. A lot of examination is performed to use the current enthusiasm on Artificial Intelligence for power network applications. • A great deal of exploration is yet to be performed to see full points of interest of this up and coming innovation for improving the efficiency of power showcase, investment & especially power systems which utilize renewable energy assets for activity. Numerous issues in power division are relying upon various non-possible necessities. Along these lines, AI procedures are the main alternative to comprehend them. Most recent methodology of AI in power system applications are:

- Planning for production of energy expansion, reactive power management, transmission network development. The voltage, power & frequency control.
- Controlling of power plants efficiently.
- Computerization for reinstatement supervision, error analysis & system safety
- Planning & operation of distribution structure, customer demand reply & supervision, smart grid operations & control, & network reconfiguration.
- The study of future electricity market, solar & wind power plants.

The application of computational intelligence techniques in power sector area are explained here

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SURVEY PAPER ON POWER SYSTEM BLACKOUTS IN INDIA & AROUND GLOBE

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Abstract

The power system plays most important role in developing the nation. It is complex network & have great impact on financial, political & societal aspects. To work with such network in a steady manner, a few control & protective methods are needed. Now a day's power system is fully equipped with various security/protective systems to avoid the unwanted failure & power outage, but still experiencing the crisis & mal-activity circumstances. If we fail to deal with such type of crisis, the system may cause cascading failure which leads the blackout. Power disappointments are especially basic at locales where nature & open security are in danger. At the point when a power system is exposed to huge disruptions control activities require to be removed to guide the system from serious outcomes. These disruptions often bring about outage of the network, which thusly causes tremendous misfortunes in the system just as financial misfortunes. The blackouts in the power system may emerge in a few different means. The most effective method to forestall a blackout is a significant difficulty in the power sector. The thought processes to intention blackouts may be the over-burdening of transmission lines, disappointment of well being or control systems, ice covering on lines, , & others. The blackouts may be forestalled via suitable control methodologies in a system to keep from a N-1 possibility, keep load innovation equalization, & course to further fault possibilities. This paper describes the Power System Blackouts in India & around the Globe.

Keywords: Voltage Collapse, Blackouts, Power outage, Voltage Instability

I.INTRODUCTION

Electricity is an integral part of the human being in this modern lifestyle. We are completely dependent on uninterrupted power supply to power our gadgets, appliances, healthcare, education, you name it and that requires electricity. The basic requirements for human survival used to be food, clothing and shelter but today electricity and internet have been added to that survival list. Our everyday life is powered by electricity. Imagine the few hours that the local power grid has a shut down – the effect is restlessness, stress, anxiety, worry and the moment the power is restored the first sound is "Ah", a big sigh of relief. From a surgeon in the operation theatre, to an engineer in a factory, to a motor-mechanic in the garage, to an officer in a company, to passengers on a railway platform, all are enjoying the interrupted service rendered by electricity. Modern transportation nowadays is moving towards electrical energy. To work with such systems in a steady mode, a few control and protective techniques are required.

National Grid

It is high voltage electrical transmission system in Indian which all the substations & generating stations are connected to each other & ensures the power generated at any place in India can be utilized to fulfill energy demand at anyplace in India.[1] The National Grid is possessed, worked, and kept up by state-claimed Power Grid Corporation of India. It is one of the biggest operational synchronous grids on the planet with 371.054 GW of introduced power generation limit starting at 30

June 2020 [2].

A. Blackout means?

A blackout is an all out accident of the power grid because of an irregularity between power generation and power utilization. A specific power cut is a controlled shutdown of the power gracefully in a given zone, to dodge a blackout. A blackout = a power outage. This state implies the loss of the power flexibly to a piece of the power framework or to entire power framework. The blackout in the power framework can cause: • power framework gear harm, • substantial affordable misfortunes, • danger of economy working, • life loss of motion in stricken pieces of nation. It is important to see that everybody is subject to dependable and quality power gracefully.

II. JULY 2012 BLACKOUT IN INDIA

2 most severe blackouts happened in India on 30th & 31st July,2012 which affected almost North & East India. Near about 400 million individuals were suffered through power outage on 30th July 2012 & it was more severe than blackout occurred in January 2001 in North India (230 million people were affected) [3]. Again on 31st July serious blackout occurred which is largest in Indian blackout history. Due to this 620 million human being suffered which almost (contributed 9 % word populace [4][5][6] or almost 50% of populace of India). Which affects 22 states [7] out of 28 states in East, North & North East states of Nation. As 32 gigawatts of generation limit were expected taken offline [8]. Of the influenced populace 320 million at first had power, while the rest of needed direct access [9].The electric help was reestablished in the influenced areas between 31st July & 1st August, 2012 [10][11]. Our nation are at position no. 3 in electricity producing after U.S & China but electric network not reliable[12][13]. An expected 27% energy produced was lost in transmission in 2012[14] while top flexibility missed the mark concerning demand by normally 9%.[14]/ The whole nation were suffered through repeated power outage for almost 10 hours[14] & about 25% of populace (300 million individuals) were in blackout [14]. The continuous efforts are taking to reduce losses in transmission & dispension & improve productivity[15].The numerous elements that provided to the start of the network collapse. The 400 kV Bina to Gwalior to Agra-2 was under planned closure from July 28, 2012 for improvement work up to 765 kV. From then on, the cuts began in the afternoon of July 29, 2012 according to [16]:

TABLE II: Succession of blackout on 29 July [1].

Sr.No	Time	Line	Reason
1	July 29, 2012 15:15	220 KV line between Kota to Badod	Line is tripped because of distance protection 3phase zone1 indications at the Badod end
2	July 29, 2012 15:40	220KV line between Bhinmal(PG) to Sirohi	Fault occurred between Phase & Earth
3	July 29, 2012 21:45	400 KV line between Bhinmal to Kankroli	Line is tripped due to insulator decapping.
4	July 29, 2012 22:18	400KV line between Zerda to Kankroli	Crisis blackout almost for two hours to takeout one Tool & Plant which got stayed with one polymer encasing.

It is seen that the 400 kV organize between Western Locale and Northern Region got drained continuously finished the late evening beginning with an arranged blackout on a high limit passageway followed by two constrained blackouts one after another. Absence of Regulation among SLDCs Regulators didn't incorporate standby power with the grid. Household Load, Business Load,

important Services Like hospital & businesses are associated with normal feeders & consequently the need based load shedding was impractical. Framework not intended to reestablish power to necessary services in minutes. Indian grid networks experienced helpless frequency summary. In the Northern grid, added loads were met with accessible generation at the expense of frequency. Power quality & Grid security was undermined throughout this stage.

B. Succession of Events on thirtieth July [1]

The NR is associated with WR by means of various interlinks anyway it became found that huge numbers of the interlinks were unavailable due planned and constrained due planned & constrained outages at perturbation of time. The four hundred(kV) line Bina to Gwalior to Agra turned into the most straightforward essential AC circuit keep on being which interface NR to WR. Therefore the energy flow from WR to NR through Bina Gwalior-Agra link rised which causes overburdening of tie lines . The close by load transmit focus started load losing to lessen the heap in this line anyway the degree taken have been lacking WR was additionally learned to decrease the generation to chop down the vitality coast through this line in any case, the reaction was currently not brief adequate. With theexpanding load, the current move through the transmission line expanded & because of absence of reactive powercompensation, the line voltage profile fell. This condition was detected by the distance relay as blunder & it stumbled the line.

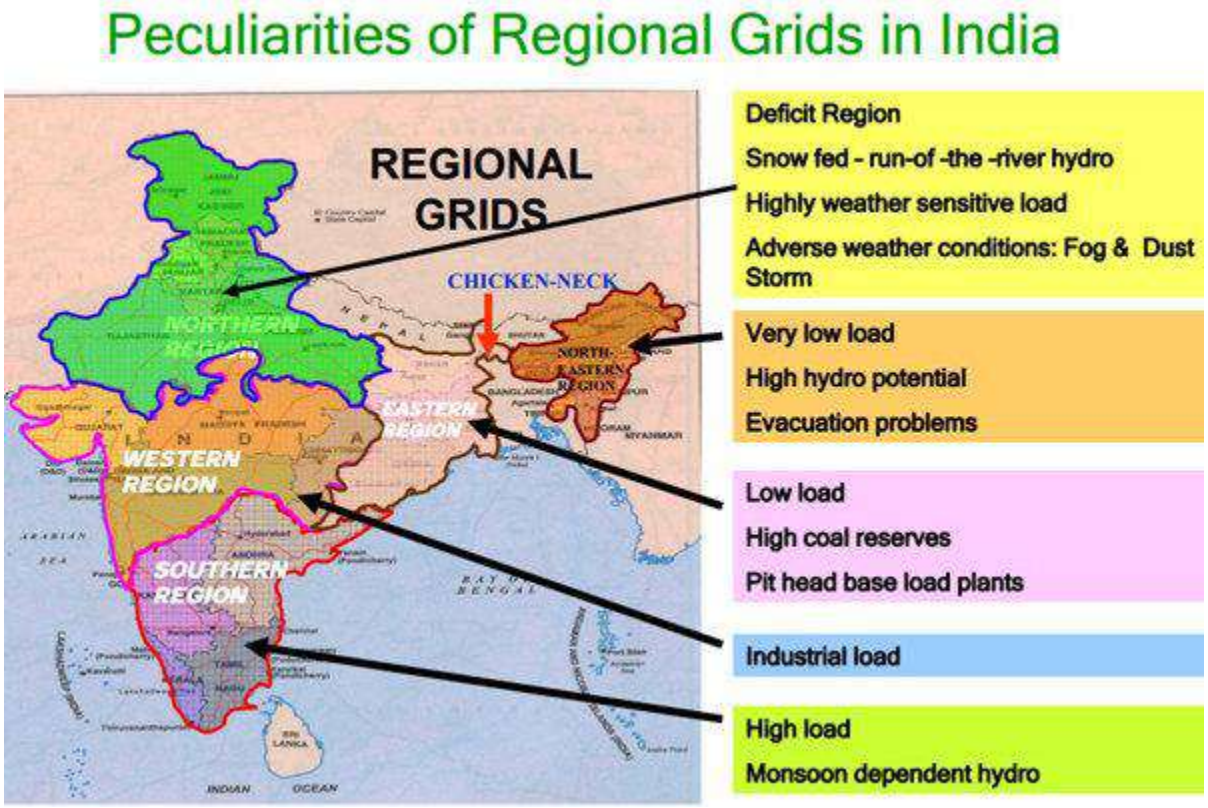


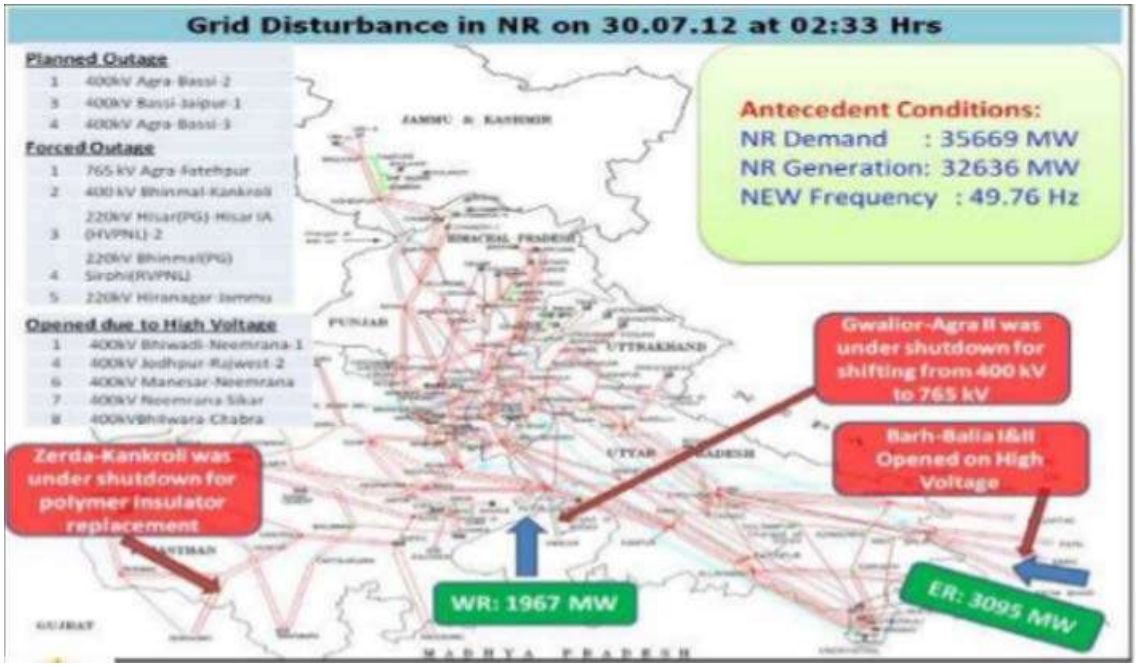
Fig. 2 Regional Grids [1]

The new framework isolated into islands enduring & other one collapsing. Figure beneath appears the frequency estimated through WAMFS sooner or later of the power outage. It's noted the divergence of the Mumbai &Kanpur frequencies veer off fundamentally. Due to events above, the entirety of the AC joins from the ER (Eastern Region) to NR (Northern Region) had been lost [17].

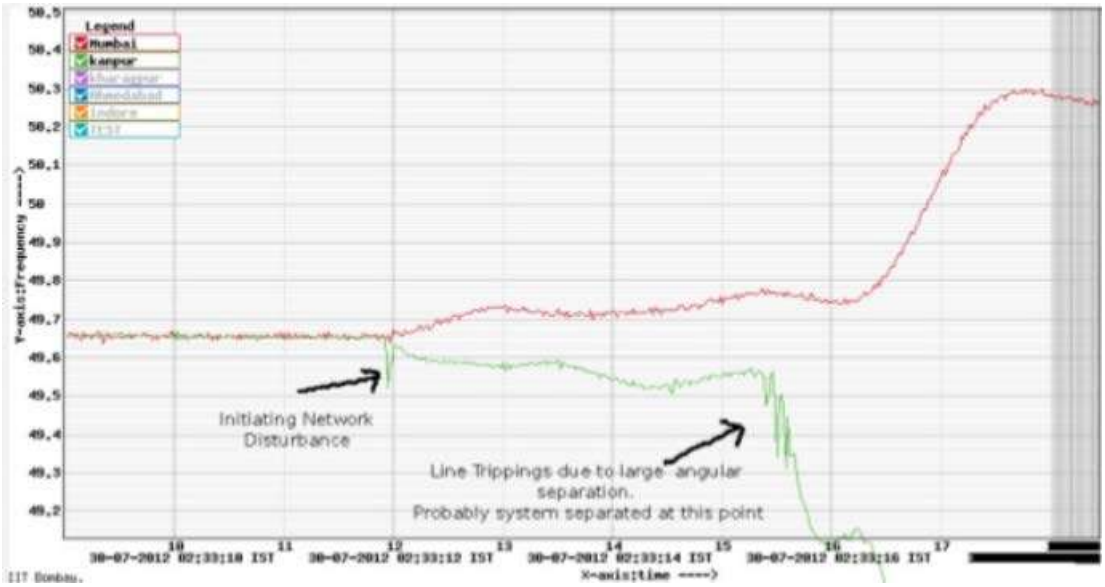
TABLE III: succession of blackout on 30th & 31st July [1]

Sr.No.	Date	Time	Line affected
1	30th July,	02:33:11	400KV line tripped between Bina to Gwalior

2	2012	02:33:13	200KV line tripped between Gwalior to Malanpur 1 (on power swing) with the above events, practically all the AC link from the WR to NR were lost
3		02:33:14	400KV line tripped between Jamshedpur to Rourkela line, line-1,2 and 3 tripped on zone 3 protection
4		02:33:14	400KV line tripped between Gorakhpur to Muzaffarpur-2 (on power swing)
5		02:33:15	400KV line 2 tripped between Balia to Boharsharif- (on power swing)
6	31 July,2012	13:00:13	400KV line 1, tripped between Bina to Gwalior , 220KV line tripped between Shivpuri-Sabalgar-1 tripped
7		13:00:15	132KV line tripped between Pichhorr to Shivpuri , 400KV line 1tripped between Ranchi to Maithon (due to power swing).
8		13:00:18	220KV Bus coupler tripped at Tarkera, tripped 400KV line 1 tripped between Jamshedpur to Rourkela
9		13:01:28	400KV line tripped between Kankroli toJodhpur because of dip in voltage, Wagoora to Kishenpur (1&2) (due to power swing)
10		13:01:30	line tripped between Ballabhgarh to Gr Noida tripped, Z1, 3phase, Kanpur-Panki-1 tripped (Under Voltage)
11		13:03:18	400KV line tripped between Patna to Balia-2 (3-ph fault), 220KV line tripped between Kankrolo to Debari (Under Voltage Protection)



Grid Disturbance



Frequency at Western Region [1]

In the Westorn Region due to loss of export to rest of new grid, the frequency shoot up to 51.46 Hz and many geneartaing units & transmission lines trapped due to process related issues & high voltage respectively. The frequaeny stabilized at 51.0 Hz.The rise in frequency only illustrate the poor level of primary response.

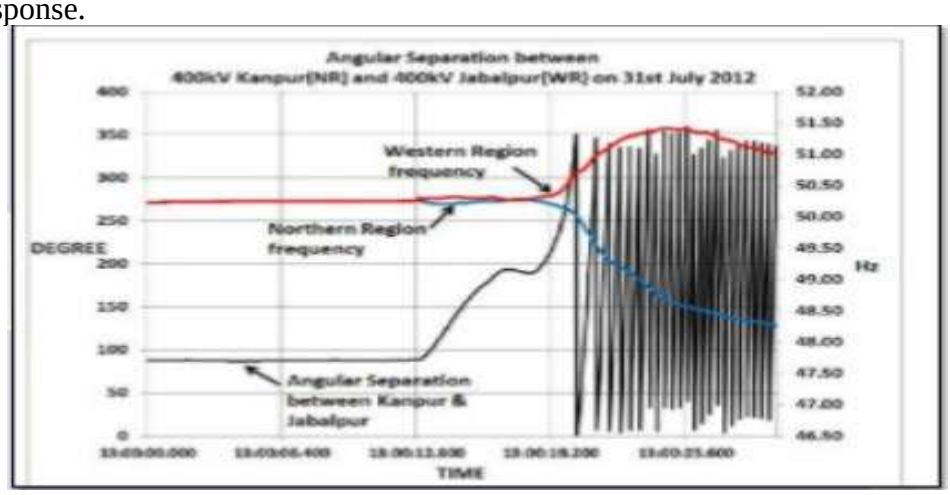


Fig.3 Frequency during power outage

III. Blackout occurred on 30th July, 2012 [1]

The circuit breaker of 400kv line between Bina & Gwalior was tripped at 2.35 am. As this line is fed into Agra to Bareilly transmission section, the breakers at the stations likewise stumbled & power outage fell through the matrix. All significant power stations were closed down in the influenced states, causing an expected lack of 32 GW [8]. The official portrayed this outage as “The worst in decade”[18]. In excess of 300 million individuals about 25% Indian populace, were without power. The railways & few airports were stop working till 8.00 [19].The busiest landing field in South Asia, Delhi airport continuing functioning as result of changed to reserve power in fifteen seconds[20] [21]. The blackout caused ‘disarray’ for Monday morning, busy time, as traveler trains were close up & traffic lights were non-operational [8]. All the trains were slow down for three to five hours[22]. So many hospitals were announces break in well being services [8]. While others depended on back-ups of generators [18]. The water plants were also closed down for few hours [20] & many thousands individuals couldn’t draw water from wells supplied by electric pumps [22].

The Blackout arised exactly at 1.00pm. This affected total 21 states & one Union territory. This cause higher effect than 30th July Blackout.

The following states were affected-

- States on Northern grid: Delhi,Himachal Pradesh, Punjab,Rajashthan,Haryana,Jammu & Kashmir,Uttarakhand,Uttar Pradesh
- States on Eastern grid: Jharkhand,West Bengal,Bihar,Orissa
- States on Northeast grid: Assam,Meghalaya,Sikkim,Arunachal Pradesh,Manipur,Mizoram,Ngaland
- The worst suffer ewer 265 miners who got trapped in coal mine in West Bengal & Jharkhad due to power outage. They were evacuated after hours of agony.

IV. BLACKOUT ON JULY 31, 2012 [1]

The electrical network affected again on this day, because of relay issues close to Taj Mahal [24] & WR detached from grid network & network was in service in an anxious situation at the frequency 49.84 Hz prior to interruption. The NR was linked to the WR through the 3 AC tie-lines however shortly all of them tripped back to back. Subsequently the power stations over the influenced areas of India again went disconnected. The NTPC limited halted 38% of its production limit [25] over 60 crore individuals (almost 50% of our nation populace). The 22 out of 28 states were in blackout [7]. In excess of 300 traveler intercity trains & suburbanite lines were closed down because of forced outage [26] [27]. The most exceedingly terrible influenced zones in the wake of power matrix's breakdown were East coast railway zone, East-central, Northern, North central with the area of South Eastern, Eastern & West central railroad zones. The Delhi metro terminated assistance on each of 6 lines & needed to clear travelers from trains that halted mid venture, helped by Delhi disaster management authority [25].

V. CAUSES AND REMEDIES [1]

Over-burdening & absence of reactive energy compensation brought about stumbling of transmission lines. All the creating units are furnished with Power System Stabilizers. Which shield the network from instability. Be that as it may, they were definitely not adjusted appropriately & consequently couldn't work well.

• The load compensation to be achieved due to operation of under frequency protective relay & df / dt was now not accomplished.

• There is a need of instruments that can appraise the condition of the framework progressively& at a quicker rate. This will empower the administrators to realize the genuine power streams on various lines.

By examining above circumstance & occasions it is seen that power outage is advanced with some normality and it very well may be separated into a few stages as precondition, starting occasions, course occasions, last satiate and rebuilding. Unique precondition occurred before power outage like framework unpleasant condition, lacking responsive force hold, significant gear unavailable, regular explanation, for example, wind, tempest and so forth starting occasions are different in various power outage. Short out, over-burden, security concealed disappointment and loss of generator are starting occasions which legitimately cause power outage [29]. The wrong operations of shielding relays leads to contribute the variety of cascade disasters & power outage. These can be set off by starting occasions causing power oscillations furthermore, voltage variances which may bring about high current & lesser voltages. It can be distinguished by other associated tie line as a flaw. Alongside power swaying & voltage variance, line over-burdens can likewise cause course occasion. Force framework flaws, line exchanging, generator detachment & the misfortune or use of burden brings about unexpected change to electrical force though mechanical force contribution to generator stays steady. These framework unsettling influences cause oscillation in machine rotor edges furthermore,

bring about extreme force stream swings. These force swing causes undesirable hand-off activity which exacerbate the force framework aggravation & bringing about significant power outage to happen. [30]

VI. BLACKOUTREVIEW: LEARN FROM PAST [1]

Previously, when power contraption was exceptionally little, its administration shape changed into more noteworthy secure. Power businesses have been supplier orientated and driven totally with the guide of the Government. With the developing burden call for deregulation of vitality ventures were included as a final product strain on power device expanded. Further, linkup with neighboring nations & uncommon areas completed the system more grounded yet it builds the opportunity on unsettling influences. In past numerous blackout occasion had happen, investigation on previous outage must be talked about to inquire about the main reason of issues and components stressed in it. On ninth Nov. 1965 US first enormous power disappointment happen as a result of overwhelming stacking condition, the reinforcement security transfers stumbled transmission lines among upper east and southwest. Too there changed into not adequate turning hold put away at that point blackout started. As an answer extra extreme voltage transmission strains have been proposed and dispensed turning hold become situated into training. On twenty eighth Sept. 2003 large outage happened in the Italy. The electric dischare due to trees strikes the Italy Switzerland interconnection. Association transformed into now not re-snared by utilizing vehicle re-closer due to a major stage differentiation all through the line, as it become firmly stacked sooner than stumbling. Inside couple of moments power deficiency in Italy headed out to create absence of synchronism with the unwinding of Europe quality system. The interconnection among Italy to France & Italy to Austria stumbled on account of separation transfer. At long last the transmission passageway among Italy and Slovenia were given over-burden & tripped. Later than various minutes, the whole Italian machine distorted in light of the fact that the national blackout. On January 2015 psychological oppressors attacked on energy transference follows in Naseerabad, Baluchistan, which This assault disturbed the 220 kVA line from the Guddu power plant in Sindh to Sibi in Baluchistan. This caused a falling impact by stumbling the 500 kVA public transmission line & compelling various power plants to close down roughly 12 PM [31].

VII. LESSION FROM PREVIOUS OUTAGE [1]

Because of fell events, the electric separation among generator & loads are expanded with the guide of stumbling generally significant transmission follows. This causes variation in generator load points and makes deficient pairing among the producing systems in light of slack of synchronizing vitality. When the edge contrast between two regions is enormous then the line in the middle of two regions can be discouraged with low voltage. Line stumbling as a result of substantial burden and discouraged voltage is caused when all is said in done by the separation security transfer as shortcoming location in area 3. In this manner, in the vitality gadget activity, holding a level voltage profile is constantly supported to maintain the safety at a superior level [31].

The blackouts by and large came to pass for because of voltage break down rather than underneath frequency conditions. At the point when a line trips, the remainder of the lines must bring the power, appropriately devour extra reactive power and diminish the voltage at the heap place without influencing the frequency. Deficiency of reactive power causes more noteworthy voltage drop at anxious line stacking conditions. Subsequently the voltage end up being as a key strain marker of the vitality device instead of the frequency. Likewise the voltage drop at the heap place proposes that the structures will understanding the low frequency after it separates into islands [32].

VIII. EFFECT OF BLACKOUTS [1]

Energy fuels our lifestyles. It powers water filtration, scrap, meals, transportation & verbal exchange structures. Modern-day social existence is impossible to assume without it. Blackout consists of measurable financial losses & much less effortlessly quantified social prices. The energy deliver will become ever more precarious because of peak oil, political instability, infrastructural overlook, international warming & the shift to renewable electricity re-sources. The energy demand will become more potent due to population growth, rising stages of affluence & the purchaser „addictions‟ which accompany this. In investigating these blackouts numerous reasons have been pronounced, which include: technical malfunction, severe climate actions, political unkindness, misleading the enemy at some stage in struggle, interfere with by narco terrorists or political fighters, poor generation capability, economic issues, corruption, elevated air conditioning use, punishment for nonpayment of power payments & a shortage of re-sources to produce electric energy [33].

Contemporary societies have grow to be depending on air conditioners, computerized system, lighting, refrigerators & freezers which can be, in turn, reliant on an continuous electric supply. Such is our dependency that our consolation, protection, communication systems, delivery, fitness, food supply, agencies & social equity systems pressure whilst electric supply interrupted. Growing numbers of humans are living longer & playing growing residing requirements. This increases call for electrical appliances. Throughout the identical term demand for energy is anticipated to grow. This can require extra giga-watts to be generated. Nobody is aware of how this can be generated. Assured electric energy is also underneath danger due to resource constraint: fossil gas depletion and the temporary nature of renewable electricity resources. The peak oil & weather exchange also are inflicting a boom inside the demand for energy.As a result, blackouts turns into greater frequent. This manner that extreme questions will need to be requested at each the man or woman & collective stage concerning what is needed and what is needed, balancing what is good for people with what is right for others & ultimately what is right for the surroundings [34].

IX. HISTORICAL BLACKOUTS

The various blackouts occurred throughout the world is explained here. Based on these past experience we can plan & improve the present power stem network to avoid system losses. Majority of blackouts occurred in big power sector like blackouts occurred in North America Or Europe. The greek island of Kefallonia suffered through power network blackouts on 24th January, 2006 Tuesday. It happened due to icing on heavily loaded transmission line & towers collapsed[35]. Almost 15 cm in diameter, ice sleeve was coated on that surface of conductor which leads to electricity cut about 3000Mwh & lot of substations installed in the Kefallonia island [34]. Furthermore the space among the towers has been reframed to endure the environmental changes. The recent & new lines have been reformed & acquired into various anti-icing techniques.

The severe & cascading blackouts are happened on 13th August 2003, Wednesday, through the various nations like Michigan, Connecticut, Vermont, Ohio, Pennsylvania, New Jersey, Massachusetts, Canada, Newyork & Ontario[36]. Because of these blackouts, 61800 MW energy is wasted & 50 millions human being were affected for the period of 4 to 7 days till the system restored back to normal. The various reasons of blackouts has been found during investigation. The system like contingency evaluation of the Midwest ISO’s & state estimators not operated efficiently during line outage. Furthermore imbalncing of reactive power , growing load management & limits on generation were insufficient at Midwest ISO’s. The obstacles of branches of trees, so many short circuits occurs. Hence trimming of such branches near the high voltage transmission line conductors must be done regularly. Also the traditional networks must be replaced by smart grids technology after these incidents. Initially Supervisory control & data acquisition system (SCADA) were utilized

in the power system network, but the system has low response & communication was only through the telephone calls. Because of this, Smart grid technology introduced , which having advanced monitoring & communication system, pervasive controlling & digitization system. This technology gives adequate control & monitoring the whole system, the cyber security system leads to provocation to the system operating personnel.

In India back to back blackouts were happened on 30th July & 31st July, 2012. It was lasted for several hours, around 620 & 700 million people were suffered through the load shedding. The 400 KV line OG Gwalior to Bina double transmission line affected due to overloading & leads to cause first blackout. Furthermore the gap between supply & demand of electrical energy the system again collapsed on 31st July, 2012 Tuesday. The main reasons found for these blackouts are 1) Improper balancing 2) wrong forecasting of upcoming contingencies 3)Unavailability of controlling mechanism 4) slow response from electricity company for frequency & voltage control 5) wrong operations of distance relay due to congestions in transmission lines. From these reasons it is observed that Indian blackouts were occurred due to improper managements in line outage & peak load.

The serious contingency occurred in Vietnam on Wednesday 22nd May, 2013. In Vietnam a disturbance on 500KV transmission line is tripped & isolated the South grid from Central & North grid. It was happened while fully loaded truck with trees bumped on 500 KV line. This event fall extra tripping og generators & transmission lines leads to cause voltage collapsing in southern grid network of Vietnam. Due to this event, various protective devices for distance protection, for relay system, over excitation limiter, including over current & under frequency load shedding relay have been introduced [37].As per simulation result[24], over excitation limiter plays key role to keep away from blackouts in Vietnam. Voltage collapsing is prime reason of blackouts worldwide [38,39]. The losses in power network components like generators, lines, transformers, or others, different components of network could be overloaded which leads to bus voltages reduces. In these circumstances, distance relays of transmission lines can trip. Furthermore overloaded elements could be tripped which leads to overloading of other components of network. If enormous network components are tripped then lagging of reactive power become further serious & consequentially generator relay can be tripped, causing short fall of frequency issue. Normally system takes time in terms of minutes to collapse the voltage which provide sufficient time for network to reply to voltage changes in voltage dynamics.

On saturday1st November, 2014, Bangladesh faced blackout throughout a day. The various[37] reasons behind this blackout are observed as follows.

- Unexpected system outage in HVDC stations
- Improper response of spinning reserve
- Few generators in western zone of Bangladesh network were under maintenance.

In this situation, the frequency reduces to 48.9 hertz & anticipated load shedding was 69 MW but actually it was 25 MW only. This process was went on 5 stages & caused system blackouts. It is advised [40] to Bangladesh power network to keep censorious operation reserve to be more than nine seconds, upgrade the under frequency security scheme with the consideration of rate of variation of frequency & managing the grid islanding methods to set up the speedy reply to Bangladesh power network. The various power networks already initiated to introduce smart grids which contain supply demand support, two way communications/transmissions, computerized techniques, load balancing & load sustainability. But it also faces various security threats, for example, internet facility is effective verbal trade to record the important information but problematic due to hackers. On dated 23rd December, 2015, Ukraine went up through cyber attacking which leads to system blackouts & influenced around 225000 clients lasted few hours. The cyber assaulting is key cause of system blackout; the ambush commandeered the SCADA system. They inserted the bogus information in the

system which causes system breakdown. The attackers have all the information about power network parameters, SCADA system, and electrical components. The least difficult arrangement is to improve the protective devices to spare you blackouts, unsettling influence or fault from digital attack. According to [41][42]], they give right caution strategies to forestall cyber attacking in the smart grid system.

Another event happened in Pacific Southwest on 8th September, 2011 which cause the San Diago to lost energy almost for 12 hours; furthermore some part of Southern California, Arizona, Baja California & Mexico suffered power lost & affected 2.7 million clients. The line tripping was the main cause observed for that blackout throughout peak load. Basically the electrical transmission line system in the Southern California & Arizon was planned to sustain single line excursion of 500 KV line. The 500 KV line between Hassyamapa to North Aila also tripped due to connecting power from Arizona throughout Imperial Irrigation District (IID) to San Diago era due to overloading. This research [43] shows that the blackout in san Diago occurred due to inadequate load shedding. As per simulation [43] outcomes, the anticipated load shedding size must be higher than actual.

Potential development schemes to keep away from blackouts

A power network may be safeguarded by using various models & techniques to optimize the security. Many power networks have installed new techniques which includes designing of relay system, latest protective devices scheme, load shedding & grid coordination mechanism. Moreover renewable energy has been expanded considerably. The blackouts occurred due to static/dynamic stability loss, voltage instability in the transmission line system, improper load shedding & continuous line tripping. The potential improvement plans consisting of grid enforcement, reactive energy optimization, voltage management, planning of generator locations, increments in tie line, preplanning of load shedding strategies, adding advanced measuring & controlling equipments, auto operating & alert signaling during serious incidents. So the advanced power network must be capacity of self healing & protection against blackouts, auto closer of transmission network & component reintegration. The power network must be capable to quick restore automatically after blackout occurs. Also by using HVDC equipments, different sensors & controllers, the system can improves the stability & avoid system blackouts.

X. Conclusion

This paper explains about causes & solution of blackouts occurred in different nations like India, Bangladesh, North America, Vietnam, Ukraine & Greece. As per detailed study it concludes that, the causes of blackouts in various countries are different. But if we can predict the causes of cascade failure, then the chances of blackouts could come to be lower. It also explains the static/dynamic stability loss, voltage instability, improper load shedding & continuous line tripping leads to blackouts. Moreover this paper summarizes essential techniques to upgrade the power structure balance & stop the power structure blackouts.

The present power circumstance in India is a huge tussle that wants to be mind fully taken care of. The call for is on a much better perspective compared to the flexibly, consequently the Indian business what's more, its general society are encountering successive power deficiencies. Blackouts are commonly a consequence of arrangement of occasion in inclination to one single. Be that as it may, it transforms into amazingly crucial to find that one single occurrence that started the process. Previous history of essential and pleasantly articulated blackouts inside the worldwide is talked about and assessment is finished with the goal that we can gain from previous records. As day by methods for day quality call for increments, so to satisfy the quality interest accentuate ought to be given on sustainable power resources like power from squander, power from tsunami and so on.

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