Analysis on impact of ‘switching off light’ event on Indian grid frequency

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Abstract. Electricity places a vital role in the development of economy of a country. Electrical power grids are the most complex of all human engineered systems. This paper presents the progress made in the energy grid and outlines the power scenario in India. It reports the impact created by the event “Switching off lights” on grid frequency. Role of POSOCO in the management of the event has been vividly described. The paper provides us the most important input for prioritizing measures or steps to be taken to cope up with the situation and possible action plan have been summarized.

1. Introduction

Of all the inventions made by human, electrical power grids are said to be most complex engineering systems. Electricity generation is one among the eight core industries of India. According to a report from international energy agency, India stands in third position globally as the largest producer of electricity and it also holds the third place as largest consumer of electricity. National Electricity grid of India has an installed capacity of 370.106 GW as of March 2020. Other highlight is that India has moved from power deficit to power surplus.

Prime minister asks the people of India to light the candle to drive out the darkness created by Corona virus and to switch-off the lights for nine minutes. The paper describes the impact created by the event “Switching off light” over the grid frequency. Section I deals with the introduction. Section II describes the evolution of Indian grid. Section III describes the “light off” event. Section IV portrays the results and waveforms obtained during the event. Section V highlights the lessons learnt from the event and conclusion is brought out in section VII.
2. Indian Grid

In the country of India, electricity production began in the year 1897. It initiated with setting a hydroelectric power plant near Darjeling. Later in the year 1899, Calcutta Electric Supply Corporation built a thermal power station. Initially during these years, the power sector growth is very slow. Till the end of the year 1920, the total installed capacity is about 130 MW. Though they saw a slow growth at the initial stage, they got a real boost during the period from 1920 to 1940 because of increase in industrialisation. [1],[2]

Ganga – Canal grid in UP is said to be India’s first grid connected system. It consists of 59 transformer substation and it was developed in the year 1930. In the year 1937, Mettur Thermal Power Plant and Pykara Power Plant were interconnected and Papanasam hydroelectric station was also attached to this system in the year 1945[3]. The importance of interconnection of grid power systems was realized well just after the independence. The interconnection of systems came into existence but the important feature, i.e., exchange of power, of any interconnected system is missing [4].

In 1960’s, to enhance the progress of power sector, it is planned to have regional grids. In 1981, Indian government had a policy decision of developing national grids, which leads a way to the development of integrated operations of transmission systems that includes central and regional one [5].

The objectives of national grid are to ensure reliable operation, transfer of power from a surplus area to deficit area and so on. Indian grid is divided into five regional grids: 1) Northern 2) Eastern 3) Western 4) North- Eastern and 5) Southern [5]. This motto “One Nation - One Grid - One Frequency” has been achieved on December 2013 when southern grid is connected to central grid. Grid control is performed at different levels of hierarchy known as

- National Load Despatch Center (NLDC)
- Regional Load Despatch Center (RLDC)
- State Load Despatch Center (SLDC) and
- Area Load Despatch Center (ALDC) [6]

Power grid is functioning in a way that it make possible the transfer of power from one area where there is deficit to another area where power demand is more.

![India Map showing Indian National grids](image-url)
Total installed capacity as on March 2020 is shown in the table 1 and table 2.

**Table 1. Installed Capacity of India (Sector Wise)**

| Sector          | MW   | % of Total |
|-----------------|------|------------|
| Central Sector  | 93,477 | 25.2%      |
| State Sector    | 103,322 | 27.9%      |
| Private Sector  | 173,308 | 46.8%      |
| **Total**       | 3,70,106 |            |

Source: Central Electricity Authority (CEA)

**Table 2. Installed Capacity of India (Fuel Wise)**

| Fuel                  | MW    | % of Total |
|-----------------------|-------|------------|
| Total Thermal         | 2,30,600 | 62.8%      |
| Coal                  | 1,98,525 | 54.2%      |
| Lignite               | 6,610  | 1.7%       |
| Gas                   | 24,937 | 6.9%       |
| Diesel                | 510    | 0.1%       |
| Hydro (Renewable)     | 45,699 | 12.4%      |
| Nuclear               | 6,780  | 1.9%       |
| RES* (MNRE)           | 87,028 | 23.5%      |
| **Total**             | 370,106 |            |

Source : Central Electricity Authority (CEA)

3. **Switch Off Light Event - Case Study**

Switching off light event is elucidated in different stages. It starts from the call by PM, then the fear spread among the public, the plan by the POSOCO and also the execution by them and the lessons learnt from the event.

3.1. *The Call*

In order to dispel the darkness created by the corona virus, Prime Minister of India urges the people of India to light a candle and to switch off lights for about 9 minutes by 9.00 pm on April 5th 2020.

Figure 2. The Call for the event Source: The Economic Times (April 4th 2020)

3.2. *The Fear*
The ideas floating on the social media is that they have to switch off all the household equipments and gadgets for safety. By considering the messages, the Ministry of Power issues a notice which clarify the necessity of switching off lights only and to keep the other home appliances in ON condition.

3.3. The plan

The National power grid observes this event as a unique event. It anticipates a 12.9 GW dip in demand considering only the lights to be turned off. POSOCO had a meeting with officials of all the State Load despatch centre. Persons from major hydro power plants also participated in the meeting. POSOCO issued an advisory note. On April 4th night mock exercise of hydro-ramping was made. The same is repeated on April 5th morning.

3.4. The Execution

The actions taken are as shown in the table III. The hydro generation was ramped accordingly, so that it meets the decrease or increase in demand. Some other advance actions such as switching off a transmission line were taken to keep the voltage within limit. Frequency will be brought to 49.9 Hz at 20:30 Hrs and 50.15 Hz at 21:09 Hrs. The event was managed in a marvellous way and there were no unpleasant happenings and also the power systems are well maintained within tolerable limits. POSOCO thanks all the stakeholders for their cooperation to make the event successful.

| S.No | Time            | Actions taken                                |
|------|-----------------|----------------------------------------------|
| 1    | 20:45 Hrs       | Hydro generation is maximised                |
| 2    | 20:45 Hrs to 21:10 Hrs | Generation reduction of 17543 MW (to match the demand reduction) |
| 3    | 20:45 Hrs to 21:10 Hrs | Thermal, Gas and Wind generation reduced     |
| 4    | 21:10 Hrs to 21:27 Hrs | Hydro generation was ramped up (to match the increase in demand) |

4. Results and Discussions

4.1. Change in frequency and Voltage:

The Power Quality analyser instrument [Fluke Model 1748] is used for recording the voltage and other related electrical parameters at LT side. The change in frequency during the event is noted. Variation of the voltage during the event is recorded and corresponding waveforms are shown below.
Inferences from the waveforms are as follows. There is a large dip in frequency during the event i.e., between 20:50 Hrs to 21:15 Hrs.

4.2. Variation of frequency

![Variation of Frequency](Image)

Figure 4. Frequency Waveform
4.3. Variation of voltage

Figure 5. Voltage Waveform

4.4. Overview of frequency and voltage

Figure 6. Overview of frequency and Voltage
4.5. Variation of frequency and voltage

Figure 7. Voltage and frequency Waveform

5. Lessons Learnt
The lessons learnt from the light off event are as follows.

- The power grid has flexibility which is proven by the event on April 5th 2020.
- The flexion is well executed by the dedicated utility personnel.
- The POSOCO plans to drop the grid frequency before the starting the event has worked well.
- In real situations, flexion cannot be done manual and therefore the automation is necessary and AI becomes essential.
- This study is relevant to higher penetration of renewable energy into grid.

6. Conclusions
Utilization of renewable energy is highly increasing and higher renewable energy penetration into the grid is seen and need to focus this area for research. The world economic forum’s framework on “future of electricity” recommends these terms: electrification, decentralization and digitization for the transformation of future electricity. Progress towards Smart Grid is essential and Smart engineers have to play their role to reap the full benefits of smart grid and also to make the Indian power sector more prosperous.

Acknowledgment
Author wishes to acknowledge, Sachin Shelar. Assistant Professor, Department of Electrical Engineering, AISSMS Institute of Information Technology, Pinnac Sumanshree, Karvenagar, Pune for providing recordings and data for this paper. Authors wishes to acknowledge the POSOCO for their preliminary report on the event. This paper is dedicated to all smart Engineers of the future.
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