Managing Power flow and support provided by SVCS/STATCOMS in maintaining Grid Stability: A Case Study & Learnings there off

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Abstract: Call requested by Prime Minister of India to switch of domestic lights from 9pm to 9.09 pm on 05/04/2020.The call was an expression of Solidarity, Integrity cum Discipline towards Nation to fight against the COVID-19 epidemic. The time chosen was so crucial when each household, public places power requirement is almost at full. It was a heroic task and a challenge for electric power grid operators to maintain grid stability during the period i.e such a small spell of time. Failing which if collapsed would be difficult to restore and normalize. It was a great challenge for the National power load control center to maintain stability and continuity with quality of power electricity parameters like V, F. In this paper, efforts had been made to understand how Indian power could remain stable during the period without fear and behavior of regional load patterns during the period.

1. Introduction

There has been a smooth growth of IPS (Indian Power Sector) since independence. However, demand also went on increasing w.r.t to increase in population and industrial growth by way of infrastructure development and economic growth. At the time of Independence,the total generation of the country was to the tune of 1200 MW and it can be seen growing to date as per exhibit shown in figure1

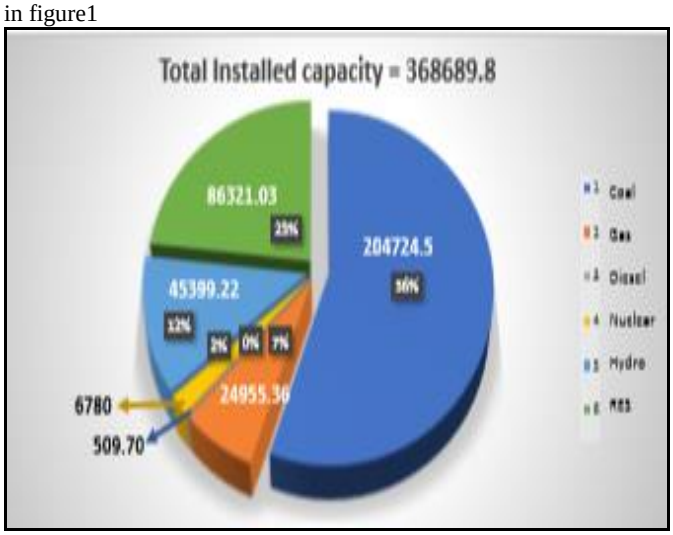

Fig.1: – Installed capacity based on source

With the development of infrastructure and economic developments, there has been a substantial increase in domestic load demand in the country. Further as of now, 100% of villages have been electrified and the government of India is committed to providing 24x7 electricity supply andinternet/communication services which ensures a reliable power supply through data sharing throughout India. Regarding this government has fabricated a slogan as Power For All. Figure 2 shown's the growth of per capita consumption in the country since 2006.

Looking into the total demand versus supply ratio, we find that on account of domestic requirement it falls around 27 % of total demand which includes industrial, commercial, traction and agriculture.Further on dividing the ratio of domestic load into lighting and other lighting gadgets. We can assume 80% of total demand as the time chosen was 9pm, a peak time for domestic users. That is lighting load would be around 21% of the total generation.

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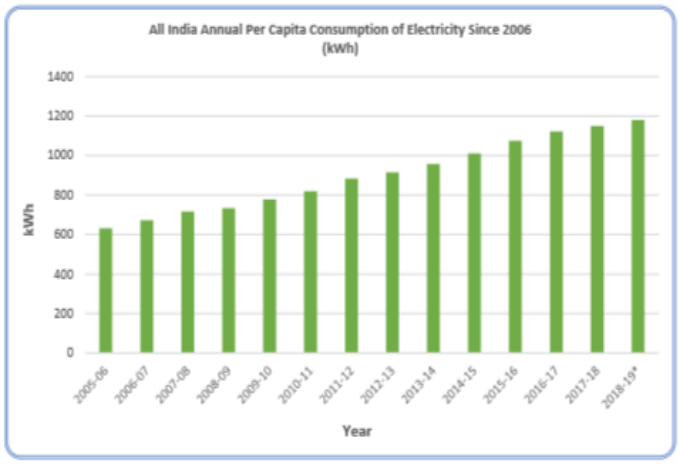

Fig.2: Per capita consumption in the country

2. Effect Of Covid-19 On Power Demand

As per POSOCO, due to COVID-19, power demand in the country has gone down. Demand forecasted on 05/04/2020 was as under(Exhibit). Based on previous data, POSOCO has envisaged drop in demand from 12 to 13GW at all India level. Precautionary guidelines were issued by various organizations like NRLDC, ERLDC, POSOCO.

Table 1: Consumption of Electricity produced, T & D Losses-21%

Per Capita Consumption (kwh)	**1181 (%)**	**Population/ produced (2018-2019)**
Industrial	43	Close and covered T & D losses
Residential	27	
Agricultral	19	
Commercial	9	
Traction	2	

Upptranco,Powergrid, Indigrid etc. Mainly covering to do the following actions at around 20.00 hrs on the day.

- Switching off capacitor banks
- Switching off few 400 & 765kv lines
- All reactors to be taken in service
- STATCOMs/SVCs to be on voltage control mode ref. level 400kv.

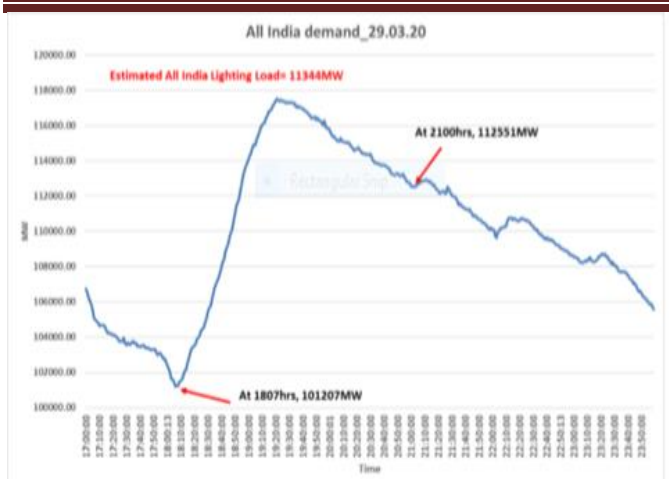

Fig. 3: Electricity demand

Figure 4, representing the total load reduction during the 9 min span on 5th April 2020.

Region Wise Details of load reduction during light switch off event on 05th April 2020

S.No.	Region	No of Rural household consumers (a)	No of urban household consumers (b)	Load of Rural household consumers (MW) (c = 50*a)	Load of urban household consumers (MW) (d = 100*b)	Reduced Load of Rural household Consumers (MW) (e = c*.80)	Reduced Load of urban household Consumers (MW) (f = d*.80)	Total Reduced Demand as reflected at consumer level (MW) (g = e+f)	Total Reduced Demand as reflected at Grid level (MW) (g / 0.8)
1	Northern Region	42293470	13214064	2115	1321	1692	1057	2749	3436
2	Western Region	35669904	19020928	1783	1902	1427	1522	2948	3686
3	Southern Region	43854642	4668665	2193	467	1754	373	2128	2660
4	Eastern Region	41183918	4515705	2059	452	1647	361	2009	2511
5	North Eastern Region	8362568	1689177	418	169	335	135	470	587
	Total	171364502	43108539	8568	4311	6855	3449	10303	12879

Fig.4: Region wise load reduction

3. Covid/Event Data

As per guidelines, all agencies involved followed instructions as a result electric load reduced drastically, voltage started rising, and vice versa. In a similar way frequency also remained between 50.26 to 49.79 C/S. The total reduction in all India demand recorded during the event was 31089 MW. All India demand started reducing from 20:45 hrs and the minimum demand of 85,799 MW was recorded at 21:10 Hrs. Subsequently, from 21:10 hrs, the demand started picking up and settled around 114400 MW at 22:10 Hrs. This rally is shown in figure 5.

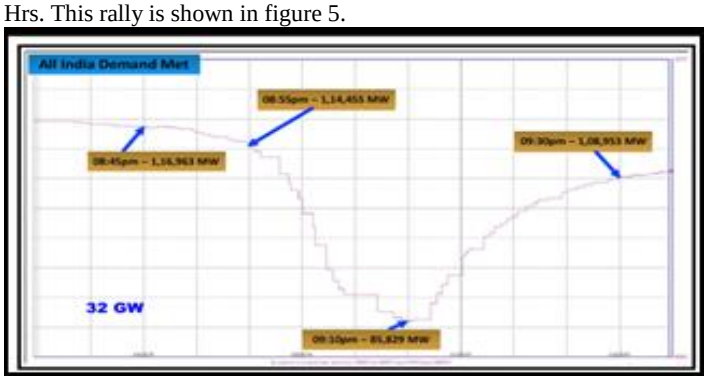

Fig.5: Electricity demand

It is seen from the graph there was a drop of 32.00 GW in 15 minutes i.e 2% per minute. Unique pneumonia happened. However, in the load demand forecasted by posoco, it had not assessed a drop of load for elements like ACs, Fans, Desert Coolers, Induction elements,etc. during the period. When one comes out from home to gallery then definitely such additional equipment will also be turned off in addition to lights.

3.1 Differential Ambient Temperature

The day PM has declared call and the day it happened had a difference of about 4 degrees i.e. AC's has been in service in domestic use as per exhibit.

CITY	Temp. (Maxm) 29/03/20	Temp. (Maxm) 05/04/20	Difference (+)	Rmks
Delhi	30	33	3	Lights & Fans ACs & Induction Heaters
Lucknow	34	38	4	Pakistan 1st Oct 19 – Night ODI Sri Lanks – Pakistan USA = 1985
Gwalior	32	36	4	

Fig.6: Temperature variation

A similar situation has already happened in Pakistan during ODI with Sri Lanka on 30/09/19. Due to fewer visitors in the stadium television load in homes increased multifold times. Due to overloading on feeder supply went two times causing an interruption of around 26 minutes in two interruptions.

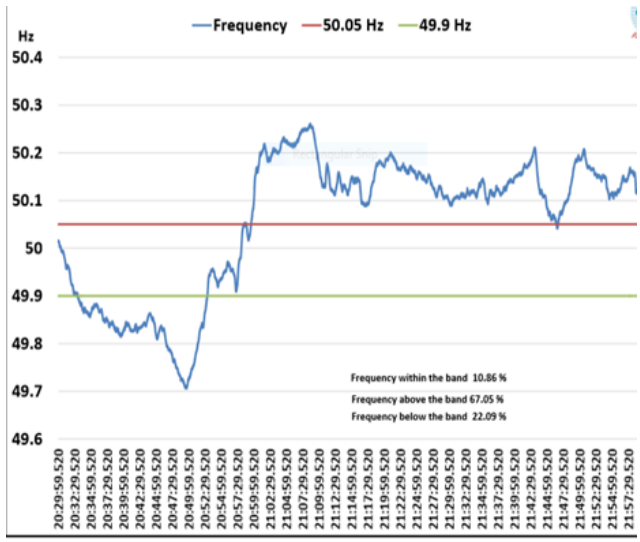

Fig.7: Frequency variation

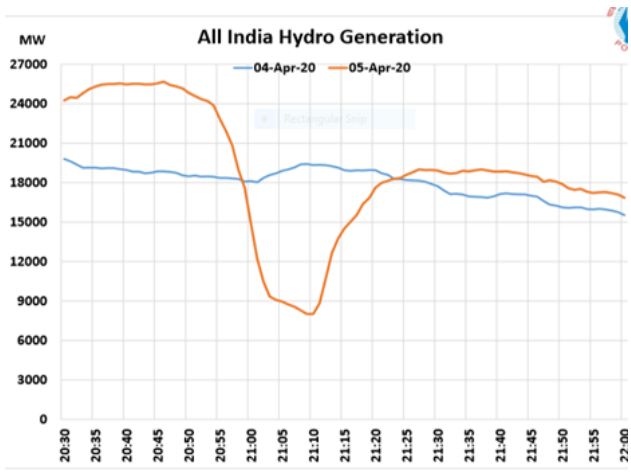

Fig.8: Hydro power generation

The voltage on the 400kv line varied between delta 4.13 to 8.91 and 765kv line from delta 3.2 to 5.4 all India level. Whereas frequency varied from 49.7 c/s to 50.26 c/s for around 85 minutes.

Hydro generation was reduced by around 19000 MW, thermal, and others by around 10500 MW and taken back

gradually as load started picking up. All the above-stated data has been shown in the graphs.

4. Support of Statcoms/SVCS

As on date around 25 SVCs/STATCOMs are in service at various stations across the country. Ist SVC was installed at Kanpur Powergrid on 400kv having ratings of +/- 240 MVAR in 1992. Subsequently, lot more added in the name of STATCOM, a modified version. SVCs provide support to system in both ways i.e. absorbs or generates reactive power to support the system as required.It operates In 2 modes dynamic mode and voltage control. Under dynamic instability responses fast and acts as required up or down. In voltage control mode it senses the voltage and operates in a predefined voltage band.Taking examples of Statcoms installed in extreme northern beltslike Ludhiana,Wanpoh(Srinagar), Nalagarh (Himachal Pradesh).

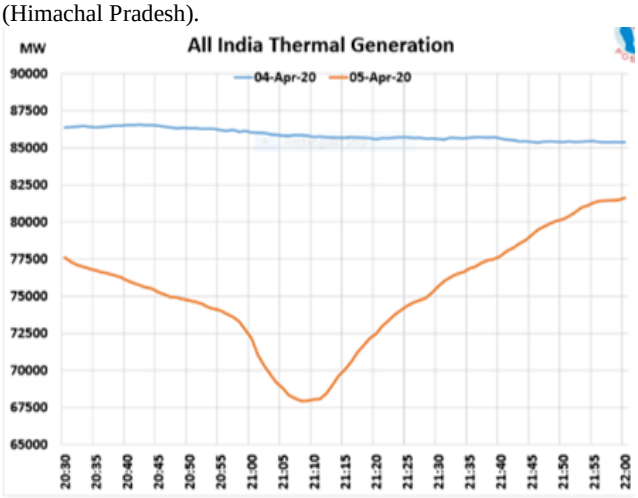

Fig.9: Thermal Power generation

Ludhiana (-400/+600) is in figure 10. It operated fully to its capacity during the period as per the exhibit below.It touched 425 MVAR ie full to itscapacity.

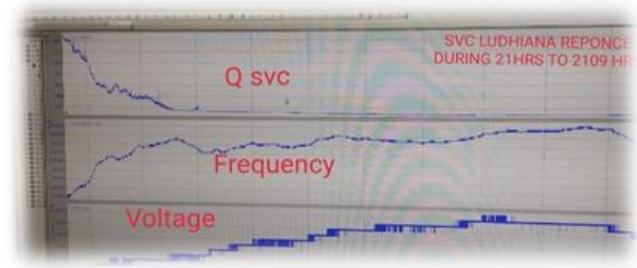

Fig.10: Ludhiana Satcom

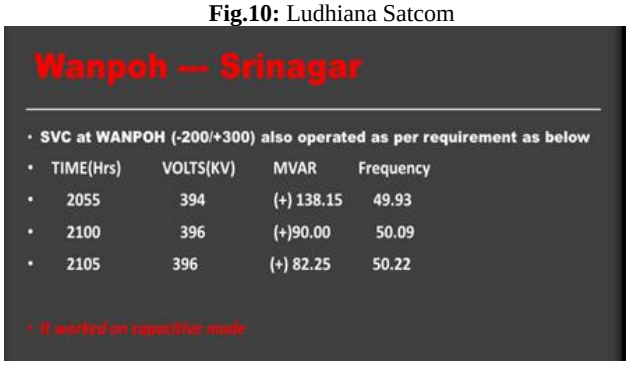

Fig.11: Wanpoh SVC

4.1 Nalagarh (-/+ 2 x 125MVAR) SVC also went to full to its capacity for 9 minutes

At Wanpoh capacitive Compensation was required to provide support to boost voltage. Due to reason URI (1 & 2) and Kishen Ganga generation were brought to almost zero. Two circuits of Kisenpur – Wanpoh were kept off due to a reduction in generation and low load available at Srinagar belt. At that instant power, flow started from Samba to Amargarh to meet the demand of Srinagar belt/province. Due to the long length of lines voltage boost was required by the system. It may be seen from the exhibit.

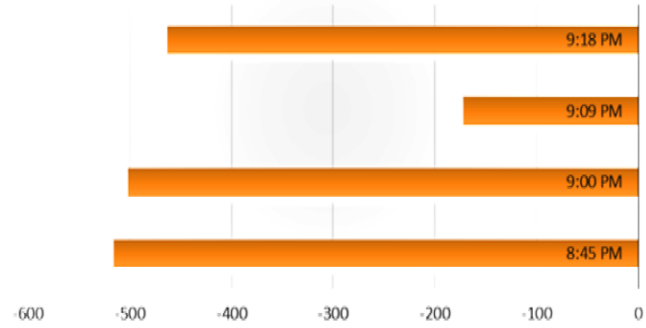

Fig.12: Power generation at URI w.r.t. time (variation in an electric grid on 5th April 2020)

Line Name : NRSS-XXIX 400 KV Samba-Amargarh TL--- One Ckt

Time	Voltage (KV)	Frequency	Power Flow (MW)	MVAR
8:45 PM	389	49.79	-64	-84
9:00 PM	391	50.16	-77	-101
9:06 PM	391	50.2	-155	-97.69
9:09 PM	391	50.24	-176	-87.83
9:12 PM	391	50.12	-118.79	-95.04
9:30 PM	391	50.12	-77	-95.00

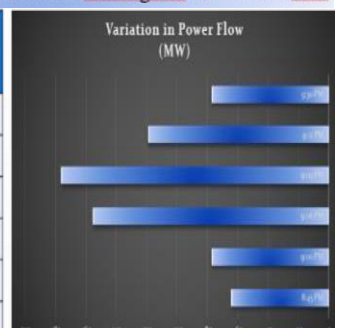

Fig.13: Power flow in Samba –Amargarh line

Line Name : 400 KV Uri Amargarh TL – One Ckt

Time	Voltage (KV)	Frequency	Power Flow (MW)	MVAR
8:45 PM	389	49.77	-258	-38.91
9:00 PM	391	50.17	-251	-28
9:09 PM	391	50.22	-86	-45
9:18 PM	391	50.13	-231.64	-32.04

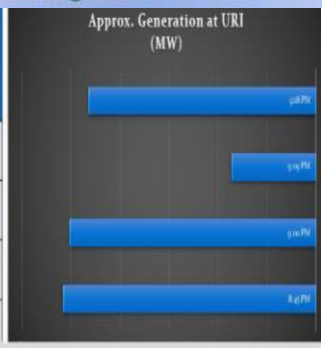

Fig.14: URI Amargarh Line

Power flow on 765KV Dhule – Aurangabad line dropped from 140mw to Zero in eight minutes and power flow reversed direction to tune of 40mw in another 8 minutes and started picking up as load started growing up towards normalcy.

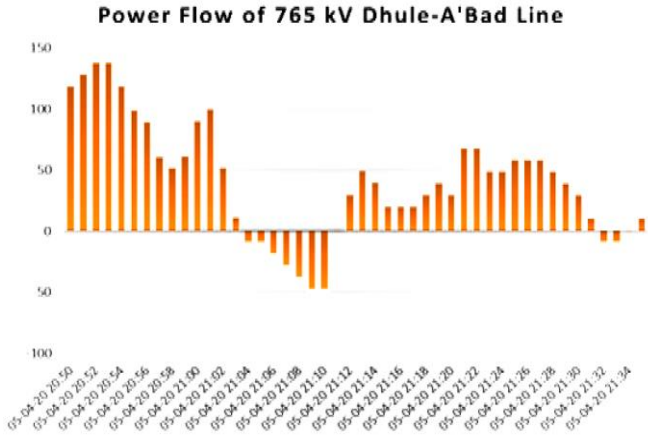

Fig.15: Power flow at Bhule-A-Bad

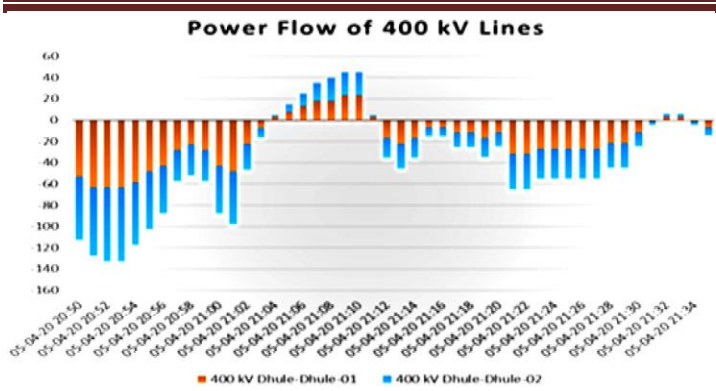

Fig.16: Power flow line in Bhopal

WRLDC also facesa similar type of situation barring a big deviation in demand as forecasted. Means there was a drop of 64% extra load drop than estimated.

Table 2: Estimate demand forecast by WRLDC

Region/ State	Estimated Demand Drop (MW) (A)	Observed Demand Drop (MW) (B)	Difference (MW) (B-A)	% Forecast Error (B-A)/A
WR	3286	9065	5579	64%
Maharashtra	1550	3683	2133	58%
Gujrat	723	1946	1223	63%
Madhya Pradesh	689	2386	1576	70%
Chhattisgarh	308	1028	720	70%
Goa	16	113	97	86%
DNH	5	23	18	78%
DD	5	13	8	62%

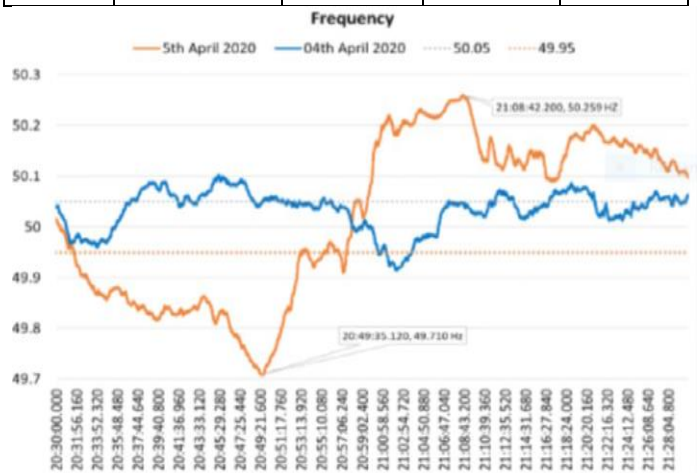

Fig.17: Frequency change for 4th and 5thApril

4.2 Role Played By Top Administration

To monitor such a historical cum technical event to happen in history. Minister of power and his staff monitored the event from NLDC in self as well as National Event. Some of the factors that helped in controlling the grid stability. Factors played the role as-

- Grid Discipline
- Effect on demand during these/the days of COVID 19
- Demand forecasted on 05/04/2020
- Generation forecasted
- Planning or scheduling
- Actual load profile
- The role played by Top hierarchy to maintain grid discipline.

4.3 Learnings

With all the above-stated facts and figures we have few learnings which are discussed below.

If Actual load touched 32GW against forecasted 12GW. This has resulted in the following consequences:

- Frequency deviated for around 85 minutes.
- Frequency shoot above the band for 67.05 % of 9 minutes
- Frequency remained below band for 22.09 % of 9 minutes
- Frequency remained in the band for 10.86 % of 9 minutes
- The actual load drop touched 2.5 times more than forecast.
- Voltage varied and remained in limits at 400 & 765 kV levels.

4.4 If load would have touched only 12 GW

- Would have caused higher frequency remained deviated for 85 minutes and that for a longer period on the higher side than on the lower side. Which is not a healthy sign for generators and as transformers.
- Voltages would have shot up on the higher side.
- Combination of both above causes higher flux on transformers. Resulting in more noise, losses, etc.
- Even generators/turbines may be affected due to over/under speed for around 85 minutes.

4.5 Actions required/recommended suggested

- There is a need to review the forecasting way of load management or it may require updating of data for future requirements/analysis.
- Need to install more SVCs/STATCOMs for MVAR & Voltage control
- Need to install mini SVCs at Transmission levels
- Need to review governor operation/response.
- Need to review the impact of over speed.

5. Conclusions

Indian power sector has once again proved to be one of the most efficient, reliable operating systems with quality standards in the world. This type of call has never been demanded by any leader or society or democracy in the world on such a wide spread scale.

Nomenclature

V – Voltage
F- Frequency
NLDC – National load despatch center.
WRLDC – Western Reginal Load Despatch Centre,
POSOCO – Power Systems Operation and Control Organisation
SVC – Static VAR compensator
CERC – Central Electricity Regulatory Commission

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