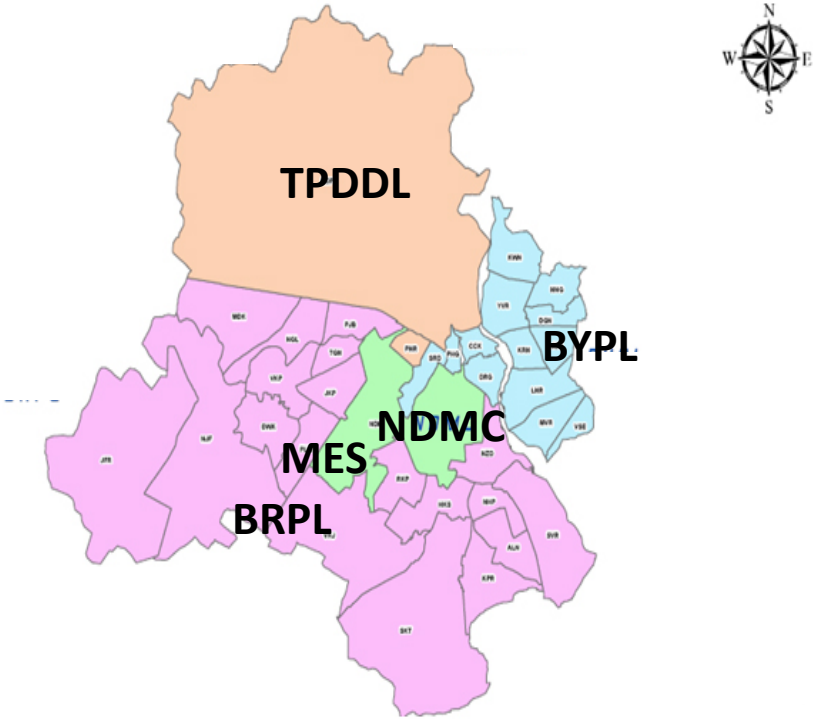
Impact of Large penetration of DERs on conventional Distribution Network

BSES Rajdhani Power Ltd.

BSES is a JV of Reliance Infrastructure (51%) and Govt. of Delhi (49%)

BRPL Profile

- BRPL is the largest Discom in Delhi, covering 750 sq. km of area (West and South) with a population density of ~3000 per sq km.
- More than 2.4 Million customers
- JV between Govt. of Delhi (49%) and Reliance Infrastructure Ltd (51%).
- Met peak demand of over 3200 MW in summer 2019



- **BSES caters to 2/3rd of Delhi**
- **South & West Delhi by BRPL**

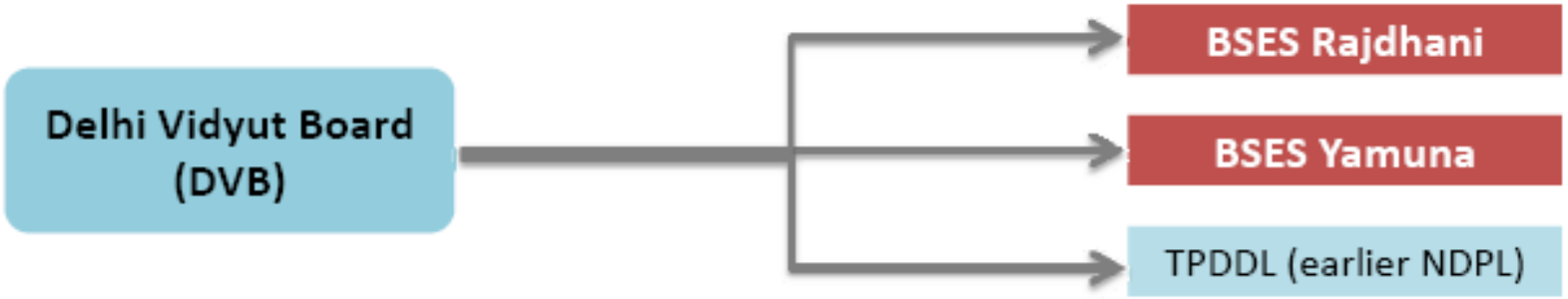
Pre-privatization: Delhi Power Situation

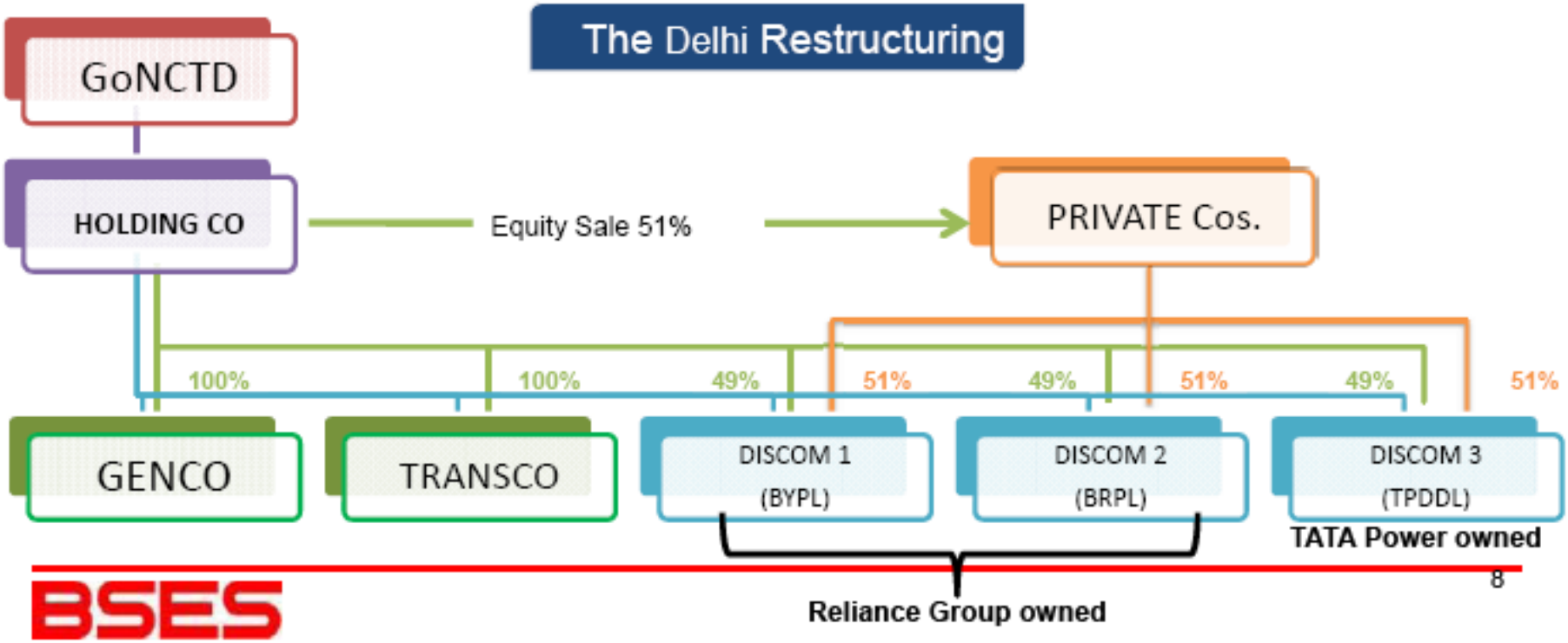
- Age Old Network
- Unprofessional Culture
- Outdated Technology
- Poor Consumer Service
- Equipment Burn outs
- High Corruption
- Inadequate Investment
- High Theft

Business inheritance marred by multiple maladies

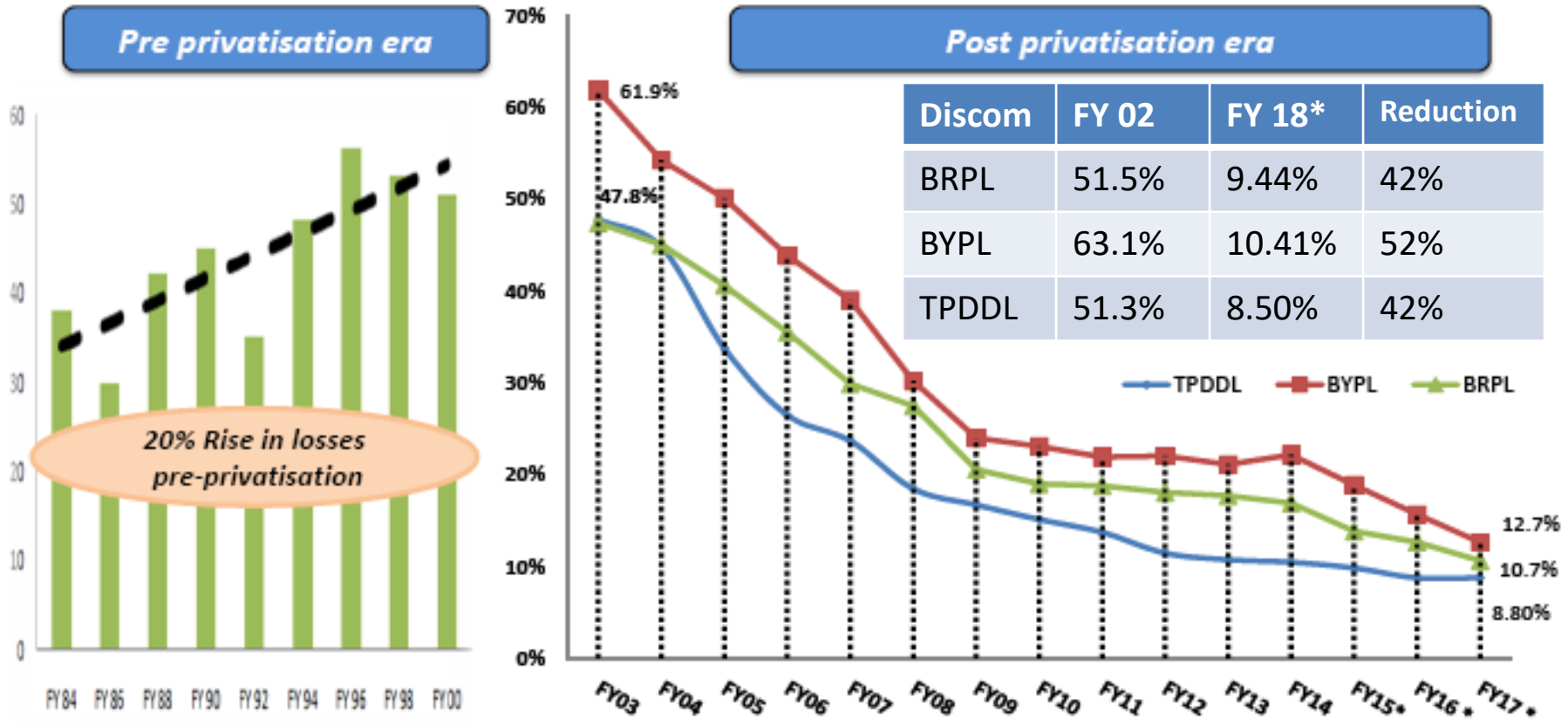
BSES

Delhi Distribution Model





Steep Loss reduction post - privatization



Discom	FY 02	FY 18*	Reduction
BRPL	51.5%	9.44%	42%
BYPL	63.1%	10.41%	52%
TPDDL	51.3%	8.50%	42%

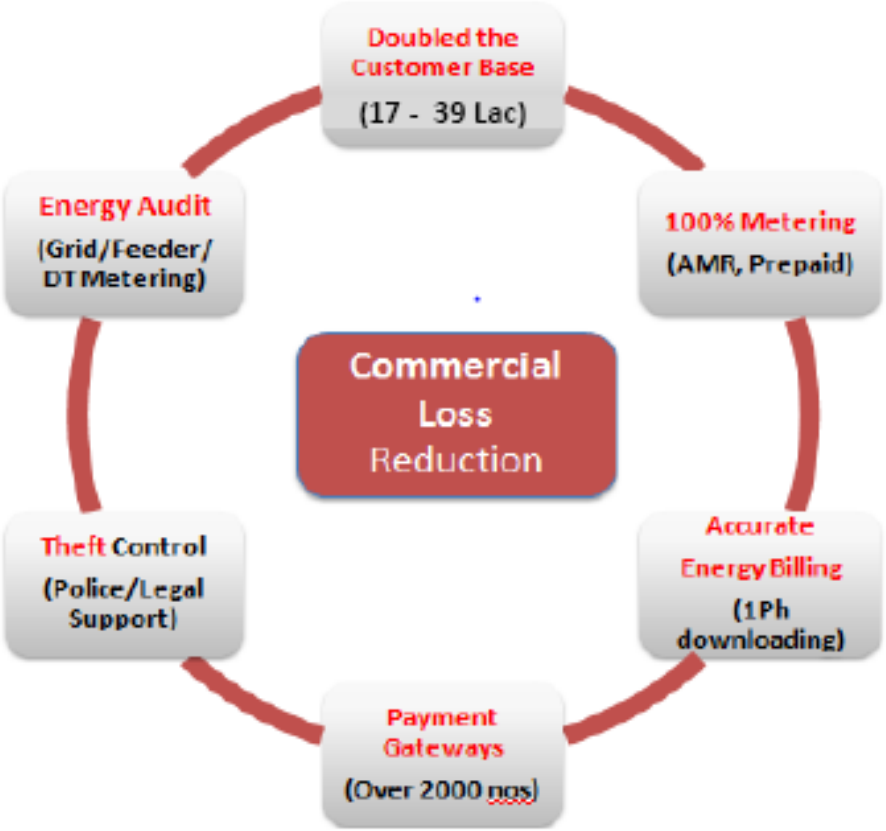
~42% reduction in losses post takeover as against 20% rise in a decade up-to privatization

BSES

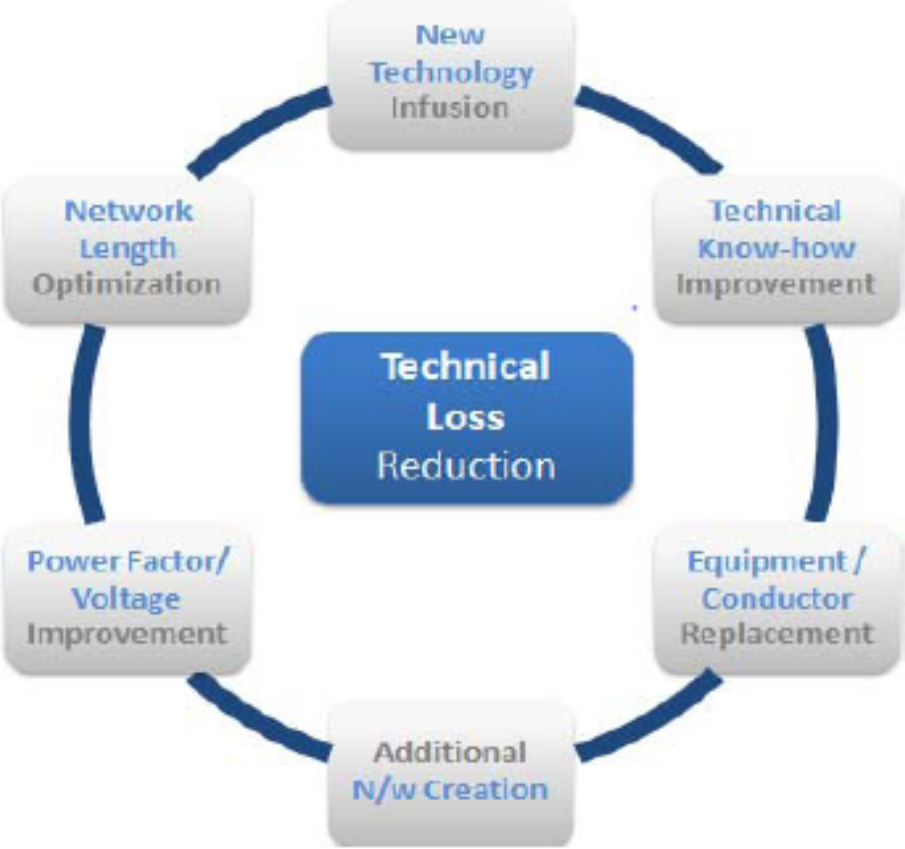
** Provisional: Subject to DERC approval*

Multi-Pronged approach taken for Loss Reduction

BSES	FY 03	FY 17*
Commercial Loss	35%	3%



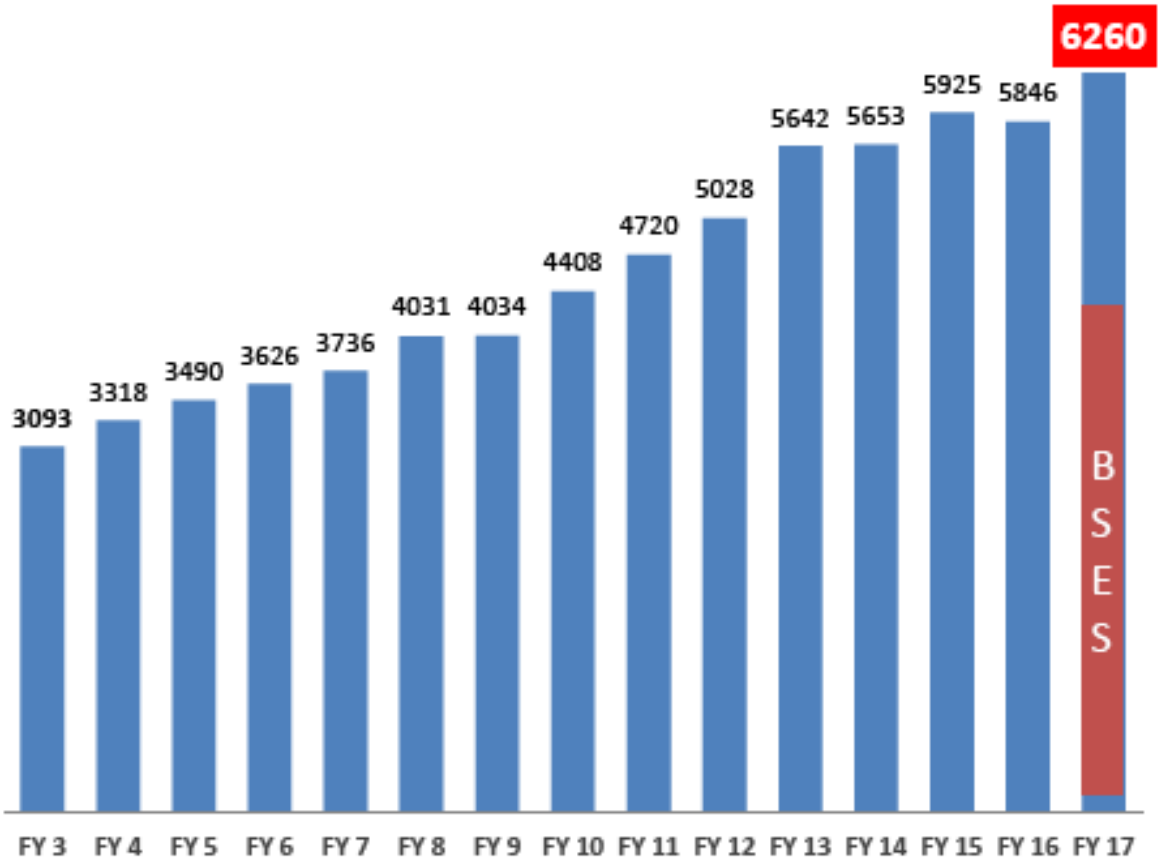
BSES	FY 03	FY 17*
Technical Loss	22%	9%



BSES

** Provisional ; Subject to DERC approval*

BSES successfully serves 67% of Delhi's Power Demand



Delhi met 7016 MW on 10th July 2018

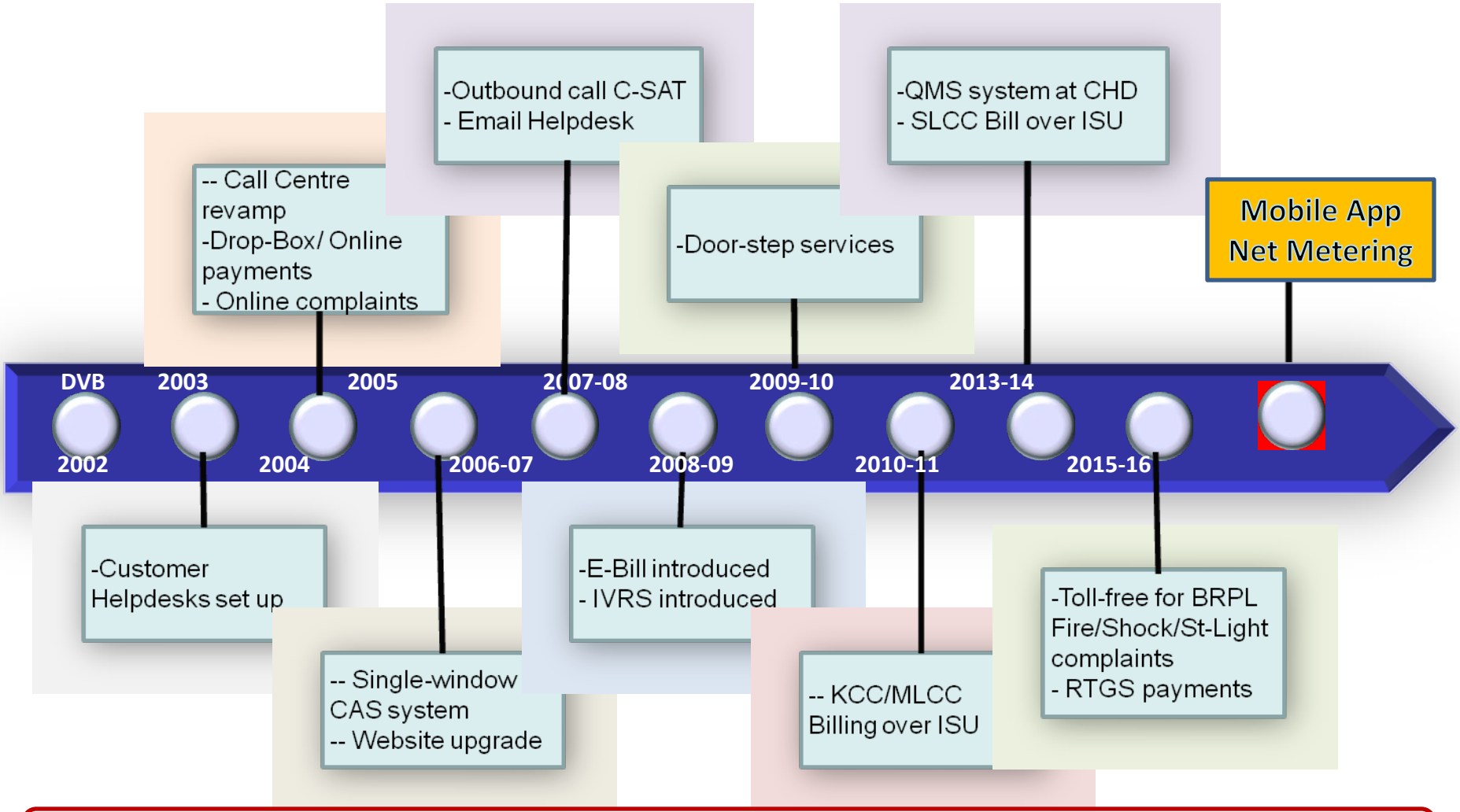
Delhi Power Demand is:

- *~70% more than Mumbai*
- *~3 times of Kolkata*
- *~4 Times of Chennai*

> 103% growth in Peak Load served since privatization

BSES

Ever Improving Customer Services Journey…



A Progressive and Sustainable Journey towards Improving Customer Service

BSES

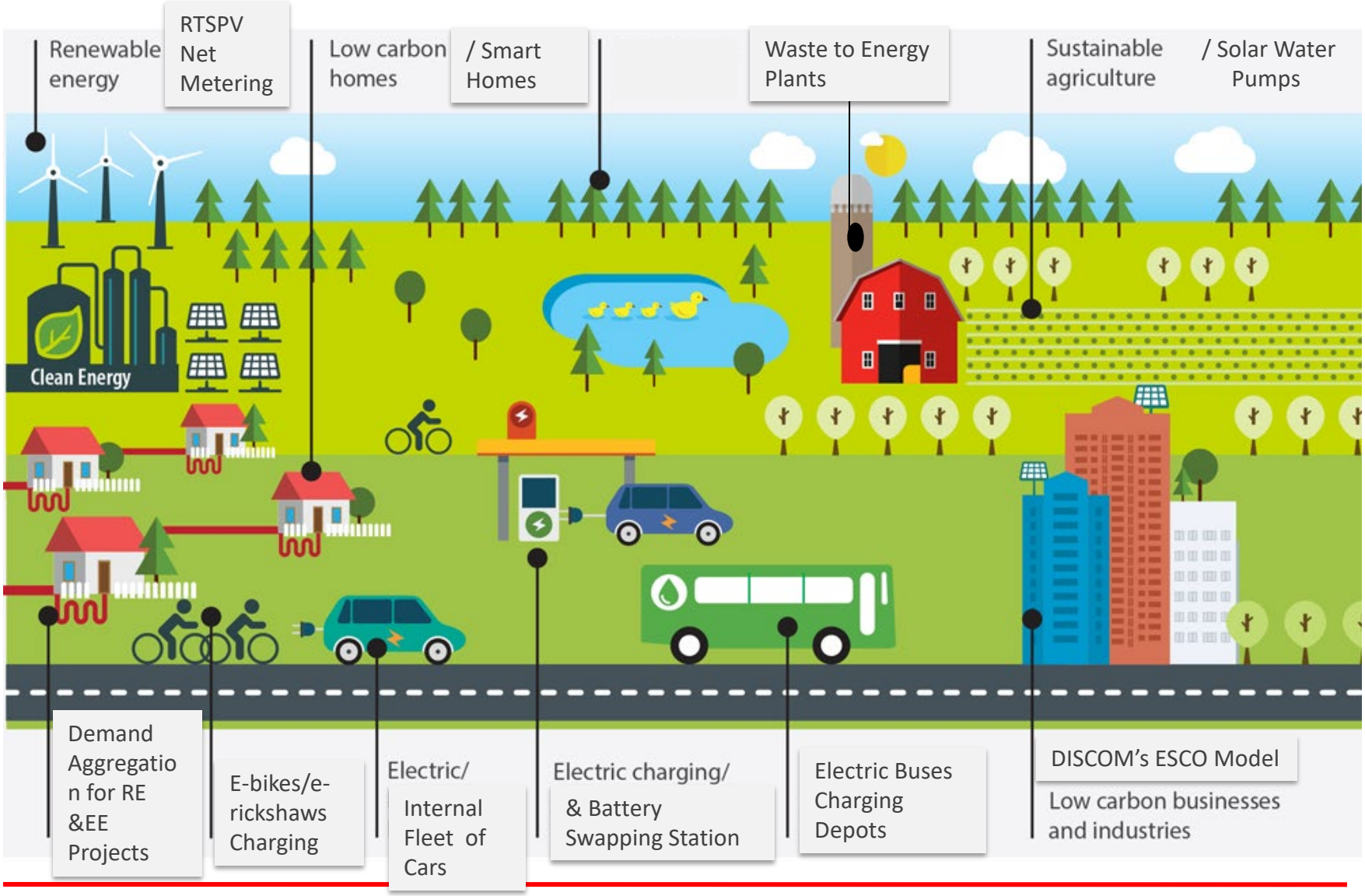
C-SAT : Customer Satisfaction
QMS : Queue Management System
CHD : Customer Helpdesk

SLCC : Small Load Consumer Category
MLCC : Medium Load Consumer Category
KCC : Key Consumer Category

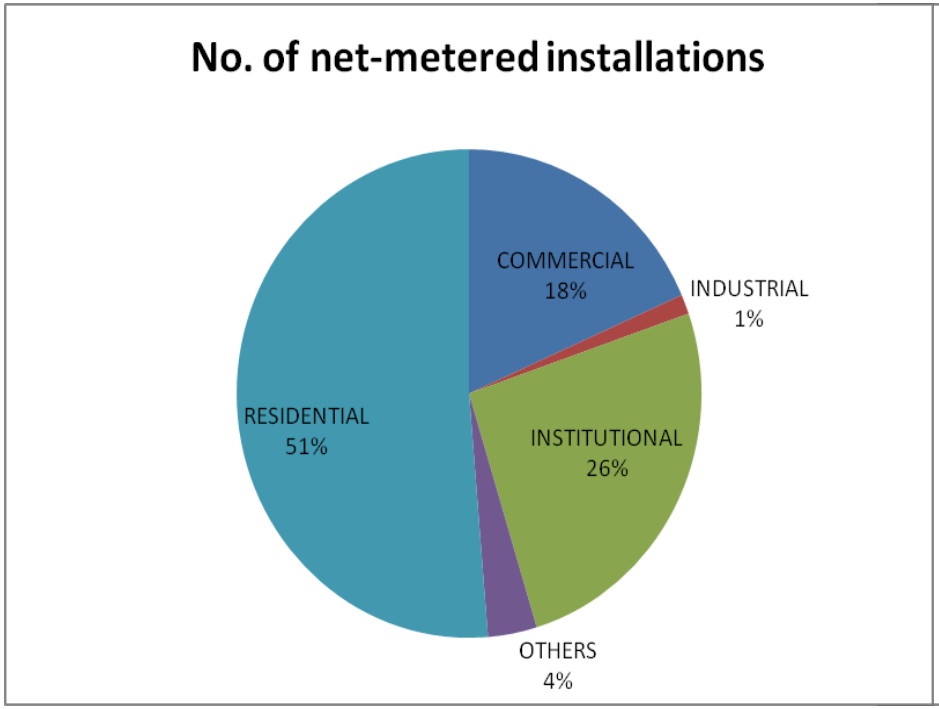
RTGS : Real Time Gross Settlement
CAS : Consumer Application System
IVRS : Interactive Voice Response System

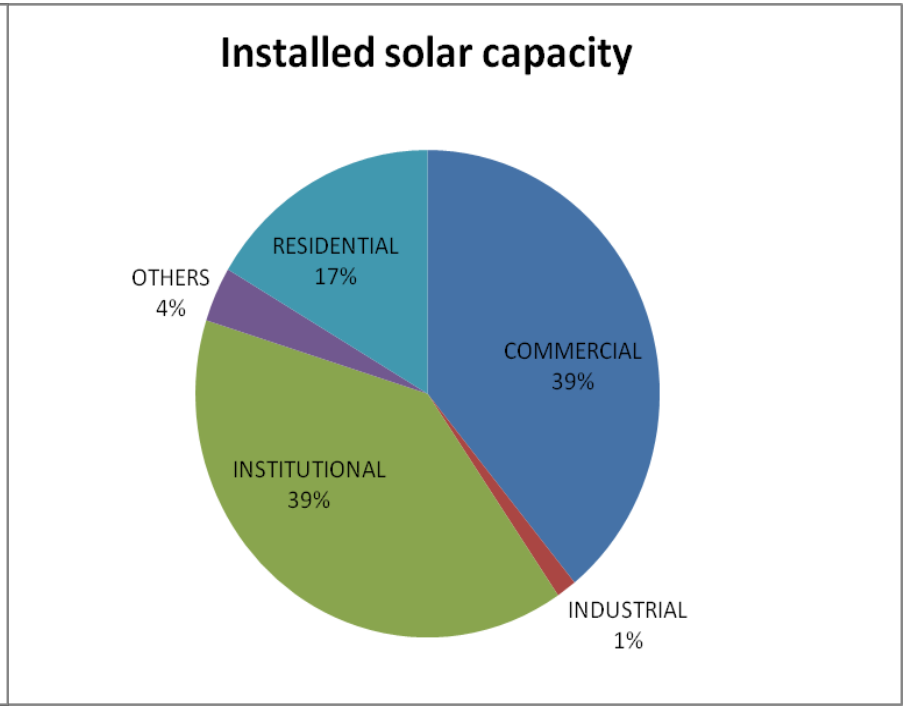
BSES Rajdhani Power Ltd.

Green Initiatives



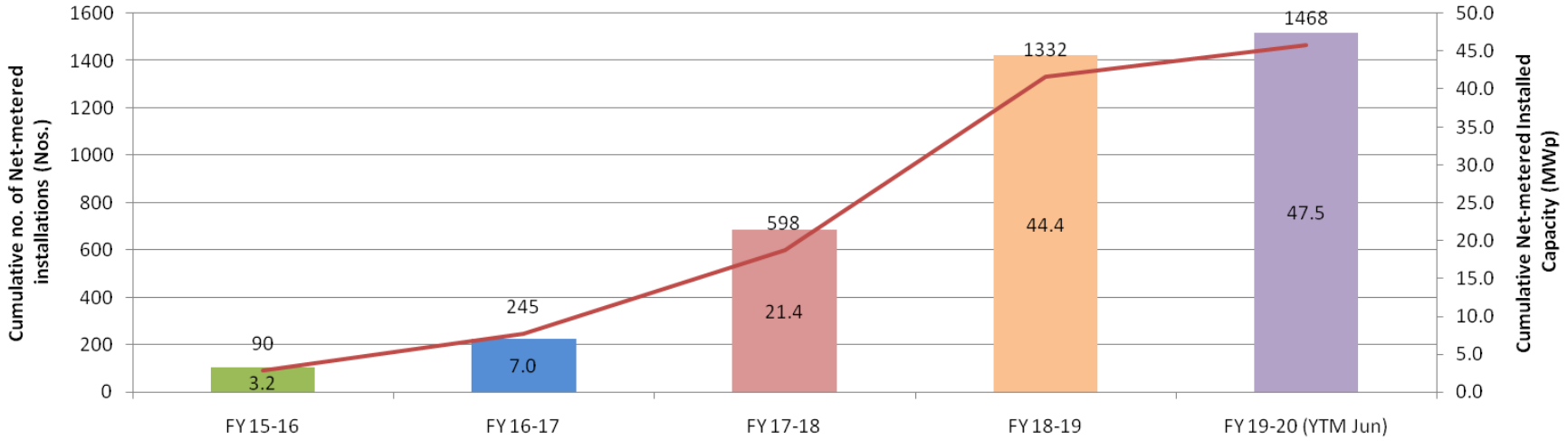
BRPL's Rooftop Journey till YTM Jun19





- 1468 Installations completed, 47.47 MWp ; Another 18.30 MWp in Progress
  - Y1: 90 Nos, 3.1 MWp, Y2: 155 Nos., 3.8 MWp , Y3: 353 Nos., 14.4 MWp, Y4: 734 Nos., 23.0 MW
- Capacity of Solar 47.47 MWp against sanctioned load of 155.1 MW (~31%)

BRPL's Rooftop Journey (YTM Jun19)



No. of net-meter installations in FY18-19 is higher than cumulative no. of installations in last 3 FYs

Waste-to-Energy , Hybrid Solar, Wind Plants in Pipeline

BRPL Online Solar Portal

Facility to submit online Net-metering application commenced

Major issues for DER integration

- GoI has set a target of 175 GW of Solar PV with 40 GW of Rooftop solar by 2022
- As the distribution grid was designed as load-only grid with unidirectional power flow, the integration of PV at 11kV feeder and lower voltage levels needs to be studied
- The major challenges for the distribution grid network and its operations are, also considered and discussed in the study report are :
  - Voltage Regulation
  - Overcurrent Protection
  - Reverse Power Flows
  - Violation of Operational Parameters
  - Impact on Dispatch and Power System Operation

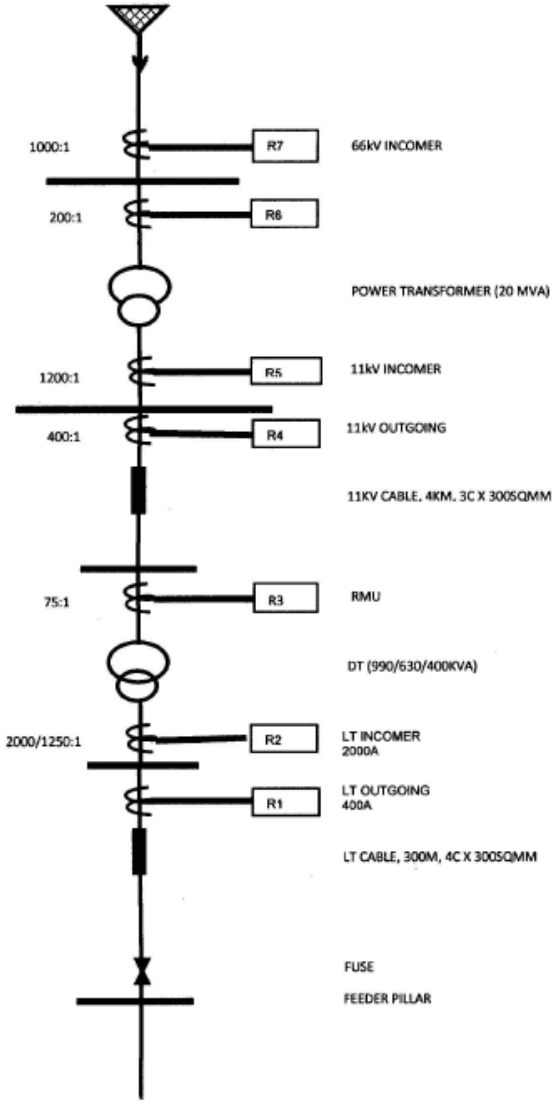
Voltage Regulation Practices

- Conventional distribution System assume no power sources on the system other than substations
- All power flows are uni-directional from Substation towards end of feeders
- Voltage limits specified as
  - ±6% in case of low tension
  - +6% to -9% in case of high tension
- With DER / RTS PV in the network, basic assumption of no other source in the network fails
- Voltage problems can ensue if the capacity of the added source is significant with respect to the distribution feeder capacity
- Varying output of PV sources can cause cyclic voltage excursions on the feeder that lead to hunting of tap changers or capacitor-switching devices

Overcurrent Protection

- Allows temporary faults to be quickly cleared from the system
- Permanent faults to be isolated in a manner minimizing the no. of customers affected & extent of any damage
- Involves coordinated operation of many devices, including circuit breakers, relays, reclosures, sectionalizing switches, and various types of fuses
- Devices are coordinated based on the various time-current response curves, relay pickup settings (where applicable), and fuse melting/damage curves.
- Presence of distribution-connected PV introduces new sources of fault currents that can change the direction of flow, introduce new fault-current paths, increase fault-current magnitudes, and redirect ground fault currents resulting into
    - Sympathetic Tripping
    - Fuse – CB coordination issue

Existing Protection Schemes



S No	Voltage Level (kV)	Circuit Breaker Details		CT Primary	Relay Details	
		Name	Breaking Cap. (kA)		Designation	Protections Available
1	0.4	Outgoing ACB	50	400	R1	O/C, E/F & O/L
2	0.4	Incomer ACB	50	1250/2000	R2	O/C & E/F
3	11	DT CB (RMU)	18.4	75	R3	O/C & E/F
4	11	Outgoing CB	25	400	R4	O/C & E/F
5	11	Incomer CB	25	1200	R5	O/C & E/F
6	66	Power Trafo CB	31.5	200	R6	O/C & E/F
7	66	Incomer CB	31.5	1000	R7	O/C & E/F

Reverse Power Flow

- Maximum reverse power flow into the grid can be allowed based on two parameters:
  - Feeder/grid asset thermal capacity
  - Over-voltage at the point of interconnection

- Following formula is used to calculate the maximum reverse power flow on a feeder:

$$P_{reversed\ (\max)} = P_{PV(\max)} - P_{load(\min)}$$

Where,

$$P_{reversed\ (\max)} = Maximum\ reversed\ power\ flow\ in\ the\ network$$

$$P_{reversed\ (\max)} = Maximum\ power\ from\ PV\ pwer\ plant\ at\ noon\ time\ (peak\ irradiance)$$

$$P_{load\ (\min)} = Minimum\ load\ at\ noon\ time\ when\ PV\ power\ at\ peak$$

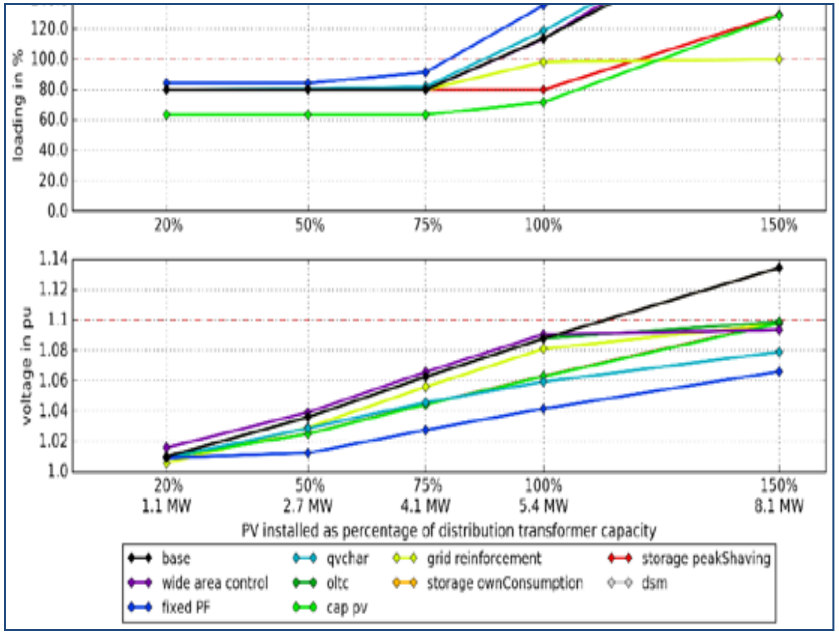
- Maximum phase current in a feeder has been calculated using the following formula:

$$I_{phase} = \frac{P_{reversed(\max)}}{\sqrt{3} x U_r}$$

Impact Assessment Study

- To assess the impact of RTS PV, **Energynautics with the support of GIZ** carried out scenario-based simulation study titled **"Analysis of Indian Electricity Distribution Systems for the Integration of High Shares of Rooftop PV"** for Delhi and Bhopal – Urban and Rural Feeder.
- Five Different scenarios built and studied for Urban and Rural feeders to understand and asses the **unmanaged** as well as **managed** hosting capacities of feeders.

S.No.	Delhi Urban Scenarios	Delhi Rural Scenarios
1	PV equally distributed with normal load	PV power plant
2	PV equally distributed with adapted load	PV equally distributed with normal load
3	PV at the end of the feeder with normal load	PV equally distributed with adapted load
4	PV at the end of the feeder with adapted load	PV equally distributed with a 3.5 MW PV power plant
5	PV at the end of the feeder with lower line cross section	PV equally distributed with the network fully cabled



Key Findings

1. PV penetration levels of **75 % of distribution transformer capacity** and higher can be implemented without having to undertake any measures to contain voltage problems or overloading.

2. At very high penetration level (close to 100%), it could be observed that **Active Power Management Strategies** of either capping PV inverter capacity or the use of peak shaving storage performed best in resolving both voltage and loading issues.

3. **Automatic voltage control** by tap changing transformers at 132/33, 220/66 or 220/33 kV should be implemented in all distribution grids regardless of PV development. For lower voltage levels (66/11 or 33/11 kV level), this strategy is very beneficial, but not strictly required if the voltage control above is adequate.

4. Voltage problems in the distribution grid, caused by both load (under voltage) and PV (overvoltage) can be efficiently eliminated by the use of a **wide area voltage measurement** and control method i.e. measuring the voltage at multiple points in the grid and operating the voltage control by transformers accordingly.

5. The distribution grid codes need to be updated to require voltage control capability.

Forum of Regulators study

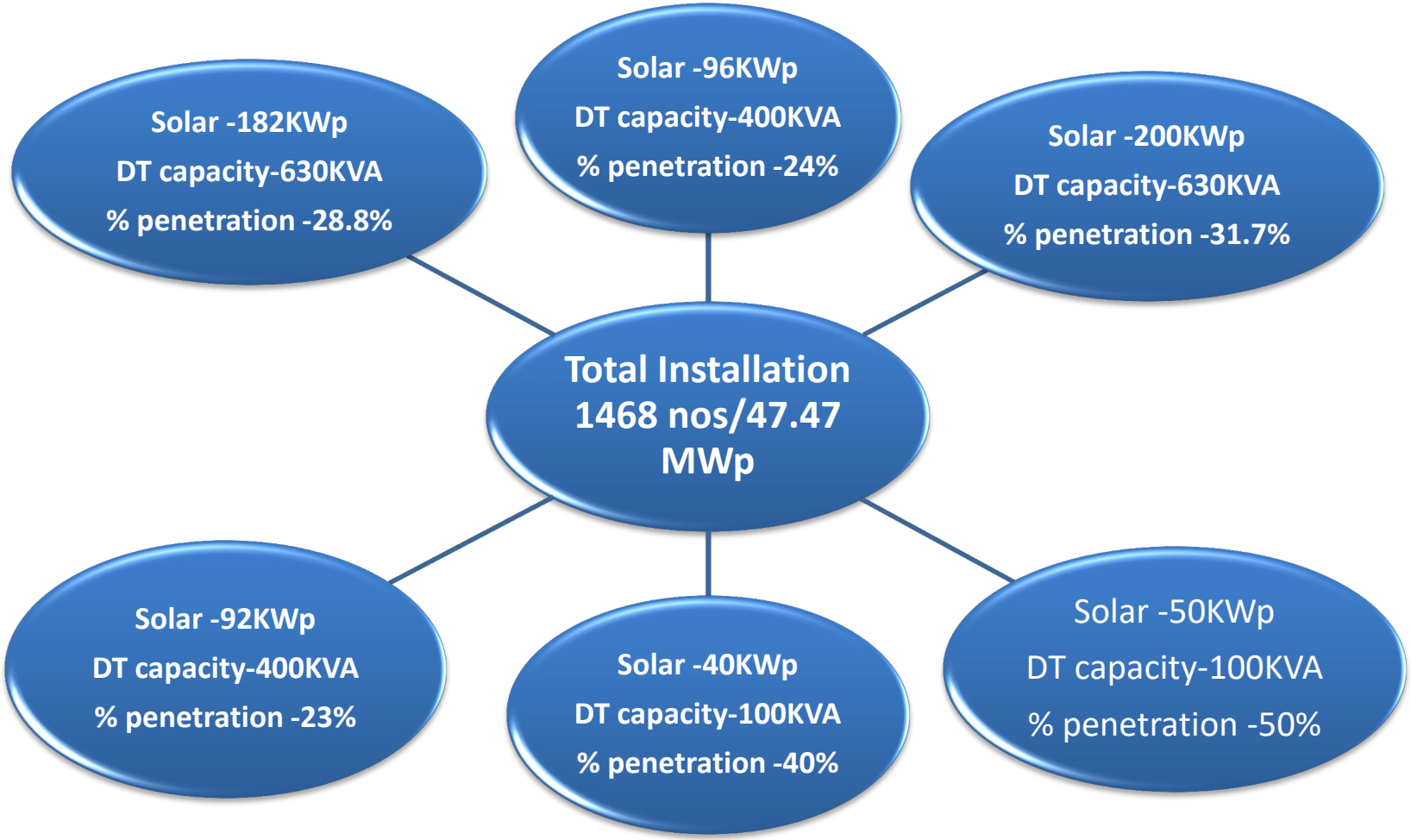
- **Safe limit** for network penetration by solar PV should be on **over-current (thermal capacity)** for symmetrically distributed solar photovoltaic systems, when permitted PV capacity (AC nominal power of inverter) is **not more than the sanctioned load/contract** demand.

- If solar PV penetration capacity **is more than the sanctioned load/contract demand**, aggregate or single PV power plant capacity (AC nominal power of inverter) that can be connected to the network has to be decided on a case by case basis, based on the loading of the respective DT and the feeder length, considering **over-voltage at PCC** as the deciding factor.

- If solar PV penetration capacity **is not more than the sanctioned load/contract demand**, aggregate PV power plant capacity (AC nominal power of inverter) that can be connected to a network can be up to 100% of DT capacity, even under worst case scenario(s), i.e. with 0% running load, considering feeder's **thermal capacity** as the deciding factor.

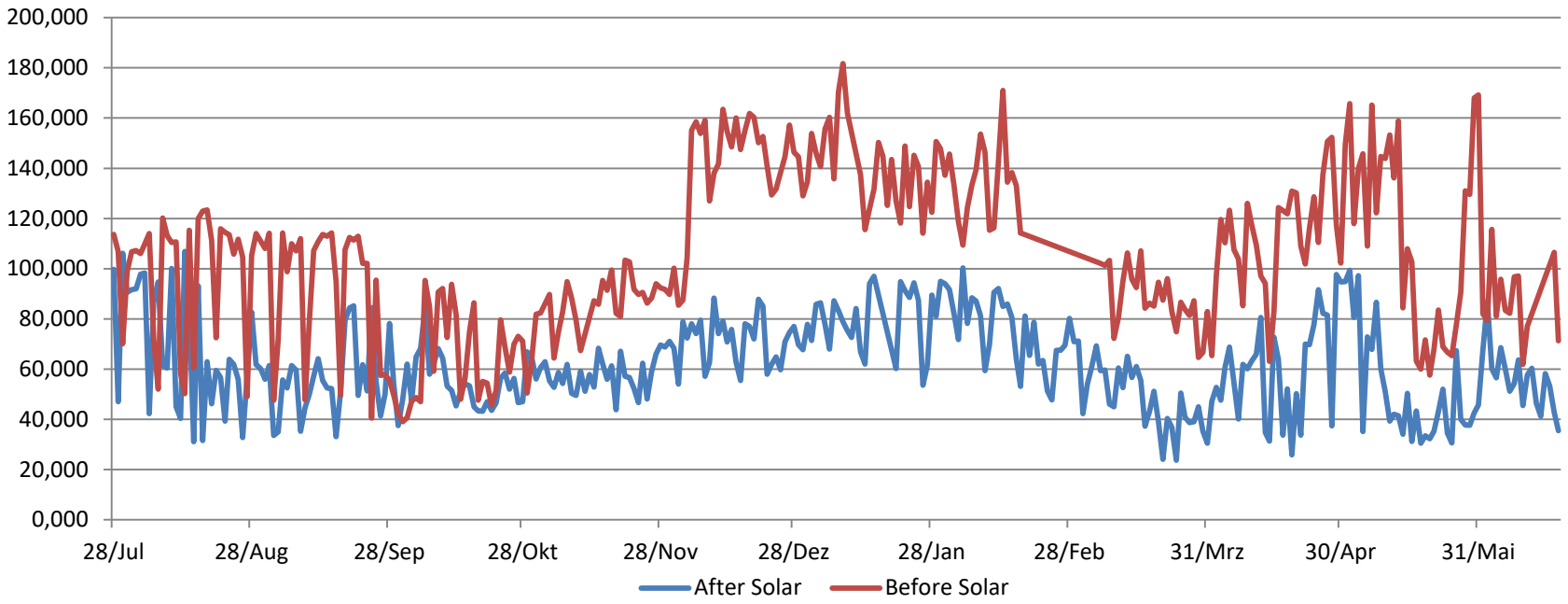
Sites identification with High Solar Penetration

In order to assess the results of these studies, few sites identified with high solar penetration in terms of Distribution Transformer rated capacity



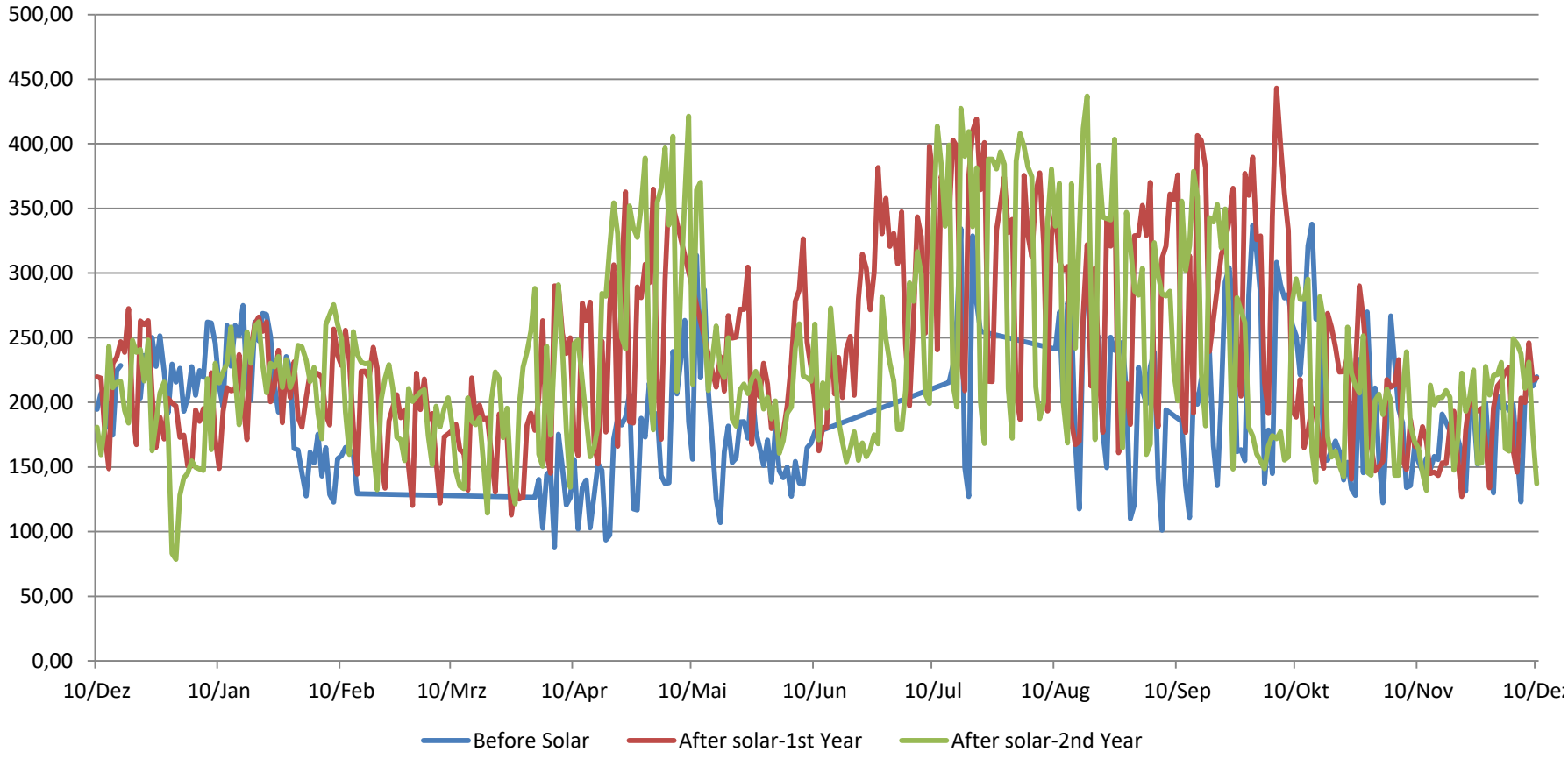
Analysis of DT Peak Loading(Day Peak)

Solar -96KWp DT capacity-400KVA; % penetration -23%;
Date of Installation -27.07.2019



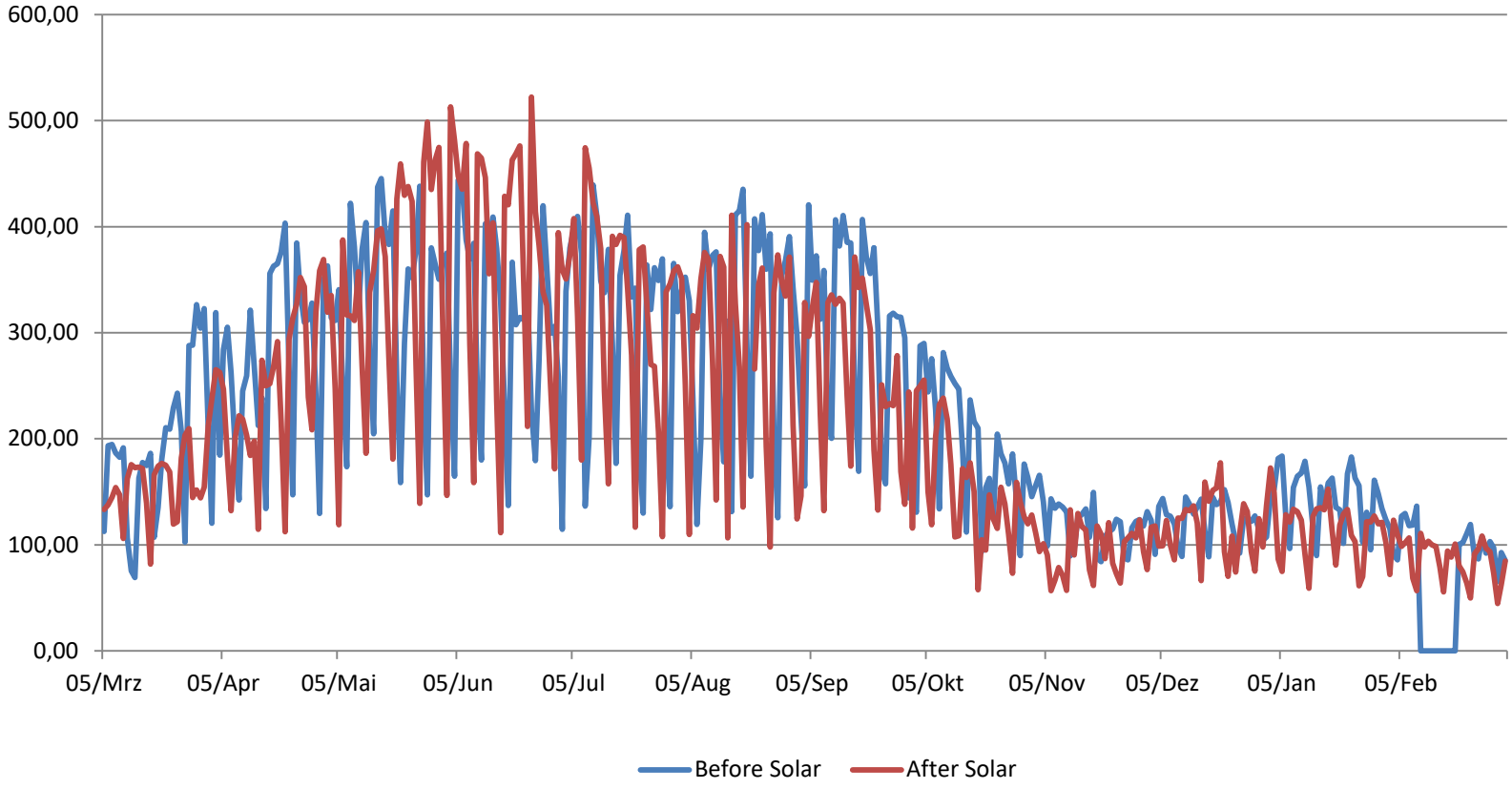
Analysis of DT Peak Loading(Day Peak)

- Solar -182KWp DT capacity-630KVA
  % Penetration -28%
  Date of Installation-10/12/2015



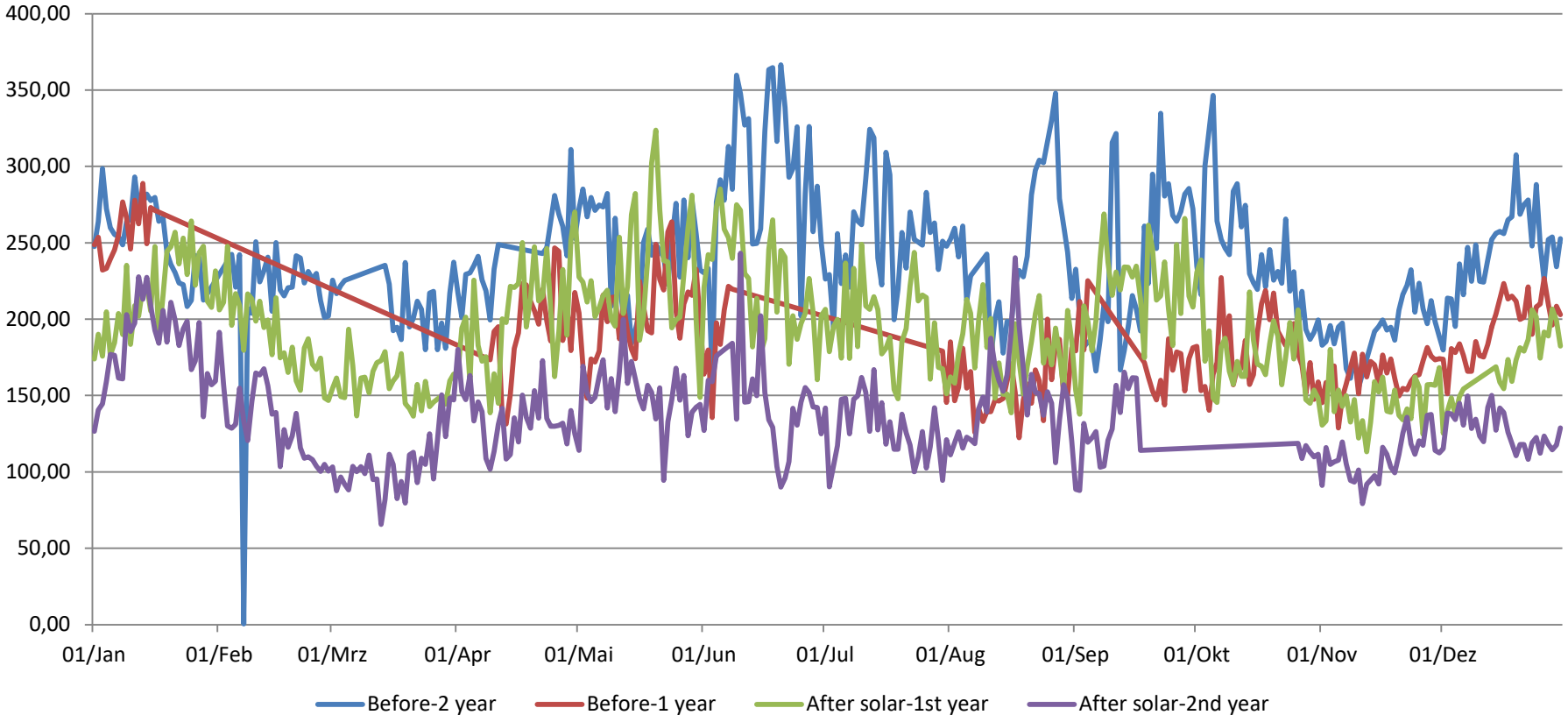
Analysis of DT Peak Loading(Day Peak)

- Solar -200KWp DT capacity-630KVA
  % penetration -31.7%
  Date of Installation -05.03.2019



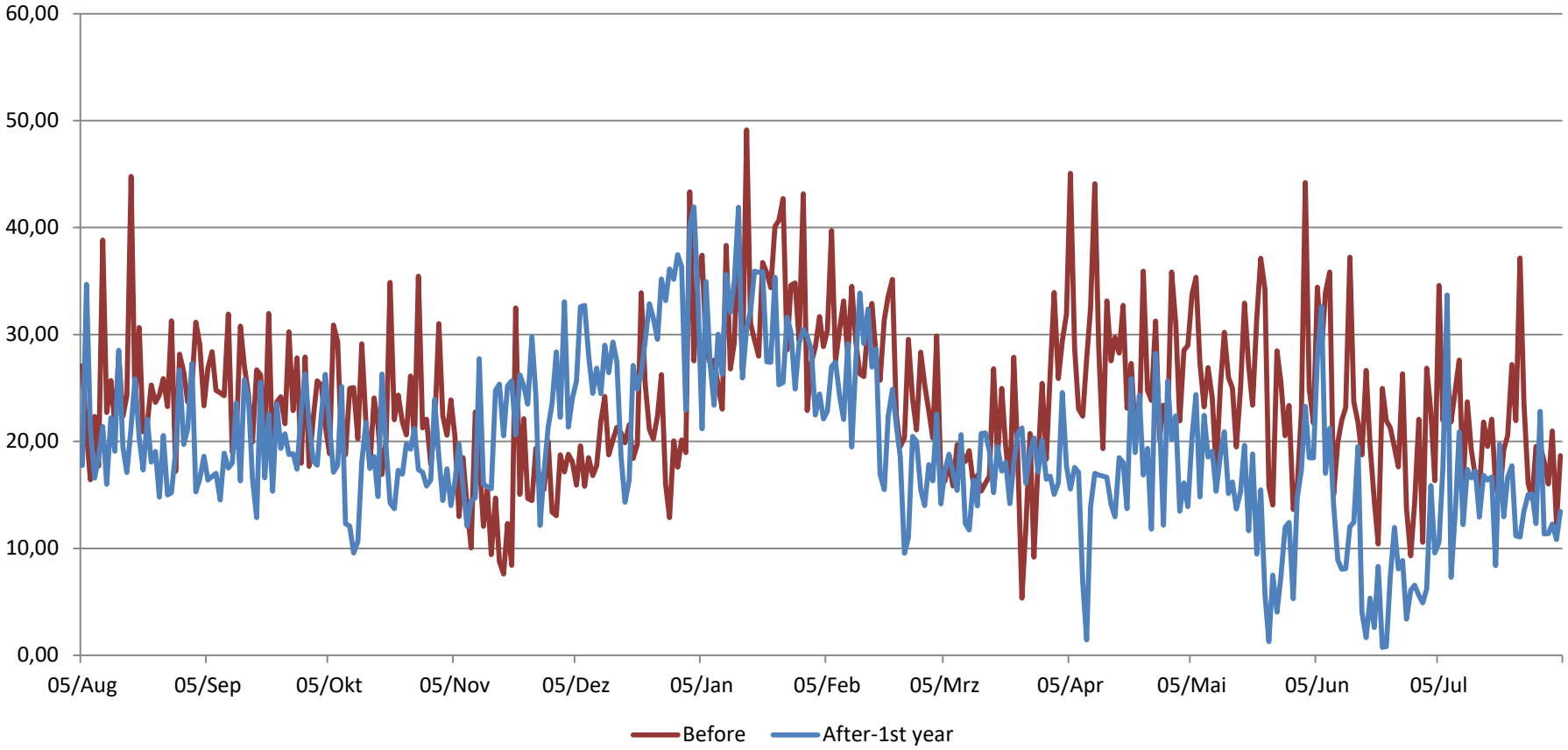
Analysis of DT Peak Loading(Day Peak)

- Solar -92KWp DT capacity-400KVA
  % penetration -23%
  Date of Installation -30.12.2015



Analysis of DT Peak Loading(Day Peak)

Solar -50KWp DT capacity-100KVA
% penetration -50%
Date of Installation -05.08.2016



Observations

- Rooftop solar helped in reducing the day peak loading
- Resulted in CAPEX deferment of DTs, having peaks during sun-hours
- No. of outages on DTs found to be reduced post-solar installations
- No complaints of over-voltage received from consumers

Conclusions

- No adverse impact noted in the selected sites with high penetration of solar.
- However, sympathetic tripping in case of large solar penetration on a single feeder can be avoided with more advanced protection schemes than are currently used on distribution circuits, such as
  - By use of directional over-current trip blocking
  - By implementing more advanced inverter algorithms that accomplish very fast fault-current limiting
- Solar Penetration upto 100% of DT rated capacity can be allowed with few measures such as solar plant limited to sanctioned load, active power curtailment, usage of volt-var characteristics of inverters, etc.

Thank You


Go SOLAR!
A SMART STEP TOWARDS A GREENER FUTURE
FOR ALL SAVING ENVIRONMENT AND MONEY
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