

Session 6: Smart Metering

PART A: Advanced Metering Infrastructure (AMI)

Session Content

- Introduction to AMI system
- Key Components of AMI system – Smart Meters, 2-Way Communication Solution, Head End System (HES), Meter Data Management System (MDMS)
- AMI Architecture and System Integration (SI)
- Prepaid Smart Meters – Example from India on the 250 million smart prepaid meter rollout
- Analytical Tools and Customized Dashboards

Speaker:

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Tata Power Delhi Distribution Limited, India

Why Smart Meters?







Problem with Static Metering Practices


























- Low meter reading accuracy
- Dependency on Meter readers
- No mechanism of real time tamper detection – Revenue Loss
- No mechanism for outage detection
- No mechanism for remote Connection/Disconnection
- AMR prevalent in some segments only; thus auditing up to DT customers only
- Slow Billing Cycle - Utility have to visit site to get meter data

Evolution in Meter Communication



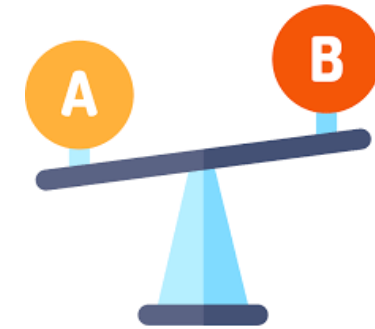
Communication Technology Evaluation

	 Coverage	 Technology Life	 Battery Life	 Scalability	 Cost	 Multi App Support
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 RF-MESH	 Limited	 Proprietary	 Utility owned network	 Utility owned network	 Capex. Intensive Opex Low	Limited mobility
 PLC	 Limited to Electrical Network	 Short	 Limited to Electrical Network	 Limited to Electrical Network	 Capex. Intensive Comm. Issues	
 4G-LTE	 Designed to support Voice as well as Data	 Short	 Low Caped With Dependency	 Low Caped With Dependency	 Low Caped With Dependency	Designed to support Voice as well as Data
 NB-IoT	 Highest Coverage Gain	 Standard Based Technology	 With Dependency	 With Dependency	 With Dependency	Designed for Smart City IoT solutions

Ability to support smart grid applications As experimented by TPDDL

S.No.	Application	Smart Grid communication tech.		
		RF mesh	PLC	Cellular
1	Distribution Automation	Yes	No	Yes
2	Automatic Demand Response	Yes	No	Yes
3	Multi interval meter reading	Yes	Yes	Yes
4	On-Demand meter reading/ Connection / Disconnection	Yes	No	Yes
5	Remote firmware upgrade	Yes	No	No
6	Real time pricing	Yes	Yes	Yes
7	Outage Management	Yes	Yes	Yes
8	Support for pre-paid meters / Net meters	Yes	No	Yes
9	Street Light Management	Yes	No	Yes
10	GSAS Backup	Yes	No	No
11	Upfront Cost	High	Moderate	Low
12	Operational Cost	Low	Low	High

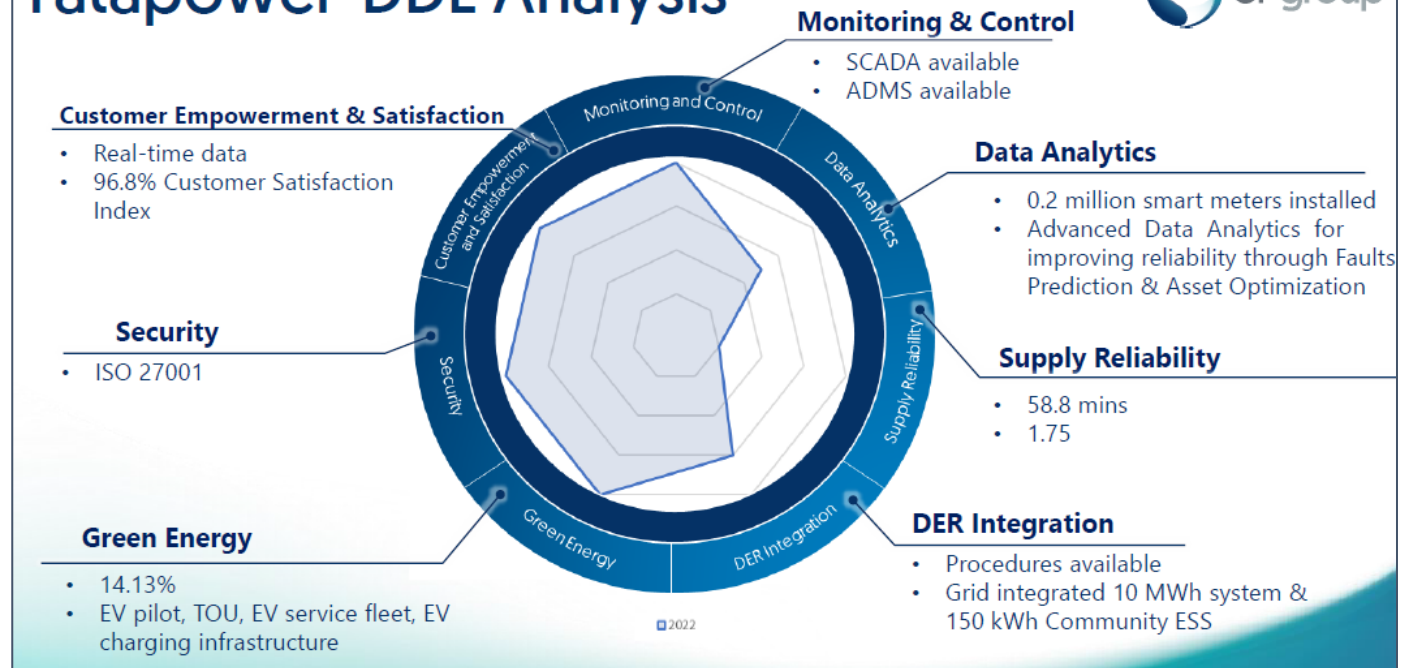


Smart Grid Index 2022 (conducted by Singapore Power)

Utility	Country/Market	Score	+ / - (%)	Best Practices
Enedis	FRA	98.2	1.8	
TaiPower	TWN	94.6	-	
UKPN	GBR	94.6	-	
ConEd	USA	92.9	-1.8	
WPD	GBR	92.9	-	
CitiPower	AUS	91.1	-1.8	
DEWA	ARE	89.3	-	
SP Energy Networks	GBR	89.3	1.8	
SDGE	USA	87.5	-	
FPL	USA	85.7	-	
Northern Powergrid	GBR	85.7	1.8	
SCE	USA	85.7	-	
Stedin	NLD	85.7	-	
ComEd	USA	83.9	-	
PG&E	USA	83.9	-3.6	
ENWL	GBR	82.1	-3.6	
Jemena	AUS	82.1	1.8	
PEPCO	USA	82.1	5.4	
Powercor	AUS	82.1	-	
Radius	DNK	82.1	-3.6	
United Energy	AUS	82.1	-	
Chubu	JPN	80.4	8.9	
Hydro Ottawa	CAN	80.4	1.8	
LADWP	USA	80.4	-	
SSEN	GBR	80.4	-	
State Grid Beijing	CHN	80.4	-	
Tata power-DDL	IND	80.4	-	
TEPCO	JPN	80.4	-1.8	

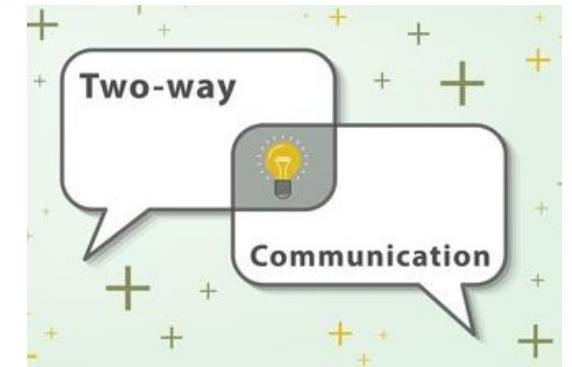
Benchmarks a total of 94 utilities across 39 countries / markets
Tata Power-DDL is the 1st Indian Utility to be positioned among Top 25 Utilities across the globe

Tatapower-DDL Analysis



Smart Meter

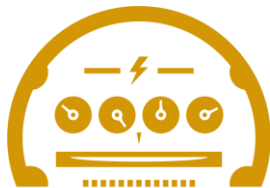
A smart meter is a new kind of electricity meter that can digitally send meter readings to your energy supplier. This can ensure more accurate energy bills. Smart meters also come with monitors, so you can better understand your energy usage.



Special Features:



Auto Time Sync & Mid Night Readings



PRE/POST/NET METER Remote Conversion



Security Feature
Stop un-authorized change in configuration



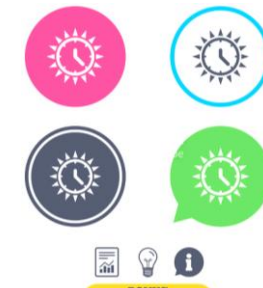
Firmware Upgrade remotely



Last Gasp and First Breath Feature



Building block of Smart Grid



Demand Management & Time Of Day(TOD) Enabled

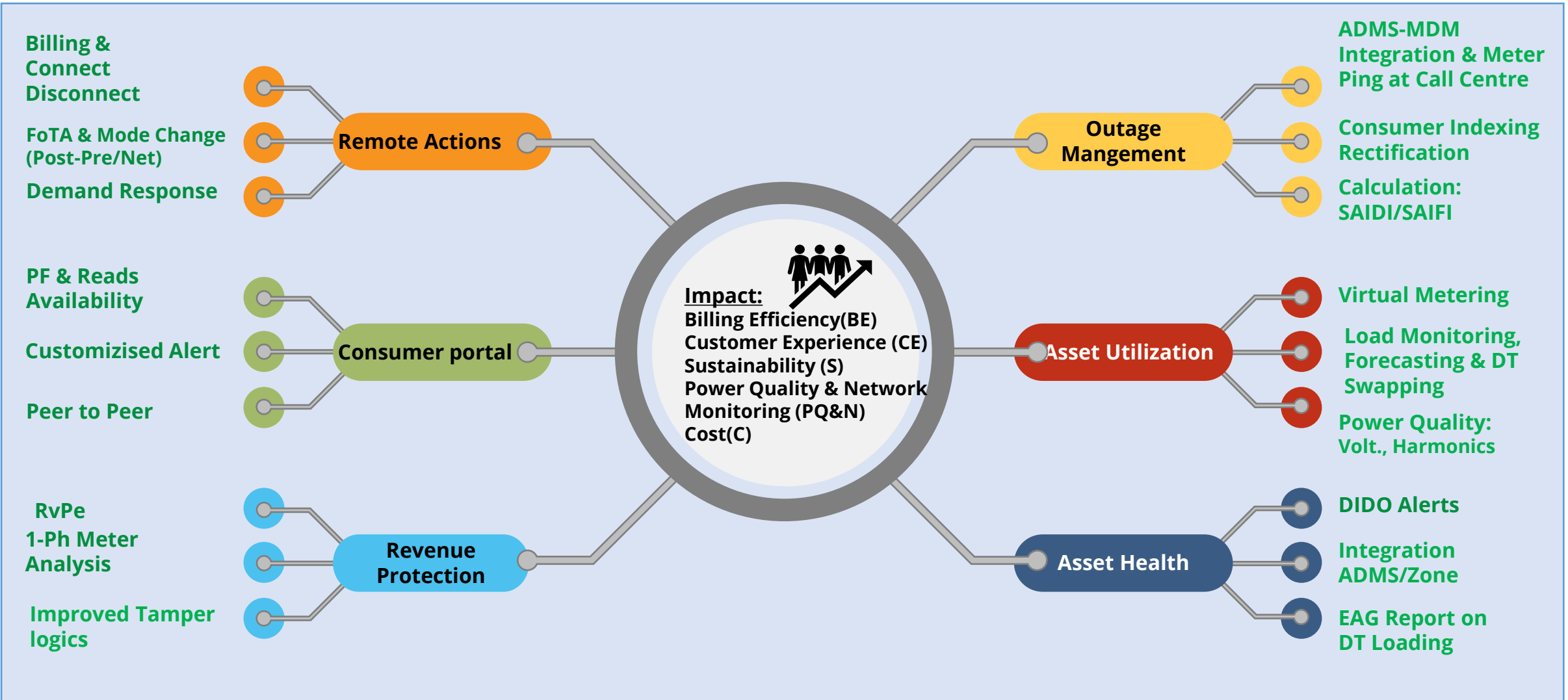


Connect/ Disconnect Switch available

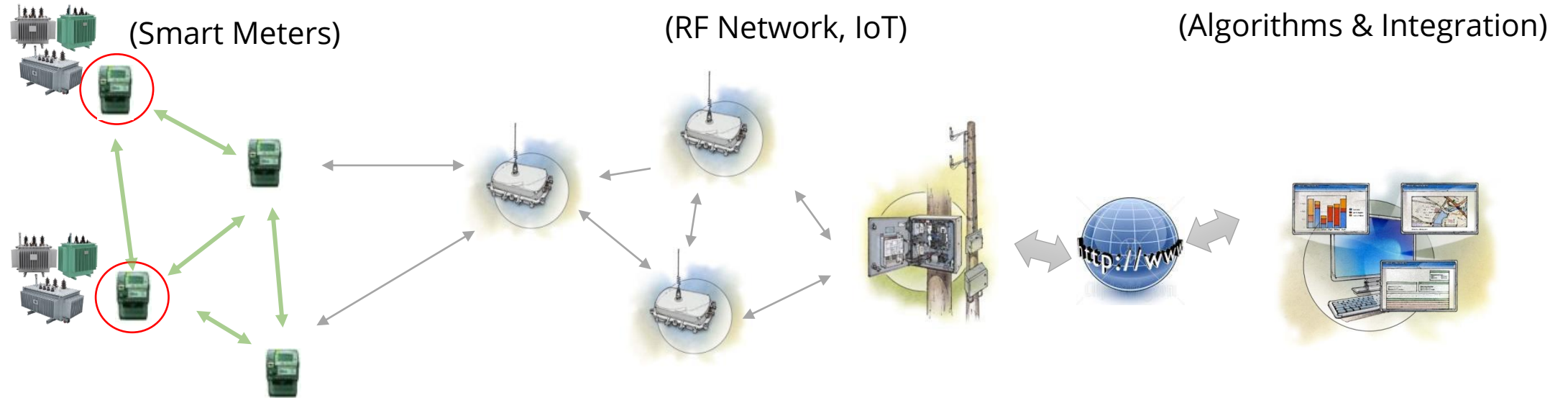
Smart Meter Continue...



Introduction to AMI System

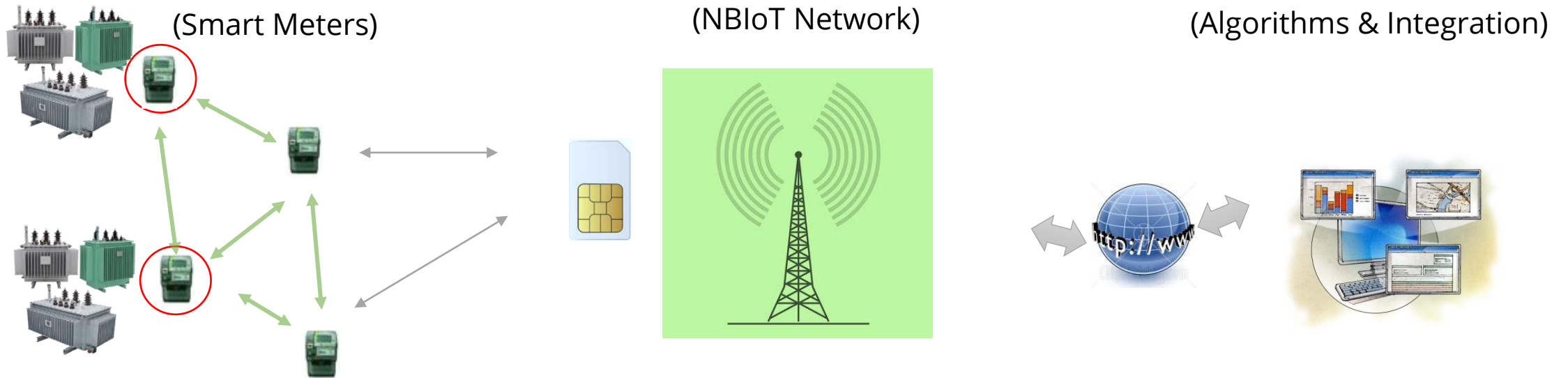


AMI System – RF Technology



Meter & DA Points	Communication	HES	ERP, GIS, ADMS & MDM
<ol style="list-style-type: none"> 3.5L+ Lacs Deployed Developed Field Tools and teams for troubleshoot Meter of different OEMs being explored. Deployed Net Meter, Pre-Paid deployment with FOTA 	<ol style="list-style-type: none"> RF-Mesh deployed 	<ol style="list-style-type: none"> OTA Commands & Upgrades done <ul style="list-style-type: none"> -Pre/Post conversion -Reconnection -Net Metering Interval/Daily/ Monthly/ Instantaneous data and reads availability 	<ol style="list-style-type: none"> Integration done & Modules Deployed In-house resources developed for modules application development

AMI System – NB-IoT Technology



Meter & DA Points	Communication	HES	ERP, GIS, ADMS & MDM
<ol style="list-style-type: none"> 50K+ Deployed Developed Field Tools and teams for troubleshoot Meter of different OEMs being explored. Deployed Net Meter, Pre-Paid deployment with FOTA 	<ol style="list-style-type: none"> NB-IoT based Cellular Network 	<ol style="list-style-type: none"> OTA Commands & Upgrades done <ul style="list-style-type: none"> -Pre/Post conversion -Reconnection -Net Metering Interval/Daily/ Monthly/ Instantaneous data and reads availability 	<ol style="list-style-type: none"> Integration done & Modules Deployed In-house resources developed for modules application development

HES - Head End System

- Application that communicates with meter via other network equipment like NIC, Router, Collector etc.,
- Ensures a legitimate equipment is communicating to AMI network
- Passes on data to other down stream systems like
 - Meter Data Management System (MDMS)
 - Outage Management System (OMS)
 - Other OT systems

Feature of Head End System



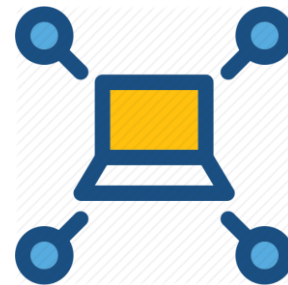
AMI module



Cyber Security
Module



Firmware
Upgrader



Network Management
Module

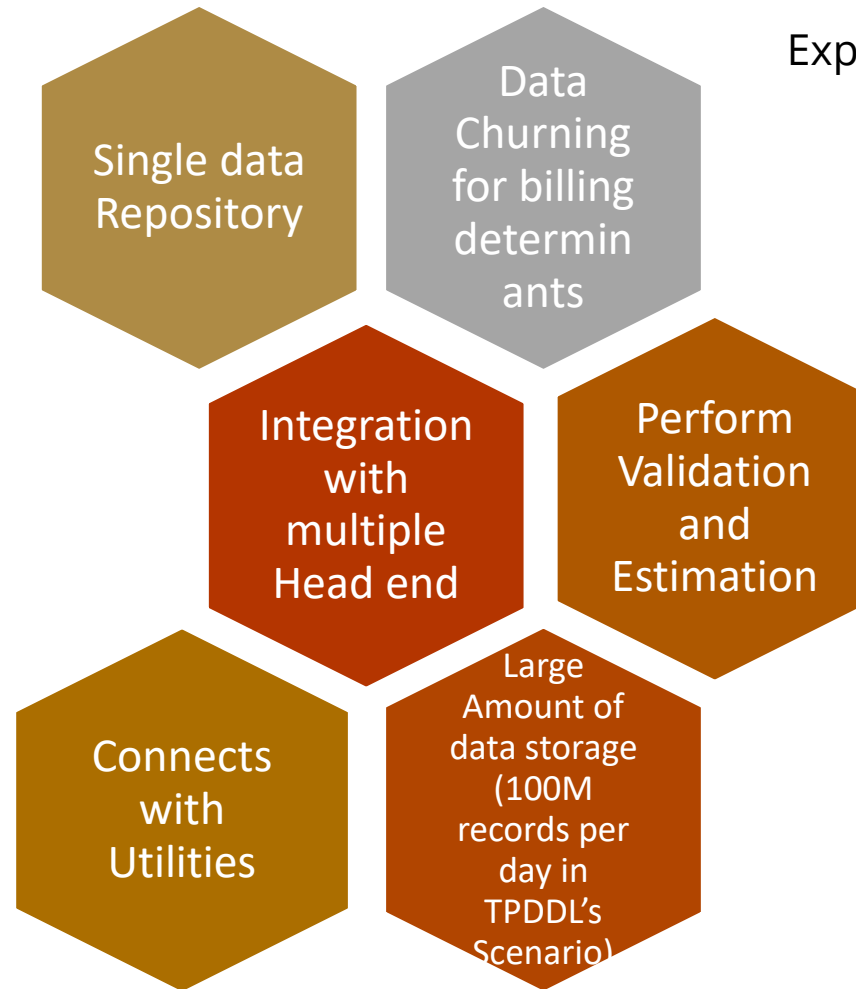


Outage
Management



Power Quality
Monitor

MDMS: Meter Data Management System

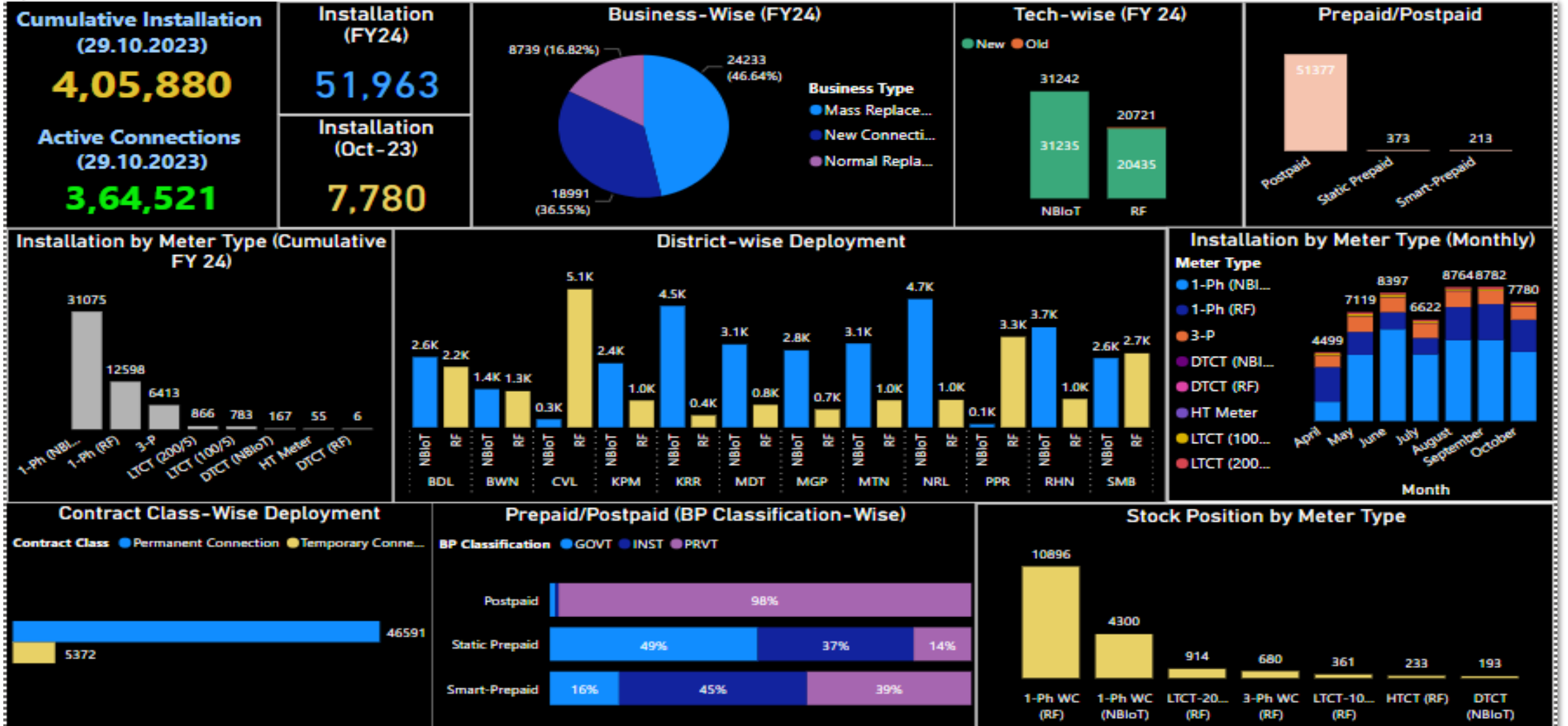


Exports data to

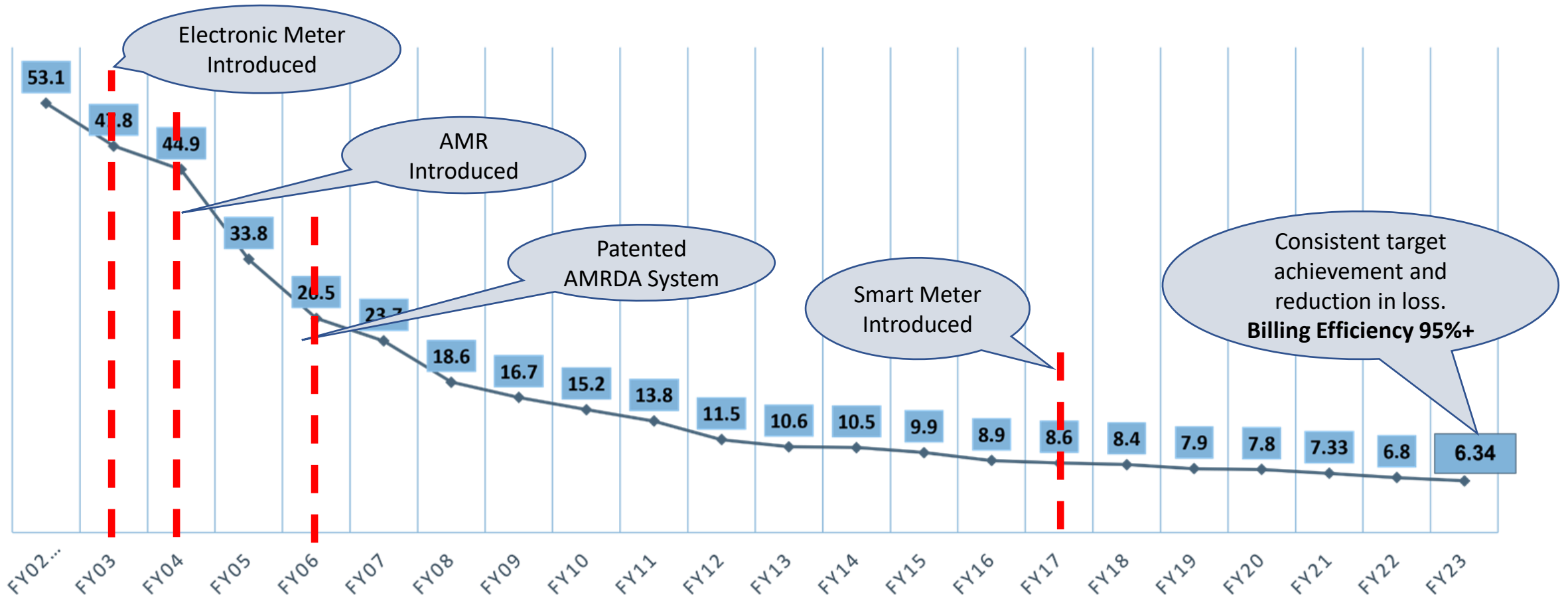
- CIS for billing
- Customer portal / Mobile App
- Big Data analytics
- Demand Response Management system (DRMS)

- CIS for Asset Information sync
- HES for all meter related transactions
- GIS for Network information sync
- ADMS / OMS for Last Gasp and First Breath messages

Tata Power-DDL Dashboard

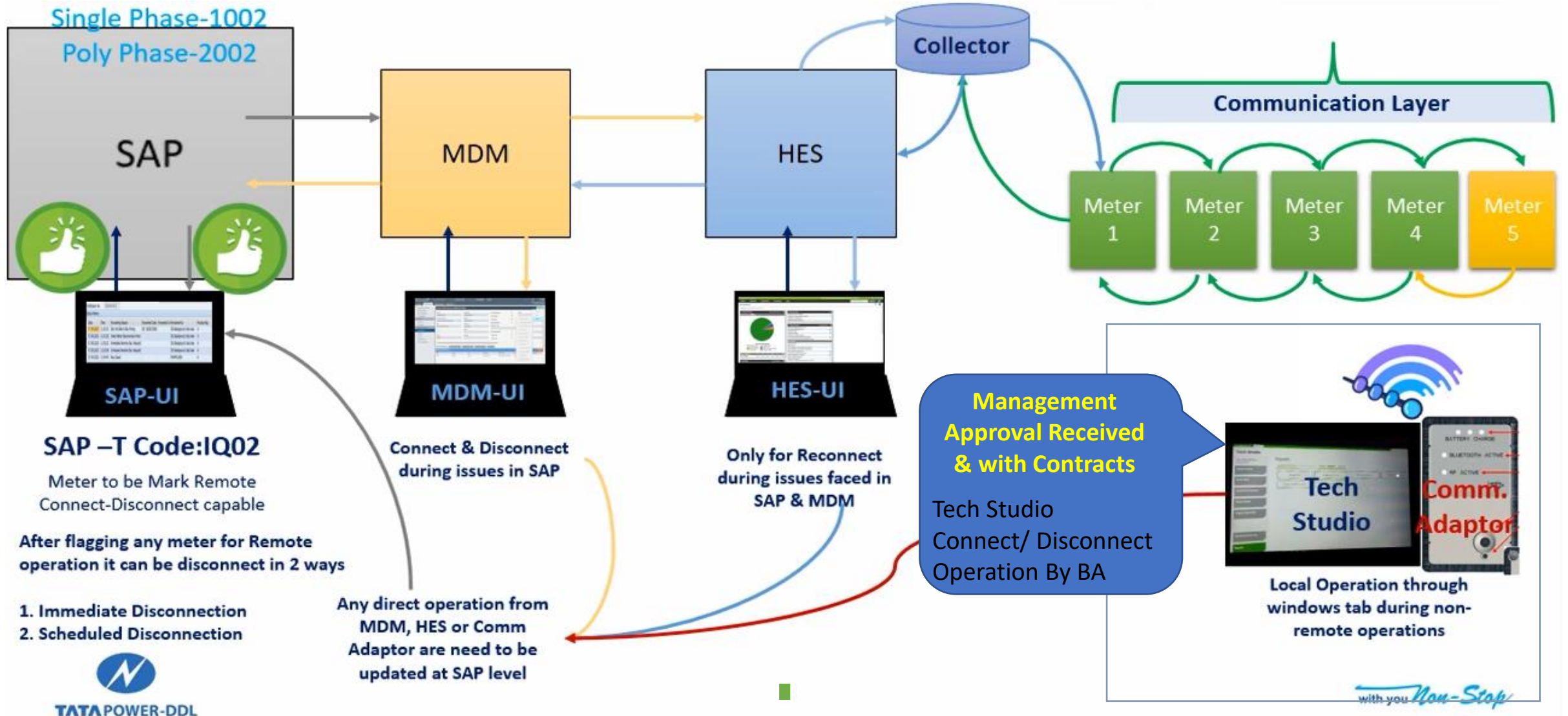


AT&C Loss reduction over the years



20 Years Turnaround Story of One of the Most Successful Private Power Distribution Utility

Remote- Connect-Disconnect



Smart Pre-Paid

A. Pre-Payment Smart Meter is most desired Solution for every utility.

1. Advance Availability of cash
2. Drawbacks Already taken care of like
 - Difficult to recharge
 - No option of remote recharge
 - Tariff updation
 - Balance Availability
 - Supply Pass issues
3. For All utilities most of consumer base of covers under low segment(SP_WC & PP_WC) & with multiple of complaints. Hence
 - Min. number of complaints related to Billing.
 - Focused Approached should be given to Bulk Consumers.
4. **Incentive Scheme:** Incentive to be given to consumers on Bulk Recharge & shifting to Post-Paid to Pre-Paid.

“what’s
in it for
ME?”



B. Need of Post Paid meters could not be denied for essential services, Bulk Consumers, Net Metering and provisions should be kept available.

Conventional Prepaid-Issues & Smart Solutions

Issues with Conventional Prepaid Meter



Smart Prepaid Meter

- Tariff & slab updation need visit to all site of meters.
- Tariff revision took time & delayed till the consumer consumes its previous balance
- No MDI based bills and sanction load updation
- Previous Arrear or Balance transfer is very tedious & time taking.
- Meters are not accessible in Government installations

- ✓ *Tariff & Slab revisions handled at backend*
- ✓ *Bills generated using actual billing engine*
- ✓ *Reading of Meter Over The Air*

- Frequent tripping due to over load & no tripping limits updated as per MDI

- ✓ *Managed from Backend*

- Technology not developed at par wrt to Post paid Meters

- ✓ *Post & Prepaid Meters are Same*

- Consumer feels difficulty in long strings of number ranging from 20 to 140

- ✓ *No Coupons insertion required*

Innovative Use of Smart Meter Data – Thin Prepaid

Objective: To make pre-payment meters friendly for consumers as well as Utility by doing the billing and other accounting at the back-end.

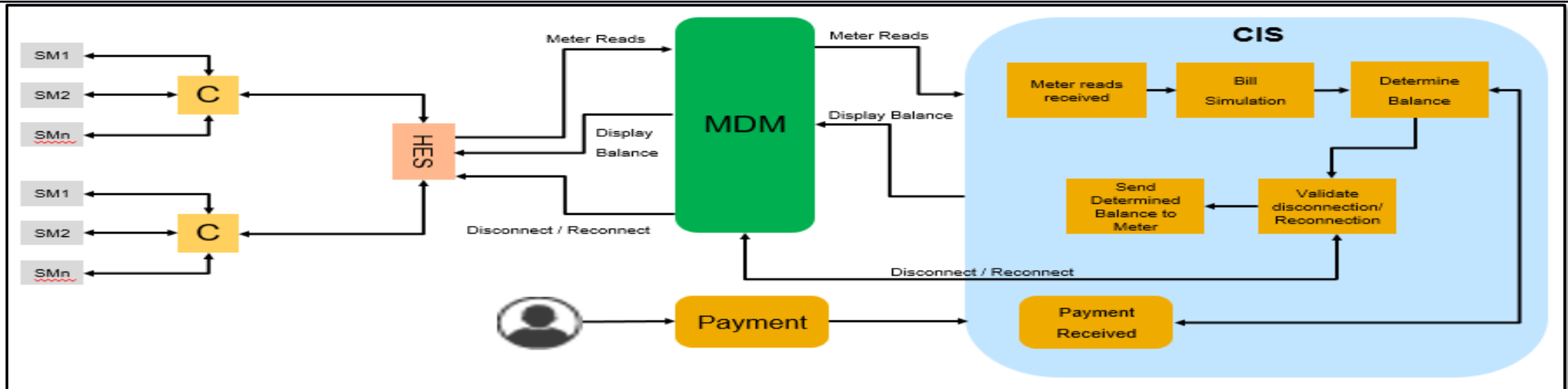
Adoption in Business Process:

- Execute billing at the back-end
- Tariff update through **FOTA**
- No need to enter lengthy coupon details in the meter.

Benefits:

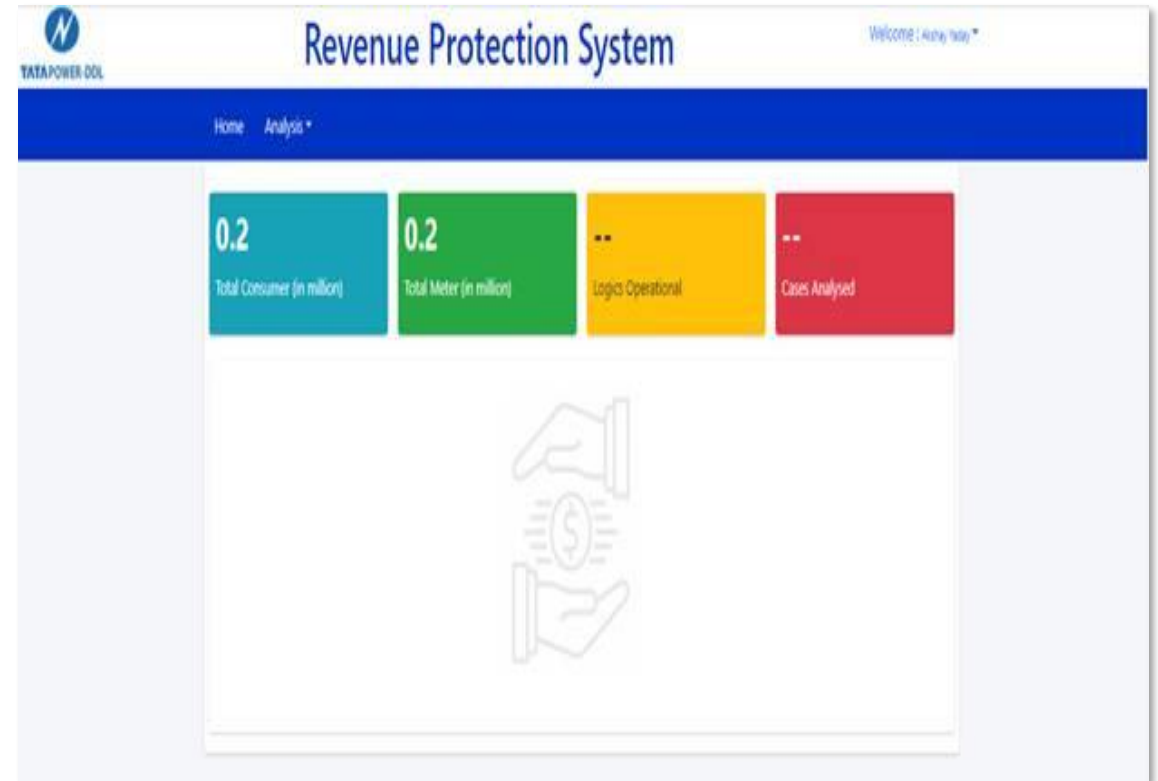
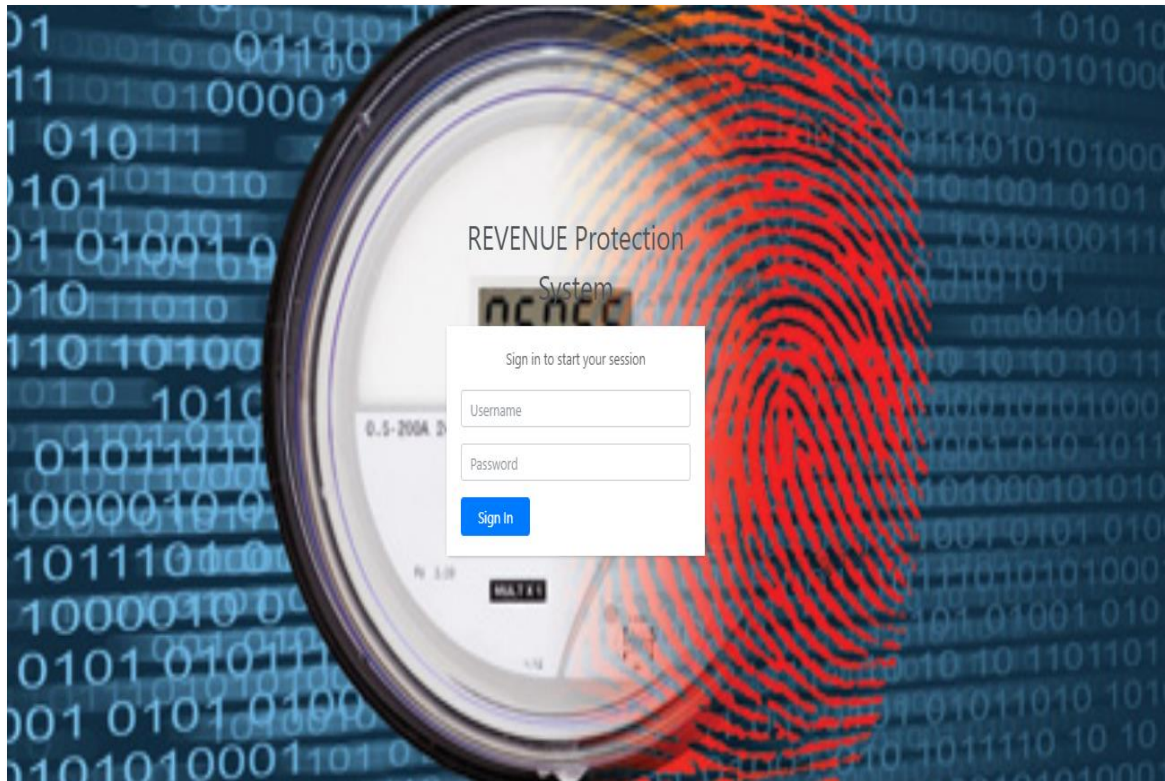
Tata Power-DDL has deployed pre-payment meters till Sep'22, benefits shown for last two years:

- More than 4500 site visits could have been saved related to Reading, Tariff Update etc.
- Customer Convenience – More than 5200 transactions could have been saved of manually entering coupon details in meter.



Revenue Protection System (RvPE)

- **Revenue Protection system** is developed in house with the help of IT to analyse the smart meter data on single platform .
- It will help analyst to improve the threshold values of logics based on the outcomes of cases referred which will further increase the efficiency of logics implemented



Innovative Use of Smart Meter Data – Revenue Protection

Objective: To protect revenue by setting up a rule-based algorithm system

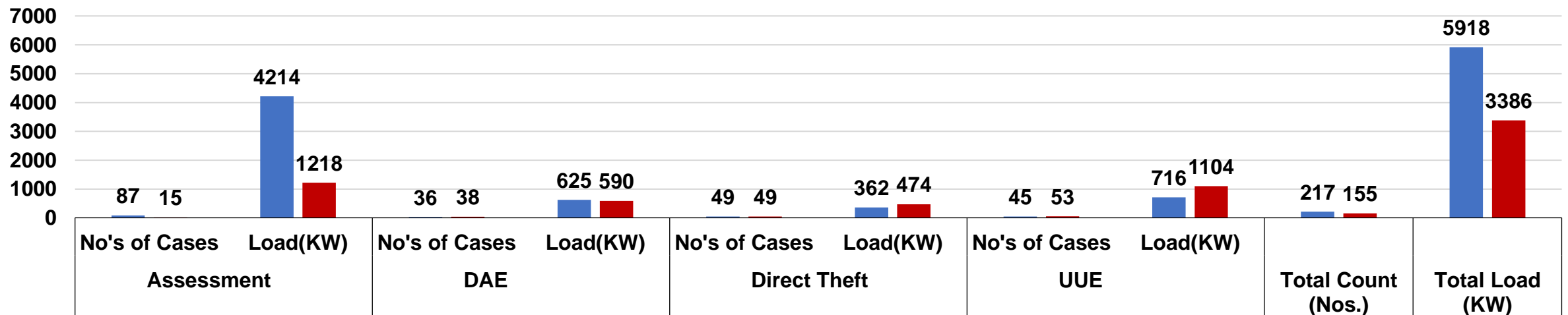
Adoption in Business Process:

- Filtration of potential cases
- Lesser effort is required as compared to previous system for AMR meters.

Benefits:

- 82% more cases booked in H1 (FY23) as compared to H1 (FY 22)
- Lesser Manpower requirement in executing the same no. of cases

Revenue Protection Module: Load Booked

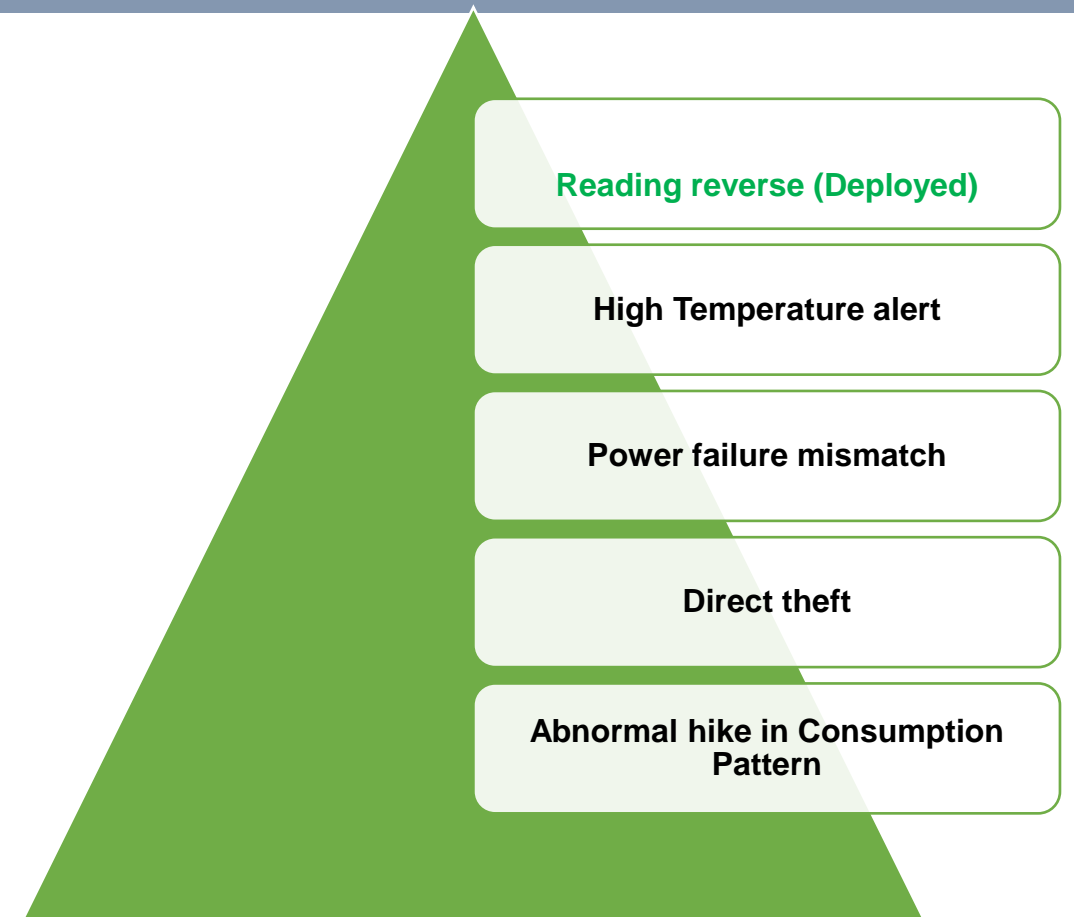


Revenue Protection System (RvPE) - Logics

Logics replicated in RvPE from AMRDA

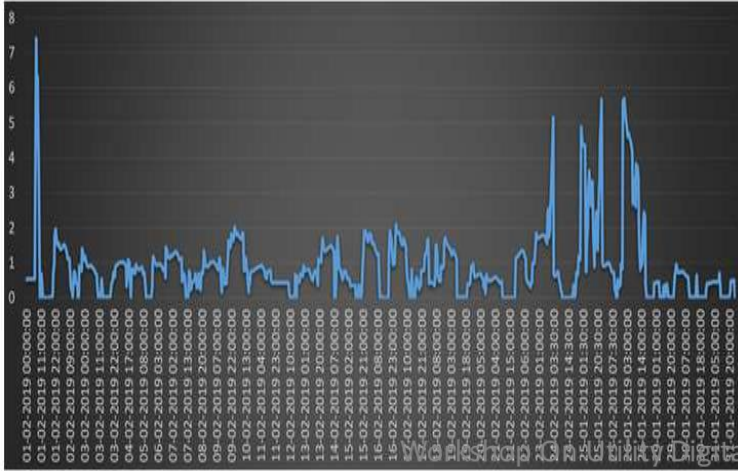
Sr no	Logic Name
1	Assessed Consumption for Industrial and Commercial Connections
2	Assessed Consumption for Domestic Connections
3	Voltage Failure
4	Power Failure
5	CT overload
6	Data Corruption
7	Low Power factor
8	Potential missing with Load Running
9	Current Missing
10	Neutral Disturbance
11	Current Reversal (To be Modified)
12	Magnet
13	Cover Open
14	Direct theft logic through neutral current
15	High Voltage
16	Current imbalance
17	Misuse
18	Drop in consumption with constant MDI

New Logics incorporated in RvPE: Delta over AMRDA

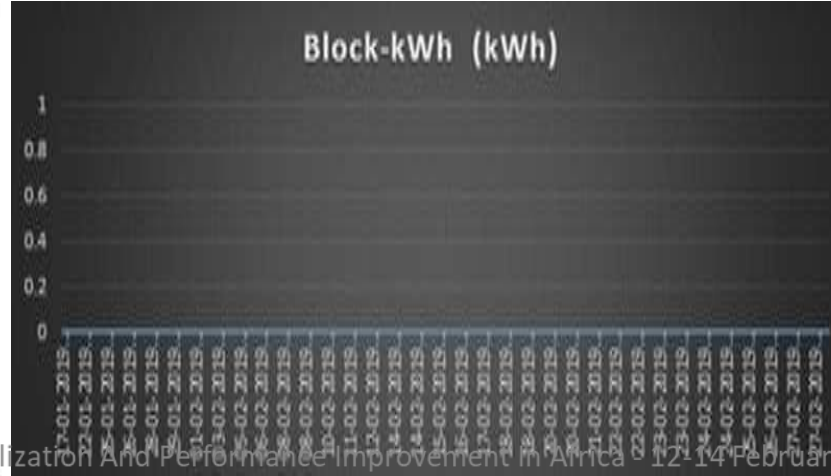


Theft Control and AT&C Improvements

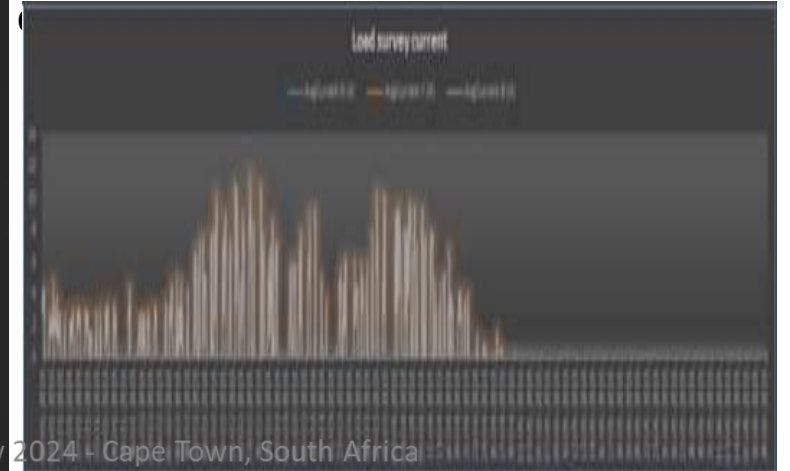
Case 1: Abnormal Hike in CP



Case 2 : Zero/Low consumption



Case 3 : Non-comm after Abnormal



Case 4: Cover Open with High Neutral

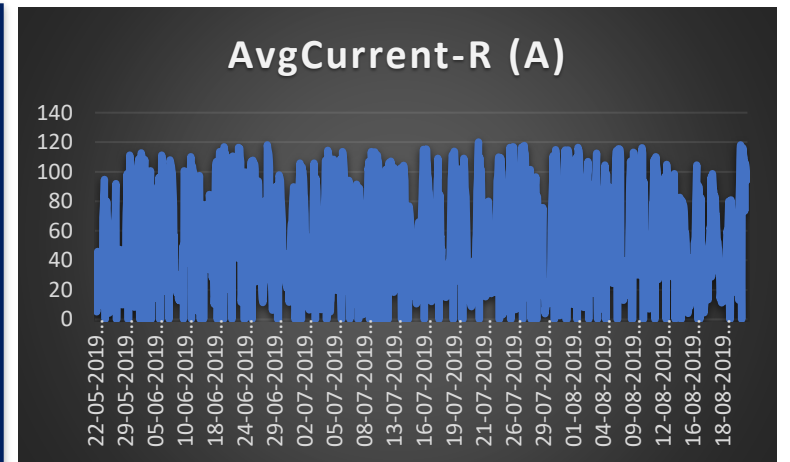
```

Meter # 10001977 Endpoint s/n 1348001164(50S8DDBC)
Command: Get Instantaneous Data
Name Value
Real Time Clock - Date and Time 02/14/2019 13:22:17
Voltage 247.31 V
Phase Current 0.872 A
Neutral Current 1.566 A
Signed Power Factor -1.000
Frequency 50.09 Hz
Apparent Power - kVA 0.189 kVA
Signed Active Power - kW (+ Forward -Reverse) 0.189 kW
Cumulative Energy - kWh Import/Forwarded 905.587 kWh
Cumulative Energy - kWh Import/Forwarded 912.294 kWh
MD - kWh Import/Forwarded 3.650 kWh
MD - kW Date & Time 02/02/2019 10:00:00
MD - kWh Import/Forwarded 3.676 kWh
MD - kVA Date & Time 02/02/2019 10:00:00
                    
```

Case 5: Reading Reversal

Time	Current	Volt	Varh	Watt	Comp	Vol	Method	Dir	Start	Last	Value	Rep
201902010000	000	124.0					UC	AK	dir			
201902010000	000	148.0					UC	AK	dir			
201902010000	000	154.0					UC	AK	dir			
201902010000	000	130.0					UC	AK	dir			
201902010000	000	176.0					UC	AK	dir			
201902010000	000	176.0					UC	AK	dir			
201902010000	000	13.8	NA				UC	AK	dir	NA		
201902010000	000	23.1					UC	AK	dir			
201902010000	000	31.9					UC	AK	dir			
201902010000	000	40.3					UC	AK	dir			
201902010000	000	94.9					UC	AK	dir			
201902010000	000	71.3					UC	AK	dir			
201902010000	000	93.1					UC	AK	dir			
201902010000	000	94.1					UC	AK	dir			
201902010000	000	139.0					UC	AK	dir			

Case 6: Abnormal High Current



Theft Control and AT&C Improvements

Case 7: Load Without Potential

Gridstream RF Endpoint Information [Meter: 10009237, s/n 1348016852(50591AD4)] - Google Chrome

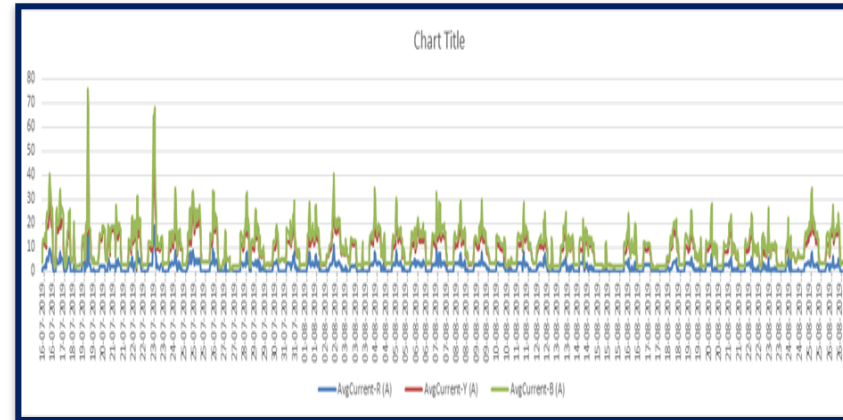
meter # 10009237 Endpoint s/n 1348016852(50591AD4)

Command: Get Instantaneous Data

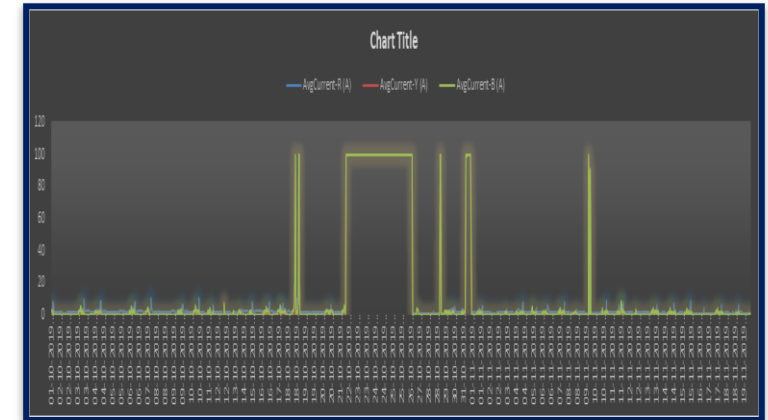
Name	Value
Real Time Clock -Date and Time	02/14/2019 15:32:20
Voltage	156.51 V
Phase Current	1.014 A
Neutral Current	1.195 A
Signed Power Factor	0.948
Frequency	49.94 Hz
Apparent Power - KVA	0.135 KVA
Signed Active Power - kW (+ Forward -Reverse)	0.128 kW
Cumulative Energy - kWh Import/Forwarded	567.503 kWh
Cumulative Energy - kWh Import/Forwarded	599.578 kWh
MD kW, Import/Forwarded	2.410 kW
MD - kW Date & Time	02/05/2019 11:30:00
MD kVA, Import/Forwarded	2.416 KVA
MD - kVA Date & Time	02/05/2019 11:30:00

Close

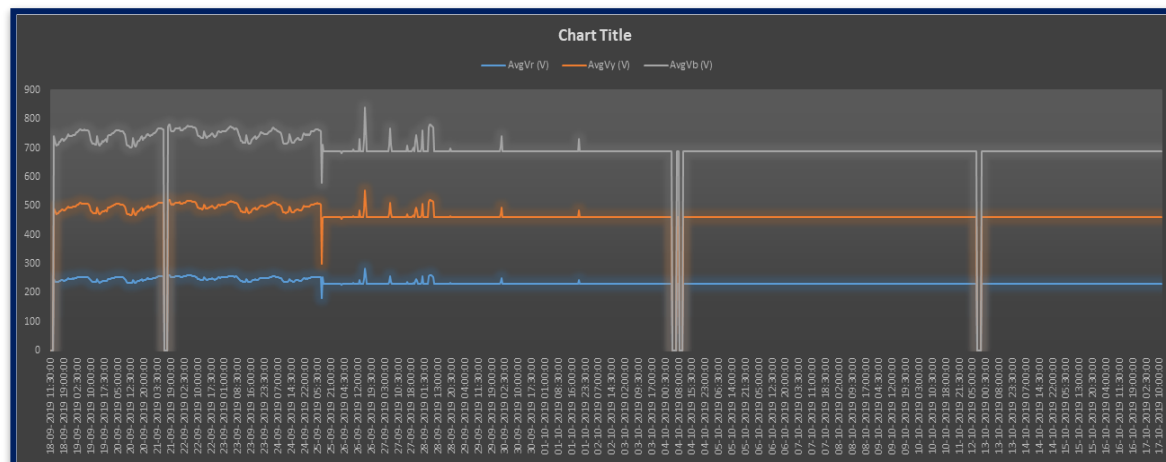
Case 8: Multiple Current related events



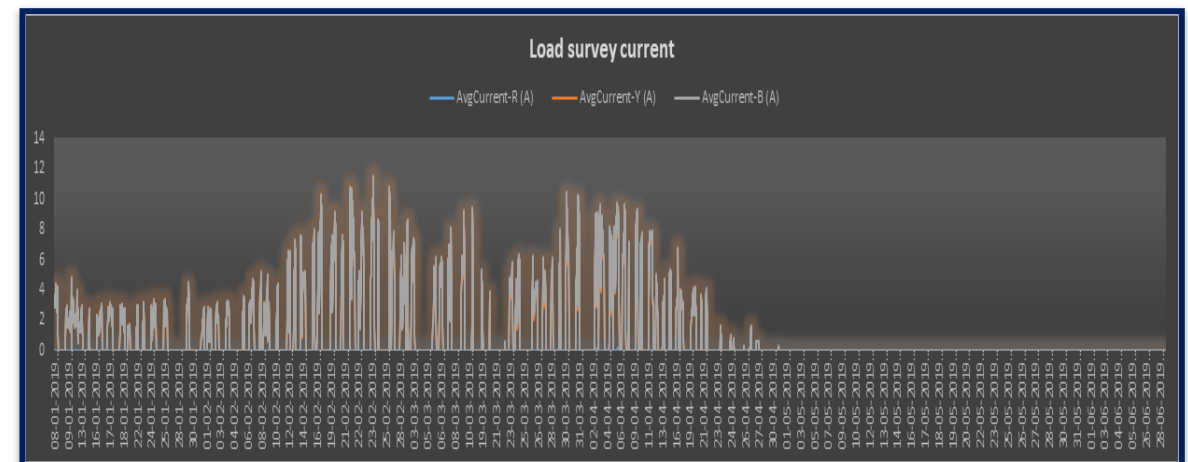
Case 9: Magnet Tamper



Case 10: Neutral Disturbance



Case 11: Abnormal Frequency Tamper



Use of Smart Meter Data - Auto Consumer Mapping Correction

Objective:

Use consumer and DT smart meter outage stampings and GIS information to detect anomaly and predict correct mapping

Adoption in Business Process

- Sustainable process to correct indexing
- Integrated to ADMS for equipment outage prediction

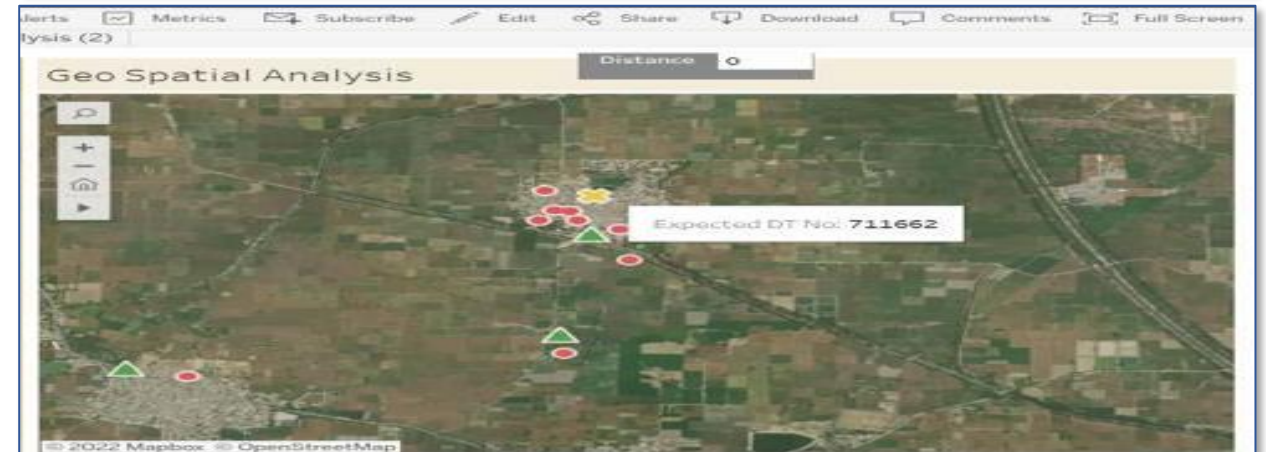
Benefits

- Correct Indexing leading to correct loss calculation, device prediction
- Reduced effort and time over conventional ways of checking indexing

Features

- Takes geographical co ordinates to validate predicted DT
- Rechecked with LT network availability of predicted DT's network in the vicinity

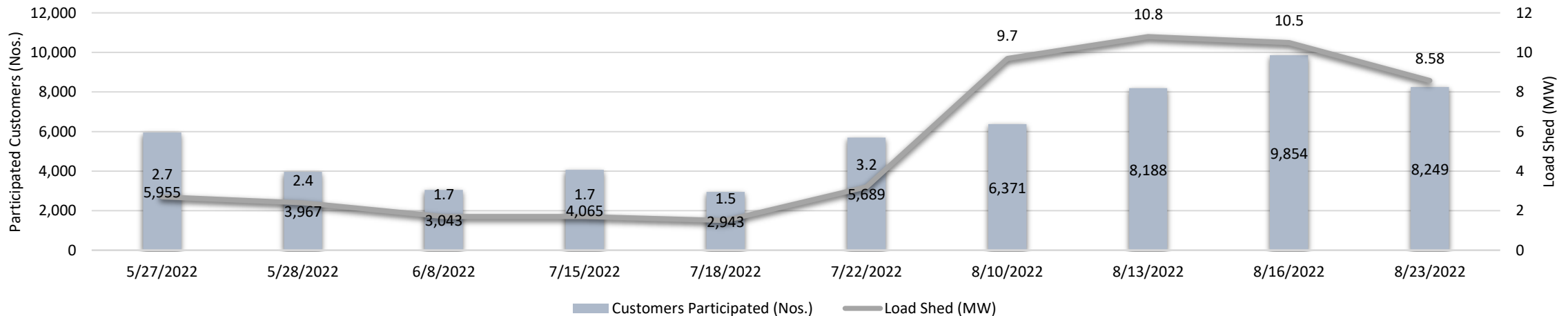
District	Zone	Expected DT Meter	Expected DT No	Current DT	CA
BAWANA	512	95405130	800661	480429	060022688323
		95402856	710701	800722	060010338519
		95403157	711662	800717	060015925586
				711613	060012583278
				K00510	060022156081
				N00612	060002098022
					060000488502
					060001388440
					060012559500
					060018144018
		95403257	K00636	K00509	060021532035
					060022375269
					060027305568
					060000476345
					060002114415
					060006975829
					060009862396
					060010320343
					060010320343



Use of Smart Meter Data – Behavioral Demand Response

- **Objective:** Educating consumers on reduction in consumption from normal levels during critical events as called by utility.
- **Duration:** May'22 to September'22 (Launched on Earth Day: 22nd Apr 22)
- **Enrolled customers: 14K+ Residential and 6.7K+ C&I customers** enrolment done
- **Number of DR events planned:** 16 Events; 8 day events, 8 night events.
- **Event duration:** 2 hours
- **DR event scheduling:** Depending on the peak demand projections, Day ahead planned event to be dispatched through FLEX and intimation to customers 24 hours advance
- Customer engagement through SMS / WhatsApp / Phone Calls / E-mailers, Dedicated Webpage.
- **DR Event Updates:** Successfully executed 10 events

Demand Response Event Details



Smart Meters, by their feature of recording and transmitting interval data, facilitate the execution of DR Programs

Implementation of AMI - Challenges

OEM

- **3rd party meters inclusion under development**
- **Communication of Mass Scale – success rate on daily basis**
- **OEM's Product not ready for Indian markets.** (LT-CT & HT-CT Meters)
- **Single party dependency:**
 - **Meter supplier, Inventory management**
 - **RF dependency**
 - **Unwillingness of TSPs on NBIoT in Delhi**
 - **Limited options for fallback on 2-G**

Utility

- **Financial – High upfront costs of smart meters**
- **Uncertainty due to New Technology**
 - Leading to multiple iterations before reaching the desired communication success
- **Absence of skilled manpower and SOP for system commissioning**
 - In depth knowledge of Telecommunications, Metering and IT.
 - Evolving Technology
 - Extensive Training program required.

Governance

- **Multiple models being tested** (Opex. Vs Capex.)
- **Billing modules tariff and IS are having Gaps**
- **Non-Coverage of 100% population of Consumer:**
 - Scattered coverage leads to non utilization of full capabilities of AMI
 - Major resistance by consumer for deployment if Smart meters

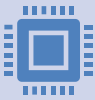
Internal

- **Robust implementation structure required-**
 - Separate vertical required for AMI implementation
- **Long procurement and installation period**
- **Cyber Security:-**
 - Applications Layer Security (Inside Data Centre), for external devices & network level security. (Proprietary security in network)
- **Site identification for Router Installation**

What Smart Metering will not achieve...



While smart meter is effective in the revenue billing, collection (smart prepaid) and recovery to certain extent, it can't resolve the revenue leakage on its own. A proper information pipeline and analysis mechanism has to be established for effective results.



Smart Meter data alone can't achieve asset health monitoring. Read in conjunction with other electrical parameters, the same can be achieved.



Correct Energy accounting cannot be ensured by standalone Smart meter data.



Individual customer consumption insights can be achieved through smart meter data but for peer to peer comparison and cohort identification, additional intelligence has to be built.

Thank You

Any questions?

Subhadip Raychaudhuri



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Annex

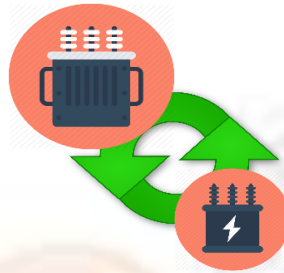
Smart Meter Data Analytics

UTILITY



Schedule Outages

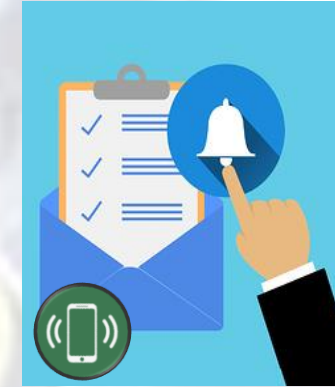
- During min. predictive load
- Monitoring of Oil & temperature level
- Maintenance planning
- Min. loses



Capacity Enhancement

- Based on load enhancement
- Help in to avoid transformer failure

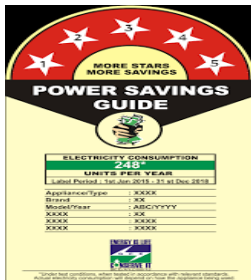
CUSTOMER



Alerts

- Scheduled
- Customized
- Push Notifications

DATA SHARING



Efficient Equipment & Automation solutions

- Data sharing for New Connection's, Shifting and renovation to Demand side management, service provider
- On the basis of consumption pattern



Power Quality Equipment

- Solutions for Power Factor Correction, Neutral Current, Harmonics
- Utility & Customer Equipment Health



Solar Solutions

- Providing solutions according to type of industry, (Morning/Evening) space available & Consumptions