A smarter grid will enable utilities to get the best out of their business investments to face the escalating challenges by selecting the optimal technology & solution; IEG provides high level, best practice turn-key solution that is needed to improve system performance and reduce cost.

Currently, the Distribution Service Operator (DSO) is obliged to adhere to the quality of supply standards, as set out by Europe's EN 50160, and at the same time is faced with growing grid challenges which involve renewables integration specifically wind, PV on the LV grid, smart developments such as electric vehicles and energy storage, amongst others.

These developments, while exciting for the energy industry as a whole, have the potential to create major technical issues such as phase unbalance, voltage control, outage management, THD and bidirectional current and feed on the MV grid.

In addition to all technical challenges, utilities have to deal with any sudden "Force Majeure" and they should take into consideration not only the continuity of power supply but also their cash flow and all related "Health, Safety & Environment" issues.

DSO monitoring and management

The integration of decentralized generation of electricity, the anticipation of operating failures and securing of the power supply, giving the customer a greater choice of services by promoting their participation in grid optimization, the reduction of the environmental impact of the electrical system in its entirety and the optimization of necessary grid reinforcements are what DSOs face today.

In this new environment, an upgrade to the entire MV & LV grid is essential to achieve tangible results where limited monitoring at the edge will not be enough; whereas, real-time data capture & analysis of Consumers' smart metering infrastructure (AMI) is a major action to overcome meter reading & billing next to grid balancing issues, a smarter grid management requires solutions that offer real time accurate monitoring of all LV energy flows. This will enable a more comprehensive understanding of what is happening on the grid and will help DSOs develop a stronger knowledge of how to balance loads and generation on the LV grid. This type of smart management will enable power utilities to get the best out of their business investments.

According to experts, there is one clear action for DSOs to take when looking to overcome these issues. A single stand-alone integrated solution under one communication umbrella that manages the whole MV & LV grid through a well-developed cloud service.
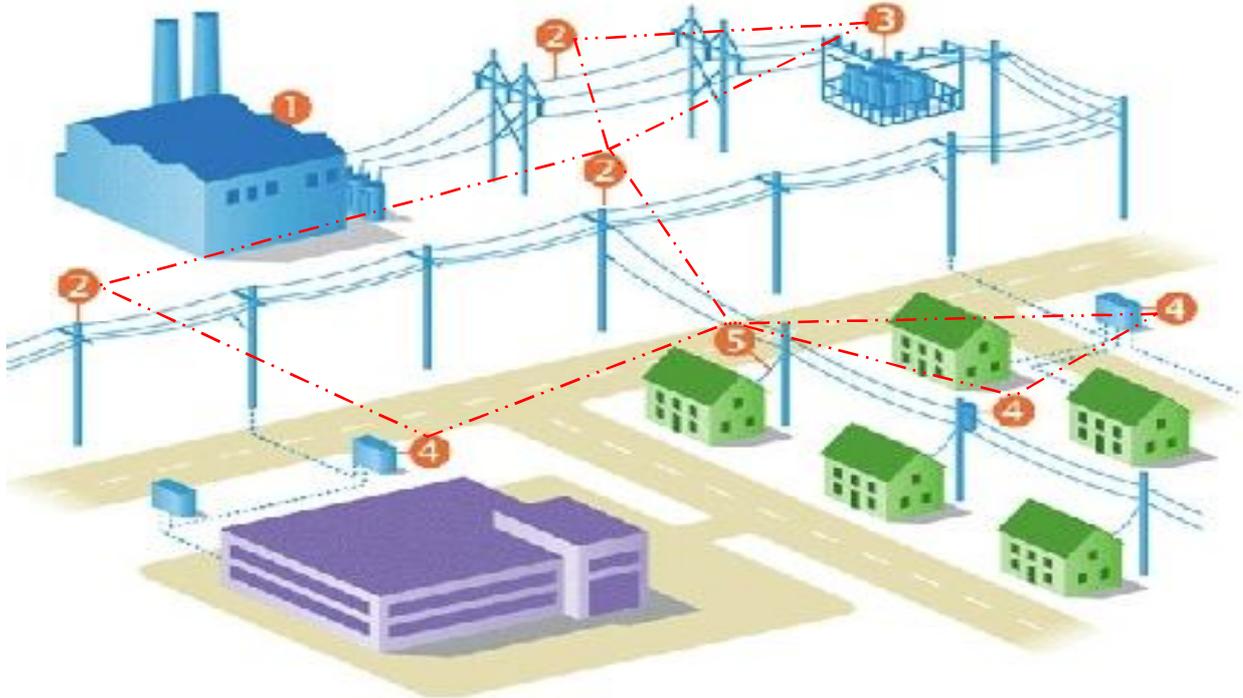
The connected products that can be integrated under one platform are:

A. IoT: Lora LPWAN Star-Mesh
B. Smart meters (5) (Electricity – Water – Gas)
C. Distribution Substation monitoring (3)
D. MV - LV line sensing equipment (2)
E. Pole Mounted Transformer (4)
F. LV feeder pillar (Panel board) monitoring (4)

These pillars are main elements to DSO for entering the world of IOT, a necessity for tomorrow's utility. Today's projects and proof of concepts demonstrate the impacts of IOT, testing new services and new usages to answer different needs which are expected to provide an added value for both the utility and customer. This orientation will DSO's.

"Digital services are great opportunities for DSOs to change working methods for a new efficient best practice. Such a decision will lead to a high level business model based on a new CAPEX / OPEX approach targeting higher performance, less cost, less risk and best customer services."

A. IOT (Internet Of Things)

IoT is becoming the main bone of smart grid communication that manages around 85% of wireless data which is small packets. As per best practice, IEG developed a hybrid technique based on the most famous LoRa LPWAN ship over the ISM band with a mix of "STAR + Mesh" features to get 100% reliability, security, scalability and wide coverage with no blind zones.

Making the LV grid smarter, safer and more efficient, IEG is helping the DSOs to implement latest techniques which is merged under one open architecture solution with the following benefits:

- IOT will enable an easy management of all electric equipment data or others irrespective of type, manufacturer and location.
- License free, No running cost as it is built on ISM bands.
- Remote energy metering consumption collection and automated billing.
- LV grid overview and status with near real time data and appropriate analysis on flow of energy as well as power quality.
- Accurate knowledge of loads and productions balance
- Support network analysis to manage impact of Distributed Energy Resources (DER).
- Optimized, scalable and flexible investments
- Complete cloud solution with minimal IT infrastructure and skills for DSO.
- Ease of use, an open platform and security of data.

IoT will allow proactive measures to build a high-level "Asset Management" tool that achieves optimum grid management in an innovative concept including AMI, secondary transformer substation monitoring & control, LV network monitoring, Outage management, power quality issues, handling assets life cycle and creating proactive decisions. It optimizes planned & unplanned network activities, operational actions, maintenance, energy management, predictive events & mobility solutions.

Data accuracy and consistency is a must for any Asset Management tool to optimize balancing among cost, performance & risk (ISO 55000) as well as reporting reliable results in KPIs form;

It is the need to have a time stamp of all interruptions (at the medium voltage & Low Voltage systems) with clear identification of affected customers to accurately report the regulator

regarding the quality of service. What is important in using such technology is the scalability of the solution and the better understanding of the network which will help DSO to take the right decisions, focused on the priorities, optimizing OPEX and CAPEX investments, adapted to DSO reality.

IEG IoT solution allows to integrate all energy assets under either SCADA Center, Standalone GIS, Google Maps or other irrespective of manufacturer. We recommend adopting this high level IoT equipment in order to recreate a new reality for an advanced infrastructure leading to quick results.
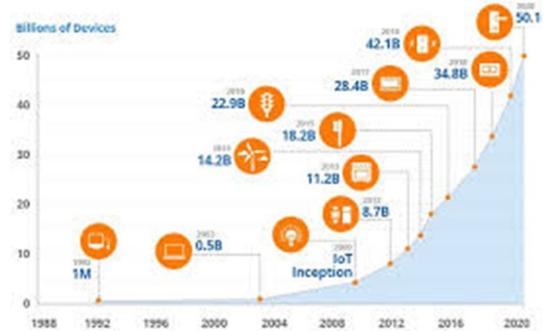
Technical Features of IoT Module

IEG selected reliable IoT modules based on LoRa Mesh that uses the ISM (Industrial - Scientific – Medical) bands that are internationally license-free & cost free.

The Wireless LoRa Pro modules are new series of upgraded networking wireless communication modules based on Semtech's SX127X chip and uses advanced LoRaTM spread spectrum modulation frequency hopping technology to achieve high sensitivity. The high penetrating power and long range communication distance are far superior to any other techniques, and have stronger anti-interference.

The "Mesh" modules can communicate to the gateway directly or indirectly using other nearby equipment as routers; data may jump over other modules to reach the gateway, with hand shaking to ensure data delivery; as a result, the network coverage reaches 100% with no blind zones.


In addition, IEG IoT modules are designed for high scalability allowing for a network with one gateway to hold up to 16,750,000 equipment. Using AES128 encryption, data security is assured to mitigate risk.

Based on the Mesh advanced features, DSO can adopt a multi-channel technique to avoid interference. DSO will reserve to each "Sub-Net" a separate channel to communicate with its

gateway and transmit data to main server either through GSM or Ethernet connection. Nearby or adjacent "Sub-Nets" will have different channels.

The system has a 40 channels capability, so physical site installation of IoT nodes of similar channels "Sub-nets" will be at a very far distance to avoid interference. In addition, the IoT node can be configured with different AES Encryption per "Subnet" to enhance data security.

- Compact Size, Easy to Install
- Long Range
- Low initial Cost
- Zero Running Cost
- Low Energy
- High Reliability, Mesh feature
- RS485 data management
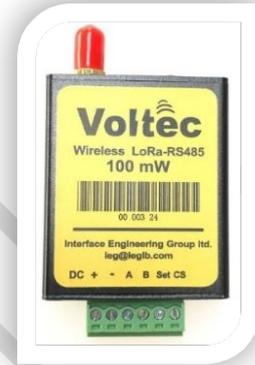
Features

- LoRa modulation, 40 channels
- Transmission distance in open area up to 15Km
- 433/470/868MHz (customizable)
- AES128 Data Encryption
- STAR- MESH working mode
- RS485 interface
- Push-Pull of data
- Sensitivity: -139 dBm
- Output power: 20mW, 50mW, 100mW, 1W, 5W

Applications

- AMI for electricity, water & gas
- Remote control
- Industrial Data Collection
- Home Automation & telemetry
- Access control system
- Energy management
- Demand side management
- Substation monitoring
- MV & LV Network monitoring

Data Base Management

1. All Backend Server application use multithreading technology which enables simultaneous communication with all connected networks.
2. Data communication between all network components is encrypted (AES128).
3. Backend server applications are developed using Microsoft visual studio.net.
4. All Databases are stored on Microsoft SQL Server.

Dashboard

Adopt a user friendly geospatial dashboard to allocate sensors & meters, and detect abnormality in case of failure or power quality issues. It is best practice for operation, maintenance & asset management.

Mobility

System design allows for simple data sharing specially for a mobility solution to share essential information in the hand of site engineer. This will improve fault attendance, reduce customer minutes lost as well as reduce cost.

B. Smart meters

IEG provides advanced metering infrastructure (AMI) that can offer necessary information to help DSO to improve billing, energy efficiency and bring other operational benefits that will help utilities manage costs more effectively and improve customer service. AMI improves the process of managing demand for natural resources.

1. Compliance Criteria

Advanced system takes into consideration the following:

1. Capture energy consumed in a multi-tariff function
2. Challenge Network topology and ensure 100% network coverage
3. Support Net-Metering
4. High Scalability
5. Flexible Connectivity
6. High Reliability
7. Adopt latest standards for metering equipment as relay control, fraud detection…
8. Outage management
9. Improvement of Key Performance Indicators
10. Accurate analysis, statistics and reporting
11. Automated processes as for example billing that accelerates cash flow
12. Demand Side Management platform
13. Enhance Health Safety & Environment for employees

2. Detailed Solution

Smart Meters are equipped with serial data ports (RS485) to allow multiple meters' management from one communication module at each service point instead of fitting a separate modem at each meter; as a result, a higher ROI can be achieved.

The IoT module at each service point will communicate through the mesh network to deliver data to the main server for further action. The system design will look like:
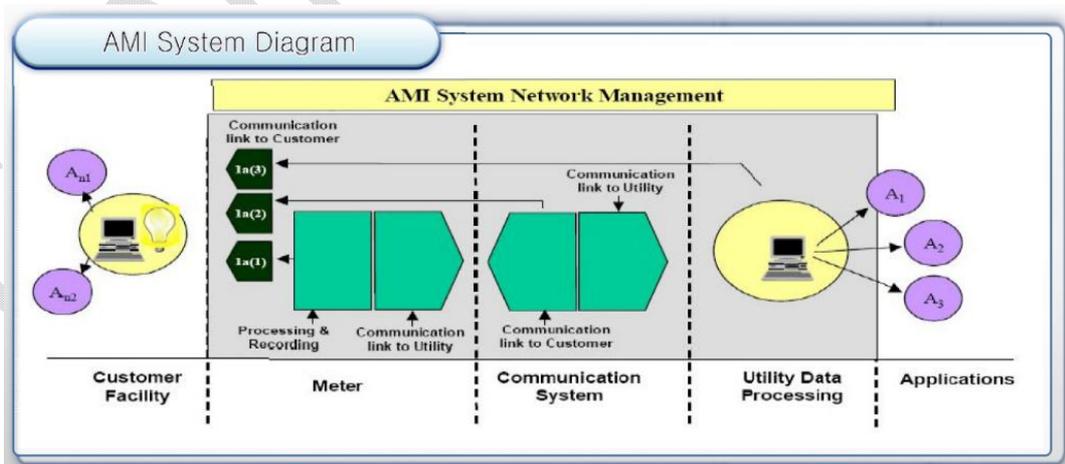
As a result:

1. Efficient and timely service-problem identification gives a DSO the ability to predict and pre-empt outages eliminating the need for the customer to call and report an outage.

2. Proactive maintenance, triggered by improved visibility of the network operation and performance, can lead to avoidance of outages due to failed equipment.
3. By installing intelligent, local monitoring system with integrated applications, utilities can also benefit from real-time, autonomous decision-making, where data can be shared across a variety of devices and platforms in a smart grid.
4. DSO will help to reduce carbon emissions.

C. Distribution Substation monitoring

Most of the available techniques are built for medium voltage system using DMS (Distribution Management System) based on SCADA whereas other assets and specially the low voltage were left behind due to high investment cost compared to return and mainly due to lack of technology. Today, new technologies are available which allows DSO to step further in a high ROI.

CAPEX Optimization

Selection of technology is affecting the utility business for long period of time as it strongly affects its budget, CAPEX and OPEX expenditure; however, once the information is available to higher management people, it will have no doubt that IoT will dominate other technologies in the market for this specified job, as seen in the side chart based on real figures.

The chart shows clearly that IEG SAMIO solution with automated wireless IoT can cover the medium voltage network and the low voltage network to complement SCADA efforts achieving best practices in high performance, less risk and low cost.

Optimization Between SCADA & SAMIO IoT
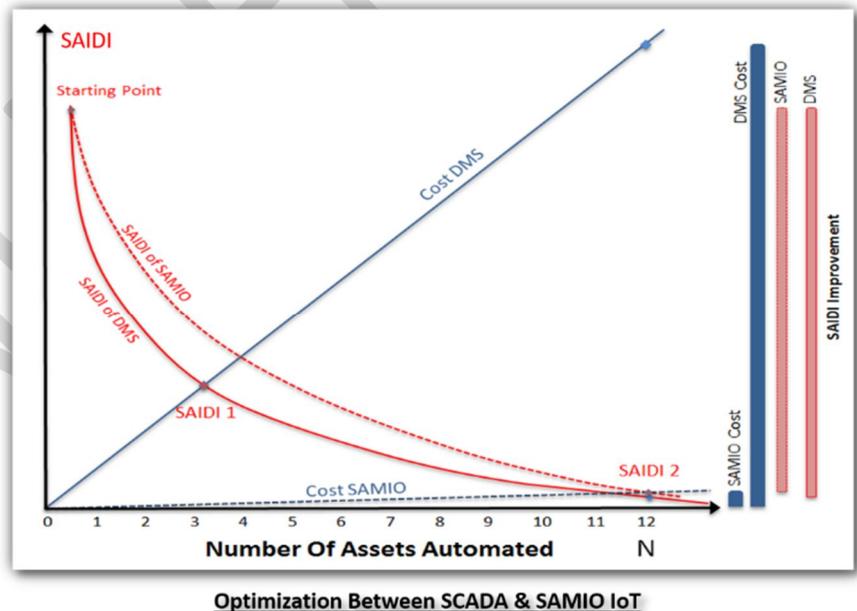
For a typical substation layout, and based on all above analysis, IEG can help to cover the following critical points in a distribution substation and tackles the following:
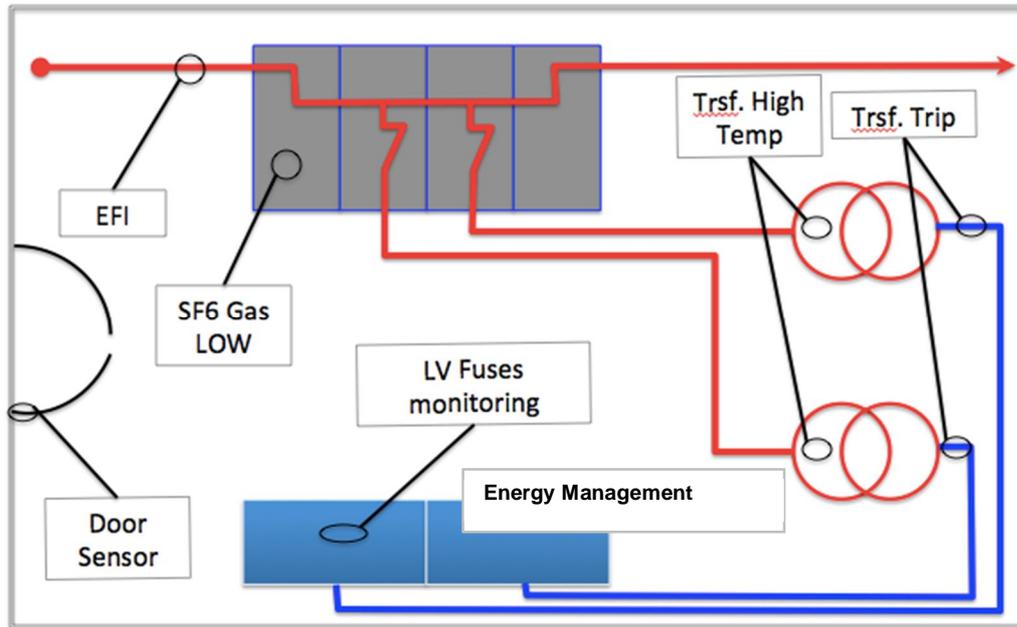
1. Link all data of a substation & link them to mesh network.
2. Transmits EFI status, instantaneously, so DSO can identify the portion of faulty cable and facilitate isolation and restoration.
3. Monitors Energy flow as V, A, P, Q, PF, THD… to dozens of circuits
4. Reports transformer tripping, MV breaker trip, LV fuse trip, overload, overvoltage / Under voltage,
5. Conveys "Door Open" alarm to control center to manage access control / fraud.
6. Transmits SF6 "Gas Low" alarm signal of a ring main unit.
7. Transmits Partial discharge alarm as part of a proactive strategy.
8. Transmits transformer high temperature alarm signal…
9. Transmits LV breaker trip or low voltage fuse(s) blown.
10. Detect over-temperature of Low Voltage cable termination to predict LV faults and mitigate any risk of fire especially in urban areas.
11. Ambient temperature measurement.
12. Relative humidity measurement.
13. Transmits any other alarm as Smoke detection, Hydrogen detection…
14. Monitors & Reports Partial Discharge
15. Control capability for two power loads.

D. MV- LV line sensing equipment

Attributes on MV-LV Over-Head Line Network that can be collected in near-real time:

- Transformer Over-pressure
- Transformer High Temperature
- Trip detection of transformer, breaker / Fuses
- Overload / Unbalanced Load
- Cabinet Door Monitoring
- Ambient Temperature Measurement
- Voltage, Current, P, Q, PF, F, THD, …
- Flicker, Harmonics 1st - 63rd
- Crest Factor, demand record, Max/Min

- Earth Fault Indicator alarms are instantaneously reported.
- Line Data is monitored in near real time.
- IoT network allows grouping of thousands of sensors to same SAMIO gateway →

Enlarging Smart Grid coverage

Local RF signals

GSM / IoT To Server
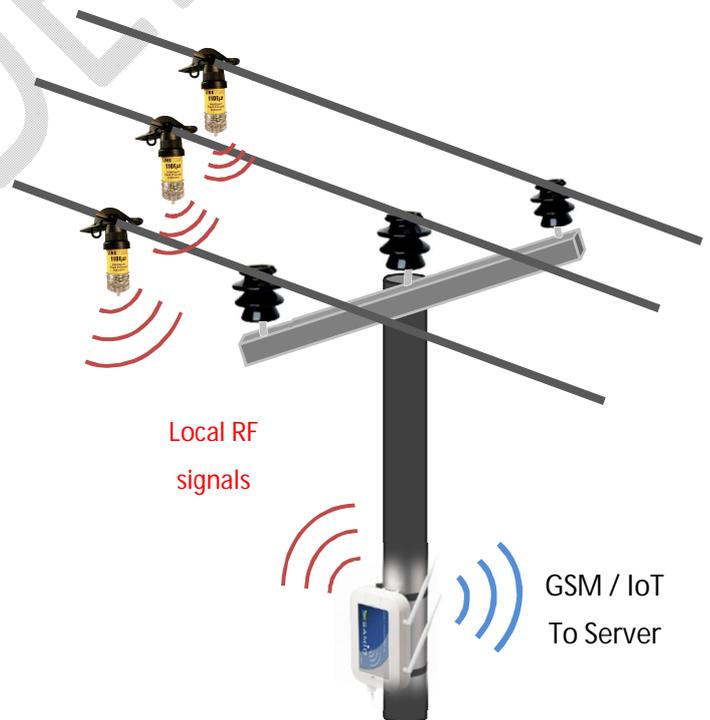
Attributes on LV Line Isolated Cable Network + Pad Mounted transformer that can be collected in near-real time:

IEG developed a unique "ALL In One" sensor dedicated to three phase insulated cables named "Smart Energy Monitoring – SEM". This unique sensor will be attached to the LV cable at any location under a mesh network to be a part of the Distribution Automation scheme (DA) to monitor energy flow as well as control power quality. The sensor can be fitted easily using split type CTs to reduce installation time as well as directly be connected to the same mesh network that is used for other sensors as KWH meters, water meters…

SEM is an "ALL IN One" sensor that integrates the following in one compact outdoor type enclosure:
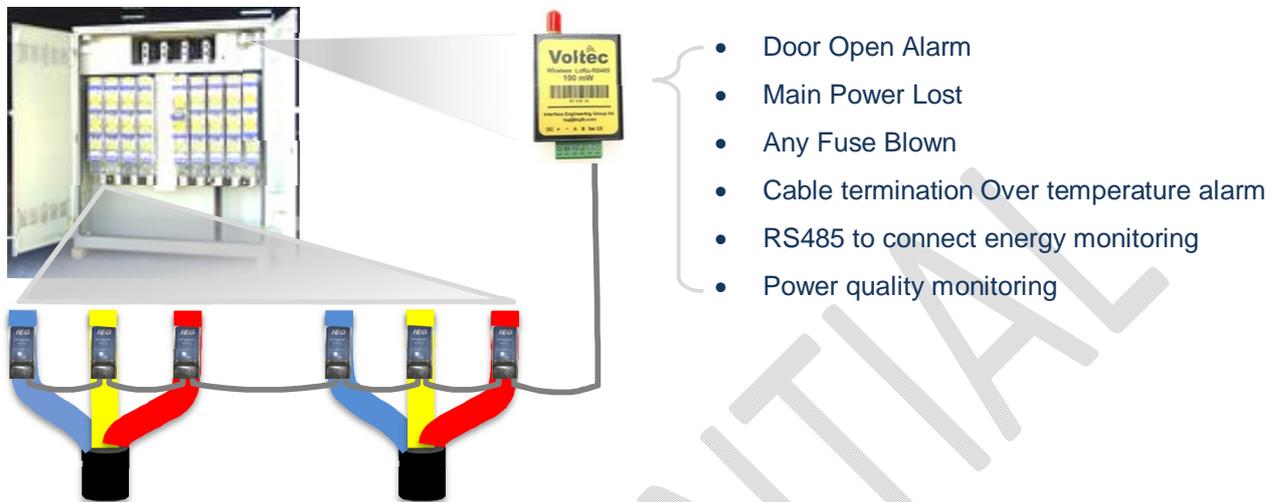
- ✓ Power supply from any of the 3 phases;
- ✓ IoT mesh module communication
- ✓ Full Energy metering unit for monitoring purposes
- ✓ Power quality surveillance with push alarm feature in case of any bypass of threshold limits
- ✓ Records of main elements for a period of time
- ✓ Lip on cable using split type CT.
- ✓ Class 1 accuracy measurement
- ✓ IP67 rated

E. LV feeder pillars

LV panels can be fitted with same IoT wireless mesh IoT communication to integrate that asset among the network as a whole system. Data captured in LV panel using many techniques will equally be routed to server the same way.

Functionality on LV Panel with fuse protection type1 (contactless solution):

- Door Open Alarm
- Main Power Lost
- Any Fuse Blown
- Cable termination Over temperature alarm
- RS485 to connect energy monitoring
- Power quality monitoring

Schematic Diagram showing Functionality on LV Panel with Smart Short Link (SSL) that operates in conjunction of Fuse protection type 2 (Physical connection):

To Server
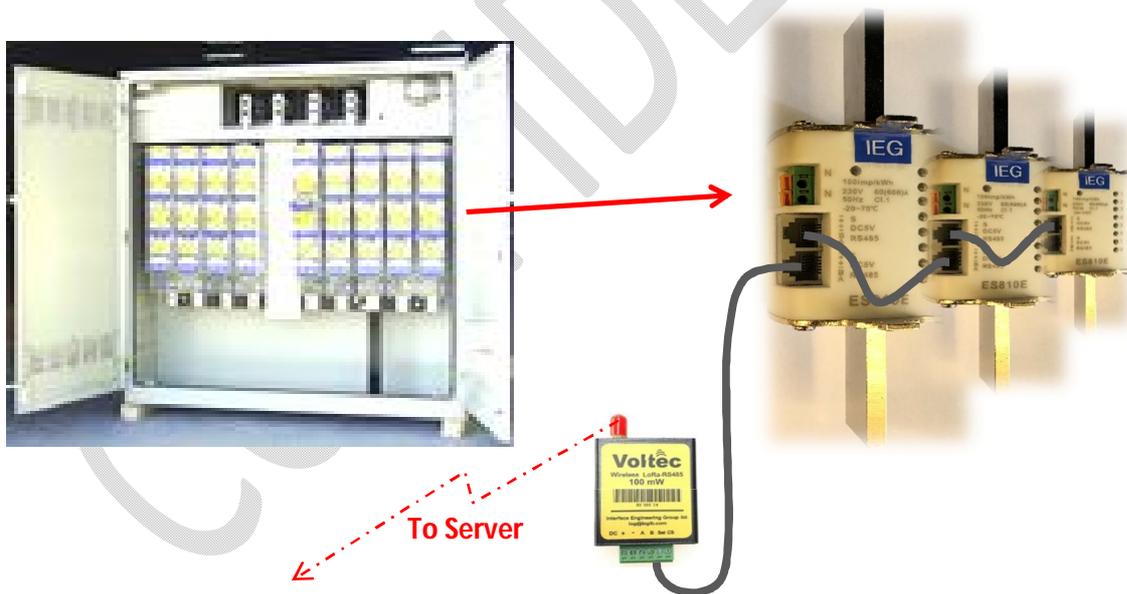
Like MV, when a low voltage breaker trips, or a fuse blows, or a high cable temperature alarm is generated, or a door is kept open, or a street light cabinet alarm is generated, the utility operator will be notified instantaneously. The emergency team will be directed to the exact location of event for necessary action. It is the proactive way to serve the community without the intervention of the customer to call the "Call Center" for help!

Schematic Diagram showing Functionality on LV Panel with breaker protection type 3 (split CT connection):
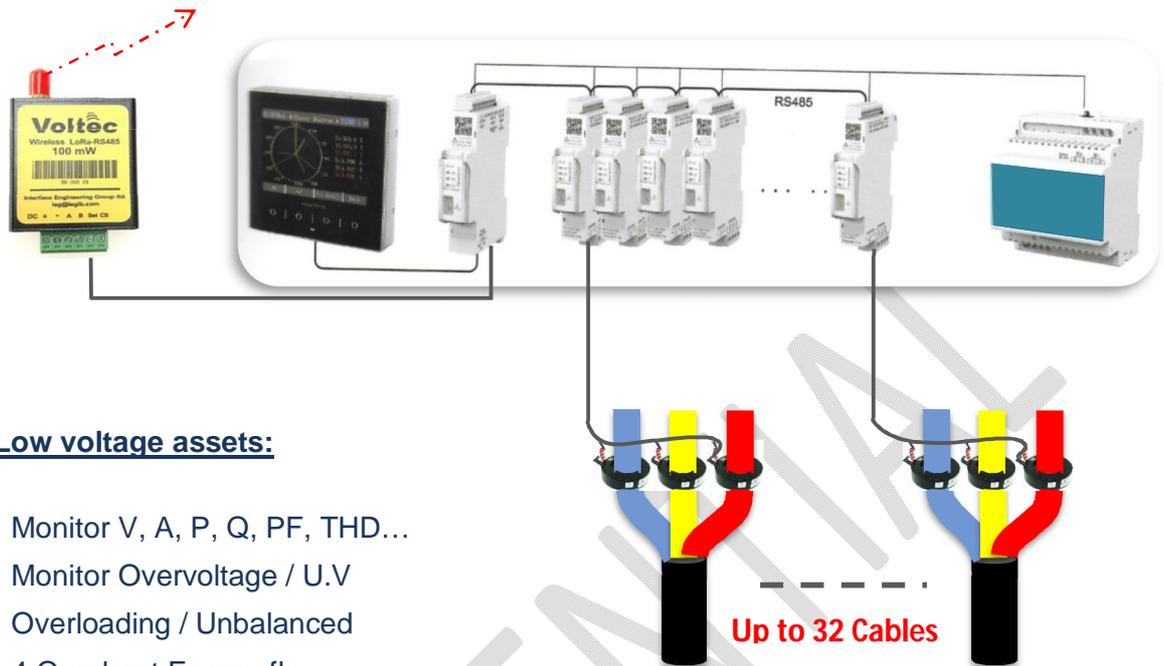
At Low voltage assets:

- Monitor V, A, P, Q, PF, THD…
- Monitor Overvoltage / U.V
- Overloading / Unbalanced
- 4 Quadrant Energy flow
- Renewable energy impact…
- Control / trip breaker
- Local Human Machine Interface

A significant reduction in time management, for faults attendance, is achieved due to the decentralized option of low voltage emergency teams. This fact will enrich the system keeping full control & energy management available.

The saving in time and fast isolation of faults will improve SAIDI and satisfy the customers knowing that the utility will not miss a single event whatever it is small or big.

Finally, IEG can add control units that operates under same IoT mesh communication in order to switch ON / OFF for specific assets under specific request like "Demand Management" requirement.