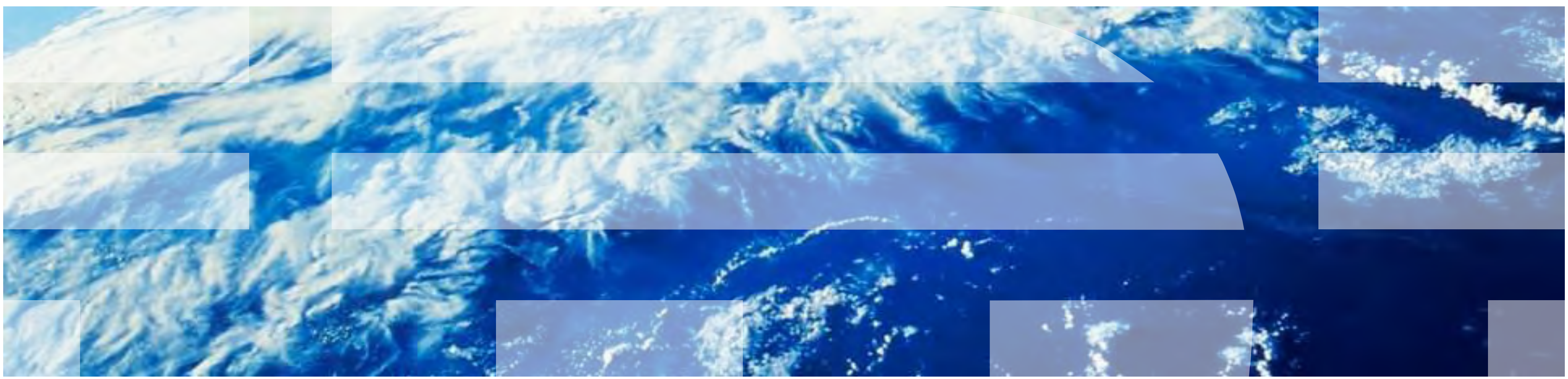
Nis Jespersen (nis@dk.ibm.com)

Smart Grids

Experiences from **DONG Energy** and **EnergyAustralia**



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Presenter Background

Accredited IT Architect within **IBM's Energy & Utilities Global Center of Competency**

Educational Background

- Master of Science (MSc) in Software Engineering
- Bachelor of Business Administration (BBA) in Marketing and Management

Experience

- 18 months at **DONG Energy**, Copenhagen, Denmark, as an IT Architect.
  The "**SmartPIT**" project leveraged decentral measurements in the distribution grid and sophisticated automated load flow calculations, enabling grid planners to better direct reinforcement investments.

- 17 months at **EnergyAustralia**, Sydney, Australia, as an IT Architect.
  The "**Distribution Monitoring & Control**" project supported EnergyAustralia to deploy in excess of 12,000 RTUs in their distribution grid over a period of 5 years.

- Various Smart Grid engagements, formulating strategies, building business cases and analytics for clients including Fortum, Eandis, Country Energy, Energinet.dk.

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Agenda

1. IBM’s **point of view on Smart Grids** – enabling multiple streams of value from technology investments.

2. How **EnergyAustralia** can exploit hidden capacity in their low voltage grid by detecting which phase customers are connected to. A case of correlation between AMI and grid sensor data – and massive computing power.

3. How planners at **DONG Energy** are squeezing out capacity of their aging distribution grid without compromising power quality. A case of advanced load flow analysis and complex load pattern statistics.

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A Smart Grids are…

INSTRUMENTED

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INTERCONNECTED

MPLS 3G

GSM GPRS Fiber

PLC/PLN Wimax

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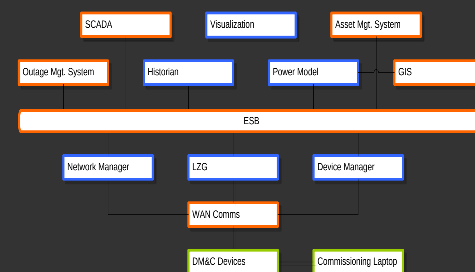

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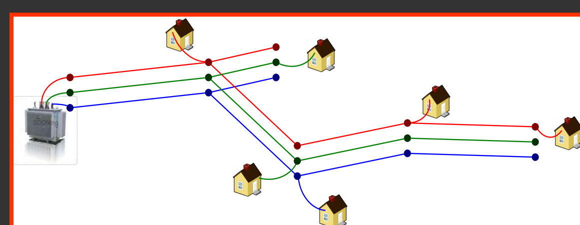
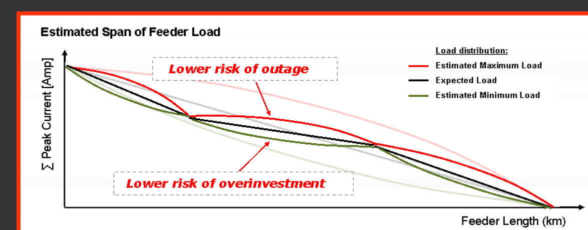
INTELLIGENT





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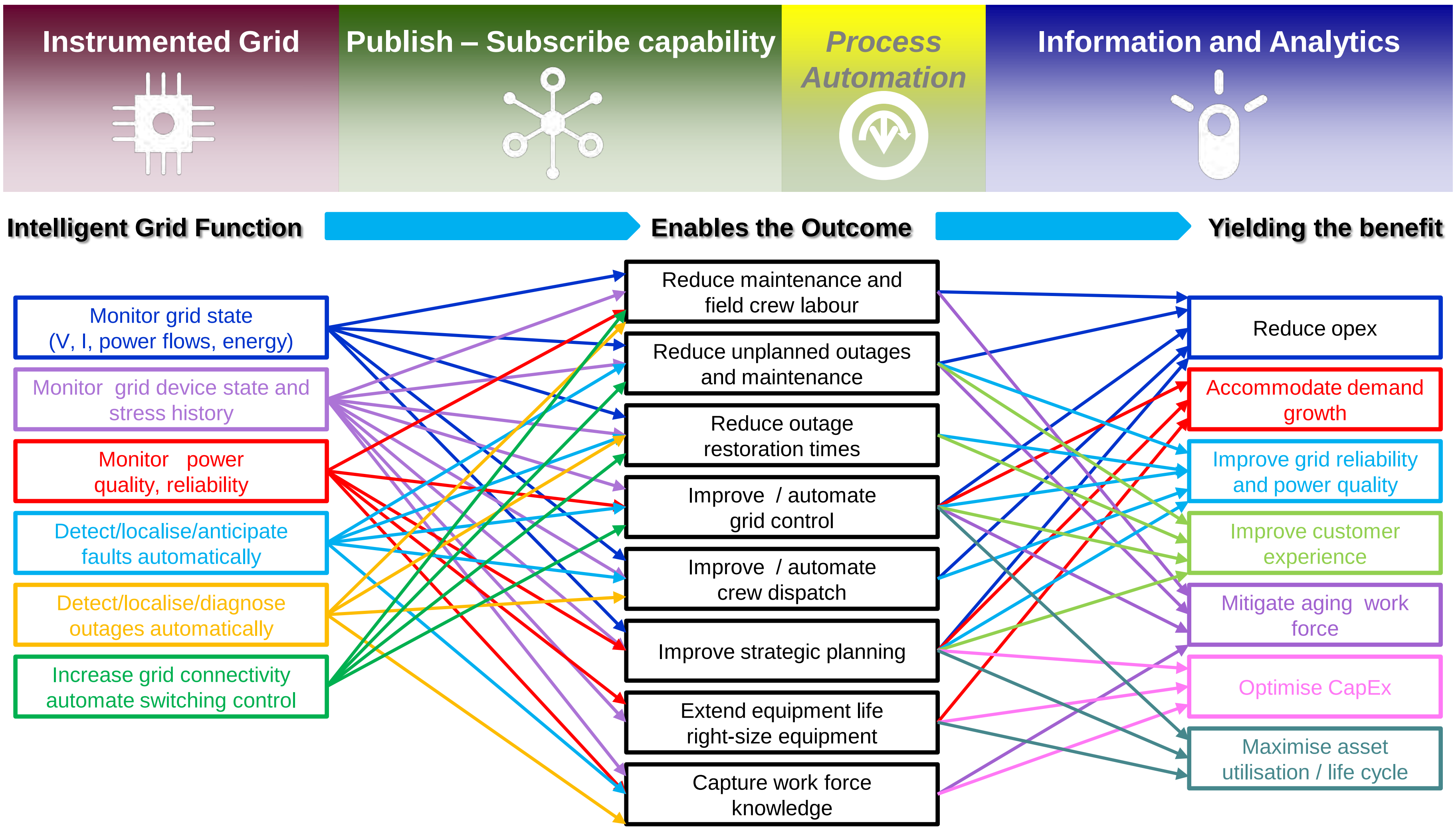
Smart Grids are about extracting multiple value streams from technology investments



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Smart Grids require a common platform for information sharing to create full value

- Technology investments should deliver multiple streams of value to the utility

- So smart grid architecture should facilitate multiple flows of information to and from the network
  - –avoid the development of islands of automation and silos of information
  - –SCADA/EMS/DMS should not be hub of all network data

- Enabling this open exchange of information requires
  - –Use of shared common reference information (e.g. grid topology)
  - –Application of standards for data exchange

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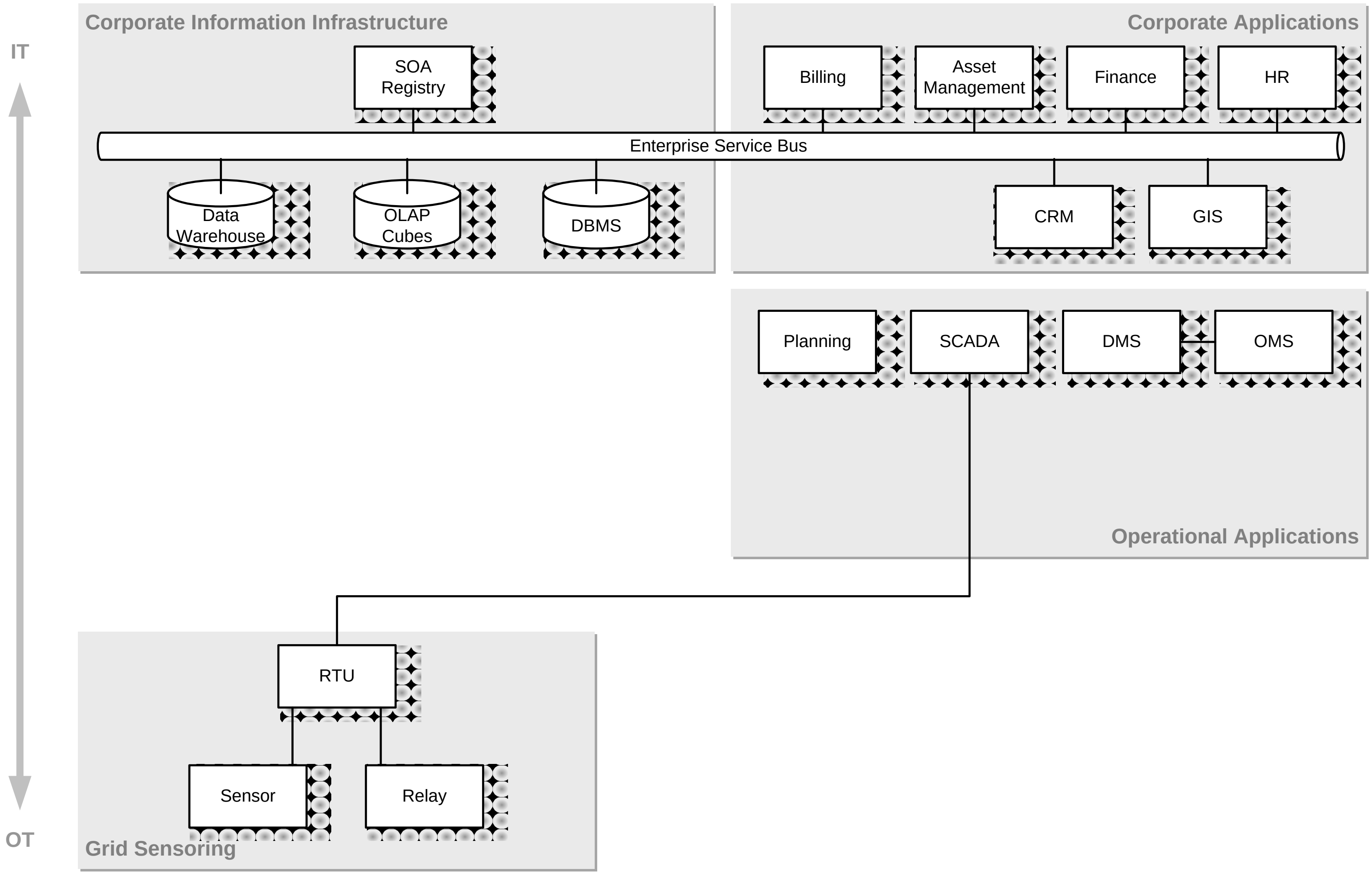
Old, Siloed Operational Architecture



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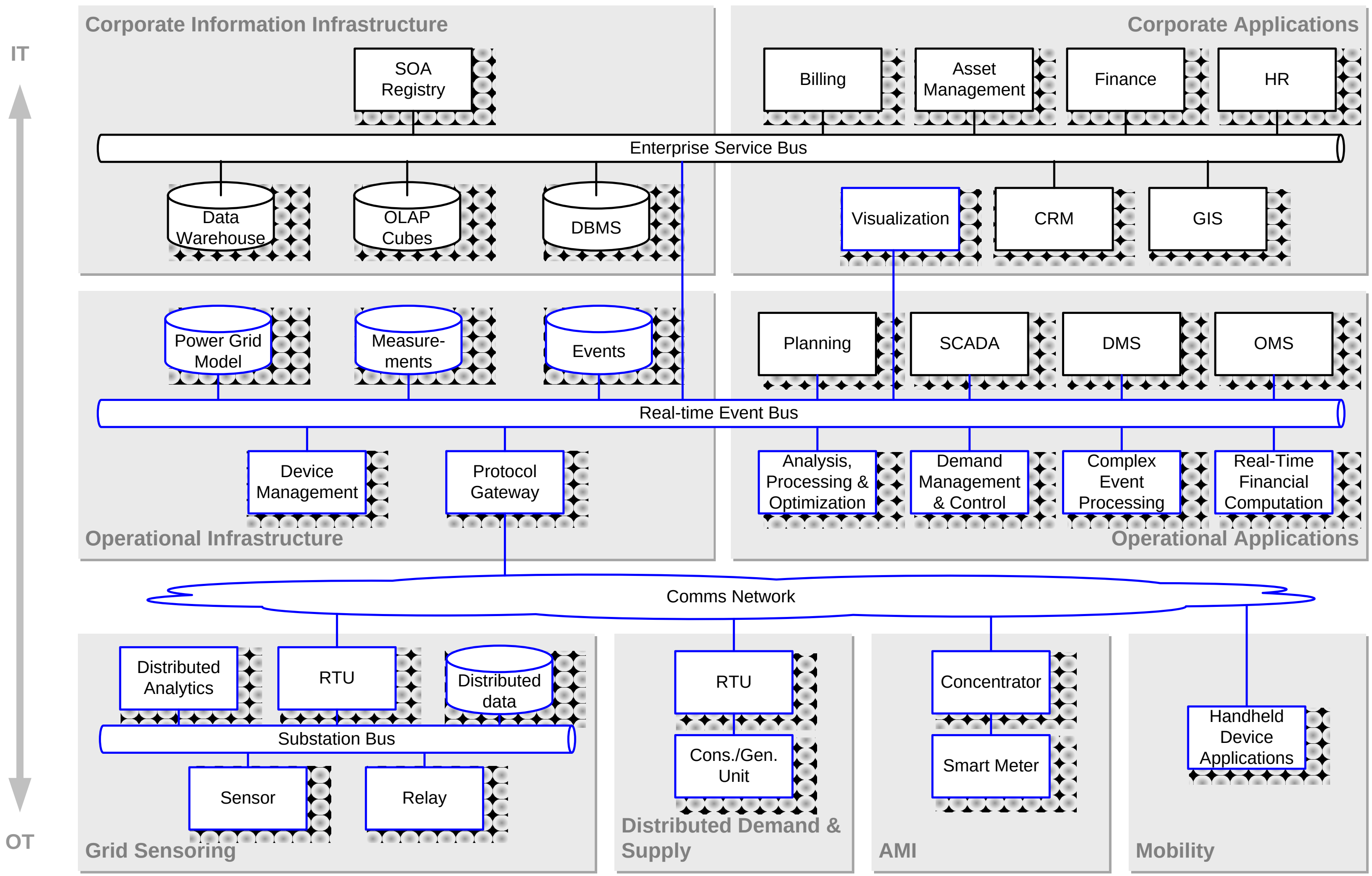
New, Interconnected Architecture



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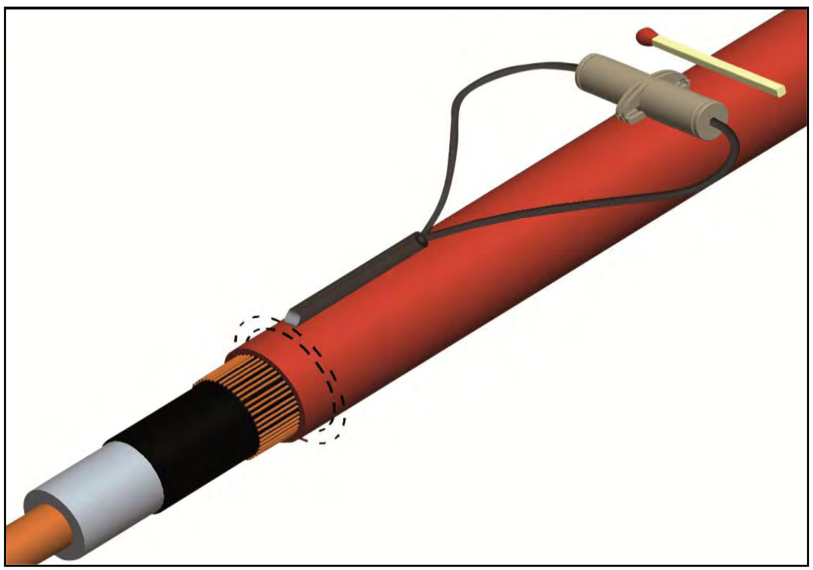
DONG Energy "SmartPIT" Introduction

In 2006 about 5% of DONG Energy's secondary substations were equipped with Powersense sensor devices, providing Network Operations distribution-level fault location and remote switching capabilities.

The goal of the SmartPIT project was to also utilize the rich set of new data for planning purposes.



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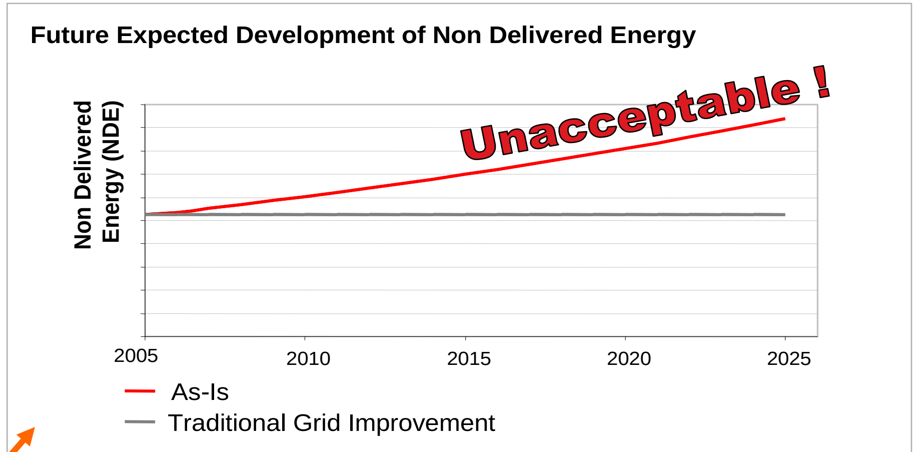
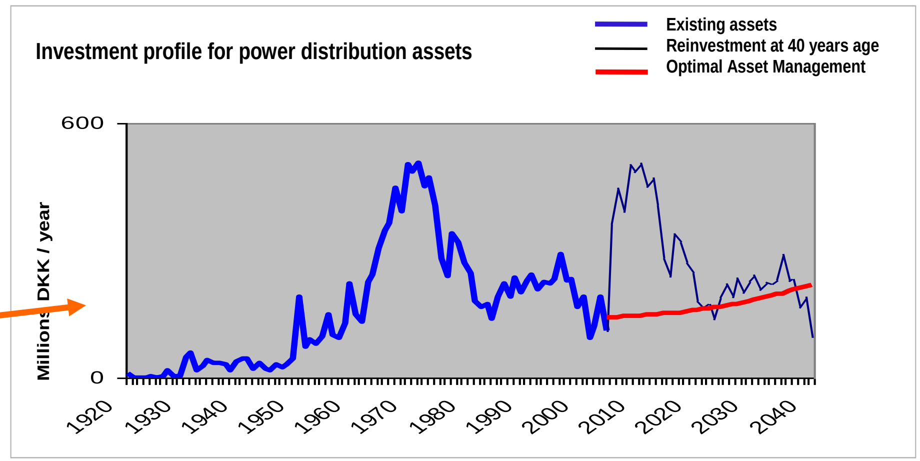
DONG Energy

- The DONG Energy business case was driven heavily by two factors:
  - –Maintenance of an aging grid which is very **expensive to reinforce**
  - –Expensive regulatory **penalties for outages**
- By understanding better where and when power is flowing, the DONG planners can make less conservative assumptions, allowing higher utilization of assets without compromising power quality.
- Thus balancing the trade-off between:
  - –Preparing for increased consumption, vs.
  - –Postponing unnecessary capital investments





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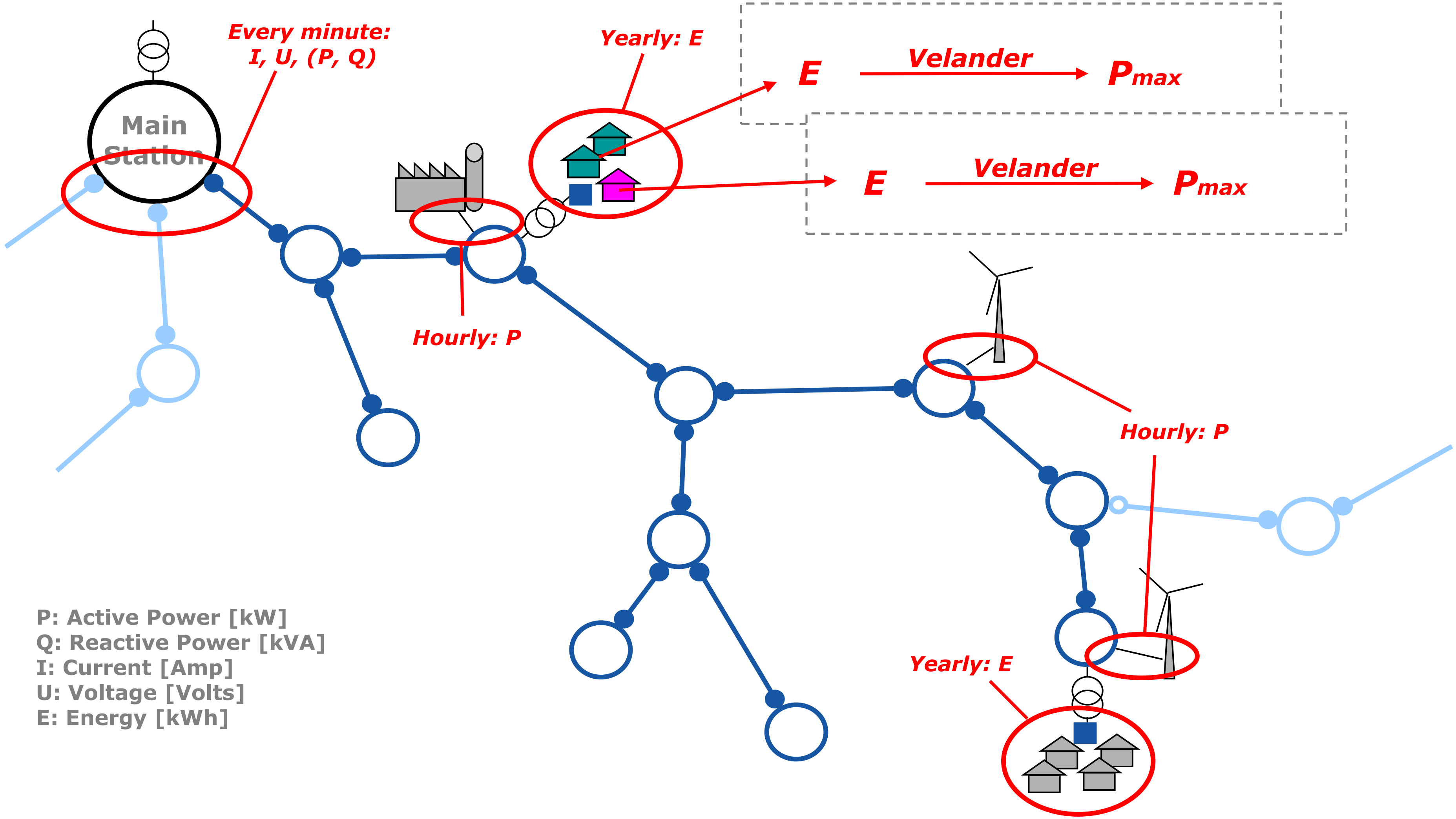
Grid Planning With Previous Data Sources



P: Active Power [kW]
Q: Reactive Power [kVA]
I: Current [Amp]
U: Voltage [Volts]
E: Energy [kWh]

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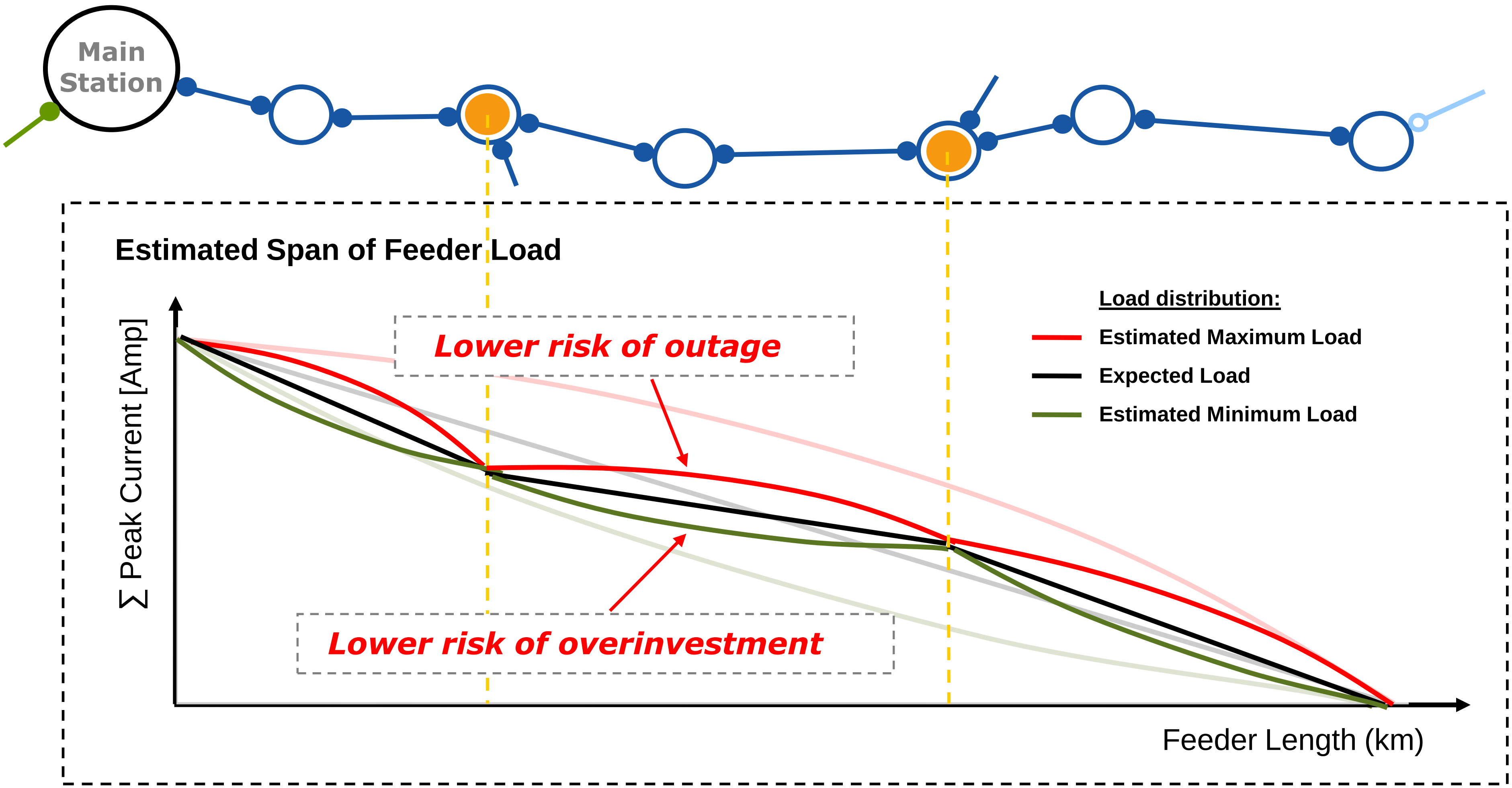
Optimizing by Measurement



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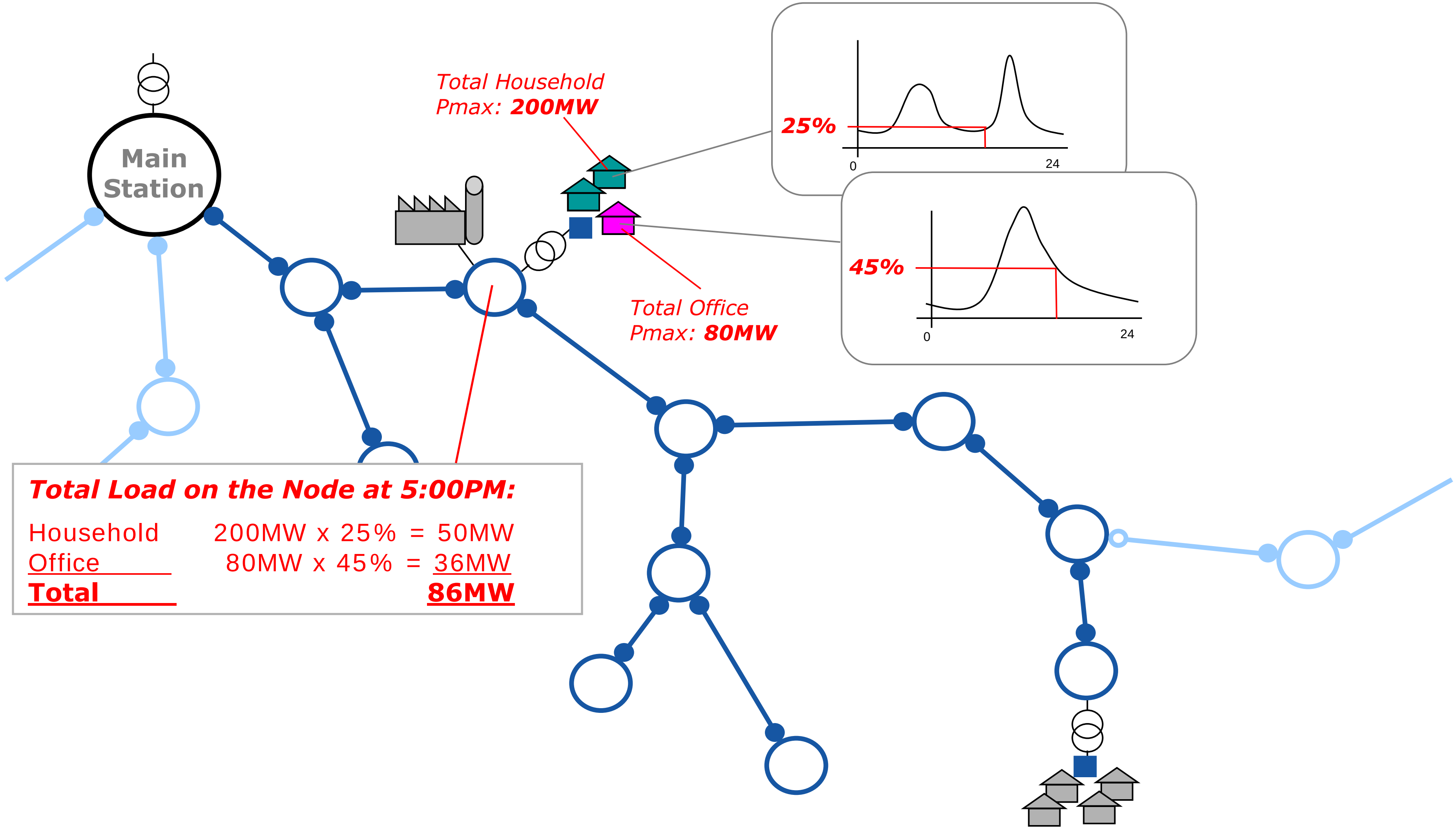
Optimizing by Calculation



Total Load on the Node at 5:00PM:

Household	200MW x 25% = 50MW
Office	80MW x 45% = 36MW
Total	**86MW**

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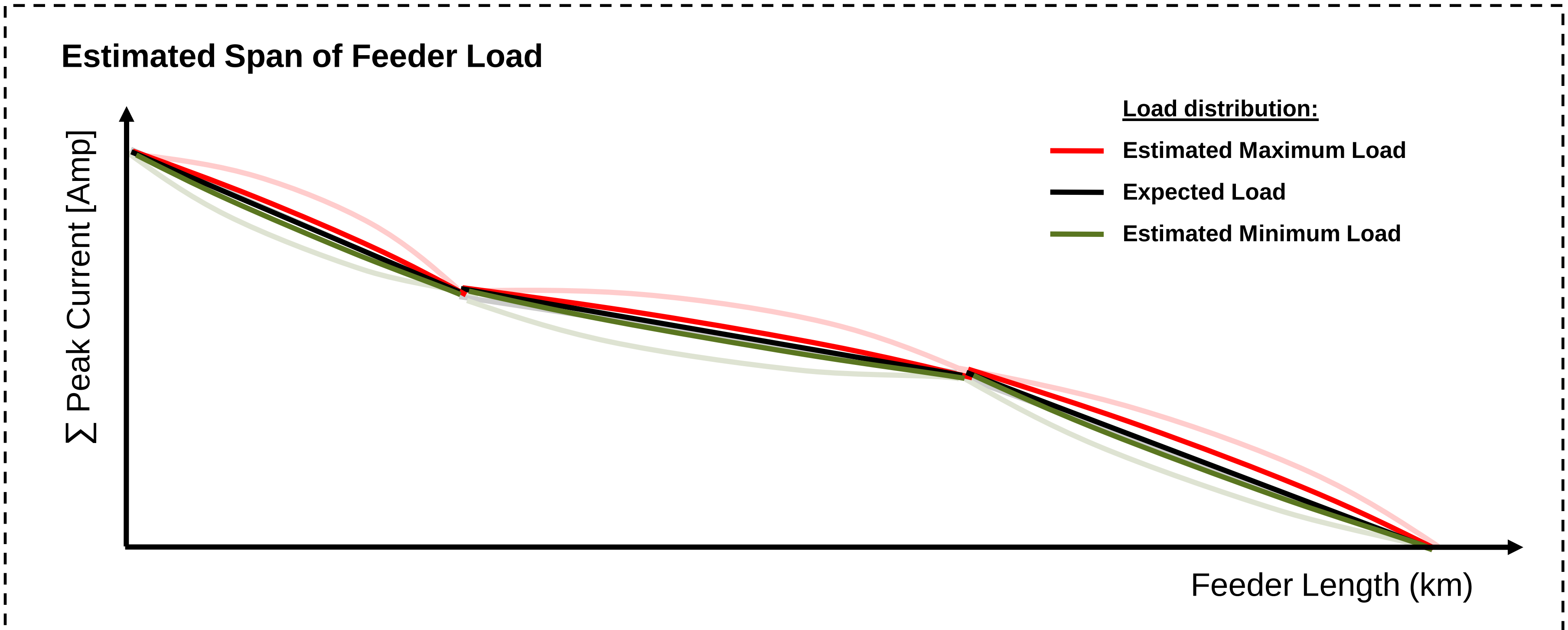
Optimizing by Calculation



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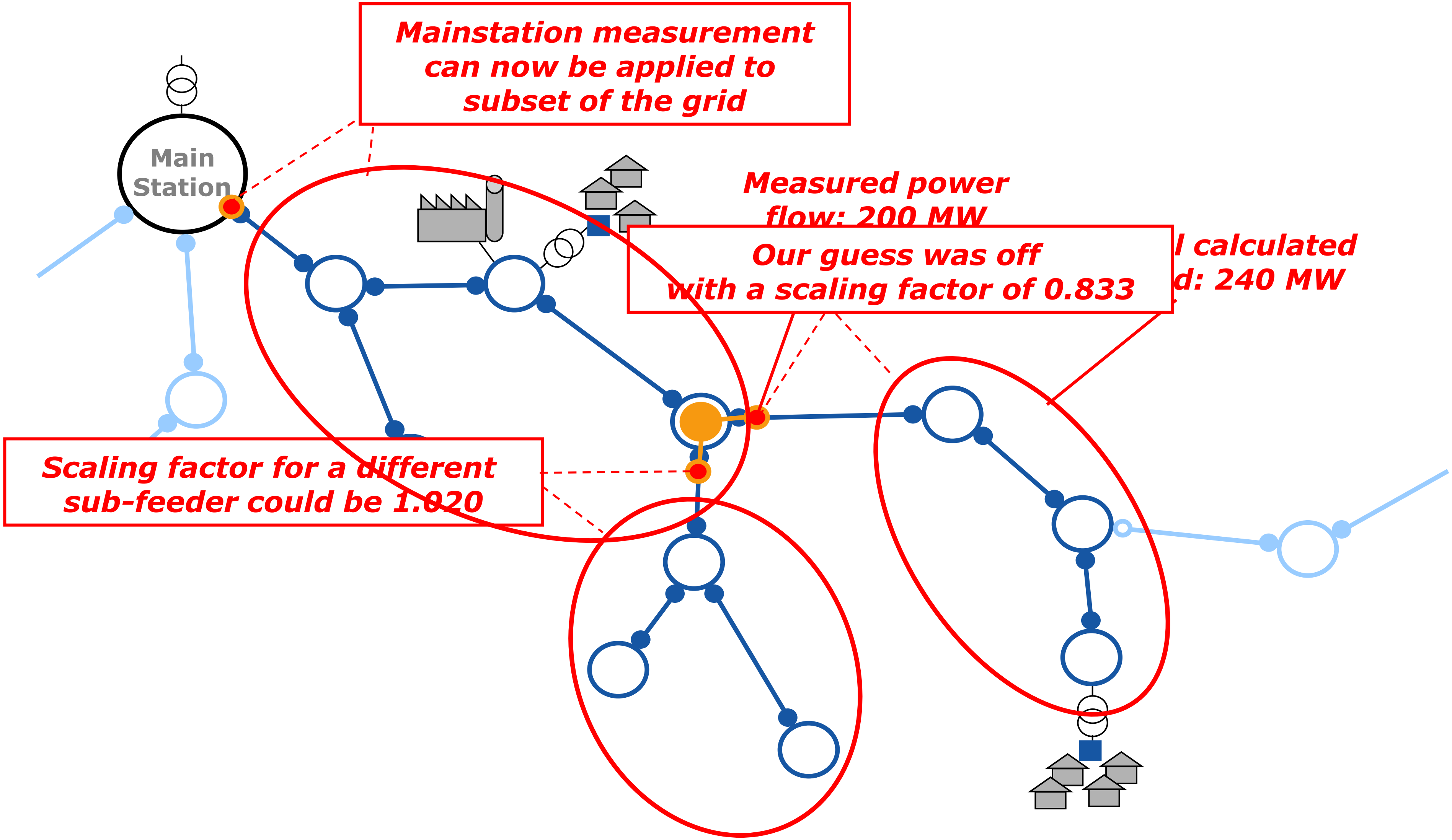
The Synergy Between Measurements and Calculations



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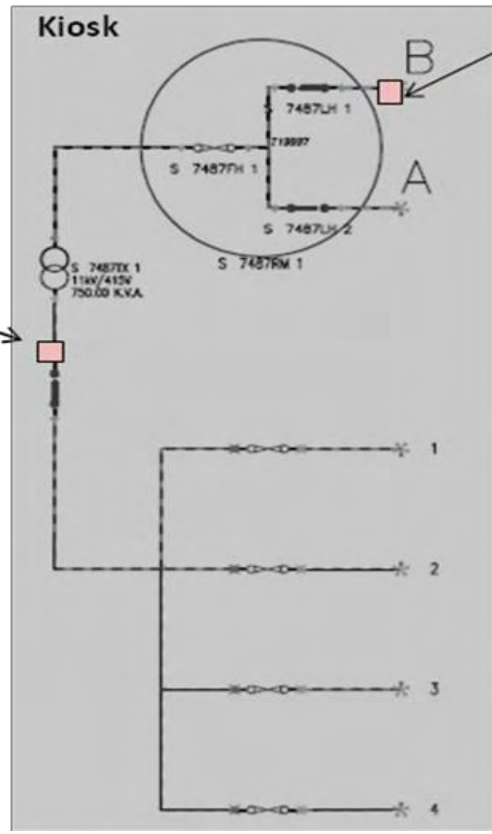
Previous Low Level of Instrumentation on the Distribution Network.



Maximum Demand Indicator

Measures only 1∅
current to +/- 20% at
Transformer, manually read
every 6 months

Earth Fault Indication

Mechanical flag drops with the presence of
an earth fault, manually used to restore
supply and manually reset

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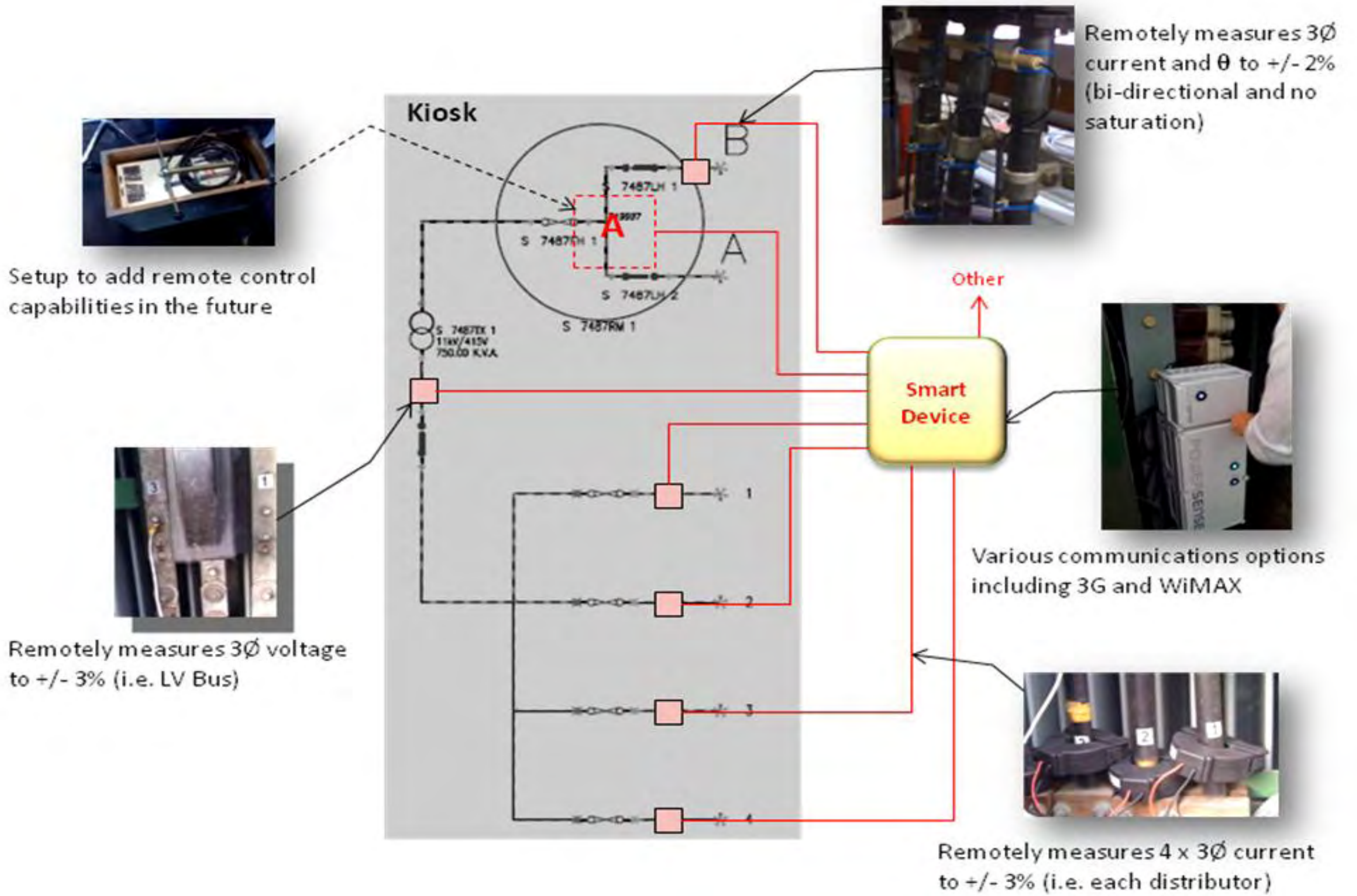
Advances in Technology Now Allow Cost-Effective Instrumentation of the Distribution Network.



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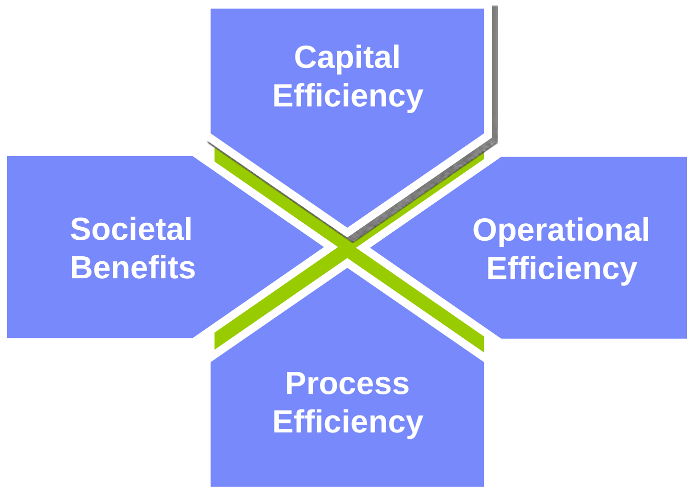
Business Benefits

- Ability to defer reinforcements on the network due to a more accurate understanding of the load distribution
- Avoided costs of installing & reading MDIs (Maximum Demand Indicators) & carrying out load surveys



- Increased service reliability
- Potential carbon footprint reduction as a result of greater network operating efficiency

- Operate closer to network limitations
- Reduce facility overload, voltage problems, and problematic switching actions to improve reliability
- Ability to monitor and analyze power quality at feeder level
- Ability to assess and manage new distributed generation and load

- Faster Identification of fault location & fault type
- Reduced time and costs associated with fault location and service restoration
- Faster customer power quality investigations
- Reduce outage truck rolls

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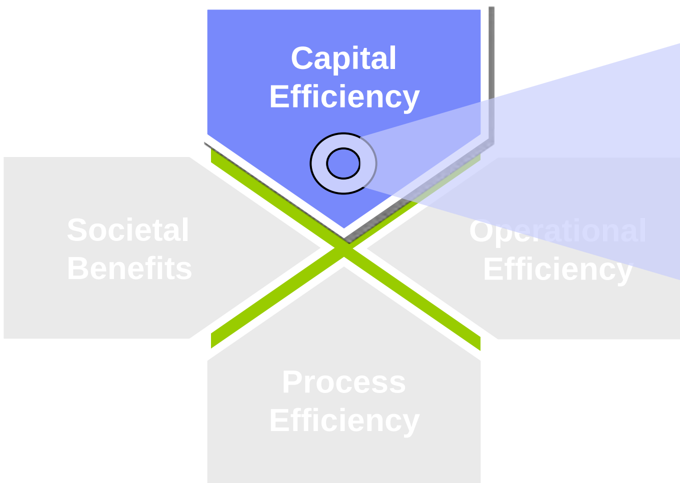
Capital Efficiency Benefits



- Ability to defer reinforcements on the networks due to a more accurate understanding of the load distribution
- Avoided costs of installing & reading MDIs (Maximum Demand Indicators) & load surveys
- Dynamically rating MVLV transformers to help defer capital investments

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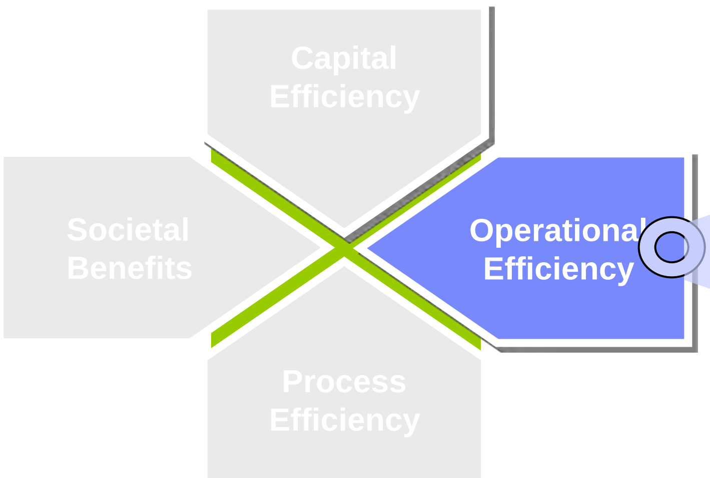
Operational Efficiency Benefits



- Operate closer to network limitations while making informed operational decisions that affect guaranteed service contracts, quality-of-service goals, and emergency response
- Reduce facility overload, voltage problems, and problematic switching actions to improve reliability
- Ability to analyze phase loading (on LV side)
- Ability to monitor and analyze power quality at feeder level
- Increase revenue by improving grid throughput, reducing technical loss
- Ability to assess the impact and continually manage new distributed generation and load

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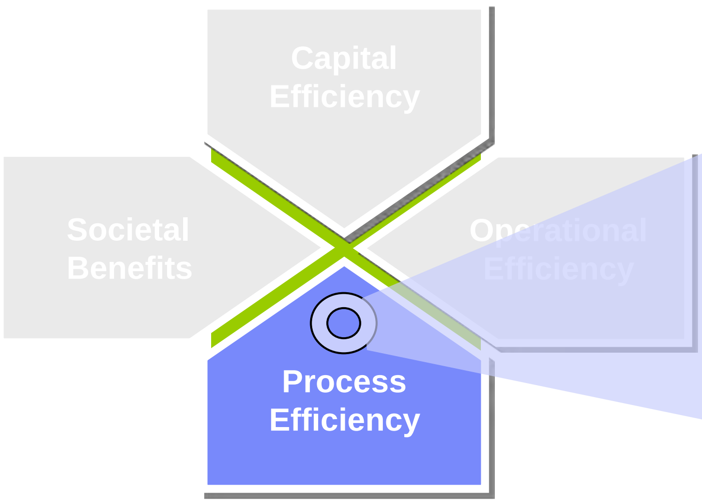
Process Efficiency Benefits



- Faster Identification of fault location & fault type
- Reduced time and costs associated with fault location and service restoration
- Inbound outage call management; identify and reduce outages and false power outage calls - Better and faster response to customer queries
- Faster customer power quality investigations
- Reduction in costs associated with investigating new connection requests
- Reduce outage truck rolls
- Improved network planning process based on richer data

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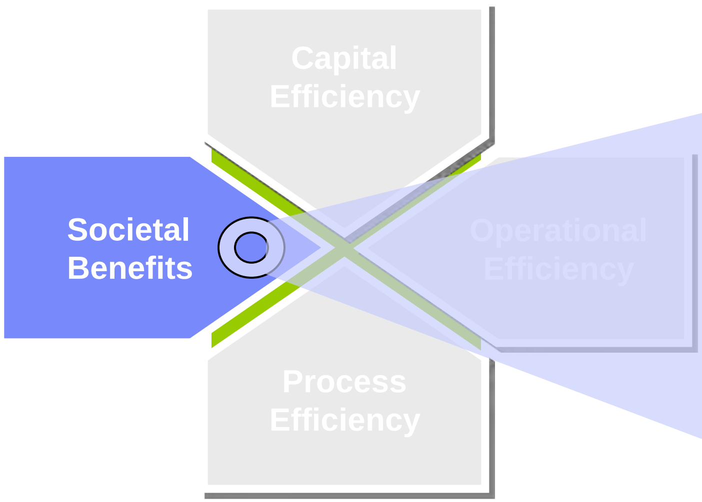
Societal Benefits



- Potential carbon footprint reduction as a result of reduction in network losses
  - by knowing where exactly to place network assets such as transformers and capacitor banks.
  - by sharing the load evenly among the network components such as feeders and distributors
- Ability to assess the impact and continually manage new distribution connected generation and load, for example: zero carbon homes, electric cars and distributed generation

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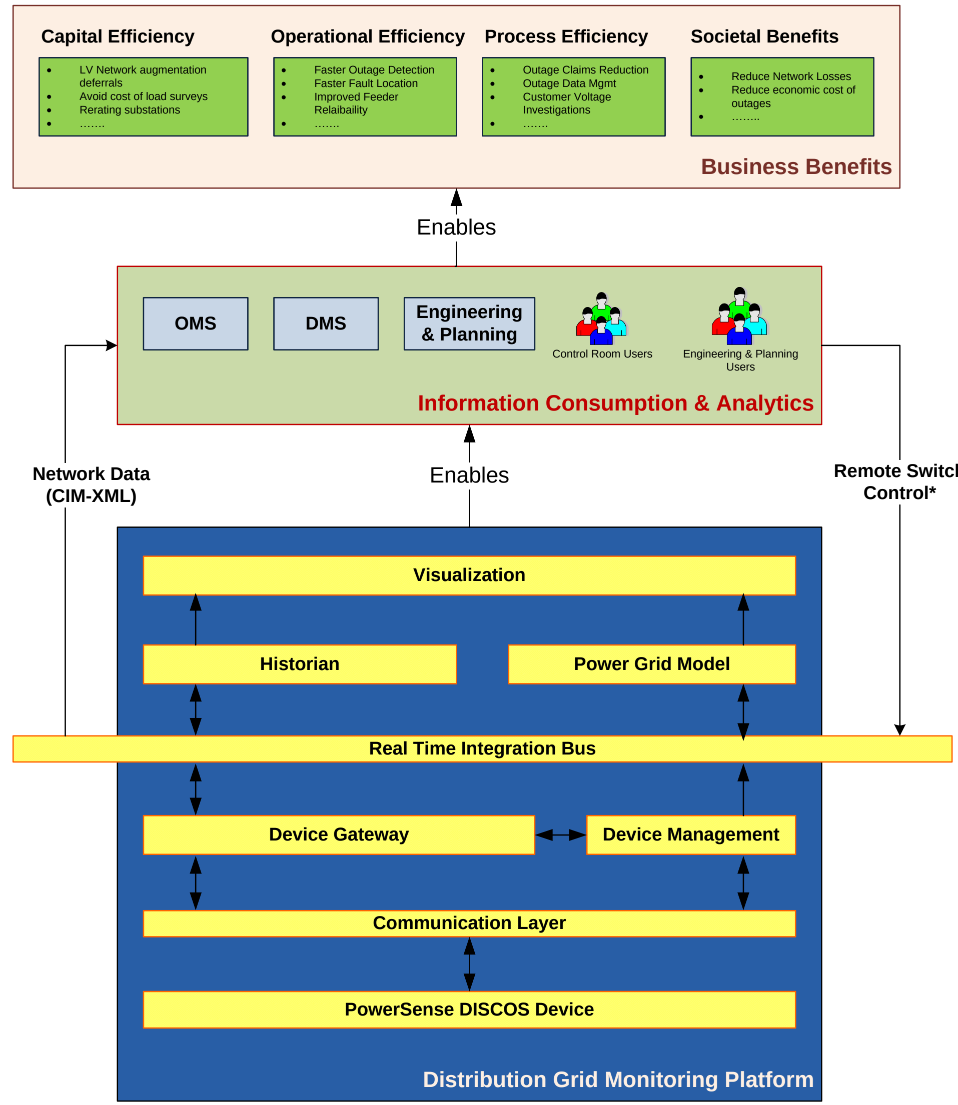
IBM delivered EnergyAustralia's DM&C Solution based on the CIM standard

- Solution gives access to grid power quality information through a IEC-61970 based interface over real time integration service bus.
- This is supported by data storage facilities for operational facts and grid connectivity meta data.
- For human users a Visualization interface is provided.
- Many business benefits are enabled through integration with other grid applications



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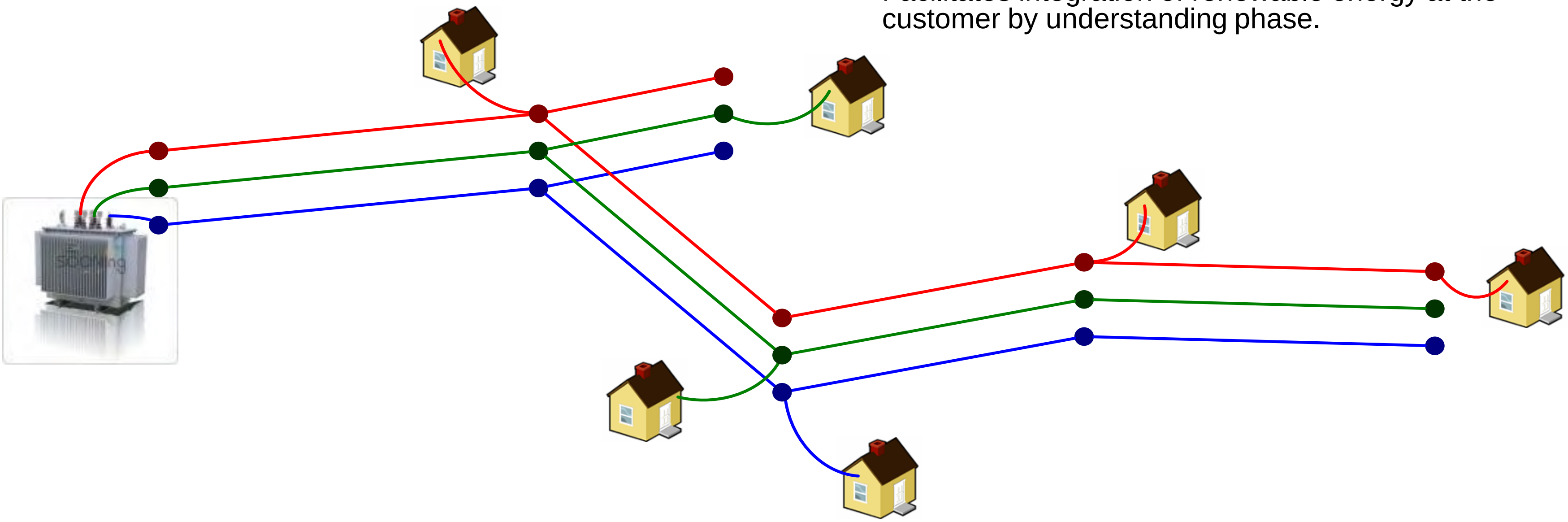
Sample Application: Phase Balancing FOAK

Problem

- Three phase voltage is typically fed into the street for customers, with each house connected to either Phase A, Phase B, or Phase C; or a combination 2-phase or 3-phase supply.
- Current process for connecting customers means that it is not known which phase a customer is connected.
- In addition, while the energy distributor may <u>initially</u> know which phase the customer is connected to, over time, due to maintenance and repair, this state of the grid becomes inaccurate.

Benefits

- Determine which customer is on which phase(s) without the need for complex phase angle voltage measurement or any additional equipment.
- Facilitates phase re-balancing programs to reduce losses and increase capital efficiency. Initial estimates indicate that $2Mil savings in a typical network is achieved annually by avoiding losses due to phase imbalances.
- No need to physically send out maintenance crews to identify phases.
- Assists the power model to be more accurate with phase data.
- Facilitates integration of renewable energy at the customer by understanding phase.



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Why is This New and Innovative?

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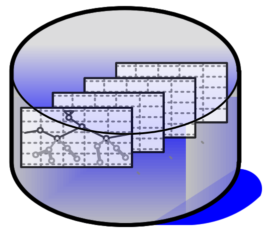

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Existing grid measurements from substation sensors

Existing meter readings collected from Smart Meters

Existing connectivity meta-data available from the information infrastructure

Advanced combinatorial algorithms and lots of processing power

Valuable information that was previously extremely difficult and expensive to obtain and manage

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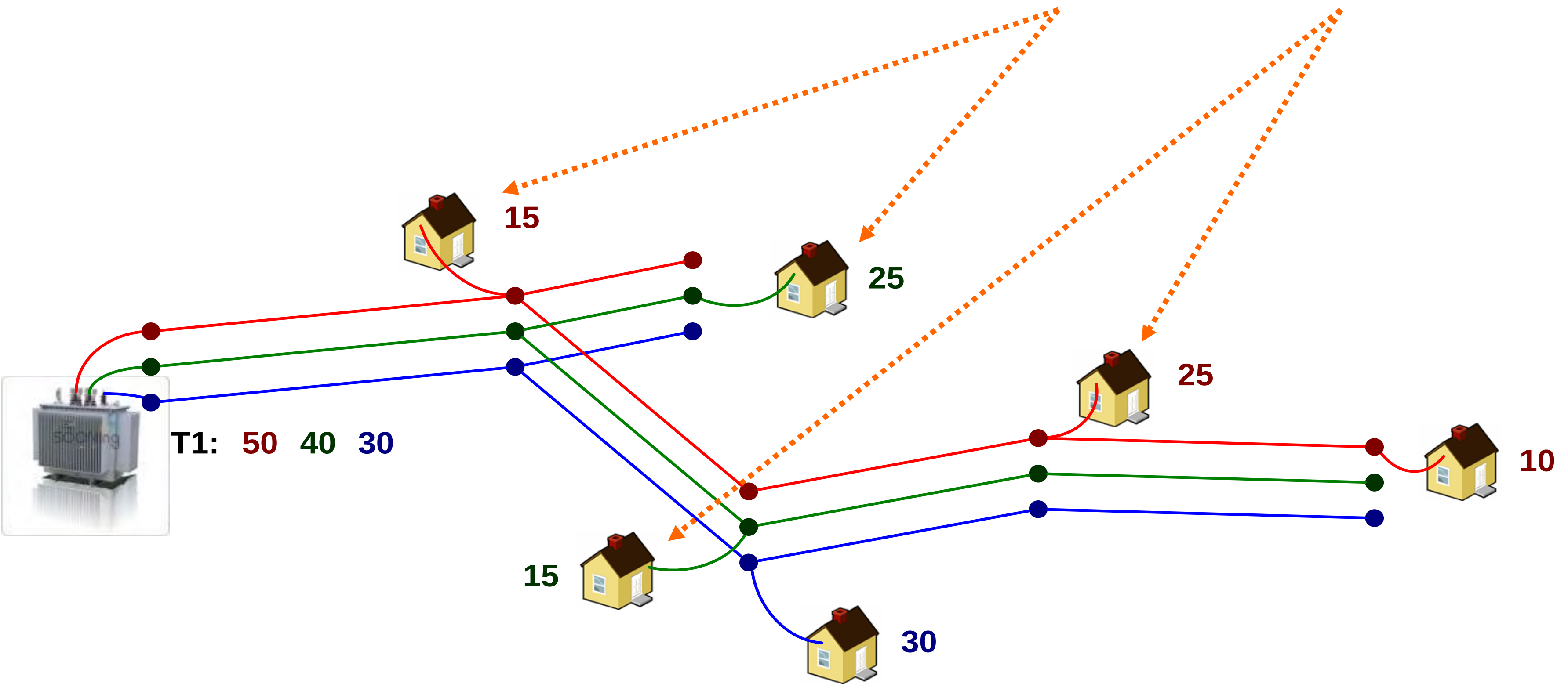
How Exactly Is This Supposed to Work…?

- First we load data into the Combinatorial Engine:
  - Current measurements on each of the three phases, measured on the transformer
  - Current at an unknown phase from each of the households connected to the transformer



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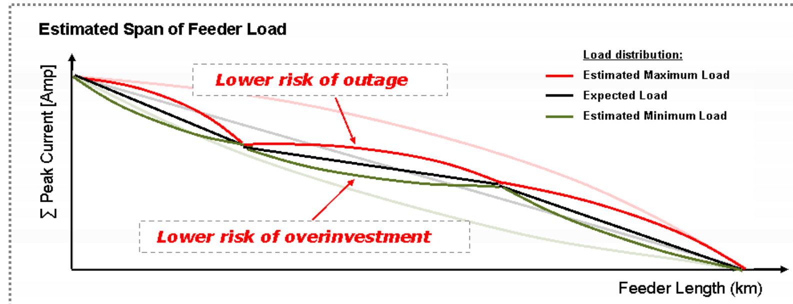
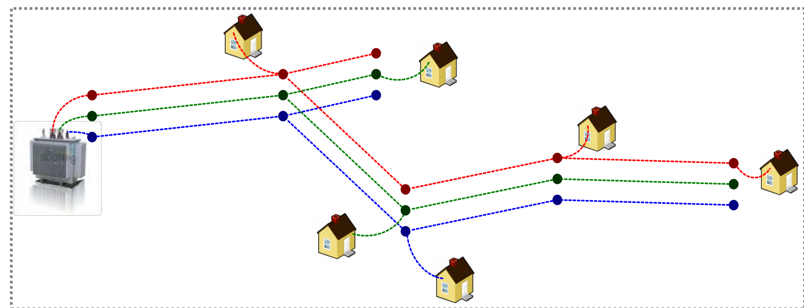
Summary

1. We have now seen how **DONG Energy** is optimizing their planning, postponing expensive reinforcements, by leveraging large volumes of operational data for network planning purposes, applying load flow calculations and load pattern statistics.



2. We have also seen how **EnergyAustralia** will unlock hidden LV network capacity through phases balancing, by correlating AMI and grid sensor data applying advanced linear equation solving algorithms.



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