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Volatility Prediction and Management by Active Network Management & Future Generation Management

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Current Situation and challenges

Current monitoring and challenges due to upcoming renewable generations

- Telemetry for P, Q and V and monitoring in SCADA at substation levels
- Increasing penetration of renewable generations
- The generation from these renewable generation changes frequently from zero to rated power
- Creates bi-directional flows in part of the network
- Results in unclear power flow directions and volatility

- Distribution System State Estimator (DSSE)
- Load and Generation Modeling
- Active Network Manager

Distribution System State Estimator

- A part of Distribution Management System Control Center runs 24X7
- Triggers periodically, on network topology change and on significant measurement change
- Provides network information as primary
  - P, Q, V and I information about every equipment
- Secondary information for a bigger picture
  - Alarms- Critical network states which required immediate intervention
  - Limit violations – Voltage and thermal violations
  - P and Q injections and exchanges with transmission grid

Distribution System State Estimator

DSSE- Input, Algorithm and output

Input

- P, Q, I, V measurements at substations and a limited set of additional measurements along the feeders
- Load and generation models

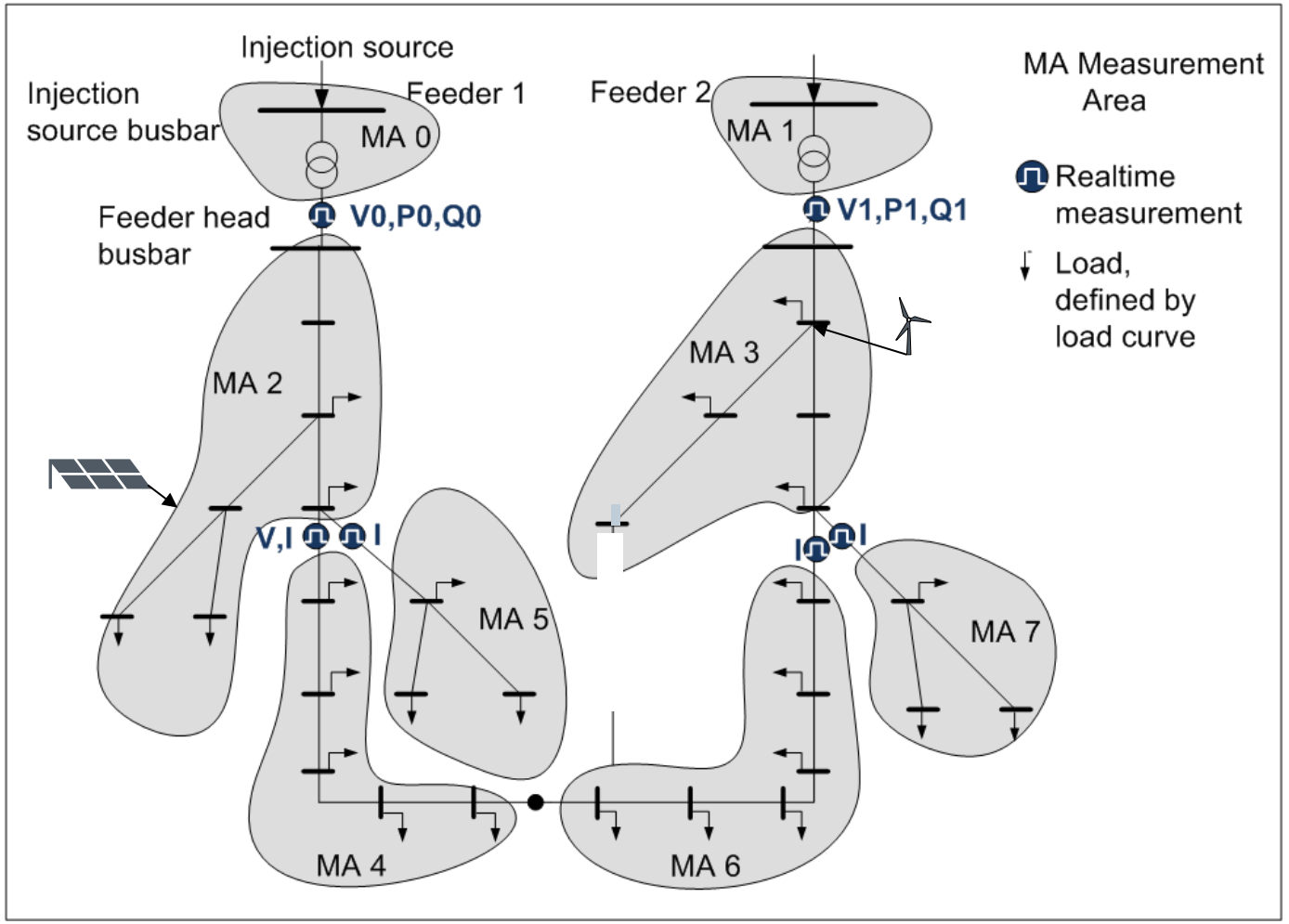
Algorithm

The estimation problem is mathematically defined as minimization function - nearest estimate to a given measurement set (measurement area) consisting of

- P and Q measurements
- Pseudo P and Q measurements at loads/load groups
- Current and voltage magnitude measurements

Output

- Detailed current, voltage and power information for every single element in the network
- Voltage and thermal limit violations
- Active and reactive power losses



Load and Generation modeling

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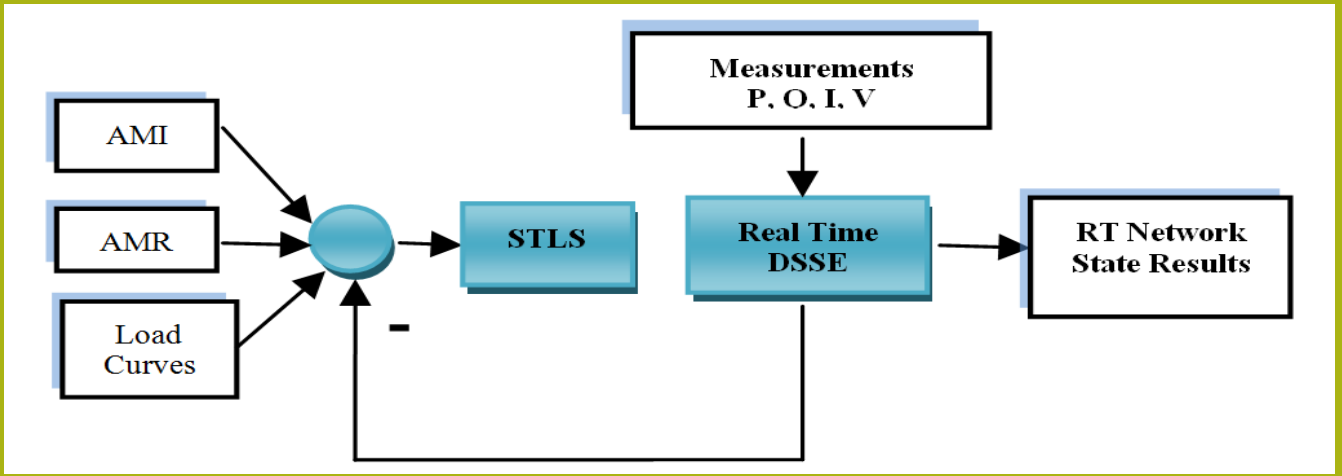
Load data sources

- **Accounting data**
- **Sampling and load classification**
  Inaccurate and unreliable data as it is not well maintained

- **Automated Meter Reading**
- **Advanced Metering Infrastructure**
  AMR and AMI are accurate enough but arrives late in system

Short Term Load Scheduler STLS

- **Small difference between initial load value and real/estimated measurements**
- **STLS works in negative feedback with DSSE to reduce the difference between default and actual load scheduled values**
- **STLS is utilized to reduce the number of iterations in subsequent estimations process**



Load and Generation modeling

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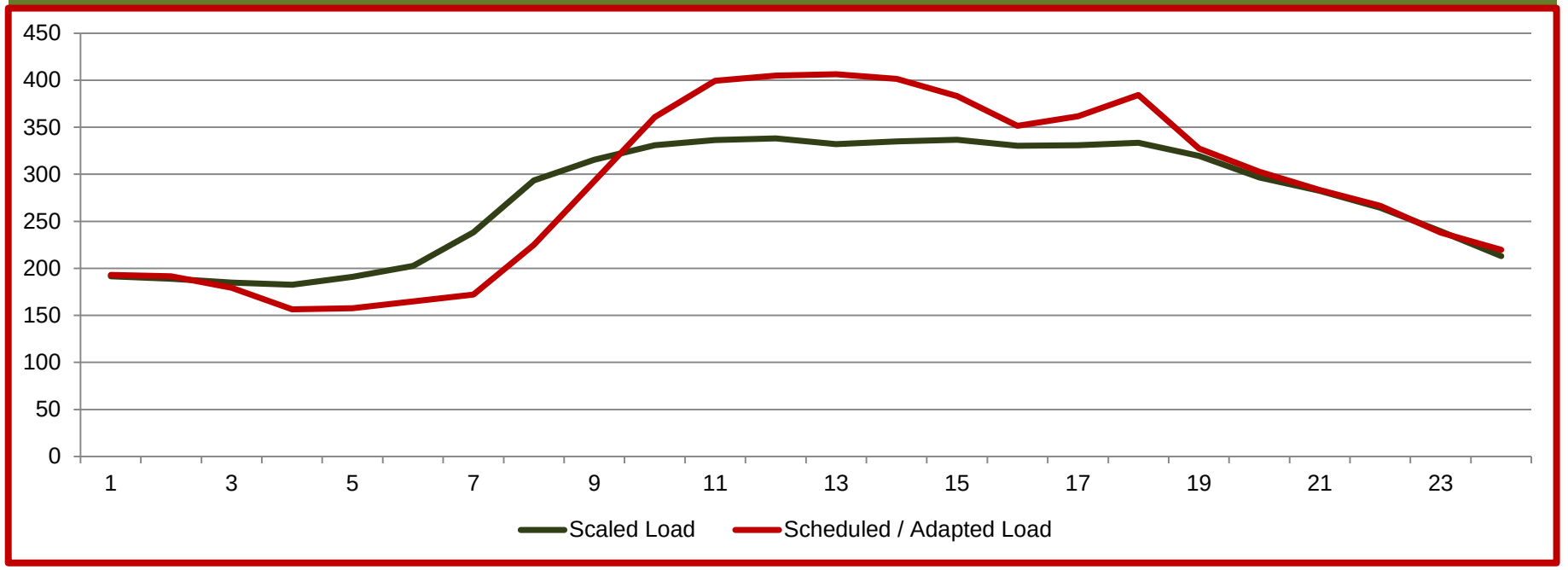
STLS -

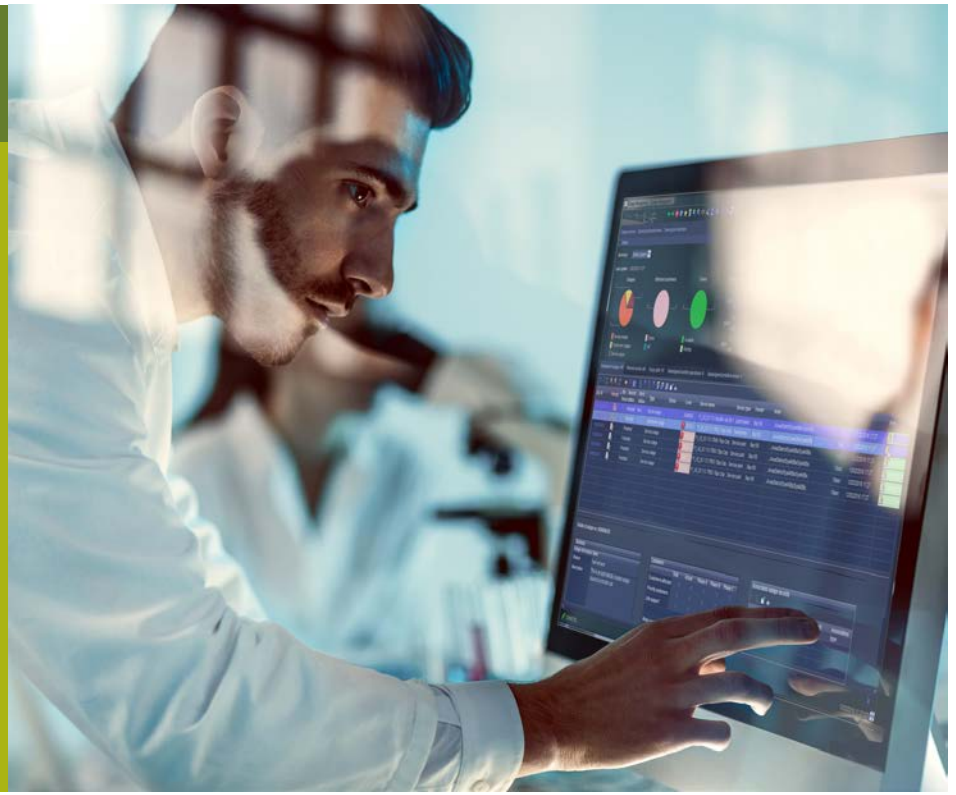
Difference between scheduled and STLS data after several weeks



Load and Generation modeling

Generation Scheduler

- **Conventionally the generation modeling was applied similar to load modeling as a static load.**
- **With increase in number of renewable sources the static curve is not reliable as changes in weather affects the generation**
- **Hence the integration of generation forecasted data into DSSE is highly valuable with regards to accuracy of results**



Active Network Manager - ANM

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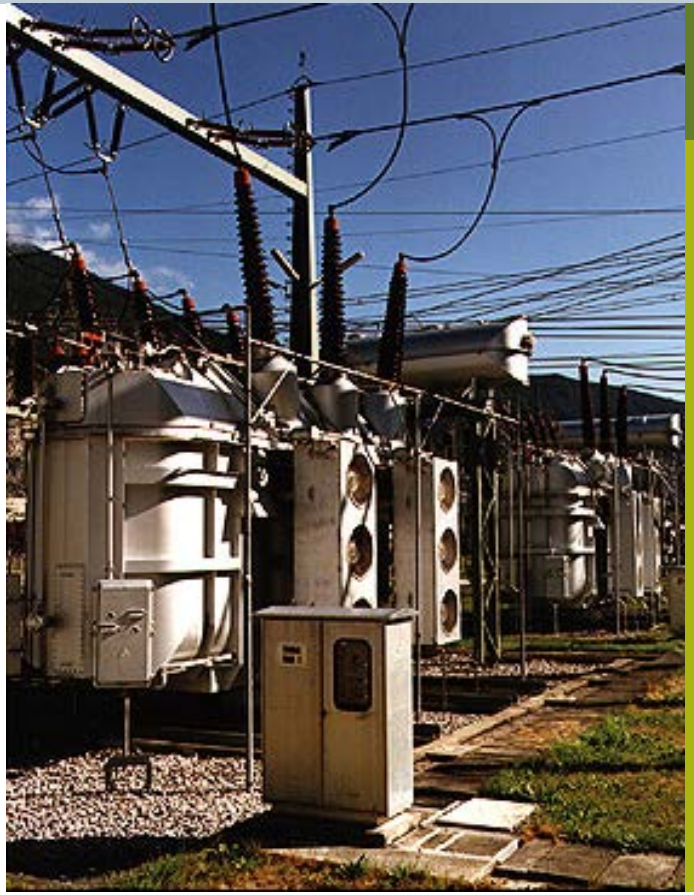
Function

- **Simulate actual status of the network as received from DSSE**
- **To check if the potential instabilities can be resolved**
- **To select appropriate counter measures to resolve the volatilities**
- **Volt-Var control : VVC supports the ANM**
    - o It calculates and simulates all the required control actions to achieve the given objective functions

Active Network Manager - ANM



Volt-Var Control VVC

- The VVC application provides distribution network optimization using voltage, var and watt controls like Load Tap Changers/Line Voltage Regulators and Regulating Capacitors as well as Batteries
- This optimization consists in minimizing an objective function that is user selectable as one mandatory and basic objective function
    - Minimize violations

and the combination of the following objectives:

- Minimize active power consumption / CVR
- Minimize reactive power consumption
- Minimize power losses
- Maximize voltage reserve

Visualization Concept

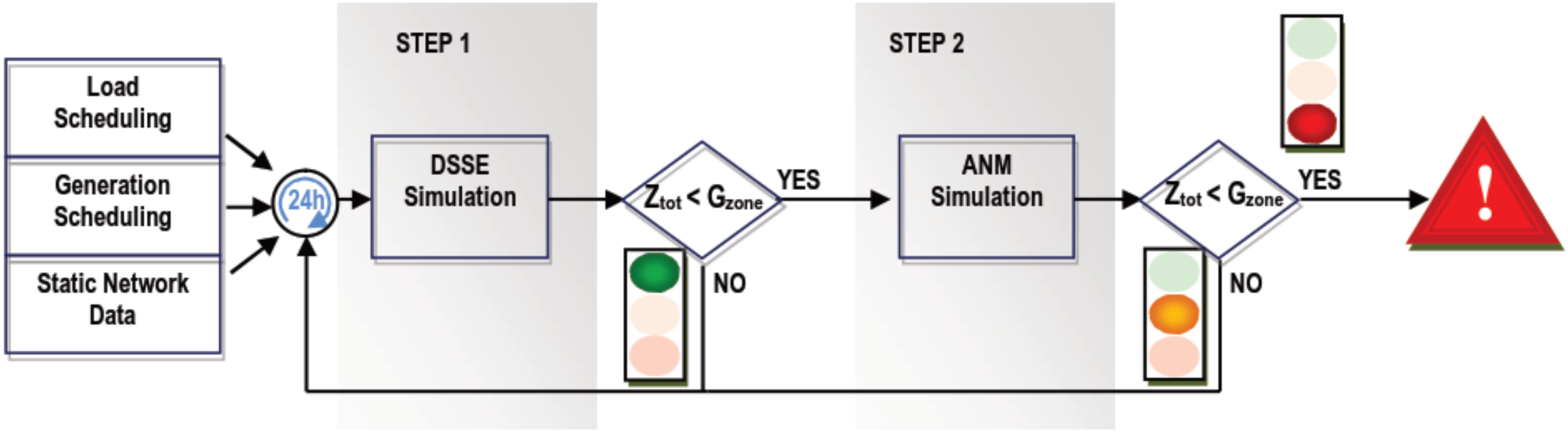
Semaphore model concept

- **Logical and visual presentation to represent the obtained network state information**
- **Uses three discrete to reflect the network state and operators ability to resolve actual and anticipated volatility**
- **Represents the visual state of the network accounting the ANM simulation results**
- **Generation of semaphore is expressed through discrete objective function**

$$Ztot = Wli * Flimits + Wlo * Floading + WR * FR + WPF * FPF$$

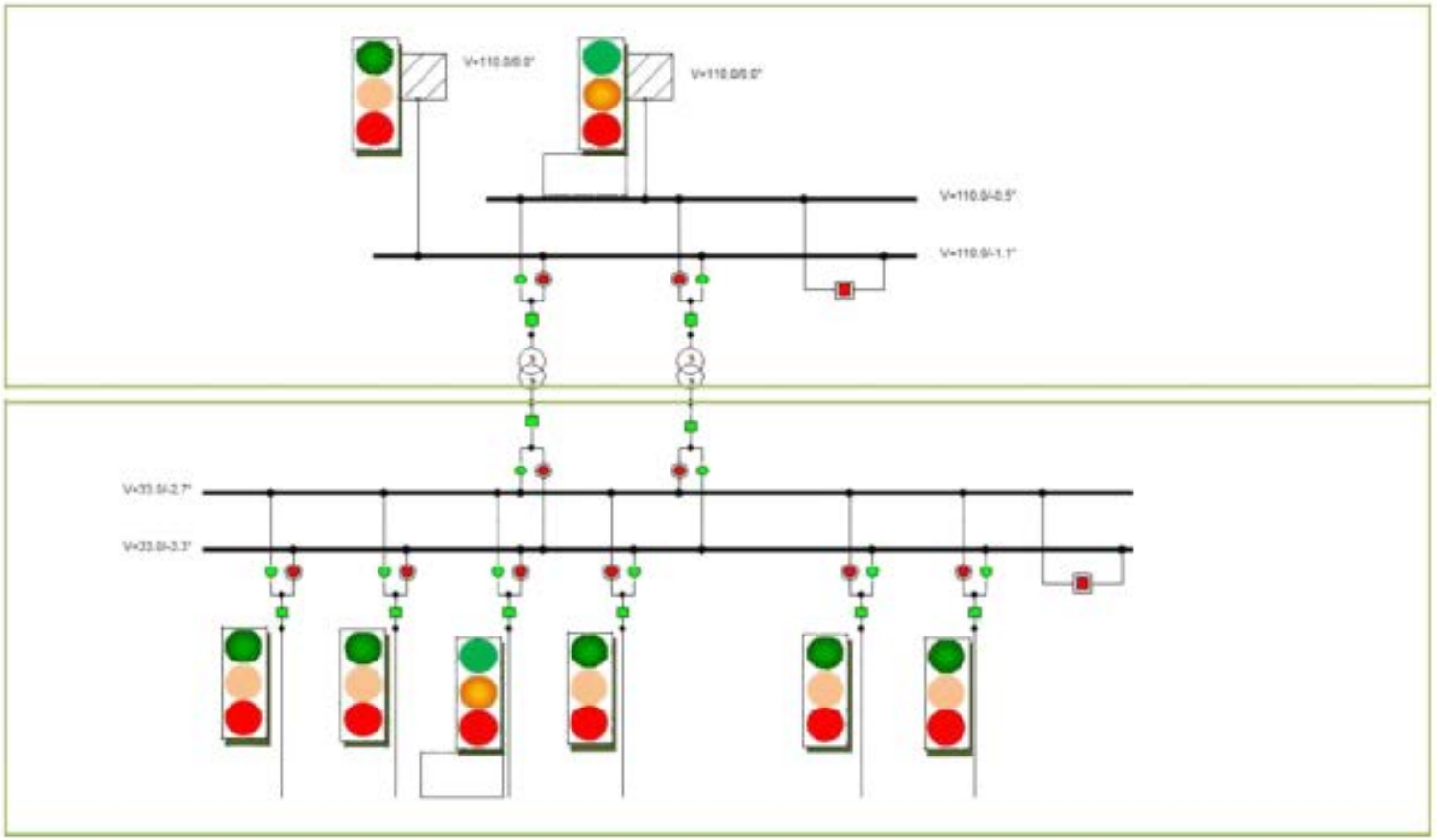
Visualization Concept

Algorithm



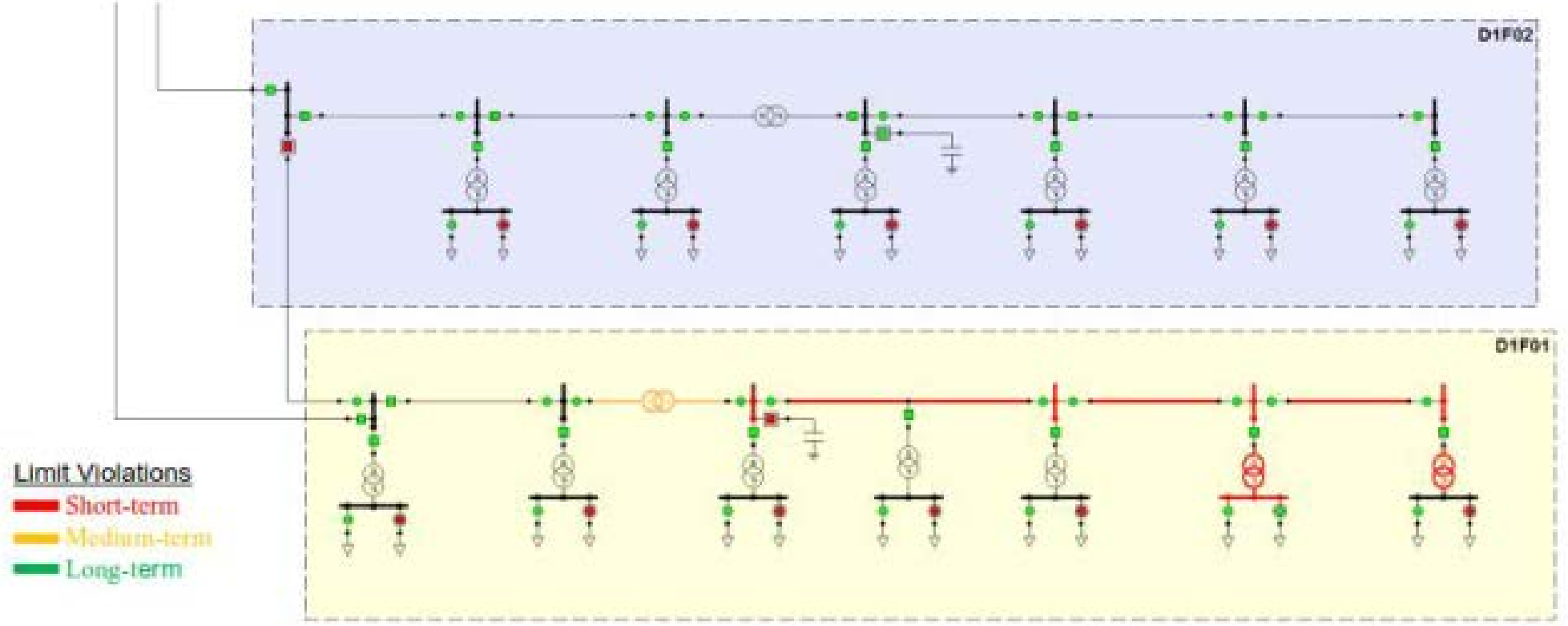
Sample visualization for Operator

Operator View



Sample visualization for Operator

Detailed View



Future Generation Management in Distribution Network

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Generation Management

- **Closed loop AGC tested at NLDC for Dadri NTPC plant**
- **Potential and need to optimize the conventional and renewable sources**
- **Generation Management**
  - o Controls ON/OFF statuses
  - o Active and Reactive power of distributed generation and storages
  - o Distributed generation can be renewable (e.g. solar , wind) or non-renewable (e.g. micro turbines, fuel cells, diesel generators)
- **Can operate for pre-determined modes : Grid connected and islanded mode**
- **Objective can be achieved**
  - o Voltage regulation
  - o Control Import/Export