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

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

STLS -
Difference between scheduled and STLS data after several weeks

Scaled Load  Scheduled / Adapted Load
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

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
  - It calculates and simulates all the required control actions to achieve the given objective functions
### 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

\[ Z_{\text{tot}} = W_{\text{li}} \times F_{\text{limits}} + W_{\text{lo}} \times F_{\text{loading}} + W_{\text{r}} \times F_{\text{R}} + W_{\text{PF}} \times F_{\text{PF}} \]
Visualization Concept

Algorithm

STEP 1

DSSE Simulation

STEP 2

ANM Simulation

Load Scheduling
Generation Scheduling
Static Network Data

$Z_{tot} < G_{zone}$

NO

YES

$Z_{tot} < G_{zone}$

NO

YES
Sample visualization for Operator

Operator View
Sample visualization for Operator

Detailed View
Future Generation Management in Distribution Network

Generation Management

- Closed loop AGC tested at NLDC for Dadri NTPC plant
- Potential and need to optimize the conventional and renewable sources
- Generation Management
  - Controls ON/OFF statuses
  - Active and Reactive power of distributed generation and storages
  - 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
  - Voltage regulation
  - Control Import/Export