

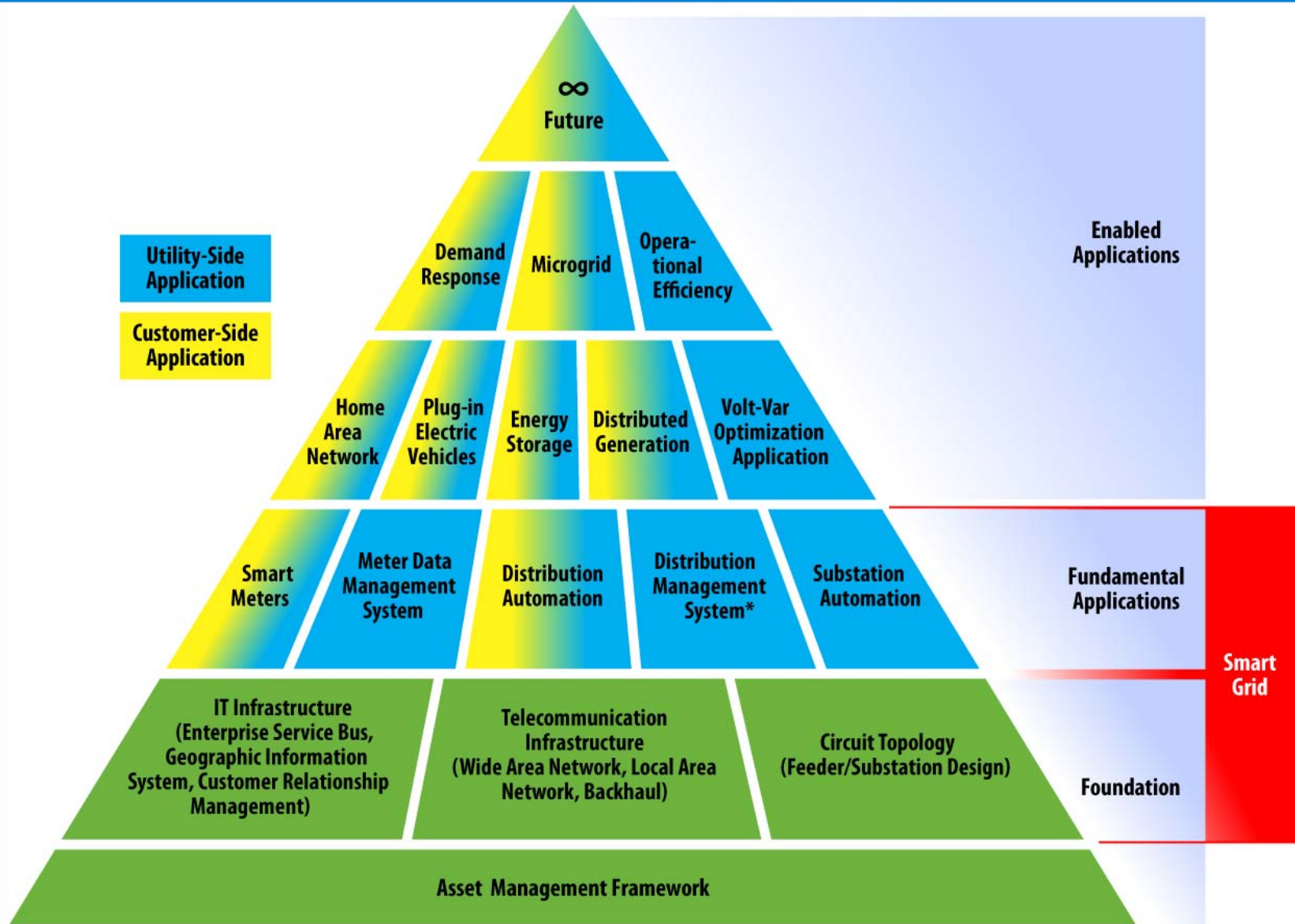
BC Hydro's Voltage and VAR Optimization Program

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BC Hydro's Smart Grid

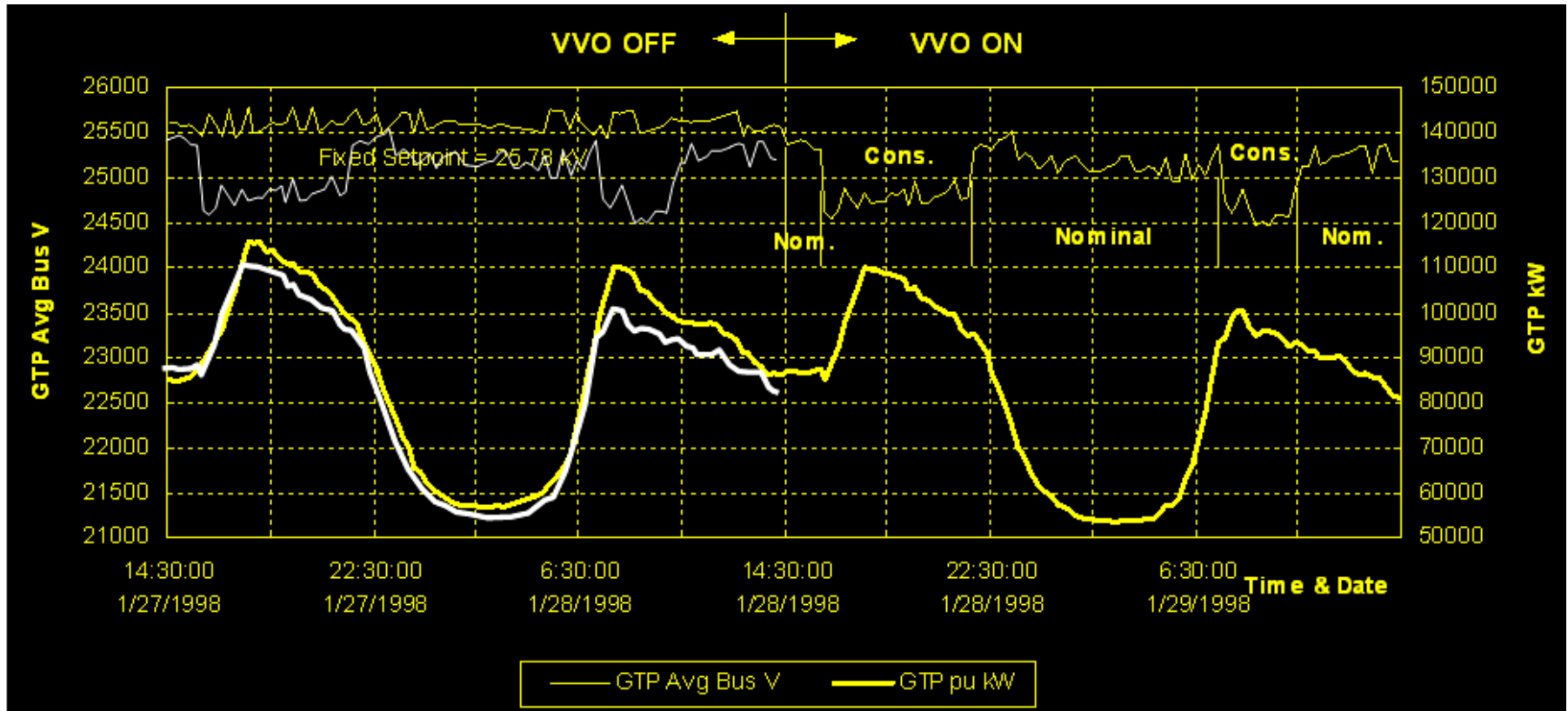


*includes Energy Management System

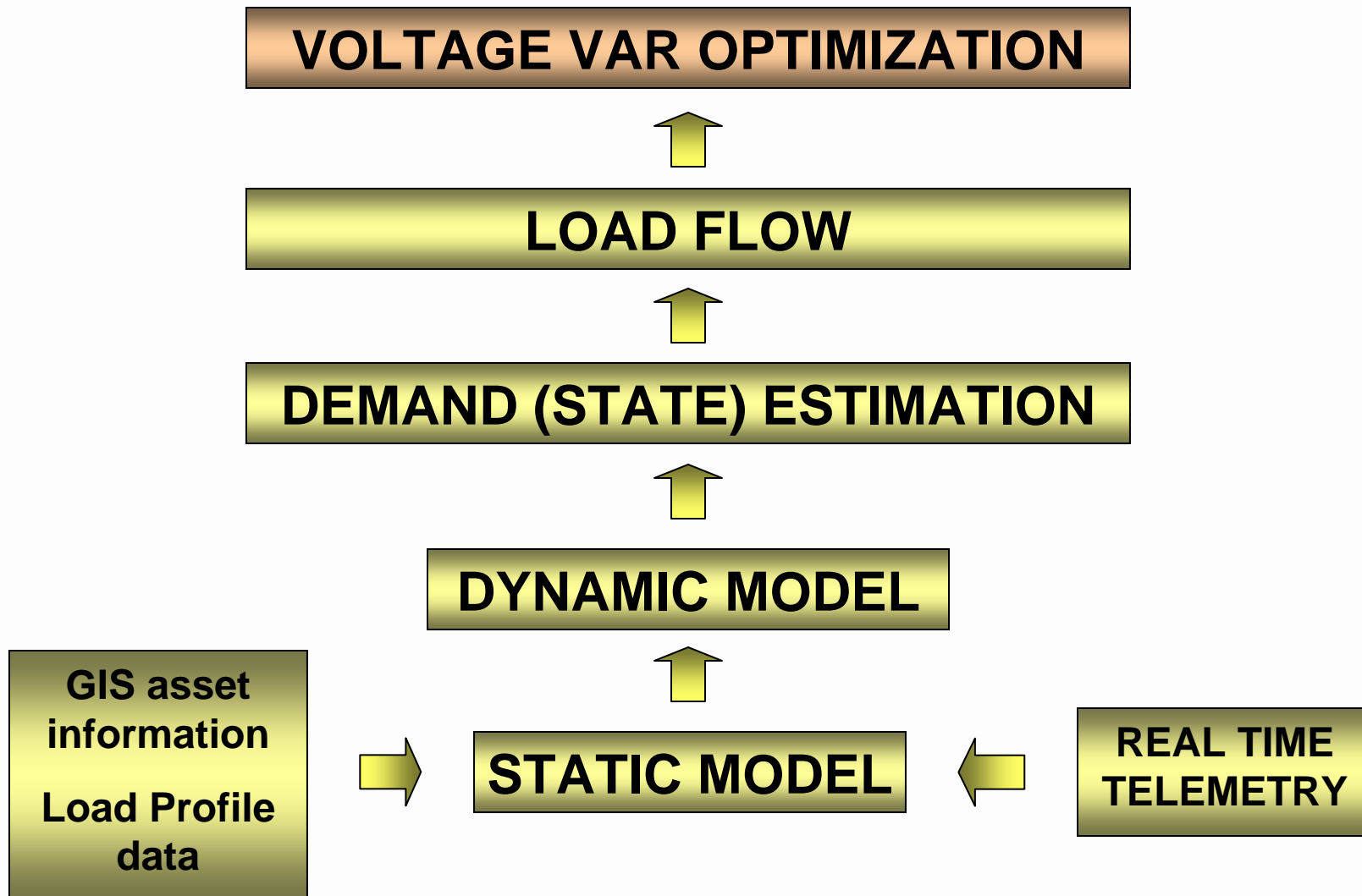
Energy Conservation (aka Maximize Profit)

- Feeder consumption = customer consumption
+ technical losses (+ theft)
- Profit = - “cost of energy per kWh” for feeder consumption
+ “revenue per kWh” for customer consumption
- If “cost of energy per kWh” > “revenue per kWh” then
 - Profit will be negative
 - Objective function will be to minimize customer consumption and technical losses according to their value
- If “cost of energy per kWh” < “revenue per kWh” then
 - Profit will be positive
 - Objective function will be to maximize customer consumption

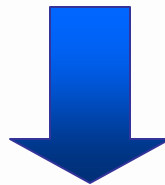
Achieved Demand Reduction



- Hardware - Substation
 - Load tap changer and controller
 - Feeder metering (as well as transformer meters, customer meters)
 - RTU and telecommunication for EMS SCADA
- Hardware - Distribution wires
 - Capacitors (fixed/local control/supervisory control)
 - Feeder voltage regulators (local control/supervisory control)
 - RTU and telecommunication for DMS SCADA
 - Discrete feeder/transformer/customer meters
 - (Temporary) meters at customer locations
- Software
 - Interfaces to EMS and DMS SCADA
 - Electrical model of the power distribution system
 - Demand (state) estimation and load flow calculation
 - Voltage VAR optimization

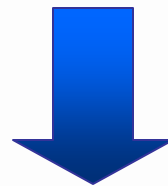


- Substation model
- Primary circuit model (3 Φ and 1 Φ)
- Distribution service transformers model
- Load model:
 - Load categories
 - P (kW) and Q (kVAR) 24h load profiles (historical profiles)
 - Load to voltage dependency of P and Q
- Secondary circuits included in the model through equivalent



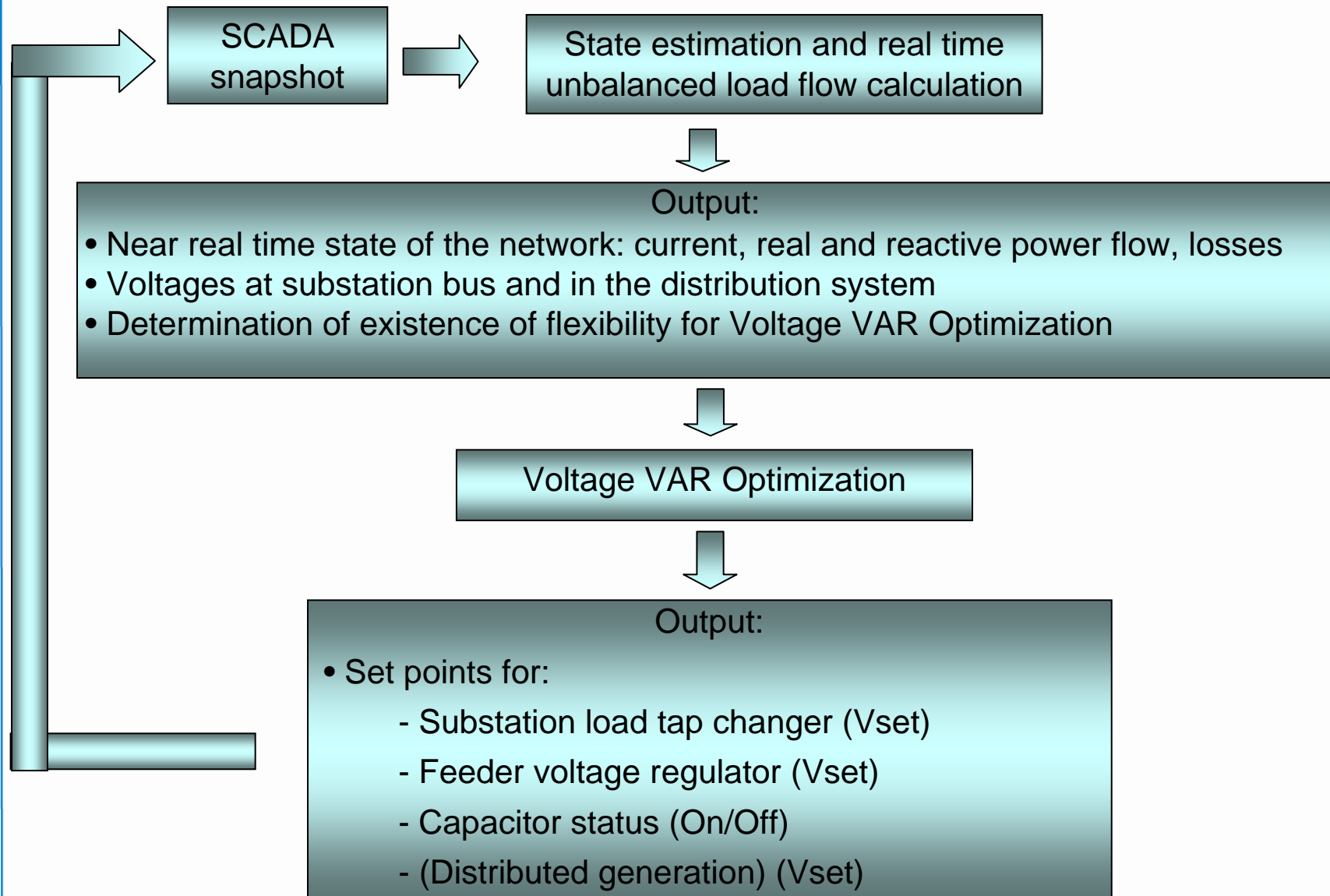
Static model of distribution system

- Substation and field device analogs and statuses from SCADA
- Updated in real time – every 4 sec – with instantaneous values
- (Metering standard requirement is 10 sec or less)
- Field devices – updated every 15 minutes or less



Dynamic model of distribution system

- 6-10 customer locations (the most critical ones) are monitored through installation of temporary meters
- Recording of P, Q, V, I over the period of time
- Synchronization of metered and calculated values to get coincidental values for analysis
- Model corrections
- Re-location of meters (if required)



- DMS State Estimation (SE) - a procedure used to calculate the state of distribution system based on:
 - distribution system configuration (topology),
 - real time measurements and
 - customer load profiles – pseudo measurement
- Consists of:
 - Static state estimation
 - Identification and re-estimation of bad measurements and parameters

- Real-time On-Line Power Flow (OLPF) executes after the state estimation
- It calculates real and reactive power flow, voltages and currents for the entire distribution system
- These results are input for all other advanced applications such as **VVO**, Network reconfiguration, Dynamic Equipment Rating (DER) etc.

- VVO based on OLPF results optimizes the distribution system to achieve specified objective (e.g. energy conservation)
- Load response to determine margin from limits
- P, Q changes to ΔV and ΔVAR
- Outputs are recommended control actions for LTC, feeder voltage regulators and capacitors
- After controls are executed SE and OLPF run and update the system state

- VVO is an integrated advanced application within DMS
- All controls through DMS SCADA
- Faster rollout of VVO program
- Visualization of the VVO control actions in real time
- Automatic model updates through GIS interface
- Distribution model accuracy improvement by extensive GIS validation
- Interface for other real-time information (more later)

- SMI telecommunications for Distribution SCADA where appropriate
- Historical load profile data improvement
 - Scheduled meter reads
 - Interval data
 - Needs to be pre-processed before updating DMS (i.e. one customer meter cannot update the whole load category)
- (Near) Real time measurement
 - Transformer/feeder meters
 - On demand meter reads
 - Instantaneous data
 - Customer meters for secondary equivalent estimation

- Increases VVO benefits
- Improvement of DMS model
 - Improvement of historical load profile data – load profiles creation and ongoing improvement Load profiles will be improved only through load research data and separately initiated studies
 - Real time SE and OLPF support – the increase in distribution system measurements decreases the uncertainty of estimated voltages
- Remove requirement for temporary meters
- Identify additional substations and or customer sites for VVO implementation

QUESTIONS



See also Paper Submission for 2010 IEEE PES T&D
Conference & Exposition, New Orleans (April 2010)