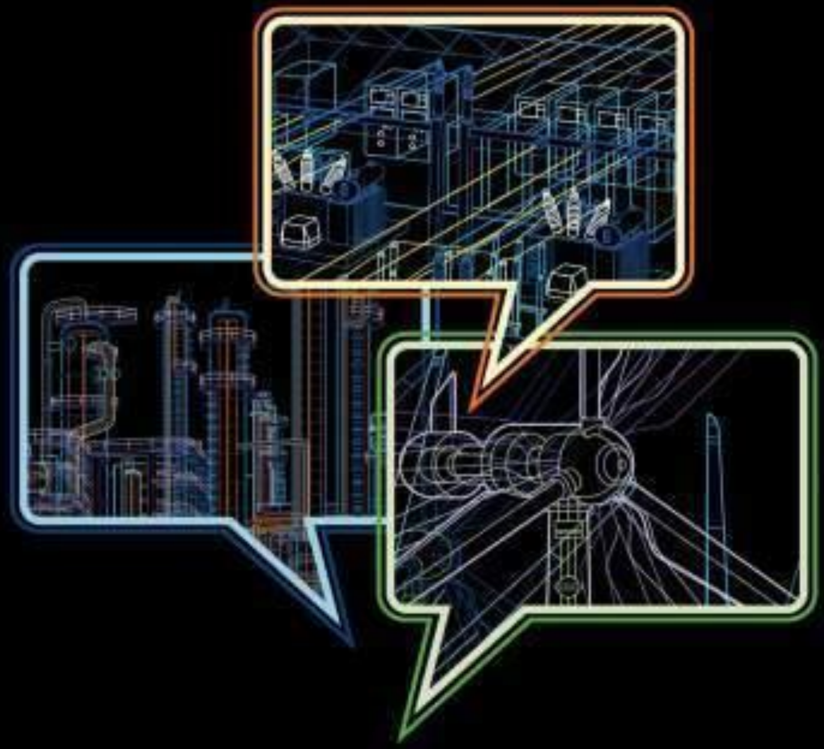

ABB Automation & Power World: April 18-21, 2011

EPO-150-1
How utilities can generate significant savings using feeder monitoring

Feeder Monitoring
GridSync™

▪ Speaker name:	Steve Lindsay
▪ Speaker title:	Marketing and Sales Manager
▪ Company name:	ABB
▪ Location:	Pinetops, NC

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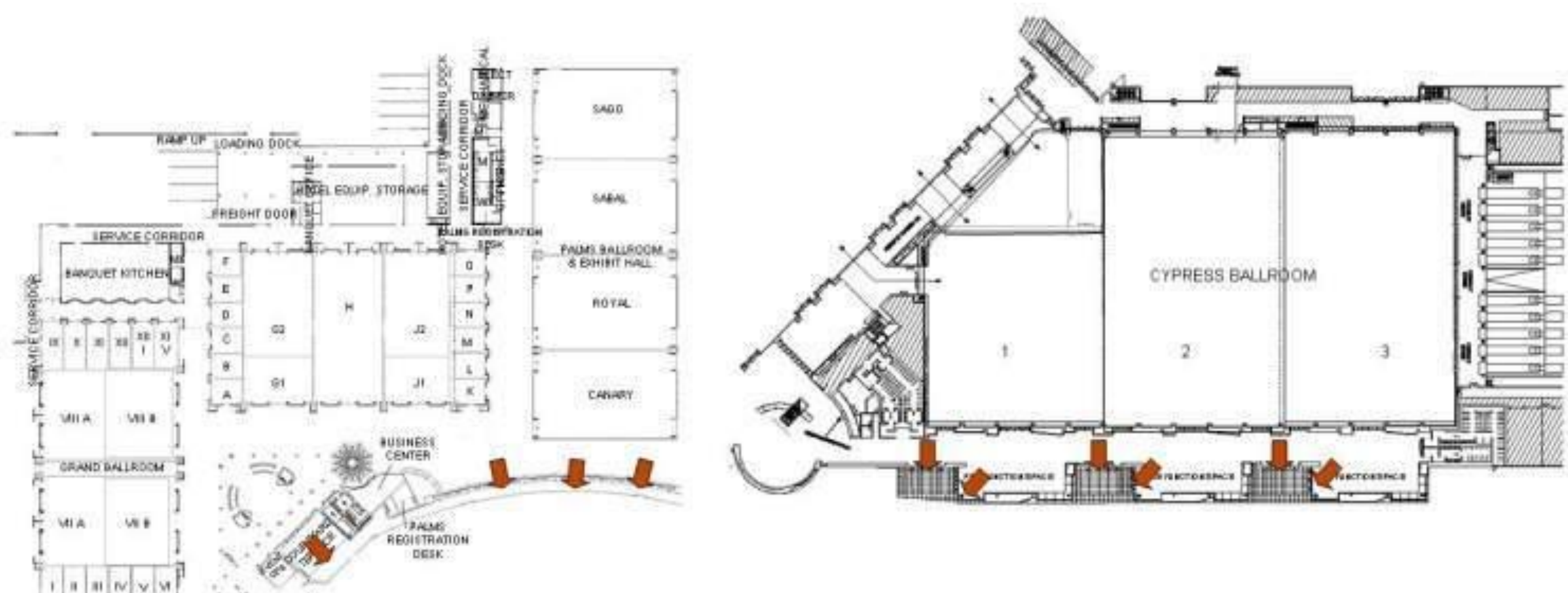

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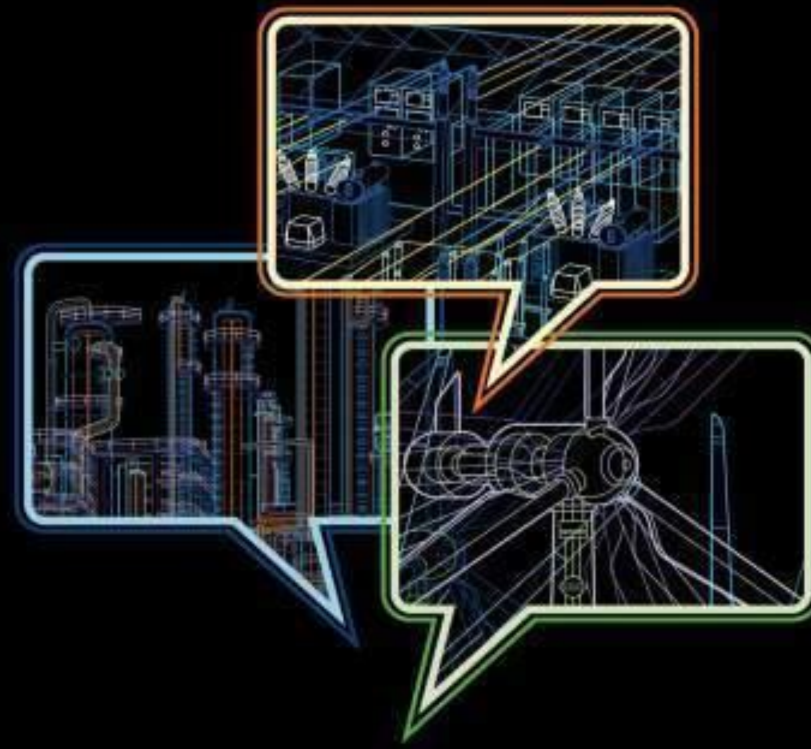
Key Points
Three takeaways

Distribution components offers smart grid solutions that will enable utilities to increase:

- Efficiency…precise management and control of power usage
- Optimization…improved power quality through volt var management
- Reliability…provide real time voltage and power status and control 24/7



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GridSync™
Increasing efficiency through volt/VAr optimization

Power and productivity for a better world™

Volt/VAr optimization
Optimizing power for maximum efficiency

Challenges

Reactive power can account for a significant portion of distribution losses. A 1% improvement in efficiency can eliminate 39 million metric tons of CO_2.

Volt/VAr optimization

Allows utilities to balance the amount of active and reactive power on the network to conserve energy and reduce power losses.

Volt/VAr optimization helps reduce:

- CO_2 emissions
- peak demand and associated costs
- generation load by as much as 4-6%

Conservation voltage reduction
Ensuring consistent energy distribution

Challenges

Utilities must regulate the voltage delivered to within ± 5% of the required nominal voltage for each consumer

Conservation voltage reduction

Allows utilities to deliver consistent power to all consumers.

Conservation voltage reduction helps utilities:

- save as much as 3-5% on generation costs
- improve customer satisfaction
- limit wasted energy and lower costs
- lessen the potential for brownouts

ABB

Explaining the value proposition
The technical side

Feeders have many variables:

- Load types (kZ vs. kP)
- Feeder lengths
- Load characteristics
- Dynamics
- Configurations

Explaining the value proposition
The technical side

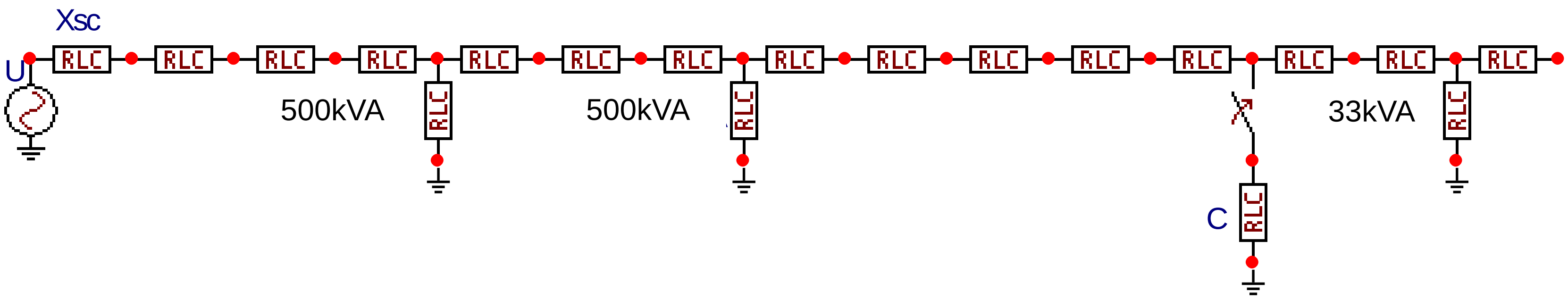
Calculations of a distribution feeder with different loads, configurations, and capacitive compensation.

Output results:

- Voltage profile and reactive power balance (VVO) along the feeder
- CVR - Conservation Voltage Reduction or Voltage Regulation
- Power loss in feeder

Explaining the value proposition
The technical side

- Radial feeder w/single source
- 15kV system, 20 kA SCC
- 3 lumped loads – varying from up to 1000 kVA and pf from 0.8-1.0

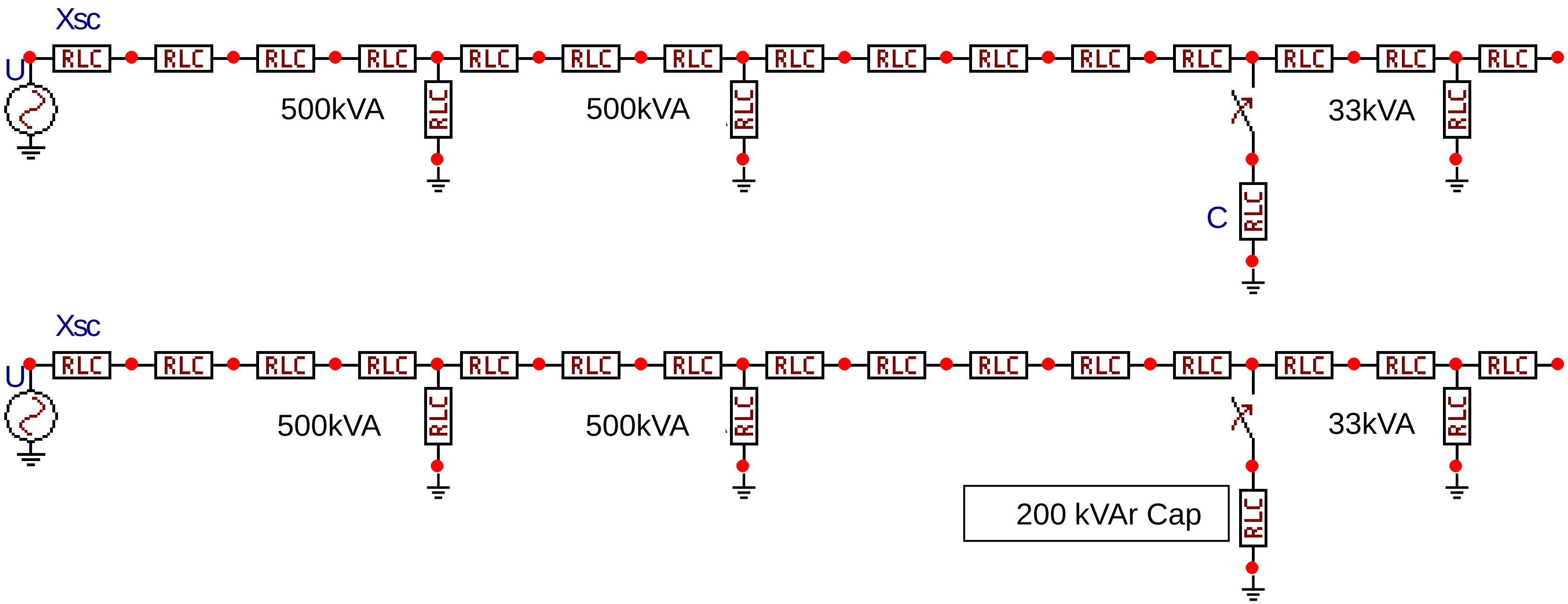


One capacitor switchable located about 80% down the line varying from 200 kvar to 800 kvar

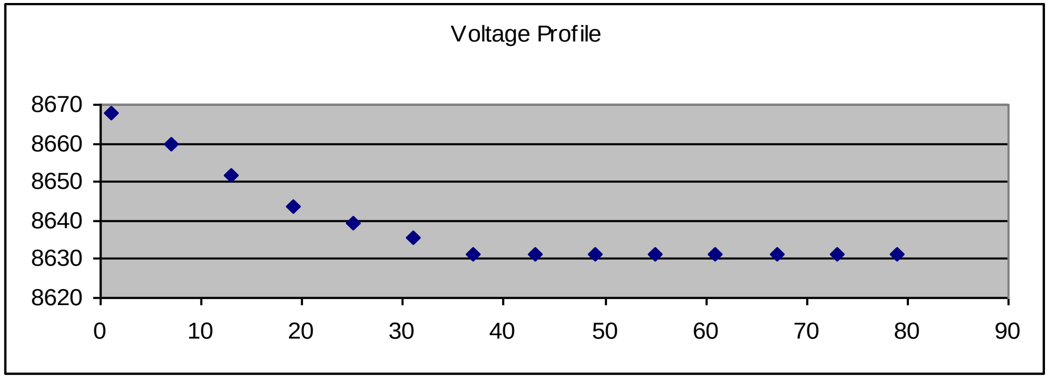
Summary of selected test cases
Volt/VAr Optimization

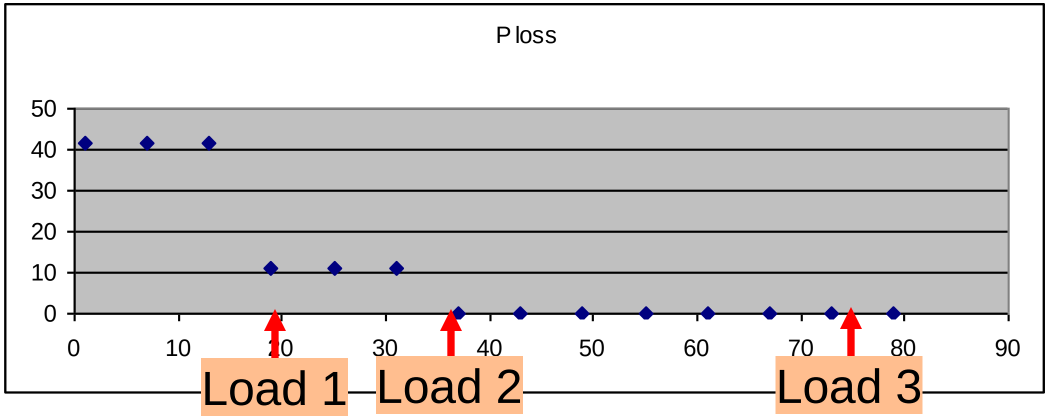
	Load 1 kVA	pf	Load 2 kVA	pf	Load 3 kVA	pf	Capacitor kVar	Comments
Ex2	5	0.85	25	0.85	33	1	0	calibration case
Ex3	200	0.8	200	0.8	33	1	0	more load
Ex4	**500**	0.8	**500**	0.8	**33**	1	**0**	**base case for comparisons**
Ex5	500	0.8	500	0.8	33	1	200	added capacitor
Ex6a	33	1	500	0.8	500	0.8	200	moved load around: heavy load is at the end
Ex7a	33	1	500	0.8	500	0.8	0	removed capacitor
Ex8	1000	0.8	1000	0.8	33	1	0	1MVA load, placed at beginning of feeder
Ex9	1000	0.8	1000	0.8	33	1	200	added 200kVAR cap
Ex10	1000	0.8	1000	0.8	33	1	800	added 800kVAR cap
	V reduction							
Ex11	1000	0.8	1000	0.8	33	1	0	5% source voltage reduction no caps, Ex.8
Ex12	1000	0.8	1000	0.8	33	1	800	5% source voltage reduction, w 800kVAR, Ex.10
	With kP load							
Ex13	1000	0.8	1000	0.8	33	1	0	5% source voltage reduction no caps, Ex.8
Ex14	1000	0.8	1000	0.8	33	1	800	5% source voltage reduction, w 800kVAR, Ex.10

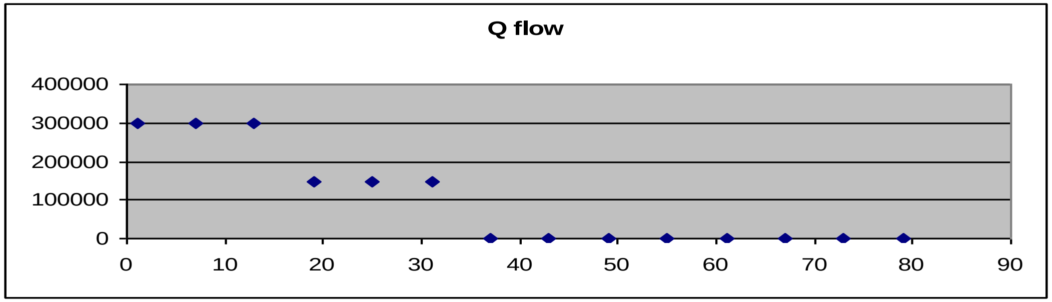
Sample feeder line
Light load, no capacitor; Light load, 200kVAr capacitor



Data results
Light load; no capacitor







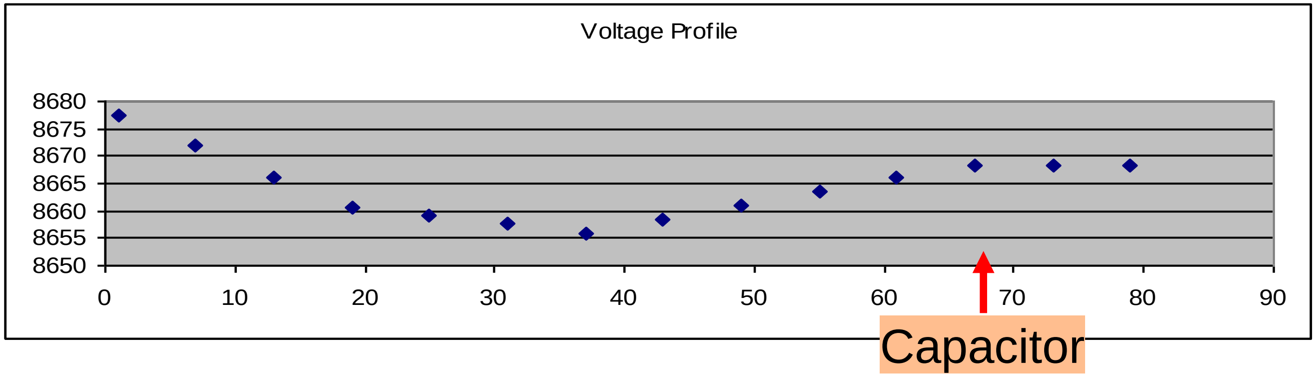
V reg = 0.42%
P loss = 314 W
P tot flow = 0.824 kW
Q tot flow = 0.602 Mvar

Data results
Light load; 200 kVAr capacitor

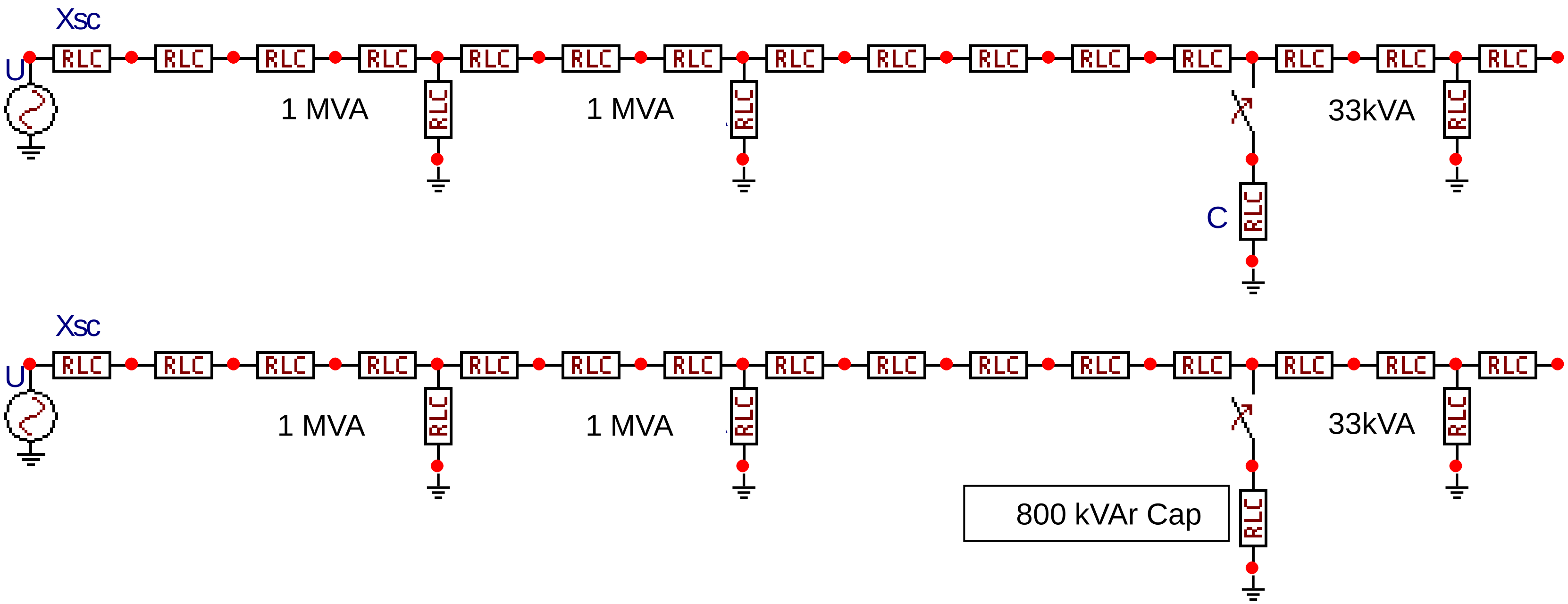
- The same total load on the feeder but added 200 kvar capacitor
- Ex 5 compared to Ex 4

V Reg	P Loss	Q Flow
40.5%	15.3%	32.6%

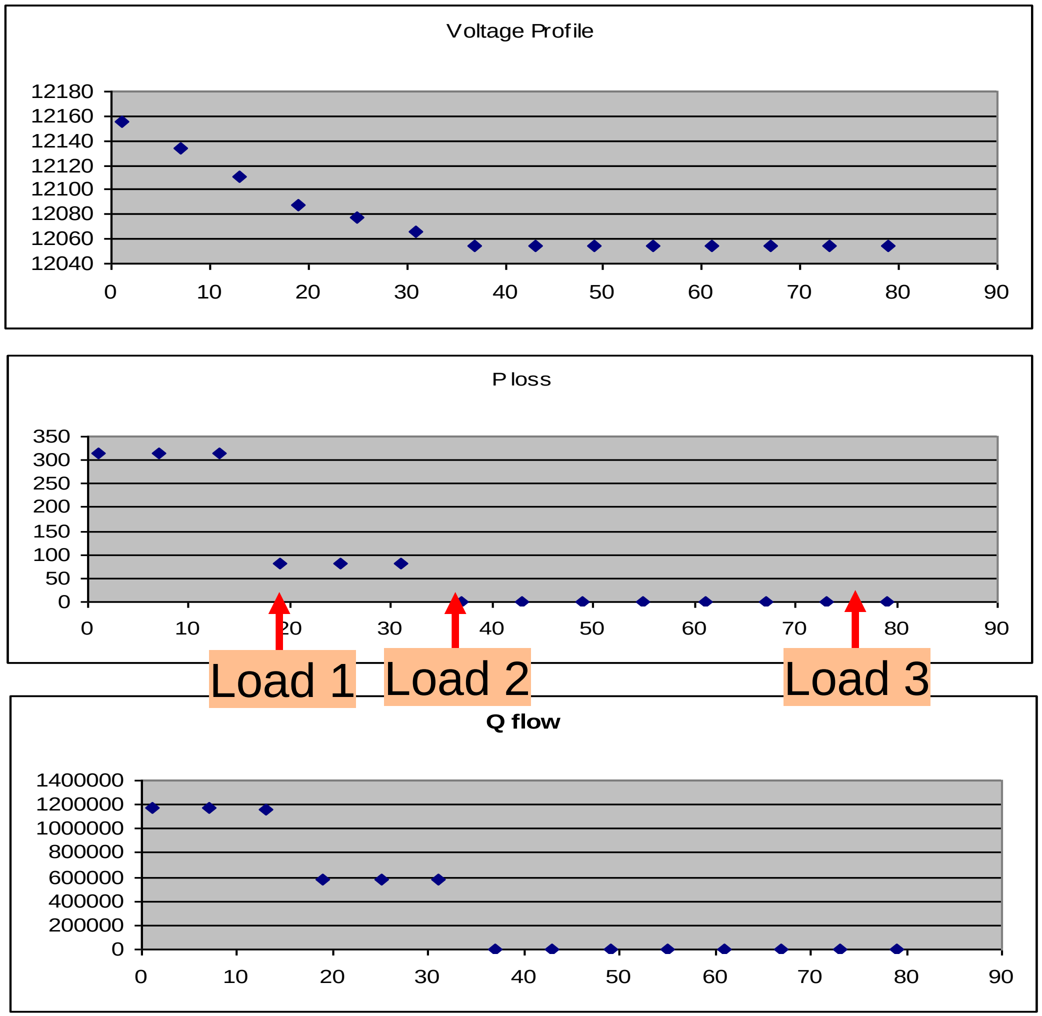
- Voltage regulations improved by 40%
- Losses improved (dropped) by 15% when switching on the cap
- Reactive power requirement dropped by 33%
- Voltage fell in the middle of the feeder - need to know the voltage



Sample feeder line
Heavy load, no cap; Heavy load, 800kVAr capacitor

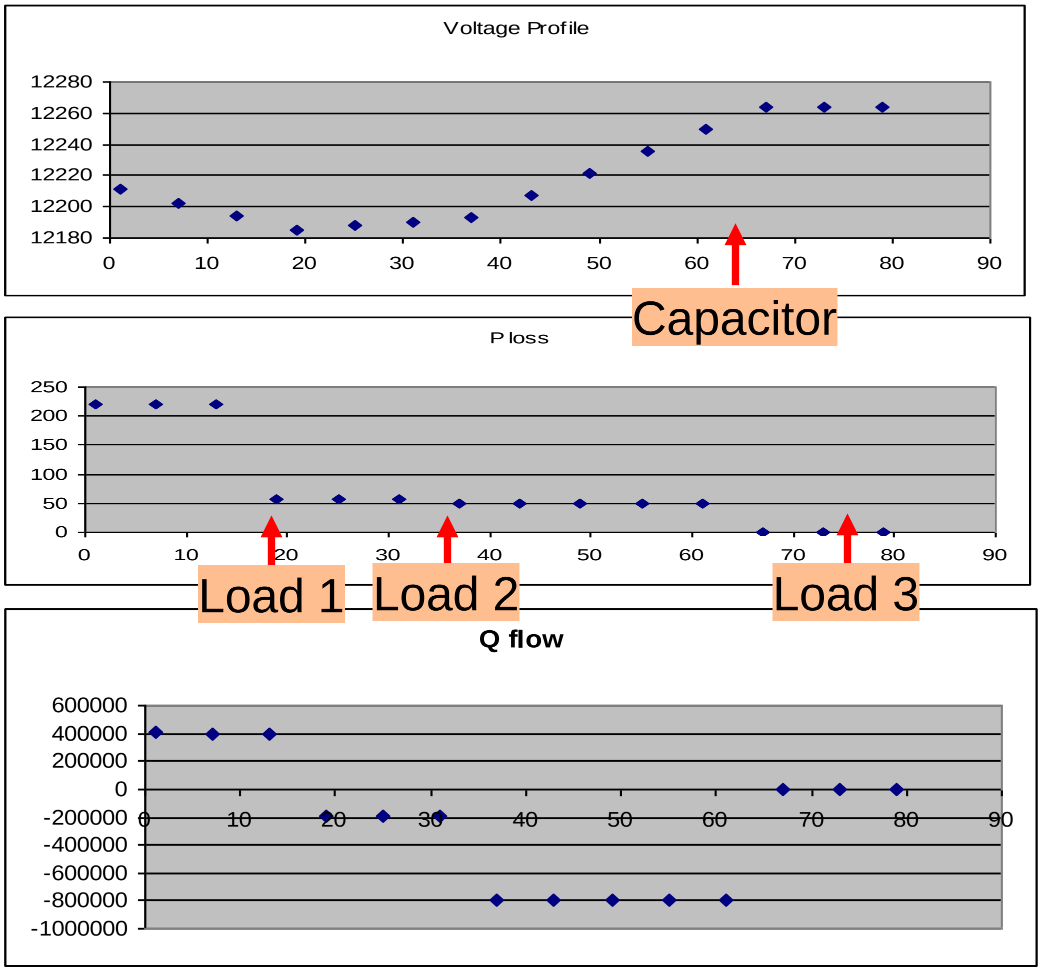


Data results
Heavy load; no capacitor



V reg=0.85%
P loss= 1185 W
P tot flow=1.58 kW
Q tot flow=1.20 Mvar

Data results
Heavy load; 800 kVAr capacitor



V reg=0.65%
P loss= 1089 W
P tot flow=1.61 kW
Q tot flow=0.42 Mvar

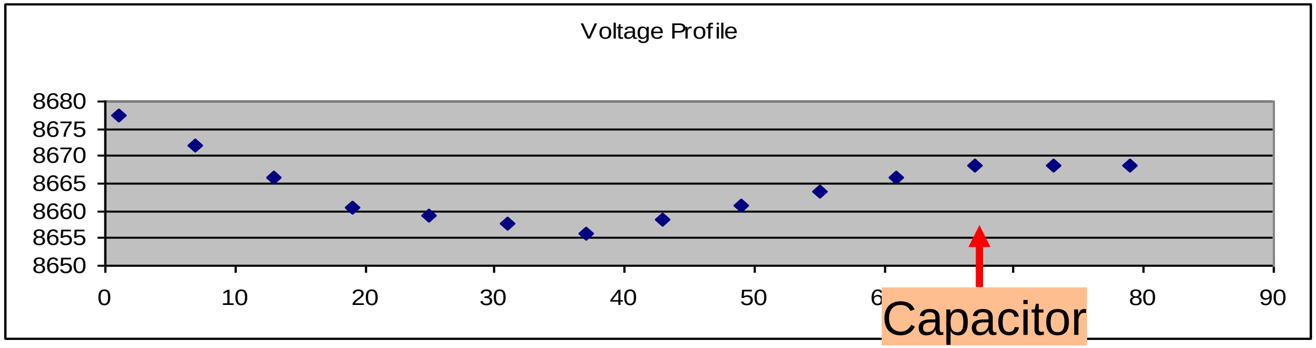
Compensation is about 67% (not close to 1.0pf)

Data results
Heavy load; 800 kVAr capacitor

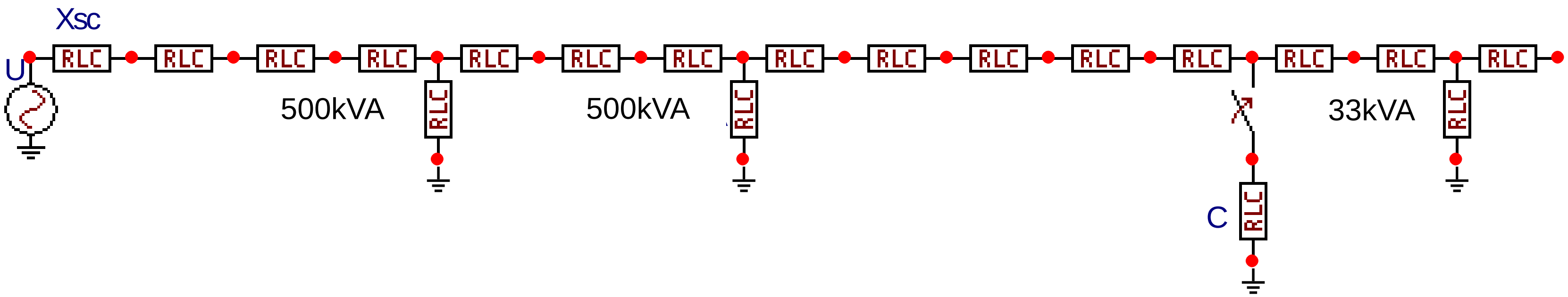
- The same total load on the feeder but added 800 kvar capacitor

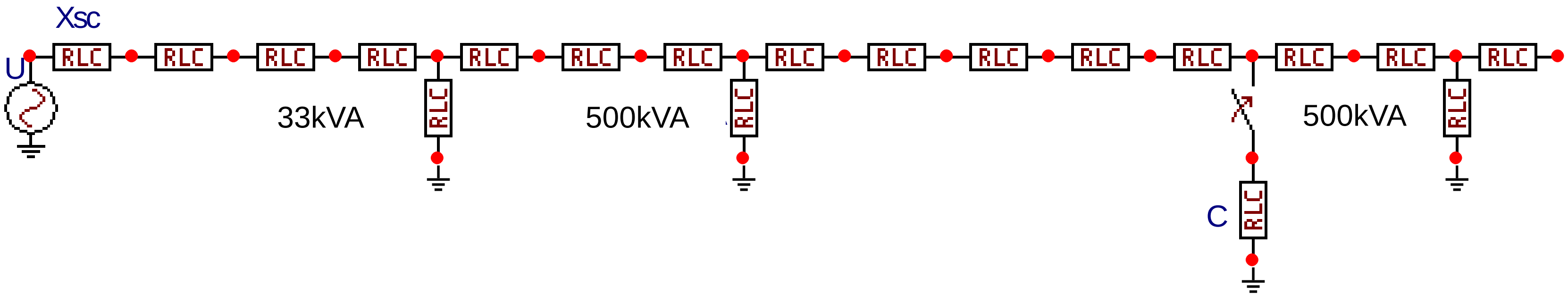
V Reg	P Loss	Q Flow
23.5%	8.1%	65%

- Voltage regulations improved by 23%
- Losses improved (dropped) by 8% when switching on the cap
- Reactive power requirement dropped by 65%



Sample feeder line
Heavy front load vs heavy back load



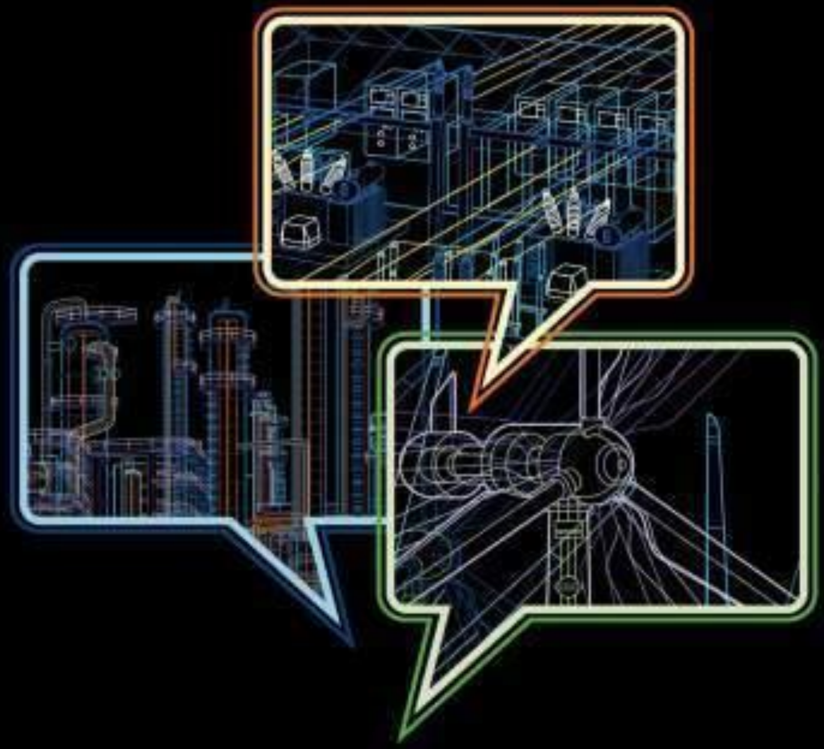


Data results
Different load distribution

- The same total load on the feeder but differently distributed

V Reg	P Loss	Q Flow
-111.9%	-96.2%	-0.3%

- Voltage regulation worsened when load is more remote
- Losses almost doubled (- 96%) when load is more remote
- Reactive requirement almost the same
- Need to know the voltage(s) on the feeder to determine regulation and losses



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Feeder monitoring
Increasing efficiency through conservation voltage reduction

Summary of selected results
Voltage regulation

Line	∆ P flow	∆ Q Flow	∆ P Loss	∆ V Reg
8 v 11	9.5%	10.0%	9.5%	0%

Model Results

Ex 8: heavy load towards beginning of the line
Ex 11: Same load, 5% source voltage reduction, no capacitors

Simple kZ load – voltage drops, load current remains equal

Conclusion:
Power loss is 9.5% less
Reactive power decreases by 10%
Voltage drop remains constant

Summary of selected results
Voltage regulation

Line	∆ P flow	∆ Q Flow	∆ P Loss	∆ V Reg
10 v 12	9.9%	9.8%	9.9%	0%

Model Results

Ex 10: heavy load towards beginning of the line, 800 kvar cap
Ex 12: Same load, 5% source voltage reduction, 800 kvar cap

Simple kZ load – voltage drops, load current remains equal

Conclusion:
Voltage drop remains constant
Reactive power decreases by 9.8%
Power loss is 9.9% less

Summary of selected results
Voltage regulation

Line	∆ Pflow	∆ Q Flow	∆ P Loss	∆ V Reg
8 v 13	0%	0%	0%	-11%

Model Results

Ex 8: Heavy (1MVa) load towards beginning of the line
Ex 13: Same load, 5% source voltage reduction

Complex kP load – power remains constant; as voltage drops, current increases

Conclusion:
Higher voltage sag
Power remains constant
Reactive power remains constant

Summary of selected results
Voltage regulation

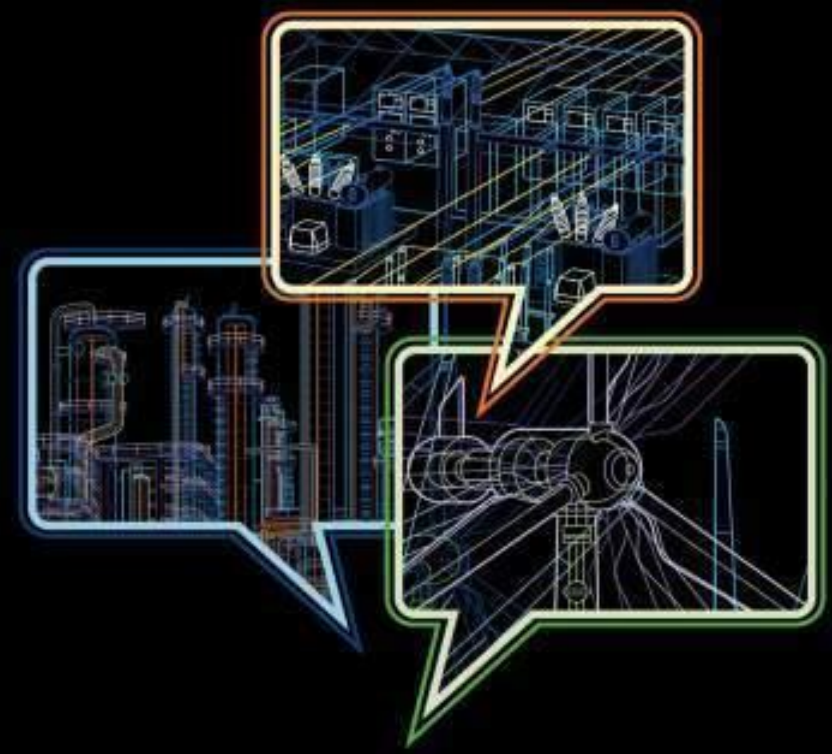
Line	∆ P flow	∆ Q Flow	∆ P Loss	∆ V Reg
10 v 14	1.9%	-16.7%	1.9%	5%

Model Results

Ex 10: heavy load at beginning of line, 800 kVAr cap
Ex 14: Same load, 5% source voltage reduction

Complex kP load – power remains constant; as voltage drops, current increases

Conclusion:
Voltage drop improved 5% with added capacitor
Power loss increased 1.9%
Reactive power increased 16.7%



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Feeder monitoring

Conclusions on feeder monitoring

Conclusion
From model to real world

Every feeder line is different

- More and varying loads
- Feeders of different length
- Loops
- Taps and branches
- Load tap changer
- Voltage regulators
- Fixed and switched capacitors

How far one can reduce the voltage depends on knowing the worst (lowest) voltage on the feeder which is dynamic depending on the load, load distribution and other factors

Conclusion
From model to real world

Every load is different

- Loads have an important effect on the distribution feeder performance
- Loads are complex and variable
  - Change dynamically 24/7
  - Load characteristics (pf, harmonics, kZ, kP, kI, etc.)
  - Grow/shrink over time
  - From feeder to feeder
  - With weather (temperature, …)

Conclusion
From model to real world

To optimize a distribution system performance means:

- To keep the voltage regulation within the limits
- To minimize the reactive power requirement
- To reduce losses

To fully optimize a distribution system performance one needs to measure:

- Voltage along the feeder (regulation and voltage profile)
- Reactive power flow
- Power losses of the feeders

Conclusion
From model to real world

- Grid Sync with VVO or CVR can reduce losses in a distribution system by as much as 5%
- This can save ~30 billion kWh (*)
- At $0.04/kWH (cost) it constitutes savings of 30B x 0.04= $120M annually
- That also translates to lowering CO_2 emissions by ~20 million metric tons
- For each 1% reduction, 7,900 MW of generation does not need to be built – (32) 250MW power plants

*** Volt/VAR Optimization Reduces Losses, Peak Demands** By: Xiaoming Feng, ABB Corporate Research and William Peterson, ABB Power Systems Raleigh, North Carolina USA

Conclusion
From model to real world

- Feeder monitoring provides the functionality to optimize the MV feeder performance
- GridSync is an important input to VVO/VVMS
- GridSync can be easily integrated into distribution systems due to its
  - Wireless communication
  - Smart metering capabilities
  - High accuracy
  - Ease of installation (installs hot, no breaking the line)
- Location and number of monitoring “points” are dependent on the nature of the feeders, loads, systems, etc.

Conclusion
From model to real world

Rules of Thumb for selecting and locating monitoring points:

You should consider feeder monitoring for:

- Feeders with significantly varying loads
- Feeders with mixed load types (kP, kZ, etc.)
- Feeders where aggregate data from Smart Meters is not available or does not add up
- Feeders where conservation voltage reduction (CVR) is to be used
- Distribution systems where performance optimization is important

Conclusion
From model to real world

Optimizing the grid will help utilities lower:

- the cost of delivering power to customers
- peak demand and associated costs
- CO_2 emissions
- the need to build additional power facilities

- GridSync:
  - Installs live without cutting the lines
  - Offers meter class accuracy for current and voltage
  - Allows for any phase control power without a battery
  - Is interoperable with all communications protocols and meter packages

Key Points
Three takeaways

Distribution components offers smart grid solutions that will enable utilities to increase:

- Efficiency…precise management and control of power usage
- Optimization…improved power quality through volt var management
- Reliability…provide real time voltage and power status and control 24/7

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