POWER
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PRESCRIPTIONS FOR THE POWER GRID IN THE DIGITAL AGE

Moving Beyond Reliability Based KPIs

Presentation Date: October 30, 2018
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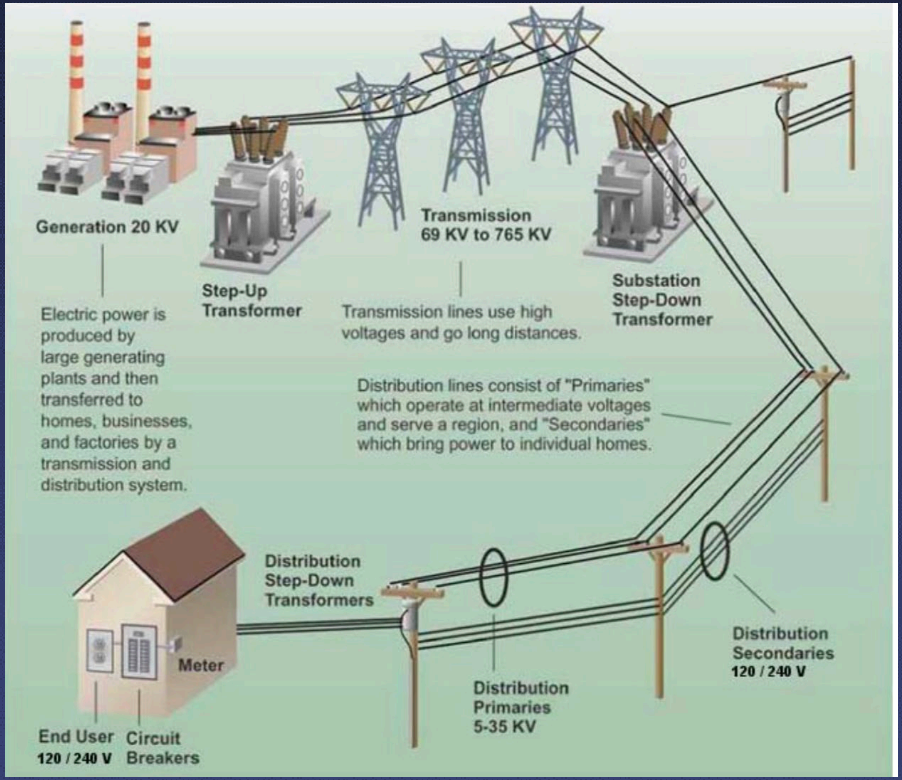
Presentation Outline

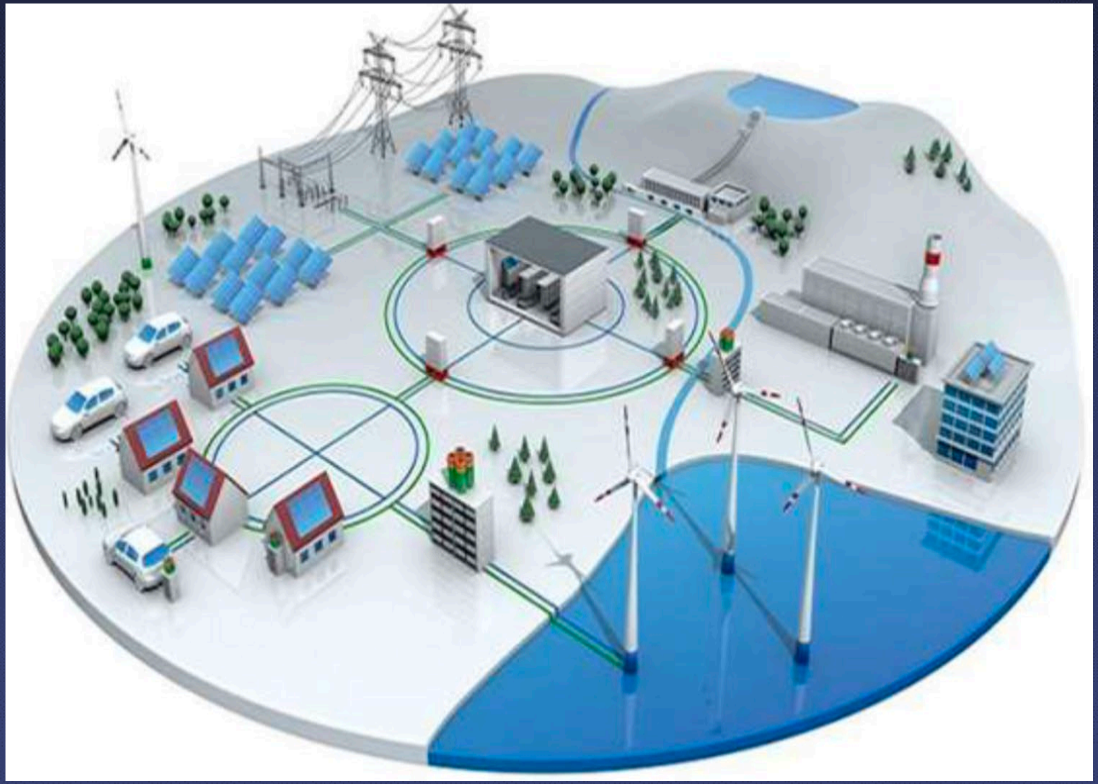
- Why Quality Based Metrics Are Needed?
- Enumerating The Costs Of Quality
- Standards That Outline Quality Metrics
- Future Grid Quality Metrics

Why Quality Based Metrics Are Needed

YesterGrid

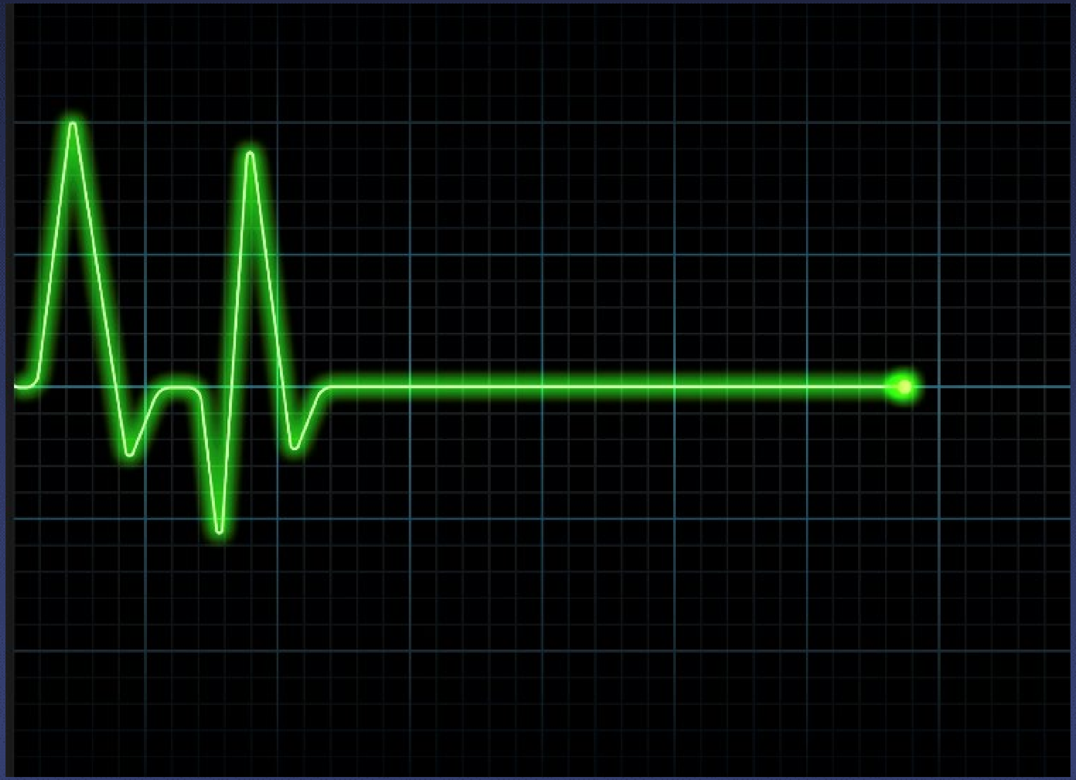


CurrentGrid

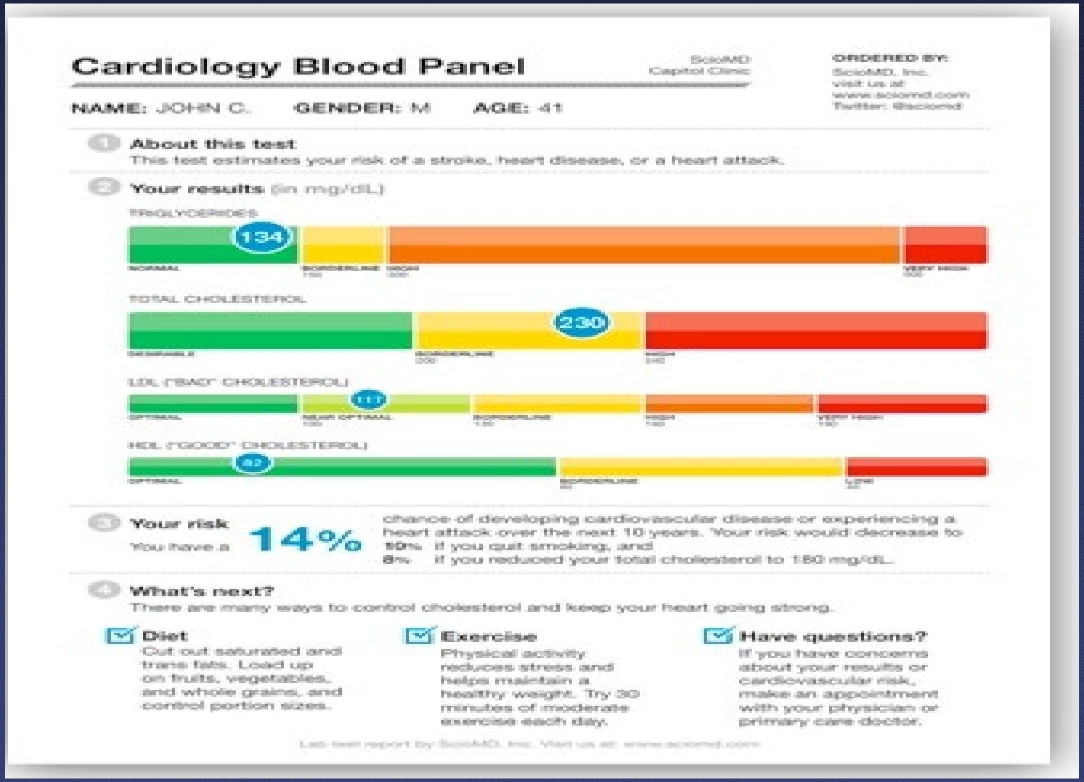


Reliability And Quality

Is The Patient Alive?



Is The Patient Healthy?



Cardiology Blood Panel

ScioMD
Capitol Clinic

ORDERED BY:
ScioMD, Inc.
visit us at
www.sciomd.com
Twitter: @sciomd

NAME: JOHN C. GENDER: M AGE: 41

1 **About this test**
This test estimates your risk of a stroke, heart disease, or a heart attack.

2 **Your results** (in mg/dL)

TRIGLYCERIDES
134
NORMAL BORDERLINE HIGH VERY HIGH

TOTAL CHOLESTEROL
230
DESIRABLE BORDERLINE HIGH

LDL ("BAD" CHOLESTEROL)
OPTIMAL NEAR OPTIMAL BORDERLINE HIGH VERY HIGH

HDL ("GOOD" CHOLESTEROL)
OPTIMAL BORDERLINE LOW

3 **Your risk**
You have a **14%** chance of developing cardiovascular disease or experiencing a heart attack over the next 10 years. Your risk would decrease to
10% if you quit smoking, and
8% if you reduced your total cholesterol to 180 mg/dL.

4 **What's next?**
There are many ways to control cholesterol and keep your heart going strong.

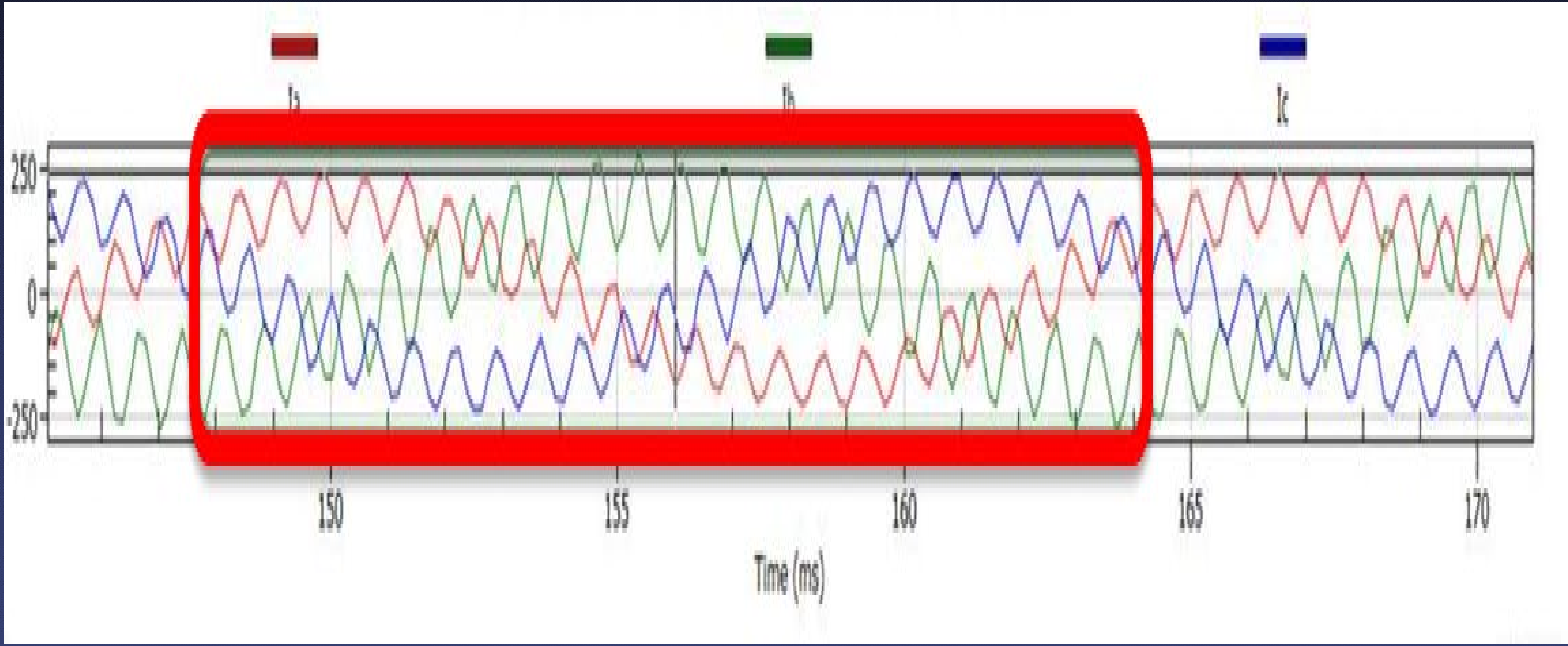
Diet
Cut out saturated and trans fats. Load up on fruits, vegetables, and whole grains, and control portion sizes.

Exercise
Physical activity reduces stress and helps maintain a healthy weight. Try 30 minutes of moderate exercise each day.

Have questions?
If you have concerns about your results or cardiovascular risk, make an appointment with your physician or primary care doctor.

Lab test report by ScioMD, Inc. Visit us at: www.sciomd.com

Alternatively, what is the conformance to our spec?



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Enumerating The Costs Of Quality

Source: Beacon Quality – Are you using the wrong quality metrics?

Does this seem familiar?

Utilities are being pushed for operational excellence and to reduce costs.

Simultaneously, there are more 3rd party generators and generator types which are all introducing entropy.

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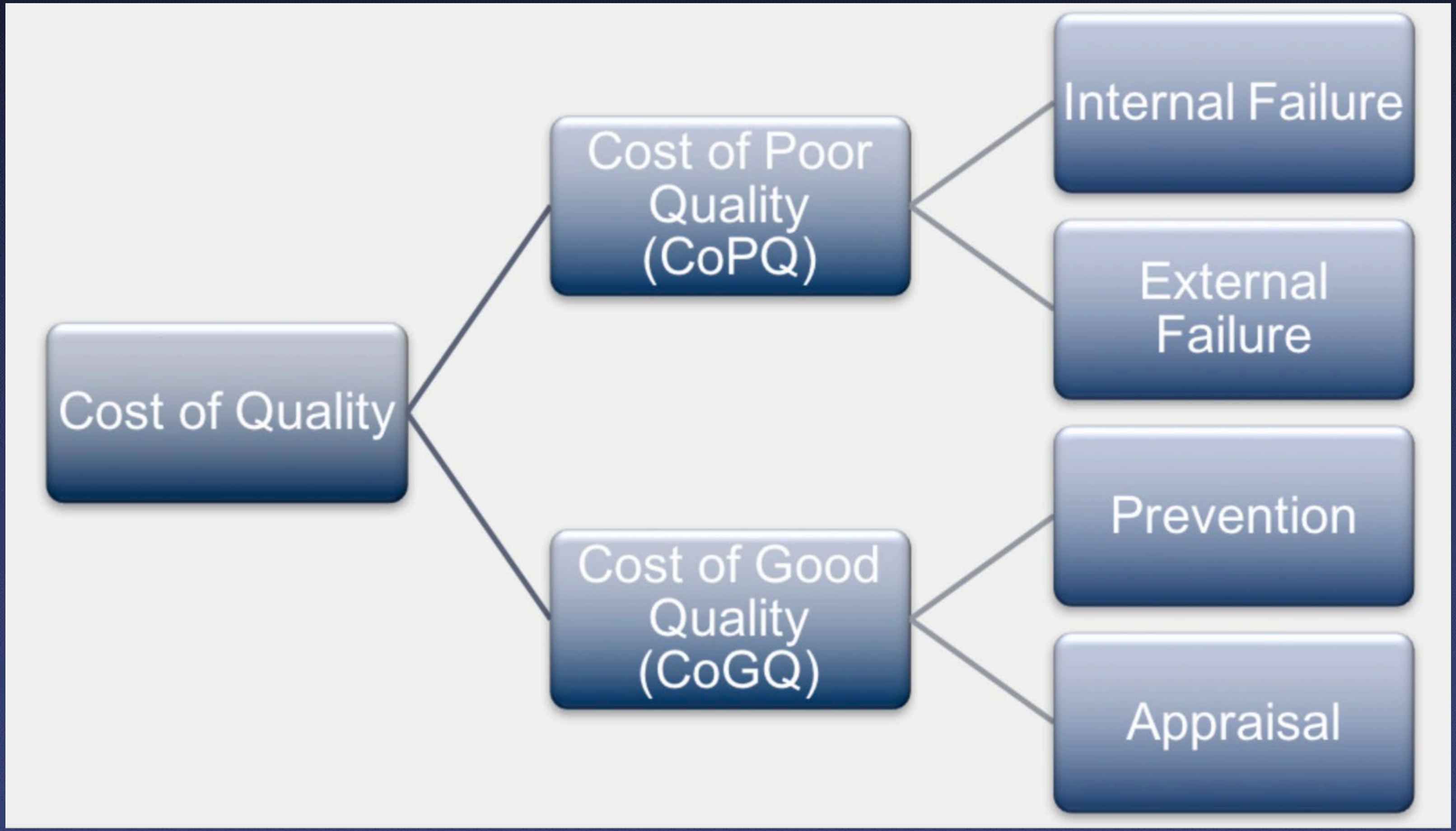
What is the cost?

According to the American Society on Quality:

“Many organizations will have true quality-related costs as high as **15 to 20 percent of sales revenue**, some going as high as **40 percent of total operations**. “



Electric Utility Industry Is $381B
Quality Related (15%) Issues -

$52B

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What are the risks?

COMPLEX SUPPLY CHAINS FUEL GREATER RISK – WITH LITTLE ROOM FOR ERROR

Tight competition and accelerating change has led to highly complex global supply chains, with manufacturers under pressure to deliver higher quality products at lower cost.

Automotive OEMs are increasingly focused on innovation and design, outsourcing components and assembly production to suppliers. Today, third parties produce more than 82% of automotive parts, compared to just 56% in 1985.[1]

53.2 MILLION VEHICLES RECALLED IN 2016.

BTW, THESE ARE OUR CUSTOMERS!

BUT, this is the way our industry is also beginning to look.

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Consequences…

- Unplanned equipment downtime
- Resources needed for failure analysis, corrective action, and redesign.
- Slow or ineffective fixes leading to an inefficient corrective action program.
- Executive time is spent on problems rather than pursuing more strategic goals.

Investing In Quality

- 1 - 10 – 100 Rule

Prevention

$1

Appraisal/Regulation

$10

Failure

$100

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Power Quality Indices Standards and Documents

- Grid Facing
  - IEEE 1564 – Guide for Voltage Sag Indices
  - CIGRE TB 596 - Guidelines for PQ Monitoring
  - CIGRE TB 718 – Benchmarking of PQ Performance
  - CIGRE TB 719 – PQ & EMC Issues with Future Networks

- Customer Facing
  - IEEE 1547 – DER Interconnection Standard
  - IEEE 1668 – Ride-Through Capability

Future Grid Metrics

- Grid Visibility Metrics
- Forecasting Exposure Metrics
- Individualized Consumer Metrics
- Reporting

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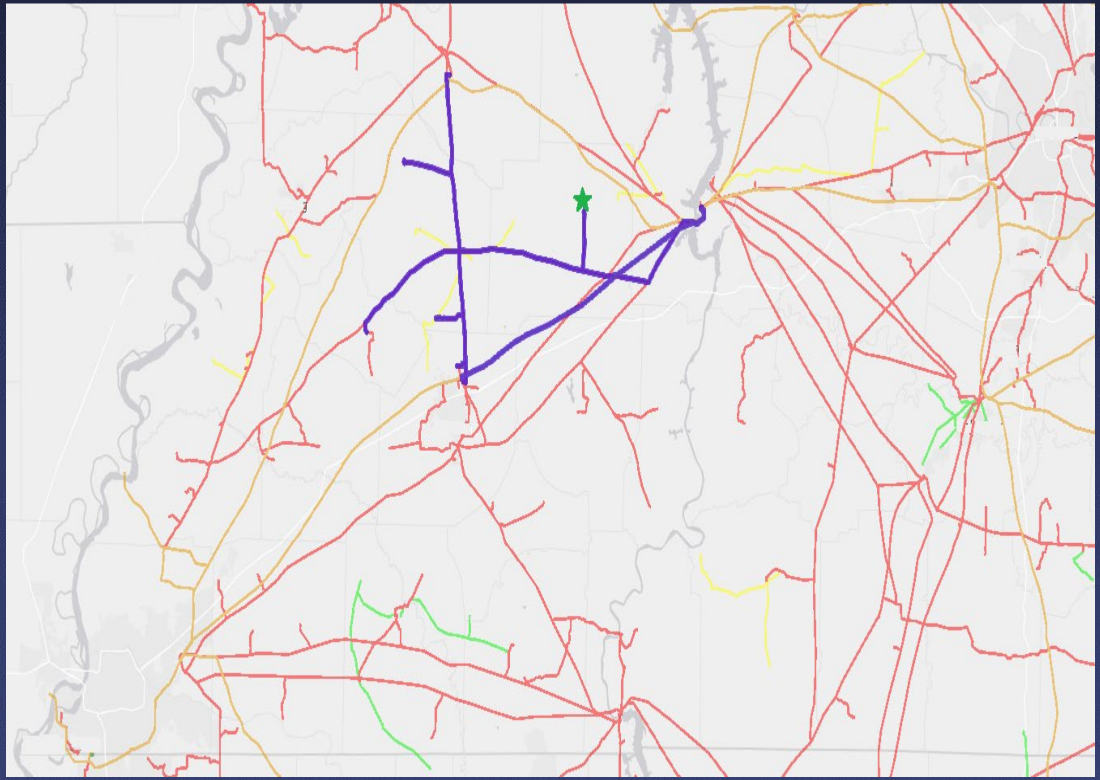
Grid Visibility KPIs

- Number Of Sites Monitored Continuously
  - Percentage Of The System With Monitoring
  - Critical Customer Loads
  - Customer Complaint Locations
  - Locations Where Problems Are Expected

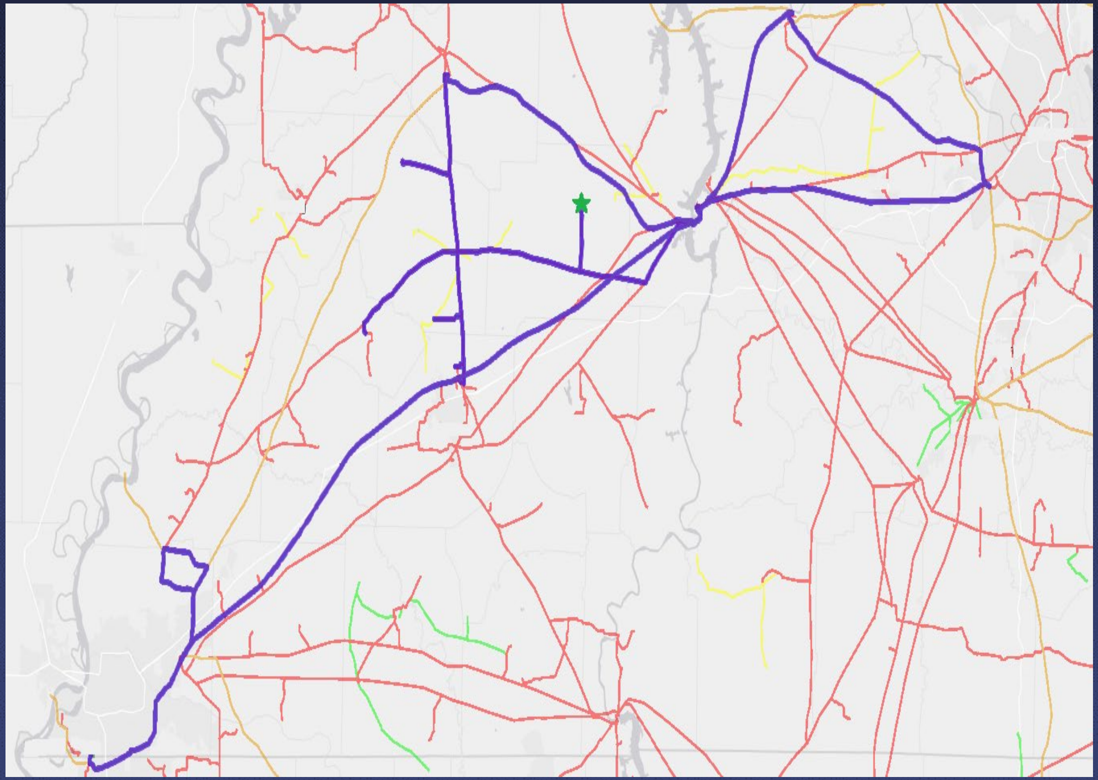
- Quantities Measured At Each Monitoring Site
  - Events: Sags, Swells, Transients
  - Steady State: Voltage, Current, Power, Frequency, Flicker, Harmonics, Voltage Unbalance, Current Unbalance.

Forecasting Exposure KPIs – Area Of Vulnerability

Before – 200 Miles



After – 600 Miles



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Individualized Consumer Metrics

- Voltage Regulation
- Voltage Balance
- Voltage THD
- Flicker
- Sag Magnitude/Duration Metrics

- Express risk in terms of cost?

Reporting

- Site PQ Compliance
  - For each metric – is site compliant?
- System PQ Compliance
  - For each metric – how many of the total number of sites are compliant? (See next slides)
- Benchmarking
  - For each metric – compare like sites

System PQ Compliance

$$I_T = \frac{N_E - N_T}{N_E}$$

Where:

I_T	=	The system PQ compliance index for event-based disturbance;
N_E	=	The total number of sites that were monitored; and
N_T	=	The total number of non-compliant sites.

Source: CIGRE TB 718, Benchmarking of Power Quality Performance In Transmission Systems.

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Example

- Utility has 100 sites
- Metric – Flicker
- CP95 Limit -1.0
- Except for sites below, all other sites are within limit

CP95	Site A	Site B	Site C	Site D	Site E
PST	1.1	1.2	1.4	1.0	1.0
1453 Compliant	N	N	N	N	N

$$\text{Flicker Compliance Index}=\frac{Total\ Sites-(Non-Compliant)}{Total\ Sites}=\frac{100-5}{100}=.95$$

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Extending The Index To A Simple System Health Index

- 4 Compliance Indices
  - Voltage Regulation (2 Sites Non-Compliant)
  - Voltage Balance (3 Sites Non-Compliant)
  - Voltage THD (1 Site Non-Compliant)
  - Flicker (5 Sites Non-Compliant)

$$System\ Compliance\ Reporting = \frac{Total\ Sites - (Non - Compliant)}{Total\ Sites} = \frac{100 - 11}{100} = .89$$

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Extending The Index To A Weighted System Health Index

Metric	Non-Compliant Sites	Weight	Index	Weighted Index
Voltage Regulation	2	1	.98	.98
Voltage Balance	3	2	.97	1.95
Voltage THD	1	3	.99	2.97
Voltage Flicker	5	4	.95	3.8

$$System\ Index = \frac{\sum Weighted\ Index}{\sum Weights} = \frac{9.69}{10} = .969$$

CIGRE C4.27 Recommended Benchmarking Quantities

- PQ Disturbances
- Harmonics
- Flicker
- Unbalance
- Sags / Swells

The system index for PQ compliance is based on the total number of non-compliant site-weeks, compared to the total number of weekly measurements at all sites across the entire system. The system compliance index is calculated as shown in Equation 4.1:

$$I_C = \frac{\sum_{i=1}^{N}(N_i - W_i)}{\sum_{i=1}^{N} N_i}$$

Equation 4.1

Where:

I_c	=	The system compliance index;
W_i	=	The number of weeks of non-compliance conditions at Site *i*;
N_i	=	The number of all weeks of valid data gathered by measurement at Site *i*; and
N	=	The total number of monitored locations.

The resulting PQ index will have a value between 0 and 1, where the former means no PQ compliance at all (i.e. all weekly indices are non-compliant at all sites) and the latter means full PQ compliance at all sites (i.e. all weekly site indices are compliant at all sites).

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Benchmarking

Additional information about each metric is needed:

- Voltage Class
  - LV
  - MV
  - EHV
- System Topology
  - Radial
  - Network
- Breaker Configuration
  - Automatic Reclosing
  - Pilot
- Event
  - Cause Codes

Conclusions

- The Grid Is Increasing In Complexity
- Reliability Alone Is No Longer A Sufficient Measure Of Utility Quality
- Power Quality Is Undervalued By Most Utilities
- Every $1 Spent On Prevention Saves $100 On Failure
- We Need Visibility Of The System – Measure Your Visibility (Internally)
- Use The Visibility Of The System To Understand The System Health
- Communicate System Health To Management
- Participate In Benchmarking
- Use These Tools To Make Inform Corrective Actions

Questions?

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