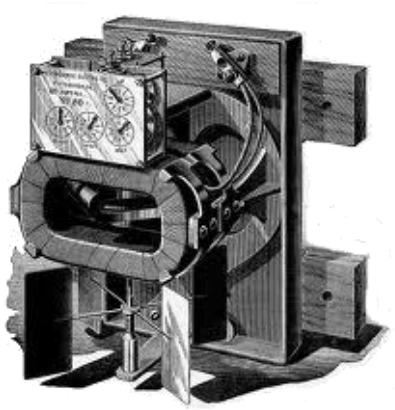
21st Century Power Measurements

Prepared by John Kretzschmar
SAMSCO

For Caribbean Meter School

Then – Now – Tomorrow?

Meters



First Meters mid-1990s

Westinghouse 1905

2005

2006

2014

2025 ???

SAMSCO

TESCO

Then – Now – Tomorrow?

Loads

YESTERDAY

TODAY

Then – Now – Tomorrow?

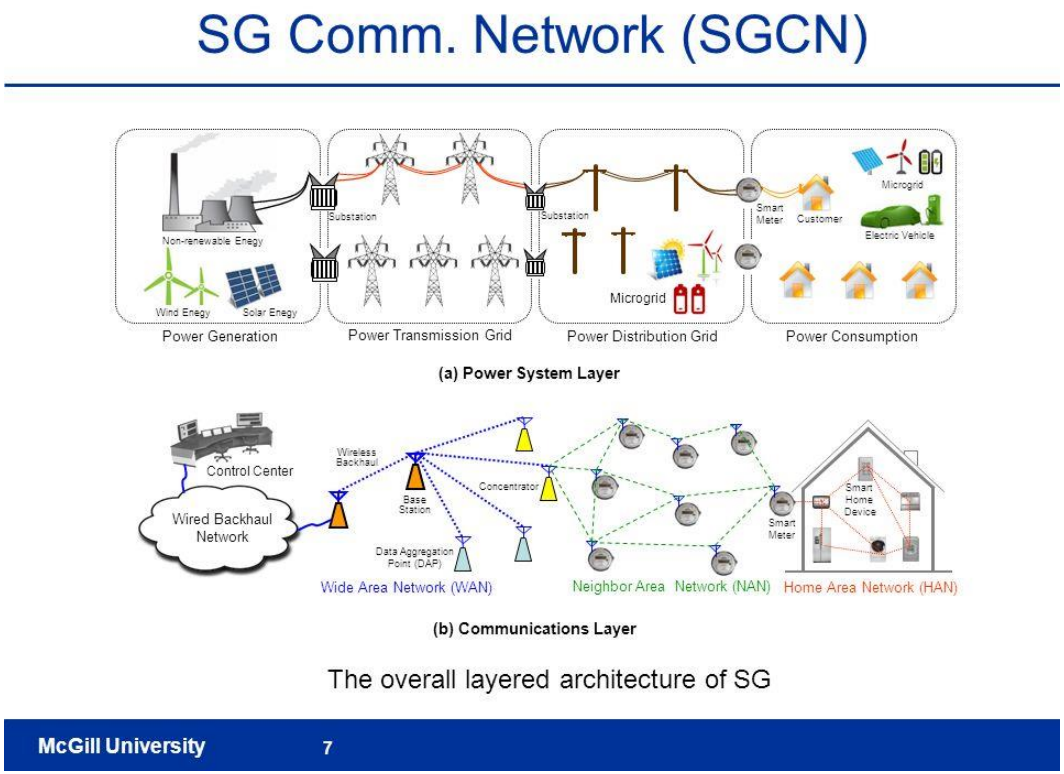
Loads

TODAY

Then – Now – Tomorrow?
Communications

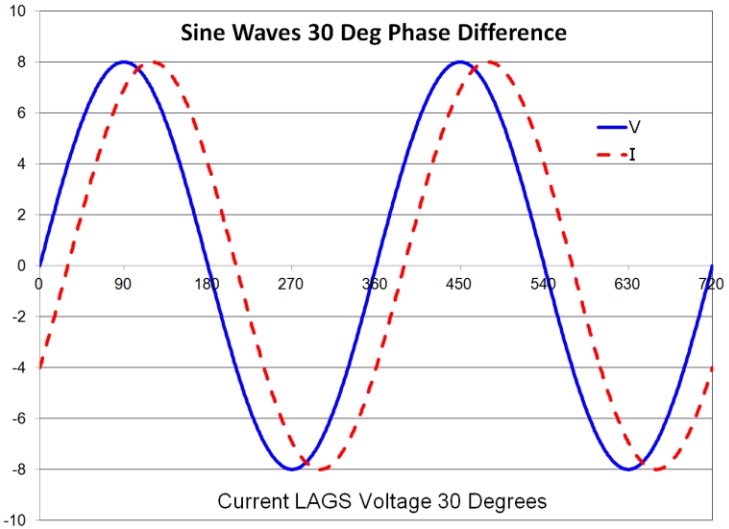
THEN

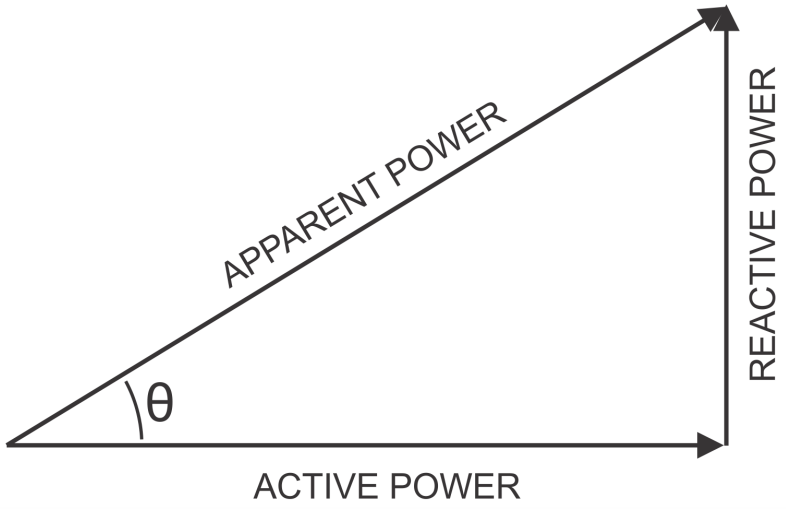
NOW



Why do these changes matter?

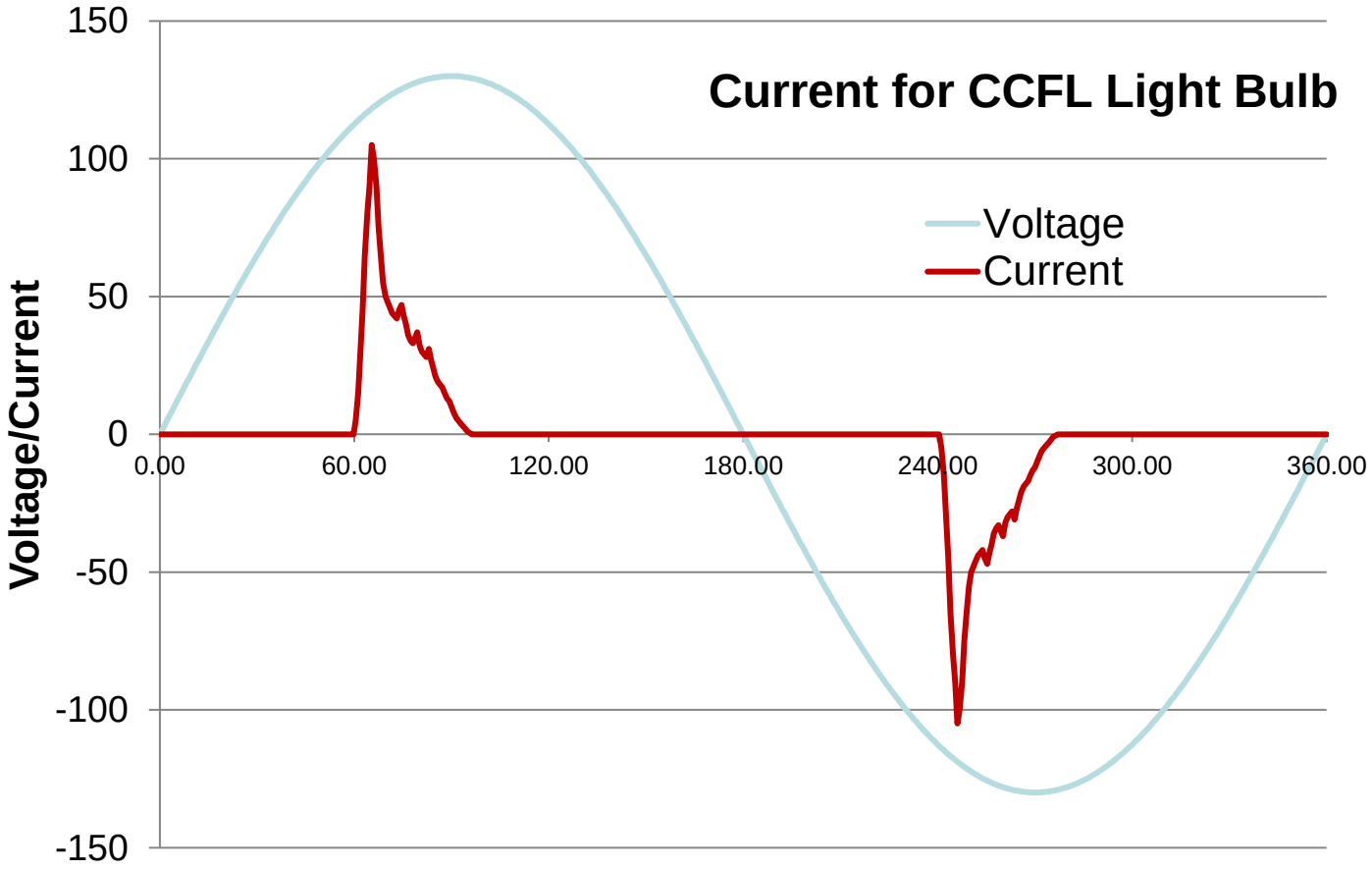
- Changes to our loads have changed the basic computations of metering.
- When loads were linear the power triangle was all we needed to know





Why do these changes matter?

- Today's loads look more like these



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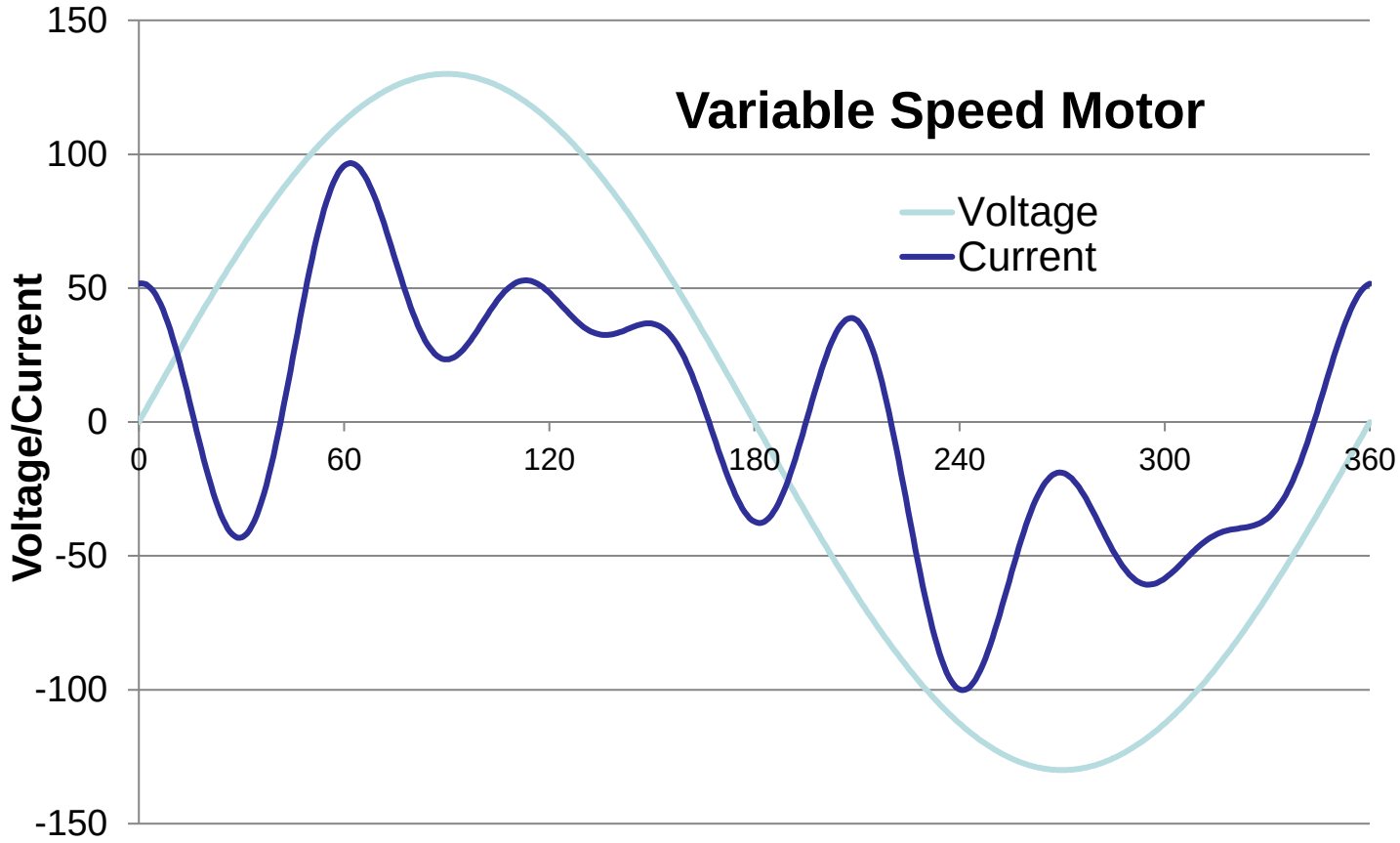

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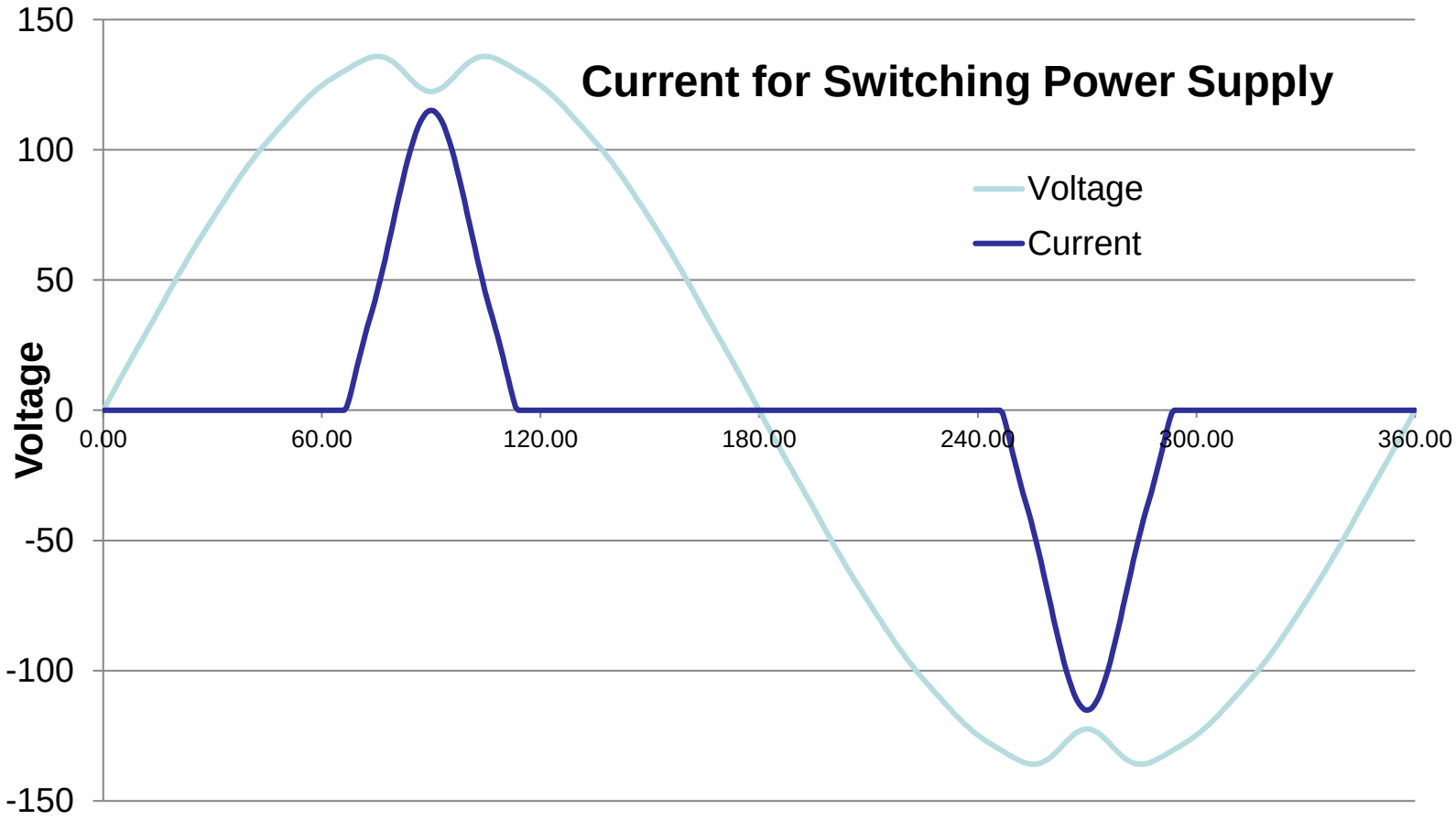

Why do these changes matter?

- Standards and practices have been very slow to respond to the changing reality
- That too is changing – by 2020 all of these issues should be fully addressed by ANSI Standards

- That will bring about tremendous change in how the industry operates

WILL YOU BE READY??

Standards Changes

- **New Revision of C12.20 in 2015**
  - Polyphase meters tested using polyphase
    - Recommended 2015, required 2020
  - Unbalanced load testing required
  - Full harmonic testing required
  - 0.1% Accuracy Class added
  - Specific call out of Non-Blondel applications where C12.20 does not apply
  - Detailed requirements and specs for test outputs added

Standards Changes

- **New Revision of C12.20 in 2015**
  - Tighter reference condition performance specifications
  - When using polyphase loading meters must be tested in each configuration used

Standards Changes

- **New Revision of C12.1 in 2015**
  - 0.5% Accuracy Class added
  - Testing required for unbalanced loads
  - Testing required under unbalanced conditions
  - Tighter reference performance requirements
  - Bi-directional energy flow testing
  - Extensive update on in service testing

Standards Changes

- **New Revision of C12.10 in 2015**
  - Accuracy tests moved here from C12.1
  - Much broader safety requirements
  - Coordinated effort with UL2735
    - Utilities exempt from UL2735 but only if they own and install the equipment

Standards Changes

- **New Revision of C12.9 in 2014**
  - Full specifications for test plugs included in standard
    - Ensures safe operation between all switches and all plugs
    - previously some combinations produced safety hazards
  - New barrier requirements between switch elements

Standards Changes

- **Communications Standards**
  - New C12.19 which replaces C12.18 and C12.19 is in ballot process
    - Major changes – major controversy has held up approval for two years
    - Standard will still not guarantee inter-operability
  - C12.23 the “Compliance Testing “ standard is nearly complete

Next Generation Standards

- **ANSI C12.46**
  - New standard in development to **replace C12.1** and **C12.20**
  - Structured like OIML IR-46
  - A true digital age standard
  - Applies to ALL energy measurements
    - Watts, VA and VAR
    - Contains precise definitions for the quantities based on digitally sampled waveforms

Next Generation Standards

- **ANSI C12.46**
  - Covers ALL waveform types
    - sinusoidal, harmonic, time varying
  - Defines the meter as everything under the cover
    - If there is auxiliary functions in the meter they must be fully operational during accuracy testing
    - If a option is added to a meter, it must be tested with the option running to remain qualified

New Energy Definitions

Time Domain

Active Power

$$P_t = \frac{1}{N}\sum_n V_i I_i$$

Apparent Power

$$S_t = VA = VrmsIrms = \sqrt{\frac{1}{N}\sum_{i=0}^{i=N-1} V_i^2 \bullet \frac{1}{N}\sum_{i=0}^{i=N-1} I_i^2}$$

Reactive Power

$$Q_t = \sqrt{S^2 - P^2}$$

New Energy Definitions

Frequency Domain

Active Power

$$P_f = \sum_n \left| \vec{V}_n \bullet \vec{I}_n \right| = \frac{1}{2} \sum_n (a_{vn} a_{in} + b_{in} b_{vn})$$

$$= \sum_n V_n I_n \cos(\theta_n)$$

Apparent Power

$$S_f = \frac{1}{2} \left[\sum_n (a_{vn}^2 + b_{vn}^2) \sum_n (a_{in}^2 + b_{in}^2) \right]^{1/2}$$

Reactive Power

$$Q_f = \sum_n \left| \vec{V}_n \times \vec{I}_n \right| = \frac{1}{2} \sum_n (a_{vn} b_{in} - a_{in} b_{vn})$$

$$= \sum_n V_n I_n \sin(\theta_n)$$

Next Generation Standards

- **ANSI C12.46**
  - View of accuracy changes
    - Currently changes with respect to reference
    - New approach is absolute error

Philosophy of C12.46 – When a meter is claimed to be of a specific accuracy class, for example , AC 0.2%, then it's accuracy under all commonly ocuring conditions should be within ±0.2% maximum error.

What does the Future Hold

- Over the next FEW years metering may have a whole new meaning
- Do these look like meters to you?

What does the Future Hold

- Each has an embedded revenue meter
- Each claims ANSI C12.1 compliance

Questions and Discussion

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This presentation can also be found under Meter Conferences and Schools on the TESCO web site: www.tesco-advent.com