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Standardizing for Energy Measurement: Considerations, Challenges, & Reality

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Current by GE / ANSI C137 ad hoc committee

Agenda:

Part 1: What is exciting about Energy Measurement?

Part 2: Why isn’t this as easy as it sounds?
…featuring a little bit of statistics that won’t hurt

Part 3: Who’s involved & What we’ve learned?

Park 4: What’s the plan?

PART 1: What is exciting about Energy Measurement?
-or-
Energy Measurement…exciting …really?

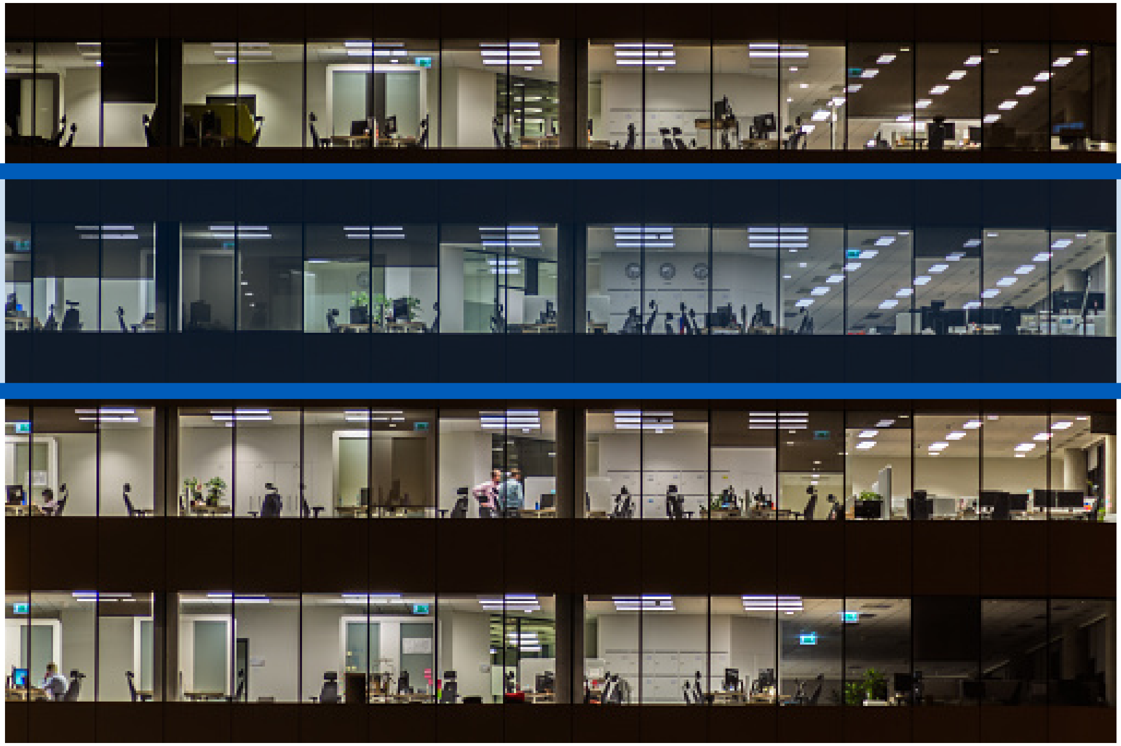
PART 1

What Does this Tell Us?

-Defined as The Truth
-Determines The Bill
-Well Understood

PART 1

What Does this Tell Us?



Retrofit

-Same overall

But for Retrofit:

-Possible confusion

-Less confident

PART 1

<<<<<<More Floors>>>>>>>

<<<<<<More Floors>>>>>>>

What Do I Want to Know?

-did I save the energy I thought I was going to?

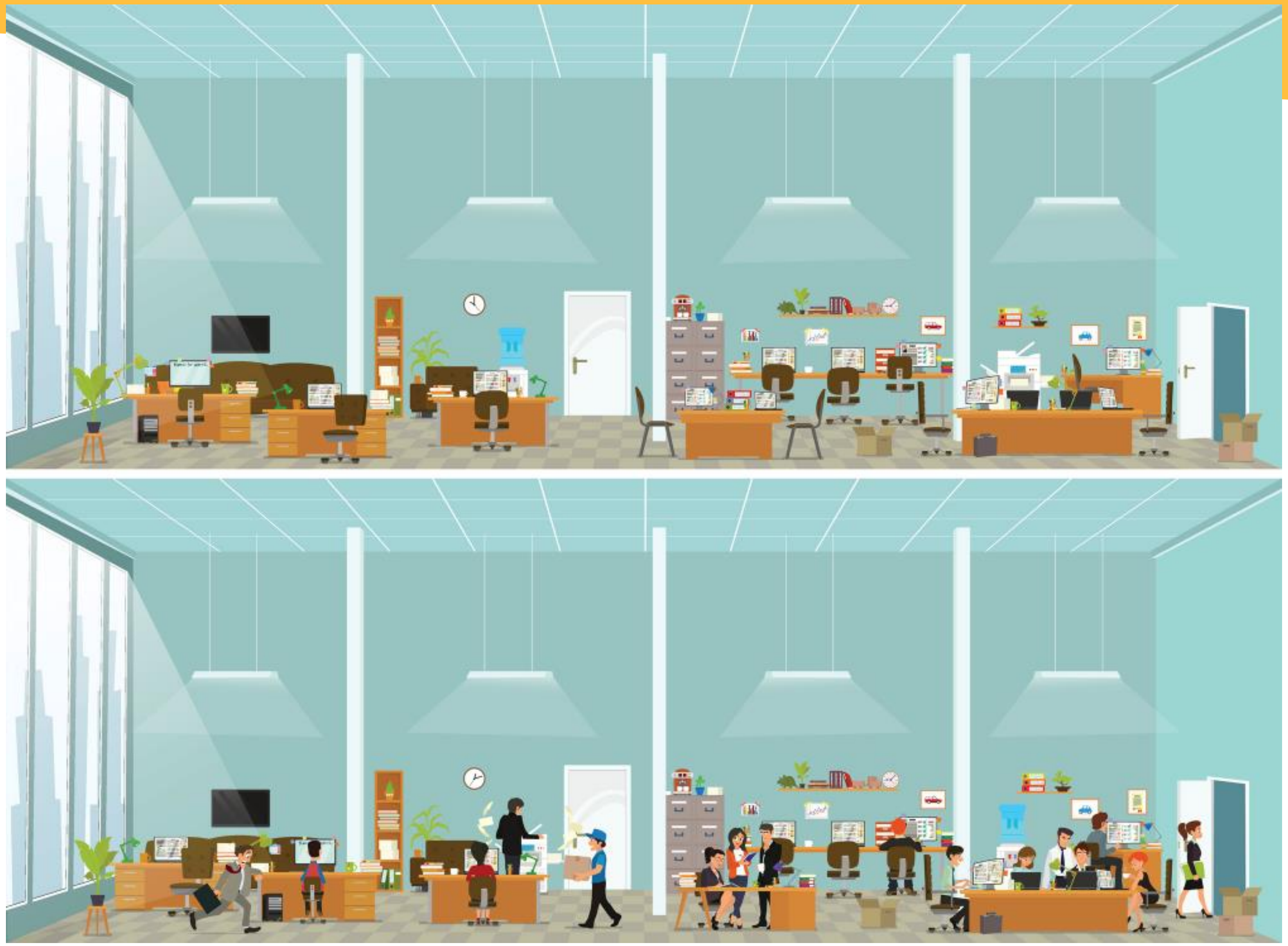
-is there a problem with my lighting?

-does everyone use the same amount of energy?

-can I tell from my history if I can voluntarily lower my demand during a certain time?

PART 1

<<<<<<More Floors>>>>>>>



<<<<<<More Floors>>>>>>>

How Is This Done?

-Permanent Sub-Meters
-Temporary Meters
-Light Loggers + Multimeter
-Building Comparison + Guess

<<<<<<More Floors>>>>>>>

<<<<<<More Floors>>>>>>>

ALTERNATE HYPOTHESIS:

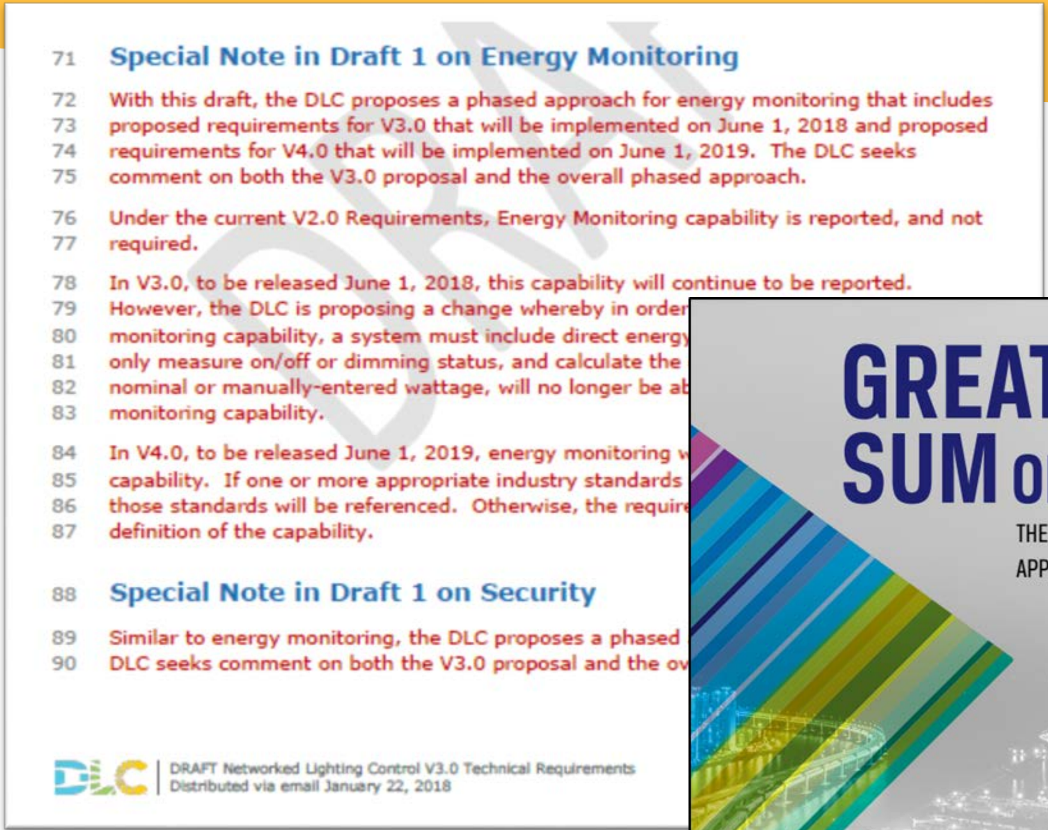
Collect the distributed data

Note: Not all loads captured

PART 1

Energy Measurement: WHY?

- Building Management
- Evaluation and Verification
  - Regulatory
  - Financial
- System Management
  - Electric Grid
  - System Efficiency Initiative (Alliance to Save Energy)
    - – www.ase.org/SEI



Special Note in Draft 1 on Energy Monitoring

With this draft, the DLC proposes a phased approach for energy monitoring that includes proposed requirements for V3.0 that will be implemented on June 1, 2018 and proposed requirements for V4.0 that will be implemented on June 1, 2019. The DLC seeks comment on both the V3.0 proposal and the overall phased approach.

Under the current V2.0 Requirements, Energy Monitoring capability is reported, and not required.

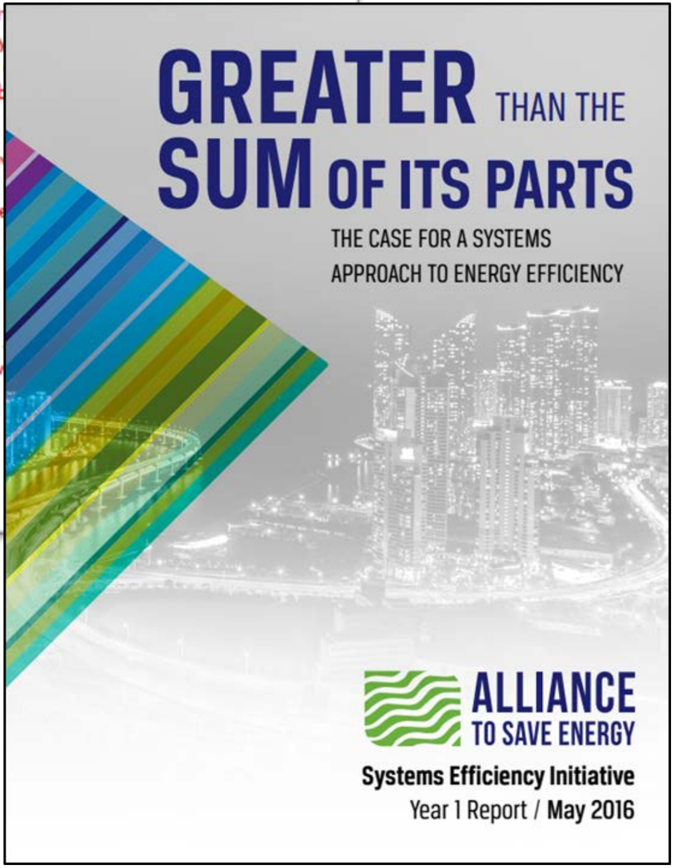
In V3.0, to be released June 1, 2018, this capability will continue to be reported. However, the DLC is proposing a change whereby in order monitoring capability, a system must include direct energy only measure on/off or dimming status, and calculate the nominal or manually-entered wattage, will no longer be ab monitoring capability.

In V4.0, to be released June 1, 2019, energy monitoring w capability. If one or more appropriate industry standards those standards will be referenced. Otherwise, the require definition of the capability.

Special Note in Draft 1 on Security

Similar to energy monitoring, the DLC proposes a phased DLC seeks comment on both the V3.0 proposal and the ov

DLC | DRAFT Networked Lighting Control V3.0 Technical Requirements
Distributed via email January 22, 2018

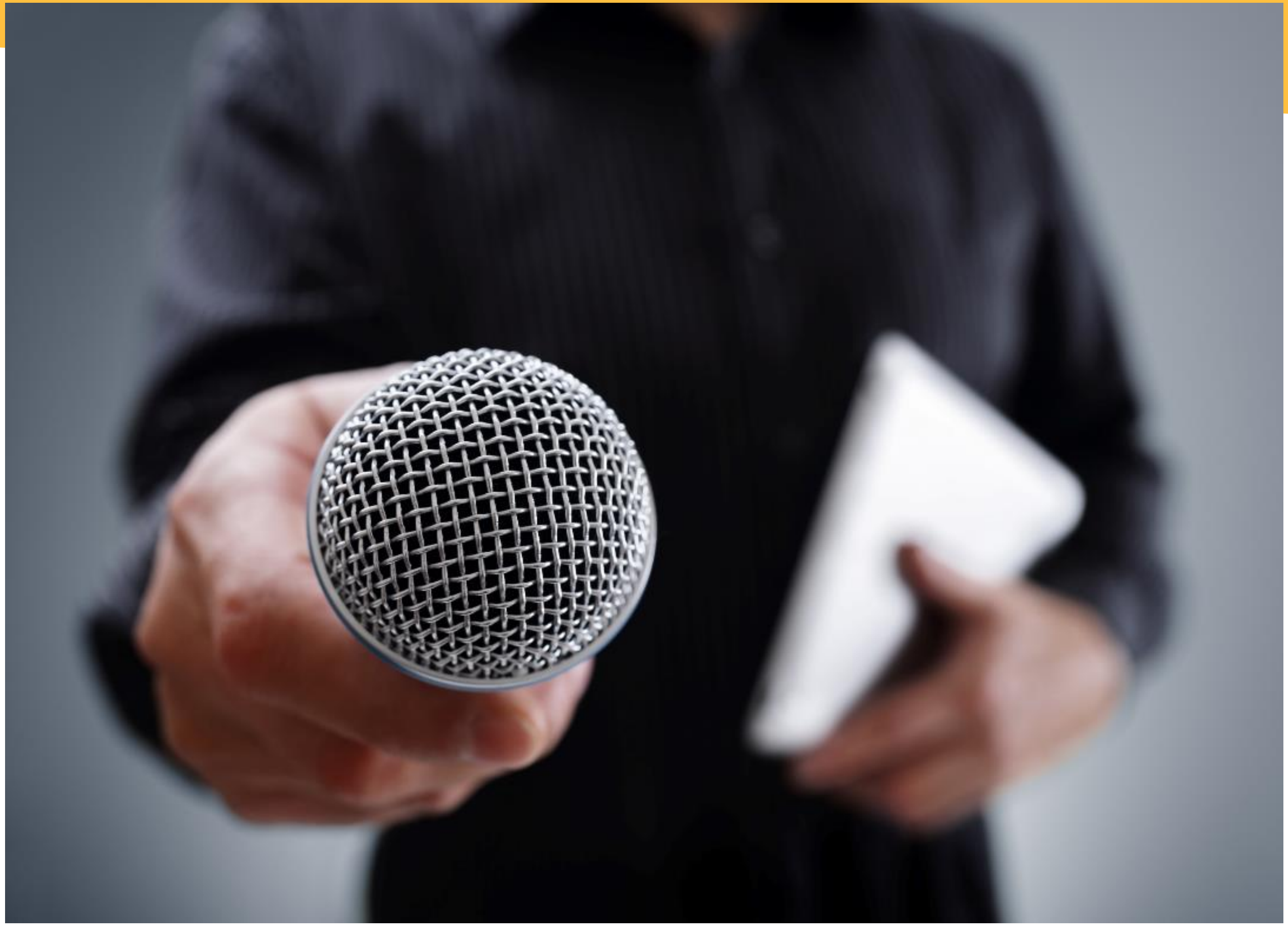


ANSI C137 ad hoc -> TARGETED USE CASES

1. Energy performance verification for contracted services.
2. Energy performance verification for utility energy efficiency programs
3. System energy management
4. Indoor or outdoor electrical distribution system performance verification and/or predictive failure diagnosis
5. Lighting device and/or system performance verification and/or failure diagnosis
6. Energy performance verification for codes, standards and certification programs

PART 1

PART 1



Is Energy Measurement Exciting?

PART 2: Why isn't this as easy as it sounds?
-or-
Are you done yet?

PART 2

?

=

Doo-Dad

+

Doo-Dad

+

Doo-Dad

PART 2

Tested and Certified to a specific Accuracy Class (.5%, 1%, 2%, etc.)
(Typically ANSI C12)

Expectation: ANY can be Field Verified

High Cost

PART 2

Low Cost

No Component Accuracy Certification (bummer)

Reliant on Other Components

Determined by System Design

What Can Go Wrong?

PART 2

-All of the devices could be offset
-Each device could be offset significantly
-There could be Bias (mostly + or -)
-There would be no way to tell

Doo-Dad

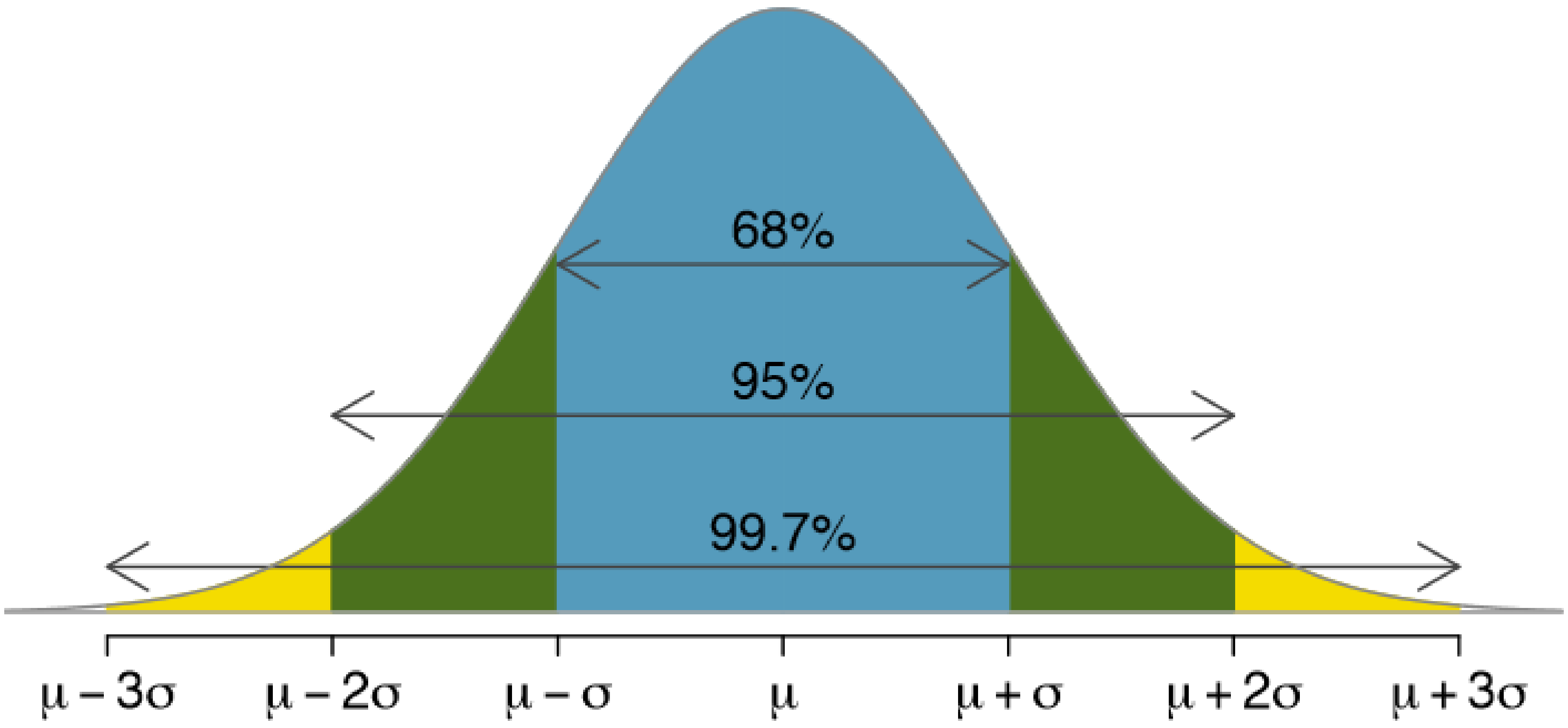
+

Doo-Dad

+

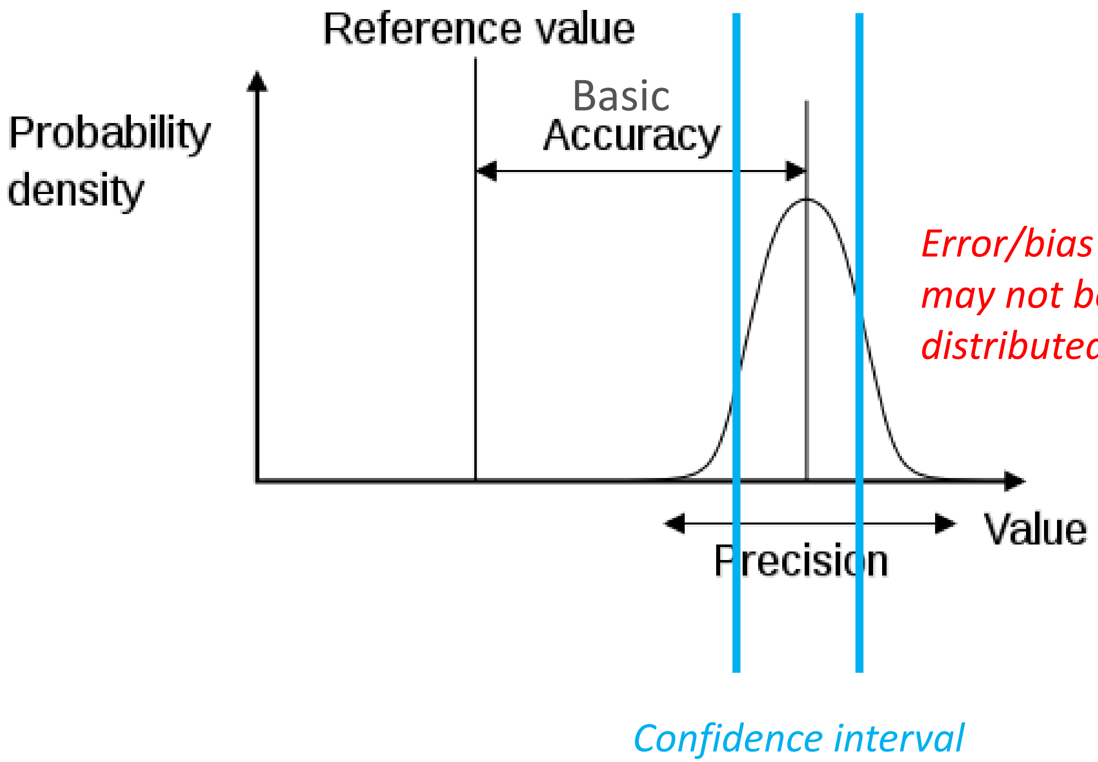
Doo-Dad

Standard Normal Distribution

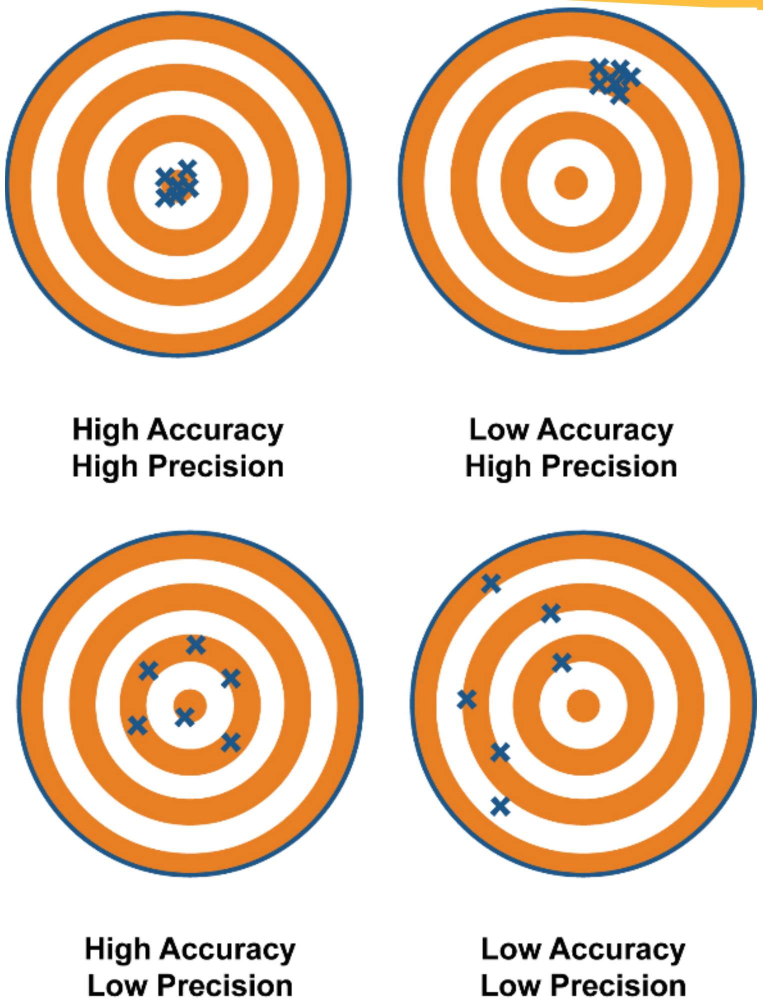


Accuracy vs. Precision

PART 2

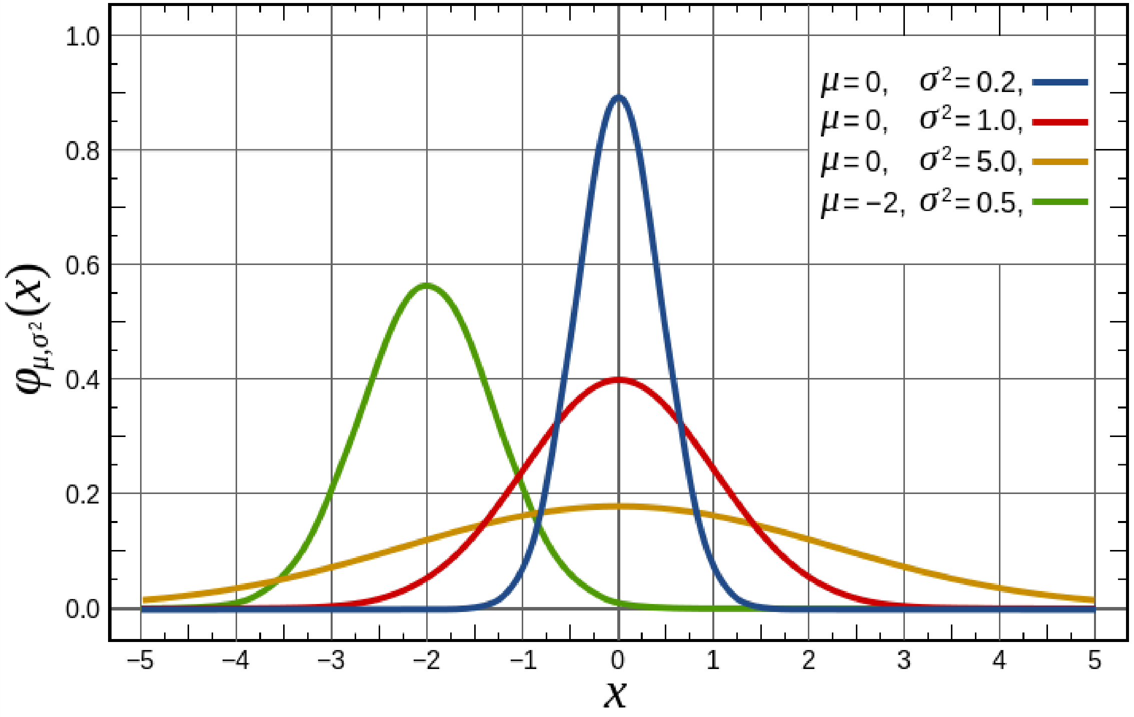


Error/bias sources may or may not be normally distributed (e.g., random)



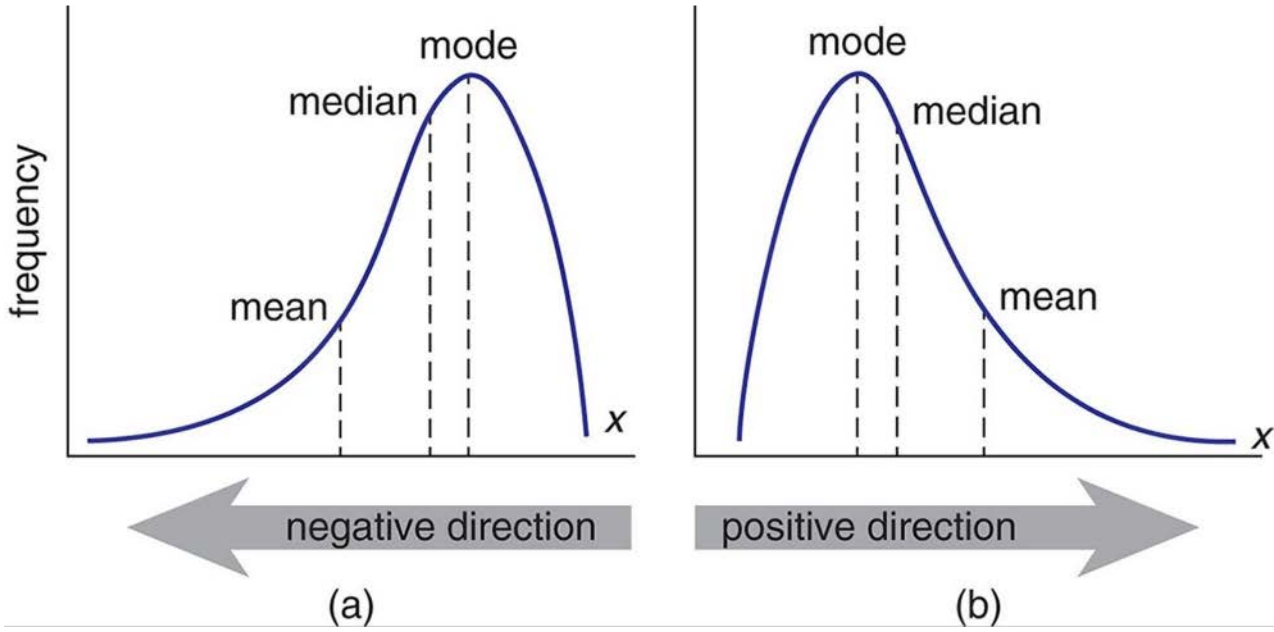
Distribution Examples

PART 2



NORMAL

NOT NORMAL



Manufacturing Variation: NEMA LSD 63

PART 2

TABLE 6-1
INDUSTRY CONSENSUS LONG TERM MANUFACTURING DATA VARIABILITY, s_{LT}/μ

Lamp/Ballast type	Luminous Flux	Lamp or Ballast Power	Efficacy or Efficiency	Color Rendering Index	Correlated Color Temperature
Tungsten filament lamp (GLS)	0.040	0.025	0.047	N/A	0.030
Tungsten halogen lamp (GLS and PAR)	0.050	0.040	0.064	N/A	0.030
Medium-based CFL	0.060	0.075	0.096	0.040	0.045
Double-based fluorescent lamp	0.050	0.025	0.056	0.040	0.025
Single-based fluorescent Lamp	0.060	0.050	0.078	0.040	0.045
High intensity discharge[3] –quartz MH lamp (pulse start only)	0.070	N/A	0.070	0.045	0.065
High intensity discharge[3] –ceramic MH lamp	0.065	N/A	0.065	0.040	0.050
High intensity discharge[3] –HPS lamp	0.040	N/A	0.040	0.020	0.025
LED lamps	0.050	0.095	0.107	0.040	0.045
Fluorescent lamp ballasts	N/A	0.026	0.025	N/A	N/A
HID ballasts–magnetic	N/A	0.020	0.010	N/A	N/A
HID ballasts–electronic	N/A	0.026	0.025	N/A	N/A

For practical purposes it is convenient to express the total variation in terms of the long term standard deviation to mean ratio, s_{LT}/μ, of the population. An estimate of known σ_{LT} for compliance determination in section 7.1 is calculated by multiplying the s_{LT}/μ ratio by the rated value, R, of the parameter of interest as in equation 6.1-1.

$$\sigma_{LT} \simeq R\left(\frac{s_{LT}}{\mu}\right) \qquad 6.1\text{-}1$$

- "Measurement methods and Performance Variation for Verification Testing of General Purpose Lamps and Systems"
- Anonymized data from high-volume lamp manufacturers statistically evaluated
- Provides guidance on the ratio of observed long term standard deviation to mean
- Gives examples showing Efficacy of LED Lamps can be in the order of 10%
- Also acknowledges a lab-to-lab variation of ~4%

- IN THE PROCESS OF BEING UPDATED

Measurement uncertainty: NIST round-robin lab testing

PART 2

Published 2016, testing completed Dec 2014

- Snapshot of 118 Solid State Lighting Testing Laboratories' Capabilities – all NVLAP labs
- F is a downlight retrofit, T is a tube light, I is Halogen
- Type F has a feedback loop
- Type T was without Socket which impacted measurements

https://www.tandfonline.com/doi/full/10.1080/15502724.2016.1189834

TABLE 5 Fit parameters for the electrical active power measurement differences for each lamp

Lamp type	Standard deviation (%)	Bias/ offset (%)	Number of points	Correlation coefficient	Critical value
F	1.09	−0.44	137	0.9803	0.9897
I	0.16	−0.10	128	0.9931	0.9897
L	0.28	−0.08	87	0.9692	0.9850
R	0.44	0.09	85	0.9679	0.9850
S	0.48	0.22	127	0.9857	0.9897
T	0.75	0.21	127	0.9572	0.9897

Ref: Luminous Flux & Efficacy +/- 4%

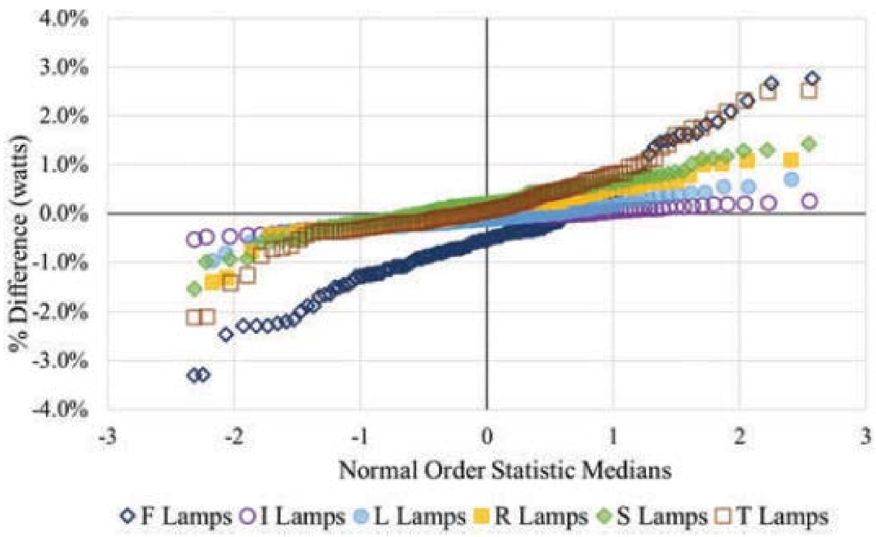
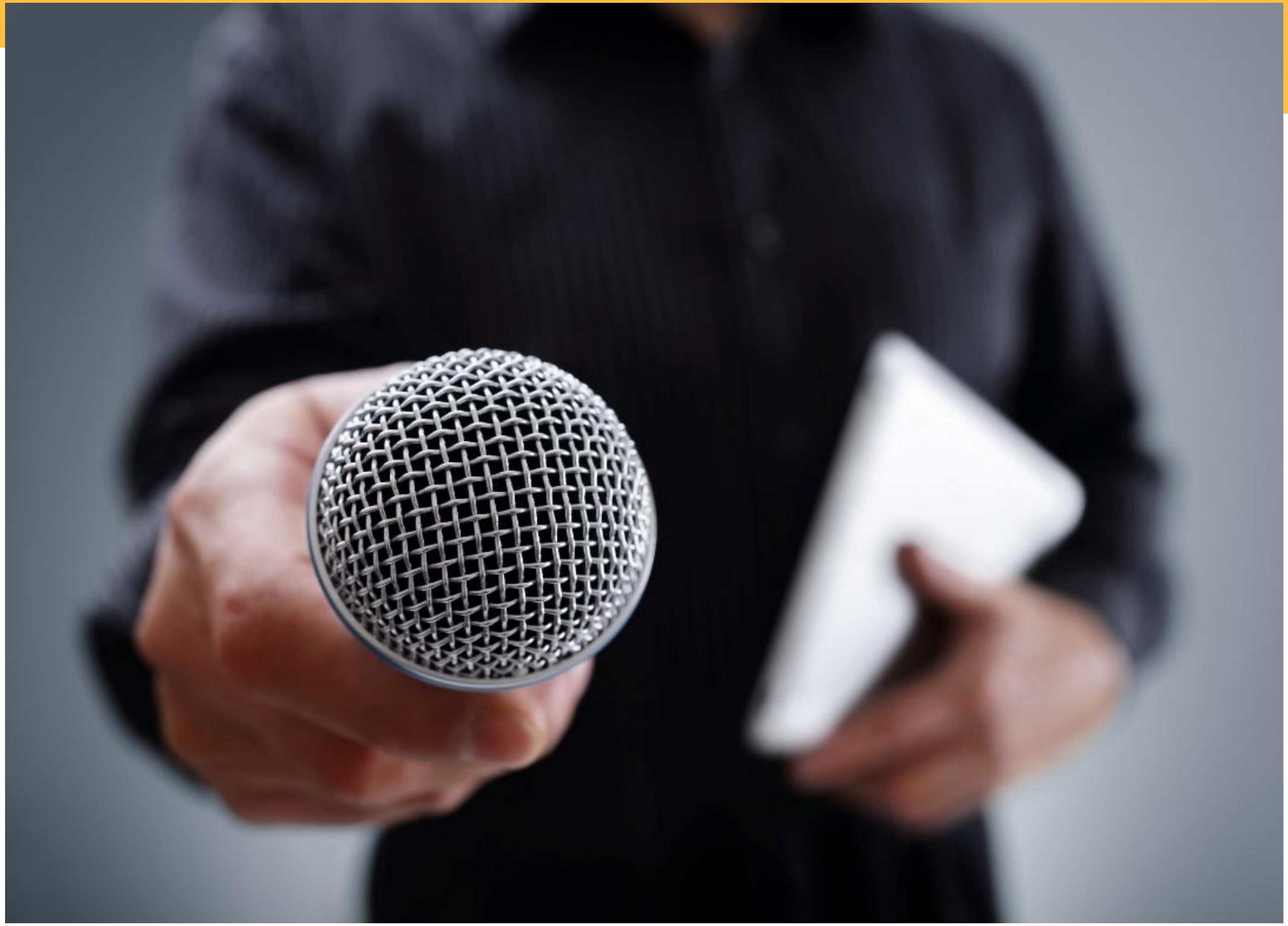


Fig. 5 Normal Probability Plots for the differences in electrical active power measurements for each lamp type.

PART 2



Would You Bet on This?

PART 3: Who’s involved & What we’ve learned?

-or-

So are we at square 1 or…?

I am Jer. We are ANSI C137 ad hoc:

PART 3

ANSI C137 is the American National Standard Committee on Lighting Systems

Atlas	Leidos
Cadmus (new)	Leviton
Cree	Lutron
Current by GE	Osram
DLC	PNNL
Duke Enegy	Schneider Electric
Eaton	Signify (Formerly Philips)
Georgia Power	Silver Spring
Hubbel	Telensa
IALD	UL
Intertech	Universal Lighting Technologies
Legrand	

Use-Case Survey Results

PART 3

Various references are cited

- 80% confidence with 20% accuracy for light loggers
- 90% confidence with 10% accuracy for watt-hour meters
- 80% confidence with 10% accuracy at portfolio

Time stamping is needed for some, but not all

- Various logging periods, from ~10-15 min down to 2 minutes
- Various retrieval periods, from ~2-3 weeks, to 1 month, or even 3 months

Both calculated (via light loggers) and measured (via multi-meters) techniques commonly used

- Various reported accuracy requirements (.5%, 1%, 2%, 5%)
- Typically 15 min logging interval for loggers, some as small as 5 min, 1 min, 30 sec
- Also just facility physical audits
- Accuracy requirements generally more relative than absolute; repeatability/precision more important than accuracy, as savings calculated pre vs. post

Use-Case Survey Summary

PART 3

Majority of completed surveys for energy performance verification use-cases. Survey responses contain significant valuable information about use-case practices, but very limited information about energy reporting accuracy needs or the relationship between accuracy and use-case objectives

There is a perception-reality gap, as expected, pointing at a desire for trust in the data but an absence of clarity. There is not an overly-entrenched agreement on a "best practice" other than conventional activities. This presents fertile ground for new work.

M&V budget: customers budget 2-3% of savings; IPMVP recommends 10% of savings

Mixed ideas about future state, some unreasonable (e.g. revenue-grade logger in every luminaire), others focused on accelerated processes, continuous commissioning

NEMA working group

PART 3

Cataloged existing utility incentive programs and their requirements/guidance

Cataloged definitional needs & gaps from existing documents relevant to our objective

Evaluated expected statistical data outcomes based on existing documents in regards to system bias

Confirmed the need to include REAL (including PF) usage (kWh) and demand (kW)

Met with CADMUS, and discussed various use cases

- Verified biggest issue is getting on site
- Most existing analysis is on portfolio-scale

Met with EVO, who sponsor IPMVP maintenance and ongoing development

Dissolved. Learnings, stakeholders (e.g., Cadmus, possibly EVO) absorbed into C137

Key Assumption DISPROVED: It appeared that there may have been a chip-level certification, but this has shown to be untrue

IPMVP

There **IS NO RECOMMENDATION** for accuracy/precision

6.5.6 Metering: "Utility-meter data are considered 100% accurate for determining savings because the data defines the payment for energy."

3.1.2 "…Selecting the appropriate sampling criteria requires balancing accuracy requirements with M&V costs."

4 "No meter is 100% accurate, through more sophisticated meters may increase the accuracy toward 100%."

Examples are given repeatedly at a "90/10 uncertainty criterion (confidence and precision) expressing a 90% confidence and +/- 10% precision

FEMP M&V Guidelines 4.0

5.3.2 "Use sample sizes that meet a confidence level of at least 80% and a precision of 20%."

5.3.2. Includes recommendations to calculate a Coefficient of Variation (Cv)….which is defined in Section 4 as a "normalized measure of variability between two sets of data" and appears to be particularly used in comparing with simulated data

PART 3

PJM Manual 18B (Forward Market Operations)

PART 3

9.2 “Sampling shall meet a statistical accuracy and precision of no less than one-tailed 90% confidence level (equivalent to two-tailed 80% confidence level) and 10% relative precision…”

12.1.6 “Any measurement or monitoring equipment that directly measures electrical demand (kW) must be a true RMS measurement device with an accuracy of no less than 2%”

12.1.9 “Data recorders must be synchronized in time, within an accuracy of +/- 2 minutes per month, with the National Institute of Standards and Technology (“NIST”).”

12.1.10 “All measurement, monitoring and data recording equipment must be calibrated…in such a way to meet or exceed the International Measurement and Verification Protocol (IPMVP)< NIST< or equivalent standard.”

12.1.15 “Any measurement, monitoring and data recording equipment that sample continuously and integrate values should collect data at a frequency of one hour or less. For devices that only sample “snapshots” or applications susceptible to data aliasing, one should collect data at a frequency of 15 minutes or less.”

M-MVDR (ISO New England Manual)

PART 3

7.2: Sampling the total population of demand reduction measures is permitted, provided the population estimates derived from sampling achieve 10% relative precision with no less than 80% confidence interval.” Calculations are in 7.2.3

7.2.2(4):”The project sponsor shall identify methods for controlling bias in sample selection…”

10.2(1) “All solid-state measurement, monitoring and date recording equipment shall meet or exceed the relevant standards set by the American National Standard Institute (“ANSI”) or equivalent standard for the equipment.”

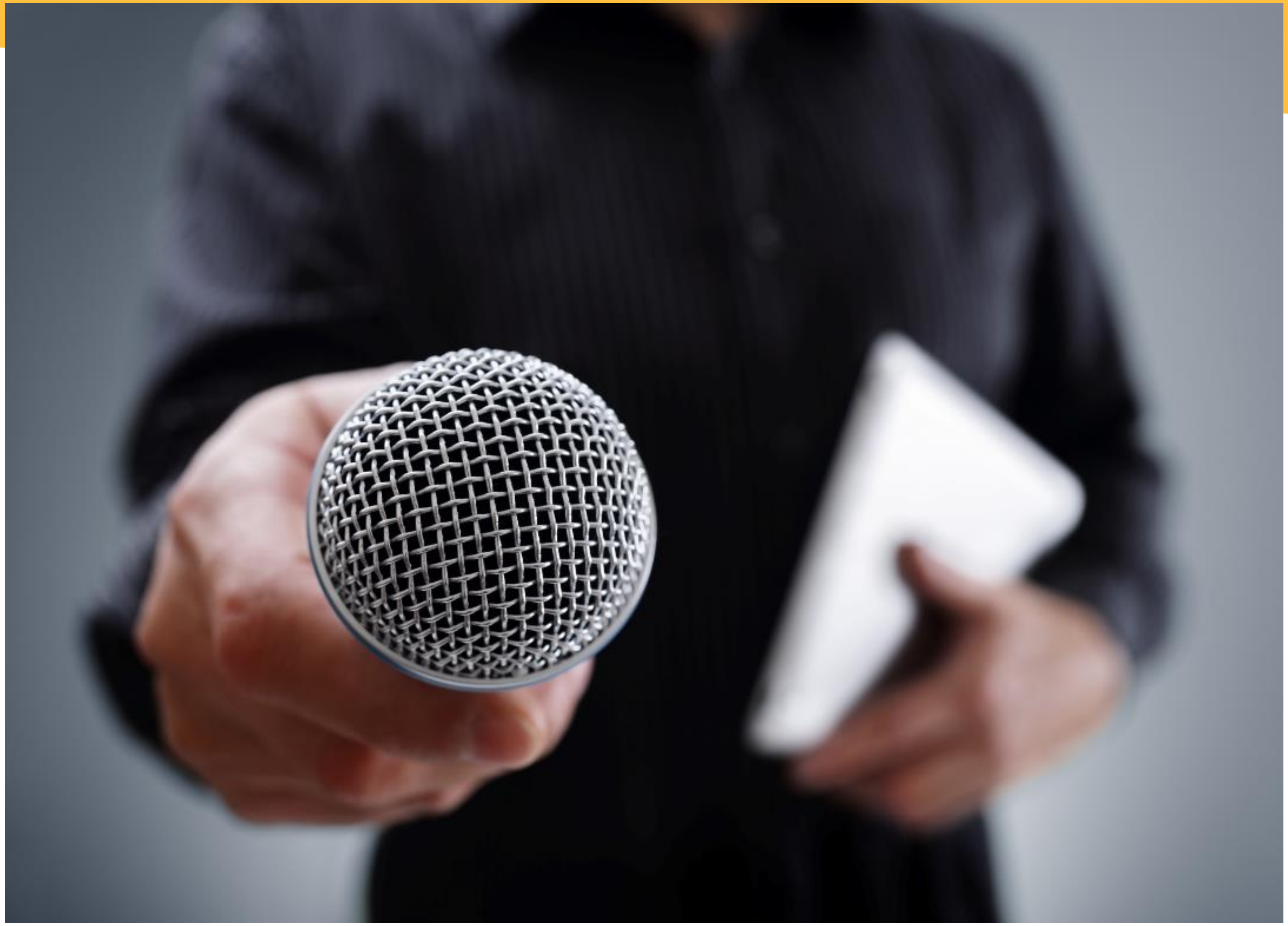
10.2 (6) “Any measurement or monitoring equipment that directly measures electrical demand (MW) shall be a true RMS measurement device with an accuracy of no less than +/-2%) [NOTE, see 10.2(9) below]

10.2 (9) “Any measurement or monitoring equipment of proxy variables that do not directly measure electrical demand, including but not limited to voltage, current, temperature, flow rates and operating hours, shall have an accuracy rating such that the overall accuracy of the calculated demand (MW) using the proxy variables is not less than +/-2%.”

10.2 (11) “Data records shall be synchronized in time, within an accuracy of +/- 2 minutes per month, with the National Institute of Standards and Technology (“NIST”).”

10.2 (12) “Interval metering devices shall collect electricity usage data at a frequency of 15 minutes or less”

PART 3



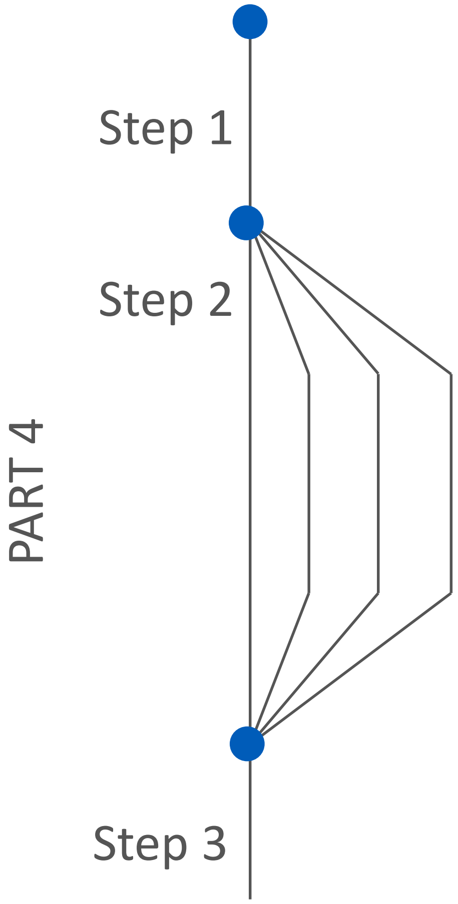
What Have We Missed?

PART 4: What's the plan?
-or-
Are you done yet?

PART 4

June 19: ANSI C137 Meeting

- Ad hoc completed research phase
- Initiated Project at ANSI to create the first Standard
- Developed strategy to address needs



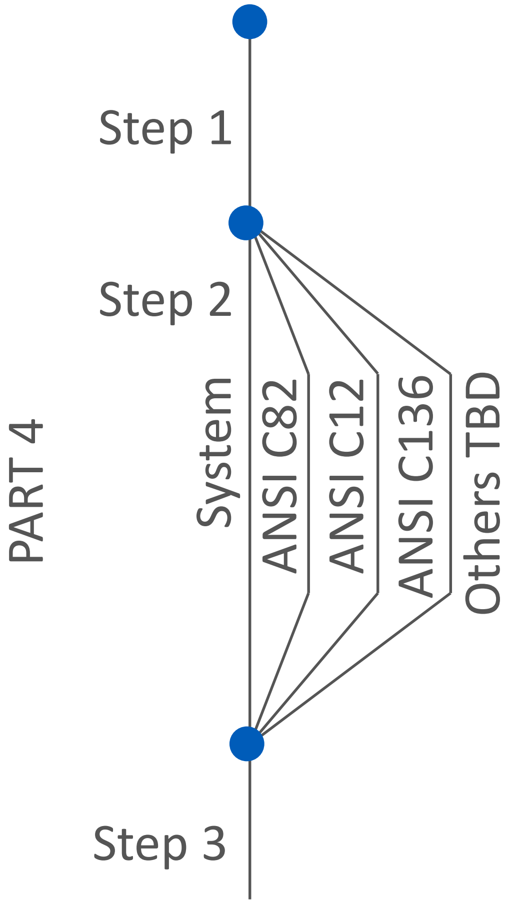
STEP 1 – Underway Now

-> ANSI C137.x – NEW STANDARD DEVELOPMENT

-Energy reporting requirements for non-revenue lighting devices

-Scope may include: accuracy, precision, and statistical representation of specific reported data values for a single performance class of energy data

-DOES NOT include Test Methods to Verify Performance



STEP 2 (planned)– Expert Focus

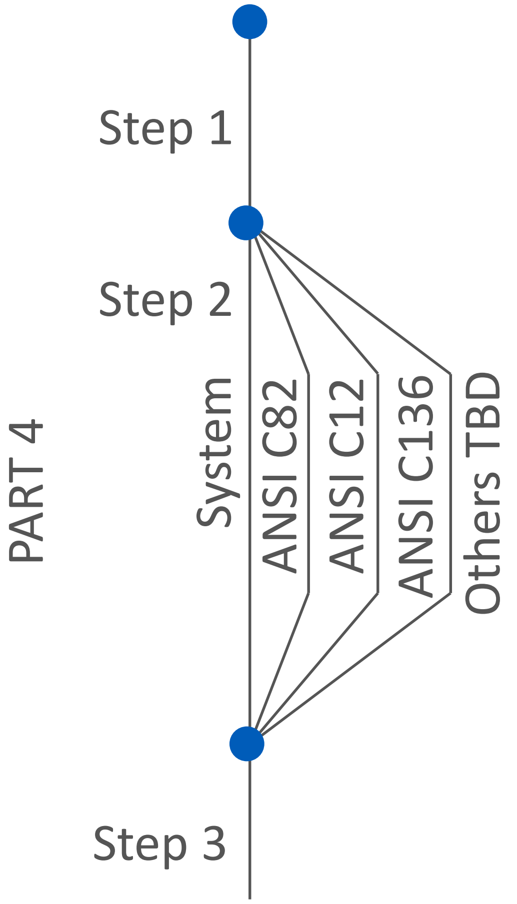
-With requirements standardized, engage existing groups of experts to move as quickly as possible

->ANSI C137 -> Focus on the system-level aspects

->Reach out to ANSI C12 -> Metering Test Method Experts

->Reach out to ANSI C82, C136 -> Device Experts

->Identify other experts



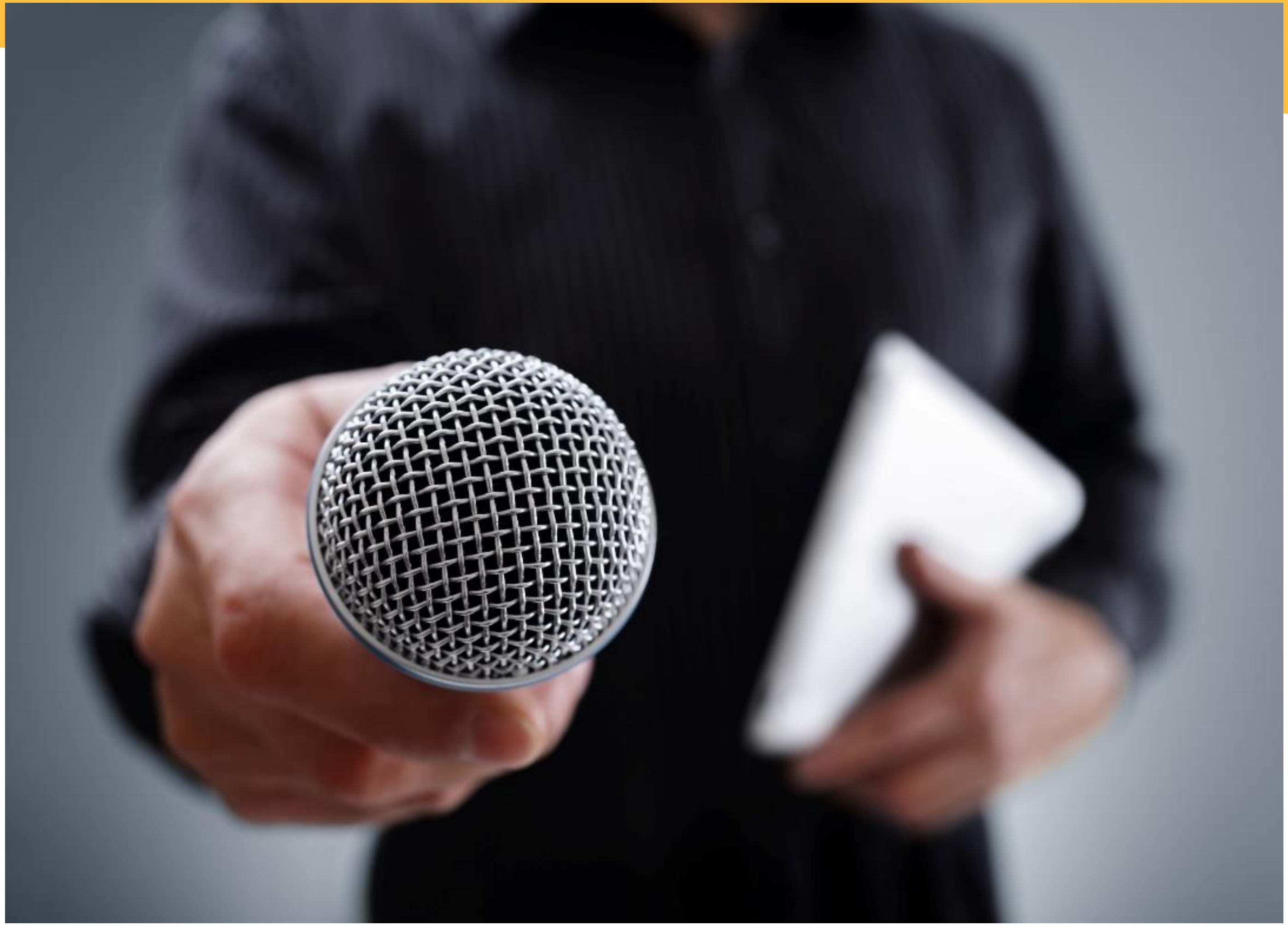
STEP 3 – To Be Determined

-Bring it all together

-Work together on rolling out

-Test, Measure, Validate

PART 3



How Does This Sound?

THANK YOU!

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