# Auditing and M&V Presentation

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**Irish Saying: You'll never plough a field by turning it over in your mind.**

# Audits

Focused on Energy Savings

Most used/accepted guidelines:



ANSI/ASHRAE/ACCA Standard 211-2018

**Standard for Commercial Building Energy Audits**



ANSI/ASHRAE/ACCA Standard 180-2018
(Supersedes ANSI/ASHRAE/ACCA Standard 180-2012)

**Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems**

# When to Audit?

➢ Know your Energy Use Index (EUI)
  ➢ EnergyStar Portfolio Manager
  ➢ EUI = Annual Energy Use (kBtus) / Building(s) Gross Area (ft²)

➢ When Required by code/law
  ➢ Seattle Tune-Up = ASHRAE Level I Audit
  ➢ Washington State Clean Budlings Act = **if EUI not met** → ASHRAE Level II Audit

➢ Noticeable increase in energy costs

➢ Sale or Acquisition of Asset

➢ Persistent Occupant Discomfort/Complaints

➢ Pressurization Issues

➢ In preparation or replacements/upgrades

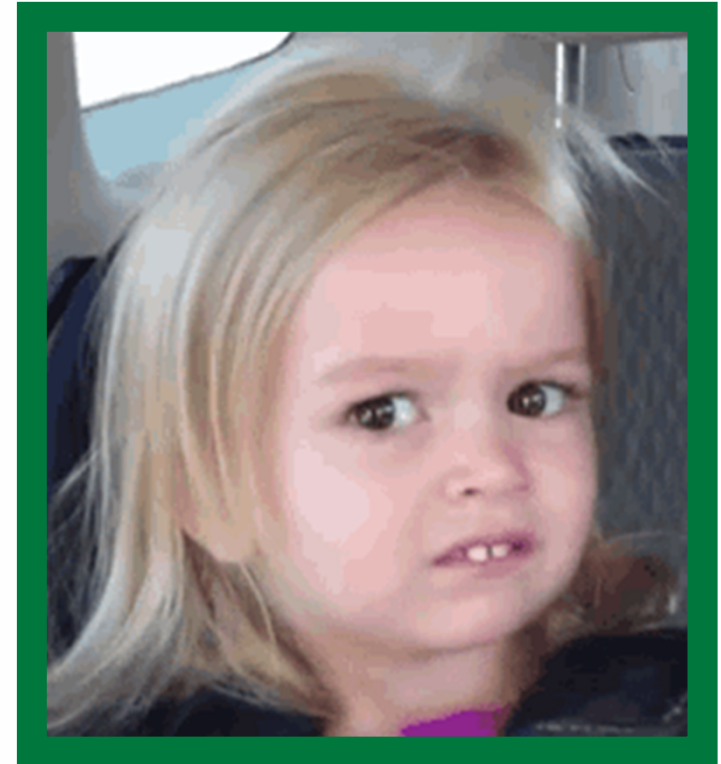➢ Validation of Capital Expenditures

# Levels

- ➤ ASHRAE Level I
  - ➤ Walk Through Analysis [Quick]
  - ✓ Establish a baseline [EnergyStar/Bills]
  - ✓ High Level Equipment Assessment [Age, Condition, Useful Life]

- ➤ ASHRAE Level II
  - ➤ Energy Survey and Analysis
  - ✓ Trending/Metering
  - ✓ Detailed Equipment Analysis
  - ✓ High Level ROM pricing and ROI calcs. for ECM's

- ➤ ASHRAE Level III
  - ➤ Detailed Analysis of Intensive Capitol Improvements
  - ✓ Investment Grade
  - ✓ Energy Modeling
  - ✓ Geared for ESCO or Major Projects

# Qualified Person/Company

Who to trust?

➢ Recommend to utilize objective 3$^{rd}$ Party

➢ ASHRAE Level I – Existing Service provider may be ok

➢ ASHRAE Level II – Formal RFQ/RFP may be overkill. Must be someone you trust, experienced, and a creative thinker!

➢ AHSRAE Level III – Formal RFP/RFQ. Recommend to also procure 3$^{rd}$ party review/oversight if needed.
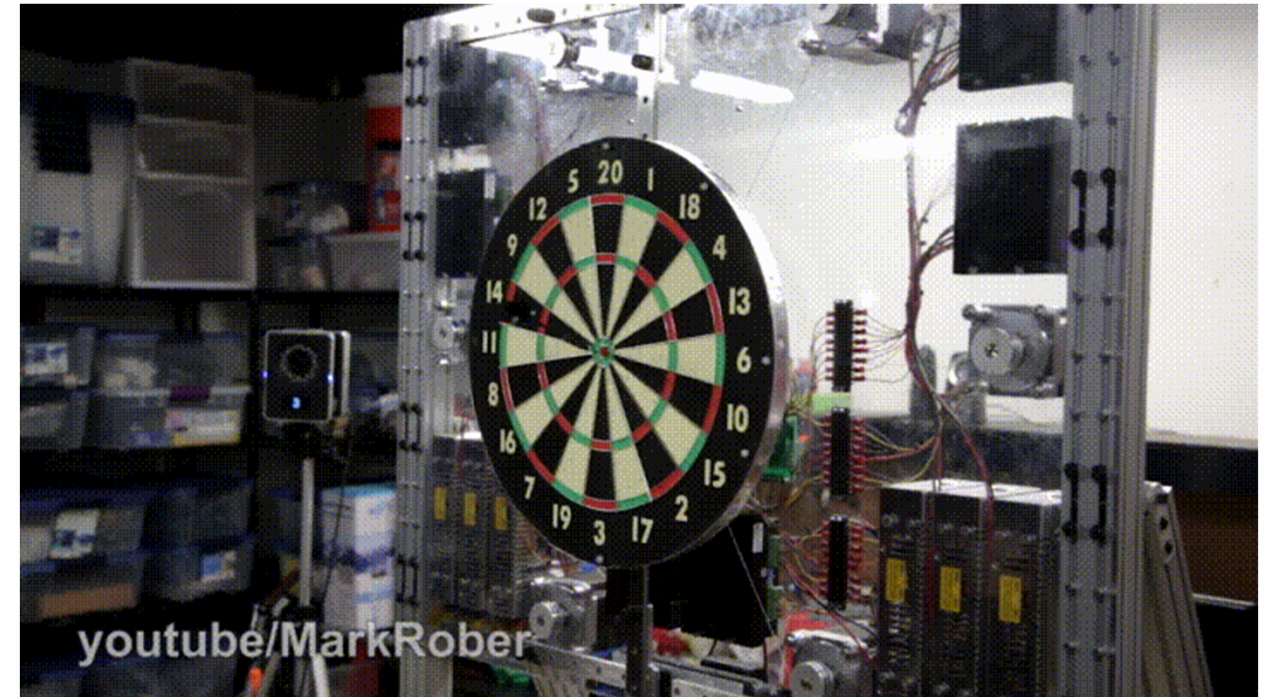
# Qualified Person/Company

Where to look?

➢ Trusted Consultant with Audit experience
  ➢ Ask for reference or sample report
➢ Peer Recommendation
➢ Utility
  ➢ Start with Utility if rebate is main goal
➢ IFMA Directory
➢ Northwest Energy Efficiency Council website
  ➢ https://www.neec.net/

# Focus of Audit

➢ Have Goal of Audit Clear and Defined

  ➢ Discuss with Facilities for insight and buy-in

➢ Compare Proposal to ASHRAE Guidelines

  ➢ Does not need to be the same but should be close

➢ Align Expectations With Budget

➢ Controls

  ➢ Start trends early if possible

  ➢ If no or limited Digital Controls, expect to see data loggers used

➢ Establish Report Format/Deliverables Early

  ➢ Include equipment inventory?

  ➢ Carbon reduction goals?

  ➢ Net Neutral/Positive?

  ➢ What rebates to target?

  ➢ Request ECM review tool with filters

    ➢ Spreadsheet

    ➢ PowerBI



youtube/MarkRober

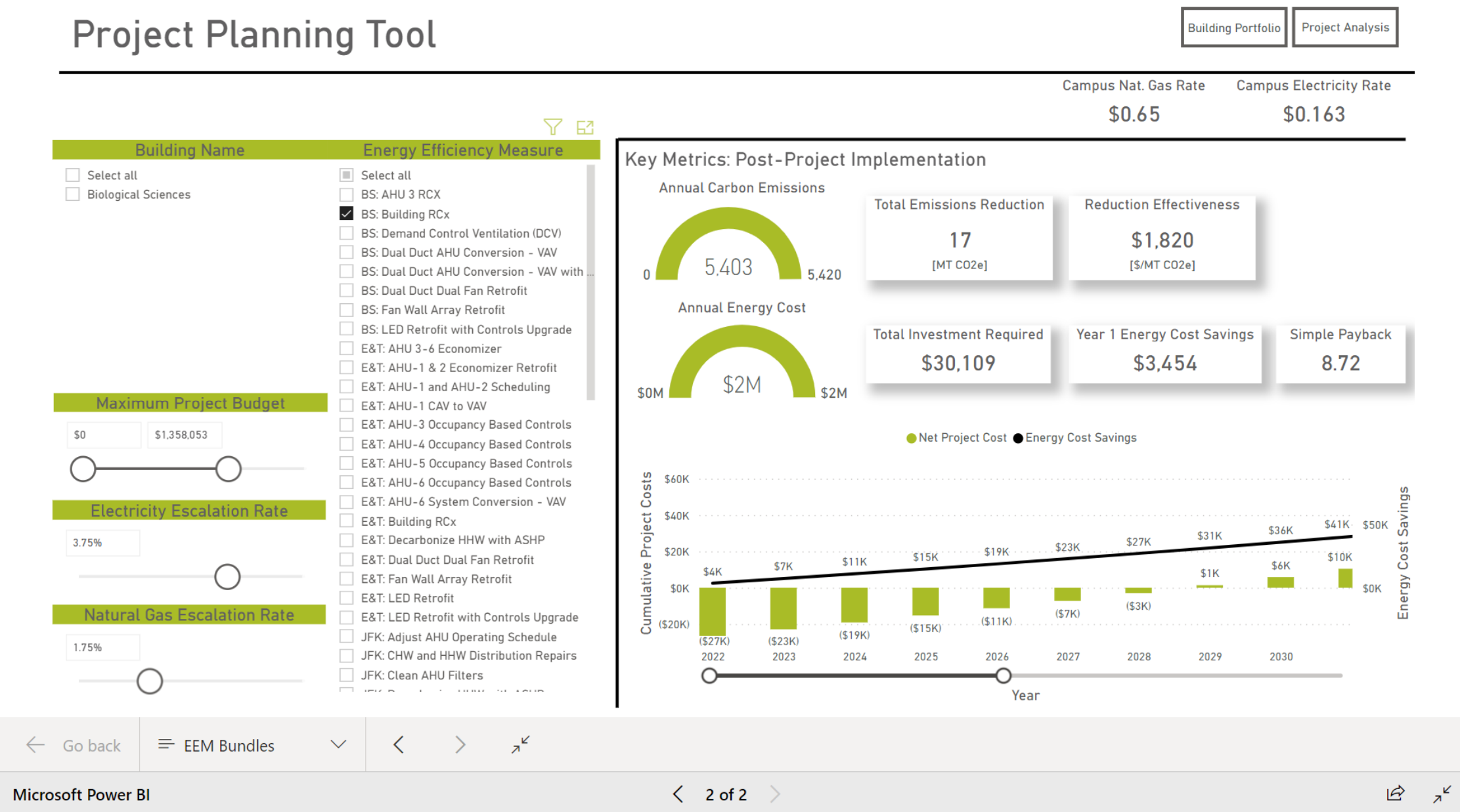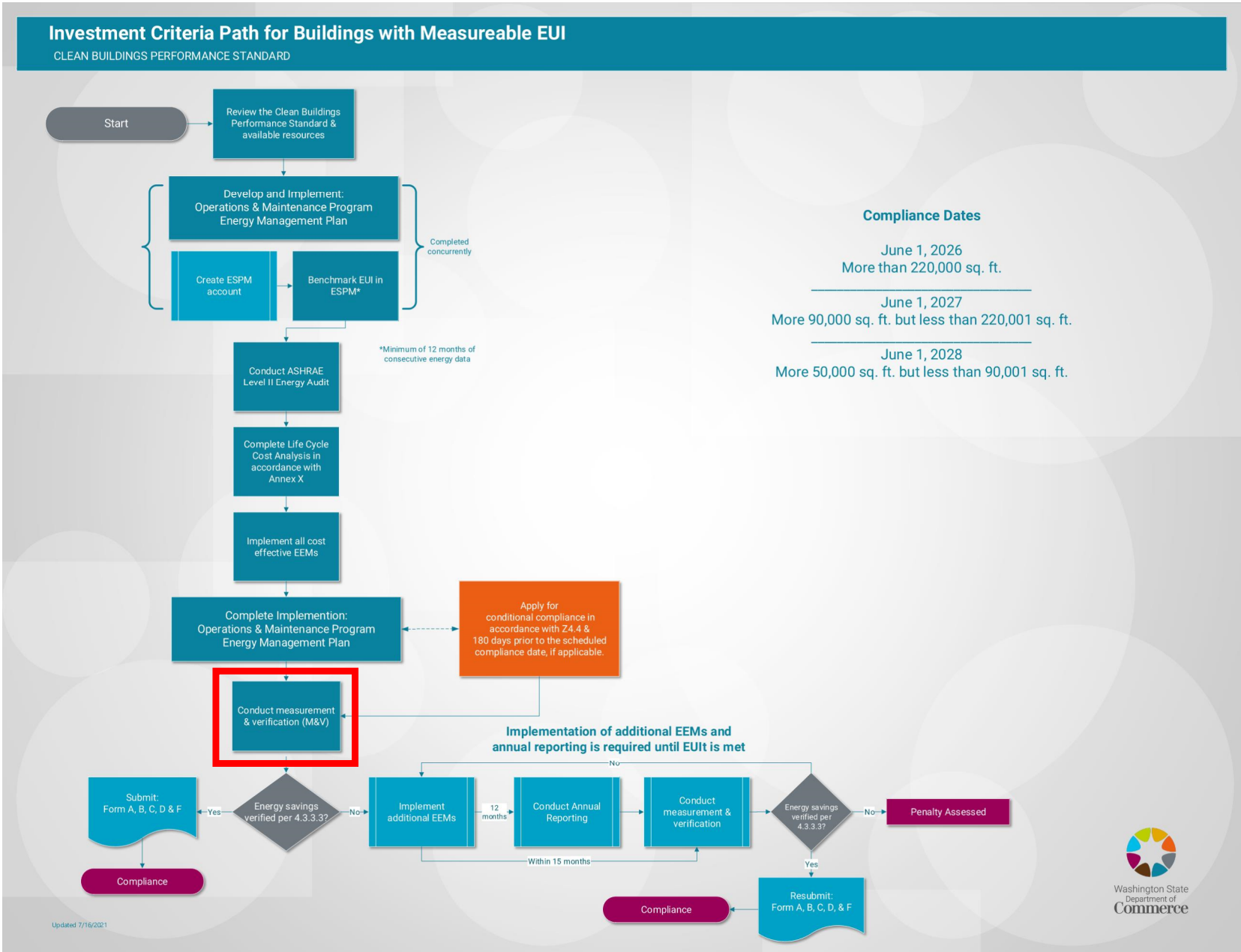# Focus of Audit – PowerBI sample format



Image courtesy of Glumac

# M&V Overview

Measurement and Verification" (M&V) is the process of planning, measuring, collecting and analyzing data for the purpose of verifying and reporting energy savings within an individual facility resulting from the implementation of energy conservation measures (ECMs). **Savings cannot be directly measured, since they represent the absence of energy use. Instead, savings are determined by comparing measured use before and after implementation of a project, making appropriate adjustments for changes in conditions**

➢ Standard is The International Performance Measurement and Verification Protocol (IPMVP)

➢ Now governed by non-profit Efficiency Valuation Organization (EVO)

   ➢ https://evo-world.org/en/

➢ Complements Audits, Proactive Maintenance and New Project Planning

➢ Will be key part of Energy Management Plan (EMP). This EMP plan is required for Washington State Clean Buildings Act (WSCBA) Compliance. 12 months data required.
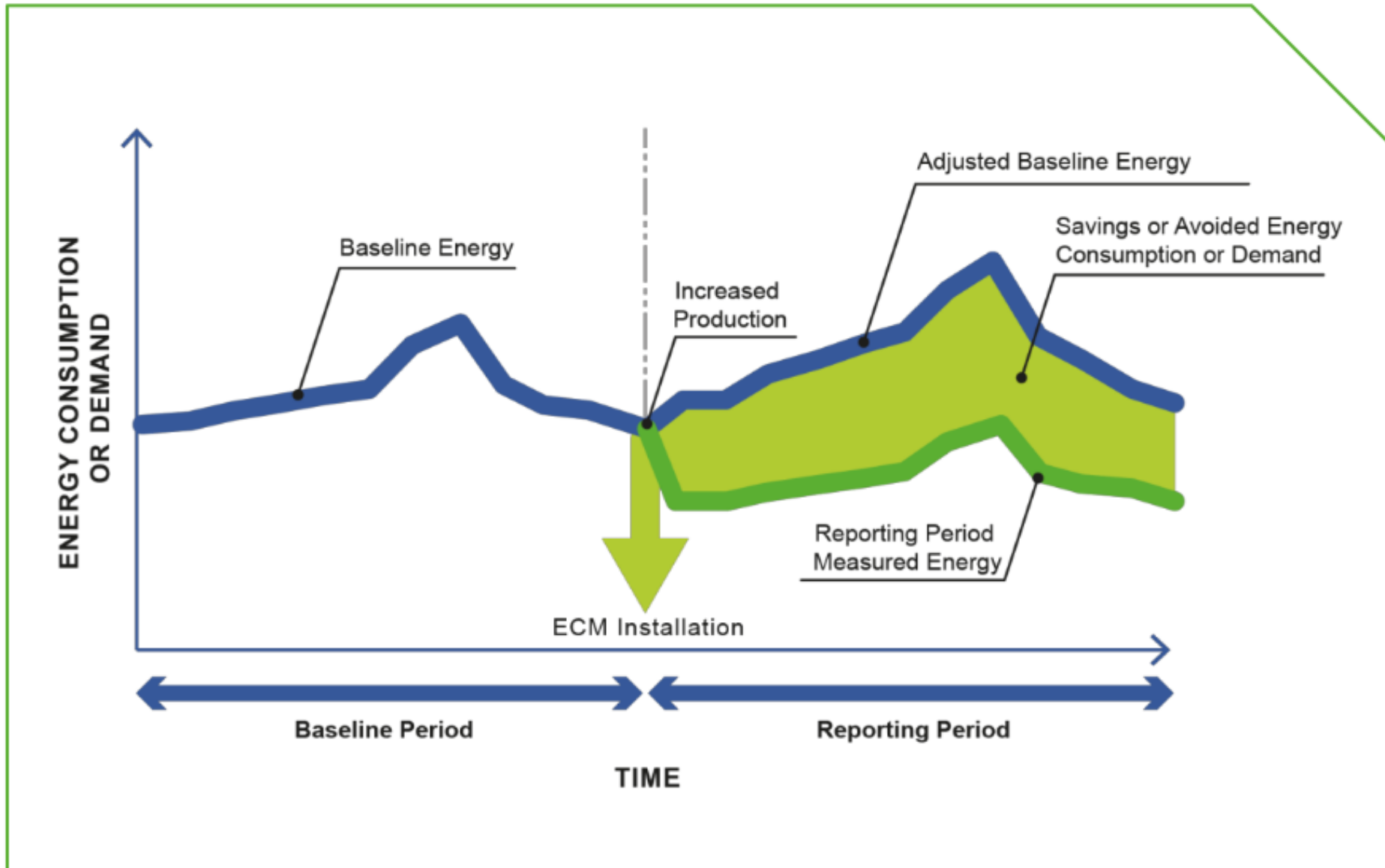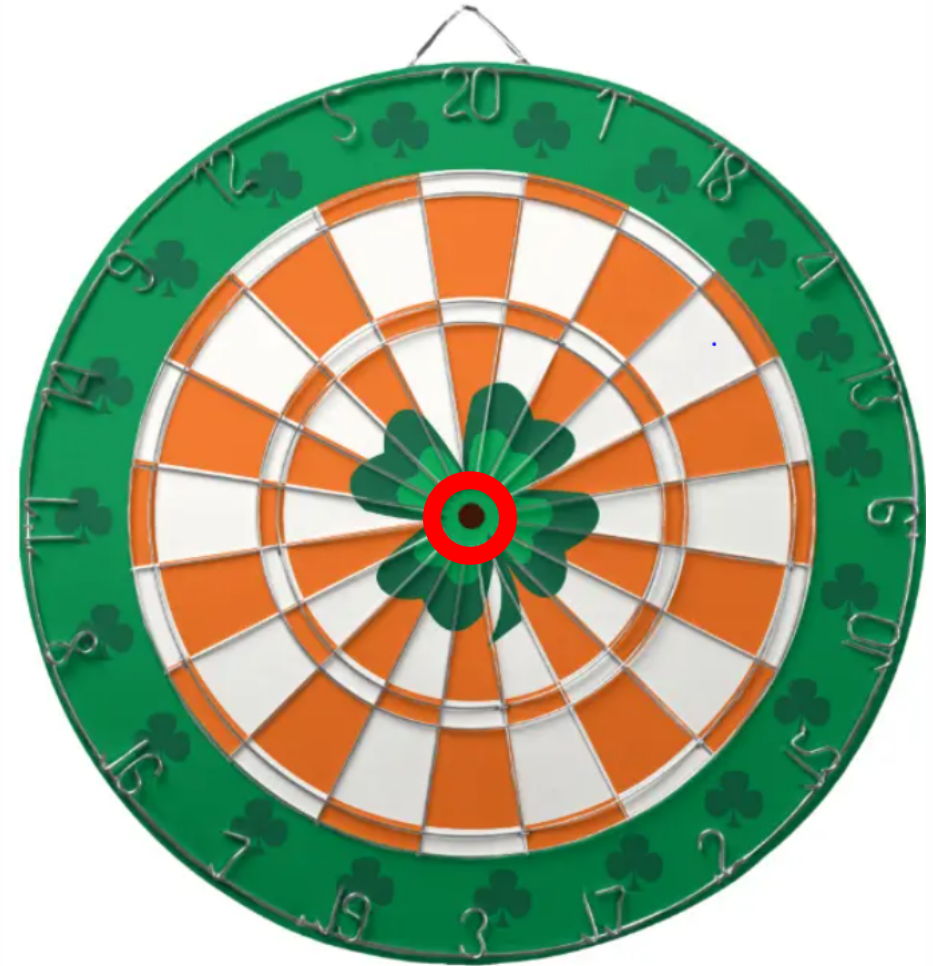
# M&V and WSCBA

# M&V Savings



Image courtesy of EVO

# Goals of M&V

➢ Increase Clarity of Energy Use

    ➢ Energy savings come from actions based on M&V data

➢ Tenant Billing

➢ Rebates

➢ Project Justification/Validation

➢ Feedback for Future Designs/Remodels

➢ Manage Energy and Maintenance Budgets

➢ Calculate Emission Reductions

➢ Fault Detection

➢ Preventative Maintenance

# What To Meter?

➢ Sub-Meter type, accuracy and locations will be based on goal
  ➢ Identify this in M&V Plan
  ➢ Encourage to make meter a long-term asset. You get what you pay for!
  ➢ There are meters available for almost any budget, large or small.
  ➢ Can be phased implementation if budget is limited.

➢ M&V can apply to one system or whole building
  ➢ Define "Measurement Boundary" in M&V Plan

➢ Different Operational Verification Approaches
  ➢ Visual Inspection
  ➢ Sample Spot Measurements
  ➢ Short Term Performance Testing
  ➢ Data Trending/Controls Review

➢ Consider applying IAQ sensors at the same time

# Meter Types

**Table 3. Key Meter Types**

| Application | Meter Category | Meter Types | Typical Accuracy | Relative Cost | Best Uses | Special M&V Issues |
|---|---|---|---|---|---|---|
| AC Current (amps) | Current transformer (CT) | Solid torroid or split core transformer | +/-1% | | | Not for use where power factor is less than 100%, or there is sinewave distortion |
| AC Voltage (volts) | Voltage leads or 'potential transformer' (PT) | Solid torroid or split core transformer | | | | |
| AC Electric Power (watts) or AC Energy (watthours) | True RMS watt meter or watthour meter | Measure watts (or amps volts and power factor), and watthours. Use digital sampling (IEEE 519-2014) to properly measure distorted waveforms | | | | Necessary for inductive loads (e.g., motors, ballasts) or circuits with harmonics from components such as a variable speed drive |
| Runtime (hours) | Measure and record equipment operating periods | Battery operated | | Lower cost than watthour recording | Logging of lighting periods | For equipment having a constant power usage rate when on |
| Temperature (degrees) | Resistance Temperature Detector (RTD) | | Reasonable | Low cost | Air and water | Widely used. Take care to compensate for different lead lengths |
| | Thermo-couple | | High | High | | Narrow range. Suited to thermal energy metering. Need signal amplifiers |
| Humidity (%) | | | | | | Regular re-calibration required |
| Liquid Flow (units/sec) | Intrusive | Differential Pressure | +/- 1-5% of max | | | |
| | | Positive Displacement | +/-1% | | | |
| | | Turbine, or hot tap insertion turbine | +/-1% | | Clean fluid, straight pipe | |
| | | Vortex Shedding | High | | | |
| | Non-intrusive | Ultrasonic | +/-1% | | Straight pipe | Spot flow measurement |
| | | Magnetic | | High | | |
| | | Bucket & Stopwatch | | Low | Steam condensate, plumbing outlet fixture | Spot flow measurement |
| Pressure | | Digital manometer | +/- 2% | | | |
| Thermal Energy | Packaged flow and temperature logging and computation | Uses accurate flow and temperature sensors. For steam may need pressure and temperature sensors | <1% | High | | Use matched temperature sensors for measuring a temperature difference. Carefully manage all possible sources of error |

Image courtesy of EVO

# Alternate Meter Types

Data Loggers





Images courtesy of Onset

# Alternate Meter Types

## People Counters

➢ Good for verifying occupancy and ultimately can be used in lieu of CO2 sensors
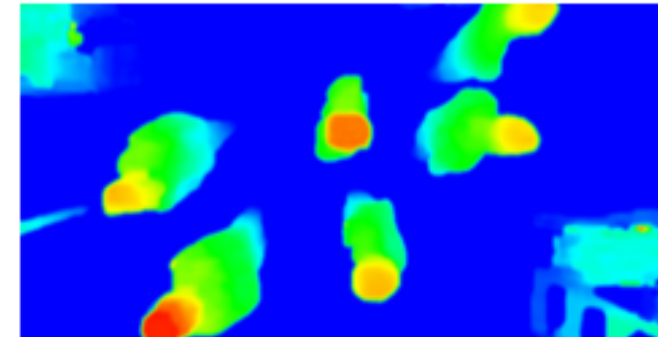






**Robust Operation**

Resistant to all kinds of external influences, such as shadows, light changes and heat emission.
Up to 9 sensors can be stitched into a single view for large area monitoring.

**Employee Exclusion**

Take accuracy to the next level by removing employee traffic from your data set by equipping staff with specially designed tags.
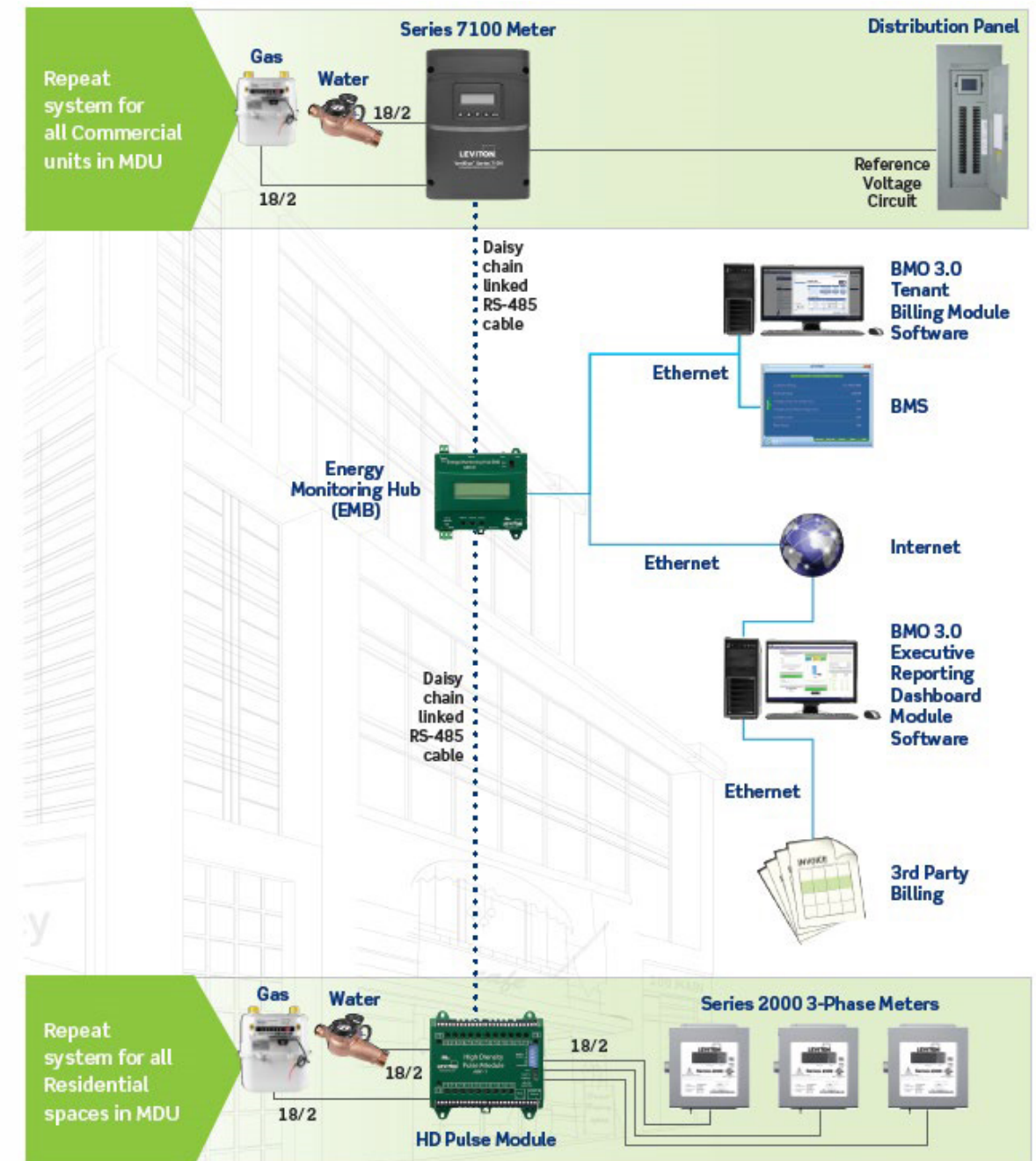
**Future Proof**

25 year MTB. Installed sensors can be upgraded in the field with firmware upgrades and new features. Artificial intelligence lays the foundation for future concepts.

Images courtesy of  SenSource

# Meter Integration/Data Collection

➢ Limitation of Legacy Systems

  ➢ System may not have ability to provide enough relevant information

  ➢ Building usage is different than when DDC was initially installed

  ➢ System speed, cable type, and memory

➢ Periptery Systems Have Limits

  ➢ Brand specific requirements

  ➢ If controls under service warranty/contract, may have to use existing service provider to integrate 3rd party meters

➢ Not enough open/free points in DDC Panels

➢ Check the protocol!

  ➢ BacNet

  ➢ Lon

  ➢ Modbus



Image courtesy of Leviton

# M&V Report Content

- Project Background

- ECM Descriptions

- M&V operation utilized

- Reporting period start/end dates

- M&V Activities
  - Start/end time for measurement period
  - Energy use data
  - Data for statistic variables used
  - Description of inspections
  - Verified savings calcs. and methodologies
  - Data analysis methods
  - Source data for calcs
  - Details on baseline or savings adjustments
  - Utility cost details
  - Clear presentation of verified energy/cost savings in comparison to proposed savings

# Fault Detection & Analytics

➢ Typically a software that is overlayed on top of the DDC controls system

  ➢ Skyspark
  ➢ BuildingFit
  ➢ CopperTree
  ➢ Clockworks
  ➢ Building Logix
  ➢ Turntide

➢ Utilizes algorithms and equations to identify potential issues

➢ Output is data that must be analyzed

➢ Does not replace Audit

➢ **Must be reviewed regularly and acted upon to be effective!**

# Fault Detection & Analytics – Building Fit Sample
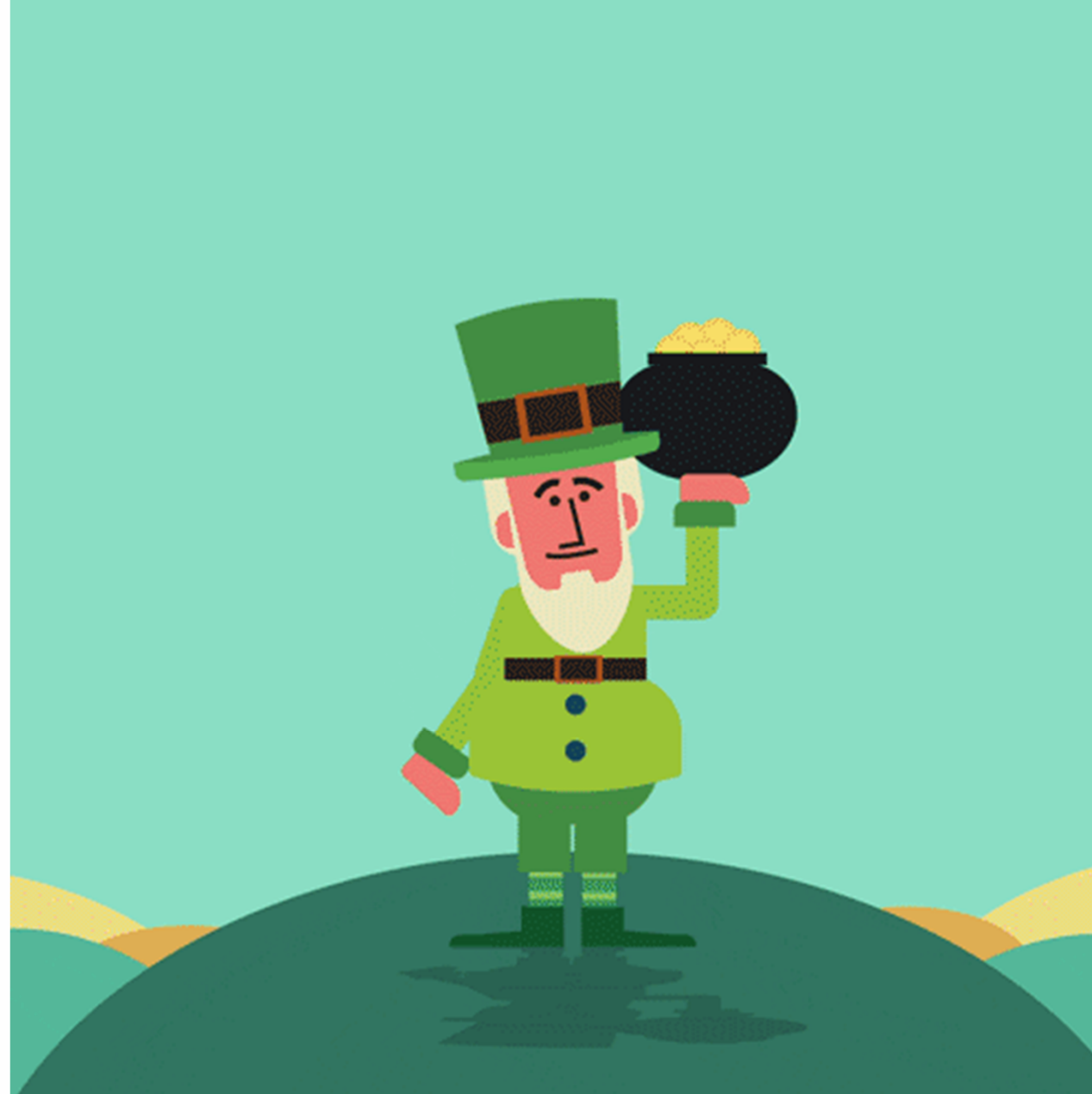
# Fault Detection & Analytics – BrainBoxAI

➤ Self adapting artificial intelligence
  - ➤ Decisions Based on Deep Learning Algorithms
  - ➤ Cloud Based Computing
  - ➤ Micro Pushes every 5 minutes
  - ➤ Claims up to 25% reduction in total energy costs
  - ➤ Better tenant comfort

➤ Three step process
  - ➤ Mapping points and leaning system behavior (6-8 weeks)
  - ➤ Optimizes HVAC operation in real time (micro pushes)
  - ➤ Continuously learning and improving

➤ Requires extreme attention to detail at deployment
  - ➤ Point mapping verification and re-verification!
  - ➤ Expect to refine operation before "set it and forget it"
  - ➤ Recommend to require that installer includes remote Cx for a min of 6 months with monthly reporting

Image courtesy of  BrainBox AI

# Summary

➢ Know your EUI
  ➢ 5 points or more below EUI target in WSCBA. See table 7-2a in WSCBA Performance Standard

➢ Find an objective partner for Audits

➢ Know the standards or hire a 3rd party who does to oversee Audit/M&V process

➢ Overlap project planning
  ➢ Audit should include M&V recommendations
  ➢ Create Energy Management and Operations and maintenance Plan (required for WSCBA)
  ➢ Good opportunity for inventory/CMMS?
  ➢ Plan out next 30+ years and begin building budgets now for long term assets
  ➢ If EUI not met, start planning for WSCBA compliance now

➢ You are in control of how deep to go with M&V
  ➢ Get the level of monitoring that meets your needs
  ➢ Be cautious of under/over metering
  ➢ Establish equipment/system level basslines before replacements/renovations
  ➢ If you have extreme budget constraints, use data loggers!

➢ Fault Detection software is great but must be acted upon to be effective
  ➢ Consider identifying an Energy Manger on staff and carve out time for them to review and act on alerts

**May misfortune follow you the rest of your life and never catch up**