NORTHEAST ENERGY EFFICIENCY PARTNERSHIPS

CHANGING EM&V PARADIGM - LANDSCAPE OF NEW TOOLS & DATA ANALYTICS

Presented by: Claude Godin, Mimi Goldberg,
Michelle Marean and Curt Puckett

July 29, 2015

SPEAKER BIOS

Mr. Godin has more than 40 years of experience in the energy market, specializing in designing and delivering large scale projects. Currently, Mr. Godin is Director of Energy Data Analytics at DNV GL where he has responsibility for the development and delivery of advanced data analytics solutions as the pertain to the electric, gas, and water utility market segment.

Miriam Goldberg, Ph.D., is DNV GL - Energy's Country Manager and Director of Policy Advisory and Research, Sustainable Use for the Americas. She oversees a team of 140 professionals including econometricians, survey specialists, and building engineers for DNV GL's consulting services on the "customer side" of the meter. This work spans demand-side planning and evaluation, and customer research for general operational support. Dr. Goldberg is a leading expert in energy efficiency program evaluation and received the *2009 International Energy Program Evaluation Conference (IEPEC) Lifetime Achievement Award* in recognition for her leadership in and contributions to energy-efficiency and demand response programs evaluation.

Ms. Marean has more than 30 years of energy, utility and engineering services experience. She spent her early career managing residential and commercial DSM and DR programs for several New Jersey utilities and the New York City Office of Energy Conservation. Ms. Marean is affiliated with Princeton University, contributed to early PRISM development, and supports PRISM users on their PRISM analyses and its application to billing analysis methods.

Mr. Puckett has worked for over 34 years in the utility industry. Curt spent his early career with Consumers Energy, formerly Consumers Power Company located in Jackson, MI, in the areas of load research and energy efficiency/demand response evaluation. In 1989, Curt started RLW Analytics with Dr. Roger L. Wright focusing on the growing need to evaluate the performance of energy efficiency and demand response programs using statistical techniques and engineering rigor. In 2009, DNV KEMA (now DNV GL) acquired RLW Analytics.

PURPOSE

Help stakeholders understand emerging trends, technologies, and techniques that can be leveraged to enhance EM&V.

CONTENTS OF THE WEBINAR

1. Definitions and Current EM&V Practices
2. Challenges to EM&V Practices
3. Emerging Technologies and Services
4. The Digital Revolution- Analytic Tools
5. Testing new M&V analytics at LBNL
6. Conclusions- Next Steps

EM&V PRACTICE

Core Questions	• What happened? • Why?
Future Practice	• The same core questions • Implementation of new data collection methods and analytical tools
Rigor	• Transparency • Replicability • Peer Review
Calculating Baselines	• Energy consumption that would have occurred without implementation of the measures, project or program.

EM&V PRACTICE

Evaluation	• A wide range of assessment studies aimed at determining the effects of a program.
Measurement & Verification	• A subset of impact evaluation documenting energy savings at individual sites or projects involving measurements, engineering calculations, statistical analyses, and/or computer simulation modeling
Evaluation and/or M&V	• In common practice, “evaluation” and “measurement and verification” are frequently, but inaccurately, used interchangeably.

EM&V METHODS AND CHALLENGES

TYPICAL IMPACT EVALUATION PROCESS & TIMING

Planning & Scoping	Recruiting & Data Collection	Data Analysis	Reporting
Stakeholder engagement	3-6 months of metering	Site data analysis	Stakeholder engagement
Data cleaning & Sampling	Recruitment, installation & retrieval	Site reporting	Reporting & review of results

DATA CHALLENGES

Data cleaning is the process of amending or removing data in a database that is incorrect, incomplete, improperly formatted, or duplicated.

Data cleaning that is not automated can take up as much as 25% of the time and effort required to complete an EM&V project.

EM&V METHODS AND CHALLENGES - SUMMARY

Deemed Savings

- Currency, relevance
- Comparability across programs and states.

Engineering Estimates

- Sources of assumptions
- Choice of formulas or models
- Comparability across programs and states

Surveys

- Response rates
- Length vs Survey fatigue
- Post survey data cleaning
- Reliability of responses
- Interpretation and scoring
- Program planning may not facilitate surveys

End-Use Metering

- Data quality
- Data access
- Customer access and scheduling
- Access to plans, schedules, info on baseline equipment

Onsite Inspection

- Customer access and scheduling
- Access to plans, schedules, and info on baseline equipment
- Availability of consumption data

Billing Analysis

- Data collection for the pre- and post-periods
- Data cleaning requirements
- Signal-to-Noise ratio
- Comparison Group Specification

EM&V METHODS AND CHALLENGES

Definition	Method	Bottlenecks
Deemed Savings An estimate of energy or demand savings for a single unit of an installed energy efficiency measure.	• Deemed savings estimates are developed from data sources and analytical methods that are considered valid for the measure and purpose. • Deemed savings calculations can be determined using standard mathematical and statistical analysis	• Often defined at the state level, differences in estimates sometimes make if difficult to compare programs and savings across states.
Engineering Estimates The use of standard formulas or models based on those formulas (typically accepted by ASHRAE for example) as the basis for calculating energy use.	• Engineering estimates are used for estimating potential savings and installed measures. They are calculated with standard mathematical and statistical analysis.	• Differences in choice of formulas or models across programs, utilities or states sometimes make it difficult to compare estimates and results between programs

EM&V METHODS AND CHALLENGES

Definition	Method	Bottlenecks
Surveys A brief interview or discussion with individuals about a specific topic.	• Surveys can be conducted in person, over the phone or collected via the web.	• Attaining high response rates • Length and survey fatigue • Post survey data cleaning • Reliability of survey data • Evaluation plan not defines during early program planning stage to facilitate survey design and collection
End-use Metering The direct measuring of energy consumption or demand for specific end-use equipment.	• Review Data • Sample & Recruit • Visit site & install meters • Data collection phase • Retrieve meters • Analysis	• Data quality • Data access • Customer access and scheduling • Access to plans, schedules, info on baseline equipment
Site Audit A review of a customer's energy usage, often with recommendations to alter the customer's demand consumption.	• Requires a site visit to a customers facility and is often combined with end-use metering. • Data collection of building and equipment characteristics and a review of consumption data	• Customer access and scheduling • Access to plans, schedules, and info on baseline equipment • Availability of consumption data

EM&V METHODS AND CHALLENGES

Definition	Method	Bottlenecks
Billing Analysis • An analytic methodology used to estimate program savings.	• Billing analysis compares billing data from program participants over a period of time before the energy efficient measures are installed at customer sites to billing data for a comparable period of time afterward. • Billing analysis is typically performed on program non-participants as a comparison group for comparison purposes.	• Data collection for the pre- and post-periods • Data cleaning requirements • Comparison Group Specification

RAISING THE BAR ON EM&V

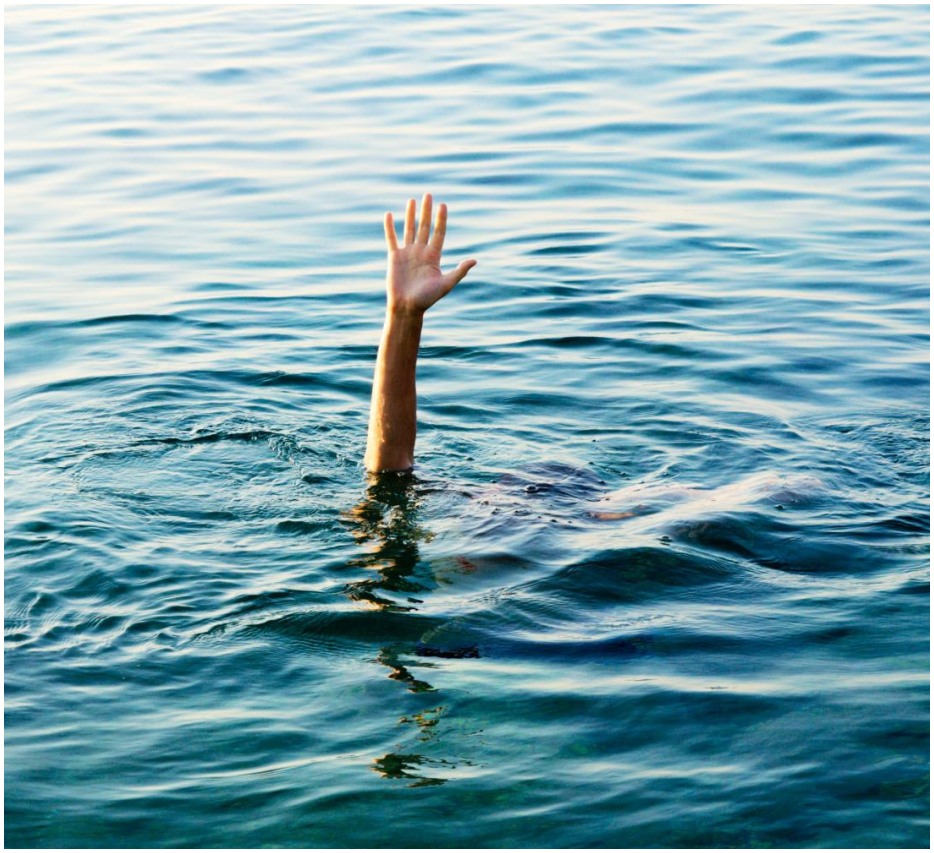
- Data collection and data processing are bottlenecks to producing timely evaluation results.
- To what extent can enhanced data collection technologies and analytics accelerate the process and reduce costs?

ENHANCED DATA COLLECTION TOOLS

IMPLICATIONS FOR EM&V

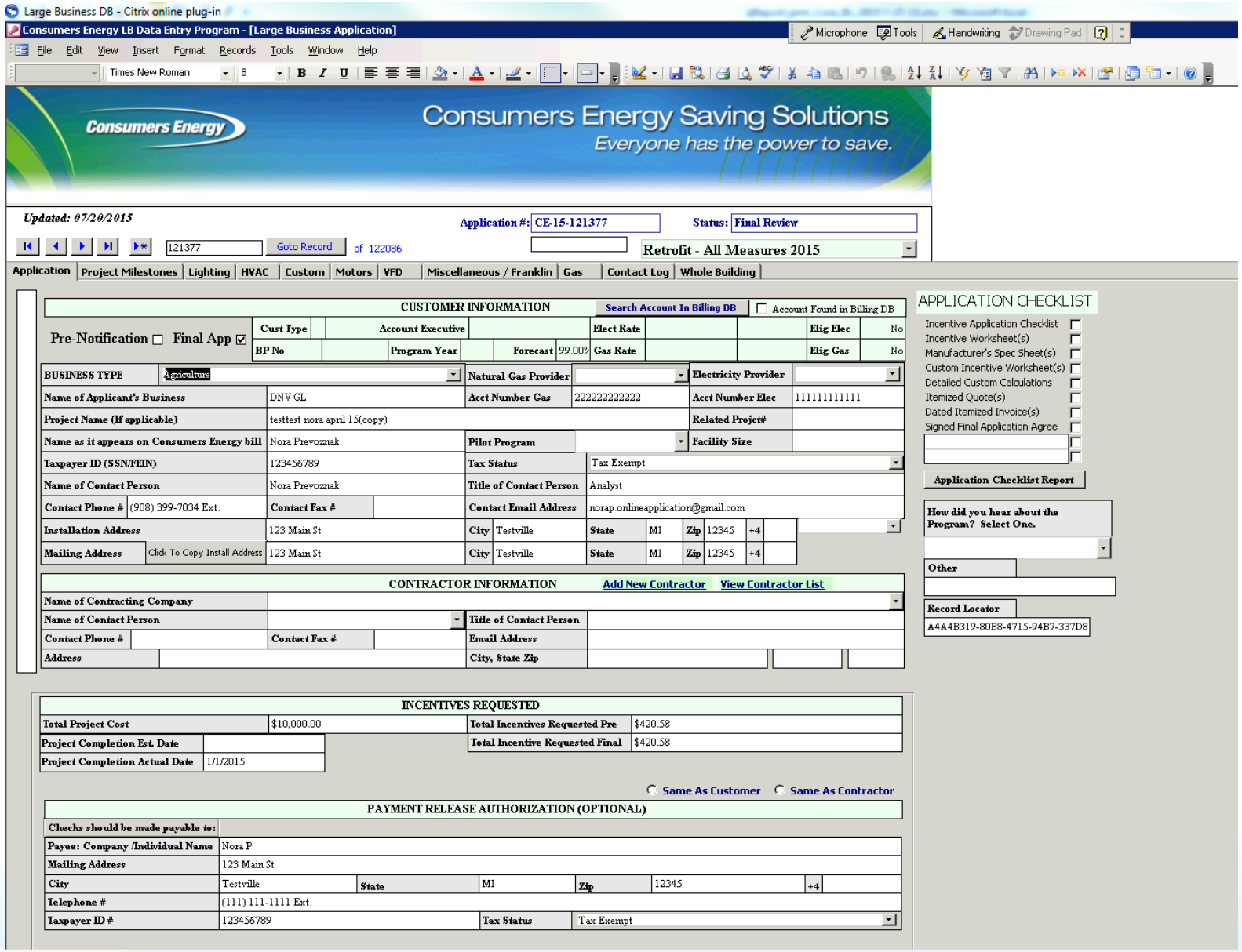
THE TECHNOLOGY LANDSCAPE

- Customer Databases
- Geo-informatics
- Smart Meters and Advanced Metering Infrastructure
- Non-Intrusive Load Monitoring
- Smart Thermostats
- Smart Devices
- Home Energy Management Systems



Keeping your head above the data

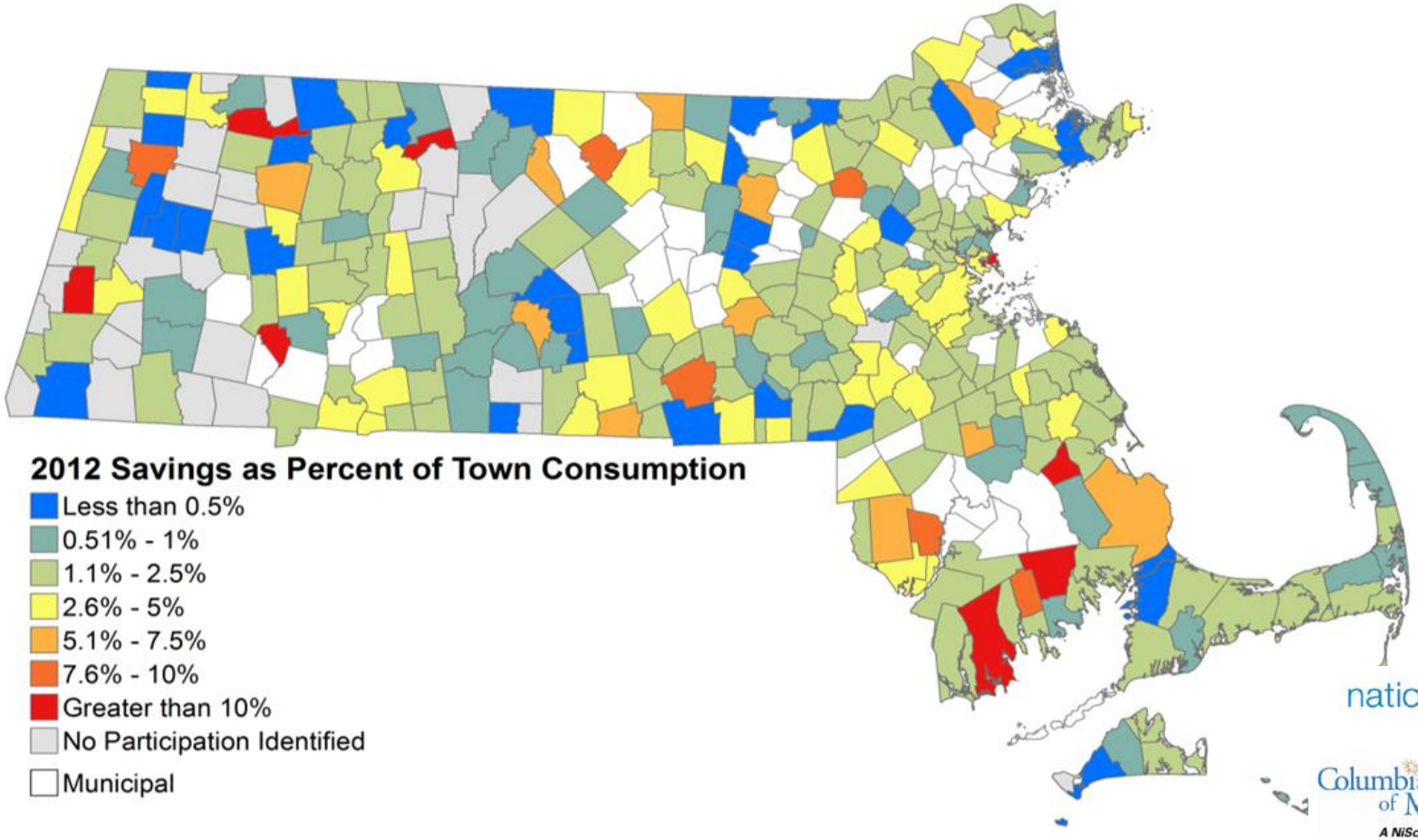
CUSTOMER DATABASES



CUSTOMER DATABASES

Function	Customer databases merge customer, consumption, program data and third party data to develop detailed customer profiles. Data from multiple utilities or jurisdictions (state or national) can be merged, correlated and analyzed
Significance	Provides a holistic picture of customer profile extending beyond energy consumption. Is only limited by types of data collected. Support GIS analysis.
Current uses/value	Accumulates program tracking, consumption and savings data over time. Can produces EUI's by customer segments, building type or other third party variables.
Challenges for Utility	Merging consumption and program data with incongruent data such as tax maps or demographic data. Protection of proprietary and customer data between utilities, stakeholders and the public.
Impact on EM&V	Allows for cross utility or regional assessment, data repository avoids multiple data requests. Samples can be drawn from a central location to avoid oversampling of customers.
Challenges for EM&V	Data quality and significant data cleaning requirements. Neither utility or third party data is standardized across utilities, towns or states.
Ethical/Regulatory issues	Must be managed by a third party to overcome privacy concerns. Data is collected at the customer level but must be reported in the aggregate (i.e., by town) to prevent exposure of PII.
Examples	Massachusetts Commercial and Industrial Customer database.

GEO-INFORMATICS



nationalgrid

Columbia Gas of Massachusetts
A NiSource Company

Cape Light Compact

NSTAR

Western Massachusetts Electric
The Northeast Utilities System

berkshire gas

Liberty Utilities
A UIL HOLDINGS COMPANY

Unitil

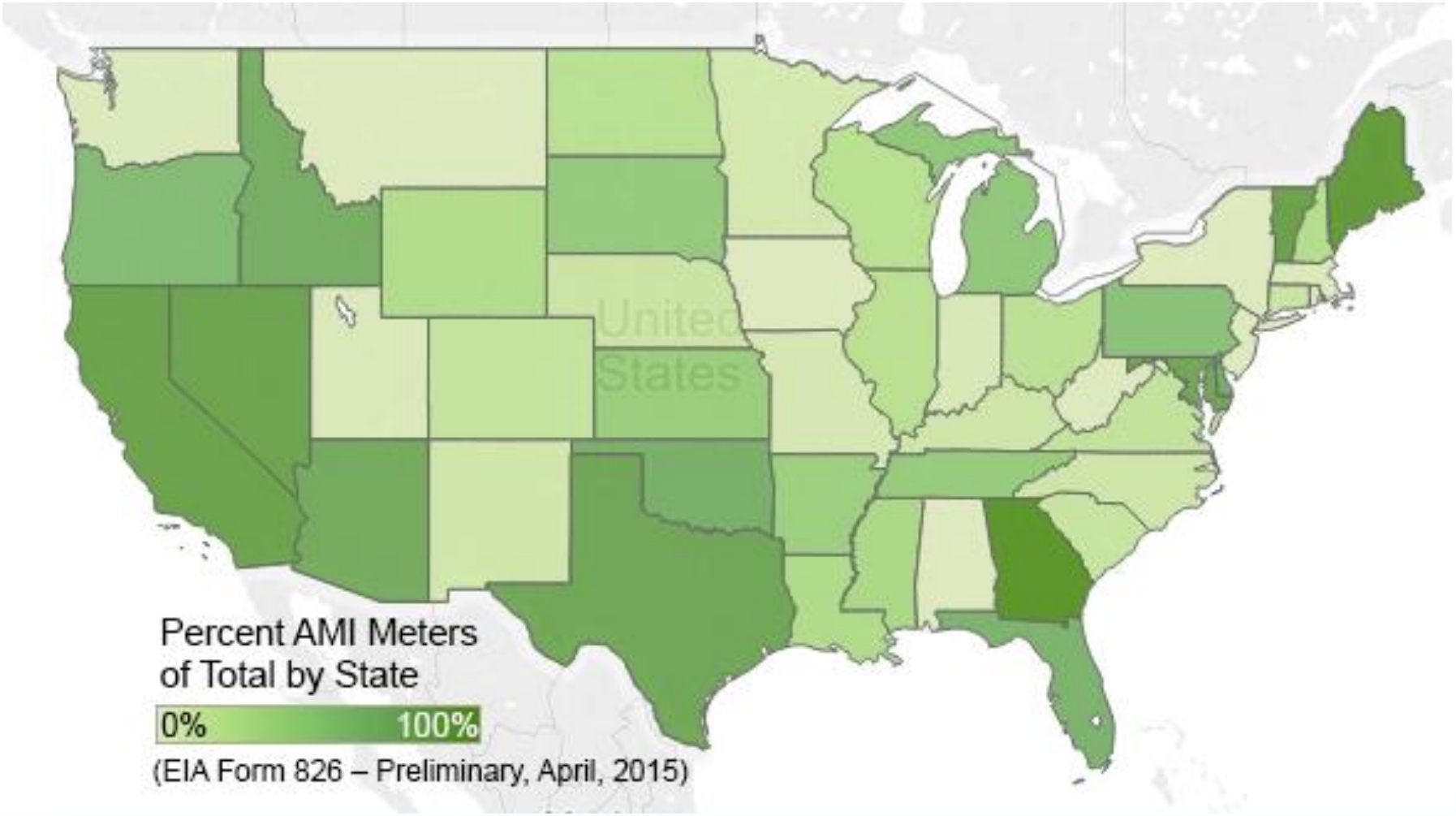
GEO-TARGETING

Significance	Used to improved accessibility to complex data for decision with visualization tools that show relationships between customers, energy profile, and geographic relationships. In-use since the early 1990's to identify locations vulnerable to network unreliability.
Current uses/value	Geo-targeting is now commonly used for program planning on it's own merits. Allows localized targeting of high EUI areas, building types, or other customer characteristics.
Challenges for Utility	Can provide more cost-effective programs by targeting high EUI areas, but program costs may be higher due to need for increased incentives.
Impact on EM&V	Program participation is considerably higher in geo-targeted areas compared to the rest of a territory. but in some areas participation drops markedly after year two.
Challenges for EM&V	Developing and maintaining the database that underlies the geo-targeting is expensive and time consuming. To make data useful for in-house decision making. third party dedicated IT support is required.
Ethical/Regulatory issues	When applies across multiple utilities or states, third party contractors are required to protect PII and proprietary information. Reporting at the site level in a multi customer database makes PII easily identifiable.
Examples	Consolidated Edison has a long-standing cost effective program, Efficiency Maine is piloting geo-targeting to reduce investments in T&D. Massachusetts PA's use it to inform program planning and tracking and evaluation.

SMART METERS
ADVANCED METERING INFRASTRUCTURE

Smart meters measure and record usage data, **at a minimum**, in hourly intervals and provide usage data **at least** daily to energy companies. They may also provide data to consumers.

SMART METERS
ADVANCED METERING INFRASTRUCTURE



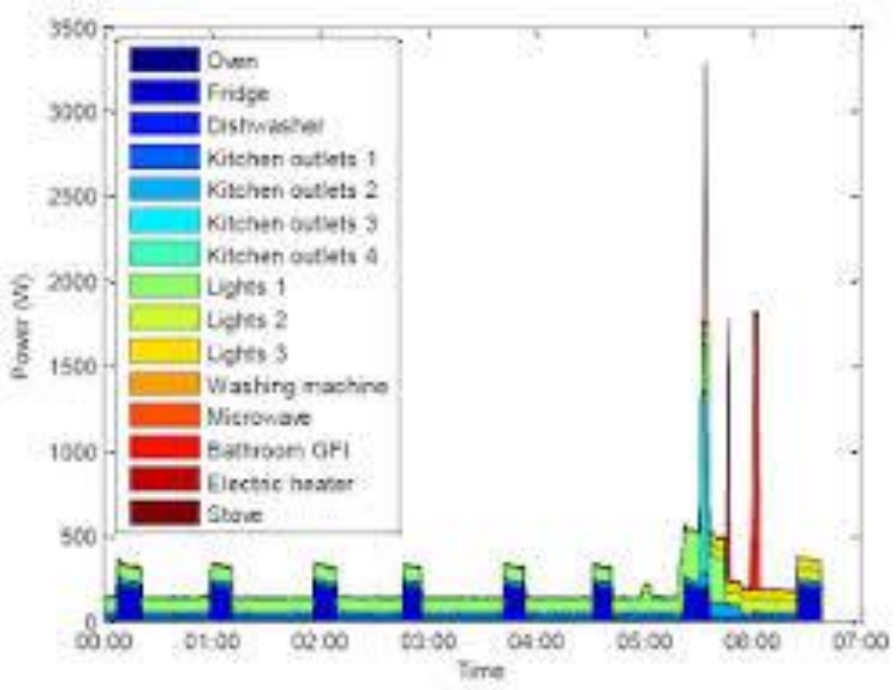
As of April of 2015, 86% of all utilities, accounting for nearly 80% of all meters, report their AMI status to the EIA on a monthly basis. These utilities have switched 41% of their meters to AMI.

SMART METERS
ADVANCED METERING INFRASTRUCTURE

Function	Smart meters range from basic hourly interval meters to real-time meters with built-in two-way communication capable of recording and transmitting instantaneous data.
Significance	Makes sub-daily consumption data possible
Current uses/value	Facilitates dynamic load profiling, time-differentiated impact estimation for EE programs, short-term forecasting and can inform rates
Challenges for Utility	Data transmission, data storage and data processing. Utilities will either have to increase IT infrastructure or out source data management which is seen as undesirable. A typical path for 15 minute interval data for a small sample of homes is from the meter, to a data collection point, to a data warehouse, to a third party database and finally is delivered to EM&V servers.
Impact on EM&V	Contributes to big data stream, increases precision under some conditions. Increases the visibility of EE behavior The ability to estimate overall changes in kWh use by time of day will help inform baselines.
Challenges for EM&V	Data access and quality. Data silos are the status quo within utilities; often difficult to transfer data between operations and EM&V functions. Data losses in transmission from meter to collection point.
Ethical/Regulatory issues	Opponents argue "the utility side of the meter" applied to the old technology but not one that gives visibility to schedules and habits. Data ownership
Examples	CPUC Whole House, SMUD, SCL, behavior program evaluations

NONINTRUSIVE LOAD MONITORING

Nonintrusive load monitoring (NILM) is a process for analyzing changes in the voltage and current going into a house and deducing what appliances are used in the house as well as their individual energy consumption.



NONINTRUSIVE LOAD MONITORING

Function	Identify loads from specific devices inside building without installing separate meters on those devices
Current uses/value	Load research, DSM program design, grid stability models
Challenges for Utility	Data transmission, installation, coordination with metering department for some products
Impact on EM&V	Load captured for multiple end uses could be captured from a single device, for multi-measure evaluations, e.g., behavioral programs at lower cost
Challenges for EM&V	Accuracy, predictability of end uses captured
Ethical/Regulatory issues	Privacy; Liability if installed on customer side
Example	New York State

SMART THERMOSTATS

SMART THERMOSTATS

Function	Self-programming thermostat, two-way communication to web/smartphone Provides hub for communications network among energy using devices
Current uses/value	Potential for significant energy savings from self-programming (learning) DLC alternative – "Bring Your Own Thermostat" Available data could facilitate targeted marketing
Challenges for Utility	Data volume, data access agreements through third parties (e.g. tstat vendor) Data quality controlled by third parties, multiple vendors with different protocols and contracting policies, efficiency an afterthought – consumers purchase for convenience, comfort, control, security, and "coolness" rather than efficiency
Impact on EM&V	After data cleaning, traditional analytics should suffice Potential greater volume and more specific-to-device usage data than sampled data options. If no systematic data loss, population level estimates rather than samples Potential for less expensive data collection.
Challenges for EM&V	More but less reliable data – requires more automated cleaning Data collection dependent on vendors Need to analyze patterns in missing data
Ethical/Regulatory issues	Privacy, Data ownership
Examples	Nest, Honeywell, Ecobee

SMART DEVICES

SMART DEVICES

Function	Smart devices can include ANY energy consuming device. They interface with a micro-computer or hub and communicate in multiple (N) directions. Some devices can be electrified like deadbolt locks for houses/cars
Current uses/value	Centralized/easy control of household devices, “Coolness”
Current Challenges	Rapid technological innovation Common communication protocols
Challenges for Utility	Communication protocols, data access, data is not actively collected or coordinated, data volume, data consistency. Efficiency an afterthought – Consumers purchase for convenience, comfort, control, security, and “coolness” rather than efficiency
Impact on EM&V	Interconnectivity of all devices in home will allow live experiments – push intervention to specific households and monitor data feeds to verify action. Smart Phones making are making traditional surveys difficult
Challenges for EM&V	More but less reliable data, traditional methods and analytics might not handle data volume and complexity, need to figure out how to leverage smart phones as communication vector.
Ethical/Regulatory issues	Data ownership, e.g. HIPAA challenges regarding personal health information on wearable devices, data privacy
Examples	Microchips installed in refrigerators can be used to optimize power and temperature, send alarm if temperature drops, store lists, record door closing and opening. Phones and tablets – the kings of smart devices, smart strips, HVAC, smoke and CO2, camera, deadbolts, etc. etc.

HOME ENERGY MANAGEMENT SYSTEMS

HOME ENERGY MANAGEMENT SYSTEMS

Function	HEMS are hardware and/or software systems that can monitor and provide feedback about a home's energy usage and/or enable advanced control of energy-using systems and devices in a home
Significance	Energy efficiency potential, demand response potential, M&V potential, distributed energy resources control potential
Current uses/value	Fun gadget for early adopters, comfort (smart Thermostat) and security (installed through home security system), some energy savings
Challenges for Utility	Validation of savings, emerging technology, data access, protecting consumer data (not an actual challenge, but public perception is concerned about it)
Impact on EM&V	Interval data collectors to confirm the savings of other measure in a home. Systems can interact with and report on a wide range of measures (lighting, plug load, appliances, HVAC) at no added cost.
Challenges for EM&V	Limited products currently ready to be deployed for M&V, new product area, control devices and thus not inherently efficient, making deemed savings a challenge.
Ethical/Regulatory issues	Concerns over homeowner data privacy and protection
Examples	Tendril, iControl, SmartThings, Nest

NEEP HOME ENERGY MANAGEMENT SYSTEMS RESEARCH REPORT

OPPORTUNITIES FOR HEMS IN ADVANCING RESIDENTIAL ENERGY EFFICIENCY PROGRAMS

- NEEPs forthcoming report explores the potential of Home Energy Management Systems (HEMS) as energy saving devices to keep the Northeast Mid-Atlantic region an energy efficiency leader and develop adequate resources to ease integration of HEMS into efficiency programs.

- With robust stakeholder input and expert contractor support, NEEP's report informs HEMS efficiency opportunities, landscape understanding, and related public policies.

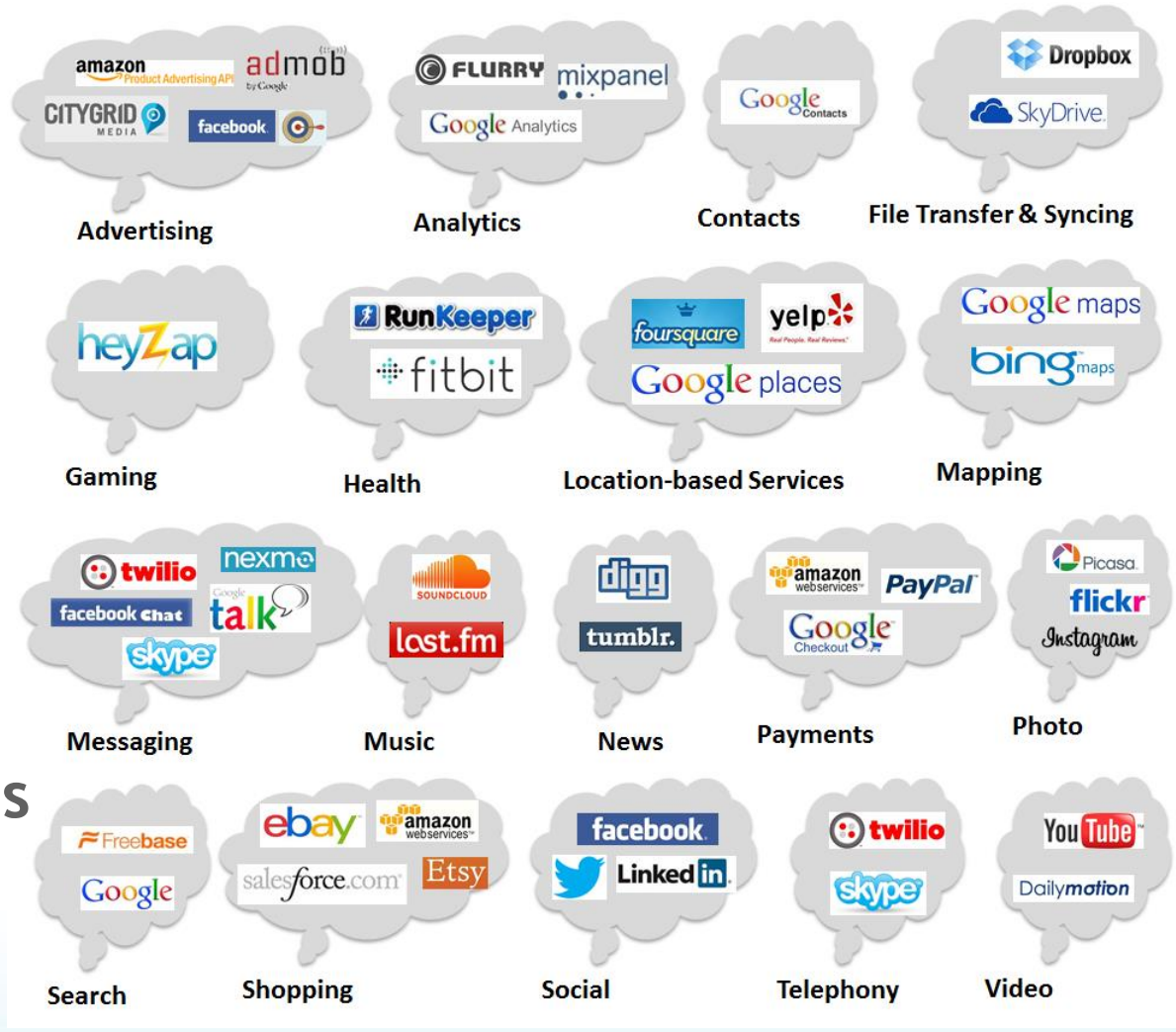
THE DIGITAL REVOLUTION

BIG DATA HAS VOLUME, VELOCITY, VARIETY

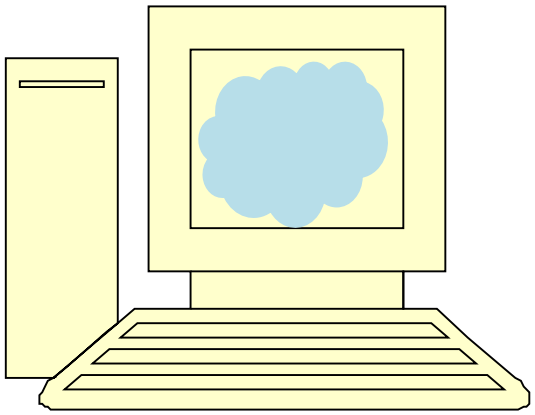
Variability and complexity are also features

Big data is:

- extremely large **data sets**
- analyzed computationally (big analytics)
- to reveal **patterns, trends, and associations**
- **especially relating** to **human behavior** and interactions.

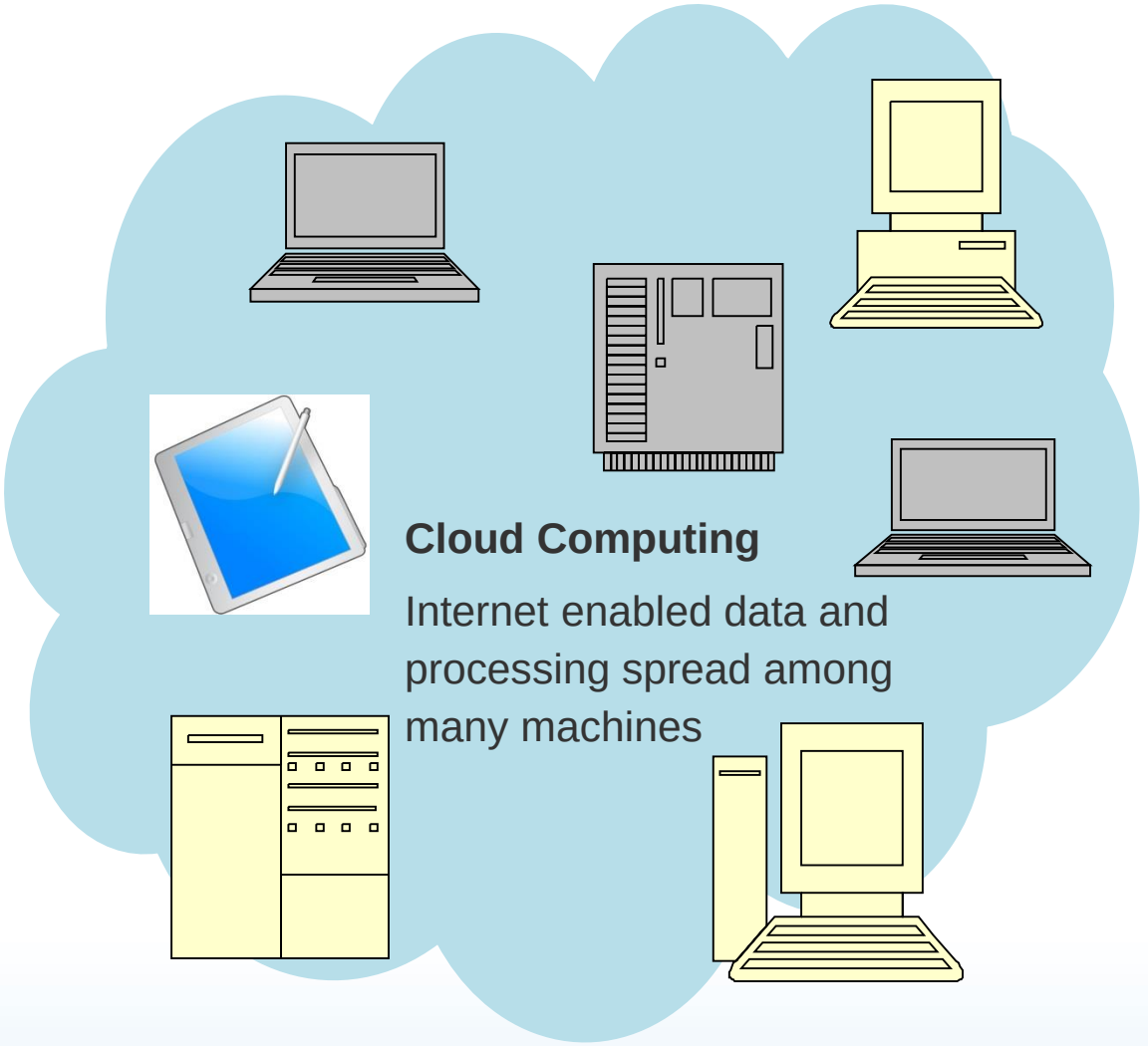


CLOUD COMPUTING



Standard Computing

Data and processing stay on single machine



Cloud Computing

Internet enabled data and processing spread among many machines

BIG ANALYTICS

Analytics

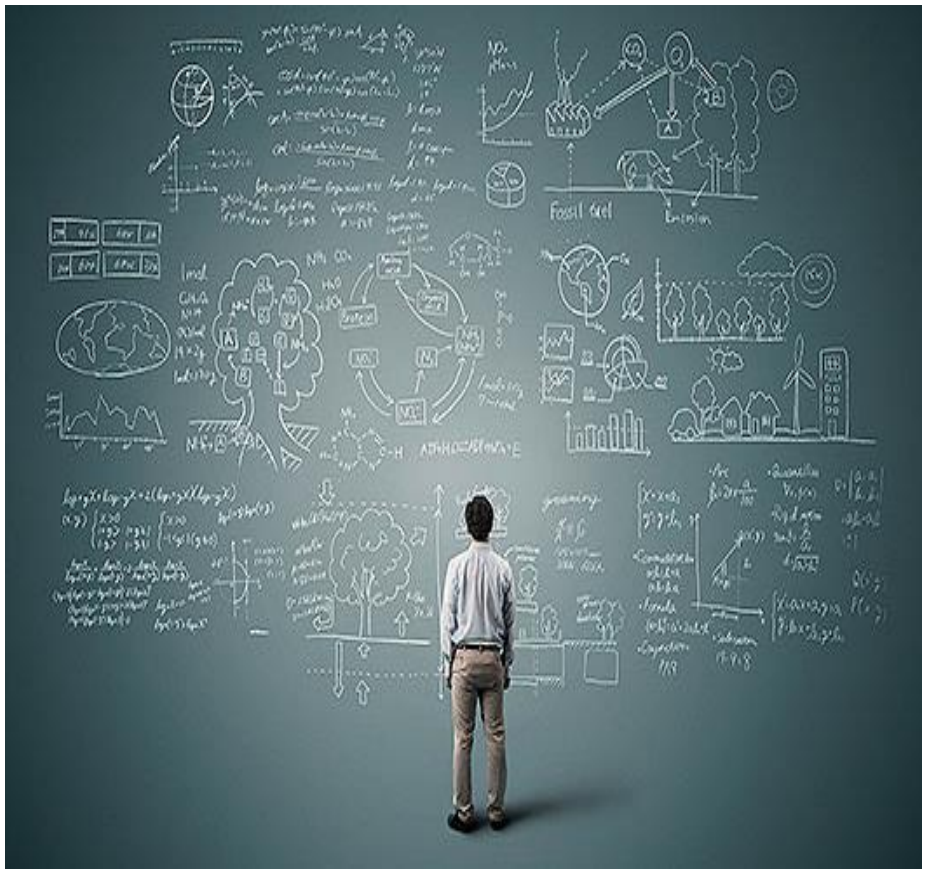
- Discovery of meaningful patterns in data
- Multidimensional

Big data

- Huge volumes
- Automated processing
- Machine Learning
- Uncovers hidden patterns

Predictive Analytics

- Standard practice in many industries
- Drive's business intelligence, risk management and continuous improvement



ENERGY ANALYTICS

- Localized servers and processing becomes expensive as data gets bigger. Cloud computing can tackle big data with high performance and reduced costs.
- Date from large sample sizes can be collected, cleaned, and analyzed faster with big data and energy analytics.
- Transitioning to wireless meter data transmission will save time and money.
- Site level (in house & industrial/large commercial) end use trend data will become more commonly available.
- Analytics can deliver accessible and up to date program performance data, and enhance techniques, such as geo-targeting, to identify customers and locations with a high potential for energy savings.
- Energy analytics provides data visualization tools to improve interpretation of results.

SOFTWARE AS A SERVICE - SaaS

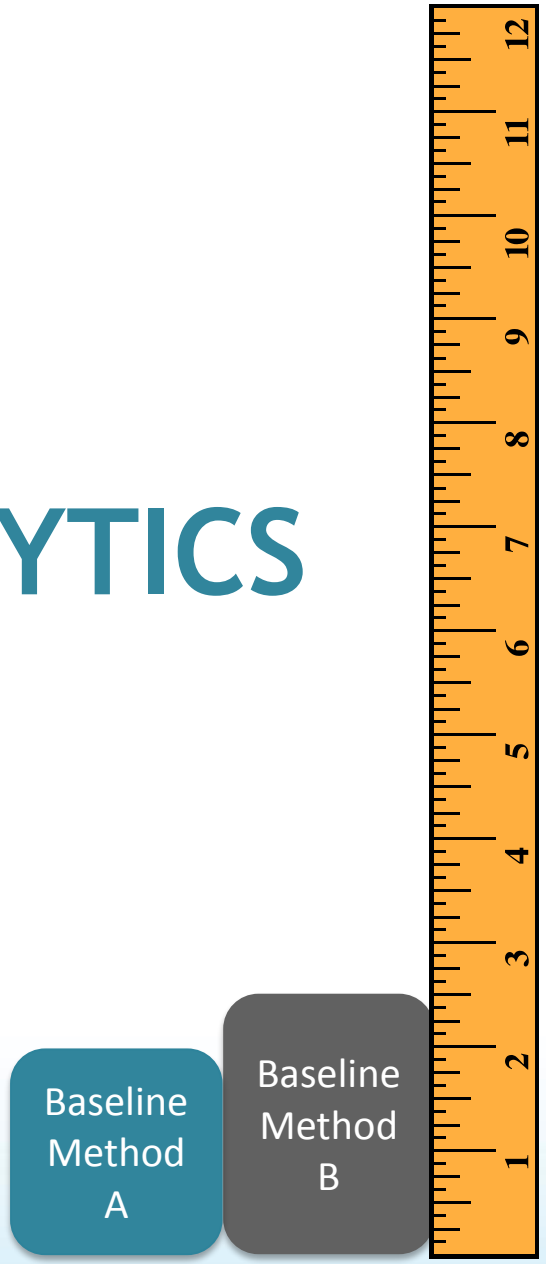
A short sample of providers

C3 Energy
ENERGYSAVVY
Retroficiency
GRIDIUM
wegowise
FIRSTFUEL

SOFTWARE AS A SERVICE - SaaS

Function	With SaaS, mature business intelligence analytics has migrated from the private sector to the utility sector. Providers use cloud based, internet enabled software and very large data sets to support decision making at utility and customer level.
Current uses/value	Measurement, verification, benchmarking, customer segmentation/targeting services, virtual energy assessments, energy audits, and customer engagement programs (not a complete list of available services). Results inform customers, program administrators and stakeholders in a much shorter time frame allowing for more agile program management and enhanced customer engagement.
Challenges for Utility	Monthly data still most common interval but is sufficient to provide results. Faces the same data quality and availability challenges.
Impact on EM&V	Timeline to deliver M&V results is shortened, resulting in agile program management. Can reach large populations. Data cleaning is rule based and automated and can be cleaned overnight. Loss of data during cleaning does not impede the objectives these products. Consumption and tracking data from December can be reported in mid-January.
Challenges for EM&V	Data
Ethical/Regulatory issues	PII management with third party data providers.
Examples	C3 Energy, EnergySavvy, FirstFuel, Gridium, Retroficiency, WegoWise

TESTING NEW ANALYTICS



LBNL WEBINAR
JULY 30TH FROM 9-10:30 AM PACIFIC TIME
12-1:30 PM EDT (TOMORROW)

RECENT FINDINGS ON THE ACCURACY OF M&V APPROACHES USING WHOLE-BUILDING INTERVAL DATA AND AUTOMATED ANALYTICS.

- **The potential** to leverage automation, interval data and analytics tools **to reduce the time and costs** of M&V, **while maintaining or improving accuracy**
- Common questions regarding the accuracy and transparency of automated methods
- A transparent M&V **model testing proce**dure
- **Novel interval data baseline energy use models** from the tool vendor and research community – both proprietary and open model forms, including results for Buildings Alive, Gridium, Lucid, UC Berkeley, Performance Systems Development, and others
- **New accuracy results** for 10 models tested against nearly 600 buildings
- The connection between **pre-qualification and vetting** and use of these approaches for **post-verification and savings reporting**
- Implications for the efficiency community, and ongoing work to facilitate adoption

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CONCLUSIONS & NEXT STEPS

THE CURRENT STATE—M&V

- Software as a Service providers deploy big analytics designed to inform program operations, improve agility of program management, and enhance customer engagement.
- The combination of new technologies and big analytics can make some kinds of M&V possible at a fraction of the cost and time of conventional methods.
- New technologies are increasing the types of available data, and data volume is growing exponentially. Big Analytics is needed to process and analyze Big Data.

THE CURRENT STATE—E

- Big Data and Big Analytics M&V technologies and tools can be used in evaluation
  - Little experience with this so far
- Evaluations are using Big Data and advanced analytics in various ways, including
  - interval data for billing analysis
  - profiles from customer databases
  - geo-analytics to segment and report results
- Some of the new technologies and services are being incorporated into programs
  - Evaluations of these program will help document their accomplishments, potential, and relative merits
  - Program administrators are looking for these evaluation results

DATA PATH TO EM&V

OUTSTANDING CHALLENGES AND QUESTIONS

- Useful application of interval data from smart meters is limited by penetration of installed meters and access to the data.
- Additional IT infrastructure is needed to handle data volume.
- Big analytics can clean data much faster at cost of increased data loss. In what contexts is that cost a problem?
- With greater amounts of data comes greater concerns regarding privacy and data ownership
- Smart thermostats and devices must resolve data ownership issues and data protocols before they can be useful to large-scale EM&V.
- Baseline and attribution questions are not necessarily resolved by more granular consumption data. Making good use of big data for evaluation is an art still in development.

NEXT STEPS

- Case studies and final report with recommendations early Fall, 2015 (draft to be reviewed by project subcommittee)

- Send comments to Julie Michals at jmichals@neep.org

THANK YOU