Opening Up Markets for Efficiency Though Open Standards

Matthew Gee

December 15th, 2015

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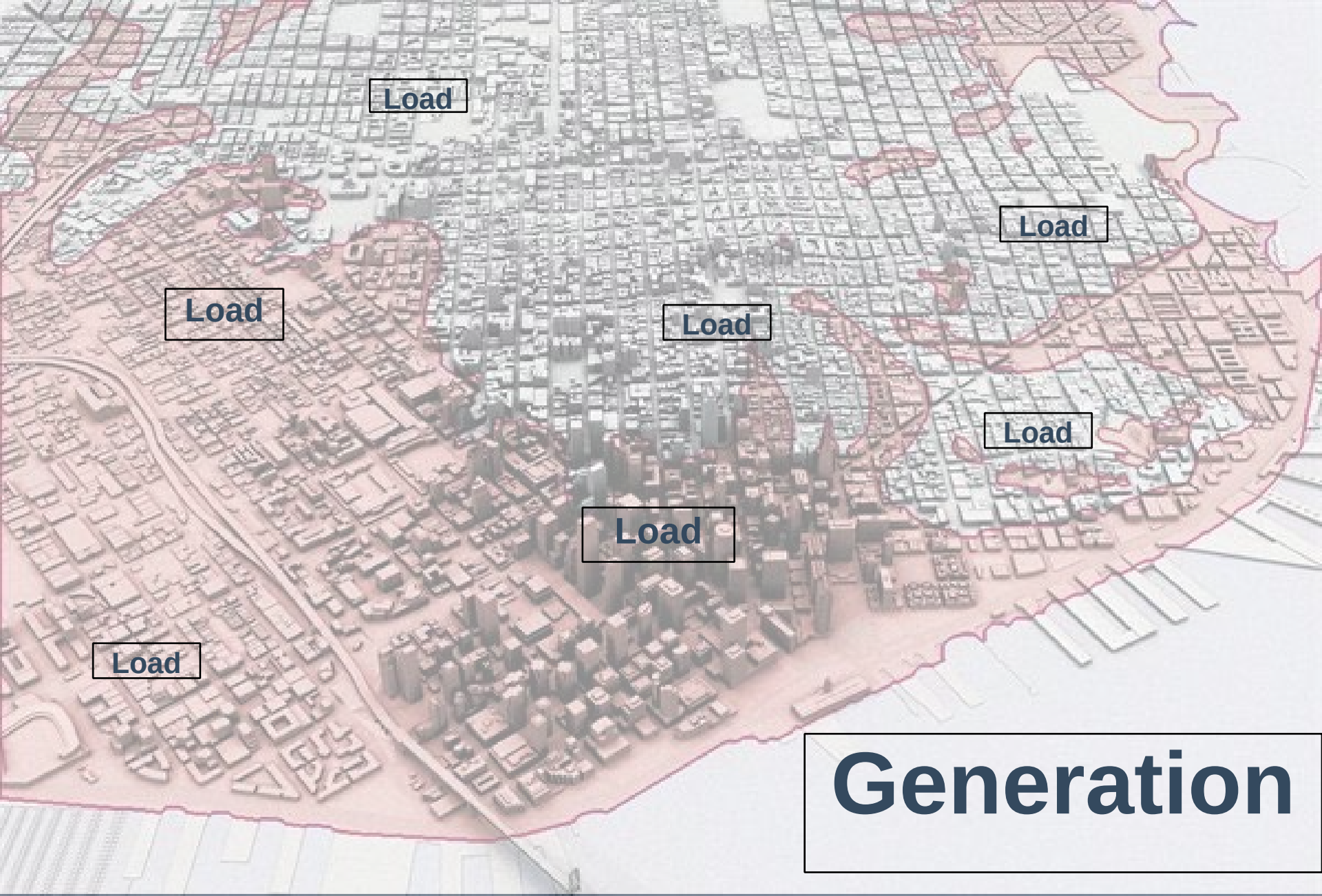
The Grid Is Changing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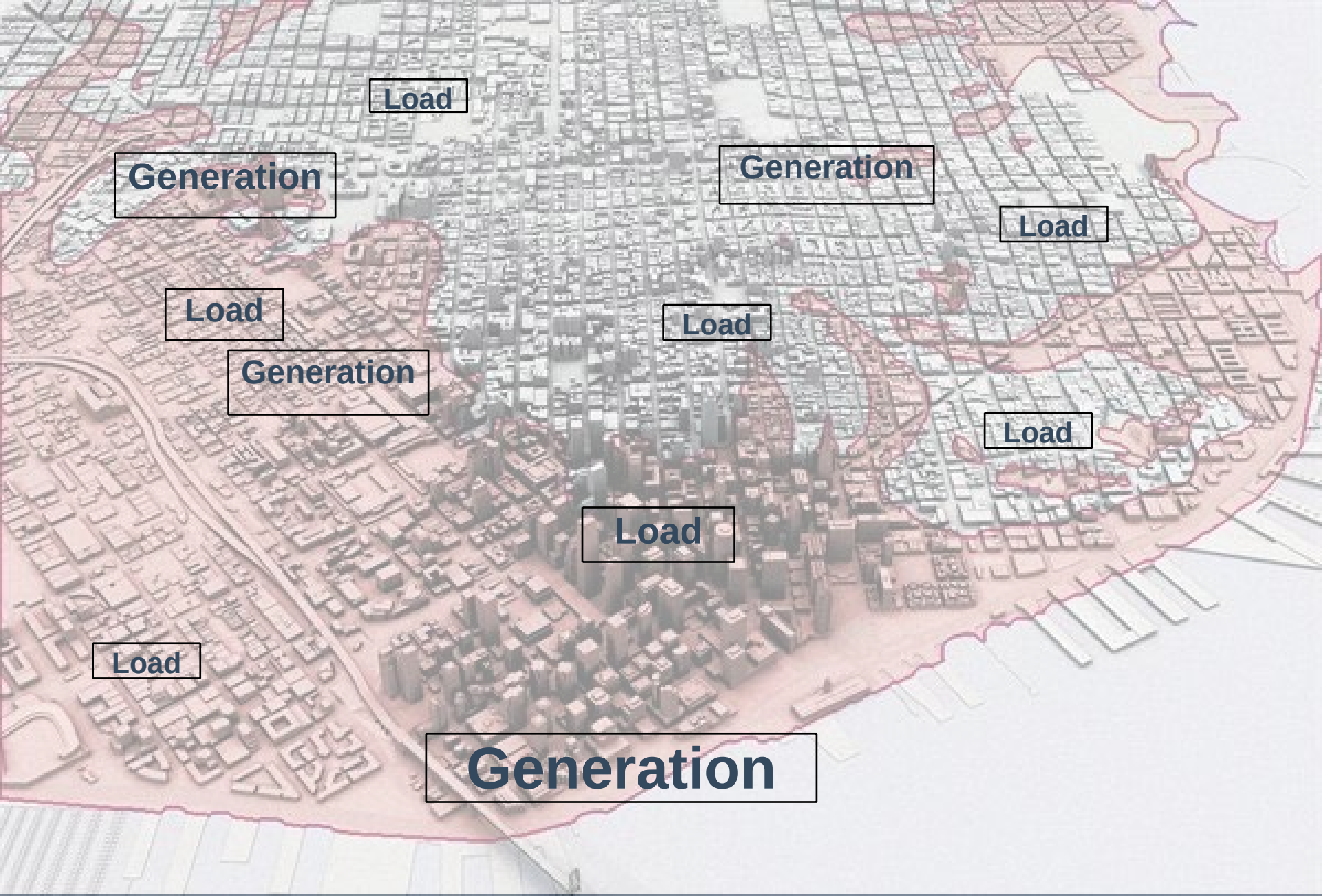
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Generation

From this

ComEd
An Exelon Company

PEOPLES
NATURAL GAS | TWP

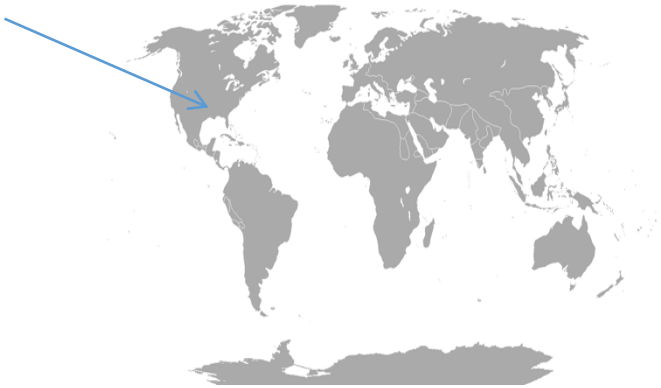
Ameren
ILLINOIS

=

To this

ComEd
An Exelon Company
SolarCity
Invenergy
PEOPLES
NATURAL GAS | TWP
run
MIDWEST WIND ENERGY
Bloomenergy
BlueStar energy solutions
Your Power. Your Choice.
Ameren
ILLINOIS
nrg
=
Johnson Controls
AGENTIS
Schneider Electric
nest
RENOVATEAMERICA
RENEWABLE FUNDING
wink
bidgely
SEALED
OPOWER
TESLA

Grid 2.0
Knowing the Where and When of Generation and Load



UTILITY
REBATE
PROGRAM
UP TO 70% INSTANT SAVINGS

STORM
RELIEF
New York State Appliance and Equipment
REBATES
NYSApplianceRebates.com

Taking Full Advantage
2013
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Incentives
mass save
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Present this certificate.
Valid for in-store use only.

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Qualified washers must be purchased and installed between January 1 and December 31, 2014
Your local water agency and PG&E are offering
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CASH BACK ON AN ENERGY STAR® MOST EFFICIENT 2014 MODEL
-OR-
Your local water agency is offering
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CASH BACK ON MODEL THAT MEETS CEE TIER 3

REBATE

Gas + Utility
Company Rebates
nicor gas
Energy Efficiency Program
USING ENERGY WISELY FOR A BETTER FUTURE
NORTH SHORE GAS
NATURAL GAS SAVINGS PROGRAM
REDUCE TODAY. SAVE TOMORROW.
PEOPLES GAS
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for Home Upgrade
Find a Home Upgrade Professional to
make your home more energy efficient.
Search Now
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UP TO $750 IN REBATES FROM DUKE, REMC & VECTREN
SMITH BROTHERS
PRECISION AIR SYSTEMS, LLC
HEATING & AIR CONDITIONING
Columbus, Indiana

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UN CLIMATE CHANGE CONFERENCE

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Project finance: The long-term financing of projects based upon projected cash flows rather than the balance sheets of its sponsors.

Toward Efficiency as Capacity

1. Have a standard measure for efficiency
2. Know where efficiency is
3. Know when efficiency is
4. Have aggregators that can provide efficiency at utility scale

The Goal of Open Energy Efficiency

Help create a standard for calculations for energy efficiency, and provide free, open source software that allows anyone to measure and aggregate savings

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Open Energy Efficiency Meter

OPEN STANDARD

OPEN SOURCE

OPEN DATA

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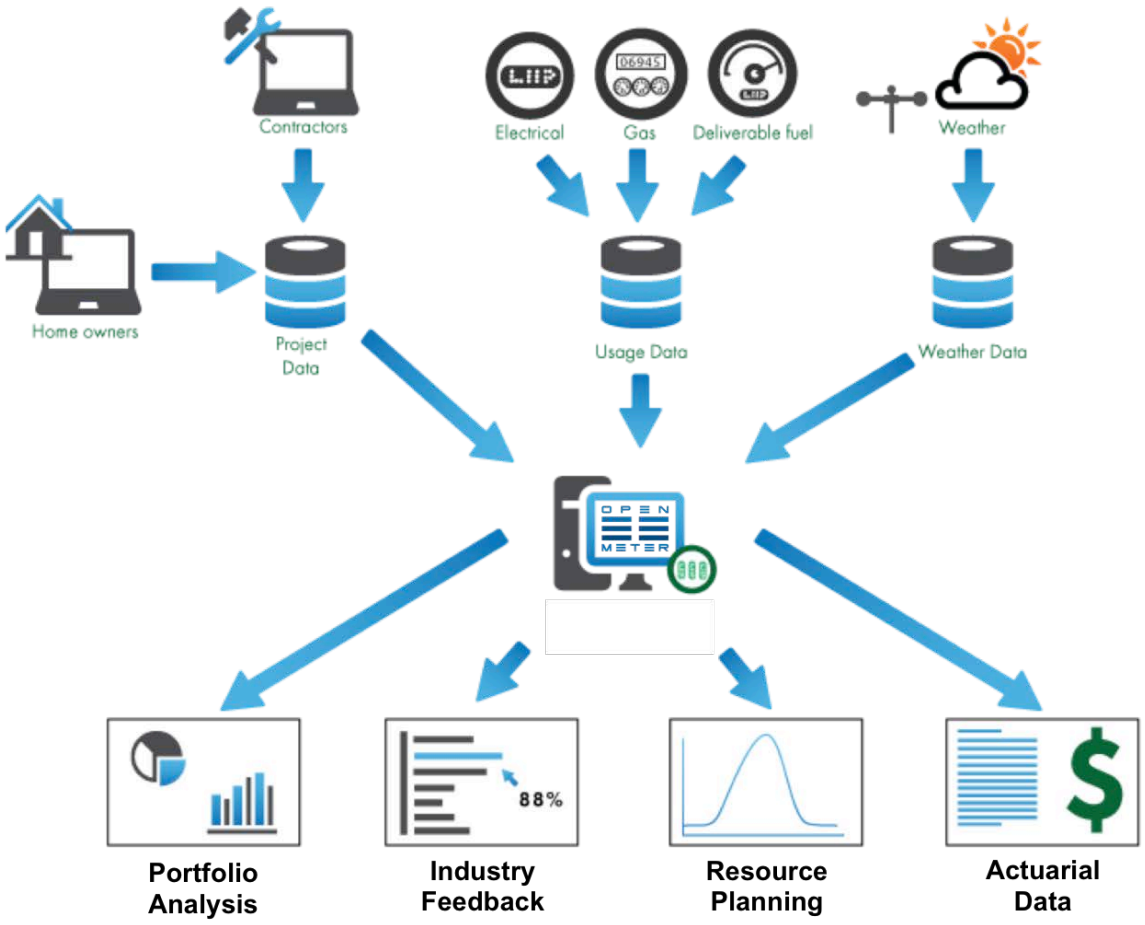
OPEN STANDARD

OPEN SOURCE

OPEN DATA



SEED PLATFORM
U.S. DEPARTMENT OF ENERGY

HP ★ XML
Home Performance XML

Green Button

python

GitHub

open source initiative
Approved License

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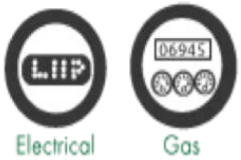
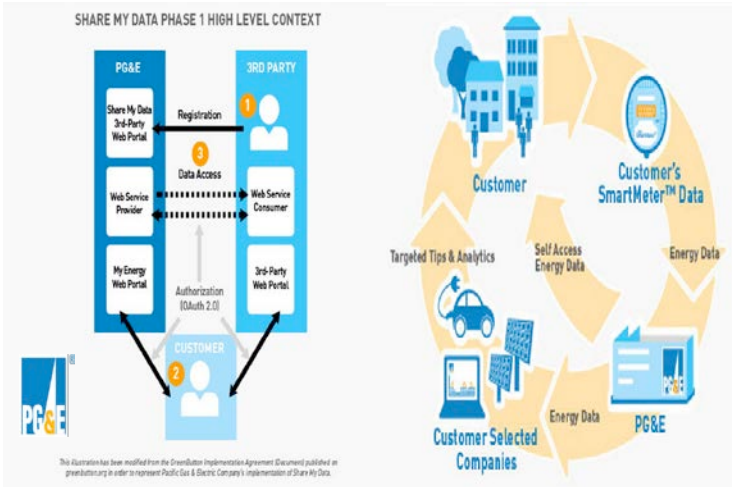
Supports Data Standards

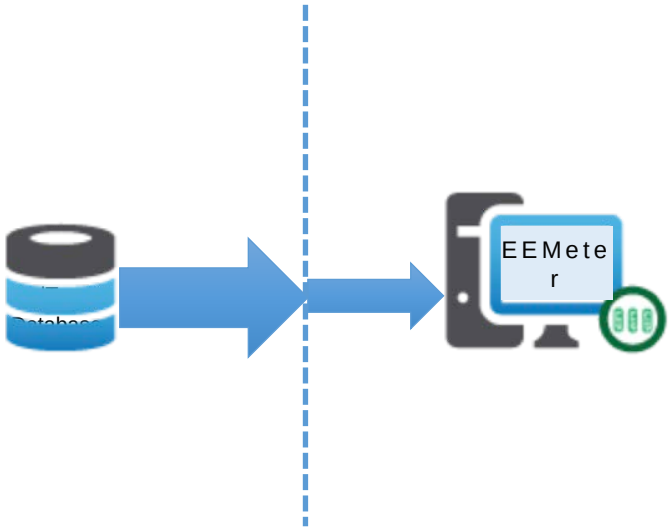
Data Access





Open & Standard Methods

Data Integration | Data Cleaning | Data Analysis



ANSI
American National Standards Institute

BUILDING PERFORMANCE INSTITUTE INC. HEALTH AND SAFETY, DURABILITY, ENERGY EFFICIENCY • COMFORT
BPI

ACCA
Air Conditioning Contractors of America

Standardized M&V

OPEN STANDARD
OPEN SOURCE
OPEN DATA

Joint ANSI Standard In Development:

Protocol for Quantifying Energy Efficiency Savings in Residential Building (EE Meter)

Uniform method for measuring energy savings resulting from efficiency improvements at the portfolio level by calculating a standard unit of gross savings for existing residential buildings based on weather-adjusted, metered utility data. The standard will also identify a process for qualifying automated systems for compliance with this standard.

ANSI
American National Standards Institute

ACCA

BUILDING PERFORMANCE INSTITUTE, INC.
BPI
™

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Open Source License & Open Source Codebase

Open Source

MIT License

The MIT License is a free software license originating at the Massachusetts Institute of Technology (MIT). It is a permissive free software license, meaning that it permits reuse within proprietary software.

Python is a widely used, open source, general-purpose, high-level programming language. Its design philosophy emphasizes code readability, and its syntax allows programmers to express concepts in fewer lines of code than would be possible in languages such as C++ or Java.

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Inbox (23) Partnership Efficiency.c Blockchain Residential Proposals Market-bas My Drive - Open EE M The Blockc Matt
Openeemeter.org
This repository Search Explore Gist Blog Help goldenmatt

datamade / open-ee-meter

Unwatch 5 Unstar 2 Fork 1

branch: master open-ee-meter / data / processors / contractor_data_prep.py

cathydeng on Dec 22, 2014 add gross savings data prep for contractors, add contractor layout, c…

1 contributor

253 lines (211 sloc) 10.881 kb Raw Blame History

```
1  import pandas as pd
2  from pandas import to_datetime
3  import numpy
4  import json
5  import re
6  import os
7
8  projects = pd.read_csv( "build/merged.csv")
9  loc = pd.read_csv( "build/latlong_clean.csv")
10
11 merged = projects.merge(loc, on="zipcode")
12
13 contractor_dict = {
14     'electricity_iou': {
15         'contractor_names' : ['Contractor 12'],
16         'actual_col' : 'weather_normalized_yearly_kwh_savings',
17         'pred_col': 'predicted_yearly_kwh_savings',
18         'hist_chunks' : [float(i)/2 for i in range(-8, 9)]
19         },
20     'gas_iou': {
21         'contractor_names' : ['Contractor 12'],
22         'actual_col' : 'weather_normalized_yearly_therm_savings',
23         'pred_col': 'predicted_yearly_therm_savings',
```

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OpenEEMeter

Search docs

Tutorial

- Introduction
- Installation
- Using an existing meter
- Loading consumption data
- Creating a custom meter
- Caching Weather Data

API

Using an existing meter

This tutorial will walk through how to use an existing meter to evaluate the energy consumption of a portfolio of buildings.

For this tutorial, we'll use sample data, but please see below for a tutorial on connecting to a database, importing Green Button XML, or importing Home Performance XML.

We will start by creating a portfolio by specifying distributions to draw parameters for simple temperature sensitivity models of electricity and natural gas consumption.

The following parameter distributions are for generating fake data using a model which takes both heating degree days (HDD) and cooling degree days (CDD) into account. This is a suitable model for monthly electricity consumption.

```
from eemeter.models import TemperatureSensitivityModel
from scipy.stats import uniform

electricity_consumption_model = TemperatureSensitivityModel(heating=True,cooling=True)

electricity_param_distributions = {
    "cooling_slope": uniform(loc=1, scale=.5), # consumption per CDD
    "heating_slope": uniform(loc=1, scale=.5), # consumption per HDD
    "base_consumption": uniform(loc=5, scale=5), # per day
    "cooling_reference_temperature": uniform(loc=70, scale=5), # degF
    "heating_reference_temperature": uniform(loc=60, scale=5) # degF
}
electricity_param_delta_distributions = {
    "cooling_slope": uniform(loc=-.2, scale=.3), # change in HDD temperature sensitivity pos
    "heating_slope": uniform(loc=-.2, scale=.3), # change in HDD temperature sensitivity pos
    "base_consumption": uniform(loc=-2, scale=3), # change in base load post retrofit
    "cooling_reference_temperature": uniform(loc=0, scale=0), # no change
    "heating_reference_temperature": uniform(loc=0, scale=0) # no change
}
```

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Utility 4

Total Projects: 22

Total Contractors: 7

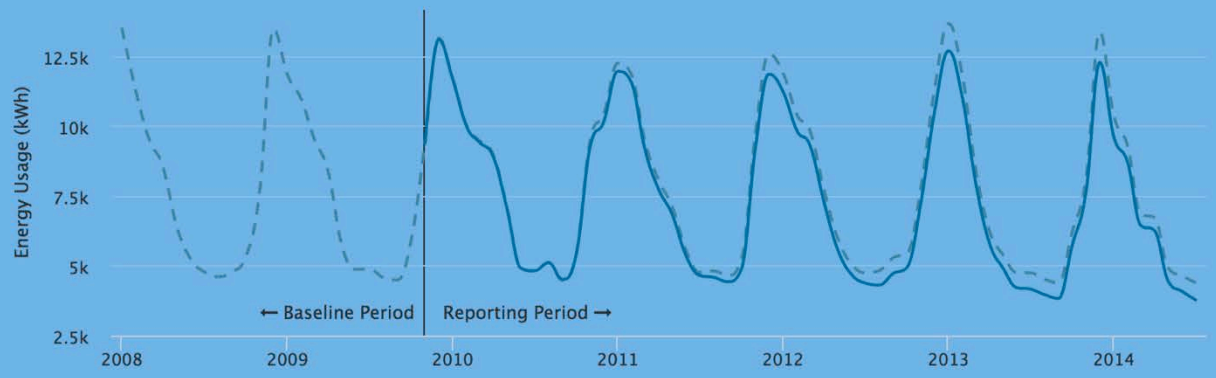
ELECTRICITY GROSS SAVINGS

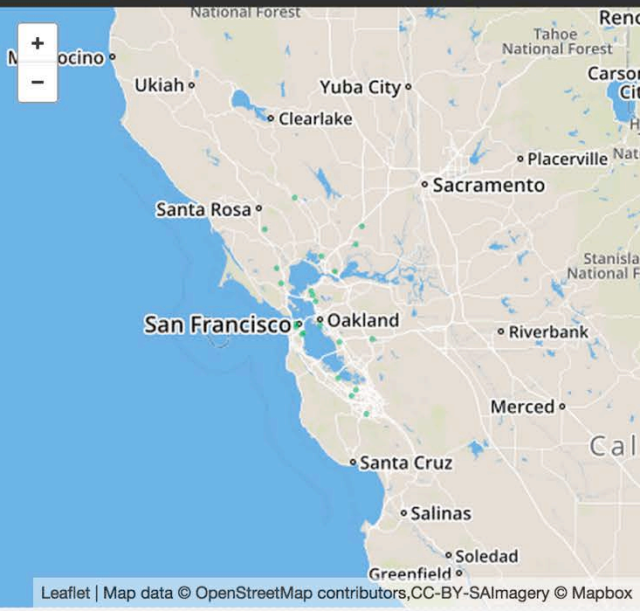
21,219 kWh

GAS GROSS SAVINGS

29,198 therm

Total Energy Usage Over Time





Electricity Savings - Block

REALIZATION RATE

85 %

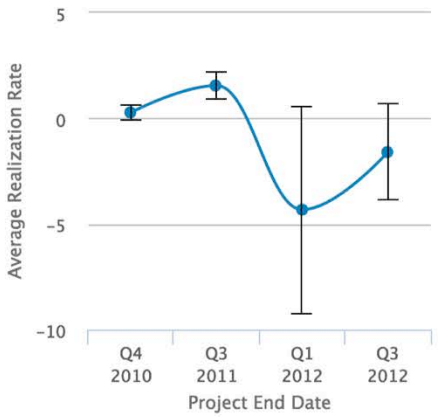
ACTUAL SAVINGS

21,219 kWh

PREDICTED SAVINGS

29,527 kWh

Average Electricity Realization Rate



Gas Savings - Block

REALIZATION RATE

62 %

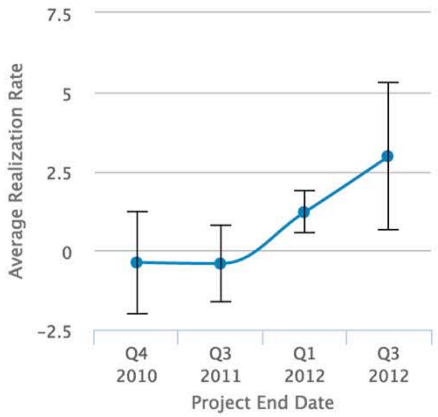
ACTUAL SAVINGS

29,198 therms

PREDICTED SAVINGS

44,411 therms

Average Gas Realization Rate



Open EE Meter In Action

Three Current Cases

California Third-party Pay-for-Success Pilot

Connected Thermostat Savings Measurement Standard

NY Automated M&V Pilot

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CalTrack

The CalTrack System will automatically calculate and report realized savings for every participating residential energy efficiency project in California based on standard input data formats and analysis methods.

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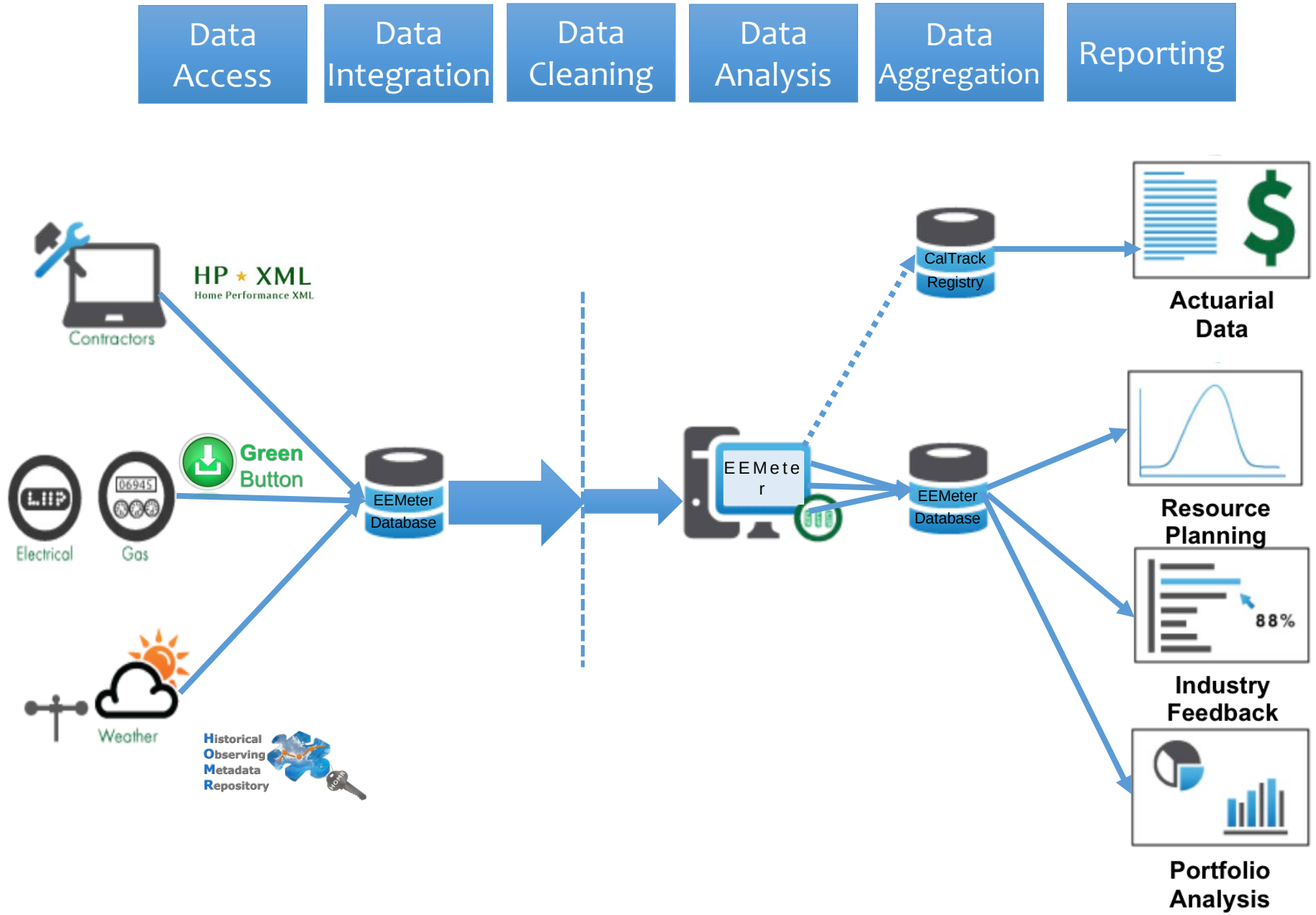

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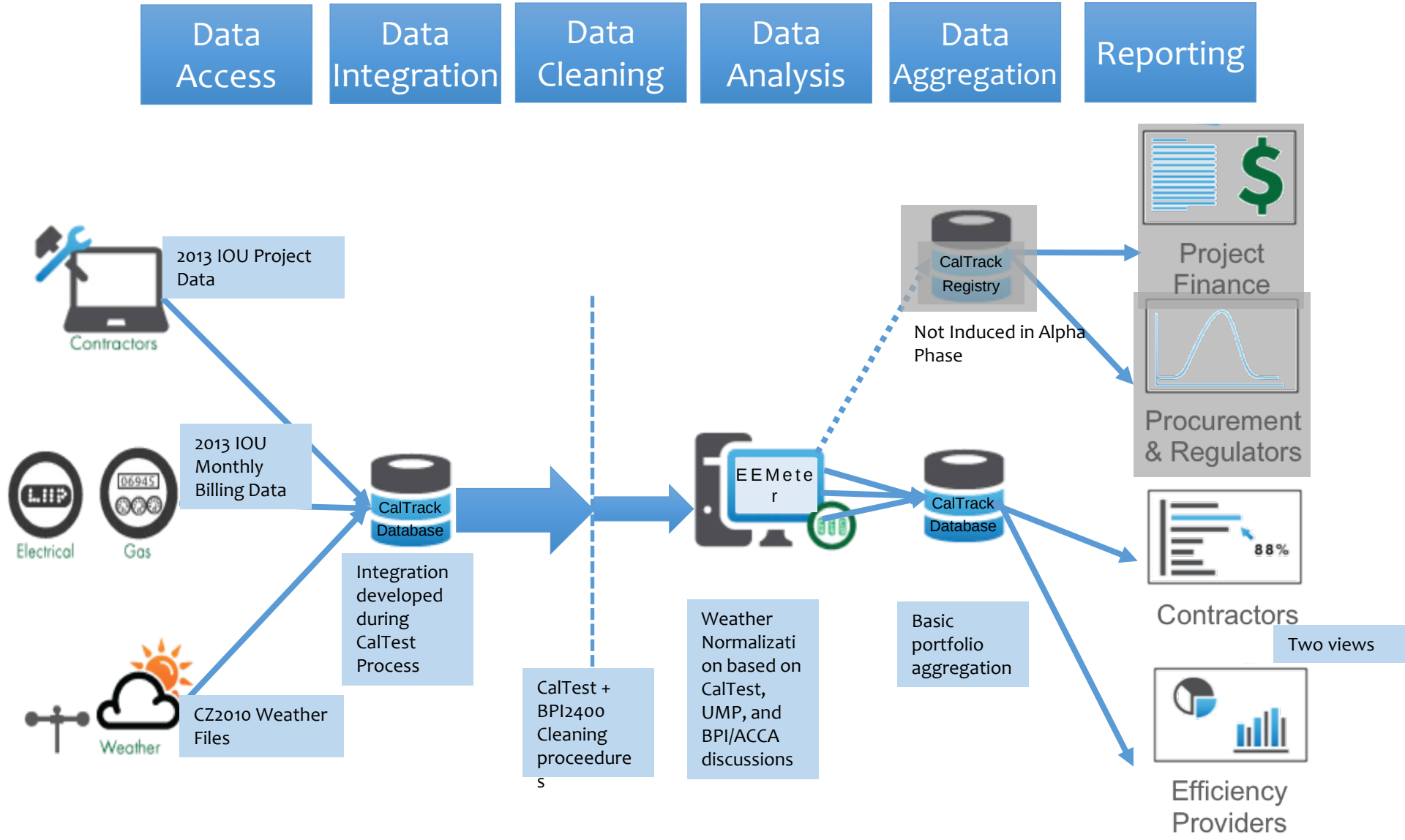
CalTrack Pilot: Alpha Version



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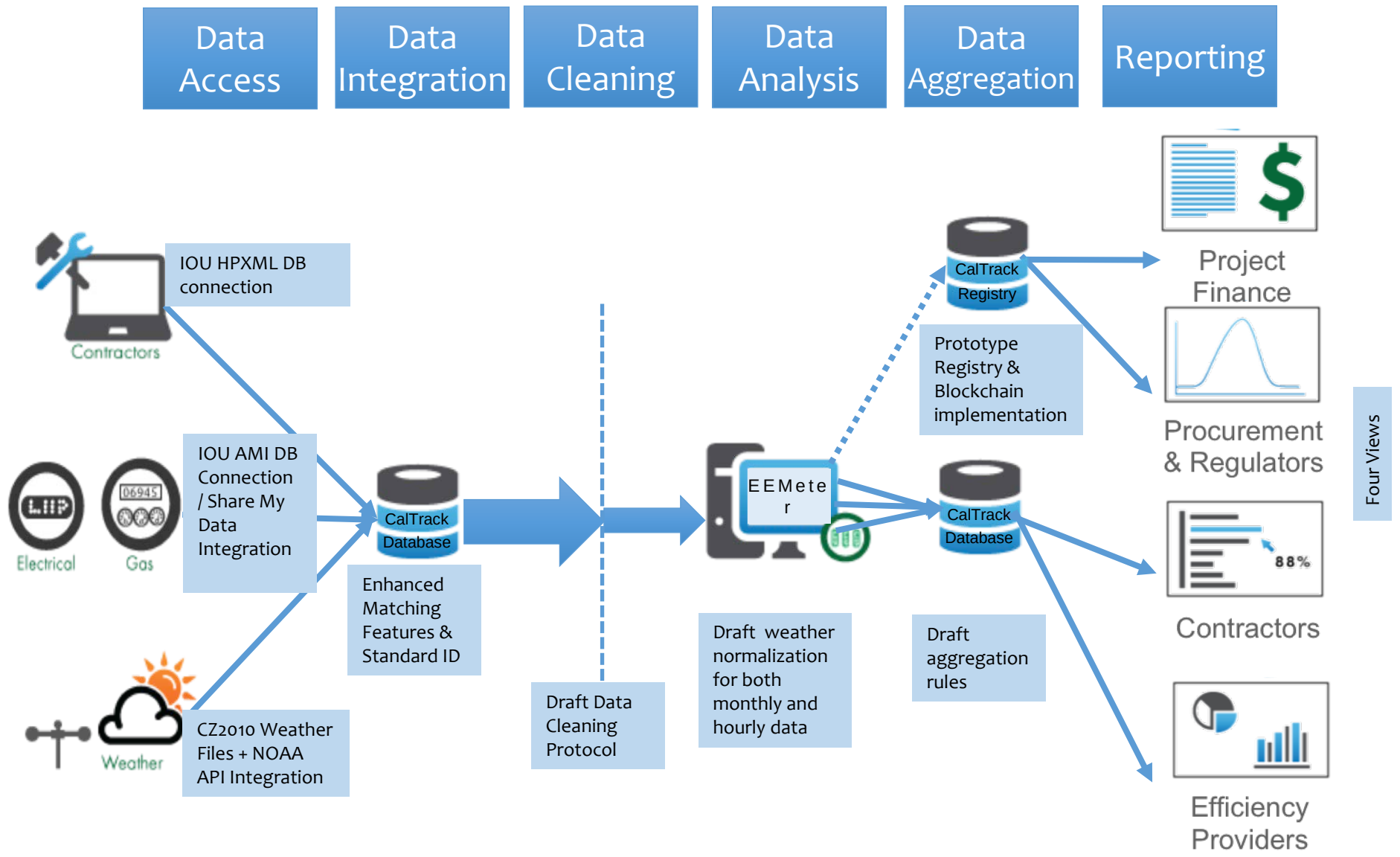
CalTrack Pilot: Beta Version



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Enabling Third Party Procurement

Pace Providers

Behavior Change Providers

Equipment Manufacturers

RENOVATEAMERICA

RENEWABLE FUNDING

WattzOn

METERHERO

ecobee

nest

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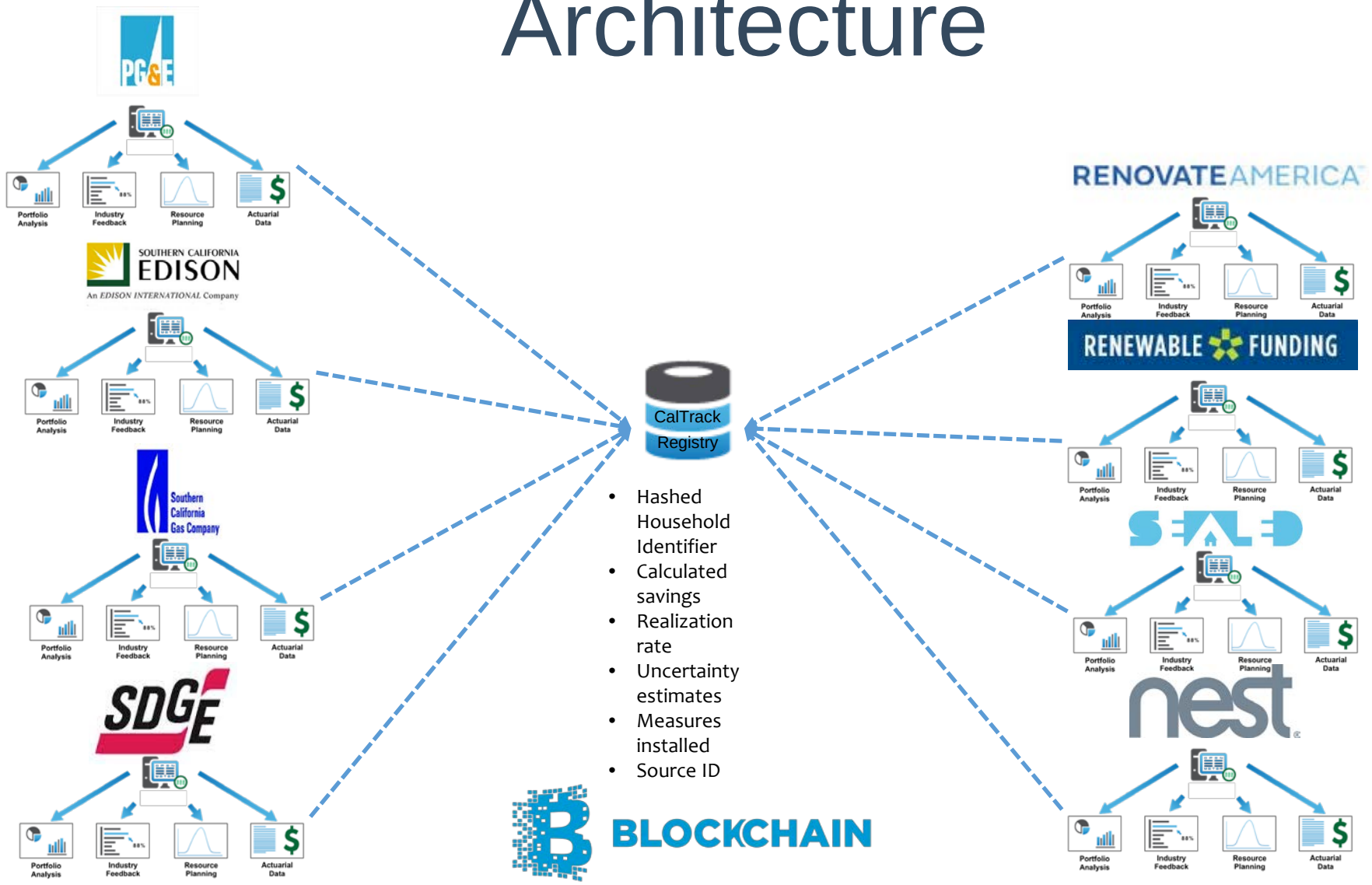
Open EE Meter's Distributed Architecture



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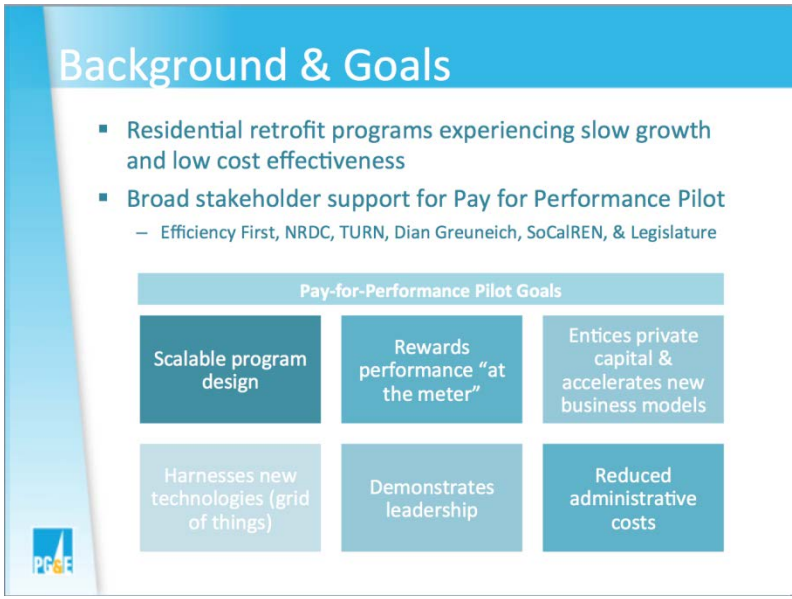
Shifting to Pay-4-Metered Performance

SB-350 / AB-802, signed into CA law in Oct 2015

- Increase of CA EE goals by 50%
- Redefines EE as normalized metered performance
- Removes regulatory barriers (code baseline, behavior, etc)
- Requires CPUC to run P4P pilots
- Implementation starts January 1st 2016

PG&E will launch Pay-4-Metered Performance Pilots for 2016:

- Open markets
- Savings based on EE Meter
- Pay for results



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Efficiency Programs

Paid on prediction
in advance

Rebate based on modeled or
deemed savings

Regulate progress through program
QA/QC and questionable cost tests

Pay-for-Performance

Paid on performance
as delivered

Savings calculated
at the meter

Align performance risk
with the market

Scalable market-based procurement of EE as a resource, yielding competitive private markets innovating to deliver the most cost efficient and reliable energy savings.

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How It Works

Paying for for actual savings at the meter

- Encourage savings persistence not just one time projects
- Relieve the requirement to regulate business models

Aligning incentives with results

- Revenue and profitability from performance at the meter
- Transfer performance risk from regulators to market actors

Turn Efficiency into a cash flow

- Pay for actual results over time as a cash flow that can be securitized
- Get rid of program overhead and encourage competitive market

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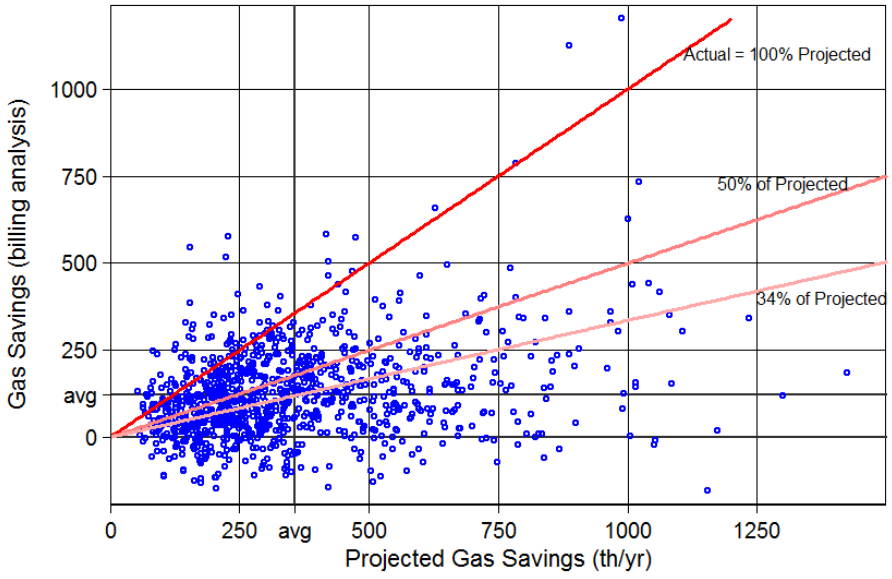
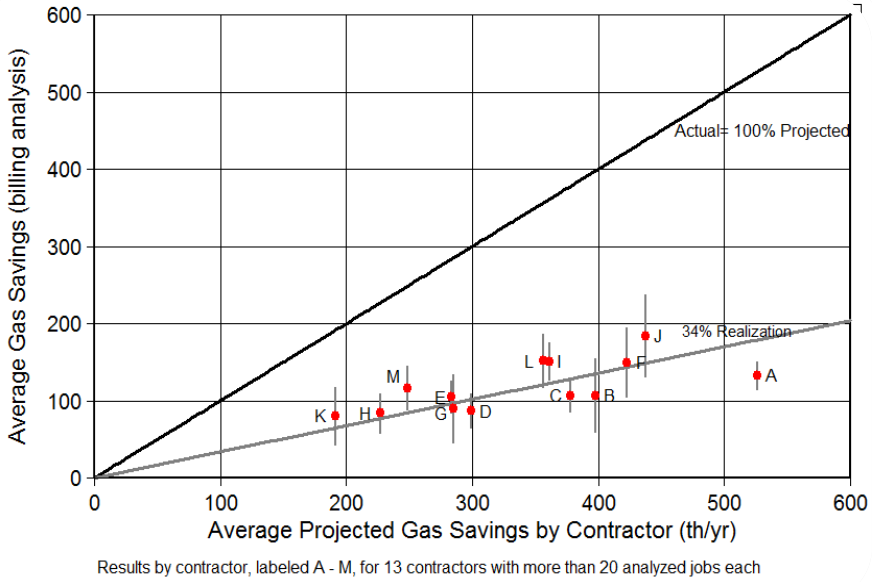
Benefits of Pay-for-Performance

Efficiency is a reliable and procurable resource

- Reliable returns at a portfolio level
- Turn efficiency into demand capacity (savings + time + location)





Uncertainty **Risk**

Two Additional Use Cases

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Measuring Savings from Connected Thermostats

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Automated M&V for SMEs

nationalgrid

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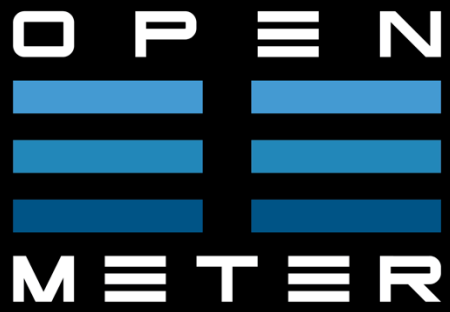

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Thank You

Questions?

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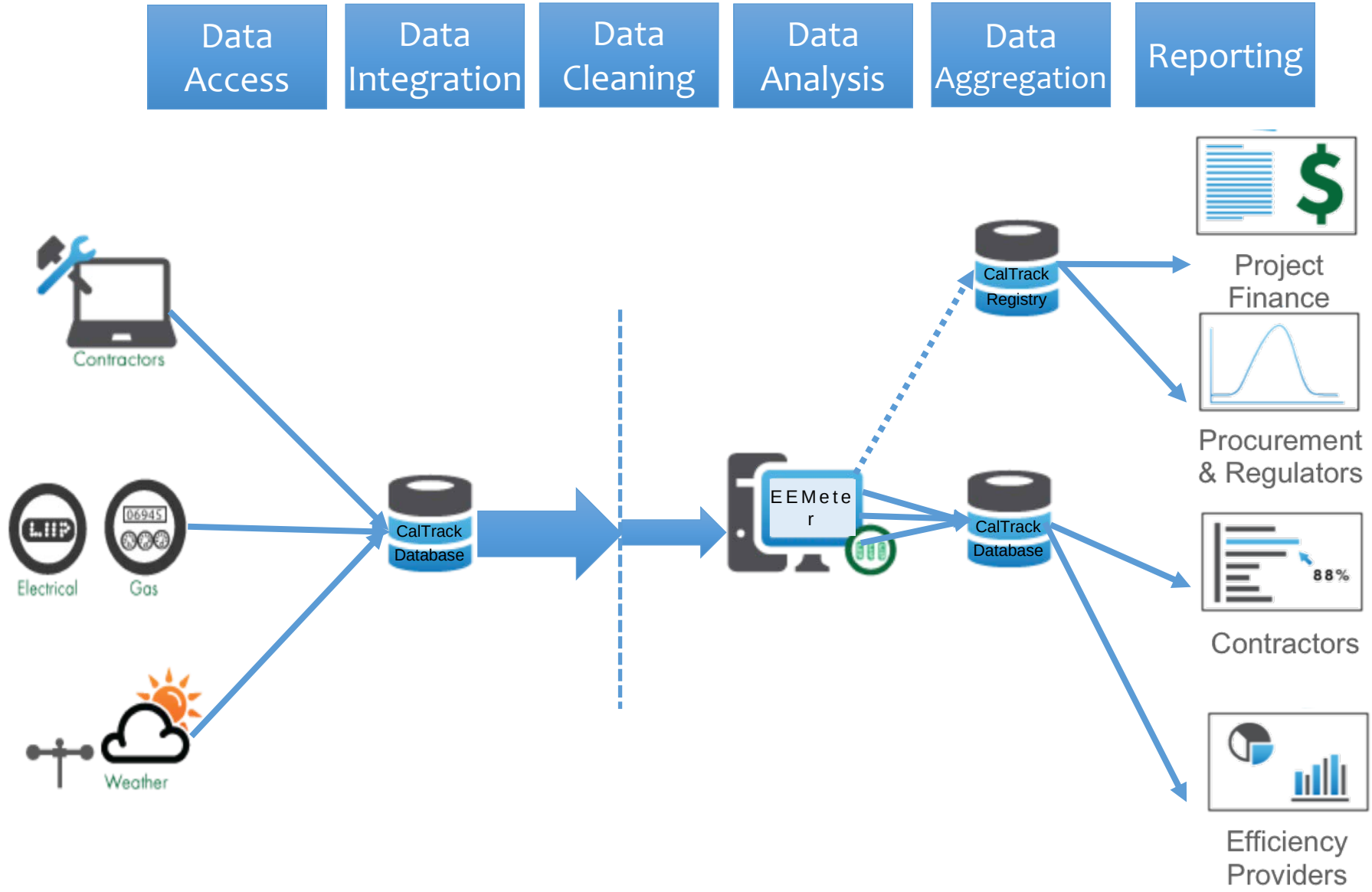
University of Chicago
mattgee@uchicago.edu
@matthewgee

Co-founder and CTO
Open Energy Efficiency

CalTrack Technical Requirement Areas

- Data Access
- Data Integration
- Data Quality
- Data Analysis
- Data Aggregation
- Data Visualization & Reporting



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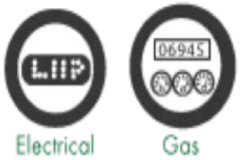
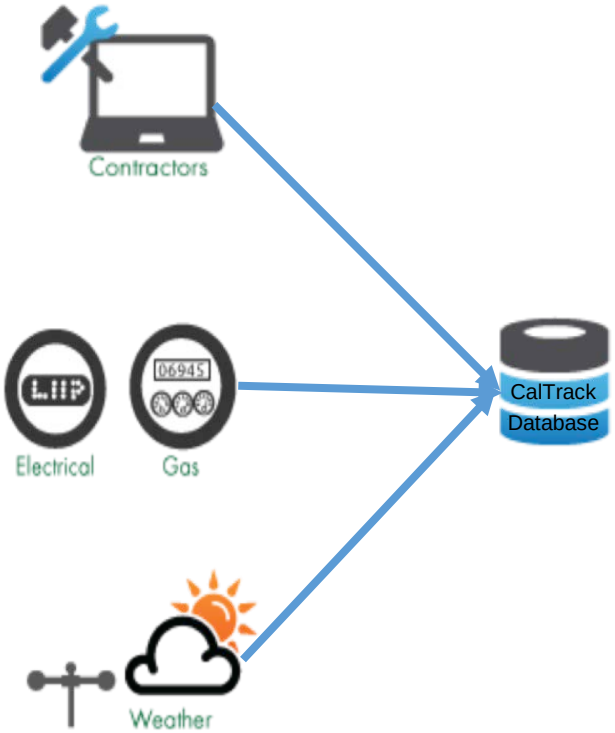
Data Access



Issues with Data Access

- Required to Access
  - Project Data
  - Usage Data
  - Weather Data
- Required of Access
  - Structured
  - Automated
  - Reliable
  - Secure
- Key Issues
  - Standard Sources
  - Authentication
  - Consent
  - Data exchange format

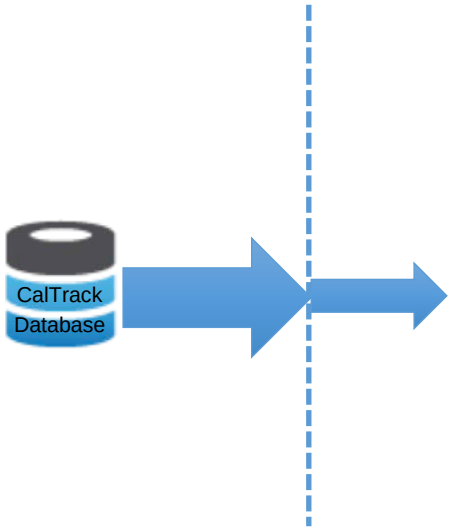
Data Integration



Overview of Data Integration

- Required to Integrate
  - Project Data
  - Usage Data
  - Weather Data
- Required of Integration
  - Standard
  - High match rate
- Key Issues
  - Unique identifiers
  - Deduplication
  - Weather station matching

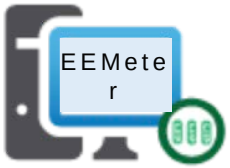
Data Cleaning



Overview of Data Cleaning

- Required to Clean
  - Project Data
  - Usage Data
  - Weather Data
- Required of Cleaning
  - Standard
  - Reproducible
  - Consistent with estimation methods
- Key Issues
  - Missing values
  - Extreme values
  - Miscoded values
  - Insufficient data
  - Imputation & deletion

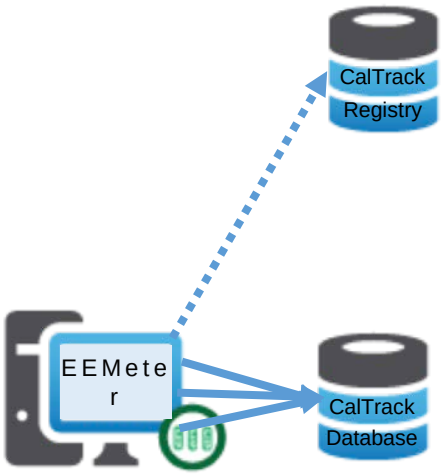
Data Analysis



Overview of Data Analysis

- Required Analyses
  - Weather-normalized savings estimates using monthly billing data
  - Weather normalized & behavior adjusted hourly savings estimates
  - Bias-adjusted cohort savings
- Required of Analysis
  - Standard
  - Open
  - Reproducible
  - Defensible
  - Actionable
- Key Issues
  - Standard monthly billing analysis
  - Hourly counter-factual generation
  - Model selection
  - Standard errors and confidence intervals
  - Post-estimation sufficiency
  - Model validation
  - Automated control groups

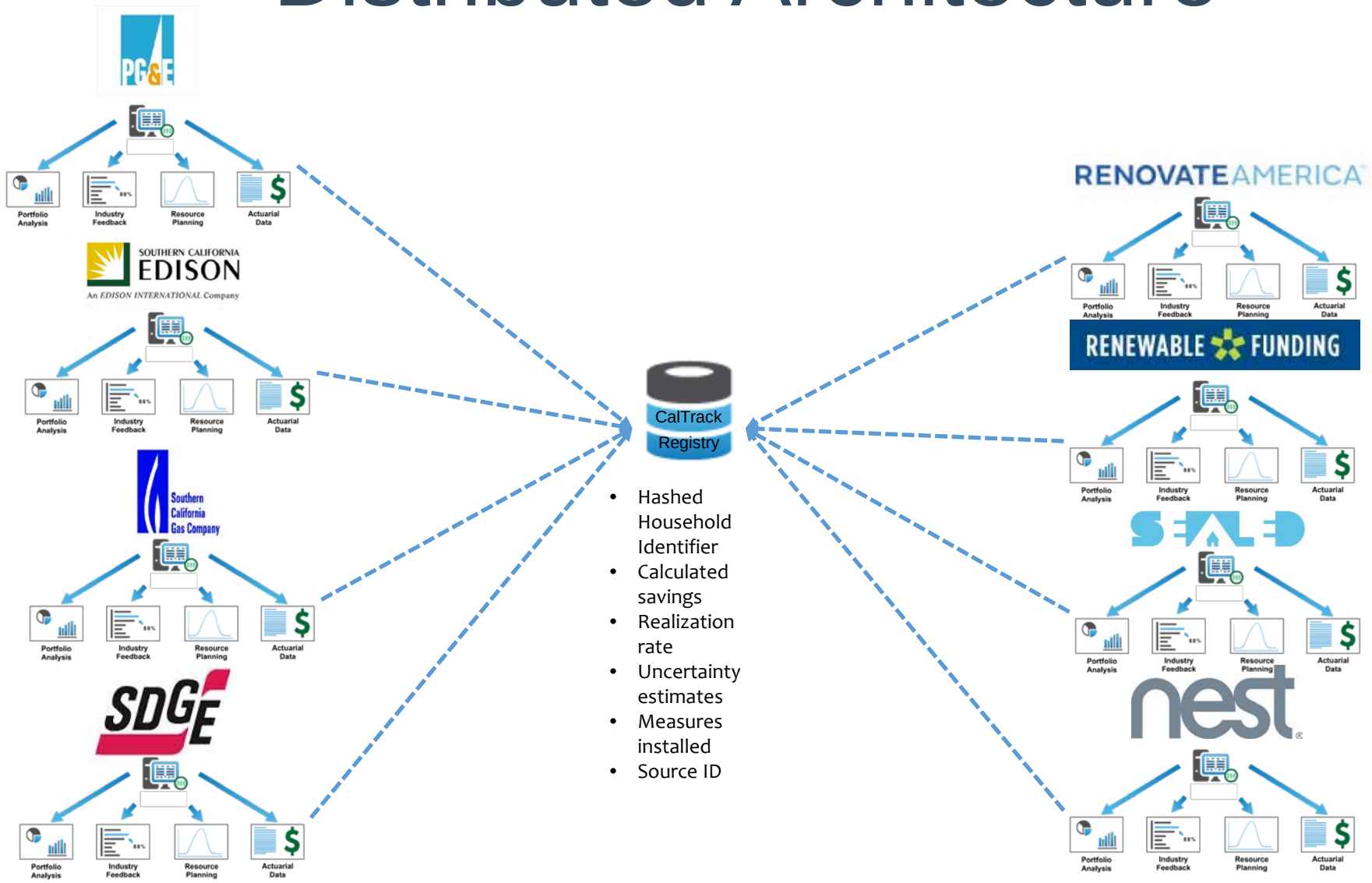
Data Aggregation



Overview of Data Aggregation

- Required for Aggregation
  - Individual household savings estimates, errors, and project data
- Required of Aggregation
  - Standard
  - Reproducible
  - Distributed
  - Traceable
  - Secure
- Key Issues
  - Portfolio savings totals, averages, & confidence intervals
  - Minimum aggregation rules
  - Savings attribution & decomposition
  - Anonymization
  - Secure exchange and provenance
  - Dedupliction & entity resolution

Distributed Architecture



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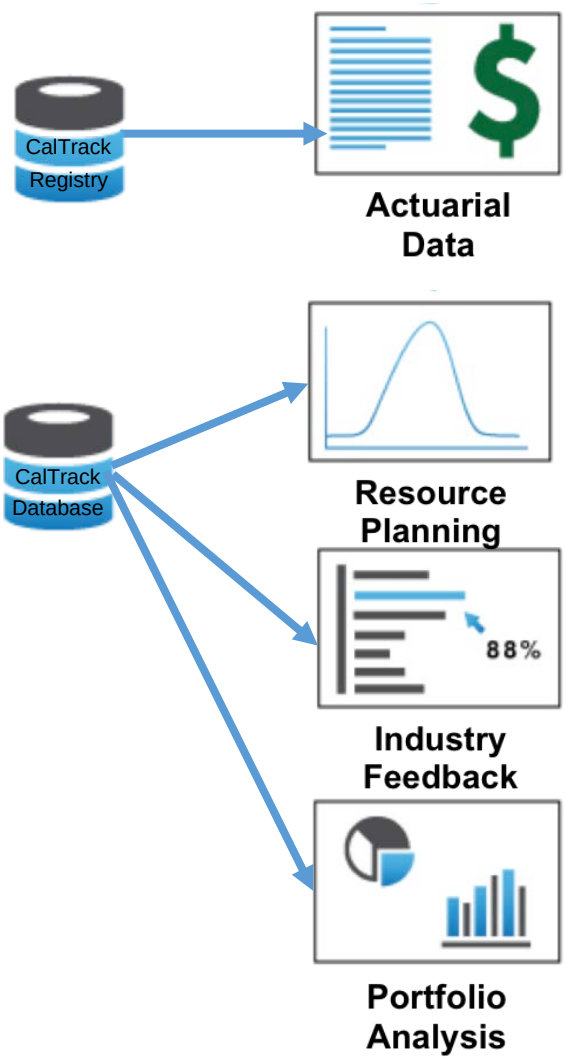
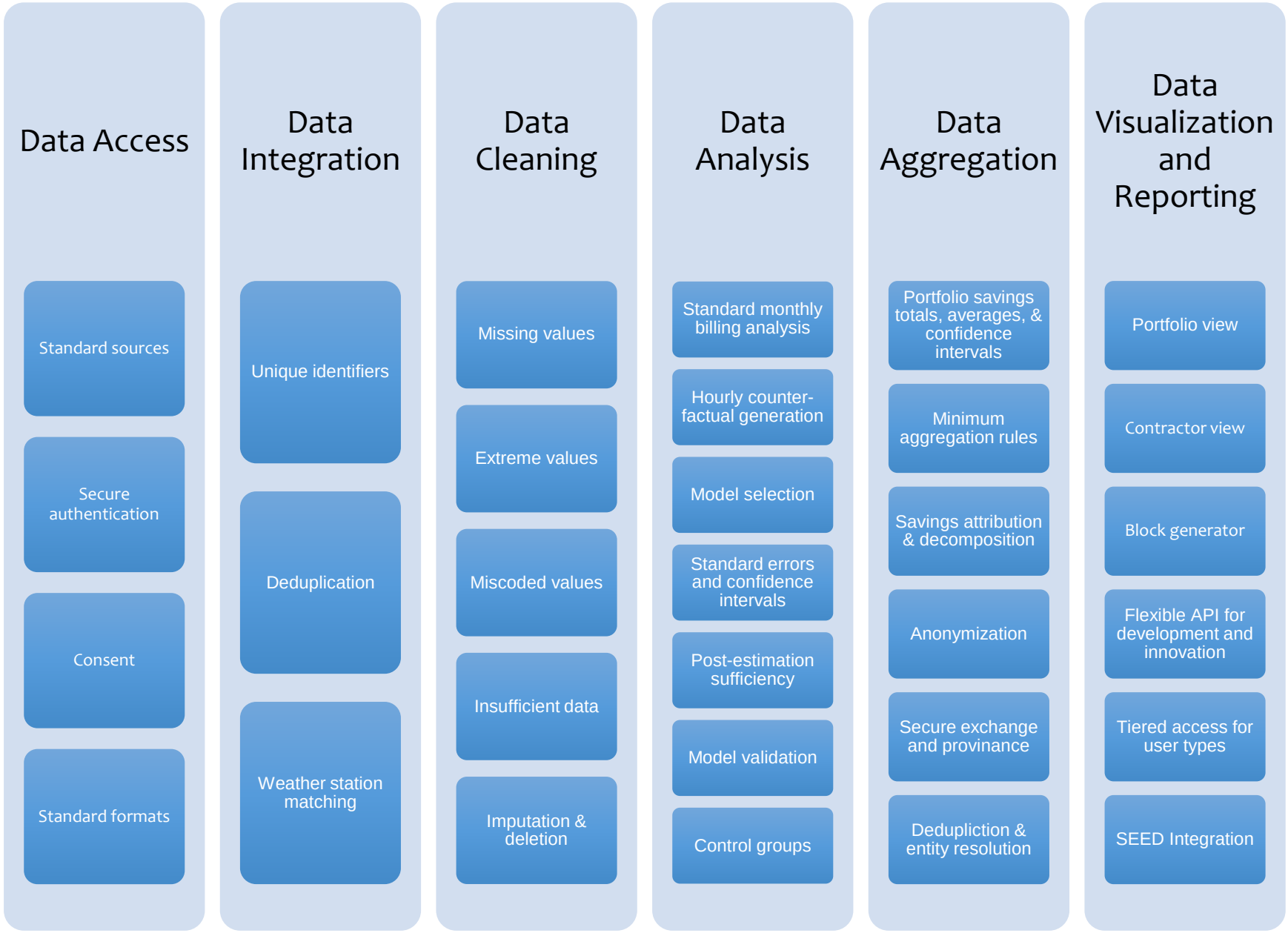


Issues with Views and Reporting

- Required for Reporting
  - All meter inputs and outputs (depending on report)
- Required of Reporting
  - Flexible
  - Customized
  - Authorized
  - Some standard reports
- Key Issues
  - Identifying key stakeholders & their information needs
  - Flexible API for development and innovation
  - Tiered access for user types
  - SEED Integration



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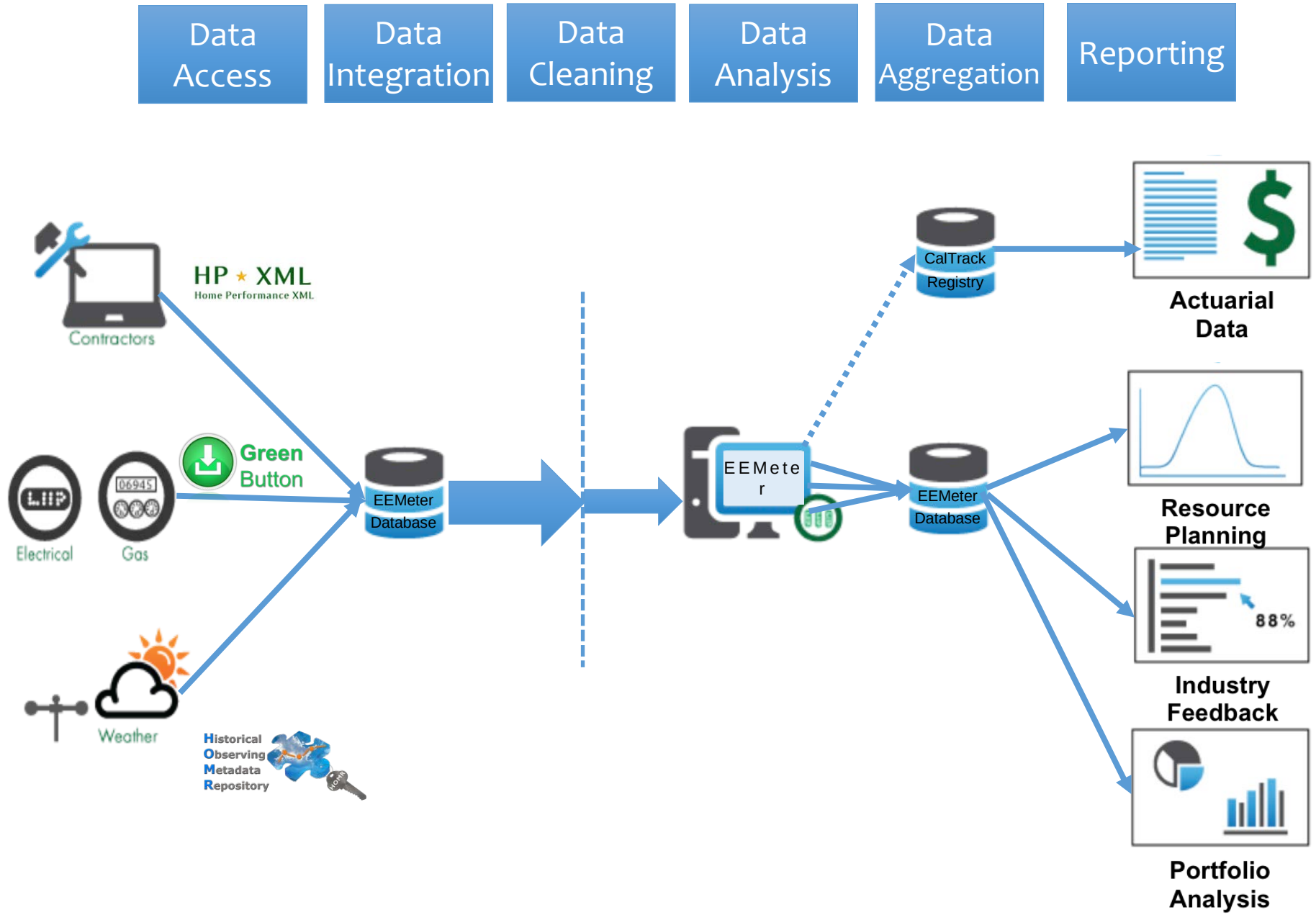

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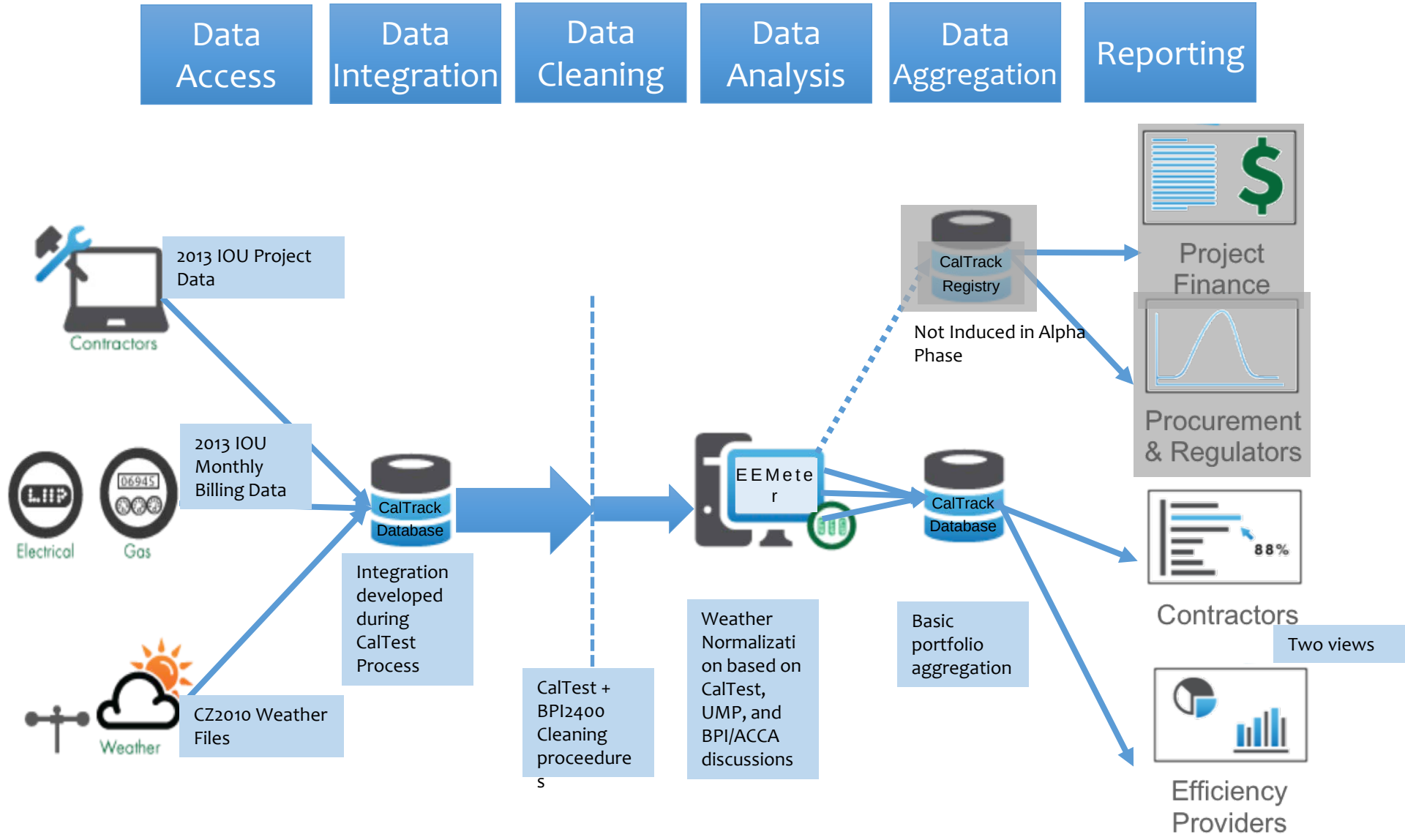
CalTrack Pilot: Alpha Version



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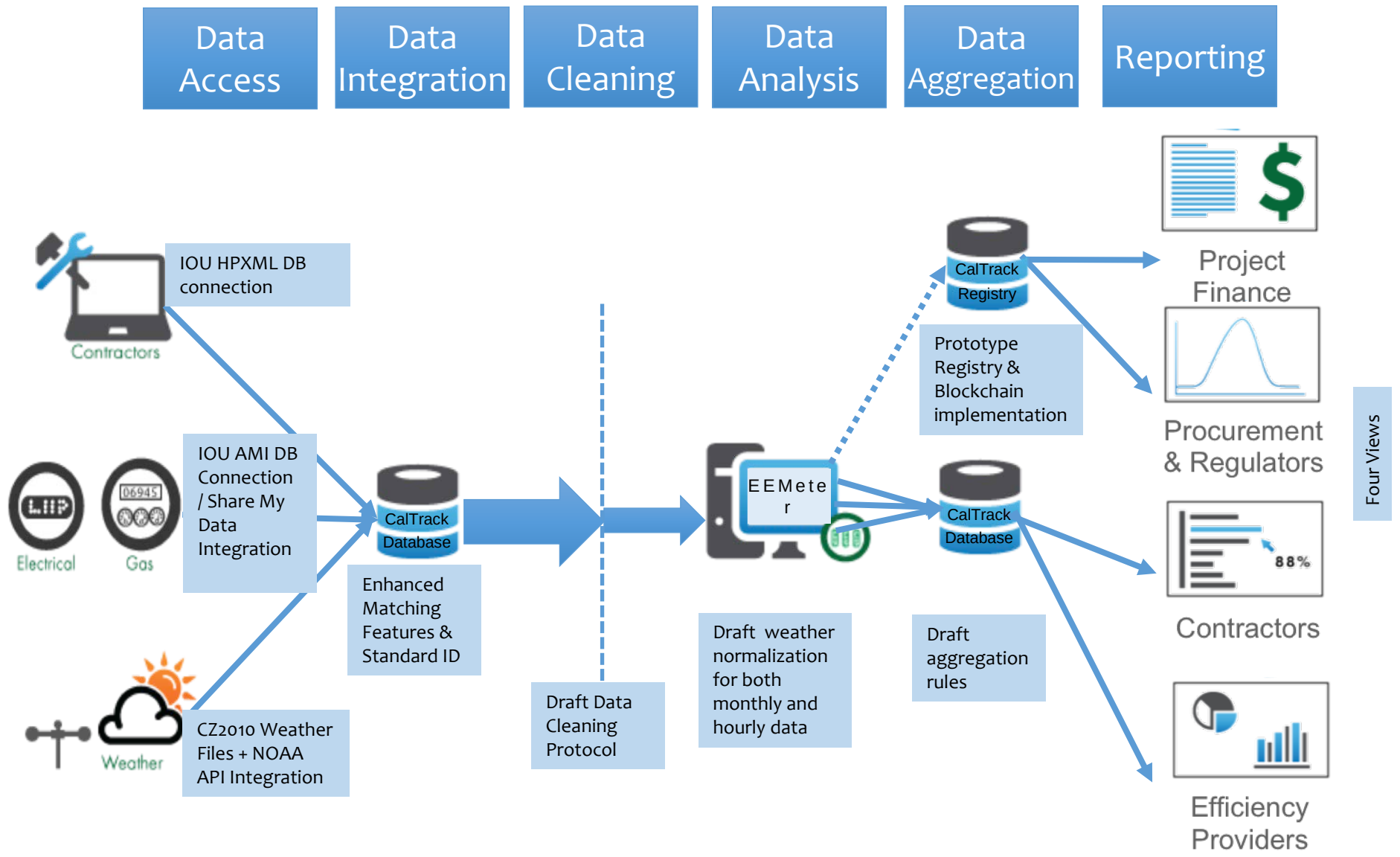
CalTrack Pilot: Alpha IOU Requirements

- Data Access Needs
  - None! We already have the data
- Support
  - None!
- Feedback
  - Bi-weekly feedback calls

CalTrack Pilot: Alpha IOU Deliverables

- IOU-specific instance of CalTrack

CalTrack Pilot: Beta Version



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CalTrack Pilot: Beta

- Data Access Requirements
  - IOU AMI DB Access
  - HPXML DB Access
  - Share My Data Authorization
- Support
  - Minimal (weekly calls with IT at start)
- Feedback
  - Bi-weekly feedback calls

Data Access Deep Dive

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Project Data Access

Past

Source: Fields manually entered into Program CRM, EPro files saved by software, or paper forms manually requested from contractors

Authentication: Report generated and manually exchange between program administrator and evaluator

Consent: Usually not collected from participants

Format: no standard format. Most time spent

Prototype

Source: Pre-formatted database of project data generated during CalTest Process from Epro files and CRMs

Authentication: Manual

Consent: Data stripped of PII

Format: CSV

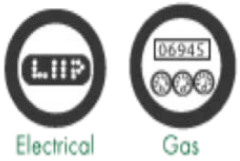
Ideal

Source: Software exports HP-XML directly to CalTrack

Authentication: Oauth

Consent: Automated upon enrollment

Format: HPXML



Usage Data Access

Past

- Source: Manual request reports from contractors
- Authentication: Manual exchange between
- Consent:
- Format: CSV

Prototype

- Source: Usage data extract from CalTest
- Authentication: Manual
- Consent: No PII
- Format: CSV

Ideal

- Source:
- Authentication: OAuth
- Consent: Automated
- Format: XML/JSON

Weather Data Access

Past

Source: No real agreement on weather data, though plenty of standard datasets to choose from (TMY2, TMY3, CZ2010, WeatherBug, AdHoc)

Authentication: Some weather data sources behind pay walls, others open requiring no authentication

Consent: None needed. No PII

Data exchange format: Each source had a standard file format, but no good open weather data APIs

Prototype

Source: CZ2010 weather files

Authentication: none

Consent: none

Data exchange format: CSV

Ideal

Source: NOAA API

Authentication: API Key

Consent: None

Data exchange format: JSON

Data Integration Deep Dive

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Data Integration

Past

Unique identifiers: AdHoc

Deduplication: Manual

Weather station matching: Nearest based on distance

Prototype

Unique identifiers
- Customer ID

Deduplication
- Exact match on select fields

Weather station matching
- Nearest weather station in climate zone based on zip code

Ideal

Unique identifiers
- Internal CustomerID

Deduplication
- Probibalistic based on all fields

Weather station matching
- Probabilistic based on fit with weather dependence

Data Cleaning Deep Dive

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Data Cleaning

Past

- Missing values
- Extreme values
- Miscoded values
- Insufficient data
- Imputation & deletion

Prototype

Missing values
- Strict requirements of fields (no missing values)

Extreme values
- Windsorizing

Miscoded values
- Strict logic rules on allowable values

Insufficient data
- Monthly: 12-month pre & post strict requirement
- AMI: Full season strict requirement

Imputation & deletion
- Only weather data imputed. (random forest)
- All non-complying observations dropped

Ideal

Missing values
- Flexible imputation procedure

Extreme values
- Flexible extreme value elimination (beyond 99%)

Miscoded values
- Miscoding detection
- Flexible omission of flags in views

Insufficient data
- Monthly: 12 month requirement or SE requirement
- AMI: Full season requirement or SE requirement

Imputation & deletion
- Random forest imputation for short numeric lapses
- Missing value flags

Data Analysis Deep Dive

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Data Analysis

Past

- Standard monthly billing analysis
- Hourly counter-factual generation
- Model selection
- Standard errors and confidence intervals
- Post-estimation sufficiency
- Model validation
- Automated control groups

Prototype

Standard monthly billing analysis
- Regression of ADG on HDD/CDD for baseload and weather dependent pre-post parameter estimate
- Annualized against standard calendar year
- Projected forward against current weather

Hourly counter-factual generation
- Same regression with time dependent fixed effects

Model selection
- MSE

Standard errors and confidence intervals
- Standard
- No autocorrelation adjustment

Post-estimation sufficiency
- Minimum R2

Model validation
- No hold-out set

Automated control groups
- None

Ideal

Standard monthly billing analysis
- Regression of ADG on HDD/CDD for baseload and weather dependent pre-post parameter estimate
- Annualized against standard calendar year
- Projected forward against current weather

Hourly counter-factual generation
- BSTS Modeling

Model selection
- Cost-validation

Standard errors and confidence intervals
- Autocorrelation & serial correlation corrections

Post-estimation sufficiency
- Adjusted fitness criteria

Model validation
- Hold-out set or common validation pool

Automated control groups
- Synthetic controls? Hashed matching?

Data Aggregation Deep Dive

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Data Aggregation

Past

- Standard monthly billing analysis
- Hourly counter-factual generation
- Model selection
- Standard errors and confidence intervals
- Post-estimation sufficiency
- Model validation
- Automated control groups

Prototype

- Standard monthly billing analysis
- Hourly counter-factual generation
- Model selection
- Standard errors and confidence intervals
- Post-estimation sufficiency
- Model validation
- Automated control groups

Ideal

- Standard monthly billing analysis
- Hourly counter-factual generation
- Model selection
- Standard errors and confidence intervals
- Post-estimation sufficiency
- Model validation
- Automated control groups