Baselines: Fact or Fiction?

or the fable of the Banker and the Engineer

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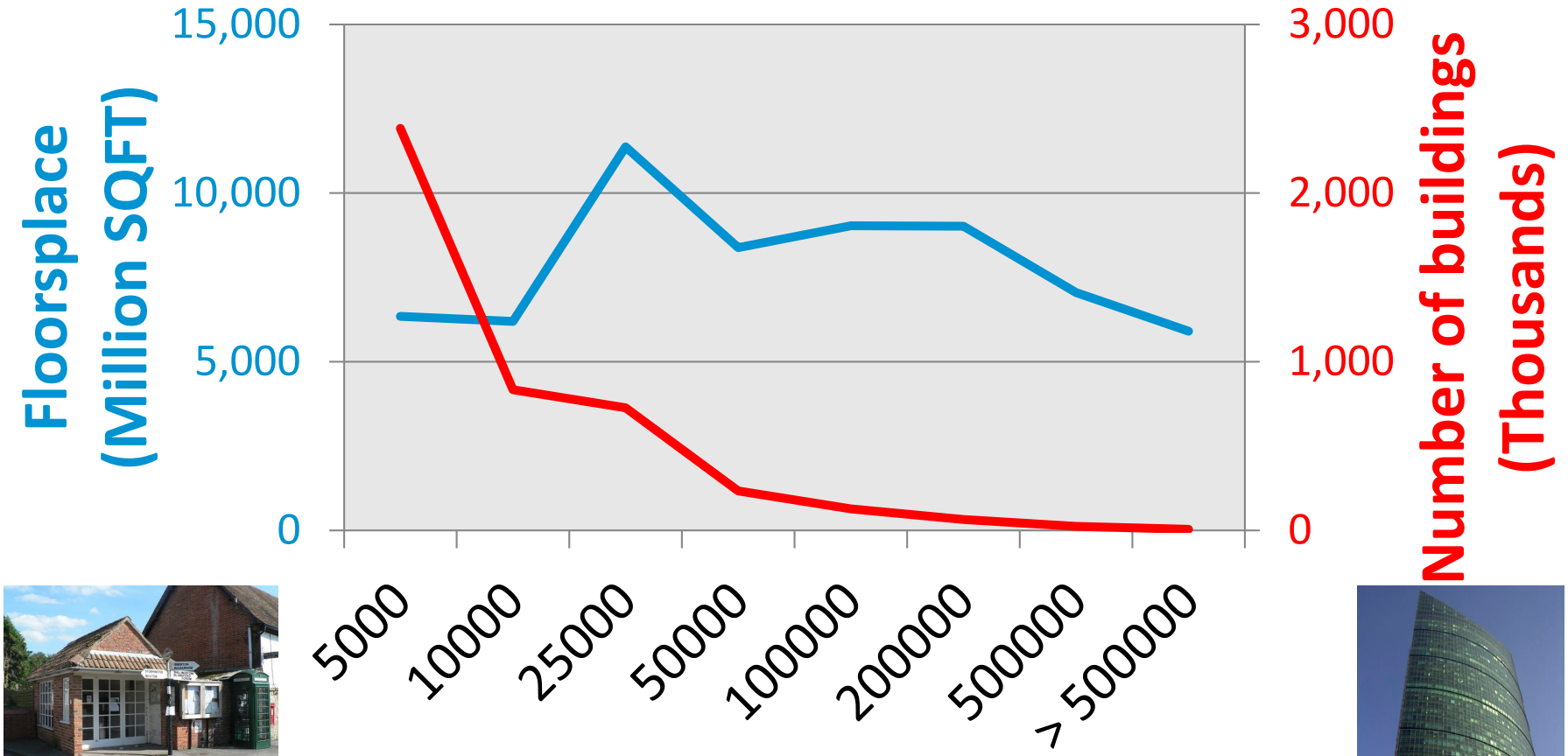
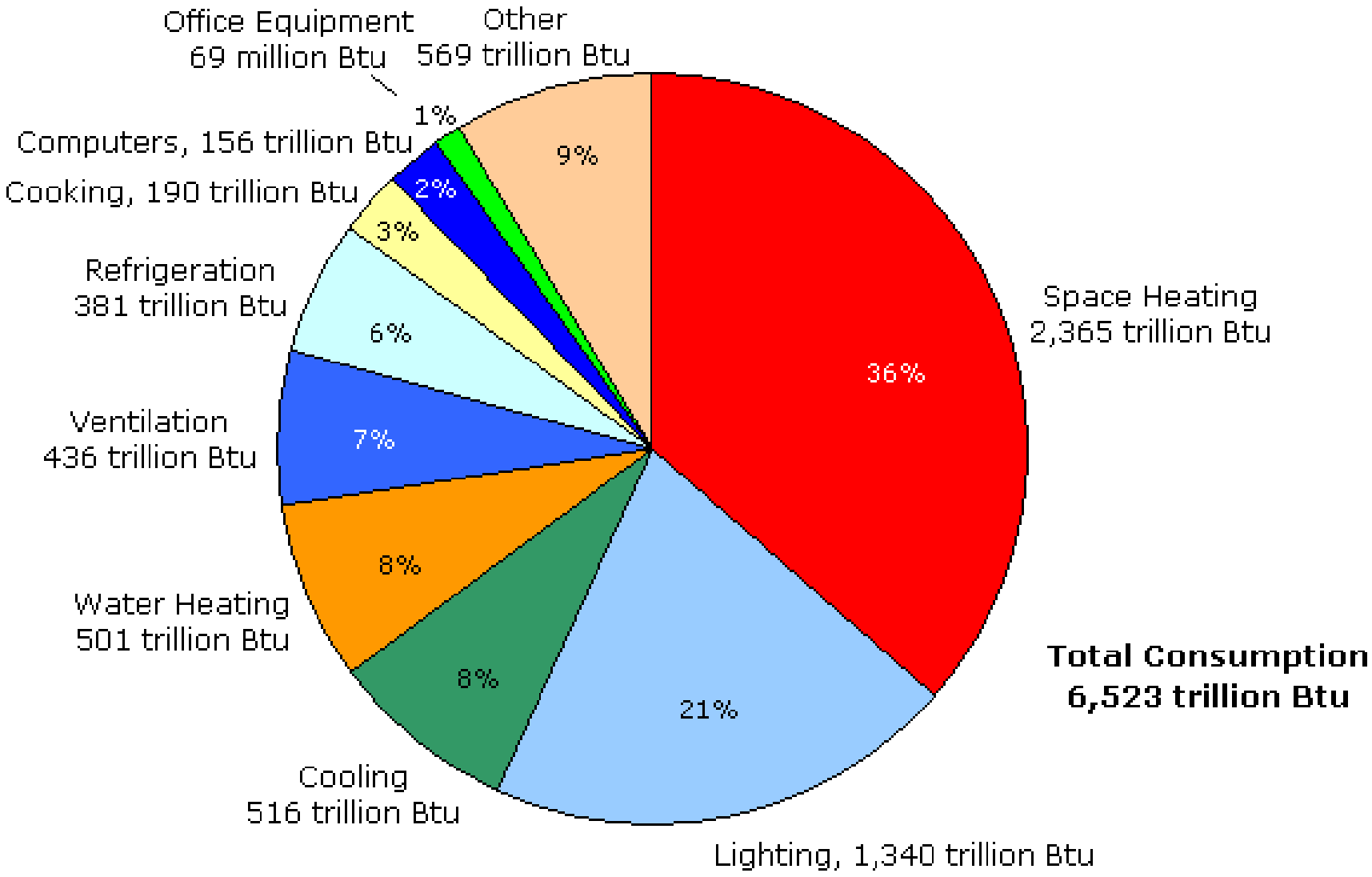
US building Stock: 80B sqft



- $15 Trillion in market value (Forbes 2012)
- Average Energy: $2.7 / sqft → $216 Billion in energy

To an ENGINEER,
this is how a building consumes:



To an OWNER,
this is how a building consumes:

Category (for an Office)	Cost
Fixed Costs	$ 3.71 / GSF
Utilities	$ 2.17 / GSF
Maintenance	$ 1.69 / GSF
Custodial	$ 1.33 / Cleanable SF
Environmental Health and Safety	$ 0.35 / GSF
Mail Services	$ 0.22 / GSF

Category	Income
Class A Office Rent (Seattle)	$ 31.44 / GSF
Asset Value (on balance sheet)	$ 524.00 / GSF
Revenue Value (Grocery Store)	$ 531.00 / GSF

Activity – your baselining exercises

- What was your metric?
- How will you keep track of it?
- What could ‘mess up’ your baseline?
- What is the level of effort to track it?
- Is your method / solution cost effective for the result you are getting?

What are some factors of your baseline?

- What were some common factors of your HW?

What were some of your baselining methods and challenges?

According to IPMVP

Savings =

+ Adjusted Baseline Energy

- Reporting Period Energy

+/- non-Routine Adjustments

Or:

Baseline - actual energy use +/- adjustments

We have to come up with an artificial boundary

Different Boundaries

- Option A: Retrofit Isolation: Key parameters
  (partial building, some data points)
- Option B: Retrofit Isolation: All parameters
  (partial Building, all data points)
- Option C: Whole Facility
  (whole building, output-driven)
- Option D: Calibrated Simulation
  (whole building, assumptions-driven)

According to IPMVP

Savings =

+ Adjusted Baseline Energy

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Or:

Baseline - actual energy use +/- adjustments

Devil's Advocate: If *someone* has to make a value judgement, how can we all agree?

Jimmy's Opinion

Energy savings do not exist.

It is a figment of engineering calculations.

You cannot *save* something you shouldn't have consumed in the first place.

What are some factors to baseline a building?

- 12 months history of energy consumption
- Operating hours
- Size of building
- Type of business
- Weather (Heating Degree Days / Cooling Degree Days)
- Location
- And others….

Run a linear regression

- $R^2 > 0.6$
- T-test > 2
- P-value < 0.005

A baseline can…

- … find outliers, do forensics and identify anomalies in historical data to ***inform*** future operations.

A baseline ***CANNOT***…

- … be used to ***predict*** the future behavior!

Uncertainty of predicting the future:

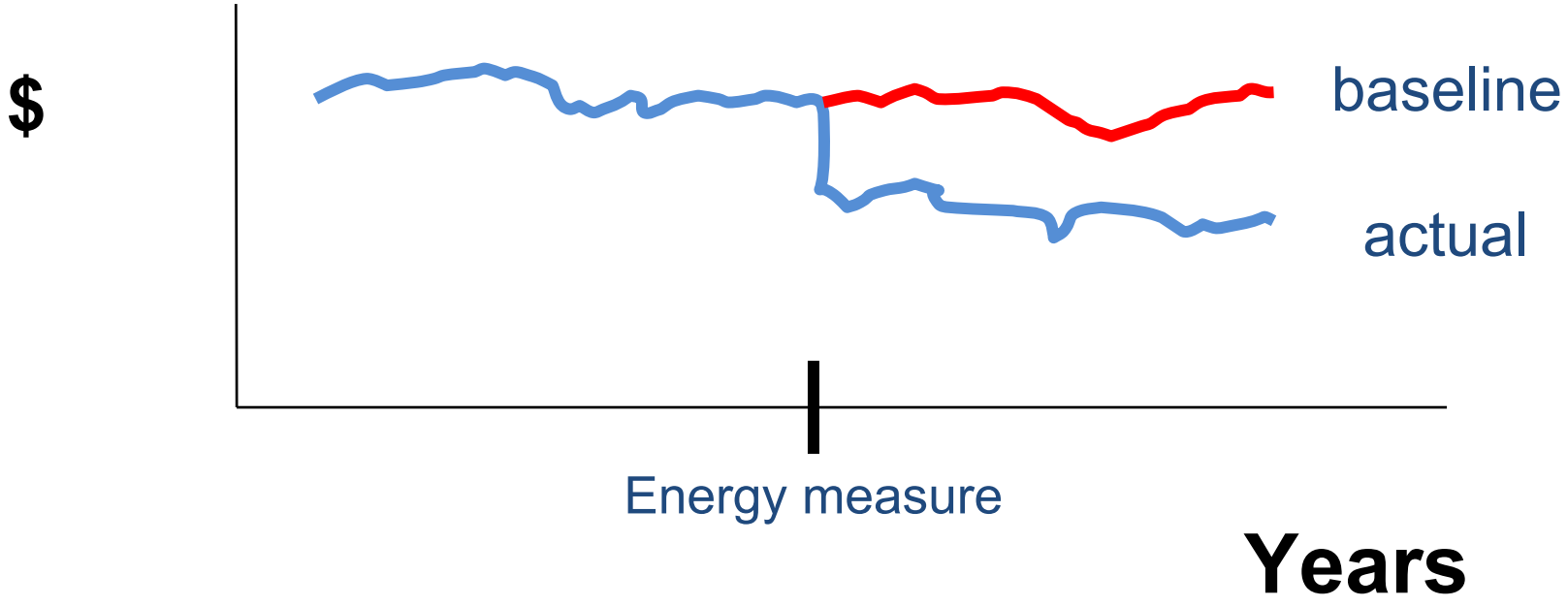
1) Do operational parameters stay static?

2) Can baselines predict what I *would have done* behaviors change (additionality problem)?

3) Are there factors outside of the model that may affect my consumption?

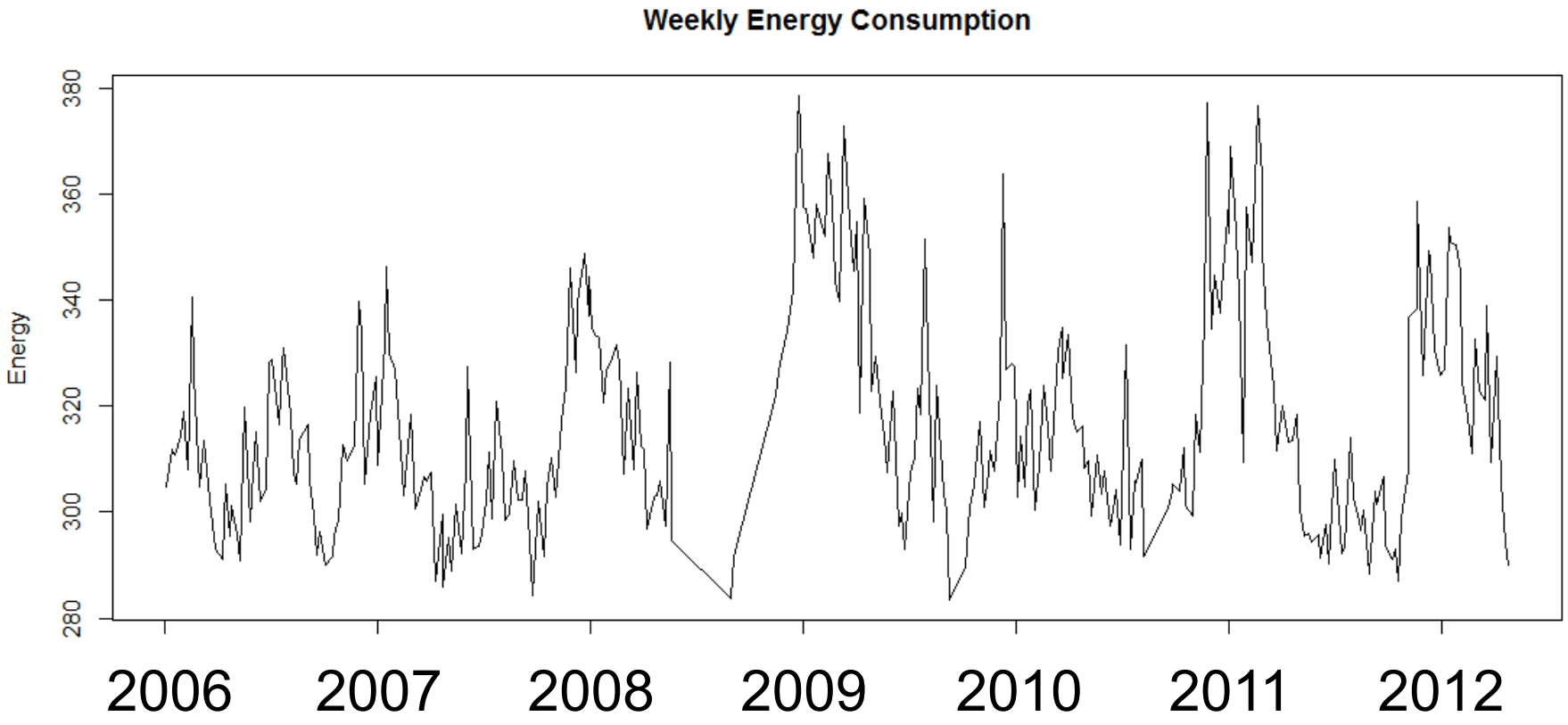
In the ideal world….

…we want a baseline to tell us how much we've ***saved***.



In the real world…

…what year did this client install LED lights?



Example: The Trend of LEED Buildings

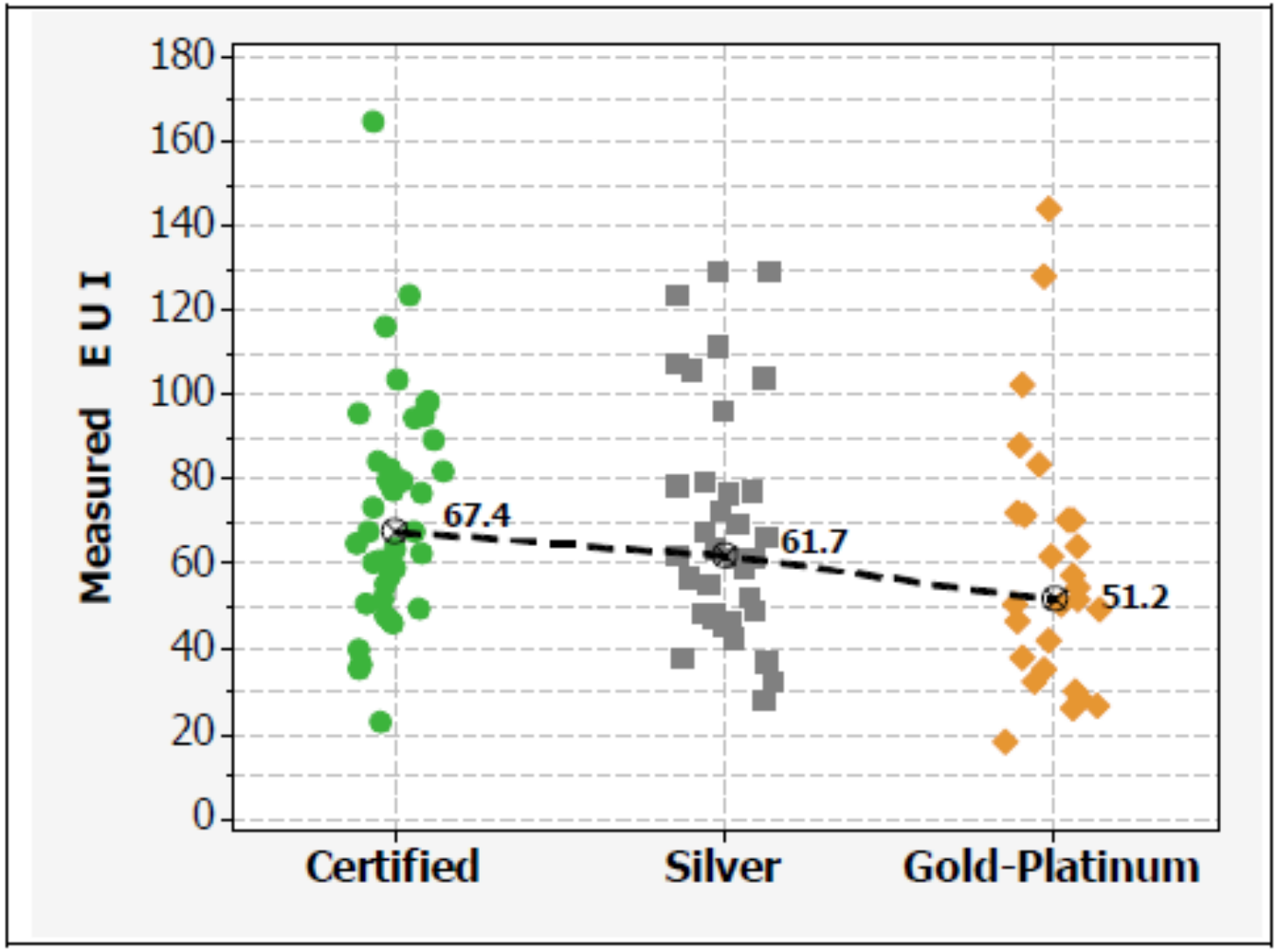
EUI = Energy use intensity; a measure of how much energy is consumed per square foot

LEED Certified:	67.4
LEED Silver:	61.7
LEED Gold-Platinum:	51.2

From Energy Performance of LEED® for New Construction buildings; New Buildings Institute, March 4, 2008

The ***noise*** is usually larger than the ***trend***

EUI = Energy use intensity; a measure of how much energy is consumed per square foot



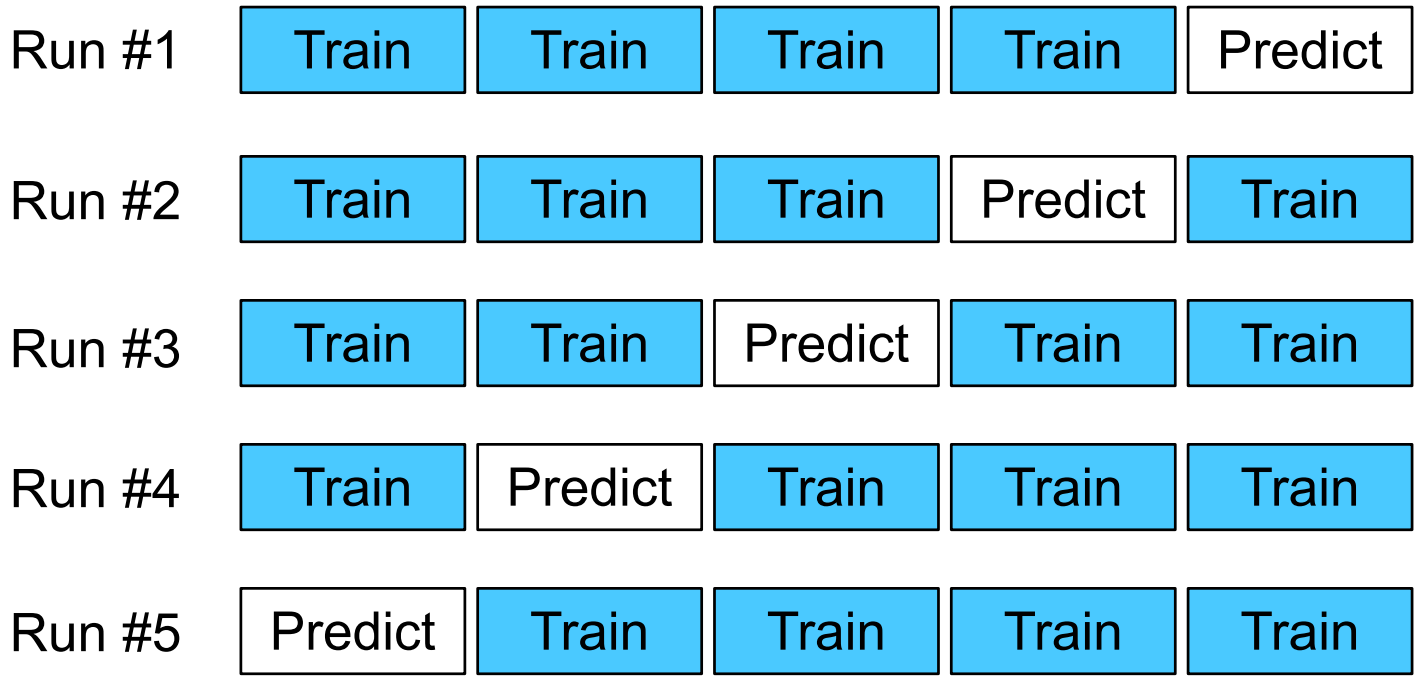
From Energy Performance of LEED® for New Construction buildings; New Buildings Institute, March 4, 2008

Lies, damn lies and statistics

The choice of Training Data for a linear regression is important!

'Good' models still have 20% error!

Energy analysis usually fails the 5-fold cross-validation test.



Model errors are getting better!

According to an LBNL study:

Day---time---temperature model,	3---5 %
LBNL model,	3---6 %
Pulse Adaptive Model,	4---6 %
Mean---week model,	3---7 %
Change---point model,	5---7 %
DEM models	3---8 %

Note: NONE of these are linear regressions!

J. Granderson; *Evaluation of the Predictive Accuracy of Five Whole-Building Baseline Models* May 2012

The problem with baselines

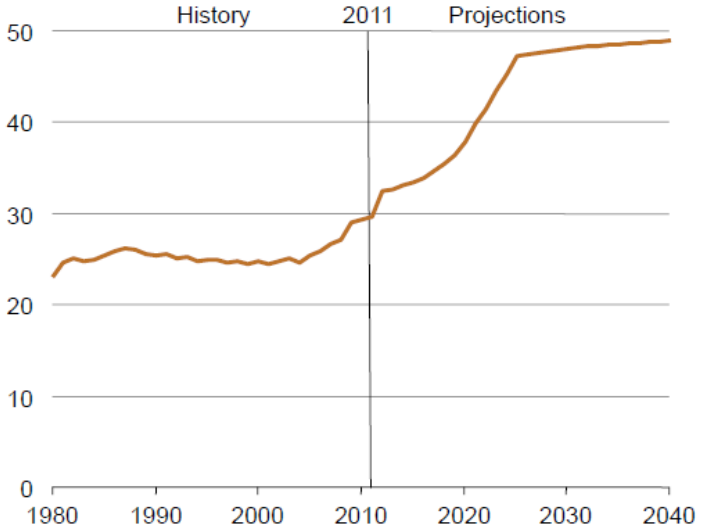
They are a comparison to something that ***no longer exist*.**

Because baseline projections are, ***predictions.***

Very few people remember to care about the ***variance.***

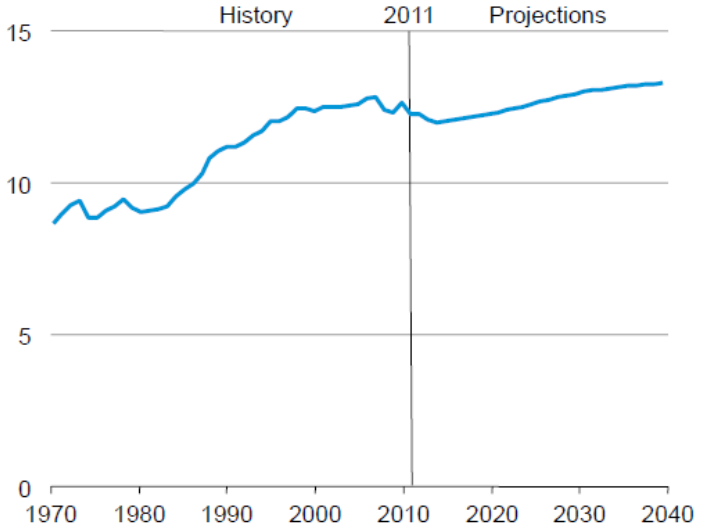
CAFE and greenhouse gas emissions standards boost light-duty vehicle fuel economy

Figure 71. Average fuel economy of new light-duty vehicles, 1980-2040 (miles per gallon, CAFE compliance values)



Travel demand for personal vehicles continues to grow, but more slowly than in the past

Figure 72. Vehicle miles traveled per licensed driver, 1970-2040 (thousand miles)

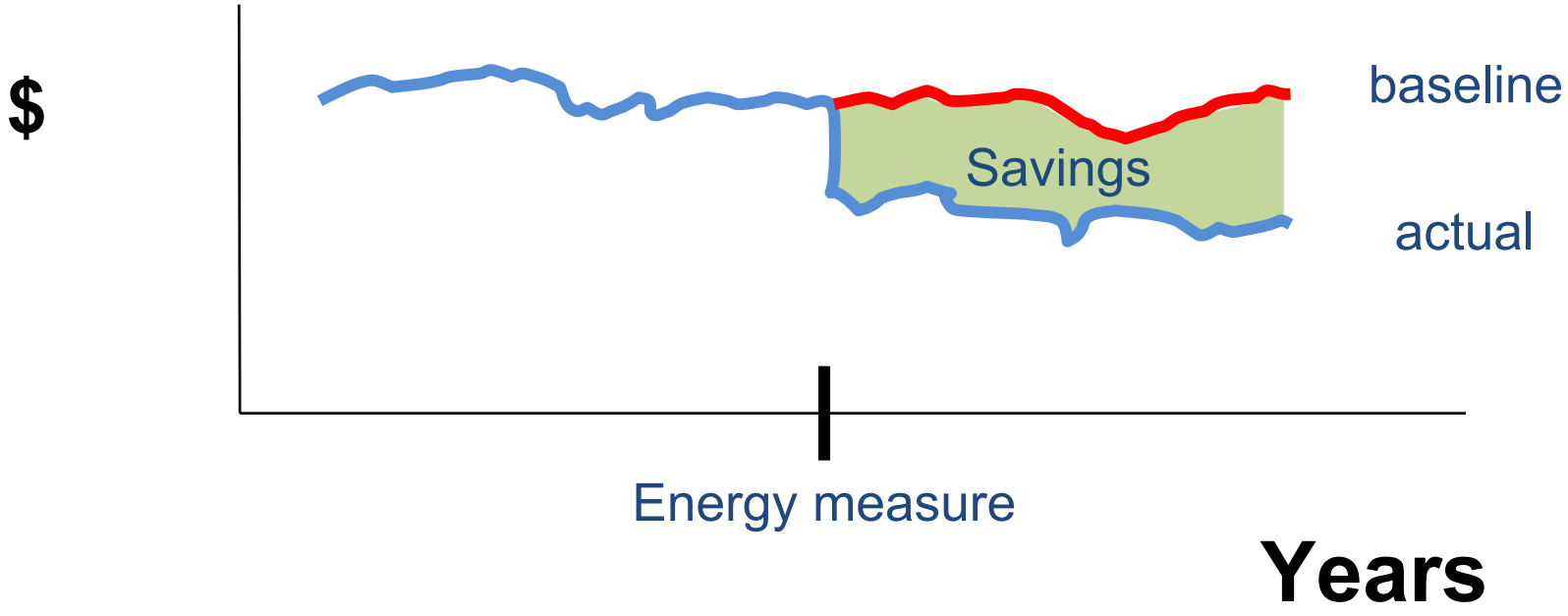


How to deal with the uncertainty

The ***uncertainty*** of the savings makes it difficult to finance

Because finance is about ***risk mitigation***

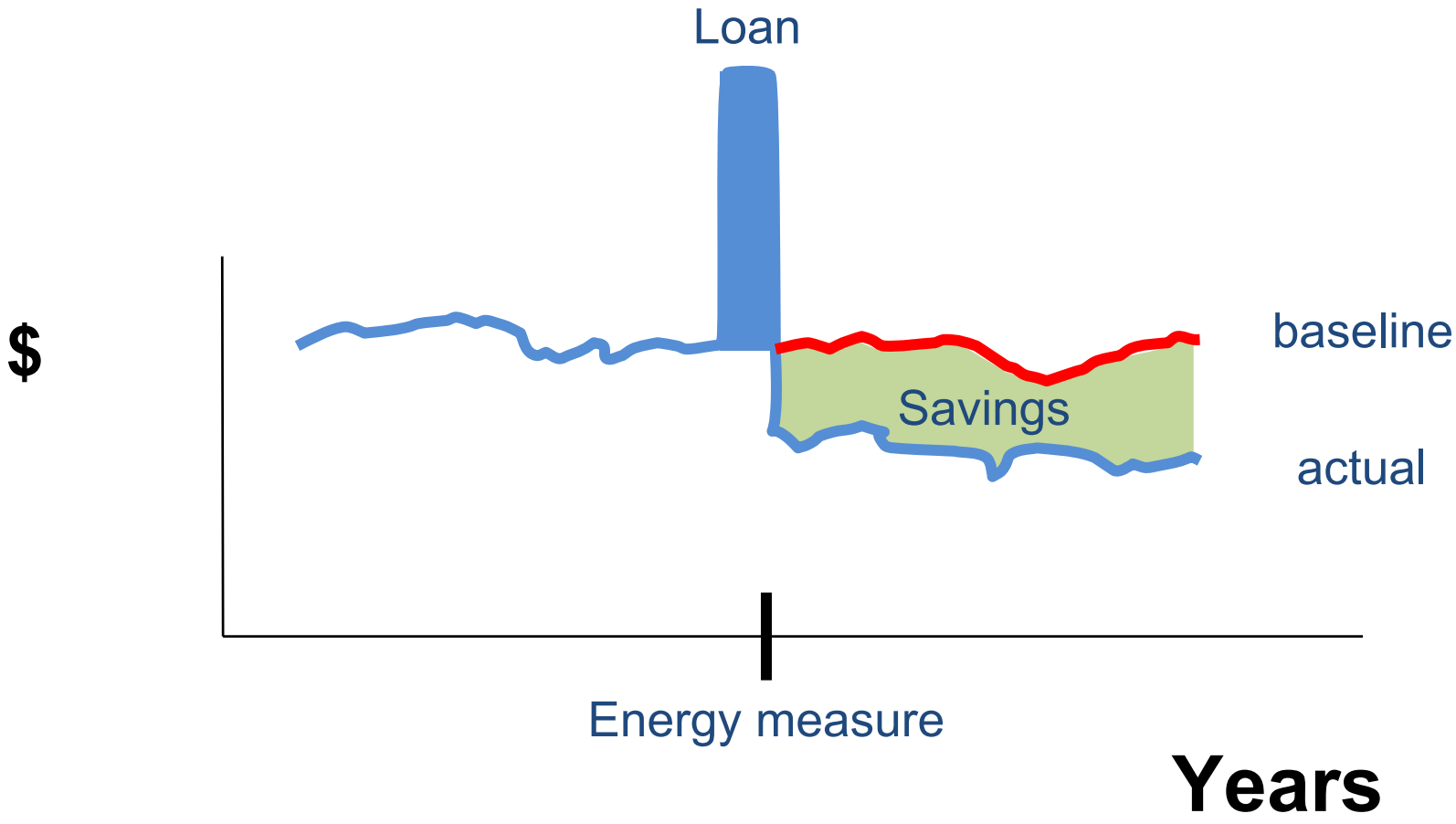
Most (all) efficiency financing tries to address this risk.



Direct Loan

Client takes out a loan and repays loan through revenue

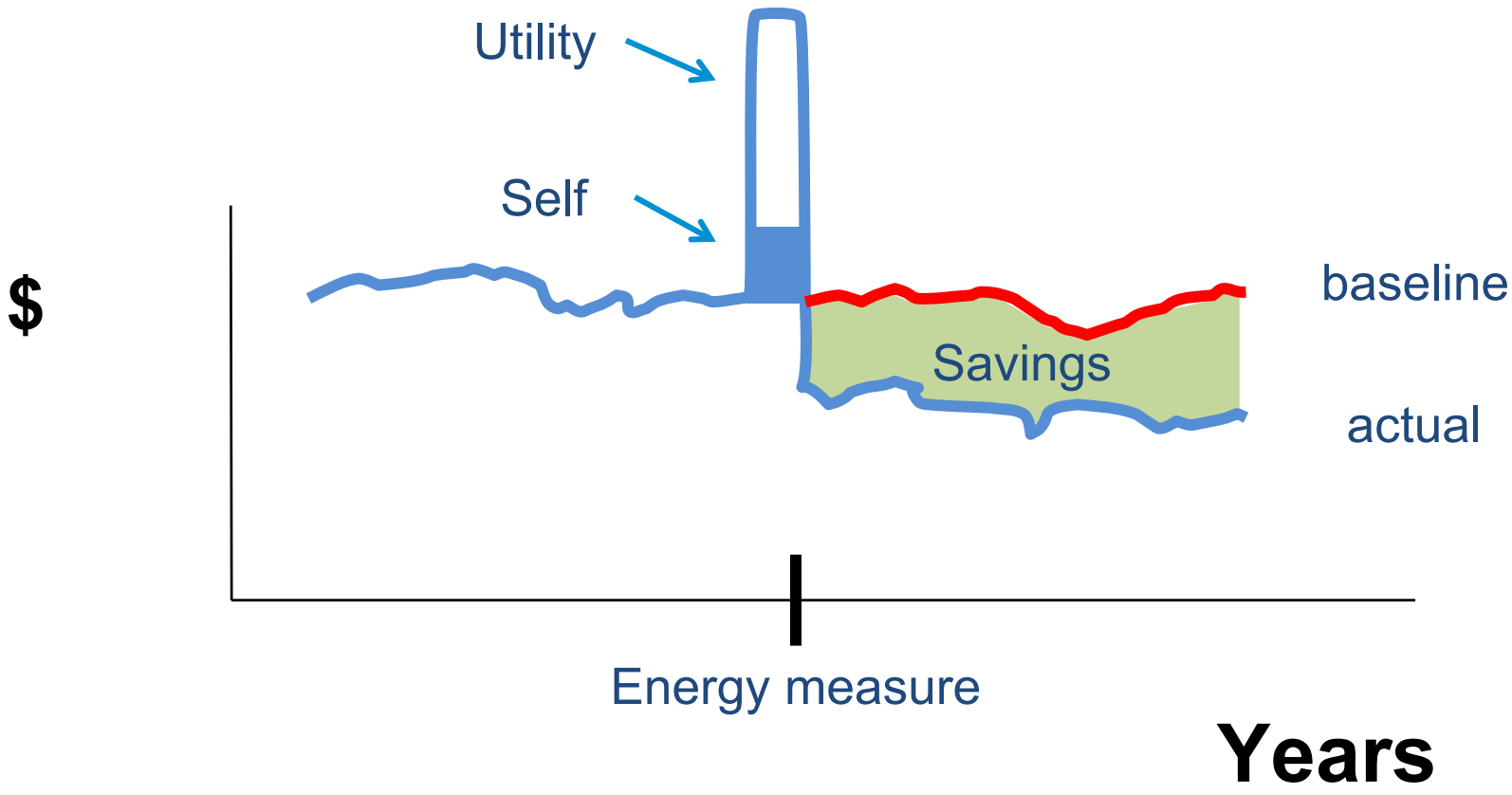
Customer holds risk of non-performance



Utility Incentive

Utility pays up to 70% of a project's costs

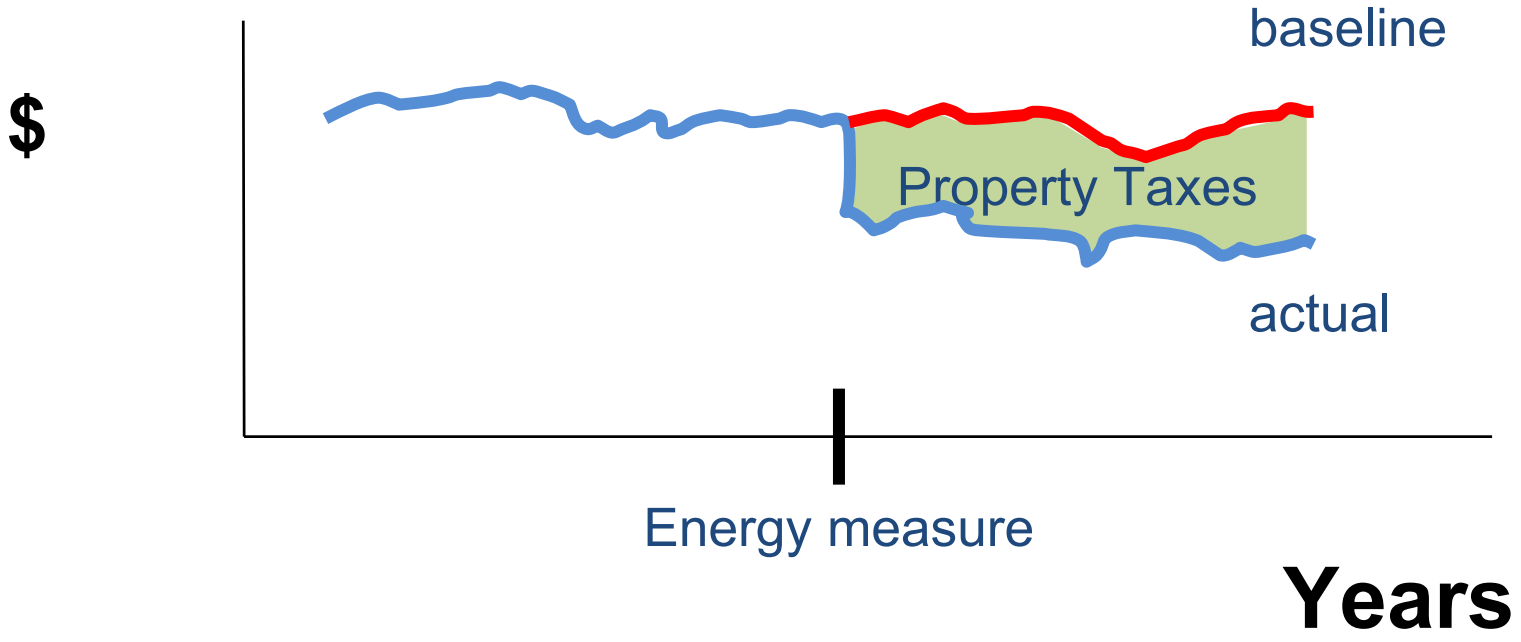
Ratepayers holds risk of non-performance



Property Assessed Clean Energy (PACE)

A government-backed loan
Customer installs new equipment at no charge
Customer repays loan via an increase in their property taxes
for 20-25 years

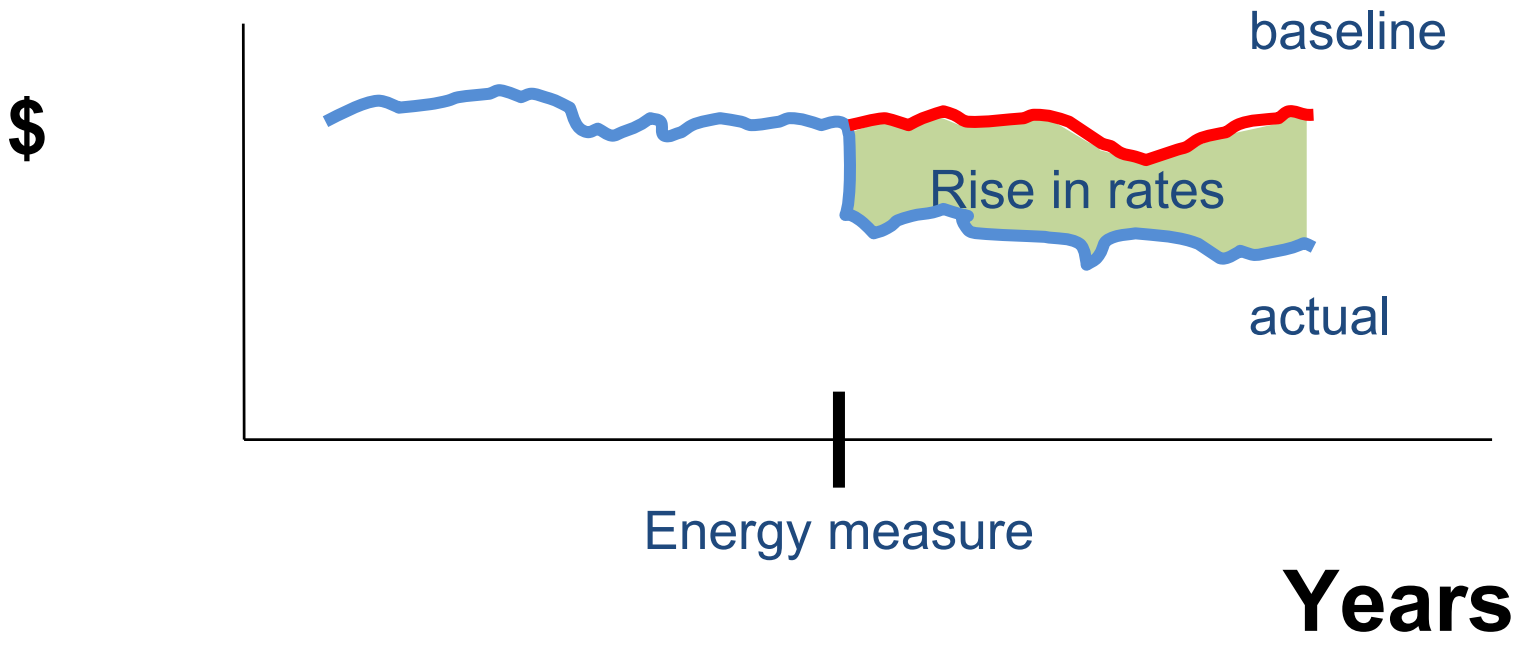
Taxpayers holds risk of non-performance



On-bill Financing and on-bill Re-financing

A utility-backed loan
Customer installs new equipment at no charge
Customer repays loan via an increase in their utility rates for 20 years

Customer holds risk of non-performance

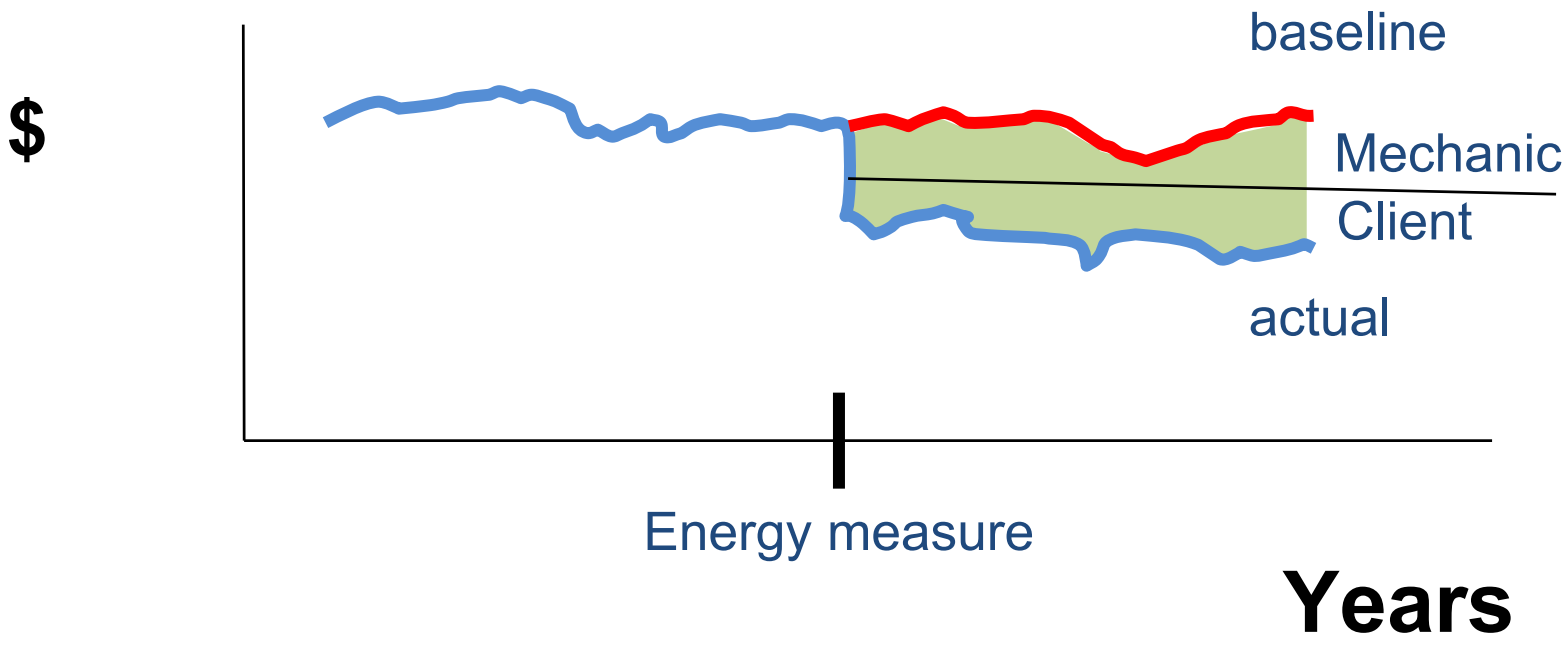


Energy Savings Contract (ESCO)

Mechanic guarantees savings and is paid a % of savings for many years

No up-front cost for client

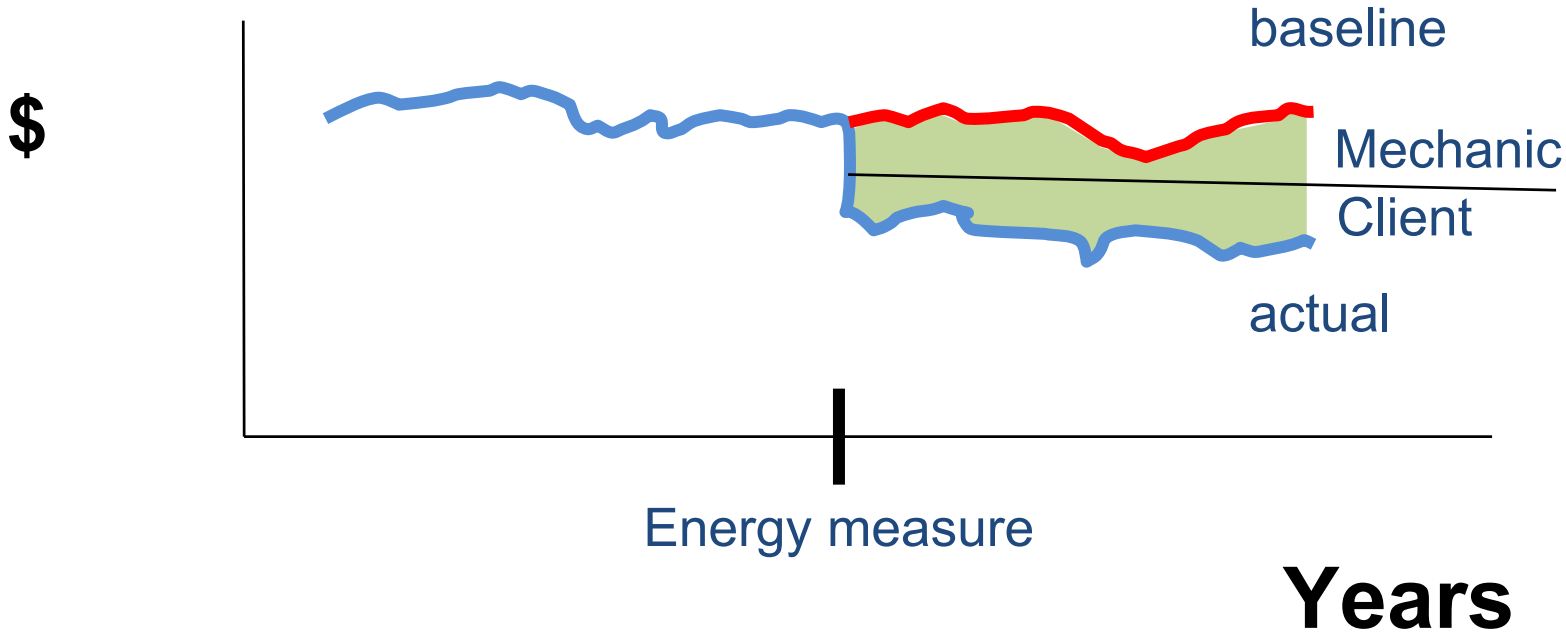
Client does not have to hold debt on the balance sheet



Energy Savings Contract (ESCO)

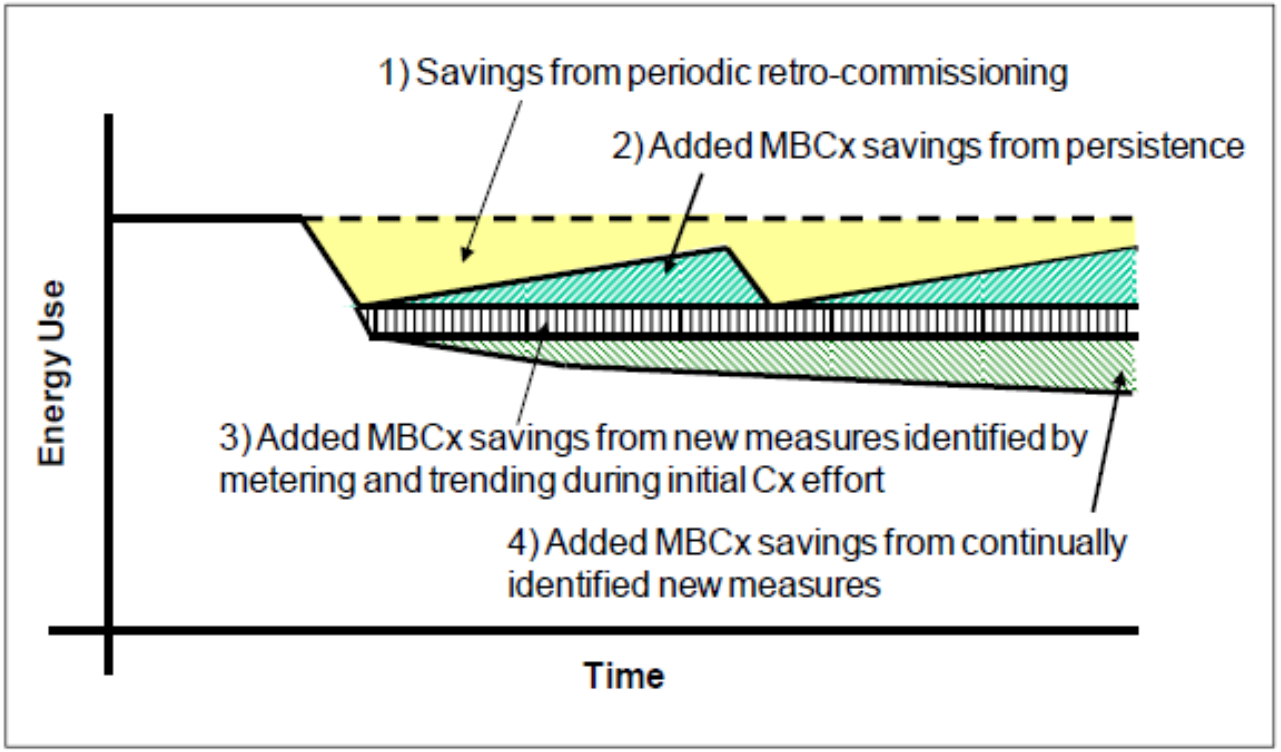
ESA: Mechanic tells you that you have now saved $100,000 per year.
Client pays utility and pays mechanic
Client holds risk of non-performance

MESA: Client pays the mechanic for all energy costs, including bills.
Mechanic/Financier holds risk of non-performance



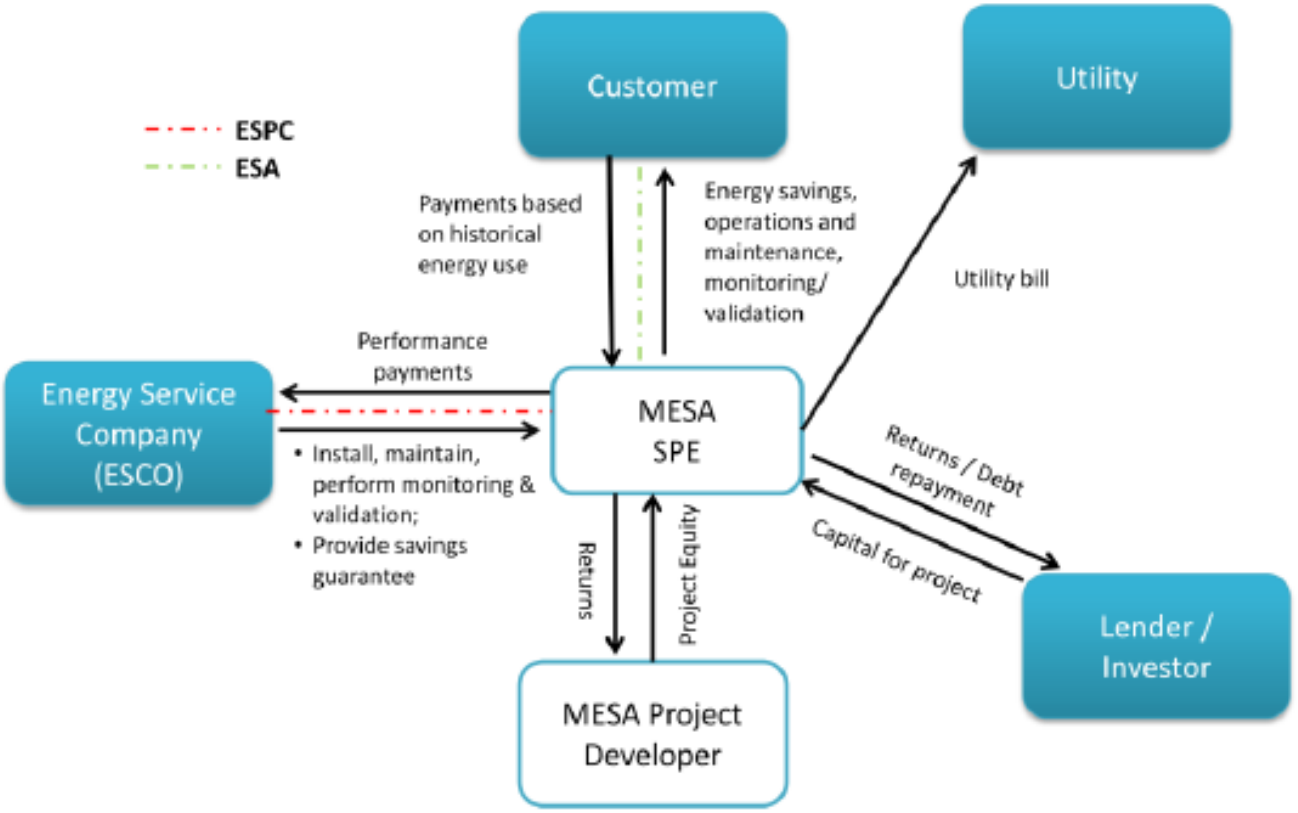
Persistence of savings

Some data suggests that a building ‘drifts’ upwards in energy consumption over 5-years. In other words, energy efficiency gains are eroded over time. Under the above models, who holds the risk that a building ‘drifts’?



Financial Structure Complexity

The financial structure for a MESA project can seem confusing to non-experts. Billions of dollars of capital is available. Why is energy efficiency financing adoption so low?



Charlotte Kim et. al., ***Innovations and Opportunities in Energy Efficiency Finance.*** **WSGR May 2012**

The banker and the engineer:

The engineer designs models that ***estimates*** how much energy you saved based on ***known factors***.

The banker wants ***guarantees*** of getting their money back by mitigating risks of ***unknown factors***.

One is unabashedly theoretical.

The other is viciously real.

Who wins the race?

Instead of looking at Savings…

- Look at productivity.
  - Can I be more productive with the unit of energy I'm consuming?
  - If yes, I should produce more.
  - If no, I should reduce energy consumed to maximize production.
- This approach to efficiency is more appealing to CFOs and managers.
  - Because it's not efficiency at all!

Thank You