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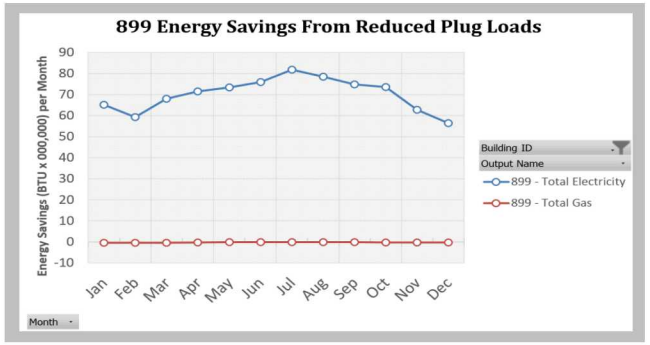

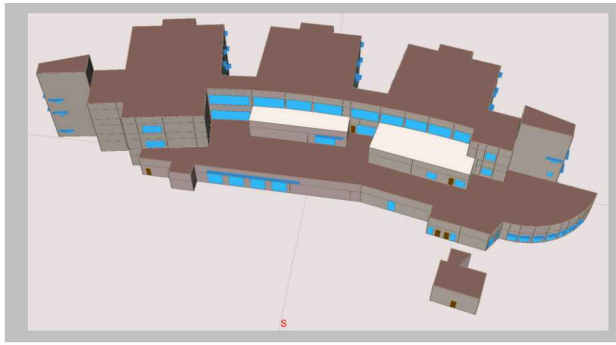

Bottom up sustainability through Institutional Transformation

Daniel Villa

This presentation is reviewed and approved for unlimited release per SAND2017-XXXX

U.S. DEPARTMENT OF ENERGY
NNSA National Nuclear Security Administration

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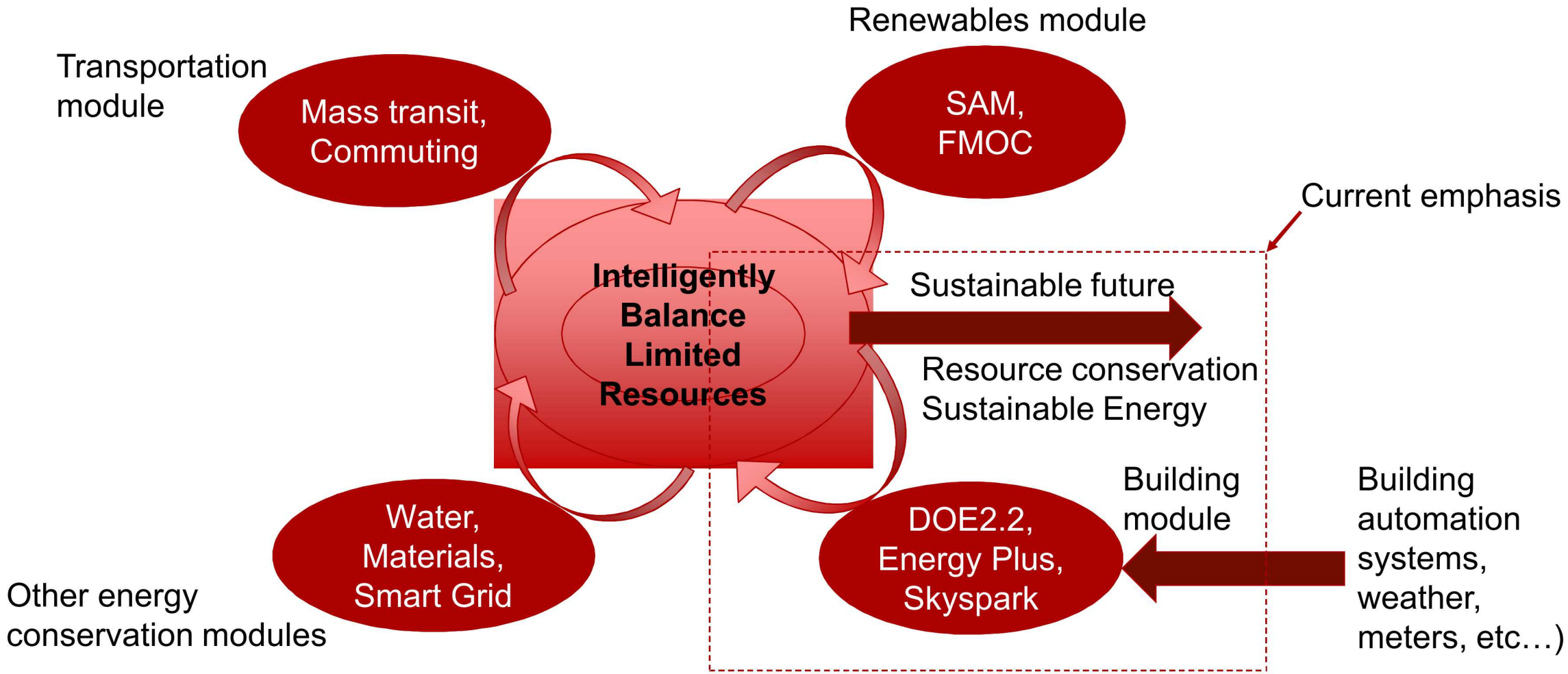
Introduction

- Hypothesis: Sustainability is best approached from the bottom-up to quantify confidence
- One bottom up approach that may offer the most return for sustainability is practical systems integration with underlying models that continuously feedback with each other.
  - The models must be setup to undergo continuous verification and validation to provide a deeper look into the optimal next step
  - A tightly integrated data/modeling system will help move toward learning whether our sustainability decisions were useful
- This is the approach of the Institutional Transformation (IX) project at Sandia National Laboratories

Vision

Sustainability through institution-wide interconnected data and modeling systems



Goals to realize the IX vision

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- Provide energy conservation measure (ECM) and renewable energy assessments that provide tradeoffs between competing scenarios
- 100% synchronization between energy models and energy policy. This would allow model/data analytics to quickly capture violations of energy policy
- 100% automated calibration between BAS data and model outputs
- Apply automated processes that isolate root causes of inefficiencies
- Provide higher fidelity databases to validate urban scale modeling efforts
- Provide resources to move building-by-building research efforts to institution-wide analyses

Modeling institutional evolution

Past site

2015 2016

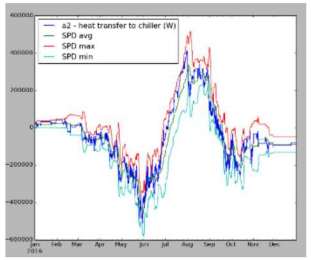
Present

2017

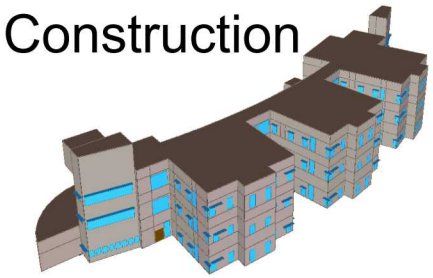
Future site

2018 2019

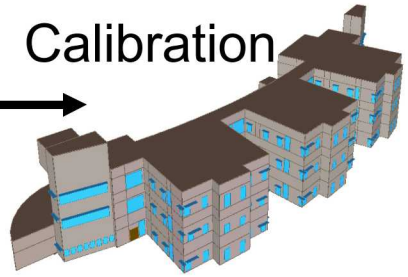
Historical data



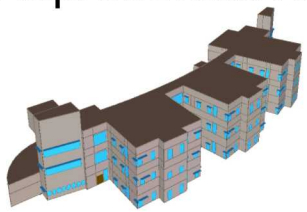
Construction



Calibration

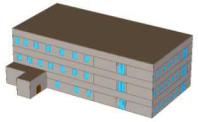


Future Representative

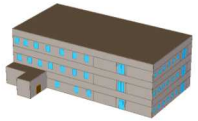


Assess site-wide energy future plan

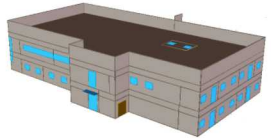
ECMs Evaluated no changes



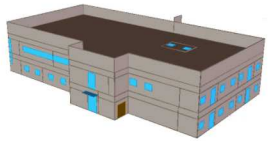
Recalibrate model



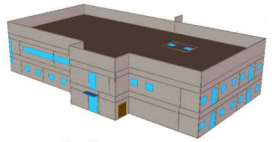
ECM Planned



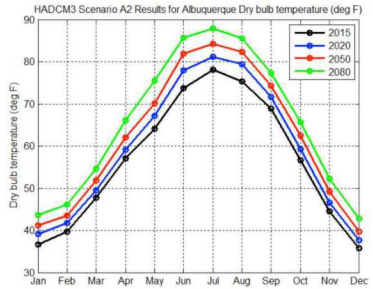
ECM Applied



Updated Model with ECM



Climate change projections



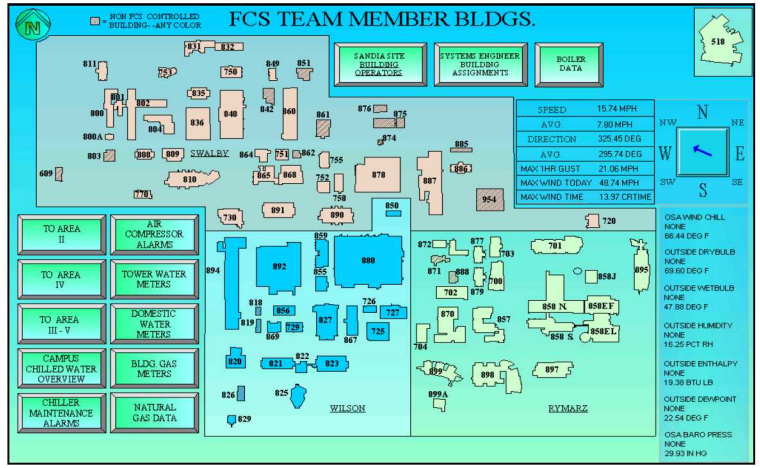
Demolition

All figures rendered in eQUEST 3.65

100-1000's of Models

+

100,000-1,000,000's of data streams



+ **Algorithms /Software**

```
   CurChar = Mid(CurCharBlock, BlockPos, 1)
' Mode 1 - move through delimiters
   ' Now check our state
   If InDelimit Then
        InDelimit = False ' This will be undone if CurChar is a delimiter
        LastWasPeriod = False 'undone later if it turns out this is true
        LastWasNewLine = False 'undone later if it turns out this is true
        Select Case CurChar
          Case vbCr, vbLf, " ", "=", ","
              InDelimit = True
              If CurChar = vbCr Or CurChar = vbLf Then
                 LastWasNewLine = True
              End If
          Case """"
             InQuotes = True
             WordStart = BlockPos
          Case "("
             If Not CurlyAndParenthesisDoNotApply Then
               InParenthesis = True
             End If
             WordStart = BlockPos
          Case "*"
             InStars = True
             WordStart = BlockPos
          Case "$"
             InComment = True
             Select Case PrevChar
                Case vbCr, vbLf
                    LastWasNewLine = True ' This means that the comment lasts the entir
```

Class Modules
- clsBuildingFile_shared
- clsBuildingInformation_shared

= Potential to fulfill IX vision

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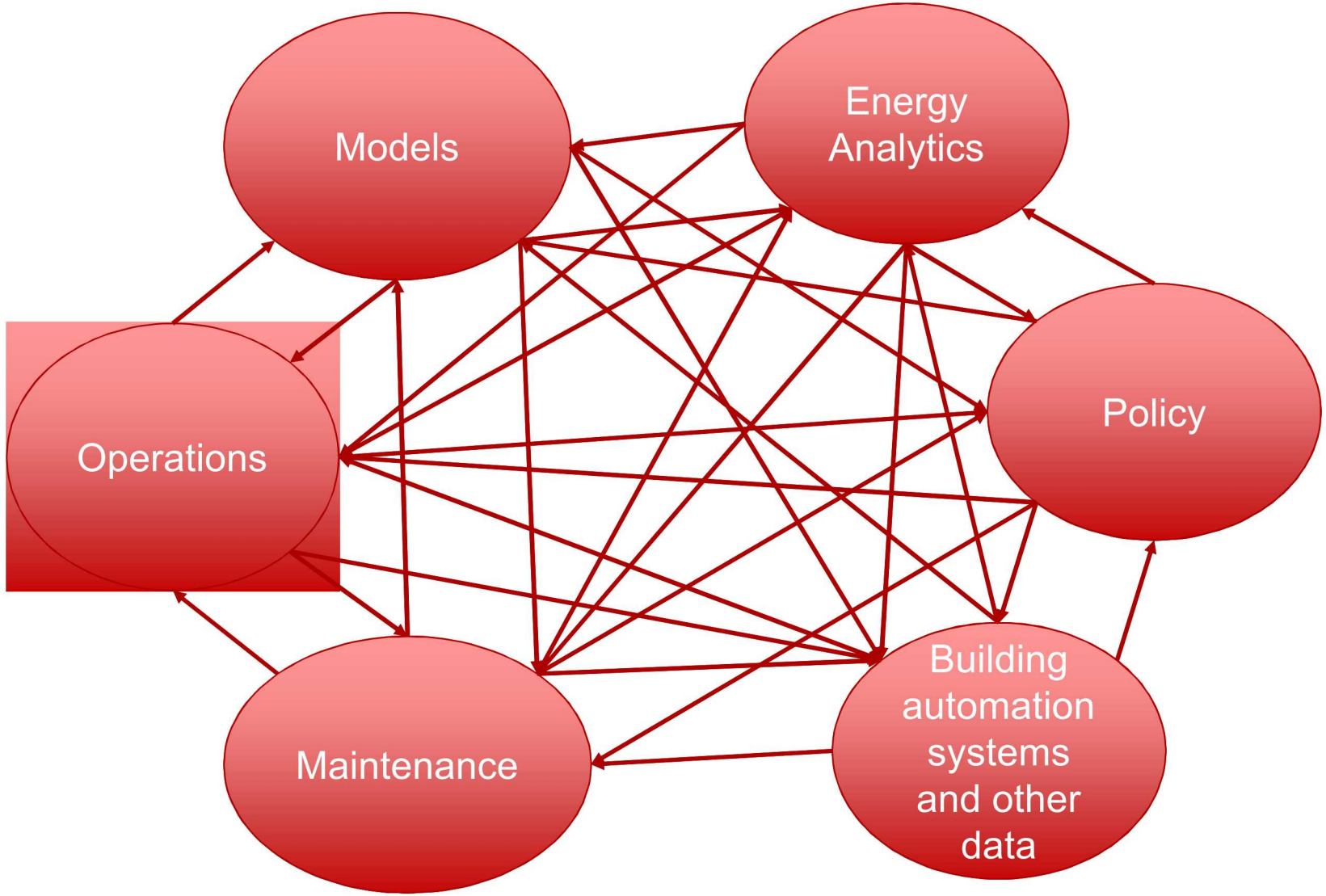
Challenges

Should everything talk to everything?



Priorities

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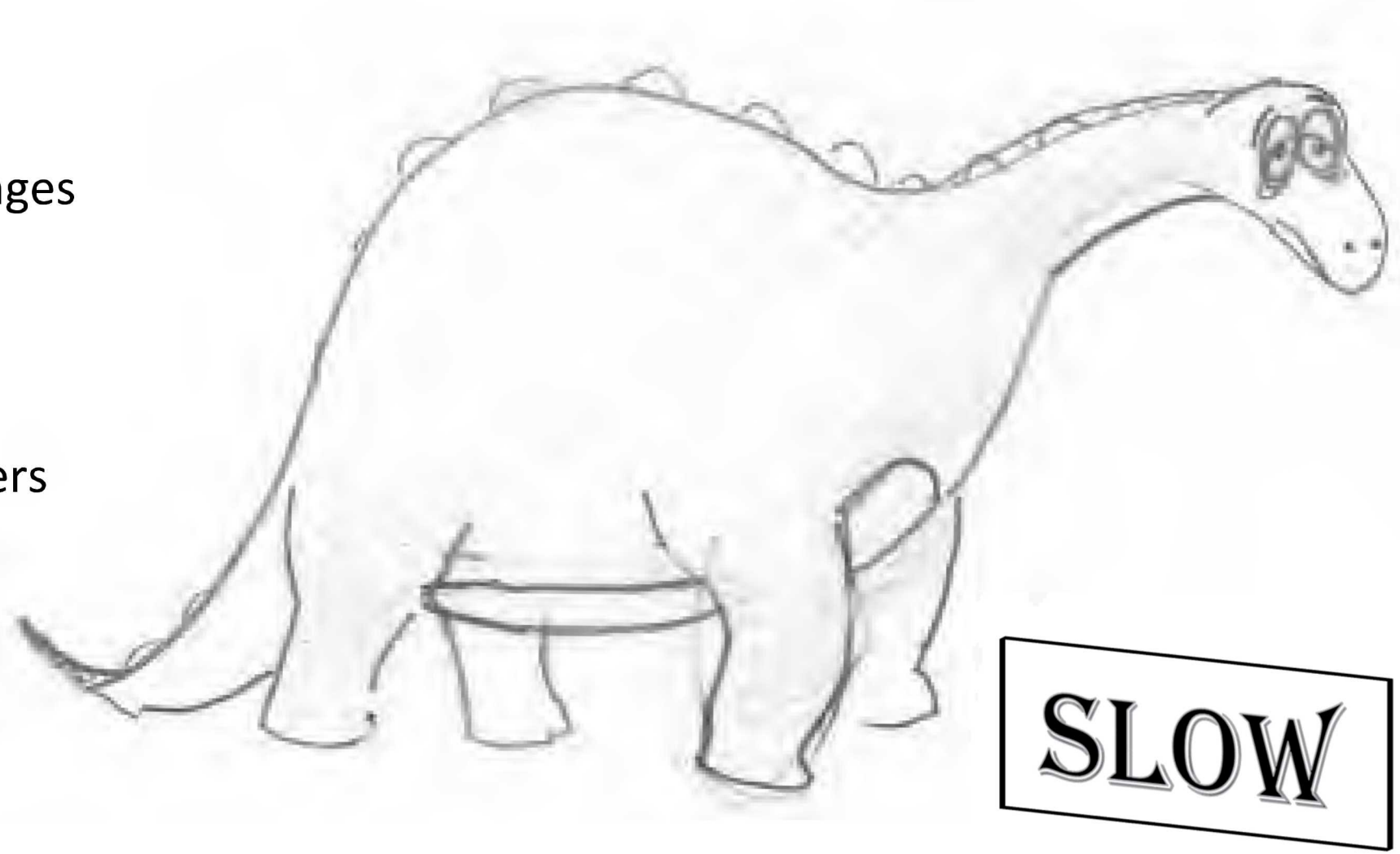
Energy is #4

1. Safety
2. Security
3. Productivity/Cost
4. Energy

Model synchronization with reality

- Schedules
- As-built and retrofit changes
- Equipment degradation/failure
- Model assumptions
- 1000’s of input parameters



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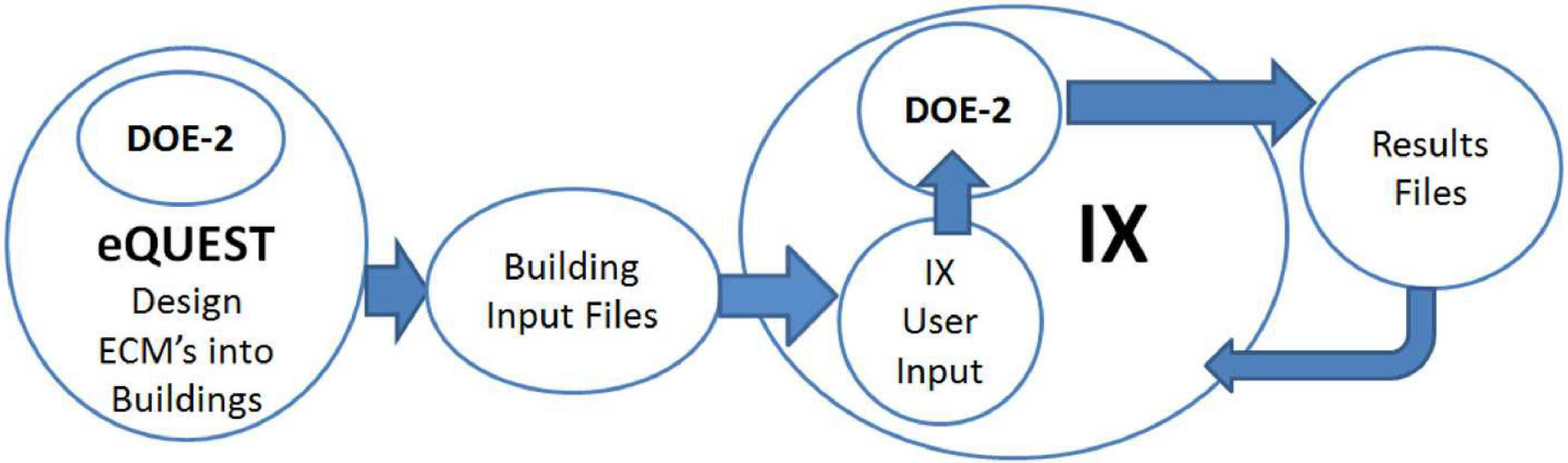
Accomplishments

What is the IX building module?

- The IX building module is a combined Microsoft Excel/Access® application with DOE-2 as a BEM runtime engine. It allows an arbitrary set of BEM's to be coordinated in scenarios that combine ECM's into the future.
- IX assumes that models are created in another tool such as eQUEST.
- Work is being done to combine this tool with real time data from our energy analytics database that is still underdevelopment.



Current Implementation

- IX building module 2.5 delivered in 2015. 2.6 is under creation and expected to be finished in early 2018.
- 121 BEM in California and New Mexico (120 DOE2.2 models and 1 E+ model)
- Manual creation and calibration of each model
- Script to connect BEM into centralized chilling loops
- Sky-spark energy analytics database connections to continuously inform models with weather data is in progress

Building 6585 eQuest Model

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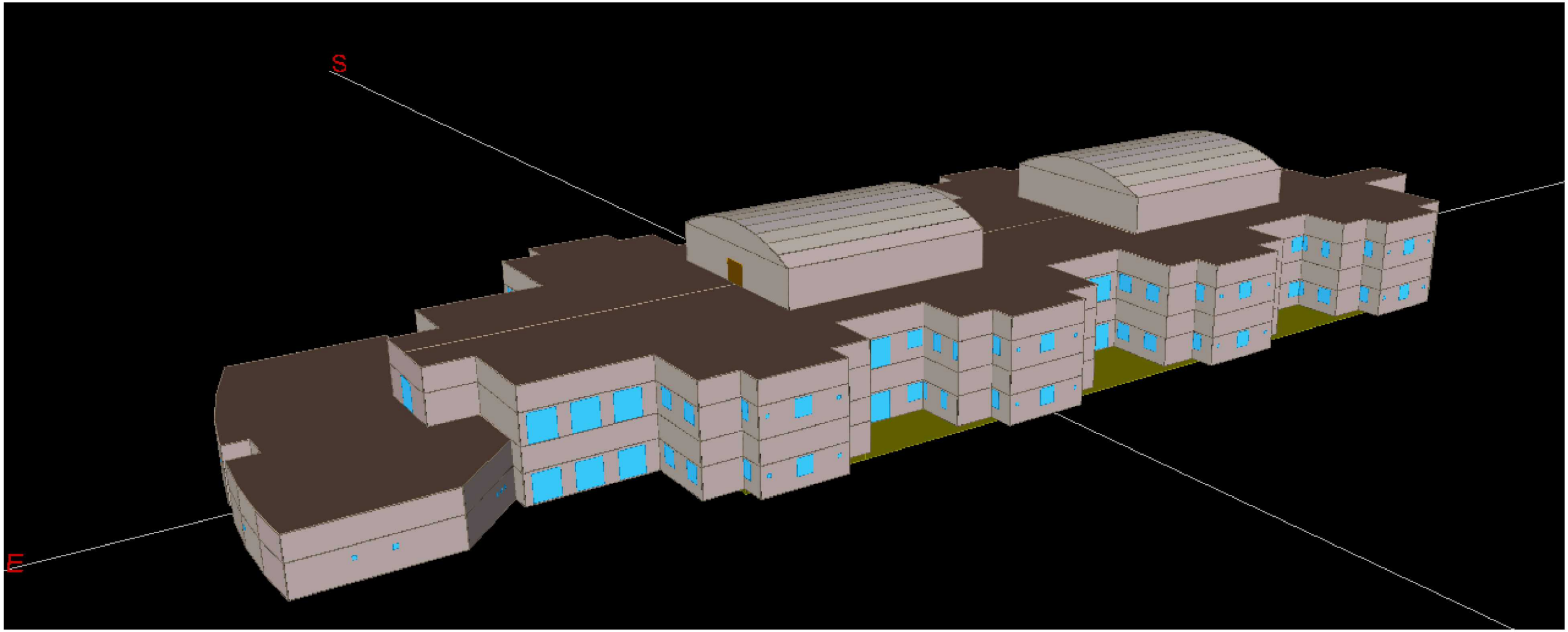
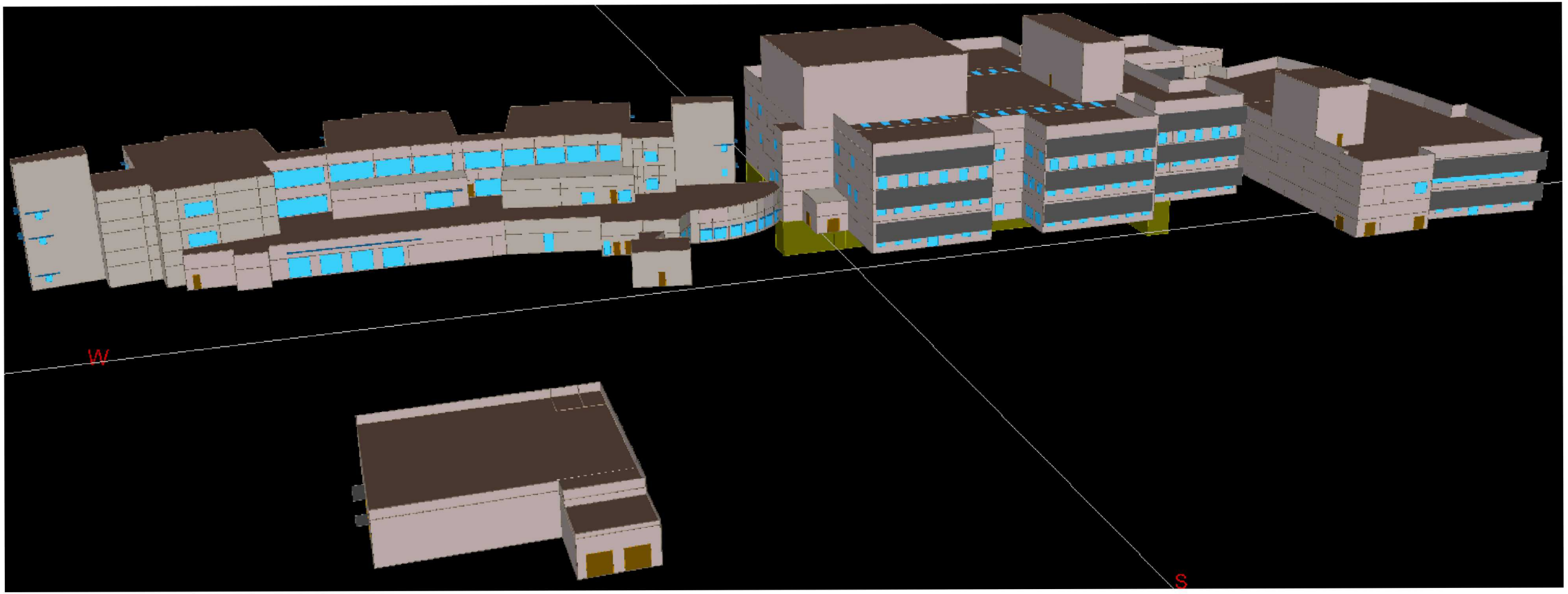
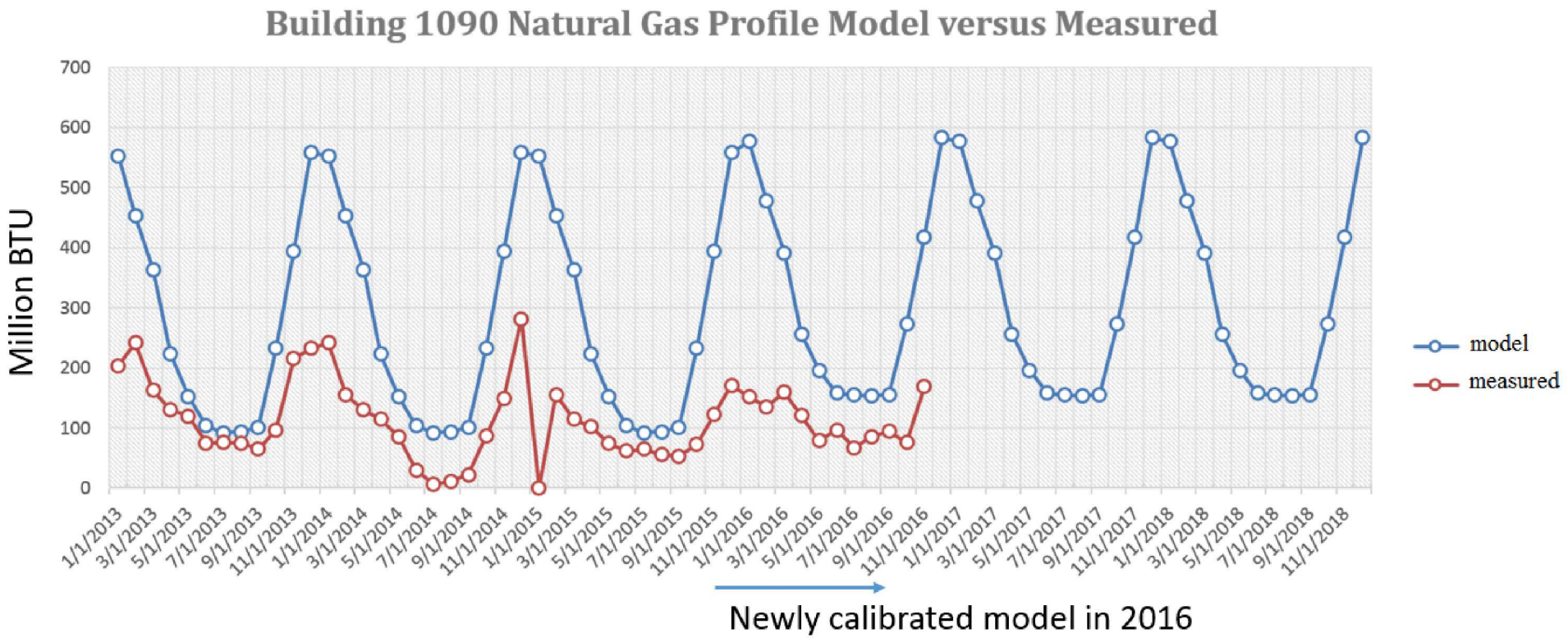


Buildings 899A, 899, & 898 eQuest Models



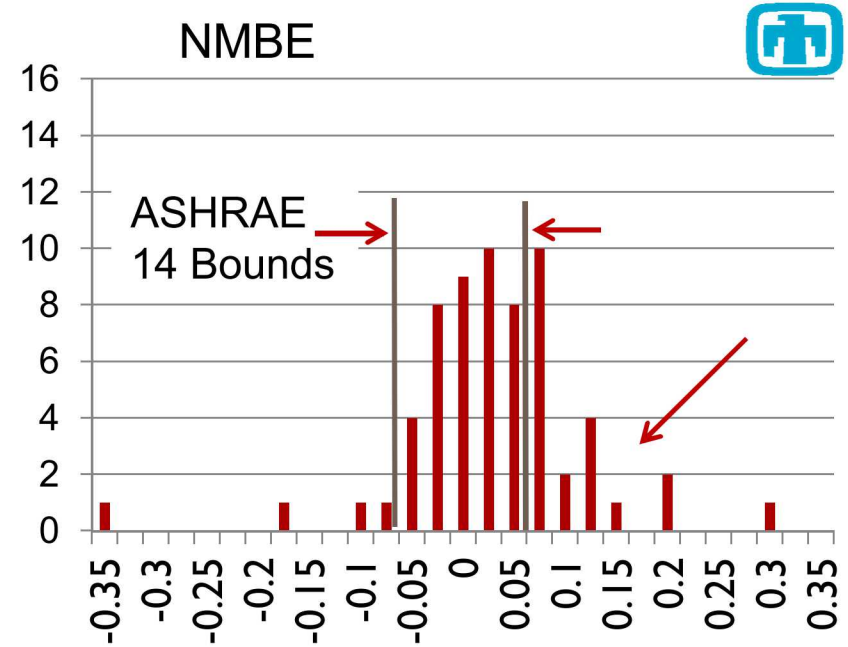
Problems (1)

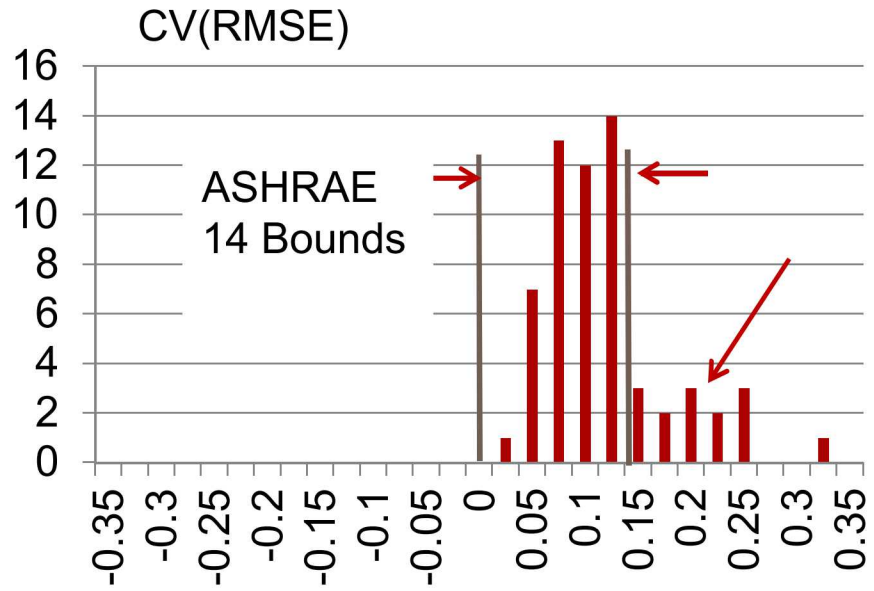
- Unreliable data: natural gas metering



Problems (2)

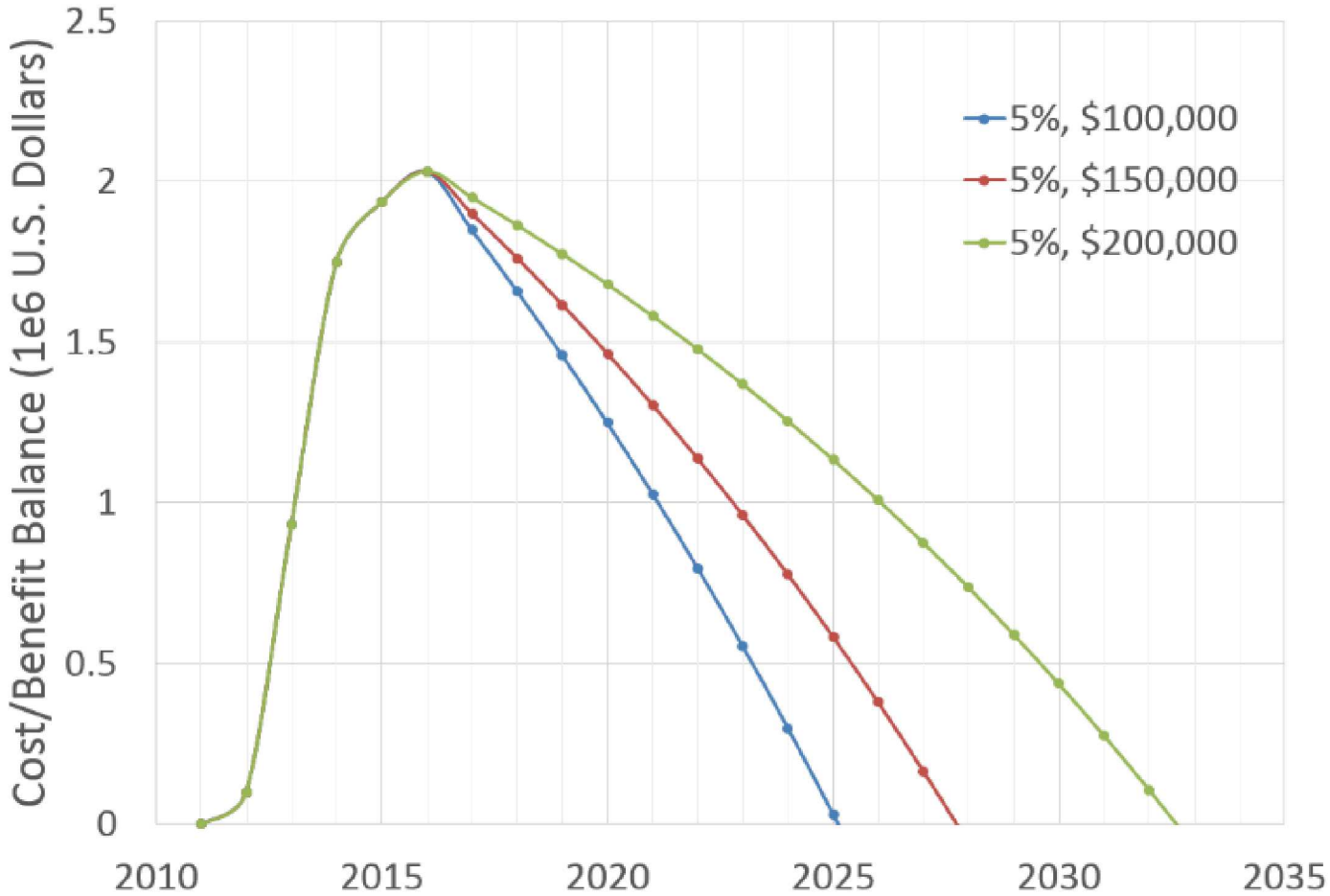
- Unreliable models
  - 51 yet to be calibrated due to lack of data
  - Of 69 evaluated
    - 54% meet |NMBE|<5%
    - 79% meet CV(RMSE) < 15
    - 31% meet ASHRAE Guideline 14
  - No way to assess confidence interval in energy savings predicted
  - No comparison made for natural gas





Problems (3)

- All of this is expensive to build and maintain!



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Now to the positive results …

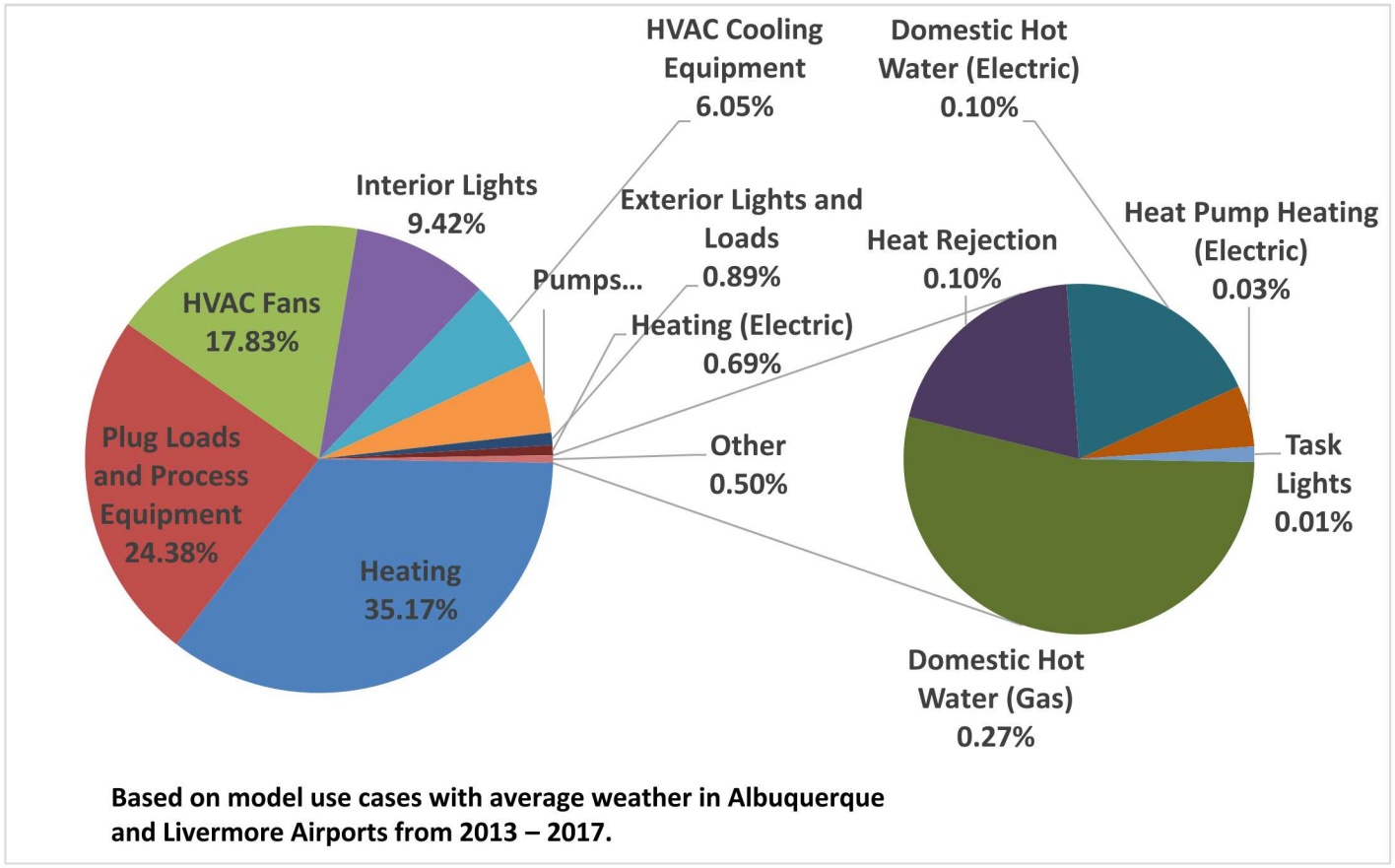
Use of IX

- Site-wide energy savings potential assessments from 2013 to the present
  - Insulation
  - Cool roofs
  - Thermo-stat Management (Lab and Office)
  - Supply air temperature resets
  - Fan Schedules (Lab and Office)
  - Chilled water/hot water resets
  - Lab exhaust ventilation
  - Lighting efficiency
  - Eliminating unnecessary 24/7 operations
  - Evaporative cooling
  - Chillers (central and local)
  - Boilers (local)
  - Climate Change

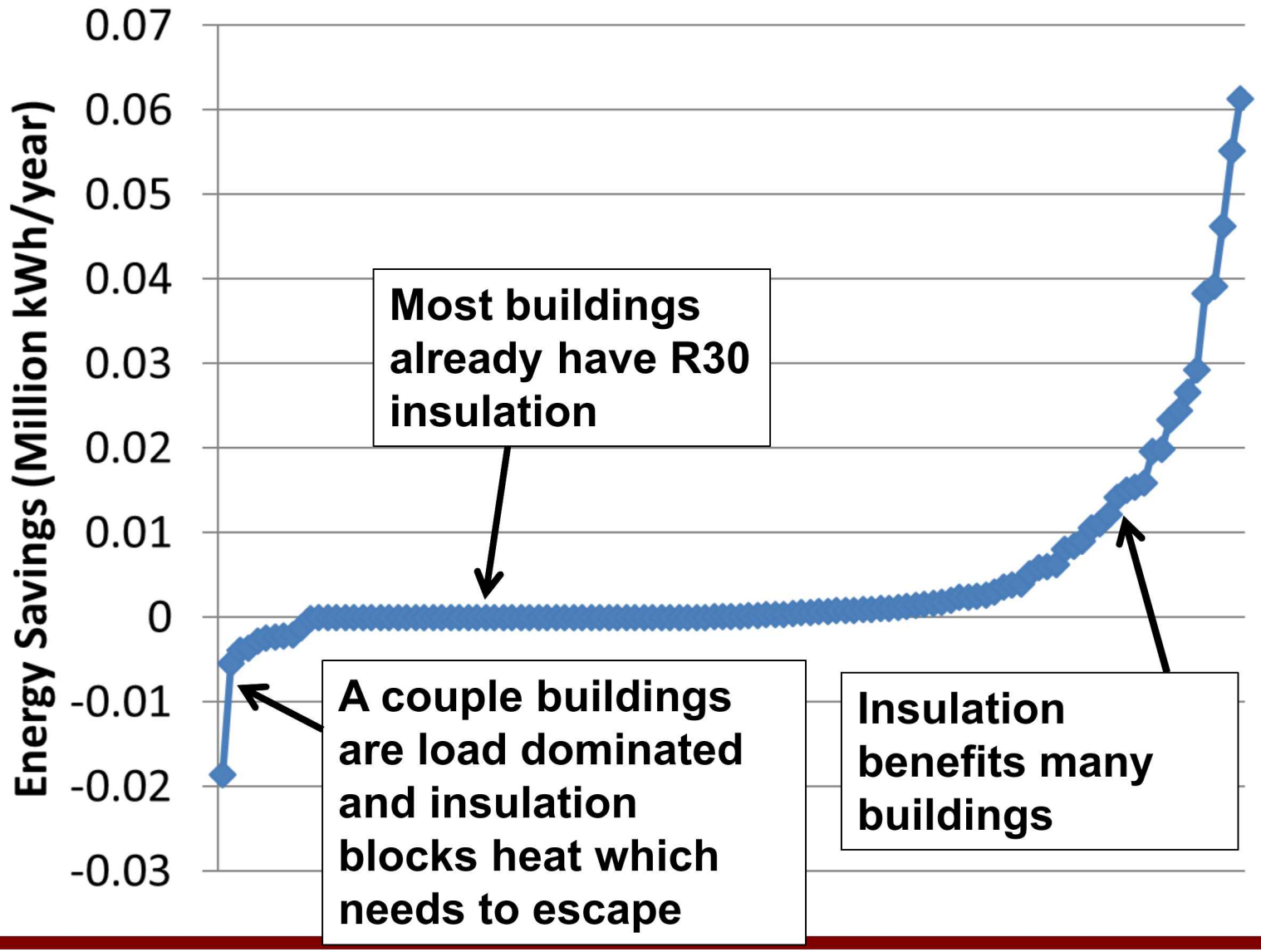
  - If an ECM is needed and it can be modeled accurately in DOE2.2, we can provide a site-wide result that disaggregates to the building level.

Energy Break Down Estimate

- Electricity
  - FY12 2.84e8 kWh
  - FY16 2.34e8 kWh
  - IX 1.50e8 kWh
- Gas
  - FY12 3.40e5 MCF
  - FY16 2.46e5 MCF
  - IX 2.73e5MCF
- Combined
  - FY12 1.34e6 MMBTU
  - FY16 1.05e6 MMBTU
  - IX 0.79e6 MMBTU

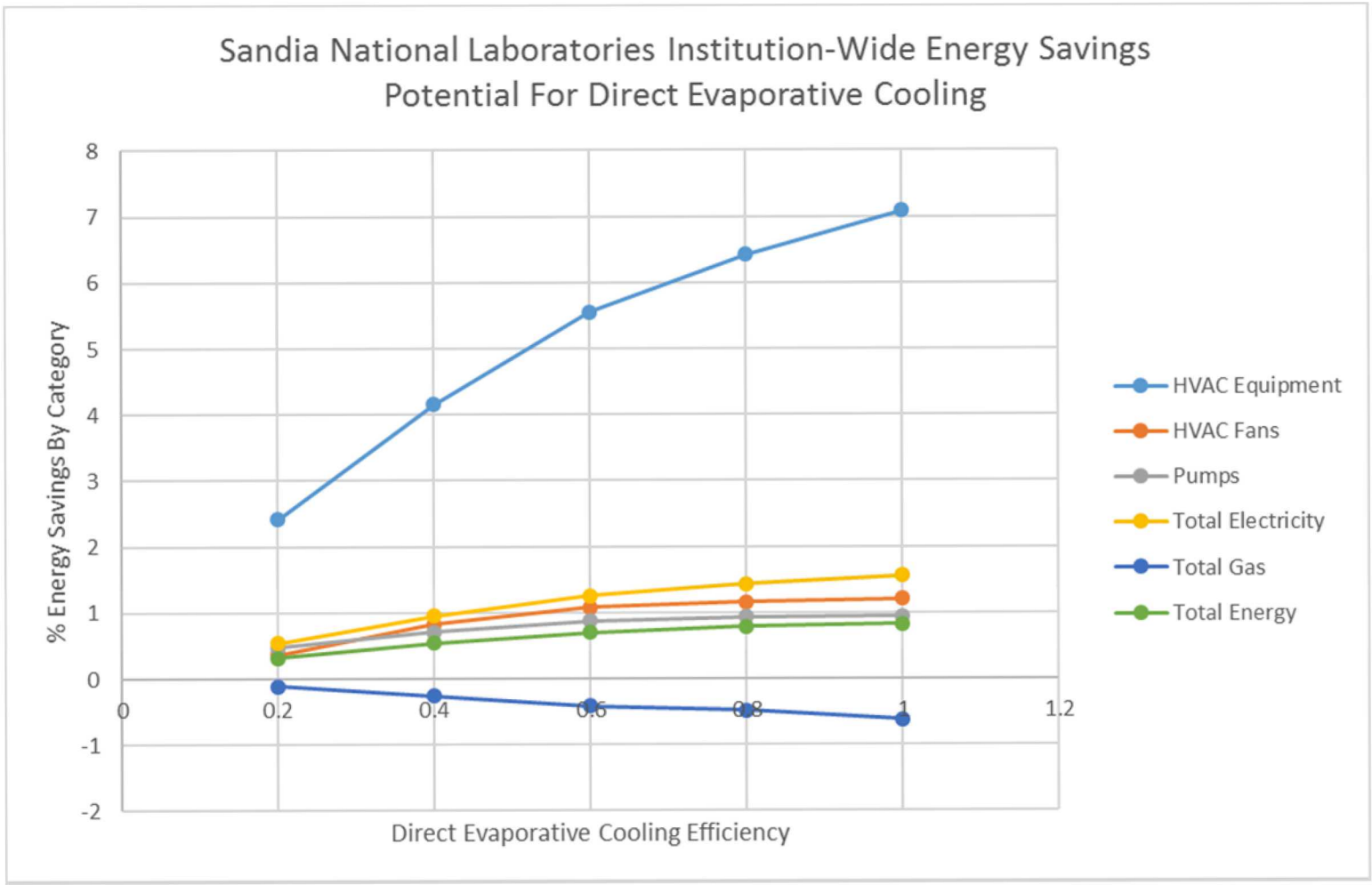


Prioritizing ECMs across the building fleet

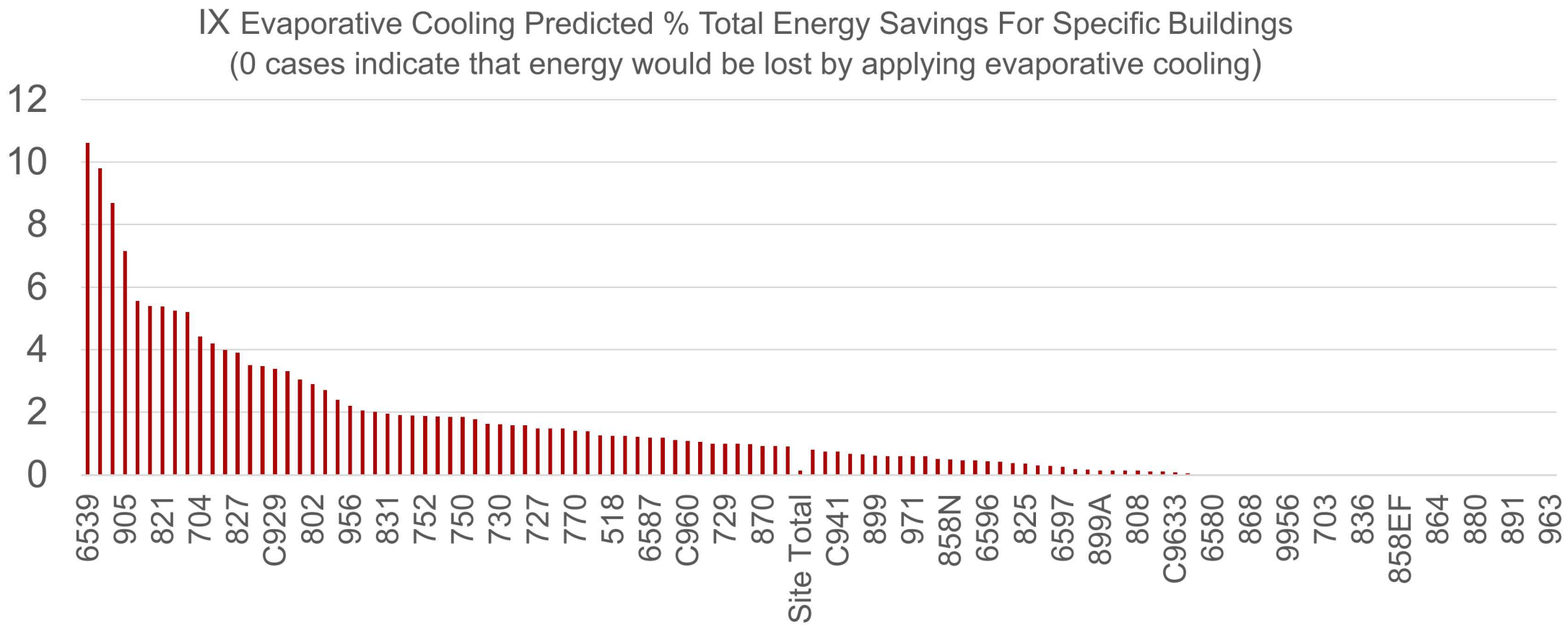


Evaporative Cooling

Direct Evaporative Cooling – 0.83% energy savings potential



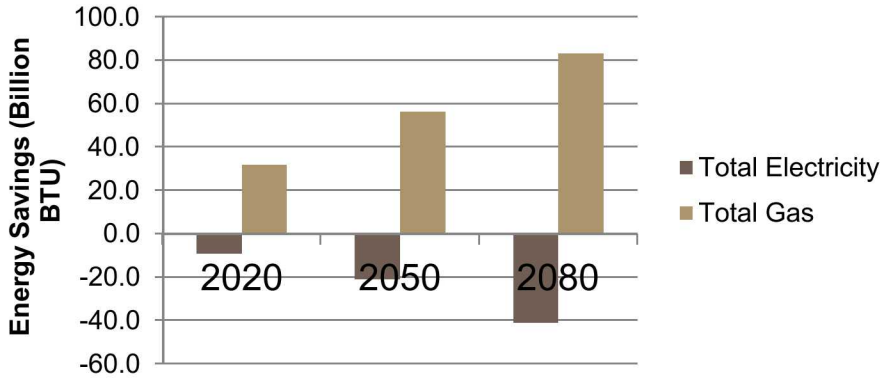
Direct Evaporative Cooling



Climate Assessment

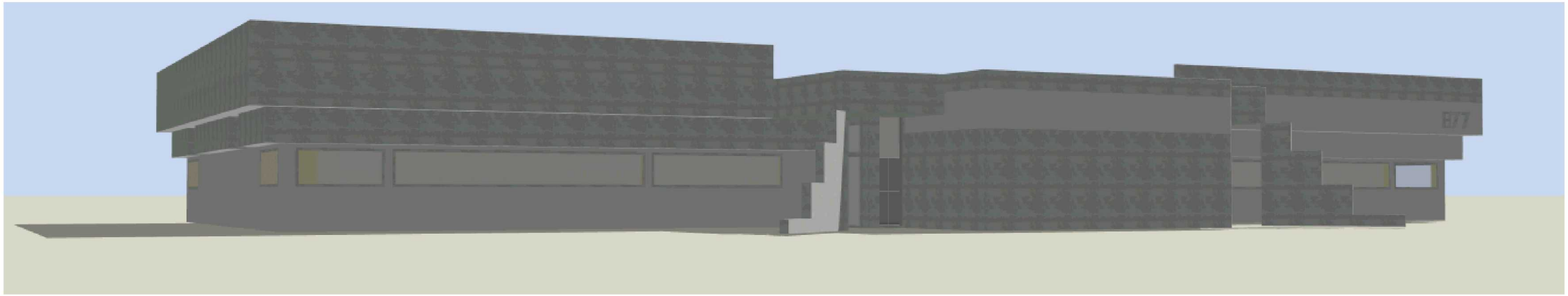
	Energy (1e9xBTU)			Energy Savings (1e9xBTU)			% Savings		
Year	Total Electricity	Total Gas	Total	Total Electricity	Total Gas	Total	% Total Electricity	% Total Gas	% Total
2015	824.7	422.1	1246.7	0.0	0.0	0.0	0.0	0.0	0.0
2020	833.9	390.4	1224.3	-9.2	31.7	22.5	-1.1	7.5	**1.8**
2050	845.7	365.7	1211.4	-21.0	56.4	35.4	-2.6	13.4	**2.8**
2080	865.7	339.0	1204.7	-41.0	83.1	42.1	-5.0	19.7	**3.4**

By 2020 a 1.8% reduction of total energy is projected due to climate change



Future plans – Energy Plus (E+)

- Enable the use of E+ models in IX building module
- Achieve 1st model predictive control loop based off of an E+ model for Sandia
- Form collaborative relationships. Can our resources catalyze other research efforts?
- Create a site-wide map between sensors and building energy models



Rendering from design builder version 5 (http://www.designbuilder.co.uk/)

Contact Information

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Questions?