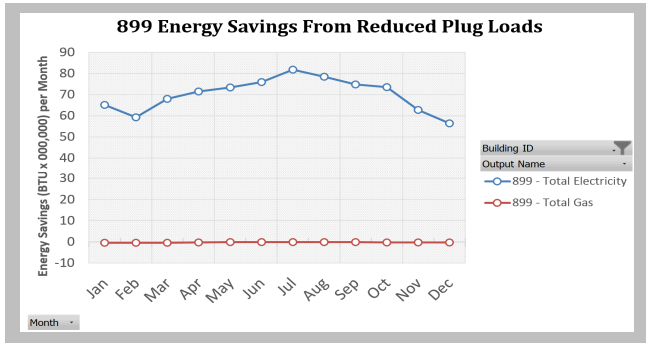
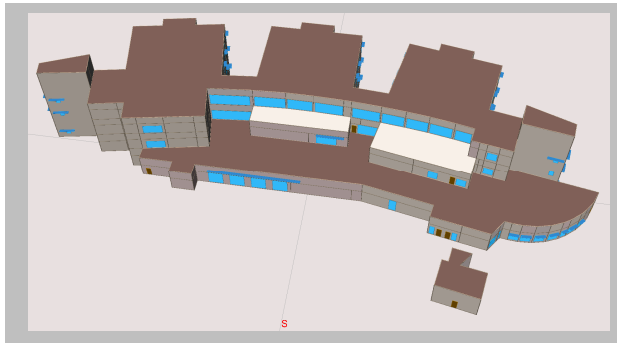
SAND2017-12849PE





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Institutional Transformation (IX)

Daniel Villa, Jerry Gallegos, Will Peplinski, Jack Mizner

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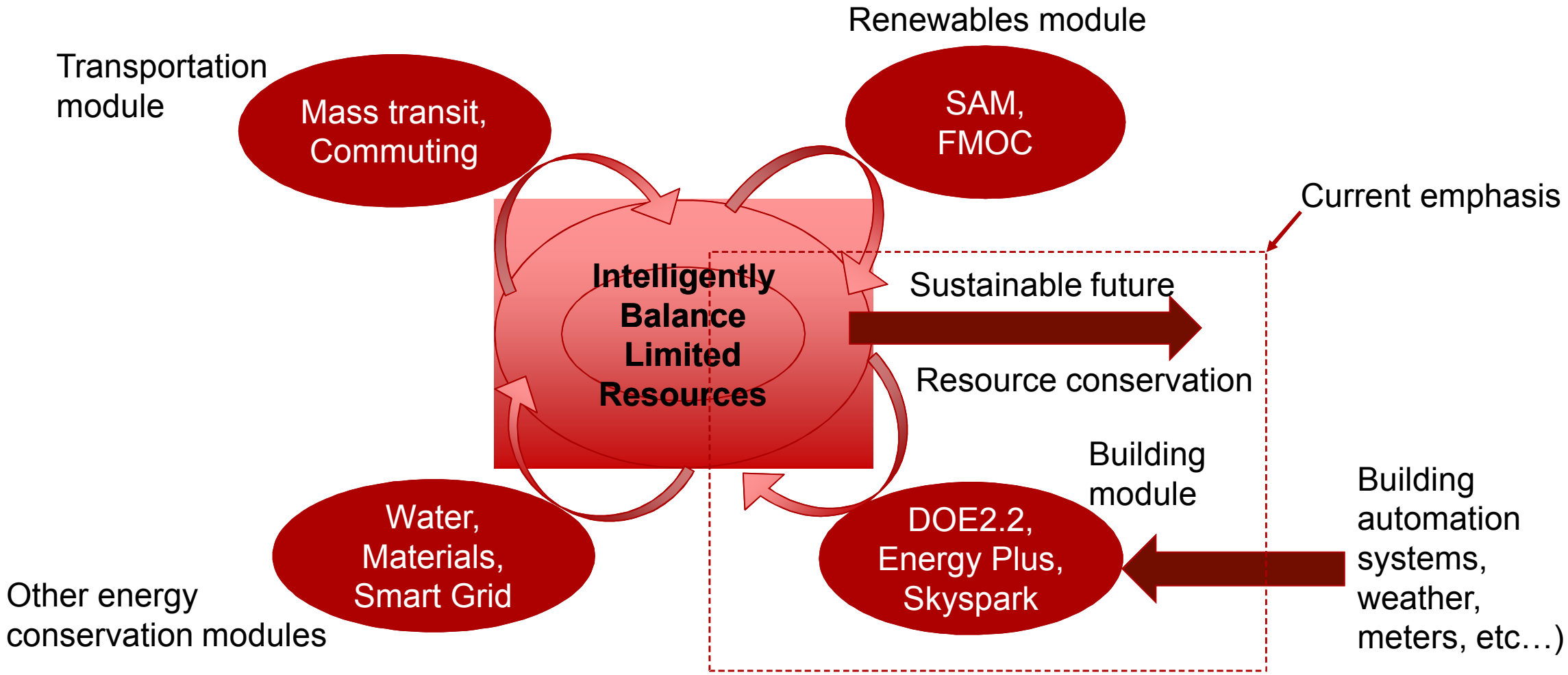
Outline

Sandia National Laboratories

- Vision
- Goals
- Institutional Evolution
- Urban versus Institutional Scales
- Challenges
- Current Implementation
  - Software
  - Problems
  - Analyses
- Plans
- Conclusions

Vision

Progress toward a sustainable institution through institution-wide data systems and models.

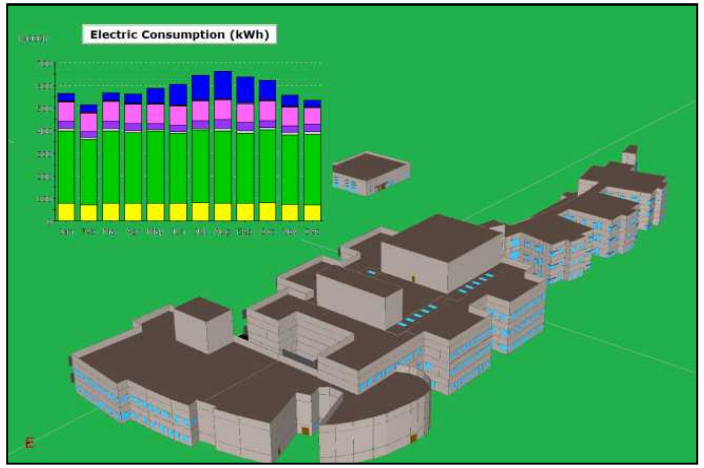


Goals to realize the IX vision

- Provide energy conservation measure (ECM) and renewable assessments that project the potential for improvement in sustainability
- 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
- with realistic tradeoffs between competing scenarios
- Provide higher fidelity databases to validate urban scale modeling efforts
- Provide resources to move building-by-building research efforts to institution-wide analyses

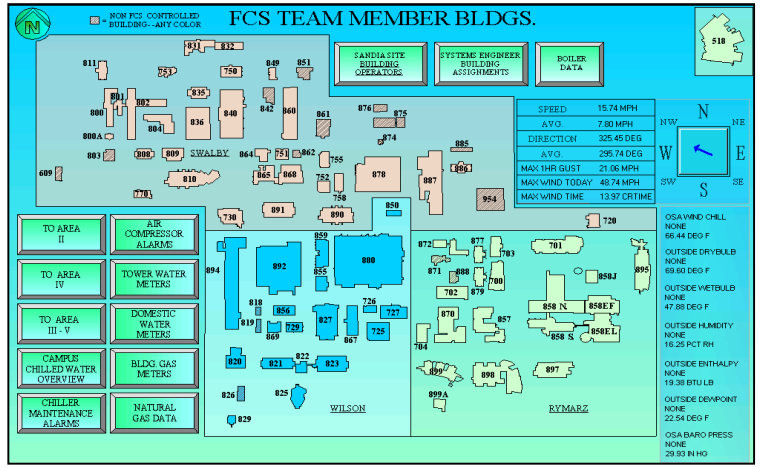
Lots of models need lots of data

100-1000's of Models



+

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



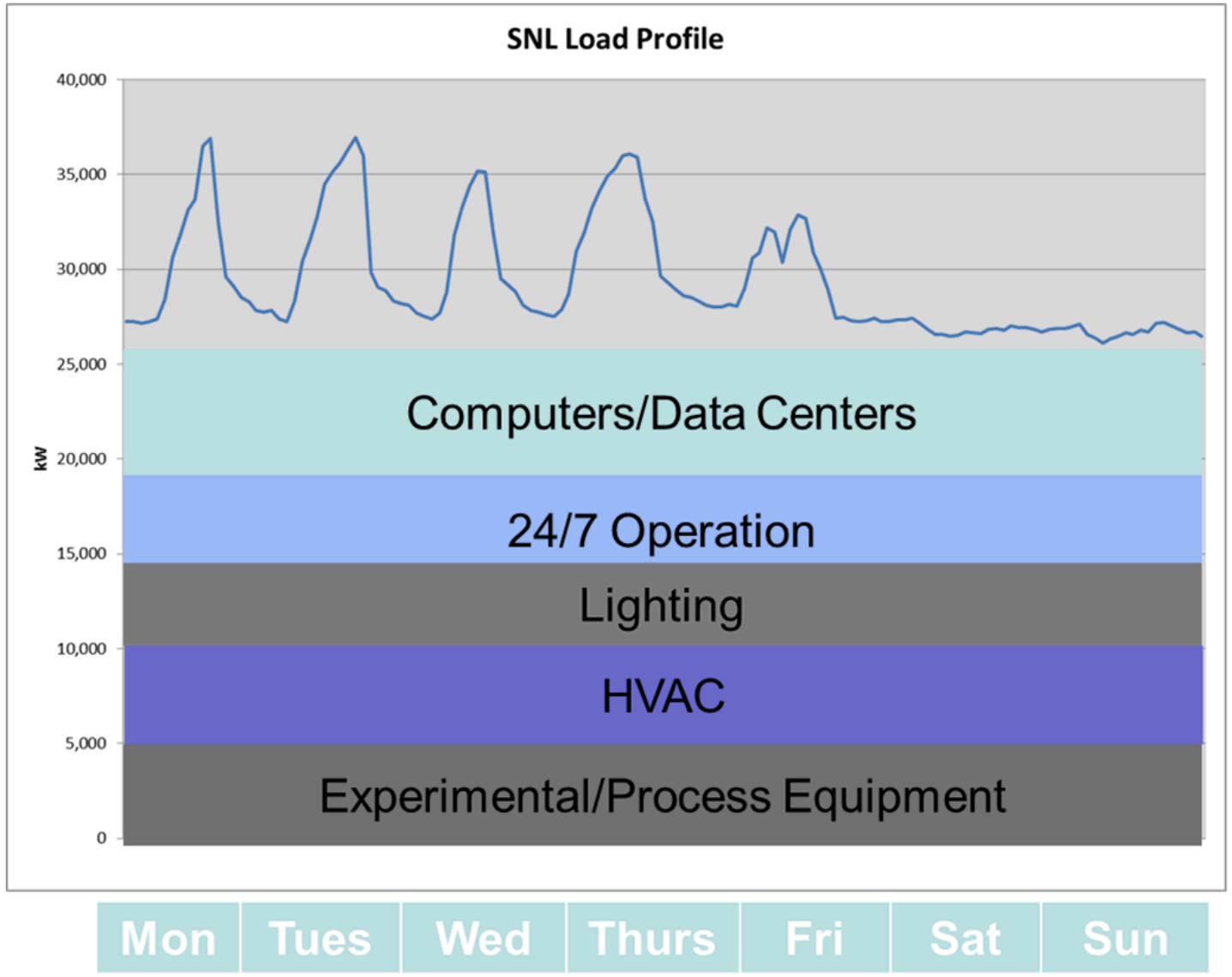
+ **Algorithms /Software**

```
   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

High potential for energy conservation

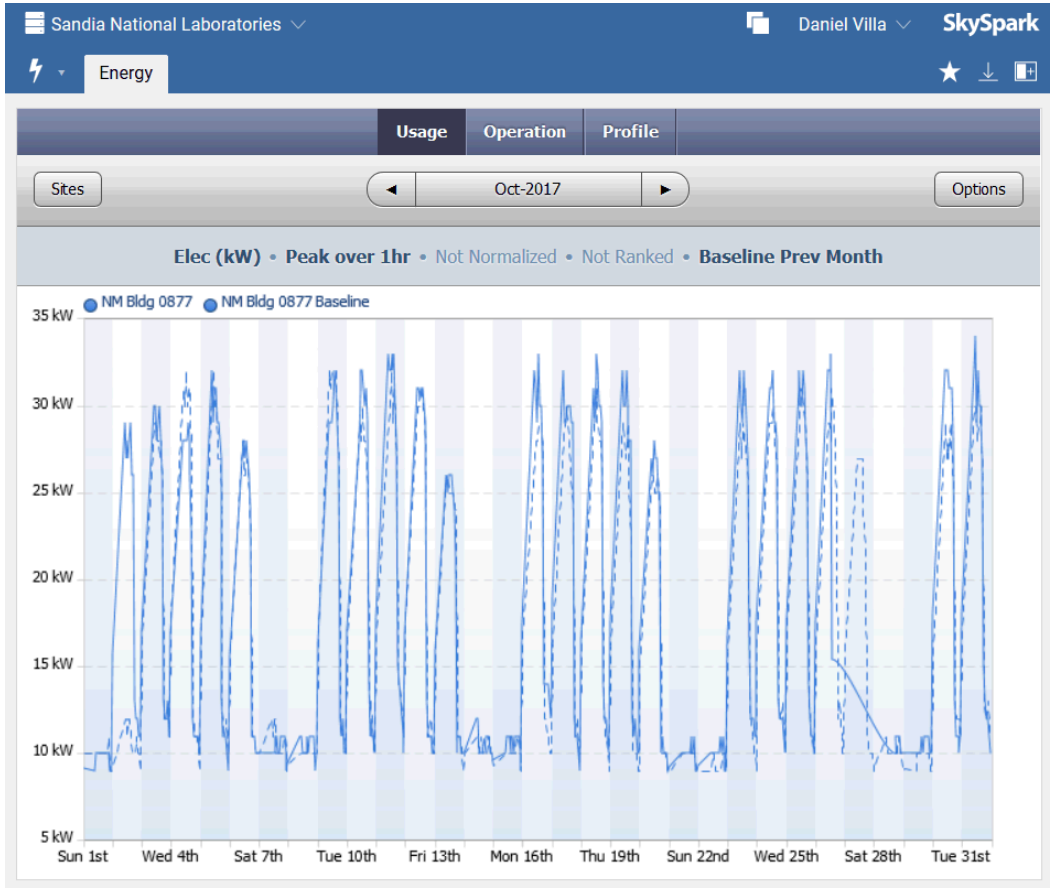


Employ Energy Strategies

- Reduce current demand; use less.
- Eliminate current demand; turn off or remove.
- Use resources efficiently; use fewer resources for the same task.

Energy Analytics

- Pilot on 17 buildings using SkySpark
- Hoping to get all BAS data into the analytics database



Modeling institutional evolution

Past site

2015 2016

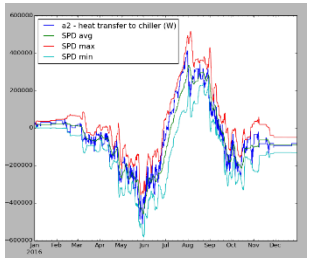
Present

2017

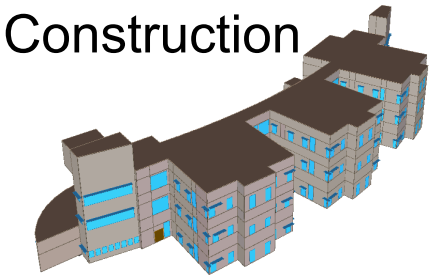
Future site

2018 2019

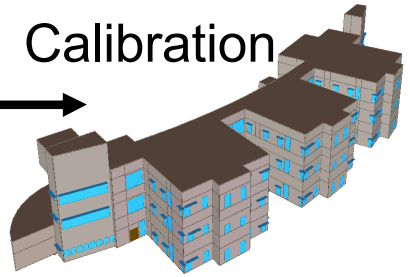
Historical data



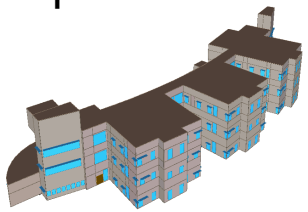
Construction



Calibration

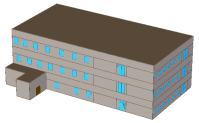


Future Representative

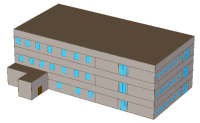


Assess site-wide energy future plan

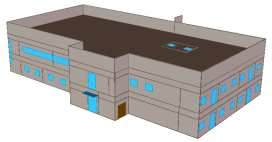
ECMs Evaluated no changes



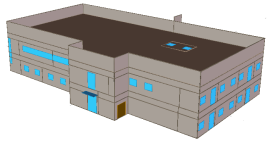
Recalibrate model



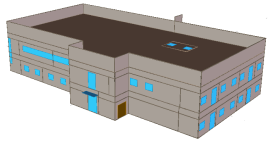
ECM Planned



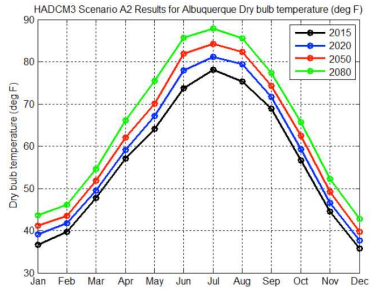
ECM Applied



Updated Model with ECM



Climate change projections



Demolition

All figures rendered in eQUEST 3.65

New Mexico Site

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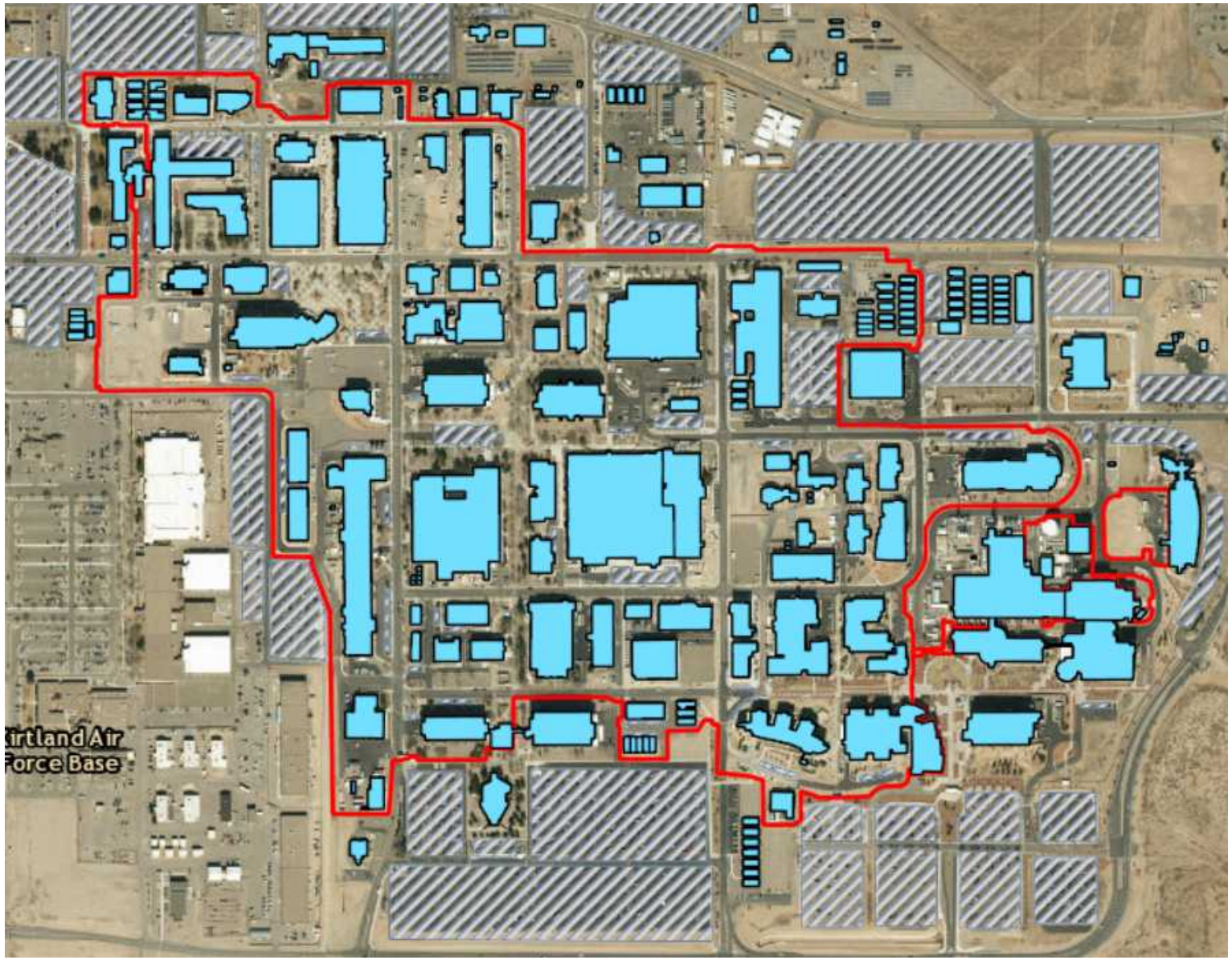
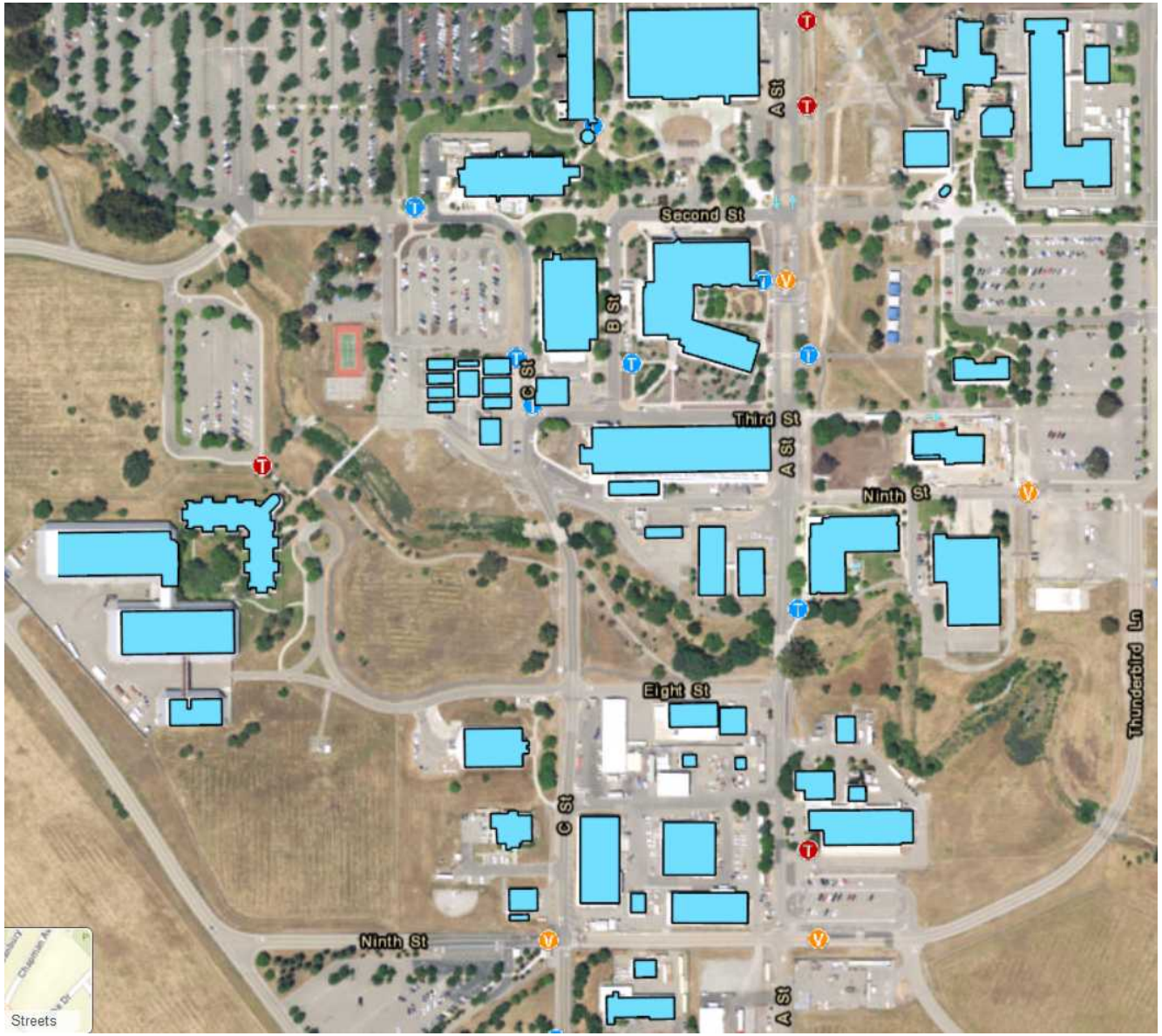
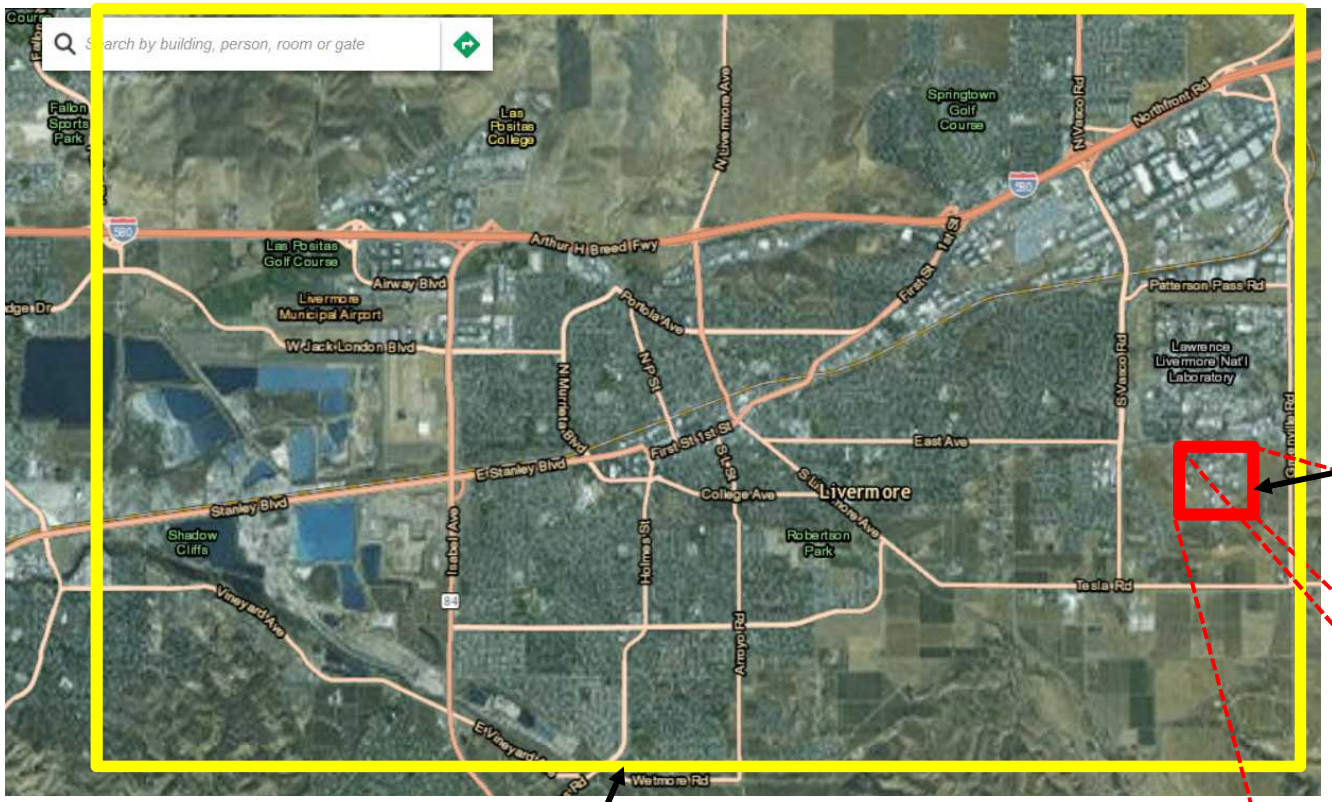


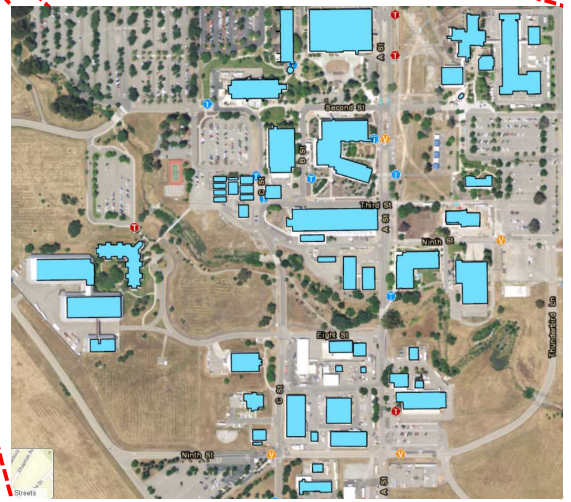
California Site

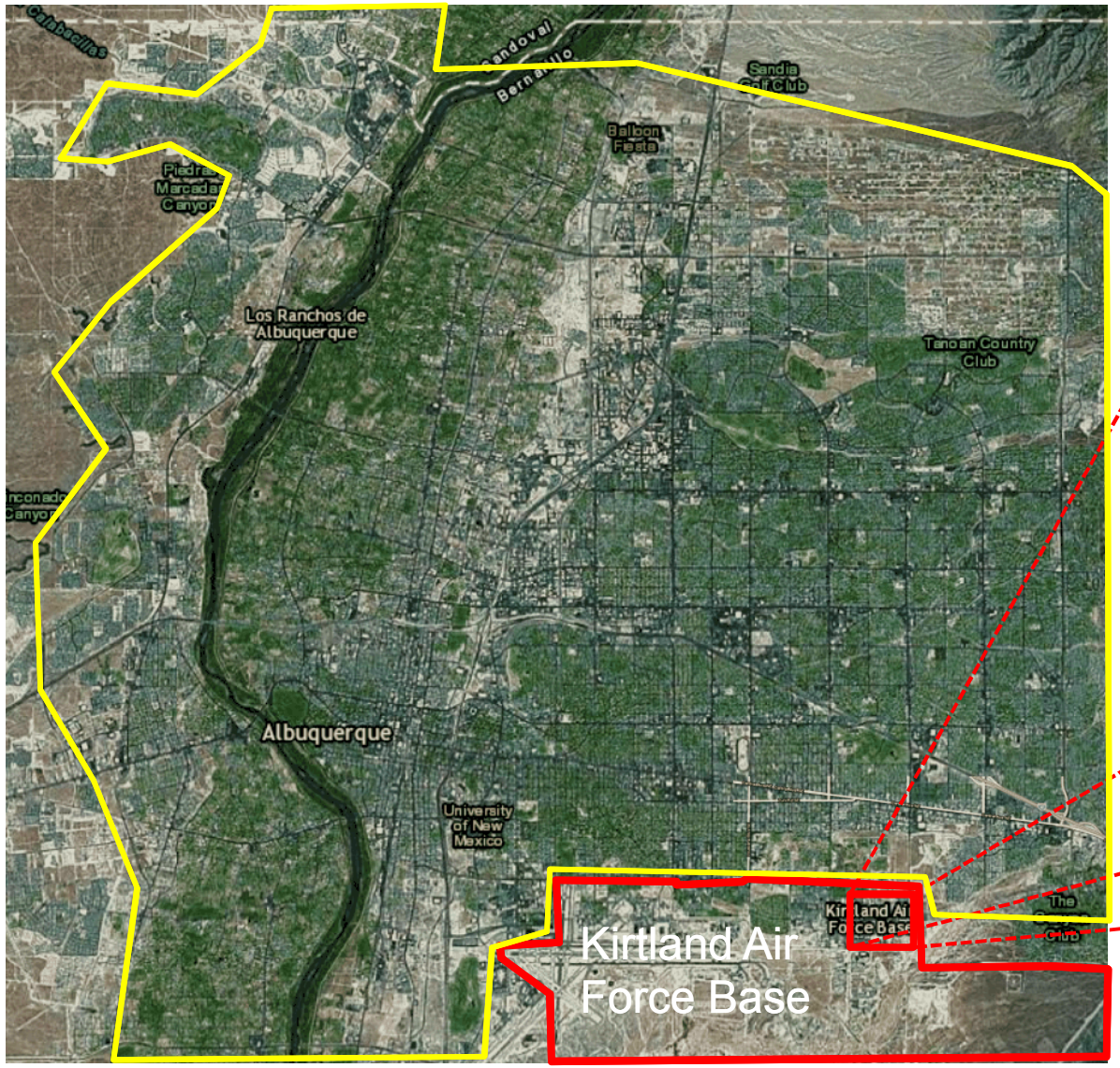




Urban scale (Livermore)

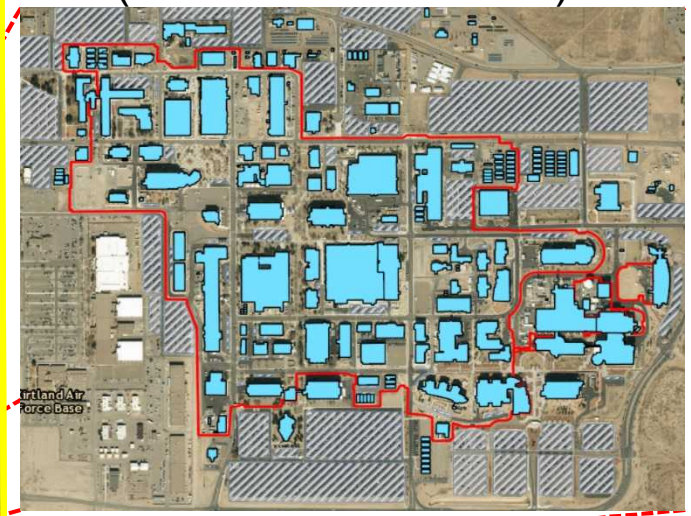
Institution site scale (Sandia California)





Urban scale
(Albuquerque)

Institution site scale
(Sandia New Mexico)



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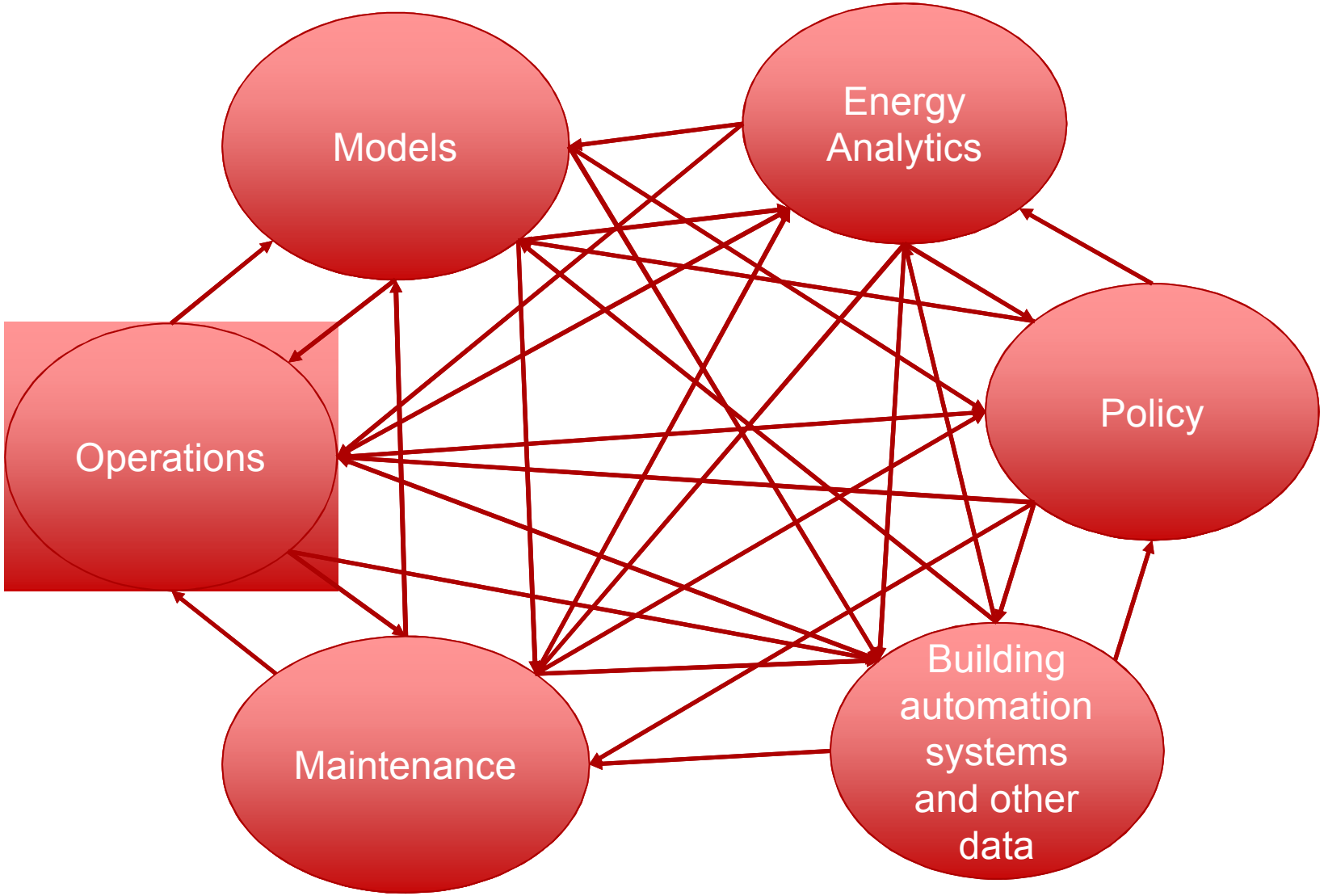
Challenges

Should everything talk to everything?



Priorities

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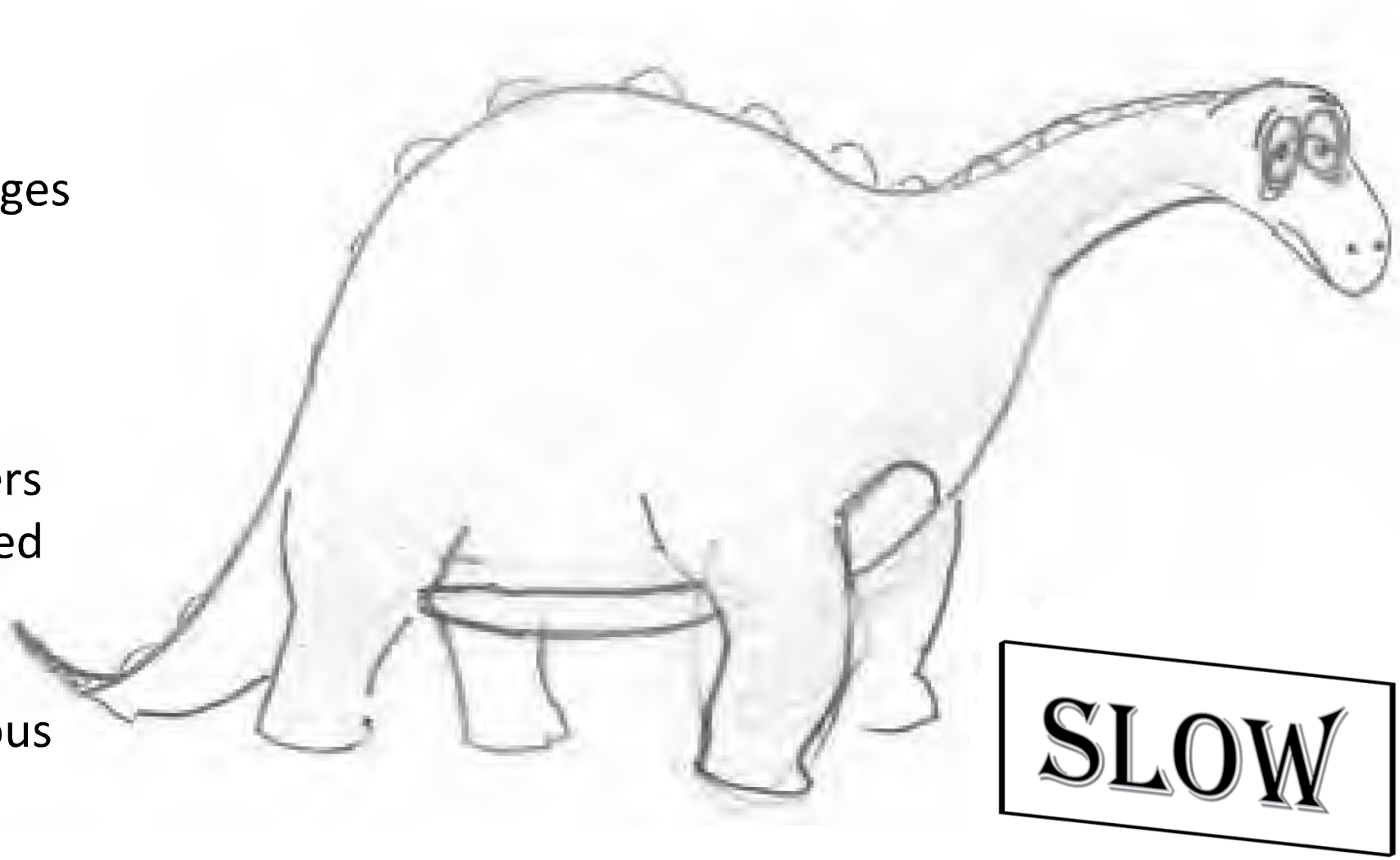
Energy is #4

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

Fortunately, high connectivity between models and data can have applications in productivity/cost also

Model synchronization with reality

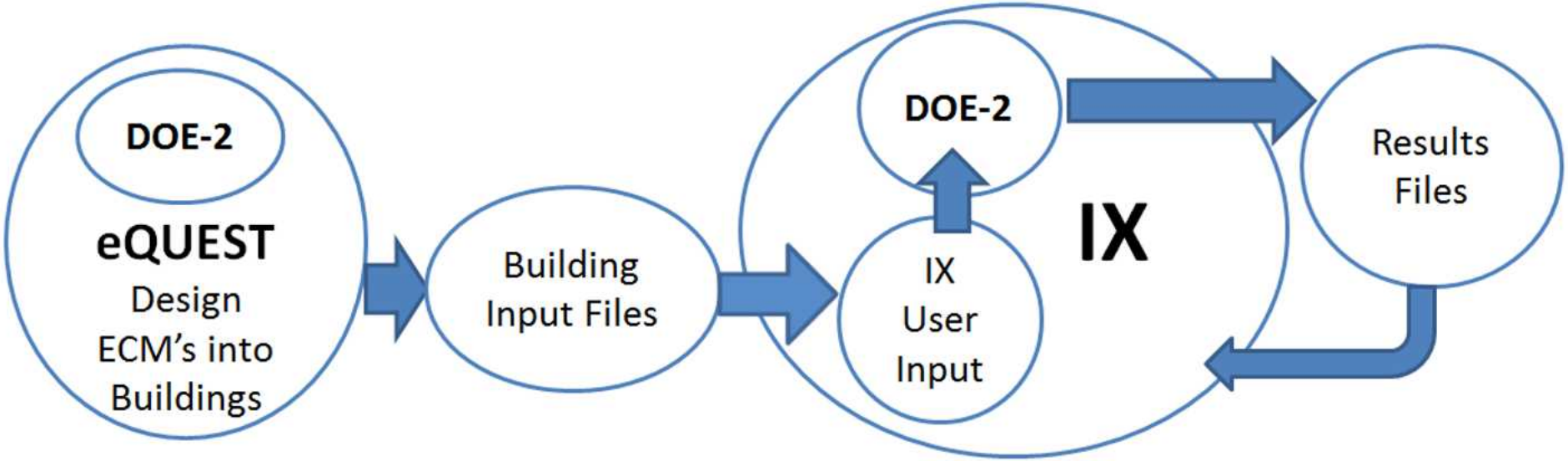
- Schedules
- As-built and retrofit changes
- Equipment degradation/disfunction
- Model assumptions
- 1000’s of input parameters that have to be maintained manually and vary statistically due to uncertainty and continuous change



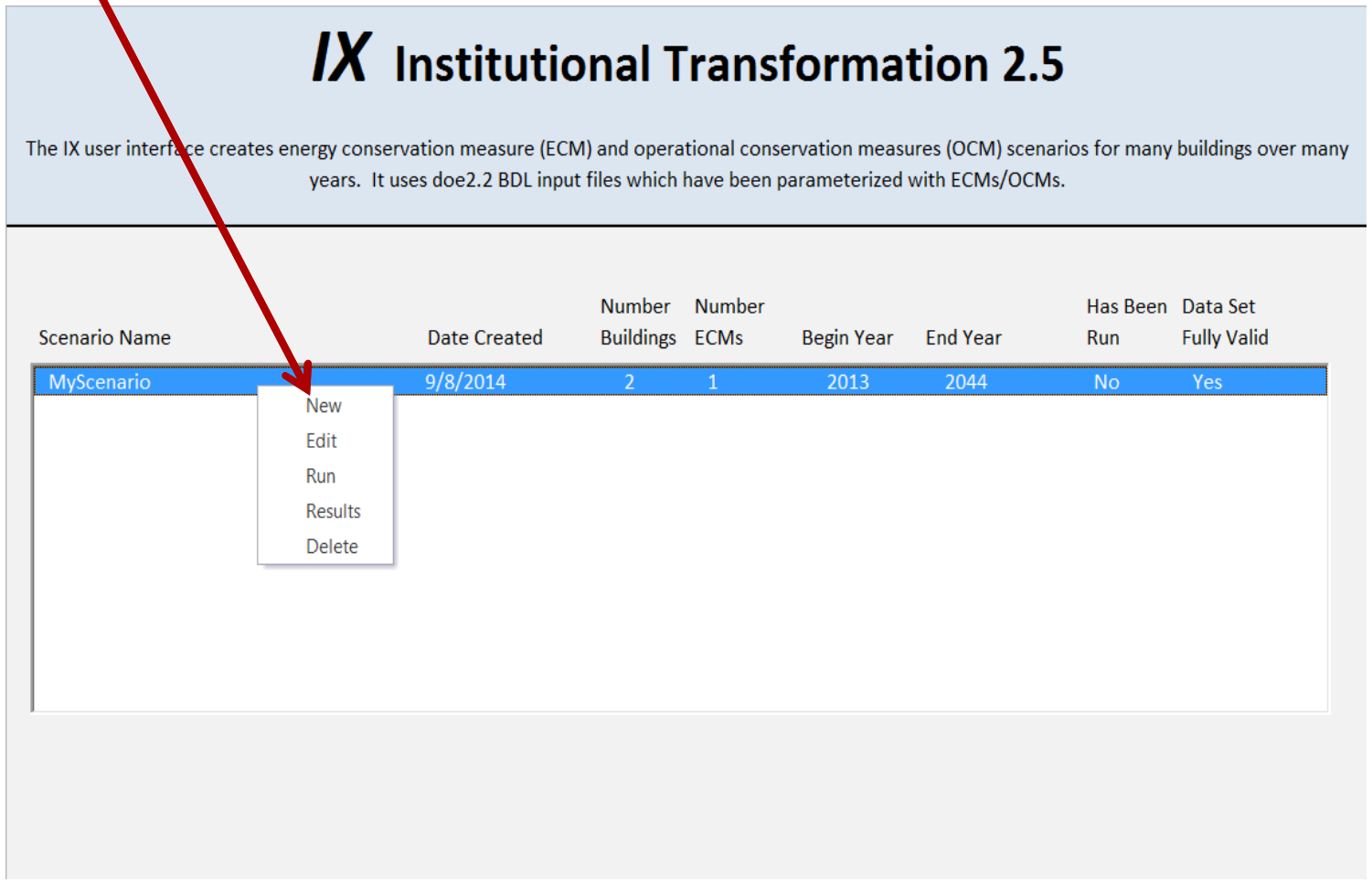
From these visions and challenges, let’s turn to what has actually been accomplished

What is the IX building module?

- The IX building module is a combined 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 like eQUEST
- Work is being done to combine this tool with real time data from our energy analytics database that is still underdevelopment.



Right click enables all functionality



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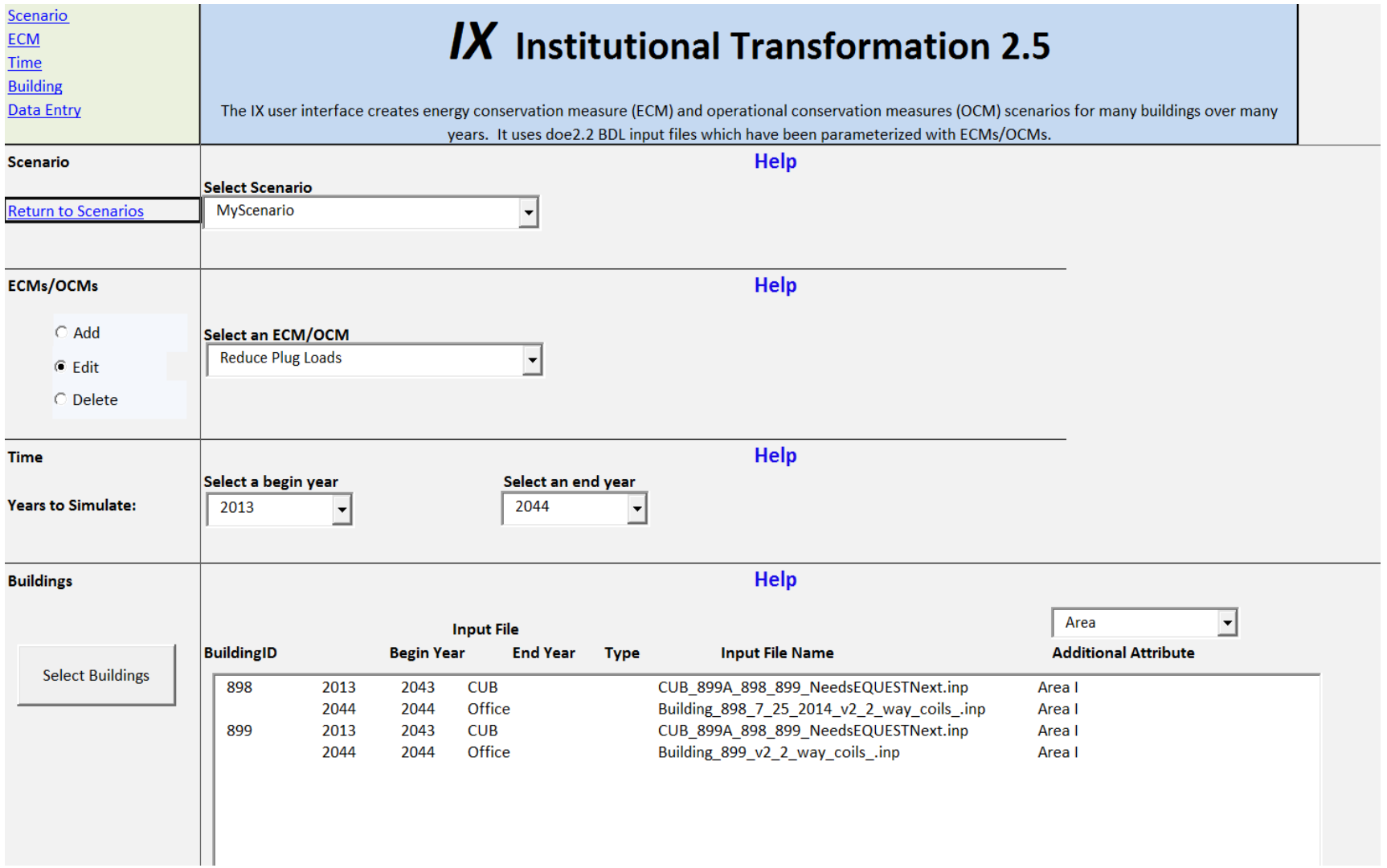
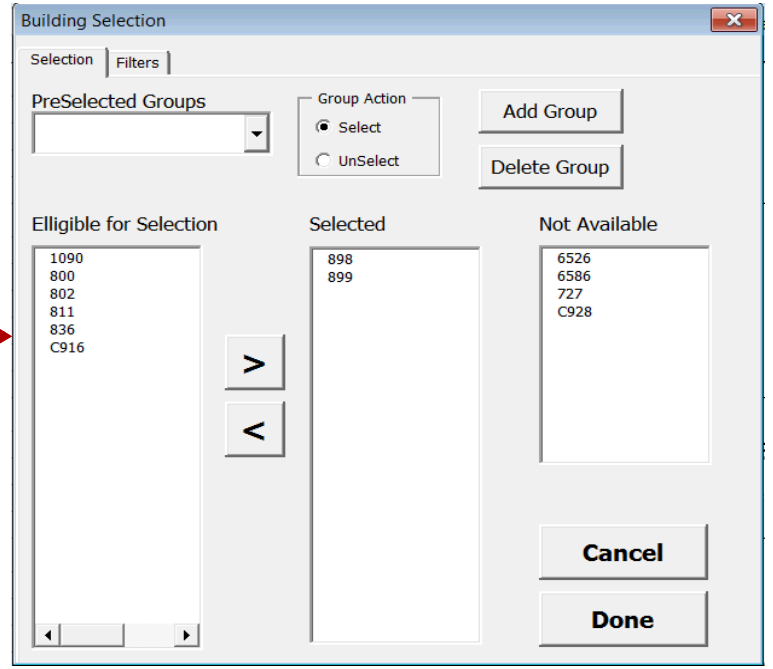


Building Selection

Dynamic table which refreshes and indicates areas of changes (only 1 table in IX2.5 which refreshes to include any parameter)



Data Entry

Propogate Entries

Edit Defaults

Commit Changes

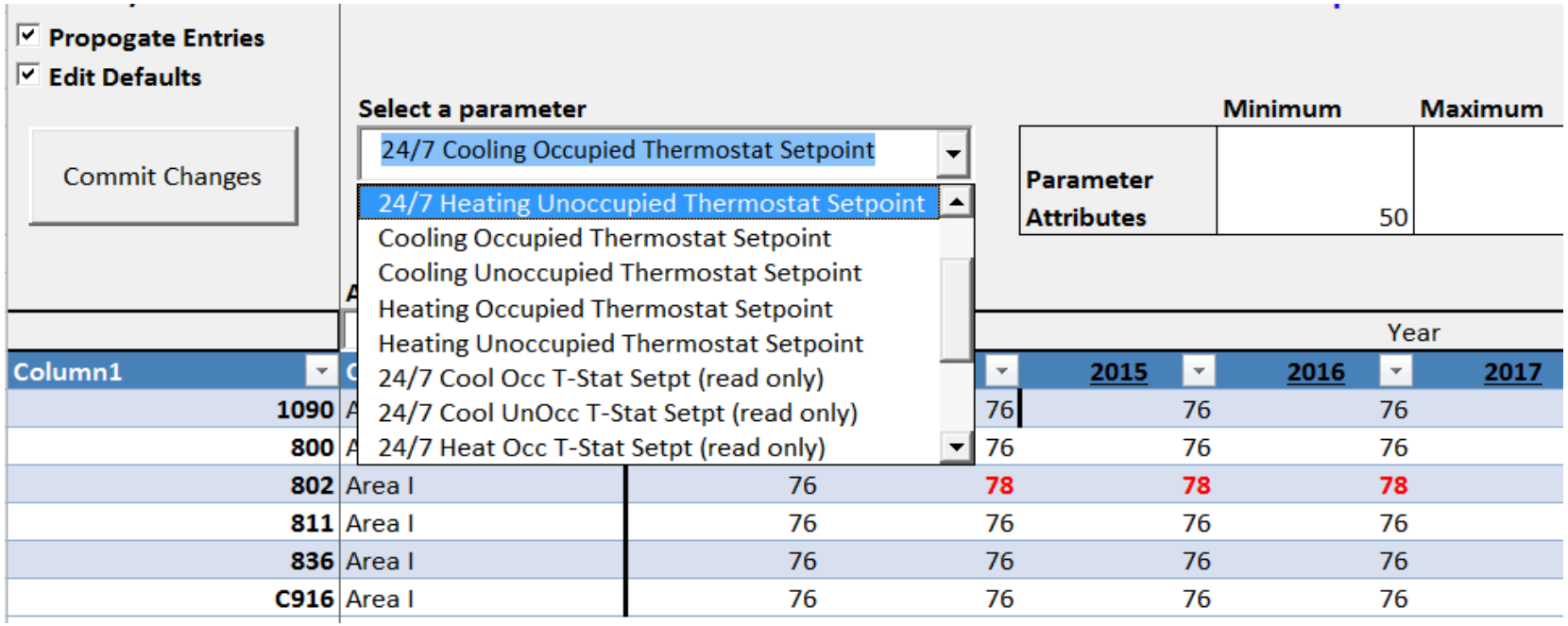
Help

Select a parameter: 24/7 Cooling Occupied Thermostat Setpoint

	Minimum	Maximum	Units
Parameter Attributes	50	100	Farenheit (F)

Additional Attribute: Area

		Year								
Column1	Column2	2013	2014	2015	2016	2017	2018	2019	2020	2021
1090	Area II, Area II	76	76	76	76	76	76	76	76	76
800	Area I	76	76	76	76	76	76	76	76	76
802	Area I	76	78	78	78	78	78	78	78	78
811	Area I	76	76	76	76	76	76	76	76	76
836	Area I	76	76	76	76	76	76	76	76	76
C916	Area I	76	76	76	76	76	76	76	76	76


Propogate Entries
Edit Defaults
Commit Changes
Select a parameter
24/7 Cooling Occupied Thermostat Setpoint
24/7 Heating Unoccupied Thermostat Setpoint
Cooling Occupied Thermostat Setpoint
Cooling Unoccupied Thermostat Setpoint
Heating Occupied Thermostat Setpoint
Heating Unoccupied Thermostat Setpoint
24/7 Cool Occ T-Stat Setpt (read only)
24/7 Cool UnOcc T-Stat Setpt (read only)
24/7 Heat Occ T-Stat Setpt (read only)
Minimum
Maximum
Parameter Attributes
50
Year
Column1
2015
2016
2017
1090
800
802 Area I 76 78 78 78
811 Area I 76 76 76 76
836 Area I 76 76 76 76
C916 Area I 76 76 76 76

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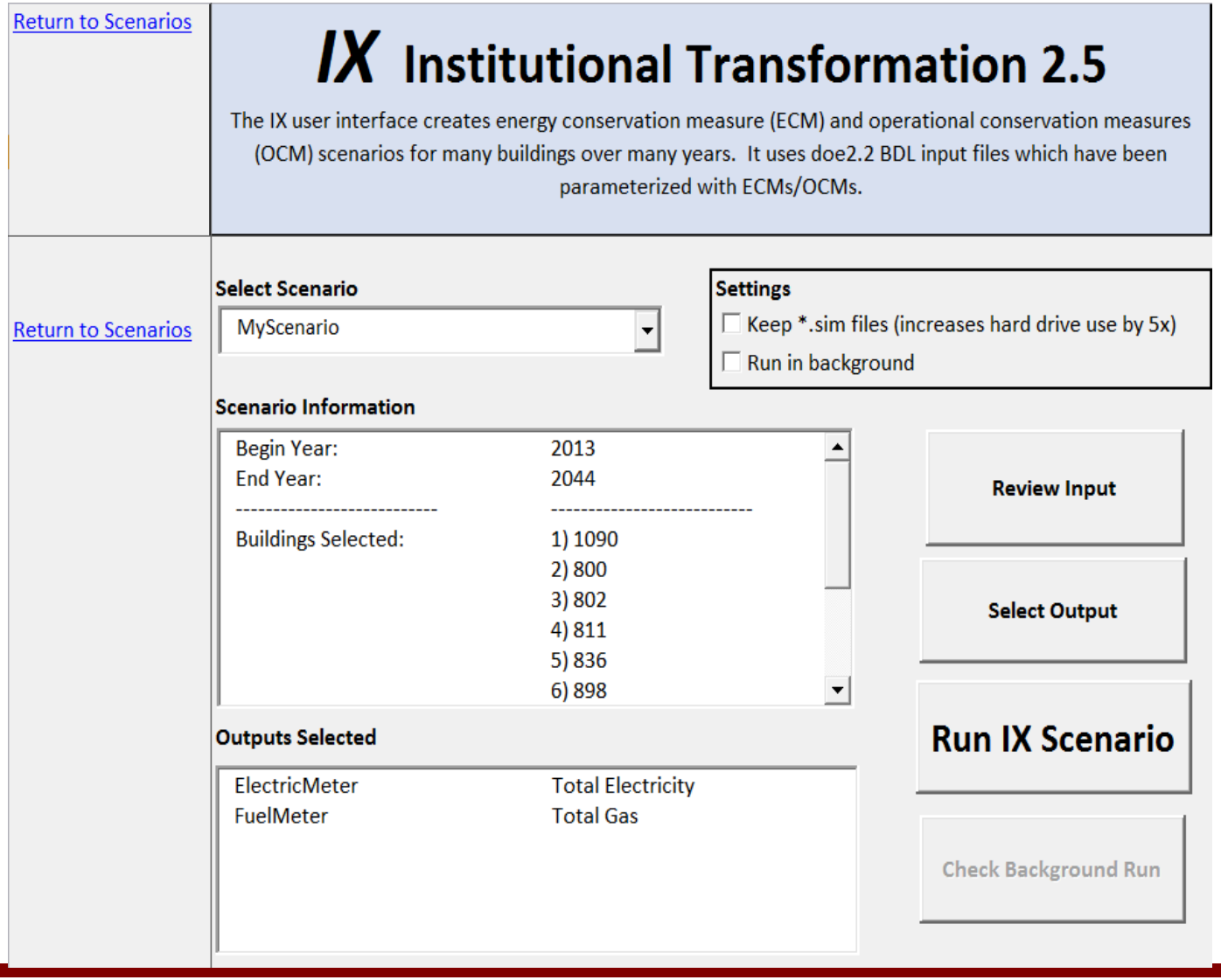


Return to Scenarios

Select Scenario

CUB899A

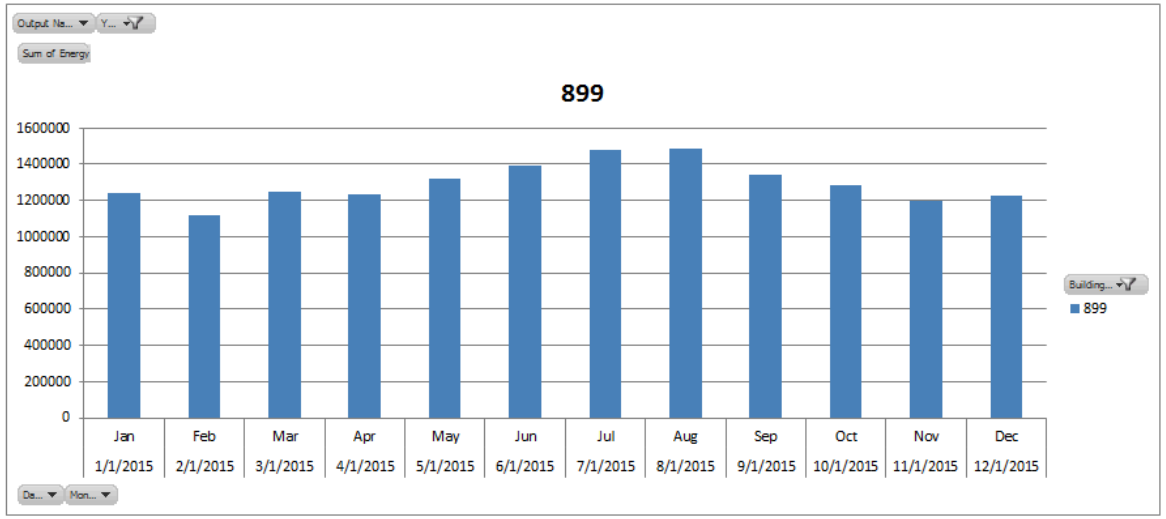
Additional Filter Attribute

Area

Units

kBTU

IX 2.5 Sandia National Laboratories



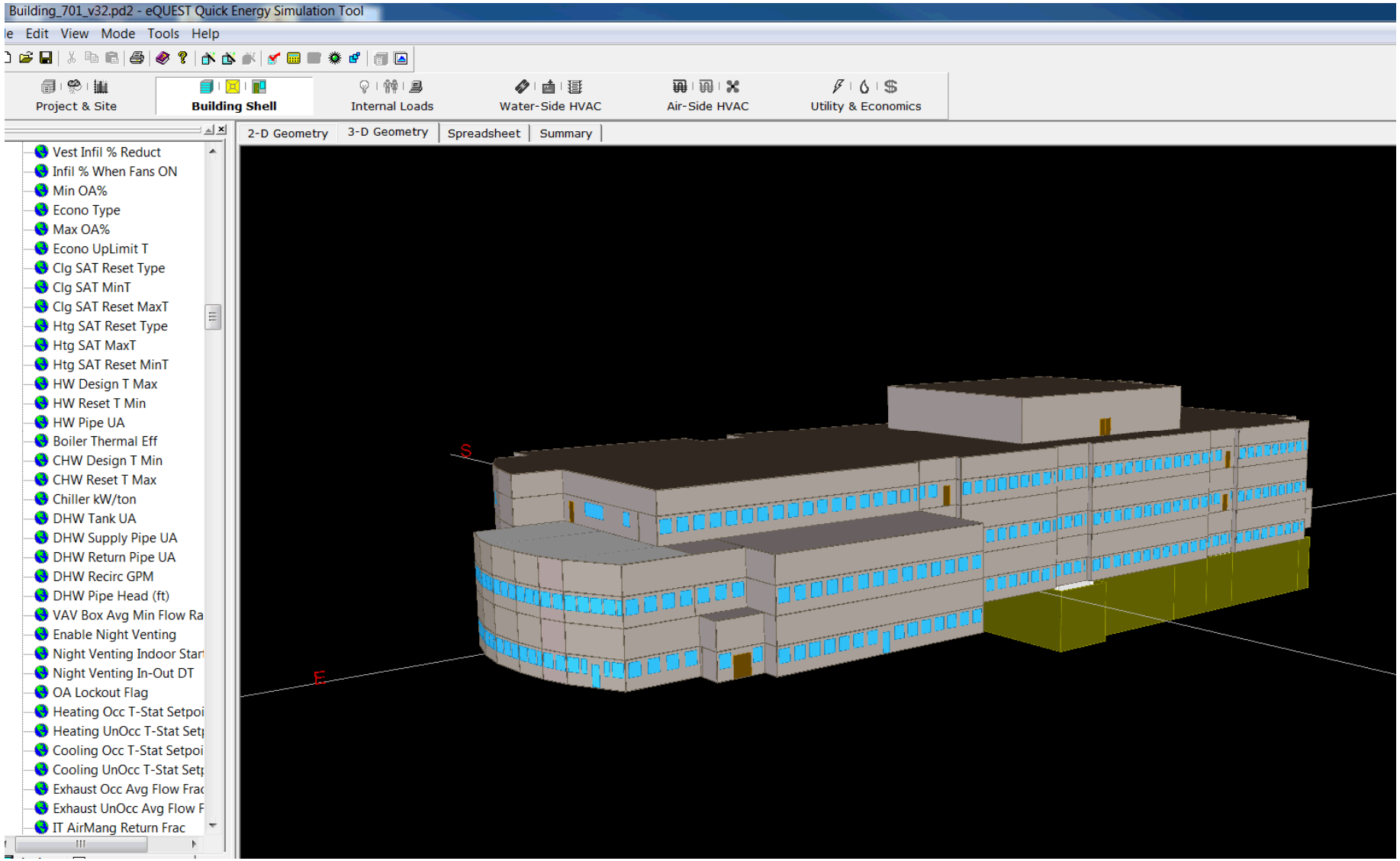
Sum of Energy	Column Labels
Row Labels	899
1/1/2015	
Jan	1237878.958
2/1/2015	
Feb	1120519.157
3/1/2015	
Mar	1250657.665
4/1/2015	
Apr	1231619.184
5/1/2015	
May	1322914.739
6/1/2015	
Jun	1393051.508
7/1/2015	
Jul	1476798.31
8/1/2015	
Aug	1484082.378
9/1/2015	
Sep	1340243.365
10/1/2015	
Oct	1285415.175
11/1/2015	
Nov	1200110.234
12/1/2015	
Dec	1226640.87

IX uses a pivot table of the results database to make reducing to specific results or aggregating to site-wide results easy.

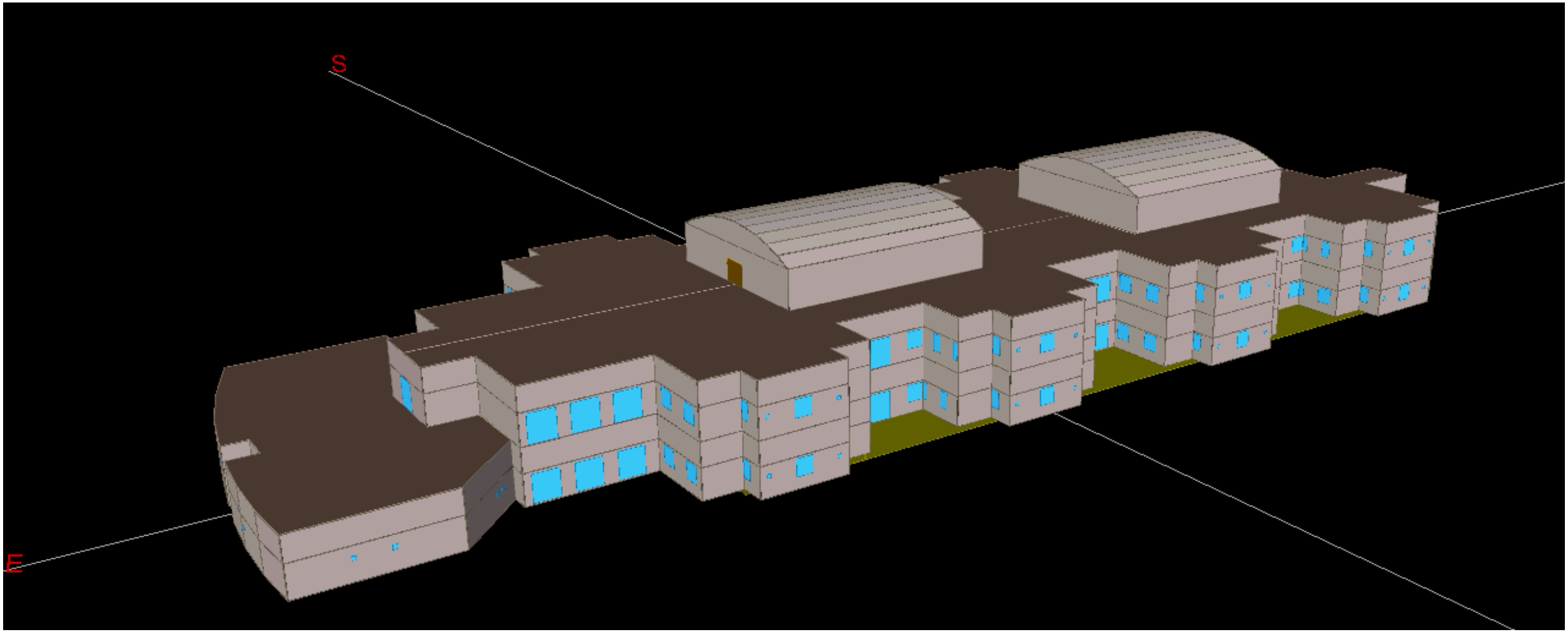
Current Implementation

- IX building module 2.5 delivered in 2015. 2.6 is under creation and expected to be finished in 2017.
- 121 BEM in California and New Mexico (120 DOE2.2 models and 1 E+ model)
- Manual creation and calibration of each model
- Scripted connect BEM into centralized chilling loops
- Sky-spark energy analytics database connections to continuously inform models with weather data is in progress

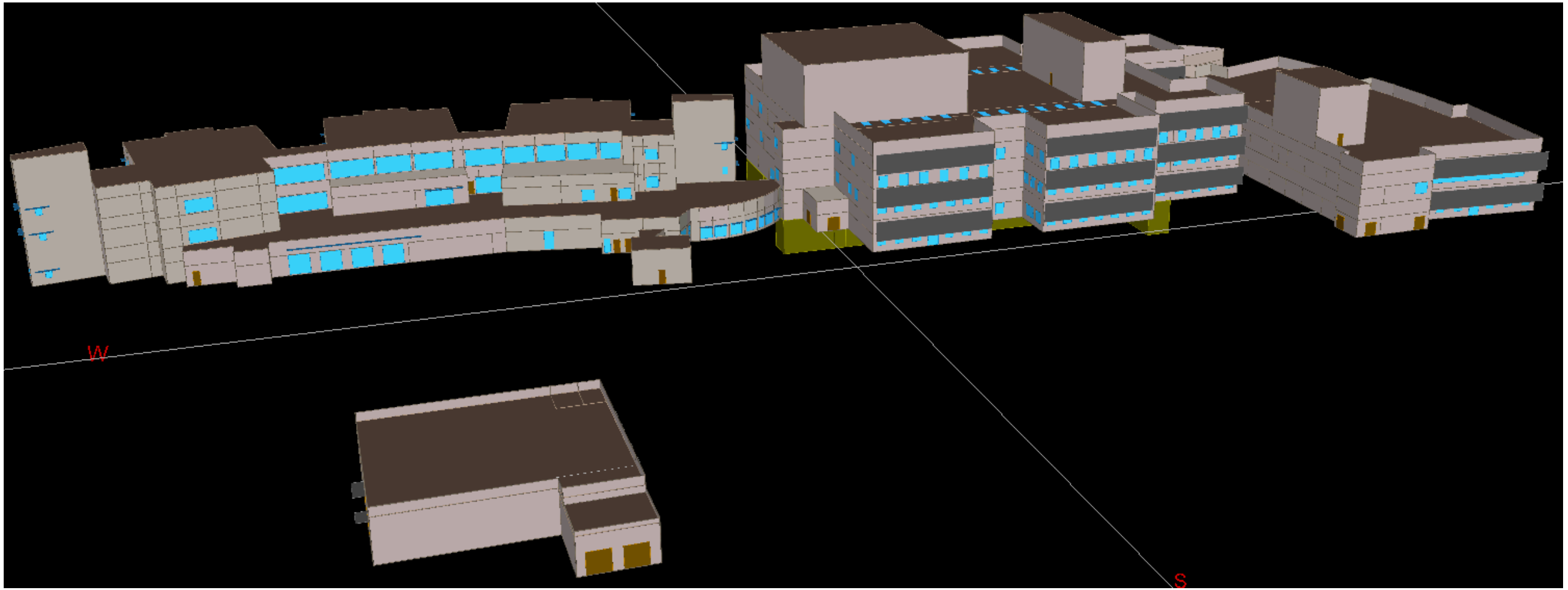
Building 701 eQuest Model



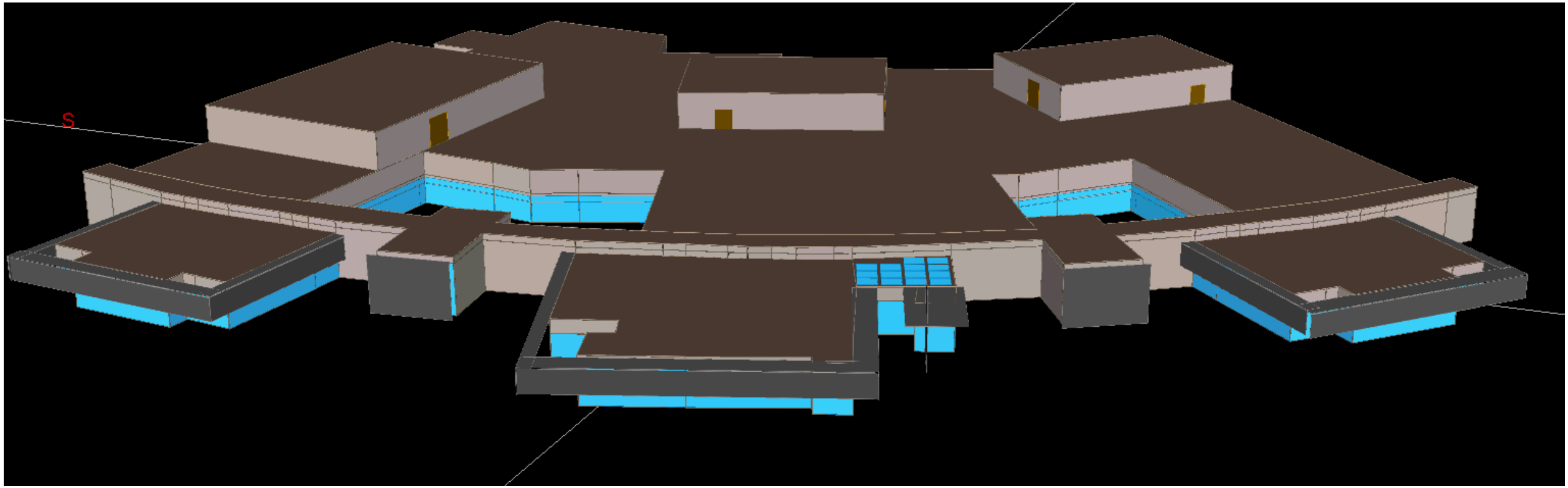
Building 6585 eQuest Model



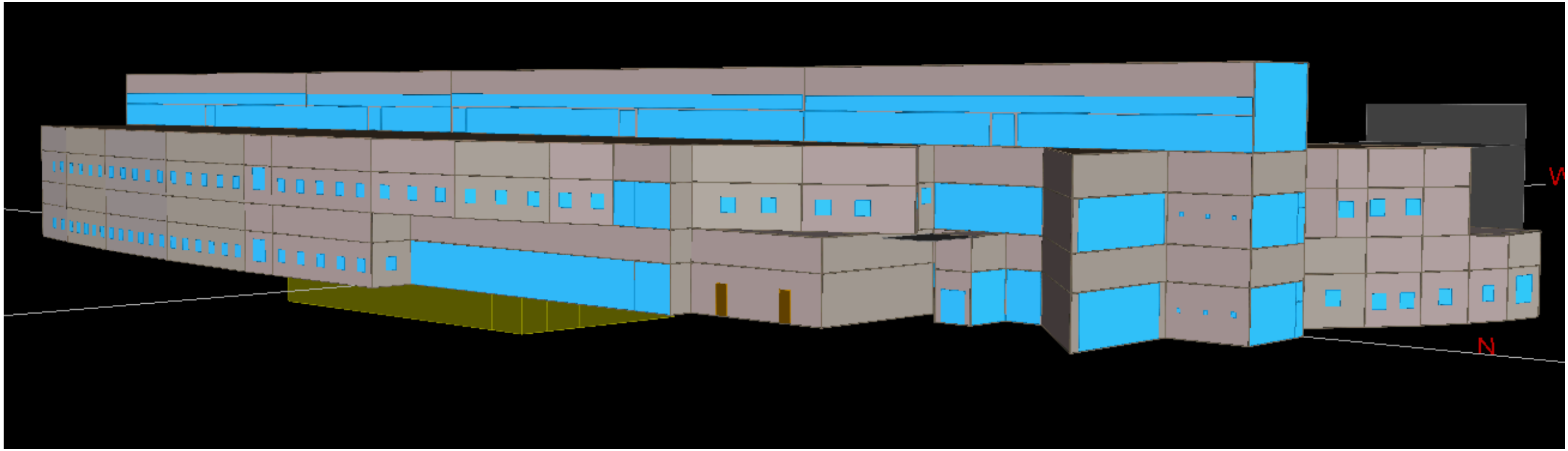
Buildings 899A, 899, & 898 eQuest Models



Building 518 eQuest Model

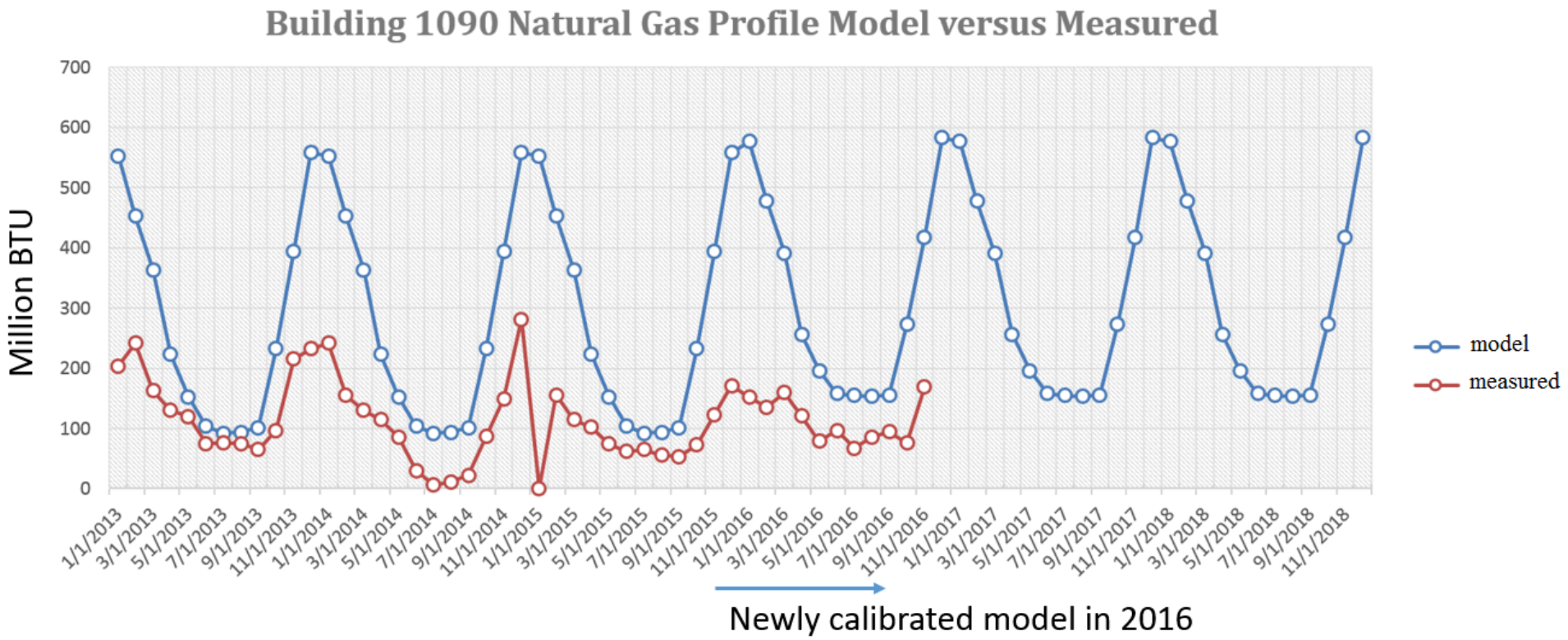


Building 895 eQuest Model



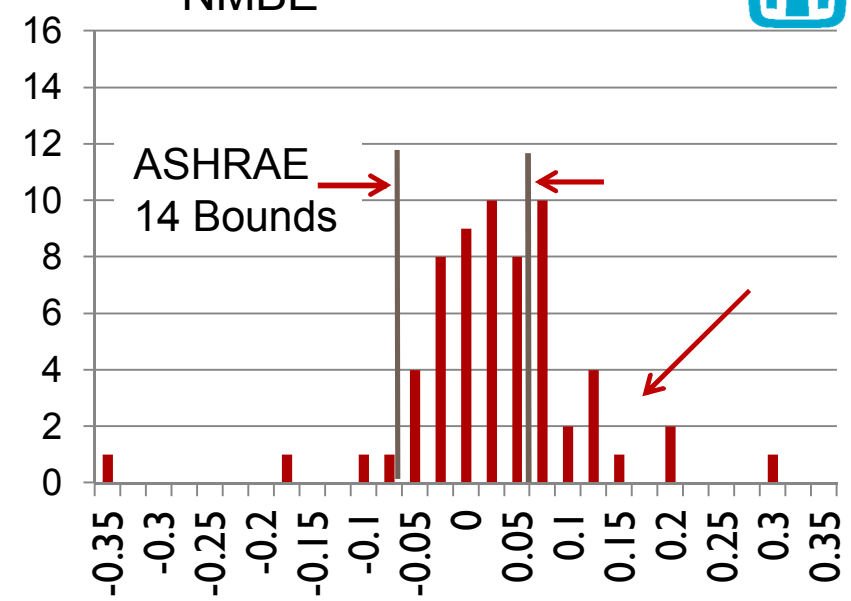
Problems (1)

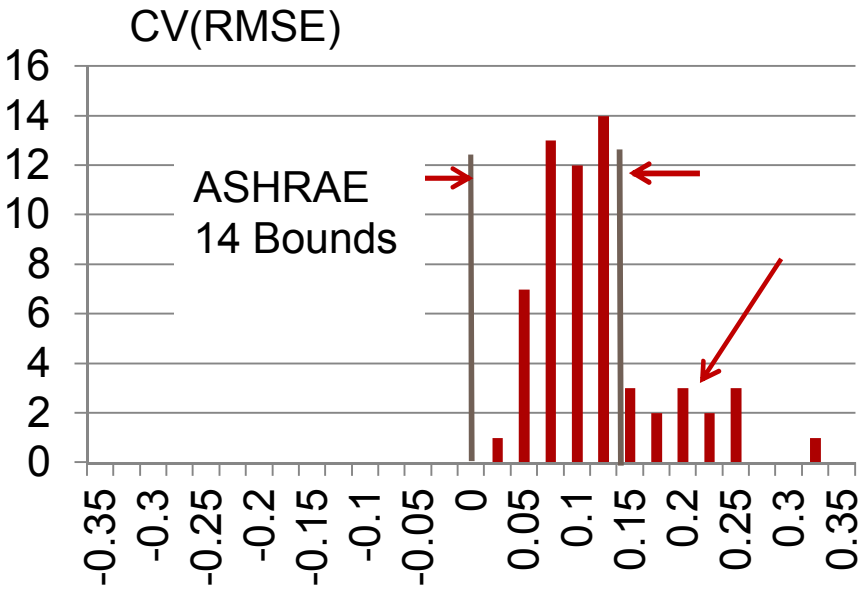
- Unreliable data natural gas metering



Problems (2)

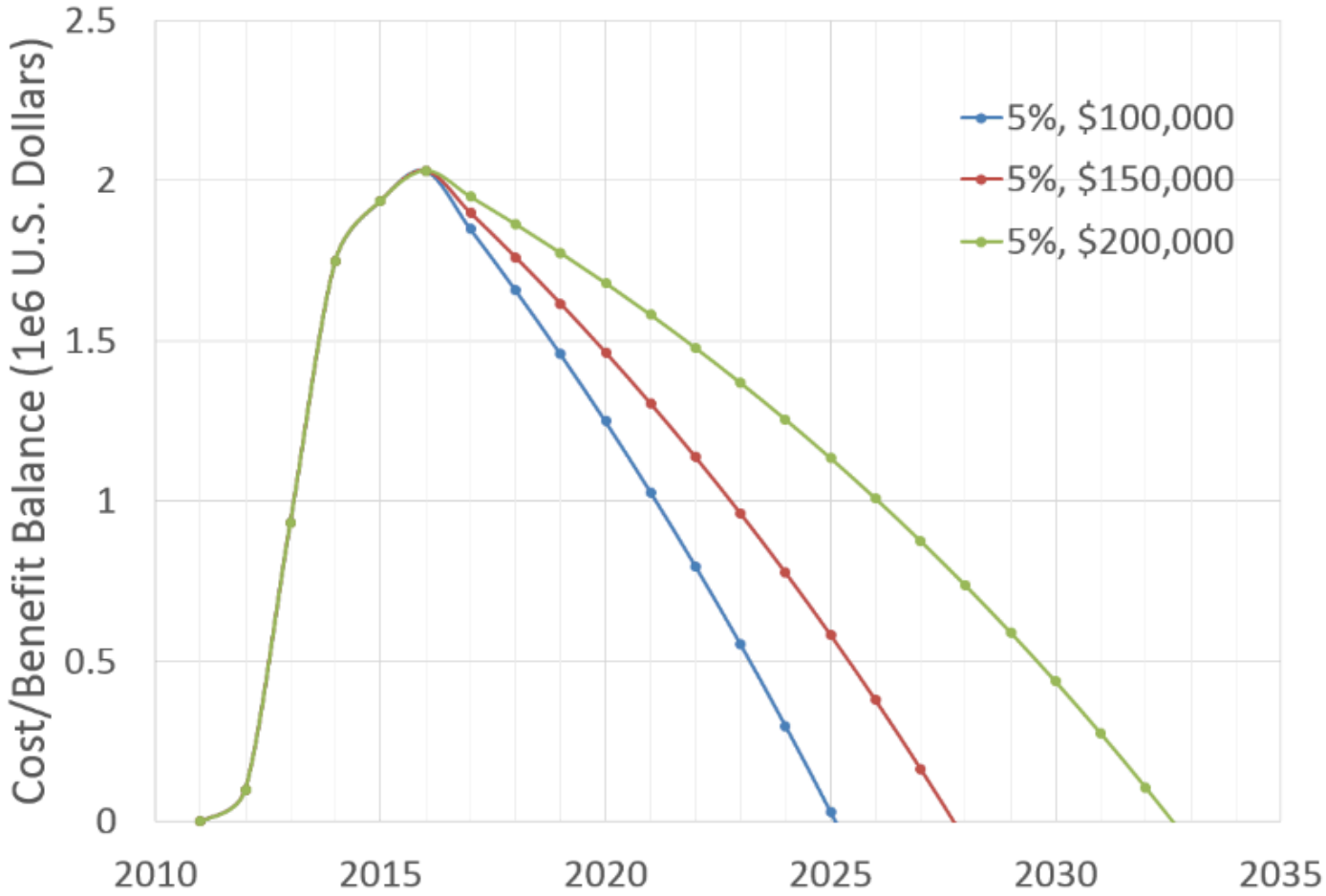
- Unreliable models
  - 51 yet to be calibrated due to lack of data
  - Of 69 evaluated
    - 54% meet |NMBE|<5%
    - 79% meet CV(RMSE) < 15
    - 31% meet ASHRAE Guideline 14
  - No way to assess confidence interval in energy savings predicted





Problems (3)

- All of this is expensive to build and maintain!



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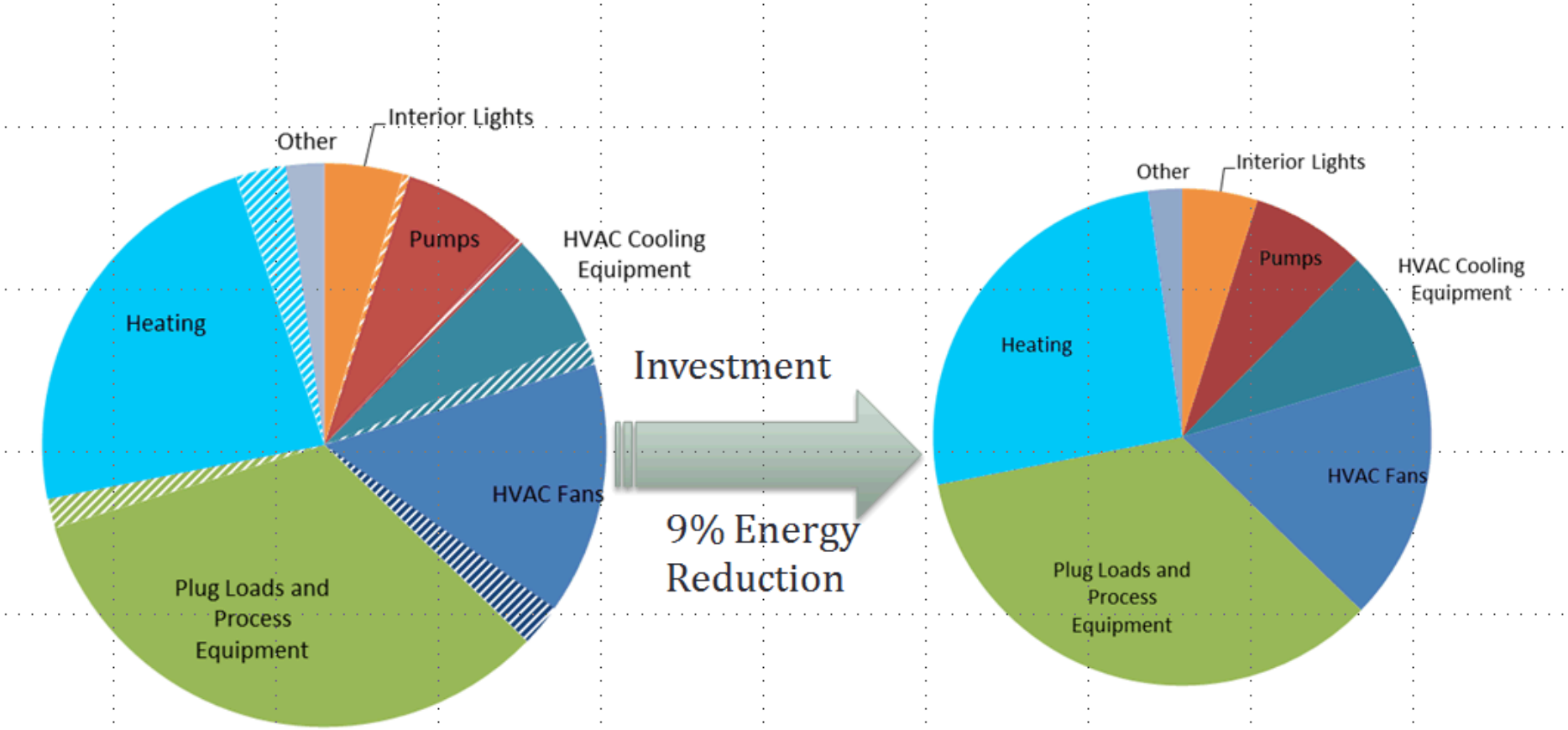
Now to the positive results …

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

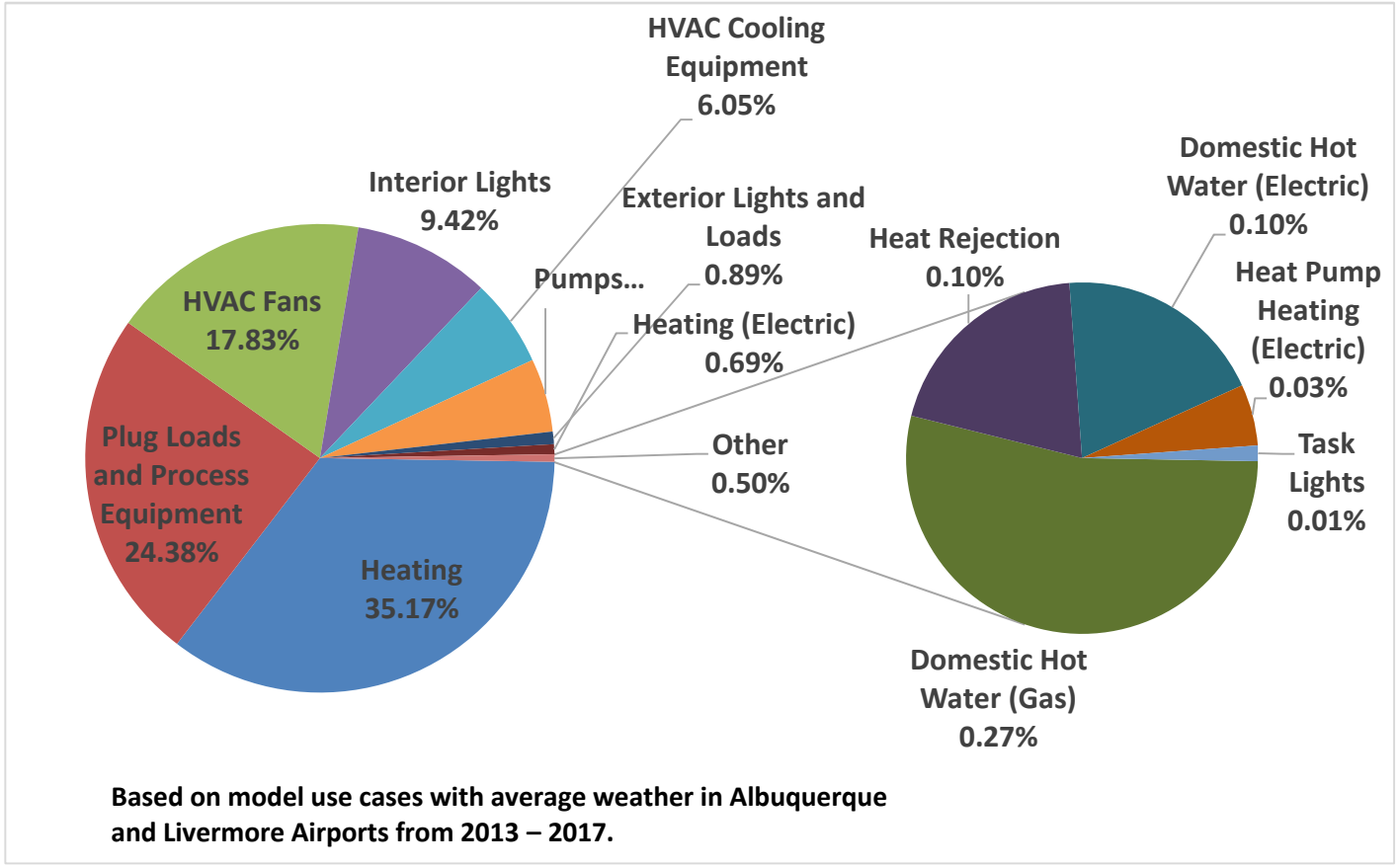
  - If an ECM is needed and it can be modeled accurately in DOE2.2, we can provide a site-wide result.

9% Energy Reduction since 2011

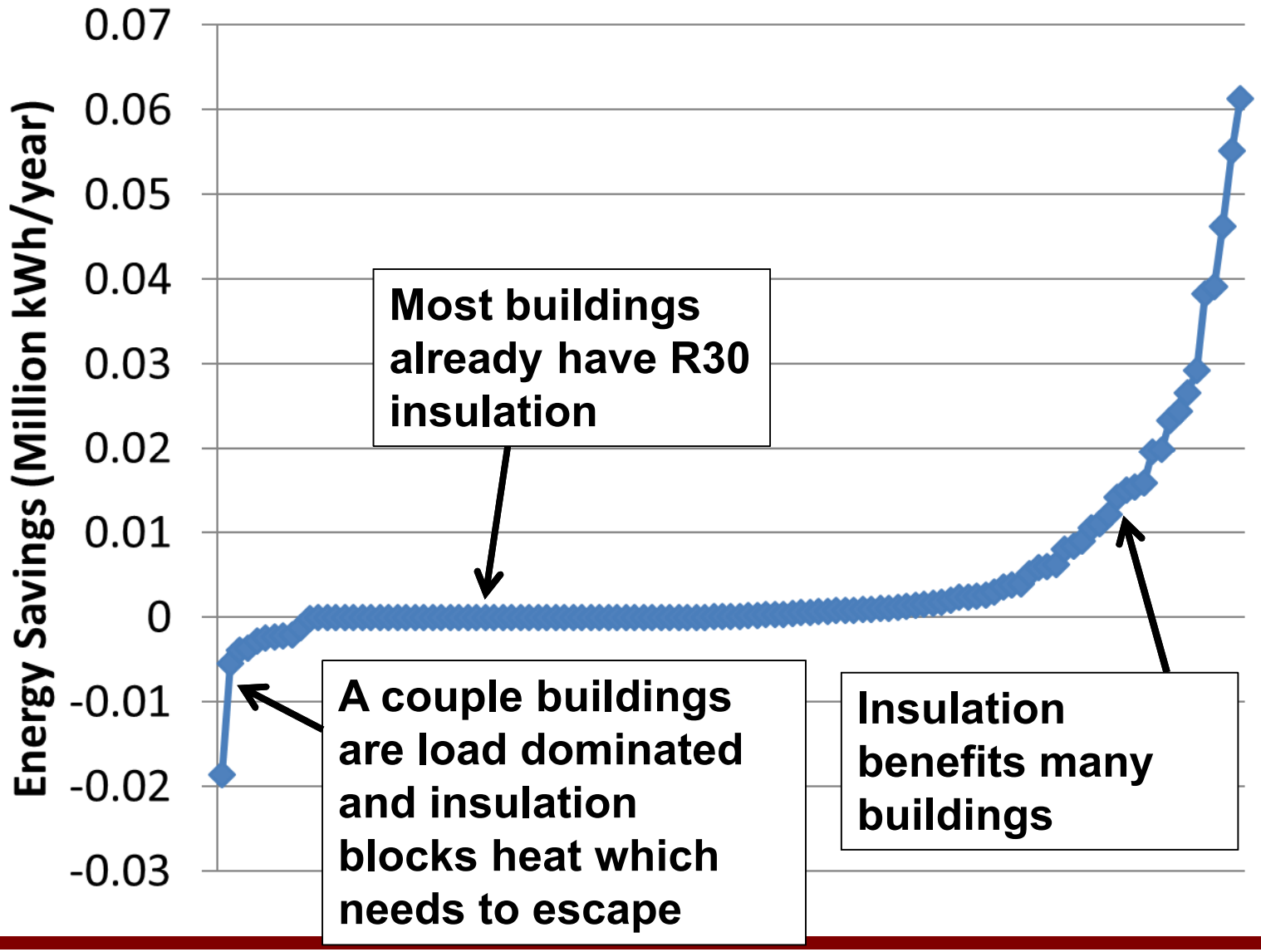


Institution-wide Energy Break Down

- 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



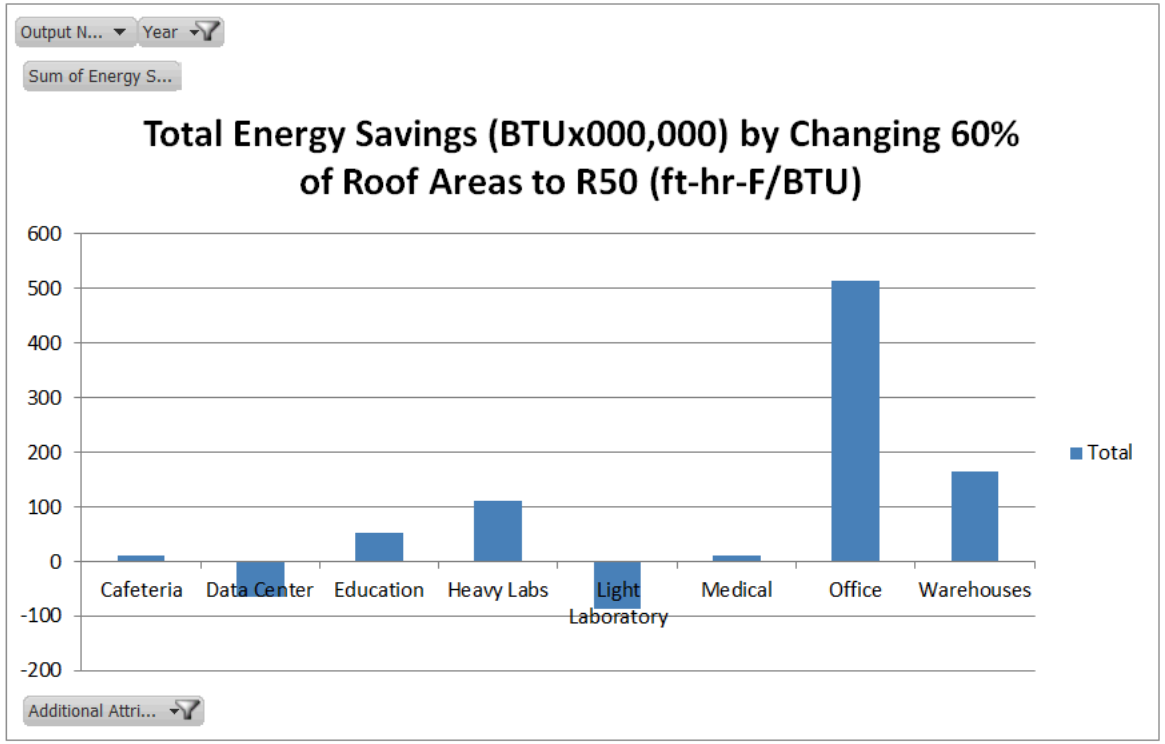
The key to making good decisions … Prioritizing ECMs



Aggregate results by many categories

The IX 2.5 Output allows larger number of ways to aggregate data.

IX 2.5 Sandia National Laboratories



Row Labels	Sum of Energy Savings
Cafeteria	11.42805961
Data Center	-64.35004385
Education	51.78489779
Heavy Labs	112.135784
Light Laboratory	-87.29167597
Medical	11.76762221
Office	513.4926488
Warehouses	164.3867036

Don’t Insulate The Roofs in California!

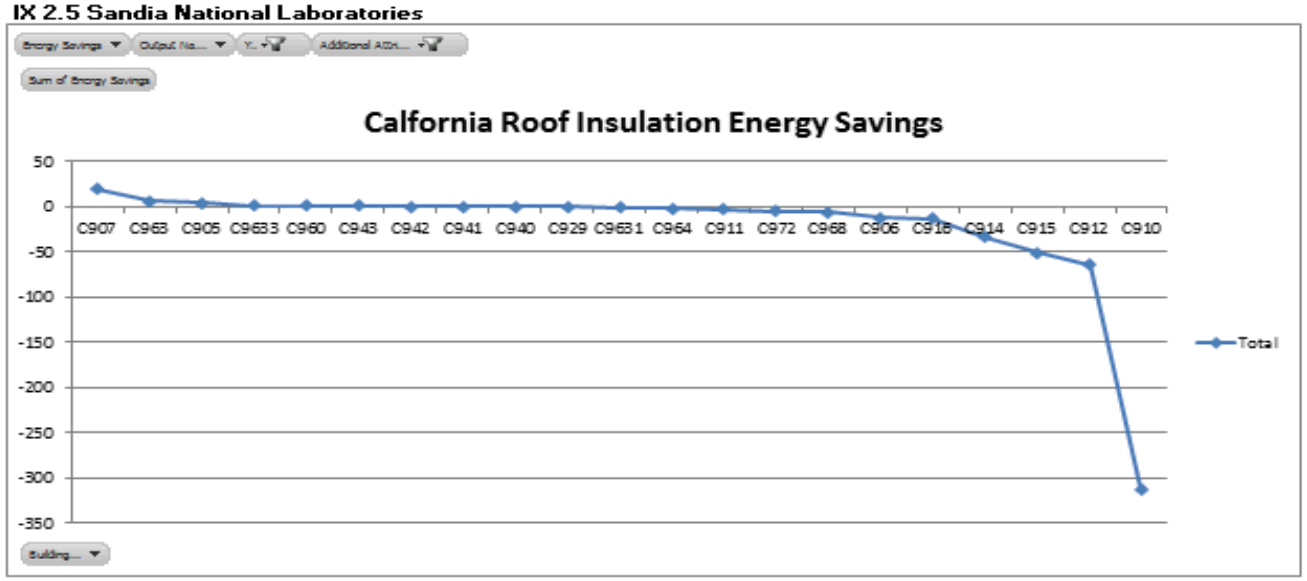
Sandia National Laboratories

Return to Scenario | Reset Sizes

Select Scenario: t3

Additional Filter Attribute: Site

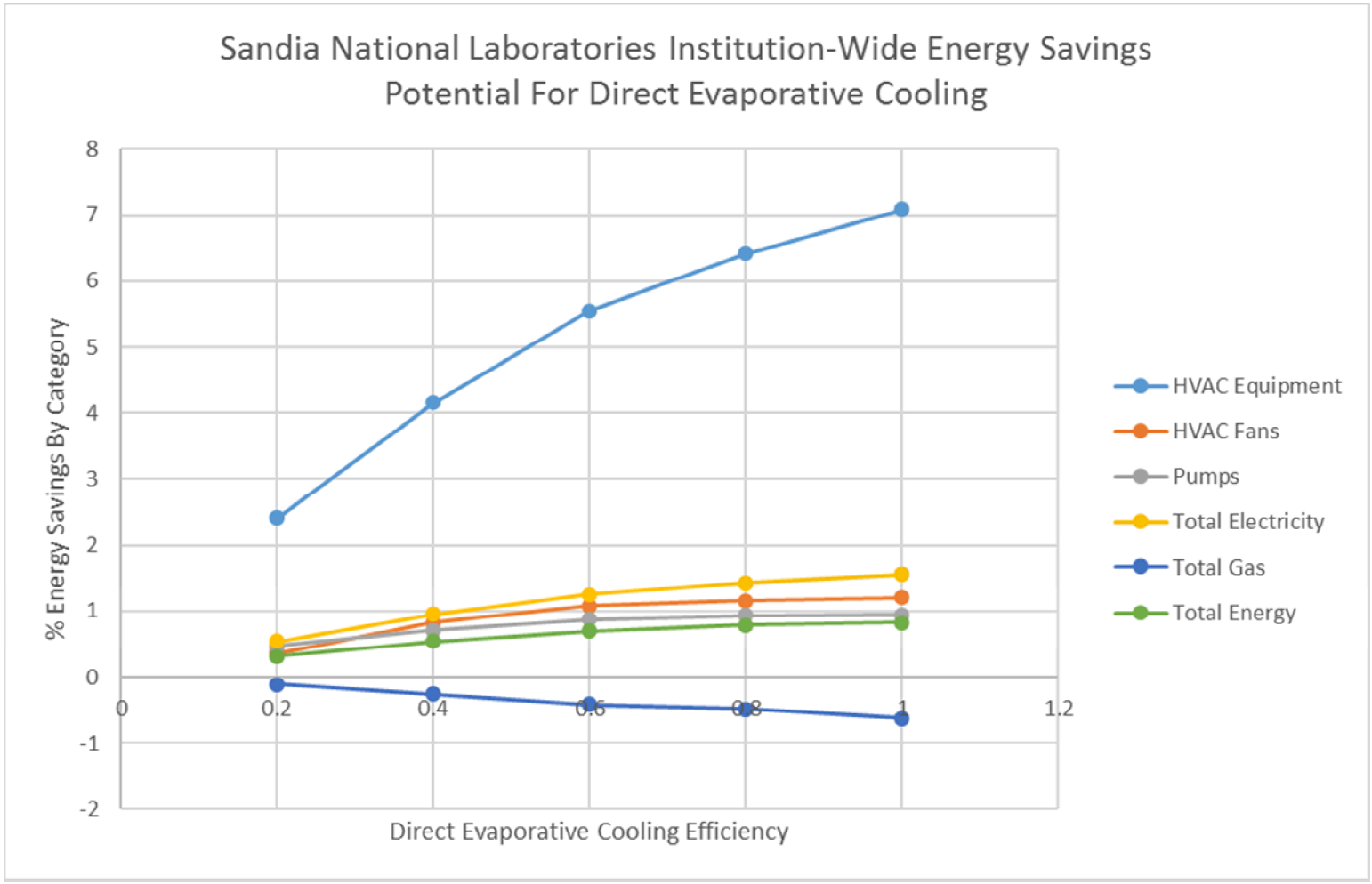
Units: BTU x 000,000



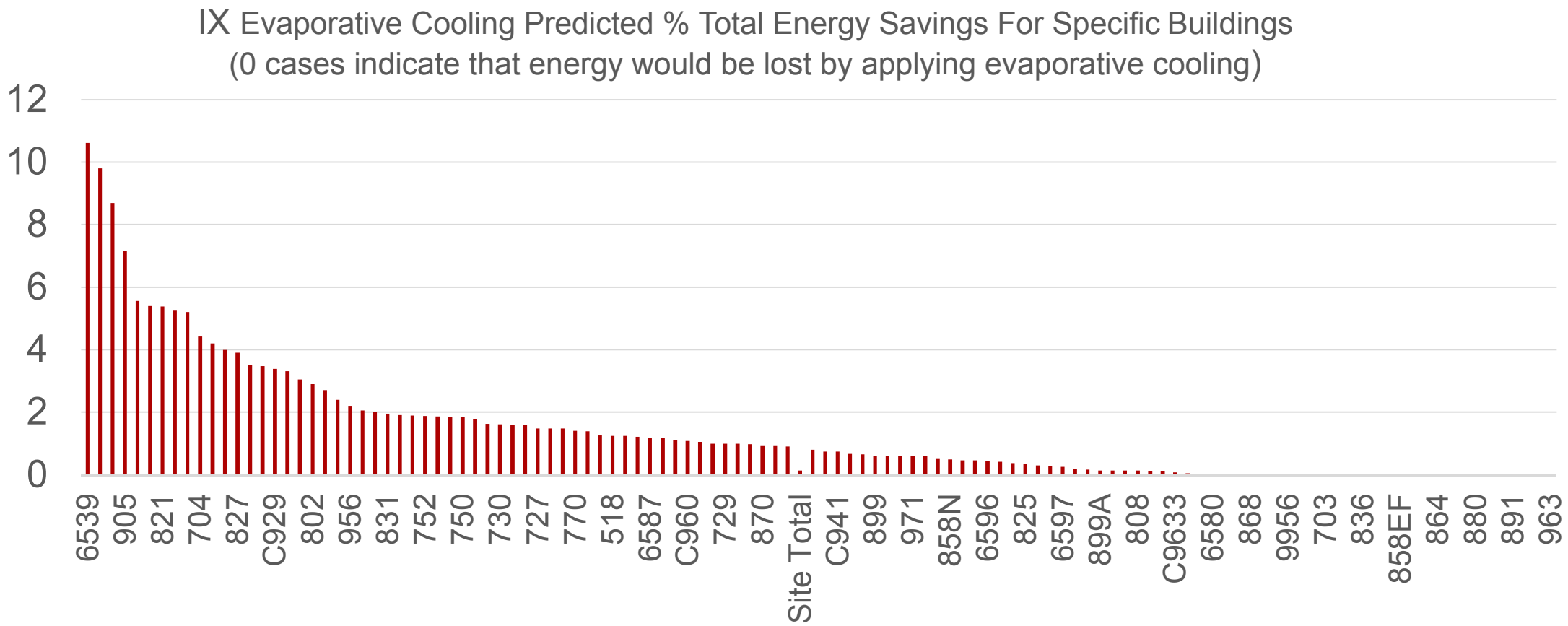
Row Labels	Sum of Energy Savings
C907	20.00599931
C963	6.644191145
C905	3.91008702
C9633	1.137846993
C960	1.059128877
C943	0.666015701
C942	0
C941	0
C940	0
C929	-0.148245842
C9631	-0.588492131
C964	-1.595551721
C911	-2.693913345
C972	-5.268722584
C968	-6.226630204
C906	-12.55589785
C916	-13.50323876
C914	-33.74103953
C915	-51.4003706
C912	-64.35004385
C910	-312.0015697

Evaporative Cooling

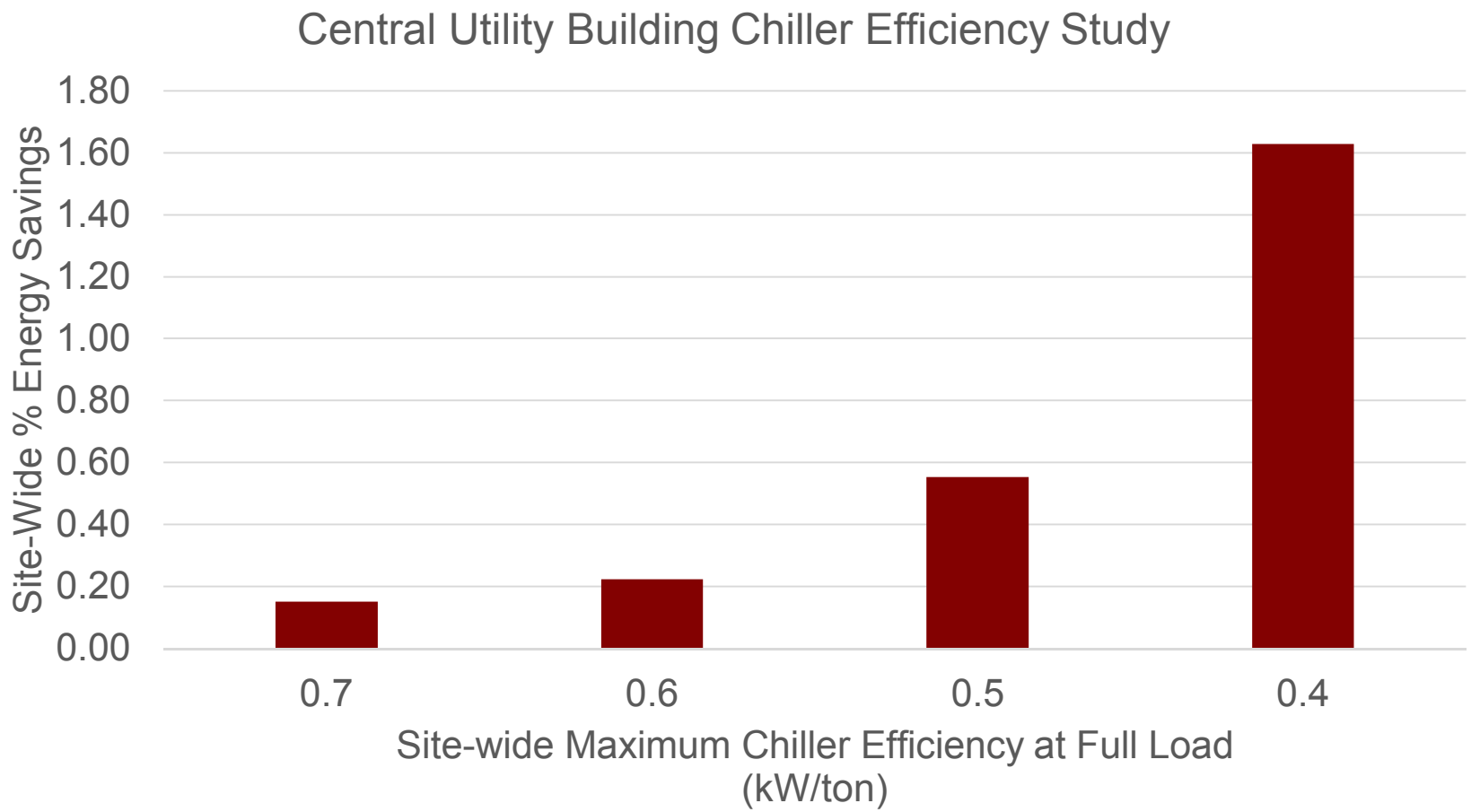
Direct Evaporative Cooling – 0.83% energy savings potential



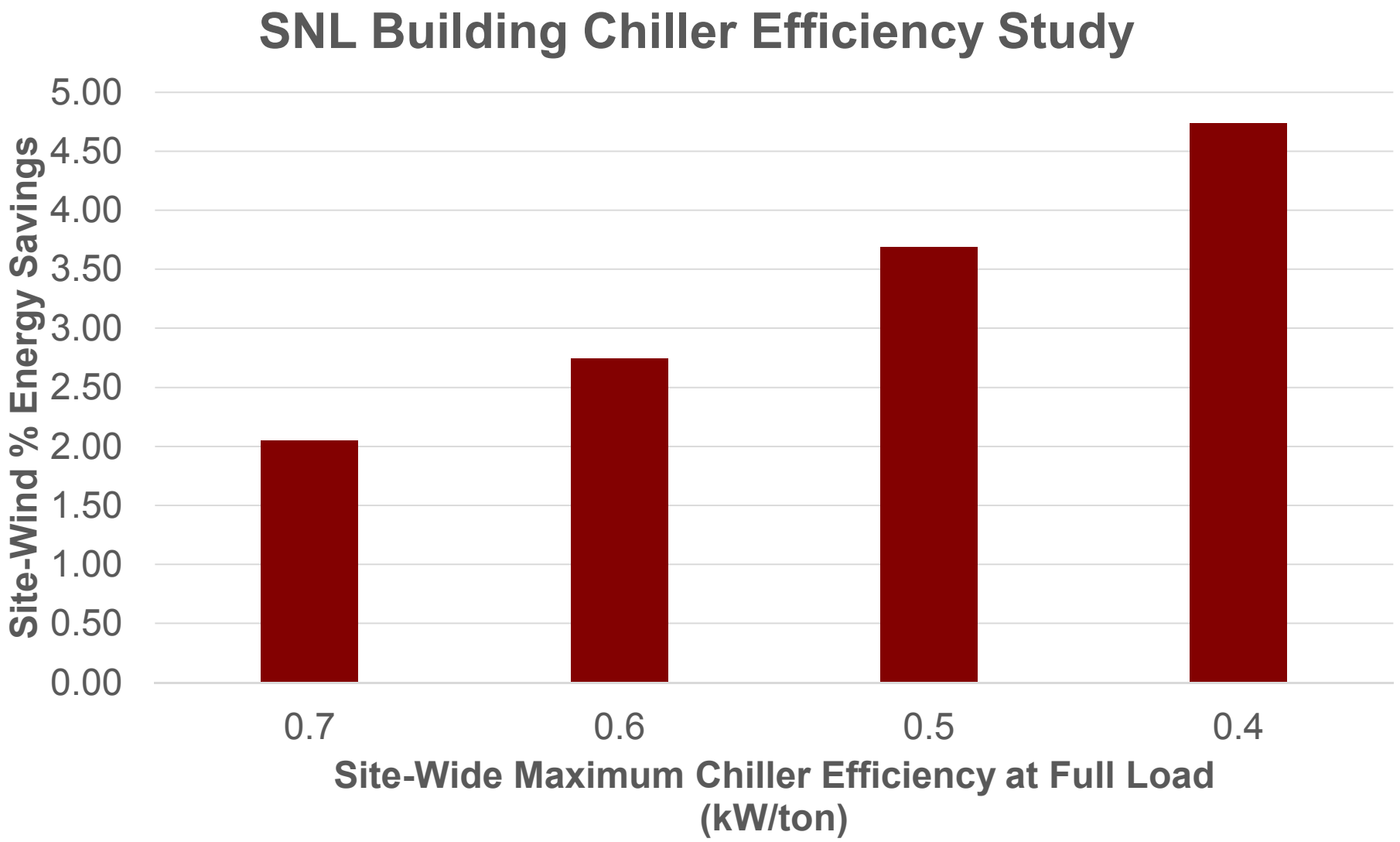
Direct Evaporative Cooling



Central utility chiller study



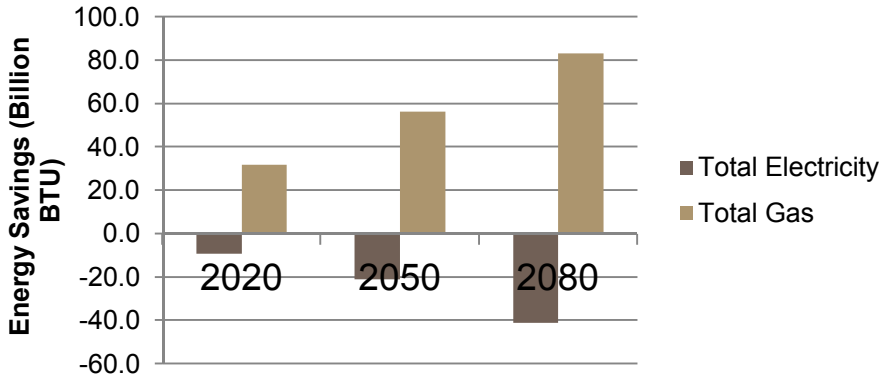
Individual building chillers



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

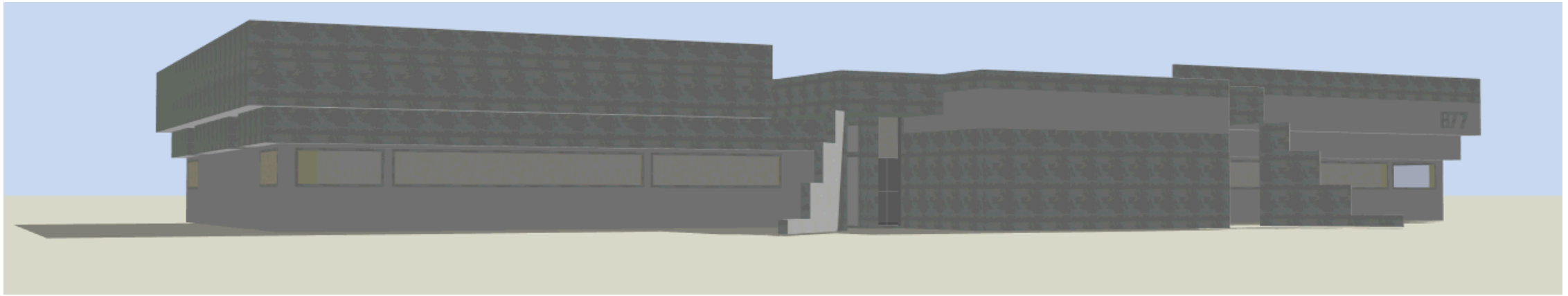


Current Plans

- Automatic ECM application to models (same as E+ measures only for DOE2.2 models)
- Copyright assertion of IX 2.6
- Automated calibration of 17 models through Tunation, LLC

Future plans

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



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

Conclusions

- The IX building module software has been shown to deliver very useful energy efficiency information
- 120 models of Sandia National Laboratories NM and CA sites have been evaluated over about 20 ECMs site-wide
- Efforts are being made to use the 120 models in other applications beyond the IX building module
- Model and data accuracy is difficult to verify and validate

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Questions?