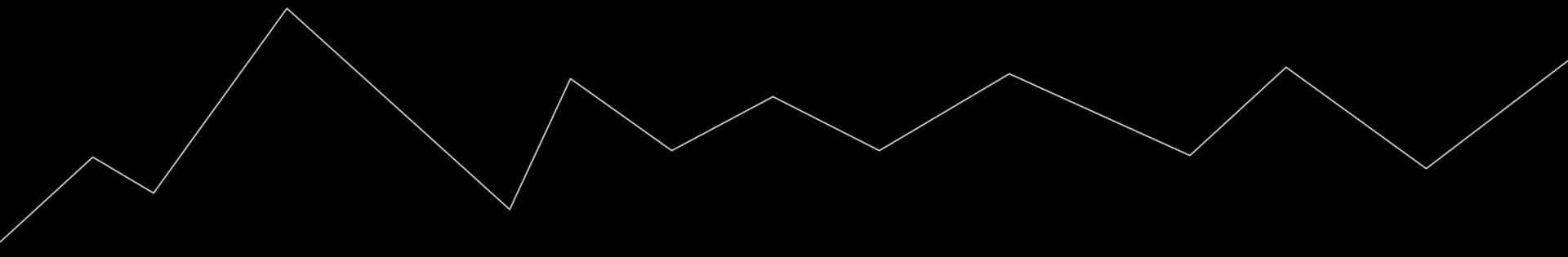
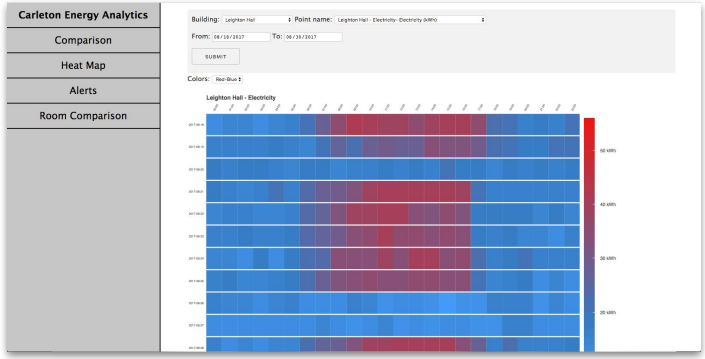
Unified Energy System: What's the Point?

Jon Bisila, Kiya Govek, Jack Lightbody,
Zephyr Lucas, Dustin Michels, Carolyn Ryan



Overview



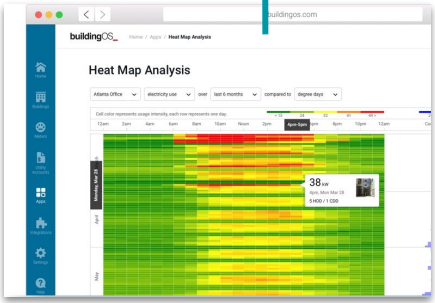
Sep 2017

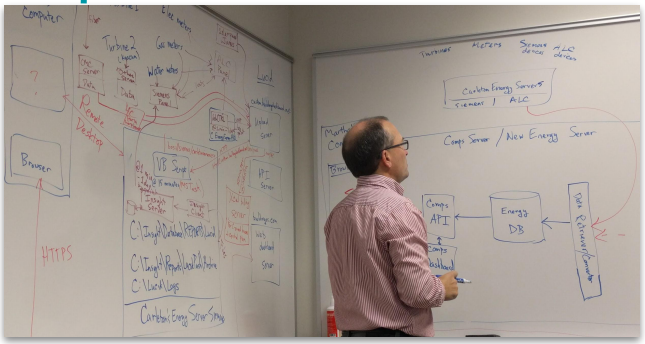
Oct 2017

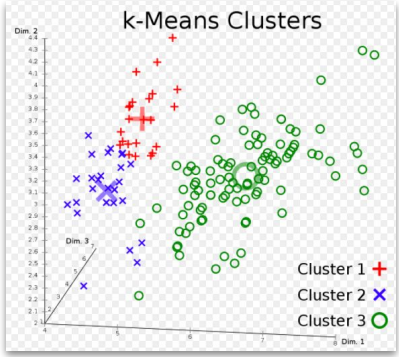
Nov 2017

Jan 2018

Feb 2018







problem
data
database
api
dashboard
analysis
conclusion

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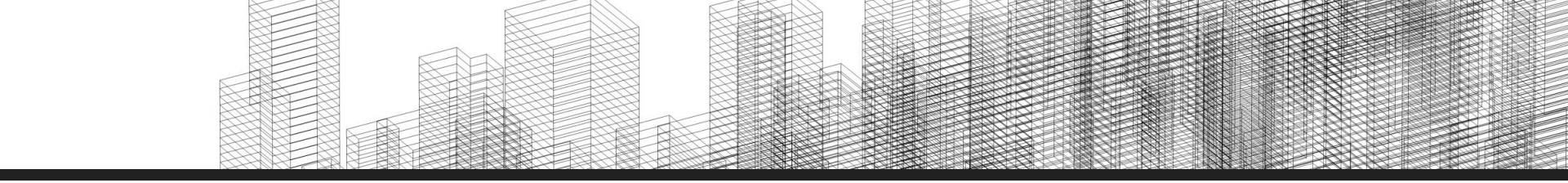
data
database
api
dashboard
analysis
conclusion

1. What is energy analytics?
2. Why do we care?
3. Current System
4. Our Task



What is “energy analytics?”

1. **What is energy analytics?**
2. Why do we care?
3. Current System
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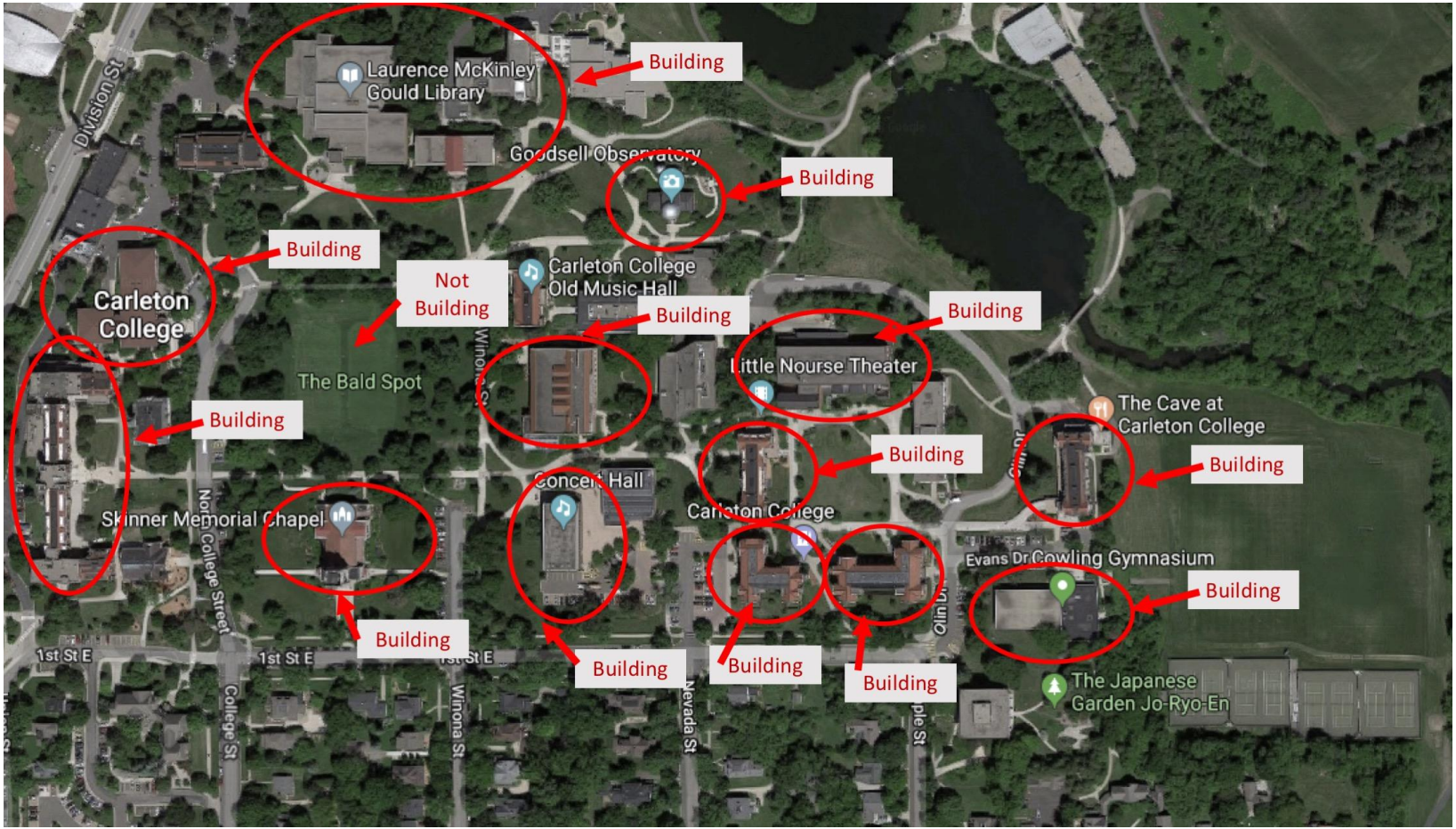
WEITZ CENTER FOR CREATIVITY


Laurence McKinley Gould Library
Building
Goodsell Observatory
Building
Building
Carleton College
Not Building
Carleton College Old Music Hall
Building
Building
Little Nourse Theater
The Bald Spot
Building
The Cave at Carleton College
Building
Building
Concert Hall
Carleton College
Skinner Memorial Chapel
Evans Dr
Cowling Gymnasium
Building
Building
Building
Building
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Building
The Japanese Garden Jo-Ryo-En
Division St
College Street
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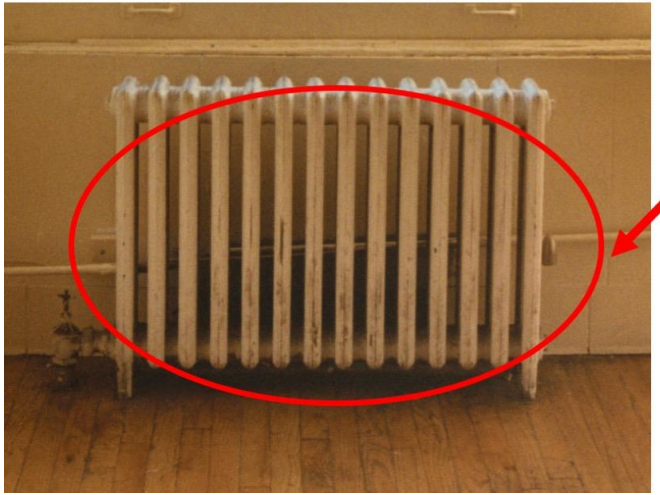
College St
Winona St
Nevada St
Olin Dr

Thermostat

VAV Box



Radiators

Air handling unit

Ideally, **equipment is...**

- Functioning properly
- Active only when necessary
- Coordinating with others / taking relevant information into account

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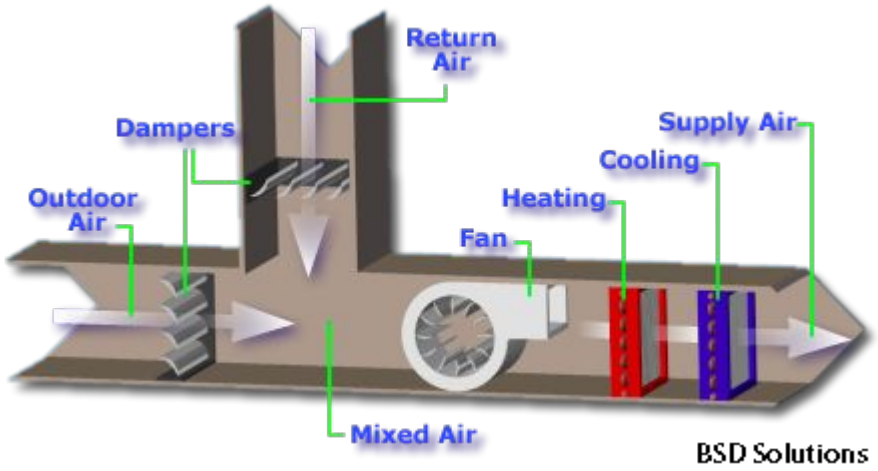
http://www.kbic.com/blog/wp-content/uploads/team-player.jpg

Ideally, equipment is...

Air side economizer



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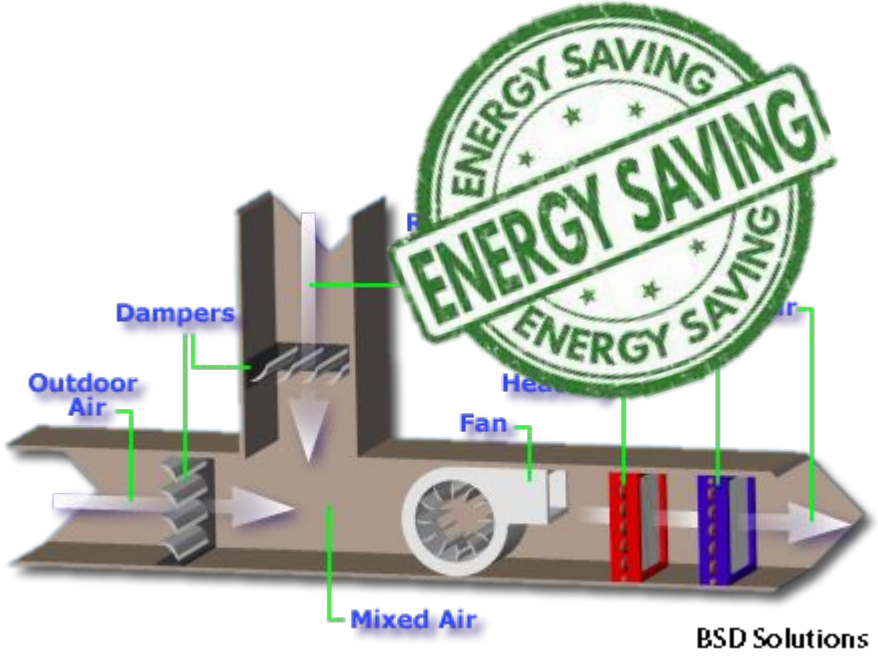

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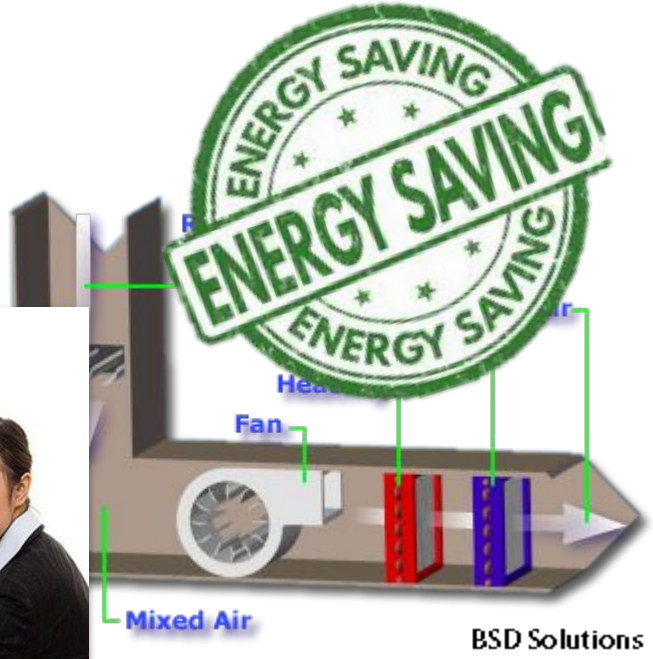

Un-ideally, **equipment is...**

- Malfunctioning / broken
- “Over-cycling” in search of target
- Fighting other equipment

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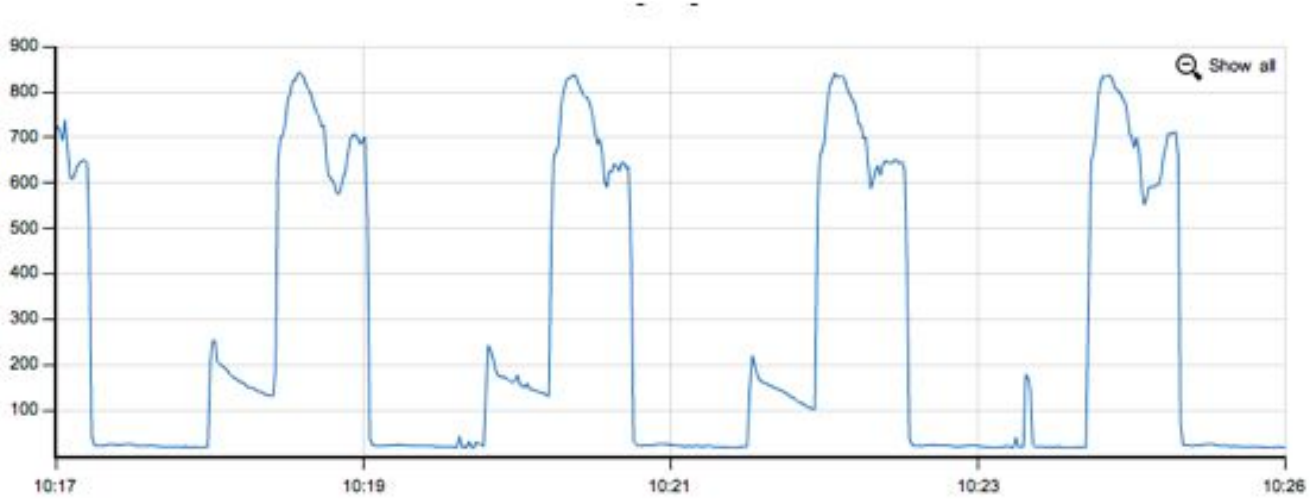

http://blog.virtjoule.com/2011/10/hvac-sensor-reporting-intervals/

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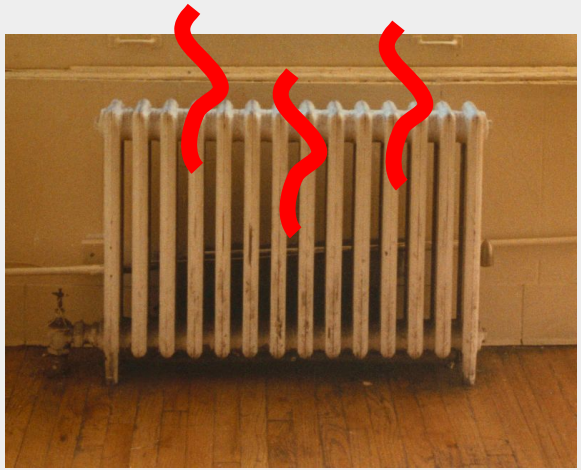

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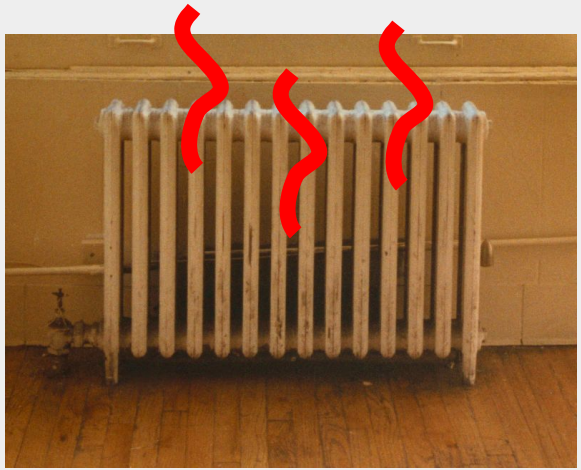

“Simultaneous heating and cooling”

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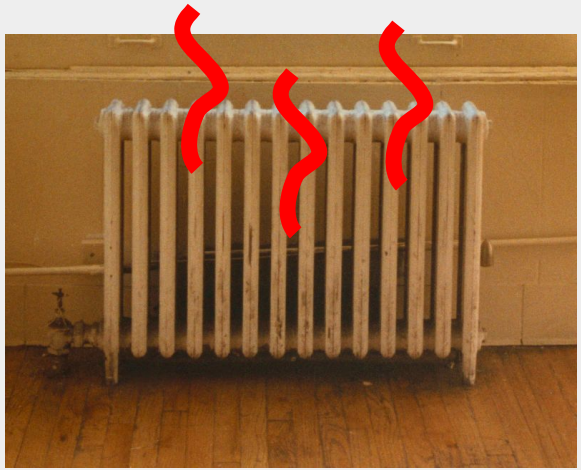

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“Simultaneous heating and cooling”

Energy Analytics Tools

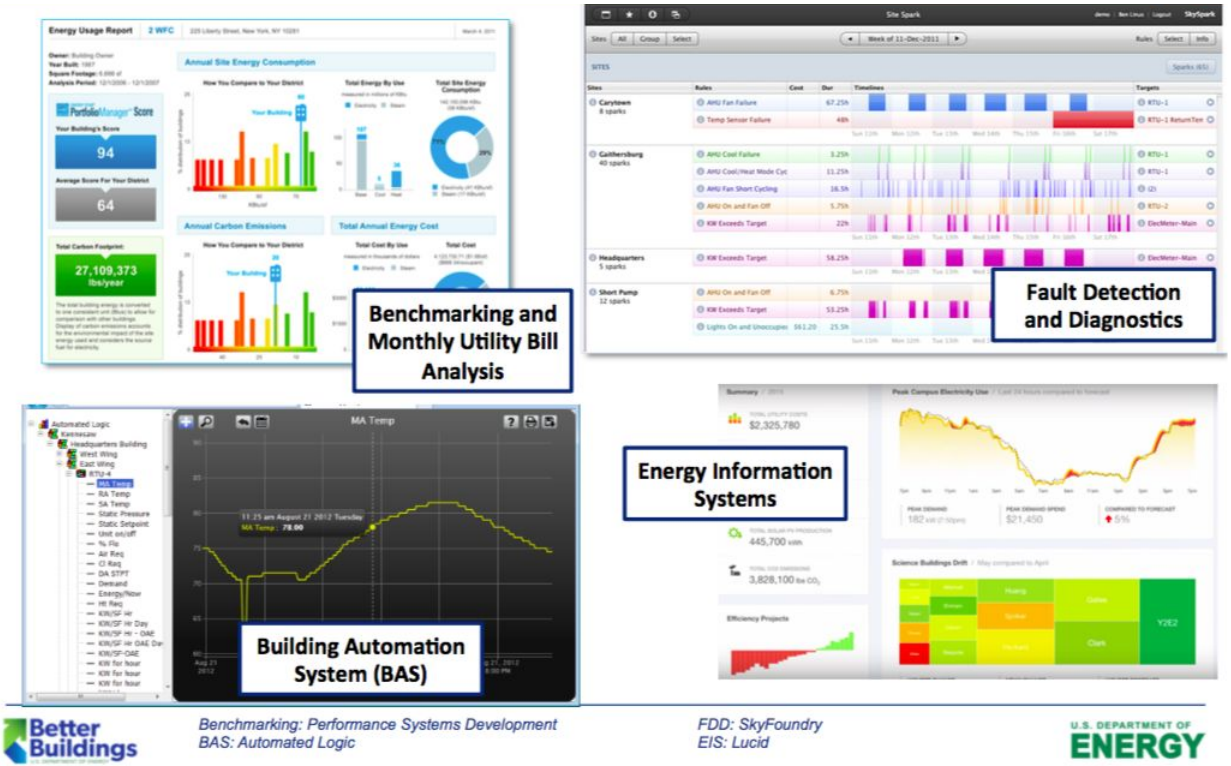
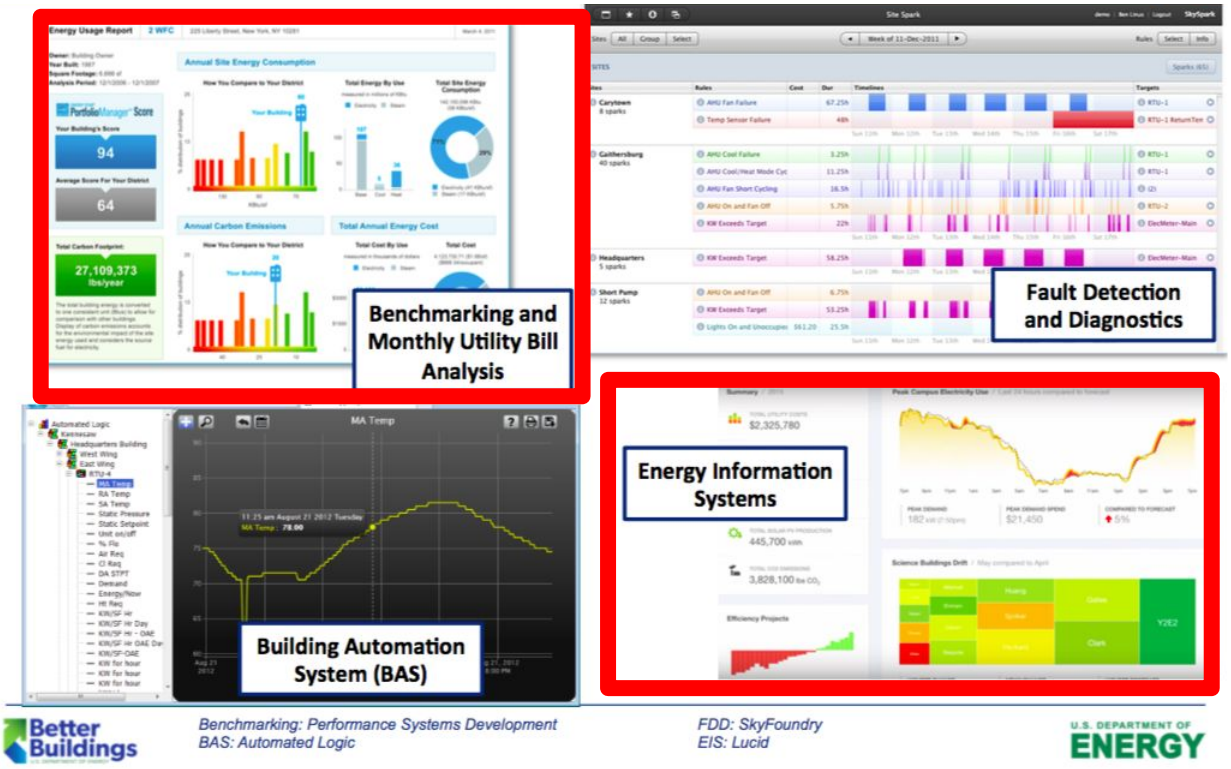


Image from: “Better Buildings Alliance EMIS Team: New Resources” (March 2017)

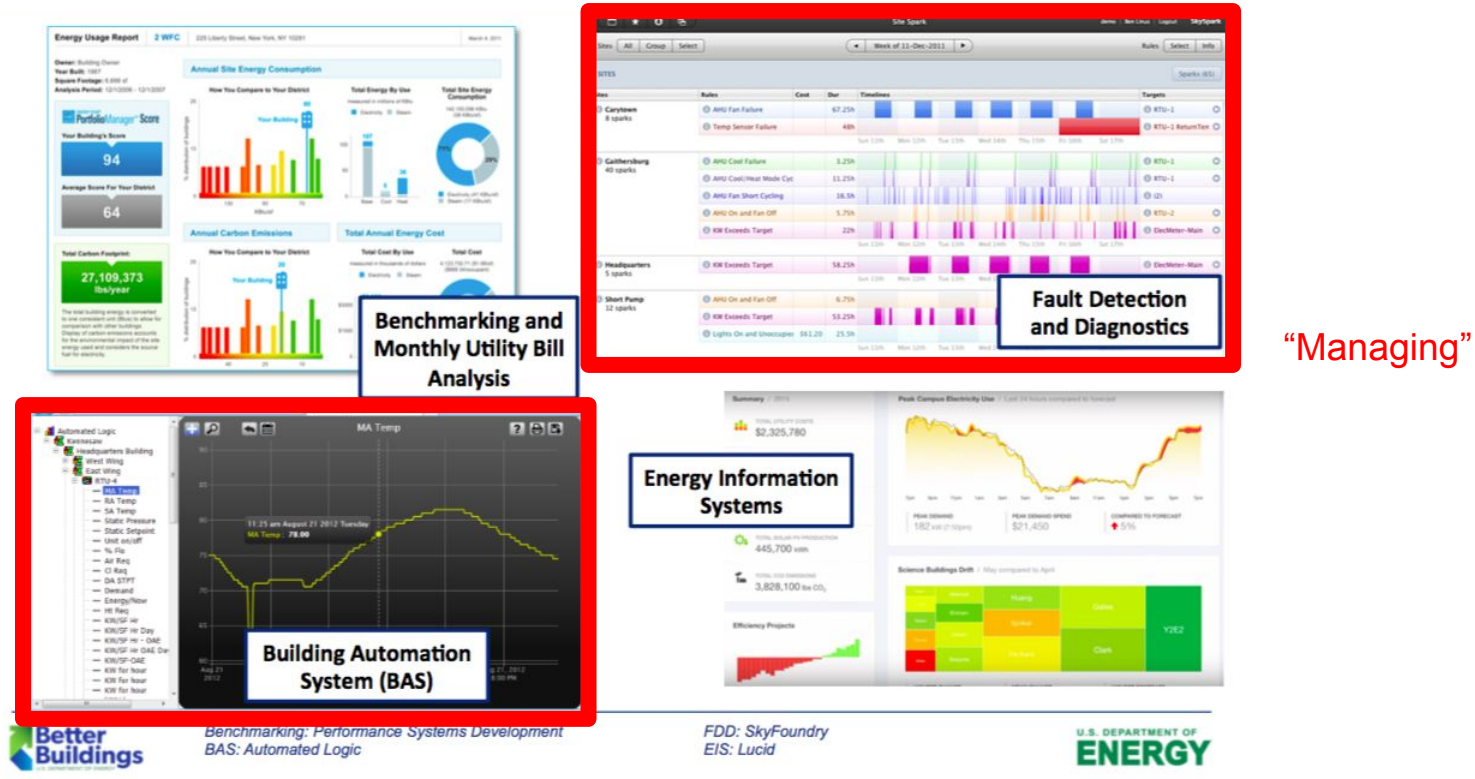
Energy Analytics Tools



"Monitoring"

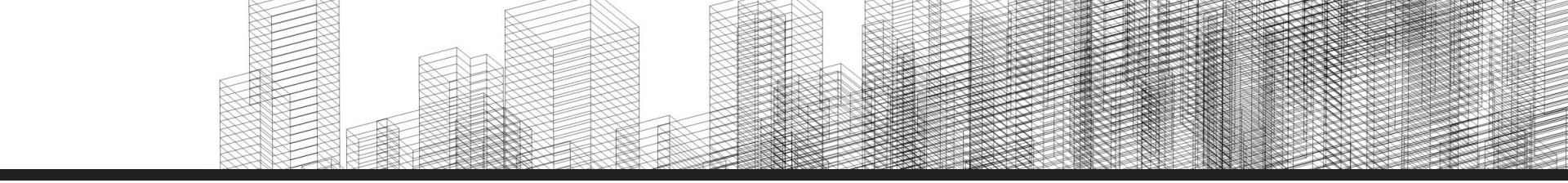
Image from: "Better Buildings Alliance EMIS Team: New Resources" (March 2017)

Energy Analytics Tools



"Managing"

Image from: "Better Buildings Alliance EMIS Team: New Resources" (March 2017)



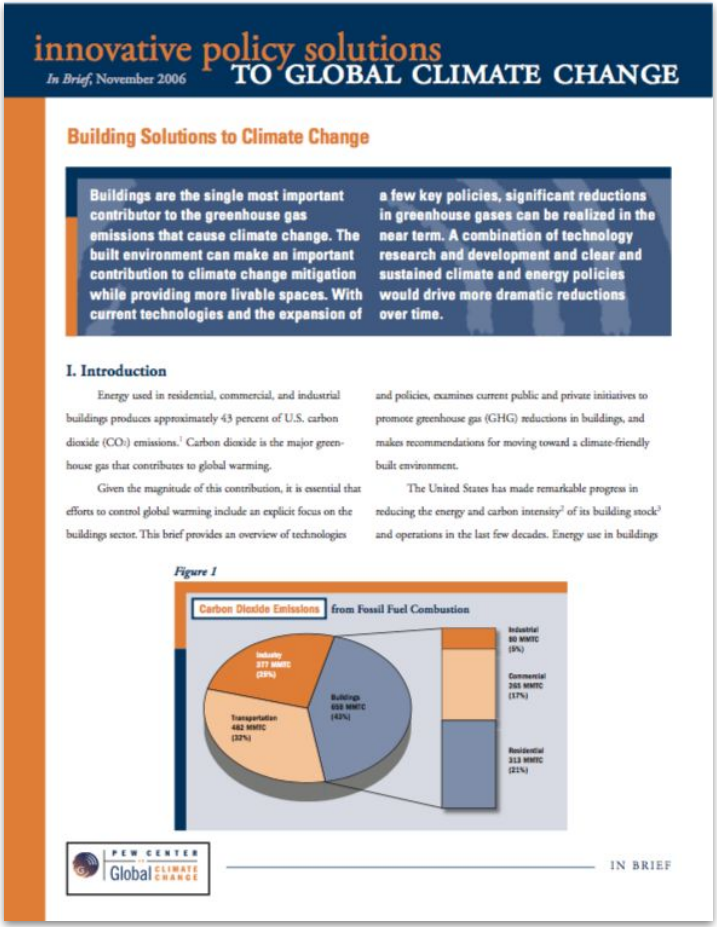
Why do we care?

1. What is energy analytics?
2. **Why do we care?**
3. Current System
4. Our Task

What’s the point?

What's the point?

1. Climate Change



innovative policy solutions
TO GLOBAL CLIMATE CHANGE

In Brief, November 2006

Building Solutions to Climate Change

Buildings are the single most important contributor to the greenhouse gas emissions that cause climate change. The built environment can make an important contribution to climate change mitigation while providing more livable spaces. With current technologies and the expansion of a few key policies, significant reductions in greenhouse gases can be realized in the near term. A combination of technology research and development and clear and sustained climate and energy policies would drive more dramatic reductions over time.

I. Introduction

Energy used in residential, commercial, and industrial buildings produces approximately 43 percent of U.S. carbon dioxide (CO_2) emissions.[1] Carbon dioxide is the major greenhouse gas that contributes to global warming.

Given the magnitude of this contribution, it is essential that efforts to control global warming include an explicit focus on the buildings sector. This brief provides an overview of technologies and policies, examines current public and private initiatives to promote greenhouse gas (GHG) reductions in buildings, and makes recommendations for moving toward a climate-friendly built environment.

The United States has made remarkable progress in reducing the energy and carbon intensity[2] of its building stock[3] and operations in the last few decades. Energy use in buildings

Figure 1

PEW CENTER Global CLIMATE CHANGE

IN BRIEF

What's the point?

1. Climate Change

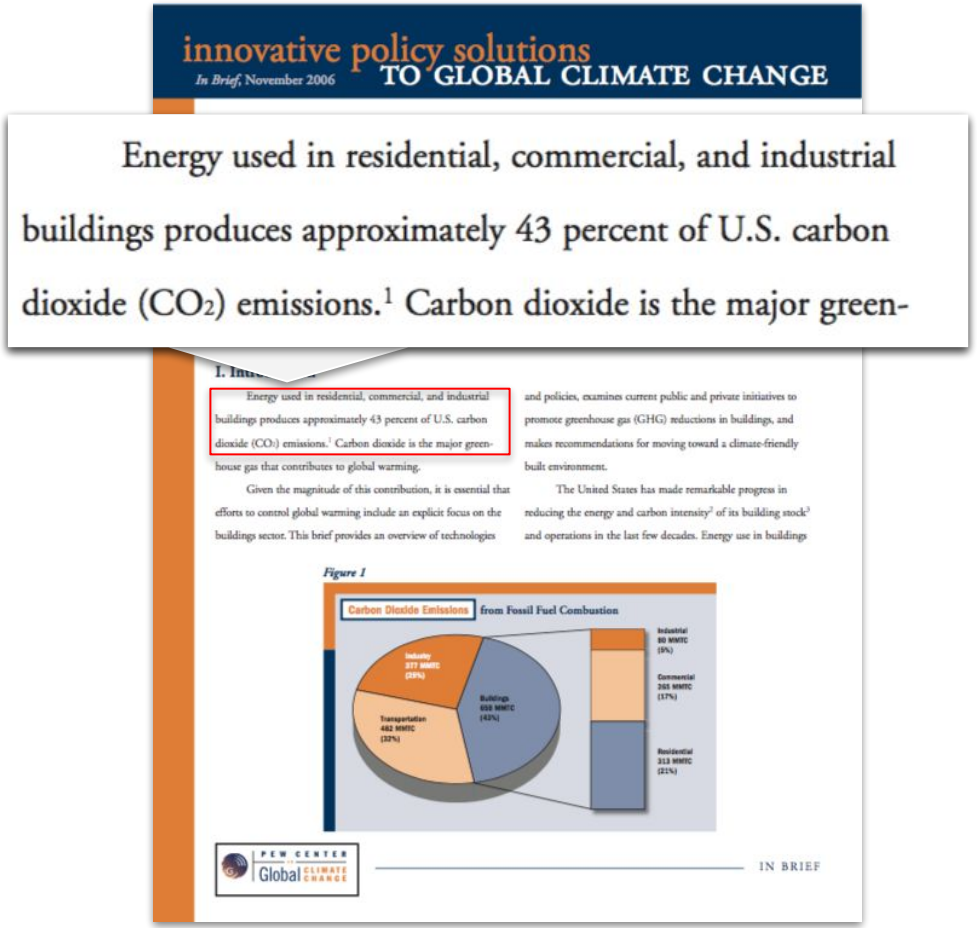


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Figure 1

Carbon Dioxide Emissions from Fossil Fuel Combustion

PEW CENTER Global CLIMATE CHANGE

IN BRIEF

What’s the point?

1. Climate Change
2. **Finance**

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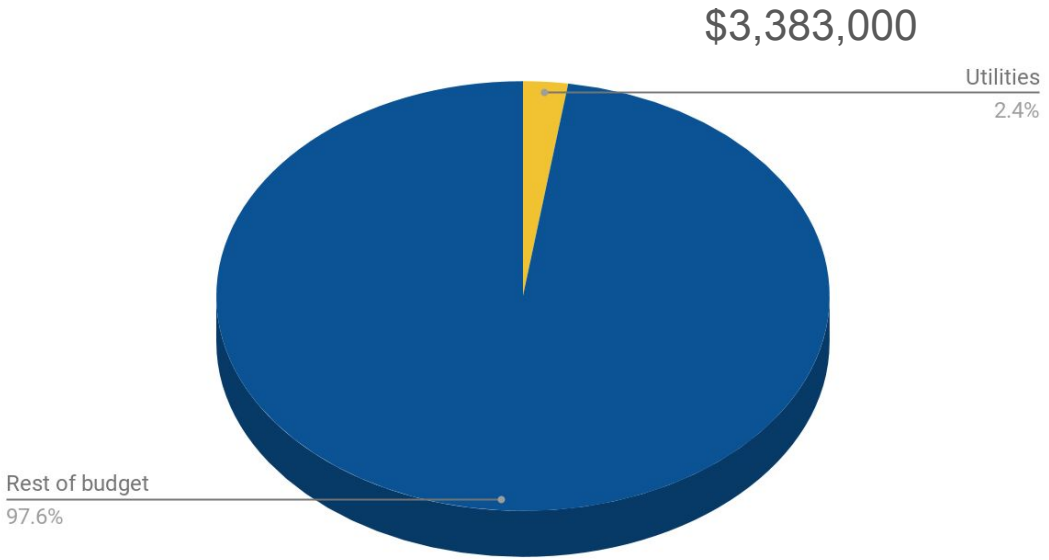
1. Climate Change
2. **Finance**



Spending 2017

What's the point?

1. Climate Change
2. Finance
3. **Knowledge for its own sake**

What's the point?

1. Climate Change
2. Finance
3. **Knowledge for its own sake**

"The unexamined building is not worth living in"
-Socrates

Carleton Already Engaged

Maintenance Staff

Martha Larson

Manager of Campus Energy and Sustainability,

Sustainability Assistants (STAs)

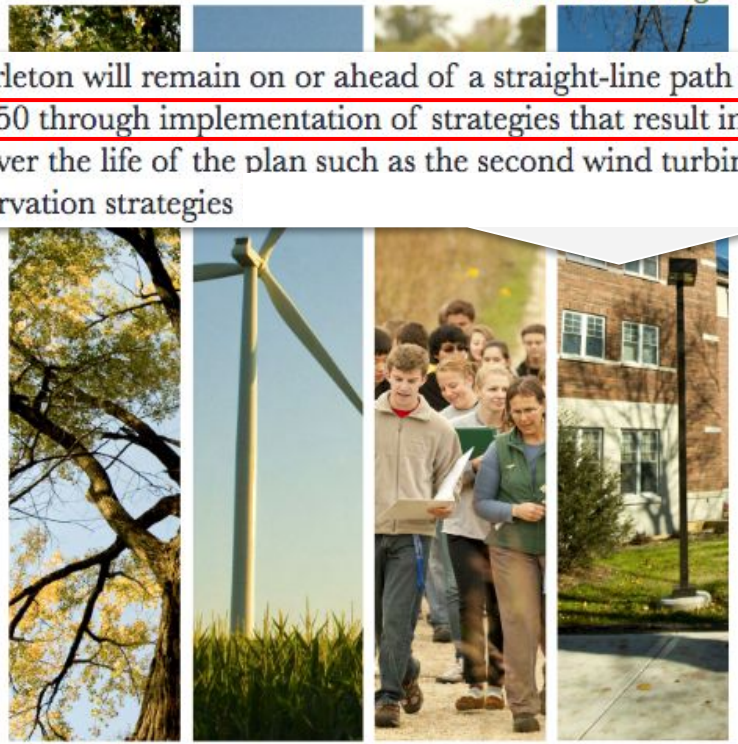
Carleton College

Climate Action Plan
May 2011

Carleton Climate Action Plan Steering Committee

Carleton College

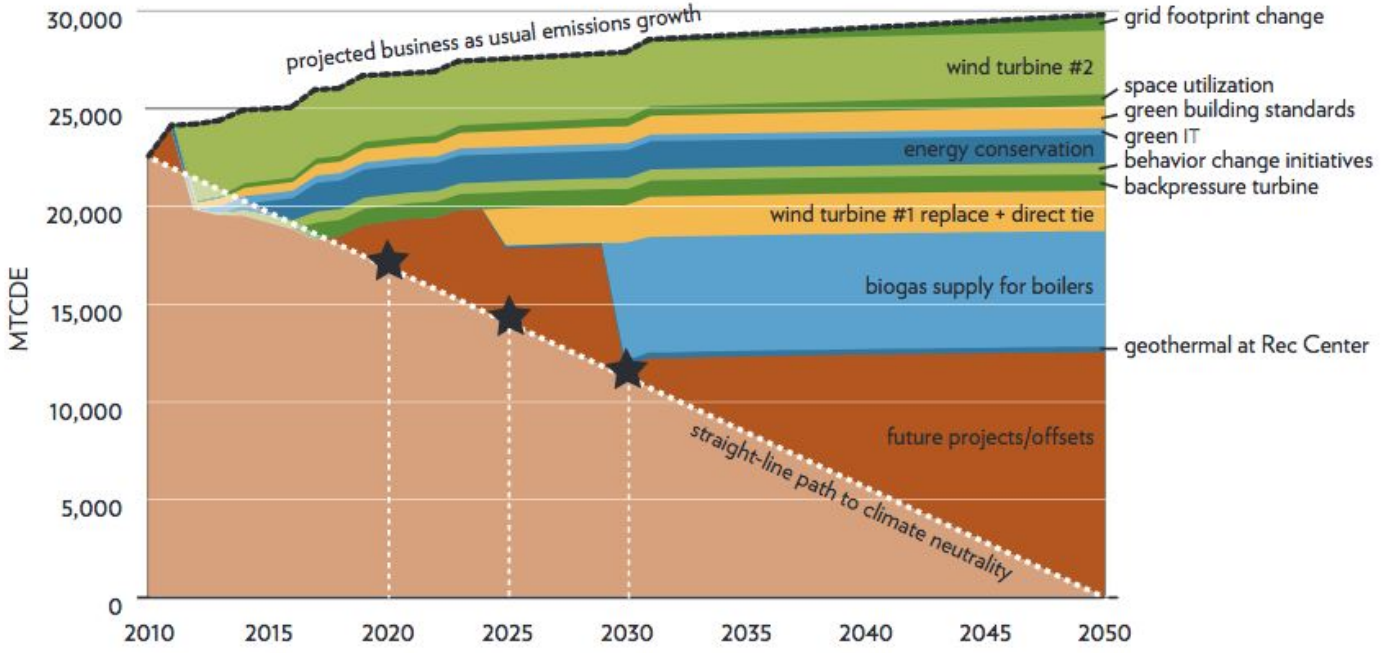
Carleton will remain on or ahead of a straight-line path to climate neutrality by 2050 through implementation of strategies that result in a net savings to the College over the life of the plan such as the second wind turbine, a portfolio of energy conservation strategies



Climate Action Plan
May 2011

Carleton Climate Action Plan Steering Committee

FIGURE VI.3: CARBON REDUCTION WEDGE DIAGRAM



★ interim net GHG emissions targets:
17,000 MTCDE by 2020; 14,000 MTCDE by 2025; 11,000 MTCDE by 2030

Climate Action Plan
May 2011

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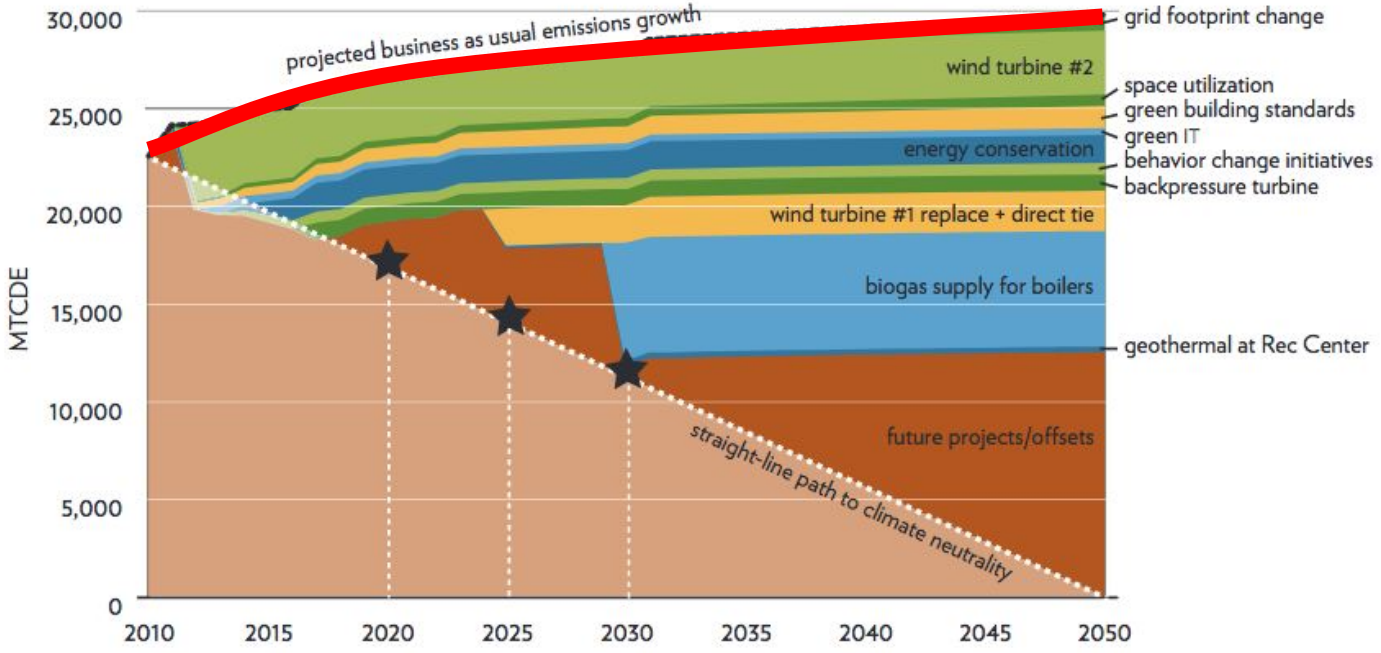

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Climate Action Plan
May 2011

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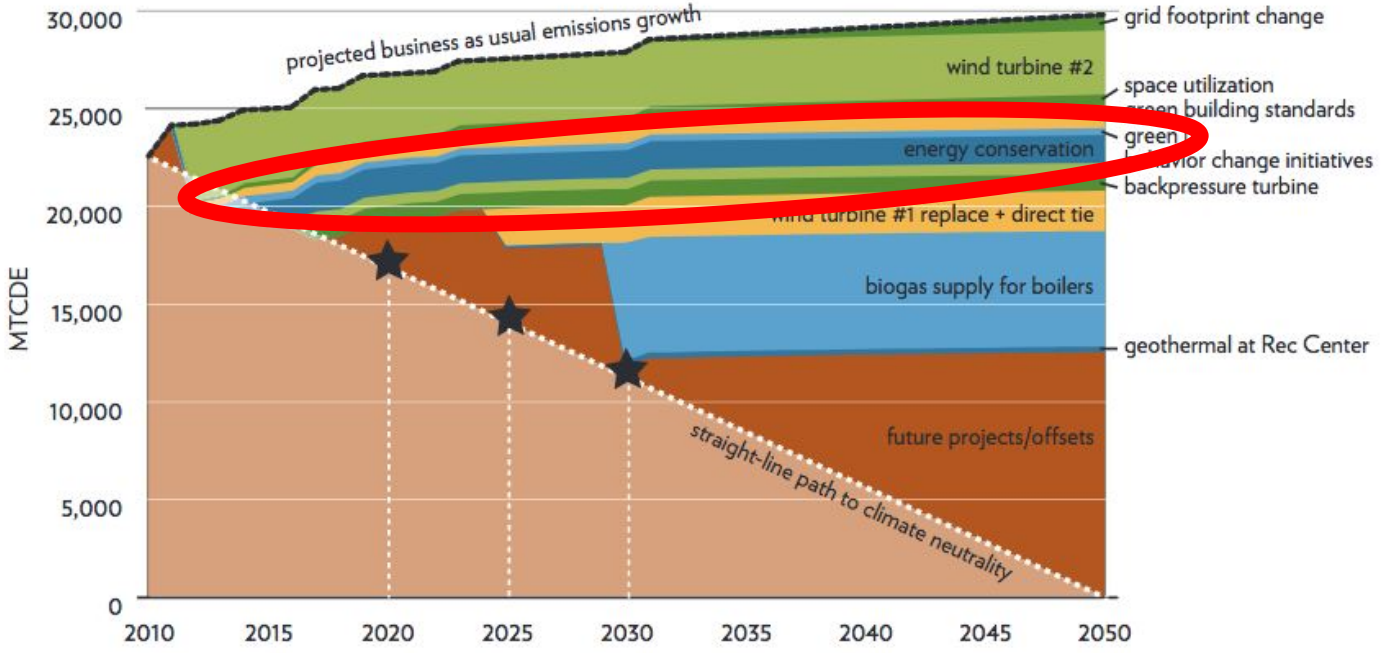

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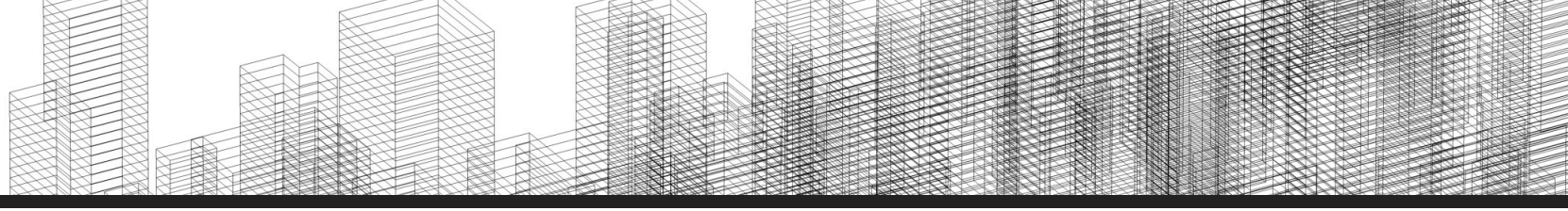
Climate Action Plan
May 2011

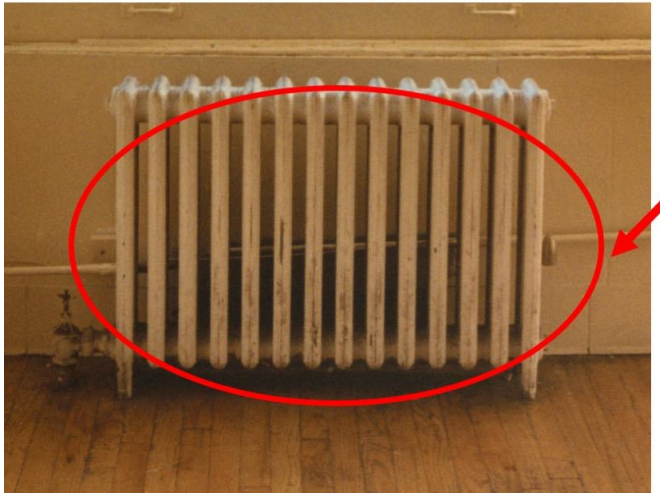


Current System

1. What is energy analytics?
2. Why do we care?
3. **Current System**
4. Our Task

Thermostat

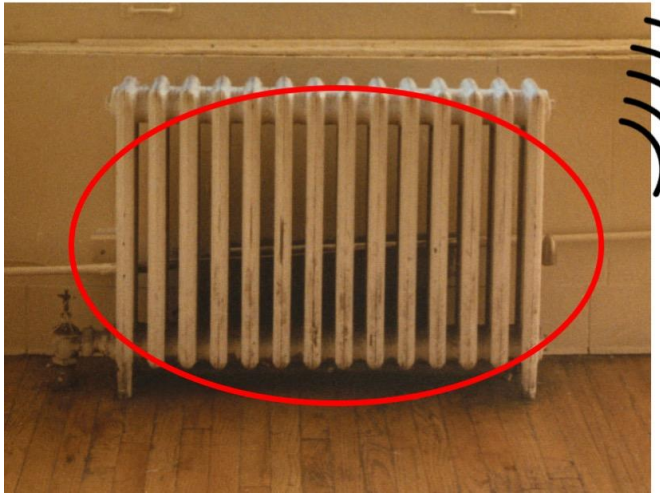
VAV Box



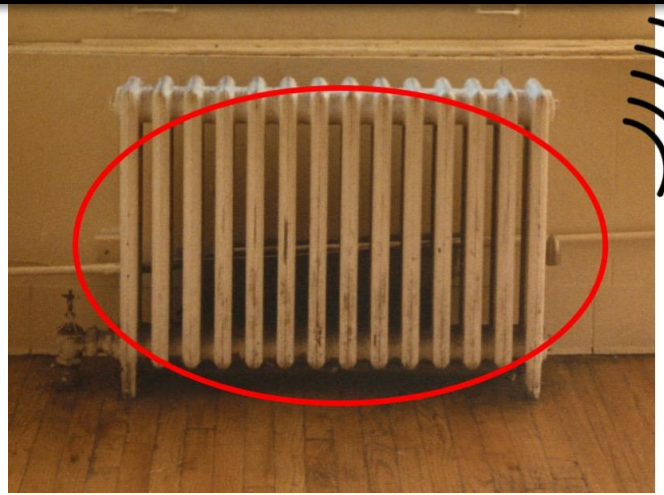
Radiators

Air handling unit


Honeywell



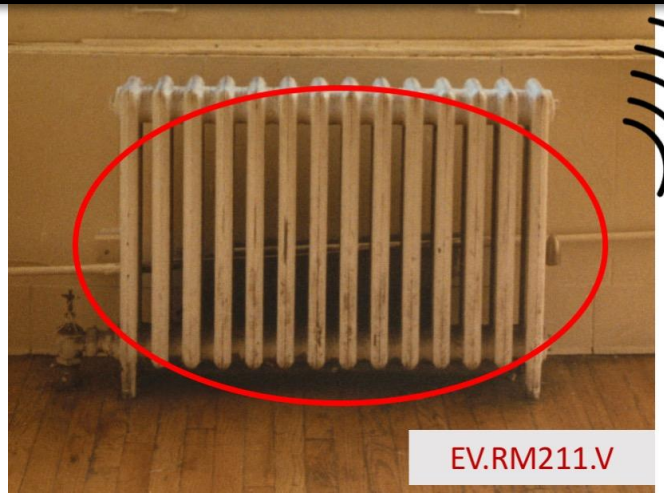
“Points”




EV.R211.RSET
EV.R211.RT
Honeywell

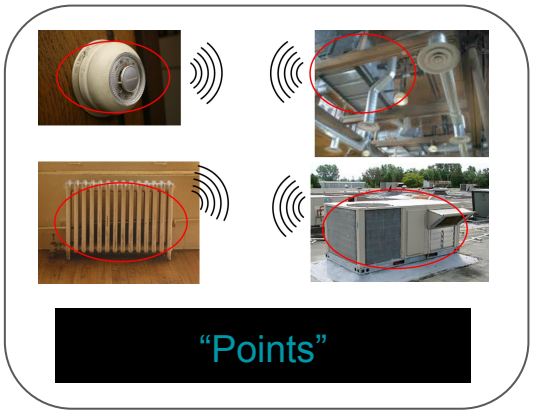

OVG08.MAT

“Points”


EV.RM211.V


ACDIN.AHU13.CTLFLMN

Current System



SIEMENS

AUTOMATEDLOGIC

United Technologies

Siemens / ALC

Siemens / ALC

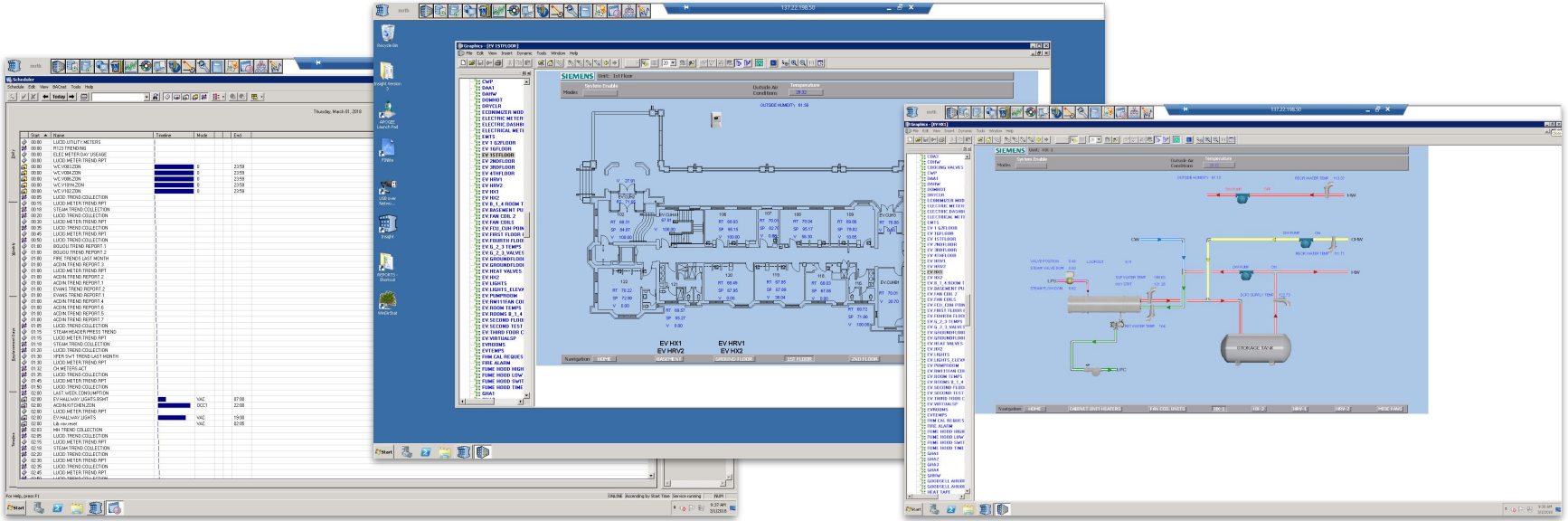
✓ Offer detailed information

✓ Configurable

✓ Interface with hardware

Siemens / ALC

- ✓ Offer detailed information
- ✓ Configurable
- ✓ Interface with hardware



Siemens / ALC

✓ Offer detailed information

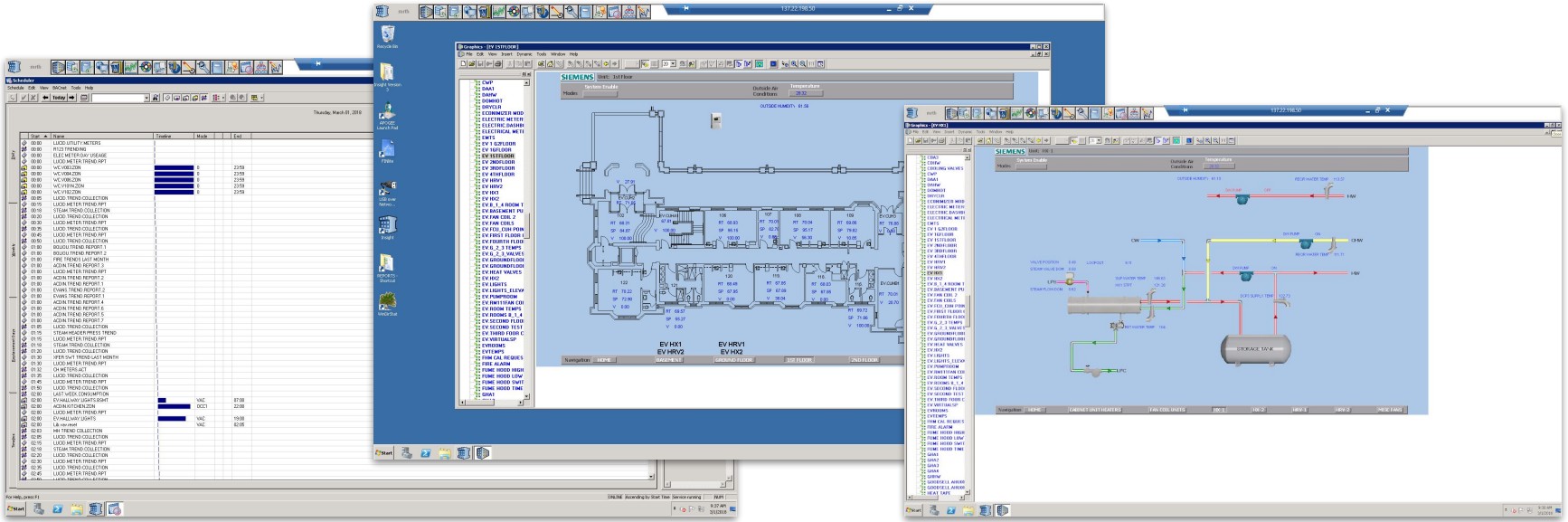
✓ Configurable

✓ Interface with hardware

✘ Difficult to use

✘ Limited data visualization capabilities

✘ Don’t offer automated analysis



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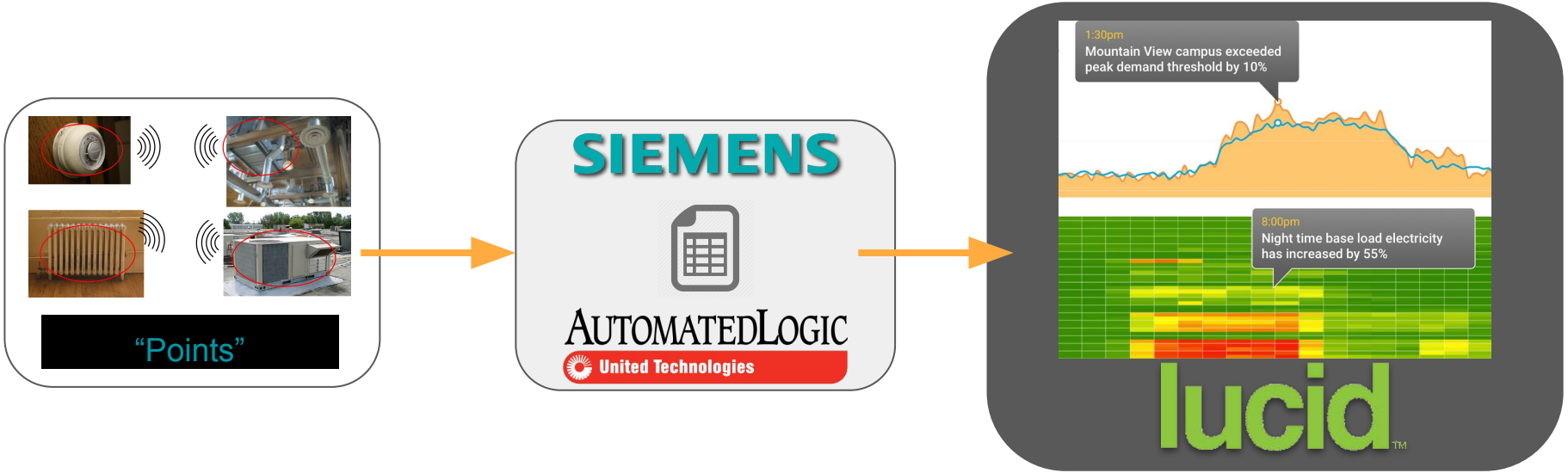

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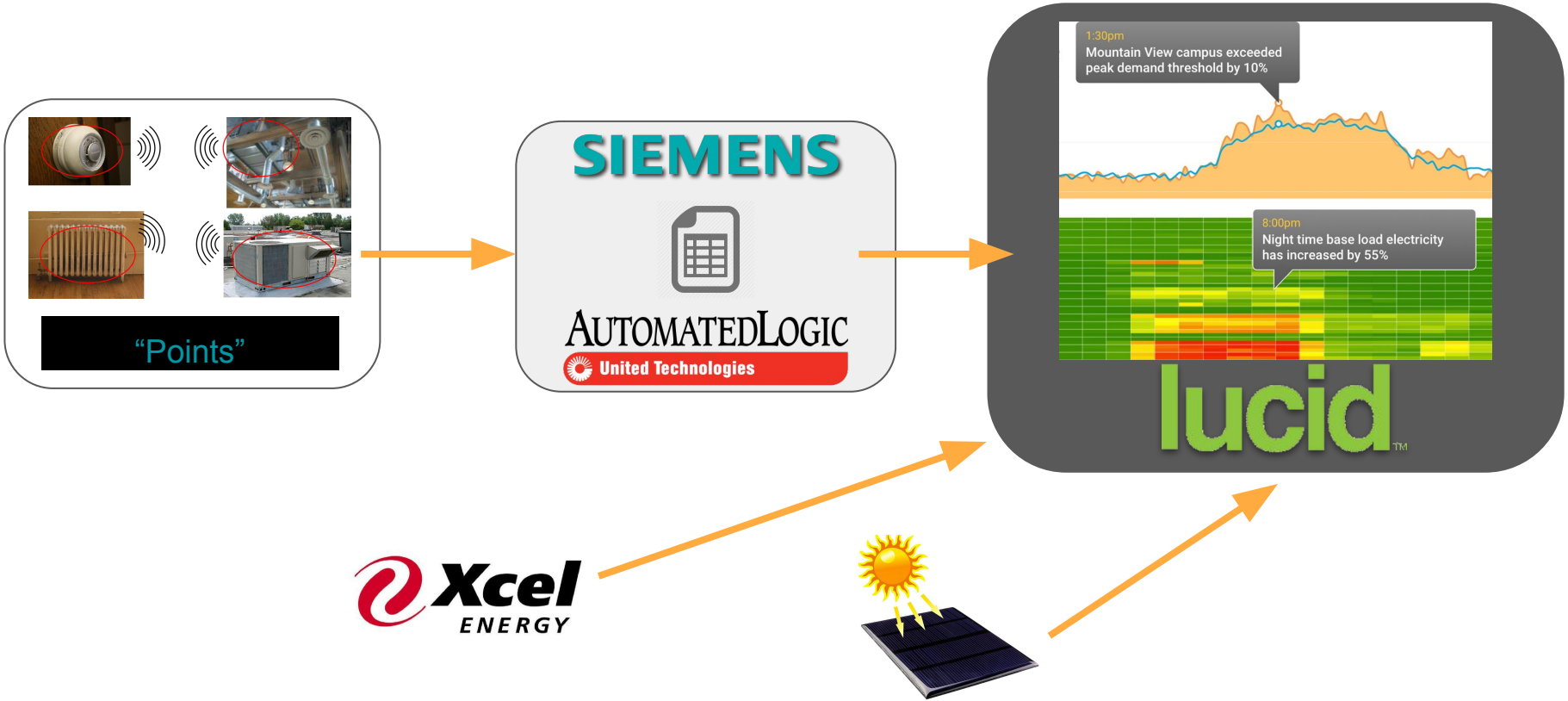
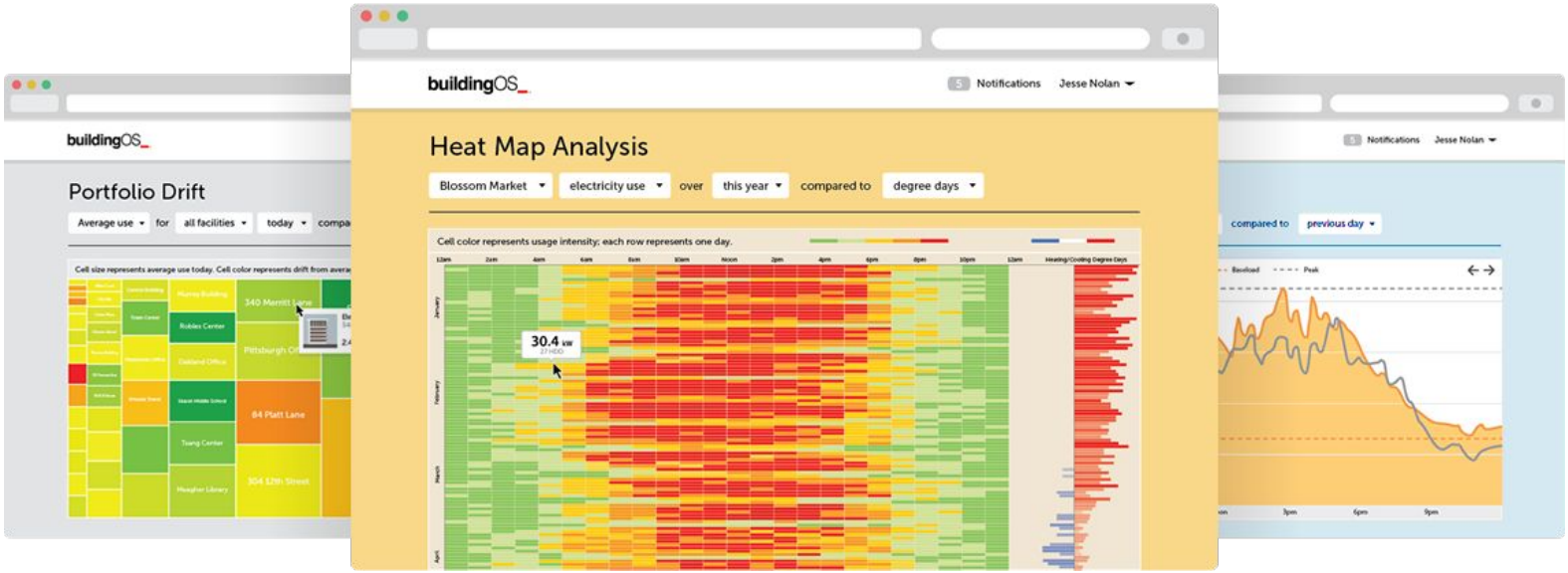


Lucid

- ✓ Modern user interface
- ✓ Slick data visualizations
- ✓ Scrape PDFs for utility $



Lucid

✓ Modern user interface

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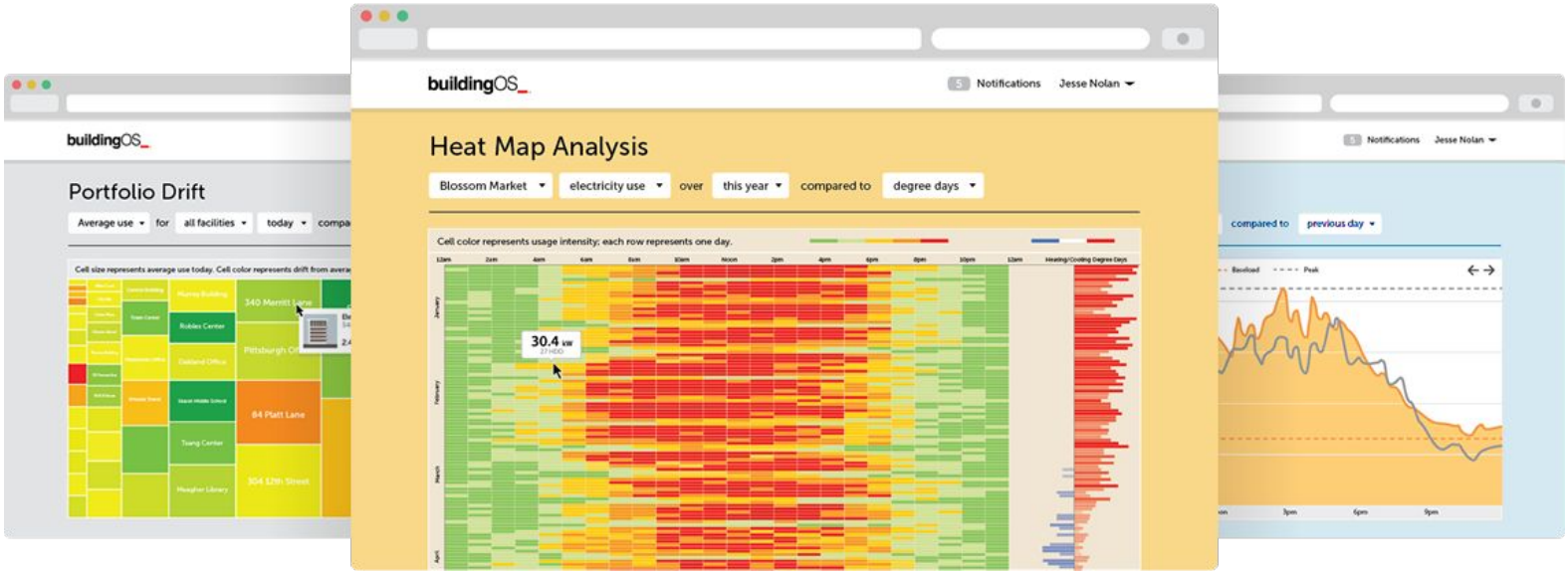
✘ “High-level” overview

✘ Not easy to customize

✘ *Also* doesn’t offer automated analysis



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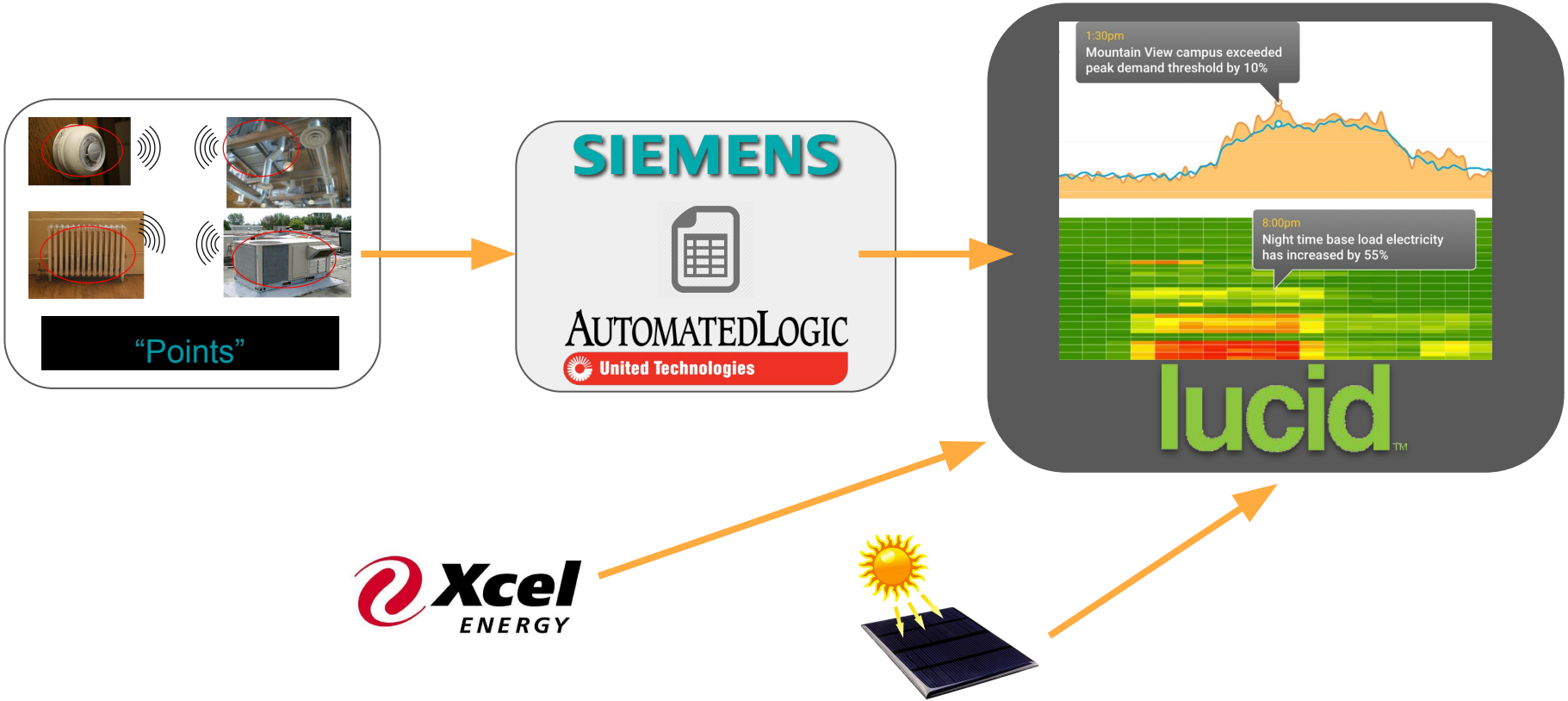

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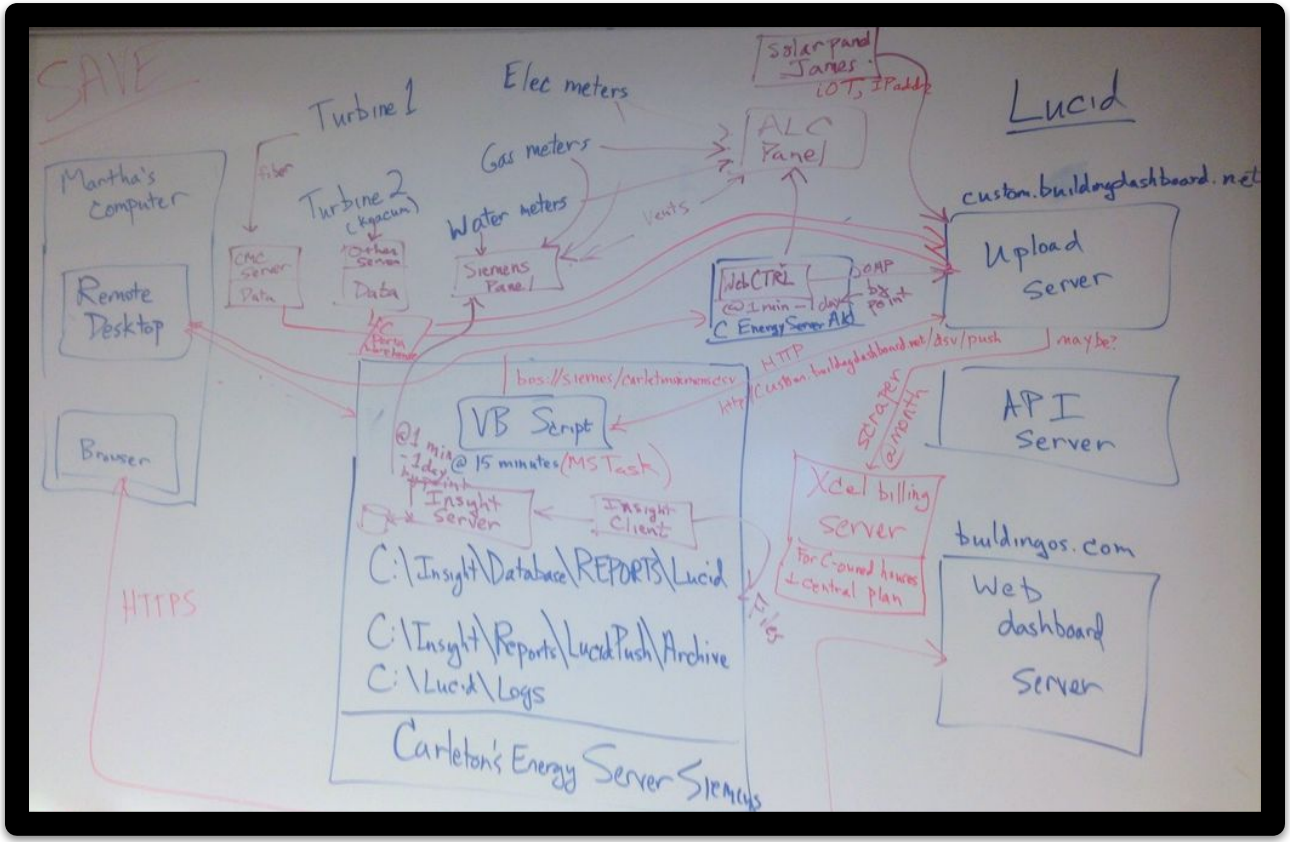

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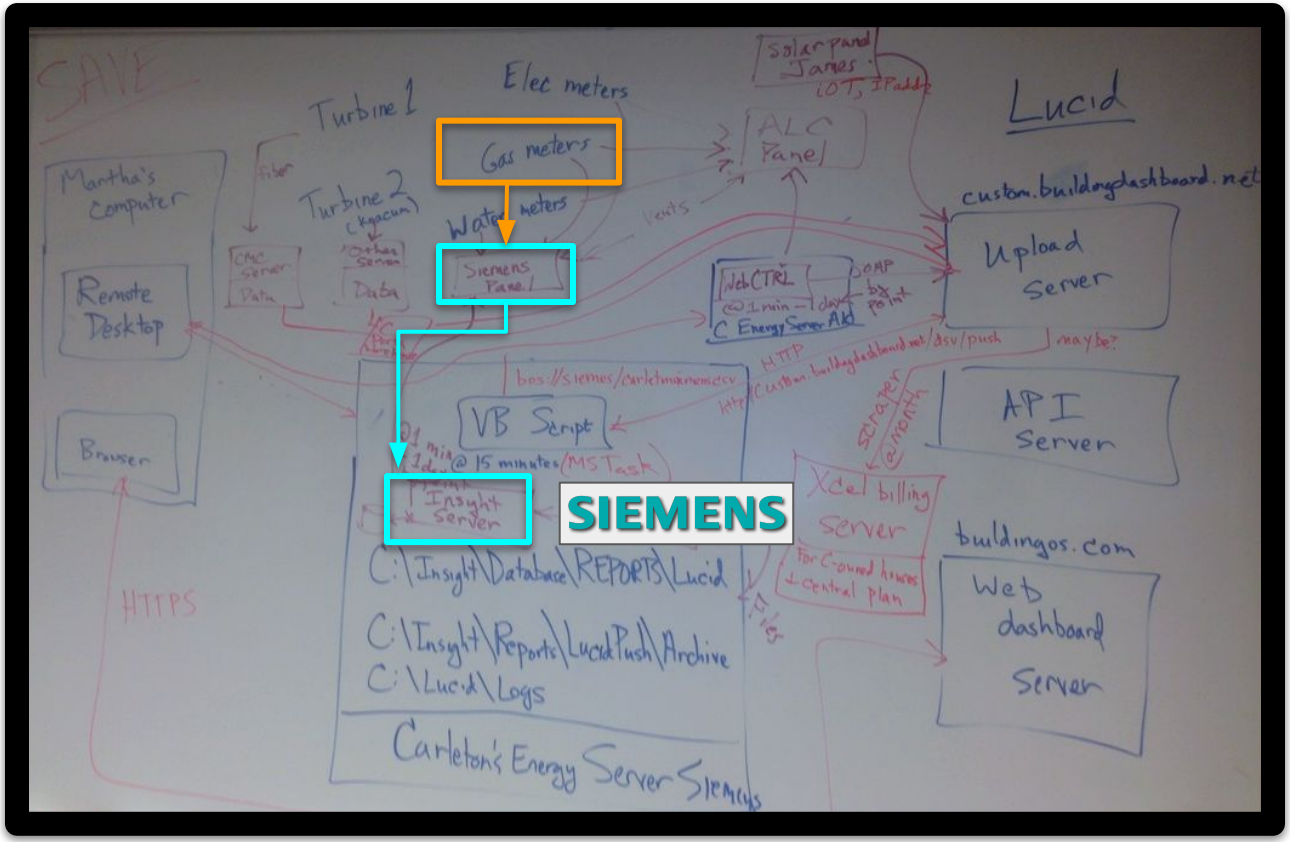

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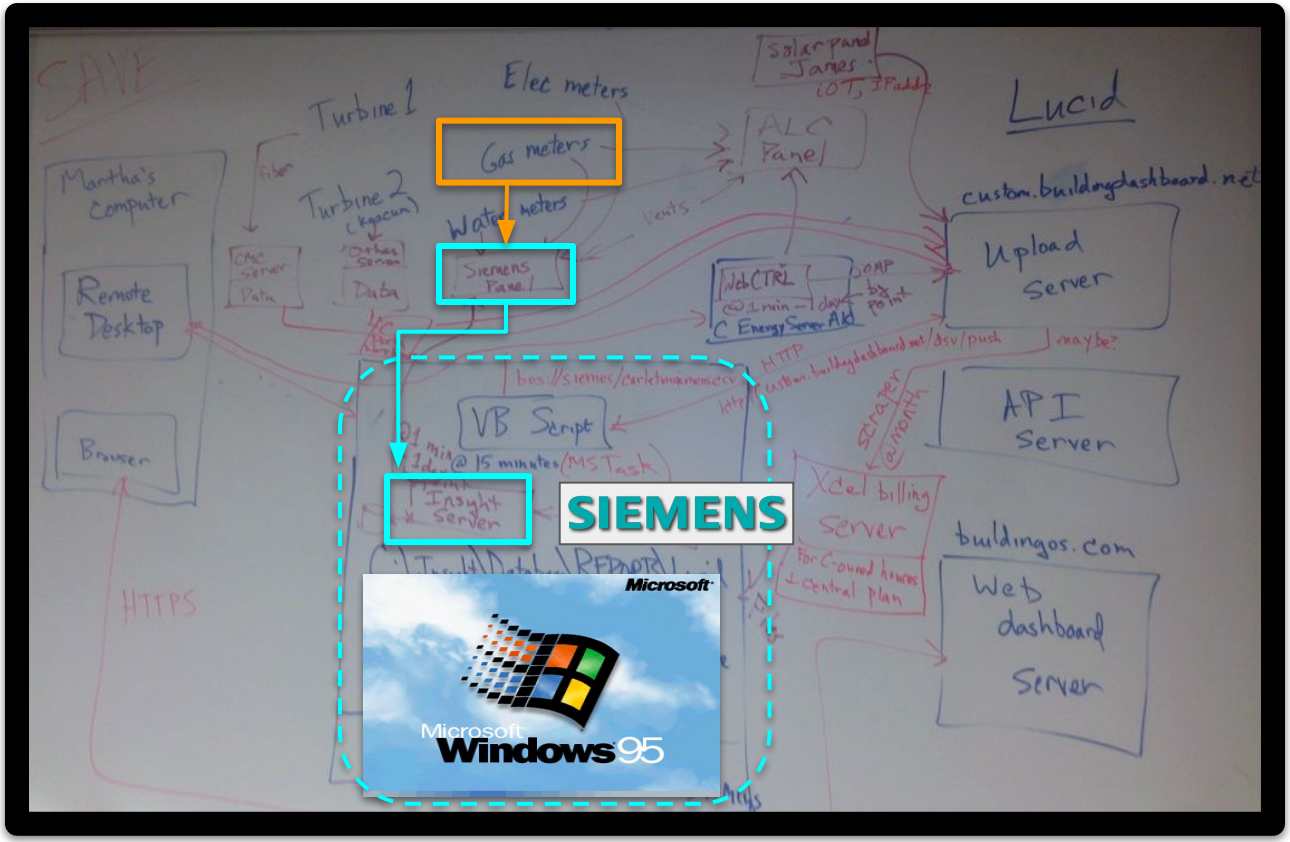

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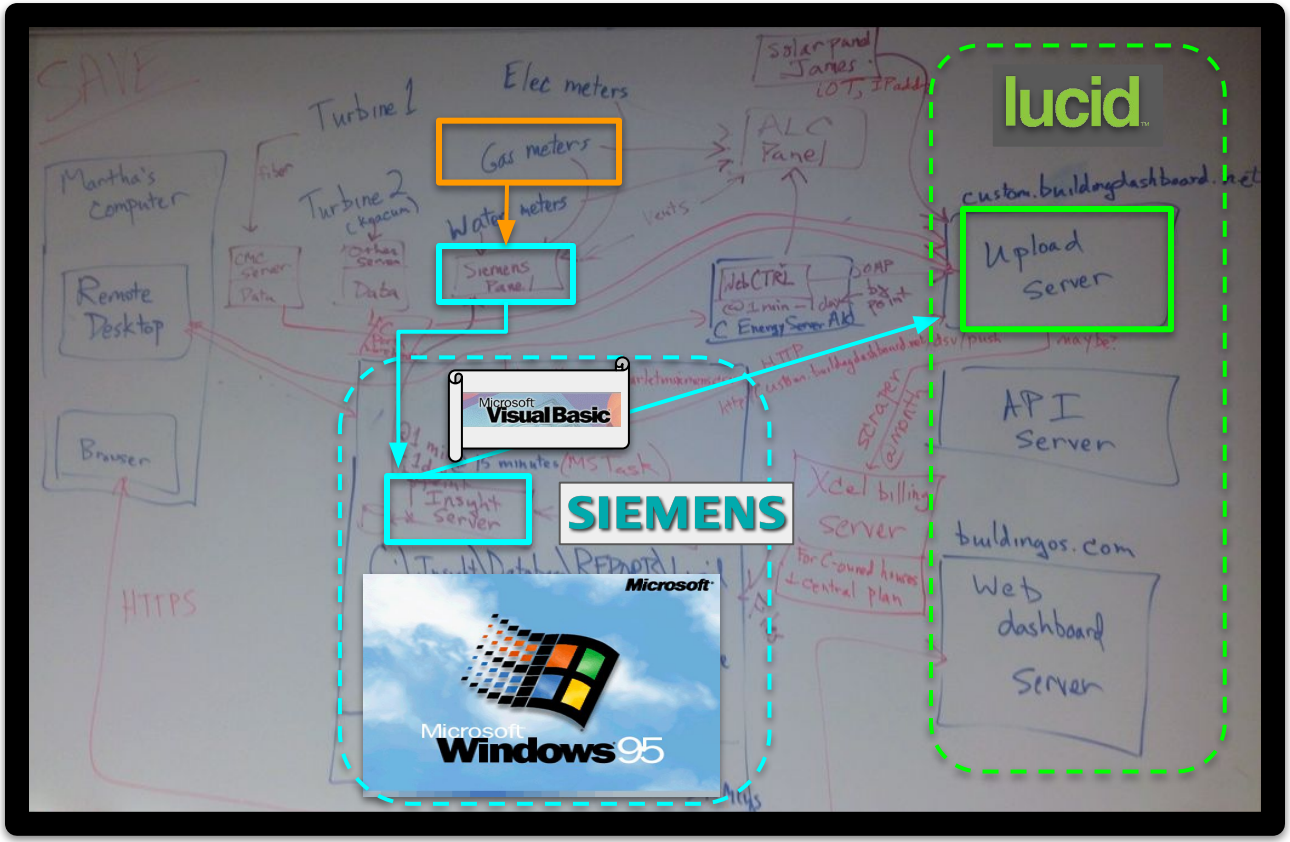

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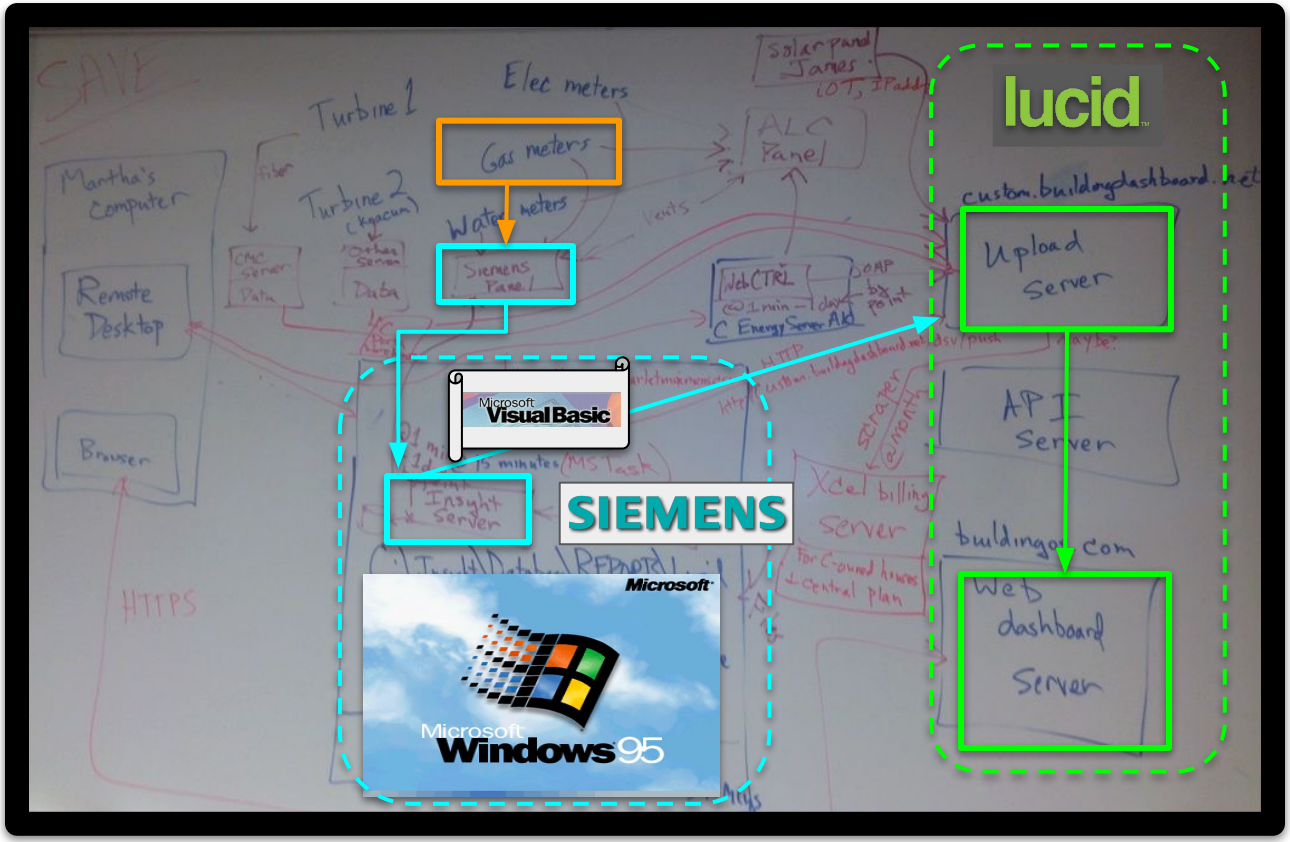
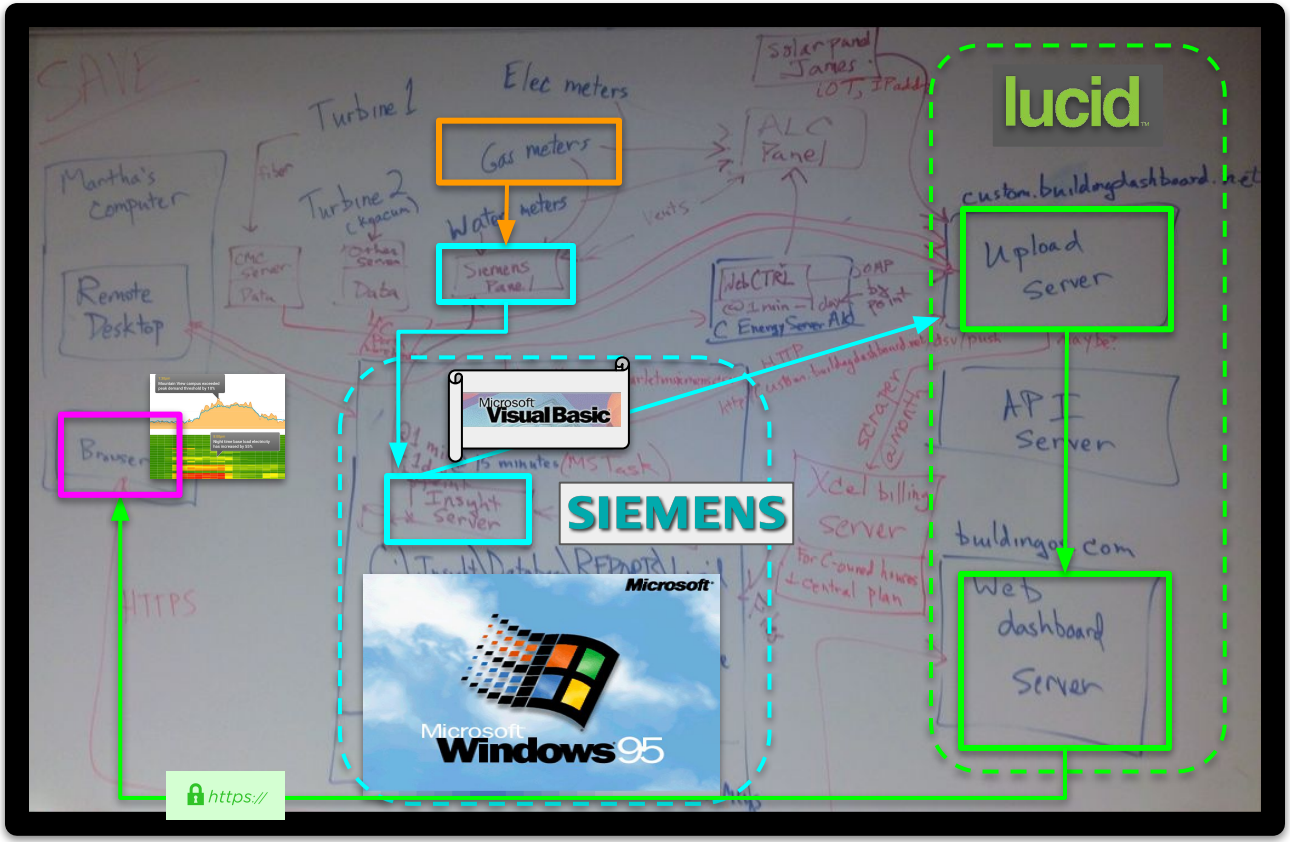
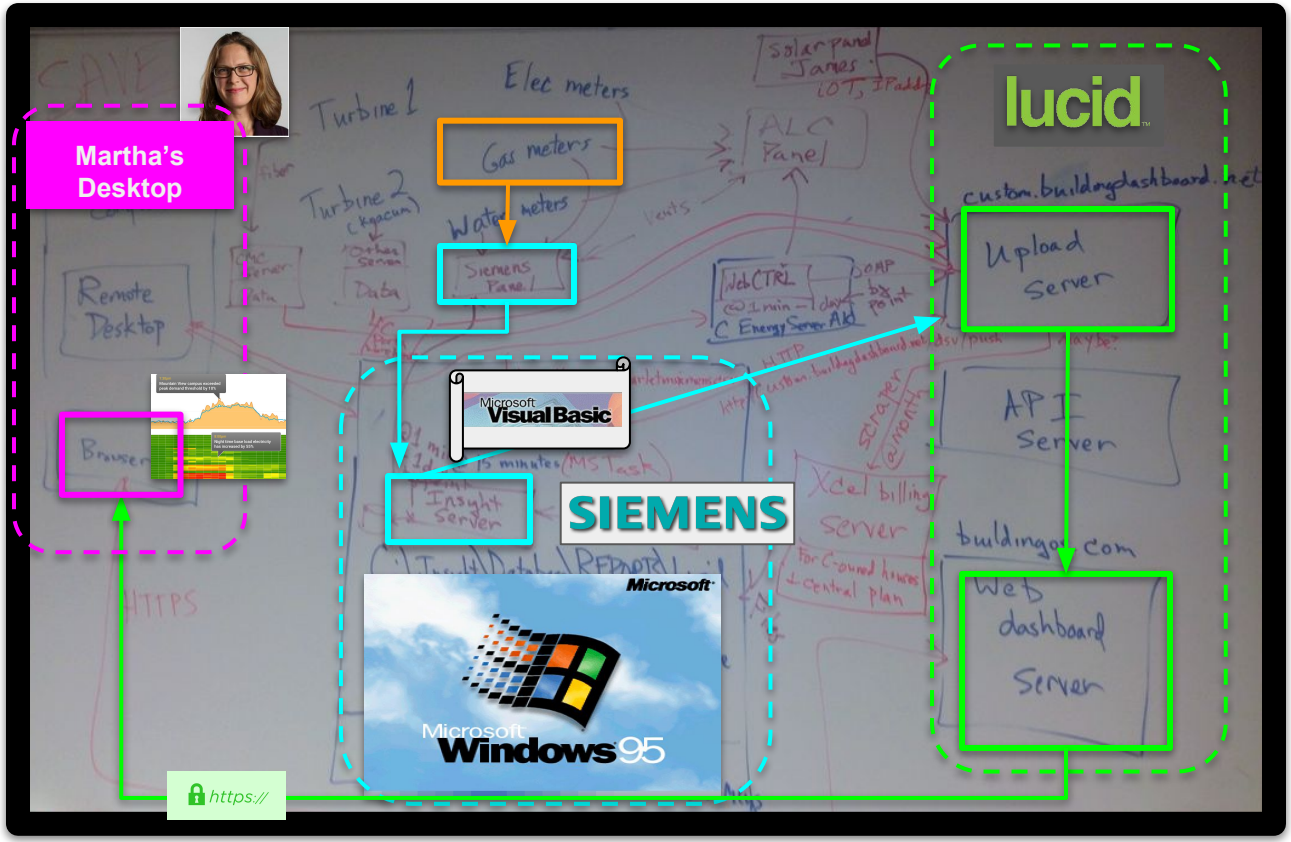


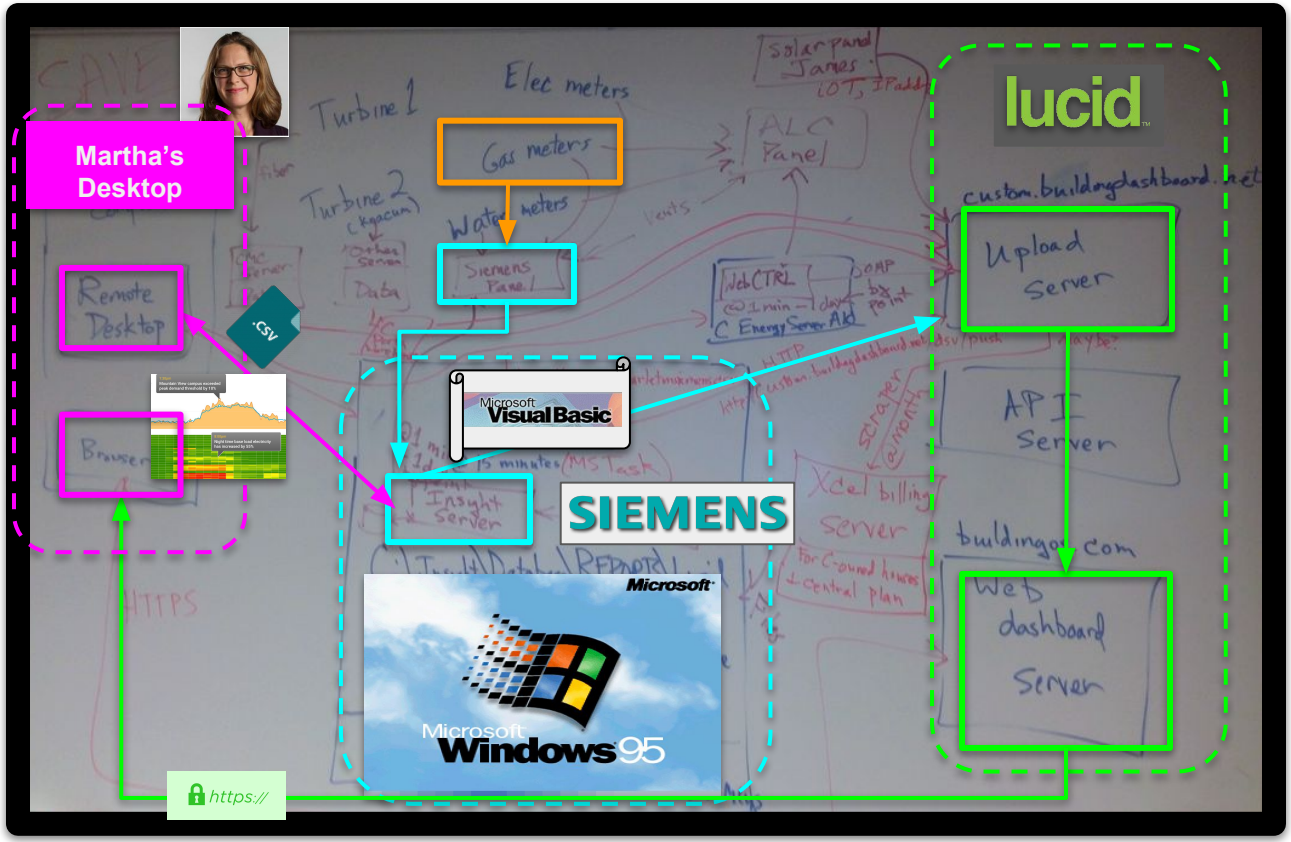
Current System



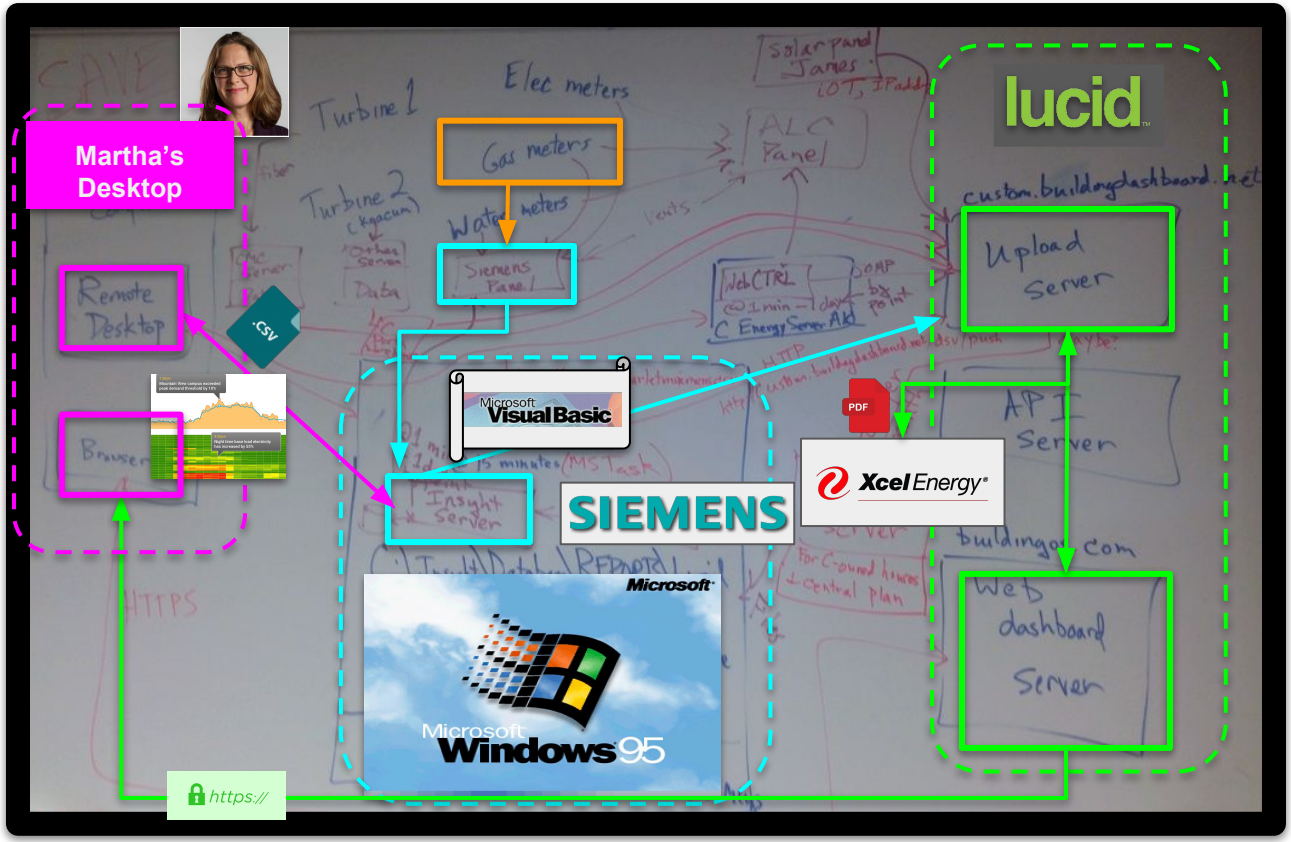
Current System



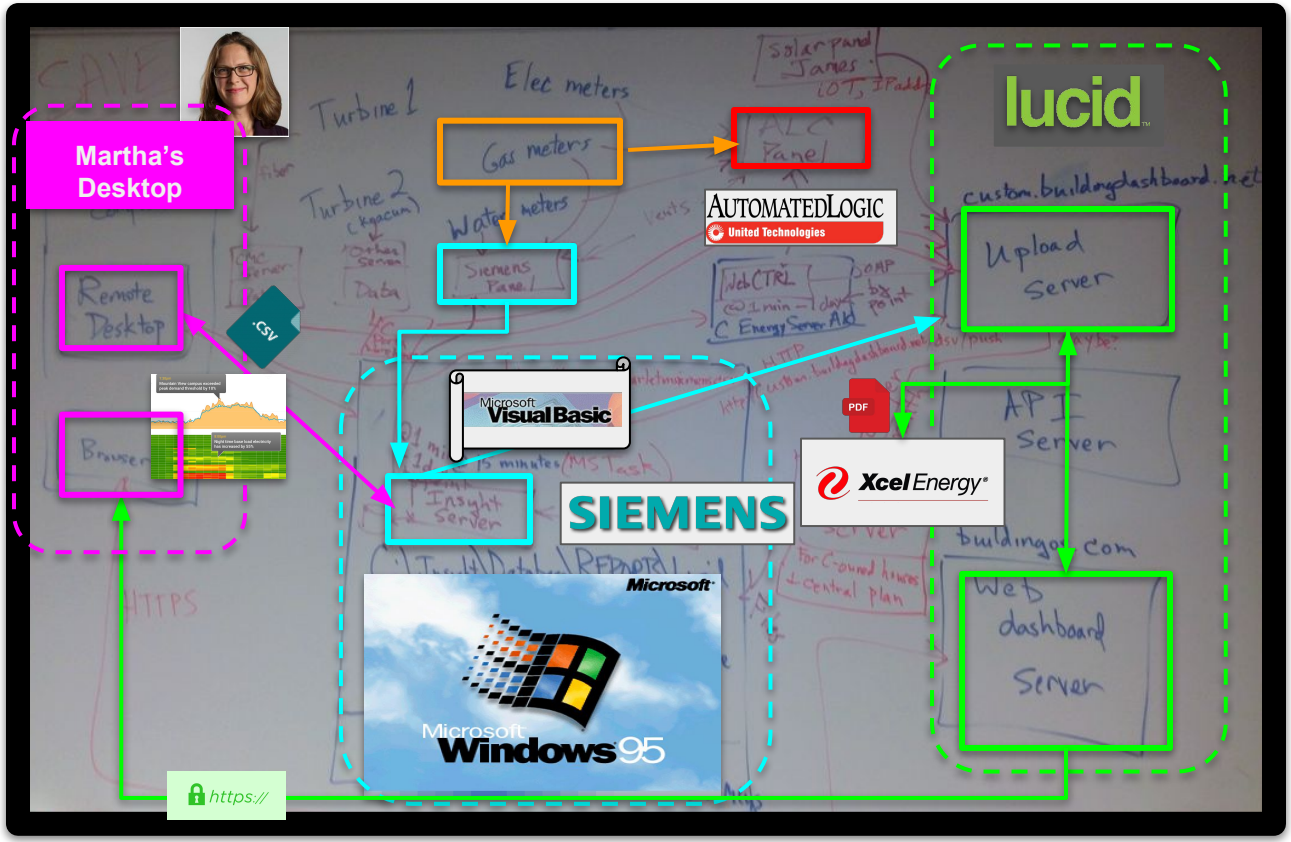
Current System



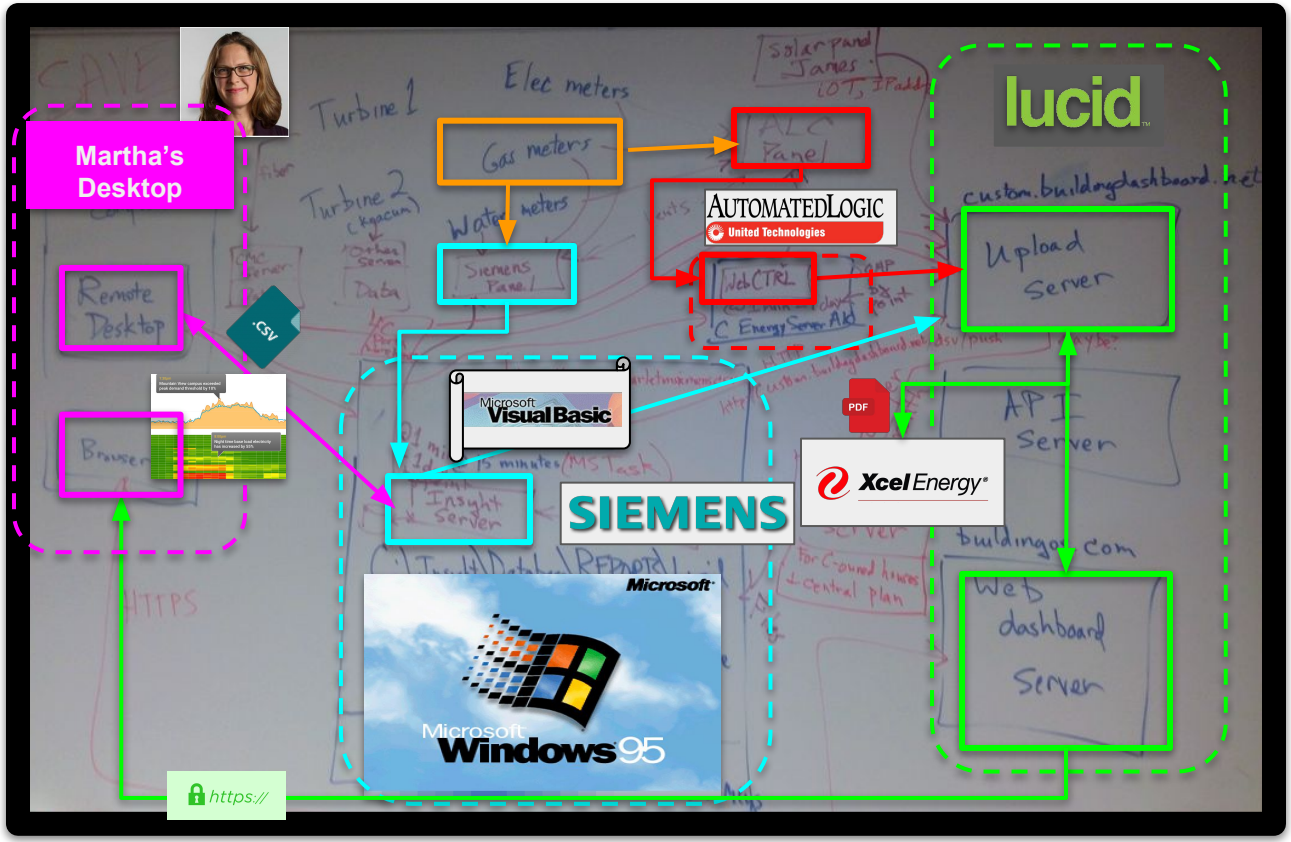
Current System



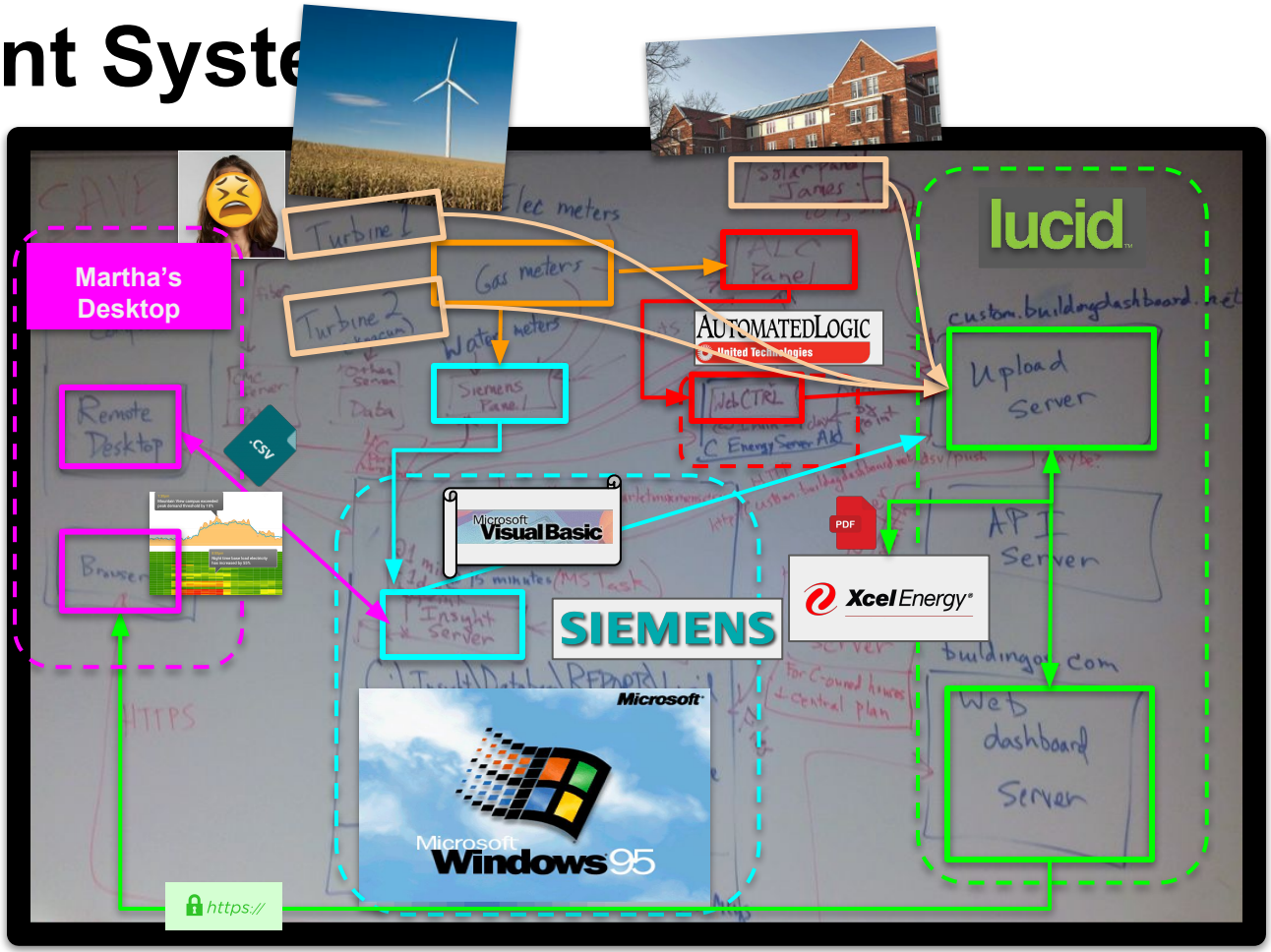
Current System

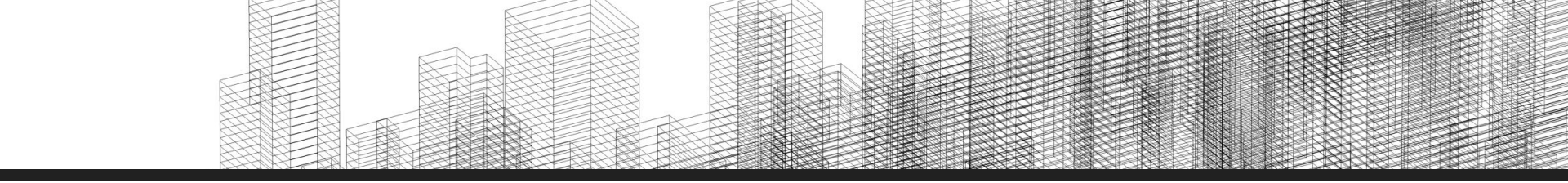


Current System



Current Syste



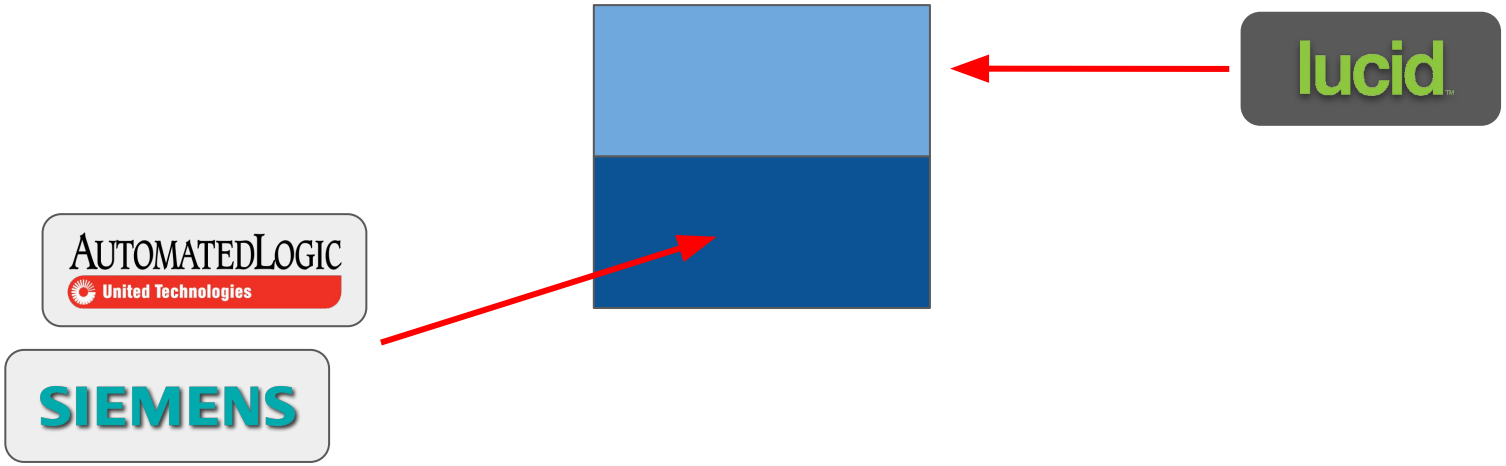


Our Task

1. What is energy analytics?
2. Why do we care?
3. Current System
4. **Our Task**

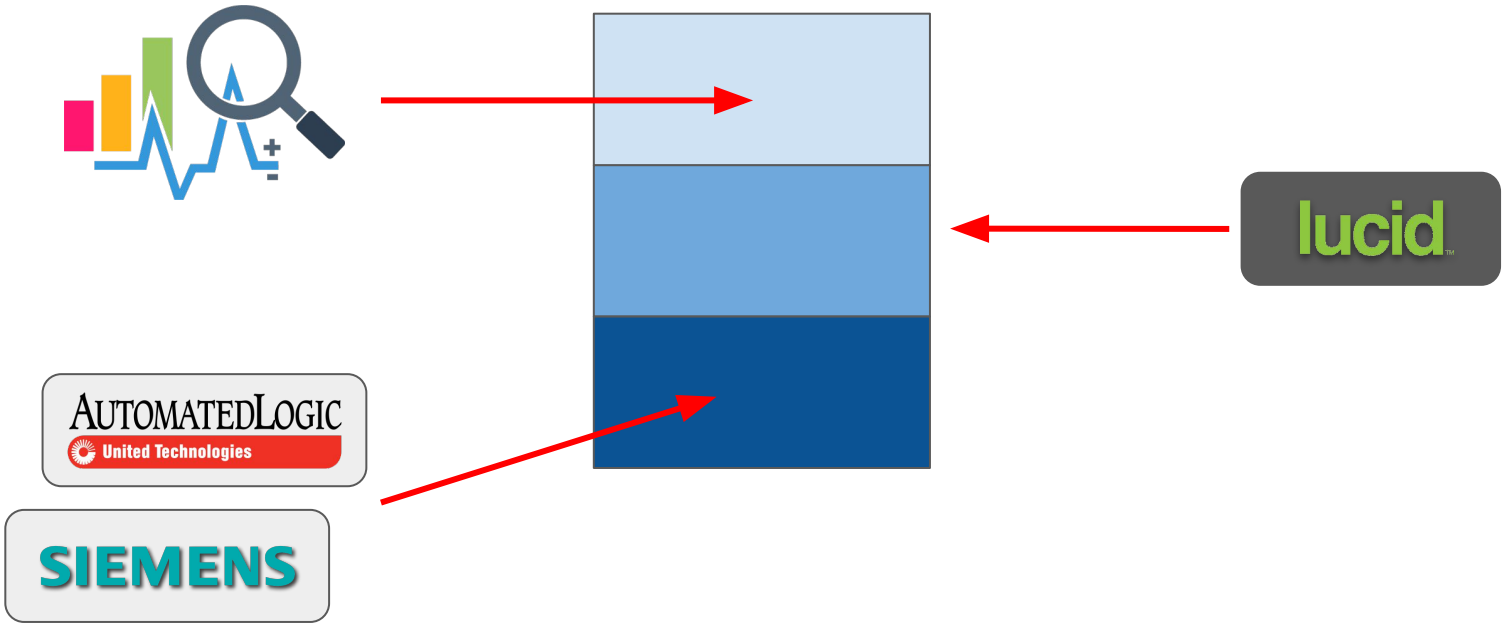
Our Task

1. Unify data into integrated system

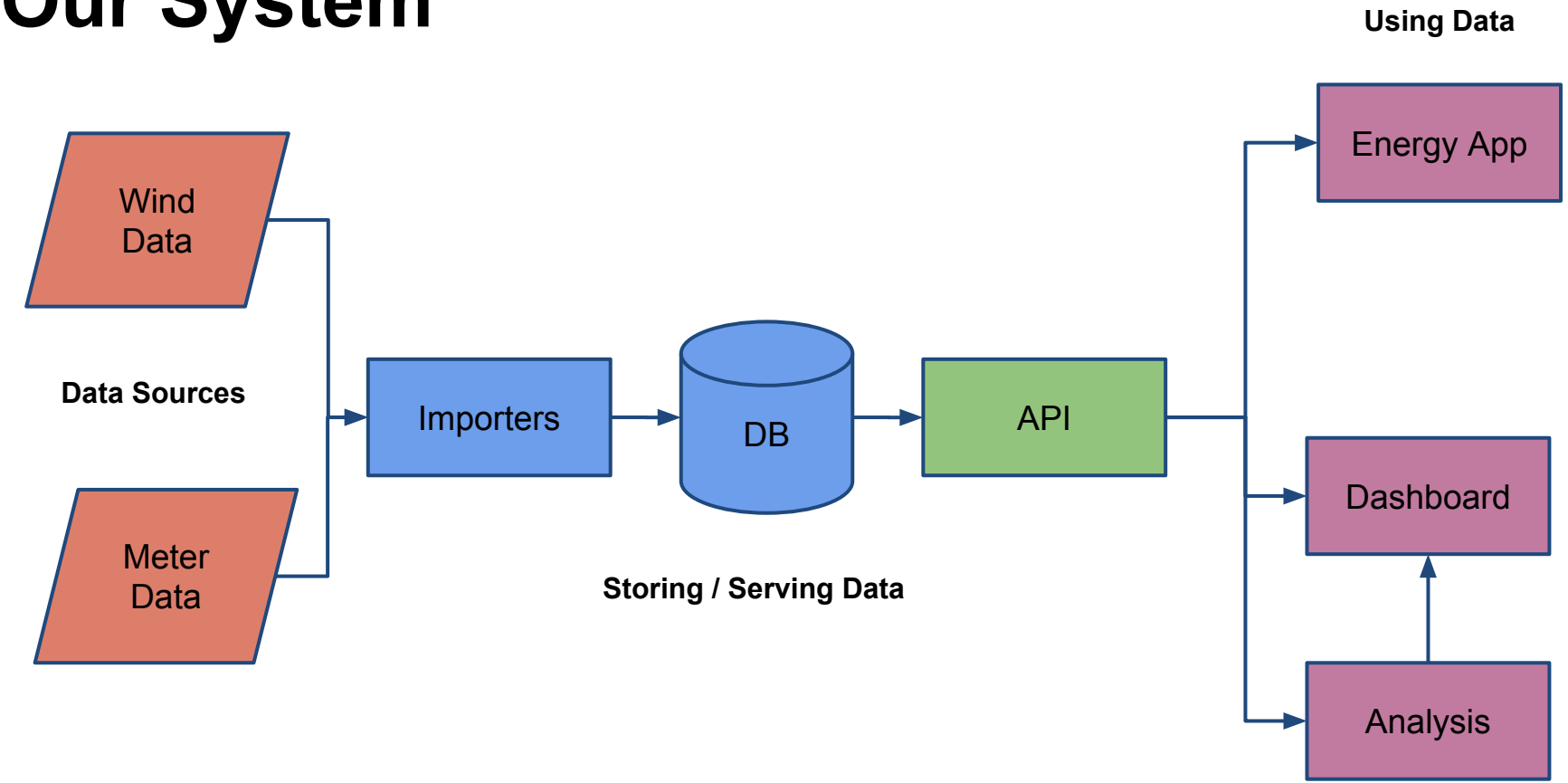


Our Task

1. Unify data into integrated system
2. Enable new forms of analysis



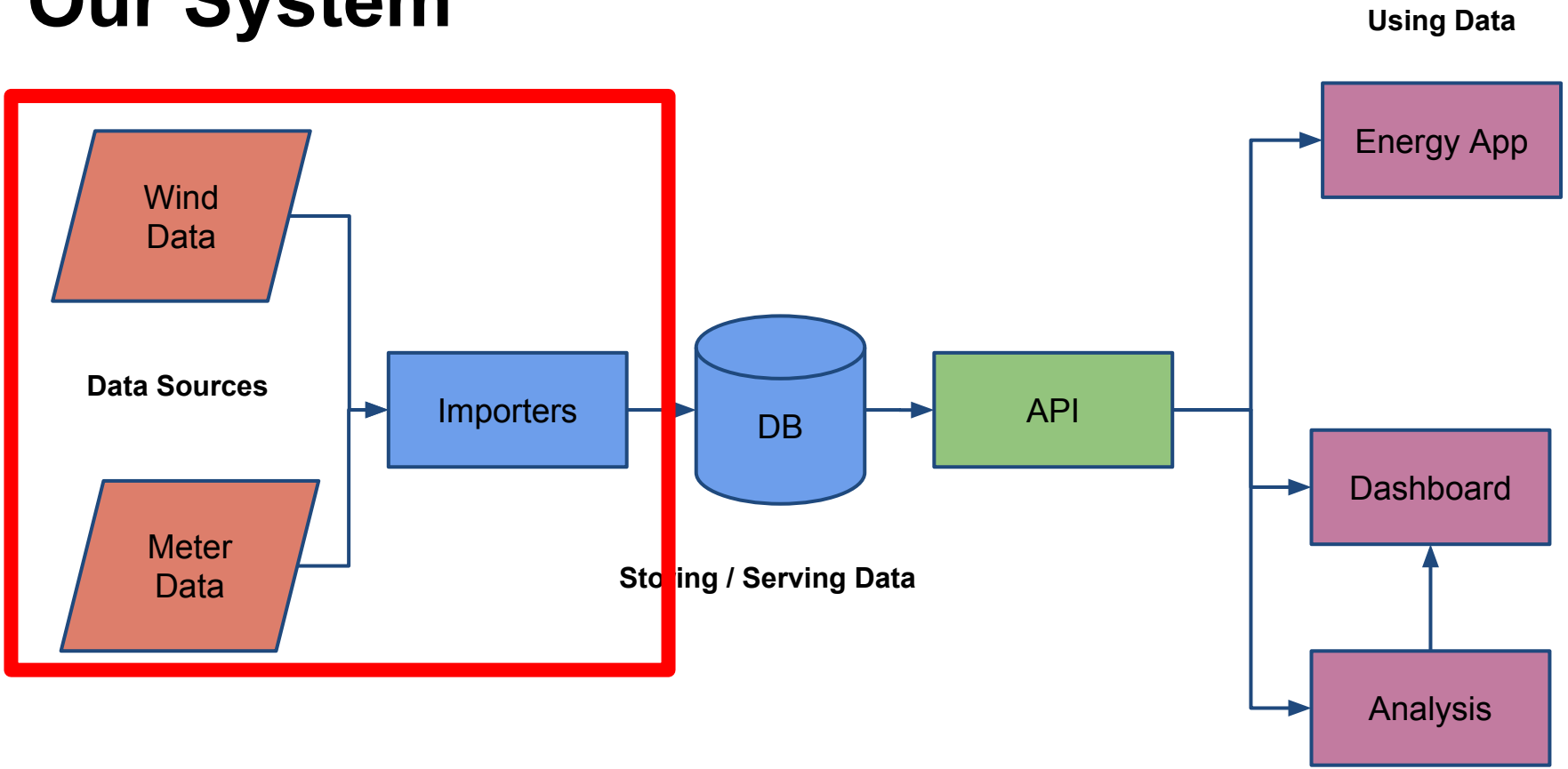
Our System


Using Data
Energy App
Wind Data
Data Sources
Importers
DB
API
Dashboard
Meter Data
Storing / Serving Data
Analysis

problem
data
database
api
dashboard
analysis
conclusion

1. The Task
2. Within Industry
3. Examples
4. Tagging

Our System


Using Data
Wind Data
Meter Data
Data Sources
Importers
DB
API
Energy App
Dashboard
Analysis
Storing / Serving Data

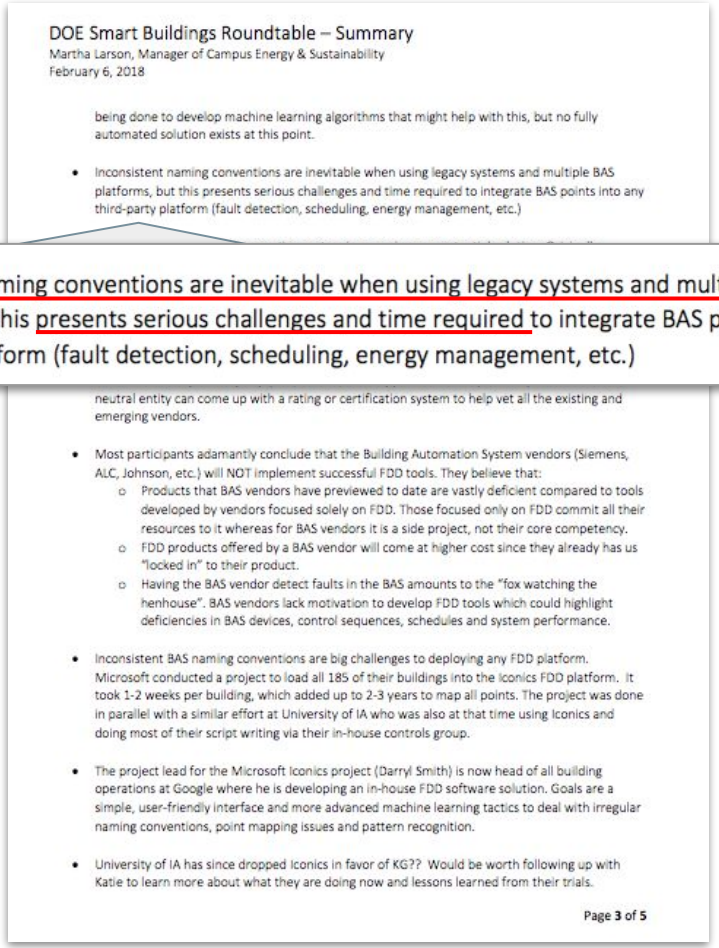
Point Naming:

The Task
Within Industry
Examples
Tagging

NOURSE.FIRE
CH.FLH.E110.STP
LIV54.ORGSTPT
HU.R215.RSET
FACCLUB.ELEC
LIA3WA
WCC-AHU14.MAT

Point Naming:

The Task
Within Industry
Examples
Tagging



DOE Smart Buildings Roundtable – Summary
Martha Larson, Manager of Campus Energy & Sustainability
February 6, 2018

being done to develop machine learning algorithms that might help with this, but no fully automated solution exists at this point.

- Inconsistent naming conventions are inevitable when using legacy systems and multiple BAS platforms, but this presents serious challenges and time required to integrate BAS points into any third-party platform (fault detection, scheduling, energy management, etc.)

Inconsistent naming conventions are inevitable when using legacy systems and multiple BAS platforms, but this presents serious challenges and time required to integrate BAS points into any third-party platform (fault detection, scheduling, energy management, etc.)

neutral entity can come up with a rating or certification system to help vet all the existing and emerging vendors.

- Most participants adamantly conclude that the Building Automation System vendors (Siemens, ALC, Johnson, etc.) will NOT implement successful FDD tools. They believe that:
  - Products that BAS vendors have previewed to date are vastly deficient compared to tools developed by vendors focused solely on FDD. Those focused only on FDD commit all their resources to it whereas for BAS vendors it is a side project, not their core competency.
  - FDD products offered by a BAS vendor will come at higher cost since they already has us "locked in" to their product.
  - Having the BAS vendor detect faults in the BAS amounts to the "fox watching the henhouse". BAS vendors lack motivation to develop FDD tools which could highlight deficiencies in BAS devices, control sequences, schedules and system performance.

- Inconsistent BAS naming conventions are big challenges to deploying any FDD platform. Microsoft conducted a project to load all 185 of their buildings into the Iconics FDD platform. It took 1-2 weeks per building, which added up to 2-3 years to map all points. The project was done in parallel with a similar effort at University of IA who was also at that time using Iconics and doing most of their script writing via their in-house controls group.

- The project lead for the Microsoft Iconics project (Darryl Smith) is now head of all building operations at Google where he is developing an in-house FDD software solution. Goals are a simple, user-friendly interface and more advanced machine learning tactics to deal with irregular naming conventions, point mapping issues and pattern recognition.

- University of IA has since dropped Iconics in favor of KG?? Would be worth following up with Katie to learn more about what they are doing now and lessons learned from their trials.

Point Naming:

The Task
Within Industry
Examples
Tagging

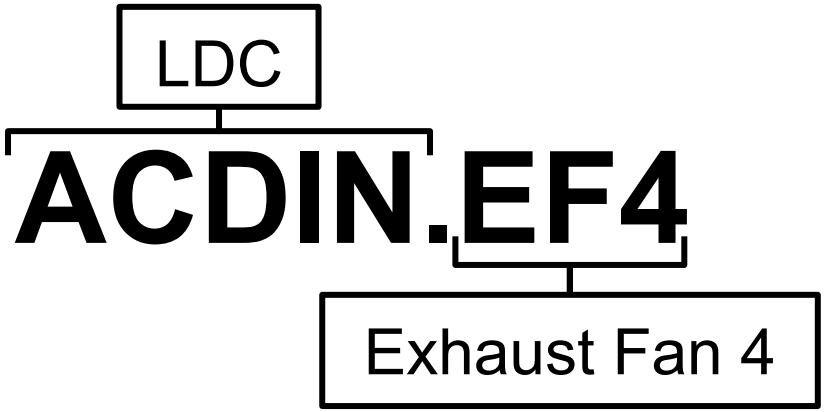
ACDIN.EF4

Point Naming:

The Task
Within Industry
Examples
Tagging

Point Naming:

The Task
Within Industry
Examples
Tagging



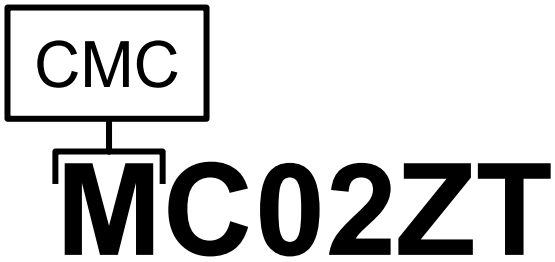
Point Naming:

The Task
Within Industry
Examples
Tagging

MC02ZT

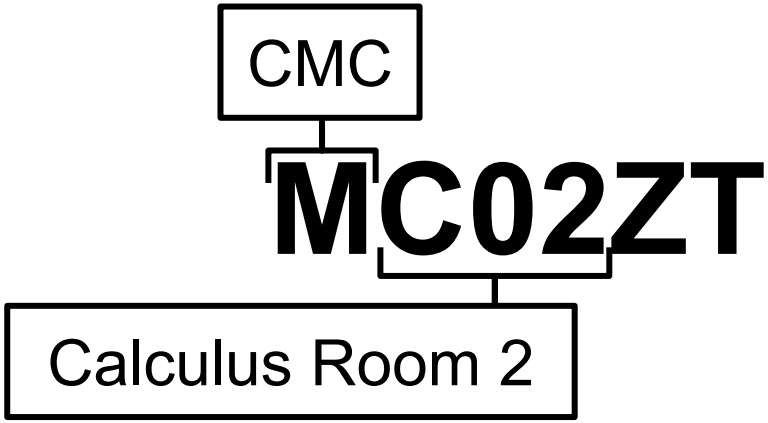
Point Naming:

The Task
Within Industry
Examples
Tagging



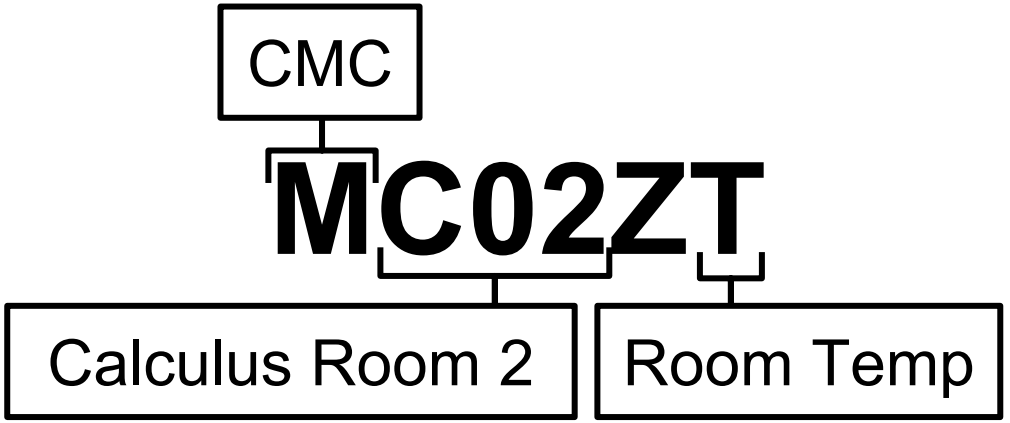
Point Naming:

The Task
Within Industry
Examples
Tagging



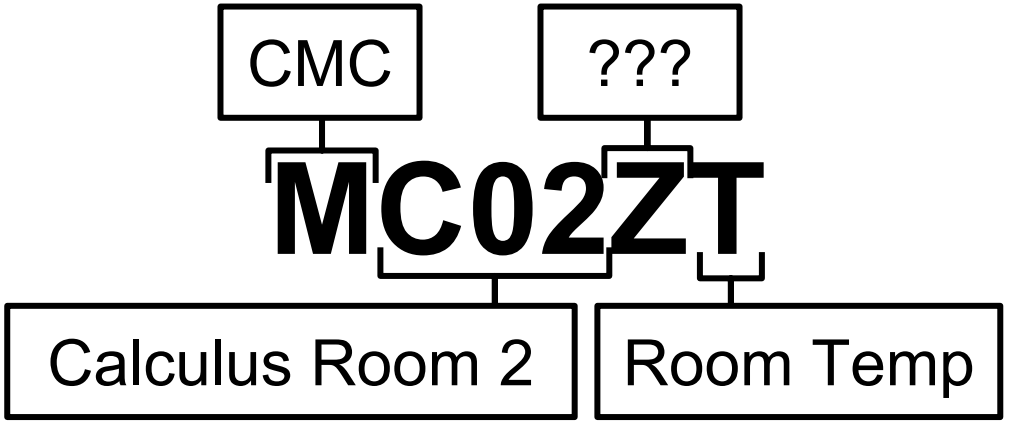
Point Naming:

The Task
Within Industry
Examples
Tagging



Point Naming:

The Task
Within Industry
Examples
Tagging



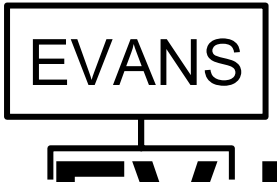
Point Naming:

The Task
Within Industry
Examples
Tagging

EV.RM102.RT

ACDIN.CHW.RT

Point Naming:

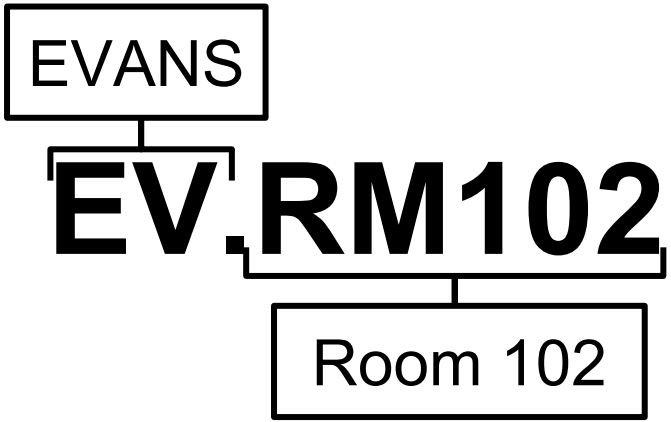


The Task
Within Industry
Examples
Tagging

ACDIN.CHW.RT

Point Naming:

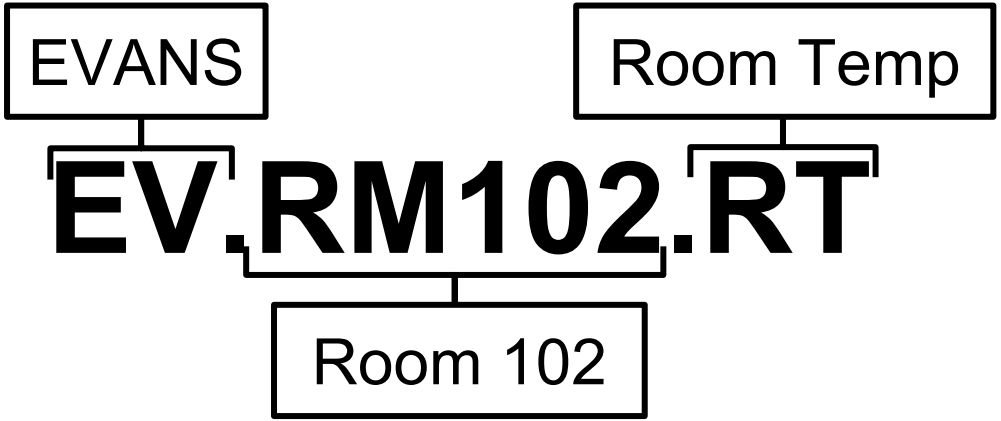
The Task
Within Industry
Examples
Tagging



ACDIN.CHW.RT

Point Naming:

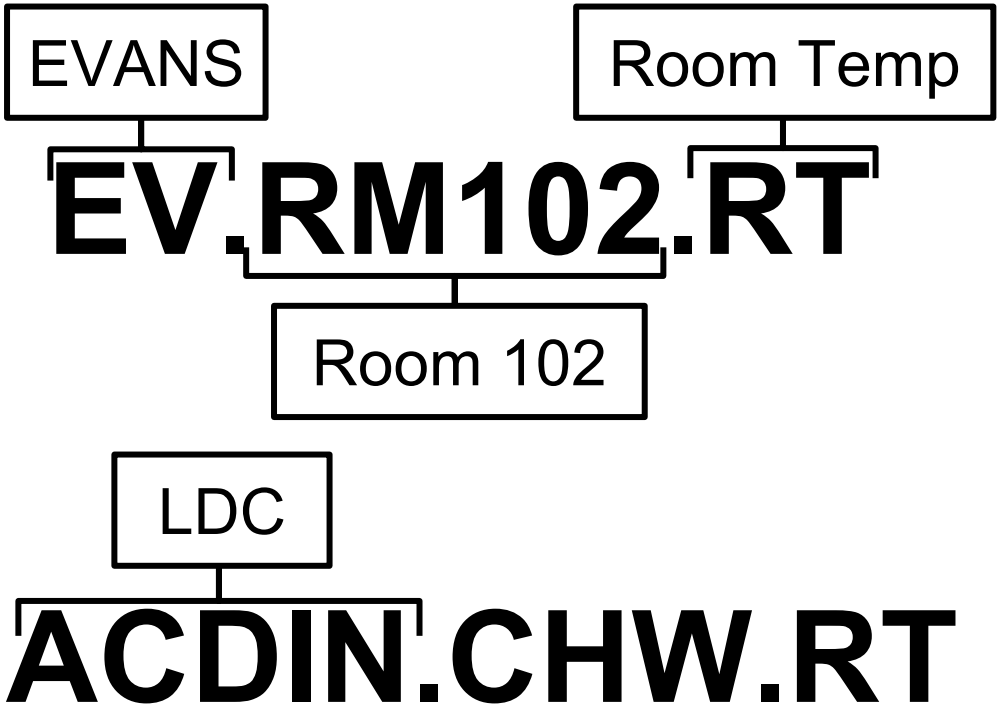
The Task
Within Industry
Examples
Tagging



ACDIN.CHW.RT

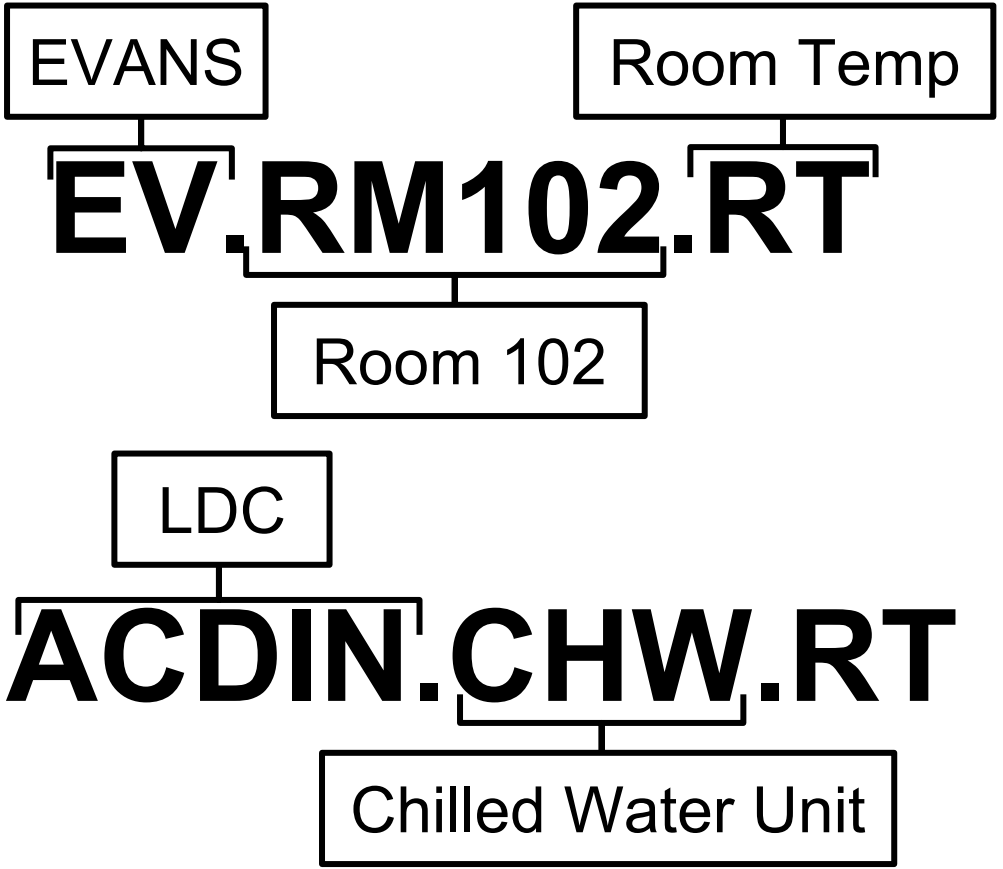
Point Naming:

The Task
Within Industry
Examples
Tagging



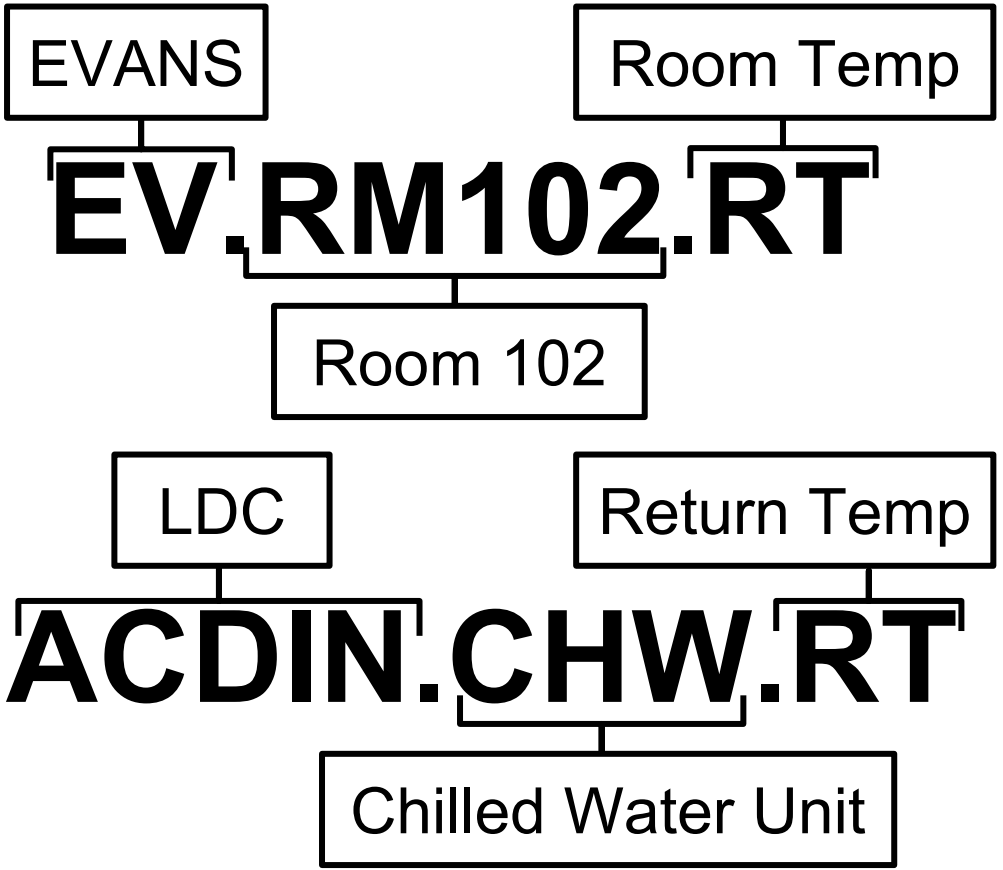
Point Naming:

The Task
Within Industry
Examples
Tagging



Point Naming:

The Task
Within Industry
Examples
Tagging



Point Naming:

TAG

The Task
Within Industry
Examples
Tagging

Point Naming:

TAG
Unique Identifier

The Task
Within Industry
Examples
Tagging

Point Naming:

TAG	
Unique Identifier	ROOMTEMP

The Task
Within Industry
Examples
Tagging

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	…

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	…
Type	

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	…
Type	Measurement

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	…
Type	Measurement
Is Indexed?	

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	...
Type	Measurement
Is Indexed?	False

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	...
Type	Measurement
Is Indexed?	False
Human Readable Description	

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	...
Type	Measurement
Is Indexed?	False
Human Readable Description	Measurement of the temperature of the room this point is located in.

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	...
Type	Measurement
Is Indexed?	False
Human Readable Description	Measurement of the temperature of the room this point is located in.
Units Information	

Point Naming:

The Task
Within Industry
Examples
Tagging

TAG	
Unique Identifier	ROOMTEMP
Parsing Information	...
Type	Measurement
Is Indexed?	False
Human Readable Description	Measurement of the temperature of the room this point is located in.
Units Information	Degrees F

Point Naming:

The Task
Within Industry
Examples
Tagging

Types of Tags:

Point Naming:

Types of Tags:

Building		

The Task
Within Industry
Examples
Tagging

Point Naming:

Types of Tags:

Building	Library	

The Task
Within Industry
Examples
Tagging

Point Naming:

Types of Tags:

Building	Library	LIV25.ORGSTPT

The Task
Within Industry
Examples
Tagging

Point Naming:

The Task
Within Industry
Examples
Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room		

Point Naming:

The Task
Within Industry
Examples
Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	

Point Naming:

The Task
Within Industry
Examples
Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM

Point Naming:

The Task
Within Industry
Examples
Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM
Equipment		

Point Naming:

The Task
Within Industry
Examples
Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM
Equipment	Air Handling Unit, 13	

Point Naming:

The Task
Within Industry
Examples
Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM
Equipment	Air Handling Unit, 13	WCC-AHU13.MAT

Point Naming:

The Task Within Industry Examples Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM
Equipment	Air Handling Unit, 13	WCC-AHU13.MAT
Set Point		

Point Naming:

The Task Within Industry Examples Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM
Equipment	Air Handling Unit, 13	WCC-AHU13.MAT
Set Point	Room Temp	

Point Naming:

The Task
Within Industry
Examples
Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM
Equipment	Air Handling Unit, 13	WCC-AHU13.MAT
Set Point	Room Temp	HU.R2AA.RSET

Point Naming:

The Task
Within Industry
Examples
Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM
Equipment	Air Handling Unit, 13	WCC-AHU13.MAT
Set Point	Room Temp	HU.R2AA.RSET
Measurement		

Point Naming:

The Task Within Industry Examples Tagging

Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM
Equipment	Air Handling Unit, 13	WCC-AHU13.MAT
Set Point	Room Temp	HU.R2AA.RSET
Measurement	Radiation Valve %	

Point Naming:

The Task Within Industry Examples Tagging

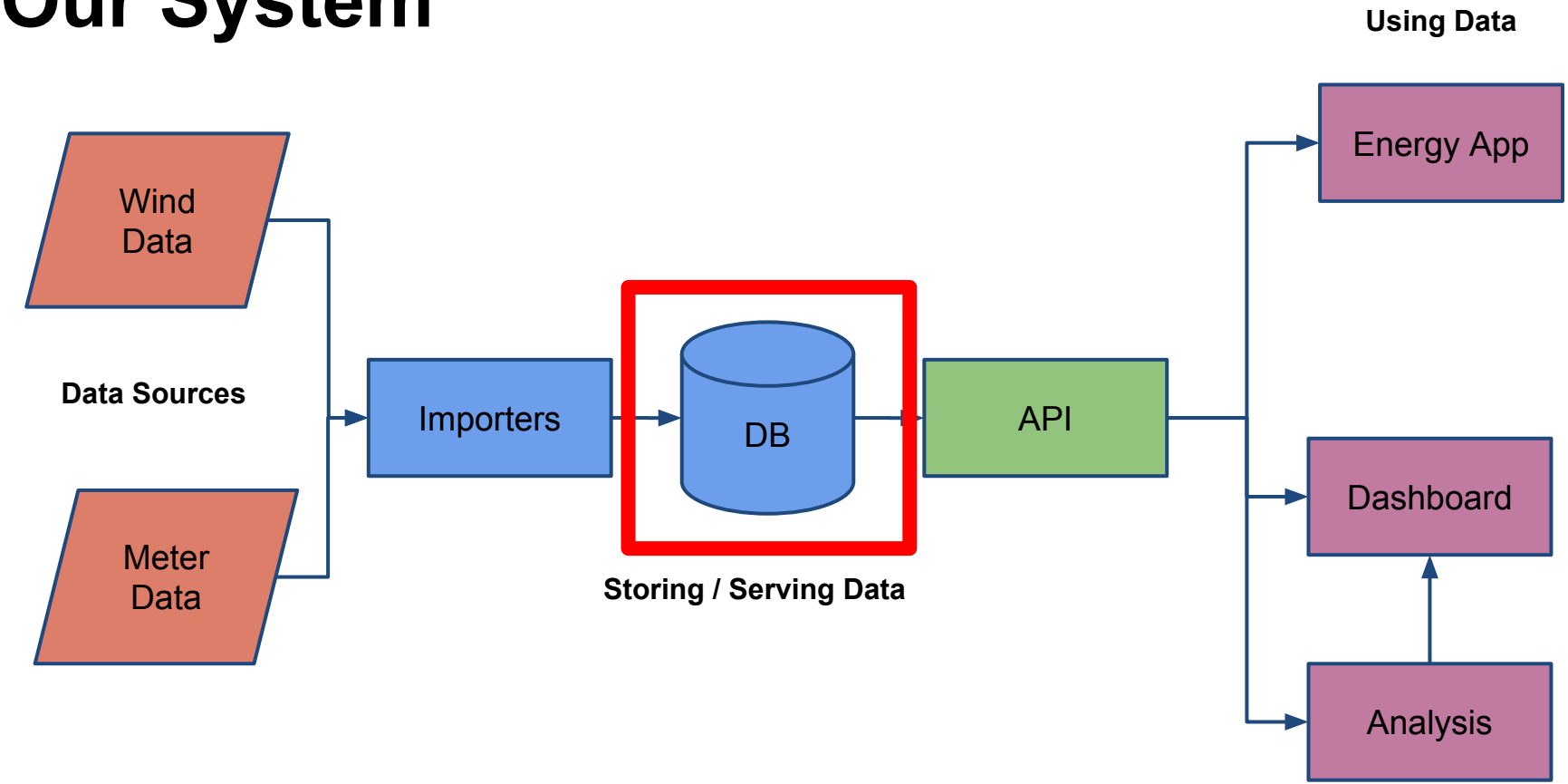
Types of Tags:

Building	Library	LIV25.ORGSTPT
Room	Room, 300	HU.R300.RM
Equipment	Air Handling Unit, 13	WCC-AHU13.MAT
Set Point	Room Temp	HU.R2AA.RSET
Measurement	Radiation Valve %	EV.RM211.V

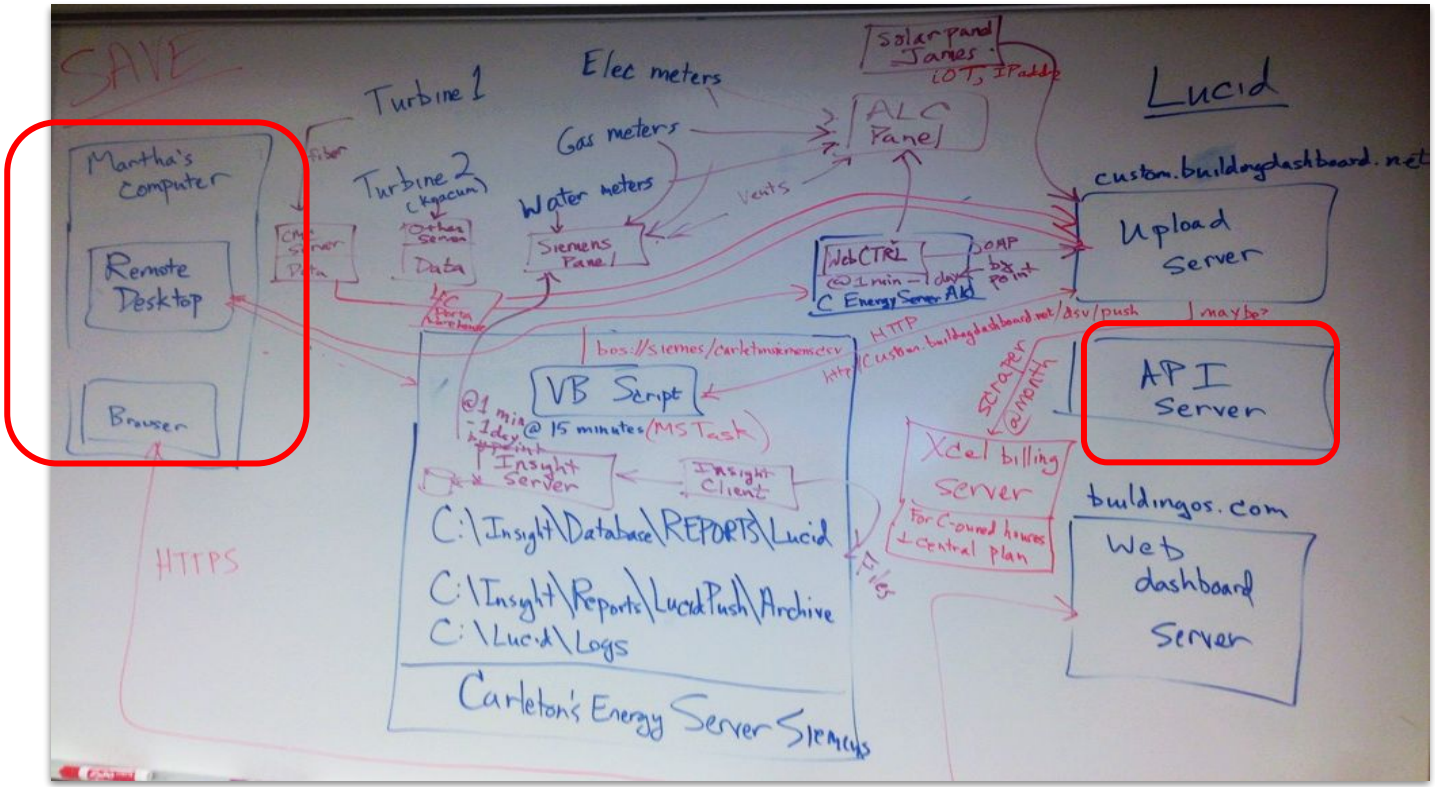
problem
data
database
api
dashboard
analysis
conclusion

1. How we get data
2. Importers
3. Overview of structure

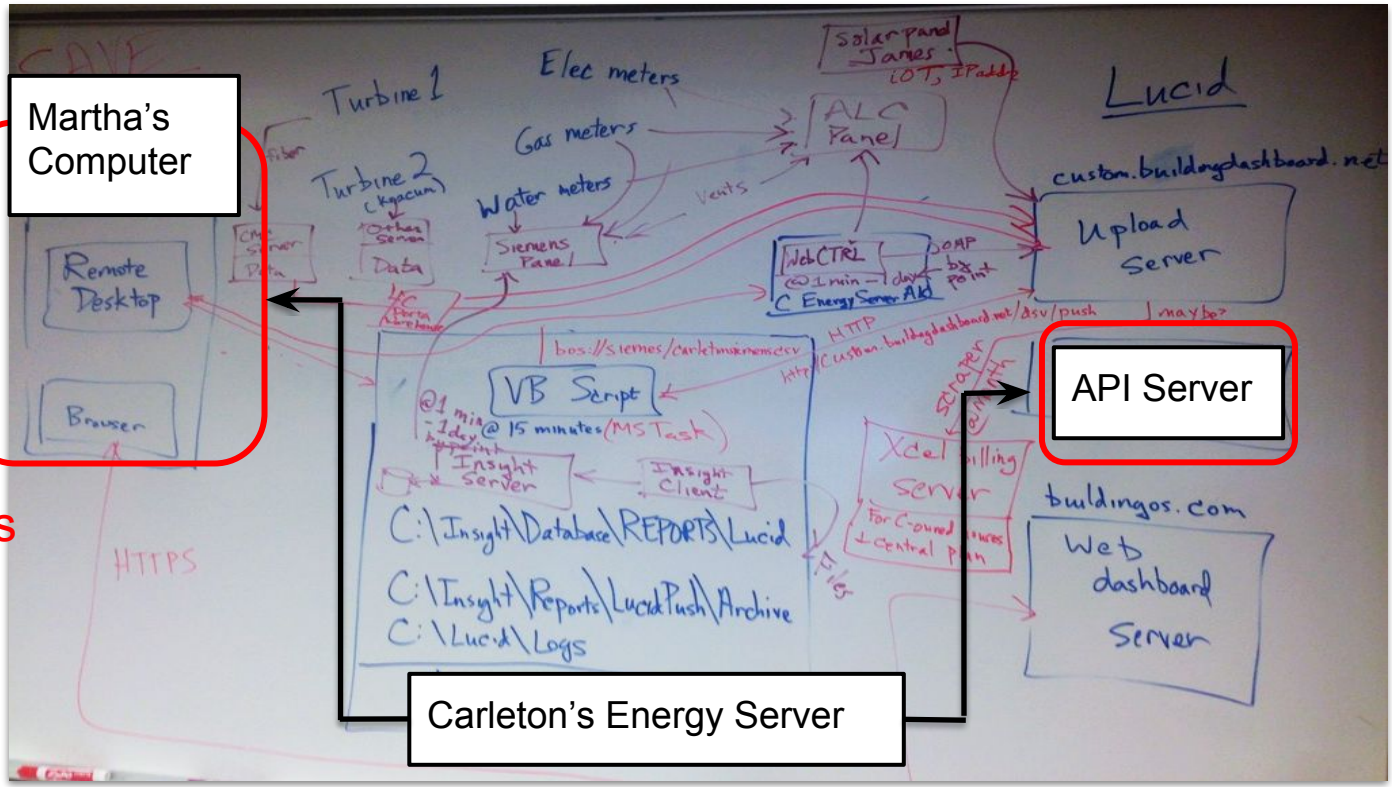
Our System


Using Data
Energy App
Wind Data
Data Sources
Meter Data
Importers
DB
API
Dashboard
Storing / Serving Data
Analysis

Where We Get Data



Where We Get Data



Siemens ALC

LUCID

Database: Importers

- CSV Dumps
- Name parsing
- Separate importers for Lucid and Siemens

Key	Name:Suffix	Trend Definitions Used
Point_1:	HU.R218.ECFM	15 minutes
Point_2:	HU.R218.EXCFM	15 minutes
Point_3:	HU.R218.OCC	15 minutes
Point_4:	HU.R218.RHV	15 minutes
Point_5:	HU.R218.RM	15 minutes

Hulings CSV

<>Date	Time	Point_1	Point_2	Point_3	Point_4	Point_5
8/18/17	0:00:00	422.53	4.23	OFF	7.83	64.26
8/18/17	0:15:00	409.94	4.1	OFF	7.8	64.25
8/18/17	0:30:00	403.05	4.03	OFF	7.8	64.25
8/18/17	0:45:00	419.96	4.2	OFF	7.78	64.24
8/18/17	1:00:00	409.94	4.1	OFF	7.81	64.26
8/18/17	1:15:00	416.64	4.17	OFF	7.76	64.23
8/18/17	1:30:00	420.08	4.2	OFF	7.83	64.27
8/18/17	1:45:00	412.9	4.13	OFF	7.84	64.27
8/18/17	2:00:00	416.86	4.17	OFF	7.76	64.23

Database: Importers

- CSV Dumps
- Name parsing
- Separate importers for Lucid and Siemens

Key	Name:Suffix	Trend Definitions Used
Point_1:	HU.R218.ECFM	15 minutes
Point_2:	HU.R218.EXCFM	15 minutes
Point_3:	HU.R218.OCC	15 minutes
Point_4:	HU.R218.RHV	15 minutes
Point_5:	HU.R218.RM	15 minutes

Hulings CSV

<>Date	Time	Point_1	Point_2	Point_3	Point_4	Point_5
8/18/17	0:00:00	422.53	4.23	OFF	7.83	64.26
8/18/17	0:15:00	409.94	4.1	OFF	7.8	64.25
8/18/17	0:30:00	403.05	4.03	OFF	7.8	64.25
8/18/17	0:45:00	419.96	4.2	OFF	7.78	64.24
8/18/17	1:00:00	409.94	4.1	OFF	7.81	64.26
8/18/17	1:15:00	416.64	4.17	OFF	7.76	64.23
8/18/17	1:30:00	420.08	4.2	OFF	7.83	64.27
8/18/17	1:45:00	412.9	4.13	OFF	7.84	64.27
8/18/17	2:00:00	416.86	4.17	OFF	7.76	64.23

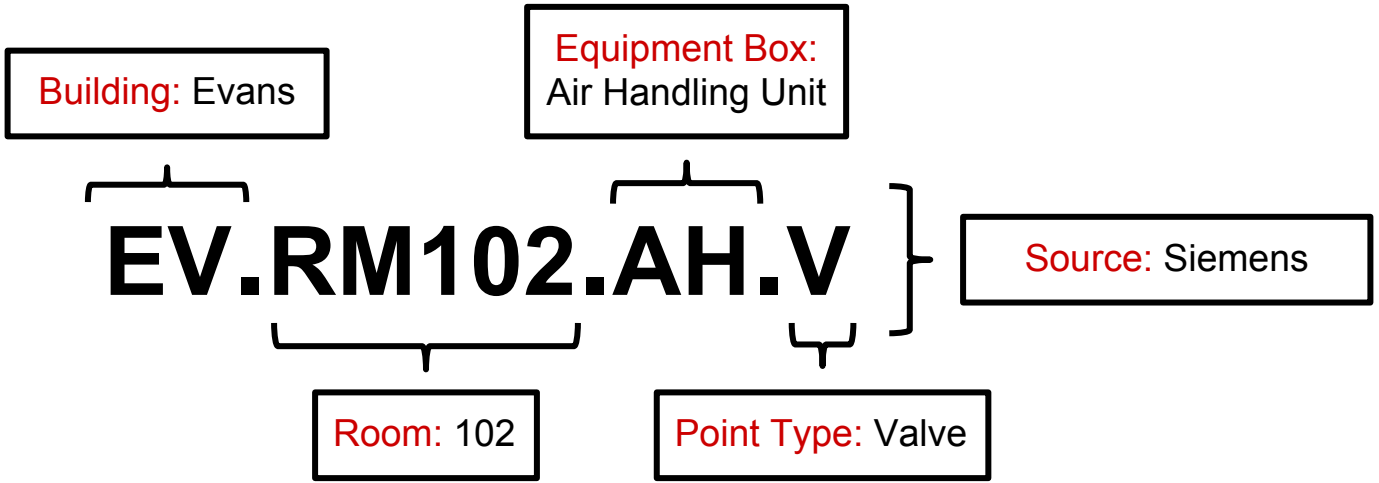
Database: Importers

- CSV Dumps
- Name parsing
- Separate importers for Lucid and Siemens

Key	Name:Suffix	Trend Definitions Used
Point_1:	HU.R218.ECFM	15 minutes
Point_2:	HU.R218.EXCFM	15 minutes
Point_3:	HU.R218.OCC	15 minutes
Point_4:	HU.R218.RHV	15 minutes
Point_5:	HU.R218.RM	15 minutes

Hulings CSV

<>Date	Time	Point_1	Point_2	Point_3	Point_4	Point_5
8/18/17	0:00:00	422.53	4.23	OFF	7.83	64.26
8/18/17	0:15:00	409.94	4.1	OFF	7.8	64.25
8/18/17	0:30:00	403.05	4.03	OFF	7.8	64.25
8/18/17	0:45:00	419.96	4.2	OFF	7.78	64.24
8/18/17	1:00:00	409.94	4.1	OFF	7.81	64.26
8/18/17	1:15:00	416.64	4.17	OFF	7.76	64.23
8/18/17	1:30:00	420.08	4.2	OFF	7.83	64.27
8/18/17	1:45:00	412.9	4.13	OFF	7.84	64.27
8/18/17	2:00:00	416.86	4.17	OFF	7.76	64.23


Building: Evans
Equipment Box:
Air Handling Unit
EV.RM102.AH.V
Source: Siemens
Room: 102
Point Type: Valve

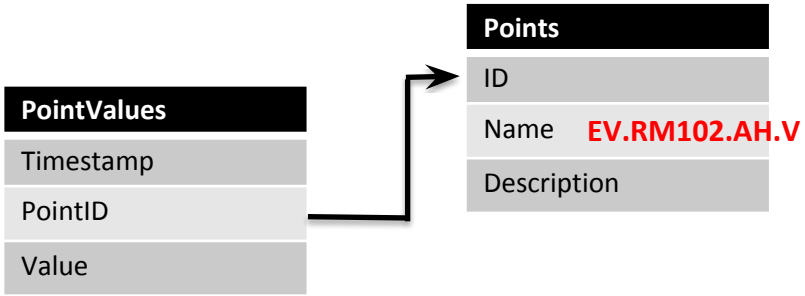
Points
ID
Name
Description

Database Schema

Points	
ID	
Name	EV.RM102.AH.V
Description	

Database Schema

EV.RM102.AH.V



Database Schema

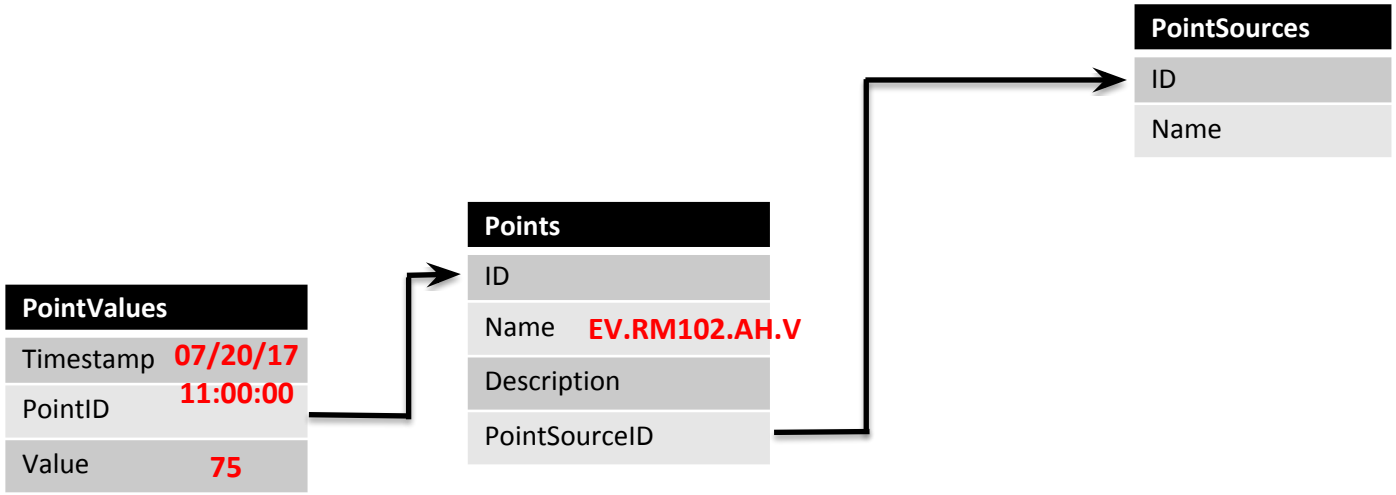
PointValues	
Timestamp	07/20/17 11:00:00
PointID	
Value	75

Points	
ID	
Name	EV.RM102.AH.V
Description	

Database Schema

07/20/17 11:00:00

75

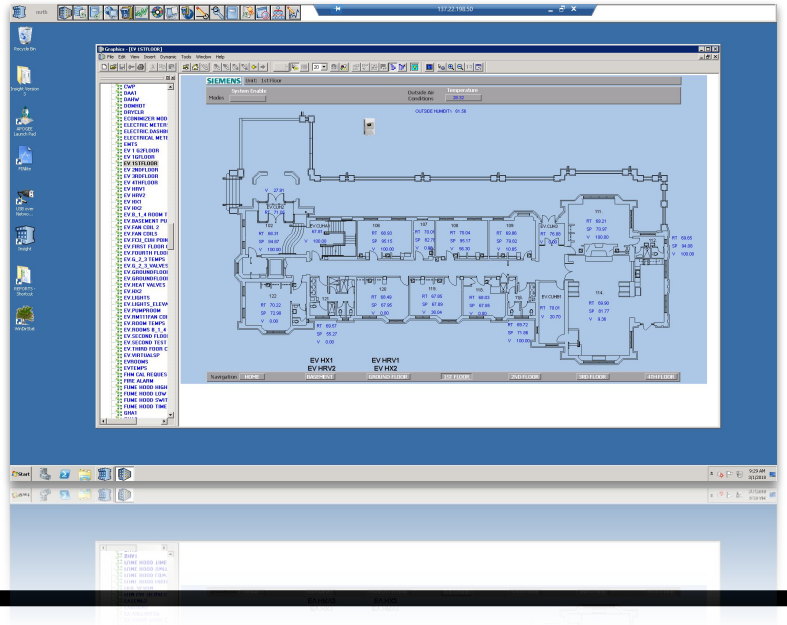


Database Schema

PointValues	
Timestamp	07/20/17 11:00:00
PointID	
Value	75

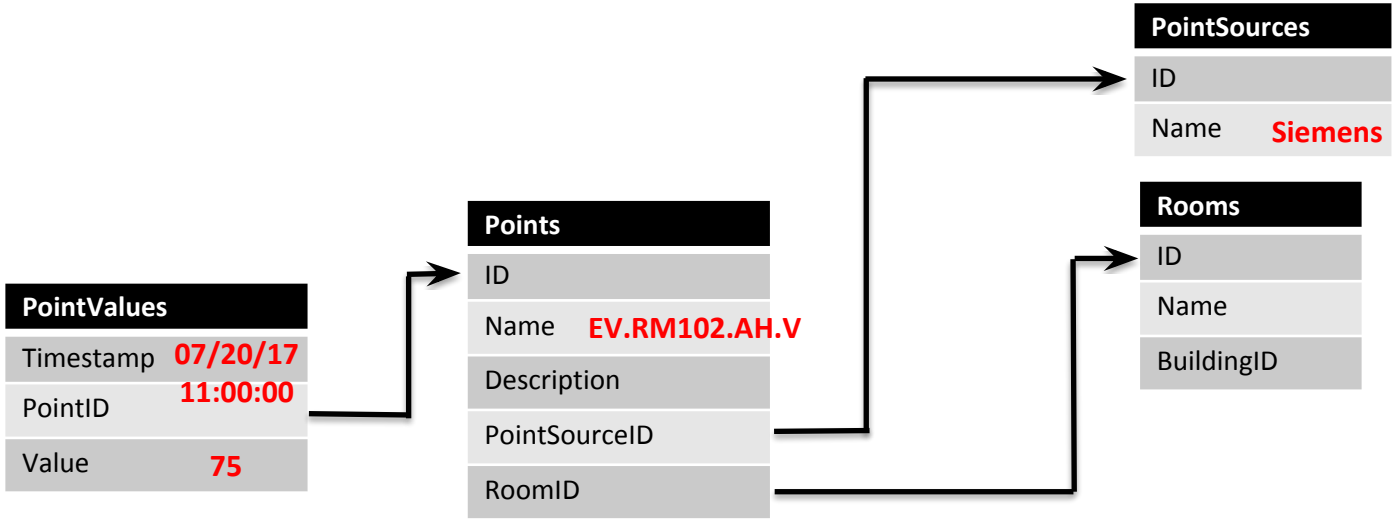
Points	
ID	
Name	EV.RM102.AH.V
Description	
PointSourceID	

PointSources	
ID	
Name	Siemens

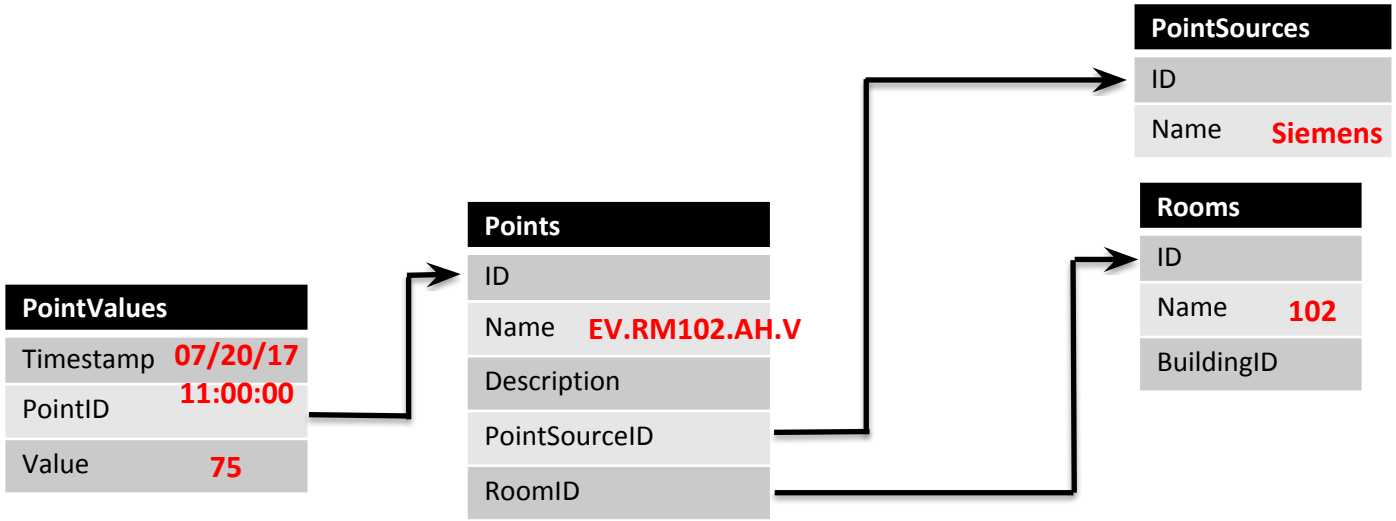


Database Schema

Siemens

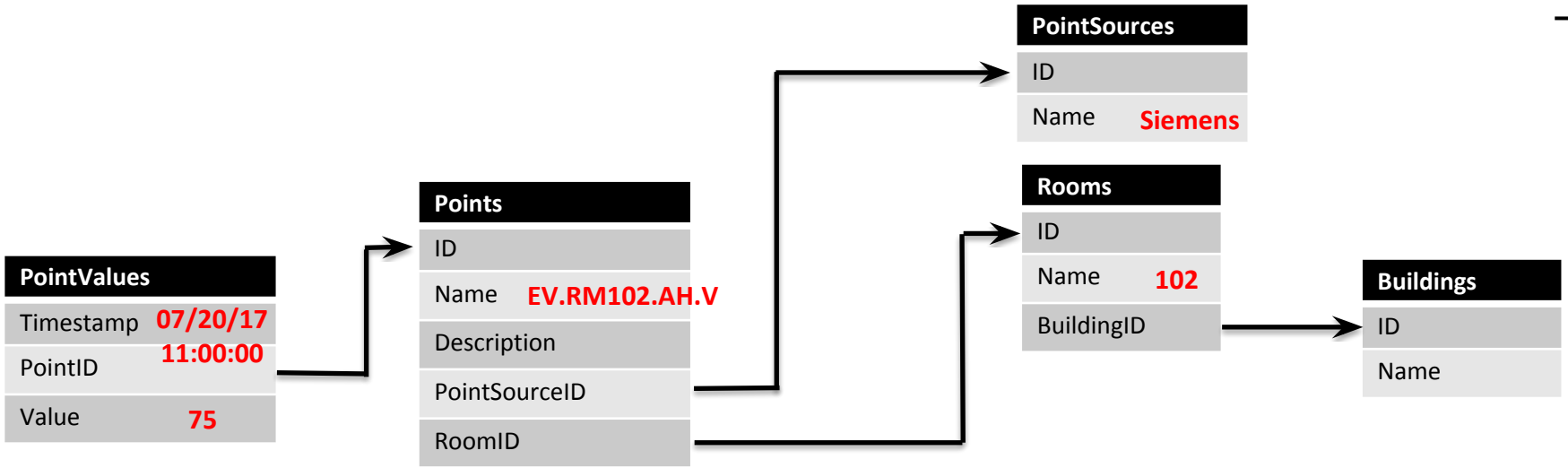


Database Schema

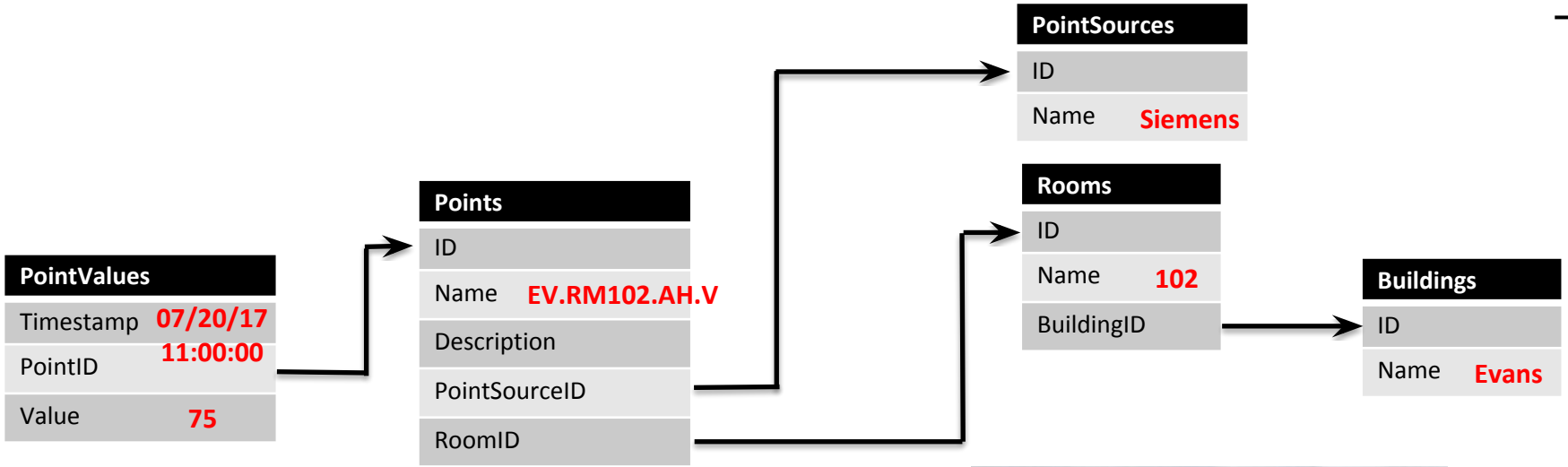


Database Schema

102

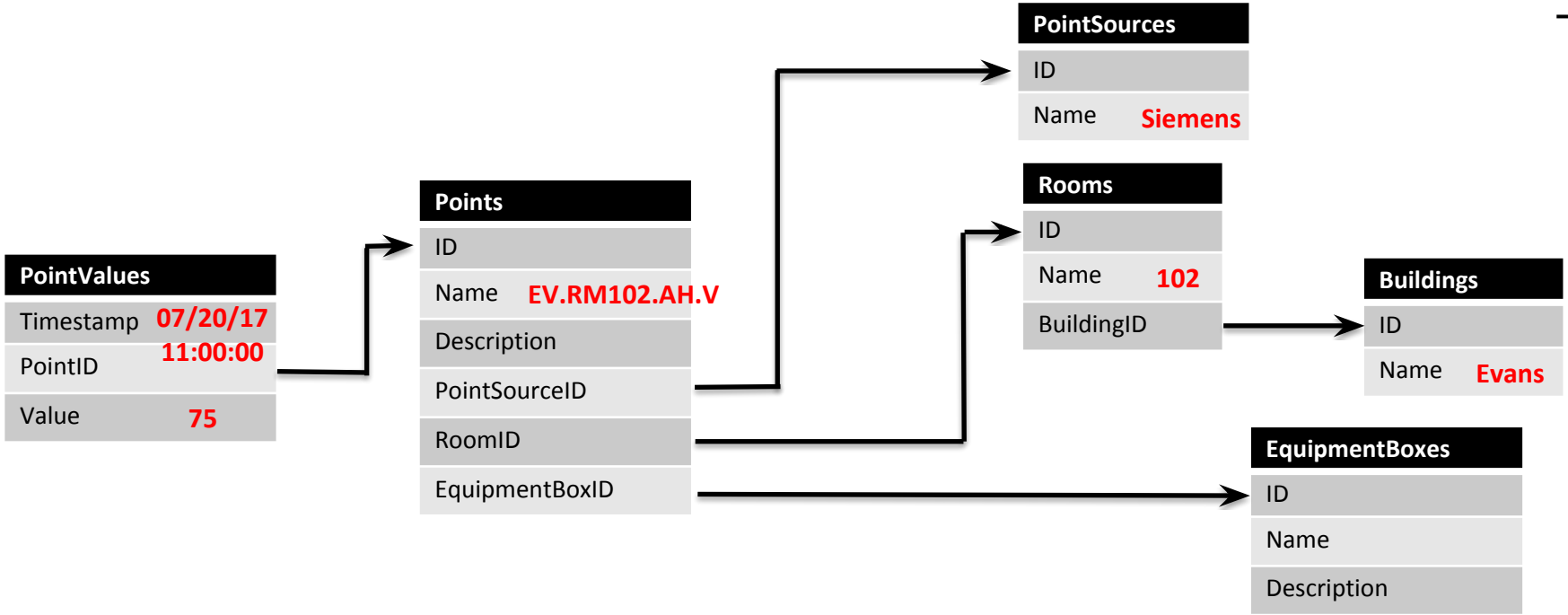


Database Schema



Database Schema

Evans



Database Schema

PointValues	
Timestamp	07/20/17 11:00:00
PointID	
Value	75

Points	
ID	
Name	EV.RM102.AH.V
Description	
PointSourceID	
RoomID	
EquipmentBoxID	

PointSources	
ID	
Name	Siemens

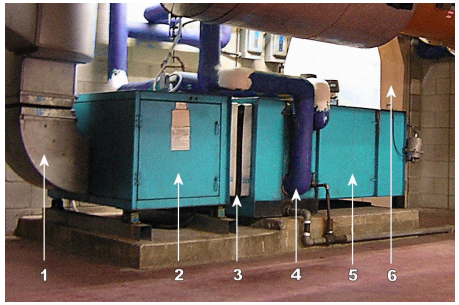
Rooms	
ID	
Name	102
BuildingID	

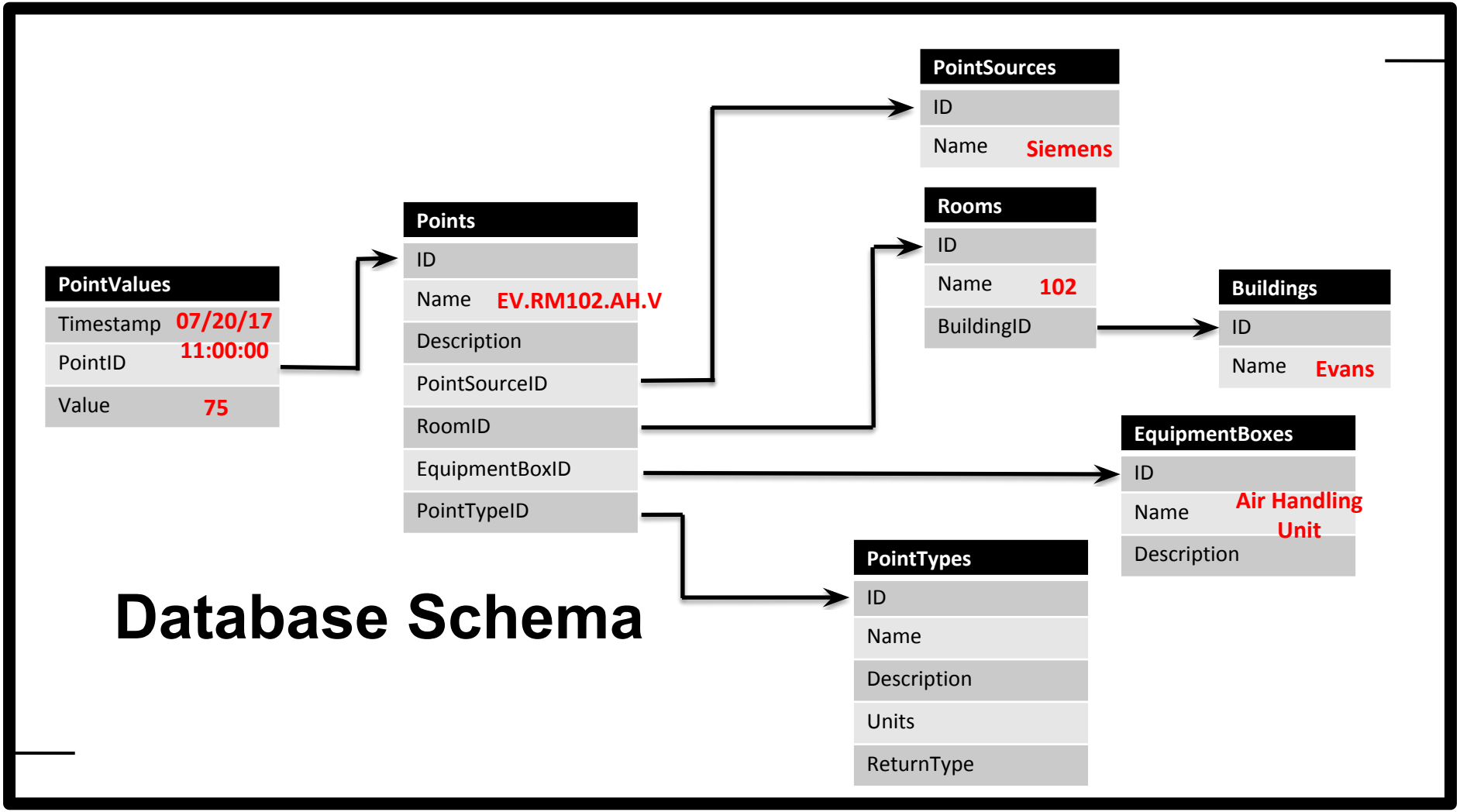
Buildings	
ID	
Name	Evans

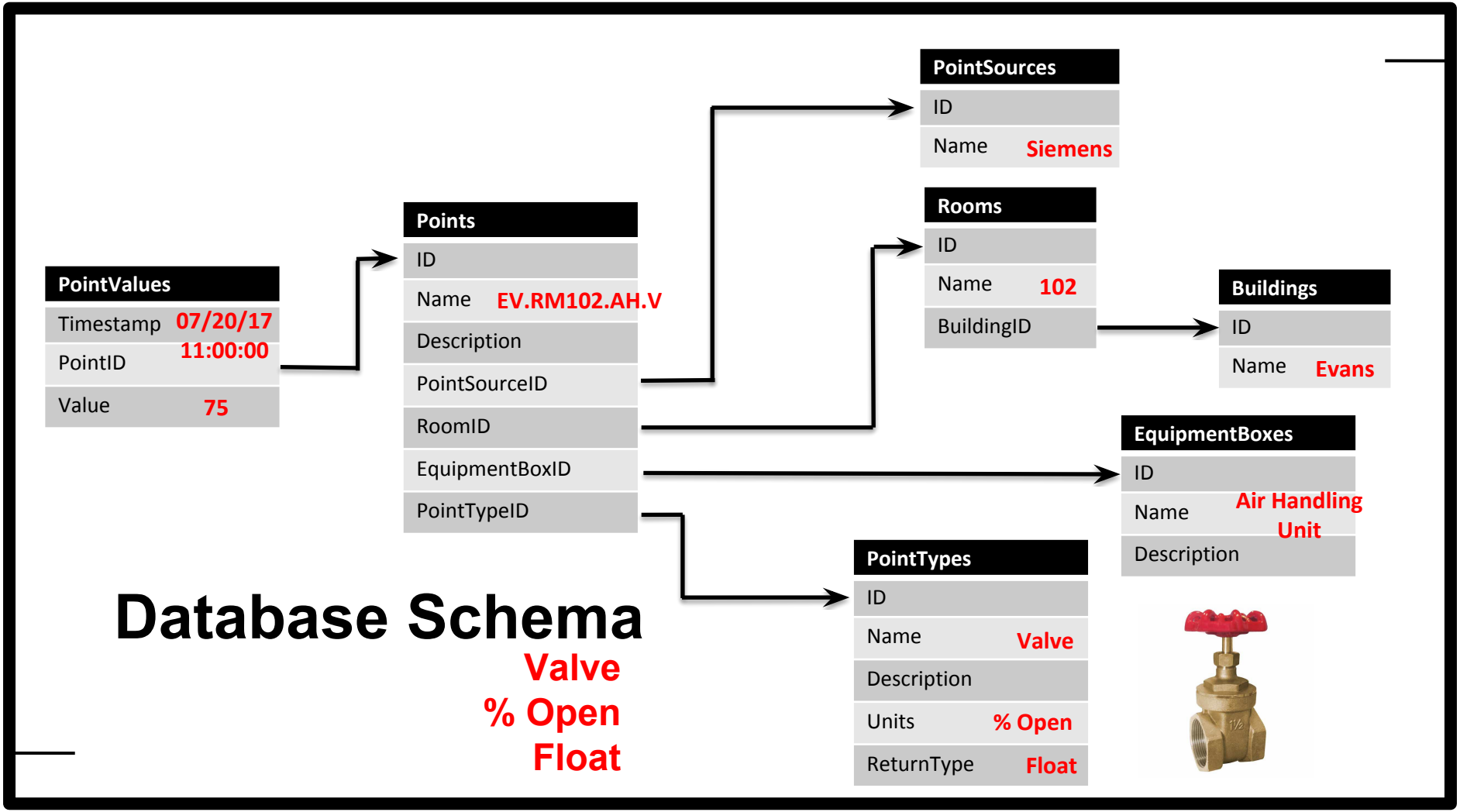
EquipmentBoxes	
ID	
Name	Air Handling Unit
Description	

Database Schema

Air Handling Unit



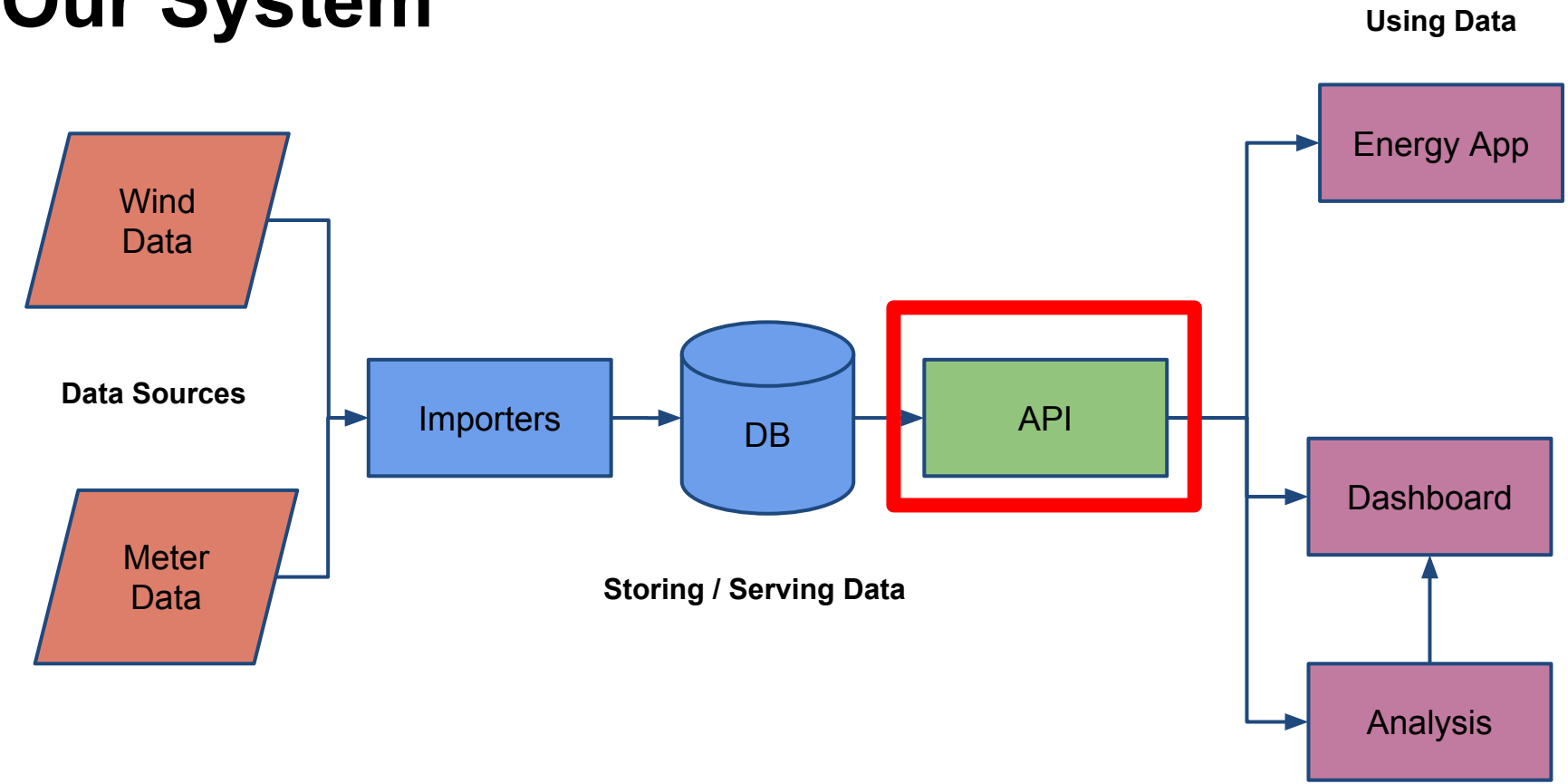

PointSources
ID
Name
Siemens
Points
ID
Name
EV.RM102.AH.V
Description
PointSourceID
RoomID
EquipmentBoxID
PointTypeID
Rooms
ID
Name
102
BuildingID
Buildings
ID
Name
Evans
PointValues
Timestamp
07/20/17 11:00:00
PointID
Value
75
EquipmentBoxes
ID
Name
Air Handling Unit
Description
PointTypes
ID
Name
Description
Units
ReturnType
Database Schema


PointSources
ID
Name
Siemens
Rooms
ID
Name
102
BuildingID
Buildings
ID
Name
Evans
PointValues
Timestamp
07/20/17 11:00:00
PointID
Value
75
Points
ID
Name
EV.RM102.AH.V
Description
PointSourceID
RoomID
EquipmentBoxID
PointTypeID
EquipmentBoxes
ID
Name
Air Handling Unit
Description
PointTypes
ID
Name
Valve
Description
Units
% Open
ReturnType
Float
Database Schema
Valve
% Open
Float

problem
data
database
api
dashboard
analysis
conclusion

1. Why?
2. What do we want?
3. How do we get it?

Our System


Using Data
Energy App
Wind Data
Data Sources
Importers
DB
API
Dashboard
Meter Data
Storing / Serving Data
Analysis

Use Cases

- What are all the buildings on campus?
- What are the names of all the points in Hulings?
- What were the temperatures in Evans 204 last week?

What do we want to return?

PointSources
ID
Name

Rooms
ID
Name
BuildingID

Buildings
ID
Name

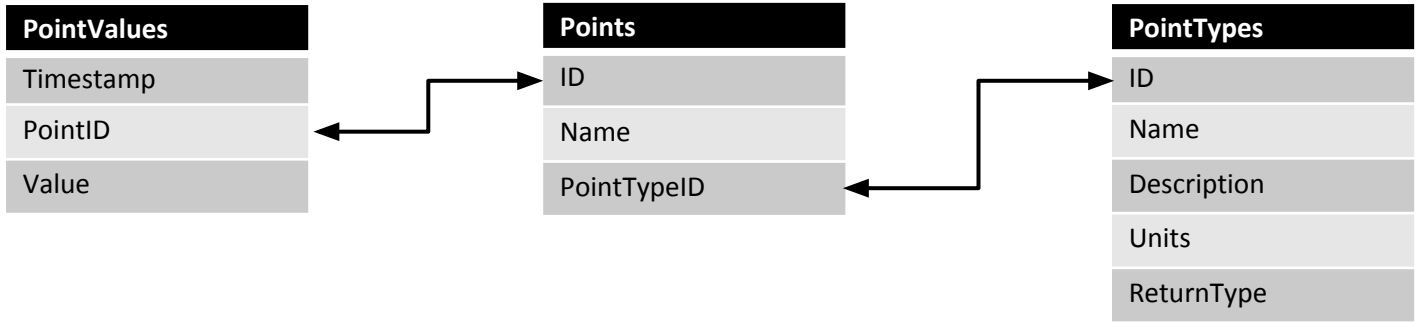
Points
ID
Name
Description
PointSourceID
RoomID
EquipmentBoxID
PointTypeID

PointValues
Timestamp
PointID
Value

EquipmentBoxes
ID
Name
Description

PointTypes
ID
Name
Description
Units
ReturnType

Limited Subset



Interpret Data

PointTimestamp	PointID	PointValue
2015-08-10 00:00:00	450	19,800,024
2015-08-10 00:00:00	212	21
2015-08-10 00:00:00	416	1

Interpret Data

PointTimestamp	PointID	PointValue	Return Type	Factor	Output
2015-08-10 00:00:00	450	19,800,024	float	5	198.00024
2015-08-10 00:00:00	212	21	float	0	21
2015-08-10 00:00:00	416	1	bool	416	True

Interpret Data

PointTimestamp	PointID	PointValue	Return Type	Factor	Output
2015-08-10 00:00:00	450	19,800,024	float	5	198.00024
2015-08-10 00:00:00	212	21	float	0	21
2015-08-10 00:00:00	416	1	bool	416	True

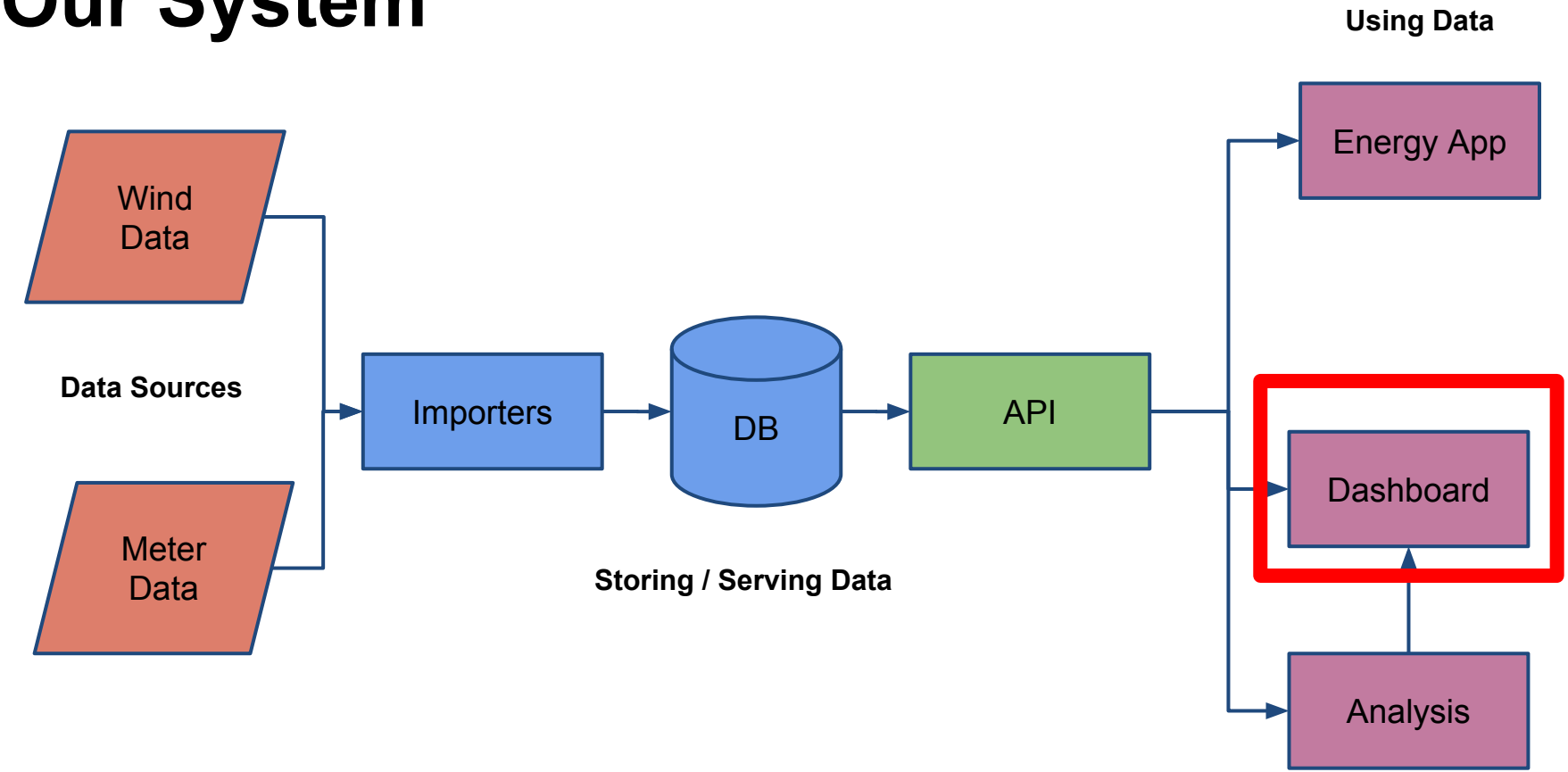
Interpret Data

PointTimestamp	PointID	PointValue	Return Type	Factor	Output
2015-08-10 00:00:00	450	19,800,024	float	5	198.00024
2015-08-10 00:00:00	212	21	float	0	21
2015-08-10 00:00:00	416	1	bool	416	True

problem
data
database
api
dashboard
analysis
conclusion

1. Background
2. Comparison
3. Heatmap
4. Alerts
5. Room Explorer

Our System


Using Data
Energy App
Wind Data
Data Sources
Meter Data
Importers
DB
API
Dashboard
Analysis
Storing / Serving Data

What is the current solution?

- Lucid does not allow for side-by-side comparisons, nor custom date selections.

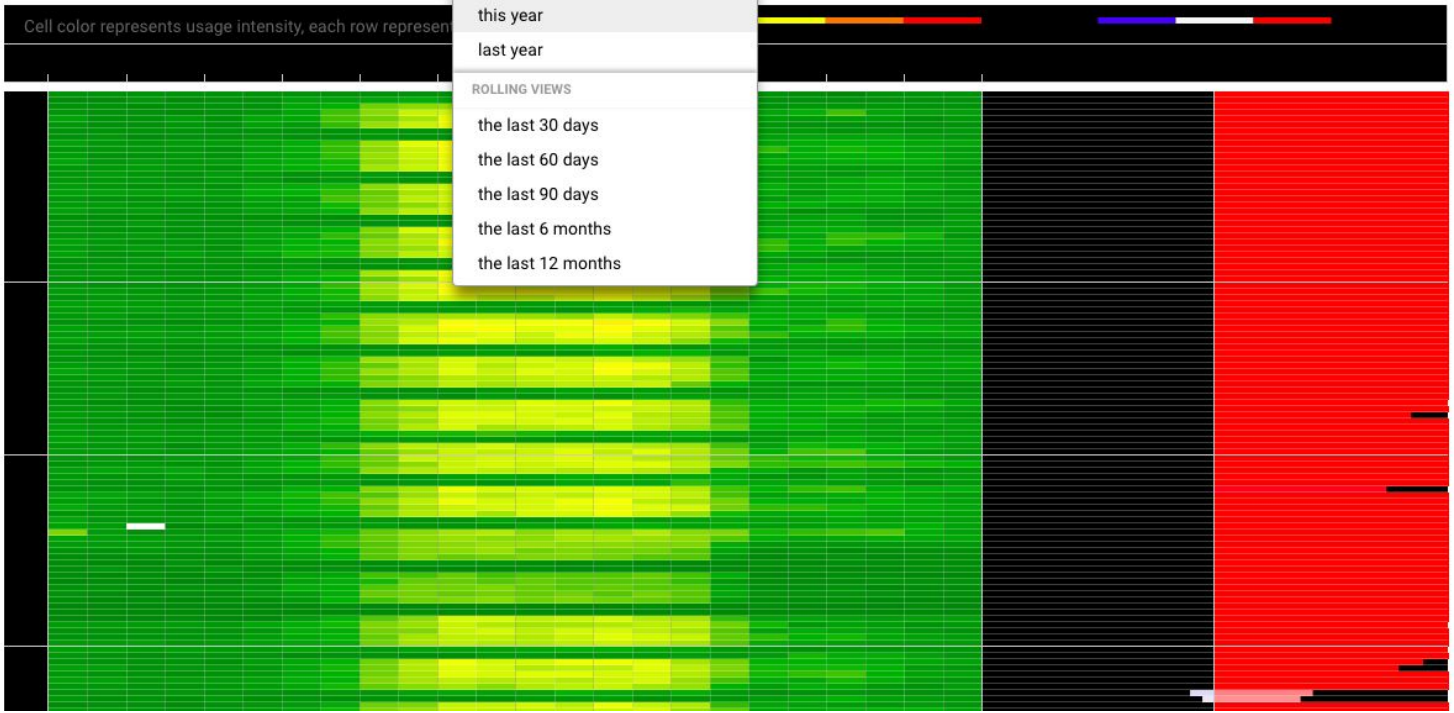
Heat Map Analysis

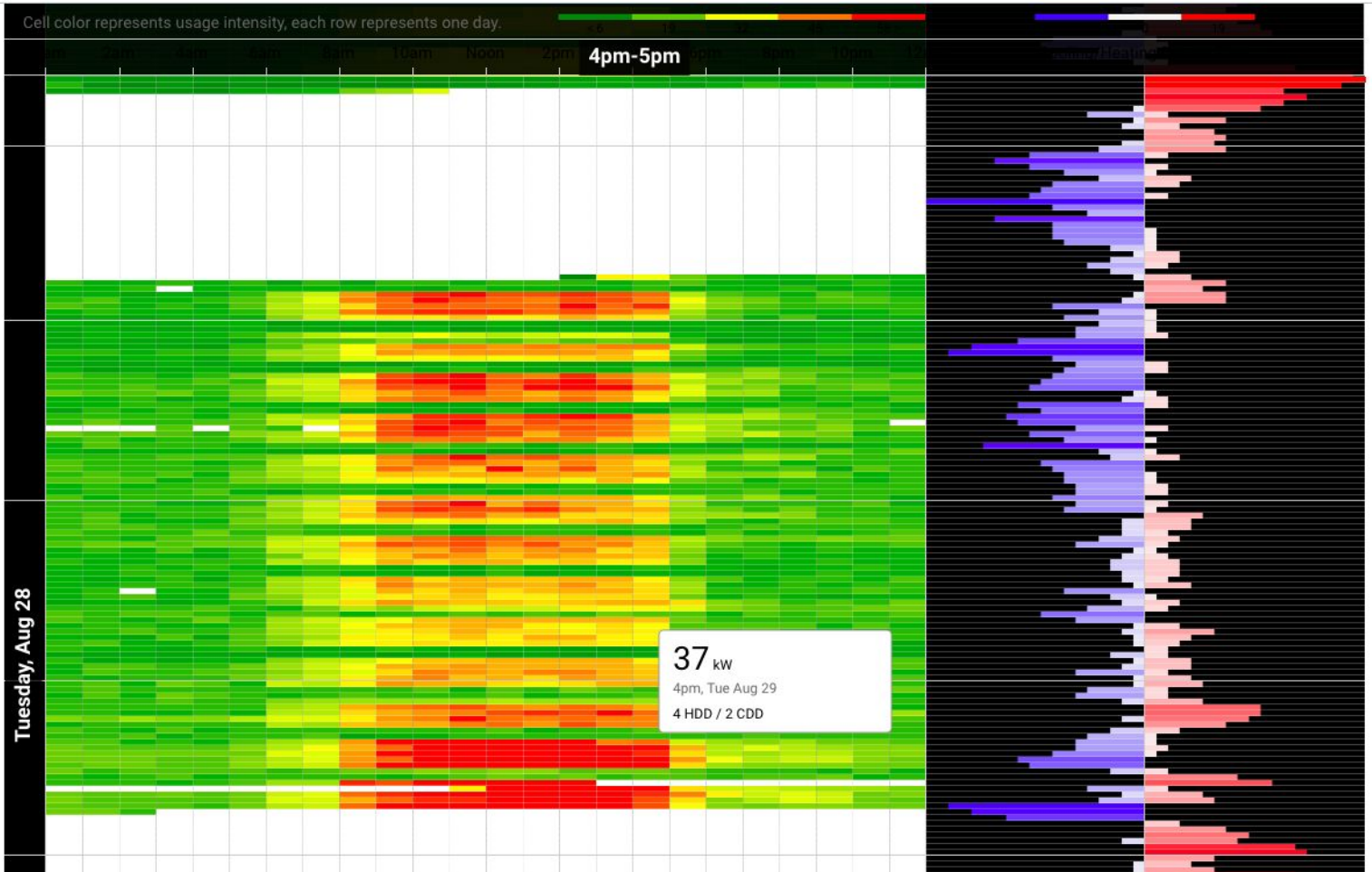
Jump to

Leighton Hall | leighton hall - electricity | over | last year | compared to | degree days

CALENDAR VIEWS
- this year
- last year

ROLLING VIEWS
- the last 30 days
- the last 60 days
- the last 90 days
- the last 6 months
- the last 12 months




Cell color represents usage intensity, each row represents one day.
4pm-5pm
Tuesday, Aug 28
37 kW
4pm, Tue Aug 29
4 HDD / 2 CDD

What is the current solution?

- Lucid does not allow for side-by-side comparisons, nor custom date selections.
- ALC and Siemens do not have any effective built-in options for data visualization or analysis.

What is the current solution?

- Lucid does not allow for side-by-side comparisons, nor custom date selections.
- ALC and Siemens do not have any effective built-in options for data visualization or analysis.
- No easy solution exists for comparing data from different sources. Facilities instead has to collate the data manually.

How can we improve this?

Provide proof-of-concept solutions for the common problems:

- Side-by-side comparisons

How can we improve this?

Provide proof-of-concept solutions for the common problems:

- Side-by-side comparisons
- Improvements on the heatmap tool

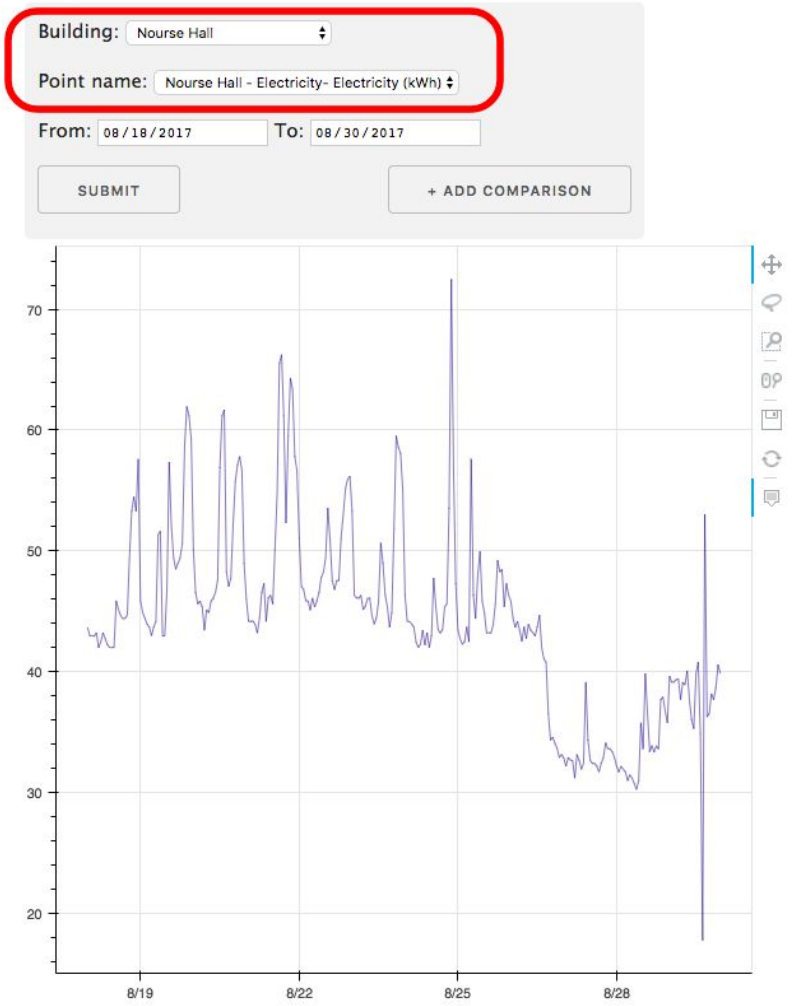
How can we improve this?

Provide proof-of-concept solutions for the common problems:

- Side-by-side comparisons
- Improvements on the heatmap tool
- Rudimentary anomaly detection

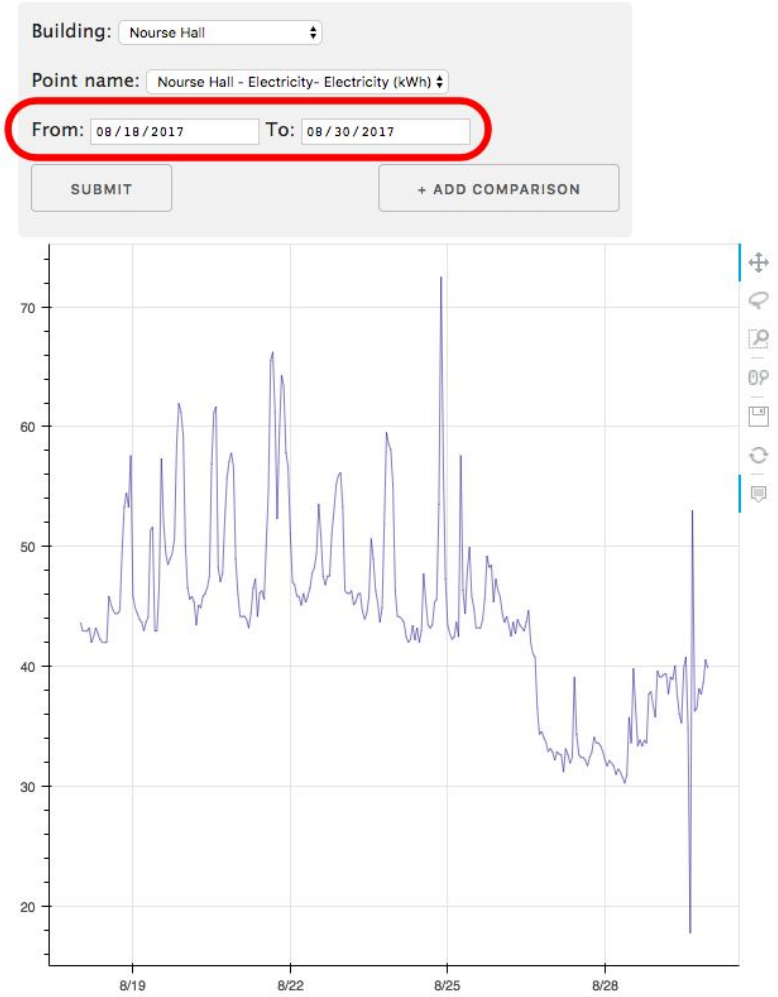
Dashboard: Comparisons

- Custom point selectors



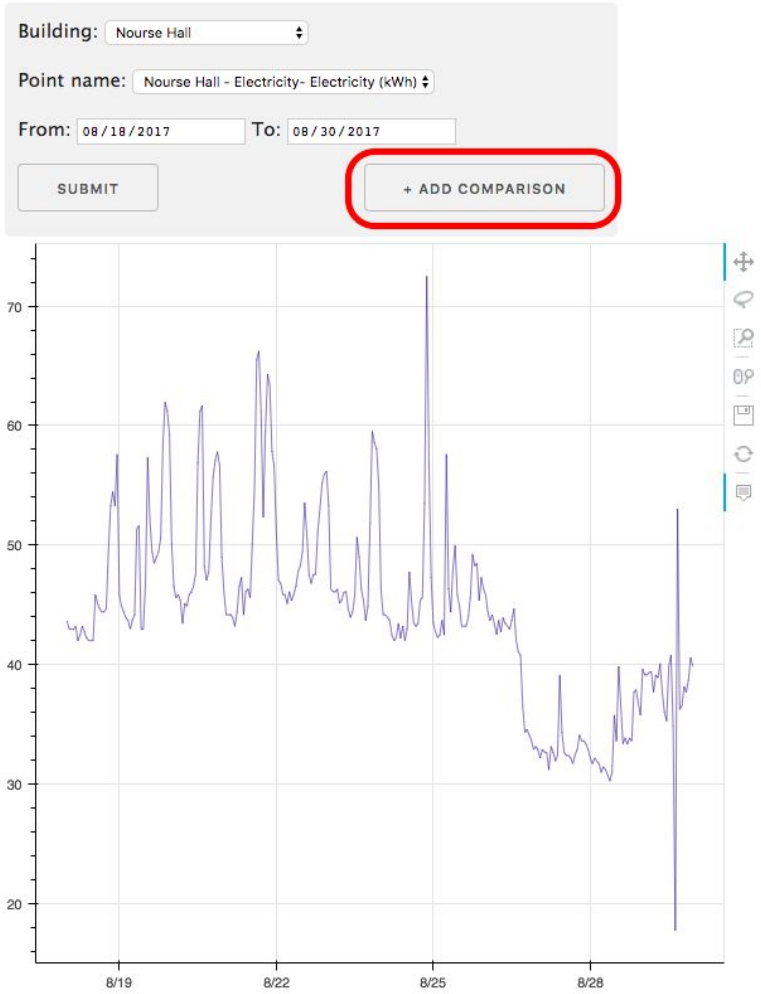
Dashboard: Comparisons

- Custom point selectors
- Custom time ranges



Dashboard: Comparisons

- Custom point selectors
- Custom time ranges
- Side-by-side comparisons



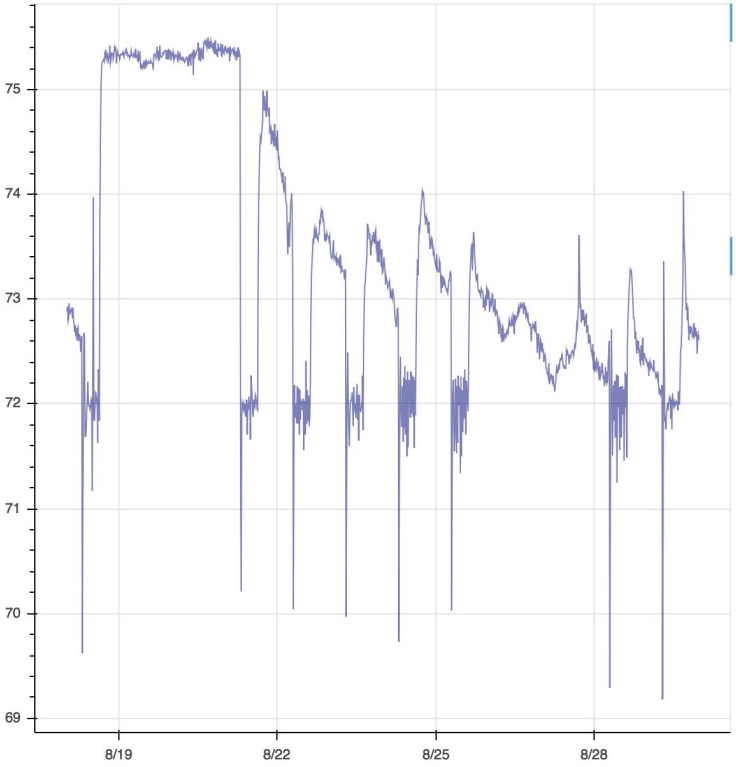
Side-by-side comparison: Hulings Room Temperature

Building: Hulings

Point name: HU.R213B.RMT- 213B TEMP

From: 2016-08-18 To: 2017-08-30

SUBMIT



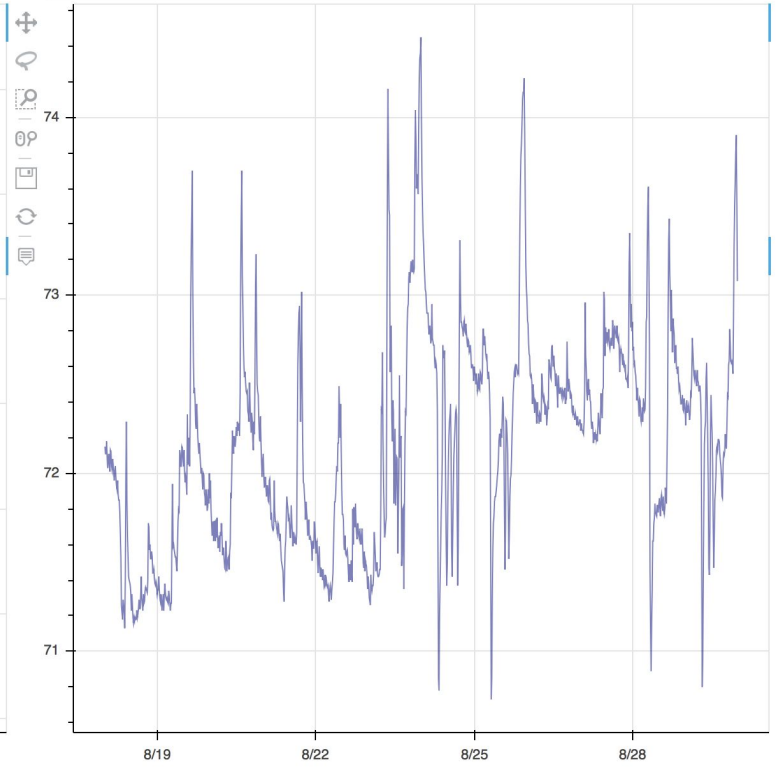
Building: Hulings

Point name: HU.R212.RMT- 212 TEMP

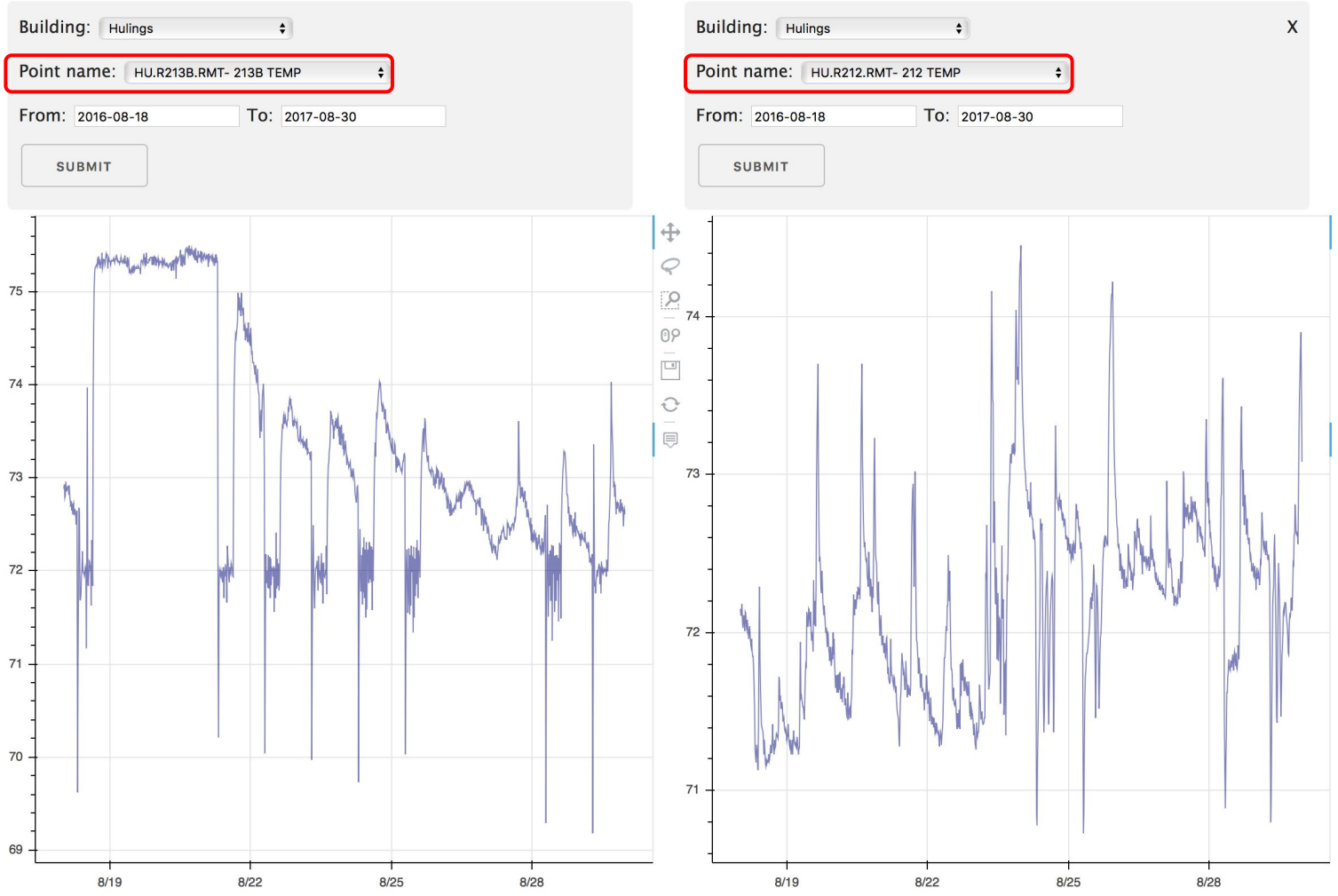
From: 2016-08-18 To: 2017-08-30

SUBMIT

X



Side-by-side comparison: Hulings Room Temperature

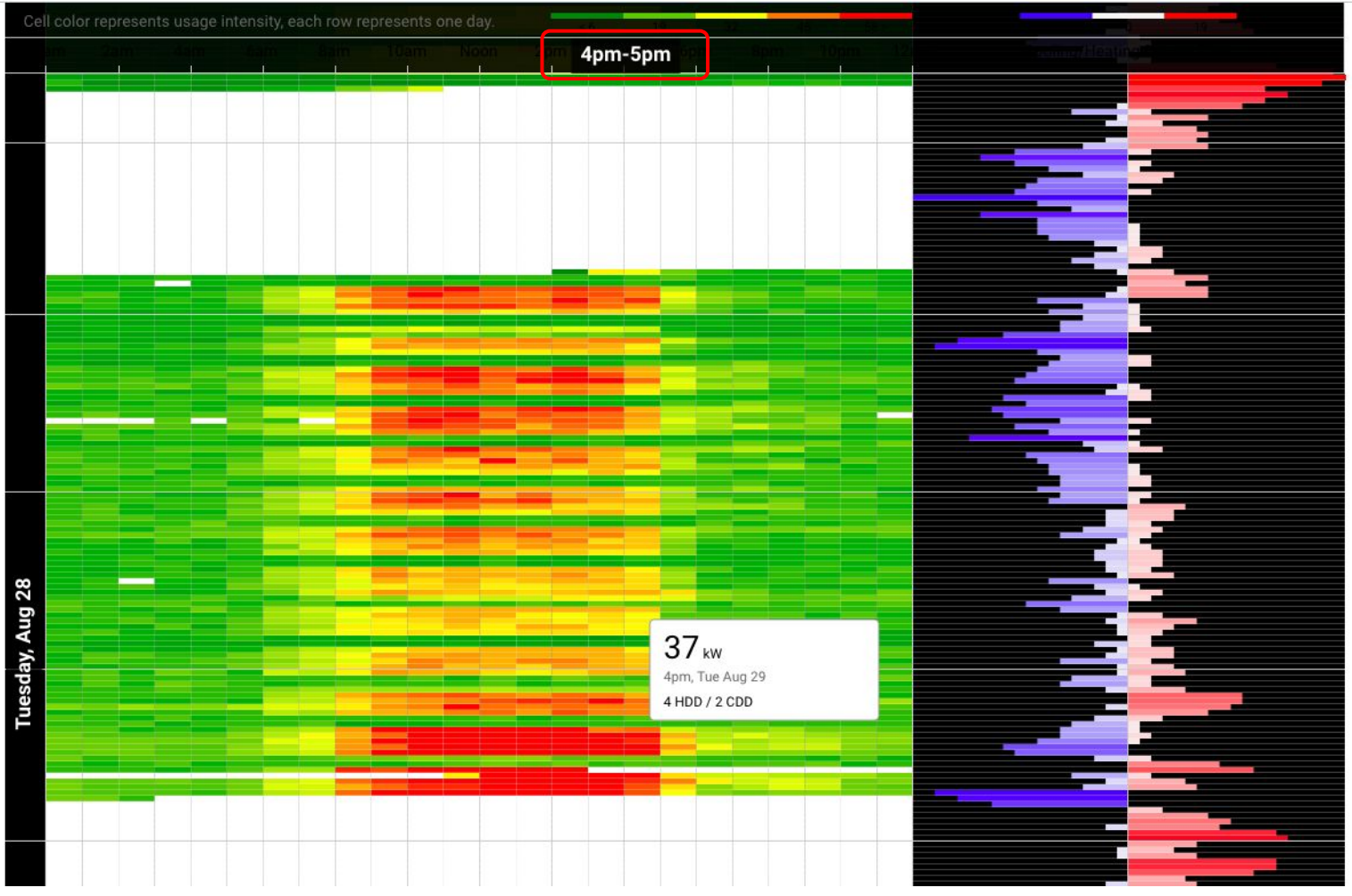


Dashboard: Heatmap

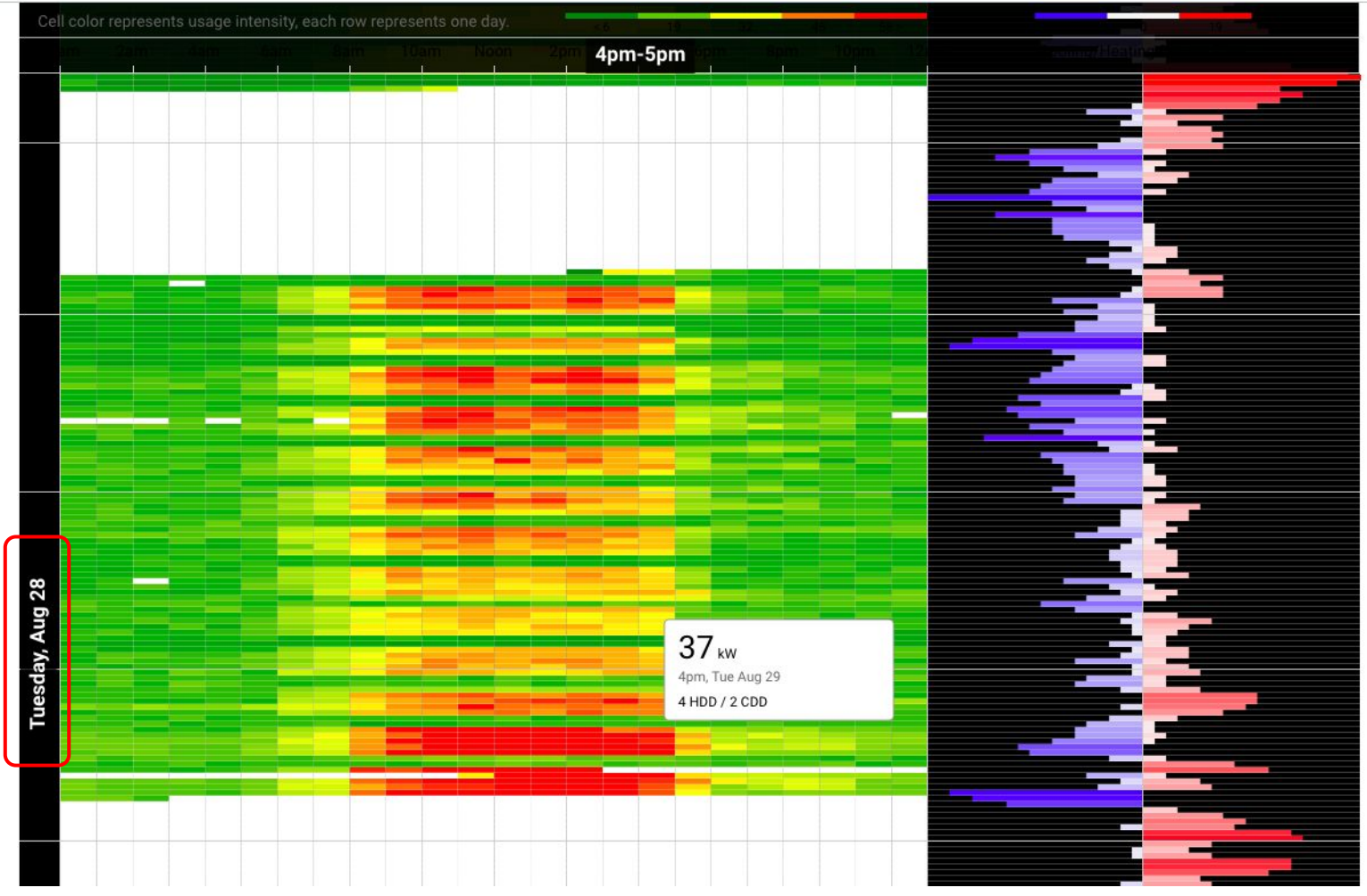
Features we wanted:

- Custom date and point selection
- Different presets for the colors
- Ability to hover over text and see values for a given point

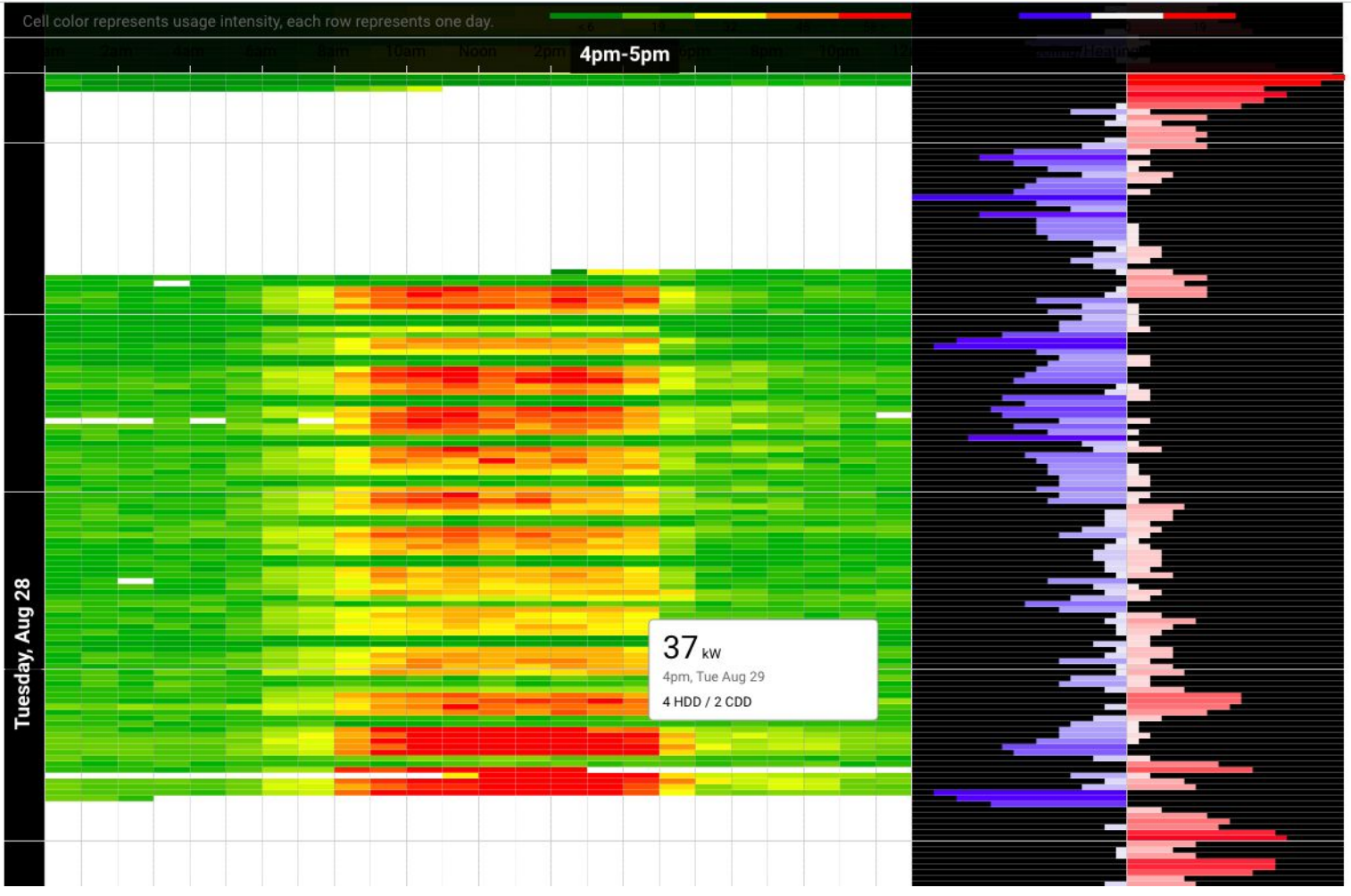
Lucid Heatmap



Lucid Heatmap



Lucid Heatmap



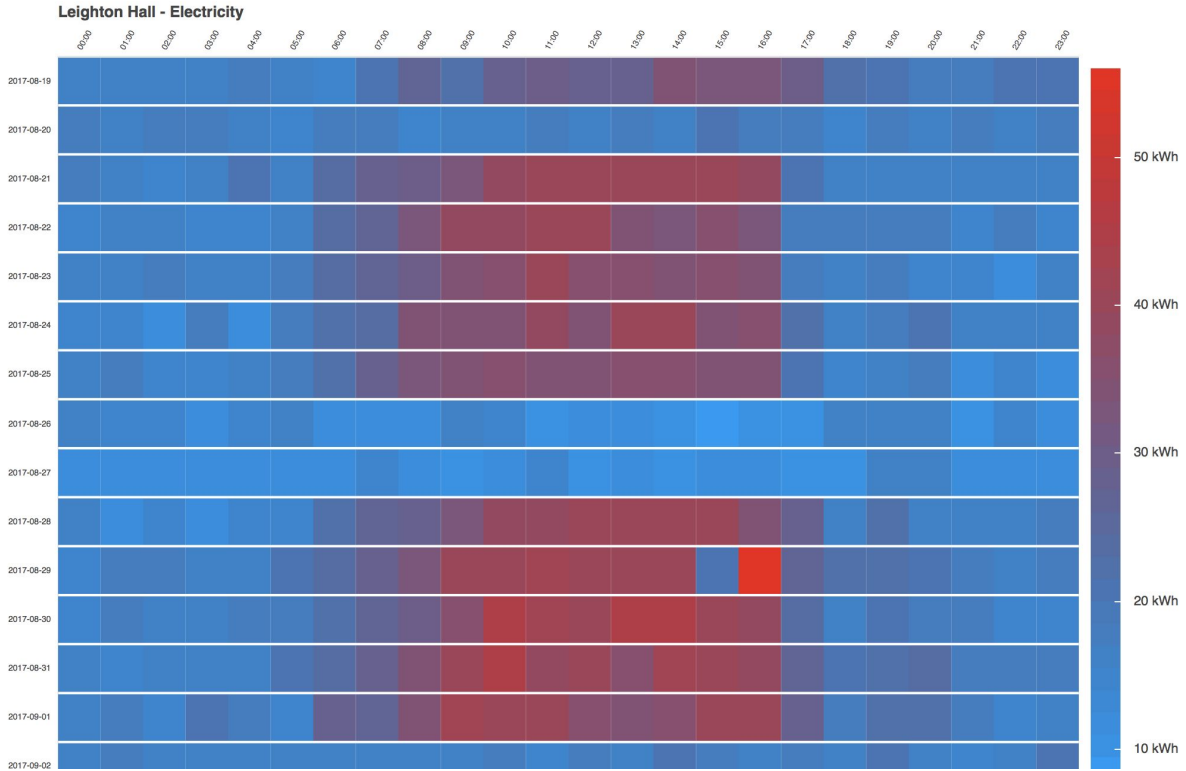
Our Heatmap

Building: Leighton Hall Point name: Leighton Hall - Electricity - Electricity (kWh)

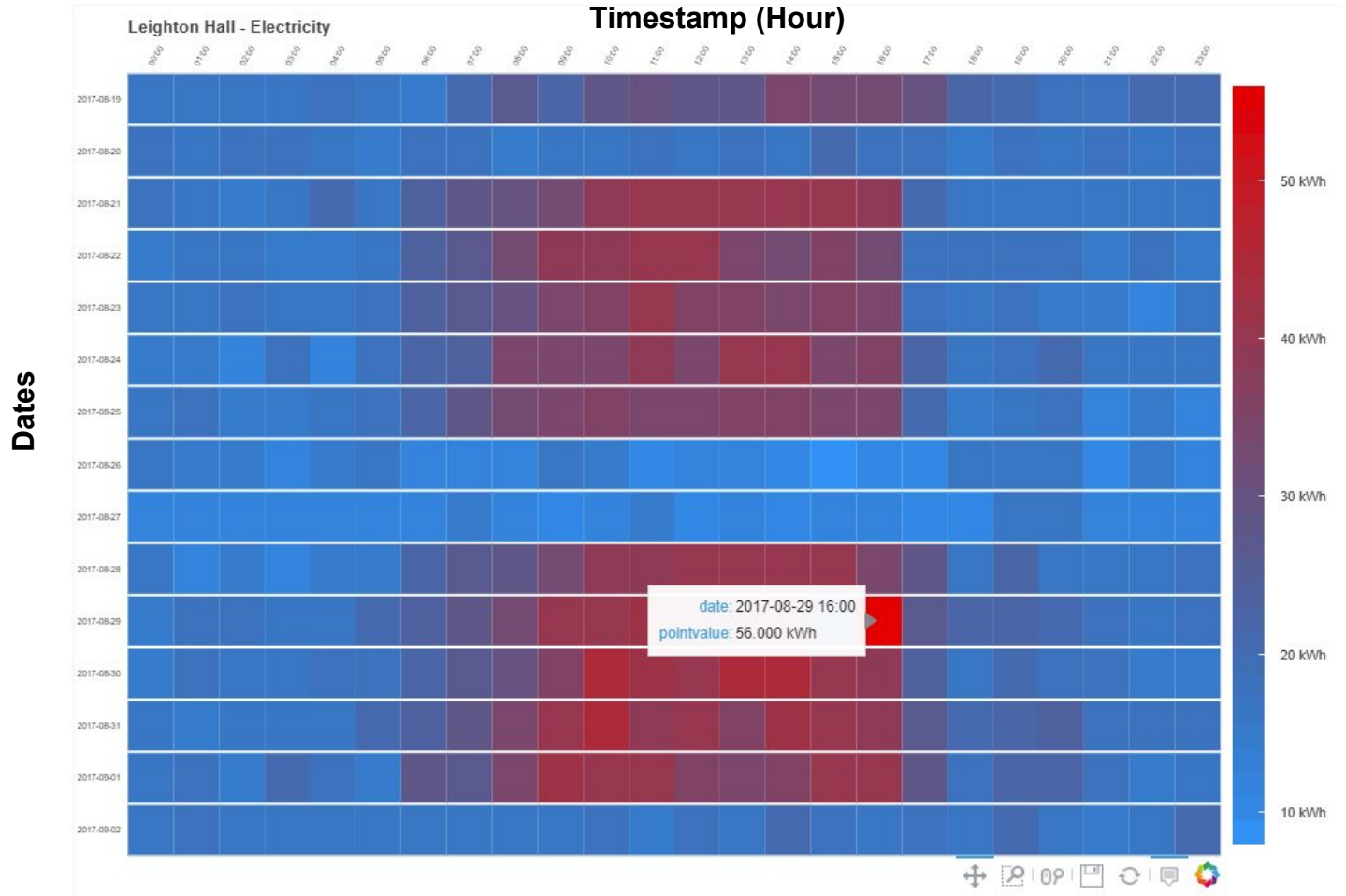
From: 2017-08-19 To: 2017-09-03

SUBMIT

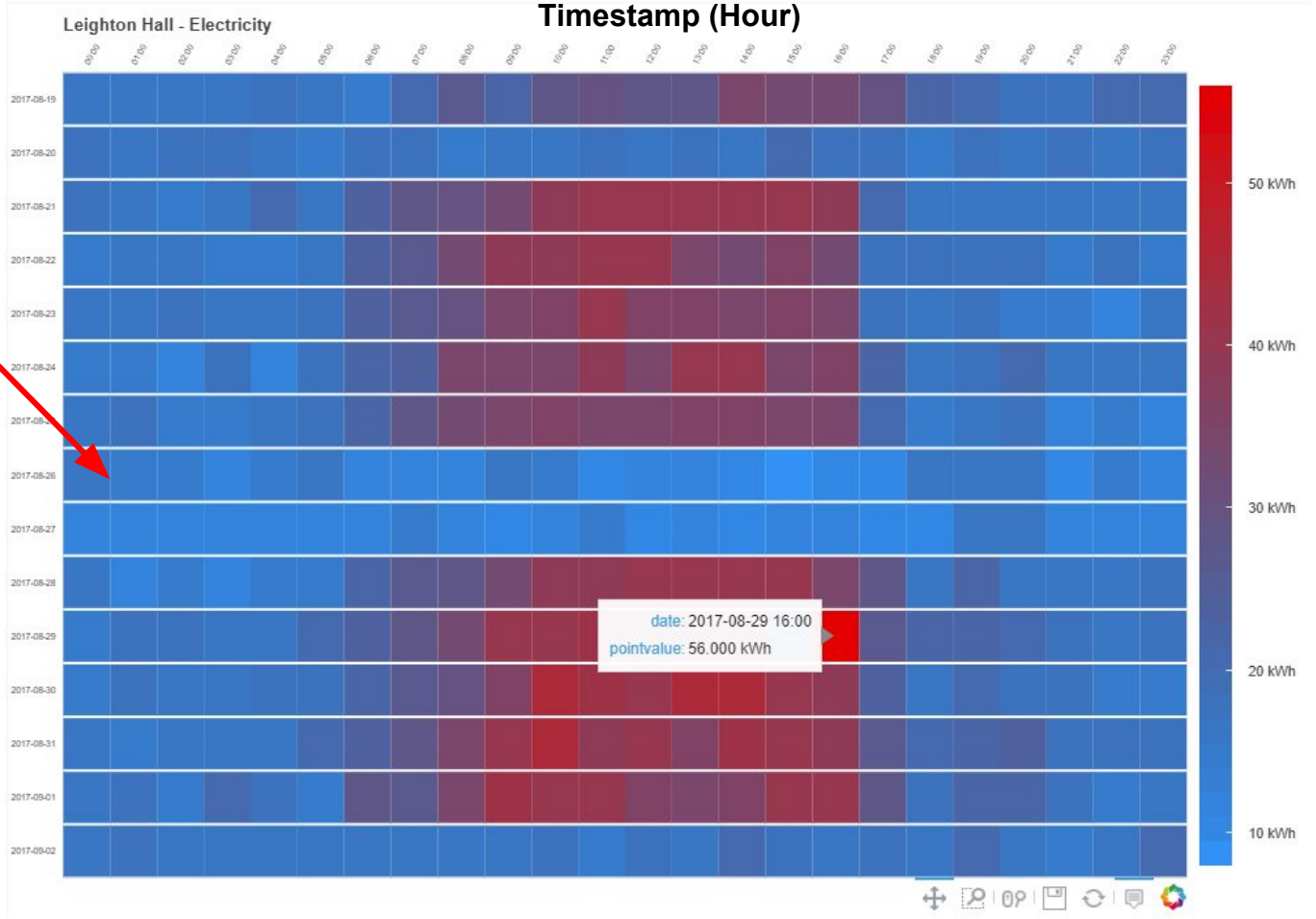
Colors: Red-Blue



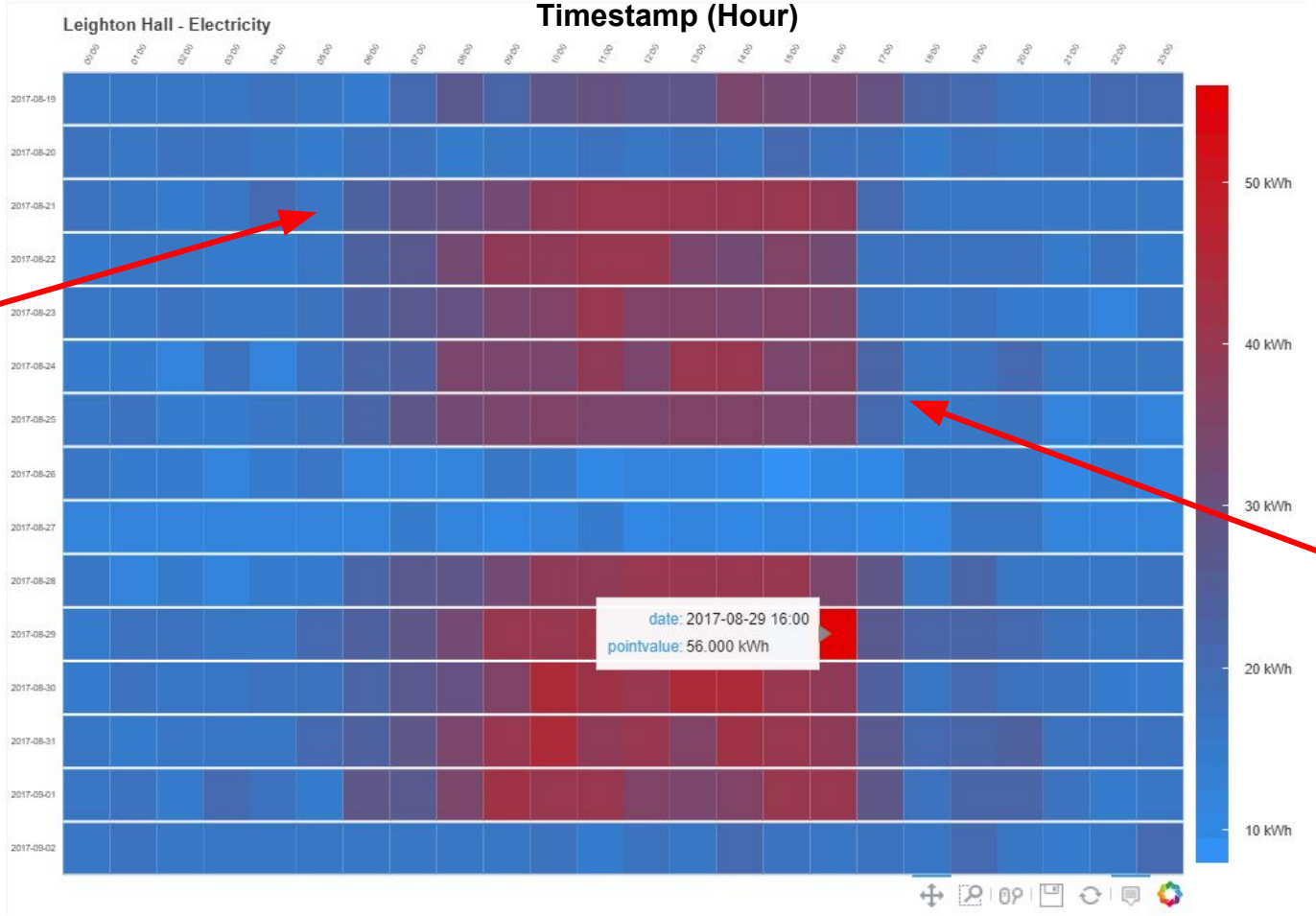
Our Heatmap


Timestamp (Hour)
Dates
Leighton Hall - Electricity
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
2017-08-19
2017-08-20
2017-08-21
2017-08-22
2017-08-23
2017-08-24
2017-08-25
2017-08-26
2017-08-27
2017-08-28
2017-08-29
2017-08-30
2017-08-31
2017-09-01
2017-09-02
date: 2017-08-29 16:00
pointvalue: 56.000 kWh
50 kWh
40 kWh
30 kWh
20 kWh
10 kWh

Our Heatmap


Timestamp (Hour)
Leighton Hall - Electricity
Dates
Weekend!
2017-08-19
2017-08-20
2017-08-21
2017-08-22
2017-08-23
2017-08-24
2017-08-26
2017-08-27
2017-08-28
2017-08-29
2017-08-30
2017-08-31
2017-09-01
2017-09-02
date: 2017-08-29 16:00
pointvalue: 56.000 kWh
50 kWh
40 kWh
30 kWh
20 kWh
10 kWh

Our Heatmap


Leighton Hall - Electricity
Timestamp (Hour)
Dates
Start of work day (6 am)
End of work day (5 pm)
date: 2017-08-29 16:00
pointvalue: 56.000 kWh
50 kWh
40 kWh
30 kWh
20 kWh
10 kWh

Dashboard: Alerts

Very basic metric for anomalies: flag points that are three standard deviations away from the mean of all values over the selected time frame.

Useful as a "proof-of-concept" in case we didn't get to other, fancier analysis for the dashboard.

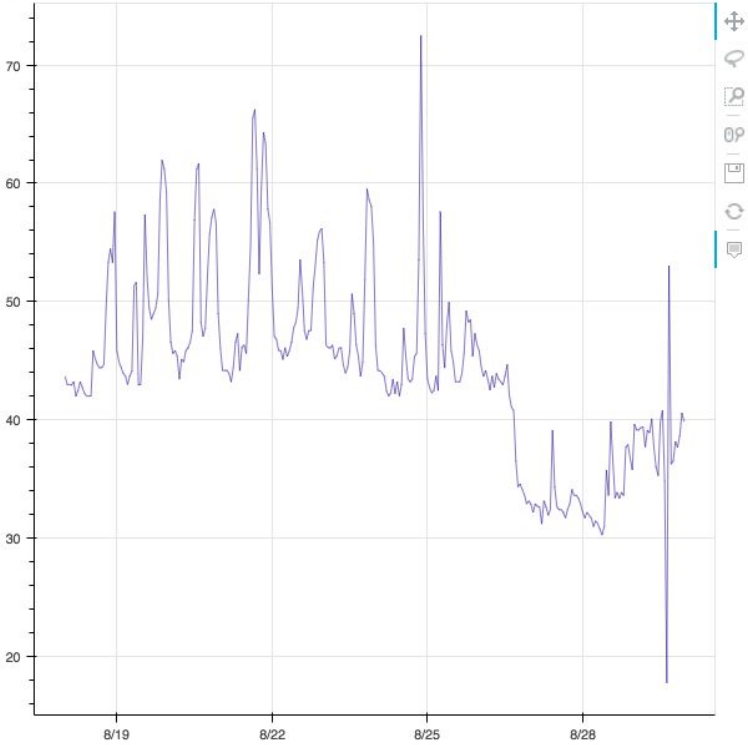
Alerts Page: Nourse Electricity Consumption

Building: Nourse Hall Point name:

Nourse Hall - Electricity- Electricity (kWh)

From: 08/18/2017 To: 08/30/2017

SUBMIT



Point Name: Nourse Hall – Electricity
Average: 44.28
Standard Deviation: 7.91

Date/Time	Value (kWh)
2017-08-24 21:00:00	72.50
2017-08-29 15:00:00	17.75

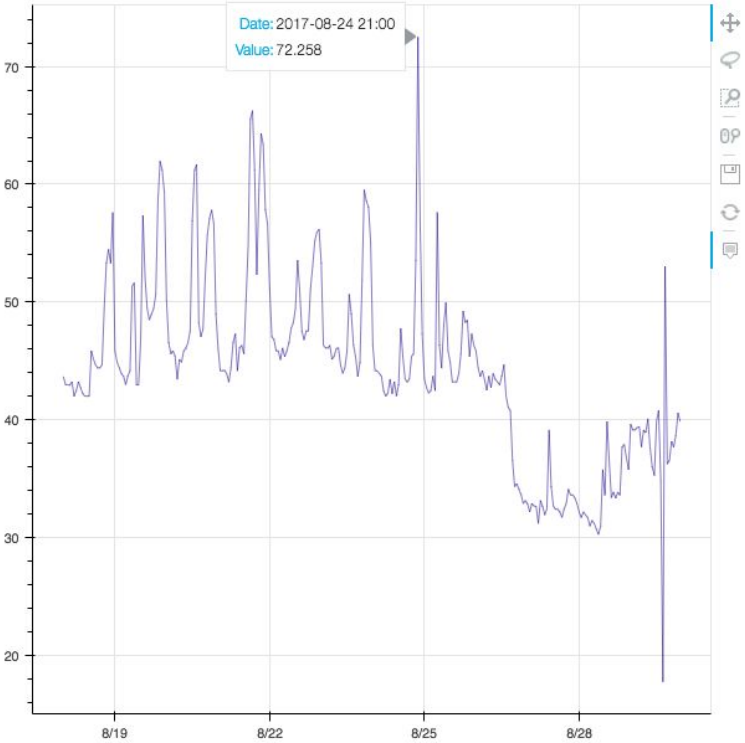
Alerts Page: Nourse Electricity Consumption

Building: Nourse Hall Point name:

Nourse Hall - Electricity- Electricity (kWh)

From: 08/18/2017 To: 08/30/2017

SUBMIT



Point Name: Nourse Hall – Electricity
Average: 44.28
Standard Deviation: 7.91

Date/Time	Value (kWh)
2017-08-24 21:00:00	72.50
2017-08-29 15:00:00	17.75

Dashboard: Room Inspection

Facilities' Experiment: How far can we push our current radiators?

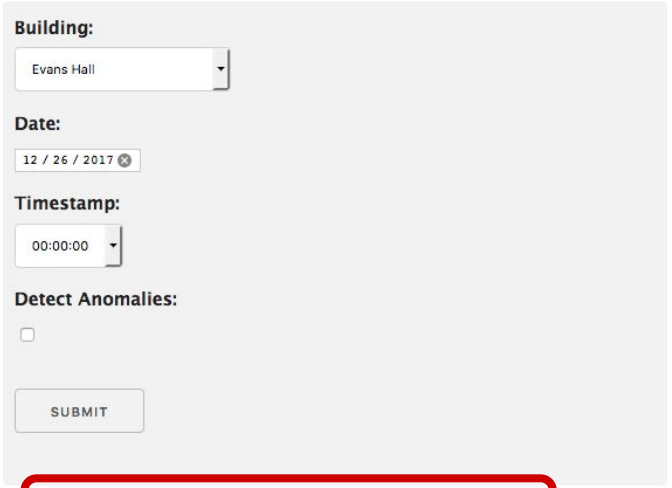
Dashboard: Room Inspection

Facilities' Experiment: How far can we push our current radiators?

Our Solution: Build a tool that can display the room temperature and the radiator valve percentage for each room in a building and detect "anomalous points".

Proof-of-Concept: Room Inspection

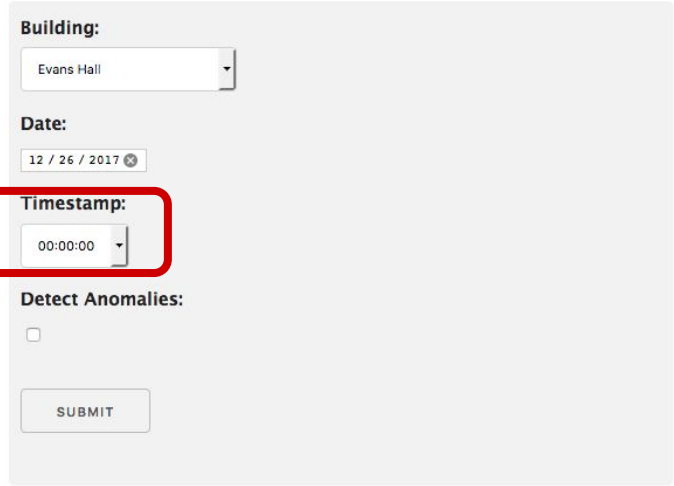
- Displays the room temperature and radiator valve percentage



Room	Room Temp (deg F)	Valve Percent (%)
003	67.85	0.0
102	68.1	100.0
106	61.58	19.86
107	70.58	40.01
108	66.05	100.0
109	69.18	40.43

Proof-of-Concept: Room Inspection

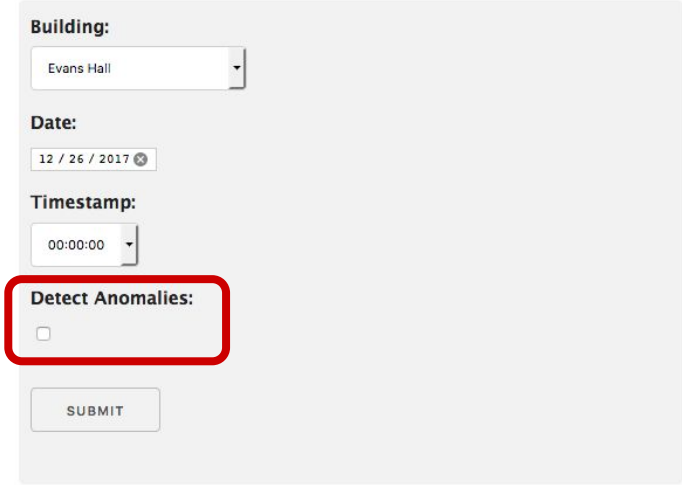
- Displays the room temperature and radiator valve percentage
- Permits viewing a "snapshot" of room temperature and valve percentage points for a building.



Room	Room Temp (deg F)	Valve Percent (%)
003	67.85	0.0
102	68.1	100.0
106	61.58	19.86
107	70.58	40.01
108	66.05	100.0
109	69.18	40.43

Proof-of-Concept: Room Inspection

- Displays the room temperature and radiator valve percentage
- Permits viewing a "snapshot" of room temperature and valve percentage points for a building.
- Optional Detect Anomalies feature



Room	Room Temp (deg F)	Valve Percent (%)
003	67.85	0.0
102	68.1	100.0
106	61.58	19.86
107	70.58	40.01
108	66.05	100.0
109	69.18	40.43

Proof-of-Concept: Room Inspection

- Performs k-means clustering to detect points that appear anomalous

Room	Room Temp (deg F)	Valve Percent (%)
003	69.11	0.0
102	69.25	100.0
106	62.09	14.89
107	70.15	35.32
108	62.27	100.0
109	69.72	18.01
111	67.81	99.99
112	67.27	100.0

Proof-of-Concept: Room Inspection

- Performs k-means clustering to detect points that appear anomalous
- Colors the cells to provide an indicator of which points appear as anomalous for that day

Room	Room Temp (deg F)	Valve Percent (%)
003	69.11	0.0
102	69.25	100.0
106	62.09	14.89
107	70.15	35.32
108	62.27	100.0
109	69.72	18.01
111	67.81	99.99
112	67.27	100.0

Dashboard: Room Inspection

Building:

Evans Hall

Date:

12 / 26 / 2017

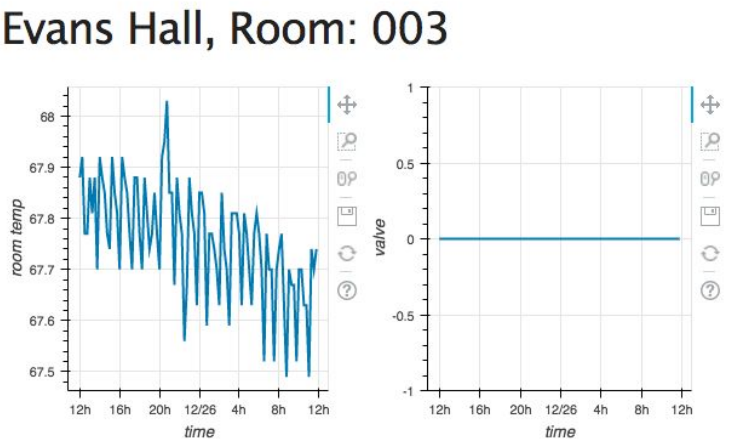
Timestamp:

00:00:00

Detect Anomalies:

SUBMIT

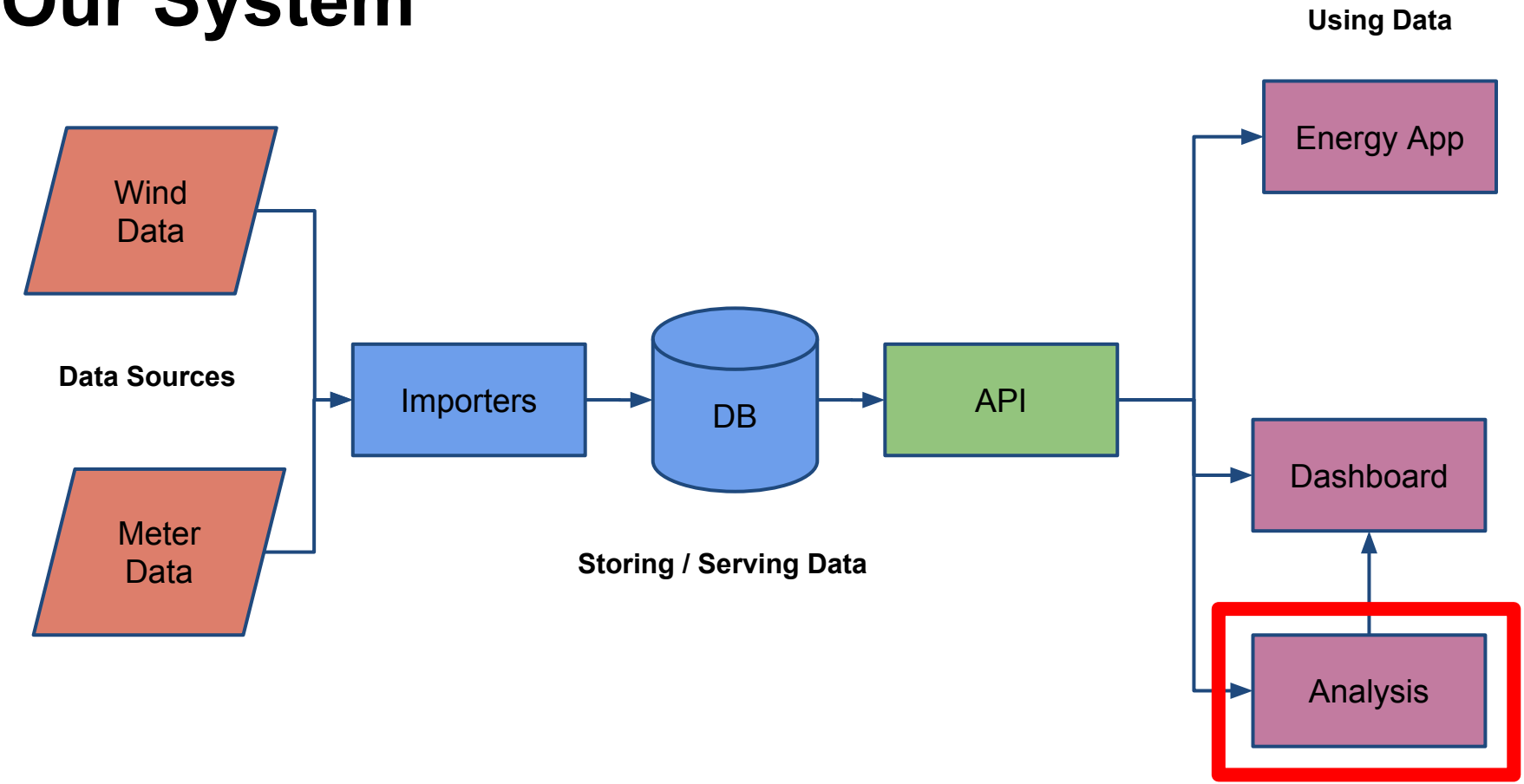
Room	Room Temp (deg F)	Valve Percent (%)
003	67.85	0.0
102	68.1	100.0
106	61.58	19.86
107	70.58	40.01
108	66.05	100.0
109	69.18	40.43



problem
data
database
api
dashboard
analysis
conclusion

1. Our data
2. Decision Trees
3. Association Rules
4. Anomaly Detection

Our System


Using Data
Energy App
Wind Data
Data Sources
Importers
DB
API
Dashboard
Meter Data
Storing / Serving Data
Analysis

What data do we have to work with?

	EV.RM203.RT	ACDIN.EF1	Evans Hall - Electricity	BI1DSP
2017-12-20 00:00:00	67.2	ON	71.41	1.5
2017-12-20 01:00:00	67.4	OFF	50.92	1.49
2017-12-20 02:00:00	68.1	OFF	<null>	1.5

What data do we have to work with?

Most points are continuous

Some points are categorical

We have no idea what this point means

	EV.RM203.RT	ACDIN.EF1	Evans Hall - Electricity	BI1DSP
2017-12-20 00:00:00	67.2	ON	71.41	1.5
2017-12-20 01:00:00	67.4	OFF	50.92	1.49
2017-12-20 02:00:00	68.1	OFF	<null>	1.5

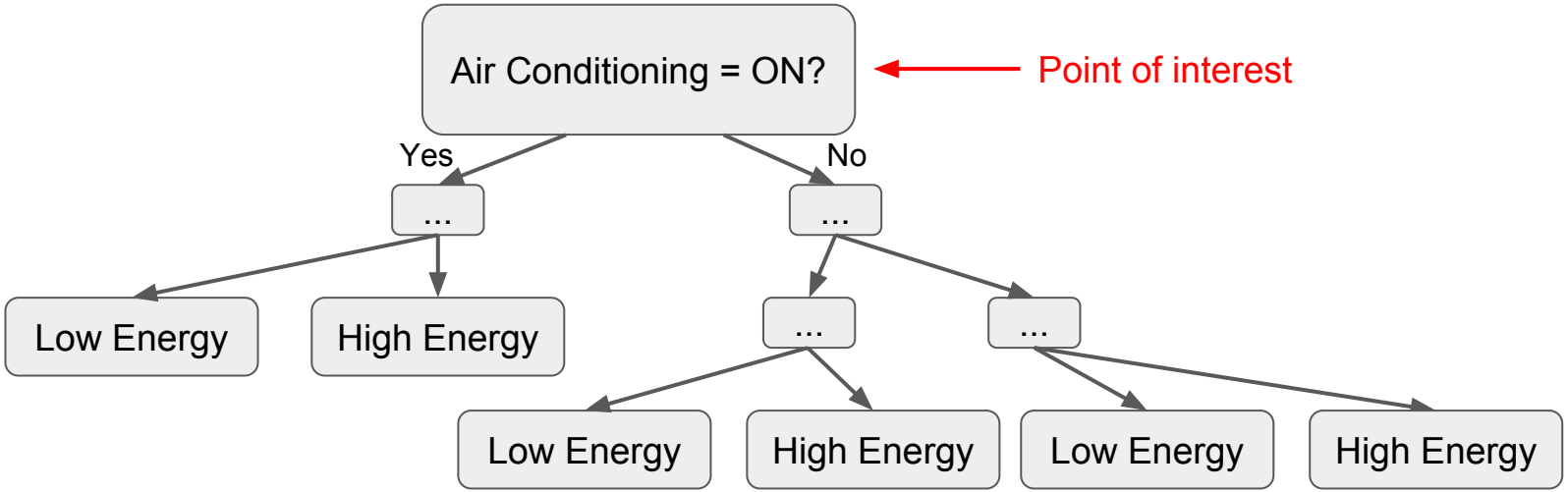
Some points are missing data

What could we use to analyze this data?

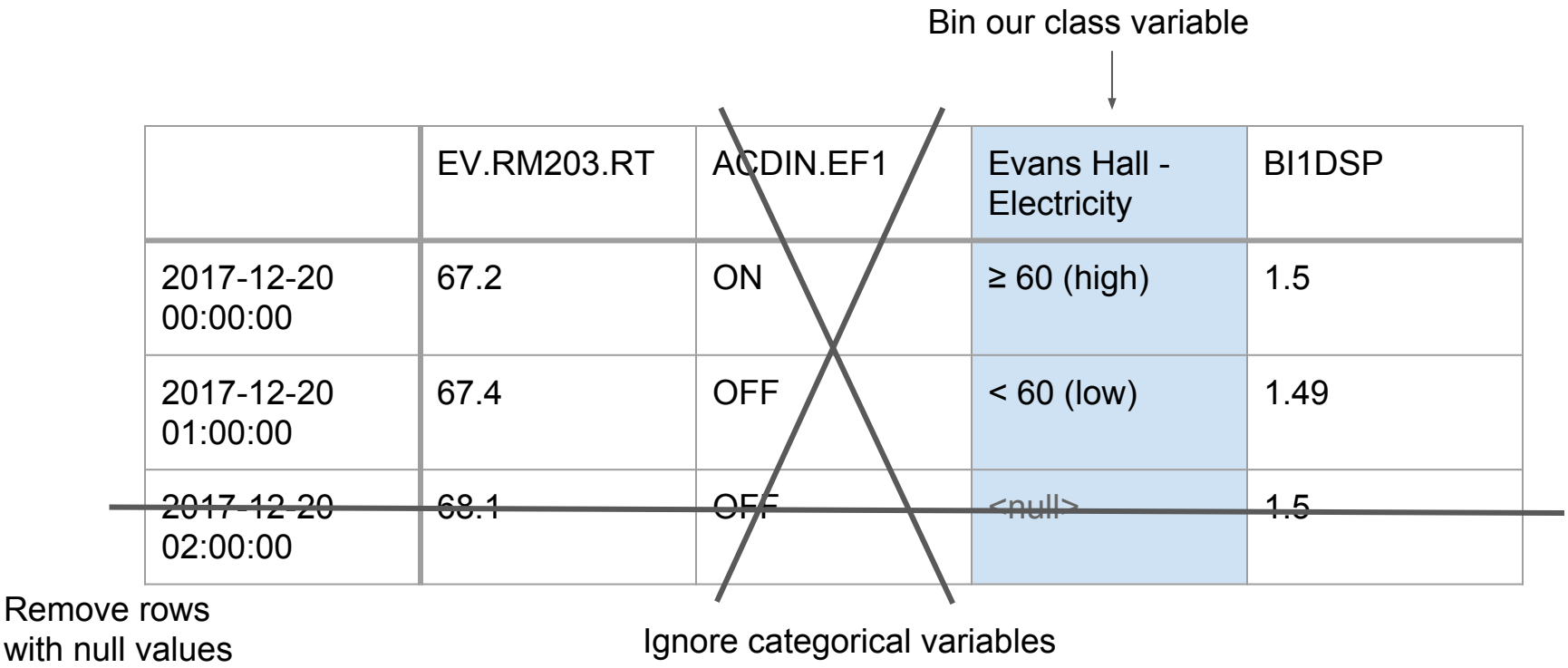
- Unsupervised
- Data-driven
- Not too complex

Decision Trees

Goal: Identify points of interest based on their placement in a decision tree

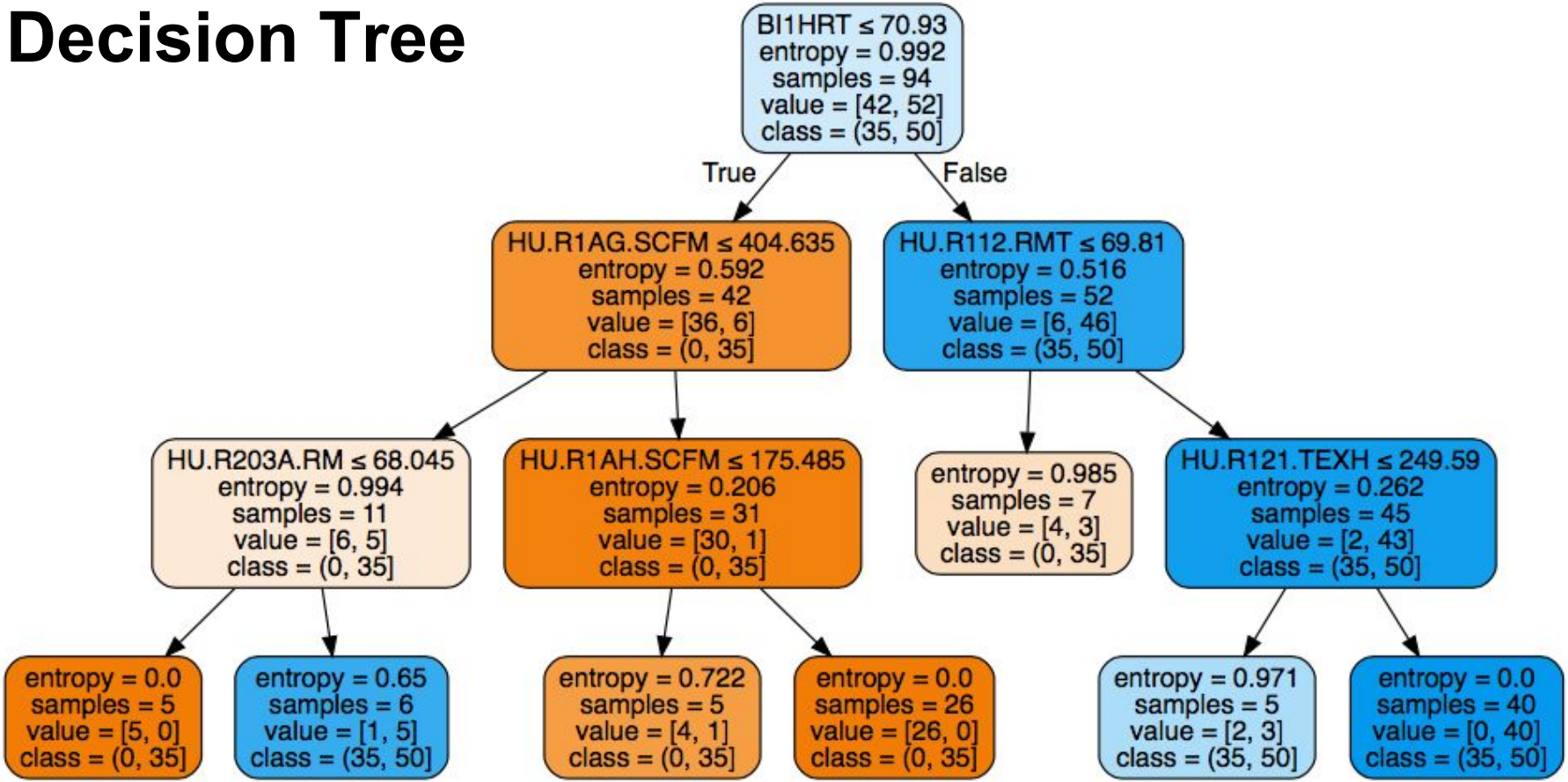


How do we have to change the data?

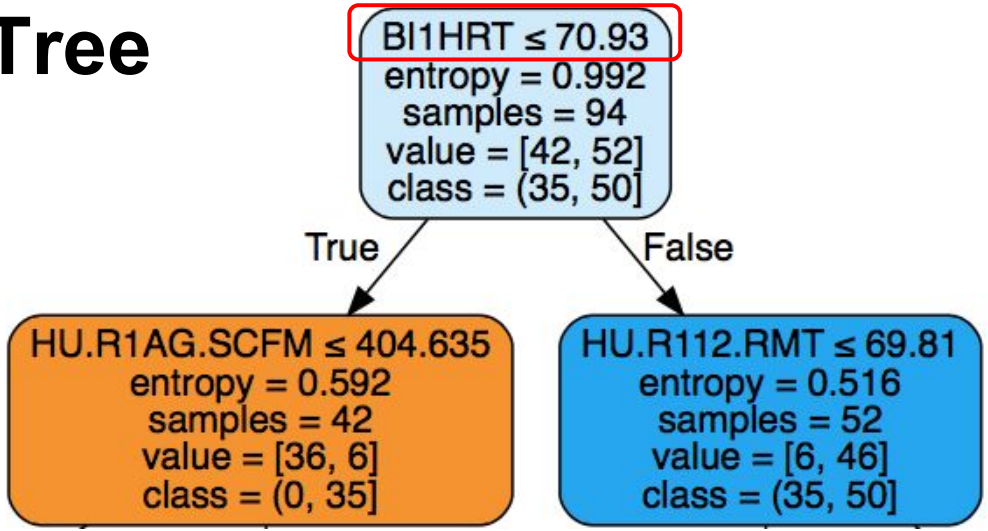


	EV.RM203.RT	ACDIN.EF1	Evans Hall - Electricity	BI1DSP
2017-12-20 00:00:00	67.2	ON	≥ 60 (high)	1.5
2017-12-20 01:00:00	67.4	OFF	< 60 (low)	1.49
2017-12-20 02:00:00	68.1	OFF	<null>	1.5

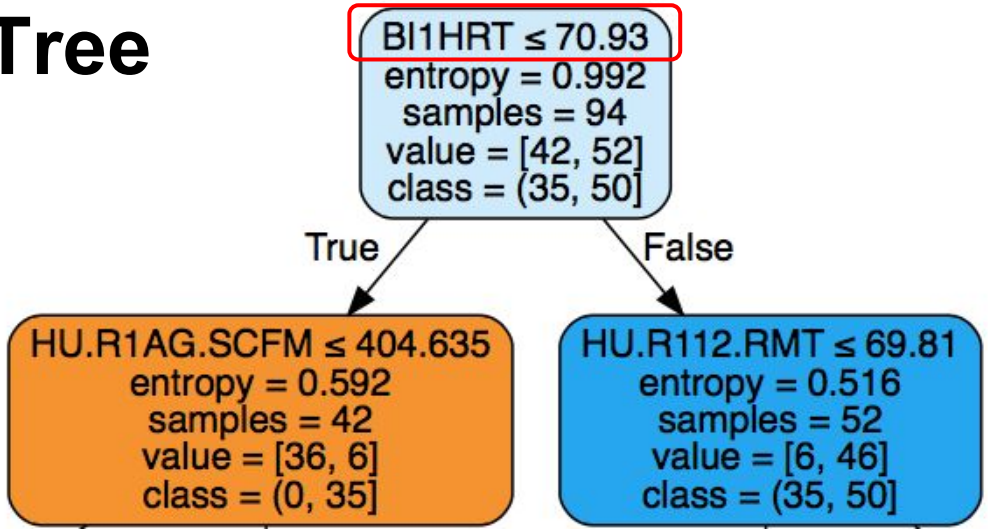
Decision Tree



Decision Tree

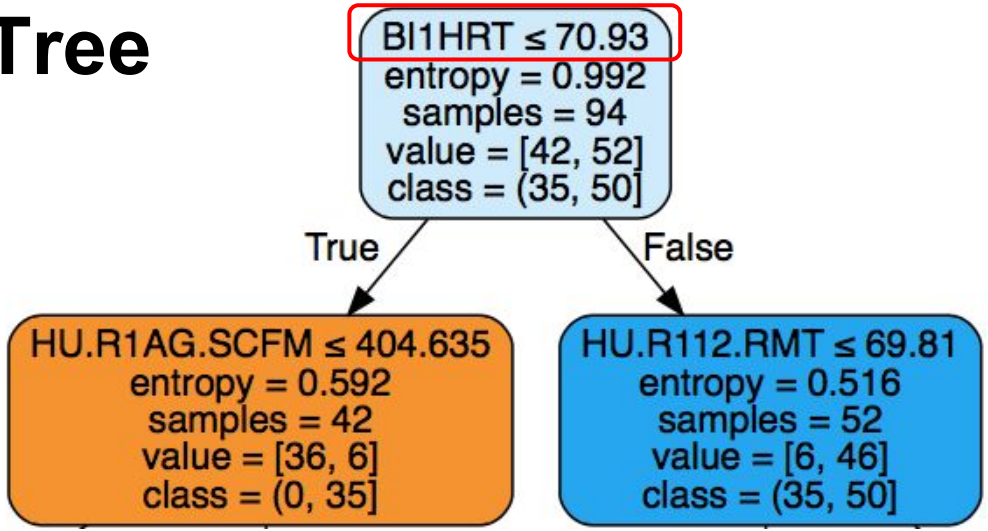


Decision Tree



“Hulings typically uses more energy when this temperature is higher than 70 °F”*

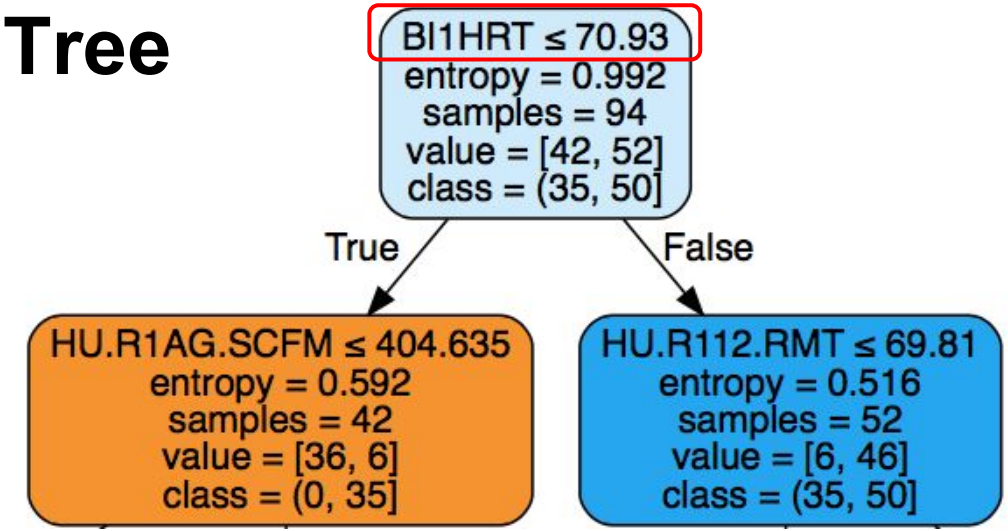
Decision Tree



“Hulings typically uses more energy when this temperature is higher than 70 °F”*

*On a specific day in August

Decision Tree



"Hulings typically uses more energy when this temperature is higher than 70 °F"*

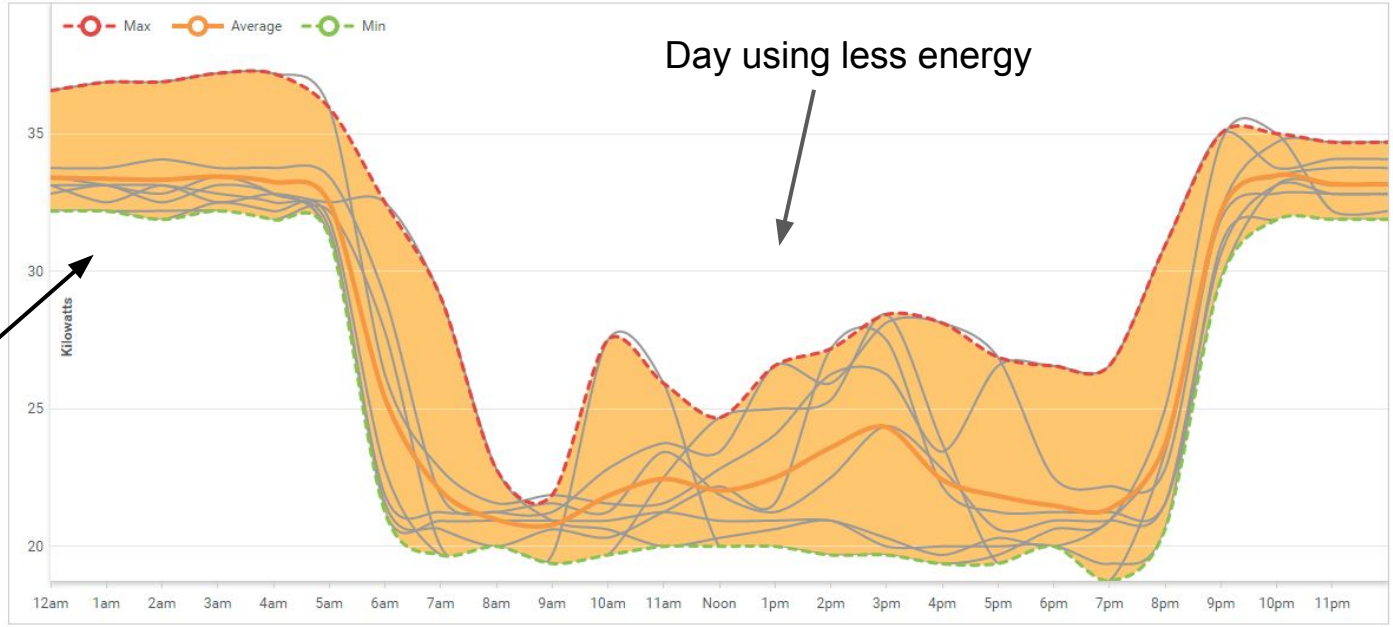
*On a specific day in August

*Which probably just means it's hot outside

Cool problem: Boliou

Load Profile Analysis

Boliou Memorial Art Bldg | boliou hall - electricity | over | the last 30 days | showing | Weekends | with | none



Date	Time	BO.1.COMM	BO.1.COMM	BO.1.COMM	BO.1.COMM	BO.1.COMM	BO.1.COMM	BO.1.COMM	BO.1.COMM	BO.1.COMM	BO.1.COMM
6/1/16	0:00:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	0:15:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	0:30:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	0:45:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	1:00:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	1:15:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	1:30:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	1:45:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	2:00:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	2:15:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	2:30:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	2:45:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	3:00:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	3:15:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	3:30:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	3:45:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	4:00:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	4:15:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	4:30:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data
6/1/16	4:45:00	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data	No Data

Association Rules

Goal: Identify links between points and points of interest

Data requirements: Boolean if data value is present or not

Association Rules

Goal: Identify links between points and points of interest

Data requirements: Boolean if data value is present or not

How do we have to change the data?

One hot encoding:

	EV.RM203.RT	ACDIN.EF1	Evans Hall - Electricity
2017-12-20 00:00:00	71	ON	65
2017-12-20 01:00:00	68	OFF	55

How do we have to change the data?

One hot encoding:

	EV.RM203.RT	ACDIN.EF1	Evans Hall - Electricity
2017-12-20 00:00:00	>= 70	ON	65
2017-12-20 01:00:00	<70	OFF	55

How do we have to change the data?

	EV.RM203.RT < 70	EV.RM203.RT >= 70	ACDIN.EF1	Evans Hall - Electricity
2017-12-20 00:00:00	FALSE	TRUE	ON	65
2017-12-20 01:00:00	TRUE	FALSE	OFF	55

How do we have to change the data?

	EV.RM203.RT < 70	EV.RM203.RT >= 70	ACDIN.EF1	Evans Hall - Electricity
2017-12-20 00:00:00	FALSE	TRUE	ON	65
2017-12-20 01:00:00	TRUE	FALSE	OFF	55

How do we have to change the data?

	EV.RM203.RT < 70	EV.RM203.RT >= 70	ACDIN.EF1 = ON	ACDIN.EF1 = OFF	Evans Hall - Electricity
2017-12-20 00:00:00	FALSE	TRUE	TRUE	FALSE	65
2017-12-20 01:00:00	TRUE	FALSE	FALSE	TRUE	55

How do we have to change the data?

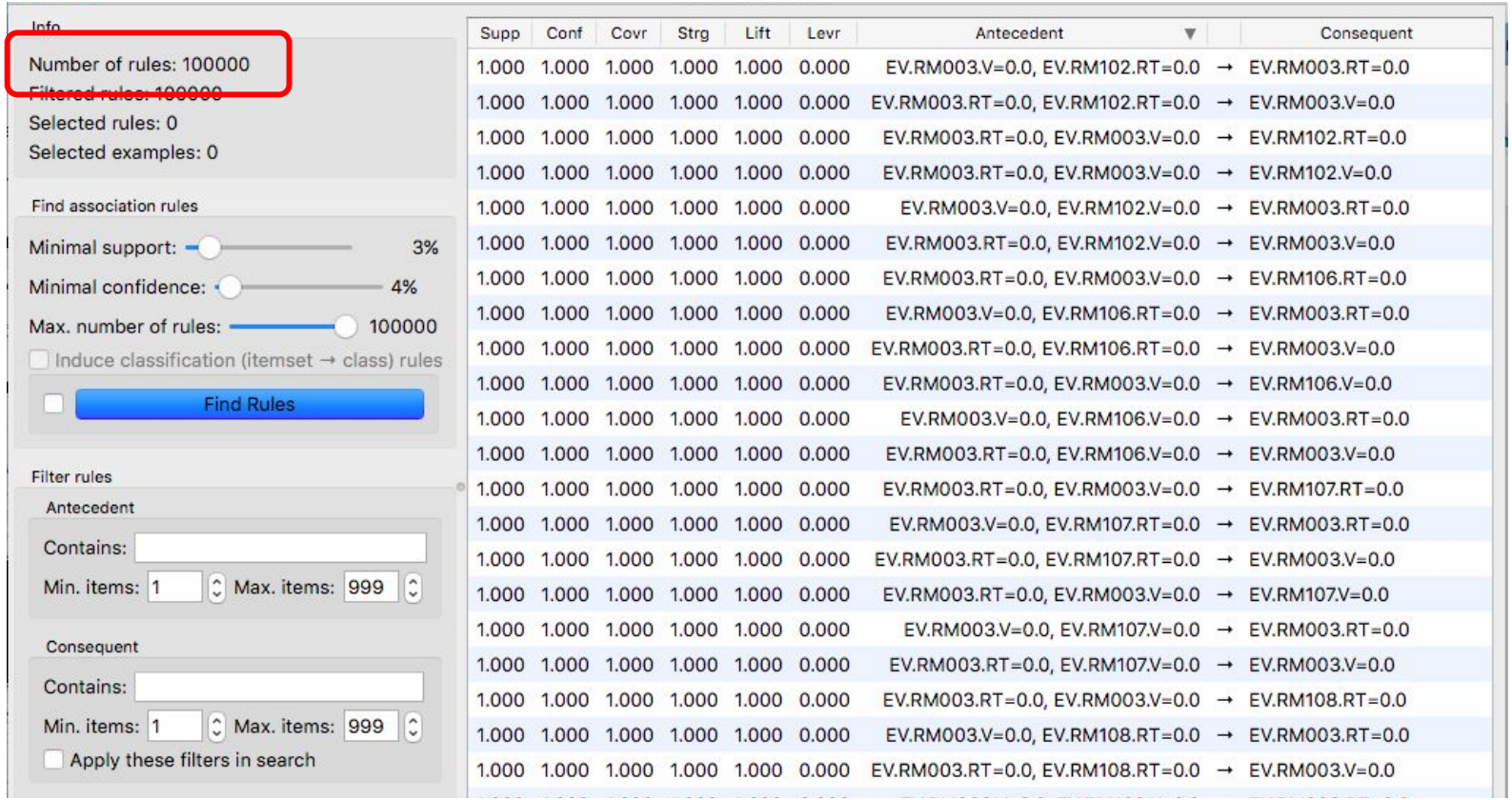
	EV.RM203. RT < 70	EV.RM203. RT >= 70	ACDIN.EF 1 = ON	ACDIN.EF 1 = OFF	Evans Hall - Electricity ≥ 50	Evans Hall - Electricity < 50
2017-12-20 00:00:00	FALSE	TRUE	TRUE	FALSE	TRUE	FALSE
2017-12-20 01:00:00	TRUE	FALSE	FALSE	TRUE	TRUE	FALSE

Association Rules

Evans Unit 4
Heat Coil Valve
< 49.26

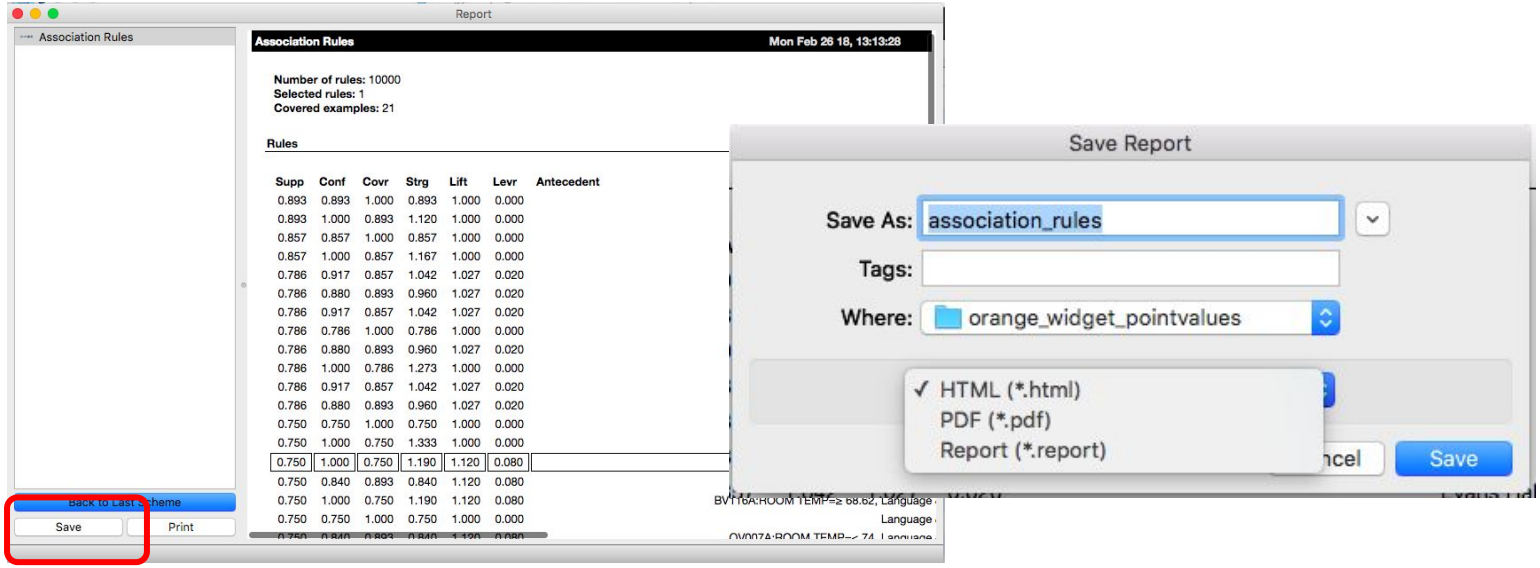
Evans Unit 5
Heat Coil Valve
< 49.26

Association Rules Software



Supp	Conf	Covr	Strg	Lift	Levr	Antecedent		Consequent
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.V=0.0, EV.RM102.RT=0.0	→	EV.RM003.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM102.RT=0.0	→	EV.RM003.V=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM003.V=0.0	→	EV.RM102.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM003.V=0.0	→	EV.RM102.V=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.V=0.0, EV.RM102.V=0.0	→	EV.RM003.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM102.V=0.0	→	EV.RM003.V=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM003.V=0.0	→	EV.RM106.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.V=0.0, EV.RM106.RT=0.0	→	EV.RM003.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM106.RT=0.0	→	EV.RM003.V=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM003.V=0.0	→	EV.RM106.V=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.V=0.0, EV.RM106.V=0.0	→	EV.RM003.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM106.V=0.0	→	EV.RM003.V=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM003.V=0.0	→	EV.RM107.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.V=0.0, EV.RM107.RT=0.0	→	EV.RM003.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM107.RT=0.0	→	EV.RM003.V=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM003.V=0.0	→	EV.RM107.V=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.V=0.0, EV.RM107.V=0.0	→	EV.RM003.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM107.V=0.0	→	EV.RM003.V=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM003.V=0.0	→	EV.RM108.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.V=0.0, EV.RM108.RT=0.0	→	EV.RM003.RT=0.0
1.000	1.000	1.000	1.000	1.000	0.000	EV.RM003.RT=0.0, EV.RM108.RT=0.0	→	EV.RM003.V=0.0

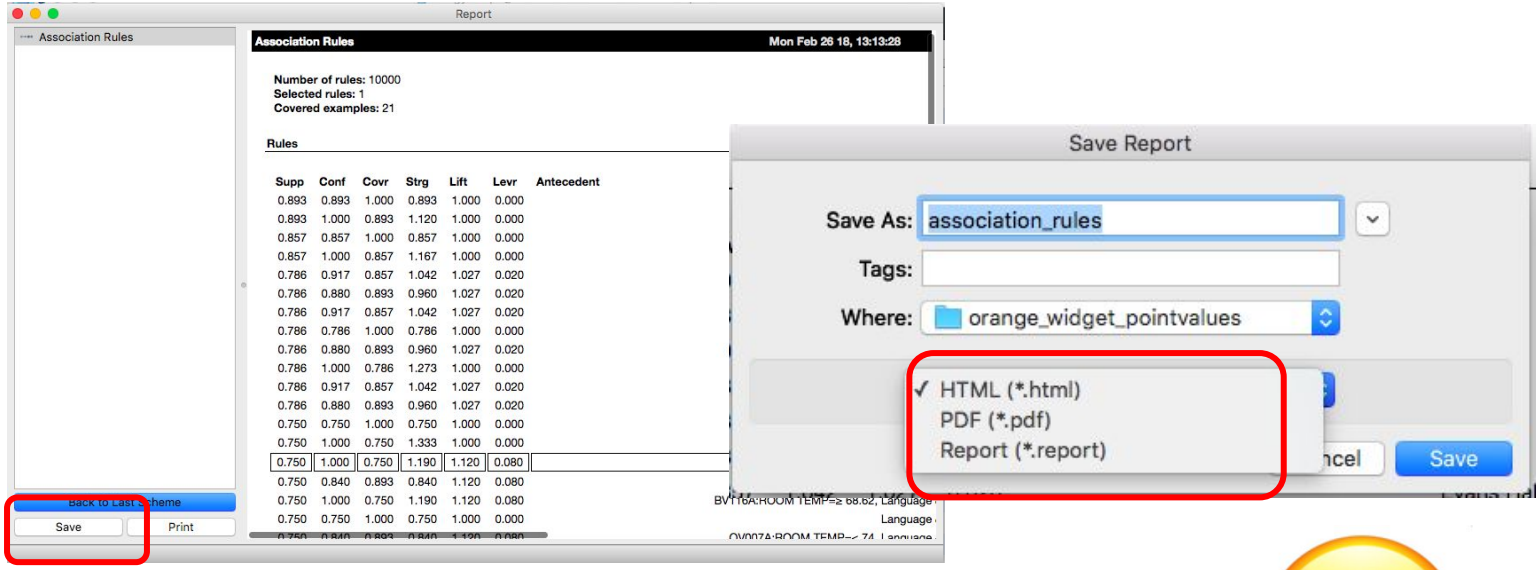
Association Rules Software



1.000	1.000	1.000	1.000	1.000	0.000	BIE25C=2.0, HU.R1AG.OSUP=0.0	→ HU.R1AH.OSUP=0.0
1.000	1.000	1.000	1.000	1.000	0.000	BIE25C=2.0	→ HU.R1AG.OSUP=0.0, HU.R1AH.OSUP=0.0
1.000	1.000	1.000	1.000	1.000	0.000	HU.R1AG.OSUP=0.0	→ BIE25C=2.0, HU.R1AH.OSUP=0.0
1.000	1.000	1.000	1.000	1.000	0.000	HU.R112.SACFM=0.0, HU.R1AH.OSUP=0.0	→ BIE25C=2.0
1.000	1.000	1.000	1.000	1.000	0.000	BIE25C=2.0, HU.R1AH.OSUP=0.0	→ HU.R112.SACFM=0.0
1.000	1.000	1.000	1.000	1.000	0.000	HU.R1AH.OSUP=0.0	→ BIE25C=2.0, HU.R112.SACFM=0.0
1.000	1.000	1.000	1.000	1.000	0.000	BIE25C=2.0, HU.R112.SACFM=0.0	→ HU.R1AH.OSUP=0.0

+ 502 more

Association Rules Software

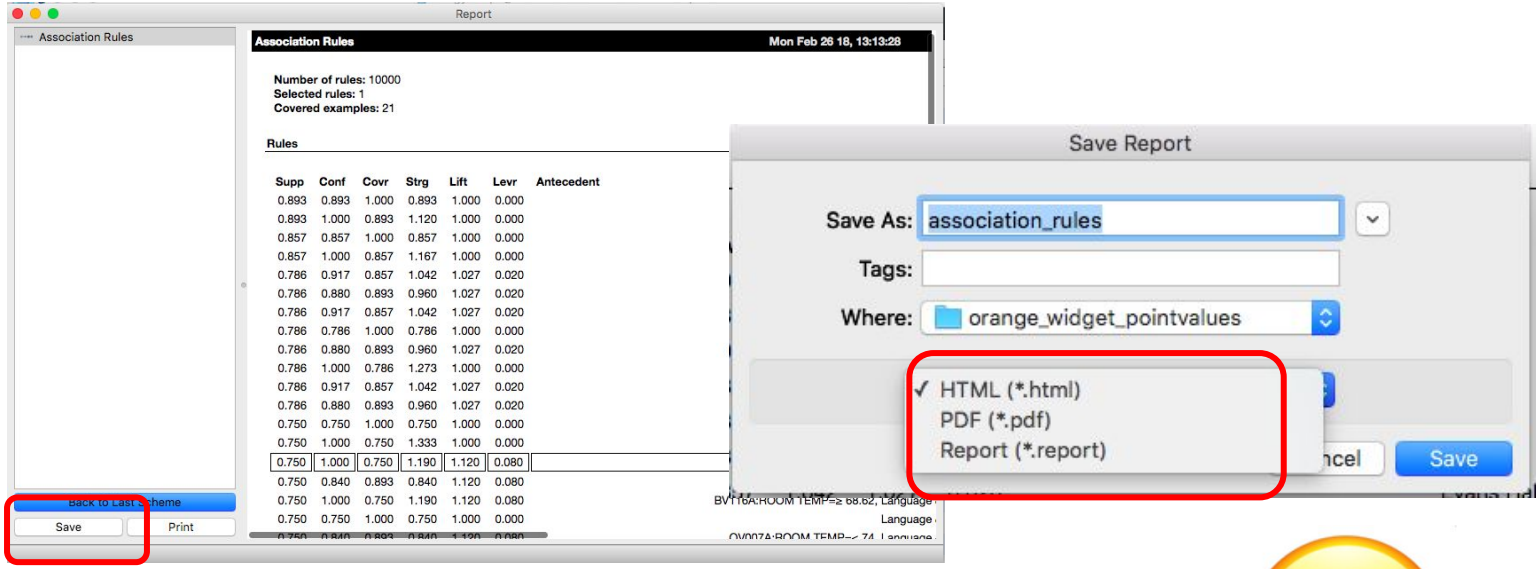


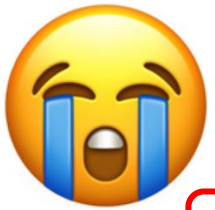
1.000	1.000	1.000	1.000	1.000	0.000
1.000	1.000	1.000	1.000	1.000	0.000
1.000	1.000	1.000	1.000	1.000	0.000
1.000	1.000	1.000	1.000	1.000	0.000
1.000	1.000	1.000	1.000	1.000	0.000
1.000	1.000	1.000	1.000	1.000	0.000
1.000	1.000	1.000	1.000	1.000	0.000

+ 502 more

BIE25C=2.0, HU.R1AG.OSUP=0.0 → HU.R1AH.OSUP=
BIE25C=2.0 → HU.R1AG.OSUP=
HU.R1AG.OSUP=0.0 → BIE25C=2.0, HU.F
HU.R112.SACFM=0.0, HU.R1AH.OSUP=0.0 → BIE25C=2.0
BIE25C=2.0, HU.R1AH.OSUP=0.0 → HU.R112.SACFM
HU.R1AH.OSUP=0.0 → BIE25C=2.0, HU.R112.SACFM=0.0
BIE25C=2.0, HU.R112.SACFM=0.0 → HU.R1AH.OSUP=0.0

Association Rules Software





1.000 1.000 1.000 1.000 0.000
1.000 1.000 1.000 1.000 0.000
1.000 1.000 1.000 1.000 0.000
1.000 1.000 1.000 1.000 0.000
1.000 1.000 1.000 1.000 0.000
1.000 1.000 1.000 1.000 0.000
1.000 1.000 1.000 1.000 0.000
+ 502 more

BIE25C=2.0, HU.R1AG.OSUP=0.0 → HU.R1AH.OSUF
BIE25C=2.0 → HU.R1AG.OSUF
HU.R1AG.OSUP=0.0 → BIE25C=2.0, HU
HU.R112.SACFM=0.0, HU.R1AH.OSUP=0.0 → BIE25C=2.0
BIE25C=2.0, HU.R1AH.OSUP=0.0 → HU.R112.SACFI
HU.R1AH.OSUP=0.0 → BIE25C=2.0, HU.R112.SACFM=0.0
BIE25C=2.0, HU.R112.SACFM=0.0 → HU.R1AH.OSUP=0.0

.0

~~Decision Trees~~

~~Association Rules~~

Anomaly Detection

Anomaly Detection via Clustering

Goal: Identify points that aren't behaving as expected

Too cold?

	EV.RM101.RT	EV.RM102.RT	EV.RM103.RT
2017-12-20 00:00:00	68.5	70.2	32.4
2017-12-20 01:00:00	68.4	70.0	32.4

Anomaly Detection via Clustering

Goal: Identify points that aren't behaving as expected

Data Requirements: Continuous data for multiple similar points, or multiple days for the same point

	EV.RM101.RT	EV.RM102.RT	EV.RM103.RT
2017-12-20 00:00:00	68.5	70.2	32.4
2017-12-20 01:00:00	68.4	70.0	32.4

↑ Too cold?

EV.RM101.RT			
	2017-12-20	2017-12-21	2017-12-22
00:00:00	68.5	68.5	74.0
01:00:00	68.4	68.6	74.2

↑ Too hot?

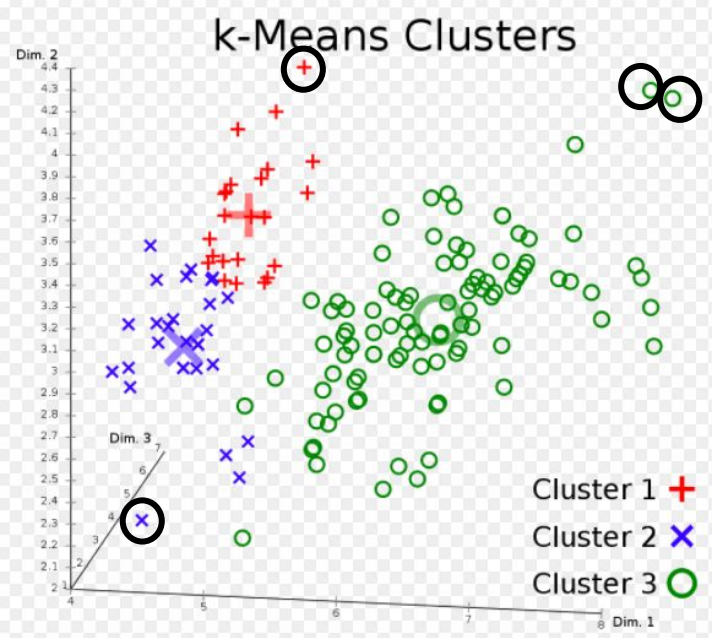
Anomaly Detection via Clustering

Goal: Identify points that aren't behaving as expected

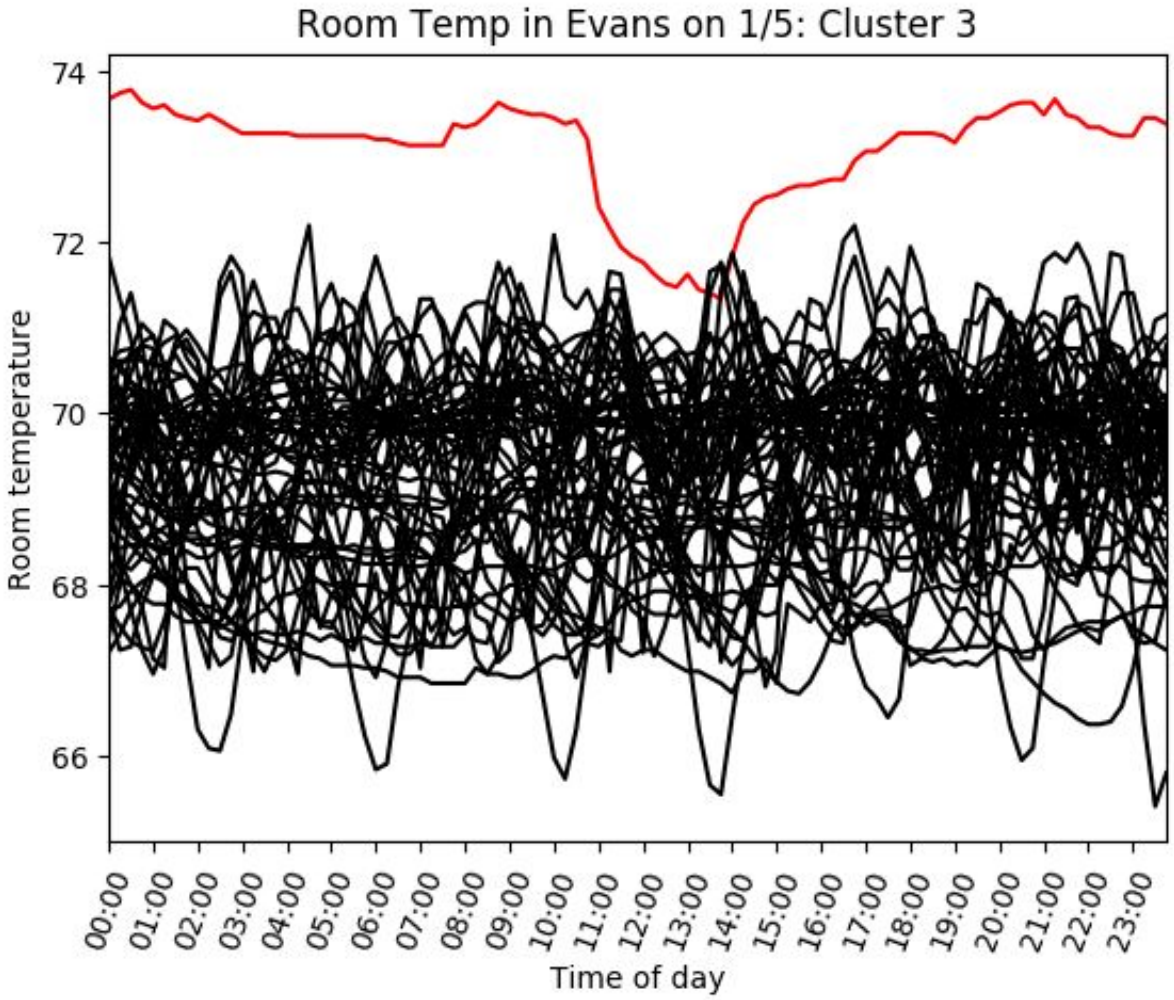
Data Requirements: Continuous data for multiple similar points, or multiple days for the same point

Method:

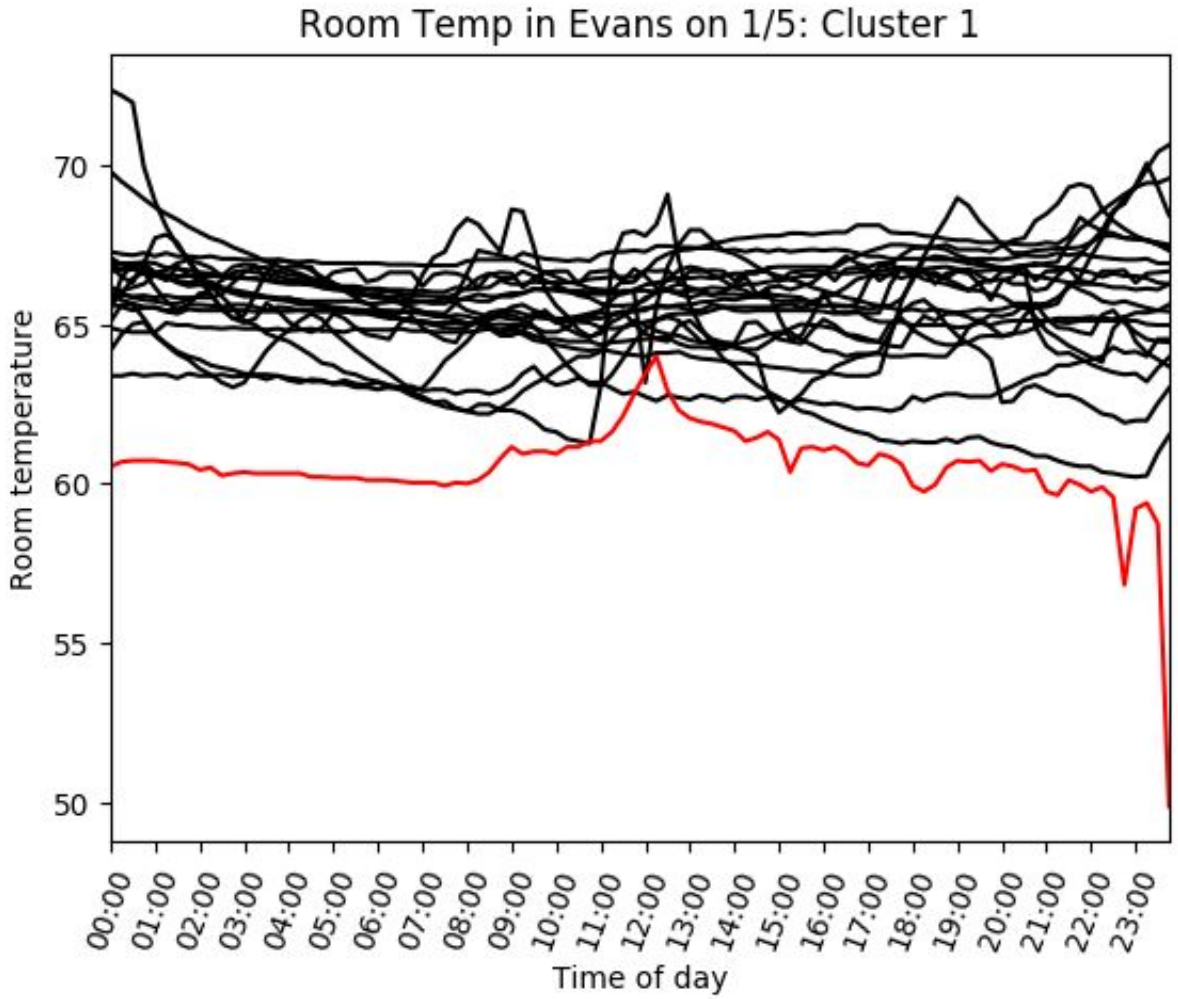
1. Perform k-means clustering
2. Pick out anomalies as points that are far from their cluster center



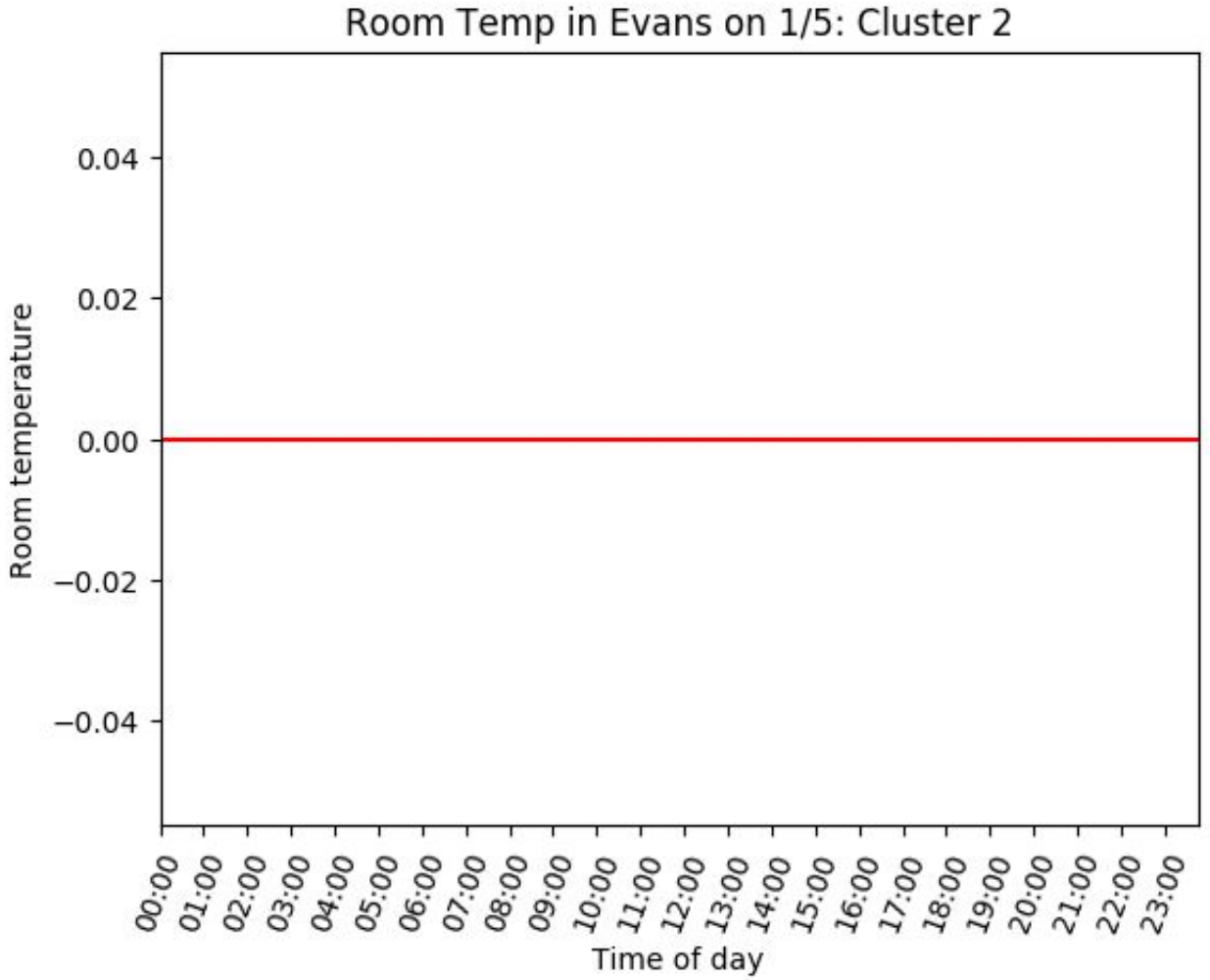
Anomaly Detection



Anomaly Detection



Anomaly Detection



Dashboard

Carleton Energy Analytics

- Comparison
- Heat Map
- Alerts
- Room Comparison

Room	Room Temp (deg F)	Valve Percent (%)
122	69.65	100.0
200	70.62	12.15
202	70.22	67.58
203	67.72	100.0
204	68.6	8.36
205	70.37	0.0
206	73.68	0.0
207	69.11	15.82
208	0.0	nan
209	68.96	nan
211	70.11	26.38
212	70.65	0.0
213	69.18	0.0
214	69.86	2.59
215	65.94	0.0

problem
data
database
api
dashboard
analysis
conclusion

1. Challenges
2. Future
3. THX

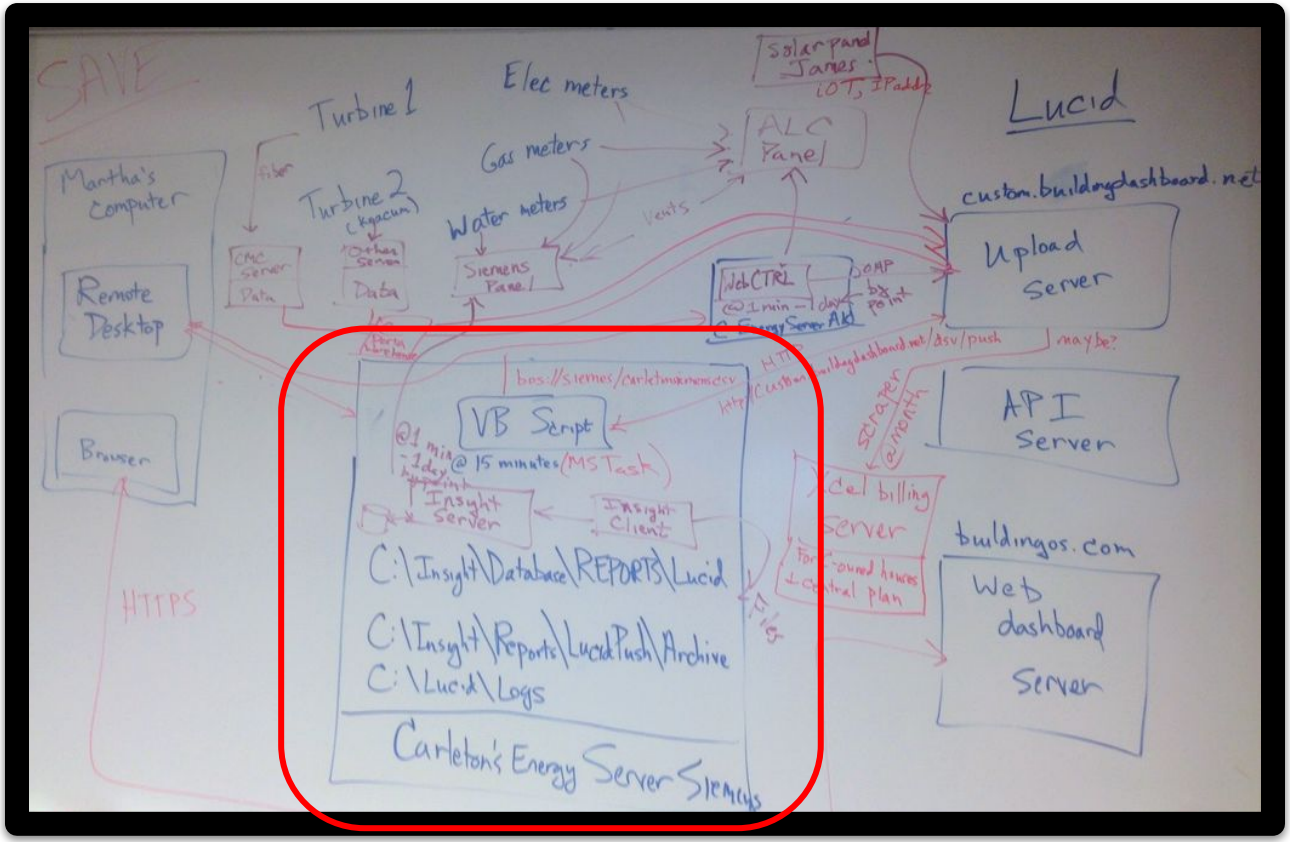
Overall challenges

- Difficulty with data
- Inexperience with field
- Design challenges

Future possibilities

- Parsing more points
- More tools for the dashboard
- Try more analysis algorithms

Live data?


SAVE
Elec meters
Turbine 1
Turbine 2
Gas meters
Water meters
Vents
Solar panel
Lucid
Martha's computer
Remote Desktop
Brouser
Upload Server
custom.buildingdashboard.net
API Server
buildingos.com
Web dashboard Server
HTTPS
VB Script
@1 min @ 15 minutes (MS Task)
Insight Server
Insight Client
C:\Insight\Database\REPORTS\Lucid
C:\Insight\Reports\LucidPush\Archive
C:\Lucid\Logs
Carleton's Energy Server
Siemens

Thank you to:

- Jeff Ondich
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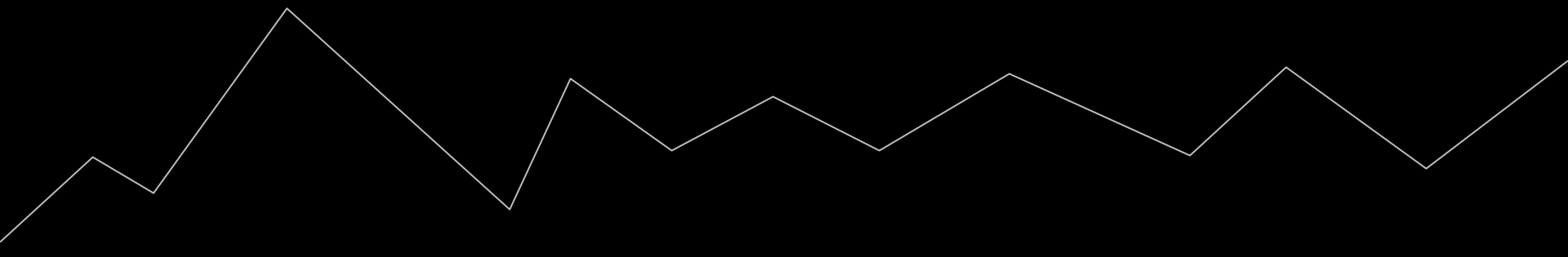
- Mike Tie, Dave Flynn
- CS Faculty and peers
- Our friends and family



Questions?