
Bottom-up Electricity Demand Model

*ENGR-333 Thermal Systems Design
Dr. Matthew Kuperus Heun
Spring 2017*

May 10, 2017

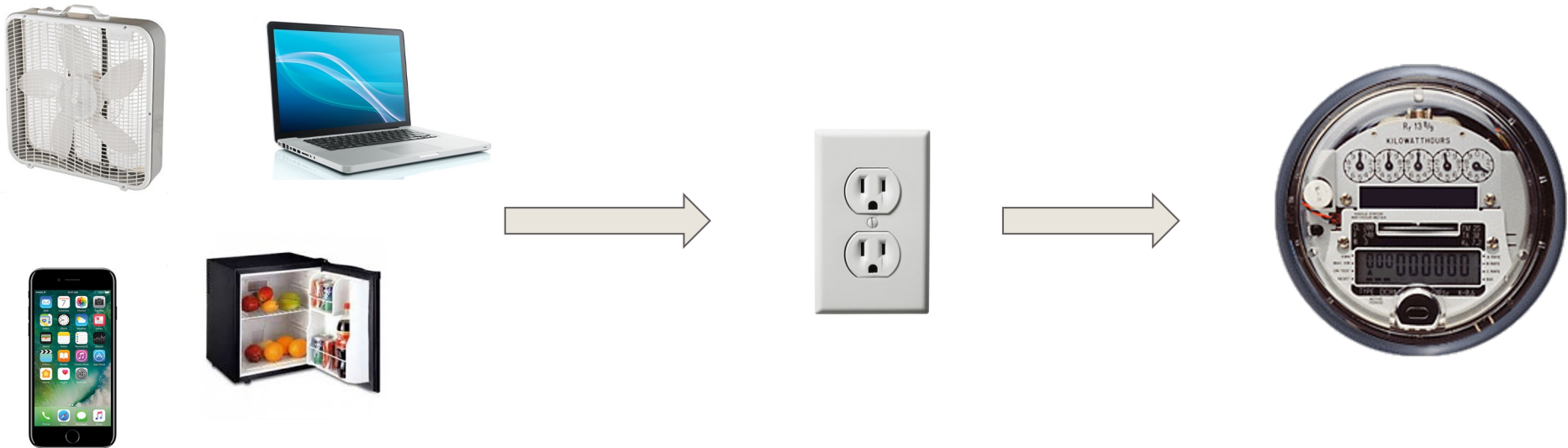


Motivation

2016 annual electricity usage: \$1,930,021.75



Bottom-up Electricity Model



Areas of Focus



Calvin College Dorms

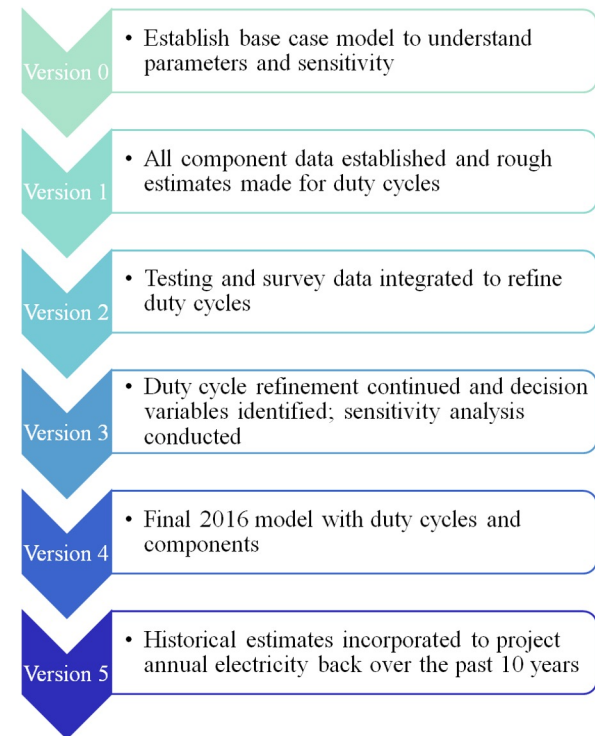
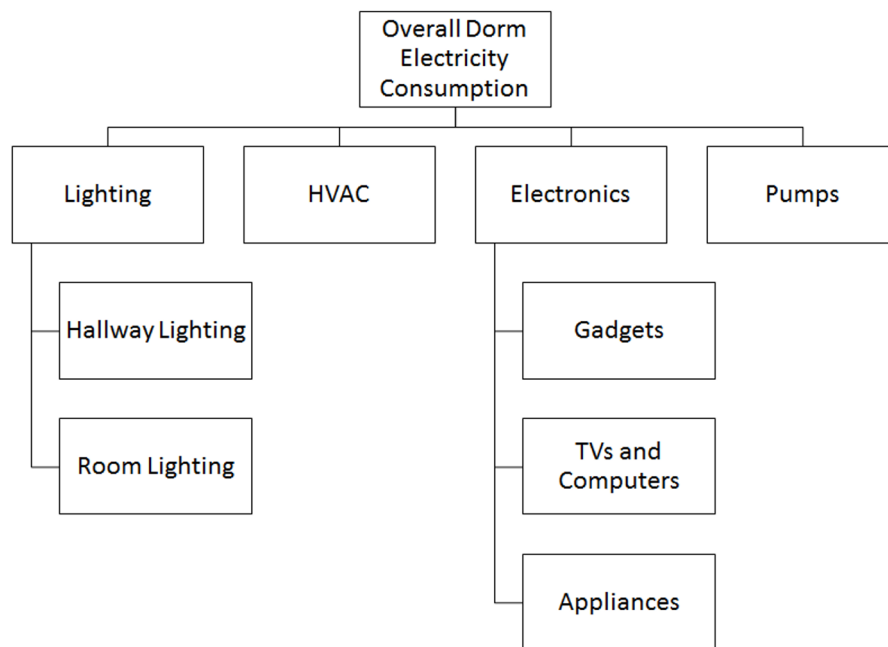
1,323,245.1 kWh = \$132,000



Spoelhof Fieldhouse Complex

4,016,969.05 - kWh = \$401,969

Organization and Model Iterations



Team Members

- Jonah Engel
- Rich Floro
- Björn Krebs
- Ethan Postmus

Rechargeable Gadgets

Rechargeable Gadgets

- Laptops
- Cell Phones
- Tablets



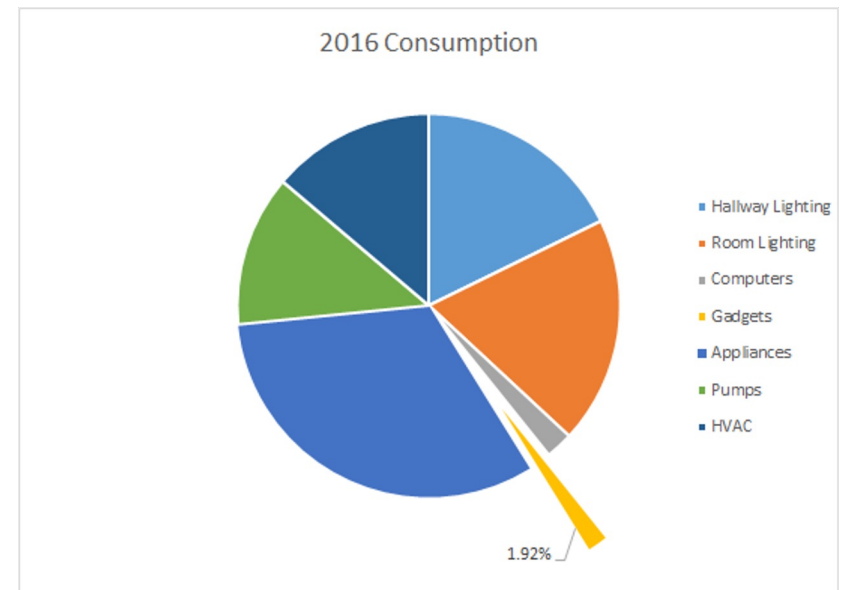
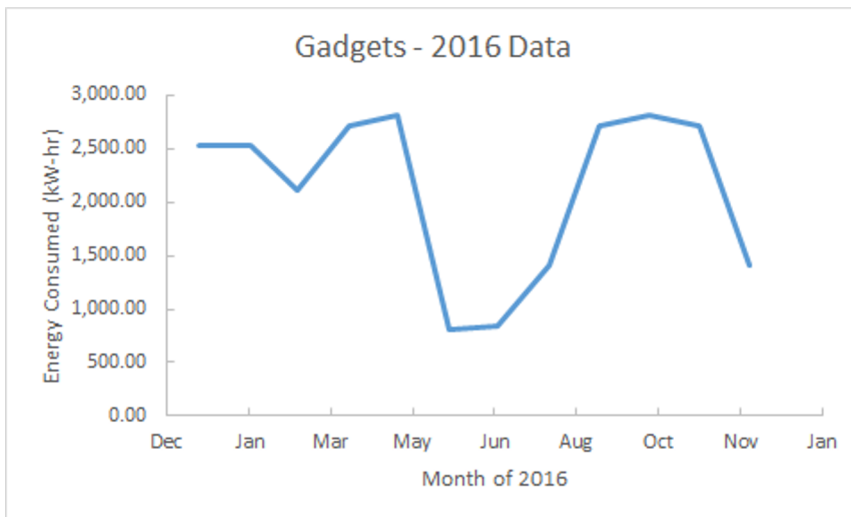
https://images-na.ssl-images-amazon.com/images/I/61p64UCyfJL._SL1000_.jpg



https://pisces.bbystatic.com/BestBuy_US/images/products/5206/5206600ld.jpg;maxHeight=460;maxWidth=460

Rechargeable Gadgets

- 2016 Total consumption - 35,454.6 kW-hr
- Overall (Dorms) Percentage Contributed - 1.92%



Team Members

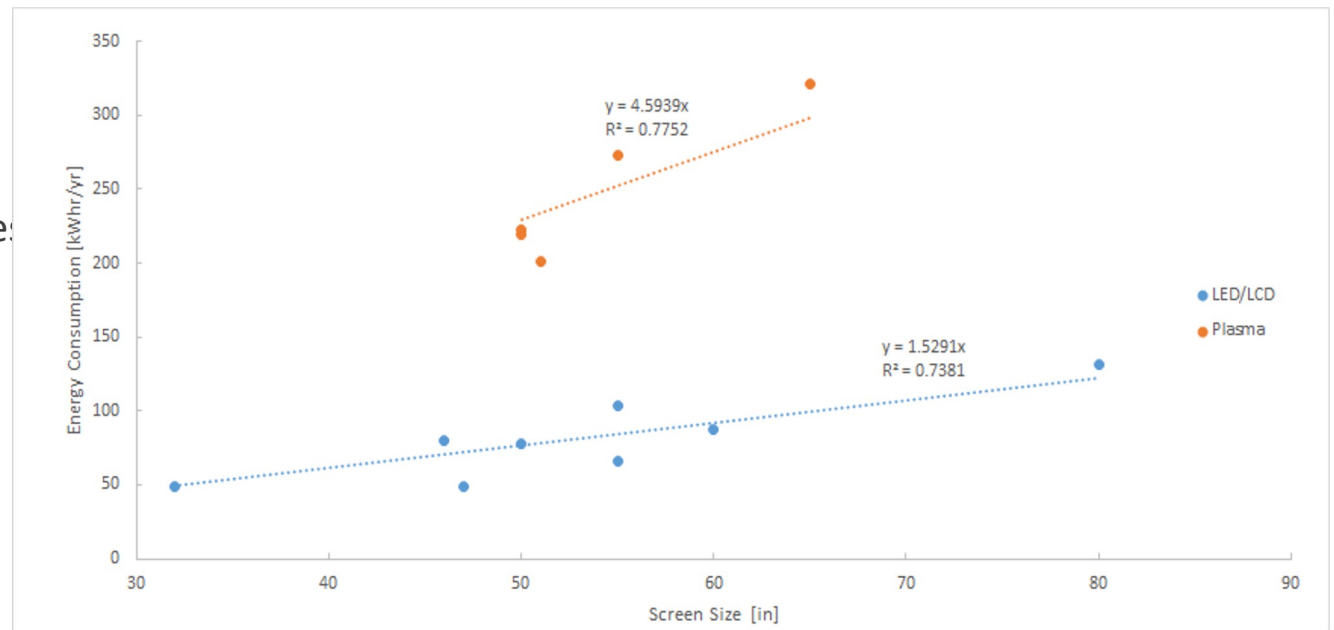
- Brendan Biesboer
- Kyle Mailhot
- Nate Zylstra

Computers and TVs

Computers and TV's

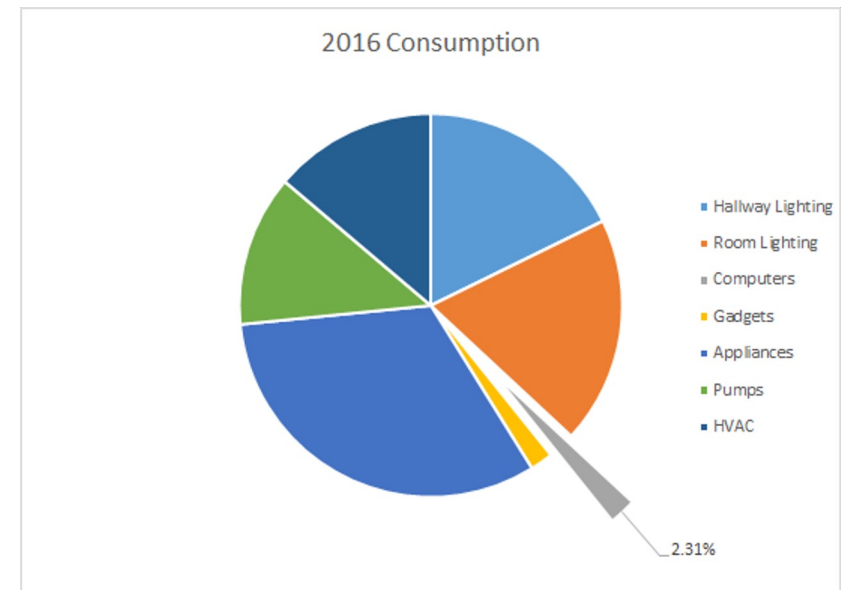
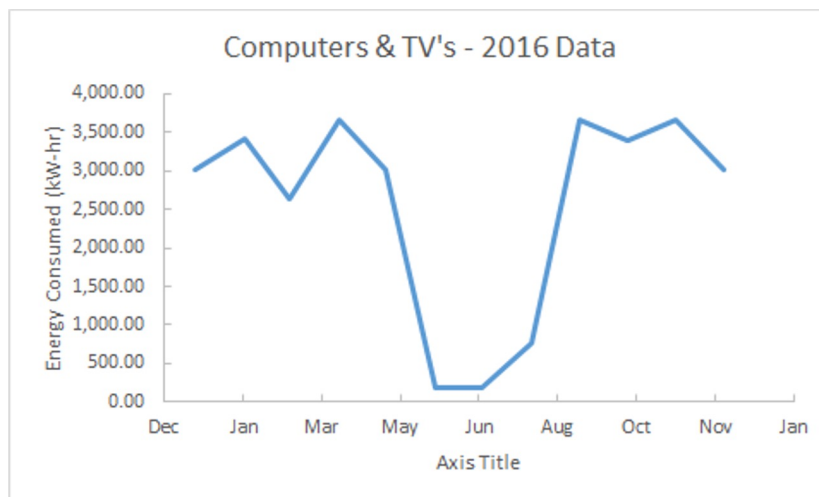
- TV's
- Desktop Computers
- Gaming systems
- Additional Accessories

- Predictive Graphs
- Technology Phasing



Computers and TV's

- 2016 Total consumption - 30,620.4 kW-hr
- Overall (Dorms) Percentage Contributed - 2.31%



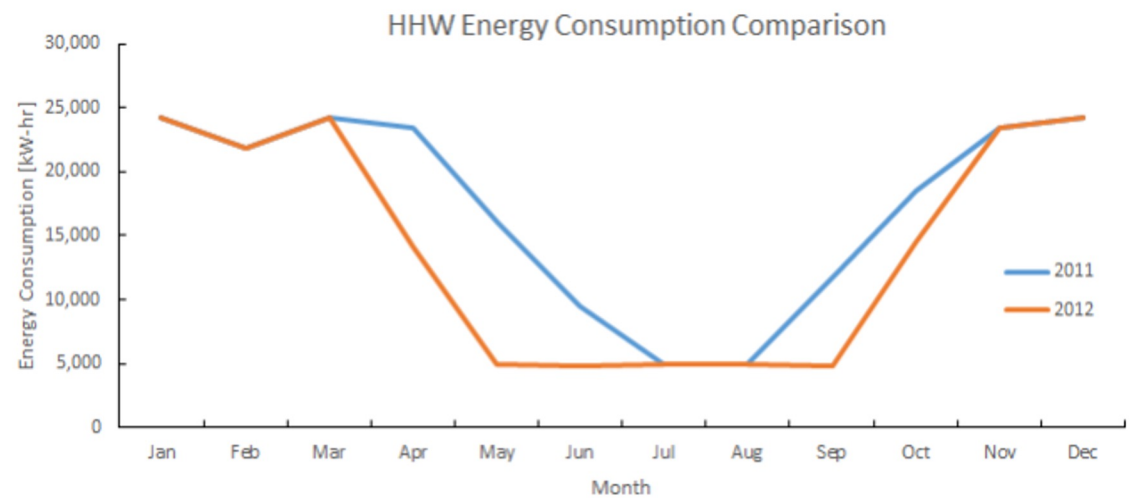
Team Members

- Ryan Beezhold
- Dillon Carhuff
- Ian McClaskie
- Jared VanderKlay

Pumps

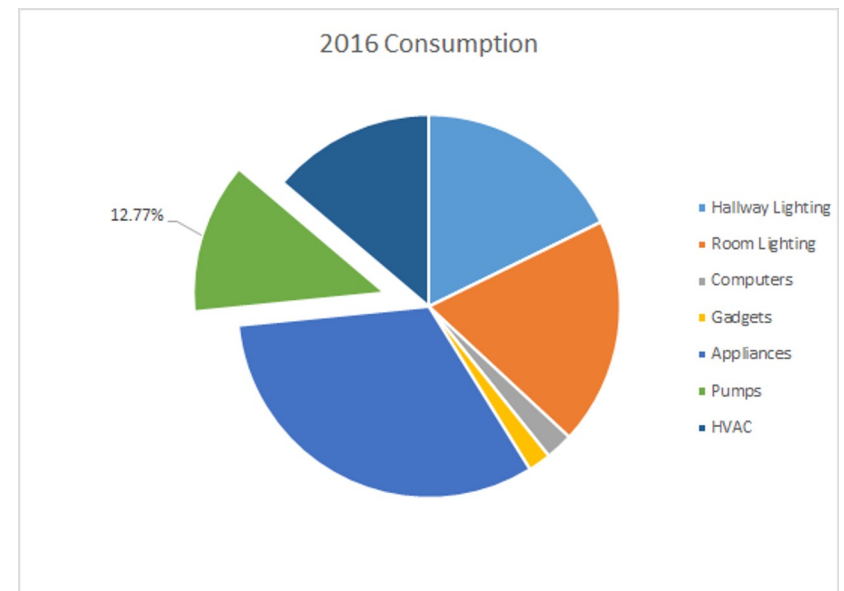
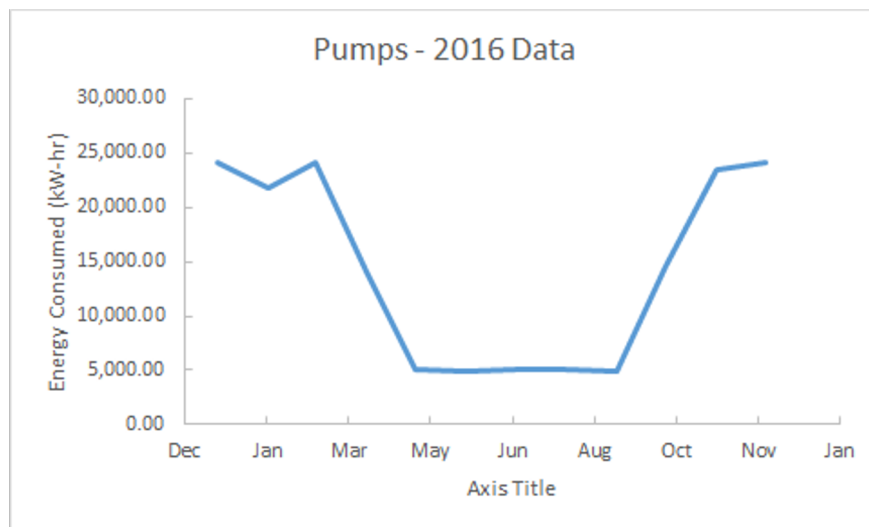
Pumps

- Heating Hot Water (HHW)
- Domestic Hot Water (DHW)
- Duty Cycle Calculations



Pumps

- 2016 Total consumption - 168,990 kW-hr
- Overall (Dorms) Percentage Contributed - 12.77%



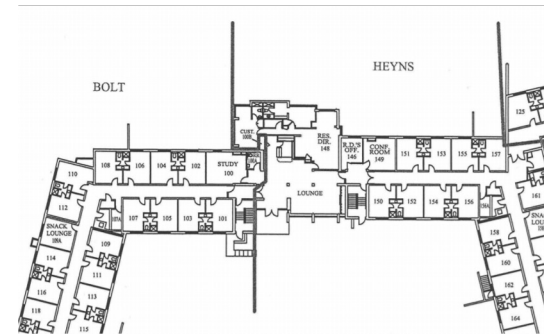
Team Members

- Rounak Chatterjee
- Toby Dalla Santa
- Jennifer Haney
- Joel Hoskins
- Caleb Senyshyn

HVAC

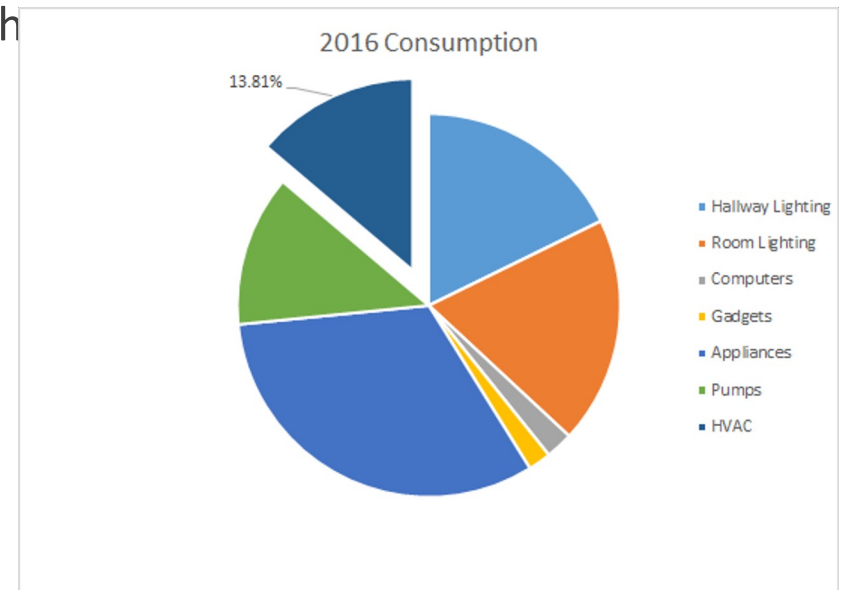
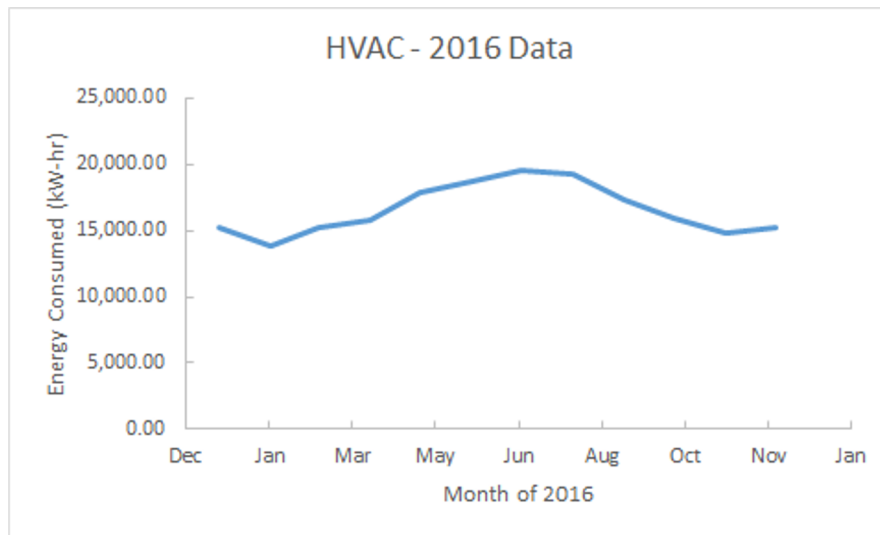
HVAC

- Establish heating parameters with pumps team
- HVAC → VAC (Ventilational and Air-conditioning)
- Model RD air-conditioning duty cycles
- MEP drawings (Outdated)



HVAC

- 2016 Total consumption - 199,017.50 kW-h
- Overall (Dorms) Percentage Contributed - 13.81%



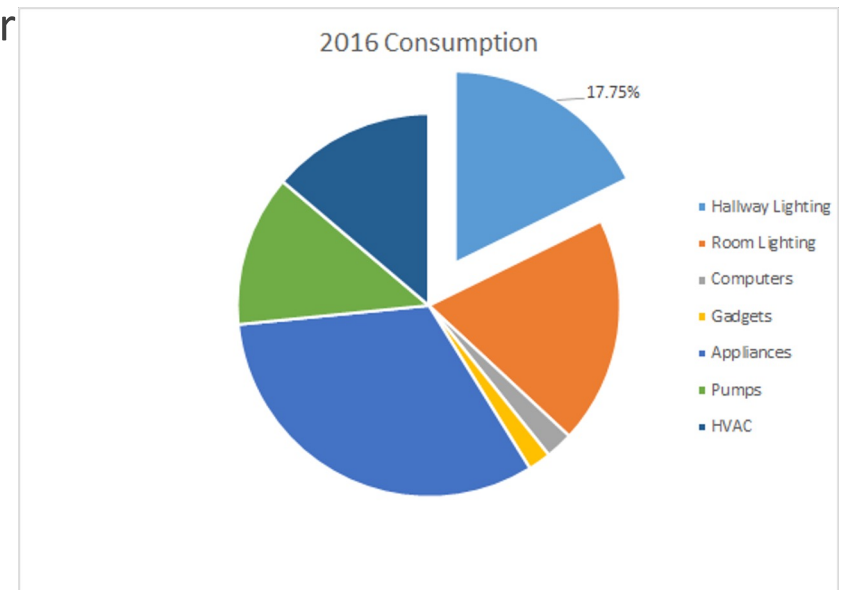
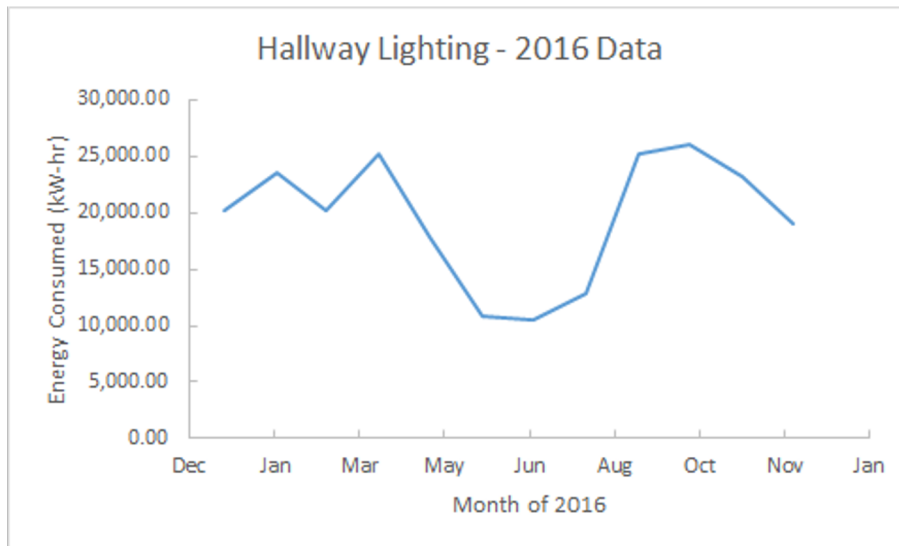
Team Members

- Alex Meador
- Scott Bokach
- Devin Auld
- Joshua Bronner

Hallway Lighting

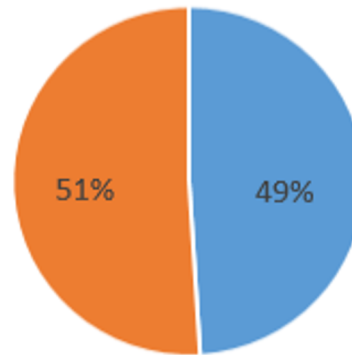
Hallway Lighting

- 2016 Total consumption - 234,880.5 kW-hr
- Overall (Dorms) Percentage Contributed - 17.75%

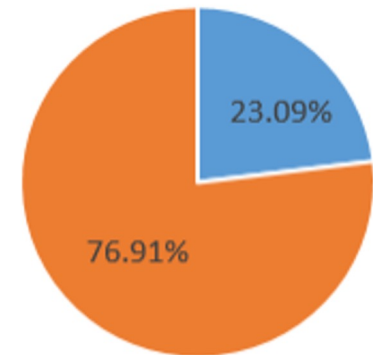


Hallway Lighting

- Comparison between motion sensing



NVW



SE

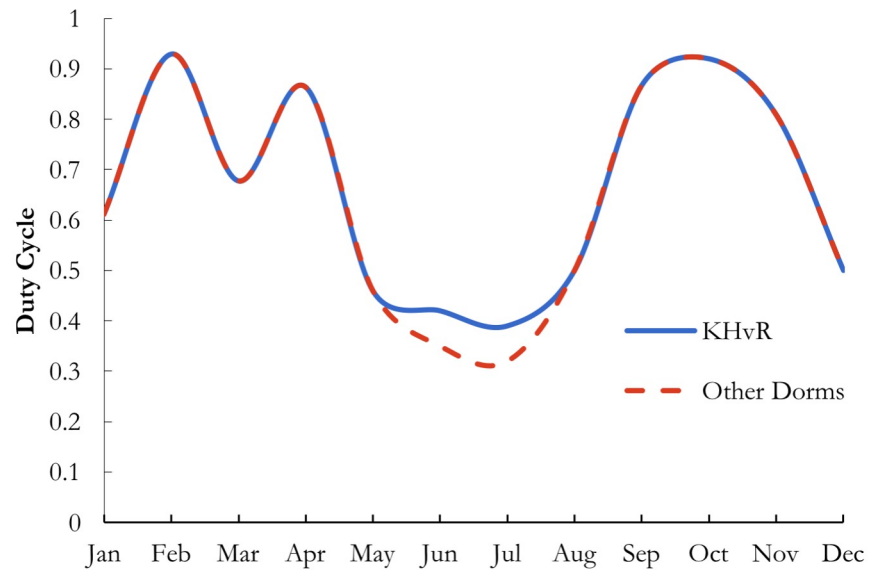
Team Members

- Elliot Slenk
- Matthew Lenko
- Robert Lanser
- Ryan Hoek

Room Lighting

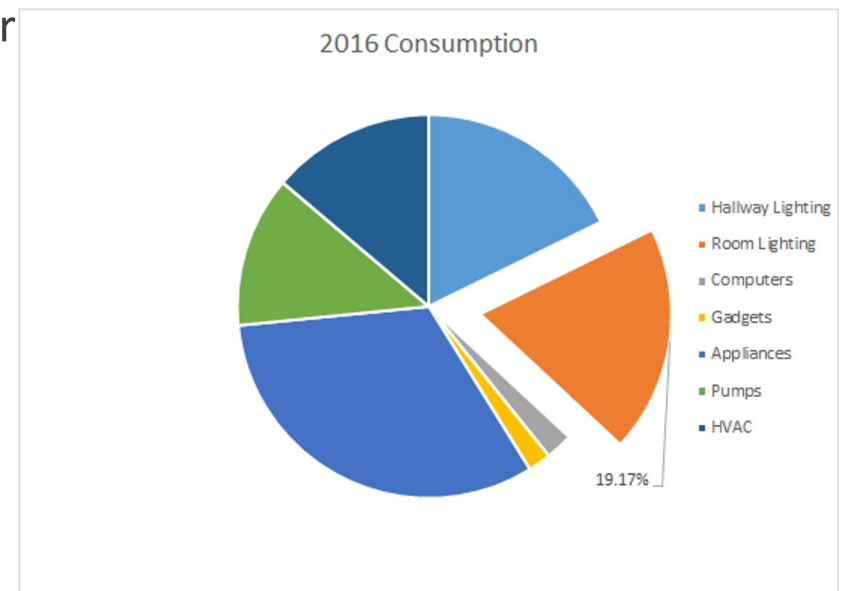
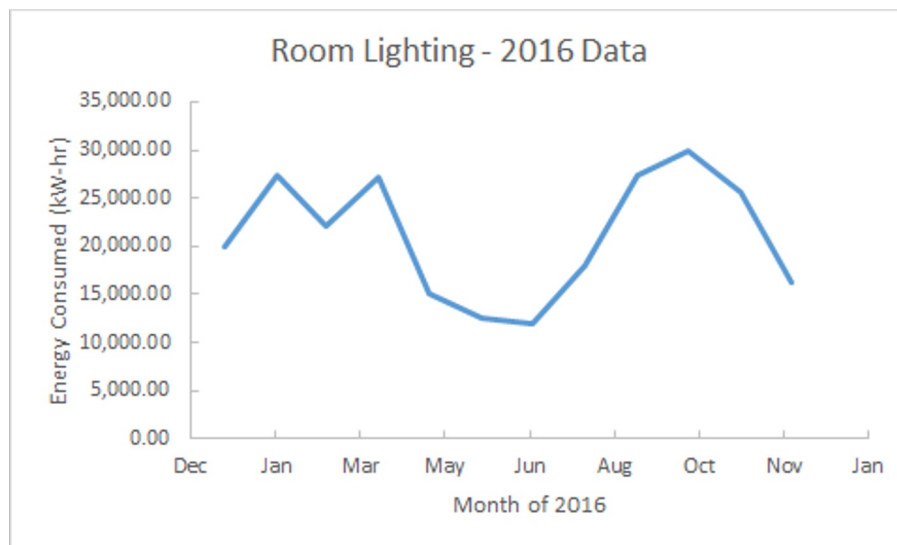
Room Lighting

- Overhead Lighting
- Closet Lighting
- Additional (Non-Calvin provided)
- Holiday Duty Cycles



Room Lighting

- 2016 Total consumption - 253,620.0 kW-hr
- Overall (Dorms) Percentage Contributed - 19.17%



Team Members

- Cameron Bell
- Caleb Bieske
- Chris Griffin
- Bernice Portugal

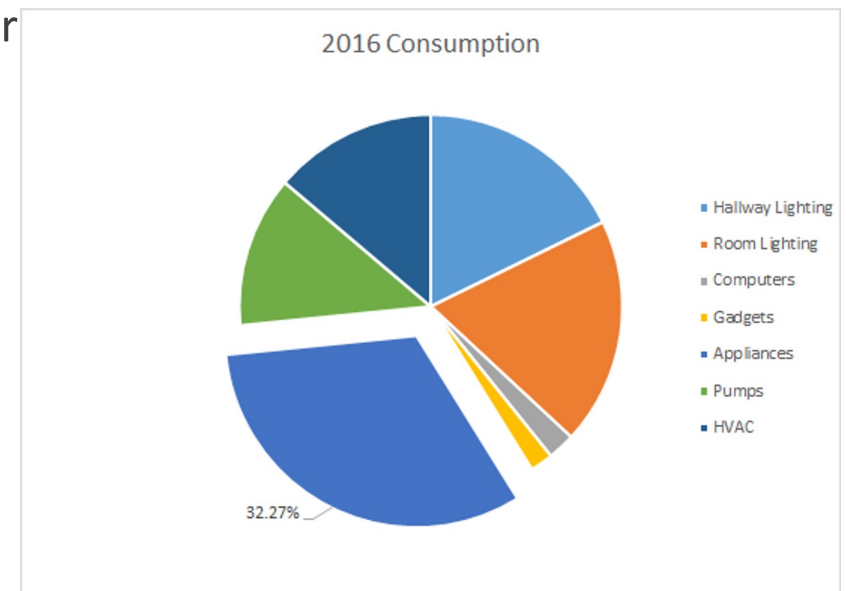
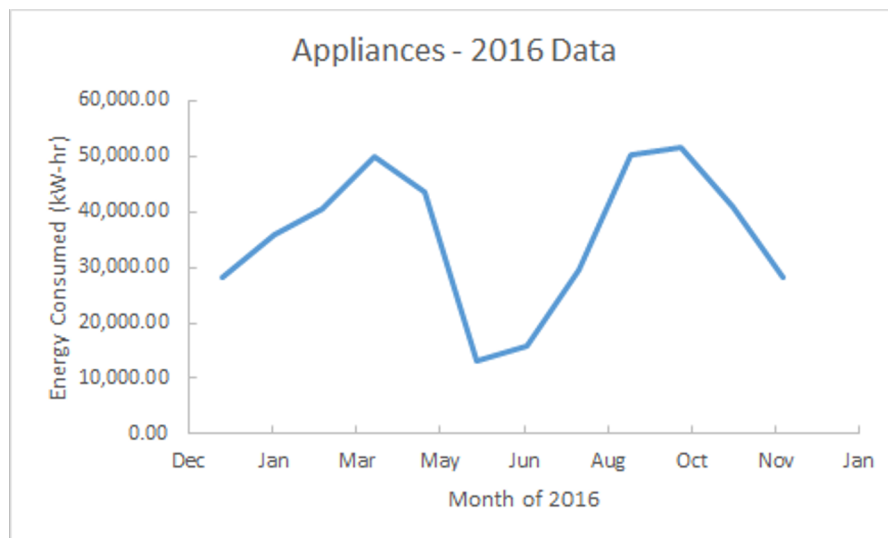
Appliances

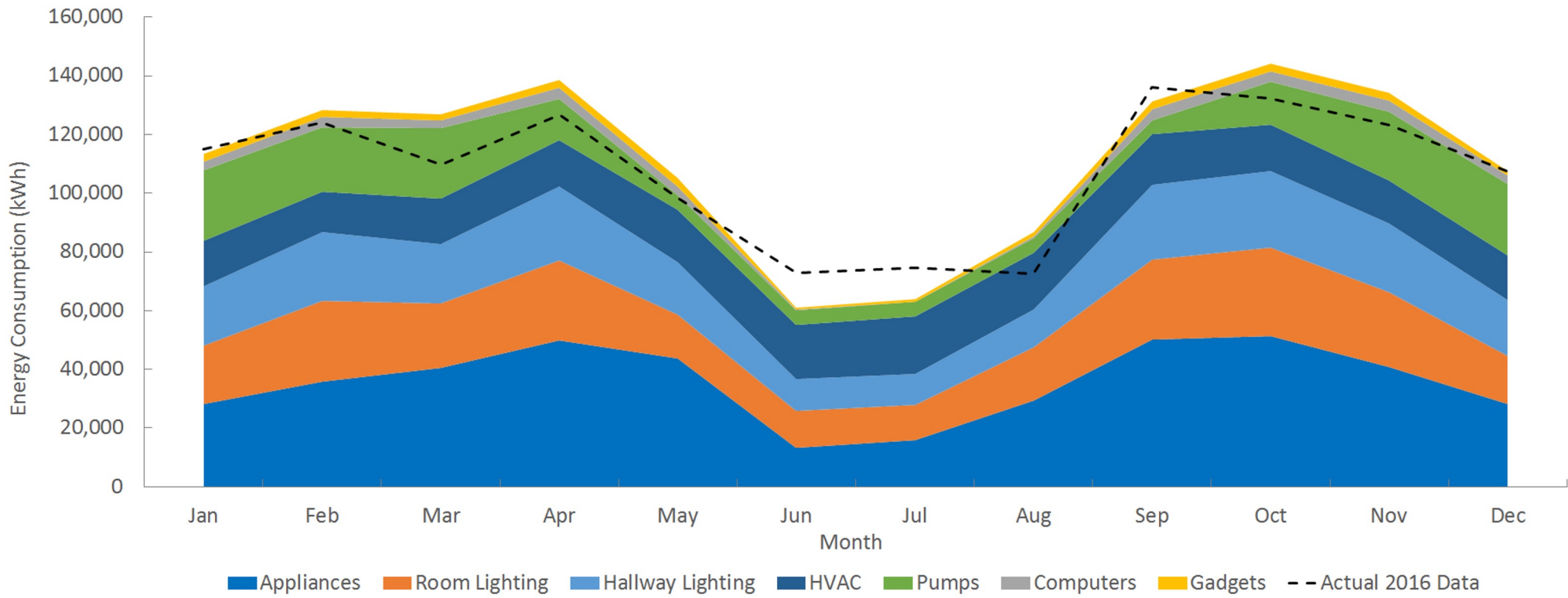
Appliances

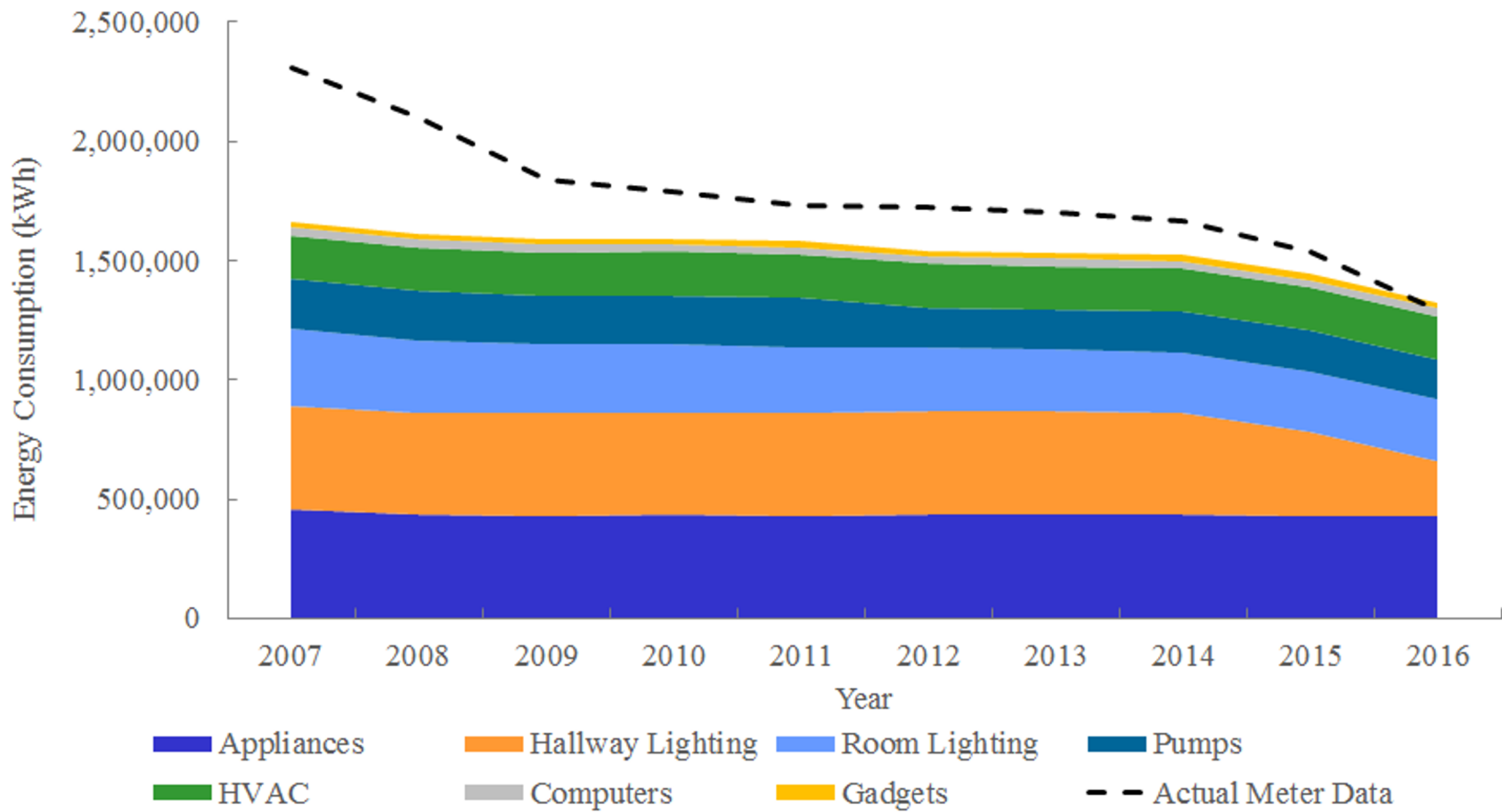
- NEED TO WORK WITH APPLIANCES TEAM ON MORE INFORMATION

Appliances

- 2016 Total consumption - 426,973.3 kW-hr
- Overall (Dorms) Percentage Contributed - 32.27%







Pictures and Other Resources

https://www.google.com/search?q=phone+picture&source=Inms&tbm=isch&sa=X&ved=0ahUKEwjB_oW0utbTAhVn5YMKHWw4BD0Q_AUICigB&biw=1440&bih=799#tbn=isch&q=mini+fridge&imgrc=qM60FeiGp2ISNM;

<http://images.clipartpanda.com/laptop-computer-images-laptop-and-netbook-computers-5131.jpg>

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https://www.google.com/search?q=phone+picture&source=Inms&tbm=isch&sa=X&ved=0ahUKEwjB_oW0utbTAhVn5YMKHWw4BD0Q_AUICigB&biw=1440&bih=799#tbn=isch&q=electrical+meter&imgrc=07Hlj4NbiYK75M;

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Bottom-up Electricity Demand Model

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Spoelhof Fieldhouse Complex





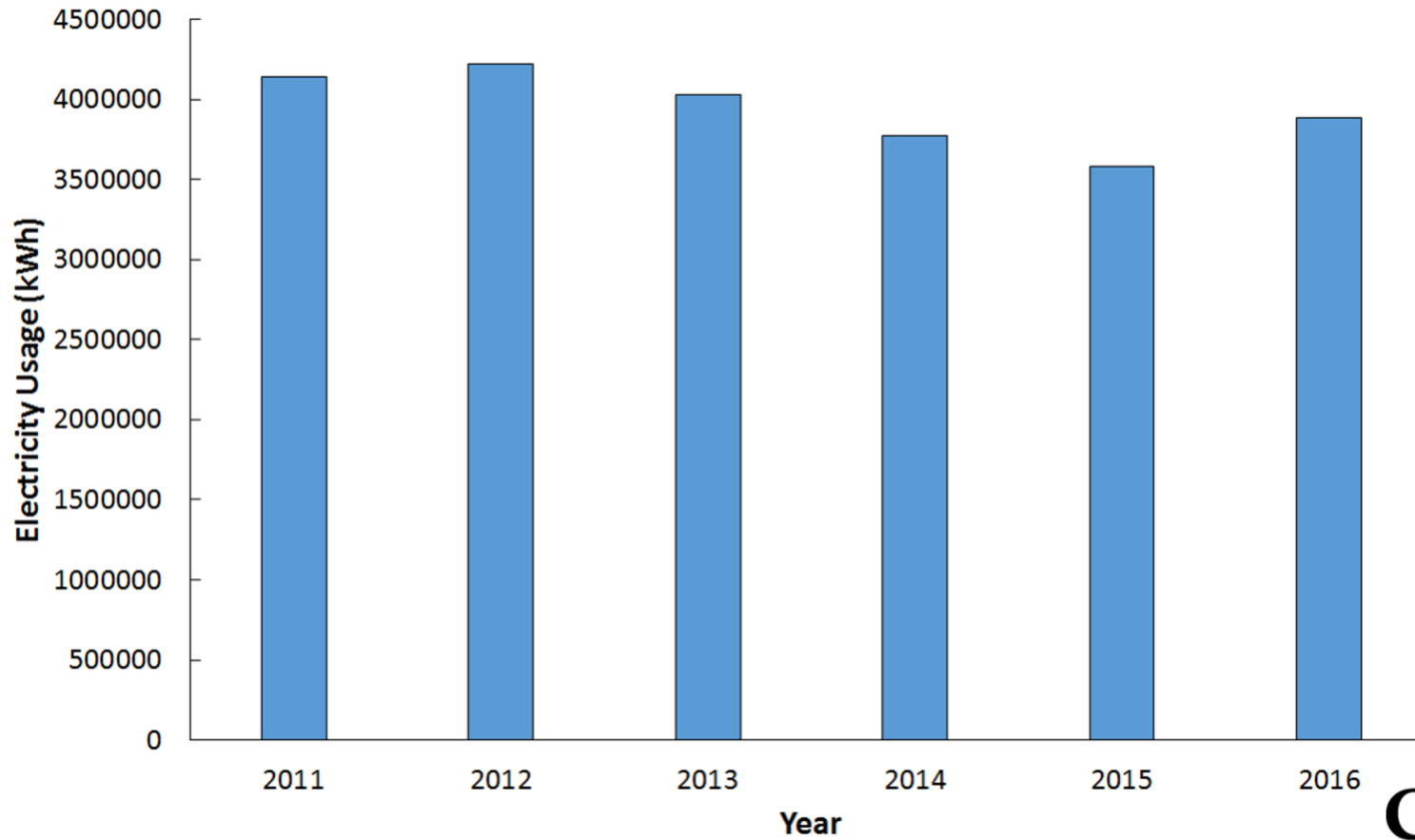






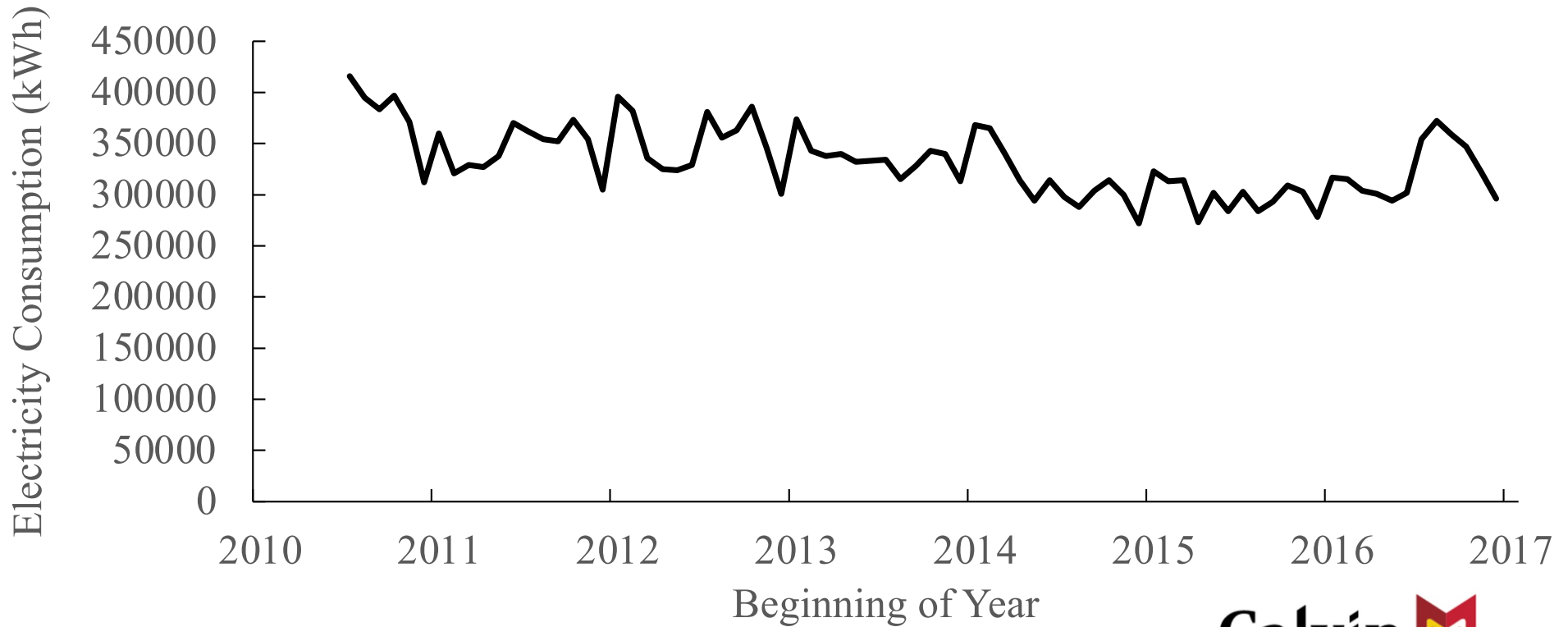


Historical Fieldhouse Electricity Usage (kWh)

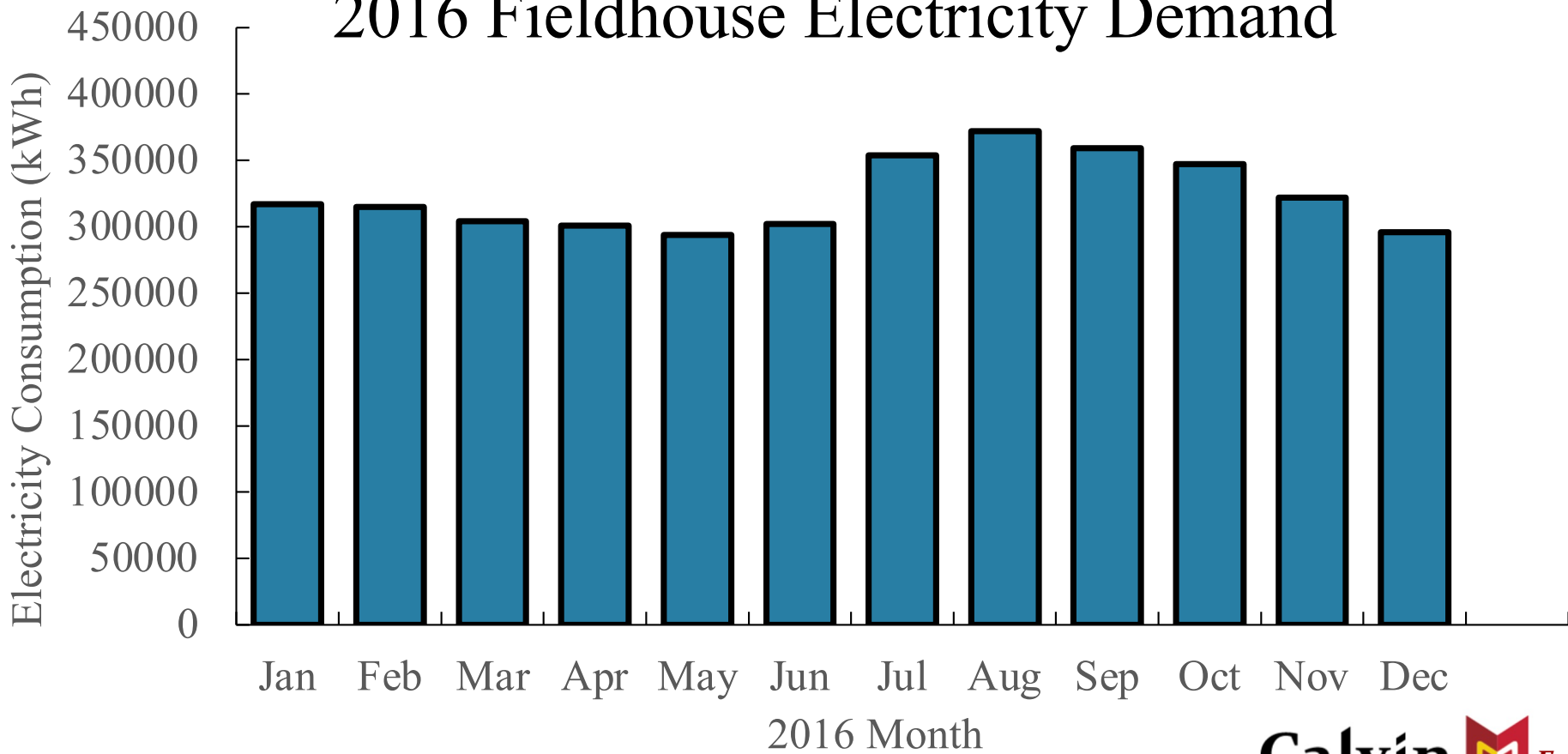


~20%
of Calvin's
Electricity
Demand

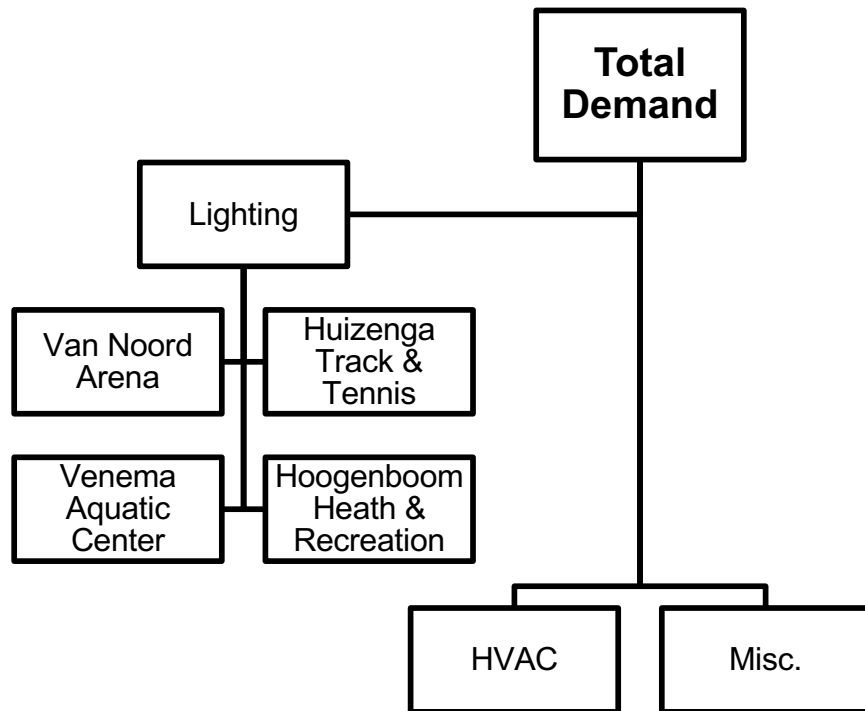
Historical Fieldhouse Electricity Demand



2016 Fieldhouse Electricity Demand



Project Organization



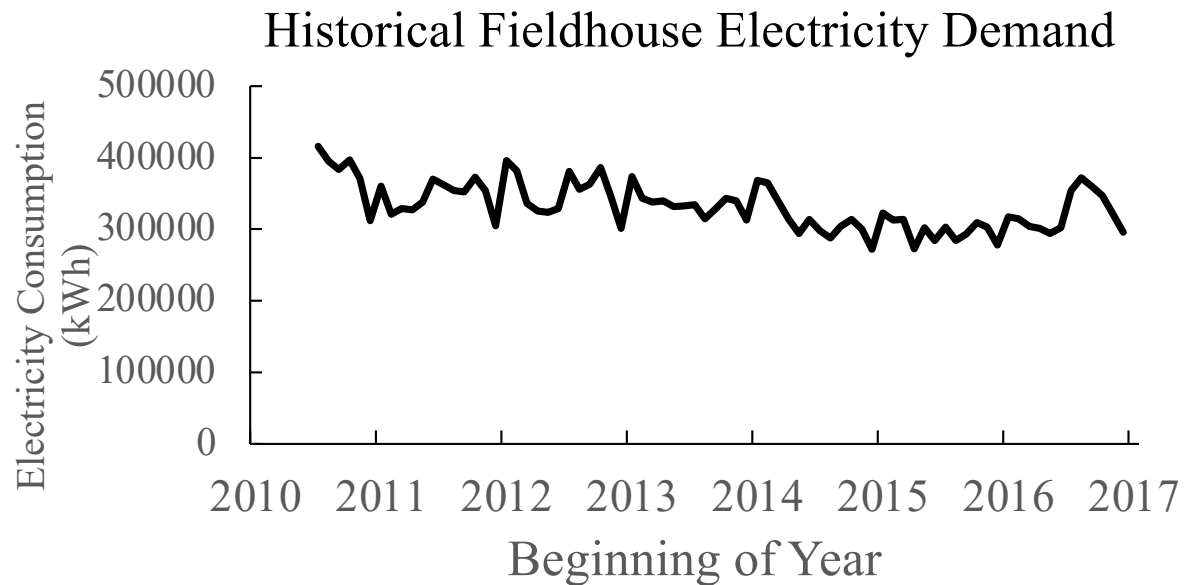
3 Design Iterations:

1. Model typical month
2. Extend model to one year
3. Backcast model with historical parameters

Key Design Questions

What are the largest contributors to electricity demand?

What drives variation in electricity demand?



Team Members

- Sam Hanover
- Dan Wharton
- Jay Noyola
- Zachary Mouw
- John Lee

HVAC

(Heating, Ventilation, Air Conditioning)

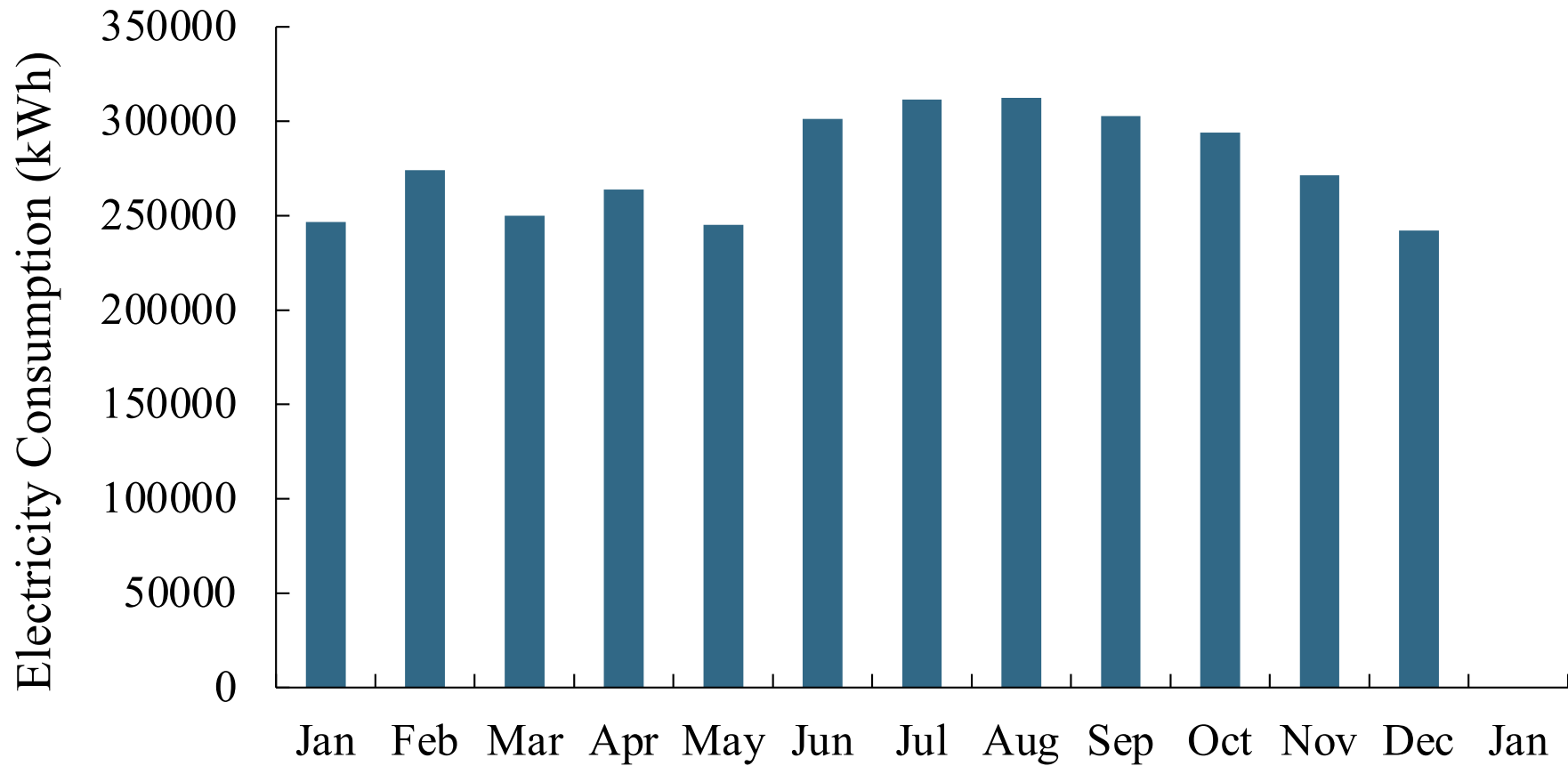
Team

Key Variables

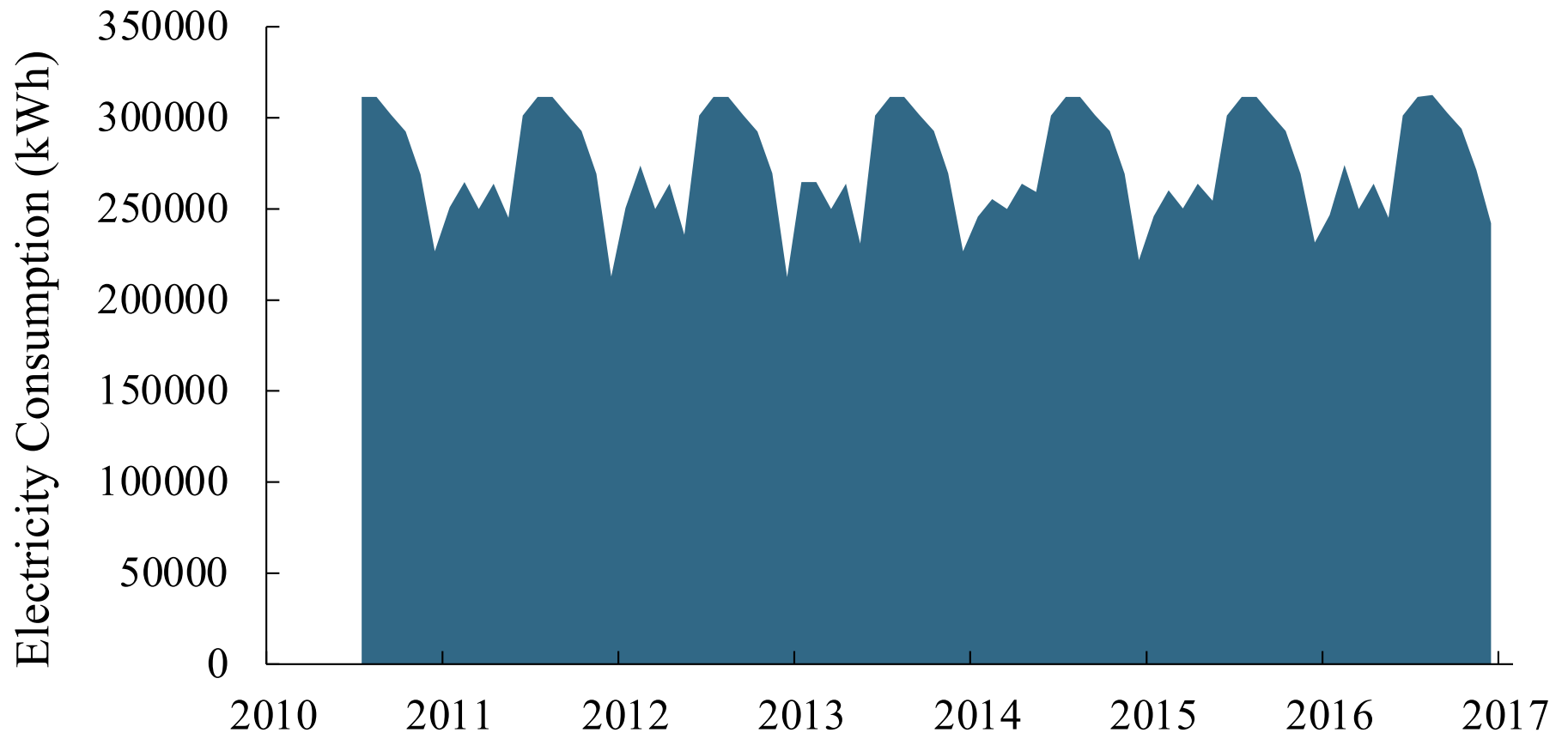
Unit-Specific Power Draw and On-Time

- Game/Event Locations and Times
- Academic Calendar - Breaks
- Weather (Temperature, Humidity)





Beginning of Year



Beginning of Year

Team Members

- Daniel Dick
- Jonathan Sager
- Nathan Swaim

TNT Lighting Team

Team Members

- Ellen Reidy
- Jordan Swets
- Joel Van Dyke

Venema Lighting Team

Team Members

- Connor Macdonald
- Josiah Markvluwer
- Justin Rohlicek

Van Noord Lighting Team

Team Members

- Adam Christensen
- Scott Stamper
- Aaron Tucker
- Bethany Waanders

A/V & Plug-in Electronics Team

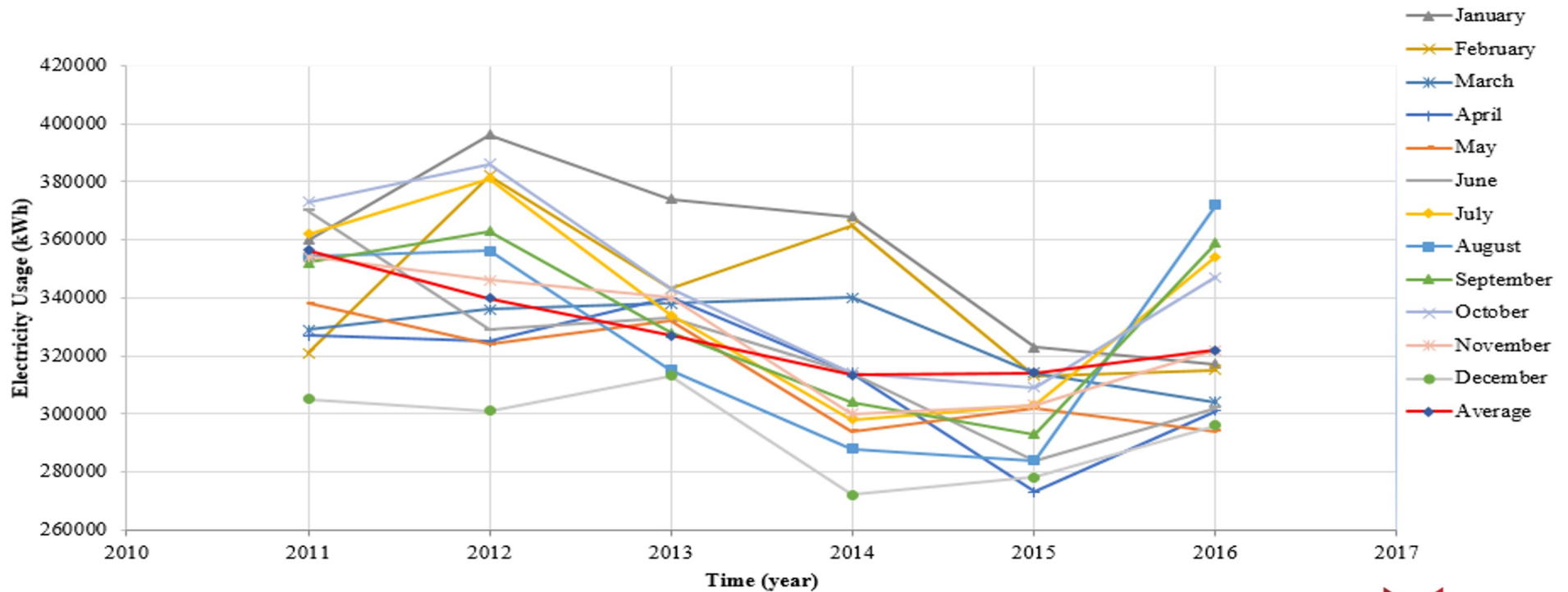
Team Members

- Joel Schaefer
- Maddie Collins
- Matthew Cok
- Philip Kim
- Steve Vanden Berg

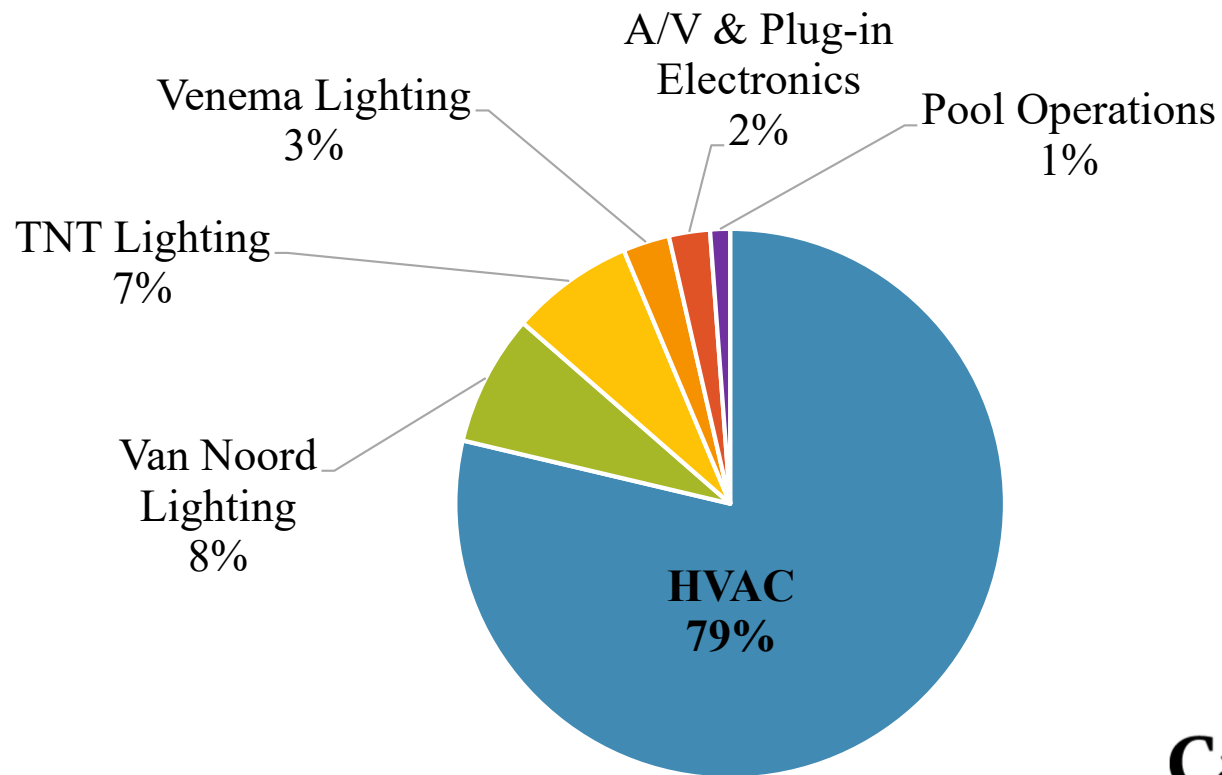
Pool Operations Team

Overall Data Analysis

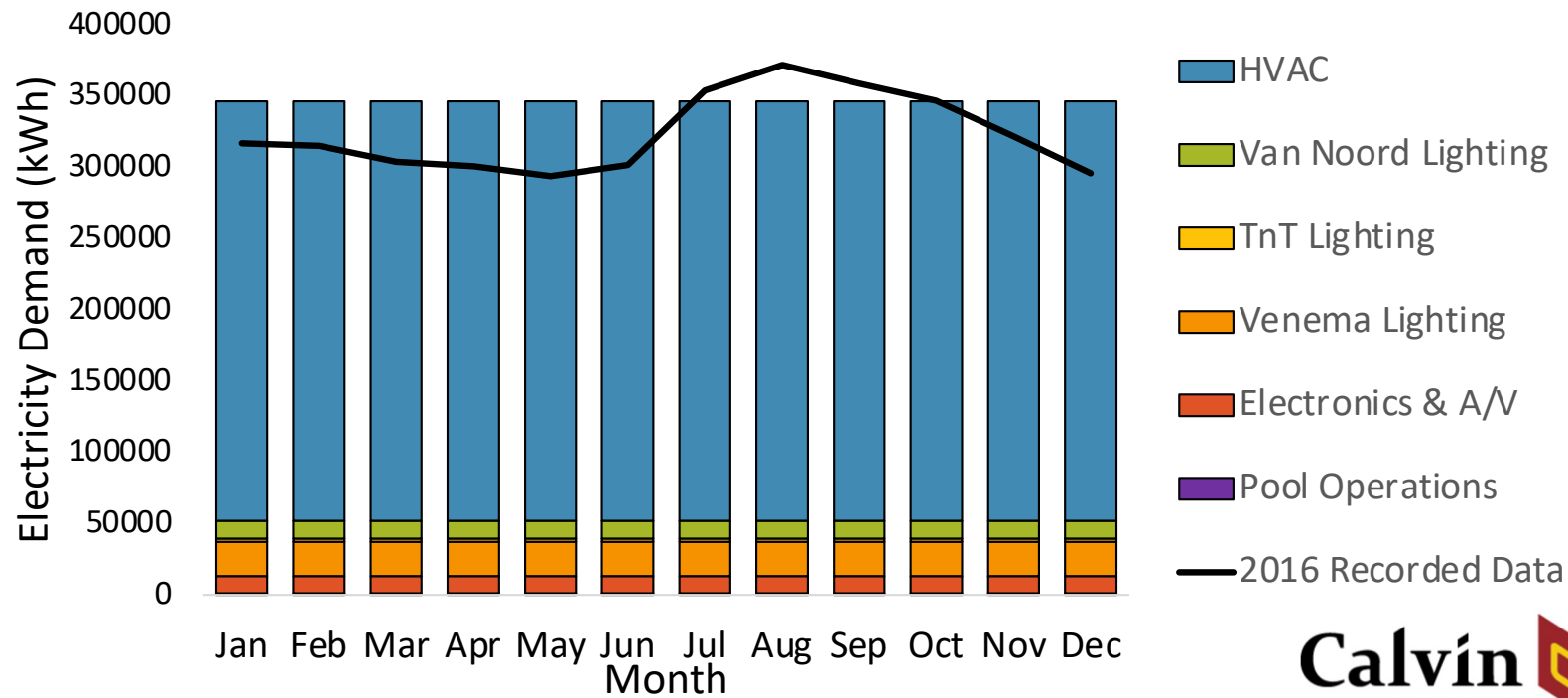
Electricity Usage per Month for Every Year



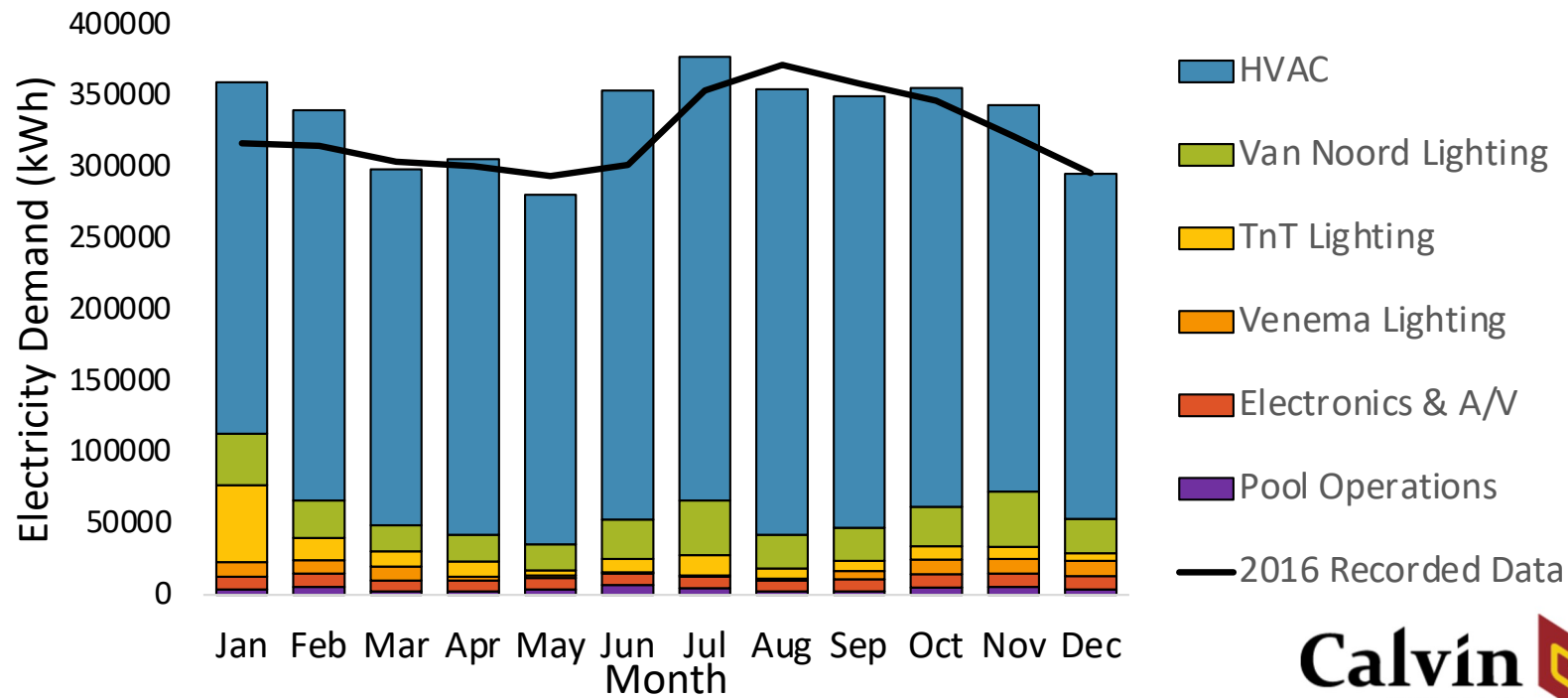
2016 Fieldhouse Demand Estimation Breakdown



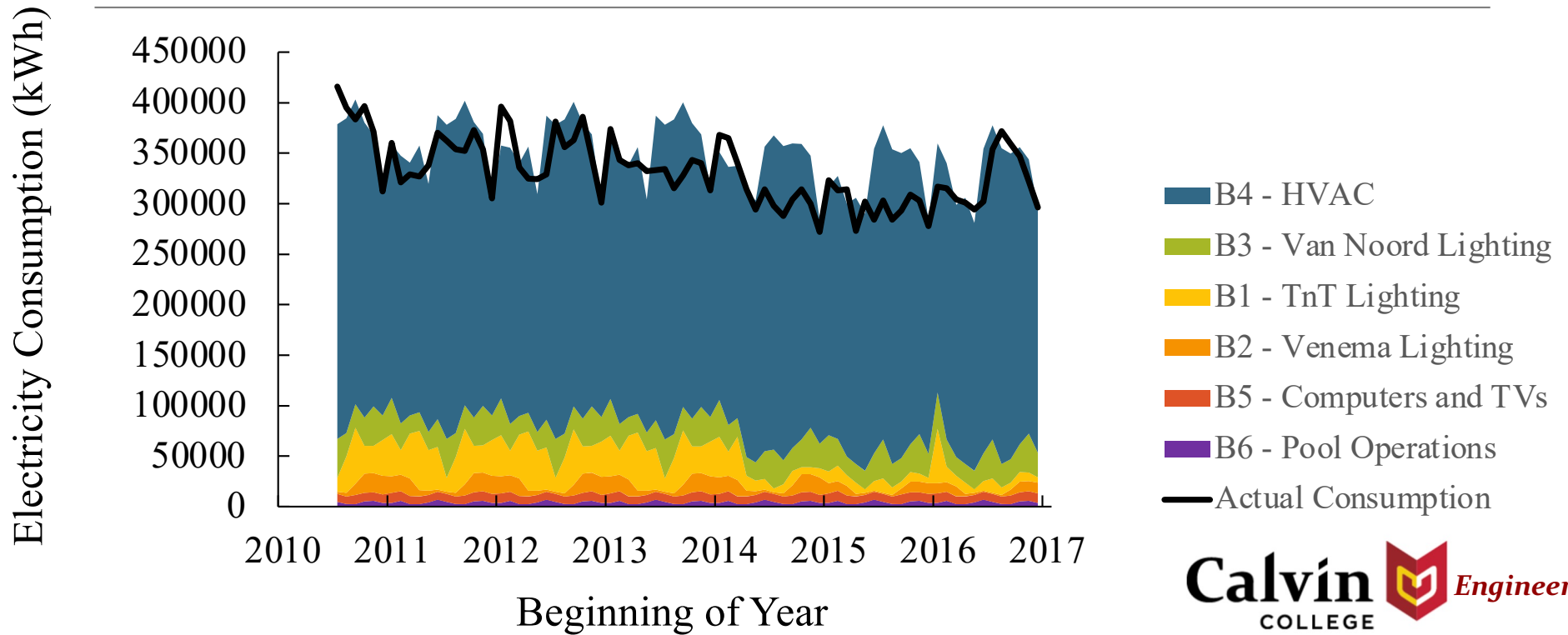
Model 1: Static Month Prediction

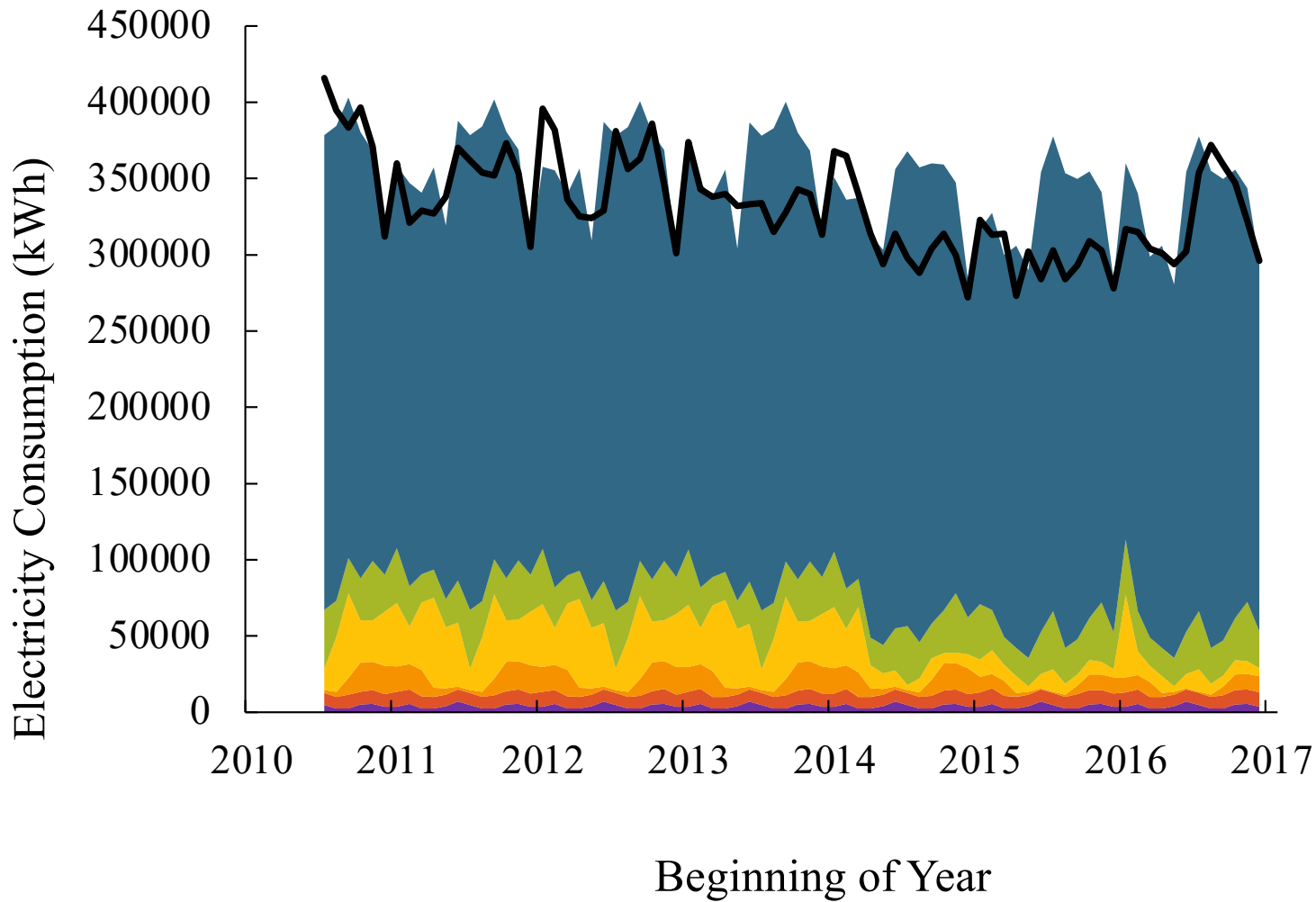


Model 2: One-Year Prediction (2016)



Model 3: Back-Cast (Mid 2010 – 2016)





Possible Electricity Demand Reductions



Photo: bigassfans.com



Possible Electricity Demand Reductions

Switch to LEDs. More description here...

Learning Outcomes

- Large-scale project management
- Resource-sharing and effective team membership
- Bottom-up model generation
- Customer interaction

Acknowledgements

Prof. Heun

Jack Phillips

Dan Slager

Barb Reitema (Box Office)

Roy Zuidema (Campus Wellness)

Campus Safety

Swimming and Basketball Coaches

Justin TeBrake

...etc (keep adding!)

Appendices Index
