EnergyFlowVis:

Visualizing energy use flows on UBC Campus

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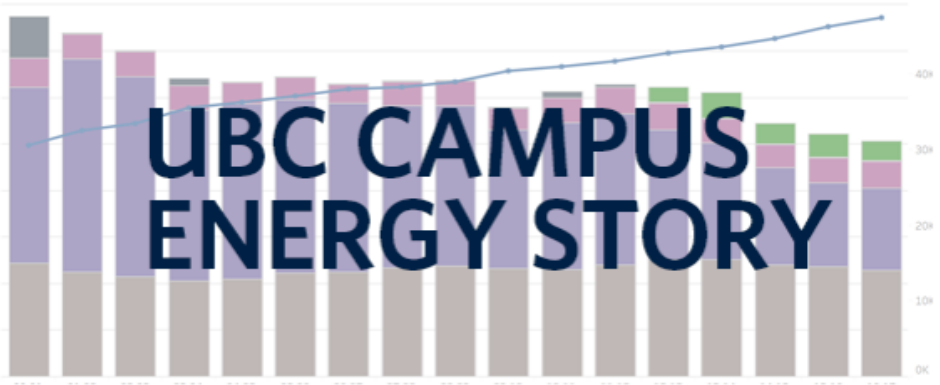
Introduction

- UBC Energy and Water Services (EWS) Unit
  - Energy savings potential
  - Greenhouse gas emissions
  - Building management systems
  - Existing applications



Team

Claude Demers-Bélanger
(MASc candidate, MECH)

Machine Learning for Building Science
Occupant Centric Control
Data Analytics
Recommendation Systems

Energy, Technology, and Architecture (ETA) Lab

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(PhD candidate, MECH)

Building energy performance
Occupant behaviour; thermal comfort
Indoor environmental quality
NEW: wellbeing and work-from-home during COVID19

Dataset

- EWS
- SkySpark platform
- InfluxDB conversion
  - Sensor metadata
  - Metering data
  - Building metadata

Data abstraction: *what?*

- Derived data
  - Multidimensional table
    - Quantitative attribute: Total energy
    - Quantitative attribute: Energy Use Index
    - Ordered key attribute: Date
    - Categorical key attribute: Energy source
    - Categorical key attribute: Building name
    - Categorical key attribute: Building use
    - Categorical key attribute: Year of construction
    - Categorical key attribute: Floor area

Data abstraction: *what?*

Clusters

Cluster types

Building use

Cluster name	No. of buildings
Laboratory	41
Classroom	11
Office	24
Residential	24
Recreational	11
Library	8
Student services	4
Others	7

Year of construction

Cluster name	No. of buildings
before 1945	7
1946 to 1959	10
1960 to 1969	29
1970 to 1979	9
1980 to 1989	7
1990 to 1999	15
2000 to 2009	17
2010 to 2014	23
After 2014	14

Floor area (m^2)

Cluster name	No. of buildings
<2000	12
2000-3000	21
3001-5000	15
5001-7000	21
7001-9000	15
9001-11,000	17
11,001-15,000	12
15,001-22,000	8
>20,000	10

Task abstraction: why?

- Analyze
  - discover
  - present
- Produce
  - derive
- Search
  - explore
  - locate
- Query
  - identify
  - compare

Task 1: Energy use on campus across different energy sources for a specific time period.

Task 2: Energy use across different energy sources for different building use clusters for a specific time period.

Task 3: Energy use across different energy sources for different building size (floor area) clusters for a specific time period.

Task 4: Energy use across different energy sources for different building age (year of construction) clusters for a specific time period.

Task 5: Energy use across different energy sources by a specific building for a specific time period.

Task 6: Compare cluster level energy use data for two different time periods.

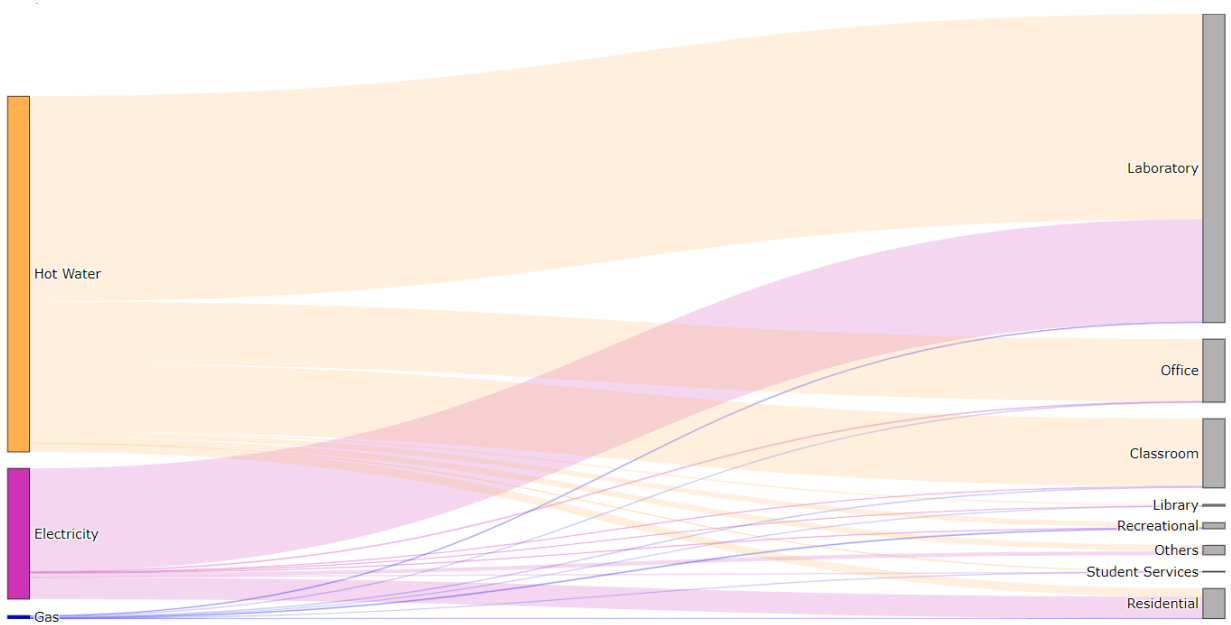
Task 7: Compare energy use data across clusters for the same time period.

Task 8: Compare building level energy use data for two different time periods.

Task 9: Compare energy use data across different buildings for the same time period.

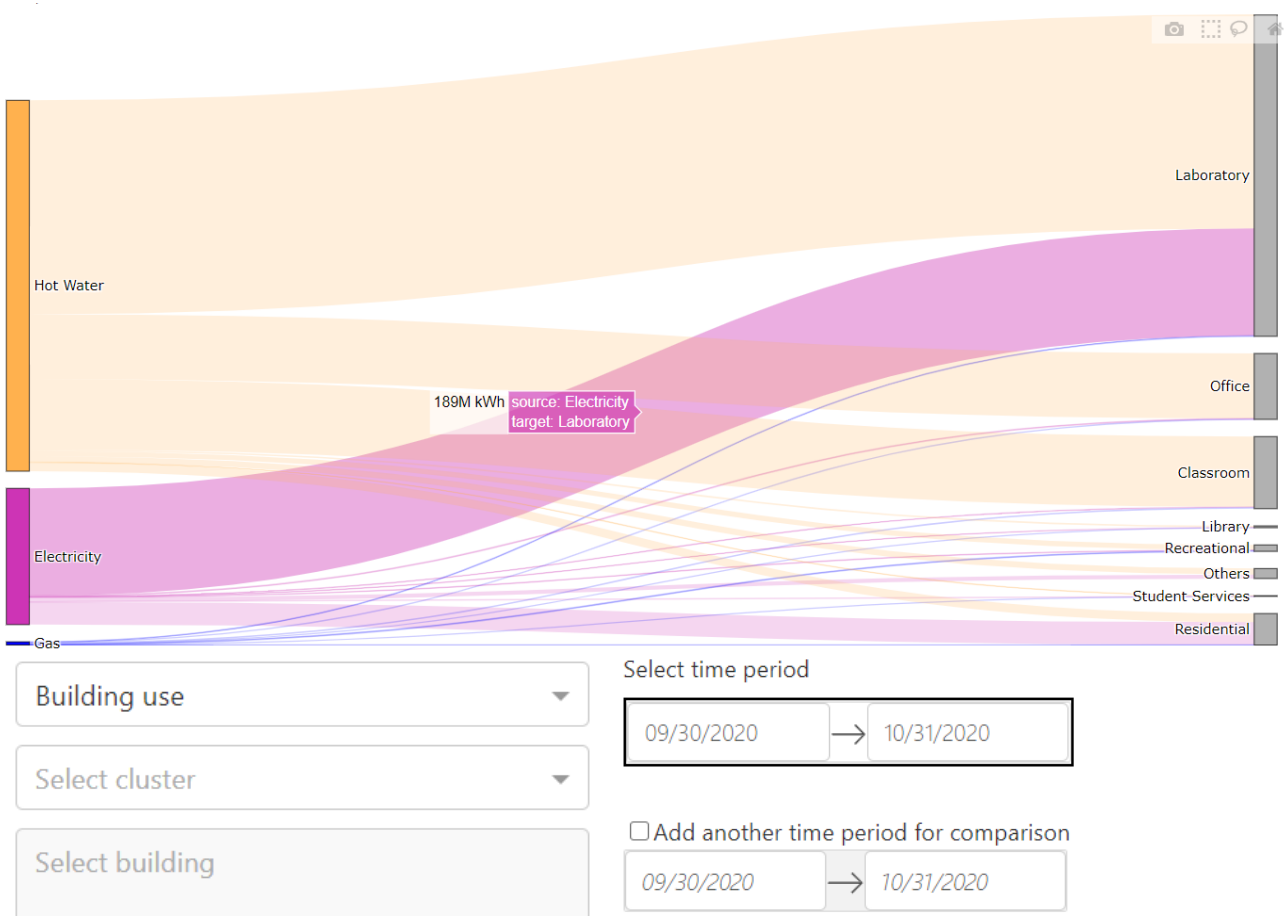
Solution: *how?*

- Technology:
  - Dash, Python, InfluxDB
- Encode
  - Area marks (energy flows) for the quantity of energy use
  - Energy sources by color
    - Categorical
  - Energy source and end uses (targets) by node position
    - Source nodes on the left
    - Target nodes on the right
      - Lower-level target nodes on extreme right



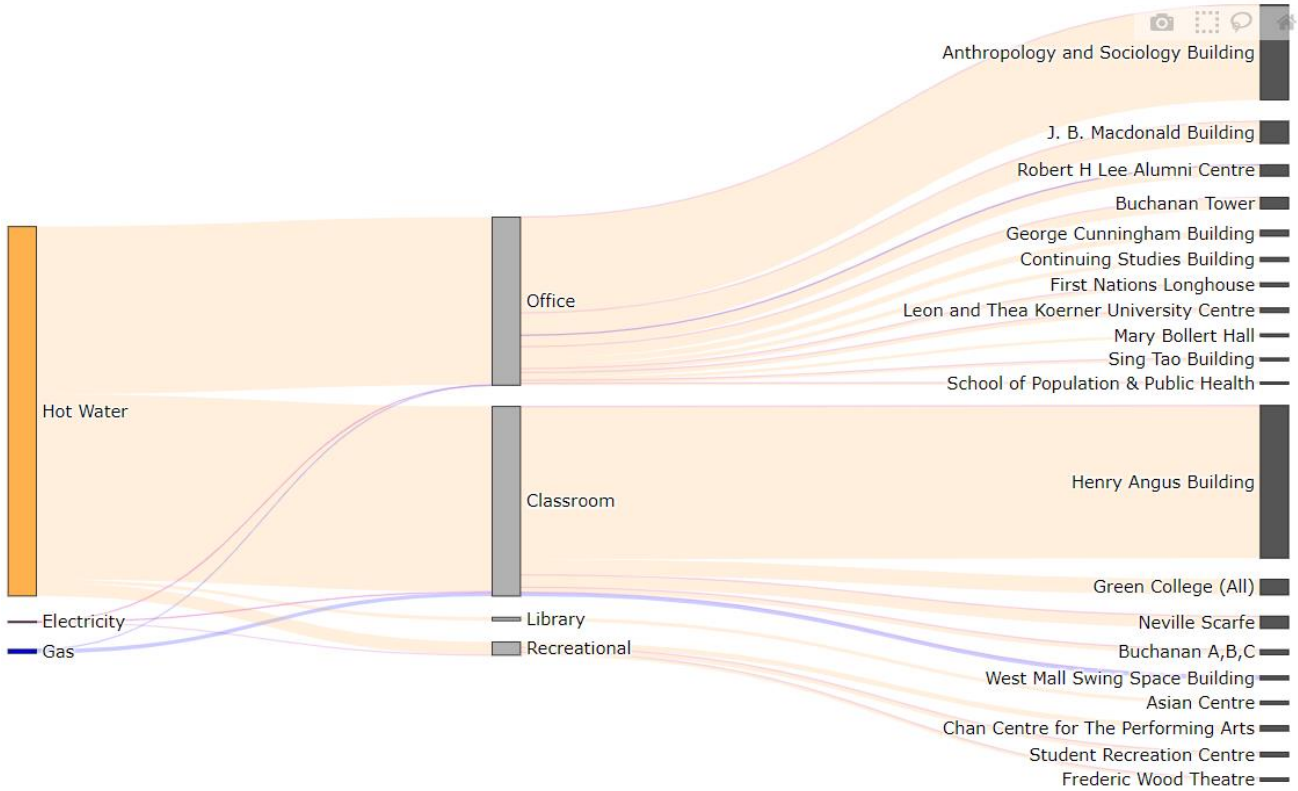
Solution: *how?*

- Manipulate:
  - Reorder, realign, animate transitions;
    - navigate between aggregation levels: cluster type → cluster → building
  - Highlighting
    - Energy flows – increasing saturation, data tags
    - Nodes – data tags
  - Reduce attributes
    - Filter through dynamic queries
  - Reduce items
    - Interactive item aggregation to change level of detail



Solution: *how?*

- Facet:
  - Superimpose:
    - two layers to compare time periods
    - multiple layers to compare clusters
    - distinguished by position of nodes
    - maximum nodes 20
  - Layers are constructed dynamically in response to user selection.



Solution: Conclusion

- Dash is good for prototype, Application not production ready
- Sankey diagrams gives a good overview of trends
  - Detailed comparison aren't as good (i.e. Bar or line charts)
- Building with low consumption can be lost
  - Users need to know what they are looking for

Future work

- Anomaly Detection before visualization
- User study
- Convert to different tech. stack if the UI bugs can’t be solved
- Go “Left” or “Right” of the graphs
  - Source of energy and detailed consumption