



Prince George's County - Building Lifecycle Utility Cost Analysis



Team: Olva Balliu, Thomas Marmo, Natasha Rokkala,
Theodore Gaidis, Pete Schultz, Conner Houtman

Abstract	3
Executive Summary	3
Methods	3
Data Overview and Cleaning Process	3
Deliverables	4
Data Visualization	4
Percentage usage of all utilities across five facilities	5
Percentage cost of all utilities across five facilities	6
Average yearly electric usage across five facilities	8
Average yearly energy cost across five facilities	10
Average yearly gas usage across five facilities	12
Average yearly gas cost across all facilities	15
Average yearly telecom usage	16
Average yearly telecom cost across facilities	18
Average yearly water usage across facilities	20
Average yearly water cost across facilities	22
Total Yearly Usage by Commodity for all facilities	23
Total Yearly Cost for All Utilities	26
Laurel-Beltsville (EUI)	28
Laurel-Beltsville (Yearly Utility Cost)	29
Palmer Park (EUI)	30
Palmer Park (Yearly Utility Cost)	31
Publick Playhouse (EUI)	32
Publick Playhouse (Yearly Utility Cost)	33
Southern Area Aquatics (EUI)	34
Southern Area Aquatics (Yearly Utility Cost)	35
Southern Tech & Rec Center (EUI)	36
Southern Tech & Rec Center (Yearly Utility Cost)	37
Analysis	38
Percentage Usage Data	38
Percentage Cost Data	38
Electricity Usage Data	39
Electricity Cost Data	39
Gas Usage & Cost Data	39
Telecom Usage & Cost Data	39
Water Usage & Cost Data	40
Recommendations	40

Abstract

Prince George's County Parks & Recreation builds, operates and maintains numerous facilities with significant lifespans. In order to better understand the impact of capital investment and changes to building codes which would then lead to reduce long term operating costs, the department seeks to have a comparative analysis performed using available utilities usage data from six large, well established facilities.

The primary business objective of this project is to understand the relationship between initial capital investment, changes in building codes, and long term operational costs. This will enable Prince George's County Parks & Recreations to make better informed decisions about the construction of new facilities and how to minimize long term operational costs. To meet the objective, the team will develop contextualized data visualizations that tell the story of how the initial capital investment affects operating costs for the buildings.

Executive Summary

This project consists of collecting and analyzing utilities data to create visualizations of the operating costs of six facilities: Southern Area Aquatics & Recreation Complex, Southern Regional Technology & Recreation Center, Palmer Park Community Center, Westphalia Community Center, Laurel-Beltsville Senior Center, and Publick Playhouse.

Due to data quality issues and time constraints of this project, the project scope changed to dropping Westphalia as a site and altering the project deliverables as follows:

- A high level overview of the long term utility usage for the five facilities.
- Visualizations using Tableau that tell the story of utility usage and costs for the five facilities.
- Python coded notebook with data cleaning and processing that can be used for future buildings.
- User documentation of the notebook
- Final report of our findings

Methods

I. Data Overview and Cleaning Process

The utilities data was received in a flat excel file containing data for all locations. The data team inspected the file and found numerous data quality problems that we would need to fix before analysis. The problems include: different names used for one building, inconsistent billing periods, repeat billing IDs, billing periods with no utilities usage, and billing periods with no cost.

A sequence of steps was followed in order to clean the data. First, the building names in the dataset were standardized. Then, duplicate billing IDs were aggregated. Following

this, rows where cost was zero were removed. Finally, the data is split into subsets by location, and then ordered chronologically by billing start date. Rows where native use was 0 were removed to create EUI graphs.

The team developed a jupyter notebook to read, clean, and produce visualizations from the data.

Deliverables

Due to misalignment of data to the physical resources we are unable to validate the quality of the visualizations and output, and we strongly recommend that a further analysis be performed to better align the data to the physical sites in order to improve the accuracy of this model.

I. Data Visualization

For our visualizations, we decided to use Tableau so we could create charts to show trends across facilities and utilities. We used the story display throughout the facilities to consolidate the usage and cost across the utilities. Below are the data visualization generated for each category:

For reference: Below is the National EUI Index by property type:

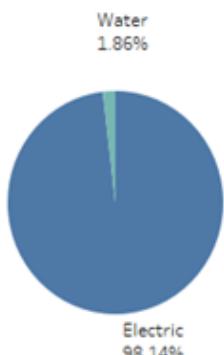
<https://portfoliomanager.energystar.gov/pdf/reference/US%20National%20Median%20Table.pdf>

Entertainment/Public Assembly	Convention Center	109.6	56.1	CBECS - Social/Meeting
	Movie Theater	112.0	56.2	CBECS - Public Assembly
	Museum			
	Performing Arts			
	Recreation	Bowling Alley	112.0	CBECS - Recreation
		Fitness Center/Health Club/Gym		
		Ice/Curling Rink		
		Roller Rink		
		Swimming Pool		
		Other - Recreation		
	Social/Meeting Hall	109.6	56.1	CBECS - Social/Meeting

A. Percentage usage of all utilities across five facilities

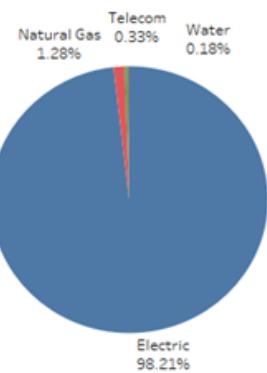
Laurel

Pie Chart of Commodity Usage	Percentage Cost of All Utilities	Average Yearly Electric Usage	Percentage Cost of All Utilities	Percentage of Total Native Usage by Commodity	Average Yearly Gas Usage
------------------------------	----------------------------------	-------------------------------	----------------------------------	---	--------------------------



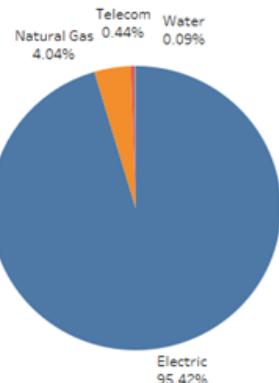
Palmer Park

Percentage Cost of All Utilities	Percentage of Total Native Usage by Commodity	Average Yearly Gas Usage
----------------------------------	---	--------------------------



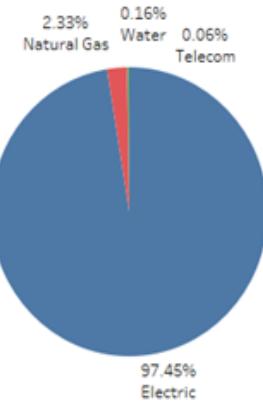
Publick Playhouse

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Yearly Electric Cost
---	---------------------------------------	------------------------------



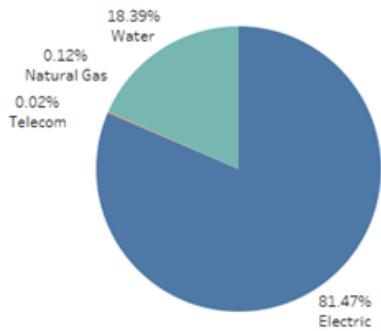
Southern Area Aquatics

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Yearly Gas Usage
---	---------------------------------------	--------------------------



Southern Tech and Rec

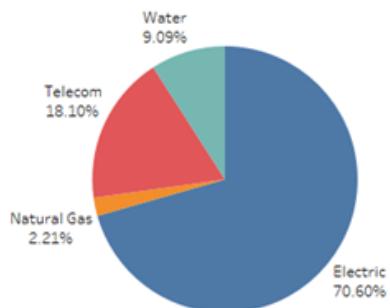
Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Yearly Gas Usage
---	---------------------------------------	--------------------------



B. Percentage cost of all utilities across five facilities

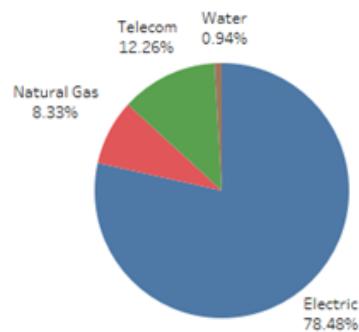
Laurel

Pie Chart of Commodity Usage	Percentage Cost of All Utilities	Average Yearly Electric Usage
------------------------------	----------------------------------	-------------------------------



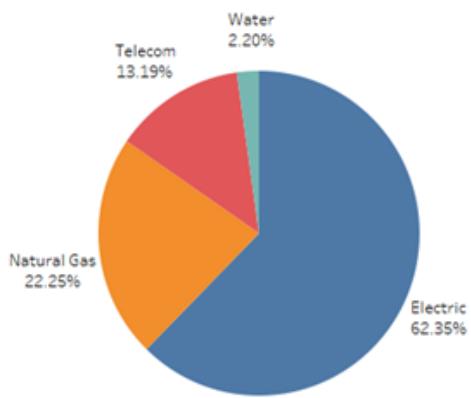
Palmer Park

Percentage Cost of All Utilities	Percentage of Total Native Usage by Commodity	Average Yearly Gas Usage
----------------------------------	---	--------------------------



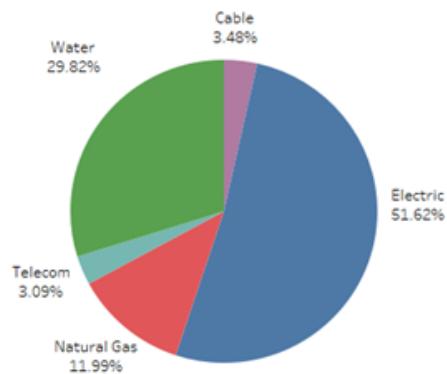
Publick Playhouse

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Yearly Electric Cost
---	---------------------------------------	------------------------------



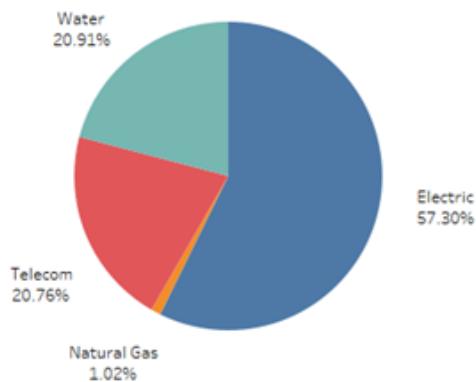
Southern Area Aquatics

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Yearly Gas Usage
---	---------------------------------------	--------------------------



Southern Tech and Rec

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Yearly Gas Usage
---	---------------------------------------	--------------------------



C. Average yearly electric usage across five facilities

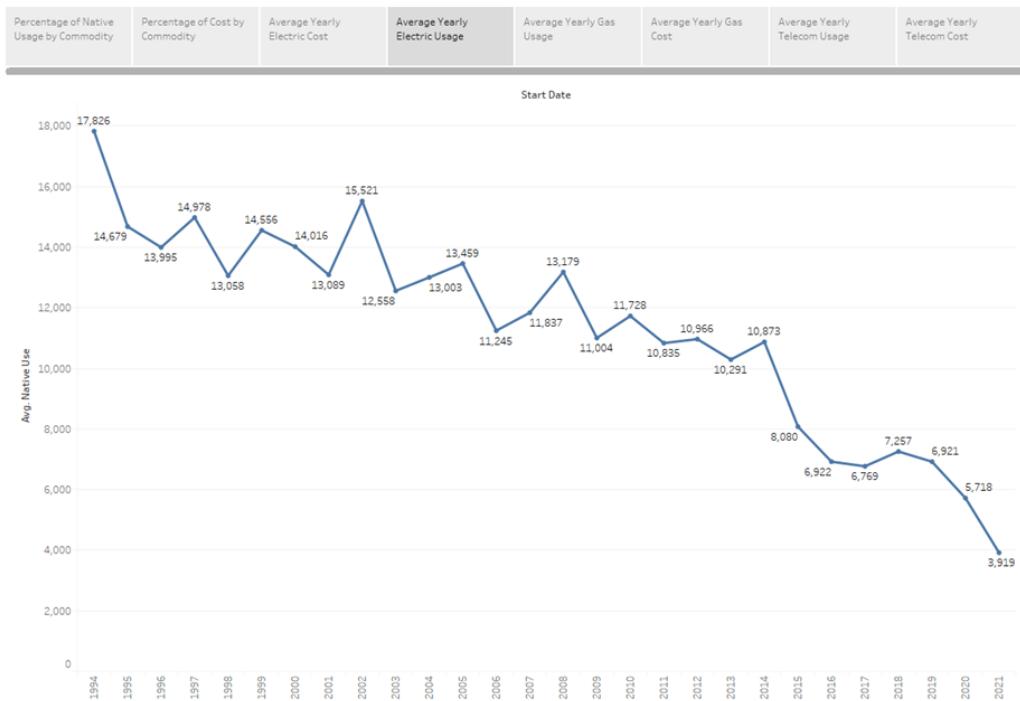
Laurel



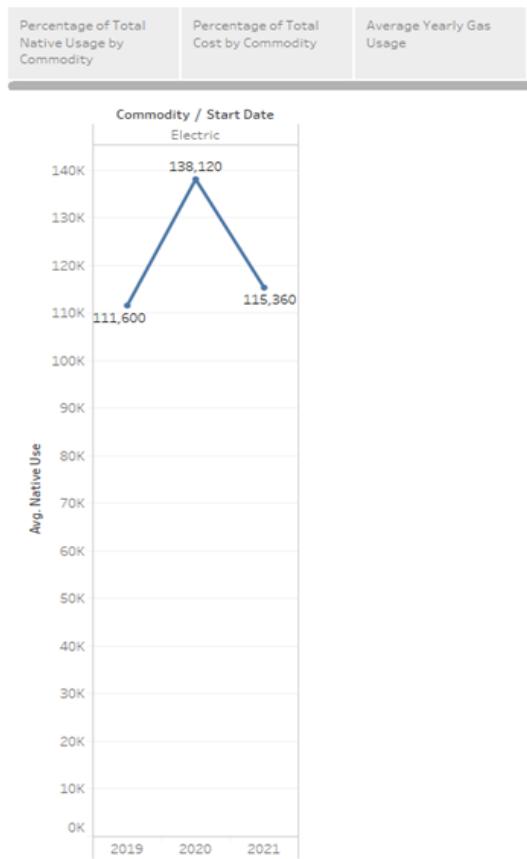
Palmer Park



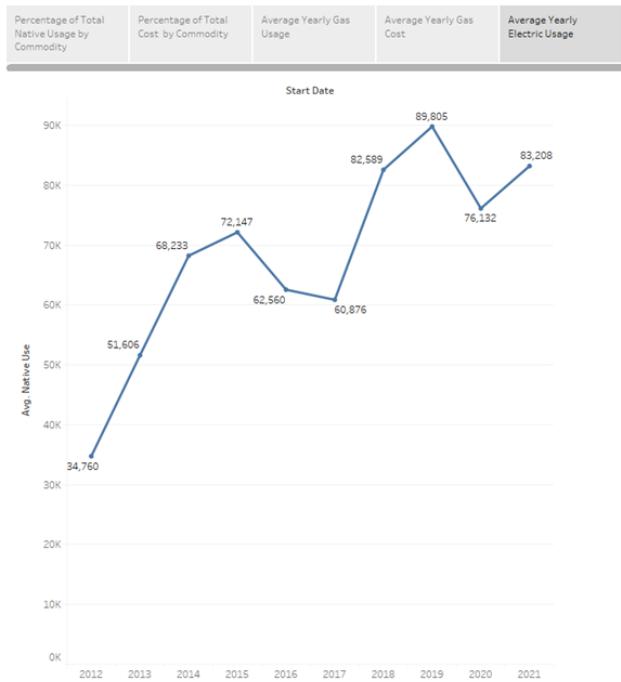
Publick Playhouse



Southern Area Aquatics

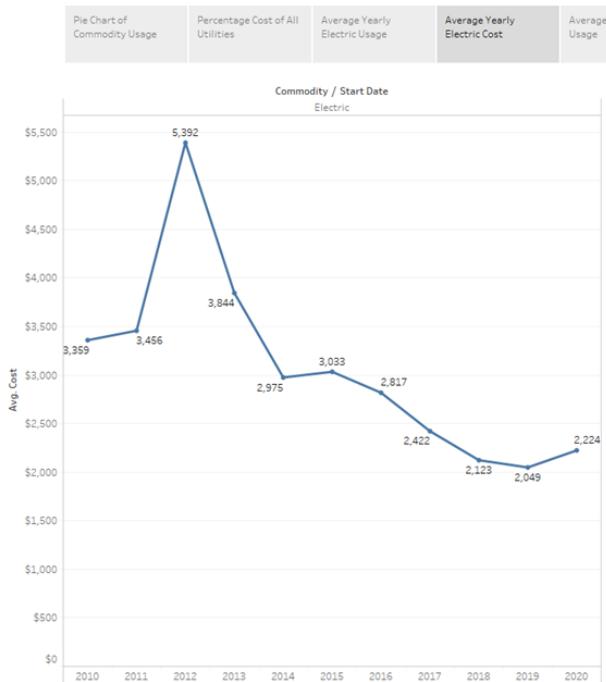


Southern Tech and Rec

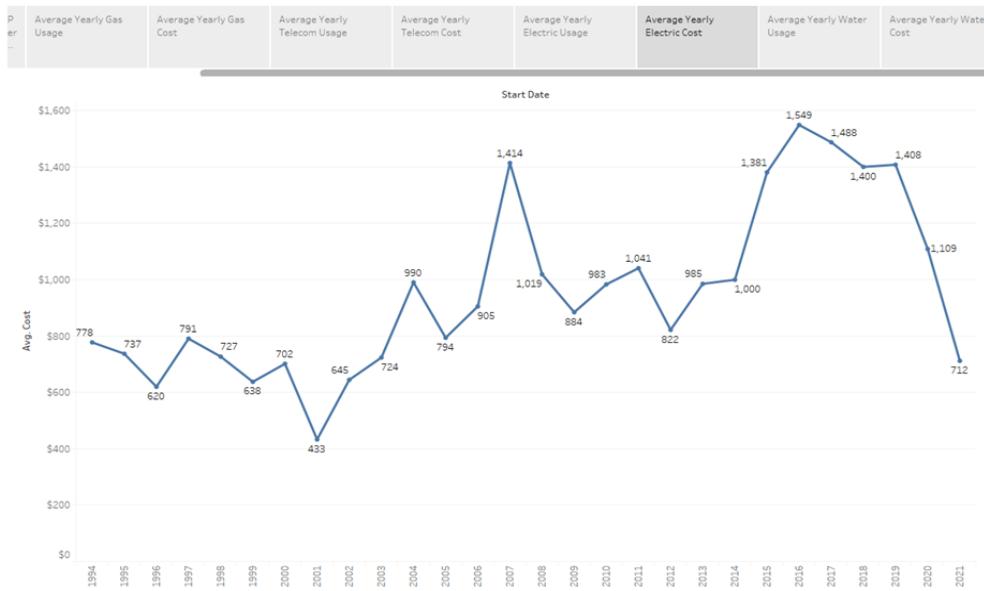


D. Average yearly energy cost across five facilities

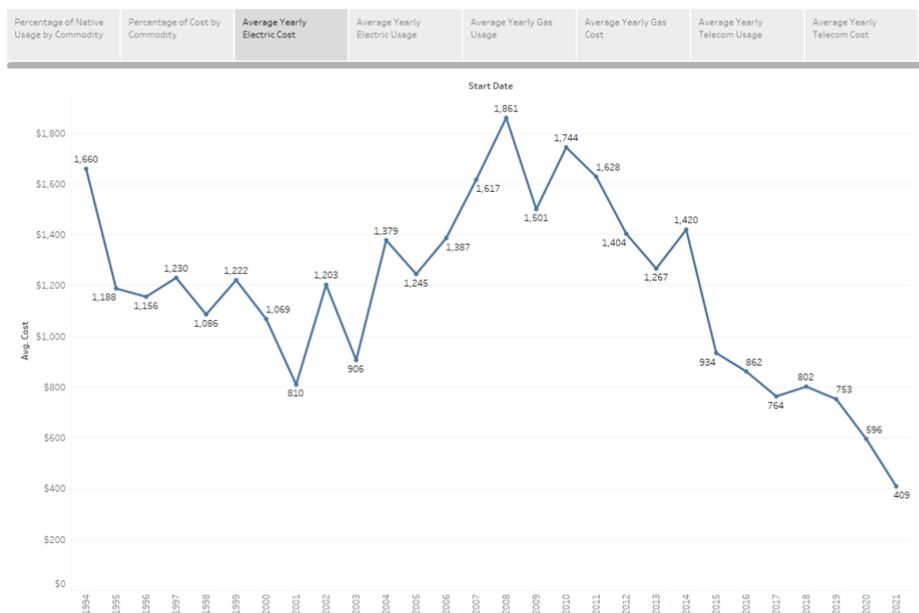
Laurel



Palmer Park



Publick Playhouse



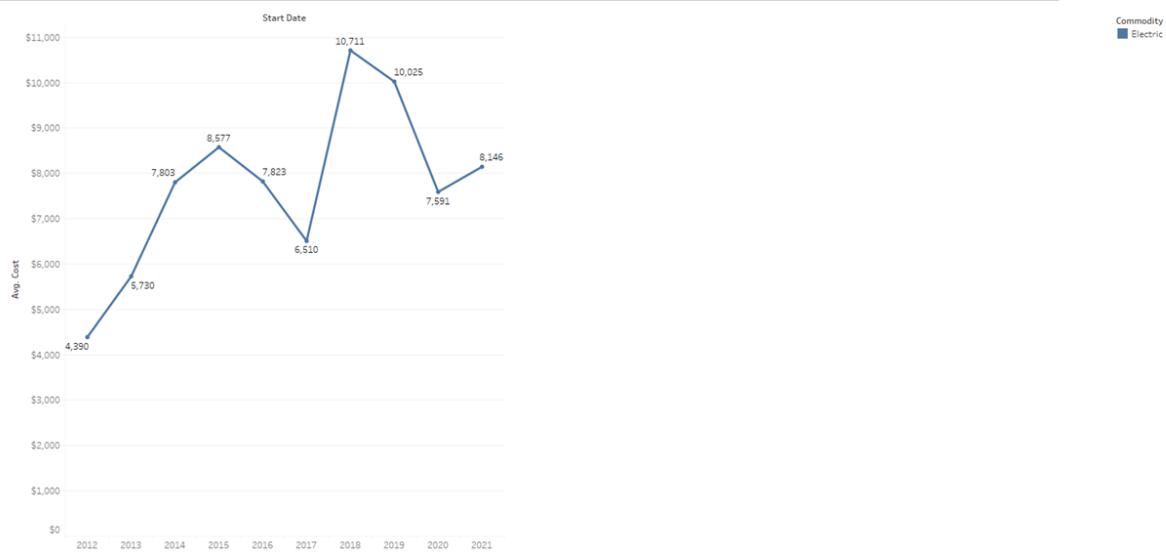
Southern Area Aquatics

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Year Usage
---	---------------------------------------	--------------------



Southern Tech and Rec

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Yearly Gas Usage	Average Yearly Gas Cost	Average Yearly Electric Usage	Average Yearly Electric Cost	Average Yearly Telecom Usage	Average Yearly Telecom Cost	Average Yearly Water Usage	Average Yearly Water Cost	Total Yearly Usage for All Utilities	To
---	---------------------------------------	--------------------------	-------------------------	-------------------------------	------------------------------	------------------------------	-----------------------------	----------------------------	---------------------------	--------------------------------------	----



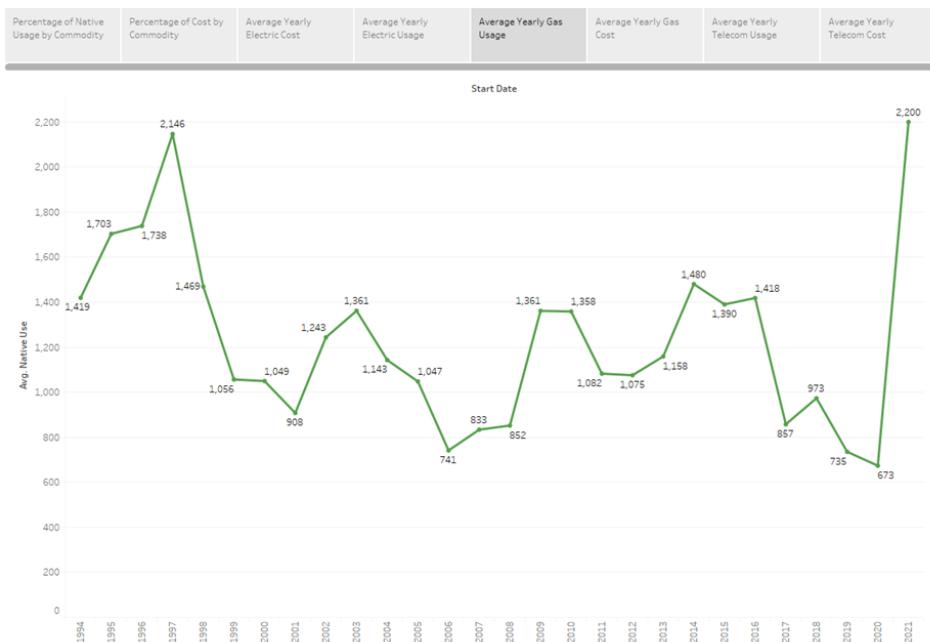
E. Average yearly gas usage across five facilities

Laurel Dataset has no gas usage.

Palmer Park

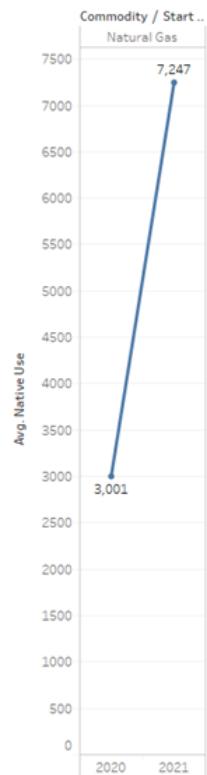


Publick Playhouse



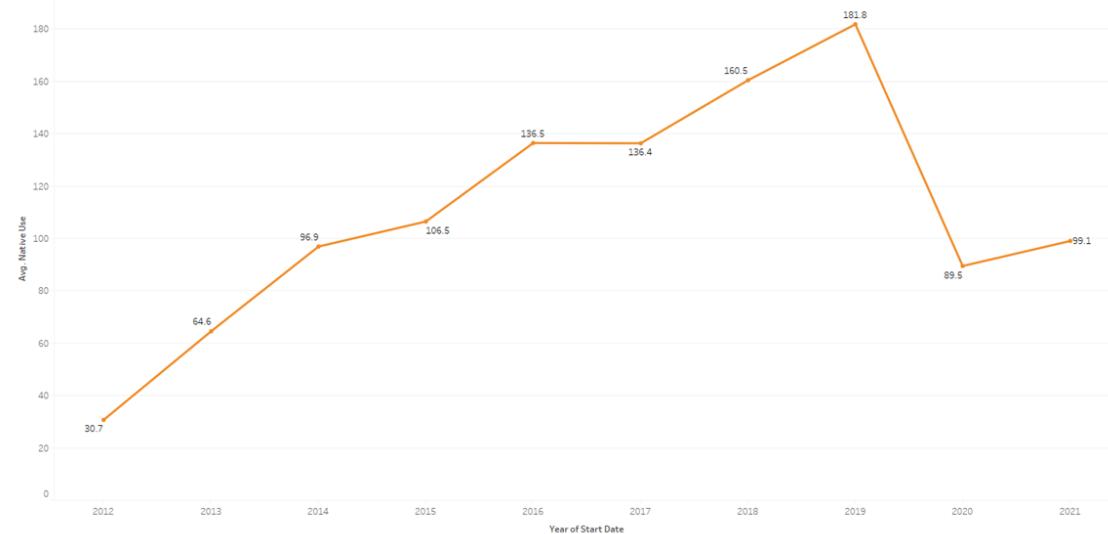
Southern Area Aquatics

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity
---	---------------------------------------



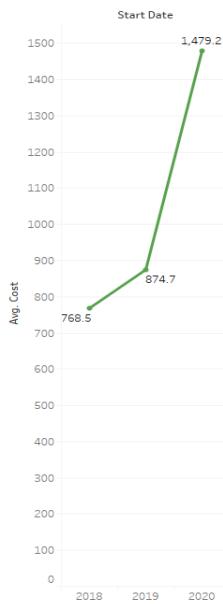
Southern Tech and Rec

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Yearly Gas Usage	Average Yearly Gas Cost	Average Yearly Electric Usage	Average Yearly Electric Cost	Average Yearly Telecom Usage	Average Yearly Telecom Cost	Average Yearly Water Usage	Average Yearly Water Cost
---	---------------------------------------	--------------------------	-------------------------	-------------------------------	------------------------------	------------------------------	-----------------------------	----------------------------	---------------------------



F. Average yearly gas cost across all facilities

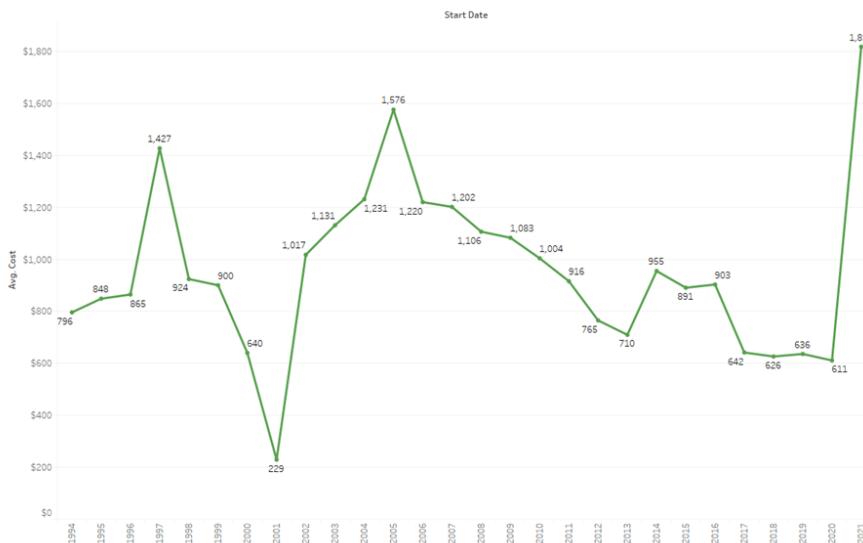
Laurel



Palmer Park



Publick Playhouse



Southern Area Aquatics

Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity
---	---------------------------------------

**Southern Tech and Rec**

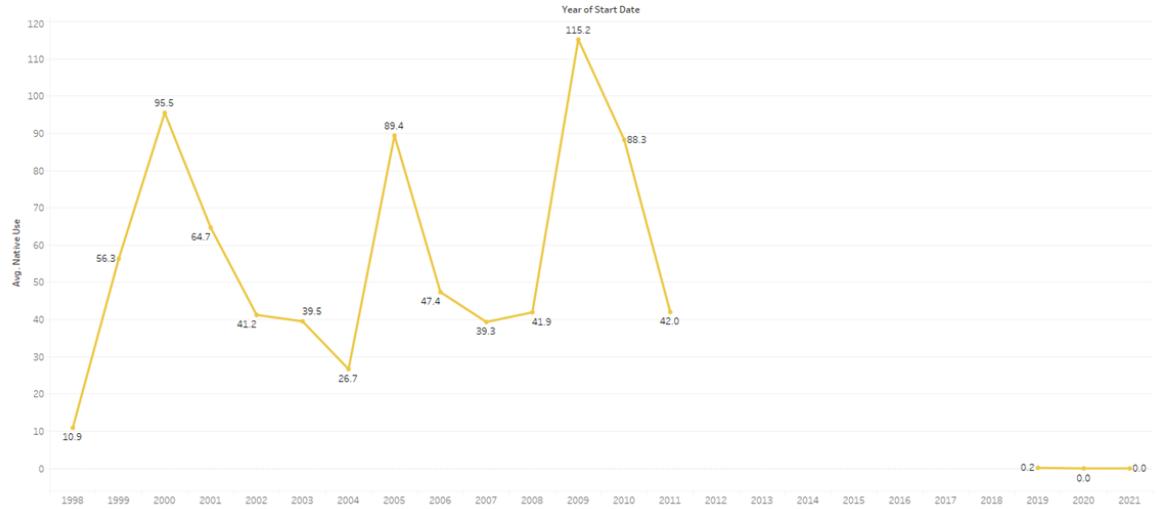
Percentage of Total Native Usage by Commodity	Percentage of Total Cost by Commodity	Average Yearly Gas Usage	Average Yearly Gas Cost	Average Yearly Electric Usage
---	---------------------------------------	--------------------------	-------------------------	-------------------------------

**G. Average yearly telecom usage**

Laurel has no telecom usage data

Palmer Park

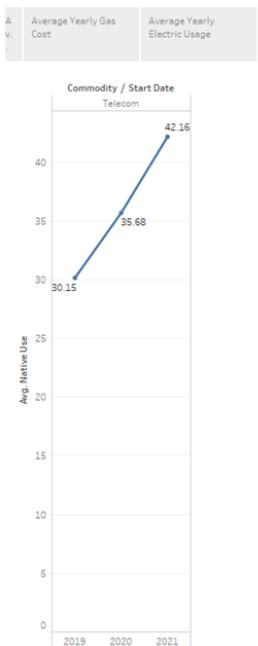
Percentage Cost of All Utilities	Percentage of Total Native Usage by Commodity	Average Yearly Gas Usage	Average Yearly Gas Cost	Average Yearly Telecom Usage	Average Yearly Telecom Cost	Average Yearly Electric Usage	Average Yearly Electric Cost	Average Yearly Water Usage	Average Yearly Water Cost
----------------------------------	---	--------------------------	-------------------------	------------------------------	-----------------------------	-------------------------------	------------------------------	----------------------------	---------------------------



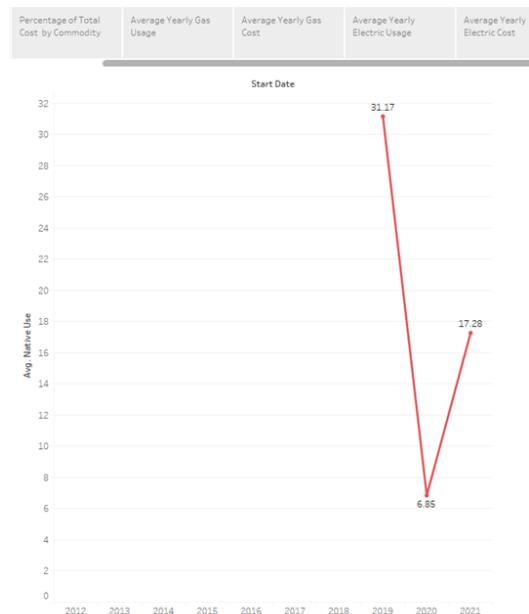
Publick Playhouse



Southern Area Aquatics

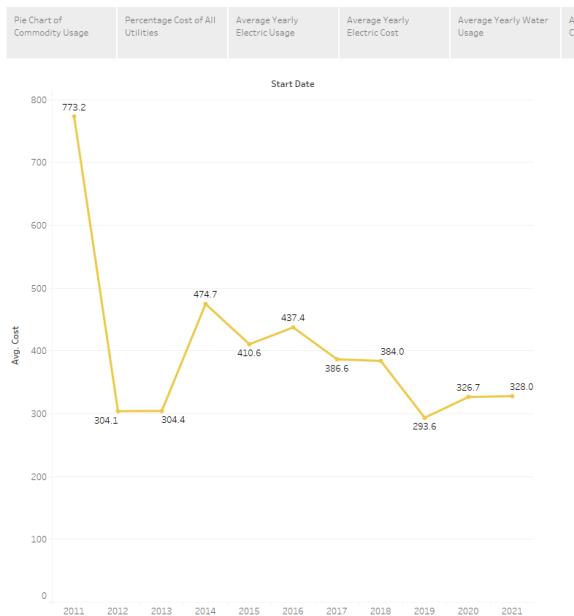


Southern Tech and Rec



H. Average yearly telecom cost across facilities

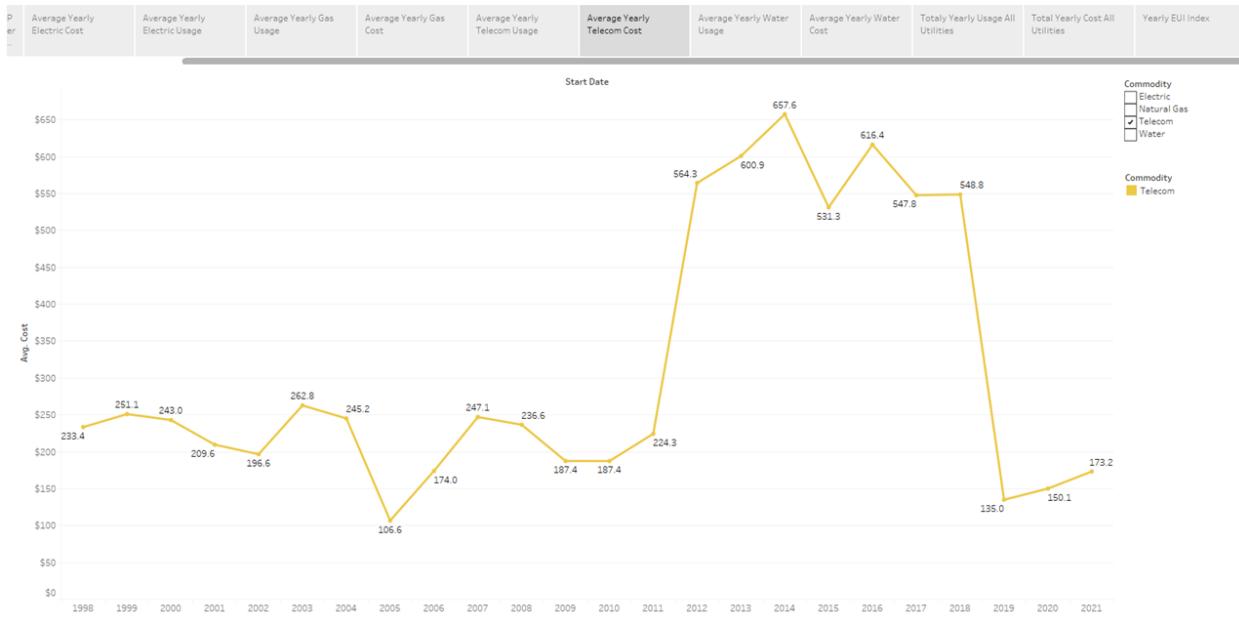
Laurel



Palmer Park

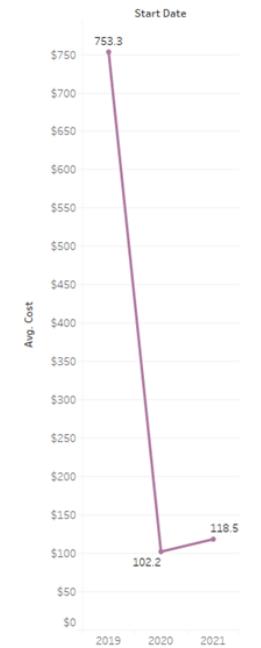


Publick Playhouse



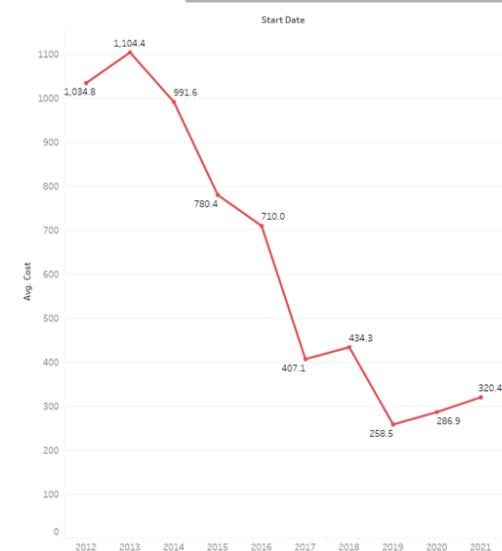
Southern Area Aquatics

A ...	Average Yearly Gas Cost	Average Yearly Electric Usage
-------	-------------------------	-------------------------------



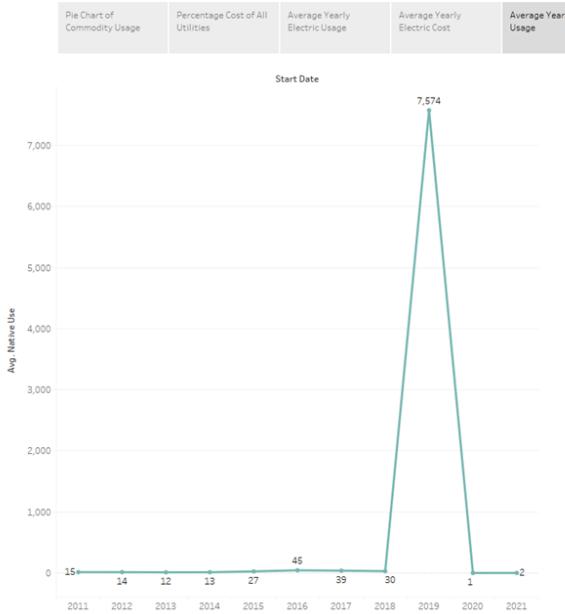
Southern Tech and Rec

P ...	Average Yearly Gas Usage	Average Yearly Gas Cost	Average Yearly Electric Usage	Average Yearly Electric Cost	Average Yearly Telecom Usage
-------	--------------------------	-------------------------	-------------------------------	------------------------------	------------------------------

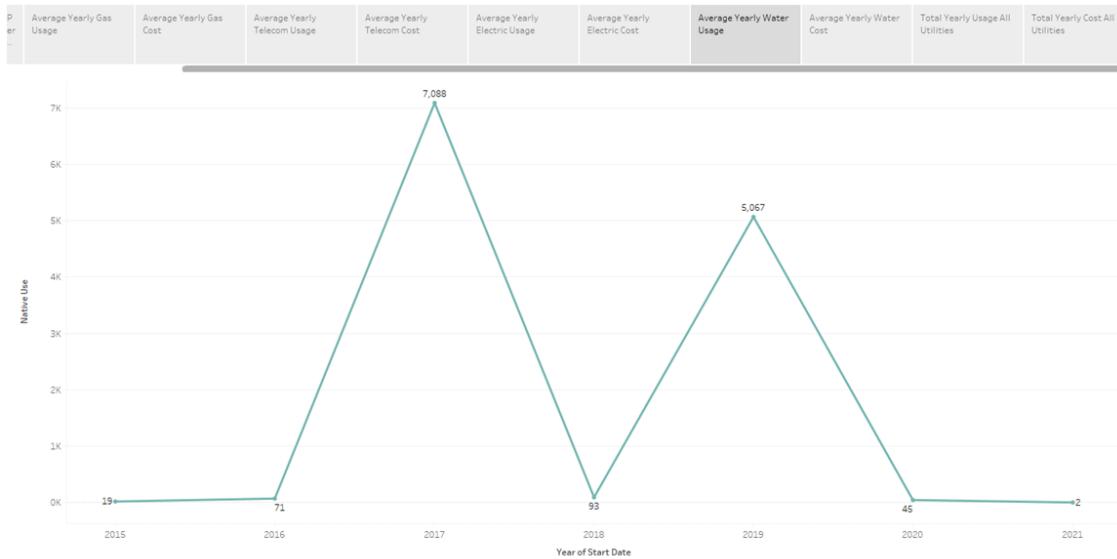


I. Average yearly water usage across facilities

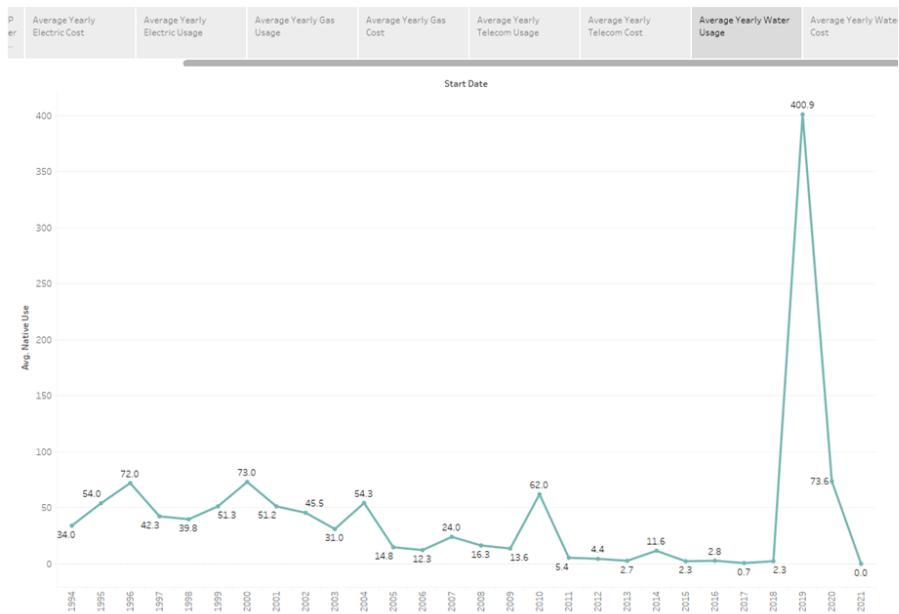
Laurel



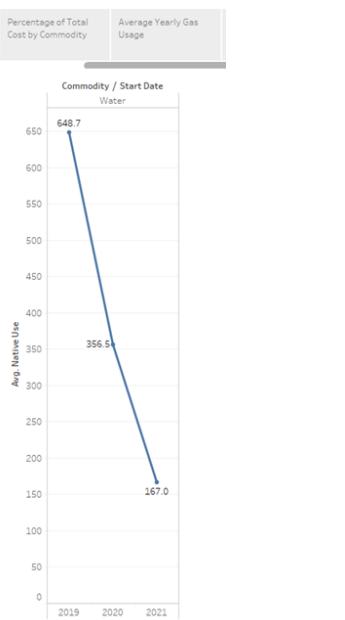
Palmer Park



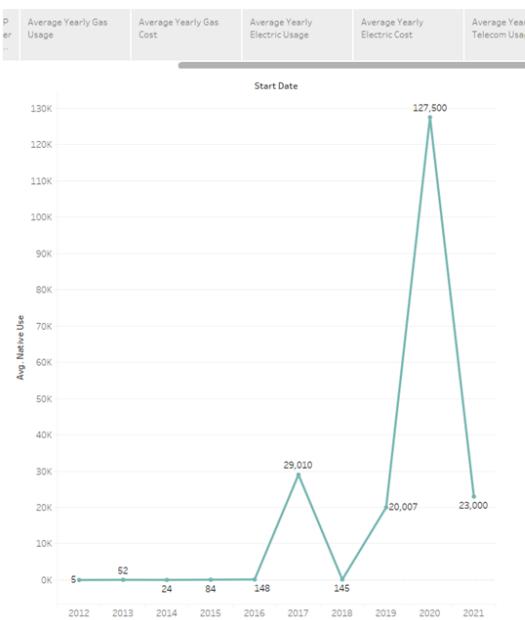
Publick Playhouse



Southern Area Aquatics

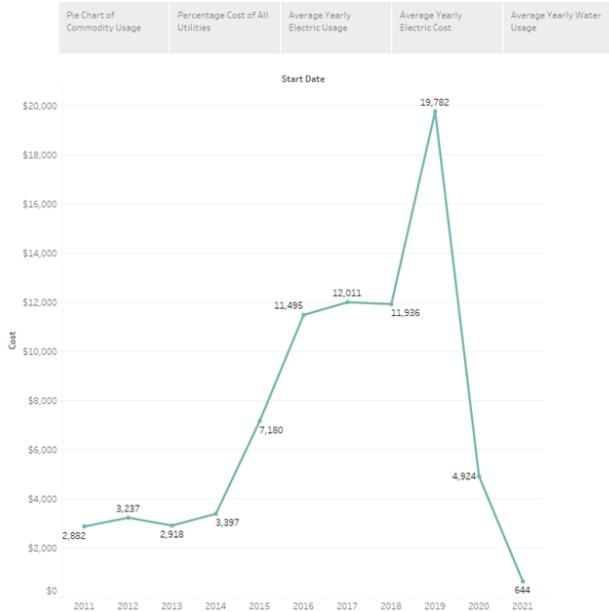


Southern Tech and Rec



J. Average yearly water cost across facilities

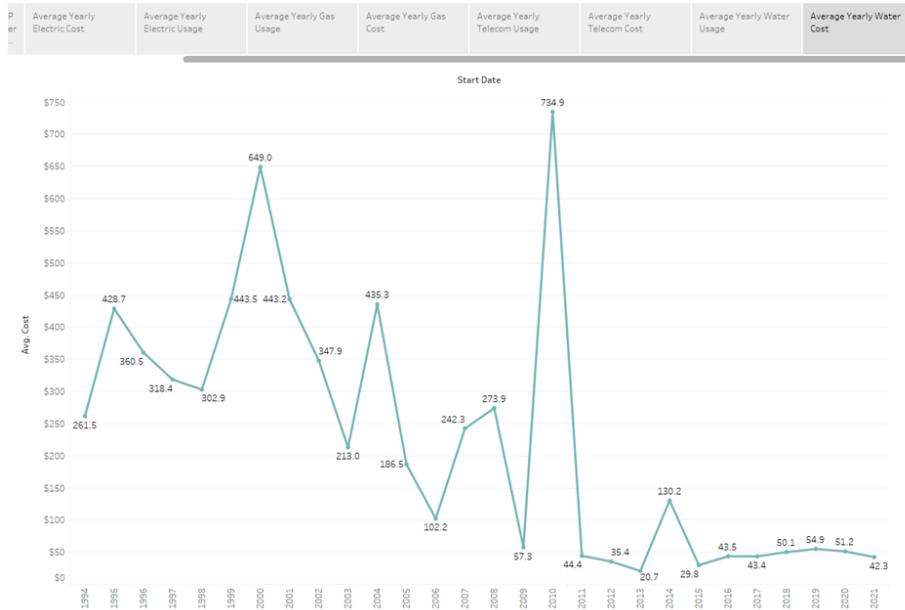
Laurel



Palmer Park



Publick Playhouse

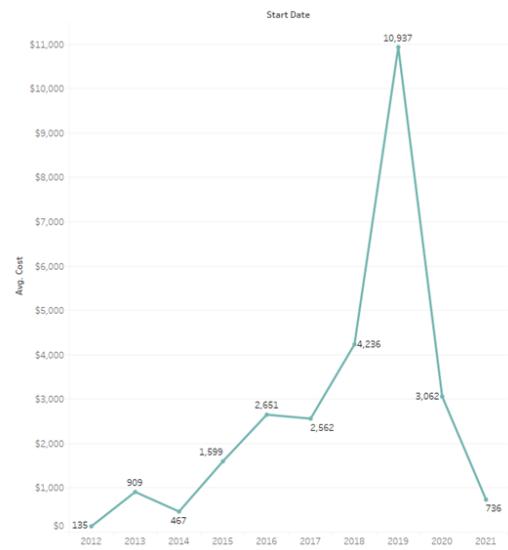
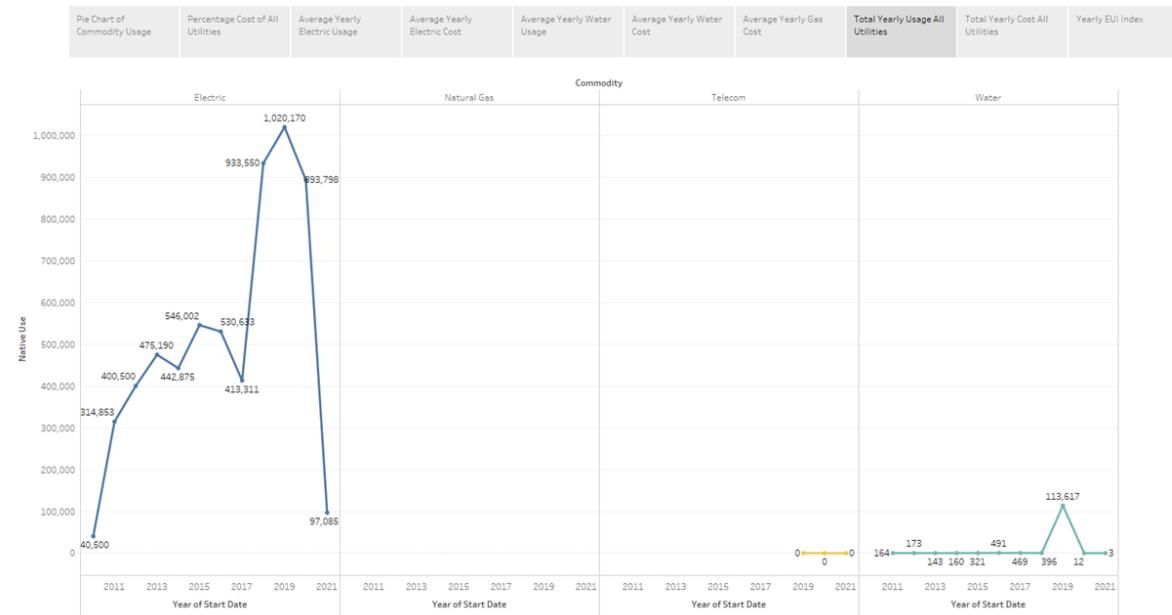


Southern Area Aquatics

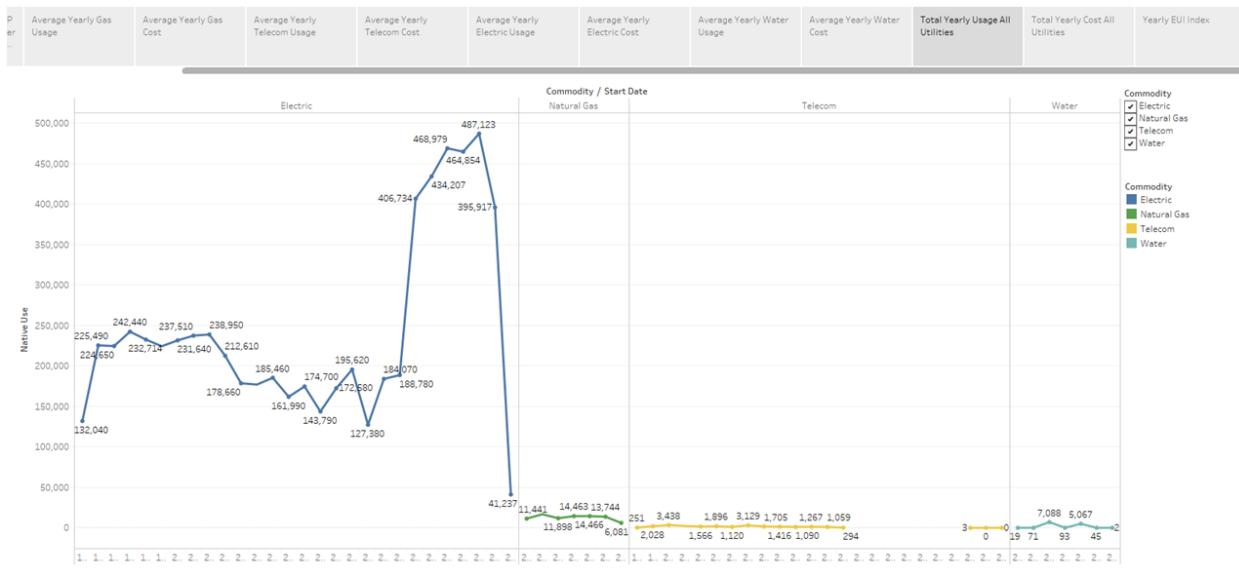
Average Yearly Gas Usage	Average Yearly Gas Cost	Average Yearly Electric Usage
--------------------------	-------------------------	-------------------------------

**Southern Tech and Rec**

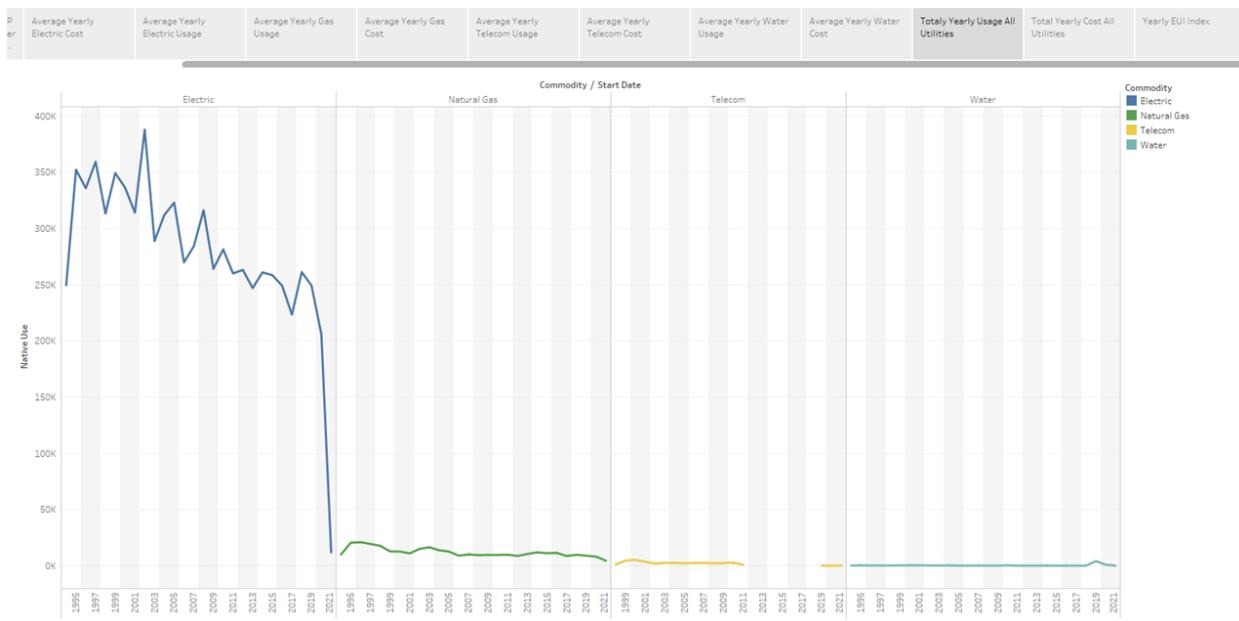
Per ...	Average Yearly Gas Usage	Average Yearly Gas Cost	Average Yearly Electric Usage	Average Yearly Electric Cost	Average Yearly Telecom Usage
---------	--------------------------	-------------------------	-------------------------------	------------------------------	------------------------------

**K. Total Yearly Usage by Commodity for all facilities****Laurel**

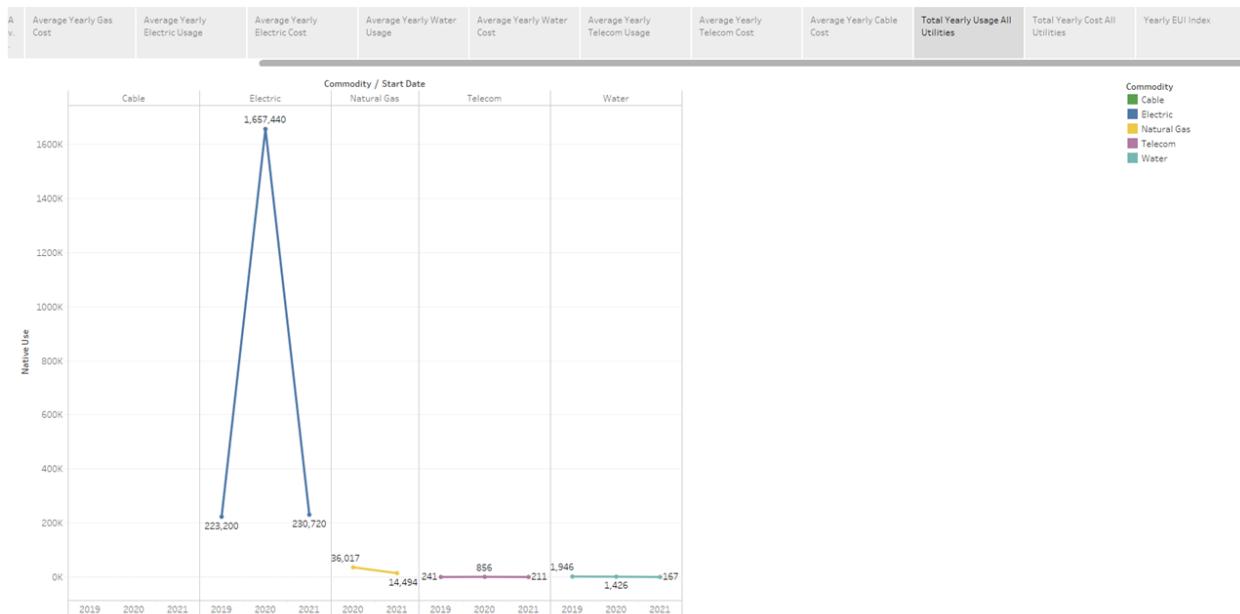
Palmer Park



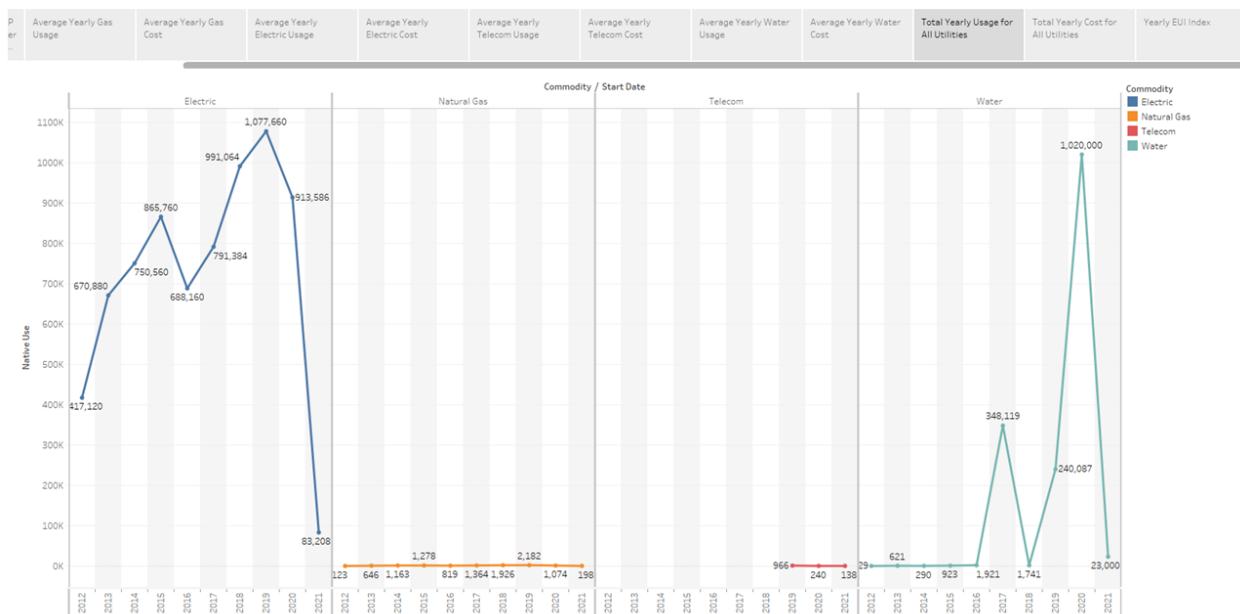
Publick Playhouse



Southern Area Aquatics

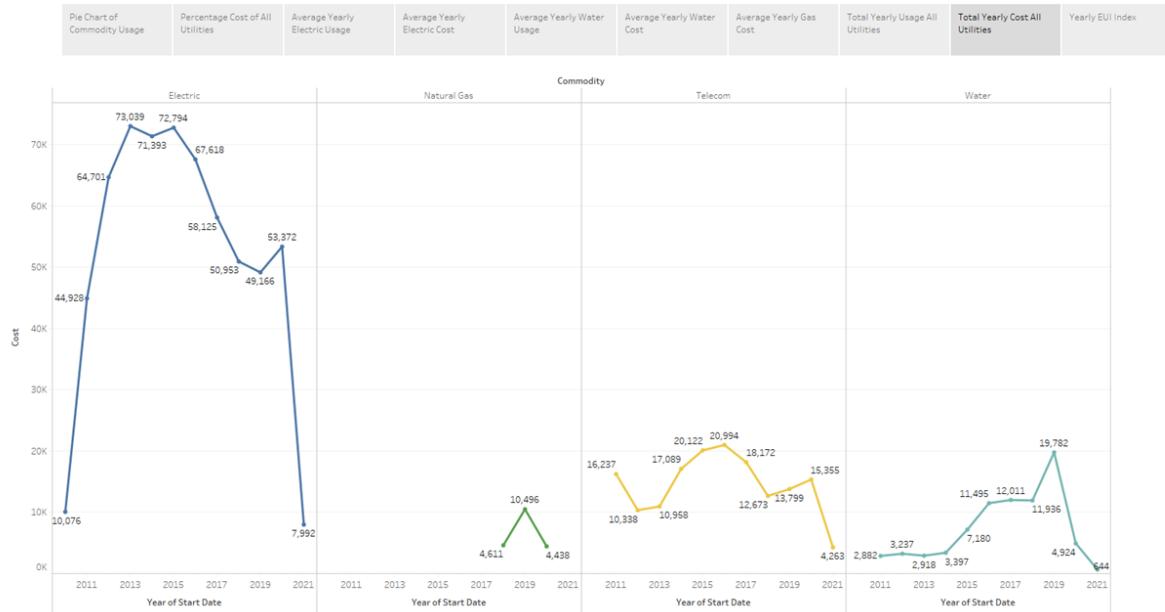


Southern Tech and Rec

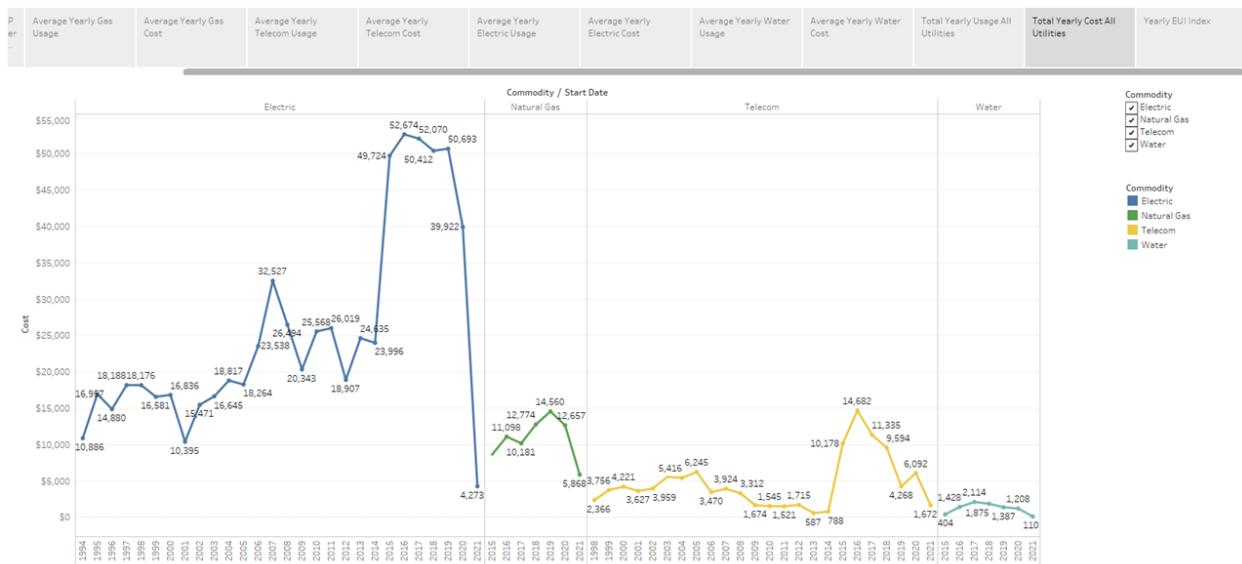


L. Total Yearly Cost for All Utilities

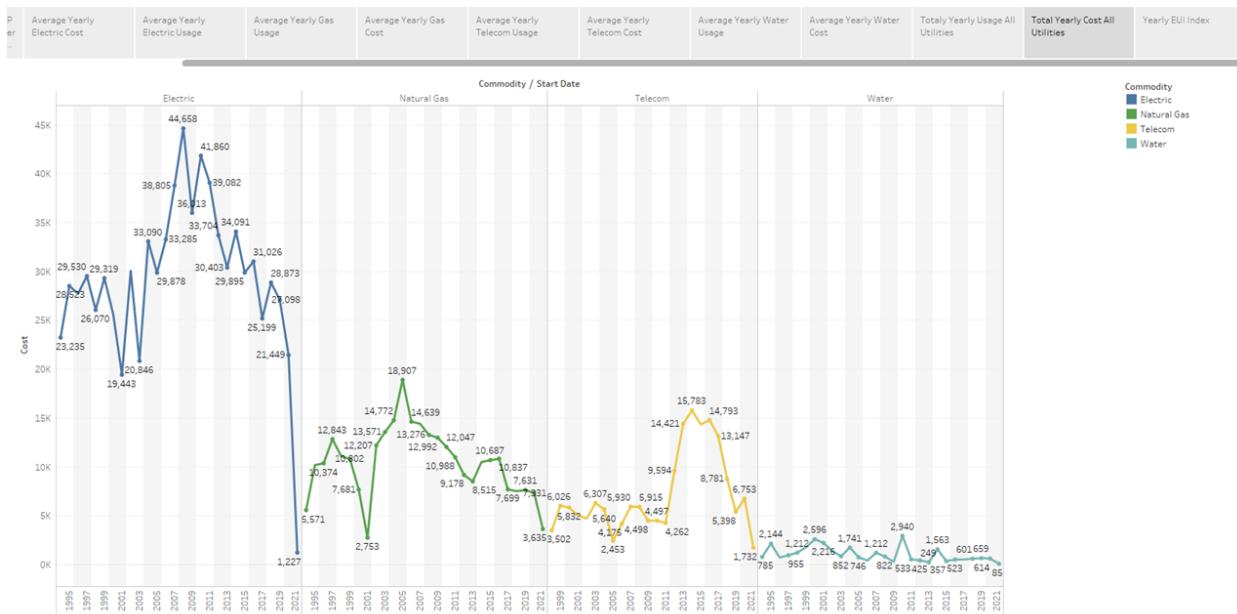
Laurel



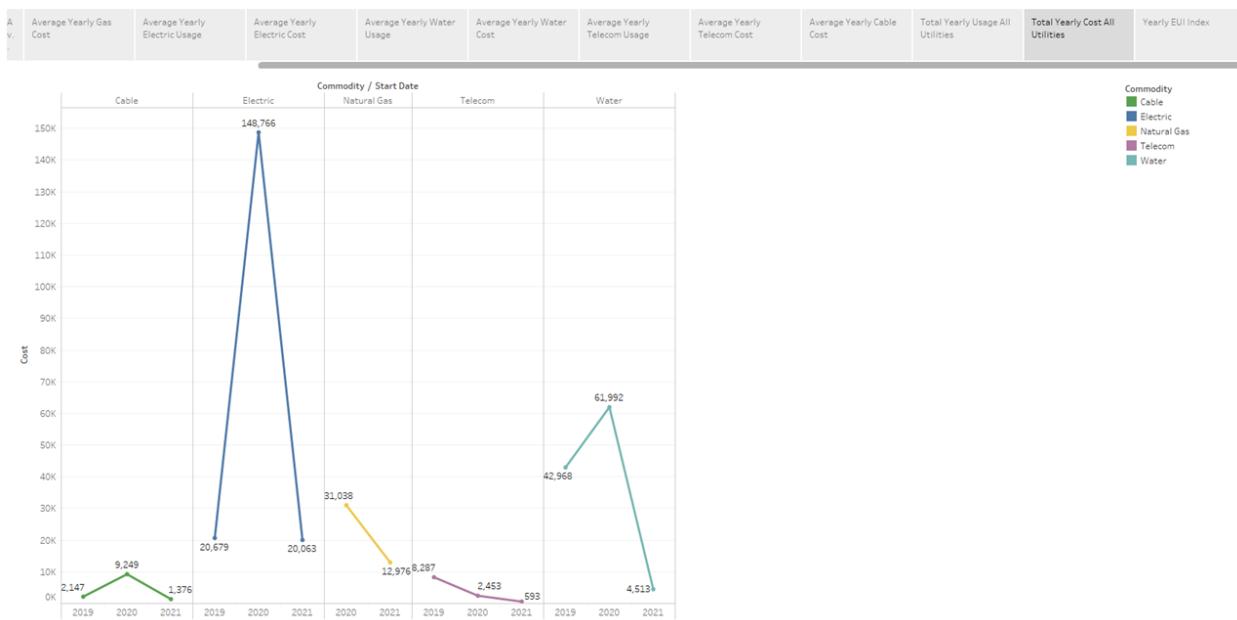
Palmer Park



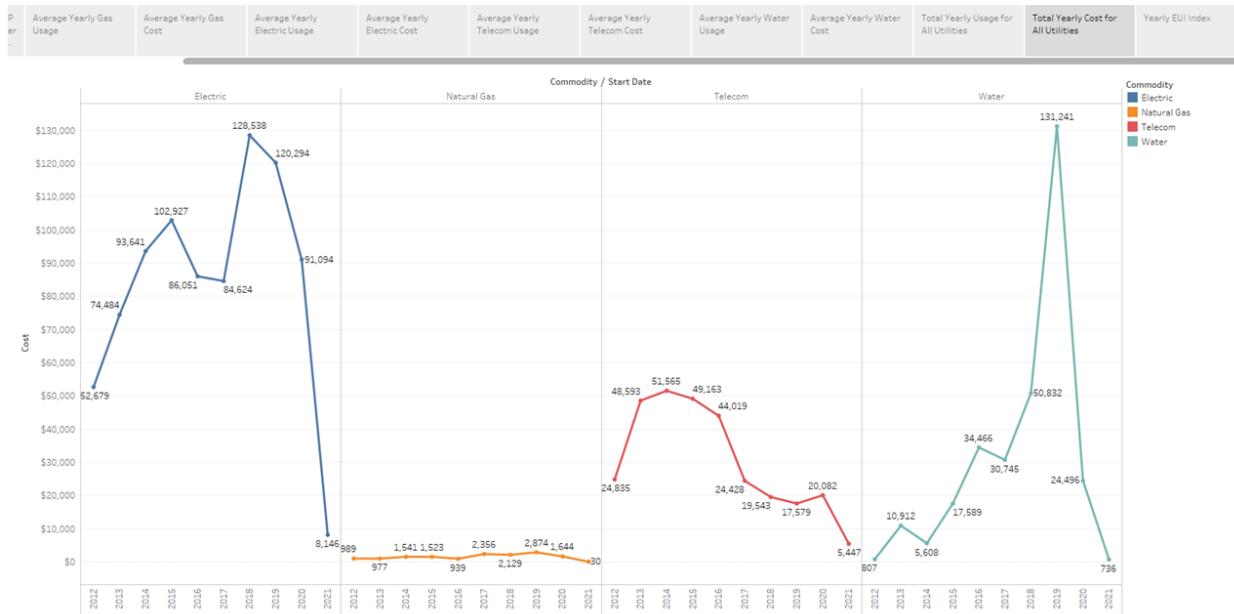
Publick Playhouse



Southern Area Aquatics

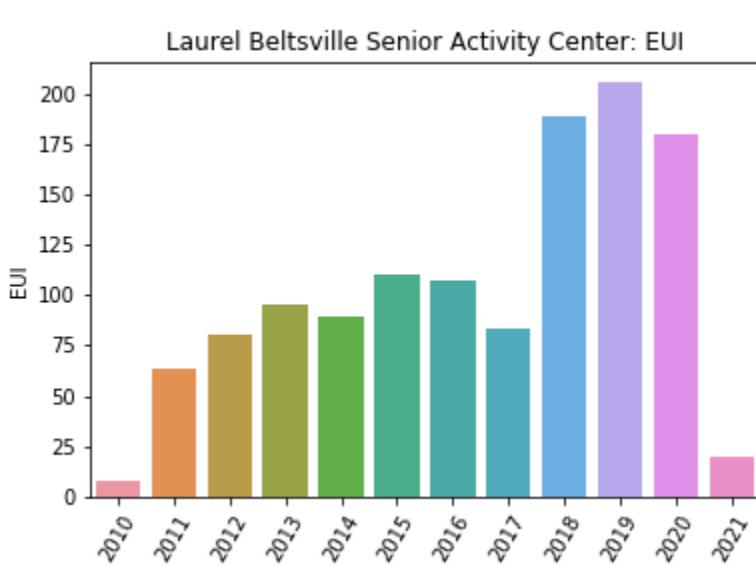


Southern Tech and Rec



To further our analysis, we measured the Energy Use Index by aggregating electric usage and natural gas for each facility, converting it to kBtu and dividing it by the gross building area. Essentially what this tells us is how energy performance is per each square footage of a building. From Energy Star the Energy Use Index per year for a recreational facility should be 112. Below are the EUI graphs, written in Python, per each facility across the years:

1. Laurel-Beltsville (EUI)



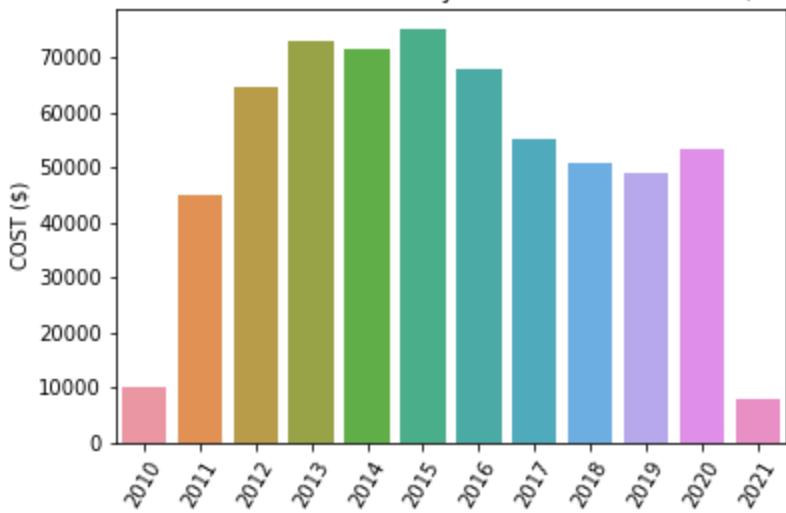
Laurel Beltsville Senior Activity Center

MISSING DATA in ELECTRIC:
 From To Days
 0 2011-01-17 2011-01-20 3 days
 1 2011-12-16 2012-01-19 34 days

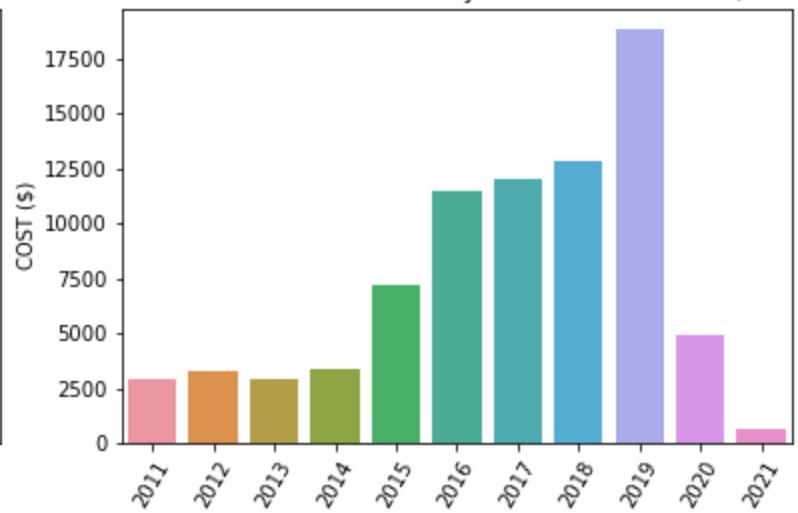
Start Date	EUI
2010	8.164609
2011	63.472877
2012	80.738907
2013	95.796058
2014	89.281507
2015	110.071422
2016	106.973105
2017	83.321544
2018	188.199267
2019	205.661450
2020	180.185452
2021	19.571877

a. Laurel-Beltsville (Yearly Utility Cost)

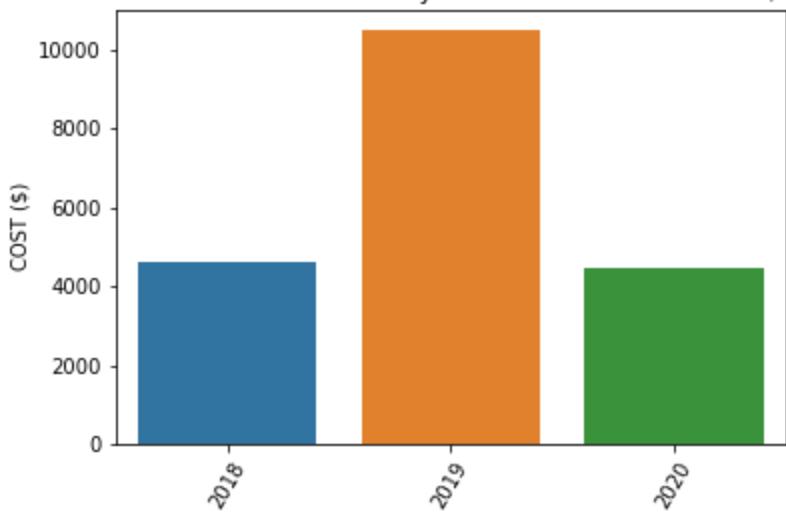
Laurel Beltsville Senior Activity Center: ELECTRIC COST/YEAR



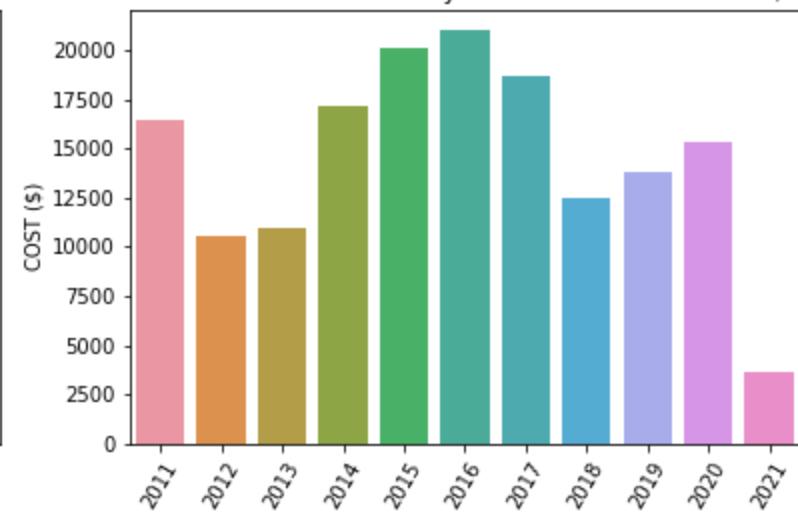
Laurel Beltsville Senior Activity Center: WATER COST/YEAR



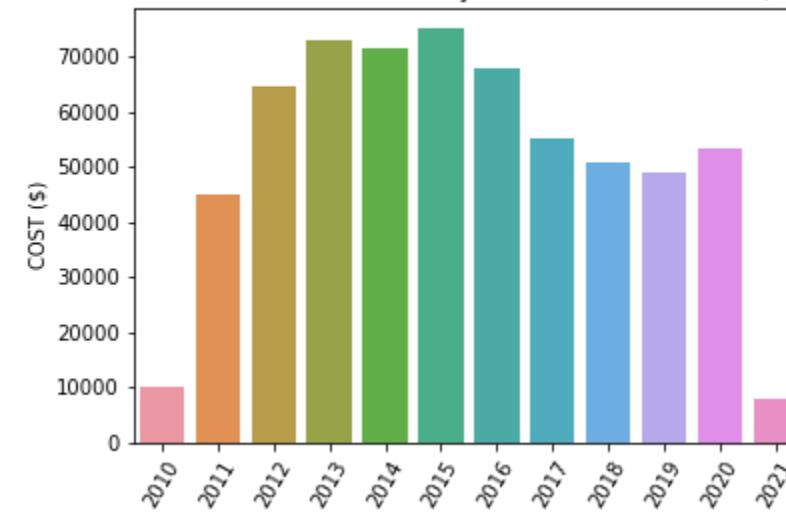
Laurel Beltsville Senior Activity Center: NATURALGAS COST/YEAR



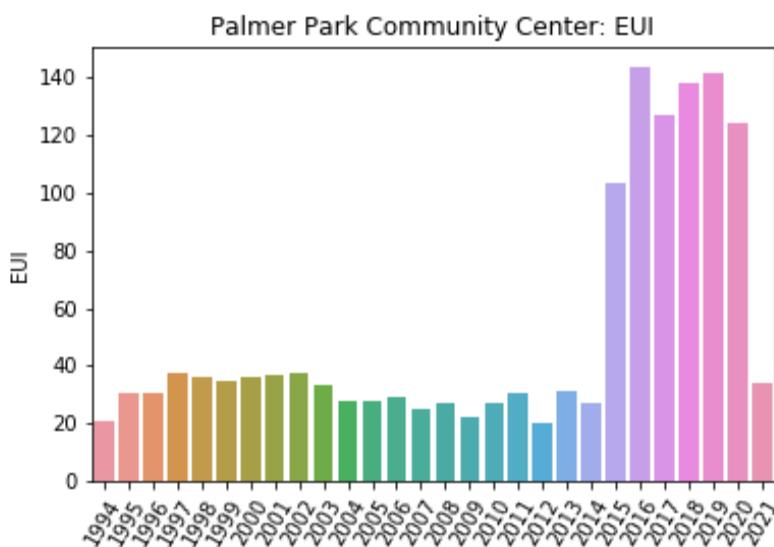
Laurel Beltsville Senior Activity Center: TELEPHONE COST/YEAR



Laurel Beltsville Senior Activity Center: ELECTRIC COST/YEAR



2. Palmer Park (EUI)



Palmer Park Community Center (EUI)

MISSING DATA in ELECTRIC:

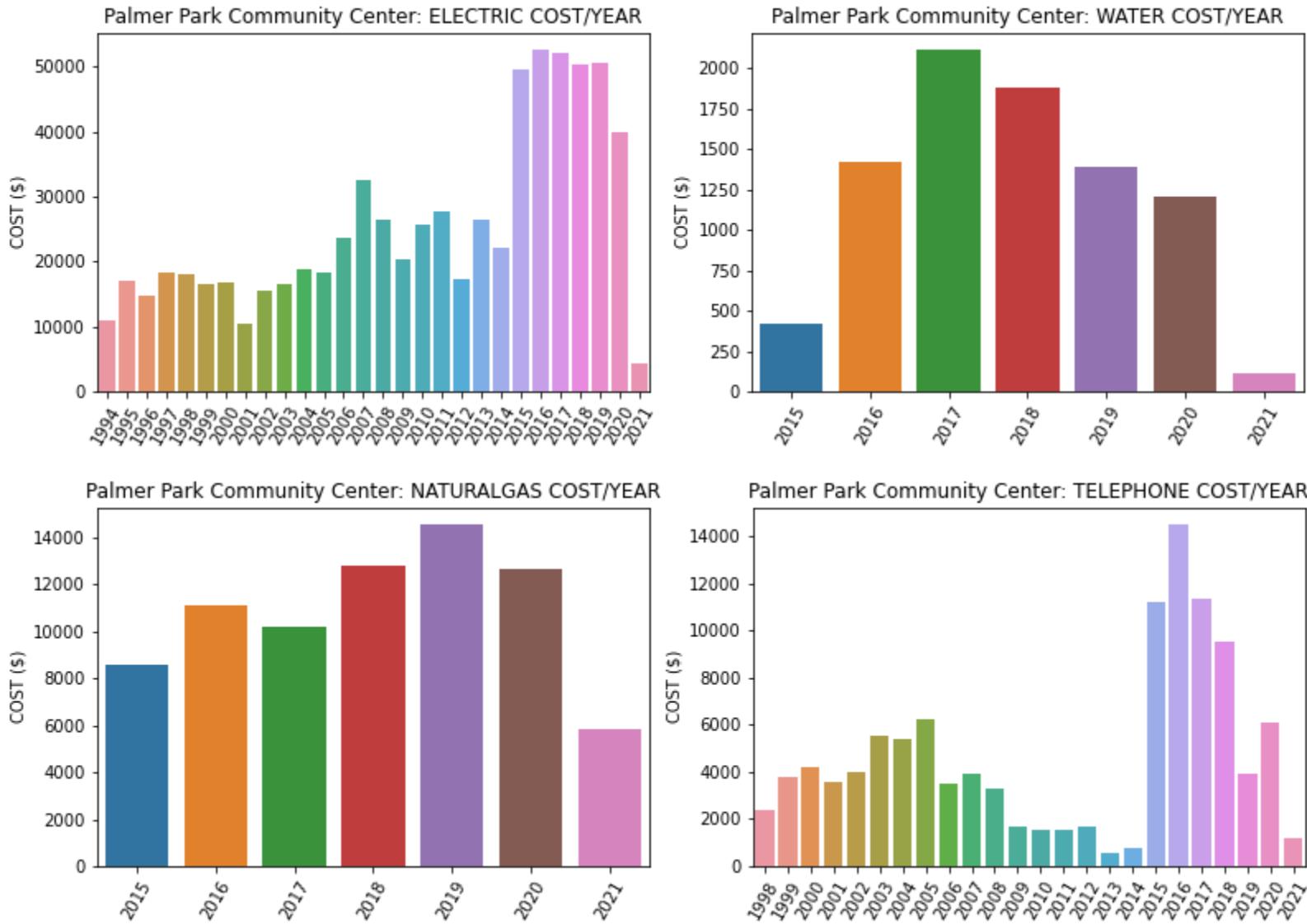
From	To	Days
0 1995-10-31	1996-01-31	92 days

MISSING DATA in NATURALGAS:

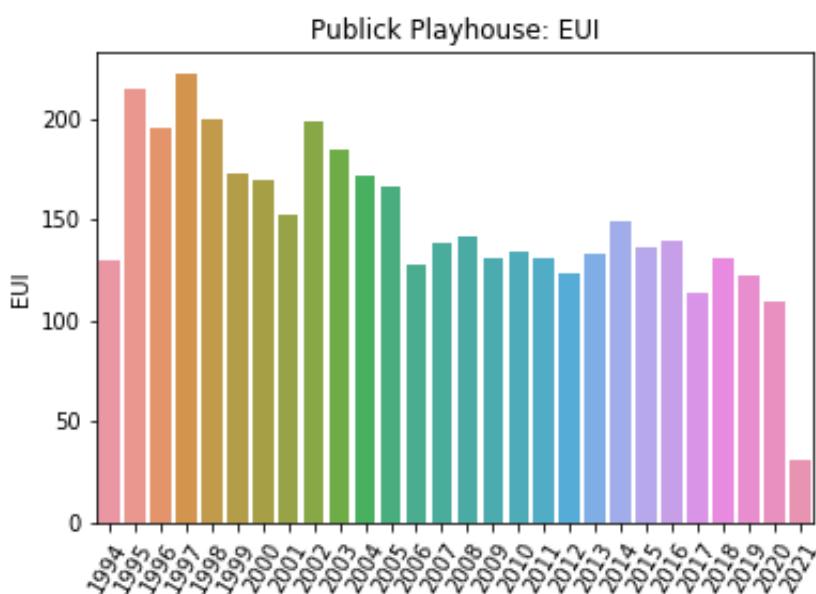
From	To	Days
0 2015-03-10	2015-07-08	120 days
1 2015-12-08	2016-01-08	31 days
2 2016-07-07	2016-09-06	61 days
3 2017-05-09	2017-11-09	184 days
4 2018-08-10	2018-10-12	63 days
5 2018-12-11	2019-01-10	30 days

	EUI
Start Date	
1994	20.632942
1995	30.687921
1996	30.790650
1997	37.735746
1998	36.221895
1999	34.926266
2000	36.054727
2001	36.054727

a. Palmer Park (Yearly Utility Cost)



3. Publick Playhouse (EUI)



Publick Playhouse (EUI)

MISSING DATA in ELECTRIC:

	From	To	Days
0	1995-11-13	1995-12-12	29 days
1	2017-10-17	2017-11-16	30 days

MISSING DATA in NATURALGAS:

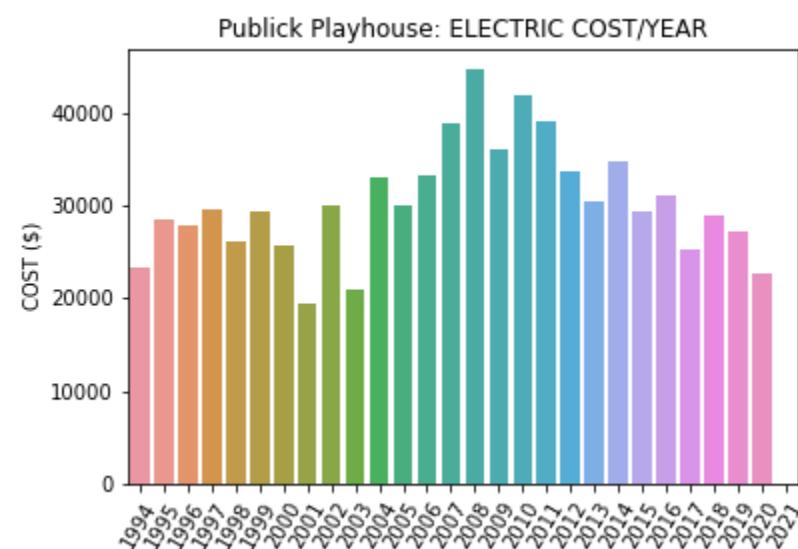
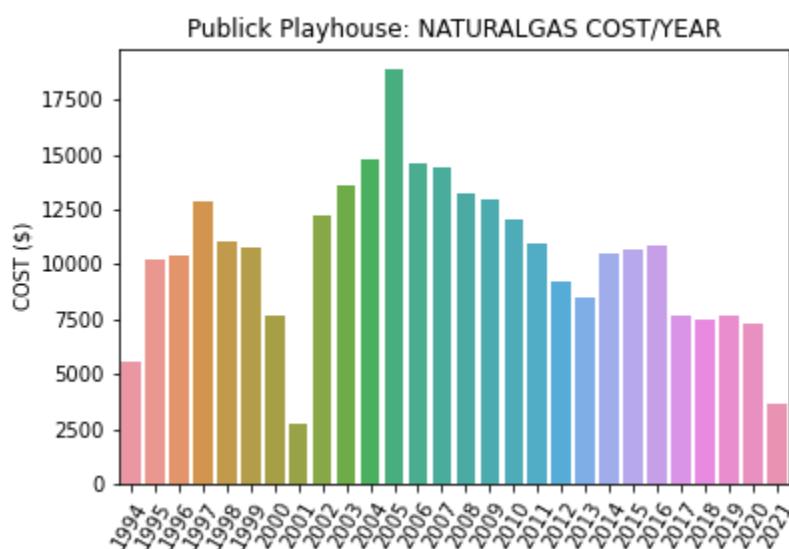
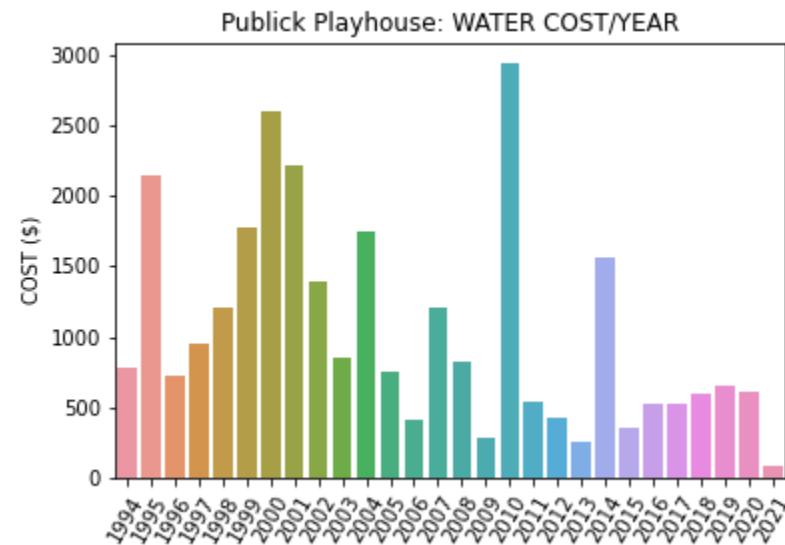
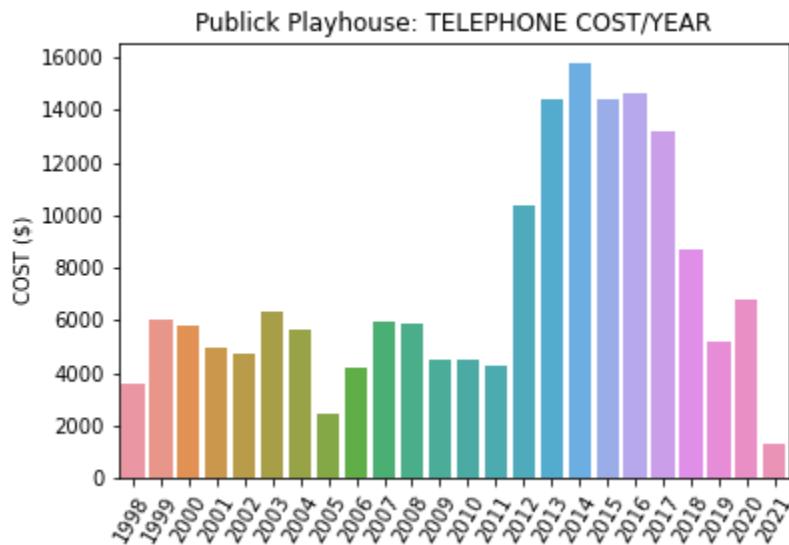
	From	To	Days
0	1995-10-07	1995-11-06	30 days
1	1996-04-10	1996-11-06	210 days
2	1997-09-09	1997-10-08	29 days
3	2014-09-04	2014-10-03	29 days
4	2018-08-09	2018-10-10	62 days

EUI

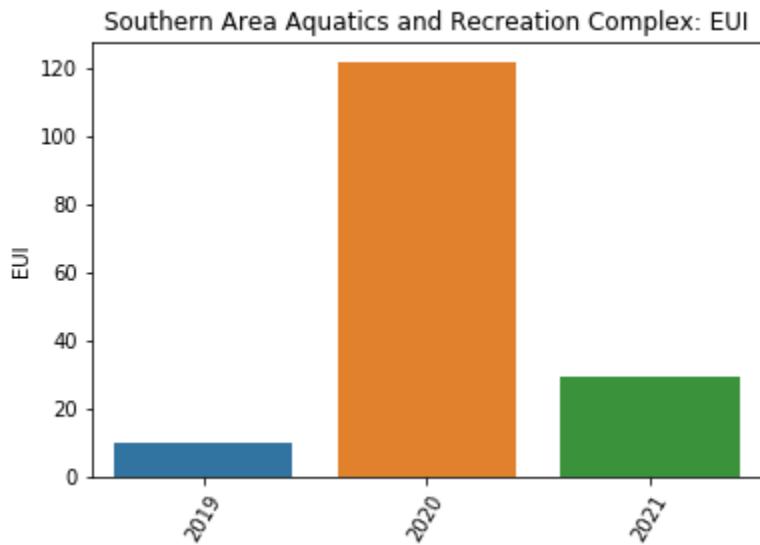
Start Date

1994	129.976136
1995	214.481440
1996	195.088168
1997	222.525308
1998	199.538499

a. Publick Playhouse (Yearly Utility Cost)



4. Southern Area Aquatics (EUI)

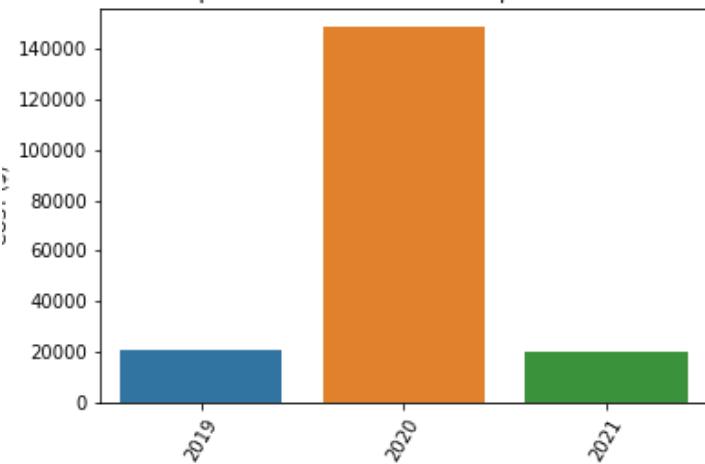


Southern Area Aquatics and Recreation Complex (EUI)

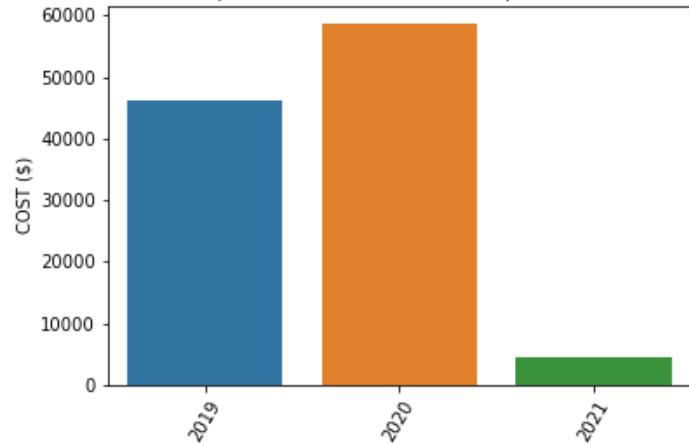
Start Date	EUI
2019	10.022615
2020	121.814785
2021	29.431199

a. Southern Area Aquatics (Yearly Utility Cost)

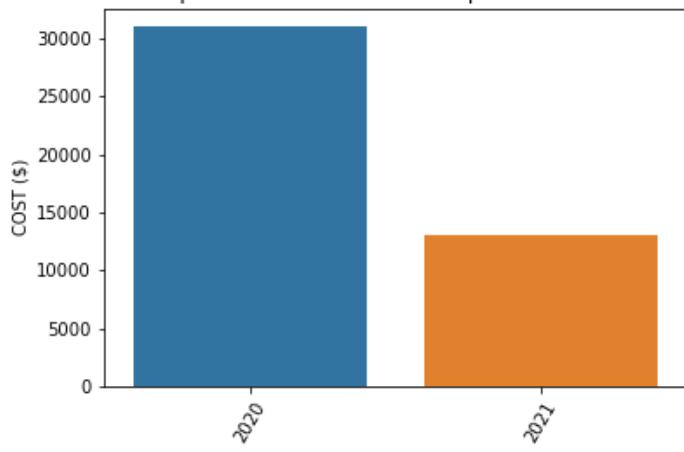
Southern Area Aquatics and Recreation Complex: ELECTRIC COST/YEAR



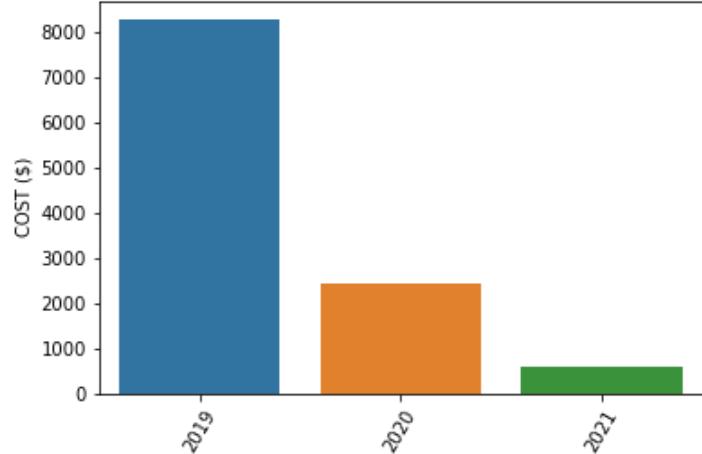
Southern Area Aquatics and Recreation Complex: WATER COST/YEAR



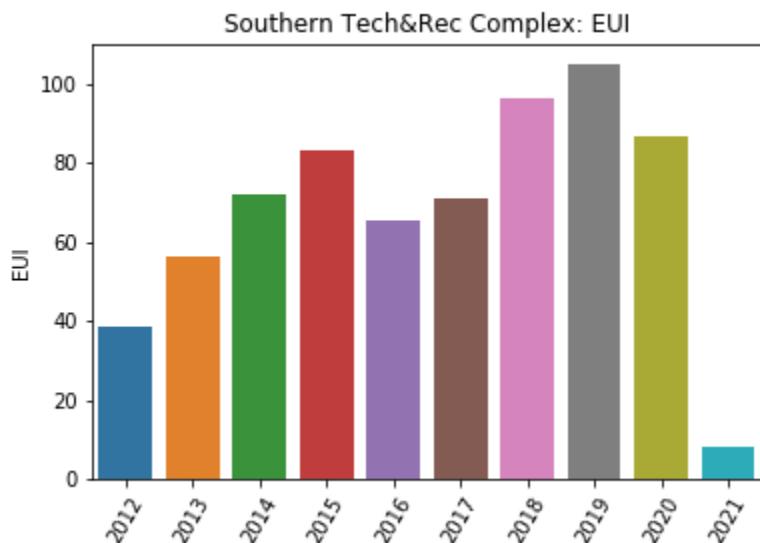
Southern Area Aquatics and Recreation Complex: NATURALGAS COST/YE



Southern Area Aquatics and Recreation Complex: TELEPHONE COST/YE



5. Southern Tech & Rec Center (EUI)



Southern Tech&Rec Complex (EUI)

MISSING DATA in ELECTRIC:

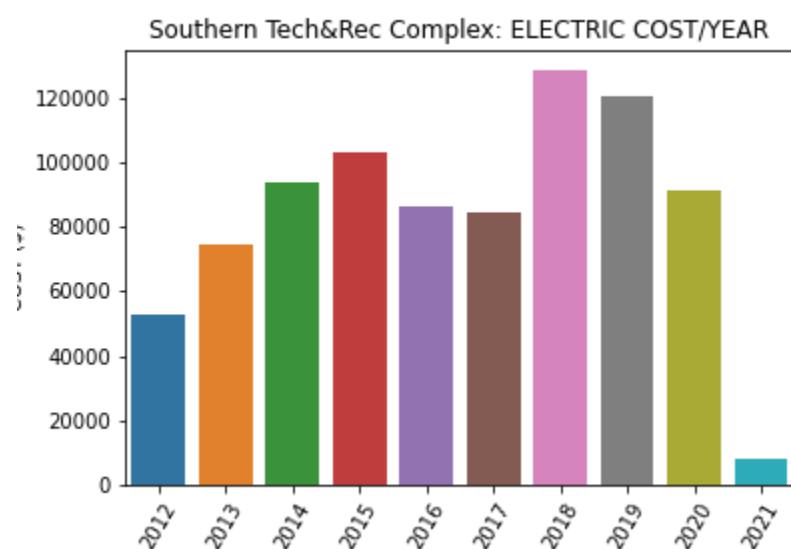
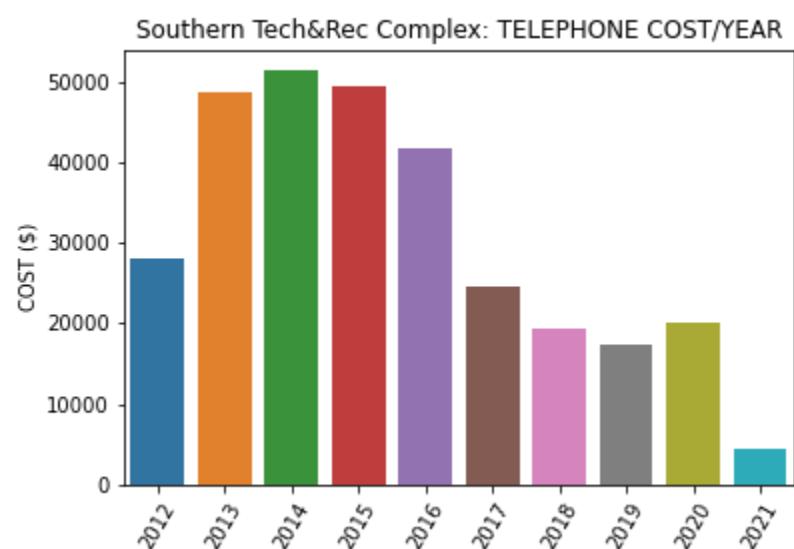
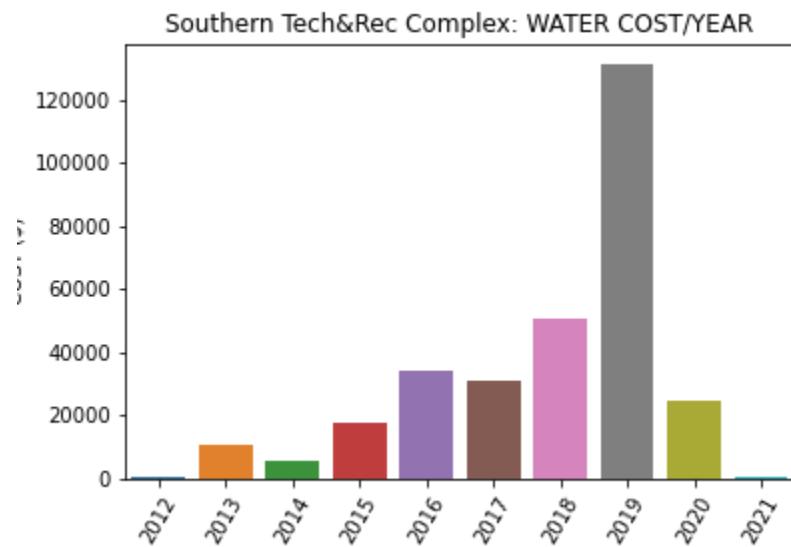
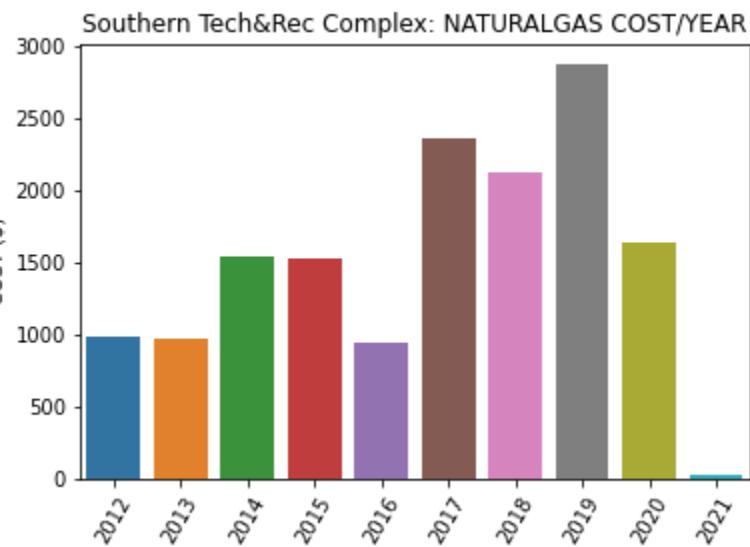
	From	To	Days
0	2013-08-21	2013-09-23	33 days
1	2017-08-25	2017-09-28	34 days

MISSING DATA in NATURALGAS:

	From	To	Days
0	2016-06-15	2017-01-24	223 days
1	2016-12-13	2017-11-17	339 days

	EUI
Start Date	
2012	38.746775
2013	56.278733
2014	72.262819
2015	83.181888
2016	65.586870
2017	71.082309

a. Southern Tech & Rec Center (Yearly Utility Cost)



II. Analysis

The visualizations created using Tableau and Python provide the trends for consumption of commodities at the Prince George's County facilities. For various levels of detail, bar graphs, line graphs and pie charts were developed to better conceptualize how the usage and costs of electricity, water, natural gas, telecommunications and cable.

A. Percentage Usage Data

The usage and cost data shows the non-unique attribute of each facility's dependency upon electricity. The electricity usage across nearly all of the facilities roughly range from 95% to 98% of all commodity usage. The outlier is the Southern Regional Technology and Recreation Complex, in which the facility's electrical usage is a more modest 81.47% of the total commodity usage. It is important to note that the vast majority of the complex's total commodity usage, 18.39%, is sourced from water usage. The only facility where natural gas usage sees significant comparative usage is the Publick Playhouse, where 4.04% of commodity usage is sourced from. A likely factor to consider is the age of the facility, given it was constructed in 1947.

B. Percentage Cost Data

More interestingly, the cost of the commodities are not all equal which differentiates each facility more so than the usage statistics. All of the facilities follow a similar cost structure, with electricity accounting for the majority of cost, but the differentiating factors of each facility create a range of percentages for each attribute. Telecommunication plays a much more significant role for cost structure, ranging from roughly 3% of cost at Southern Area Aquatics & Recreation Complex to nearly 21% at the Southern Regional Technology and Recreation Complex. Despite the differences in their telecommunication costs, the two recreational facilities have a much larger water cost footprint, likely due to the nature of the complexes. Cable is only factored into the newest facility, Southern Area Aquatics & Recreation Complex, although accounts for less than 4% of the overall cost. The last commodity is the most telling, which is natural gas. There is still a need for the resource in newer facilities, as the underlying cost is still present. Publick Playhouse serves as an example of newer systems being less natural gas reliant, as nearly a quarter of the building's commodity costs are derived from natural gas.

C. Electricity Usage Data

Due to the unanimously large overall footprint of electricity usage and cost, we developed year-by-year visualizations. Assessing the average yearly electric usage shows unique differences in the yearly trend for each facility. Ignoring 2021 as to only include full-year readings, there are extreme changes in some timelines, in which some may be due to volatile construction periods. Laurel-Beltsville Senior Center has seen considerable volatility after its completion in 2012 but is on an overall upwards trend. Palmer Park Community Center's usage has been on a downwards trend since 1994 but saw a massive several year all-time high for several years surrounding the renovations that were completed in 2016. Publick Playhouse has seen electricity usage plummet since 1994; 2020 being roughly 1/3 of 1994's usage. Southern Region Tech and Recreation Center is quite the opposite, with 48% higher usage in 2020 than when its doors opened in 2013. Lastly, Southern Area Aquatics & Recreation Complex is showing a moderate upwards trend, although it's recent grand opening means that there is a small amount of data from times of standard-operation.

D. Electricity Cost Data

The usage of a commodity does not necessarily mean a one-to-one correlation to cost. An example of this being Laurel-Beltsville Senior Center's electricity cost directly contradicting the heightened usage, hosting a downwards cost trend. Publick Playhouse sees a similar starting and end point, but heavily deviates and sharply heightens for the decade of 2004 to 2014. Southern Area Aquatics & Recreation Complex, Palmer Park Community Center, and Southern Area Aquatics & Recreation Complex are much more coherent to their counterparts of usage, correlating neatly.

E. Gas Usage & Cost Data

As mentioned previously, natural gas is relied upon much less heavily in the newer facilities and recently renovated facilities than Publick Playhouse, the oldest facility on this list. The Laurel-Beltsville Senior Center dataset did not include any gas usage, although the cost roughly doubled from 2018 to 2020. Palmer Park Community Center shows a neatly correlated slow decline in usage and cost from 2015 to 2020. A similar correlative property is seen between the usage and cost data for Publick Playhouse and Southern Region Tech and Recreation Center. It is important to note that the 2021 data provides a sharp incline for each facility, with an exception for Southern Region Tech and Recreation Center. Southern Area Aquatics & Recreation Complex only shows data from 2020 and 2021, and may require a lengthier data collection time to accurately compare pricing and usage.

F. Telecom Usage & Cost Data

Telecommunications is a sizable portion of commodity cost for the majority of facilities, but is comparatively less, usage-wise. Laurel's telecom usage data is not available again, although the cost data is, in which a downwards trend is present. Southern Area

Aquatics & Recreation Complex only has three years of data which directly contradict one another; usage spiking upwards and costs spiking downwards. Construction costs may be a factor as the expense of telecommunication installation is not detailed. Publick Playhouse has a weak level of correlation, considering a usage spike surrounding 2000 with a much less significant expense. Southern Region Tech and Recreation Center's cost has seen a considerable decline over nearly a decade but has little usage data until 2019. Palmer Park shows the least consistency out of all the buildings where there is very volatile usage year-by-year.

G. Water Usage & Cost Data

Each of the facilities have some form of utility and cost data concerning water, although the Laurel-Beltsville Senior Center seems to be missing a large portion of pre 2019 usage data. Compared to the usage data, there are few other explanations to source the volatile cost metrics. Palmer Park Community Center seems to have a similar issue, only having the usage data for 2017 and 2019, with more realistic cost data. The same can be seen with Publick Playhouse and Southern Region Tech and Recreation Center where there are many near-zero years for water usage where data is not available despite cost data showing a more realistic measurement year-by-year. The outlier was Southern Area Aquatics & Recreation Complex, given it's recent introduction in 2020, where the average usage and costs are neatly correlated each year.

Recommendations

While we appreciate the resources that have been provided, we have some recommendations for the future so that this project can be even more insightful.

Data Collection Suggestions:

- Thermostat Data
 - Insights into how much money goes toward heating/ cooling
 - Is it too hot/ cold in the building?
 - Any inefficiencies in the system?
- Building Traffic
 - How many people enter and exit in a day?
 - Cost/ person to operate?
 - Can conduct surveys on building climate
 - Is it too hot, too cold, etc
 - How long does each person spend there?
- Mapping out which meters control which utilities
 - How much do lights cost?
 - How much does AC cost?
 - How much does heat cost?
- Initial cost of building
- Cost of required updates
- Cost of Maintenance
- Is building over or under staffed?