



# City of Calgary (Corporate) Energy Consumption and the Impacts of COVID -19



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# City of Calgary Corporate Energy Consumption

## Business Case:

- With the recent emergence of the COVID-19 pandemic, daily routines have been majorly disrupted with the Federally and Provincially enforced lockdowns.
- What impact did the COVID lockdown have on City of Calgary facilities consumption
  - Are there areas where C of C Corporate energy consumption have experienced increases/decreases?
- Overall usage rates of Electrical, Natural Gas, Solar power
  - How are they changing? What trends are emerging? Forecasting future energy requirements for each form
  - Solar power usage has seen an exponential increase – requires a deeper look.
- How is green energy supplementing the energy demands of the city's facilities. Can more be done in the new emerging form of energy?



# Business Modeling Tools



Identify and Design Relationship

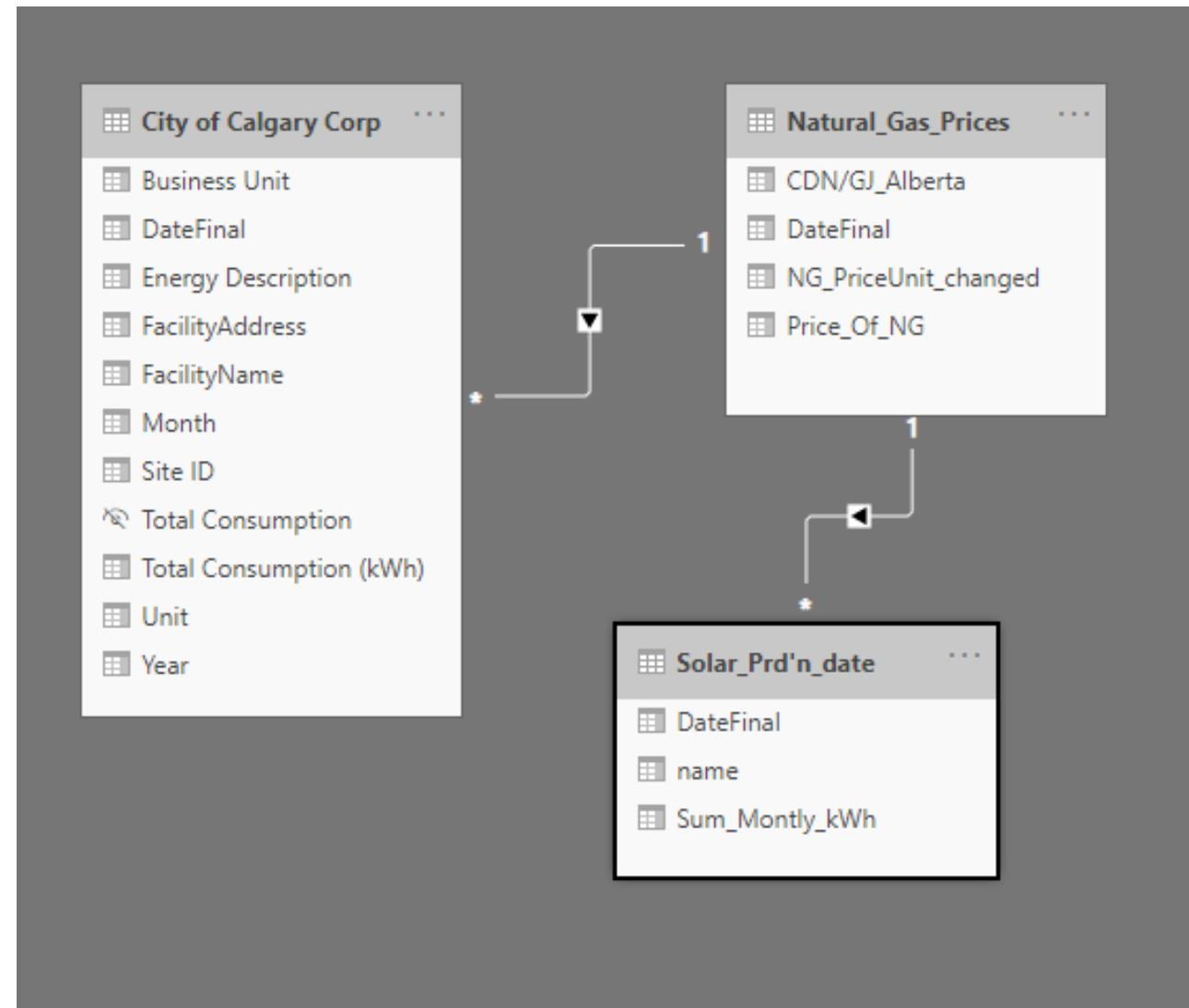


Data Dictionary



Data Map

# Identify and Design Relationships



- The datasets are related to one another by date time via the ***DateFinal*** entity

# Data Dictionary

- *District Energy* - the name used for energy distributed to clusters of buildings for heating purposes
- *Facility Management* - the energy used to heat and power city facilities
- *Solar Power* - the conversion of energy from sunlight into electricity, commonly using photovoltaics
- *Photovoltaics* - the conversion of light into electricity using semiconducting materials (Solar Panels)
- *Semiconductor* – a material that has an electrical conductivity falling between a conductor, and an insulator
- *Solar Thermal Energy* - Solar power which is used to heat water or air
- *Natural Gas* - a non-renewable and naturally occurring hydrocarbon gas used primarily for heating, cooking, and generating electricity
- *Kilowatt Hour(kWh)* - A measure of electrical energy commonly used as the billing unit for electrical utilities, equal to 3600 kilojoules

# Data Map

**Identify issues that can hinder utility delivery to the general public through city facilities**

- The governing body of Alberta has the largest say in the Energy policies.
- The limits on our analysis highlight the value of comprehensive and timely electricity data, which are currently not available for most of Canada.
- Is the energy source (electrical/natural gas/solar) the most cost effective for the City of Calgary?

# Six Stage Problem-Solving Process



Explore the mess



Searching for information



Identifying a problem



Searching for solutions



Evaluating solutions



Implementing a solution

# Explore the Mess



In early Part of 2020, the first COVID-19 case was recorded in Alberta

What was the cause and effect of the enforced shutdowns on Energy consumption

Looking at three small, clean data sets:

Energy consumption from the City of Calgary Corporate  
Alberta Gas pricing dataset  
City of Calgary Solar production and consumption

- <https://data.calgary.ca/Environment/Corporate-Energy-Consumption/crbp-innf>
- <https://economicdashboard.alberta.ca/NaturalGasPrice>
- <https://data.calgary.ca/Environment/Solar-Energy-Production/ytdn-2qsp>



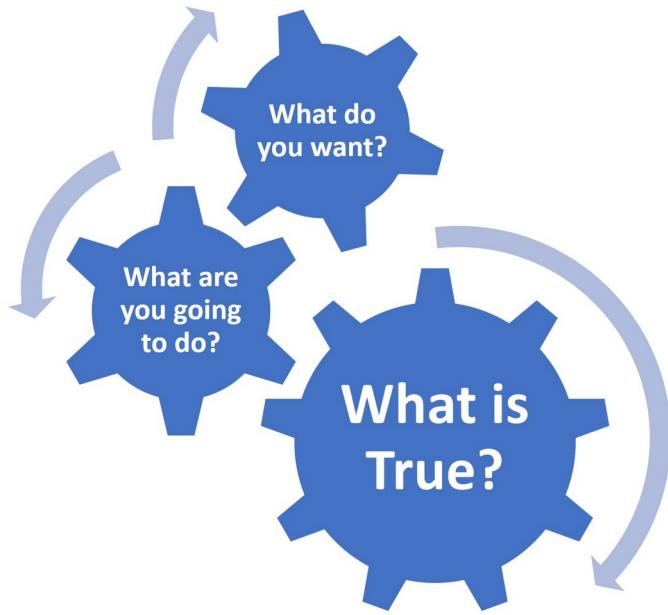
# Searching for Information

Historically Natural Gas and Electricity have been the primary energy sources for the City of Calgary

Have other sources of energy been explored for cost reductions?

3/4 of all natural gas and electricity consumed by City of Calgary facilities are; Water Services, Calgary Transit, Facility Management, Calgary Recreation and Roads.

In Calgary, the Southland Leisure Centre is the only facility currently using Solar Thermal as one of its energy sources.



# Identify a Problem

Two energy units of measure (kWh & GJ) – convert to one:

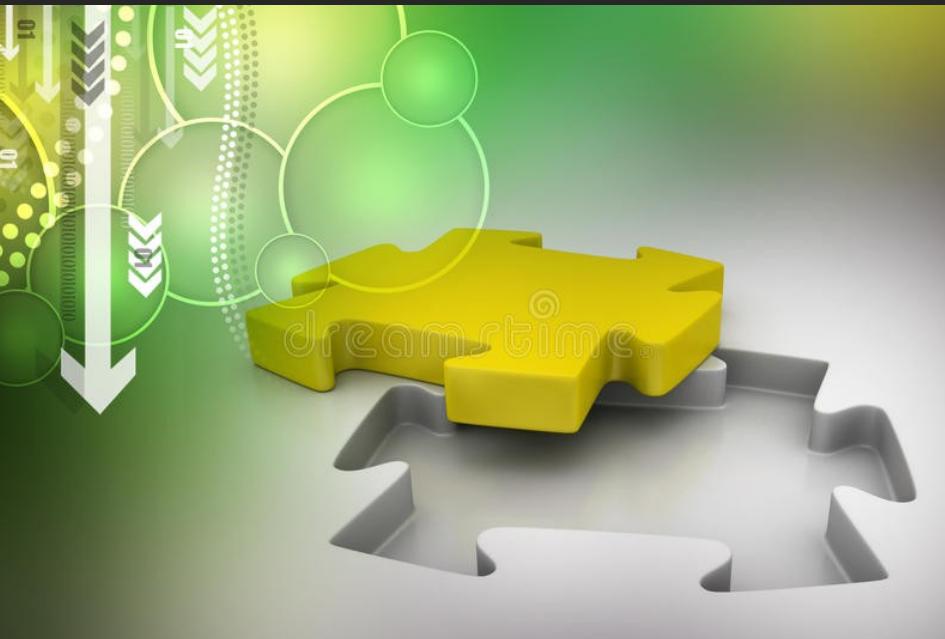
Heating is measured in GJ

Electricity is measured in kWh

How can the different energy sources be smartly/economically utilized?

How can the use of renewable energy be maximized?

Is Solar power an achievable source of power?  
Production vs. Consumption?



# Searching for Solutio ns

Natural Gas and Electrical are stable, proven sources of energy but there is desire to phase out hydrocarbons. How can this be achieved?

A gradual staggered implementation of Solar energy systems in all government facilities throughout the city is a great starting point.

Provide technical and financial incentives to organizations that are interested in adopting solar energy as energy generators.

<https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/renewable-energy/solar-thermal/7301>



# Evaluating Solutions

Geographically, Calgary is in a Northern latitude therefore seasonal daylight hours need to be considered

Finance and resources to embark on a new project

Accessing affordable financing to invest in energy efficiency is a major barrier for property owners

# Implementing a Solution



The green energy push is in motion as projects in various stages are moving ahead in Calgary

Energy demands are expected to grow in the years to come.

Public is supportive of more balanced energy methods going forward

Not enough support for companies that champion renewable energy production



**Calgary**

# City of Calgary Corporate Energy Consumption

Visuals in Power BI

# Data Modeling – Predictive Models

- The datasets that have been collected for the case study lend themselves to be modeled with Predictive Analysis Tools
- Forecasting will be done to determine future consumption numbers for the City of Calgary Corporate
- Historical data from 2014 will help in defining:
  - year-over-year models for consumption, through to year end 2022
  - The effect of COVID-19, projecting into the future for three months



# Data Preparation

## Python Stats

**Number of Rows:** 134,793

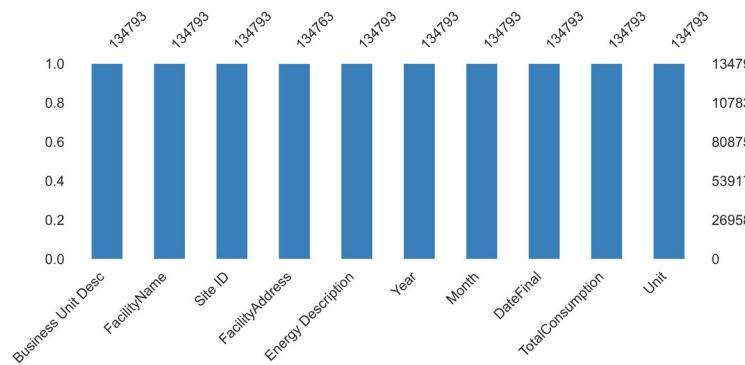
**Columns:** 10

**Missing Values(Address):** 30

**Final Number of Rows:  
134,763**

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 134793 entries, 0 to 134792
Data columns (total 10 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Business Unit Desc    134793 non-null   object 
 1   FacilityName          134793 non-null   object 
 2   Site ID               134793 non-null   object 
 3   FacilityAddress        134763 non-null   object 
 4   Energy Description     134793 non-null   object 
 5   Year                  134793 non-null   int64  
 6   Month                 134793 non-null   object 
 7   DateFinal             134793 non-null   object 
 8   TotalConsumption      134793 non-null   float64
 9   Unit                  134793 non-null   object 
dtypes: float64(1), int64(1), object(8)
memory usage: 10.3+ MB
```

**Raw Data Info**



**Missing values using dataprofiling**

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 134763 entries, 0 to 134792
Data columns (total 10 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   Business Unit Desc    134763 non-null   object 
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 8   TotalConsumption      134763 non-null   float64
 9   Unit                  134763 non-null   object 
dtypes: float64(1), int64(1), object(8)
memory usage: 11.3+ MB
```

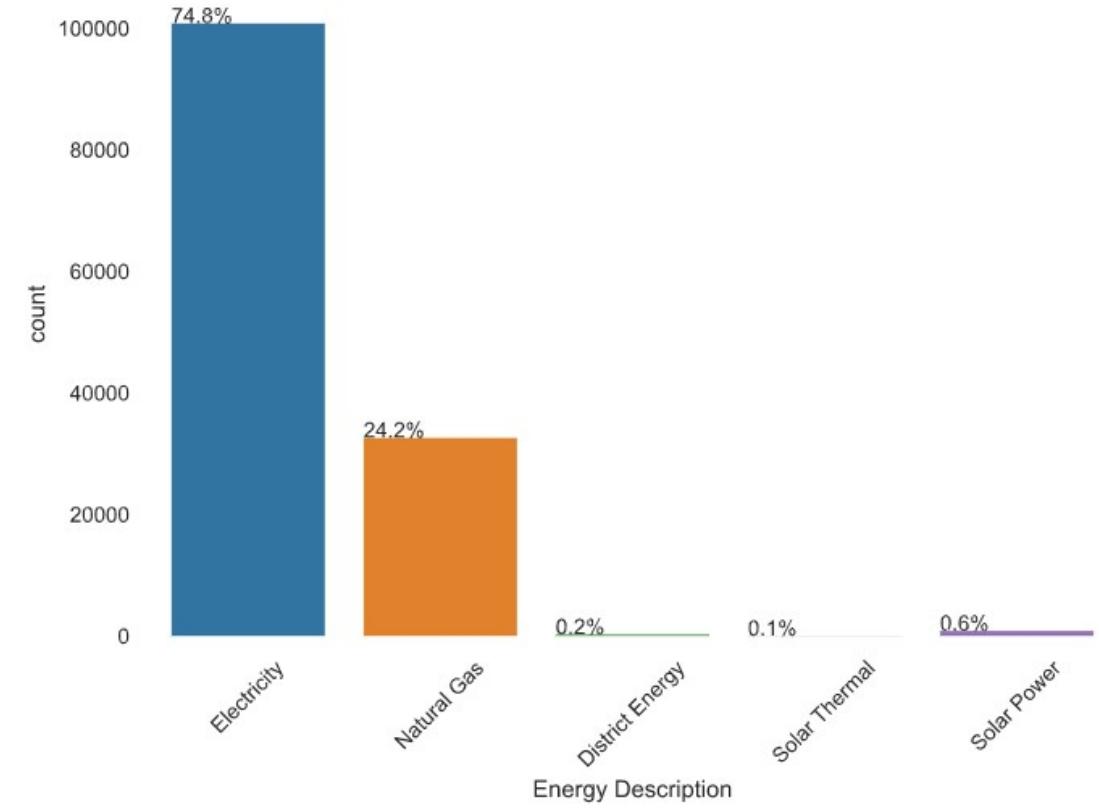
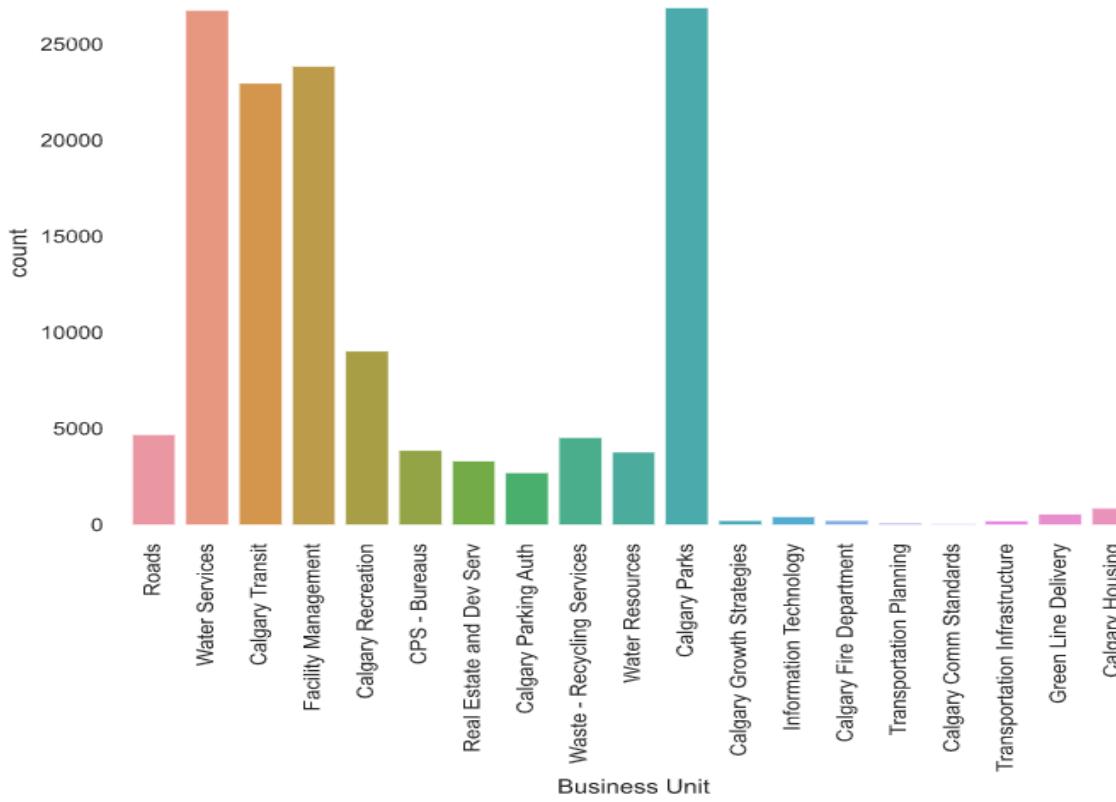
**Data Info after (dropna)**

	Year	TotalConsumption
count	134793.000000	1.347930e+05
mean	2016.697277	4.835626e+04
std	1.851228	2.994861e+05
min	2014.000000	-2.806000e+03
25%	2015.000000	2.700000e+01
50%	2017.000000	1.607000e+03
75%	2018.000000	1.442000e+04
max	2020.000000	1.112766e+07

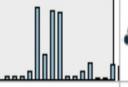
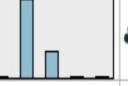
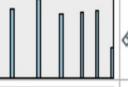
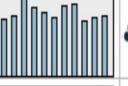
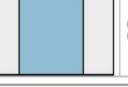
**Data Describe**

# Data Prep Using Python

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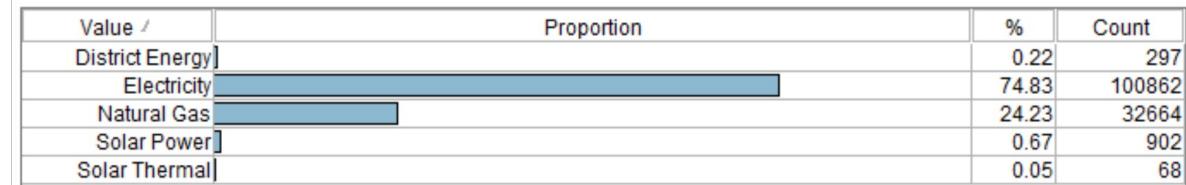


# Data Prep Using SPSS Modeler

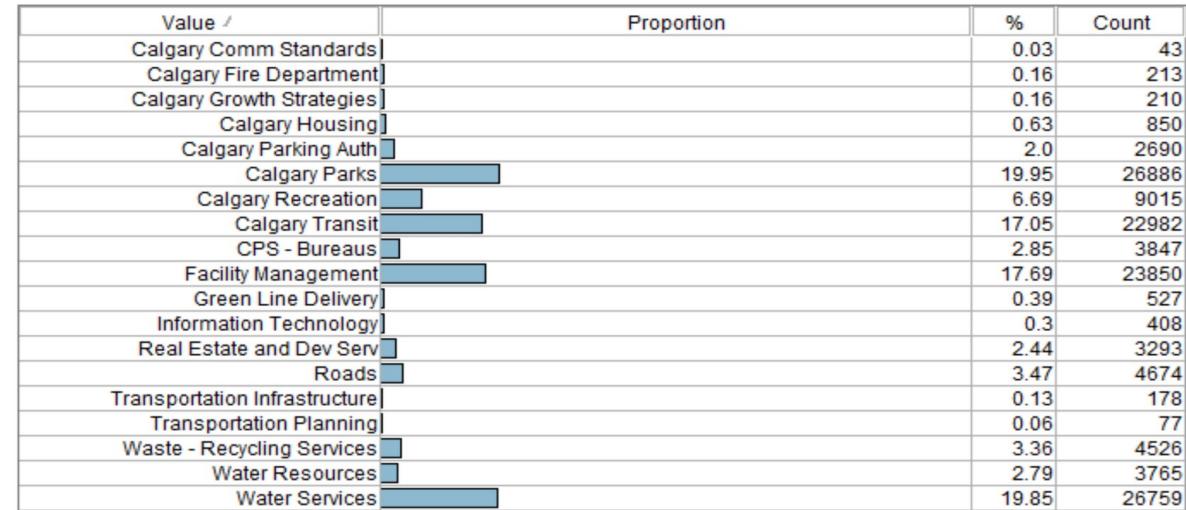
Field	Sample Graph	Measurement	Min	Max	Mean	Std. Dev	Skewness	Unique	Valid
A BusinessUnitDe...		Nominal	--	--	--	--	--	19	134793
A EnergyDescription		Nominal	--	--	--	--	--	5	134793
Y Year		Continuous	2014.000	2020.000	2016.697	1.851	0.092	--	134793
A Month		Nominal	--	--	--	--	--	12	134793
Y TotalConsumption		Continuous	-2806.000	11127658.000	48356.262	299486.080	18.781	--	134793
A Unit		Flag	--	--	--	--	--	1	134793

<sup>1</sup> Indicates a multimode result   <sup>2</sup> Indicates a sampled result

## Data Audit

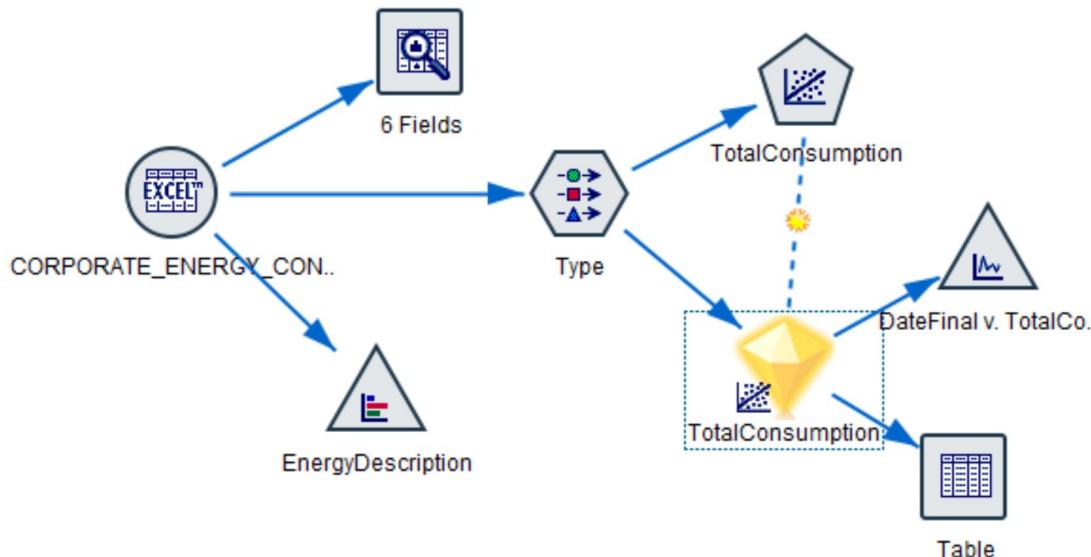


### Energy Description Distribution Plot

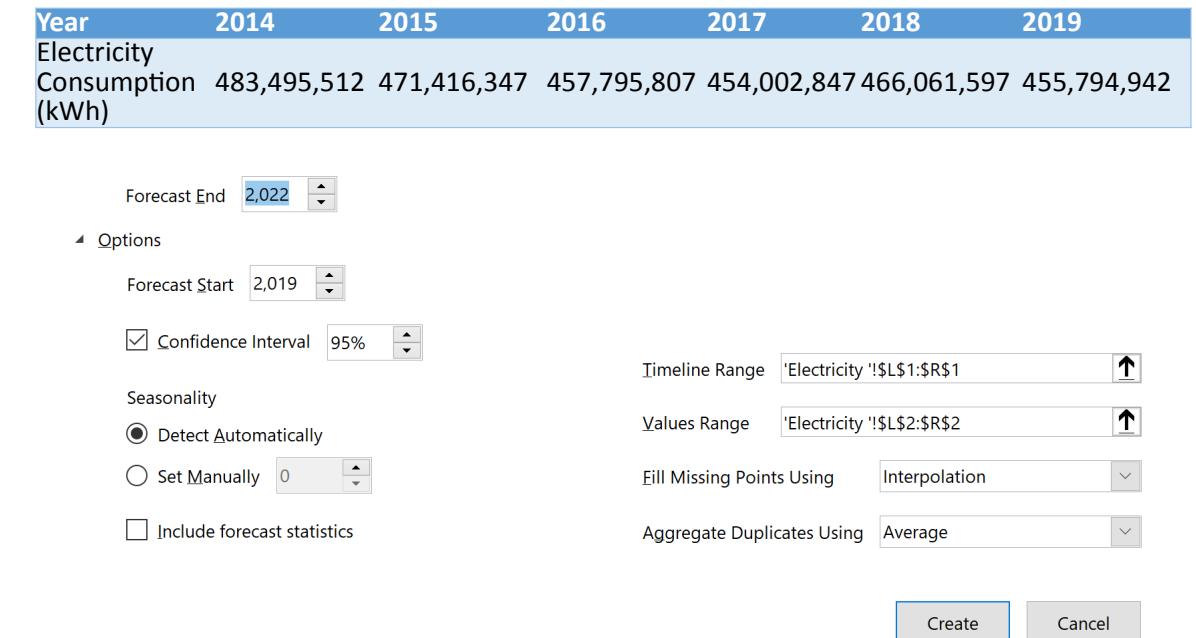


### Business Unit Distribution Plot

# Forecasting Software

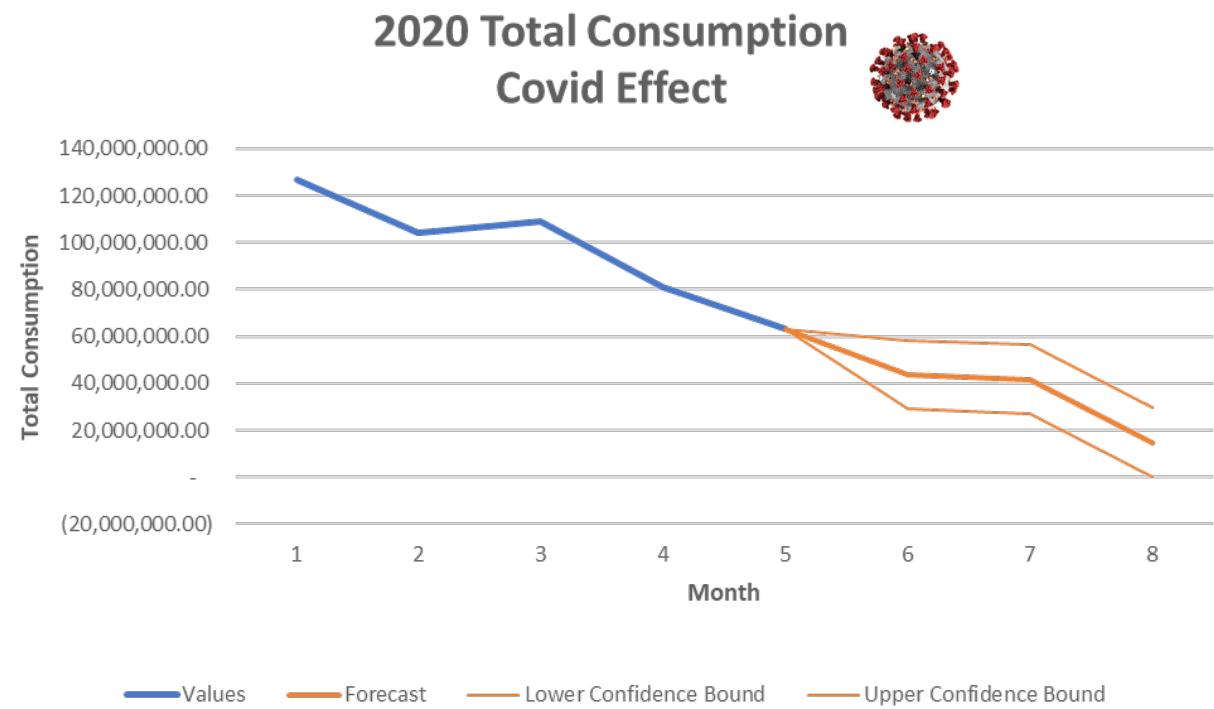
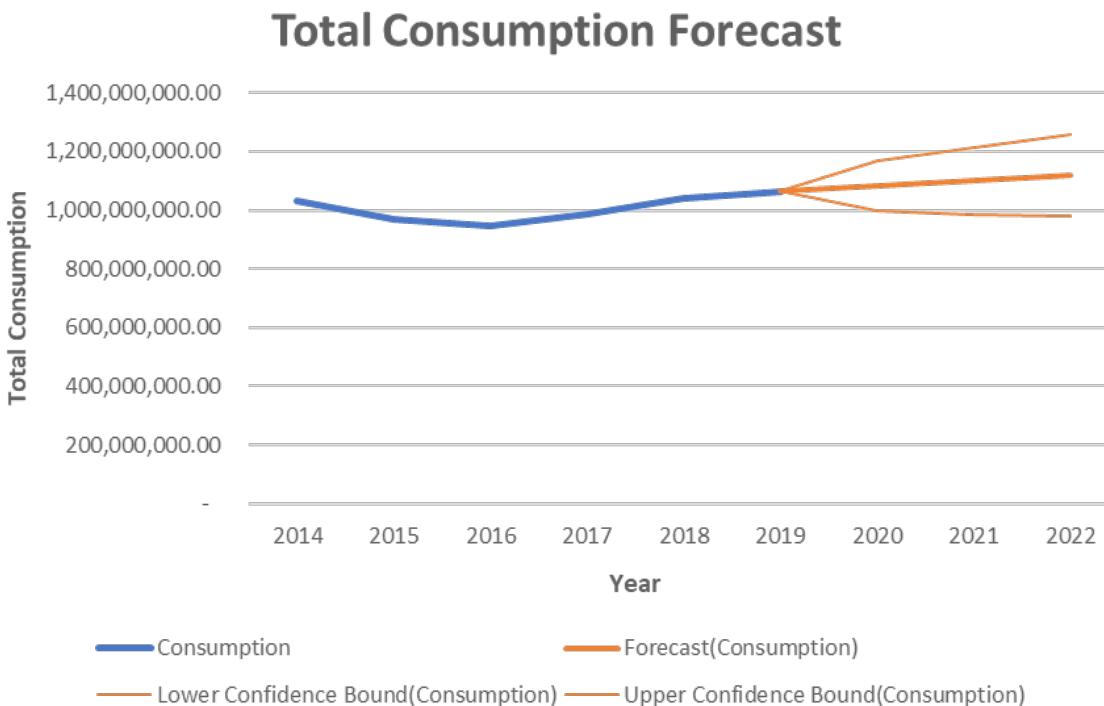


SPSS Modeler

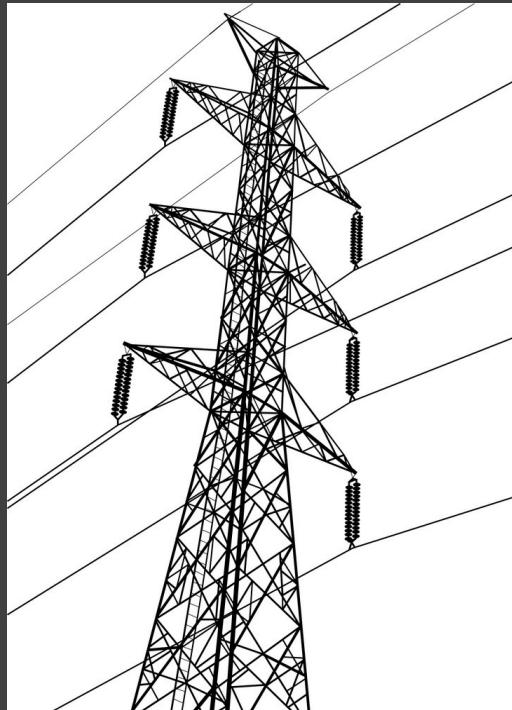


Excel Data Forecast

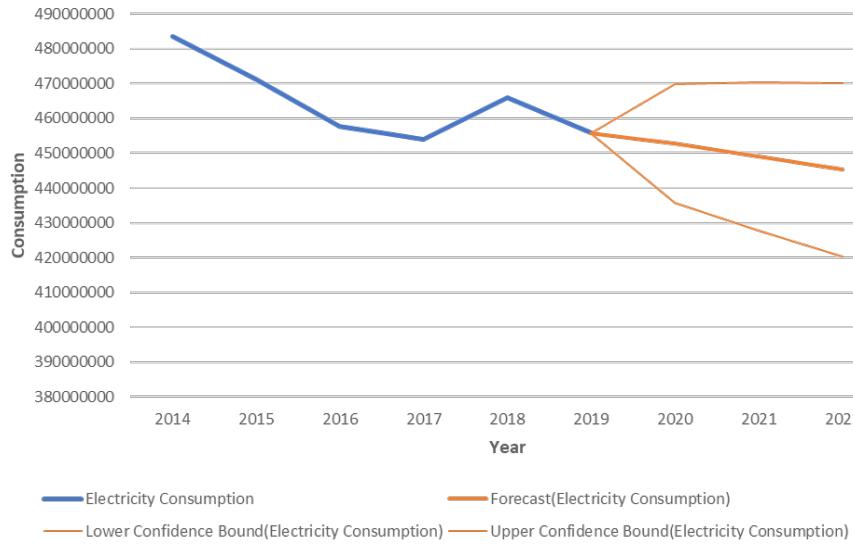
# Total Energy Consumption



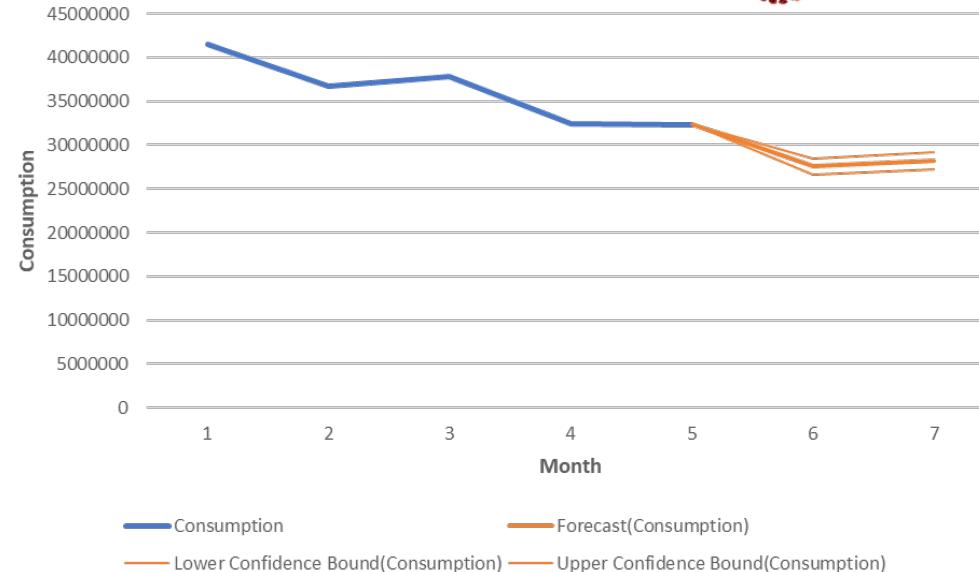
# Electricity Forecasts



Electricity Consumption Forecast



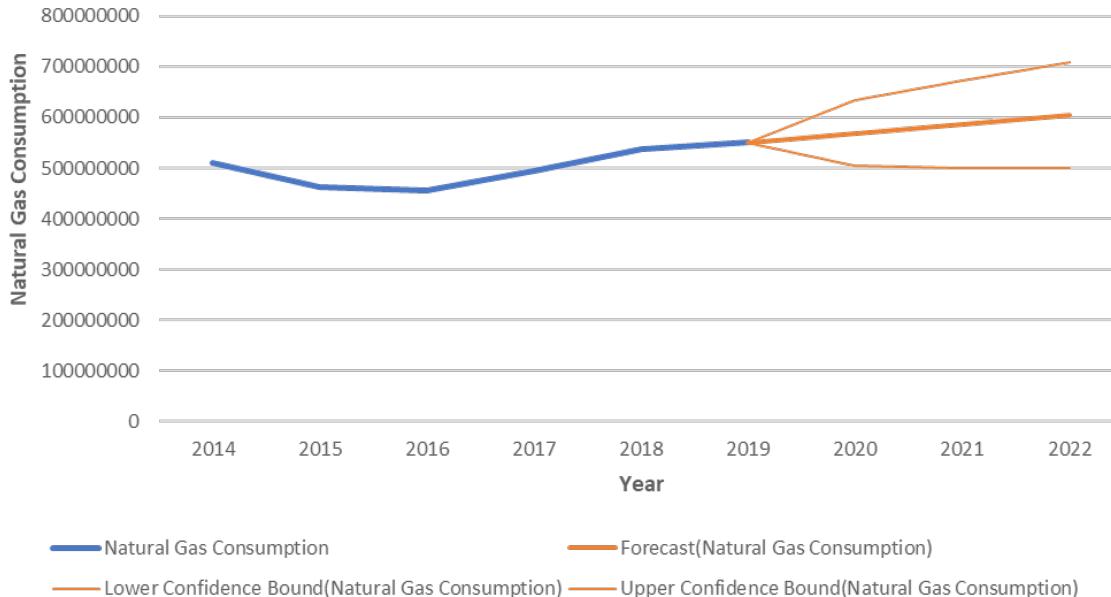
2020 Electricity Forecast  
(COVID Effect)



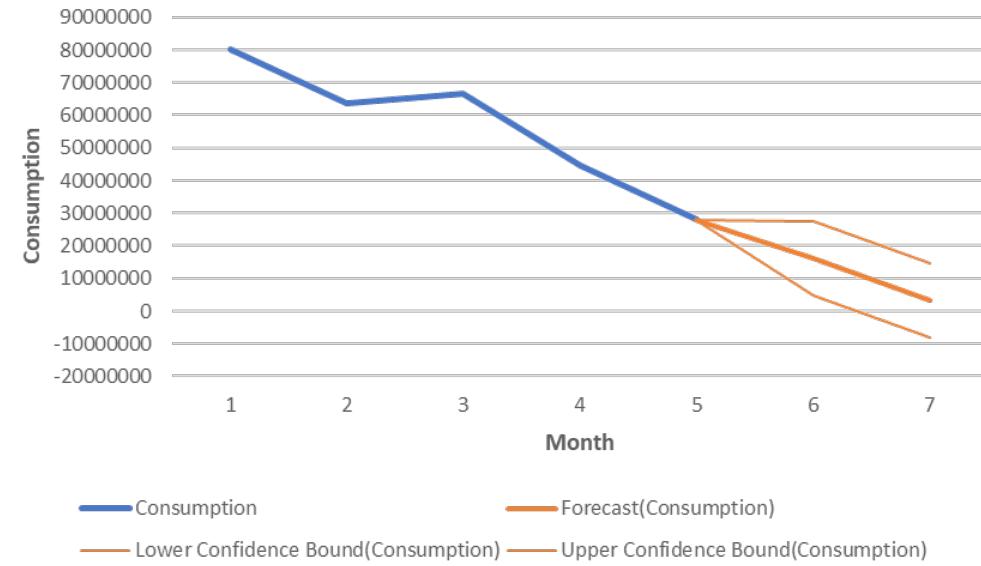
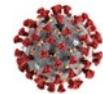
# Natural Gas Forecasts



Natural Gas Consumption Forecast

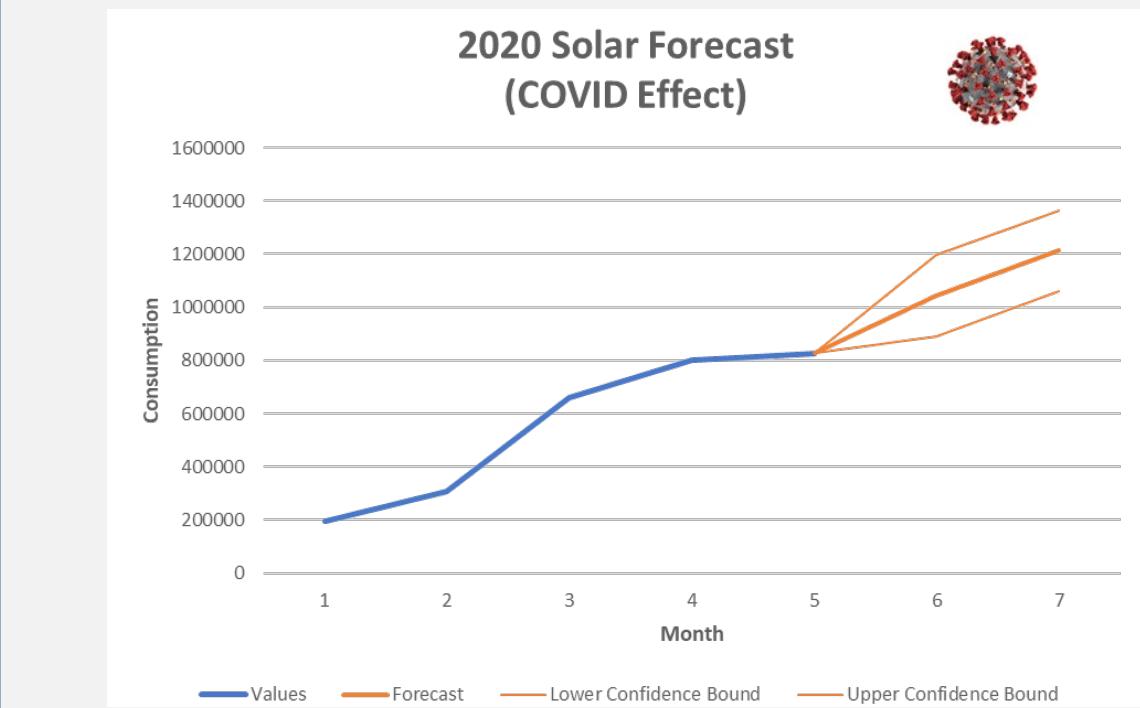
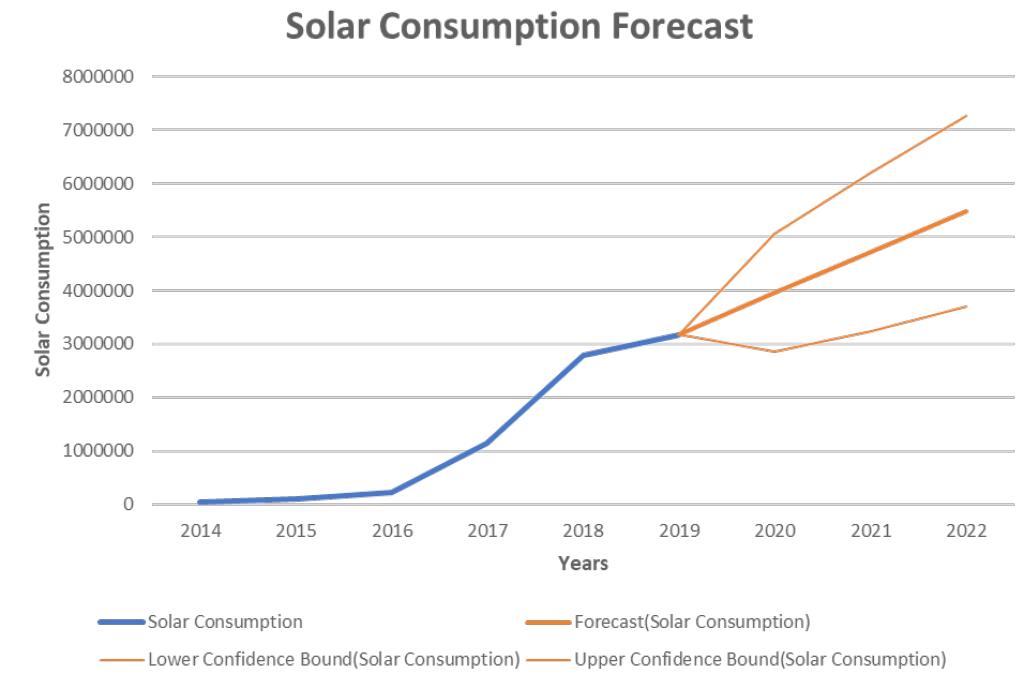


2020 Natural Gas Forecast  
(COVID Effect)



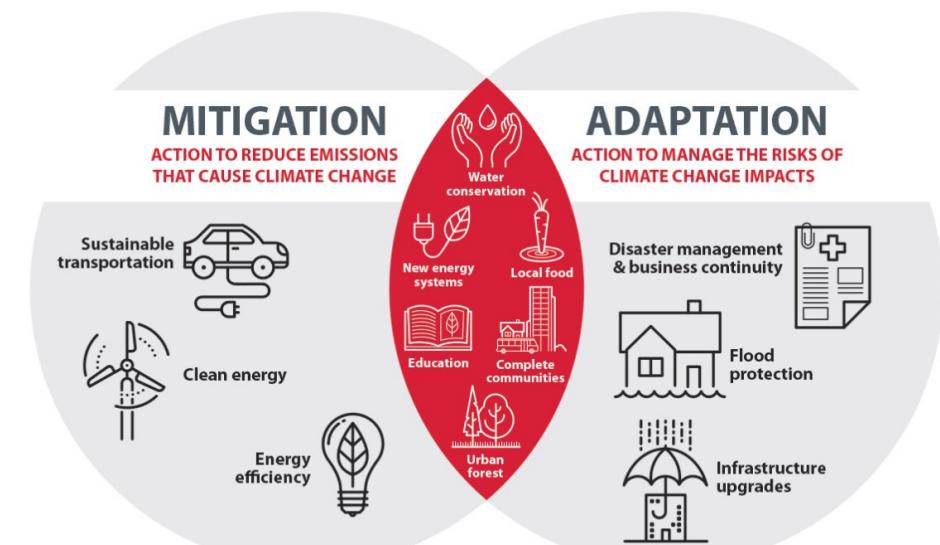
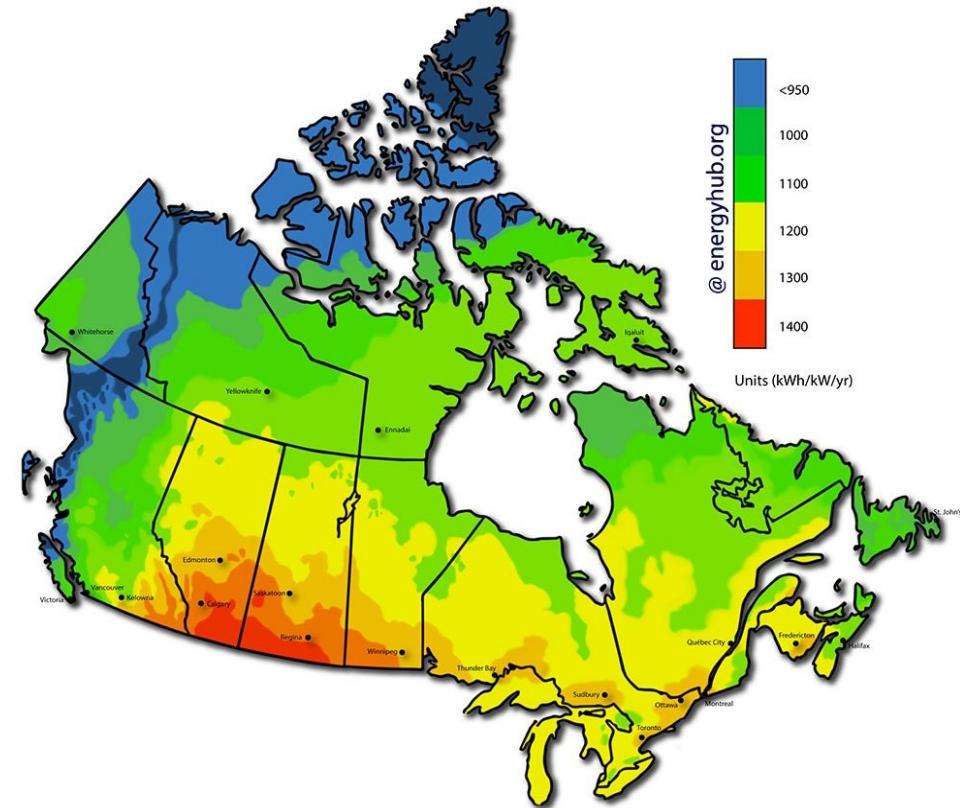


# Solar Forecasts



# Going Green

- Alberta is ranked as the 2nd best province to install a solar energy system
- In 2012, City of Calgary committed to reduce greenhouse gas emissions by 20% (from 2005 levels) by 2020, and 80% by 2050
- City of Calgary has invested in collecting and utilizing solar power primarily at Water treatment facilities
- Some other ways Calgary is becoming greener include combined heat and power from biogas, converting landfill gas to power, and wind generated electricity.



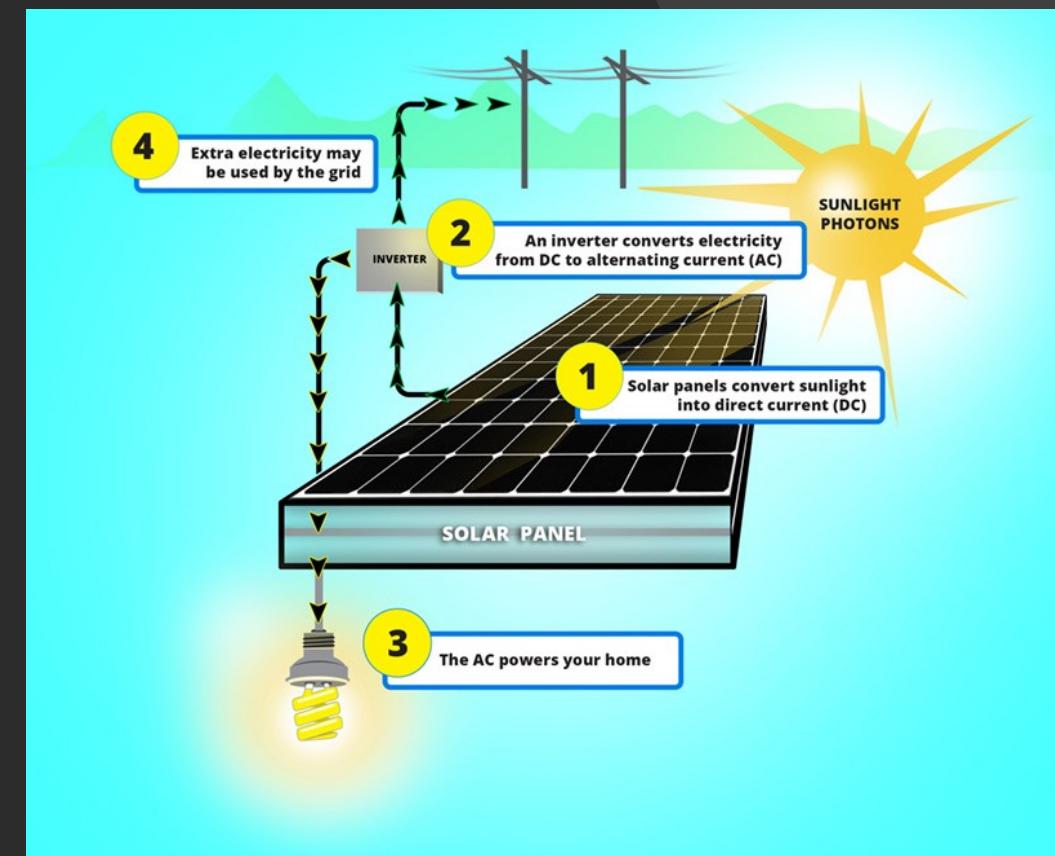
# Embracing Solar Power

- Calgary receives an average of 2,396 hours of sunlight each year
- The city has solar projects dating back to 2008
- Sites range from water treatment plants to fire halls, leisure centers to landfills.
- Their use will improve our ecological footprint, increase the supply of renewable energy, and reduce utility costs, given a long enough time frame



# How it works

- Photovoltaic solar panels are mounted to a south or west facing rooftop to be exposed to sunlight
- An inverter will convert direct current electricity from the panels into other forms of useable electricity
- Converted electricity is distributed throughout the building
- A monitoring system will detect the amount of energy being produced by the system
- Any surplus energy not in use in the building will pass through the City electrical grid and provide power to others





## Harnessing the Power

- The City currently utilizes 21 different solar sites of varying capacities
- The consumption data set included all 22 sites, however the production data set included only 8 sites
- These 8 sites rely on the electricity generated by these projects to offset electrical costs, and supply surplus power directly to the electrical grid
- The efficiency of these sites have created interest in the Albertan Solar market, and have encouraged foreign investment in our City



# Southland Leisure Centre

- Cities first large-scale Photovoltaic project, completed in 2015
- These panels provide between 161,000 – 184,000 kWh
- The system offsets approximately \$24,000 in electricity costs for the facility annually
- The system will produce electrical energy for at least 25 years
- Total Lifetime energy production: 592.84 MWh



# Bearspaw Water Treatment Plant

- Completed in late 2017 with a total cost of ~\$1.35M
- This system is comprised of 1740 panels, capable of offsetting approximately 900,000 kWh annually
- The power produced here is used to offset utility power requirements for plant loads, with a capacity of 499.5 kWh
- Responsible for reductions in Greenhouse Gas Emissions of 500 tonnes/year of CO<sub>2</sub>
- Total lifetime energy production: 1.81 GWh



# City of Calgary Solar Energy Data Collection

- Solar Potential Interactive Map:
- [Calgary Solar Map](#)
  
- SolarEdge Data Hub (Bearspaw):
- [Bearspaw Water Treatment Plant Data hub](#)



**Calgary**



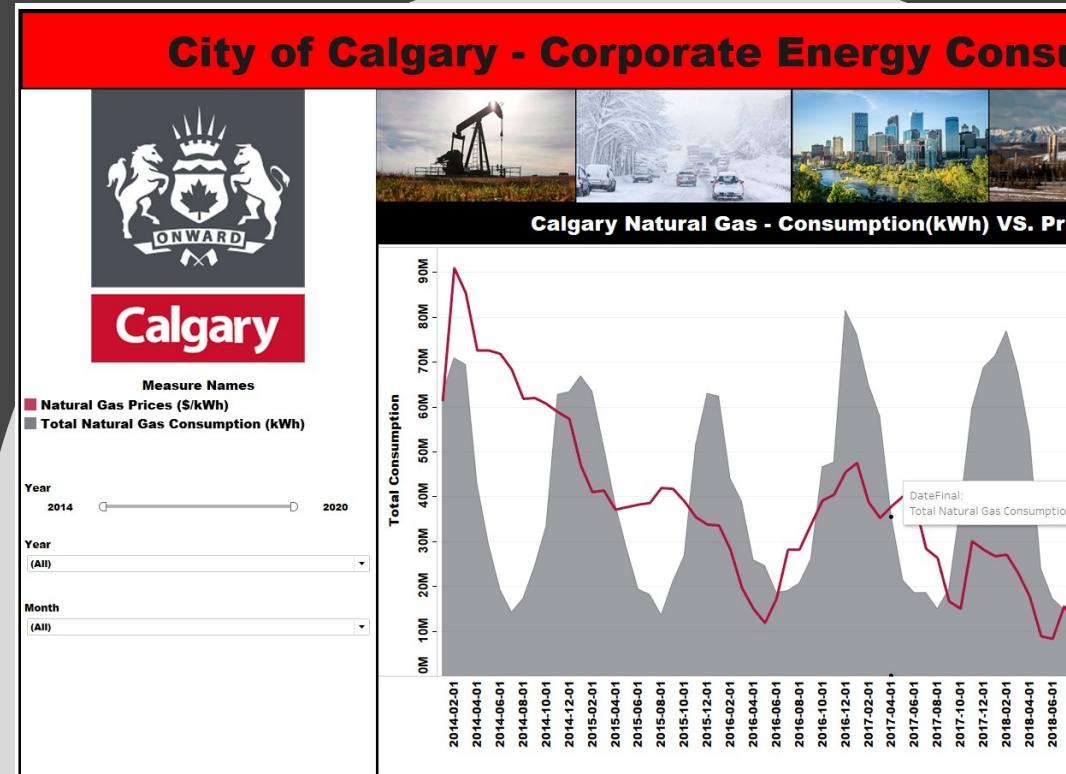
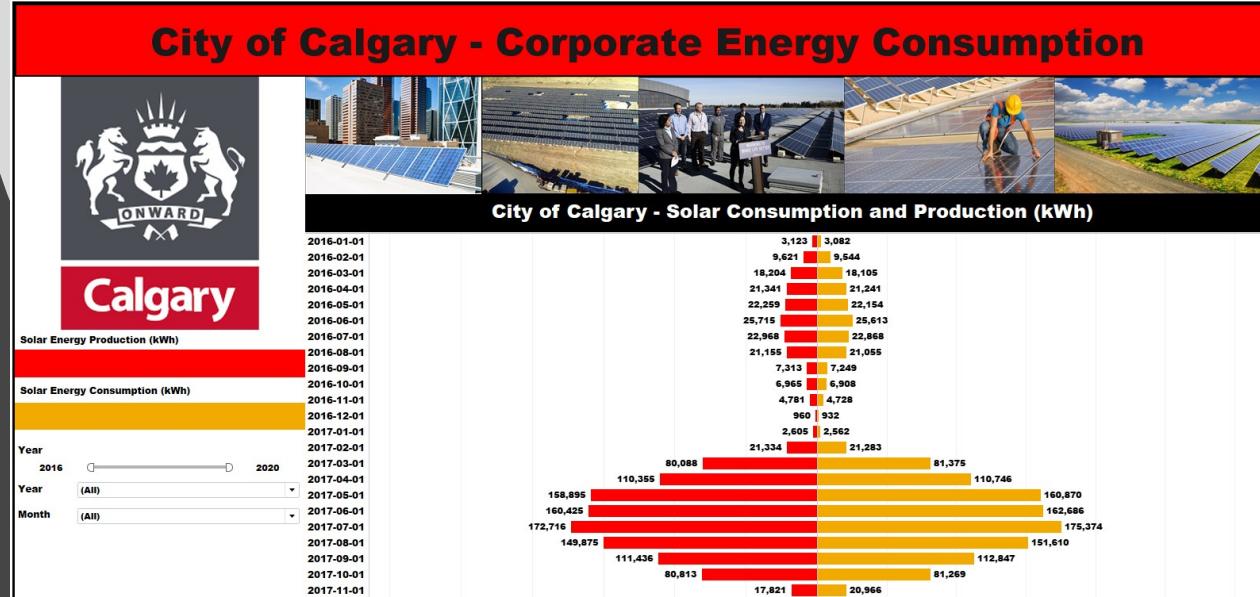
name	DateFinal	Sum_Monthly_kWh
Southland Leisure Centre	2015-09-01	15475.746
Southland Leisure Centre	2015-10-01	15068.149
Southland Leisure Centre	2015-11-01	4302.924
Southland Leisure Centre	2015-12-01	1722.964
Southland Leisure Centre	2016-01-01	3081.863
Southland Leisure Centre	2016-02-01	9544.109
Southland Leisure Centre	2016-03-01	18105.476
Southland Leisure Centre	2016-04-01	21241.109
Southland Leisure Centre	2016-05-01	22154.348
Southland Leisure Centre	2016-06-01	25612.561
Southland Leisure Centre	2016-07-01	22867.97
Southland Leisure Centre	2016-08-01	21054.531
Southland Leisure Centre	2016-09-01	7248.866
Hillhurst Sunnyside Community Association	2016-10-01	1698.431
Southland Leisure Centre	2016-10-01	6908.17
Southland Leisure Centre	2016-11-01	4727.843
Hillhurst Sunnyside Community Association	2016-11-01	809.24
Calgary Fire Hall Headquarters	2016-11-01	0.427
Southland Leisure Centre	2016-12-01	703.615
Hillhurst Sunnyside Community Association	2016-12-01	197.868
Calgary Fire Hall Headquarters	2016-12-01	0.005
Richmond - Knob Hill Community Hall	2016-12-01	76.437
City of Calgary North Corporate Warehouse	2016-12-01	228.847
City of Calgary North Corporate Warehouse	2017-01-01	40.556

## Integrating Other Datasets

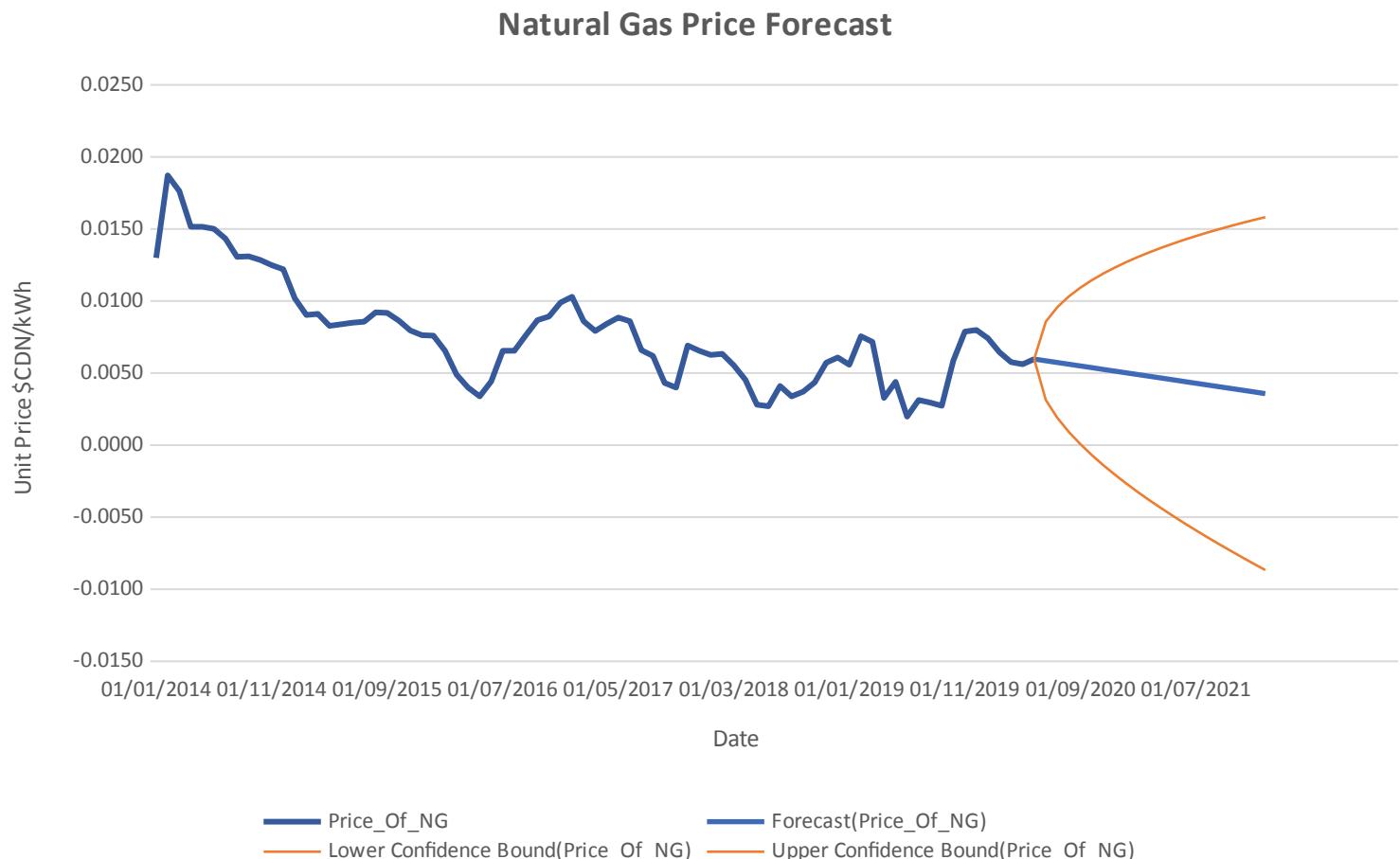
- Our main dataset is limited to energy consumption
- Need to answer new questions related to other elements than consumption
- How we incorporate other supportive dataset
- Alberta Natural Gas Prices and Calgary Solar Energy Production

# Tableau Visualizations

- Calgary Natural Gas - Consumption and Prices
- Calgary Solar - Consumption and Production



# Natural Gas Price Forecast



# Conclusion

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- Solar Energy and Natural Gas consumption statistically increasing. Consider supplemental energy sources.
- Consumption Predictions are limited due to small Covid dataset. However all energy sources, apart from solar power, are predicted to decrease due to COVID-19.?
- Outside of COVID-19, Electricity consumption is expected to decrease, Natural gas and Solar Energy total consumption are increasing
- Looked at Natural Gas Prices, Solar Energy Production, Energy offset and optimization methods: Solar Panels, LED bulbs
- Used multiple tools and techniques for case study analysis
- Recommendations: Analyse larger COVID-19 dataset, Different forecasting(exponential), Greener energy production for future increased demands,



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Questions?