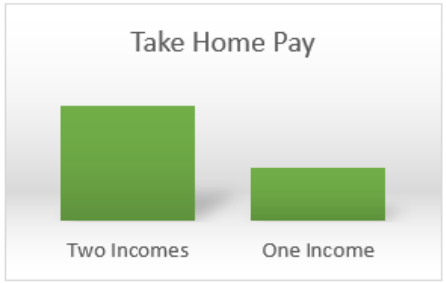
Process Improvement Project – Reducing Spending

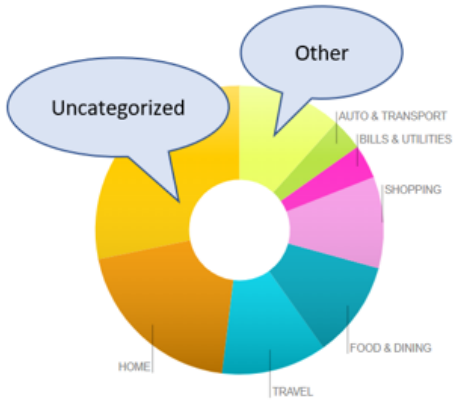
Define

Problem Statement:
Our take home pay has been drastically reduced, and we expect this to continue for the next 12 months.



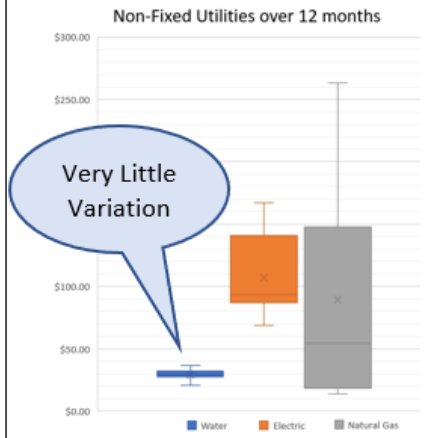
Goal:
Reduce consumption and avoid incurring additional debt.

Baseline:
This was difficult to establish, because we hadn't been tracking purchases closely.

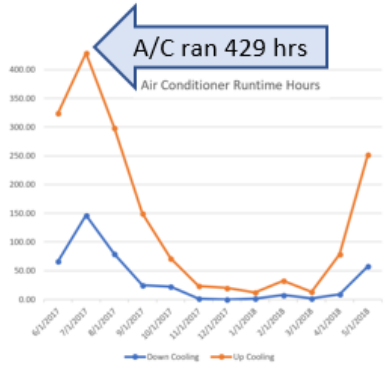


Measure

Box and Whisker Plot:
Non-fixed utility spending was measured / visualized. Water bills varied the least; Gas bills varied the most.

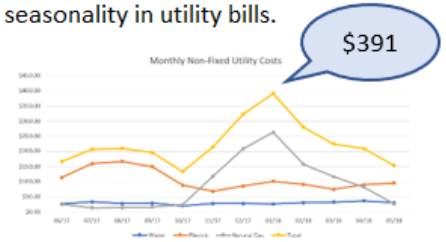


HVAC **Runtime Data** was gathered and visualized.

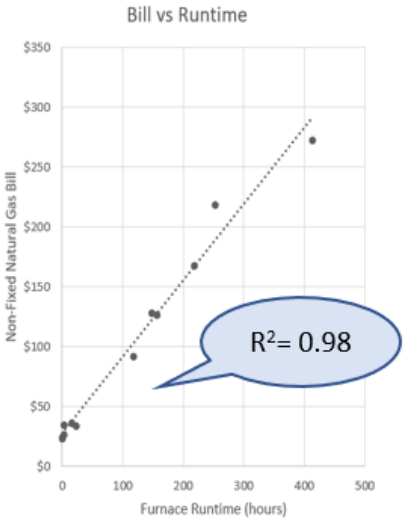


Analyze

Line Chart:
A Line Chart was used to visualize seasonality in utility bills.



Simple Linear Regression:
A SLR was run on Electric bill vs A/C Runtime and Gas Bill vs Furnace Runtime.



The model showed that Furnace usage accounts for a large amount of the Gas bill.

Improve

I improved our process by starting to track spending more closely.

More Improvements:

Reduced withholdings **$16,488** per year

Can save up to **$900** per year by using an alternative to prepackaged frozen lunches.

Made a plan to save **$595** per year on salon costs.

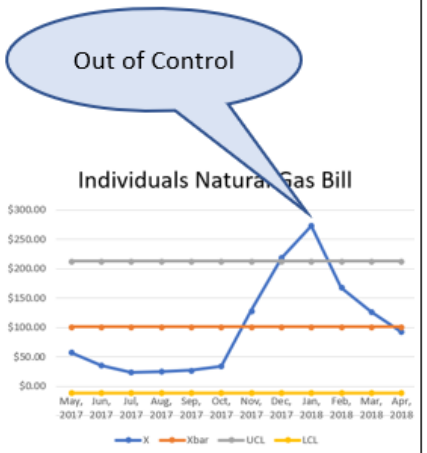
Switched my brand of cat food to save **$188** per year.

Used programmable thermostats to decrease HVAC runtime.

Expect to save **$84**/month this winter by not running the gas fireplace in the evenings.

Control

Moving Range Control Chart:
I utilized a Moving Range chart to see if my Gas Bills were in control.



Never Stop Improving

This project focused on utility usage, and then started to dabble in shopping and food expenses. In order to be successful, next I need dive deeper into shopping and food expenditures. These categories accounted for a large portion of our spending in the last 12 months, and must be investigated further. Once appropriate x-variables are identified, we need to make action plans to benefit from potential savings.

Define

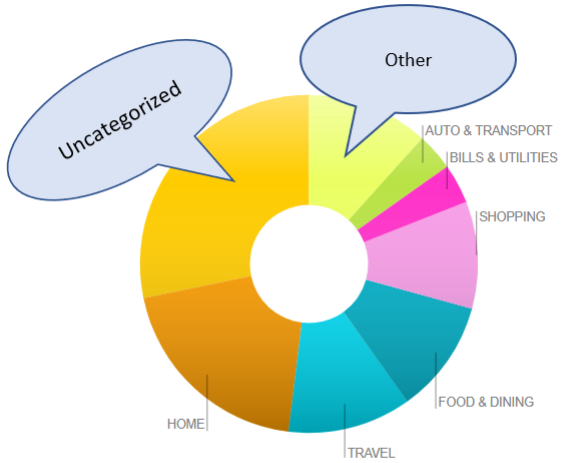
DMAIC

- **Problem Statement:**
  - I resigned from my job in order to become a full time student. As a result, our household take-home pay has decreased by approximately 50% each month (exact dollar amount has been redacted for privacy). This is expected to last for 12 months.
  - Our current process is not well controlled, so we don't have a good idea of how much money we spend each month. However, I think it's safe to assume that we were not spending only 50% of our take home pay per month and putting the rest into savings.
  - Therefore, in order to cover our monthly expenses, we will need to make adjustments, such as (but not limited to): increasing take-home pay, decreasing spending, selling items we no longer use, going into debt, dipping into savings, etc.
- **Goal:**
  - Adjust to a temporary job loss, avoiding taking on additional debt if possible. At the end of the 12 months, if we are not carrying any additional debt, we will know that we were successful.
- **Operation Definitions:**
  - Our inputs (x) are our expenditures.
- **Scope: The following areas of reduction will be explored:**
  - 401K contributions / Taxes withheld
  - Utilities (Water, Electric, Natural Gas)
  - Shopping, including on Food and Dining
- **Baseline:**
  - It is difficult to define current spending because if varies so much by month, and the last year has been atypical due to extensive travel.
  - What we do know is the amount of the new take home pay at project start, and if we had been spending the full old take home pay, what the monthly shortfall would be (exact dollar amounts have been redacted for privacy).
- **Action Plan:**
  - Look into reducing withholdings to increase take home pay.
  - Go ahead and spend less money in obvious areas. Avoid eating out, going to movies, buying clothes, going on vacations. This is only for 12 months and should not present an undue hardship.
  - Then, look for additional areas to save money. Can we save money by reducing utility usage? Check the internet for advice on common areas to save money.
  - Finally, get back in the habit of carefully looking at where our money goes each month. This will be the big, overall process change and will lead us to change smaller changes that will help us spend less money.

Define – Process Map

DMAIC

- **Current Process:**
  - Our current process is not under control.
  - We are not paying attention to where our money is going.
  - We are not being careful or deliberate with our spending.
  - A quick glance at data from MINT is not very helpful, because a large portion of our spending in the last 12 months were not categorized.



Last 12 months of Spending
(Data from Mint)

Old Process:

Take-home pay is determined by benefits selected during annual open enrollment, tax marital status/exemptions, and 401K contributions.

→

Take-home pay is direct deposited into a checking account. One job deposits every two weeks. The other job deposits on the 15th and 30th of each month.

→

There are bills / expenses throughout the month. Some are automatically drafted from checking or automatically charged to a credit card.

Once per month, constant:

Mortgage, Car payment, Life Insurance, Cell phone, Internet, HBO, Netflix, Google Music, Pest Control.

Once per month, variable:

Water
Electricity
Natural Gas

Throughout the month, variable:

Gas for cars, Food, Shopping, Movies/rentals, etc.

→

If I happen to notice that our checking account balance looks much smaller or larger than usual, I will move money to or from savings accordingly.

Measure – Data Collection Overview

DMAIC

- **Important Note:** The scope of this real life project is quite large. For this presentation, I chose to focus mainly on utility usage/expenses because the data was readily available and appropriate for many of the tools we've discussed this quarter.
- **Utility Cost / Usage**
  - Utility cost / usage data was collected from utility bills (paper and website downloads) and the Ecobee thermostat website.
- **Utility Efficiency**
  - Utility efficiency information was estimated based on US Government Energy Guide literature.

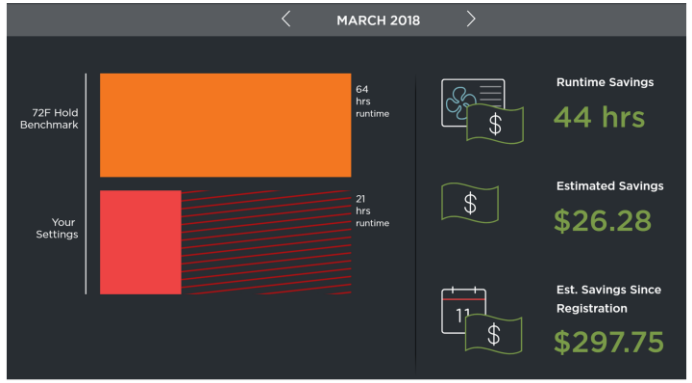
- **Shopping**
  - Possible savings by changing shopping habits were calculated by documenting the price I pay for particular goods/services and calculating how much money I could save if I decreased my consumption by a particular amount.
  - In some cases, I was able to calculate what I actually spent for good/services and was able to specify how much money would be saved if I changed my shopping behavior in specific way.
- **Data Type**
  - Most data was continuous (dollars, temperatures, kWh, Therms)
  - The data used to calculate SQL was discrete, because it was count data.
- **Sample Size**
  - I typically collected at least 12 months of data, because this covers a reasonable range of time but was not unduly onerous to collect.
  - When seasonality was a factor, a data set of 12 consecutive months was analyzed.
  - For Ecobee data, the data only went back to Feb 2016, when we purchased our Ecobee thermostats.
  - For utility bills, the amount of data available varied, but I could not go back further than May 2015, the first full month we occupied our current home.
- **Measurement Error**
  - For cases where I compared utility usage to utility bills, there's some room for error. This is because my usage information is per day, from 12 in the morning to 12 midnight. My billing information is per month, and most bills aren't explicit about what time of day the meter was checked.

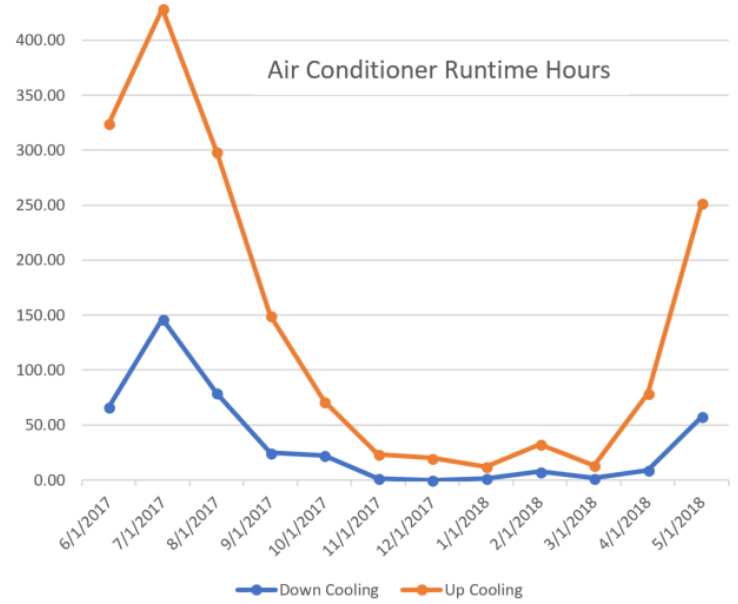
Measure – Sigma Quality Level

DMAIC

- **Data Collection:** In order to demonstrate an SQL calculation, I decided to utilize data from my Ecobee thermostats. Ecobee provides a monthly run-time report, showing my HVAC runtimes and comparing them with a 72 degree benchmark. This is discrete data because it is counts. I was able to gather 25 months of data for the downstairs thermostat and 27 months of data from the upstairs thermostat, for 52 total months (a few months were missing from Ecobee's website).
- **Operational Definition:** I defined a defect as a month where my HVAC runtime exceeded the 72 degree benchmark runtime.
- **Results:** There were three months when my upstairs HVAC units ran for more hours than the 72 degree benchmark (June 2016, Jun 2017, and July 2017). The SQL is 3.1
- **Discussion:** All of my defects were upstairs during the summer months. In order to improve my SQL, I need to take care not to run the air conditioning so much upstairs. Graphically, we can see that I ran my A/C much more upstairs during some months. For example, in July 2017, the upstairs A/C ran 429 hours, almost three times as many hours as the downstairs A/C.

Example Ecobee Runtime Report





SQL	
D =	1
U =	52
D x U =	52
A =	3
A/DU = DPO	0.0577
DPO x 100	5.77
DPO X 1,000,000	57,692
SQL	3.1

Measure: Data Stratification Tree

DMAIC

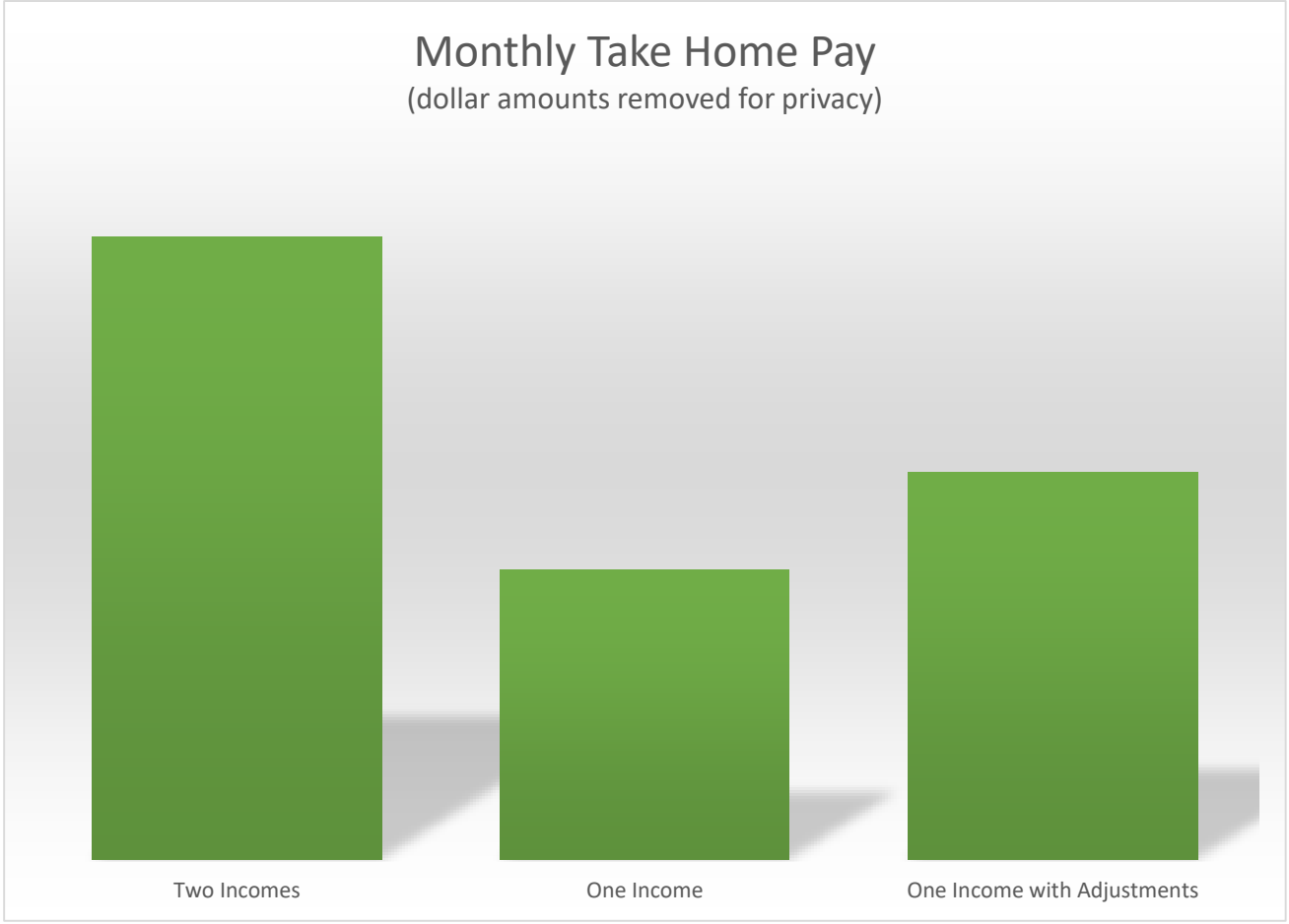
Note: Below is a list of data I set out to gather. It wasn't practical to gather it all, but I do feel that what I was able to gather gave me insights on how to improve my process.

Questions about the Process	X Variables	Measurements
How much can we increase take home pay?	401K witholding	dollars per month
	Tax witholding	dollars per month
How much do we spend on utilites?	Water Bills	Non-Fixed cost per month
	Electric Bills	Non-Fixed cost per month
	Natural Gas Bills	Non-Fixed cost per month
What impacts our utility bills?	Furnace Runtime	Hours / Month, convert into dollars per month
	Air Conditioner Runtime	Hours / Month, convert into dollars per month
	Gas Fireplace Runtime	Hours / Month, convert into dollars per month
	Gallons of water used	Gallons / Month, convert into dollars per month
	Appliance Efficiency	Estimated cost per month based on efficiency
What impacts our Food/Grocery/Shopping expenses?	Non nutritional food expenses such as sodas	dollars per month
	Eating in vs Eating out (includes lunch)	dollars per month
	Buying pre-cut foods, salad kits, single servings	dollars per month
	Buying high end makeup / skin products	dollars per month
	High end salon expenses	dollars per month
	Monthly subscriptions that we don't really use	dollars per month

Measure – Income – Bar Graph

DMAIC

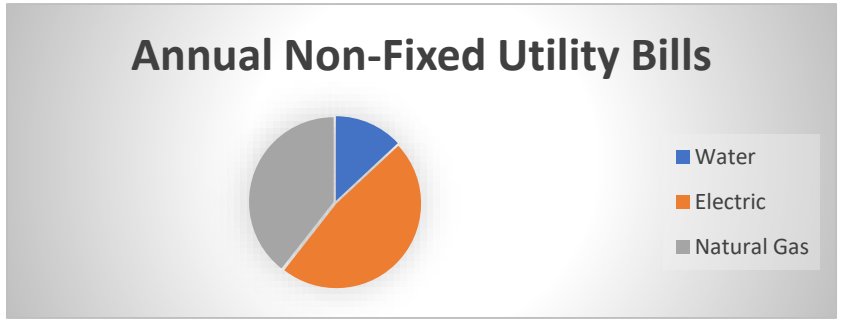
- The first step in my action plan was to measure how much we can increase our take home pay by making adjustments to withholdings.
- **Taxes** - We originally opted to have tax withheld at the single rate with no deductions on one spouse's income, to avoid owing taxes at the end of the year. This made sense for a two income family, but is no longer necessary. Updating our tax withholdings, we can increase our monthly take home by $345.
- **401K** – We were contributing $1,363 per month to a 401K. If we reduce this to $334 per month, we will be able to get the maximum employer match but increase our monthly take home pay by $1,029 per month.
- By changing withholdings, we can increase our take home pay by $1,374 per month.
- Note: It will be important to re-adjust withholdings once we go back to being a two income family.

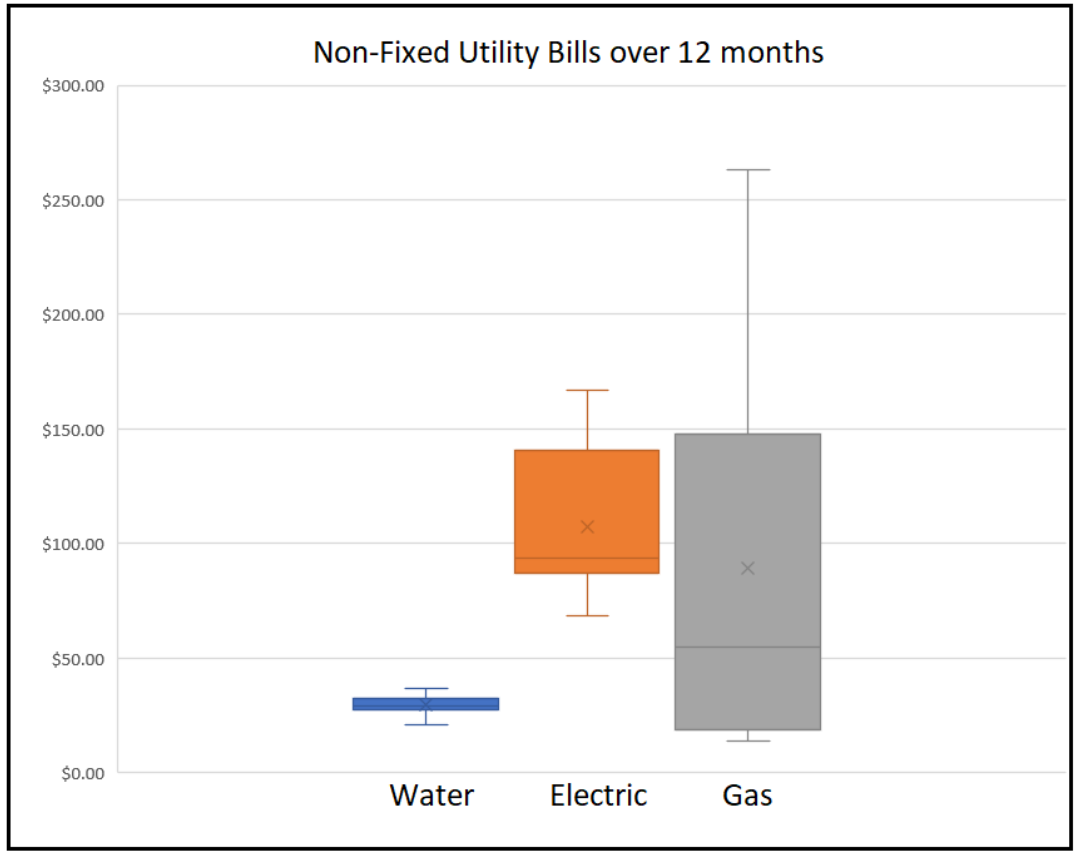


Measure – Utilities - Box and Whiskers / Pie

DMAIC

- One X-Variable addressed in the Data Stratification Tree was utility usage/spending. I used a box and whiskers plot to visualize our non-fixed utility spending from the last 12 months.
- **Water -** there is a fixed cost of $22 per month regardless of usage. The average non-fixed cost is $29 per month, so there are limited savings possibilities. Also of note, there is very little variation in monthly bills due to seasonality.
- **Electric -** there is no fixed cost. The lowest bill was $68 and the highest bill was $167. Is it possible that this $99 variation is due to heavy usage of our air conditioner during warmer months?
- **Natural Gas -** there is a $10 fixed cost. The bill was $14 and the highest bill was $263 (fixed costs have been excluded). Is it possible that this $249 variation is due to heavier usage of our furnace and gas fireplace during colder months?
- Conclusion: Gas and Electric bills have a higher variation than water bills. Also of note, electricity (48%) and gas (39%) usage account for 87% of our annual non-fixed utility bills.



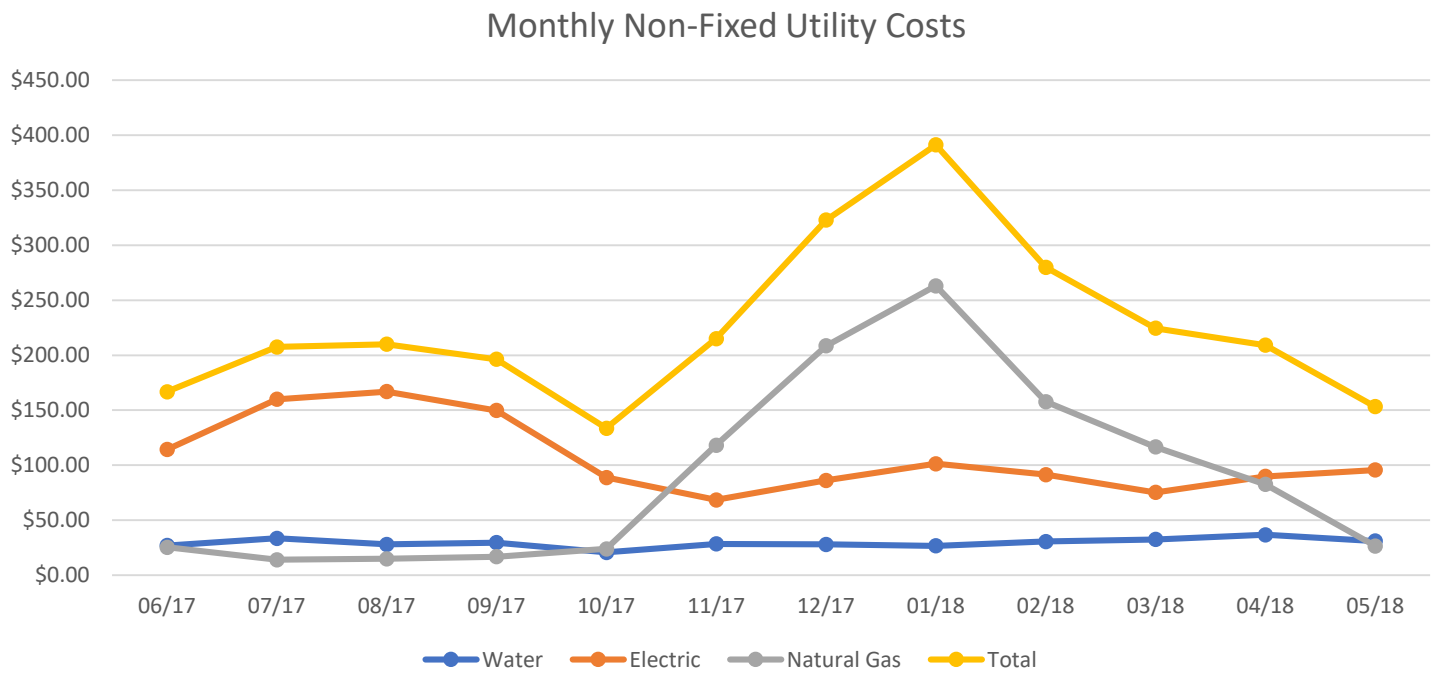


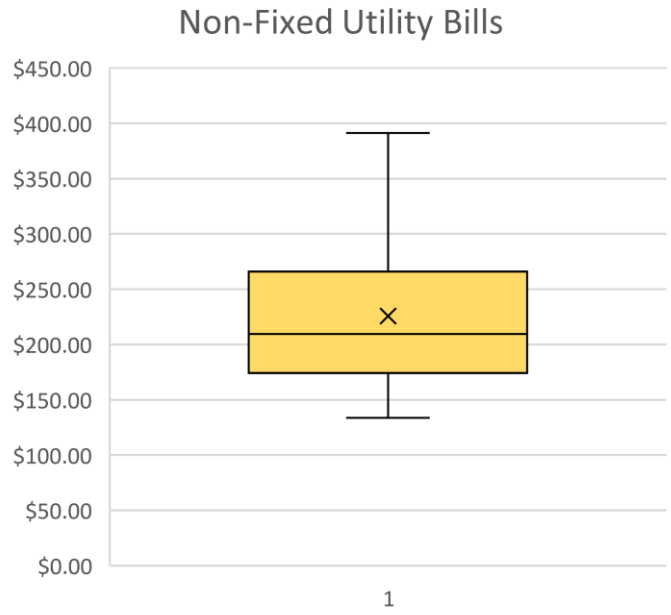
Analyze – Utilities – Line Chart

DMAIC

- The Line Chart below shows that while **Water** bills remain fairly constant, **Electric** and **Natural Gas** bills spike seasonally.
- The spike in **Natural Gas** bill is more pronounced than the spike in the **Electric** bill.
- It is also clear that some months, the **Total** utility bill will be much higher than others, so we need to be prepared for this.

  Although the average monthly cost is $225, it ranges between $134 and $391, for a total range of $257.





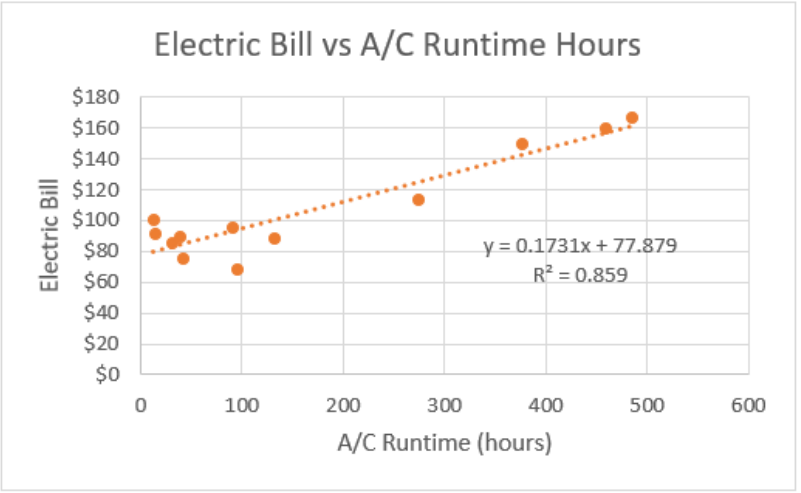
Analyze –Electricity- Scatter Plot / Linear Regression

DMAIC

- **Practical** - Are higher electric bills associated with longer A/C runtimes? Conceptually, it makes sense. I will need to divide up my Ecobee data by Electric bill time period, rather than simply by month before moving forward.
- **Graphical** – If I plot my Electricity data on a graph, I do see what appears to be a positive correlation.
- **Analytical** - I ran a regression using the Electric Bill cost and the A/C runtime for the same date ranges as the Electric Bills. The equation allows me to predict that for every hour I run my A/C, my bill will go up by $0.17. I am 95% confident that the cost is between $.012 and $0.22 per hour.
- **Conclusion:** By setting the thermostat higher in warmer months, my electric bills will be reduced. My model predicts that my A/C usage accounts for $347 of my annual electric bill, or 27%. However, during some months, it accounts for nearly 50%.
- **Sample Size Discussion:** The 95% confidence interval for this data was 0.12, 0.22. I am satisfied with this, so I'm concluding that my sample size is adequate. If I were not satisfied with my confidence interval, I would need to increase my sample size.

Simple Linear Regression

Time Period	A/C Runtime	Electric Bill
May 6 to Jun 6	273	$114
Jun 7 to Jul 7	458	$160
Jul 8 to Aug 4	484	$167
Aug 5 to Sep 7	376	$150
Sep 8 to Oct 5	131	$89
Oct 6 to Nov 3	95	$68
Nov 4 to Dec 5	31	$86
Dec 6 to Jan 5	12	$101
Jan 6 to Feb 6	14	$91
Feb 7 to Mar 7	41	$75
Mar 8 to Apr 5	38	$90
Apr 6 to May 4	91	$96



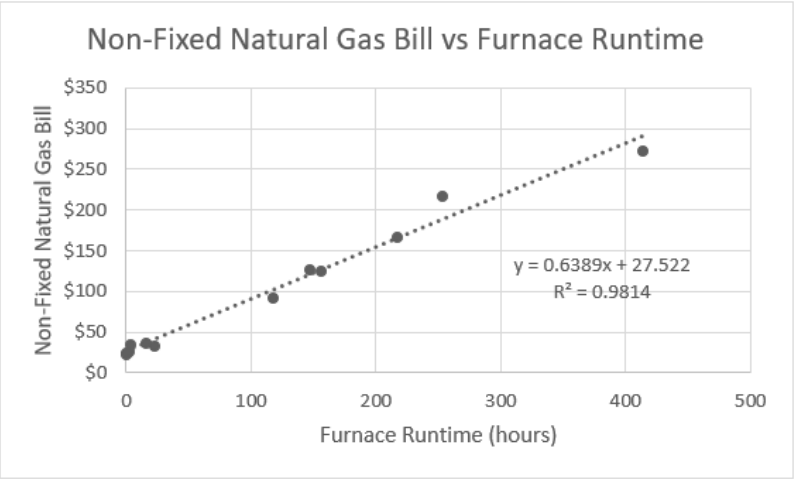
Correlation	0.93	There is a relationship
R Squared	0.86	Proportion of variation in Electric Bill that can be explained by variation in A/C Runtime.
X Variable P-Value	1.46E-05	This number is small enough that we can conclude A/C Runtime has significance
Confidence Interval	0.12, 0.22	We are 95% confident that the slope of the regression line is between these values.
Residual R Squared	3.00E-31	Our residuals are random, so the data set is appropriate for a regression

Analyze – Gas- Scatter Plot / Linear Regression

DMAIC

- **Background:** I was surprised that Electric Bill wasn't correlated more strongly with A/C Runtime hours, and wanted to create the same type of model for Natural Gas, to see how it compared.
- **Result:** After running the regression, I can predict that for ever hour I run my furnace, my bill will go up by $0.64.
- **Comparison to Electricity:** It is of note that there is a stronger relationship between gas bill and gas usage (0.99 vs 0.93), and the proportion of variation of the bill that can be explained by HVAC usage is higher for gas (0.98 vs 0.86). The estimated cost per hour of run time is much higher ($0.64 vs $0.17).
- **Conclusion:** By setting the thermostat lower in cooler months, my gas bills will be reduced. My model predicts that my Furnace usage accounts for $858 of my annual gas bill, or 72%.

Time Period	Furnace Runtime (in hours)	Non-Fixed Natural Gas Bill
5/19 to 6/21	3	$35
6/22 to 7/20	0	$24
7/21 to 8/21	0	$25
8/22 to 9/20	2	$27
9/21 to 10/21	22	$34
10/22 to 11/18	147	$128
11/19 to 12/18	253	$219
12/19 to 1/19	413	$273
1/20 to 2/19	217	$168
2/20 to 3/20	156	$127
3/21 to 4/21	117	$93
4/22 to 5/21	15	$37



Correlation	0.99	There is a strong relationship
R Squared	0.98	Proportion of variation in non-fixed gas Bill that can be explained by variation in Furnace runtime.
X Variable P-Value	5.48E-10	This number is small enough that we can conclude Furnace Runtime has significance
Confidence Interval	.58, .70	We are 95% confident that the slope of the regression line is between these values.
Residual R Squared	9.00E-30	Our residuals are random, so the data set is appropriate for a regression

Improve – Process Map

DMAIC

- The new overall process requires that we pay more attention to what we are spending/being charged, and making adjustments to reduce spending. I've started to really dig into the MINT records so expenses could be properly categorized. It needs to be a continual process of looking for ways to reduce consumption.
- It is already paying off in the following ways:
  - I found a credit card charge of **$622** for a hotel stay in May. My husband thought that work was paying for the stay and he just gave his card for incidentals, but we were charged for the stay! After I found the charge, we were able to get his company to reimburse us for the charge.
  - I found four subscriptions that we were paying for but weren't really using. We were able to cancel the subscriptions, saving $73/month (**$876**/yr).

New Process

Take-home pay is determined by benefits selected during annual open enrollment, tax marital status/exemptions, and 401K contributions.

→

Take-home pay is direct deposited into a checking account. One job deposits every two weeks. The other job deposits on the 15th and 30th of each month.

→

There are bills / expenses throughout the month. Some are automatically drafted from checking or automatically charged to a credit card.

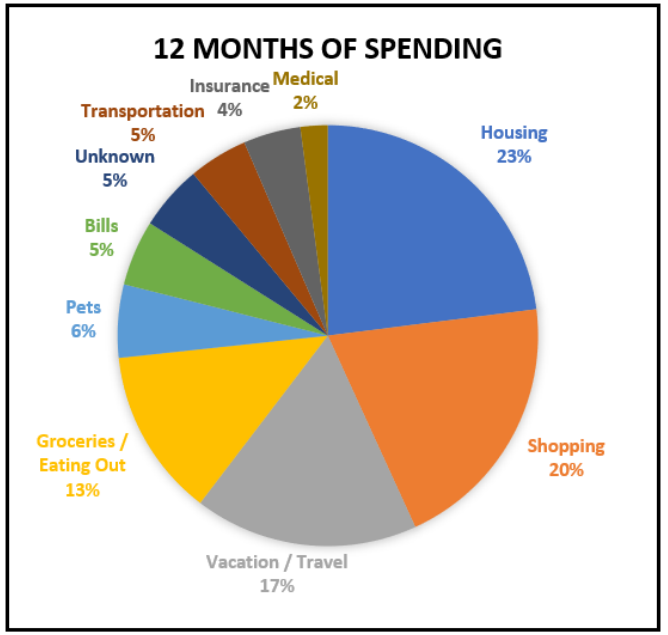
Once per month, constant:	Once per month, variable:	Throughout the month, variable:
Mortgage, Car payment, Life Insurance, Cell phone, Internet, HBO, Netflix, Google Music, Pest Control.	Water Electricity Natural Gas	Gas for cars, Food, Shopping, Movies/rentals, etc.

↓

Throughout the month, pay attention to consumption. Try to spend less when possible. Pay attention to prices while shopping. Take advantage of sales and coupons.

↓

At the end of the month, measure how much money was spent, and on what. Compare spending with budget. Flag items that caused us to go over budget, or have a "near miss." Make a plan to reduce consumption the next month. **Never stop improving!** If we were significantly above or below budget, move money from savings to checking or vice versa.



Improve

DMAIC

- **Implemented**
  - Withholdings – By reducing withholdings, we increased our take home pay by $1,374 per month (**$16,488** per year).
  - Food – I've moved to making my own pasta lunch ($.50 per serving) rather than buying pre-packaged frozen means ($3/serving). I've determined that I can save up to $75 per month this way (up to **$900** per year).
  - Utilities– I tend to reduce the upstairs thermostat temperature at night, because I find it difficult to sleep if I feel too warm. I don't always think to turn it back up during the day, and cool upstairs an unnecessary amount during the day, when no one is upstairs. I have programmed my upstairs thermostat to decrease the temperature to 72 degrees at night and allow the temperature to increase to 75 degrees during the day.
- **Plan to implement**
  - Salon – I spent $1,569 at the salon over the past 12 months (data collected from Mint). I was getting multiple services every 6 weeks, but I've decided to space out some services to every 12 weeks. My plan will save **$595** per year.
  - Cat Food – I spent $396 on 81 lbs high-end dry cat food during the past 12 months (data collected from Amazon.com). I plan on switching to a grocery store brand, and 81 lbs will only cost $208, saving me **$188** over the course of the next year.
  - Gas Fire Place: I estimate that I will save **$84** per month by not using my gas fireplace this winter (we used it a lot last winter).
- **Not Implemented**
  - I have been trying to grow Zucchini in order to reduce my food costs, and for fun, but I think the squirrels are sabotaging me. I've decided that the amount of money I could save on food is not enough to offset the cost of buying a protective housing for the plans. The squirrels win this one.
  - I did do some measurements around appliance efficiency, but after seeing the numbers, I decided that many of my appliances were pretty efficient, and there's not much money to be saved by taking shorter showers or turning the hot water heater temperature down.

X Variables	Estimated Monthly Energy Cost
Dishwasher	$2.17 (based on EnergyGuide)
Clothes Washer	$0.75 (based on EnergyGuide)
Hot Water Heater	$22.67 (based on EnergyGuide)
Fridge/Freezer	$6.58 (based on EnergyGuide)

Control

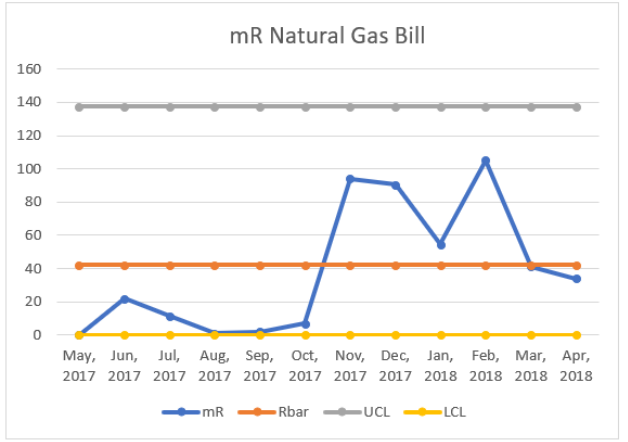
DMAIC

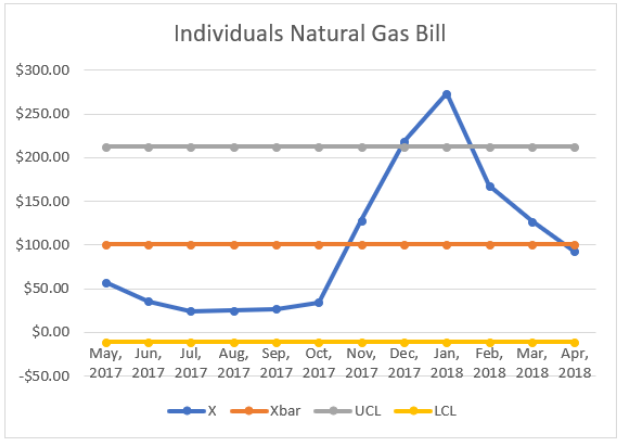
Moving Range:

- I decided to utilize a Moving Range control chart to look at my Natural Gas bills, and I found that the months of December and January were not in control.
- If I want to reduce the variability in my gas bill, I need to run my Furnace and Gas Fireplace less in the cold months.
- After I implement my plan of not running the gas fireplace this coming winter, I can re-evaluate using a Moving Range chart and see if I was able to stay in control.

Final Words:

- I need to continue looking for ways to reduce spending if I am going to be successful in living on a significantly reduced take home pay for the next 12 months without incurring debt.
- Once we are a two income family again, we won't have to go to such extremes, but there are significant benefits to continuing to keep spending down. The less we spend today, the more money we can save for retirement. The smaller our "required income" during retirement is, the sooner we'll have enough saved to retire. I'm not in a rush to retire, but being financially independent enough *to be able* to retire gives great peace of mind.
- In conclusion, this needs to be an ongoing, lifelong project.
- Never Stop Improving!





n=1

Moving Range

Gas Bill Date	Amount	mR	Rbar	UCL	LCL
May, 2017	$57.28	NO VALUE	42.0755	137.5867	0
Jun, 2017	$35.42	21.86	42.0755	137.5867	0
Jul, 2017	$24.01	11.41	42.0755	137.5867	0
Aug, 2017	$24.96	0.95	42.0755	137.5867	0
Sep, 2017	$26.88	1.92	42.0755	137.5867	0
Oct, 2017	$33.93	7.05	42.0755	137.5867	0
Nov, 2017	$128.19	94.26	42.0755	137.5867	0
Dec, 2017	$218.58	90.39	42.0755	137.5867	0
Jan, 2018	$273.11	54.53	42.0755	137.5867	0
Feb, 2018	$167.79	105.32	42.0755	137.5867	0
Mar, 2018	$126.65	41.14	42.0755	137.5867	0
Apr, 2018	$92.65	34.00	42.0755	137.5867	0
	Rbar =	42.1			

UCL = D_4 * Rbar	137.58674
LCL = D_3 * Rbar	0

Individuals

X	Xbar	UCL	LCL
$57.28	100.7875	212.7082	-11.1332
$35.42	100.7875	212.7082	-11.1332
$24.01	100.7875	212.7082	-11.1332
$24.96	100.7875	212.7082	-11.1332
$26.88	100.7875	212.7082	-11.1332
$33.93	100.7875	212.7082	-11.1332
$128.19	100.7875	212.7082	-11.1332
$218.58	100.7875	212.7082	-11.1332
$273.11	100.7875	212.7082	-11.1332
$167.79	100.7875	212.7082	-11.1332
$126.65	100.7875	212.7082	-11.1332
$92.65	100.7875	212.7082	-11.1332
Xbar =	100.8		

UCL = ar + E_2 * Rbar	212.7082
LCL = ar - E_2 * Rbar	-11.1332