Commercial Sales Forecasting

A structured modeling approach

Eric Fox and Mike Russo

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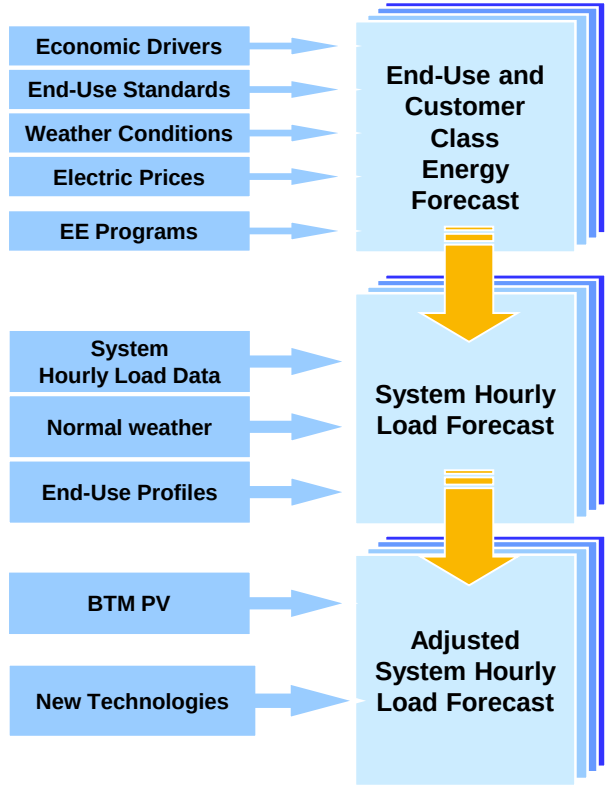
June 28th , 2021

NYISO BOTTOM-UP SYSTEM FORECAST

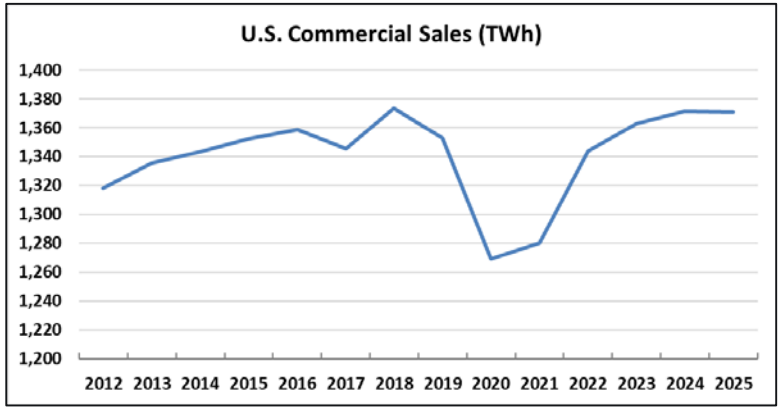
Monthly sales and customer models are estimated for:
- Residential
- Commercial
- Industrial
- Street Lighting

Monthly peak model driven by end-use energy forecasts

Hourly load models that incorporate the impact of new technologies:
- Behind the meter solar
- Cold climate heat pumps
- Electric vehicles
- Battery storage
- Other?

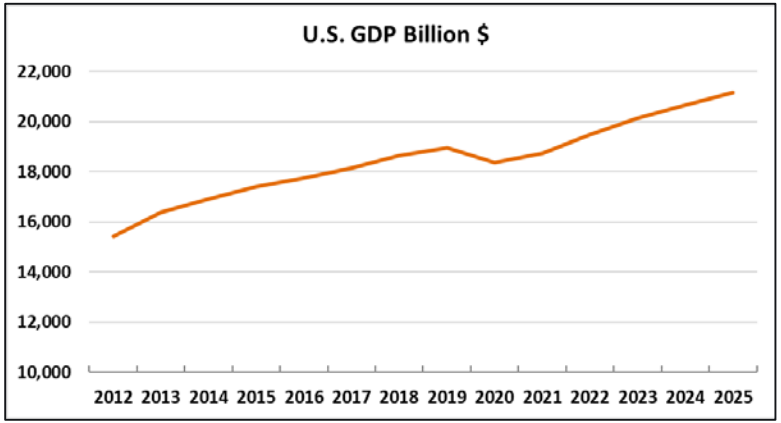


COMMERCIAL SALES VS GDP



Before COVID19, commercial sales Have been averaging 0.5% annual growth

Between 2012 and 2019, commercial sales increased 2.6% while GDP is up 22%.



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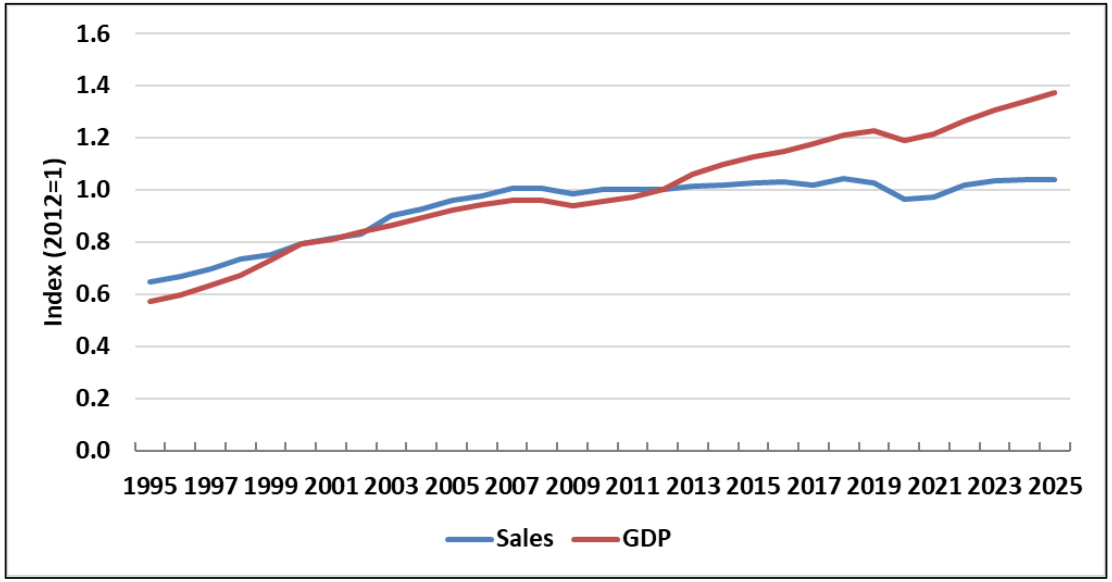
COMMERCIAL SALES VS GDP



Through most of history there was a strong correlation between sales and GDP. A simple model that related commercial sales to GDP worked well.

Started breaking down starting in 2012.

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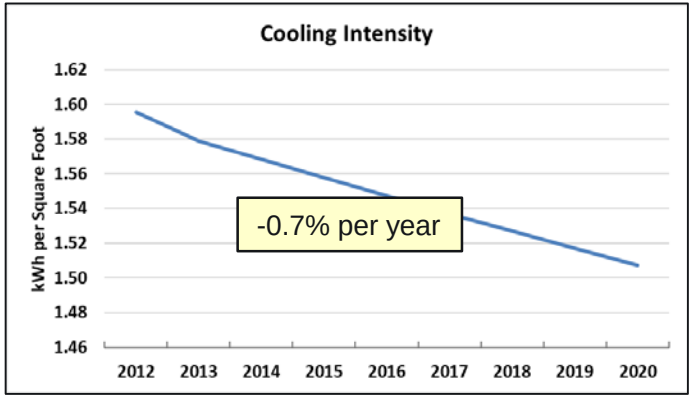
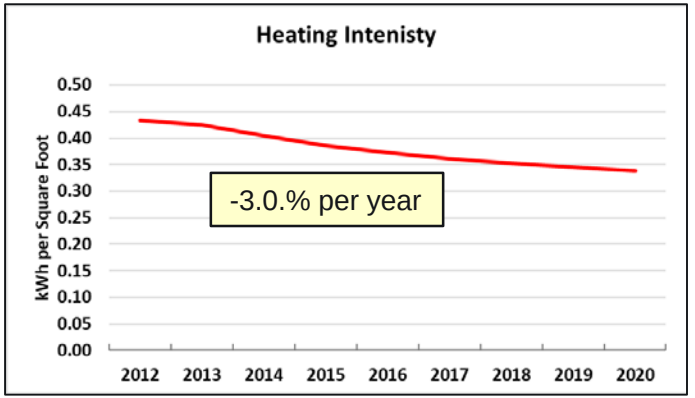
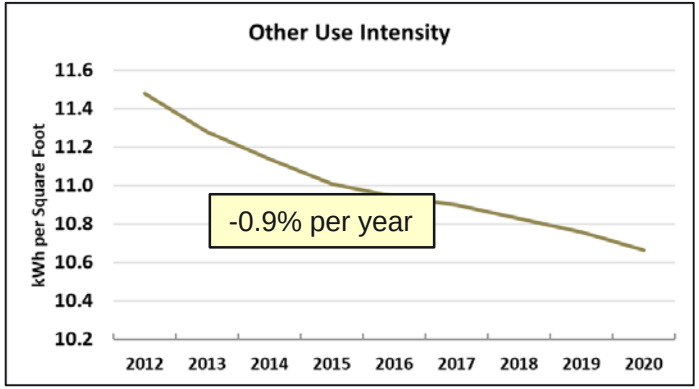
WHY THE BREAKDOWN?
SIGNIFICANT INCREASE IN ENERGY EFFICIENCY







Total US commercial energy intensity is 7.4% lower than it was in 2012.

Need to account for efficiency in the forecast model

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THE COMMERCIAL SECTOR

Building Types

- Assembly
- Education
- Food Sales
- Food Services
- Health Care
- Lodging
- Small Office
- Large Office
- Merchant/Services
- Warehouses
- Other

End-Uses

- Heating
- Cooling
- Ventilation
- Water Heating
- Cooking
- Refrigeration
- Lighting
- Office Equipment (PCs)
- Miscellaneous

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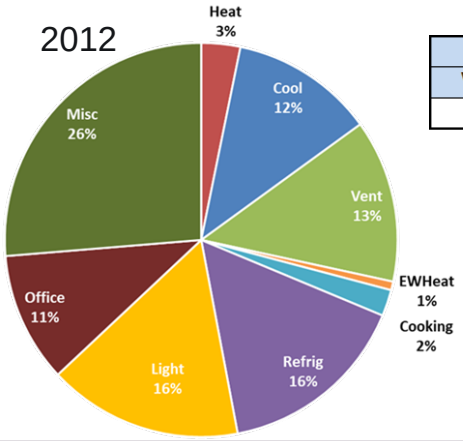
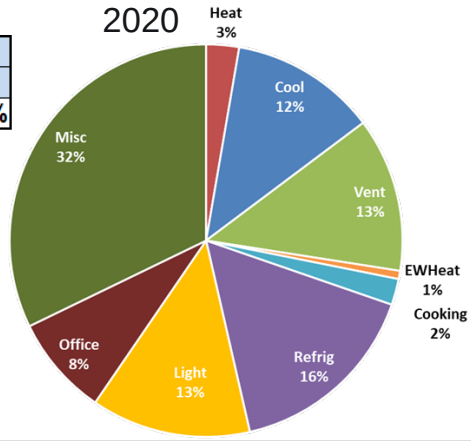
U.S. COMMERCIAL END-USE INTENSITIES (CBECS, 2012)

kWh per Square Foot

Building Type	Assembly	Education	Food Sales	Food Service	Health Care	Lodging	Large Office	Small Office	Merc/Service	Warehouse	Other	All Buildings
Heating	0.37	0.51	0.70	1.07	0.62	0.78	0.42	0.48	0.42	0.15	0.22	0.42
Cooling	1.53	2.09	1.82	4.74	6.37	1.62	1.96	1.31	1.23	0.55	0.77	1.58
Ventilation	0.61	1.34	3.18	5.21	5.37	1.91	4.86	2.63	1.46	0.17	0.49	1.79
WtrHeat	0.02	0.16	0.06	0.52	0.29	0.30	0.03	0.03	0.09	0.01	0.05	0.09
Cooking	0.09	0.08	2.11	8.10	0.75	0.45	0.06	0.02	0.03	0.00	0.05	0.29
Refrig	0.79	0.88	42.12	19.66	2.18	1.74	0.60	0.44	2.59	0.56	0.50	2.11
Lighting	0.88	1.78	4.72	2.70	4.90	1.83	3.08	1.97	2.77	1.44	1.44	2.08
Office	0.42	1.76	1.19	0.81	2.43	0.32	3.21	2.57	0.80	0.41	1.22	1.31
Misc	3.36	3.23	5.38	5.99	4.96	7.08	3.65	3.30	3.88	2.06	2.90	3.60
Total	8.07	11.83	61.29	48.80	27.86	16.04	17.87	12.75	13.28	5.35	7.63	13.28



Avg Annual Growth Rate (2012-20)						
Vent	EWHeat	Cooking	Refrig	Light	Office	Misc
-1.6%	-1.4%	-1.0%	-0.7%	-3.4%	-4.1%	1.6%



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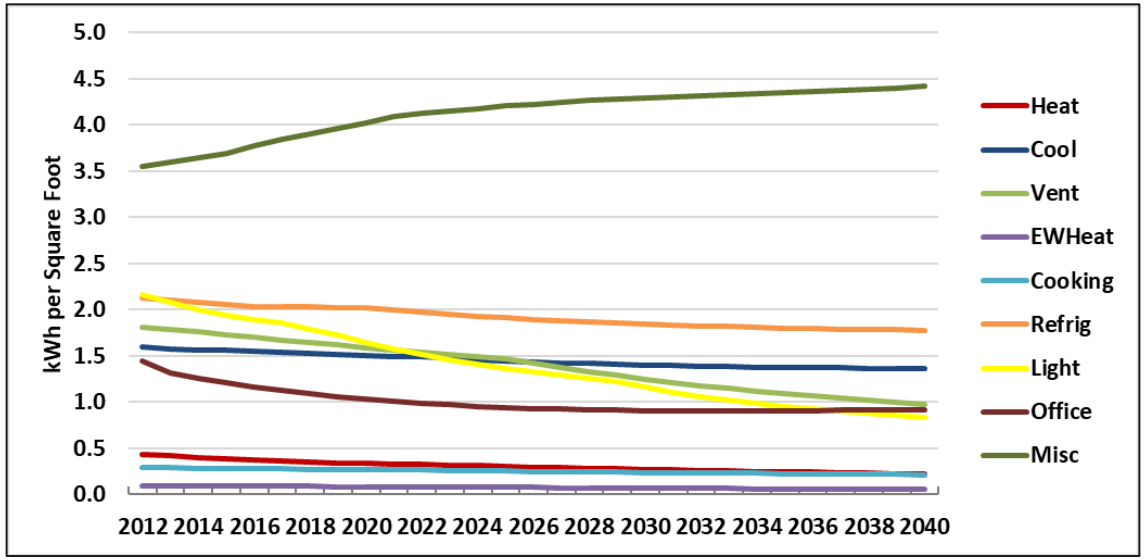
COMMERCIAL END-USE INTENSITY PROJECTIONS (2021 AEO)



» Miscellaneous is the only end-use showing positive growth:

- Non-PC office equipment (servers, mainframe computers)
- Other equipment (elevators, medical imaging equipment, etc.)

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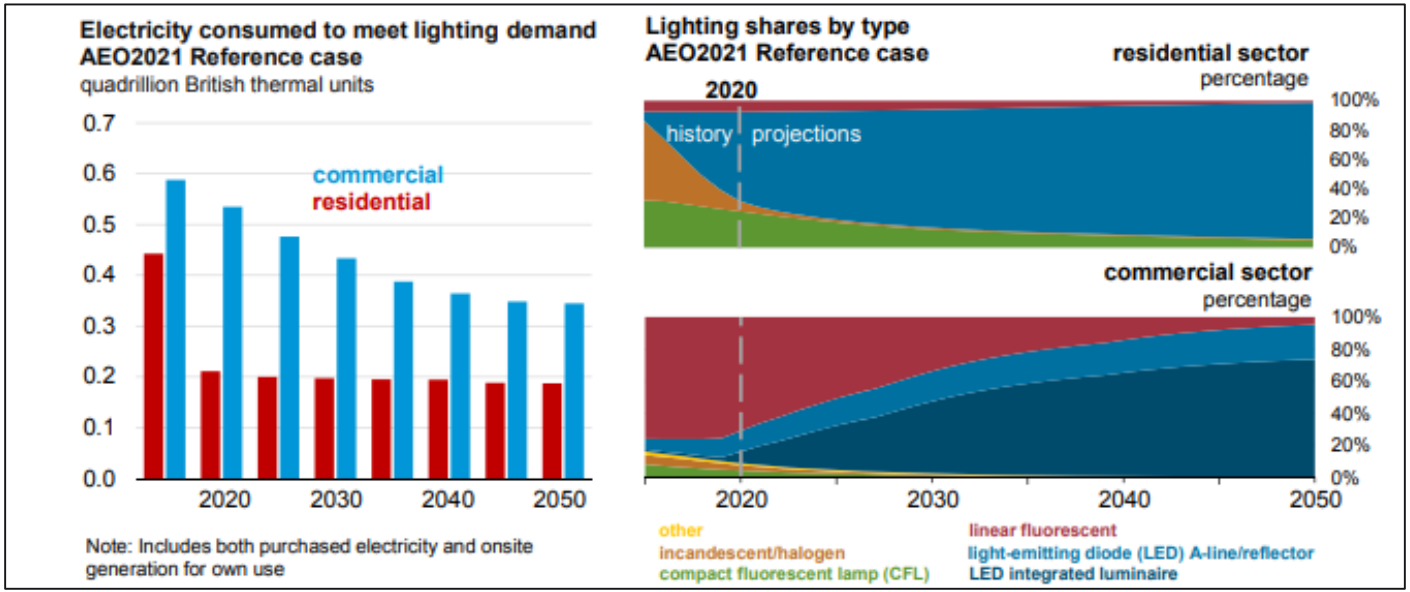
LARGE POTENTIAL LIGHTING SAVINGS



Source: U.S. Energy Information Administration, Annual Energy Outlook 2021

Unlike residential lighting, where LED penetration is nearly complete, the commercial sector still has room for large efficiency improvements.

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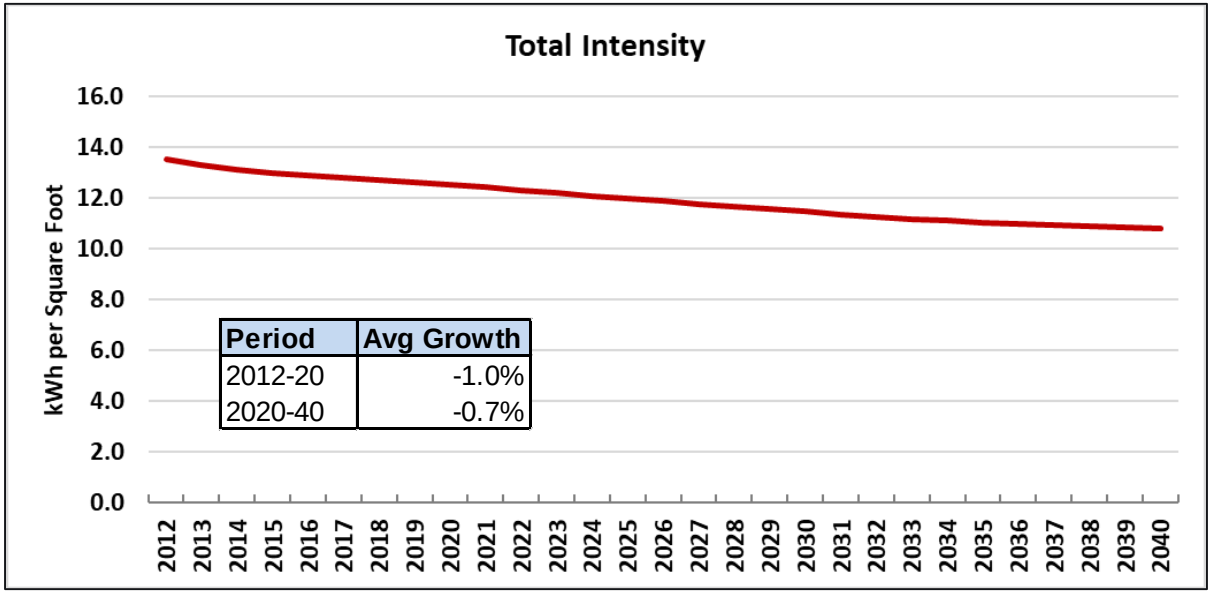
COMMERCIAL U.S. ENERGY INTENSITY (2021 *ANNUAL ENERGY OUTLOOK*)



Period	Avg Growth
2012-20	-1.0%
2020-40	-0.7%

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COMMERCIAL END-USE MODEL FRAMEWORK

1. $$Sales_{et} = EI_{et} \times SqFt_{et} \times Utilization_{et}$$

2. $$EI_{et} = \left(\frac{kWh}{SqFt}\right)_{et}$$

3. $$SqFt_t = f(Employment_t, Output_t)$$

4. $$Utilization_t = f(Output_t, HrsLight_t, CDD_t)$$

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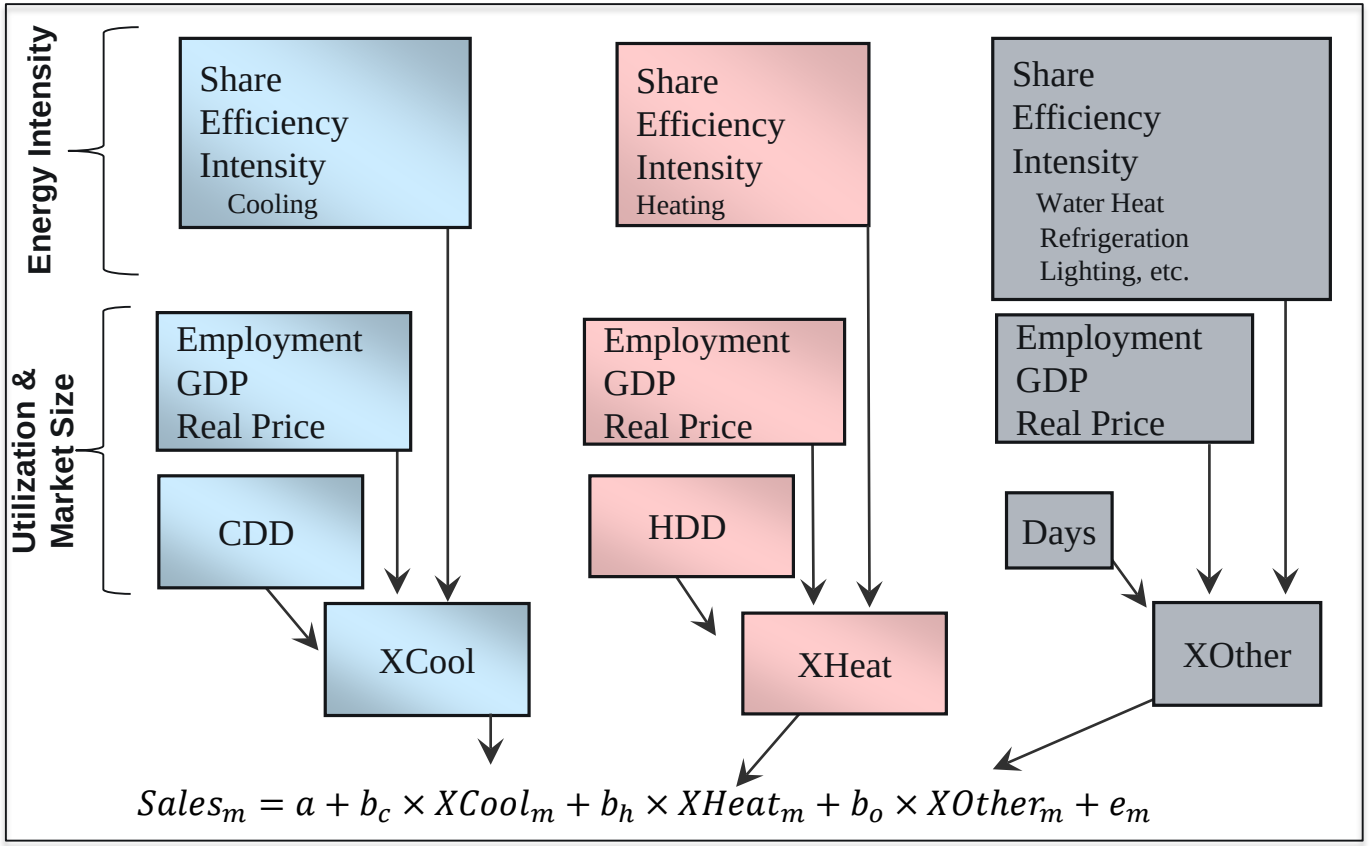
COMBINING END-USE AND STATISTICAL-BASED MODELS



COMMERCIAL MODEL: *XCOOL*

$$Sales_m = b_0 + b_1 \times XCool_m + b_2 \times XHeat_m + b_3 \times XOther_m$$

$$XCool_m = CoolIndexy \times CoolUse_m$$

$$CoolIndex_y = CoolkWh_{2012} \times \left(\frac{CoolEI_y}{CoolEI_{2012}}\right)$$

$$CoolUse_m = \left(\frac{CDD_m}{CDD_{2012}}\right) \times \left(\frac{Output_m}{Output_{2012}}\right)^{0.60} \times \left(\frac{\mathrm{Pr}\,ice_m}{\mathrm{Pr}\,ice_{2012}}\right)^{-0.10}$$

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COMMERCIAL MODEL: *XOTHER*

$$Sales_m = b_0 + b_1 \times XCool_m + b_2 \times XHeat_m + b_3 \times XOther_m$$

$$XOther_m = OtherIndex_y \times OtherUse_m$$

$$OtherIndex_y = OtherkWh_{2012} \times \left(\frac{OtherEI_y}{OtherEI_{2012}}\right) \times (month_fraction_m)$$

$$OtherUse_m = \left(\frac{BDays_m}{30.5}\right) \times \left(\frac{Output_m}{Output_{2012}}\right)^{0.60} \times \left(\frac{\mathrm{Price}_m}{\mathrm{Price}_{2012}}\right)^{-0.10}$$

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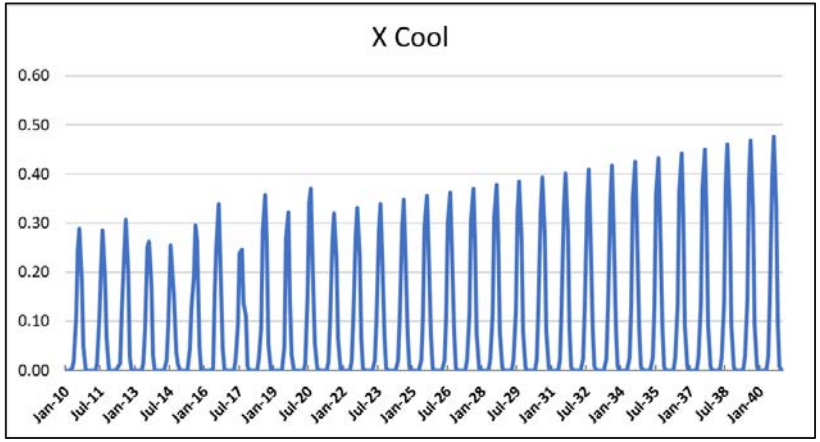
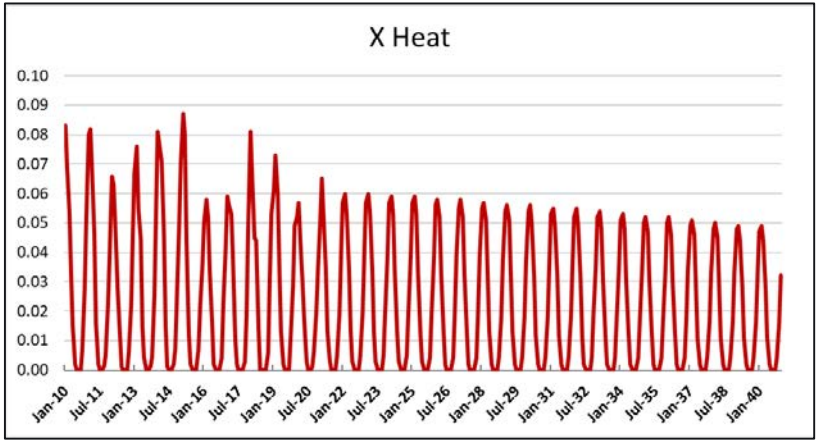
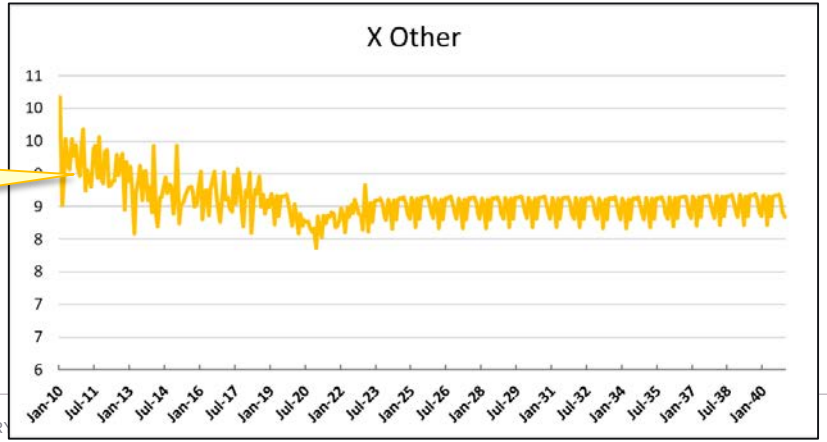
MODEL VARIABLES





Noise in Xother reflects variation in billing days



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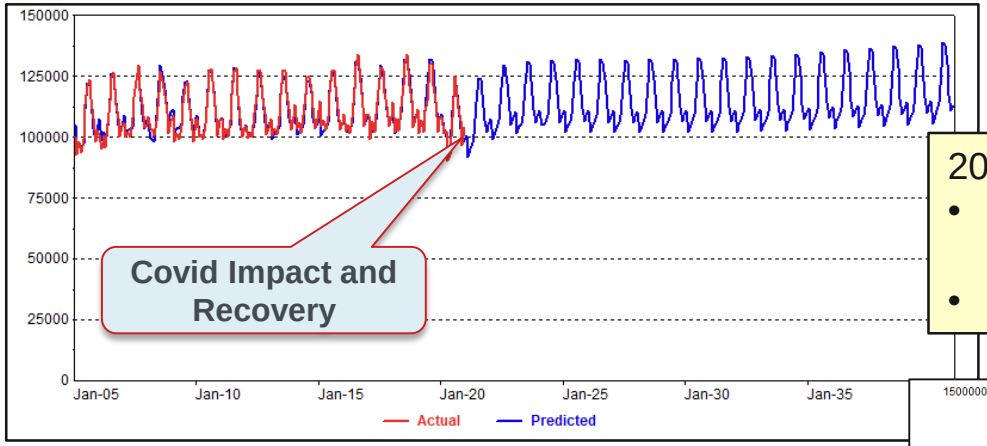
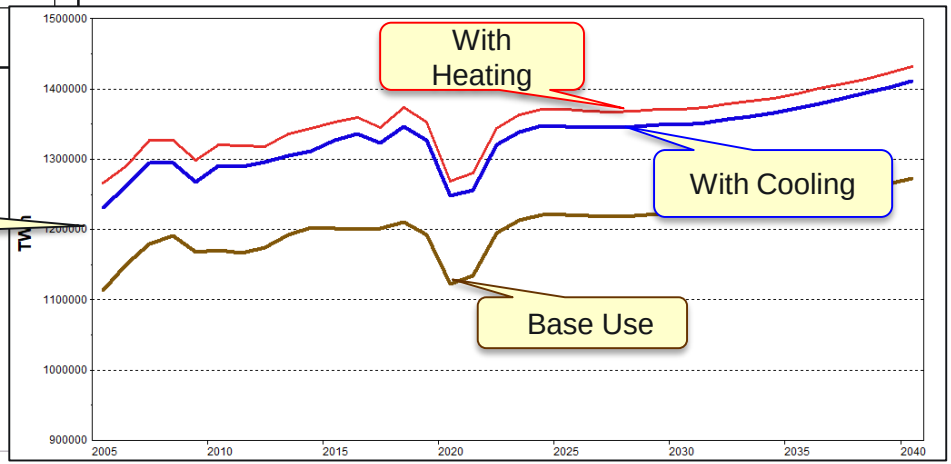
2021 U.S. COMMERCIAL SALES FORECAST



2020 to 2030:

- Sales growth 0.8% per year
  (0.3% growth excluding Covid recovery)
- GDP growth 2.4% per year

Estimated model can be used to breakout base, heating, and cooling sales



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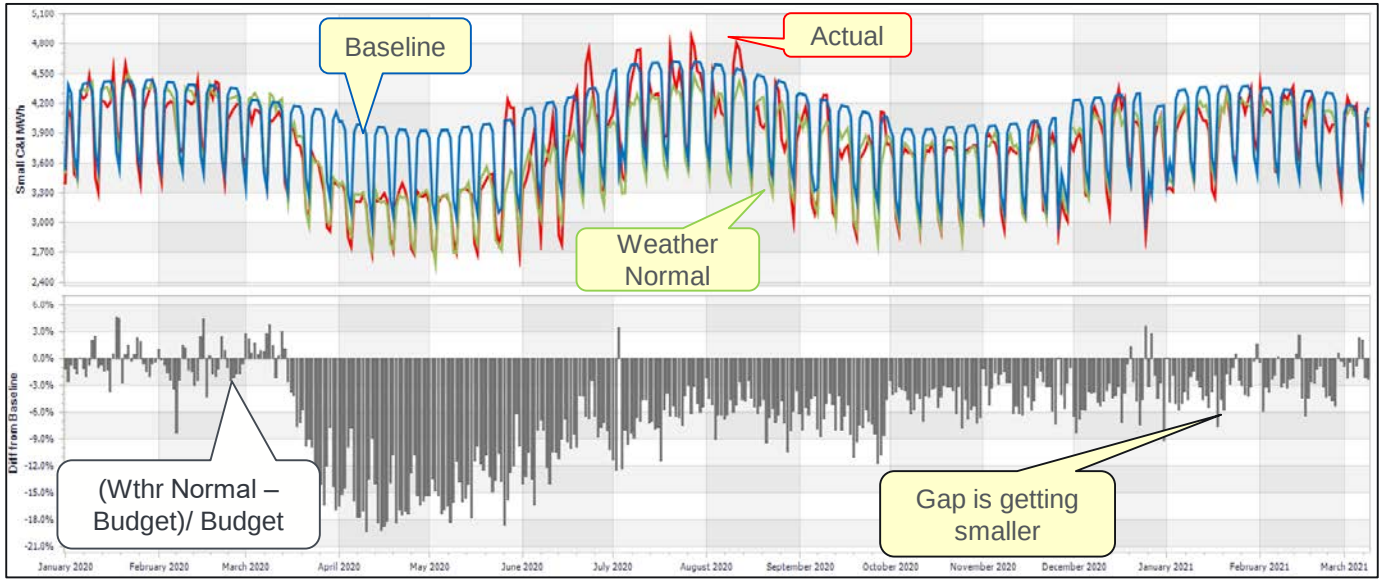
COVID19 IMPACT ON COMMERCIAL SALES



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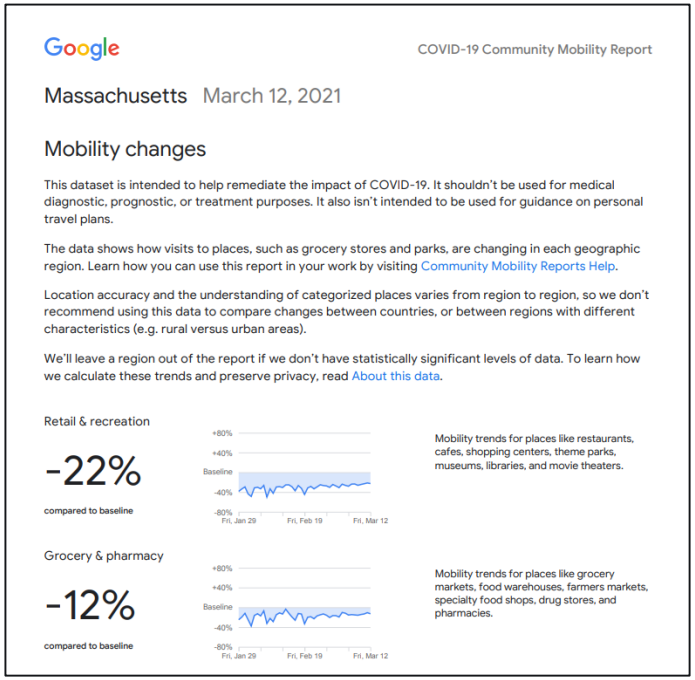
CONSTRUCT COVID VARIABLE FROM GOOGLE MOBILITY DATA

GOOGLE MOBILITY REPORT



Google

COVID-19 Community Mobility Report

Massachusetts March 12, 2021

Mobility changes

This dataset is intended to help remediate the impact of COVID-19. It shouldn't be used for medical diagnostic, prognostic, or treatment purposes. It also isn't intended to be used for guidance on personal travel plans.

The data shows how visits to places, such as grocery stores and parks, are changing in each geographic region. Learn how you can use this report in your work by visiting Community Mobility Reports Help.

Location accuracy and the understanding of categorized places varies from region to region, so we don't recommend using this data to compare changes between countries, or between regions with different characteristics (e.g. rural versus urban areas).

We'll leave a region out of the report if we don't have statistically significant levels of data. To learn how we calculate these trends and preserve privacy, read About this data.

Retail & recreation

-22%

compared to baseline

+80% +40% Baseline -40% -80% Fri, Jan 29 Fri, Feb 19 Fri, Mar 12

Mobility trends for places like restaurants, cafes, shopping centers, theme parks, museums, libraries, and movie theaters.

Grocery & pharmacy

-12%

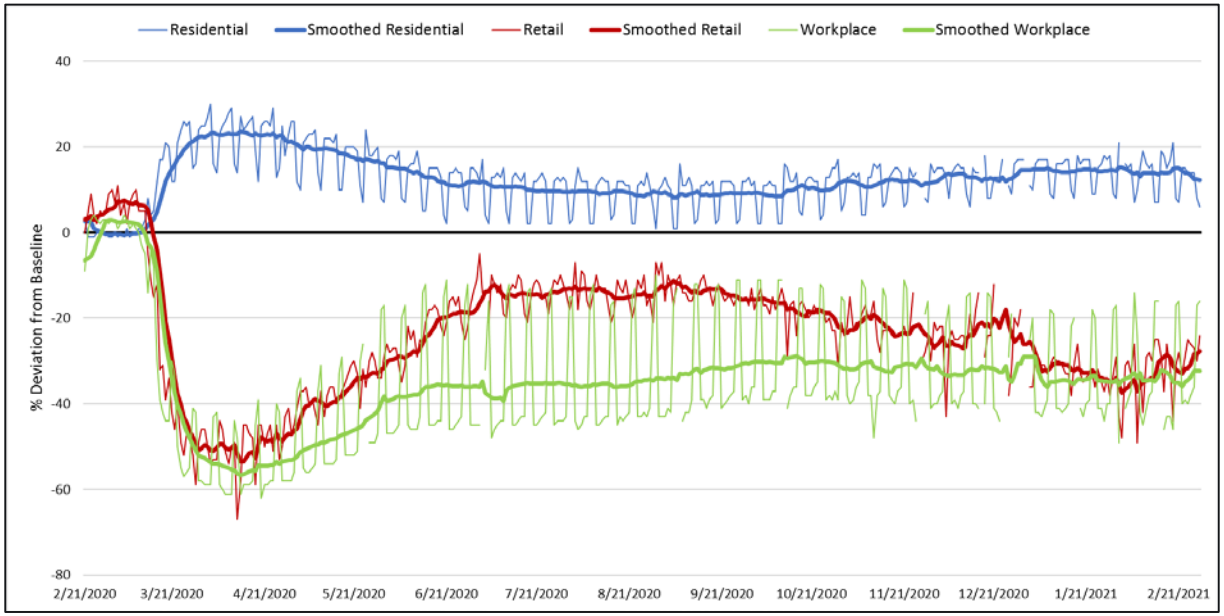
compared to baseline

+80% +40% Baseline -40% -80% Fri, Jan 29 Fri, Feb 19 Fri, Mar 12

Mobility trends for places like grocery markets, food warehouses, farmers markets, specialty food shops, drug stores, and pharmacies.

- » Uses cell phone location data to show how visits to places have changed in reference to a pre-COVID baseline
- » Country, State, County level data
- » Daily data for 6 “place/location” categories
  - Retail & Recreation*
  - Grocery & Pharmacy
  - Parks
  - Transit Stations
  - Workplaces*
  - Residential*

GOOGLE MOBILITY DATA



» Generate indices from seven day moving average.

- For commercial sales, weighting the retail and workplace indices.

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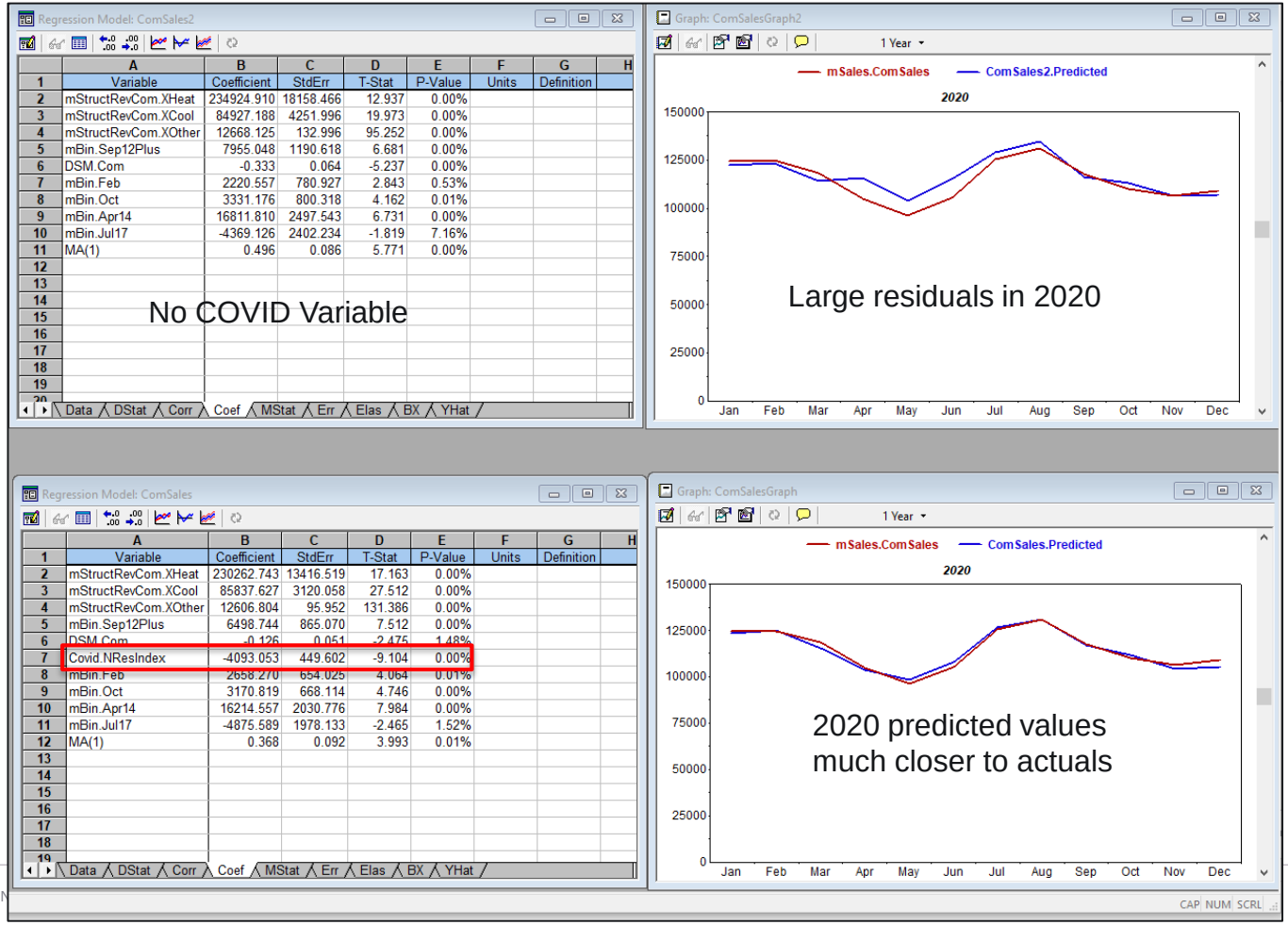
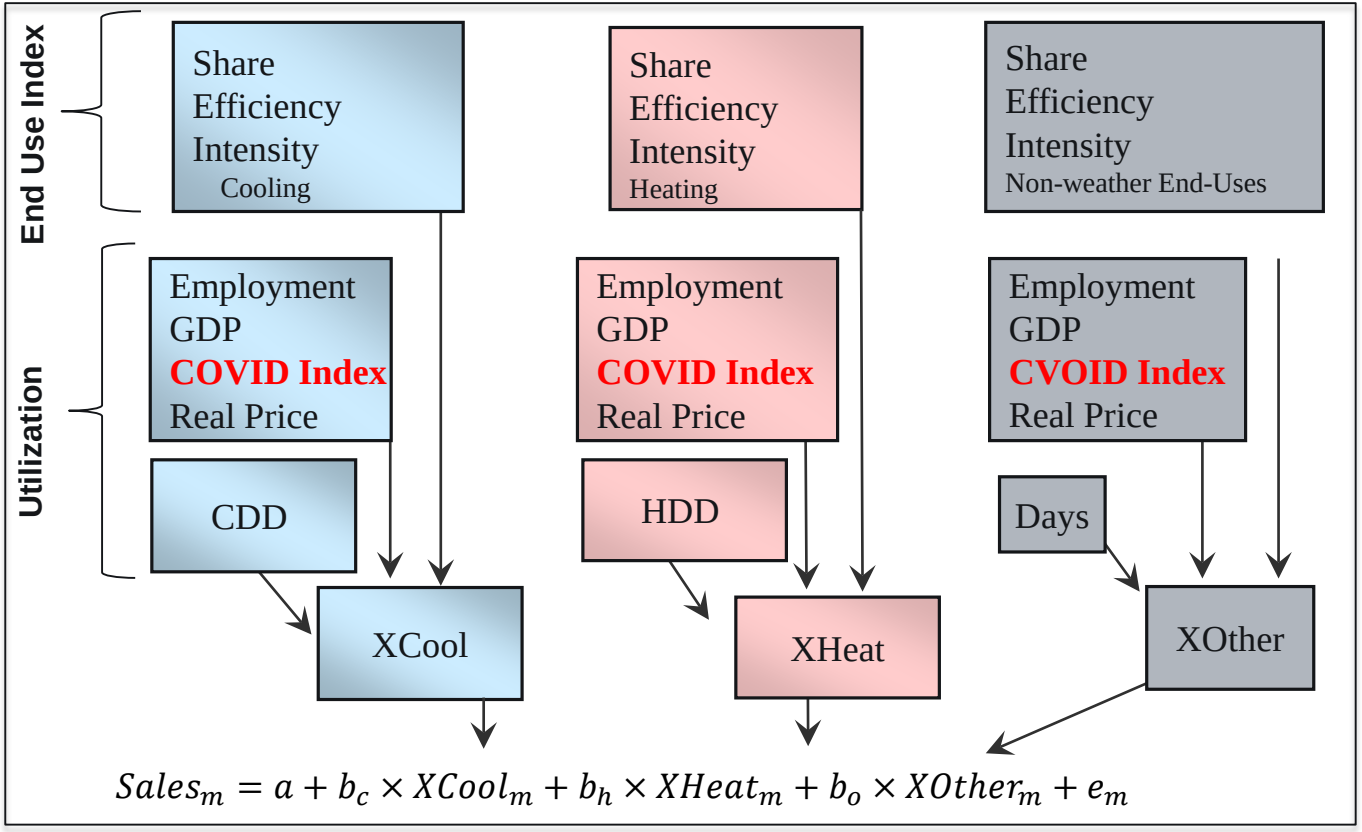
COMMERCIAL SALES MODEL WITH COVID VARIABLE



INTEGRATING COVID IMPACT THROUGH THE END-USE VARIABLES



COMMERCIAL COOLING VARIABLE (XCOOL)

$$Sales_m = b_0 + b_1 \times XCool_m + b_2 \times XHeat_m + b_3 \times XOther_m$$

$$XCool_m = CoolIndex_y \times CoolUse_m$$

$$CoolIndex_y = CoolkWh_{2012} \times \left(\frac{CoolEI_y}{CoolEI_{2012}}\right)$$

$$CoolUse_m = \left(\frac{BDays_m}{30.5}\right) \times \left(\frac{CDD_m}{CDD_{2012}}\right) \times \left(\frac{Output_m}{Output_{2012}}\right)^{0.60} \left(\frac{COVIDIndex_{y,m}}{COVIDIndex_{BaseYear}}\right)^{0.6} \times \left(\frac{\mathrm{Price}_m}{\mathrm{Price}_{2012}}\right)^{-0.10}$$

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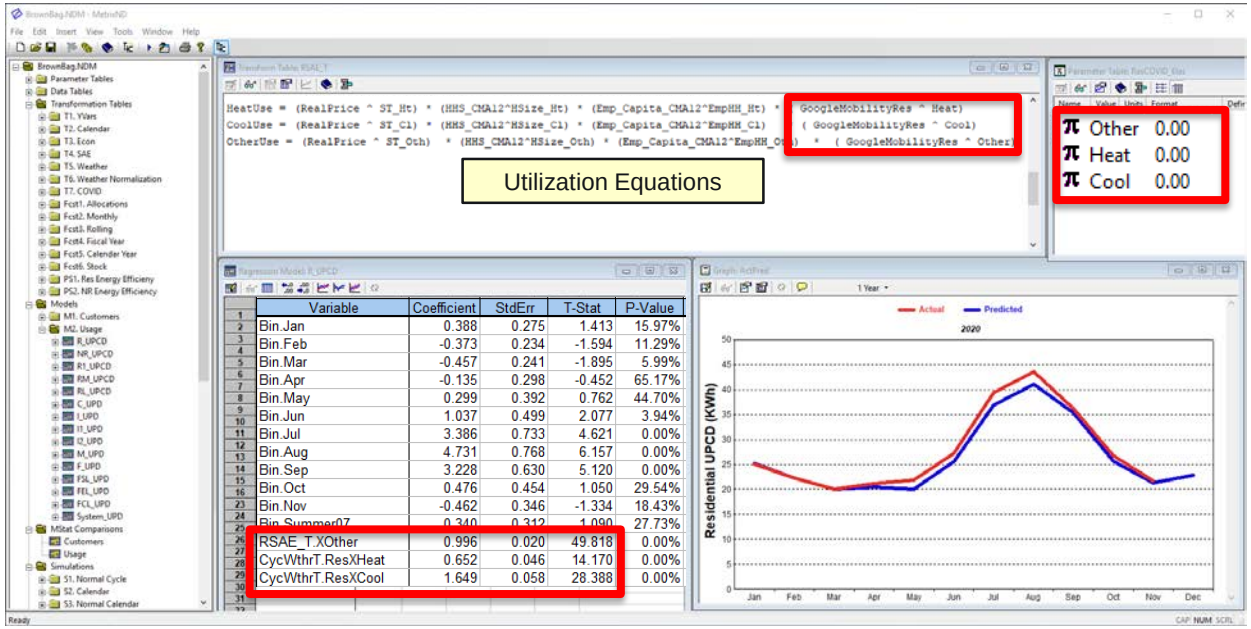
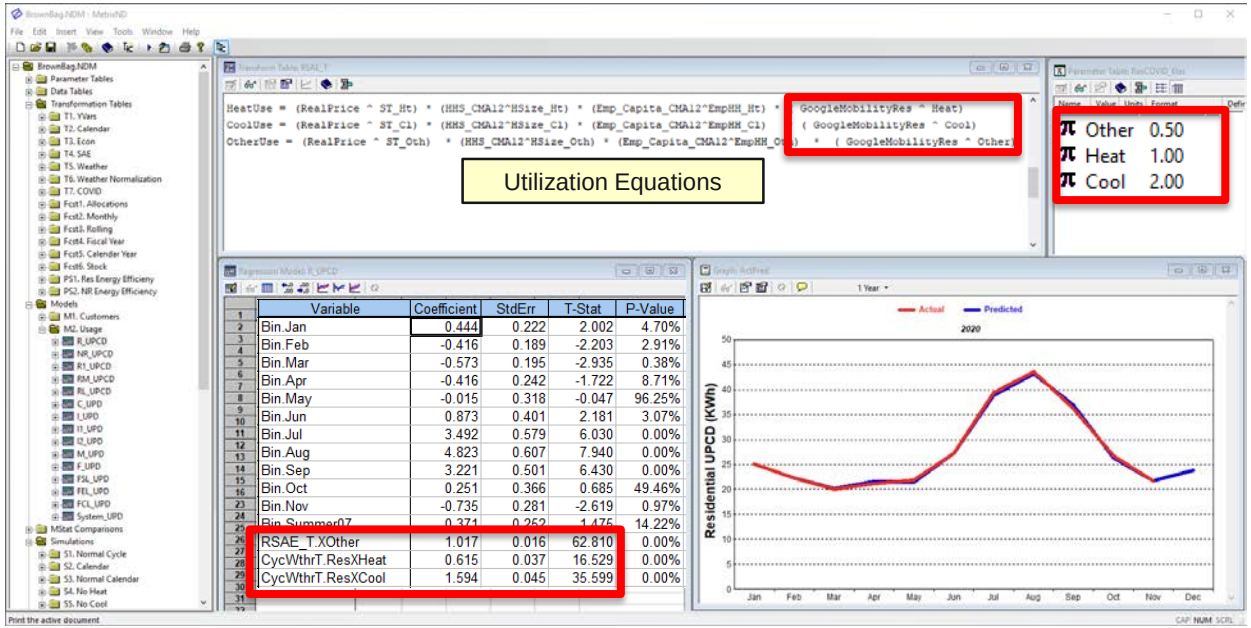
SAE MODEL WITHOUT COVID IMPACTS

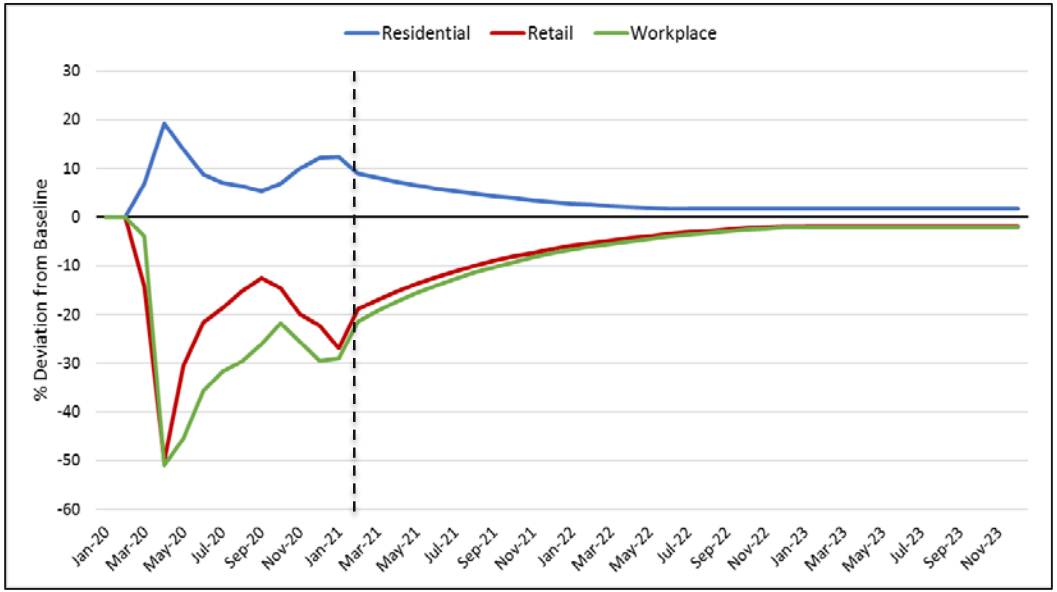


	Variable	Coefficient	StdErr	T-Stat	P-Value
2	Bin.Jan	0.388	0.275	1.413	15.97%
3	Bin.Feb	-0.373	0.234	-1.594	11.29%
4	Bin.Mar	-0.457	0.241	-1.895	5.99%
5	Bin.Apr	-0.135	0.298	-0.452	65.17%
7	Bin.May	0.299	0.392	0.762	44.70%
8	Bin.Jun	1.037	0.499	2.077	3.94%
9	Bin.Jul	3.386	0.733	4.621	0.00%
10	Bin.Aug	4.731	0.768	6.157	0.00%
11	Bin.Sep	3.228	0.630	5.120	0.00%
12	Bin.Oct	0.476	0.454	1.050	29.54%
13	Bin.Nov	-0.462	0.346	-1.334	18.43%
14	Bin.Summer07	0.340	0.312	1.090	27.73%
15	RSAE_T.XOther	0.996	0.020	49.818	0.00%
16	CycWthrT.ResXHeat	0.652	0.046	14.170	0.00%
17	CycWthrT.ResXCool	1.649	0.058	28.388	0.00%

SAE MODEL WITH COVID IMPACTS



THE BIG UNKNOWN
WHAT DOES THE FUTURE LOOK LIKE ?



- Are there long-term structural changes?
- How close to pre-COVID trend do we get?
- When do we get there?

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Questions?

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Thank You