

Smart Meter Dataset with Weather Information

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Preparing the Dataset & Determining the Home's Environment



Discovering the Dataset

- Contains 33 attributes in total, including:
 - Time (1)
 - Power readings of various appliances collected by a smart meter (19)
 - Outdoor weather conditions (13)
- Spans almost an entire year (from Jan. 1, 2016 0 a.m. to Dec. 15, 2016 10 p.m.)
- Two consecutive readings are separated by a time period of 1 minute (503 910 minutes in total)

time	use [kW]	gen [kW]	House overall [kW]	Dishwasher [kW]	Furnace 1 [kW]	Furnace 2 [kW]	Home office [kW]	Fridge [kW]	Wine cellar [kW]	Garage door [kW]	Kitchen 12 [kW]	Kitchen 14 [kW]	Kitchen 38 [kW]	Barn [kW]	Well [kW]
1451624400	0.932833333	0.003483333	0.932833333	3.33E-05	0.0207	0.061916667	0.442633333	0.12415	0.006983333	0.013083333	0.000416667	0.00015	0	0.03135	0.001016667
1451624401	0.934333333	0.003466667	0.934333333	0	0.020716667	0.063816667	0.444066667	0.124	0.006983333	0.013116667	0.000416667	0.00015	0	0.0315	0.001016667
1451624402	0.931816667	0.003466667	0.931816667	1.67E-05	0.0207	0.062316667	0.446066667	0.123533333	0.006983333	0.013083333	0.000433333	0.000166667	1.67E-05	0.031516667	0.001
1451624403	1.02205	0.003483333	1.02205	1.67E-05	0.1069	0.068516667	0.446583333	0.123133333	0.006983333	0.013	0.000433333	0.000216667	0	0.0315	0.001016667

Well [kW]	Microwave [kW]	Living room [kW]	Solar [kW]	temperature	icon	humidity	visibility	summary	apparentTemperature	pressure	windSpeed	cloudCover	windBearing	precipIntensity	dewPoint	precipProbability
0.001016667	0.004066667	0.001516667	0.003483333	36.14	clear-night	0.62	10	Clear	29.26	1016.91	9.18	cloudCover	282	0 24.4		0
0.001016667	0.004066667	0.00165	0.003466667	36.14	clear-night	0.62	10	Clear	29.26	1016.91	9.18	cloudCover	282	0 24.4		0
0.001	0.004066667	0.00165	0.003466667	36.14	clear-night	0.62	10	Clear	29.26	1016.91	9.18	cloudCover	282	0 24.4		0
0.001016667	0.004066667	0.001616667	0.003483333	36.14	clear-night	0.62	10	Clear	29.26	1016.91	9.18	cloudCover	282	0 24.4		0



Cleaning the Dataset

- Corrected UNIX timestamp to have a 1-minute interval between two readings and shifted time zone to UTC-5
- Replaced erroneous text values in *cloudCover*
- Removed duplicate like *House overall [kW]*, *Solar [kW]* and null columns like *precipIntensity*
- Created a lighter copy of the dataset by averaging the power readings and weather data hour by hour

time	corrtime	UTC-5	datetime
1451624400	1451624400	1451606400	1/1/16 0:00
1451624401	1451624460	1451606460	1/1/16 0:01
1451624402	1451624520	1451606520	1/1/16 0:02
1451624403	1451624580	1451606580	1/1/16 0:03
1451624404	1451624640	1451606640	1/1/16 0:04
1451624405	1451624700	1451606700	1/1/16 0:05

Index	datetime
0	01/01/2016 00:00
60	01/01/2016 01:00
120	01/01/2016 02:00
180	01/01/2016 03:00
240	01/01/2016 04:00
300	01/01/2016 05:00
360	01/01/2016 06:00
420	01/01/2016 07:00
480	01/01/2016 08:00

Determining the Home's Environment

- UTC-5 Time Zone → U.S. East Coast
- Large House with a Barn and a Well → Countryside & Family Home
- Temperature Averages → Virginia or North Carolina

→ Final Choice: Virginia



Dividing the Appliances into Categories

Dependencies

- Barn
- Garage Door
- Well
- Wine Cellar



Heating

- Furnace 1
- Furnace 2



Kitchen

- Dishwasher
- Fridge
- Microwave
- Kitchen 12
- Kitchen 14
- Kitchen 38



Living

- Home Office
- Living Room



Finding the Purpose of the Analysis

The Company: Dominion Energy

- Virginia-based power utility company
- Serves over 5 million retail customers in the Midwest, mid-Atlantic and Northeast regions of the U.S.
- Carries out production, transmission and distribution activities of electricity and natural gas



Why?

- Launched in 2011 a Smart Pricing pilot program
- Goal: Help better manage its energy production resources by reducing the electricity used in peak periods





My Role

At the end of 2016, the company asked me to:

- Analyze the home's electricity consumption in 2016
- Identify usage patterns and extract insights from this data
- Determine if the Smart Pricing plan benefited the family by lowering the electricity bill



Dominion Energy's Smart Pricing Plan

Dynamic Pricing

- Price for electricity varies depending on the energy demand
- Encourages participants to use energy when the demand is low

Each day is classified as a:

- high-priced (A) day (no more than 30 per year)
- medium-priced (B) day
- low-priced (C) day (at least 280 per year)

Highest prices are during:

- Summer: middle of the day, between 1 p.m. and 7 p.m.
- Winter: early morning and early evening

Smart Pricing Plan - Day Classification Calendar

Select Energy Year: June 2016 - May 2017

August 2016						
SUN	MON	TUE	WED	THU	FRI	SAT
	1 B	2 B	3 B	4 B	5 B	6 B
7 C	8 B	9 B	10 A	11 A	12 A	13 A
14 A	15 A	16 A	17 A	18 B	19 B	20 B
21 B	22 C	23 C	24 C	25 C	26 C	27 C
28 C	29 C	30 C	31 A			

Day Count August

- A 9
- B 12
- C 10

Energy Year to Date Day Count

- A 26
- B 55
- C 11

Energy Year Target

- A 30 - Max
- B 55 - Approx
- C 280 - Min

Base Pricing vs Dynamic Pricing

Schedule 1 Base Rates	Schedule 1 Rates (effective 1/1/2016)
DISTRIBUTION CHARGES	
Basic Customer Charge	\$ 7.00
Energy Charge - Summer	
First 800 kWh-Summer	\$ 0.02244
Add'l Peak kWh-Summer	\$ 0.01271
Energy Charge - Winter (Base)	
First 800 kWh-Base	\$ 0.02244
Add'l Peak kWh-Base	\$ 0.01271
GENERATION CHARGES	
Energy - Summer	
First 800 kWh	\$ 0.03795
Over 800 kWh	\$ 0.05773
Energy - Winter (Base)	
First 800 kWh	\$ 0.03795
Over 800 kWh	\$ 0.02927

Dynamic Pricing Rates Effective 1/1/2016	"A" Days	"B" Days	"C" Days
	30 Days	55 Days	280 Days
DISTRIBUTION CHARGES			
Basic Customer Charge	\$ 7.00	\$ 7.00	\$ 7.00
Energy Charge (per kWh)	\$ 0.00381	\$ 0.00381	\$ 0.00381
Demand Charge (per kW)	\$ 2.05900	\$ 2.05900	\$ 2.05900
TRANSMISSION CHARGES			
Energy Charge (per kWh)	\$ 0.00970	\$ 0.00970	\$ 0.00970
GENERATION CHARGES			
COOLING SEASON (per kWh)	April 16 - October 15		
12 am - 10 am	\$ 0.02620	\$ 0.01429	\$ 0.00338
10 am - 1 pm	\$ 0.08962	\$ 0.05742	\$ 0.02693
1 pm - 7 pm	\$ 0.49102	\$ 0.05742	\$ 0.02693
7 pm - 10 pm	\$ 0.08962	\$ 0.05742	\$ 0.02693
10 pm - 12 am	\$ 0.02620	\$ 0.01429	\$ 0.00338
HEATING SEASON (per kWh)	October 16 - April 15		
5 am - 11 am	\$ 0.30392	\$ 0.05835	\$ 0.02562
11 am - 5 pm	\$ 0.05289	\$ 0.03181	\$ 0.00964
5 pm - 10 pm	\$ 0.30392	\$ 0.05835	\$ 0.02562
10 pm - 5 am	\$ 0.05289	\$ 0.03181	\$ 0.00964

Base Pricing

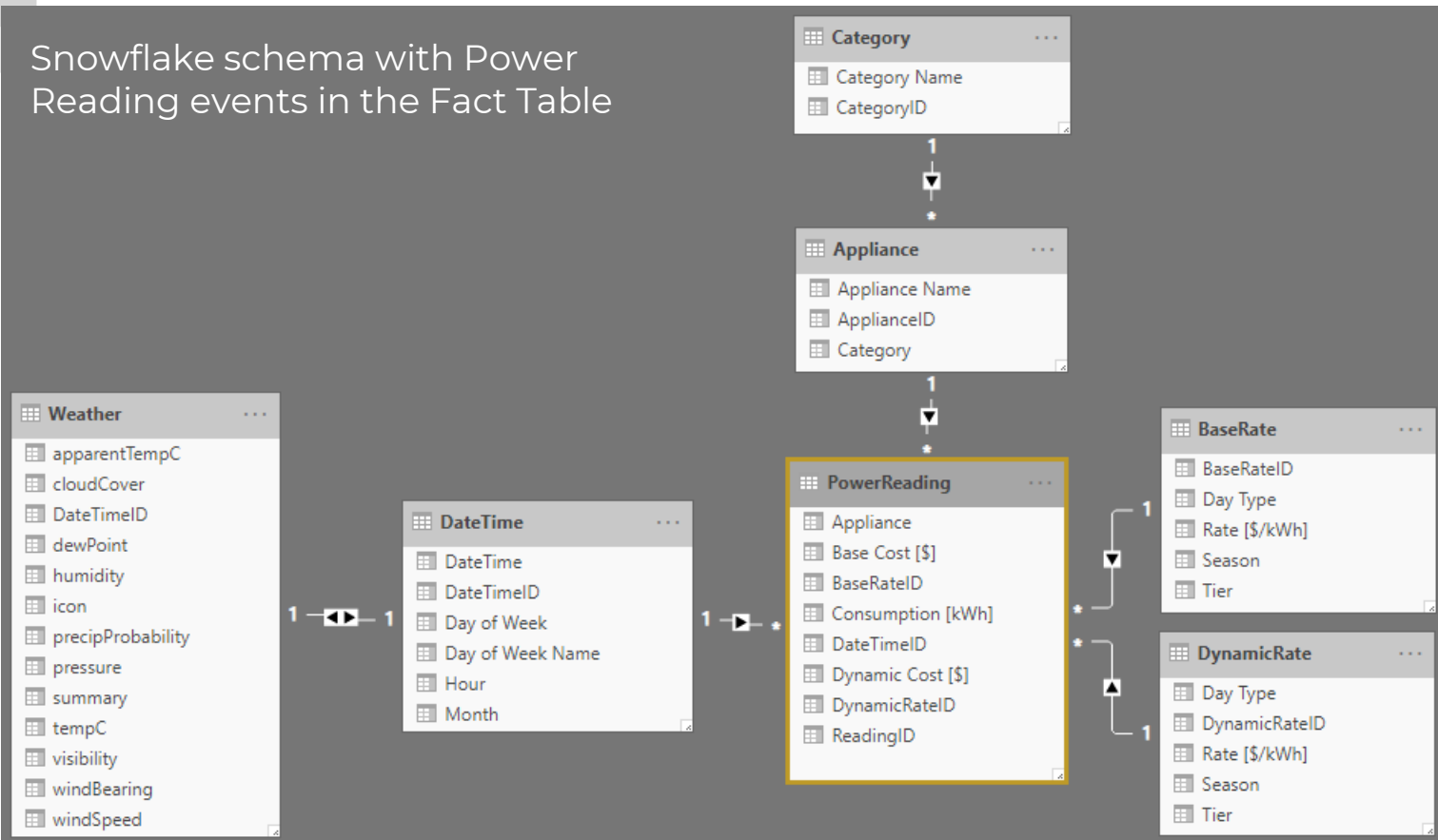
- Single monthly rate for both summer and winter
- Additional charge for every kWh after the first 800 kWh of the month

Dynamic Pricing

- Variable rate depending on the season, day classification, and time of day

Creating a Model from the Dataset

Snowflake schema with Power Reading events in the Fact Table

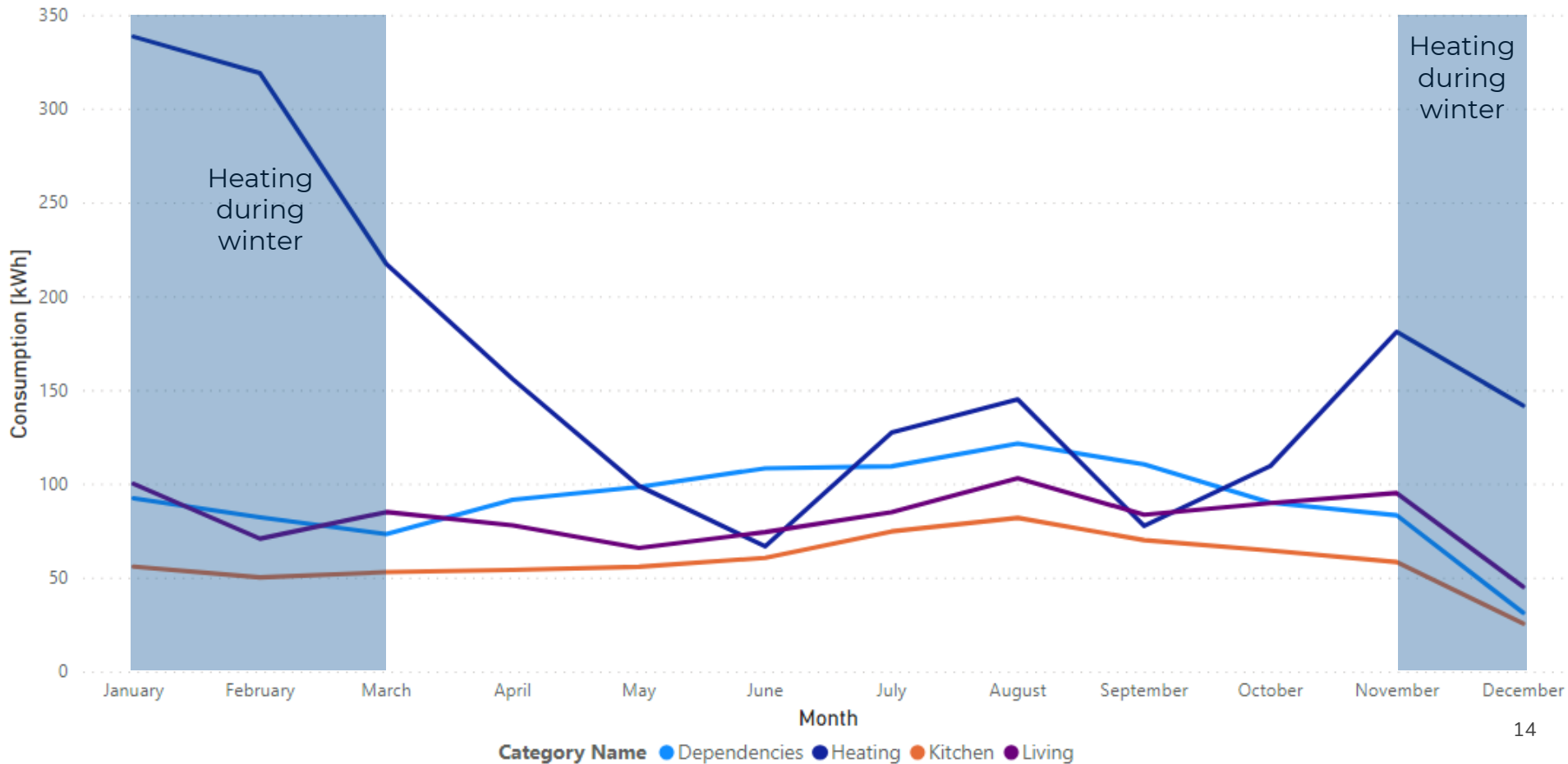




Identifying Usage Patterns & Extracting Insights

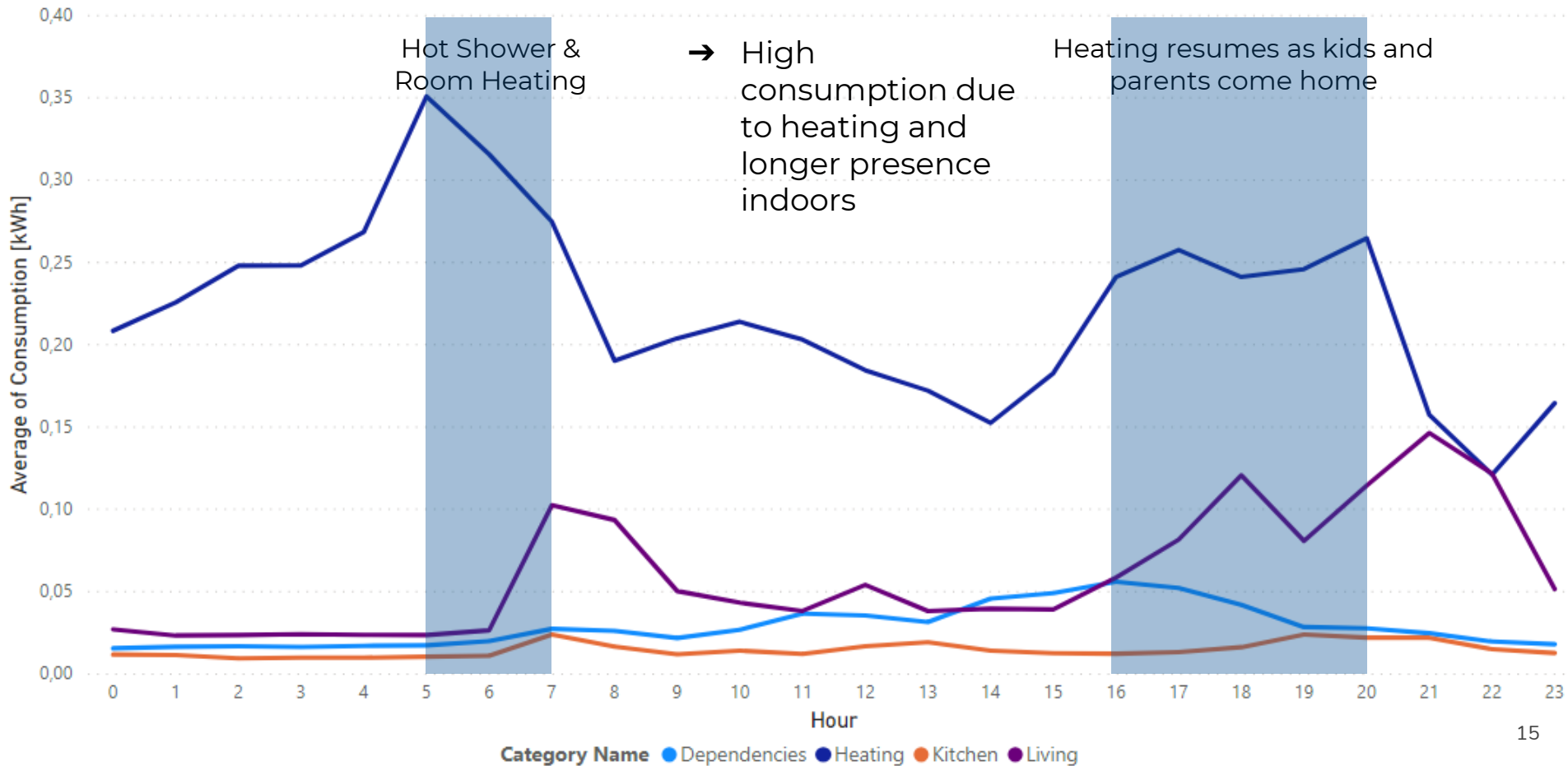
Monthly Consumption by Category

Consumption [kWh] by Month and Category Name



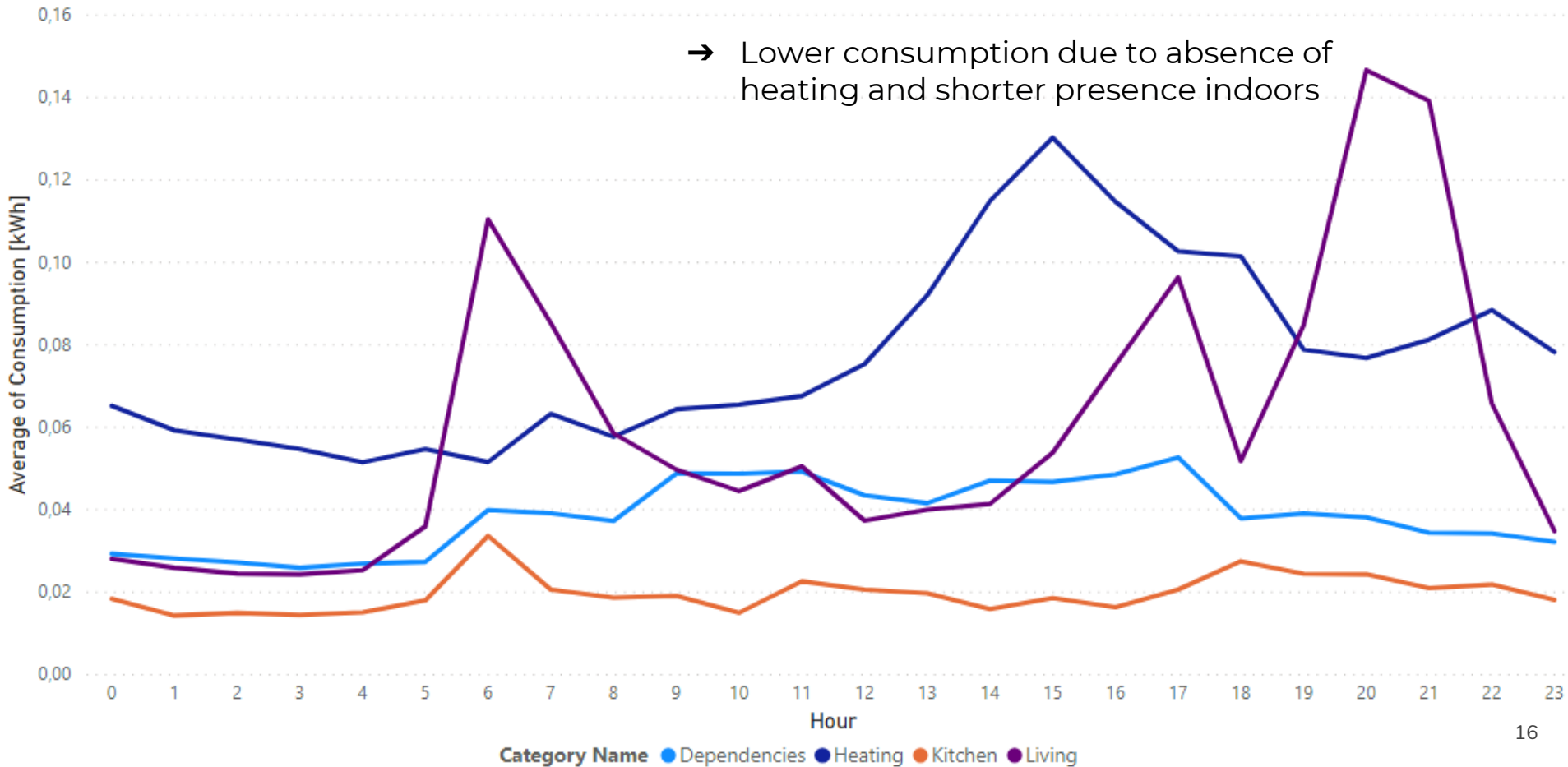
Winter Day Consumption by Hour

Average of Consumption [kWh] by Hour and Category Name



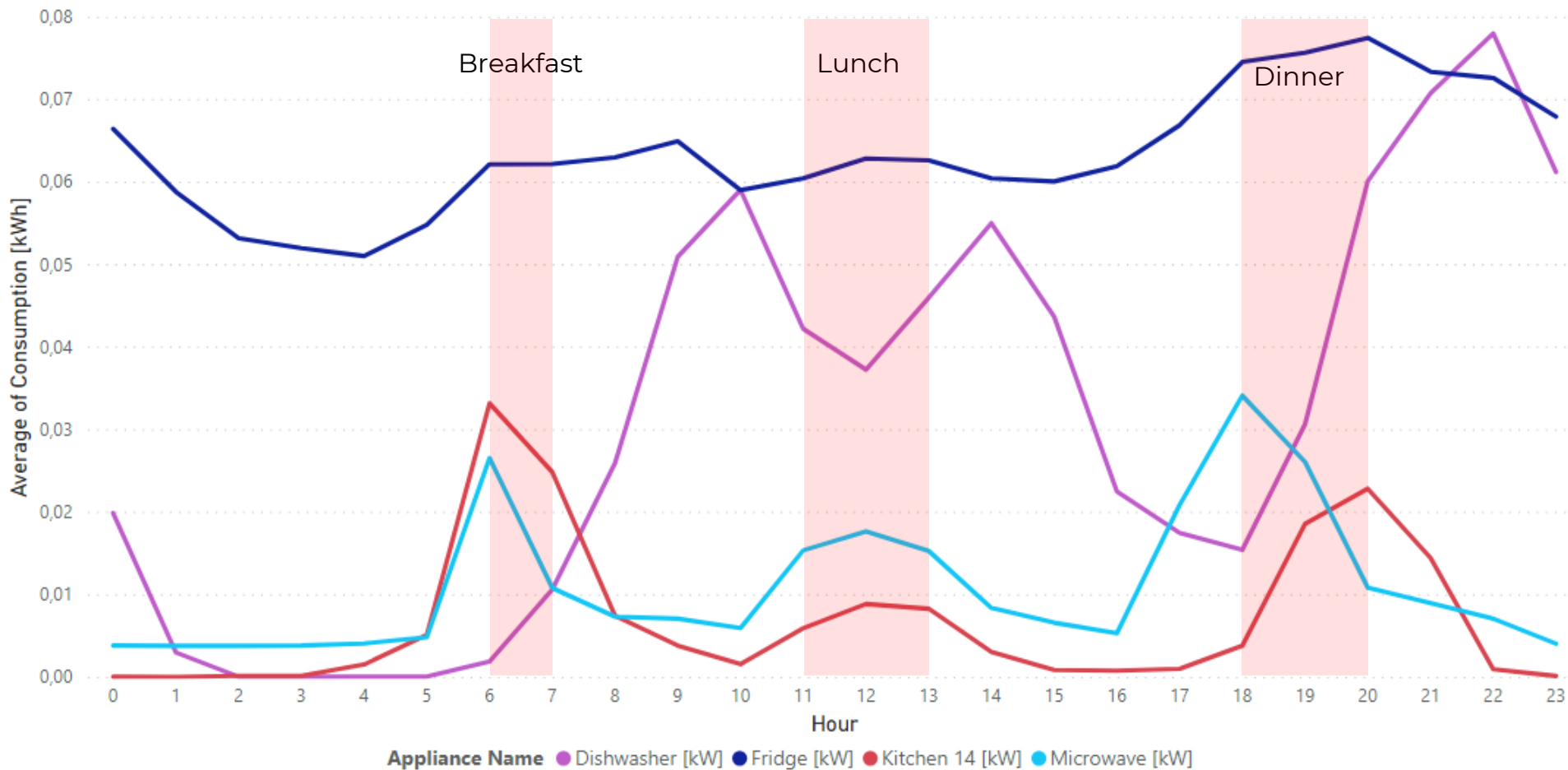
Summer Day Consumption by Hour

Average of Consumption [kWh] by Hour and Category Name



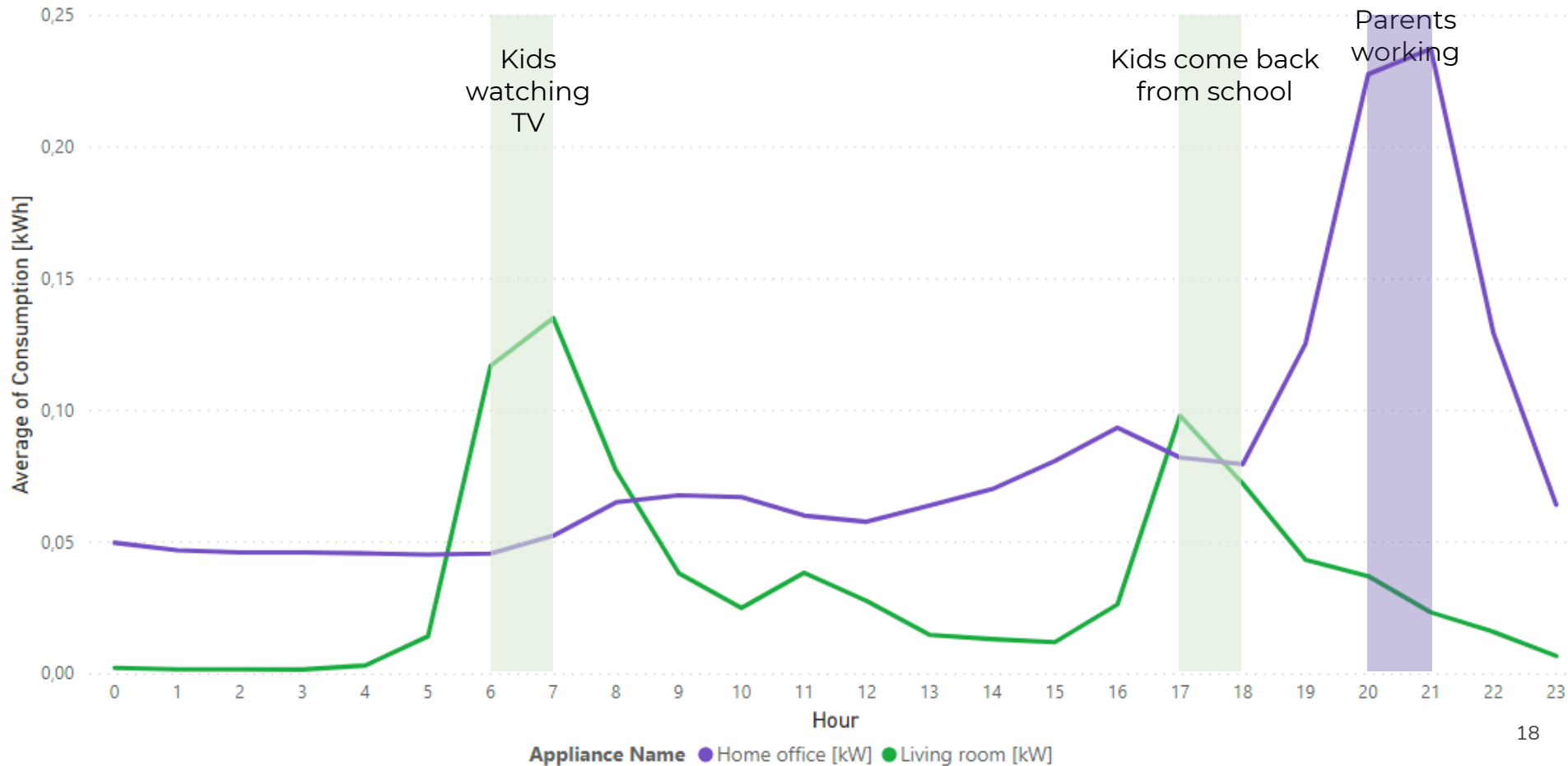
Typical Kitchen Consumption by Hour

Average of Consumption [kWh] by Hour and Appliance Name



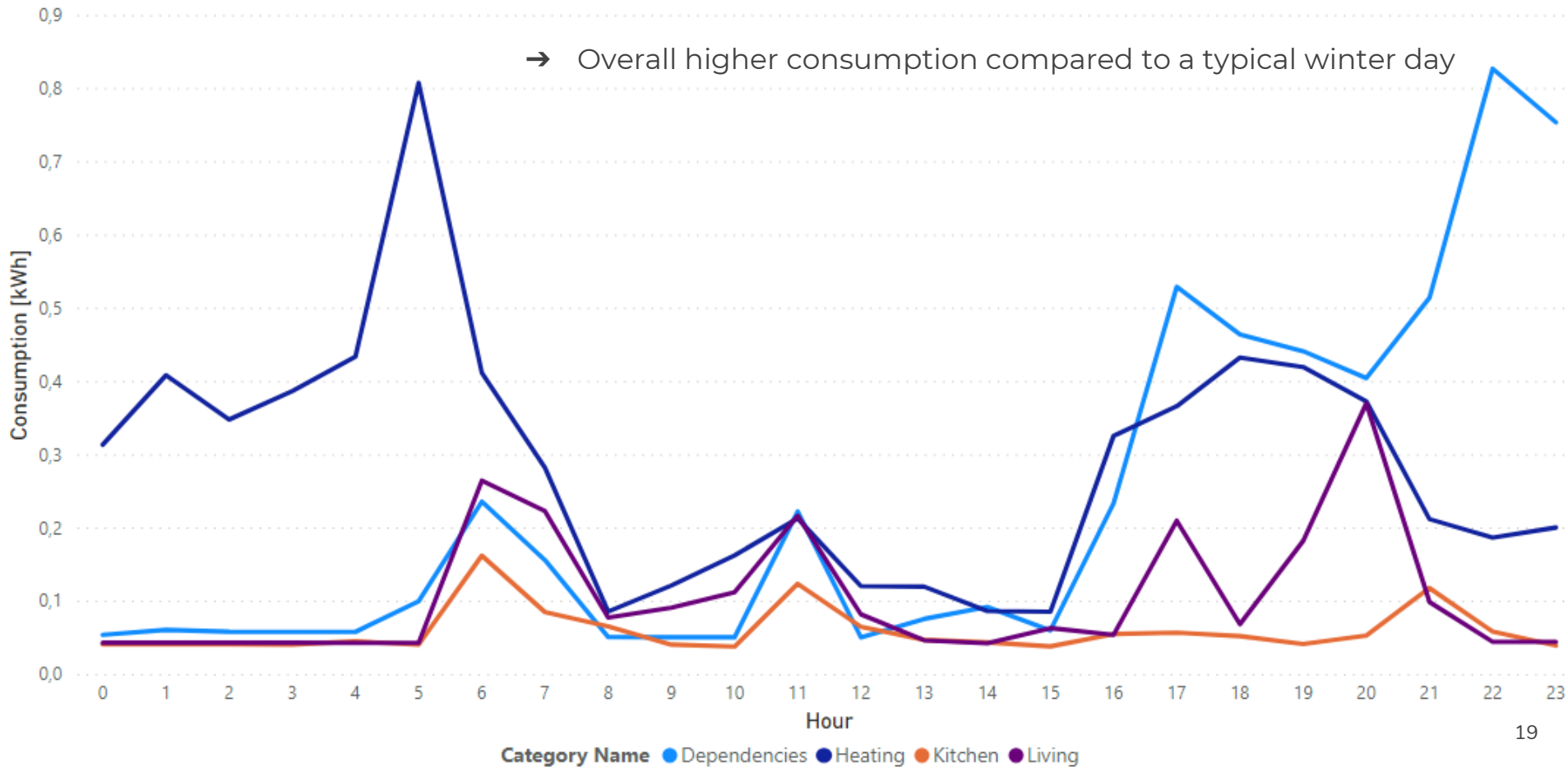
Typical Living & Office Consumption by Hour

Average of Consumption [kWh] by Hour and Appliance Name



Holiday Consumption by Hour: Thanksgiving

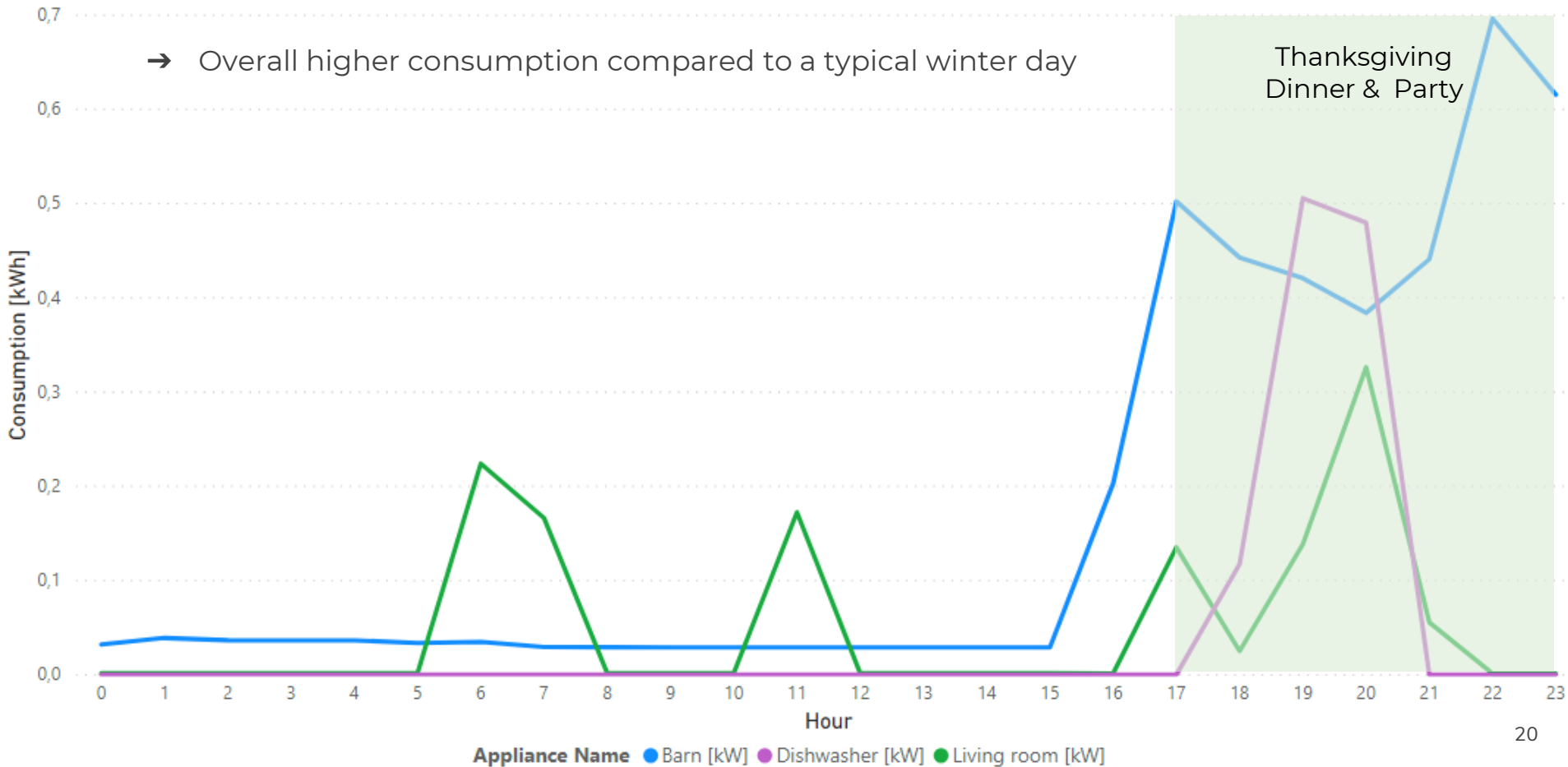
Consumption [kWh] by Hour and Category Name



Holiday Consumption by Hour: Thanksgiving

Consumption [kWh] by Hour and Appliance Name

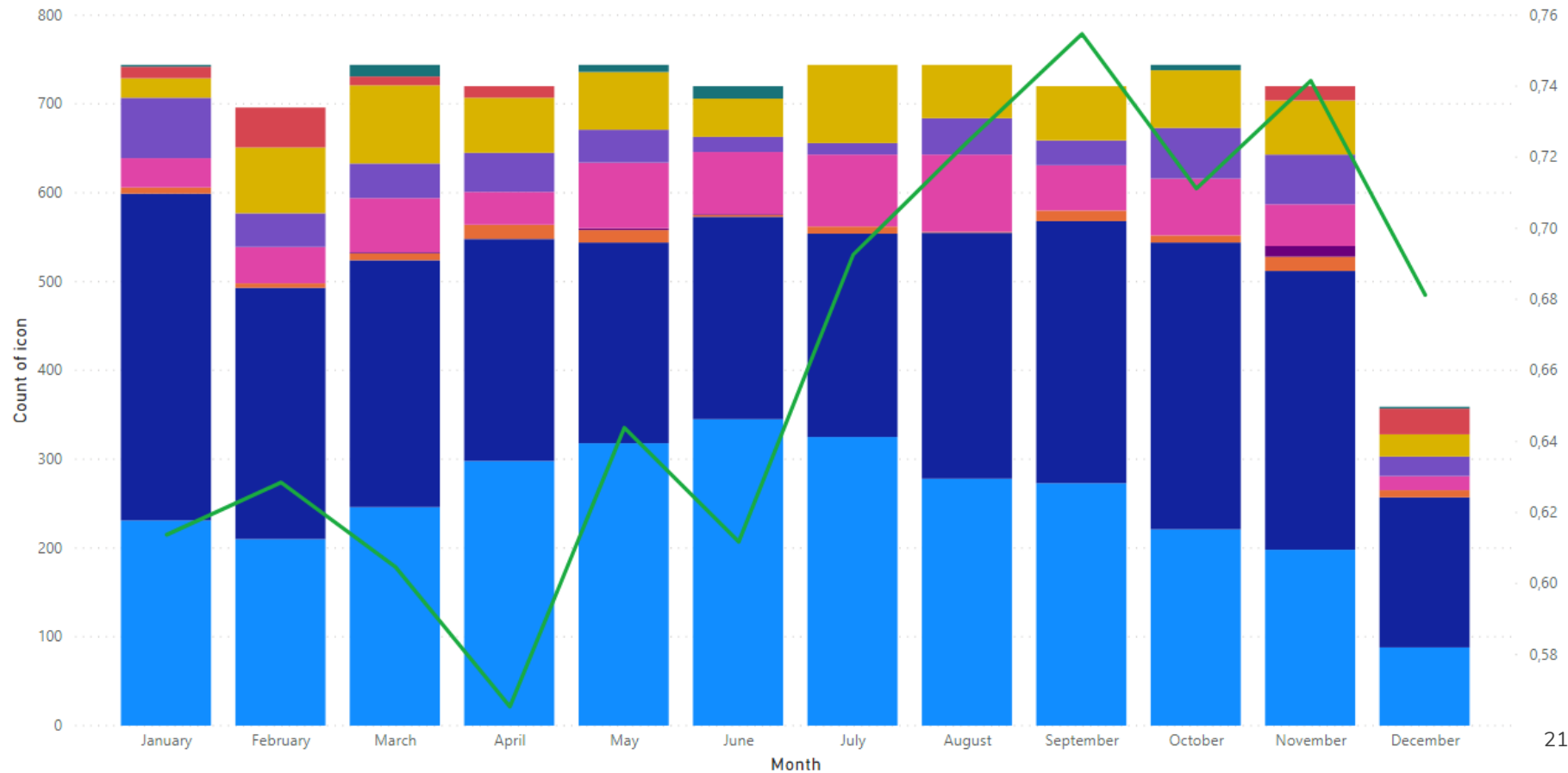
→ Overall higher consumption compared to a typical winter day



Weather & Humidity

Count of icon and Average of humidity by Month and icon

icon ● clear-day ● clear-night ● cloudy ● fog ● partly-cloudy-day ● partly-cloudy-night ● rain ● snow ● wind ● Average of humidity

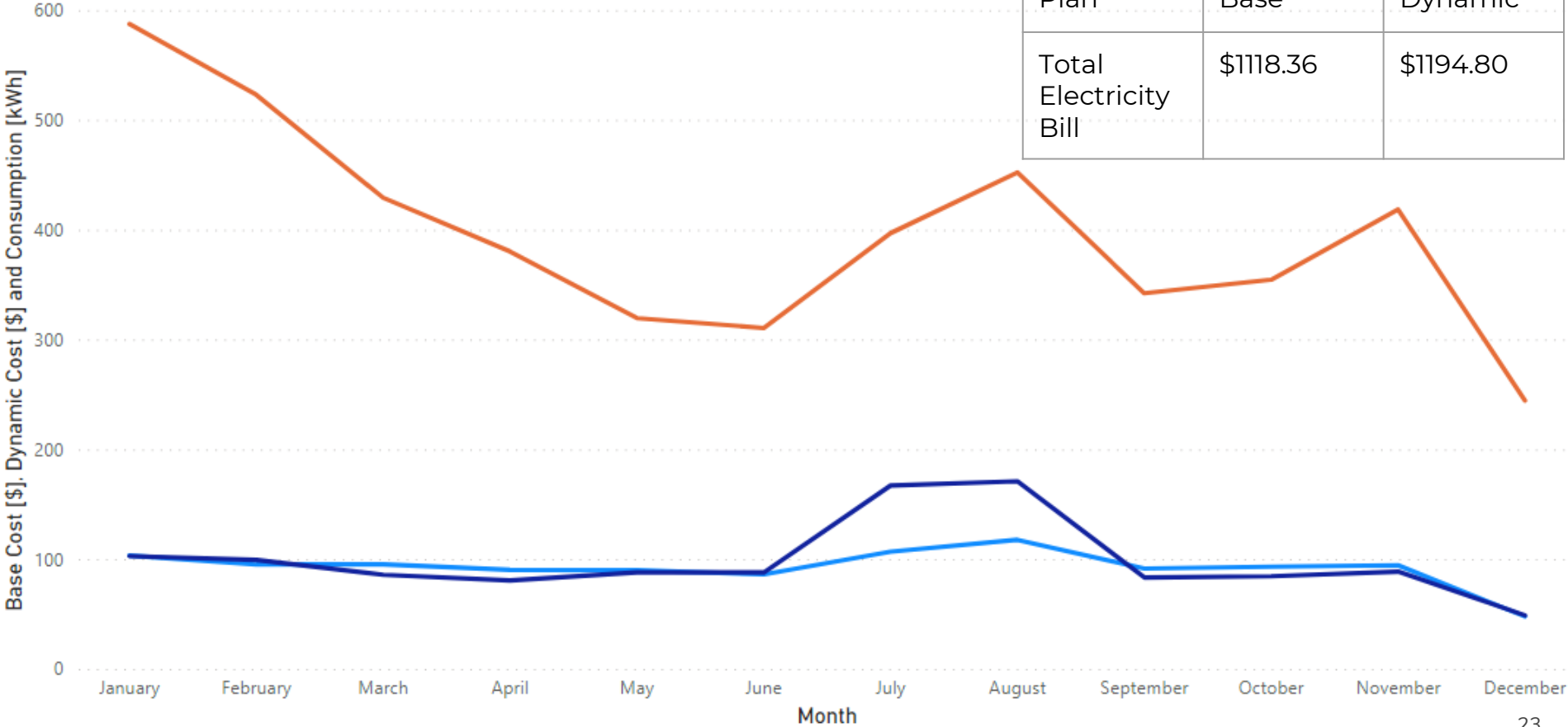


Concluding on the Effects of the Smart Pricing Plan

Base vs Dynamic Cost Comparison

Base Cost [\$], Dynamic Cost [\$] and Consumption [kWh] by Month

Plan	Base	Dynamic
Total Electricity Bill	\$1118.36	\$1194.80





Effects of the Smart Pricing Plan

Why did the family have a slightly higher electricity bill with the Smart Pricing plan compared to the Base Pricing plan?

- No change in life habits and usage patterns
- Other households did not change their habits either
- Demand was not lowered enough during peaks to warrant lower prices

How can Dominion Energy improve its plan in order to reach its desired goal?

- Better communicate the benefits of shifting energy usage to non-peak hours
- Convince more customers to switch to the Smart Pricing plan



**Thank you for your
attention!**