Energy Application for Time-Based Electricity Pricing

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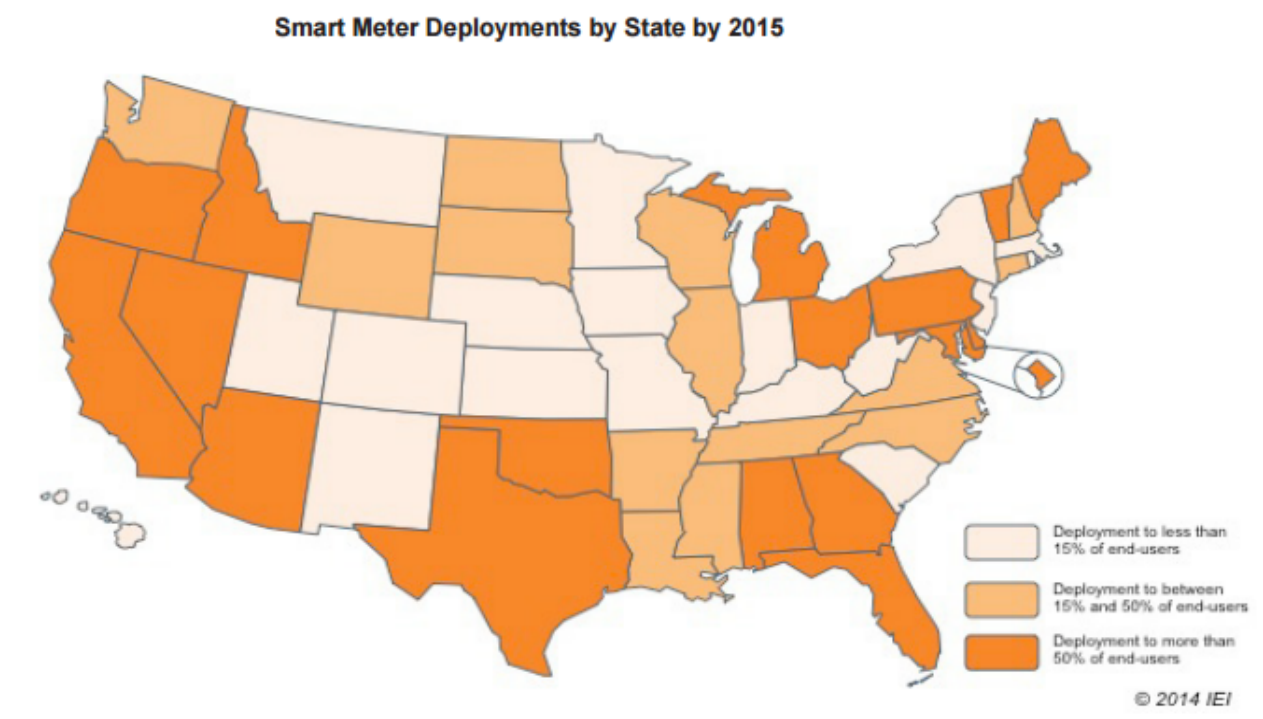
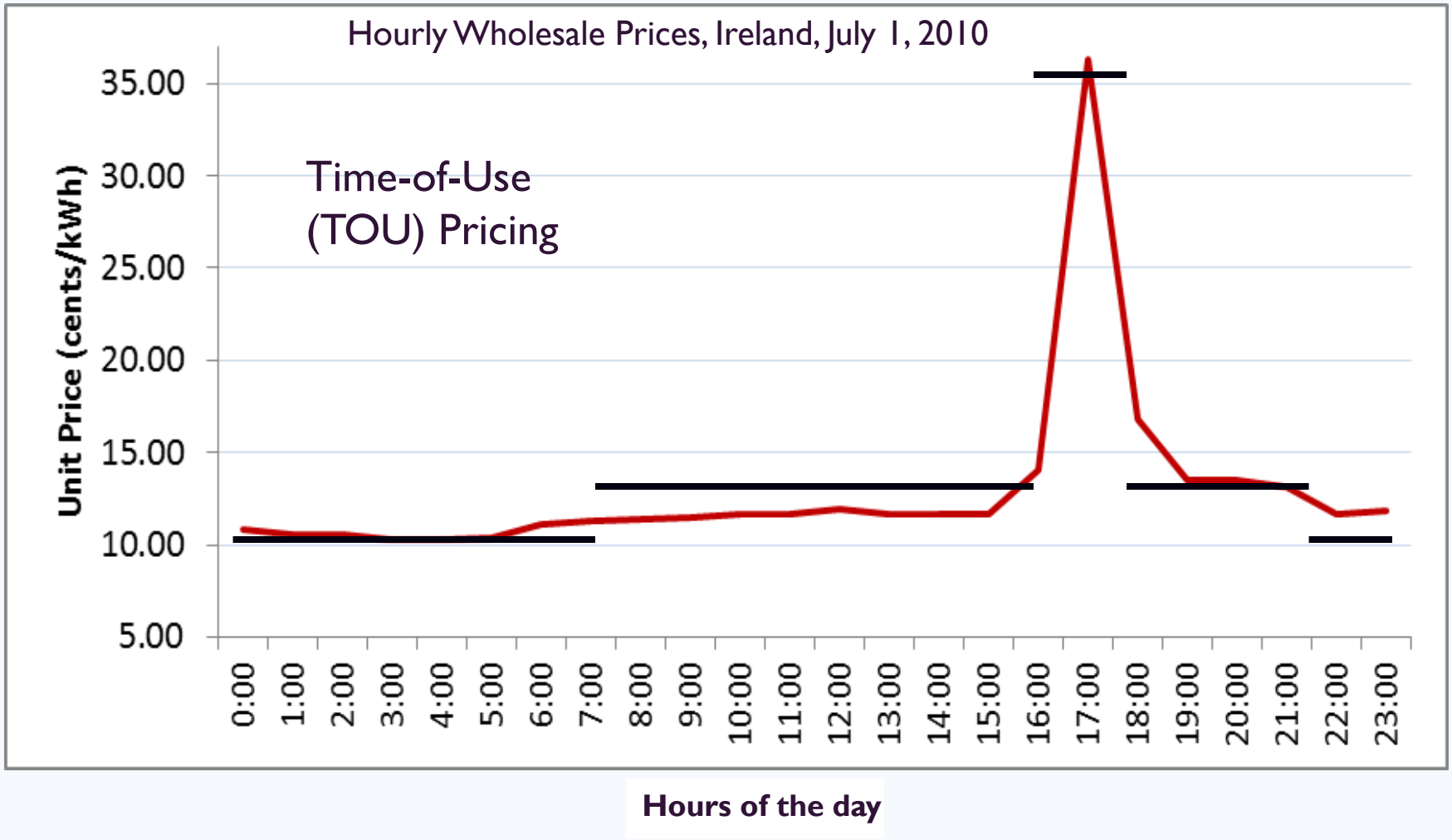
May 22, 2019

How widespread are smart meters…

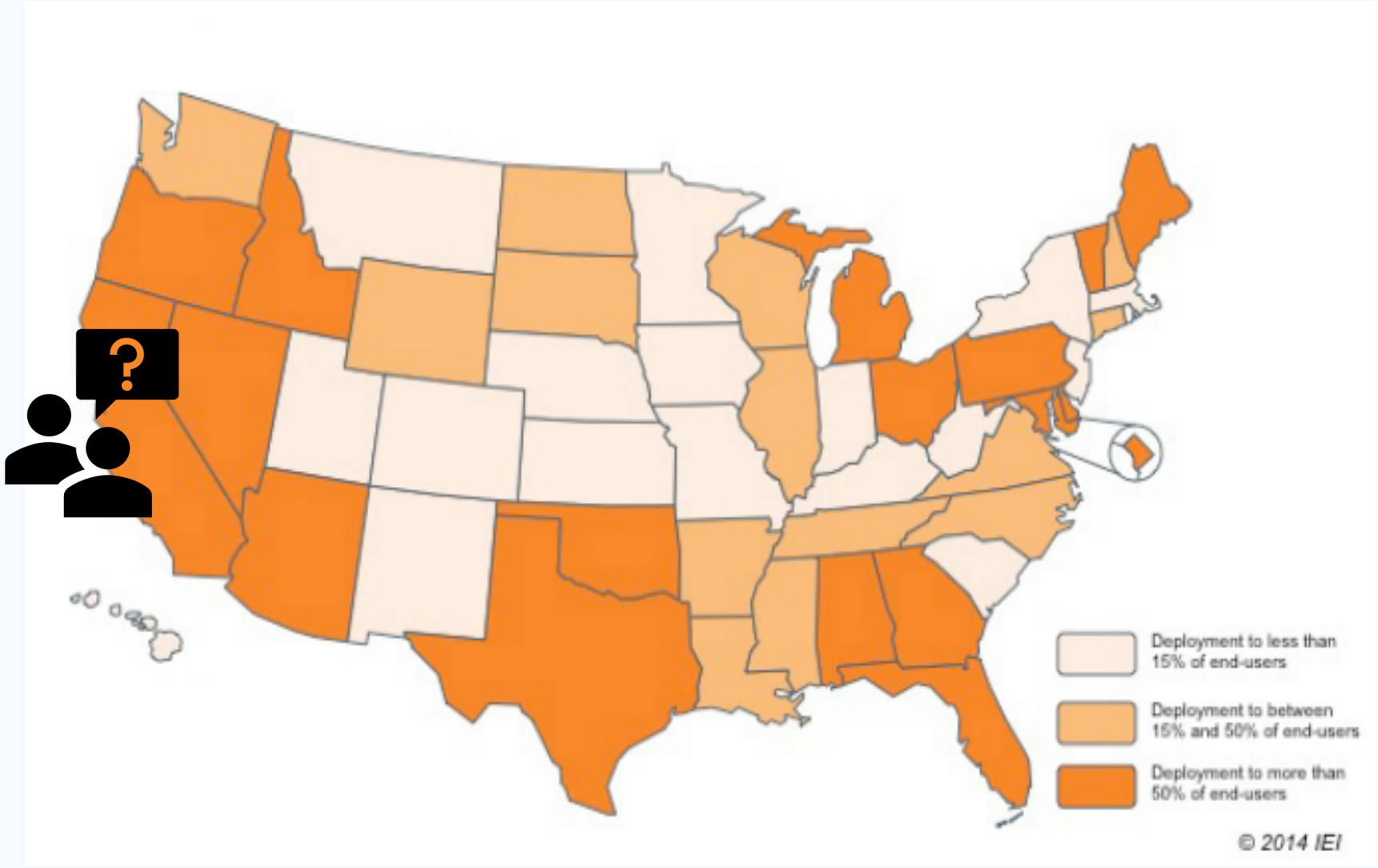
- **…in the United States?**
- 2015: 64.7M smart meter installations. 57.1M were residential customers (EIA).



Before smart meters: Flat Rate!



Flat Rate or Time-of-Use Rate? Electricity Bills, Environmental Impact?



Energy App

Consumer:

Appliances, demographics

Location, Pricing

Energy App

Results:

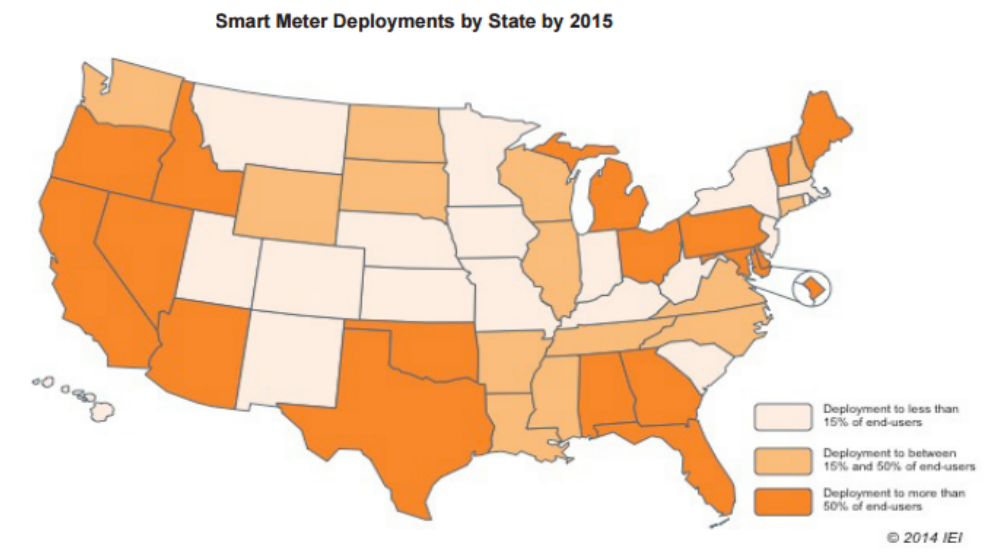
Future Electricity Bills

Environmental Impact

Flat Rate or Time-of-Use Rate?

Where is the data to train the model?

- **…in the United States?**
- 2015: 64.7M smart meter installations. 57.1M were residential customers (EIA).



- **…in the European Union?**
  - Replace >80% of meters with smart meters by 2020 (EC).

Consumption and Survey Data: Time-based Pricing Field Experiment

Residential time-of-use pricing field experiment

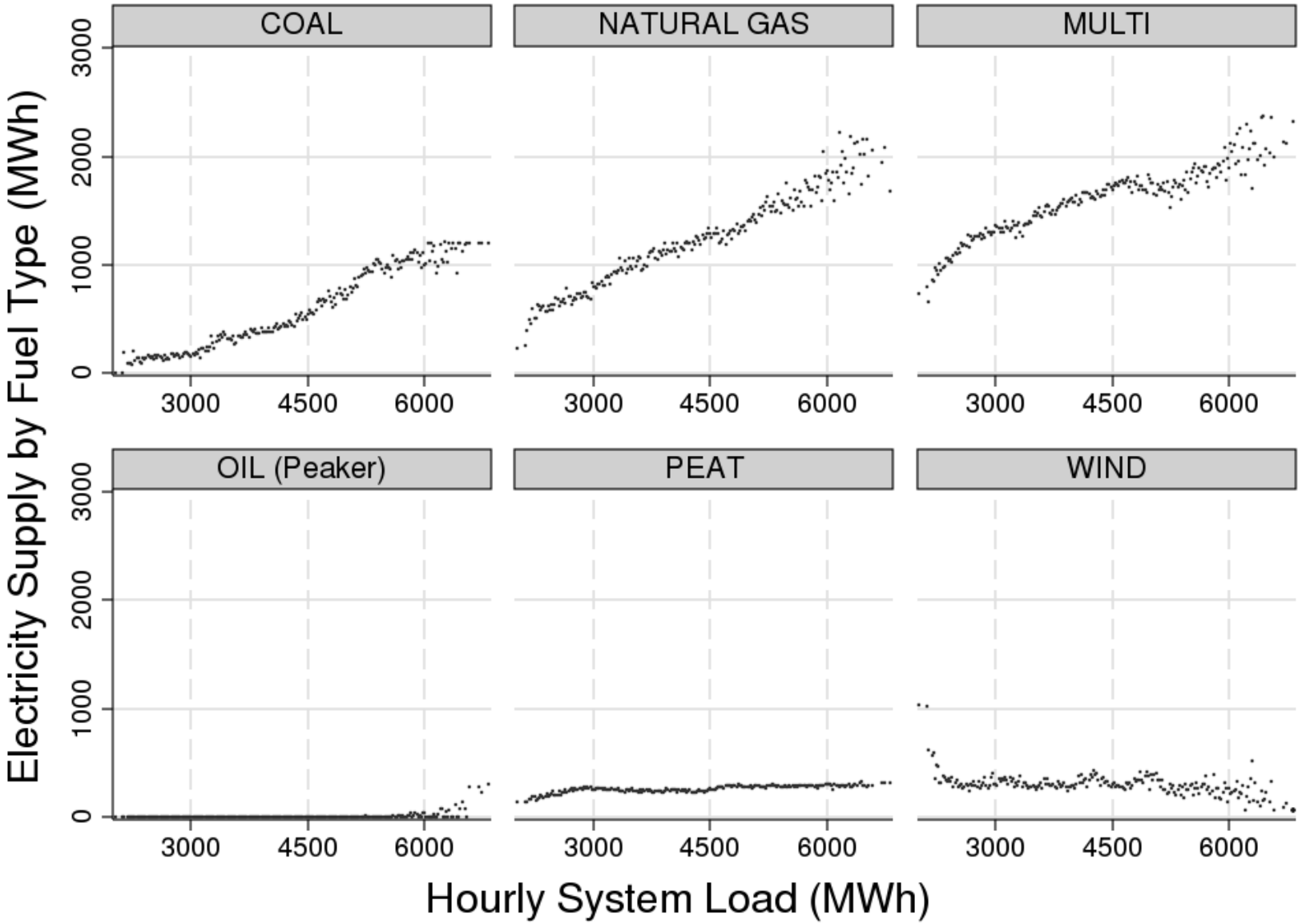
- Irish Commission for Energy Regulation (CER)
- 4225 households
- 30-min. consumption, demographics, appliances (~5 GB)
- July 2009 - December 2009 : **Benchmark Period**
- January 2010 - December 2010 : **Experiment Period**

			Weekday Prices (¢/kWh)	
Group	Group Size (household)	Day	Peak	Night
A	938	14	20	12
B	364	13.5	26	11
C	962	13	32	10
D	364	12.5	38	9
E	762	14.1	14.1	14.1

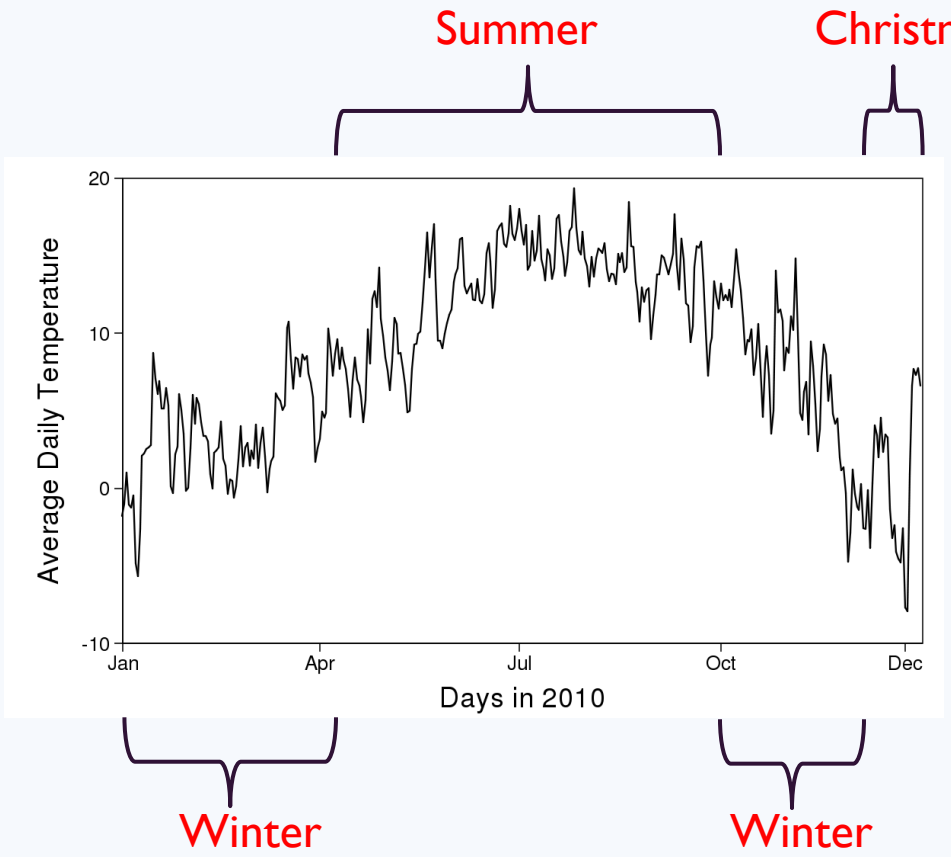
TREATMENT GROUPS

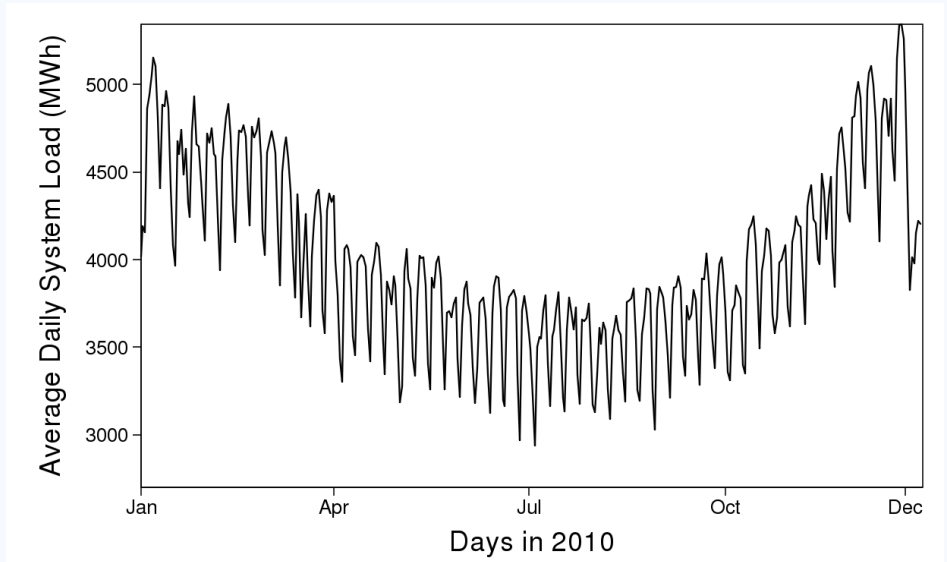
CONTROL GROUP

(Natural gas, distillate)



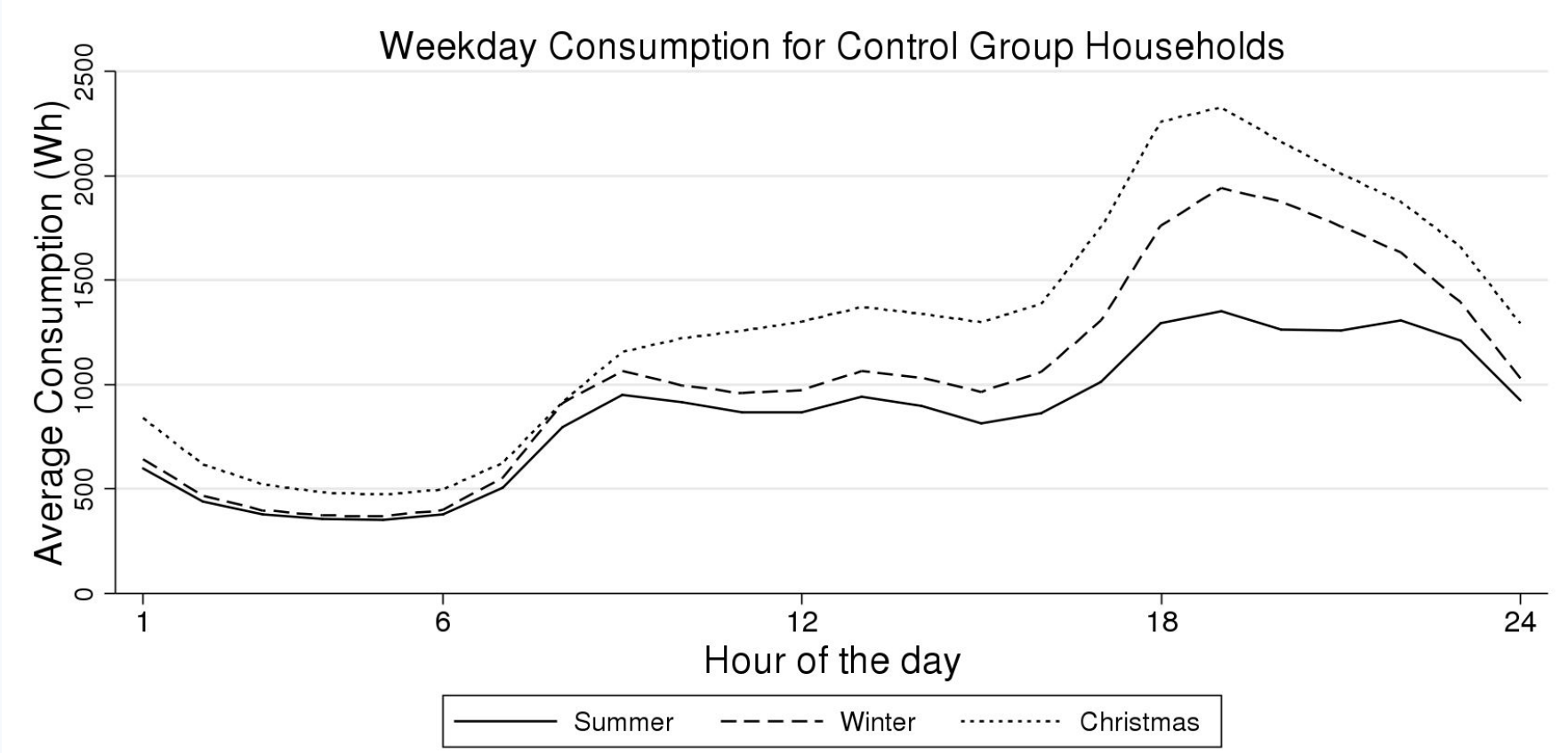
Temperature and average consumption have an inverse relationship.



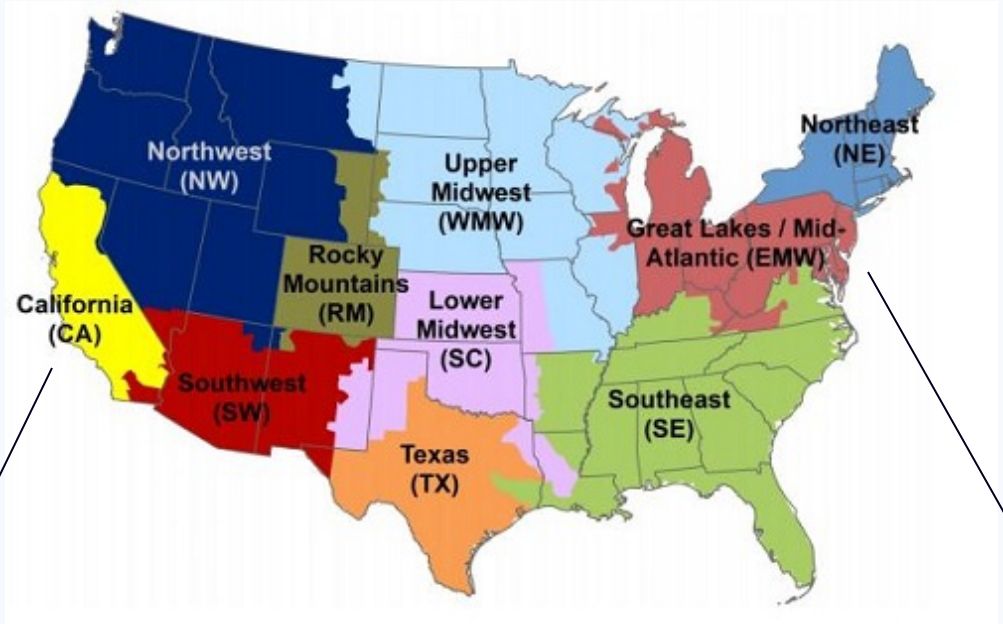


Electric heating >>> A/C use.

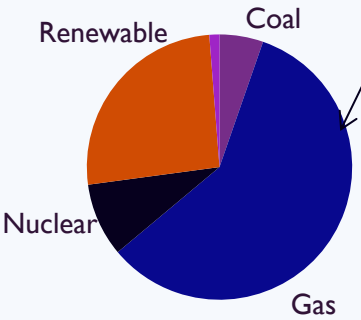
Consumer demand has seasonal variation.



Environmental Impact: The U.S. Case

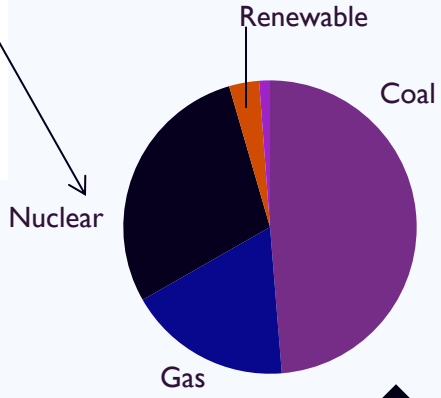


CALIFORNIA

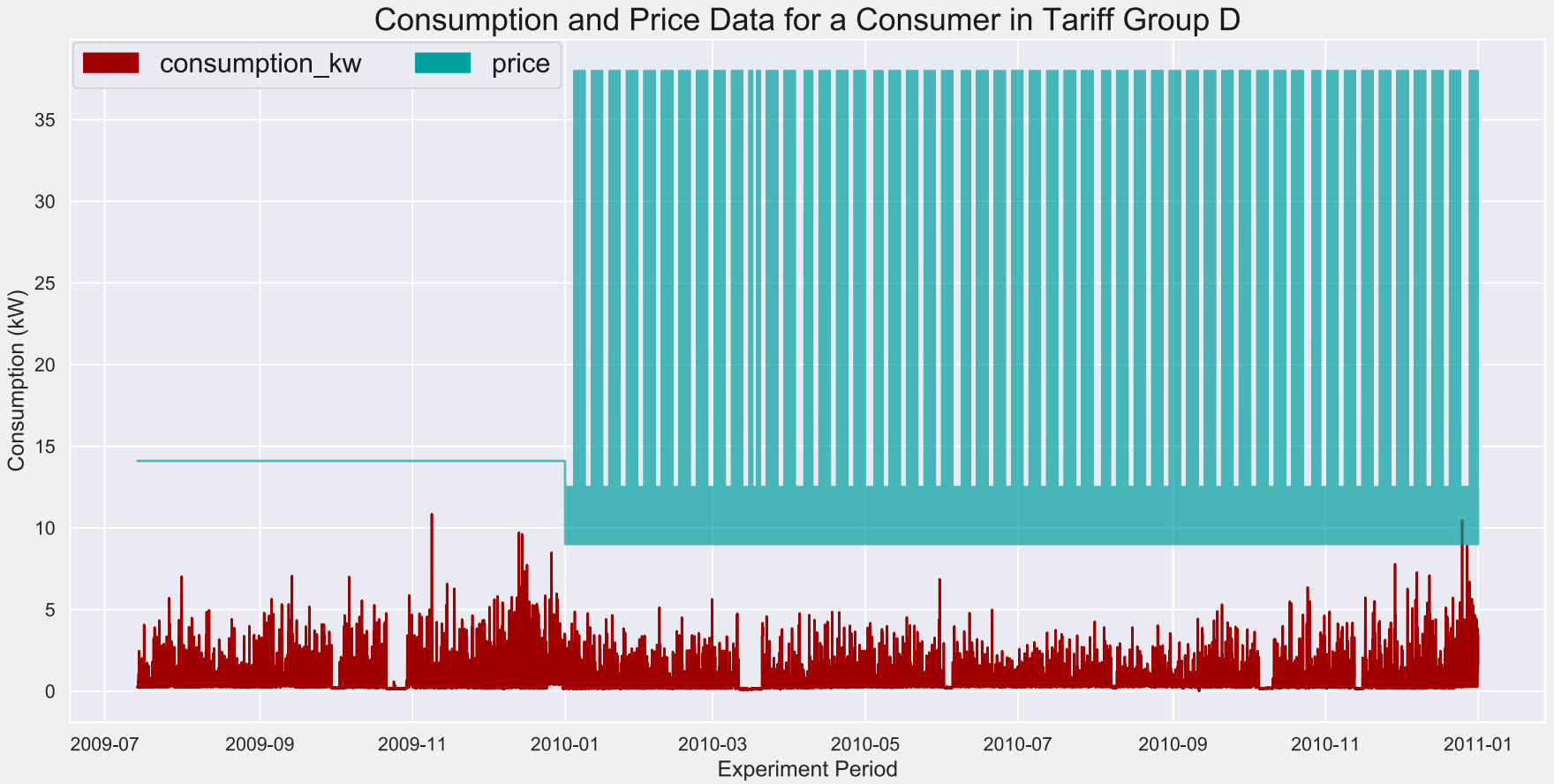


CO_2 emissions

MID-ATLANTIC



CO_2 emissions


Consumption and Price Data for a Consumer in Tariff Group D
consumption_kw
price
Consumption (kW)
0
5
10
15
20
25
30
35
2009-07
2009-09
2009-11
2010-01
2010-03
2010-05
2010-07
2010-09
2010-11
2011-01
Experiment Period

Preliminary Findings and Plans

- Multi-step multivariate time series forecasting to predict next month's hourly consumption
- Model selection:

1. Univariate per-customer ARIMA model
2. Multivariate per-customer linear versus non-linear ML models (RandomForestRegressor>LinearRegression in terms of MSE)
3. Multivariate per-customer-group and across all customers ML models
4. Recursive versus direct forecasting methods

- Predict the price elasticity of demand for different customer segments to predict the price response even without green button data.