

# Energy Application for Time-Based Electricity Pricing

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# Richer Data in the Energy Industry

## Analog Meters



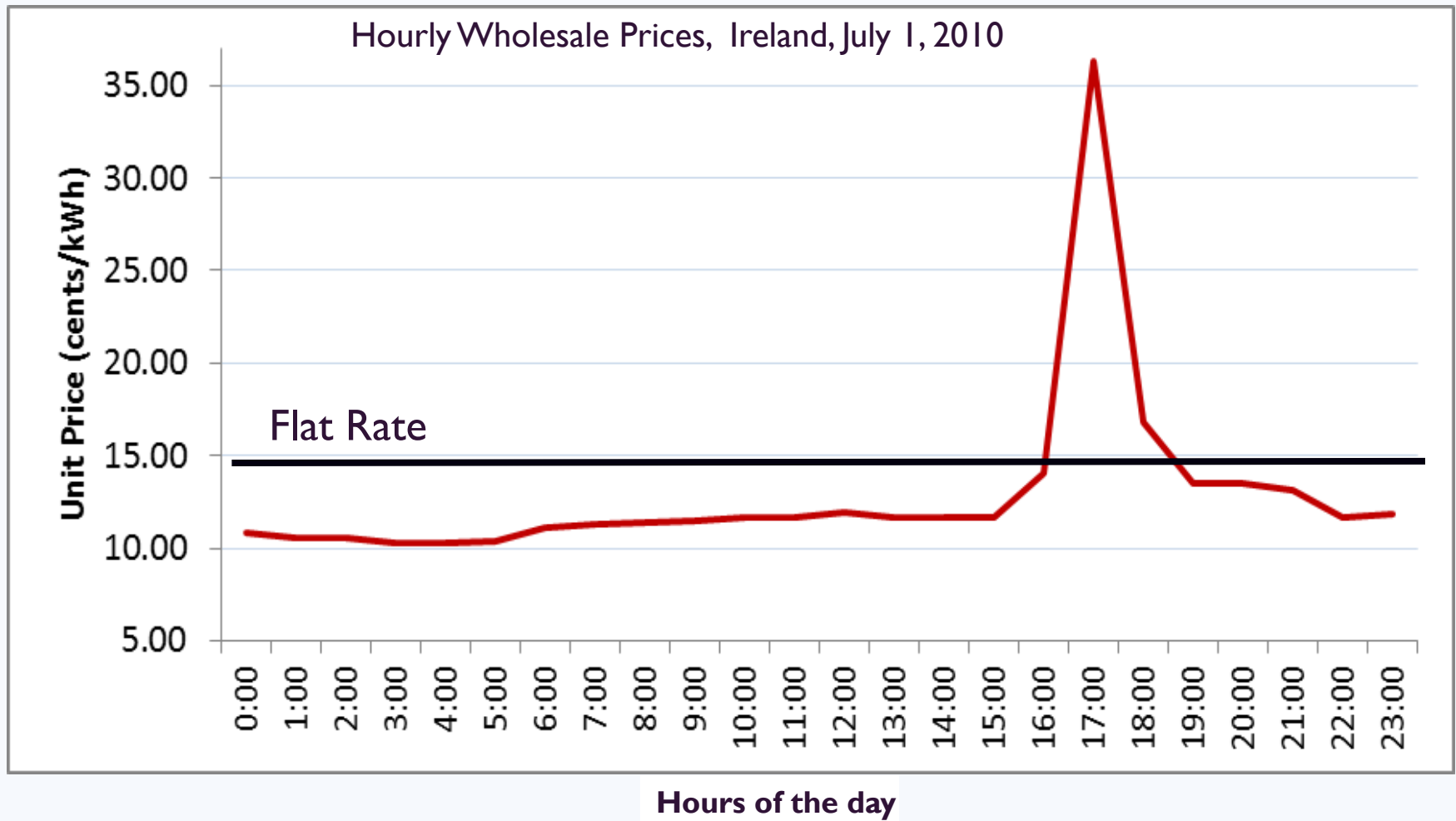
1 meter reading  
per month

## Smart Meters (AMI)

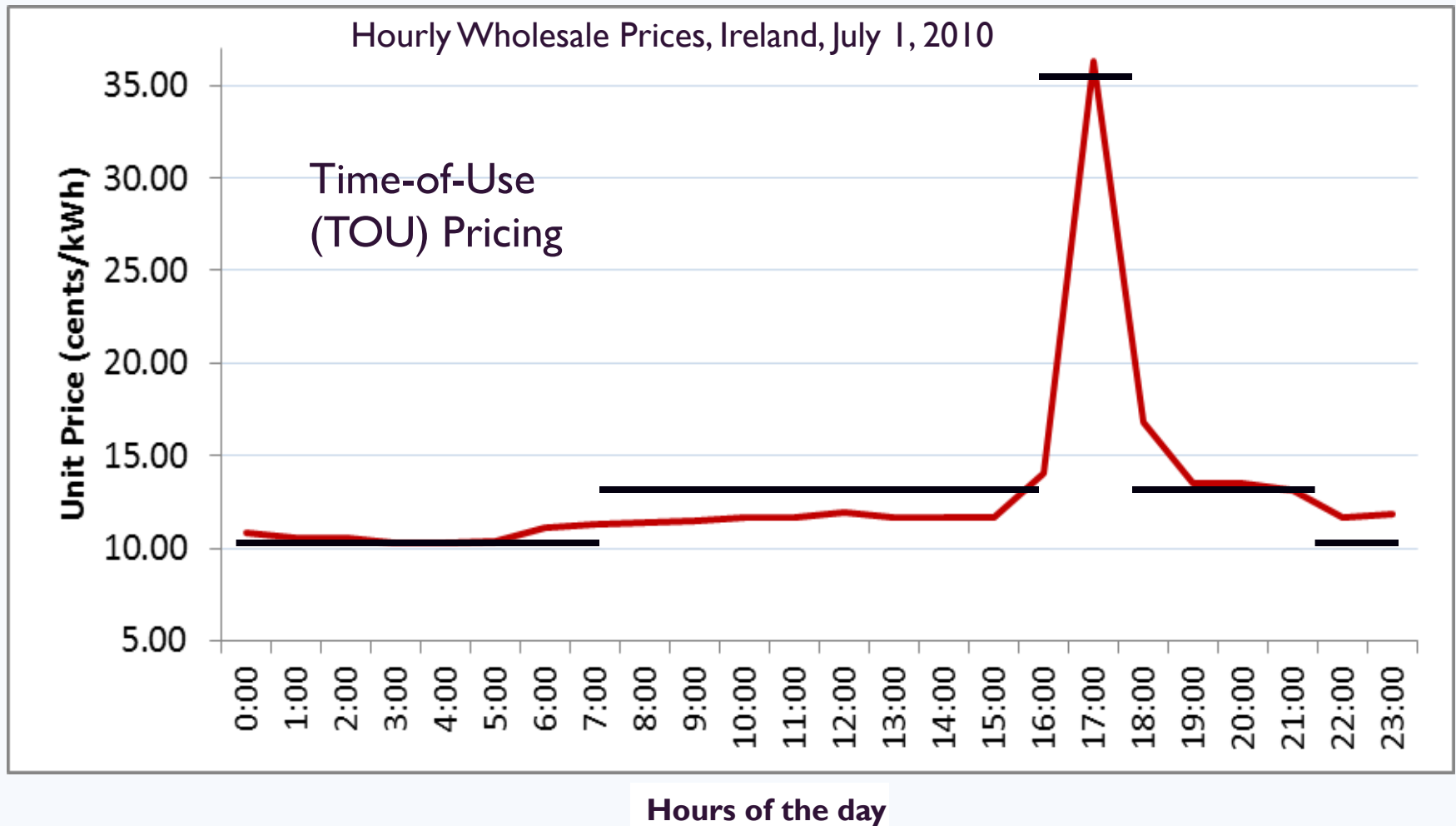


Electricity consumption  
data in at least hourly  
intervals

# Before smart meters: Flat Rate!

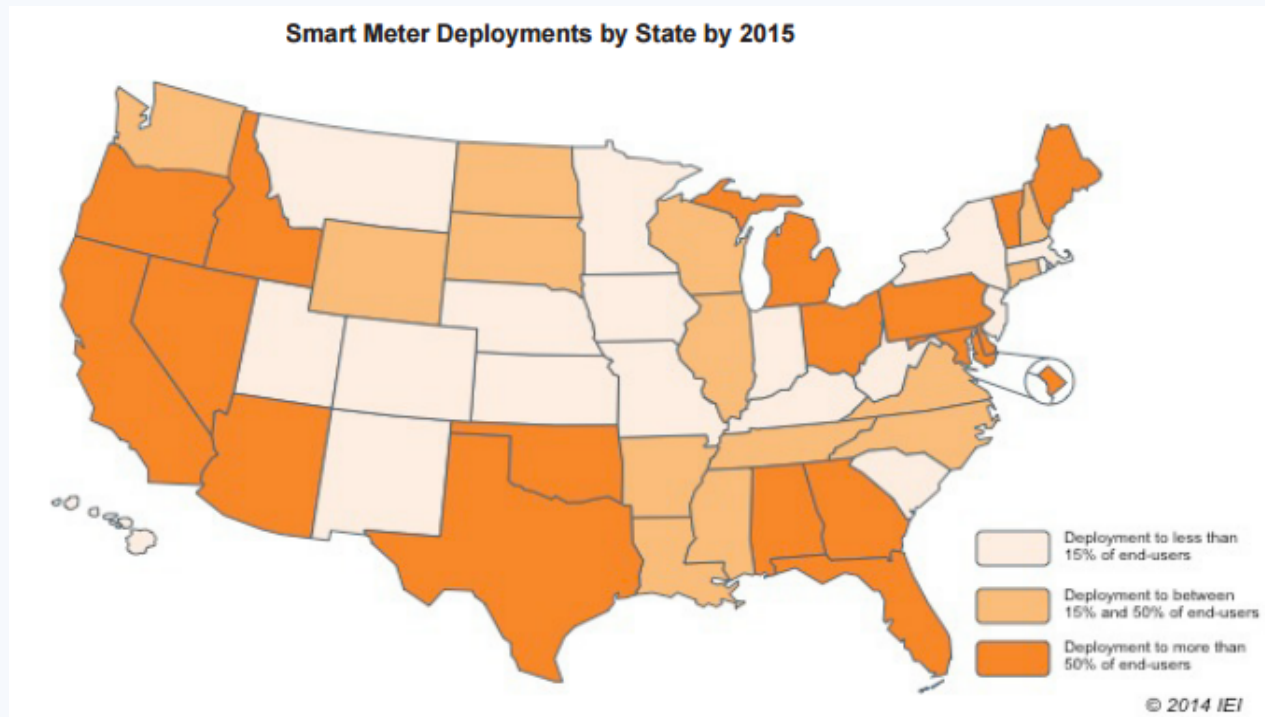


# Before smart meters: Flat Rate!



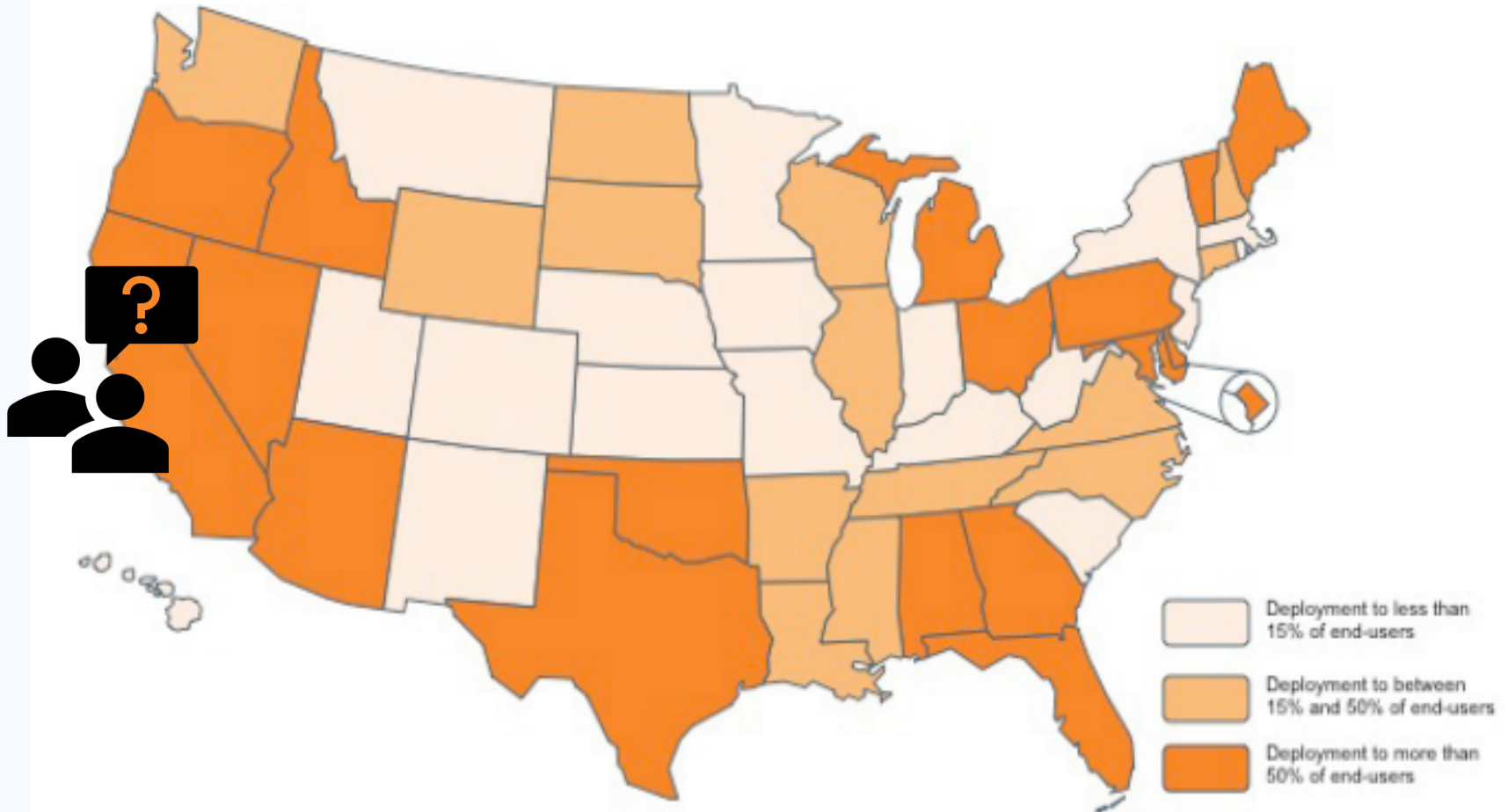
# How widespread are smart meters...

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

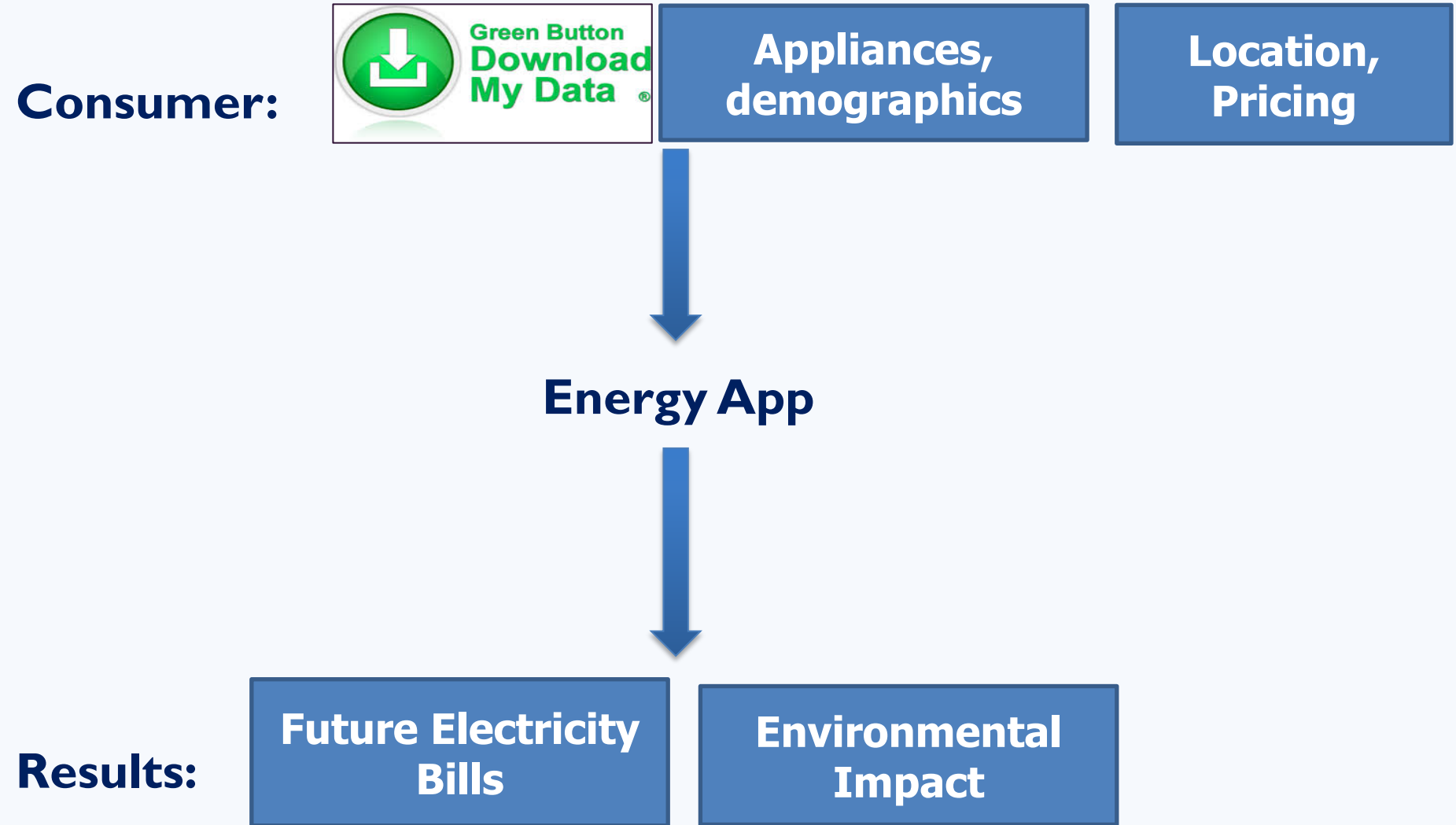


# Flat Rate or Time-of-Use Rate?

## Electricity Bills, Environmental Impact?

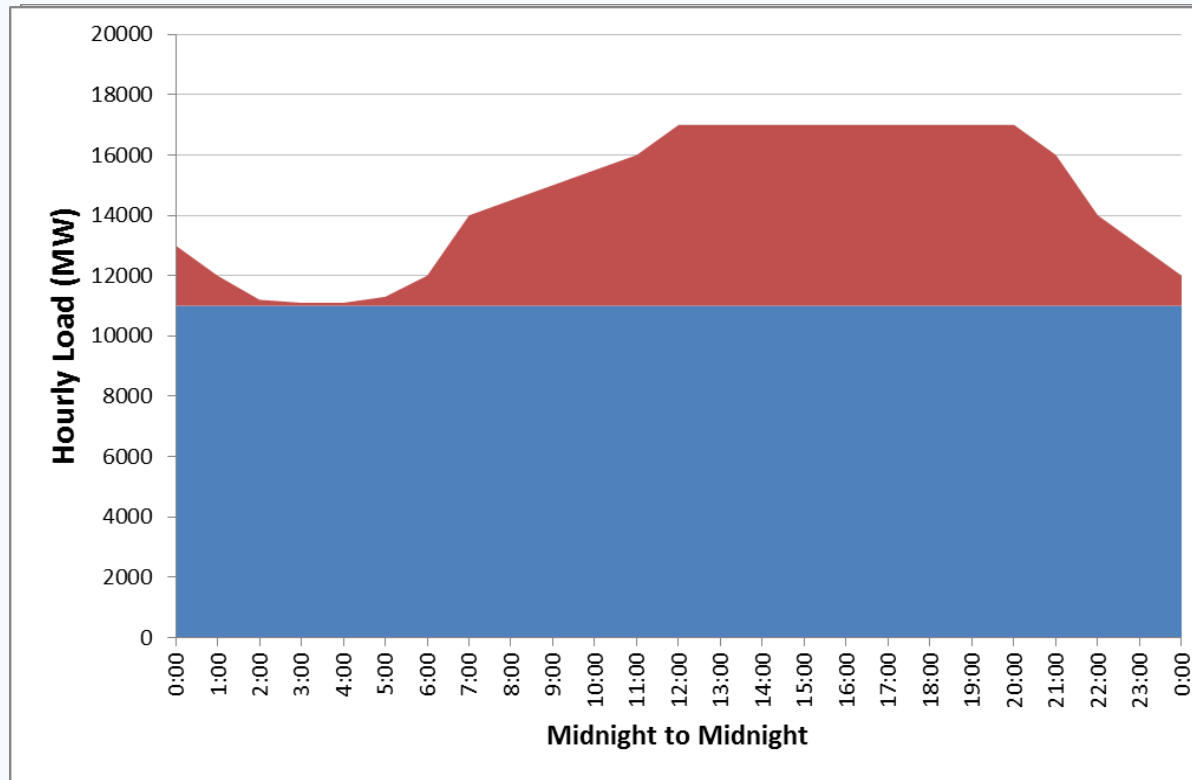


# Energy App



**Flat Rate or Time-of-Use Rate?**

# How does time-based pricing affect the environment?



**PEAK LOAD**

**INTERMEDIATE  
LOAD**

**BASE LOAD**

**PEAK LOAD**

**PEAKER NG**

**OIL**

**BASE LOAD**

**COAL**

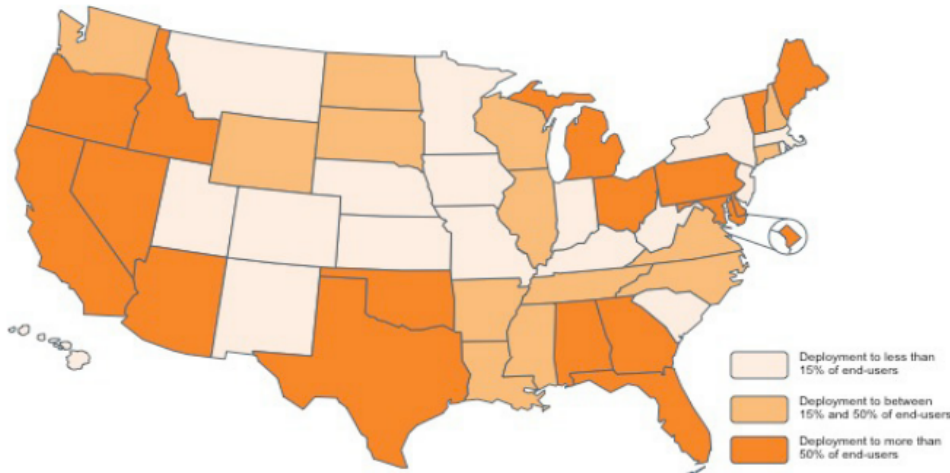
**NUCLEAR**



# 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).

Smart Meter Deployments by State by 2015



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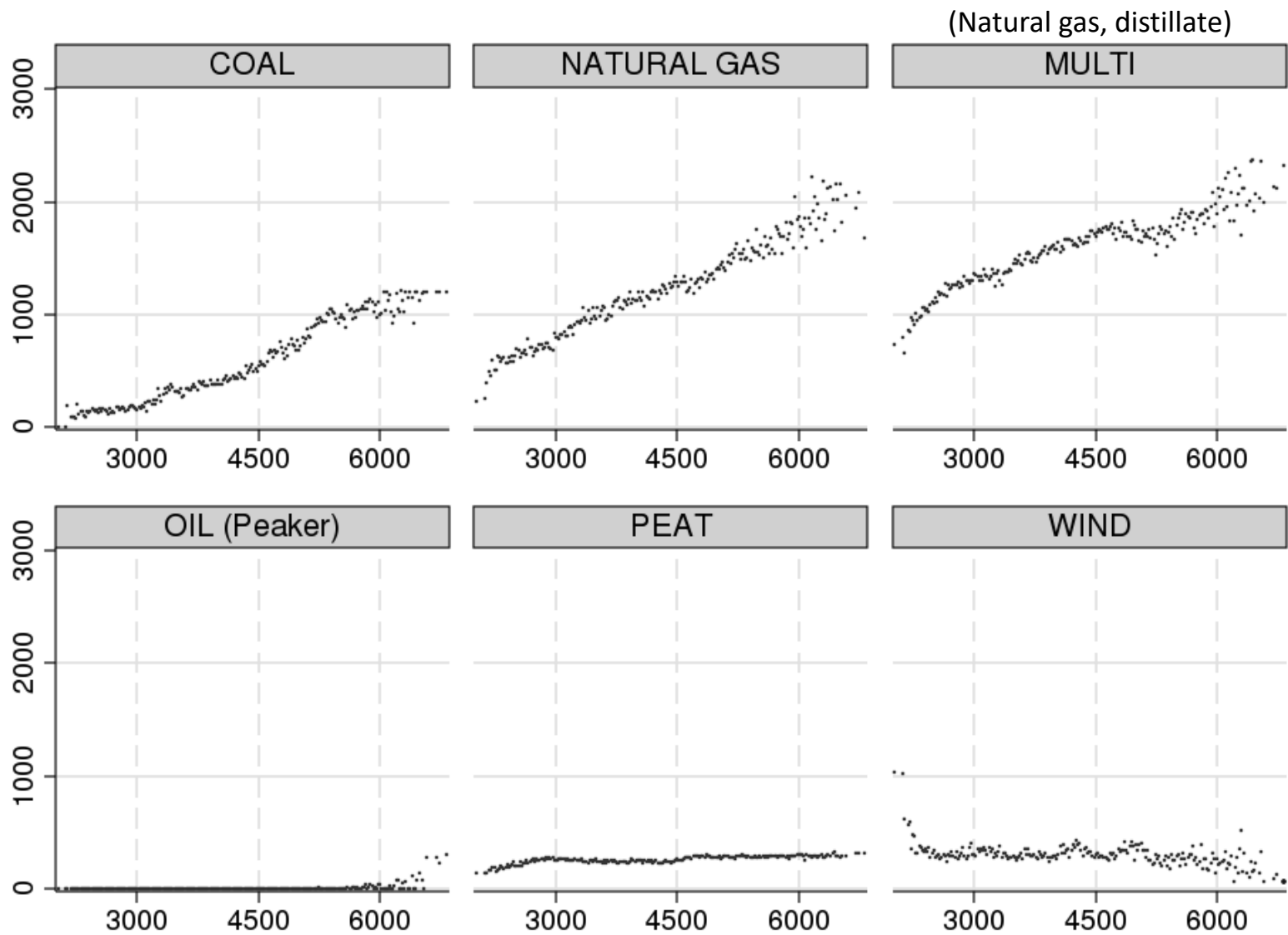
# Consumption and Survey Data: Time-based Pricing Field Experiment

## 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
TREATMENT GROUPS	{	A	938	14	20	12
		B	364	13.5	26	11
		C	962	13	32	10
		D	364	12.5	38	9
CONTROL GROUP	{	E	762	14.1	14.1	14.1

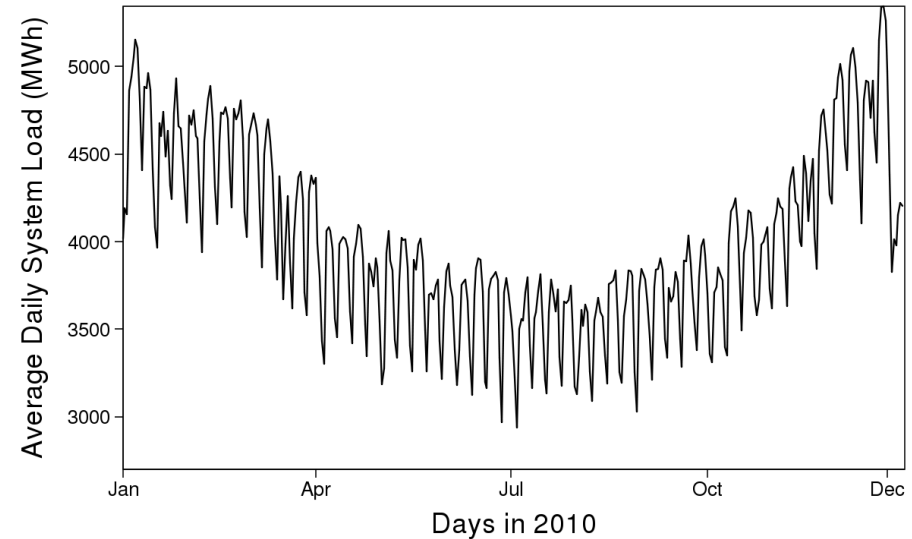
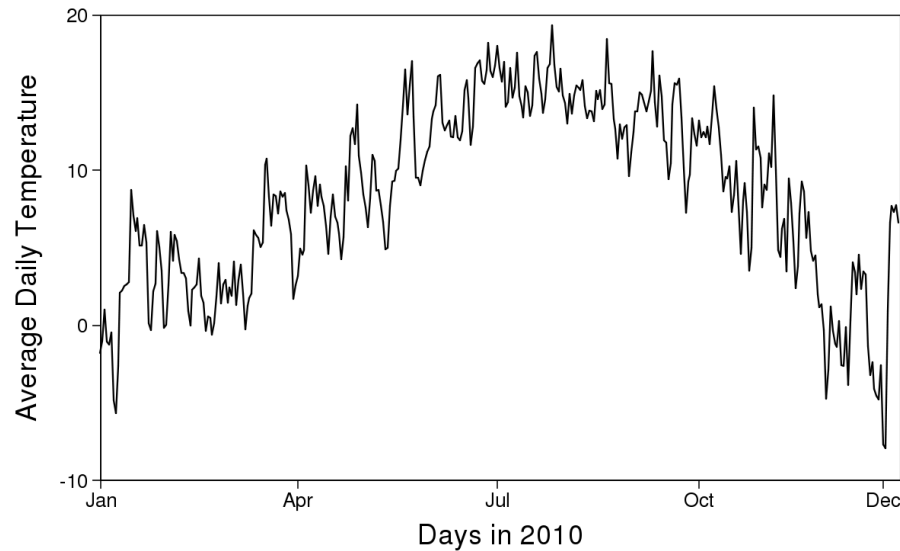
Electricity Supply by Fuel Type (MWh)



Hourly System Load (MWh)

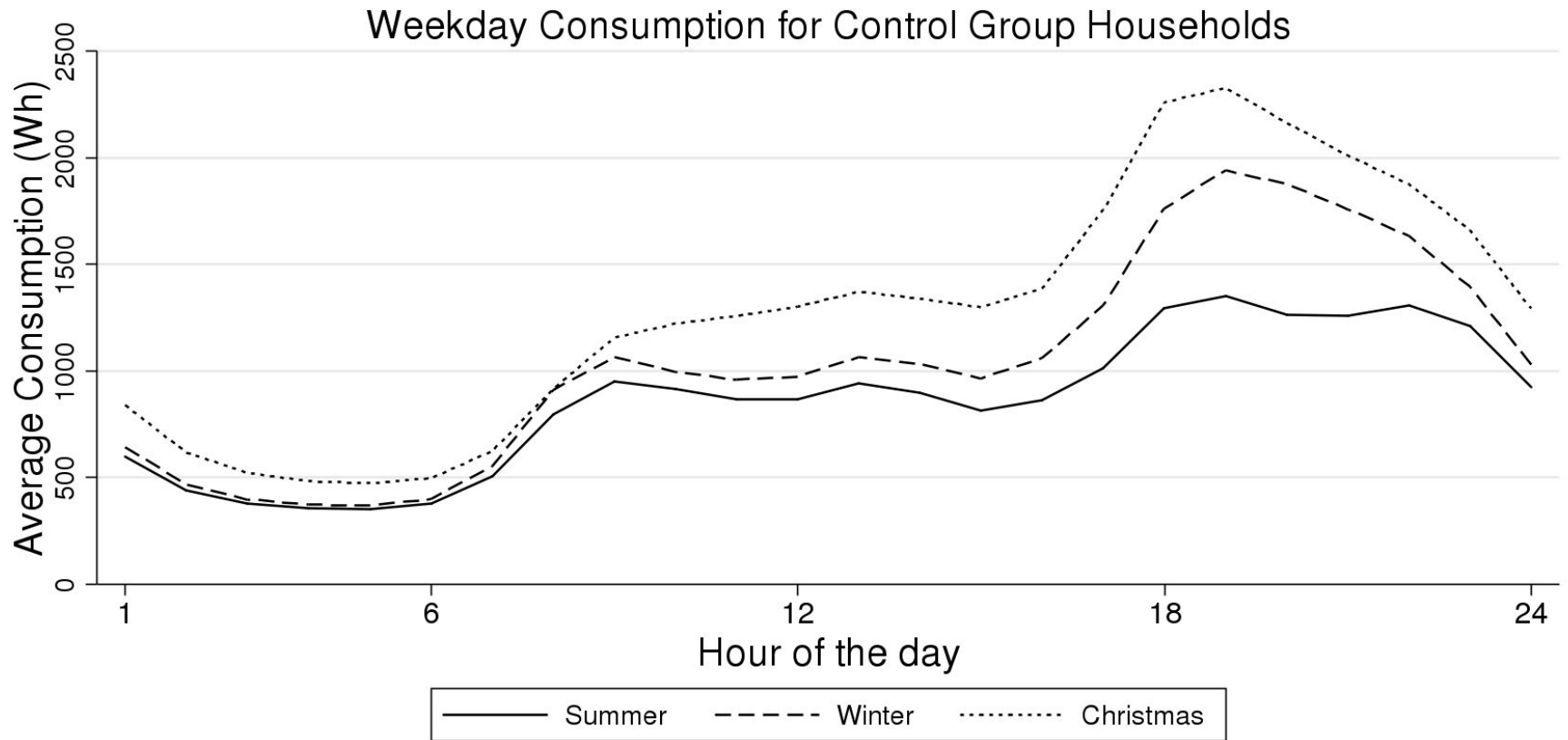
# Temperature and average consumption have an inverse relationship.

Summer Christmas

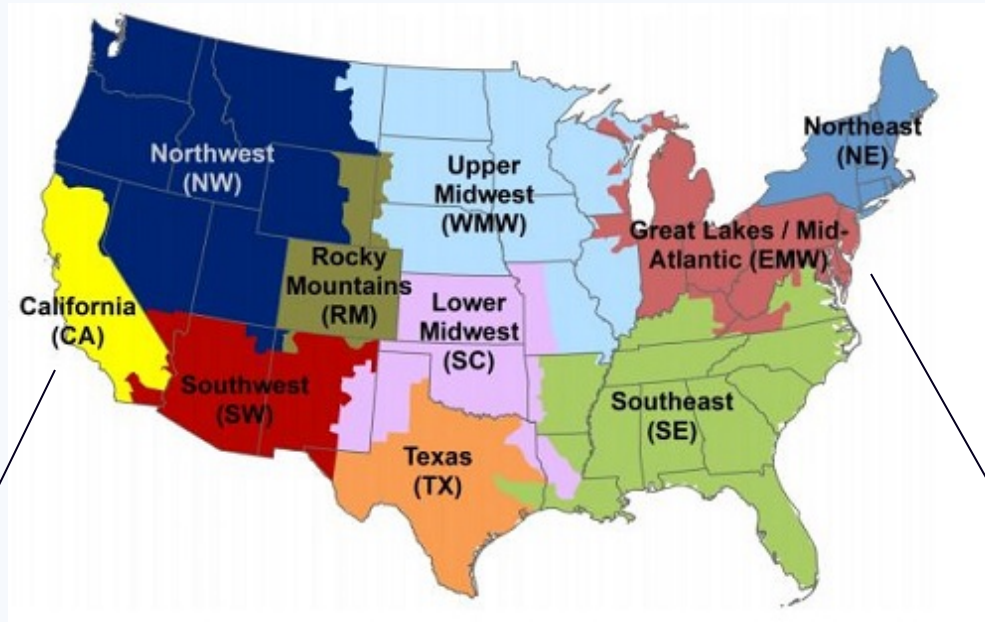


Electric heating >>> A/C use.

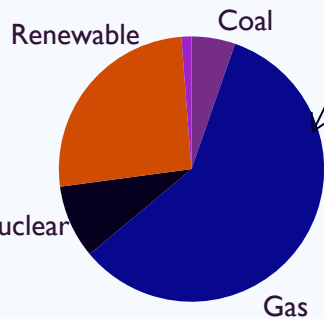
# Consumer demand has seasonal variation.



# Environmental Impact: The U.S. Case



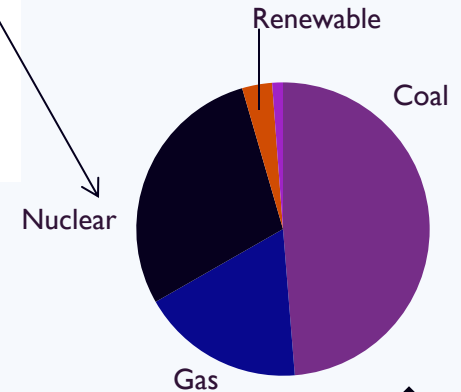
## CALIFORNIA



CO<sub>2</sub>  
emissions



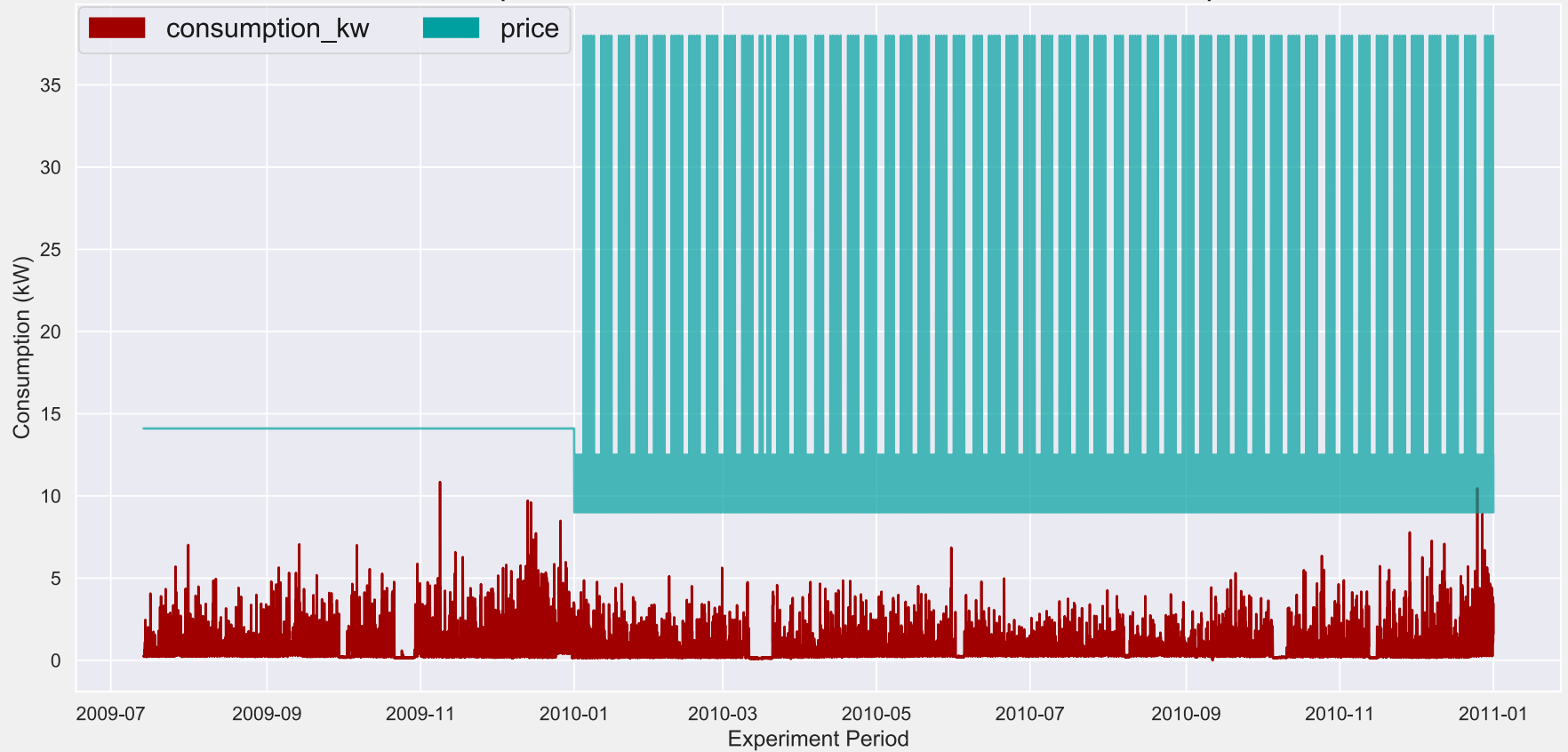
## MID-ATLANTIC



CO<sub>2</sub>  
emissions



Consumption and Price Data for a Consumer in Tariff Group D



# 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.



Time-based pricing flattens the demand curve:  
Capacity ↓ Utilization ↑ Reliability ↑ Cycling ↓

