BUILDING ENERGY MODELS & EMISSIONS

October 2020

WattTime

"Giving people the power to choose cleaner electricity"

Who We Are

- High-tech nonprofit dedicated to accelerating the development & spread of new sustainability techniques

- Built by 200+ volunteers from Google, MIT, Climate Corp, DOE, and more

- Joined forces with Rocky Mountain Institute in 2017

What We Do

- Obsessed with understanding grid emissions at a granular level and building tools to help others use that information to maximize impact and advance goals

- Effectively utilize granular emissions data (5 minute intervals) over 100 U.S. grid regions
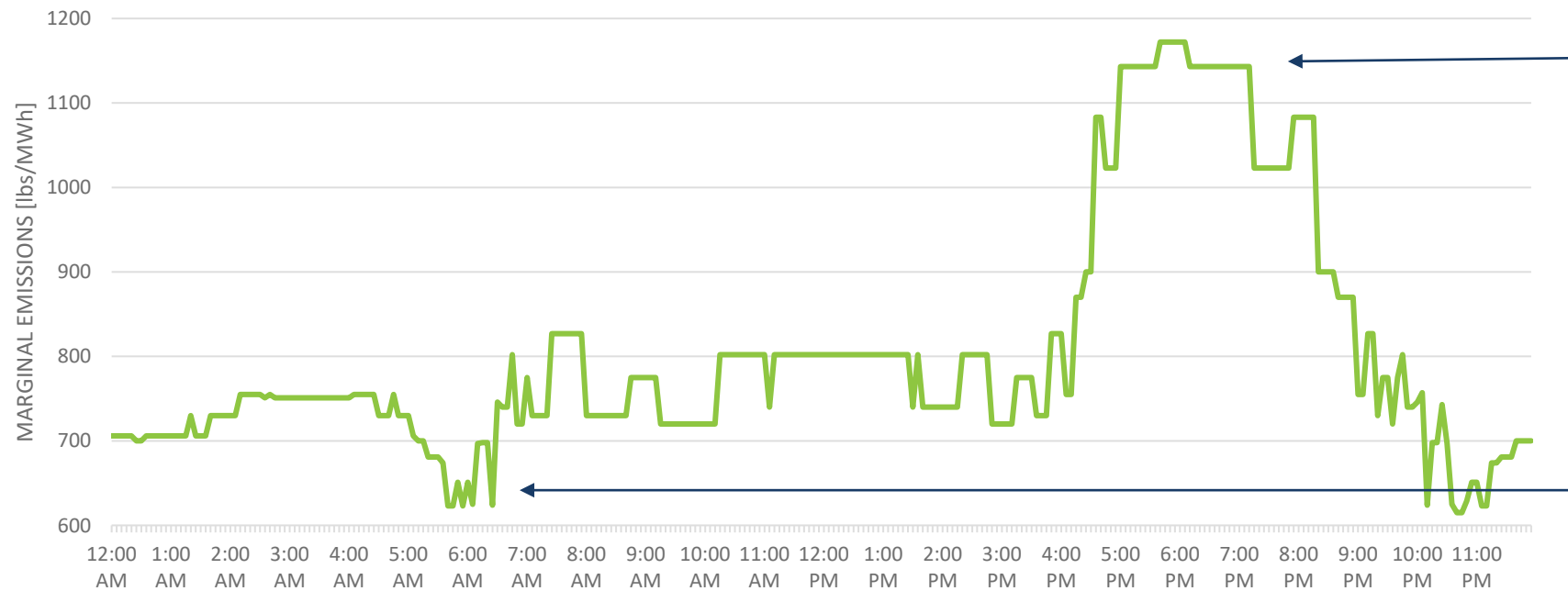
UNDERSTANDING GRID EMISSIONS

Not All Kilowatt Hours Are Created Equal
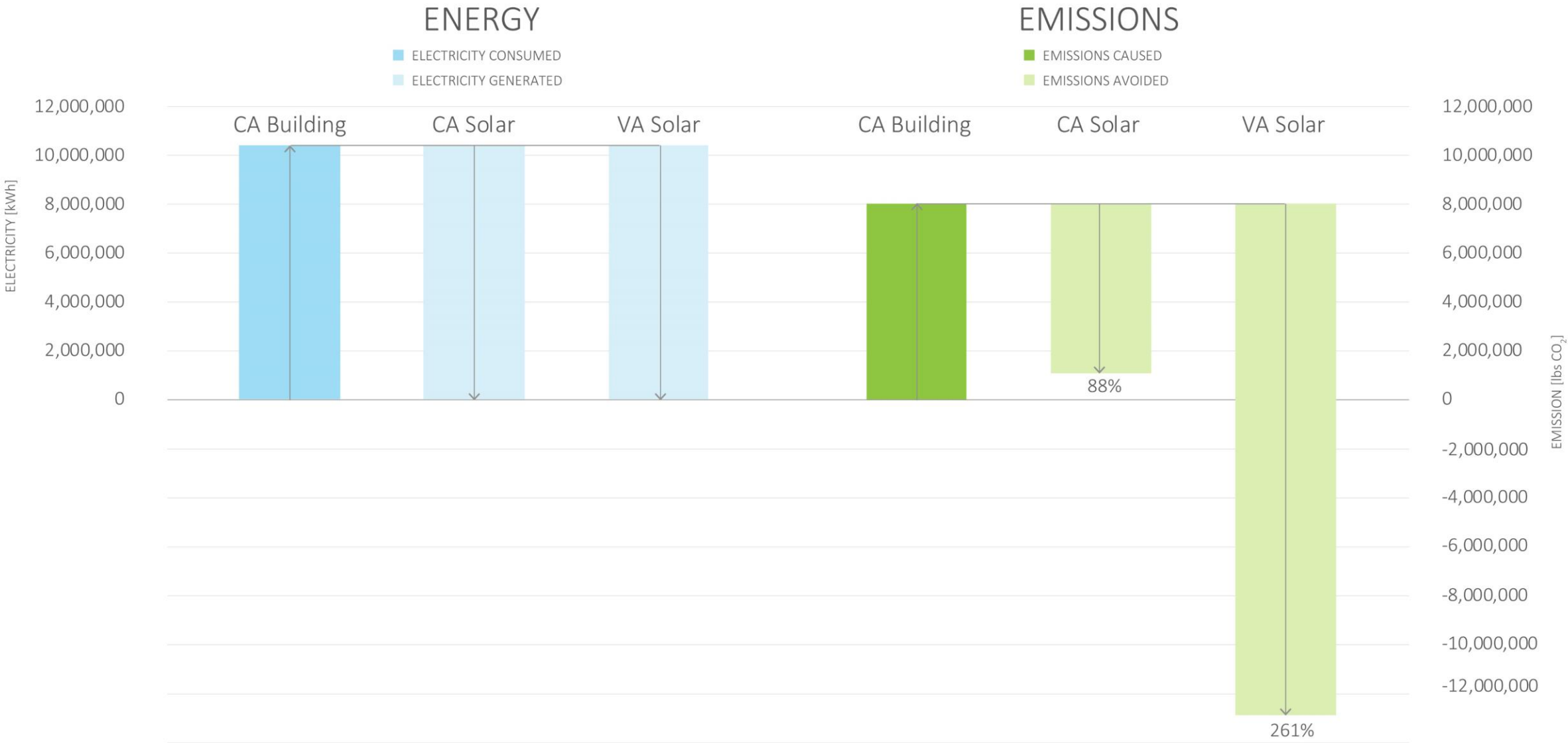
Grid Emissions Vary By Time

The marginal power plant that reacts when demand changes is different throughout the day
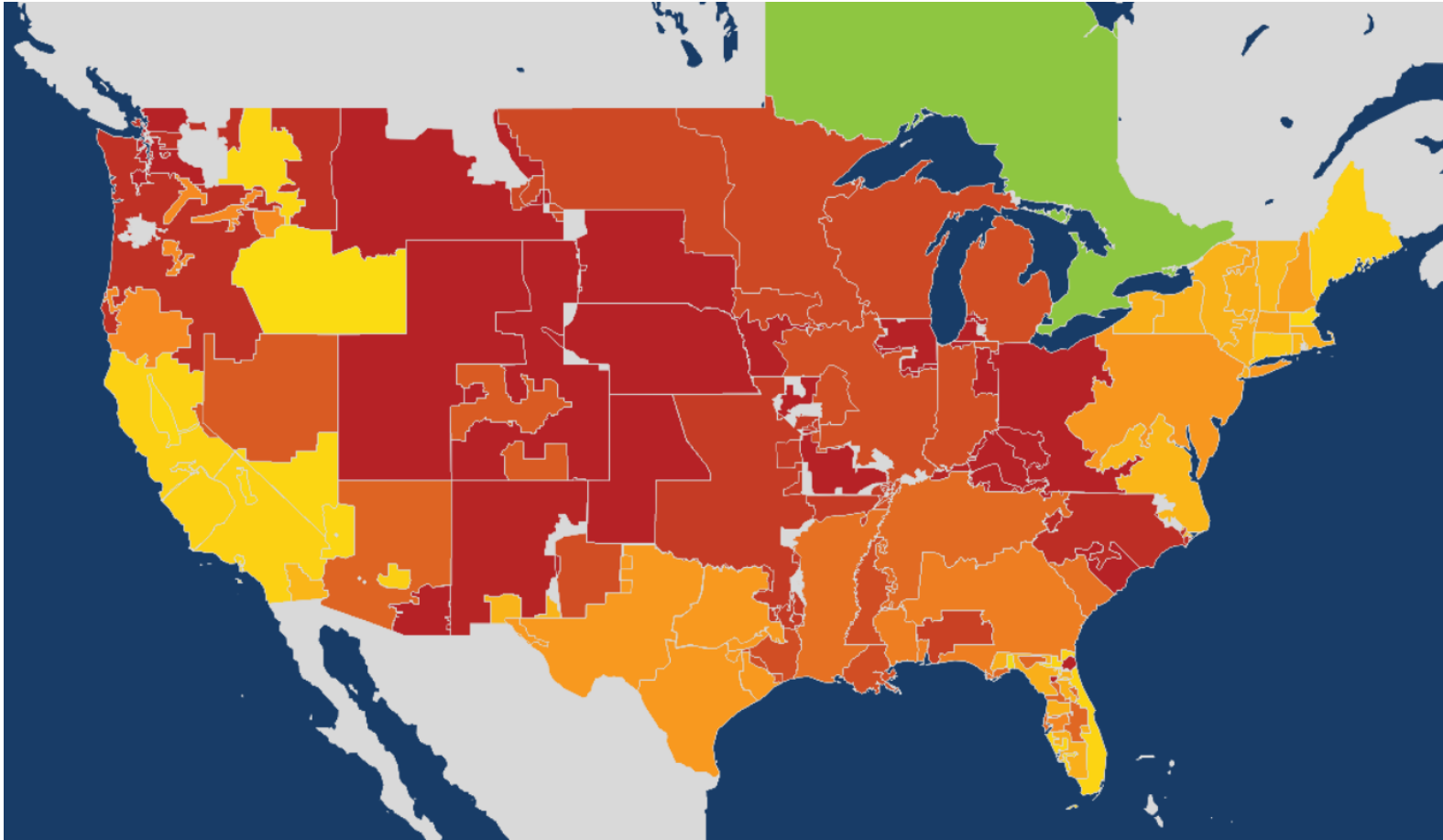
ISONE MARGINAL EMISSIONS - JANUARY 5, 2017

A dirty time on the grid. Using electricity at this time causes more carbon emissions.

A clean time on the grid. Using electricity at this time causes fewer carbon emissions.
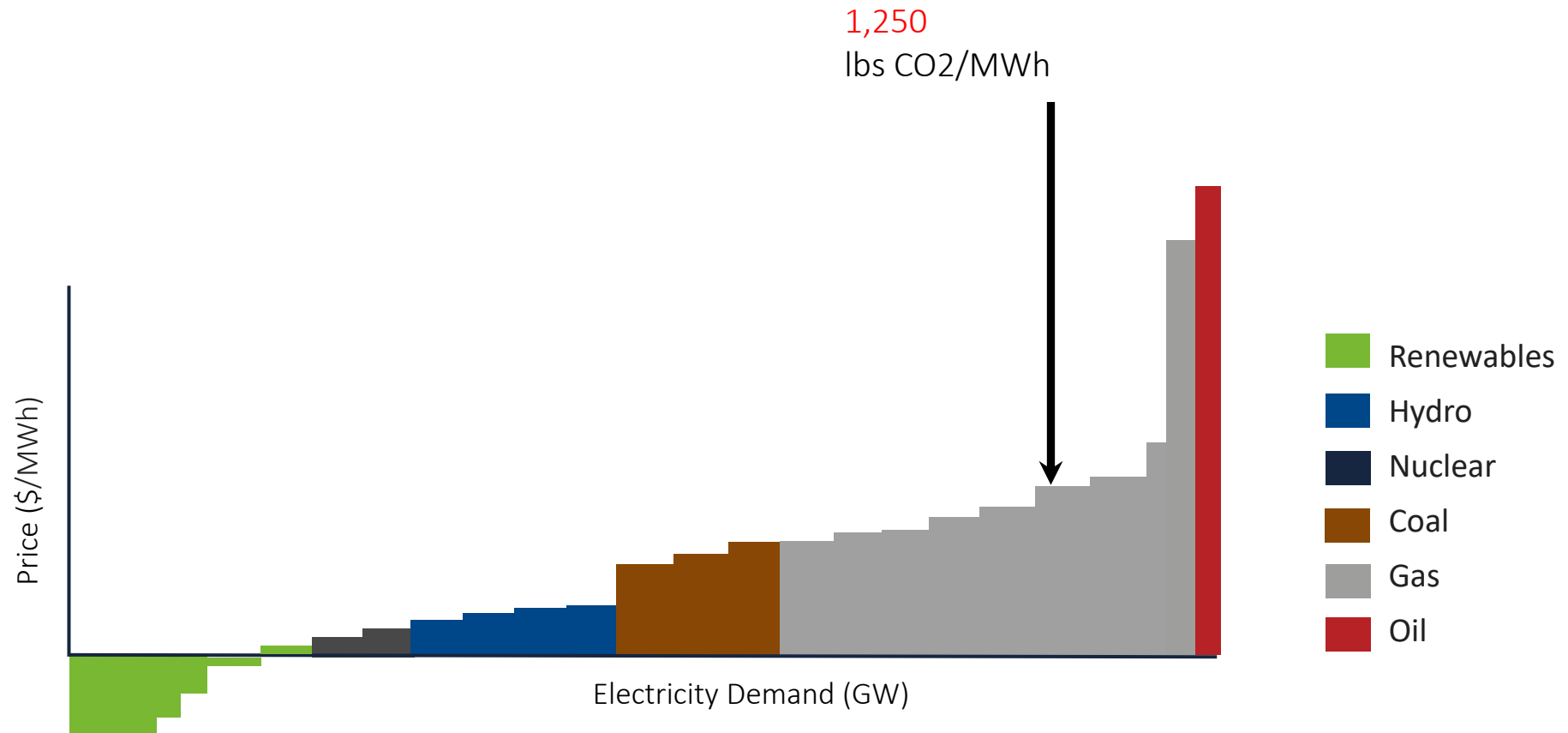
Grid Emissions Vary By Location

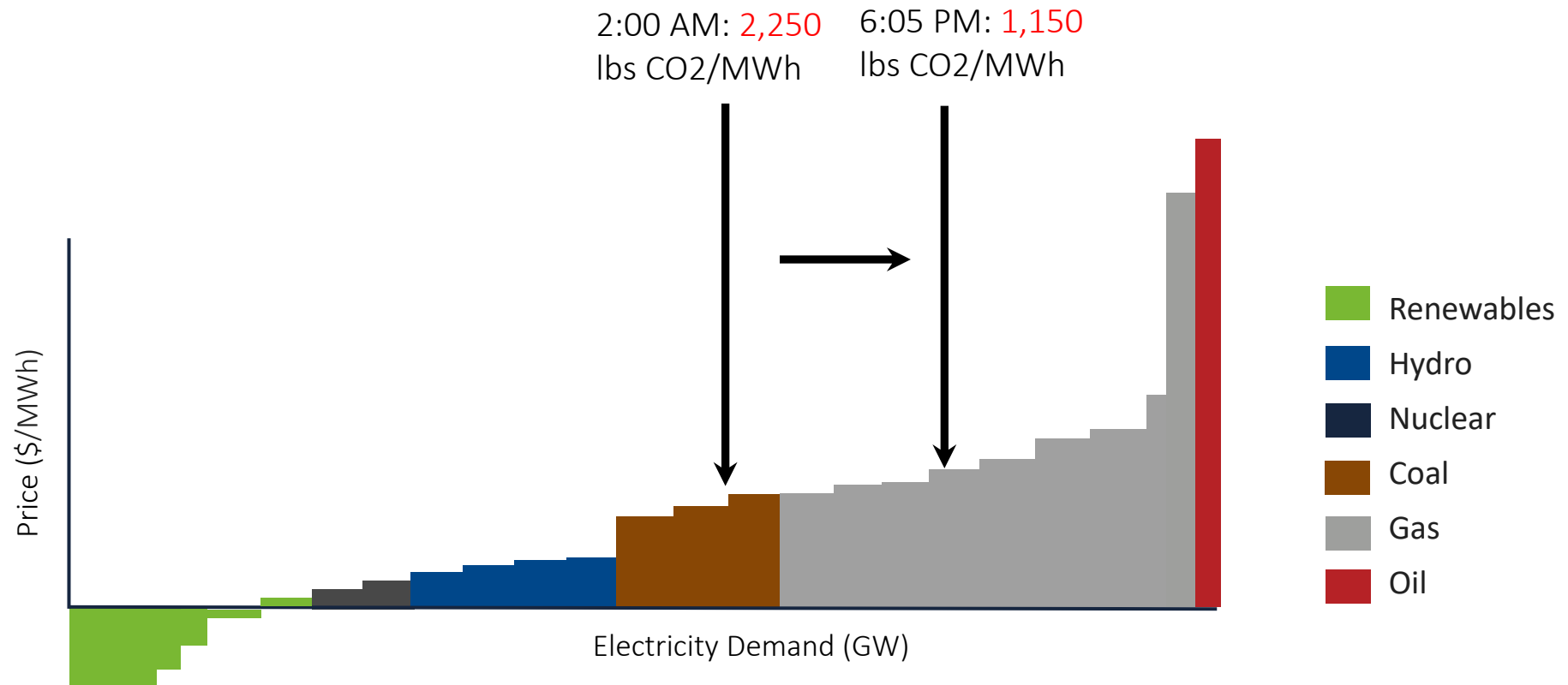The emissions of electricity depends on which region you are located in

The US electric grid is comprised of different regions, each regulated by a balancing authority. The balancing authority manages electricity within each region and between neighboring regions to maintain a balanced supply and demand. This balance is maintained by turning on or off energy generating power plants or by exporting or importing electricity with neighboring grid regions.

The largest balancing authorities are called Independent Services Operators and Regional Transmission Organizations (ISOs/RTOs).
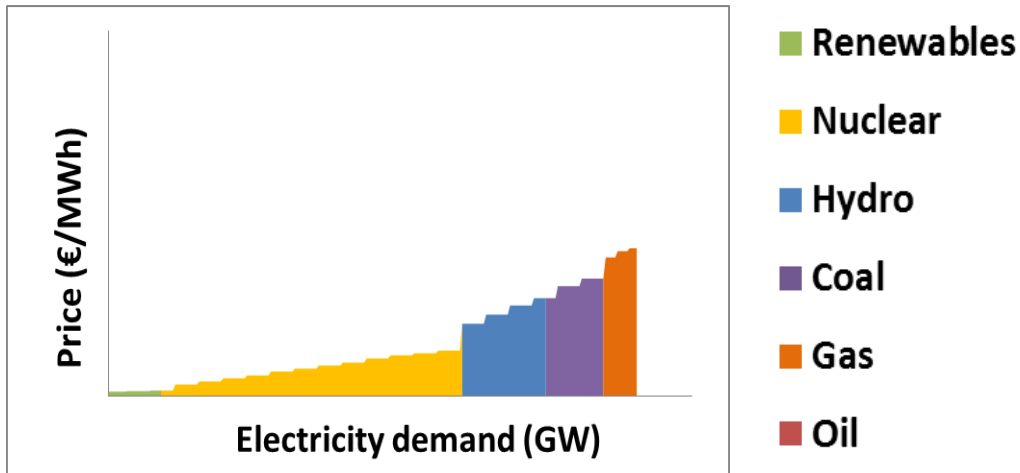
Why emissions factors vary by time (sample grid)

1,250
lbs CO2/MWh

Price ($/MWh)

Electricity Demand (GW)

- Renewables
- Hydro
- Nuclear
- Coal
- Gas
- Oil

Wholesale Cost Does Not Always Equal Emissions

2:00 AM: 2,250 lbs CO2/MWh

6:05 PM: 1,150 lbs CO2/MWh

Price ($/MWh)

Electricity Demand (GW)

Renewables
Hydro
Nuclear
Coal
Gas
Oil

How We Actually Calculate Emissions

Price-Based Method

- **Renewables**
- **Nuclear**
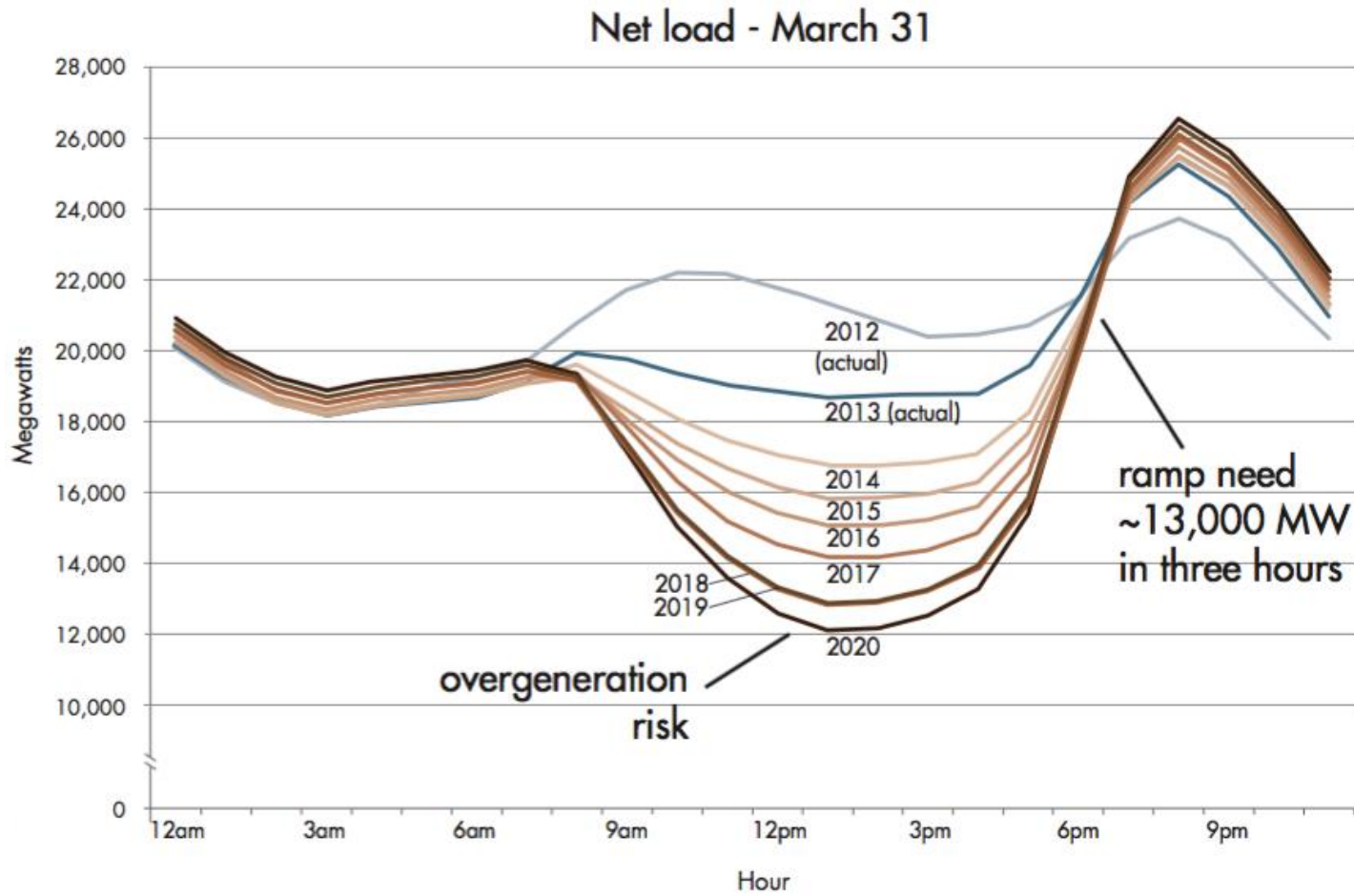- **Hydro**
- **Coal**
- **Gas**
- **Oil**

Empirical Method
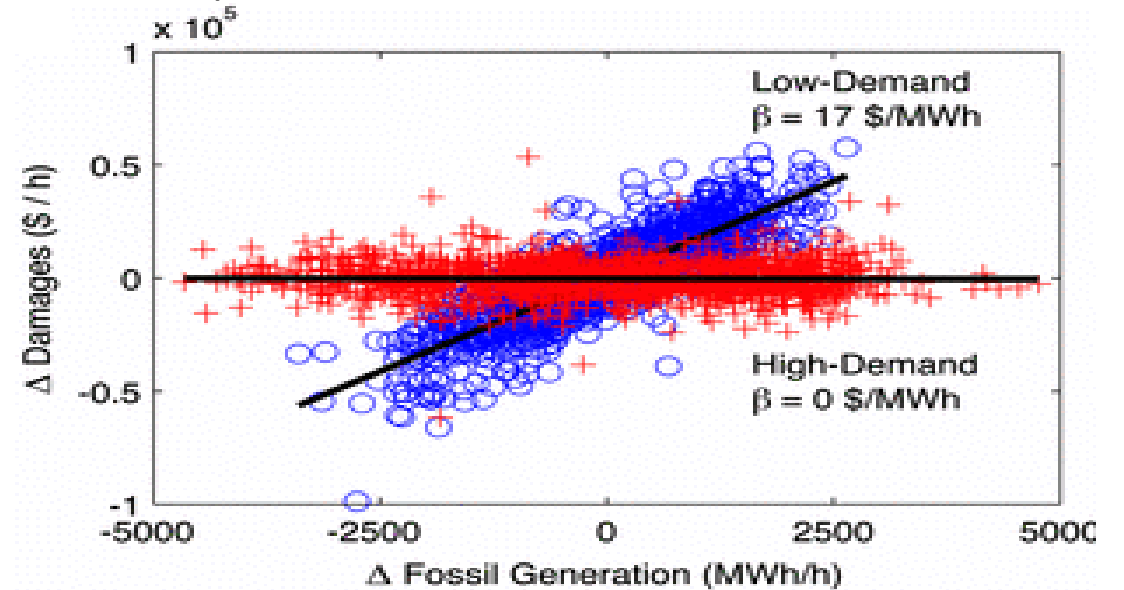
Data sources:

- EPA's Continuous Emissions Monitoring System (CEMS)

- ISOs' Open Access Same-Time Information System (OASIS)

- Combined by algorithms from CMU, MIT, UCB, UCSD, WSU, & Yale

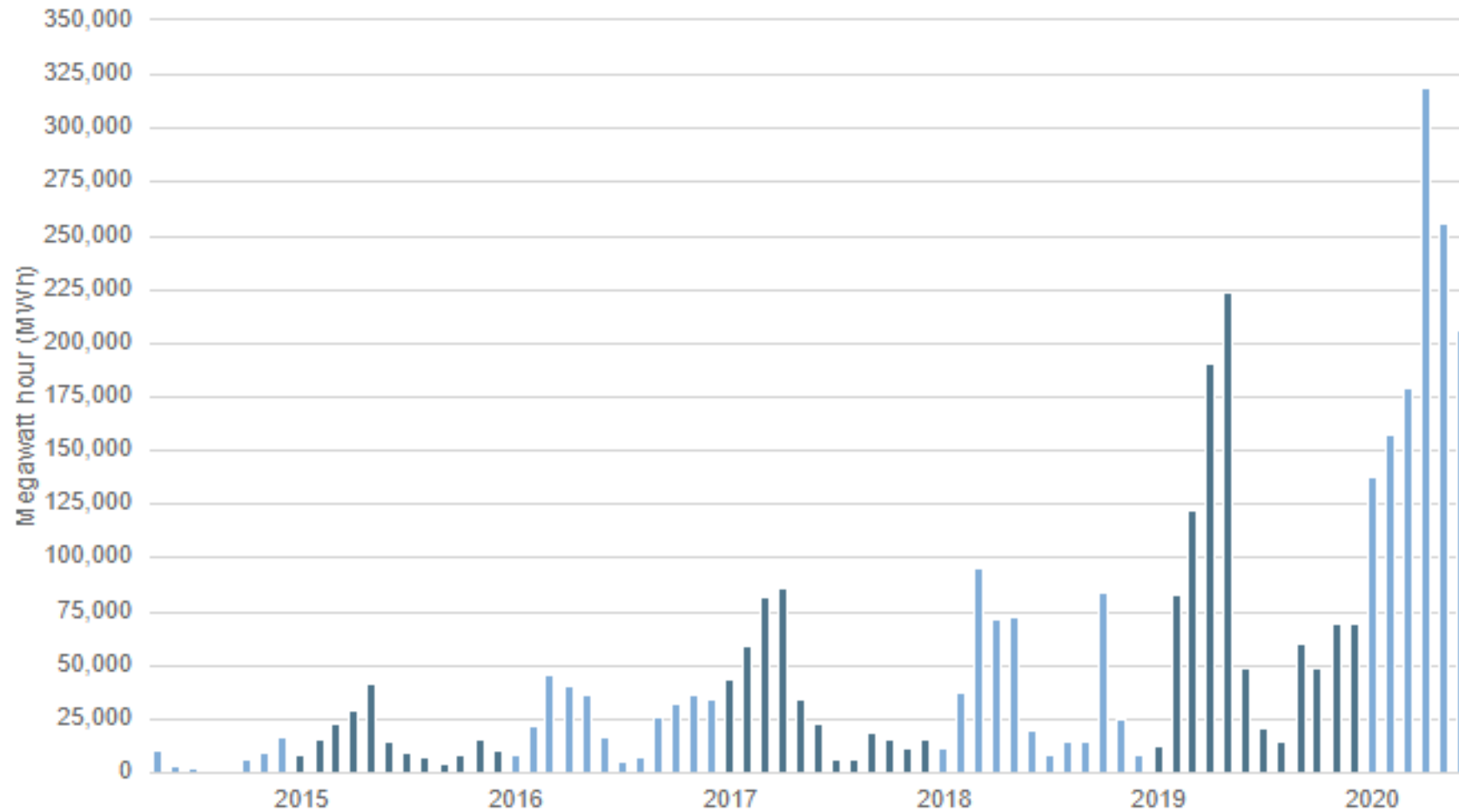- Notably Rogers et al (2013) and Siler-Evans et al (2013)

The Duck Curve

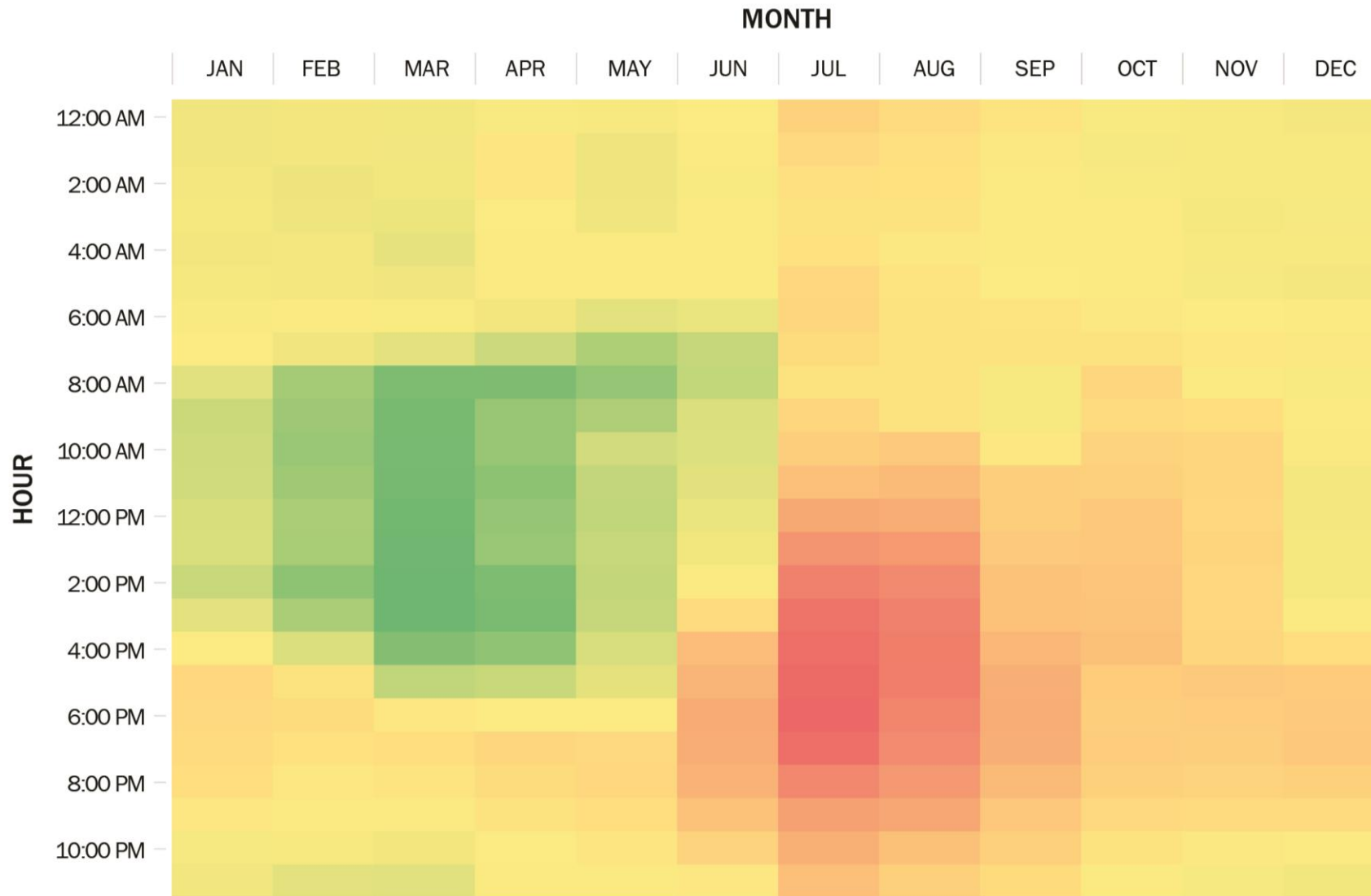Solar Penetration in California

Net load - March 31

Renewable Curtailment

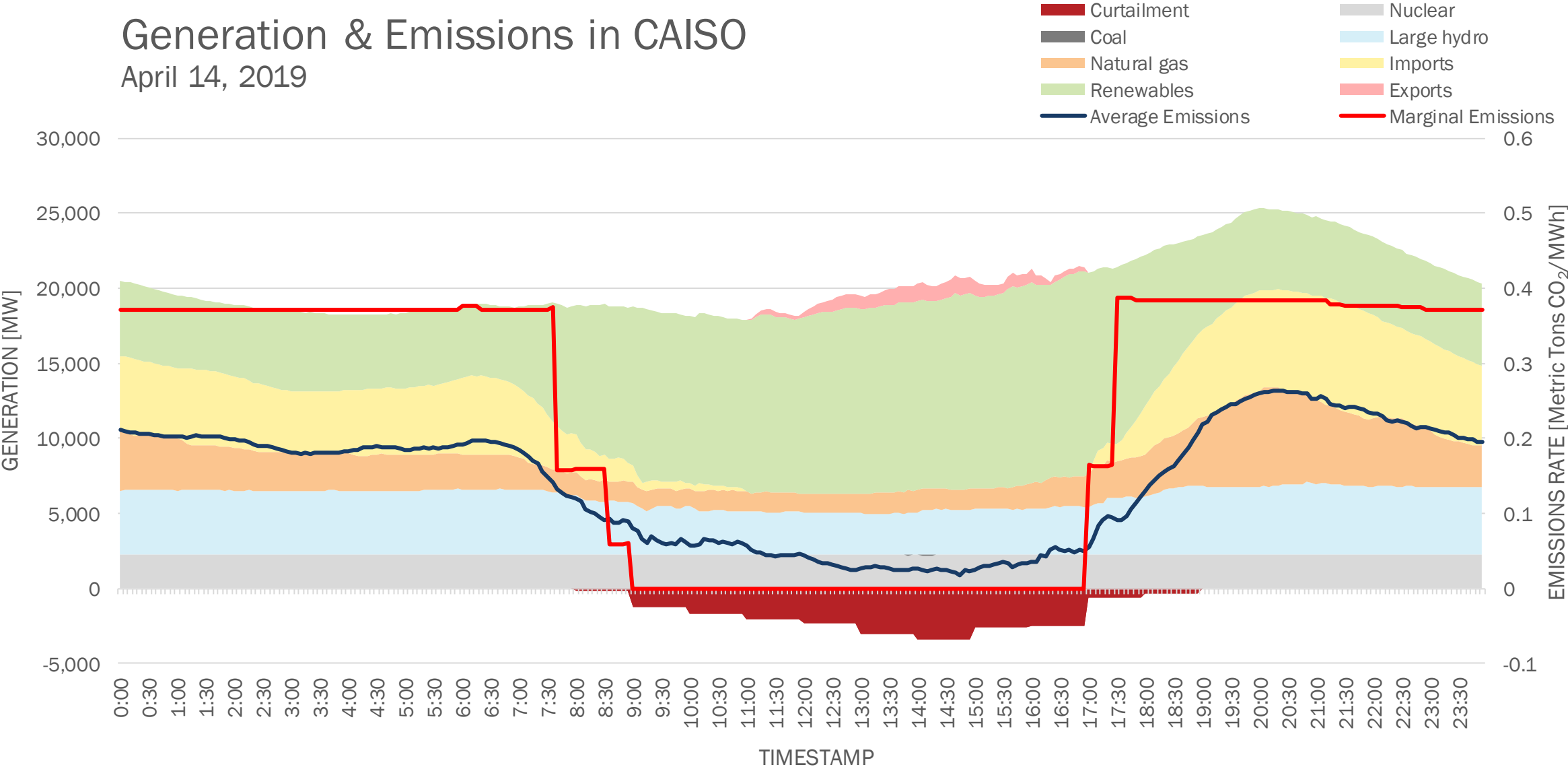Solar and wind energy being thrown away in California

Typical Grid Emissions
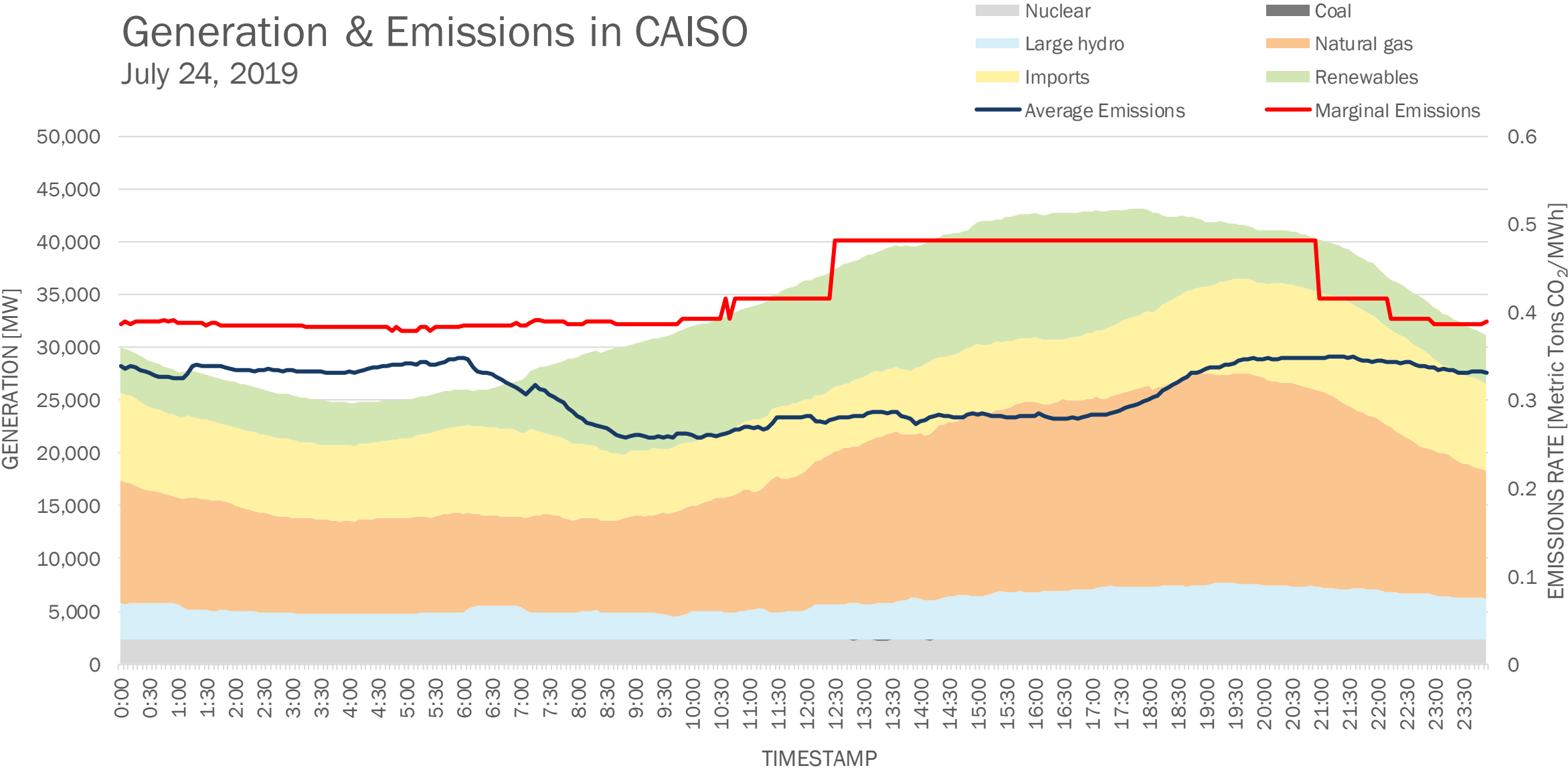
Detailed Emissions – CAISO Spring

Generation & Emissions in CAISO
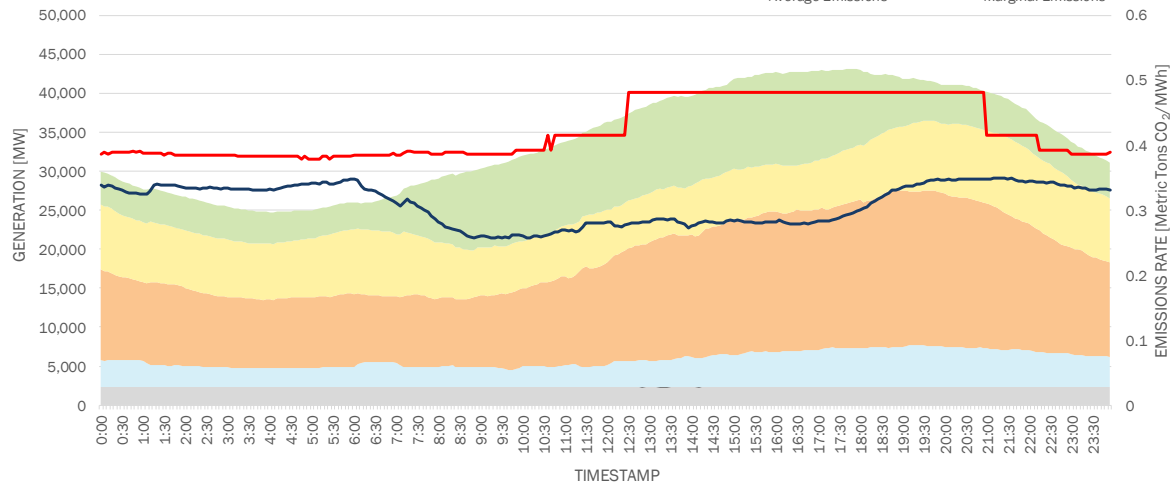April 14, 2019

Detailed Emissions – CAISO Summer

Generation & Emissions in CAISO
July 24, 2019
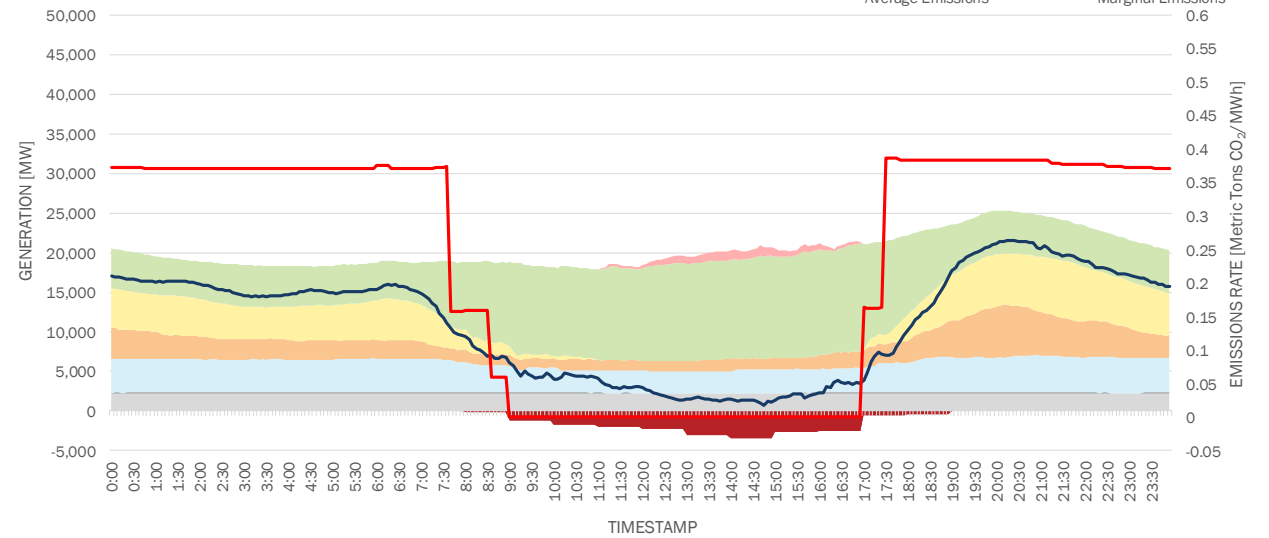
Detailed Emissions – CAISO Comparison

Generation & Emissions in CAISO
July 24, 2019

Generation & Emissions in CAISO
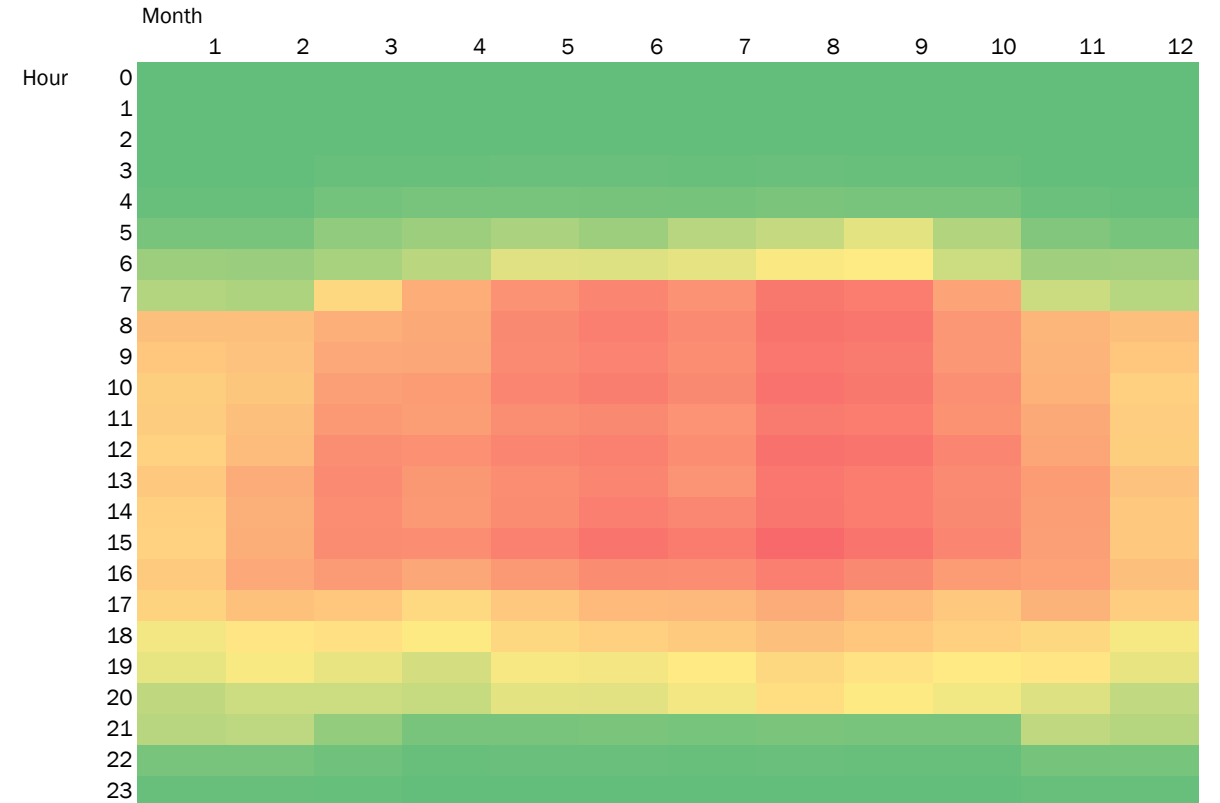April 14, 2019

EMISSIONS ASSESSMENT FOR BUILDING DESIGN

Reconciling Grid Emissions and Building Performance

Marginal Emissions Rates
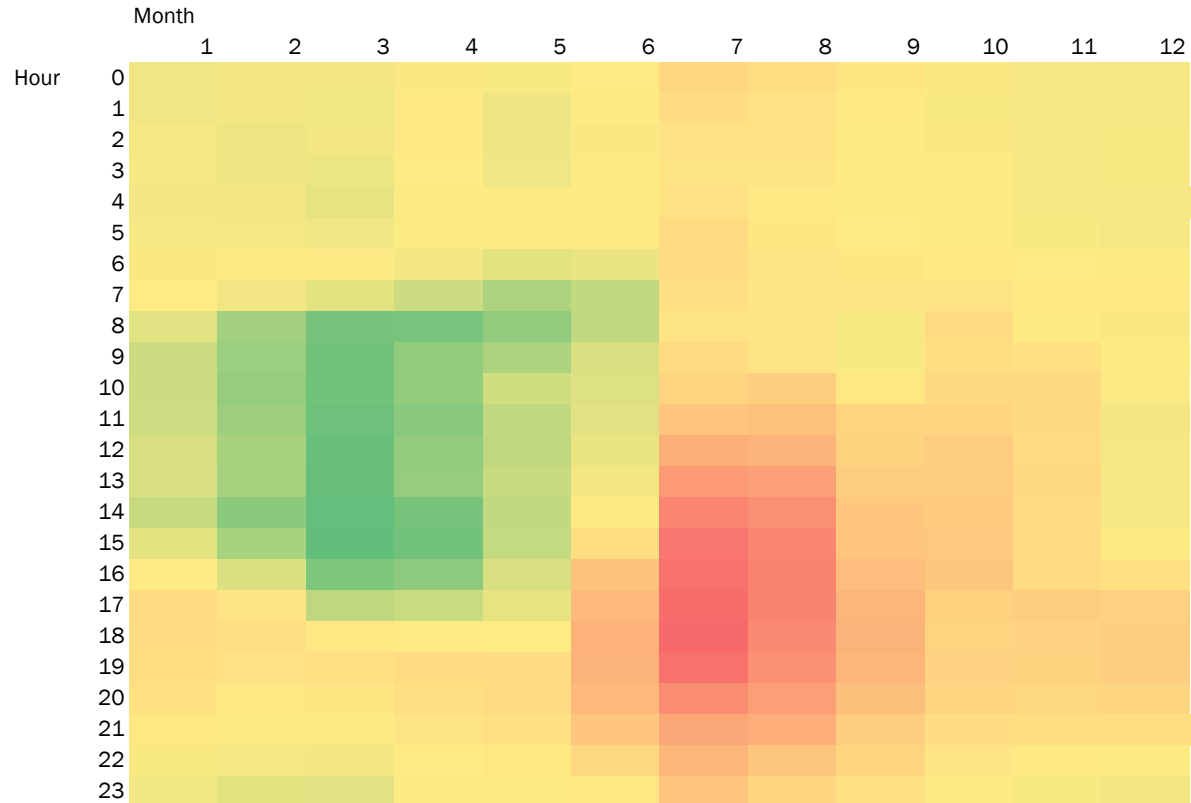
Building Electricity Consumption

Typical Grid Emissions Profiles


Typical Grid Emissions Profile
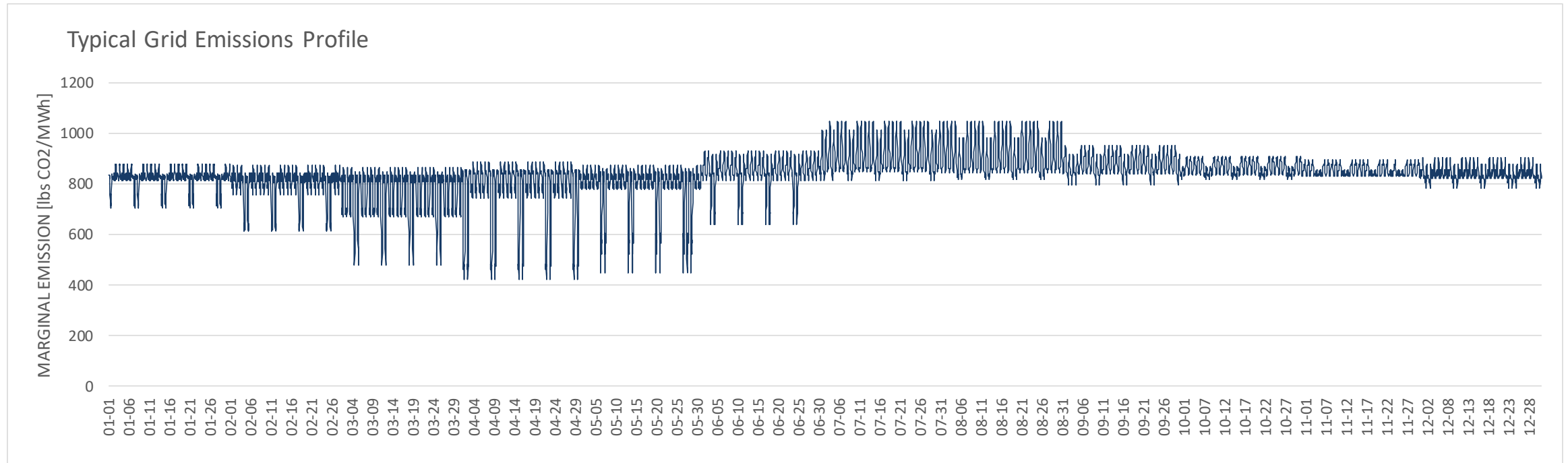
- Based on 2-3 years of historical emissions data
- Normalized to account for typical meteorological year
- Indicate building location and simulation year

https://www.atelierten.com/app/uploads/2019/07/Carbon-methodology-paper-190724.pdf
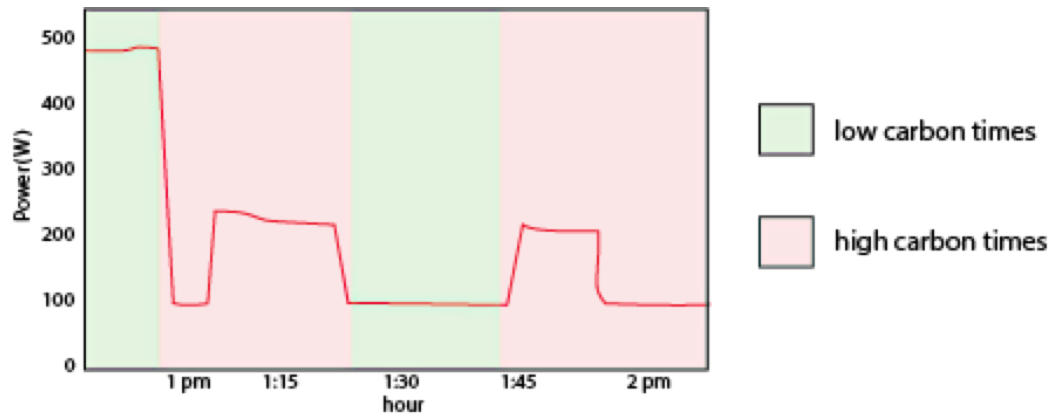
Emissions Reductions Through Timing

- Much electricity use is at least partially flexible in time
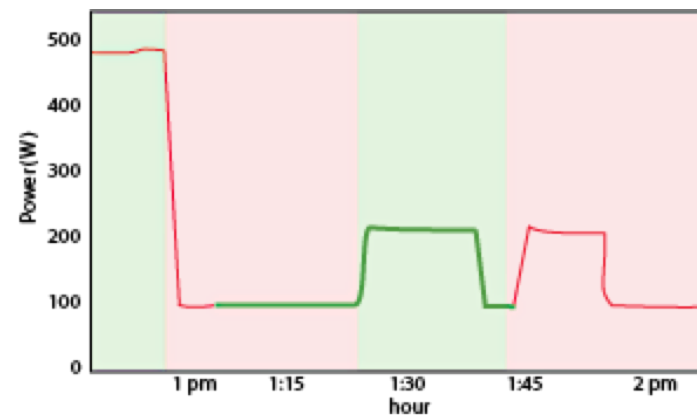- E.g. devices with compressor cycles can sync cycles to cleaner moments

Example: fridge cycles

Normal operation

low carbon times

high carbon times
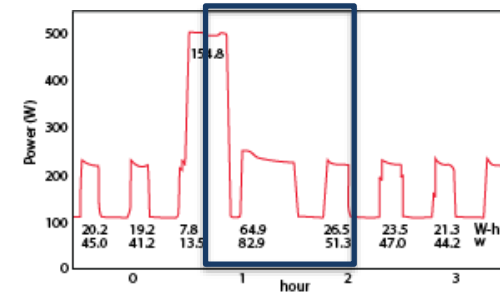
Emissions-optimized

Types of Data

Typical Carbon Profiles

- For building energy modelling
- Similar to Typical Meteorological Year (TMY) weather files
- Normalized historical data to match energy models

Real-Time Marginal Emissions

- Used for real-time device control
- 24-hour rolling forecasts used in device/end-use control algorithms for active control
- Historical marginal emission and forecasts used to train control algorithm

Thank You

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