Load Shifting Effect Analysis Using Marginal Emission Rates

Case Studies in California

Aoyu Zou
PhD Student

Center for the Built Environment
University of California, Berkeley

CBE
CENTER FOR THE BUILT ENVIRONMENT

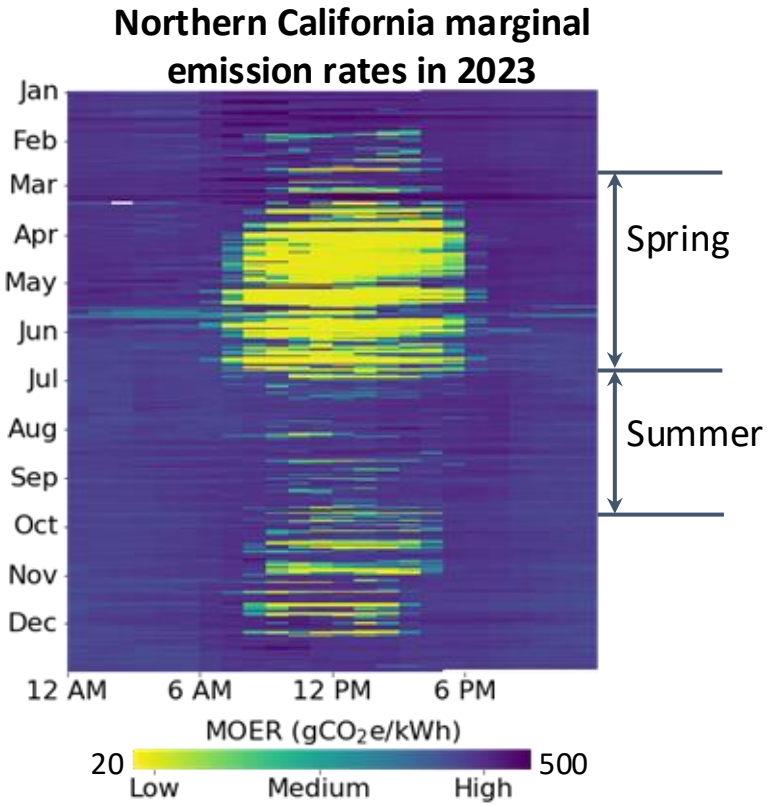
Grid marginal carbon emissions

Marginal emission rates

- Considers generating plant dispatch order
- Reflects grid demand and renewable supply
- Varies with seasons and times of day

Implication

- Using electricity at different times will impact carbon emissions
- Shifting load to right time may reduce carbon emissions



Case I: Quantifying office building chiller load shift potential

Objective

- Assess avoided carbon emissions from HVAC load shift strategy

Method

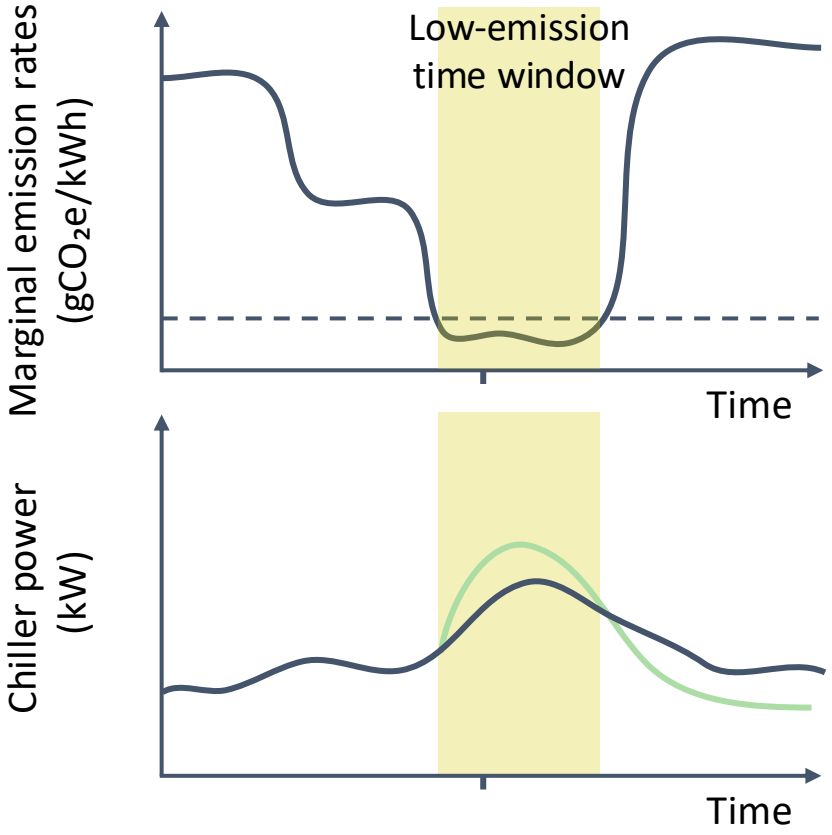
- Use grid marginal emissions rate to determine HVAC operational emissions
- Develop chiller load shift control strategies

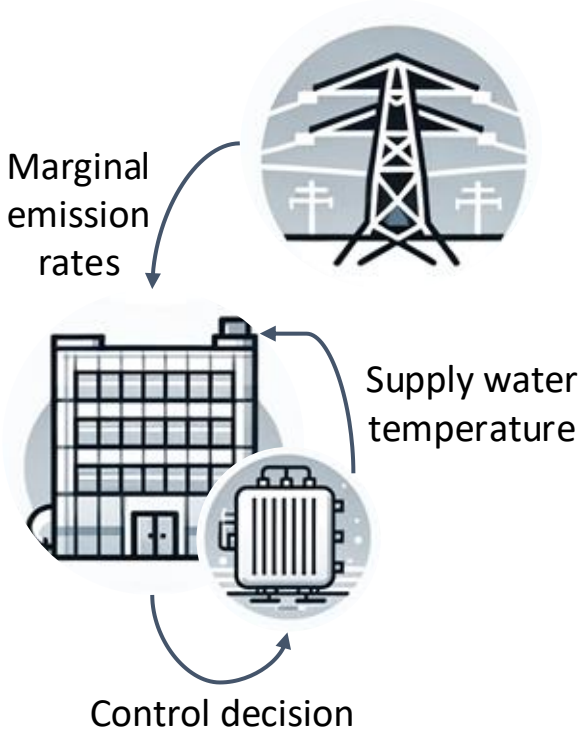
Funding

- CBE Funding
- CalNEXT

(Case study building)

Chiller load shift control

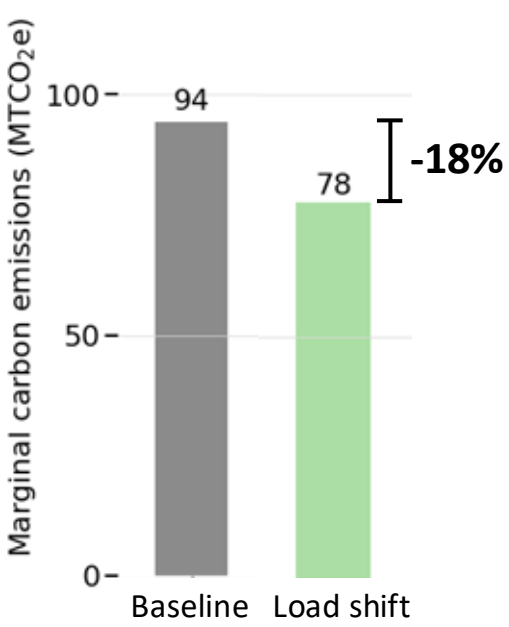




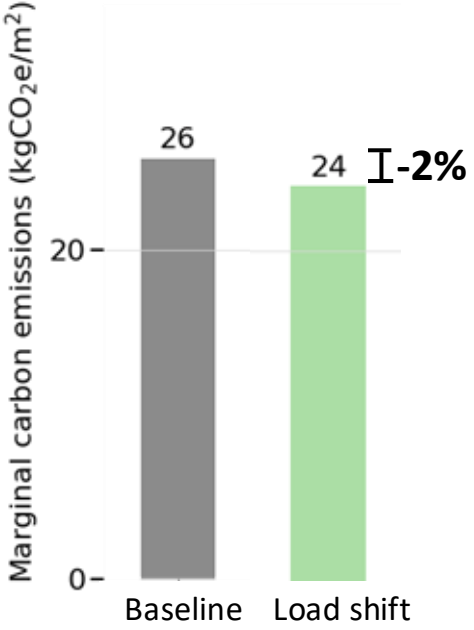
Avoided emissions from chiller load shift control

- **Effective** in spring

1 metric ton (MT) = 1.1 US ton



- **Less overall effect**
- Load shift only is not a sufficient solution for decarbonization



Case II: Quantifying residential heat pump water heaters load shift potential

Objective

- Field evaluation of heat pump water heaters advanced load shift retrofit in California

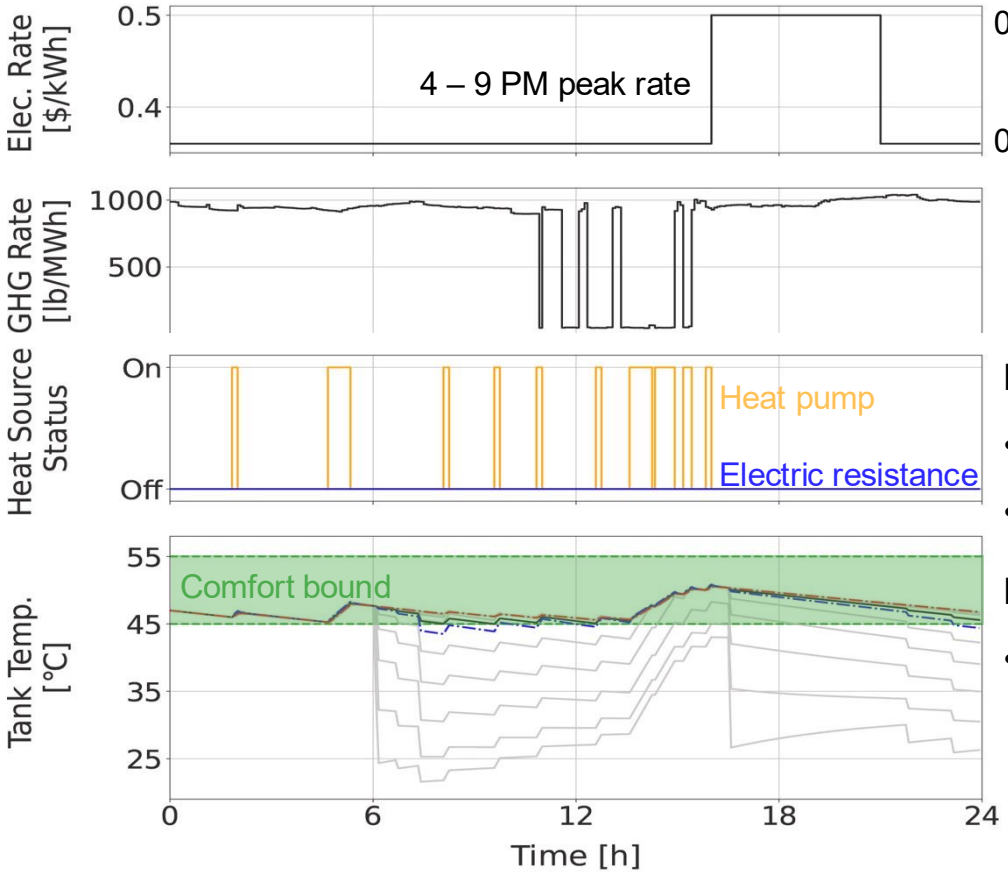
Method

- Model predictive control to minimize energy cost and marginal emission rates
- Use grid marginal emissions rate and PG&E TOU (4 – 9 PM peak time window)
- 23 units from Woodland CA and San Jose CA

Funding

- CEC, UC Davis
- CalNEXT
- CBE Funding

MPC load shift control



Model predictive control

- Dynamically reset tank temperature setpoint
- Blend cost function for optimization

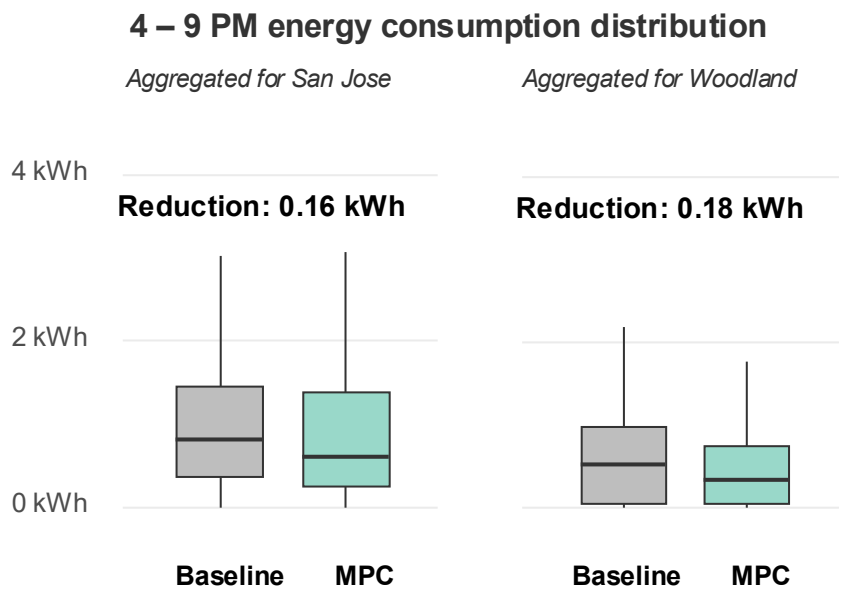
Baseline control

- Default fixed temperature setpoint control

HPWH energy and marginal emission rates distribution

- Significant reduction of HPWH energy during peak TOU period (30% utility rate difference)

- Load shift effect depends on the magnitude of arbitrage opportunity (e.g., peak-valley ratio in TOU or Hourly Flex Pricing)

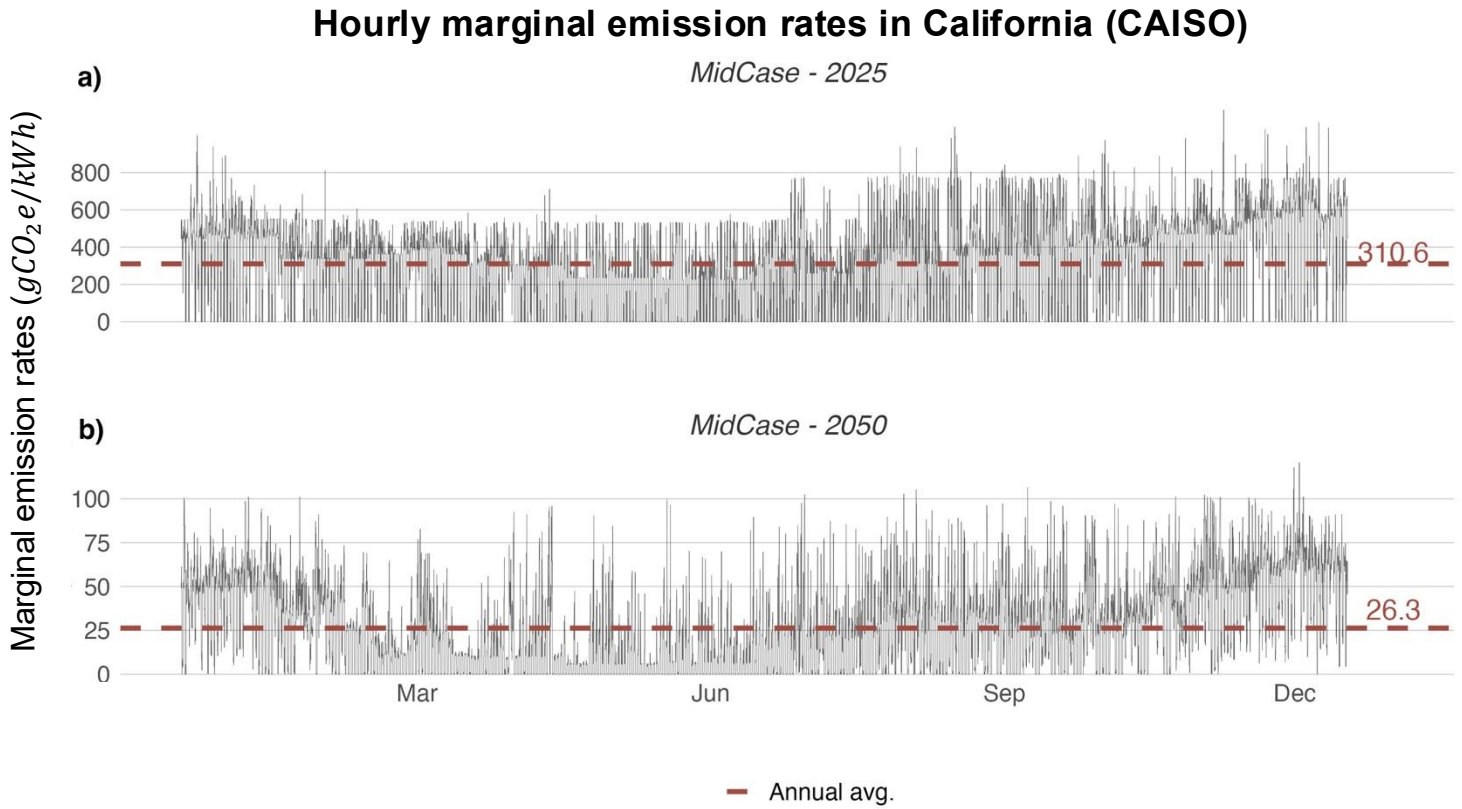


Implication of load shift case studies

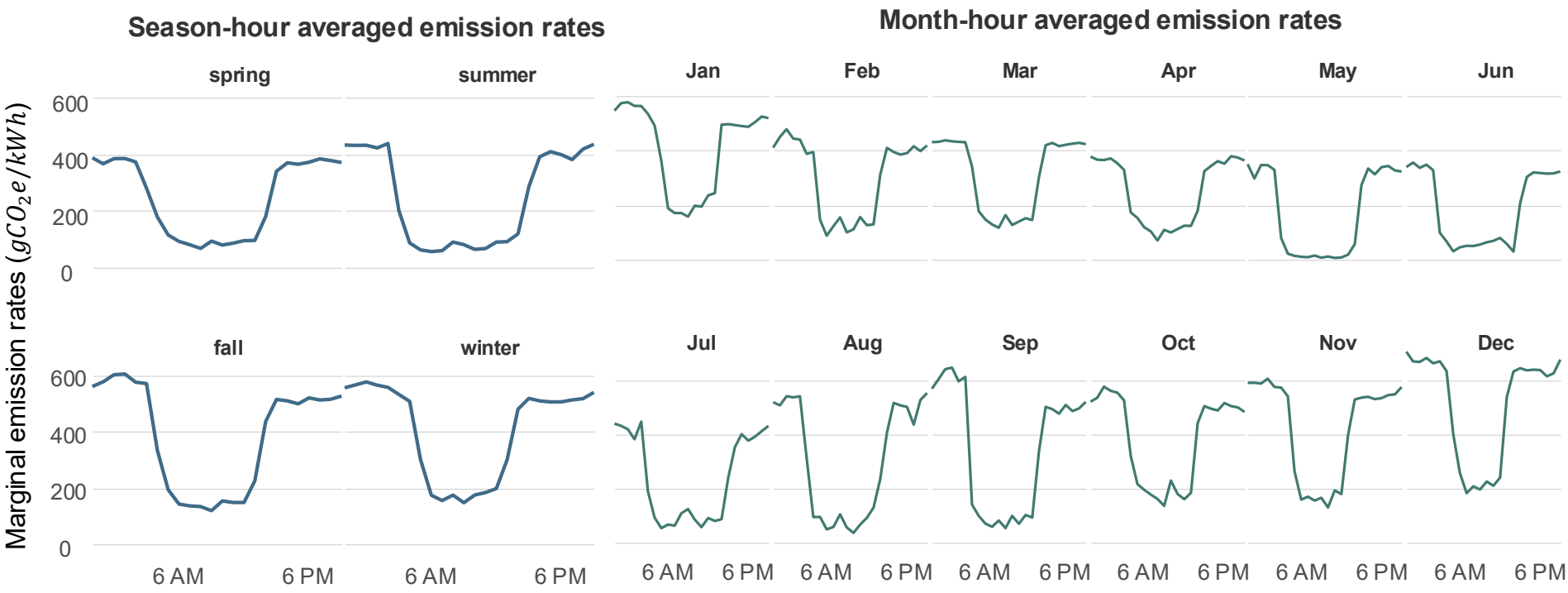
Conclusions:

- Emission-based load shift is most effective in spring for North California grid
- Off-peak utility rate periods do not always coincide with low-emission grid conditions
- Load shift effect depends on input objective function and time interval assessed

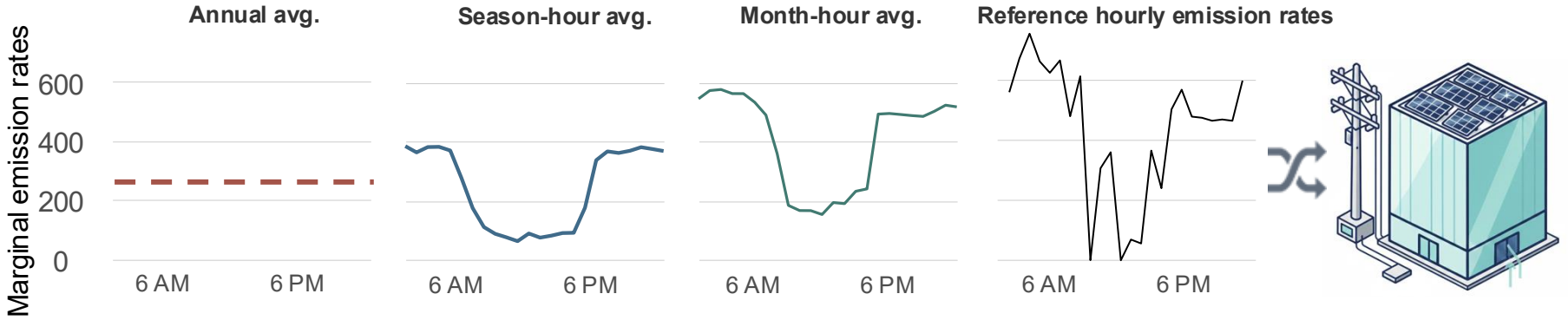
Temporal resolution of grid emission factors

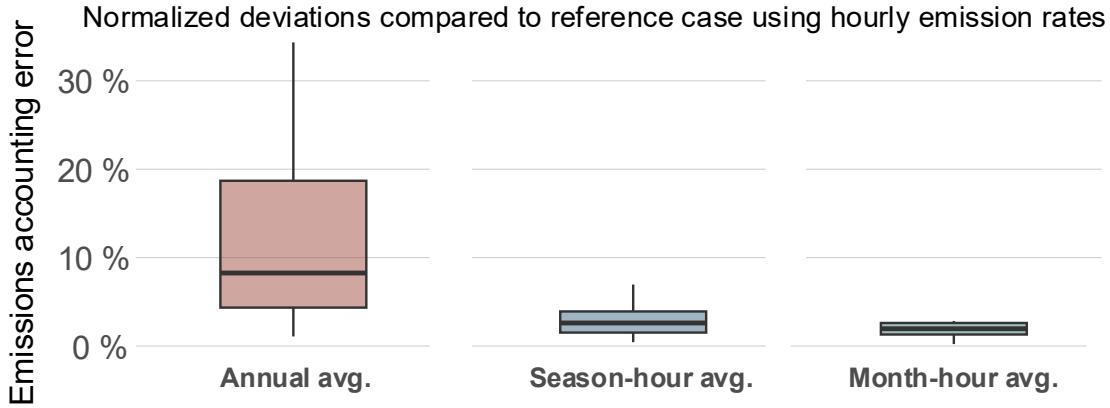


Recommended alternative emission factors to assess avoided emissions



Error distribution due to simplification of temporal resolution





Q&A

Aoyu Zou
aoyuzou@berkeley.edu

Temporal Resolution Matters: Evaluating Carbon Emission Factors for Accurate Accounting in Commercial Buildings.
(http://dx.doi.org/10.2139/ssrn.5745346)