Energy Consumption in PC Gaming

Addressing the California Energy Commission's New Regulations

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Computer gaming in California consumed $700 million in energy bills, with emissions of 1.5 million tons of Carbon Dioxide in 2016 … approximately 7% of commercial energy usage in California

Per the CEC's Research and Development Report, 2019

The CEC's new regulations aim to lower power consumption of PCs *bought and sold in California*

1. **PCs must not exceed a threshold of power consumption**
   - Determined by ***expandability score*** of the components.
   - Only applies to power consumption *while idle* – **consumption under load is irrelevant**.
2. **PCs must now use *Gold Efficiency*-rated power supplies.**
3. ***All* PCs must now be tested and submitted to the CEC's public database**

Addressing Efficacy Problem

- How effective are these regulations?
  - Primarily answered through data analysis and exploration
- Specifically, are two primary requirements resulting in less power consumption?
  - i.e. Gold Power Supplies and High-Expandability Motherboards
- Most importantly, provide suggestions for improvement based on model results.

Addressing Labor Problem

- **Impossibly large combinations to test**
  - **Example:**

    27 unique motherboards, 15 Gold Power Supplies, 20 GPUs, 26 CPUs

    = 27*15*20*26 via *rule of product*

    = **210,600 unique combinations,** or 157,950 hours worth of testing
- **Solution:** Can we build a model that can accurately predict untested combinations of components?
  - Can be used to rule out combinations that wouldn't pass certification
  - Replace actual testing?

The Data

CPU Cores	Core Speed (GHz)	Number of hard disk drives	Number of extra solid-state drives	GPU Bandwidth	Ram Speed (GB/s)	RAM Capacity (GB)	Motherboard	PSU	PSU Size (Watts)	Short-Idle Power (Watts)
8.0	3.5	0.0	1.0	512.0	28.8	16.0	MSI Z590 GAMING EDGE WIFI	220-G5-0850-X	850.0	52.69
8.0	3.5	0.0	1.0	512.0	28.8	16.0	MSI Z590 PRO WIFI	220-G5-0850-X	850.0	49.13
10.0	3.7	0.0	1.0	512.0	28.8	16.0	ASROCK Z490 TAICHI (WI-FI)	XPG CORE REACTOR	650.0	46.80

- Data directly from the CEC's Public Database, MAEDbS
- Data Description:
  - 1,672 unique submissions from 16 different manufacturers
  - 10 attributes, all ***discrete*** values.
  - Variable of interest: **Short-Idle Power (Watts)**

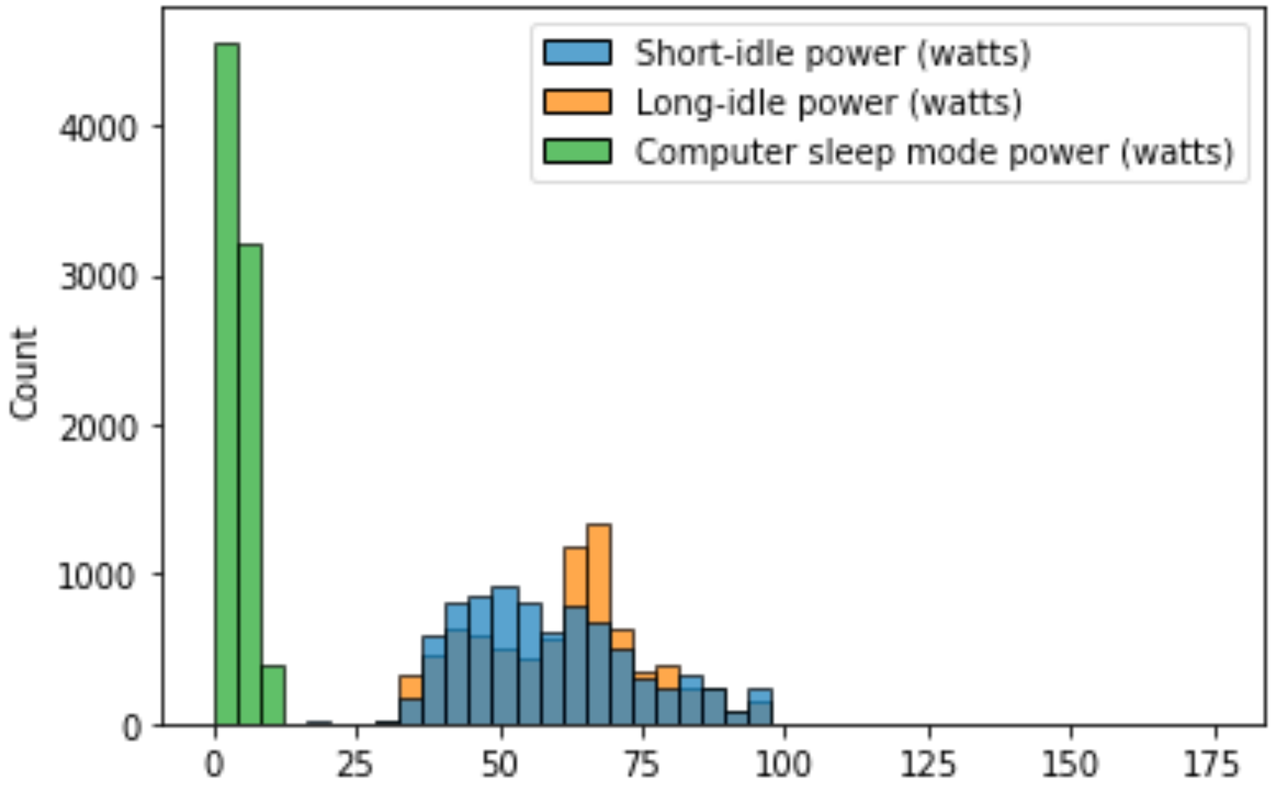
Data Collection Methodology

3 measurements of average power consumption (in watts) for 15 minutes each:

1. **Short-Idle State**
2. Long-Idle State
3. Sleep Mode

Why focus on Short-Idle?

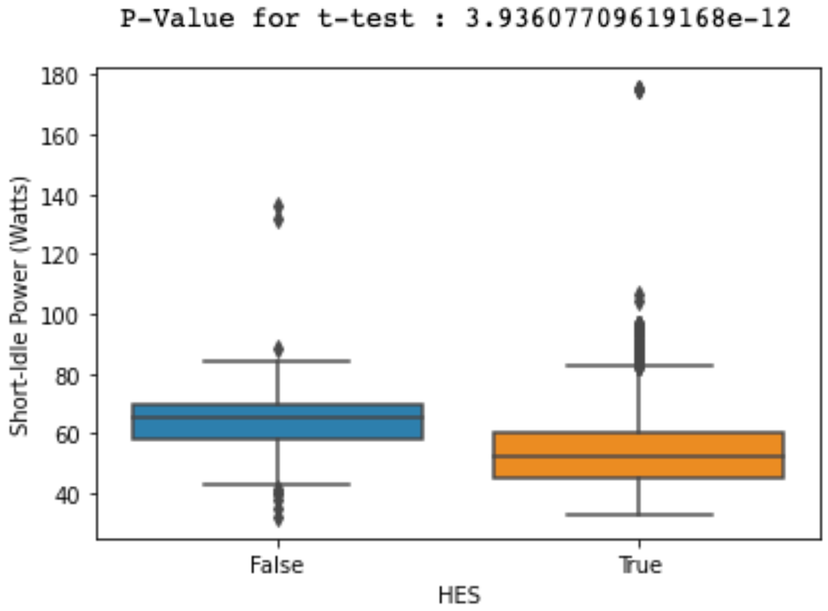
	Short-idle power (watts)	Long-idle power (watts)	Computer sleep mode power (watts)
mean	58.958719	60.870154	4.266051
std	15.260163	14.972945	2.086310



Efficacy of High-Expandability

- High-Expandability Score: More modern features, slots = higher score
- Short answer: **Yes, very effective regulation.**
- Results are contrary to popular opinion that higher expandability = *more* power.

HES	mean	std
False	64.287917	14.781234
True	54.427978	13.394013



Efficacy of Gold-rated Power Supplies

- Short answer: ***not* effective**
- T-test comparing Bronze vs Gold PSUs power consumption:
  - 168 Samples from computers with same CPU, Motherboard, PSU Wattage, and GPU.
  - Insignificant differences

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Mean for Bronze PSU: 49.57
Mean for Gold PSU: 50.86

P-Value comparing Bronze vs Gold 650 watt PSU : 0.4214969328487391
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Modeling for Short-Idle Power Consumption

CPU Cores	Core Speed (GHz)	Expandability Score	Number of hard disk drives	Number of extra solid-state drives	GPU Bandwidth	Ram Speed (GB/s)	RAM Capacity (GB)	PSU Size (Watts)	Chipset_B550	Chipset_B560	Chipset_X570	Chipset_Z590
8.0	3.6	510.0	0.0	0.0	912.0	25.6	16.0	750.0	1	0	0	0
8.0	3.6	610.0	0.0	0.0	608.0	28.8	16.0	750.0	0	0	0	1
8.0	3.8	730.0	0.0	0.0	608.0	25.6	32.0	750.0	0	0	1	0
8.0	3.8	730.0	0.0	0.0	608.0	25.6	16.0	750.0	0	0	1	0
12.0	3.7	730.0	0.0	0.0	608.0	28.8	32.0	850.0	0	0	1	0

- Modeling ***only*** for products tested by Skytech Gaming
- Using **Random Forest Regressor** and **Gradient Boosting Regressor**
- Preprocessing:
  - SMOTE Oversampling for Chipsets
  - MinMax Scaling, One-Hot Encoding

Results

Gradient Boosting Outperforms

Random Forest Regressor

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Tuned Random Forest Results
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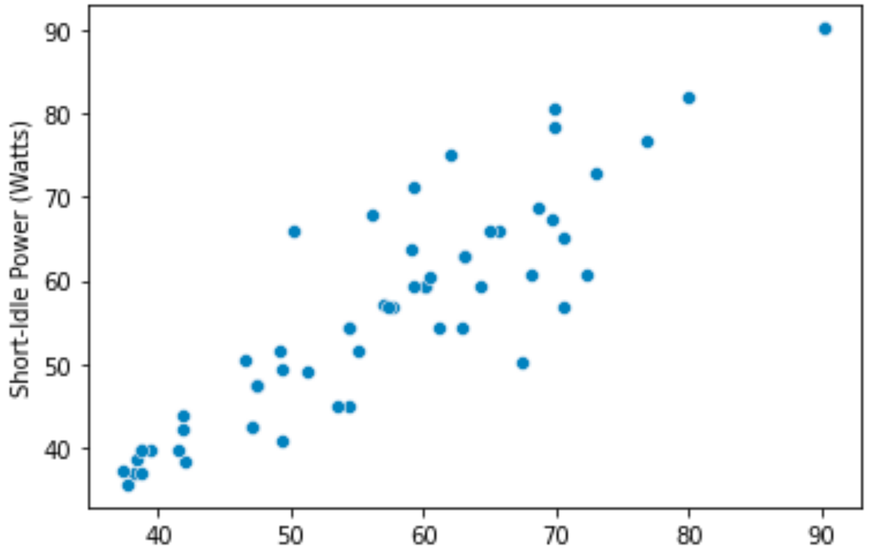
Training R^2 Score: 0.82
Testing R^2 Score: 0.73
Training RMSE: 6.54
Training RMSE: 6.93
```

Actual vs. Predicted Plot



Gradient Boosting Regressor

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Tuned Gradient Boosting Results
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Training R^2 Score: 0.9
Testing R^2 Score: 0.77
Training RMSE: 4.92
Training RMSE: 6.45
```
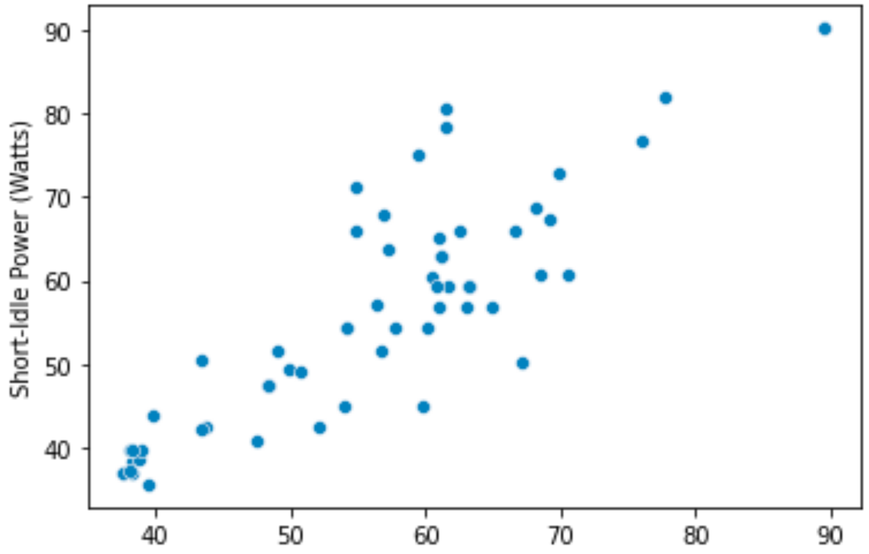
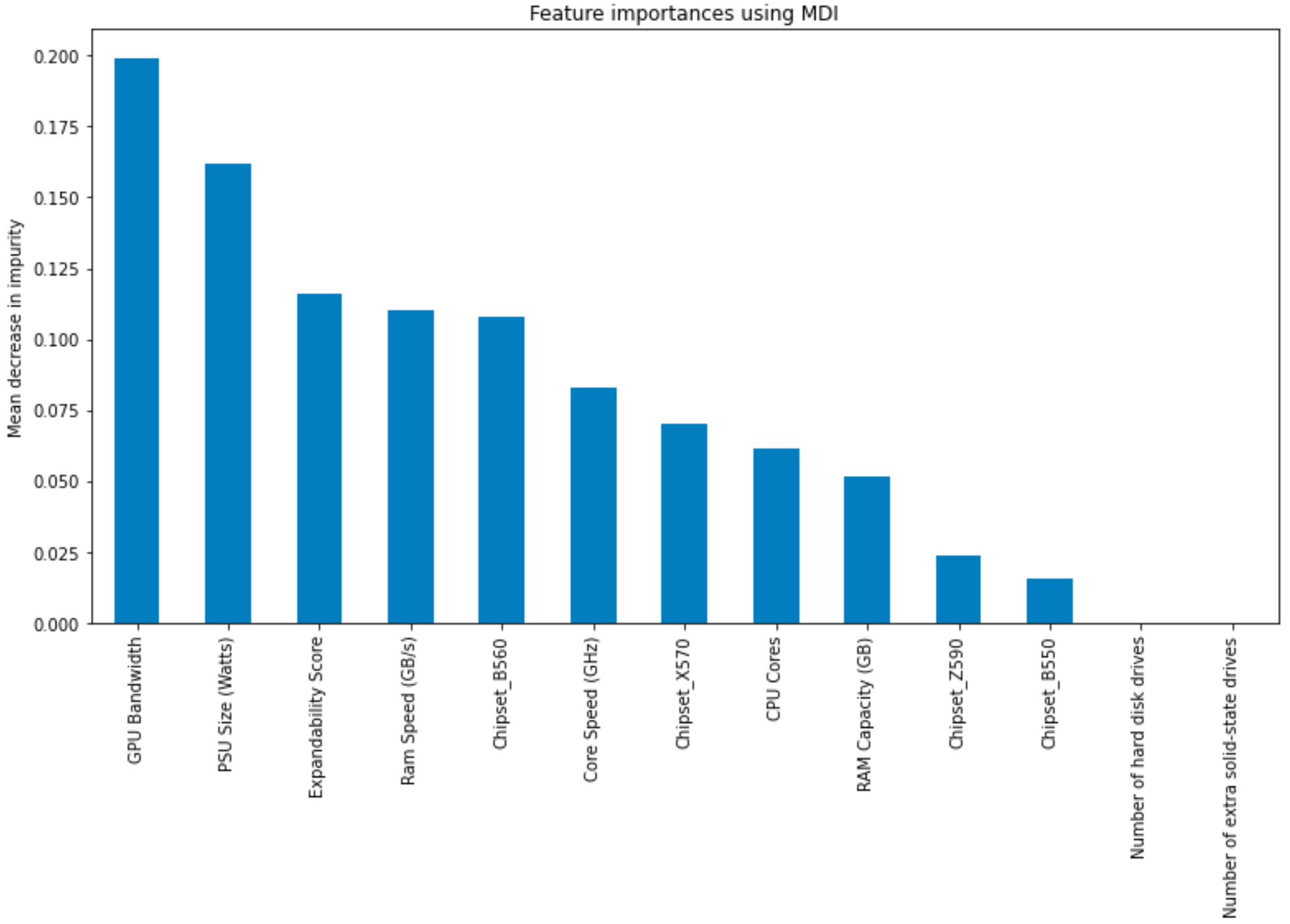

Actual vs. Predicted Plot




Feature importances using MDI
Mean decrease in impurity
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
GPU Bandwidth
PSU Size (Watts)
Expandability Score
Ram Speed (GB/s)
Chipset_B560
Core Speed (GHz)
Chipset_X570
CPU Cores
RAM Capacity (GB)
Chipset_Z590
Chipset_B550
Number of hard disk drives
Number of extra solid-state drives

Takeaways

- **Problem 1:** Effective Regulations? **Yes and no**.
  - High HES Motherboards are more efficient
  - Gold rated PSUs may not be necessary*
  - **Higher barrier of entry**
  - More information related to graphics card needed, as it holds the most weight.
- **Problem 2:** Can a model reduce labor problems?
  - Not good enough to replace labor; ethical concerns.
  - Better application in the CEC’s hands.