

# SIM Home Testing: Device Use Profile Approach



**Dr. Joy Pixley**

**Dr. Michael Klopfer**

**Saniya Syed**

**Mahejabeen Kauser**

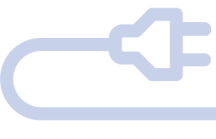
**G.P. Li**

**California Plug Load Research Center**

**University of California, Irvine**

**Southern California Edison**

[www.calplug.org](http://www.calplug.org)

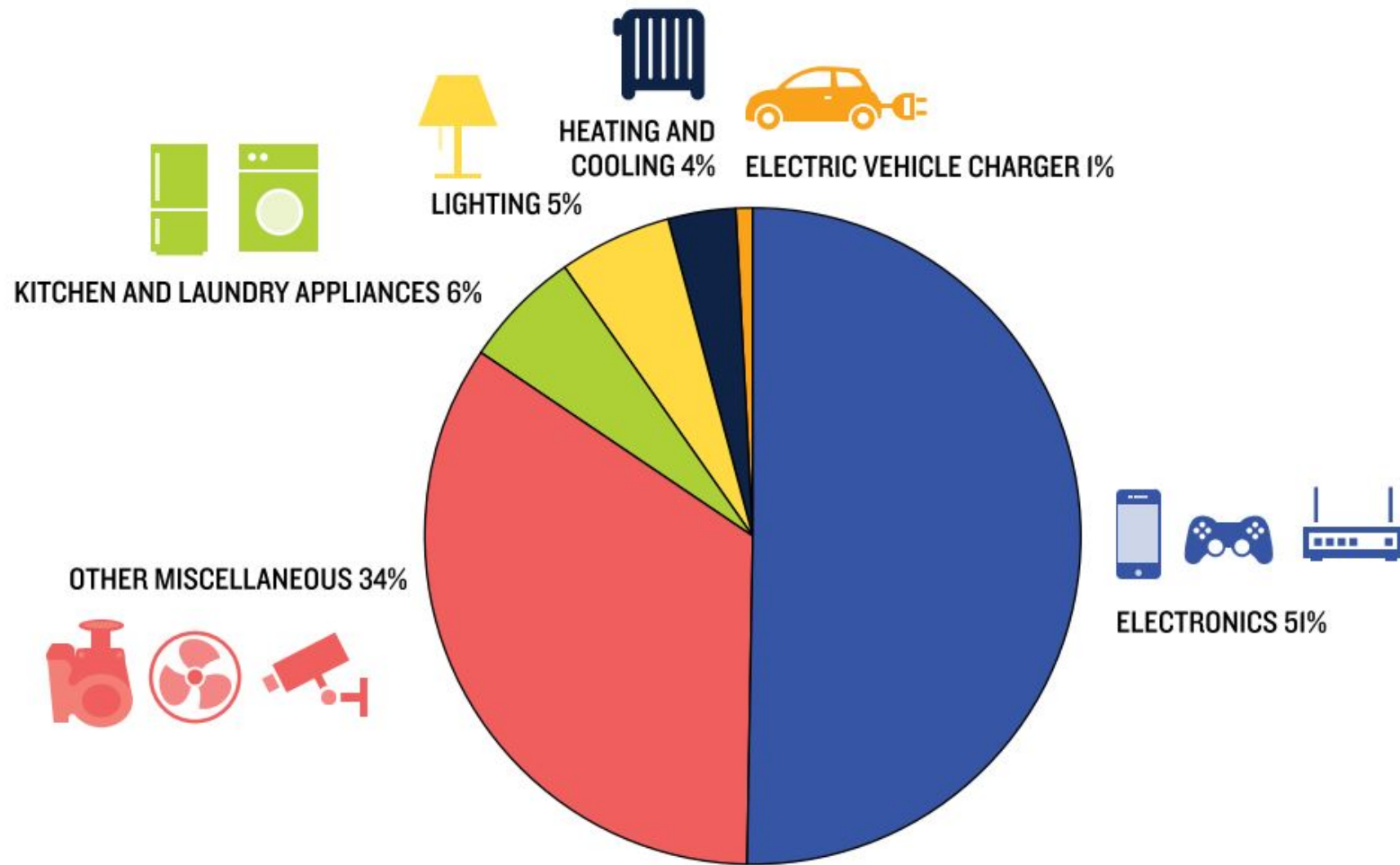


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# Electrification Exacerbates the Plug Load Energy Problem

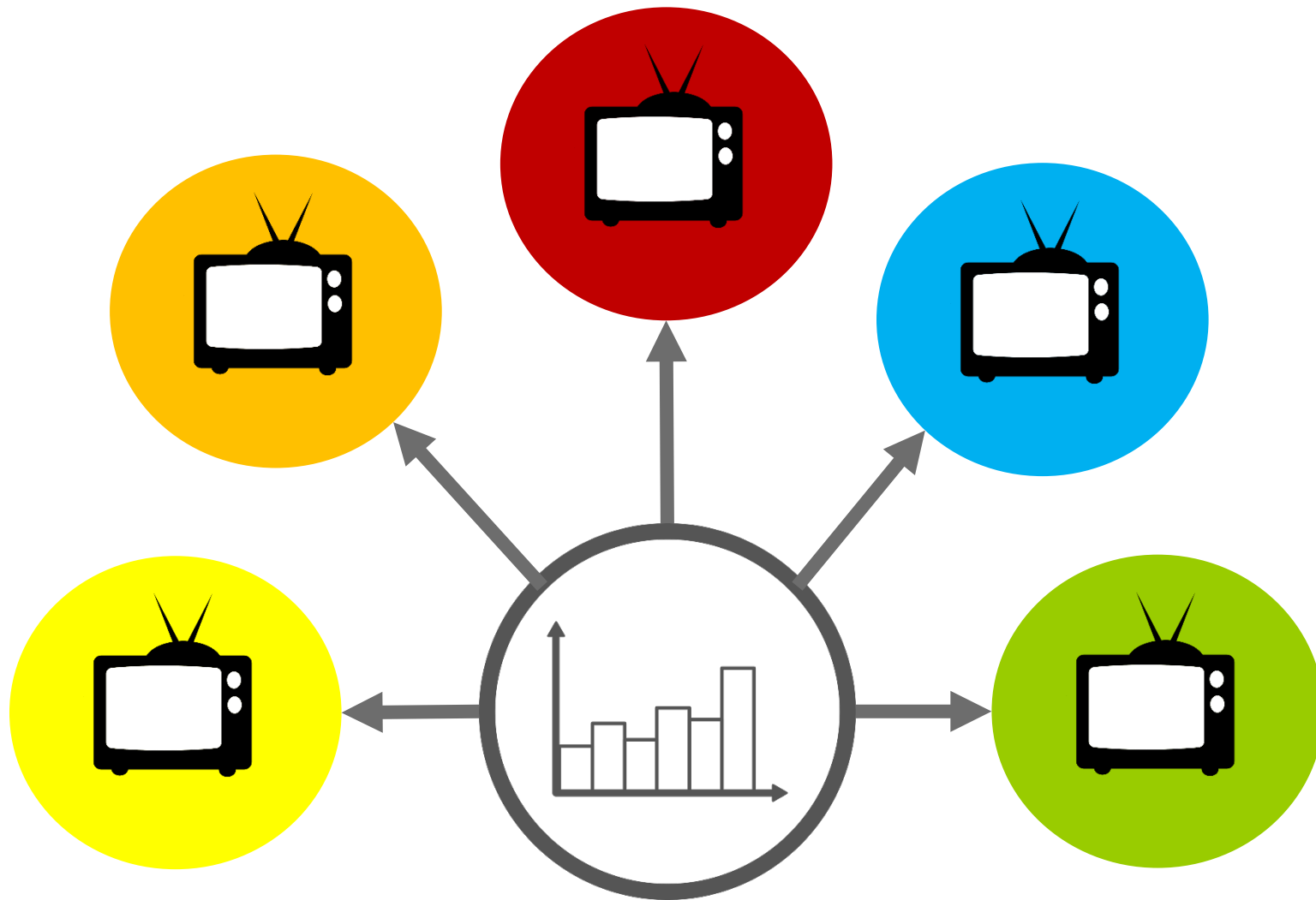
Figure 10: Idle (Always-On) Loads by Major Product Category in 10 Homes Audited



Source: Delforge, Schmidt, and Schmidt 2015

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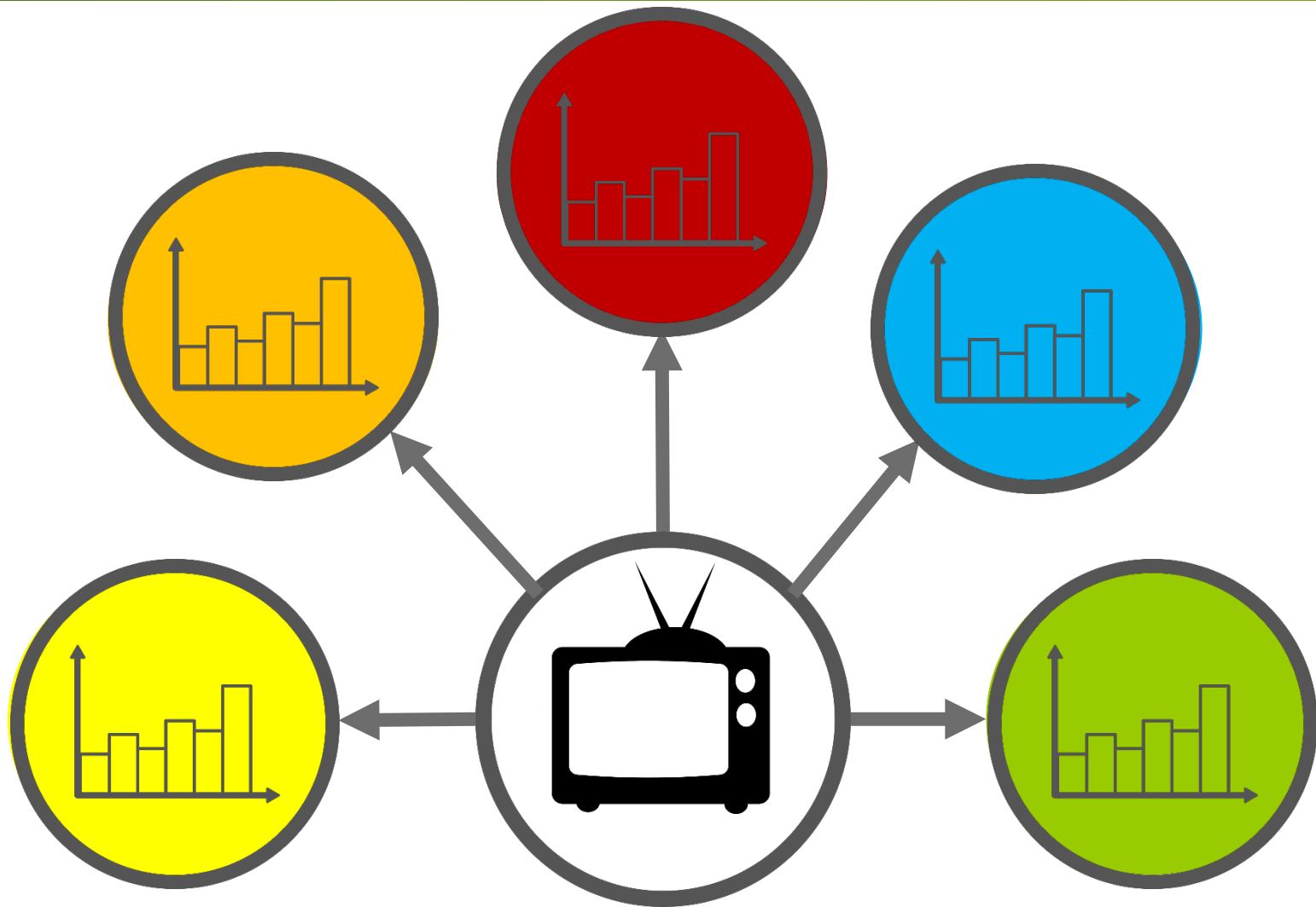
# Standard Testing Approach



**One use profile across many devices**



# Device Use Profile Approach



**One device across many use profiles**

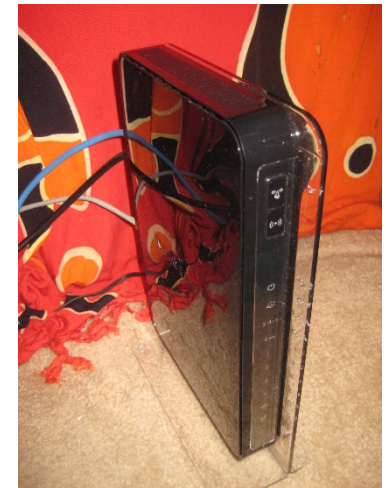


# Device Use Profiles Concept

Vary on 3 aspects:

- Active use
- Pattern of use
- Power management

*More relevant to  
some devices  
than others*





# Devices Studied

- **Televisions: HD and 4K**
- **Sound bar**
- **Set-top box**
- **Streaming device**
- **Video game console**
  
- **Desktop computer**
- **Laptop computer**
  
- **Pod coffee makers (2)**
- **Rice cooker**



# Methods

- **Determine states for each device**
- **Test power for all states of each device**
- **Develop a set of usage profiles for each device**
- **Use PLSim tool to calculate energy use for each profile**
- **Analysis:**
  - **Range of outcomes – size, and direction relative to the standard profile**
  - **Variation of outcomes – how much is attributed to each of the three aspects**



# Constructing Device Use Profiles

## ➤ Active use

- low = 10<sup>th</sup> percentile
- moderate = median usage
- high = 90<sup>th</sup> percentile

“Standard” profile:  
mod-low-mod

Typical profile set:  
3 aspects x 3 levels = 27 profiles

## ➤ Pattern of use

- low = all at once
- moderate = same amount in two usage periods
- high = same amount in four usage periods
- *alternates*, e.g., for amount of time between uses

## ➤ Power management

- low = sleep settings disabled / no manual PM
- moderate = default sleep settings / no manual PM
- high = default sleep settings / user always turns off
- *alternates*, e.g., other sleep settings







# Profile Aspects

## Example: Rice Cooker

### Active use

Low	1 cup
Moderate	2 cups
High	3 cups

### Pattern

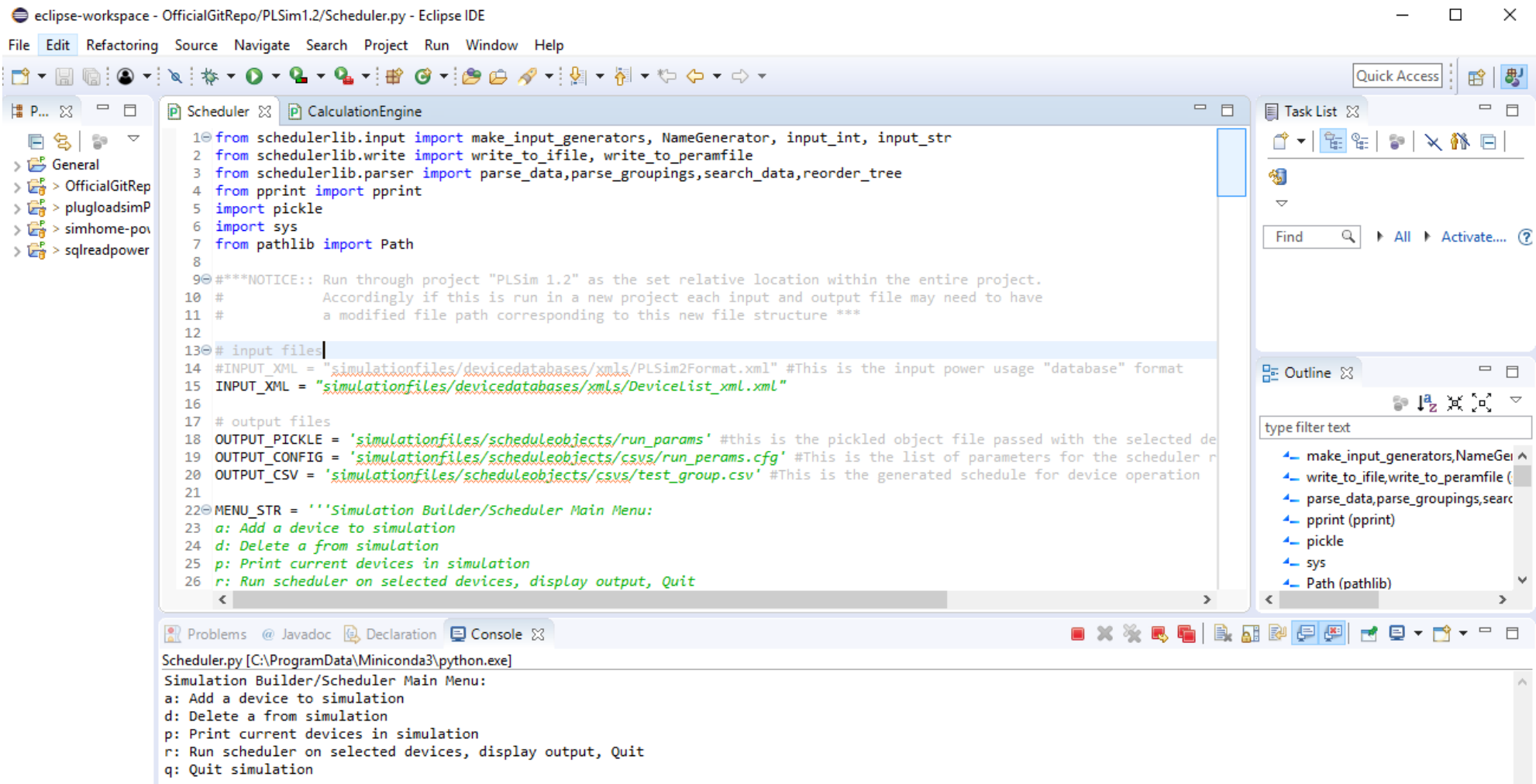
Low	1 use per day
Moderate	2 uses per day (5 hours in between)
High	3 uses per day (5 hours in between)

### Power Management

Low	User leaves on warm all day, no matter how many pots they make (user turns off at hour 16)
Moderate	User leaves on warm for 1 hour then turns off
High	User turns off immediately after cooking is completed



# Run the Numbers through PLSim



The screenshot shows the Eclipse IDE with the Scheduler.py file open. The file contains Python code for a simulation scheduler. The console output shows the execution of the script, displaying the simulation menu and the results of the simulation.

```
eclipse-workspace - OfficialGitRepo/PLSim1.2/Scheduler.py - Eclipse IDE
File Edit Refactoring Source Navigate Search Project Run Window Help

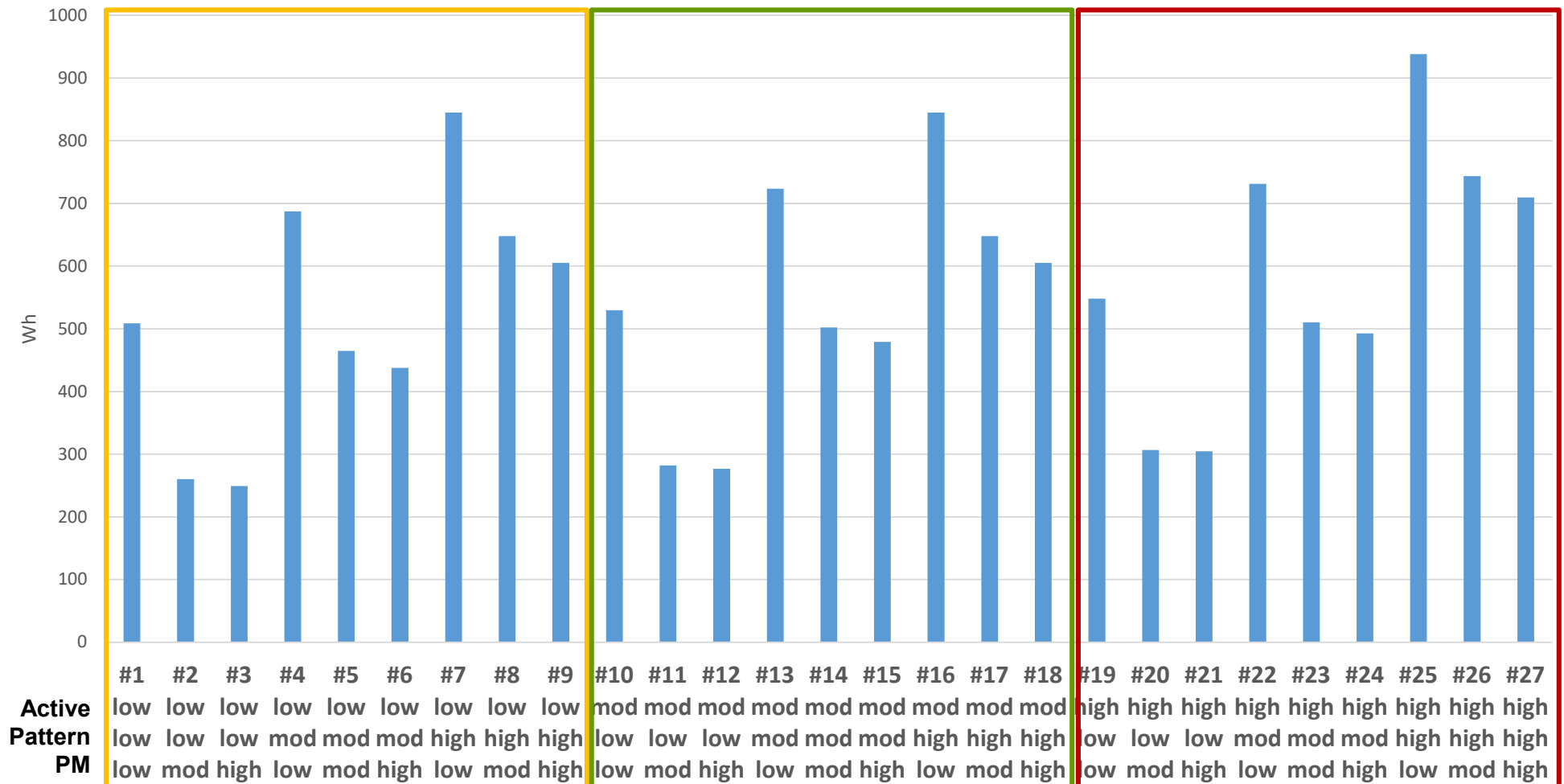
1 from schedulerlib.input import make_input_generators, NameGenerator, input_int, input_str
2 from schedulerlib.write import write_to_ifile, write_to_peramfile
3 from schedulerlib.parser import parse_data, parse_groupings, search_data, reorder_tree
4 from pprint import pprint
5 import pickle
6 import sys
7 from pathlib import Path
8
9 *****NOTICE:: Run through project "PLSim 1.2" as the set relative location within the entire project.
10 # Accordingly if this is run in a new project each input and output file may need to have
11 # a modified file path corresponding to this new file structure ***
12
13 # input files
14 #INPUT_XML = "simulationfiles/devicedatabases/xmls/PLSim2Format.xml" #This is the input power usage "database" format
15 INPUT_XML = "simulationfiles/devicedatabases/xmls/DeviceList_xml.xml"
16
17 # output files
18 OUTPUT_PICKLE = 'simulationfiles/scheduleobjects/run_params' #this is the pickled object file passed with the selected de
19 OUTPUT_CONFIG = 'simulationfiles/scheduleobjects/csvs/run_perams.cfg' #This is the list of parameters for the scheduler r
20 OUTPUT_CSV = 'simulationfiles/scheduleobjects/csvs/test_group.csv' #This is the generated schedule for device operation
21
22 MENU_STR = '''Simulation Builder/Scheduler Main Menu:
23 a: Add a device to simulation
24 d: Delete a from simulation
25 p: Print current devices in simulation
26 r: Run scheduler on selected devices, display output, Quit
```

Scheduler.py [C:\ProgramData\Miniconda3\python.exe]  
Simulation Builder/Scheduler Main Menu:  
a: Add a device to simulation  
d: Delete a from simulation  
p: Print current devices in simulation  
r: Run scheduler on selected devices, display output, Quit  
q: Quit simulation

# Pattern of Energy Use

## Example: Rice Cooker

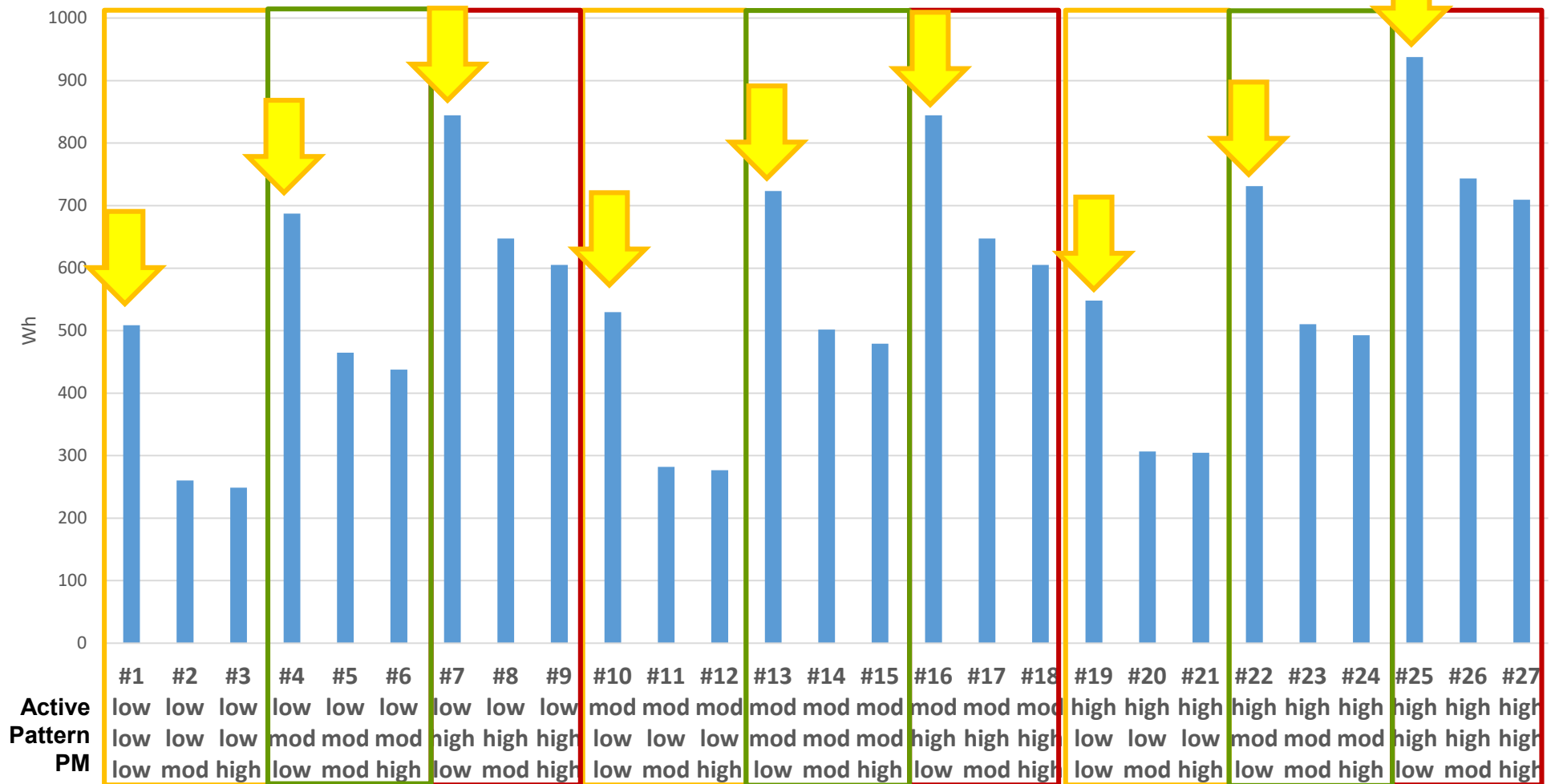
Rice Cooker  
Daily Energy Usage (Wh)



# Pattern of Energy Use

## Example: Rice Cooker

Rice Cooker  
Daily Energy Usage (Wh)



# Device-level Profile Results Range

## Example: Rice Cooker

	Standard (Wh)	Median (Wh)	Min (Wh)	Max (Wh)	Range (Wh)
Rice Cooker	282.2	529.4	249.0	937.9	688.9
% from standard			-12%	+232%	244%

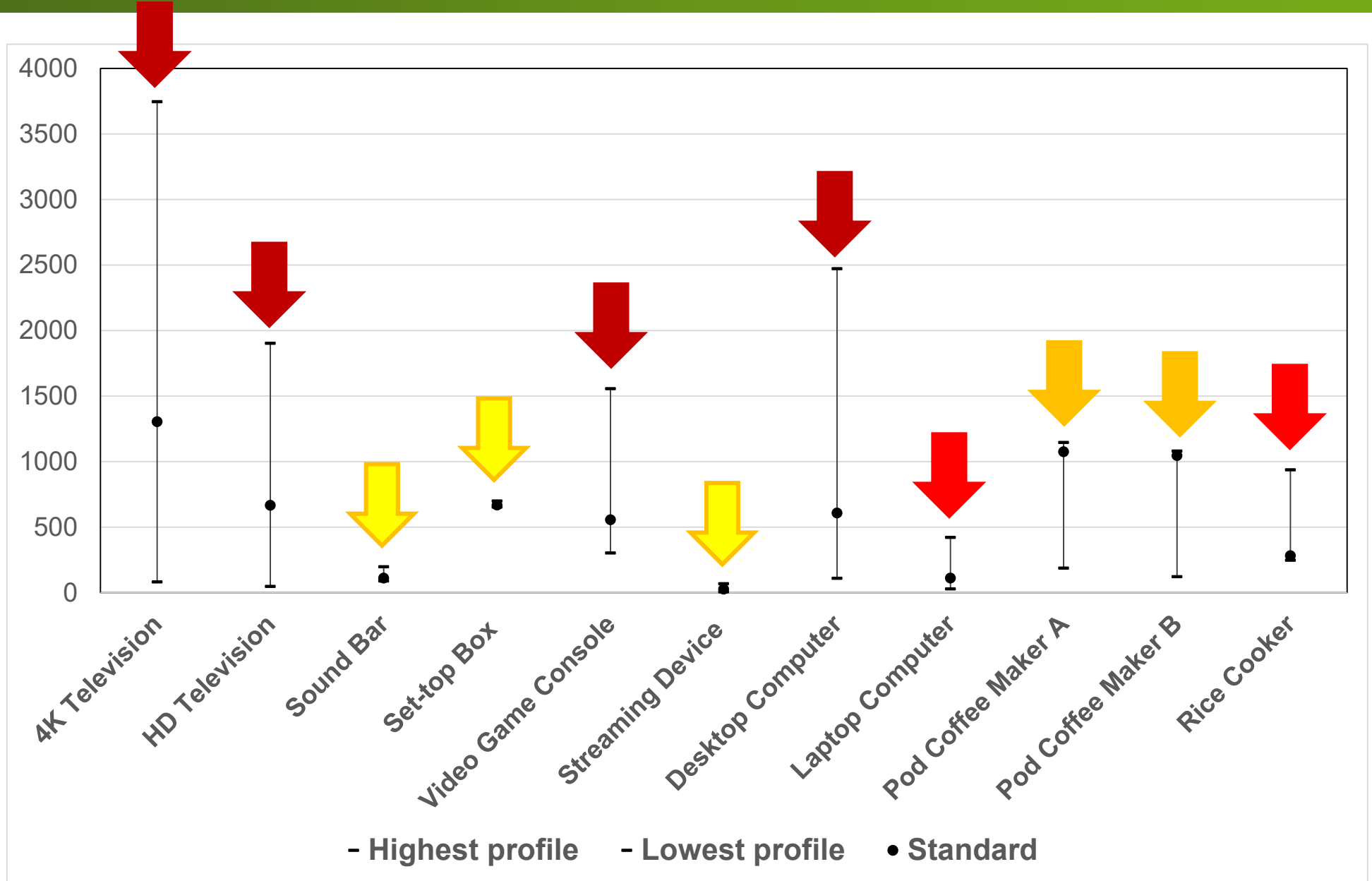
- Is a large range necessarily bad? No: we should see *some* range.

	Standard (Wh)	Median (Wh)	Min (Wh)	Max (Wh)	Range (Wh)
Set-top Box	669.9	684.6	654.1	699.7	45.7
% from standard			-2%	+4%	7%

- But a range much higher than the standard is a concern



# Range of Energy Use Across Profiles



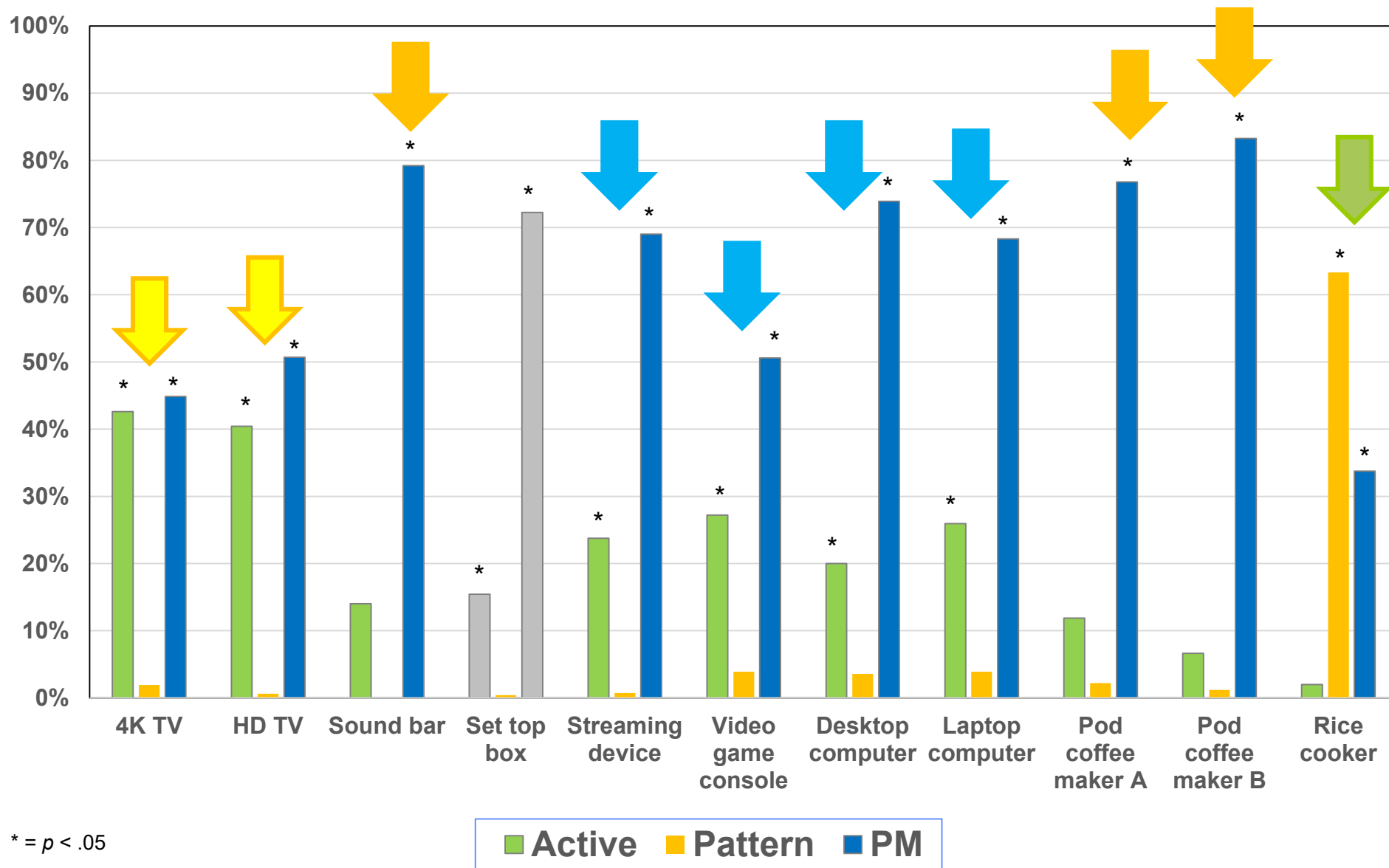


# Multivariate Regression Analyses

	Active Model			Pattern Model			PM Model			Full Model		
Predictors	B	SE	P	B	SE	p	B	SE	p	B	SE	p
Active Low	-416.35	311.10	0.1899							-343.64	91.09	0.0008
Ref: Active Moderate	---									---		
Active High	506.78	285.77	0.0854							536.75	81.47	<.0001
Ref: Pattern Low				---						---		
Pattern Moderate-1				-139.23	393.94	0.7262				139.23	94.08	0.1505
Pattern Moderate-2				126.92	393.94	0.7495				126.92	94.08	0.1885
Pattern High-1				216.94	557.12	0.6996				281.31	141.77	0.0575
Pattern High-2				463.66	440.44	0.3006				259.66	108.63	0.0241
PM Low							1332.39	172.01	<.0001	1332.39	81.47	<.0001
Ref: PM Moderate							---			---		
PM High							-195.96	172.01	0.2628	-195.96	81.47	0.0233
Intercept	1258.18	190.51	<.0001	1161.12	278.56	0.0002	944.21	121.63	<.0001	717.95	95.05	<.0001
F	4.12			0.29			46.75			67.11		
p	<b>0.0252</b>			<b>0.8829</b>			<b>&lt;.0001</b>			<.0001		
R <sup>2</sup>	<b>0.200</b>			<b>0.036</b>			<b>0.739</b>			0.952		

\*\*\* = p < .001; \*\* = p < .01; \* = p < .05

# Percent of Variance Due to Each Aspect



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# So, what does this tell us?

- **Quantification of the issue: Combining results on the size and direction of the range with the proportion of that variance due to each aspect identifies problem areas for each type of device.**
- **Examples:**
  - **Rice cooker**
    - **Most profiles higher energy use than the standard**
    - **Pattern had the largest impact, more so than PM**
    - **Why? Fixed costs of one pot, regardless of amount of rice in that pot + low energy needed for keeping warm → focus on cook cycle (active state)**
  - **Video game console**
    - **Large range, much more higher than lower**
    - **PM had largest impact but active also significant**
    - **Standby state effective, but without settings or user input, game pauses indefinitely in “menu” mode, which uses almost as much energy as active game play → possible long idle?**



# Effects of Aspects

- **Active use**
  - **Less impact than PM (but note selection of devices)**
  - **However, reducing energy use during active states would ameliorate PM problems too**
- **Pattern**
  - **Pattern should be affected by PM if enabled (sleep delays) or transition costs (although none have long warm up periods)**
  - **Any effect drowned out by PM for most devices**



# Effects of Aspects

- **Power Management**
  - Low-power states not saving energy (set-top box)
  - Low-power states not effectively used
    - Low-power states not enabled by default (pod coffee makers)
    - PM options limited (e.g., HDTV had no auto-off tied to user input, and shortest delay for auto-off in the 4KTV was 4 hours)
    - Dire consequences if PM settings are disabled and users fail to turn off devices (most devices) → user interface, better options
  - Devices stay fully functional during long idle periods (game console)
  - Missed opportunities for PM based on connected device input



# Conclusions

- **Approach:** promising (quantified, systematic)
- **Ranges:** too large and high, except when they're too small
- **Aspects:** big impact of power management, but also others
- **Overall:** It's not enough to make sure devices are efficient under *ideal conditions*.
- **Definitions of aspect levels** rely on limited data and assumptions
  - Need more and better data on real-life usage
- **Device use profiles** show what *could be* but not what proportion of users/households would fall into each profile
  - However, the profile results are so skewed that we'd need multiple "do gooders" to make up for each "do badder".
- **Read the report for more!**





***Thank you!***

**Dr. Joy Pixley**  
**jpixley@uci.edu**

**Dr. Michael Klopfer, Saniya Syed, Mahejabeen Kauser, G.P. Li**  
**California Plug Load Research Center**  
**California Institute for Telecommunications and Information Technology**  
**University of California, Irvine**

