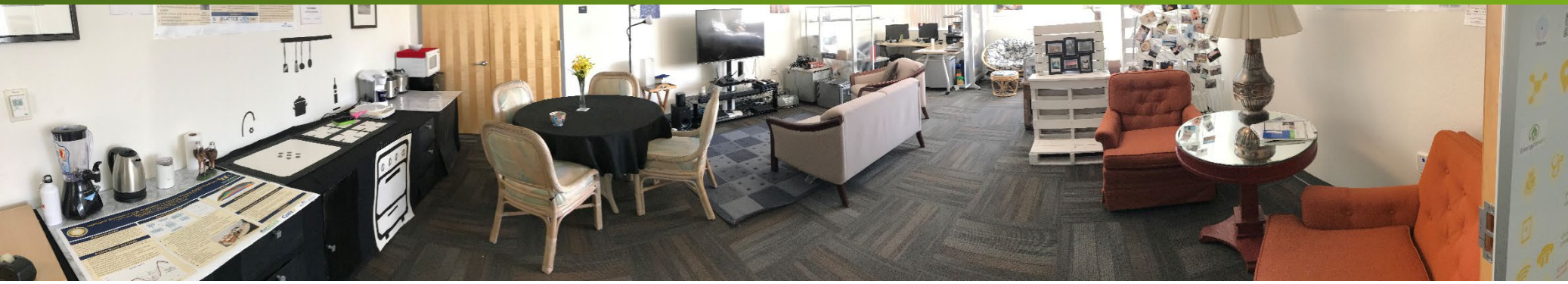
SIM Home Testing:
Device Use Profile Approach



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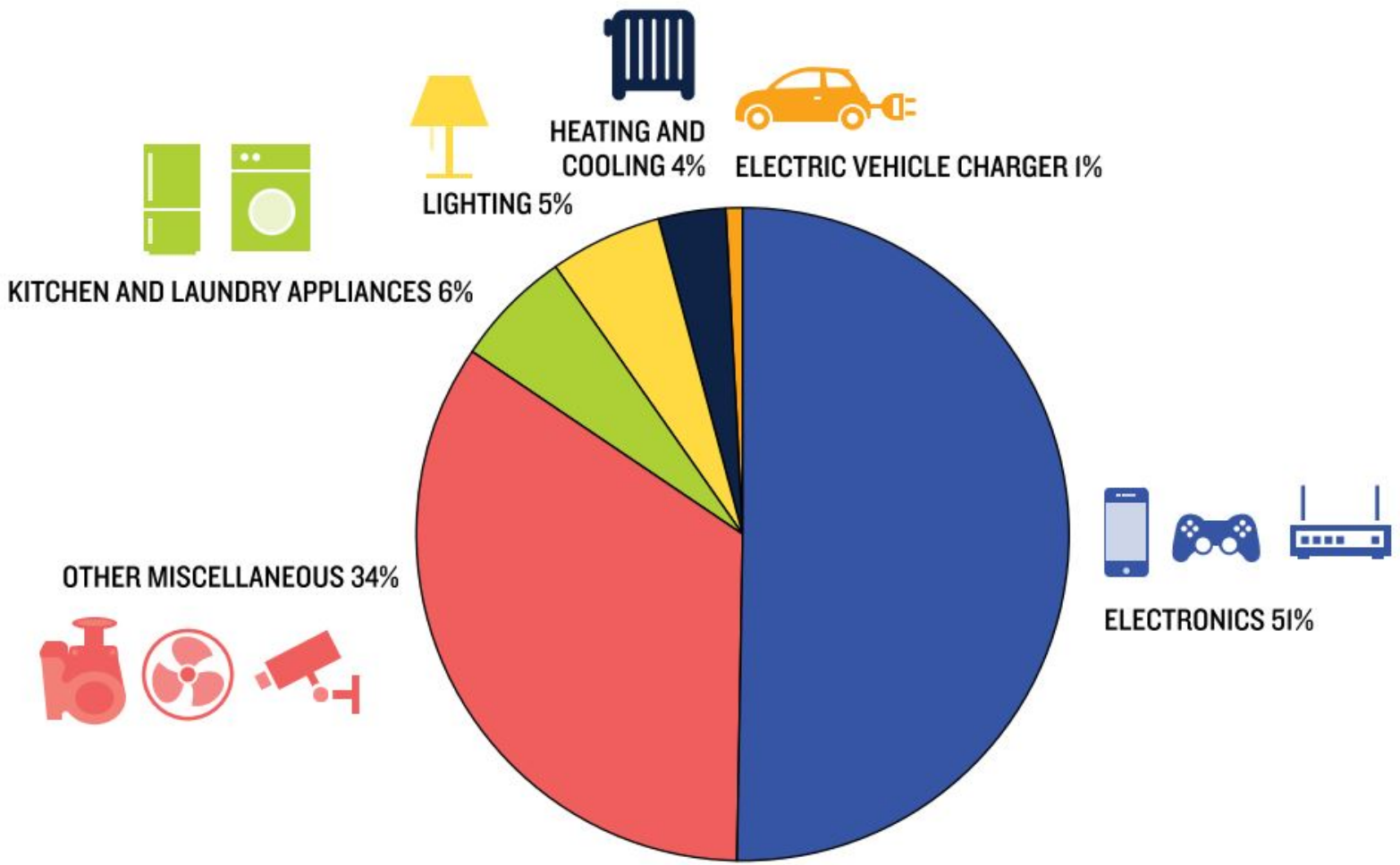
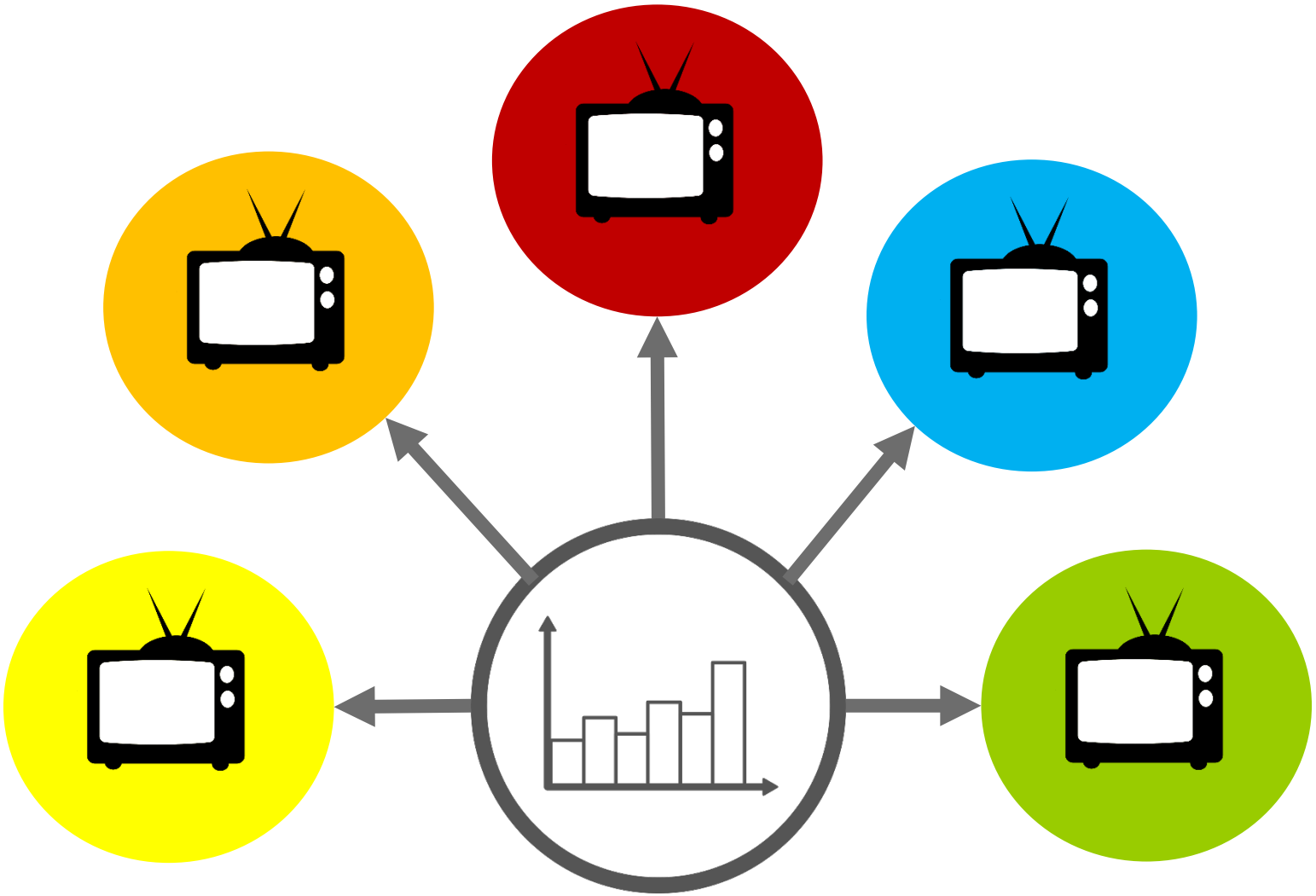
Electrification Exacerbates the Plug Load Energy Problem

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



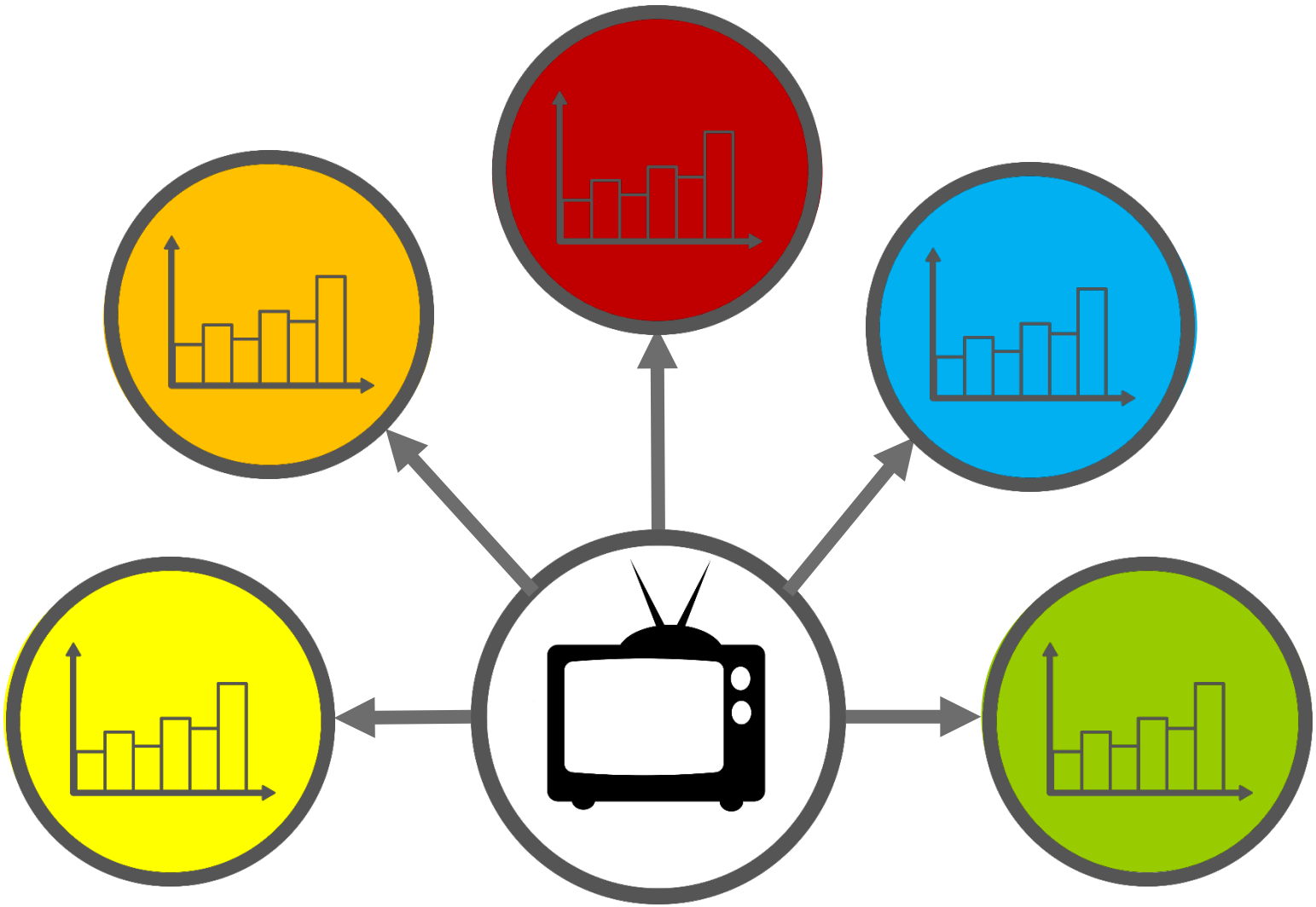
Source: Delforge, Schmidt ,and Schmidt 2015

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 = 10th percentile
  - moderate = median usage
  - high = 90th percentile
- 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

"Standard" profile:
mod-low-mod

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

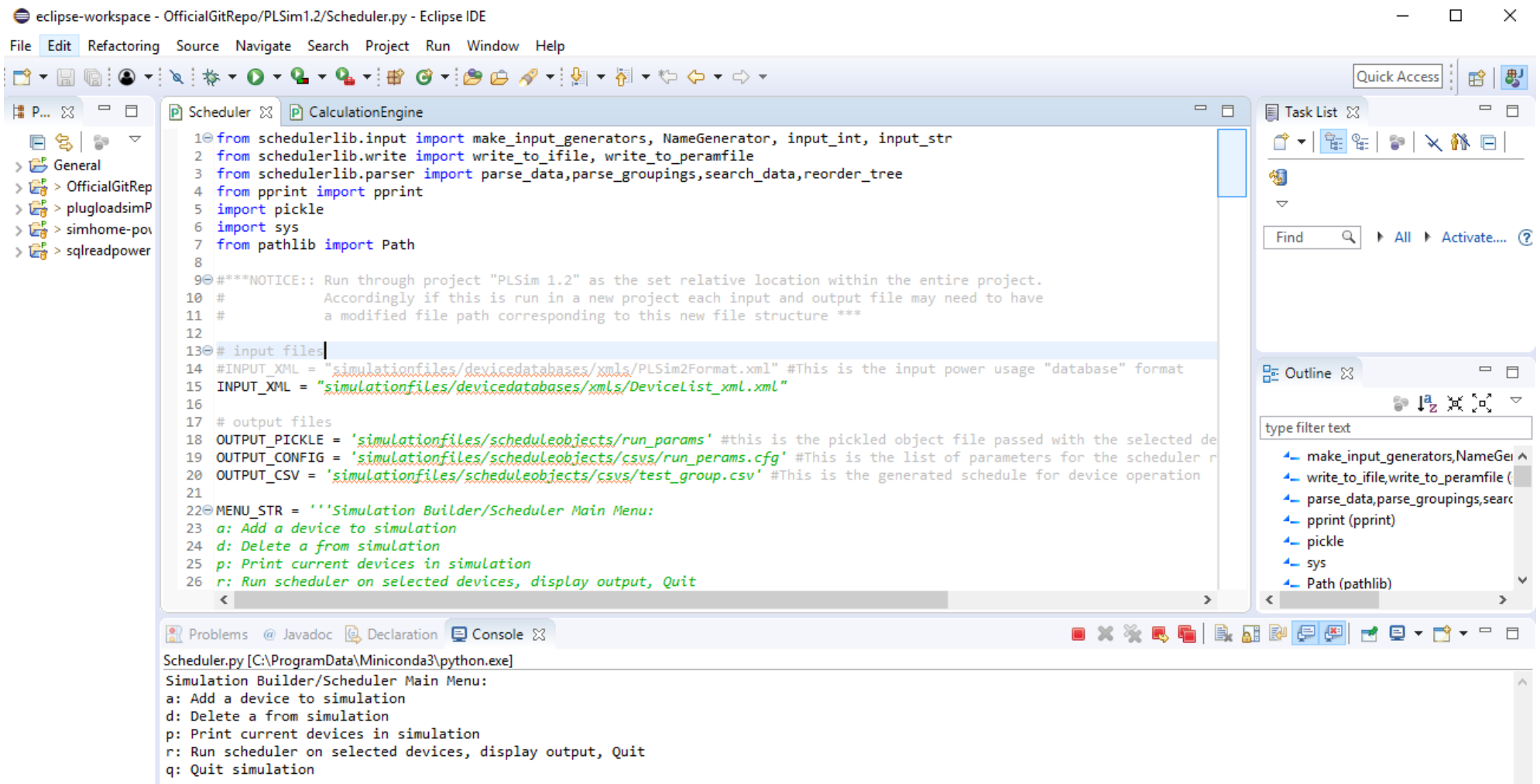
Profile Aspects
Example: Rice Cooker

Active use	
Low	1 cup
Moderate	2 cups
High	3 cups

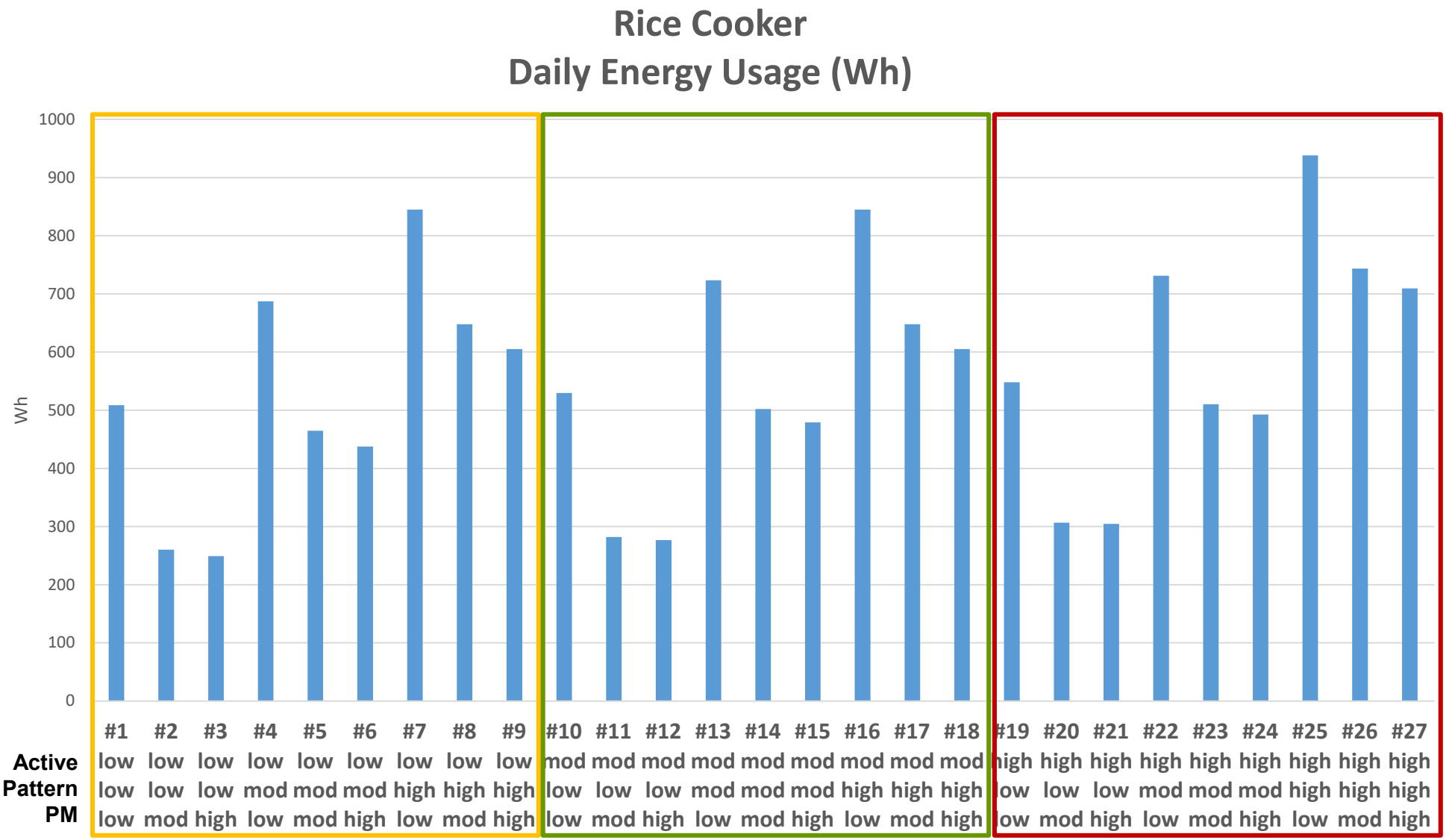
Pattern	
Low	1 use per day
Moderate	2 uses per day (5 hours in between)
High	3 uses per day (5 hours in between)

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

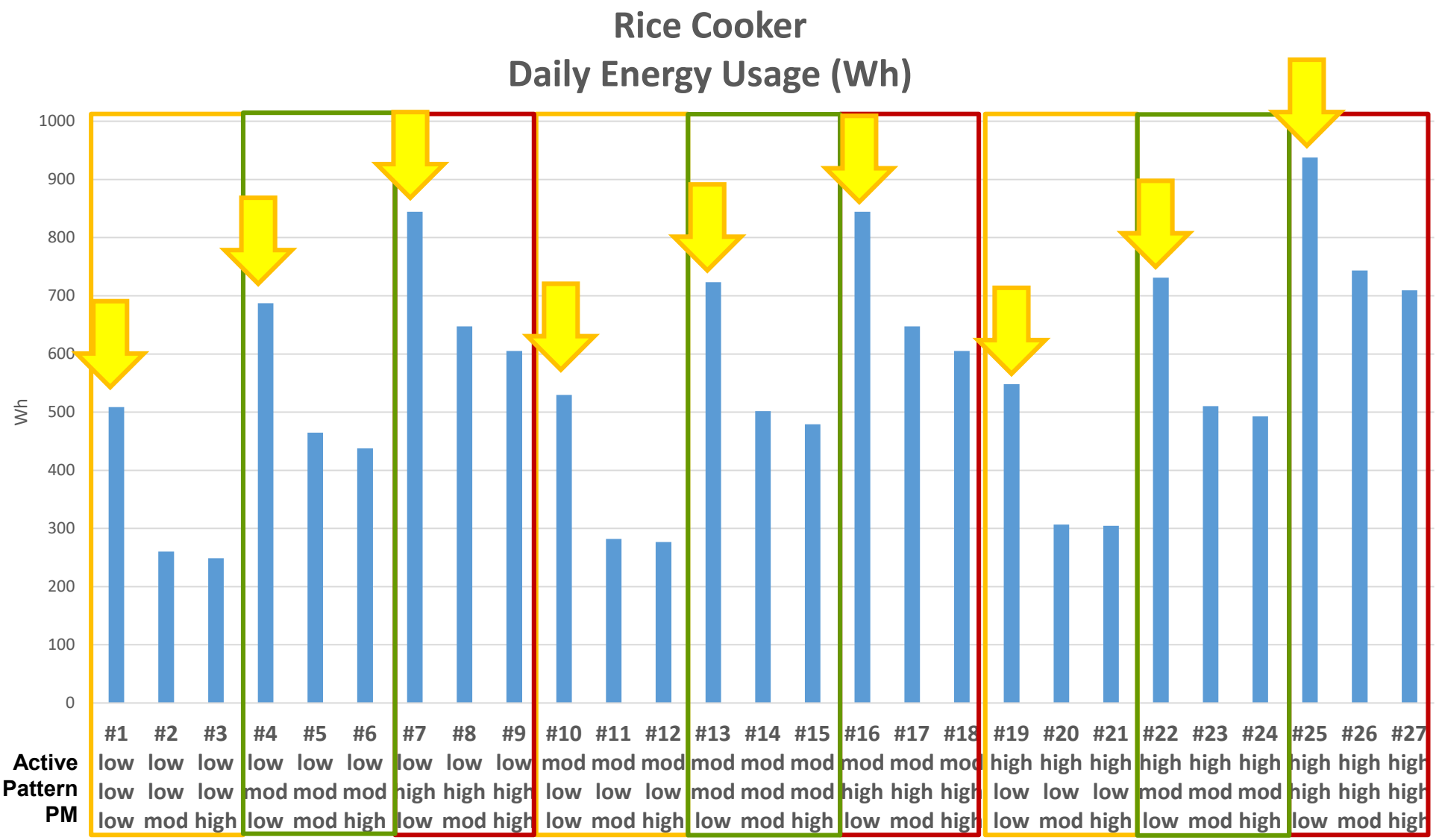
Run the Numbers through PLSim



Pattern of Energy Use Example: Rice Cooker



Pattern of Energy Use
Example: Rice Cooker



Device-level Profile Results Range Example: Rice Cooker

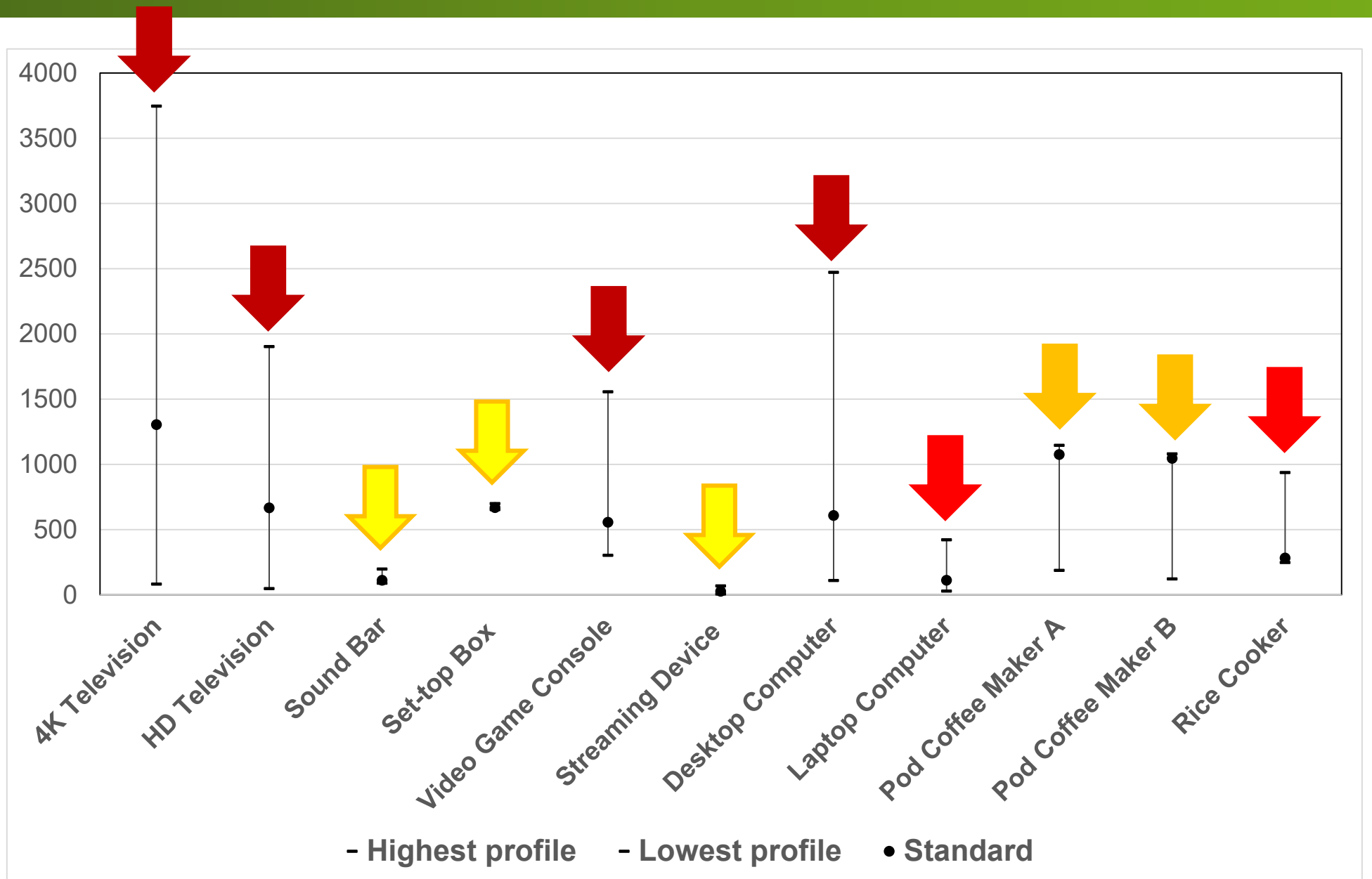
	Standard (Wh)	Median (Wh)	Min (Wh)	Max (Wh)	Range (Wh)
Rice Cooker	282.2	529.4	249.0	937.9	688.9
% from standard			-12%	+232%	244%

- **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

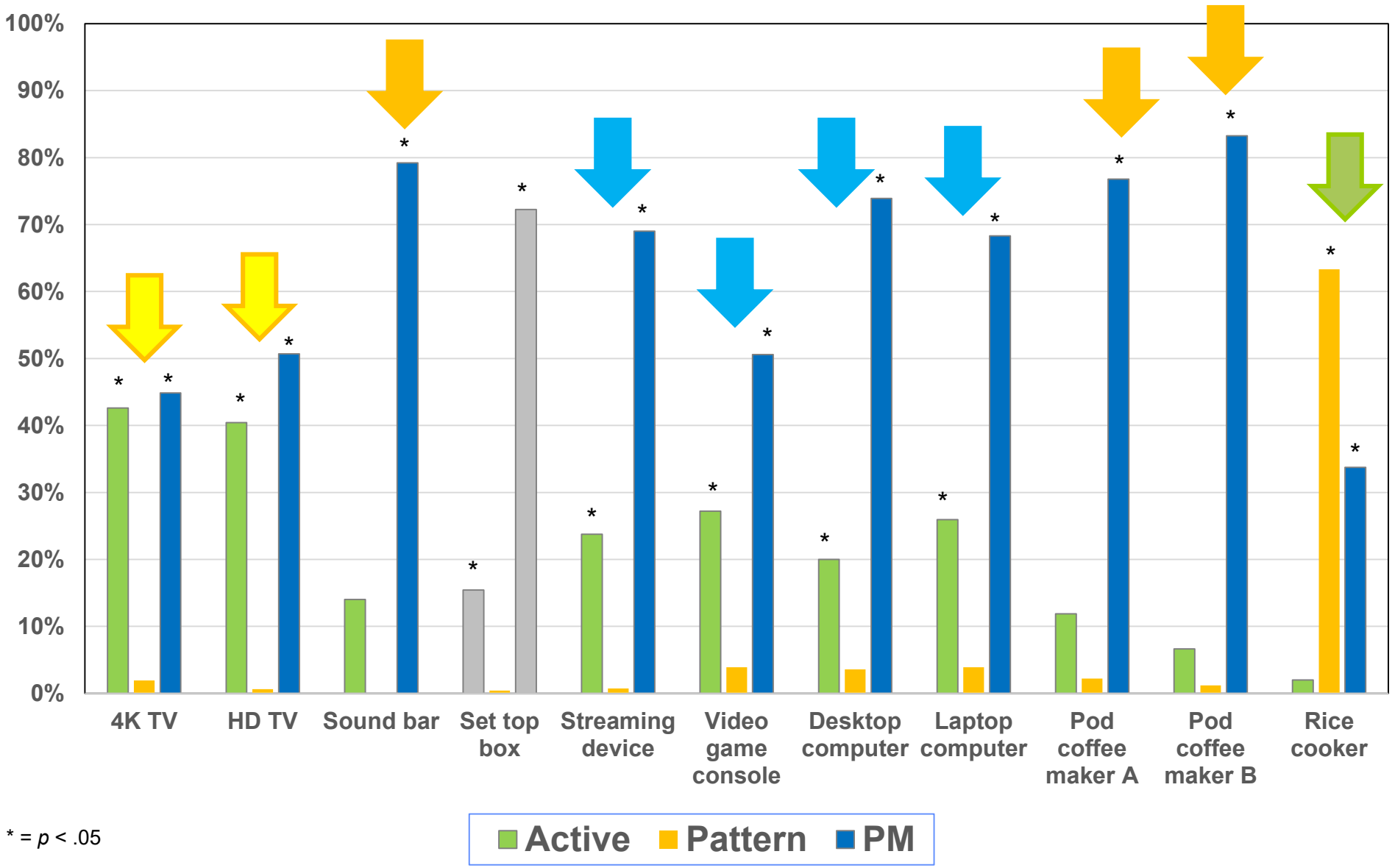


Multivariate Regression Analyses

	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	**0.0252**			**0.8829**			**<.0001**			<.0001		
R^2	**0.200**			**0.036**			**0.739**			0.952		

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

Percent of Variance Due to Each Aspect



* = $p < .05$

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!

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