Linux* Laptop Battery Life

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Agenda

- Measuring Laptop Power
- Laptop measurement Axioms
- Battery Life Toolkit
- Example Measurement Results

Laptop Measurement Methods I

- AC Watt Meter
  - remove battery, if possible
  - But includes AC/DC converter brick
  - But laptops usually run differently on AC

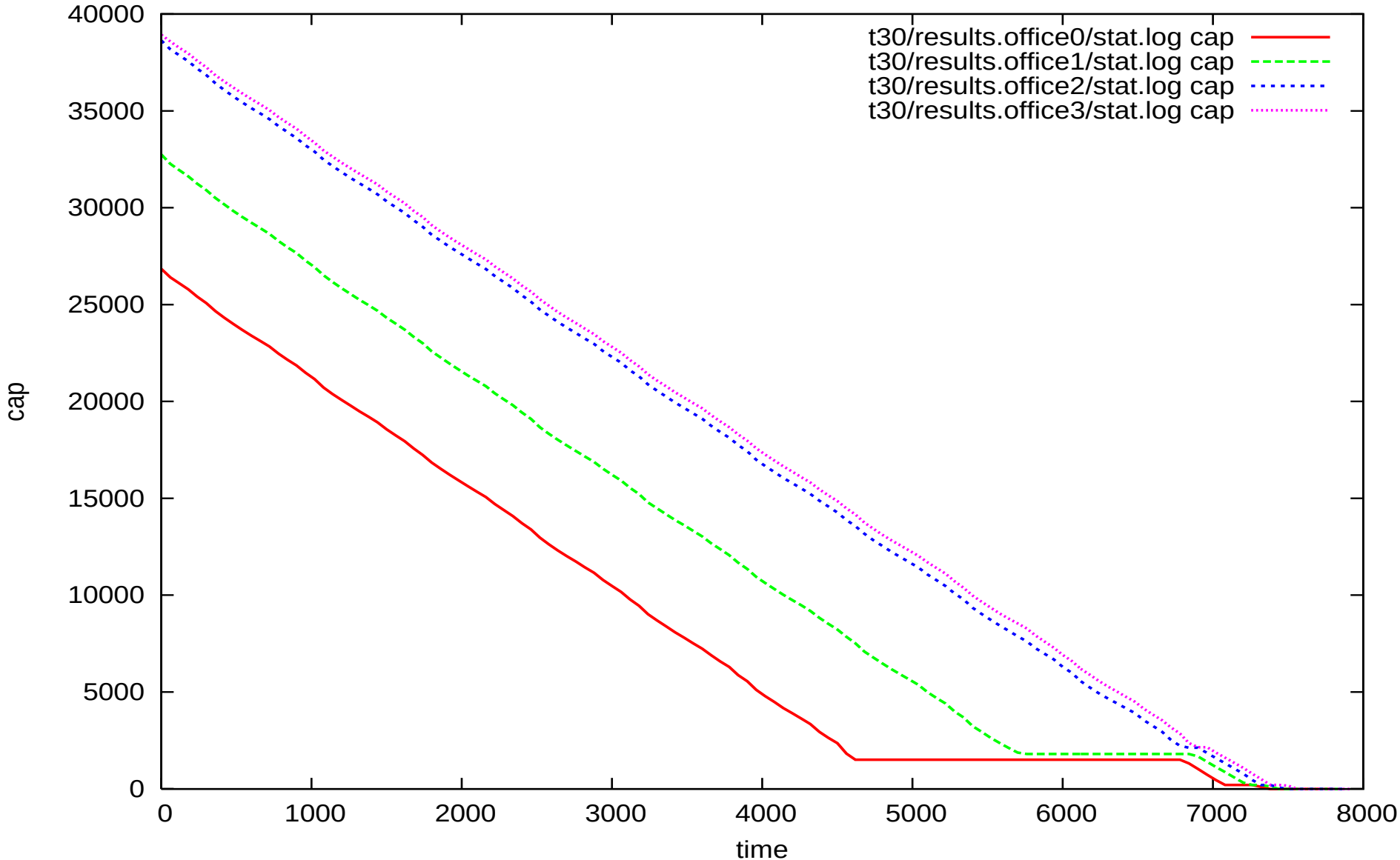
Laptop Measurement Methods II

- DC Watt Meter on AC/DC converter
  - excludes brick, but still AC mode
- DC Power Supply
  - spoof (destroy) the battery
  - But sometimes laptops change behavior on partially charged battery.
- DC Watt Meter on instrumented Battery
  - need data logger + soldering iron...

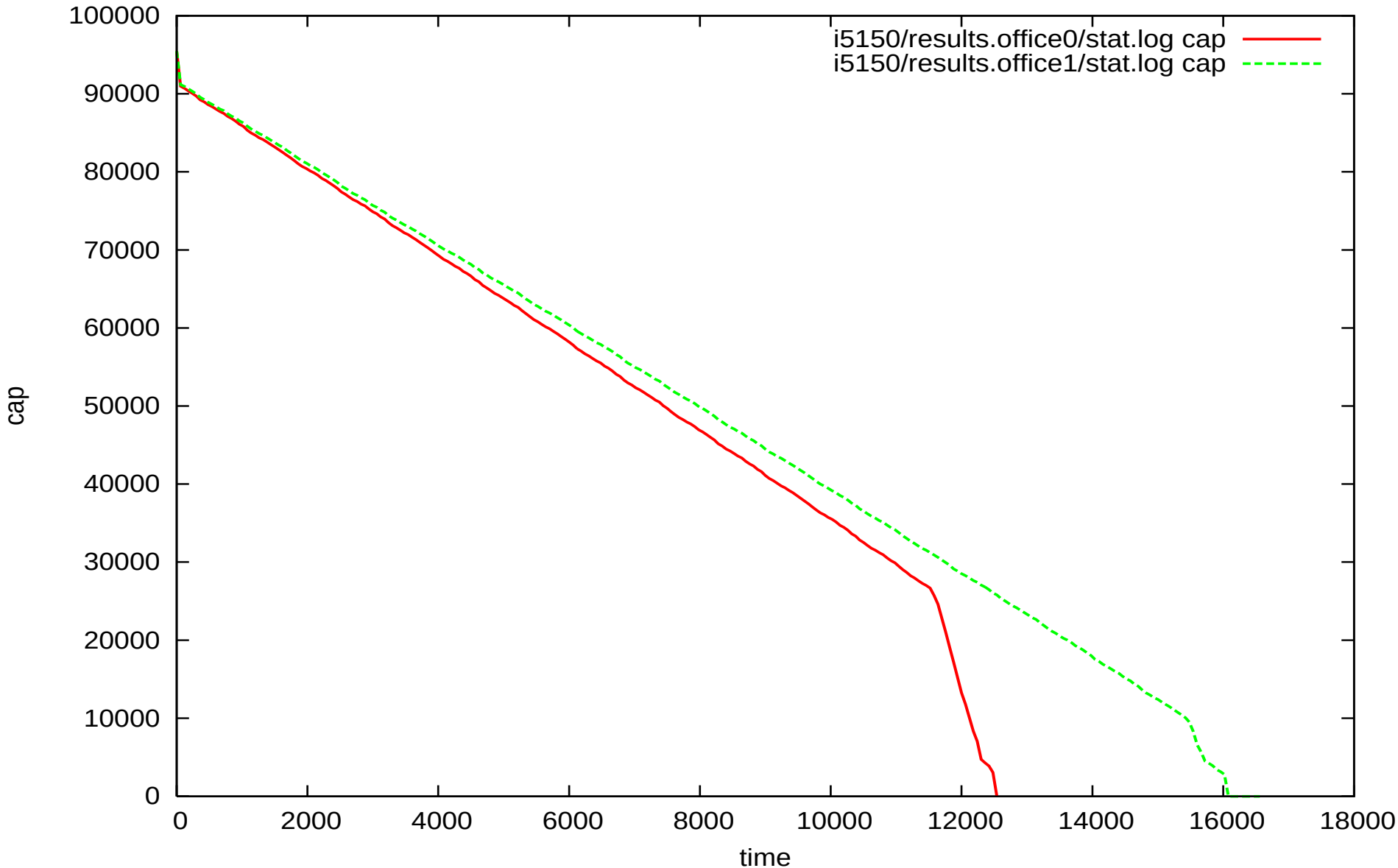
Laptop Measurement Methods III

- Use built-in battery instrumentation
  - /proc/acpi/battery/*/info, state
  - YMMV...
- Run new battery from full to empty
  - Exactly what a user will see
  - Can calculate approx. Watts from capacity/time

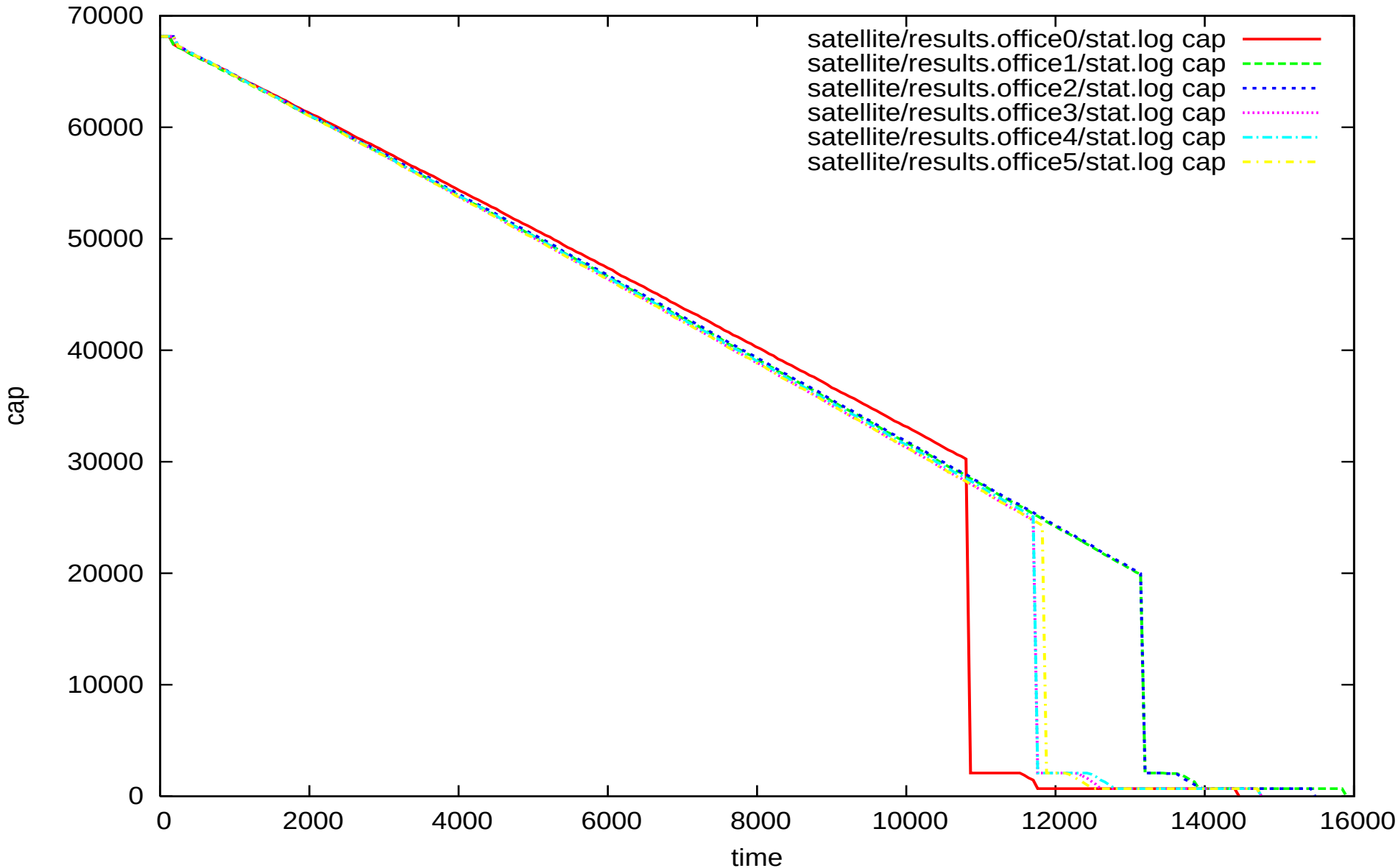
System A: Under-Reports Capacity until conditioned



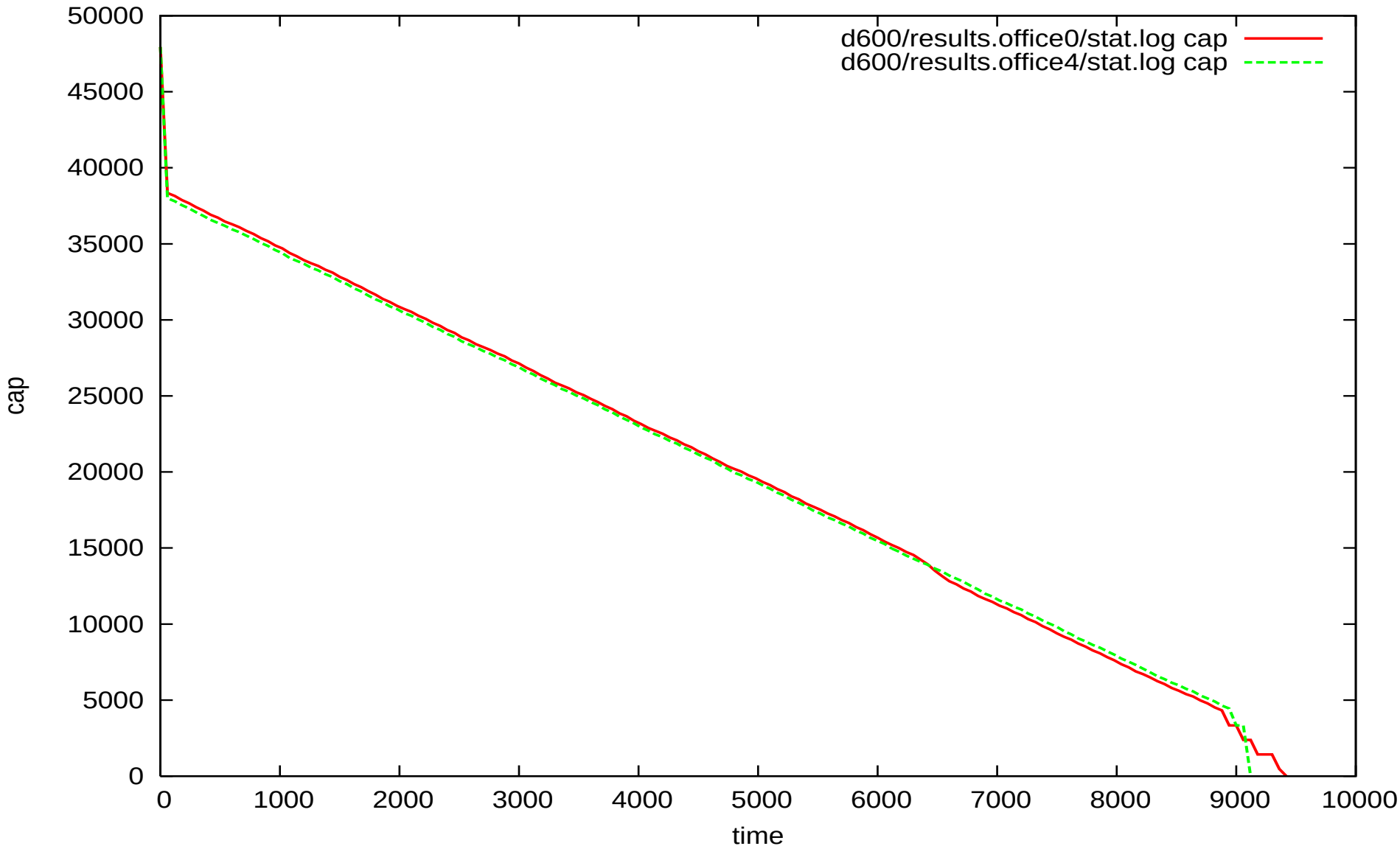
System B: Over-Reports Capacity until conditioned



Sys C: Over-Reports Final Capacity Conditioning does not help



SysD: Over-Reports Initial Capacity Conditioning does not help



Laptop Electricity: Measurement Axioms

- Measure on real DC battery power source
- Condition the battery
- Disable battery alarms
- Start at fully charged
- Complete at full discharged

BLTK (Battery Life Toolkit)

BLTK is:

An open source release of some tools that Intel OTC developed to measure and improve power management on Linux.

The intent is to help the community measure and improve itself.

BLTK is NOT:

an industry standard benchmark.

Battery Life Toolkit Framework

- records system configuration
- forks (any) workload
- records score

Battery Life Toolkit Workload: Idle

- trivial
- built into framework
- constant (0) work/time
- very important in real life
- easy to compare to other platforms

Battery Life Toolkit Workload: Web Reader

- simple: turn a page every 2 minutes
- built into framework
- constant (~0) work/time
- effectively = idle + eye candy
- easy to compare to other platforms

Battery Life Toolkit Workload: Open Office

- oowriter/oocalc/oodraw
- requires OO 1.1.4
- constant work/time
- In addition to Battery Life,Reports Performance Score

- 720 sec. Iteration = workload_time + Idle
- Workload_time = Active_time + Delay_time
- Score = 100 * reference/Average_active_measured

Battery Life Toolkit Workload: DVD Playback

- simple: play a (known) DVD repeatedly forever
- requires mplayer
- constant work/time
- real life usage model
- easy to compare to other platforms

Battery Life Toolkit Workload: Software Developer Workload

- simple: Linux kernel browse/edit/build
- requires Linux kernel source tree
- constant work/time
- attempts to model real user
- Performance Score = 100 * ref/Average_active_measured

Battery Life Toolkit Workload: 3D Game

- problematic, 3D not widely available on Linux
- requires a game, eg. Unreal Tournament* Demo, or at least glxgears...
- NOT constant work/time
- Performance = FPS_measured/reference

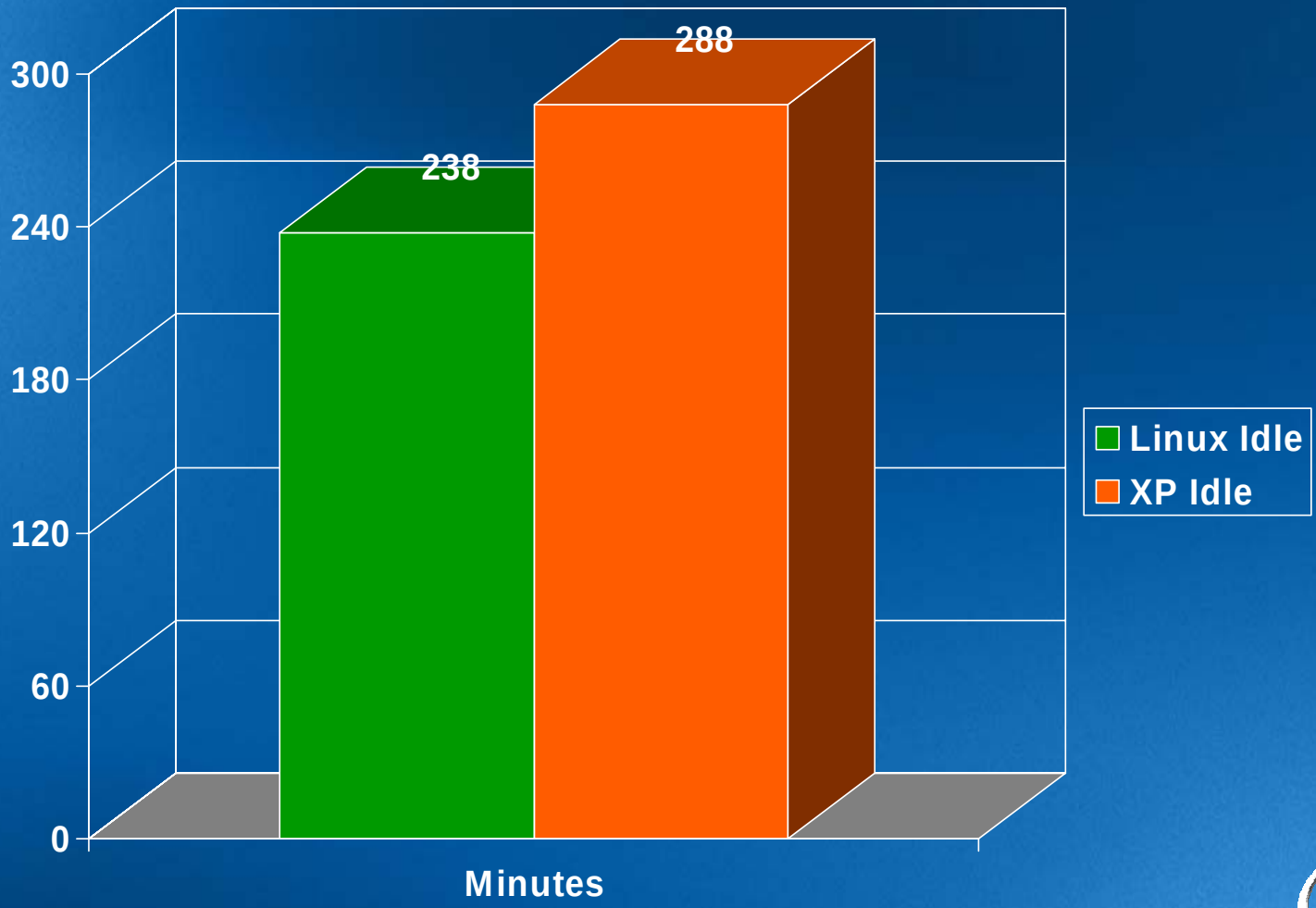
Battery Life Example (53WH Battery)

- **Dell Inspiron* 6400**
  - Intel® Core™ Duo T2500 (2.0GHz)
  - 15” WXGA LCD
    - minimum brightness
  - 1GB DDR2
  - 40GB 5400RPM
  - LAN, Wireless: off
  - Linux: 2.6.16+
    - Init 5
    - cpufreq: ondemand
    - disk spin-down: default

Hours	Minutes	Watts
1	60	53.0
2	120	26.5
3	180	17.7
4	240	13.3
5	300	10.6
6	360	8.83
7	420	7.57
8	480	6.62

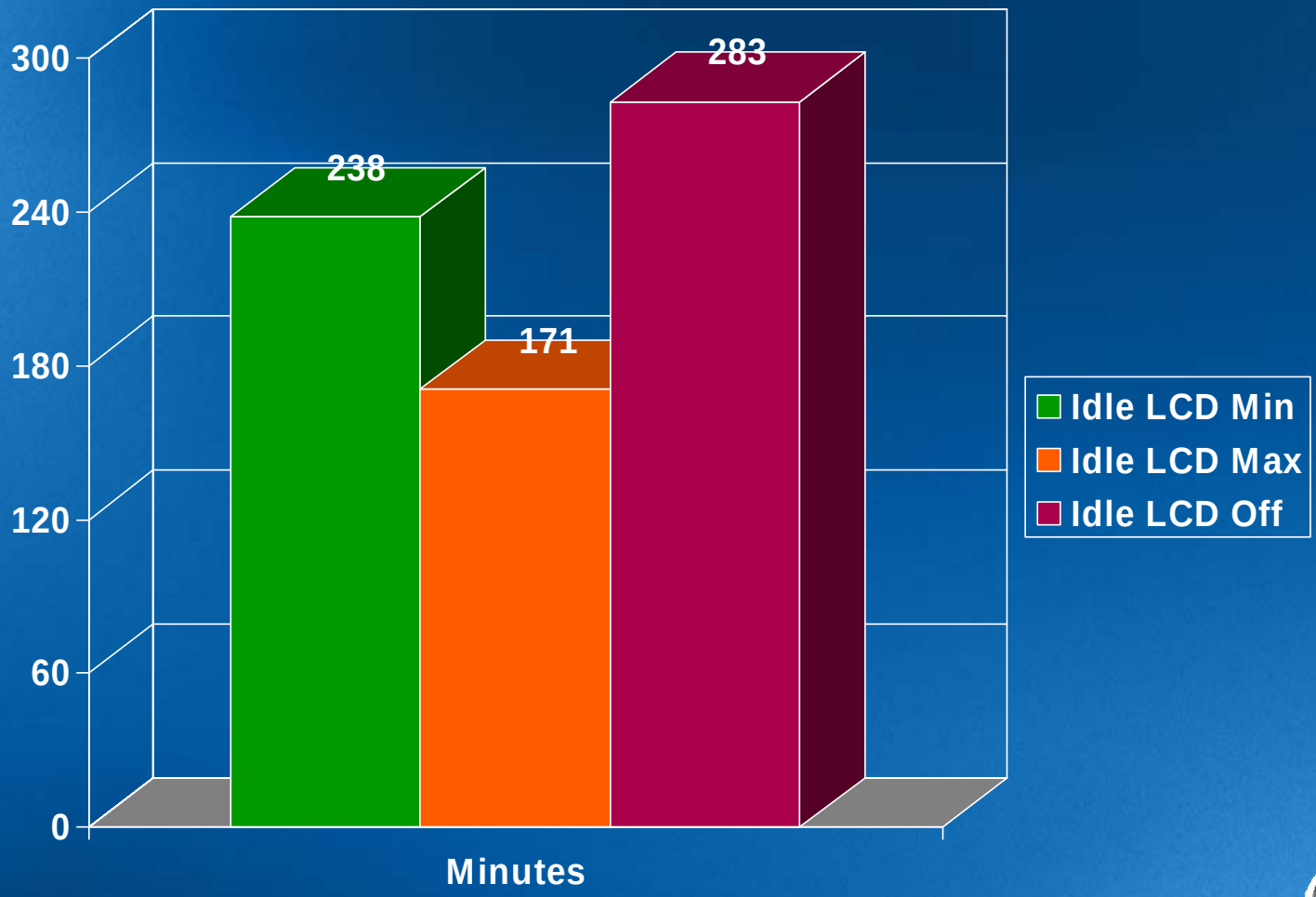
Linux vs. Windows* XP Idle Battery Life

50 minute gap due 13.4W – 11.0W = 2.4 Watt difference



Effect of LCD Brightness on Battery Life

Over 1 hour (> 25%) battery hit from bright vs. dim screen

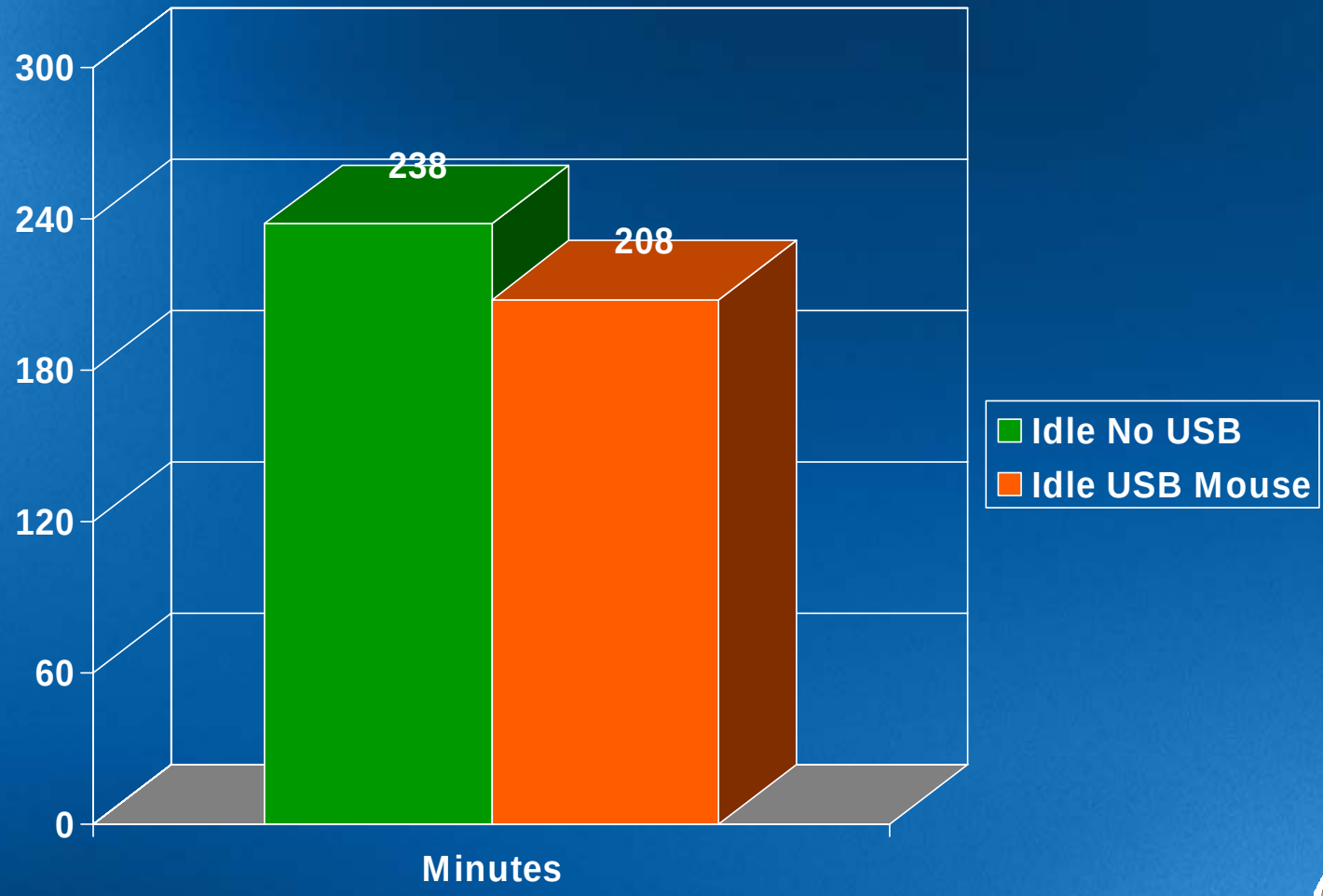


What to do about the LCD?

- All measurements here are at MIN brightness unless otherwise specified
- LCD OFF might be more useful for system vs. system comparisons due to different screen types and sizes.

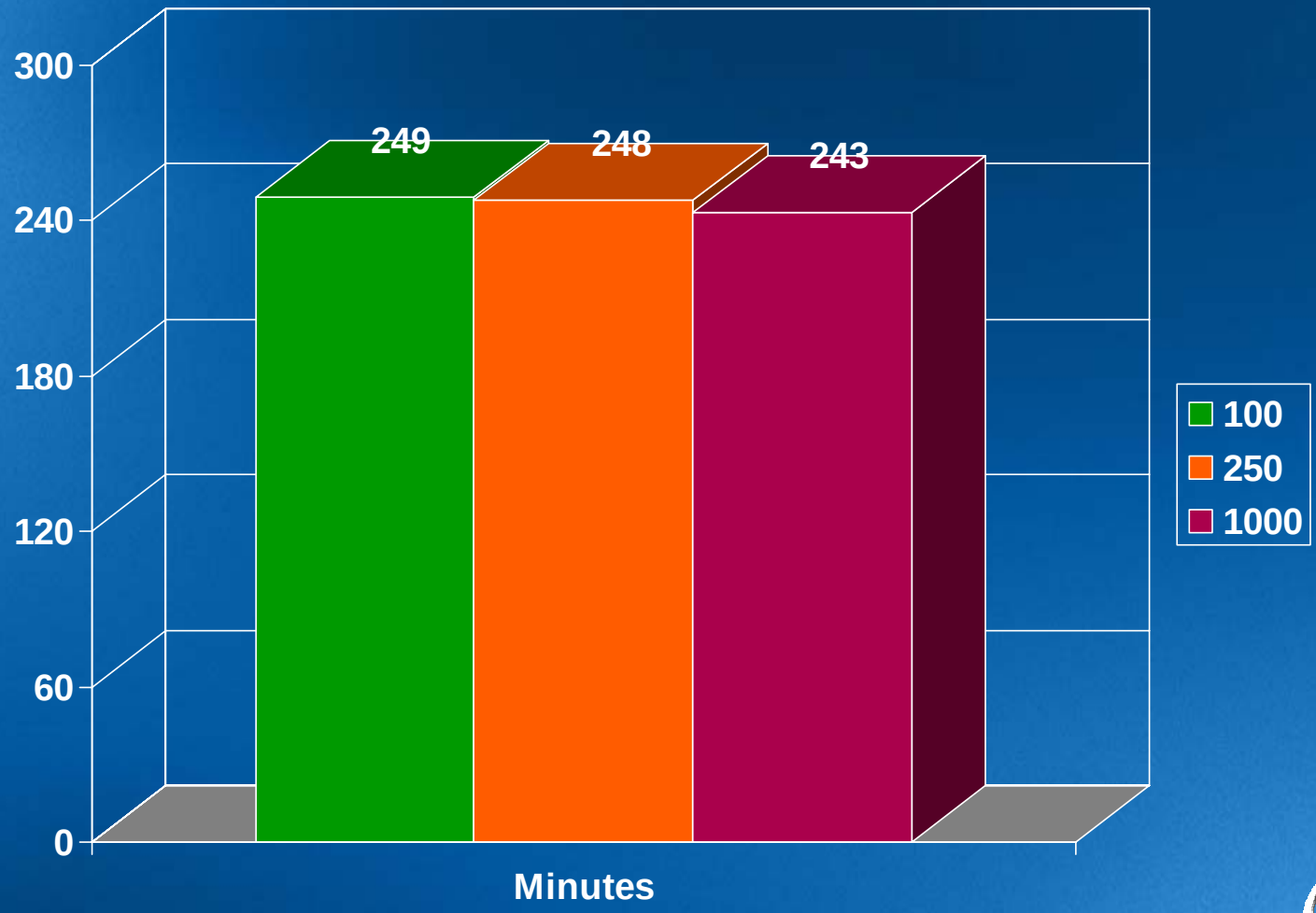
Effect of connecting USB Mouse on Battery Life

30 minute hit from simply connecting a USB mouse (0.7W)



CONFIG_HZ Effect on Battery Life

Single User mode used to measure small difference – YMMV



Measuring at init5 vs. init1
Not a large factor in this example

- init5: 238 minutes, 12.8W
- init1: 248 minutes, 13.4W
- 10 minutes = 4%, 0.6W

- YMMV...

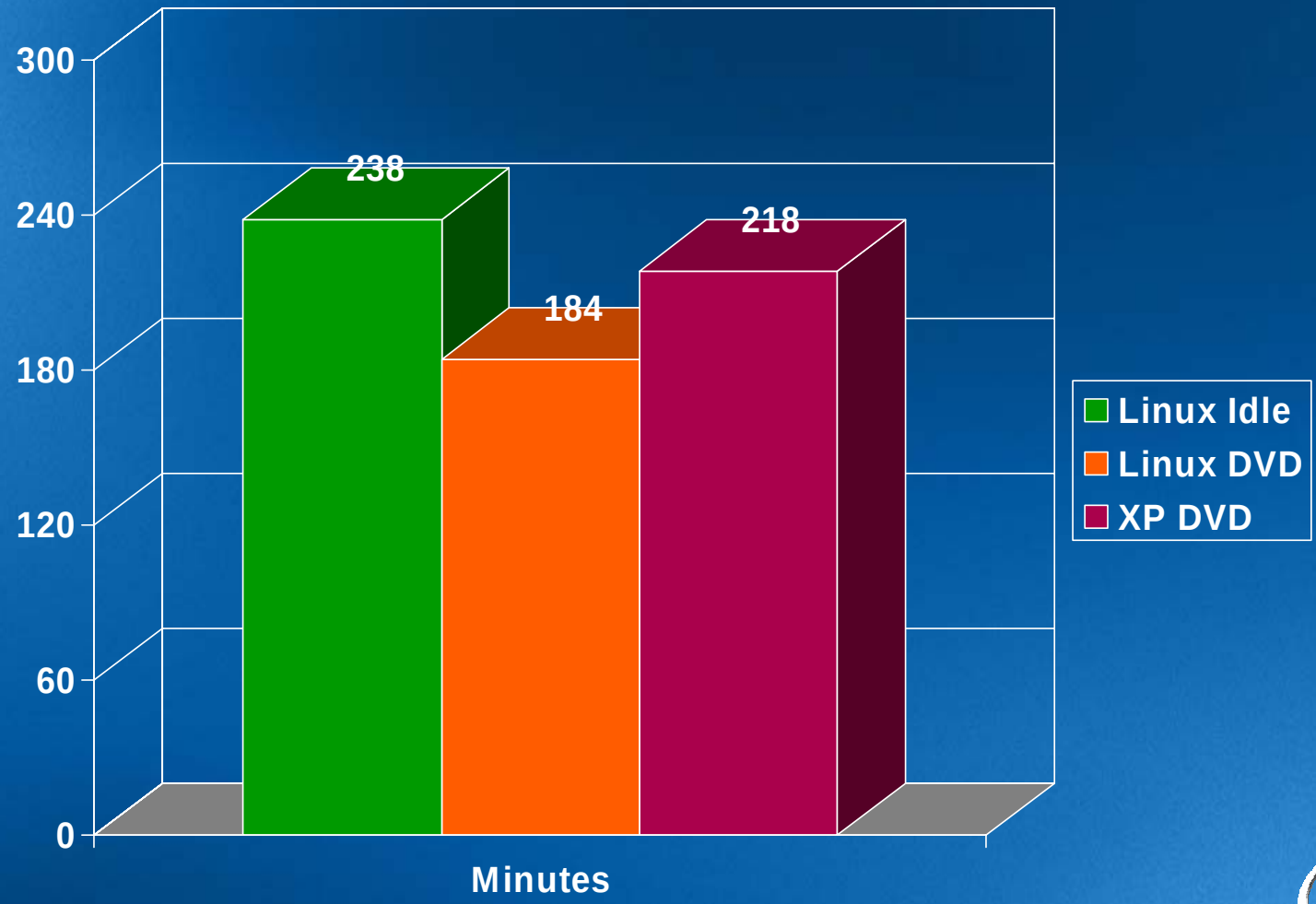
Throttling saves Power
Throttling does not save Energy

- Power [Watts]= f(cycles/time) [MHz]
- Energy = Power * time
- Energy [KWHr] = f(cycles)

- e.g. cut frequency in half, cuts performance by half, but takes same energy to complete the task.
- So on your power-saved GUI, do NOT check that little box to enable processor throttling – all it will do is slow down your laptop.

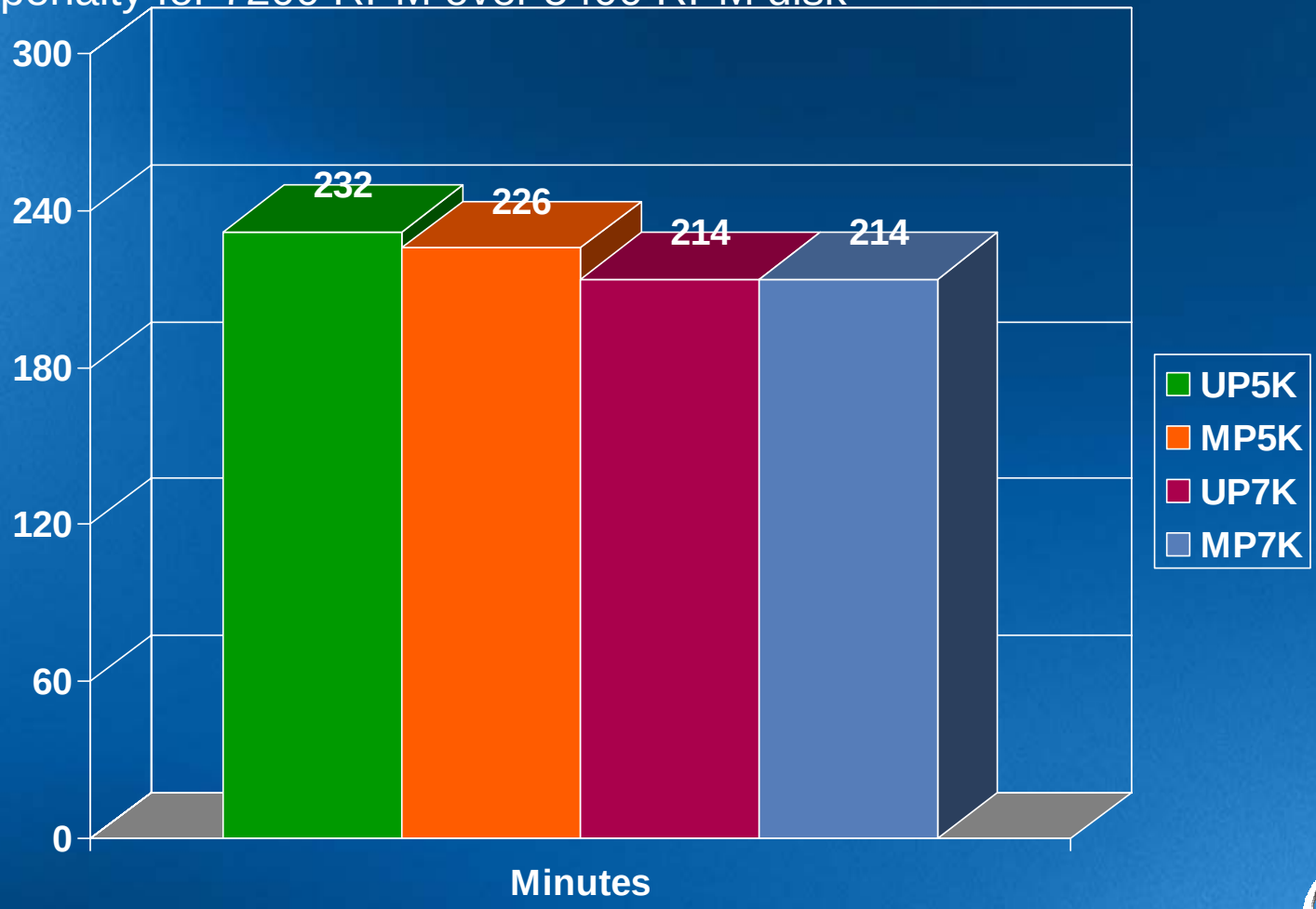
Linux vs. XP DVD Playback Battery Life

3 hours Linux vs. 3.6 hours XP



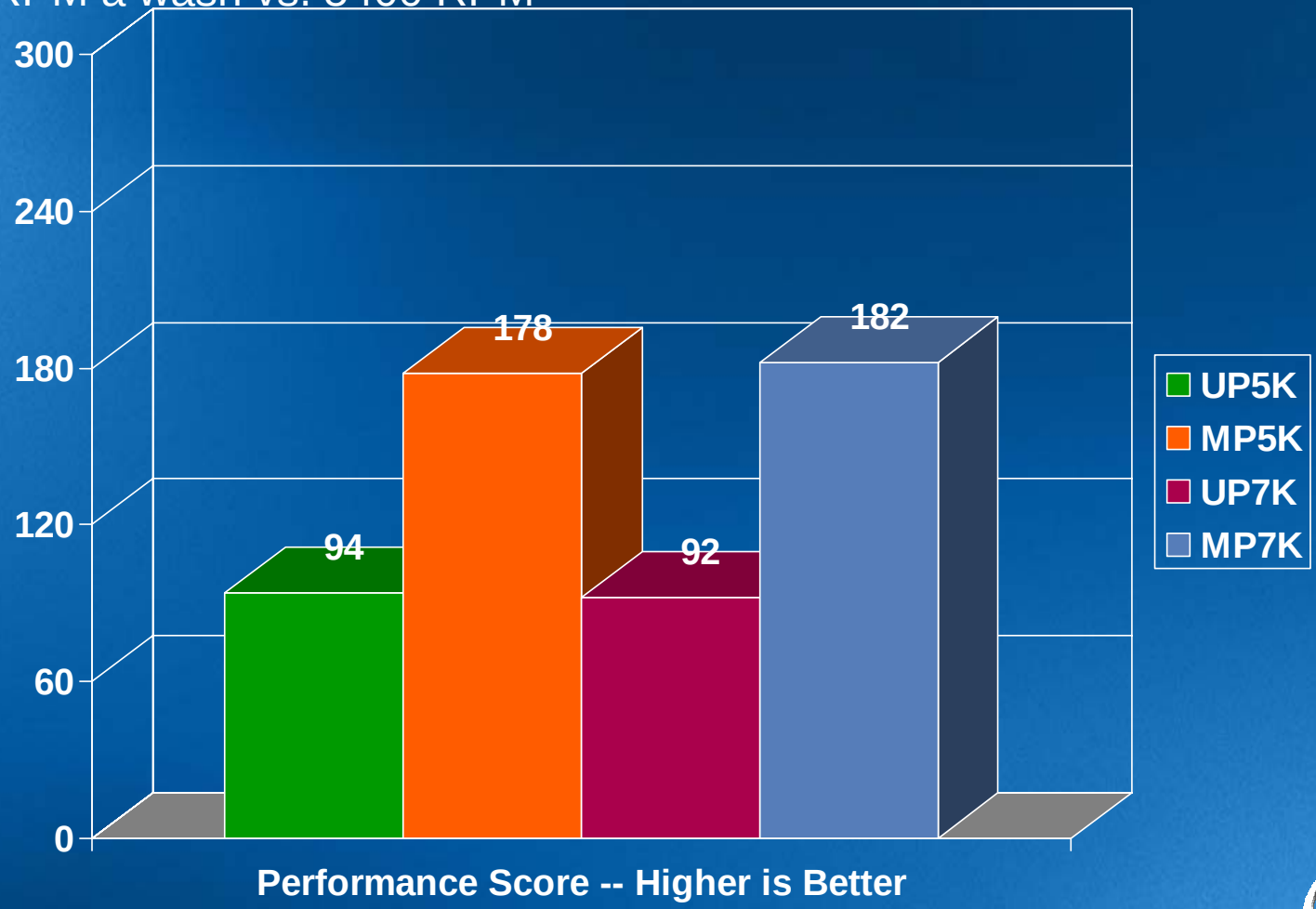
Open Office Battery Life

Small to no penalty for Multi-Core vs. UP
Small penalty for 7200 RPM over 5400 RPM disk



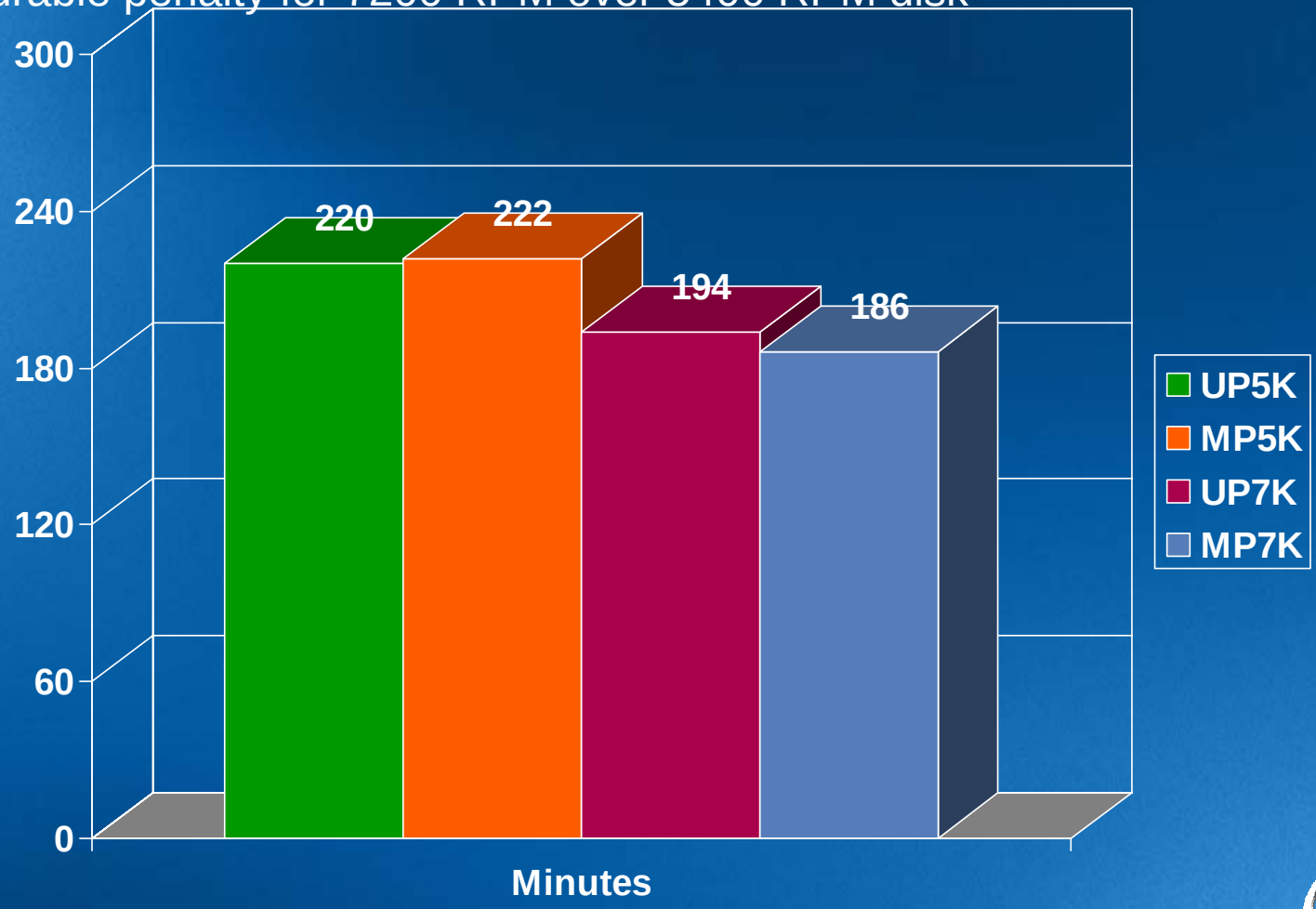
Open Office Performance

Multi-Core Rocks!
7200 RPM a wash vs. 5400 RPM



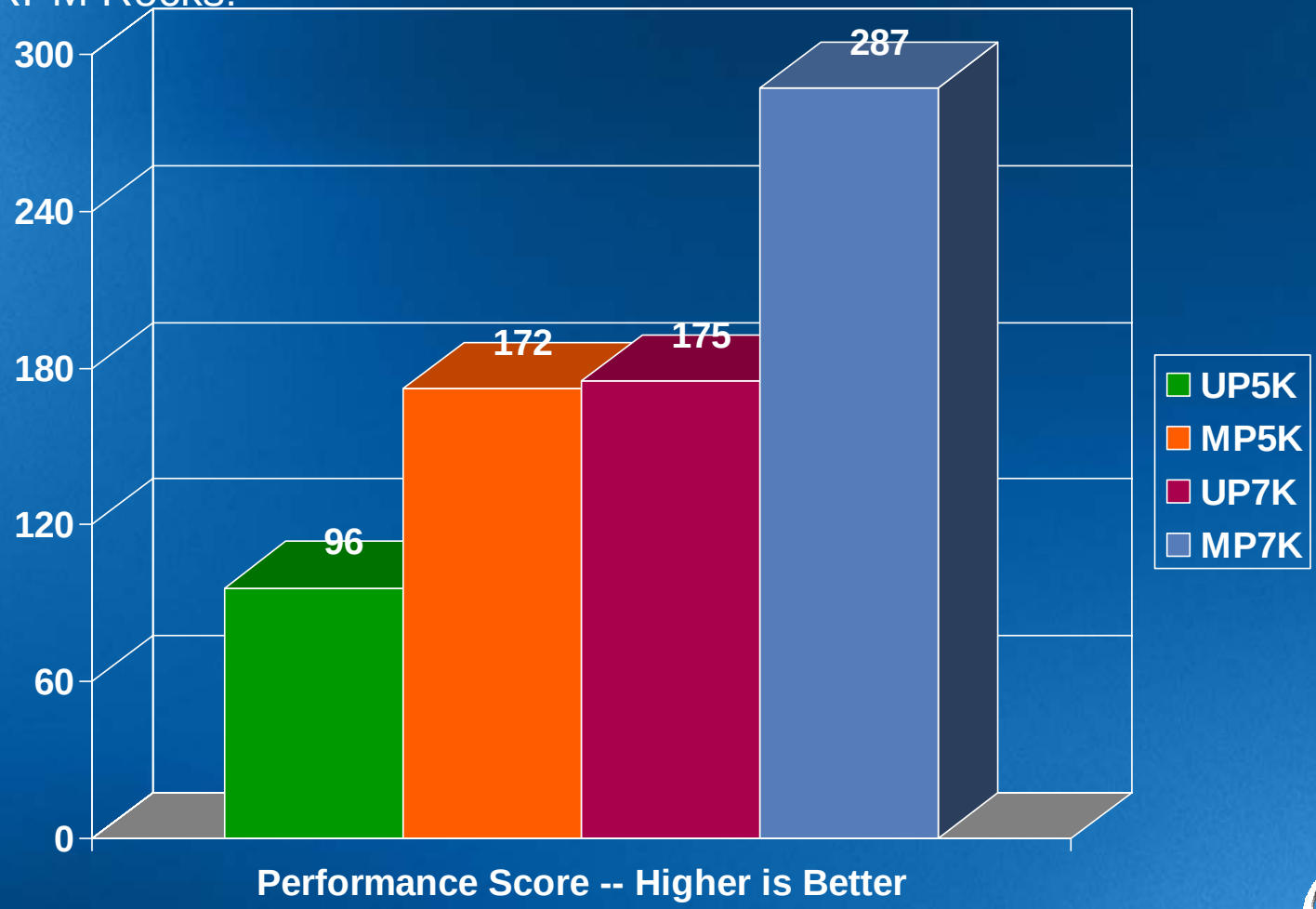
SW Developer Battery Life

Small to no penalty for Multi-Core vs. UP
Measurable penalty for 7200 RPM over 5400 RPM disk



SW Developer Performance

Multi-Core Rocks!
7200 RPM Rocks!



Thank You

Download from:

http://ftp.kernel.org/pub/linux/kernel/people/lenb/acpi/utils/bltk

Where to discuss:

linux-laptop@vger.kernel.org

linux-acpi@vger.kernel.org

linux-pm@lists.osdl.org

Feedback to:

the authors

Intel® Core™ Duo Processor SV

	Name	Vcc	Watt
C0	High Frequencey Mode (P0)	1.3	31
C0	Low Frequency Mode (Pn)	1.0	
C1	Auto Halt Stop Grant (HFM)		15.8
C1E	Enhanced Halt (LFM)		4.8
C2	Stop Clock (HFM)		15.5
C2E	Enhanced Stop Clock (LFM)		4.7
C3	Deep Sleep (HFM)		10.5
C3E	Enhanced Deep Sleep (LFM)		3.4
C4	Intel Deeper Sleep	0.85	2.2
DC4	Intel Enhanced Deeper Sleep	0.80	1.8

*Intel® Core™ Duo Processor 65nm Process – Datasheet