http://xkcd.com/892/

The Future of Green Enterprise Computing

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cs303, April 29, 2011

Outline

Brief intro to PowerNet

Characterizing energy use in Gates

Championing laptops

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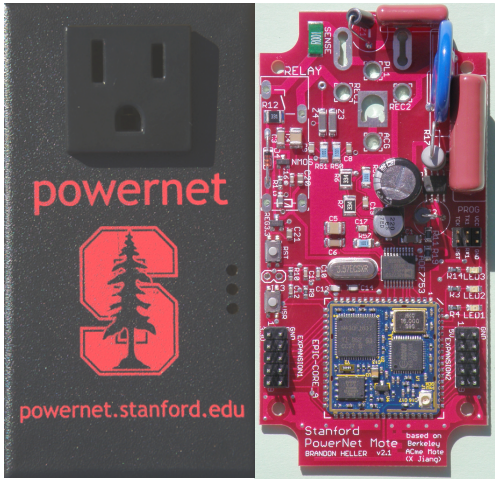
PowerNet

A measurement infrastructure that collects power and utilization data

Currently measuring over 200 devices:

- laptops
- desktops
- servers
- thin clients
- networking equipment
- LCD monitors



Quick Demo

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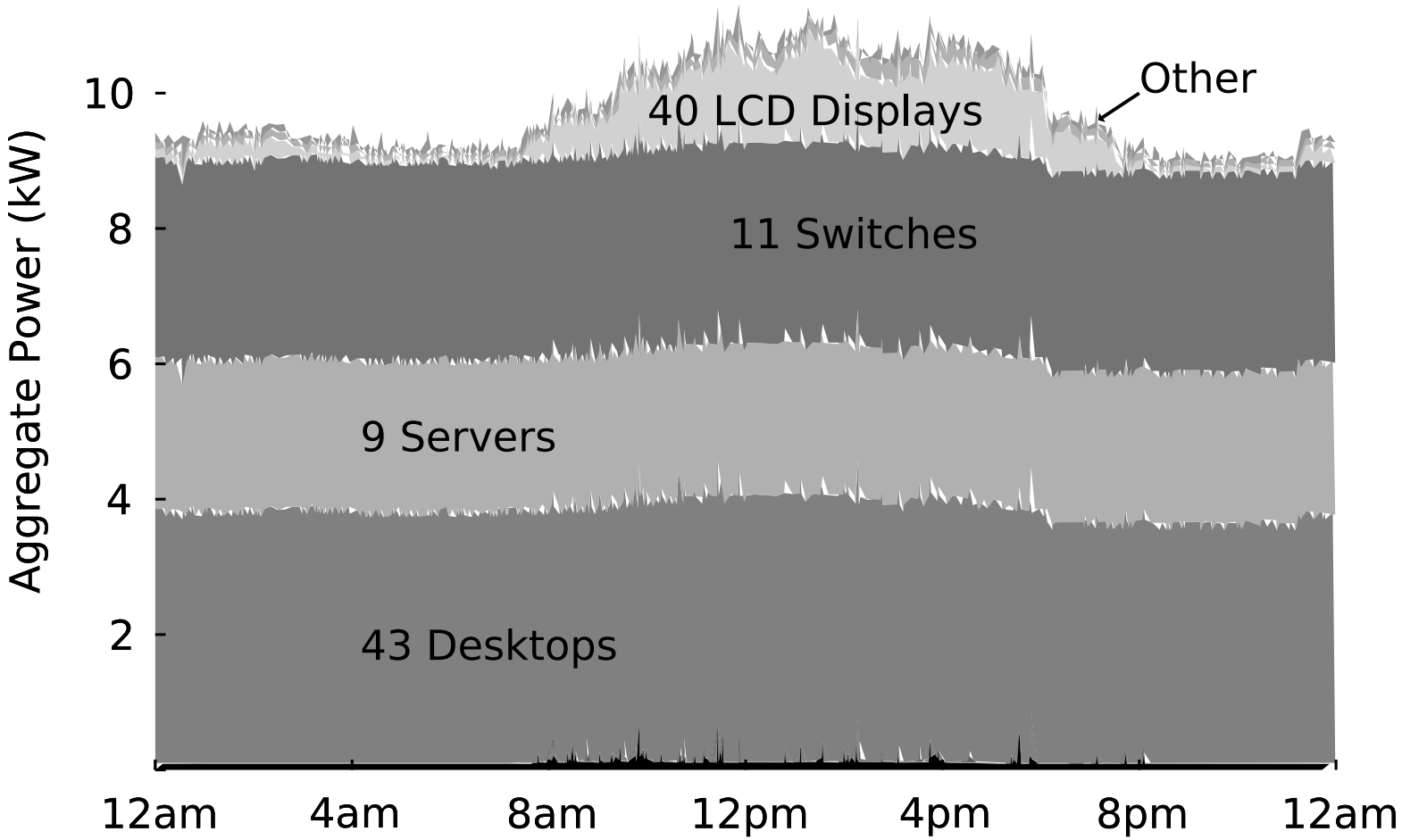
Empirical Data

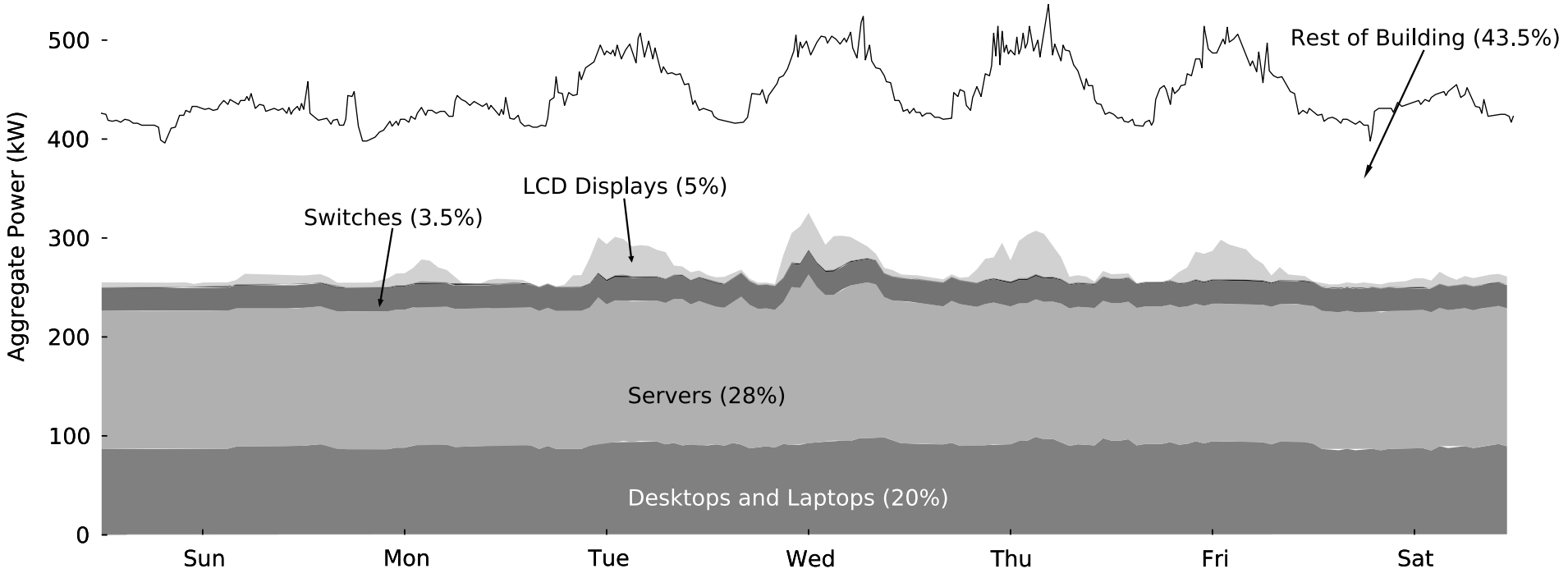


How Do We Extrapolate?

- Inventory
- Surveys
- Manual inspection

- Assumptions?

Whole-Building Breakdown



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Let's Do Something About the Desktops

- Software
  - Power management tools
  - Network proxies
  - Virtual machines
- Hardware
  - Laptops

How to Compare

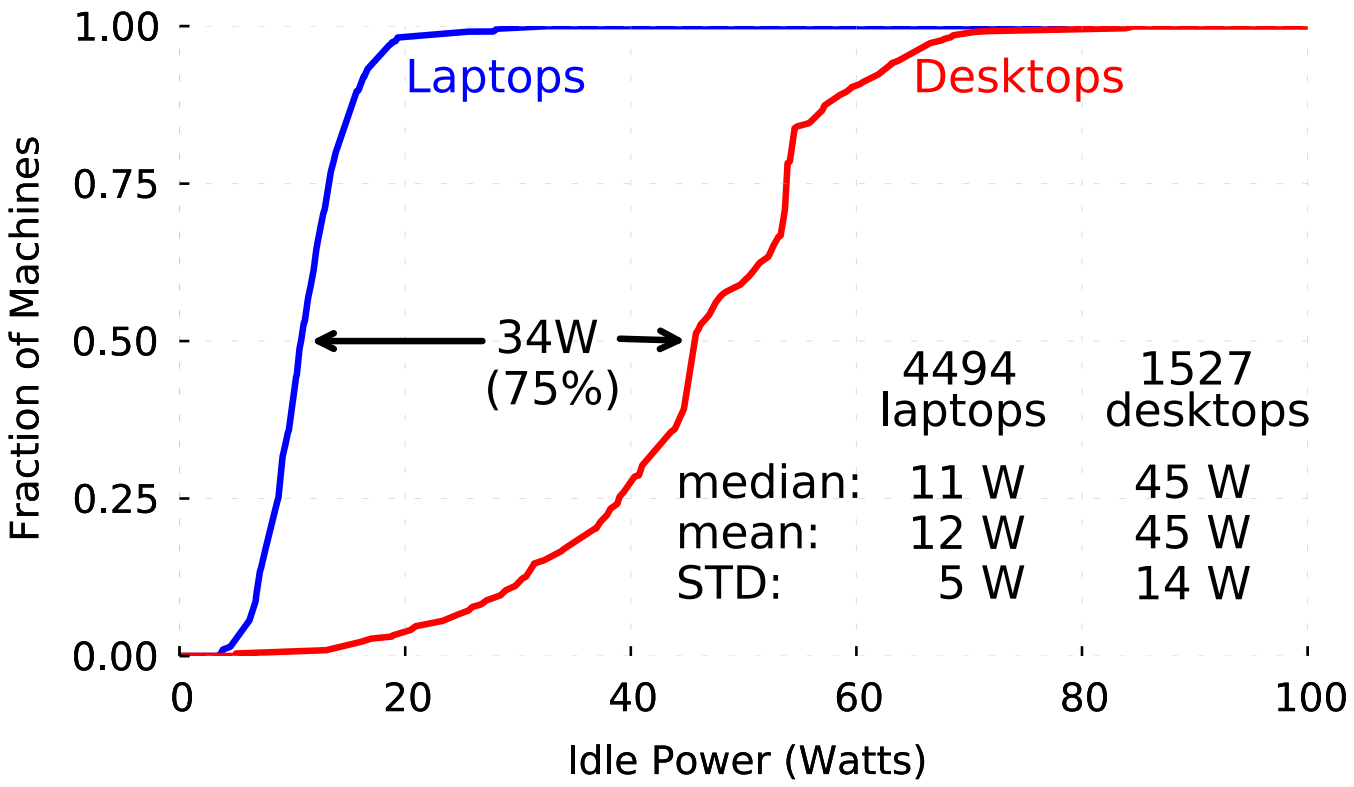
- Pick a few energy-saving solutions
- Determine how well each solution does
- Do we evaluate everything ourselves?

Using Others' Data

- "Our findings … are very promising, with energy savings of 72-74% with LiteGreen compared to 32% with existing Windows and manual power management."

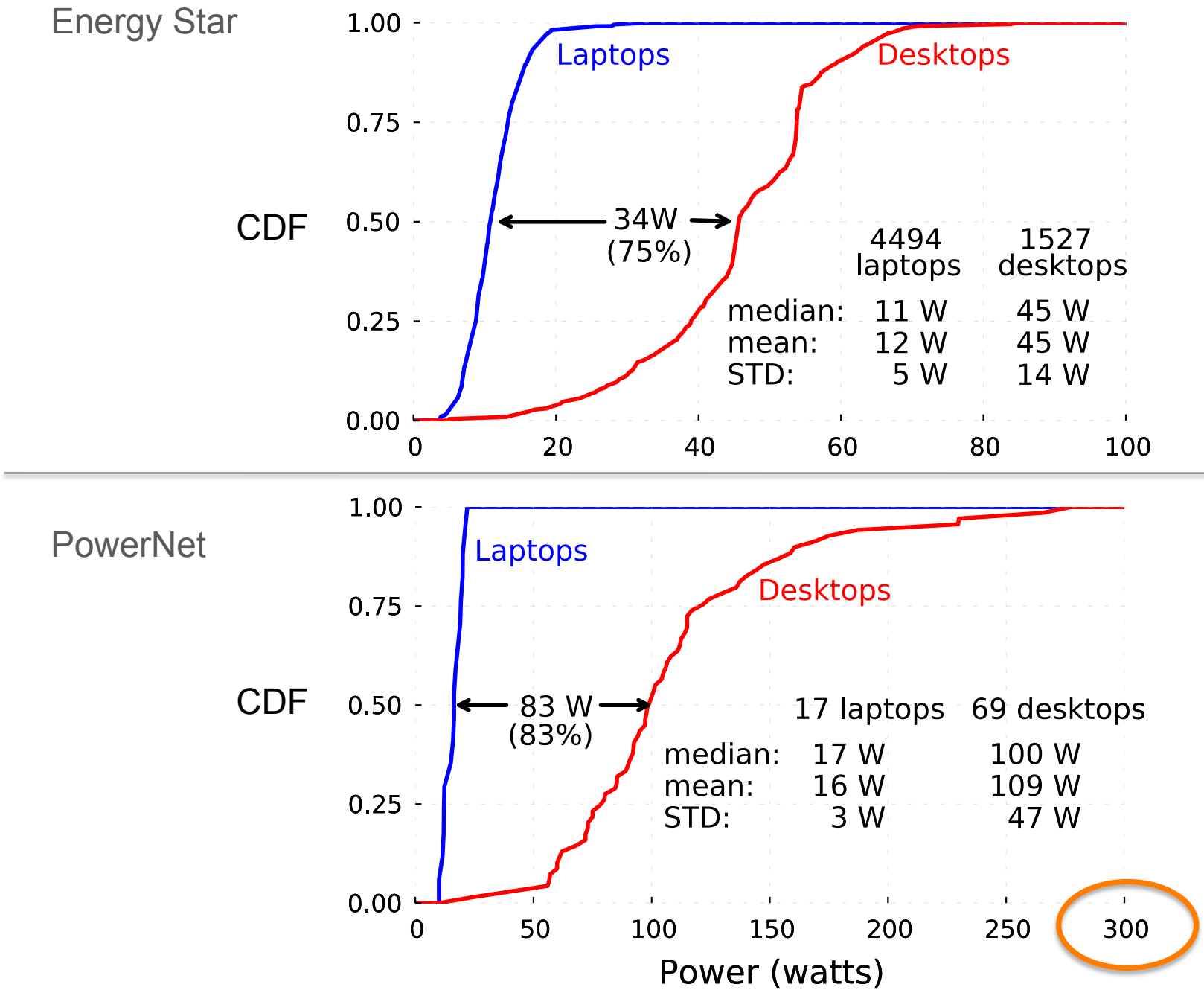
- "The measured energy savings across all machines in our deployment for the month of September range from 27% to 86%, with an average savings of 60%."

Energy Star Data



Potential Problems

- How were the measurements collected?
  - this is self reported data
- Is the data set biased?
  - only Energy Star-certified machines


Energy Star
CDF
1.00
0.75
0.50
0.25
0.00
0
20
40
60
80
100
Laptops
Desktops
34W
(75%)
4494 laptops
1527 desktops
median: 11 W 45 W
mean: 12 W 45 W
STD: 5 W 14 W
PowerNet
CDF
1.00
0.75
0.50
0.25
0.00
0
50
100
150
200
250
300
Power (watts)
Laptops
Desktops
83 W
(83%)
17 laptops
69 desktops
median: 17 W 100 W
mean: 16 W 109 W
STD: 3 W 47 W

Comparing Approaches

Approach	Annual Cost	$ Saved	% Saved
Desktop	$100	-	-
Manual Sleep	$78	$32	32%
Network Proxy	$40	$60	40%
VM	$26	$74	74%
Laptop	$17	$83	83%

What Could Go Wrong?

- Why not use other hardware, such as thin clients and Mac Minis?

- Can laptops handle desktop workloads?

- Don’t laptops cost more?

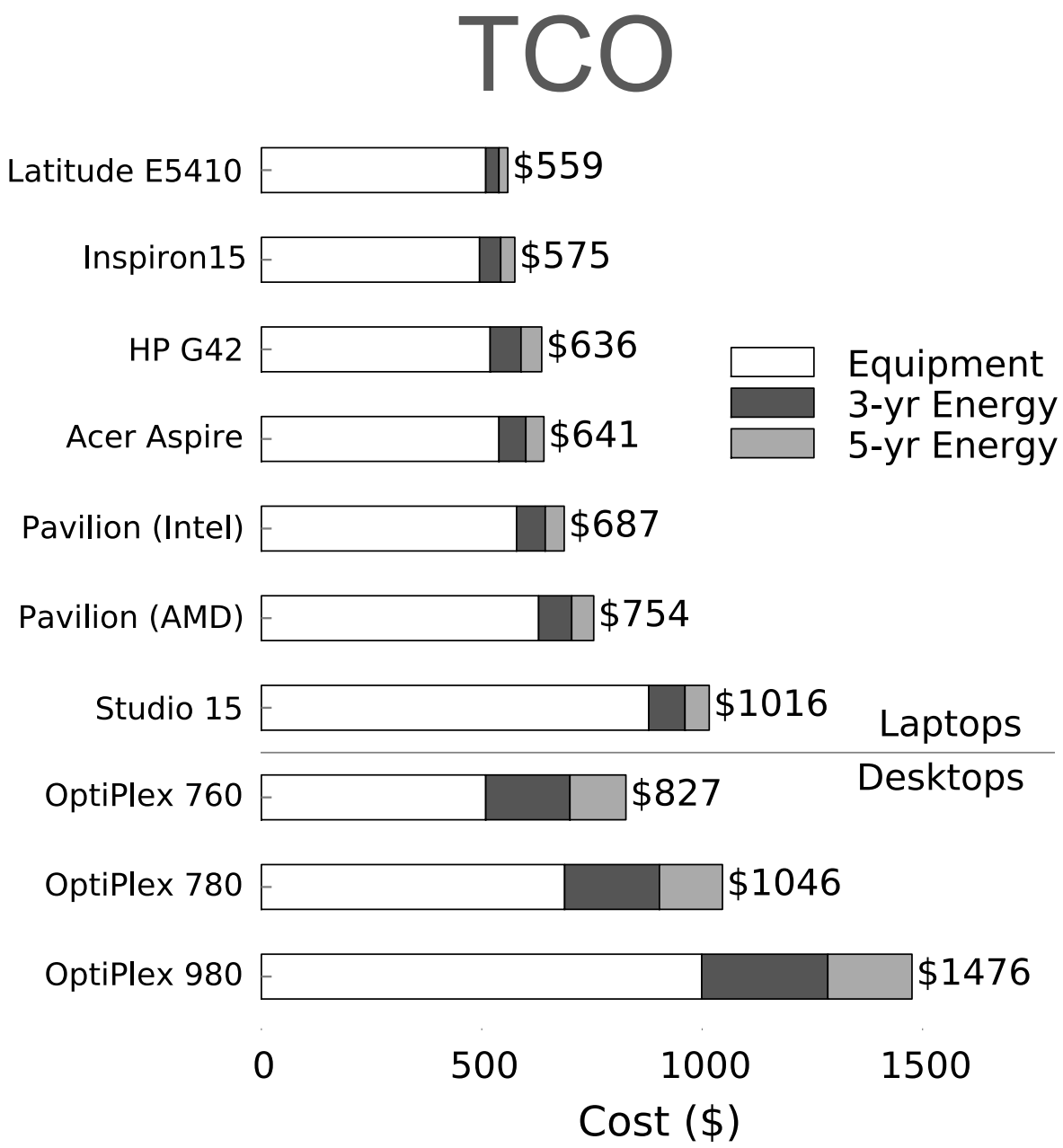
CPU Utilization

Machine Type	Percentile CPU 5^{th}	50^{th}	95^{th}
high-end custom-built	0%	1%	57%
Dell Optiplex 745	1%	9%	58%
Dell Precision T3400	0%	4%	29%
Dell Precision T3400	0%	1%	13%
Dell Inspiron 530	1%	1%	8%
HP Pavilion Elite m9250f	0%	0%	25%
Dell Precision T3400	0%	1%	7%

students

Machine Type	Percentile CPU 5^{th}	50^{th}	95^{th}
Dell OptiPlex SX 280	0%	0%	10%
Dell OptiPlex SX 280	0%	0.75%	5.45%
Dell OptiPlex 745	0%	1.55%	9.25%
Dell Dimension 9200	0%	0.75%	3.1%
Dell Precision 690	0%	0.7%	3.9%
Dell Dimension 9200	0%	1.55%	7.7%
Dell OptiPlex 760	0%	0%	5.45%
Dell OptiPlex 760	0%	1.55%	16.9%

staff


TCO
Latitude E5410
$559
Inspiron15
$575
HP G42
$636
Acer Aspire
$641
Pavilion (Intel)
$687
Pavilion (AMD)
$754
Studio 15
$1016
Laptops
Desktops
OptiPlex 760
$827
OptiPlex 780
$1046
OptiPlex 980
$1476
Equipment
3-yr Energy
5-yr Energy
0
500
1000
1500
Cost ($)

Latest News

Dell OptiPlex 990, Intel Core i7 2600 (3.4GHz)

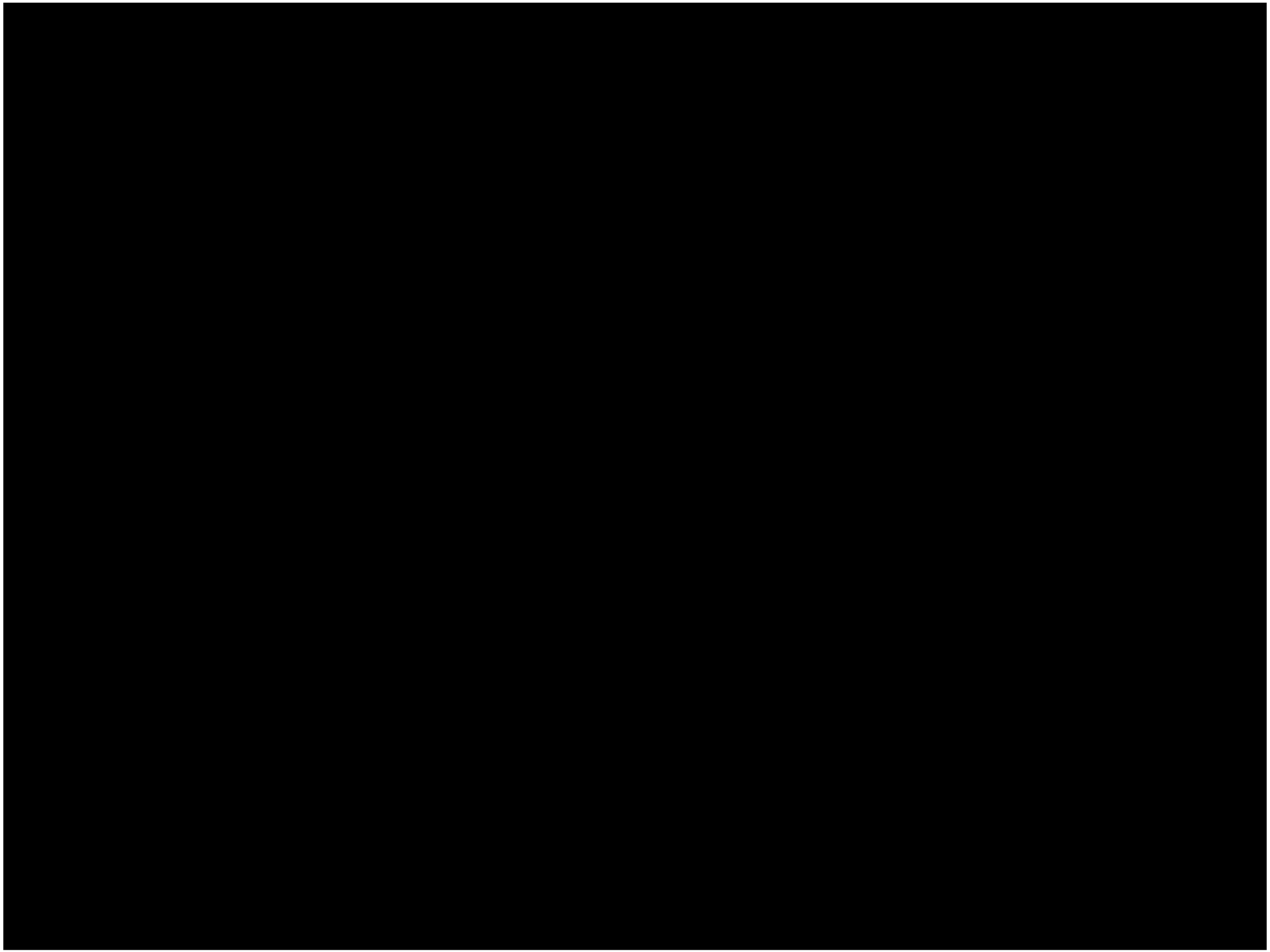
$1,147.60 ~45 watts

Latitude E5420, Intel Core i5-2540M (2.60GHz, up to 3.3Ghz)

$1,138.00 ~10 watts

Questions/Discussion

- What other data would you collect?
- How would you test user satisfaction with laptops?

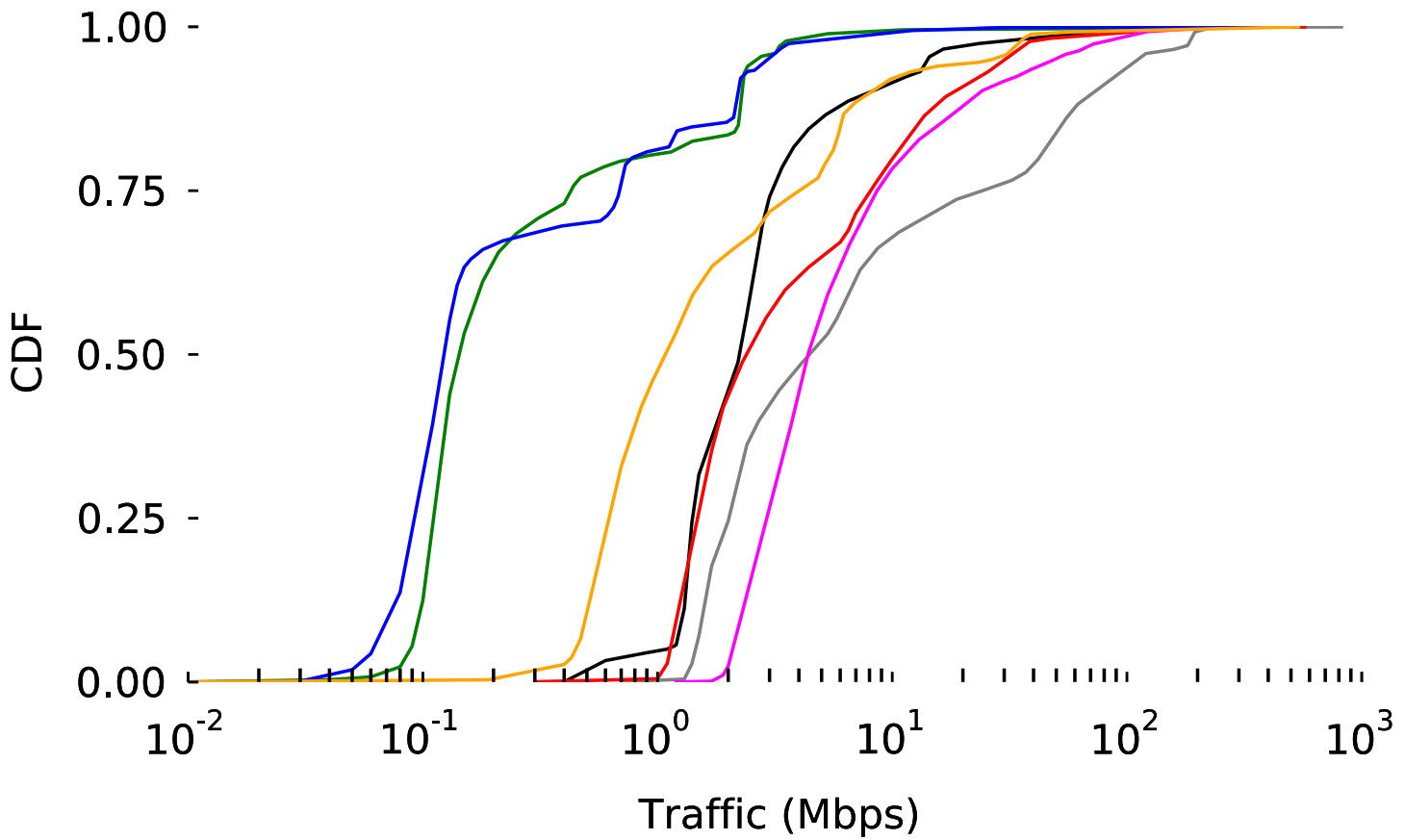


STANFORD UNIVERSITY
Facilities Operations
Utilities Division

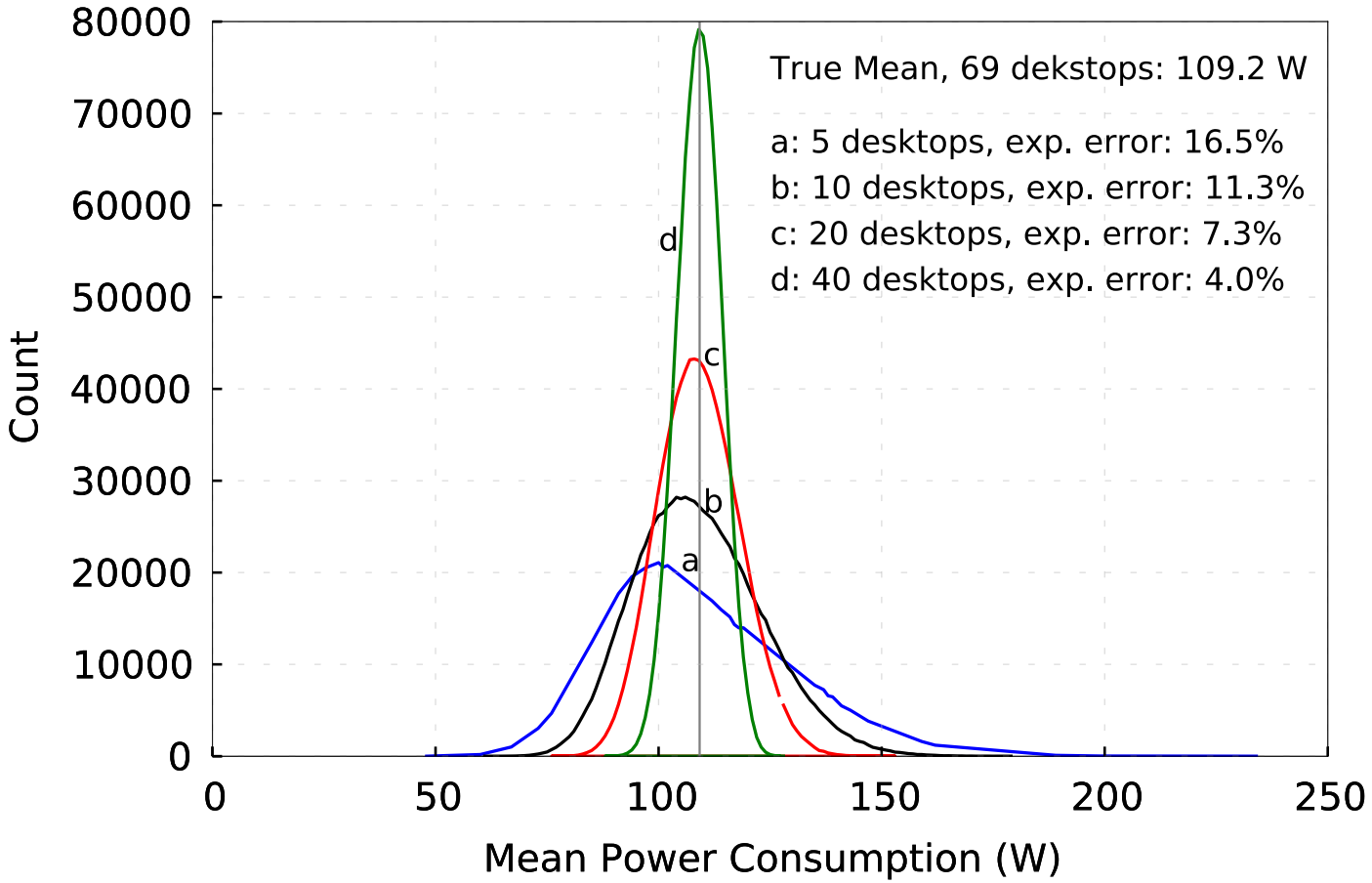
December 2009

	Consumption	Daily Average	Daily Avg Difference	Cost
CHILLED WATER	46,089	1,646	-11.02%	$14,380
DOMESTIC WATER	51,762	1,849	-38.71%	$339
ELECTRICITY	314,585	11,235	1.28%	$36,303
STEAM	546,262	19,509	70.8%	$9,379
WASTE SEWER	51,762	1,849	-38.71%	$238
Total Cost				$60,638

Network Utilization



Sampling


True Mean, 69 dekstops: 109.2 W
a: 5 desktops, exp. error: 16.5%
b: 10 desktops, exp. error: 11.3%
c: 20 desktops, exp. error: 7.3%
d: 40 desktops, exp. error: 4.0%
Count
Mean Power Consumption (W)
0
10000
20000
30000
40000
50000
60000
70000
80000
0
50
100
150
200
250
a
b
c
d