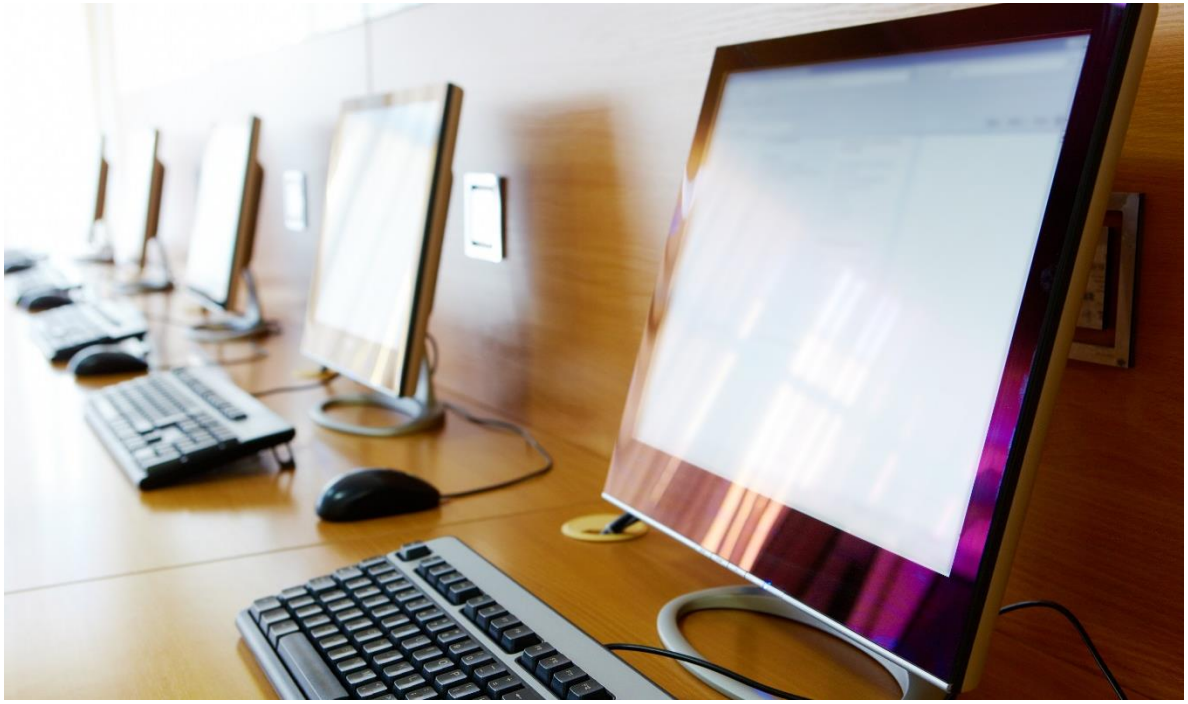
PREPARATORY STUDY ON THE REVIEW OF REGULATION 617/2013

Stakeholder meeting – technical analysis

16th January 2017

Project's website: https://computerregulationreview.eu/



AGENDA

1. Welcome & agenda of the meeting
2. Context and aims of the study
3. Timeline and presentation of the study team
4. Overview of task reports
5. Scope and product definitions
6. Market and stock data

Q&A session (15 min)

7. Trends in product designs
8. Use patterns
9. Data availability and quality for energy consumption

AGENDA

10. Standardized test methods

Q&A session (15 min)

11. Average technology & BAT of personal computers
12. Average technology & BAT of components
13. Use of materials for average technology & BAT
14. Overview of BNAT

Q&A session (15 min)

12:40-13:40 - Lunch break

15. Presentation of base cases

AGENDA

16. Life cycle cost analysis
17. Suggested energy efficiency policy options (in separate slides)

Q&A session (30 min)

18. Material efficiency aspects: policy options (in separate slides)

Q&A session (30 min)

19. Next steps

Additional Q&A (10 min)

16:45 - End of meeting

AIMS OF THE STUDY

MANDATE FOR THE REVIEW

Assess:

1. Technological progress
2. Appropriateness of the scope of current Regulation
3. Current levels of ambition
4. New ways to measure energy efficiency (energy use versus performance) in realistic usage conditions, really assessing "efficiency" and not just capping energy consumption
5. Opportunity to dramatically simplify current categories and allowances (in analogy to what done for electronic displays)
6. Feasibility to limit use of allowances
7. Feasibility for addressing energy use of integrated displays

MANDATE FOR THE REVIEW

Assess (cont.):

8. Battery-related issues.
9. Coherence with Energy Star and other major programs (at least for testing/measuring)
10. Ecodesign and/or Energy labelling requirements on alternative significant environmental aspects (WEEE, Circular Economy…).
11. Any other relevant aspect…

KEY ASPECTS

General:

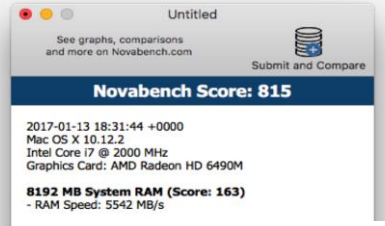
- Can detailed product definitions be avoided (swiftly evolving market, see ex. portable all-in-one PCs)?
- Potential to streamline the legislation (less burden on industry, ease work by MSAs)?

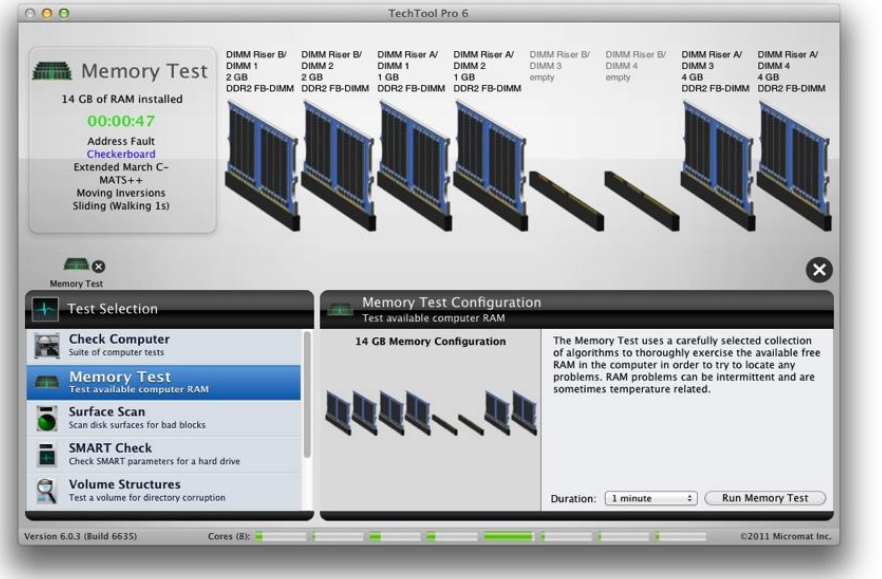
KEY ASPECTS

Energy efficiency:

- Steadily improving, far beyond current Ecodesign requirements
- Two (main) product categories, different in respect to EE issues:
  - Non-mobile computers: split incentives present
  - Mobile computers: no (major) split incentives


TechTool Pro 6
Tests
Tools
Reports
480Mbps USB
6MB Cache
2.5GHz Processor
65Mbps Network
800Mbps FireWire
Test Selection
Check Computer
Suite of computer tests
Memory Test
Test available computer RAM
Surface Scan
Scan disk surfaces for bad blocks
SMART Check
Check SMART parameters for a hard drive
Volume Structures
Test a volume for directory corruption
Check Computer Configuration
Suite of computer tests
Check Computer examines critical subsystems of the computer and is recommended for periodic preventive maintenance.
Model: MacBook Pro Intel Core 2 Duo 2.5GHz
Built: August 2008
Location: China
Power: AC Power. Fully Charged.
Run Check Computer
Version 6.0.1 (Build 5833)
Cores (2):
©2011 Micromat Inc.


Untitled
See graphs, comparisons and more on Novabench.com
Submit and Compare
Novabench Score: 815
2017-01-13 18:31:44 +0000
Mac OS X 10.12.2
Intel Core i7 @ 2000 MHz
Graphics Card: AMD Radeon HD 6490M
8192 MB System RAM (Score: 163)
- RAM Speed: 5542 MB/s


TechTool Pro 6
Memory Test
14 GB of RAM installed
00:00:47
Address Fault
Checkerboard
Extended March C- MATS++
Moving Inversions
Sliding (Walking 1s)
DIMM Riser B/ DIMM 1 2 GB DDR2 FB-DIMM
DIMM Riser B/ DIMM 2 2 GB DDR2 FB-DIMM
DIMM Riser A/ DIMM 1 1 GB DDR2 FB-DIMM
DIMM Riser A/ DIMM 2 1 GB DDR2 FB-DIMM
DIMM Riser B/ DIMM 3 empty
DIMM Riser B/ DIMM 4 empty
DIMM Riser A/ DIMM 3 4 GB DDR2 FB-DIMM
DIMM Riser A/ DIMM 4 4 GB DDR2 FB-DIMM
Memory Test
Test Selection
Check Computer
Suite of computer tests
Memory Test
Test available computer RAM
Surface Scan
Scan disk surfaces for bad blocks
SMART Check
Check SMART parameters for a hard drive
Volume Structures
Test a volume for directory corruption
Memory Test Configuration
Test available computer RAM
14 GB Memory Configuration
The Memory Test uses a carefully selected collection of algorithms to thoroughly exercise the available free RAM in the computer in order to try to locate any problems. RAM problems can be intermittent and are sometimes temperature related.
Duration: 1 minute
Run Memory Test
Version 6.0.3 (Build 6635)
Cores (8):
©2011 Micromat Inc.


TechTool Pro 6
Tests
Tools
Reports
Job Results From Last Run
Job
Result
SMART
Passed
SMART Results
Passed
Device description
1 TB WDC WD10EACS-00ZJB0
Volumes on device
Xanadu
Pass
Fail
Raw Read Error Rate (1)
Spin-Up Time (3)
Start/Stop Count (4)
Reallocated Sectors Count (5)
Seek Error Rate (7)
Power-On Hours (9)
Spin Up Retry Count (10)
Drive Calibration Retry Count (11)
Drive Power Cycle Count (12)
Power-off Retract Count (192)
Load/Unload Cycle Count (193)
Internal Temperature (194)
Reallocation Event Count (196)
Current Pending Sector Count (197)
Uncorrectable Sector Count (198)
UltraDMA CRC Error Count (199)
Write Error Count (200)
Test Selection
Check Computer
Suite of computer tests
Memory Test
Test available computer RAM
Surface Scan
Scan disk surfaces for bad blocks
SMART Check
Check SMART parameters for a hard drive
Volume Structures
Test a volume for directory corruption
SMART Check Configuration
Check SMART parameters for a hard drive
1 TB WDC WD10EACS-00ZJB0
1 TB WDC WD10EACS-00ZJB0
1 TB Hitachi HDS721010CLA332
1.50 TB ST31500541AS
The SMART Check test reads the SMART parameters of an ATA or SATA hard drive in order to warn of impending drive failure while time remains to take preventative action.
Run SMART Check
Version 6.0.3 (Build 6635)
Cores (8):
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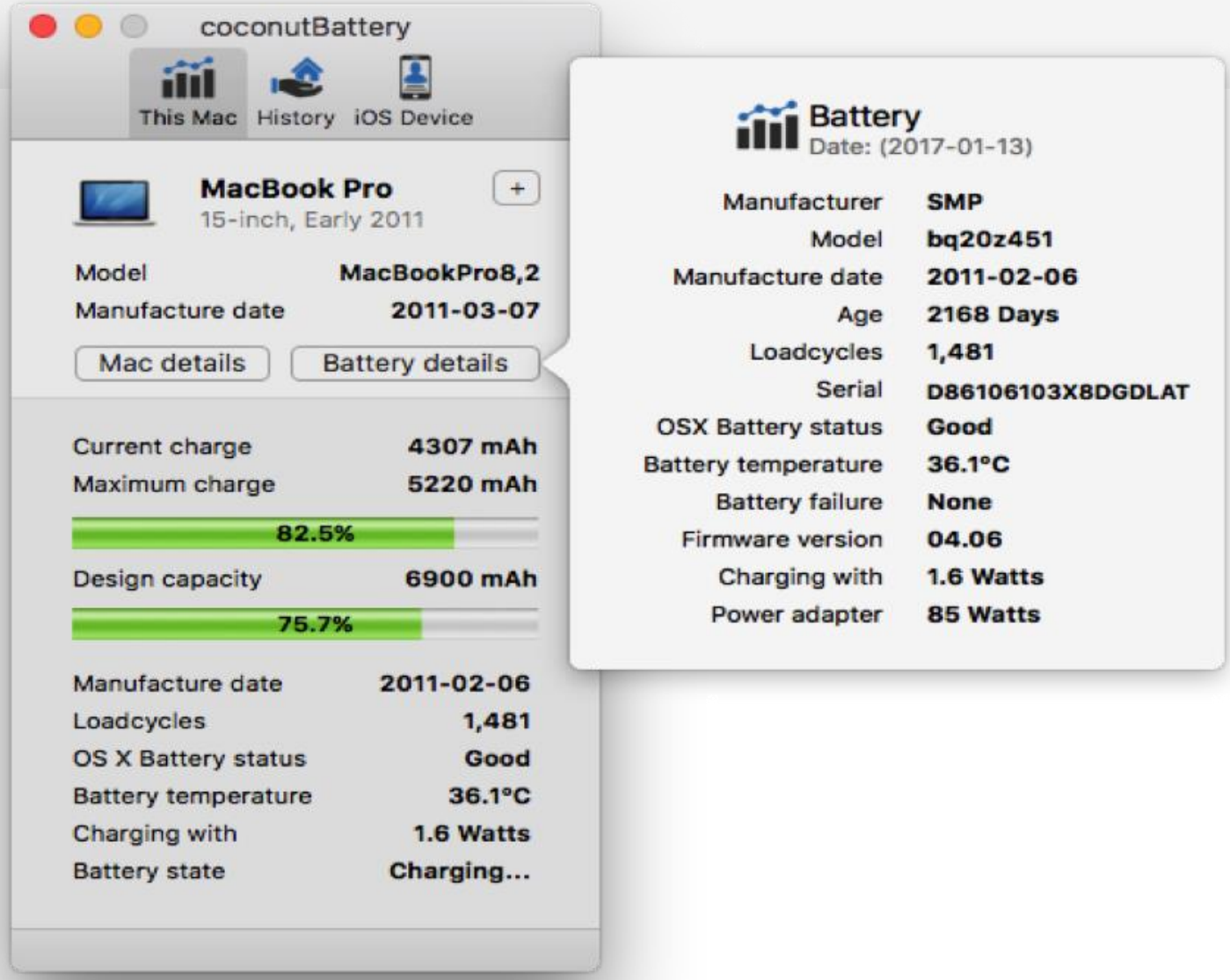
DriveDx
DIAGNOSTICS
Volume3, Volume1, Vo...
Health Indicators 14
Errors Log 0
Self-tests 1
Macintosh HD 2, Macint...
Health Indicators 21
Device Statistics 5
Errors Log 2
Self-tests 21
Advanced S.M.A.R.T. Status: OK 1 issue found
Overall Health Rating: GOOD 97.8 %
Overall Performance Rating: GOOD 100 %
SSD Lifetime Left Indicator: GOOD 99.0 %
Save Report...
General Information
Volumes: Volume3, Volume1, Volume2
Device Path: /dev/disk0
Serial No: xxxxxxxx7 (WWN Id: x xxxxxx xxxxxxx7)
Total Capacity: 512.1 GB (512,110,190,592 bytes)
Sector Size: 512 bytes
Model Family: Samsung based SSDs
Model: SAMSUNG SSD 830 Series (Firmware Version: CXM03B1Q)
Power On Time: 447 hours (18 days 15 hours)
Power Cycles Count: 83
Problems Summary
Failed Indicators (life-span / pre-fail): 0 (0 / 0)
Failing Indicators (life-span / pre-fail): 0 (0 / 0)
Warnings (life-span / pre-fail): 1 (1 / 0)
Failed Self-tests (Short / Full): 0 (0 / 0)
Time in Under / Over temperature: 0 (0 / 0) minutes
Important Health Indicators
005 Reallocated Sector Count: 0 Status: 100 % OK
177 Wear Leveling Count: 1 Status: 99.0 % OK
179 Used Reserved Block Count Total: 0 Status: 100 % OK
182 Erase Fail Count Total: 0 Status: 100 % OK
199 CRC Error Count: 0 Status: 100 % OK
241 Total LBAs Written: 1,018,070,214 (485.5 GB) Status: 99.0 % OK
Last checked: Today 21:07:57

KEY ASPECTS

Resource efficiency:

- WEEE Directive: refers to Ecodesign as tool to tackle upstream the end-of-life issues
- Circular Economy strategy: refers to Ecodesign as crucial tool to tackle aspects such as
  - Durability
  - Reparability
  - Reuse
  - End of life treatment

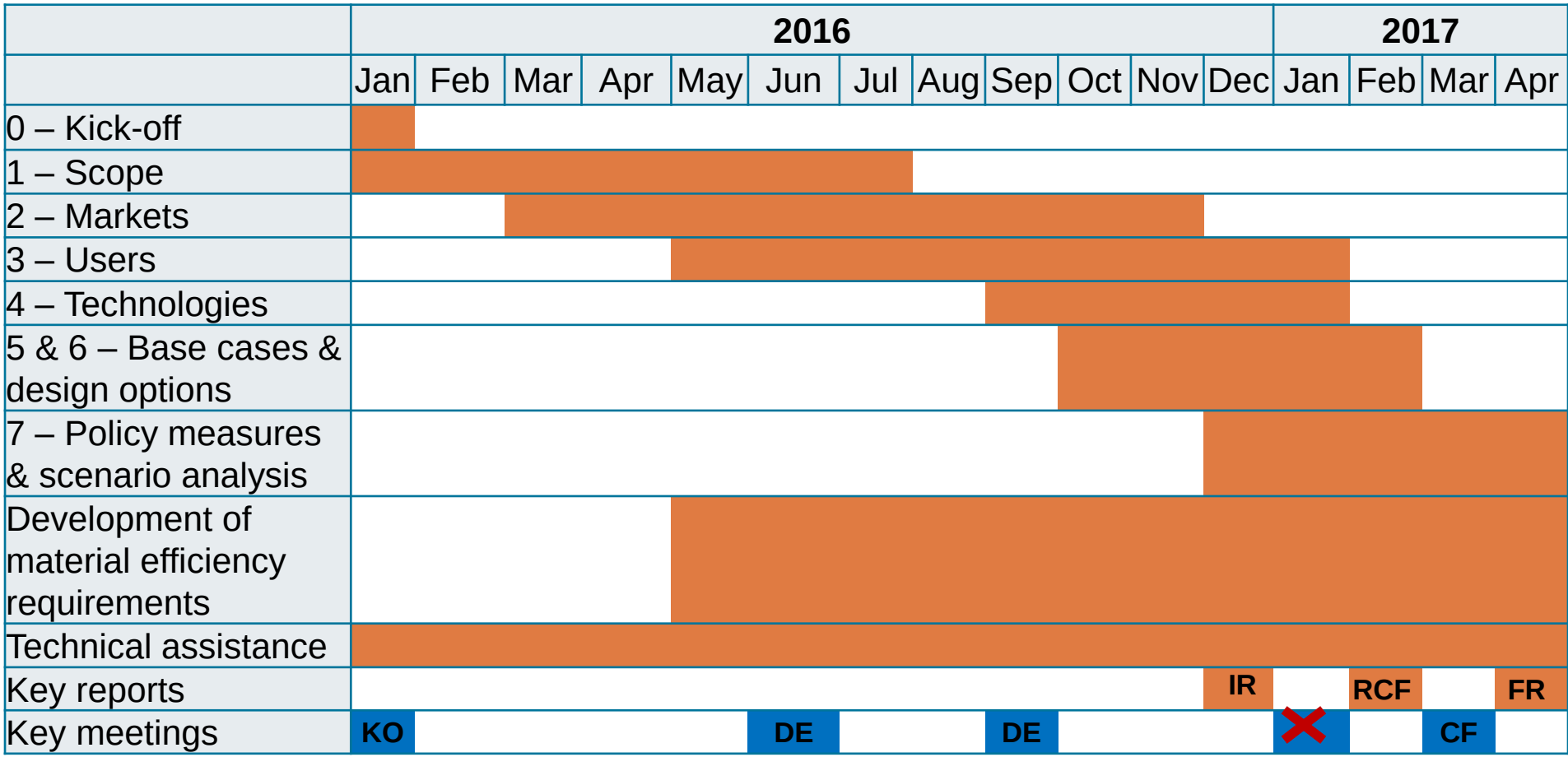
… many expectations on aspects such as durability, reparability, reusability, reciclability (Foak)


coconutBattery
This Mac
History
iOS Device
MacBook Pro
15-inch, Early 2011
Model
MacBookPro8,2
Manufacture date
2011-03-07
Mac details
Battery details
Current charge
4307 mAh
Maximum charge
5220 mAh
82.5%
Design capacity
6900 mAh
75.7%
Manufacture date
2011-02-06
Loadcycles
1,481
OS X Battery status
Good
Battery temperature
36.1°C
Charging with
1.6 Watts
Battery state
Charging...
Battery
Date: (2017-01-13)
Manufacturer
SMP
Model
bq20z451
Manufacture date
2011-02-06
Age
2168 Days
Loadcycles
1,481
Serial
D86106103X8DGDLAT
OSX Battery status
Good
Battery temperature
36.1°C
Battery failure
None
Firmware version
04.06
Charging with
1.6 Watts
Power adapter
85 Watts

TIMELINE AND PRESENTATION OF STUDY TEAM

TIMELINE

This review study follows the MEErP methodology and in some cases it is adapted to fit the aims of the study



STUDY TEAM

Name	Role	Organisation
Larisa Maya-Drysdale	Project manager	Viegand Maagøe
Jonathan Wood	Technical expert	External consultant
Mette Rames	Project assistant & data analyst	Viegand Maagøe
Jan Viegand	Technical expert, backoffice support	Viegand Maagøe
Karolien Peeters	Contract manager	VITO
Paolo Tecchio, Fulvio Ardente & Fabrice Mathieux	Development of material efficiency requirements	JRC
Christian Clemm & Max Marwede	Technical support on material eficiency requirements	TU Berlin
Paolo Tosoratti	EU Policy Officer	European Commission

OVERVIEW OF TASK REPORTS

OVERVIEW TASK REPORTS

Task 1 – Scope	▸ Assesses current scope in light of technological developments, recent legislation, standardization & voluntary agreements ▸ Current scope & definitions → Refined scope & definitions
Task 2 – Markets	▸ Sales and stock models according to recent/future market trends ▸ Product design trends ▸ Consumer expenditure data
Task 3 – Users	▸ Use patterns from consumer perspective ▸ Update on energy consumption data & standardized test methods ▸ User behaviour on repair/replace practices & EOL

OVERVIEW TASK REPORTS

Task 4 – Technologies	▸ Technology overview: Average, BAT, BNAT at product & component levels ▸ Specifications of average technologies, energy consumption & material use at product level
Task 5/6 – Base cases & design options	▸ Presentation of base cases incl. energy consumption & LCCs ▸ Literature review of LC GWP ▸ Identification of design options used to define reviewed ecodesign requirements
Task 7 – Policy analysis	▸ Policy options: rationale, barriers & opportunities ▸ Scenario analysis: energy and material savings compared to BAU

SCOPE AND PRODUCT DEFINITIONS

SCOPE AND PRODUCT DEFINITIONS

- EC Computers Regulation No 617/2013: wide range of computers and computer servers in scope.

- Focus on assessing current scope - given recent preparatory study on computer servers, only covers small-scale servers (by design they are desktop computers adapted to provide basic server functions in a small-office/home-office environment).

- Additional changes to products categorization and definitions which better reflect the changing landscape of computer types on the market.

SCOPE AND PRODUCT DEFINITIONS

- Current regulation has kept alignment with ENERGY STAR.

- Continued to provide coherence and convergence since these are strongly desirable to facilitate market exchange.
- However, experience shows it is not possible to keep product category definitions and specific requirements fully aligned.

SCOPE

- Alignment with ENERGY STAR Program

ENERGY STAR	Ecodesign Regulation
Voluntary requirements	Mandatory requirements
Reflect most efficient products	Remove least efficient products
Label only certified products	Tiers of requirements included
Label requirements revised each 2-4 years	Regulations reviewed every 3 years
Swift revision process	Comprehensive political & stakeholder process

SCOPE

- Alignment with ENERGY STAR Program

ENERGY STAR	EU Energy Label
Voluntary requirements	Mandatory labelling
Reflect most efficient products	Seven classes (A-G) grouping products
Label only certified products	Labels on all products
Label requirements revised each 2-4 years	Labels re-scaled every 10 years
Swift revision process	Comprehensive political & stakeholder process
No distinction between best and average	Distinctions are visible along the energy classes

SCOPE

- Introduction of two new, overarching categories:

Mobile and **non-mobile personal** computers

- Applies separately – additional product types listed as subgroups
- Different incentives for users and producers
- Different issues regarding energy efficiency, recycling and durability

ECODESIGN DEFINITIONS

- **Personal computer**
  - A computer designed to be used by a single user at a time
  - Can have internal or external power supply for converting AC current to DC current
- **Non-mobile personal computer**
  - Designed to be used in a permanent location
  - Constant connection to electricity mains
- **Mobile personal computer**
  - Designed for portability
  - Capable of operating on internal power source
  - Generally includes integrated display
  - Typically designed to support home and office applications

ECODESIGN DEFINITIONS

- Non-mobile computers

Desktop computer

- Stationary on desk, floor or stand
- Often shipped with operating system
- Includes integrated desktop computers

Desktop workstation

- High-performance for computationally intensive tasks, and shipped with EEC memory

Desktop thin client

- Relies on remote computing resources
- No integrated rotational storage media
- Including integrated thin clients

ECODESIGN DEFINITIONS

- Mobile computers

Notebook computer

- Mobile personal computer
- Integrated display, keyboard and pointing device

Tablet/slate

- Integrated, touch-sensitive display as main input device
- No integrated, physical keyboard

Portable all-in-one

- Battery allows for limited portability
- Integrated, touch-sensitive display
- No integrated, physical keyboard

ECODESIGN DEFINITIONS

- Mobile computers

Mobile Thin Client

- Mobile personal computer
- Relies on remote computing resources
- No integrated rotational storage media

Mobile Workstation

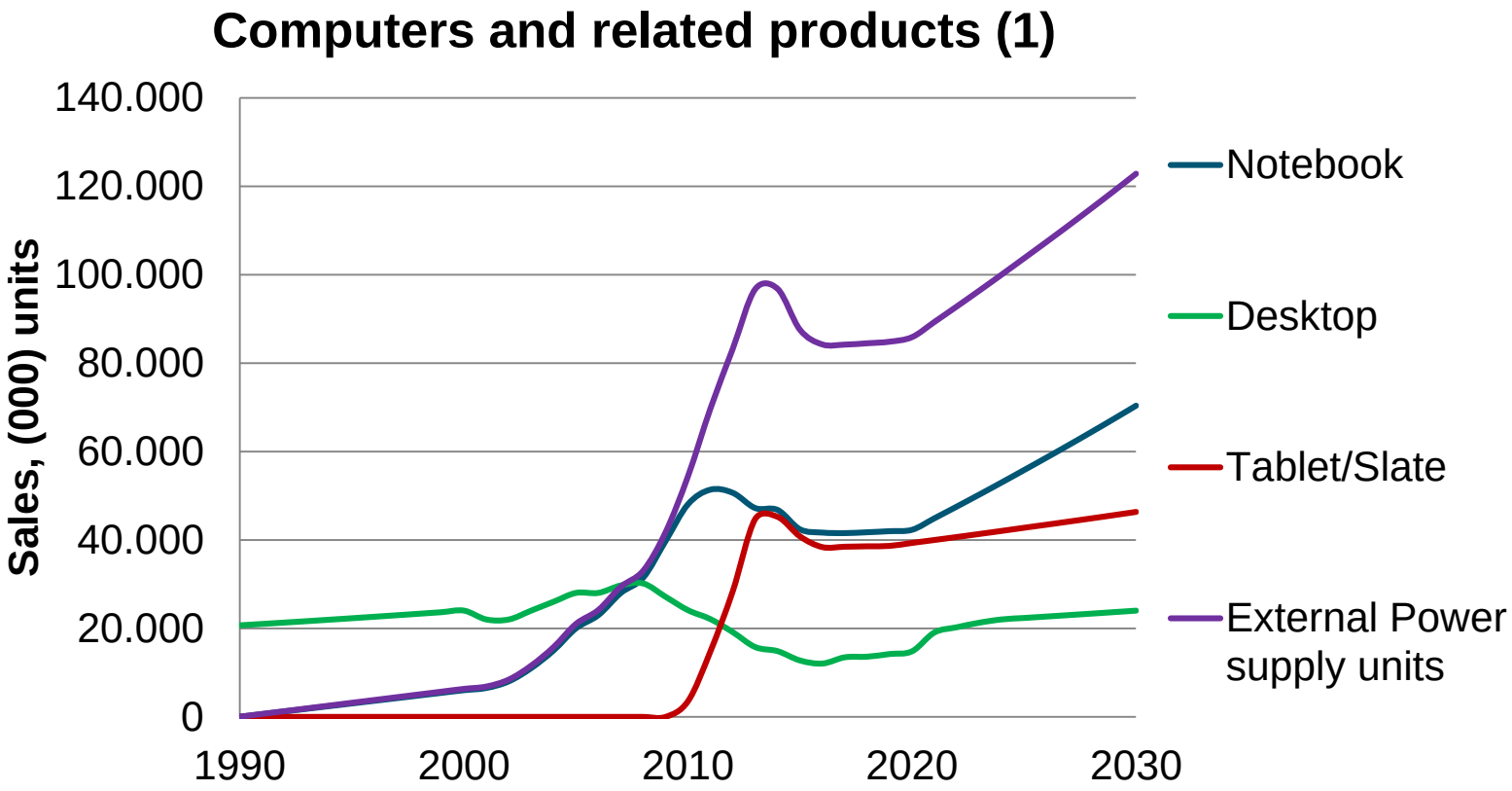
- Mobile, high-performance, for computationally intensive tasks

MARKET AND STOCK DATA

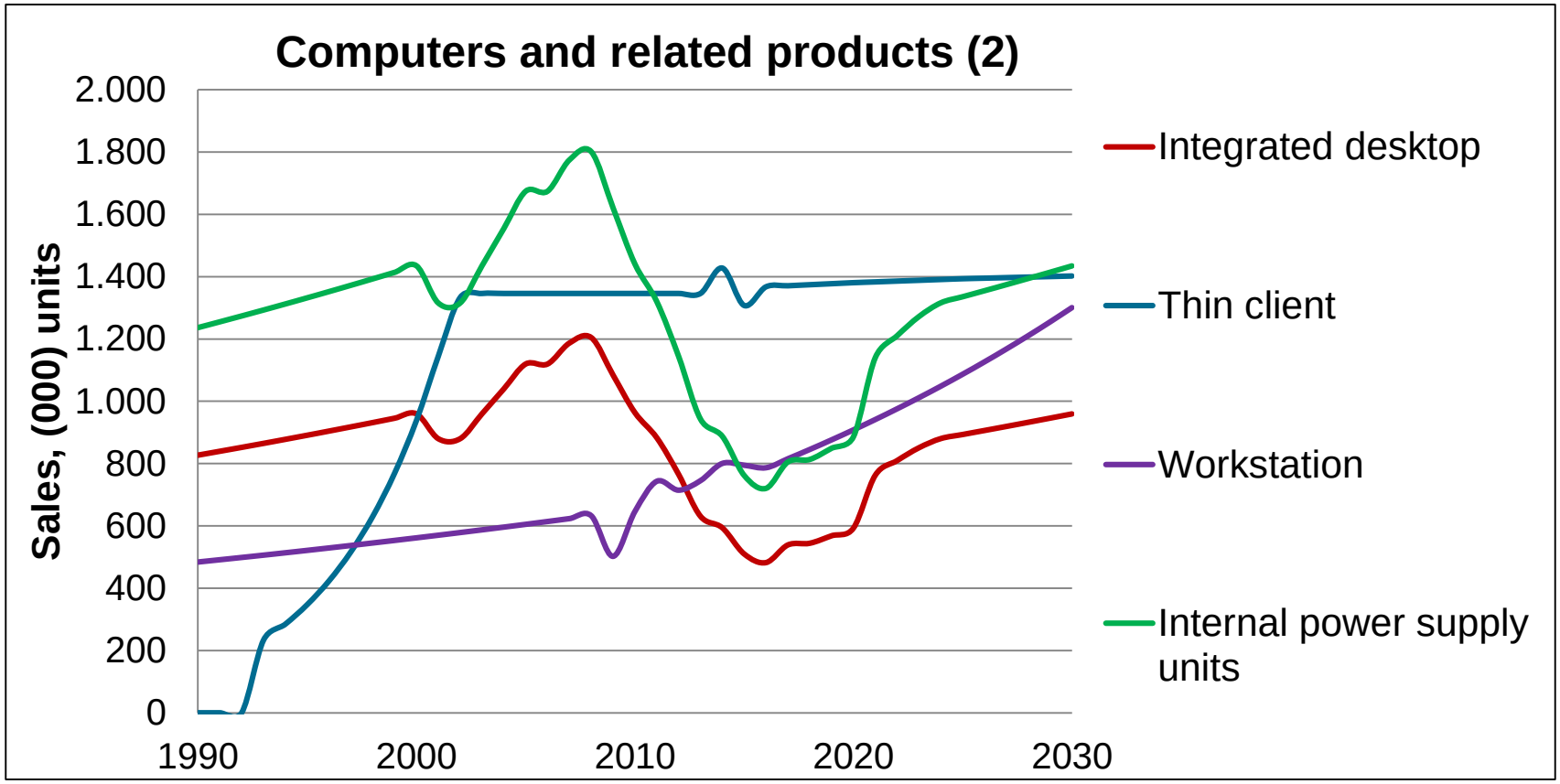
MARKET AND STOCK DATA: SALES

- Sales data from various sources
  - IDC, Statista, Gartner,
  - ENERGY STAR market report
  - Impact assessment, 2013
  - Preparatory study, 2007
  - Other computer websites
- Assumptions used for past and future sales to fill data gaps.

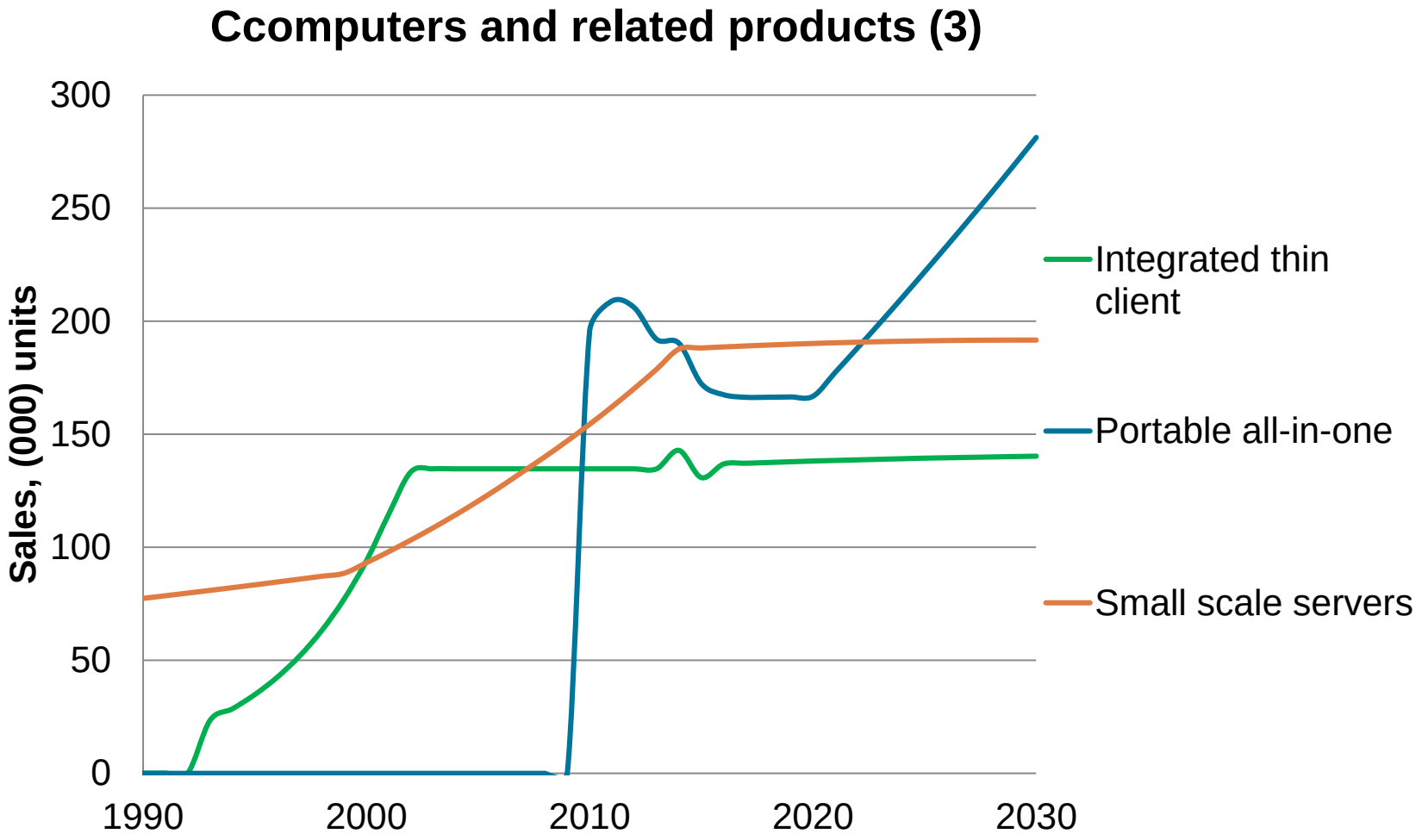
MARKET AND STOCK DATA: SALES



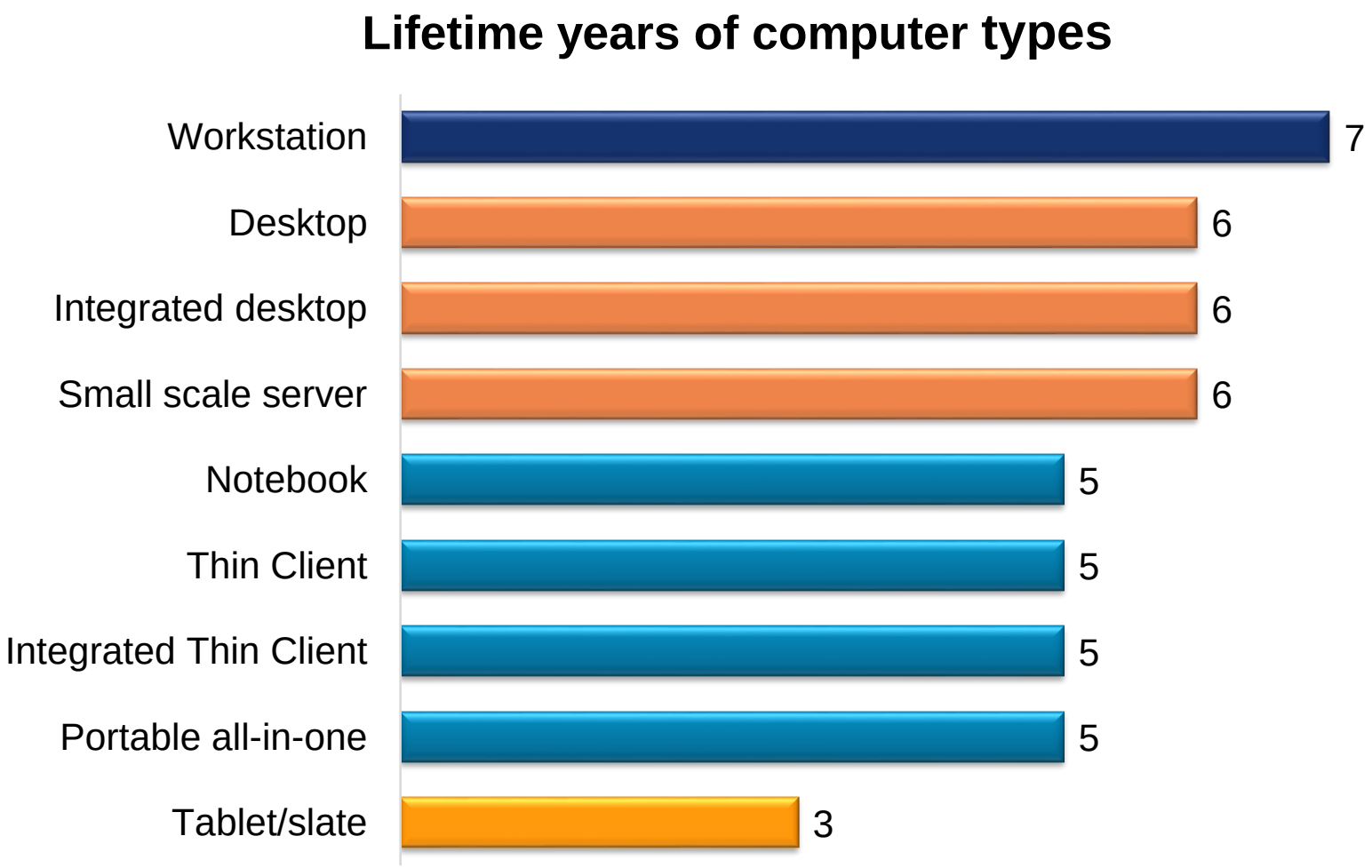
MARKET AND STOCK DATA: SALES



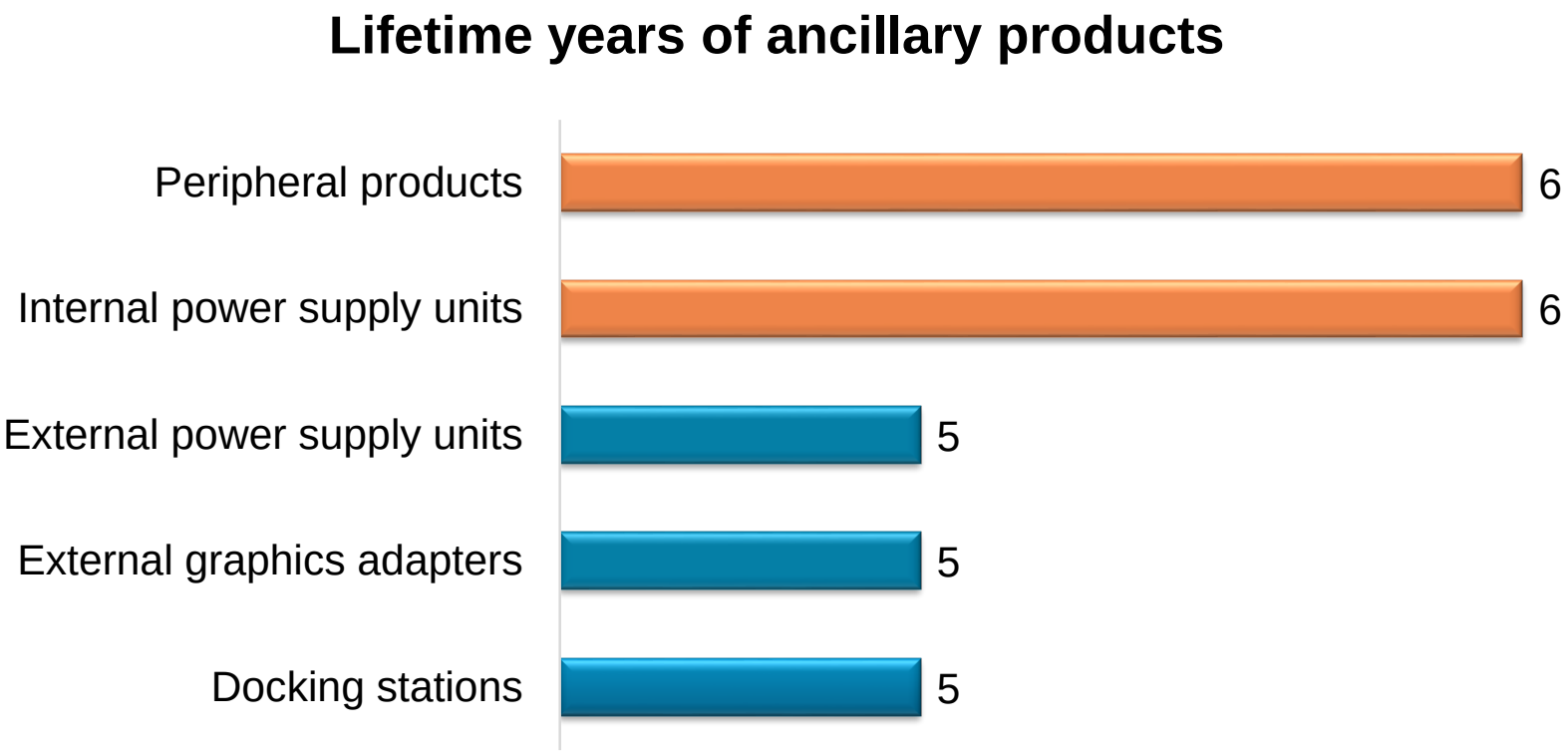
MARKET AND STOCK DATA: SALES



MARKET AND STOCK DATA: LIFETIME

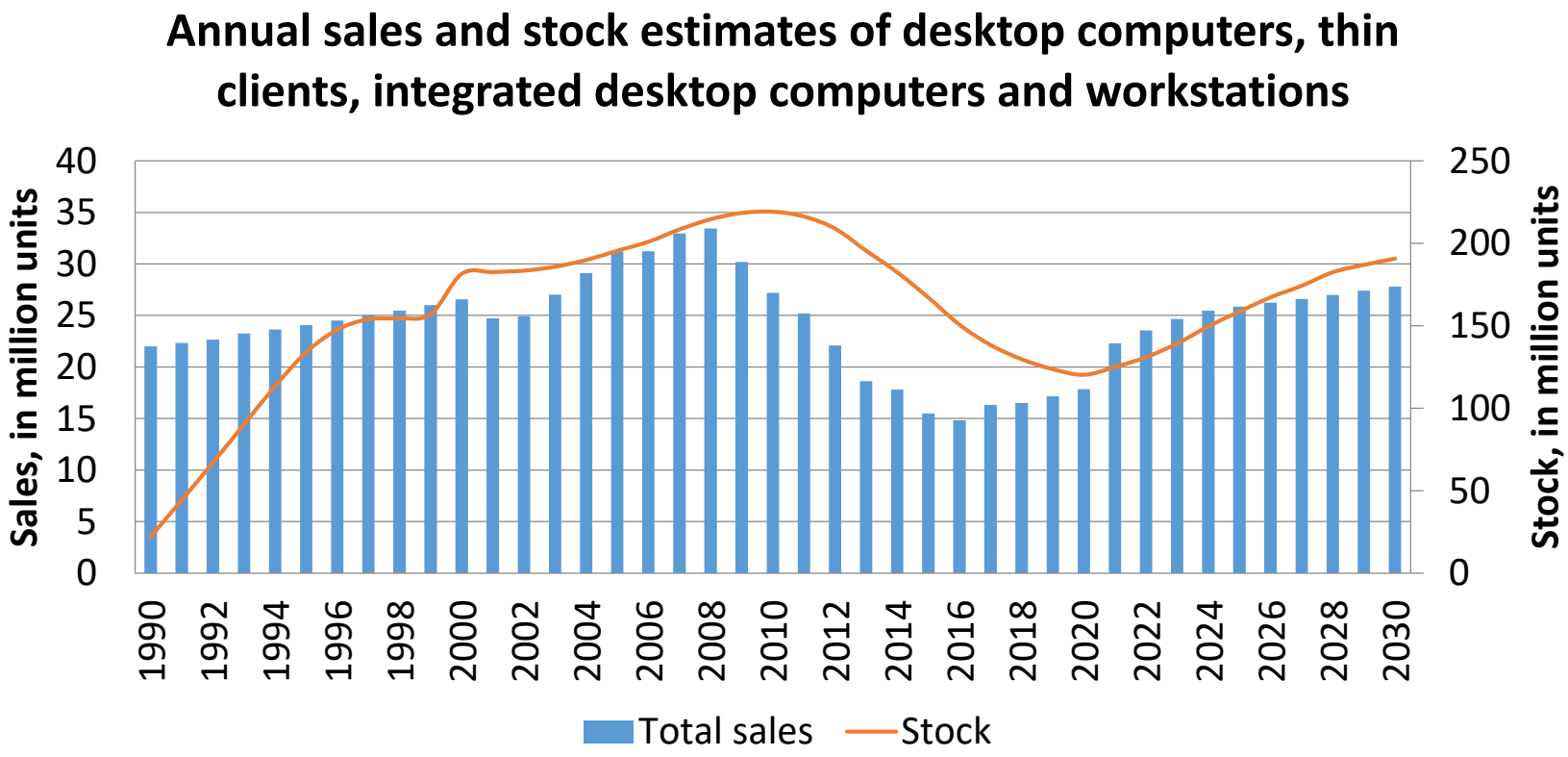


MARKET AND STOCK DATA: LIFETIME



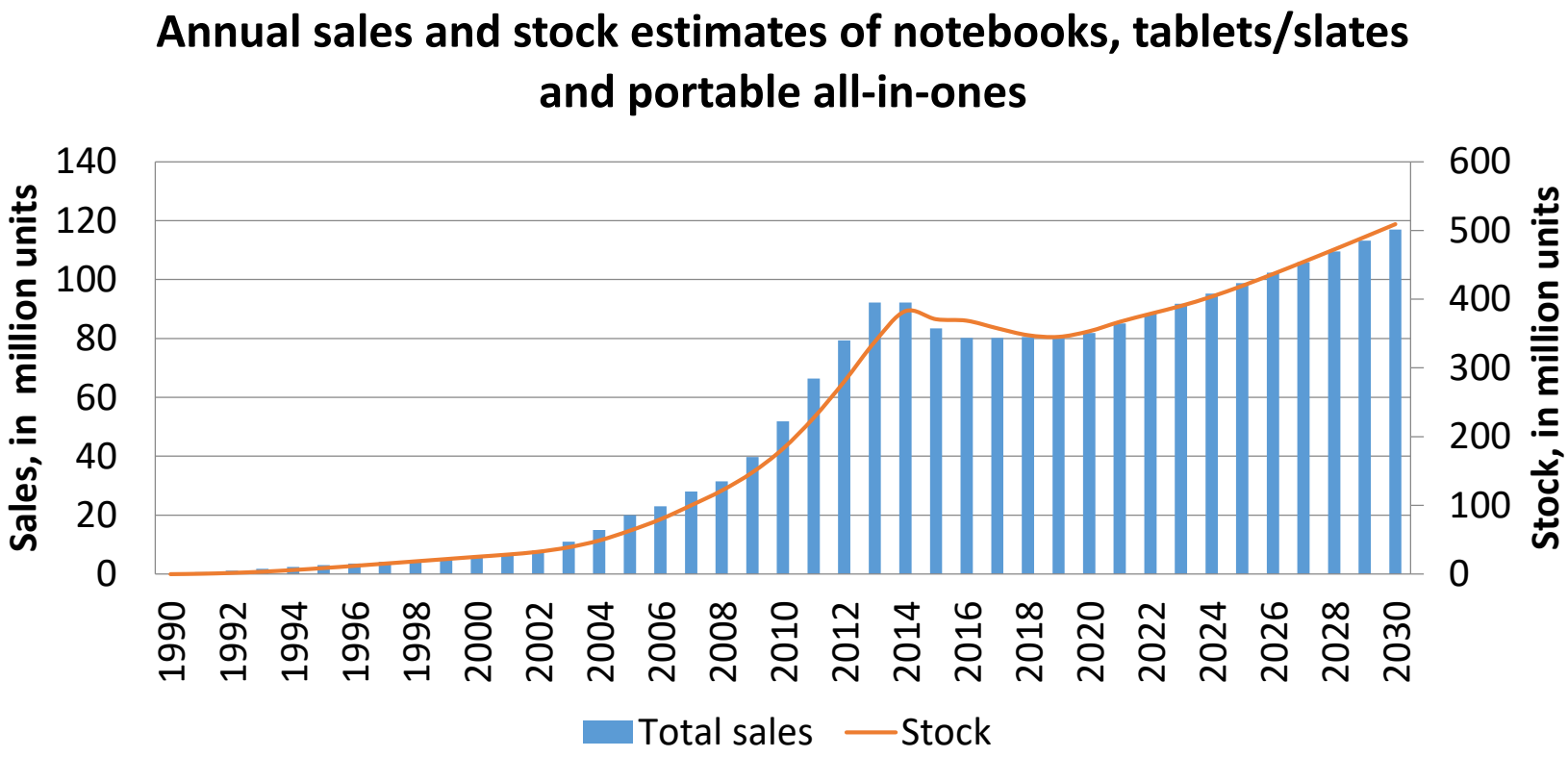
MARKET AND STOCK DATA

- Total stock, non-mobile computers



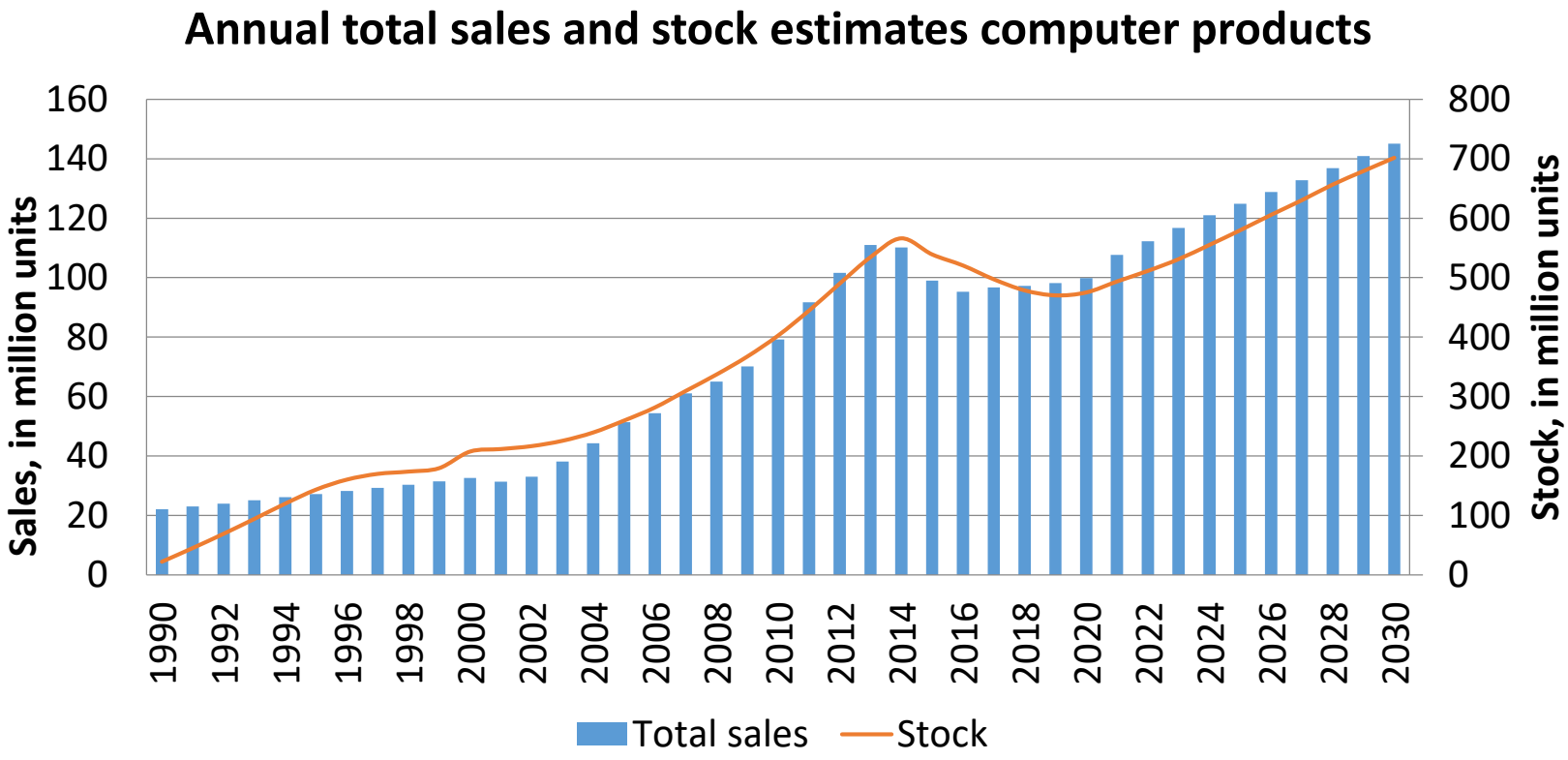
MARKET AND STOCK DATA

- Total stock, mobile computers



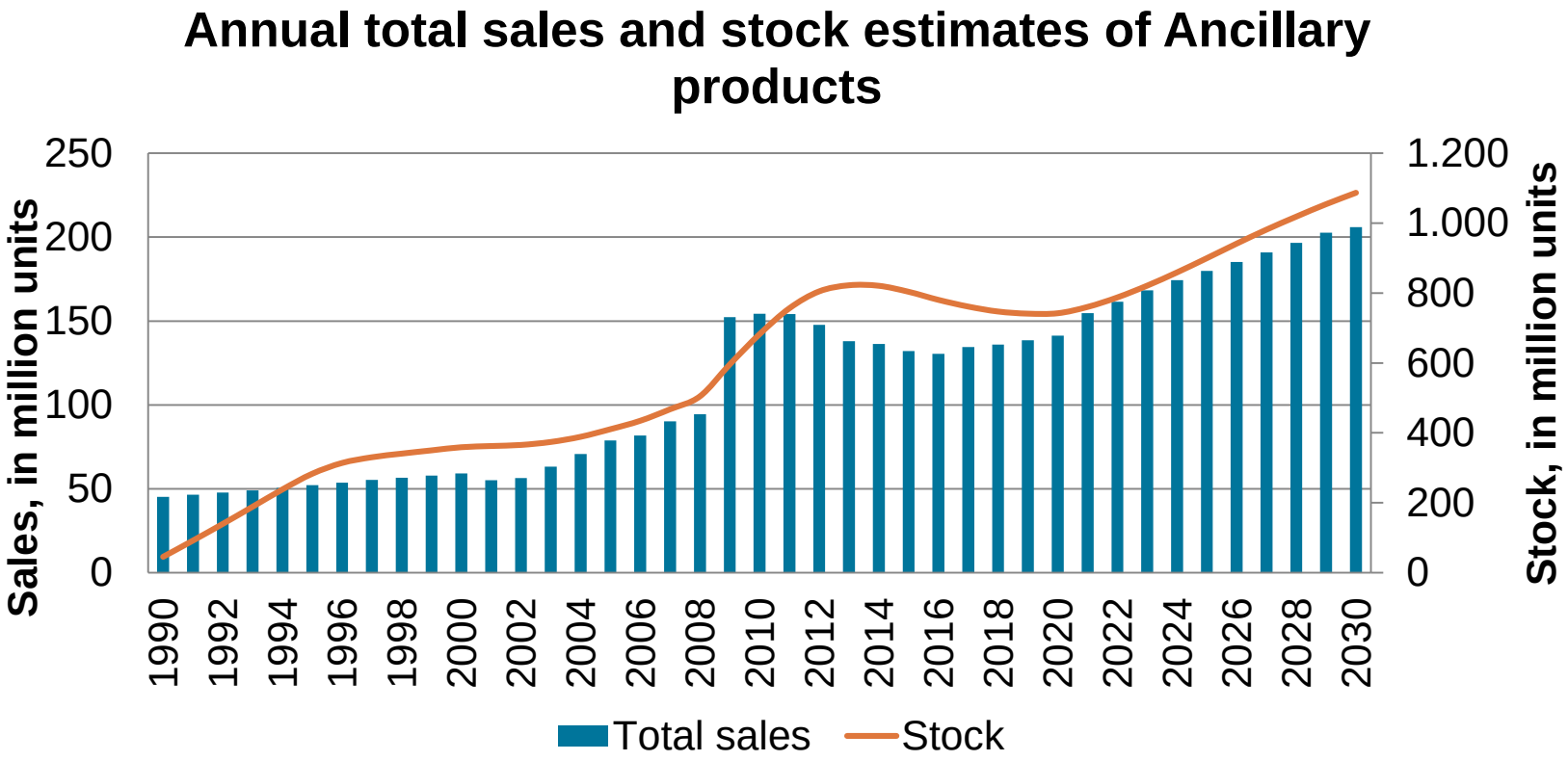
MARKET AND STOCK DATA

- Total stock, all computers



MARKET AND STOCK DATA

- Total stock, Ancillary products



QUESTIONS?

TRENDS IN PRODUCT DESIGN AND FEATURES

TRENDS IN PRODUCT DESIGNS AND FEATURES

- IDC Top five Vendors for Europe, the Middle East, and Africa (EMEA) Personal Computer Shipments.

Vendor	2014 Shipments million units	2015 Shipments million units	2014 Share	2015 Share
HP	20.65	17.91	22.2%	23.5%
Lenovo	17.03	15.22	18.3%	19.9%
Dell	9.20	8.14	9.9%	10.7%
ASUS	8.16	7.15	8.8%	9.4%
Acer Group	9.91	6.81	10.6%	8.9%
Others	28.19	21.11	30.3%	27.7%
Total	93.14	76.35	100.0%	100.0%

TRENDS IN PRODUCT DESIGNS AND FEATURES

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energy people

Convergence / specialisation	Computing performance	Environmental impacts
▸ Similar functions and hardware	▸ Continued need for better performance	▸ Reduced energy consumption
▸ Difficult to determine category	▸ High replacement rates, low lifetimes	▸ Reduced hazardous material contents
▸ Specialised or high performance functionalities used to distinguish	▸ Levelled out for office/home products	▸ Smaller products → glued/soldered parts → decrease rate of recovery and reparability
	▸ Led to new product types to increase demands	

TRENDS IN PRODUCT DESIGNS AND FEATURES – COMPONENTS

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CPUs	Power management technologies	Graphics solutions
▸ Increasing energy efficiency ▸ Decreased transistor size ▸ Better insulation ▸ Dynamic voltage ▸ Frequency scaling	▸ Manual power saving modes often disabled by user ▸ Automatic power down of main components (CPU, GPU etc.) ▸ Large potential savings	▸ dGfx power savings similar to those used in CPUs ▸ Improved iGfx perform as mid-range dGfx, but with lower power demand ▸ Switchable graphics

TRENDS IN PRODUCT DESIGNS AND FEATURES – COMPONENTS

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Power supply units

- EPS and IPS
- IPS mainly for desktop form factor
- EPS generally more efficient
- Wide range of efficiencies in both

Integrated displays

- General efficiency increase
- E.g. LED and DBEF

Panel self-refresh

- PSR allows power-down of high power components when no display refresh is required
- Requires RAM in display itself
- Mainly used for notebooks

TRENDS IN PRODUCT DESIGNS AND FEATURES – COMPONENTS

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energy people

Storage

- HDD and SSD
- SSD generally more efficient
- New SSD types with even lower power demand
- Still large variations within each type

Memory

- Multiple RAM modules increased energy use
- DDR4 likely to offer savings compared to DDR3 due to “Deep power down mode”
- Newer technologies coming to market soon

Enhanced connectivity

- Connection of external products
- New connections allows for more data and power transfer
- Power, video and audio through a single connection
- E.g. Thunderbolt 3

USE PATTERNS

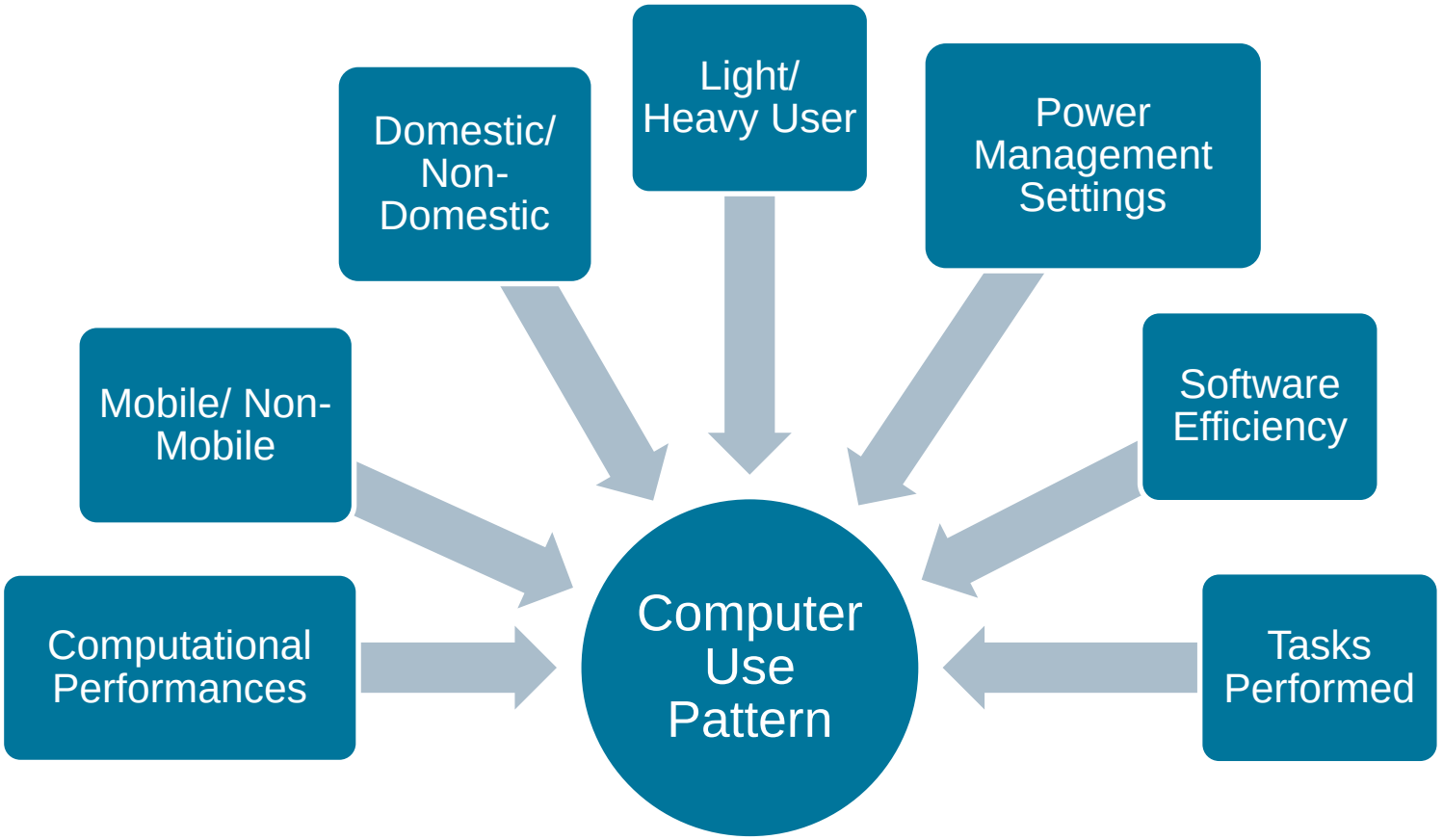
USE PATTERNS

- Overview of power modes

Computer Power States/Modes						
On modes			Low Power modes			
Active states	Idle modes				Off states	
Computational Intensity	Short Idle	Long Idle	Sleep	Hibernate	Off Mode	Mechanical Off
Maximum ⟷ Low						

USE PATTERNS

- Use pattern mainly determined by type of user, but also many other factors:



USE PATTERNS

- Estimates around how long computers are used for vary considerably across different studies even for the same type of computer (e.g. desktop computer)

Computer Type	Average Usage (hours/ day)	Average Usage (hours/ year)	Average Low Power (hours/ year)
Desktop (Max. estimate)	7.4	2716.0	6044.0
Desktop (Min. estimate)	2.5	913.5	7846.5
Notebook (Max. estimate)	6.3	2058.0	2202.0
Notebook (Min. estimate)	1.9	710.5	8049.5

- Variation in use hour estimates due to factors shown on previous slide (e.g. user type, power management settings, task performed etc)

USE PATTERNS

- ENERGY STAR use profiles based on largest survey into usage

	Desktop		Notebook	
Power Mode	% Time Spent in Each Power Mode	Use Hours Per Year	% Time Spent in Each Power Mode	Use Hours Per Year
Off	45%	3942	25%	2190
Sleep	5%	438	35%	3066
Long idle	15%	1314	10%	876
Short idle	35%	3066	30%	2628

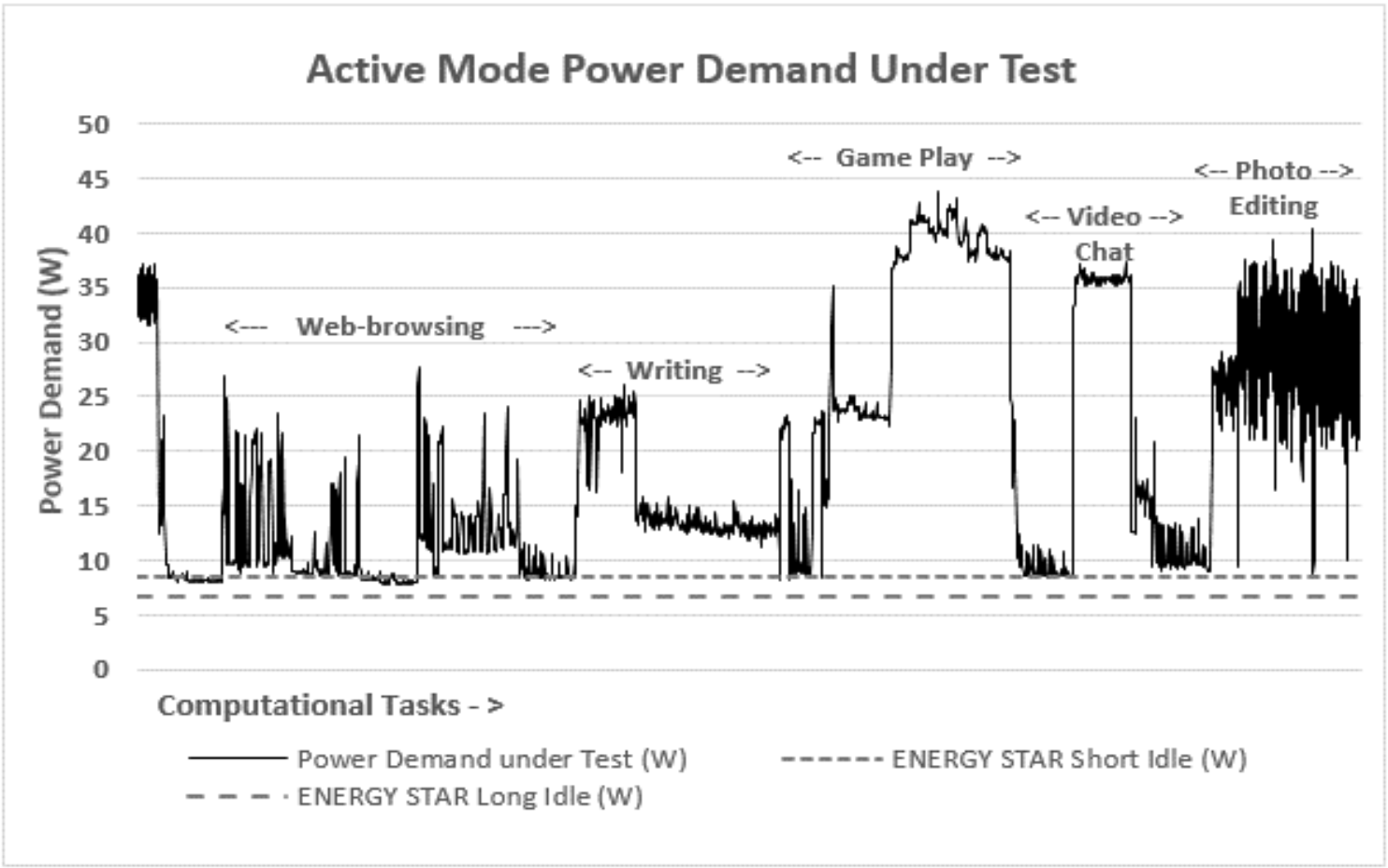
- No consideration of active state power demands

USE PATTERNS

- Estimated time computers spend in an active state varies according to source
- Desktop – estimated time spent in active states varies from 9% to 70% of ”on time”.
- Notebook - estimated time spent in active states varies from 20% to 63% of ”on time”.

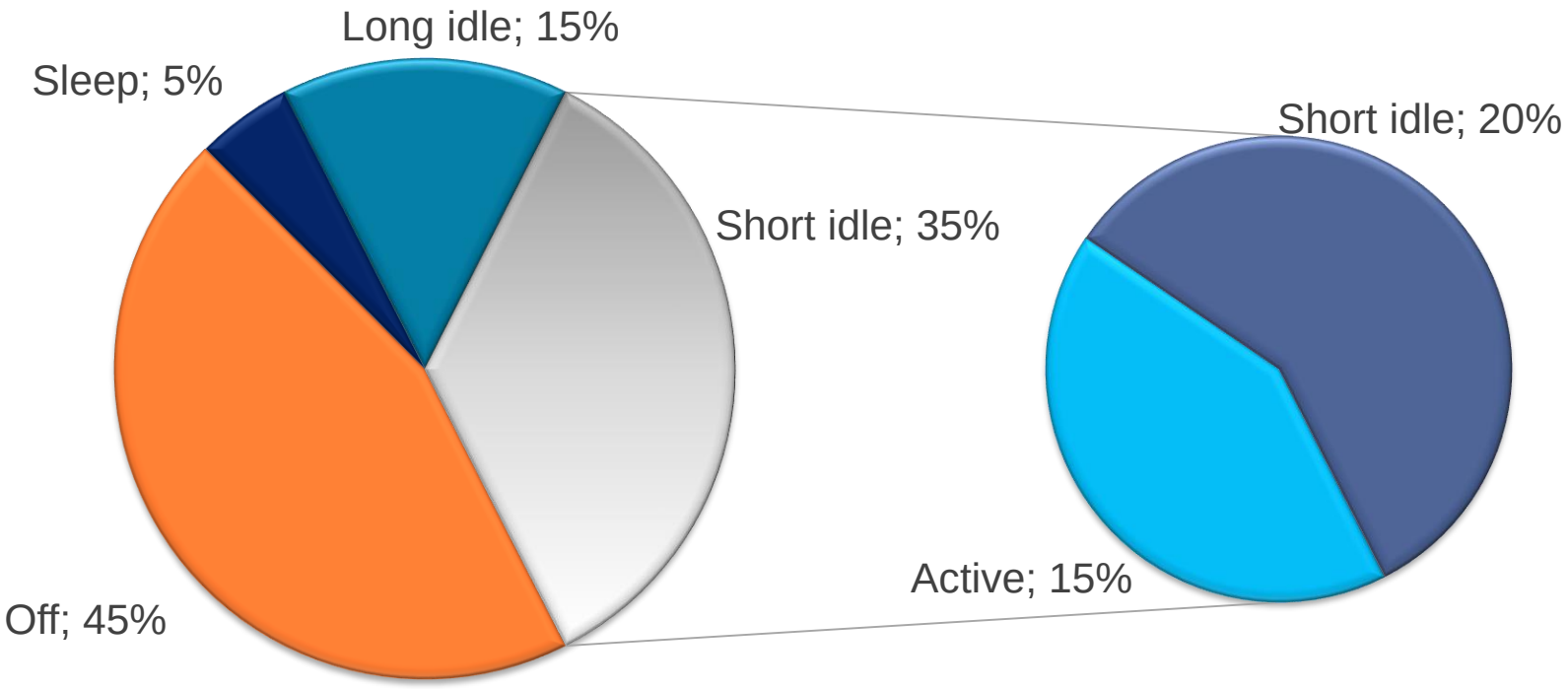
USE PATTERNS

- Active state power demand variations in an ENERGY STAR qualified notebook computer



USE PATTERNS

- Power mode use times for desktop computer:

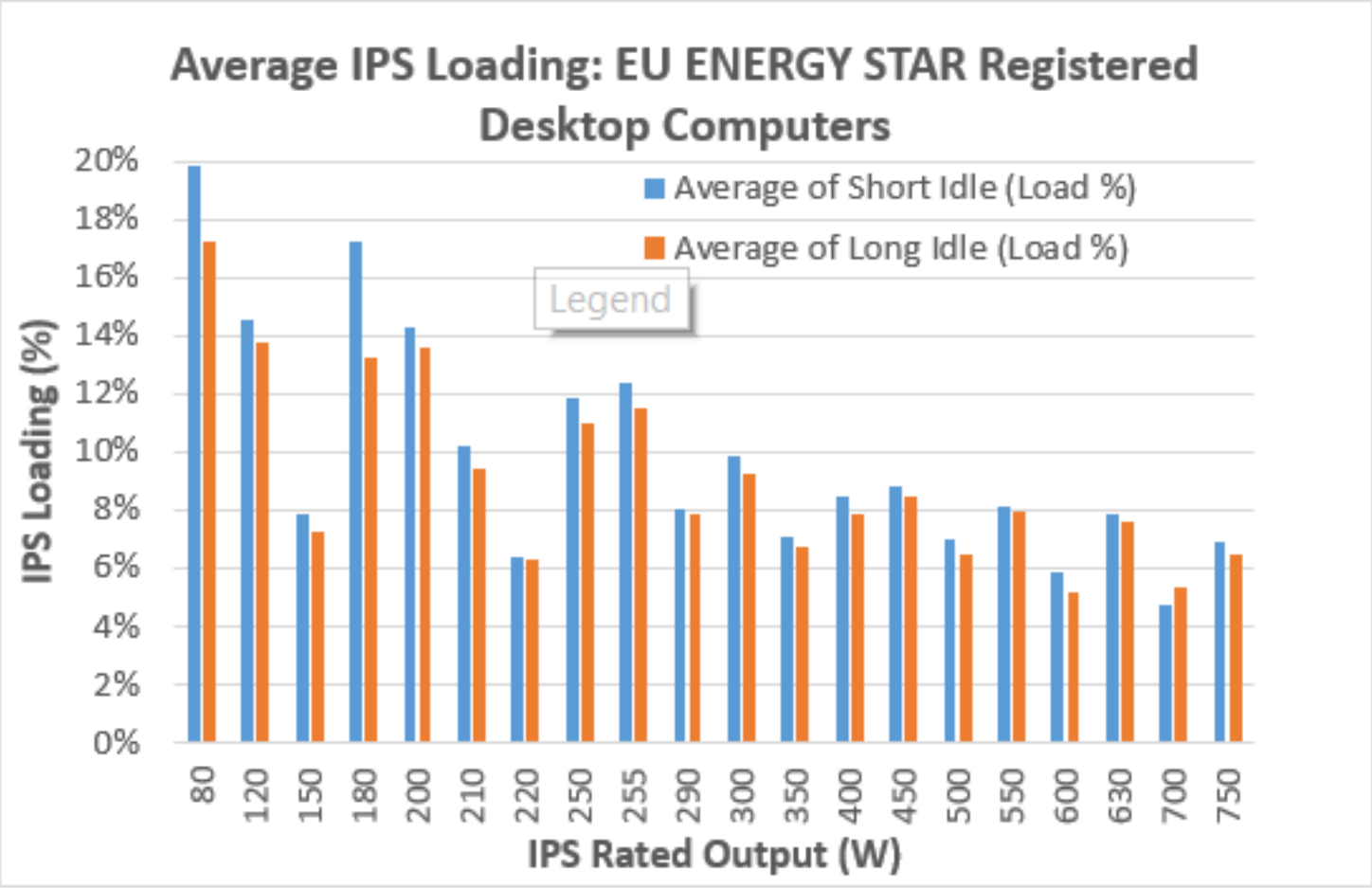


ENERGY STAR

Active time estimate

USE PATTERNS

- Internal Power Supply (IPS) idle mode loading rates



USE PATTERNS

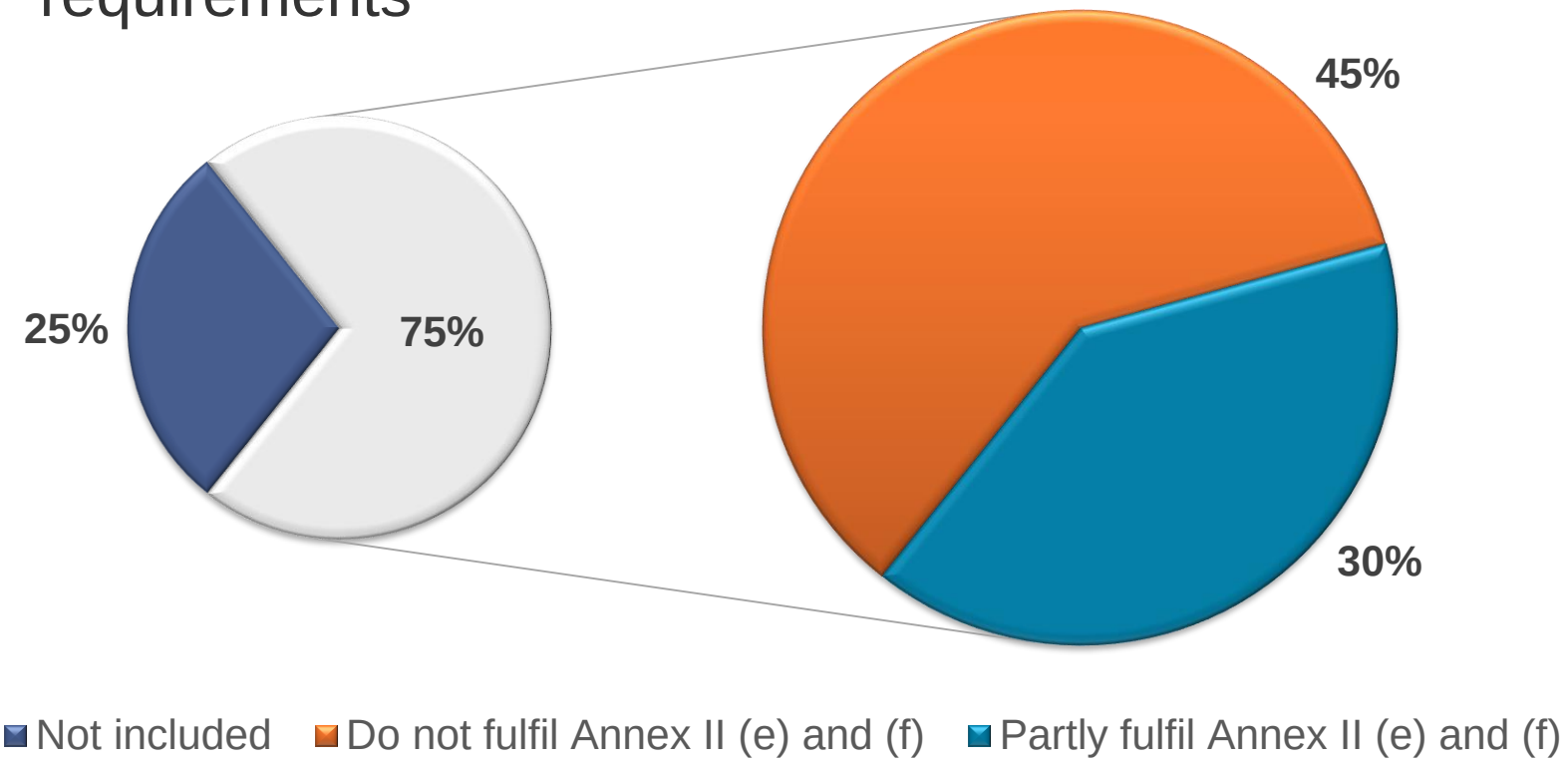
- 80PLUS tested IPS efficiency results (Ecova/EPRI)

Sample #	Rated Power	80 PLUS Badge Level	Loading							
			6W Load	1%	3%	5%	10%	20%	50%	100%
1	200	Bronze	58.0%	37.5%	58.2%	67.5%	77.0%	83.3%	86.6%	83.8%
2	300	Standard	53.4%	41.9%	59.1%	65.6%	74.4%	81.6%	85.3%	83.5%
3	350	Bronze	52.8%	43.7%	61.8%	67.0%	77.1%	83.5%	86.6%	85.3%
4	350	Platinum	56.9%	45.2%	69.7%	77.8%	86.1%	91.0%	92.5%	90.2%
5	400	Bronze	59.9%	53.5%	68.3%	74.2%	81.4%	86.1%	87.6%	84.7%
6	400	Bronze	47.7%	37.9%	60.5%	69.9%	79.2%	84.5%	86.8%	85.1%
7	450	Gold	42.0%	35.7%	61.2%	71.5%	83.6%	88.6%	90.8%	88.1%
8	450	Standard	32.5%	27.9%	50.5%	61.7%	73.7%	81.4%	84.9%	82.5%
9	500	Titanium	35.0%	38.9%	83.1%	87.7%	92.0%	94.1%	94.2%	91.9%
10	500	Bronze	44.8%	40.3%	65.0%	73.8%	82.7%	87.2%	88.2%	83.7%
11	500	Bronze	43.2%	40.3%	61.8%	69.7%	79.3%	84.4%	86.3%	83.2%
12	500	Gold	43.8%	43.6%	50.5%	71.0%	83.4%	89.3%	90.8%	88.4%

DATA AVAILABILITY & QUALITY FOR ENERGY CONSUMPTION

DATA AVAILABILITY & QUALITY: ERP COMPLIANCE

- **0%** of the brands constituting at least **75 % of the market** comply with **all** of the ecodesign reporting requirements



ENERGY CONSUMPTION DATA DURING USE

- Two main possible sources:
  - Ecodesign data sheets from supplier websites
  - ENERGY STAR database

- Data availability and data quality available online is not sufficient to be representative for the EU market

DATA AVAILABILITY & QUALITY: ENERGY STAR DATABASES

- EU/US databases different formats

Differences in databases	Examples
Number of columns/missing data	105 in EU and 630 in US
Order of columns	TEC: column EL-EM vs DI-DT
Names of columns	*"Category 0: TEC of Model (kWh)"* vs. "*Reported Category 0 TEC at 230 V (kWh)",* category names
Available data	Not available: Display data, EPS data, dGfx category,
No common product identifier	PD_ID / ENERGY STAR Unique ID

ENERGY STAR AND ERP COMPARISON

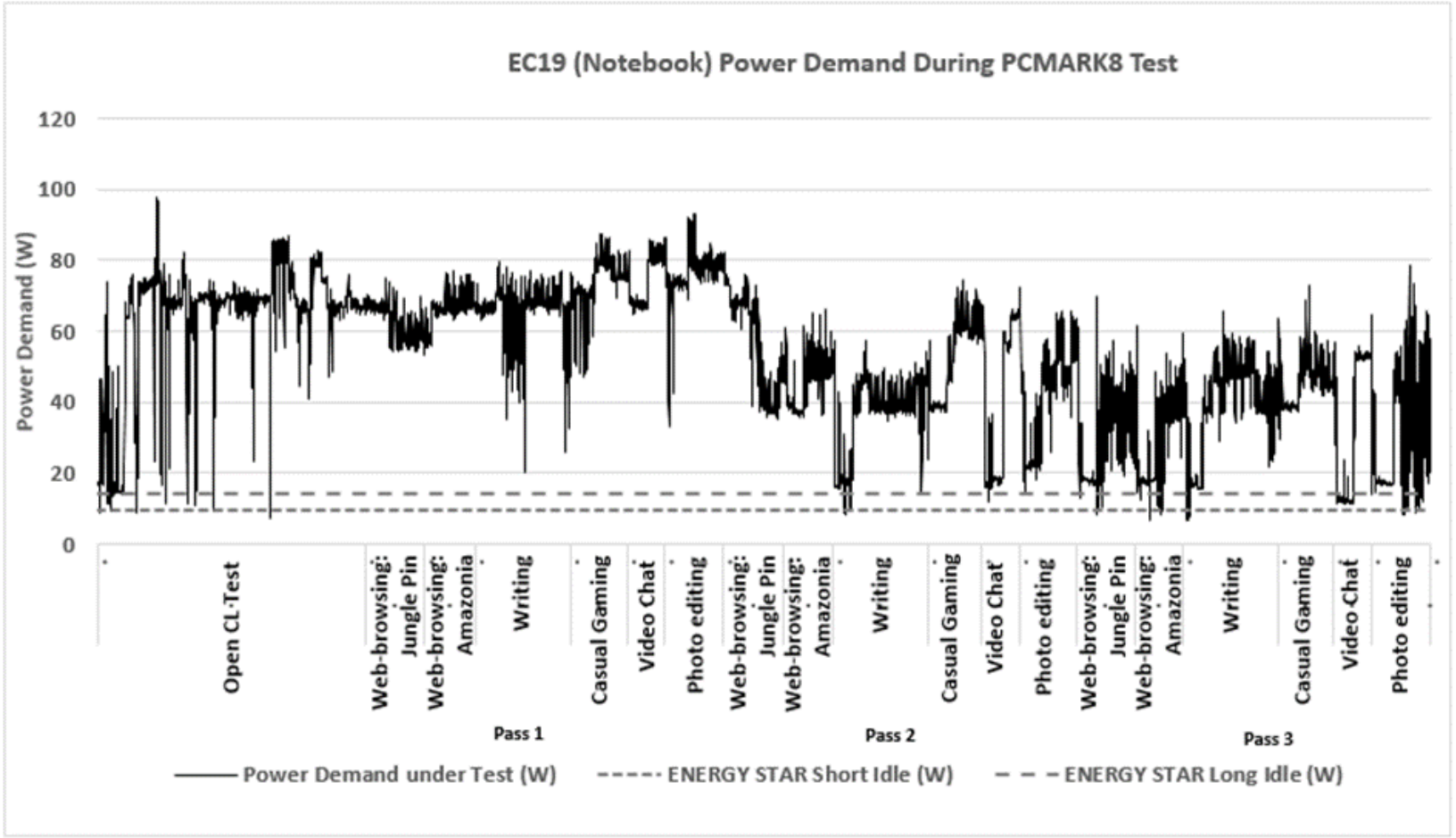
- Comparison based on E TEC values only
  - Calculated from ecodesign formula

Category	Collected ErP data	ENERGY STAR	Difference
Desktops – all years	102 kWh	97.5 kWh	8%
Desktops – 2015/2016	94.1 kWh	96.9 kWh	3%
Notebooks	21.0 kWh	16.9 kWh	19.5%
Notebooks - 2015/2016	19.2 kWh	15.1 kWh	21.4%
Tablets	13.7 kWh	11.7 kWh	-14.5%
Tablets – 2014/2016	13.7 kWh	12.5 kWh	-8.8%
Workstations	68.8 kWh	48.4 kWh	29.7%
Workstations – 2014/2016	70.4 kWh	33.4 kWh	52.6%

STANDARDIZED TEST METHODS

STANDARDIZED TEST METHODS

- Active state power demand variations in an ENERGY STAR qualified notebook computer (ineffcient?)



STANDARDIZED TEST METHODS

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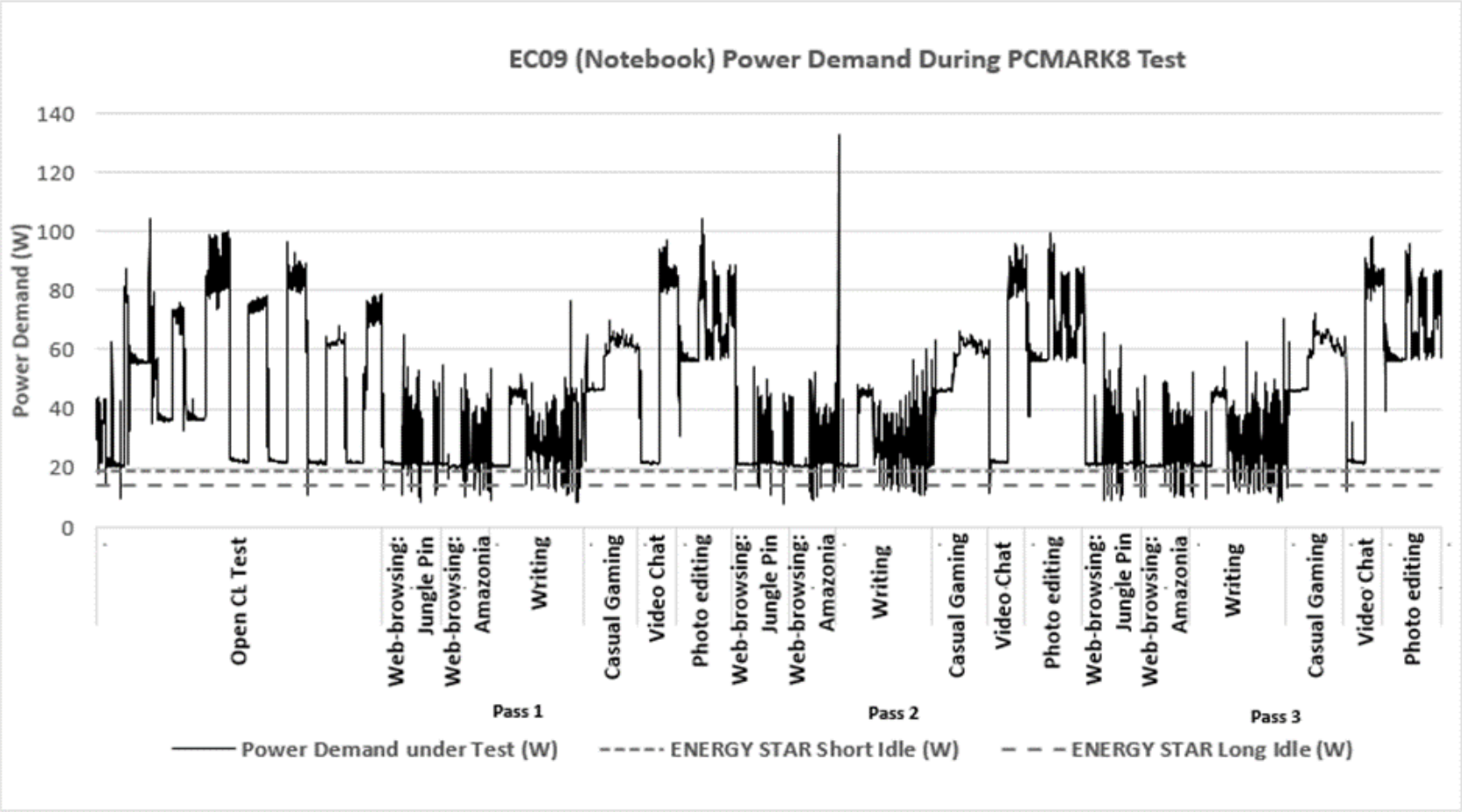
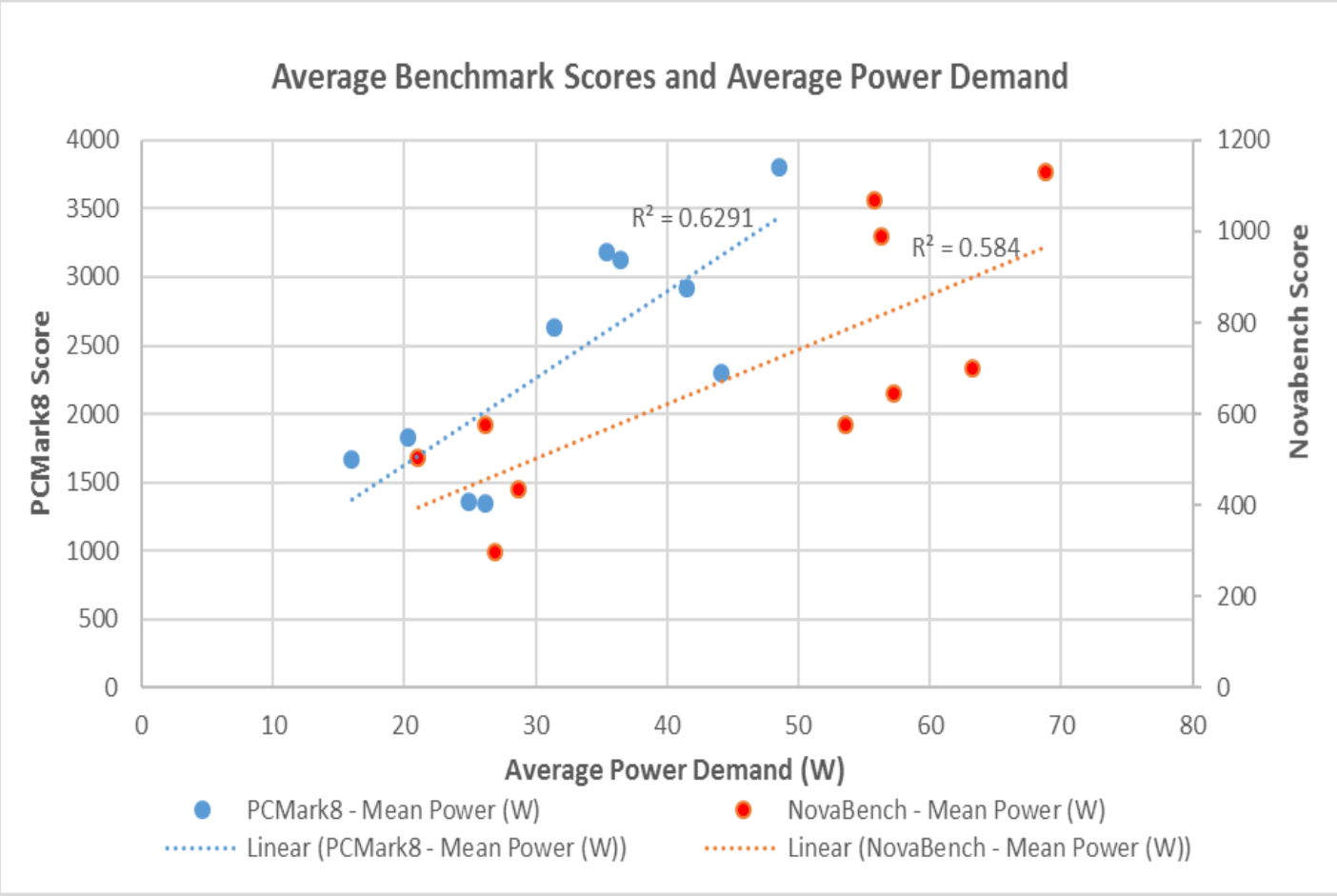


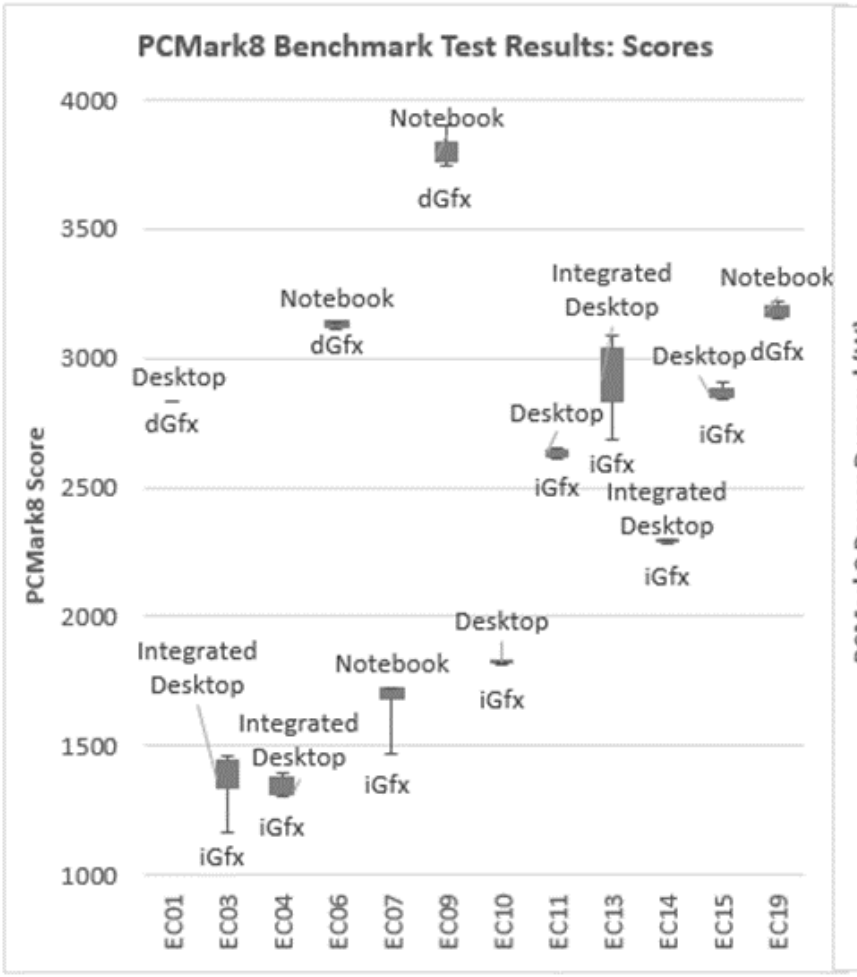
STANDARDIZED TEST METHODS

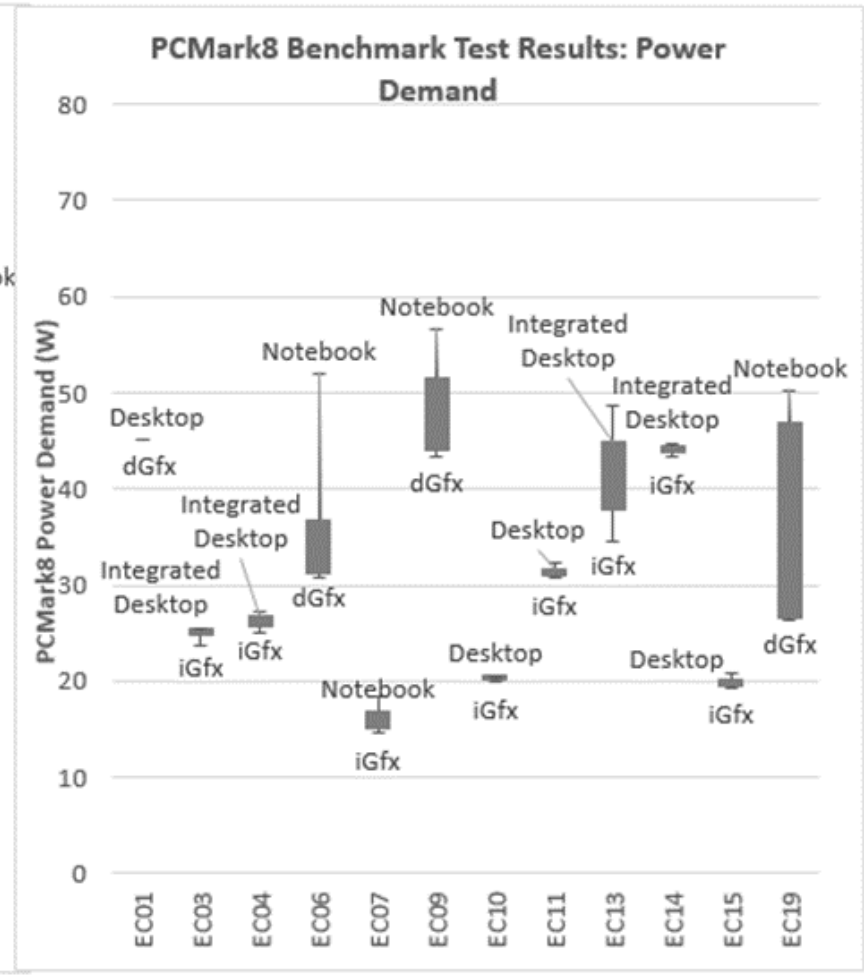


Overall Average Benchmark Score and Power Demand.

STANDARDIZED TEST METHODS

- Variabilities under test





STANDARDIZED TEST METHODS

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Overall Average Benchmark Score, Power Demand and Efficiency (Minus Integrated Display power demand): Sorted by highest efficiency.

Product Type	Project Product Code	PCMark8 - Mean Score	PCMark8 - Mean Power (minus display power) (W)	PCMark8 - Efficiency (Score/W)	Product Type	Project Product Code	Novabench - Mean Score	Novabench - Mean Power (minus display power) (W)	Novabench - Efficiency (Score/W)
Notebook	EC07	1663	11.7	141.8	Notebook	EC07	502	16.7	30.0
Notebook	EC19	3188	30.2	105.5	Integrated Desktop	EC04	434	16.2	26.7
Integrated Desktop	EC14	2295	21.9	105.0	Desktop	EC10	575	26.1	22.0
Notebook	EC06	3128	32.2	97.3	Notebook	EC06	1067	51.5	20.7
Integrated Desktop	EC04	1345	13.8	97.1	Notebook	EC19	990	51.1	19.4
Integrated Desktop	EC03	1364	14.2	95.7	Integrated Desktop	EC14	644	35.0	18.4
Desktop	EC10	1823	20.3	89.8	Integrated Desktop	EC03	298	16.2	18.3
Integrated Desktop	EC13	2920	33.1	88.3	Notebook	EC09	1130	63.9	17.7
Notebook	EC09	3807	43.6	87.3	Integrated Desktop	EC13	702	54.8	12.8
Desktop	EC11	2634	31.4	83.9	Desktop	EC11	578	53.6	10.8

QUESTIONS?

AVERAGE TECHNOLOGY AND BAT OF COMPUTERS

AVERAGE TECHNOLOGY & BAT OF PERSONAL COMPUTERS

- Focus on technologies
- Average Technology
  - Most frequent value for each technical parameter for each computer type
  - Based on ENERGY STAR database
  - Not necessarily a specific product that fits on all parameters
- Best Available Technology (BAT)
  - Example of specific product on the market
  - Better performance on main parameters
  - Lower energy consumption (ETEC)
  - Also BAT at specific component level discussed
  - BAT used to define BOMs

AVERAGE TECHNOLOGY & BAT OF DESKTOP

Performance parameter	Most frequent value	BAT – Apple, Mac Mini
TEC at 230V (kWh)	101.0	20.94
CPU cores (no.)	2	2.00
Base CPU Speed (GHz)	3.4	3.00
CPU performance score	6.8	6.00
RAM (GB)	4	16.00
GPU type	n.a.	iGfx
GPU GB/sec	-	-
IPS efficiency, 10%	79%	88%
IPS efficiency, 20%	84%	89%
IPS efficiency, 50%	87%	90%
IPS efficiency, 100%	83%	89%
Noise level (operator)	n.a.	12dBA at idle

AVERAGE TECHNOLOGY & BAT OF INTEGRATED DESKTOP

Performance parameter	Most frequent value	BAT – Apple, iMAC
TEC at 230V (kWh)	133.3	59.5
CPU cores (no.)	2	2
Base CPU Speed (GHz)	3.00	3.80
CPU performance score	6.0	7.6
RAM (GB)	8	2
Display Size (dm2)	10.39	11.03
Display Resolution (MP)	2.07 MP	1.44
Storage Type	HDD	HDD
Storage drives count	1	1
Total Storage capacity (GB)	500	500
GPU type	n.a.	iGfx
PSU rated output (W)	180	120
IPS efficiency, 10%	87%	84%
IPS efficiency, 20%	89%	89%
IPS efficiency, 50%	90%	92%
IPS efficiency, 100%	89%	90%

AVERAGE TECHNOLOGY & BAT OF NOTEBOOK

Performance parameter	Most frequent value	BAT – Apple, MacBook
TEC at 230V (kWh)	24.75	8.94
CPU cores (no.)	2	2.00
Base CPU Speed (GHz)	2.6 GHz	1.10
CPU performance score	5.2	2.2
RAM (GB)	8	8.00
Display Size (dm2)	6.65	4.18
Display Resoluition (MP)	1.03	3.32
Storage Type	HDD	Flash
Storage drives count	1	1
Total storage capacity (GB)	500	
GPU type	n.a.	iGfx
GPU GB/sec	-	-
EPS rated output (W)	65	29.00
EPS average efficiency	88%	88%

AVERAGE TECHNOLOGY & BAT OF SLATE/TABLET

Performance parameter	Most frequent value	BAT – Apple iPad Pro
TEC at 230V (kWh)	13.23	6.92
CPU cores (no.)	2	2.00
Base CPU Speed Per Core (GHz)	1.3 GHz	2.30
CPU performance score	2.6	4.6
RAM (GB)	2	2.00
Display Size (dm2)	1.29	2.91
Display Resoluition (MP)	2.07	3.15
Storage Type	SSD	Flash memory
Storage drives count	1	1
Total storage capacity (GB)	32	n.a.
GPU type	n.a.	iGfx
EPS rated output (W)	10	10.70
EPS average efficiency	88%	79%

AVERAGE TECHNOLOGY & BAT OF WORKSTATION

Performance parameter	Most frequent value	BAT – Lenovo, ThinkStation P910
Power Demand (PTEC)	39.8	41.80
CPU cores (no.)	4	14.00
Base CPU Speed Per Core (GHz)	3.5 GHz	2.00
CPU performance score	14.0	28
RAM (GB)	16	32.00
Storage Type	HDD	SSD
Storage drives count	2	2.00
Total storage capacity (GB)	1500	n.a.
GPU type	G7	G7
GPU GB/sec	64	192
IPS rated output (W)	700	n.a.
IPS efficiency, 10%	84%	84%
IPS efficiency, 20%	91%	91%
IPS efficiency, 50%	92%	92%
IPS efficiency, 100%	90%	89%

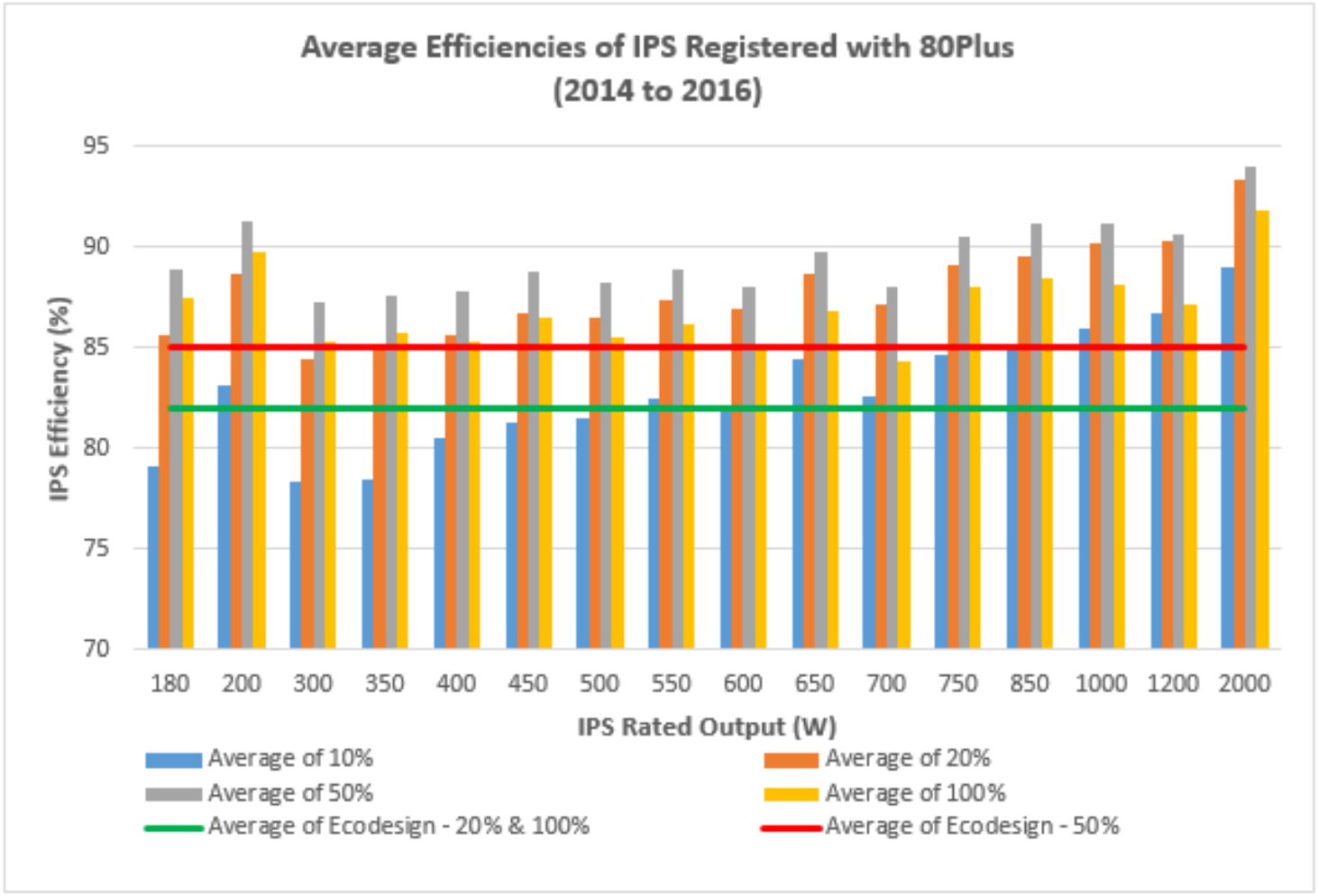
AVERAGE TECHNOLOGY & BAT OF THIN CLIENT

Performance parameter	Most frequent value	BAT – IGEL UD2 series
TEC at 230V (kWh)	29.3	22.29
CPU cores (no.)	2	4
Base CPU Speed (GHz)	1.0 GHz	1.90
CPU performance score	2.0	7.60
RAM (GB)	2.00	2.00
GPU type	n.a.	iGfx
EPS average efficiency	88%	85%

AVERAGE TECHNOLOGY AND BAT OF COMPONENTS

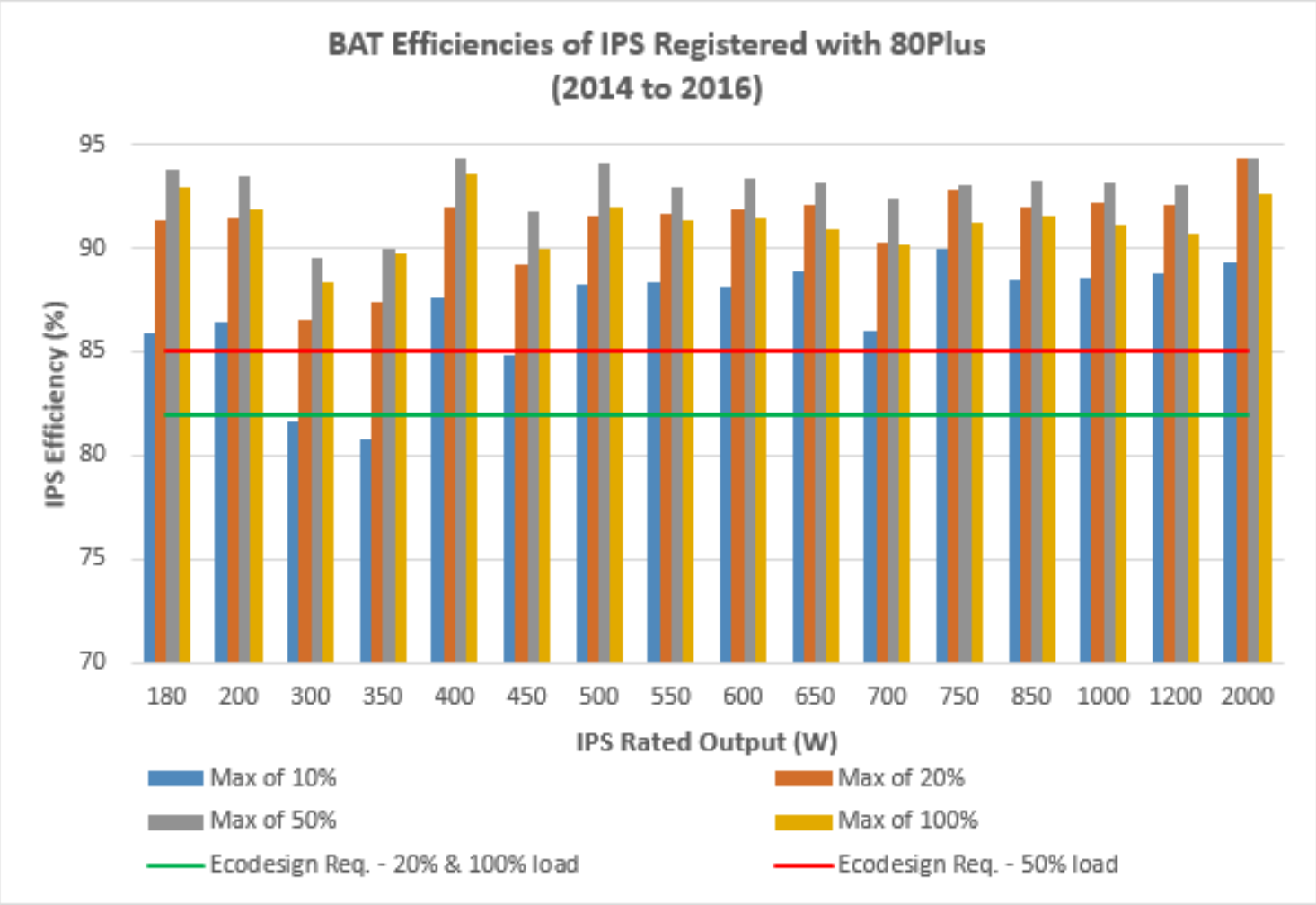
AVERAGE TECHNOLOGY & BAT OF COMPONENTS

- Average Technology - IPS



AVERAGE TECHNOLOGY & BAT OF COMPONENTS

- BAT - IPS



AVERAGE TECHNOLOGY & BAT OF COMPONENTS

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- CPU (Average Technology)
  - Dynamic frequency scaling (DFS) and dynamic voltage scaling (DVS)
  - Leakage of current reduced
  - Support for high C-states
- CPU (BAT)
  - More of above
  - OS handing control of frequency and voltage scaling back to the CPU itself
  - Modern Standby

AVERAGE TECHNOLOGY & BAT OF COMPONENTS

- Storage (Average Technology)
  - Hard disk drive (HDD)
  - Solid State drive (SSD)
  - Hybrid drives
- Storage (BAT)
  - PCIe based SSD's
  - 2.5 inch SSD

AVERAGE TECHNOLOGY & BAT OF COMPONENTS

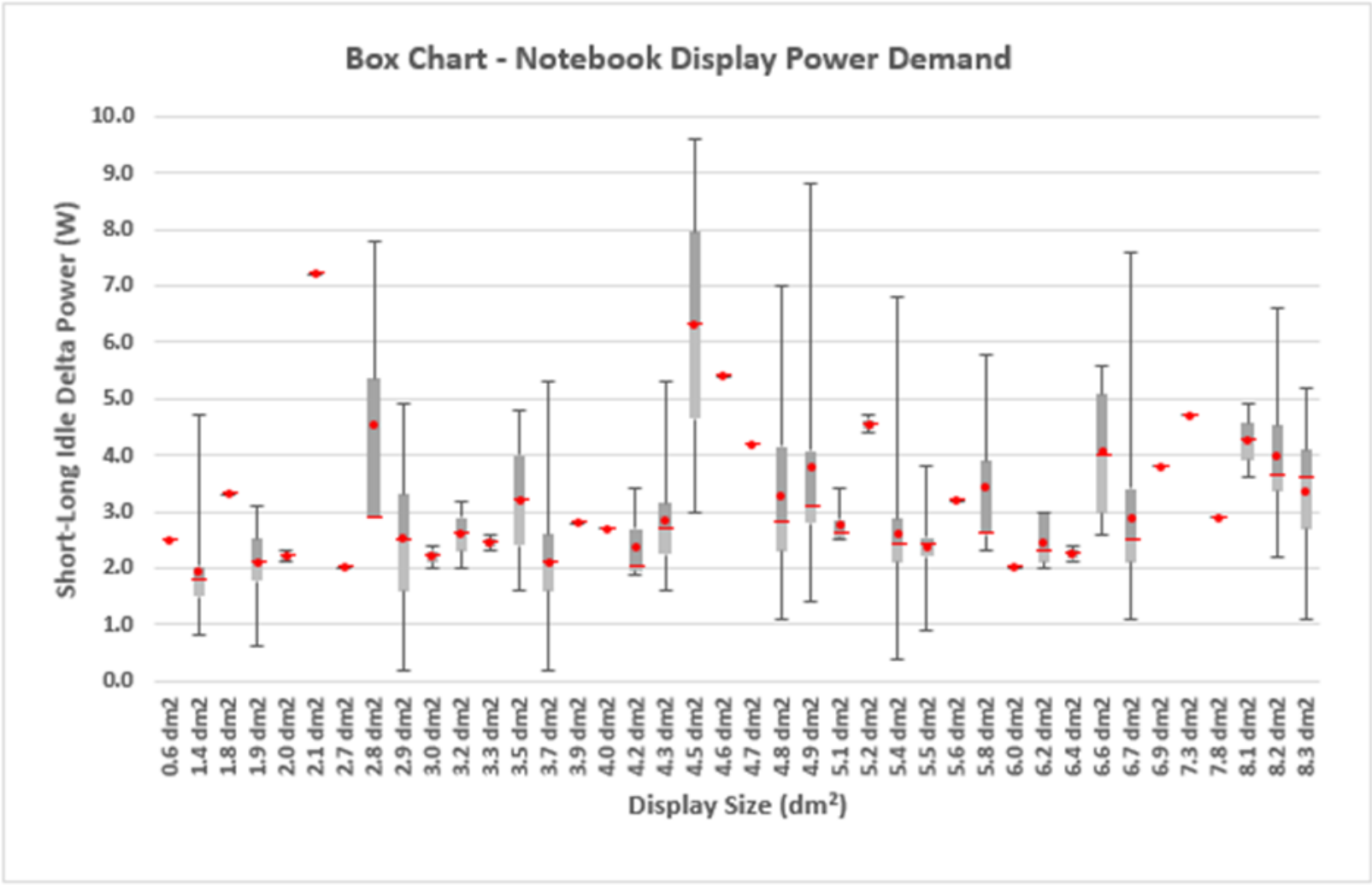
- Software efficiency (Average Technology)
  - Power management mostly works
  - Short(ish) delays in resume times
- Software efficiency (BAT)
  - Power management works
  - Short(ish) delays in resume times

AVERAGE TECHNOLOGY & BAT OF COMPONENTS

- Software efficiency (Average Technology)
  - Power management mostly works
  - Short(ish) delays in resume times
- Software efficiency (BAT)
  - Modern Standby
  - Quick resume times

AVERAGE TECHNOLOGY & BAT OF COMPONENTS

- Notebook integrated display power demand



USE OF MATERIALS – AVERAGE & BAT

USE OF MATERIALS: AVERAGE & BAT

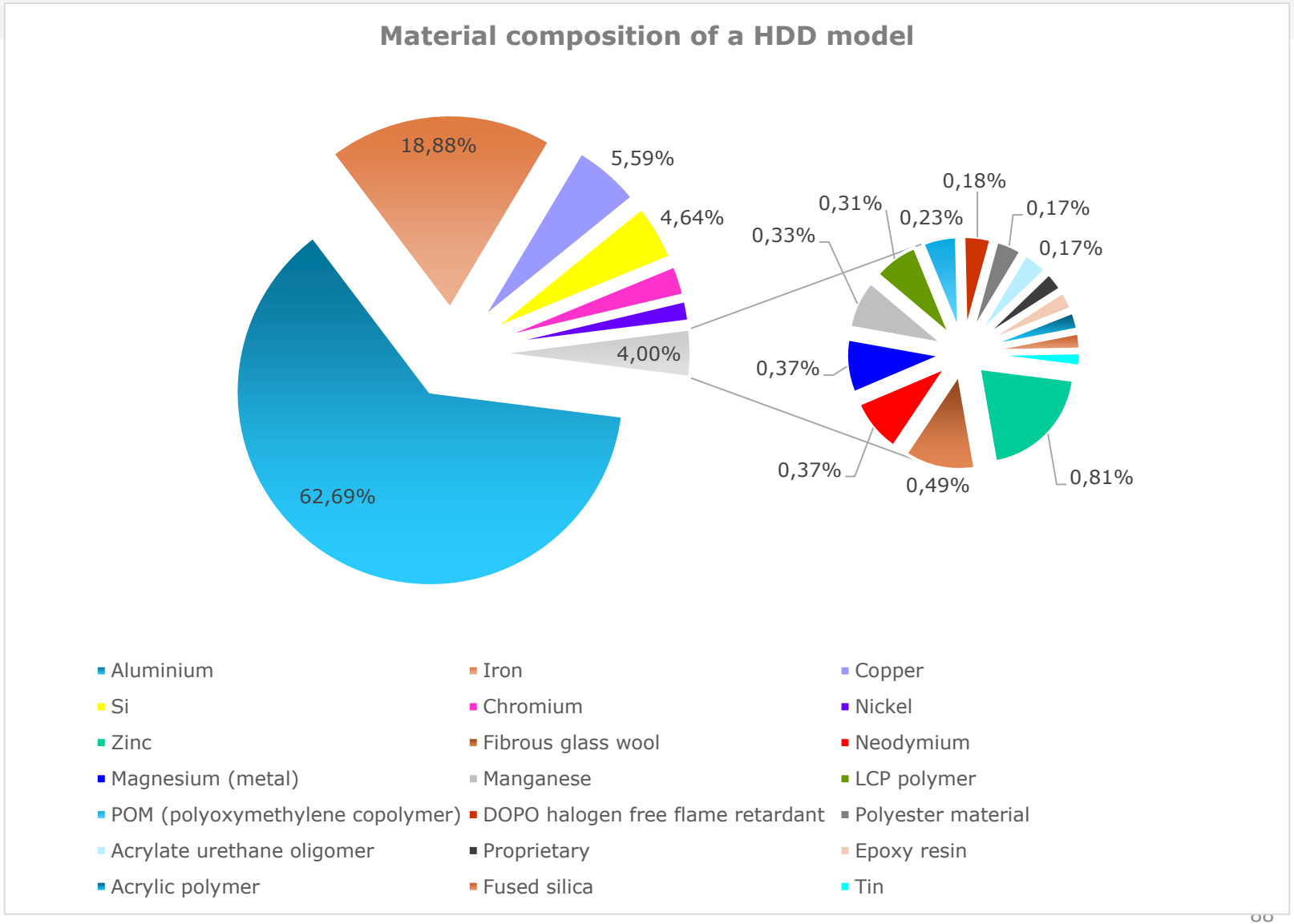
- Aim: to get an overview of bill of components average vs. BAT, incl. material use for key components
- Desktop, integrated desktop, notebook and tablet/slate computers
- Broad geographical coverage
  - Manufacturing at different times and places
- Investigate possibilities for reuse/recycling of key components to decrease material use/ environmental impacts (hotposts are production and use stages)

BILL OF COMPONENTS - DESKTOP COMPUTERS

- Average and BAT

Component	Weight in average technology (kg)	Weight in BAT (kg)
Housing	4.94	0.78
PCB	1.18	0.33
HDD/SSD*	0.33	0.10
PSU	0.99	0.09
Cable	0.37	0.06
Fan	0.07	not present
Radiator**	0.57	not present
Total weight	8.45	1.36

BOM – HDD DESKTOP COMPUTERS



BILL OF COMPONENTS: INTEGRATED DESKTOP COMPUTERS

- Average and BAT

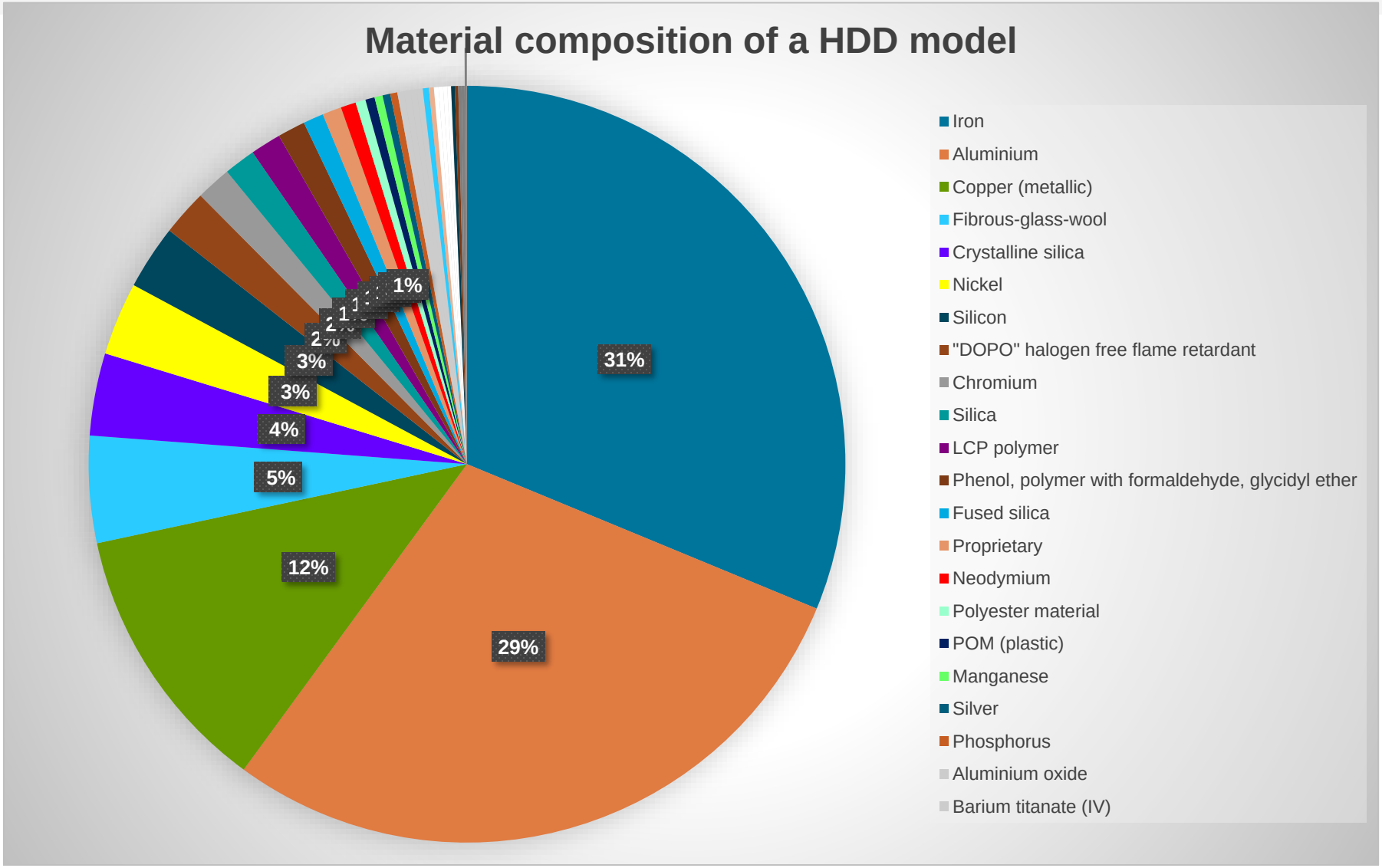
Component	Weight product 1 (kg)	Weight product 2 (kg)	Weight product 3 (BAT) (kg)
Housing	3.66	4.05	2.56
Display unit	2.26	3.20	2.04
PCB	0.17	0.52	0.31
Storage	0.09	0.42	0.10
CPU	0.01	not declared	not declared
RAM	0.02	not declared	not declared
PSU	0.20	0.48	0.29
Cables	0.02	0.13	0.10
Speakers	0.07	0.48	0.26
LED backlight	0.01	not declared	not declared
Fans	0.04	fanless	fanless
Total weight	6.50	9.29	5.68

BILL OF COMPONENTS: NOTEBOOK COMPUTERS

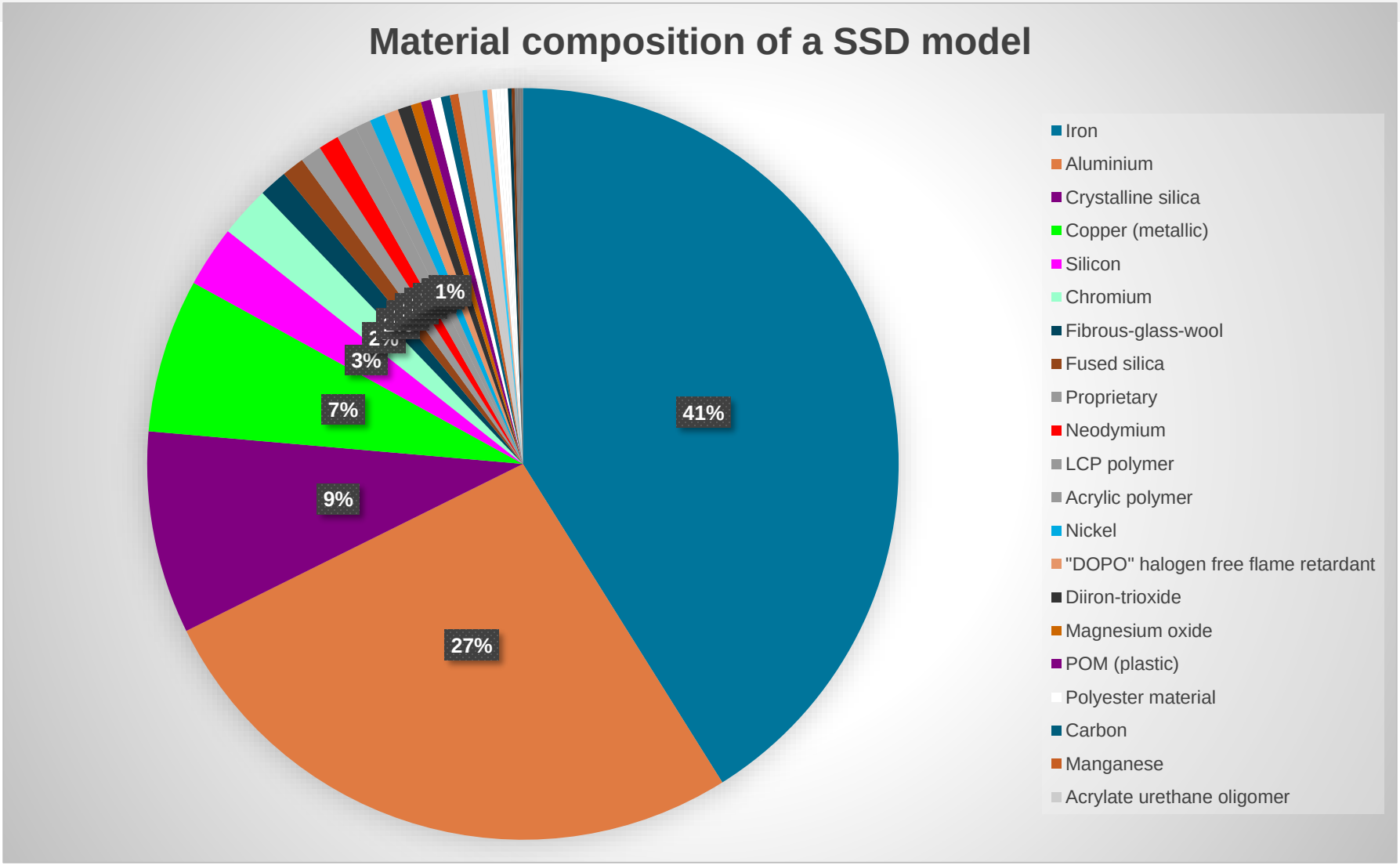
- Average and BAT

Component	Weight in average technology (kg)	Weight in BAT (kg)
Housing	0.74	0.35
PCBs	0.24	0.05
HDD	0.08	not declared
SSD	0.02	not declared
Optical disk drive	0.18	not present
Display unit	0.28	0.15
PSU incl. cable	0.21	0.06
Fan	0.01	not present
Speakers	0.005	not declared
Keyboard/pad	0.14	0.11
Battery	0.31	0.19
Total weight	2.23	0.92

BOM – STORAGE NOTEBOOK COMPUTERS



BOM – STORAGE NOTEBOOK COMPUTERS



BILL OF COMPONENTS: TABLET/SLATE COMPUTERS

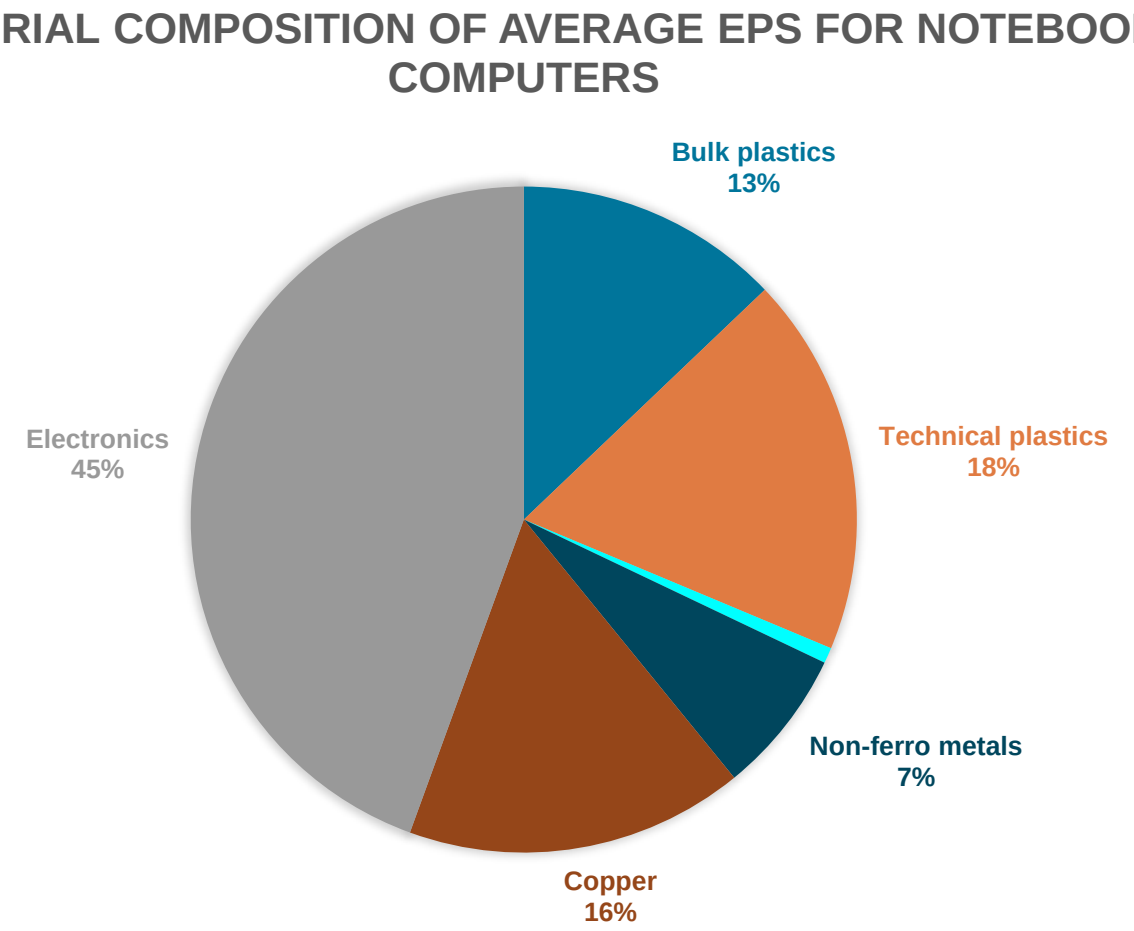
- Average and BAT

Component	Weight in average technology (kg)	Weight in BAT (kg)
Housing	0.14	0.08
PCB	0.04	0.04
Display unit	0.17	0.17
PSU incl. cable	0.05	0.03
Speakers	0.003	not declared
Battery	0.13	0.13
Total weight	0.53	0.45

EPS FOR NOTEBOOK COMPUTERS

- Interest to know the amount of materials/ resources saved by avoiding the use of product/model specific EPS units
- Replacing them with universal types that can be used with several notebooks and/or computer products
- The material composition of the average EPS for notebook computers was investigated by JRC.

BOM EPS FOR NOTEBOOK COMPUTERS



OVERVIEW OF BNAT

OVERVIEW OF BNAT

- CPU efficiency
  - reductions in process size continue (i.e. down to 7nm and 5nm).
  - New materials and architecture designs will be required to reduce leakage.
  - Better and wider implementation of SI0x states across CPUs and SoC designs to support of software based solutions such as Modern Standby.

OVERVIEW OF BNAT

- Software Efficiency
  - Modern Standby holds the potential to significantly reduce energy usage
- Graphics Processing Unit (GPU) Efficiency
  - Energy efficiency likely to continue to increase in future
  - Usage of high band width memories (HBM) likely lead to significant performance improvements and reduced energy use.

OVERVIEW OF BNAT

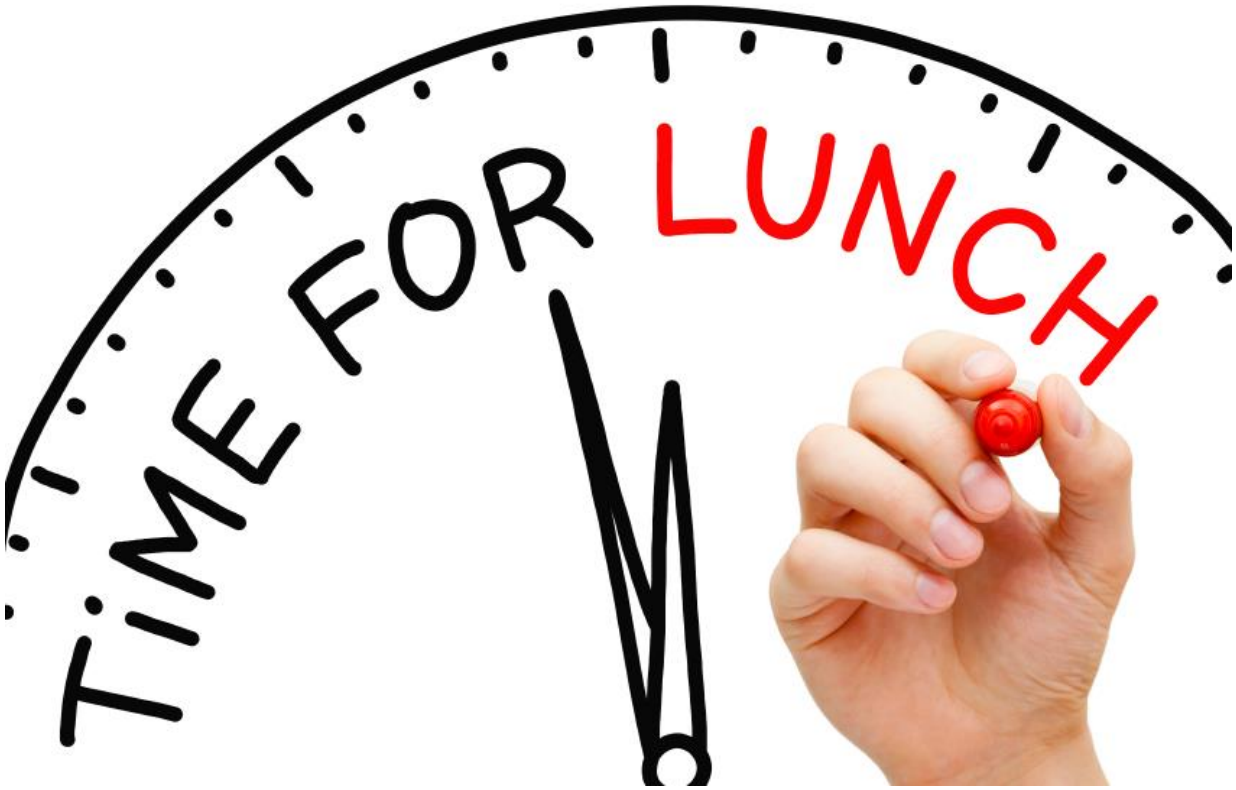
- IPS Efficiency
  - Two stage IPS tackle inefficiencies at low load levels.
- Integrated Display Efficiency
  - Mirror improvements found in televisions
  - Quantum dot based integrated displays

OVERVIEW OF BNAT

- Memory Efficiency
  - DDR4 move to a 10nm process.
  - Power demand saving of 10% to 20%
  - HBM use in RAM modules
- Storage Technologies
  - New types of storage products provide non-volatile memory (NVM) at RAM retrieval performance levels

QUESTIONS?

LUNCH BREAK



DEFINITION OF BASE CASES

DEFINITION OF BASE CASES

- Based on ENERGY STAR data
  - Enough data points to analyse for most products
- BAU consumption for each category
  - Average values for each sub-category (I1, I2, I3, D1, D2, 0)

DEFINITION OF BASE CASES

Parameter	Desktop	Integrated desktop	Notebook	Slate/tablet
Measured power consumption				
Off mode power (W)	0.643	0.520	0.332	0.420
Sleep mode power (W)	1.767	1.72	0.742	0.797
Short idle power (W)	23.47	32.8	8.01	5.742
Long idle power (W)	22.14	17.8	5.06	5.50
Other parameters				
E TEC value (kWh)	103.6	123.5	27.70	17.6
EPS efficiency (%)	85.7	89.7	88.6	85.4
PSU rated power (W)	238.9	142.3	71.11	31.25
IPS eff. 100% load (%)	84.0	90.5		
IPS eff., 50% load (%)	86.8	91.9		
IPS eff., 20% load (%)	84.5	90.1		
IPS eff., 10% load (%)	79.3	85.9		

DEFINITION OF BASE CASES

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Parameter	Portable all-in-one	Workstation	Thin client	Integrated thin client
Measured power consumption				
Off mode power (W)	0.40	1.72	0.873	
Sleep mode power (W)	1.00	4.20	1.430	
Short idle power (W)	31.4	54.15	9.027	
Long idle power (W)	16.3	52.85	8.372	
Max power (W)		231.2		
Other parameters				
E TEC value (kWh)	114.2	30.5	42.32	
EPS efficiency (%)	88.0		87.0	
PSU rated power (W)	110			
IPS eff. 100% load (%)		89.6		
IPS eff., 50% load (%)		92.0		
IPS eff., 20% load (%)		90.6		
IPS eff., 10% load (%)		86.5		

LIFE CYCLE COSTS

LIFE CYCLE COSTS

- LCC includes:
  - Purchase
  - Installation
  - Repair and maintenance
  - Upgrades
  - Use phase electricity
  - Disposal
- Average of private and industry costs based on market shares for each computer type

LIFE CYCLE COSTS: PURCHASE PRICE

- The purchase prices are the same as the average prices from task 2

Base cases at product type level	Purchase Price
Desktop	1 612 €
Integrated Desktop	1 069 €
Notebook	1 346 €
Slate/Tablet	1 182 €
Portable All-in-one	2 608 €
Thin Client	869 €
Integrated Thin Client	460 €
Workstation	2 826 €

LIFE CYCLE COSTS: REPAIR AND MAINTENANCE

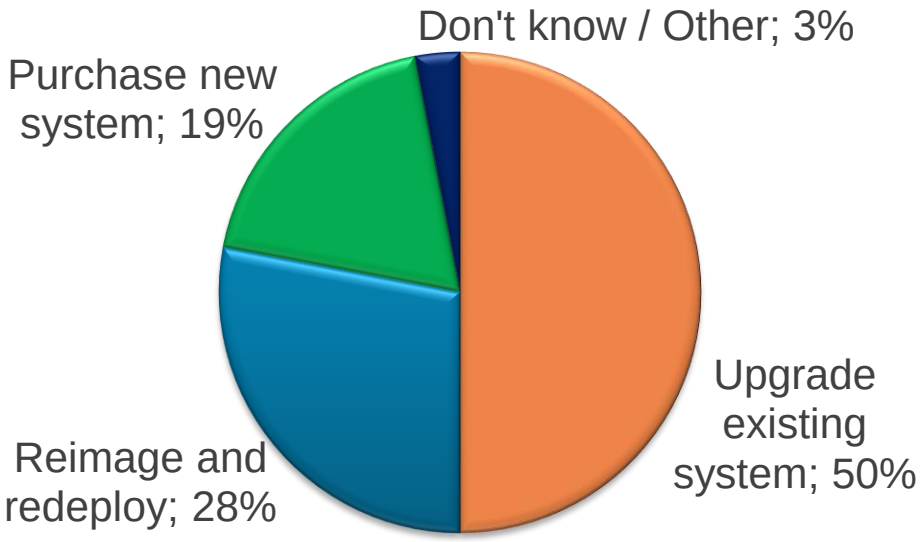
- Repair and maintenance practices defined
- Costs identified for the repair and maintenance of the products in scope
  - Service agreement (maintenance)
  - Repair

End-user	B2B			B2C	
Service agreement	Hourly-paid	Monthly-paid	In-house	Extended warranty	Pay for repair
Share	7.5%	17.5%	75%	63%	37%
Price	88.2 €/hour	41.5 € per computer per month	54 € per computer per month	251 € once	364 € once

LIFE CYCLE COSTS: REPAIR AND MAINTENANCE

Base cases at product type level	Repair and maintenance cost
Desktop	2 901 €
Integrated Desktop	2 901 €
Notebook	1 411 €
Slate/Tablet	1 407 €
Portable All-in-one	1 322 €
Thin Client	3 262 €
Integrated Thin Client	3 262 €
Workstation	4 348 €

LIFE CYCLE COSTS: UPGRADES



	Upgrade rates	
Base case	**B2C**	**B2B**
Desktops	50%	50%
Notebooks	40%	50%
Workstations	70%	70%
All other	0%	0%

Base case	RAM	Storage	GPU	Battery	CPU	Cooling	Total costs
Desktop	75%	25%	30%	0%	5%	2.5%	97 €
Notebook	60%	10%	0%	75%	0%	0%	54 €
Workstation	80%	25%	50%	0%	10%	10%	195 €

LIFE CYCLE COSTS: USE PHASE ELECTRICITY

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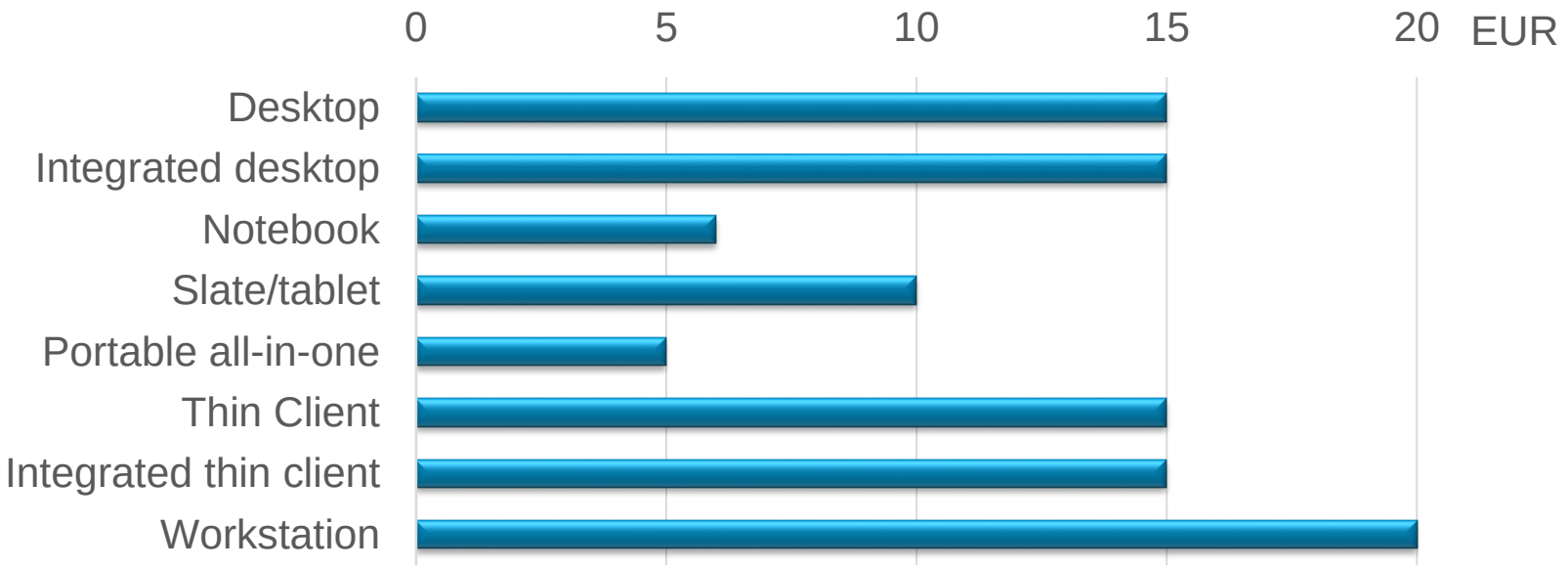
Computer type	Short idle (W)	Active (W)	Active time	Total costs
Desktop	22.9	58.8	14.7%	112 €
Integrated desktop	32.9	84.6	14.7%	187 €
Notebook	7.1	18.2	12.6%	30 €
Slate/tablet	4.1	10.5	12.6%	11 €
Thin Client	14.4	37.0	14.7%	103 €
Integrated thin client	14.4	37.0	14.7%	36 €
Portable all-in-one	0.4	1.03	12.6%	36 €
Workstation	69.5	178.5	20.0%	140 €

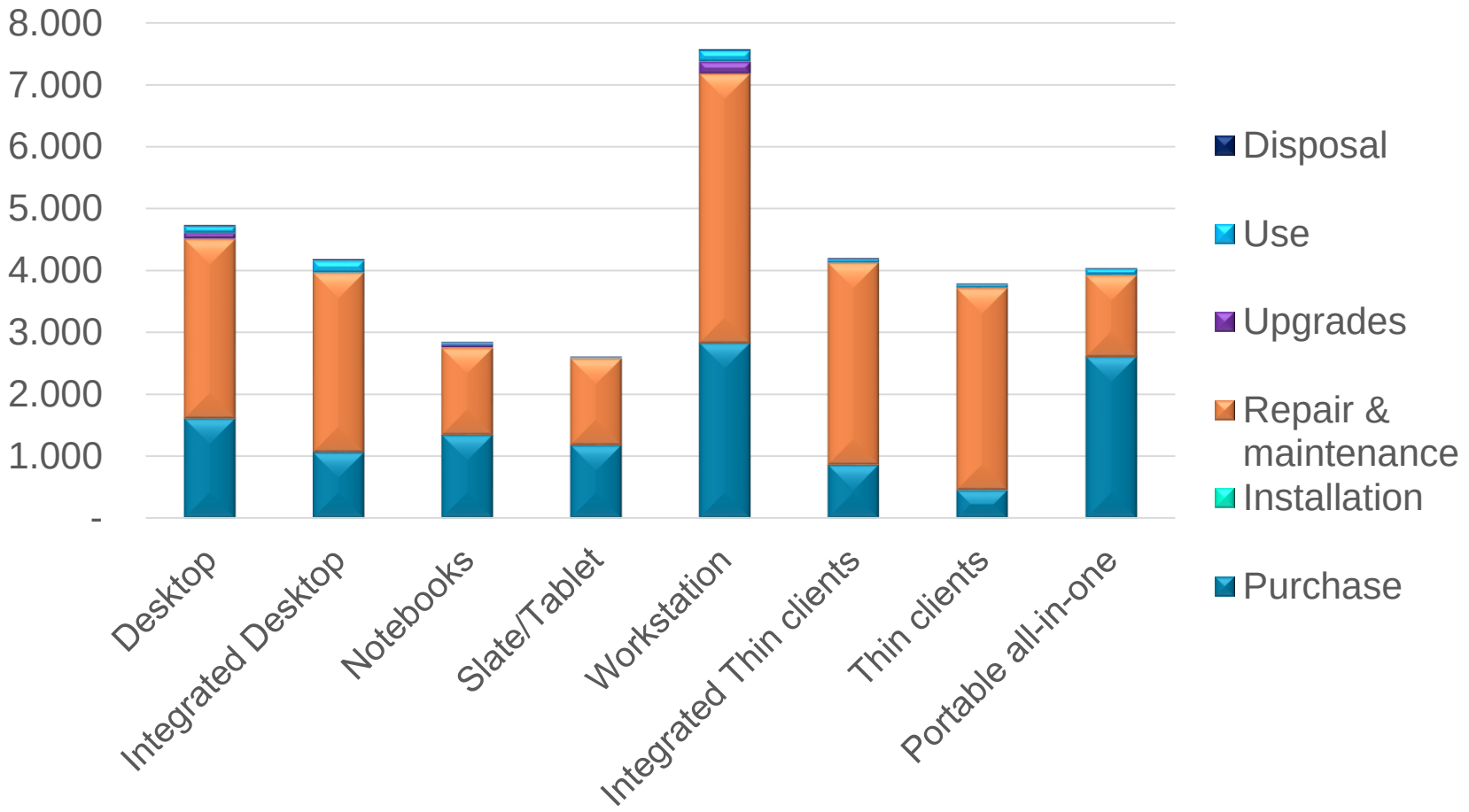
Load-%	80-plus basic	Non-qualified
25%	82%	70%
50%	85%	75%
100%	82%	70%

LIFE CYCLE COSTS: DISPOSAL COSTS

- Private consumers do not pay for disposal
- 70% of commercial users pay for disposal
- Prices: 30 € for desktops / 21 € for notebooks



LIFE CYCLE COSTS OVERVIEW



NEXT STEPS

NEXT STEPS

- Input from stakeholders to task reports – Deadline 28th of February. Format available at project's website: https://computerregulationreview.eu/documents

Preparatory study on the Review of Ecodesign Regulation 617/2013 (Lot 3) - Computers and Computer servers

Organization:	Name:	Date:

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team

NEXT STEPS

- Report for Consultation Forum – to be published end of February incl. input from stakeholders.
- Consultation Forum – end of March (tentative)
- Final report, incl. input from CF – end of April (tentative)
- End of contract – end of April

NEXT STEPS

- Consultants additional work:
  - Improve task reports based on stakeholders' input
  - Improve policy options (energy efficiency & material efficiency) based on stakeholders' input
  - Scenario analysis:
    - Energy savings potentials (VM)
    - Cost benefits from implementing energy efficiency requirements (VM)
    - Environmental benefits from reuse/recycling icw. material efficiency requirements (JRC)

ADDITIONAL QUESTIONS?

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