The ARM Vision
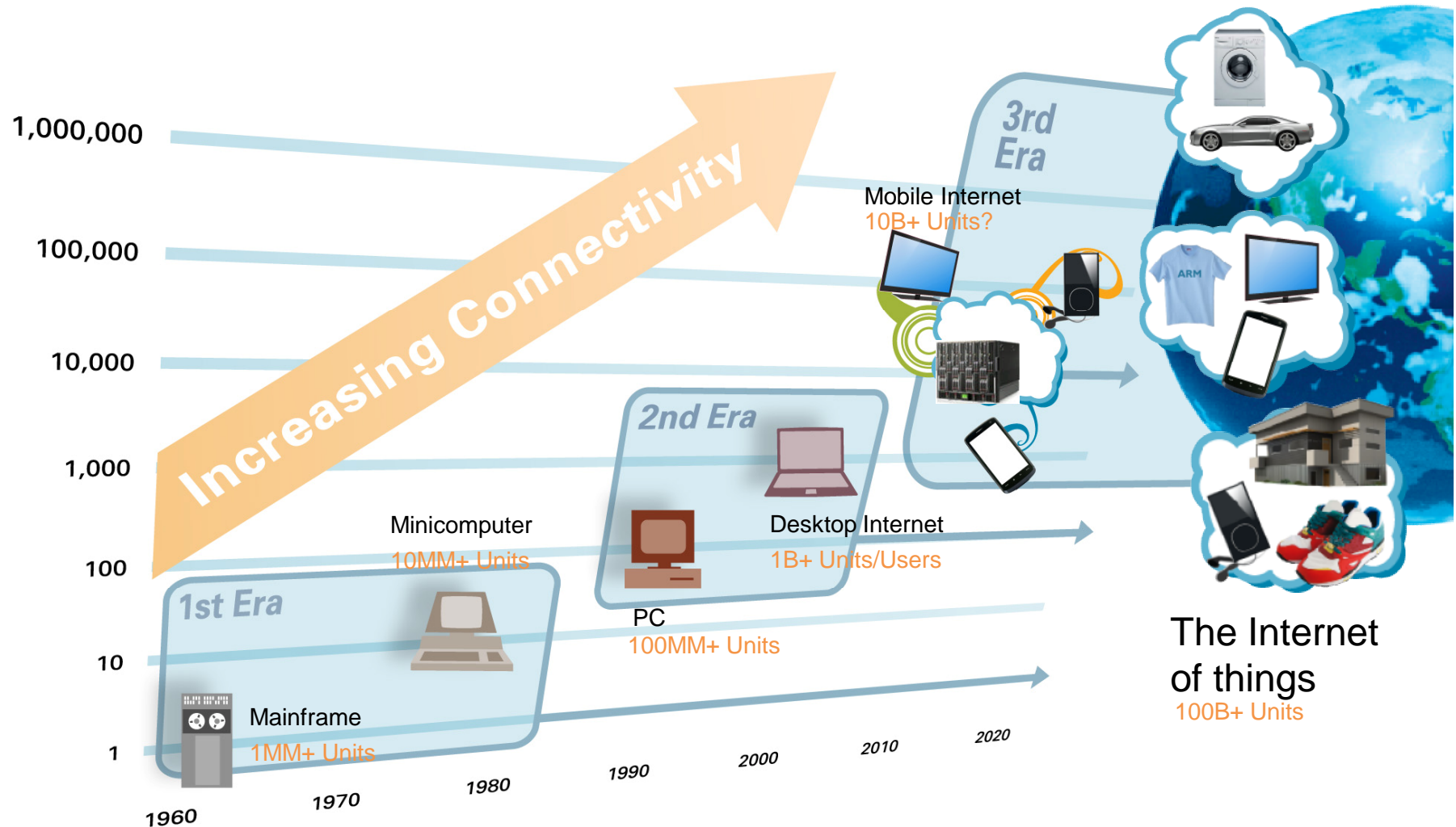
A world in which all electronic products and services are based on energy-efficient technology from ARM, making life better for everyone

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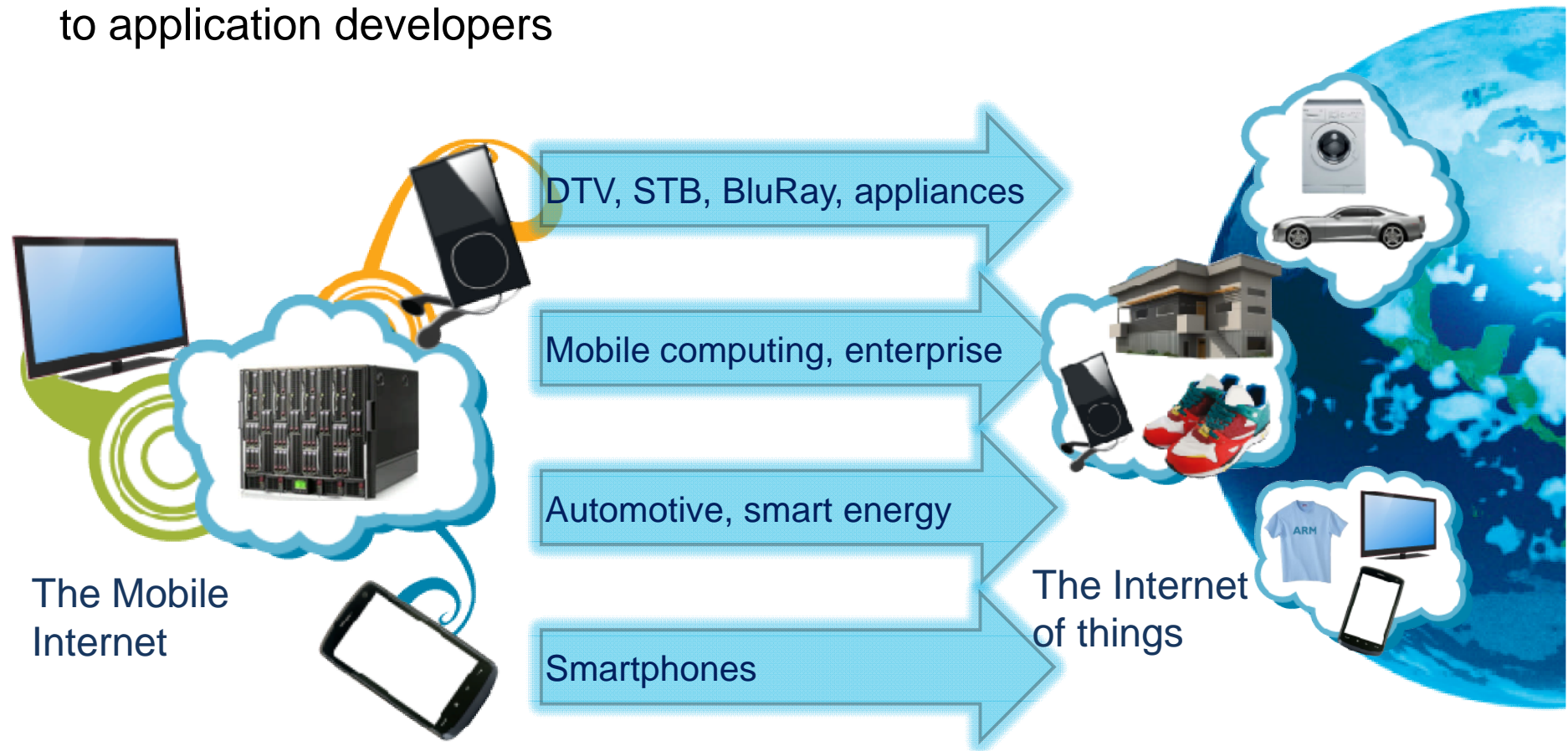
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Electronics is Everywhere

Connectivity Driving The Future

It's Not Just Connectivity

- Future driven by connectivity, software and open standards
- Re-use of hardware and software IP across markets
- ARM has the healthiest eco-system from hardware to application developers

The Mobile Internet

DTV, STB, BluRay, appliances

Mobile computing, enterprise

Automotive, smart energy

Smartphones

The Internet of things

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Huge Opportunity Ahead

20+ billion cores accumulated to date
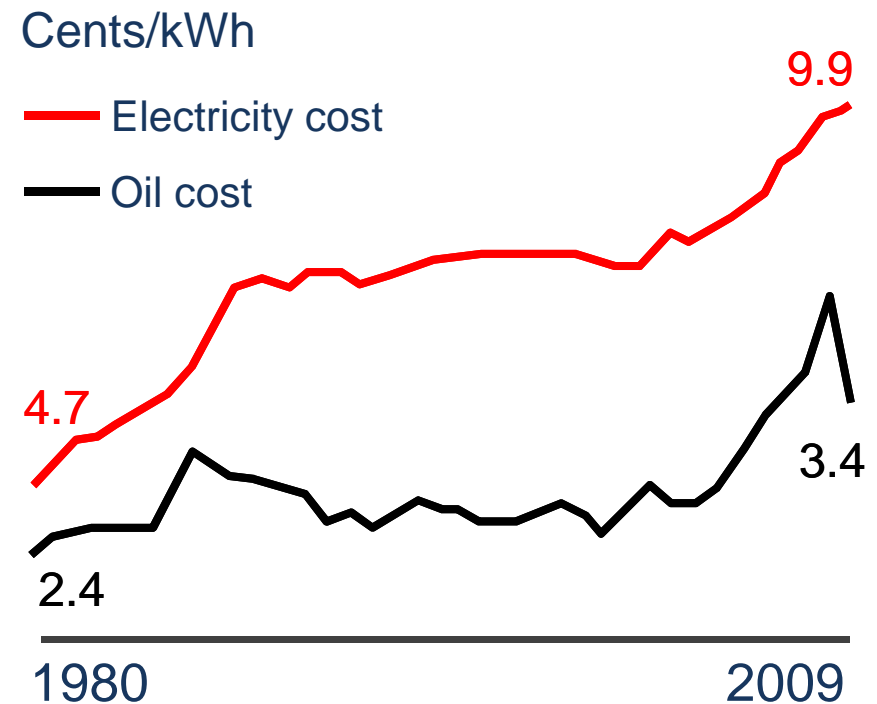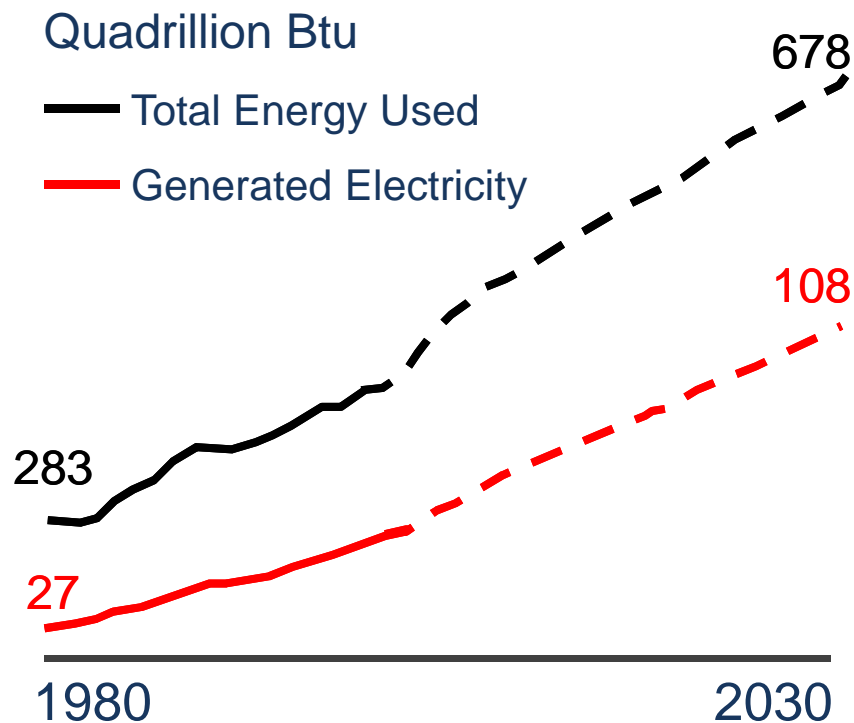
100+ billion cores accumulated after next 10 yrs

1998   2010   2020
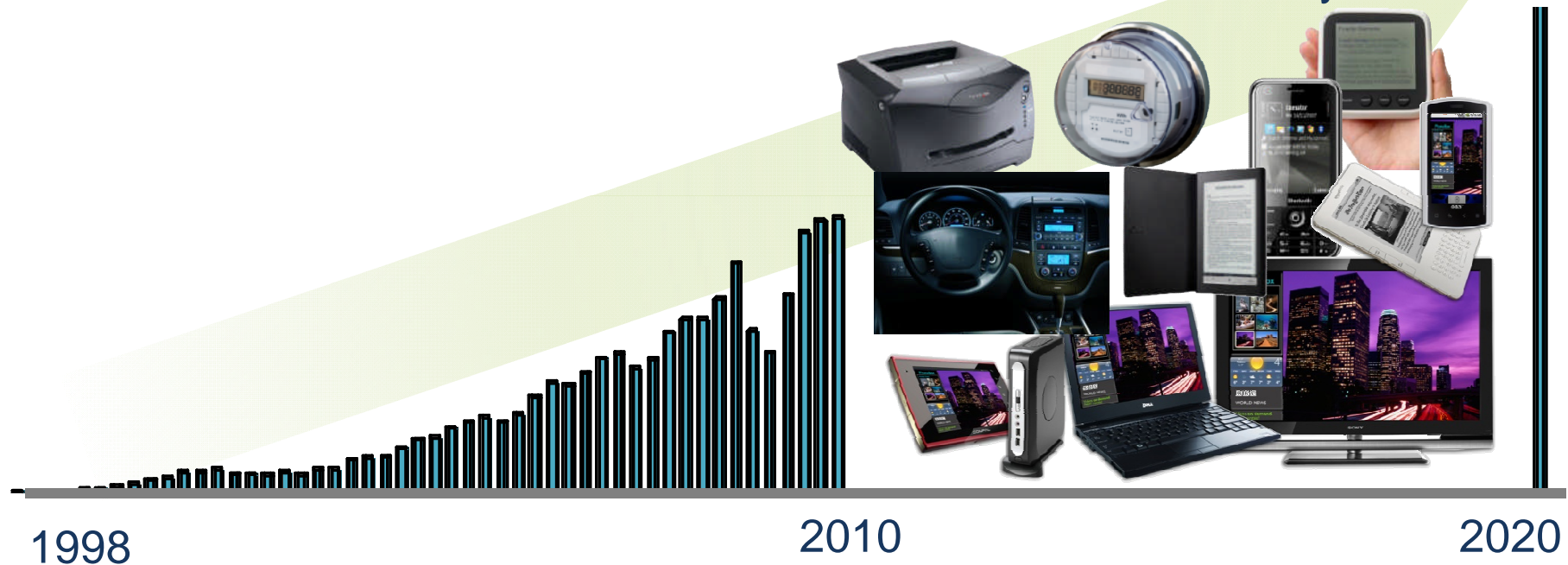
Current "Big Thing": Energy

- Surging demand for new products and the continuing existence of inefficient products will drive energy use up
- Increased energy use is raising energy costs
- Energy efficiency will drive demand for new products

Quadrillion Btu

— Total Energy Used

— Generated Electricity

678

108

283

27

1980   2030

Cents/kWh

— Electricity cost

— Oil cost

9.9

4.7

3.4

2.4

1980   2009

Source: US Energy Information Administration, June 2010

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Electricity is Very Inefficient

- 12.4% of fuel use to delivered electricity worldwide
- 28.7% of fuel wasted in electricity losses
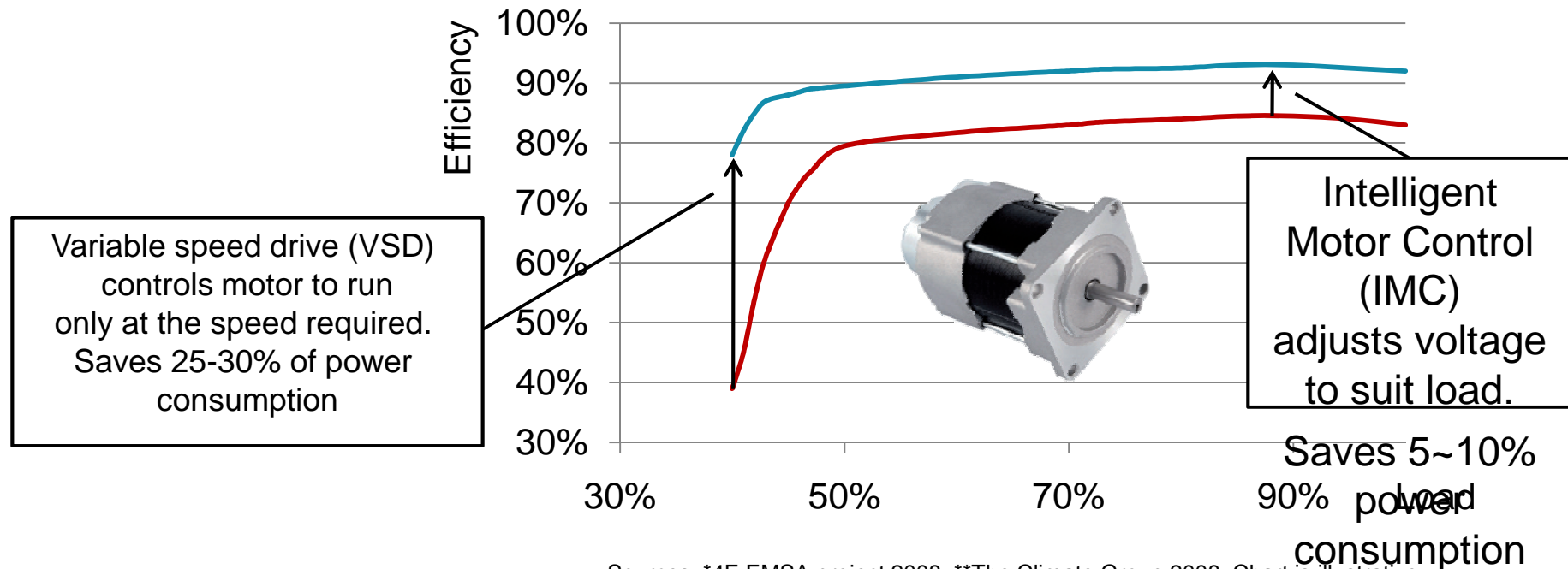- >50% of electricity used in motors
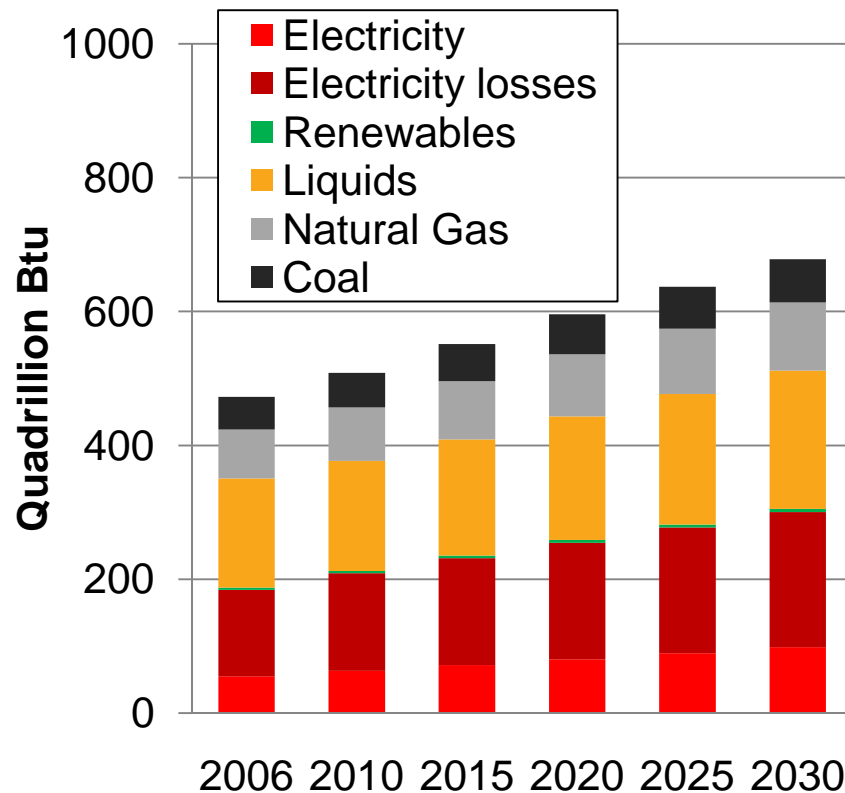
Source: Energy Information Administration (EIA), 2010 Projection 2009
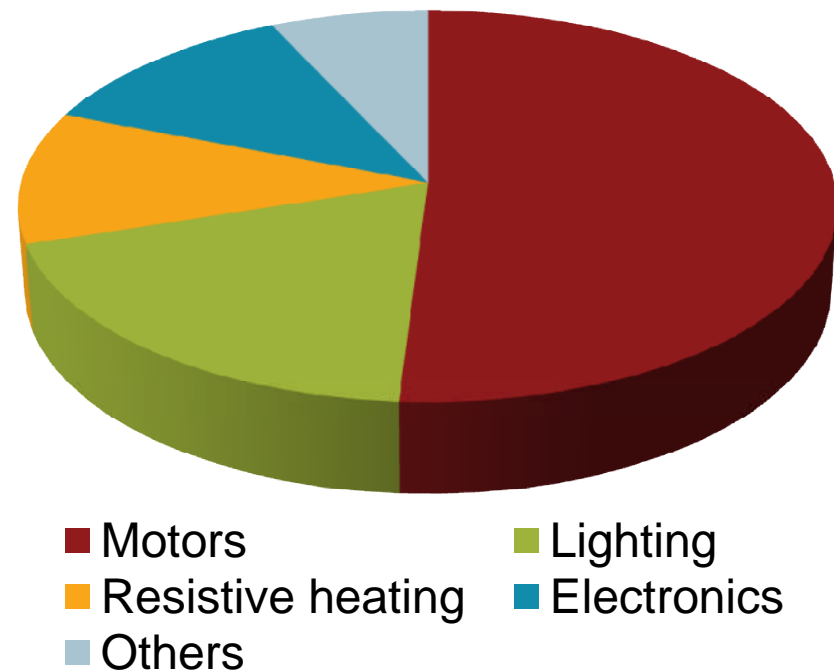
We Need to Start With Motors

- >300 million 0.75kW-375kW motors in industry generate ~3.5GtCO$_2$ of emissions*

- Motors in 2020 will cause 7% of global carbon emissions and 10% of China's emissions**

- Smart control can cut power consumption 25-40%

Variable speed drive (VSD) controls motor to run only at the speed required. Saves 25-30% of power consumption

Intelligent Motor Control (IMC) adjusts voltage to suit load. Saves 5~10% power consumption

Sources: *4E EMSA project 2008, **The Climate Group 2008, Chart is illustrative

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Similar Inefficiencies in Many Devices

- Servers, personal computers, power supplies, lights, appliances, cars,… show a similar curve of inefficiency
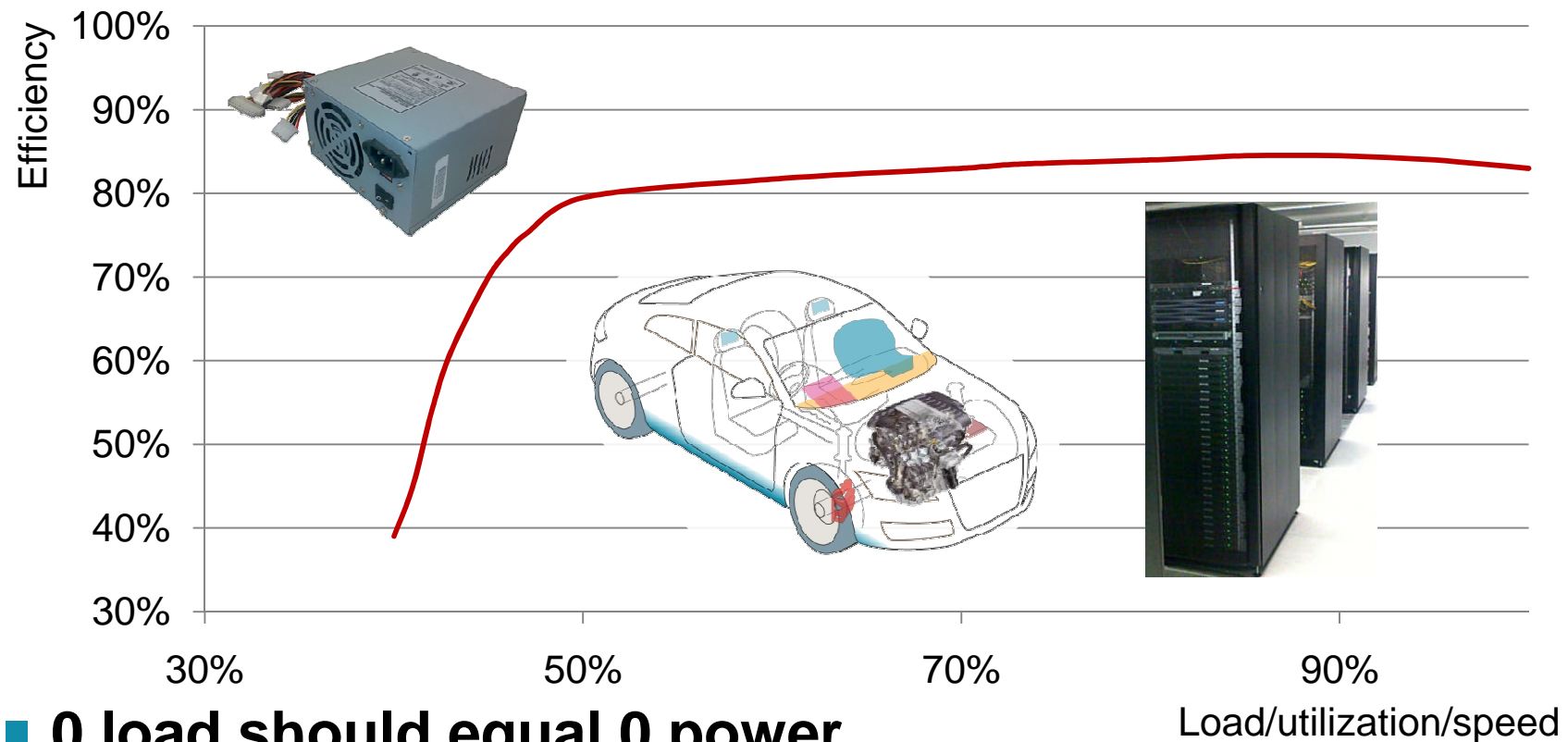
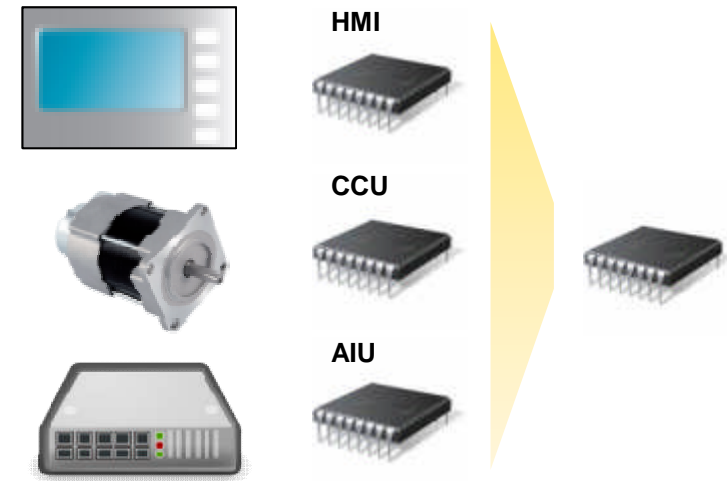- **0 load should equal 0 power, smart devices can achieve this**

Design and Manufacturing Trends

- Past appliance design – modular but inefficient
    - HMI   8-bit MCU   ~ $1.5
    - CCU   DSP   ~ $2.0
    - AIU   8-bit MCU   ~ $2.5
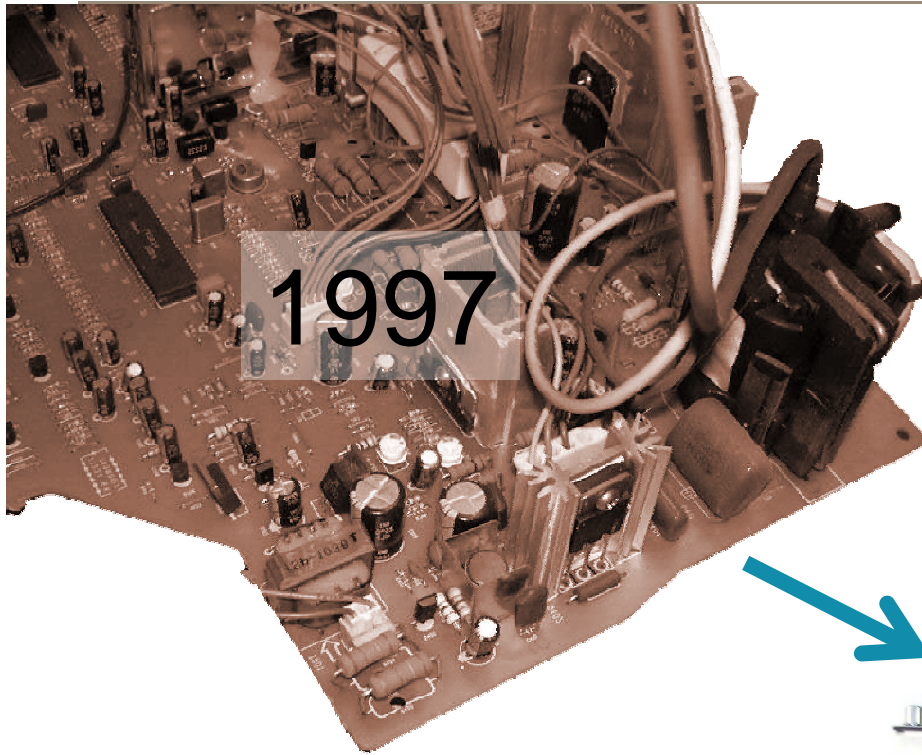- This can be combined more efficiently into a single 32-bit MCU ~$2.0

- **Reduction in components = cost saving**
- **Smarter design = energy efficiency**

Component	Current Part Number	Future Part Number	Est. Annual Savings (mm)
A	150	42	$ 10.0
B	70	27	$ 8.0
C	113	28	$ 5.0
D	180	36	$ 5.0
E	33	19	$ 2.0
F	14	4	$ 2.0

Example of Whirlpool's efforts to implement lean design and manufacturing to improve product costs

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The Shrinking TV

1997

- Single-board
- Highly integrated chips and I/O
- Advanced functionality
- Cool

2008

- Mother & daughter boards
- Discrete components
- Heat sinks
- Lots of wires
- Limited functionality

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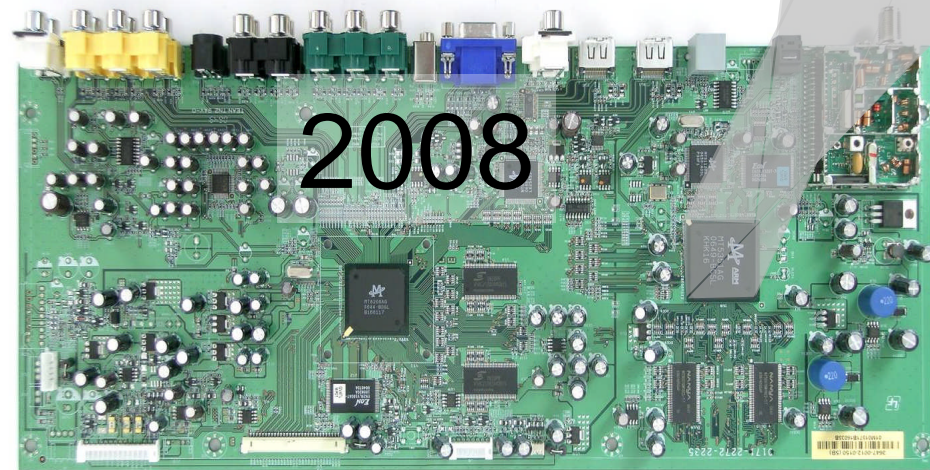
Focus on Software in Embedded MCU

		Intuitive display	Device interaction	Reduced energy consumption
Product benefits	32-bit	More responsive UI	Better connectivity	Lower component count & reduced product weight
Chip features	Motor control Display driver Low power Cost effective Legacy 8-bit	Faster operating system	Communication protocol stacks	Energy-efficient motor control algorithms

Standard Platform Software Advantage

Legacy code across all company products

Fragmentation in the 8-Bit MCU market (Different Architectures by Revenue: Gartner 2006)

Toolchain

Microcontrollers

FPGA's

Applications processors, System-on-Chip etc.
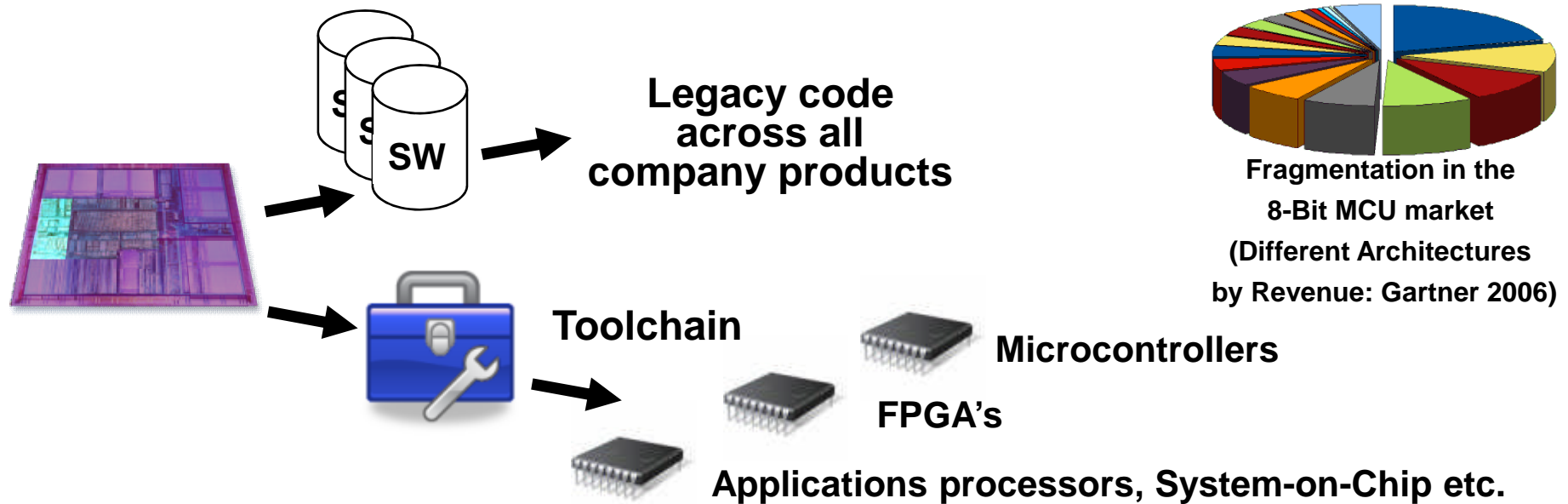
- ■ ARM enables a single platform for embedded development
  - ■ Protecting investment in software design
  - ■ Removed 8/16/32-bit legacy
    - ■ It as a 'Software Engine'
  - ■ Enable reuse, not just from MCU to MCU but onto other digital solutions

PCs – Problem or Solution?

Power
Cost

PC

Laptop

Netbook

Smartbook

Time
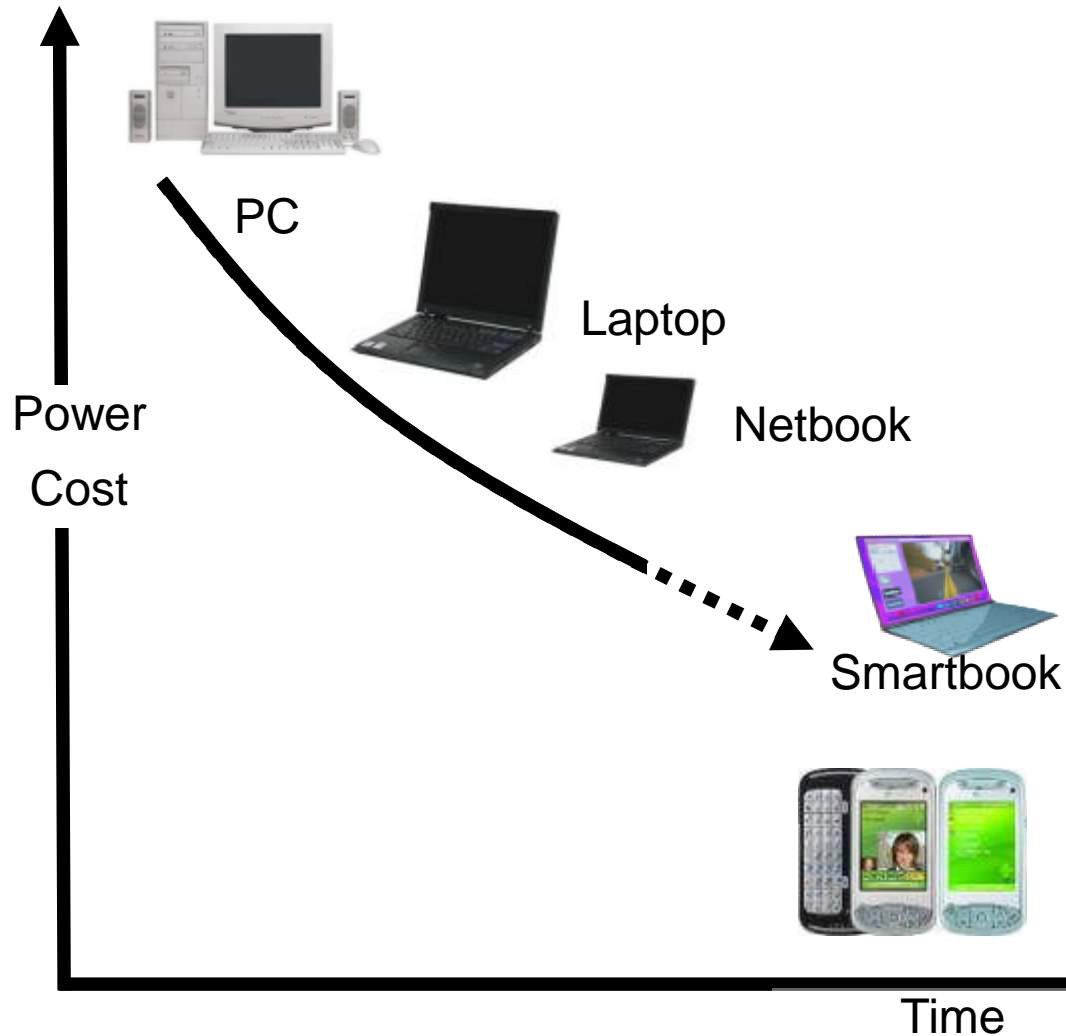
- Worldwide PC growth continues
  - Consuming even more power
- PCs are very inefficient
  - Users don't want 100W heaters
- PC growth in lower power, lower cost laptops
- Trend towards "always on"
  - Enabled by even lower power
  - Closer to smartphones
- Ubiquitous computing
  - Trend towards Cloud Computing
  - Powered by Mobile Internet
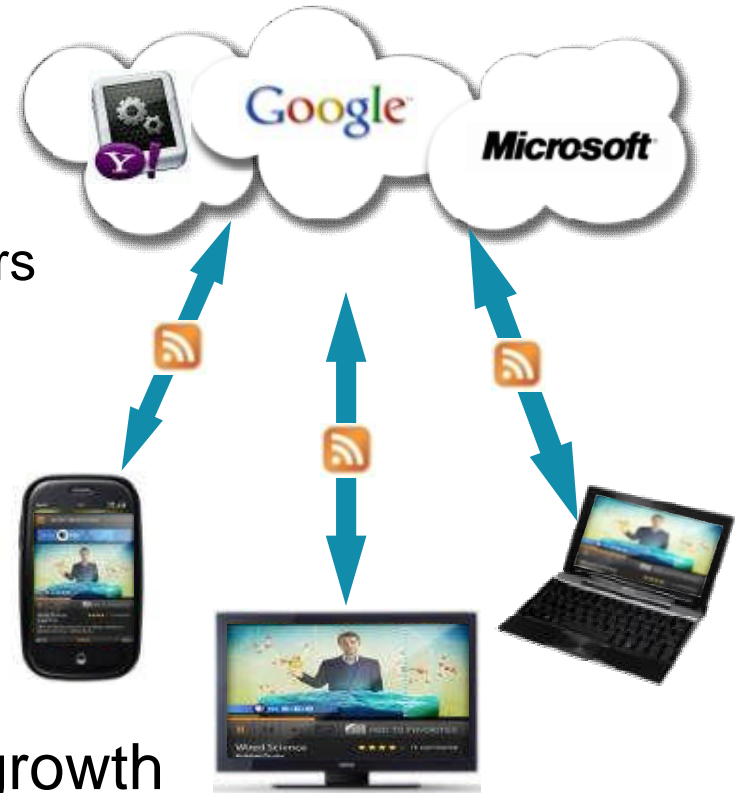
Cutting PC Emissions
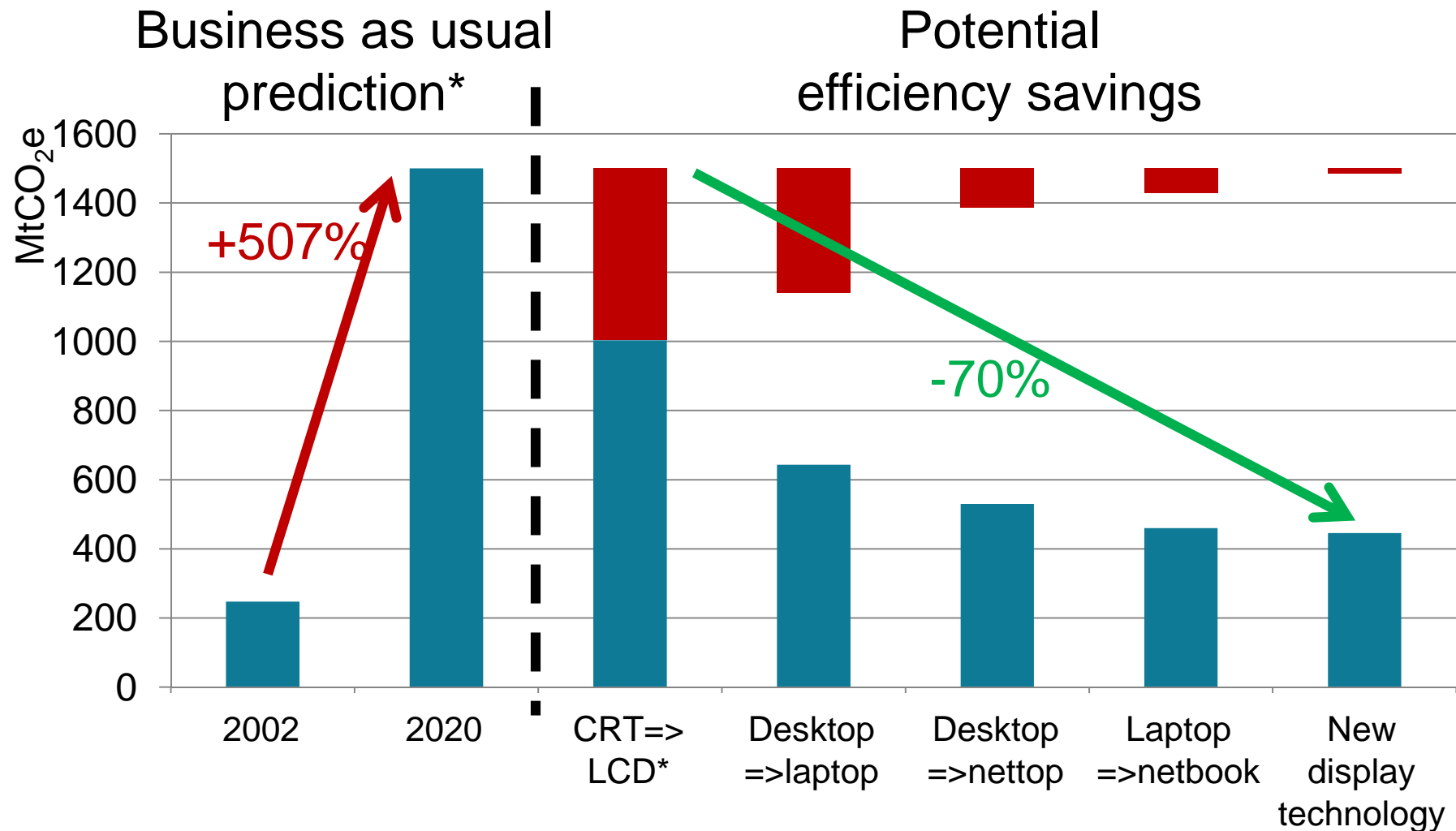
Sources: *The Climate Group 2008, potential savings estimated by ARM

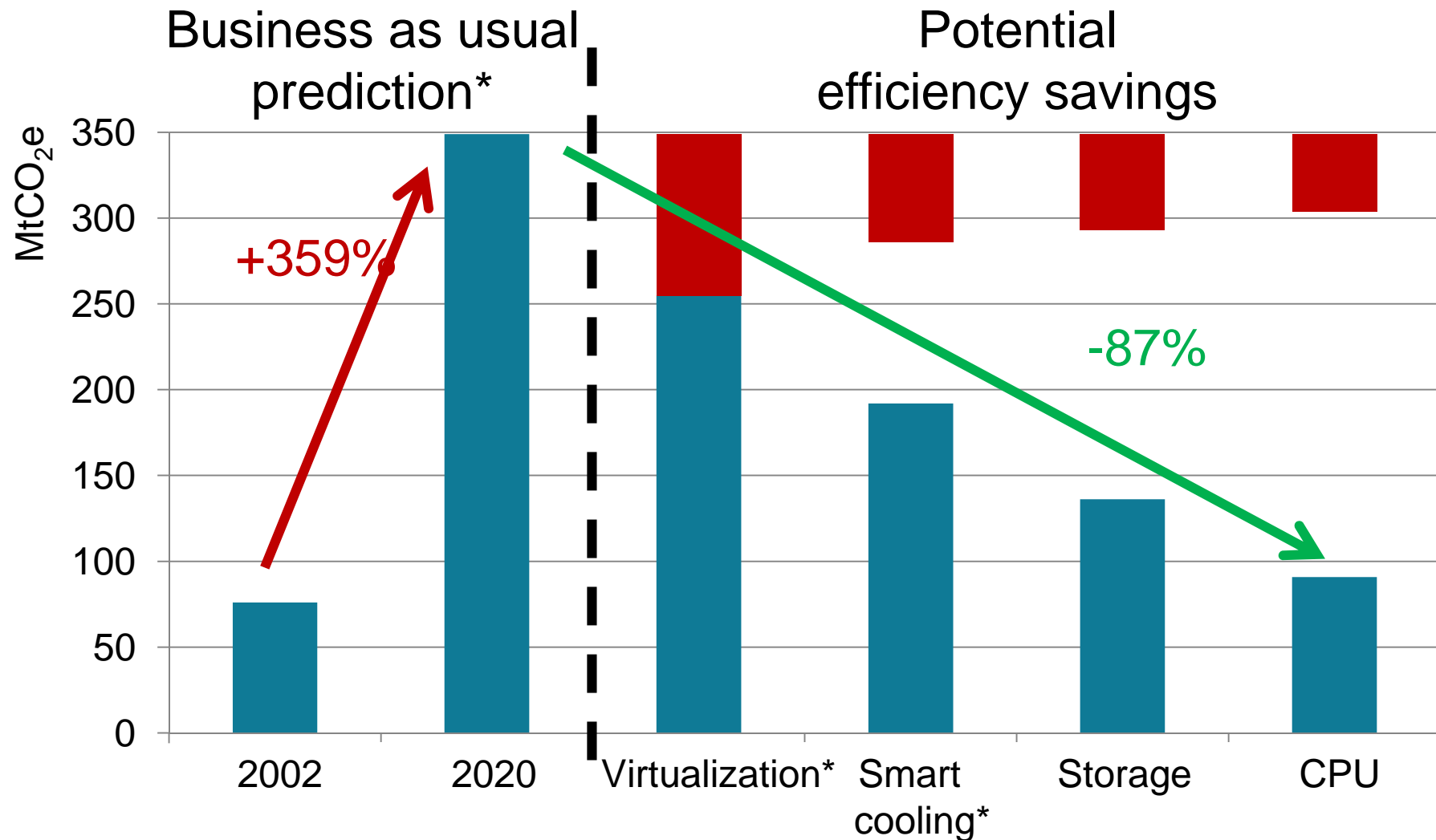The Architecture for the Digital World®   ARM®

Power in the Cloud

- Software services are driving transformation to Cloud Computing
  - Delivering a large pool of applications
  - Targeting all screen sizes and form factors
  - Stimulating competition and innovation
  - Enabled by lower power and lower cost consumer devices

- But what about the Infrastructure?
- Server farms are experiencing huge growth
- Communications power increasing dramatically
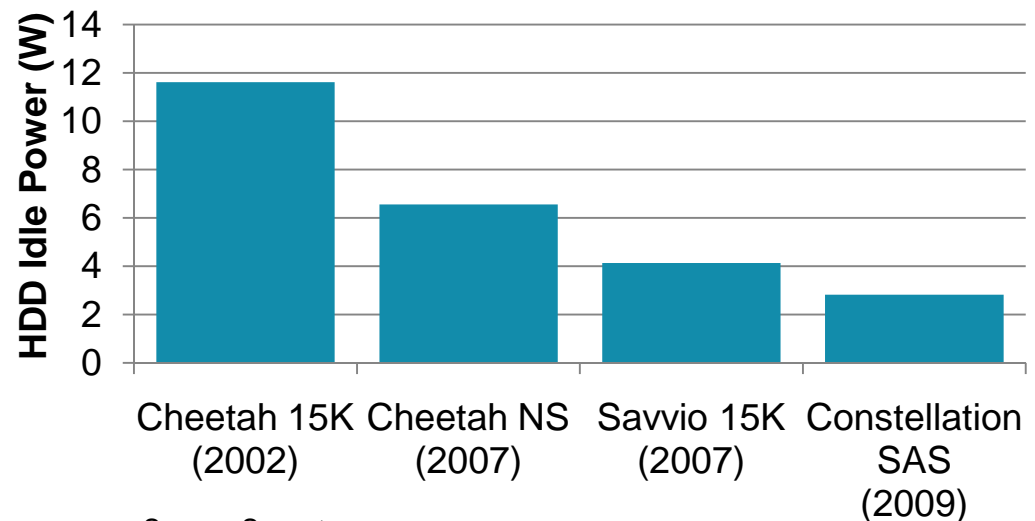 - We have to drive this power down

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Cutting Data Center Emissions

Business as usual prediction*

Potential efficiency savings

MtCO$_2$e

+359%

-87%

350
300
250
200
150
100
50
0

2002 | 2020 | Virtualization* | Smart cooling* | Storage | CPU

Sources: *The Climate Group 2008, Storage and CPU potential savings estimated by ARM

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HDD Example Solution: Seagate

- "Storage currently accounts for 37-40% of overall data center energy usage…" StorageIO Group

- Data centers routinely have 10k hard drives, some have >100k

- Seagate small form factor SAS drives use 20-40% less power with improved performance

- Smaller drives = more drives in the same space

- "…by replacing 3.5" disk drives with 2.5" disk drives the world would be a greener place with a reduction of **7.5 million metric tons of CO_2 per year**"
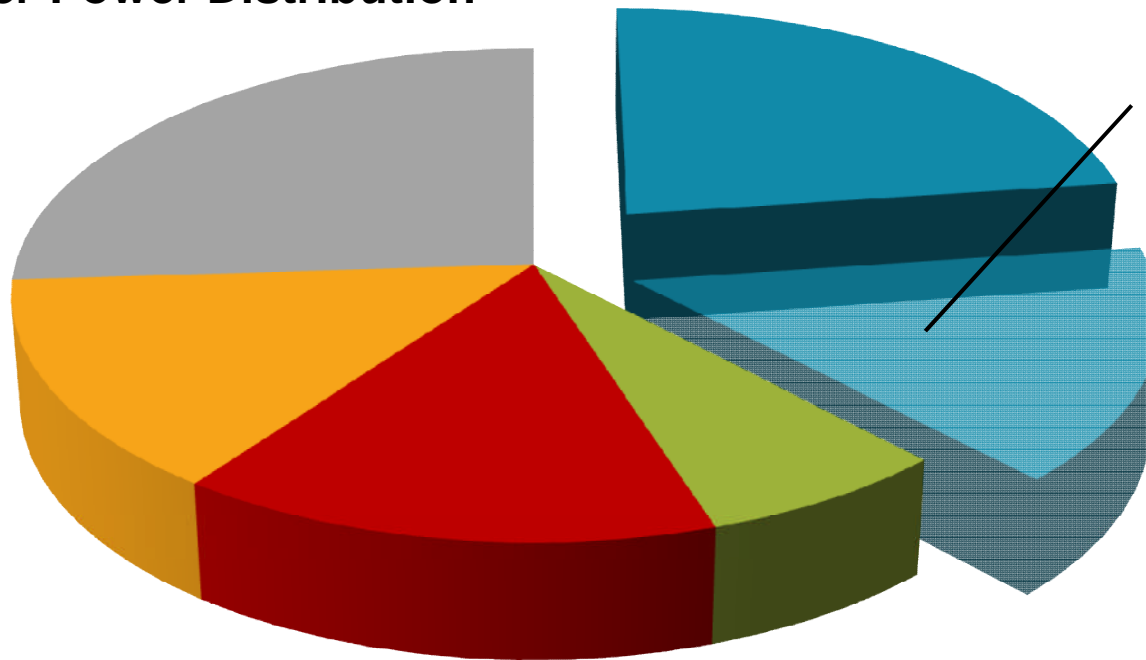
HDD Idle Power (W)

14
12
10
8
6
4
2
0

Cheetah 15K (2002) Cheetah NS (2007) Savvio 15K (2007) Constellation SAS (2009)

Source: Seagate

Memory Solution: Samsung DDR3

- Memory ~38% of server power consumption
- DDR3 >40% power reduction
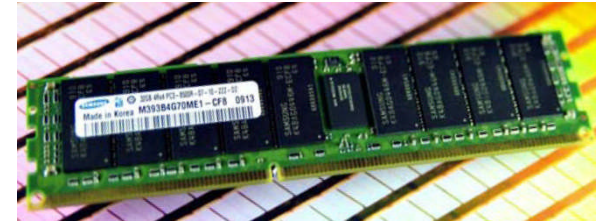
Server Power Distribution

DDR3 Memory: 40% saving reduces server power consumption by 15.2%

Legend: ■ Memory ■ Memory potential saving ■ HDD ■ Power Supply ■ Other ■ CPU

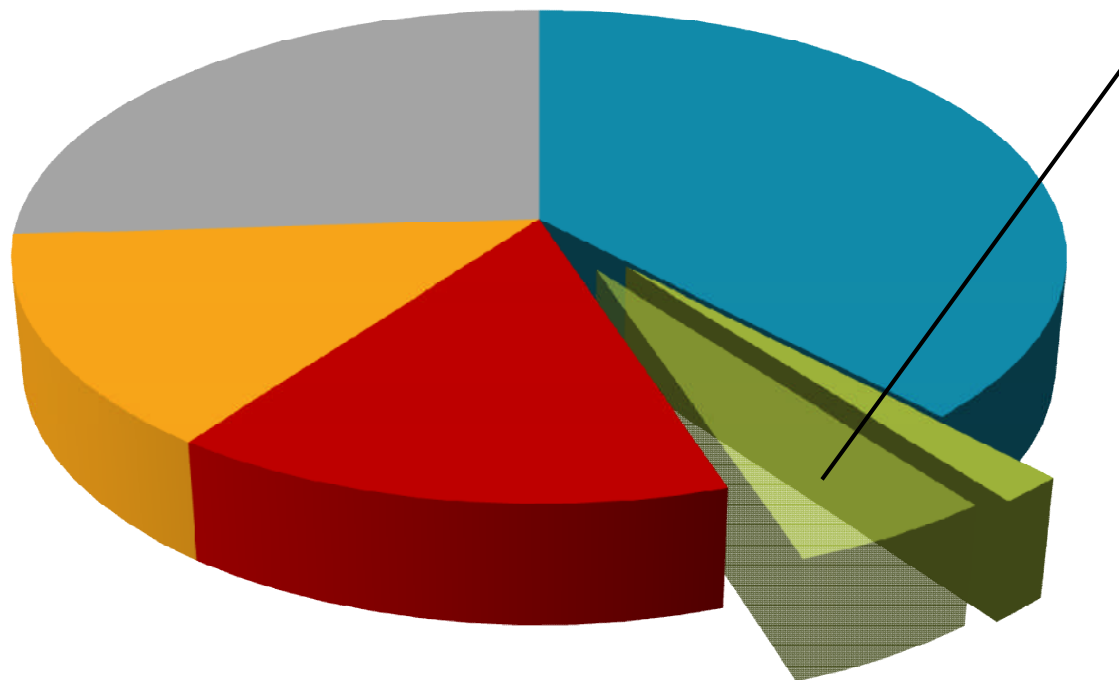The Architecture for the Digital World®

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Memory Solution: Samsung SSD

- Memory ~7% of server power consumption
- SSD >75% power reduction

Server Power Distribution
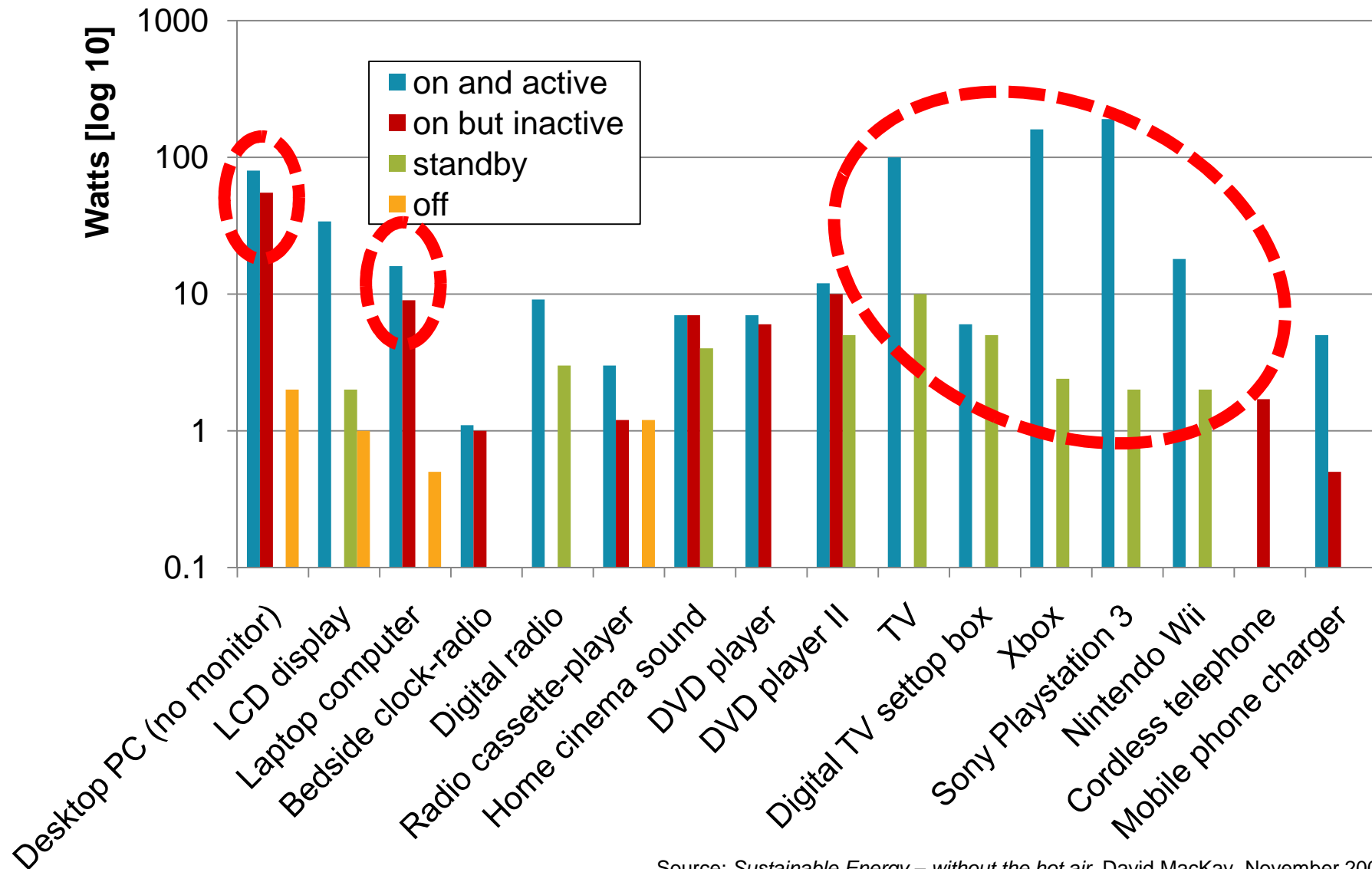

SSD replaces HDD: 75% saving reduces server power consumption by 5.25%

Legend: ■ Memory ■ HDD ■ HDD potential saving ■ Power Supply ■ Other ■ CPU

Source: Samsung
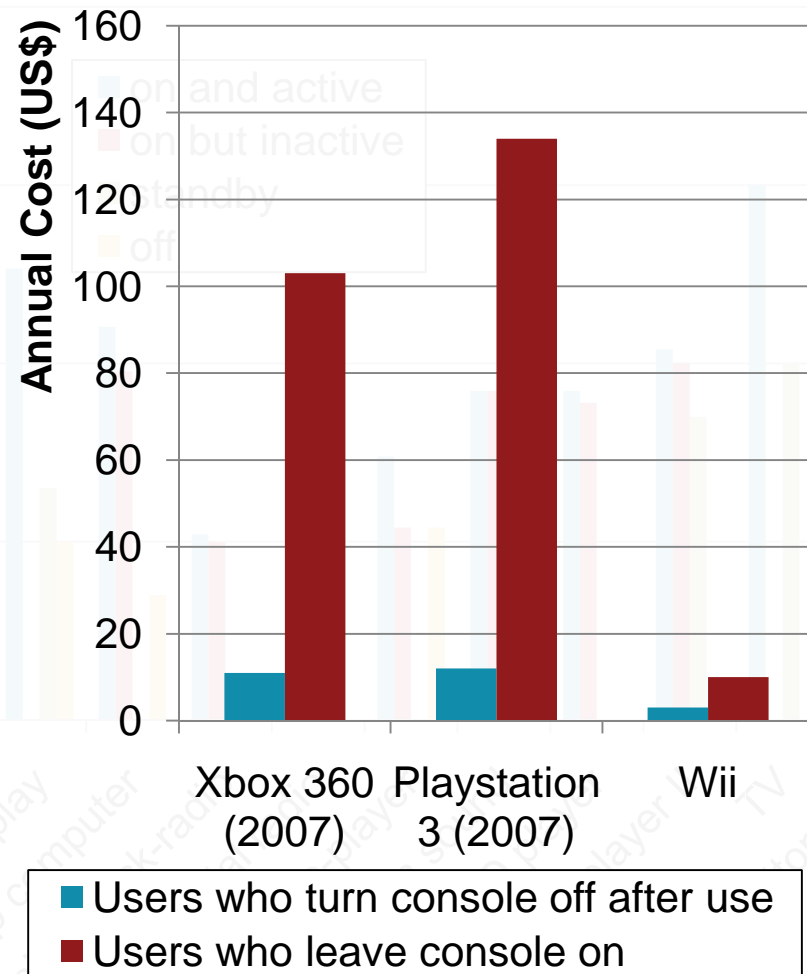
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Some Examples of Poor Design?

Source: *Sustainable Energy – without the hot air*, David MacKay, November 2008

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How Much Can Smart Design Save?

- Helping users power down their games consoles could save 11 bn kWh of electricity in the US and avoid emissions of >7MtCO$_2$ each year

Source: *Improving the Energy Efficiency of Video Game Consoles*, NRDC, November 2008

Legend:
- Users who turn console off after use
- Users who leave console on

Chart axis: Annual Cost (US$) — 0, 20, 40, 60, 80, 100, 120, 140, 160

Categories: Xbox 360 (2007), Playstation 3 (2007), Wii, Xbox, Sony Playstation 3, Nintendo Wii
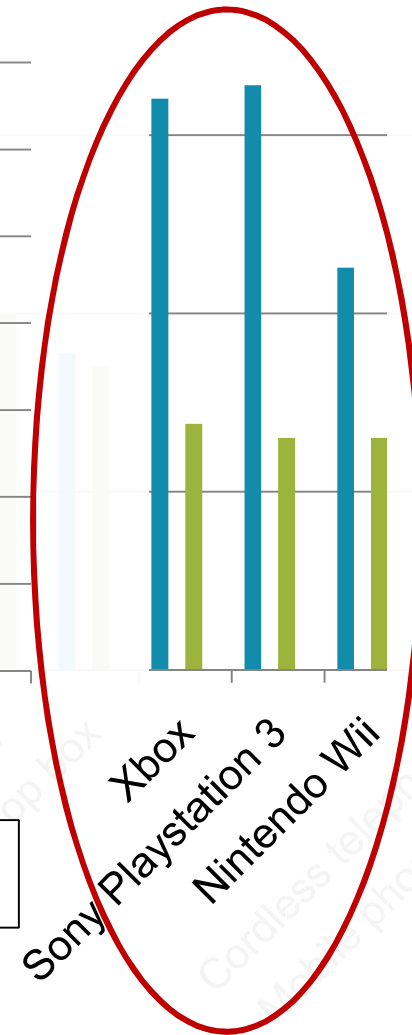
Conclusion

- Use and availability of electronics increasing globally

- World Energy Demand increasing

- Use of "Smart" and low power technology are being used to dramatically reduce emissions

- Electronic products need to be intelligently designed
  - More focus on lower operating energy
  - Lower power consumption means lower total cost

- Smart technology already improving quality of life in many different areas of consumer electronics

Success Through Partnership

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