

Examining the Embodied Energy Consumption of Cloud Computing Datacenters

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Objectives

- Develop a model to estimate the growth of operational and embodied energy consumption of datacenters.
- Optimize the replacement cycle of components for overall energy consumption.

- Taking advantage of advancements in energy efficiency of next generation would require constant replacement of components associated with storage, netorking and computation.

- Replacement is not only costly but also results in increased energy consumption in fabrications and factories producing those components.

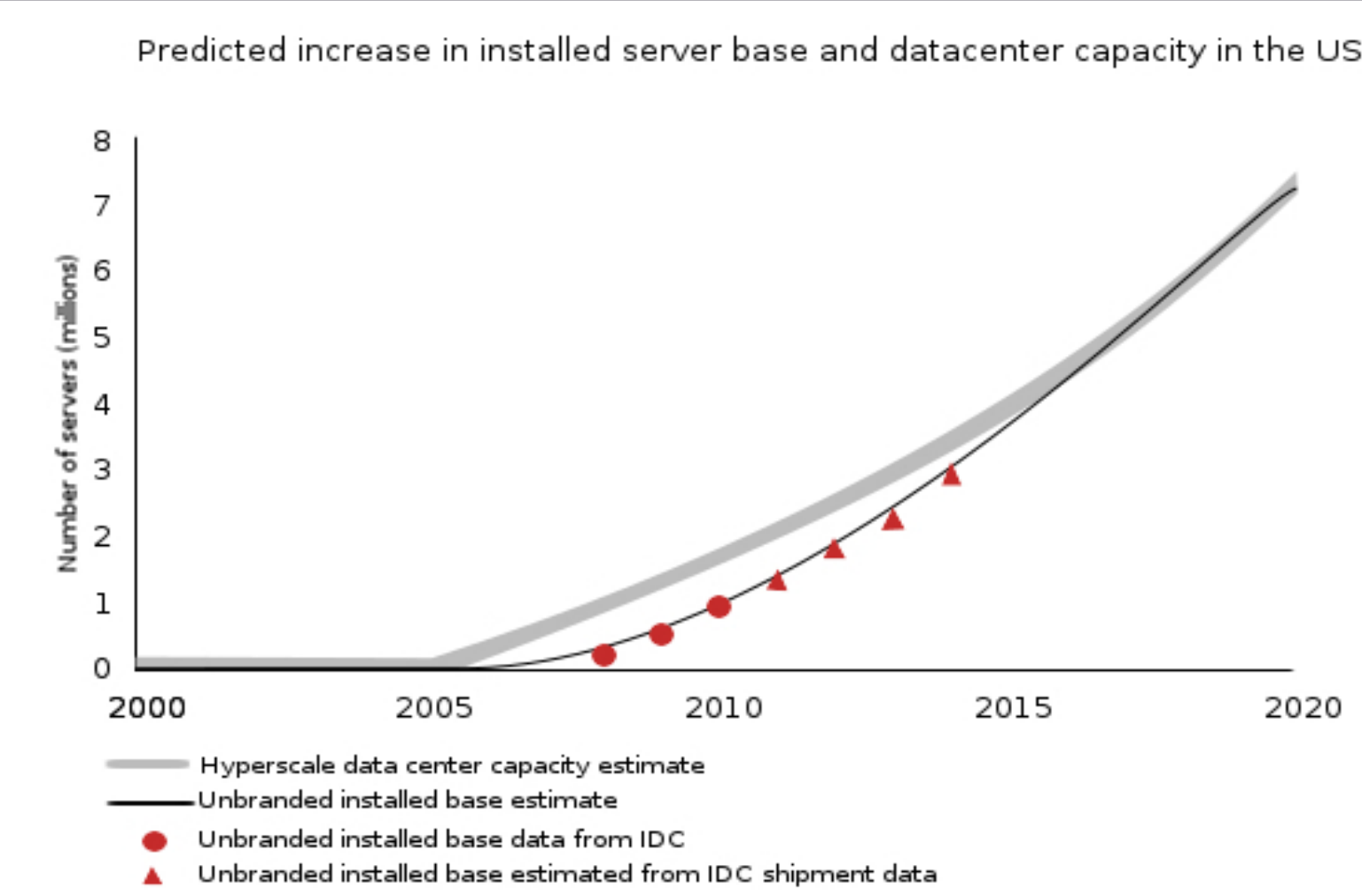
- Only 32.2% e-waste was recycled in the EU in 2014, resulting in a significant sociological and physical impact of extraction of raw materials.

- Reducing the overrall impact of data centers means limiting the production energy whilst maintaining the benefits of next gen technology.

- Data centers consumed between 1% and 2% of the total worldwide energy consumption in 2011.

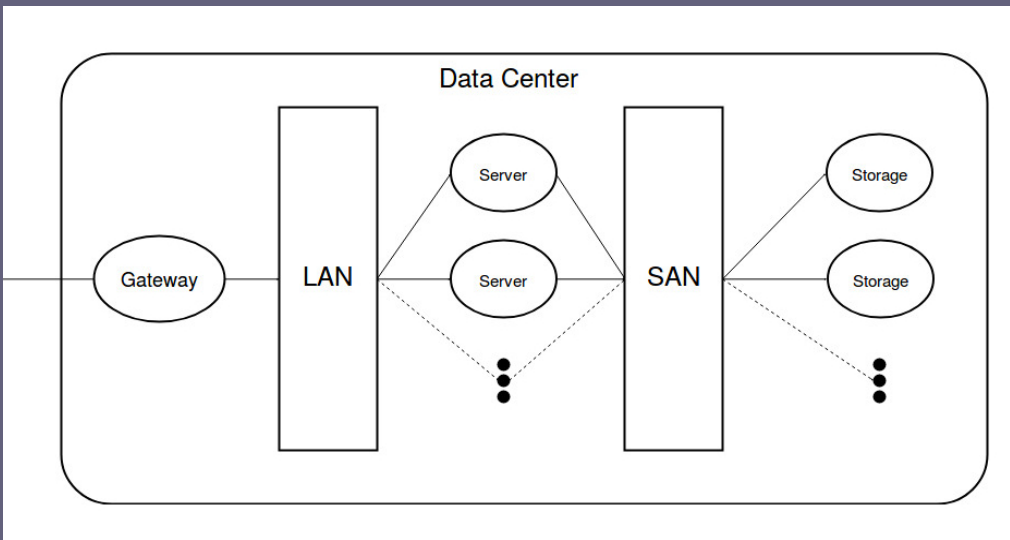
- Energy consumption in data centers contributes a significant cost of running for cloud service providers.

- Installed server base and datacenter capacity increasing every year.



Total energy consumption of a data center can be defined as the combined impact of the operational and embodied energy consumption.

$$E_{total} = E_{op} + E_{em}$$



- Specific data for the energy used in the production of components is not made readily available by the IT sector.

- Reasonable estimates can be made using the material breakdown of components, and data from readily available and well maintained databases presenting the embodied energy and recycling rates of raw materials.

Component	PCB(%)	Semiconductors(%)	Steel(%)	Other(%)	Source
Server	37.23	30.76	24.03	7.98	
Switch	29.71	53.99	13.23	3.07	
SSD	3	93	1	N/A	

Monte Carlo Simulation

- Performance predictions for next generation equipment are not precise.

- Uncertainty is accounted for by using Monte Carlo simulation techniques.

- The replacement of components due to normal failure, as well as those which components which are upgraded at the appropriate time in the replacement cycle, are simulated using random sampling.

- The ratio of power consumption at idle to full levels of utilization for blade servers shows a steady downwards trend, indicating an increase in energy proportionality and therefore energy efficiency.

- The power consumption for enterprise SSDs has remained at a steady rate, while the capacity of said SSDs has increased, showing again a trend towards more energy efficient offerings.

