

# *Systems Thinking for Radically Efficient and Profitable Data Center Design*

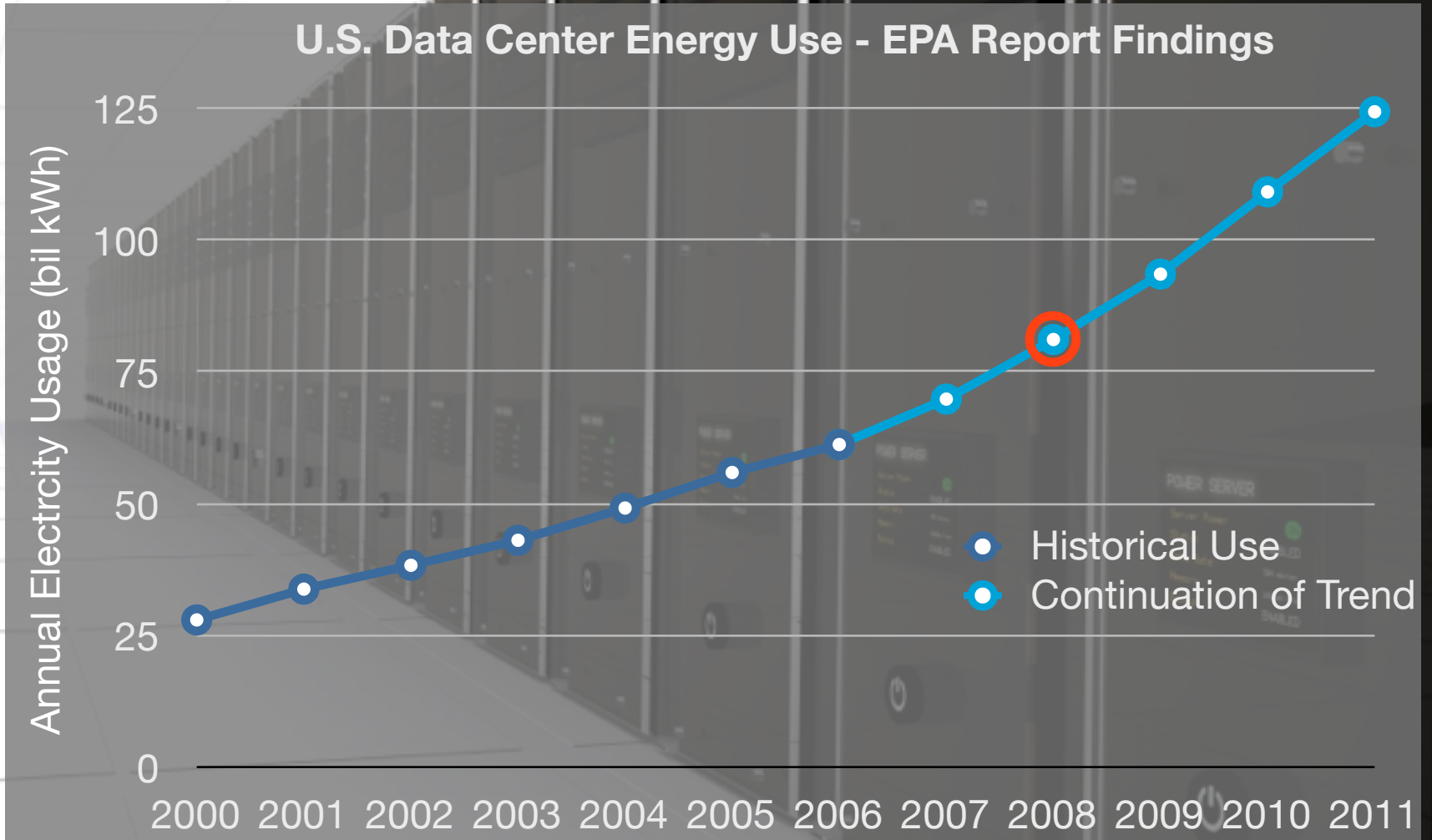
**Bryan Palmintier & Sam Newman**  
**Rocky Mountain Institute**

**Next Generation Data Centers Conference**  
**August 5, 2008**



**Rocky Mountain Institute**

Energy use and cost for data centers is rising exponentially, demanding attention.



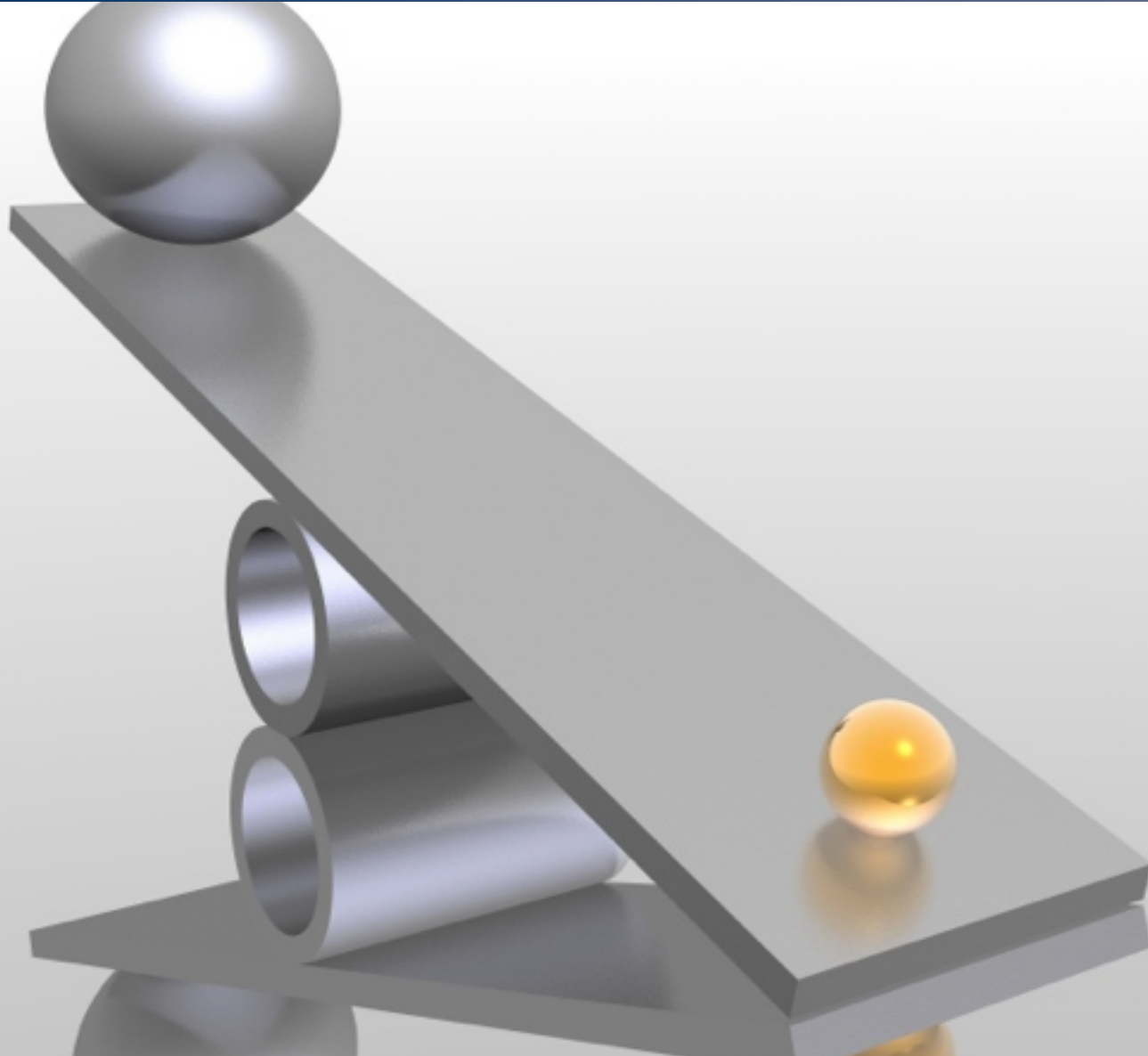
Energy now affects everyone involved in the data center and IT business.



Data center energy growth threatens profitability and contributes to global climate change.



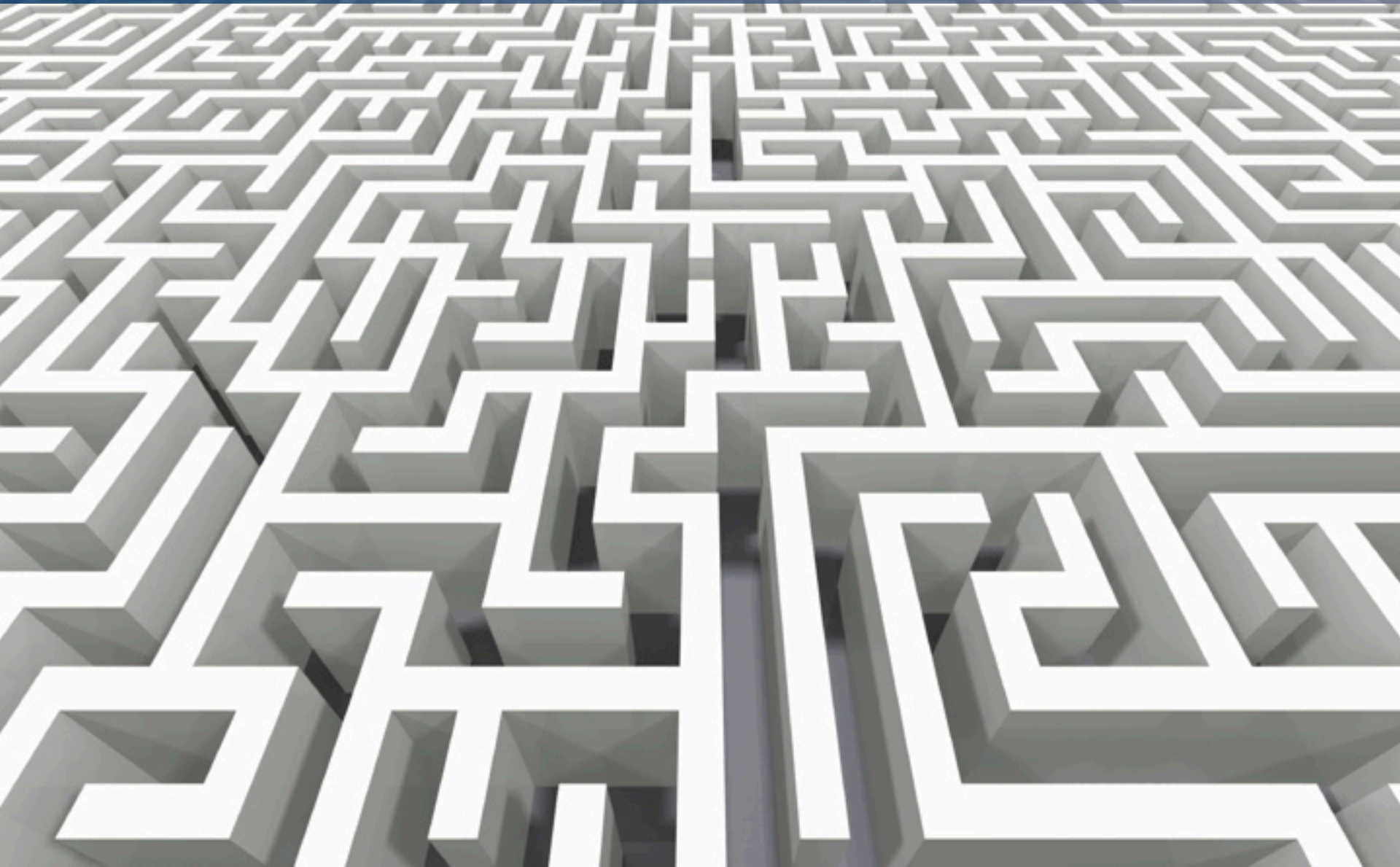
But, it is possible to provide computing services with 95-99% less energy than today.



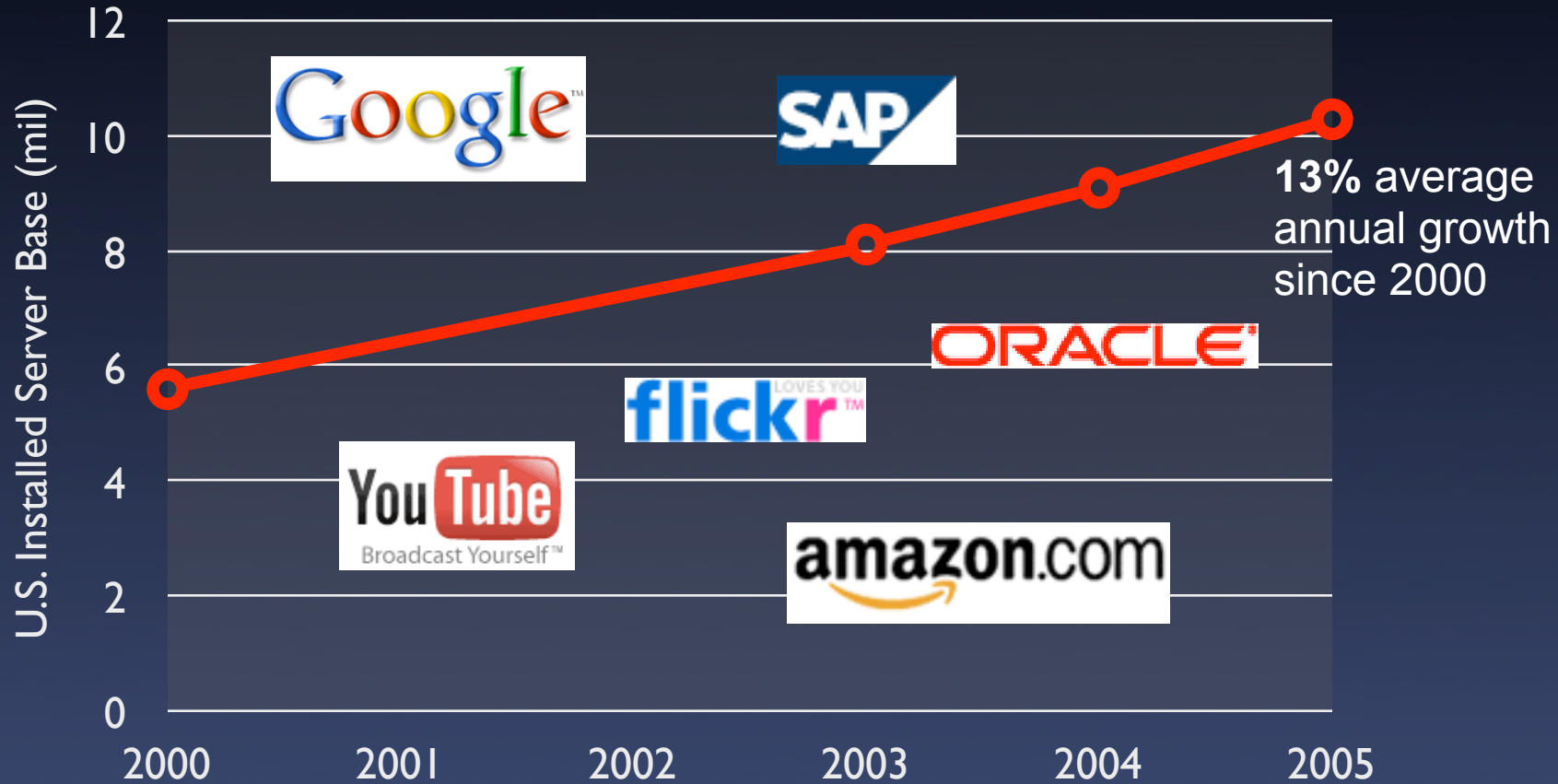
How? Through systems thinking applied to readily available technologies.



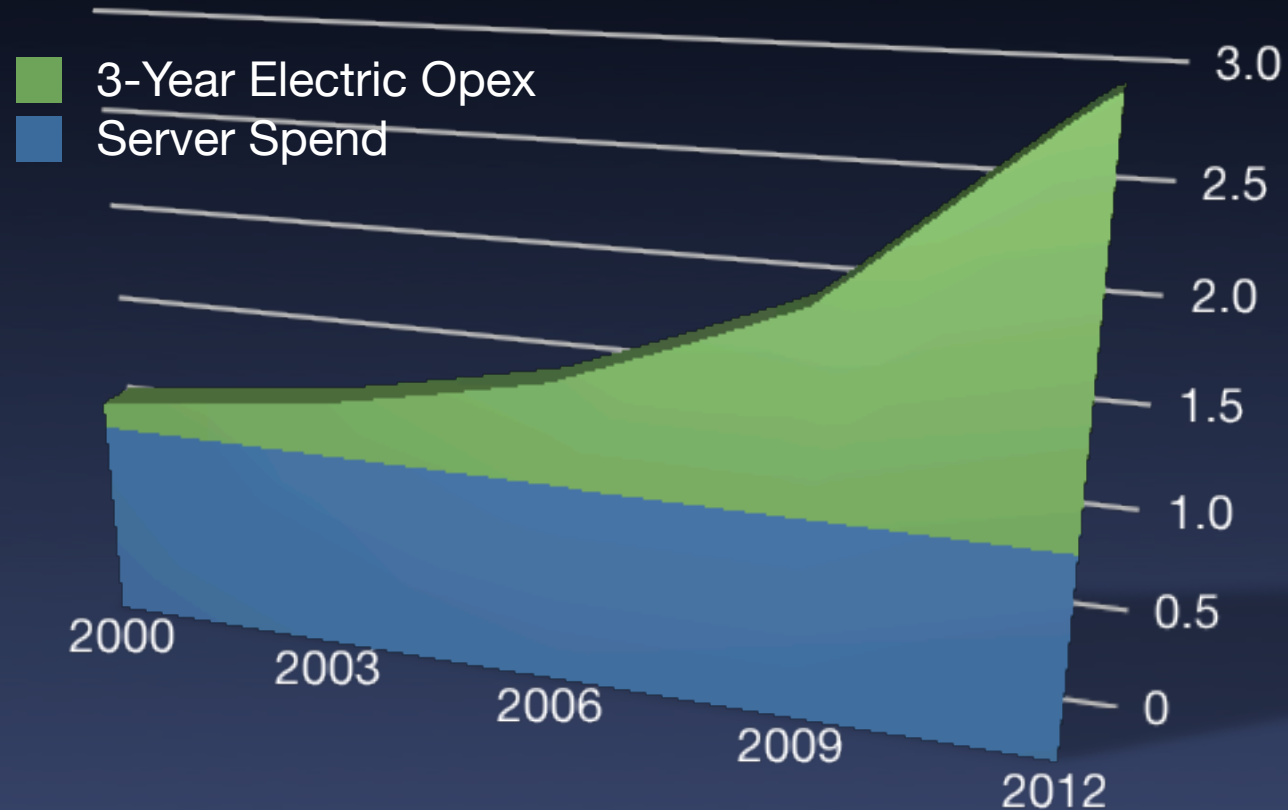
First, how did we get into this mess?



# Business growth in the IT sector has driven data center capacity expansions.



Historically, data center designers and operators all but ignored energy usage.



Because energy costs were once just a small part of overall cost structure.

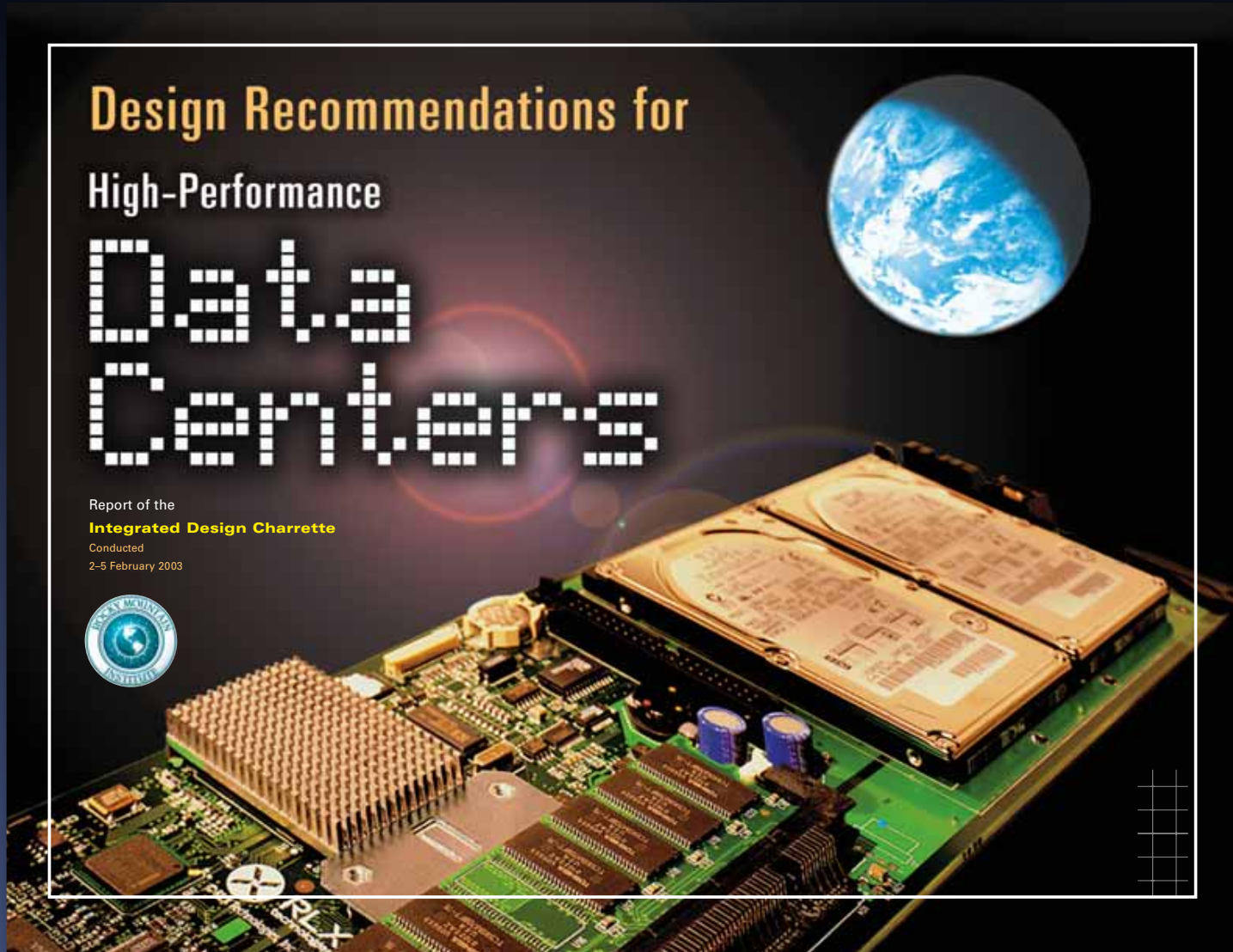
Today's rapidly rising energy costs are putting us on a collision course with flatter revenue growth.



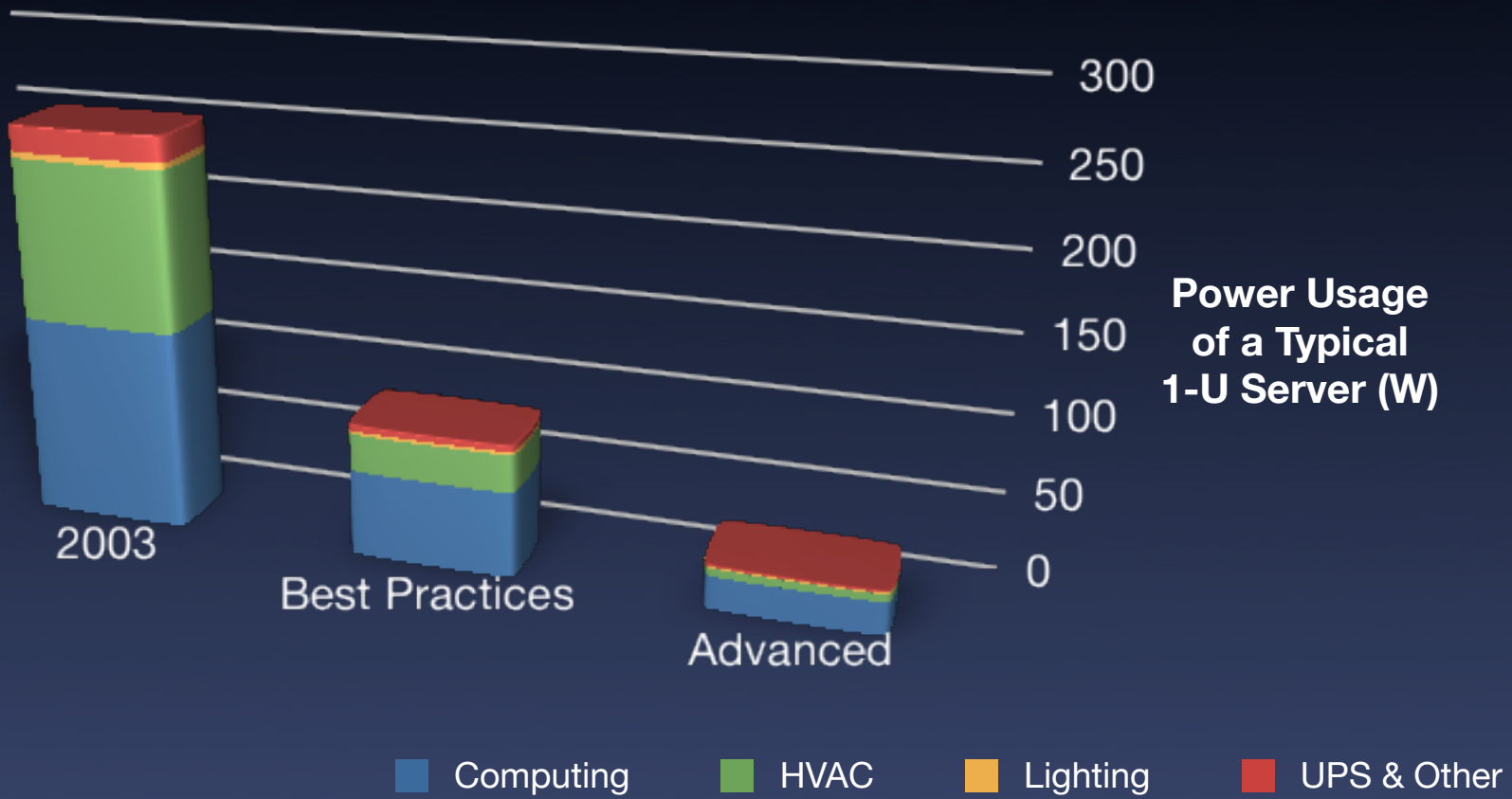
Now, how do we get out of this mess?



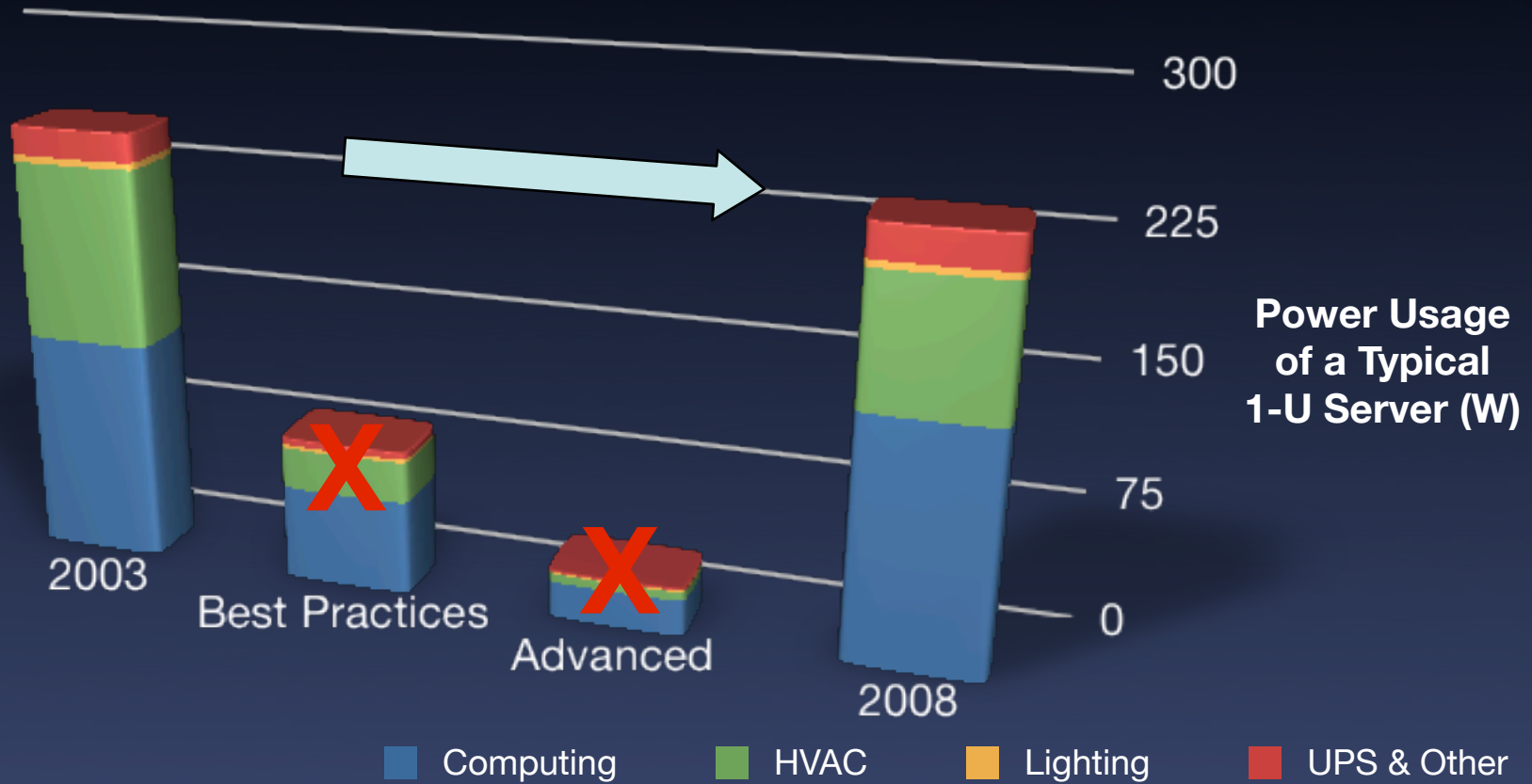
In 2003, RMI hosted a design charrette for high performance data centers.



In 2003, the transdisciplinary team identified 10x in energy savings potential.



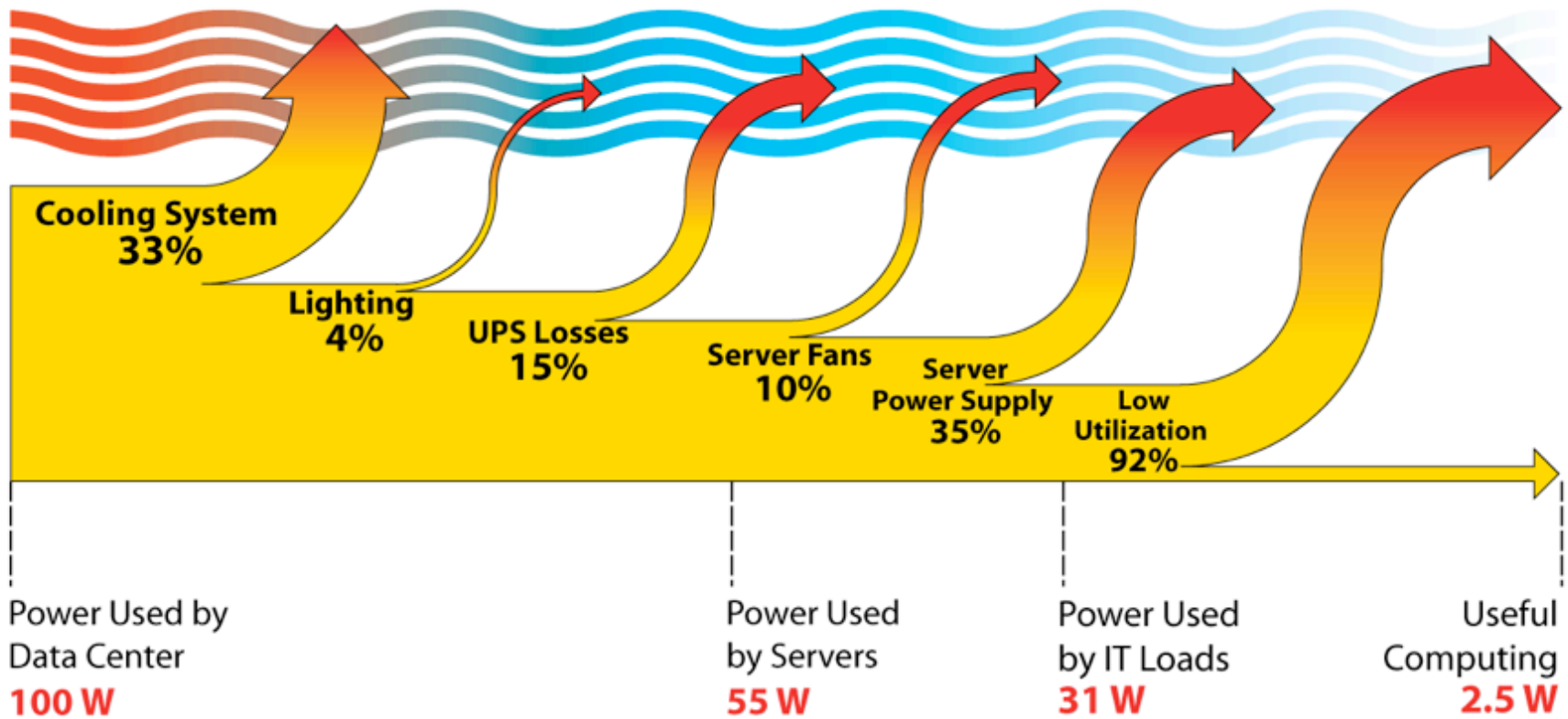
# Yet today, data centers remain remarkably inefficient.



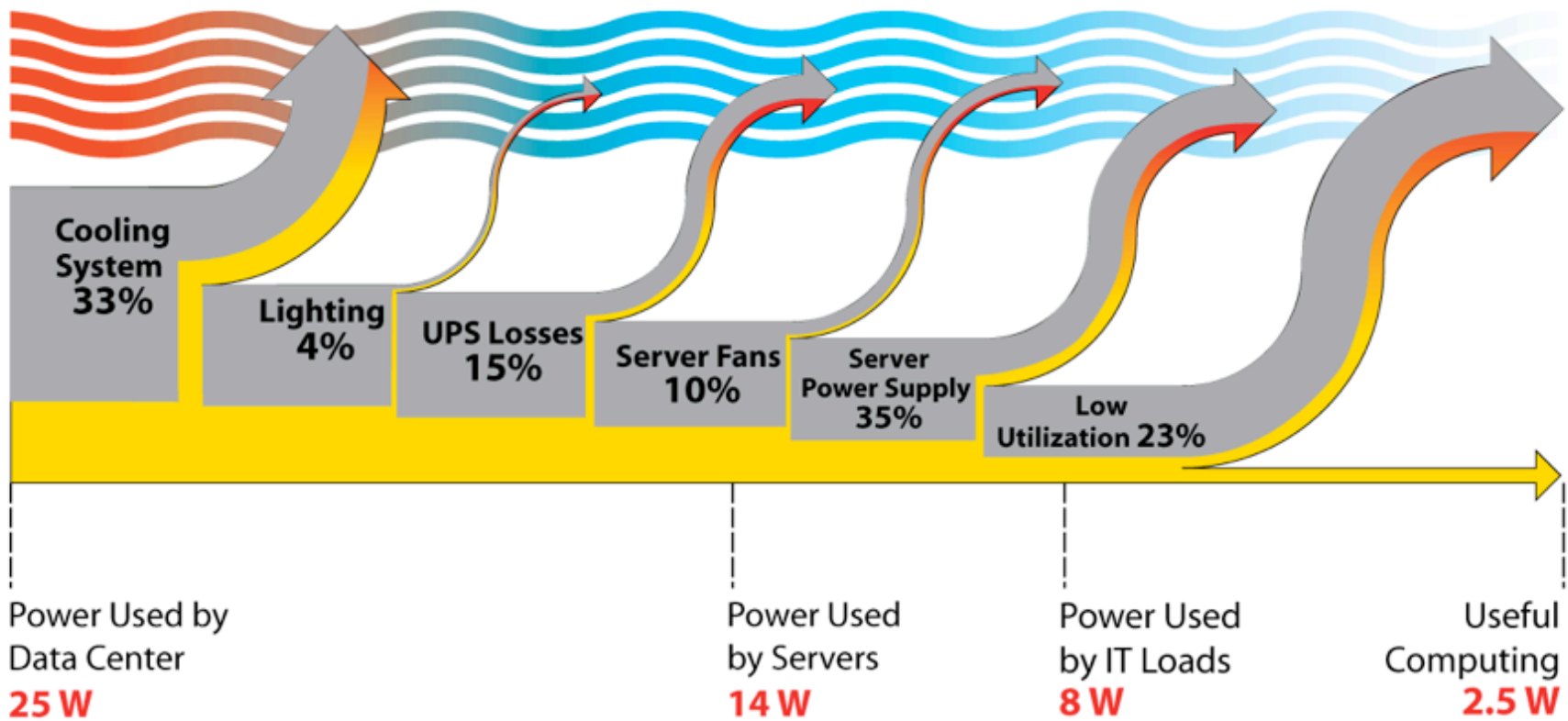
Why?



# Whole systems design: Focus (first) on the desired *service* output.



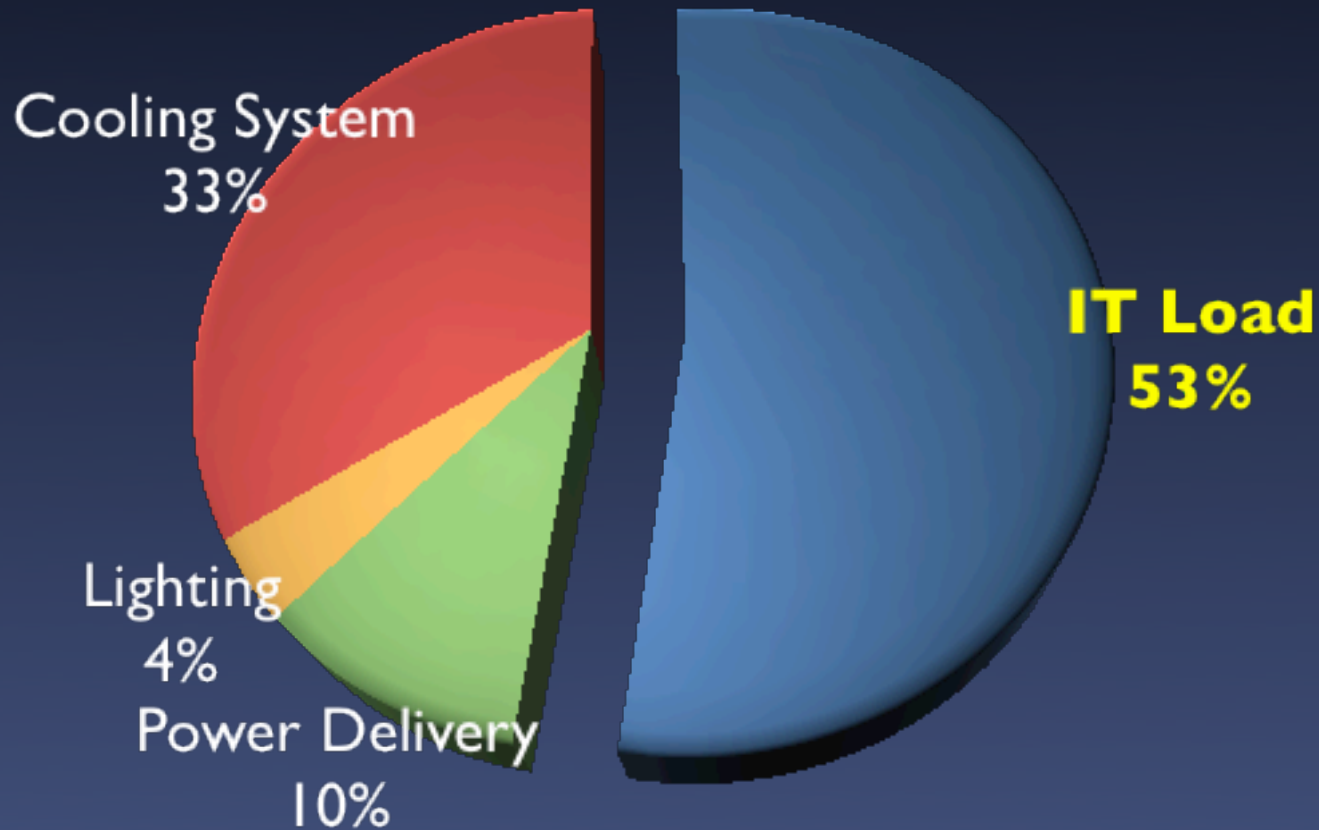
# Whole systems thinking: end use efficiency savings multiply through upstream inefficiencies.



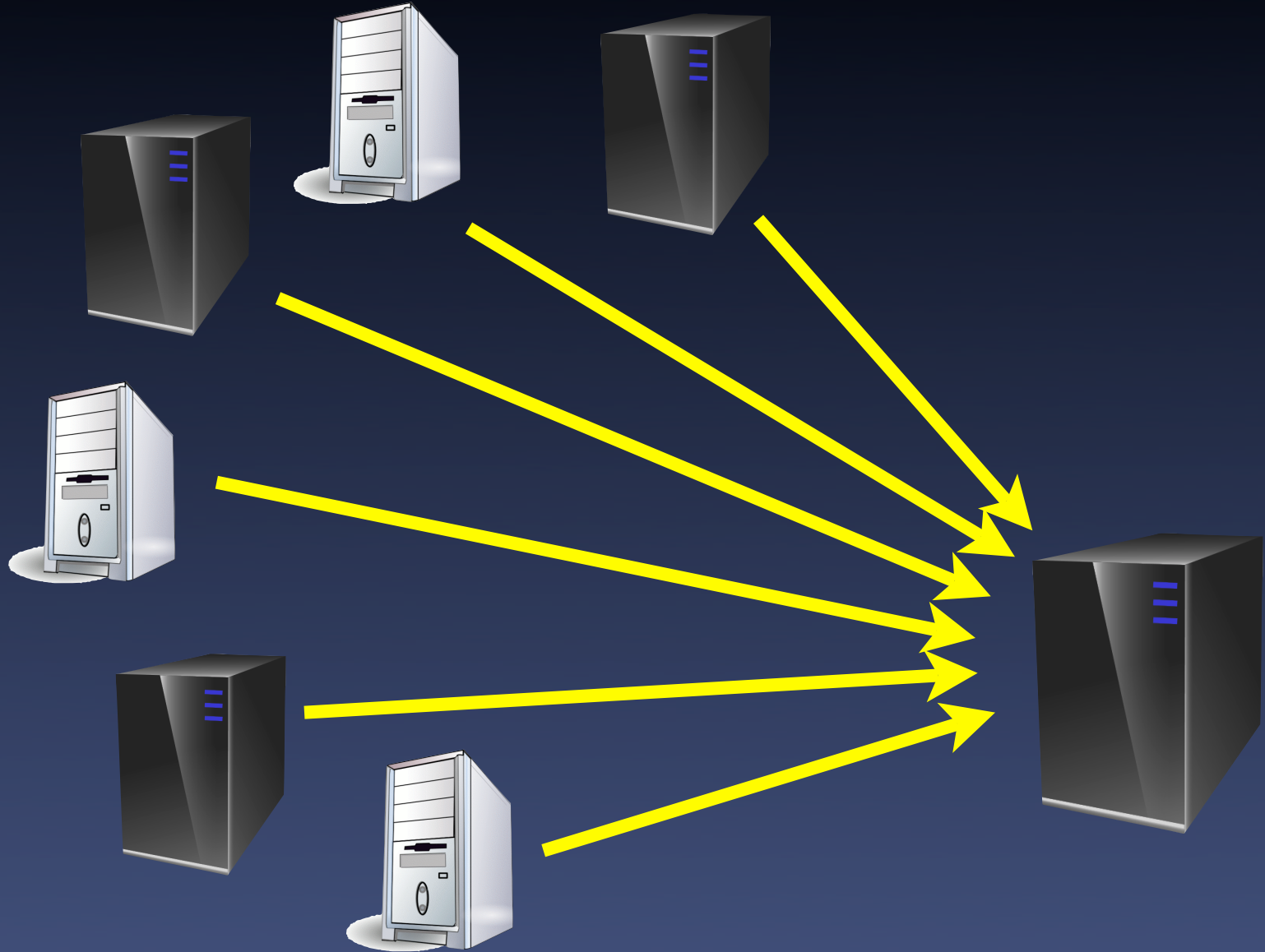
Let's walk through savings strategies collected from a number of real designs in our client work.



# IT load

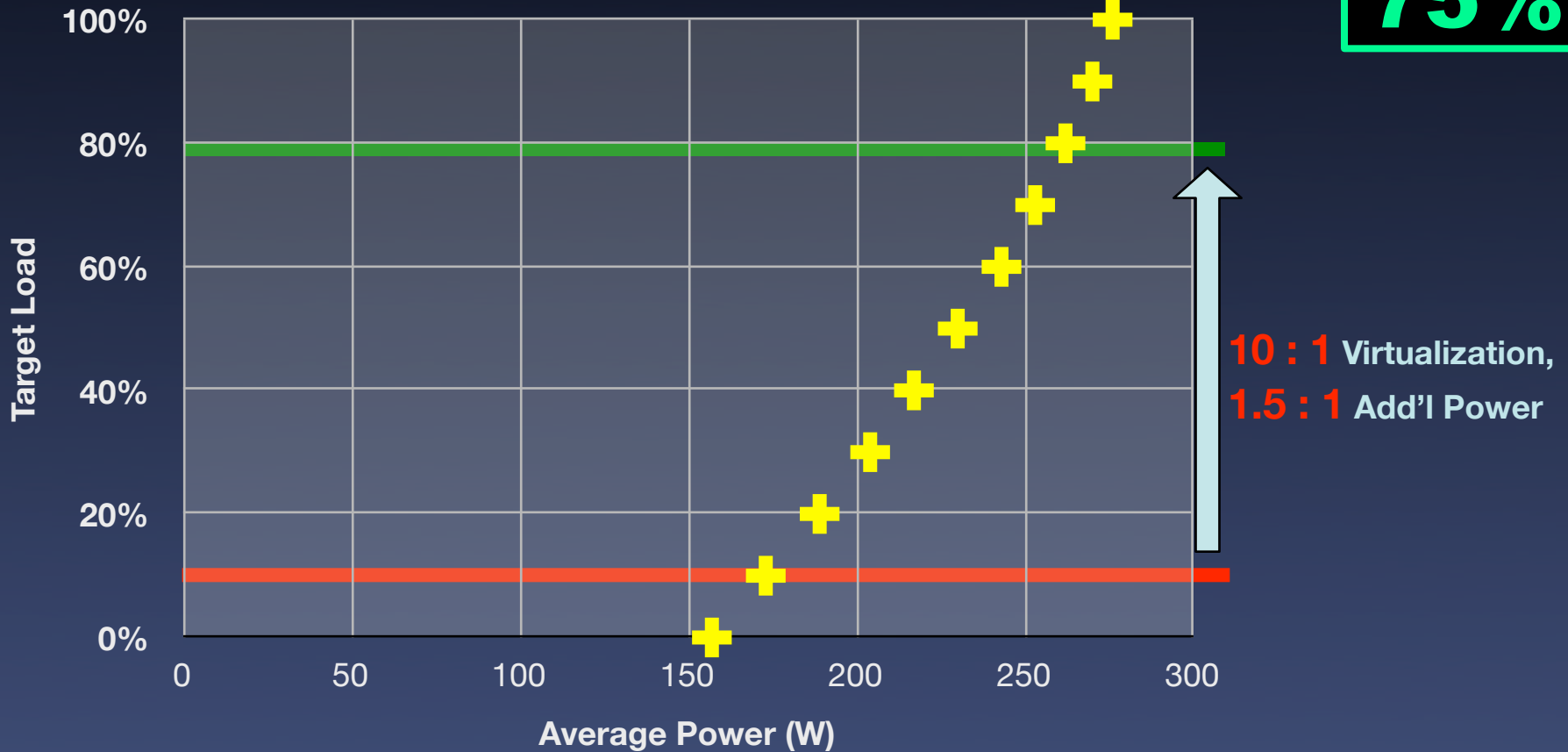


# Server virtualization delivers tremendous energy savings...



# Server virtualization delivers tremendous energy savings...

Server Savings  
**75%**



Data for Dell 2950 III (Intel Xeon E5440) from specPower

... but, it is only the beginning.

- As many as 10% of running servers are not used at all.
- Multiple applications can run on a single virtual machine.

Server  
Savings

**15%**

And these other types of *consolidation* provide further energy reductions.

... but, it is only the beginning.



Selecting and configuring efficient server models and builds provide large savings.

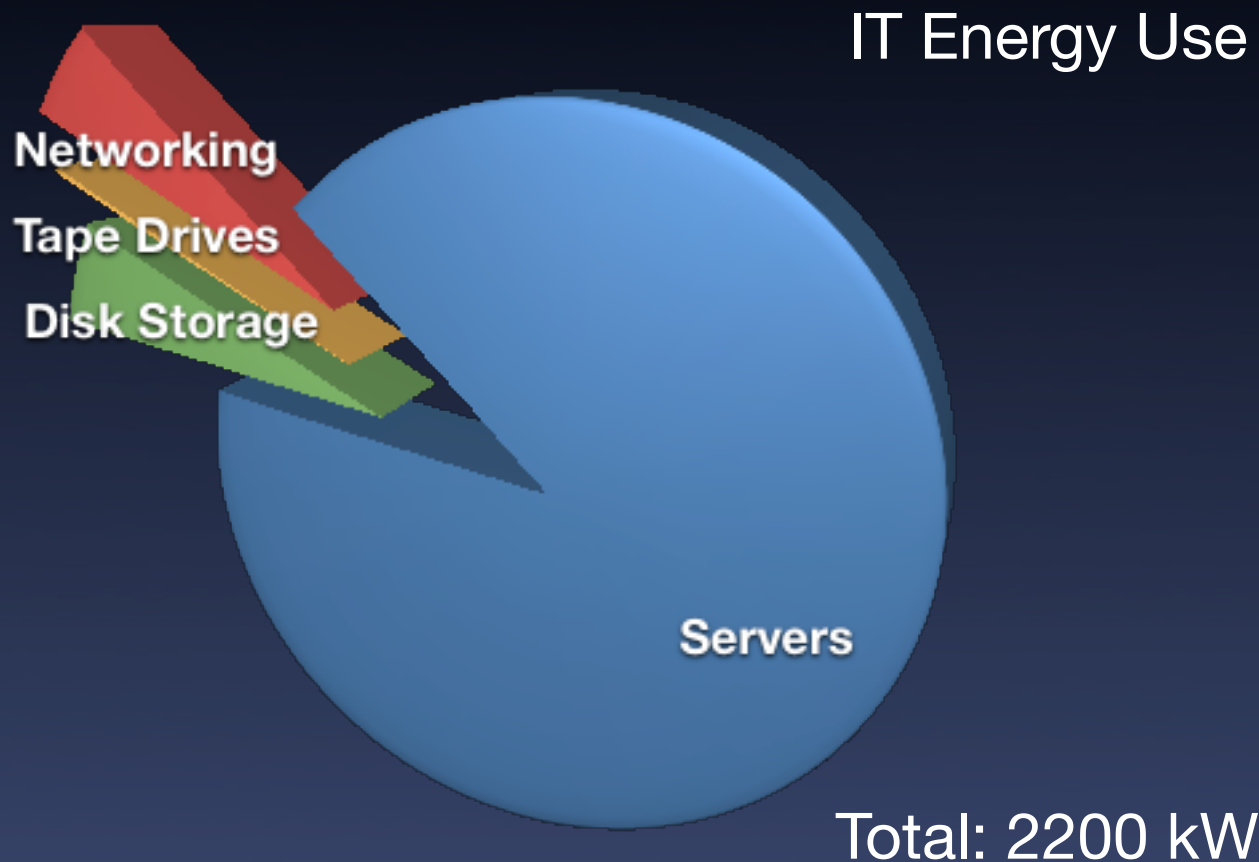
Server power supplies are another potential source of savings.



Server  
Savings

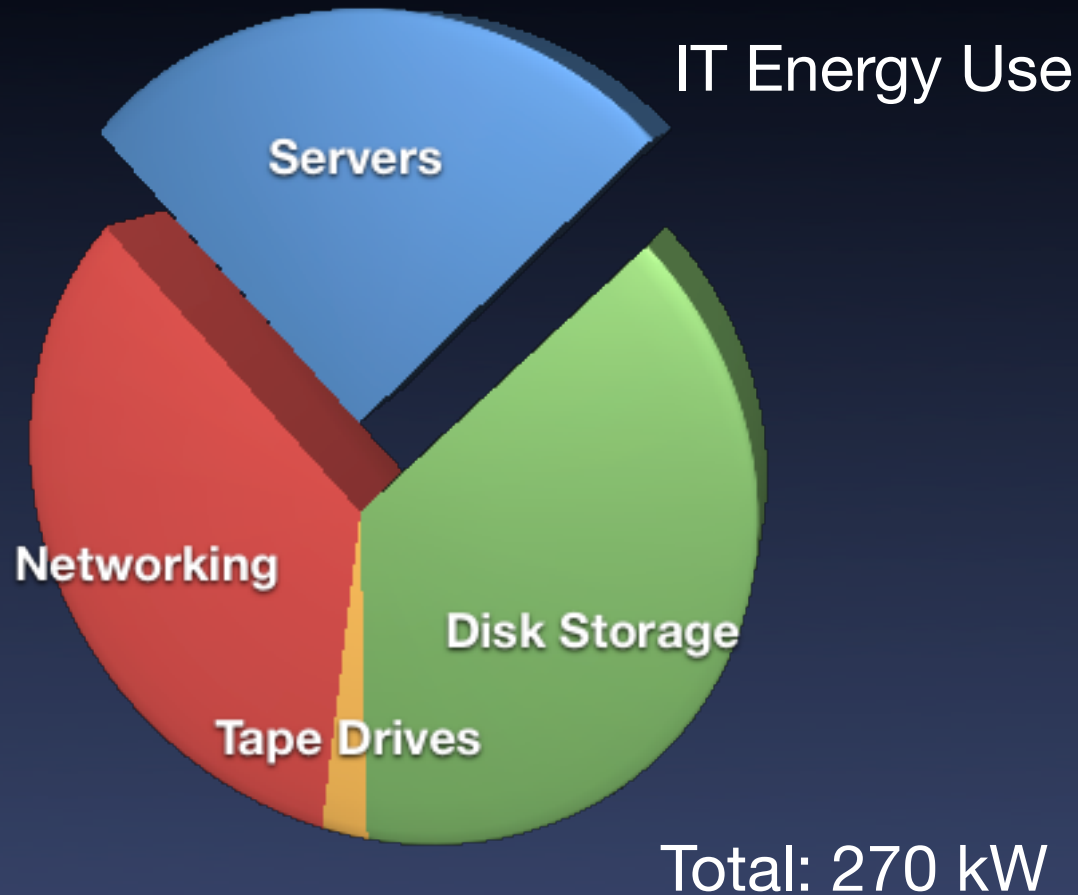
**40%**

And don't forget other hardware, particularly storage and networking.



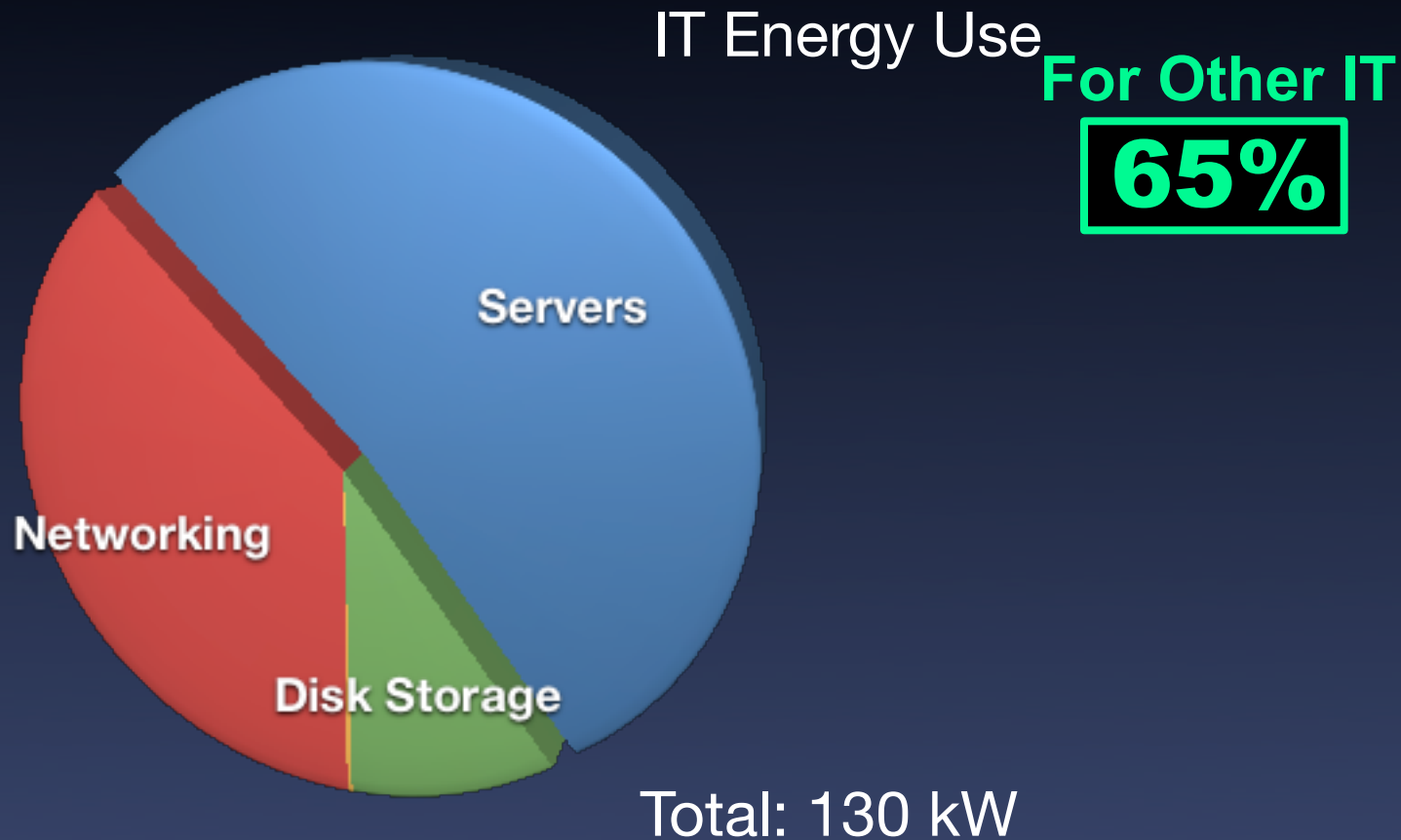
Today, these loads are small compared to servers.

And don't forget other hardware, particularly storage and networking.



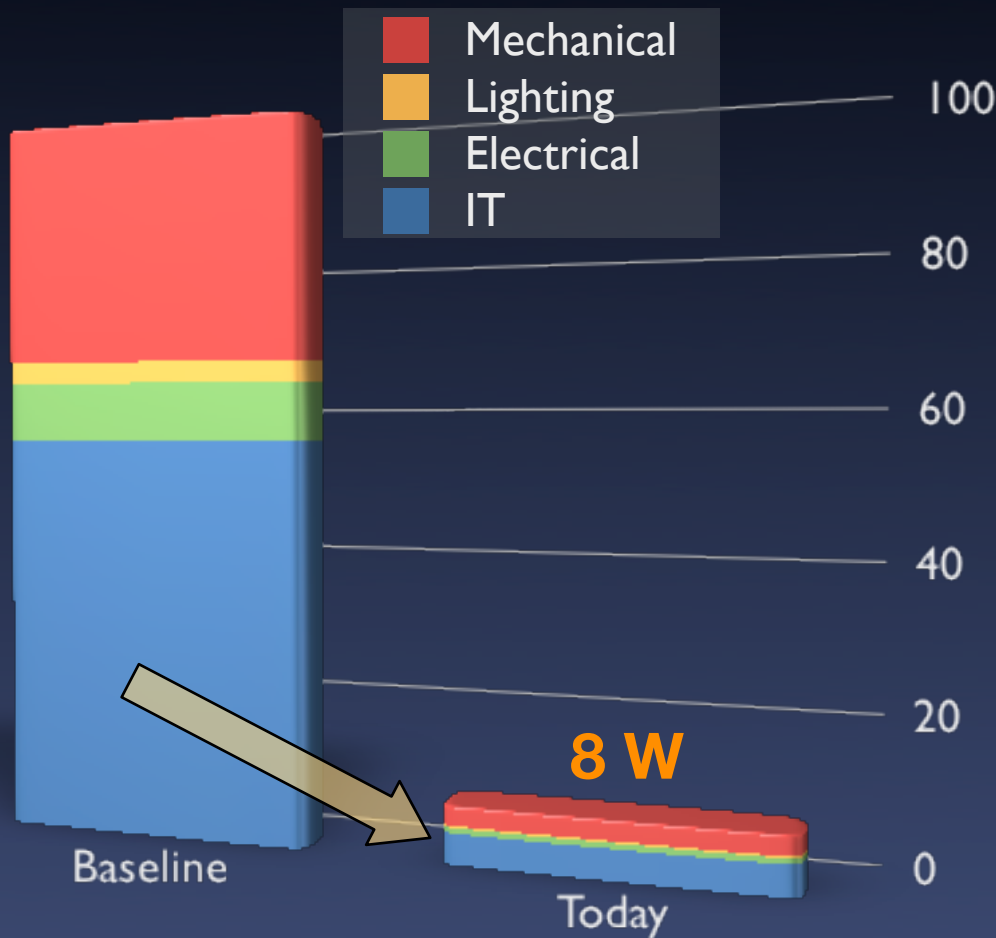
But after server virtualization and consolidation, these “other” loads dominate.

And don't forget other hardware, particularly storage and networking.



Efficient hardware and consolidation of networking and storage provide big savings in a virtualized data center.

# Savings from IT system optimization:



Total  
IT Savings

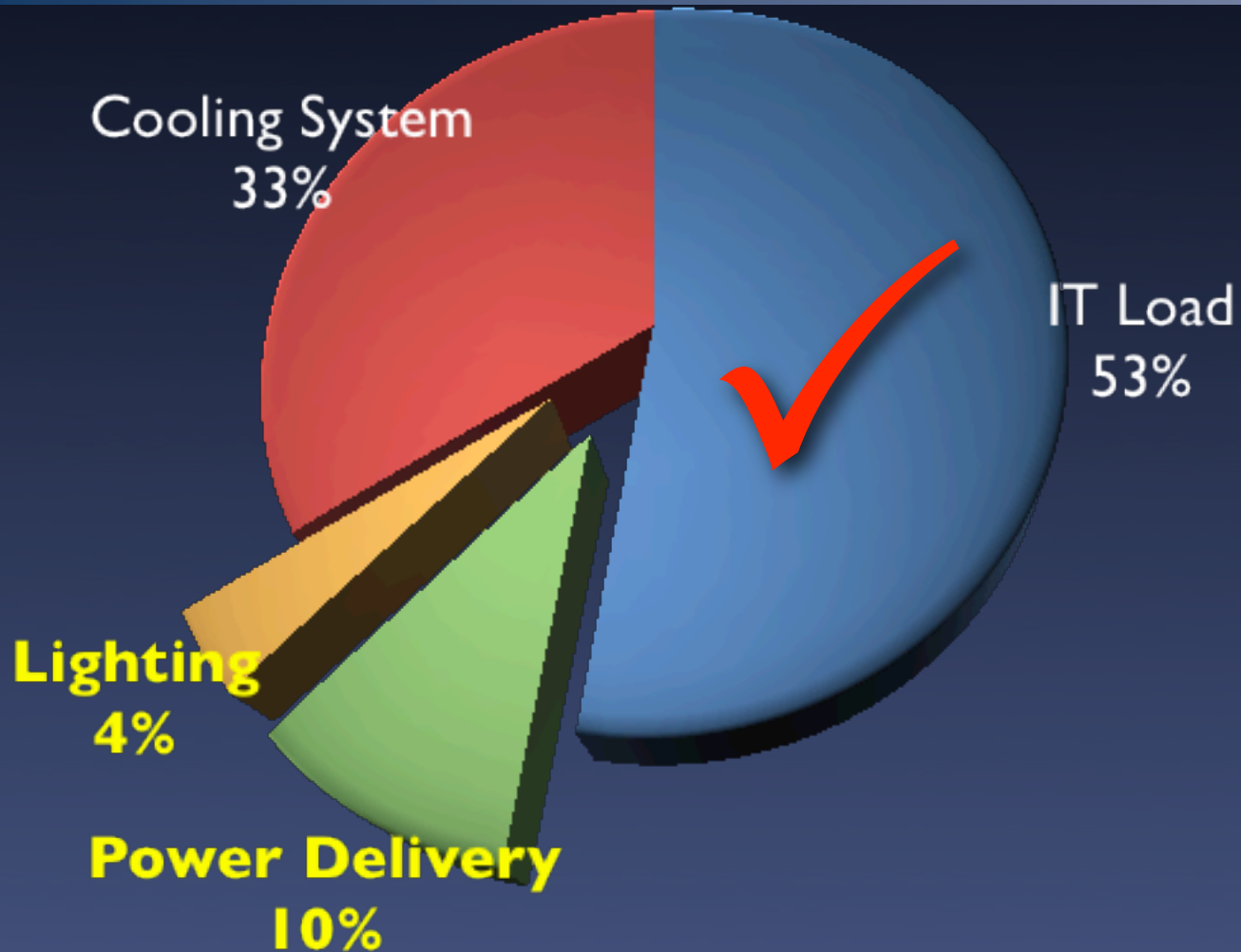
**92%**

Datacenter  
Savings for IT  
alone

**92%**

Effects of IT Savings only

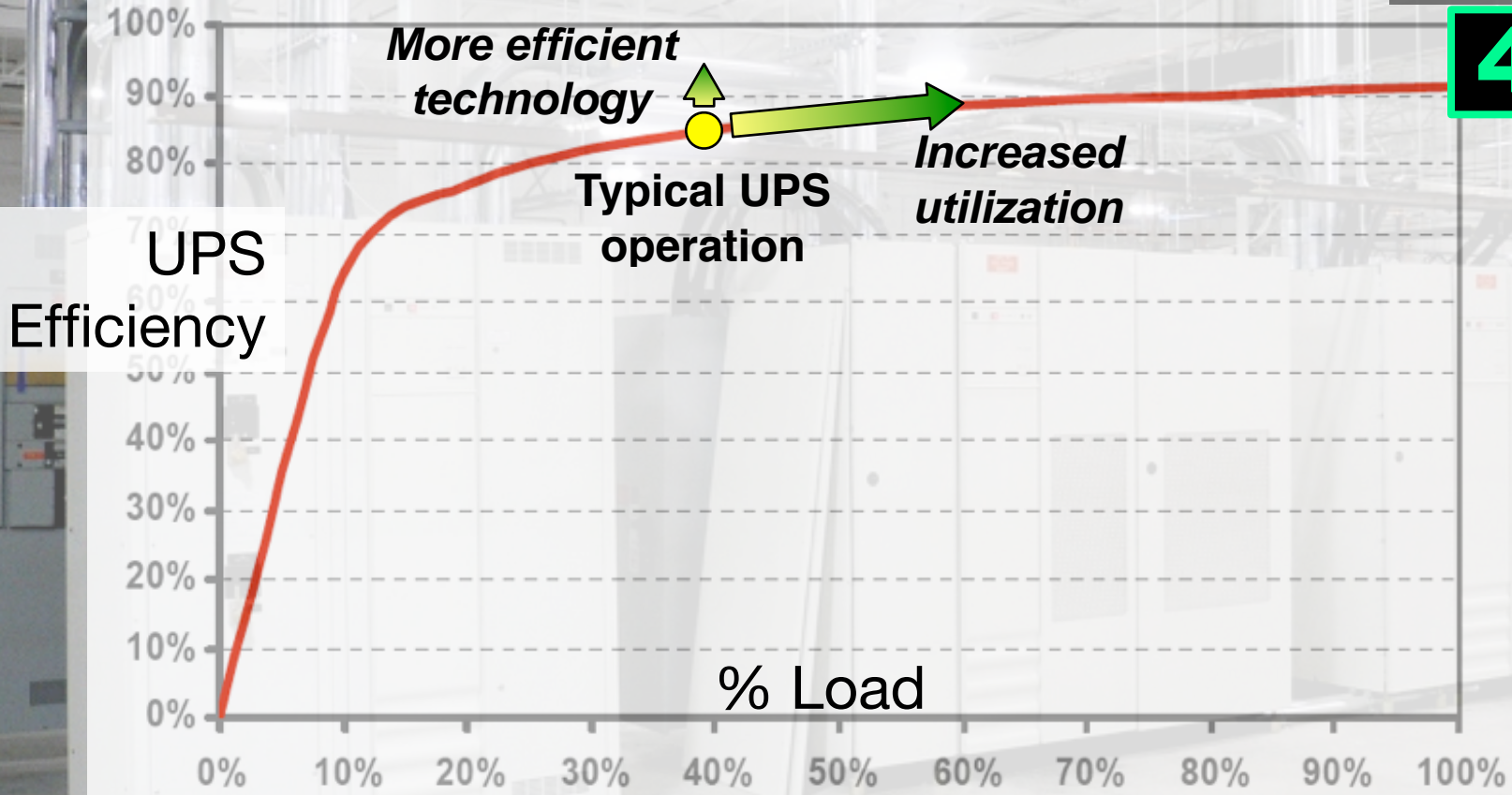
# Additional Loads



# Right sizing, efficient equipment, and increased utilization reduce electric supply losses.

UPS Loss Reduction

**40%**



UPS Efficiency

More efficient technology

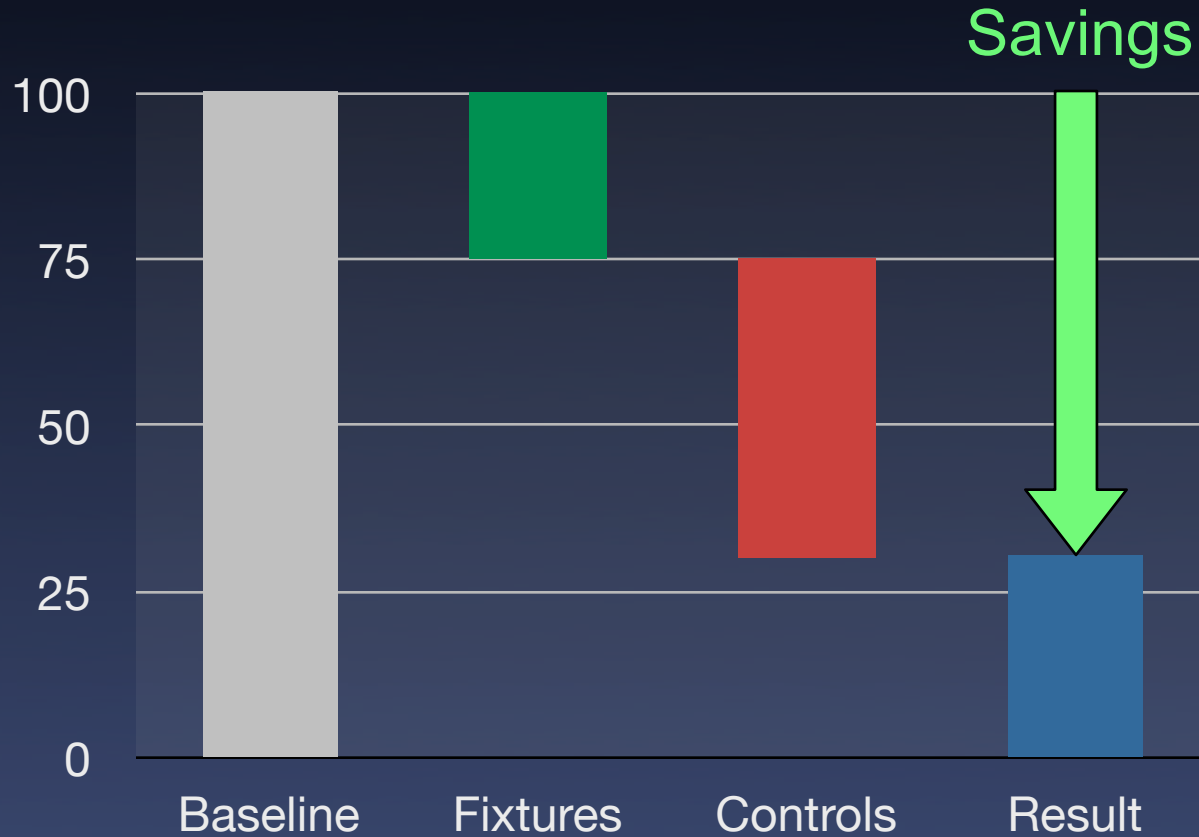
Typical UPS operation

Increased utilization

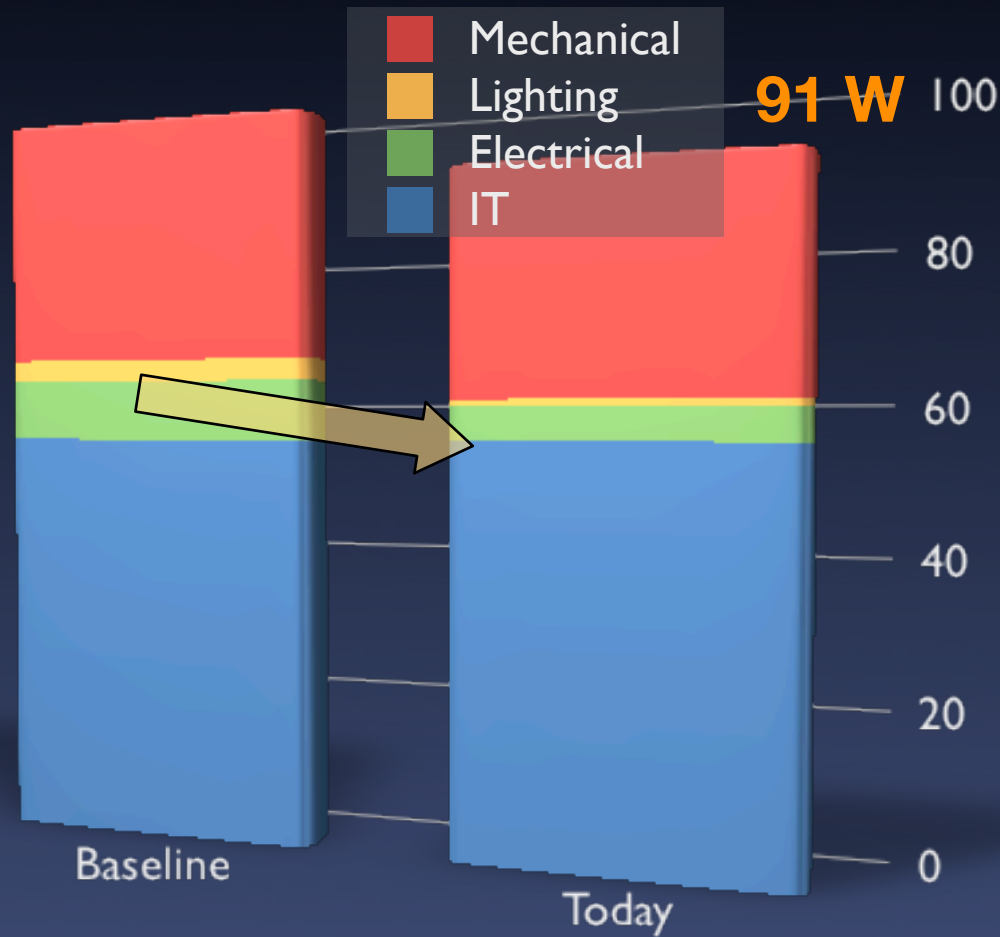
% Load

# Better technologies and controls reduce lighting loads.

Lighting Savings  
**70%**



# Savings from electrical and lighting optimization:



**Electric + Light Savings**

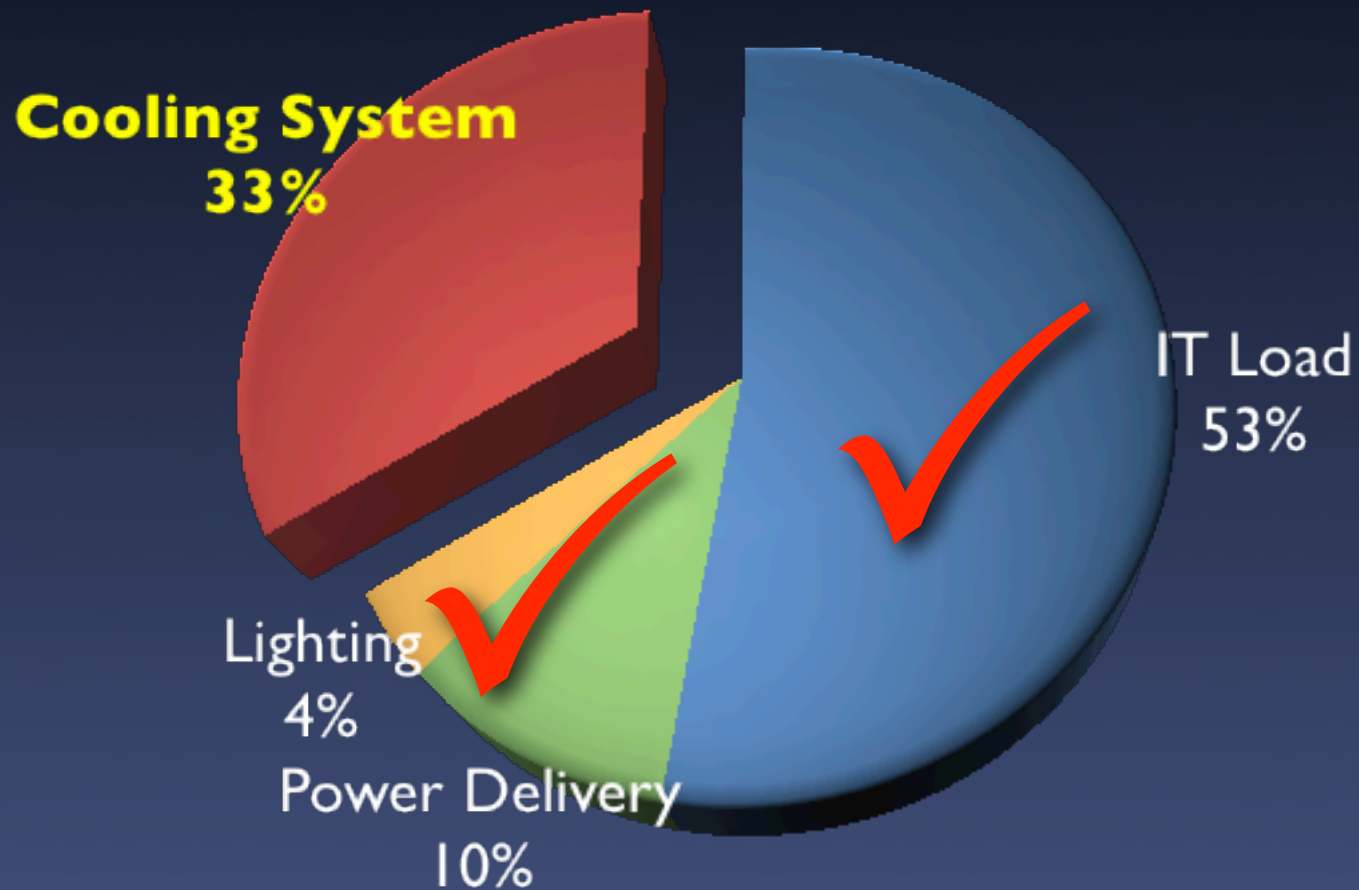
**70%**

**Datacenter Savings for Electric + Light alone**

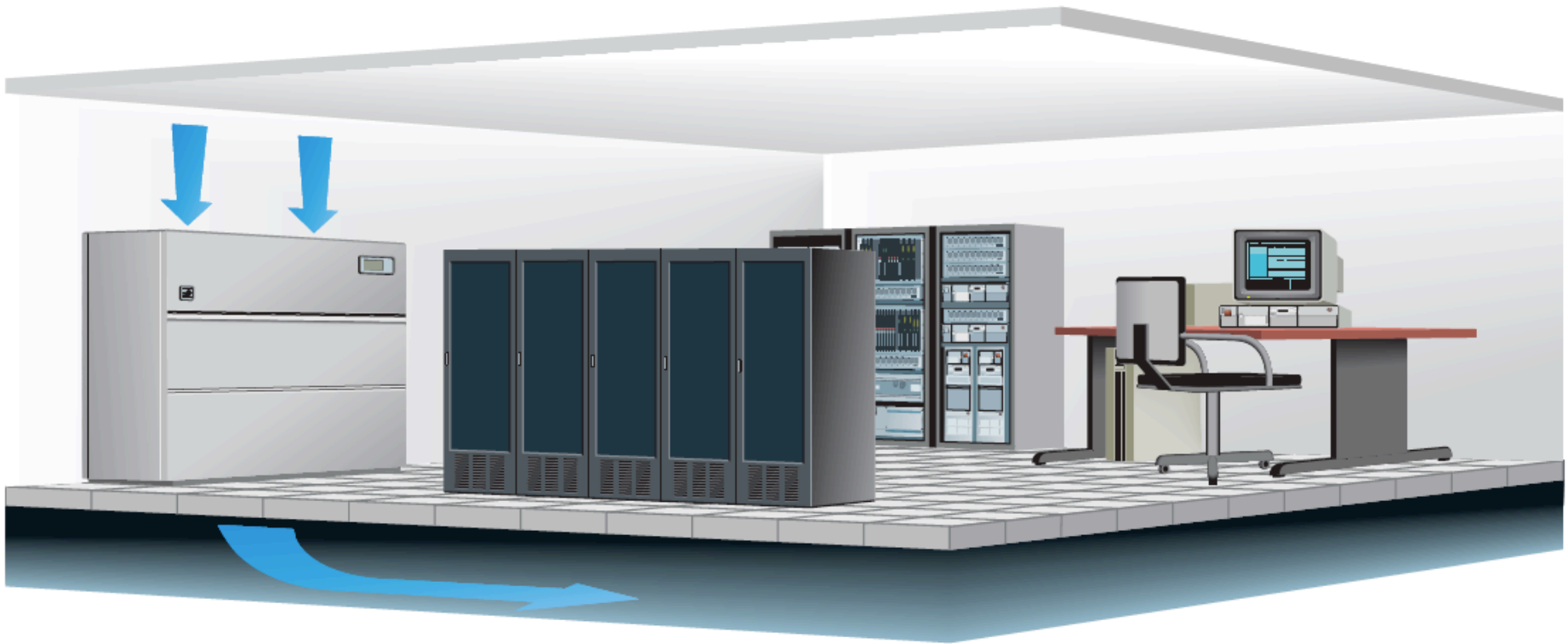
**9%**

Effects of Lighting & Electrical Savings only

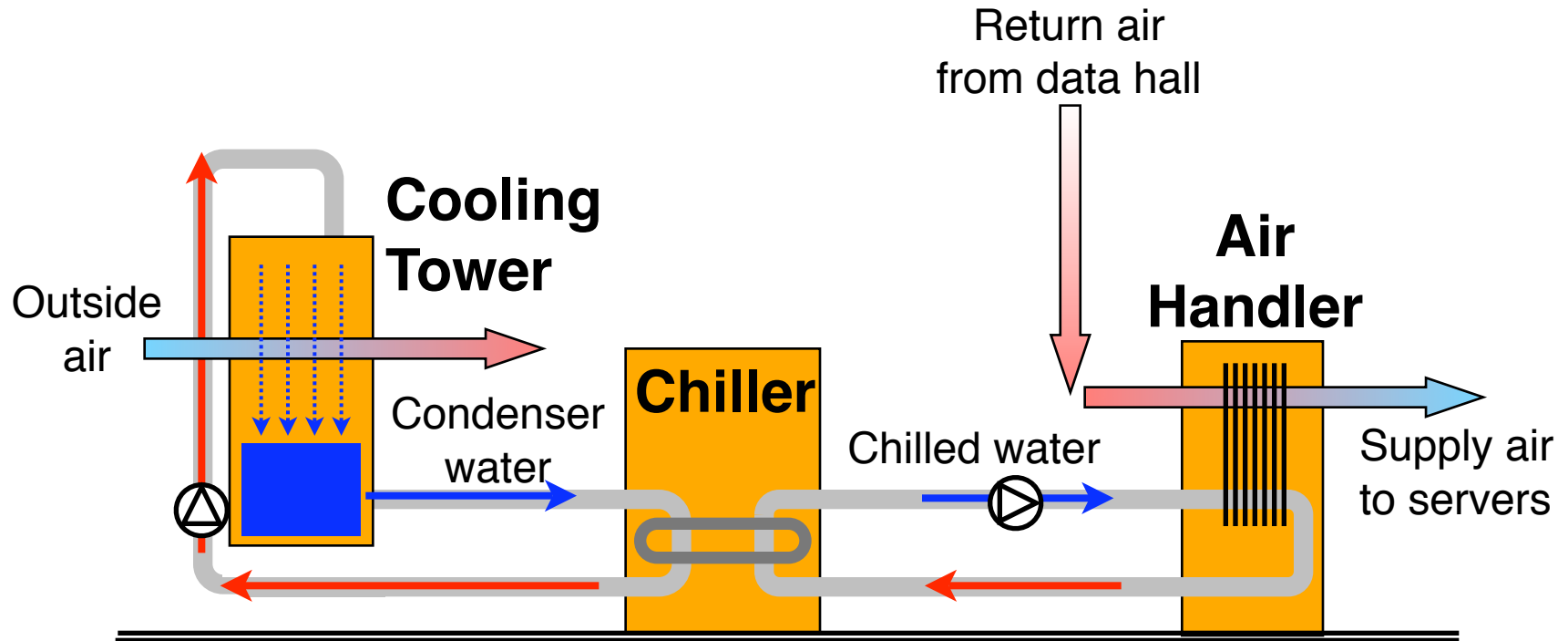
# Cooling



Today's cooling systems tend to be closed loop based on lots of small units.

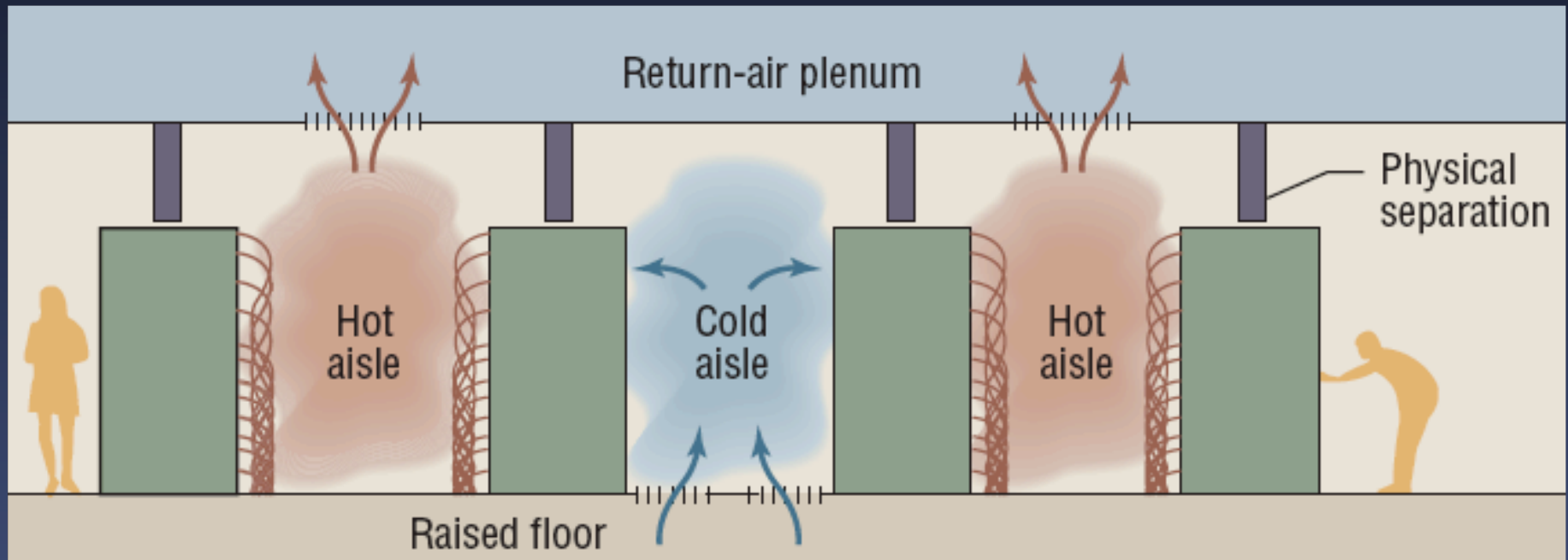


# A centralized cooling system cuts energy use by at least half.



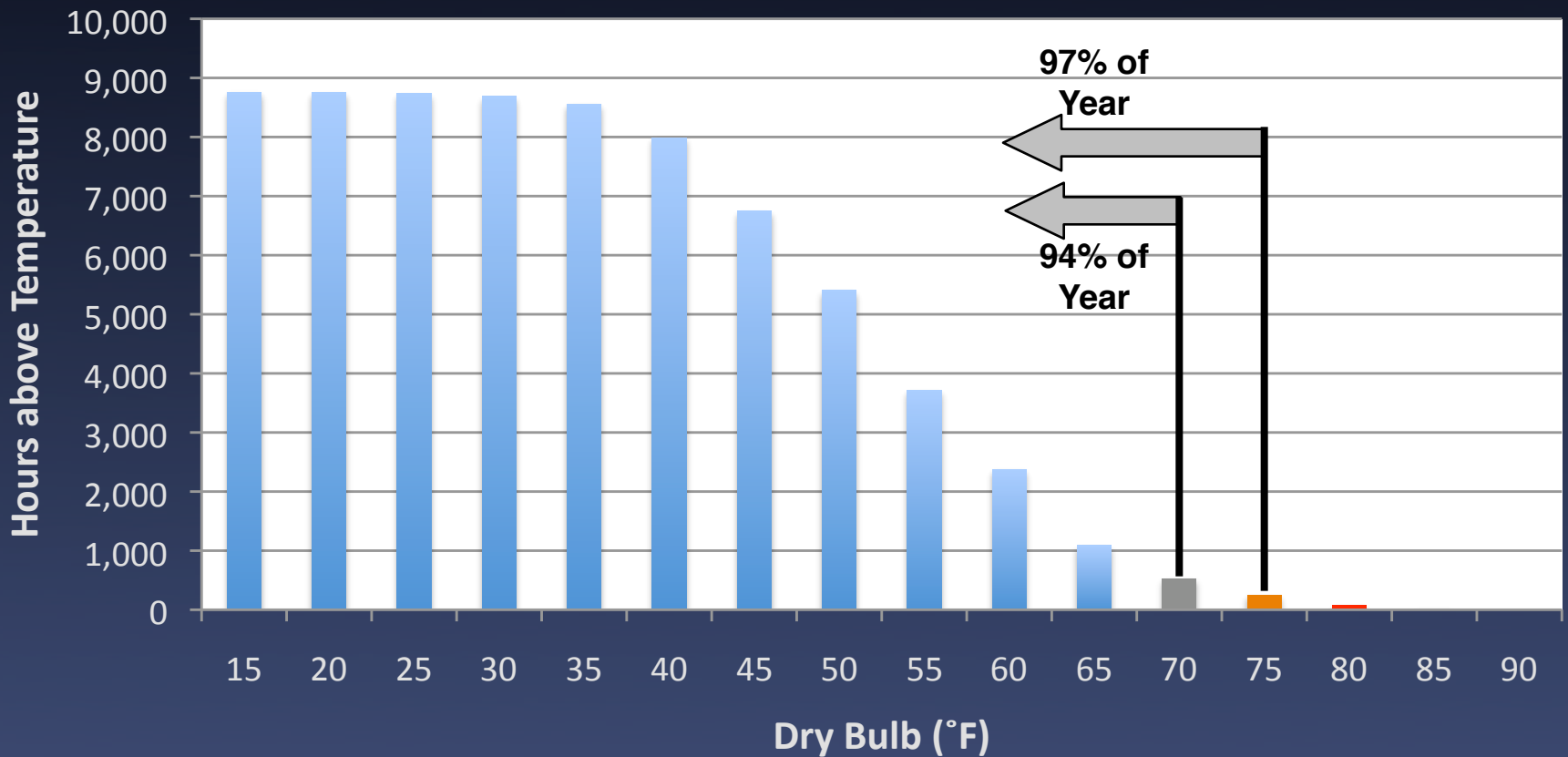
# Efficient delivery systems are also important.

- Hot aisle/cold aisle isolation
- Alternative flow paths
- Big fat pipes, small pumps

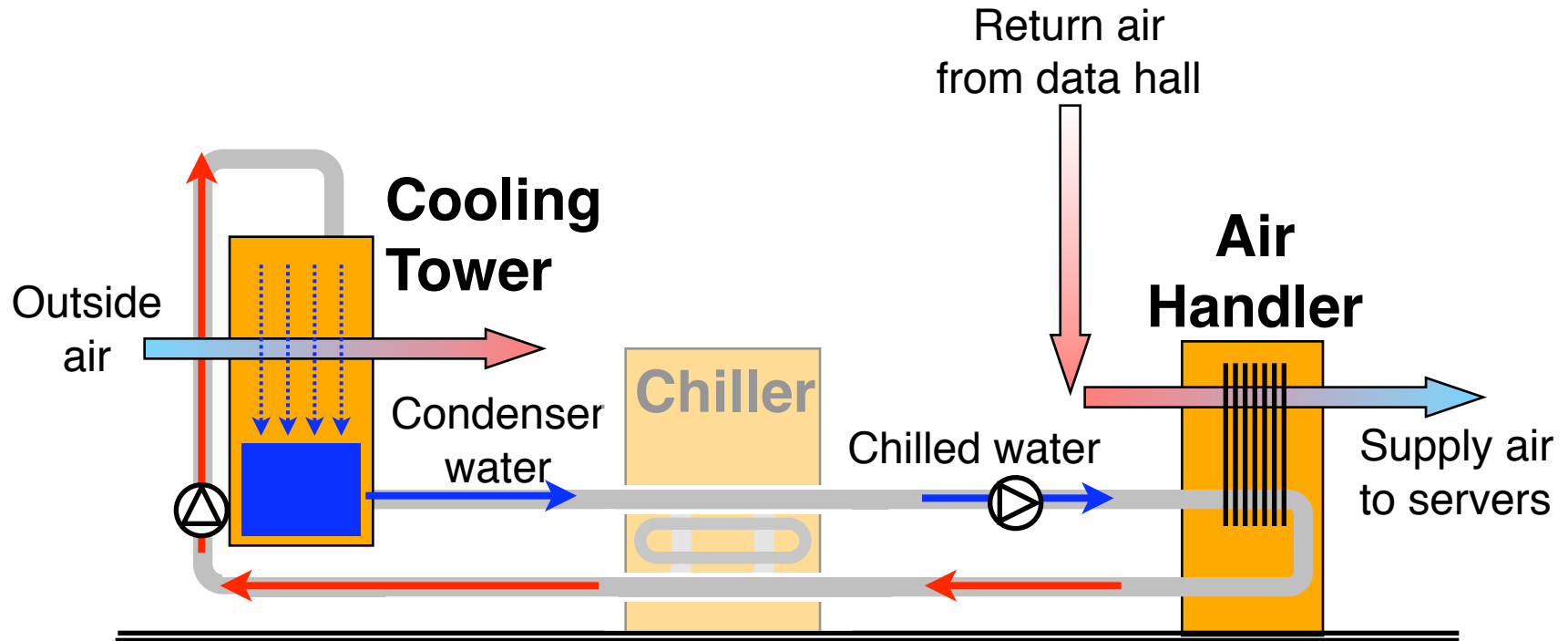


In a cool climate, the air is often cooler outside than in.

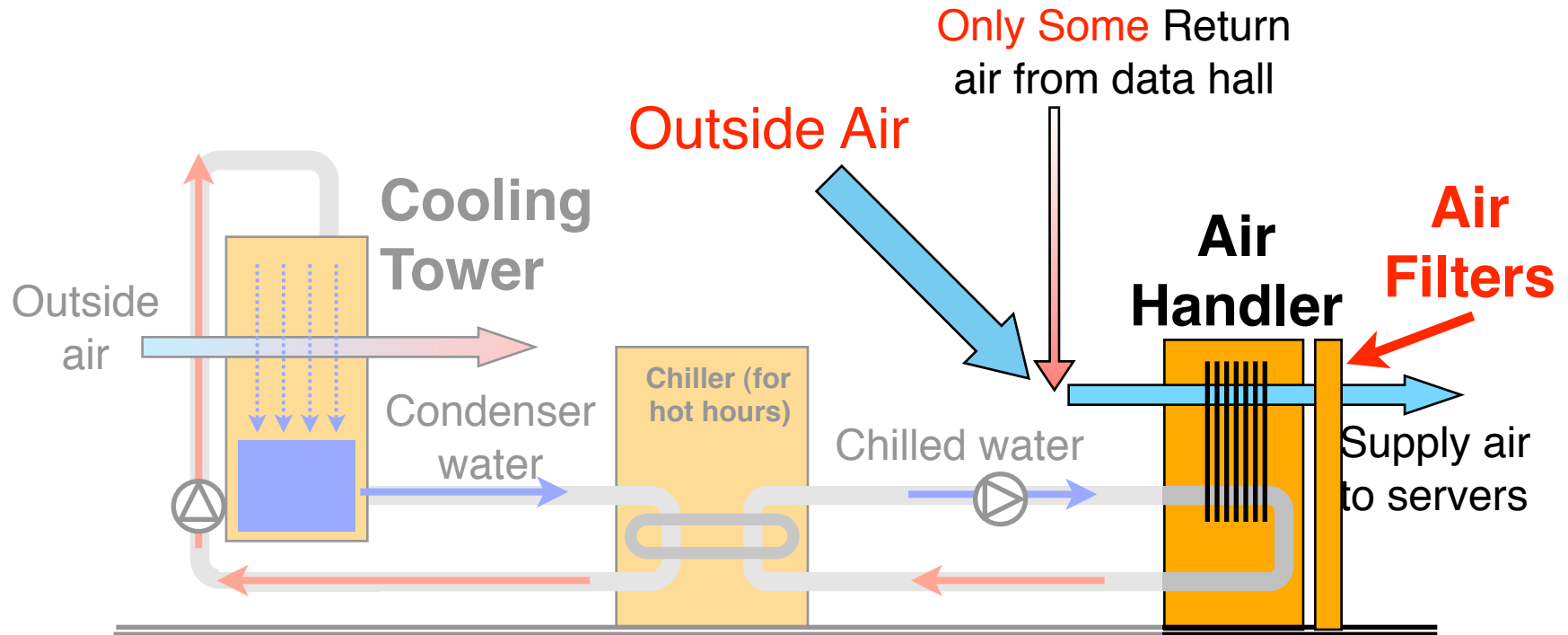
Hours per Year Above Temperature  
Seattle, WA



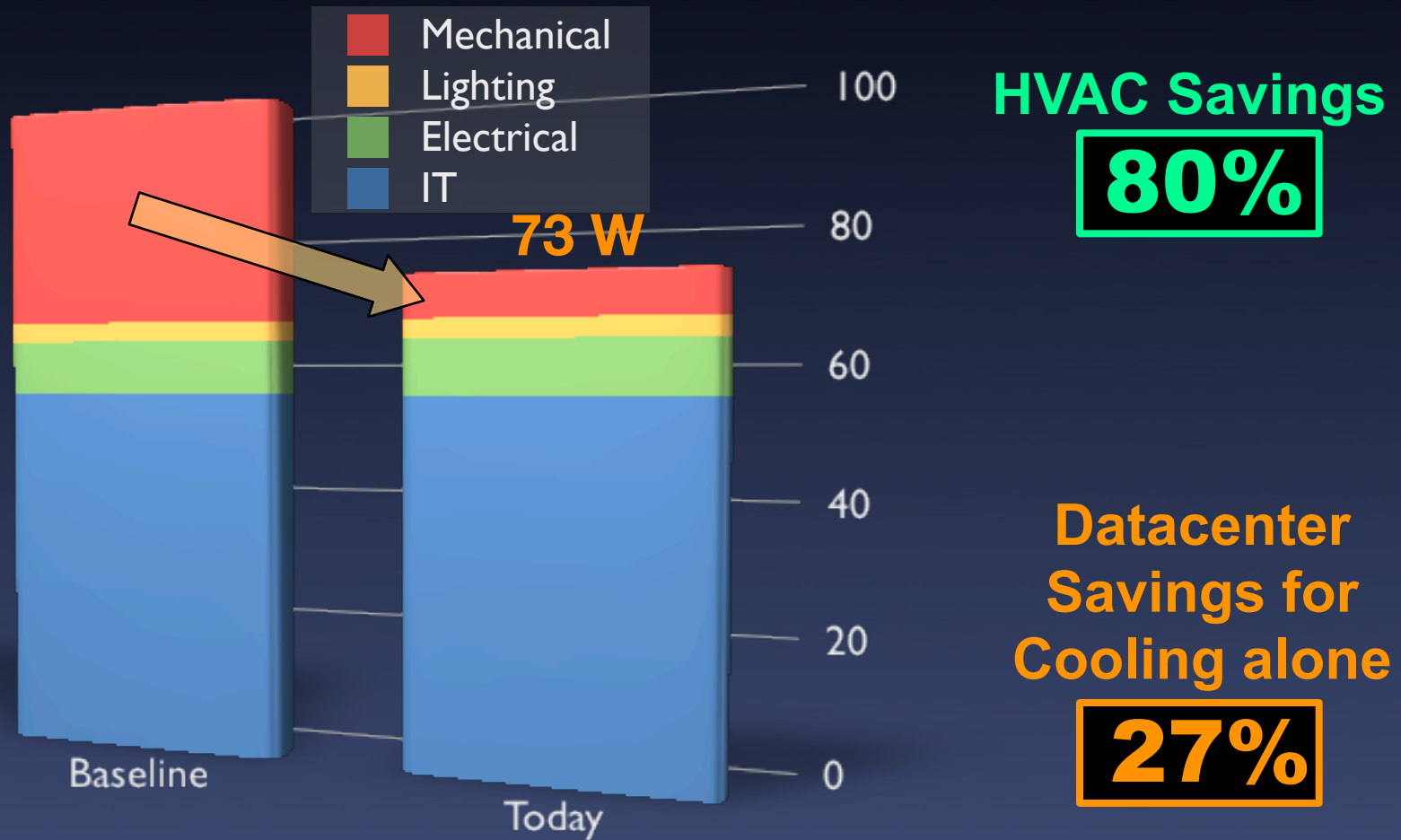
A water side economizer can reject heat directly out the cooling tower.



In cool climates, an airside economizer can provide free cooling.

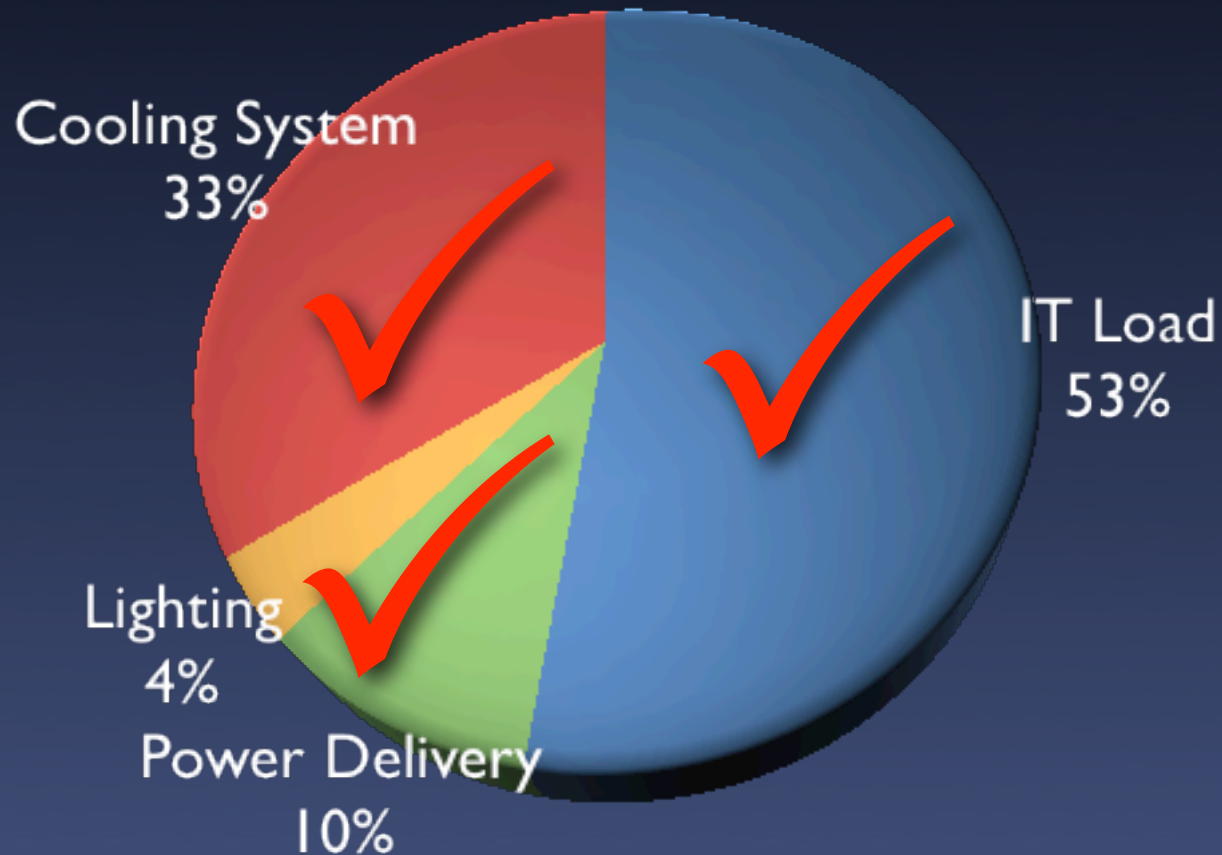


# Savings from cooling system optimization:

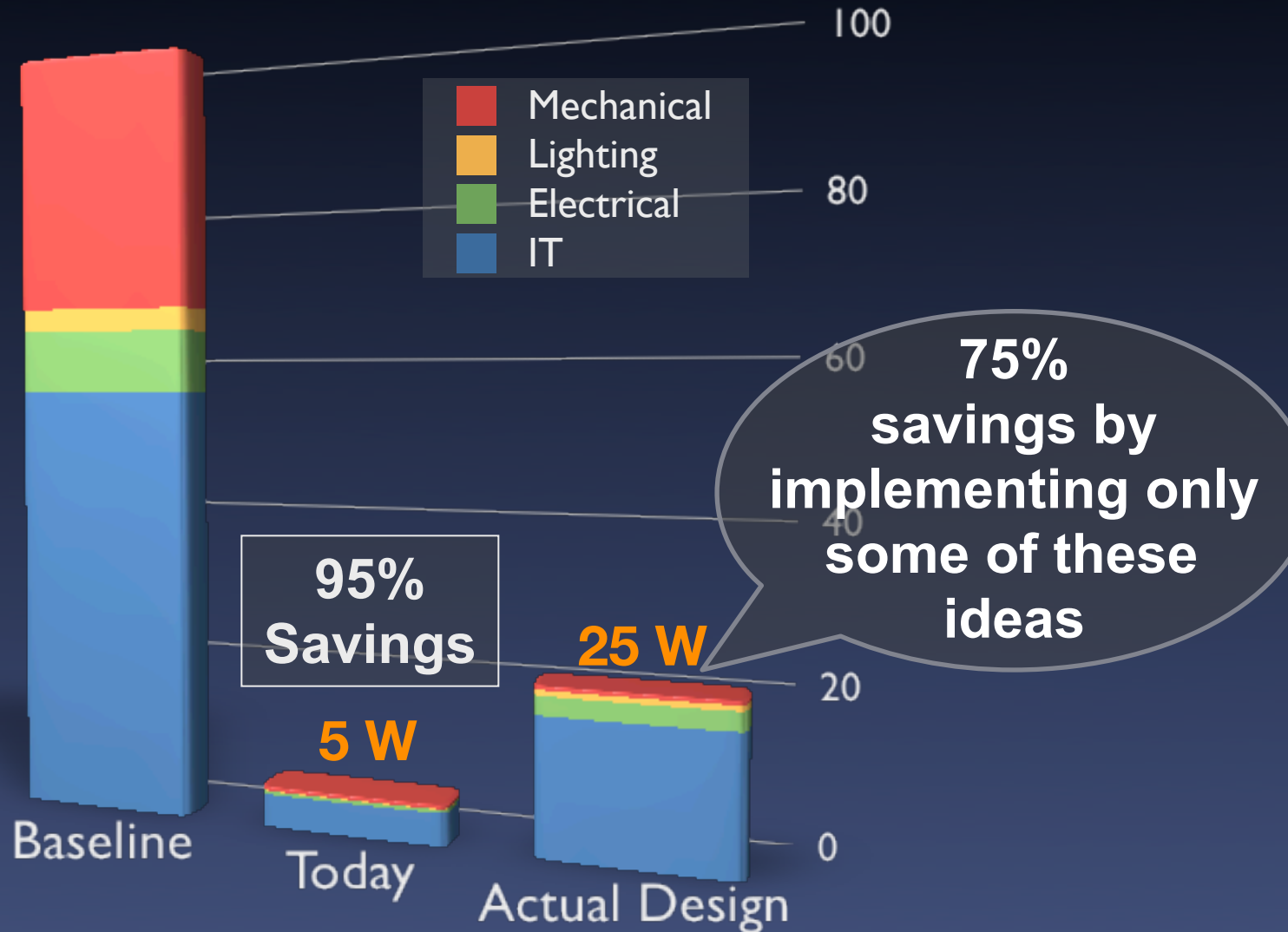


Effects of HVAC Savings only

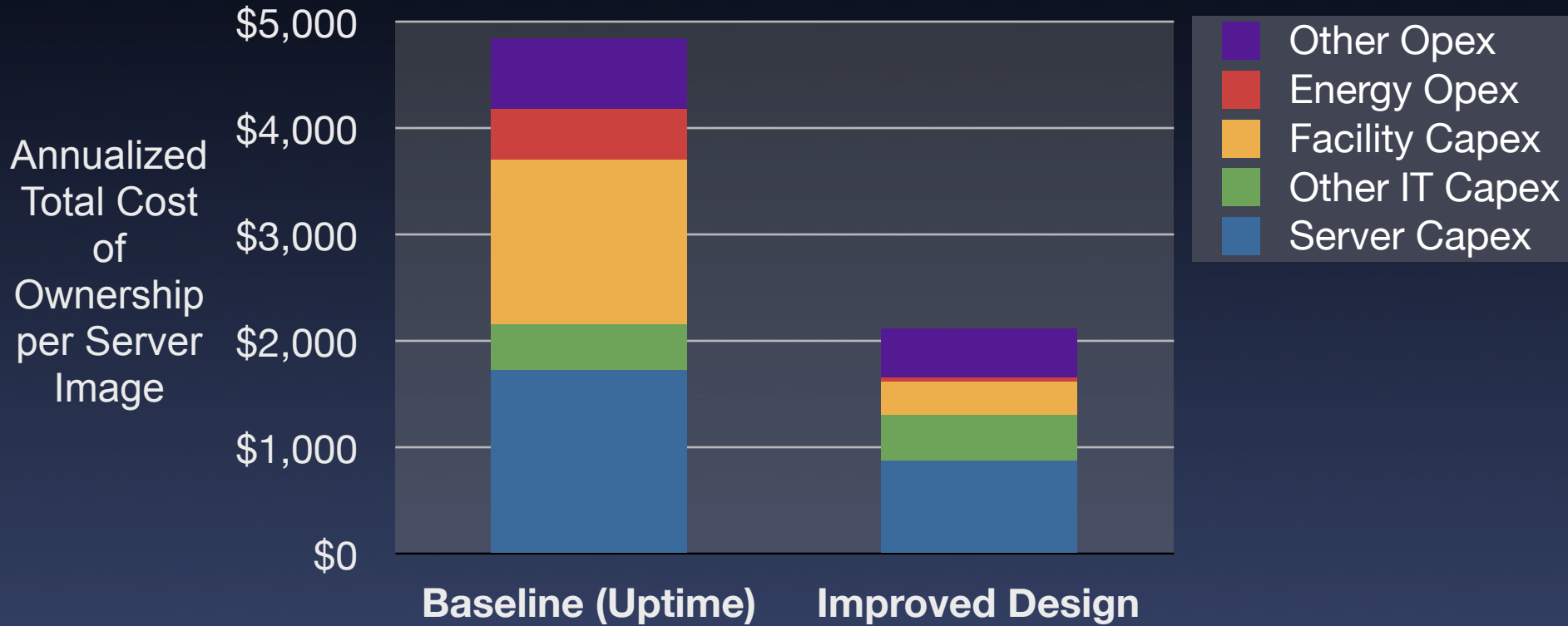
# Bringing it all together



# Put it all together - Savings from integrated design:



# How much will this all cost?



Capital: Much less, on a “per compute” basis.

Lifecycle: Much less than today

But new data centers are just part of the story...



*Image from Flickr user extraspecial*

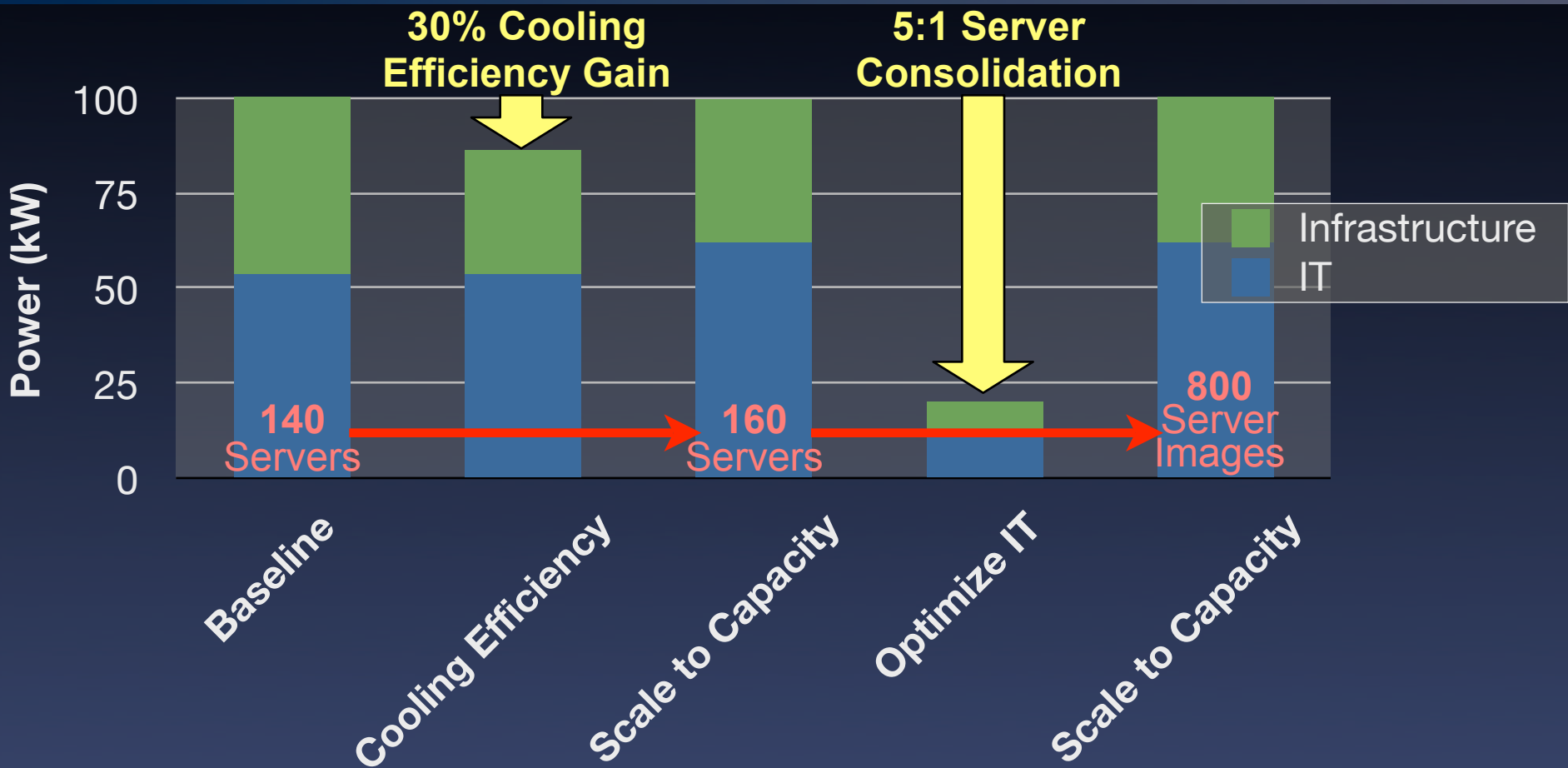


Existing data centers are often notoriously inefficient, offering great efficiency potential.

- Virtualization
- Efficient Hardware (servers, power supplies, UPS, network, storage, motors, pumps, etc)
- Airflow management
- Economizers
- Lighting

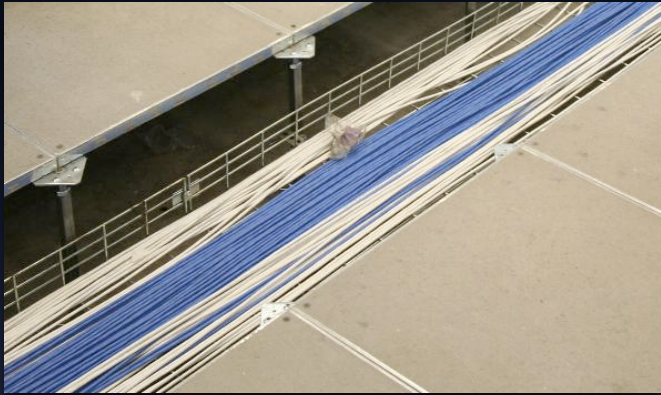
*... And more*

Thus efficiency savings allow substantial capacity increases in “full” data centers.



Cost impacts and ease of implementation depend on facility design and specific system constraints.

# Cost effectiveness of potential retrofits depends on system constraints.



**Raised floor**



**Utility**



**UPS**



**Cooling**

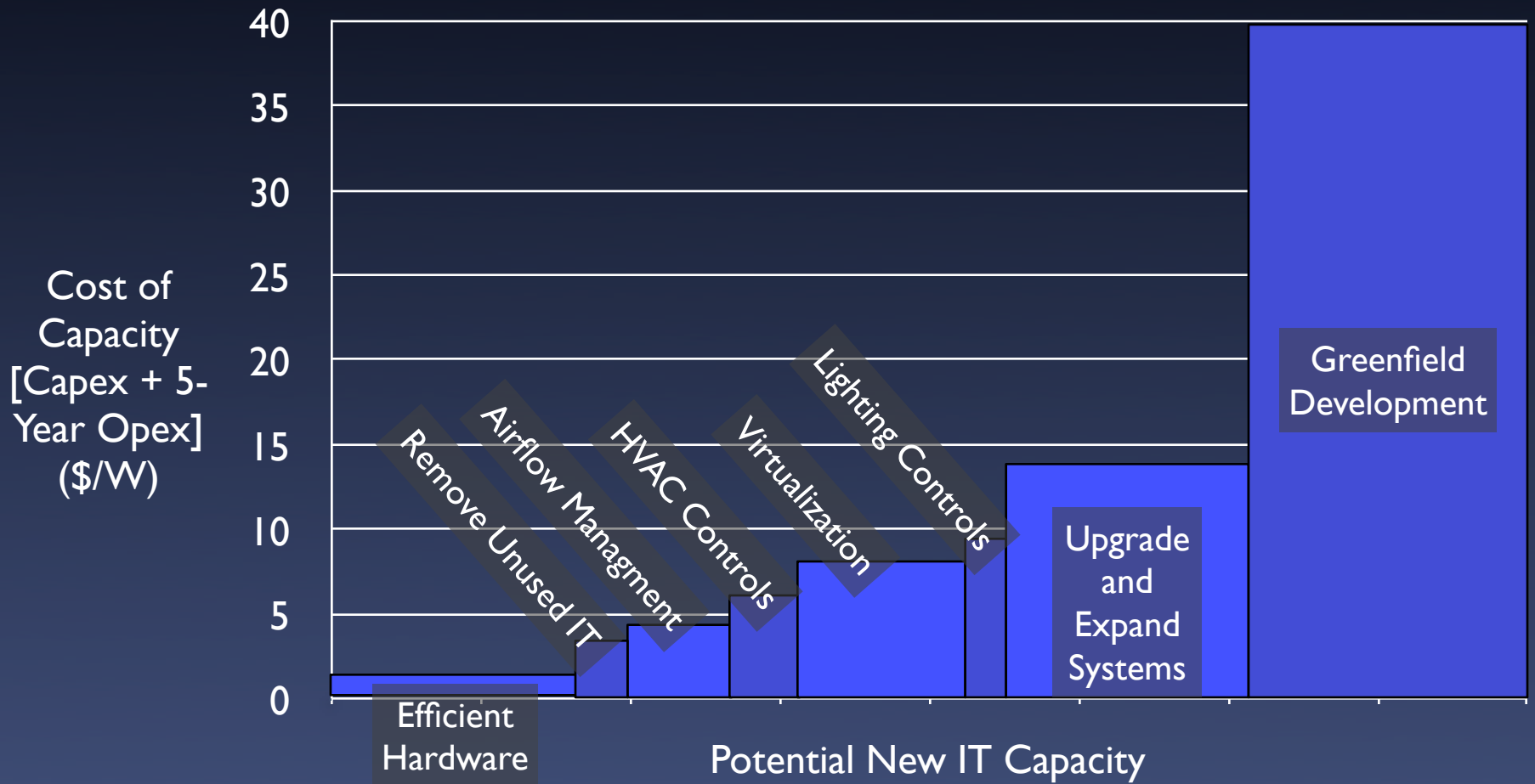


**Generator**



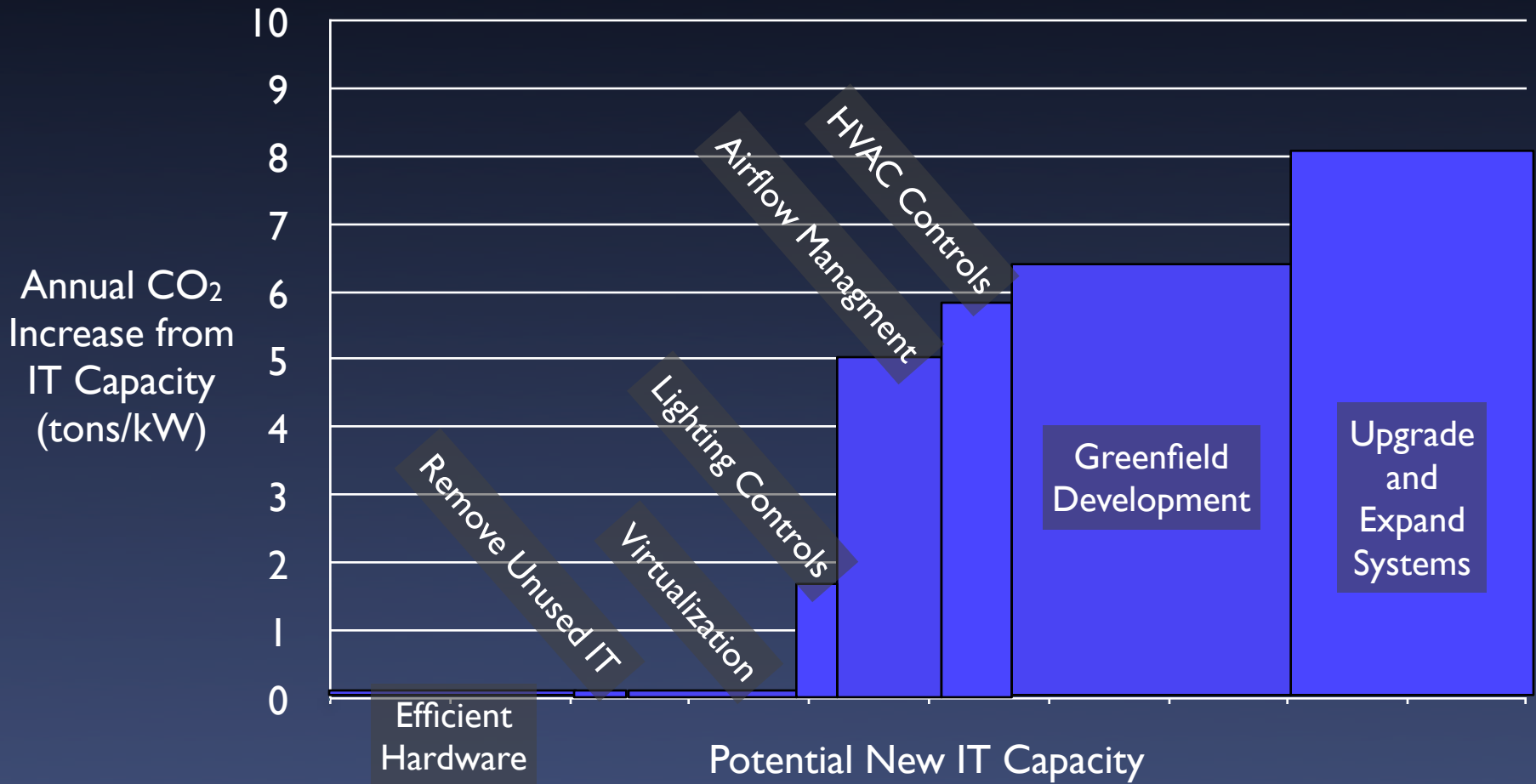
# Investment decisions for new capacity should be guided by lifecycle cost.

## Cost of New Capacity (Conceptual Example)

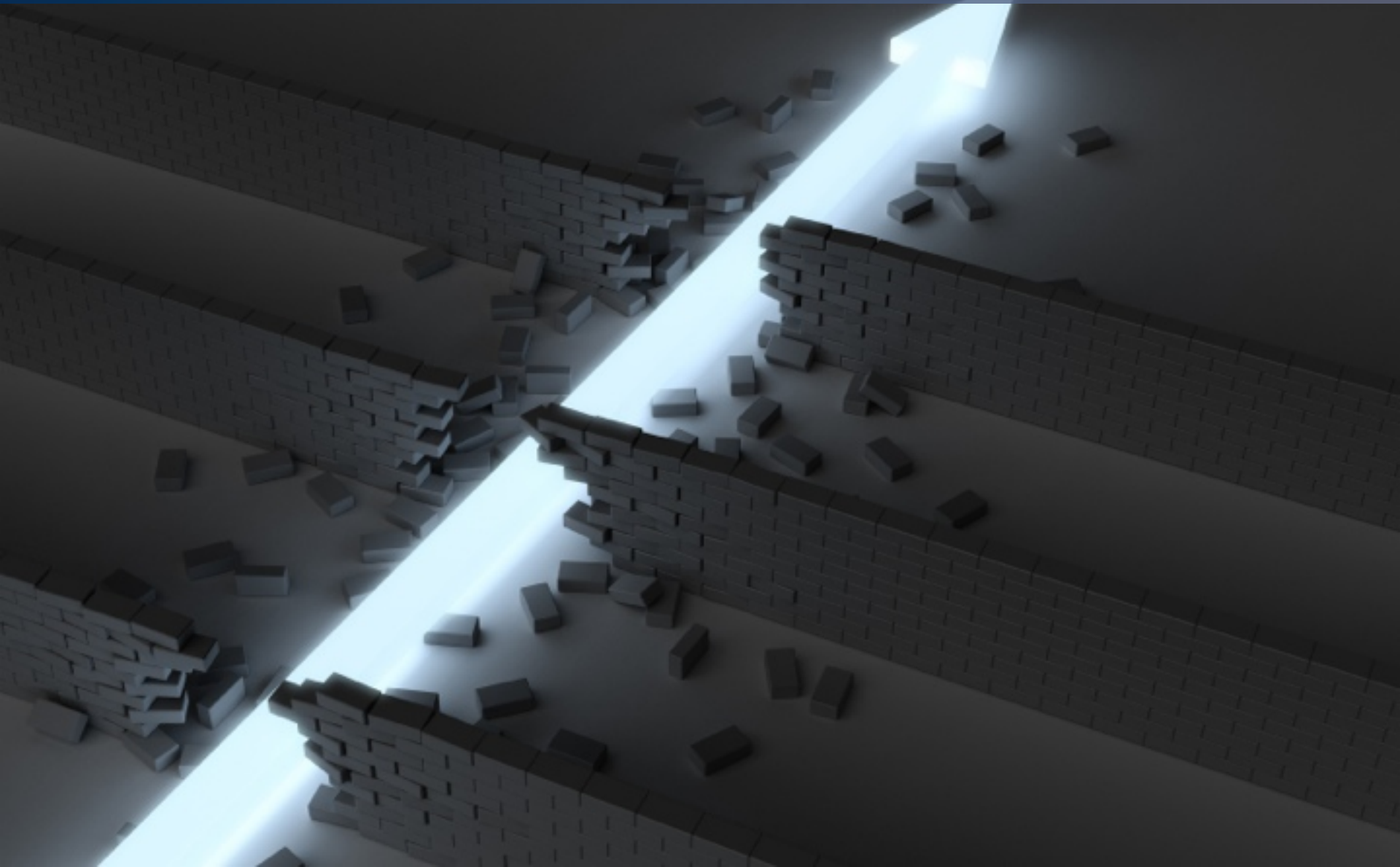


# New capacity decisions should also take future carbon emissions into account.

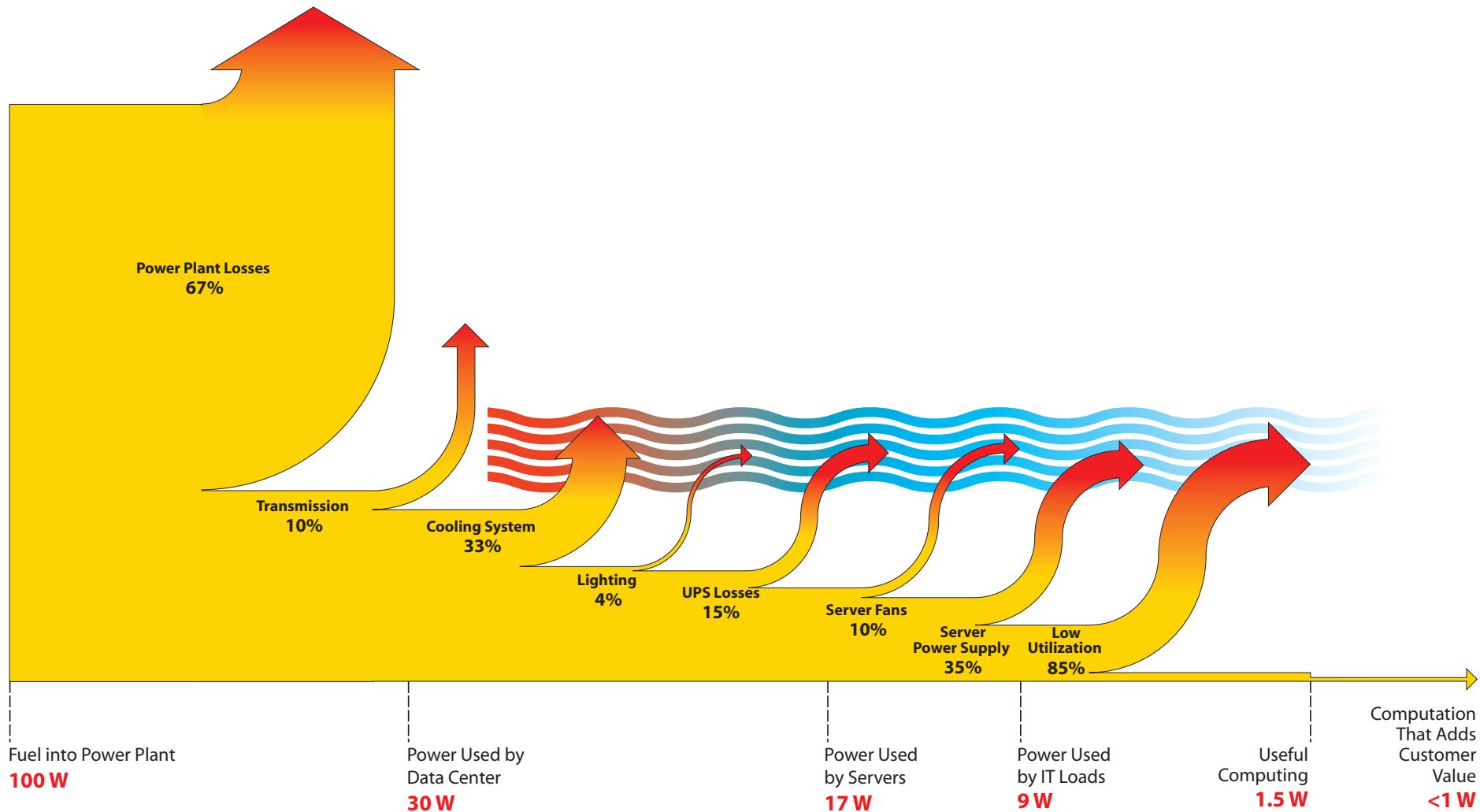
## Carbon Impact of New Capacity



In the near future, there will be additional savings opportunities, and pressures to change.



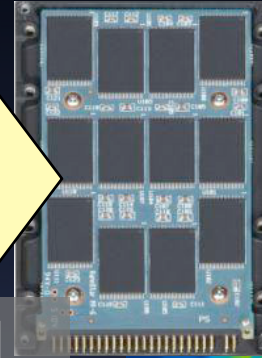
# Looking downstream, only a fraction of the computing power provides desired services.



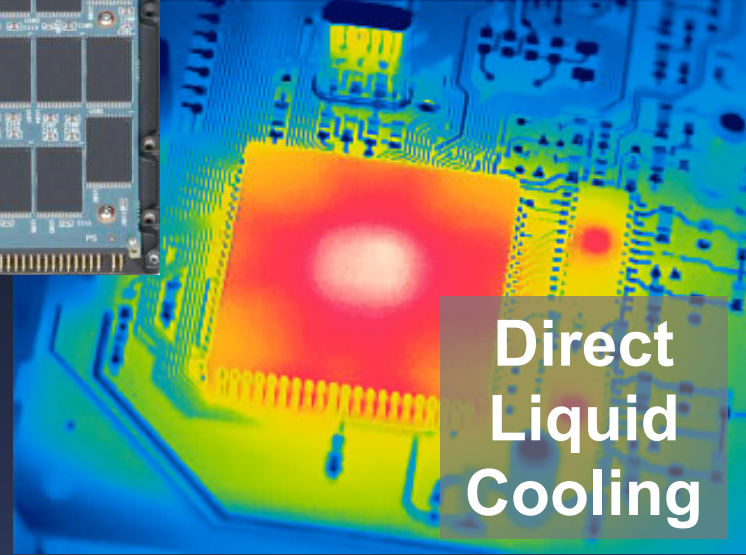
# Future developments will continue to reduce the energy intensity of computing.

Efficient Applications

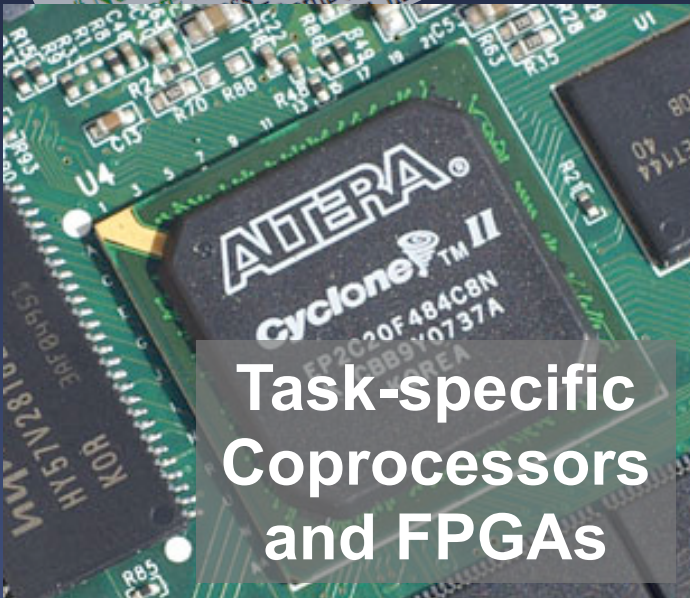
```
--- Run No. ... Sequ... (Sfile, Sseason, @tool_list);  
Sfile = process_... (Sfile, Sseason, @tool_list);  
# save current file name to ...  
Spre_ftemp_file = Sfile;  
Sfile = process_ftemp(Sfile, Sseason);  
Sfile = copy_to_simpler_name(Sfile, Sseason, "-processed");  
#resume processing non-ftemp file  
Sfile = Spre_ftemp_file;  
#--- Bin Avg  
Note there is a bug in bin average when reading item  
we bin average first and then ftemp  
sbe_tools(Sfile, Sseason, ["BinAvg"]  
name(Sfile, Sseason, "-processed-")
```



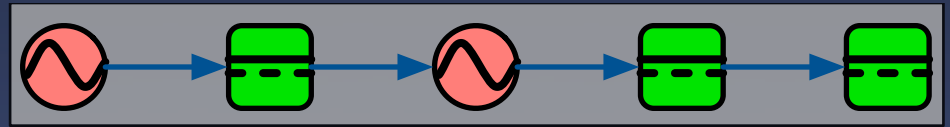
Solid State Storage



Direct Liquid Cooling



Task-specific Coprocessors and FPGAs

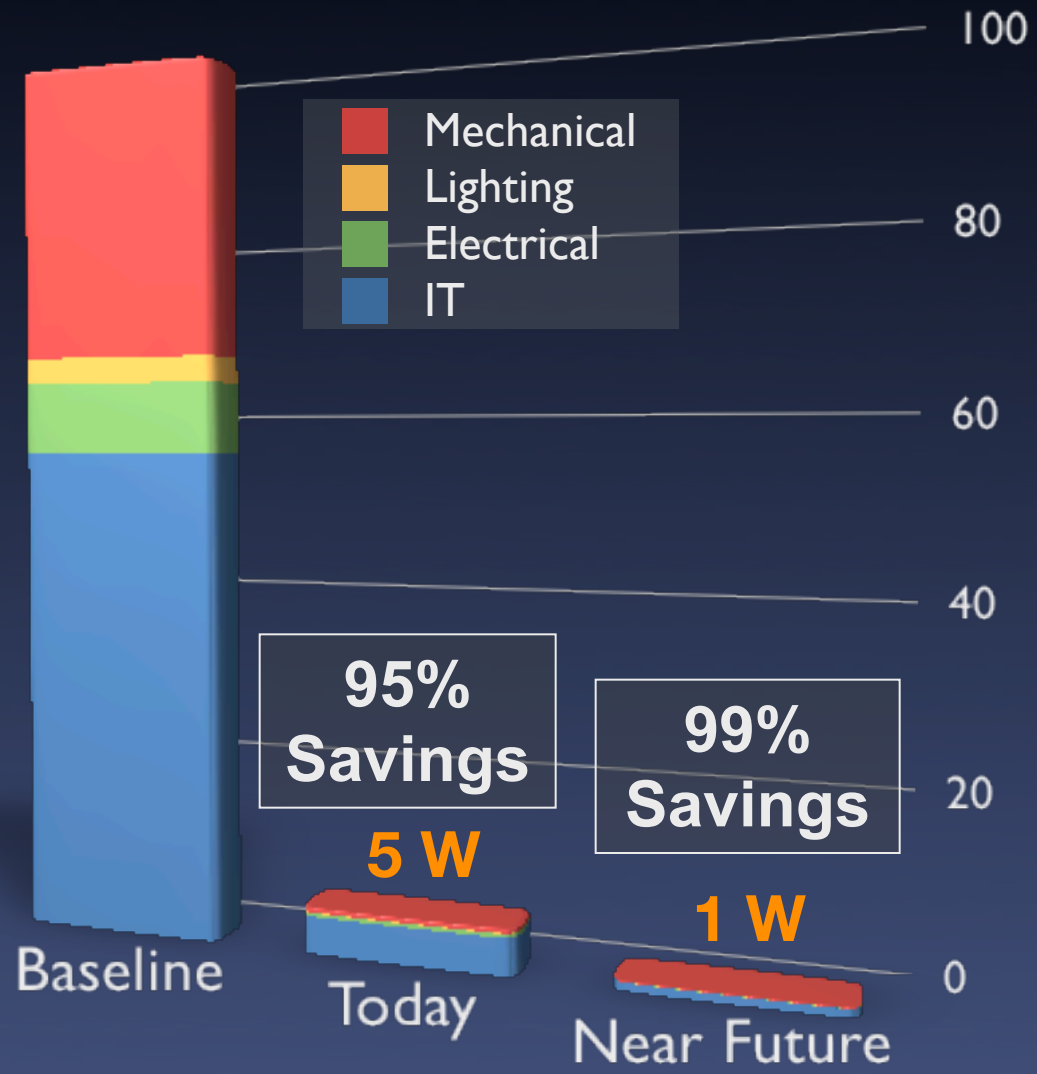


DC Power

Additional Savings

**75+%**

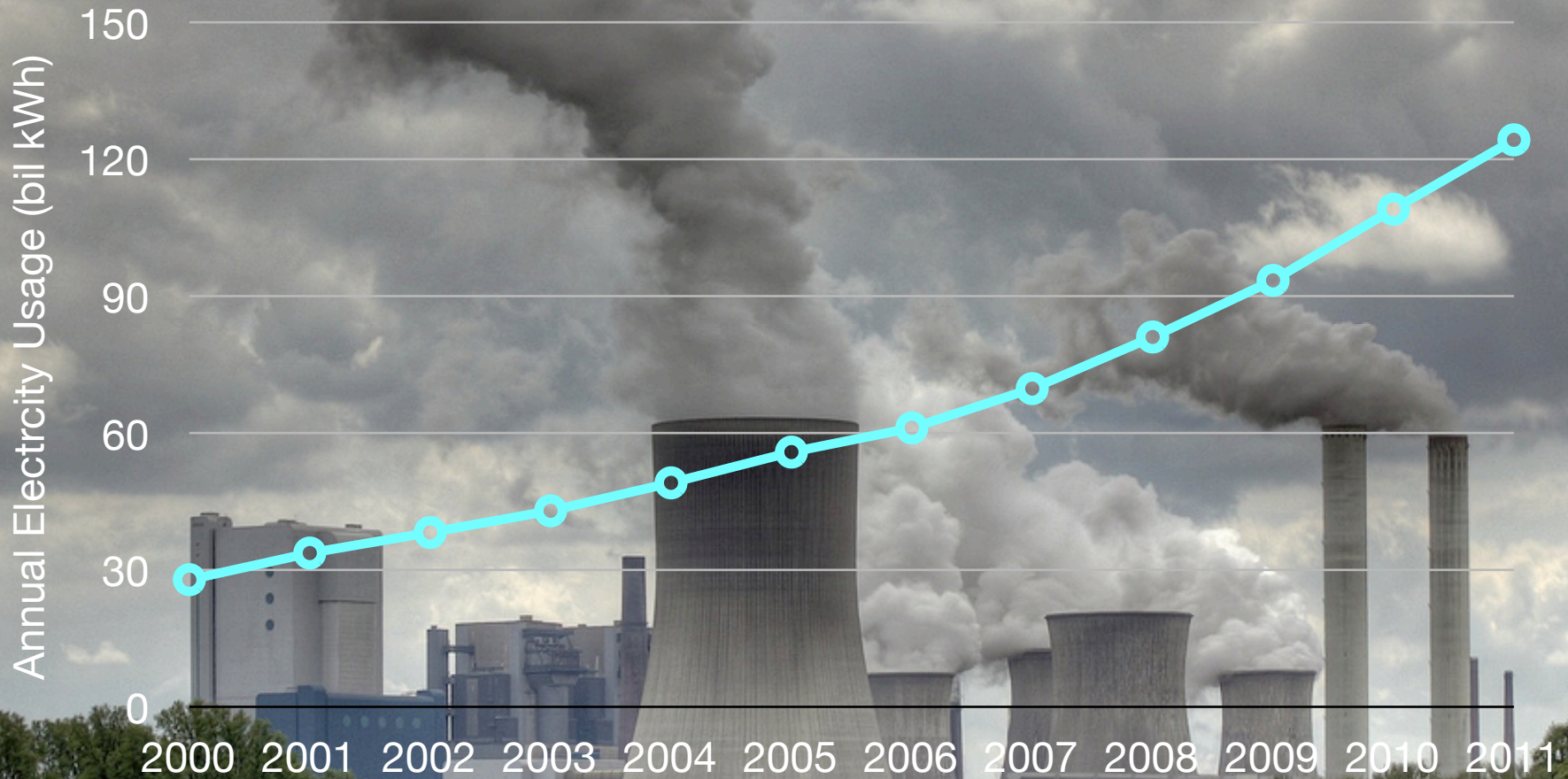
Systems design approaches to these advanced concepts, can save 100x in the near future.



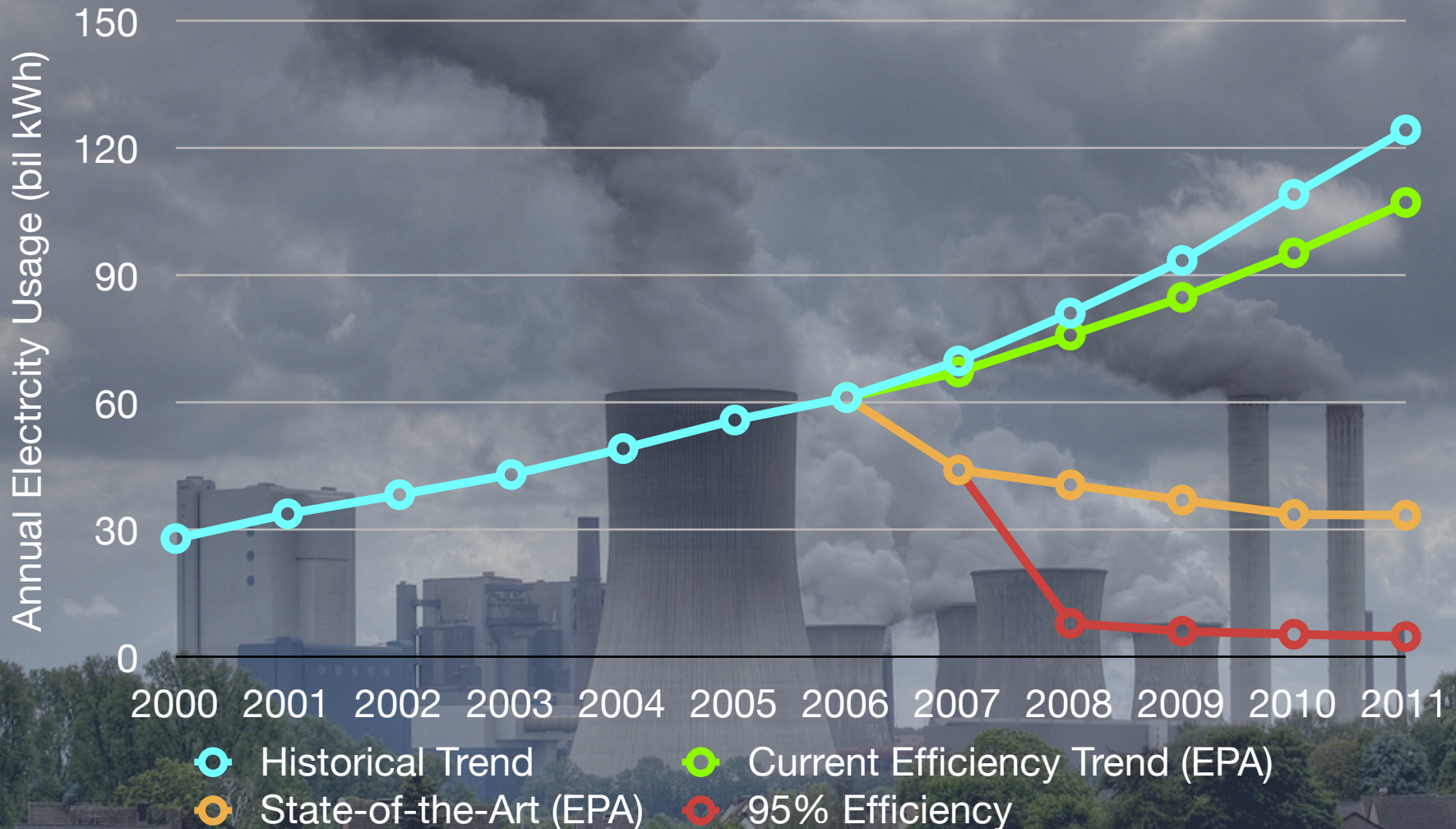
Efficiency offers a large opportunity that makes business sense.



# Rapidly rising energy usage threatens traditional business models and the planet's climate...



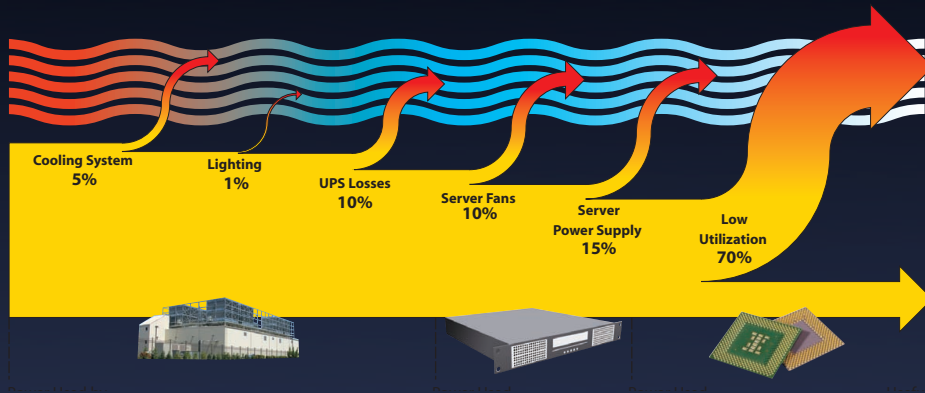
...but that trend can be reversed.



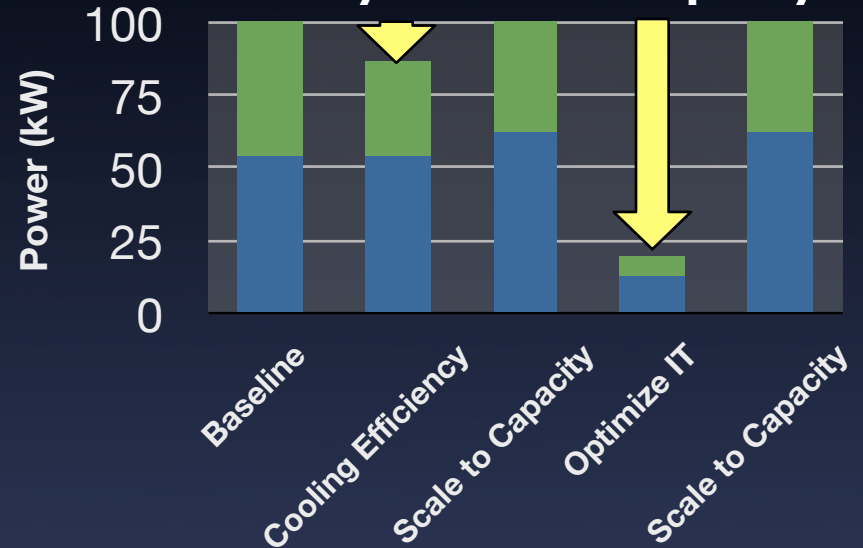
Data from EPA report on data center energy use, 2007

# Best practices can reduce power consumption by 99%, reducing environmental and business risks.

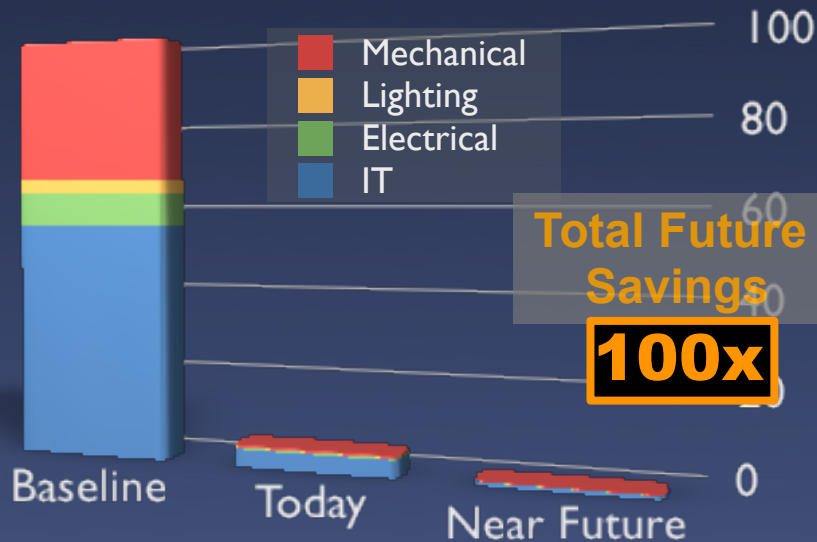
## Compounding Power Losses



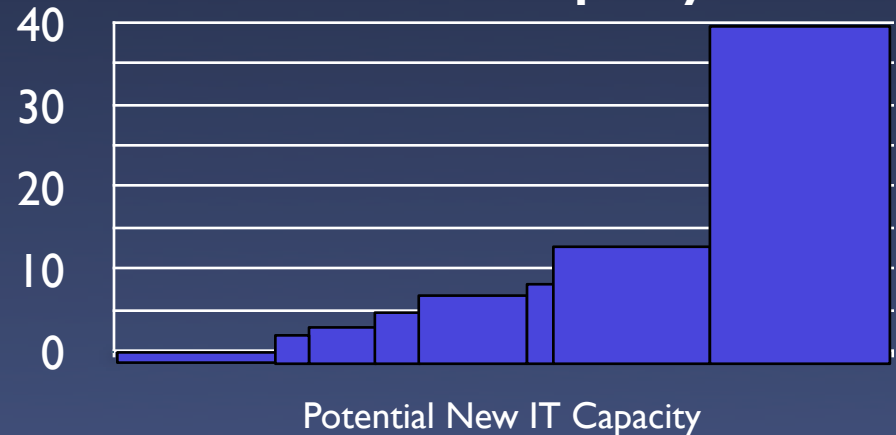
## Efficiency Generates Capacity



## 20x-100x Power Reduction



## Cost of New Capacity



# Questions?

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Rocky Mountain Institute