

Data Center Efficiency

Are my current data centers efficient?

Reducing energy consumption

The ROI of efficiency improvement

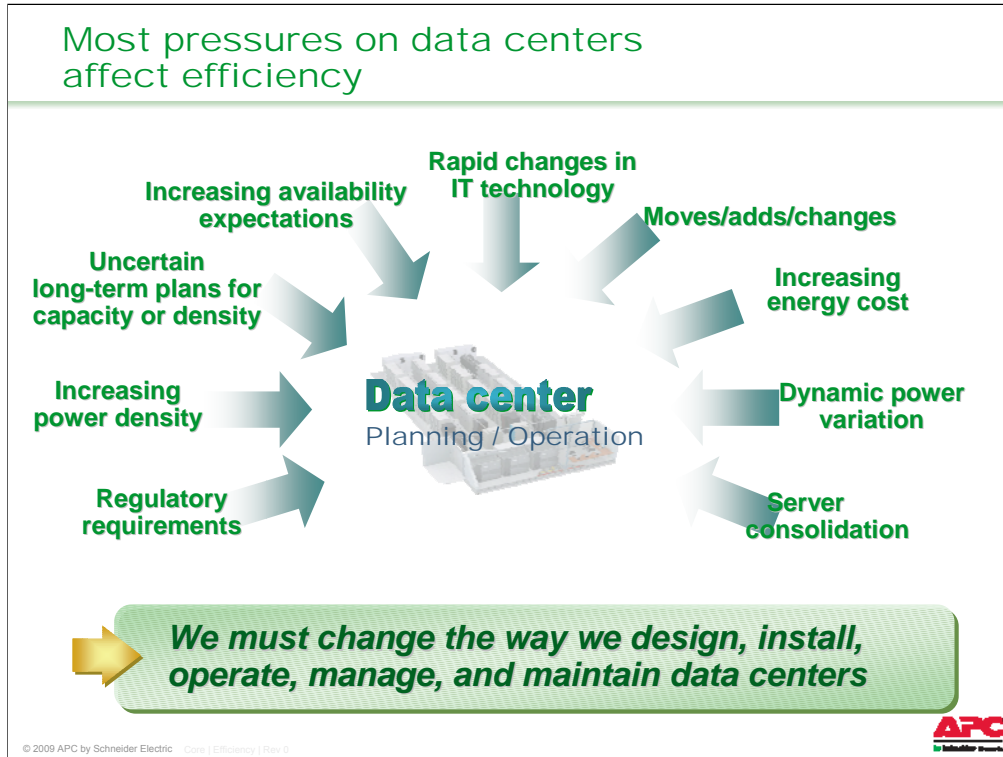


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Please send feedback and improvement ideas to the Data Center Science Center – DCSC@apc.com. Thank you!

Executive summary of this presentation:

Discusses why you should care about data center efficiency, regulatory drivers, quantifiable \$\$\$\$ results you could expect to achieve by deploying APC power, cooling, management, racks and services. APC is not only a UPS provider, they can partner with you on your mission to drive efficiency through your data center.



In addition to the desire to understand and control the costs, there are also some substantial challenges that many companies are facing today in the data center:

Rapid changes in IT technology

I have a number of data center operators who tell me stories like “They told me what was going to be in this facility; I built it; only one third of what they told me is actually what ended up here. The other two thirds are things that weren’t even on the radar screen when I started this project. How am I supposed to design for that?... you know, I was trying to design to the circuit level – the branch circuit level in this facility – and they can’t even tell me a year ahead what’s going to be there and what’s going to plug into it.”

High density

This is one of the biggest subjects of critical importance to people today because it’s so destabilizing as far as data center design goes. The new densities we’re talking about, as we all know, are an order of magnitude greater than the densities in typical data centers today.

High operating and service cost:

People are looking at those bills and saying “What can I do to get these under control or reduce them over time?”

Regulatory requirements:

forcing unusual structural changes, partitioning of equipment, isolating it

Key reference points

- **More than 50% of power** going into a typical data center goes to the power and cooling systems – **NOT to the IT loads**
- The typical 1MW (IT load) data center is continuously wasting about 400kW or **2,000 tons of coal per year** due to poor design (DCiE = 50%, instead of best-practice 70%)
- **Every kW saved** in a data center saves about **\$1,000 per year**
- **Every kW saved** in a data center reduces carbon dioxide emissions by **5 tons per year**
- **Every kW saved** in a data center has a carbon reduction equivalent to **eliminating about 1 car from the road**
- A **1% improvement** in data center infrastructure efficiency (DCiE) corresponds to approximately **2% reduction** in electrical bills

White
paper



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Three ways we are helping our customers reduce carbon footprint

- **Optimize existing data centers**

- Efficiency assessment services
- Energy management software tools

- **Specify and design efficient data centers**

- High-efficiency reference designs
- Detailed efficiency data on products and complete systems

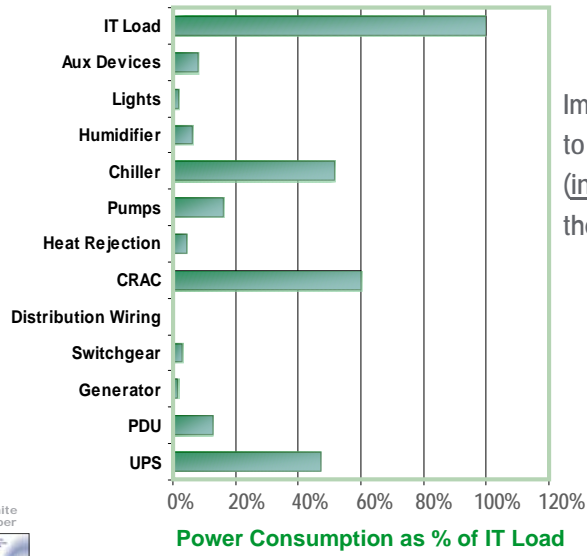
- **Offer the most efficient data center solutions**

- Industry-leading efficiency for power and cooling equipment
 - Row-based cooling
 - High-efficiency scalable UPS

Primary drivers of inefficiency

- Oversizing of power and cooling equipment
- Pushing cooling systems to cool densities higher than they were designed for
- Ineffective room layout
- Ineffective airflow patterns
- Redundancy (for availability)
- Inefficient power and cooling equipment
- Inefficient operating settings of cooling equipment
- Clogged air or water filters
- Disabled or malfunctioning cooling economizer modes
- Raised floor clogged with wires

Power consumptions compared to the IT load



Improving efficiency means working to reduce power consumption (increase efficiency) for each of these device categories



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Data for a typical tier 4 data center operating at 30% of rated load



Helping customers optimize existing data centers

- **Basic application guidance from our experienced sales engineers**

- Validating design concepts
- Basic sizing and specification
- Translating clear needs into configured solutions

- **Professional data center assessment services**

- Data center efficiency & carbon impact assessment
- Power and cooling assessment (capacities and reliability)

- **Efficiency improvement projects**

- Implement efficiency improvements
- Upgrade inefficient equipment
- Install efficiency monitoring equipment
- Upgrade zones to high density/efficiency “pods”

Dropped ceiling return Optimized rack layout
 Deep raised floor Optimized tile placement

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PDUs without transformers Coordinated CRAC/CRAH
 Blanking panels N/A VFD heat rejection pumps
 Economizer N/A VFD chilled water pumps

Heat rejection redundancy:

 Lighting:

Standby generator CRAC/CRAH on UPS

Air distribution:

 CRAC/CRAH redundancy:

 Power redundancy:

 Cooling system:

 Chiller:

 Electricity cost per kWh: \$

UPS system:

Annual electricity cost € 1,599,258

Efficiency curve Efficiency Curve

0% 52.6% 100%

INPUTS **RESULTS**

Data center capacity:

Data Center Infrastructure Efficiency (DCiE)

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CO2 emissions (kg/kWh) Footprint: 0.924 Avoided: 1.096

Based on avoided equivalent tonnes of CO2

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Electricity cost per kWh: \$0.11

Scenario 1: 1000 kW Scenario 2: 1000 kW

Location of Data Center: Australia (AUD)

Scenario 2: 65% (PUE= 1.5)

IT load About this tool **INPUTS**

Data center infrastructure efficiency (DCIE)

Scenario 1: 55% (PUE= 1.8)

in Electricity cost per year* Fewer tonnes of CO2 emissions per year** Fewer cars on the road

* 15 year electricity cost savings: \$3,908,820
** 15 year reduction CO2 emissions: 40,284

\$260,595 2,686 592

Savings from scenario 1 to scenario 2 equivalent to:

CO2 tonnes per year (footprint)	14,717	12,453
Equivalency in cars	2,244	2,745
Total kWh per year	15,927,273	13,476,923
Electricity cost per year	\$ 1,693,865	\$ 1,433,271

RESULTS


Utility input power (kW)	Scenario 1: 1,818	Scenario 2: 1,538
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Data Center Carbon Calculator
Impact of changes in data center efficiency on energy costs and carbon footprint

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Sample statement of work for an electrical efficiency assessment



Statement of Work

Professional Services



Data Center Electrical Efficiency Assessment

Service

1.0 Executive Summary

The Data Center Electrical Efficiency Assessment provides an analysis of the Power and Cooling systems to determine the operating efficiency of the complete system. In addition, the system is benchmarked against the expected values of efficiency based on the inherent design, and against other similar data centers. The projected efficiency under changing IT loads such as a growth plan, is calculated.

Our service professionals will provide an accurate assessment of the factors that are limiting the achievable efficiency of the data center and will make recommendations for changes to maximize efficiency. This will include:


- Assessment and analysis of the data center's as-built electrical efficiency
- Breakdowns of losses into power, cooling, and lighting losses
- Breakdown of the cooling system losses into CRAH, humidification, and outdoor heat rejection losses.
- Breakdown of the power system losses into UPS and power distribution.
- Creating and providing a mathematical model of the data center that can be used for benchmarking or scenario analysis
- Comparing the actual efficiency to the efficiency that should be expected based on the design, and identifying any constraints that are preventing the system from achieving its expected efficiency
- Detailed recommendations for improving the efficiency of the data center, taking into consideration the constraints of the facility

2.0 Features & Benefits

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Typical findings of an electrical efficiency assessment

- Benchmark vs. comparable data centers – overall and by subsystem
- Operations problems impacting efficiency
- Configuration problems impacting efficiency
- Short-term quick efficiency improvement options
- Long-term opportunities

Designing and specifying high efficiency

- Method for specification of efficiency
 - DCiE or PUE (they are equivalent)
 - Annualized over the seasons
 - As a function of IT load
 - Target depends on tier level
- Decision support tools (carbon impact analysis)
- Standardized concept-specification-design process
- Automated data center design tools that enforce high efficiency design
- Published efficiency data for all products

Four ways to express efficiency

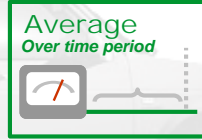
Manufacturer's
SPECIFICATION
for this car



Manufacturer's
BENCHMARKS
for similar cars



Actual
AVERAGE
during operation



Actual
INSTANTANEOUS
during operation

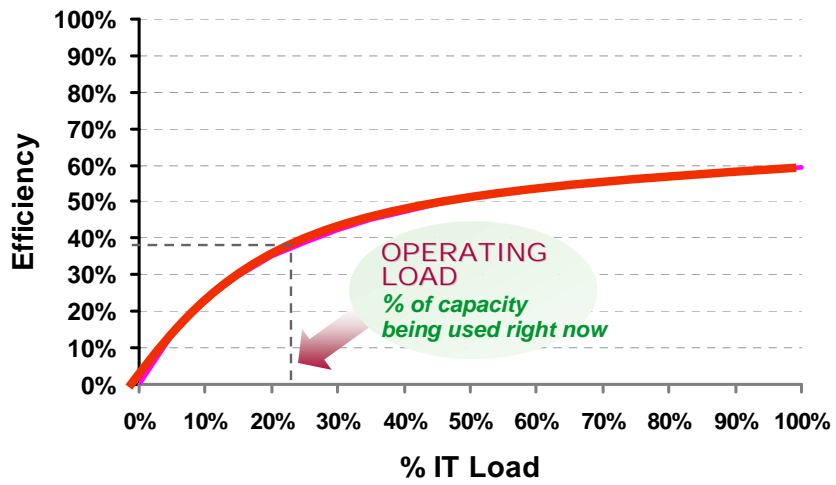


Beware! Much of existing published efficiency data is ambiguous regarding how it is expressed and what is included in the calculation

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Data center efficiency as a function of IT load



Efficiency varies dramatically with load, so you can't specify it without specifying the load



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Example of an appropriate efficiency specification

The data center will be designed to achieve an annual average DCiE of 65% in New York City at 50% of the 2MW rated IT load.

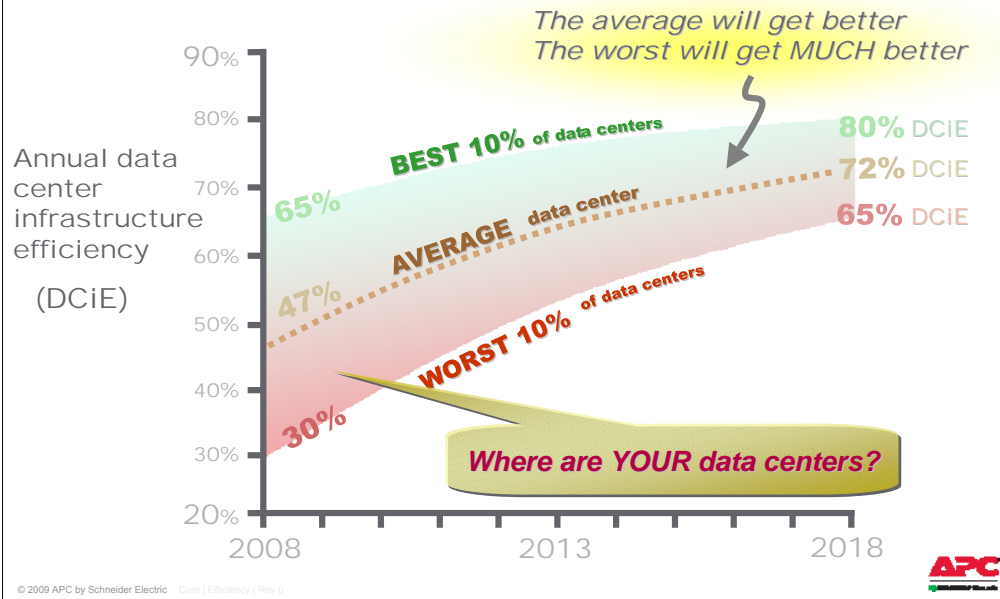
For the efficiency calculations, loads will be categorized as follows:

IT loads: Servers, storage, networking equipment, network operations center stations

Data Center Infrastructure: UPS, PDUs, switchgear, wiring, generator, controls, air handlers, chillers, pumps, heat rejection systems, data center ventilation systems, white- and grey-space lighting, data center humidifiers

Not included: Office lighting, outdoor lighting, office HVAC, office equipment, kitchen equipment

A realistic data center infrastructure efficiency plan for the industry



Drivers of infrastructure efficiency gains (Baseline: Average of existing installed base)

IMPROVEMENT	Device Gain	DCiE Gain	\$\$ saved over 15 years in a 1MW data center**
Move from room cooling to dynamic row/rack cooling	70%	8%	\$5,900,000
Cooling economizers	38%	4%	\$2,500,000
Right-sizing through modular power and cooling equipment	4%	4%	\$2,400,000
Higher UPS efficiency	8%	4%	\$1,900,000
415/240 V transformerless power distribution (NAM)*	4%	2.5%	\$1,500,000
Dynamic control of cooling plant (VFD fans, pumps, chillers)	25%	2.5%	\$1,200,000

TOTAL to get industry from 47% to 72% DCiE  **25%** **\$14,700,000**

*No benefit outside of NAM; Transformer-based PDUs typically in NAM only

**\$\$ values based on \$.15 per kwhr electric cost, starting DCiE of 47%, ave density 8KW/rack

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Is there an efficiency vs density tradeoff?

NO
They work together

- High density and high efficiency are related
- Many people think high density makes efficiency worse
 - ↳ Only true when trying to push existing data centers to cool high density
- High density enables high efficiency in a properly designed new data center or a pod in an existing data center
 - Shorter pipe lengths → Less pump power
 - Shorter air flow lengths } → Less fan power
 - Less air mixing }
 - Higher return air temperatures → Less humidification/dehumidification power and chiller power



The highest efficiency data centers will be high density data centers



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Many people assume that by going to high density, they will pay a penalty when it comes to energy efficiency. That is NOT true.

In fact, high density and high efficiency are very closely related.

Implementing high density pods in a data center actually enables higher efficiency, if the right design approach is applied.. And why is this.. Things like:

Shorter pipe lengths which leads to Less pump power

Shorter air flow lengths & Less air mixing leads to less fan power

Higher return air temperatures Less humidification/dehumidification power and chiller power

Achieving high efficiency in high-density data centers

Products we offer as part of our solutions

- 1 **Row-based cooling**
- 2 **Ultra-high efficiency UPS**
- 3 **Capacity and energy management software for power, cooling, and racks**
- 4 **Scalable power and cooling equipment**
- 5 **High-efficiency AC power distribution**



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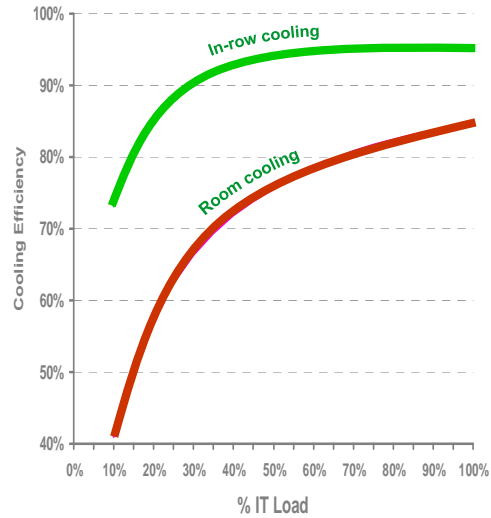


Row-based cooling

- Inherently higher power density capability than room designs
- Fan power reduced by 50%
- Needless dehumidification / re-humidification is eliminated
- Need for high-bay areas and raised floors is reduced or eliminated (particularly for small installations)
- Cooling capacity can “follow” IT loads that move due to virtualization and server power management



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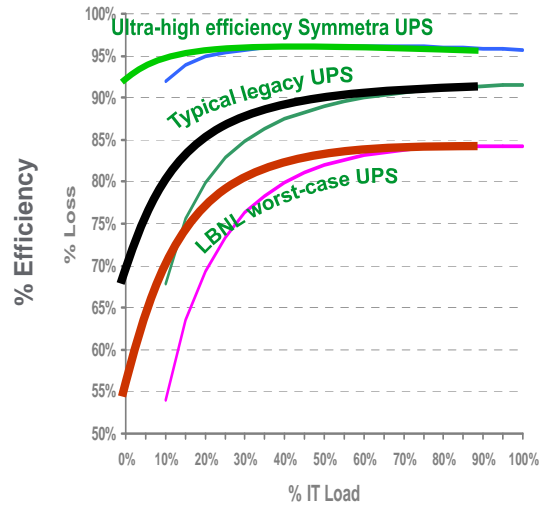


Cooling efficiency = useful cooling power / (power consumed + useful cooling power)



High-efficiency UPS

- UPS efficiency has large effect on data center efficiency because total IT load goes through it
- Improvement over typical from 80% to 96% efficiency at 20% load corresponds to loss reduction of 80%
- Electricity savings can pay for the UPS in many cases
- Side effect of high efficiency design: UPS is nearly silent

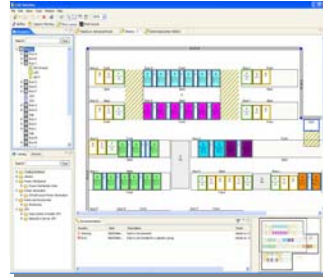


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Capacity and energy management

- Poor utilization of capacity is a primary cause of inefficiency
- Software can identify available capacity (even by rack) and help prevent creation of stranded capacity
- Side effect is you can fit more IT equipment in the power and cooling “envelope” of the data center
- Energy management can identify efficiency improvement opportunities



InfraStruXure Central software
with Capacity Manager

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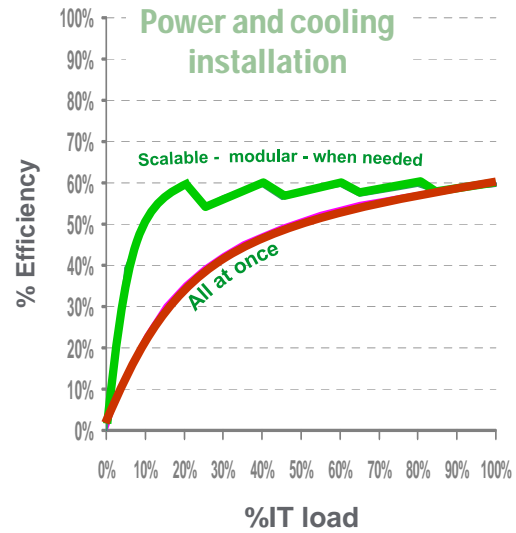
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Scalable power and cooling

- Over half the power and cooling losses in a data center are fixed and do not vary with the IT load (so efficiency degrades as IT load declines)
- Oversizing is therefore a primary contributor to inefficiency
- Virtualization and server power management will make this problem worse, if power and cooling are sized to peak IT loads that are not typical
- New power and cooling devices can scale in capacity, reducing fixed losses



Higher voltage AC power distribution (NAM Only)

- Distributes voltage to loads at international standard 400/230 instead of conventional US 208/120
- Eliminates the need for PDU transformers and associated losses
- Reduces copper requirements
- Overall efficiency increase of over 5% for a high availability data center
- By-product is that **4,000 lbs of copper** and **30,000 lbs of PDUs** are saved per MW, reducing floor loading and saving space



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DC power for data centers?



Not needed

- Studies by Lawrence Berkeley National Labs found existing data center power systems with efficiencies as low as 67%, and that hypothetical DC systems could be as high as 85-95%
- The inefficiencies are much worse in North America and Japan due to transformers and lower voltage distribution.
- **BUT:** Recent advances in the performance of AC power systems have raised efficiency of AC to 95% for equipment that is available now, *making an industry switch to DC unnecessary.*
- DC will mainly be used in proprietary architectures inside cabinets, chassis, and containers



Given that the latest available AC and hypothetical DC systems have nearly equivalent efficiency, and given the regulatory, safety, compatibility, and cost issues associated with DC, future data centers will remain AC powered

Tools we provide to help manage data center carbon footprint

- ✓ Efficiency Assessment and Carbon Assessment services
- ✓ **InfraStruXure** Designer
- ✓ Standard data center specifications 
- ✓ Highest efficiency power and cooling equipment
- ✓ ISX Central data center management software
- ✓ Detailed power and cooling device efficiency data
- ✓ 

Data center efficiency
Summary



Are my data centers efficient?

Probably 5-20% less efficient than they could be; you can learn a lot from a data center efficiency assessment

How do I reduce energy consumption?

Identify the inefficiencies and correct them. Simple changes like temp settings can lead to remarkable improvements. Design new data centers and/or zones for high density. Use right-sized, high-efficiency power and cooling equipment

Does efficiency improvement have a good ROI?

Many improvements are essentially free during design of NEW data centers or zones. Most EXISTING data centers have significant quick-win opportunities that can be identified during an assessment