Towards the Net-Zero Data Center: Development and Application of an Energy Reuse Metric

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Sustainability
Knows No Borders!

Learning Objectives for this Session

- Highlight the importance of modeling the off-design performance of equipment in data centers as a consequence of their dynamic behavior.
- Describe an experimentally validated tool for modeling the energy use of the data center and cooling infrastructure.
- Understand how to navigate Standard 90.1– 2010 version and its recent updates to data center applications
- Understand some of the limitations to the ECB method specific to data center applications
- Learn about a novel cooling strategy for IT equipment that has been shown to be more energy efficient than other commercially offered cooling solutions.
- Learn about a technology that has the ability to provide cooling with higher temperatures which would reduce or eliminate the need for compressor based cooling.

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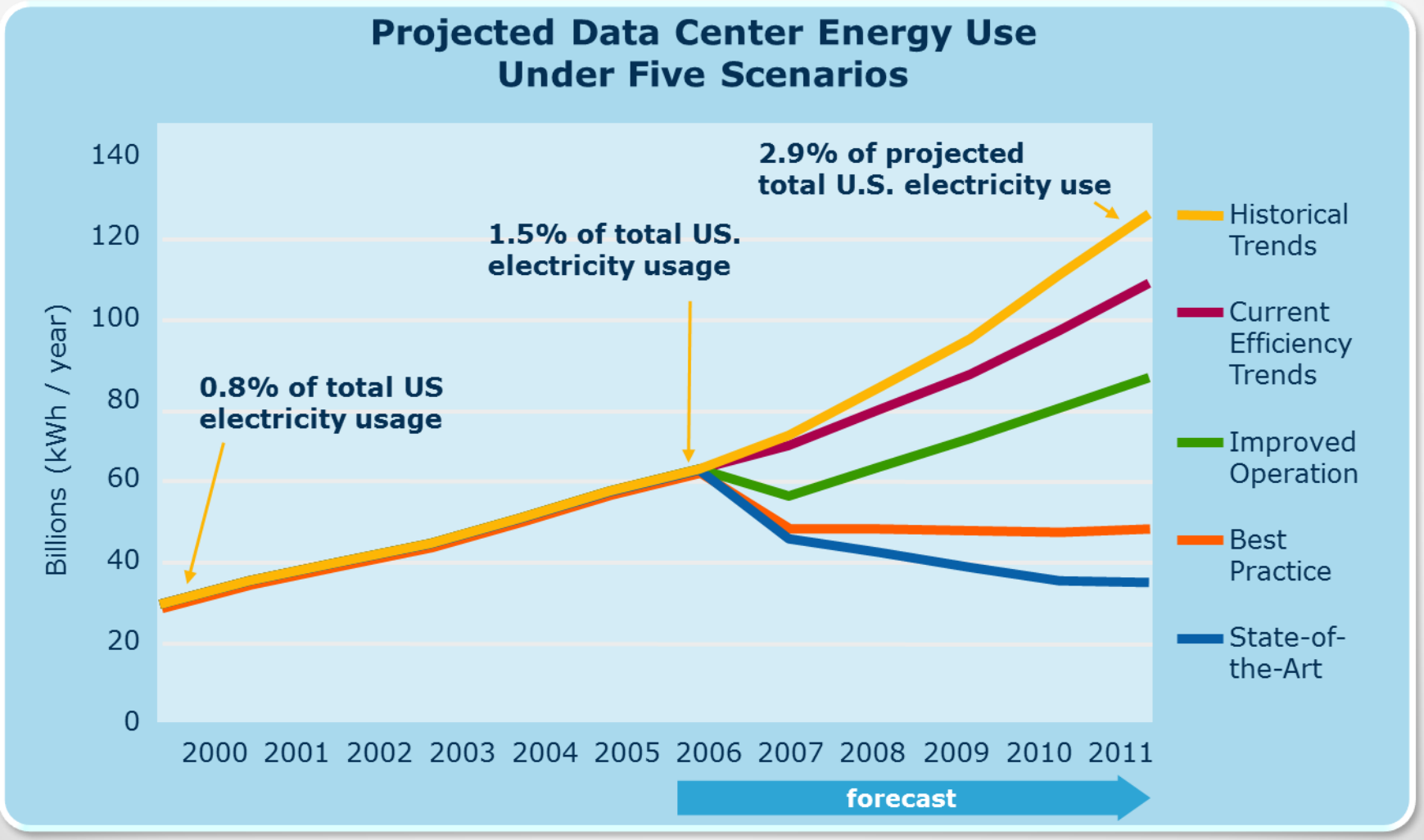
When State-of-the-Art isn't good enough



“I am re-using waste heat from my data center on another part of my site and my PUE is 0.8!”

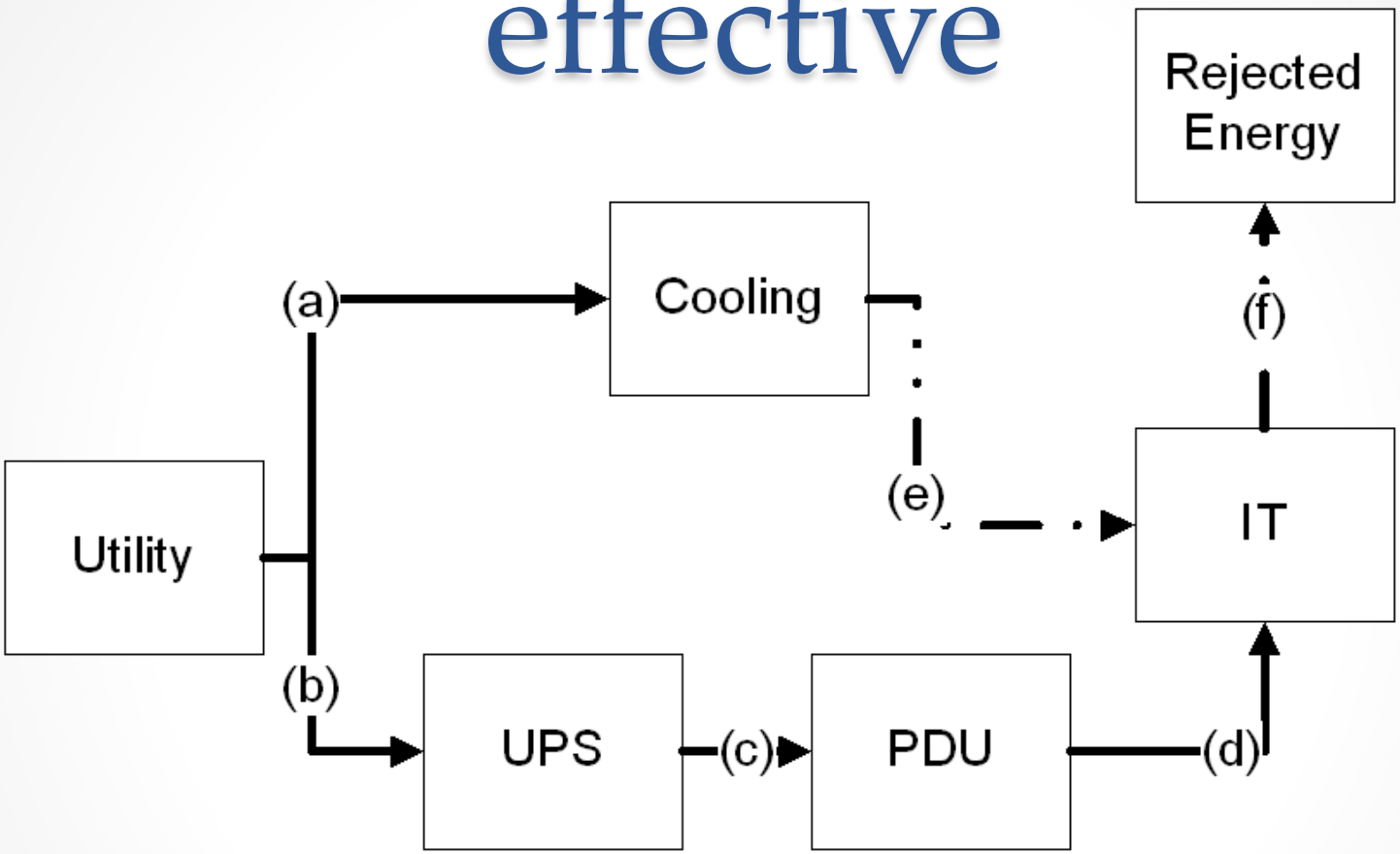
“I am re-using waste heat from my data center on another part of my site and my PUE is 0.91”

ASHRAE & friends (DOE, EPA, TGG, 7x24, etc..) do not allow reused energy in PUE

http://www.thegreengrid.org/en/Global/Content/Reports/RecommendationsForMeasuringandReportingOverallDataCenterEfficiencyVersion2

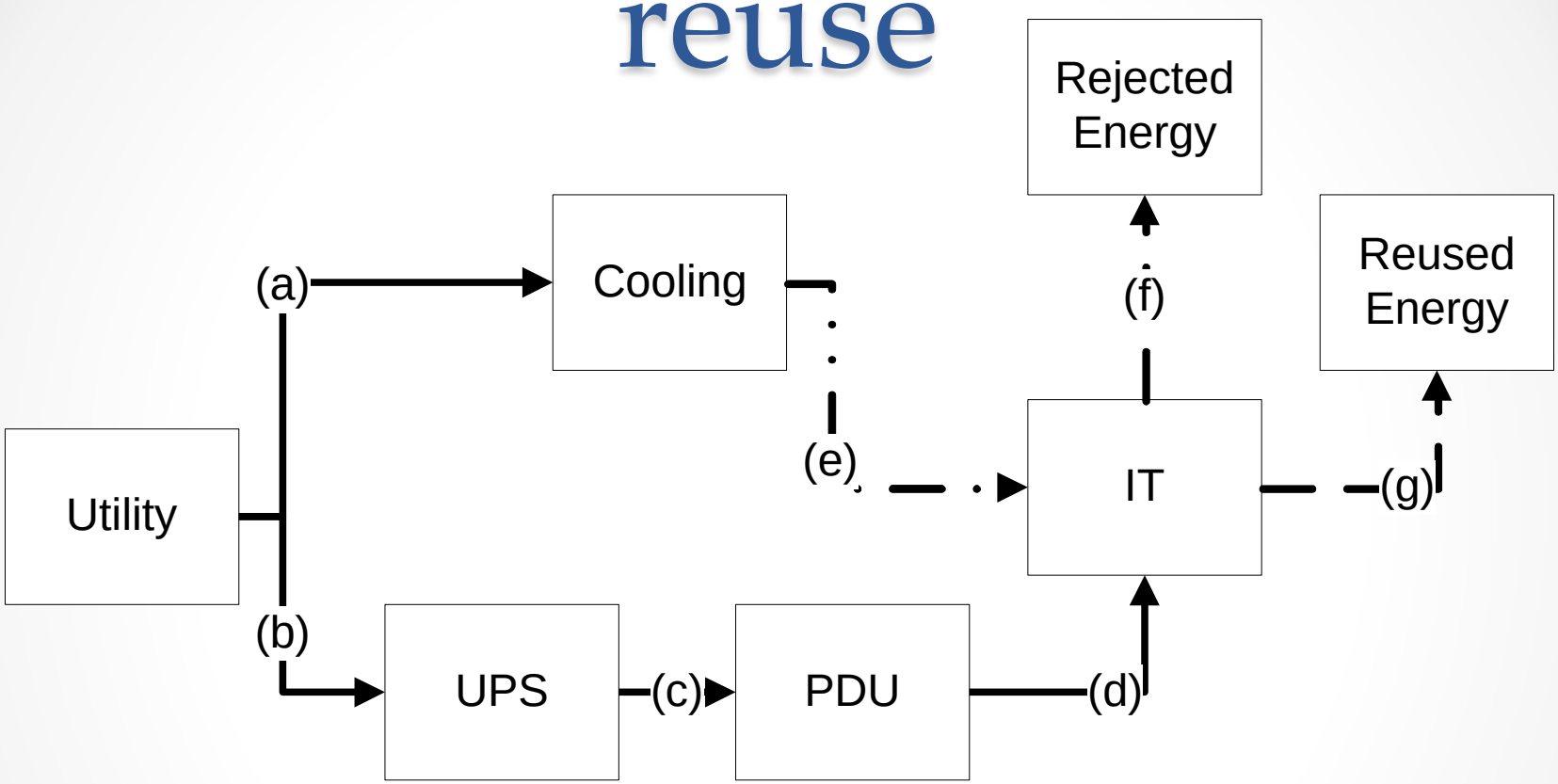
Another metric has been developed by The Green Grid; ERE – Energy Reuse Effectiveness

PUE – simple and effective



$$PUE = \frac{Total\ Energy}{IT\ Energy} = \frac{Cooling + PowerDistribution + Misc + IT}{IT} = \frac{a+b}{d}$$

ERE – adds energy reuse



$$ERE = \frac{Total\ Energy - Reuse\ Energy}{IT\ Energy}$$

$$= \frac{Cooling + PowerDistribution + Misc + IT - Reuse}{IT} = \frac{a + b - g}{d}$$

Alternative Development

can it be related to PUE?

$$ERE = \frac{Total\ Energy - Reuse\ Energy}{IT\ Energy}$$

$$ERF = \frac{Reuse\ Energy}{Total\ Energy}$$

$$ERE = (1 - ERF) \times PUE$$

As ERF ➔ 0 (no energy reuse) then ERE ➔ PUE

PUE and ERF Ranges

$$1 \leq PUE \leq \infty \qquad \text{PUE} = \frac{\text{Cooling} + \text{Power} + \text{Lighting} + \text{IT}}{\text{IT}}$$

$$0 \leq \text{RER} \leq 1 \qquad \text{RER} = \frac{\text{Reuse Energy}}{\text{Total Energy}}$$

$$0 \leq \text{ERF} \leq \infty \qquad \text{ERF} = \frac{\text{Cool} + \text{Pwr} + \text{Light} + \text{IT} - \text{Reused}}{\text{IT}}$$

The Challenge to NZEBs

- ASHRAE's Advanced Energy Design Guide (2008):
  - 5,000 ft2 small office building: 100 MBtus for heating in a typical year.
  - Energy to heat? ~22 servers, about ½ of one IT rack
- IT equipment energy in a typical data center will equal or exceed the heating demands of the most buildings. NZEBs are a technical challenge without this additional energy.
- ASHRAE's GreenGuide (2003):
  - cooling loads for advanced buildings: 3 to 6 watts per square foot
  - Datacenters ~ 75 to 150 watts per square foot range for low density and the more efficient designs are typically over 300 watts per square foot.
- Net-Zero status will require a fully integrated energy strategy, including an aggressive reuse of the heat from the datacenter.

NZEBs and NZECs

- May be better to consider a Net Zero Energy Campus
  - energy densities in a single building/data center may make an NZEB unobtainable
- Fully integrated campus energy plan is needed to be successful for an NZEC
  - Heat reuse for a number of buildings can make NZ easier to obtain
- Include targets for Data Center PUE and ERE
  - PUE <1.2
  - ERE < 0.5

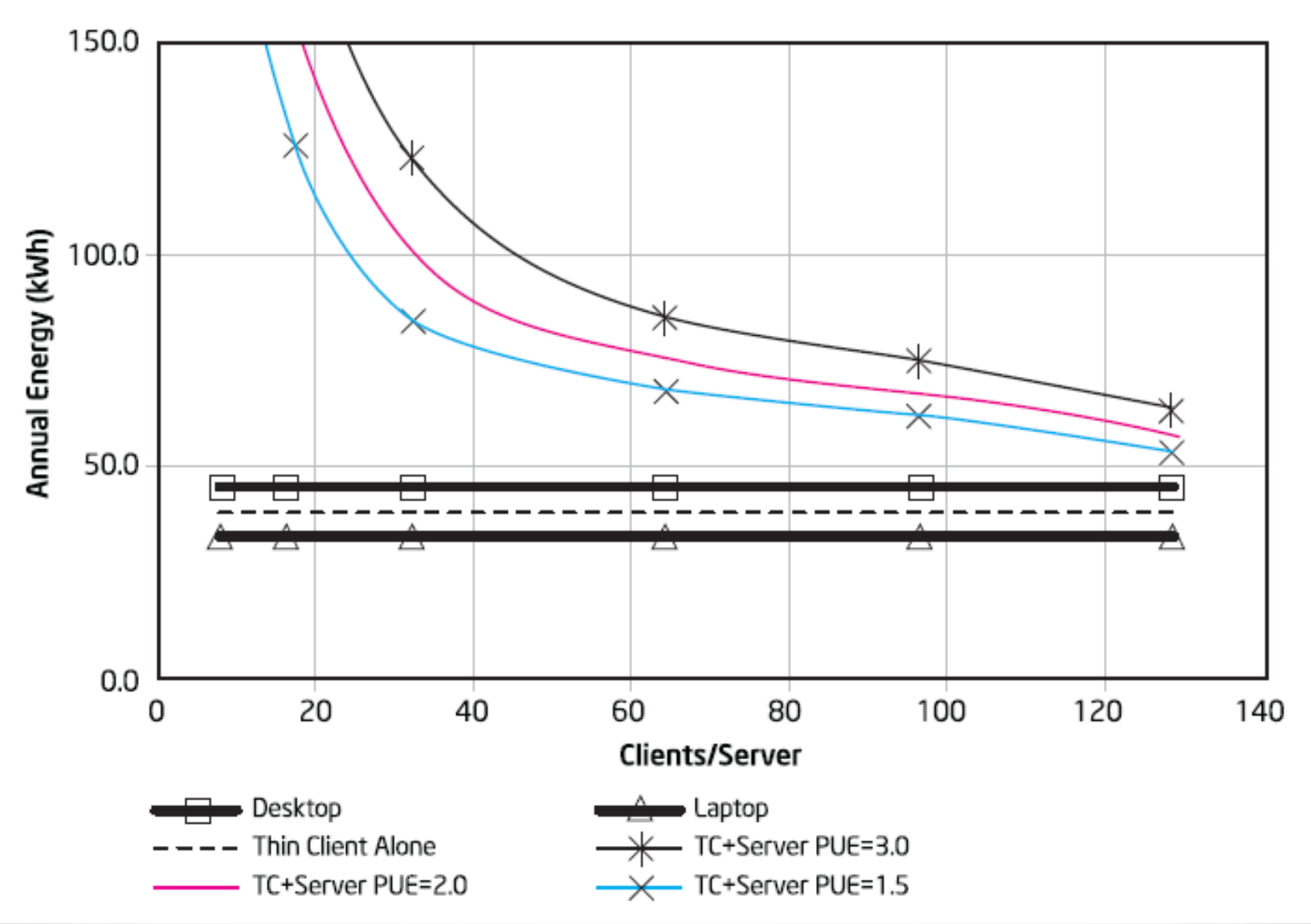
Case Studies

Site	ERE	PUE	Renewables
Oregon Sustainability Center	<1.0	tbd	Solar
Notre Dame	~0.25	~1.15	n/a
Laval University	~0.6	1.08	Hydro power
CSCS (Swiss Supercomputing Center)	n/a	<1.25	Cooling Energy
CSCS phase II	<1.0	<1.25	Cooling Energy
NREL (Nat Renewable Energy Lab)	<1.0	~1.06	Wind and solar
LBNL (Lawrence Berkeley Nat Lab)	<1.0	tbd	n/a

Accounting and Thin Clients

- Issue: how do we address off site IT use?
- An example:
  - Thin clients creating a lot of buzz
  - Low on site per client energy use
  - Ignores the computing in the data center!
  - When you consider the full IT picture, thin clients often the worst option for energy efficiency
- Still an open issue; NZEBs accounting must account for all energy use

Let's get the PowerPoint out of the data center!



Summary

- NZEBs and NZECs with data centers will need IT energy reuse to have a chance of NZ!
- New metric ERE introduced to measure energy reuse
- PUE and ERE needed to consider data center energy balance
- Case-studies demonstrate that energy re-use is becoming more prevalent and the need for the ERE metric becomes a priority
- IT accounting issues still a challenge and need to be addressed

Thank You!

Questions?