A market position paper
from the experts in Data Center
Infrastructure Management

Recycling Ratios: The Next Step for Data Center Sustainability

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The Increasing Importance of Environmental Issues

Environmental issues are increasingly important for data center management as these facilities become subject to a growing number of sustainability, data collection and reporting programs. While CO2 emissions are the primary metric for these initiatives to date, emerging issues include improved water and solid waste management.

The focus on CO2 emissions, of course, is related to the energy-intensive nature of data center operations. Data centers are under pressure from numerous sources to identify their environmental, social, energy and resource impacts ranging from the initial build phase through end-of-life. The main drivers in the discussion have centered on two issues:

- **The build-phase**, addressed primarily through the U.S. Green Building Council's LEED for New Construction; and
- **Operational energy,** with consumption metrics from The Green Grid and the U.S. EPA ENERGY STAR® for Data Centers providing critical data. Both of these metrics are based on power usage effectiveness, commonly known as PUE.

While PUE provides a metric for measuring data center energy inputs and outputs, there remains a glaring gap in the discussion when it comes to measuring the material inputs and outputs of a data center. These materials include everything required to run a data center, from paper and toner cartridges to IT hardware and supporting equipment that is often refreshed as frequently as every nine months. With organizations such as the Sierra Club promoting zero-waste policies, companies need an easily understood metric for measuring progress.

E-waste, a major component of data center material flow, represents the fastest growing municipal waste flow in the U.S. and likely around the globe with recent reports indicating an 8.6% growth rate. In 2007 alone over 41 million computers were discarded in the U.S. with only 18% being properly recycled. The growth rate for e-waste from data centers is poised to accelerate as facilities shift to shorter refresh cycles in pursuit of improvements in energy efficiency and compute performance. With organizations such as the Sierra Club promoting zero-waste policies, companies need an easily understood metric for measuring progress.

To help companies meet this challenge, this paper introduces new metrics that address the daily inflow of materials and outbound flow of goods, services, compared with the subsequent material that is recycled, reclaimed, repurposed, or disposed of as solid waste.

Material Recycling Ratio (MRR)

The first metric is **MRR – Material Reclamation Ratio.** MRR is the ratio of:

> Recycled/reclaimed/repurposed material (expressed in mass) over the inbound (received) material less outbound finished goods and services (also expressed as mass).

The result of the equation would be a ratio expressed as a percentage – with 100 percent recognized as the goal. Companies achieving a 100 percent MRR have zero **waste.**

$$MRR = \frac{\text{Total: Recycled/Reclaimed/Reused Material in Mass (lbs/Kg)}}{\text{Total: In-Bound Material – Outbound Product \& Service in Mass (lbs/Kg)}}$$

MRR is expressed as a percentage with 100 percent the target.

To support detailed reporting, MRR enables an organization, or data center, to report its effective ratio in total as well as in subcategories such as:

- **MRR(lifecycle)** includes all building infrastructure, equipment and tenant improvements, along with all operational items;
- **MRR(building)** includes only the core building infrastructure and shell;
- **MRR(operations)** is a better fit for daily operations and includes any assets that are not depreciated on the same schedule as the building; and
- **MRR(e-Waste)** would include electronic equipment containing hazardous materials, such as computers and lead-acid batteries, that require special handling. With growing awareness of the environmental problems caused by e-waste, including the the recent release of the Story of Electronics (www.storyofstuff.org/electronics), this material becomes more relevant as a reported sub-metric.

A PUE-Like Option: Material Reuse Effectiveness

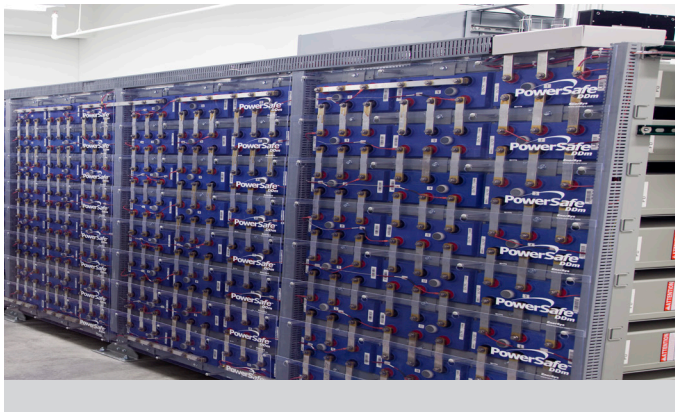
For organizations that prefer to report whole numbers, like the PUE metric for energy consumption, the inverse of the MRR provides **MRE – Material Reuse Effectiveness.** MRE is expressed as:

Inbound (received) material less outbound finished goods and services, expressed as mass over the recycled/re claimed/repurposed material (again expressed in mass).

Just as PUE is expressed as a ratio, with overall efficiency improving as the quotient decreases toward 1, MRE also provides a goal of 1.

$$MRE = \frac{\text{Total In-Bound Material – Outbound Product \& Service in Mass (lbs/Kg)}}{\text{Total Recycled/Reclaimed/Reused* Material measured in Mass (lbs/Kg)}}$$

MRE is expressed as a number, typically greater than 1, with 1 as the target



Measuring Progress OverTime

MRR and MRE offer a system that is easy to deploy and manage to enhance reporting on progress. Much like reporting the business use of energy, MRR or MRE would be reported as a function over time.

The following example illustrates how MRR(lifecycle), or MRR(l), works over the lifespan of a data center. Keep in mind that MRR(l) is a long-term metric that will not move frequently. However, it is important for tracking major data center infrastructure that includes hazardous materials, such as lead-acid battery systems.

At Startup

During startup of a data center, the ratio may be quite low – close to zero percent – as the only outbound materials would be discarded packaging and any equipment that fails early in the launch. Calculating the initial MRR(l) requires a highly accurate record of all the materials brought into the building. In addition to supporting the MRR(l) calculation, this information is important to the company's Chief Sustainability Officer (or similar designate) for meeting reporting requirements regarding the volume and composition of materials:

- Disposed of as solid waste;
- Sent to recycling centers; and
- Repurposed or reclaimed, either inside or outside the organization.

Figure 1 shows that a total of 83,000 lbs. of material are brought into the data center. Since everything is new, only the packaging would be sent for recycling. The MRR(I) ratio would be as follows:

$$\text{MRR (b)} = \frac{3{,}000}{83{,}00} = 3.6\%$$

Figure 1.

Equipment	Description	Weight (lbs.)
UPS	8 units, 2,000 lbs. each	16,000
Battery plant	4-strings, 160 batteries each string; 30 lbs. per battery	19,200
Battery racks	Cabling, containment, other	4,000
Air conditioning equipment	10 Computer Room Air Conditioners, 1,000 lbs. each	10,000
Packaging	Boxes, pallets	3,000
Miscellaneous	Raised floor and supports, duct work, other	30,800
TOTAL In-Bound		**83,000**
Less Reuse + Outbound		**3,000**
Net Balance on hand		**80,000**

MRR at First Refresh (Year 7)

To show how the metric evolves as a data center matures, consider the flow of materials for a typical data center refresh at around year seven. At this point, UPS batteries may require replacement, which presents an opportunity to take advantage of improvements in technology and density to reduce size and environmental footprint by eliminating lead-acid batteries. To ensure appropriate disposition of toxic materials, recyclers must provide printed confirmation that all of the content was safely recycled or reclaimed.

In this scenario, the **inflows** – the denominator in our equation – include the open balance of 83,000 lbs. To it we add 640 replacement batteries at 27 lbs. each for a total 17,280 lbs. We also add 1,720 lbs. of packaging and pallets required to bring the replacement equipment into the facility. This brings our **total Inflows** to 102,000 lbs (see Figure 2).

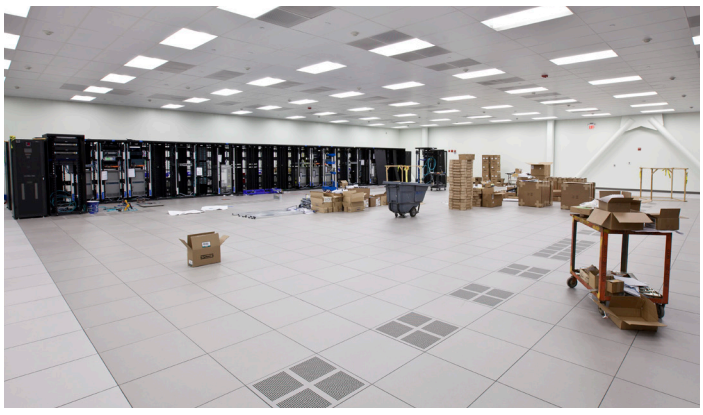
Figure 2.

Equipment	Description	Weight (lbs.)
Existing materials	See Figure 1	83,000
Replacement batteries	640, 27 lbs. each	17,280
Packaging	Boxes, pallets	1,720
TOTAL		**102,000**

Our **outflows** – the numerator – include the 3,000 lbs. of pallets and packaging from the initial build together with 19,200 lbs of old batteries that are being recycled via a certified recycling plant. Since the packaging and pallets are recycled or reused, the 1,720 lbs. added to inflows above are also included with outflows. When added together, total outflows are 23,920 lbs.

$$\text{Our New MRR (I)} = \frac{23{,}920}{102{,}000} = 23\%$$

This scenario shows that MRR(I) has increased substantially from the startup phase.



MRR When Relocating

MRR(I) improves further when the company decides to vacate the data center and move to a new site. The new owner/tenant may decide to keep some of the improvements, such as the raised floor, lighting, and duct work. These items can be categorized as Repurposed equipment in MRR reporting. However, the new tenants ask the company to remove the UPS equipment, battery plant, and precision cooling units. All of this material is either reused at the new facility, or recycled appropriately. As a result, outflows match the original inflows:

$$\text{Our New MRR (I)} = \frac{102{,}000}{102{,}000} = 100\%$$

To learn more about MRR, try our calculator on www.efficientdatacenters.com.

Conclusion

While the push for data center sustainability began with a focus on energy consumption, IT leaders must recognize the critical need to address a wider range of environmental issues. By providing a clear, easily understood metric, MRR and MRE can help data center leaders assess whether materials are handled in an environmentally responsible manner – and how to improve towards the goal of reducing waste and increasing recycling and reuse.