modius®

OpenData
Power Usage Effectiveness

Practical Guidelines for Measuring and Managing Data Center Efficiency in the Real World

INTRODUCTION

Modius Uniquely Enables Continuous and Comprehensive Measurement of PUE Metrics
As companies look for new ways to increase efficiencies and reduce costs, attention is increasingly turning to the data center – the capacity of which is almost universally strained by the unmitigated expansion of IT gear, both in terms of the addition of new servers, as well as the overall growth in the power-density of equipment.

Power Usage Effectiveness (PUE) is an emerging metric that, as its name implies, gives data center managers and business executives a highly useful yardstick for gauging how efficiently their data center facility consumes power – a determination that varies significantly depending on the compute load, the design of the cooling systems, and general efficiency of facilities equipment.

Gartner notes that PUE will become an increasingly widespread measurement standard during the next five years, primarily because PUE provides operators with a valuable "indication of opportunities for improved datacenter energy efficiency."[1] Already, the U.S. Department of Energy (DoE) and industry organizations like The Green Grid have made PUE (and newer variants, such as Energy Usage Effectiveness or EUE) the focal point of their efficiency measurement initiatives.

1: "How to Use the DCiE and PUE Metrics," by Rakesh Kumar, Gartner, February 23, 2009, Publication ID Number: G00165036

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IN SEARCH OF AN IMPROVED PUE

However, Gartner also notes that there are some limitations with PUE as the metric is currently used. Generally, because it is either captured intermittently, or based on only few instrumentation points, PUE generally only "provides a simple point-in-time snapshot of the energy efficiency of the data center."[2] By using PUE only in a high-level, snapshot format, operators miss valuable insights into their data center operations, including how:

- Efficiency varies during the course of the day
- It is influenced by seasonal and long-term business cycles
- It is correlated to other factors such as outside air temperature.

Modius has designed a solution that addresses this challenge. Modius uniquely allows PUE to be monitored both at an extremely comprehensive level (with as many instrumentation points as possible), as well as continuously throughout the day. This approach captures minute-by-minute changes in power consumption that characterize today's highly dynamic, globally oriented data center environments. The company believes that continuous and comprehensive measurement of PUE is essential to leverage this metric as a means to pinpoint strategies that can reduce energy consumption, and ensure that data center reliability is uncompromised.

THE POWER OF PUE: INFORMATION & INSIGHT

In its basic form, the Power Usage Effectiveness metric provides a way to determine:

- Opportunities to improve a data center's operational efficiency
- How a data center compares with industry standards or other competitive data centers[3]
- If the data center operators are improving the designs and processes over time
- Opportunities to expand capacity for additional IT equipment.

In terms of capacity, PUE can be used as a multiplier for calculating the real impact of the IT system's power demands. For example, if a server demands 500 watts and the PUE for the data center is 3.0, then the power from the utility grid needed to deliver 500 watts to the server is 1,500 watts. Likewise, lowering the PUE expands capacity for a given supply of power from the utility.

To convert this power number to real cost, a good estimate is that one wattyear costs about $1. This assumes an average utility cost of about 11 ½ cents per kilowatt-hour. So, in the above example, powering and cooling that server for a year would cost about $1,500. Reducing PUE to 2.5 would then save 250 watts, or $250 per server per year.

2: Ibid.

3: Only in a gross fashion. Please see "The Modius approach to measuring PUE" section for detailed discussion.

POWER USAGE EFFECTIVENESS: HOW IT'S DEFINED

Conceptually simple, PUE is defined as:

$$PUE = \frac{\text{TOTAL FACILITY POWER}}{\text{I.T. EQUIPMENT POWER}}$$

'Total Facility Power' is defined as the total power consumed only by the data center facility. This definition is important in mixed-use buildings where the data center is only one of several of consumers of power, such as office buildings. The 'IT Equipment Power' is defined as the total power consumed by the equipment that is used to manage, process, store or route data within the data center.

It is important to understand the components for the loads in the metrics:

1: Total Facility Power: This is an all-inclusive metric that includes everything that consumes power in the facility:

- All power distribution components, such as uninterruptable power supplies (UPS), switch gear, generators, power distribution units (PDUs), batteries and distribution losses external to the IT equipment
- All cooling system components such as chillers, computer room air conditioning units (CRACs), air handler units, pumps and cooling towers
- All IT equipment, such as servers, network and storage nodes
- All other miscellaneous component loads, such as data center lighting.

Generally, Total Facility Power is measured at or near the utility meter(s) of the facility to accurately reflect the power entering the data center. However, in mixed-mode facilities, adjustments need to be made for shared resources such as chillers.

2: IT Equipment Power: This includes the total load consumed by all of the IT equipment – such as computer, storage, and network equipment – along with supplemental equipment such as monitors and workstations/laptops used to monitor or otherwise control the data center, including KVM (Keyboard, Video/Visual Display Unit, Mouse) switches and other rack gear.

IT Equipment Power should be measured after all power conversion, switching and conditioning activities are completed, but before it is consumed by the IT equipment itself. This measurement should represent the total power delivered to the IT equipment racks in the data center. The most likely measurement point is at the output of the computer room PDUs, but many other measurement points are also valid.

PUE 101: STARTING WITH THE GREEN GRID APPROACH

In 2009 The Green Grid, an association of IT professionals seeking to dramatically raise the energy efficiency of data centers (www.thegreengrid.org) produced some best-practice guidelines on how PUE should be measured and reported.

1: IT Load should be measured as close to the CPU chip as possible. In Green Grid terms, PUE-Level 1 is measured at the UPS, PUE-Level 2 is measured at the PDU and PUE-Level 3 is measured at the server (see Figure 1 below).

2: Clearly, the power consumed by shared resources such as heating/ventilation/air conditioning (HVAC) units and chiller plants should be adjusted or prorated as part of Total Facility Power. In Green Grid terms: PUE-Level 1 means no adjustments for shared-use equipment. PUE-Level-2 means that selected shared HVAC resources are adjusted appropriately. PUE-Level 3 means that all shared resources (including lighting, security, etc) are adjusted.

3: The third concept is how frequently PUE is measured. PUE-Level 1 means monthly or weekly. PUE-Level 2 means daily. PUE-Level 3 means continuous.

FIGURE 1: "GREEN GRID" RECOMMENDATIONS FOR LEVELS OF DATA CAPTURE FOR PUE MEASUREMENT

	Level 1 (Basic)	Level 2 (Intermediate)	Level 3 (Advanced)
IT Equipment Power Measurement From…	UPS	PDU	Server, …
Total Facility Power Measurement From…	Data Center input power	Data Center input less shared HVAC	Data Center input less shared HVAC plus building lighting, security…
Minimum Measurement Interval	Monthly/Weekly	Daily	Continuous (xx min)

THE MODIUS APPROACH TO MEASURING PUE

In general, Modius has built its approach to PUE measurement in concert with The Green Grid recommendations. However, Modius recommends that the data center operators start with data that is collected continuously throughout the day (i.e. approximately once a minute), and then increase the comprehensiveness (i.e. the granularity of the instrumentation points) over time.

This recommendation is based on the fact that a continuous sample rate is absolutely necessary to understand important energy consumption fluctuations during the day. Even if only relatively few instrumentation points are being used to record data center performance, continuous collection allows more insightful correlation with other factors such as outside air temperature. Once performance adjustments are made, new instrumentation points can then be added to provide new insights.

In general, the more granular the data, the easier it is to perform trend analysis and correlations. But more importantly, to increase efficiency, the data center operator also needs to identify transient phenomena – such as hot spots or cold spots, or temporary compute loads – that impact efficiency during the course of the day. By capturing data continuously throughout the day, operators increase their ability to make incremental adjustments to their infrastructure that drive increased efficiency.

THREE RECOMMENDED LEVELS OF INSTRUMENTATION

To achieve the best PUE reports, Modius recommends operators approach their PUE data capture in terms of three ascending levels of instrumentation granularity:

BASIC P.U.E.

A Basic PUE measurement involves instrumentation points at the utility feed into the facility (either at the utility feed or the output of the transfer switch) and IT-level measurement points after the majority of the power transformation has occurred. Generally, this occurs at the UPS level (depending on the power configuration). As shown below, a Basic PUE measurement provides the minimum data necessary for a PUE calculation.

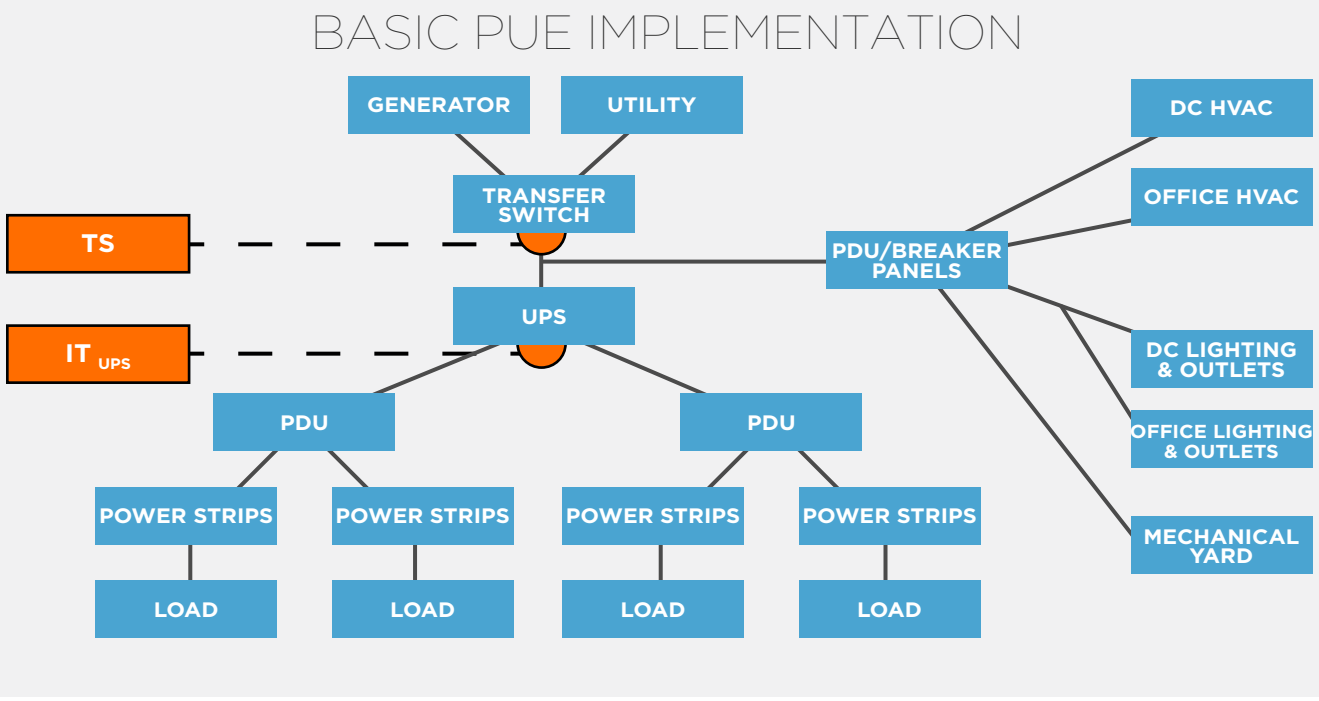

Figure 2: Shown above are example instrumentation points for Basic PUE. Data is captured from the output of the transfer switch and the output of the UPS, and the ratio of these two points provides Basic PUE. A general adjustment factor can be used to account for shared-use resources, such as energy consumed by the mechanical yard for non-data center usage (e.g. general office space use).

Basic PUE is relatively simple, and because it has a relatively few instrumentation points, is easy to deploy and has the least impact on the facility. In this scenario, a general adjustment factor is made to account for distributions to non-data center uses of power.

However, the associated instrumentation has several drawbacks. Most importantly, it is not ideal for accurately capturing power consumption in shared-resource scenarios (e.g. with non-data-center space, such as offices, labs and manufacturing), or for capturing a detailed picture of power use by individual IT assets and facility subsystems.

INTERMEDIATE P.U.E.

A more detailed, Intermediate PUE measurement incorporates additional instrumentation points at the outputs of the PDUs and the outputs of the breaker panels. This approach captures a more accurate measurement of energy consumed by IT equipment, as well as a more detailed breakout of non-IT energy consumption in the data center.

Figure 3 illustrates the additional measurement points that would be captured. Again, a general adjustment factor is made to account for distributions to shared-use resources.

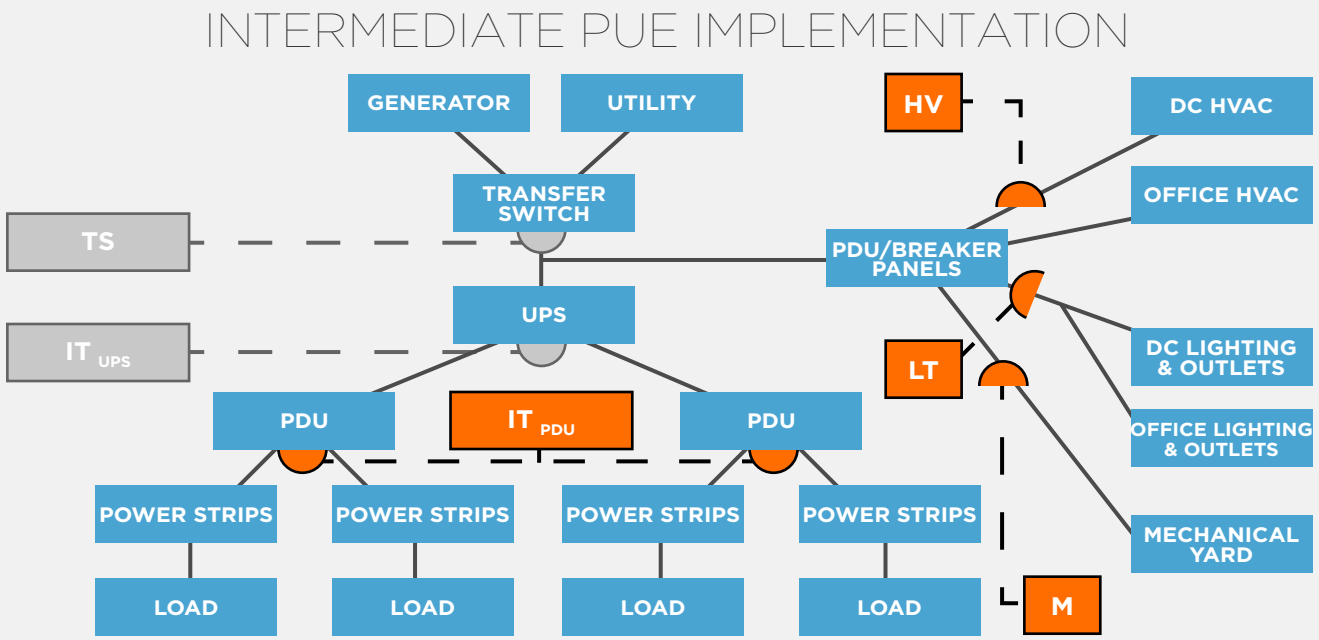

Figure 3: Shown above are example instrumentation points for Intermediate PUE. Intermediate PUE expands upon Basic PUE by adding instrumentation points at the outputs of the PDUs, and the outputs of the breaker panels. This instrumentation strategy provides more detailed information on the actual consumers of power in the data center, and also allows for more accurate adjustment factors for shared-use resources such as lights and mechanical yard.

The benefit of an intermediate approach to PUE measurement is that is allows data center managers to accurately capture several important factors to overall efficiency, including UPS & PDU transformer loss and the relative distributions to non-IT consumers of power such as HVAC and lighting.

It should be noted that there are an almost infinite number of ways to capture Intermediate PUE. Generally, Modius finds that most data centers are set up to instrument the different HVAC components, but not the mechanical yard, so adjustment factors for mechanical yard consumption are used instead. The exact instrumentation will vary considerably by facility design and by business objective.

ADVANCED P.U.E.

Finally, to achieve the most comprehensive level of PUE measurement, Advanced PUE, Instrumentation is also required at the outputs of the power strips and more detailed instrumentation of the mechanical yard. This provides much more granular insight into power consumption by IT and the supporting infrastructure.

Figure 4 below illustrates the additional instrumentation points for measuring Advanced PUE, which include the outputs of the power strips (or intelligent power strips, iPDUs) for more granular IT information, as well as additional instrumentation points in the mechanical yard to more accurately calculate data center usage.

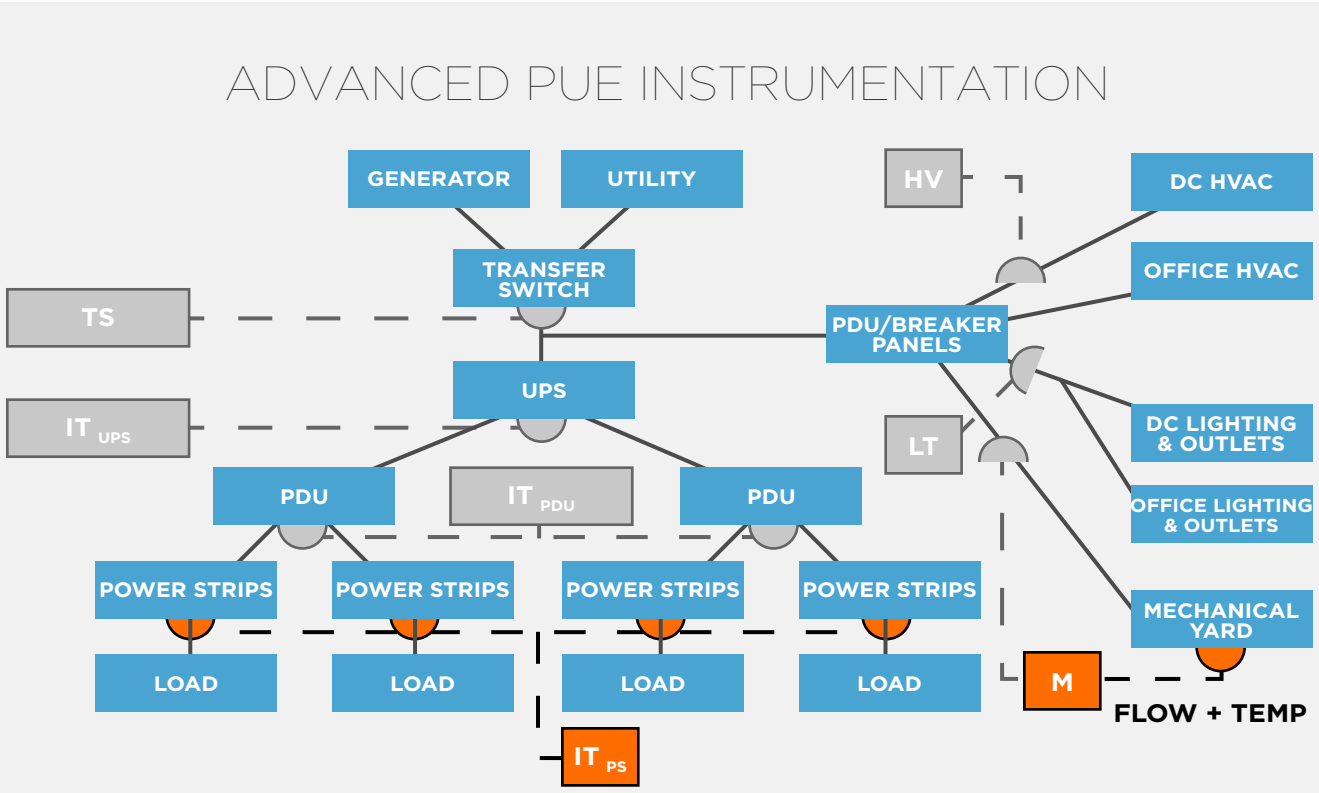

Figure 4: Shown above are example instrumentation points for Advanced PUE. Advanced PUE expands upon Intermediate PUE by instrumenting the power strips, and capturing additional instrumentation points in the mechanical yard. This instrumentation strategy allows for rack or plug-level power metering of IT usage. It also supports a more accurate measurement of energy consumption in the mechanical yard by capturing additional data points that allow Modius to calculate chiller output specifically related to data center usage.

SUMMARY OF MODIUS RECOMMENDATIONS

Based on these alternatives, Modius offers three guidelines for how best way to capture PUE, and in turn has designed its solution to meet these requirements:

START WITH BASIC, THEN EXPAND TO ADVANCED

Modius recommends that data center operators start with a basic deployment and start capturing a baseline of PUE data. Once this is achieved, the facility can move toward higher levels of granularity and fidelity, over time.

Modius solution: Modius provides a single toolset that lets users start with Basic PUE and then expand to more complex Advanced PUE, along with every variation in between. After the initial solution is deployed, Modius allows users to easily add new devices directly into the system; data center personnel can easily adjust the underlying computations to account for the new data sources.

AUTOMATE THE COMPUTATION OF METRICS

Effective PUE measurement, whether Basic, Intermediate or Advanced, involves many calculations and adjustment factors. Because every data center is different, these calculations will vary from one facility to the next, and the data capture solution needs to have a flexible computational capability built into it.

Modius solution: Through its computed points technology, Modius provides an extremely easy and flexible way both to calculate these metrics, as well make adjustments to the calculations as they are collected. Modius lets users change these underlying computations without programming, complicated SQL queries or other procedures seen in other systems. Instead, Modius provides a simple and intuitive interface.

CAPTURE PUE DATA CONTINUOUSLY

Finally, and most importantly, Modius believes that operators should continuously capture all the necessary data throughout the day. Rather than collect it only intermittently, Modius recommends that the system be able to record data as often as once a minute.

Modius solution: To achieve this requirement, Modius has developed a monitoring and measurement technology that actively polls each device multiple times a minute to collect the most up-to-date performance information. The solution then records the data in a centralized database for easy trending and analysis over time.

THE BENEFITS OF CONTINUOUS AND COMPREHENSIVE PUE

By capturing PUE continuously and comprehensively, Modius offers a breakthrough solution that allows data centers to achieve energy cost savings and maximize the efficient use of data center capacity in several important ways.

- First, energy costs can be dramatically reduced. Modius enables optimization adjustments to key data center equipment – CRAC units, HVAC systems, chillers and generators – that can translate into substantial cost savings and rebates. Thus, Modius allows PUE to be reduced and maintained within acceptable limits, improving energy performance.

- second, data center capacity that appears to be maximized is often simply poorly configured. Modius provides critical information on the myriad microclimates within the data center, helping facilities professionals to reorganize equipment to harmonize the IT load. This prolongs the life of existing data centers and allows companies to defer or eliminate CapEx investments in new data center facilities.

- Third, the holistic view on data center health and reliability that Modius provides helps impart peace of mind that facilities management and executives alike can appreciate. Modius allows data center teams to take a proactive approach to managing the data center by identifying conditions that have drifted from their original design, instead of perpetually reacting to emergency situations after they occur.

The real-time information Modius provides is essential in managing power usage in today's constantly changing data center environment. by affording continuous granular insight into PUE, Modius helps to reduce the cost, and stress, of managing one of an enterprise's most volatile physical assets.

ABOUT MODIUS

Modius is an independent software vendor based in San Francisco, California. Founded in 2004, Modius develops intelligent measurement systems for mission critical facilities that improve business continuity, energy performance, and carbon management. Modius solves the challenge of integrating both IT and facilities management information into a single, comprehensive measurement system. Modius empowers 'smart' data center management through:

1: Widespread, practical, low-cost collection of all physical-layer performance data

2: Trustworthy and reliable analysis tools based on comprehensive data and rich analytic capabilities

3: Useful and actionable intelligence through highly-configurable business logic

4: Customized workflows, **delivering the right intelligence to the right people at the right time**.

TECHNICAL SPECIFICATIONS

Modius OpenData is a software application that can be installed on-premise or hosted in the cloud. Some customers choose to run the application within VMWare ESX. Software platform requirements are as follows:

- **Windows Server** - 2008, 2008 R2, 2012
- **Database** - Express, Workgroup (Up to 2012) and MS SQL Server 2008 - 2016

CONTACT YOUR MODIUS REPRESENTATIVE FOR MORE INFORMATION ABOUT HOW OPENDATA CAN FREE UP TRAPPED CAPACITY IN YOUR DATA CENTER, SIGNIFICANTLY REDUCING OPERATING COSTS.

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