

Data Center Carbon Usage

This technical white paper provides information about carbon usage within the scope of OpenManage Enterprise and OpenManage Enterprise Power Manager.

Abstract

This white paper provides guidance to measure the data center's carbon usage based on energy consumed during operations. Emissions measurement is crucial to meet data center sustainability goals.

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Acronyms

Acronyms	Expansion
OME	OpenManage Enterprise
OMEPM	OpenManage Enterprise Power Manager
iDRAC	Integrated Dell Remote Access Controller
CMC	Chassis Management Controller
MCM	Multi Chassis Management
MM	Management Module
REST	REpresentational State Transfer
GUI	Graphical User Interface
API	Application Programming Interface
EPR	Emergency Power Reduction
CEF	Carbon Emission Factor
PUE	Power Usage Effectiveness
CUE	Carbon Usage Effectiveness
DCiE	Data Center Infrastructure Efficiency
kWh	Kilowatt-hour
kgCO ₂ e	Kilogram of carbon dioxide equivalent

Executive summary

This white paper describes how to measure carbon usage of a data center during operations. It also covers aspects related to carbon usage tracking over time and tips to reduce the same using OpenManage Enterprise console and Power Manager plugin.

1 Determining emission conversion factor

This section explains how to calculate and set a factor to estimate the carbon emission for a unit of energy consumed. Importance of Power Usage Effectiveness (PUE) and configuring the setting are also explained.

Note: Managing infrastructure devices in a manner that reflects their physical organization in the data center is essential for extracting best results. For more information about managing physical groups, see the [Managing physical grouping of infrastructure devices in OpenManage Enterprise Power Manager](#) white paper.

1.1 Calculating emission conversion factor

The data center can have a mix of power sources behind the core power structure. These can constitute non-renewable energy sources like fossil fuel, nuclear power, and so on, and renewable energy sources like hydro-electric, solar, wind, geothermal and so on. Each type of source has an associated carbon emission factor, typically non-renewable sources have a higher factor than the renewable ones. A unit to identify the factor would be:

$$\text{kgCO}_2\text{e} / \text{kWh} = \text{Kilogram of carbon dioxide equivalent per Kilowatt-hour of energy}$$

There are regional and state-level authorities that are responsible for publishing emission conversion factors pertaining to various types of energy sources. We recommend you consult them for receiving factors applicable for your data center location and energy source types being consumed.

Note: One such source for example or reference is the United States Environmental Protection Agency, which publishes data each year.

For example, let us consider a data center receiving power from two types of sources. Following table depicts how to calculate data center level emission conversion factor based on source types.

Table 1 Emission Conversion Factor Calculation

Energy Source Type	Emission Conversion Factor	Contribution to Total Data center Energy	Total
Natural gas-based	0.407 kgCO ₂ e / kWh	70%	0.407 * 70 = 28.49
Hydro-electric	0.024 kgCO ₂ e / kWh	30%	0.024 * 30 = 0.72
Resultant Conversion Factor			(28.49 + 0.72) / 100 = 0.2921 kgCO₂e / kWh

1.2 Configuring emission conversion factor

To configure emission conversion factor in Power Manager plugin, do the following

- Log in to Dell EMC OpenManage Enterprise and navigate to **Plugins → Power Management → Settings** page.
- Click **Edit**.
- Under **Carbon Emission → Emission Conversion Factor**, enter a desired value and then click **Apply**.
- Allowed values are between 0 and 1.

- Default value is 0.3731 (country level factor in 2020 as per U.S. Environmental Protection Agency).

Note: This action is allowed for users with Administrator role only. The configured conversion factor will be used for calculations across the console.

API to view and configure settings: /api/PowerService/Settings

1.3 Configuring Power Usage Effectiveness

Power Usage Effectiveness (PUE) is an indicator for measuring the energy efficiency of a data center. It evaluates the energy efficiency of the data center by calculating the ratio of the energy used as a whole as compared with the energy used by just the infrastructure devices. To configure the value in Power Manager plugin:

- Log in to Dell EMC OpenManage Enterprise and navigate to **Plugins → Power Management → Settings** page.
- Click **Edit**.
- Under **Energy Consumption Cost → Power Usage Effectiveness**, enter a desired and then click **Apply**.
- Allowed values are greater than and equal to one.
- Default value is 1.5.

Power Manager will use this setting for calculating the total facility energy consumption pertaining to energy consumed by respective infrastructure devices.

Note: This action is allowed for users with Administrator role only. It is recommended to consult the data center facility team for an accurate number. The configured PUE will be used for calculations across the console.

The following table represents the PUE associated with generally accepted data center efficiency levels:

Table 2 PUE and Data Center Infrastructure Efficiency (DCiE) Relationship

PUE	DCiE	Level of Efficiency
3.0	33%	Very Inefficient
2.5	40%	Inefficient
2.0	50%	Average
1.5	67%	Efficient
1.2	83%	Very Efficient

Note: Use this table as a reference for interpreting PUE values only. It should not be used for determining the PUE for your data center.

API to view and configure settings: /api/PowerService/Settings

Edit Power Manager Preferences ? X

Change the default preferences based on your data center and monitoring requirements.

Enforce
Enable to force shutdown a device when graceful shutdown is unsuccessful while enabling EPR. No ▾

Staggered EPR Removal

Enforce
Enable staggering of power when EPR is disabled. Yes ▾

Time Delay
Set a delay time for staggering power. 5 Seconds

Energy Consumption Cost

Flat Rate /kWh
Set a fixed cost of energy consumed per kWh. 1

Power Usage Effectiveness
Set a value that is a multiplier of the data center energy which estimates the facility energy. 1.5

Currency
Set a currency to display the cost. US Dollar (USD ▾)

Carbon Emission

Emission Conversion Factor
Set a factor to estimate the carbon dioxide emission for a unit of energy consumed. 0.2921 kgCO₂e / kWh

Figure 1 Carbon Emission Conversion Factor and PUE Settings

2 Visualizing carbon usage

This section explains how carbon usage can be visualized for various monitored entities like infrastructure devices and groups. It is presented w.r.t. the device energy consumption and associated energy consumption by facility in the data center.

2.1 Visualizing carbon usage of devices

- Log in to Dell EMC OpenManage Enterprise and navigate to the **Devices** page.
- Click **Name** of a device that is being monitored.
- Click on the **Power Management and Monitoring** tab.
- Under **Metrics and Monitoring History**, see the **Energy Consumption Cost and Carbon Emission** table for details.
- Select a desired **Duration** from the available drop-down list to filter the data.

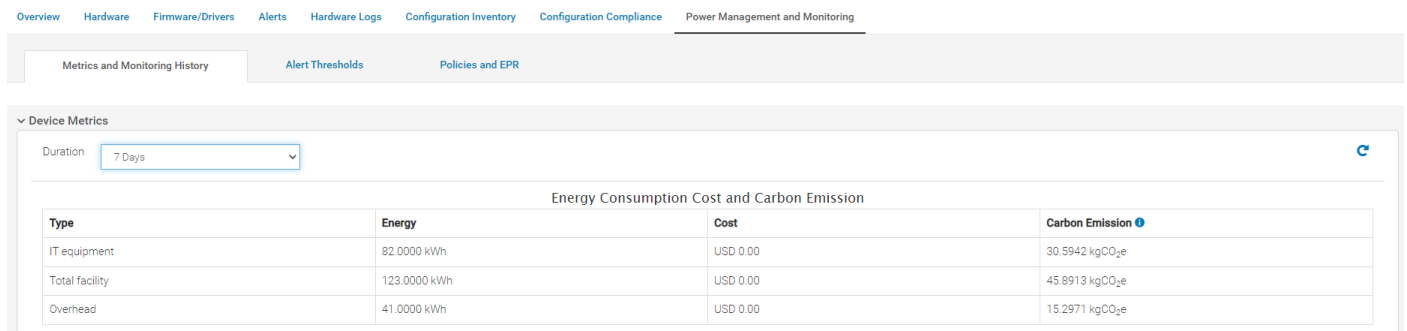


Figure 2 Device Carbon Usage

Note: Carbon emission is related to the use phase of the product. Emissions from manufacturing, transportation, and end-of-life are excluded.

API to view device carbon emission: `/api/PowerService/CarbonEmission`

2.2 Visualizing carbon usage of groups

- Log in to Dell EMC OpenManage Enterprise and navigate to the **Devices** page.
- In the left pane, select a monitored group under **Custom Groups** → **Static Groups**, or **PLUGIN GROUPS** → **Physical Hierarchy**.
- Click on the **Group Details** tab.
- Under the **Metrics and Monitoring History** tab, see the **Energy Consumption Cost and Carbon Emission** table for details.
- Select a desired **Duration** from the available drop-down list to filter the data.

Visualizing carbon usage

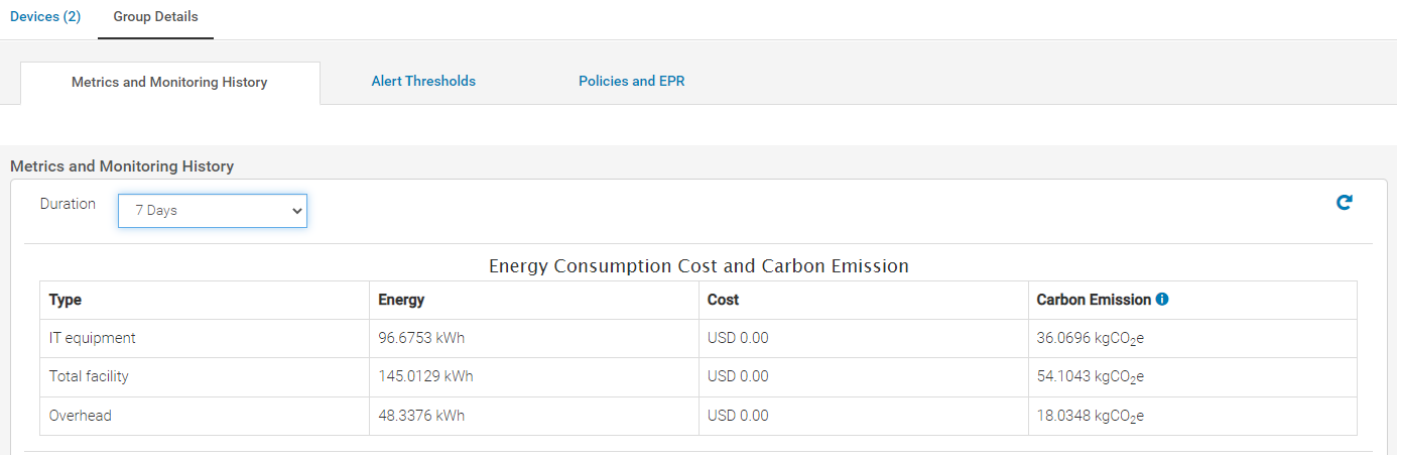


Figure 3 Group Carbon Usage

Note: Carbon emission is related to the use phase of the product. Emissions from manufacturing, transportation, and end-of-life are excluded.

API to view group carbon emission: </api/PowerService/CarbonEmission>

3 Carbon usage reports

This section explains about the reports that are available for extracting carbon usage data of devices and groups. These reports are built-in, and corresponding collections are also made available for custom report creation. The reports contain predefined parameters, which when run, provide data over configured time intervals.

3.1 Device carbon usage report

- **Type:** Built-In
- **Category:** Power Manager Devices
- **Name:** Power Manager: Greenhouse Gas Emissions Report (Carbon Dioxide Equivalent) for Servers and Chassis
- **Description:** This report contains information about greenhouse gas emissions for servers and chassis that are monitored in Power Manager.
- **Advantages:** Extract data for all monitored devices at once for different time intervals.

Snippet of a sample run:

Reports > Power Manager: Greenhouse Gas Emissions Report (Carbon Dioxide Equivalent) for Servers and Chassis 190

Power Manager: Greenhouse Gas Emissions Report (Carbon Dioxide Equivalent) for Servers and Chassis							Mar 14, 2022 9:38:13 PM
Group: All Devices							
Description: This report contains information about greenhouse gas emissions for servers and chassis that are monitored in Power Manager.							
DEVICE NAME	DEVICE TYPE	DEVICE MODEL	DEVICE IDENTIFIER	ENERGY CONSUMPTIO...	GREENHOUSE GAS EML...	DATE ADDED	
100.96.24.188	SERVER	PowerEdge R740	CFCFOC3	1.4920	0.4358	2022-03-14 16:01:19.9...	
100.96.24.188	SERVER	PowerEdge R740	CFCFOC3	3.2190	0.9403	2022-03-14 04:46:03.0...	
100.96.24.188	SERVER	PowerEdge R740	CFCFOC3	3.2190	0.9403	2022-03-13 04:46:04.2...	
100.96.24.188	SERVER	PowerEdge R740	CFCFOC3	3.2310	0.9438	2022-03-12 04:46:02.7...	
100.96.24.188	SERVER	PowerEdge R740	CFCFOC3	3.2310	0.9438	2022-03-11 04:46:03.7...	
100.96.24.21	SERVER	PowerEdge R740	S316XM3	0.4310	0.1259	2022-03-14 16:01:17.1...	
100.96.24.76	SERVER	PowerEdge R740	D26XB33	0.8620	0.2518	2022-03-14 16:01:14.9...	
100.96.24.76	SERVER	PowerEdge R740	D26XB33	1.9000	0.5550	2022-03-14 04:46:03.0...	
100.96.24.76	SERVER	PowerEdge R740	D26XB33	1.8990	0.5547	2022-03-13 04:46:02.9...	
100.96.24.76	SERVER	PowerEdge R740	D26XB33	1.8880	0.5515	2022-03-12 04:46:02.7...	
100.96.24.76	SERVER	PowerEdge R740	D26XB33	1.9080	0.5573	2022-03-11 04:46:03.7...	

Figure 4 Device Carbon Usage Report

Note: If you are logged in as a Device Manager, only the device groups and devices that are in your scope are available for viewing and management. For example, if you are logged in as a Device Manager DM1 user, and a group G1 is assigned to the Device Manager DM1 user, you can view only the devices in the G1 group.

API to run a report: `/api/ReportService/Actions/ReportService.RunReport`

3.2 Group carbon usage report

- **Type:** Built-In
- **Category:** Power Manager Groups
- **Name:** Power Manager: Greenhouse Gas Emissions Report (Carbon Dioxide Equivalent) for Groups
- **Description:** This report contains information about greenhouse gas emissions for static and physical Groups that are monitored in Power Manager.
- **Advantages:** Extract data for all monitored groups at once for different time intervals.

Snippet of a sample run:

Reports > Power Manager: Greenhouse Gas Emissions Report (Carbon Dioxide Equivalent) for Groups 57

Download Email

Power Manager: Greenhouse Gas Emissions Report (Carbon Dioxide Equivalent) for Groups Mar 14, 2022 9:41:17 PM

Description: This report contains information about greenhouse gas emissions for static and physical Groups that are monitored in Power Manager.

GROUP NAME	LOCATION	ENERGY CONSUMPTIO...	GREENHOUSE GAS EMI...	DATE ADDED
Room1	DC	5.3140	1.5522	2022-03-10 16:01:30.4...
Room1	DC	12.0480	3.5192	2022-03-11 16:02:11.3...
Room1	DC	10.8320	3.1640	2022-03-12 16:02:03.6...
Room1	DC	10.6740	3.1179	2022-03-13 16:02:06.2...
Room1	DC	10.6750	3.1182	2022-03-14 16:02:10.1...
Room 001	DC BDC	8.7270	2.5492	2022-03-10 16:01:30.4...
Room 001	DC BDC	20.0040	5.8432	2022-03-11 16:02:11.3...
Room 001	DC BDC	20.2100	5.9033	2022-03-12 16:02:03.6...
Room 001	DC BDC	20.2250	5.9077	2022-03-13 16:02:06.2...
Room 001	DC BDC	20.2700	5.9209	2022-03-14 16:02:10.1...

Figure 5 Group Carbon Usage Report

Note: If you are logged in as a Device Manager, only the device groups and devices that are in your scope are available for viewing and management. For example, if you are logging in as a Device Manager DM1 user, and a group G1 is assigned to the Device Manager DM1 user, you can view only the devices in the G1 group.

API to run a report: `/api/ReportService/Actions/ReportService.RunReport`

4 New sustainability metric: CUE

The impact of operational carbon usage is emerging as an extremely important factor in the design, location, and operation of data centers. To address this need, a new metric called Carbon Usage Effectiveness (CUE) has been proposed. It represents carbon emissions associated with data centers. When used in combination with the power usage effectiveness (PUE) metric, data center operators can quickly assess the sustainability of their data centers, compare the results, and determine if any energy efficiency and/or sustainability improvements need to be made.

Unlike PUE, CUE has dimensions while PUE is unit-less. Another important difference is the range of values. PUE has an ideal value of 1.0, implying that all energy used at the site goes to the infrastructure devices, and there is no theoretical upper boundary for PUE. CUE has an ideal value of 0.0, indicating that no carbon use is associated with the data center’s operations. Like PUE, CUE also has no theoretical upper boundary.

4.1 Calculating carbon usage effectiveness

For data centers that obtain their entire power source from the energy grid and do not generate local CO2, CUE is defined as follows:

$$CUE = \frac{CO2\ emissions\ caused\ by\ total\ datacenter\ energy}{IT\ equipment\ energy}$$

An alternate approach to calculating CUE is to multiply the carbon emission factor (CEF) by the data center’s annual PUE:

$$CUE = CEF \times PUE$$

Following example demonstrates how to calculate CUE for a rack using Power Manager. It can be calculated for any desired data center entity, even the whole data center.

Table 3 Carbon Usage Effectiveness Calculation

Data center Entity	Associated total facility CO2 emission	Energy consumption by devices	CUE
RACK001	21.65 kgCO2e	49.42 kWh	21.65 / 49.42 = 0.4380 kgCO2e / kWh

5 Reducing carbon usage

Following are some tips on reducing carbon usage of a data center:

- Move to renewable energy sources which have negligible carbon impact.
- Improve the efficiency of data center operations, thereby improving overall PUE.
- Have power policies that control power draw limits during periods when constrained performance can be accommodated.

Note: Use Power Manager's static policies to intuitively budget power at device or rack level. For more information about static policies, see the [Static Power and Temperature-Triggered Policies with OpenManage Enterprise Power Manager](#) white paper.

- Consolidate workloads and turn off idle or underutilized infrastructure devices.

Note: Use Power Manager's **Idle Server Detection** feature to identify underutilized servers in the data center.

6 Conclusion

Using this white paper one can easily measure carbon usage of a data center during operations in OpenManage Enterprise console and Power Manager plugin.

A Technical support and resources

[Dell.com/support](https://dell.com/support) is focused on meeting customer needs with proven services and support.

A.1 Related resources

- Knowledge Base for Dell EMC OpenManage Enterprise [LINK](#)
- Knowledge Base for Dell EMC OpenManage Enterprise Power Manager [LINK](#)
- Dell EMC OpenManage Enterprise Power Manager Version 3.0 User's Guide [LINK](#)
- Dell EMC OpenManage Enterprise Power Manager RESTful API Guide version 3.0 [LINK](#)
- Dell EMC OpenManage Enterprise RESTful API Guide version 3.9 [LINK](#)
- Dell EMC OpenManage Enterprise Power Manager 3.0 Release Notes [LINK](#)
- Managing physical grouping of infrastructure devices in OpenManage Enterprise Power Manager [LINK](#)
- Static Power and Temperature-Triggered Policies with OpenManage Enterprise Power Manager [LINK](#)