Green Archival Storage

A white paper that explores the energy cost and environmental impact of common archival storage technologies

Abstract

Rising electricity costs, new legislation on climate change and increased environmental awareness are all factors driving organizations to take a careful look at the energy consumption of their IT infrastructure. Choosing energy efficient IT products and strategies can dramatically reduce escalating electricity bills and improve operational efficiencies while developing environmentally responsible corporate policies. One area where significant green gains can be realized is in the archival storage of business information.

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Executive Summary

Rising electricity costs, new legislation on climate change and increased environmental awareness are all factors driving organizations to take a careful look at the energy consumption of their IT infrastructure. Choosing energy efficient IT products and strategies can dramatically reduce escalating electricity bills and improve operational efficiencies while developing environmentally responsible corporate policies. One area where significant green gains can be realized is in the archival storage of business information.

Industry regulations and corporate policies demand that important business information be retained and made accessible for long periods of time. Depending on the industry and record type, retention periods can vary from five to 100 years with cultural and historic information often retained indefinitely. This requirement places a unique burden on the operations of a digital archive. Records must be available for many years, but may be accessed very infrequently. The need for long-term record accessibility combined with infrequent access patterns makes the digital archive an obvious place to achieve reductions in energy consumption and environmental impact within the larger IT infrastructure.

This paper compares the electrical requirements and carbon footprint of network attached digital archive solutions from three leading storage vendors. The products selected were the FAS 3020 magnetic disk solution from Network Appliance (NetApp), two different configurations of the EMC magnetic disk Centera product (Generation 4, LP), and Plasmon's UDO (Ultra Density Optical) Archive Appliance™ based on professional archival storage technology.

Figure 1 summarises the results of the analysis comparing the electrical cost of the four different products for a 40TB (terabytes) archive over 10 years of operation using an average energy cost from New York, London and Tokyo with a consecutive 8% yearly increase. The chart also reflects two different archive strategies for each product. The first deploys a single archive at a primary site and the second, which adds a redundant archive at another site for Disaster Recovery (DR).

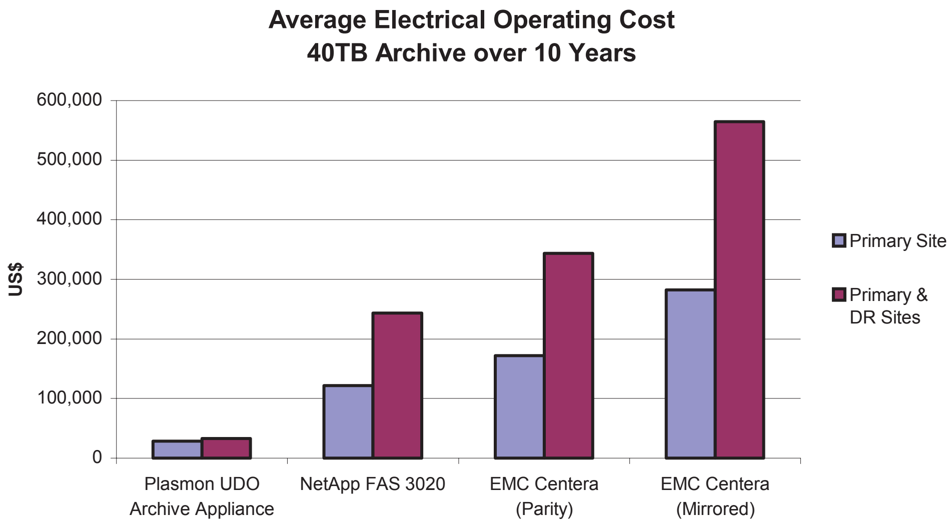


Figure 1 – Average Archive Operating Cost in US$ for Primary and DR Sites

The results from the analysis are striking in three ways. First, there are substantial differences between the NetApp and EMC offerings even though they are both based on magnetic disk technology. This reflects major architectural differences in the efficiency of the two products. Second, Plasmon's UDO Archive Appliance solution is dramatically less expensive than either the NetApp or EMC alternatives. In the most extreme case, the Plasmon solution is more than 17 times less expensive to operate. Third, the Plasmon disaster recovery strategy provides a solution that is only incrementally more expensive to operate compared to the disk-based solutions that double energy requirements.

The energy consumption of each archive systems has a direct environmental impact, producing tons of carbon each year to generate the required electricity. Operating a UDO Archive Appliance produces between 4 and 5 metric tonnes of carbon annually, which is approximately half of the per capita carbon emission for an individual in the UK and Japan, and 25% of the yearly carbon footprint of a US resident. By contrast the NetApp alternative generates between 16 and 38 tonnes a year and the EMC configuration outputs between 23 and 88 tonnes. The worst case EMC configuration is equivalent to the average annual carbon footprint of 8 people in the UK or Japan.

While many factors should be considered when selecting a storage technology for an archive strategy, electrical costs, access to sufficient power, and environmental concerns are becoming key decision criteria. Organizations are looking for ways to reduce operating cost and those in both major cities and developing countries are struggling to satisfy their growing energy demands. It is not uncommon to see computer rooms half populated with equipment, simply because there is insufficient power available to operate a full data center. These financial and operational concerns are accentuated by growing pressure to establish more responsible environmental policies that curb energy demand and minimize carbon footprint. The analysis detailed in the body of this report dramatically demonstrates the energy consumption and environmental consequences of choosing a particular technology, and provides a method of assessing the green credentials of a professional archive strategy.

A Changing Environment

Climate change is one of the most important global issues facing mankind in the 21st century. For those of us in the developed world, it will have a major impact on how we conduct our lives both personally and professionally. We now recognize that our traditional energy supplies are neither endless nor secure, and there is a growing understanding of how their use and overuse is harmful to our environment. As a consequence, governments, corporations and individuals are taking action to raise awareness and curb excessive and damaging use of energy resources.

While the politics of specific multinational agreements, national legislation, and local initiatives may be complex and controversial, there is no denying the tide of change entrusting all of us with a new level of environmental responsibility. It is against this backdrop of growing environmental awareness and increasing energy costs that organizations are seeking to reduce the financial burden and minimize their carbon footprint.

A major consumer of increasingly expensive electrical power is the IT infrastructure within all organizations. Many companies are actively working to establish environmental policies and procedures regarding the acquisition, operation and recycling of servers, storage and IT networking technology. The energy consumption profiles of individual IT products are under scrutiny in ways that they have never been before. Electrical efficiency is now a major consideration in the IT decision process. Organizations are looking for solutions that meet their technical requirements, while reducing energy dependency and its subsequent environmental consequences.

Archival Storage

Organizations are being required to retain strategic business records for longer periods of time. This is being driven by industry regulations, corporate policies on risk management and a competitive need to fully exploit valuable information assets. Digital documents of all types and across all industries are routinely retained for many years or decades. This can include: financial transactions and reports, medical images and patient records, pharmaceutical trials, legal and law enforcement documents, engineering designs, maintenance and safety logs, emails, human resource information, and cultural and historic documents.

Archive records are characterised by a number of key attributes and requirements. Unlike data that is being actively created or modified, archive documents are static and in many cases must be carefully protected against alteration. Access to archive data is also different than that of active data since they must be available for long periods of time, but recall can be very random and infrequent. The challenge for an IT administrator is to develop an archive strategy that segregates archive data into an environment that meets authenticity, longevity and access requirements using the most appropriate and affordable technology.

Archive Configurations

This analysis compares three products that are specifically positioned by their vendors as archival storage solutions. In order to fairly compare the alternatives, only network-attached solutions were selected. This avoids the complexity of additional server or network hardware and reflects the market trend toward fully integrated offerings.

The products chosen were the NetApp FAS 3020 with SnapLock software, the EMC Centera (Generation 4, LP), and Plasmon's UDO Archive Appliance. Both the NetApp and EMC solutions use high-capacity, SATA magnetic disk technology for storing archive records. In the case of EMC, two product configurations have been included: Parity and Mirrored. These are configuration options for the Centera product that provide different levels of magnetic disk redundancy. Both options have been included since each has a very different impact on energy utilization. By contrast, the UDO Archive Appliance is a hybrid solution that uses a small amount of SATA disk for high-performance cache, in front of automated library that contains 60GB UDO2 media.

Vendor	Product Name	Capacity
Plasmon	AA638	38.3 TB
NetApp	FAS 3020	43.5 TB
EMC	Centera (Parity)	42.5 TB
EMC	Centera (Mirrored)	41.4 TB

Figure 2 – Selected Products and Archive Capacities

The target archive capacity is 40TB of usable storage and the analysis calculates costs over a 10 year period. Because it is not possible to configure the different systems to precisely match the 40TB target capacity, the closest capacity configuration has been used. In order to compensate for the difference in system capacity, total energy costs are adjusted up or down using a ratio of the actual capacity to the 40TB target capacity.

Power Consumption Analysis

System Load Calculations

Total System Load is defined as the electrical power required to operate each of the archive systems. All power consumption calculations are based on specifications published on product datasheets available directly from each vendor's Web site.

The specified UDO Archive Appliance (AA638) is configured with 2TB of magnetic disk cache combined with a 638 slot UDO library with six UDO2 drives, providing 38.3TB of archive capacity. System Load for the NetApp FAS 3020 is based on an 5 shelf system using 70 x 750GB disk drives with a total usable capacity of 43.5TB. The EMC, Centera Parity Low Power (LP) system is a 20 node configuration with 80 x 750GB SATA drives, providing 42.5TB of usable storage. The EMC Centera mirrored configuration provides a higher degree of system redundancy using 32 nodes with 128 drives for a usable capacity of 41.4TB. Chapter 10 provides a detailed explanation of the capacity and power calculations summarized in Figure 3.

Vendor – Product	Capacity (TB)	System Power (Watts)
Plasmon – AA638	38.3	485
NetApp – FAS 3020	43.5	2,360
EMC – Centera LP (Parity)	42.5	3,250
EMC – Centera LP (Mirrored)	41.4	5,200

Figure 3 – System Load Power Consumption

In order to compensate for the difference in system capacity, total energy costs are adjusted up or down using a ratio of the actual capacity to the 40TB target capacity. While this method may not reflect the precise energy costs for an actual system, it provides a fair way of comparing the operating cost of different capacity systems.

Since most professional archives are only powered down infrequently for system upgrades or maintenance, the analysis assumes worse case 24x7x365 operation (8760 hours/year) when calculating electricity consumption.

Power Breakdown

In order to realistically approximate total electricity cost, both direct and indirect consumption must be considered. This can be broken down into the System Load required to actually drive the storage system and the Network-Critical Physical Infrastructure (NCPI) load, which provides cooling, circulation, humidification and overhead for Uninterrupted Power Supply (UPS) infrastructure. Using generally accepted industry standards, this analysis assumes that NCPI power requirements are equal to System Load requirements (1:1.25 ratio). Figure 4 shows the actual breakdown of System and NCPI components used in the analysis.

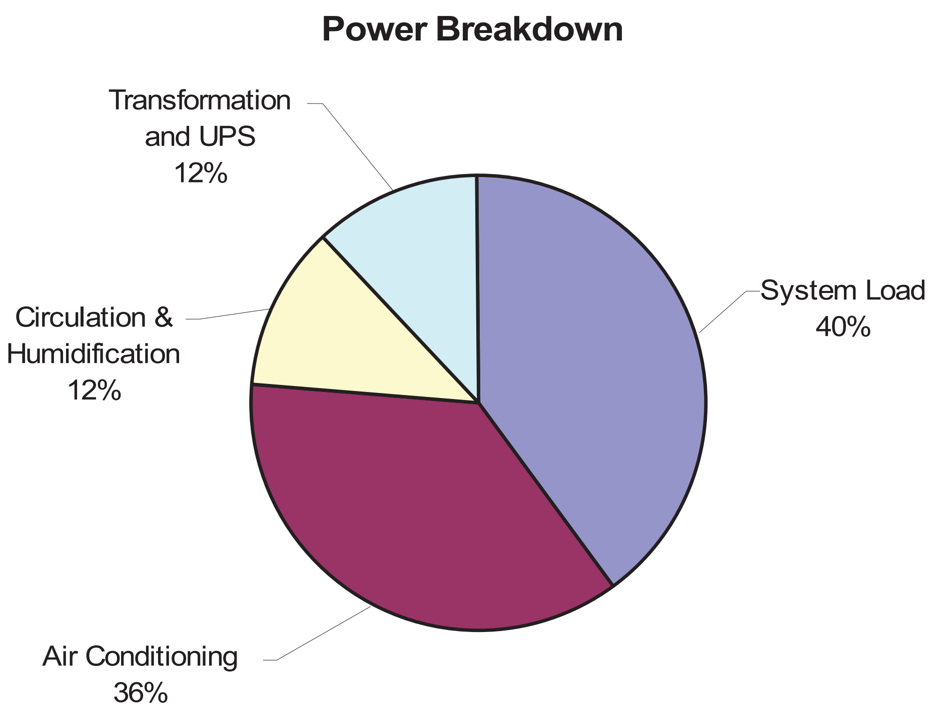


Figure 4 – Power Breakdown – System and NCPI Load

Electricity Costs

Electricity costs can vary dramatically from one location to another. In order to reflect these differences, the analysis is conducted using a major city in North America, Europe and Asia. The cost to generate and supply electrical power is least expensive in New York, followed by London and Tokyo (refer to Figure 5). The electricity costs used are based on 2005/2006 averages published by the Energy Information Administration (www.eia.doe.gov) and the European Entrepreneur's e-Guide (www.businessupdated.com). As energy costs are unlikely to remain static over time, a conservative 8% compound growth rate in electricity prices has been used when calculating total cost over 10 years.

Location	Energy Costs (US$/KWH)
New York	0.15
Tokyo	0.21
London	0.23

Figure 5 – Local Energy Costs in US$/KWH

Single Primary Archive Site

The chart and table below reflects the electrical cost in US$ for operating the selected archive systems over a 10 year period with 8% compound growth in energy cost. This is based on an adjusted 40TB archive at a single primary site in New York, Tokyo and London.

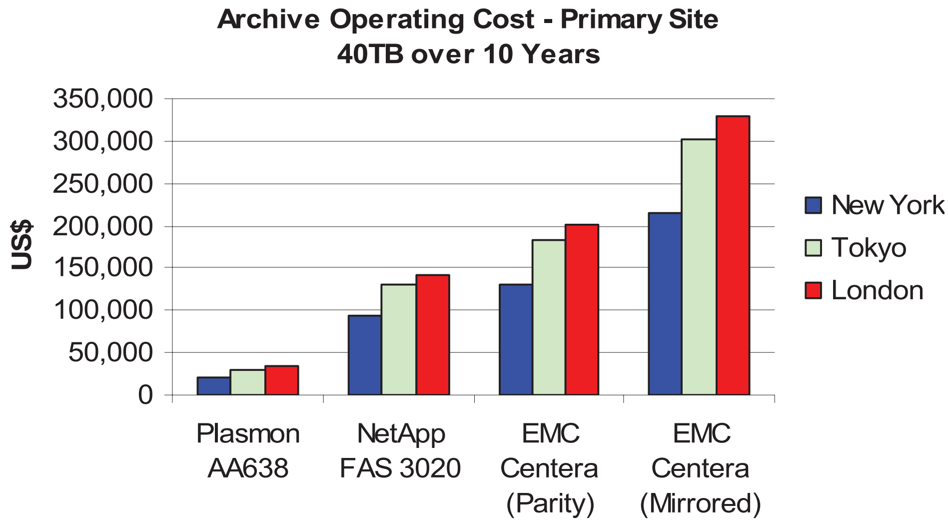


Figure 6 – Archive Operating Cost in US$ for Primary Archive Sites

Primary Site	New York	Tokyo	London
Plasmon – AA638	$21,694	$30,372	$33,265
NetApp – FAS 3020	$92,945	$130,123	$142,516
EMC – Centera (Parity)	$131,008	$183,411	$200,879
EMC – Centera (Mirrored)	$215,182	$301,255	$329,946

Figure 7 – Archive Operating Cost in US$ for Primary Archive Sites – Data Summary

The Plasmon AA638 is significantly less expensive to operate than the NetApp or EMC alternatives, irrespective of location. In the most expensive city, the AA638 costs $33,265 to operate for 10 years, contrasted with a Centera mirrored configuration that would generate an electricity bill of $329,946. This represents a near 10-fold increase in energy operating cost between the Plasmon and EMC configurations.

It is also interesting to note that the NetApp configuration is substantially less expensive than the EMC mirrored system even though they are both based on SATA disk drive technology. This can be accounted for through two significant design differences. The Centera mirrored configuration provides higher redundancy, requiring more drives to meet the 40TB capacity target and is also comprised of four-drive nodes, each with their own processor. This design draws much more power than the simpler NetApp RAID architecture. While the NetApp solution provides more useable capacity per drive, it is implemented with a standard RAID architecture that may not provide the same level of resilience as the Centera configuration. These system level redundancy issues are not a consideration for the UDO Archive Appliance since it is based on non-volatile UDO storage media.

Vendor – Product	Cost Ratio Primary Site
Plasmon – AA638	1.00
NetApp – FAS 3020	4.28
EMC – Centera (Parity)	6.04
EMC – Centera (Mirrored)	9.92

Figure 8 – Primary Site Cost Ratio Summary

While the NetApp system is less expensive to operate than the EMC alternative, it remains more than 4 times more expensive than the Plasmon UDO Archive Appliance. The Plasmon solution is much less power hungry since it employs only a small amount of spinning magnetic disk as a high-performance cache and uses a very power efficient library when archiving data on removable UDO media. The power consumption numbers for the UDO Archive Appliance assume a worst-case scenario with the disk drives, library and UDO drives in full operation. In practice this will seldom be the case, the UDO drives and library sit idle when not being used, saving additional power. By contrast, the NetApp and EMC systems consume massive amounts of power spinning and cooling magnetic disks even when there are no users accessing the archive.

Primary and Disaster Recovery Sites

Archive records are typically high-value documents that cannot be reproduced, are retained for long periods of time and must be kept available for quick access. These characteristics mean that the risk is too high to retain a single copy at one physical location. Most organizations implement a Disaster Recovery (DR) strategy that secures a second copy of their archive data at another site in order to provide continuity if the first site is inaccessible or to rebuild the archive in the event of a site disaster.

Since secondary DR sites are extremely common, an additional energy cost analysis has been performed comparing the cost of operating an archive on both primary and secondary DR sites. In the case of the EMC and NetApp solutions, the recommended DR strategy is to deploy a second identical magnetic disk-based archive. This effectively doubles the energy consumption requirement.

With the UDO Archive Appliance there are two DR alternatives. The first is to deploy a second UDO Archive Appliance similar to the EMC and NetApp strategy, and the second is to make duplicate copies of removable UDO media and to store this media at the DR site together with a UDO Desktop Drive. If data from the DR site is required, it can be accessed manually using the UDO Desktop Drive until the primary site has resumed operation. Storing offline UDO media at a DR site does not provide the same access performance as a second, fully operational system and it does require additional administration, but it offers a distinctly greener alternative. Using an offline media DR strategy consumes far less energy than creating a DR site with a fully redundant system. The offline DR site requires only a fraction of the power required to operate the primary site. In this analysis power consumption for the offline DR site is calculated at 15% of the primary archive. For organizations that require faster access to DR site data, a second UDO Archive Appliance may need to be installed, but for many companies the cost benefits of an offline DR strategy outweigh performance requirements.

The chart and table below reflects the electrical cost in US$ for operating a primary and DR site over a 10 year period with 8% compound growth in energy cost. This is based on an adjusted 40TB archive at primary and DR sites in New York, Tokyo and London. The EMC and NetApp configurations use duplicate archive systems at the DR site and the UDO Archive Appliance deploys an offline DR strategy.

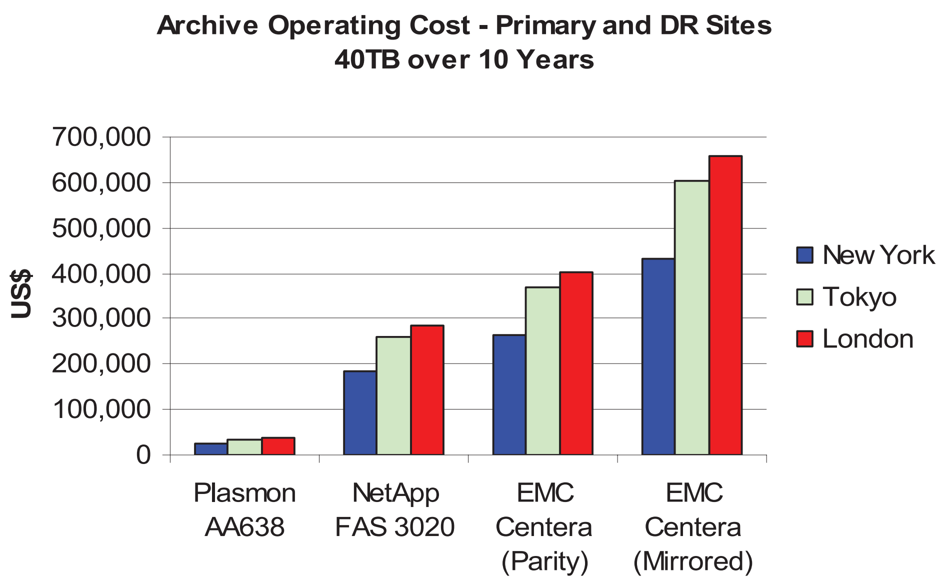


Figure 9 – Archive Operating Cost in US$ for Primary and DR Sites

Primary & DR Sites	New York	Tokyo	London
Plasmon – AA638	$24,948	$34,928	$38,254
NetApp – FAS 3020	$185,890	$260,246	$285,031
EMC – Centera (Parity)	$262,106	$366,822	$401,758
EMC – Centera (Mirrored)	$430,364	$602,510	$659,892

Figure 10 – Archive Operating Cost in US$ for Primary and DR Sites – Data Summary

The ability to deploy an offline DR strategy for the UDO Archive Appliance widens the operating cost gap even further between the UDO and magnetic disk-based systems. In London, the UDO Archive Appliance costs only $38,254 to operate the primary and DR sites for 10 years, compared with a Centera mirrored configuration on two sites, which would generate an electricity bill of $659,892. This represents an enormous 17-fold increase in cost between the two systems.

Vendor – Product	Cost Ratio Primary & DR Sites
Plasmon – AA638	1.00
NetApp – FAS 3020	7.45
EMC – Centera (Parity)	10.50
EMC – Centera (Mirrored)	17.25

Figure 11 – Primary and DR Site Cost Ratio Summary

Cost per TB of Archive Capacity

Another way to look at the operating cost of the different archive solutions is to break the cost down per TB of archive capacity. Bearing in mind that this analysis makes no attempt to factor in the cost of data or system administration, it is interesting to see just how expensive it is to simply power an archive system and the potential savings that can be achieved by selecting low energy consumption hardware. Figure 12 summarizes the US$ cost of powering a single TB of archival storage in its first year of operation. The product architecture of the UDO Archive Appliance provides a much less expensive alternative than the EMC or NetApp products.

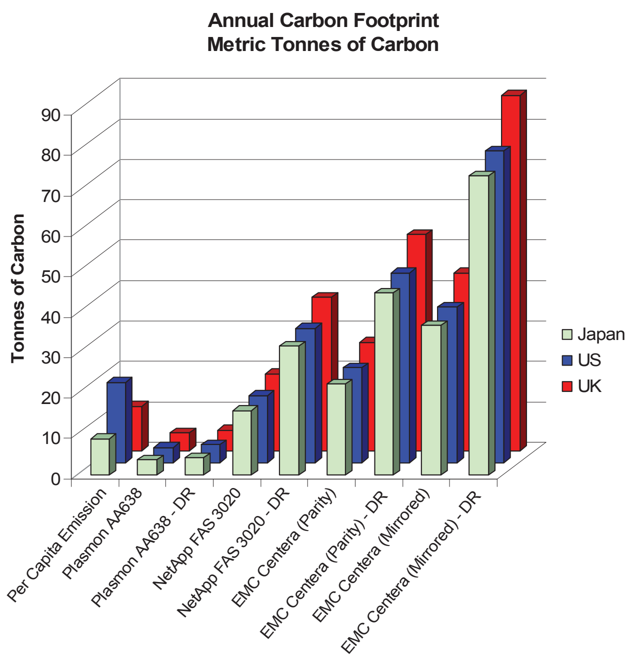
Vendor – Product	New York Primary Site	New York Primary & DR Sites	Tokyo Primary Site	Tokyo Primary & DR Sites	London Primary Site	London Primary & DR Sites
Plasmon – AA638	$37	$43	$52	$60	$57	$66
NetApp – FAS 3020	$160	$321	$225	$449	$246	$492
EMC – Centera (Parity)	$226	$452	$317	$633	$347	$693
EMC – Centera (Mirrored)	$371	743	$520	$1,040	$569	$1,139

Figure 12 – Power Cost per TB for Year 1 in US$

Carbon Footprint

To put the above figures into more practical terms, the energy consumption numbers can be used to calculate the carbon footprint of each archive solution. The carbon footprint results summarized in the charts and table below are based on the carbon footprint calculator available online from "SafeClimate for Business" (www.safeclimate.net), a joint public/private sector organization that promotes business practices that reduce industry's ecological footprint, contribute to conservation and create value for the companies that adopt them.

The charts in Figure 13 take a view of carbon footprint using two different perspectives. The first calculates the number of metric tonnes of carbon that are emitted annually from the electrical consumption of each archive and the second compares each archive to annual per capita carbon emissions. In both cases it is necessary to look at these numbers using the geographical locations defined earlier in the analysis. Electricity production in each of the three countries emits different amounts of carbon depending on the method of generation (coal, hydroelectric, nuclear, etc.), and the average per capita consumption of carbon also varies between countries.



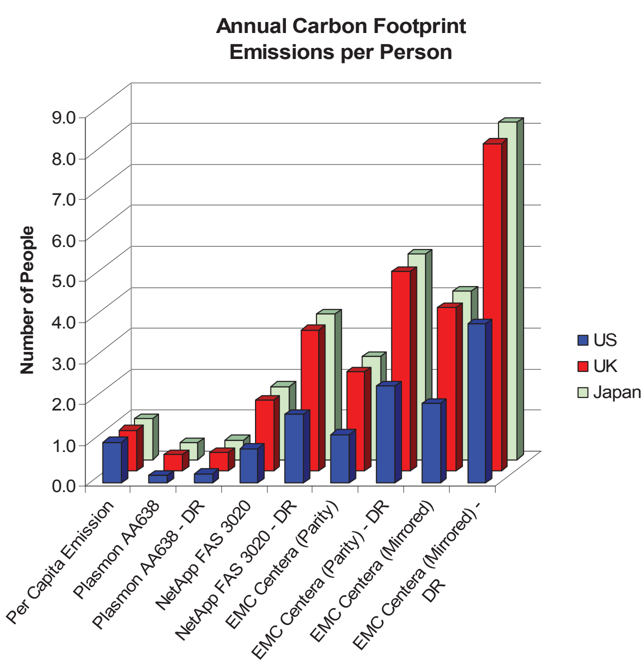


Figure 13 – Annual Carbon Footprint in Tonnes of Carbon and Emissions per Person

	Metric Tonnes of Carbon			Emission per Person		
	Japan	US	UK	Japan	US	UK
Per Capita Emission	9	20	11	1.0	1.0	1.0
Plasmon AA638	4	4	4	0.4	0.2	0.4
Plasmon AA638 – DR	4	4	5	0.5	0.2	0.5
NetApp FAS 3020	16	17	19	1.8	0.8	1.7
NetApp FAS 3020 - DR	32	33	38	3.8	1.7	3.5
EMC Centera (P)	23	24	27	2.5	1.2	2.4
EMC Cenera (P) – DR	45	47	54	5.0	2.4	4.9
EMC Centera (M)	37	39	44	4.1	1.9	4.0
EMC Centera (M) – DR	74	77	88	8.2	3.9	8.0

Figure 14 – Annual Carbon Footprint – Data Summary

There is a dramatic difference between the tonnes of carbon production and average per capita emission when viewing the US data. This is because US per capita emissions are double that of Japan and the UK. The average American produces 20 tonnes of carbon compared to the Japanese at 9 tonnes and the British at 11 tonnes.

The greatest producer of carbon is the EMC Centera system, generating 88 tonnes annually in the UK for a mirrored configuration and a DR site deployed. With a UK per capita average emission of 11 tonnes, this equates to the carbon emission of 8 people each year. In practical terms, this is 73 roundtrip tickets between New York and London every year (1.2 tonnes/ person/roundtrip flight), the annual electricity consumption would run a television for 78 years (290 watts), and you would have to plant a forest of more than 117 trees to offset the yearly carbon emission.

The Plasmon UDO Archive Appliance is by far the most green archive solution, producing between 4 and 5 tonnes each year, which represents only a fraction of the average per capita emission in each country.

Summary

Selecting a storage technology that forms the foundation of an archival storage strategy requires careful consideration. All requirements for the archive should be defined and evaluated. This includes factors such as performance, record authenticity, data longevity, system maintenance, administration, acquisition costs and operating costs. This analysis looks in detail at only one of the factors in a technology decision, but a factor that is growing in importance. Gone are the days when energy costs, power availability and their environmental consequences could be ignored. Organizations of all sizes are compelled by budgets, business efficiency, competition, legislation and their own environmental conscience to make greener technology choices.

This analysis illustrates just how dramatic energy consumption can vary between and among storage technologies, but the facts are clear. Archive strategies that rely solely on magnetic disk technologies are exceptionally power hungry in comparison to Plasmon's hybrid UDO Archive Appliance. The greener architecture of the UDO Archive Appliance combines the strength of magnetic disk and UDO technology, enabling organizations to meet their technical requirements, financial constraints, and environmental objectives.

Capacity and Power Calculation Summary

Plasmon – UDO Archive Appliance

AA638 Configuration:	638 pieces of 60GB UDO2 media
System Capacity:	638 x 60GB = **38.3TB**
Power Consumption:	8 x disk drives (500GB SATA drives)
	6 x UDO2 drives
	UDO library and controller = **485 watts**

NetApp – FAS 3020

14 drives / shelf (750GB SATA drives)
5 shelves = 70 drives
2 parity drives / 14 drives
2 hot spare drives
70 total drives – 10 parity drives – 2 hot spare drives = 58 usable drives
58 x 750GB = **43.5TB** usable capacity
472 watts per shelf
5 shelves x 472 watts = **2,360 watts**

EMC – Centera (Gen4LP)

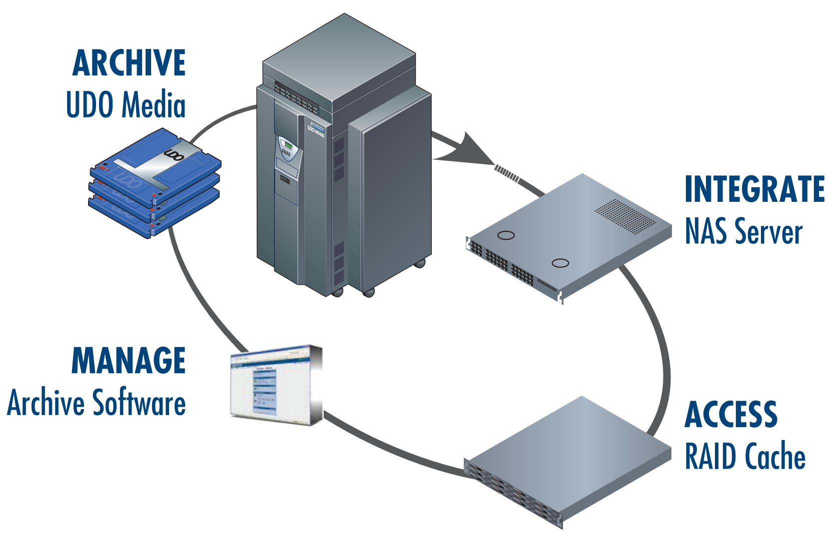
Parity Configuration
4 drives / node (750GB SATA drives)
1 node set = 4 nodes
2.36TB per node
18 storage nodes x 2.36 = **42.5TB**
18 storage nodes + 2 control nodes = 20 nodes total
650 watts / 4 node set (Gen4LP)
5 node sets (20 nodes) x 650 watts = **3,250 watts**

Mirrored Configuration
4 drives / node (750GB SATA drives)
1 node set = 4 nodes
1.38TB per node
30 storage nodes x 1.38 = **41.4TB**
30 storage nodes + 2 control nodes = 32 nodes total
650 watts / 4 node set (Gen4LP)
8 node sets (32 nodes) x 650 watts = **5,200 watts**

UDO Archive Appliance Product Summary

Plasmon's UDO Archive Appliance has been designed specifically for the secure, long-term storage of valuable business information. Using a unique hybrid architecture, the UDO Archive Appliance leverages the strengths of high performance magnetic disk, and the longevity and authenticity of UDO (Ultra Density Optical) to meet demanding archive requirements in a way that traditional, monolithic storage products cannot match.

The UDO Archive Appliance is a network-attached device that is simple to install and configure. The NAS interface presents the solution as a standard network drive and all archived data is cached on magnetic disk RAID for rapid access, and immediately committed to UDO for long-term retention. Data is written to removable UDO media by moving the target media from a storage slot within the UDO Archive Appliance to one of the multiple UDO drives using high-duty cycle robotics. This automated library is also used to access older data that may no longer be available on the RAID cache. The most recently read or written data is retrieved from the RAID cache in milliseconds and data recalled from UDO media takes only a few seconds to access.



UDO Archive Appliance product line ranges in capacity from 1TB to over 76TB in a single configuration, supporting entry level to Enterprise archive requirements. Thousands of organizations worldwide rely on UDO technology to meet their regulatory compliance obligations and risk management policies for authenticity and long-term accesses. Data recorded on UDO true WORM (Write Once Read Many) media cannot be altered, providing a degree of record authenticity that is far superior to rewritable magnetic disk technology. The 50-year media life of UDO also means that data can be retained for much longer than magnetic disk technologies, lowering risk and dramatically reducing the long-term TCO (Total Cost of Ownership).

The UDO Archive Appliance is a proven solution for demanding archival storage requirements, and the overall system architecture offers significant energy consumption and environmental advantages over traditional magnetic disk storage. By minimizing the amount of server and disk cache resource within the system, the UDO Archive Appliance requires dramatically less electricity to operate resulting in a smaller carbon footprint. The removable nature of UDO media further reduces electrical demand by enabling cost-effective off-line vaulting and disaster recovery. In addition, the much longer hardware obsolescence cycles of UDO technology and the reduced mechanical circuitry has a smaller environmental impact than disk technology when systems are retired and recycled. The insightful design of the UDO Archive Appliance allows organizations of all sizes to satisfy their growing archival storage requirements in a way that is both financially responsible and environmentally sensitive.

Plasmon offers the only enterprise-class active archive solution that ensures data permanence, authenticity, access, longevity and removability, at the low total cost of ownership that businesses demand.

Archive Without Compromise.™

Plasmon is ISO 9001 certified.

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Plasmon

Global Sales

Americas & Asia Pacific Sales HQ
370 Interlocken Blvd., Suite 600
Broomfield, CO 80021
800.451.6845
Sales@plasmon.com

EMEA Sales HQ
Whiting Way, Melbourn
Hertfordshire, SG8 6EN
+44 (0) 1763 262963
Sales@plasmon.co.uk

Plasmon.com