



# The Business Case for Green Storage Equipment

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## Introduction

Two major benefits derive from green IT: saving for the bottom line of the organization, and savings in reduced CO<sub>2</sub> emissions to the environment. There are challenges in showing a convincing business case for either benefit. IT is usually not responsible for facilities, and therefore usually has no budget line item to demonstrate savings. Savings to the environment are generally not part of most balance sheets.

In the light of the current unsettled economic environment, the key question this study addresses is “Do environmental costs matter?” To help address this broad question, the question is broken down into four:

1. What is the size of the environmental costs, taking all other equipment costs into consideration?
2. Is the difference significant between the average alternative and best?
3. Is the difference significant between the worst alternative and best?
4. What is the greenest technology available?

To simplify the range of the question, a single important part of IT (i.e. networked storage arrays) is analyzed in detail.

Four workload scenarios, each requiring different tiers of storage arrays, are defined, and the leading storage arrays within each tier selected and configured. Formal business cases for each of the four scenarios are constructed comparing the best-of-breed array with other arrays. The results are then analyzed to answer the four questions above. General conclusions and recommendations are drawn about the importance of environmentals, and executive actions are suggested.

## Case Study Environments

Four workload scenarios each requiring different tiers of storage arrays are defined, and the leading storage arrays within each tier selected and configured. Table 1 gives a summary description of the case study environments.

Case #	Case Description	TB	\$/TB	# Minimum drives without thin provisioning and virtualization	Workload
1	Average Tier 1/Tier 1.5	462	\$3,000	662	I/O Intensive for 75% of Drives
2	Entry Tier 1.5	87	\$2,700	184	I/O Intensive for all Drives
3	Entry Modular Tier 2	33	\$2,400	35	I/O light for all Drives
4	Large Tier 1	739	\$3,300	2,048	I/O Intensive and maximum configuration

**Table 1 – Summary Description of Four Case Study Environments**

The number of terabytes varied from 33 TB in an array with 35 SATA drives for an I/O light tier 2 modular array workload to a maximum tier 1 I/O intensive workload with 739 TB in an array with 2,048 high performance drives. Some arrays have virtualization and

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thin provisioning functionality which reduce the number of drives required and therefore the environmental impact. Very conservative benefits (i.e. a 10% reduction) are assumed for virtualization and thin provisioning; the same benefits were used for all vendors who claimed the functionality. It is assumed that only drives are saved, as the high I/O in most environments will not allow reduction of other parts of the array. The Appendix has more detail on the assumptions. Benefits from compression, encryption, and de-duplication functionality are not applicable to the high I/O scenarios or image management scenarios assumed in the workload assumptions.

The acquisition cost/TB is assumed to be different for each case environment. Within each environment, between three and nine different arrays from different vendors were analyzed in detail. However, the same acquisition cost was used for all arrays within a case environment.

Additional detail of the four case study environments and the assumptions are given in the Appendix.

## Case Study Results

A summary of the results of the detailed analysis of the four case studies is given in Table 2 (below). All the figures are shown in \$/TB, to allow easier comparison across the case studies. The three columns of data in each of the four tables are:

1. The worst case column is the array with the highest environmental costs (the acquisition costs were held constant for all the arrays within a case study);
2. The average column was the average of all the arrays except the best array;
3. The best case column is the array with the lowest environmental costs.

The five rows in each of the tables were:

1. The discounted (a financial discount rate of 5% is used throughout the study to normalize the time cost of money) cost/TB of acquisition and maintenance costs of the array(s) in the columns over five years;
2. The discounted cost/TB of all environmental costs over five years;
3. The total discounted cost of storage equipment over five years (the sum of rows 1 & 2);
4. The percentage of the total cost that is attributable to environmentals;
5. The percentage reduction on the storage array that is necessary to achieve business case equality against the best-case column.

Full details of the assumptions and calculations are given in the Appendix.

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<b>Case 1 Summary: 5-year Net Present Cost/TB for Tier 1/1.5 Arrays with I/O Intensive 462 TB workload</b>	<b>Worst Case</b>	<b>Average Case</b>	<b>Best Case</b>
5-year Discounted Equipment Acquisition & Maintenance Costs	\$5,455	\$5,455	\$5,455
5-year Discounted Environmental Costs	\$1,409	\$1,128	\$441
5-year Total Discounted Equipment Costs	\$6,864	\$6,583	\$5,896
% Environmental Costs	21%	17%	7%
Reduction in Storage Acquisition Cost Necessary to Achieve Business Case Equality with Best Case	32%	23%	0%
<b>Case 2 Summary: 5-year Net Present Cost/TB for Tier 1.5 Arrays with I/O Intensive 87 TB workload</b>	<b>Worst Case</b>	<b>Average Case</b>	<b>Best Case</b>
5-year Discounted Equipment Acquisition and Maintenance Costs	\$4,909	\$4,909	\$4,909
5-year Discounted Environmental Costs	\$3,113	\$2,003	\$735
5-year Total Discounted Equipment Costs	\$8,023	\$6,912	\$5,645
% Environmental Costs	39%	29%	13%
Reduction in Storage Acquisition Cost Necessary to Achieve Business Case Equality with Best Case	88%	47%	0%
<b>Case 3 Summary: 5-year Net Present Cost/TB for Tier 2 Arrays with I/O Light 33 TB workload</b>	<b>Worst Case</b>	<b>Average Case</b>	<b>Best Case</b>
5-year Discounted Equipment Acquisition & Maintenance Costs	\$4,364	\$4,364	\$4,364
5-year Discounted Environmental Costs	\$1,646	\$1,164	\$700
5-year Total Discounted Equipment Costs	\$6,010	\$5,528	\$5,064
% Environmental Costs	27%	21%	14%
Reduction in Storage Acquisition Cost Necessary to Achieve Business Case Equality with Best Case	39%	19%	0%
<b>Case 4 Summary: 5-year Net Present Cost/TB for Tier 1 Arrays with I/O Intensive 739 TB workload</b>	<b>Worst Case</b>	<b>Average Case</b>	<b>Best Case</b>
5-year Discounted Equipment Acquisition & Maintenance Costs	\$6,000	\$6,000	\$6,000
5-year Discounted Environmental Costs	\$1,430	\$1,234	\$488
5-year Total Discounted Equipment Costs	\$7,431	\$7,234	\$6,488
% Environmental Costs	19%	17%	8%
Reduction in Storage Acquisition Cost Necessary to Achieve Business Case Equality with Best Case	29%	23%	0%

**Table 2 – Summary of Results from Four Case Studies**

Figure 1 (below) is a summary of all the case studies. It allows the first three questions posed at the beginning to be answered. The first three original questions were:

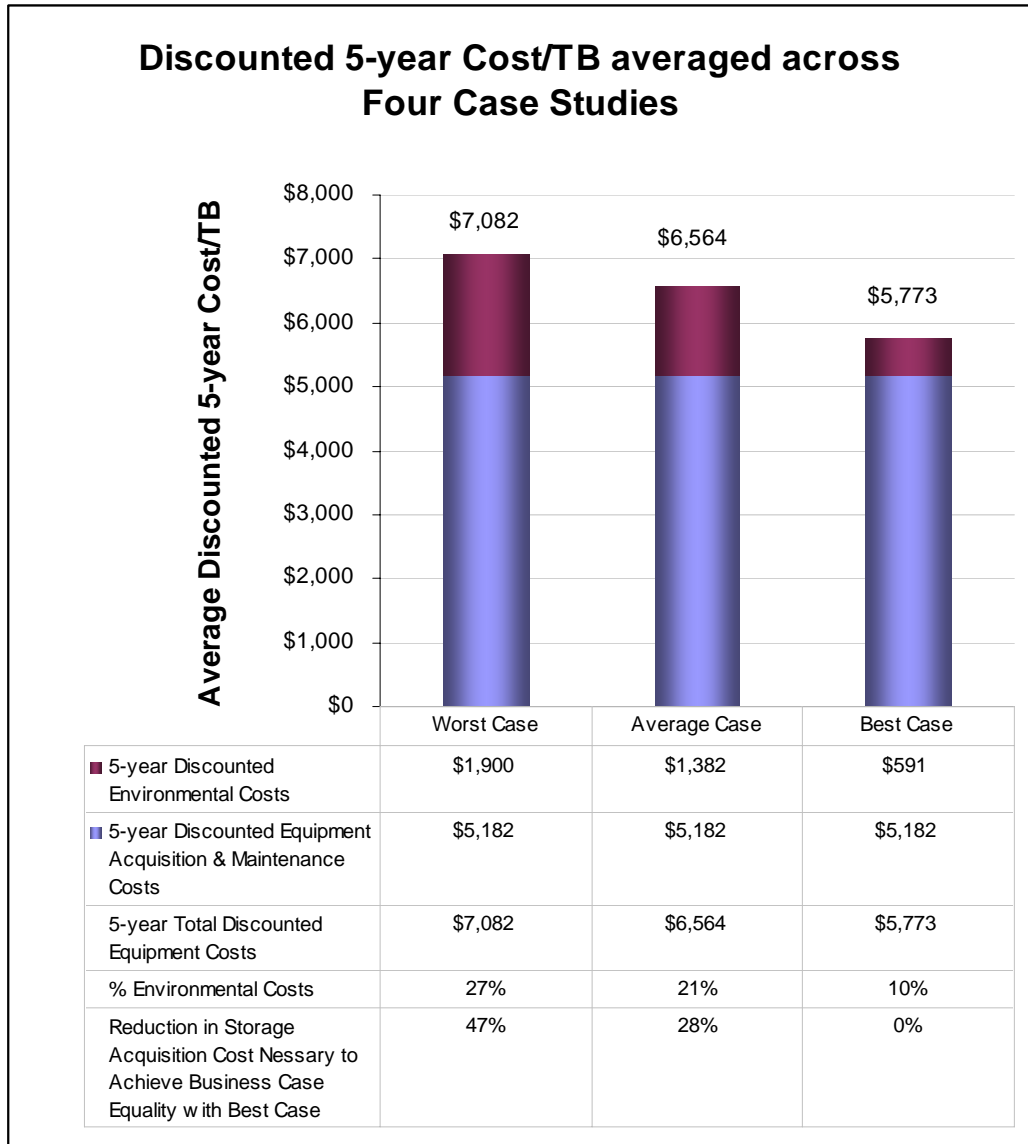
- What is the size of the environmental costs, taking all other equipment costs into consideration?
- Is the difference significant between the average alternative and best?
- Is the difference significant between the worst and best?

The answers to these questions taken from Figure 1 (below) are as follows:

- Best-of-breed arrays have 10% overhead for environmentals, with a range 7-14%;
- Average arrays have an overhead of 21%, 11 percent more than best-of-breed arrays, with a range 17-29%;
- The worst arrays have 27% overheads for environmental, 17% more than best-of-breed arrays, with a range 19-39%
- The discount required on an average array to make it equal in 5-year discounted costs to a best-of-breed array is 28%, with a range 19-47%

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- The discount required on the worst array to make it equal in 5-year discounted costs to a best-of-breed array is 47%, with a range of 29-88%.



**Figure 1 – Summary of Findings across all Four Case Studies**

The fourth question posed earlier was:

- What is the greenest technology available?

The answer to this question is shown in Table 3 (below). It shows that Hitachi is the greenest storage vendor in all the case studies by a wide margin. The biggest example is the Hitachi VSP, saving nearly \$700K over a five year period against a competing Tier 1 storage vendor. The potential for that kind of saving to the corporation cannot be ignored by senior management.

Case #	Case Description	Greenest Storage Array	Total 5-year Discounted Environmental Costs	5-year Discounted Savings (Average Green - Greenest)	5-year Discounted Savings (Worst Green - Greenest)
1	Average Tier 1/Tier 1.5	Hitachi VSP	\$203,719	\$317,558	\$447,325
2	Entry Tier 1.5	Hitachi VSP	\$63,984	\$110,240	\$206,870
3	Entry Modular Tier 2	Hitachi AMS 2100	\$23,106	\$15,303	\$31,205
4	Large Tier 1	Hitachi VSP	\$360,286	\$551,486	\$696,675

Table 3 – Savings from Best-of-breed Arrays by Case

## Discussion

### The Reasons Behind Successful Green Storage

One of the very clear findings in the study was the extent to which Hitachi storage arrays were consistently best of breed in all four case studies. The difference between Hitachi and other vendors was very large, as Table 3 (above) shows clearly.

ITCentrix believes there are two main reasons for this finding:

1. Hitachi, as a corporation, has a clear corporate goal of reducing carbon emissions. The Hitachi target is a reduction of 100 million tones by 2025. Hitachi also takes an end-to-end view by producing products that are carbon neutral from manufacturing, customer usage and disposal. Hitachi's definition includes its suppliers and partners – it would be much easier to meet targets if the carbon intensive parts of any product were outsourced, but would defeat the objective. Overall, the approach taken is very real in its setting of corporate objectives and monitoring progress towards them.
2. As a consequence of the corporate objectives, the design on the Hitachi storage arrays is very power efficient at every stage of the process. This includes the use of very efficient power supplies, the use of 2.5 inch disks instead of the lower-cost 3.5 inch disks so as to reduce power, and purpose designed storage networking components rather than of-the-shelf volume components.

This approach is in sharp contrast to the approach of other leading storage vendors and indeed most US organizations. Their corporate environmental objectives in general are vague aspirations with no specific objectives or measurement, and the storage arrays are built of standard volume components which are low-cost but not energy efficient. Responsibility for green strategies are owned by marketing or PR, and not the product design teams.

### Study Limitations

The study looked at four specific commercial case studies, and drew general conclusions. Although ITCentrix is comfortable that these cover a broad range of practical environments, it is not all encompassing. Some of the areas excluded by this study include:

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- Storage built for a very particular purpose, such as video support or long-term archiving
- Storage arrays with large amounts (or even 100%) of solid state disks (SSDs). At the moment most arrays are delivered with relatively small number of SSD drives, and SSDs were not included as part of the arrays to simplify the process. As SSDs improve in performance and cost performance, this will change over the next few years. However, as at the amount of SSD is less than 1% of the storage, SSD has not been included as it would skew the results.
- Storage vendors that have taken new approaches to storage array architectures (such as Nimbus Storage, SolidFire and Tinri) with much higher levels of flash, but have not yet become pervasive in the marketplace.
- Storage that uses new techniques such as erasure encoding to reduce the cost of availability
- The methodology did not include staff costs or potential effects on server efficiency. Storage evaluators should include these factors as part of an overall storage evaluation, as well as others such as local skills, levels of service, migration, etc.
- US average pricing was used for the cost of power. The power savings would be much higher in many other countries.
- US average pricing was used for data center space. This figure could be higher or lower in different parts of the US and internationally.
- SAN configurations only were used in the case studies. The use of NAS or iSCSI topologies might change the storage network power requirements. However, it would not significantly change the array requirements, which is the focus of this study.

## Executive Actions Items

ITCentrix recommends that the total cost of power and space be taken into account in the business case of all IT equipment purchases, and especially including storage. In the four case studies examined, the impact on the business case was always significant, between 8% and 39% of the equipment budget. In order to be able to achieve this, IT should own the power and facilities budget for data centers and other equipment.

IT is a significant user of power within the organization. IT is also the most significant saver of power, as a result of deploying applications that improve efficiency, lower distribution costs, lower travel costs, and monitor usage. It follows that IT should take a leading role in driving energy efficiency and compliance within most organizations.

In the US there is still a political debate about the impact of CO<sub>2</sub> on the environment, and there is not high acceptance that business should take “green” issues seriously. For most US businesses, green issues are part of marketing, used when the story is good and forgotten when not. This is not the case in Europe and most of Asia, where the political debate is over and significant legislation is in progress.

Among IT vendors, Hitachi stands out as a clear leader in setting corporate goals for improving energy efficiency and creating carbon neutral products (including its supply chain, impact while in operation, and disposal). No other US IT vendor (and very few US organizations) get anywhere near matching Hitachi's carbon neutral plan. Hitachi was best of breed in all four case studies in this study, and the technology choices made by Hitachi were clearly influenced by the corporate carbon neutral goals. For example, the Hitachi VSP storage array used 2.5 inch drives and used optimized technology rather

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than off-the-shelf components. As a result of this focus, Hitachi's IT technology is clearly the market leader in end-to-end energy efficiency.

As corporations in the rest of the world adopt similar carbon neutral strategies, the pressure on suppliers to these corporations to be carbon neutral will increase significantly. Senior business and IT executives in the US and the rest of the world should recognize pragmatically that it is a business imperative to establish and execute on a carbon neutral strategy. IT should be a prime driver; where competitive, Hitachi would be a best-of-breed partner for an IT carbon neutral strategy. Senior management will need to ensure that responsibility for carbon product strategies should be with product development, not product marketing.

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## Appendix: Details of Case Studies

### Case Study 1 – Details

Case 1 compares the hardware and environmental costs of leading Tier 1 and Tier 1.5 arrays. Within the array are 412 TB high performance disks and 150 SATA 2TB disks, giving minimum of 662 drives in total assuming no virtualization or thin provisioning is available. The minimum with virtualization and thin provisioning is 537 drives. The part of the workload using the high performance disks is I/O intensive, and workload component using the SATA disks is I/O light to moderate. As this is a high performance environment, no compression or de-duplication is done. It is assumed that the workload is not helped significantly by SSD storage. If thin provisioning and/or virtualization is available in the array, the number of disk drives is reduced.

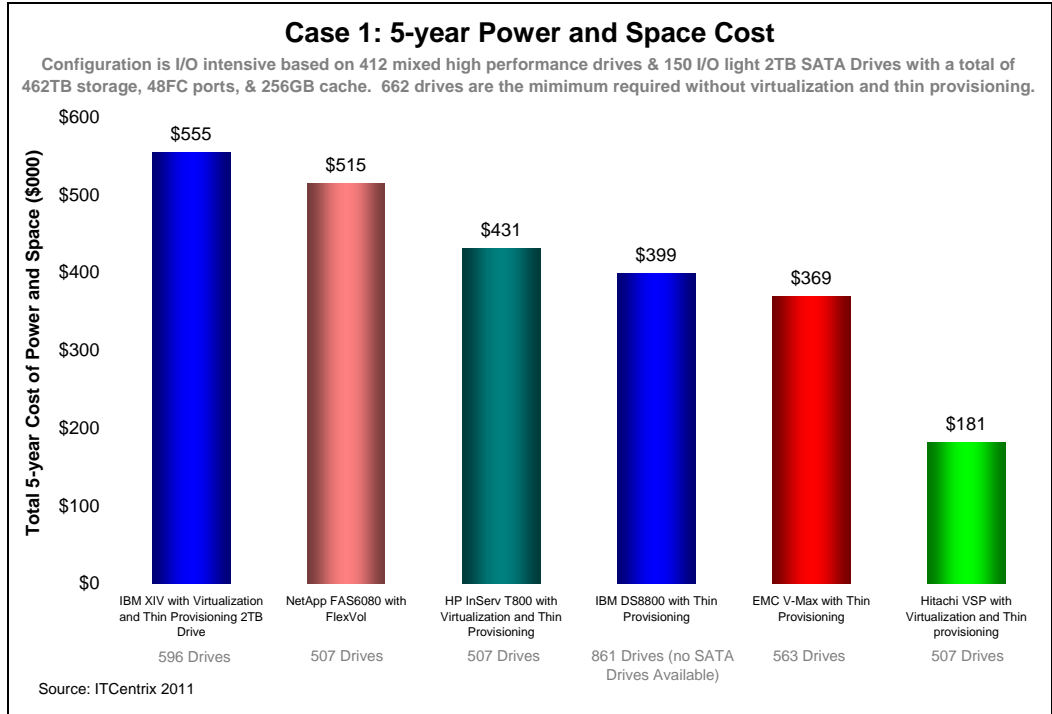
Table 4 (below) shows the six leading arrays that were compared. If access was available to a vendor configuration tool, the tool was used to calculate the power and space requirements. A standard uplift for service space was added for all arrays (1.5 x floor space).

Key Metrics from Case Study 1								
Storage Array	Terabytes	Internal Drives required to meet TBs & Performance	Power Requirement (kVA) with UPS & Cooling Overheads	Tons CO2 Released	Car Equivalents	5-year Total Cost of Power & Cooling	Capital Cost of Provisioning Power & Cooling	5-year Total Cost of Space
Configuration is I/O intensive based on 412 mixed high performance drives & 150 I/O light 2TB SATA Drives with a total of 462TB storage, 48FC ports, & 256GB cache. 662 drives are the minimum required without virtualization and thin provisioning.								
IBM XIV with Virtualization and Thin Provisioning 2TB	462	687	59.9	1,958	68	\$314,919	\$138,564	\$101,114
NetApp FAS6080 with FlexVol	462	537	63.4	1,498	52	\$333,410	\$146,700	\$34,478
HP InServ T800 with Virtualization and Thin Provisioning	462	537	52.5	1,444	50	\$276,021	\$121,449	\$33,469
IBM DS8800 with Thin Provisioning	462	911	44.7	1,137	40	\$234,880	\$103,347	\$60,525
EMC V-Max with Thin Provisioning	462	596	40.1	1,102	38	\$210,690	\$92,704	\$65,882
Hitachi VSP with Virtualization and Thin provisioning	462	537	18.7	512	18	\$98,028	\$43,132	\$40,199

Table 4 – Key Metrics from Case Study 1

The total 5-year costs are shown in figure 2 (below). The figures are not discounted, and no factors have been applied to reflect future changes to power, or space. The capital cost of facilities equipment is included in the costs.

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**Figure 2 – Case 1 5-year Power & Space Cost**

The assumptions behind the figures in Case 1 are shown in table 5 (below). The estimate of 44% capital overhead for power facilities was performed by ITCentrix in previous work, taking into account the capital and installation cost of CRAC units, air ducting, etc. The capacity of most data centers is constrained by the availability of power and cooling, and it is therefore justified to take this into account.

The assumptions for the impact of virtualization and thin provisioning on the number of drives required are conservative at 10% for each. ITCentrix did a study on the average time that storage arrays are installed, with a finding of 4.7 years; therefore a 5-year financial analysis was chosen.

Most of the arrays are using 3.5 inch drives. Hitachi uses 2.5 inch drives in the VSP array, and IBM does so in the DS8800 array. The 2.5 inch drives are higher performance for the same capacity 3.5 inch drive, because of the greater number of heads over the same data area (bit density is constant). To ensure that all drives had the same capacity and same approximate performance, 10K drives were selected for the arrays supporting 2.5 inch drives.

The carbon emission per kWh is taken from the EPA web site, and is the average US value. There is significant difference in different parts of the US, depending on the energy sources used. Areas with high fossil fuel sources will be higher, and areas with nuclear, hydro, and wind plants will be lower. The conversion of tons in car equivalents (i.e. divided by the average amount of carbon used by a single car) is also taken from the EPA site. The carbon trading sites are at an early stage, and both current and future prices are volatile. \$15/ton is a conservative estimate against some future estimates of \$40-\$80 per ton.

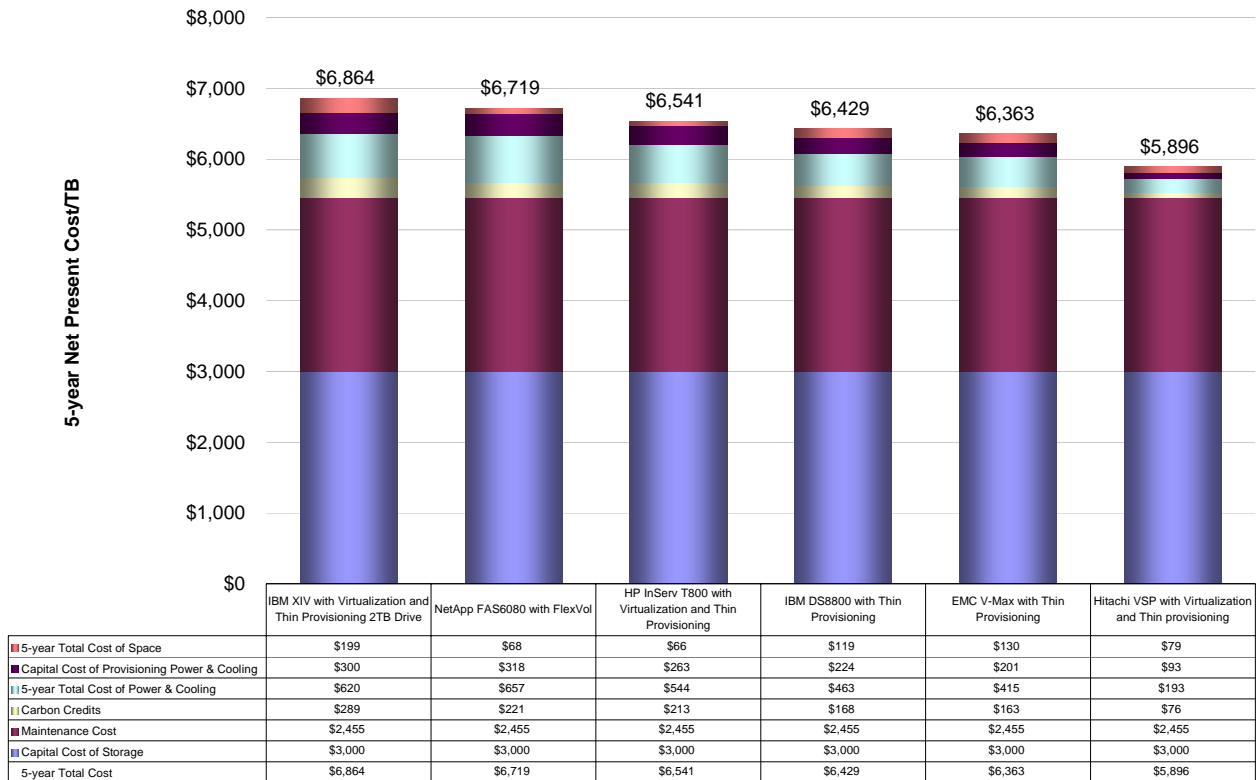
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<b>Case 1: Assumptions</b>
Tier 1/1.5 configuration is I/O intensive based on 412 mixed high performance drives & 150 I/O light 2TB SATA Drives with a total of 462TB storage, 48FC ports, & 256GB cache.
662 drives are the minimum required without virtualization and thin provisioning.
Cost of Power ( \$ per kVA per hour ) - \$0.120
Cost of Space ( \$ per square foot per year ) - \$150
Overhead from Electrical Provisioning (UPS, PDUs, etc) - 40.0%
Additional Overhead from Thermal Cooling (CRAC units, Etc.) - 40.0%
Overall Data Center Infrastructure Efficiency (DCiE) - 51%
Impact of Heterogeneous Virtualization (Hitachi & Partners) - 10.0% (this impacts the number of drives)
Impact of Homogeneous Virtualization - 10.0% (this impacts the number of drives)
Impact of Thin Provisioning - 10.0% (this impacts the number of drives)
Impact of Dynamic Provisioning (Hitachi & Partners) - 10.0% (this impacts the number of drives)
Multiplier to calculate actual space used from equipment dimensions - 2.5
Number of Years for Assessment - 5 years
The performance of SAS 10K drives is approximately equal to FC 15K drives with same capacity
The US average lbs CO2/kWh = 1.329 - Source: EPA
The US average lbs CO2/car/year = 11,450 - Source: EPA
Carbon Credit is assumed be \$15/ton for all years - Source: Barclays Carbon Credits (2012 projected \$14-\$16)

**Table 5 – Assumptions for Case 1**

Figure 3 (below) shows the discounted environmental costs by array in \$/TB. The cost of the Case 1 arrays are broken down by all the equipment and environmental CAPEX and OPEX line items, and including the capital cost and maintenance costs.

**Case 1: Net Present Total Cost/TB of Leading Tier 1/1.5 Arrays with 462TB Mixed Workload**



**Figure 3 – Case 1: Total Net Present Costs by Array**

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Figure 3 (above) is used to develop a business case for green storage detailed in Table 6 (below). An underlying assumption is that all the arrays are priced at the same \$/effective TB, and the capital cost of the arrays are the same. The same maintenance costs are also assumed. The business case is focused on capital equipment and direct running costs – non-equipment costs such as staff are not included. The differences in the business cases are purely the costs associated with space and power. There are three scenarios compared:

1. **Greenest Storage Array** – the array with lowest cost of space and power and other directly related energy costs;
2. **Average Green Storage Array** – the average of all the other arrays, excluding the greenest array;
3. **Worst Green Storage Array** – the array with the highest cost of space and power.

The comparisons within the table are between:

- Greenest vs. average storage array(s);
- Greenest vs. worst storage array.

The Business Case for Green Storage (Case 1)									
		Year 1	Year 2	Year 3	Year 4	Year 5	Total	Total/TB	CO <sub>2</sub> (Tons)
<b>Greenest Storage</b>									
Terabytes	462								
Capital Cost/TB	\$3,000	\$1,384,539					\$1,384,539	\$3,000	
Maintenance (% Capital/year)	18%	\$249,217	\$249,217	\$249,217	\$249,217	\$249,217	\$1,246,085	\$2,700	
Cost of Space		\$8,040	\$8,040	\$8,040	\$8,040	\$8,040	\$40,199	\$87	
Cost of Power		\$19,606	\$19,606	\$19,606	\$19,606	\$19,606	\$98,028	\$212	
Capital Cost of Power Provisioning		43,132					\$43,132	\$93	
Carbon Credit (\$15/ton)	\$15	\$7,680	\$7,680	\$7,680	\$7,680	\$7,680	\$38,399	\$83	512
<b>Total</b>		<b>\$1,712,214</b>	<b>\$284,542</b>	<b>\$284,542</b>	<b>\$284,542</b>	<b>\$284,542</b>	<b>\$2,850,383</b>	<b>\$6,176</b>	
<b>Net Present Cost (5%)</b>							<b>\$2,721,186</b>	<b>\$5,896</b>	
<b>Average Green Storage</b>									
Terabytes	462								
Capital Cost/TB	\$3,000	\$1,384,539					\$1,384,539	\$3,000	
Maintenance (% Capital/year)	18%	\$249,217	\$249,217	\$249,217	\$249,217	\$249,217	\$1,246,085	\$2,700	
Cost of Space		\$11,819	\$11,819	\$11,819	\$11,819	\$11,819	\$59,094	\$128	
Cost of Power		\$54,797	\$54,797	\$54,797	\$54,797	\$54,797	\$273,984	\$594	
Capital Cost of Power Provisioning		120,553					\$120,553	\$261	
Carbon Credit (\$15/ton)	\$15	\$21,413	\$21,413	\$21,413	\$21,413	\$21,413	\$107,067	\$232	1,428
<b>Total</b>		<b>\$1,842,338</b>	<b>\$337,246</b>	<b>\$337,246</b>	<b>\$337,246</b>	<b>\$337,246</b>	<b>\$3,191,321</b>	<b>\$6,915</b>	
<b>Net Present Cost (5%)</b>							<b>\$3,038,195</b>	<b>\$6,583</b>	
<b>Net Present Cost Difference between Average &amp; Greenest Storage Arrays (5%)</b>							<b>\$317,009</b>	<b>\$687</b>	
<b>Percentage Reduction in Capital Cost to reduce Net Present Savings to \$0</b>							<b>23%</b>	<b>23%</b>	
<b>Worst Case Green Storage</b>									
Terabytes	462								
Capital Cost/TB	\$3,000	\$1,384,539					\$1,384,539	\$3,000	
Maintenance (% Capital/year)	18%	\$249,217	\$249,217	\$249,217	\$249,217	\$249,217	\$1,246,085	\$2,700	
Cost of Space		\$20,223	\$20,223	\$20,223	\$20,223	\$20,223	\$101,114	\$219	
Cost of Power		\$62,984	\$62,984	\$62,984	\$62,984	\$62,984	\$314,919	\$682	
Capital Cost of Power Provisioning		\$138,564					\$138,564	\$300	
Carbon Credit (\$15/ton)	\$15	\$29,376	\$29,376	\$29,376	\$29,376	\$29,376	\$146,879	\$318	1,958
<b>Total</b>		<b>\$1,884,903</b>	<b>\$361,799</b>	<b>\$361,799</b>	<b>\$361,799</b>	<b>\$361,799</b>	<b>\$3,332,100</b>	<b>\$7,220</b>	
<b>Net Present Cost (5%)</b>							<b>\$3,167,825</b>	<b>\$6,864</b>	
<b>Net Present Cost Difference between Worst &amp; Greenest Storage Arrays (5%)</b>							<b>\$446,639</b>	<b>\$968</b>	
<b>Percentage Reduction in Storage Capital Cost to reduce Net Present Savings to \$0</b>							<b>32%</b>	<b>32%</b>	

**Table 6 – Case 1: The Business Case for Green Storage**

Table 7 (below) shows the key financial metrics of this comparison, which are equivalent to the NPV and IRR metrics of a traditional business case. They show a \$317-\$447K Net Present Saving by taking the greenest array (Hitachi VSP), with an IRR equivalent of between 23%-32%. Put another way, you would need a discount of between 23%-32% off the price of alternative arrays to make up for the additional environmental costs.

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Key Financial Metrics for Case 1; 462TB Tier 1/1.5 Storage	Average Green Array - Best Green Array	Worst Green Array - Best Green Array
Net Present Cost Difference between Average, Worst & Greenest Storage Arrays (5%) (NPV)	\$317,009	\$446,639
% Reduction in Storage Capital Cost to achieve Business Case Equality (IRR)	23%	32%

Table 7 – Key Financial Metrics from Business Case 1

## Case Study 2 – Details

Case 2 is an entry version of case 1, and compares the hardware and environmental costs of leading Tier 1 and Tier 1.5 arrays. Within the array are 87 TB of high performance disks. There are a minimum of 184 drives in total if no virtualization or thin provisioning is available. As this is a high performance environment, no compression or de-duplication is in place. The configurations do not have SSD storage.

Table 8 (below) shows the nine arrays that were compared. If access was available to a vendor configuration tool, the tool was used to calculate the power and space requirements. A standard uplift for service space was added for all arrays (1.5 x floor space).

Key Metrics from Case Study 2										
	Terabytes	Internal Drives required to meet TBs & Performance	Power Requirement (kVA) with UPS & Cooling Overheads	Tons CO2 Released	Car Equivalents	Carbon Credits	5-year Total Cost of Power & Cooling	Capital Cost of Provisioning Power & Cooling	5-year Total Cost of Space	5-year Total Environmental Costs
Entry configuration is I/O intensive with 87TB storage, 18FC ports & 128GB cache.										
184 drives are the minimum required without virtualization and thin provisioning.										
IBM XIV with Virtualization and Thin Provisioning 2TB Drive	87	191	26	721	25	\$54,086	\$138,044	\$60,739	\$40,445	\$293,314
IBM DS5020	87	184	18	487	17	\$36,491	\$93,136	\$40,980	\$25,826	\$196,433
Dell EqualLogic	87	150	15	249	9	\$18,658	\$77,804	\$34,234	\$40,445	\$171,141
Dell Compellent Storage Center with Virtualization and Thin	87	150	15	406	14	\$30,484	\$77,804	\$34,234	\$40,445	\$182,967
HP 3PAR InServ T800 with Thin Provisioning & Virtualization	87	150	15	421	15	\$31,604	\$80,573	\$35,452	\$22,313	\$169,942
EMC VMAX Se with Thin Provisioning	87	166	14	420	15	\$31,531	\$74,603	\$32,825	\$29,484	\$168,444
IBM DS6800	87	184	15	408	14	\$30,637	\$78,196	\$34,406	\$22,986	\$166,226
NetApp FAS6080 with FlexVol	87	150	14	395	14	\$29,637	\$75,642	\$33,282	\$22,985	\$161,546
Hitachi VSP with Virtualization and Thin Provisioning	87	150	6	155	5	\$11,646	\$30,685	\$13,501	\$13,542	\$69,374

Table 8 – Key Metrics from Case Study 2

The total 5-year costs are shown in figure 4 (below). The figures are not discounted, and no factors have been applied to reflect future changes to power or space. The capital cost of facilities equipment is included in the costs.

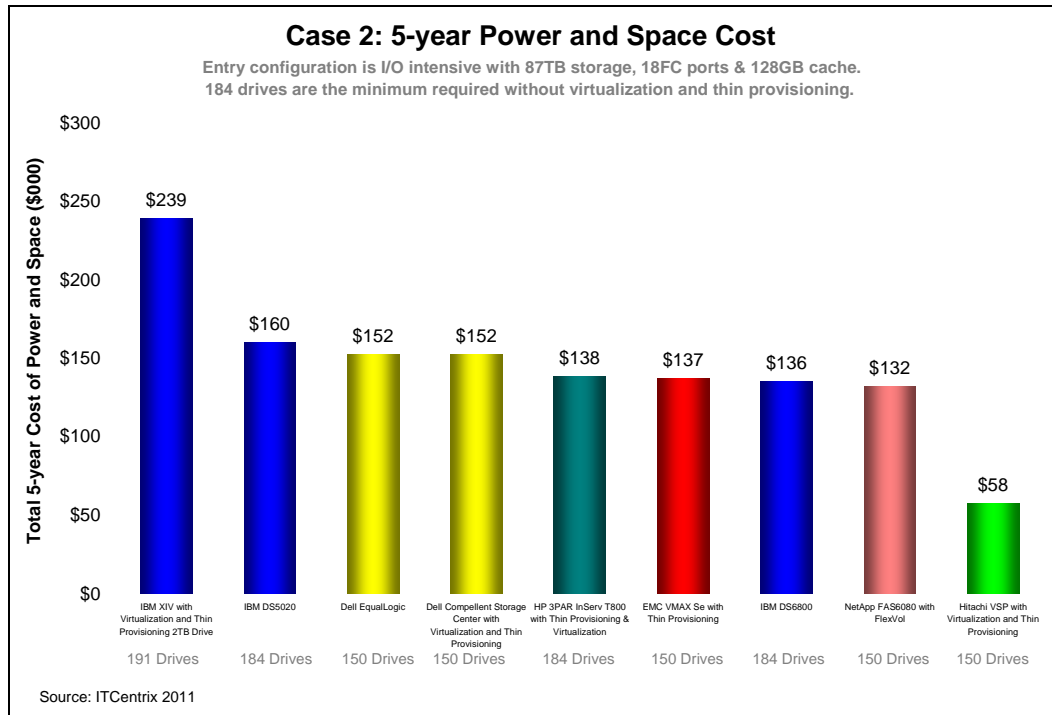


Figure 4 – Case 2: 5-year Power & Space Cost

The assumptions behind the figures in Case 2 are shown in table 9 (below). The estimate of 44% capital overhead was performed by ITCentrix in previous work, taking into account the capital and installation cost of CRAC units. Most data centers are constrained by the availability of power and cooling, air ducting, etc. The capacity of most data centers is constrained by the availability of power and cooling, and it is therefore justified to take this into account.

The assumptions for the impact of virtualization and thin provisioning on the number of drives required are conservative at 10% for each. ITCentrix did a study on the average time that storage arrays are installed, with a finding of 4.7 years; therefore a 5-year financial analysis was chosen.

Most of the arrays are using 3.5 inch drives. Hitachi uses 2.5 inch drives in the VSP array, and IBM does in the DS8800 array. The 2.5 inch drives are higher performance for the same capacity 3.5 inch drive, because of the greater number of heads over the same data area (bit density in constant). To ensure that all drives had the same capacity and same approximate performance, 10K drives were selected for the arrays supporting 2.5 inch drives.

The carbon emission per KWh is taken from the EPA web site, and is the average US value. There is significant difference in different parts of the US, depending on the energy sources used. Areas with high fossil fuel sources will be higher, and areas with nuclear, hydro and wind plants will be lower. The conversion of tons in car equivalent is also taken from the EPA site. The carbon trading sites are at an early stage, and both current and future prices are volatile. \$15/ton is a conservative estimate against some estimates of \$40-\$80 per ton.

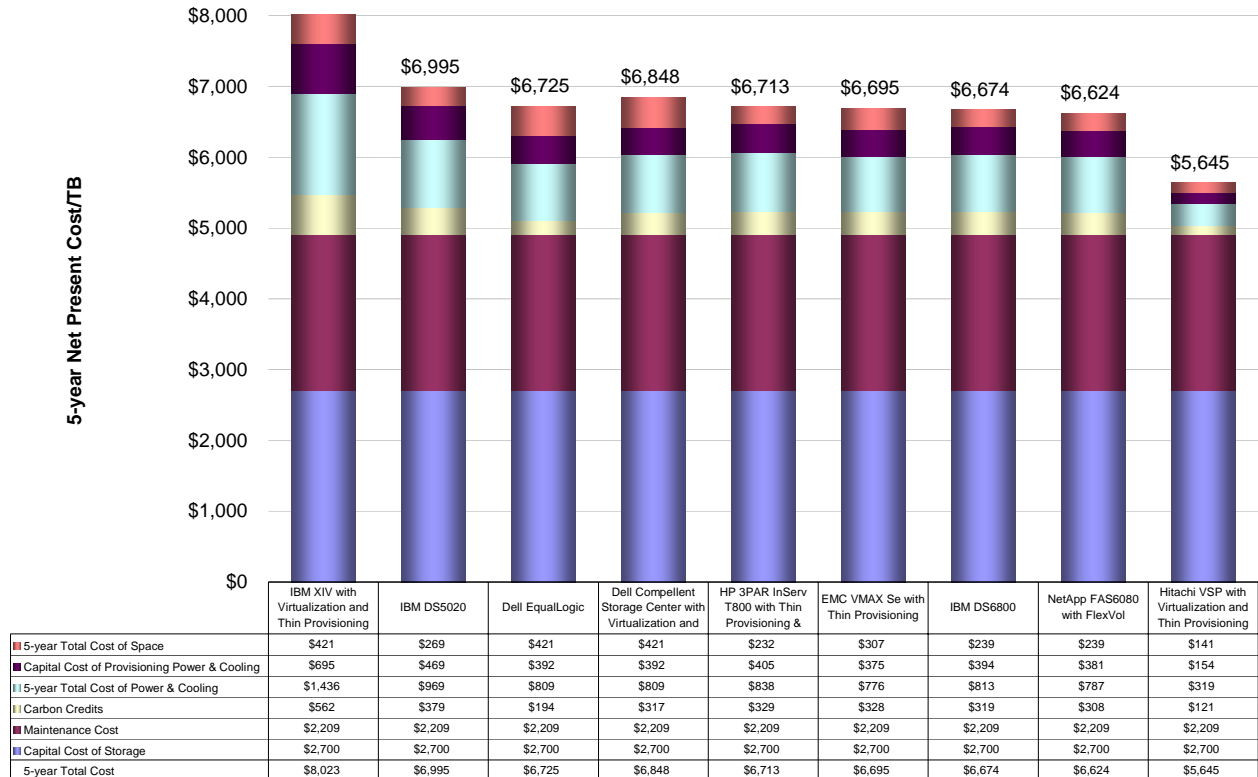
## The Business Case for Green Storage Equipment

<b>Case 2: Assumptions</b>
Tier 1/1.5 storage arrays with entry I/O intensive configuration with 87TB storage, 18FC ports & 128GB cache.
184 drives are the minimum required without virtualization and thin provisioning.
Cost of Power ( \$ per kVA per hour ) - \$0.120
Capital cost of Power is 44% total cost of Power
Cost of Space ( \$ per square foot per year ) - \$150
Overhead from Electrical Provisioning (UPS, PDUs, etc) - 40.0%
Additional Overhead from Thermal Cooling (CRAC units, Etc.) - 40.0%
Overall Data Center Infrastructure Efficiency (DCiE) - 51%
Multiplier to calculate actual space used from equipment dimensions - 2.5
Impact of Virtualization - 10.0% (this impacts the number of drives)
Impact of Thin Provisioning - 10.0% (this impacts the number of drives)
The performance of SAS 10K drives is approximately equal to FC 15K drives with same capacity
Number of Years for Assessment - 5 years
The US average lbs CO2/kWh = 1.329 - Source: EPA
The US average lbs CO2/car/year = 11,450 - Source: EPA
Carbon Credit is assumed be \$15/ton for all years - Source: Barclays Carbon Credits (2012 projected \$14-\$16)

**Table 9 – Assumptions for Case 2**

Figure 5 (below) shows the discounted environmental costs by array in \$/TB. The cost of the Case 2 arrays are broken down by all the equipment and environmental CAPEX and OPEX line items, and including the capital cost and maintenance costs.

**Case 2: Net Present Cost/TB of Leading Tier 1/1.5 Arrays with 87TB I/O Intensive Workload**



**Figure 5 – Case 2: Total Net Present Costs by Array**

## The Business Case for Green Storage Equipment

Figure 5 (above) is used to develop a business case for Green storage detailed in Table 10 (below). An underlying assumption is that all the arrays are priced at the same \$/effective TB, and the capital cost of the arrays are the same. The same maintenance costs are also assumed. The business case is focused on capital equipment and direct running costs – non-equipment costs such as staff are not included. The differences in the business cases are purely the costs associated with space and power. There are three scenarios compared:

4. **Greenest Storage Array** – the array with lowest cost of space and power and other directly related energy costs;
5. **Average Green Storage Array** – the average of all the other arrays, excluding the greenest array;
6. **Worst Green Storage Array** – the array with the highest cost of space and power.

The comparisons within the table are between:

- Greenest vs. average storage array(s);
- Greenest vs. worst storage array.

The Business Case for Green Storage (Case 2)									
Greenest Storage		Year 1	Year 2	Year 3	Year 4	Year 5	Total	Total/TB	CO <sub>2</sub> (Tons)
Terabytes	87								
Capital Cost/TB	\$2,700	\$236,062					\$236,062	\$2,700	
Maintenance (% Capital/year)	18%	\$42,491	\$42,491	\$42,491	\$42,491	\$42,491	\$212,456	\$2,430	
Cost of Space		\$2,708	\$2,708	\$2,708	\$2,708	\$2,708	\$13,542	\$155	
Cost of Power		\$6,137	\$6,137	\$6,137	\$6,137	\$6,137	\$30,685	\$351	
Capital Cost of Power Provisioning	\$	13,501					\$13,501	\$154	
Carbon Credit (\$15/ton)	\$15	\$2,329	\$2,329	\$2,329	\$2,329	\$2,329	\$11,646	\$133	155
<b>Total</b>		<b>\$303,229</b>	<b>\$53,666</b>	<b>\$53,666</b>	<b>\$53,666</b>	<b>\$53,666</b>	<b>\$517,892</b>	<b>\$5,923</b>	
<b>Net Present Cost (5%)</b>							<b>\$493,525</b>	<b>\$5,645</b>	
Average Green Storage		Year 1	Year 2	Year 3	Year 4	Year 5	Total		
Terabytes	87								
Capital Cost/TB	\$2,700	\$236,062					\$236,062	\$2,700	
Maintenance (% Capital/year)	18%	\$42,491	\$42,491	\$42,491	\$42,491	\$42,491	\$212,456	\$2,430	
Cost of Space		\$6,123	\$6,123	\$6,123	\$6,123	\$6,123	\$30,616	\$350	
Cost of Power		\$17,395	\$17,395	\$17,395	\$17,395	\$17,395	\$86,975	\$995	
Capital Cost of Power Provisioning	\$	38,269					\$38,269	\$438	
Carbon Credit (\$15/ton)	\$15	\$6,578	\$6,578	\$6,578	\$6,578	\$6,578	\$32,891	\$376	439
<b>Total</b>		<b>\$346,919</b>	<b>\$72,588</b>	<b>\$72,588</b>	<b>\$72,588</b>	<b>\$72,588</b>	<b>\$637,270</b>	<b>\$7,289</b>	
<b>Net Present Cost (5%)</b>							<b>\$604,311</b>	<b>\$6,912</b>	
<b>Net Present Cost vs. Greenest Storage (5%)</b>							<b>\$110,786</b>	<b>\$1,267</b>	
<b>Percentage Reduction in Storage Capital Cost to reduce Net Present Savings to \$0</b>							<b>47%</b>	<b>47%</b>	
Worst Case Green Storage		Year 1	Year 2	Year 3	Year 4	Year 5	Total		
Terabytes	87								
Capital Cost/TB	\$2,700	\$236,062					\$236,062	\$2,700	
Maintenance (% Capital/year)	18%	\$42,491	\$42,491	\$42,491	\$42,491	\$42,491	\$212,456	\$2,430	
Cost of Space		\$8,089	\$8,089	\$8,089	\$8,089	\$8,089	\$40,445	\$463	
Cost of Power		\$27,609	\$27,609	\$27,609	\$27,609	\$27,609	\$138,044	\$1,579	
Capital Cost of Power Provisioning	\$	60,739					\$60,739	\$695	
Carbon Credit (\$15/ton)	\$15	\$10,817	\$10,817	\$10,817	\$10,817	\$10,817	\$54,086	\$619	721
<b>Total</b>		<b>\$385,808</b>	<b>\$89,006</b>	<b>\$89,006</b>	<b>\$89,006</b>	<b>\$89,006</b>	<b>\$741,832</b>	<b>\$8,485</b>	
<b>Net Present Cost (5%)</b>							<b>\$701,419</b>	<b>\$8,023</b>	
<b>Net Present Cost vs. Greenest Storage (5%)</b>							<b>\$207,894</b>	<b>\$2,378</b>	
<b>Percentage Reduction in Storage Capital Cost to reduce Net Present Savings to \$0</b>							<b>88%</b>	<b>88%</b>	

**Table 10 – Case 2: The Business Case for Green Storage**

Table 11 (below) shows the key financial metrics of this comparison, which are equivalent to the NPV and IRR metrics of a traditional business case. They show a \$111-\$208K Net Present Saving by taking the greenest array (Hitachi VSP), with an IRR equivalent of between 47-88%. Put another way, you would need a discount of

## The Business Case for Green Storage Equipment

between 47%-88% off the price of alternative arrays to make up for the additional environmental costs. That is some discount!

Key Financial Metrics for Case 2; 487TB Tier 1.5 Storage	Average Green Array - Best Green Array	Worst Green Array - Best Green Array
Net Present Cost Difference between Average, Worst & Greenest Storage Arrays (5%) (NPV)	\$110,786	\$207,894
% Reduction in Storage Capital Cost to achieve Business Case Equality (IRR)	47%	88%

Table 11 – Key Financial Metrics from Business Case 2

### Case Study 3 – Details

Case 3 compares the hardware and environmental costs of leading Tier 2 arrays. Within the array are 33 TB of mixed mixed high performance and SATA disks, giving minimum of 35 drives in total assuming no virtualization or thin provisioning is available. The workload component using the SATA disks is I/O light. The workload is assumed to be dealing with images, and no compression or de-duplication is done. It is also assumed that the workload is not helped significantly by SSD storage. If thin provisioning and/or virtualization is available in the array, the number of disk drives is reduced.

Table 12 (below) shows the six leading arrays that were compared. If access was available to a vendor configuration tool, the tool was used to calculate the power and space requirements. A standard uplift for service space was added for all arrays (1.5 x floor space).

Key Metrics from Case Study 3										
Configuration is I/O light with 33TB storage, 4FC ports & 4GB cache.  35 drives are the minimum required without virtualization and thin provisioning.	Terabytes	Internal Drives required to meet TBs & Performance	Power Requirement (kVA) with UPS & Cooling Overheads	Tons CO2 Released	Car Equivalents	Carbon Credits	5-year Total Cost of Power & Cooling	Capital Cost of Provisioning Power & Cooling	5-year Total Cost of Space	5-year Total Environmental Costs
IBM DS5020	33	35	4.7	128	4	\$9,597	\$24,493	\$10,777	\$12,913	\$57,779
NetApp FAS2050	33	29	3.9	108	4	\$8,111	\$20,701	\$9,108	\$12,913	\$50,833
HP 3PAR InServ F200 with Thin Provisioning & Homogeneous	33	29	3.2	87	3	\$6,520	\$16,624	\$7,315	\$12,913	\$43,371
EMC CX4 120	33	35	2.1	58	2	\$4,321	\$11,029	\$4,853	\$12,913	\$33,116
Dell EqualLogic PS6510 with Virtualization and Thin Provisioning	33	29	1.8	50	2	\$3,756	\$9,572	\$4,212	\$12,913	\$30,453
HP EVA4400 with Virtualization	33	32	1.8	51	2	\$3,791	\$9,675	\$4,257	\$12,417	\$30,140
Hitachi AMS 2100 with Power Saving & Thin Provisioning	33	29	1.4	56	2	\$4,195	\$7,153	\$3,147	\$10,230	\$24,725

Table 12 – Key Metrics from Case Study 3

The total 5-year costs are shown in figure 6 (below). The figures are not discounted with the time value of money, and no factors have been applied to reflect future changes to power, or space. The capital cost of facilities equipment is included in the costs.

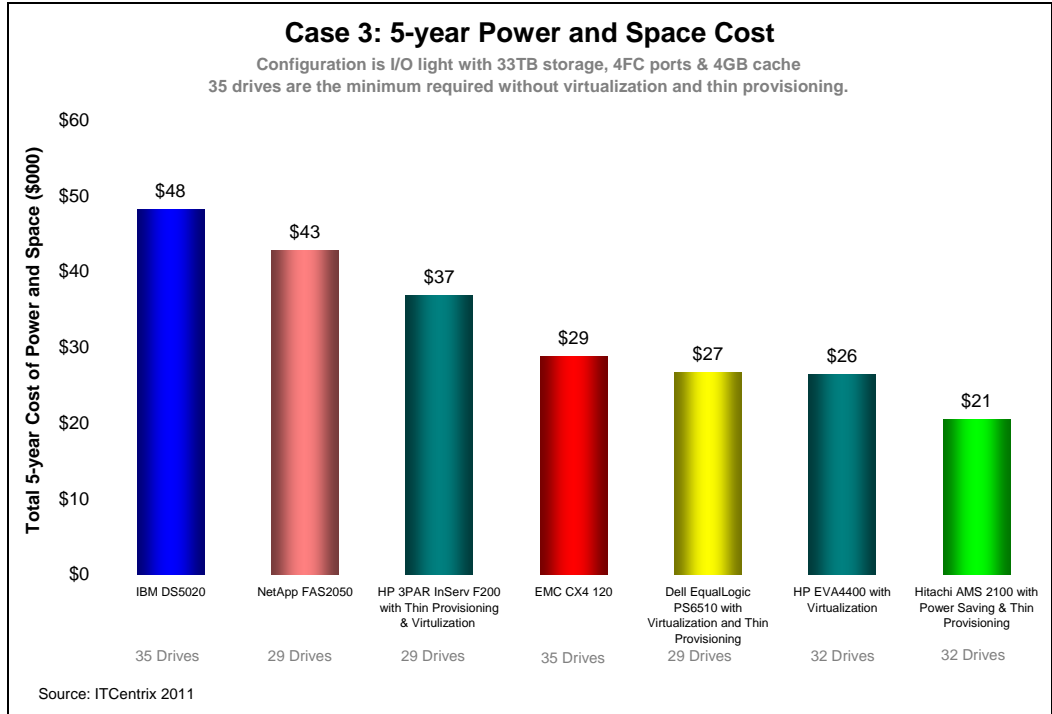


Figure 6 – Case 3: 5-year Power & Space Cost

The assumptions behind the figures in Case 3 are shown in table 13 (below). The estimate of 44% capital overhead for power facilities was performed by ITCentrix in previous work, taking into account the capital and installation cost of CRAC units, air ducting, etc. The capacity of most data centers is constrained by the availability of power and cooling, and it is therefore justified to take this into account.

The assumptions for the impact of virtualization and thin provisioning on the number of drives required are conservative at 10% for each. ITCentrix did a study on the average time that storage arrays are installed, with a finding of 4.7 years; therefore a 5-year financial analysis was chosen. All the Tier 2 arrays in case 3 are using 3.5 inch drives.

The carbon emission per kWh is taken from the EPA web site, and is the average US value. There is significant difference in different parts of the US, depending on the energy sources used. Areas with high fossil fuel sources will be higher, and areas with nuclear, hydro and wind plants will be lower. The conversion of tons in car equivalent is also taken from the EPA site. The carbon trading sites are at an early stage, and both current and future prices are volatile. \$15/ton is a conservative estimate against some future estimates of \$40-\$80 per ton.

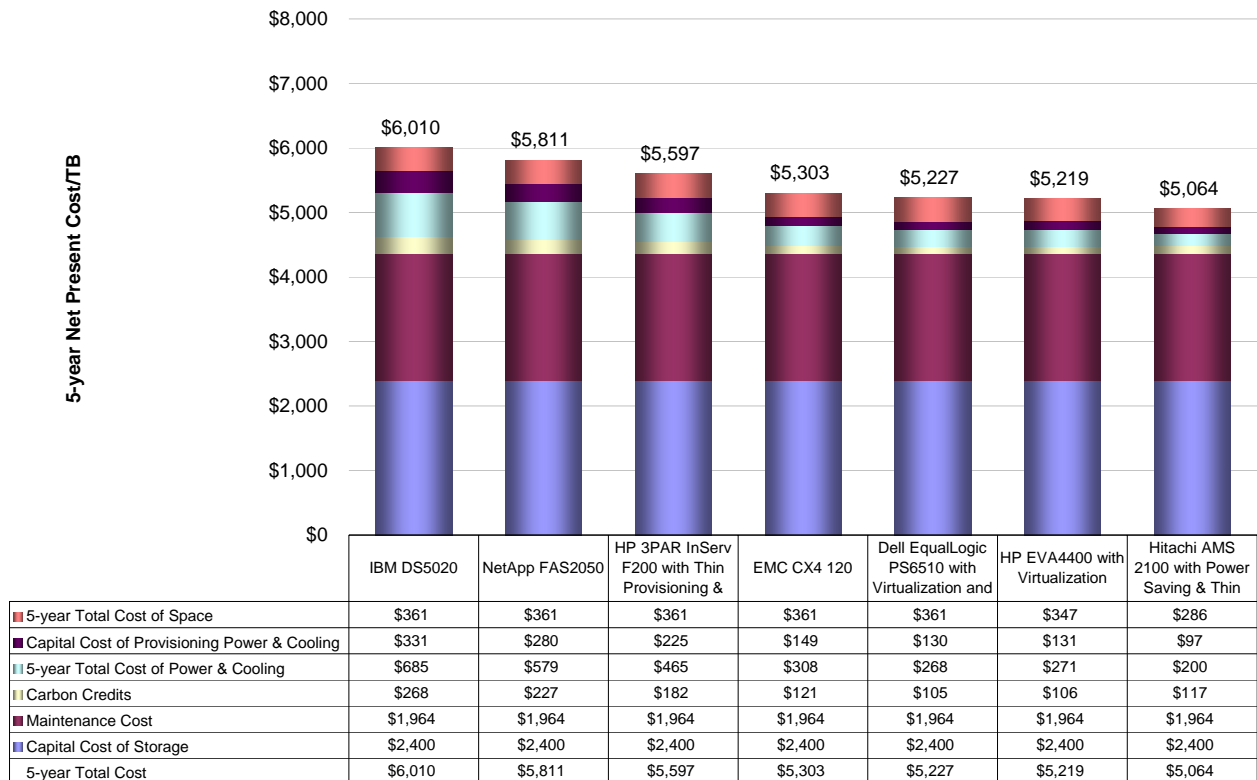
## The Business Case for Green Storage Equipment

<b>Case 3: Assumptions</b>
Tier 2 storage array entry configuration is I/O light with 33TB storage, 4FC ports & 4GB cache.
35 drives are the minimum required without virtualization and thin provisioning.
Cost of Power ( \$ per kVA per hour ) - \$0.120
Capital cost of Power is 44% total cost of Power
Cost of Space ( \$ per square foot per year ) - \$150
Overhead from Electrical Provisioning (UPS, PDUs, etc) - 40.0%
Additional Overhead from Thermal Cooling (CRAC units, Etc.) - 40.0%
Overall Data Center Infrastructure Efficiency (DCiE) - 51%
Multiplier to calculate actual space used from equipment dimensions - 2.5
Impact of Virtualization - 10.0% (this impacts the number of drives)
Impact of Thin Provisioning - 10.0% (this impacts the number of drives)
The performance of SAS 10K drives is approximately equal to FC 15K drives with same capacity
Number of Years for Assessment - 5 years
The US average lbs CO2/kWh = 1.329 - Source: EPA
The US average lbs CO2/car/year = 11,450 - Source: EPA
Carbon Credit is assumed be \$15/ton for all years - Source: Barclays Carbon Credits (2012 projected \$14-\$16)

**Table 13 – Assumptions for Case 3**

Figure 7 (below) shows the discounted environmental costs by array in \$/TB. The cost of the Case 3 arrays are broken down by all the equipment and environmental CAPEX and OPEX line items, and including the capital cost and maintenance costs.

**Case 3: Net Present Cost/TB of Leading Tier 2 Arrays with 33TB I/O Light Workload**



**Figure 7 – Case 3: Total Net Present Costs by Array**

Figure 7 (above) is used to develop a business case for Green storage detailed in Table 14 (below). An underlying assumption is that all the arrays are priced at the same

## The Business Case for Green Storage Equipment

\$/effective TB, and the capital cost of the arrays are the same. The same maintenance costs are also assumed. The business case is focused on capital equipment and direct running costs – non-equipment costs such as staff are not included. The differences in the business cases are purely the costs associated with space and power. There are three scenarios compared:

7. **Greenest Storage Array** – the array with lowest cost of space and power and other directly related energy costs;
8. **Average Green Storage Array** – the average of all the other arrays, excluding the greenest array;
9. **Worst Green Storage Array** – the array with the highest cost of space and power.

The comparisons within the table are between:

- Greenest vs. average storage array(s);
- Greenest vs. worst storage array.

<b>The Business Case for Green Storage (Case 3)</b>								CO <sub>2</sub>
		Year 1	Year 2	Year 3	Year 4	Year 5	Total	Total/TB (Tons)
<b>Greenest Storage</b>								
Terabytes	33							
Capital Cost/TB	\$2,400	\$78,033					\$78,033	\$2,400
Maintenance (% Capital/year)	18%	\$14,046	\$14,046	\$14,046	\$14,046	\$14,046	\$70,230	\$2,160
Cost of Space		\$2,046	\$2,046	\$2,046	\$2,046	\$2,046	\$10,230	\$315
Cost of Power		\$1,431	\$1,431	\$1,431	\$1,431	\$1,431	\$7,153	\$220
Capital Cost of Power Provisioning	\$	3,147					\$3,147	\$97
Carbon Credit (\$15/ton)	\$15	\$839	\$839	\$839	\$839	\$839	\$4,195	\$129
<b>Total</b>		<b>\$99,542</b>	<b>\$18,362</b>	<b>\$18,362</b>	<b>\$18,362</b>	<b>\$18,362</b>	<b>\$172,989</b>	<b>\$5,320</b>
<b>Net Present Cost (5%)</b>							<b>\$164,652</b>	<b>\$5,064</b>
<b>Average Green Storage</b>								
Terabytes	33							
Capital Cost/TB	\$2,400	\$78,033					\$78,033	\$2,400
Maintenance (% Capital/year)	18%	\$14,046	\$14,046	\$14,046	\$14,046	\$14,046	\$70,230	\$2,160
Cost of Space		\$2,566	\$2,566	\$2,566	\$2,566	\$2,566	\$12,830	\$395
Cost of Power		\$3,070	\$3,070	\$3,070	\$3,070	\$3,070	\$15,349	\$472
Capital Cost of Power Provisioning	\$	6,754					\$6,754	\$208
Carbon Credit (\$15/ton)	\$15	\$1,203	\$1,203	\$1,203	\$1,203	\$1,203	\$6,016	\$185
<b>Total</b>		<b>\$105,672</b>	<b>\$20,885</b>	<b>\$20,885</b>	<b>\$20,885</b>	<b>\$20,885</b>	<b>\$189,212</b>	<b>\$5,819</b>
<b>Net Present Cost (5%)</b>							<b>\$179,729</b>	<b>\$5,528</b>
<b>Net Present Cost vs. Greenest Storage (5%)</b>							<b>\$15,078</b>	<b>\$464</b>
<b>Percentage Reduction in Storage Capital Cost to reduce Net Present Savings to \$0</b>							<b>19%</b>	<b>19%</b>
<b>Worst Case Green Storage</b>								
Terabytes	33							
Capital Cost/TB	\$2,400	\$78,033					\$78,033	\$2,400
Maintenance (% Capital/year)	18%	\$14,046	\$14,046	\$14,046	\$14,046	\$14,046	\$70,230	\$2,160
Cost of Space		\$2,583	\$2,583	\$2,583	\$2,583	\$2,583	\$12,913	\$397
Cost of Power		\$4,899	\$4,899	\$4,899	\$4,899	\$4,899	\$24,493	\$753
Capital Cost of Power Provisioning	\$	10,777					\$10,777	\$331
Carbon Credit (\$15/ton)	\$15	\$1,919	\$1,919	\$1,919	\$1,919	\$1,919	\$9,597	\$295
<b>Total</b>		<b>\$112,257</b>	<b>\$23,447</b>	<b>\$23,447</b>	<b>\$23,447</b>	<b>\$23,447</b>	<b>\$206,043</b>	<b>\$6,337</b>
<b>Net Present Cost (5%)</b>							<b>\$195,397</b>	<b>\$6,010</b>
<b>Net Present Cost vs. Greenest Storage (5%)</b>							<b>\$30,745</b>	<b>\$946</b>
<b>Percentage Reduction in Storage Capital Cost to reduce Net Present Savings to \$0</b>							<b>39%</b>	<b>39%</b>

Table 14 – Case 3: The Business Case for Green Storage

Table 15 (below) shows the key financial metrics of this comparison, which are equivalent to the NPV and IRR metrics of a traditional business case. They show a \$15-\$31K Net Present Saving by taking the greenest array (Hitachi VSP), with an IRR equivalent of between 19-39%. Put another way, you would need a discount of between 19%-38% off the price of alternative arrays to make up for the additional environmental costs.

## The Business Case for Green Storage Equipment

Key Financial Metrics for Case 3; 33TB Tier 2 Storage	Average Green Array - Best Green Array	Worst Green Array - Best Green Array
Net Present Cost Difference between Average, Worst & Greenest Storage Arrays (5%) (NPV)	\$15,078	\$30,745
% Reduction in Storage Capital Cost to achieve Business Case Equality (IRR)	19%	39%

Table 15 – Key Financial Metrics from Business Case 3

### Case Study 4 – Details

Case 4 compares the hardware and environmental costs of leading high-end Tier 1 arrays. Within the array are 739 TB on high performance disks giving a minimum of 2,048 drives in total assuming no virtualization or thin provisioning is available. The minimum with virtualization and thin provisioning is 1,659 drives. As this is a high performance environment, no compression or de-duplication is done. It is assumed that the workload is not helped significantly by SSD storage. If thin provisioning and/or virtualization are available in the array, the number of disk drives is reduced.

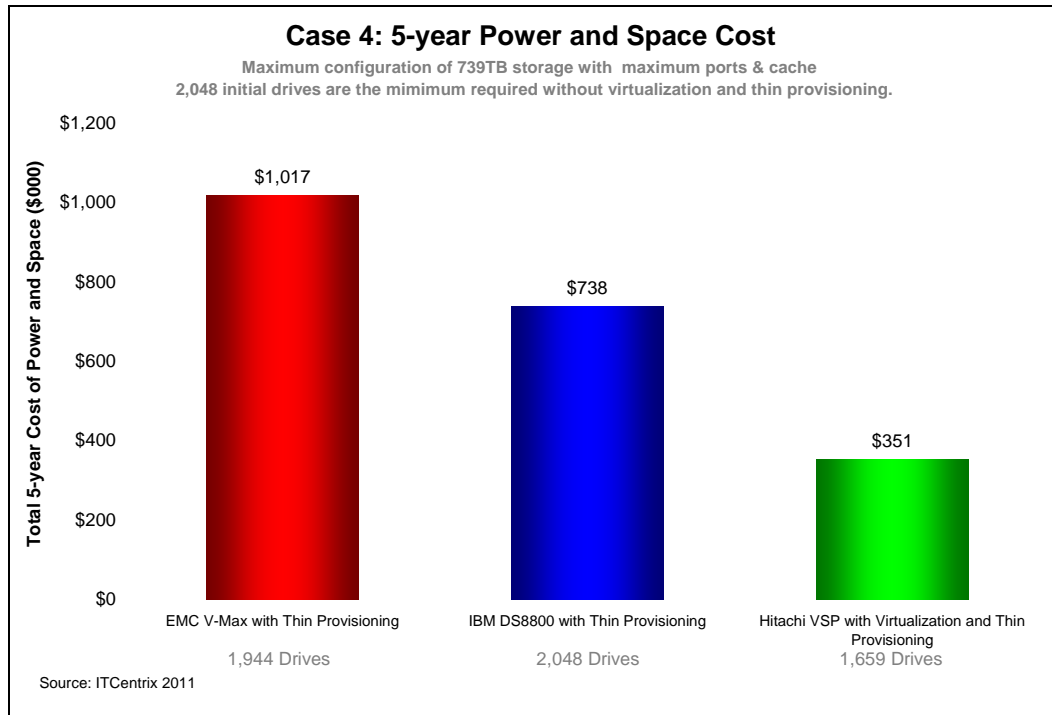
Table 16 (below) shows the three Tier 1 arrays that were compared. If access was available to a vendor configuration tool, the tool was used to calculate the power and space requirements. A standard uplift for service space was added for all arrays (1.5 x floor space).

Key Metrics from Case Study 4										
Storage Array	Terabytes	Internal Drives required to meet TBs & Performance	Power Requirement (kVA) with UPS & Cooling Overheads	Tons CO2 Released	Car Equivalents	Carbon Credits	5-year Total Cost of Power & Cooling	Capital Cost of Provisioning Power & Cooling	5-year Total Cost of Space	5-year Total Environmental Costs
Maximum configuration of 739TB storage with maximum ports & cache.  2,048 initial drives are the minimum required without virtualization and thin provisioning.										
EMC V-Max with Thin Provisioning	739	1844	112.7	1,580	55	\$118,474	592,128	\$260,536	\$164,706	\$1,135,844
IBM DS8800 with Thin Provisioning	739	2048	81.5	1,142	40	\$85,668	428,553	\$188,563	\$121,050	\$823,834
Hitachi VSP with Virtualization and Thin Provisioning	739	1659	35.7	494	17	\$37,081	187,400	\$82,456	\$80,873	\$387,810

Table 16 – Key Metrics from Case Study 4

The total 5-year costs for all arrays are shown in figure 8 (below). The figures are not discounted, and no factors have been applied to reflect future changes to power, or space. The capital cost of facilities equipment is included in the costs.

## The Business Case for Green Storage Equipment



**Figure 8 – Case 4: 5-year Power & Space Cost**

The assumptions behind the figures in Case 4 are shown in table 17 (below). The estimate of 44% capital overhead for power facilities was performed by ITCentrix in previous work, taking into account the capital and installation cost of CRAC units, air ducting, etc. The capacity of most data centers is constrained by the availability of power and cooling, and it is therefore justified to take this into account.

The assumptions for the impact of virtualization and thin provisioning on the number of drives required are conservative at 10% for each. ITCentrix did a study on the average time that storage arrays are installed, with a finding of 4.7 years; therefore a 5-year financial analysis was chosen.

EMC uses 3.5 inch drives in the VMAX, Hitachi uses 2.5 inch drives in the VSP array, and IBM does in the DS8800 array. The 2.5 inch drives are higher performance for the same capacity 3.5 inch drive, because of the greater number of heads over the same data area (bit density is constant). To ensure that all drives had the same capacity and same approximate performance, 10K drives were selected for the arrays supporting 2.5 inch drives.

The carbon emission per KWh is taken from the EPA web site, and is the average US value. There is significant difference in different parts of the US, depending on the energy sources used. Areas with high fossil fuel sources will be higher, and areas with nuclear, hydro and wind plants will be lower. The conversion of tons in car equivalent is also taken from the EPA site. The carbon trading sites are at an early stage, and both current and future prices are volatile. \$15/ton is a conservative estimate against some future estimates of \$40-\$80 per ton.

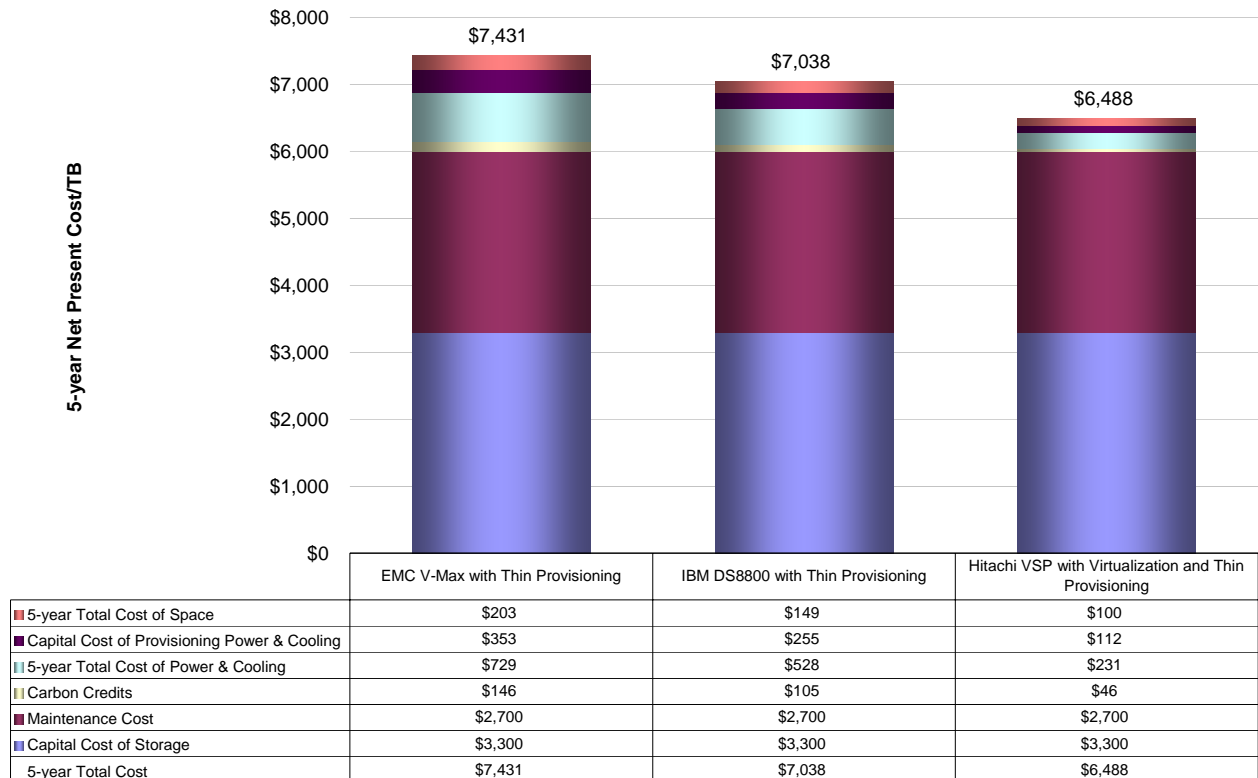
## The Business Case for Green Storage Equipment

Case 4: Assumptions
Tier 1 storage arrays in an IO intensive environment with 739TB high performance storage & maximum ports & 2,048 initial drives are the minimum required without virtualization and thin provisioning.
Cost of Power ( \$ per kVA per hour ) - \$0.120
Capital cost of Power is 44% total cost of Power
Cost of Space ( \$ per square foot per year ) - \$150
Overhead from Electrical Provisioning (UPS, PDUs, etc) - 40.0%
Additional Overhead from Thermal Cooling (CRAC units, Etc.) - 40.0%
Overall Data Center Infrastructure Efficiency (DCiE) - 51%
Impact of Heterogeneous Virtualization (Hitachi & Partners) - 10.0% (this impacts the number of drives)
Impact of Homogeneous Virtualization - 10.0% (this impacts the number of drives)
Impact of Thin Provisioning - 10.0% (this impacts the number of drives)
Impact of Dynamic Provisioning (Hitachi & Partners) - 10.0% (this impacts the number of drives)
Multiplier to calculate actual space used from equipment dimensions - 2.5
Number of Years for Assessment - 5 years
The performance of SAS 10K drives is approximately equal to FC 15K drives with same capacity
The US average lbs CO2/kWh = 1.329 - Source: EPA
The US average lbs CO2/car/year = 11,450 - Source: EPA
Carbon Credit is assumed be \$15/ton for all years - Source: Barclays Carbon Credits (2012 projected \$14-\$16)

**Table 17 – Assumptions for Case 4**

Figure 9 (below) shows the discounted environmental costs by array in \$/TB. The cost of the Case 4 arrays are broken down by all the equipment and environmental CAPEX and OPEX line items, and including the capital cost and maintenance costs.

**Case 4: Net Present Cost/TB of Leading Tier 1 Arrays with 739TB IO Intensive Workload**



**Figure 9 – Case 4: Total Net Present Costs by Array**

## The Business Case for Green Storage Equipment

Figure 9 (above) is used to develop a business case for Green storage detailed in Table 18 (below). An underlying assumption is that all the arrays are priced at the same \$/effective TB, and the capital cost of the arrays are the same. The same maintenance costs are also assumed. The business case is focused on capital equipment and direct running costs – non-equipment costs such as staff are not included. The differences in the business cases are purely the costs associated with space and power. There are three scenarios compared:

10. **Greenest Storage Array** – the array with lowest cost of space and power and other directly related energy costs;
11. **Average Green Storage Array** – the average of all the other arrays, excluding the greenest array;
12. **Worst Green Storage Array** – the array with the highest cost of space and power.

The comparisons within the table are between:

- Greenest vs. average storage array(s);
- Greenest vs. worst storage array.

<b>The Business Case for Green Storage (Case 4)</b>								CO <sub>2</sub>	
<b>Greenest Storage</b>		Year 1	Year 2	Year 3	Year 4	Year 5	Total	Total/TB	(Tons)
Terabytes	739								
Capital Cost/TB	\$3,300	\$2,437,306					\$2,437,306	\$3,300	
Maintenance (% Capital/year)	18%	\$438,715	\$438,715	\$438,715	\$438,715	\$438,715	\$2,193,575	\$2,970	
Cost of Space		\$16,175	\$16,175	\$16,175	\$16,175	\$16,175	\$80,873	\$109	
Cost of Power		\$37,480	\$37,480	\$37,480	\$37,480	\$37,480	\$187,400	\$254	
Capital Cost of Power Provisioning	\$	82,456					\$82,456	\$112	
Carbon Credit (\$0/ton)	\$15	\$7,416	\$7,416	\$7,416	\$7,416	\$7,416	\$37,081	\$50	494
<b>Total</b>		<b>\$3,019,548</b>	<b>\$499,786</b>	<b>\$499,786</b>	<b>\$499,786</b>	<b>\$499,786</b>	<b>\$5,018,691</b>	<b>\$6,795</b>	
<b>Net Present Cost (5%)</b>							<b>\$4,791,764</b>	<b>\$6,488</b>	
<b>Average Green Storage</b>		Year 1	Year 2	Year 3	Year 4	Year 5	Total		
Terabytes	739								
Capital Cost/TB	\$3,300	\$2,437,306					\$2,437,306	\$3,300	
Maintenance (% Capital/year)	18%	\$438,715	\$438,715	\$438,715	\$438,715	\$438,715	\$2,193,575	\$2,970	
Cost of Space		\$28,576	\$28,576	\$28,576	\$28,576	\$28,576	\$142,878	\$193	
Cost of Power		\$102,068	\$102,068	\$102,068	\$102,068	\$102,068	\$510,341	\$691	
Capital Cost of Power Provisioning	\$	224,550					\$224,550	\$304	
Carbon Credit (\$0/ton)	\$15	\$20,414	\$20,414	\$20,414	\$20,414	\$20,414	\$102,071	\$138	1,361
<b>Total</b>		<b>\$3,251,629</b>	<b>\$589,773</b>	<b>\$589,773</b>	<b>\$589,773</b>	<b>\$589,773</b>	<b>\$5,610,721</b>	<b>\$7,597</b>	
<b>Net Present Cost (5%)</b>							<b>\$5,342,935</b>	<b>\$7,234</b>	
<b>Net Present Cost vs. Greenest Storage (5%)</b>							<b>\$551,171</b>	<b>\$746</b>	
<b>Percentage Reduction in Capital Cost to reduce Net Present Savings to \$0</b>							<b>23%</b>	<b>23%</b>	
<b>Worst Case Green Storage</b>		Year 1	Year 2	Year 3	Year 4	Year 5	Total		
Terabytes	739								
Capital Cost/TB	\$3,300	\$2,437,306					\$2,437,306	\$3,300	
Maintenance (% Capital/year)	18%	\$438,715	\$438,715	\$438,715	\$438,715	\$438,715	\$2,193,575	\$2,970	
Cost of Space		\$32,941	\$32,941	\$32,941	\$32,941	\$32,941	\$164,706	\$223	
Cost of Power		\$118,426	\$118,426	\$118,426	\$118,426	\$118,426	\$592,128	\$802	
Capital Cost of Power Provisioning		\$260,536					\$260,536	\$353	
Carbon Credit (\$0/ton)	\$15	\$23,695	\$23,695	\$23,695	\$23,695	\$23,695	\$118,474	\$160	1,580
<b>Total</b>		<b>\$3,311,619</b>	<b>\$613,777</b>	<b>\$613,777</b>	<b>\$613,777</b>	<b>\$613,777</b>	<b>\$5,766,726</b>	<b>\$7,808</b>	
<b>Net Present Cost (5%)</b>							<b>\$5,488,041</b>	<b>\$7,431</b>	
<b>Net Present Cost vs. Greenest Storage (5%)</b>							<b>\$696,277</b>	<b>\$943</b>	
<b>Percentage Reduction in Capital Cost to reduce Net Present Savings to \$0</b>							<b>29%</b>	<b>29%</b>	

**Table 18 – Case 4: The Business Case for Green Storage**

Table 19 (below) shows the key financial metrics of this comparison, which are equivalent to the NPV and IRR metrics of a traditional business case. They show a \$551-\$696K Net Present Saving by taking the greenest array (Hitachi VSP), with an IRR equivalent of between 23-29%. Put another way, you would need a discount of between 23%-29% off the price of alternative arrays to make up for the additional environmental costs.

**The Business Case for Green Storage Equipment**

	Average Green Array - Best Green Array	Worst Green Array - Best Green Array
<p align="center"><b>Key Financial Metrics for Case 4; 739TB Tier 1 Storage</b></p> <p>Net Present Cost Difference between Average, Worst &amp; Greenest Storage Arrays (5%) (NPV)</p> <p>% Reduction in Storage Capital Cost to achieve Business Case Equality (IRR)</p>	<p>\$551,171</p> <p>23%</p>	<p>\$696,277</p> <p>29%</p>

**Table 19 – Key Financial Metrics from Business Case 4**

### About ITCentrix

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ITCentrix is a consultancy that primarily serves the needs of CIOs and technology professionals. Its main emphasis is using tools and analytic modeling techniques to advise clients on increasing company performance through improved resource allocation and better infrastructure management.

The company's products and services have been used at several hundred organizations in North America, Europe, the Asia/Pacific region, and emerging countries to focus investments on returning optimal business value.