VAccelerate Servers

Capacity Planning Report

Prepared for:

ABC Ltd.

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1 Executive Summary

This document contains the results of the VAccelerate Servers capacity planning service performed for ABC Ltd.. It provides an in-depth of analysis of the current server environment, identifies server virtualization candidates and presents virtual infrastructure solution options.

1.1 Key Benefits

Based on the results detailed in this report, ABC Ltd. should be able to achieve the following benefits:

Consolidation Ratio	Power Savings	Server Reduction	Space Savings
39:1	**$114,207**	**75%**	**75%**

1.2 Key Findings

152 servers were analyzed for virtualization suitability. Here is a summary of the results:

Virtualization Candidates:	117
Exclusion Candidates:	35

Please refer to Section 9 for definitions of selection criteria.

1.2.1 Virtualization Candidate Summary

The results indicate that the majority of analyzed servers are candidates for virtualization.

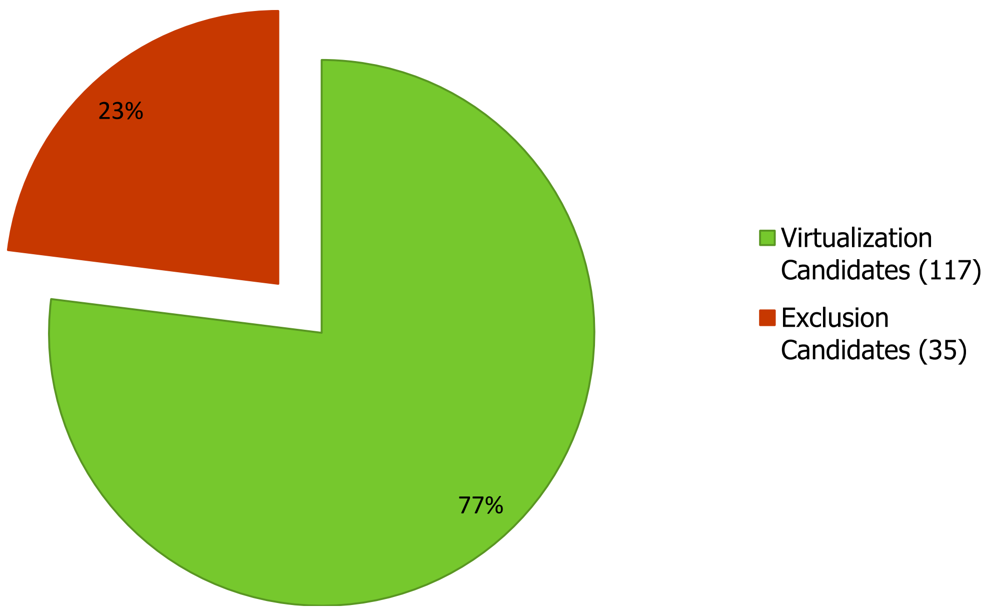

Chart 1.2.1: Virtualization Candidate Summary

The results indicate that ABC Ltd. will be able to virtualize a significant number of servers analyzed. The results of what-if scenario modelling are presented in the table below:

1.2.2 What-if Modelling Results

Solution				
Scenario	IBM System x3550 M2 96 GB (optimize) on Citrix XenServer	Sun Fire X4170 48 GB (optimize) on Citrix XenServer	IBM System x3550 M2 96 GB (optimize) on VMware ESX vSphere 4	Sun Fire X4170 48 GB (optimize) on VMware ESX vSphere 4
Virtualization Platform	Citrix XenServer	Citrix XenServer	VMware ESX vSphere 4	VMware ESX vSphere 4
Target Servers				
Count	3	6	3	6
Consolidation Ratio	39:1	19:1	39:1	19:1
Total Rack Units	3	6	3	6
Total Cost				
Per Virtual Machine - 3 years	$987.28	$1,216.12	$1,133.54	$1,468.71

TCO - 3 years	$115,512.17	$142,285.56	$132,623.72	$171,838.71
Total Cost Savings				
Power Savings - 3 years	$114,207.88	$107,000.48	$114,207.88	$107,000.48
Total Savings				
Server Reduction (%)	75	74	75	74
Space Savings (%)	75	74	75	74
Total Energy				
Power Consumption (kW)	2.46	5.04	2.46	5.04
Power Savings (kW)	84.23	81.65	84.23	81.65
Power Consumption Per VM (W)	21	43	21	43

1.3 Next Steps

All virtualization projects rely upon appropriate planning to ensure success. A typical virtual infrastructure project consists of the following phases:

Figure 1.1.1: Virtualization Project Methodology

Upon completion of the capacity planning service and assuming pre-requisites for analysis phase sign-off have been met, the project moves into the design phase. For more information about planning and design services, please contact Redapt Systems using contact details below:

Redapt Systems
inquiry@redapt.com
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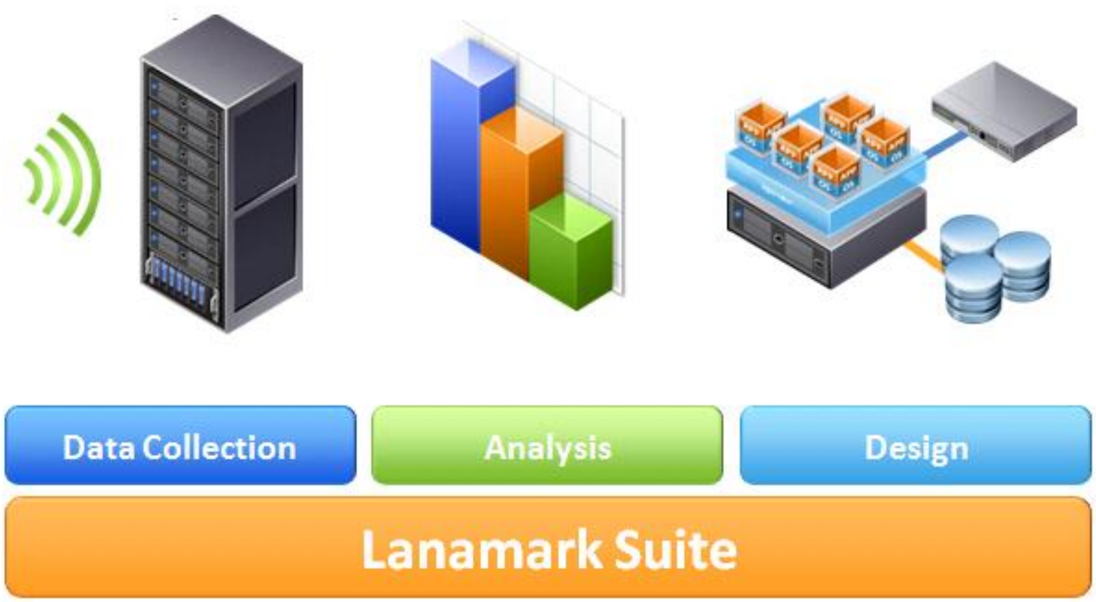
1.4 Methodology

Data collection, analysis and solution modelling were performed using advanced IT infrastructure analysis and design software called Lanamark Suite to accomplish the following objectives:

- Collect hardware, software and performance data
- Identify servers most suitable for virtualization
- Right-size virtual infrastructure to avoid under- or over-provisioning
- Optimize resource allocation to virtualized servers to maximize utilization and minimize TCO
- Maximize performance and availability of virtualized servers by optimally placing them across target virtual machine hosts



2 Project Overview

2.1 Purpose

The purpose of this project is to assist ABC Ltd. in making informed IT infrastructure design and purchasing decisions.

This VAccelerate Servers Report is designed to:

- Provide a detailed analysis of hardware, software, workloads and utilization
- Support and validate the business case for server virtualization
- Identify server virtualization and redeployment candidates
- Lay the foundation for a successful design phase
- De-risk subsequent virtualization project phases
- Demonstrate due diligence to key stakeholders
- Serve as a reference point throughout design, implementation and migration

Review of the VAccelerate Servers Report acts as a demarcation point for the completion of the Analysis phase.

2.2 Project Outline

The following key activities were completed in support of the project objectives.

Phase	Key Activities
Data Collection	• Discuss servers to be monitored, network topology and authentication • Communicate data collection and target system requirements • Remotely install the data collector • Assist with the discovery of servers • Track data collection progress
Analysis	• Analyse hardware, software, workloads and utilisation • Determine compute, storage and network requirements • Identify server virtualization and re-deployment candidates
Modelling	• What-if modelling across leading hardware and virtualization platforms based on customer preferences.
Report	• Delivery of VAccelerate Servers Report Package

2.3 Deliverables

The key deliverables of this project were:

- Comprehensive reporting and analysis of existing servers
- Identification of servers most suitable for virtualization
- What-if modelling of hardware and leading virtualization platforms
- Detailed comparison of multiple virtual infrastructure configurations

2.4 Assumptions & Constraints

It is possible that there are additional unknown constraints or issues that were not considered during this project. ABC Ltd. should carefully review all analyses and recommendations, as the overall subject matter experts of their own environment.

Other considerations include:

- Design, migration and deployment are not within the scope of this report
- Solution modelling results are based upon specific criteria and are not meant to identify all components in a virtual infrastructure solution or to serve as a design blueprint, a bill of materials or a budgetary estimate
- Application migration, dependency resolution and/or coding is the responsibility of ABC Ltd. and are not addressed in this project
- ABC Ltd. is responsible for complying with all operating system and application vendor license agreements on all physical and virtual machines
- Virtualization candidate selection is based on the most recent performance data collected and is subject to change with time and seasonal variations
- Demands on resources can vary and as such all recommendations should formally be vetted with a final detailed design per solution best practices and tested in a pre-production environment prior to production deployment

3 Virtual Infrastructure Overview

Virtual infrastructure is comprised of multiple components. This section outlines these components and their functions.

3.1 Hypervisor

A hypervisor is software that allows multiple workloads (operating system + applications), with heterogeneous operating systems, to run on a single physical server. The physical server running the hypervisor is known as the host and each virtual server on top of the hypervisor is referred to as a virtual machine or a guest. The hypervisor manages compute resources of the physical hardware and distributes them across all the virtual machines.

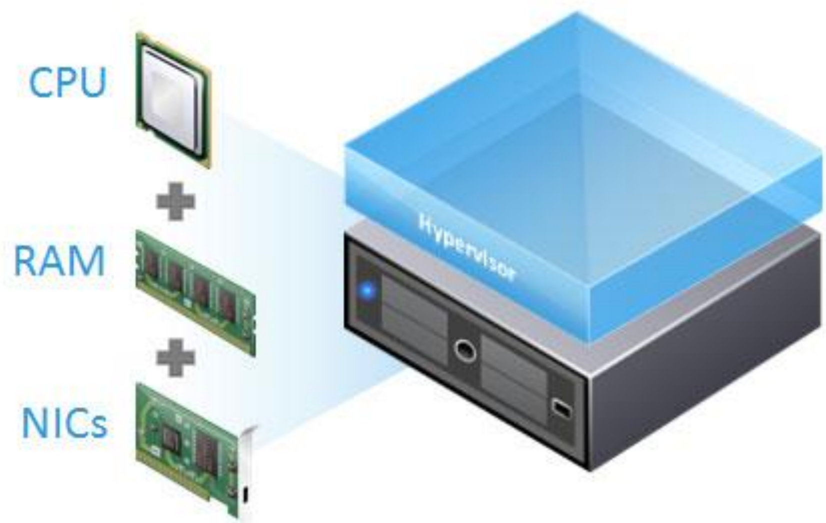


Figure 3-1: Hypervisor Compute Resources

There are two hypervisor types:

> **Type 1** – Type 1 hypervisor, often also referred to as a 'bare-metal hypervisor', runs on the server, taking direct control of the physical hardware. Examples of Type 1 hypervisors are Microsoft Hyper-V, VMware ESX and Xen.
>
> **Type 2** – Type 2 hypervisor, sometimes referred to as 'hosted hypervisor', is installed on top of an operating system. It provides no operating system of its own. Examples of Type 2 hypervisors are Microsoft Virtual Server and VMware Workstation.

Parallels Virtuozzo Containers is an additional variation. Unlike competing products, Parallels Virtuozzo Containers virtualizes the host operating system and therefore provides high consolidation density for homogenous environments.

3.2 CPU Virtualization

Virtualized CPU (vCPU) resources are managed by the hypervisor. Physical CPU cores on the host are shared among virtual machines running on that host. Each virtual machine can have one or more vCPUs assigned to it, just as each physical server can have one or more physical processors. The hypervisor ensures that virtual machines are unaware that they may be sharing a physical processor with other virtual machines.

3.3 Memory Virtualization

The hypervisor manages the allocation of memory to each virtual machine. Physical memory installed in the host server is divided among virtual machines managed by the hypervisor. Some virtualization platforms support sharing and oversubscription of memory, thereby allowing total memory allocated to virtual machines to exceed memory installed on a physical server.

Calculations in this report determine how many servers can be virtualized on each host using workload memory usage and physical memory installed on the host.

3.4 Storage

Virtual machines are typically run from shared storage in order to leverage key virtualization features such as live migration, dynamic load balancing and high availability. Storage should be designed to take into consideration disk space, I/O rates and projected growth requirements. Depending on workload profiles and the number of virtual machines, multiple storage technologies and topologies may be considered.

The following storage technologies are most common in virtualization solutions:

- Fibre Channel
- iSCSI
- Local SAS/SCSI

Figure 3-2: Virtualization Storage

Several logical storage technologies from hardware and virtualization vendors exist to assist with rapid provisioning of virtual machines and to reduce storage requirements. These storage technologies include:

- Linked Clones
- De-duplication
- Thin Provisioning

Data gathered during this project is crucial during the design phase to ensure that the underlying storage infrastructure meets disk I/O and space requirements of all workloads. It is also used to right-side storage allocation to ensure that allocated capacity closely bounds actual storage requirements.

3.5 Networking

The virtual networking layer consists of virtual network devices through which virtual machines and the hypervisor interface with the rest of the network. Virtual infrastructure relies on the virtual networking layer to support communication between virtual machines, other systems and users. In addition, virtual networks can also be used to communicate with iSCSI SANs, NAS storage and other central storage devices. The virtual networking layer includes virtual network adapters and virtual switches.

Profiling network usage is an important consideration when designing the virtual networking layer. Network usage data is used to ensure that aggregate network loads will not exceed network capacity of virtual infrastructure at peak times.

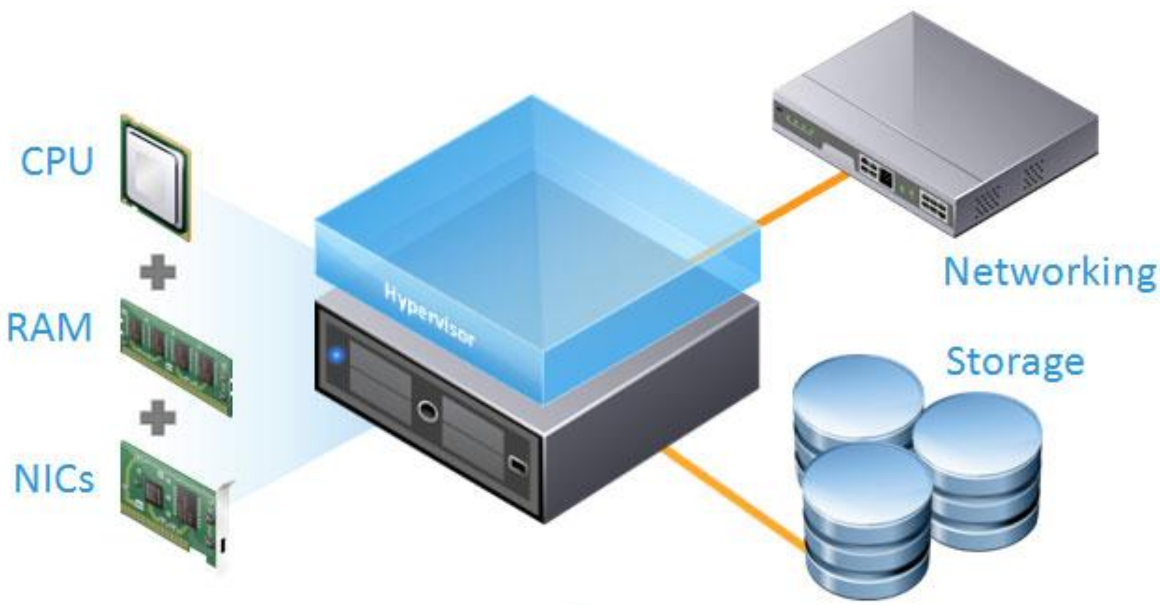


Figure 3-3: **Virtualization Networking**

3.6 Virtual Machines

Each virtual machine acts as a container for a workload and is comprised of CPU, memory, network and storage components. Virtual machine specifications should be derived from the results of this analysis.

Detailed workload profiles are used to optimize virtual machine sizing and placement across target servers so that hardware capacity closely matches workload demand. This approach helps minimize resource contention, maximize workload performance and justify to application owners why virtual machine specifications do not necessarily need to match (under-utilized) source hardware specifications.

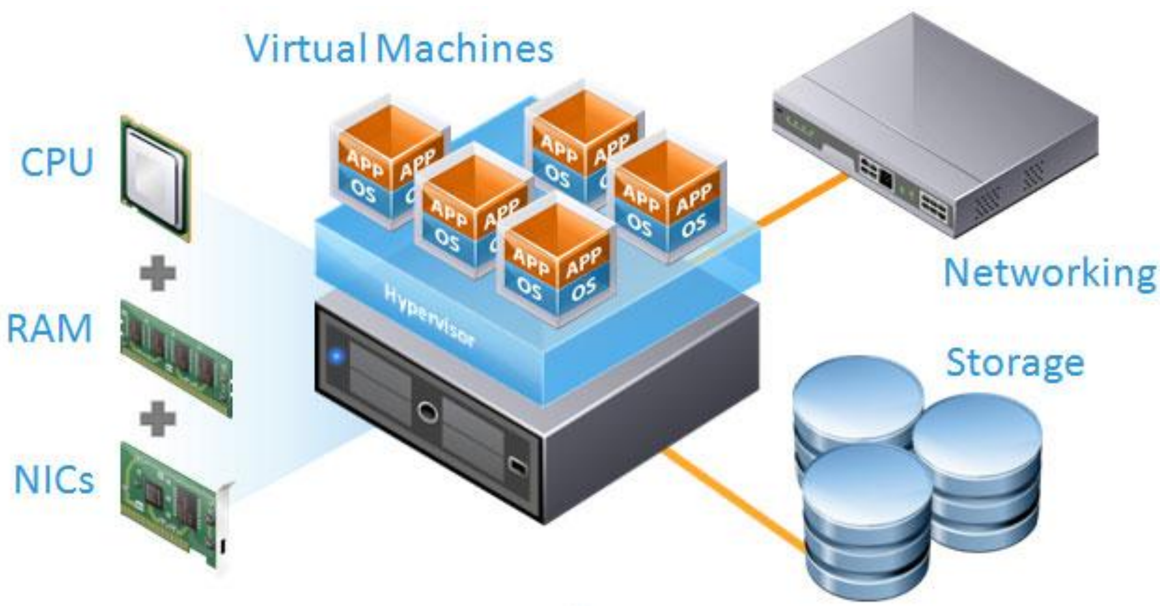


Figure 3-4: Virtual Machines

3.7 Benefits of Virtualization

Here are the primary benefits of virtualization:

- Minimize space, power and cooling expenses
- Reduce administrative, maintenance and support costs
- Maximize hardware utilization through server consolidation
- Provision new virtual machines in minutes, rather than days
- Run multiple workloads with different operating systems on the same hardware
- Leverage advanced functionality such as live migration, dynamic load balancing and fault-tolerance to increase performance and availability of workloads

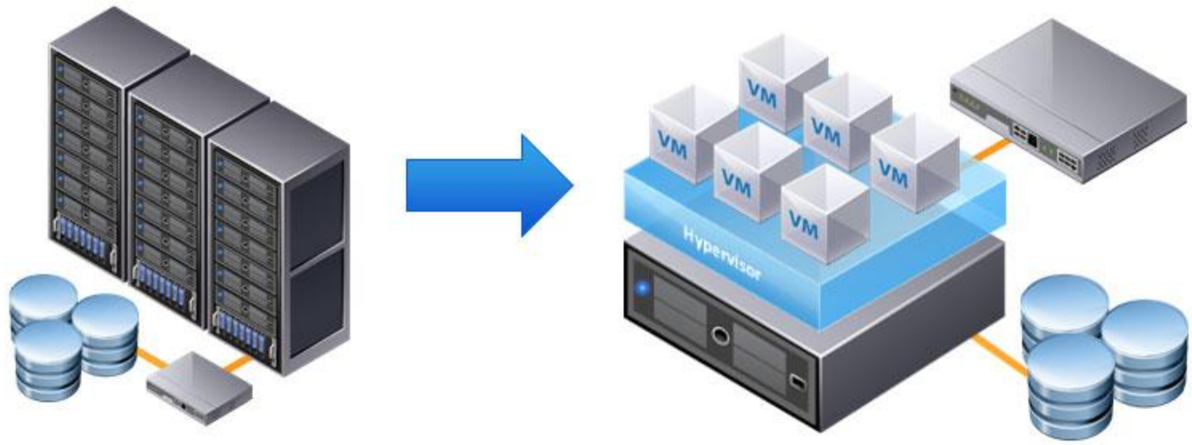


Figure 3-5: Virtualization provides multiple benefits in the data centre

4 Report Overview

4.1 Hardware Analysis

This section conducts a top-down examination of physical servers, highlighting attributes that are useful for total cost of ownership analysis and hardware re-use candidate selection.

4.2 Utilization Analysis

This section examines physical server utilization. This information is key to understanding data centre efficiency and identifying under- and over-utilized physical servers.

- CPU utilization
- Memory utilization

4.3 Workload Analysis

This section examines workloads running on physical machines. The information below is key to measuring workloads and identifying most suitable candidates for virtualization. It is also used for sizing virtual machines and the underlying virtual infrastructure.

- Operating systems
- CPU usage
- Memory usage
- Storage allocation and usage
- Disk I/O usage
- Network I/O usage

4.4 Virtualization Recommendations

This section outlines criteria for virtualization candidate selection and exclusion. It also lists exclusion candidates.

4.5 What-if Modelling

What-if modelling criteria and key analysis findings are covered in this section.

4.6 Environmental Analysis

The environmental impact of modelled scenarios is analyzed across the following metrics:

- Power consumption
- Power consumption per virtual machine
- Carbon footprint reduction

4.7 Space Analysis

This section provides an overview of space requirements and space reduction for modelled scenarios.

4.8 Financial Analysis

This section provides a financial analysis of modelled scenarios, including hardware, software and power costs as well as the resulting total cost of ownership.

5 Hardware Analysis

5.1 Processors

5.1.1 Physical Machines vs. CPU Core Count

Reports server CPU data, grouped by the number of CPU cores. Machines with four or more CPU cores may also be candidates for re-deployment as virtual machine hosts. It is not uncommon for a host to run three or more virtual machines per CPU core.

> *<u>Example</u>: machines in the '2' category are equipped with 2 CPU cores. This includes machines with a single dual-core processor or two single core processors.*

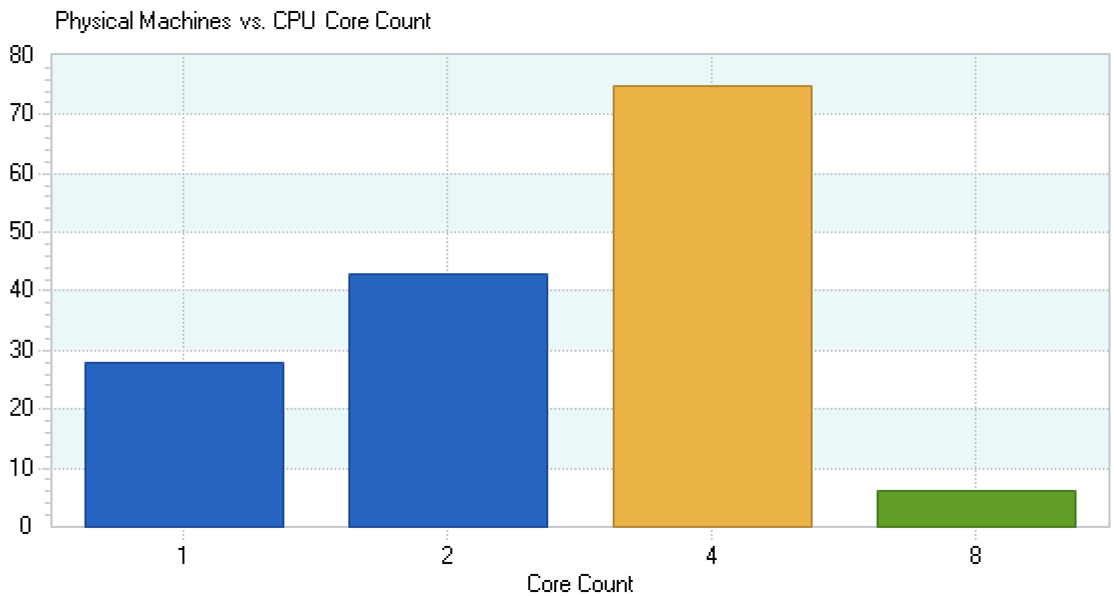


Chart 5.1.1: Physical Machine Count vs. CPU Core Count

5.2 Memory

5.2.1 Physical Machine vs. Memory Installed (GB)

Reports physical memory installed in analysed servers.

<u>Example</u>: machines in the '2' category have between 1 GB and 2GB of memory installed.

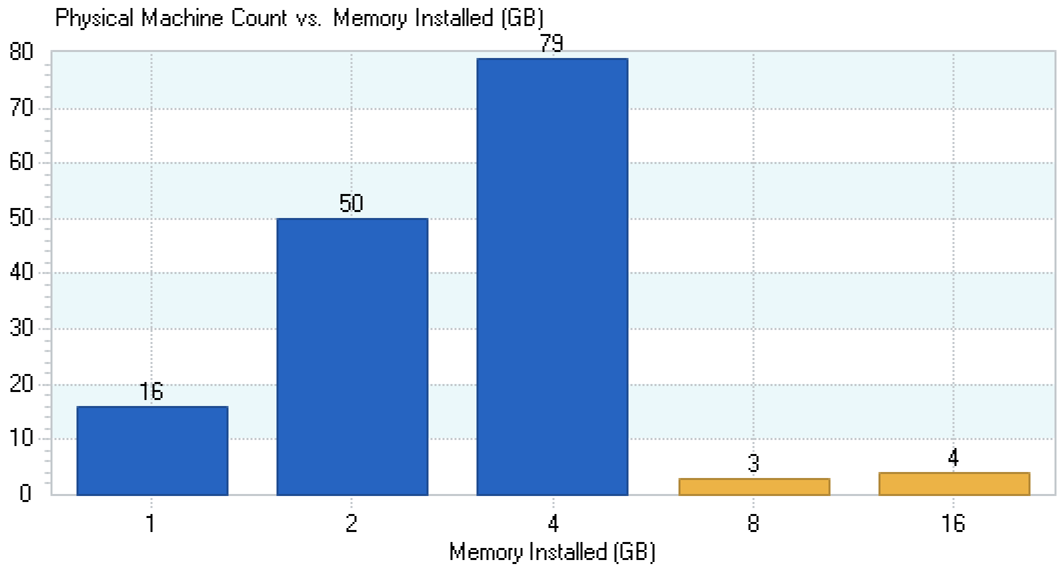


Chart 5.2.1: Physical Machine Count vs. Memory Installed (GB)

5.3 Age and Warranty

5.3.1 Server Age

Breakdown of servers by age.

<u>Example</u>: machines in the 2 category are 1-2 years old

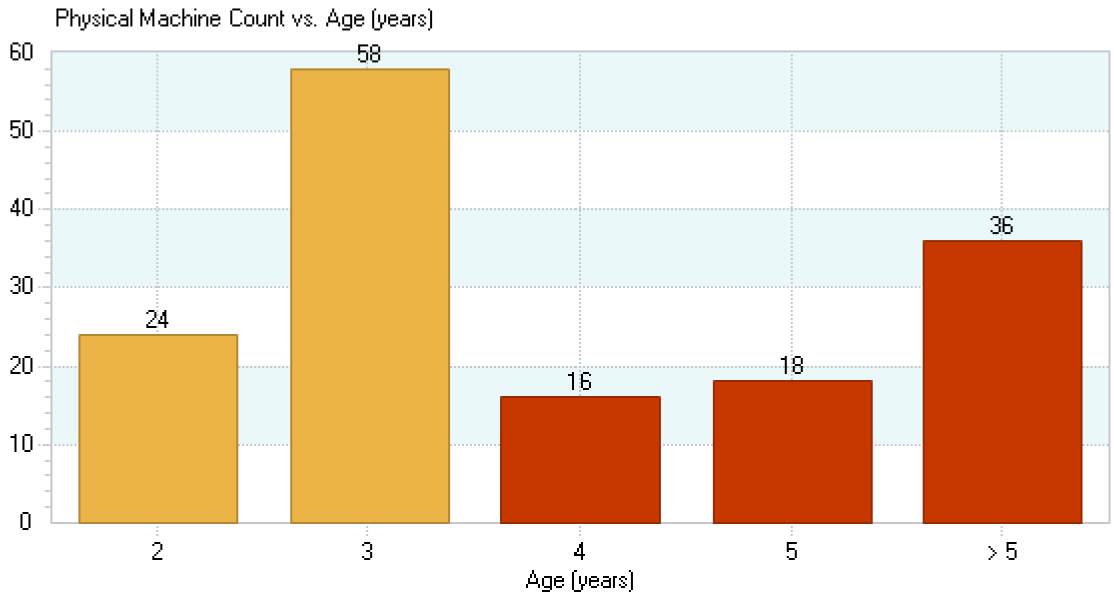


Chart 5.3.1: Physical Machine Count vs. Age

5.3.2 Estimated Server Warranties

Breakdown of physical machines by warranty remaining, including servers with expired warranty.

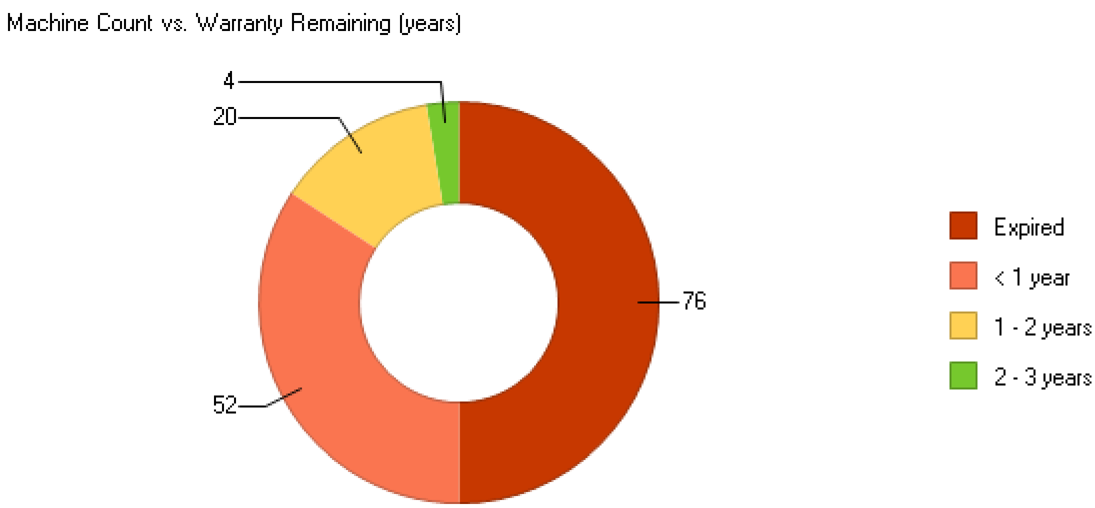


Chart 5.3.2: Machine Count vs. Warranty Remaining

To minimize the cost of maintenance contract extensions for out-of-warranty machines, these machines should be given priority consideration for virtualization.

Note: Whenever possible, age and warranty remaining is obtained from major server vendors. If this information is not available, warranty remaining is estimated based on hardware lifecycle using a three-year warranty period.

5.4 Hardware Reuse Candidates for Virtualization Hosts

This section reports the total number of analyzed servers that may be suitable for redeployment as virtual machine hosts. Actual selection may be performed during the design phase based on more specific requirements from ABC Ltd. and validation that server hardware is supported by the target hypervisor.

Machines meeting the following criteria have been considered as possible candidates for redeployment:

- Minimum 12 months warranty remaining
- Support for at least 32GB of physical memory
- 64-bit CPU with Intel VT or AMD-V virtualization extensions
- At least four cores across all CPUs

Note: Physical machines with different CPU makes or processor architectures may prevent features such as live migration from being used.

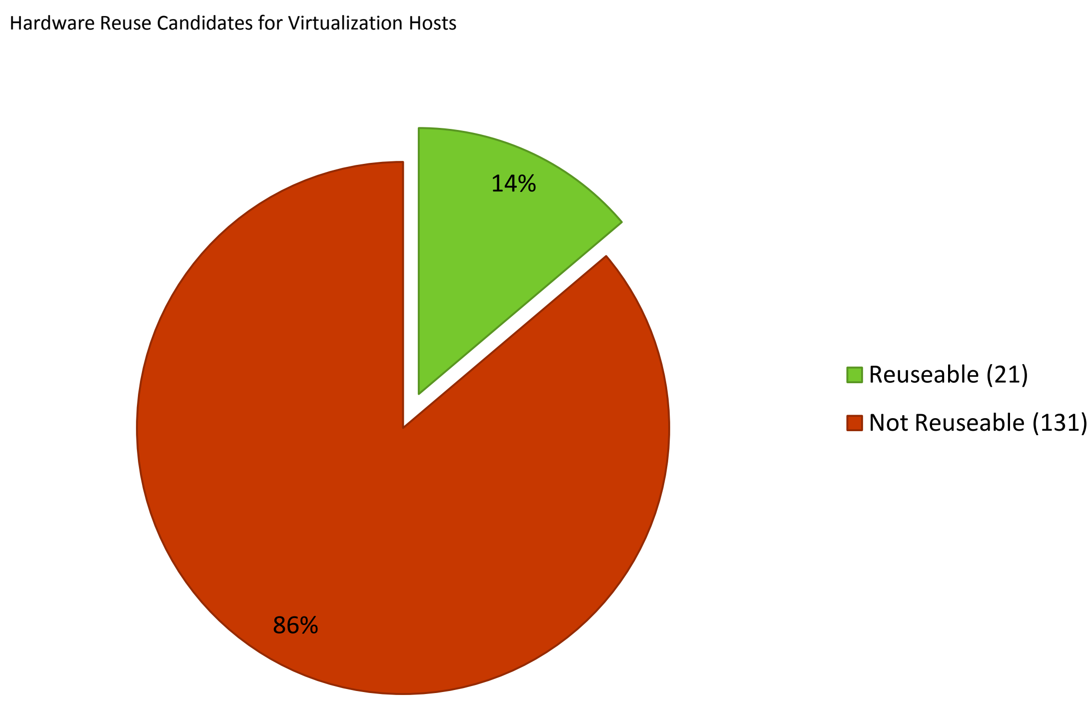


Chart 5.4.1: Hardware Reuse Candidates for Virtualization Hosts

5.4.1 Redeployment Candidates

The following physical servers meet the criteria specified above and should be considered for redeployment as virtual machine hosts:

Machine			Processor		Memory	
Name	**Model**	**Warranty Remaining (months)**	**Count**	**Total Cores**	**Allocated (GB)**	**Max Supported (GB)**
Host009	HP ProLiant DL385 G2	14	2	4	4	32
Host144	HP ProLiant DL365 G1	15	2	4	2	32
Host022	HP ProLiant DL385 G2	14	2	4	4	32
Host127	HP ProLiant DL385 G5	23	2	8	4	64
Host080	HP ProLiant DL385 G5	23	2	8	4	64
Host044	HP ProLiant DL365 G1	15	2	4	2	32
Host041	HP ProLiant DL365 G1	15	2	4	2	32
Host049	HP ProLiant DL385 G2	15	2	4	10	32
Host002	HP ProLiant DL385 G2	15	2	4	12	32
Host024	HP ProLiant DL385 G5	23	2	8	4	64
Host129	HP ProLiant DL385 G2	15	2	4	4	32
Host082	HP ProLiant DL385 G2	15	2	4	12	32
Host035	HP ProLiant DL365 G1	15	2	4	2	32
Host140	HP ProLiant DL385 G5	23	2	8	4	64
Host093	HP ProLiant DL385 G5	23	2	8	4	64
Host032	HP ProLiant DL380 G5	24	2	8	3	64
Host007	HP ProLiant DL360 G5	21	1	4	2	64
Host098	Dell PowerEdge 1950	45	2	4	4	32
Host004	Dell PowerEdge 1950	40	2	4	4	32
Host142	Dell PowerEdge 1950	17	2	4	4	32
Host001	Dell PowerEdge 1950	37	2	4	2	32

6 Utilization Analysis

6.1 CPU

6.1.1 Physical Machines vs. Peak CPU Utilization

Machines grouped by peak processor utilization measured as a percentage of total CPU capacity available in a physical machine.

> *<u>Example</u>: machines in the '20' category have a peak hour CPU utilization of 10% - 20% over the monitoring period*

Note: CPU utilization is relative to the age and specification of the CPU. For example a 10 year old server may show higher utilization compared to current processors.

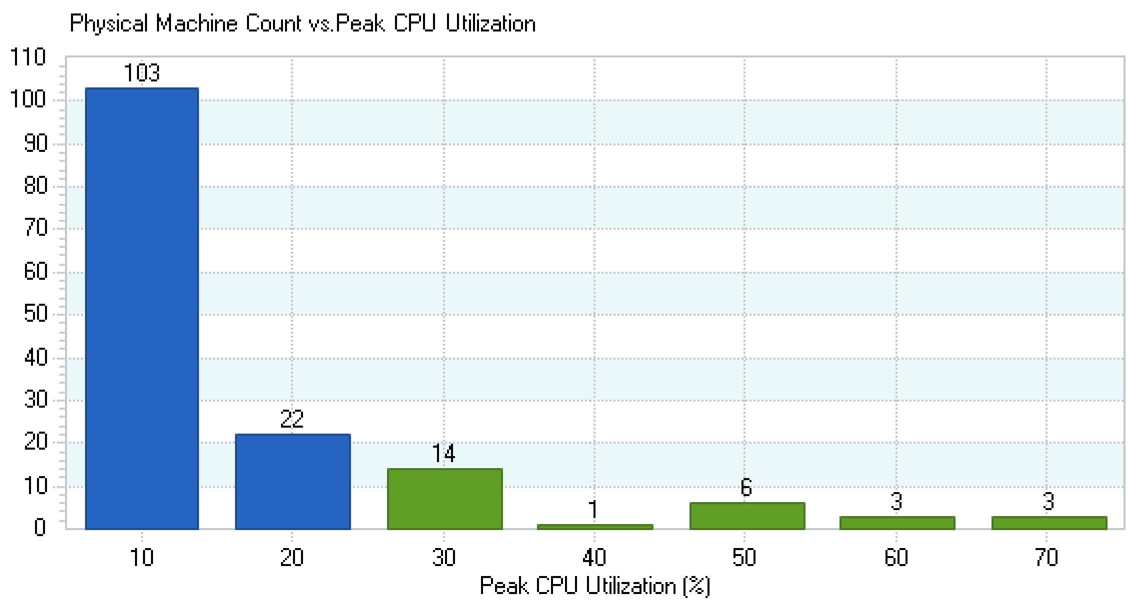


Chart 6.1.1: Physical Machine Count vs. Peak CPU Utilization

The results indicate that the majority of servers are underutilized. This provides additional support for consolidating physical machines into virtual machines to increase data centre utilization and reduce energy costs.

6.1.2 Physical Machines vs. Average CPU Utilization

The chart illustrates processor utilization for all physical machines, averaged across all weeks during the data collection period.

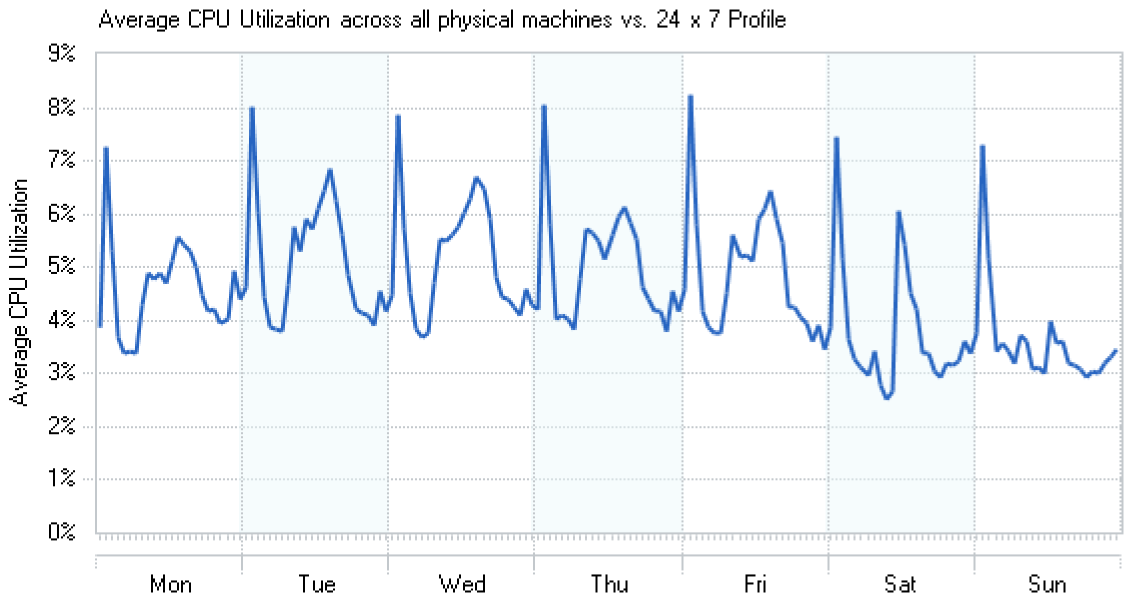


Chart 6.1.2: Physical Machiness vs. Average CPU Utilization (24x7)

This information is valuable for identifying daily and hourly compute resource fluctuations in the data centre. It is also useful for justifying virtualization of existing underutilized servers which consume far more energy compared to virtual machines running workloads on shared physical processors.

6.1.3 Top 20 Physical Machines vs. CPU Utilization

The top 20 physical machines based on average and peak hour CPU utilization are presented below. This data highlights current bottlenecks that may need to be addressed regardless of whether or not the physical machines are virtualized.

Workloads running on physical machines with medium-to-high CPU utilization are not necessary poor candidates for virtualization. Each workload must be normalized to the CPU architecture on target servers. This is performed as part of what-if modelling in Section 9.

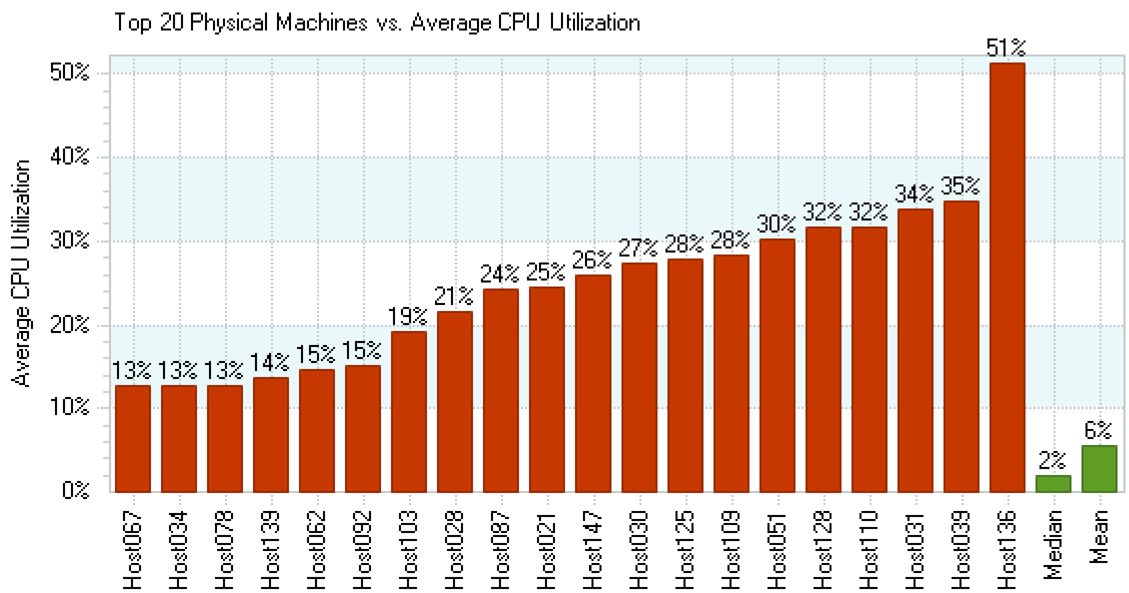


Chart 6.1.3: Top 20 Physical Machines vs. Average CPU Utilization

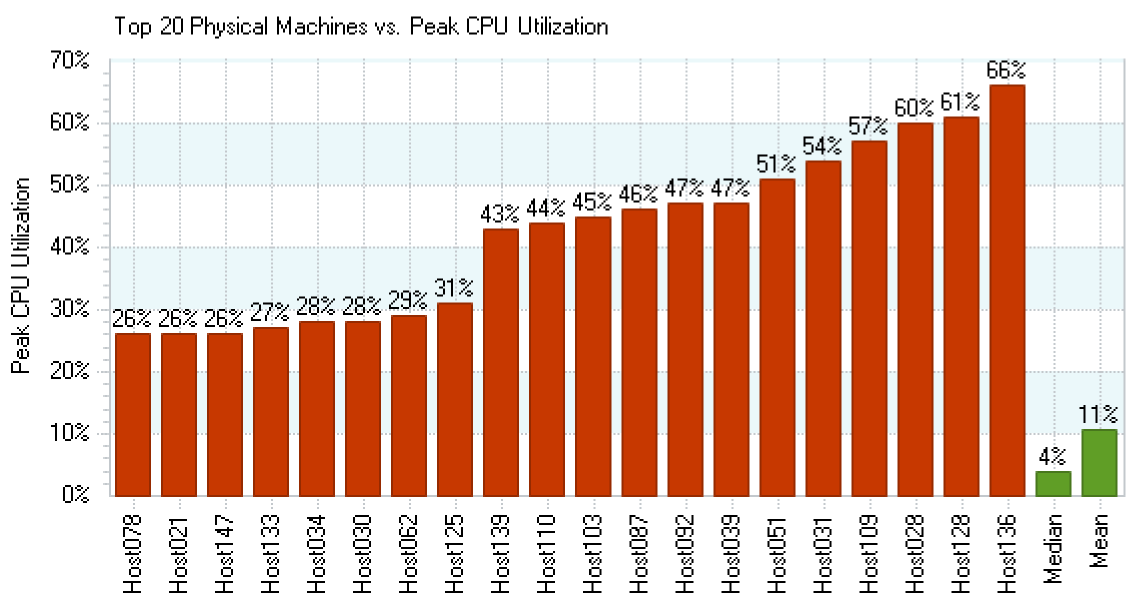


Chart 6.1.4: Top 20 Physical Machines vs. Peak CPU Utilization

6.1.4 Bottom 20 Physical Machines vs. CPU Utilization

The bottom 20 physical machines based on average and peak hour CPU utilization are presented below. This data highlights physical machines with the lowest utilization in the data centre. Workloads running on these machines are often good candidates for virtualization but need to be examined across other critical dimensions: memory, disk and network.

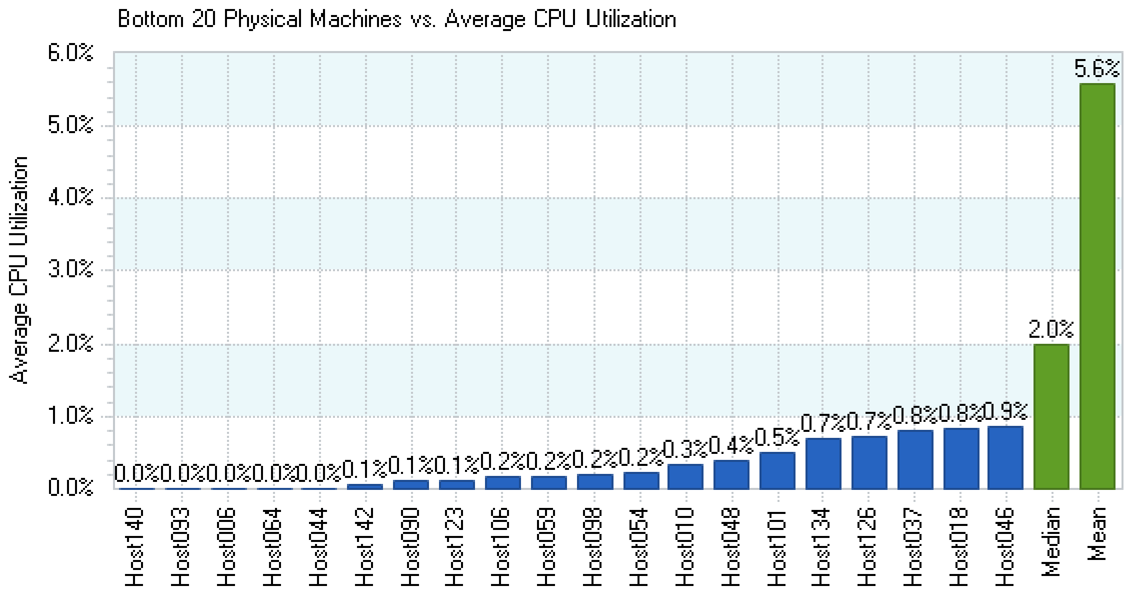


Chart 6.1.5: Bottom 20 Physical Machines vs. Average CPU Utilization

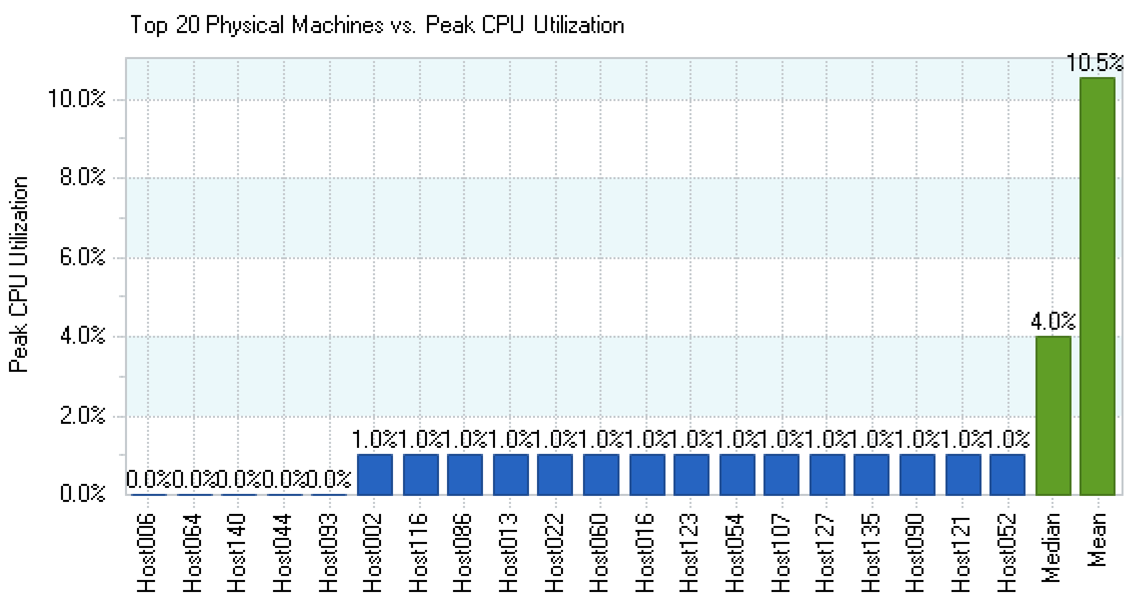


Chart 6.1.6: Bottom 20 Physical Machines vs. Peak CPU Utilization

6.2 Memory

6.2.1 Physical Machines vs. Average Memory Utilization

The following chart illustrates physical machines grouped by average memory utilization.

Example: machines in the '30' category have 20-30% average memory utilization

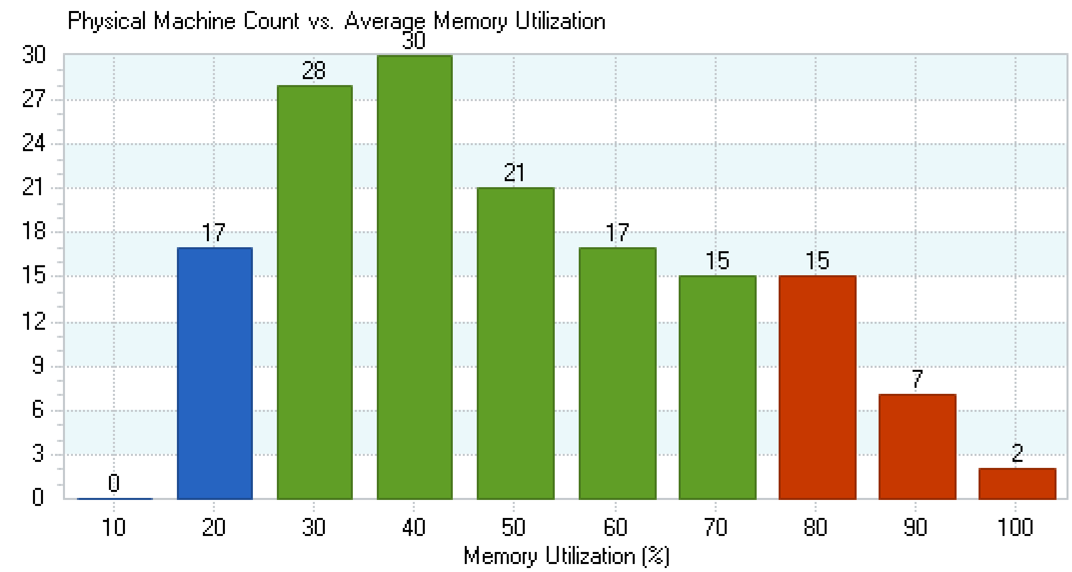


Chart 6.2.1: Physical Machine Count vs. Memory Utilization

6.2.2 Average Memory Utilization Across All Physical Machines (24x7)

Average memory utilization across all physical machines is shown below.

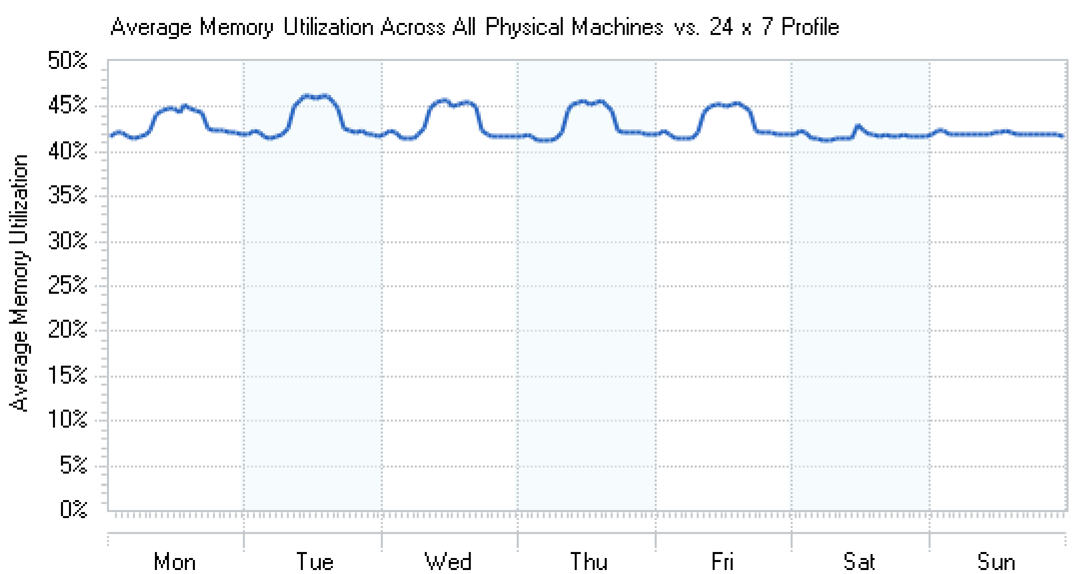


Chart 6.2.2: Average Memory Utilization Across All Physical Machines

6.2.3 Top 20 Physical Machines vs. Memory Utilization

The following charts list the top 20 most utilized physical machines based on average and peak memory utilization. These charts can also highlight current bottlenecks that may need to be addressed regardless of whether or not these physical machines are virtualized.

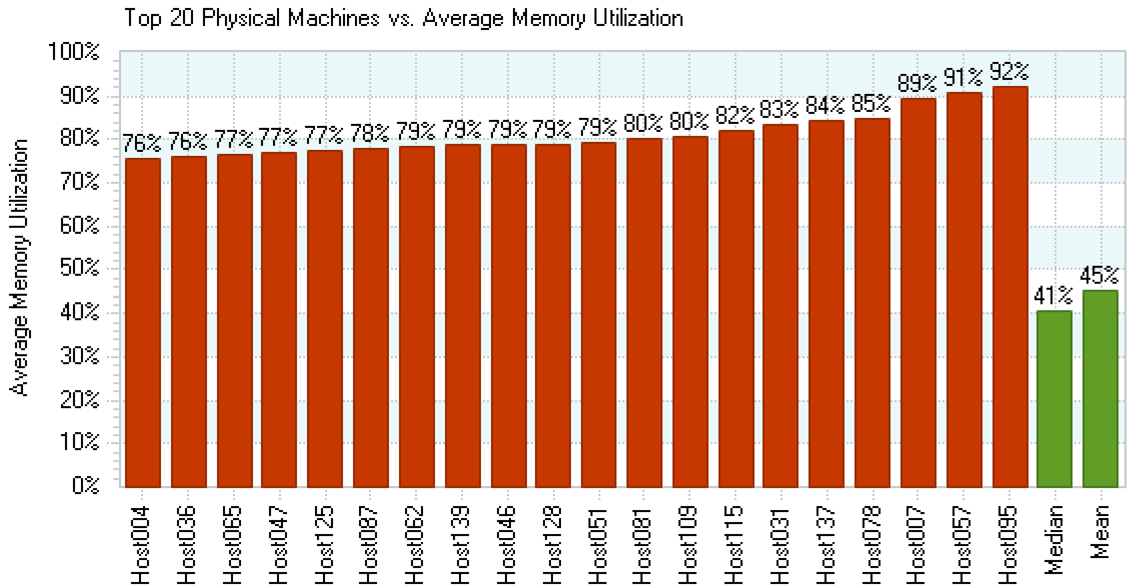


Chart 6.2.3: Top 20 Physical Machines vs. Average Memory Utilization

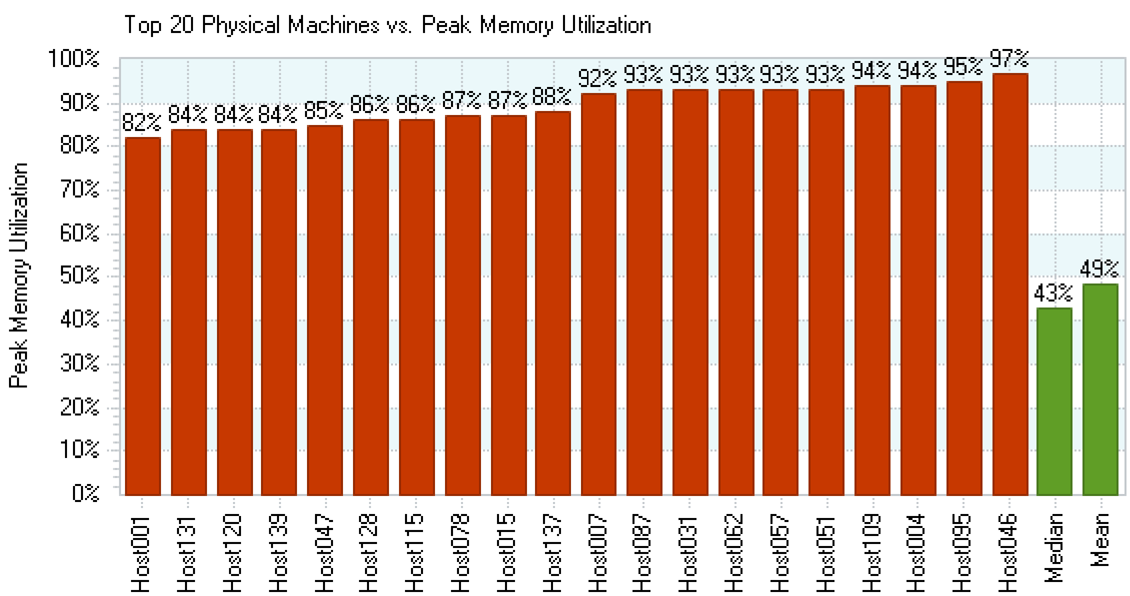


Chart 6.2.4: Top 20 Physical Machines vs. Peak Memory Utilization

6.2.4 Bottom 20 Physical Machines vs. Memory Utilization

The chart below lists 20 hosts with the lowest average and peak memory utilization. These hosts are either running small server workloads which may be good candidates for virtualization or have ample physical memory to possibly serve as virtual machine hosts.

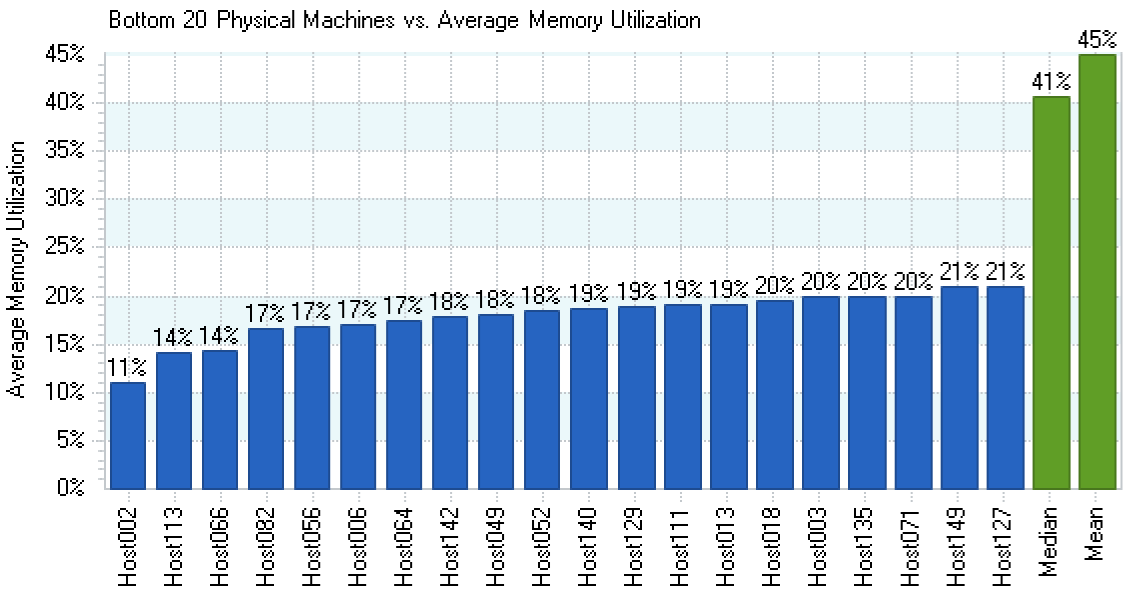


Chart 6.2.5: Bottom 20 Physical Machines vs. Average Memory Utilization

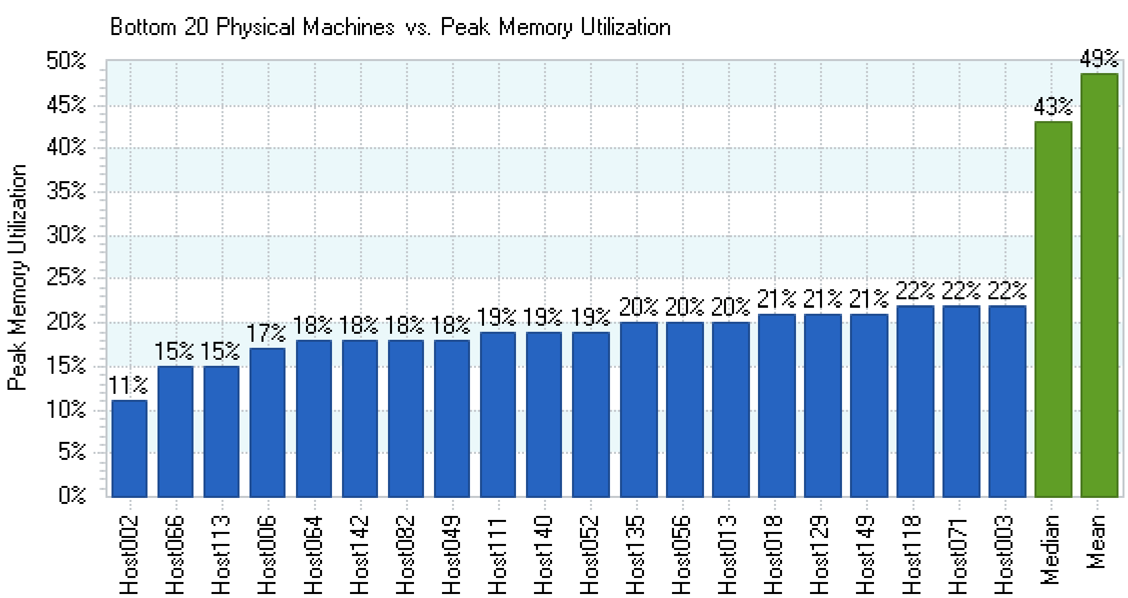


Chart 6.2.6: Bottom 20 Physical Machines vs. Peak Memory Utilization

7 Workload Analysis

7.1 Operating Systems

7.1.1 Breakdown of Workloads vs. Operating System Type

The following chart shows a breakdown of workloads by operating system type. This information should be cross-referenced with supported guest operating systems on target virtualization platforms.

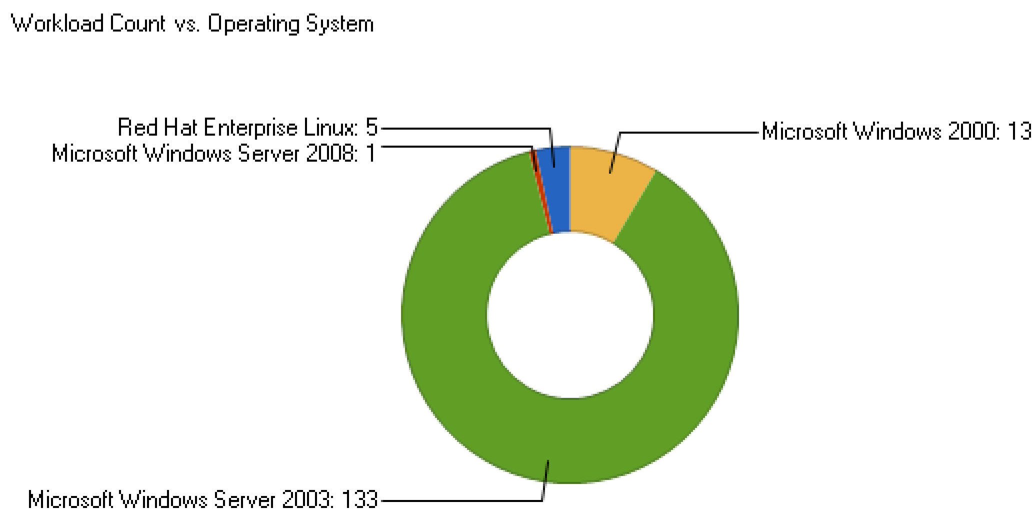


Chart 7.1.1: Workload Count vs. Operating System

7.1.2 OS Licensing Implications

Software vendors such as Microsoft have different licensing models for multiple workloads running on the same physical hardware. These implications can dramatically increase or decrease the cost of a server virtualization solution and should be considered during the design phase of the project.

For example, Microsoft Windows Server 2008 R2 Enterprise supports one instance of the server software in the physical operating system environment (POSE) and up to four instances of the server software in the virtual operating system environment (VOSE). If running 4 instances in the VOSE then the instance running in the POSE can only be used to manage the 4 instances of the OS running in the VOSE.

In contrast, Microsoft Windows Server 2008 R2 Datacenter supports one instance of the server software in the POSE and an unlimited number of instances of the server software in the VOSE.

7.2 CPU Usage

7.2.1 Workloads vs. CPU Usage

Below is an overview of workloads grouped by average processor usage measured in MHz. Workloads within the green band are typically good virtualization candidates, within the orange band require further investigation and within the red band, are typically not recommended for virtualization.

> *<u>Example</u>: workloads grouped under the chart bin numbered '1000' are using between 500 MHz and 1000 MHz on average*

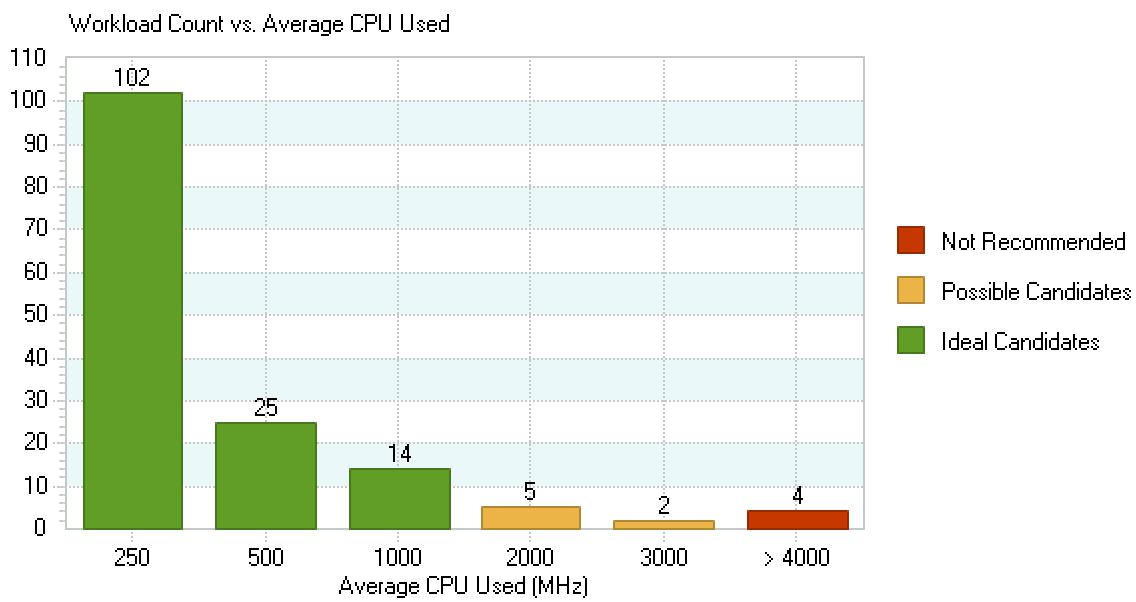


Chart 7.2.1: Workload Count vs. Average CPU Used and Virtualization Candidacy

Based on CPU usage, the majority of workloads may be suitable for virtualization. However before drawing final conclusions, workloads need to be examined across other resource dimensions: memory, disk and network.

Normalization of workloads, particularly in terms of CPU usage is a key consideration during what-if modelling that is summarized in Section 9. If workloads are not properly normalized to target server CPU architecture, then the number of required servers and required CPU hardware may be significantly overestimated.

7.2.2 CPU Used vs. 24 Hour Profile

The chart illustrates total CPU usage for all workloads over a 24-hour period.

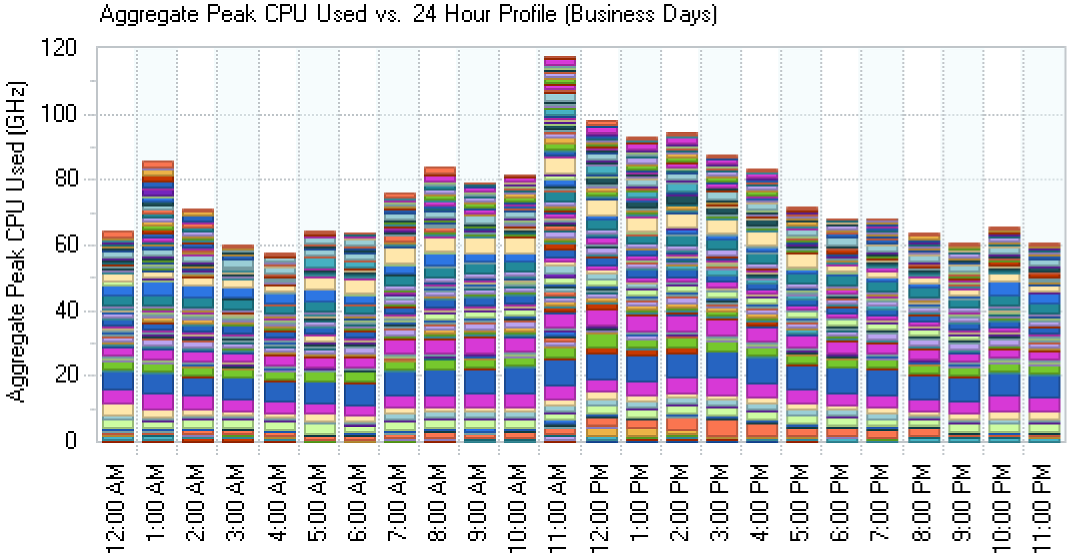


Chart 7.2.2: Aggregate Peak CPU Used vs. 24 Hour Profile (Business Days)

7.3 Memory Usage

7.3.1 Workload Count vs. Memory Used

Below is a summary of workloads based on average memory usage.

<u>Example</u>: workloads grouped in the '2' category are using on average between 1 GB and 2 GB

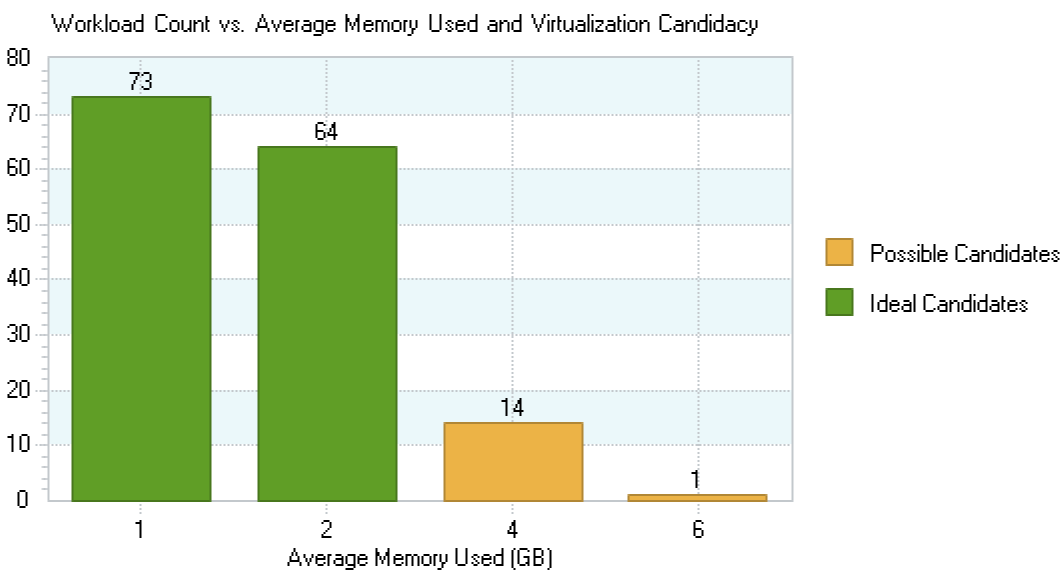


Chart 7.3.1: Workload Count vs. Memory Used and Virtualization Candidacy

7.3.2 Aggregate Peak Memory Used vs. 24 Hour Profile

Average memory usage by all workloads within a 24 hour period (excludes Saturdays and Sundays) is illustrated below. This chart provides a reference point for specification of total physical memory requirements in virtualization hosts. However, it does not take into account headroom required for workloads inside virtual machines and virtualization overhead.

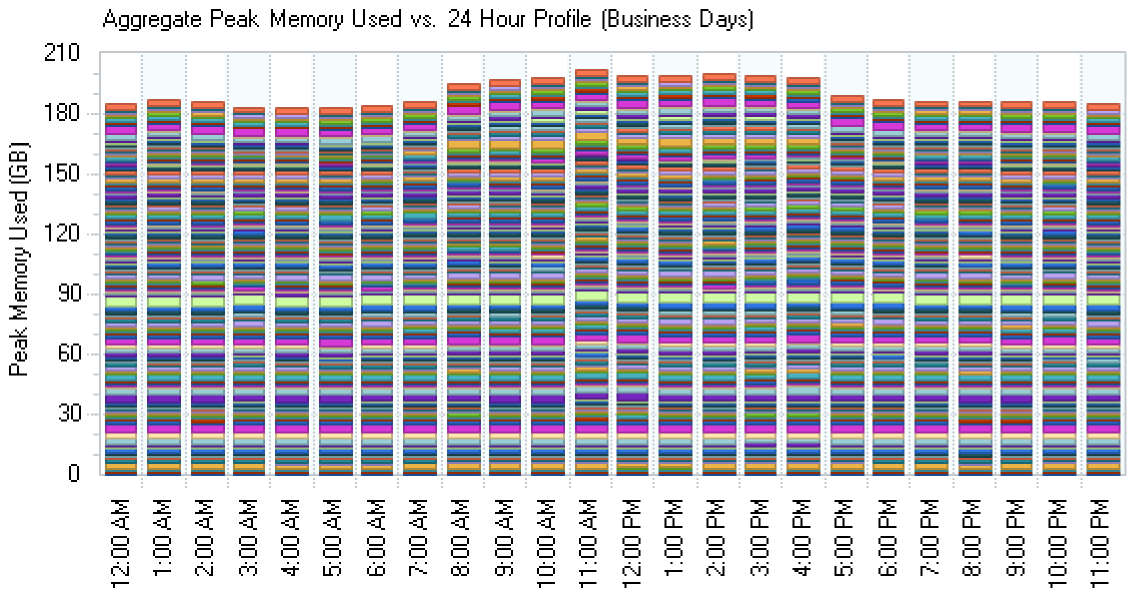


Chart 7.3.2: Aggregate Peak Memory Used vs. 24 Hour Profile (Business Days)

7.4 Storage Usage

Server virtualization presents an opportunity to right-size storage allocated to workloads. This is particularly important when migrating from local to central storage to avoid storage over-provisioning.

Note: servers connected to storage systems with virtualization features, such as thin provisioning may not report actual physical disk usage.

7.4.1 Disk Space Allocated Breakdown

The following chart shows total disk space allocated per workload across all disks.

Example: workloads in the '100' category have 50 GB to 100 GB disk space allocated

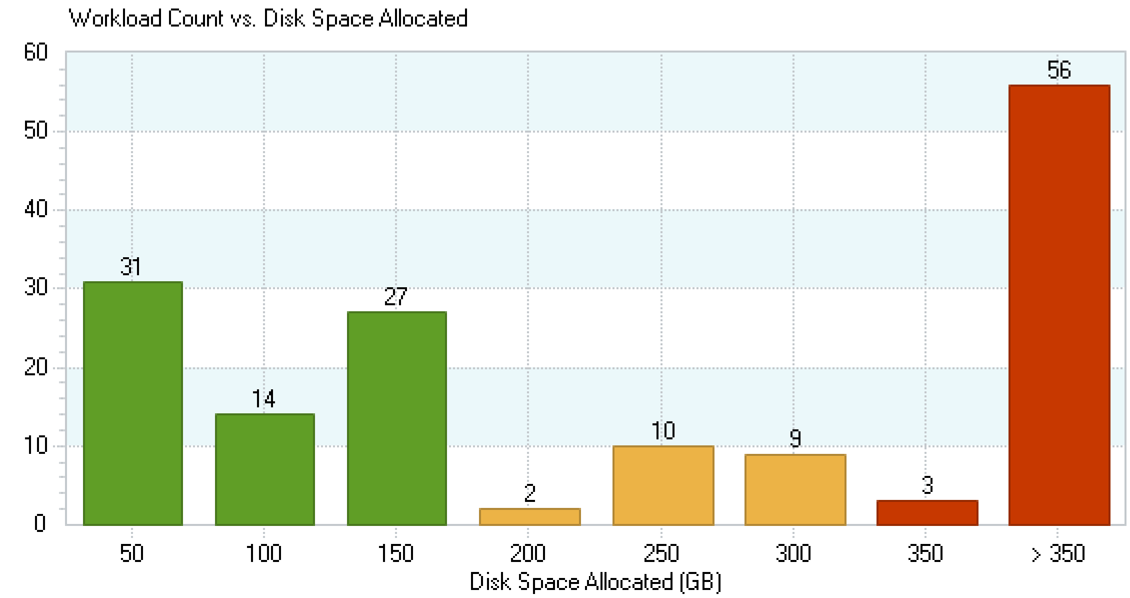


Chart 7.4.1: Workload Count vs. Disk Space Allocated

7.4.2 Disk Space Usage Breakdown

A breakdown of total disk space used is illustrated below. Compared to the chart above, it is clear that storage is significantly over-allocated.

> *<u>Example</u>: workloads in the '150' category are using 100 GB to 150 GB of disk space*

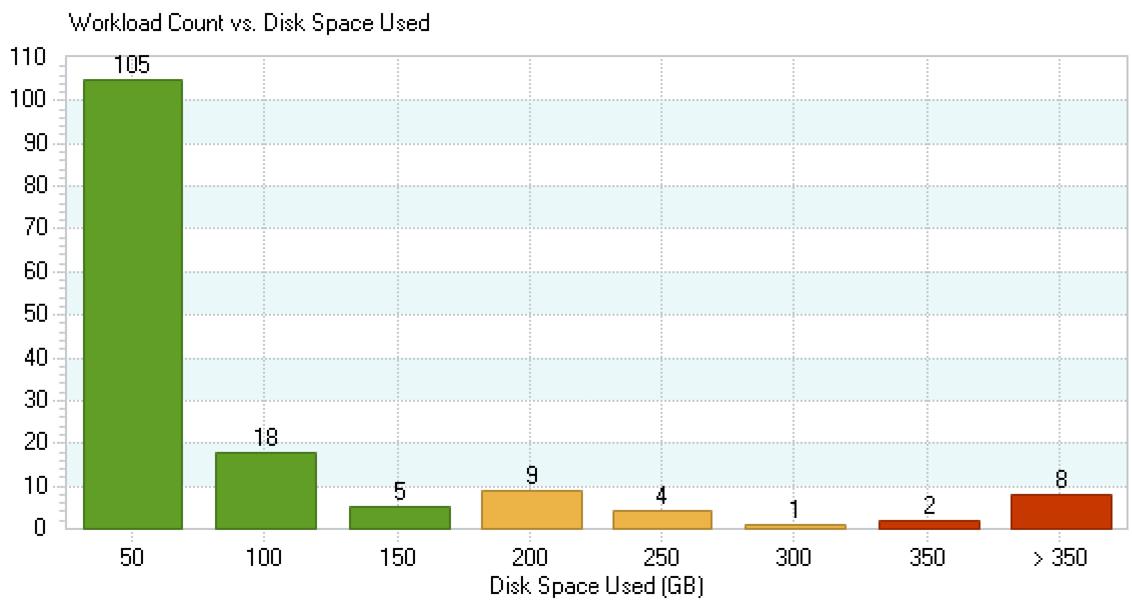


Chart 7.4.2: Workload Count vs. Disk Space Used

7.5 Disk I/O Usage

The following charts provide guidelines for minimum storage I/O capacity that would be needed in a virtualized environment.

7.5.1 Aggregate Disk I/O Across All Workloads

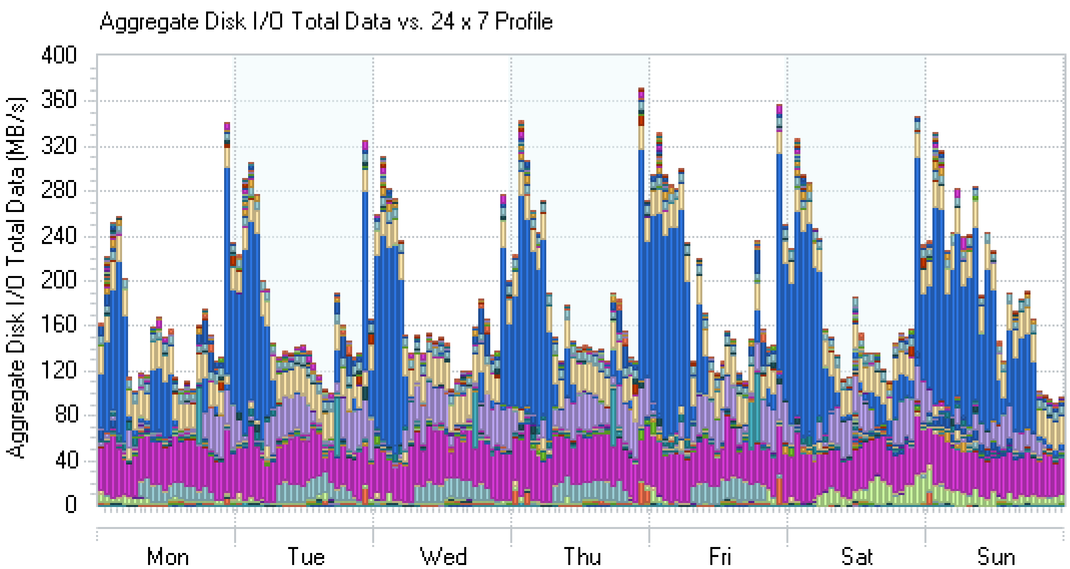


Chart 7.5.1: Aggregate Disk I/O Total Data vs. 24x7 Profile

7.5.2 Aggregate Disk I/O Transfers Across All Workloads

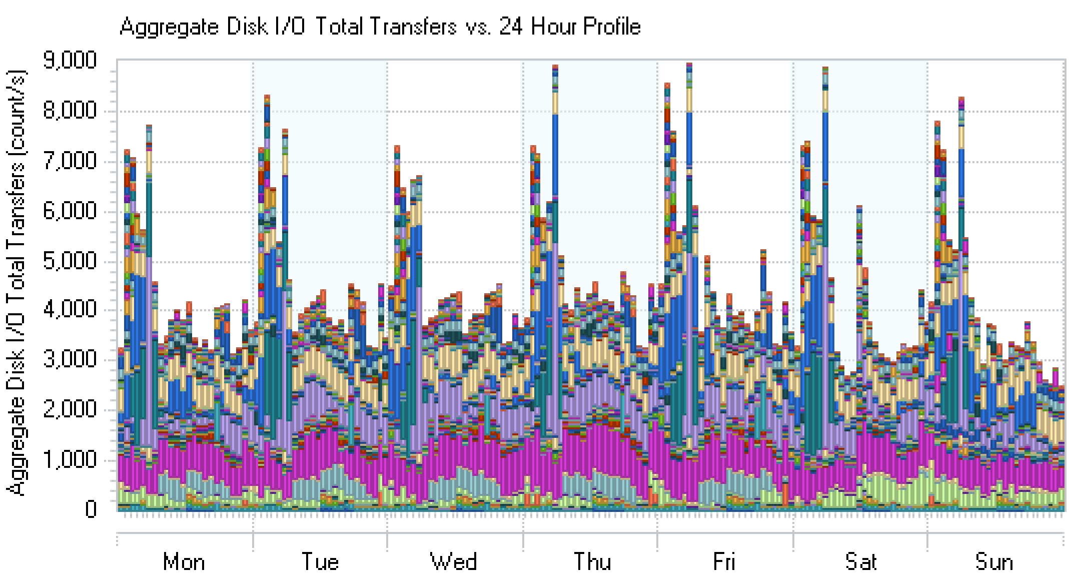


Chart 7.5.2: Aggregate Disk I/O Total Transfers vs. 24x7 Profile

Peak rates are likely to be caused by maintenance tasks such as backup operations or batch processing, which tend to be performed overnight and during weekends.

7.6 Network I/O Usage

Guidelines for minimum network I/O capacity that would be needed in a virtualized environment are provided below.

7.6.1 Aggregate Network I/O Data Across All Workloads

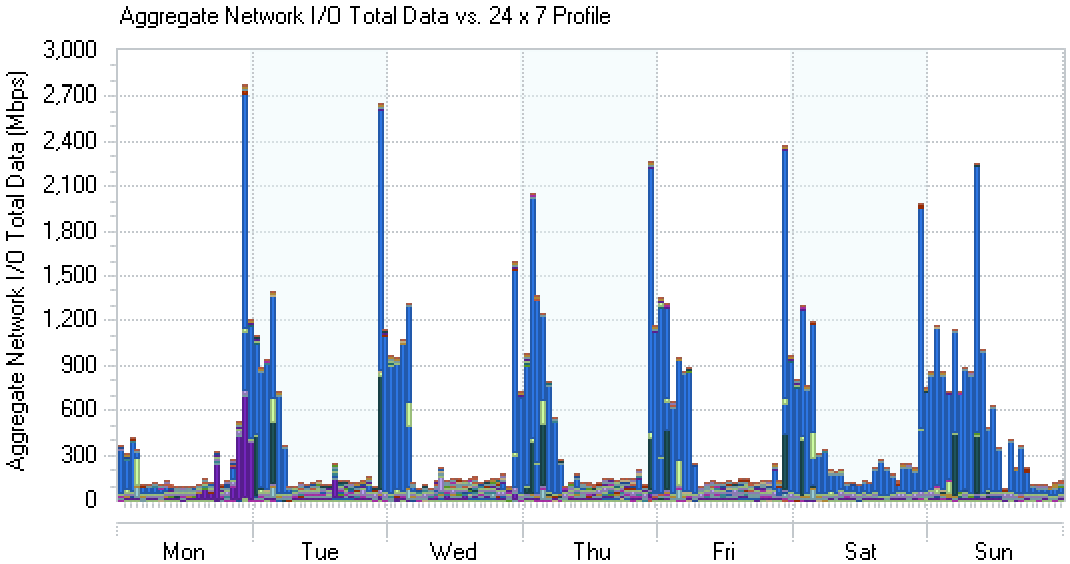


Chart 7.6.1: Aggregate Network I/O Data vs. 24x7 Profile

7.6.2 Aggregate Network I/O Packets Across All Workloads

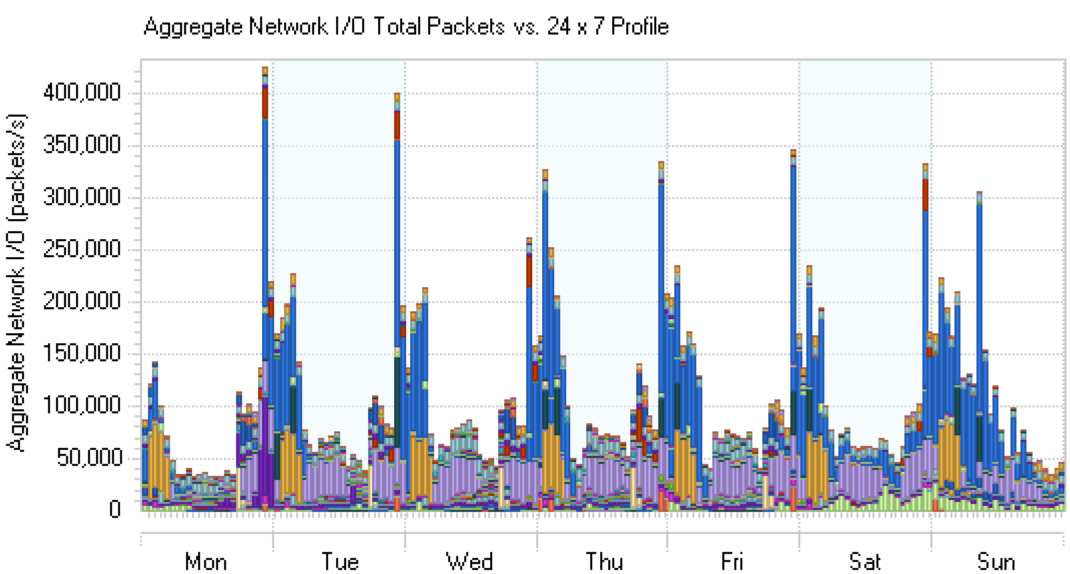


Chart 7.6.2: Aggregate Network I/O Packets vs. 24x7 Profile

Peak rates are likely to be caused by maintenance tasks such as backup operations or batch processing, which tend to be performed overnight and during weekends.

8 Virtualization Recommendations

8.1 Virtualization Candidates

The virtualization analysis has provided detailed information on each workload. From the captured information, workloads have been assigned into two categories: Virtualization Candidates and Exclusion Candidates.

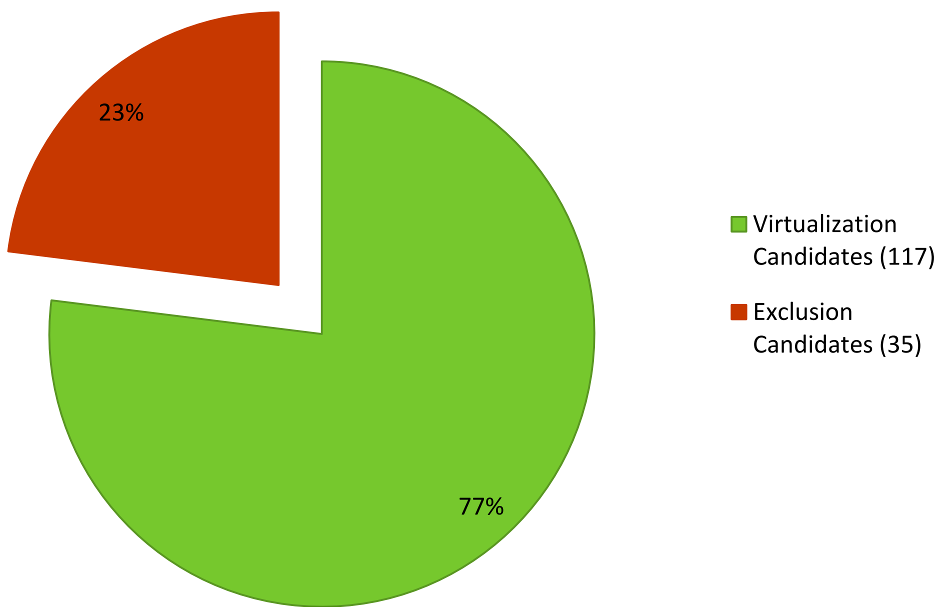


Chart 8.1.1: Virtualization Candidate Summary

117 out of 152 were identified as candidates for virtualization. A complete list of these candidates can be found in *Virtualization Candidates.xls*.

The list of virtualization candidates is a preliminary list of workloads that most likely can be virtualized. However usual diligence should be undertaken to validate application, licensing, security and performance requirements before migrating workloads from physical to virtual machines. This may include staging and proof of concept exercises to provide assurance and real world experience of likely performance.

8.2 Exclusion Candidates

8.2.1 Exclusion Criteria

The virtualization candidate exclusion criteria are as follows:

Resource	Average	Peak Hour
CPU Usage	> 2 GHz	> 4 GHz
Memory Usage	> 6 GB	> 8 GB

Disk IO		> 2000 IOPS
Network IO		> 300 Mbps

8.2.2 Excluded Workloads

Virtual Machine		**Processor**	**Memory**	**Disk I/O Allocated**	**Network I/O**
Name	**Exclusion Reason**	**Used - Avg (MHz)**	**Used - Avg (MB)**	**Total Transfers (count/s)**	**Total - Avg (Mbps)**
Host081	Workload matched exclusion criteria	173	1020	17	0.44
Host103	Workload matched exclusion criteria	1996	1054	28	0.54
Host114	Workload matched exclusion criteria	454	1388	14	0.45
Host031	Workload matched exclusion criteria	3526	3417	801	1.69
Host136	Workload matched exclusion criteria	6161	1750	14	0.31
Host147	Workload matched exclusion criteria	2697	1040	8	0.37
Host064	Workload matched exclusion criteria	19	705	3	0.04
Host028	Workload matched exclusion criteria	607	3410	58	19.81
Host133	Workload matched exclusion criteria	244	2834	30	8.44
Host039	Workload matched exclusion criteria	3601	1017	19	0.90
Host116	Workload matched exclusion criteria	69	1176	9	0.18
Host069	Workload matched exclusion criteria	821	2216	622	16.45
Host022	Workload matched exclusion criteria	98	1610	337	0.07
Host033	Workload matched exclusion criteria	88	1545	46	0.56

Host138	Workload matched exclusion criteria	175	2566	68	0.50
Host091	Workload matched exclusion criteria	231	5122	23	12.36
Host030	Workload matched exclusion criteria	2845	1017	8	0.22
Host146	Workload matched exclusion criteria	178	1751	448	1.88
Host110	Workload matched exclusion criteria	3292	964	536	0.03
Host046	Workload matched exclusion criteria	49	808	0	0.11
Host151	Workload matched exclusion criteria	139	578	0	0.79
Host104	Workload matched exclusion criteria	55	526	0	0.16
Host115	Workload matched exclusion criteria	77	840	5	0.34
Host068	Workload matched exclusion criteria	225	1833	0	1.97
Host043	Workload matched exclusion criteria	14	355	0	0.05
Host054	Workload matched exclusion criteria	46	498	0	
Host112	Workload matched exclusion criteria	13	223	0	0.04
Host065	Workload matched exclusion criteria	177	1568	27	2.11
Host018	Workload matched exclusion criteria	42	399	0	
Host123	Workload matched exclusion criteria	10	540	0	0.05
Host076	Workload matched exclusion criteria	8	253	0	0.02
Host029	Workload matched exclusion criteria	8	250	0	0.02
Host134	Workload matched exclusion criteria	19	277	0	0.02

Host037	Workload matched exclusion criteria	92	2400	0	1.72
Host142	Workload matched exclusion criteria	23	727	3	0.56

9 What-If Modelling

The following scenarios have been created to illustrate possible server virtualization outcomes across virtualization platform and hardware combinations.

9.1 Key Findings

Solution				
Scenario	IBM System x3550 M2 96 GB (optimize) on Citrix XenServer	Sun Fire X4170 48 GB (optimize) on Citrix XenServer	IBM System x3550 M2 96 GB (optimize) on VMware ESX vSphere 4	Sun Fire X4170 48 GB (optimize) on VMware ESX vSphere 4
Virtualization Platform	Citrix XenServer	Citrix XenServer	VMware ESX vSphere 4	VMware ESX vSphere 4
Target Servers				
Count	3	6	3	6
Consolidation Ratio	39:1	19:1	39:1	19:1
Total Rack Units	3	6	3	6
Total Cost				
Per Virtual Machine - 3 years	$987.28	$1,216.12	$1,133.54	$1,468.71
TCO - 3 years	$115,512.17	$142,285.56	$132,623.72	$171,838.71
Total Cost Savings				
Power Savings - 3 years	$114,207.88	$107,000.48	$114,207.88	$107,000.48
Total Savings				
Server Reduction (%)	75	74	75	74
Space Savings (%)	75	74	75	74
Total Energy				
Power Consumption (kW)	2.46	5.04	2.46	5.04
Power Savings (kW)	84.23	81.65	84.23	81.65
Power Consumption Per VM (W)	21	43	21	43

9.2 Server and Virtualization Scenarios

This section analyzes chosen hardware and virtualization platform solutions and compares them across criteria such as consolidation ratios, power consumption and TCO.

9.2.1 Summary

Solution				
Scenario	IBM System x3550 M2 96 GB (optimize) on Citrix XenServer	Sun Fire X4170 48 GB (optimize) on Citrix XenServer	IBM System x3550 M2 96 GB (optimize) on VMware ESX vSphere 4	Sun Fire X4170 48 GB (optimize) on VMware ESX vSphere 4
Virtualization Platform	Citrix XenServer	Citrix XenServer	VMware ESX vSphere 4	VMware ESX vSphere 4
Target Servers				
Count	3	6	3	6
Consolidation Ratio	39:1	19:1	39:1	19:1
Total Rack Units	3	6	3	6
Target Server Configuration				
Model	IBM System x3550 M2	Sun Fire X4170	IBM System x3550 M2	Sun Fire X4170
Form Factor	Rack	Rack	Rack	Rack
Rack Units	1	1	1	1
Total Cost				
TCO - 3 years	$115,512.17	$142,285.56	$132,623.72	$171,838.71
Total Energy				
Power Consumption (kW)	2.46	5.04	2.46	5.04
Power Consumption Per VM (W)	21	43	21	43

9.2.2 Details

Solution				
Scenario	IBM System x3550 M2 96 GB (optimize) on Citrix XenServer	Sun Fire X4170 48 GB (optimize) on Citrix XenServer	IBM System x3550 M2 96 GB (optimize) on VMware ESX vSphere 4	Sun Fire X4170 48 GB (optimize) on VMware ESX vSphere 4
Virtualization Platform	Citrix XenServer	Citrix XenServer	VMware ESX vSphere 4	VMware ESX vSphere 4
Target Servers				
Count	3	6	3	6
Consolidated Workloads	117	117	117	117
Consolidation Ratio	39:1	19:1	39:1	19:1
Total Rack Units	3	6	3	6
Target Server Configuration				
Model	IBM System x3550 M2	Sun Fire X4170	IBM System x3550 M2	Sun Fire X4170
Form Factor	Rack	Rack	Rack	Rack
Rack Units	1	1	1	1
Processor Name	Quad-Core Intel Xeon Processor DP X5570	Quad-Core Intel Xeon Processor DP E5540	Quad-Core Intel Xeon Processor DP X5570	Quad-Core Intel Xeon Processor DP E5540
Processor Count	2	2	2	2
Processor Speed (GHz)	2.93	2.53	2.93	2.53
Physical Memory (GB)	96	48	96	48
Power Consumption (W)	410	420	410	420
Processor				
Total Processors	6	12	6	12
Total Cores	24	48	24	48
Total Speed (GHz)	70.39	121.44	70.39	121.44
Utilization - Avg (%)	57	33	59	34

Memory				
Total Installed (GB)	288	288	288	288
Total Used - Avg (GB)	149	151	145	149
Utilization - Avg (%)	52	52	50	52

10 Environmental Analysis

10.1 Overview

This section compares the solutions against environmental criteria such as power consumption and carbon footprint.

10.1.1 Server Hardware vs. Total Energy

Solution				
Scenario	IBM System x3550 M2 96 GB (optimize) on Citrix XenServer	Sun Fire X4170 48 GB (optimize) on Citrix XenServer	IBM System x3550 M2 96 GB (optimize) on VMware ESX vSphere 4	Sun Fire X4170 48 GB (optimize) on VMware ESX vSphere 4
Virtualization Platform	Citrix XenServer	Citrix XenServer	VMware ESX vSphere 4	VMware ESX vSphere 4
Total Energy				
Power Consumption (kW)	2.46	5.04	2.46	5.04
Power Savings (kW)	84.23	81.65	84.23	81.65
Heat Dissipation (BTU/h)	8394	17197	8394	17197
Heat Reduction (BTU/h)	287388	278584	287388	278584
Carbon Footprint Per Hour (kg)	1.488	3.049	1.488	3.049
Carbon Footprint Reduction Per Hour (kg)	50.948	49.387	50.948	49.387
Carbon Footprint Per Year (tonne)	13.0	26.7	13.0	26.7
Carbon Footprint Reduction Per Year (tonne)	446.3	432.6	446.3	432.6
Power Consumption Per VM (W)	21	43	21	43
Cars Off the Road	2	5	2	5

10.1.2 Power Usage before Consolidation

This chart shows the breakdown of the power consumption per physical machine.

Example: machines in the '350' category consume between 250 W and 350 W of power

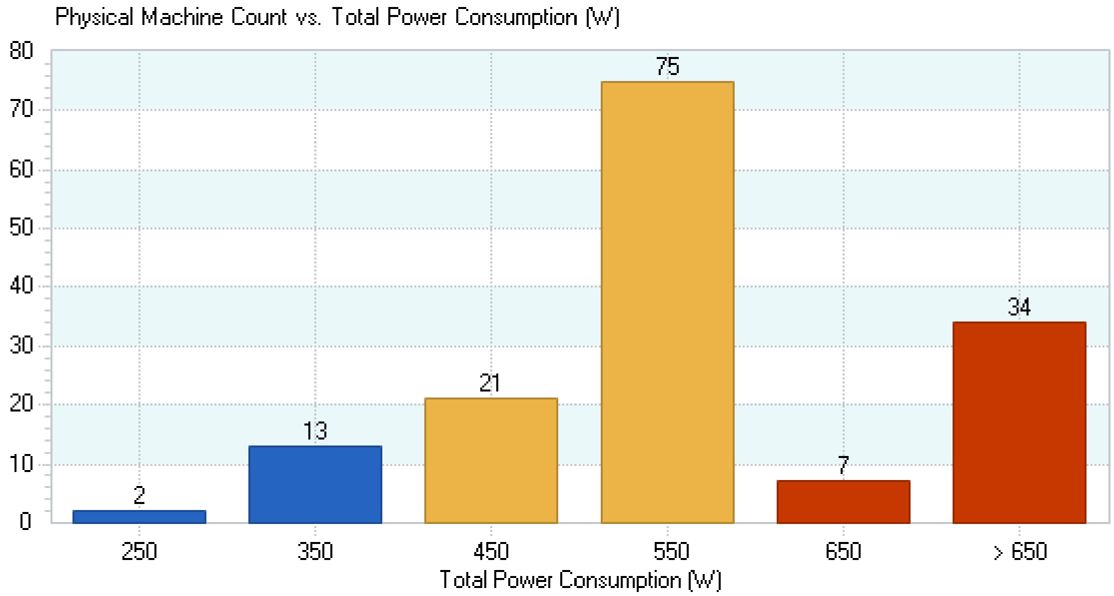


Chart 10.1.1: Physical Machine Count vs. Total Power Consumption

Note: Actual power usage can only be measured using specialized instrumentation. Power consumption is estimated based on server make, model and configuration as well as the Data Centre Infrastructure Efficiency (DCiE) factor specified. DCiE is a percentage of power consumed by IT equipment such as servers over total facility power consumed.

10.1.3 Power Consumption

The chart below illustrates power consumption across all modelled scenarios, including excluded servers.

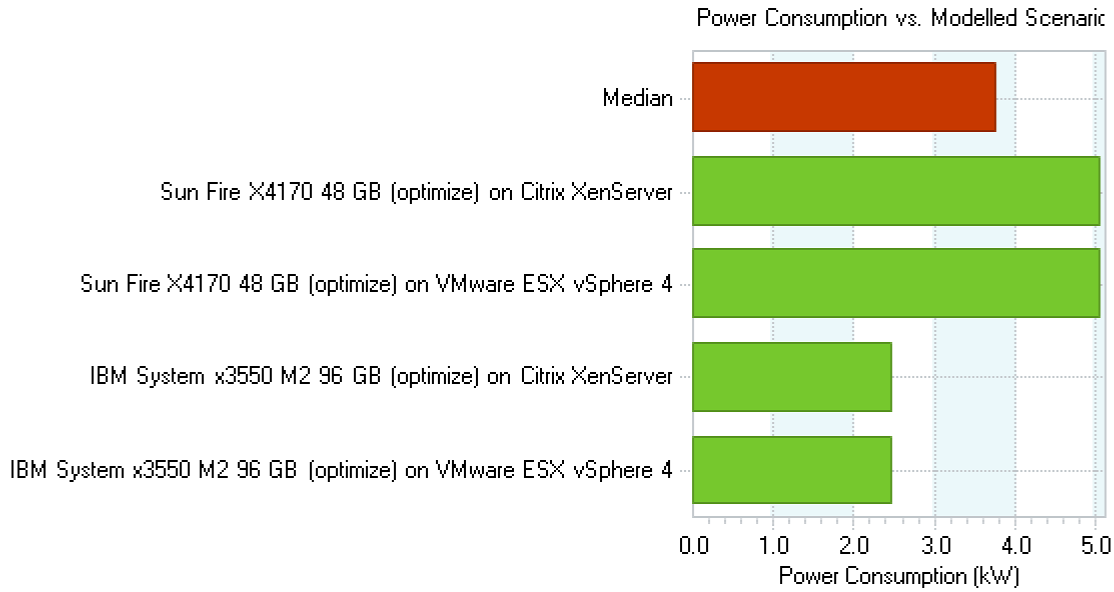


Chart 10.1.2: Power Consumption vs. Modelled Scenarios

10.1.4 Power Consumption per VM

Power consumption per virtual machine across all modelled scenarios is show below.

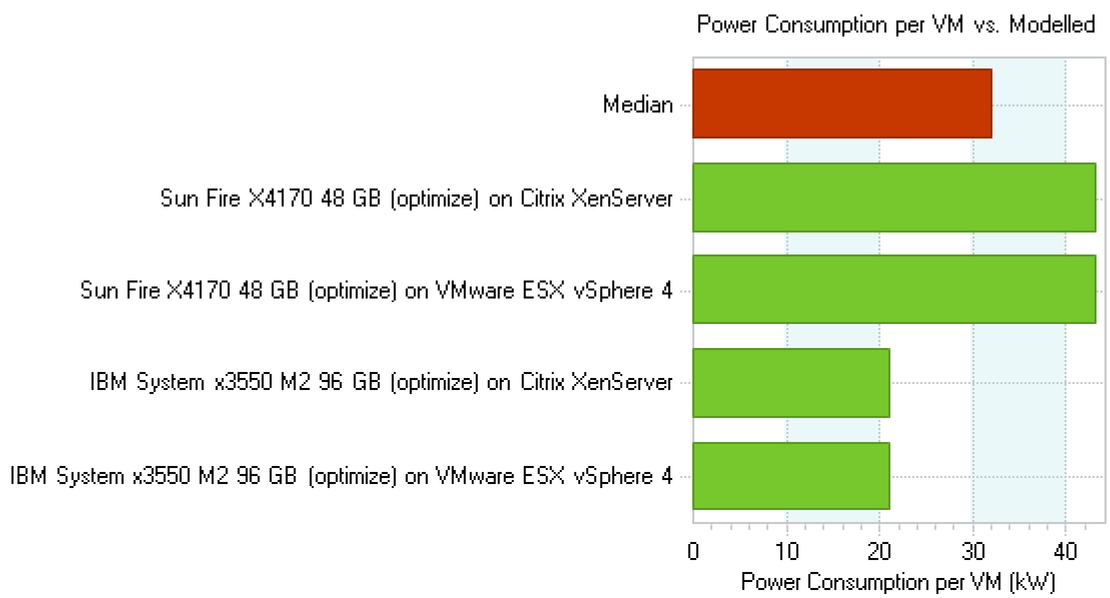


Chart 10.1.3: Carbon Footprint Reduction pr Year vs. Modelled Scenarios

10.1.5 Carbon Footprint Reduction

The chart below illustrates carbon footprint reduction per year across all modelled scenarios.

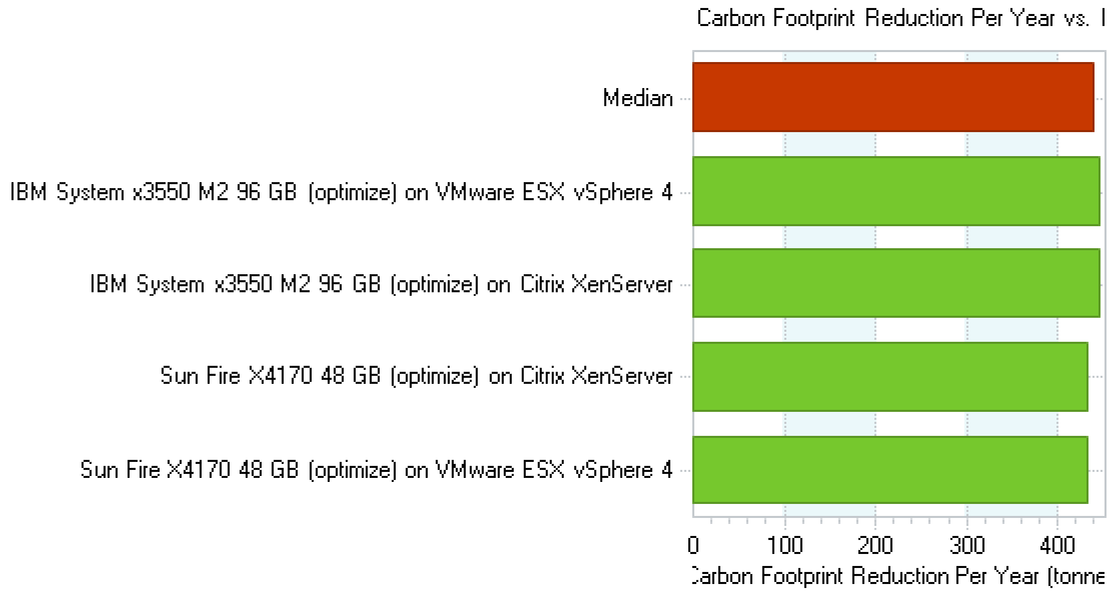


Chart 10.1.4: Carbon Footprint Reduction pr Year vs. Modelled Scenarios

11 Space Analysis

11.1.1 Space Requirements

The number of rack units that will be needed for target servers across modelled scenarios is shown below.

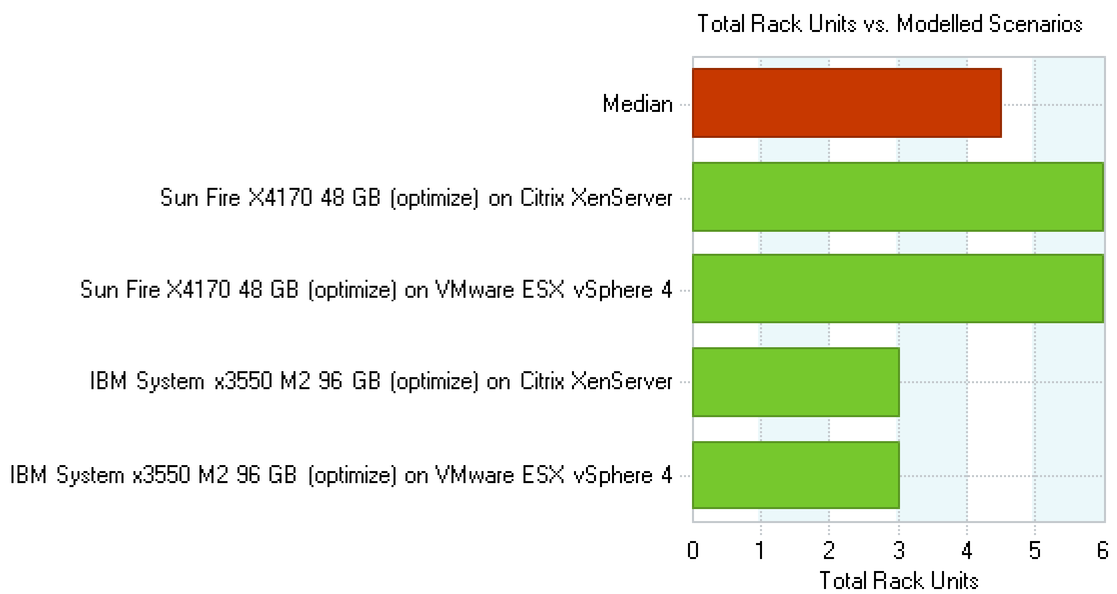


Chart 10.1.1: Rack Units vs. Modelled Solutions

11.1.2 Space Reduction

The chart below illustrates the reduction in the number of rack units across modelled scenarios.

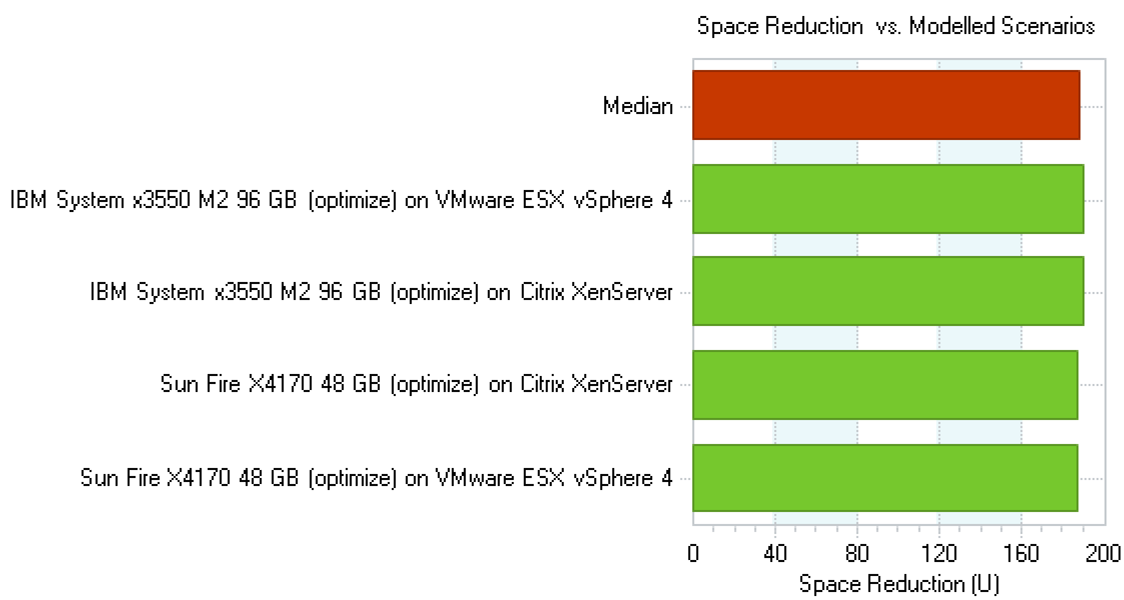


Chart 10.1.2: Space Reduction (U) vs. Modelled Solutions

12 Financial Analysis

12.1 Overview

This section compares scenarios across key financial dimensions such as total cost and savings for hardware, software, services and power.

12.1.1 Hardware, Software, Power, Cooling and TCO

Solution				
Scenario	IBM System x3550 M2 96 GB (optimize) on Citrix XenServer	Sun Fire X4170 48 GB (optimize) on Citrix XenServer	IBM System x3550 M2 96 GB (optimize) on VMware ESX vSphere 4	Sun Fire X4170 48 GB (optimize) on VMware ESX vSphere 4
Virtualization Platform	Citrix XenServer	Citrix XenServer	VMware ESX vSphere 4	VMware ESX vSphere 4
Total Cost				
Hardware	$57,390.00	$68,706.00	$57,390.00	$68,706.00
Software	$11,250.00	$19,500.00	$28,361.55	$49,053.15
Services	$40,000.00	$40,000.00	$40,000.00	$40,000.00
Power Consumption - 3 years	$6,872.17	$14,079.56	$6,872.17	$14,079.56
Per Virtual Machine - 3 years	$987.28	$1,216.12	$1,133.54	$1,468.71
TCO - 3 years	$115,512.17	$142,285.56	$132,623.72	$171,838.71
Total Cost Savings				
Hardware Refresh Cost Avoidance	$710,200.00	$710,200.00	$710,200.00	$710,200.00
Power Savings - 3 years	$114,207.88	$107,000.48	$114,207.88	$107,000.48
Total Savings - 3 years	$824,407.88	$817,200.48	$824,407.88	$817,200.48

12.1.2 Power Cost

This chart compares the cost of power across modelled scenarios.

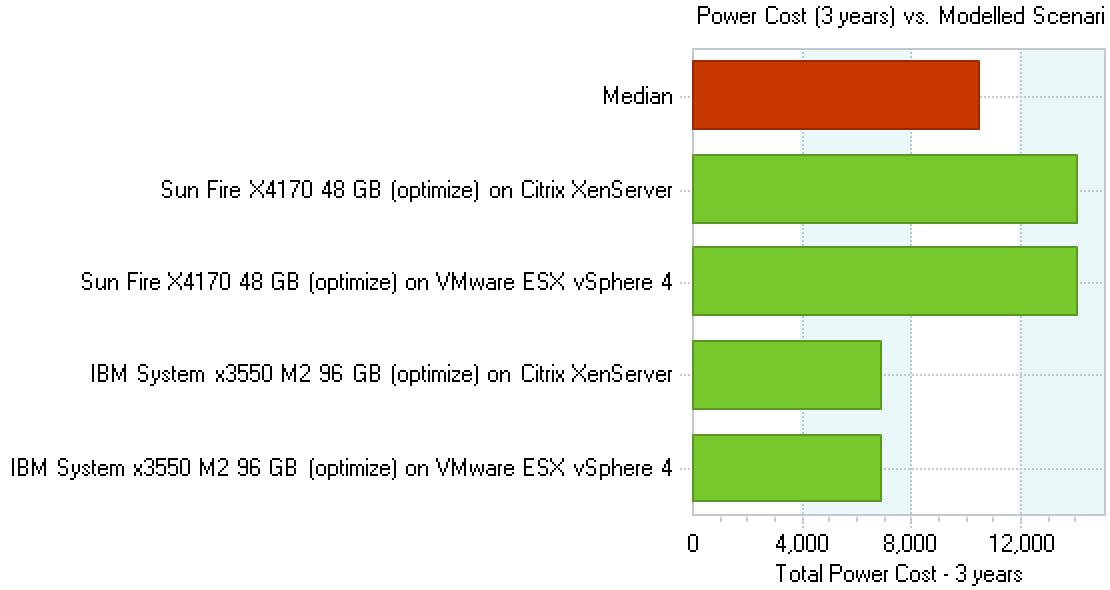


Chart 12.1.1: Power Cost vs. Modelled Scenarios

12.1.3 TCO

This chart compares the estimated total cost of ownership over 3 years across modelled scenarios.

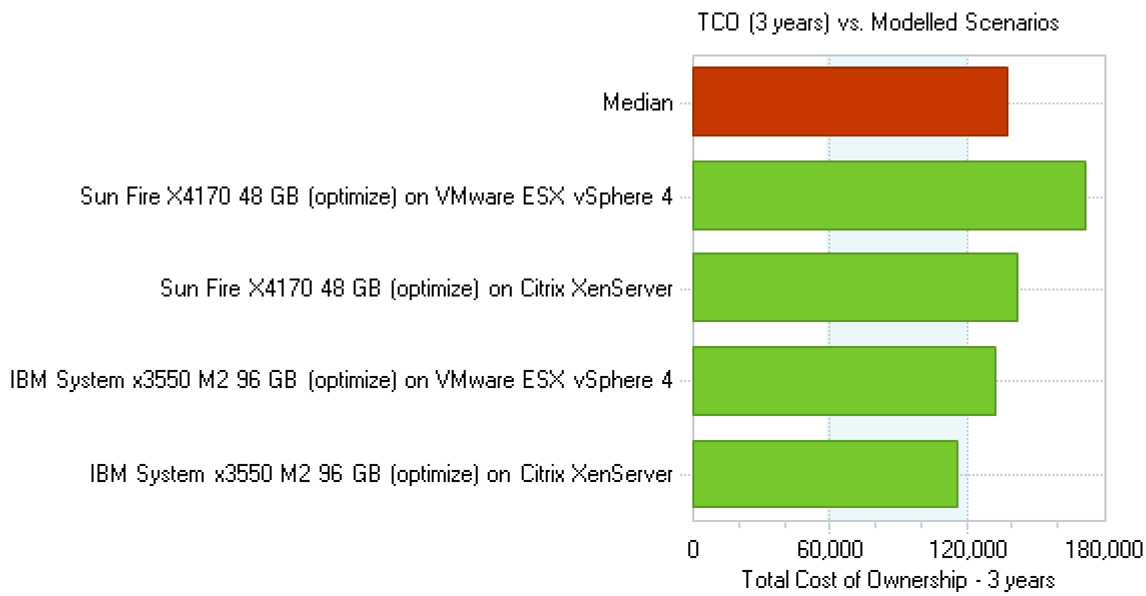


Chart 12.1.2: TCO (3 years) vs. Modelled Scenarios

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