TPC Benchmark® E
Full Disclosure Report

HP ProLiant DL580 G7
using Microsoft SQL Server 2008 R2 Enterprise Edition
on Microsoft Windows Server 2008 R2 Enterprise Edition

First Edition
June 21, 2010
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All performance data contained in this report was obtained in a rigorously controlled environment. Results obtained in other operating environments may vary significantly. Hewlett-Packard Company does not warrant or represent that a user can or will achieve similar performance expressed in transactions per second (tpsE®) or normalized price/performance ($/tpsE®). No warranty of system performance or price/performance is expressed or implied in this report.


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Abstract

Overview
This report documents the methodology and results of the TPC Benchmark® E (TPC-E) and TPC Benchmark® Energy (TPC-Energy) test conducted on the using HP ProLiant DL580 G7. The operating system used for the benchmark was Microsoft Windows Server 2008 R2 Enterprise Edition. The report also includes the results of the TPC Benchmark® Energy (TPC-Energy) test conducted on the same system.

TPC Benchmark® E Metrics
The standard TPC Benchmark® E metrics, tpsE® (transactions per second), price per tpsE® (three year capital cost per measured tpsE®) and the availability date are reported as required by the benchmark specification.

TPC Benchmark® Energy Metrics
The standard TPC Benchmark® Energy metrics, watts per tpsE is optionally reported by the benchmark specification.

Standard and Executive Summary Statements
The following pages contain the Executive Summary of the benchmark results for the system.

Auditor
The benchmark configuration, environment and methodology used to produce and validate the test results, and the pricing model used to calculate the cost per tpsE®, were audited by Lorna Livingtree of Performance Metrics, Inc. to verify compliance with the relevant TPC specifications.
### HP Proliant DL580 G7

Intel Xeon X7560 2.27 GHz 24MB L3  
C/S with 4 ProLiant DL 360 G5

<table>
<thead>
<tr>
<th>TPC-E Throughput</th>
<th>Price/Performance</th>
<th>Availability Date</th>
<th>Total System Cost</th>
<th>TPC-Energy Metric</th>
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</table>

#### Database Server Configuration

<table>
<thead>
<tr>
<th>Operating System</th>
<th>Database Manager</th>
<th>Processor/Cores/Thread</th>
<th>Memory</th>
</tr>
</thead>
</table>
| Microsoft Windows Server 2008 R2 | Microsoft SQL Server 2008 R2 Enterprise Edition | 4/32/64  
Intel Xeon X7560 2.27 GHz 24MB L3 | 1024 GB |

#### Tier B: Server

**HP Proliant DL580G7**

- 4 x Intel Xeon Processor X7560 2.27 GHZ  
- 1024GB Memory  
- 1 x HP NC364T PCI Express Quad Port Gigabit Server Adapter  
- 2 x HP 72GB 3G SAS 15K SFF DP

#### Database Log

**Tier A: Clients**

- 4 x ProLiant DL360g5  
- 1 x Quad-Core Intel Xeon processor E5420 2.50GHz  
- 16 x 72GB SAS 10K SFF DP  
- 2 x Onboard 1Gbps Ethernet  
- 2 x HP NC360T PCIE Dual Port

**Storage**

- 10 x HP Smart Array P411/512 MB  
- 40 x HP StorageWorks D2700 Disk Enclosure  
- 750 x 72GB 6G SAS 15K SFF DP  
- 240 x 146GB SAS 15K SFF DP

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<th>Initial Database Size</th>
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<td>8,938.1 GB</td>
<td>RAID10:Log/RAID10:Data</td>
<td>752x72GB 15K, 240x146GB 15K, 4x300GB 10K</td>
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## HP ProLiant DL580G7

Intel Xeon X7560 2.27 GHz 24MB L3

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<tr>
<th>Description</th>
<th>Part Number</th>
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<th>Qty</th>
<th>Extended Price</th>
<th>3 Yr Maint Price</th>
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<td>HP’s Large Configuration Discount *</td>
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<td><strong>5,292</strong></td>
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</table>

**Total Extended Price**: $804,303

**Total Discounts**: $116,688

**Grand Total**: $687,760

**Three-year Cost of Ownership**: $682,874

**tpsE**: 2,001.12

**$ USD/tpsE**: $347

---

*Pricing: 1=HP Direct 809-203-6748 2=Microsoft 3=Note 1: Discount based on HP Direct guidance applies to all lines where pricing = 1. Note 2: All the hardware are available to order. Note 3: The benchmark results were audited by Lorna Livanos of Performance Metrics.

Prices used in TPC benchmarks reflect the actual prices a customer would pay for a one-time purchase of the stated components. Individually negotiated discounts are not permitted. Special prices based on assumptions about past or future purchases are not permitted. All discounts reflect standard pricing policies for the listed components. For complete details, see the pricing sections of the TPC benchmark specifications. If you find that the stated prices are not available according to these terms, please inform at pricing@tpc.org. Thank you.
<table>
<thead>
<tr>
<th>Company</th>
<th>Hewlett-Packard</th>
<th>HP ProLiant DL580G7</th>
<th>TPC-E Rev. 1.10.0</th>
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<td>TPC-Energy 1.1.1</td>
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<td>TPC-E Throughput</td>
<td>2001.12 tpsE</td>
<td>Price/Performance</td>
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<td>Total System Cost</td>
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<td>TPC-Energy Metric</td>
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<td>Price/Performance</td>
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<td>TPC-E Throughput</td>
<td>2001.12 tpsE</td>
<td>5.84 watts/tpsE</td>
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<tr>
<td>Additional Numerical Quantities</td>
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<tr>
<td>Database Server</td>
<td>0.85</td>
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<td>12.4%</td>
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<tr>
<td>Storage</td>
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<tr>
<td>Total REC</td>
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<td>100%</td>
<td>100%</td>
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Numerical Quantities For Reported Energy Configuration:
REc Idle Power: 10,600 watts
Average Power of REC: 11,683 watts

Items in Measured Energy Configuration:
- 1 HP LE1851w 18.5-Inch wide Monitor  Part Number  NK033AA#ABA

Items in Reported Energy Configuration not in the Measured Energy Configuration:
None
### Numerical Quantities Summary

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<th>Minimum</th>
<th>Average</th>
<th>90th %tile</th>
<th>Maximum</th>
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<td>Market Feed</td>
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Preface

Document Structure

This is the full disclosure report for a benchmark test of the using Microsoft SQL Server 2008 R2 Enterprise Edition. It meets the requirements of the TPC Benchmark® E Standard Specification, Revision 1.10.0 dated Sept 2009. TPC Benchmark® E was developed by the Transaction Processing Performance Council (TPC). It is the intent of this group to develop a suite of benchmarks to measure the performance of computer systems executing a wide range of applications. Hewlett-Packard Company and Microsoft, Inc. are active participants in the TPC.

The requirements for this Full Disclosure Report are in Clause 9 of TPC Benchmark® E Specification.

TPC Benchmark® E Overview

TPC Benchmark™ E (TPC-E) is an On-Line Transaction Processing (OLTP) workload. It is a mixture of read-only and update intensive transactions that simulate the activities found in complex OLTP application environments. The database schema, data population, transactions, and implementation rules have been designed to be broadly representative of modern OLTP systems. The benchmark exercises a breadth of system components associated with such environments, which are characterized by:

- The simultaneous execution of multiple transaction types that span a breadth of complexity;
- Moderate system and application execution time;
- A balanced mixture of disk input/output and processor usage;
- Transaction integrity (ACID properties);
- A mixture of uniform and non-uniform data access through primary and secondary keys;
- Databases consisting of many tables with a wide variety of sizes, attributes, and relationships with realistic content;
- Contention on data access and update.

The TPC-E operations are modeled as follows:

- The database is continuously available 24 hours a day, 7 days a week, for data processing from multiple Sessions and data modifications against all tables, except possibly during infrequent (e.g., once a month) maintenance Sessions.
- Due to the worldwide nature of the application modeled by the TPC-E benchmark, any of the transactions may be executed against the database at anytime, especially in relation to each other.

The TPC-E benchmark simulates the OLTP workload of a brokerage firm. The focus of the benchmark is the central database that executes transactions related to the firm’s customer accounts. In keeping with the goal of measuring the performance characteristics of the database system, the benchmark does not attempt to measure the complex flow of data between multiple application systems that would exist in a real environment.

The mixture and variety of transactions being executed on the benchmark system is designed to capture the characteristic components of a complex system. Different transaction types are defined to simulate the interactions of the firm with its customers as well as its business partners. Different transaction types have varying run-time requirements.
Clause 1: General Items

1.1 Orders and Titles

The order and titles of sections in the Report and Supporting Files must correspond with the order and titles of sections from the TPC-E Standard Specification (i.e., this document). The intent is to make it as easy as possible for readers to compare and contrast material in different Reports. (9.1.1.1)

The order and titles of the sections in this report correspond with those specified in the TPC-E specification.

1.2 Pricing

The FDR must follow all reporting rules specified in the effective version of the TPC Pricing Specification, located at www.tpc.org. (9.1.1.2)

The pricing rules for this FDR follow the current standard at the time of publication, TPC Pricing Specification 1.5.0.

1.3 Executive Summary Statement

The TPC Executive Summary Statement must be included near the beginning of the Report. (9.2)

The Executive Summary statement is included after the preamble of this Full Disclosure Report, as well as a separate document.

1.4 Supporting Files

A directory structure for the supporting files must be followed. (9.1.1.3)

The accompanying support files are in the proper structure as defined by the specification.

1.5 Auditor

The name of the Auditor who certified the result must be included after the Price Spreadsheet. (9.2.2.2)

This Benchmark, Executive Summary, and Full Disclosure Report were audited by Lorna Livingtree of Performance Metrics, Inc. The attestation letter is included in this FDR.

1.6 Configuration Diagrams

Diagrams of both Measured and Priced Configurations must be reported in the Report, accompanied by a description of the differences. (9.3.1.2, 9.3.1.3)

The Benchmarked and Priced configurations of the driver, SUT Server, and DBMS server are the same and illustrated in Figure 1.1.
Figure 1.1 Benchmarked and Priced Configuration

1.7 Hardware Configuration

A description of the steps taken to configure all of the hardware must be reported in the Report. Any and all configuration scripts or step by step GUI instructions are reported in the Supporting Files (see Clause 9.4.1.1). The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-E specification could recreate the hardware environment.

A description of any firmware updates or patches to the hardware.

A description of any GUI configuration used to configure the system hardware.

A description of exactly how the hardware is combined to create the complete system. For example, if the SUT description lists a base chassis with 1 processor, a processor update package of 3 processors, a NIC controller and 3 disk controllers, a description of where and how the processors, NIC and disk controllers are placed within the base chassis must be reported in the Report.

A description of how the hardware components are connected. The description can assume the reader is knowledgeable of computer systems and the TPC-E specification. For example, only a description that Controller 1 in slot A is connected to Disk Tower 5 is required. The reader is assumed to be knowledgeable enough to determine what type of cable is required based upon the component descriptions and how to plug the cable into the components.
The HP ProLiant DL580 G7, in the benchmarked configuration, consists of a single cabinet with 4 sockets. Each socket has 1 processor installed, along with 64 x 16 GB DIMMs. The various HBA’s, NICS, and other IO cards are installed in the various chassis as defined in the file HWConfig.pdf in the \Supporting Files\Introduction\TierB “Introduction” directory. Additionally, the DiskConfig.pdf file in the Supporting Files directory shows how the SmartArray and disk subsystem were configured.

1.8 Software Configuration

A description of the steps taken to configure all software must be reported in the Report. Any and all configuration scripts or step by step GUI instructions are reported in the Supporting Files (see Clause 9.4.1.2). The description, scripts and GUI instructions must be sufficient such that a reader knowledgeable of computer systems and the TPC-E specification could recreate the software environment. This includes, but is not limited to:

A description of any updates or patches to the software.

A description of any changes to the software.

A description of any GUI configurations used to configure the software.

The file Win2008Setup.pdf in the \SupportingFiles\Introduction\TierB directory outlines the steps taken to configure the OS and DBMS. The file DiskDriverCfg.pdf in RaidDriver outlines the steps to configure the disk driver used for the Smart Array Controllers. The file PerfDriver.reg is the registry entry for the initial performance driver settings. The file SQL2008Setup.doc in \SupportingFiles\Introduction\TierB likewise outlines the steps taken to setup the DBMS. Other supporting files (registry, configuration) are also included in the respective directories.
**Clause 2: Database Design, Scaling & Population Items**

### 2.1 Physical Database Organization

*The physical organization of tables and indices, within the database, must be reported in the Report.*

The database tables and indices were organized into two SQL Server filegroups as shown in Table 2.1 below. The tables that grew during the run, defined as **growing tables** in the TPC-E specification, were placed in a file group called Growing, while the tables that do not grow during the run, designated as **fixed and scaling**, and were placed in a filegroup called Fixed.

Directory **Clause2** in **Supporting Files** contains the scripts used to create the database filegroups, tables, constraints, and indices. In addition, files to create TEMPDB files before the build and remove them after the build are included, as well as a script to remove the LOAD_FG files and filegroup after the build and before the initial backup.

<table>
<thead>
<tr>
<th>Fixed</th>
<th>Growing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Account_Permission</td>
<td>Security</td>
</tr>
<tr>
<td>Address</td>
<td>Watch_Item</td>
</tr>
<tr>
<td>Company</td>
<td>Watch_List</td>
</tr>
<tr>
<td>Company_Competitor</td>
<td>Charge</td>
</tr>
<tr>
<td>Customer</td>
<td>Commission_Rate</td>
</tr>
<tr>
<td>Customer_Account</td>
<td>Exchange</td>
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<tr>
<td>Customer_TaxRate</td>
<td>Industry</td>
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<tr>
<td>Daily_Market</td>
<td>Sector</td>
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<tr>
<td>Financial</td>
<td>Status_Type</td>
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<tr>
<td>Last_Trade</td>
<td>TaxRate</td>
</tr>
<tr>
<td>News_Item</td>
<td>Trade_Type</td>
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<tr>
<td>News_Xref</td>
<td>Zip_Code</td>
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<tr>
<td>Broker</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.1 – FileGroup Table Assignments

### 2.2 Table and Row Partitioning

*While few restrictions are placed upon horizontal or vertical partitioning of tables and rows in the TPC-E benchmark (see Clause 2.3.3), any such partitioning must be reported in the Report.* (9.3.2.2)

No partitioning was done for this benchmark.

### 2.3 Replication, Duplication

*Replication of tables, if used, must be reported in the Report.* (9.3.2.3).  
Additional and/or duplicated columns in any table must be reported in the Report along with a statement on the impact on performance. (9.3.2.4)

No replication or duplication was done for this benchmark.
2.4 Cardinality of Tables

The cardinality (e.g. the number of rows) of each table, as it existed after database load must be reported in the Report. (9.3.2.5)

The TPC-E database was configured using 1,050,000 customers. Table 2.2 below shows the cardinality of each table.

<table>
<thead>
<tr>
<th>Table</th>
<th>Rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCOUNT_PERMISSION</td>
<td>7454828</td>
</tr>
<tr>
<td>ADDRESS</td>
<td>1575004</td>
</tr>
<tr>
<td>BROKER</td>
<td>10500</td>
</tr>
<tr>
<td>COMPANY</td>
<td>525000</td>
</tr>
<tr>
<td>COMPANY_COMPETITOR</td>
<td>1575000</td>
</tr>
<tr>
<td>CUSTOMER</td>
<td>1050000</td>
</tr>
<tr>
<td>CUSTOMER_ACCOUNT</td>
<td>5250000</td>
</tr>
<tr>
<td>CUSTOMER_TAXRATE</td>
<td>2100000</td>
</tr>
<tr>
<td>DAILY_MARKET</td>
<td>938621250</td>
</tr>
<tr>
<td>FINANCIAL</td>
<td>10500000</td>
</tr>
<tr>
<td>LAST_TRADE</td>
<td>719250</td>
</tr>
<tr>
<td>NEWS_ITEM</td>
<td>1050000</td>
</tr>
<tr>
<td>NEWS_XREF</td>
<td>1050000</td>
</tr>
<tr>
<td>SECURITY</td>
<td>719250</td>
</tr>
<tr>
<td>WATCH_ITEM</td>
<td>104941231</td>
</tr>
<tr>
<td>WATCH_LIST</td>
<td>1050000</td>
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<tr>
<td>CASH_TRANSACTION</td>
<td>16692481567</td>
</tr>
<tr>
<td>HOLDING</td>
<td>928855578</td>
</tr>
<tr>
<td>HOLDING_HISTORY</td>
<td>24316103321</td>
</tr>
<tr>
<td>HOLDING_SUMMARY</td>
<td>52216631</td>
</tr>
<tr>
<td>SETTLEMENT</td>
<td>18144000000</td>
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<tr>
<td>TRADE</td>
<td>18144000000</td>
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<tr>
<td>TRADE_HISTORY</td>
<td>43545559454</td>
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<tr>
<td>TRADE_REQUEST</td>
<td>0</td>
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<tr>
<td>CHARGE</td>
<td>15</td>
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<tr>
<td>COMMISSION_RATE</td>
<td>240</td>
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<tr>
<td>EXCHANGE</td>
<td>4</td>
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<tr>
<td>INDUSTRY</td>
<td>102</td>
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<tr>
<td>SECTOR</td>
<td>12</td>
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<tr>
<td>STATUS_TYPE</td>
<td>5</td>
</tr>
<tr>
<td>TAXRATE</td>
<td>320</td>
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<tr>
<td>TRADE_TYPE</td>
<td>5</td>
</tr>
<tr>
<td>ZIP_CODE</td>
<td>14741</td>
</tr>
</tbody>
</table>

Table 2.2 Initial Cardinality of Tables
2.5 Disk Configuration

The distribution of tables, partitions and logs across all media must be explicitly depicted for the measured and Priced Configurations.(9.3.2.6)

Table 2.3 shows the configuration of the HP SmartArray P411 750 Drives configured for data connected to 10 HP SmartArray P411 controllers in 40 x D2700 enclosures, and 4 Drives configured for the log connected to 1 x HP Smart Array P410i controller in internal bay. All 40 x D2700 were configured as RAID1+0 arrays across all 25 disks in each enclosure, including the log.

Each data array was partitioned with 3 types of partitions: Growing, Fixed, and Backup. The first two types were used during the performance run, and the Backup partition was used for database backups. The first 2 partitions were RAW; the 3rd was configured as NTFS. Access to all the partitions was by using mount points, no drive letters were used except for the log and the boot/utility drives.

<table>
<thead>
<tr>
<th>SA #, Type</th>
<th>Cab, Bay, Chassis, Slot</th>
<th>Disk #</th>
<th>Drives Enclosure RAID Lvl</th>
<th>Path Filesystem Partition</th>
<th>Size</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, P410i Internal, 1-6,0,0</td>
<td>1</td>
<td>2x72 SCSI, Internal RAID1</td>
<td>C:, NTFS</td>
<td>72GB</td>
<td>Win2008 Boot, PageFile, Utility, Scripts Mount Point Root, DB Root File</td>
<td></td>
</tr>
<tr>
<td>2, P411 1-4,1-100,1,1</td>
<td>2</td>
<td>4x300 SCSI, Internal RAID1</td>
<td>F:, RAW</td>
<td>558.7GB</td>
<td>Database log</td>
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Table 2.3 Disk/Partition Configuration (continued)
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| 14 | 1+0 | D2700 | 50x72 | P411 | 25-28, 1-100, 1, 7 | 3.01 GB | Fixed FG  
|    |      |       | SAS | D2700 | RAID1 | Grow FG |
| 15 | 1+0 | D2700 | 50x72 | P411 | 25-28, 1-100, 1, 7 | 3.01 GB | Fixed FG  
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</table>
2.6 Database Interface

A statement must be provided in the Report that describes:

The Database Interface (e.g., embedded, call level) and access language (e.g., SQL, COBOL read/write) used to implement the TPC-E Transactions. If more than one interface / access language is used to implement TPC-E, each interface / access language must be described and a list of which interface/access language is used with which Transaction type must be reported. (9.3.2.7)

The data model implemented by the DBMS (e.g., relational, network, hierarchical). (9.3.2.7)

The methodology used to load the database must be reported in the Report. (9.3.2.8)

Client software interfaced to SQL Server through stored procedures invoked by the clients with ODBC calls. The application code was C++.

The data model implemented by Microsoft SQL Server 2008 R2 Enterprise Edition is relational.

The methodology used to load the database is contained in the file MSTPCE Database Setup Reference.pdf in the CLAUSE2 directory in SupportingFiles directory.
Clause 3: Transaction Related Items

3.1 Code Functionality

A statement that vendor-supplied code is functionally equivalent to Pseudo-code in the specification must be reported in the Report. (9.3.3.1)

Secondary sponsor-supplied code is functionally equivalent to pseudo-code in the specification.

3.2 Database Footprint

A statement that the database footprint requirements were met must be reported in the Report. (9.3.3.2)

Database footprint requirements were met.
Clause 4: SUT, Driver and Network Related Items

4.1 Network Configuration

The Network configurations of both the measured and Priced Configurations must be described and reported in the Report. This includes the mandatory Network between the Driver and Tier A) and any optional Database Server interface networks (9.3.4.1)

The network configurations for both the priced and reported configurations are the same. All network connections were through two HP ProCurve 2910al-24G networking switches. The 1 driver machine and the 4 client machines were networked via their built in 1Gbps ports and one external HP 360T dual port NIC while the other was used for access by the driver during the runs. The DBMS server used one internal quad port 1Gbps NIC and one external HP 364T quad port NIC for data base traffic during the measured run. Figures 1.1 shows configuration of the network.
Clause 5: Egen Related Items

5.1 Egen Version

The version of EGen used in the benchmark must be reported in the Report. (9.3.5.1)

Egen Version used for this test was 1.10.0

5.2 Egen Code

A statement that all required TPC-provided EGen code was used in the benchmark must be reported in the Report. (9.3.5.2)

All required TPC provided Egen code was used in this benchmark.

5.3 Egen Modifications

If the Test Sponsor modified EGen, a statement EGen has been modified must be reported in the Report. All formal waivers from the TPC documenting the allowed changes to EGen must also be reported in the Report if any of the changes to EGen do not have a formal waiver that must also be reported in the Report.

No modifications to Egen were done for this report.

5.4 Egen Loader Extensions

If the Test Sponsor extended EGenLoader the use of the extended EGenLoader and the audit of the extension code by an Auditor must be reported in the Report (9.3.5.4)

Egen Loader was not extended for this report.

5.5 Egen Loader Make Files

The make/project files used to compile/link EGenLoader and EGenValidate must be reported in the Supporting Files. The compiler/linker options and flags used to compile/link EGen Objects for the SUT must be reported in the Supporting Files. (9.3.5.5)

The Visual C++ project files are included in the EgenMakeFiles directory in the Clause5 directory in the Supporting Files directory.
Clause 6: Performance Metrics and Response Time Related Items

6.1 EgenDriver and MEE instances

The number of EGenDriverMEE and EGenDriverCE instances used in the benchmark must be reported in the Report (9.3.6.1).

24 instances of both the EgenDriverMEE and EgenDriverCE were used in this report.

6.2 Measured Throughput

The Measured Throughput must be reported in the Report (9.3.6.2).

Measured tpsE for this run was 2,001.12 tpsE.

Test Run Graph and Steady State Measurement

A Test Run Graph of throughput versus elapsed wall clock time must be reported in the Report for the Trade-Result Transaction (9.3.6.3).

The method used to determine that the SUT had reached a Steady State prior to commencing the Measurement Interval must be reported in the Report (9.3.6.4).

After initial ramp-up, throughput and response time were observed until both were constant, generally to within less than a percent of the reported throughput. Throughput and response time were determined by examining the data after the run was terminated. The data was reported over every 60 second window during the test run. Ramp up and steady state can be seen from the graph below.
6.4 Work Measurement

A description of how the work normally performed during a Test Run, actually occurred during the Measurement Interval must be reported in the Report (for example check-pointing, writing Undo/Redo Log records, etc). (9.3.6.5)

During the run, the Customer Emulator engines (Driver Engines) generated transactions via the audited stored procedures as per the TPC-E specification. Each transaction was time-stamped, response time verified, and the transactions logged into individual log files. Communication was done between the Driver Engine Customer Emulators and Market Emulators to the SUT Server emulators, which in turn generated commands via ODBC connections to Microsoft SQL Server 2008 R2 Enterprise Edition. Satisfying these ODBC requests constitute the primary load on the server during the run.

Checkpoints were performed to flush all dirty pages from memory, and write a record of this fact to the transaction log. This was accomplished by setting the SQL Recovery Interval to 32767, which effectively tells SQL to not checkpoint automatically. Near the beginning of the test run, a script was started that did manual checkpoints, specifying an interval of 435 seconds. SQL Server was run with run flag 3502, which caused it to display messages when checkpoints were started and ended. This was used to verify the checkpoints were done in the time intervals as required by the TPC-E specification.

6.5 Transaction Reporting
The recorded averages over the Measurement Interval for each of the Transaction input parameters specified by clause 6.4.1 must be reported in the Report. (9.3.6.6)

Table 6.2 shows the Averages for the Test Run.

<table>
<thead>
<tr>
<th>Transaction</th>
<th>Overall Parameter</th>
<th>Value</th>
<th>Range Check</th>
<th>Acceptable Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Position</td>
<td>By Tax ID</td>
<td>49.98%</td>
<td>Ok</td>
<td>48.00% - 52.00%</td>
</tr>
<tr>
<td></td>
<td>Get History</td>
<td>50.00%</td>
<td>Ok</td>
<td>48.00% - 52.00%</td>
</tr>
<tr>
<td>Trade Lookup</td>
<td>Frame 1</td>
<td>29.98%</td>
<td>Ok</td>
<td>28.50% - 31.50%</td>
</tr>
<tr>
<td></td>
<td>Frame 2</td>
<td>30.03%</td>
<td>Ok</td>
<td>28.50% - 31.50%</td>
</tr>
<tr>
<td></td>
<td>Frame 3</td>
<td>30.00%</td>
<td>Ok</td>
<td>28.50% - 31.50%</td>
</tr>
<tr>
<td></td>
<td>Frame 4</td>
<td>9.99%</td>
<td>Ok</td>
<td>9.50% - 10.50%</td>
</tr>
<tr>
<td>Market Watch</td>
<td>By Watch List</td>
<td>60.01%</td>
<td>Ok</td>
<td>57.00% - 63.00%</td>
</tr>
<tr>
<td></td>
<td>By Customer Acct</td>
<td>34.99%</td>
<td>Ok</td>
<td>33.00% - 37.00%</td>
</tr>
<tr>
<td></td>
<td>By Industry</td>
<td>5.00%</td>
<td>Ok</td>
<td>4.50% - 5.50%</td>
</tr>
<tr>
<td>Trade Update</td>
<td>Frame 1</td>
<td>33.01%</td>
<td>Ok</td>
<td>31.00% - 35.00%</td>
</tr>
<tr>
<td></td>
<td>Frame 2</td>
<td>33.01%</td>
<td>Ok</td>
<td>31.00% - 35.00%</td>
</tr>
<tr>
<td></td>
<td>Frame 3</td>
<td>33.98%</td>
<td>Ok</td>
<td>32.00% - 36.00%</td>
</tr>
<tr>
<td>Security Detail</td>
<td>Access LOB</td>
<td>1.01%</td>
<td>Ok</td>
<td>0.90% - 1.10%</td>
</tr>
<tr>
<td>Trade Order</td>
<td>By Non-Owner</td>
<td>10.00%</td>
<td>Ok</td>
<td>9.50% - 10.50%</td>
</tr>
<tr>
<td></td>
<td>By Company Name</td>
<td>39.99%</td>
<td>Ok</td>
<td>38.00% - 42.00%</td>
</tr>
<tr>
<td></td>
<td>Buy on Margin</td>
<td>8.00%</td>
<td>Ok</td>
<td>7.50% - 8.50%</td>
</tr>
<tr>
<td></td>
<td>Rollback</td>
<td>0.99%</td>
<td>Ok</td>
<td>0.94% - 1.04%</td>
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<tr>
<td></td>
<td>LIFO</td>
<td>35.01%</td>
<td>Ok</td>
<td>33.00% - 37.00%</td>
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<tr>
<td></td>
<td>Trade by Qty 100</td>
<td>25.00%</td>
<td>Ok</td>
<td>24.00% - 26.00%</td>
</tr>
<tr>
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<td>Trade by Qty 200</td>
<td>24.98%</td>
<td>Ok</td>
<td>24.00% - 26.00%</td>
</tr>
<tr>
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<td>Trade by Qty 400</td>
<td>25.01%</td>
<td>Ok</td>
<td>24.00% - 26.00%</td>
</tr>
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<td>Trade by Qty 800</td>
<td>25.01%</td>
<td>Ok</td>
<td>24.00% - 26.00%</td>
</tr>
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<td>Ok</td>
<td>29.70% - 30.30%</td>
</tr>
<tr>
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<td>Market Sell</td>
<td>30.00%</td>
<td>Ok</td>
<td>29.70% - 30.30%</td>
</tr>
<tr>
<td></td>
<td>Limit Buy</td>
<td>20.00%</td>
<td>Ok</td>
<td>19.80% - 20.20%</td>
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<tr>
<td></td>
<td>Limit Sell</td>
<td>10.01%</td>
<td>Ok</td>
<td>9.90% - 10.10%</td>
</tr>
<tr>
<td></td>
<td>Stop Loss</td>
<td>9.98%</td>
<td>Ok</td>
<td>9.90% - 10.10%</td>
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Table 6.2 Average Transaction Parameters
Clause 7: Transaction and System Properties

7.1 ACID Tests

The results of the ACID tests must be reported in the Report along with a description of how the ACID requirements were met, and how the ACID tests were run. (9.3.7.1)

The Atomicity, Consistency, Isolation, and Durability tests are specified by the TPC-E specification. These requirements are translated into audited procedures which are executed either on a fresh database (Isolation, Atomicity), or after a test run (Consistency). Instructions for running these tests are included in the file MSTPCE ACID Procedures.pdf. This file, along with results of these tests is contained in the Supporting Files directory under Clause 7.

Durability test consisted of Data Accessibility and Business Recovery tests. The procedures for each are outlined below.

7.2 Redundancy Level and Data Accessibility Tests

The Test Sponsor must report in the Report the Redundancy Level and describe the Data Accessibility test(s) used to demonstrate compliance.(9.3.7.2)

Redundancy level 1 was used for all tests and the measured run.

The Data Accessibility Test was performed according to the following steps

1. The rows in the Settlement table were counted to establish the initial count of trades present.
2. A run was started using the same profile and configuration as the test run (reported result) and ramped up to 95% of the Reported Throughput.
3. After more 5 minutes of running at >= 95% of the Reported Throughput, a data disk in the RAID10 data arrays was pulled, and a few seconds later, a log disk in the RAID10 log array was pulled.
4. The benchmark was allowed to run for 5 more minutes at steady state, all at >= 95% of Reported Throughput.
5. After the 5 minutes, the disks were replaced by different disks of the same size and a rebuild of the volumes started automatically by the Smart Array controllers.
6. The run continued for more than 20 minutes at >=95% of the Reported Throughput.
7. The run was also crashed as a part of the Business Recovery test. Various reports were run. No errors were reported at any time in this process.
8. The rows in the Settlement table were counted again to establish the final number of trades present in the database.
9. The initial count was subtracted from the final count and was verified against the reported number of Trade-Result transactions
10. After the two disks were rebuilt, the recovery was considered complete.
7.3 Data Accessibility Graph

A Data Accessibility Graph for each run demonstrating a Redundancy Level must be reported in the Report. (9.3.7.3)

7.4 Business Recovery Tests

The Test Sponsor must describe in the Report the test(s) used to demonstrate Business Recovery. (9.3.7.4)

This test measures the time it takes to recover to 95% of the reported throughput after a system power loss.

1. The rows in the Settlement table were counted to establish the initial count of trades present.
2. A run was started using the same profile and configuration as the test run (reported result) and ramped up to 95% of the Reported Throughput.
3. Primary power to Tier B server was removed (i.e., the plug was pulled).
4. Drivers noted transaction failures almost immediately, and the driver environment was terminated while the servers were booting back up.
5. Power was restored to Tier B server, and the machines rebooted.
6. After the OS was running, SQL Server was started, which automatically started transaction recovery of the primary TPCE data base. This process reads the transaction log and reapplies all committed transactions and rollback any incomplete transactions. At the end of this process, the database on disk will be logically consistent.
8. After SQL finished recovery of TPCE and reported that the data base was available, the Trade-Cleanup Transaction was executed.
9. The benchmark was started and ramped up as before to 95% of the Reported Throughput.
10. The benchmark was allowed to run at $\geq 95\%$ for 20 minutes.
11. The driver environment was terminated gracefully. No errors were reported.
12. The rows in the Settlement table were counted again to determine the final number of trades present.
13. The initial count was subtracted from the final count was calculated, and this number was verified to be greater than or equal to the number of Trade-Result transacts as logged during the run.
14. The Consistency scripts were run to verify the data base was logically consistent.
15. The beginning of the first window of time where $\geq 95\%$ for 20 minutes was noted, which marked the end of the Business Recovery interval.

Business Recovery Time was 1 hour 10 minutes and 49 seconds. This is also reported in the Executive Summary.

![Business Recovery Test Run](image)

**Figure 7.2 The Business Recovery Tests Graph**
Clause 8: Pricing Related Items

8.1 60-Day Space

Details of the 60-Day Space computations along with proof that the database is configured to sustain a Business Day of growth must be reported in the Report. (9.3.8.1)

Below is the 60 Day Space spreadsheet as prepared by the auditor and verified from the IO configuration.
8.1 Attestation Letter

June 20, 2010

Mr. Paul Cao  
Senior System Engineer  
Hewlett-Packard Company  
20555 SH 249  
Houston, TX 77070

I have verified by remote the TPC Benchmark™ E for the following configuration:
Platform: HP ProLiant DL580 G7  
Database Manager: Microsoft SQL Server 2008 R2 Enterprise Edition  
Transaction Monitor: Microsoft COM+

<table>
<thead>
<tr>
<th>System Under Test:</th>
<th>CPU’s</th>
<th>Memory</th>
<th>Disks (total)</th>
<th>TpsE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 Intel 8 core @ 2.3 Ghz</td>
<td>Main: 1.00 TB</td>
<td>752 @ 72 GB, 4 @ 300 GB, 240 @ 146 GB</td>
<td>2,001.12</td>
</tr>
<tr>
<td></td>
<td>4 Clients (Tier A): ProLiant DL360 G5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In my opinion, these performance results were produced in compliance with the TPC requirements for the benchmark. The following attributes of the benchmark were given special attention:

- All EGen components were verified to be version 1.10.0.
- The database files were properly sized and populated for 1,050,000 customers.
- The transaction components were properly implemented.
- The required network between the driver and the transaction harness was configured.
- The ACID properties were successfully demonstrated.
- The database was verified to have no Trade-Request rows prior to the start of the test run.
- The test run met all the requirements for timing, mix, and response times.
- Input data was generated according to the specified percentages.
- One and only one Data-Maintenance process was running during the test run.
- There were no inactive load units during the test run.
- Eight hours of mirrored log space was present on the measured system.
- Eight hours of growth space was present on the measured system.
- The data for the 60 day space calculation was verified.
- The steady state portion of the test was 120 minutes.
- Checkpoint interval was verified to be equal to or less than 7.5 minutes and no two checkpoints lasted longer than 15 minutes.
- The system pricing was checked for major components and maintenance.
- Third party quotes were verified for compliance.
- The FDR, Executive Summary and Supporting Files were reviewed and verified as required.

Auditor Notes: None.

Sincerely,

[Signature]

Lorna Livingtree, Certified Auditor
Clause 9: Supporting Files

9.1 Supporting Files

The Supporting Files contain human readable and machine executable (i.e., able to be performed by the appropriate program without modification) scripts that are required to recreate the benchmark Result. If there is a choice of using a GUI or a script, then the machine executable script must be provided in the Supporting Files. If no corresponding script is available for a GUI, then the Supporting Files must contain a detailed step-by-step description of how to manipulate the GUI.
Appendix A: Third Party Pricing Quotes/Pricing

Microsoft

Hewlett-Packard Company
Paul Cao
20555 SH 249
Houston, TX 77070

Here is the information you requested regarding pricing for several Microsoft products to be used in conjunction with your TPC-E benchmark testing. All pricing shown is in US Dollars ($).

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Unit Price</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>B10-07580</td>
<td>SQL Server 2008 R2 Enterprise Edition&lt;br&gt;Per Processor License&lt;br&gt;Open Program - Level C&lt;br&gt;Unit Price reflects a 33% discount from the retail unit price of $23,749.</td>
<td>$19,186</td>
<td>4</td>
<td>$76,752</td>
</tr>
<tr>
<td>P72-04217</td>
<td>Windows Server 2008 R2 Enterprise Edition&lt;br&gt;Server License with 25 CALs&lt;br&gt;Open Program - Level C&lt;br&gt;Unit Price reflects a 43% discount from the retail unit price of $3,999.</td>
<td>$2,280</td>
<td>1</td>
<td>$2,280</td>
</tr>
<tr>
<td>P73-04165</td>
<td>Windows Server 2008 Standard Edition&lt;br&gt;Server License with 5 CALs&lt;br&gt;Open Program - Level C&lt;br&gt;Unit Price reflects a 39% discount from the retail unit price of $999.</td>
<td>$711</td>
<td>4</td>
<td>$2,844</td>
</tr>
<tr>
<td>N/A</td>
<td>Microsoft Problem Resolution Services&lt;br&gt;Professional Support&lt;br&gt;(1 Incident)</td>
<td>$259</td>
<td>1</td>
<td>$259</td>
</tr>
</tbody>
</table>

All Microsoft products listed above are currently orderable and available through Microsoft’s normal distribution channels. A list of Microsoft’s resellers can be found at the Microsoft Product Information Center at [http://www.microsoft.com/products/info/render.aspx?view=22&type=how](http://www.microsoft.com/products/info/render.aspx?view=22&type=how). Defect support is included in the purchase price. Additional support is available from Microsoft PSS on an incident by incident basis at $259 per call.

This quote is valid for the next 90 days.

Reference ID: TPCE_g3wOpiq6ZAtgzdrQQtWbatNjU7f+RiCyr_V1.0.0.
Appendix B: TPC-Energy Disclosure Report

B.1. TPC-Energy Clause 2-related items (Methodology)

B.1.1. Minimum ambient temperature
The minimum ambient temperature must be disclosed.

Minimum Temperature reported by EMSC = 20.47 °C

B.1.2. External electric power source characteristics
The characteristics of the external electric power source must be disclosed. In particular, the voltage, frequency in Hertz, and phase information must be reported.

The external electric power source has the following characteristics: 208V, 60Hz, single phase.

B.1.3. Air-pressure alterations
A statement is required that assures that nothing was done to alter the air-pressure in the measurement environment.

Nothing was done to alter the air-pressure in the measurement environment.

B.1.4. Temperature measurement
A description of where the temperature was measured and how it was determined that this was representative of the lowest ambient temperature is required.

The temperature was measured at the SUT air inlet located at the lowest temperature of the SUT.

B.1.5. Cooling method
If a method of cooling other than circulation of ambient air is employed in the REC, a statement describing this method must be included.

No other method of cooling was used.

B.1.6. PTD license
To be compliant with licenses associated with EMS, the following statement must be included in every FDR which contains a TPC-Energy Metric:

The power and temperature characteristics of the MEC were measured using TPC’s Energy Measurement Software (EMS). This includes the EMS-PTD, a modified version of the SPEC PTDaemon, which is provided under license from the Standard Performance Evaluation Corporation (SPEC).
B.2. TPC-Energy Clause 3-related items (Metrics)

B.2.1. Primary Metric

The normalized work derived from the Performance Metric (as described in Clause 3.2.1) must be disclosed

\[5.84 \text{ watts / tpsE}\]

The computation for total energy used for each measurement segment that contributes to a Performance Metric must be disclosed. If the energy of the entire Priced Configuration is not derived from direct measurements, the methods for deriving the energy for components that were not measured must be disclosed (See Clause 7.3.3.4)

<table>
<thead>
<tr>
<th>PMU</th>
<th>Full Load Average Watts</th>
<th>% of Reading Uncertainty</th>
<th>Watts Reading Correction</th>
<th>Wattage Range Setting</th>
<th>% of Range Uncertainty</th>
<th>Wattage Range Correction</th>
<th>Total Wattage Correction</th>
<th>Accuracy Correction Factor</th>
<th>Reported Watt-Seconds</th>
<th>Adjusted Watt-Seconds</th>
<th>Reported Average Watts</th>
<th>Adjusted Average Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB Server PMU-1</td>
<td>1696.34</td>
<td>0.10%</td>
<td>+1.70</td>
<td>3000</td>
<td>0.10%</td>
<td>+3.00</td>
<td>+4.70</td>
<td>0.28%</td>
<td>12,215,344</td>
<td>12,249,162</td>
<td>7,200</td>
<td>1,701.27</td>
</tr>
<tr>
<td>DB Server Total</td>
<td>1696.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12,215,344</td>
<td>12,249,162</td>
<td>7,200</td>
<td>1,701.27</td>
</tr>
<tr>
<td>Storage PMU-1</td>
<td>2921.57</td>
<td>0.10%</td>
<td>+2.92</td>
<td>6000</td>
<td>0.10%</td>
<td>+6.00</td>
<td>+8.62</td>
<td>0.31%</td>
<td>20,318,134</td>
<td>20,381,858</td>
<td>7,200</td>
<td>2,830.79</td>
</tr>
<tr>
<td>Storage PMU-2</td>
<td>2498.64</td>
<td>0.10%</td>
<td>+2.50</td>
<td>6000</td>
<td>0.10%</td>
<td>+6.00</td>
<td>+8.50</td>
<td>0.34%</td>
<td>17,992,675</td>
<td>18,053,874</td>
<td>7,200</td>
<td>2,507.48</td>
</tr>
<tr>
<td>Storage PMU-3</td>
<td>2663.42</td>
<td>0.10%</td>
<td>+2.66</td>
<td>6000</td>
<td>0.10%</td>
<td>+6.00</td>
<td>+8.66</td>
<td>0.33%</td>
<td>19,179,277</td>
<td>19,241,862</td>
<td>7,200</td>
<td>2,672.45</td>
</tr>
<tr>
<td>Storage PMU-4</td>
<td>1066.9</td>
<td>0.10%</td>
<td>+1.07</td>
<td>3000</td>
<td>0.10%</td>
<td>+3.00</td>
<td>+4.07</td>
<td>0.38%</td>
<td>7,682,779</td>
<td>7,712,065</td>
<td>7,200</td>
<td>1,071.12</td>
</tr>
<tr>
<td>Storage Total</td>
<td>9050.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>65,172,665</td>
<td>65,389,258</td>
<td>9,081.84</td>
<td>9,081.84</td>
</tr>
<tr>
<td>App Server PMU-1</td>
<td>767.27</td>
<td>0.10%</td>
<td>+0.77</td>
<td>1500</td>
<td>0.10%</td>
<td>+1.50</td>
<td>+2.27</td>
<td>0.30%</td>
<td>5,525,101</td>
<td>5,541,428</td>
<td>7,200</td>
<td>769.64</td>
</tr>
<tr>
<td>App Server Total</td>
<td>767.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,525,101</td>
<td>5,541,428</td>
<td>7,200</td>
<td>769.64</td>
</tr>
<tr>
<td>Misc PMU-1</td>
<td>101.22</td>
<td>0.10%</td>
<td>+0.10</td>
<td>600</td>
<td>0.10%</td>
<td>+0.60</td>
<td>+0.70</td>
<td>0.69%</td>
<td>728,887</td>
<td>733,936</td>
<td>7,200</td>
<td>101.94</td>
</tr>
<tr>
<td>Monitor Name Plate</td>
<td>28</td>
<td>0.00%</td>
<td>+0.00</td>
<td>0</td>
<td>0.00%</td>
<td>+0.00</td>
<td>+0.00</td>
<td>0.00%</td>
<td>201,600</td>
<td>201,600</td>
<td>7,200</td>
<td>28.00</td>
</tr>
<tr>
<td>Misc Total</td>
<td>129.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>930,487</td>
<td>935,536</td>
<td>129.94</td>
<td>129.94</td>
</tr>
<tr>
<td>REC Total</td>
<td>11,643.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>83,843,796</td>
<td>84,115,385</td>
<td>11,683</td>
<td>11,683</td>
</tr>
</tbody>
</table>

All monitors power consumption in the Miscellaneous Subsystem were calculated using nameplate values.

The duration of each measurement that produces a Performance Metric must be disclosed

The duration of the measured run was 120 minutes. The idle measurement was 10 minutes.

The average power requirement for each measurement that produces one of these metrics,
### Secondary Metrics

<table>
<thead>
<tr>
<th>Description</th>
<th>Watts / tpsE</th>
<th>Full Load Avg Watts</th>
<th>Full Load % of REC</th>
<th>Full Load Watt Secs</th>
<th>Idle Avg Watts</th>
<th>Idle % of REC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database Server</td>
<td>0.85</td>
<td>1,701.27</td>
<td>14.6%</td>
<td>12,249,162</td>
<td>1,315.87</td>
<td>12.4%</td>
</tr>
<tr>
<td>Storage</td>
<td>4.54</td>
<td>9,081.84</td>
<td>77.7%</td>
<td>65,389,258</td>
<td>8,431.85</td>
<td>79.5%</td>
</tr>
<tr>
<td>Application Server</td>
<td>0.38</td>
<td>769.64</td>
<td>6.6%</td>
<td>5,541,428</td>
<td>722.20</td>
<td>6.8%</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.06</td>
<td>129.94</td>
<td>1.1%</td>
<td>935,536</td>
<td>130.03</td>
<td>1.2%</td>
</tr>
<tr>
<td>Total REC</td>
<td>5.84</td>
<td>11683</td>
<td>100%</td>
<td>84,115,385</td>
<td>10600</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Total SUT Work

<table>
<thead>
<tr>
<th>Description</th>
<th>Watts / tpsE</th>
<th>Full Load Avg Watts</th>
<th>Full Load % of REC</th>
<th>Full Load Watt Secs</th>
<th>Idle Avg Watts</th>
<th>Idle % of REC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total SUT Work</td>
<td>14,408,064</td>
<td>14,408,064</td>
<td>100%</td>
<td>84,115,385</td>
<td>10600</td>
<td>100%</td>
</tr>
</tbody>
</table>

Total REC Energy Consumption = 84,115,385 watt-seconds
SUT Total Work = 14,408,064 transactions

84,115,385 watt-seconds / 14,408,064 = 5.84 watts / tpsE

### B.2.2. Secondary Metrics At Reported Performance

If the TPC-Energy Secondary Metrics are reported, the components of the REC that are included in each subsystem must be identified. This can be achieved with separate lists to be included in the FDR or with a specific designation in the price spreadsheet. Every component in the REC that consumes energy must be included in exactly one subsystem.

TPC-Energy secondary metrics are reported.
For each defined subsystem, the calculations defined for the TPC-Energy Secondary Metrics in Clause 3.3 must be reported, using the Performance Metric of the entire SUT and the energy consumption for each REC subsystem.

### Secondary Metrics

<table>
<thead>
<tr>
<th>Watts / tpsE</th>
<th>Full Load Avg Watts</th>
<th>Full Load % of REC</th>
<th>Full Load Watt Secs</th>
<th>Idle Avg. Watts</th>
<th>Idle % of REC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Database Server</strong></td>
<td>0.85</td>
<td>1,701.27</td>
<td>14.6%</td>
<td>12,249,162</td>
<td>1,315.87</td>
</tr>
<tr>
<td><strong>Storage</strong></td>
<td>4.54</td>
<td>9,081.84</td>
<td>77.7%</td>
<td>65,389,258</td>
<td>8,431.85</td>
</tr>
<tr>
<td><strong>Application Server</strong></td>
<td>0.38</td>
<td>769.64</td>
<td>6.6%</td>
<td>5,541,428</td>
<td>722.20</td>
</tr>
<tr>
<td><strong>Miscellaneous</strong></td>
<td>0.06</td>
<td>129.94</td>
<td>1.1%</td>
<td>935,536</td>
<td>130.03</td>
</tr>
<tr>
<td><strong>Total REC</strong></td>
<td>5.84</td>
<td>11683</td>
<td>100%</td>
<td>84,115,385</td>
<td>10600</td>
</tr>
</tbody>
</table>

### Additional Numerical Quantities

<table>
<thead>
<tr>
<th>PMU</th>
<th>Idle Average Watts</th>
<th>% of Reading Uncertainty</th>
<th>Watts Reading Correction</th>
<th>Wattage Range Setting</th>
<th>% of Range Uncertainty</th>
<th>Wattage Range Correction</th>
<th>Total Wattage Correction</th>
<th>Accuracy Correction Factor</th>
<th>Reported Watt Seconds</th>
<th>Adjusted Watt Seconds</th>
<th>Reported Seconds</th>
<th>Adjusted Average Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DB Server PMU-1</strong></td>
<td>1310.87</td>
<td>0.10%</td>
<td>+1.31</td>
<td>1500</td>
<td>0.10%</td>
<td>+1.50</td>
<td>+2.81</td>
<td>0.21%</td>
<td>787,833</td>
<td>789,523</td>
<td>800</td>
<td>1,315.87</td>
</tr>
<tr>
<td><strong>DB Server Total</strong></td>
<td>1310.87</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>787,833</td>
<td>789,523</td>
<td>800</td>
<td>1,315.87</td>
</tr>
<tr>
<td><strong>Storage PMU-1</strong></td>
<td>2542.89</td>
<td>0.10%</td>
<td>+2.54</td>
<td>6000</td>
<td>0.10%</td>
<td>+6.00</td>
<td>+8.54</td>
<td>0.34%</td>
<td>1,528,159</td>
<td>1,533,293</td>
<td>800</td>
<td>2,555.49</td>
</tr>
<tr>
<td><strong>Storage PMU-2</strong></td>
<td>2432.73</td>
<td>0.10%</td>
<td>+2.43</td>
<td>6000</td>
<td>0.10%</td>
<td>+6.00</td>
<td>+8.43</td>
<td>0.35%</td>
<td>1,462,072</td>
<td>1,467,140</td>
<td>800</td>
<td>2,445.23</td>
</tr>
<tr>
<td><strong>Storage PMU-3</strong></td>
<td>2456.13</td>
<td>0.10%</td>
<td>+2.48</td>
<td>6000</td>
<td>0.10%</td>
<td>+6.00</td>
<td>+8.46</td>
<td>0.34%</td>
<td>1,476,137</td>
<td>1,481,219</td>
<td>800</td>
<td>2,468.70</td>
</tr>
<tr>
<td><strong>Storage PMU-4</strong></td>
<td>956.88</td>
<td>0.10%</td>
<td>+0.98</td>
<td>3000</td>
<td>0.10%</td>
<td>+3.00</td>
<td>+3.96</td>
<td>0.41%</td>
<td>575,082</td>
<td>577,460</td>
<td>800</td>
<td>962.43</td>
</tr>
<tr>
<td><strong>Storage Total</strong></td>
<td>8388.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,041,450</td>
<td>5,059,113</td>
<td>8,431.85</td>
<td></td>
</tr>
<tr>
<td><strong>App Server PMU-1</strong></td>
<td>718.78</td>
<td>0.10%</td>
<td>+0.72</td>
<td>1500</td>
<td>0.10%</td>
<td>+1.50</td>
<td>+2.22</td>
<td>0.31%</td>
<td>431,989</td>
<td>433,323</td>
<td>800</td>
<td>722.20</td>
</tr>
<tr>
<td><strong>App Server Total</strong></td>
<td>718.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>431,989</td>
<td>433,323</td>
<td>800</td>
<td>722.20</td>
</tr>
<tr>
<td><strong>Misc PMU-1</strong></td>
<td>101.16</td>
<td>0.10%</td>
<td>+0.10</td>
<td>600</td>
<td>0.10%</td>
<td>+0.60</td>
<td>+0.70</td>
<td>0.69%</td>
<td>60,799</td>
<td>61,221</td>
<td>800</td>
<td>102.03</td>
</tr>
<tr>
<td><strong>Monitor Name Plate</strong></td>
<td>28</td>
<td>0.00%</td>
<td>+0.00</td>
<td>0</td>
<td>0.00%</td>
<td>+0.00</td>
<td>0.00%</td>
<td></td>
<td>16,800</td>
<td>16,800</td>
<td>800</td>
<td>28.00</td>
</tr>
<tr>
<td><strong>Misc Total</strong></td>
<td>129.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>77,599</td>
<td>78,021</td>
<td>800</td>
<td>130.03</td>
</tr>
<tr>
<td><strong>REC Total</strong></td>
<td>10,547.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6,338,872</td>
<td>6,359,978</td>
<td>10,600</td>
<td></td>
</tr>
</tbody>
</table>

B.2.3. Idle Power reporting

The Idle Power measurement/calculation for the REC must be reported as numerical quantities.

The Idle power measurement for REC = 10,600 watts.

If TPC-Energy Secondary Metrics are reported, then the Idle Power measurement/calculation for each subsystem must also be reported as numerical quantities.
The length of time between the conclusion of the performance measurement and the start of the idle measurement must be reported.

Idle measurement was started 12 minutes after all data processing was completed.

The duration of the idle measurement must be reported

Idle measurement duration was 10 minutes.

A statement is required that assures that the system is in a state that is ready to run the Application(s) of the benchmark for the duration of the idle measurement.

The system is in a state that is ready to run the Application(s) of the benchmark for the duration of the idle measurement. This was verified by executing one transaction after the idle measurement interval was completed. The transaction time was compared to the allowed 90th percentile and found to meet the required specifications.

B.2.4. Disclosure requirements when only part of the REC is measured for power

If all PMU’s of the REC are not measured for energy use, the FDR must include a description of which PMUs of REC were measured with a power analyzer. The FDR must disclose which PMUs of the REC were computed based on the energy measurements of similar PMUs. A diagram must be included that identifies the portions of the configuration which were measured for energy use and which were calculated. This diagram may be combined with other diagrams required by the TPC Benchmark Standard.

- The method used to determine which PMUs were measured must be disclosed.
- The power values for the each partial-REC measurement for duration of the performance and idle measurements must be disclosed.
- The calculation for the power requirements of the entire REC and, if applicable, each subsystem must be disclosed.

The monitor power consumption in the Miscellaneous Subsystem was calculated using the nameplate value.

B.2.5. Disclosure requirements when component substitution is used

If the TPC Benchmark Standard allows the Priced Configuration to differ from the Measured Configuration, the methods used to assign energy or power characteristics to the substitute components must be disclosed.

The Priced Configuration was identical to the Measured Configuration.
The method used to determine which PMUs were measured must be disclosed.

All priced PMUs were measured except for the monitor which the nameplate value was reported.

The power values for the each partial-REC measurement for duration of the performance and idle measurements must be disclosed.

See Chart Above.

### B.3. TPC-Energy Clause 4-related items (Drivers /Controller)

A statement indicating the version of EMS used must be included in the FDR, including a statement that no alterations of this code were made for the benchmark, except as specified by Clause 7.3.4.3. This includes levels for the EMS-PTD Manager, EMS-PTD and EMS-controller

EMS version was 1.1.1 and no alterations were made.

Input parameters for the EMS software must be disclosed

Any changes in the EMS components must be documented. Documentation must include a description of the issue, the reason the change was necessary for disclosure of the Result, and the changes made to resolve it. Any change to TPC-Provided Code must be included with the submission as a Supporting File.

No changes to EMS components were made.

### B.4. TPC-Energy Clause 6-related items (Instrumentation)

#### B.4.1. Power Analyzer information
# Power Analyzer Specifications and Settings

<table>
<thead>
<tr>
<th>PMU</th>
<th>Make</th>
<th>Model</th>
<th>Serial Number</th>
<th>Calibration Date</th>
<th>Wattage (W)</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
<th>% of reading</th>
<th>% of Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB Server PMU-1</td>
<td>Yokogawa</td>
<td>WT210</td>
<td>91J713272</td>
<td>8/26/2009</td>
<td>1500</td>
<td>300</td>
<td>5</td>
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<td>Storage PMU-1</td>
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<td>WT210</td>
<td>91GB53023</td>
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<td>300</td>
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<td>91GC21887</td>
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<td>2</td>
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</tbody>
</table>

## B.4.2. Temperature Sensor information

Make and model:
Digi Watchport/H Temperature Probe.

Accuracy and the source of info:
Temperature accuracy from Manufacturer’s Datasheet:
+/- 3.6°F (+/- 2°C) at -40°F to 14°F (-40°C to -10°C)
+/- 0.9°F (+/- 0.5°C) at 14°F to 185°F (-10°C to 85°C)

## B.5. TPC-Energy Clause 8-related items

### B.5.1. Auditor’s attestation letter.

June 20, 2010

Mr. Paul Cao  
Senior System Engineer  
Hewlett-Packard Company  
20555 SH 249  
Houston, TX 77070  

I have verified by remote the TPC Benchmark™ E for the following configuration:  
Platform: HP ProLiant DL580 G7  
Database Manager: Microsoft SQL Server 2008 R2 Enterprise Edition  
Transaction Monitor: Microsoft COM+

<table>
<thead>
<tr>
<th>System Under Test:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CPU’s</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>4 Intel 8 core @ 2.3 Ghz</td>
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<tr>
<td>4 Clients (Tier A): ProLiant DL360 G5</td>
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<tr>
<td>1 Intel quad core @ 2.50 Ghz</td>
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</tbody>
</table>

In addition to the performance metric, the energy consumption was measured during the performance runs in compliance with the TPC-Energy specification.

- The power analyzers used were verified to be approved and calibrated within one year prior to this measurement.
- The energy measurements met all requirements of the specification unless an exception is noted below.
- The calculations for the TPC-Energy Primary Metric were verified as completed correctly.
- The EMS software was verified to be the correct version and without any changes.
- The executive summary page and the FDR were verified for accuracy.

Auditor’s Notes: None.

Sincerely,

Lorna Livingtree, Certified Auditor
## B.6. TPC-Energy Supporting Files Index

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<th>Clause</th>
<th>Description</th>
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<td>REC-Temperature-001.xml</td>
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