

# Environmental Benefits of Thin Computing

*A comparison of the environmental impacts of conventional desktop and thin computing*



*This White Paper has been prepared for Wyse Technology Inc.*

## Overview

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This White Paper examines the environmental benefits of thin computing compared to conventional desktop business PCs. By examining four key issues associated with the environmental aspects of computing in general – energy efficiency, life span/reliability, reduction of hazardous and raw materials, and recyclability – this White Paper provides an analysis showing how thin computing can have a positive environmental impact by reducing the environmental footprint of computing processes. Considering the entire lifecycle from cradle-to-cradle, the Global Warming Potential<sup>1</sup> (GWP) of thin vs. conventional desktop computing is introduced. This analysis and accompanying guidance will facilitate informed decision making and communication with stakeholders.

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<sup>1</sup> Definition GWP: [http://en.wikipedia.org/wiki/Global\\_warming\\_potential](http://en.wikipedia.org/wiki/Global_warming_potential)

## Introduction

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### **The environmental impacts of computing**

In today's world, computers are ubiquitous. They are found at the workplace, in schools, at home, in hospitals, and in cars. All the while, they have an unseen environmental impact in all phases of their lifecycle: from production, through use, and finally in disposal at end-of-life. The global information and communications technology (ICT) industry accounts for approximately two percent of global carbon dioxide (CO<sub>2</sub>) emissions, a figure equivalent to aviation, according to an estimate by Gartner, Inc.

An average desktop computer with monitor requires approximately 10 times its weight in chemicals and fossil fuels to produce.<sup>2</sup> During use, a computer's electricity consumption and, to a lesser degree, heat output, are the most critical impacts on the environment. In fact, it is estimated that 15% of an organization's energy costs and carbon footprint results from information technology use<sup>3</sup>, of which 39% is attributed to the use of PCs. This is of particular concern in an environment of rising or uncertain energy costs. Finally, when a computer is at the end of its useful life, hazardous substances and materials contained in it such as heavy metals and brominated compounds place a burden on the environment, especially if not disposed of properly. According to the National Recycling Coalition, between 1997 and 2007 nearly 500 million personal computers became obsolete.<sup>4</sup> Nearly two million tons of used electronics, including computers and televisions, are discarded each year in the United States, with a continuing upward trend.<sup>5</sup>

### **What are thin clients?**

Thin clients are small, silent devices which communicate with a central server to deliver a computing experience to the user that is largely identical to that of a PC. They have no hard drives, no moving parts, minimum processing power and a relatively small amount of RAM. When a key on the keyboard is pressed or the mouse is moved, the thin client sends this information to the central server which processes the inputs and returns an updated image to the terminal's screen. All applications are stored and run on the server.

### **What is thin computing?**

Thin computing is the combination of a datacenter that stores, controls, and/or executes applications and a thin device that displays the results and handles processing for certain tasks like multimedia and sound.

According to IDC, worldwide enterprise thin client shipments in 2006 reached more than 2.7 million units, a 20% increase over the prior year. IDC expects worldwide enterprise thin client shipments to reach 7.4 million by 2011.<sup>6</sup> IDC also predicts that in mature IT markets, such as the United States and Western Europe, thin clients will represent over 7% of desktop computing devices in 2009 and nearly 11% in 2010.

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<sup>2</sup> "Crucial role of green IT," A.T. Kearney, 2008, <http://www.atkearney.com/main.taf?p=8,2,3,5,1>

<sup>3</sup> "Greening of Government ICT Report", UK Cabinet Office, July 2008.

<sup>4</sup> "Monitoring the Environment," National Recycling Coalition, Oct 2007.

<sup>5</sup> U.S. Environmental Protection Agency (EPA), Fact Sheet, April 2007 (revised July 2008) EPA530-F-08-014, <http://www.epa.gov/epawaste/conserva/materials/ecycle/docs/fact7-08.pdf>

<sup>6</sup> "Connected Clients Study," International Data Corp. (IDC), Bob O'Donnell, October 2006.

## **Environmental analysis of alternatives**

To determine the environmental benefits of thin computing vs. traditional desktop computing, devices should be compared using certain criteria. These are:

- Energy efficiency,
- Life span/reliability,
- Reduction of manufacturing inputs, and
- Recyclability.

At first look the environmental benefits of thin computing over conventional computing may be obvious, but in order to quantify these benefits, a thorough analysis with actual and projected data is necessary. It is also important to consider the additional server hardware and energy required for larger thin computing installations.

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## **Problem Statement**

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In designing more environmentally sustainable solutions for products and processes, one must seek to reduce the consumption of resources and other inputs and similarly to reduce emissions and other outputs. As computer deployment and use has proliferated over the last two decades -- with no signs of slowing down -- computers are increasingly scrutinized for their impact on sustainability. Information Technology purchasers are under growing pressure to invest in computers with minimal environmental impact, due in part to new purchasing policies at various levels of government. To this end, this White Paper examines four specific environmental implications:

- 1) Energy efficiency: Can thin computing significantly lower an organization's environmental footprint by reducing energy consumption and CO<sub>2</sub> emissions during the use phase?
- 2) Life span/reliability: How does device longevity affect environmental impact?
- 3) Reduction of manufacturing inputs: Does the smaller size of thin clients affect the materials and energy needed to produce and ship computing equipment?
- 4) Recyclability: How do thin clients and PCs compare at end-of life?

Climate change is often seen as an organizing principle or common metric for measuring and comparing environmental impact between alternatives. In this case, we will also consider the overall comparative contribution to climate change by examining the global warming potential (GWP) of thin and conventional computing.

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## **Comparative benefits of thin computing**

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There are a number of studies published related to the economical and environmental benefits of thin computing. One such study that was conducted in April 2008 by Germany's Fraunhofer Institute<sup>7</sup> used a lifecycle assessment (LCA) approach to provide a cradle-to-cradle environmental analysis of conventional desktop PC computing and thin computing. This study examined the environmental impacts across each of the key areas of focus and supported findings that thin computing has a lower environmental impact than PCs in every area.

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<sup>7</sup> "Environmental Comparison of the Relevance of PC and Thin Client Desktop Equipment for the Climate," Fraunhofer Institute, 2008, [http://it.umsicht.fraunhofer.de/TCecology/docs/TCecology2008\\_en.pdf](http://it.umsicht.fraunhofer.de/TCecology/docs/TCecology2008_en.pdf)

## 1.0 Energy efficiency <sup>8</sup>

While conventional desktop PCs consume an average of 85 to 110 Watts (W), thin clients typically consume 6 to 15 Watts. When including the prorated portion of the server operation and data room cooling, a thin computing system consumes an additional 2 to 7 Watts more per unit in all modes.

Table 1 below examines the energy consumption (kWh), electricity cost (\$), and CO<sub>2</sub> emission (lbs) of three PC and thin computing installations. A small business is represented by the 100 unit example, a medium-sized business by 1,000 units, and a large enterprise is represented by 5,000 units to illustrate the relative magnitude of results for these types of installations.

The scenario in the table below uses EPA/LBNL assumptions of 2,601 hours per year of active and idle mode for thin computing and PCs with power management (PM) enabled, and 6,293 hours per year for PCs without PM enabled. Thin computing and PM-enabled PCs are typically in sleep mode for 2,947 hours per year, while PCs without PM enabled won't go into sleep mode. All scenarios assume 3,121 hours per year at a 36% night time and weekend turn off rate.

The additional server burden in a thin client computing environment has been taken into account where appropriate for all power modes below, as these typically run continually regardless of the client power mode. More details and additional assumptions for Table 1 are provided in the Appendix.

**Table 1.** Comparison of PC and thin computing energy consumption, electricity cost, and CO<sub>2</sub> emissions.

Examples of small, medium and large installations.	Average power consumption (W) per unit				Power consumption per year (kWh)	Operational phase over 5 years		
	Active	Idle	Sleep	Off		Consumption (kWh)	Electricity cost (\$)	CO <sub>2</sub> emissions (lbs)
100 Thin clients (32-bit)	19.4	18.4	8.8	6.9	13,023	65,115	6,199	100,277
100 Thin clients (64-bit)*	15.0	14.0	4.4	2.5	5,575	27,875	2,654	42,927
100 PCs without PM**	110	85.0	-	3.0	54,733	273,666	26,053	421,445
100 PCs with PM**	110	85.0	4.0	3.0	24,530	122,650	11,676	188,880
1000 Thin clients (32-bit)	19.4	18.4	8.8	6.9	130,230	651,152	61,990	1,002,773
1000 Thin clients (64-bit)	16.3	15.3	5.7	3.8	78,094	390,468	37,173	601,321
1000 PCs without PM	110	85.0	-	3.0	547,331	2,736,655	260,530	4,214,449
1000 PCs with PM	110	85.0	4.0	3.0	245,299	1,226,495	116,762	1,888,802
5000 Thin clients (32-bit)	19.9	18.9	9.3	7.4	688,392	3,441,960	327,675	5,300,618
5000 Thin clients (64-bit)	16.5	15.5	5.9	4.0	405,364	2,026,821	192,953	3,121,304
5000 PCs without PM	110	85.0	-	3.0	2,736,655	13,683,275	1,302,648	21,072,244
5000 PCs with PM	110	85.0	4.0	3.0	1,226,495	6,132,475	583,812	9,444,012

\* 64-bit OS on datacenter servers provides additional user density for a given server. No additional servers required.

\*\* PC energy use only: assumes no addition datacenter server burden

This analysis illustrates the significant impact that thin computing can have in terms of energy cost savings and greenhouse gas emissions reductions. For large enterprise-scale installations, cost savings

<sup>8</sup> The examples in the methodology and procedure should be used as guidelines that can be applied to your specific environment and infrastructure. The calculated results are relative. Changing certain parameters in the calculation will not change the overall ratio of power consumption between different devices.

can be in the hundreds of thousands of dollars per year, and commensurate emissions reductions available in the millions of pounds of CO<sub>2</sub>.

## 2. Life span/reliability

On average, thin clients last twice as long as conventional desktop PCs. A PC is typically considered obsolete after just three years (or two Moore’s Law cycles) because of advances in computing speed, storage capacity, and hardware/software functionality. By contrast, because a thin client has no hard drive and hosts no applications, it does not outlive its usefulness in the same time period.

In addition, the larger number of moving parts contained in a PC leads to greater chance of mechanical failure. With no moving parts, such as disk drives and fans, thin clients tend to have a lower failure rate. According to Gartner, the MTBF of the average thin client is roughly 175,000 hours, compared to the PC average of approximately 25,000 hours.<sup>9</sup> This results in a longer lifespan for thin clients, typically five to seven years. Another consideration directly related to the higher reliability of thin clients is the reduced carbon emissions from transportation (parts and unit shipments for off-site repair) due to fewer lifetime service incidents.

Environmental benefits accrue from this extended lifespan both in terms of production inputs and waste generation. Based on assumptions of replacement rates noted above and an assumed average weight of 24 pounds for desktop PCs and 6 pounds for thin clients, an 82% reduction in materials is predicted. For example, when normalized over an annual period, a 100-seat thin client installation results in 680 fewer pounds per year of waste equipment. A 5,000 seat installation saves approximately 34,000 pounds of e-waste per year. This further translates to commensurate reductions in packaging waste, raw materials, and energy inputs for production and shipping, which will be discussed in greater detail in the following section.

**Table 2.** Comparison of PC and thin computing materials consumption due to lifespan and reliability benefits.

Size of installation	100 seats		5,000 seats	
	PC	Thin client	PC	Thin client
Hardware type	PC	Thin client	PC	Thin client
Average weight per unit (lbs)	24	6	24	6
Typical replacement schedule	3 years	5 years	3 years	5 years
Total weight (lbs) over 20 years*	16,000	2,400	800,000	120,000
Normalized weight per year	800	120	40,000	6,000
Weight reduction per year (lbs)	680		34,000	
Weight reduction (percent)	82%		82%	

\* Total weight over 20 years = average weight per unit / replacement schedule x installation size x 20

<sup>9</sup> “Thinking Thin,” Processor, Jan 20, 2006, [www.processor.com/editorial/article.asp?article=articles%2Fp2803%2F32p03%2F32p03.asp](http://www.processor.com/editorial/article.asp?article=articles%2Fp2803%2F32p03%2F32p03.asp)

### **3. Reduction of hazardous and raw materials**

Manufacturing a single computer requires raw materials (metals and fossil fuels), water, electricity, and chemicals. The fewer components a device contains, such as in the case of a thin client, the fewer resources are typically required. A reduced number of components also require fewer electromechanical connections (solder joints) and fewer mechanical fasteners and adhesives.

In addition, thin clients are approximately 60 - 70% lighter in weight and smaller in size than PCs. This directly affects transportation needs and associated CO<sub>2</sub> or greenhouse gas (GHG) emissions. Due to their smaller size, more thin clients can be shipped in the same container, lowering fuel requirements and the environmental impact per unit shipped. Smaller items also require less packaging, which both consumes raw material resources and energy and contributes to generation of solid waste. Since each case is unique, the specific effects of device size on materials usage and shipping impact should be determined through a lifecycle assessment (LCA) study.

### **4. Recyclability**

While computer hardware recycling dates back more than two decades, there has been an increase in focus since introduction (in 2001) and implementation (in 2006) of the European Union's Waste Electrical and Electronic Equipment Directive (WEEE) Directive. Since all computers contain various levels of heavy metals and flame retardants in plastics, the reduced number of internal components in thin clients directly results in fewer hazardous materials to be disposed of at the end of the product life. Modern recycling operations are typically able to recover greater than 90% of thin client device components for the secondary metals and other recycle markets. Like conventional PCs, recovered thin clients typically return value to the process, but must be handled in an environmentally responsible manner.

In economic terms, smaller size of thin clients noted above results in lower landfill taxes on hardware disposed. Although per-pound costs to dispose of non-CRT e-waste can be relatively low in North America, large installations of 50,000 units can realize upwards of \$91,000 saved per year by switching from desktops to thin clients.

### **Global Warming Potential: An organizing principle**

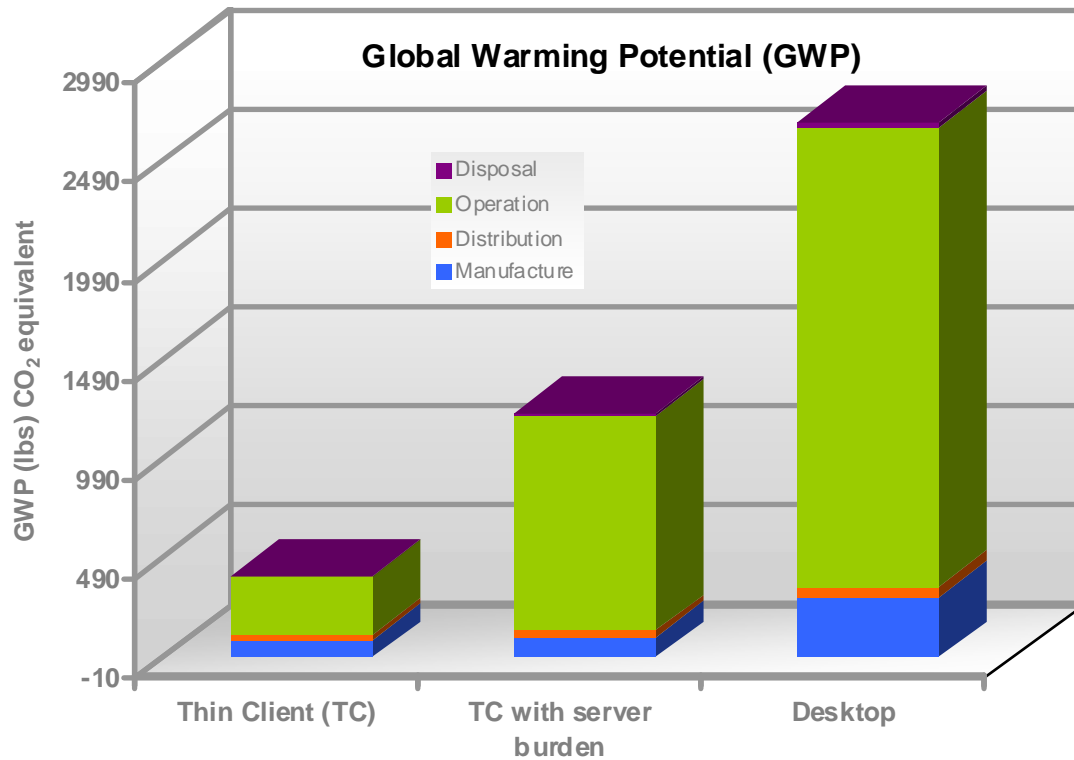
It is useful to compare alternatives across all phases of product lifecycle and against a common metric. In this case, an examination of the Global Warming Potential (GWP) shows us that most CO<sub>2</sub> emissions occur during the operating phase, typically due to consumption of energy that is associated with greenhouse gas emissions.

Depending on the mix of the energy generation sources (various contributions from natural gas, fossil fuel, nuclear or renewable energy), the CO<sub>2</sub> emission output may vary. For the operating phase, data from the GEMIS<sup>10</sup> program was used. Data for all other phases came from the IVF, 2007 EuP study.

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<sup>10</sup> "Global Emission for Model Integrated Systems," Oeko Institut: November 2008, <http://www.oeko.de/service/gemis/de/index.htm>

**Figure 1.** Relative contribution of Global Warming Potential (GWP) of thin computing and desktop PCs across lifecycle phases.



## Implications for an Organization

### How to use the above information

This White Paper is intended to raise awareness of the environmental benefits of thin computing and provide the user information need to develop a framework for considering environmental impacts while evaluating computing investments. The information and data points provided can be used to build a model for a sustainable computing project that corresponds to the individual applicable scenario.

### How to project specific benefit for your organization

Thin computing provides a viable way to provision desktop hardware in low-intensity, standardized desktop environments and appeal to stakeholders eager to “green” their organization and reduce the overall environmental footprint of an organization.

Start with an assessment of your current IT infrastructure including the current usage pattern of desktops throughout the organization and project future computing needs. Define the environmental benefits that are important for your organization and evaluate the value of a thin computing vs. conventional desktop strategy. Consider the entire product life span from procurement to disposal/recycling.

### **How to measure and communicate this benefit to your stakeholders**

Create a “thin-computing environmental benefits” overview by using some or all of the examples discussed in this paper. Apply this to the context of the organization’s computing needs and size of installation. Use energy consumption ratings and energy bills to determine actual energy usage to calculate the cost of powering the IT infrastructure. In the case of reducing energy cost, it is important understand current power consumption and usage patterns. Estimate the number of users that could switch to thin computing and calculate the resulting potential power and CO<sub>2</sub> emissions savings. These savings, as well as those derived from an extended lifespan and reduced end-of-life fees, can be considered in the context of acquisition costs for the hardware. It is useful to internalize these normally “hidden” costs and thus widen the analysis to include the manufacture (material resources), operation (power consumption), and final disposition (landfill costs) of the hardware.

The new ENERGY STAR Program Requirements for Computers, Version 5.0<sup>11</sup>, released on November 14, 2008, now includes thin clients, defined as devices with no rotational storage media and intended for permanent location. The finalized requirements in this new specification will go into effect on July 1, 2009, and may be used in the analysis as it provides a standardized approach of measuring power consumption in various operating modes. Companies seeking to become carbon neutral need to determine actual emissions and create programs to offset this footprint.

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## **Summary and Conclusions**

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It is no longer the case that IT purchasers are solely interested in cost and performance. Environmental concerns are playing an increasingly important role in IT procurement as organizations become more and more sensitized about the environment and are particularly concerned about the energy efficiency of IT equipment.

As the cost of hardware decreases and the cost of service, energy, and waste disposal rises, the environmental and economic advantages of thin computing grow.

Thin computing fares much better than conventional desktop computing from all four perspectives studied in this paper: energy efficiency, life span/reliability, reduction of manufacturing inputs, and recyclability. Consequently there is less of an impact on the environment overall and should be considered as a valuable tool in reaching a company’s environmental goals.

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<sup>11</sup> [http://www.energystar.gov/ia/partners/prod\\_development/revisions/downloads/computer/Version5.0\\_Computer\\_Spec.pdf](http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/computer/Version5.0_Computer_Spec.pdf)

## Appendix

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### 1. Assumptions<sup>12</sup>

- One year has 8,760 hrs (24 hrs x 365 days)
- Active Power is the average amount of energy in Watts (W) the unit consumes when active I/O transactions taking place. The assumed average active power consumption (on mode) for a thin client = 15 Watts (W), based on the power rating of various thin clients on the market<sup>13</sup>. Not factored in is the additional burden on the server side when compared with PC computing environments. The assumed server burden for the case study is explained below.
- The assumed average active power consumption (on mode) for a traditional business desktop PC = 110 Watts.
- Idle Power is assumed when the unit is running on power (on mode), but no I/O transactions taking place and therefore the CPU and graphic processor require slightly less energy. The assumption for a thin client = 10 Watts vs. 85 Watts for a typical PC.
- Sleep Power is the amount of energy in watts the unit uses when in a low-power sleep mode. Assumed is between 4 to 4.4 Watts (the higher number is for the Wake on LAN (WoL) feature commonly used in thin computing environments).
- % Time in Sleep mode is the percentage of time a unit is in the low-power sleep condition during a typical workday. The assumption is set at 58%.
- 36% of computers are assumed to be turned off after work (based on Lawrence Berkeley National Lab data), 100% turned off on weekends and holidays. Off mode means the device still consumes power in average 2-3 Watts.
- No monitors have been included in this case study.

2. **Calculating the Power Consumption (kWh)** = Average Power Consumption (W) in Active Mode \* Total time (Hrs) of Active Mode per year + Average Power Consumption (W) in Idle Mode \* Total time (Hrs) of Idle Mode per year + Average Power Consumption (W) in Sleep Mode \* Total time (Hrs) of Sleep Mode per year \* Operating Phase (Number of years) / 1000.
3. **Calculating the Electricity Cost (\$)** = Total Operating Phase Energy Consumption (kWh) \* Commercial Electricity Cost (\$0.0952/kWh)<sup>14</sup>
4. **Calculating CO<sub>2</sub> Emission (lbs)** = Total Operating Phase Energy Consumption (kWh) \* CO<sub>2</sub> Emission Factor (1.54 lbs/kWh)<sup>15</sup>
5. **Total Energy Consumption (kWh)** includes all the electricity the product consumes during the operation of the various installations over a set period of time (operational phase), in the example 5 years.
6. **Total Electricity Cost (\$)** provides an estimate of the cost to power the various installations over a set period of time (operational phase), in the example 5 years.
7. **Total CO<sub>2</sub> Emission (lbs)** illustrates the CO<sub>2</sub> emissions associated with the operation of the various installations over a set period of time (operational phase), in the example 5 years.

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<sup>12</sup> Based on Department of Energy and EPA data

<sup>13</sup> [www.wyse.com](http://www.wyse.com), power rating in product datasheets

<sup>14</sup> US EPA 2008 Average Commercial Electricity price

<sup>15</sup> US EPA 2008 Electricity to CO<sub>2</sub> Emission conversion factor

## 8. Server burden

The average power consumption of 244 Watts per server is based on the 2005 world data for volume servers<sup>16</sup>. An additional 244 Watts is required for cooling and auxiliary infrastructure in the datacenter and added to the server burden<sup>17</sup>. Given a 24x7 availability, the servers consume 3,890 kWh/year including cooling.

In a typical 32-bit thin computing environment, one server (CPU + RAM + DISKS) supports between 65 and 90 thin clients. In a 64-bit environment, the number of thin clients supported by one server is between 200 to 280 thin clients, depending on the type of application running on the client side.<sup>18</sup> The assumed maximum number of concurrent user sessions (thin clients in use) is 90 on a 32-bit operating system and 280 on a 64-bit operating system.

The calculation in Table 1 also assumes that both thin clients and PCs are connected to at least one server as a baseline. Once the number of concurrent user sessions of thin clients exceeds the maximum number allowed, an additional server is added to the infrastructure.

Based on the above, Table 1 assumes that in a 32-bit environment there is an additional 4.9 Watt server burden per thin client. In a 64-bit environment, which requires less physical server power than a 32-bit environment, the additional server burden is calculated to be up to 1.5 Watts per thin client.

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<sup>16</sup> Jonathan G. Koomey, Ph.D., LBNL, Final report, Estimating total power consumption by servers..., February 2007

<sup>17</sup> Total electricity consumption (including cooling and auxiliary equipment) is twice that of the direct server power consumption, based on typical industry practice (Jonathan G. Koomey, Ph.D., LBNL, Final report, Estimating total power consumption by servers..., February 2007)

<sup>18</sup> Enterprise Application Scaling of 64-Bit Terminal Services: [http://www.scapatech.com/pdf/Enterprise\\_Application\\_Scaling\\_of64Bit\\_TS.pdf](http://www.scapatech.com/pdf/Enterprise_Application_Scaling_of64Bit_TS.pdf)