MSC MALAYSIA
Spearheading Transformation

A CONSULTATIVE STUDY for assessing the feasibility of using refurbished hardware in schools

Ministry of Education, Malaysia

MDEC
Driving Transformation

Contents


District Health Office

A CONSULTATIVE STUDY FOR ASSESSING THE FEASIBILITY OF USING REFURBISHED HARDWARE IN SCHOOLS

1 Introduction

Information and communication technology (ICT) has of late emerged as a very powerful tool for imparting knowledge and training students to successfully face the challenges posed by the information-based global economy. This has further led to an increase in the demand for basic computing hardware in schools, thus straining their limited resources. Governments in many countries are aware of this paradigm shift from pencil and paper-based teaching to an ever-increasing reliance on electronic learning (e-Learning). This is reflected in their respective education policies stressing on the need for greater technology access for students.

Most countries are inhibited by their inability to spend on acquiring new computers due to the paucity of resources. PC refurbishment thus offers an attractive option of being able to provide computer access not only in schools but also to the general population at large.

Many developed countries such as the United States and the United Kingdom are among some of the active donors to a number of hardware refurbishment plans being run either by global organizations such as the United Nations (UN) or by independent, regionalized non-governmental organizations (NGOs). A number of corporations, including vendors from both the hardware and software sectors are also involved in these projects as they see this as part of fulfilling their social responsibility.

In order to achieve the full potential of ICT for enhancing the learning

experience, it is vital to increase the number of students with access to computers. PC refurbishment forms an integral component for the success of programs such as the Smart School initiative in Malaysia. The retrofitted PCs offer an attractive and cost-effective opportunity for installing computers in 10,000 schools across the country.

The Malaysian Context

The former Prime Minister of Malaysia, Dr. Mahathir Mohamad conceptualized the Vision 2020 plan for the country. This vision aimed to map out the steps required for a sustained growth in the long run and achieve all the desired economic and social objectives by 2020.

A technologically literate and analytically thinking population forms the cornerstone of this vision. This coupled with the education system's aim to nurture students into spiritually, intellectually, and emotionally inclined individuals, lead to the formulation of the Smart School Concept.

Smart School is a flagship application of the Multimedia Super Corridor and is driven primarily with the goal of transforming Malaysia into an information-based economy. Based on the concept of e-Learning, this entire application gives rise to the demand in computers.

PC refurbishment is used successfully to cater to this demand in computers despite the availability of low resources. The government bodies, the Multimedia Development Corporation Sdn. Bhd. (MDeC) and the Ministry of Education, Malaysia (MoE) are collectively conducting a pilot project to assess the effectiveness of using such retrofitted computers in the Malaysian environment.

Retrofitted or refurbished computers are second-hand computers that have been repaired, serviced, and upgraded in a manner that suits the ultimate objective which, in this case, is to run Teaching and Learning Materials (TLM) in the classroom environment; they are also used for other relevant PC-based activities.

Additionally, the use of refurbished hardware presents a financially attractive option. The cost effectiveness of using such equipment in the school environment is high over a three- to four-year period, as compared to similar newer hardware. Retrofitted equipment helps to reduce the financial burden for government bodies such as the MDeC and the MoE in providing technology access

to all students. The total cost of ownership analysis, provided later in this document, looks at a cost comparison between deploying refurbished hardware and new equipment.

This document purports to assess the feasibility of this initiative and identify the level of effectiveness of these PCs in teaching, learning, and administrative processes.

1.1 BENEFITS OF PC REFURBISHMENT

PC refurbishment has a number of benefits for both donors and as well as recipients. These benefits not only include the cost effectiveness of using retrofitted equipment, but also work toward achieving desired social objectives of providing technology access.

For providers, the benefits are as follows:

- Making **surplus computers a valuable resource** for schools rather than just electronic waste at an affordable cost
- Contributing to **removing the 'digital divide'** by assisting in providing computer access to all students
- Helping to **develop a workforce** that will be ready to face the challenges of a knowledge-based society
- **Discharging their social responsibility** of providing technology access to a segment of the population that would otherwise not have access to such resources

For recipients, the benefits are as follows:

- Access to technology that would otherwise have proved elusive to use and understand. This would include **hands-on experience** in using various software applications as well
- Preparing them to become part of a **more effective and knowledgeable workforce**
- Refurbishment initiatives help in **reducing the student-to-computer ratio in schools**, thus increasing e-Learning effectiveness
- **Adding to students' skill sets** and expanding their horizons in terms of available information

1.2 CHALLENGES OF PC REFURBISHMENT

Conversely, retrofitting hardware has some challenges, but if proper care is taken when collecting and refurbishing PCs, the impact of these challenges can be obviated in the overall scheme of things. Some causes of concern are as follows:

- Older computers are limited by their functionalities in terms of processing power and compatibility with new hardware. The hardware failure rate is also slightly higher than normal as the equipment reaches the final stage of its life cycle. **However, with proper care, this rate can be kept within acceptable limits. This, coupled with lower replacement costs, tends to negate any large-scale impact of failure**
- Sometimes it becomes impossible to upgrade older PCs due to a number of constraints ranging from obsolete technology to high costs involved. **The impact of these constraints**

can be reduced by setting minimum standards on the types of machines or equipment that are used for retrofitting

- Maintaining older computers might require diverse technical skills in terms of understanding varying technologies. This might pose a problem especially for on-site personnel, such as the ITC in the context of the Malaysian Smart School project. **This issue can be resolved with a proper training mechanism stressing on continuous learning for all support personnel concerned**

- Unlike newer PCs, refurbished PCs do not avail organizations of free technical support. However, **service level agreements can be put in place with vendors to ensure timely support and maintenance**
- Hidden costs in terms of shipping, storage, and hardware upgrades sometimes tend to impose stress on the limited resources available to such projects. **Taking into account the impact of all these individual factors at the planning stage would help to minimize any type of adverse effect in the long run**.

PC refurbishment is being considered as an attractive option that provides technology access to students at lower prices

2 Benchmarking

This section looks at the various PC refurbishment projects carried out across the globe for installing computers in schools. The country case studies featured in this section include Canada, Kenya, Colombia and New Zealand.

Most hardware refurbishment initiatives are carried out by respective federal governments with the aim to provide technology access to students. However, in the case of many African nations, a number of Non-Governmental Organizations (NGO) are responsible for running such projects.

PC refurbishment is being considered as an attractive option that provides technology access to students at lower prices. Such prices enable schools to have a higher number of PCs per classroom, thus enhancing students' learning experience.

Figure 2-1: Standard Configurations of Refurbished Computers given to schools in different parts of the world, 2005

Comparison of Refurbished Computers Provided to Schools				
	Canada	**Columbia**	**Kenya**	**New Zealand**
Maximum Processing Power	Pentium-III 450 Mhz	Pentium-III 300 Mhz	Pentium-III	Pentium-III 1 Ghz
Maximum RAM used	256 Mb	256 Mb	128 Mb	256 Mb
Oldest generation of PC in schools	Intel 486 based computer	Intel 486 based computer	Pentium-I based computer	Pentium-I based computer

Source: Frost & Sullivan, 2005

Apart from governmental organizations, many corporations have also been involved in initiatives for refurbishing hardware. Microsoft launched a program for refurbishing computers in 133 countries across Europe, the Middle East, and Africa in 2004. Most computers distributed through this program use Windows operating system and are

Figure 2-2: Standard Configurations of Refurbished Computers used for the Pilot Phase of the PC Refurbishment Project in Malaysia, 2005

Standard Configuration for the PC Refurbishment Pilot Project	
Processor	Pentium III – 667 Mhz
Operating System	Windows XP Professional
Memory	128 Mb RAM
Hard Drives	10 Gb Hard Disk
Monitors	CRT 15"
Others	Network card; Sound Card/Speaker; CD-ROM; Floppy Drive; Printers (HP Business Inkjet 1000); Keyboard and Mouse
Cost	Provided to Schools **FREE** of cost

Source: Multimedia Development Corporation Sdn. Bhd. (Malaysia), 2005

presented to schools, charities, and other non-profit organizations.

Figure 2-1 shows the standard configurations of refurbished computers given to schools in different parts of the world in 2005.

Figure 2-2 shows the standard configurations of refurbished computers used for the pilot phase of the PC refurbishment project in Malaysia.

Figure 2-2 can also be used to compare the specifications of the computers used in the pilot with the ones given in the case studies.

2.1 CANADA

2.1.1 Background

A pioneer in introducing the use of PCs in schools, Canada has a well-established mechanism to ensure a smooth supply of computers not only for education, but also for various other community projects as well.

The PC refurbishment initiative in this country goes back to the early 1990s when 'Innovators in Schools' program was launched. The main purpose of this program was to increase the students' level of interest in subjects such as science,

engineering, and mathematics. In order to do so, contact between schools and industry professionals were encouraged at the highest levels. Simultaneously, another industry initiative took place to connect some schools together using the Internet. This required the use of large number of computers in schools across the country. Hence, schools were able to leverage on their existing contacts to obtain surplus computers from the industry. This was made possible after some policy changes were implemented at the federal level.

The idea of installing computers in schools started to take shape in 1993 and was given a boost when the government took over the initiative. This helped in bringing even the federal surplus computers into the fold of the project, thus increasing the available school inventory.

TelecomPioneers, a volunteer organization of retired and contemporary telecommunication experts involved with community service across the North American continent, was entrusted the task of setting up Computers-for-Schools (CFS) workshops across the country. This initiative culminated in establishing workshops in every province in Canada and provided over 300 computers to schools within the first six months.

CFS is now a national level government-run project that incorporates help from all the provincial authorities, the private

sector and a multitude of volunteer organizations. The program is responsible for collecting, repairing and retrofitting donated computers from both the public as well as private sectors, and subsequently putting them primarily in schools, followed by other mass use areas such as public libraries. Some Canadian non-profit learning institutions have also benefited through this program.

For encouraging donations of equipment to the CFS program, the Canadian Government also offers tax benefits to companies. This initiative has distributed more than 650,000 computers to various schools and libraries across Canada. Due to its extensive support base, the program is now able to distribute up to 70,000 to 80,000 computers annually through more than 50 refurbishing workshops across the country. These workshops employ volunteers such as students and former telecom workers.

The CFS model has of late become a very attractive option for various countries to implement at their own national levels. This model has been studied and in some cases successfully implemented by a number of countries including South Africa, Australia, China, the United States, Uruguay, Nigeria, Chile, and Colombia.

2.1.2 Current Scenario

Retrofitting old hardware has now become a common practice throughout the world. This process not only helps in managing the electronic waste being produced, but also provides an effective option for providing low-cost computing equipment. The different stakeholders involved in the CFS believe that the schools now need to focus on having efficient PC disposal mechanisms as well for end-of-life equipment.

In most scenarios where refurbished PCs are installed in schools, the average life span of such computers is three years. Out of all the hardware that CFS receives from donors, only 50 percent is useful and can be reworked for use. The success of this program at the national level has seen CFS receiving up to 120,000 computers every year from various sources.

CFS has managed to improve on its output level and is currently distributing 100,000 computers in schools every year. This has led to an increase in the PC-to-student ratio, which currently stands at one computer for every five students. The number of workshops retrofitting hardware has also increased from 50 to 55.

Thirteen years of the CFS program has had a large impact on the ICT situation in schools with the ratio of students to computers rapidly declining.

Figure 2-3 shows the availability of computers in elementary and secondary schools across Canada in 2004.

Figure 2-3: ICT Availability of Computers in Elementary and Secondary Schools (Canada), 2004

ICT in Canadian Elementary and Secondary Schools			
	All Schools	**Primary**	**Secondary**
Number of schools	15,500	10,100	3,400
% of schools with Internet-ready PCs	97.7	98.2	99.1
Average number of computers per school	71.6	53.2	134.2
Median number of students per computer	5	5.5	4.3

Source: Information and Communications Technologies in Schools Survey (Canada), 2004

Figure 2-4 shows the standard configurations for refurbished computers provided to schools under the CFS program in Canada during 2005.

The standard CFS configuration mentioned in Figure 2-4 costs RM273.31 to provide to schools. Given that the equipment is available to schools free of cost, CFS is dependent on donations from the government, the private sector, and other volunteer organizations for its operations.

CFS has a certain minimum standard for accepting PCs for refurbishment. This helps in setting an efficient clearing mechanism and accelerates the process of retrofitting PCs that are shipped to schools. For Windows-based computers, it accepts only Pentium class and above PCs, whereas Macintosh-based machines use Power PC level and above. The most current demand is for Windows-based computers, as

Figure 2-4: Standard Configurations for Refurbished Computers provided to schools under the CFS Program (Canada), 2005

Standard PC Configuration for CFS	
Processor	Pentium III – 450 Mhz and above (Minimum requirement since 1 July 2005)
Operating System	Windows 98, 2000 and XP installed on P3-450 Mhz systems and above
Memory	64 to 128 Mb RAM on Windows 98 SE based systems 128 to 256 Mb on Windows 2000 and XP based systems
Hard Drives	Matched with the OS being installed
Monitors	SVGA 15"
Others	Network Card; Floppy Drive; Sound Card; CD-ROM; Printers (Optional); Keyboard and Mouse
Cost	Provided to Schools **FREE** of Cost

Source: Computer for Schools (Canada), 2005

they are most compatible with the different types of software applications that schools tend to use.

Other peripherals and equipment such as color monitors, printers, scanners, servers, CD-ROM drives, keyboards, and mice are also accepted only after they satisfy CFS's acceptance criteria.

Microsoft has an arrangement with some provincial authorities in Canada to provide free operating systems and MS Office for less than RM15.10 per PC per year, for certain disadvantaged schools.

Internet services to schools in Canada are provided through the SchoolNet program. Similar to the Smart School initiative in Malaysia, SchoolNet was established to promote the effective use of information and communication technologies (ICT) in the teaching and learning processes. This program was activated in 1999 with partnerships between the provincial and territorial governments along with the education community and the private sector. According to the 2003-2004 survey, 85.8 percent of the schools in Canada at least have a high-speed line, with the most popular being DSL connections.

The software used in the Canadian schools include word processing applications, Internet browsers, educational (drill and practice) programs, spreadsheet and database applications, presentation software, graphic programs, desktop publishing applications, e-mail software, simulation programs, geographical information systems, mathematical/statistical business-oriented programs, and computer aided design and computer aided manufacturing applications.

2.2 KENYA

2.2.1 Background

The PC refurbishment initiative in Kenya is modeled after the highly successful Computers-for-Schools (CFS) program being run in Canada. The flag bearer of this initiative is the Computers for Schools Kenya (CFSK). Similar to its Canadian counterpart, the CFSK is a non-profit and non-governmental organization. The project is carried out with assistance from the Kenyan Ministry of Education along with some volunteer groups and aid from the private sector. CFSK collects, repairs, retrofits, and distributes them free of cost to secondary schools throughout Kenya.

The aim of this program is to bridge the digital divide between the Kenyan students and their counterparts in other countries. This initiative aims to provide technology access to students for whom this might otherwise prove elusive, as well as practical computing skills that are difficult to comprehend. Both the government and various private sector organizations operating in the country provide computers for this program.

This program has been operational in the country since early 2003, and had started with a pilot program of deploying 200 computers in 10 schools across Kenya. Some of the driving factors behind implementing this plan in Kenya include the following:

- High costs of ICT equipment, hence unaffordable by schools

- Insufficient technical expertise for installation and maintenance of ICT infrastructure in schools
- Insufficient capacity in schools to train students in the use of ICT and make use of advantages offered by e-Learning
- The increasing digital divide between the have and have-nots, thus impacting the country in terms of unskilled workforce

CFSK has a cost-effective and easy-to-manage business model. A number of computer-related issues, starting from providing general support to maintenance of the equipment it distributes are taken care of by it.

As most refurbished computers are provided to schools and community centers free of cost, CFSK has devised its own revenue-generation models to suit the country's economic conditions. The school computer labs are treated as community ICT access points after school hours. This helps in providing access not only to students, but also to the general public.

2.2.2 Current Scenario

Since its inception, the program has come a long way and has been successfully implemented on a larger scale. CFSK now has a very effective and efficient organizational network in the country. Its business model has been developed keeping in mind the specific challenges of operating in the harsh economic and social environment in Kenya.

Hitherto, CFSK has succeeded in expanding its deployment reach to over 151 schools. It has so far managed to deploy 3,000 computers in these schools. The program also provides technical support required for these computers and conducts maintenance checks twice a year to ensure smooth functioning. For certain cases, it has volunteers stationed in some of the schools to take care of support activities. If there are some major issues

that cannot be addressed by these volunteers or the IT teachers themselves, then the equipment is replaced and shifted back to the refurbishment centers.

The program has also been involved in training more than 1,240 IT teachers, principals, parent teacher association (PTA) members, and other general administrative staff.

As CFSK is working towards addressing lack of resources in terms of available manpower, it makes sure that at least two teachers along with the main decision maker in each of the recipient schools are trained in the use of IT for both teaching and administrative purposes. These teachers are given the responsibility of training students and other academic staff on using ICT. CFSK also organizes workshops during school breaks to conduct its own training sessions for the school staff.

Figure 2-5 shows the standard configurations for refurbished computers provided under the CFSK program in Kenya during 2005.

Figure 2-5: Standard Configurations for Refurbished Computers provided to schools under the CFSK Program (Kenya), 2005

Standard PC Configuration for CFSK	
Processor	Pentium I, II or III (300 Mhz and above)
Operating System	Windows 2000 installed on P2-400 Mhz systems and above All other systems will be installed with Windows 98SE
Memory	64 to 128 Mb RAM based on the OS
Hard Drives	2 Gb with Windows 95, 98 and NT; 5Gb with Windows 98, 2000 and XP
Monitors	SVGA 15"
Others	Network Card; Modem; Sound Card (Optional); Video Card (Optional); CD-ROM 8x; Floppy Drive; Stereo Headphones (Optional); Keyboard and Mouse
Cost	Provided to Schools **FREE** of Cost

Source: Computer for Schools (Kenya), 2005

All schools availing the benefits of the CFSK are required to pay a one-time registration and an annual fee to take care of repairs, servicing, and consulting services.

Figure 2-6 shows the pricing of support services provided under the CFSK program in Kenya.

Figure 2-6: Pricing of Support Services provided under the CFSK Program (Kenya), 2005

CFSK Support Services Pricing Structure	
One-time Registration Fee	RM102.88 per computer
Annual Maintenance and Support Charges	RM154.32 per computer per year

Source: Computer for Schools (Kenya), 2005

2.3 COLOMBIA

2.3.1 Background

Another successful implementation of the Canadian CFS concept can be found in Colombia, where the idea was developed further and customized to suit its own social and economic objectives. Known as Computadores para Educar (CPE), which literally means 'Computers for Educating', was established in 2000. CPE is run with government support and donations from the private sector both in terms of funding and equipment.

The central objective of this initiative is to provide refurbished PCs to schools free of cost, so as to ensure that an

increasing number of students have access to technology. In Colombia, this program sources most of its equipment from the corporate sector and relies on their periodic technology replacement cycles for surplus hardware.

Unlike the CFS in Canada, which primarily refurbishes PCs for schools, the Colombian model also takes into account the lack of computing knowledge and public access. Differences between the two programs have emerged over the last few years, as the Colombian initiative has expanded.

One of the primary concerns addressed in formulating a roadmap for CPE was the fact that in Canada, students would have access to computers even outside schools, whereas this is unlikely in the case for a country like Colombia, given that a large majority of the population is economically constrained.

In order to minimize the cost of refurbishment, Colombian authorities have made it mandatory for students enrolled in Servicio Nacional de Aprendizaje (SENA), a national level technical education program, to spend one semester working in the country's five refurbishment centers.

Along with the computers installed in schools, the CPE also provides training to teachers and other on-site personnel. This is one of the differences of the Canadian program, as it is primarily focused on retrofitting and installing computers rather than training users. Teacher training includes both technical aspects of supporting the computing infrastructure as well as the use of e-Learning as an effective teaching tool for enhancing the learning process. Other than teachers, each school is designated a computer specialist, who is given training to handle minor technical issues.

2.3.2 Current Scenario

The success of the program can be measured by the large number of refurbished computers that is available in schools. Since its inception, this initiative has so far distributed 95,000 computers in more than 5,300 institutions throughout Colombia.

To make this program even more effective, the government offers tax credit to companies that donate computers. This, along with discounts given to donors for purchasing new hardware, has led to an increase in the amount of equipment given to CPE for refurbishment.

In 2005 alone, more than 20,000 computers were donated for refurbishment, thus indicating the rising popularity of the program. It also aims to distribute 17,000 PCs to over 1,400 institutions in 2006. Figure 2-7 shows the progress of the CPE program in Colombia from 2000 to 2005.

The CPE program has now reached a critical mass and is able to set the minimum levels of equipment that it is willing to take in for refurbishment. For donations from foreign sources, the guidelines have been made even more stringent such that only Pentium processor PCs are accepted and a minimum

Figure 2-7: Progress of the CPE Program in Colombia, (2000–2005)

Computadores para Educar (CPE), Colombia – A Numerical Perspective							
	2000	2001	2002	2003	2004	2005 (End Sep'05)	Total
Computers received in donation	952	18,641	18,397	19,009	18,824	15,979	**91,802**
Reconditioned computers	378	3,906	10,664	11,340	15,236	13,519	**55,043**
Reconditioned printers	–	429	938	1,489	1,282	1,224	**5,362**
Computers dispatched to schools	–	1,904	9,102	11,778	13,300	9,115	**45,199**
Schools with reconditioned computers	–	332	968	1,256	1,330	769	**4,655**
Potentially benefited teachers	–	3,300	13,092	14,040	16,260	15,522	**62,214**
Potentially benefited students	–	88,770	352,393	340,470	413,275	358,200	**1,553,108**

Source: Computadores para Educar (Colombia), 2005

donation of 30 computers with VGA/ SVGA color monitors is required.

For companies unable to ship equipment to the refurbishment centers, CPE has a facility to collect computers from the donor's premises, provided the minimum criteria for hardware pick up has been met. Figure 2-8 highlights the standard configurations for refurbished computers distributed by CPE to various schools in Colombia.

The CPE program is not only for providing students access to computing technologies, but also to ensure integration of e-Learning methodologies in daily teaching.

Some of the social and economic goals specified in the roadmap for this program are quite similar to the Malaysian Smart School Flagship application.

Figure 2-8: Standard Configurations for Refurbished Computers under the CPE Program, 2005

Standard PC Configuration for CPE	
Processor	486 to Pentium I, II and III
Operating System	Windows OS based on Processor speed (Windows NT, 98SE, 2000 and XP on offer)
Memory	64 to 256 Mb RAM based on the OS
Hard Drives	Matched with the OS being installed
Monitors	VGA & SVGA 15"
Others	Network Card; Multimedia & Fax Modem; CD-ROM; Floppy Drive; Printers (Optional) – (Bubblejet/Inkjet/Laser Printers available); Keyboard and Mouse
Cost	Provided to Schools **FREE** of Cost

Source: Computadores para Educar (Colombia), 2005

Colombia is the third largest and growing Internet market in Latin America; this has filtered down to the school level with speeds up to 128 Kbps available in schools.

2.4 NEW ZEALAND

2.4.1 Background

Computer refurbishment in New Zealand has continued since 1999, when the Computer Access NZ (CANZ) Trust was established. This trust was set up as a coordinated effort between the New Zealand Ministry of Education, various teacher associations, and a number of computer recycling companies.

Learning Power (LP) is a national level program leveraging on the CANZ Trust to provide computers to schools at affordable costs. CANZ refurbishes the hardware and LP helps the schools to buy upgraded computers and peripherals. The largest difference between the LP project and other similar computer for schools projects around the world is that schools are required to pay for the hardware that is used. Depending on the system specifications and the quantity ordered the CANZ Trust sets the pricing mechanisms.

This computer for schools project was formulated as a part of the national government's overall ICT strategy for the country. The aim of this initiative is to address the following:

- Provide good quality computers

to schools in sufficient numbers and at affordable prices
- Assist in solving the e-Waste management issue to a certain degree

Most computers that are collected by the CANZ Trust-accredited companies are refurbished to handle all the popular applications used in schools. These applications include MS Office, access e-mails, browsing Internet, and other e-Learning software. Even if certain hardware does not meet the minimum standard, it is still accepted and its usable parts cannibalized for future use. For the benefit of the schools, computers that satisfy their requirements are categorized under the CANZ Trust's LP brand.

The guiding principles for the LP program are based on a diverse range of issues spanning technical, holistic, and social issues. Some of them include:

- Need for a common minimum standard for PCs that can be used in the classroom environment and other administrative purposes. With a brand categorization in place, the schools do not need to spend much time in checking whether the selected computers meet their requirements
- The most important issue for schools is the availability to acquire the required hardware at acceptable costs. The LP initiative achieves this through the CANZ Trust
- In order to achieve the desired student-to-computer ratio of one computer for every five students, a wholehearted effort is required not only from schools, but also from the corporate world by providing sufficient donations. LP ensures quality of equipment for the schools along with providing them the avenue to source the required quantity.

2.4.2 Current Scenario

Currently, there are two accredited companies associated with the CANZ project. They have also been approved as LP computer equipment suppliers, keeping in view the minimum specifications imposed on them by CANZ. Most of the Trusts' systems are sold with warranties; discounts are available depending on volume, equipment availability, and so forth.

Figure 2-9: Students-to-Computer Ratio (New Zealand), 2005

Students-to-Computer Ratio, New Zealand		
Year	Primary	Secondary
1995	18	10
1999	11	6
2003	7	4

Source: Survey of ICT in Schools, 2003 (Ministry of Education, New Zealand)

Figure 2-9 shows the Students-to-Computer Ratio for New Zealand in 2005.

With the introduction of the LP initiative, the student-to-computer ratio has constantly declined in New Zealand. The last ICT survey conducted by the Ministry of Education, New Zealand, in 2003, revealed that there were four students per one computer in secondary schools, and seven students per computer in the primary schools. For special schools, this ratio was even lower with one computer for every three students.

CANZ enforces its pricing mechanisms stringently to ensure that schools enjoy good deals for their desired configurations and quantity. Prices would be further decreased, if the schools decide to go for lower performance equipment in terms of RAM, hard disk, or monitor size, or even if they decide to install the software themselves.

The New Zealand Ministry of Education has licensing agreements in place with Microsoft to ensure the availability of Windows XP professional version for all refurbished PCs. These computers also come with pre-installed software such as

Office XP and Encarta Encyclopedia to enhance the learning experience.

Figure 2-10 shows the standard configurations for refurbished computers under the CANZ initiative in New Zealand during 2005.

Schools in New Zealand are provided Internet access at very high speeds, with secondary school students accessing the net at speeds as high as 512 Kbps. According to the 2003 School ICT Survey, 90 percent of the secondary school students had access to high speed Internet through school computers; conversely, this number was merely 34 percent in the case of primary school students.

The software applications currently being used in schools in New Zealand include MS Office Suite, MS Publisher, multimedia players (Real Player, QuickTime), MS FrontPage, Adobe Photoshop, video editing applications (iMovie, Pinnacle), MS Works, AppleWorks, Visual Basic, Dreamweaver, Kid Pix, Hyper Studio, Creative Writer/Fine Artist, Lotus SmartSuite, Open Office, and Star Office.

Figure 2-10: Standard Configurations for Refurbished PC under the CANZ Initiative (New Zealand), 2005

Standard PC Configuration for CANZ			
	Basic WorkHorse	**Higher performance**	**High performance**
Processors	Pentium II – 350 Mhz	Pentium III – 500 Mhz	Pentium III – 1 Ghz
Operating System	Windows XP Professional		
Memory	128 Mb RAM	192 Mb RAM	256 Mb RAM
Hard Drives	6 Gb	10 Gb	20 Gb
Monitors	17" Monitors		
Others	Network Card; Modem; Sound Card; CD-ROM; Floppy Drive; Keyboard and Mouse		
Cost	**US$ 174.82**	**US$ 244.75**	**US$ 314.68**

Source: Computer Access NZ Trust (New Zealand), 2005


ABDULLAH

The aim of this pilot is to assess the feasibility of using refurbished PCs in *Pembestarian* of 10,000 schools throughout the country.

3 Strategic Analysis

The Ministry of Education (MoE), Malaysia along with the Multimedia Development Corporation (MDeC) has implemented a refurbished PC pilot project in two select schools. The aim of this pilot is to assess the feasibility of using refurbished PCs in *Pembestarian* of 10,000 schools throughout the country. Frost & Sullivan has conducted a feasibility study for the same.

The refurbished hardware pilot was conducted over a period of three months starting July 2005 to October 2005. The two schools used for the pilot project include the following:

- **Secondary School:** SMK Sungai Kapar Indah, Klang
- **Primary School:** SK Bukit Rimau, Shah Alam

Two vendors, Basis Bay Sdn Bhd and ePixel (M) Sdn Bhd, were selected based on their initial proposals by MDeC and MoE to provide refurbished hardware. This

hardware was provided to the schools on a loan basis for the duration of the pilot project over three months. These vendors provided 20 refurbished PCs, one refurbished server, and a printer each to the schools.

As the schools selected for the pilot are yet to be made Smart Schools, teachers from both the institutions underwent a one-day training organized by the MDeC and the MoE. The objective of the training was to enable the teachers to understand how Smart School and other MoE Teaching and Learning Materials (TLM) can be integrated in their daily classroom activities.

Figure 3-1 gives a snapshot of the refurbished hardware pilot project conducted in Malaysia in 2005.

Figure 3-1: Snapshot of the Refurbished Hardware Pilot Project (Malaysia), 2005

School	
SK BUKIT RIMAU	**SMK SUNGAI KAPAR INDAH**
Vendor	
Basis Bay Sdn Bhd	**ePixel (M) Sdn Bhd**
Specifications	
SERVER	
Brand: Dell (second hand)	Brand: IBM (refurbished)
Pentium IV 2.8 Ghz Processor	Pentium III 800 Mhz Dual Processor
256 Mb RAM	512 Mb ECC RAM
80 Gb Hard Disk	18GB X 3 SCSI Hard Disk
1 Gb Network Card	10/100 Network Card
17" Dell Monitor	17" Monitor
Integrated Sound Card	Integrated Sound Card
CD-ROM Drive	CD-ROM Drive
1.44 Mb Floppy Disk Drive	1.44 Mb Floppy Disk Drive
Mouse and keyboard	Mouse and keyboard
DESKTOP	
Brand: Dell (refurbished)	Brand: Ipex (refurbished)
Pentium III 677 Mhz	Pentium III 700 Mhz
128 Mb RAM	128 Mb RAM
10 Gb Hard Disk	20 Gb Hard Disk
10/100 Network Card	10/100 Network Card
15" CRT Monitor	17" IPEX Monitor
Sound Card/Speaker	Built-in speaker
CD-ROM Drive	CD-ROM Drive
1.44 Mb Floppy Disk Drive	1.44 Mb Floppy Disk Drive
Mouse	IBM scroll point mouse
Keyboard	IPEX PS2 Keyboard
PRINTER	
Brand: HP (new)	Brand: HP (refurbished)
HP Business Inkjet 1000	HP Laser Plus Fax Model 3150

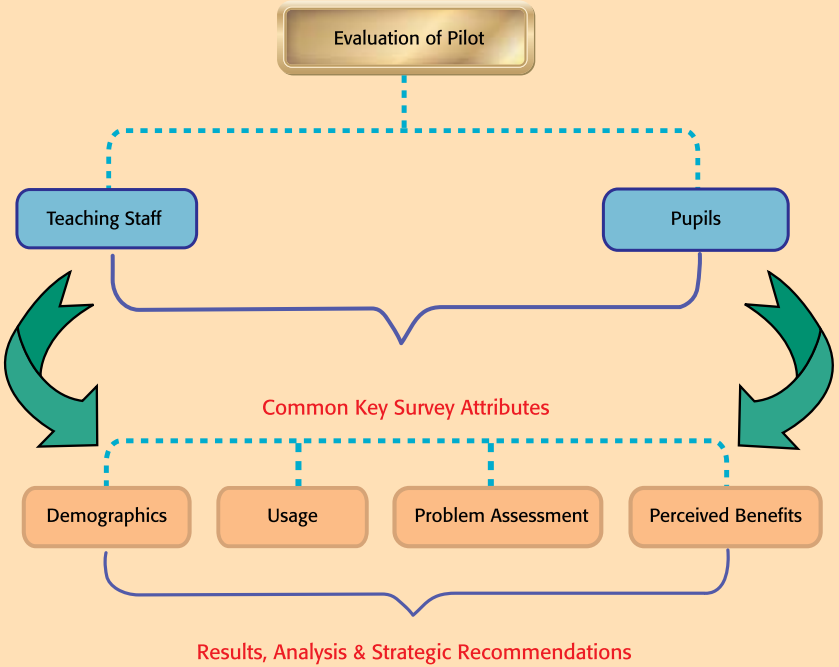
Source: Multimedia Development Corporation, Malaysia' 2005

METHODOLOGY AND APPROACH

A total of 348 students, 24 teachers, and two IT coordinators were interviewed as part of this feasibility assessment study. The sample of the survey was divided between one primary and secondary school each, depending on their enrolment.

Chart 3.1 provides the scope of the PC refurbishment feasibility assessment study conducted in Malaysia in 2005.

Chart 3.1: Scope of the PC Refurbishment Feasibility Assessment Study (Malaysia), 2005



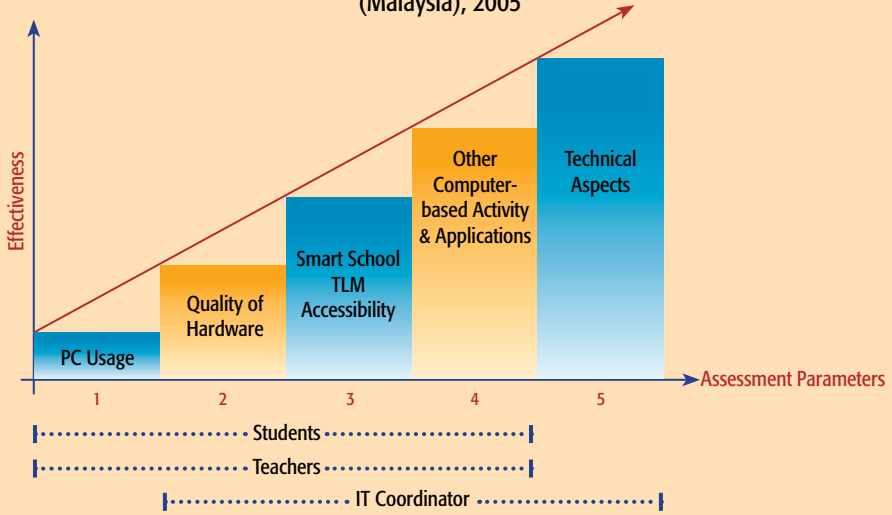
Source: Frost & Sullivan, 2005

The Frost & Sullivan Management Information System (MIS) Support Professionals conducted stress tests to assess the performance of the refurbished hardware, details of which are given later in the document. Information on the usage of the computers for both accessing TLM and performing other activities was collected to obtain an overall idea of the success or failure of the refurbished PCs in the school environment.

Most of the hardware was assessed based on the five main parameters addressing issues faced by all the stakeholders. The parameters range from the usage of the hardware, quality of equipment, effectiveness in accessing TLM, assisting in administration of teaching and learning, to technical issues such as compatibility, network integration and stress testing.

Chart 3.2 provides the assessment approach adopted to assess the refurbished hardware pilot in Malaysia in 2005

Chart 3.2: Assessment Approach Adopted for the Refurbished Hardware Pilot (Malaysia), 2005



Source: Frost & Sullivan, 2005

3.1 SURVEY FINDINGS

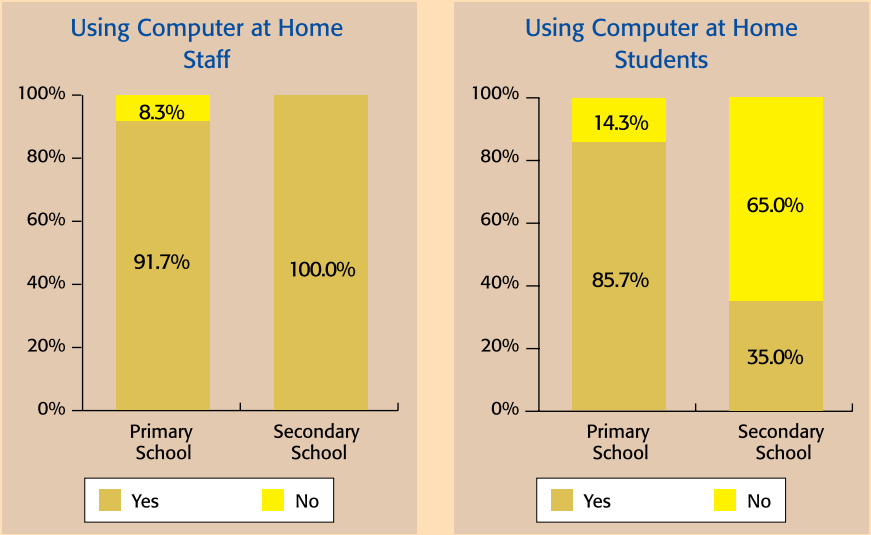
For assessing the refurbished equipment, a two-pronged approach was followed. Feedback was collected from the various users about the functioning of the equipment. The hardware was also examined and its performance assessed by the MIS support professionals from Frost & Sullivan. This section contains information collected from all the sources. The breakdown of respondents from whom this data was collected is as follows:

Respondent Profiles			
	Teachers	IT Coordinator	Students
Primary School	11	1	64
Secondary School	13	1	284
Total Respondents	24	2	348

Most of the staff and students surveyed have access to computers at home, thus providing them with a valid point of reference to compare the performance of the refurbished PCs.

Chart 3.3 shows the ratio of staffs and students from the pilot schools that have access to computers at home.

Chart 3.3: Ratio of Staff and Students from the Pilot Schools Accessing Computers at Home (Malaysia), 2005

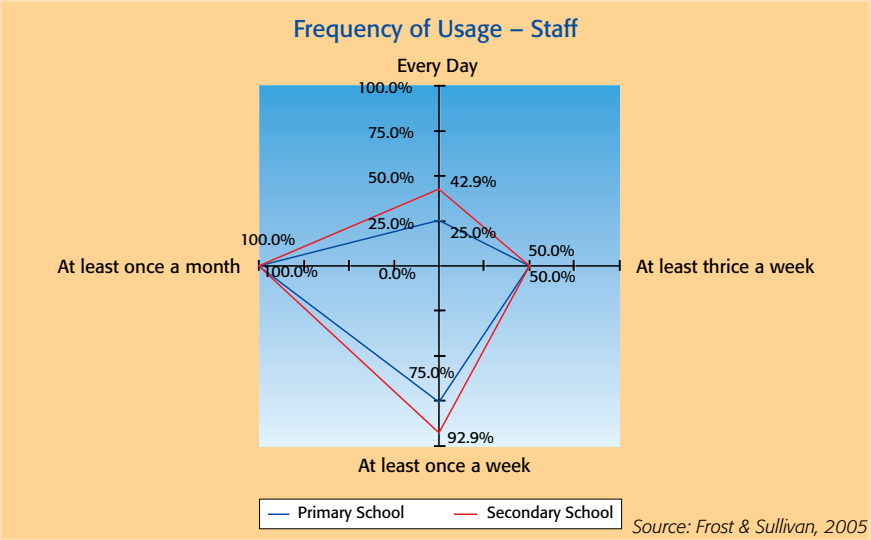


Source: Frost & Sullivan, 2005

3.1.1 PC Usage

The usage patterns of computing facilities vary both among stakeholders and also between schools under consideration. The students have computer-based lessons everyday, whereas for some teachers the computing classes occur only once a week or even less.

Chart 3.4: Frequency of Usage of Computer Facilities at the Refurbished Hardware Pilot Schools (Malaysia), 2005



Source: Frost & Sullivan, 2005

a) Staff:

Chart 3.4 shows the frequency of usage of computer facilities at the refurbished hardware pilot schools in Malaysia in 2005.

In the primary school, only 25.0 percent of the teachers interviewed accessed the computer labs on a daily basis, whereas in the secondary school, the number was higher at 42.9 percent.

In both cases, more than 50.0 percent of the staff accessed the computer labs at least thrice a week. The level of access is currently being determined mainly by two factors, which include **limited time allocation in the**

teacher's weekly time tables as well as the currently low number of PC terminals in schools.

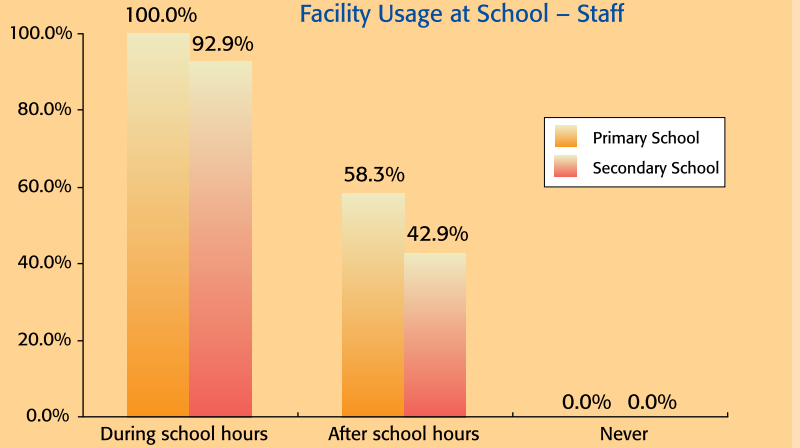
Chart 3.5 shows the computer lab usage by staff in the pilot schools.

Due to insufficient terminals and the staff's willingness to use the computing facility for their work, access to lab after school is relatively high for both the schools. This is more profound in the case of the primary school with nearly 60.0 percent of the respondents accessing the lab after school hours.

Chart 3.6 shows the computer lab duration for the academic staff in the pilot schools.

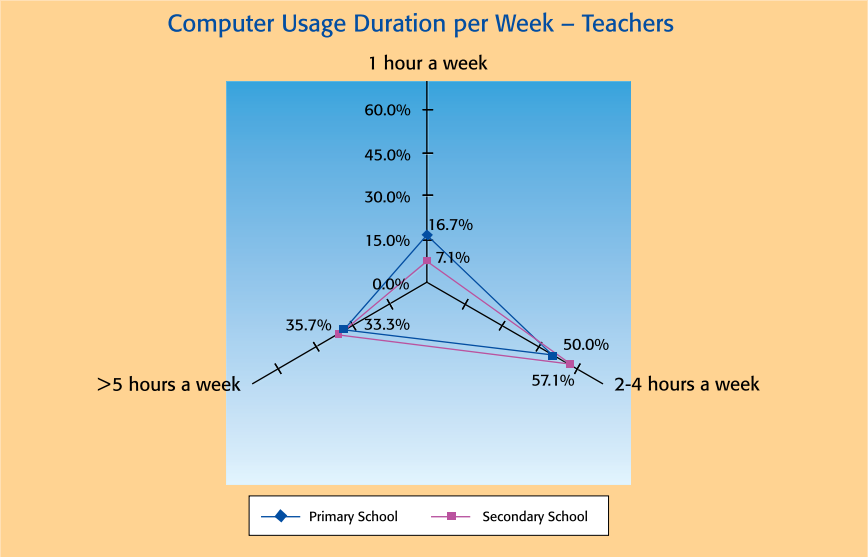
On a weekly basis, the duration of use for both schools is quite similar, as shown in Chart 3.6. More than 50.0 percent and more than 57.0 percent of the teachers from the primary and secondary schools, respectively, use the computing facilities for two to four hours a week.

Chart 3.5: Computer Lab Usage by Staff in the Pilot Schools (Malaysia), 2005



Source: Frost & Sullivan, 2005

Chart 3.6: Computer Lab Usage Duration for Academic Staff in the Pilot Schools (Malaysia), 2005



Source: Frost & Sullivan, 2005

b) Students:

Chart 3.7 shows the computer lab facility usage by students in the pilot schools.

Students still prefer to access the computer facilities mostly during school hours. Most of the time this access is limited to their daily computer-based learning lessons for the main subjects of Bahasa Malaysia, Science, Mathematics, and English.

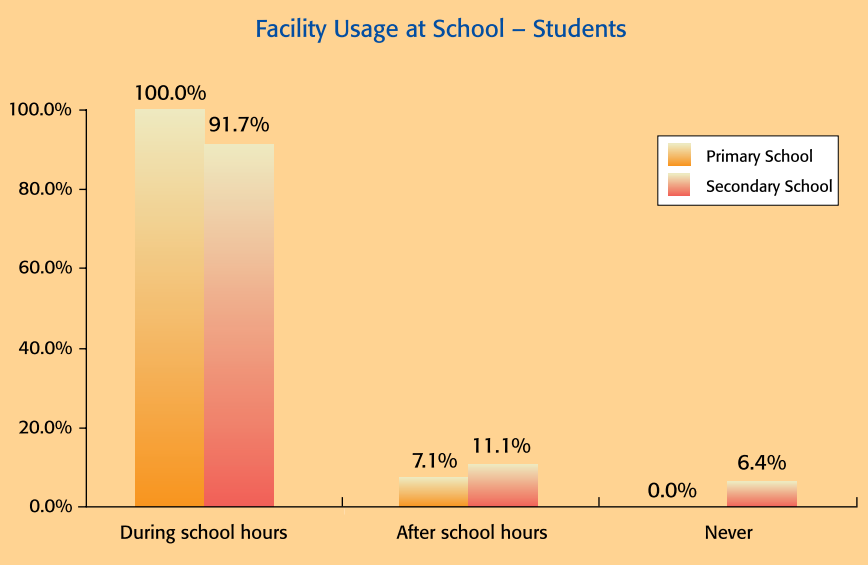
Access after school hours by secondary students is higher; this is in line with the fact that more primary school students have computers at home as compared to

students from secondary schools (See Chart 3.7).

CONCLUSION

The high degree of usage of computing facilities in both schools by not only the students, but also the staff augurs well for the Smart School initiative. Access after school hours is a strong indication of the stakeholders' desire to use the computer facilities available. ***Overall, the PC refurbishment project provides a unique opportunity to all stakeholders for using computers to enhance both teaching and learning***.

Chart 3.7: Computer Lab Facility Usage by Students in the Pilot Schools (Malaysia), 2005



Source: Frost & Sullivan, 2005

3.1.2 Quality of Hardware

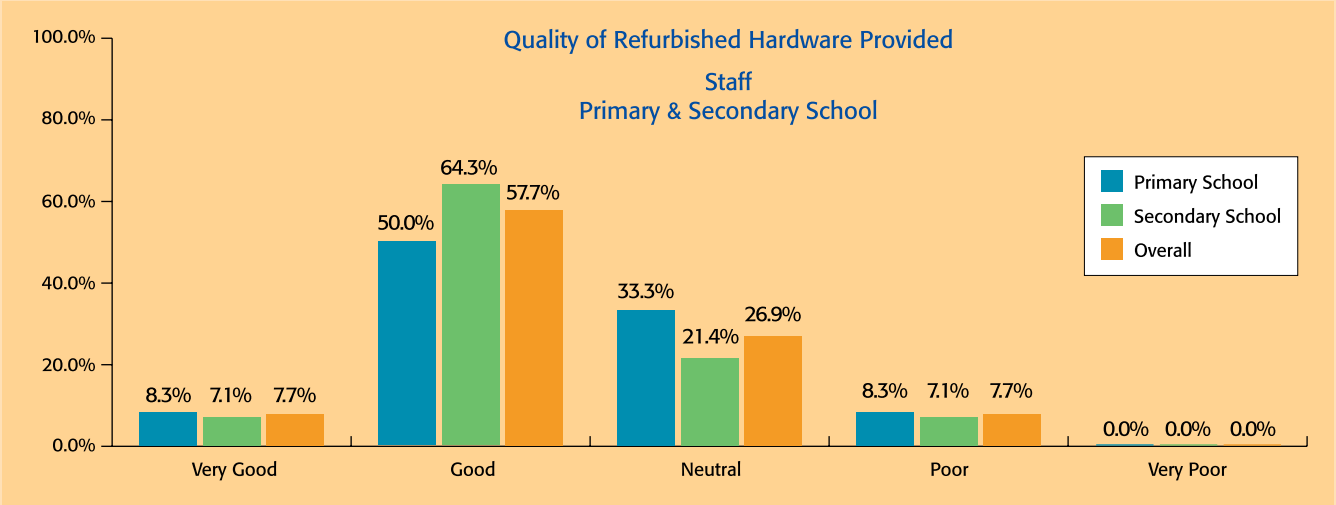
a) Staff:

Chart 3.8 shows the quality of hardware provided in computer labs as perceived by the staff members in the pilot schools.

Almost 60 percent and 70 percent of the respondents from primary and secondary schools, respectively, rated the facilities as being of good quality. However, the high percent of neutral responses (primary – 33.3 percent and Secondary – 21.4 percent) may be a cause for concern.

As shown in Chart 3.9, secondary school respondents have identified

Chart 3.8: Quality of Hardware Provided in Computer Labs as Perceived by Staff Members in the Pilot Schools (Malaysia), 2005

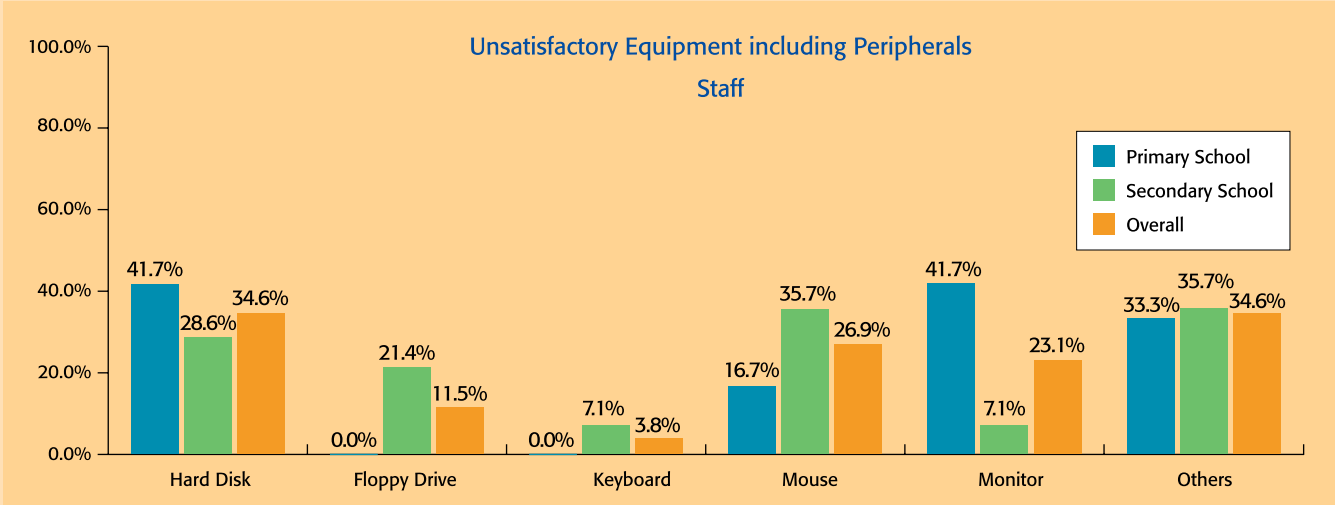


Source: Frost & Sullivan, 2005

the mouse as a major area of concern with more than 50.0 percent pointing them out as unsatisfactory. On the other hand, the primary school respondents are dissatisfied with the performance of the monitors and the hard disk provided with the computers, with 42.0 percent of them indicating this as their main concern.

The staff believes that unsatisfactory functioning of some of the Teaching and Learning Materials (TLM) is due to problematic hard disks. As a result, 41.7 percent of the primary school staff singled this out as a concern. However, **Performance**

Chart 3.9: Unsatisfactory Equipment as Indicated by the Staff of the Pilot Schools (Malaysia), 2005



Source: Frost & Sullivan, 2005

Testing performed by Frost & Sullivan MIS Support Professional indicated that the **hard disks are operating optimally**. Hard disks can handle multitasking with a number of memory and processor intensive applications running at the same time, thus dispelling the notion of unsatisfactory hardware. As most of the hard disk issues highlighted by the respondents occurred mainly while using the TLM, there is perhaps a need to examine and assess the user friendliness and other technical aspects of these applications.

Chart 3.9 shows the unsatisfactory equipment as indicated by the staff of the pilot schools.

The 'Others' category includes hardware such as random access memory (RAM), printer, and network-related equipment. More than a third of respondents from both the schools have highlighted the hardware in this category as unsatisfactory. A majority of the respondents felt that while the computers are adequate for the required applications, they are currently slow with the bottleneck being the RAM. A number of respondents suggested increasing the RAM to enhance performance.

b) Students:

More primary school students face problems in using the computing hardware than those in secondary school level. The **reason for this is perceived to be the lack of elementary skills in computing on the part of the students**.

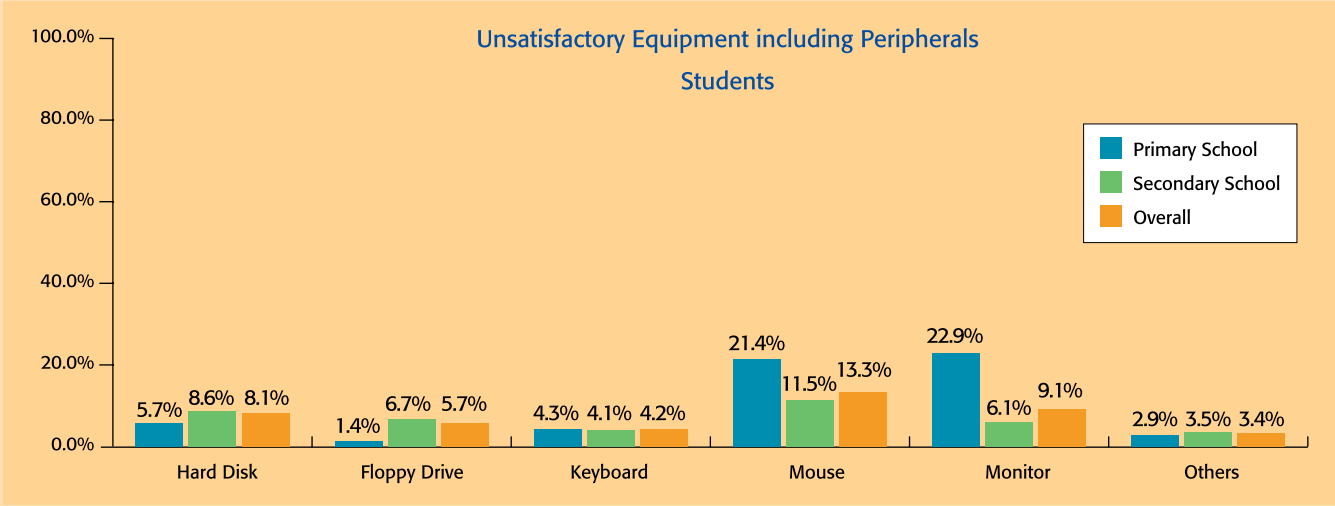
Most of the students surveyed had complaints regarding the sound quality of speakers used during their lessons. The other equipment of concern were the monitors and mice.

The 'Others' category listed in Chart 3.10 mainly indicates issues relating to Internet access, both in terms of slow speed and in some cases the inability to use the Internet.

Most of these problems can be attributed to the network and server configurations currently being used.

Chart 3.10 shows unsatisfactory equipment as indicated by students in the refurbished hardware pilot schools.

Chart 3.10: Unsatisfactory Equipment as Indicated by Students in the Refurbished Hardware Pilot Schools (Malaysia), 2005



Source: Frost & Sullivan, 2005

CONCLUSION

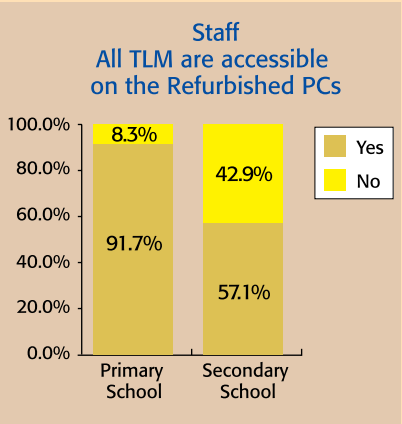
The most problematic equipment highlighted by both the stakeholders, staff, and students are the speakers used during computer-based learning lessons. The primary school would like to see the size of the hard disk increased. The secondary school, on the other hand, would like to have new mice and better monitors. The hard disk issues are believed to be mainly due to mistaken responsibility for non-performing TLM. ***Given, all the concerns raised, the quality of the hardware is of acceptable standards and fulfils the required specifications, barring a few exceptions in case of peripherals.***

3.1.3 TLM Accessibility

a) Staff:

Chart 3.11 shows the accessibility of TLM while using refurbished computers as perceived by the pilot school staff.

Chart 3.11: Accessibility of TLM while Using Refurbished Computers as Perceived by the Pilot School Staff (Malaysia), 2005



Source: Frost & Sullivan, 2005

The main objective of the entire refurbished PC pilot is to provide a sufficient number of computer terminals to all schools for accessing the TLM at a lower cost. Hence, this section is of critical importance to assess the feasibility and effectiveness of refurbished computers.

In the case of the primary school, 91.7 percent of the staff respondents were able to access the relevant applications on the refurbished PCs. This number is lower for the secondary school and stands at 57.1 percent. The respondents, however, made it clear that the reason for them not being able to access the TLM properly might not

be the malfunctioning or inadequate hardware, but rather improper or corrupt TLM on the PCs. It should also be noted that the staff has mentioned the lack of user-friendliness in the TLM software, which inhibits the staff from realizing all the accrued benefits that TLM offers.

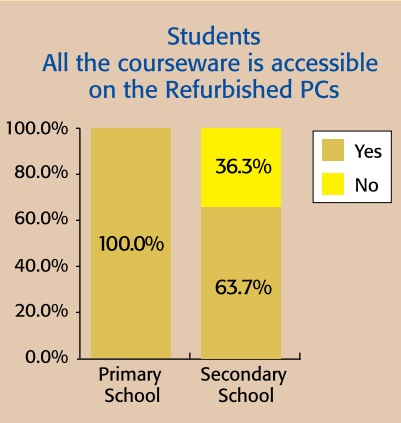
Some of these accessibility issues are due to the lack of knowledge in using TLM on the part of the staff. This can easily be addressed by providing better staff training on the use of such applications. A menu for the TLM installed in the server will further help in using all the TLM, as well as addressing the issue of TLM inaccessibility. A majority of the respondents, however, pointed out the low performance of the PCs in terms of processing speed for certain processor intensive applications.

b) Students:

Chart 3.12 shows the accessibility of e-Learning TLM while using refurbished computers as perceived by students.

Primary school students are able to access all their TLM on the refurbished PCs without any problems. On the other hand, the secondary school students face accessibility issues with more than 36 percent of the respondents having problems in accessing TLM on these computers. **Lack of user-friendliness of the TLM was highlighted as one of the major reasons behind TLM inaccessibility**.

Chart 3.12: Accessibility of e-Learning TLM while Using Refurbished Computers as Perceived by Students (Malaysia), 2005



Source: Frost & Sullivan, 2005

CONCLUSION

Most of the problems relating to the accessibility of TLM have been identified to mainly arise due to the lack of relevant technical knowledge or training on the part of the users, coupled with low user-friendliness of the TLM (Auto-Run Design, and so on). From the **overall assessment of the hardware it has been found that the refurbished PCs are able to perform satisfactorily when TLM applications are run by a knowledgeable or experienced user**.

3.1.4 Other Computer-based Activities and Applications

a) Staff:

Chart 3.13 shows the computer-based activities for academic staff in the refurbished hardware pilot schools.

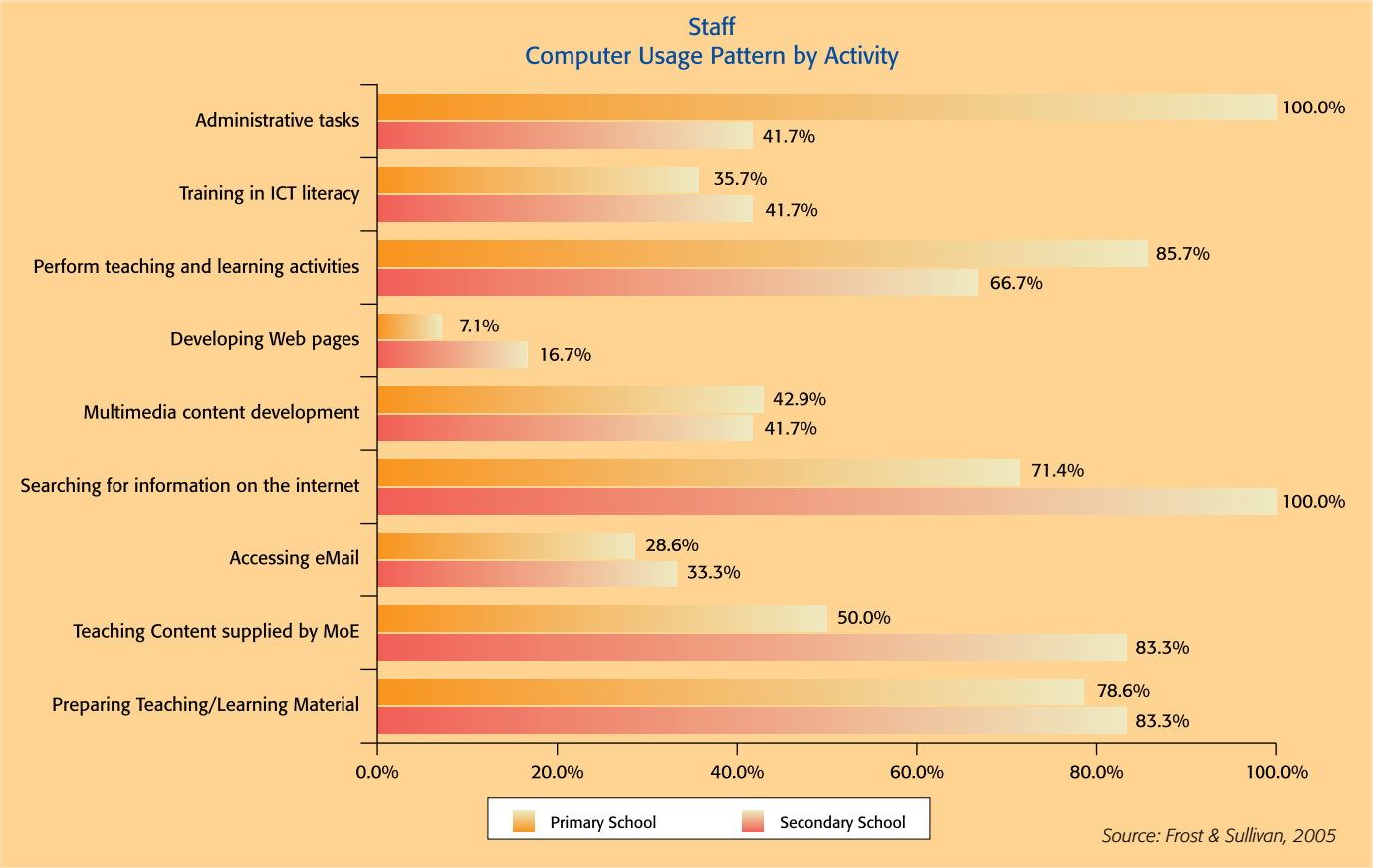
As intended by the Smart School initiative, the **computer facilities in both the primary and secondary schools are used for activities other than merely running the teaching/learning material** provided by the MoE.

For secondary schools, the most practiced activity is browsing the Internet for information (100.0 percent of the respondents), followed by preparation of teaching material by staff members (83.3 percent of the respondents).

In the case of primary schools, all staff uses the computer lab for various administrative tasks (100.0 percent of the respondents). The use of computers for teaching and learning is the second most favored activity (85.7 percent of respondents).

There are a large number of various applications, other than the TLM, that the school staff uses on the refurbished computers.

Chart 3.13: Computer-based Activities for Academic Staff in the Refurbished Hardware Pilot Schools (Malaysia), 2005



Source: Frost & Sullivan, 2005

Microsoft Office Suite is the most used application among both the secondary and primary school staff. All respondents across schools and functional categorizations use MS Word application.

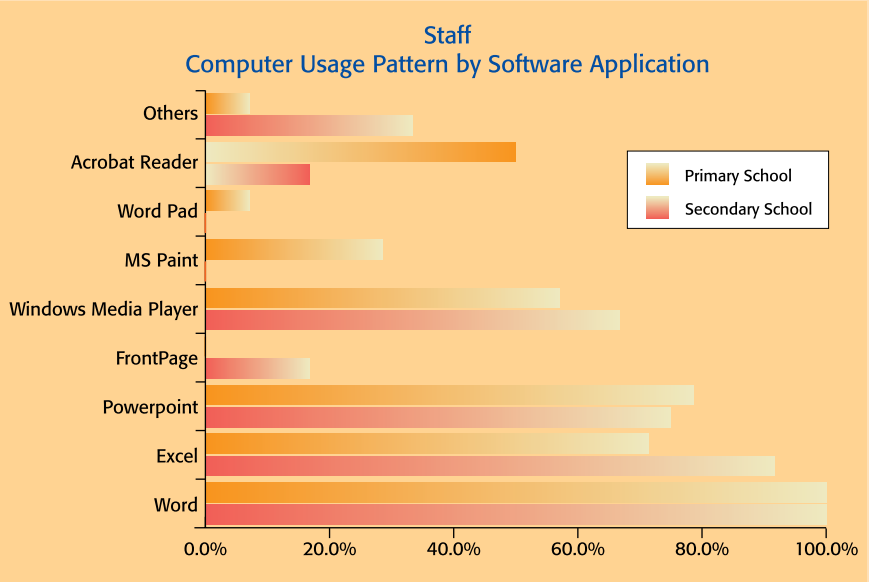
Chart 3.14 shows the software applications (except TLM) used by the staff in refurbished hardware pilot schools.

Apart from Office Suite, Windows Media Player is one of the most widely used applications, followed by Acrobat Reader for opening PDF files. The point to note here is the lack of use of MS FrontPage across schools. This needs to change if collaborative knowledge sharing is to take place between all educational institutions.

b) Students:

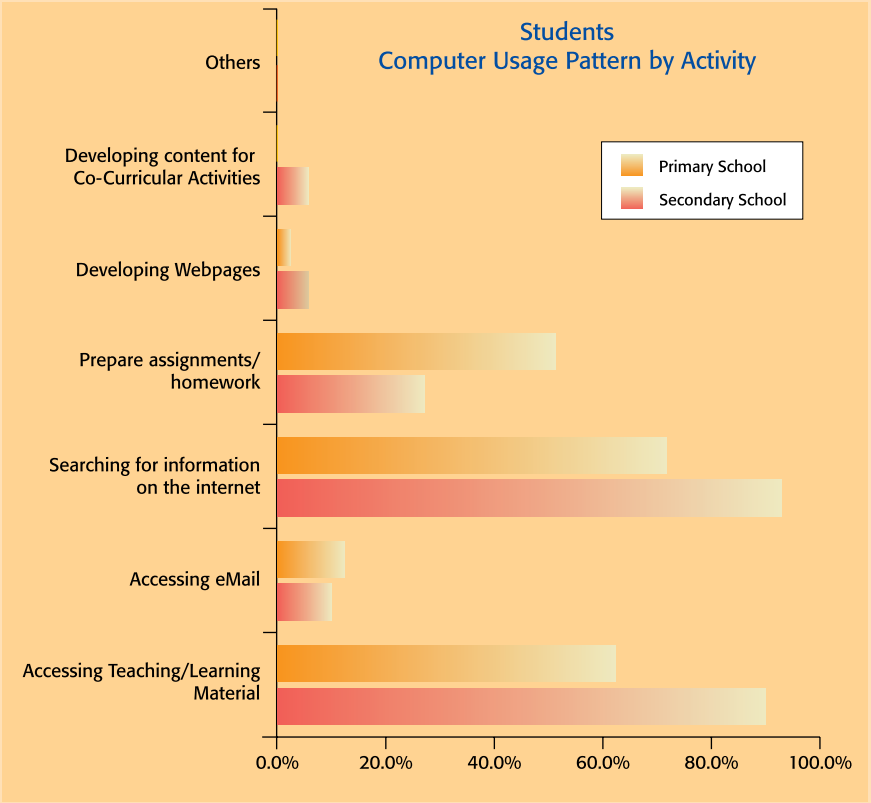
Chart 3.15 shows the computer-based activities for students in refurbished hardware pilot schools.

Chart 3.14: Software Applications (Except TLM) Used by the Staff in Refurbished Hardware Pilot Schools (Malaysia), 2005



Source: Frost & Sullivan, 2005

Chart 3.15: Computer-based Activities for Students in Refurbished Hardware Pilot Schools (Malaysia), 2005



Source: Frost & Sullivan, 2005

CONCLUSION

The wide range of activities being performed on the refurbished PCs by both the staff and the students indicate the good performance of the hardware. This is further enhanced by successful albeit slow usage of some memory intensive applications. **Overall the PCs performance has been satisfactory in running various applications and supporting a multitude of activities**.

3.1.5 Technical Issues

In order to assess the various technical issues involved in using refurbished computers and hardware, Frost & Sullivan interviewed the IT coordinators (ITCs) from both the schools under consideration. It must be noted that the ITCs are schoolteachers, who have been given the added responsibility of managing the computer labs in addition to teaching. They have been provided some form of training to perform this task.

Frost & Sullivan also provided a MIS Support Professional to assess the performance of hardware, their interoperability, and integration with existing equipment.

The ***findings from the ITC interviews*** are as follows:

1. **Primary School:**
   The **ITC from this school was satisfied with both the quality and performance of the hardware provided**. The only point of concern was networking between different computers through the server. Although the server is capable of handling the expected traffic during school hours, the configuration settings for the network tends to affect the performance of network-based resources. Additionally, some issues related to the ink cartridges for the printer need to be resolved.

2. **Secondary School:**
   Major pains identified by the ITC include unresponsive mice, occasional problems while printing and networking issues. Low sound quality of the speakers has been highlighted as an area needing immediate attention. Similar to the primary school, the network resource access is slow for this school

as well. **Overall, the ITC was satisfied with the hardware, and had issues mainly with peripherals**.

The ***findings of the Frost & Sullivan MIS Support Professional*** are as follows:

- Refurbished PCs being used are sufficient for TLM and Microsoft Office applications
- Multitasking between basic applications does not affect the performance of the PCs
- The server load during an active classroom session was less than 20 percent, hence indicating the potential for further expansion.

Note of Caution:
Although most computer parts tested satisfactory during inspection, the hardware failure rate for hard disks and so forth is expected to be higher than normal due to their operational age of more than four to five years.

Stress Testing

As its name suggests, this technique of testing the reliability and stability of computer systems involves testing beyond the normal operational capacity, to the point of system failure, in order to observe its performance in terms of recovering from such a scenario.

Some of the issues observed while conducting stress tests on computers are:

- Does the system save its state or crash completely?
- Does the system just hang and freeze, or does it show error messages while crashing?
- When the system restarts, does it effectively recover from the last known good condition?
- Does the system inform the user about previous system failure through understandable error messages, or does it merely show incomprehensible coding?
- Is the user/password security of the system still intact, or has it been compromised?

Findings of Frost & Sullivan MIS Support Professional:

Stress testing was successfully carried out on both the PCs and the server, the results of which are as follows:

1) *The performances of the processor and RAM were optimum* when testing was carried out on both the server and desktops
2) There was *an acceptable lag period/delay in processing program requests*
3) Responses to user commands was *satisfactory even at the maximum resource usage* levels

The refurbished equipment provided to schools is primarily based on machines running Intel processors and Windows operating system (OS). The ITC from both the schools and the MIS support professional found no hardware integration issues. All the computers are easily integrated together through the server to set up a network. However, some amount of network optimization is required to increase the access speed for network resources and other network-based computing.

CONCLUSION

The refurbished hardware provided is capable of handling the applications and performing up to the desired service levels. However, **some network optimization is required in order to address the ITC complaints with regards to networking issues. The failure rate for individual parts such as hard disks, RAM, and so on, might be higher than normal, given operational age and intensive usage**.

3.2 TOTAL COST OF OWNERSHIP ANALYSIS

A total cost of ownership (TCO) analysis forms an essential part of any planning process especially when it comes to budget-related issues and investment decisions related to technology. Conducting this analysis becomes even more crucial in the case of institutions such as schools, as they are already constrained in terms of financial ability.

Once the required hardware has been acquired and the computing infrastructure put in place, there are some major factors that influence budgetary allocations in the long term. The TCO for using computers in schools would hence include the following:

- ***Professional Development***

  This is one of the more important components of the TCO, as it determines the ability of a school to achieve its e-Learning objectives. If the staff does not understand the intricacies of using technology, then the purpose of providing computer access to schools would get defeated. School boards and education authorities worldwide are allotting 25.0 percent to 30.0 percent of their budget for training staff in the use of technology.

- ***Support***

  After the installation of computers, support staff/services are required to maintain the computing facilities to ensure smooth functioning of the hardware and also resolve issues faced by the users. Support is an essential component as prolonged downtime for any equipment has a direct impact on the performance of e-Learning activities. Normally, a business computer is repaired or replaced in a matter of hours, whereas in the case of student or

educational PCs, the downtime can extend to a number of days. Hence, reliable support services are essential to achieve the full benefits of technology. Service level agreements (SLAs) with equipment vendors go a long way in ensuring the best support possible quickly. This, however, comes at a price as discussed later.

- ***Connectivity***

  This component forms a relatively smaller part of the total cost of providing technology/ computing access in schools. Under normal conditions, these are not considered as part of the TCO for hardware, but in this case as the PCs are extensively used for searching information on the Internet; it is taken into account while calculating overall costs.

- ***Software***

  In certain scenarios, the cost of buying relevant software can sometimes be higher than that of obtaining the required hardware. The accepted range for software prices are normally up to 20.0 percent to 25.0 percent of the cost of the total system. However, for the educational environment, many vendors including Microsoft are providing large discounts to encourage the use of their software applications. Microsoft has even come out with student versions of its OS.

- ***Replacement Costs***

  Technology is changing rapidly, as are the requirements of educational institutions. An accepted life span of a PC is up to five years in the case of newer computers and three to four years for older PCs. Replacement costs hence form an essential component for the TCO analysis.

In the case of newer computers, a five-year life cycle is followed globally to ensure students have access to the most current technologies. For refurbished hardware this life cycle decreases to three years.

- ***Retrofitting***

  As the term suggests, this component takes into account all the costs incurred in having an existing classroom ready for computer-based learning. Normally, retrofitting costs are not taken in to account when a TCO is done, but when providing schools with computing access, these costs sometimes tend to be an inhibitor. However, techniques are now in place to keep such retrofitting costs to a minimum and ensure a smooth transition.

Figure 3-2 shows a qualitative comparison of the TCO between New and Refurbished Hardware used in the Pilot Schools.

As illustrated in Figure 3-2, the components of support and replacement costs are the two major differentiating factors between deploying newer computers in relation to refurbished PCs. Frost & Sullivan has developed a costing model to show the effectiveness of using refurbished computers in schools over a longer duration.

However, there are a few assumptions that form the basis of this TCO analysis. These are as follows:

1. The lifecycle of a new computer is assumed to be five years and that of a refurbished computer to be three years
2. Costing is done on the basis of present day pricing for hardware and support services
3. The support charges considered for computation are tentative and based on an average of prevailing rates

Figure 3-2: A Qualitative Comparison of TCO between New and Refurbished Hardware (Malaysia), 2005

Parameters for Calculating Total Cost of Ownership		
Components	**Costing**	
	New Hardware	**Refurbished Hardware**
Equipment Cost	Initial acquisition cost paid for buying new hardware	Initial acquisition cost paid for buying retrofitted hardware
Professional Development	Costing for this component is **same for both new and refurbished hardware**. Training Academic/Non-Academic staff to use computers is necessary whether new or refurbished hardware is used	
Support	20-25% of the cost of the PC per year	45-50% of the cost of the PC per year
Connectivity	Costing for this component is **same for both new and refurbished hardware**. The Internet services are provided through the SchoolNet initiative by MoE. The pricing is independent of the kind of hardware used	
Software	Costing for this component is **same for both new and refurbished hardware**. MoE has agreements in place with vendors such as Microsoft to provide software (Windows OS, Office suite, etc.). The pricing is independent of the kind of hardware used	
Replacement Costs	It is dependent on the hardware failure rate, which in this case is 2-5% per year. The support costing mentioned earlier, already **includes** this costing	It is dependent on the hardware failure rate, which in this case is 8-10% per year. The support costing mentioned earlier, already **includes** this costing
Retrofitting	Costing for this component is **same for both new and refurbished hardware**. Getting the school/classrooms ready in terms of required network cabling etc., is independent of the kind of hardware used	

Source: Frost & Sullivan, 2005

4. Maintenance charges include the cost of replacing the defective hardware as well, depending on the conditions set in the SLAs
5. Best possible configurations have been taken into consideration while computing costs (a combination of PCs, server, and printers) are across various vendor offerings
6. In the case of printers, vendors prefer to have newer hardware rather than putting in refurbished equipment due to various reasons such as life cycle and cost effectiveness.

Figure 3-3 shows the comparison of TCO for labs with new and refurbished computers.

Figure 3-3: Comparison of TCO for Labs with New and Refurbished Computers (Malaysia), 2005

TCO for a Computer Lab with 20 PCs (Over a Five Year Period)		
New Computers (Lifespan = 5 years)		
	1 Computer	20 Computers
Cost of Hardware	RM 2,699.54	RM 53,990.80
Maintainence & Support Charges		
1 year	RM 533.91	RM 10,678.20
5 years	RM 2,699.54	RM 53,990.80
Total Cost of Ownership for a lab of New PCs over a 5 year period		RM 107,981.69
Refurbished Computers (Lifespan = 3 years)		
	1 Computer	20 Computers
Cost of Hardware	RM 539.49	RM 10,789.80
Maintainence & Support Charges		
1 year	RM 242.77	RM 4,855.76
3 years	RM 728.31	RM 14,566.52
Total Cost of Ownership for a lab of Refurbished PCs over a 3 year period		RM 25,356.32
Total Cost of Ownership for a lab of Refurbished PCs over a 5 year period		RM 45,857.64

Source: Frost & Sullivan, 2005

Figure 3-4 shows the comparison of TCO for a computer lab with new and refurbished servers.

Vendors prefer the use of new printers, as the life cycle for a printer is shorter than the computer itself due to various reasons. Refurbished printers could end up costing more in the long run due to its rapid obsolescence cycle coupled with falling prices for newer basic models.

Hence, for the purpose of computing the TCO, the pricing of a new printer has been taken into consideration. A point to note in the case of TCO for printers is that the cost is mainly for logistical issues involved. The principal

Figure 3-4: Comparison of TCO between a New and Refurbished Server (Malaysia), 2005

TCO for a Computer Lab with 1 Server (Over a Five Year Period)	
New Server (Lifespan = 3 years)	1 Server
Cost of Hardware	RM5,717.23
Maintainence & Support Charges	
1 year	RM1,429.33
3 years	RM4,287.98
Total Cost of Ownership for a lab of New Server over a 3 year period	**RM10,005.21**
Total Cost of Ownership for a lab of New Server over a 5 year period	**RM18,581.10**

Refurbished Server (Lifespan = 3 years)	1 Server
Cost of Hardware	RM3,089.59
Maintainence & Support Charges	
1 year	RM1,544.81
3 years	RM4,634.43
Total Cost of Ownership for a lab of Refurbished Server over a 3 year period	**RM7,724.02**
Total Cost of Ownership for a lab of Refurbished Server over a 5 year period	**RM13,903.23**

Source: Frost & Sullivan, 2005

vendor takes care of repair and others provided the warranty is valid.

Figure 3-5 shows the TCO for a HP Business Inkjet 1000 printer used for the refurbished hardware pilot.

Figure 3-5: TCO for a HP Business Inkjet 1000 Printer (Malaysia), 2005

TCO for a Computer Lab with 1 Printer (Over a Five Year Period)	
New Printers (Lifespan = 3 years)	
	1 Printer
Cost of Hardware	RM 575.04
Maintainence & Support Charges	
1 year	RM 114.99
3 years	RM 344.97
Total Cost of Ownership for a lab of New Printer over a 5 year period	RM 1,725.03

Source: Frost & Sullivan, 2005

Figure 3-6 shows a comparison of the total costs for installing new hardware in 10,000 schools, in relation to refurbished hardware. The assumption taken while computing this cost is that any

Figure 3-6: Costing Forecast for 10,000 Schools over Five Years (Malaysia), 2005

Hardware Costing Forecast for 10,000 Schools	
New Hardware	
TCO for 1 Lab of 20 computers over a 5 year period	RM 107,981.69
TCO for 1 Printer over a 5 year period	RM 1,725.03
TCO for 1 Server over a 5 year period	RM 18,581.10
TCO for 20 Licenses of Windows XP OS	RM 10,240.00
TCO for 20 Licenses of MS Office	RM 22,000.00
Total cost for 1 School over a 5 year period	RM 160,527.82
Total cost for 10,000 Schools over a 5 year period	**RM 1,605,278,200.00**
Refurbished Hardware	
TCO for 1 Lab of 20 computers over a 5 year period	RM 45,857.64
TCO for 1 (New) Printer over a 5 year period	RM 1,725.03
TCO for 1 Server over a 5 year period	RM 13,903.23
TCO for 20 Licenses of Windows XP OS	RM 10,240.00
TCO for 20 Licenses of MS Office	RM 22,000.00
Total cost for 1 School over a 5 year period	RM 93,725.90
Total cost for 10,000 Schools over a 5 year period	**RM 937,259,000.00**

Source: Frost & Sullivan, 2005

school lab will constitute 20 PCs, one server, and a printer along with 20 licenses each for Windows XP OS and MS Office.

Figure 3-6 shows the costing forecast for 10,000 schools over a five year period.

One of the options often exercised for such a large-scale deployment is that of using leasing to acquire the hardware required, instead of paying the equipment cost outright. Figure 3-7 shows the TCO (inclusive of hardware acquisition costs and maintenance charges and others) for installing computers in 10,000 schools using the leasing option vis-à-vis purchasing, over a six-year period. It must be noted that due to the varying lifespan of the equipment, lease amounts have been calculated for a period of six years in order to maintain standardization. **The leasing amount has been calculated using present value with annual installments at an interest rate of 5.5 percent**.

Leasing comes in various forms and types, but in the case of deploying computers in 10,000 schools with the objective of providing access to newer technologies, an operating lease is a better option. Some of the leases also offer the lessee the opportunity of owning the equipment after the leasing contract expires at a nominal buy-out price, which can be as low as 1RM.

Figure 3-7 shows the costing forecasts for 10,000 schools in Malaysia in terms of Leasing Vs. Purchasing hardware.

Although leasing seems to be a slightly expensive option from Figure 3.7, it offers certain important advantages especially in terms of technology obsolescence and managing budget limitations during deployment. Some of these advantages are explained in greater detail below.

Advantages of Leasing:

- *Systematic and timely technology replacement* – Leasing gives

Figure 3-7: Costing Forecasts for 10,000 Schools, Leasing vs. Purchasing (Malaysia), 2005

Hardware Costing Forecast for 10,000 Schools (Over 6 Years)		
	Leasing Option (with Technology Obsolescence Protection)	Purchase Option
New Hardware		
TCO for 1 Lab of 20 computers over a 6 year period	RM 121,963.63	RM 118,659.89
TCO for 1 Printer over a 6 year period	RM 1,860.87	RM 1,840.02
TCO for 1 Server over a 6 year period	RM 20,238.54	RM 20,010.43
Total cost for 1 School over a 6 year period	RM 144,062.71	RM 140,510.34
Total cost for 10,000 Schools over a 6 year period	**RM 1,440,627,100.00**	**RM 1,405,103,400.00**
Refurbished Hardware		
TCO for 1 Lab of 20 computers over a 6 year period	RM 51,286.98	RM 50,713.40
TCO for 1 (New) Printer over a 6 year period	RM 1,860.87	RM 1,840.02
TCO for 1 Server over a 6 year period	RM 15,623.01	RM 15,448.04
Total cost for 1 School over a 6 year period	RM 68,770.86	RM 68,001.46
Total cost for 10,000 Schools over a 6 year period	**RM 687,708,600.00**	**RM 680,014,600.00**

Source: Frost & Sullivan, 2005

the flexibility of upgrading the equipment as soon as it approaches obsolescence. New equipment can be obtained and then returned to the vendor when the lease contract ends. This way a set equipment life cycle can be established and the hardware continually upgraded accordingly

- *Manageable IT Spending* – Leasing helps in addressing budget challenges involved with acquiring hardware at such a large scale as well as the cost of maintaining and upgrading it over an extended period of time.

- *Standardization of equipment* – Carefully negotiated leasing contracts can help organizations manage their IT needs effectively and consistently help in reducing various other costs such as maintenance, support, logistics, and others.
- *Easy disposal of end-of-life equipment* – The leasing option will ensure that the cost of getting rid of end-of-life hardware is kept to a negligible in the long run. As the leasing contract closes to its end, the older equipment can easily be returned to the vendor and newer hardware obtained with another new leasing cycle.

However, there are certain **disadvantages of using leasing** as well. Few of them are listed as follows:

- As the equipment under a leasing contract remains the property of the lesser, the lessee needs to keep track of all the equipment and take good care in order to avoid any damage. Inadequate asset management can lead to leasing being a very expensive option in the long run.
- Signing long contracts with a single vendor can lead to lock-in and further reduce the bargaining power of the lessee at the time of lease renewal. Care needs to be taken when such contracts are negotiated to include exit options in case of problems.
- It becomes essential to adhere to the industry-established life cycle of the equipment in question in order to achieve maximum benefits from using leasing as an effective option.

3.3 THE LAST WORDS...

After taking into account the five parameters (PC usage, quality of hardware, smart school TLM accessibility, other computer-based activities and applications, technical aspects), considered for the evaluation of the PC refurbishment pilot project, the following conclusions can be drawn:

1) The positive response to the pilot indicates a **step in the right direction** by the MoE and the MDeC for providing refurbished computers to schools. This practice has already proved very successful in countries such as Canada, Colombia, Kenya, Australia, South Africa, India, New Zealand, and others.
2) The large degree of computer lab usage in both schools especially after school hours reflects the **enthusiasm on the part of the staff and the students about using the refurbished computers** provided to them
3) The **overall satisfaction with the quality of hardware** (barring a few exceptions in terms of unresponsive mice and slow performance for certain applications) is encouraging
4) Most **TLM are easily operated** on the computers. The feasibility assessment study found the refurbished computers to be effective in teaching and learning processes.
5) The refurbished PCs are able to **support a host of other computer-based activities and multiple applications** apart from the TLM-related activities and applications. The computers can easily be used to perform activities such as accessing the Internet, accessing and developing multimedia content, and running the TLM provided by the MoE for enhancing the students' learning experiences.
6) The technical **performance of the refurbished hardware-based** infrastructure is **up to the desired level** for the school environment. However, some kind of **minimum performance benchmarking** has to be done by the MDeC in order to **ensure consistent performance levels for all computers** across different schools.
7) There are **no integration issues** between the new and existing hardware or among the refurbished hardware itself

8) **Network optimization can be carried out** to further enhance and improve on access to network-based resources and effective collaborative learning. Some of the techniques that can be used in the schools to make the network more effective are as follows:

a. ***Background Services*** – Unnecessary services that occupy memory should be disabled both on the server and the workstation in order to provide more resources to required applications

b. ***Resource Allocation*** – There are commercially available software in the market that allows the administrator to allocate resources for certain key applications, thus ensuring high performance levels for essential network-based programs

c. ***LAN Segmentation*** – One of the easiest methods to optimize the LAN is the use of segmentation. Segmentation can be either physical (using intelligent switches) or logical (by creating TCP/IP subnets). This results in noticeable reduction in traffic congestion.

d. ***Paging File*** – In order to maximize the performance of the server/desktops, the paging file (paging file should be at least 1.5 times the physical RAM) should be put on a hard disk partition that is not heavily taxed by other uses.

e. ***Proxy servers*** – Proxy servers provide dual advantages of security and speed. By shielding the LAN from the Internet they act as firewalls, and by caching frequently accessed pages, they speed up Internet access.

9) **The refurbished PCs are almost as good as newer ones when it comes to effectiveness in the school environment**; however, they come at a cheaper price

thus putting less strain on the resources of both the MoE and MDeC.

For 10,000 "Pembestarian" schools across Malaysia, a minimum of 20 to 30 computers would be required per school. The cost advantage offered by refurbished hardware, by having almost similar levels of effectiveness as a new PC albeit at a much lower price, becomes even more profound when the number of computers is taken into consideration (as shown in the TCO analysis). Hence, **the refurbished PCs are highly cost effective for the "Pembestarian Sekolah" initiative**.

At an overall level, these computers have emerged as a very effective mode of enhancing the classroom learning experience barring a few exceptions especially for the secondary school. However, some tweaking and further maintenance is required to ensure the computing facilities operate at their optimal levels.

Figure 3-8 shows a report card to assess the overall effectiveness of refurbished computers in the school environment.

3.3.1 Recommendations

Frost & Sullivan recommends the following to ensure a successful and highly effective large-scale deployment of refurbished hardware for over 10,000 schools in Malaysia.

I. Strategic Recommendations

- Frost & Sullivan has developed five critical success factors (CSFs) for the PC refurbishment initiative to succeed. These CSFs are based both on experiences of existing refurbishment programs worldwide and also the unique requirements of the Malaysian Smart School program. The CSFs are as follows:

1) ***Quality Control***

   There is a need to ensure that the retrofitted equipment provided to schools is up to a common minimum standard. This standard

should be set keeping in mind software requirements and the desired performance levels. Stringent quality control measures are necessary to avoid any defective or sub par hardware from being shipped to schools.

2) *Sustainable Supply*

For any hardware refurbishment initiative to be successful, the continuous flow of donations of equipment is extremely critical. The number of computers required to fulfill the vision of smart school is very large and hence requires a sustainable supply of computers over a long period of time. For this to

Figure 3-8: A Report Card to Assess the Overall Effectiveness of Refurbished PCs in the School Environment (Malaysia), 2005

Refurbished PCs Pilot – A Report Card		
Assessment Parameters	**Effective**	**Remarks**
Refurbished PCs are effective in Teaching & Learning (T&L)		Computers are effective in the T&L processes
Refurbished PCs are effective in administration of T&L		The current performance levels are satisfactory but can still be improved further in terms of processing speed and RAM
Refurbished PCs are suitable for accessing the Internet, run Multimedia software and Courseware provided by MoE, etc.		PCs run all the current applications required for the School environment. However as newer memory/processor intensive applications are introduced as part of the curriculum, the computers might have to be upgraded
Refurbished PCs are easily integrated with existing Hardware and Peripheral Devices		Although, there are no integration issues, Network Optimization will further enhance the performance of network-based resources
Refurbished PCs are cost effective for the "Pembestarian" of 10,000 schools		The cost effectiveness of refurbished hardware is high for the "*Pembestarian*", but it has to be kept in mind that the expected hardware failure rate would be slightly higher than that for new PCs
Overall Effectiveness		**Given all the assessment results, Refurbished PCs are a cost-effective and efficient solution for providing computer access to all students**

Source: Frost & Sullivan, 2005

succeed, it has to be ensured that the vendors are committed to the project and can sustain to provide the required hardware over an extended period of time.

3) ***Inventory Management***
As the failure rate of some of the refurbished parts is expected to be high, coupled with the three-year phase out cycle for computers, an effective inventory management system is essential for a smooth implementation.

This system will be able to keep track of equipment being shipped to various locations, have spares in inventory for up-gradation and repair purposes, and ensure that the computers are continually updated to suit the requirements. This will help in tracking and comparing the current ability to supply refurbished hardware against the expected future demand.

4) ***Good Technical Support***
As most of the hardware is being retrofitted and is going to be used by new users, the probability of things going awry is high. This combination of inexperienced users along with coupling of old hardware with new indicates the need for according high priority to good technical support mechanisms. The helpdesk should have competent people for ensuring a smooth operation. Focus should be on training ITCs and technicians to handle the bulk of the problems themselves.

5) ***Partnerships/Agreements***
Developing partnerships with various non-governmental organizations (NGOs) and vendors forms the cornerstone for this initiative to take off. There are a large number of NGOs involved in computing hardware refurbishments projects all over the world. Having agreements with such organizations will ensure access to multiple sources for getting computers.

Vendors play an active role in providing both applications and spare parts for retrofitting the equipment. Having Service Level Agreements (SLA) with these vendors is an effective way for getting post sales hardware support in case of major equipment failures.

- **The "Thin-Client"** approach is fast becoming popular in the use of refurbished computers. This approach centers on a set of older computers working around a relatively newer and powerful PC acting as a server. This allows the older computers to run applications off the newer computer and make use of all the extra processing power available.

This allows for any software upgrade to be made only on the central server PC rather than upgrading software on all machines individually. The server in this case runs a terminal server software to manage all the computers (clients) connected to it. Most of the client machines are bare-bone and are booted directly from the server machine. The system integrators will have to be involved to implement this approach in the Smart Schools. This approach is currently widely tested in countries such as Colombia, Kenya, South Africa, and others where the cost of installing servers and new computers in schools would be prohibitive for any initiative.

Some advantages of using the "Thin-Client" approach in schools include:

1) Enhanced access and manageability of the network – as most applications reside on the server, the cost of deploying and maintaining software on multiple machines is drastically reduced. The software environment is easily standardized as everybody accesses the same version from the server.

2) It increases the PC lifespan – Older computers are easily able to run newer hardware intensive programs directly from the server, thus extending the life cycle of any computer and offering further cost effectiveness
3) Remote access – This architecture even allows users outside the school network to access the relevant TLM, and is only inhibited by the Internet connection speed of the user
4) Single point of control – It provides the administrators with a single access point to control the entire network including servers, and others
5) Reduces PC lab support and maintenance costs – Eliminates the need to tamper with individual desktops for standardization
6) Enhances Security – Improves on security as access can easily be restricted to certain specific machines using login names. Data can be securely stored on the server with restricted access.
7) Cost Effectiveness – The thin-client approach offers cost advantages both in terms of hardware and software **However, it needs to be noted that most of the cost benefits comes from the software used with the thin clients**. *The cost savings in terms of licensing and other fees can be very significant because of both the usage of open source software and also the appreciably low number of licenses required for client machines*.

Figure 3-9 shows the TOC for the thin-client approach for the hardware.

II. Operational Recommendations

- All refurbished computers being considered for the school environment, should undergo both performance and stress testing to ensure consistent performance and satisfactory quality.

- One of the major concerns raised by all stakeholders was the performance of the speakers during computer-aided lessons. This issue has to do with both the sound quality of speakers and also the timing of using most of them together when accessing TLM. As the computers have been provided with multimedia speakers of their own, there tends to be large-scale confusion when all of them are turned on at the same time. This tends to hamper the students ability to properly understand what is being taught.

  Frost & Sullivan hence recommends that individual headphones be provided to students and microphones to teachers to ensure a better acoustic environment in the classroom. The Smart School concept is based primarily on e-Learning and collaborative knowledge sharing. Provision of Web cameras, microphones, and headphones

Figure 3.9: TOC for the Thin-Client Approach in 10,000 Schools (Malaysia), 2005

Hardware Costing Forecast for 10,000 Schools (Thin-Client Approach)	
New Hardware	
TCO for 1 Lab of 20 clients over a 5 year period	RM 89,180.58
TCO for 1 Printer over a 5 year period	RM 1,725.03
TCO for 1 Server over a 5 year period	RM 27,871.67
Total cost for 1 School over a 5 year period	RM 118,777.28
Total cost for 10,000 Schools over a 5 year period	**RM 1,187,772,800.00**
Refurbished Hardware	
TCO for 1 Lab of 20 clients over a 5 year period	RM 38,566.12
TCO for 1 (New) Printer over a 5 year period	RM 1,725.03
TCO for 1 Server over a 5 year period	RM 20,854.85
Total cost for 1 School over a 5 year period	RM 61,146.00
Total cost for 10,000 Schools over a 5 year period	**RM 611,460,000.00**

Source: Frost & Sullivan, 2005

would help in realizing this vision in the long run.

- Any kind of downtime for the hardware is going to adversely affect the teaching-learning processes in the schools. Hence, it is essential to ensure that this downtime be kept to a minimum.
  a) The SLAs with the vendors should contain clauses to make sure that onsite support is provided and in the minimum possible time
  b) At least two backup machines should be kept in schools in case of hardware failure to minimize the impact
  c) The ITC and some of the other staff should be adequately trained to resolve certain smaller issues themselves rather than relying on outside help for everything.

III. Going Forward

For a successful large-scale deployment of refurbished PCs across schools in Malaysia, Frost & Sullivan recommends the following:

1) Another pilot should be conducted in a larger number of schools to achieve a better representative sample, which further highlights the main points of stakeholders
2) The sample should comprise both Smart and non-Smart Schools to ensure that information pertaining to different school environments is captured

3.3.2 Conclusion

The Smart School initiative is expected to have a wide-ranging impact on the Malaysian society as a whole. This will be mainly due to the exposure of its future leaders to ICT and the global knowledge warehouse, the Internet. Provision of computers to schools is the first step toward achieving the goal of a knowledge-centric and technology-savvy workforce.

The performance of the pilot project is expected to impact the entire education system in Malaysia and

especially the Smart School flagship. The technical aspects covered during the pilot set the benchmarks necessary for a large-scale rollout of refurbished hardware. The pilot also gives an opportunity to assess the effectiveness of various vendors in providing the required equipment and looks at the technical issues that could affect the program in the long run.

A worldwide success of similar models for providing refurbished hardware to schools augurs well for this initiative. Through this pilot, the policy makers themselves get a chance to assess all the factors and issues related to the PC refurbishment program and decide on the relevant course of action for making it a success. Suitable and supportive government policy will go a long way in ensuring the sustainability of this initiative over an extended duration.

The pilot phase has been successful with both the staff and students satisfied with the performance and the impact of using refurbished hardware in the school environment. There are also tremendous cost advantages in using refurbished hardware, as shown in the total cost of ownership analysis given earlier in the research service. The five critical success factors of quality control, sustainable supply, inventory management, good technical support and partnerships/agreements will be helpful in ensuring an effective and efficient large-scale rollout of refurbished hardware.

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