SUSTAINABLE IT

REDUCING CARBON FOOTPRINT AND MATERIALS WASTE IN THE IT ENVIRONMENT

LECTURE TWO

PRODUCT SERVICE SYSTEMS AND THE PRODUCT CYCLE

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EDUCATIONAL AIMS OF LECTURES

Lecture 1: Drivers and Benefits of Sustainable IT

The aim of this lecture is to discuss the drivers and benefits of *Sustainable IT*, particularly for the customer. Drivers and benefits range through business, economic, environmental and legislative domains.

Lecture 2: Product Service Systems and the Product Cycle

The aim of this lecture is to discuss *product service systems*, their barriers and lessons from past implementations, as well as the opportunities to reduce energy and materials consumption in packaging and equipment through end-of-life processing.

Lecture 3: Client Equipment

The aim of this lecture is to discuss a four-step process for reducing energy consumption, materials consumption and materials toxicity in client equipment.

Lecture 4: Data Centres and HP Case Study

The aim of this lecture is to discuss a seven-step process for reducing energy consumption in data centres and to present a *Sustainable IT* case study of IT vendor HP.

Lecture 5: Roadmap and Success of Sustainable IT

The aim of this lecture is to discuss the strategies, activities and actions upon which customers and vendors should focus in order to successfully transition to, maintain and promote their *Sustainable IT* solutions at the organisation and industry level.

Sustainable IT

Lecture 2: Product Service Systems and the Product Cycle

Educational Aim

The aim of this lecture is to discuss product service systems, their barriers and lessons from past implementations, as well as the opportunities to reduce energy and materials consumption in packaging and equipment through end-of-life processing.

Required Reading

Reference	Page
Vassiliadis, B., Stefani, A., Tsaknakis, J. and Tsakalidis, A. (2006) 'From application service provision to service-oriented computing: A study of the IT outsourcing evolution', *Telematics and Informatics*, vol. 23, no. 4, November 2006, pp. 271-293.	pp. 271-293
Degher, A. (2002) 'HP's worldwide take back and recycling programs: lessons on improving program implementation', *Electronics and the Environment*, 2002 IEEE International Symposium on 6-9 May 2002, pp. 224-227.	pp. 224-227
Amezquita, T., Hammond, R., Salazar, M. and Bras, B. (1995) 'Characterising the remanufacturability of engineering systems', Proceedings 1995 ASME Advances in Design Automation Conference, Boston, Massachusetts, vol. 82, pp 271-278. Available at http://www.srl.gatech.edu/education/ME4171/DETC95_Amezquita.pdf. Accessed 16 May 2007.	pp 271-278

Learning Points

Product Service Systems

1. In *product service systems*, customers receive the services of IT hardware and software products, while the vendor maintains the ownership and responsibility of the products. Vendors may perform a combination of several activities as part of a successful *product service systems* implementation, which are spread over a number of steps; i.e. plan, prepare, commission, operate, decommission, end-of-contract, and end-of-life. *Product service systems* can include the provision of client hardware and software, data centre hardware and software, as well as help desk and support staff.
2. There are several barriers to *product service systems,* including:
   - Customers' and vendors' poor understanding of the concepts.[1]

[1] Vassiliadis, B. *et al* (2006).

- Unrealistic expectations of *product service systems*.
- Some hardware products (equipment) were not designed for remanufacturing, particularly older equipment.
- Vendors carry the high costs of while customers reimburse over time. Some activities in *product service systems* that are not part of the conventional purchase system pose high costs.
- Several legislative and regulatory barriers to *product service systems*, including: acquiring expert understanding to ensure violations are avoided;[2] international transportation regulations and treaties;[3] Customs procedures;[4] reporting requirements; waste handling restrictions; finance and tax issues;[5] and the variety of payment systems imposed by different governments who mandate equipment take-back.[6]
- A large number of uncertainties in *product service systems* can potentially become barriers, including: service availability and response time, security, scalability, service monitoring, socio-political legitimacy, service composition, vendor overhead, structural changes, customization, exit provision, redistribution of responsibility, integration, immature economics, and switching costs.

3. To develop successful *product service systems*, it is critical to study and learn from past and new implementation attempts:
   - A study of six large companies suggests that that there are specific activities that contribute to the success of *product service systems*, including:[7] highlighting short-term successes; striving for continuous improvement; obtaining upper management support to facilitate changes; encouraging customer understanding and acceptance through marketing activities; implementing education and training, and enforcing customer-employee development; forming project teams to manage and develop the new processes such that they penetrate and integrate with existing operational processes.
   - Several relevant lessons arose from the introduction of previously popular IT service systems, including:[8] large financial investments or government support does not guarantee the adoption of the system – the system must also be marketed correctly; trends in the small enterprise market are difficult to predict; failure after hype increases the perception of uncertainty for both customers and vendors; ensure that vendors and customers understand the concepts and purpose of the system.
   - Failure to reach expected customer participation levels can hinder *product service systems'* viability due to economies of scale.

[2] Vassiliadis, B. *et al* (2006).
[3] Vassiliadis, B. *et al* (2006).
[4] Vassiliadis, B. *et al* (2006).
[5] Degher, A. (2002).
[6] Hewlett-Packard Development Company (2006) *Real consumer cost for electronic equipment recycling as low as 1 Eruo cent*.
[7] Hochstein, A., Zarnekow, R. and Brenner, W. (2005).
[8] Vassiliadis, B. *et al* (2006).

- Services must be defined to match the customer's business objectives, rather than the vendor's.[9] However, solutions that heavily favour either vendor or customer are likely to result in disputes or performance underachievement.[10]
- Planning and negotiations should involve representatives from accounting, legal, operations, treasury and top management.[11]
- The most common disputes involve subleasing and parts substitution during upgrades.[12] Thus, it is important to have options for ambiguous activities written into the contract.
- The performance and compensation terms are usually unreliable in dispute resolution[13] because the definitions are ambiguous or the language between the vendor and customer is inconsistent.[14] Thus, it is important for performance measurement and compensation terms to be well-defined and consistent.
- Some options in *product service systems* may be taken to minimize economic cost despite high environmental cost. Thus, terms for critical environmentally-preferable activities should be included in the contract. These activities can be supported by an environmental indicator, targets and policies system to encourage customers to consider environmental criteria.[15]
- Lessons from each new customer case should be applied towards further customising the solutions for the Australian market. Furthermore, *c*ustomers should also be encouraged to allocate more of their current IT budget on innovation rather than simply maintaining operations.

The Product Cycle

4. In *product service systems*, vendors ultimately take-back all hardware products (equipment). Thus, vendors engage in several pre-delivery and end-of-life activities for their packaging equipment. There are three main activities that contribute to sustainability.
5. *Design for End-of-Life Processing*: End-of-life processing is technically easier and more cost-effective when equipment is designed with the expectation that it will eventually be dismantled, reused and recycled. Designing for end-of-life processing optimises equipment salvage value by considering several design features.[16]
6. *Packaging Materials*:[17] All IT equipment is delivered in some type of packaging, which is usually discarded in-tact as waste. Packaging waste is minimised in *product service systems* since the vendor takes-back the packaging after equipment is delivered, installed and commissioned. Packaging take-back, as with equipment take-back, provides an economic incentive for vendors to reuse or recycle packaging rather than dispose of it and forfeit its value. It preferable to reuse packaging than to recycle it. Packaging can potentially have severe toxic effects, especially since it is usually treated as waste and thus may leach into waterways, be decomposed in landfill or be burned. Thus, it is important to avoid using toxic materials in packaging.

[9] Vassiliadis, B. *et al* (2006).
[10] Charles, C. and Holmes, B. (n.d.).
[11] Vosicky, J.J. (1992).
[12] Vosicky, J.J. (1992).
[13] Vassiliadis, B. *et al* (2006).
[14] Lewis, E. (2000).
[15] Brezet J.C., Bijma, A. and Silvester, S. (2000).
[16] Amezquita, T. *et al* (1995).
[17] Hewlett-Packard Company (2008), p 7.

7. *End-of-Life Management*: Equipment end-of-life management includes collection, reuse, refurbishment, remanufacturing, recycling and disposal. Vendors can collect end-of-life equipment through returns, trade-ins, lease terminations and donations.[18] Equipment reuse and refurbishment are the preferred end-of-life processes, followed by remanufacturing and recycling, and finally disposal. Reuse and recycling can extend equipment life.[19] Even when not suitable for reuse, IT equipment is still very valuable.[20] To effectively provide end-of-life management services, it is important for vendors to have a range of experience, expertise, capacities, controls, standards and services.[21]

[18] Hewlett-Packard Development Company (2007) *HP FY07 Global Citizenship Report: Web Content*, p 96.
[19] Hewlett-Packard Development Company (2007) *Global Citizenship*.
[20] Hewlett-Packard Development Company (2007) *Global Citizenship*.
[21] Hewlett-Packard Company (2008), pp 7-9.

Brief Background Information

Product Service Systems

In *product service systems*, customers receive the services of IT hardware and software products, while the vendor maintains the ownership and responsibility of the products. Vendors may perform a combination of several activities as part of a successful *product service system* implementation (see Table 2.1). *Product service systems* can include the provision of client hardware and software, data centre hardware and software, as well as help desk and support staff. Vendors must also at least match the customer's operating hours. Global customers may operate 24/7, across different time zones and locations, thus the vendor may also need to be operating continuously.[22]

Table 2.1. Activities performed by vendors at each stage of product service systems

Plan	Prepare	Commission	Operate	Decommission	End-of-contract	End-of-life
Consulting Audit current assets Design solution Strategic planning Financial planning Contract Logistics	Acquire and test assets Load software Temporary storage	Delivery Manage IT refresh programs Place assets in location Remove waste Power up and test assets On-desk data transfer On-desk data destruction	Consulting Backup and disaster recovery Asset management Performance monitoring	Data wiping/ hard drive destruction Remove old equipment Operation testing Cosmetic inspection Secure data wiping/ hard drive destruction Package and transport assets Purchase of assets	Consulting Refurbish and re-licence Product remarketing Renew contract	Process end-of-life assets Reuse/ refurbish/ recycle/ sell components Safe disposal

Source: Vosicky, J.J. (1992)[23]; Macquarie Bank (n.d.)[24]; Hewlett-Packard Development Company (2006)[25]; Charles, C. and Holmes, B. (n.d.)[26]; Hewlett-Packard Development Company (2004)[27].

Barriers to Product Service Systems

There are several barriers that can hinder *product service systems* success:

- *Poor understanding of concepts*: The main cultural barrier to *product service systems* is related to customers' and vendors' poor understanding of the concepts.[28] Best practice case studies aid in understanding,[29] though they are currently relatively scarce.

[22] Davey, N. (n.d.).
[23] Vosicky, J.J. (1992); Macquarie Group website – *Remarketing services*.
[24] Macquarie Bank website – *IT and Technology Financing*; Macquarie Bank website – *Macquarie Technology Services*.
[25] Hewlett-Packard Development Company (2006) *2006 Global Citizenship Report*, p 28.
[26] Charles, C. and Holmes, B. (n.d.).
[27] Hewlett-Packard Development Company (2004).
[28] Vassiliadis, B. *et al* (2006).

- *Unrealistic customer expectations*: Customers can be misled into having unrealistic expectations of *product service systems*. Influences include over-ambitious technology objectives; focussing on technology rather than on business issues; relying on *product service systems* to address fundamental business issues; misguiding consultants; and a lack of metrics that estimate return on investment or impact on the customer.[30]

- *Some equipment is not designed for remanufacturing*: Remanufacturing costs can be reduced if hardware products (equipment) are designed accordingly. Complications arise when, for example, equipment consists of a variety of inseparable materials, equipment cannot be disassembled without damaging components, or handling of components is not safe. These complications arise particularly for older equipment.

- *Vendors carry the high costs while customers reimburse*: Some activities in *product service systems* that are not part of the conventional purchase system pose high costs. One study suggests that high costs are attached to providing: multiple software licences; personnel for service, management and consulting; and solution customisation,[31] including mid-contract modifications[32] and integration with legacy systems, particularly for large customers.[33] Another study of six large companies suggests that other high costs are also attached to: planning and coordination; system development; contracting and training personnel; project marketing; and quality control, including process monitoring and performance measurement.[34] Finally, one IT vendor's equipment take back operations in the USA have found that, for end-of-life processing, fulfilment processes contribute more than 95 percent of the costs.[35]

- *Legislation and regulation*: There are several legislative and regulatory barriers to *product service systems*, including acquiring the expert understanding to ensure violations are avoided. For example, vendors must be aware of equipment classification frameworks for collection, handling and recycling activities, often at both national and state level.[36] Vendors must also be aware of international transportation regulations and treaties, such as the Basel Convention and NAFTA.[37] Finally, vendors must be aware of Customs procedures, especially with regard to disassembled, non-saleable equipment.[38] Other barriers include reporting requirements, waste handling restrictions, finance and tax issues,[39] and the variety of payment systems imposed by different governments who mandate equipment take back.[40]

- *Uncertainties*: There are a large number of uncertainties in *product service systems*, which can potentially become barriers. The array of uncertainties in *product service systems* that could hinder success are summarised in Table 2.2.

Table 2.2: Uncertainties in product service systems and their causes

[29] Vassiliadis, B. *et al* (2006).
[30] Vassiliadis, B. *et al* (2006).
[31] Pring and Ambrose (2002) cited in Vassiliadis, B. *et al* (2006).
[32] Hochstein, A., Zarnekow, R. and Brenner, W. (2005).
[33] Vassiliadis, B. *et al* (2006).
[34] Hochstein, A., Zarnekow, R. and Brenner, W. (2005).
[35] Degher, A. (2002).
[36] Degher, A. (2002).
[37] Degher, A. (2002).
[38] Degher, A. (2002).
[39] Degher, A. (2002).
[40] Hewlett-Packard Development Company (2006) *Real consumer cost for electronic equipment recycling as low as 1 Eruo cent*.

Uncertainty Factor		Cause
Technological	Service availability and response time	Internet connections
	Security	Sharing of client's data with the vendor; transfer of sensitive data over a network
	Scalability	Lack of vendor's expertise
Organizational/ Social/ Cultural	Service monitoring	Lack of valid performance monitoring mechanisms
	Socio-political legitimacy	Laws and standards have not been established
	Service composition	Coordination amongst vendors
	Vendor overhead	Multiple customers sharing the same services
	Structural changes	Role changes for IT department management personnel within customer company
	Customization	'One size fits all' failed, lack of focus
	Exit provision	Lack of reliable exit provision agreements
	Redistribution of responsibility	Large dependence on the vendor
Economic	Integration	High cost to integrate with legacy applications
	Immature economics	Inflexible pricing models/offers
	Switching costs	Costs for adopting IT outsourcing

Source: Vassiliadis, B. *et al* (2006)

Learning from Successful Product Service Systems Implementation

To develop successful *product service systems*, it is important to study and learn from past and new implementation attempts:

- *Activities that yield success:* A study of six large companies suggests that there are specific activities that contribute to the success of *product service systems*:[41]
    - Highlighting short-term successes and thereby demonstrating the usefulness of *product service systems*.

[41] Hochstein, A., Zarnekow, R. and Brenner, W. (2005).

- Striving for continuous improvement to facilitate sustained success.
- Obtaining upper management support to facilitate changes.
- Encouraging customer understanding and acceptance through marketing activities such as using internal publication media; running road shows, workshops and seminars; and managing expectations.
- Implementing education and training, and enforcing customer employee development.
- Forming project teams to manage and develop the new processes such that they penetrate and integrate with existing operational processes.

- *Beware of high expectations*: Several relevant lessons arose from the introduction of previously popular IT service systems, including:[42]
  - Large financial investments from large companies or government support do not guarantee the adoption of the system. Nor does the level of innovation. The system must also be marketed correctly.
  - Trends in the small enterprise market are difficult to predict so be sceptical of large growth in this market. When revenues are overestimated, it is difficult to secure more capital for expansion, which limits a vendor's ability to meet the customer's increasing demands.
  - Failure after hype increases the perception of uncertainty for both customers and vendors, especially when risks are emphasised.
  - Ensure that vendors and customers understand the concepts and purpose of the system.

  Failure to reach expected customer participation levels can hinder *product service systems'* viability. Most materials processors prefer receiving large quantities of materials, which makes it difficult for vendors to cost-effectively processes materials when customer participation is low and material quantities are small.[43]
- *Customer priority*: Services must be defined to match the customer's business objectives, rather than the vendor's.[44] However, solutions that heavily favour either vendor or customer are likely to result in disputes or performance underachievement.[45]
- *Business stability*: *Product service systems* success can be critical to a customer's operations, so planning and negotiations should involve representatives from accounting, legal, operations, treasury and top management.[46] Do not assume the capacity of the vendor to deliver the solution. Even some high-profile vendors have been bankrupted mid-contract.[47]
- *Contracts*: Many lawsuits have been filed that relate to computer leasing and remarketing. The most common disputes involve subleasing and parts substitution during upgrades.[48] Thus, it is important to have options for ambiguous activities written into the contract. Consider especially subleasing, parts substitution, small-ticket product substitution and conditions for modifying

[42] Vassiliadis, B. *et al* (2006).
[43] Degher, A. (2002).
[44] Vassiliadis, B. *et al* (2006).
[45] Charles, C. and Holmes, B. (n.d.).
[46] Vosicky, J.J. (1992).
[47] Vosicky, J.J. (1992).
[48] Vosicky, J.J. (1992).

performance requirements.[49] Unspoken agreements or agreements represented in contracts in general terms should, where possible, be avoided, as they have led to costly disputes. For example,[50] New Hampton, Inc., a US$400-million company, had an agreement for leased equipment that stated that the lessor would not 'unreasonably withhold' its consent for New Hampton to sublease equipment to another firm. When needing to add memory to the leased mainframe, New Hampton found that although a sub-lessor could provide the upgrade for US$50,000, they were locked into the lessor's US$230,000 upgrade solution.

- *Performance measurement and compensation terms*: The conventional approach to performance measurement is based on service level agreements and service credits, which are like refunds for inadequate performance that are deducted from the vendor's compensation.[51] This approach results in regular disputes between the customer and vendor, especially in relation to performance definitions, responsibility for performance inadequacies, and service credits value.[52] The performance and compensation terms are usually unreliable in dispute resolution[53] because the definitions are ambiguous or the language between the vendor and customer is inconsistent.[54] Thus, it is important for performance measurement and compensation terms to be well-defined and consistent.

- *Address environmental issues*: Despite the promise, sometimes the environmental benefits of *product service systems* are not delivered. In fact, few vendors are developing *product service systems* with environmental issues in mind,[55] perhaps since innovations in these systems are driven by technology and competitiveness rather than environmental issues.[56] For example, given the option, most customers would opt for disposal services rather than equipment end-of-life management because disposal currently costs less,[57] especially in countries where equipment take-back is not mandatory. Therefore, terms for critical environmentally-preferable activities should be included in the contract.

  Customers may, however, welcome environmentally preferable options if there is little difference in cost. For example, a study of *product service systems* in five types of services, including IT services, suggests that an environmental indicator system for services be developed to encourage customers to consider environmental criteria.[58]

- *Facilitating product service systems development*: *Product service systems* are in their infancy in Australia. Thus, lessons from each new customer case should be applied towards further customising the solutions for the Australian market. A term that should be detailed in contracts is the release of performance information by the customer for reporting and case study development. Furthermore, customers should also be encouraged to allocate more of their current IT budget on innovation rather than simply maintaining operations. For example, cost savings from initial *product service systems* or their components can be reinvested in expansion or progression.

[49] Vosicky, J.J. (1992).
[50] Vosicky, J.J. (1992).
[51] Lewis, E. (2000).
[52] Lewis, E. (2000).
[53] Vassiliadis, B. *et al* (2006).
[54] Lewis, E. (2000).
[55] Charter (1999) cited in Heiskanen, E. and Jalas, M. (2003).
[56] Stahel (2001) cited in Heiskanen, E. and Jalas, M. (2003).
[57] Fishbein *et al* (2000) cited in Ness, D. *et al* (2005).
[58] Brezet J.C., Bijma, A. and Silvester, S. (2000).

The Product Cycle

Product service systems require vendors to maintain the ownership and responsibility of the products, which means that vendors ultimately take-back all hardware products (equipment). Thus, vendors engage in several pre-delivery and end-of-life activities for their packaging and equipment to close the product cycle. Three main activities that assist in cost-effectively closing the product cycle are:

1. Designing equipment to make end-of-life processing easier.
2. Designing low-toxicity packaging materials for reuse and recycling.
3. Providing end-of-life management services.

Design for End-of-Life Processing

End-of-life processing is technically easier and more cost-effective when equipment is designed with the expectation that it will eventually be dismantled, reused and recycled. Designing for end-of-life processing optimises equipment salvage value by considering:[59]

- *Ease of disassembly:* Where disassembly cannot be avoided, making it easier can reduce the time required for this non-value-adding activity. Permanent fastening such as welding or crimping should not be used if the equipment is intended for remanufacture, ensuring that components are not damaged during disassembly.
- *Ease of cleaning:* Used components will likely require cleaning. Components can be designed for easy cleaning by understanding the cleaning methods, making the surfaces to be cleaned accessible, and ensuring that cleaning residues cannot accumulate on the component.
- *Ease of inspection:* Minimise the time required for this non-value-adding activity.
- *Ease of part replacement:* Components that wear should be easily accessible so as to minimise the time required for reassembly and prevent damage during component insertion.
- *Ease of reassembly:* Minimise the time required for reassembly – if the equipment is being processed at end-of-life then it will be assembled multiple times throughout its life. Be aware of tolerances between components.
- *Reusable components:* Increasing the number or reusable components increases the cost effectiveness of end-of-life processing.
- *Modular components:* Modular systems require less time for assembly and disassembly.
- *Fasteners:* Using fewer different fasteners reduces the complexity of assembly, disassembly and the materials handling.
- *Interfaces:* Using fewer different component interfaces reduces the number of different components required to produce a family of equipment, which helps build economies of scale and improve re-manufacturability.

[59] Amezquita, T. *et al* (1995).

Packaging Materials

All IT equipment is delivered in some type of packaging,[60] which is usually discarded in-tact as waste. Packaging waste is minimised in *product service systems* since the vendor takes-back the packaging after equipment is delivered, installed and commissioned. Packaging take-back, as with equipment take-back, provides an economic incentive for vendors to reuse or recycle packaging rather than dispose of it and forfeit its value. When packaging reuse is not a practical option, packaging recycling can be facilitated by:

- Selecting materials based on their recyclability (which varies geographically), and their size and mass (which contributes to transportation energy). Many types of packaging can safely comprise a high proportion of recycled materials without compromising the packaging's ability to protect its contents.
- Avoiding permanent adhesives, especially when joining different materials.
- Clearly embossing or marking an applicable code that identifies parts.

Packaging can potentially have severe toxic effects, especially since it is usually treated as waste and thus may leach into waterways, be decomposed in landfill or burned. Major groups of toxic materials to avoid include:

- *Ozone depleting substances*: chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) in plastic foam as foaming agents, and methyl bromide sterilization used on wood.
- *Heavy metals*: lead, mercury, cadmium and hexavalent chromium – maximum collective concentration of 100ppm by mass.
- *PVC:* which contains toxic ingredients as stabilisers and other additives.[61]

End-of-Life Management

Product service systems rely heavily on equipment end-of-life management, which includes collection, reuse, refurbishment, remanufacturing, recycling and disposal. Vendors can collect end-of-life equipment through returns (sometimes for cash), trade-ins, lease terminations and donations.[62] Equipment reuse and refurbishment are the preferred end-of-life processes, followed by remanufacturing and recycling, and finally disposal. Reuse and recycling can extend equipment life, and 2.5 million refurbished items of IT equipment are currently remarketed each year.[63] Even when not suitable for reuse, IT equipment is still very valuable. For example, one IT vendor collects 230-280 grams of gold, silver, palladium and other precious metals per ton of equipment - while a typical extractive mine collects 170 grams per ton.[64] Furthermore, recycled materials can be used in a range of products, including IT equipment. To effectively provide end-of-life management services, it is important for vendors to work towards the following:[65]

- Accept and mange responsibly of the equipment in accordance with applicable legislations and policies, including specifying the processing and next-use for recovered materials.

[60] Hewlett-Packard Company (2008), p. 7.
[61] Scheirs, J. (2003).
[62] Hewlett-Packard Development Company (2007) *HP FY07 Global Citizenship Report: Web Content*, p 96.
[63] Hewlett-Packard Development Company (2007) *Global Citizenship*.
[64] Hewlett-Packard Development Company (2007) *Global Citizenship*.
[65] Hewlett-Packard Company (2008), pp 7-9.

- Have the capacity to process their own end-of-life equipment rather than outsourcing.
- Manage the chain of custody (inventory, storage, shipping and evaluating next-use) to ensure that materials are controlled and handled in accordance with applicable legislations and policies.
- Arrange for take-back and offer revenue sharing with customers for resold equipment or cash for unwanted equipment.
- Ensure data security and privacy along the chain of custody, including offering flexible and validated data erasure options and offering proof of destruction for documents with serial numbers of equipment that has been processed.
- Have the capacity to recover, inspect, evaluate, test, refurbish, recycle and remarket equipment, even other vendors' equipment.
- Have established recycling standards for any outsourced recyclers, including processes for auditing, qualifying and measuring recyclers' performance.
- Have knowledge about the secondary IT equipment market.

Optional Reading

1. Brezet J.C., Bijma, A. and Silvester, S. (2000). 'Innovative electronics as an opportunity for Eco-efficient Services', *Proceedings of Electronics Goes Green conference,* September 11-13, 2000, Berlin, Germany, pp. 859-865.
2. Charles, C. and Holmes, B. (n.d.) *The Route to Restoring Efficiency*, CXO, pp. 39-44. Available at http://www.cxo.eu.com/pastissue/article.asp?art=25029&issue=134. Accessed 10 June 2008.
3. Hewlett-Packard Development Company (2006) *Real consumer cost for electronic equipment recycling as low as 1 Euro cent*, HP Development Company Available at http://www.hp.com/hpinfo/globalcitizenship/environment/pdf/nr_costofrecycling.pdf. Accessed 10 June 2008.
4. Hochstein, A., Zarnekow, R. and Brenner, W. (2005) 'Evaluation of service-oriented IT management in practice', *International Conference on Services Systems and Services Management*, pt.1, vol. 1, pp. 80-84.
5. Lewis, E. (2000) 'Building Business-based service levels for IT outsourcing contracts: the Measure to Manage (M2P) performance measurement system', Proceedings of the 8th European Conference on Information Systems, Trends in Information and Communication Systems for the 21st Century, ECIS 2000, Vienna, Austria, July 3-5, 2000. Available at http://is2.lse.ac.uk/asp/aspecis/20000093.pdf. Accessed 10 June 2008.
6. Scheirs, J. (2003) *End-of-life Environmental Issues with PVC in Australia*, Environment Australia, pp 17-26. Available at http://www.environment.gov.au/settlements/publications/waste/pvc/. Accessed 11 June 2008.
7. Vosicky, J.J. (1992) 'Capturing the benefits of high-tech leasing', *Financial Executive*, July-August. Available at http://www.allbusiness.com/technology/computer-software-management/332405-1.html. Accessed 10 June 2008.

Key Words for Searching Online

Sustainable IT, product service systems, service level agreement (SLA), Basal Convention, NAFTA, product take-back, design for end-of-life, design for disassembly, design for assembly, design for remanufacturing, design for recycling, packaging design, reuse, refurbished, remanufacture, recycling.