REUSE AND RECYCLING OF SERVERS: NEXT STEPS TOWARDS SUSTAINABILITY

evoswitch
NEXT GENERATION DATACENTERS

As well as state-of-the-art technology, servers contain valuable, and toxic, materials, and server owners are obliged under current legislation to dispose of them responsibly. However, the current reuse and recycling stages of the product lifecycle leave a lot to be desired. This paper, based on a Master's Thesis conducted with EvoSwitch support by the University Leiden, looks at the Amsterdam Region. It argues that, at both the reuse and recycling stages of the server lifecycle, improvements can be made which would deliver both commercial and environmental benefits. The principle proposed changes/subjects for further discussion would be improved life cycle analysis and specification development at procurement, reduced shredding and increased dismantling/reuse at end of first owner use, and a new trackable reuse business model which keeps valuable materials and components in the region.

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INTRODUCTION

As the backbone of today's IT infrastructure, and a high energy consumer, the data centre industry has taken its responsibilities seriously in recent years and made major strides in engaging with renewable power providers and ensuring maximum energy efficiency. This paper proposes that, as waste levels grow and resources become scarcer, it is time to research and collaborate in a new area where major environmental and commercial improvements are possible - the reuse and recycling of servers.

This paper, a digest of a much more detailed thesis on the subject focusing on the Amsterdam Region, looks at the current structure of the product cycle, the incentives it provides for those involved in the cycle to dispose of servers correctly, and the ways in which the current process could be improved.

Server Growth in the Data Centre

Data centres house a huge number of servers, and with the rise of the cloud, the role of the data centre service provider in ICT provision is set to grow:

- Today, data centres are responsible for one sixth of the total ICT footprint (Vereecken et al., 2012).
- According to research by the Dutch Datacenter Association in May 2016, 28% of all company firm server racks were located in data centres, and by 2020 it is predicted that 50% of all server racks will be located in data centres (Vermeulen & Patel, 2016).

While not a direct agent in the current server product cycle, it is clear that the more environmentally responsible data centre service providers could take an active informational or facilitating role in improving product cycle environmental and business outcomes.

The Server Waste Stream: Toxic and Valuable

Waste Electrical and Electronic Equipment (WEEE) is the fastest growing solid waste stream (Elliot, 2007; Toffel, 2003), and redundant servers make up a significant and potentially dangerous portion of this.
To avoid contamination and the waste of resources entailed in landfill or incineration, proper disposal through recycling or reuse is imperative:

- Electrical and electronic equipment is responsible for 10-20% of natural resources depletion (Georgiadis & Besiou, 2010).
- Servers contain iron, copper, aluminium, cobalt, nickel, tin and zinc, as well as precious metals such as gold, silver and palladium.

- Many of the substances involved are toxic; mercury, cadmium, lead and other rare earth elements can leak into the environment through disposal in landfills or form dangerous compounds through incineration (Elliot, 2007; Forge, 2007; Hanselman & Pegah, 2007; Vanner et al., 2014).
- High-grade WEEE, which includes the waste categories IT, telecommunications and consumer equipment is particularly valuable (Alsheyab, 2014), with a rich portion of precious metals (Bigum, Brogaard, & Christensen, 2012).

Short Life Cycles

The waste challenge is exacerbated by Moore's Law (that the number of transistors per square inch on integrated circuits doubles every year), which makes faster processors possible for the same price (D'Amico & White, 2012). This motivates owners of data centre servers to keep lifecycles of servers short. Lifecycles are generally three to five years (Peagam, McIntyre, Basson, & France, 2013; Whitehead, Andrews, Shah, & Maidment, 2015), but can be as short as a year (Whitehead, Andrews, & Shah, 2015).

Current Legislation

The European Union has acted on the problems of WEEE by creating the WEEE Directive, which enforces the concept of Extended Producer Responsibility [EPR]. This responsibility is managed through Producer Responsibility Organisations [PROs], financed by the producers of EEE to recycle WEEE (Sander et al., 2007). However, the WEEE Directive is focused primarily on the disposal of consumer electronics, and data centre servers are business-to-business (B2B) waste. For B2B waste the WEEE Directive only partly applies, and products are not collected at PROs. Instead they are processed in a separate treatment network consisting of a range of contractors and informal agreements (Peagam et al., 2013). The consequence is that B2B waste is not reported on, and thus is hard to track or to control (Ylä-Mella et al., 2014; Zoeteman, Krikke, & Venselaar, 2010).

The goal of the EPR programme is to create a 'closed-loop reverse supply chain', where products or materials return to the original producer (Fleischmann et al., 1997). In some circumstances this is considered more sustainable than an open-loop system, where products are recovered by other parties outside the original supply chain who will reuse or repurpose the product or materials. However, particularly bearing in mind the shortness of server life cycles in data centres, the question of whether a closed or an open loop supply chain is practical or preferable for servers remains open. That said, the introduction of partial EPR to the B2B market has not yet been successful in making recovery of disposed IT hardware more environmentally friendly.

The Scale of the Challenge in the Netherlands

Usually in looking into the WEEE recycling flows, only the flows through PROs are taken into account. However, Huisman et al. (2012) looked into the complementary flows of B2B as well in a case study of WEEE flows in the Netherlands. From this it can be concluded that the B2B flow is slightly less than half the size of the WEEE coming through PROs; 2.7 kg/inh (kilos per inhabitant) for businesses versus 7.5 kg/inh for PROs. Of this 2.7 kg/inh, 0.41 kg/inh (approximately 15%) comes from the IT sector.

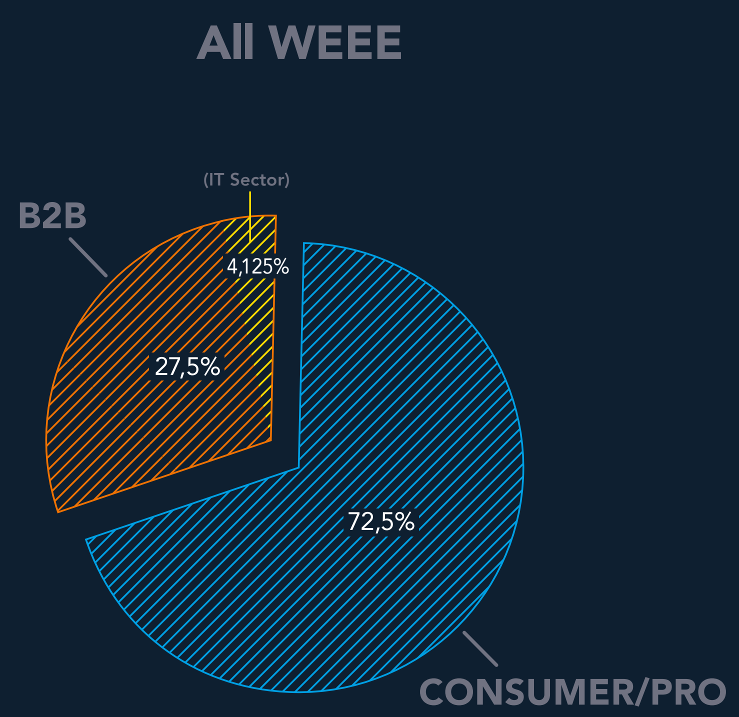


Figure 1: Scale of the Challenge, Netherlands

ASSESSING THE CHALLENGE THREE KEY QUESTIONS

To shed light on the current situation and move towards a solution, three key questions need to be answered:

1. How is the waste stream process currently organised?

2. What are the incentives for those involved in the process?

3. What can we change to move towards a more environmentally friendly and financially advantageous model?

1. Defining the waste stream
How is the waste stream process currently organised?'

WEEE in general is receiving increased attention. EEE producer responsibility is implemented by two organisations - Wecycle and ICT Milieu. Of the electronics ending up at these PROs, 79% of the weight at collection is recycled to recover the raw materials, which are metals, plastics and glass (ICT Milieu, 2014); 18% of the weight of collected waste is used for energy recovery; the remainder (3%) is either

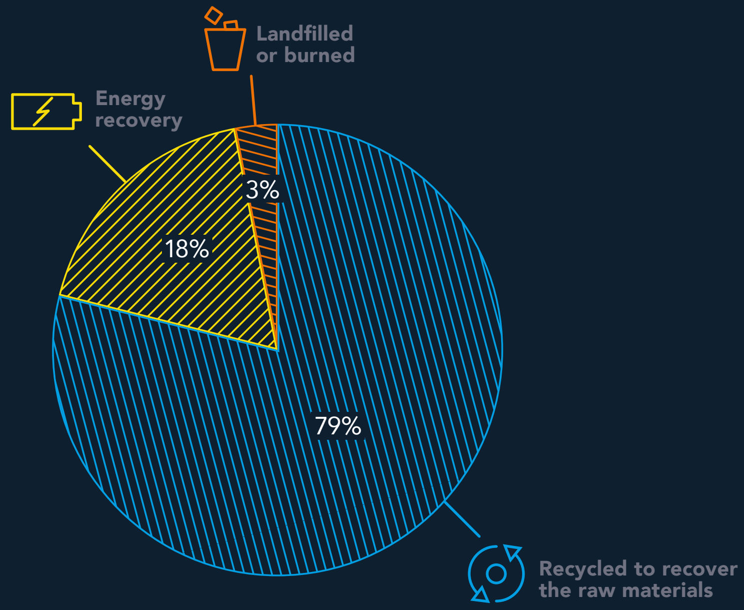


Figure 2: PRO recycling outcomes in the Netherlands (consumer WEEE)

landfilled or burned. Figure 2 provides a graphical overview of this. However, in the Netherlands B2B waste does not flow through PROs. Currently in the B2B sector the principle of Extended Producer Responsibility applies, but with looser regulation and definition, such as the omission of the financial guarantee system (Sander et al., 2007). This financial guarantee system pays the PROs, which is why the B2B sector does not participate in the PRO system.

Instead, in the current Dutch B2B product cycle server dispo al is organised as follows:

Procurement: Servers are procured from OEMs.

Operation & Data Destruction: The servers are then used, until a decision is made to dispose of them. To dispose of the servers, a service is contracted from a recycling company, a refurbisher or an ITAD (IT Asset Disposition) solution provider. The servers are collected, serial numbers are removed and data is destroyed, and a certificate of destruction is given out. The method of data destruction selected influences the rest of the flow. Currently servers can be degaussed (using magnets to rearrange particle polarity) or erased using multiple passes through specialist software, or they can be shredded. Certificates of data destruction are then provided.

Four scenarios then emerge:

- **Shredding:** When servers are shredded for data security, refurbishment becomes impossible, as well as the material recycling route in which servers are dismantled manually. Instead the shredded server parts need to be sorted into different materials which are then sold to smelters.
- **Dismantling:** The second scenario is also material recycling, but in this case the products are dismantled instead of shredded. More value is recovered, but more costs are incurred through the manual dismantling. With dismantling it is possible to separate the circuit boards, which are sold to a specialised smelter located outside the region.
- **Refurbishment and Regional Reuse:** The two scenarios involve refurbishing servers either as a whole or in parts. Here, the crucial part is what happens when servers are sold. Currently they are sold to brokers, and it is not possible to control where they end up. While bearing in mind that old servers use more power, it is still environmentally advantageous that they should be reused, as more value is recovered, and ideally these refurbished servers and parts can be reused in the region. This is currently however not an enforceable option, as there is no successful business model for ensuring that servers are reused within the region.
- **Refurbishment and Reuse outside the Region:** in fact servers are extremely likely to be resold outside the original region, where demand for second-hand servers and recycled materials is higher, particularly in developing markets. When servers are resold outside the region control over the resources is lost, never to be recovered.

Overview of flow scheme for data centre server disposal

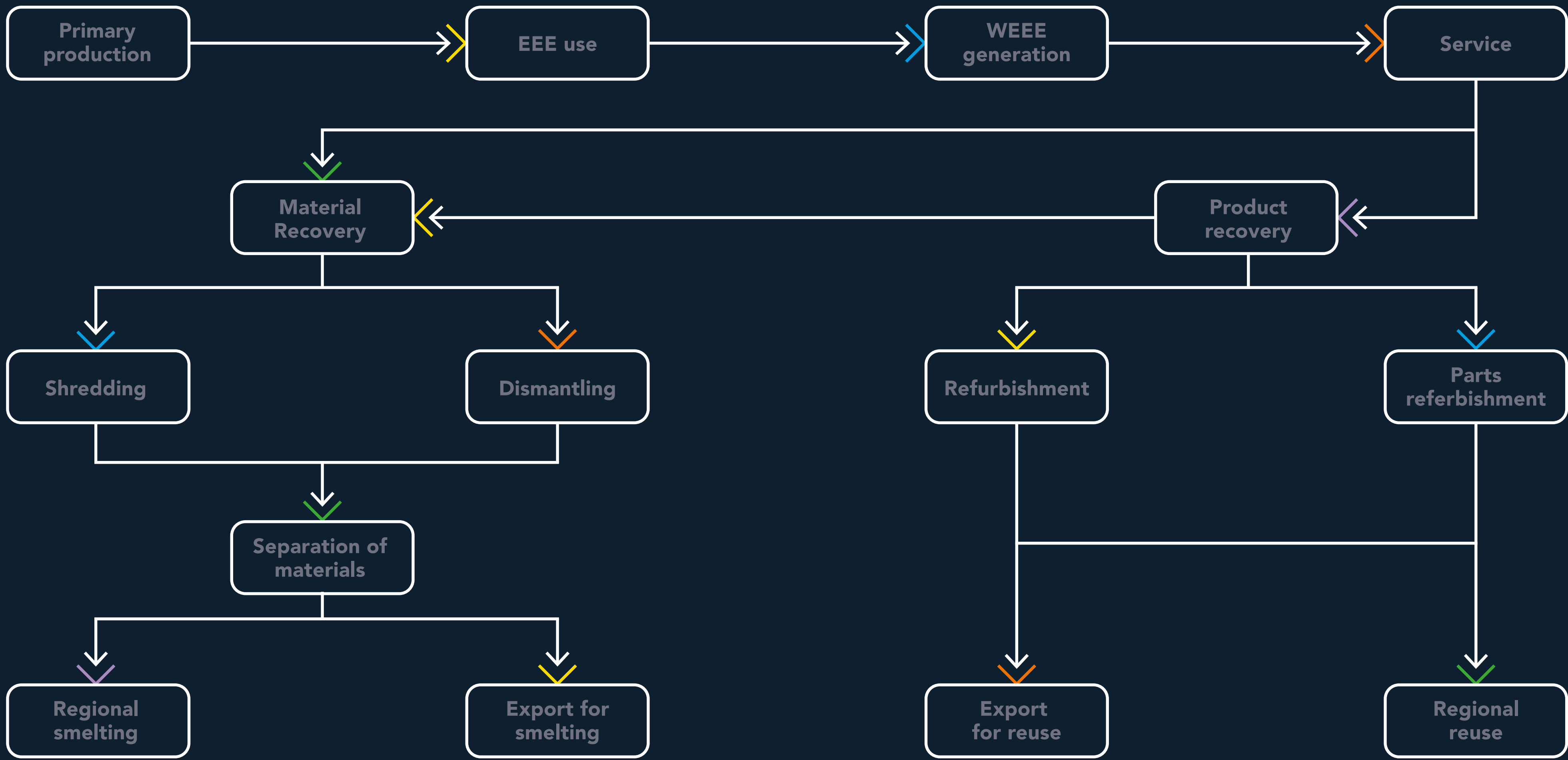


Figure 3: Overview of flow scheme for data centre server disposal

2. Assessing incentives
What are the incentives for those involved in the process?

What fuels this flow? In order to develop any proposals for improving the current cycle it is necessary to know what incentives and threats (i.e. negative incentives) drive businesses to choose certain routes of server disposal over others:

1. **Procurement drivers:** This starts at the purchase stage. Currently purchase is based primarily on price, but here there is clearly an opportunity for server users to push for sustainability on all fronts.

2. **Disposal point decision:** Generally this decision is made when the server stops working or the maintenance contract runs out, book value is nil, or the existing operating system or software is no longer supported (which generally means there is a next generation server available). Here the economic incentive is to take as many variables into consideration as possible in deciding the ideal point for disposal of a server. Often only depreciation and hardware support contract costs are taken into account.

3. **Disposal method drivers:** In the actual disposal of a server, data security is an important incentive. In some ways, due to current legislation and fines, it is too important. Deletion of data with multiple runs through deletion packages can be certifiably effective, leaving components intact for dismantling, which generates greater value. However, fear of data leakage is often so strong that shredding is selected as the safest option. There is an imbalance in incentives here; the incentive to secure data is stronger than the environmental and economic incentive.

4. **Refurbishment for resale:** Refurbishers will accept a product as long as it has market value. Because of the current regulatory structure (i.e. no PROs) refurbished products are not tracked, and they are often resold again and again before they end up with an end-user. For refurbishers it is commercially preferable not to limit sales to the region, as often parties from foreign countries are interested. And even if they try to limit sales to the region, it is very likely that servers will end up outside the region in the end. Here the economic incentive and transportation/environmental incentive are clearly not aligned.

3. Opportunities for improvements
What can we change to move towards a more environmentally friendly and financially advantageous model?

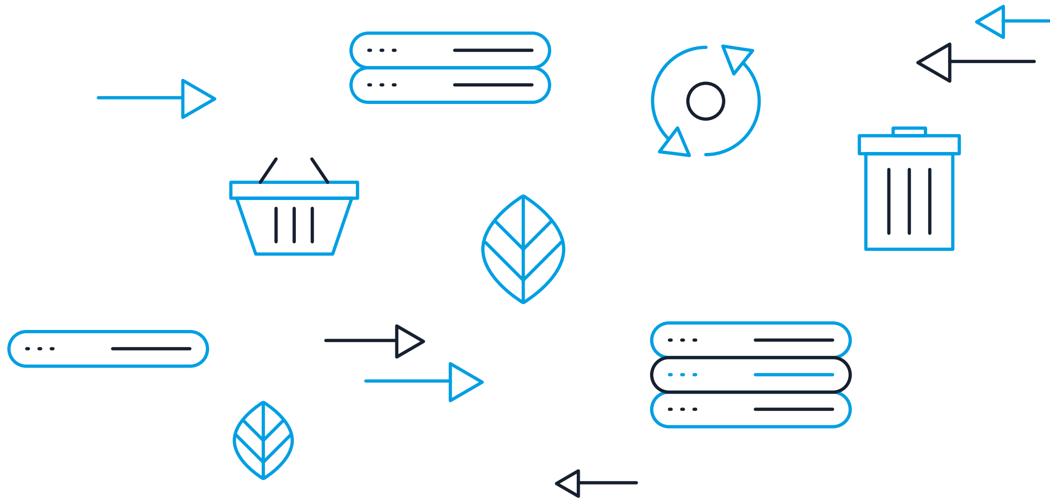
What can the industry do to develop an effective regional reverse supply chain? Interviewees proposed a number of opportunities worth exploring:

1. **Include upgrade and recycling criteria at procurement:** Firstly, the procurement process for servers could motivate OEMs to produce servers from which more value is recovered through recycling, and which are more upgradable. A current problem with upgradability is that only marginal upgrades are possible, which makes it difficult to lengthen lifecycles. If major upgrades were possible, it would be possible to improve the energy efficiency of existing servers, making it environmentally desirable to lengthen server lifecycles. Upgrades in energy efficiency are environmentally desirable as the operational impact is lowered with minimal embodied impact. If users were to demand upgradability and recyclability (ensuring servers are easy to dismantle) this would bring them financial benefits as well as motivating OEMs to collaborate with recyclers, smelters and refurbishers to improve on the current approach. There would also clearly be an opportunity for product differentiation by OEMs.

2. **Give users more information about efficient server management and secure disposal:** With more information more informed decisions can be made. Possible improvements would be retaining more financial and environmental value by dismantling servers instead of shredding, for instance by securing data destruction without shredding. For server management, users should be encouraged to consider the impact of operational and embodied energy use more, something which is not currently happening and could lead to significant savings. This is a major opportunity. By helping users to manage all the relevant costs, including the cost of energy use and the possible savings from replacement by more energy efficient servers, more environmentally and commercially advantageous decisions could be made.

3. **Encourage regional reuse:** In the reuse scenarios, the regional reuse scenario is much more environmentally friendly, but currently not realistic. It is not yet possible to refurbish servers and sell them for reuse in such a way that the materials stay in the region, which is preferable to exporting. The participants in this study rightly said that new business models are needed to solve this problem. Leasing second hand servers might be a solution, for example, as ownership (and therefore recycling responsibility) would be retained by the refurbisher. However the problem here is that the economic incentive for refurbishers is to export servers as long as local demand for older servers is low. A solution might be for users of servers to demand that servers stay in the region after refurbishment, when they contract refurbishers. However with demand higher outside the region refurbishers may not 'buy into' this, in every sense. While there is no obvious solution in this area, it is clear that something needs to be done. the winners from the also rans.

CONCLUSION
MOVING SERVER MANAGEMENT AND DISPOSAL IN THE RIGHT DIRECTION



While specific approaches to aligning environmental and commercial incentives for the improved management and disposal of data centre servers still need to be devised and tested, it is clear what direction they should take.

Dismantling v Regional Reuse: an open question

Without more in-depth information based on tracking and analysis of usage it is not currently possible to tell which scenario - dismantling or regional reuse – is preferable. With reuse more value is retained, where this value would be lost with dismantling and recycling a server. However, old servers consume more energy, and as operational impact for servers is greater than embodied impact, replacement of a server with a new and more energy efficient one is often more environmentally friendly than keeping an old server in use. That said, the general direction we should move towards is clear; to achieve a more environmentally friendly, resource efficient and economically viable reverse supply chain for data centre servers, the dismantling and regional reuse scenarios are much more sustainable than the two scenarios of shredding servers and exporting for reuse.

Promotion of dismantling at procurement

The promotion of dismantling for reuse would bring clear benefits. On the one hand, improving upgradability and recyclability/ease of dismantling at the OEM end could create significant financial and environmental benefits. This is something which users can drive at the procurement stage or through forming working groups with OEM suppliers.

Promotion of dismantling at end of use

In order to motivate users to dismantle servers, they should be informed about the possibilities for data destruction which do not involve shredding, but still provide adequate data destruction. This is something that could be driven by a mix of green NGOs, data centre service providers (as neutral intermediaries with access to a large number of users) and recyclers themselves.

Effective server lifecycle management

In investing in server materials, asset lifecycle management could be a useful way to make more efficient use of servers. The lifecycle of a server should be a more planned process, incorporating energy use, book value, resale value and other relevant factors. A server is bought and planned for across a certain period, and during its life owners should be able to assess whether it is still needed, whether it would be more economically advantageous to replace it, or if it should be upgraded. This would make for a more environmentally friendly server lifecycle as well as a more economically advantageous approach to TCO, however it would require more detailed analysis/tool development, possible from a collaboration between users, green NGOs and OEMs.

Encouraging regional reuse

Regional reuse of servers either in parts or as a whole presents a more complex challenge. In order for servers to be reused regionally, a new business model is needed that guarantees materials will stay in the region, instead of entering the uncontrollable global second hand server market. The difficulty here is that the economic incentive currently fuels the global export route. Collaboration among the key actors here – users, refurbishers and green NGOs – could result in a new and mutually advantageous solution which is more sustainable.

Amsterdam Region: an excellent starting point

And finally, the area in which this case study was undertaken may prove to be an excellent environment in which to try out new approaches to improve the current server disposal process. Based on interviewee responses during the study there appears to be clear support for an environmentally and economically driven reversed server supply chain. There is also support from governmental bodies concerned with creating a server recycling community (Cramer, 2014; Cramer & Nederstigt, 2015). The companies in the region are active in becoming more sustainable, which is defined in a voluntary multi-year agreement (MJA-3) between a large portion of companies and the Dutch government (Nederland ICT, 2013). In this drive to be more sustainable the inclusion of care for WEEE could become the next target. WEEE in general is receiving increased intention on a Dutch and European level (Huisman et al., 2015). In addition to the focus on properly recycling WEEE, the Netherlands is also being promoted proactively as a hotspot for the circular economy, through ambassadorship by a very diverse array of companies and governmental organisations (Douma, 2016). The Netherlands is also a clear case in which the WEEE B2B waste is organised separately from consumer waste. The combination of the separately organised waste stream within a country with positive preconditions towards sustainability would make for a unique opportunity for more detailed lifecycle and disposal analysis.

SOURCES

This paper is based on a recently-completed Master's thesis by Casper van Hoorn of Utrecht University. Supervised and facilitated by Eric Lisica of EvoSwitch, the study was based on primary qualitative research involving 18 interviewees in the Amsterdam Region:

- 5 from OEMs
- 6 server users in the data centre
- 2 recyclers/refurbishers
- 1 refurbisher
- 2 ITAD (IT Asset Disposition) solution providers
- 1 environmental IT NGO

The thesis concentrates on the current product cycle, incentives and opportunities for improvement in the context of the Netherlands in general and the Amsterdam Region in particular.

Colophon

Text
The Communication Matrix Ltd
Eric Boonstra
Patrick van der Wilt
Sander Deutekom

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www.evoswitch.com