
Environmental Impacts of electronic products

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Do electronic products influence our environment?

Bernd Kopacek



Environmental Impacts (1)

- Google pays 50 million € per year for electricity
- Only for the operation of computing centers about 14 large power plants with a capacity of 1000 MW each are needed worldwide. This is equivalent to nearly 100 power plants „Freudenau“ in Vienna with 145 MW each.
- More than 1000 hazardous substances are used to manufacture electronic products.

Environmental Impacts (2)

- Shortages of water supply in the Silicon Valley caused by increased chip production
- 2009 more than 12 million tons of electronic scrap occurred with the EU27
- 2010 more than 300 million computers and monitors will be exchanged in the US alone
- More than half of the obsolete IT will be exported to China and India

How do legislators react?

Legal Framework EU

- **WEEE** (Waste from Electrical and Electronic Equipment)
- **RoHS** (Reduction of Hazardous Substances)
- **EuP** (Energy using Products)
- **REACH** (Registration, Evaluation and Authorisation of Chemicals)
-

WEEE - Directive

- **Producer (=Importer) has been made responsible for the total life cycle**
- **4 kg WEEE per inhabitant per year has to be collected from private households** (Rev: 65% of the average weight of EEE placed on the market over the last 3 years or 85% of WEEE generated)
- **Recycling and recovery quota for 10 different product categories** (Rev: +5%)
- **Obligations for treatment, reporting and information**

RoHS - Directive

- Ban of hazardous substances since July 2006
 - Lead
 - Mercury
 - Cadmium
 - hexavalent Chromium
 - brominated flame retardants (PBB, PBDE)
- Exceptions for certain applications!

EuP - Directive

- Defining Ecodesign-requirements for Energy using Products (EuP)
- For all products that use electricity, fossile fuels or renewable energies to function properly
- Exempted are vehicles for the transport of passengers or goods
- Conformity will be checked in the framework of the CE marking by a declaration

EuP - Directive

- Framework Directive
=> the real requirements and criteria will be defined in „implementing measures“ for each product group
- The following criteria are valid for defining implementing measures:
 - significant volume of more than 200.000 products sold or traded per year within the EU
 - the product has a significant environmental impact
 - the EuP shall present significant potential for improvement in terms of its environmental impact without entailing excessive costs

REACH - Directive

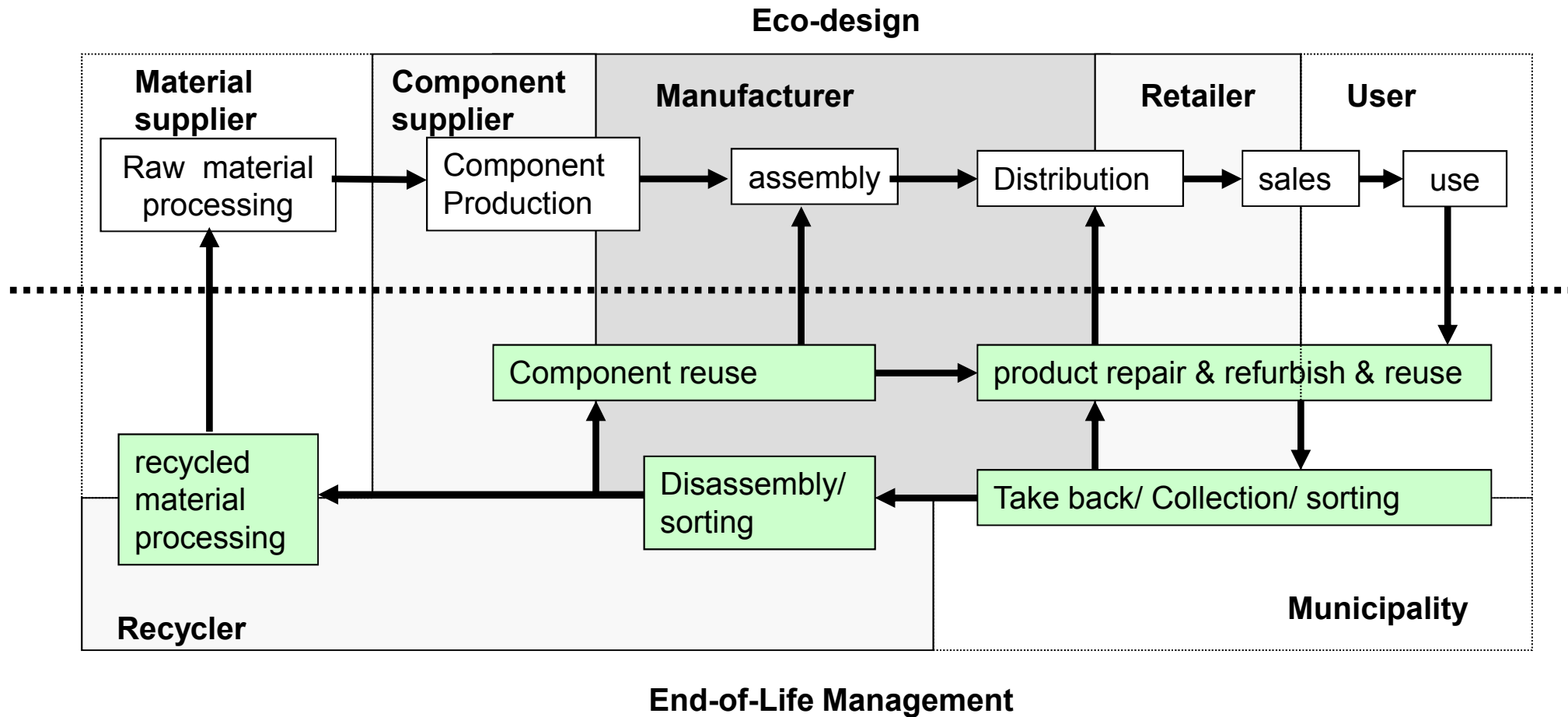
- The REACH-Directive deals with the **R**egistration, **E**valuation, **A**uthorisation and Restriction of **C**hemical substances since July 2007
- The following stakeholders are affected by the REACH-Directive
 - Producer and importers of chemical substances
 - Professional users of chemicals (Downstream user)
 - Traders of chemicals

REACH - Directive

- From June 2008 the following chemical substances must be registered:
 - substances that are produced in quantities bigger than 1000 tons per year
 - substances with a risk potential R50 to R53 that are produced in annual quantities bigger than 1000 tons
 - substances with CMR properties that are produced in annual quantities bigger than 1 ton
- The registration contains:
 - safety data sheets
 - technical dossiers
 - defined release scenarios
 - risk assessments

Who has to act?

Involved Stakeholders



What can be done?

Product Re-design

Design methods for sustainable products

- Design for Environment
- Design for Disassembly
- Design for Sustainability
- Ecodesign

Design tools

- LCA –Tools
- Ecodesign-Checklists
- Guidelines for Design for Disassembly
- Supply chain analysis

Eco-efficient Technologies

- Energy efficiency
- Dematerialization
- Substitution of hazardous substances
- Sustainable Production of Service Oriented Products

Eco-efficient materials and processes

- Benchmark
- Investigate potential materials/processes, future aspects
- Estimation of environmental impact

Practical Approaches

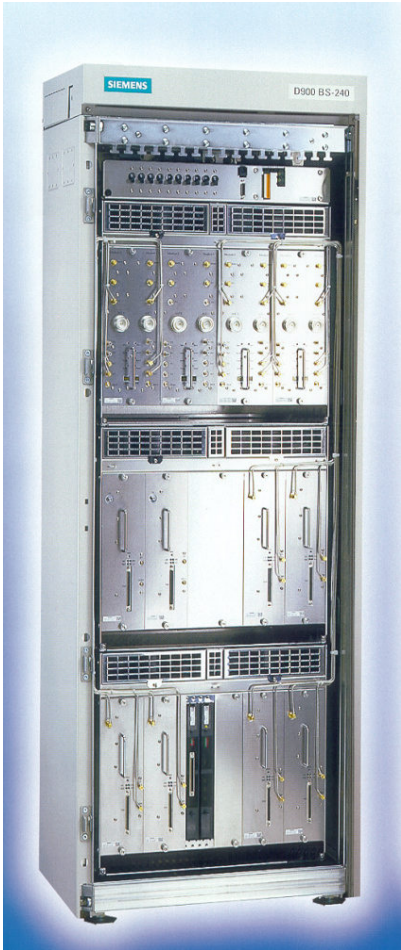
Motorola – Green Phone



- Use of lead-free solder
- Bromium-free PWB
- Housing of recycled plastic
- Energy-efficient charger (stand-by)

Practical Approaches

Siemens – Base station



→ Base station

- Volume reduction: 8 transmission units instead of 6
- New air condition system without outdoor system
- Al + chem oxidized + coated + printed replaced by noble steel + laser inscription

→ Subrack

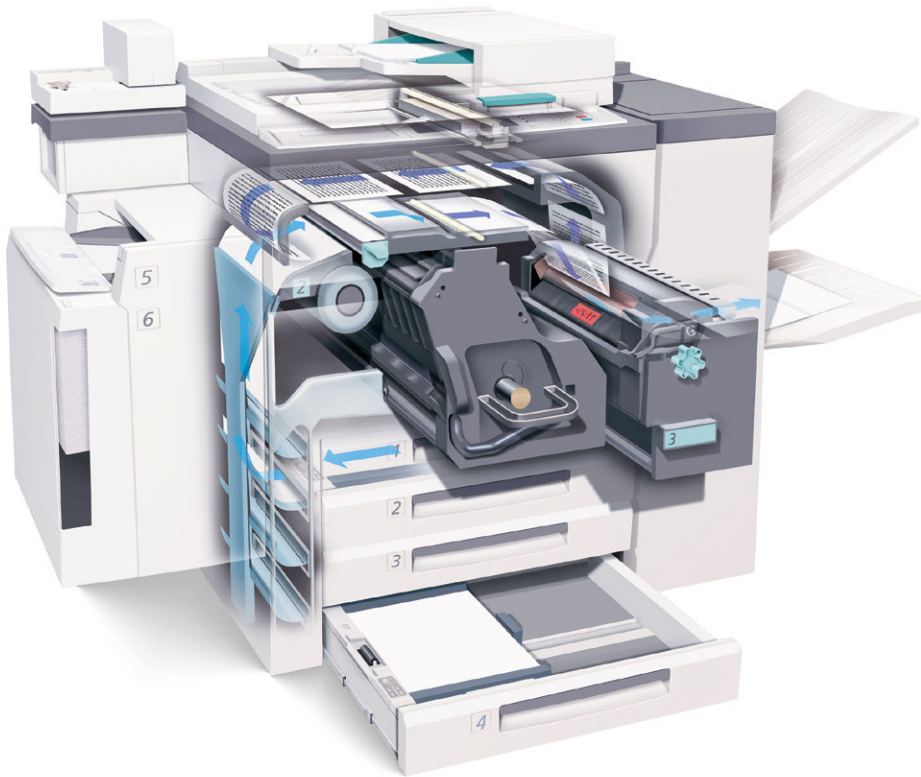
- 17 instead of 66 parts
- 1 pure material instead of 4
- Costs 22% instead of 100%

→ Cooling system

- Weight reduction 50%
- Volume reduction 38%
- Energy consumption reduction

Practical Approaches

Xerox – Green Line Copiers



- Design for easy dismantling in order to maximize reusability of components in Green Line Copiers
- Re-use on the highest possible level
- Through remanufacture diverted 67.000 tonnes of material from landfill in 1999
- Cartridge return programme diverted 3700 tonnes for remanufacture or recycling during 1999
- Zero landfill design goal
- To date 92% recovery rate of returned products

Function Innovation

Technology shift

- Substitute/eliminate functions
- New functions with lower environmental impact
- Classification
- Reduction potential

Product-service-shift

- Systematic development of eco-efficient product service systems
- Handle unexpected innovations
- Obstacles/risks in bringing PSS to market

IT on Demand – Towards an Environmental Conscious Service System for Vienna (AT)

Bernd Kopacek



Project Partners



funded by:



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Motivation

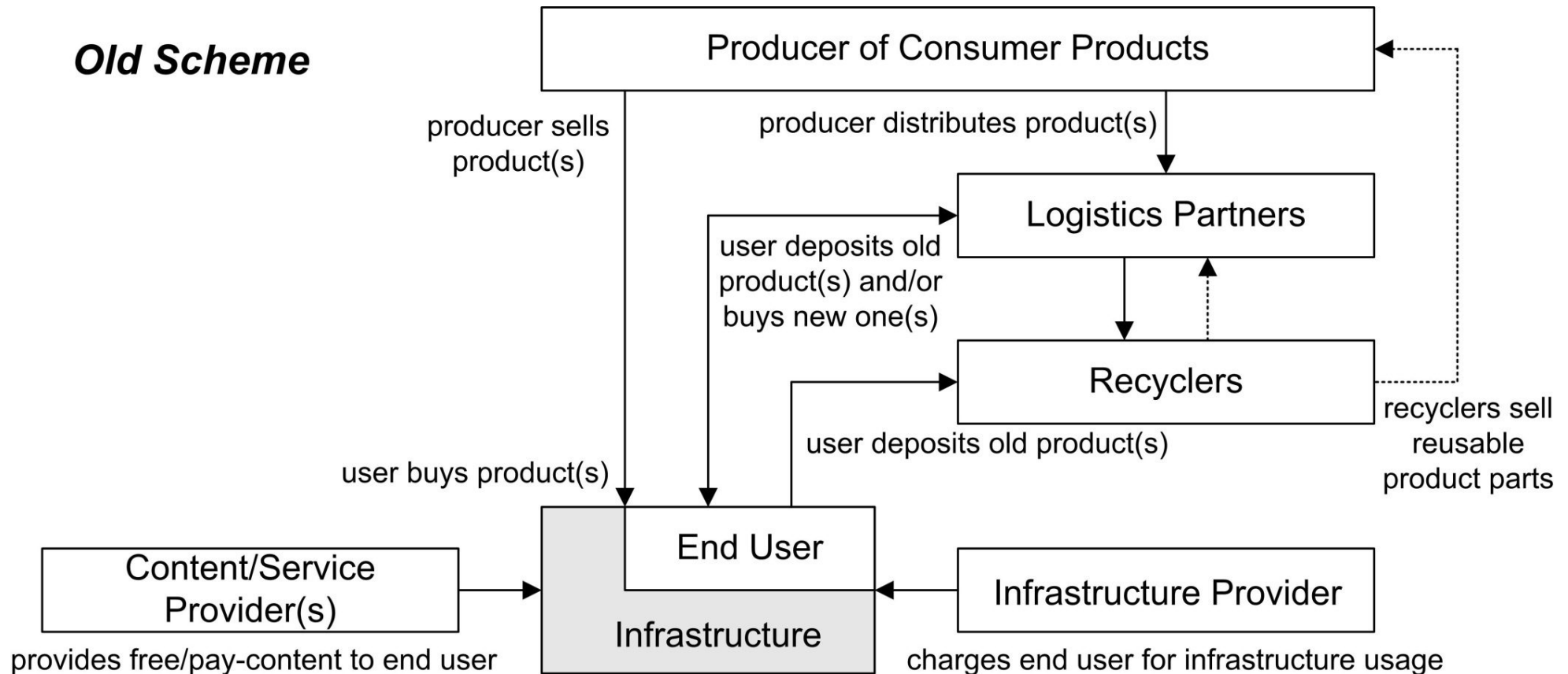
- Overcome the trend of shortening life times of ICT products
- Finding new ways to fulfil consumer needs
- Implementation of multi life cycle use of ICT equipment
- By means of new service systems reducing the amount of generated waste
- Understanding the main drivers and barriers for PSS

B2C: ICT sector today

- **Currently every user owns his hard and software**
- **Usage time approximately 2-5 years**
- **Fast technology pace, trend to decreasing life times**
- **Value of PC lies primarily in easier, faster and cheaper accomplishment of tasks**
- **For this purpose a user does not need to own the ICT equipment**

Today products and services are offered separately

Old Scheme



Pros and cons

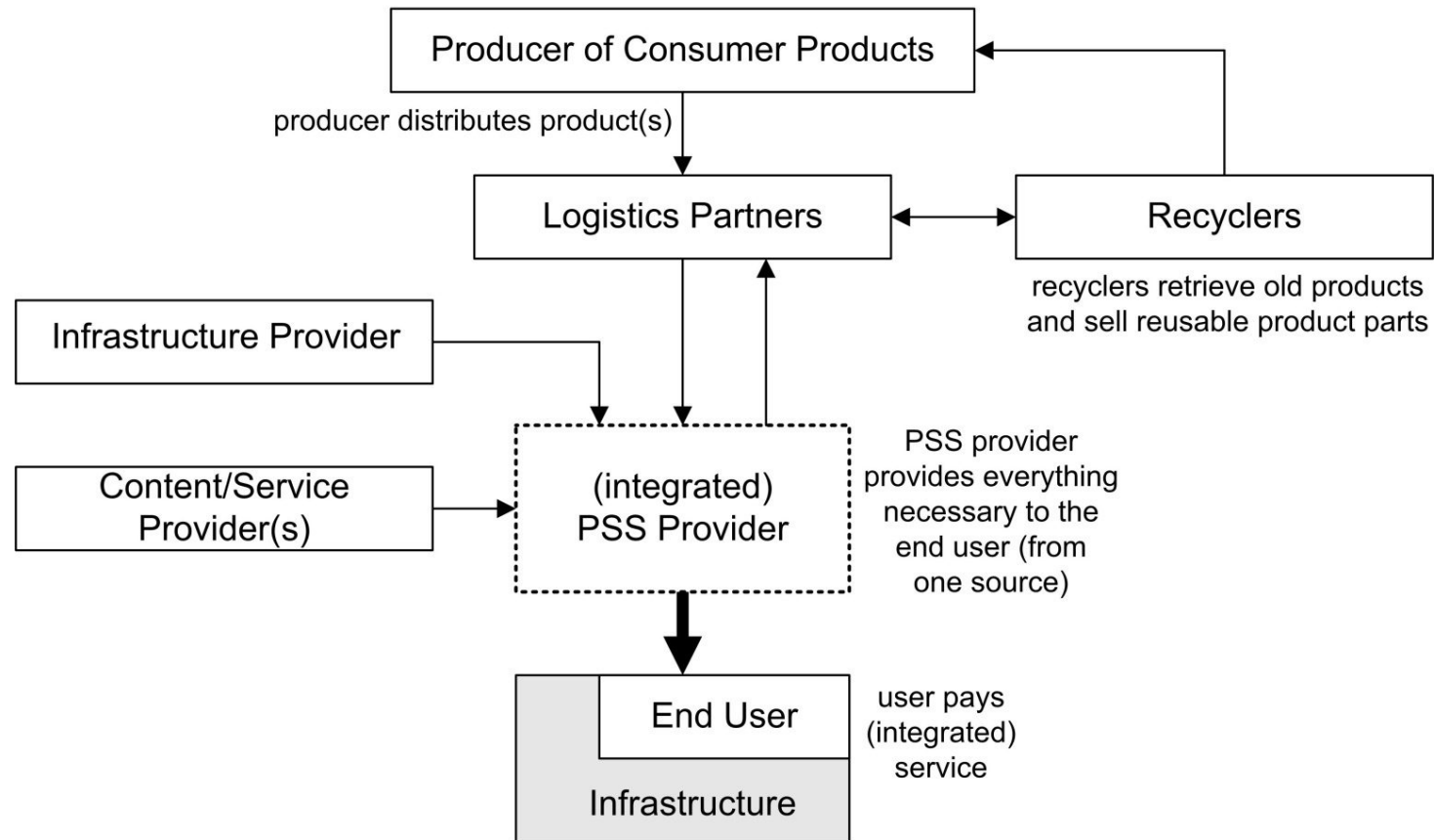
- Customers have to organize the providers by themselves, difficult to control costs (real costs)
- Average (low experienced) user has to deal with a lot of functions he does not need
- User is in charge to keep updated and dispose of products at EOL appropriately
- But: product ownership gives the user high flexibility (e.g. availability)

Definition of PSS

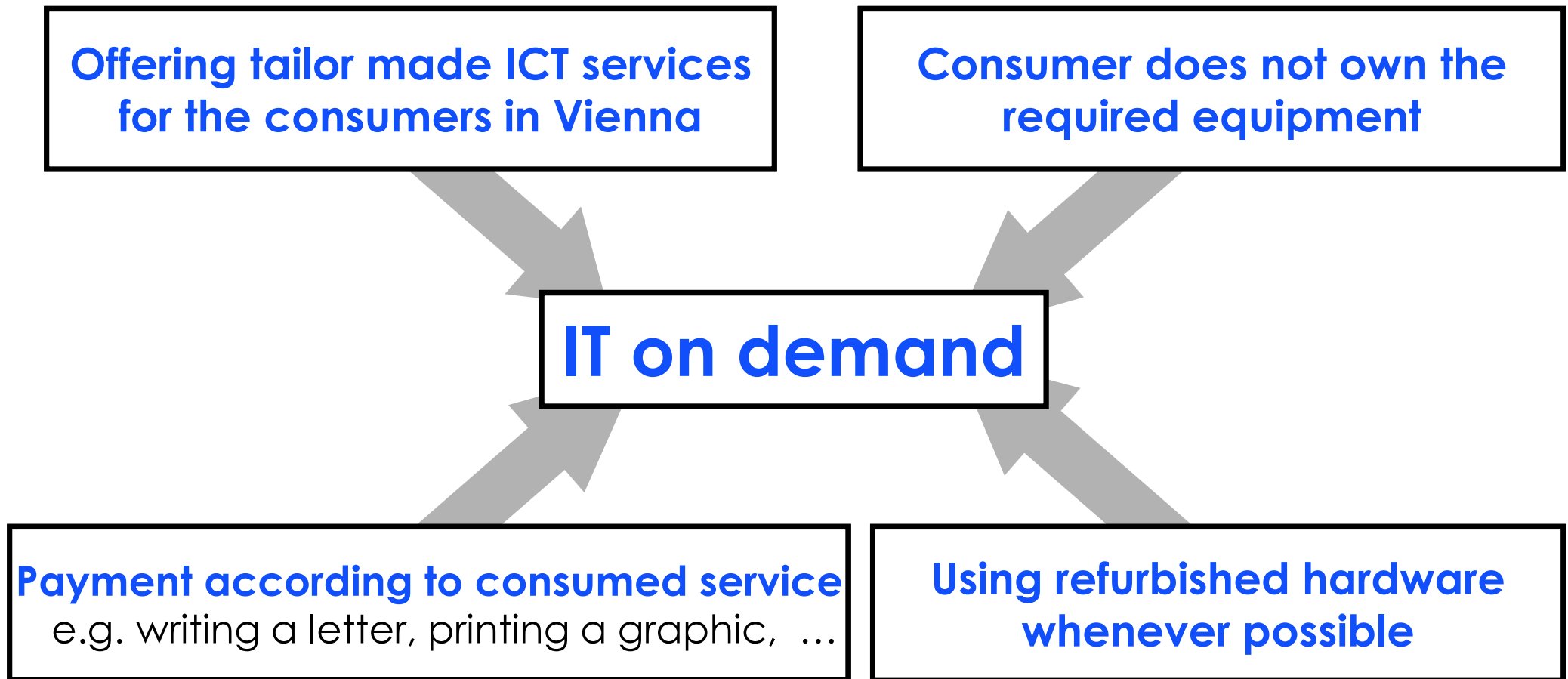
A Product-Service System consists of tangible products and intangible services designed and combined so that they jointly are capable of fulfilling specific customers needs.

The integrated approach of PSS

Ideal PSS Scheme



Framework for IT on demand



Open questions

- What is the best location of the equipment for which purpose?
- Which needs and services should be bundled to raise consumer acceptance and bring down costs?
- Which target groups can be identified for these kind of services?
- Feasibility of the developed scenarios

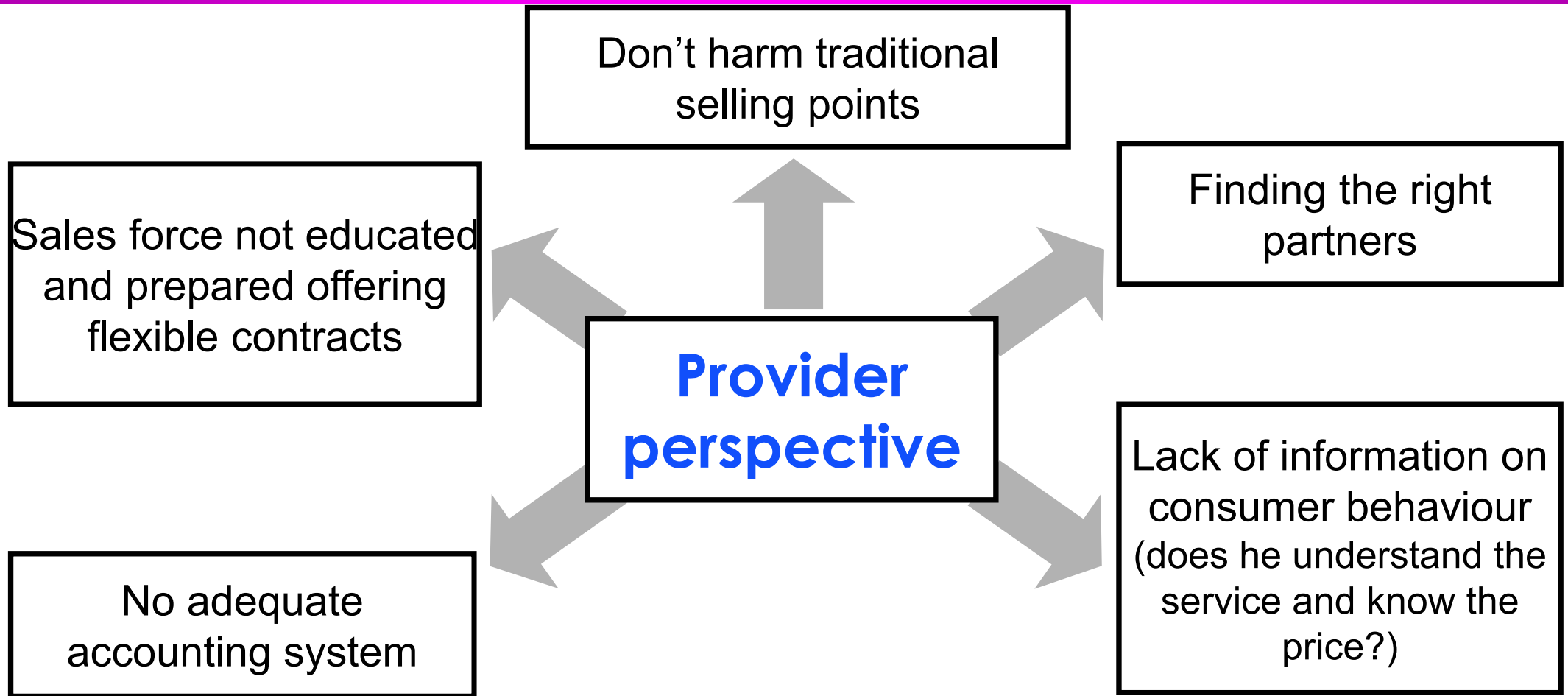
Our approach to new ICT based Service Systems

1. **Analyze already existing PSS in order to identify main drivers and barriers**
2. **Identify consumer needs in the ICT sector**
3. **Analysis of the local general requirements towards customers, infrastructure, companies, ...**
4. **Identification of PSS opportunities**
5. **Scenario building, evaluation and selection of best ideas**

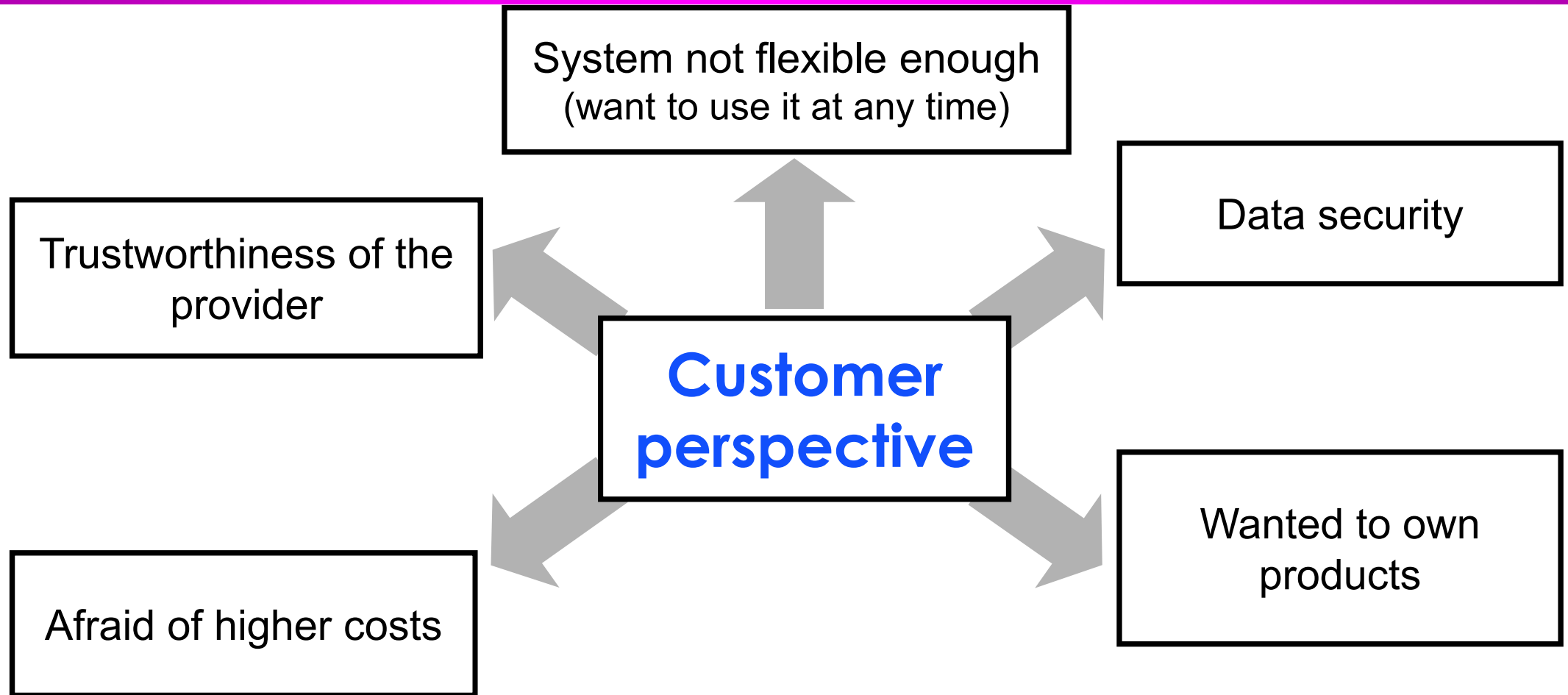
Step 1: Analysis of (existing) Systems

- **Siemens EXTRA-Rent (Austria)**
- **Xerox (photocopiers)**
- **Kodak (single use camera)**
- **Electrolux (Euroclean)**
- **PC E@sy**
- **Aon.tv (Austria)**
- **UMTS networks and applications in Austria**
- ...

Step 2: Main barriers for PSS



Main barriers for PSS



Step 3: Identify consumer needs in ICT



7 consumer needs in the ICT area (1)

- **Physiological/Basic Needs**

- need for satisfying hunger, thirst
- need for sleep
- need for avoiding pain
- need for realising one's sexual instinct
- "need for an adequate home (e.g. a clean apartment, heating) (depends on standard of living)"
- "need for physical health and well-being (i.e. no injuries)"
- "need for mental health and well-being (i.e. no stress)"

7 consumer needs in the ICT area (2)

- **Need for safety/security**

- need for a safe job
- "need for financial independence (e.g. a high income, shares)"
- need for order/organisation
- "need for individual time management (i.e. organise my day)"
- "need for phases of recreation"
- "need for phases of work"
- need for control
- need for retraction and isolation (e.g. anonymity)
- "independence from others (i.e. no need to be dependent from persons and their services)"

7 consumer needs in the ICT area (3)

- **Need for comfort**

- "need for low physical (and/or mental) stress (e.g. no hard or monotonous work)"
- "need for enough time for own interests (e.g. hobbies, friends)"
- "need for (simple) communication and information acquisition (e.g. use a mobile phone)"
- "need for permanent availability of information, goods and services (e.g. adequate infrastructure in surroundings like shops, banks etc.)"
- "need for mobility (e.g. by using a car or public transportation)"
- "need for entertainment (e.g. TV, books, theatre)"

7 consumer needs in the ICT area (4)

- **Need for socialisation**

- need for human contact and interaction (e.g. friendships, colleagues)
- need for exchanging ideas with others (e.g. intellectual development and suggestion)
- need for acceptance
- need for social affiliation (e.g. need for acceptance by society, being member of a social group)
- need for responsibility
- need for helping others
- need for admiration
- need for love (e.g. family, relationship)

7 consumer needs in the ICT area (5)

- **Need for self-actualisation**

- need for autonomy (i.e. to decide autonomously on sthg)
- "need for independence and freedom (e.g. financial independence)"
- "need for freedom from pressure of opening hours (e.g. flexible closing time of shops) "
- "need for individuality (e.g. design your own T-shirt)"
- need for creation (e.g. being an architect) and implementing one's creativity (e.g. painting a picture, writing a book)
- need for power over and influence on other people (e.g. being member of political party)
- need for status and prestige
- need for respect

7 consumer needs in the ICT area (6)

- **Need for change/alternation**

- need for broadening one's horizon (e.g. learning a new language, travelling, job-related development)
- need for eagerness for knowledge (e.g. questioning new things, need for knowledge and understanding)
- need for entertainment (e.g. visiting a concert, watching TV)
- need for satisfying one's play instinct (e.g. playing computer games, parlor games)

7 consumer needs in the ICT area (7)

- **Need for esteem**

- Need for achievement, accomplishment, activity
- Need for competition
- Need for impressing
- Need for avoiding/minimising failures/flops

Step 4: Analysis of needs and identification of opportunities for ICT

1. Identification of main application areas for ICT by analysing current products

2. Link with consumer needs

3. Analysis of consumer behaviour and marketing data

4. Identification of opportunity areas

Application areas for IT on demand (1)

- **Several dimensions to be considered for an ICT Service System:**

- **Supply of a service**

- Self provision: allocation of hard-, software and infrastructure, customer uses the equipment according to his needs (e.g. writing an email)
- External provision: Customer is only interested in the result of a service (e.g. what is the cheapest price for product xyz)

- **Local availability**

- Within flat
- Within apartment house
- Outside house (within certain distances)
- Mobile

Application areas for IT on demand (2)

→ **Temporary availability**

- At any time
- one hour, day, weekend, ...

→ **Use frequency**

- frequently (e.g. every hour, day)
- Rarely (once a year)

→ **Functionality of required equipment**

- High: computer → more difficult to handle
- Low: TV set
- Usability of required equipment

Application areas for IT on demand (3)

- **Required space and design**
- **Maintenance efforts**
- **Energy consumption**
- **Costs of equipment**
- **User Demographic**
 - Age
 - Income
 - Education
 - Mobility
 - Value of time
 - Early adapter, fast follower, ...

Step 5: Development of scenarios

- **Based on consumer needs and location of service provision:**
 - **In the flat**
 - Banking and administration
 - eLearning
 - Entertainment
 - **Within the apartment house**
 - Home office
 - Mobility and itinerary
 - Surf & (local) Information station, reservation tool
 - **Mobile**
 - City Guide
 - Leisure information service
 - Appointment service

Scenario: apartment house

- **Application varieties (including printing and scanning):**
 - email on demand
 - Internet + email on demand
 - Internet + email + office on demand
- **Workstations located in an extra room**
- **On average 23 user for 5 workstations (one typical apartment house)**
 - Higher utilisation of workstations compared to single user - single workstation system
- **Amortisation after less than 2/3 year compared to traditional system**
- **Average monthly rate**
 - new system around 45€
 - Traditional system around 82€ (including software)

Overcome barriers for service system

Advantage of traditional system:

**Availability and flexibility of
owning the hardware**

Perception of higher price

Data security (hard disk)

strategy for new system:

**24h access and
extra laptop service**

**Transparency of
billing**

**Provision of secured
virtual memory
and/or memory stick**

Scenario: apartment house

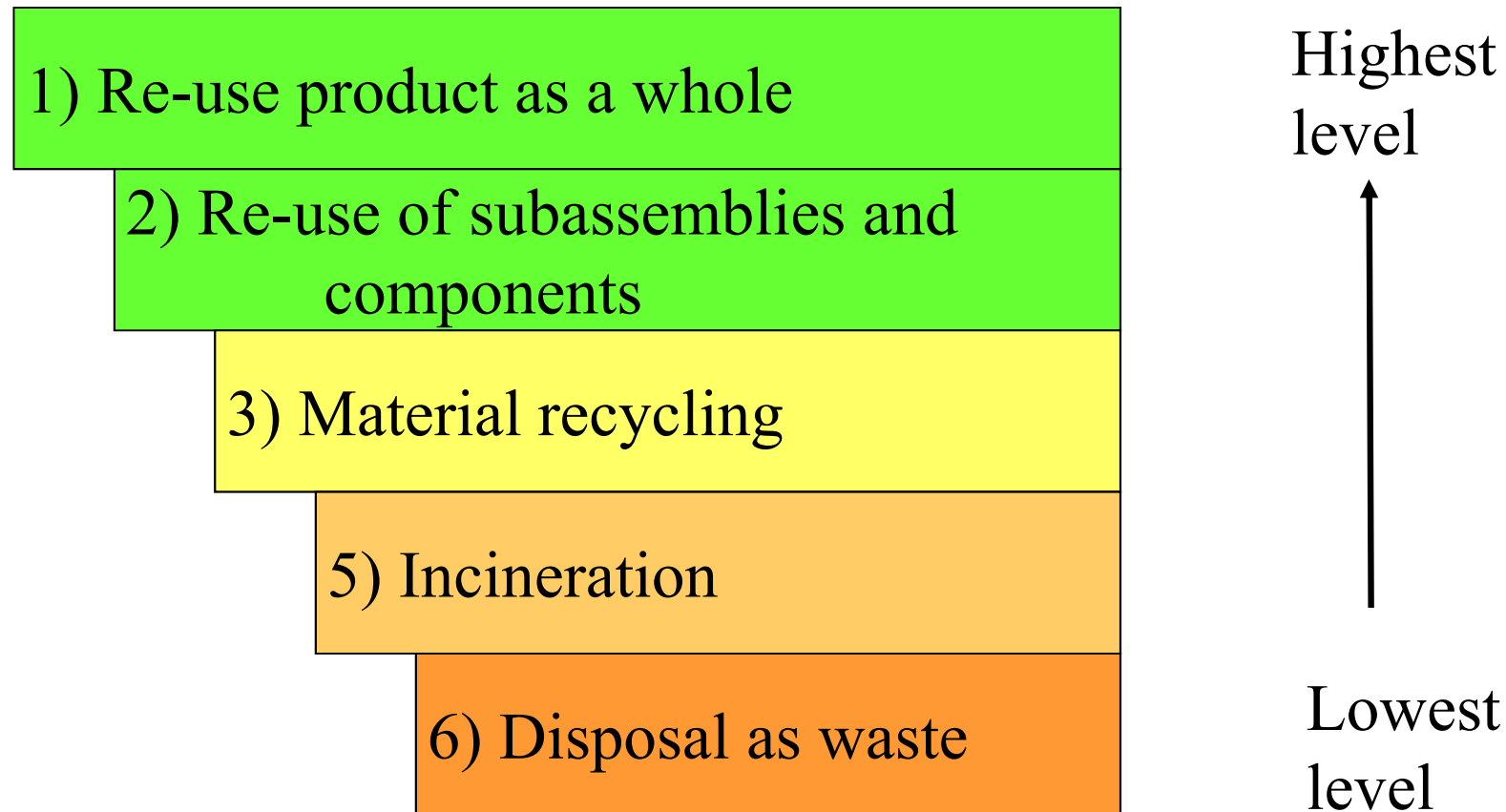
- „IT on demand“ in big apartment house
- Basic application „E-Mail on demand“
- 342 PCs for 2.270 users
- “Pooling-concept“ in combination with notebooks
- Cost calculation
- Internet portal for reservation and ordering
- Offering also service personal (Concierge)

Results „E-Mail on demand“

	WEEE	Electricity consumption during use	Electricity consumption during production
Private use: 2.270 PCs	300.000 kg	3.800.000 kWh	3.300.000 kWh
PSS: 342 PCs	45.000 kg	740.000 kWh	165.000 kWh
Savings potential	85%	81%	95%

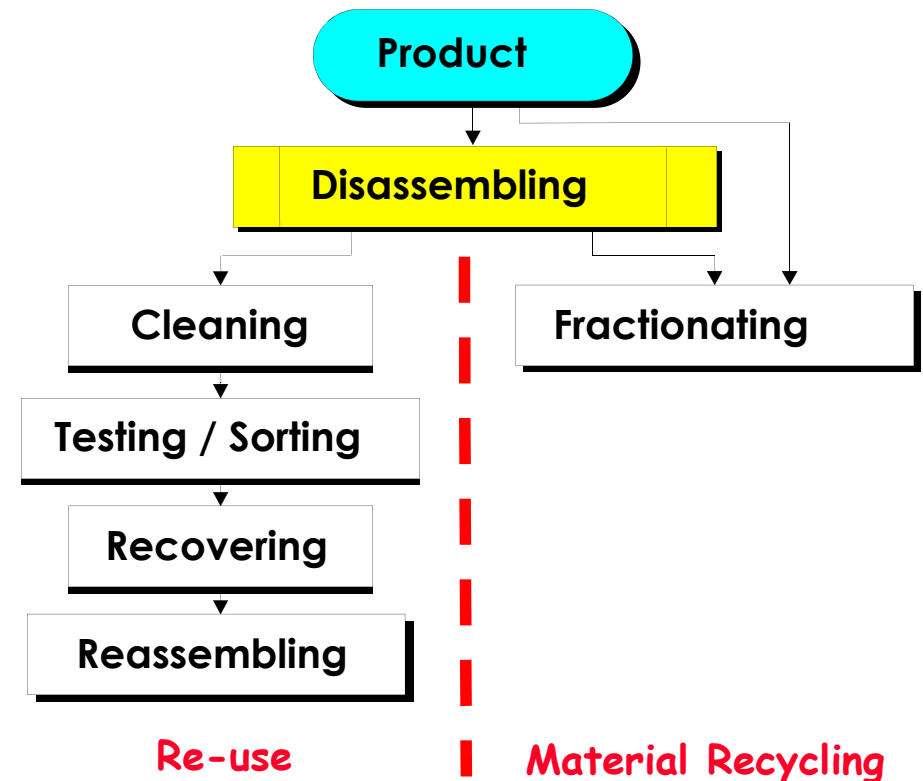
What can be done at End-of-Life?

EOL Options for EEE

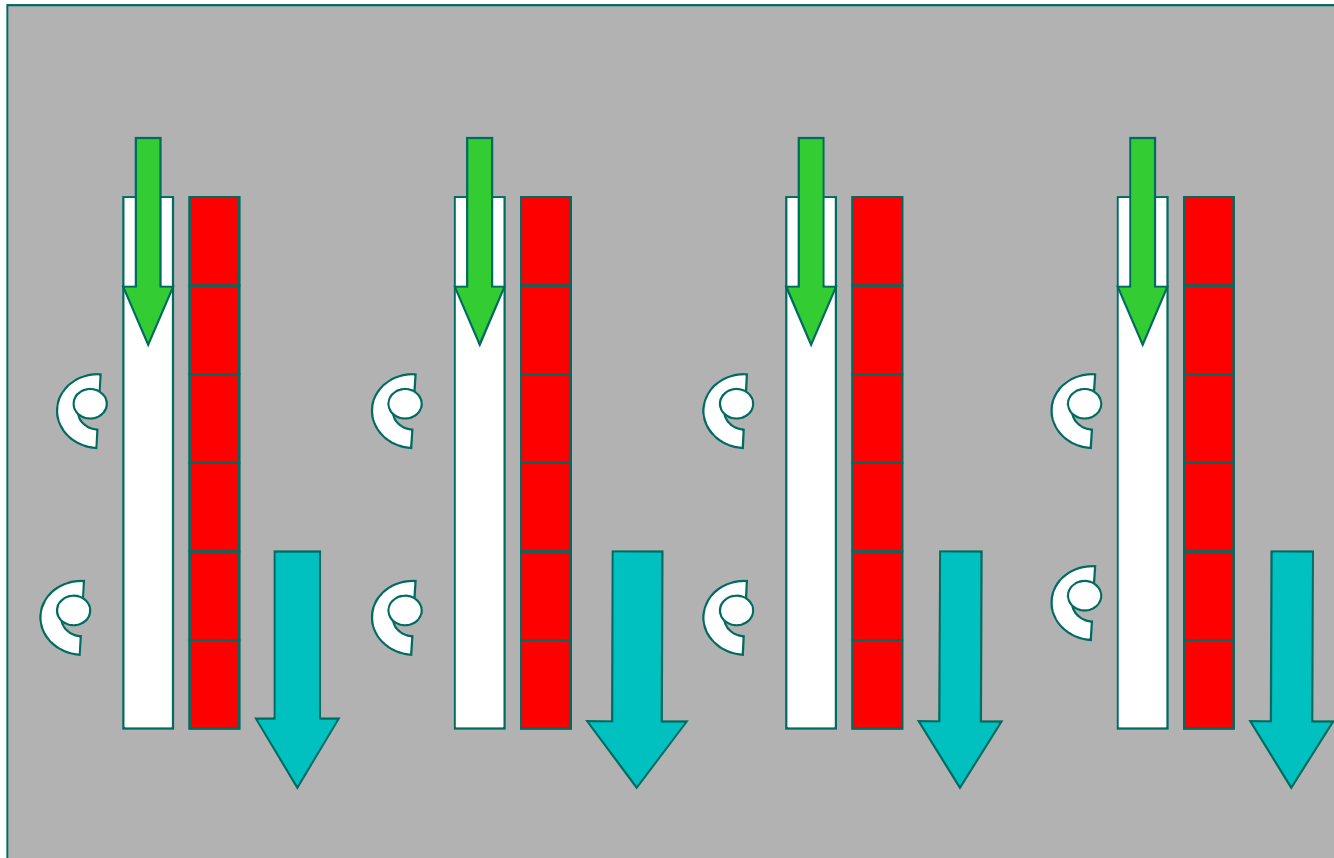


Disassembling

- Mainly a manual process
- Developments and perspectives:
 - Flexible Disassembly Cells
 - Active Disassembly using smart materials



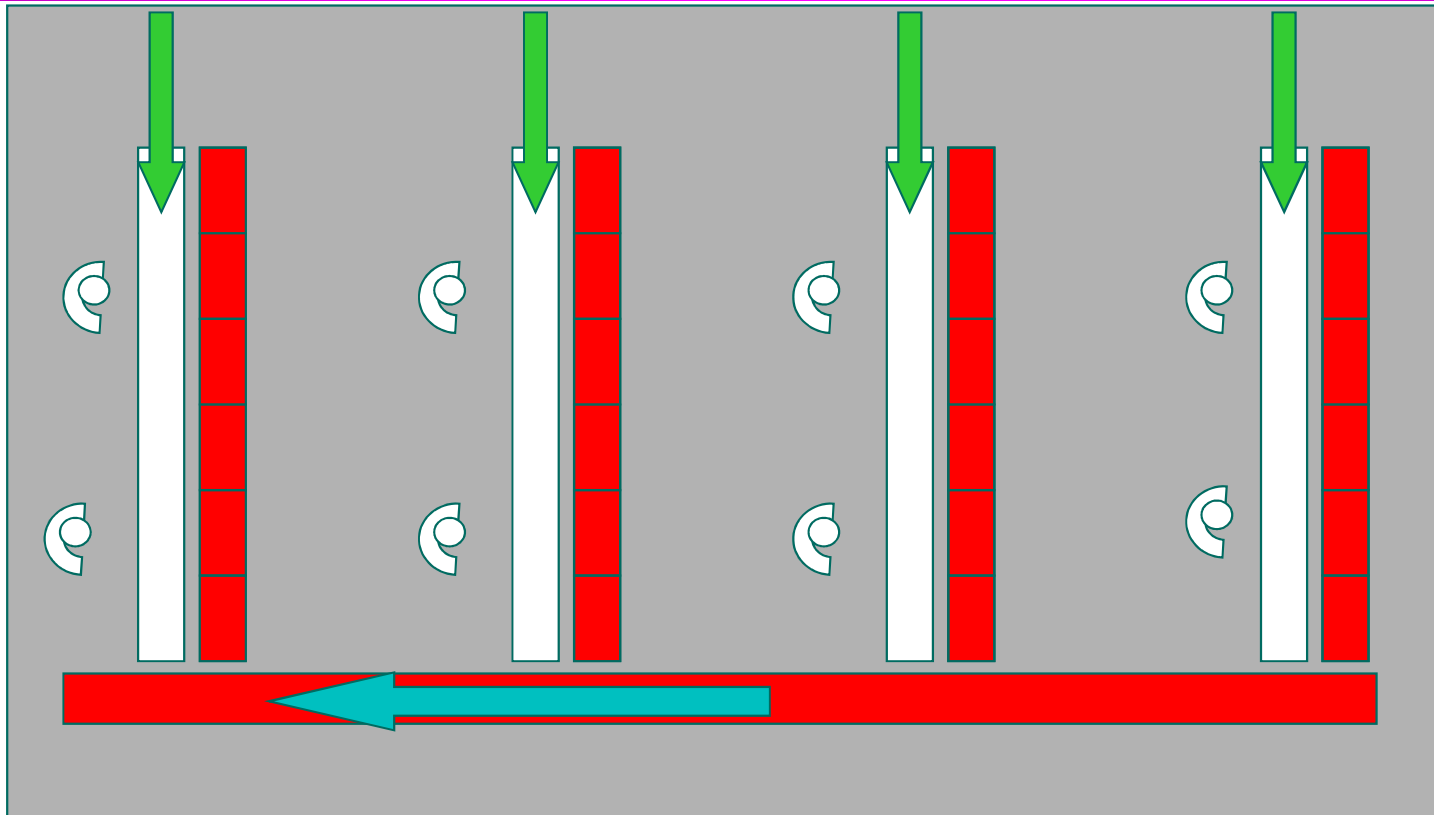
Manual Workplaces Layout



■ Products in

■ Fractions out

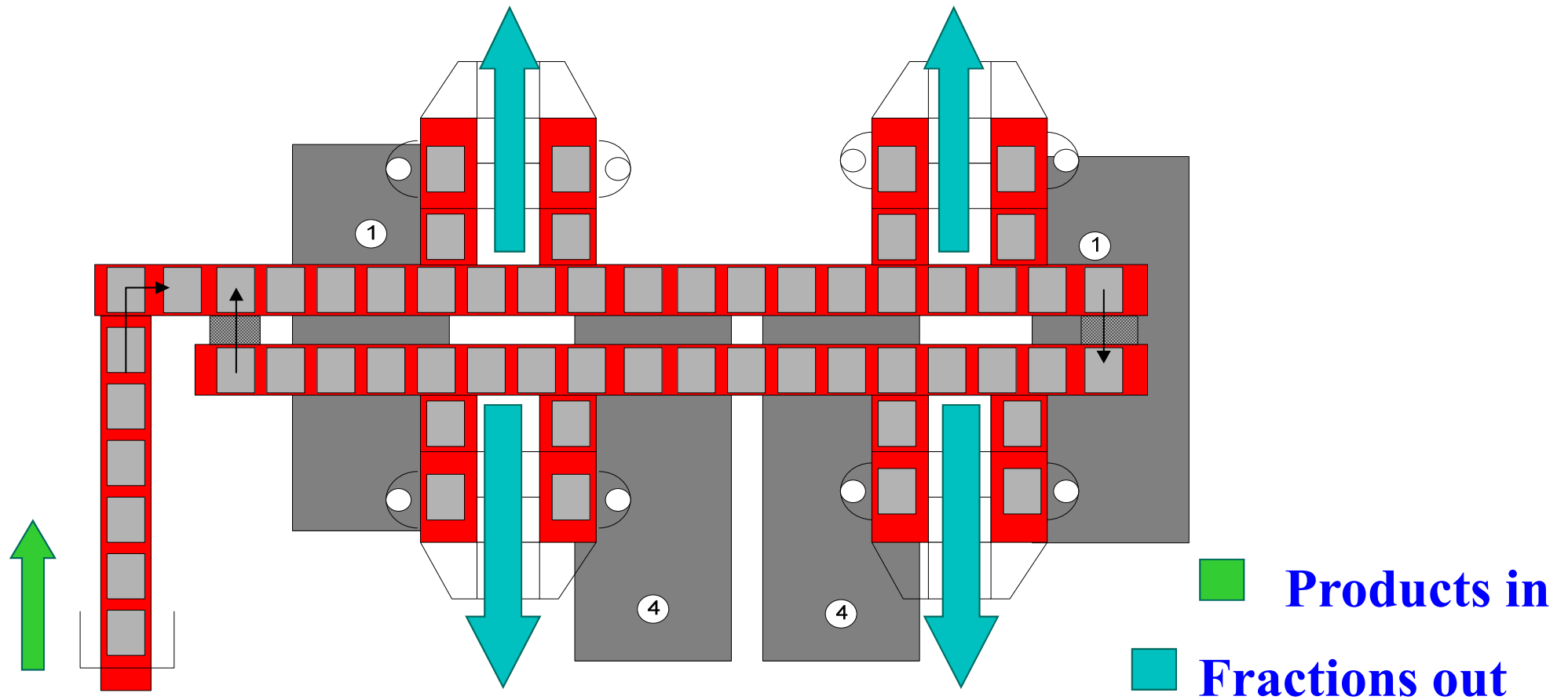
Manual Workplaces Layout



■ Products in

■ Fractions out

Manual Workplaces Layout



Material Recycling Technologies

- **Shredding**
- **Separation Technologies**
 - **Size separation**
 - Rotary screens
 - Vibration screens
 - Disk screens
 - **Gravity separation**
 - Gravity separation table
 - Pneumatic classifier

Material Recycling Technologies

- **Wet separation technologies**

Technologies based on aerodynamic/hydrodynamic properties and density of the materials

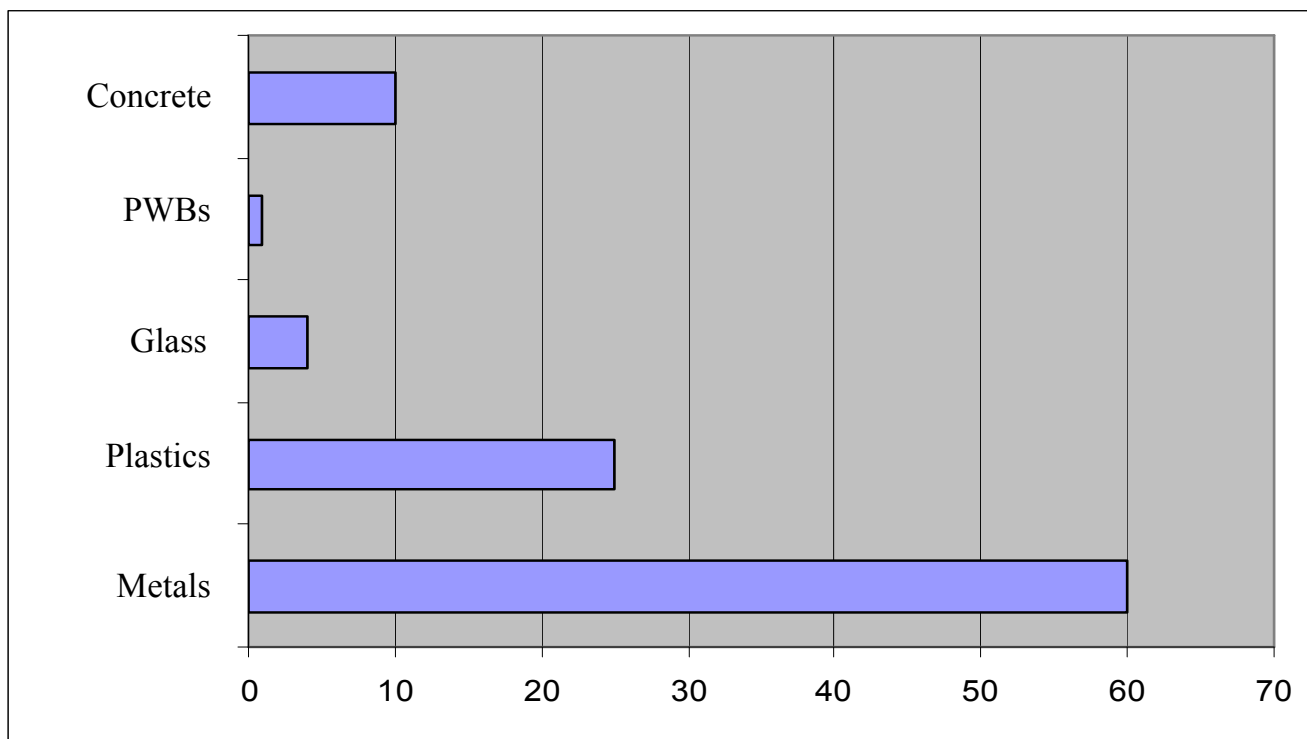
- Elutriator
- Sink/float separation
- Floatation
- Hydrocyclone
- Shaking or wifly table
- Centrifuge
- Magnetic separation
- Eddy current separation
- Electrostatic separation
- Corona drum separator (metal-plastic separation)
- Triboelectric separator (plastic-plastic separation)
- ...

White Goods (Washing machines,...)

- **Characteristics:** Constructed using mostly ferrous metals
- **Decontamination:** Possibility of the presence of hazardous components (PCB or oil capacitors)
- **Treatment**
 - Manual removing of hazardous components
 - Impact shredders / large car shredders

WEEE-Directive – White Goods (Example: Washing Machine)

Fractions of a typical Washing Machine:



WEEE-Directive:

Rate of Recovery

At present: 85%

Required: 80%

Re-use and Recycling:

At present: 60%

Required: 75%

Refrigerators, Freezers,...

- Hazardous Waste according to the EWL (European Waste List) given in Community Decision 2000/532/EC
- Decontamination: Cooling circuits may contain

- Oil + CFCs or HCFCs
- Oil + HFCs or HCs
- Ammoniac solution + Cr^{+6}

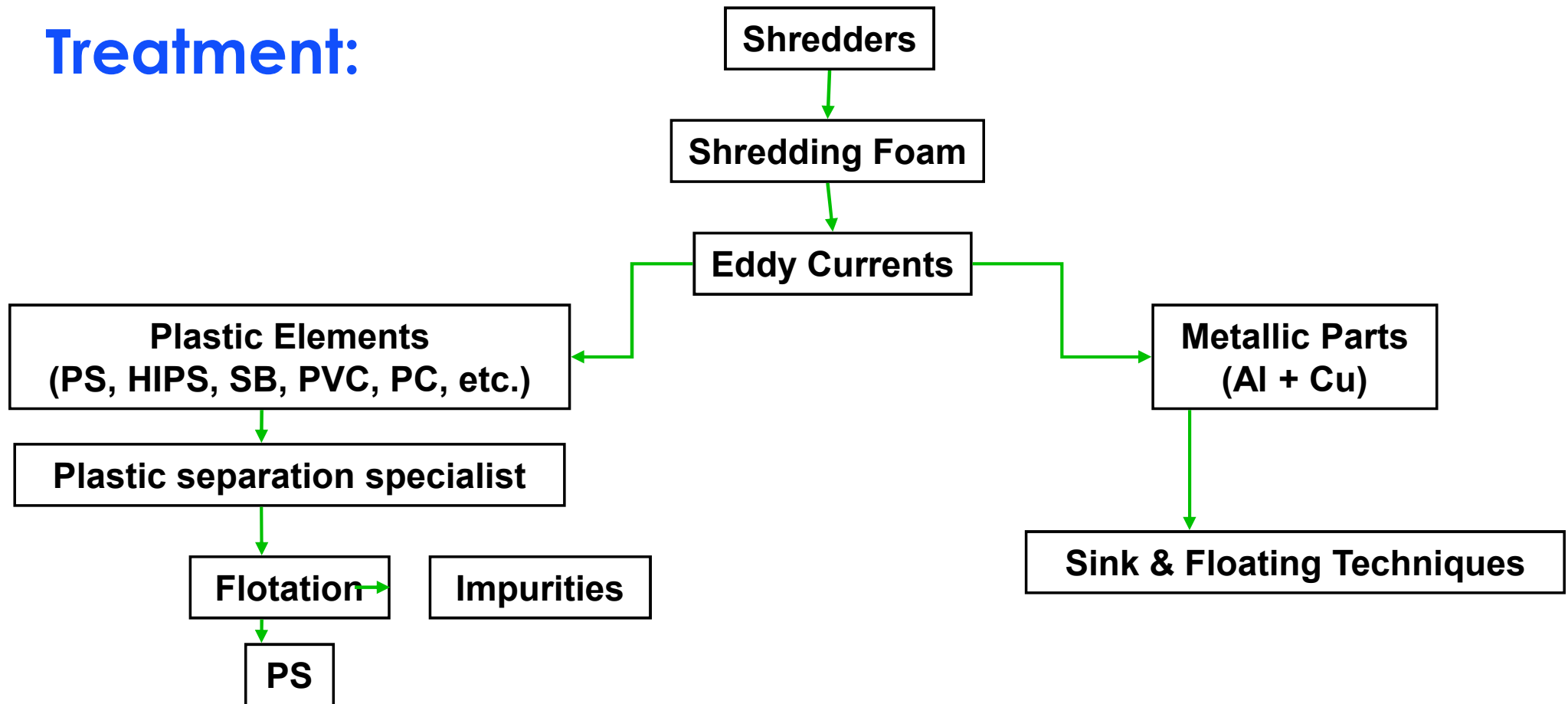
To extract these substances
small suction treatment
plants are used.

Perforating clamp + Evaporator + Condenser

- Treating of metals and plastics → like white goods

Refrigerators, Freezers,...

Treatment:

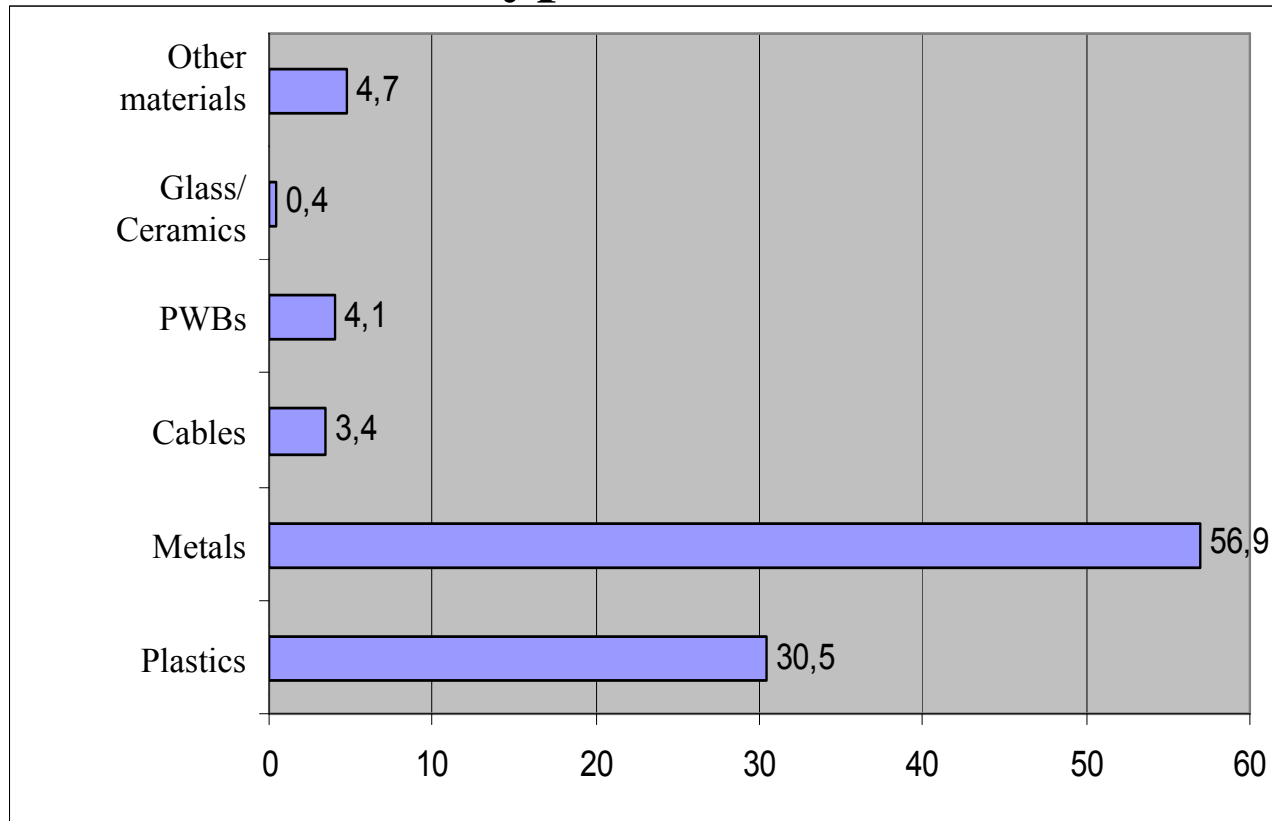


Brown goods (radio, video,...)

- **Characteristics:** Plastics and iron predominate in these category
- **Decontamination:** Different types of dangerous batteries
- **Treatment:**
 - **Manual disassembling**
 - An operator frees the plastic casing from the screws or clips
 - The plastic case is treated in specialised installation
 - The PWBs, loudspeakers, peripherals cables, etc. are removed and treated by different methods already mentioned
 - **Shredding and material separation**

WEEE-Directive – Brown Goods (Example: Radio Set)

Fractions of a typical Radio Set:



WEEE-Directive:

Rate of Recovery

At present: 85%

Required for consumer equipment: 75%

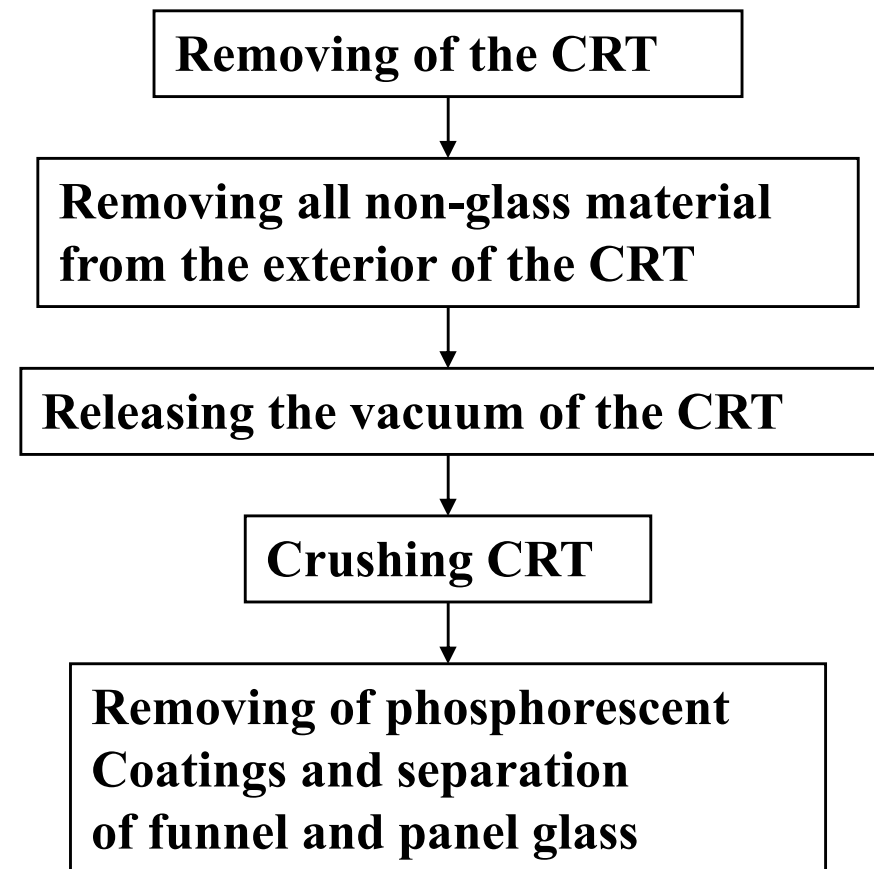
Re-use and Recycling:

At present: 60%

Required for consumer equipment: 65%

TV Sets and Monitors (CRTs)

- products contain CRTs and in small quantities LCDs or TFTs
- **Decontamination: CRTs ⇒ Dangerous waste on the EWL**
- **Treatment**
 - Disassembling – manual in most cases
 - Automation difficult through the variety of sizes and models



Dismantling of TV Sets

- Remove Back cover
- Take out PS, PCBs and cables
- Remove CRT
- Divide glasses
- Clean panel glass



TV Sets and Monitors (CRTs)

Technologies for CRT separation:

- Hot wire separation
- Separation by cutting with a circular saw
- Separation by chemical attack
- Engraving and thermal shock

Automation of Disassembling

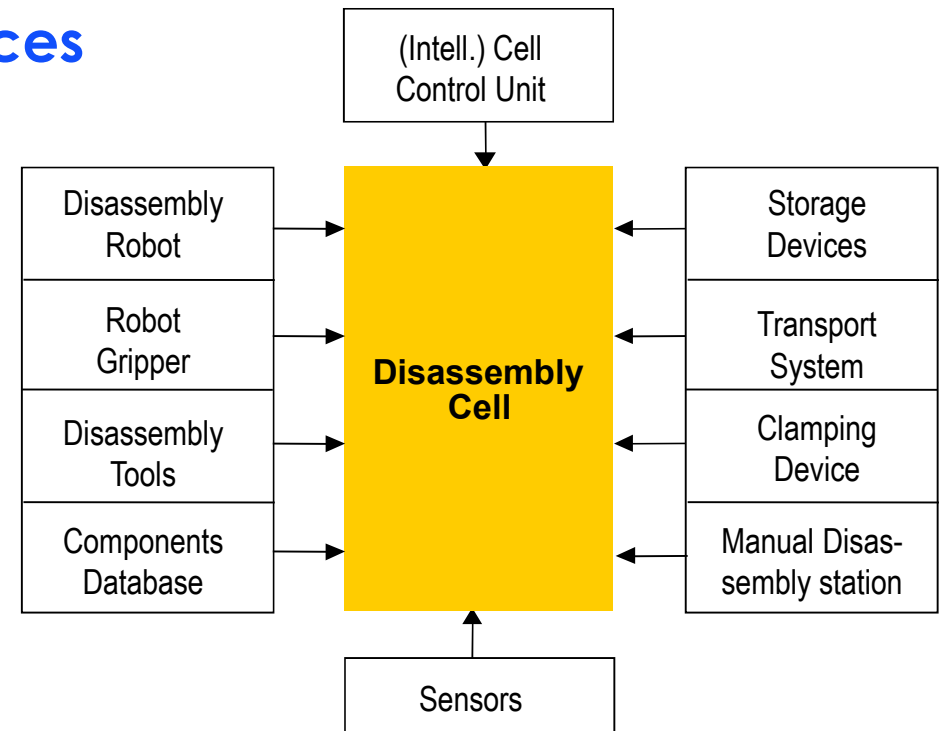
Main Goals

- reduce the costs of disassembling,
- extend the performance of the disassembling process,
- optimize the different recycling processes,
- extend the life cycle of a product because of the better possibility for reconditioning, and
- create a human working environment in disassembly factories.

Modular, Flexible Disassembly Cell

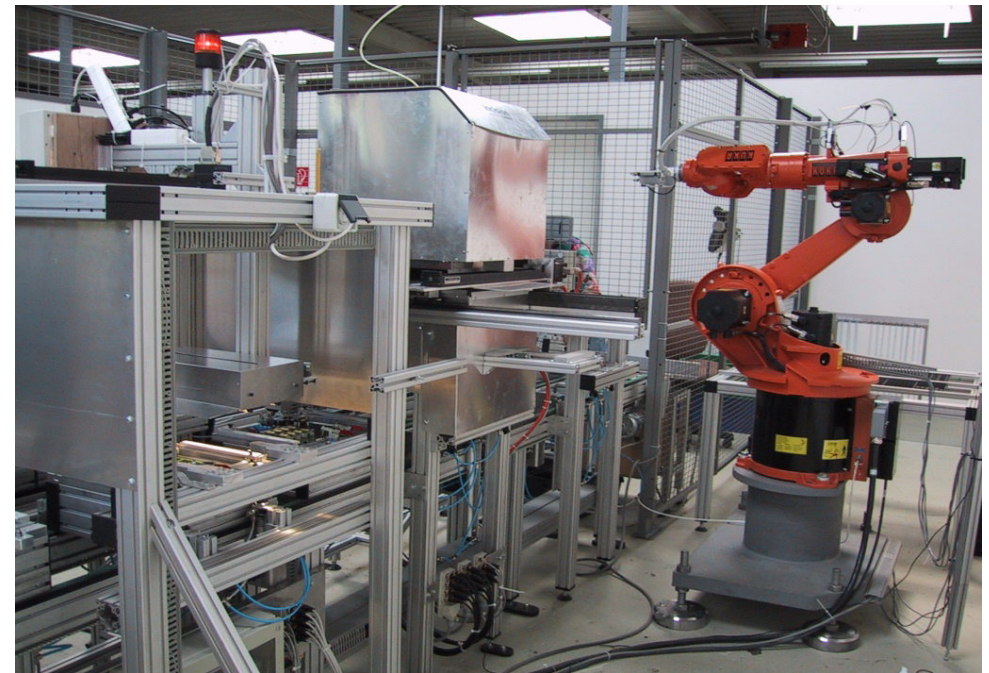
Main Modules:

- Industrial robots or handling devices
- Special gripping devices
- Disassembly tools
- Feeding and storage systems
- Transport systems
- Fixture systems
- Manual disassembly stations
- Intelligent control units
- („low cost“) vision systems for part recognition
- Various sensors
- Electronic components DB

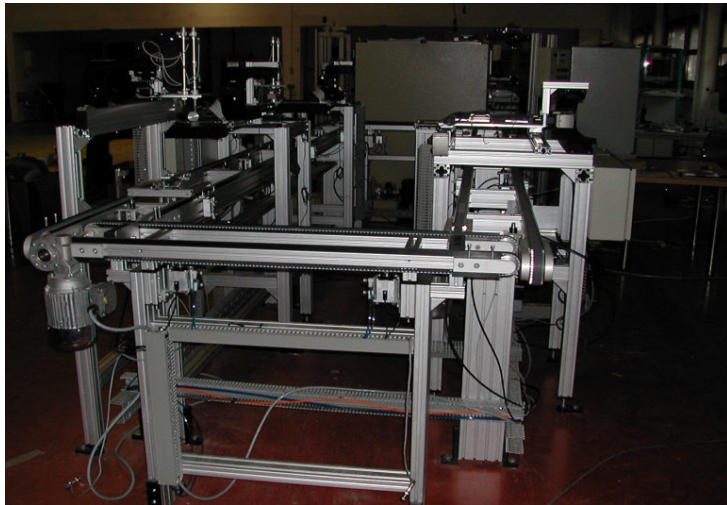
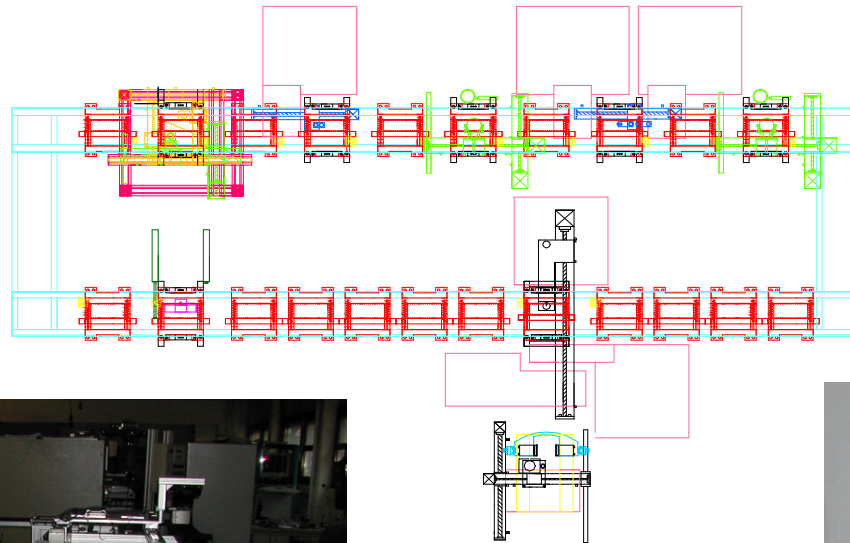


Example – Disassembly Cell for PWBs

- Recognition System
 - Laser de-soldering station
 - disassembly robot
 - operation guided by market information
 - minimal thermal stress for the components
- ↑ extended life-time for re-use components



Example – Disassembly Cell for Mobile Phones

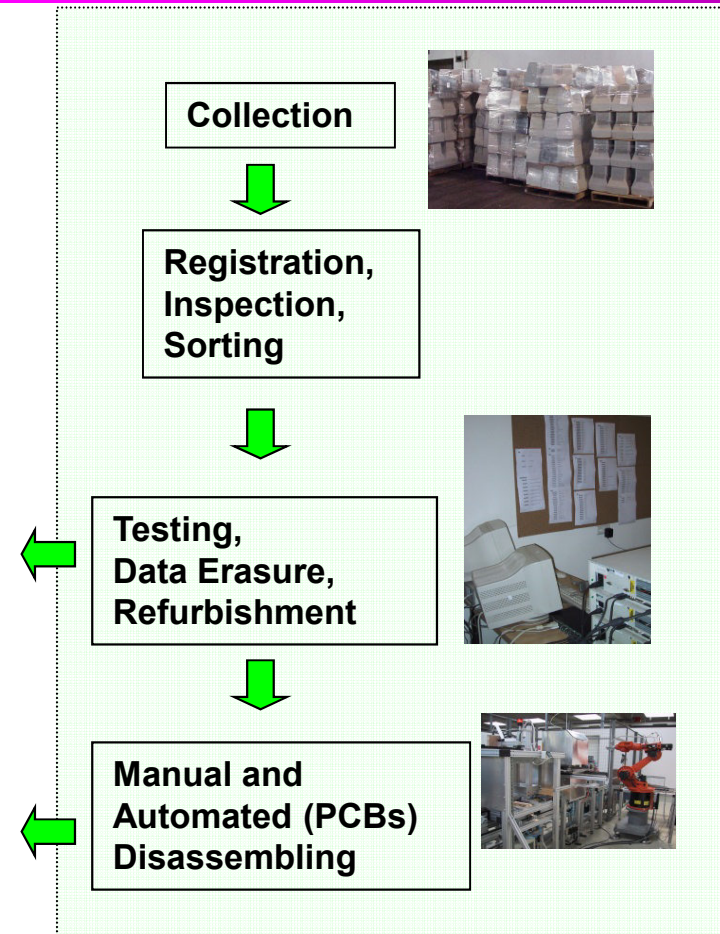
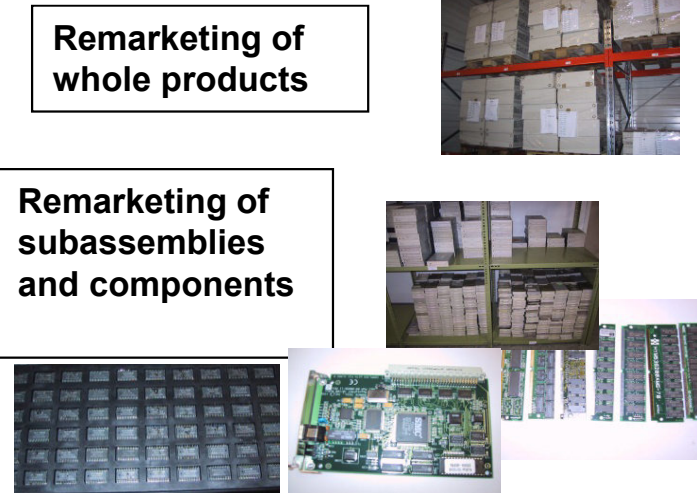


Re-Use

- **Re-Use Possibilities for products**
 - Second Hand
 - Repair and Reconditioning
 - Upgrading
- **Re-Use possibilities for subassemblies and components**
 - Old for Old – use of used components as spare parts
 - Old for New – use of used subassemblies and components for the production of new products
 - “New” for New – use of overstock subassemblies and components for the production of new products

Example of a Re-Use Process

Re-Use process for IT equipment:



Examples

- Coolrec (NL)
- Ecotronics / STENA Technoworld (AT)
- MüGu / METRAN / MBA Polymer
<http://www.youtube.com/watch?v=oaQp0fCQ-74&feature=related>