Technical Report 2018

SENS
Swico
SLRS

Technical Report
2018

Quality over quantity – sooner or later

We all know that things are never boring in our industry. 2017 offered a number of highlights that ensured an extra dose of excitement – plastics recycling, CENELEC and ADR compliance were just three areas that posed daily challenges for us and these matters are covered accordingly in this Technical Report. This year, however, we would like to make particular mention of a demand that has been placed on our sector for years, a demand that is requiring continuously higher standards from us, but which we nevertheless do not tire of talking about: the demand for quality.

As you all know, the people of Switzerland are good at getting rid of waste – when it comes to volume at any rate. With 16 kilograms of electronic waste per person, per year, we are global leaders – at least in terms of quantity. More pertinent than the high collection rates, however, is the question of the quality of the collected material. How do we at SENS eRecycling, Swico and the Swiss Lighting Recycling Foundation ensure that the expert processing of electronic waste that we advocate with our organisations is actually implemented? There are differing opinions when it comes to the speed with which the European Committee for Electrotechnical Standardization (CENELEC) standard is introduced. We can, however, all agree on one thing: the CENELEC standard is coming and, sooner or later, it will be a mutual objective we all share.

The centrepiece of our eRecycling cycle – and this should be emphasised here once again – is our partnership-based cooperation with our disposal partners. Only with the careful selection of collection points, disassembly facilities and recyclers is it possible to realistically meet the high quality demands placed on us. After all, only with competent and reliable partners can we control and guarantee systematic separate collection, the clean separation of appliances containing lithium ions, efficient transportation and expert processing in Switzerland. The high quality demands are regularly reviewed, discussed and continually improved by the three systems in the joint Technical Commission (TC) in order to achieve as high a processing quality as possible and to systematically eliminate hazardous substances. You are sure to have heard the persistent myth that our electronic waste is shipped to Africa and processed there? This is so-called “fake news” that we can nip in the bud with the transparency and professionalism we exhibit in our cooperation.

Everybody knows that quantity doesn’t equal quality – our primary objective, however, must be to recover as much high-quality raw material as possible. The ambitious goals and visionary projects in this Technical Report show that we are doing our best to do just this and that we are on the right path.

Jean-Marc Hensch
Swico

Heidi Luck
SENS

Silvia Schaller
SLRS

SENS Foundation, Swico and SLRS: competent and sustainable

For more than 20 years, Switzerland's three take-back systems, SENS eRecycling, Swico and the Swiss Lighting Recycling Foundation (SLRS), have been guaranteeing the resource-efficient return and reuse and proper disposal of electrical and electronic equipment. The increasing take-back quantities bear witness to the success of the three systems.

In Switzerland, there are three take-back systems for electrical and electronic appliances. There are historical reasons for the existence of three systems: in the early years of institutionalised recycling, industry-specific systems were established. The aim of these was to guarantee proximity to the relevant industry in order to answer to its specific requirements. It also allowed initial reservations about participation in a take-back system, which remains voluntary to this day, to be broken down. Depending on the type of electrical or electronic equipment in question, SENS, Swico or the Swiss Lighting Recycling Foundation (SLRS) is now responsible for recycling.

In 2017, the three systems disposed of around 122,800 tonnes[1] of old electrical and electronic equipment. This means that Swico, SENS eRecycling and SLRS have also made a significant contribution to reintroducing valuable resources into the production cycle. With the international networking of the three organisations at a European level – for example as members of the Forum for Waste Electrical and Electronic Equipment (WEEE) – they also help to set cross-border standards for the recycling of electrical and electronic appliances.

The Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE) obliges retailers, manufacturers and importers to take back appliances they stock in their product range free of charge. In order to be able to finance sustainable and environmentally responsible recycling of electrical and electronic appliances, an advance recycling fee (ARF) is included in the sale price for these appliances. The ARF is an efficient financing instrument which guarantees that SENS, Swico and SLRS can ensure proper processing of the appliances in their respective area and continue to face challenges in the future.

SENS

SENS eRecycling is an independent, neutral, non-profit organisation that operates under the SENS eRecycling brand. It focuses on the return, reuse and disposal of electrical and electronic appliances from the small and large domestic appliance sector, as well as construction, garden and hobby equipment and toys. To this end, SENS works in close conjunction with specialist networks in which the parties involved in the recycling of electrical and electronic appliances are represented. In cooperation with its partners, SENS is geared towards ensuring that the recycling of these appliances is compliant with economic and ecological principles.

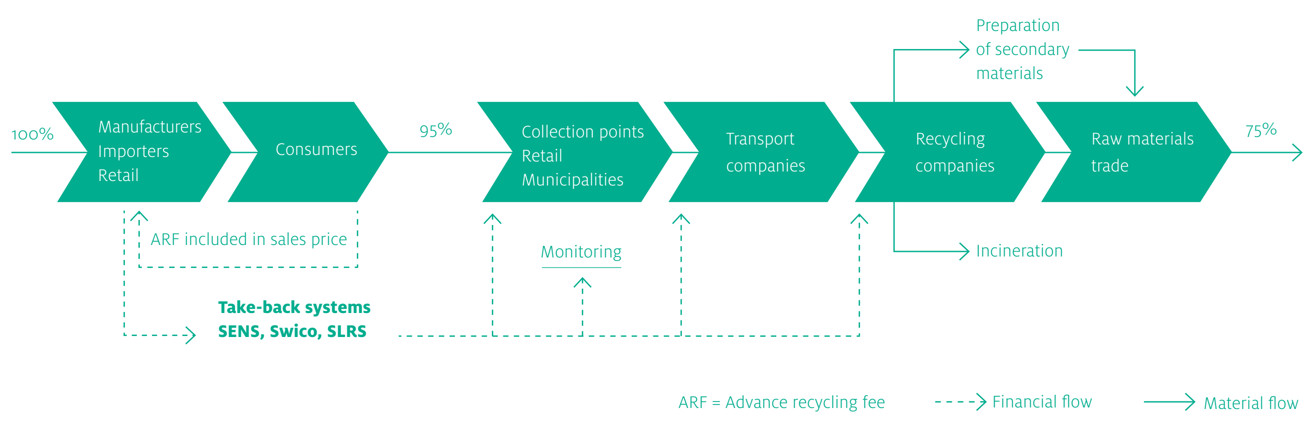
Swico

Swico Recycling is a special fund within the Swiss Industrial Association Swico and deals exclusively with cost-covering recycling of old equipment. Swico aims to extract raw materials and dispose of pollutants in an environmentally friendly way. The focus of Swico is on equipment in the fields of computing, consumer electronics, office equipment, telecommunications, the printing industry as well as measuring and medical instruments, such as copiers, printers, televisions, MP3 players, mobile phones, cameras, etc. Close cooperation with the Swiss Federal Laboratories for Materials Testing and Research (Empa), a research and service institute for material sciences and technology development within the ETH, plays a crucial role in ensuring that Swico can enforce high and uniform quality standards throughout Switzerland with all waste management services.

SLRS

The SLRS bears basic responsibility for lamps and lighting equipment. SLRS deals with the organisation of comprehensive waste disposal systems for lamps and lighting equipment across the whole of Switzerland. In order to finance these activities, SLRS administers a fund each for lamps and lighting equipment, which is fed from the relevant ARF. Training and sensitisation of market participants with respect to the recycling of lamps and lighting equipment and providing information to stakeholders also form part of SLRS's remit. SLRS maintains a close partnership with the SENS Foundation across all areas. For example, as a contract partner to SLRS, the SENS Foundation provides not only collection and transport via its take-back and recycling system, but also the recycling, monitoring and reporting with regard to lamps and lighting equipment on an operational basis.

Figure 1: Overview of the take-back systems.



[1] This is the quantity confirmed by the material flow reports from the recycling companies. It is not the same as the quantity calculated in accordance with the annual and company reports for SENS eRecycling and Swico Recycling.

Recycling quotas and condensers

Roman Eppenberger and Heinz Böni

Following the decision of the SENS eRecycling and Swico systems to conduct their audits according to two different technical principles (see 2017 Technical Report), the SENS TC and Swico TC focussed on important technical issues in 2017.

The economic situation is tense due to low commodity prices, and the situation of many recycling companies has become more difficult. To ensure that SENS eRecycling and Swico can continue to guarantee a high level of processing quality, a spontaneous audit was conducted on a random basis in addition to the annual announced monitoring audits. This revealed that established practice outside the one-day audits also satisfies the requirements. Further spontaneous audits are planned for 2018. These improve the level of trust in the audited partners and show that the Swiss recycling sector can also perform successfully in a difficult environment.

Closer examination of technical issues

Following the successful introduction of audit logging in accordance with the SN EN 50625 series (CENELEC), the adjustment of the auditors' handbook is now being addressed. In 2018, the document will be revised and subsequently also made accessible to the recycling companies and other interested parties. It is key that the audits performed by the auditors are based on the same implementing provisions of the CENELEC standard. On the other hand, the audited companies should know how they need to prepare for the audit and how the requirements are checked during operations.

The calculation of recycling and recovery quotas is repeatedly a controversial topic of discussion, not only in Switzerland, but also in the EU. The fact that certain European countries report recycling quotas of more than 100 per cent suggests that it is not only languages that differ in Europe, but also that different countries are not talking about the same thing. Last year, the Swico and SENS TCs set about looking at this topic in a working group and aligning it with the requirements of the EN 50625 series (see article by Rolf Widmer und Heinz Böni).

With the decline in condensers containing PCB in waste electrical and electronic equipment, the systems are increasingly being confronted with the demand of recyclers to dispense with the removal of condensers. As the EN 50625 series requires the removal of PCB condensers and electrolyte condensers with a height of more than 25 mm "that contain potentially harmful substances", SENS eRecycling and Swico have launched a project to clarify whether condensers containing PCB are still contained in waste electrical and electronic equipment and whether electrolyte condensers contain potentially harmful substances. The project will be completed during the course of 2018 and the results will be presented in the 2019 Technical Report. These results are likely to also be of significant interest to other countries, as it is largely unclear whether there are even potentially harmful substances in electrolyte condensers and, if so, which ones.

Technical Commissions

The Technical Commissions underwent various personnel changes in 2017. Due to the surprising and tragic death of Emil Franov (see separate acknowledgement), Niklaus Renner from IPSO ECO AG was added to the SENS eRecycling auditor team. With Niklaus Renner, the team has gained a specialist who has already supported our long-standing auditor and refrigerators expert Geri Hug in the background for a considerable time. This should ensure that Geri Hug's high level of specialist expertise in the recycling of refrigerators is maintained in the Technical Commissions even after his retirement. Two experienced plastics experts are to be added to the Swico auditor team. Michael Gasser will take on the tasks of Esther Thiébaud, while Arthur Haarman will join the team in place of Patrick Wäger, who has assumed a management role at Empa.

Swico certificates for CENELEC-compliant recycling partners

Heinz Böni

The Swiss standard EN 50625-1:2014, which was issued by CENELEC and published in Switzerland by Electrosuisse as a Swiss standard, has been in force since January 2014. Following a two-year pilot phase between 2015 and 2016, compliance with the series of standards by Swico recycling partners has been contractually required since 1 January 2017. Where do the recycling partners stand one year after the introduction?

Photo 1: Certificate delivery according to the Swiss standard SN EN 50625 by Swico to six recycling partners on 23 April 2018. From left to right: Jean-Marc Hensch (Director Swico), Robert Grill (Immark AG), Markus Stengele (Solenthaler Recycling AG), Monica Cum Nicastro (Roadstar Recycling SA), Urs Gerig (RUAG Environment AG), Sebastién Piguet (Consortium Cablofer Recycling SA/le Bird Sàrl), Sacha Moser (Bühlmann Recycling AG) and Heinz Böni (Empa, Head of the Technical Control Board of Swico).

In recent years, the SN EN 50625 family of standards has grown and has been supplemented with additional standards and technical specifications, meaning that the set of standards is now practically complete. Following the pilot phase, SENS eRecycling has initially opted against an introduction. It will continue to follow the Swico and SENS technical regulations, which in 2012 were declared state of the art by the Swiss Federal Office for the Environment. The audits of the two systems' recycling partners will, however, continue to be conducted together.

Interim assessment

One year following the introduction, the initial interim results have been positive. The Swico recycling partners have largely implemented the requirements, which in some cases have been expanded in terms of their scope and defined more narrowly with respect to their content. This is not something that should be taken for granted in the light of stagnating or even falling metal prices and the resulting cost pressure in the area of processing. Maintaining a high level of recycling quality while at the same time ensuring the removal of hazardous substances in accordance with the relevant regulations is posing significant challenges to recycling companies. There are also additional requirements relating to collection logistics due to risks arising from appliances with lithium batteries. In light of the increasing risk potential, Swico switched the collection of appliances from containers to pallets and frames back in 2016. Detailed information on the handling of Swico appliances containing hazardous substances, and especially the question of under which conditions container transportation is still possible, is provided in the data sheet on the handling of Swico WEEE containing hazardous substances, which is based on the EN 50625 series. This data sheet also clarifies which components containing hazardous substances need to be removed from appliances prior to mechanical crushing. These components, which are designated as category 1 in the standard, include components containing mercury, lamps, parts containing asbestos, toner cartridges, liquid crystal displays and condensers containing PCB. In this area, efforts are still required by individual recycling companies.

Outlook

One area that will be subject to increasing demands in 2018 is compliance with the documentation obligations specified in the CENELEC standards. These obligations require, in particular, the provision of detailed information and evidence with respect to the fractions generated during recycling (volumes and composition), details of their subsequent treatment (downstream recipients, treatment technologies) and evidence of the removal of hazardous substances. Alternatively, should these hazardous substances not yet have been removed by Swico or SENS, documentation of how this will be ensured during downstream treatment must be provided. This information goes hand in hand with the more detailed recording of results from batch tests and the introduction of more disaggregated material flow analyses planned for 2020.

The CENELEC handbook, which will be available from summer 2018 to all involved parties as the basis for the annual audits, will clarify the CENELEC provisions and present them in a uniform and practical manner for implementation in Switzerland. The handbook, which is being prepared in 2018 in cooperation with the SENS TC, will be based on the enforcement aid for determining state-of-the-art technology of the revised ORDEE, which is likewise being drawn up during the course of 2018.

Six Swico recycling partners that perform initial mechanical processing and passed the audit conducted in 2017 in accordance with SN EN 50625 without critical deviations received a certificate issued by Swico on 23 April 2018 that is valid until the next audit date or 31 December 2018 at the latest. Two companies still need to provide evidence that they have rectified their critical deviations prior to receiving the certificate. Should it not be possible to rectify critical deviations within six months of the audit protocol being approved, companies must anticipate, following a Swico hearing and the possible setting of a new rectification deadline, that their contract will be terminated as a last resort.

Changed composition and slight decline in volumes

Michael Gasser

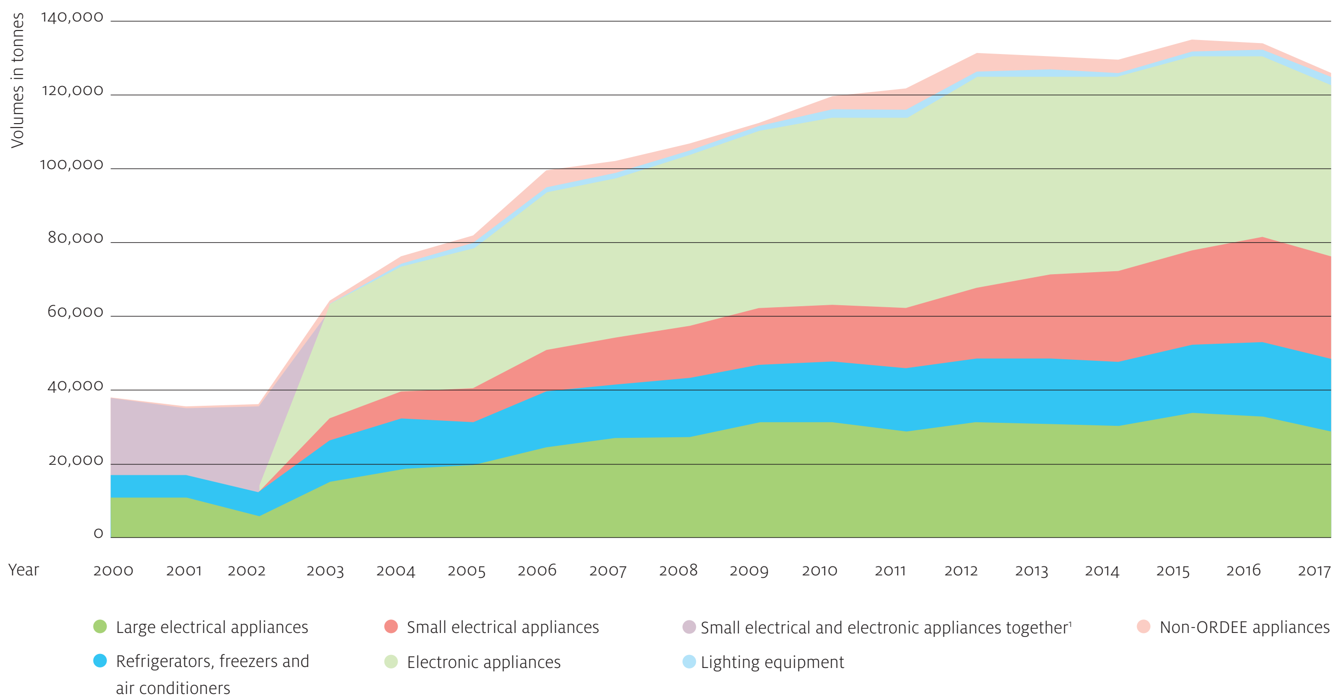
Following several years of continuously increasing volumes, a decline of 7 per cent was seen in the amount of processed waste electrical and electronic equipment this year. This can be attributed, in particular, to declining volumes in the categories of electronic appliances, small electrical appliances and large electrical appliances, while volumes in categories such as refrigerators and, in particular, photovoltaics bucked the general trend.

In 2017, the Swico and SENS recycling companies processed around 122,800 tonnes of electrical and electronic (E&E ap-pliances. Relative to the previous year, the equates to a reduction of 7 per cent. (Table 1 and figure 1). The greatest fall was seen in the processing of non-ORDEE appliances, that is, those that are not included in the lists of the Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE). There was also a decline in the processed volume of large electrical appliances (–14%), electronic appli-ances (–6%) and small electrical appliances (–4%). In the case of large electrical appliances, the decline in volumes can be attributed at least in part to the change in the recording methodology: since 2017, large household appliances have no longer been recorded by unit according to standard weight, but rather weighed directly. In the category of electronic appliances, there was a further decline in the volume of heavy cathode ray tubes from computer monitors and televisions. In contrast, the volume of refrigerators has risen once more even if this increase was not as marked as in recent years. The volume of processed photovoltaic equipment increased threefold com-pared to the previous year. At a total of 300 tonnes, however, the share of this category remains small.

Table 1: Total processed electrical and electronical equipment in Switzerland in tonnes from the material flow analysis.

Year	**Large electrical appliances**	**Refrigerators, freezers and air conditioners**	**Small electrical appliances**	**Electronic appliances**	**Lighting equipment**	**Photovoltaics**	**Non-ORDEE appliances**	**Total Tonnes/year**
2009	30,400	15,300	14,900	47,300	1,100		1,200	110,200
2010	30,700	15,900	15,400	50,700	1,130		3,500	117,400
2011	27,800	16,800	16,300	51,300	1,110		5,200	118,500
2012	30,300	17,500	18,800	55,500	960		6,000	129,100
2013	30,600	16,700	22,300	53,200	1,100		4,000	127,900
2014	29,400	17,200	23,900	52,000	1,100		3,000	126,600
2015	32,900	18,100	25,000	51,900	1,100	100	3,000	132,100
2016	32,500	19,200	27,900	49,000	1,100	100	1,900	131,800
2017	28,100	19,400	26,700	46,000	970	300	1,300	122,800
Change on previous year	**–14%**	**1%**	**–4%**	**–6%**	**–12%**	**200%**	**–32%**	**–7%**

Figure 1: Development of the volumes of appliances processed in Switzerland in tonnes.



Materials recycling

Of the electrical appliances processed, the recyclables and hazardous substances are obtained through manual and auto-matic processing (figure 2). The largest fraction of recyclable material is metals, at 62 per cent. The slight shift in the shares of plastics-metal mixtures (17 per cent) and plastics (10 per cent) can be attributed to the changed recording of plastics mixtures with residual metal contents. The proportion of glass from cathode ray tubes processing roughly halved relative to the previous year and now makes up 2 per cent. The especially valuable circuit boards account for only 1.3 per cent of the total volume. Nevertheless, it is often worthwhile to manually remove these materials prior to mechanical processing and to recover them as completely as possible. The generated recyclable material fractions are processed further by down-stream companies and recycled or utilised thermally where possible. SENS and Swico recyclers are to provide material flow evidence for further processing that describes the further processing of these fractions. In general, ferrous metals are ultimately processed in Swiss smelting plants and non-ferrous metals in European smelting plants. Plastics-metal mixtures are further separated; depending on the separation process and composition, the metals and, in some cases, also the plastics are recovered. Certain mixed fractions continue to be sent directly for energy recovery, although this share has fallen significantly in recent years thanks to new processing options. Special recovery methods are also used for glass fractions (screen glass, plate glass and recycled glass from lighting equipment), as well as cables, circuit boards and batteries.

[1] Until 2002, small electrical and electronic appliances were recorded together.

Hazardous substance removal

The proportion of hazardous substances increased slightly and accounts for 1 per cent (figure 2). This can be attributed to an increase in the number of appliances containing batteries, as well as to a more precise data collection process for the removal of hazardous substances (e.g. background lighting from flat-screen displays). Besides reintroducing recyclable materials into the material cycle, the removal of hazardous substances is one of the main tasks of Swiss recyclers. The hazardous substances are largely removed by hand at the disassembly facilities. For example, condensers in large household appliances are removed, as well as batteries from electronic appliances and the background lighting of flat-screen displays, scanners and photocopiers. The removal of hazardous substances and the handling of these hazardous substances has to be constantly adapted to changing technologies and the latest state of the art. The companies must, however, also still be able to professionally remove and dispose of hazardous substances from older generations of appliances. This places high demands on the work of the recycling companies and necessitates robust quality assurance systems.

Take-back and composition of electronic appliances

Swico Recycling regularly investigates the take-back amounts and the composition of electronic appliances. To this end, Swico Recycling performs market basket analyses and processing tests of product groups (table 2). In 2017, Swico Recycling took back 48,525 tonnes[1] of electronic appliances, 7.3 per cent less than in the previous year. The weights and quantities of CRT monitors and televisions taken back are continuing to fall in line with the long-term trend. For flat-screen monitors and televisions, the number of appliances being taken back is continuing to rise, although the total weight remains roughly the same due to declining average weights. The quantity of mobile phones is also continuing to increase: the further decline in average weight has, however, led to a reduction in the aggregate weight of –22 per cent. A similar but less marked trend is also being observed on a mixed basis in the consumer electronics category. The composition of the individual appliance categories is determined by means of processing tests carried out by Swico recycling companies and supervised by Empa. In this process, a previously defined number of appliances is collected and the resulting material groups are documented. The detailed volumes of electronic equipment taken back and their composition are shown in table 2.

Page left

[1] This number is larger than the 46,000 tonnes of electronic equipment in table 1, since this also includes electronic appliances which A-signatories have disposed of via direct contracts.

Figure 2: Composition of the fractions generated in per cent in 2017.
Hazardous substances, which make up a total of just 1 per cent of the fractions generated, are shown separately.

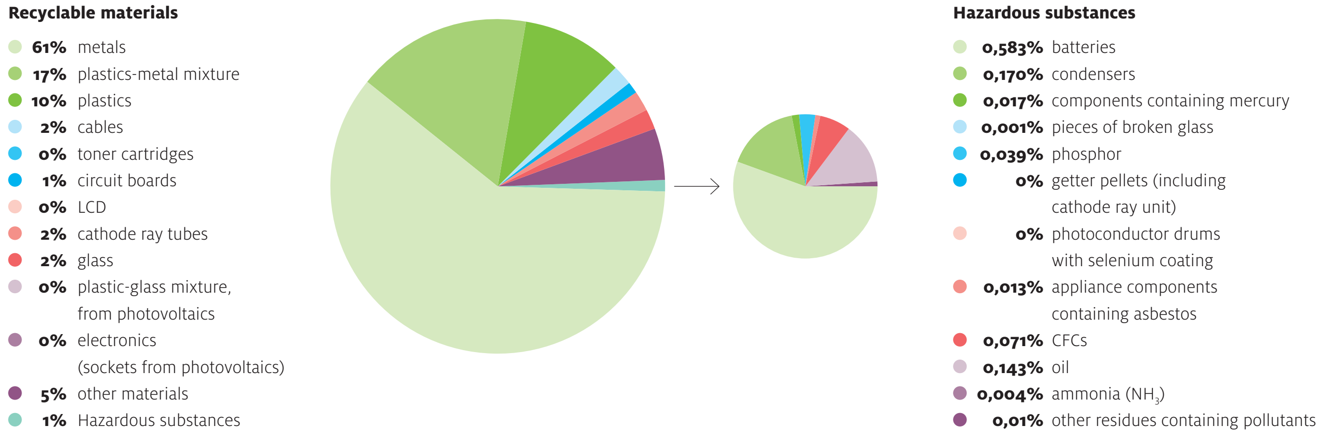


Table 2: Swico volumes collected and composition by type of appliance.

Appliance type	Quantity[4] (in thousands)	Average weight (in kg)	Metals (in tonnes)	Plastics (in tonnes)	Metal-plastics mixture (in tonnes)	Cables (in tonnes)	Glass and/or LCD modules (in tonnes)	Circuit boards (in tonnes)	Hazardous substances (in tonnes)	Other[5] (in tonnes)	Total (in tonnes)	Increase/decrease compared to 2016
PC monitor, CRT	52	18	136	185	88	24	406	85	0.1	4	927	–26%
PC monitor, FPD[1]	631	5.8	1,434	1,156	70	45	570	259	33.5	91	3,658	–5%
PCs/servers	413	11	3,732	263	12	139		378	14		4,538	1%
Laptop	458	2.8	378	373	131	6.6	113	186	89	5.4	1,282	9%
Printers	474	12	2,015	3,060	350	31	39	99	1.7	92	5,688	–10%
Largescale copiers and equipment	54	132	3,914	269	2,570	130	4.8	58	62	184	7,192	–5%
IT, mixed[2]	618	3.2	1,076	71	712	36	1.0	15	17	50	1,977	–6%
CRT TVs	242	24	573	1,188	193	21	3,757	71	5	3.1	5,810	–24%
FPD TVs[1]	215	19	1,970	733	430	56	357	342	45	142	4,076	8%
Consumer electronics, mixed[3]	3,234	3.3	5,758	388	3,877	195	5.5	84	93	271	10,672	–4%
Mobile phones	743		18	40			5.8	25	23		111	–22%
Remaining phones	1,463		1,273	84	843	42	1.2	18	20	59	2,340	–12%
Photo/video	200		87	5.7	58	2.9	0.1	1.3	1.4	4.1	160	–1%
Dental											93	0%
Total in tonnes			**22,363**	**7,817**	**9,334**	**726**	**5,260**	**1,621**	**404**	**906**	**48,525**[6]	**–7,3%**
Total in per cent			**46%**	**16%**	**19%**	**1%**	**11%**	**3%**	**1%**	**2%**	**100%**	

Page Right

[1] FPD: flat-screen displays, different technologies (LCD, plasma, OLED, etc.).
[2] IT equipment, mixed, without monitors, PCs/servers, laptops, printers, large-scale copiers and equipment.
[3] Consumer electronics, mixed, not including televisions.
[4] Projection.
[5] Packaging and other waste, toner cartridges.
[6] This number is larger than the 46,000 tonnes of electronic equipment in table 1, since this also includes electronic appliances which A-signatories have disposed of via direct contracts.

Source: Michael Gasser, Empa, based on Swico processing and market basket analyses, 21 March, St. Gallen.

Refrigerators
(reporting period 2017)

Geri Hug and Niklaus Renner

The four Swiss refrigerator recycling companies processed only slightly fewer refrigerators and freezers from the household and industry sectors than in the previous year. From a total of 350,000 appliances (equating to around 17,500 tonnes), refrigerants and propellants from compressors and insulation foam were recovered in compliance with stringent technical requirements. Here, the uptrend in environmentally friendly VHC appliances is clearly continuing, with these appliances now accounting for a share of 64 per cent with respect to refrigerants. If a distinction is made according to the type of propellant in the polyurethane (PU) foam, this share of the appliance mix attains 71 per cent.

An average household refrigerator that is sent for recycling in Switzerland is comprised as follows (approximate empirical values):

- Metals (iron, aluminium, copper): 64%
- Plastics: 22%
- PU foam: 10%
- Propellant and refrigerant mixture (VFC and VHC) and compressor oil: 2%
- Other (shelves, etc.): 2%

While around 88 per cent of the appliance weight was deemed to be free of hazardous substances and could, in principle, be processed using conventional recycling process technology, the proportion of ozone-depleting and climate-active components (refrigerants and PU foam including the propellants contained therein) of around 12 per cent means a highly specialised plant construction is necessary. Before the appliances can be dismantled into their fractions using rotary shears as well as downstream magnet and eddy current separators and pellet presses (treatment stage 2), the refrigerants must first be extracted without losses from the compressors (treatment stage 1).

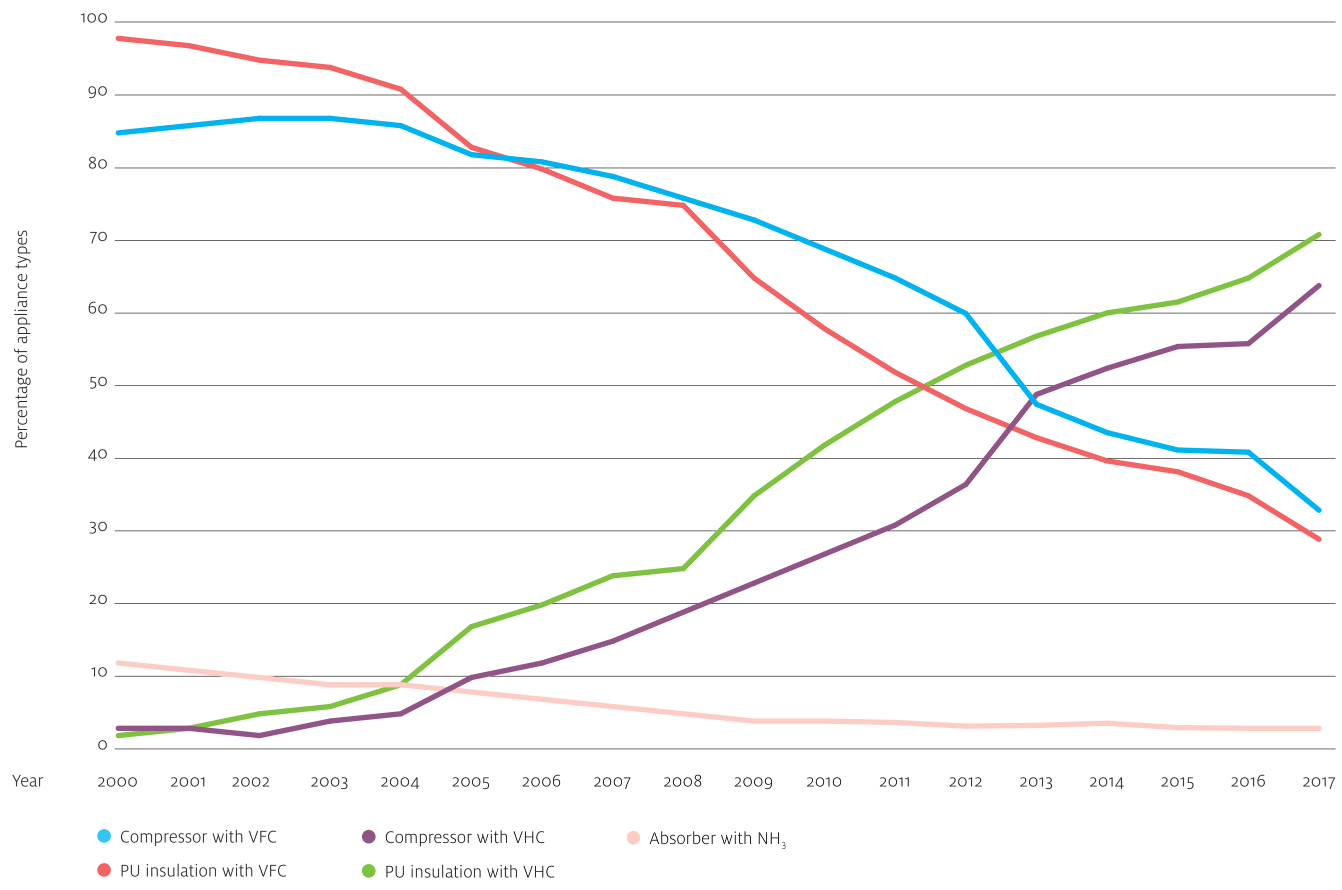
The controlled outgassing and condensation of propellants at stage 2 is performed using mechanical refrigeration technology as well as through the application of liquid nitrogen at low temperatures of down to −90°C. The waste air flows of the plants are continually monitored for trichlorofluoromethane (R11) and dichlorodifluoromethane (R12) after passing through various filtering units.

The plants are audited every two years and validated on the basis of so-called batch tests, which see the application of calculation and assessment methods in accordance with the CENELEC standard EN 50625-2-3 and the technical specifications 50625-3-4.

VHC appliances gaining more ground than expected

During the current reporting period, old appliances with compressors driven by environmentally friendly hydrocarbons (volatile hydrocarbons, VHC) that are treated at stage 1 already accounted for a share of 64 per cent, representing a marked increase of 8 per cent on the previous year. In contrast, the share of VFC (volatile fluorocarbons) compressors fell to 33 per cent. The number of appliances with ammonia-containing absorption systems has hardly changed for a number of years and accounts for around 3 per cent (see figure 1). In the reporting period, the PU insulation for 71 per cent of all refrigerators sent for recycling was foamed with VHC propellants, meaning that relative to the previous year the increase in the proportion of environmentally friendly appliances also exceeded expectations at stage 2 (+6 per cent).

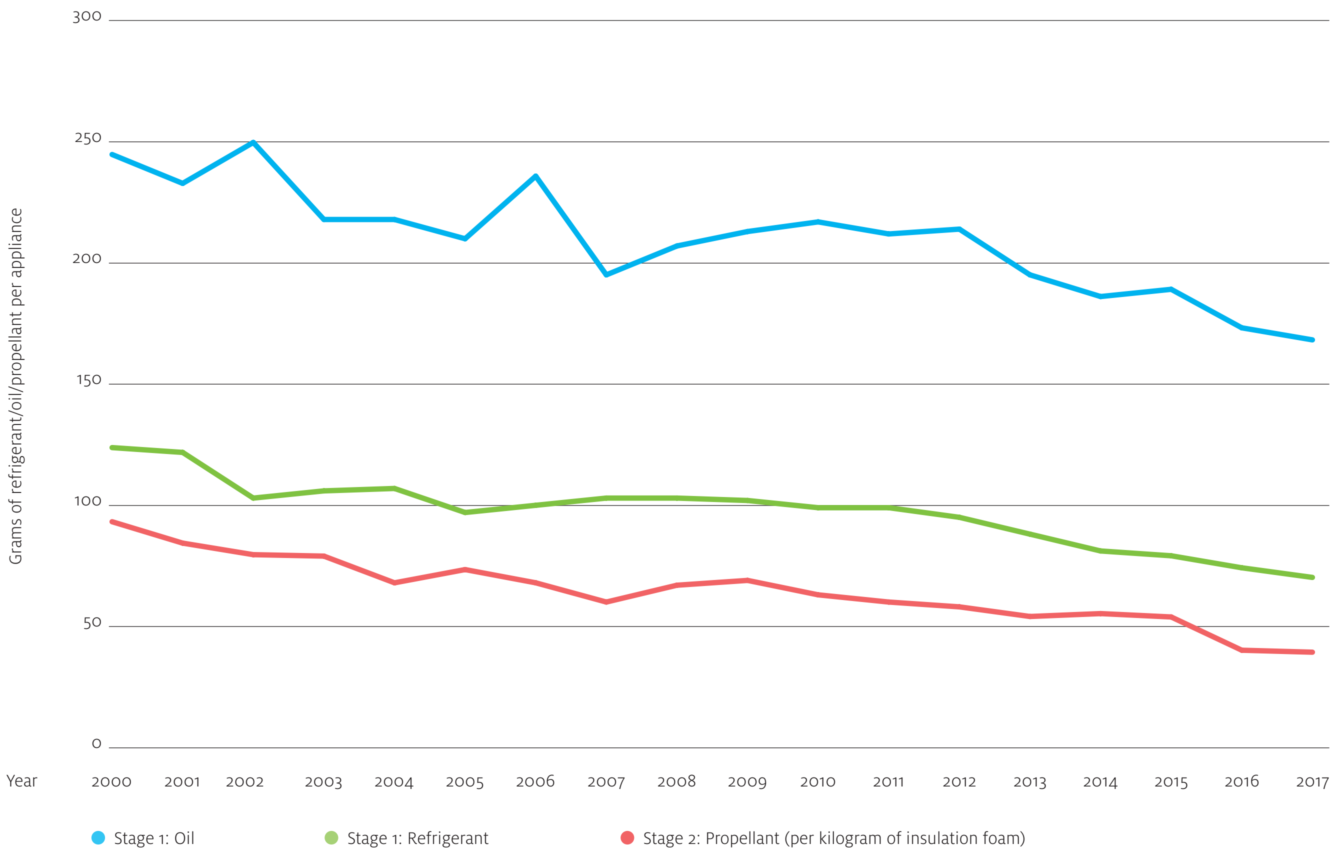
Figure 1: Development of appliance types processed at stage 1 (VFC-/VHC-containing compressors, ammonia-containing absorption systems) and stage 2 (VFC-/VHC-containing PU insulation foam).



Trend in the appliance mix reflected in recovery rates

The decline in VFC appliances on the input side is also being observed at both treatment levels in terms of output in the form of lower recovery rates for refrigerants and propellants. Two factors are responsible for this effect: 1) the much lower VHC filling weights/concentrations in the PU insulation and 2) the lower specific weights of isobutane/cyclopentane relative to conventional VFC (82 grams of VFC/38 grams of VHC per kilogram of PU foam according to performance tests and manufacturer specifications). While in 2015 almost 80 grams of refrigerants was extracted from every compressor at stage 1, this figure stood at 74 grams in 2016 and 70 grams in 2017. The amount of oil fell during the same period from 189 grams to the current figure of 168 grams. This visibly supports the assumption that it is not only the refrigerant filling weights in VHC compressors that are falling, but also the amount of oil. The same trend is also being witnessed at stage 2: while

Figure 2: Development of recovery rates at stage 1 (grams of refrigerant and oil per appliance) and stage 2 (grams of propellant per kilogram of insulation foam).



amounts of around 80 grams per kilogram of PU were still recovered around the turn of the millennium, this figure has since dropped continuously. In 2015, the average already stood at just less than 54 grams. An abrupt fall to 40 grams followed in 2016 (due to an adjustment to the calculation method). In the current survey year, this figure changed little at around 39 grams. The real amount of recovered propellants amounted to 175 grams per processed appliance housing in 2017. The data is consistent with the observed increase in the number of VHC housings accompanied by a simultaneous decrease in the specific weight of the propellant mixture.

See figure 2. The exact course that the curve of the end-of-life VFC appliances will take cannot be predicted accurately; what can be anticipated, however, is that it will approach zero asymptotically. Until then, the mixed processing of VFC and VHC appliances in the highly specialised Swiss recycling plants will remain in line with the latest technological standards.

An impressive comparison

While in 2016 the atmosphere was spared 370,000 tonnes of carbon dioxide thanks to the recovery of refrigerants and propellants and their subsequent controlled destruction, this figure was 290,000 tonnes of carbon dioxide in 2017 due to the changing appliance mix. Nevertheless, the environmental relevance of refrigerator recycling remains high, as illustrated by the following comparison: a Swiss car (emission of 134 grams of CO_2/km) would have to cover more than 2 billion kilometres or circumnavigate the world more than 54,000 times in order to emit an equivalent amount of carbon dioxide.

Photo 1: Delivery of refrigerators to the recycling company.

Photo 2: Refrigerators prior to being processed at stage 2 (shredding with recovery of propellants).

A tour of regulations and standards

Rolf Widmer and Heinz Böni

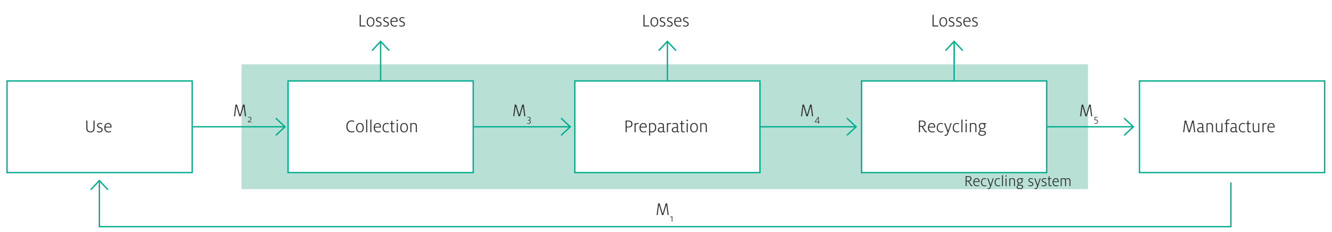
The recycling and recovery performance of all Swico and SENS processing partners is determined each year. The process has been defined for some time by the applicable Swico and SENS technical regulations (TR: 2012). The Swiss set of standards SN EN 50625, which for now is contractually binding for Swico recycling partners, clarifies and supplements the TR:2012 with respect to this issue.

Background

In the European waste management industry, recycling performance is now measured on the basis of the following two key figures: the recycling quota (RcQ) and the recovery quota (RvQ). In principle, the recycling quota corresponds to the proportion of a material that is recycled, while the recovery quota also includes the proportion of a material that is recovered in the form of energy. There are individual recycling and recovery objectives (RcRvO) for the different waste streams, i.e. minimum specified recycling and recovery quotas (RcRvQ).

The simplified disposal system presented in the following graphic illustrates that even apparently simple indicators such as recycling and recovery quotas can lead to confusion. The quotas are to be defined as mass fractions. For example, the recycling quota for waste electronic and electrical equipment (WEEE) could be the proportion of the total mass of all recycled materials (M_5) relative to the total mass of all collected equipment (M_2), i.e. RcQ = M_5/M_2. This appears obvious and plausible, but recycling quotas are usually not defined in this way. The determination of the recycling and recovery quotas of Swico and SENS is based on, for example, RcQ = M_5/M_2 or RcQ = M_4/M_3, i.e. the input into or output from the recycling divided by the input at the Swico and SENS recycling partners. Certain EU states use RcQ = M_2/M_1, i.e. collected WEEE divided by the sold new devices. All in all, it is possible to find almost all conceivable ways of dividing the five masses M1 to M5 and thus also very different recycling and recovery quotas. It is often unclear what exactly is meant by the “total mass” of a material that is recycled or recovered in the form of energy. For example, in the case of the thermal recovery of a plastic (P) in a waste incinerator with heat utilisation (R1 waste incineration plant), should its total mass be deemed to have been recovered or should the proportion (approx. 35 per cent) that escapes through the chimney as waste heat be deducted? Or should, for example, a pure aluminium fraction, that is converted into 90 per cent aluminium ingots and 10 per cent unusable aluminium oxide in a smelting plant be deemed to be 100 per cent recycled?

Figure 1: Simplified disposal system in which M1 to M5 represent total mass flows at a certain point in the processing chain. “Preparation” refers to all manual and mechanical processing procedures that generate final fractions for the last treatment stage, i.e. recycling.



The technical regulations TR:2012[1] have been in force since 2012 and address such questions, among others. Based on the WEEE Directive on the handling of WEEE, they stipulate that a company must demonstrably achieve set recycling and recovery objectives. This can be validated with batch tests or, where feasible, using annual substance flow balances. In the case of generated fractions that are delivered to so-called recipients for further separation, evidence of their composition and the recycling and recovery quotas in these external processing procedures must be provided. Here, all external companies that accept fractions and break them down into further fractions by means of treatment are deemed to be recipients. Implicitly, therefore, the entire processing chain must be documented until every fraction (or rather their components) can be assigned to one of the following five usage classes upon the use of a final recognised recovery technology:

MR	Material recycling
ER	Energy recovery
TD	Thermal disposal[2]
LD	Landfill disposal
RU	Reuse[3]

[1] See under documents at https://www.bafu.admin.ch/bafu/de/home/themen/abfall/fachinformationen/abfallpolitik-und-massnahmen/vollzugshilfe-ueber-den-verkehr-mit-sonderabfaellen-und-anderen-/umweltvertraegliche-entsorgung-von-sonderabfaellen-und-anderen-k/umweltvertraegliche-entsorgung-von-elektrischen-und-elektronisch.html
[2] This classification also applies to all non-combustible materials that reach an incinerator.
[3] Without destruction of original function.

The recycling and recovery quotas are calculated using the RepTool, a piece of software provided by the WEEE Forum (www.wf-reptool.org). The recycling partner must document its investigations and provide the necessary evidence. It must also grant the Technical Commission (TC) access to the required data, calculations and evidence so that it can perform its own calculations. For certain fractions for which the TC is aware of their further treatment, the standard recycling and recovery quotas listed in the TR:2012 can be used without any obligation to provide evidence. Changes to all internal or external processing procedures that may change the recycling and recovery quotas must be reported to the TC immediately. Since 2017, the provisions of the Swiss set of standards SN EN 50625 have applied to the processing of Swico WEEE. It clarifies several specifications of the TR:2012 with respect to recycling and recovery quotas.

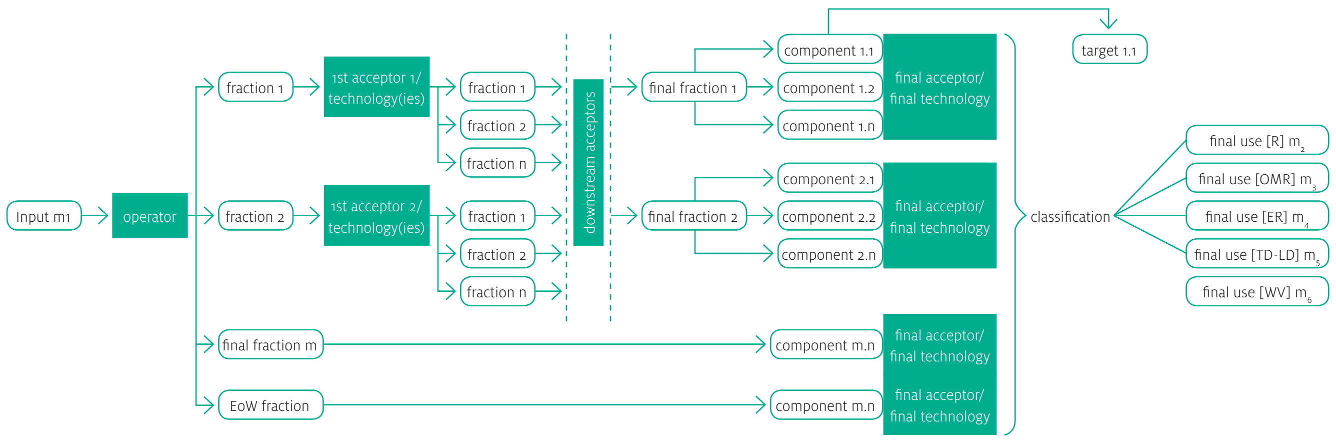
Aktuelle Methode zur RVQ-Bestimmung

Current method for determining recycling and recovery quotas:

- The recycling and recovery quotas must be determined at least once a year for each treatment current. In the case of a single current, this may possibly be determined on the basis of the annual mass balances. For several mixed currents, one batch test per current and location is required at least every two years.
- The recycling and recovery quotas determined on the basis of batch tests must be compared with those from the annual mass balance and, should the difference be smaller than 10 per cent, the values of the annual mass balance must then be declared. Otherwise, the values from the batch tests are to be used and the deviation stated.

The infrastructure for the calculation of the annual mass balances at Swico and SENS still does not currently allow the recycling and recovery quotas to be calculated; the tools, in particular the Toocy software, are being revised to this end. Until this time, the systems are planning annual batch test series that, together with other data collection measures, will allow for representative statements to be made on recycling and recovery performance. The explanations provided in the standard clarify the underlying processing and calculation

Figure 2: Processing and calculation model in accordance with SN EN 50625. For the calculation of the recycling and recovery quotas, the components of the final fractions must be classified into one of the possible four uses during the final treatment stage (final acceptor/final technology). On the basis of this classification, each fraction component is assigned to one of the masses m_2 to m_5 (m_6 = 0 as not permitted in the Swico and SENS system).



model, which is fully implemented in the RepTool (figure 2). According to this model, output fractions generated by a treatment can have three states:

State 1: "EoW", the fraction is no longer waste,

State 2: "Final", a final fraction that is sent to a "final recipient", or

State 3: "Neither EoW nor final", a fraction that is to be processed further.

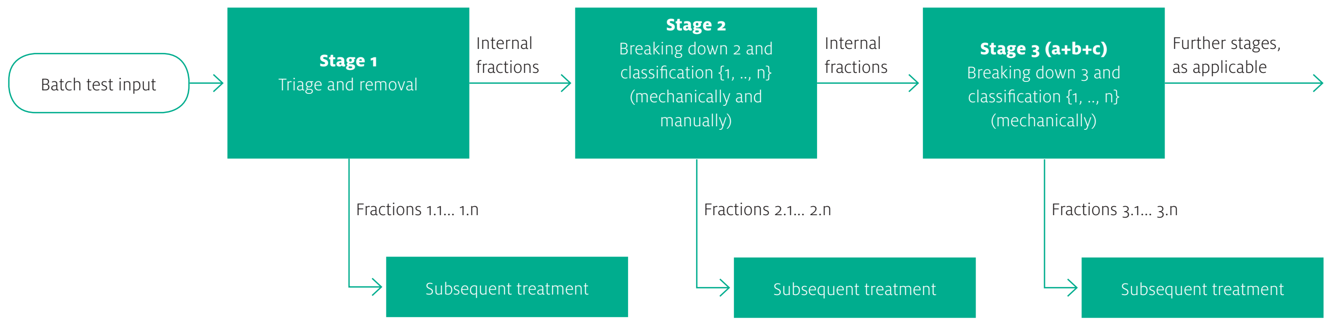
There are also "pure" fractions for which impurities make up a share of less than 2 per cent of their total mass. Impurities are deemed to be all materials that do not correspond to the target material to be recovered, for example a transformer comprising iron core and cupronickel may be almost exclusively made of metal but is not "pure".
In order to collect information on the internal processing activities of a recycling partner (operator) right through to the generation of its output fractions, its internal processing procedures are recorded in the RepTool according to the same scheme applied to external processing procedures.
A simplified process flow chart (PFC) is used to this end. The number of stages it includes corresponds to the number of procedures (e.g. grinder) performed to break down the materials. The generated output fractions are assigned to the associated classification procedure (e.g. eddy current) (e.g. the fraction "Al pure 2.3." is generated during stage 2 and assigned to classification 3). Within the RepTool, each internal step therefore assumes the same role as an external recipient. This structure also allows for the mapping of companies with internal processing activities distributed across several locations (figure 3).

The recycling and recovery quotas can ultimately be calculated on the basis of this continuous chain:
$RQ = m_2 / m_1$
$RvQ = RcQ + (m_3 + m_4) / m_1$

Only the final fraction components and their usage classification are therefore required for the calculation of the recycling and recovery quotas. Compared to the TR:2012, the new "other material recovery" (OMR) category, which is not included in the recycling quota (e.g. filling) is added, while thermal disposal and landfill disposal are consolidated. In contrast to the TR:2012, three targets must now be achieved instead of the previous two for some metals in accordance with TS 50625-5[1]: in addition to the other recycling and recovery quotas, a yield (y) of ≥90% for Cu, Ag, Au and Pd must be demonstrably achieved during the "final treatment". The yield is defined as the proportion of a specific metal in the final fraction (infeed) that is converted into a pure metal, pure alloy or pure salt during the final treatment in the smelting plant (shown in figure 2 as "component 1.1" to "target 1.1").

If a final fraction is "pure" and the final treatment is designed for the recovery of this material, a high yield can be anticipated. Without knowing the yield, a recycling quota of 100 per cent is usually assumed to simplify matters. The same principle is often also applied for "impure" final fractions, i.e. any final fraction that is sent for specialised final treatment is deemed to be 100 per cent recycled. This can considerably gloss over the actual recycling and recovery performance.[2]

Figure 3: Simplified process flow chart (PFC) for internal processing. Here, it is indicated that stage 3 processing takes place at the three locations a, b and c.



By definition, all "EoW" fractions are deemed to be recycled or recovered, but their composition as well as final recipient/treatment must be known. Although none of the Swico and SENS recyclers currently generate such fractions, there is also the question here of whether an "impure" "EoW" fraction should also be deemed to be 100 per cent recycled. The "RcRvQ" working group was established in order to, among other things, clarify this question. It recommends the following:

- To take account of the different classification options, two assessment levels are used in RepTools:
  At the "National" assessment level, conditions that are as close as possible to reality are used for the joint recycling and recovery quotas of SENS and Swico; e.g. the common yields for the target material/energy are taken into account[3].
  For the "Model" assessment level, the usual conditions in Europe with respect to recycling and recovery quotas are applied.
- The following applies for the "National" assessment level:
  If a fraction is designated as "pure" without the provision of any further evidence, it is assumed that 2 per cent of the fraction comprises impurities and this portion is not included in the recycling quota. Further losses of the target material during the final treatment (e.g. yield <100 per cent) are to be taken into account.
- If the fraction is demonstrably "pure", it does not contain any further compounds, i.e. it comprises just one target material. This does not mean, however, that its yield during final treatment in 100 per cent![4]

Outlook

The following background data is being revised for the assessment of this year's batch tests:

- Table 5.1 "Standard recycling and recovery quotas for specific fractions " from the TR:2012 is being further developed jointly by the Swico and SENS TCs.
- Table 6.2 "Recognised forms of recycling and recovery" for the TR:2012 is to be replaced by the corresponding up-to-date table from the RepTool.
- The list of existing RepTool packages (current, recognised treatment processes) is to be inspected, added to and, where necessary, revised.

In order to simplify the transfer of data from the companies' batch tests to the RepTool, the electronic data recording screens are being improved, with the matching of the companies' internal fraction designations to the so-called RepTool codes especially contributing here.

[1] TS 50625-5 "Specification for the final treatment of fractions from waste electrical and electronic equipment – copper and precious metals".
[2] Recycling quota magic: www.tomm-c.de/fileadmin/pdf/2017/Obermeier_Recycling-Quotenzauber_20170915_final.pdf
[3] For example, for plastics in an R1 waste incineration plant, only the organic portion of the fraction's mass weighted by the minimum efficiency level of 65 per cent is included as ER, i.e. the recovery quota is 65 per cent in the best case scenario, while the recovery quota is 100 per cent under the "Model" assessment level.
[4] For example, for Al "pure" the Al yield is assumed to be 95 per cent, i.e. 5 per cent of the Al final fraction is not included in the recycling quota (unless the dross is also used as a product. Under the "Model" assessment level, the recycling quota is 100 per cent.

A rocky road to a clean circular economy

Michael Gasser and Arthur Haarman

Plastic recycling is currently an important topic of discussion, both in WEEE recycling and in public discourse. Alongside metals, plastics are the main bulk material fraction in electrical and electronic equipment. However, they are recycled to a lesser extent due to technological and economic challenges. As recycling rate targets increase, WEEE plastic recycling becomes more and more of a necessity for recycling operators. However, recent developments including market disruptions and more stringent treatment requirements may actually hamper WEEE plastic recycling.

Photo 1: Reuse of packaging with RoHS-compliance label in the informal plastics recycling sector in India (image: Arthur Haarman).

The plastic content in waste electrical and electronic equipment tends to increase every year, and currently sits at an average of approximately 25% by weight. At the end of a product's life, plastic fractions can be either materially recycled or incinerated with energy recovery. From an environmental perspective, the recycling of plastics, especially the high-grade types used in electrical and electronic equipment, is often more beneficial than incinerating them.

Plastic fractions are, however, one of the most challenging bulk fractions found in waste electrical and electronic equipment for recycling. The challenge of waste plastic processing lies largely in the sorting steps, where fractions need to reach a sufficient purity. Incompatible plastic types have to be separated from each other. In addition, plastics additives that are banned nowadays, such as certain flame retardants, need to be removed before recycling.

WEEE plastics have therefore historically been recycled to a lesser degree. However, the flow of WEEE plastics has changed dramatically in recent years. Every year, less plastic is sent directly for incineration, while increasing shares are processed further. In 2007, less than 10% of mixed plastic fractions underwent further processing, a figure that increased to approximately 30% in 2011 and reached 35% in 2016. In the processing of mixed plastic fractions, technological innovations nowadays allow for additional types of plastic to be recycled. There has also been an increase in the manual removal of plastics. Such fractions often have a very high purity and can in some cases be processed directly into secondary raw materials.

Recycling of plastic fractions is an established part of the recycling of electrical and electronic equipment today. Previous batch tests show that recycling partners can only reach the currently mandated recycling rates if at least some plastics are recycled. This is especially true for the ICT equipment and small household appliance categories, where plastic content can be much higher than the average (approximately 50% by weight).

Current developments: disrupted market and tightening treatment requirements

Different WEEE plastic fractions often require specialised processors and users. This results in complex and often cross-border material flows, which are quite vulnerable given the few alternatives available. Small changes in the rules and norms concerning the treatment or trade of plastic waste can therefore have greater consequences on overall recycling rates for WEEE plastics. Some of the current developments in this area are discussed hereafter.

As part of its National Sword policy, China, traditionally one of the main importers of plastic scrap, has recently banned the import of certain plastic wastes. This has led to a shortfall of processing capacity and users of secondary raw materials in the plastic recycling industry. It is still unclear how and to what extent the ban will affect WEEE plastics in particular. In the short term, this development represents a considerable risk for WEEE plastic recycling. In the longer term, however, it could actually represent an opportunity to strengthen recycling capacity in Europe.

In the move towards a closed-loop economy, there remains a conflict of objectives between an increase in the recycling rate and a removal of legacy substances in material cycles. After a substance has been banned, it is often replaced by substances with similar concerns, which are subsequently also banned a few years later (an effect known as regrettable substitution). Waste streams therefore often contain several generations of prohibited substances, with different transitional arrangements for each substance. Polybrominated diphenyl ethers (PBDEs), which are an important group of brominated flame retardants (BFR), should be mentioned as an example. In May 2017, decabromodiphenyl ether (DecaBDE), the last economically relevant compound of PBDEs as a persistent organic pollutant (POP), was included in the Stockholm Convention.

In Europe and Switzerland, the electronics sector is well prepared for this change, as the RoHS Directive already heavily restricts the use of all PBDEs. Nevertheless, WEEE contains measurable concentrations of DecaBDE like other, previously banned PBDEs. For practical reasons, the treatment regulations laid down in the SN EN 50625 standard are even more comprehensive in the recycling of EAGs. For plastics from certain groups of equipment, the norms state that plastics can only be recycled if their total bromine concentration is below 2,000 ppm. The industry is therefore already prepared today for future bans on further brominated flame retardants. Prohibitions of other flame retardants, such as those containing phosphorus, would have far-reaching consequences.

In order to ensure adequate removal of pollutants, comparable requirements must apply to all material flows concerned. The SN EN 50625 standard currently exempts plastics from household appliances from the depollution requirement. Single measurements have, however, detected PBDEs in such plastics. An ongoing study at the European level currently collects data and verifies whether this exemption remains justified. The results to date indicate that the European concentration limits should not be exceeded in unsorted fractions. Large household appliances, especially non-refrigerating appliances, can nevertheless contain considerable quantities. Countries with stricter requirements than the European standard could override this exemption, which could lead to additional treatment and documentation obligations.

Photos 2 and 3: Sampling of plastics from large household appliances to determine their pollutant content (images: Arthur Haarman).

Outlook

In the future, mandated recycling rates may increase further. Most bulk materials except plastics are already being recovered to a significant degree and thus can contribute very little to increased recycling rates. Plastics will therefore remain a key challenge in achieving even higher rates. This is true not only for the recycling of electronics, but also for other wastes such as packaging and automobiles. The EU Commission has identified plastics as a key priority within the EU Action Plan for a circular economy, and has developed a strategy for plastics in the circular economy. In the strategy, the EU commits itself to leading the transition to the plastics of the future by building a new plastics economy.

The existing conflict of interest between the elimination of legacy chemicals and increased recycling is likely to grow, pushing the demand for innovative technical solutions. Developing and emerging economies may benefit from the commitment of the EU. In these countries, plastic recycling can be a matter of subsistence for many low-income households, or may represent a still-untapped potential to create wealth from waste. The handling of legacy substances remains a largely unsolved issue in these countries

Waste as a resource for sustainable development

Heinz Böni, Rolf Widmer, Michael Gasser and Arthur Haarman

Take-back and recycling systems for disused electrical and electronic appliances have existed in Switzerland for more than 20 years. Based on this long-standing experience, the State Secretariat for Economic Affairs (SECO) decided back in 2002 to support developing countries and emerging markets with their efforts to develop e-waste management systems. Empa was entrusted with the performance of these activities. SENS eRecycling and Swico are members of the advisory support committee.

Photo 1: Skinning of cables and colour-sorting of fractions in the informal sector in Delhi, India.

In developing countries, the recycling of materials from waste is largely conducted in the so-called "informal" sector, i.e. by poor people who are also poorly qualified and equipped to perform this activity. This poses numerous risks, including environmental pollution, health hazards and the spreading of dangerous materials. In general, there is a lack of appropriate awareness, i.e. with respect to generally accepted and implementable quality and sustainability standards. Since 2003, the State Secretariat for Economic Affairs (SECO) has been developing knowledge partnerships in the area of e-waste management. As part of the Swiss e-Waste Programme, Switzerland has supported India, China, South Africa, Columbia and Peru with their efforts to improve their e-waste management systems. Corresponding guidelines have now been issued in nearly all of these partner countries.

This success has led to the development of a more comprehensive approach in the form of the Sustainable Recycling Industries (SRI) follow-up programme. The development objective of the SRI programme is the sustainable integration and involvement of small and medium-sized companies from developing countries and emerging markets in the global recycling of secondary resources. The SRI programme is once again being financed by the SECO and is being implemented jointly by Empa[1], the WRF[2] and ecoinvent[3] via three linked programme components.

- Life cycle assessments: the SRI programme compiles regional life cycle inventories (LCI) for the evaluation of the environmental and social life cycle performance of industrial and informal activities. To this end, the required local and regional expertise is being expanded and developed in Brazil, India and South Africa.
- Recycling initiatives: together with private and public institutions, the SRI programme provides support in making existing local e-waste recycling capacities in Columbia, Egypt, Ghana, India, Peru and South Africa more sustainable, including, in particular, within the informal sector.
- SRI Roundtable: the SRI programme promotes stakeholder consultation with the objective of improving e-waste management systems and, in particular, developing sustainability criteria for secondary materials in the form of an ISO document.

Plastics recycling in India

It is estimated that between 0.5 and 1 million people in India work in the area of plastics recycling. A large share of these activities take place in the "informal" sector without government regulation and support. Plastics recycling is an important source of income for poverty-hit population groups, provides the industrial sector with secondary raw materials and ensures significant reductions in CO_2 emissions. There are, however, major challenges, such as substandard recyclates, the insufficient removal of prohibited additives, the unprofessional disposal of hazardous substances and a lack of safety measures under labour law.

The SRI programme is supporting the Indian plastics recycling sector in developing more sustainably with a focus on flame-retardant plastics. This relates to the international requirements for the removal of persistent organic pollutants (POP) (see also article on "plastics recycling").

Thanks to professional removal, improved granulate properties and thus broader market access are achieved, which in turn also creates scope for further environmental and social improvements. As part of the project, various technologies for the removal and disposal of contaminated plastics fractions are being evaluated, with training being provided to different stakeholders. The findings are being implemented in flagship projects and are thus contributing to a smooth "formalisation" and improvement of the recycling sector.

The recycling of plastics, and especially plastics from waste electrical and electronic equipment with harmful additives, poses a problem in most developing countries and emerging markets. The experiences gained and the successes achieved in India are therefore attracting interest around the world and are also being applied successfully in other countries.

CENELEC auditing in Columbia and Peru

The project activities were launched in Colombia and Peru around 10 years ago. With the support of the Swico CEO at this time, various events were held in close cooperation with the local ministry of the environment and with the support of the environment minister as well as the national industry associations Andi (Colombia) and SNI (Peru). The objective here was to make producers, importers, wholesalers, administrative bodies and industry associations aware of the problem and encourage them to cooperate.

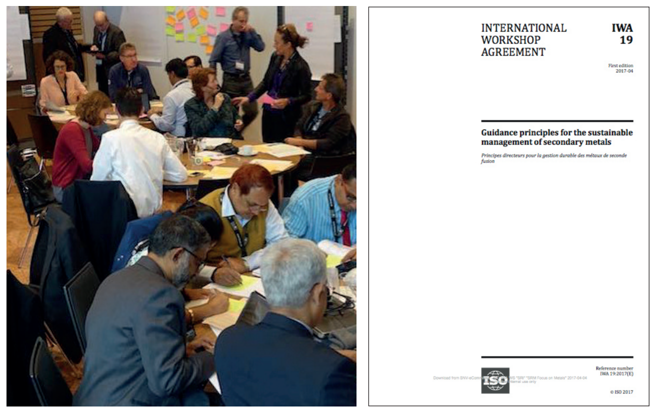
Various studies supported the process and led to the first legal regulations on the take-back and recycling of computers and their peripheral appliances. National acts, which assign increased product responsibility to producers, importers and wholesalers, were ultimately passed in Peru in 2012 and in Colombia in 2013. Various technical standards were also developed and issued.

As a result of these legal framework conditions, several collective take-back systems for disused electrical and electronic appliances were established in both Colombia and Peru. In Columbia, nine recycling companies established the ACORAEE association in 2017: Latin America's first association of e-waste recyclers. At the initiative of the Ecocomputo and Red Verde collective take-back systems, initial audits were performed by Empa experts at 10 companies in 2016 and 2017 on the basis of the international EN 50625 standard (CENELEC). Audits were also conducted in Peru. The results are

[1] www.empa.ch/tsl – Swiss Federal Laboratories for Materials Testing and Research/Technology and Society Department.
[2] www.wrforum.org – World Resources Forum.
[3] www.ecoinvent.org – The world's most consistent & transparent life cycle inventory database.

Photo 2: Audit in accordance with EN 50625 at a recycling company in Lima, Peru.

Photo 3: Working groups developing the concept for the GP at the WRF in Davos in 2018 and the result – IWA 19 with a further 18 months of intensive work.

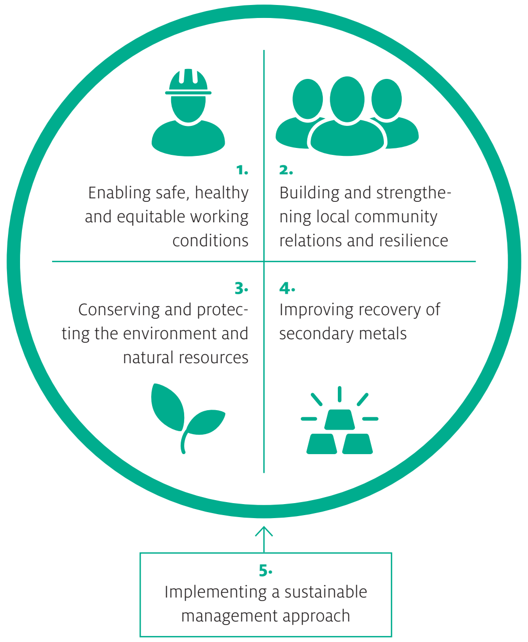


impressive: most companies that perform manual dismantling work comply with European requirements. At individual companies, there is still need for improvement with respect to the removal of hazardous substances and the proper handling of components containing hazardous substances or dangerous components that are removed from waste appliances, such as lithium batteries, background lighting from flat-screen displays containing mercury and plastics.
After around 10 years of cooperation with Colombia and Peru, these two countries are now pioneers in South America for the sustainable handling of waste electrical and electronic equipment. The larger take-back systems in Colombia, which came together to form an umbrella association in 2017, are planning to join the WEEE Forum this year.

Guidance principles for the sustainable management of secondary metals

From 2015, the SRI programme summoned important stakeholders to a roundtable in order to advance the development of "Guidance principles for the sustainable management of secondary metals" (GPs) and ultimately to publish the result as an International Workshop Agreement as part of the International Organization for Standardization (ISO). This ISO IWA process was a consensus-building process, which comprised four workshop sessions with subsequent public reviews and was completed with the publication of the IWA at the end of 2016. This activity was overseen by the Swiss Standards Association (SNV) on behalf of the ISO and implemented by the SRI Roundtable.

Photo 4: The five principles and 17 associated objectives.



17 Objectives

- 1.1 Enable safe and healthy workplaces.
- 1.2 Establish working terms and conditions that are decent and equitable.
- 1.3 Eliminate child labour, forced labour and all forms of discrimination.
- 1.4 Ensure freedom of association and the right to collective bargaining.
- 1.5 Provide clear channels for communication and dialogue with workers.
- 2.1 Respect and foster local communities' rights.
- 2.2 Enable social inclusion of workers in the community.
- 2.3 Establish clear channels for communication and dialogue with local communities.
- 3.1 Conserve and protect water, air and soil resources.
- 3.2 Restore severely damage areas from metals recovery operations.
- 3.3 Conserve and protect biodiversity, ecosystems and ecosystem services.
- 4.1 Promote technologies and strategies to increase secondary metals recovery.
- 5.1 Evaluate existing baseline conditions of secondary metals operations.
- 5.2 Mitigate negative and strengthen positive impacts of operations through a management plan.
- 5.3 Strengthen the organisational capacity of economic operators.
- 5.4 Ensure compliance with local and national laws and regulations.
- 5.5 Eliminate bribery, money laundering and corruption.

The objective of the GPs is to create a credible global framework for the sustainable management of secondary metals. They aim to provide economic agents (e.g. individuals, micro, small and medium-sized companies as well as large firms) as well as governments, standardisation organisations and other interested parties with guidance in connection with this issue.

The GPs formulate 17 objectives for the sustainable management of secondary materials, which are in turn assigned to these five principles:

Principle 1: enabling safe, healthy and equitable working conditions

Principle 2: building and strengthening local community relationships and resilience

Principle 3: conserving and protecting the environment and natural resources

Principle 4: improving recovery of secondary metals

Principle 5: implementing a sustainable management approach

The GPs are currently being tested with respect to their applicability in various SRI projects, as the IWA must be developed further into an ISO standard within three years. Specific application experience in the field is required to this end.

Outlook

The success story of the SRI programme and its predecessor, the Swiss e-Waste Programme, will likely continue. Together with the programme managers, the SECO is currently discussing where the focus of a continuation of the SRI programme from 2019 might lie and what shape it could take. Irrespective of this, the achievements of these programmes in the form of new knowledge and expertise will be spread and developed further within the partner countries and associations by the many individuals involved.

Further information on the SRI programme:
www.sustainable-recycling.org
www.sustainable-recycling.org/e-library/publications
www.sustainable-recycling.org/wp-content/uploads/2015/06/161230_GPVersionDraft3.0.pdf

ADR compliance in the recycling of lighting equipment

Roman Eppenberger

Lighting equipment is classified as hazardous waste, and for a long time, only required an accompanying certificate for hazardous waste. Since 1 July 2015, lighting equipment has been subject to the ADR (ADR 2015). What does this now mean for the taking back of lighting equipment? In principle, the ADR does not apply to private individuals with respect to lighting equipment. Private individuals can take disused lighting equipment from their households to a point of sale or collection point without being subject to requirements.

Some things do change, however, for professional and commercial companies. The ADR regulations do not apply to all lighting equipment, but rather to "lighting equipment that contains dangerous goods". The dangerous good in the case of lighting equipment is mercury. But even this does not apply to all lighting equipment containing mercury. Provided the amount of mercury is less than one gram per piece of lighting equipment, the special provision SV 366 is applied.

SV 366 stipulates a number of conditions that must be met for this "exemption" to be valid. Each piece of lighting equipment may contain a maximum of 1 gram of mercury, each package may contain a maximum of 30 grams of mercury, and the mercury must remain enclosed within the package. In ADR jargon, this is referred to as full packaging. The packaging unit must be closed on all six sides (below, above and at the sides). If this packaging falls from a height of 1.20 metres, the contents may break, but the powder containing mercury must not escape from the packaging. The other conditions stipulated under SV 366 are met without difficulty, as a fluorescent tube contains less than 0.005 grams (5 milligrams) of mercury. And if an absolutely full post pallet without an insert contains 1,500 fluorescent tubes, we are also below the limit of 30 grams of mercury for the package.

What does the situation now look like with respect to the transportation of lighting equipment?

No change is required for special forms, provided they are transported in pallets or pallet boxes with PE inliners. The PE inliners must be attached for the transportation, which is then deemed compliant in accordance with SV 366 (see photo 1).

For rod-shaped lighting equipment, however, the situation is different, as the currently used form of transportation with shrink-wrapped post pallets does not pass the test for full packaging (see photo 2).

SENS has therefore looked around the market and found a solution that has already been used successfully in Germany for some time. The solution contains an insert in the post pallet that is subsequently shrink-wrapped after the pallet has been filled. A film that shows the installation of these inserts can be found on the SENS homepage by selecting "Information" and then "Media and downloads" (see photo 3).

These inserts will be introduced on the market at the start of 2018 on a rolling basis. The full introduction, however, will certainly still extend into 2019. Other packaging variants are also possible in principle, provided they are compliant with SV 366. Examples here include plastic and metal boxes that are already equipped with a test certificate. SENS/SLRS has opted for the solution with the inserts to ensure that the widely used application of post pallets can also be guaranteed in future.

Photos 1 to 3: The transportation of lighting equipment.

Photo 1: This is compliant.

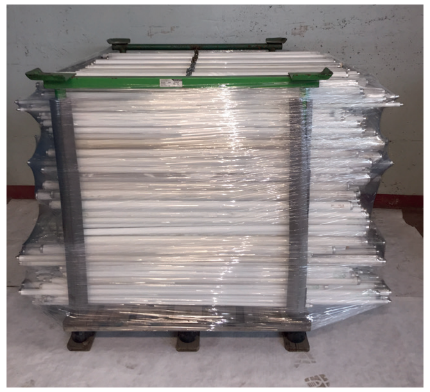


Photo 2: This delivery form is no longer compliant.

Photo 3: This delivery form is now ADR-compliant.

ADR (Wikipedia)

ADR (formally, the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)) is a 1957 United Nations treaty that governs transnational transport of hazardous materials. "ADR" is derived from the French name for the treaty: Accord européen relatif au transport international des marchandises Dangereuses par Route).

In memory of Robert Hediger,
SENS Managing Director
from 1991 to 2008

Dr nat. sc. Robert Hediger

In 1990, Robert Hediger successfully completed a stay abroad in Australia, where he worked as a researcher in the area of genetic engineering for cattle and sheep. In preforming his work, he established a leading position in this field of research. After returning to Switzerland, he learnt that the professorships available for an academic career in his area of expertise at the ETH Zurich and the University of Zurich were already occupied for a number of years. He therefore kept his eyes open for something new. I offered him the position of Managing Director of the recently founded SENS Foundation. Just a few days later, he accepted the offer and later took up his role in January 1991.

Just before this, SENS had received a mandate from the Swiss Professional Association for Electrical Appliances in Household and Industry (FEA) to develop a concept for the comprehensive disposal of refrigerators and freezers in Switzerland. During the first months of 1991, intensive work was performed on pragmatic solutions for the areas of technology, logistics and financing. In summer 1991, the results were presented to the FEA and FEA-founded IG Logistik, with SENS subsequently being entrusted with their implementation. On 1 November 1991, SENS launched the first disposal sticker for refrigerators and freezers, which consumers had to purchase in order to dispose of these appliances. The successful development of the disposal sticker equipped with a barcode, as well as the entire process flow, was the work and responsibility of Robert Hediger, who was completely absorbed in this task. He was an exceptional team player who developed an outstanding network over many years comprising individuals who were highly competent in their area and whom he could trust blindly. This allowed him to keep the Head Office small and establish a strong organisation with expert freelancers. Following the transfer of the Head Office from Aarau to Zurich, where he had worked for some time at a 50 per cent employment level for SIGA/ASS (predecessor organisation to Pusch), the relocation and establishment of the Head Office at Obstgartenstrasse followed. From the very beginning, it was very important to SENS to achieve a high level of transparency as regards material and goods flows and that our recycling partners also met this objective, which we had defined as a standard. Robert Hediger achieved this goal with the establishment of the SENS TC, which he tasked with regularly checking the recycling companies with respect to their compliance with the SENS requirements. From the outset, it was not only a matter of simply completing tables, but also ensuring that the recycling companies as a whole properly performed the work stipulated in the recycling contract.

In hindsight, the switch from the disposal sticker (as a direct disposal fee) to the advance recycling fee in 2001/2002 was one of the most challenging projects that Robert Hediger faced as SENS Managing Director, and one that he mastered with aplomb. It was not simply about developing an independent IT system (instead of taking on an existing system, converting it with a great deal of work and paying expensive fees each year), but rather about estimating how great the financial outlay would be, especially during the first six months. Robert Hediger's masterstroke here was finding the right balance and establishing the required trust with all contractual partners and stakeholders. As Managing Director of one of Europe's leading take-back systems, Robert Hediger was involved in the foundation of the WEEE Forum, where over the years he established a dream team – himself as chairman of the WEEELABEX project and myself as president – and succeeded in transferring significant parts of the Swiss standard for the recycling of electrical and electronic equipment to a European standard. SENS is greatly indebted to Robert Hediger for his work as its first Managing Director.

Dr Andreas Röthlisberger, President of the SENS Board of Trustees, Zurich, February 2018

In memory of Emil Franov
Emil Franov passed away
on 10 August 2017 at the age of 48

Emil Franov

As a graduate environmental scientist at ETH Zurich, Emil Franov began his work as an environmental consultant in 1996. He worked for five years as an environmental consultant at an international service company. From 2001, he worked at Carbotech AG in Basel as a consultant, project manager and divisional head and was also a member of the Management Board, focussing on environmental consultancy, life cycle assessments and compliance. He worked on various contracts involving annual corporate life cycle assessments and the identification of environmental key indicators in line with different internationale standards. From 2002, he was an audit expert and member of the Technical Commission at the SENS Foundation.

Thanks to his long-standing cooperation with SENS, Emil Franov gradually expanded his activities and knowledge and specialised in the recycling of large household appliances and lighting equipment. Furthermore, he was also the qualified WEEELABEX lead auditor of SENS, meaning he was very familiar with the situation in Europe. He provided important support to the sustainability communication of SENS by drafting the life cycle balance for 25 years of the SENS Foundation and communicated the abstract environmental figures with clear illustrations. He introduced the auditors Flora Conte and Silvan Rüttimann to the SENS and Swico TC and successfully provided them with support during their induction period.

Emil Franov was greatly valued by everybody in his professional environment. SENS viewed him as an expert partner and good listener who sought sustainable and pragmatic solutions. This impression was also shared by the recyclers audited by him. We remember Emil Franov as an invariably friendly, pleasant and interesting individual who showed great interest in his work. He shared his knowledge and ideas with everyone. His thoughts and approaches remain omnipresent to this day.

For Emil Franov, environmental protection was a primary concern. He was aware of the urgency of global issues and shared his knowledge in a manner that showed everybody that it is possible and feasible to take action. Emil Franov therefore lived strictly by his environmental beliefs. In everyday life, the way he lived, his choice of food or how he travelled – protecting the environment was always a consideration in the decisions he made. He was a role model and pioneer for everybody wanting to contribute to a greater level of sustainability and a motivating reference for those who until now had not dealt with environmental impacts. At the same time, Emil exhibited considerable attentiveness and empathy in his dealings with fellow human beings and radiated a joy for life. This rubbed off on his family and working environment, to which he contributed a great deal of positivity.

Emil leaves behind a large void. We are all happy and grateful that we knew him and were able to experience his energy and kind and warm manner.

Flora Conte and Roman Eppenberger

Heinz Böni

After graduating as an agricultural engineer at ETH Zurich, and a post-graduate course in domestic water supply construction and water conservation (NDS/EAWAG), Heinz Böni worked as a research associate at EAWAG Dübendorf. After holding the position of project manager at the ORL Institute of ETH Zurich and a stint at UNICEF in Nepal, Heinz Böni took up the position of Managing Director of Büro für Kies und Abfall AG in St. Gallen. After that he was a co-owner and managing director of Ecopartner GmbH St. Gallen for several years. He has been at Empa since 2001, where he is head of the CARE (Critical Materials and Resource Efficiency) group. Since 2009, he has held the position of Head of the Technical Audit Department of Swico Recycling and has been an audit expert for Swico since 2007.

Michael Gasser

Michael Gasser completed a Master's degree in environmental science at ETH Zurich. Since 2014, he has worked as a research associate in the Technology and Society Department at Empa, where he supports and manages various projects in the area of recycling. His areas of expertise include, in particular, the development and monitoring of recycling systems in Switzerland as well as in developing countries and emerging markets and the recovery of plastics. He has been part of the Technical Audit Department of SENS and Swico since 2017. He has recorded the annual material flows and audited Swico recyclers since 2018.

Flora Conte

Flora Conte completed her Master's degree in environmental science, with a major in biogeochemistry and pollutant dynamics, at ETH Zurich. She has been working in the environmental consulting department of Carbontech AG since 2013. She manages various projects in areas such as renewable energy, recycling and entrepreneurship at a national and international level. Since 2015, she has been a member of the SENS and Swico TC and an auditor for SENS and Swico dismantling companies and collection points. Flora Conte has been auditing SENS recyclers since 2016. In addition to her activities as an environmental consultant, she is also involved in setting up and managing small companies in Switzerland and abroad.

Arthur Haarman

Arthur Haarman completed a Master's degree in industrial ecology at the Delft University of Technology and Leiden University. Since 2015, he has worked as a research associate at Empa in the Technology and Society Department. His areas of expertise include the development of quantitative instruments such as material flow analyses and life cycle assessments for the optimisation of (electronic) waste management systems and the conception and evaluation of waste sampling and test campaigns. He is part of the Technical Audit Department of SENS and Swico and has audited Swico recyclers since 2017.

Roman Eppenberger

Roman Eppenberger completed his degree in electrical engineering at ETH Zurich. In tandem with his professional activities, he completed the post-graduate course Executive MBA at the University of Applied Sciences of Eastern Switzerland (FHO). He gained his first industrial experience as an engineer and project manager in the field of medical and pharmaceutical robotics. As a project manager, he moved to the Contactless Division of the company Legic (Kaba), where he was responsible for the worldwide purchasing of semiconductor products. Since 2012, Roman Eppenberger has been a member of the management board of the SENS Foundation and is the Head of the Technology & Quality Division. In this position, he coordinates the Swico/SENS Technical Commission in conjunction with Heinz Böni.

Dr Geri Hug

After studies in chemistry and a subsequent thesis at the Institute of Organic Chemistry, University of Zurich, Geri Hug was a research associate and project manager at IPSO ECO AG in Rothenburg (formerly Roos+Partner AG in Lucerne). From 1994 to 2011, he was a partner, and from 1997, managing director of IPSO ECO AG. He offers environmental consulting in 15 sectors in accordance with the EAC codes, accompanies environmental audits and prepares environmental compatibility reports in compliance with UVPV standards. Geri Hug is the Control Officer of the SENS Foundation in the field of electrical and electronic waste disposal and lead auditor for environmental management systems pursuant to ISO 14001 at SGS. He is a member of the CENELEC Working Group on the development of standards for the environmentally friendly recycling of refrigerators.

Niklaus Renner

Niklaus Renner studied environmental sciences at ETH Zurich. Since 2007, he has worked as a research associate and project manager at IPSO ECO AG in Rothenburg (formerly Roos + Partner AG in Lucerne). As part of various studies, he deals with the environmental compatibility of scrap metal and e-waste recycling. Among other things, he was involved in conducting a survey on the mercury levels of fractions of processed lamps for the SENS and SLRS Foundations. He also dedicates himself to the monitoring of environmental law, maintaining the legal compliance tool LCS and acting as an expert for legal issues relating to contaminated sites and soil protection.

Rolf Widmer

Rolf Widmer graduated in electrical engineering (MSc ETH EE) with a NADEL postgraduate qualification (MAS) from ETH Zurich. He spent several years researching at the Institute for Quantum Electronics at ETH and currently works at the Technology and Society Lab at Empa, which is the materials research institute for the ETH division. Rolf Widmer is currently managing several projects involving electronic waste management and, in this context, is dealing with closed material circuits for electro-mobility. His is particularly interested in the extraction of rare metals which are increasingly being accumulated in "urban mines".

Daniel Savi

After graduating as an environmental scientist from ETH Zurich, Daniel Savi joined SENS as Head of Collection Centres and Head of Quality Assurance. He held these positions for seven years before joining Büro für Umweltchemie GmbH as a research associate, where he focuses on the health hazards and environmental effects associated with construction work and waste recovery. He has been a partner and managing director of the company since 2015.

Patrick Wäger

After studying chemistry at ETH Zurich and a subsequent thesis at the ETH Institute for Toxicology and Zurich University, Patrick Wäger was for two years an environmental consultant at Elektrowatt Ingenieurunternehmung, Zurich. Since then, he has been a research associate and project manager at Empa, collaborating on numerous research projects on waste disposal and recovering materials from end-of-life products. He is a technical auditor for Swico and was temporarily lead auditor for environmental management systems according to ISO 14001. Patrick Wäger has various lecturing assignments in environment and resource management and, among other things, is a member of the management board of Swiss academic society for environmental research and ecology (SAGUF). Most recently, he has headed the Technology and Society Department since 2016.

13 Links

International links

www.weee-forum.org
The WEEE Forum (Forum for Waste Electrical and Electronic Equipment) is the European association of 41 systems for collecting and recycling electrical and electronic waste.

www.step-initiative.org
Solving the E-waste Problem (StEP) is an international initiative under the auspices of the United Nations University (UNU), which not only includes key players involving the manufacturing, reuse and recycling of electrical and electronic equipment, but also government and international organisations. Three additional UN organisations are members of the initiative.

www.basel.int
The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, dated 22 March 1989, is also known as the Basel Convention.

www.weee-europe.com
WEEE Europe AG is an amalgamation of 15 European take-back systems and since January 2015 has allowed manufacturers and other market players to fulfil their various national obligations from a single source.

National links

www.eRecycling.ch
www.swicorecycling.ch
www.slrs.ch

www.swissrecycling.ch
As the umbrella organisation, Swiss Recycling promotes the interests of recycling organisations operating in the separate collection sector in Switzerland.

www.empa.ch
The Swiss Federal Laboratories for Materials Testing and Research (Empa) is a Swiss research institute for applied materials science and technology.

www.bafu.admin.ch
In the "Waste" section of its website, the Swiss Federal Office for the Environment (FOEN) provides a range of further information and news on the topic of recycling electrical and electronic equipment.

Cantons with devolved powers

www.awel.zh.ch
On the website of the Office of Waste, Water, Energy and Air (WWEA), the "Waste, raw materials and contaminated areas" section provides a raft of information of direct relevance to the recycling of electrical and electronic equipment.

www.ag.ch/bvu
On the website of the Department for Construction, Traffic and Environment of the Canton of Aargau, the "Environment, nature and agriculture" section provides further information on the topics of recycling and reusing raw materials.

www.umwelt.tg.ch
On the website of the Office for the Environment of the Canton of Thurgau, the "Waste" section provides relevant regional information about the recycling of electrical and electronic equipment.

www.afu.sg.ch
The website of the Office for Environment and Energy St. Gallen contains general information, notices on individual issues and information on current topics, which can be found under "Environmental information" and "Environmental facts".

www.ar.ch/afu
The website of the Office for Environment Appenzell Ausserrhoden contains general information and publications on individual issues and all matters involving the environment.

www.interkantlab.ch
The website of the Intercantonal Laboratory of the Canton of Schaffhausen offers a wide range of information on recycling electrical and electronic equipment, which can be found under "Information on specific types of waste".

www.umwelt.bl.ch
The website of the Office for Environment Appenzell Ausserrhoden contains general information and publications on individual issues and all matters involving the environment.

www.zg.ch/afu
The website of the Office for Environmental Protection of the Canton of Zug contains general information and notices on the topic of waste, which can be found under "Waste management" Detailed information on the collection of individual recyclable materials is available from the Association of Local Authorities of the Canton of Zug for Waste Disposal Administration (ZEBA) at www.zebazug.ch.

14 Contact and legal information

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