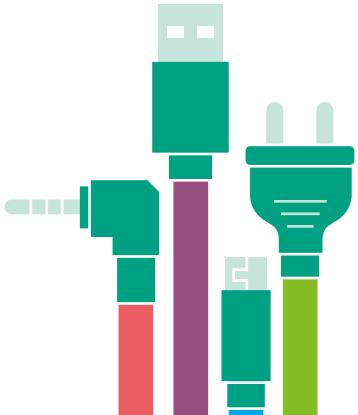
TECHNICAL REPORT 2022



SENS
Swico

Technical Report
2022

Impetus towards the circular economy

Spring is in the air! After two challenging years marked by uncertainty and occasional stagnation, the Swiss recycling industry can look to the future with confidence and optimism. Important decisions at the political level and restructuring within the industry provide fresh impetus and welcome momentum.

It was long in coming, but it arrived last autumn: the Federal Council's decision on the Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE). The approval of the technical revision of the ordinance helps further to boost the recycling of old appliances and to close the resource cycle even more efficiently.

Particularly worth mentioning is the extension of the scope of application and the specification of the appliance catalogue as well as the related alignment with the EU list of appliances.

We followed, and actively participated in, the discussions around the parliamentary initiative to amend the Environmental Protection Act with great interest. The envisaged amendment of the law offers a great opportunity to create up-to-date framework conditions for a modern, environmentally friendly circular economy in Switzerland, to reinforce proven industry agreements and, at the same time, to create a legal basis for the financing of disposal solutions for WEEE.
Our own sector does not sit idle either. SENS eRecyling and SLRS have decided to join forces. The two organisations have been working together successfully for over 15 years. However, in order to ensure the survival of private-sector take-back systems in the future, structures and processes will have to be simplified. It is also against this backdrop that the two foundations have decided not only to cooperate, but to merge.

Reliable political support, great solidarity within the sector and an undiminished high level of acceptance among the population: the conditions are well in place to meet the increasingly dynamic developments in the field of eRecycling with innovative ideas and to successfully master the resulting challenges – and, thus, to move more vigorously towards a true circular economy.

Judith Bellaiche
Swico

Pasqual Zopp
SENS

Swico, SENS and the SLRS
Competent and sustainable

For more than 20 years, the three take-back systems of Swico, SENS and the Swiss Lighting Recycling Foundation (SLRS) have been guaranteeing the resource-efficient return and reuse and proper disposal of electrical and electronic appliances.

In view of the ongoing revision of the Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE), SLRS and SENS have decided to step up their already close partnership.

With retroactive effect from 1 January 2021, the two foundations have merged and joined forces to form a joint network. SENS has taken over all cooperative ventures of SLRS and continues to manage them according to the agreements with the cooperation partners. The simplification of structures and processes associated with the merger yields many advantages. This created a single point of contact for customers and service partners across all sectors. This is an important prerequisite for a private-sector take-back system in order to optimally procure the funds required for the fulfilment of its purpose as well as to use them efficiently and effectively in the future as well.

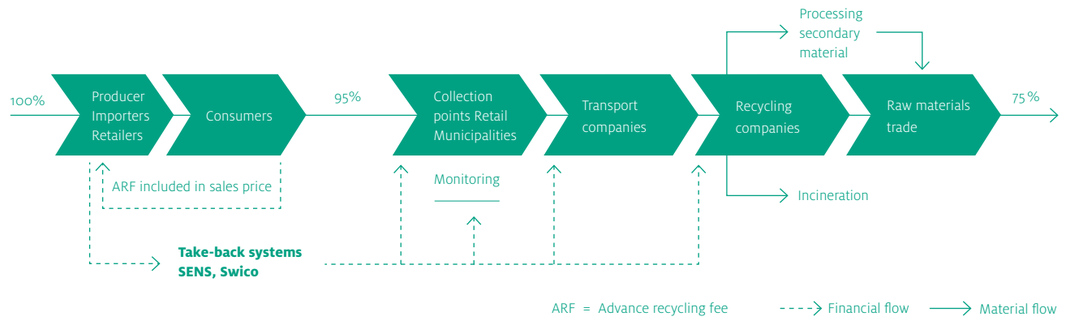
There are historical reasons for the division into formerly three and now two take-back systems, as sector-specific systems were established in the early years of institutionalised recycling. The aim of these was to guarantee proximity to the relevant sector in order to respond to its specific requirements. 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 appliance in question, Swico or SENS is now responsible for take-back systems. In 2021, the two systems disposed of around 127,100 tonnes of old electrical and electronic appliances. This means that Swico and SENS have made a significant contribution to reintroducing valuable resources into the production cycle. With the international networking of the organisations at a European level – for example as members of the Forum for Waste Electrical and Electronic Equipment (WEEE Forum) – they also help to set cross-border standards for the recycling of electrical and electronic appliances.

The ORDEE obliges retailers, manufacturers and importers to take back – free of charge – appliances they stock in their product range. In order to be able to finance sustainable and environmentally responsible recycling of electrical and electronic appliances competitively, an advance recycling fee (ARF) is included in the sale price for these appliances. The ARF is an efficient financing instrument which guarantees that Swico and SENS 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 foundation 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, toys and photovoltaics. Since January 2021, it has also taken over the organisation of the comprehensive disposal of lighting equipment and lamps, which was previously handled by SLRS. 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 appliances. Swico Recycling aims to extract raw materials and dispose of pollutants in an environmentally friendly way. The focus of Swico is on appliances 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 Science and Technology (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.

Figure 1: Overview of the take-back systems.



Technical Commission of
Swico and SENS: ORDEE, power supply units and lithium-ion batteries

Heinz Böni and Roman Eppenberger

The second year of the COVID-19 pandemic was also a mix of keeping one's distance and meeting in person again for the joint Technical Commission of Swico and SENS. The commission met virtually three times. In autumn, a training session on the handling of lithium batteries and a physical meeting of the entire commission were held.

With regard to the eagerly awaited amended Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE), 2021 was the year of major revelations. For a long time it was unclear what the auditing of recycling companies would look like in the future after the new law came into force. An auditing system that had been in place for 25 years and had had a decisive influence on developments at the European level, but also in individual developing countries (see separate article). The draft for consultation of May 2020 provided for state-regulated financing of collection, transport and treatment as well as centralised audits. Against this background, the Technical Commission had postponed some planned activities, including the development of a new material flow analysis system, but also the further development of various audit documents. In autumn 2021, the cloak of secrecy was finally lifted, and the new text of the ordinance was revealed. Fortunately, there will not be any changes to the system. The Swico and SENS eRecycling take-back systems continue to be responsible for monitoring the recycling companies commissioned by the systems and their partners.

Power supply units as potential sources of hazardous substances

In terms of content, the focus of the activities of the Swico and SENS Technical Commission was on power supply units and lithium-ion batteries (LIBs). The capacitor study completed in 2019 had shown, among other things, that power supply units (e.g. of laptops) represented a significant source of electrolytic capacitors larger than 25 millimetres. So far, this fact has received little attention. Power supply units are usually resold by recycling companies as commodities. Buyers then process them further. The condition in which the capacitors emerge from the recycling processes and whether this ensures the removal of hazardous substances in accordance with the requirements of the SN EN 50625 series of standards has thus largely gone unanswered until now. In the past year, the follow-up treatment of the power supply units was therefore clarified with all recycling companies. For this purpose, special batch tests (manual and mechanical) were carried out to show whether the capacitors can be separated via eddy current separation in a distinguishable and controllable process and what the degree of damage is.

Photo 1: Participants of further training (from left to right) Manuele Capelli, Daniel Savi, Roman Eppenberger, Flora Conte, Roger Gnos, Anahide Bondolfi, Heinz Böni, Niklaus Renner, Stephanie Conrad.

Photo 2: Phase 1 – The "thermal runaway" (chain reaction in the battery) due to the short circuit of individual cells.

Dangers in handling lithium batteries

As LIBs represent an enormous fire risk along the entire recycling chain, a special training course was organised in autumn headed by Viktor Häfeli. At the Swissfire Center in Zofingen, the participants not only learned a great deal of theory, but were also given an impressive demonstration of what happens when individual cells of a battery short-circuit. The topics covered included fire prevention measures and safeguards, and the requirements for the correct handling of this type of battery during collection, transport and recycling.

There have also been two changes in the auditors: Charles Marmy left the Swico auditing team in mid-2021. He was replaced by Manuele Capelli, who was introduced to auditing in 2021 and will work as an auditor starting in 2022. Thekla Scherer joined SENS from IPSO ECO AG. She, too, will commence auditing in 2022. The auditing team currently has nine auditors: Anahide Bondolfi, Andreas Bill, Heinz Böni, Manuele Capelli, Stephanie Conrad, Flora Conte, Niklaus Renner, Daniel Savi and Thekla Scherer.

Photo 3: Phase 2 – The battery is on full fire and generates an enormous heat wave.

Photo 4: Phase 3 – The residues after completion of the fire test.

Constant collection quantities
and slight change in composition

Flora Conte and Fabian Elsener

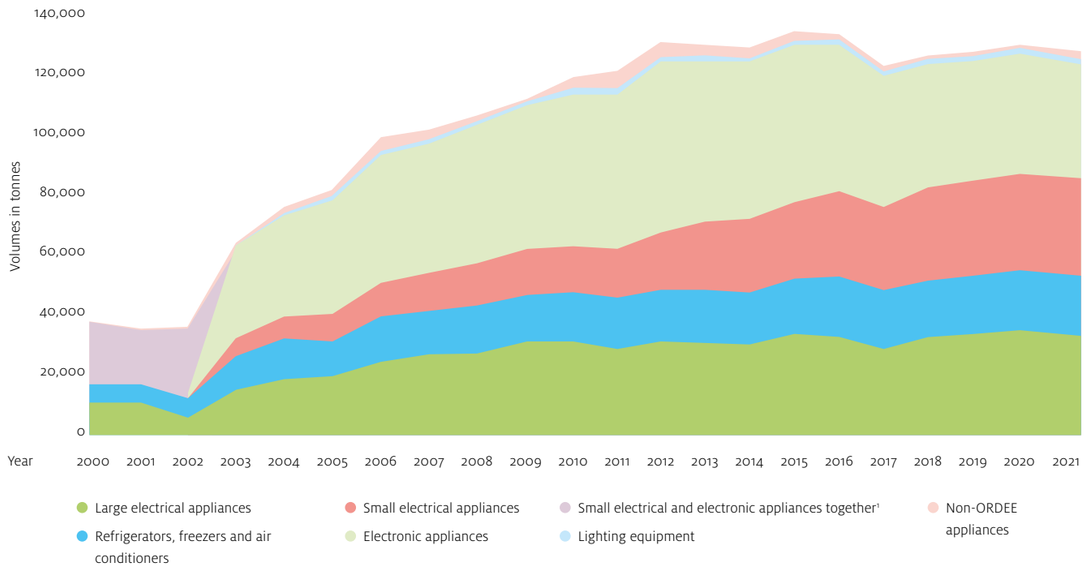
The quantities of waste electrical and electronic equipment processed are still in line with the long-term average, but are decreasing slightly. The composition according to individual categories changes further. The quantities of large electrical appliances and electronic appliances fell, which was partly compensated by higher quantities of small electrical appliances.

In 2021, the Swico and SENS recycling companies processed around 127,100 tonnes of waste electrical and electronic equipment (WEEE). Relative to the previous year, this represents a slight reduction. However, the quantities are still in line with the long-term average (table 1 and figure 1). But the long-term changes in the various categories continue. The quantities of compressor appliances (refrigerators, freezers and air conditioners) and lighting equipment remain constant. The volume of electronic appliances (–9 %) continues to decrease in line with the long-term trend. This was in part due to the decline in heavy cathode ray tubes (CRT) from computer monitors and televisions. Following a change to the recording methodology in 2017, a decrease (–5 %) in the volume of large electrical appliances is observed for the first time. This could be due to the fact that the average weight of certain large appliances is declining: more plastics, fewer metals. As in the previous year, a further increase can be observed in small electrical appliances (+5 %). The largest amount of photovoltaics has been processed since the beginning of processing in 2021. This could be due, among other things, to extensive hail damage. The quantities of non-ORDEE appliances that are not included in the lists of the Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE) almost doubled compared to the previous year.

Table 1: Total processed electrical and electronic appliances 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 per 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
2018	34,200	19,900	27,600	41,900	1,100	300	1,000	125,900
2019	35,800	19,900	28,700	41,000	1,000	300	1,000	127,600
2020	37,100	20,100	29,800	40,600	1,000	200	1,000	129,800
2021	35,300	20,200	31,300	36,900	1,000	500	1,900	127,100
Change relative to previous year	**–5 %**	**0 %**	**5 %**	**–9 %**	**0 %**	**150 %**	**90 %**	**–2 %**

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



Materials recycling

Of the WEEE processed, the recyclables and hazardous substances are obtained through manual and automatic processing (figure 2). The largest fraction of recyclable material is metals, at 60 per cent. Plastics-metal mixtures (20 %) and plastics (8 %) were the two next-largest fractions. The proportion of glass from CRTs processing declined by a further 10 per cent relative to the previous year, and now only makes up 0.7 per cent. The especially valuable circuit boards account for only 1.2 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 recyclable material fractions from SENS and Swico recycling companies are sent for further processing. This is where they are recycled or utilised thermally. SENS and Swico recycling companies must provide material flow evidence for further processing that describes the subsequent treatment of these fractions. Certain downstream buyers are audited by the auditors of the SENS/Swico TC. Ferrous metals generally undergo final processing 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 thermal recycling, although this share has fallen significantly in recent years thanks to new processing options, such as for toner cartridges, and sorting plants for plastics-metal mixtures. Special recovery methods, often performed abroad, 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.

Removal of hazardous substances

The proportion of hazardous substances accounts for around 1 per cent of the total volume (figure 2). Besides re-introducing recyclable materials into the material cycle, the removal of hazardous substances is one of the main tasks of Swiss recycling companies. The hazardous substances are either removed by hand in disassembly facilities or separated mechanically using specialised processes. For example, capacitors are removed from large household appliances or ballast units, and batteries are removed from electronic appliances. The removal of hazardous substances and the handling of these hazardous substances have to be constantly adapted to changing technologies and the latest state of the art. For example, it is now possible to remove mercury-containing background lighting from flat screens mechanically. However, companies must continue to be able to remove and dispose of hazardous substances from older generations of appliances properly as well. 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 volumes and the composition of electronic appliances. To this end, Swico Recycling performs market basket analyses and processing tests of product groups (table 2). In 2021, Swico Recycling took back 43,200 tonnes[1] of electronic appliances, 8 per cent less than in the previous year. As a result of the COVID-19 pandemic, fewer large-scale copiers were disposed of, which explains almost half of the decline. The weights and quantities of CRT monitors and televisions taken back are continuing to fall in line with the long-term trend. The quantity of flat-screen monitors taken back fell by 10 per cent compared to the previous year, with the quantity of flat-screen TVs taken back remaining roughly the same. In addition, the volume of PCs, laptops, printers, photocopiers and other IT appliances processed decreased, which can be attributed to a decline in quantities. The quantity of mobile phones continues to rise, which corresponds to an increase in the amount processed while the weight remains the same. In the consumer electronics category, both the average weight and the quantity remained relatively constant.

The composition of the individual appliance categories is determined by means of processing tests carried out by Swico recycling companies. In this process, a previously defined number of appliances is collected and the resulting fractions are documented. The detailed volumes of electronic appliances taken back and their composition are shown in table 2.

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[1] This number is larger than the 36,900 tonnes of electronic appliances in table 1, since this also includes appliances which A-signatories have disposed of via direct contracts.

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[2] FPD: flat-screen displays, different technologies (LCD, plasma, OLED, etc.).
[3] IT equipment, mixed, without monitors, PCs/servers, laptops, printers, large-scale copiers and appliances.
[4] Consumer electronics, mixed, not including televisions.
[5] Projection.
[6] Packaging and other waste, toner cartridges.
[7] This number is larger than the 36,900 tonnes of electronic appliances in table 1, since this also includes appliances which A-signatories have disposed of via direct contracts.

Source: Fabian Elsener, Carbotech, based on Swico processing and market basket analyses (2021)

Figure 2: Composition of the fractions generated in per cent in 2021 Hazardous substances, which make up a total of just 1 per cent of the fractions generated, are shown separately.

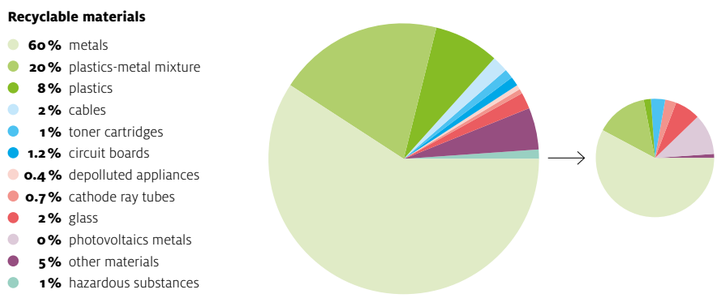


Table 2: Swico volumes collected and composition by type of appliance.

Appliance type	Quantity[4] (in thousands)	Average weight (in kilograms)	Metals (in tonnes)	Plastics (in tonnes)	Plastics-metal mixtures (in tonnes)	Cables (in tonnes)	Glass and/or LCD modules (in tonnes)	Circuit boards (in tonnes)	Hazardous substances (in tonnes)	Other[6] (in tonnes)	Total (in tonnes)	Increase/decrease compared to 2020
PC monitor, CRT	9	17.6	24	33	15	4	72	15	0	1	164	−23 %
PC monitor, FPD[2]	558	6.9	1,509	1,217	73	47	601	272	35	95	3,850	−10 %
PCs/servers	328	11.5	3,101	219	10	116	–	314	12	–	3,772	−12 %
Laptops	460	2.4	325	322	113	6	97	160	76	5	1,103	−8 %
Printers	441	11.4	1,781	2,705	309	27	34	88	2	81	5,027	−5 %
Large-scale copiers/appliances	38	125.1	2,587	178	1,699	86	3	38	41	122	4,754	−23 %
IT, mixed[3]	822	2.6	1,162	77	769	38	1	16	18	54	2,136	−16 %
CRT TVs	42	25.7	106	221	36	4	698	13	1	1	1,079	−24 %
FPD TVs[2]	357	23.9	4,123	1,545	899	117	748	717	95	298	8,532	2 %
CE mixed[4]	3,596	2.9	5,629	379	3,788	191	5	82	91	265	10,428	−0 %
Mobile phones	989	0.2	25	53	–	–	8	33	30	–	148	9 %
Remaining phones	1,121	1.8	1,098	72	726	36	1	16	17	51	2017	−9 %
Photo/video	227	0.7	87	6	58	3	–	1	1	4	159	−2 %
Dental	–	–	–	–	–	–	–	–	–	–	65	7 %
Total in tonnes	**–**	**–**	**21,561**	**7,015**	**8,497**	**675**	**2,268**	**1,766**	**419**	**975**	**43,235**[7]	**−8 %**
Total in per cent	**–**	**–**	**50 %**	**16 %**	**20 %**	**2 %**	**5 %**	**4 %**	**1 %**	**2 %**	**100 %**	**–**

Recycling of refrigerators
in households and industry: performance requirements driven by sustainability considerations

Niklaus Renner and Thekla Scherer

Although the share of old R11/R12/R134a appliances continues to dwindle, it is still enormously important not to compromise on the high standards required of recycling processes until the last conventional refrigerators have been stripped of their climate-damaging substances and these have been destroyed in a controlled manner. The high-tech facilities will remain indispensable for air-quality reasons. Major changes are currently taking place at Swiss facilities: two new plants will go into operation between autumn 2022 and spring 2023.

In 2021, Swiss refrigerator recyclers treated just over 370,000 units of temperature exchange equipment at both processing stages and another 55,000 at the first stage only. The gap between the recycled, more climate-friendly VHC1 appliances and the old VFC2 appliances is widening, as expected.

More VHC appliances in the input …

Whereas in 2013 the shares of the two refrigerant types were still exactly balanced, in 2021, among the old appliances treated at stage 1, those whose compressors were operated with the more climate-friendly hydrocarbons (VHC) already account for 72 per cent (+6 per cent compared to the previous year). The current share of appliances whose PU insulation was foamed with VHC is as high as 78 per cent (+3 per cent). The turnaround already occurred here in 2011, i.e. two years earlier, as no transition substances, such as HCFCs, were available for refrigerants. The share of ammonia-containing absorption systems has remained virtually unchanged at 2 per cent for a few years now (see figure 1).

… means lower quantities in the output

The decline in VFC appliances on the input side is still 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 compressor filling weights and/or VHC concentrations in PU insulation; and
2) the lower specific weights of isobutane and/or cyclopentane relative to conventional VFC.

Currently, the following recovery rates are achieved over the year for temperature exchange equipment treated at both stages (see figure 2):

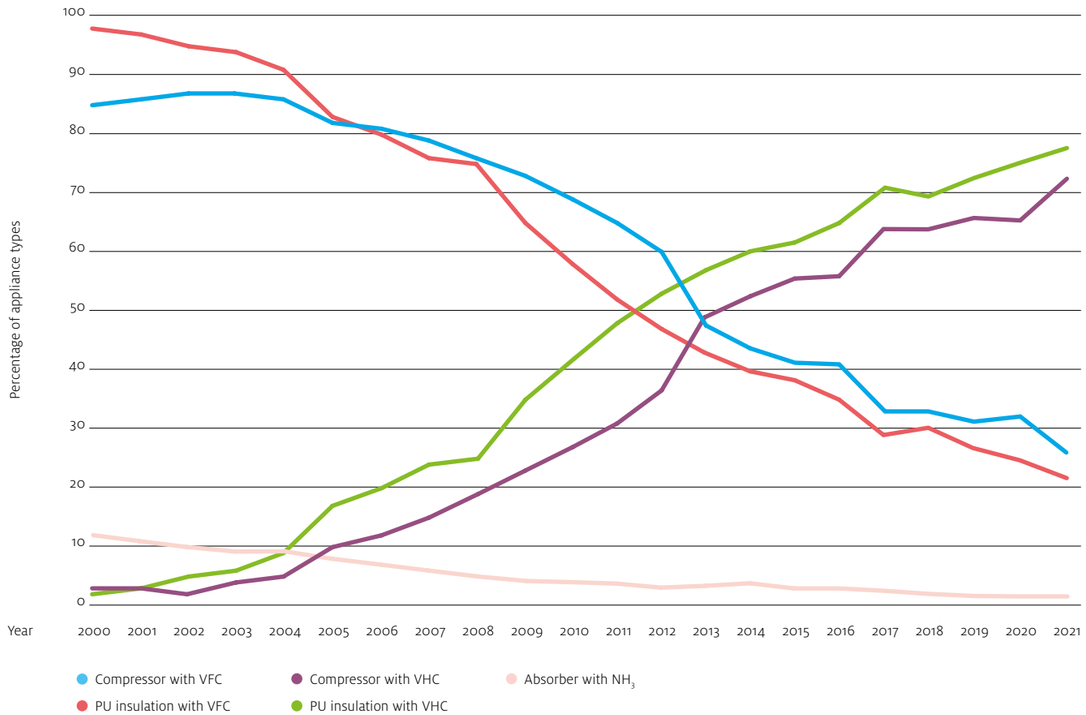
- Refrigerant: 61 grams per appliance (–3 %)
- Compressor oil: 124 grams per appliance (–10 %)
- Propellant: 35 grams per PU foam kilogram (–6 %)

Why is it necessary to recover the gases from VHC appliances in a controlled manner as well?

It is true that those appliances that contain VHC in the compressor and/or the PU insulation are a more climate-friendly type of appliance. While the VFC compounds of the older appliances are harmful to the ozone layer (with ozone depletion potential – ODP) and also have a high greenhouse potential (global warming potential – GWP up to 10,000 times higher than that of CO_2), VHC appliances are nothing short of a blessing for the climate. Nevertheless, it must not be forgotten that they must also be treated via the processes of the refrigerator recycling plants, which are optimised in what is known as “mixed mode”, since an uncontrolled release of the VHC leads to the formation of ground-level ozone and thus endangers human health.

[1] VHC: volatile hydrocarbons (e.g. isobutane R-600a or cyclopentane); VFC: volatile fluorocarbons (e.g. R-11, R-12, R-134a, etc.).

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).



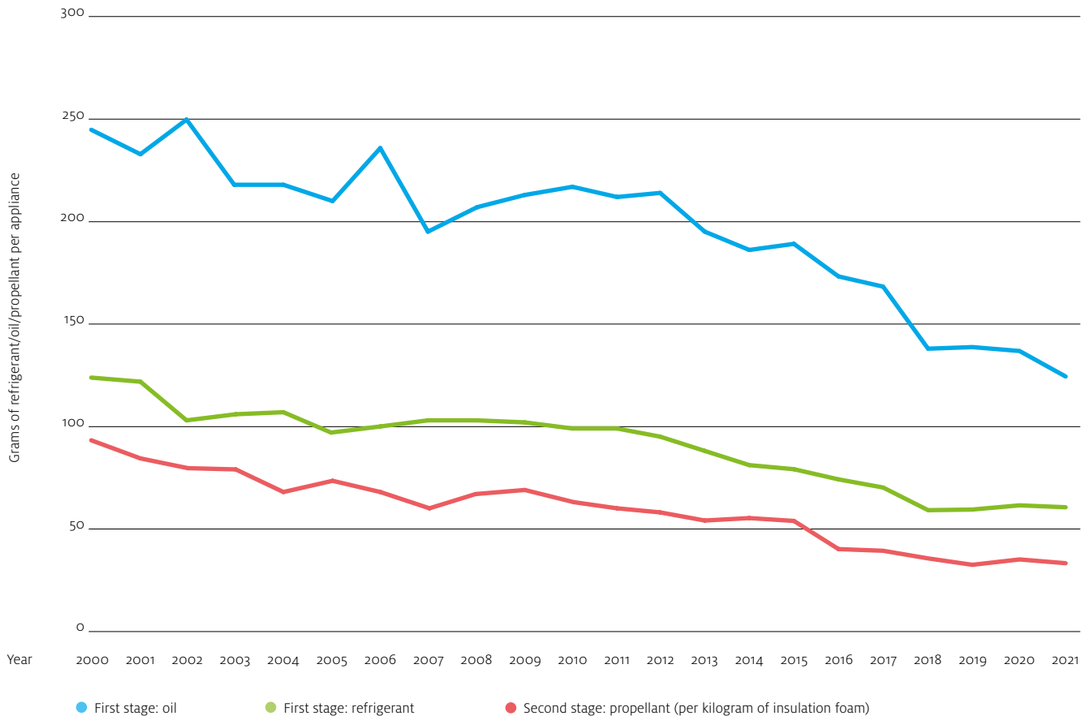
Stage 1 appliances continue to gain ground

Large household appliances that have a heat pump (e.g. recent energy-efficient tumble dryers, but also conventional dehumidifiers and mobile air conditioners) also belong to the category of temperature exchange equipment. They contain refrigerants that have to be extracted, as in the case of refrigerators, before the (non-PU foamed) casings can be shredded in a “regular” shredder (large shredder, cross-flow shredder, ripper, hammer mill, etc.). Such stage 1 appliances are increasingly being returned. As such, 55,000 units were extracted in 2021, representing 12 per cent of all appliances treated at stage 1.

High demands on system performance

The performance of the refrigerator recycling plants is assessed on the basis of biennial performance tests under defined conditions. Both the requirements for the procedure and the minimum results to be achieved as well as the calculation and evaluation methods are based on the standard SN EN 50625-2-3 and the technical specification TS 50625-3-4.

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).



The following hurdles have to be overcome at stage 1 (100-appliance test):
- The refrigerant must be separated from the compressor oil.
- The amount of refrigerant extracted must be at least 90 per cent of the expected amount.
- The halogen content in the extracted compressor oil must be under 0.2 per cent.
- The maximum amount of oil remaining in the compressor directly after the extraction process must not exceed 15 grams per compressor.

The following criteria are assessed in the stage 2 performance test (1,000 appliances):
- The amount of propellant recovered must be at least 90 per cent of the expected amount. In the process, an input-based and an output-based evaluation method validate each other.
- The PU residues in metal fractions must not exceed 0.3 per cent each.
- The PU residues in the plastics fraction must not exceed 0.5 per cent.

Photo 1: Temperature exchange equipment ready for processing.

- The residual propellant content in the PU fraction must be less than 0.2 per cent.

These requirements can only be met if the plants are in technically perfect condition and the process-air treatment units are maintained regularly.

Ensuring a continuously high level of environmental benefit

The declared purpose of refrigerator recycling is to recover the highest possible proportion of ozone-depleting and greenhouse-active substances and, then, to destroy them in a controlled manner. Despite the unstoppable trend towards ozone-layer-friendly and only marginally greenhouse-relevant appliances, there is no reason to relax the strict SENS requirements: in future, too, it will be extremely important to maintain a high level of recycling quality until the last conventional refrigerators have passed through the high-tech recycling process. Afterwards, industrially dimensioned refrigerator recycling plants will by no means become obsolete, as only they can meet the limit values of the Air Pollution Control Ordinance due to their encapsulated shredder and complex process air treatment systems.

Changes in Swiss facilities

In this respect, the Swiss plants for dismantling refrigerators are currently undergoing significant changes. Thommen Group will start operating its new plant at the Aarwangen site as early as autumn 2022 (Immark Ltd Aarwangen). E. Flückiger AG is also planning to commission a new plant at the Rothrist site in spring 2023. This means that there will be sufficient state-of-the-art capacities available in Swiss refrigerator recycling in future as well. We will provide more details on the status of the new facilities in the next technical report.

Electro Bag: pilot project in Geneva
for the home collection of domestic appliances to be recycled or reused

Anahide Bondolfi and Sabrina Bjöörn

Between January and April 2022, Geneva's citizens will be able to have their old domestic appliances picked up at home. Two destinations are proposed, recycling and reuse. This project is jointly managed by SENS and the Post Office with the support of the Services industriels de Genève (SIG) éco21 programme for reuse.

Photo 1: Electro Bag for easy recycling of electrical and electronic appliances.

Pilot projects in Bern, Zurich and, now, Geneva

In 2019 and 2020, SENS conducted two domestic appliance home collection pilot projects in Bern and Zurich. Following the success of these two first projects with 7,000 Electro Bags and more than 9,000 kg of domestic appliances collected, SENS decided to extend the idea. Collection in Geneva began in January 2022 with a few sacks already obtained in the first month. As for the first pilot programmes, the citizens of Geneva reached by the scheme can order a free collection bag to fill with their old appliances and leave near their letter boxes to be collected by postal service on their usual mail delivery round.

First novelty: the reuse supply chain

For the first time, two options are made available: recycling by the usual SENS chain as previously or reuse for still functional appliances. In the latter case, the sacks collected from users are labelled with a ReUse sticker and then sent to be reused by Établissements publics pour l'intégration (EPI), a social institution based in Geneva. These appliances are then sorted, tested and refurbished. All the reusable appliances are then resold at an advantageous price by Geneva second-hand businesses or entrusted to associations with a social purpose, in order to give them a new life. These different steps that allow reuse are framed by a partnership agreement signed between SIG and EPI, in order to ensure compliance with good reuse practices.

Second novelty: reusable bags

The Geneva pilot project also brings another novelty in terms of sustainability: the new collection bags, supplied by Kickbag, are collapsible recycled PET sacks that can be reused up to 30 times, thus with lower environmental impact than single-use bags not from recycled material.

Supporting the circular economy

With the option of reuse when relevant and not only recycling, this project aims to support the circular economy by offering some appliances a second life in a very local context. This project is also an opportunity to collect data on the proportion of truly reusable appliances, in order to provide food for thought to better integrate this option in the future. This pilot supports the creation of reuse sectors, which will be able to continue beyond its own scope by allowing reuse actors to test, set up and strengthen partnerships for the re-marketing of these second-hand appliances.

The circular economy within SIG éco21

The SIG éco21 waste and circular economy programme, launched in 2019 under the mandate of the government of Geneva, aims to help reduce the amount of waste produced in the canton of Geneva. Among the priorities are waste electrical and electronic equipment. SIG éco21 has notably launched a project to support the redistribution of electrical and electronic appliances, encouraging their reuse, repair and sharing. Among the measures implemented, SIG éco21 supports those involved in reuse by offering them a partnership formalised by a standard agreement. This agreement provides a framework for appliance redistribution action laying the best practice foundations for the field: compliance with legal requirements in terms of recycling, data erasure and cleaning, information for the customer on practices to extend the life of appliances, traceability, etc. SIG éco21 partners are trained in the implementation of these requirements. In addition, they can receive a financial incentive for each second-hand appliance put back on the market (second-hand sale or donation), repaired or shared (rental or loan) in Geneva. This framework agreement and its associated requirements also intend to reinforce credibility.

Revision of the CENELEC standard
EN50625

Daniel Savi

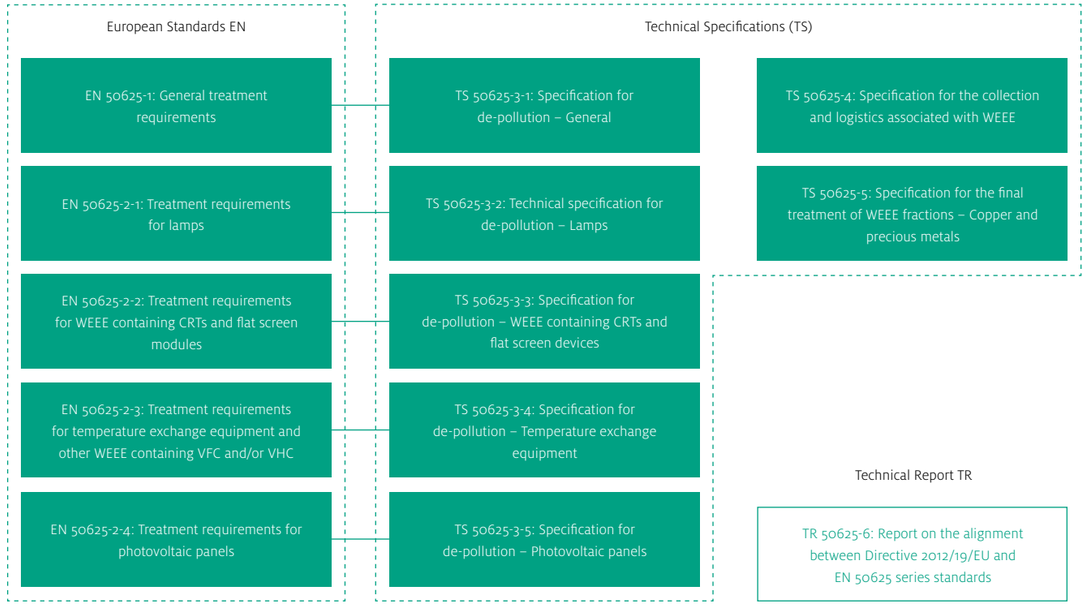
Last year, the CENELEC Working Group dealt intensively with the revision requirements of the EN 50625 series of recycling standards. The result is fully in line with the Swiss take-back systems: the standards remain stable and their period of validity is extended.

For five years now, the CENELEC standards of the EN 50625 series have formed the basis for the recycling of Swico appliances in Switzerland. The standard was introduced for SENS appliances three years ago. Standards are valid for five years, technical specifications for three years. Consequently, the Working Group on the EN 50625 series of standards was already faced with the question of whether the standards should be revised. For the Swiss systems, it was clear from the beginning that the standards should remain stable and that they should not be adjusted at this time. There are already supplementary technical regulations on EN 50625 issued by SENS and Swico. These are tailored to Swiss requirements and allow questions of interpretation to be clarified.

The CENELEC Working Group collected and discussed all amendment requests of the member countries in a detailed process. Following consultations, the Working Group submitted a request to the relevant CENELEC Technical Commission for the extension of all standards in the series. This proposal was also submitted to the standards committees of the CENELEC member countries for a vote.

The vote then clearly showed that the EN 50625 standards are considered to be readily applicable and up to date. Nine countries voted in favour of the extension, two abstained and one country committee opposed the extension. As a result, the documents of the standards series will be valid until at least 2025.

Figure 1: Collection, logistics and treatment of waste electrical and electronic equipment.



Tracking down PCBs: handling ballast units

Flora Conte

While only very few PCBs are measured in the processing of large appliances, RESH analyses of small appliances have regularly shown high PCB loads for years. The SENS and Swico Technical Commission is, therefore, examining various hypotheses about the origin of the hazardous substances that have been banned for decades. The most important clue currently leads to the capacitors in ballast units in lamps. These are difficult to detect.

The use of PCBs in old electrical appliances has been banned since 1986. However, especially in the processing of small appliances, unexpectedly high PCB loads have been measured in the RESH and in plastic fractions in recent years. A prime suspect is the PCB-containing capacitor in ballast units in lamps. A single forgotten capacitor containing PCBs exceeds the limits and reference values. At the same time, it is not easy to find and sometimes difficult to remove. This article is therefore intended to show what is particularly important when dealing with ballast units so that as many PCB-containing capacitors as possible are discovered in ballast units and disposed of properly.

A not-so-trivial finding

Ballast units come in as many different sizes and shapes as the lamps in which they are installed (see photo 1). There is not always a suspect capacitor in every ballast unit. But if one is present, the probability that it actually contains PCBs is greater than 50 per cent.[1] In view of the high toxicity and persistence of PCBs, it is therefore important to always play it safe when sorting.

So far, there is no conclusive list of criteria that can clearly show which ballast units contain capacitors suspected of containing PCBs. But various characteristics can help to sort out the suspects.

There are different types of ballast units:

- Magnetic ballast units composed of a capacitive part with a capacitor and one or more inductive parts. Inductive parts usually contain a copper coil and iron core and are heavier than the capacitive part. Some ballast units are purely inductive and therefore not suspect. Often there is an electrical diagram on the appliance showing the capacitor, see photo 2. Very old, rusted magnetic ballast units are particularly suspect.
- Electronic ballast units: These do not include PCB-containing capacitors. They are found in more recent lamps. They are lighter in weight than magnetic ballast units. Frequently, they are brighter or white. The housing may be made of plastic, see photo 3.

Capacitors from magnetic ballast units are not always visible at first glance. They are either:

- without housing and freely accessible, i.e. easy to detect and remove;
- covered, but easily accessible, thus easy to remove as soon as detected;
- welded into the housing, thus difficult to detect and remove. Sometimes a round shape indicates the capacitor; looking at both ends helps.

Given these differences, it is particularly important that

Photo 1: In this square lamp, the ballast unit consists of three inductive parts and a capacitor.

Photo 2: Two suspect ballast units found in a container with non-suspect ballast units during quality assurance. The electrical diagram on the right ballast unit points to the capacitor (capacitive part) with a symbol and the description “Kap”.

Photo 3: Electronic ballast unit (not suspected of containing PCBs).

[1] Daniel Savi, Ueli Kasser, Rolf Widmer (2019) Liquids in capacitors: Determining liquids in electrical capacitors, including the definition and classification of substances of concern.

collection points, disassembly facilities and recycling companies do the following:

a) conduct regular training;
b) assign experienced staff to the sorting of ballast units; and
c) have a clear, cross-site overview of where the material flows of ballast units lead to and where the necessary quality assurance happens.

Systematic approach

As the detection of ballast units is often fraught with errors despite experienced personnel, the SENS Technical Commission recommends the following steps:

1. Separate all lamps from small appliances.
2. Remove all ballast units from lamps (electronic ballast units, in case of magnetic ballast units, both capacitive and inductive parts) and collect them in a separate container (see photo 4).
3. Separate ballast units into suspected or not suspected of containing PCBs.
4. Remove capacitors from the suspected ballast units. Careful handling of the capacitors and appropriate protective equipment are important. Where the capacitors are very difficult to remove, it is recommended that they be disposed of together with the other capacitors including the housing.
5. Declare capacitors and suspicious welded-in ballast units as special waste and dispose of them in high-temperature incineration (transport is subject to ADR for PCBs above 50 ppm).
6. Always have a trained person inspect stripped lamps, non-suspect ballast units or copper-containing fractions from stripped ballast units for defects before processing or reselling. Confusion, for example, with power supply units, should be avoided as far as possible.

The SENS Technical Commission is worried that many capacitors in ballast units do not enter the SENS and Swico material flows at all. The visual similarity between lamps and mixed metals is high and both scrap dealers and their depositors (e.g. electricians) are not always sufficiently sensitised to the issue. Particular attention should therefore be paid to separating lamps made of mixed metals, see photo 5.

SENS has published a notice for the identification of ballast units suspected of containing PCBs, which can be found at this link.

Photo 4 (top): A separate container for all ballast units is an important step for the detection of ballast units suspected of containing PCBs.
Photo 5 (bottom): It is very likely that lamps together with ballast units and capacitor will be disposed of undetected in mixed waste.

LED recycling – rethink and try!

Flora Conte

The proportion of discarded LED lighting equipment increases year by year. The need to recycle LED has now become acute. Recyclers of lighting equipment are therefore looking for concrete technical solutions. SENS is monitoring this development. It is exciting.

LED recycling is uncharted territory

Sorting lighting equipment has never been easy: different shapes, ionising and non-ionising high intensity discharge (HID), protective foils, incandescent bulbs and now more and more light-emitting diodes (LEDs). LEDs are at least as diverse as fluorescent tubes and energy-saving lamps. But there is one big difference: they do not contain mercury. They pose no danger to people or the environment if they break. This opens up possibilities for the recovery of recyclable materials from LEDs. So far, not much research has been done in the field of LED recycling. The recycling partners and the SENS Technical Commission are charting new territory together.

It could be said that LEDs are very similar to waste electrical and electronic equipment (WEEE) that is free of hazardous substances. Besides diodes, they contain electronics, plastics, aluminium, glass and more. But attempts to process LED together with WEEE have not been satisfactory so far. The size of LEDs alone makes it difficult to recover recyclable materials in WEEE recyclers' facilities. Given the diverse composition of LEDs, the clean separation of materials is also a major challenge. New LED types are constantly arriving on the market. For example, 13 types of LED were found at a recycler of lighting equipment (see photo 1). In the process, housings were found made of plastic or glass, with bases made of aluminium or flame-retardant plastics. The most valuable material, the printed circuit boards, was sometimes clearly visible, sometimes infused and hidden in a ceramic substrate (see photo 2).

Avoiding confusion

Another reason that currently speaks in favour of separate processing of LEDs is the likelihood that LEDs will not be sorted properly. There will be errors in sorting as long as mercury-containing lighting equipment is predominantly deposited. This is because similarities are sometimes striking. Trained eyes of specialists are therefore required, even though LEDs are free of hazardous substances. In addition, incorrectly sorted lighting equipment poses little concern if it is processed in a facility that extracts the mercury.

Innovation and openness are required in order to specifically extract the recyclable material from LEDs. LEDs are causing us to rethink things. Two different technologies are currently being tested in Switzerland. LED batch trials are very exciting because no one knows what to expect. Soon we will have a clearer picture of the most suitable technologies to recycle LEDs.

Photo 1: Non-rod-shaped LEDs in 13 different material combinations.

Photo 2: The valuable printed circuit boards are embedded in certain LEDs.

Findings from special batch trials

Andreas Bill, Anahide Bondolfi and Manuele Capelli

Consumer goods that cannot be operated directly with 230-volt alternating current from the mains socket require power supply units for voltage conversion. Many appliances use external power supply units, for example, laptops, tablets, lamps or various battery-operated household appliances and tools. These external power supply units contain electrolytic capacitors which, according to the standard, must be separated in a distinguishable stream when processing electrical waste.

Capacitors are essential components of electronic appliances and, as such, are found in almost all waste electrical equipment. Capacitors are used to store an electrical charge for a short period of time. In electronic appliances, they are used in a variety of applications and exist in different formats, both in terms of shape and size as well as in terms of technology and composition. The standard (SN EN 50625-1) specifies the removal of hazardous substances with regard to two types of capacitors. On the one hand, capacitors suspected of containing PCBs, a substance that has been banned for many years, must be removed in a separate process before crushing.[1] On the other hand, electrolytic capacitors (> 25 millimetres or proportionally similar volume) containing substances of concern must be separated during processing as a distinguishable (part of a) stream.

For some time now, the Swico/SENS TC has been investigating the question of which substances of concern are found in electrolytic capacitors and how these capacitors should be processed. In 2018, Büro für Umweltchemie wrote the study “Liquids in capacitors”, and in 2019 and 2021, articles on these issues were published in the Swico and SENS technical report.

[1] PCBs were banned from being placed on the market in 1986. Today, PCBs-containing capacitors in appliances sold before 1986 are found in particular in ballast units for lamps and, occasionally, in large household appliances and small household appliances from the SENS stream. See also: Capacitor study and technical report article 2020.

Further specific aspects were put under the microscope in two special batch trials in February and March 2022:

1. Quantity and size distribution of electrolytic capacitors by manual disassembly: Electrolytic capacitors are found in all external power supply units. The 2018 capacitor study also shows that at least laptop power supply units also contain electrolytic capacitors larger than 2.5 centimetres, which must be separated during processing in accordance with the standard. Swico/SENS TC’s research has demonstrated that not all buyers are aware that power supply units may contain electrolytic capacitors larger than 2.5 centimetres. In collaboration with the company Thévenaz Leduc (THL), external power supply units were disassembled by hand for this reason, and the quantity and size distribution of electrolytic capacitors were determined.

2. Localisation of electrolytic capacitors in output fractions and condition after mechanical processing: Electrolytic capacitors larger than 2.5 centimetres may also be removed after mechanical processing, provided that this allows them to be separated “as a distinguishable (part of a) stream” and that the mechanical treatment does not cause uncontrolled dispersion of hazardous substances. In order to investigate the behaviour of electrolytic capacitors in a specific mechanical treatment process, two tonnes of pure power supply units were processed at the Solenthaler Recycling (SOREC) plant. The capacitors were then localised in the different fractions and their condition assessed.

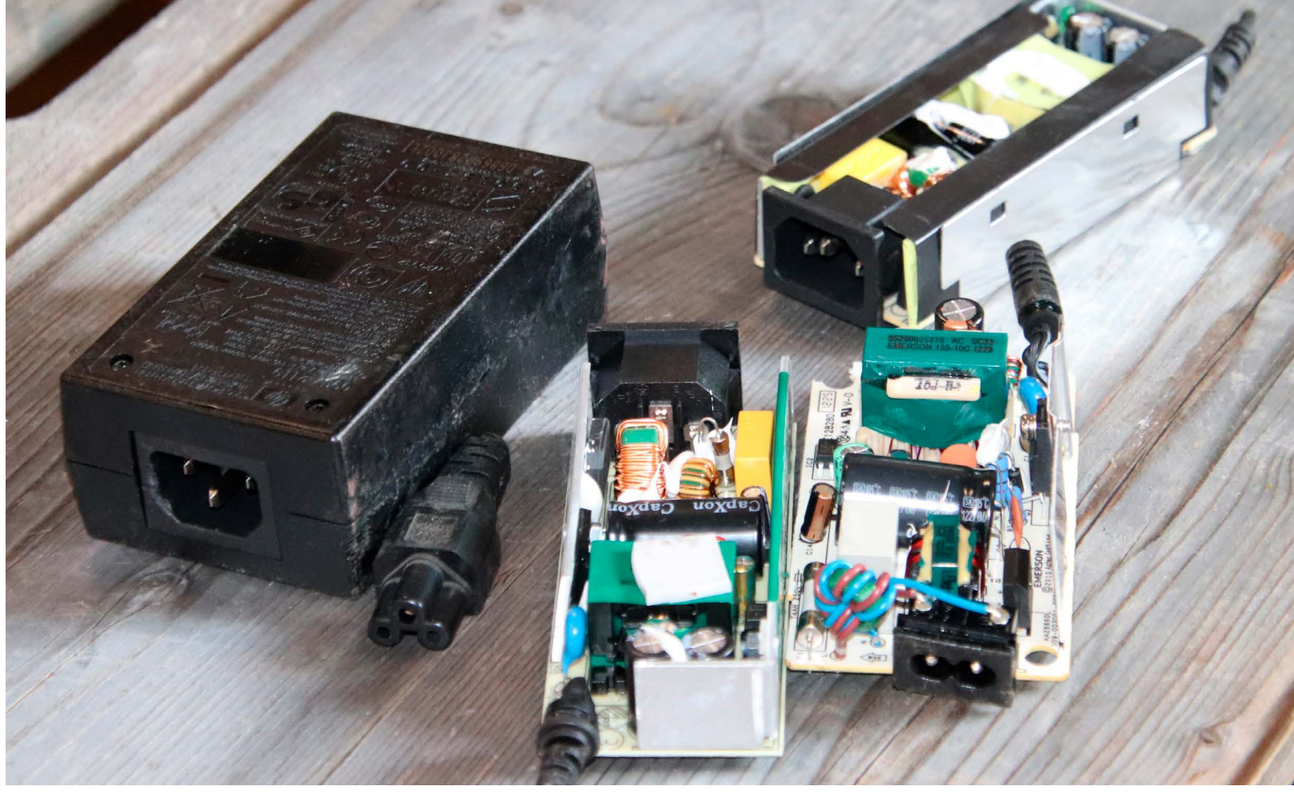
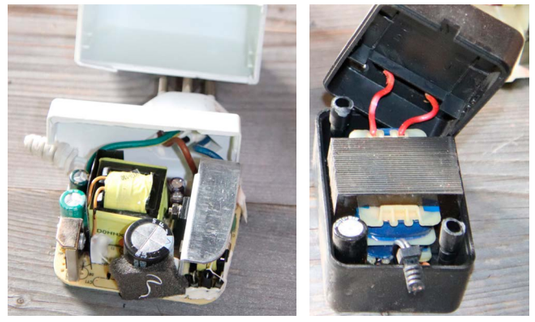


Photo 1: Open power supply units category 2.

For the disassembly tests (special batch test 1), two categories of external power supply units were established based on operating voltage (see photo 1). From each category, 150 pieces were separated into five fractions: plastics, (old) transformers, electronic appliances, electrolytic capacitors larger than 2.5 centimetres and electrolytic capacitors smaller than 2.5 centimetres. The composition by category is shown in figure 2. The plastic housing accounts for about a quarter of the weight in both categories. For category 1 (operating voltage 5 to 12 volts), it seems that many old power supply units are still being returned. These can be identified by the heavy transformers, which have been replaced by much smaller and lighter components in more modern appliances. The test showed that there are virtually no electrolytic capacitors larger than 2.5 centimetres in the category 1 power supply units. In total, electrolytic capacitors account for 2.5 per cent by weight in this category. Category 2 (operating voltage 12 to 32 volts) presented a different picture, with virtually every external power supply unit containing an electrolytic capacitor larger than 2.5 centimetres as well as several smaller capacitors. Electrolytic capacitors account for 5.7 per cent of the total weight in this case.

In addition to the disassembly test at THL, two tonnes of external power supply units, consisting of a mixture of the categories previously considered separately, were mechanically processed at the Solenthaler Recycling plant (special batch test 2).



Photos 2–3: Open power supply units category 1.

The purpose was to check whether the capacitors could be cleanly separated and whether there was any leakage of liquid during the process. Following the material breakdown, large capacitors were sorted out by workers on the sorting belt in regular operation, while small capacitors, according to reports by those in charge, were separated via the aluminium fraction. It was confirmed that the aluminium fraction contained a high proportion of small electrolytic capacitors, while other fractions contained virtually no capacitors. A total mass fraction of 3.14 per cent electrolytic capacitors was reported, of which 42 per cent were large capacitors (> 2.5 centimetres) and 58 per cent small capacitors. Another finding of the test was that the capacitors were slightly damaged during mechanical

Figure 1: Category 1.

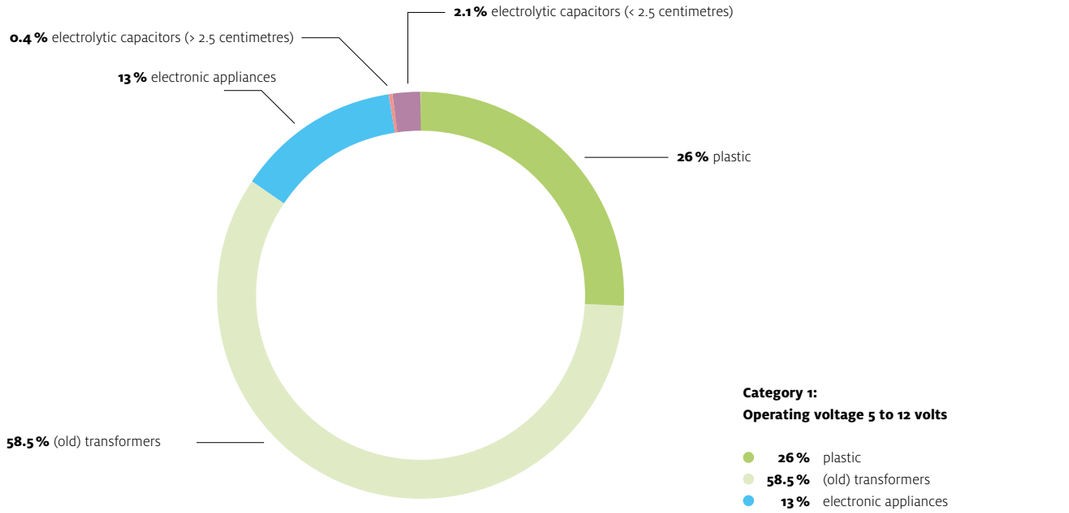
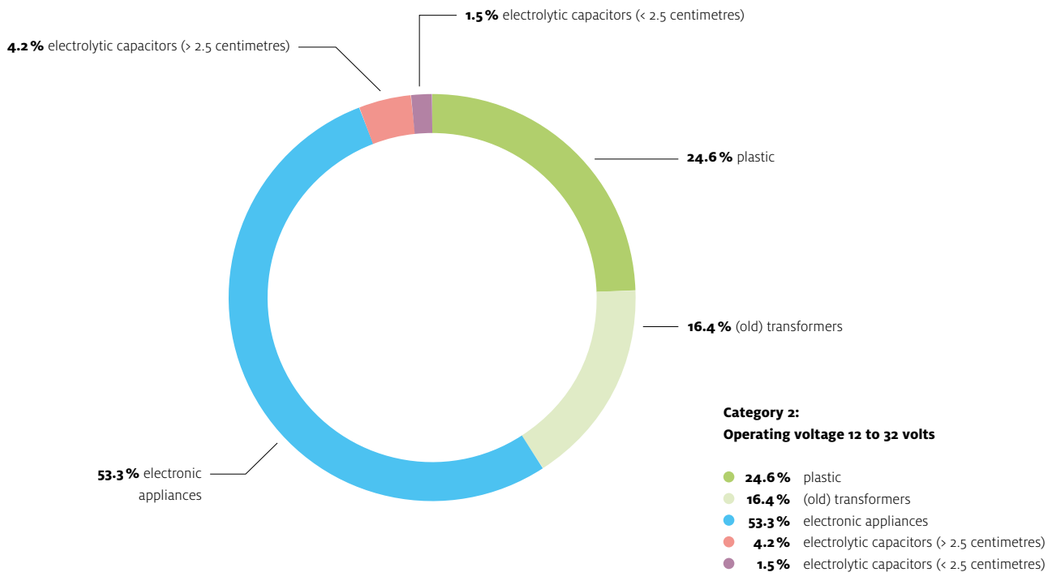


Figure 2: Category 2.



treatment (see photos 4–5), but not destroyed. No relevant liquid leakage was apparent from the slightly damaged capacitors.

The special batch tests at THL and SOREC have shown that external power supply units, especially those with a higher output voltage, contain electrolytic capacitors larger than 2.5 centimetres which, according to the standard, must be removed during processing. However, it has also been shown that electrolytic capacitors can be efficiently concentrated in a target fraction in a low-impact, mechanical process without causing serious damage. The interpretation of these results is currently being discussed by the Swico and SENS Technical Commission. For this purpose, among other things, tests are still being carried out to determine possible liquid losses in capacitors that have been slightly damaged during mechanical processing at SOREC.

Photos 4–5: Capacitors damaged following mechanical processing.

Photo 6: Input material.

Twenty years of development cooperation in the sustainable management of electronic waste

Heinz Böni and Andreas Bill

Developing countries also produce large amounts of electronic waste. With the financial support of the State Secretariat for Economic Affairs (SECO) and under the technical direction of Empa, programmes have therefore been implemented in some countries since 2003 to set up recycling systems for electronic waste. In Ghana, where a national technical directive was developed two years ago as a basis for assessing regular audits of operations, training in auditing recycling companies of electronic waste was provided to staff of the national environmental authority in July and November last year.

Photo 1: EPA auditors at a pilot audit in Tema, Ghana.

Switzerland is regarded worldwide as a great role model when it comes to dealing with waste: For more than 25 years, organic waste has been either composted (separately collected green waste) or thermally recycled (household and commercial waste). In the separate collection of recyclable materials such as paper, glass, metal, etc., there is a high level of environmental awareness among the population, which has led to record-breaking recycling quotas. Switzerland also has a firmly established and customer-friendly collection infrastructure for electronic waste, which is why it has been one of the countries with the highest collection rates in Europe for years. This extensive experience prompted the State Secretariat for Economic Affairs (SECO) in 2002 to promote international development programmes in which the legal framework and technical directives are developed with partners in developing and emerging countries, the establishment of take-back systems is supported, and the development and expansion of the recycling sector is stepped up. Activities led by Empa began under the heading "Swiss e-waste programme" in India, China and South Africa in 2003 and were extended to Colombia and Peru in 2008. In 2013, the activities were renamed the Sustainable Recycling Industries Programme.[1] This programme was also used to launch activities in Ghana and Egypt.

[1] See: www.sustainable-recycling.org.

The World Resources Forum (WRF), a spin-off of Empa, joined as an international implementation partner in 2013. WRF coordinates and monitors all activities and provides technical support together with Empa.

The success achieved through the programmes is impressive: Several of the partner countries have created a legal basis that obliges manufacturers and importers of electrical and electronic appliances to take them back at the end of their useful life by way of extended product responsibility. Building on this, collective take-back systems have been set up, new recycling companies have emerged, and existing ones have been able to expand their activities. Technical directives have been issued to make the state of the art mandatory for all licensed recycling companies. In order to monitor compliance, auditor training courses have been organised in all countries since 2021 under the direction of Empa. The first was Ghana in 2021, followed by Colombia and Egypt in 2022 and Peru and South Africa in 2023.

Two-part training course

The training in Ghana was delivered in two parts due to COVID-19 restrictions. In a first, virtual part in July 2021, basic knowledge on the topics of legislation, environmentally sound handling of e-waste as well as audit preparation, implementation and technology was taught over three days together with the Ghanaian national Environmental Protection Agency (EPA). In November 2021, the knowledge imparted in July was consolidated in a training course and practically applied in two companies.

There were around 15 training participants who showed great interest and commitment and were able to benefit from the many years of auditing experience of the two Empa experts. The pilot audits in the two companies identified the core issues in the auditing process. A critical, reflective, open and persistent, but also cooperative attitude towards the representatives of the audited companies helps to show them possibilities for improvement without simultaneously embarrassing them. Ultimately, it is not only about compliance, but also about support in the continuous improvement of the environmental performance and operational situations of the companies. Checklists were designed to help the auditors during the audit, but were not meant to be worked off mechanically. A technical discussion can be used to identify gaps and potentials that cannot be covered by yes/no questions. This requires both technical understanding and communication skills on the part of the auditors.

Switzerland's multidimensional contribution

With Switzerland's support, new jobs have been created in the partner countries over the past 20 years, valuable raw materials have been recovered in an environmentally sound manner and components containing hazardous substances have been disposed of in an environmentally sound manner. It became clear that the correct handling of waste would create ecological as well as economical and social opportunities for society. Electronic waste is a prime example because the content of recyclable materials clearly exceeds all other waste streams.

At the international level, a new ISO standard on the sustainable use of secondary raw materials (ISO 59014), which combines aspects of the circular economy with those of fair and inclusive recycling, has been in the works since last year under the leadership of WRF. A first draft is expected by the end of 2022.

Switzerland can look back with pride on 20 years of successful international cooperation in the sustainable management of electronic waste.

WEEE plastics recycling – update

Andreas Bill

The general conditions in WEEE plastics recycling continue to be in a state of flux. In order to promote the circular economy, politicians and citizens in all sectors are working towards more plastics recycling and increased recycled content in products. In the case of WEEE plastics, however, this is offset by stricter quality assurance requirements. Here is an overview of current developments and their impact on Swiss WEEE recycling.

Photo 1: Plastic fraction from the treatment of large household appliances.

The recycling of WEEE plastics makes ecological sense and contributes significantly to the achievement of ambitious (weight-based) recycling quotas. At the same time, however, there are economic, technical and regulatory hurdles. In 2019, the Swico and SENS technical report provided an overview of WEEE plastics recycling in Switzerland. Since then, a new version of the European POPs Regulation has entered into force (mid-2019) and new rules on the cross-border movement of plastic waste have been created through the Basel Convention (early 2021, see technical report article 2021).

The POPs Regulation sets the tone

When the new POPs Regulation came into force, it was already envisaged that the limit value introduced for polybrominated diphenyl ethers (PBDEs, a group of brominated flame retardants) would be reviewed by mid-2021 and, possibly, lowered further. This process was taken up with some delay at the end of 2021. In their report of 9 February 2022, the rapporteur of the European Parliament proposes a new limit value of 200 milligrams per kilogram for PBDEs, to be reduced to 100 milligrams per kilogram after five years. In addition, all plastic fractions in which the POPs limit values are exceeded are to be classified as hazardous waste in future. At the time of writing this article, these proposals are still being debated in the European Parliament.

If the POPs Regulation is updated in accordance with the above proposals, this will also have an impact on WEEE plastics recycling in Switzerland. The emphasis is on two aspects:

1. The proposed limit value for PBDEs of 200 milligrams per kilogram corresponds to the quantification limit reported by standard laboratories for the determination of these substances in samples of mixed plastic waste. The analytical uncertainties for lower measured values are so significant that values below 200 milligrams per kilogram are only reported as "< 200 milligrams per kilogram". Taking into account the uncertainties in sampling, the proposed limit value cannot be adequately verified by conventional laboratory analytical methods.[1] As long as no alternative methods are available to verify these limits, all mixed plastic fractions from WEEE recycling would have to be declared as containing POPs and fed into a specialised process to remove plastics with brominated flame retardants, or incinerated.

2. Mixed plastic waste from Swiss WEEE recycling is mostly either incinerated or recycled in nearby countries by recycling companies specialising in WEEE plastics. As a rule, these companies do not have a permit to accept hazardous waste. If plastic waste containing POP substances had to be classified as hazardous waste in the EU in future, specialised plastics recyclers would no longer be allowed to accept it until the appropriate acceptance codes had been approved. This would probably cause, at least temporarily, a halt to recycling and, in the meantime, increased thermal recycling of WEEE plastics.

The general conditions for WEEE plastics recycling in Europe are continuously evolving. In this context, political decision makers are walking a tightrope between the desired circular economy and the consistent removal of hazardous substances from recycled materials. This situation is extremely challenging in terms of the further development and promotion of WEEE plastics recycling, as there is a great deal of uncertainty due to the changes in legislation.

[1] Creating a representative sample of mixed plastic waste from the mechanical treatment of WEEE is a major challenge. A recently published study by Empa addresses this issue in detail: https://doi.org/10.1016/j.resconrec.2021.105956.

Swico and Immark
promote the training of specialists

Sabine Krattiger and Roger Gnos

Projects involving important resources are being promoted in the third round of calls for proposals for the Swico Recycling Innovation Fund. One of them is designed to make people in the subsidised secondary labour market fit for the primary one. We present this in more detail here.

Since the foundation of Swico Recycling in 1994, the secondary labour market has grown into an important partner for the recycling industry. Due to the miniaturisation of appliances and the high proportion of LIB waste, manual pre-sorting and careful partial assembly of electronic waste will continue to be of great importance in future[1].

Around 800 to 1,000 people from the secondary labour market are employed in 120 social disassembly facilities, and the renowned recycling company Immark Ltd, among others, cooperates with them. In view of the development of the labour market, education and qualification measures in social assistance are becoming an increasingly important prerequisite for sustainable labour market integration. Thommen Group, to which Immark Ltd belongs, believes that the two can be combined and is launching a pilot project in cooperation with the Swiss Red Cross (SRC) of the canton of Bern and the Fachstelle Arbeitsintegration Region Bern (Farb AG).

The advisory board of the Swico Innovation Fund decided that this deserved to be supported: The Innovation Fund supports a specialist course in recycling for social assistance recipients with CHF 220,000.00.

The low-threshold, multilevel support enables employees in the secondary labour market to acquire an industry diploma and a prerequisite for training as a Recyclist VET (Federal Diploma of Vocational Education and Training) and thus transition to the primary labour market. The support includes the advancement of everyday and basic skills as well as qualification offers below the vocational training level. At the same time, Thommen Group and other companies benefit by taking on staff and apprentices, which solves part of their problem of a shortage of young talent and workers.

We provide a more detailed introduction to the specialist course on the next page.

[1] See also: Technical Report 2021, page 34.

Photo 1: Social assistance recipients during the qualification assignments.

Sabine Krattiger, Managing Director, Immark Ltd.

“The pilot project is unique in Switzerland and makes an important contribution to the integration of these employees and to the sustainable supply of recycling know-how with respect to electronic appliances.”

A classic win-win, according to Roger Gnos, Chairman of the Advisory Board of the Swico Innovation Fund.

“With its objective, the intended benefits for people and the environment and through the partnership structure with the two social partners, the project has the potential to be continued or scaled up in other cantons as well.”

Specialist course in recycling: new perspectives for persons dependent on social assistance

Sabine Krattiger and Roger Gnos

The Farb AG and the SRC of the canton of Bern have launched a two-year pilot project with Immark Ltd. This is the first time that two social institutions and a private company have joined forces in order to give people on social assistance targeted, sector-specific qualifications and thus new prospects for the primary labour market.

What is it about?

With its Fractio offer, Farb AG runs a disassembly facility for Immark Ltd, which is operated at a Thommen Group site in Köniz and is therefore close to the primary labour market. The disassembly facilities, as providers of jobs in the secondary labour market, have grown to become an important partner in the electronic appliances recycling industry: Due to the miniaturisation of appliances and the high proportion of LIB waste, manual pre-sorting and careful partial assembly of electronic waste will continue to be of great importance in future.

The low-threshold, multilevel support enables employees in the secondary labour market to acquire an industry diploma and a prerequisite for training as a Recyclist VET (Federal Diploma of Vocational Education and Training) and thus transition to the primary labour market.

What does the project achieve?

The entire recycling sector needs a skilled workforce. The two social institutions Farb AG and SRC of the canton of Bern are responding to this need by implementing sector-specific training for social assistance recipients. Thommen Group, as well as other recycling companies, collection points and similar businesses, benefit by taking on staff and trainees, which solves part of their problem of a shortage of young talent and workers.

What is the status of the project?

The project is now ready for the implementation phase thanks to the support of the canton of Berne (Department of Health, Social Affairs and Integration) and financial contributions from the Swico Recycling Innovation Fund, the Verein für Arbeitsbeschaffung (Association for Job Creation) and the UBS Foundation for Social Issues and Education. The course has been announced for the social assistance offices, and the first course was successfully started in April.

Who can attend?

The qualification programme is aimed at:
- Social assistance recipients capable of working
- Provisionally admitted and recognised refugees with B/F permit
- Foreign nationals with B/C permit

What is the course structure?

The specialist course in recycling consists of two modules:
- "Basic" module: Six-month module consisting of lessons at the SRC of the canton of Bern as well as specialist modules from Thommen Group and qualification assignments. In addition, the participants complete an internal forklift course (R1).
- "Advanced" module: Three-month module consisting of lessons at the SRC of the canton of Bern as well as specialist modules from the industry association Swiss Recycling and qualification assignments.

Which companies are involved?

Farb AG

Farb AG offers a wide range of employment opportunities for social and occupational integration for recipients of social assistance. Farb AG is one of the largest providers of BIAS (employment and integration programmes of social assistance) services in the canton of Bern. More than 50 municipalities with 15 regional social services are affiliated with the institution.

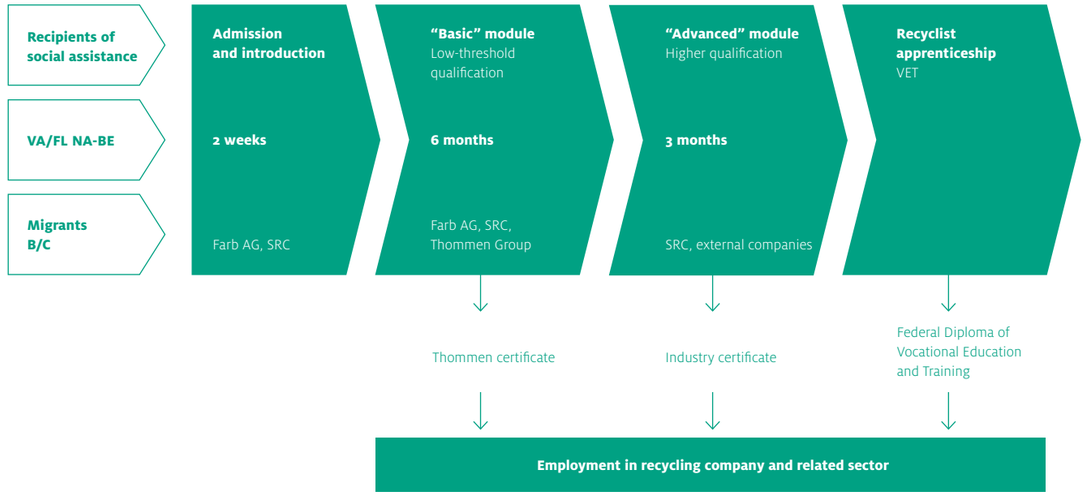
SRC of the canton of Bern

The SRC of the canton of Bern is a humanitarian organisation that advocates more solidarity throughout the canton. Around 700 employees and 2,400 volunteers are involved in the areas of relief, health promotion, education and integration. The SRC of the canton of Bern has around 80,000 members.

Thommen Group

Thommen Group is a family business that has acquired a wealth of experience and valuable expertise in the recycling of metal, iron and electronic waste over the past 85 years. The Thommen brand represents the Swiss recycling business, the Metallum brand the international trading business and the Immark brand the electronic waste business. Thommen Group has more than 600 employees at 25 locations in Switzerland, Germany, Italy, Belgium and China.

Figure 1: Concept of specialist course in recycling.



The activities of the technical audit departments in the last 25 years

Daniel Savi and Heinz Böni

Even though it is still a relatively recent aspect, the technical auditing of electrical appliance recycling has seen a rapid evolution. What started as isolated activities with few stakeholders is now integrated into a Europe-wide recycling and auditing process. We take a look back at the significant events of the last 25 years of expert work in the service of environmentally friendly recycling of electrical or electronic appliances.

It is impossible in retrospect to reconstruct exactly when the auditors of Swico Recycling and SENS started their work. The 1994 activity report of Swico Recycling already mentions Empa's work as the audit department of Swico Recycling. The oldest technical report of the SENS Technical Audit Department for the attention of the Head Office dates back to 1997. This means that the auditors of SENS and Swico Recycling have been active for at least 25 years. Initially, Empa and the two SENS technical auditors worked largely independently of each other. Joint audits began in 1999. Nine years later, the cooperation was so close that the two audit departments were transferred to a joint body. Finally, in 2009, the technical and environmental requirements for recycling were also harmonised in the contracts between Swico Recycling and SENS with the recycling partners.

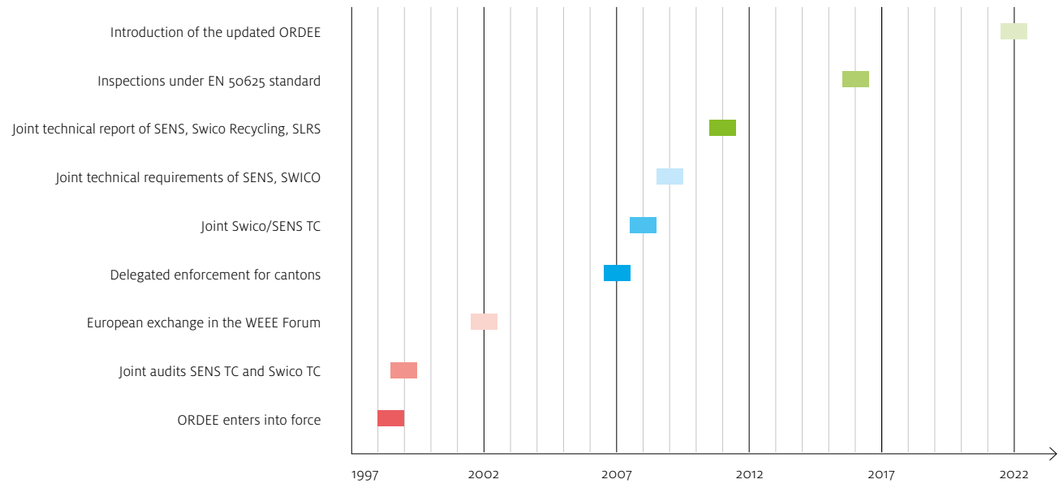
Focus on hazardous substances

At the beginning of the audit activities, the correct separation and disposal of components containing hazardous substances from electrical or electronic appliances kept the committees very busy. The focus was on batteries containing heavy metals, getter pills containing barium from screens, CFCs from temperature exchange equipment, capacitors containing PCBs and appliance oils. Later, new problematic components appeared: on the one hand, lithium batteries cause difficulties in the recycling process, and on the other hand, new appliances with specific hazardous substances appeared, such as flat screens, lighting equipment or medical devices. Over time, the analysis of material flows at recyclers and the identification of subsequent treatment and disposal routes became more important. Procedures to demonstrate the most extensive recycling and environmentally friendly disposal of materials from appliances were developed and implemented. Recently, there has been an increased focus on promoting the recovery of recyclable materials and on continuously improving know-how about the substances contained in appliances.

Influence on European developments

Like their clients, the technical audit departments developed dynamically. The take-back systems of SENS and Swico became operational before the Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE) came into force in 1997. Auditing activities also started before the ordinance came into force. It was only the ORDEE that created the legal basis for a take-back and recovery obligation for old electrical appliances. The technical exchange between the SENS and Swico Recycling Technical Committees intensified with the introduction of joint audits by SENS and Swico Recycling. This helped to improve material flow analysis at recyclers and the development of key figures for assessing recycling quality. The public also became aware of the intensified cooperation after the joint technical report was published for the first time in 2011. The findings were discussed as part of a European framework in the WEEE Forum as early as 2002. Swiss experts were heavily involved in the development of a European standard for the recycling of electrical and electronic appliances from the very beginning. These activities resulted in the WEEELABEX standard and the 50625 series CENELEC standards. WEEELABEX-based audits were not introduced in Switzerland. Once the European EN 50625 series of standards was completed, it became the technical basis for Swico Recycling's audits from 2017 and SENS's audits in 2020.

Figure 1: Timeline of the development of the Technical Commission.



The expertise that the members of the audit departments have acquired over the years has also led to increased demand for support abroad. In 2002, for example, the State Secretariat for Economic Affairs (SECO) tasked Empa with clarifying possible projects for the sustainable handling of electronic waste in developing countries. This gave rise to projects in several countries in Africa, Latin America and Asia, for which Empa provided management and technical support.

A large number of experts have served as auditors over the years. Kurt Münger took over the chairmanship of the Swico Technical Commission at the beginning, followed by Johannes Gauglhofer, Martin Eugster and Heinz Böni. The SENS Technical Commission initially consisted of Ueli Kasser and Geri Hug. In the early years, Robert Hediger, as Managing Director of SENS, played a decisive role in the development of the SENS Technical Commission and its strategic focus. As it grew, Ueli Kasser took over as chair. The management was taken over by SENS staff members Daniel Savi, Paul Scherer and Roman Eppenberger starting in 2008. All the experts involved had a strong influence on the development of the auditing practice of SENS. In addition to those already mentioned, these were Anahide Bondolfi, Anne-Christine Chappot, Flora Conte, Emil Franov, Niklaus Renner and Silvan Rüttimann. Empa has deployed various members of staff in the audit team over the years, some of whom served as auditors only for a shorter period of time. Although they cannot all be listed here, they each made an important contribution to the development of auditing. Long-standing auditors, in addition to the chairs of the Swico Technical Commission, were Esther Thiebaud, Patrick Wäger and Rolf Widmer.

From an environmental point of view, temperature exchange equipment has always held a special position. Since refrigeration and air-conditioning equipment mostly contained CFCs as a refrigerant until 1990, the safe recovery and destruction of the refrigerant has been an important auditing task since the beginning of the experts' work. Year after year, recyclers reported the shares of CFC-containing and CFC-free refrigeration equipment. Early on, the auditors made forecasts on when CFC-containing appliances would have to be disposed of. In retrospect, it is evident that the phase-out of CFCs was expected to happen much faster than it is now proving to be in practice. According to a 2000 forecast, all refrigeration equipment containing CFCs was expected to be disposed of by 2022. In reality, a quarter of the cycles in the appliance return still contain CFCs.

In the case of information technology and consumer electronics appliances, CRT screens have long occupied a prominent position in auditing activities. In the past, they made up a significant part of the weight of recovered appliances in the Swico stream, representing up to 35 per cent of the total. The focus was on the clean separation of lead-containing and residual glass, the separation of getter pills containing barium and the proper disposal of plastics containing hazardous substances. In addition, the luminescent layer contains hazardous substances on the one hand, but is also rich in rare elements on the other hand. This luminescent layer must be removed and sent to landfill. This example shows that today it is standard practice to dispose of hazardous substances in an environmentally friendly way or to isolate them from the environment. However, it has not yet been possible to return

Figure 2: Effective development of VFC and VHC appliances by 2021.

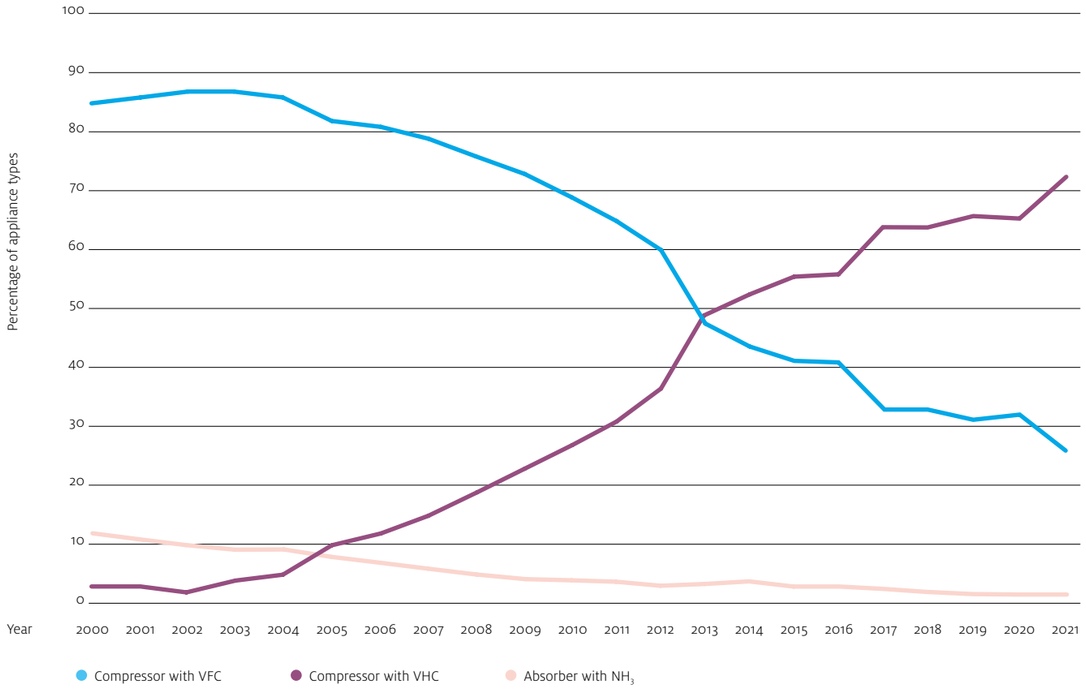
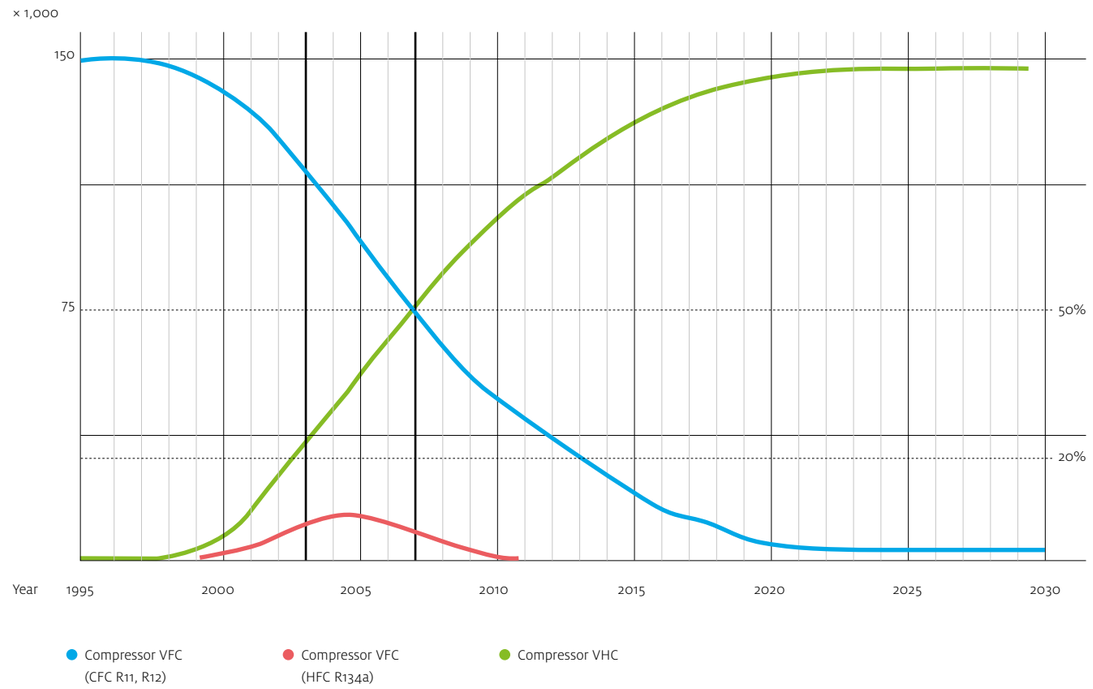


Figure 3: Forecast for the development of refrigerators from the 2000 Technical Report.



all recyclable materials from mixtures, such as the rare earths from the luminescent layer, back into the raw material cycle.

The second major issue relating to hazardous substances, especially where large household appliances are concerned, was that of PCBs-containing capacitors. Before the introduction of the SENS system, large household appliances were still mostly disassembled by hand. If the appliances were crushed in the shredder, this was done without prior removal of hazardous substances. In the 1990s, shredding became the standard for the disposal of large household appliances. This resulted in the requirement starting in 2000 that capacitors containing hazardous substances had to be removed before they could be mechanically processed. The rule of thumb was implemented back then. According to this rule, all capacitors that are the size of a thumb or larger must be removed from appliances by hand. At the time, probably no one imagined that this rule would come to be included in a European regulation and standard later on. With the decrease in capacitors containing PCBs in large household appliances, it is now a question of when this rule should be lifted again. In this context, the environmental consequences of a repeal have to be weighed against the cost of the separate disposal of an ever smaller quantity of PCBs.

Plastics have always been an important fraction, especially in household appliances and consumer electronics. But their share in all other appliance categories has also increased steadily over the last 25 years. The large number of different types of plastic, the flame retardants that are often present and the mixed plastics that are frequently used make recycling them a complex and challenging task. The share of recycled plastics is still far from what is required for a circular economy. In addition, new plastics are cheap raw materials. As a result, the economic incentives for increased plastics recycling are low. In future, it will be a challenge for take-back systems and auditors to promote plastics recycling through smart incentives.

With the introduction of the updated ORDEE and the still outstanding implementation aid regarding state-of-the-art technology, WEEE recycling in Switzerland will have an updated legal basis in 2022. Miniaturisation in electronics, the increased use of plastics and mains-independent appliances are constantly creating new requirements for recycling. This dynamic will continue to shape the future work of the technical audit departments of SENS and Swico.

Flora Conte
SENS TC, Carbotech AG

Flora Conte completed her Master's degree in Environmental Science, with a focus on 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. She has been a member of the Swico/SENS TC since 2015. Until 2020, she audited disassembly facilities of SENS and Swico. Flora Conte has been auditing SENS recyclers since 2016. In addition to her activities as an environmental consultant, she is also involved in a non-profit organisation for access to solar energy in developing countries.

Anahide Bondolfi
SENS TC, Abeco GmbH

Anahide Bondolfi holds a Bachelor's degree in Biology and a Master's degree in Environmental Sciences from the University of Lausanne. She began her work in the field of electronic waste in 2006 while working on her Master's thesis in South Africa, in collaboration with Empa. She then worked for almost 10 years as an environmental consultant and project manager at two Swiss environmental consulting firms, first at LeBird in Prilly and then at Sofies in Geneva. In January 2017 she founded Abeco Sàrl. She has been a member of the Swico/SENS TC since 2015. She is responsible for almost half of all the audits of the Swico and SENS disassembly facilities. Since 2016, Anahide Bondolfi has also been auditing several SENS recyclers and collection points.

Manuele Capelli
Swico Conformity Assessment Office
SN EN 50625, Empa

Manuele Capelli studied Environmental Sciences and Management, Technology, and Economics (MTEC) at ETH Zurich. He gained his first experience in electronic waste through a university internship at the WRF in cooperation with Empa. Since 2021, he has been working at Empa as a research assistant in the Technology and Society Department. He is responsible for projects on the circular economy and recycling systems in Switzerland, as well as for supporting projects to set up electronic waste recycling systems in developing and emerging countries. He is a member of the Swico TC and has performed audits since 2022.

Andreas Bill
Swico Conformity Assessment Office
SN EN 50625, Empa

Andreas Bill completed his Master's degree in Energy Management and Sustainability at the Swiss Federal Institute of Technology (ETH) in Lausanne and subsequently gained initial experience in the field of electronic waste at Empa while completing is civilian service. Since 2019, he has been working there as a research assistant in the Technology and Society Department. His core task is to support projects for the establishment of electronic waste recycling systems in developing and emerging countries. He is part of the Swico TC and has audited Swico recyclers since 2020.

Roger Gnos
Member of Technical Audit Department,
Swico and TC

Roger Gnos has been rooted in recycling since 1991 and has actively experienced and shaped the development in the recycling of old electrical and electronic appliances. He worked for almost 20 years as a company manager at an e-waste processing company. He has been with Swico Recycling for 10 years, advising the collection points. In 2019, he worked on the launch of the Swico Innovation Fund and has since served as Chairman of the Advisory Board. He is fascinated by technology, but also by the people behind recycling.

Thekla Scherer
SENS TC, IPSO ECO AG

Thekla Scherer studied Environmental Sciences at ETH Zurich. After graduating, she worked for about 10 years in an engineering firm with a main focus on air pollution control and energy. She has been working at IPSO ECO AG in Rothenburg since 2016. As a project manager there, she prepares environmental impact reports and, at the same time, travels to construction sites as an environmental construction supervisor. As someone with a wide range of interests, she covers a broad spectrum of environmental topics in her work, including waste, environmentally hazardous substances and disposal. Since 2021, Thekla Scherer has been a member of the SENS Technical Commission and an auditor specialising in companies recycling refrigerators.

Fabian Elsener
Carbotech AG

Fabian Elsener holds a bachelor's degree in Industrial Engineering awarded by the Eastern Switzerland University of Applied Sciences (OST) in Rapperswil. He is currently completing a master's degree in Environmental Studies and Natural Resources, specialising in green technology and life cycle analysis, at the Zurich University of Applied Sciences (ZHAW) in Wädenswil. During his internship at V-ZUG he gained an initial experience with the recycling of electrical and electronic equipment by following a batch test for V-ZUG. Since the summer of 2021 he has been working in the Environmental Consultancy Department of Carbotech AG, focusing mainly on life cycle assessment for technical products and systems.

Heinz Böni
Head of Swico Conformity Assessment Office
SN EN 50625, Empa

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 assistant 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 Critical Materials and Resource Efficiency (CARE) group. Since 2007, he has been Swico's audit expert and since 2009 Head of the Technical Audit Department of Swico Recycling.

Daniel Savi
SENS TC, Büro für Umweltchemie

After graduating as an environmental scientist from ETH Zurich, Daniel Savi joined SENS as Head of Collection Points and Head of Quality Assurance. He held these positions for seven years before joining Büro für Umweltchemie GmbH as a research assistant. Since 2015, he has been Co-Owner and Managing Director of Büro für Umweltchemie GmbH. He deals with health hazards and the environmental impact of construction and waste recycling.

Sabine Krattiger
Swico recycling partner, Immark Ltd

Working in the recycling of electronic appliances since 1992; since 2009, Managing Director of Immark Ltd. With her expertise in the disposal of electronic appliances, she supports the professional association VREG Geräte-Entsorgung (specialising in the ORDEE-compliant disposal of appliances), the R-Suisse Recyclist training programme and the European Electronics Recyclers Association (EERA) as a board member.

Niklaus Renner
SENS TC, IPSO ECO AG

After completing his studies at the Lucerne School of Music, Niklaus Renner studied Environmental Sciences at ETH Zurich. Since 2007, he has worked at IPSO ECO AG in Rothenburg (formerly Roos + Partner AG in Lucerne). He focuses on contaminated areas, soil protection and the environmental compatibility of various recycling processes and advises companies on their conformity with environmental law. Together with Dr Erhard Hug, he developed the mathematical assessment model for the European refrigerator recycling standard CENELEC EN 50625-2-3. Since 2017, Niklaus Renner has been a member of the SENS Technical Commission and an auditor for recycling companies. His area of expertise includes audits and equipment performance tests at companies recycling refrigerators.

Roman Eppenberger
Head of SENS Technical Inspection,
Head of Technology and Quality at SENS

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 is the Head of the Technology and Quality Division at the SENS Foundation. In this position, he coordinates the Swico/SENS Technical Commission in conjunction with Heinz Böni.

International links

www.weee-forum.org
The Forum for Waste Electrical and Electronic Equipment (WEEE Forum) is the European association of 46 systems for collecting and recycling electrical and electronic appliances.

www.step-initiative.org
Solving the E-waste Problem (StEP) is an international initiative that not only includes key players involving the manufacturing, reuse and recycling of electrical and electronic appliances, but also government and international organisations. Three 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 19 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.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/care
Since the beginning of Swico's recycling activities in 1994, ETH Zurich's Department of Materials Science and Technology research centre Empa has been responsible for auditing the recycling partners – as the conformity assessment office for the Swico recycling partners. CARE – Critical Materials and Resource Efficiency – headed by Heinz Böni is responsible for this.

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 appliances.

Cantons with delegated enforcement

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 appliances.

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 appliances.

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 appliances, which can be found under "Information on specific types of waste".

www.umwelt.bl.ch
The website of the Office for Environmental Protection and Energy (AUE) of the canton of Basel-Landschaft contains information on recycling and reusing raw materials in electrical and electronic appliances, which can be found under "Waste>Controlled waste>Electronic waste".

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.

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