SCYCLE's Origins & Milestones

A History, 1994-2021

Foreword

After a 27-year-long journey under United Nations University (UNU), the Sustainable Cycles Programme (SCYCLE) is completing its transition to the United Nations Institute for Training and Research (UNITAR). The journey began with my part-time engagement at the Tokyo-based UNU Centre in the mid-1990s and grew, over the years, into a prospering Programme with more than a dozen full-time core staff at the UN Campus in Bonn.

SCYCLE grew to become the global leader in research and trainings related to electronic waste and other ubiquitous goods. Worldwide writing, commenting, and campaigning around waste electrical and electronic equipment is rarely taken on without incorporating SCYCLE's data and expertise.

The related methodologies developed serve as a model for our engagement in other areas of pressing concern for humankind, such as batteries, the automotive industry, etc. The E-waste Academies have also become unique, go-to trainings for representatives of governments, companies, and science, mobilising a strengthened global cooperation.

SCYCLE's work on environmental crime is assisting further research to sustainably solve transnational shipment issues. The Programme is also pushing to look further into the whys (no longer concentrating only on the hows) – considering, to a greater degree, the societal aspects of its work.

As such, to the degrees extent feasible under UNITAR, SCYCLE will also invest substantially in converting its research findings on circular economy into actual trainings for a diverse set of stakeholders across the globe.

SCYCLE's journey was shaped by its permanent acquisition efforts being a 100% project-financed Programme. This was only possible because of a team spirit, which is the driving factor of SCYCLE's success story. And the various Rectors' and Vice-Rectors' strong support, giving SCYCLE the framework to develop, also strongly contributed to the Programme's achievements.

Special thanks go to UNU Rector David M. Malone and UNITAR Executive Director Nikhil Seth for believing in us, supporting our transition to UNITAR, and allowing us to further develop.

I hope this report on SCYCLE's origins and milestones makes for engaging reading and, for the many individuals involved across its history, elicits a few nice memories. But I also hope that others will be inspired by the great and important work the SCYCLE team undertakes and be energized and motivated to further engage with us.

Ruediger Kuehr
Director UNU-ViE SCYCLE

Zero Emissions:

Historical Context as a Precursor to SCYCLE

first ZEF office outside of Japan was opened at Osnabrück University in Germany, on initiation by Professor György Széll. In **2000**, Ruediger Kuehr began working with the Environmental Policy Centre at Berlin's Free University, building it into a new hub of ZEF work in Europe. In **2003-2004**, the UNU-ZEF European Focal Point also partially operated from the headquarters of The Natural Step International in Stockholm. And in **2003**, the first UNU Institute in Germany opened in Bonn: the Institute for Environment and Human Security (UNU-EHS), directed by „University of Bonn" Professor Janos Bogardi. Hence, on request of UNU's Rector Professor Hans van Ginkel, the UNU-ZEF European Focal Point also took office at the UN Campus in Bonn and has since operated from there.

In **1994,** the Tokyo, Japan-based United Nations University (UNU) launched a new initiative designed to research various approaches and technological breakthroughs necessary for meeting the natural challenges posed by a new type of industrial system.

The initiative's visionaries were optimistic that value-added uses for waste materials could be identified that might generate dividends for both the economy and the environment. From **1994-1998,** UNU's Zero Emissions research focused on investigating technological solutions for industry, especially for biomass-based processes. Results included the development of a 'biorefinery' idea, whereby input materials for plastics and other organic-based products are derived from plant matter. The Zero Emissions concept was communicated to industry, government, and civil society through events such as the annual World Congress on Zero Emissions. As a result, many businesses, government agencies (both local and national), and local communities, especially in Japan, adopted the Zero Emissions concept as a basis for improving environmental performance.

From **1999-2009**, UNU adopted more of a facilitating role in fostering Zero Emissions-related activities through the formation of an organisation known as the **UNU Zero Emissions Forum (ZEF)**. The forum had both Japanese and international components – the former comprised of more than 150 representatives from Japanese businesses, local governments, academia, and NPOs. In 1999, initiated by the by University of Tokyo Professor Motoyuki Suzuki, the

About the Zero Emissions Concept

Back to a Natural Cycle

The Zero Emissions concept represents a shift from the traditional industrial model (where waste is the norm) toward integrated systems, in which all things have use. The concept advocates for an industrial transformation whereby businesses emulate the sustainable cycles found in nature and society minimises its aggressive depletion of natural resources and endeavors to accomplish more with the resources that the earth produces.

The goal of the Zero Emissions concept is for all industrial inputs to be used in final products or converted into value-added inputs for other industries or processes. The vision is for industries to be reorganised into clusters, such that industry's waste or by-products become fully matched with the input requirements of another industry and the integrated whole produces no waste.

The elimination of waste is the ultimate solution to pollution problems that threaten ecosystems at local, national, and global levels. And full use of raw materials, coupled with a shift towards renewable sources, means that utilisation of the earth's resources can ultimately return to sustainable levels.

The United Nations University building in Tokyo, Japan
Photo by: UNU

For businesses, Zero Emissions can mean increased competitiveness. Zero Emissions also represents a continuation of its inevitable drive toward efficiency. First came labor and capital productivity, and now comes the productivity of raw materials: producing more from less. In a historical sense, Zero Emissions represents the third phase in the evolution of the control and reduction of emissions from industrial pollution sources:

1. End of Pipe – use of pollution control technologies to treat processed waste

2. Cleaner Production – redesign of processes and products such that fewer emissions are actually produced

3. Zero Emissions – conversion and use of process outputs as inputs for other processes

Zero Emissions Requires Large-Scale Societal Changes

Since production and consumption are tightly intertwined activities, implementing Zero Emissions requires consideration of the larger societal system that industrial activities take place within. Achieving Zero Emissions at the societal level requires addressing such issues as:

- urban and regional planning

- consumption patterns
- energy conservation

- upstream industrial clustering

- the reuse and recycling of products

- the interactions of abovementioned activities with the local industrial production base

Note on the Term 'Zero Emissions'

Per physical laws, zero emissions – defined as zero output from a process except for its single desired product – is not technically feasible. Chemical reactions, for example, do not reach exactly 100% yield, so waste heat emissions are inevitable. As such, the concept of 'Zero Emissions' asserts not that all emissions of a set of industrial processes can actually reach zero, but rather, that:

1. One should adopt a systems perspective. Even if emissions are inevitable from a given process, viewing it in the context of other industrial and natural processes that utilise the waste can possibly lead to net 'zero' emissions, equating to no measurable impact on the environment.

2. Continuous progress toward an idealised goal is made. The approach has been successful in management standards such as Zero Defects and Zero Inventory.

In 2009, UNU-ZEF succeeded in fulfilling its original goals, as the Zero Emissions concept was adopted by industry and governments worldwide, so UNU-ZEF ended its work. Also in 2009, the former UNU ZEF European Focal Point in Bonn became an operating unit of the newly established UNU Institute for Sustainability and Peace (UNU-ISP) under University of Tokyo Professor and UNU Senior Vice-Rector Kazuhiko Takeuchi. This change equated to the official start of SCYCLE.

Alliance for Global Eco-Structuring

This Zero Emissions (ZE) progress was made in the late 1990s and early 2000s concurrent with the development of more and more sustainability-focused concepts, such as Ecological Footprinting (EF), the Factor X Concept, Factor 10 and The Factor 10 Institute, Zero Waste (ZW), Cleaner Production (CP), Sustainable Technological Development (STD), The Natural Step (TNS), and The Natural Step Framework (TNSF).

Likewise, calls for clarification of similarities, overlaps, and purposes of these existing approaches and calls for harmonisation of terms and measures were beginning to emanate from environmental initiatives, industry, and political decision makers. For example, the Zero Emissions in an Industrialised Society conference in Tokyo in November 1999 highlighted the need to internationally harmonise sustainability-related terminology, provide understandable and easy-to-implement definitions, coordinate and systemise multiple approaches, and identify the strengths and features of the initiatives. The conference's speakers and attendees were in agreement when they realised that eco restructuring activities had been marked by substantial overlaps, unrecognised linkages, and gaps – and, for that matter, continue to be.

To explore these implications, UNU and the Factor 10 Institutes, led by nuclear chemist and researcher, Professor Friedrich Schmidt-Bleek, brought together the leaders of a number of important initiatives. The leaders began comprehensive planning for sustainable development, which can be facilitated by a systems approach to sustainability. They formed the Alliance for Global Eco-Structuring under UNEP's Cleaner Production work and jointly presented a model of interrelated and essential elements of sustainable development, relating the model to well-known tools and organisational initiatives. The model was based on a systems perspective and utilised principles for how a system is constituted (i.e. ecological and social principles), how it incorporates principles for a favourable outcome for our planning within the system (sustainability), and how it lists important, key elements for the process to reach the outcome (strategic principles for sustainable development); the model also listed tools for monitoring actions aligned with the strategic principles (tools for management, community building, and auditing).

The model described the primary focus of Ecological Footprinting (EF), the Factor X Concept, Factor 10 and The Factor 10 Institute, Zero Emissions (ZE), Cleaner Production (CP), Sustainable Technological Development (STD), The Natural Step (TNS), and The Natural Step Framework (TNSF). It concluded that a systems perspective is helpful for comprehensive and strategic planning, as well as for the selection and design of tools to monitor the societal transition toward sustainability.

The variation in primary focus, multiple perspectives, and numerous tools of different organisational initiatives provides a potential for a synergistic approach to sustainable development.

On invitation by Swedish Professor Karl-Henrik Robèrt, the cooperation under AGES was further developed in 2003 and 2004 by Ruediger Kuehr from The Natural Step's International headquarters in Stockholm.

Computers and the Environment

2000, a team of researchers from UNU's Global Environment Information Centre met with Professor Monte Cassim and his team at the Ritsumeikan University in Kyoto, Japan. The outcome was the initial idea for a collaboration on addressing the growing problems relating to production, usage, and final disposal of modern technologies. This idea culminated in the 2003 publication of *Computers and the Environment: Understanding and Managing their Impacts,* co-edited by Ruediger Kuehr and Eric Williams.

The book examines a variety of environmental impacts associated with computer production processes. Per the study, the main impacts are believed to be

- Significant energy use and resource consumption in the production and operation of computers.

- Possible long-term health effects on workers, families, and neighboring communities, due to chemical exposure and emissions from production stages (such as microchip fabrication).

- Possible health impacts, due to exposure to hazardous materials contained in computer products, particularly brominated flame retardants and lead. The main risk of exposure is likely either from computers that have been dumped in landfills or from environmentally unsafe recycling processes in the developing world.

ECO-EFFICIENCY IN INDUSTRY AND SCIENCE SERIES

Computers and the Environment
Understanding and Managing their Impacts

Ruediger Kuehr and Eric Williams (Eds.)

Computer manufacturing is extremely energy- and resource-intensive and is thus a significant contributor to climate change and depletion of fossil fuel resources. Though computers use relatively less energy when in operation, the combination of high-tech/high-energy manufacturing processes and short lifespans increase their lifetime environment-related energy impacts to equate roughly to those of refrigerators – among the more energy-intensive of all home appliances.

Computers and the Environment showed that manufacturing a 24 kg (53 lb) desktop computer with monitor requires, on average, at least 10 times the unit's weight in fossil fuels and chemicals; as such, manufacturing a computer is much more materials-intensive than manufacturing an automobile or refrigerator, which require only 1-2 times their weight in fossil fuels.

Computers and the Environment has become a go-to source in the fields of technology and sustainability. The book also sold unusually well for a scientific publication, attracting coverage across international media outlets.

UNU identified several options available to national, regional, and local governments intent on mitigating the environmental and health impacts of computers. Such options include the environmental regulation of manufacturing processes (such as setting standards for emissions from semiconductor factories) and the environmental characteristics of computer products (such as banning the use of lead and other heavy metals); mandatory product take-back, recycling systems, and voluntary programs (such as eco-labeling); and funding of research/analysis as well as education and public awareness campaigns on the environmental impacts of computers.

SCYCLE's Beginnings, Vision, & Objectives

SCYCLE's vision

SCYCLE's mission

SCYCLE's objectives

SCYCLE fosters solutions-oriented dialogue, cooperation, and consensus. With-in this context, SCYCLE:

- Conducts research on eco-structuring to create sustainable societies

- Develops interdisciplinary and multi-stakeholder public-private partnerships

- Assists governments in developing e-waste legislation and standards

- Is responsible for education, training, and capacity development

- Facilitates and disseminates practical, science-based recommendations to the United Nations and its agencies, governments, scholars, industries, and the public

As detailed across the following pages, SCYCLE's work exists across partner-ship initiatives, trainings and education, quantification and statistics, environ-mental crime, waste management systems, resources, and social dimensions.

is to promote sustainable societies. The activities of the unique UNU/UNITAR Programme focus on the development of sustainable production, consumption, and disposal patterns for electrical and electronic equipment (EEE), as well as for other ubiquitous goods such as batteries, automobiles, plastics, etc. As such, SCYCLE (Sustainable Cycles) leads global e-waste discussions and trainings, advancing sustainable e-waste management strategies based on life-cycle and circular thinking.

is to enable societies to reduce the environmental load of production – inclu-ding but not limited to the disposal of electrical and electronic equipment – to sustainable levels through independent, comprehensive, and practical research and training that provide facts for more thorough policy development and decision-making.

Partnership Initiatives

SCYCLE and the UN value partnerships and coalitions, recognising them to be key in combating e-waste.

The resulting innovation's four main approaches to dealing with the e-waste issue are:

1. Processing obsolete electronics in industrialised countries, but exporting reusable computers and components

2. Processing obsolete electronics in industrialised countries under strict environmental and occupational health standards

3. Designing toxic materials out of computers while designing in ease of dismantling/reuse

4. Implementing import and export bans

The initiative was begun for developing a number of stakeholder task forces dedicated to exploring specific aspects of the e-waste problem and for tackling the four main approaches to dealing with the issue, as outlined above. These task forces collaborate internally and meet to exchange information.

At the 2004 Electronics Goes Green conference in Berlin, a number of stakeholders from international organisations, academia, industry, business, governments, and civil society agreed on these principles, laying the ground for the Solving the E-waste Problem (StEP) Initiative. The StEP Initiative was formally launched in 2007 at the UN Secretariat in New York and functions as part of UNU till 2018.

Via the ZEF European Focal Point, the ISP Operating Unit, and, ultimately, SCYCLE, UNU exclusively steered the global, public-private StEP Initiative with cofounder Ruediger Kuehr as its Executive Secretary until 2018. At its peak, StEP had upwards of 100 members from every continent. Major high-tech manufacturers – including Hewlett-Packard, Microsoft, Dell, Ericsson, Philips, and Cisco Systems – partnered with the UN and with governmental, NGO, and academic institutions, as well as with recycling/refurbishing companies. Basic goals of StEP included: standardising recycling processes globally to harvest valuable components in electrical and electronic scrap (e-scrap), extending the life of products and markets for reuse, and harmonising world legislative and policy approaches to e-scrap.

The StEP Initiative

The work on **Computers and the Environment** inspired Eric Williams and Ruediger Kuehr of UNU, Klaus Hieronymi of Hewlett-Packard, and Axel Schneider of Promotionteam to develop an initiative for assessing ways of addressing the environmental impacts of end-of-life electronics recycling. The attempt was to create a global community of practice that shares knowledge on e-waste recycling worldwide, thus developing a clear vision for effective solutions to the problem that respects each region's specific situation and paves the way toward implementation.

step
solving the e-waste problem

Under UNU's leadership, StEP became a global trailblazer addressing the quickly-growing e-waste challenge, pushing government, companies, researchers, and civil society to prioritise addressing it.

Through 2018, StEP published 20 white and green papers on key topics such as e-waste take-back system design, definition of e-waste, standards for collection, necessary prevention measures, transboundary movements, etc. Remaining members sought to institutionalise StEP, which successfully shifted from SCYCLE's leadership to become an association under Austrian law in 2018.

UN E-Waste

On 21 March 2018, the most e-waste-focused organisations in the UN system signed **a letter of intent** paving the way for the coordination and collaboration of UN system-wide support for e-waste management. Signatory organisations included UNEP, ITU, UNU, ILO, ITC, the Basel Convention, UNITAR, UNIDO, and UN-Habitat.

The letter's signing stems from the work of the Environmental Management Group which supported the coordination of UN organisations to promote system-wide action and collaboration in the area of e-waste. Through the initiative of the UNU Rector Malone and SCYCLE, the EMG created an issue management group on e-waste.

The coalition's goals are to:

- Support countries in reducing and managing WEEE, with the aim of creating jobs while protecting workers, human health, and the environment.

- Strengthen the capacity of countries to formulate and implement integrated WEEE management policies and practical measures.

- Create synergies and add value to existing programmes, partnerships, and projects by avoiding duplication of resources and efforts. UN entities should 'deliver as one'.

- Increase awareness and engagement of key WEEE stakeholders at the global, regional, national, and local levels.

- Support the development of a circular economy of e-products, using existing international expertise.

- Prevent illegal trafficking of WEEE via transboundary movements, ensuring that such movement is carried out in accordance with international requirements. Promote opportunities for non-state actors (for example, industry) to be part of the solution on WEEE challenges.

Education and training are also key to combating e-waste, and UNU and SCYCLE have led the way in terms of education and trainings for professionals, researchers, and statisticians around the world.

Trainings and Education

E-waste Academies

From the start of UNU's e-waste-related work at the turn of the century, it was clear that existing understanding of this complex waste stream is limited. So, UNU initiated the development of E-waste Summer Schools, which later became the **E-waste Academies,** providing tailored and targeted training for the following stake-holder groups:

- The E-waste Academy for Managers **(EWAM)** for small- and mediumsized enterprises and policy-makers

- The E-waste Academy for Scientists **(EWAS)** for young researchers

- The Business Boot Camp **(BBC)** for entre-preneurs developing an e-waste business

EWAM focuses on policy development and e-waste system design and is intended for policy-makers, government officials, and representatives of small enterprises in e-waste refurbishment and recycling. The group provides a platform for open discussions and exchange of best practices and expert feedback.

EWAS gathers young researchers from around the world who work to solve the e-waste problem from varying disciplinary perspectives. EWAS is intended to help doctoral candidates develop key skills for young researchers and create a global network of e-waste scholars.

BBC is geared specifically to help entre-preneurs in developing and emerging countries with an existing e-waste-related start-up business develop the necessary skills and knowledge. The boot camp enables participants to connect to investor networks and helps European recyclers extend their business opportunities; it also supports the development and setting up of environmentally and commercially sound e-waste management solutions.

The first-ever EWAM took place in 2012 in Ghana, followed by events in El Salvador, Kenya, Tanzania, Thailand, and Costa Rica. The first EWAS events took place in summer 2009 in the Netherlands and Belgium, and many more events have since taken place – in Switzerland, China, etc. BBC is still in development, but the first successful boot camp took place in 2018 in Berlin.

The first-ever EWAM took place in 2012

www.ewasteacademy.org

E-waste Statistics Trainings

Since 2017, building on the Global E-waste Statistics Partnership's successes...

Since 2017, building on the Global E-waste Statistics Partnership's successes (outlined in the following section), SCYCLE's e-waste statistics trainings have focused on providing statisticians from National Statistical Offices and experts from selected Ministries of Environment (or equivalent institutions) with detailed expertise relating to e-waste statistics.
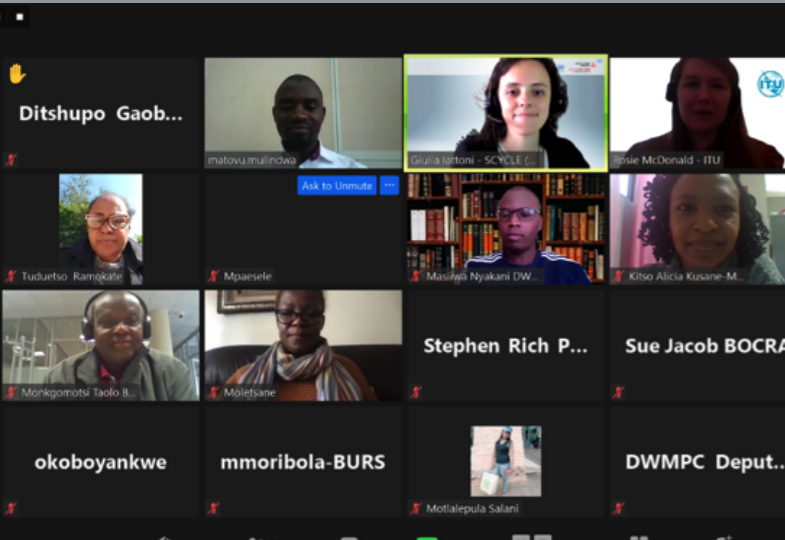
SCYCLE's e-waste statistics trainings exist mostly as workshops. Participants are provided with Excel tools and comprehensive guidelines that assist them in the compilation of internationally comparable e-waste statistics. At the end of SCYCLE's workshops, the statisticians and experts acquire the necessary knowledge to compile national e-waste statistics, perform regular updates, and track development over time.
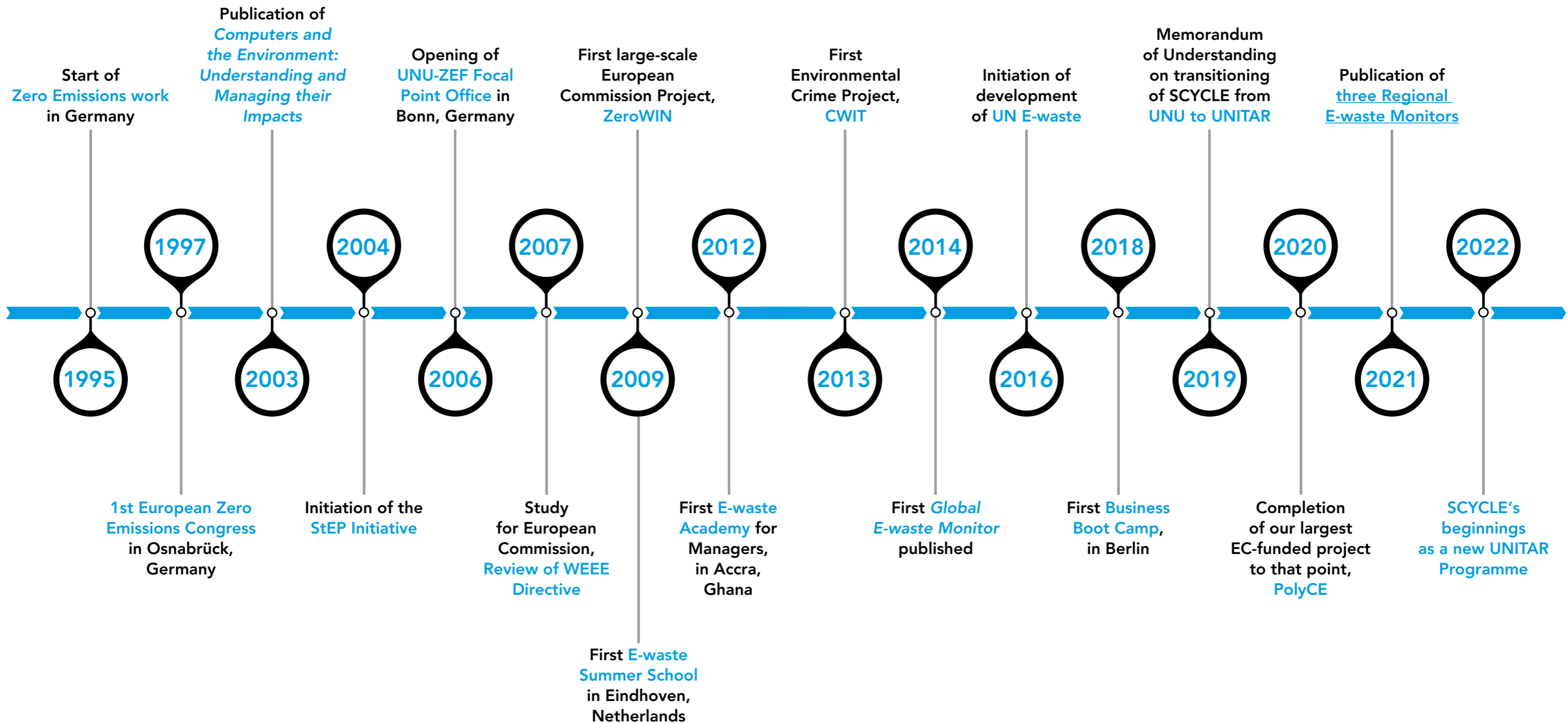
The enhanced knowledge and understanding allows the individuals to identify gaps and deficiencies in environmental data and contribute to the production of regular, accurate, and reliable e-waste statistics that can allow developing indicators and accounts relevant to policy-making and SDG-monitoring.

SCYCLE has conducted more than 50 regional capacity-building workshops in East Africa, Latin America, Eastern Europe, the Arabian States, and the CIS countries since 2017. To date, more than 1,400 professionals have been trained, with SCYCLE workshops taking place in more than 65 countries around the world. During the COVID-19 pandemic, SCYCLE conducted online e-waste statistics training, successfully continuing to build e-waste statistics capacity.
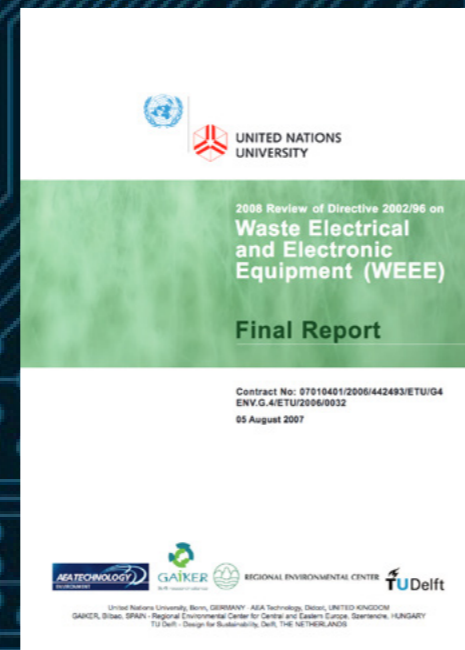
Historic Milestones Relating to SCYCLE

Start of Zero Emissions work in Germany
1997
1995 — 1st European Zero Emissions Congress in Osnabrück, Germany

Publication of *Computers and the Environment: Understanding and Managing their Impacts*
2004
2003 — Initiation of the StEP Initiative

Opening of UNU-ZEF Focal Point Office in Bonn, Germany
2007
2006 — Study for European Commission, Review of WEEE Directive

First large-scale European Commission Project, ZeroWIN
2012
2009 — First E-waste Academy for Managers, in Accra, Ghana

First E-waste Summer School in Eindhoven, Netherlands

First Environmental Crime Project, CWIT
2014
2013 — First *Global E-waste Monitor* published

Initiation of development of UN E-waste
2018
2016 — First Business Boot Camp, in Berlin

Memorandum of Understanding on transitioning of SCYCLE from UNU to UNITAR
2020
2019 — Completion of our largest EC-funded project to that point, PolyCE

Publication of three Regional E-waste Monitors
2022
2021 — SCYCLE's beginnings as a new UNITAR Programme

The WEEE Directive Review

In 2006, UNU's growing e-waste team was awarded a study: *the 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE)*.

UNITED NATIONS UNIVERSITY

2008 Review of Directive 2002/96 on
Waste Electrical and Electronic Equipment (WEEE)

Final Report

Contract No: 07010401/2006/442493/ETU/G4
ENV.G.4/ETU/2006/0032
05 August 2007

United Nations University, Bonn, GERMANY · AEA Technology, Didcot, UNITED KINGDOM
GAIKER, Bilbao, SPAIN · Regional Environmental Center for Central and Eastern Europe, Szentendre, HUNGARY
TU Delft - Design for Sustainability, Delft, THE NETHERLANDS

Contributions to Legislation and Standards

The objective of the Commission's study was to complete the information needed to inform an analysis of options for review of the Directive and to provide that analysis. The information and analysis were used as the main content of a future impact appraisal of options for review of the Directive. The study's objective was to thoroughly evaluate the impacts, efficacy, and efficiency of the Directive from an environmental, economic, and social perspective by analysing the collection and treatment of various WEEE categories.

The study – led by Jaco Huisman (UNU) and jointly performed with AEA Technology, Gaiker, The Regional Environmental Centre for Central and Eastern Europe, and TU Delft – drew significant attention not only from the decision makers in Brussels, but also among the various stakeholders and stakeholder groups around the world; the study also facilitated the development of WEEE Directive Recast.

Related studies on WEEE directed by the European Commission include: the *Study on WEEE Collection Rates of Waste Electrical and Electronic Equipment (WEEE)* **(2014)** and the *Study on WEEE recovery targets, preparation for re-use targets and on the method for calculation of the recovery targets* (2015).

Development of Standards for Collection, Transport, and Treatment of E-waste

SCYCLE contributed to the development of the WEEELABEX standard in 2008 and 2009 under coordination of the WEEE Forum. This standard was the base for the current EU EN50625 series of standards, which are regarded as globally leading standards.

SCYCLE has also been involved in the **CEWASTE Project** (2018-2021), setting up requirements for the collection and treatment of e-waste containing critical raw materials to enable their recycling, including a verification and certification system.

CEWASTE
Voluntary certification scheme for waste treatment

Support for the European Commission for the Implementation of Waste Legislation

In 2019, SCYCLE joined a framework contract with the European Commission for supporting the Commission in the implementation of EU waste legislation. The consortium under this contract is led by BIO Innovation Services. Under this contract, SCYCLE has, since 2020, been reviewing exemptions from the substance restrictions of Directives 2011/65/EU (RoHS Directive) and 2000/53 EC (End-of-Life of Vehicles Directive).

Quantification & Statistics

Quantification of data and compilation and analysis of statistics comprise a key foundation for understanding and combating the e-waste challenge at the global level.

## Global E-waste Statistics Partnership

The International Telecommunication Union (ITU), SCYCLE, and the International Solid Waste Association (ISWA) joined forces to create the **Global E-waste Statistics Partnership** (GESP), which was founded in 2017. Its main objectives are to improve and collect worldwide e-waste statistics in an internationally standardised way. The Partnership also increases visibility on the importance of tracking e waste and facilitates capacity-building workshops.

In 2017, the GESP co-published the *Global E-waste Monitor 2017* – a series initiated by SCYCLE in 2014 – which, in its **third edition** (2020), shows a continued global growth in the generation of E-waste. In addition to publishing the *Global E-waste Monitor*, one of the GESP's main deliverables is the interactive website: **www.ewastemonitor.info**.

The site displays national, regional, and global data and links to reference material and upcoming work. This has made the website a one-stop shop for e-waste-related information.
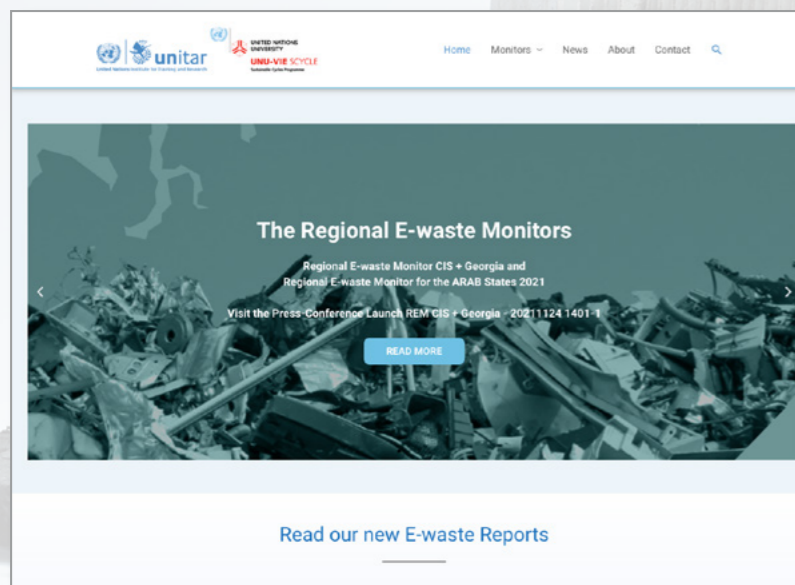
Flagship Publications

Monitoring e-waste quantities and flows is essential for evaluating developments over time and for setting and assessing targets toward a sustainable society and circular economy. The development of a recycling infrastructure, sound policies, and legal instruments are more efficiently implemented on the basis of sound e-waste data. Without a global, regional, and national picture of e-waste, the true nature of e-waste challenges includes collection and recycling rates, national and regional countermeasures, and transboundary movements, and illegal shipments can sometimes also be incomprehensible.

So, with input from international researchers and experts, SCYCLE is authoring studies known as **e-waste monitors** – publications at the global, regional, and national levels for addressing the respective e-waste situations.

1. Global E-Waste Monitors

First initiated by SCYCLE in 2014, three *Global E-waste Monitors* (GEMs) have been published thus far (2014, 2017, and 2020). The GEMs introduce the wider public to the global e-waste challenge, explaining how it currently fits into international efforts to reach the UN's 17 **Sustainable Development Goals** (SDGs) and discussing how to create a circular economy and sustainable societies. We also encourage decision-makers to increase their activities to measure and monitor e-waste by using and adopting SCYCLE's internationally recognised methodological framework in collaboration with the Partnership on Measuring ICT for Development.

The *Global E-waste Monitors* are among UNU's, UNITAR's, and ITU's most popular publications. The *Global E-waste Monitor 2020* has been downloaded more than 45,000 times and received media coverage in nearly 100 countries and more than 30 languages, with an estimated global reach (in terms of population) of 4.5 billion people.

2. Regional E-waste Monitors

Applying the same methodology, the *Regional E-waste Monitors* (REMs) allow for analysing the e-waste situation in a specific global region in greater depth. The REMs provide substantially more information on e-waste, policies and legislations, key-stakeholders, projects, and shipments in the region; they also include recommendations for how to improve the situation.

So far, SCYCLE has covered the **European Union**, **East Asia**, the **Commonwealth of Independent States**, **Latin America**, and **Arab States** in regional monitors and strives not only to continually update existing REMs but to analyse remaining global regions in future REMs as well.
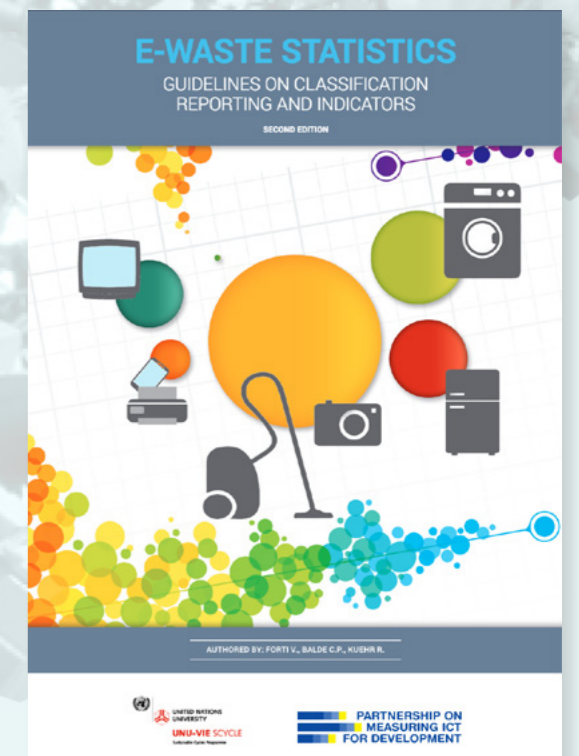
3. National E-Waste Monitors

The *National E-waste Monitors* (NEMs) provide the highest level of detail for the e-waste situation in a country. This detailed knowledge is important for monitoring the situation at the country level and developing appropriate countermeasures in an internationally comparable manner. Thus, these studies have special interest by the respective compliance schemes and environmental agencies assigned to deal with the e-waste issue. But they also provide first-hand information to municipalities often in charge of waste management, customs and policy, recyclers, and producers (among others) as key players in e-waste treatment. SCYCLE has authored or co-authored NEMs for the **Netherlands, Belgium, France, Switzerland, Ireland, Romania, Italy, and other countries.**

E-waste Statistics Guidelines

In order to improve comparability between countries, SCYCLE has proposed a sound measurement framework that integrates available statistical data and non-statistical data sources into e-waste statistics. The framework captures e-waste's most important elements and is relevant to all countries gathering data and compiling statistics on e-waste. Indicators can be constructed from the framework – providing a useful overview of the size of a country's market for electronic and electrical products, as well as the country's e-waste generated and e-waste collection performance – and serve as a resource for policymaking.

The EU has followed the measurement framework's concepts, which have resulted in the official adoption of the common methodology to track the collection and recycling target for article 7 in the EU WEEE Directive. As well, the Organisation for Economic Co-operation and Development (OECD), the United Nations Statistics Division (UNSD), the United Nations Environment Programme (UNEP), and the United Nations Economic Commisson for Europe (UNECE) are currently using the measurement framework globally for monitoring e-waste in the Sustainable Development Goals.

Environmental Crime

**CWIT
DOTCOM Waste
WasteForce
STRIKE**

DOTCOM Waste project: Field trip of SCYCLE team – inspection of containers at the Port of Bari, Italy

WasteForce project: Face-to-face training workshop in Lisbon, Portugal

Over the past decade, SCYCLE has focused on preventing and combating environmental and waste crime, analysing the illicit transboundary movements of various waste streams (including e-waste, plastics, ELVs, and mercury waste), and combating the modus operandi of criminal and corporate organisations.

SCYCLE's main work in this area includes applied research – i.e. strategic risk analysis on waste flows, criminal actors, emerging waste streams, and trends – training needs assessment, and capacity building in law enforcement. A set of training tools has been produced under the umbrella of EC-funded projects such as **CWIT**, **DOTCOM Waste**, **WasteForce**, and the ongoing **STRIKE** project.

The training materials (compiled as a result of the background research), interviews, focus groups with the stakeholders, and the analsis of case law provided by the end users have been used in a number of training activities, both face-to-face and online. Over the years, SCYCLE has organised a number of multi-agency and multidisciplinary training sessions – for inspectors, investigators, and prosecutors that deal with waste crime, both at the EU and internationally – as well as ad-hoc webinars.

SCYCLE is part of an extensive network focused on combating environmental crime that includes national authorities, international organisations, academic actors, and agencies involved in multilateral cooperation. SCYCLE has recently been integrating its expertise on statistics in the waste crime research area, developing a methodology for quantifying and estimating future flows of illicit waste as a way of strengthening intelligence and investigation activities in the enforcement chain.

Projects relating to combating environmental crime include STRIKE, WasteForce, and DOTCOM Waste.

Person in the Port Project

Person in the Port Project

Lagos, Nigeria

step solving the e-waste problem

ASSESSING IMPORT OF USED ELECTRICAL AND ELECTRONIC EQUIPMENT INTO NIGERIA

PERSON IN THE PORT PROJECT

CO-AUTHORED BY

UNITED NATIONS UNIVERSITY

UNU-VIE SCYCLE
Sustainable Cycles Programme

FINANCED BY

Federal Ministry for Economic Cooperation and Development

EPA United States Environmental Protection Agency

A two-year study (2015-2016) on used electrical and electronic equipment (UEEE) transported to Nigeria (mostly from European ports) revealed an ongoing, 'severe' problem of non-compliance with international and national rules governing such shipments. The report concluded the first-ever long-term study of containers and vehicles in a known destination country for UEEE and WEEE, including a review of import documents. It was conducted in two Nigerian ports in Lagos under the Person in the Port (PiP) project, implemented by the Basel Convention Coordination Centre for the Africa Region (BCCC-Africa) and UNU, as part of the StEP Initiative. The study showed that at least 15,600 metric tonnes of non-functional UEEE is imported into Nigeria every year. UEEE containing hazardous substances, such as mercury and (H)CFCs, are among the products with the highest non-functionality rates and the highest import volumes. And nearly all importers or agents are Nigerians, of whom 80% are located in Lagos's metropolitan area.

Though the international shipments of e-waste still comprise a staggering issue, the related research and trainings performed are limited; as such, the Person in the Port Project was a lighthouse project and concept for combating the problem.
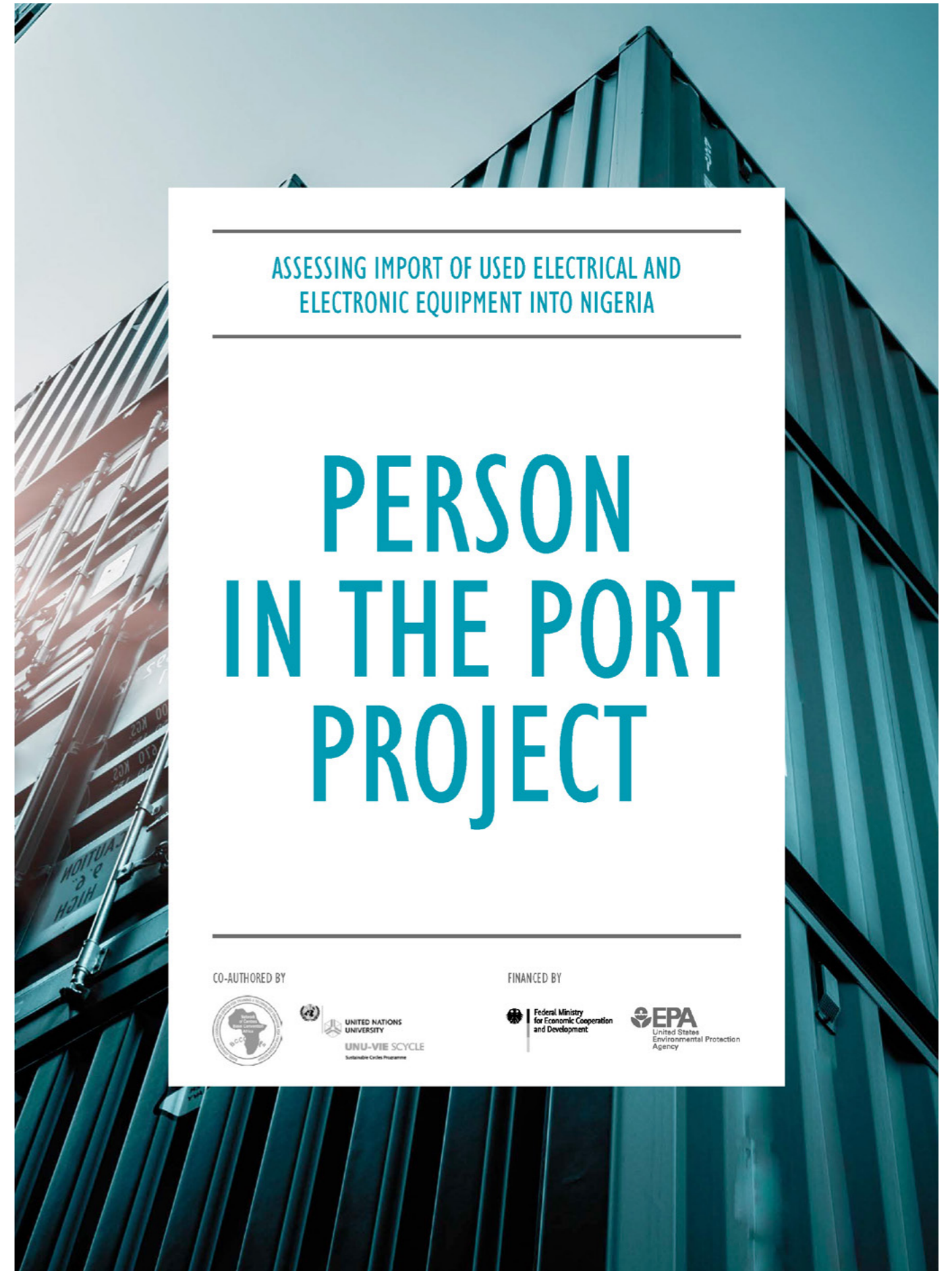
Waste Management Systems

Several studies have been coordinated for managing waste, both in Europe and internationally.

targeted policy recommendations supporting the development of industrial networks in practice. This includes a thorough policy analysis, stakeholder consultation, and synthesis of the results from case studies. Specifically, the stake-holder consultation has shown that there still seems to be a general skepticism in industry regarding industrial networking and its underlying principle of exchanging by-products, energy, water, materials, and production waste.

However, the results from the case studies – which looked, for example, at defining technical requirements for redesigning existing photovoltaic systems in Spain and at establishing a resource-efficient construction network in the UK, Germany, and Portugal – showed that all case studies can achieve a 30%+ reduction in greenhouse gas emissions and 70%+ overall reuse/recycling of waste by successfully engaging in an industrial network.

SCYCLE also works to address issues relating to production, usage, and disposal of other ubiquitous goods, from batteries to vehicles, plastics to mercury.

EwaMP Ethiopia Project

The EwaMP Ethiopia Project is an international coordination and consultancy for UNIDO within the E-waste Management Project in Ethiopia that is focused on establishing an e-waste management system in the country. The project included a study on possibilities for selling e-waste parts dismantled in Ethiopia on local and international markets; the study included guidelines and background on optimum preparation of these parts for maximising their market value.

WEEE Flows

The WEEE Flows project provided well-evidenced information and recommendations for the European Commission and Member State policymakers about the challenges in meeting the

e-waste collection targets for 2019, as well as the status of implementing the WEEE Directive 2012/19/EU.

Towards Zero Waste in Industrial Networks (ZeroWIN)

ZeroWIN was a five-year-long project for developing effective strategies for waste prevention through industrial networks. Industrial networks exchange by-products, energy, water, and materials in such a way that waste from one industry becomes raw material for another. The ZeroWIN project tested these networks through 10 industry case studies in the automotive, construction, electronics, and photovoltaic industries. The project was funded by the European Commission under its 7th Research Framework Programme. SCYCLE led Work Package 8 of the ZeroWIN project, which focused on providing
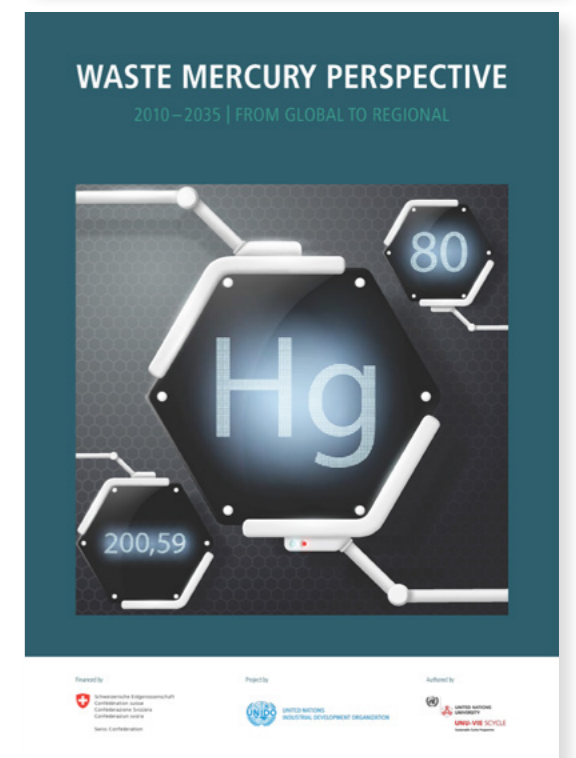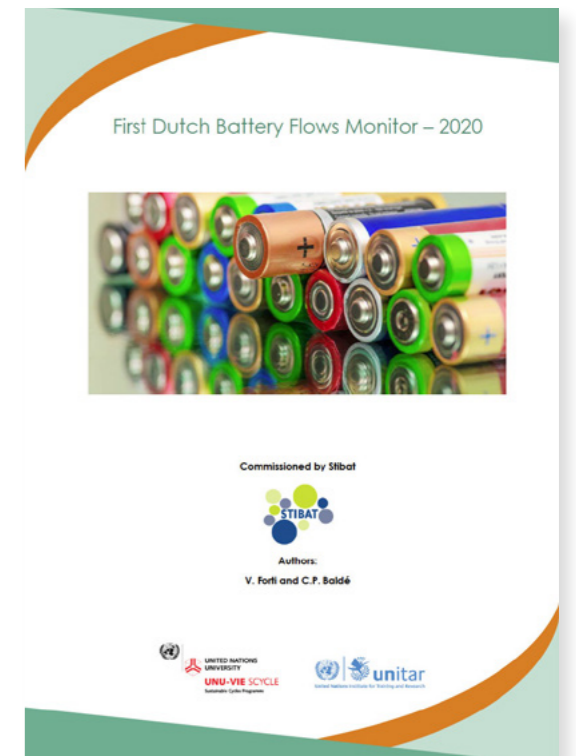
Batteries

Various SCYCLE projects, such as a methodology for the identification of unit-to-weight conversion factors for rechargeable batteries, provide well-evi-denced quantitative information on portable battery flows in the Netherlands. SCYCLE is also in the development stages of preparing both Global and Regional Batteries Monitors.

Mercury

A desk study researched the annual mercury waste volume produced in the various UN regions, including estimation of the volume for the next 10-20 years and a breakdown at the sub-regional level.

Waste Statistics

Under the auspices of the Conference of European Statisticians, UNU co-led the Taskforce of Measuring Waste Statistics, which led to a new framework on waste statistics that will be applied at the global level.

First Dutch Battery Flows Monitor – 2020

Commissioned by Stibat

Authors: V. Forti and C.P. Baldé

WASTE MERCURY PERSPECTIVE

2010–2035 | FROM GLOBAL TO REGIONAL

Resources

SCYCLE has been involved in developing various resources furthering sustainability, including projects and briefs.

Post-Consumer High-tech Recycled Polymers for a Circular Economy (PolyCE)

The **PolyCE** Project assessed feasibility of circular plastics' supply and value chain and elaboration on a harmonised set of technical requirements addressing the entire value chain; the project also developed a grading system for recycled plastics according to their material properties and final application suitability. PolyCE assisted in strengthening the market for recycled plastics through an online platform integrating multiple plastic grades. In parallel, the technical and economic feasibility, as well as environmental benefits of using recycled plastics, were validated in several electronics demonstrators. PolyCE also provided guidelines for designing new electronics products with recycled plastics.

Optimising quality of information in Raw Materials data collection across Europe (ORAMA)

The development of an EU knowledgebase on primary and secondary raw materials, begun by a series of European-funded projects and known as **ORAMA**, addressed specific challenges relating to data availability, geographical coverage, accessibility, standardisation, harmonisation, interoperability, quality, and thematic coverage in Member States. ORAMA also analysed data collection methods and recommendations from past and ongoing projects to identify best practices, develop practical guidelines, and provide training to meet specific needs. These actions demonstrated how to improve datasets for mineral occurrences, minerals intelligence data, and economic, technical, environmental, and social data for prim-ary and secondary raw materials.

The ProSUM Projekt

The Prospecting Secondary raw materials in the Urban mine and Mining wastes (**ProSUM**) project established a European network of expertise on secondary sources of critical raw materials (CRMs), which are vital to today's

high-tech society. The **ProSUM** Project directly supported the European Innovation Partnership (EIP) on Raw Materials and its Strategic Implementation Plan calling for the creation of a European raw materials knowledge base. Data on primary and secondary raw materials are available in Europe but are scattered across a variety of institutions, including government agencies, universities, NGOs, and industry. By establishing an EU Information Network (EUIN), the project coordinated efforts to collect secondary CRM data and collate maps of stocks and flows for materials and products of the '**urban mine**'.

The focus was on the particularly relevant sources for secondary CRMs: electrical and electronic equipment, vehicles, batteries, and mining tailings. The project constructed a comprehensive inventory identifying, quantifying, and mapping CRM stocks and flows at national and regional levels across Europe. Via a user-friendly, open-access **Urban Mine Knowledge Data Platform (EU-UMKDP)**, ProSUM communicates the results online and combines them with primary raw materials data from the ongoing **Minerals4EU** project.

To maintain and expand the EU-UMKDP in the future, ProSUM provides update protocols, standards, and recommendations for additional statistics and improved reporting on CRMs in required waste flows. The ProSUM Project began in 2015 and was satisfactorily completed in 2017.
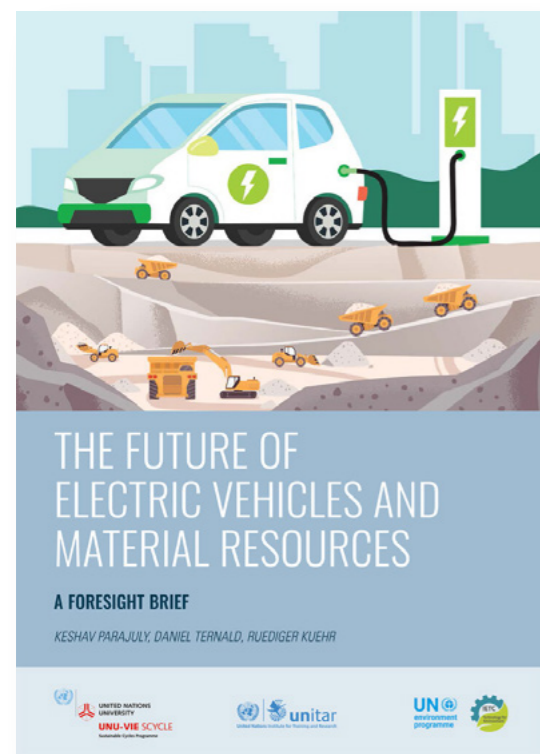
The Future of Electric Vehicles and Material Resources

A Foresight Brief developed in 2020 by SCYCLE and **UNEP-IETC** provides a snapshot of the recent developments in the electric vehicles (EV) sector. The report, *The Future of Electric Vehicles and Material Resources*, highlights major challenges and opportunities in the mainstreaming of EVs and in ensuring a sustainable supply of material resources with a focus on the end-of-life (EoL) management of EV batteries.

Social Dimensions

SCYCLE also conducts research on social dimensions in the production, usage, and disposal of ubiquitous goods – often an insufficiently addressed area. Governments and industries have taken action to facilitate a circular system for electronics. But these initiatives are often focused on techno-economic solutions, such as improving product designs and introducing new business models. These initiatives are frequently ineffective, primarily because they fail to consider the behavioural aspects of everyday consumers.

We are therefore exploring behavioural theories and intervention models, as well as their relevance to the circular economy in the context of electrical and electronic products. Furthermore, we aim to identify challenges and opportunities for facilitating a more circular system for the electronics sector and the related policy implications. Our goal is to address the research gaps by designing intervention strategies to promote more circular behaviours among consumers.

Related publications include: 1. K. Parajuly, C. Fitzpatrick, O. Muldoon, R. Kuehr. *Behavioral change for the circular economy: A review with focus on electronic waste management in the EU*. United Nations University and University of Limerick (2020). **2.** K. Parajuly, C. Fitzpatrick. *Understanding the Impacts of Transboundary Waste Shipment Policies: The Case of Plastic and Electronic Waste*. United Nations University and University of Limerick (2020). **3.** Parajuly, K., Kuehr, R., Awasthi, A. K., Fitzpatrick, C., Lepawsky, J., Smith E., Widmer, R., Zeng, X. *Future E-Waste Scenarios*, StEP Initiative, 2019.

SCYCLE's Past, Present, and Future

The SCYCLE Team

A uniquely expertise-driven and impassioned team, under keen leadership, has helped to facilitate the many forms of progress outlined herein. The SCYCLE team is key to SCYCLE's continued success. Ruediger Kuehr started the development of SCYCLE c. 2000, following significant time at the UNU head-quarters in Tokyo in the late 1990s. The SCYCLE team-building started in 2003 with Mathias Weiss working alongside Ruediger Kuehr. Weiss was succeeded by Mark Drenhaus and Claudia Luepschen, who assisted substantially in developing the StEP Initiative and in developing the Bonn office.

For many years, Jaco Huisman spearheaded the team in quantification and policy development and Federico Magalini steered the European Commission-related work. Deepali Sinha Khetriwal was key in developing the E-waste Academies. And without the administrative support of Wesley Crock, Sunghee Choi, and Romona Anton, SCYCLE would not have achieved its many successes.

In 2021, SCYCLE's core team consists of the following individuals:

Dr. Ruediger Kuehr, Director

Elena D'Angelo, Research Associate

Susan van den Brink, Research Associate

Dr. Kees Baldé, Senior Programme Officer

Elise Veermersch, Research Associate

Giulia Iattoni, Programme Associate

Dr. Otmar Deubzer, Scientific Advisor

Vanessa Forti, Programme Associate

Dr. Keshav Parajuly, PostDoc & Visiting Scholar

Vittoria Luda di Cortemiglia, Project Manager

Michelle Wagner, Research Associate

Madan Kantharaj, Administrative Programme Coordinator

Supervision

SCYCLE developed over more than 20 years under the supervision of four UNU Rectors and eight Vice Rectors:

UNU Rectors

- Prof. Heitor Gurgulino de Souza (Brazil) (1987-1997)
- Prof. Hans J. A. van Ginkel (Netherlands) (1997-2007)
- Prof. Konrad Osterwalder (Switzerland) (2007-2013)
- Dr. David M. Malone (Canada) (2013-)

UNU Vice Rectors

- Prof. Takashi Inoguchi (Japan), Senior Vice-Rector (1995-1997)
- Prof. Motoyuki Suzuki (Japan), Vice-Rector (1998-2003)
- Prof. Itaru Yasui (Japan), Vice-Rector (2003-2007)
- Prof. Kazuhiko Takeuchi (Japan), Senior Vice Rector (2008-2016)
- Prof. Jakob Rhyner (Switzerland), Vice Rector in Europe (2010-2018)
- Mr. Sebastian von Einsiedel (Germany), Vice Rector in Europe (2018-2019)
- Prof. Dirk Messner (Germany), Vice Rector in Europe a.i. (2019)
- Prof. Shen Xiaomeng (China), Vice Rector (2020-)

Special UNU supporters of SCYCLE include:

- Dr. Juha I. Uitto, Senior Academic Officer, UNU-ESD (1994-1999)
- Dr. Libor Jansky, Senior Academic Programme Officer, UNU-ESD (1999-2005)
- Dr. Kazuhiko Takemoto, Director UNU-IAS (2011-2015)
- Dr. Zita Sebesvari, Officer in Charge UNU-EHS/-ViE (2020)

Transitioning to UNITAR

SCYCLE continues to undergo exciting developments as it moves into the future. Beginning January 2022, SCYCLE will be merged with the United Nations Institute for Training and Research (UNITAR) and will be a full-fledged programme under the UNITAR Division for Planet.

unitar
United Nations Institute for Training and Research

SCYCLE's Origins
& Milestones

A History, 1994-2021

UNITED NATIONS
UNIVERSITY

UNU-VIE SCYCLE

Sustainable Cycles Programme

unitar

United Nations Institute for Training and Research