Going Green
CARE INNOVATION 2023

Conference Program & Abstract Book

Towards a Circular Economy

8th International Symposium and Environmental Exhibition

An event to discuss future strategies, meet your clients and form strategic partnerships

May 9-11, 2023
Parkhotel Schönbrunn
Vienna, Austria

CARE ELECTRONICS

EcoDesign

EGG ELECTRONICS GOES GREEN

International Program Committee

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Miquel Ballester, Fairphone
Todd Brady, Intel
Gianluca Brotto, Electrolux
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Katrin Mueller, Siemens
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CARE Electronics

Advances in electronics have revolutionized the way in which we live and do business. However, today's technological advance and mass consumption has a subsequent impact on the global environment. CARE Electronics (= Comprehensive Approach for the Recycling and Eco-efficiency of Electronics) is a strategic initiative to understand the international and national implications of sustainability for the electr(on)ics industry in the future.
CARE Electronics is an independent, industrial R&D network with members from large and small companies and research organisations.

CARE Electronics

- forecasts products, technologies, services & societal expectations
- identifies and researches strategic issues
- provides a platform for dialogue with government, business, academia and society,
- initiates and supports a series of projects, which deliver sustainable solutions.

Message from the Chair

On behalf of the International Program Committee and the Organisers it is a pleasure to welcome you to the **Going Green – CARE INNOVATION 2023** conference and to Vienna.

With this three-days event we celebrate 25 years of CARE INNOVATION conferences in Vienna, Austria, always alternating with Electronics Goes Green in Berlin, Germany.

Going Green – CARE INNOVATION 2023 will provide a platform to discuss how the electronics and other innovative industries, science and politics approach the global environmental and social challenges.

An exciting Conference Program will be offered including important and wide-ranging contributions. They cover state-of-the-art research results that address contemporary problems and provide new insights on our path *Towards a Circular Economy*.

To accelerate the networking between the participants, an extensive social program has been organized. It includes a Reception by the Mayor of Vienna in the magnificent, historical state rooms of the Viennese Town Hall and a Conference Dinner at a typical Viennese *Heuriger*.

Vienna – the bridge between East and West in the past and even more today – has been selected as the conference location to find synergies between economy and ecology.

I hope that in addition to attending the Technical Program, you will find time to explore and enjoy Vienna – the world famous metropolis of music, art and culture – and if possible extend your stay to include a relaxing and memorable holiday.

I would like to express my appreciation to all the sponsors, workshop organizers, authors, session chairs, panelists, exhibitors and all participants for contributing to the success of the Conference and I am immensely grateful to the International Program Committee and my Organization Team for making this unique event possible.

Program at a Glance

Monday, May 8, 2023

17.00 – 19.00	Registration		
14.00 – 17.30	iNEMI Workshop		

Tuesday, May 9, 2023

09.00 – 18.00	Registration		
10.30 – 11.45	Opening and Keynote Presentation		
11.45 – 13.00	Sustainability – the way forward in the automotive sector		
14.00 – 16.00	Market-driven Developments	WEEE Management	Environmental exhibition
16.30 – 19.00	Towards Sustainability	Efficient recovery processes of Precious Metals from European end of life resources with novel technologies	
19.30	Dinner at Viennese Heuriger		

Wednesday, May 10, 2023

08.00 – 18.00	Registration		
08.30 – 10.30	Circular Product Design and New Business Models	Workshop: From recyclability to circularity assessment – Methods, Metrics and Monitoring	Environmental exhibition
11.00 – 13.00	Green Deal – Connecting the dots of EU legislation initiatives and its impact to corporate compliance programs	Plastics Recycling	
14.00 – 16.00	Legislation Updates	Advanced Recycling Technologies	
16.30 – 18.30	Information Management (Digital Product Passport)	3R and Automated Dismantling	
20.00	Reception by the Mayor of Vienna in the City Hall		

Thursday, May 11, 2023

08.00 – 14.00	Registration		
08.30 – 10.30	Life Cycle Assessment	Interdisciplinary team up to escape the rare earth trap	Environmental exhibition
11.00 – 13.00	Towards Circularity	Challenges in e-waste recycling in the Global South	
14.00 – 16.00	Sustainability Assessment	Resource Management	
16.00 – 17.00	Closing Session		

Online (pre-recorded) Sessions

How can ICT enable Circular Economy Business Models?	Circular Economy in practice in the Electric and Electronic sector	Paving the way for innovative Circular Economy products and services in the electronic and automotive sectors: Lessons learned and way forward

Going Green – CARE INNOVATION 2023

May 9 – 11, 2023
Parkhotel Schönbrunn, Vienna (Austria)

Monday, May 8, 2023

17.00 – 19.00	Registration (Parkhotel Schönbrunn, 1130 Vienna, Hietzinger Hauptstraße 10-14)

Tuesday, May 9, 2023

09.00 – 18.00	Registration (Parkhotel Schönbrunn, 1130 Vienna, Hietzinger Hauptstraße 10-14)
10.30 – 13.00	**Opening and Keynote Presentation** (Room Österreich & Ungarn) Chair: B. Kopacek, SAT, AT
10.30 – 11.45	**Welcome and Opening** B. Kopacek, Conference Chair **NTT's Challenges in Space, Environment and Energy to Realize a Resilient Society** Y. Maeda, NTT Space Environment and Energy Laboratories, JP
11.45 – 13.00	**Sustainability – the way forward in the automotive sector** (Room Österreich & Ungarn) powered by EIT Manufacturing Chair: J. Hunschofsky, EIT Manufacturing East, AT
	Welcome Speech J. Hunschofsky, EIT Manufacturing East, AT **Expert panel discussion: Sustainability – the way forward in the automotive sector** A. Pernas Contin, SEAT CODE, ES E. Haberschreck, MAGNA STEYR Fahrzeugtechnik, AT F. Kehr, Mercuri Urval, DK M. Abuteir, TTTech, AT **Tech Impulse Talks by technology providers** J. Valente, AZITEK, PT J. Nyvang, STILRIDE, SE H. Yin, TEGnology, DK
13.00 – 14.00	**Lunch Break**

Tuesday, May 9, 2023

	Room Österreich	Room Ungarn
	Market-driven Developments Chair: F. Mullany, iNEMI, US	**WEEE Management** Chair: C. Slijkhuis, MGG Recycling, AT
14.00 – 16.00	**A study on environmental impact assessment in a radical future pioneered by ICT** X. Zhang, NTT Space Environment and Energy Laboratories, JP **Metrics for Energy Efficiency of Data Centres** H.-P. Siderius, Netherlands Enterprise Agency, NL **Sustainability and circularity of electric vehicles' battery electronics: design, function and composition study** L. Talens Peiro, Autonomous Univ. of Barcelona, ES **Definition, classification, and mapping of pervasive electronic products** H. Steiner, A. Jandric, S. Salhofer, Univ. of Natural Resources and Life Sciences, AT; C. Zafiu, H. Böni, EMPA, CH **Improved sales forecasting methods for new-released products and a support model for additional production decisions using forecasting** H. Kanagaki, K. Tanaka, Univ. of Tokyo, JP **Deutsche Telekom – Sustainable scoring of tender responses – a practical case study** J. Spear, epi Consulting, UK	**Electronics recycling and the Circular Economy: A dream or a reality?** M. Costache, GreenWEEE International, RO **Mainstreaming the Costs of Going Circular - Bottlenecks and Solutions** P. Singhal, S. Sehgal, S. Aggarwal, Karo Sambhav, IN **Electronics Recycling, the ultimate & challenging step in its circularity - an end-processor´s viewpoint** S. Art, Umicore, BE **Interim findings from multiple innovation projects in the WEEE sector** P. Leroy, WEEE Forum, BE **A new approach to recycling and recovery rates to promote circularity and sustainability in WEEE recycling** A. Wehrli, K. Remmen, EMPA, CH **Governance of the Circular Economy for the electronics industry: What role do e-waste management standards play?** M. Toal, KU Leuven, BE
16.00 – 16.30	**Coffee Break**	

Tuesday, May 9, 2023

<table>
<tr><th rowspan="3">16.30 – 19.00</th><th>Room Österreich</th><th>Room Ungarn</th></tr>
<tr><th>Towards Sustainability
Chair: P. Leroy, WEEE Forum, BE</th><th>Efficient recovery processes of Precious Metals from European end of life resources with novel technologies - Technologies developed by 4 EU funded projects PEACOC & FIREFLY, Pheidias & Lydia
Chair: N. Akil, PNO Innovation, BE</th></tr>
<tr><td>Connecting ICT with nature - a holistic view on target setting and impact assessment
J. Isoaho, P. Tanskanen, S. Kallio, A. Rezaki, Nokia, FI

Epson Dry Fiber Technology: Circularity in Paper and Textile Recycling
H. Ohlsson, Epson, DE

New assessment method for corporate value including ESG issues toward well-being society
M. Hara, NTT Space Environment and Energy Laboratories, JP

REthinking Electronics
C. Dehmey, SERI (Sustainable Electronics Recycling International), US

Deglobalization or how can manufacturing regionalization not only boost Circular Economy but also mitigate risk of product shortage?
P. Carminati, Lexmark, CH

Ecotron: Creating value with sustainable electronics
C. Rentrop, TNO, NL

Decreasing environmental footprint with printed electronics
L. Hakola, VTT, FI

Reducing electronic waste created by printed circuit boards through additive printing onto novel substrates
J. Kettle, S. Zhang, R. Mukherjee, K. Grant, Univ. of Glasgow, UK</td><td>PEACOC (HORIZON Europe) - “Pre-commercial pilot for the efficient recovery of Precious Metals from European end of life resources with novel low-cost technologies”:

Objectives and concept of the PEACOC project
N. Akil, PNO Innovation, BE

Unlocking value in low-grade PCBAs
P. Andre, Univ. of Liege, BE

Innovative separation technologies for WEEE valorization
F. Di Maio, TU Delft, NL

Microwave assisted leaching of PGMs from EoL autocatalysts.
F. Kukurugya, Vito, BE

Gas-Diffusion Electrocrystallization
L.F. Leon, Vito, BE

Selective recovery of PGMs from spent autocatalyst using deep eutectic solvents
M. Ibanez, Tecnalia, ES

FIREFLY (HORIZON Europe) - “Flexible, predictive and renewable electricity powered electrochemical toolbox for a sustainable transition of the catalyst-based European chemical industry”
S. Thayumanasundaram, Vito, BE

The Pheidias and Lydia EIT Raw Materials Upscaling projects: “Recovering Platinum Group Metals from Automotive Catalysts and Fuel Cells/Electrolyzers using a Universal Hydrometallurgical Process”
I. Yakoumis, MONOLITHOS Catalysts & Recycling, GR</td></tr>
<tr><td>19.30</td><td colspan="2">Dinner at typical Viennese Heuriger</td></tr>
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Wednesday, May 10, 2023

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<tr><td rowspan="3">08.30 – 10.30</td><td>Room Österreich</td><td>Room Ungarn</td></tr>
<tr><td>Circular Product Design and New Business Models
Chair: P. Singhal, Karo Sambhav, IN</td><td>Workshop: From recyclability to circularity assessment – Methods, Metrics and Monitoring
Chair: V. S. Rotter, TU Berlin, DE</td></tr>
<tr><td>Designing for short or long cycles? - A discussion on life-span trade-offs in circular product design
A. Mestre, Univ. of Lisbon, PT
R. C. Savaskan, Susdesign - Sustainable Design Research & Consultancy, PT

Barriers to the circular design of invasive laparoscopic instruments with electronic components
T. Hoveling, J. Faludi, C.A. Bakker, TU Delft, NL

Modular smartphones – potentials and limits
M. Proske, E. Poppe, N. Nissen, M. Schneider-Ramelow, Fraunhofer IZM, DE

Product-as-a-service for critical raw materials: challenges, enablers, and needed research
T. Sakao, E. Sundin, J. Vogt Duberg, Linköping Univ., SE
P. Golinska-Dawson, TU Poznan, PL
J. Hidalgo Crespo, A. Riel, Univ. Grenoble Alps, FR
J. Peeters, KU Leuven, BE
A. Green, D. Cassidy, Compliance and Risks, IE
F. Mathieux, European Commission JRC Ispra, IT

When are Connectivity PSS feasible in Infrastructure ICT?
K. Grobe, S. Jansen, ADVA Optical Networking, DE

The road toward a resource-efficient economy needs key resources and new roles for orchestrating the implementation of a sustainable business model: the case of small household equipment sharing
H. Kooli-Chabane, Univ. Paris Nanterre, FR
O. Pialot, Toulon Univ., FR
C. Kuszla, OMNES Education, FR</td><td>The interactive workshop aims at collecting perspectives on the status of measuring circular performance of products, identifying use-cases, opportunities, and challenges as well as barriers. The input provided during the workshop will feed into the development of a data management and monitoring framework for future assessments.

Lead questions:
• What is the status and pathway of harmonization and standardization for the assessment product’s circular performance?
• What metrics help to guide circular product design and product life-cycle management?
• What are data requirements and data management strategies to assess circular product performance?

K. Remmen, A. Wehrli, M. Gasser, EMPA, CH

V. S. Rotter, V. Wewer, TU Berlin, DE</td></tr>
<tr><td>10.30 – 11.00</td><td colspan="2">Coffee Break</td></tr>
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Wednesday, May 10, 2023

	Room Österreich	Room Ungarn
	Green Deal – Connecting the dots of EU legislation initiatives and its impact to corporate compliance programs Chair: J. Johnson, Cisco Systems, US	**Plastics Recycling** Chair: C. Handwerker, Purdue University, US
11.00 – 13.00	**Regulatory instruments – holistic view on Taxonomy, Eco-crime, Market Surveillance, CS3D, CSRD but also material compliance under e.g. REACH** M. Schneider, Assent Compliance, DE **EU policy making mechanism** S. Andrews, Assent Compliance, UK **Compliance management 2.0 - managing through the regulatory jungle** M. Piotrowski, Assent Compliance, DE **Outlook DPP, ESPR, Batteries, etc – regulatory demands at the horizon affecting supply chain engagement** M. Schneider, S. Fortunato-Esbach, Assent Compliance, DE **Understanding your new legal obligations and potential liabilities under emerging EU Digital Themed regulations which defines a wide range of software applications as products, which require an unprecedented amount of new data collection to meet the numerous reporting obligations** R. Takhar, Assent Compliance, UK S. Fortunato-Esbach, Assent Compliance, DE	**Adding new plastic types to the list of plastics recycled from WEEE** C. Slijkhuis, MGG Polymers, AT **Challenges and opportunities using innovative technologies for recycling plastics containing flame retardants** M. Schlummer, L. Strobl, S. Wagner, Fraunhofer IVV, DE L. Tange, ICL-IP, NL **Advanced sorting classification models based on Raman spectroscopy and chemometrics to improve WEEE plastics recycling** A. Pocheville, I. Uria, P. Espana, O. Salas, GAIKER, ES T. Caris, A.R.C. Neiva, Coolrec, NL **Automated spectroscopic analysis of non-valorised plastics from WEEE** S. Van den Eynde, S. Waumans, T. Dimas, D.J. Diaz-Romero, I. Zaplana, J. Peeters, KU Leuven, BE **Alkaline sulfide leaching of antimony bearing fire resistant plastics - Closing the loop between plastics and minerals** M. Simao, Univ. Liege, BE **Circular Economy Concepts for Fuel Cells** S. Grieger, J. Oehl, Fraunhofer IWKS, DE F. Sauer, MAIREC Edelmetallgesellschaft, DE K. Kramer, Electrocycling, DE T. Wannemacher, Proton Motor Fuel Cell, DE E. Schulte, KLEIN Anlagenbau, DE
13.00 – 14.00	**Lunch**	

Wednesday, May 10, 2023

	Room Österreich	Room Ungarn
	Legislation Updates Chair: T. Fischer, Landbell, DE	**Advanced Recycling Technologies** Chair: J. Visser, Mirec, NL
14.00 – 16.00	**The Challenges of Regulating the Circular Economy for EU/EEA Member States: Between pioneering and wait-and-see approaches** E. Maitre-Ekern, Univ. of Oslo, NO **Market Surveillance and the Ecodesign Directive** R.D. Huulgaard, A.M. Bundgaard, Aalborg Univ., DK **Convergence: How Circular Economy, Sustainability and Climate Change are influencing Compliance paradigms and driving organizational change in the Corporate Technology sector** J. Johnson, Cisco Systems, US **Emerging EPR type policies in North America region and how does it compare with EU legislation** F.P. Mosciatti, Landbell Group, DE **America Invented the Throwaway Economy, and Right to Repair Is Trying to Fix It** E. Chamberlain, K. Wiens, iFixit, US **Mexico Circular Economy and Waste Management updates** E. Perrier, ORBIS Compliance, US **Evolution of EPR for Enabling Circularity** P. Singhal, S. Sehgal, S. Aggarwal, Karo Sambhav, IN	**EC funded Project ALR4000 - Preliminary outcomes and case study** L. O´Donoghue, Votechnik, IE **NEW-RE Neodymium and Rare Earth from Waste Recycling** V. Corbellini, A. Accili, L. Campadello, Erion, IT **A short comparative overview on the precious metals hydrometallurgical recovery from spent autocatalyst and spent photovoltaic panels** P. Romano, I. Birloaga, F. Veglio, Univ. of L´Aquila, IT **The emergence of NdFeB-magnet recycling from an innovation systems perspective** M. Koese, S. van Nielen, R. Kleijn, Leiden Univ., NL **Comparison of the analytical methods ICP-MS and XRF for the analysis of PC motherboards** A. Jandric, C. Zafiu, F. Part, S. Salhofer, Univ. of Natural Resources and Life Sciences, AT **Improving the recycling of embedded electronics in passenger vehicles (Project EVA II)** M. Capelli, C. Marmy, EMPA, CH
16.00 – 16.30	**Coffee Break**	

Wednesday, May 10, 2023

	Room Österreich	Room Ungarn
	Information Management (Digital Product Passport) Chair: K. Grobe, ADVA Optical Networking, DE	**3R and Automated Dismantling** Chair: M. Matsumoto, AIST, JP
16.30 – 18.30	**Circular Economy and Sustainable Product Development Case Study: A Digital Portal for product information delivery and potential for Product Digital Passport** D. Poon, Cisco Systems, US **Digital Product Passports: the key to end gadget hoarding and ensure responsibility** R. Koppelaar, EcoWise Ekodenge, UK **As less as possible and as much as necessary: WEEE recycler´s information needs and technical requirements in context of the digital product passport** E. Wagner, E. Poppe, M. Schneider-Ramelow, Fraunhofer IZM, DE D. Baumgärtel, M. Malzacher, I. Budde, Circular Fashion, DE **Proof of concept for traceability of recycled gold using a blockchain-based digital product passport (DPP)** F. Hänel, A. Dymek, R. Rainoldi, M. Dos Santos, iPoint-systems, DE **Data exchange platform for a green, detectable and directly recyclable lithium-ion battery** F. Hänel, M. Dos Santos, iPoint-systems, DE **Digital Twin for Circular Economy - Literature Review and Concept Presentation** J. Mügge, Fraunhofer IPK, DE	**How did Product Value Retention Processes Perform During Supply Chain Disruption?** D. Fitzsimons, European Remanufacturing Council, BE **Mobile phone reuse businesses in Japan and an estimation of the their environmental load reduction effects** M. Matsumoto, AIST, JP C. Clemm, Fraunhofer IZM, DE H. Awazu, J. Tominaga, NewsedTech, JP **Design and evaluation of a robotic unscrewing station for the non-destructive semi-automated disassembly of EoL electronics** M. Piessens, M. Abdelbaky, C. Zhou, Y. Wu, B. Engelen, D. De Marelle, J. Peeters, KU Leuven, BE **A Cobot Based Application For PCB Disassembly** L. Gandini, P. Rosa, S. Terzi, Politecnico di Milano, IT **Computer vision based defect detection in color and depth images for electrical and electronic equipment (EEE) reuse: a case study for laptops** Y. Wu, C. Zhou, W. Sterkens, M. Piessens, D. J. Diaz-Romero, W. Dewulf, J. Peeters, KU Leuven, BE **Envisioning the potential reuse and repair of electric vehicle batteries** L. Talens Peiro, M. Sanclemente Crespo, X. Gabarrell i Durany, Autonomous Univ. of Barcelona, ES M. Fervorari, M. Colledani, Politecnico di Milano, IT F. Alarte, B. Alvarez, ENVIROBAT, ES
20.00	**Reception by the Mayor of Vienna at the City Hall** (Wappensaal, **Rathaus**, entrance: 1010 Vienna, Lichtenfelsgasse 2, Feststiege 2)	

Thursday, May 11, 2023

08.00 – 14.00	Registration (Parkhotel Schönbrunn, 1130 Vienna, Hietzinger Hauptstraße 10-14)	
	Room Österreich	**Room Ungarn**
	Life Cycle Assessment Chair: M. Hara, NTT Space Environment and Energy Laboratories, JP	**Interdisciplinary team up to escape the rare earth trap** Chair: A. Bachmaier, Austrian Academy of Sciences, AT
08.30 – 10.30	**Design aspects and environmental impacts of using Wide Gap based semiconductor technology in consumer chargers** S. Glaser, Vienna Univ. of Technology, AT A. Diaz, ECODESIGN company engineering @ management consultancy, AT M. Makoschitz, AIT Austrian Institute of Technology, AT **Comparative LCA of a pluggable SIM card and an eSIM: Methodological considerations when assessing digital services** D. Sanchez, K. Schischke, Fraunhofer IZM, DE T. Szolkovy, Giesecke+Devrient Mobile Security, DE **Leasing and Refurbishment of Electronics: A Sustainable Business Model? Two LCA case studies of consumer electronics** P. Murphy, Logitech, IE B. Schwartze, M. Stock, M. Ajie, iPoint systems, DE **Methodological Concepts for Calculation of Avoided Impacts of ICT Systems** A. Andrae, Huawei Technologies, SE **The carbon footprint of an Internet-of-things system** N. Ullrich, F. Piontek, C. Herrmann, Sphera Solutions, DE **Simplified-LCA-based optimum EEE lifetime analysis** K. Grobe, ADVA Optical Networking, DE	**Nanostructured magnets with tuneable properties by severe plastic deformation** A. Bachmaier, L. Weissitsch, S. Wurster, Erich Schmid Institute of Materials Science of the Austrian Academy of Sciences, AT **Bulk rare earth free permanent magnets** L. Weissitsch, S. Wurster, A. Bachmaier, Erich Schmid Institute of Materials Science of the Austrian Academy of Sciences, AT **Electric machine design and system-level optimization for reduced rare-earth material usage** E. Marth, G. Bramerdorfer, Johannes Kepler Univ. Linz, AT **Lose your bearings and magnets: Possibilities to reduce magnetic material in the life cycle of bearingless disposables** W. Gruber, Johannes Kepler Univ. Linz, AT **The potential of new magnet grades for a more sustainable electric machine production** A. Bachmaier, G. Bramerdorfer, E. Faigen, M. Benner, E. Marth, A. Kovacs, M. Gusenbauer, T. Schrefl, Erich Schmid Institute of Materials Science of the Austrian Academy of Sciences, AT **Multiscaling strategies in computational magnet design** M. Gusenbauer, H. Özelt, A. Kovacs, J. Fischbacher, T. Schrefl, CD Lab for magnet design through physics informed machine learning, AT **Global production networks of rare earth permanent magnets: From lab-based research, development and innovation to industrial-scale production** E. Faigen, M. Benner, A. Bachmaier, G. Bramerdorfer, E. Marth, A. Kovacs, M. Gusenbauer, T. Schrefl, Univ. of Vienna, AT
10.30 – 11.00	**Coffee Break**	

Thursday, May 11, 2023

	Room Österreich	Room Ungarn
	Towards Circularity Chair: C. Dehmey, SERI, US	**Challenges in e-waste recycling in the Global South** Chair: A. Jandric, StEP Initaitive, AT
11.00 – 13.00	**Silicon as a carbon-free reductant: Yellow phosphorus production from phosphoric acid** A. Okamoto, S. Kashiwakura, S. Kosai, E. Yamasue, H. Ohtake, Ritsumeikan Univ. JP **Ecodesign as a business element for ensuring future competitiveness and changing business model** A.X. Saeidiani-Rädler, S. Rädler, AC Rädler Umwelttechnik, AT **Characteristic Analysis of Elderly Workers for Human-Centric Production Systems** K. Hayakawa, Y. Kishita, S. Kondoh, S. Shirafuji, Y. Umeda, Univ. of Tokyo, JP M. Nishio, Toyota, JP **DISTENDER EU project: Integrating mitigation and adaptation strategies to climate change risks at local level through a participatory process** R. San Jose, J.L. Perez-Camano, TU Madrid, ES **Developing Architecture-based scenario design methodology for platform-enabled circular economy business: A case study of waste collection system** M. Tsunezawa, T. Hirota, K. Sugiyama, K. Tasaka, KDDI Research, JP Y. Kishita, Y. Umeda, Univ. of Tokyo, JP **Study on P2P power simulation of battery deployment for urban decarbonization** K. Sato, T. Obara, K. Tanaka, Univ. of Tokyo, JP	**Opening remarks and StEP introduction** **20 years of international cooperation in WEEE management in developing and emerging economies** Heinz Böni, EMPA, CH **Challenges in e-waste management in the Caribbean** S. Salhofer, Univ. of Natural Resources and Life Sciences, AT **Challenges of e-waste management in India** P. Singhal, Karo Sambhav, IN **Waste compensation as a financing mechanism for electronic waste collection in Africa** R. Smit, Closing the Loop, NL **Implementation of co-working space concept for incorporation of e-waste informal sector** D. A. Wehrli, A Social Impact Startup, CH
13.00 – 14.00	**Lunch**	

Thursday, May 11, 2023

	Room Österreich	Room Ungarn
	Sustainability Assessment Chair: C. Herrmann, Sphera Solutions, DE	**Resource Management** Chair: D. Fitzsimons, European Remanufacturing Council, BE
14.00 – 16.00	**Miniaturization in infrastructure ICT equipment - environment vs. functionality** K. Grobe, ADVA Optical Networking, DE **ICs as drivers of ICT carbon footprint: an approach to more accurate die size assessment** M. Billaud, D. Sanchez, M. Proske, C. Clemm, L. Stobbe, N. Nissen, M. Schneider-Ramelow, Fraunhofer IZM, DE **Comparison of Additive and Conventional Manufacturing in the context of LCA** T. Heckmann, O. Vetter, C. Herrmann, A. Saraev, Sphera Solutions, DE **Sobriety, Efficiency and End-users´ Satisfaction; An innovative Pathway to Green Growth and "Sobriety by Design" rationalized business processes: an illustration of through the Artificial Intelligence sector** C. Gans Combe, Inseec Business School, FR J. Yun Jun Kim, W. Mouhali, A. Baccar, Y. Rakotondratsimba, ECE Paris Graduate School of Engineering, FR **Evaluating energy consumption in distributed recycling system for plastic wastes using home-based 3-D printers in Japan** H. Mizoguchi, S. Kosai, S. Kashiwakura, E. Yamasue, Ritsumeikan Univ., JP	**Promoting circular economy through resource-efficient electronic recycling across Latin America** A. Cueva, C. Hernandez, S. Alhilali, K. Ives-Keeler, B. Casanas, UNIDO United Nations Industrial Development Organization, AT **Toolbox - Transforming Informal E-Waste Scrap Yards into Formalized Recycling Sites in Ghana** M. Spitzbart, C. Stolzenberg, V. Johannes, R. Baldwin Asiedu, F. Acheampong, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), DE **Joint Association for CSR (JAC) – Status of goals, targets and practical action towards Net Zero and Circularity in the global telecommunications supply chain** K. Taylor, epi Consulting, UK **Scenario analysis towards sustainable lithium-ion battery circulation system** R. Sun, Y. Kishita, F. Tao, Y. Umeda, Univ. of Tokyo, JP C. Scheller, S. Blömeke, T. Spengler, C. Herrmann, TU Braunschweig, DE **Finnish perspective on nickel in EV batteries lifecycle - system dynamic modelling of demand, waste generation, and effect of R-strategies** P. Slotte, E. Pohjalainen, J. Hanski, P. Kivikytö-Reponen, VTT, FI
16.00 – 17.00	**Closing Session** (Room Österreich)	

Online (pre-recorded) Sessions

How can ICT enable Circular Economy Business Models?	Circular Economy in practice in the Electric and Electronic sector	Paving the way for innovative Circular Economy products and services in the electronic and automotive sectors: Lessons learned and way forward
Introduction to C-SERVEES V. Vert Belenguer, AIMPLAS, ES **Introduction to the Circular Economy Business Models in C-SERVEES** M. Osmani, Loughborough Univ., UK **The C-SERVEES digital information exchange platform** T. Oberhauser, Circularise, NL **How will the Circularise web application enhance value chain transparency?** T. Oberhauser, Circularise, NL **How will the Soltel platform foster public information exchange?** J.C. Liebana, Soltel, ES **How will the RINA-C logistics tool improve circularity?** S. Fozza, RINA-C, IT **Implementation of the C-SERVEES Circular Economy Business Models in the demonstrations** A.I. Diaz, GAIKER, ES	**Introduction to C-SERVEES** F. Aparicio, AIMPLAS, ES **Introduction to the Circular Economy Business Models in C-SERVEES** M. Osmani, Loughborough Univ., UK **Implementation of the C-SERVEES Circular Economy Business Models in the demonstrations** A.I. Diaz, GAIKER, ES **The TV and washing machines demonstrations** Ö. Ünlüer, Arcelik, TR **Lessons learnt from the ALM (monitoring equipment used in telecoms) demonstration** K. Grobe, ADVA Optical Networking, DE **The printer and toner cartridges demonstration** P. Carminati, Lexmark, CH **Results of the optimization and validation (technical, economic, environmental performance) of the demonstrations** F. Aparicio, AIMPLAS, ES	**General animation & Welcome** I. Carracedo Fernandez, AIMPLAS, ES **An introduction to C-SERVEES Circular Economy Business Models' Innovation & PSS demonstration** M. Osmani, Loughborough Univ., UK **How ICT tools can help in implementing Circular Economy Business Models?** T. Oberhauser, Circularise, NL J.C. Liebana, Soltel, ES S. Fozza, RINA-C, IT **Panel discussion "How did the C-SERVEES Circular Economy Business Models work in practice? Demonstrations on TVs, ALMs, printers and toner cartridges and washing machines"** M. Liberati, PNO Innovation, IT; A.I. Diaz, GAIKER, ES; Ö. Ünlüer, Arcelik, TR; K. Grobe, ADVA Optical Networking, DE; P. Carminati, Lexmark, CH; H.-C. Eberl, European Commission DG RTD **Panel discussion "Resource-efficient Circular Product-Service Systems (ReCiPSS) and how large-scale implementation of circular manufacturing systems in the electronics / white goods and automotive sectors can lead to a stable circular economy in the EU"** A. Farazee, KTH Royal Institute of Technology, SE; A. Mihelic, Gorenje, SI; M. Wagner, C-ECO, DE; R. de Bruijckere, Signifikant, SE; H.-C. Eberl, European Commission DG RTD **Panel discussion "Policy-relevant results and insights for the Circular Economy, jointly provided by C-SERVEES and ReCiPSS"** F. Rosasco, RINA-C, IT; J. Koller, Fraunhofer IPA, DE; Ö. Ünlüer, Arcelik, TR; M. Furkel, Lexmark, BE; A. Mihelic, Gorenje, SI; M. Wagner, C-ECO, DE; O. Chassais, European Commission DG ENV

Evening Program

Dinner at a Viennese Heuriger

Tuesday, May 9, 2023, 19.30

The real Viennese "Heurige" or wine taverns. Numerous songs have been dedicated to them; they have served as a backdrop for many films. However, in the legendary comfortable atmosphere, they primarily offer the Viennese and their guests entertainment, fine Viennese wines and the fitting culinary accompaniment. A place in which to feel good, in which everyone is warmly welcome. The real Viennese Heurige, in which only Viennese wines are served, are identified by a bunch of pine branches and by the word "Ausg'steckt" written on a board, which simultaneously shows when the tavern is open.

However, the word "Heurige" does not just describe the tavern itself, but also the wine from the current vintage, which – in accordance with tradition - may be so-called until 11 November (St Martin's Day). Alongside the pleasant wine by the glass, the Viennese Heurige also offer their guests fine wines sold in "Bouteillen" (0.75 litre bottles), reflecting the richness of the variety and the special Viennese climate, and corresponding glass and tableware.

Location: Bio-Weingut und Heuriger Zahel
Entrance: 1230 Vienna, Maurer Hauptplatz 9
www.zahel.at/en/
Tram Station "Maurer Hauptplatz" (60)

Reception by the Mayor of Vienna in the City Hall

Wednesday, May 10, 2023, 20.00

The Reception by the Mayor of Vienna will take place in the Vienna City Hall, one of the most splendid landmarks amongst the numerous monumental buildings along Vienna's Ring Road. Designed by Friedrich Schmidt (1825 – 1891), it was erected between 1872 and 1883. The architecture of the Ringstraße is dominated by Historicism. The City Hall was built in Gothic style, with a tower similar to Gothic cathedrals.

Today the City Hall is the head office of Vienna's municipal administration. More than 2000 people work in the building. Visitors are stunned by the magnificent appointments of the state rooms, which frequently provide an atmospheric backdrop to various events such as concerts or balls.

Location: Wappensaal, Rathaus
Entrance: 1010 Vienna, Lichtenfelsgasse 2, Feststiege II
Tram 1, D, 71 or U2Z "Rathausplatz, Burgtheater"
Tram 2 "Rathaus"

Abstract Book

1.1. Market-driven Developments

1.1.1. A study on environmental impact assessment in a radical future pioneered by ICT

X. Zhang, NTT Space Environment and Energy Laboratories, JP

With the Covid-19 pandemic as a turning point, information and communications technology (ICT) has made great progress, especially in the last few years. ICT is playing an important role in promoting economic development and reducing environmental impact. In this research, a radical scenario about development of ICT is depicted with a long-term perspective up to 2050. In addition, the environmental impact in the created ICT scenario was predicted using a computable general equilibrium (CGE) model. From the results, the introduction of these ICTs can be expected reduce greenhouse gas (GHG) emissions by 91Mtons, about 10% of the total GHG emissions in Japan, in 2050. The largest expected effect is in the transportation sector.

1.1.2. Metrics for Energy Efficiency of Data Centres

H.-P. Siderius, Netherlands Enterprise Agency, NL

Data centers use a significant amount of energy. Policy makers and industry are looking for measures and actions to reduce energy consumption and/or CO2-emissions from data centers. This paper focuses on metrics to define and assess energy efficiency of data centers in a way that is relevant for policy makers. Because it is difficult to define and measure the performance of a data center, it suggests an approach based on avoiding energy losses in data centers, i.e. focusing on the energy not spent on delivering the performance. The power usage effectiveness (PUE) is a well-known example of such a metric but it does not capture losses in the IT equipment itself. In addition, this paper introduces the data center idle coefficient (DCIC) as a parameter to assess the losses of IT equipment, especially servers. It shows how the DCIC is calculated from data collected from the interface of a server.

1.1.3. Sustainability and circularity of electric vehicles' battery electronics: design, function and composition study

L. Talens Peiro, Autonomous Univ. of Barcelona, ES

The increasing sales of electric vehicles will inevitably lead to a greater number of batteries due to be managed after their first lifespan, after 15 years at maximum. For example, in Catalonia, the electric vehicle sales are expected to increase up to 25-fold in 2030 and 72-fold in 2040, according to the target of the Spanish Climate Change Law. To extend the battery usage and reduce the carbon footprint of the batteries it is important to assess the potential reuse of battery components. One key aspect to ensure the reuse is the analysis of the disassembly of battery components. In this paper, we present the results of the disassembly for diverse typologies of EV batteries. The batteries have been manually disassembled as part of the DigiPrime project (ID 873111) with the objective to validate the DigiPrime platform services for the support of the disassembly operations for the implementation of circular economy strategies. The method followed to assess the ability to repair, and reuse is inspired by the CEN/CENELEC standards. The results shows that even though the components do not vary considerably between battery models, there is a great diversity in the location and accessibility of some parts which affects the disassembly tasks to follow. The results also show how standards could help provide more comprehensive information about product potential for reuse and repair.

1.1.4. Definition, classification, and mapping of pervasive electronic products

H. Steiner, A. Jandric, S. Salhofer, Univ. of Natural Resources and Life Sciences, AT; C. Zafiu, H. Böni, EMPA, CH

Digitalization, rapid technological development, and falling production costs have led to the omnipresence of electronic devices in everyday life. Over the last two decades, three main trends have shaped the electronics market: electronic devices becoming smaller with increasing technological capabilities, electronics becoming more affordable, and they tend to have shorter lifespans. Consequently, the proliferation of electronic devices has also led to increasing quantities of electronic waste. Furthermore, Electronic components are increasingly added to products for aesthetic or functional purposes, such as ski boots with heating functions or board games with built-in LEDs. These product groups, where the definitional distinction between electronic products and non-electronic products is blurred, have been defines as "Pervasive Electronics". This conference contribution aims to provide a comprehensive definition and categorization of Pervasive electronics, outline a general shar of pervasive electronic products on the market, and assess the potential impacts of these products on the waste management system.

1.1.5. Improved sales forecasting methods for new-released products and a support model for additional production decisions using forecasting

H. Kanagaki, Univ. of Tokyo, JP

Inventory disposal has become a major social problem. To maintain appropriate inventory, accurate sales forecasting is necessary. This study proposes improved forecasting methods that improve the existing NM method by using pre-clustering and a regression model and a support system for additional production decisions using the proposed forecasting methods. In a case study using actual data of an apparel brand, it is confirmed that the improved NM forecasting methods improve accuracy in comparison to the existing methods. In addition, by applying the support system for additional production decisions to some actual cases, it is confirmed that the system can eliminate unnecessary additional production. The major values of this study are to present highly accurate and practical sales forecasting methods for new-released products and to show that the support system for additional production decisions using the proposed forecasting method has the potential to use practically.

1.1.6. Deutsche Telekom – Sustainable scoring of tender responses – a practical case study

J. Spear, epi Consulting, UK

Deutsche Telekom (DT) have a target of 25% reduction in supply chain emissions by 2030 and to reach Net Zero by 2040. In the area of Circular Economy, DT want to be leading the way and implementing it for all technologies and devices by 2030. Given that the supply chain represents approximately 90% of DT's carbon footprint and is critical to delivering against DT's Circular Economy goals, DT need to engage its supply chain and stimulate practical action and evaluate suppliers progress as it relates to the products and services bought by DT.

To engage the supply chain, Buyin, the Joint venture procuring on behalf of Deutsche Telekom and Orange have raised the sustainability aspect of tender evaluation to 20%. This presentation will cover the recent trial sustainability evaluation of two tender exercises, one for Fiber Optic cable and one for IP Routers and how DT and the practical considerations of how you evaluate both suppliers and products and produce a score which inputs into contract award.

1.2. WEEE Management

1.2.1. Electronics recycling and the Circular Economy: A dream or a reality?

M. Costache, GreenWEEE International, RO

"Circular economy is the future", "Circular economy is the best", "Why circular economy is the best fit for x industry?", "Transition towards circular economy" and so the list of headlines containing #circulareconomy continues. It is a trendy buzzword and thus very present in our lives.

- What is the circular economy?
- Is the circular economy something new?
- Should we look at the circular economy as the "Yin and Yang" concept?
- How and who can make it happen?

These are the questions to be answered to understand better what circular economy is and where is heading.

1.2.2. Mainstreaming the Costs of Going Circular - Bottlenecks and Solutions

P. Singhal, S. Sehgal, S. Aggarwal, Karo Sambhav, IN

This paper examines various types of costs that must be incurred for achieving material Circularity. Such costs include but are not limited to e.g. the costs of setting up and driving systems for formal collection, catalyzing consumer behavioral change, developing high-quality recycling solutions, and utilization of secondary materials in production of original or similar products. The paper also discusses how to ensure sustained & fair financing of the systems which are essential to drive circularity.

1.2.3. Electronics Recycling, the ultimate & challenging step in its circularity - an end-processor´s viewpoint

S. Art, Umicore, BE

Reality has shown so far that electronics recycling is not a commodity business. Recent years have indicated that the e-waste market is a dynamic system where one must adapt to survive. Miniaturization, device convergence, cloud computing and other new trends and technologies have brought, and will continue to bring, dramatic changes in the size, composition and complexity of devices. The overall impact of these trends has already been significant in mature markets, resulting in stabilizing or even shrinking tonnages, as well as declining/changing content of precious metals. On top of that, local and international regulations tend to become more strict for transport of e-waste. In a situation with lack of vessel space and containers, leading to changing vessel routes and with a rigid and complicated notification procedure, this may not only seem to better control the export of e-waste to developing countries, but will also harm the correct and compliant import routes of e-waste towards developed nations unnecessarily.

1.2.4. Interim findings from multiple innovation projects in the WEEE sector

P. Leroy, WEEE Forum, BE

The WEEE Forum are involved in a number of EU grant-funded projects regarding resource efficiency, critical raw materials, future availability of secondary raw materials, digital product passports, battery separation, resource information management systems, circular digital health devices and deploying recycling technologies in south-eastern Europe. All of them except one commenced in 2022. The presentation will be a moment to disseminate the interim findings arising from these innovation projects and to embed them in a narrative that enables an evaluation of WEEE legislation. More specifics regarding speakers, specific projects, themes and whether or not we need to schedule a break-out workshop, e.g. for FutuRaM, can be shared with CARE in the new year.

1.2.5. A new approach to recycling and recovery rates to promote circularity and sustainability in WEEE recycling

A. Wehrli, K. Remmen, EMPA, CH

Put simply, proper WEEE management has two main goals: Recovery of valuable materials and separation and environmentally sound recovery or disposal of pollutants. These two objectives are implemented along a chain of manual, mechanical and chemical treatment processes in which the target substances are separated and concentrated into fractions, and then recovered or disposed of. Typically, these target substances either yield an economic return and/or are pollutants or other substances that contribute to the fulfilment of requirements and guidelines.
In Switzerland, the monitoring of WEEE treatment against its goals has various weaknesses, including the fact that the current recycling and recovery rates do not provide any information on the environmental benefits of recovering the various target substances from WEEE. Hence, a new method for the evaluation of the performance of WEEE recycling

against the avoided damage and generated benefits for the environment and society is required, both at company and system levels.

1.2.6. Governance of the Circular Economy for the electronics industry: What role do e-waste management standards play?

M. Toal, KU Leuven, BE

The electronics industry is rapidly transitioning towards circular economy business models at the producer level. Yet there has been little investigation into how this shift is being managed in the businesses which handle the end-of-life of electronic products. It is important to consider the role these businesses can play in the wider circularity framework of the industry and the governance tools which shape that interaction. This research looks at the R2 standard for e-waste management, a voluntary standard which can certify electronics recycling, repair and other facilities as sustainable. The paper investigates the influence of this standard in terms of shaping the internal circular business models of facilities as well as the part it plays in the circularity of the electronics industry as a whole. Through an analysis of industry sustainability reports, facility websites, and the text of the standard, the findings indicate that the R2 standard has an impact in all four key indicators of circular transition outlined by the Ellen MacArthur Foundation.

1.3. New Technologies & Materials

1.3.1. Connecting ICT with nature - a holistic view on target setting and impact assessment

P. Tanskanen, J. Isoaho, S. Kallio, A. Rezaki, Nokia, FI

Pressure on the planet is increasing with the depletion of natural resources, e.g., global warming, geo- and biodiversity loss. The impact of human activity on nature must be considered in relation to the three areas of climate change (air), geodiversity loss (geo), and biodiversity loss (bio) as they are all strongly interlinked. Climate change is one of the main drivers of biodiversity loss, but biodiversity loss also accelerates climate change and increases vulnerability to it when nature's ability to regulate greenhouse gas emissions and protect against extreme weather decreases. Geodiversity also has strong links to climate change, as half of global emissions come from material production. These challenges for industries and society need to be managed with a common approach. Measurements are needed to set targets, act, and follow progress. Companies can utilize frameworks such as GHG protocol, SBT, ITU- L.1410 for climate action. Policies and frameworks (e.g., EU Biodiversity strategy, SBT for Nature) around biodiversity and geodiversity are being developed while they are not yet as mature as for GHG emissions. Upcoming EU regulation and related reporting standards will give more guidance on the reporting and target setting of environmental aspects. The linkage of the air, bio and geo still needs to become clearer so that the actions in one area do not counteract benefits in the other areas.

1.3.2. Epson Dry Fiber Technology: Circularity in Paper and Textile Recycling

H. Ohlsson, Epson, DE

In this paper Epson will outline the opportunities afforded by Dry Fiber Technology (DFT) in delivering circularity in both paper and textile recycling. Epson has developed new technoloty with far reaching implications for achieving in paper recycling, textile and garment production.

1.3.3. New assessment method for corporate value including ESG issues toward well-being society

M. Hara, NTT Space Environment and Energy Laboratories, JP

To move towards a more circular economy of electrical and electronic equipment (EEE), information about their material composition and design shall be more widely available. This is particularly needed in the case of printed circuit boards (PCBs) which are virtually contained in all electrical and electronic devices. The Database of SEmiconductors and other components (DoSE) merges as a new database of electronic and electrical components mainly used in PCBs. The objective of DoSE is twofold: to help quantify the amount of materials contained in PCBs to allow a better environmental impact assessment of EEE and also to help estimate the economic value of such waste stream in order to optimize the recycling processes and reduce the losses of valuable materials. This paper explains how the DoSE is being developed to provide the material composition for the PCBs and fill the current gap in the assessment of EEE.

1.3.4. REthinking Electronics

C. Dehmey, SERI (Sustainable Electronics Recycling International), US

For years, the focus has been on proper e-waste management to prevent the negative impacts of toxins when disposing of electronic equipment. While this is still important, our thinking is evolving. We want a circular economy, which requires a shift from managing e-waste to preventing it altogether. To achieve a circular economy, we need to REthink electronics. SERI´s vision is a world where there is responsible reuse and recycling everywhere and electronics become sustainable. Join SERI in exploring the ways we need REthink what we normally do to transform electronics into a circular world free of e-waste.

1.3.5. Deglobalization or how can manufacturing regionalization not only boost Circular Economy but also mitigate risk of product shortage?

P. Carminati, Lexmark, CH

Driven by multiple factors, in 2011, decision was made at Lexmark to move from a global manufacturing strategy to a more regional one for its laser cartridges in Europe
Drivers were: Need to reduce inventory, Customer service level (much lower transit time, as well as demand for locally manufactured products), Risk mitigation
Decision: was made based on Total Cost of Ownership. Considering the cost to manufacture locally as well as the freight cost, the inventory cost while goods are in transit, expediting shipments.

Challenge: make a European case competitive versus China and Mexico where labor was at least 2 to 4 times lower than in any EU countries, identify the best location and best trade off in term of freight cost and lead time
Enabler: Circular Economy
Lexmark is pioneer in its industry as it relates to Circular Economy for laser cartridges, it is remanufacturing its products for more than 25 years. It therefore developed a collection program and set remanufacturing operations, which remanufacturing was processed overseas.
The remanufacturing benefits of reusing cores (used products) regionally has been the trigger to swing the case and allow for manufacturing regionalization. Operations started in 2013 and steadily grow to now represent 75+% of the products placed on the market in Europe. The remaining products being old architecture and/or low volume products which are globally sourced. Not only this drove customer satisfaction, the site is used as a show room, but while the business case was about neutral, market conditions, year after years drove the case to be highly positive on a monetary viewpoint. On a social viewpoint, more than 400+ jobs were created, both low and high skilled jobs. On an environmental viewpoint, the CO2 emission has been drastically lowered by reducing oversee containers. All this thanks to the Circular Economy benefits which helps to swing the case.

1.3.6. Ecotron: Creating value with sustainable electronics

C. Rentrop, TNO, NL

A growing desire for continuous data collection, real time information and connectivity has resulted in increased demand for electronic functionalities that are fully integrated in everyday objects. Consumer electronics, lighting healthcare, wearable electronics, IoT and smart packaging are examples of market segments that follow this trend. However, recycling and/or dismantling of the PCB and electronics is hardly done or occurs at very well-defined conditions. As simultaneously the lifetime of such electronic products is decreasing (or are even becoming completely disposable), the environmental pressure rises exponentially, which requires dedicated climate actions to allow sustainable and responsible production and consumption of electronics.

1.3.7. Decreasing environmental footprint with printed electronics

L. Hakola, VTT, FI

Printed electronics is an additive manufacturing technology offering possibility for new types of thin, low-weight and flexible devices. From sustainability perspective it is also characterized by less energy and material use when compared to traditional electronics manufacturing processes. Another advantage is compatibility with renewable and abundant materials, such as bio based substrates. This paper reviews opportunities for decreasing environmental footprint of electronics when using manufacturing workflows based on printed electronics. A life-cycle approach by highlighting opportunities from design, raw materials, manufacturing, integration, use phase, and end-of-life management is used. A holistic evaluation for overall sustainability assessment and benchmarking of electronic products is used with case examples from wearables.

1.3.8. Reducing electronic waste created by printed circuit boards through additive printing onto novel substrates

J. Kettle, S. Zhang, R. Mukherjee, K. Grant, Univ. of Glasgow, UK

For more than 50 years, advances in electronics have revolutionized all socioeconomic sectors. Electronics underpin the digital transformation that affects all businesses, industries and value chains and are critical to delivering the UN Sustainable Development Goals. There is little doubt that the modern world will continue to rely heavily on smart technologies, and with this reliance comes a phenomenal demand for more products and energy to power such products. However, in pursuit of this goal, the industry has evolved whereby the materials and manufacturing processes are decided by the technical and economic requirements, and not sustainability, resulting in poor practices and unintended outcomes. These technologies are major greenhouse gas (GHG) emitters in households and industries, especially when one considers the Information and Communications Technologies (ICT) such as lighting, food and heating that underpin these technologies. With the threats of climate change more impactful than ever before, extensive changes need to be made to the way these new technologies are developed and consumed in order to procure a sustainable future and meet net zero targets.

1.4. Efficient recovery processes of Precious Metals from European end of life resources with novel technologies – Technologies developed by 4 EU funded projects PEACOC & FIREFLY, Pheidias & Lydia

PEACOC (Horizon Europe) – "Pre-commercial pilot for the efficient recovery of Precious Metals from European end of life resources with novel low-cost technologies:

1.4.1. Objectives and concept of the PEACOC project
N. Akil, PNO Innovation, BE

1.4.2. Unlocking value in low-grade PCBAs
P. Andre, Univ. of Liege, BE

1.4.3. Innovative separation technologies for WEEE valorization
F. Di Maio, TU Delft, NL

1.4.4. Microwave assisted leaching of PGM´s from EoL autocatalysts
F. Kukurugya, Vito, BE

1.4.5. Gas-Diffusion Electrocrystallization
L.F. Leon, Vito, BE

1.4.6. Selective recovery of PGMs from spent autocatalyst using deep eutectic solvents
M. Ibanez, Tecnalia, ES

1.4.7. FIREFLY (Horizon Europe) – "Flexible, predictive and renewable electricity powered electrochemical toolbox for a sustainable transition of the catalyst-based European chemical industry
S. Thayumanasundaram, Vito, BE

1.4.8. The Pheidias and Lydia EIT Raw Materials Upscaling projects: "Recovering Platinum Group Metals from Automotive Catalysts and Fuel Cells/Electrolyzers using a Universal Hydrometallurgical Process"
I. Yakoumis, MONOLITHOS Catalysts & Recycling, GR

2.1. Circular Product Design and New Business Models

2.1.1. Designing for short or long cycles? – A discussion on life-span trade-offs in circular product design

A. Mestre, Univ. of Lisbon, PT, R. C. Savaskan, Susdesign - Sustainable Design Research & Consultancy, PT

The circular economy has increasingly gained prominence within current political, industrial, and academic spheres, and where circular product design plays a fundamental role in the discussion of successful product and business cases representing the practical implementation of this new paradigm. Within this context, the authors developed a conceptual framework in a previous study: "Circular Product Design: A Multiple Loops Life Cycle Design Approach for the Circular Economy". Four design strategies centered upon life cycle design phases aimed at energy and material efficiency were proposed, and design guidelines presented. This paper further explores the above-mentioned approach, discussing the differences between designing for long cycles and short cycles, where there are inherent trade-offs (e.g. reduced materials use for efficiency versus greater use of materials to ensure durability, and designing products for longevity versus biodegradability at end of life) at the initial briefing phase of the design process that determine design decisions throughout the product life cycle when utilizing the circular design strategies, affecting final design characteristics, functional performance, and materials (and energy) consumption. Further research that supports designers and product developers in leading with these circular product design trade-offs is needed.

2.1.2. Barriers to the circular design of invasive laparoscopic instruments with electronic components

T. Hoveling, J. Faludi, C.A. Bakker, TU Delft, NL

Laparoscopic procedures are performed over 13 million times per year to help us prevent, diagnose and treat diseases in a minimally invasive manner. However, they make an unnecessary contribution to globally increasing (e-) waste. Practices that help devices loop back into the economy, such as reuse, remanufacturing, and recycling, seem promising but are challenging endeavors in this context. In this paper, we aimed to uncover why this is particularly challenging by exploring the barriers to these circular practices for laparoscopic instruments that more and more often contain electronic components. We did this by synthesizing data from literature and expert interviews with healthcare professionals, medical device manufacturers, decontamination experts, hospital procurement, and others. All barriers were sorted based on a thematic analysis for each different circular recovery flow, resulting in an overview of existing barriers and opportunities to overcome them.

2.1.3. Modular smartphones – potentials and limits

M. Proske, E. Poppe, N. Nissen, M. Schneider-Ramelow, Fraunhofer IZM, DE

Smartphones generate most of their environmental impact in their production phase due to the energy and resource intensive production processes of electronic components in them and at the same time very efficient, but short use phase. Service life extension is therefore an important approach to reducing the overall use of resources and the quantity of goods produced. Modular design offers potential for longer use, which would be environmentally beneficial, even when initial production impacts might be slightly increased. At the same time, there are several conflict of goals on technical level, but also from perspective of user expectations and business models. In the current market, cascade use enabled by basic modularity allowing for repair and maintenance seem to be the most efficient choice.

2.1.4. Product-as-a-service for critical raw materials: challenges, enablers, and needed research

T. Sakao, E. Sundin, J. Vogt Duberg, Linköping Univ., SE,, P.Golinska-Dawson, TU Poznan, PL, J. Hidalgp Crespo, A. Riel, Univ. Grenoble Alps, FR, J. Peeters, KU Leuven, BE, A. Green, D. Cassidy, Compliance and Risks, IE, F. Mathieux, European Commission, JRC Ispra, IT

The efficiency of using critical raw materials (CRMs) needs to be increased urgently in light of a circular economy (CE). This conference paper describes the benefits, current challenges, enablers, and needed research regarding product-as-a-service (PaaS) for CRMs in the context of a CE. In particular, it will analyze PaaS with electrical and electronic equipment (EEE) in the home appliance sector from five relevant perspectives: design, remanufacturing, recycling, costing, and regulations. Based on a literature review and analysis, important topics are documented, for instance, user-centered design, user behavior, reverse logistics, cost assessment and allocation, use of Industry 4.0 technologies, and governmental regulations. Also, the importance of systemic innovation is pointed out.

2.1.5. When are Connectivity PSS feasible in Infrastructure ICT?

K. Grobe, S. Jansen, ADVA Optical Networking, DE

In the EU Horizon 2020 project C-SERVEES, the feasibility of several PSS (product-service systems) was investigated for infrastructure ICT equipment. We compared three PSS types, 1) product sales plus maintenance services and EoL take-back, 2) product leasing incl. maintenance and take-back, and 3) service leasing: Connectivity-as-a-service (CaaS), incl. maintenance and take-back. Several ICT infrastructure products were investigated. The PSS have all been identified as commercially feasible, but the respective optimum PSS choice strongly depends on customer size and service capabilities. In addition, a remarkable finding was that as long as EoL take-back is done, no environmental difference has been identified between the three PSS.

2.1.6. The road toward a resource-efficient economy needs key resources and new roles for orchestrating the implementation of a sustainable business model: the case of small household equipment sharing

H. Kooli-Chabane, Univ. Paris Nanterre, FR, O. Pialot, Toulon Univ., FR, C. Kuszla, OMNES Education, FR

This paper contributes to overcoming the lack of empirical studies in the field of Sustainable Business Models - SBMs in the sharing economy. Our research question is: what are the influencing factors for an optimal orchestration of activities and resources to reach a SBM which successfully implements a shared Product Service System - PSS? We adopted a qualitative exploratory approach in the context of small household equipment through a French firm case study. The paper's contribution is two levels: theoretical and practical. First, we used the management control lens to developpe a methodology to identify and analyze the challenges of SBM implementation. Our analysis approach was realized at a fine-grained level through Strategic Risk Factors - SRF and Critical Success Factors – CSF. Second, our results highlighted four types of challenges to be overcome to optimize the orchestration of the value offer: (1) organizational, (2) cultural, (3) financial, and (4) governance.

2.2. Workshop: From recyclability to circularity assessment - Methods, Metrics and Monitoring

K. Remmen, A. Wehrli, M. Gasser, EMPA, CH, V. S. Rotter, V. Wewer, TU Berlin, DE

This interactive workshop aims at collecting perspectives on the current status and providing an outlook on how to measure circularity performance of products. During the workshop standards such as EN 45555 and IEC/TR 62635 will be discussed as well as identifying use-cases, opportunities, challenges and barriers [1,2]. The input provided during the workshop will feed into the development of a data management and monitoring framework for future assessments, which will support implementation of circular economy strategies to prevent waste generation by prolonging the use of products, components and embedded secondary raw materials (SRMs).

2.3. Green Deal – Connecting the dots of EU legislation initiatives and its impact to corporate compliance programs

2.3.1. Regulatory instruments – holistic view on Taxonomy, Eco-crime, Market Surveillance, CS3D, CSRD but also material compliance under e.g. REACH

M. Schneider, Assent Compliance, DE

This abstract discusses the importance of taking a holistic view of the regulatory landscape, which includes various key elements such as Taxonomy, Environmental Crime, Market Surveillance, CS3D, CSRD, ESPR, and Product Compliance. It argues that the EU Green Deal represents an industrial transformation and that several of these instruments play a crucial role in driving compliance and enforcement. The abstract notes that Taxonomy can incentivize compliant behavior in the realm of Product Compliance, and that this behavior can be transformed into Key Performance Indicators (KPI) using the means of CSRD and ESPR. Additionally, Market Surveillance and the Environmental Crimes Directive are important tools for enforcing regulations and ensuring compliance.
However, to fully realize the potential of these instruments, the abstract suggests the need for a data-driven digitization effort and the removal of data silos in the areas of product compliance and ESG. By doing so, companies can more easily demonstrate compliance and regulators can more effectively monitor and enforce regulations, ultimately leading to a more sustainable and environmentally conscious industrial landscape.

2.3.2. EU policy making mechanism

S. Andrews, Assent Compliance, UK

The EU policy making mechanism – based on the regulatory developments described in Session 1 this session will describe the typical timelines, complications, type of changes to be expected during the process etc. to establish robust regulations. Referencing experiences from the 2011 EU RoHS Directive and the work of industry groups & national surveillance authorities to give ‘real life’ examples.

2.3.3. Compliance management 2.0 - managing through the regulatory jungle

M. Piotrowski, Assent Compliance, DE

Companies face numerous challenge daily in securing their business operations and achieving sustainable growth. Regulatory obligations are just one aspect of these challenges, but the number of regulations related to Environmental, Social, and Governance (ESG) criteria and sustainable business practices is increasing rapidly. In regions like the European Union, efforts to decrease environmental impact and improve human health have resulted in initiatives like the "European Green Deal" and the "EU Circular Economy Action Plan," which raise questions about how companies will be affected and whether they have regulatory obligations to manage or benefit from these trends. Companies often have established a basic set of compliance programs to serve multiple purposes from material compliance to environmental, social and governance (ESG) obligations. As regulations continue to grow, companies need to evolve their compliance systems to ensure they can effectively manage their obligations while still focusing on their core business. This paper focuses on giving food for thought on how to build effective compliance programs. Ultimately, compliance is not their main focus, but it is crucial for long-term success.

2.3.4. Outlook DPP, ESPR, Batteries, etc – regulatory demands at the horizon affecting supply chain engagement

M. Schneider, S. Fortunato-Esbach, Assent Compliance, DE

Newly proposed EU product legislation under the EU Green Deal such as the Ecodesign for Sustainable Products Regulation and the Digital Product Passport, Batteries Regulation, and the Packaging and Packaging Waste Regulation will bring with them a host of requirements, some of them novel, and others recognizable from other EU product legislation. The data points to fulfil these requirements largely come from the supply chain. This session will look at what that means for manufacturers and their supply chains, and how manufacturers will have to rethink supply chain engagement to collect robust and reliable data in order to meet these upcoming legal requirements.

2.3.5. Understanding your new legal obligations and potential liabilities under emerging EU Digital Themed regulations which defines a wide range of software applications as products, which require an unprecedented amount of new data collection to meet the numerous reporting obligations

R. Takhar, Assent Compliance, UK, S. Fortunato-Esbach, Assent Compliance, DE

Manufacturers of physical products are faced with a vast array of different legislation, each with unique reporting obligations and liabilities. These types of product reporting obligations cover key activities from sourcing raw materials from suppliers, distribution of materials across internal facilities or external suppliers, assembly, manufacture, test, through to sales and transporting products to a given marketplace. The reporting obligations may include provisioning technical documentation and obtaining appropriate certifications. Additional measures may be required to cover any end-of-life recycling activities. In comparison, technology companies have faced much less regulatory scrutiny beyond basic data protection rules. However, new winds of change are emerging, especially in Europe where new legislative proposals are bringing more and more reporting obligations. This research paper aims to identify gaps in existing literature by comparing obligations between the physical and digital worlds.

2.4. Plastics Recycling

2.4.1. Adding new plastic types to the list of plastics recycled from WEEE

C. Slijkhuis, MGG Polymers, AT

Plastics from one category of WEEE have hardly been recycled to date, namely polymers from Large Domestic Appliances. The reason is two-fold. One the one hand Large Domestic Appliances are often shredded in car-shredders and the plastics thus get lost in the complex shredder residue fractions. Secondly, the plastics mainly consist of Polypropylene, with different types of mineral fillers, making it very hard to separate into pure polymers. Research of several years by MGG Polymers, has now resulted in 2 new plastic types that can be recovered from separately treated Large Domestic Appliances, and tests have shown that these 2 mineral-filled types of Polypropylenes can replace virgin material for similar or same applications in new white goods. Furthermore, the standards for new appliances are changing over time and this results in product development of Post-Consumer Recycled polymers, particularly regarding the Relative Thermal Index (RTI) requirements regarding strength and impact resistance.

2.4.2. Challenges and opportunities using innovative technologies for recycling plastics containing flame retardants

M. Schlummer, L. Strobl, S. Wagner, Fraunhofer IVV, DE, L. Tange, ICL-IP, NL

Today being part of a circular economy, the most preferred option for an end-of-life treatment of WEEE plastics is material recycling as it has the lowest carbon footprint. However, due to REACH and other legislation already more than 200 substances of very high concern (SVHC's) may be present in these plastics and restrict the typically used re-melting recycling process. Such SVHCs include additives that have been compliant to legislation during previous production but no longer do, i.e. so-called legacy additives. To ensure both, safe treatment of SVHC and material recycling, sorting process cascades have been established to concentrate SVHC containing plastics. For these, new solvent based purification processes are being developed to further separate polymer from the legacy additives, which finally need to be destroyed in a chemical recycling process. As such, this paper indicates how mechanical, dissolution-based recycling and pyrolysis may be combined to enable a circular economy of a complex waste stream like WEEE plastics.

2.4.3. Advanced sorting classification models based on Raman spectroscopy and chemometrics to improve WEEE plastics recycling

A. Pocheville, I. Uria, P. Espana, O. Salas, GAIKER, ES, T. Caris, A.R.C. Neiva, Coolrec, NL

Waste of Electric and Electronic Equipment (WEEE) plastics are currently treated by mechanical separation, being a large part of these plastics not recovered due to the presence of certain additives like pigments or brominated flame retardants (BFR), which make it difficult to correctly identify polymers with usual spectroscopic techniques. One of the objectives of the EU-funded Horizon 2020 project PLAST2bCLEANED is to develop an advanced sorting process to increase the recycling rates of WEEE plastics by identifying polymers in any color, including black polymers, to further enhance plastics circularity. With that aim, different classification models were developed combining Raman spectroscopy and chemometrics to improve the identification and separation of *High Impact Polystyrene* (HIPS) and *Acrylonitrile Butadiene Styrene* (ABS) fractions from WEEE streams. Classification models were assessed considering technical requirements of the WEEE plastics recycling industry and quality requirements of the end users of recycled plastics.

2.4.4. Automated spectroscopic analysis of non-valorised plastics from WEEE

S. Van den Eynde, S. Waumans, T. Dimas, D.J. Diaz-Romero, I. Zaplana, J. Peeters, KU Leuven, BE

This article presents a novel method developed for automated X-Ray Fluorescence and Fourier Transform Infrared analysis of shredded plastic waste to identify the polymer types and determine the concentrations of relevant elements such as bromine and chlorine. The purpose of the analysis is to determine the composition of plastic waste streams treated by sorting companies. The performed analysis gives operators valuable information that can be used to optimize the consecutive plastic sorting processes so that both the yield and the purity of the sorting operation can be increased. The overall goal of the method is to assist sorting companies to limit as much as possible the amount of plastic waste that goes to landfill or incineration after sorting.

2.4.5. Alkaline sulfide leaching of antimony bearing fire resistant plastics - Closing the loop between plastics and minerals

M. Simao, Univ. Liege, BE

Plastic usage in EEE and transport applications accounted for 10,9% of total plastic production in 2017, nearly 50 Mt. These plastics are often doped with antimony (Sb) to enhance their fire-resistant properties, which is a critical raw material. Disregarding it when recycling fire resistant plastics (FRPs) is therefore economically wasteful. This work employs an alkaline sulfide leaching solution to leach the Sb in FRPs, and H_2O_2 to precipitate it in an industry-ready form. The influence of NaOH and Na_2S concentration, temperature, agitation, residence time, liberation and pulp density are studied. Optimal conditions yielded 67% of Sb leaching, at 2M NaOH, and 0.26 M Na_2S, 95°C and 400 RPM, for two hours. An activation energy of 53.6 kJ/mol was obtained. This is indicative of a chemically controlled reaction, in accordance with the literature. Hydrogen peroxide addition precipitated ~100% of the antimony in 2 hours, likely in $NaSb(OH)_6$ form.

2.4.6. Circular Economy Concepts for Fuel Cells

S. Grieger, J. Oehl, Fraunhofer IWKS, DE, F. Sauer, MAIREC Edelmetallgesellschaft, DE, K. Kramer, Electrocycling, DE, T. Wannemacher, Proton Motor Fuel Cell, DE, E. Schulte, KLEIN Anlagenbau, DE

In the course of the energy transition, fuel cell applications in the transport sector become more and more mature. This development requires circular economy options to recover the material content such as precious metals as well as further strategies such as re-use and remanufacturing. In the joint project BReCycle, a verified recycling approach comprising of mechanical pre-treatment and chemical separation processes is introduced that ensures a high degree of recovery of the raw materials used and which is superior in terms of environmental compatibility and economic efficiency. Based on the knowledge gained from the investigations on recycling and recovery of stack elements, design for circularity guidelines for future generations of PEM fuel cell systems are deduced.

2.5. Legislation Updates

2.5.1. The Challenges of Regulating the Circular Economy for EU/EEA Member States: Between pioneering and wait-and-see approaches

E. Maitre-Ekern, Univ. of Oslo, NO

This paper investigates the opportunities and tensions of shared competences between EU and EU/EEA Member States in the area of sustainable product regulation and the Circular Economy. It confronts the frontrunning approach of France to the more general wait-and-see attitudes of other European countries, and discusses the benefits and risks of those approaches.

2.5.2. Market Surveillance and the Ecodesign Directive

R.D. Huulgaard, A.M. Bundgaard, Aalborg Univ., DK

The Ecodesign Directive (2009/125/EC) and its successor, the Ecodesign for Sustainable Products Regulation, play important roles in ensuring more sustainable products. The Ecodesign Directive has proven effective in reducing energy consumption and CO_2 emissions. A key aspect in ensuring the full potential of the Directive is that regulations are enforced by the authorities, which renders market surveillance imperative. 10-20% of the products entering the European market are not in compliance with the ecodesign requirements. In this article, we analyze the challenges of market surveillance focusing on three Nordic countries, by answering the research question: How are the material efficiency requirements within the Ecodesign Directive verified through market surveillance and what are the challenges and potentials of the current approach? Our results show that the current experiences with market surveillance of the adopted material efficiency requirements are limited and that there are significant synergetic effects related to effective market surveillance.

2.5.3. Convergence: How Circular Economy, Sustainability and Climate Change are influencing Compliance paradigms and driving organizational change in the Corporate Technology sector

J. Johnson, Cisco Systems, US

The increasing global focus on sustainability and climate change over the last decade has fundamentally changed the spectrum of environmentally – related forces influencing product compliance in the technology sector. The need for ‘circularity’ with respect to critical resources, increasing recognition of global corporate responsibility, escalation of customer-driven environmental criteria and a changing regulatory paradigm have converged to drive significant change in organizational focus and structure in the sector. This presentation will examine the evolution of forces driving sustainable change in electronics, identify related shifts in organizational resourcing, and suggest organizational approaches to effective execution of increasingly diverse product environmental sustainability criteria.

2.5.4. Emerging EPR type policies in North America region and how does it compare with EU legislation

F.P. Mosciatti, Landbell Group, DE

Extended Producer Responsibility (EPR), implemented first in Europe and covering multiple waste streams: electrical and electronic equipment, batteries and packaging, has proven to be an efficient tool to increase take-back and recycling. This led to effective waste management with increased recycling rate and better quality. The concept of EPR has been evolving at a steady pace around the globe. Multiple new policies are being developed in North America - ranging from conventional producer extended responsibility, through state financed collection and treatment systems to instruments as right to repair for broken equipment. This creates new obligations for producers. However, due to the lack of federal policies, legislation on state/province levels can vary, making the tracking of the compliance requirements a complex task. This paper provides an overview of existing electronic waste regulations in example states in Canada and the United States, and how those compare to the European policy framework.

2.5.5. America Invented the Throwaway Economy, and Right to Repair Is Trying to Fix It

E. Chamberlain, K. Wiens, iFixit, US

Since the last Going Green: CARE conference, the legislative effort to protect consumers' right to repair their own things has begun to see significant success around the world: France introduced a repair index, Austria started to pay toward citizens' repairs under a repair bonus scheme, and Australia required motor vehicle manufacturers to share diagnostic data with independent repair shops. Repair is essential to a resource-efficient, circular economy, and increasingly, countries are recognizing that centrality in their efforts at addressing the climate crisis.
The Right to Repair movement in the United States has been unusual in its breadth and variety, with bills passed in 2022 focused on powered wheelchairs (in Colorado) and electronics (New York). Bills have been introduced in 43 states so far, 5 federal bills are under consideration, and there has been a wide assortment of extra-legislative regulatory efforts (through the Federal Trade Commission and the Environmental Protection Agency, among others). In this presentation, we will summarize the history and current status of US Right to Repair legislation and regulation, discuss implications for the electronics industry, and point to directions for future research.

2.5.6. Mexico Circular Economy and Waste Management updates

E. Perrier, ORBIS Compliance, US

Latin America has embraced green initiatives rapidly in the past years from Brazil and Chile starting actions plans for Green Hydrogen, Brazil publishing its first ESG Standards and moving forward with REACH , and Mexico formally enforcing Circular Economy measures and Waste Management nationally on December 5th, 2022 and currently working on is mandate to enforce waste management for electronic and electric products.

2.5.7. Evolution of EPR for Enabling Circularity

P. Singhal, S. Sehgal, S. Aggarwal, Karo Sambhav, IN

In countries like India managing different types of wastes and implementing EPR has been a complex challenge. EPR in India started being implemented in a systemic way since 2017 when both E-waste and Plastic waste Rules with collection targets for producers were introduced. Since the EPR regulations were released for e-wastes, battery waste and plastic packaging wastes, there has been a gradual improvement in the formal collection and recycling systems. Stakeholder awareness on the need for responsible recycling of products has also increased thereby causing some behavioral changes w.r.t consumption and disposal.

2.6. Advanced Recycling Technologies

2.6.1. EC funded Project ALR4000 - Preliminary outcomes and case study

L. O´Donoghue, Votechnik, IE

Over 200 million LCD displays are sold per annum making them one of the fastest growing waste streams on the planet. The WEEE directive requires the mandatory removal of the components containing the hazardous substances mercury and liquid crystals. Mercury and liquid crystals within LCDs, from which the device gets its name, are hazardous. Mercury is considered by WHO as one of the top ten chemicals of major public health concern having toxic effects on the nervous, digestive, and immune systems, and on lungs, kidneys, skin & eyes. Exposure to mercury in even small amounts may cause serious health problems. While liquid crystals are showing potential to be persistent, bio-accumulative contaminants and have toxic properties. These substances threaten the air quality of our cities and the health of those at recycling facilities while their leakage from landfill can contaminate soil and water. There the need for a cost-effective solution for LCD depollution is great.

2.6.2. NEW-RE Neodymium and Rare Earth from Waste Recycling

V. Corbellini, A. Accili, L. Campadello, Erion, IT

The EU's energy transition to electric mobility is driving demand for rare earth magnets to grow rapidly, especially in the automotive sector. Unfortunately, most of the world's accessible rare earths are in China, as are the magnets manufacturers. The New-RE project, funded by EIT Raw Materials, proposes an all-European rare earth recycling solution. The project addresses the entire value chain, which begins with the capture of permanent magnets in streams from end-of-life electric motors and WEEE, their pretreatment, and treatment to recover rare earths. To improve material pretreatment practices, a system to automate PMs disassembly is planned to be developed and tested. Rare earth recovery will be done through a hydrometallurgical process. A full pilot demonstrator will be installed and validated with the goal of reaching TRL7. New-RE aims to improve the value circularity of European REEs by reducing costs, increasing profits, and decreasing environmental impact.

2.6.3. A short comparative overview on the precious metals hydrometallurgical recovery from spent autocatalyst and spent photovoltaic panels

P. Romano, I. Birloaga, F. Veglio, Univ. of L´Aquila, IT

A compressive overview on the precious metals recovery from spent auto catalyst and PV panels by hydrometallurgical processes is presented within this paper. The hydrometallurgical processes are considered to be very efficient processes with reduced costs and more environmentally friendly than the other metallurgical processes. Spent auto catalysts represent an important secondary resource of platinum metals (Pt, Pd and Rh). However, the quantities of this waste will be considerable reduced as cars with internal combustion tends to be more and more replaced by electrical cars. The spent photovoltaic panels have a considerable concentration of silver and as the generation of this waste will continue to grow in the next years. Most of all hydrometallurgical processes adopted for PGMs recovery form spent auto catalysts are based on these elements solubilization using a halide oxidation reduction leaching system. These are applied after different pretreatments (i.e., mechanical, and thermal or aqueous) and at elevated temperatures levels.

The recovery from achieved solutions is performed by different hydrometallurgical methodologies like reduction, solvent extraction, precipitation, and adsorption. For Ag recovery from spent PV panels there are just a few investigations as a higher fucus is given to the recovery of other elements that are present within the structure of this waste. Considering the achievements of literature data, can be stated that there is still a stringent need of research and development to obtain a more sustainable technologies of recycling.

2.6.4. The emergence of NdFeB-magnet recycling from an innovation systems perspective

M. Koese, S. van Nielen, R. Kleijn, Leiden Univ., NL

Demand for Rare Earth Elements (REEs) has grown drastically the past few decades and is expected to increase even further in the future. One of the most important applications of REEs are neodymium-iron-boron (NdFeB) magnets, used in electronics, electric vehicles and wind turbines. However, it is not guaranteed that primary supply can keep up with this growing demand. Therefore efforts regarding permanent magnet recycling have increased the past few years. In this paper, a Technological Innovation Systems (TIS) approach is taken to analyze the emergence of NdFeB magnet recycling from a system dynamics perspective. Through the lens of the innovation system, we assess the rise of this recycling industry in relation to the context in which this industry emerged. This approach reveals the functioning of the system around permanent magnet recycling and explores how these functions influence each other and affect the innovation development and diffusion.

2.6.5. Comparison of the analytical methods ICP-MS and XRF for the analysis of PC motherboards

A. Jandric, C. Zafiu, F. Part, S. Salhofer, Univ. of Natural Resources and Life Sciences, AT

Determining the material composition of waste samples can be a complex task due to the presence of a wide range of metallic, organic, and inorganic compounds. Printed circuit boards (PCBs) add to this complexity as they are found in almost all electronic devices, come in various types and models. Analyzing PCBs with ICP-based methods require careful preparation of samples, instrument calibration, and interpretation of results. In contrast, XRF analysis requires homogeneous material but can analyze solid samples directly, and calibration is standardized by the manufacturer. XRF is an efficient and cost-effective method that can analyze a wide range of samples quickly without requiring in-depth knowledge of analytical chemistry. This presentation will examine the potential and limitations of XRF in analyzing printed circuit boards by classifying the PCB components based on their metal content.

2.6.6. Improving the recycling of embedded electronics in passenger vehicles (Project EVA II)

M. Capelli, C. Marmy, EMPA, CH

Modern passenger cars contain a considerable amount of embedded electronic devices (EED). On average, the total weight of all EED per vehicle is estimated to be between 30 and 50 kg. In recent years, the number of these devices has increased significantly. Similar to home electronic devices (computers, telephones, printers, monitors, etc.), they are mostly made of base metals (iron, aluminum, and copper), but also contain many precious metals, rare earth elements and target plastics.

In Switzerland, the fleet of passenger vehicles in 2020 amounted to 4.7 million vehicles, of which each year more than 60'000 end-of-life (EoL) vehicles are scrapped within the country. Today, a large part of EED is not removed when a vehicle reaches the end of its life cycle. In the current system, the EED still present in the vehicle are mechanically treated together with the rest of the vehicle in a large shredder. After this mechanical treatment, the precious metals as well as target plastics contained in EED are concentrated in the shredder light fraction (SLF), which is incinerated. In this process, most of the materials contained are lost. The revised Swiss Ordinance on the Return, Take-Back and Disposal of Electrical and Electronic Equipment ("VREG"), stipulates that the EED contained in vehicles must be recycled separately, provided it is economically viable and environmentally sound.

2.7. Information Management (Digital Product Passport)

2.7.1. Circular Economy and Sustainable Product Development Case Study: A Digital Portal for product information delivery and potential for Product Digital Passport

D. Poon, Cisco Systems, US

Cisco is the largest Networking Equipment manufacturer in the world, and we have been providing the majority of our product information, such as Installation & Service Guide, Regulatory Compliance and Safety Information, SW licensing, Warranty ...etc. online since 2005. However, due to regulatory mandates and customer satisfaction requirements, Cisco is still delivering a significant amount of content via printed documents. In FY2020, the annual paper consumption was 80M sheets of paper, equivalent to 8100+ trees and the carbon emission was 2770 metric tons.

2.7.2. Digital Product Passports: the key to end gadget hoarding and ensure responsibility

R. Koppelaar, EcoWise Ekodenge, UK

Closing the loop on Waste Electrical and Electronic Equipment (WEEE) requires societal cultural and behavior changes. To end the throw-away practice where 5.3 billion mobile phones are disposed of globally every year and a multi-fold number are hoarded in drawers at home (WEEE Forum 2022). Cultural shifts include how we perceive useful end-of-use products, instead of waste as valuable resources in the language we use and the unwritten norms agreed upon in society. And behavior changes in the daily to monthly routines we carry out around what we do with our WEEE once it is unwanted, either as we desire a product upgrade or because of product failures. A key part of the solution are Digital Product Passports as these can enable traceability up to individual product levels combined with information exchanges across product life cycle actors. Digital Product Passports make a product universally identifiable both offline and online on the internet, such that specific information can be retrieved and updated either as a product series or for each individual product. If legislated within the EU as a requirement at the individual product level, they could be rolled out universally to the 1.3 billion consumer electronic and household appliances annually placed on the EU market (Deloitte 2022). A decision to this end, whether Digital Product Passports will be legislated at individual product level is to be made under the Sustainable Products Initiative of the European Commission, likely as part of delegated acts for different product categories in the 2023 to 2027 period.

2.7.3. As less as possible and as much as necessary: WEEE recycler´s information needs and technical requirements in context of the digital product passport

E. Wagner, E. Poppe, M. Schneider-Ramelow, Fraunhofer IZM, DE, D. Baumgärtel, M. Malzacher, I. Budde, Circular Fashion, DE

The transition towards a circular economy is supported by digital technologies and increasing data availability. The digital product passport (DPP) is seen as a promising tool to collect and make information available along the entire product life cycle. However, due to the heterogeneity of actors in the life cycle chain, different requirements arise. From a technical point of view there are several challenges when collecting information e.g. on the material composition of a product from the manufacturer, “carrying” throughout the entire product lifetime and distributing to waste treatment. To determine the needs of recyclers, this study first elaborates on information requirements and challenges coming from legislation (REACH, WEEE and Ecodesign Directive) in the context of the diversity of product lifetimes of electronic devices. Second, principles of WEEE treatment processes are described to derive product group specific requirements, coming from their size, recyclability, functional or material value. Third, interviews have been conducted to verify previous findings and furthermore explore openly on further technical and information requirements for waste treatment and recycler. The results of this study allow to build scenarios on product group level for a digital product passports by showing benefits and pitfalls on the core aspects of possible technology (QR code vs. RFID), identification level (product group vs. model identification) and information disclosure (minimum compliance data vs. extended data sets). It concludes with recommendations on a potential implementation roadmap for a minimal viable to a comprehensive DPP.

2.7.4. Proof of concept for traceability of recycled gold using a blockchain-based digital product passport (DPP)

F. Hänel, A. Dymek, R. Rainoldi, M. Dos Santos, iPoint-systems, DE

Gold is not only attractive for the jewelry and finance industry, but is also contained in electronic products due to its excellent conductivity. However, it’s extraction from ores is energy-intensive and promotes social grievances, posing its use a risk for environmental and social sustainability. With the aim of mitigating energy related CO2-emissions, environmental pollution, as well as human rights violations, the demand for recycled gold is continuously increasing. However, the challenge of proving the origin of the recycled metal within a product remains. The aim of this study is to investigate whether digital means such as blockchain technology and digital product passports (DPP) are a solution for certifying the origin of recycled gold. Furthermore, it was analyzed, whether blockchain and DPPs can serve as tools for exchanging trusted product data in supply chains, and if they can improve the efficiency and effectiveness of industrial production and promote the circular economy. To achieve this, a software demonstrator for a blockchain-based DPP was developed and its suitability to trace recycled gold was tested and evaluated within a gold supply chain. Preliminary results demonstrate, that the prototype enables actors of the supply chain to provide documented evidence of a material´s origin in a reliable manner. It illustrates how digital mapping of materials can be implemented by combining digital tokens representing recycled gold with the concept of a DPP. Based on the demonstrator’s generic structure it serves as a universal template for any metal-containing product and can, thus, be transferred to other industry sectors.

2.7.5. Data exchange platform for a green, detectable and directly recyclable lithium-ion battery

F. Hänel, M. Dos Santos, iPoint-systems, DE

According to the International Energy Agency the global electric vehicle stock is going to increase by an annual average growth rate of nearly 30 % to almost 145 million vehicles by 2030. Consequently, equivalent numbers of electric vehicle batteries (EVB) will reach their end-of-life status in the subsequent years. A sustainable and industrial end-of-life treatment of such batteries still poses problems. Digital Battery Passports (DBP) aim to support the efficient recycling of lithium-ion batteries (LIB), which is of utmost importance due to the limited availability of raw materials and the environmental impact of their mining and refining. In this study a DBP was designed for a new, and sustainably produced lithium-ion battery (LIB) by mapping its entire life cycle therein. The identification of the LIB and its components was enabled by magnetic and fluorescent particles. The particle´s characteristics were analyzed and the results were used to collect requirements for a data carrier connecting the material battery and its digital information. To aid the recycling of LIBs and increase the circularity of their materials, the information required by recycling companies to properly dismantle them, was identified and relevant data attributes were specified. These attributes acted as a guideline to develop a concept for a data exchange platform, which allows accessing relevant information via a DBP to automatically extract, sort and process EVB components for efficient recycling. The platform will enable supply chain actors processing end-of-life EVBs to improve their workflows, increase the reuse of battery materials and promote the circular economy in the electric vehicle sector.

2.7.6. Digital Twin for Circular Economy - Literature Review and Concept Presentation

J. Mügge, Fraunhofer IPK, DE

Digital twins offer a promising approach to sustainable value creation by providing a specific data base for the monitoring and execution of circular economy strategies. By analyzing product, component and material as well as process data, it is possible to create transparency throughout a products lifecycle and address current challenges such as climate change and resource scarcity. The concept of a digital twin for circular economy enables to build a data-driven ecosystem and supports new business and value creation models from SMEs to large enterprises. This paper identifies application scenarios, their technological readiness level and challenges of digital twins for circular economy in the manufacturing industry based on a systematic literature review. As a second result, a generic concept of a digital twin for circular economy is presented.

2.8. 3R and Automated Dismantling

2.8.1. How did Product Value Retention Processes Perform During Supply Chain Disruption?

D. Fitzsimons, European Remanufacturing Council, BE

Value Retention Processes (such as remanufacture, refurbishment and reconditioning) are expected to provide a stabilizing influence during periods of supply volatility for new products. The two year period beginning in January 2020 saw extensive global disruption to supply chains. Based on interviews with companies operating remanufacturing lines in a variety of product sectors, this presentation categorizes the types of responses to the disruption and asks to what extent the investment case for value retention processes has been changed by the experience of 2020 to 2022. It proposes further research questions to consider.

2.8.2. Mobile phone reuse businesses in Japan and an estimation of the their environmental load reduction effects

M. Matsumoto, AIST, JP, C. Clemm, Fraunhofer IZM, DE, H. Awazu, J. Tominaga, NewsedTech, JP

Reuse, refurbishment, remanufacturing and repairing of mobile phones are emerging business activities with a great potential for expansion along with global trends and increasing demand for more sustainable societies. This study provides an overview on the trends, barriers, and challenges faced by mobile phone reuse, refurbishment, remanufacturing and repairing businesses in Japan. The markets were slow to take off due to initial barriers but grew considerably in recent years. The study further attempts to estimate environmental load reduction effects due to mobile phone reuse businesses' activities. A web-questionnaire survey was conducted to estimate the effects of reuse businesses on the usage time of mobile phones, indicating an average increase by 35%. The implications on the environmental load of the mobile phone market are discussed.

2.8.3. Design and evaluation of a robotic unscrewing station for the non-destructive semi-automated disassembly of EoL electronics

M. Piessens, M. Abdelbaky, C. Zhou, Y. Wu, B. Engelen, D. De Marelle, J. Peeters, KU Leuven, BE

To alleviate the shortage of rare earth element supply in Europe, the NEW-RE project targets the recycling of Nd from permanent magnets from hard disk drives (HDDs). Nowadays, the dismantling of electronic devices and removal of HDDs is mostly performed manually. The HDDs themselves are, because of economic reasons, to date frequently processed in a shredder-based process in which the Neodymium (Nd) containing magnets cannot be recovered. To enable the recycling of Nd from permanent magnets from hard disk drives, the development of a (semi-)automated unscrewing system is developed to increase the economic viability of end-of-life (EoL) electronics disassembly in areas with high labor costs, Because prior research already demonstrated the unfeasibility of centralizing large numbers of HDDs (>150,000/year) with today's reverse logistic schemes in Europe, operating a dedicated industrial dismantling system for HDDs at full capacity is only expected to be realistic in exceptional cases. Therefore, to maximize the overall equipment effectiveness (OEE) of the developed disassembly system a modular and flexible system is targeted that can handle a wide range of different electronic devices. Since this variety of products and models requires a flexible system, an operator will collaborate with the robotic disassembly station and will perform those tasks best suited for manual labor e.g., component removal, wire unclipping and product reorienting. In parallel, the automated system will perform the repetitive tasks, such as screw localization, screw classification, unscrewing and screw removal. . To steer the ongoing developments of this semi-automated disassembly system, the times needed for both the robotic and manual operations to disassemble HDD's for Nd permanent magnet recovery is determined by both empirical experiments and based on time estimates calculations. Simulation results show that unscrewing a HDD using a semi-automated unscrewing system can reduce the disassembly time with up to 77% compared to manual disassembly with a pneumatic screwdriver. The results indicate that HDDs could be effectively disassembled using a semi-automated unscrewing system because of the numerous fasteners they contain which are easily reached by a robotic screwing system.

2.8.4. A Cobot Based Application For PCB Disassembly

L. Gandini, P. Rosa, S. Terzi, Politecnico di Milano, IT

This article will focus on enforcing the Circular Economy (CE) with Industry 4.0 (I4.0) enablers. The article will go through realization of an application at the I4.0 Laboratory of the Politecnico di Milano, within the European projects FENIX and TREASURE. Those projects deal with the recovery of PCB components through desoldering operations with a collaborative robot (cobot). The objective is to create a Graphical User Interface (GUI) to improve the collaboration between the human and the cobot within the TREASURE project, to increase the automation level of the already FENIX semi-automated disassembly process. The application will be carried out with a Franka Emika Panda Cobot. The GUI implementation will be presented in detail including the construction of the ROS working environment to manage all the communications within the GUI, the human and the cobot.

2.8.5. Computer vision based defect detection in color and depth images for electrical and electronic equipment (EEE) reuse: a case study for laptops

Y. Wu, C. Zhou, W. Sterkens, M. Piessens, D. J. Diaz-Romero, W. Dewulf, J. Peeters, KU Leuven, BE

Defect detection is of great importance for evaluating the residual value of Electrical and Electronic Equipment (EEE). However, current defect detection methods mainly rely on visual inspection by trained operators. To increase the cost-efficiency and reduce the subjectivity that are inherent to human involvement in defect detection, the presented research developed an automated defect detection system based on Faster R-CNNFPN using the fusion of color (RGB) and depth (D) images to identify two of the most commonly encountered defects in end-of-first-life laptops: absent battery and damaged surface. Two fusion methods, backbone and neck fusion, are adopted to investigate the performances of different RGB-D fusion methods. A dataset containing 304 high quality RGB and depth images of laptops has been created and manually annotated to facilitate this research. The experiment results show that the mAPs of backbone-fused and neck-fused networks are 83.7% and 82.3%, while the mAPs of RGB- and depth-based networks are respectively only 71.9% and 74.8%. Hence, the results indicate that multi-modal fusion methods can improve the accuracy of detectors, highlighting the potential for automated EEE defect detection for reuse using computer vision and data fusion techniques.

2.8.6. Envisioning the potential reuse and repair of electric vehicle batteries

L. Talens Peiro, M. Sanclemente Crespo, X. Gabarrell i Durany, Autonomous Univ. of Barcelona, ES, M. Fervorari, M. Colledani, Politecnico di Milano, IT, F. Alarte, B. Alvarez, ENVIROBAT, ES

This article presents a novel method developed for automated X-Ray Fluorescence and Fourier Transform Infrared analysis of shredded plastic waste to identify the polymer types and determine the concentrations of relevant elements such as bromine and chlorine. The purpose of the analysis is to determine the composition of plastic waste streams treated by sorting companies. The performed analysis gives operators valuable information that can be used to optimize the consecutive plastic sorting processes so that both the yield and the purity of the sorting operation can be increased. The overall goal of the method is to assist sorting companies to limit as much as possible the amount of plastic waste that goes to landfill or incineration after sorting.

3.1. Life Cycle Assessment

3.1.1. Design aspects and environmental impacts of using Wide Gap based semiconductor technology in consumer chargers

S. Glaser, Vienna Univ. of Technology, AT, A. Diaz, ECODESIGN company engineering @ management consultancy, AT, M. Makoschitz, AIT Austrian Institute of Technology, AT

In recent years, Wide Band Gap (WBG) materials like silicon carbide (SiC) and gallium nitride (GaN) have increasingly become an alternative to standard silicon semiconductors used in e.g., power converters. This paper is the outcome of selected work of Task B: "Energy and environmental related Life Cycle Assessment (LCA)", of the Power Electronic Conversion Technology Annex (PECTA) of the Technology Collaboration Program Energy Efficient End-Use Equipment by the IEA (4E). This paper in particular focuses on chargers for electronic devices such as notebooks and mobile phones, and concentrates on two main areas: 1) The effects of incorporating GaN components for energy conversion on the product design; and 2) The resulting environmental impacts along the life cycle of the chargers. To answer these questions, the authors contacted experts from academia, research and industry to discuss the effects of WBG on the product design level. A functional structure of a power converter was used to describe the impact of using GaN transistors. A streamlined Life Cycle Assessment with the selected Climate change indicator Global Warming Potential (GWP) was completed for a conventional 65W Si-based laptop charger, taken as the reference product, and a novel 65W GaN-based multi charger. The inventory data for these chargers were obtained from power measurements carried out in PECTA (Task F), and their bills of materials (BOMs) were obtained from tearing down the two products. In general, the effect of using GaN on the design of the charger brings the possibility to increase the switching frequency, which enables size and weight reductions of components. Depending on pre-defined customer specification also a higher energy efficiency can be achieved (e.g., if Si or GaN transistors are utilizing the same operating frequency). In turn, both have repercussions on the environmental impact of the charger. For 500 to 1500 charging cycles the GWP due to WBG power semiconductor material also including the manufacturing phase (production of the WBG device itself) is compared with the reference Si-based charger. When the battery charger operates for 1500 charging cycles, the GWP of the materials and production of the WBG device must be lower than 3,50 kg CO2-eq. If the WBG charger would be used for only 500 charging cycles, the GWP of the materials and production of the WBG device should be lower than 1,64 kg CO2-eq. The results of this study show, that a reduction of environmental impacts over the entire life cycle may be possible through the use of WBG technology.

3.1.2. Comparative LCA of a pluggable SIM card and an eSIM: Methodological considerations when assessing digital services

D. Sanchez, K. Schischke, Fraunhofer IZM, DE, T. Szolkovy, Giesecke+Devrient Mobile Security, DE

With the current trend towards digitalization in Information and Communication Technology (ICT), the mobile phone sector has seen an increase in the use of eSIMs in the recent years, with some forecasts predicting that they will make up 76% of all smartphone connections until 2030. In this context, Fraunhofer IZM and Giesecke+Devirent Mobile Security GmbH (G+D) performed a comparative Life Cycle Assessment (LCA) in which the pluggable SIM card is compared to the eSIM, as alternative method for mobile profile authentication. This paper presents an overview of said LCA and its main findings, discussing both the methodological approach to perform a fair comparison between a physical and a digital product. The result was unambiguous: across a full product lifecycle, the LCA showed that the use of an eSIM generates 46% less emissions than a pluggable SIM card (123g CO2 versus 229g CO2 equivalent).

3.1.3. Leasing and Refurbishment of Electronics: A Sustainable Business Model? Two LCA case studies of consumer electronics

P. Murphy, Logitech, IE, B. Schwartze, M. Stock, M. Ajie, iPoint systems, DE

Within the exploration of refurbishment-based business models (RBM) in the consumer electronics industry, the carbon impact reduction potential of RBM at product level is not commonly assessed. In this paper, the results of a Life-Cycle Assessment (LCA) of various RBM scenarios is presented. Important driving factors for product-level carbon impact reduction within RBM for a computer mouse are identified. The value of parametric LCA modelling for identifying 'win-win' RMB scenarios is demonstrated. In this case, win-win means an RBM that both encourages a societal reduction in consumption and production in the medium to long term while also reducing product-level carbon impact in the short term.

3.1.4. Methodological Concepts for Calculation of Avoided Impacts of ICT Systems

A. Andrae, Huawei Technologies, SE

There is a tremendous interest for estimating the extent to which specific products, services and solutions can help avoid impact by reducing resource use and emissions in larger contexts. However, although the attempts made are plentiful there is no commonly agreed methodology for calculation of the total net reduction effect. Life Cycle Assessment (LCA) is a common denominator for most methodologies. Moreover, it is argued that Consequential LCA (CLCA) should be used to capture market effects realistically. Another emerging method is the handprint approach which describes how to estimate so called positive environmental impacts. Anyway, to cover more aspects than state-of-the-art, the idea is that the existing handprint approach could be further developed in combination with CLCA. The handprint and CLCA methodological concepts are discussed for four cases in the ICT domain. Handprint with causal system expansion seems the least uncertain LCA method for ICT and is generally applicable and recommended.

3.1.5. The carbon footprint of an Internet-of-things system

N. Ullrich, F. Piontek, C. Herrmann, Sphera Solutions, DE

Digitalization processes are often assessed as not crucial in terms of environmental impacts. However, the increasing trend towards more and more digital communication rein-forces the need to critically question this assumption. For this reason, this paper presents an approach to quantify the environmental impacts of Internet-of-things (IoT) systems. Additionally, it shows potential results in terms of carbon footprint of a theoretical example. The analysis indicates that the electricity consumption and manufacturing impacts of local servers dominate the overall carbon footprint, followed by servers in cloud data center. The results show that cloud migration in IoT applications might reduce the environmental impacts under specific circumstances, even though it causes additional loads on the IP data transmission network. All results are highly sensitive to the configuration of the system and the back-ground assumptions. Nevertheless, the presented approach is flexible and can therefore be adapted for life cycle assessment of varies IoT systems.

3.1.6. Simplified-LCA-based optimum EEE lifetime analysis

K. Grobe, ADVA Optical Networking, DE

Energy and raw-material consumption are the most relevant environmental impacts of electronic products. Related design and assessment guidelines are covered in many references, which, however, lack simple classification which of the two consumption parameters dominates. Here, a classification figure is derived, based on lifecycle analysis and the global warming potential. The resulting classification figure allows comparatively simple identification of product lifetime, above which further product usage becomes net negative with regard to the global warming potential. This is demonstrated in several products case studies. From there, clear lifetime limitation can be derived for products with high utilization and 24/7 always-on use mode. The classification figure can therefore be used for simple identification of the most relevant products environmental impact, associated ecodesign steps, and product classification for assessments and regulations.

3.2. Interdisciplinary team up to escape the rare earth trap

3.2.1. Nanostructured magnets with tuneable properties by severe plastic deformation

A. Bachmaier, L. Weissitsch, S. Wurster, Erich Schmid Institute of Materials Science of the Austrian Academy of Sciences, AT

3.2.2. Bulk rare earth free permanent magnets

L. Weissitsch, S. Wurster, A. Bachmaier, Erich Schmid Institute of Materials Science of the Austrian Academy of Sciences, AT

3.2.3. Electric machine design and system-level optimization for reduced rare-earth material usage

E. Marth, G. Bramerdorfer, Johannes Kepler Univ. Linz, AT

3.2.4. Lose your bearings and magnets: Possibilities to reduce magnetic material in the life cycle of bearingless disposables

W. Gruber, Johannes Kepler Univ. Linz, AT

3.2.5. The potential of new magnet grades for a more sustainable electric machine production

A. Bachmaier, G. Bramerdorfer, E. Faigen, M. Benner, E. Marth, A. Kovacs, M. Gusenbauer, T. Schrefl, Erich Schmid Institute of Materials Science of the Austrian Academy of Sciences, AT

3.2.6. Multiscaling strategies in computational magnet design

M. Gusenbauer, H. Özelt, A. Kovacs, J. Fischbacher, T. Schrefl, CD Lab for magnet design through physics informed machine learning, AT

3.2.7. Global production networks of rare earth permanent magnets: From lab-based research, development and innovation to industrial-scale production

E. Faigen, M. Benner, A. Bachmaier, G. Bramerdorfer, E. Marth, A. Kovacs, M. Gusenbauer, T. Schrefl, Univ. of Vienna, AT

3.3. Towards Circularity

3.3.1. Silicon as a carbon-free reductant: Yellow phosphorus production from phosphoric acid

A. Okamoto, S. Kashiwakura, S. Kosai, E. Yamasue, Ritsumeikan Univ. JP

Although yellow phosphorus is used for medical and electronics industries, its production not only requires a large amount of carbon and poses significant resource risk. In this study, we propose silicon sludge, a waste material, as an alternative reductant, and we investigate the feasibility of using silicon sludge as an alternative method for yellow phosphorus production and assess its impact on carbon reduction through a life cycle assessment. It was found that the volatilization rate of yellow phosphorus using Si is superior to that utilizing carbon at a temperature of 1273K, which is a lower temperature than the conventional system. It is also found that the global quantity of generated silicon sludge suffices for the yellow phosphorus production and the proposed method contributes to a 1.5 Mt reduction in carbon emission.

3.3.2. Ecodesign as a business element for ensuring future competitiveness and changing business model

A.X. Saeidiani-Rädler, S. Rädler, AC Rädler Umwelttechnik, AT

Significant reduction in diesel, water, electricity-consumption, avoidance of COÇ emission by maintaining industrial operated tubular heat exchangers by switching from common cleaning technology (high-pressure) to a new smart drilling cleaning method.

3.3.3. Characteristic Analysis of Elderly Workers for Human-Centric Production Systems

K. Hayakawa, Y. Kishita, S. Kondoh, S. Shirafuji, Y. Umeda, Univ. of Tokyo, JP, M. Nishio, Toyota, JP

The aging of workers in production systems is becoming a pressing issue in Japan. While there is a growing demand for human-centric manufacturing towards Industry 5.0, achieving productivity and well-being of elderly workers remains a big challenge. Aiming to tackle this challenge, this study analyzes the characteristics of elderly workers in production sites. This study focuses on the Set Parts Supply (SPS) process, a part of the automobile production process, because it is difficult to fully automate the SPS process, where more elderly workers will be engaged in the future. For data collection, we conducted experiments by recruiting 17 people at ages of 19-62. In the experiments, we used an Elderly Experience Teaching Suit (EETS) that simulates an elderly worker for deeper analysis. Their subjective mental workload was assessed based on post-experiment questionnaire surveys using NASATLX. Results revealed that elderly workers tend to have difficulties in moving multiple body parts simultaneously, which increases workers' mental workload.

3.3.4. DISTENDER EU project: Integrating mitigation and adaptation strategies to climate change risks at local level through a participatory process

R. San Jose, J.L. Perez-Camano, TU Madrid, ES

DISTENDER is an EU-funded project to develop a methodological framework that guide the integration of adaptation and mitigation strategies through participatory approaches in ways that respond to the impacts and risks of climate change, supported by quantitative and qualitative analysis that facilitates the understanding of interactions, synergies and trade-offs. Holistic approaches to mitigation and adaptation must be tailored to the context-specific situation and this requires a flexible and participatory planning process to ensure legitimate and salient action. DISTENDER will develop a set of multi-driver qualitative and quantitative socio-economic-climate scenarios through a facilitated participatory process that integrates bottom-up knowledge and locally-relevant drivers with top-down information. DISTENDER will follow a pragmatic approach applying methodologies and toolkits across five case studies of national, regional and urban scale and six additional follower case studies. The knowledge generated by DISTENDER will be offered by a decision support system (DSS) which will help policy makers.

3.3.5. Developing Architecture-based scenario design methodology for platform-enabled circular economy business: A case study of waste collection system

M. Tsunezawa, T. Hirota, K. Sugiyama, K. Tasaka, KDDI Research, JP, Y. Kishita, Y. Umeda, Univ. of Tokyo, JP

Digital platforms (DPs) are a key enabler for transforming a conventional business based on linear economy into a circular economy (CE) business. In many cases, DPs are used to enable the transaction of goods and information among multiple stakeholders (e.g., manufacturers, service providers, local governments, and consumers). Such a DP-enabled CE business faces difficulties in understanding and designing the business due to its inherent complexity. The authors have developed an architecture to represent the interaction among business vision and goal, value, business model, activity, product lifecycle, and functions and implementations [4]. Although the architecture is useful for clarifying what elements need to be considered in the DP-enabled CE business and how to represent them, how to design them has not yet been examined.

3.3.6. Research on the Contribution of Local Communities to Decarbonization

T. Obara, K. Tanaka, Univ. of Tokyo, JP

Battery usage objectives and electricity demand trends vary by urban component. The purpose of this study is to propose a quantitative evaluation method for subsidy measures for the introduction of batteries in cities, based on the assumption of individual autonomous decision making. First, a city was reproduced by combining autonomously moving agents. Then, a P2P electricity trading simulation was conducted to quantitatively evaluate the battery installation policy. The research results show that the target of the subsidy should be changed according to the trend of the trading market. Assuming that the average transaction price in the assumed city is about 13 yen/kWh and that fluctuations should be disbursed first to households and then to commercial entities.

3.4. Challenges in e-waste recycling in the Global South

3.4.1. 20 years of international cooperation in WEEE management in developing and emerging economies

Heinz Böni, EMPA, CH

3.4.2. Challenges in e-waste management in the Caribbean

S. Salhofer, Univ. of Natural Resources and Life Sciences, AT

3.4.3. Challenges of e-waste management in India

P. Singhal, Karo Sambhav, IN

3.4.4. Waste compensation as a financing mechanism for electronic waste collection in Africa

R. Smit, Closing the Loop, NL

3.4.5. Implementation of co-working space concept for incorporation of e-waste informal sector

D. A. Wehrli, A Social Impact Startup, CH

3.5. Sustainability Assessment

3.5.1. Miniaturization in infrastructure ICT equipment - environment vs. functionality

K. Grobe, ADVA Optical Networking, DE

Infrastructure ICT ("Internet backbone") is responsible for almost 10% of the total global electricity consumption. The emissions caused by this are positively overcompensated by the ICT-enabled decarbonization in other sectors like manufacturing and buildings, but the challenge (and cost) of increasing energy consumption remains. One way of decreasing the environmental footprint in infrastructure ICT consists of miniaturization of the required fiber-optic WDM (wavelength-domain multiplexing) transceivers into small pluggables that can directly be accommodated in the respective slots of the client equipment (IP routers, Ethernet switches, servers, mobile equipment). This leads to smaller equipment with less material intake, less power consumption but also less functionality. In the case of typical data-center interconnectivity (DCI), the total WDM configuration's power consumption as well as the production global warming potential can go down to almost 10% of the non-miniaturized configuration. In turn, maximum transport reach is severely limited and certain operational functionalities are missing. This limits the potential application of this miniaturization approach to less than 50% of all DCI cases.

3.5.2. ICs as drivers of ICT carbon footprint: an approach to more accurate die size assessment

M. Billaud, D. Sanchez, M. Proske, C. Clemm, L. Stobbe, N. Nissen, M. Schneider-Ramelow, Fraunhofer IZM, DE

The area of semiconductor dies contained in chip packages on printed circuit board assemblies is a main driver for the environmental impacts of information and communication technology equipment in life cycle assessment and carbon footprint analyses. Approaches to the estimation of die area contained in a device can be based on assumed die-to-package ratios, radiographic imaging, or direct measurement. This paper demonstrates the impact that different approaches to die area estimation have on the estimated total life cycle environmental impact of a smartphone.

3.5.3. Comparison of Additive and Conventional Manufacturing in the context of LCA

T. Heckmann, O. Vetter, C. Herrmann, A. Saraev, Sphera Solutions, DE

The usage of additive manufacturing is expanding across many sectors of the global economy, including the electronic industry. From a sustainable development perspective, gathering of information relating Life Cycle Assessment (LCA) is important to determine the impact of additive technologies on the ecosystem. The paper presents investigations of the environmental impact of additive manufacturing processes based on the process data obtained. The analyses include the evaluation of additive manufacturing of metal and polymer parts and the comparison of additive manufacturing with conventional manufacturing. The focus of the investigations is on the feedstock production and the manufacturing phase. The knowledge gained provides supporting environmental information and can be used to further technology develop for additively manufactured products.

3.5.4. Sobriety, Efficiency and End-users´ Satisfaction; An innovative Pathway to Green Growth and "Sobriety by Design" rationalized business processes: an illustration of through the Artificial Intelligence sector

C. Gans Combe, Inseec Business School, FR, J. Yun Jun Kim, W. Mouhali, A. Baccar, Y. Rakotondratsimba, ECE Paris Graduate School of Engineering, FR

Sobriety (frugality) is a critical variable in different energy transition scenarios (Balzani, 2019) and a pillar of the ecological transition. Some businesses, like AI, are particularly tense about these issues (Stein, 2020). Current solutions oppose energy efficiency and performance (Ikhlasse, Benjamin, Vincent & Hicham, 2021). We find this unacceptable given the industry's promises for mankind through automation, smart decision-making, and more. Thus, we present an operational foundation for a model of AI sobriety that won't reduce performance or accuracy. AI systems rely on "accuracy" to meet expectations or needs (Giese & Cote, 2000). When a procedure produces enough output to answer a given question without statistically unacceptable error, it's satisfactory. This imperative implies the existence of a "satisfaction function". As such, satisfaction is directly associated to system production, which is itself a function of resource allocation, which we mapped using activity best costing (ABC) methods (Ray & Gupta,1992). This mapping allows us to identify the main AI drivers and assess their influence on accuracy, the desired deliverable. The ABC approach documents that satisfaction is a function of activities and resource allocation, with specific interdependencies and restrictions. We investigated drivers' dependencies, showing that energy usage was a function of the applied algorithm and the volume of data required to train the learning system. By highlighting interlinkages and tensions, we found that optimal accuracy was reached at 68% data consumption and that further data processing did not increase precision. By studying drivers and resource interdependencies, the satisfaction approach can find sobriety pools and minimize AI system usage by 32% without modifying the process nor its efficiency. AI systems are 32% sober. This analytical approach should be transferrable beyond the current proof of concept because it analyses homogeneous activity drivers (Thomas & Gervais, 2010).

3.5.5. Evaluating energy consumption in distributed recycling system for plastic wastes using home-based 3-D printers in Japan

H. Mizoguchi, S. Kosai, S. Kashiwakura, E. Yamasue, Ritsumeikan Univ., JP

The disposal of plastic wastes is an urgent issue across the globe. Current plastic recycling system is classified as the centralized recycle system, in which enormous transport energy is consumed because of collecting garbage from a wide area. In order to reduce transport energy, the distributed recycling system to be carried out in the home was proposed in the recent studies. To evaluate the advantages of distributed recycling system the from the environmental perspective, life cycle assessment (LCA) has been executed. However, there were limitations in of the specific target area and system boundary in the existing studies. Thus, the objective of this study is to evaluate energy consumption reduction through the transition from conventional centralized recycling system to the distributed one on a national scale.

3.6. Resource Management

3.6.1. Promoting circular economy through resource-efficient electronic recycling across Latin America

A. Cueva, C. Hernandez, S. Alhilali, K. Ives-Keeler, B. Casanas, UNIDO United Nations Industrial Development Organization, AT

Latin America faces important challenges in carrying out environmentally sound management (ESM) of waste from electrical and electronic equipment (WEEE) and moving towards a circular-economy model. This document aims to report on the contributions made by the UNIDO-GEF project "Strengthening of National Initiatives and Enhancement of Regional Cooperation for the Environmentally Sound Management of POPs in Waste of Electronic or Electrical

Equipment (PREAL)". The project strengthens national initiatives and improves regional cooperation to upgrade the conditions for carrying out WEEE management and for creating enabling conditions for the efficient recycling of WEEE into new resources or products, which paves the transition to a circular economy model.

3.6.2. Toolbox - Transforming Informal E-Waste Scrap Yards into Formalized Recycling Sites in Ghana

M. Spitzbart, C. Stolzenberg, V. Johannes, R. Baldwin Asiedu, F. Acheampong, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), DE

In all major cities in Ghana, the vast majority of e-waste appliances is collected by informal scrap deal-ers. Collected e-waste is brought to informal scrap yards, where metals such as iron, copper, aluminum and others are mainly recovered from e-waste devices for recycling through manual dismantling. While collection is characterized by an extremely high collection rate, the improper dismantling of e-waste causes serious environmental pollution and health hazards.

3.6.3. Joint Association for CSR (JAC) – Status of goals, targets and practical action towards Net Zero and Circularity in the global telecommunications supply chain

K. Taylor, epi Consulting, UK

JAC has a membership that comprises 27 of the world's largest Telecommunications Operators (TCO's) across all regions of the world. Action on climate change, waste and resource scarcity (Circular Economy) is a top priority amongst the membership base. At the beginning of 2023, JAC undertook a detailed survey of its membership looking at these topics and how the global telecommunications sector is addressing them. The survey aimed to understand levels of commonality amongst targets and timescales and also the impact and importance of the supply chain in meeting net zero and circularity targets.
The survey also explored the action that TCO's are taking to address the supply chain and identified best practice amongst TCO's in driving action by the supply chain. In particular, the survey investigated the standards that are being followed and the tools and techniques that are practically being implemented now and are planned to be implemented to meet targets in the future.

3.6.4. Scenario analysis towards sustainable lithium-ion battery circulation system

R. Sun, Y. Kishita, F. Tao, Y. Umeda, Univ. of Tokyo, JP, C. Scheller, S. Blömeke, T. Spengler, C. Herrmann, TU Braunschweig, DE

Electric vehicles are becoming more popular towards achieving carbon neutrality, the risk of resource scarcity caused by manufacturing traction batteries cannot be ignored. This paper proposes a method for conducting what-if analysis with the aim to clarify conditions for sustainable battery circulation system. For this purpose, we combine scenario analysis and traction battery circulation model, which evaluates the balance of the supply and demand of spent batteries. A case study of the Japanese market was carried out, where four different scenarios were described. Results showed that using spent batteries to meet the ESS demand can reduce CO2 emissions greatly.

3.6.5. Finnish perspective on nickel in EV batteries lifecycle - system dynamic modelling of demand, waste generation, and effect of R-strategies

P. Slotte, E. Pohjalainen, J. Hanski, P. Kivikytö-Reponen, VTT, FI

EU has ambitious targets for reaching climate neutrality. In practice to achieve the targets, electrification of transport sectors is needed and currently most viable option to realize this are EVs with Ni containing lithium-ion batteries (LIBs). This paper studies the demand for Ni as well as the amount of Ni in waste originating from EV batteries lifecycle and the effect of R-strategies (recycling and life extension strategies, i.e., remanufacturing and repurposing) on Ni material flows in Finland. For the purpose system dynamic model is used. The model is based on the prediction of yearly Finnish EV fleet with a forecast to 2060. This study proved that dynamic and complex Ni material flow system can be studied with system dynamic model and that the results can be used to determine the design of efficient circular economy policies.

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