



DICE
NETWORK+

DIGITAL INNOVATION
& CIRCULAR ECONOMY



EFUTURES

SIGNALS TODAY.
SOLUTIONS TOMORROW.

Agenda

09:30	Registration and coffee
10:00	Welcome
10:10	Keynote - Bridging the Gap
10:25	The Outer Loops: Materials & Resource Security, overcoming the Feasibility Gap
11:10	Coffee break
11:30	The Inner Loops: Value Retention, Life Extension & Standardisation
12:15	Networking Lunch
13:00	Solution focused workshops based around 4-5 challenge areas
14:45	Reflections and closing comments
15:00	Close

Welcome

Prof Gosia Swadźba-Kwaśny

DICE Network+ Co-Lead



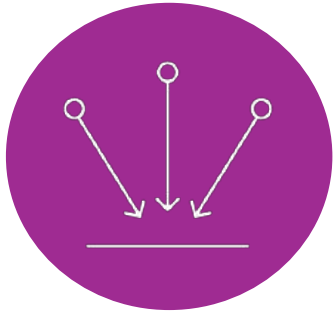
Beth McEvoy

eFutures 4.0 Co-Lead



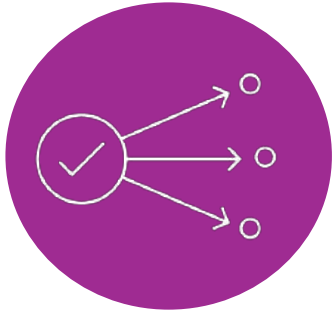
Digital Innovation & the Circular Economy

CHALLENGE AREAS



Embed

Embedding sustainability & circularity within the design & development of digital & communication technologies.



Enable

Realising the potential of the digital revolution to enable a circular economy across sectors.

THE ROLE OF DICE N+

DICE N+ accelerates circular economy adoption by generating insights, funding innovation, & translating research into practical solutions.

Our Network of Networks

We connect & convene communities.



Our key pillars of activity:

- 1 INSIGHT & EVIDENCE
- 2 CAPACITY BUILDING & KNOWLEDGE EXCHANGE
- 3 RESEARCH, IMPACT & LEGACY
- 4 INCLUSIVE COMMUNITY

Our progress



INSIGHT & EVIDENCE



300+

Accessed the Data Centre Policy Brief

- Convened 30+ stakeholders in Data Centre collaborative
- Produced 27 knowledge outputs, including case studies & thought leadership

CAPACITY BUILDING & KNOWLEDGE EXCHANGE



55+

ECR Community Members

- Engaged with 380+ partners & 20+ networks
- 80+ audience at Data Centre World panel discussion
- Launched Digital Traceability Working Group

RESEARCH, IMPACT & LEGACY



£435K+

Flex Funds awarded

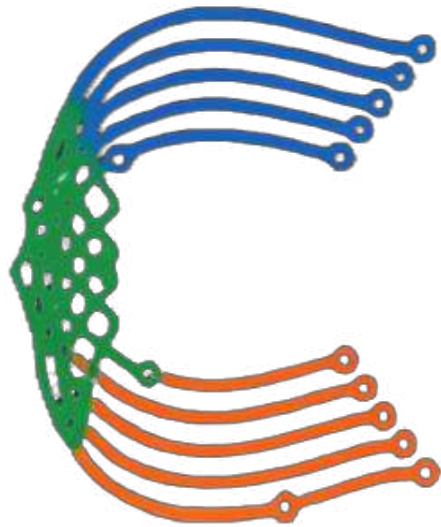
- 17 active high-impact research projects with industry collaboration for real-world impact
- Informing policy through Government Buying Standards and APPG for Data Centres



INCLUSIVE COMMUNITY

Underpinning all activity, we build and coordinate an inclusive DICE Network+ community to enable and empower collaboration across diverse user groups

With thanks to our collaborators



EFUTURES

SIGNALS TODAY.
SOLUTIONS TOMORROW.

Circularity at Source: Can Semiconductor Manufacturing Ever be Sustainable?

Professor Paul Meredith
DICE Network+ Co Lead





Swansea
University
Prifysgol
Abertawe

Centre for Integrative Semiconductor
Materials
Y Ganolfan Deunyddiau Lled-ddargludol
Integreiddiol



Circularity@Source: Can Semiconductor Manufacturing Ever be Truly Circular?

Paul Meredith, EPSRC Fellow

The Wolfson*

FOUNDATION



DER
Driving the
Electric Revolution
Industrialisation Centres



Llywodraeth Cymru
Welsh Government

Cyngor Cyllido Addysg
Uwch Cymru
Higher Education Funding
Council for Wales

hefcw



INDUSTRIAL
STRATEGY



Engineering and
Physical Sciences
Research Council



Research
England



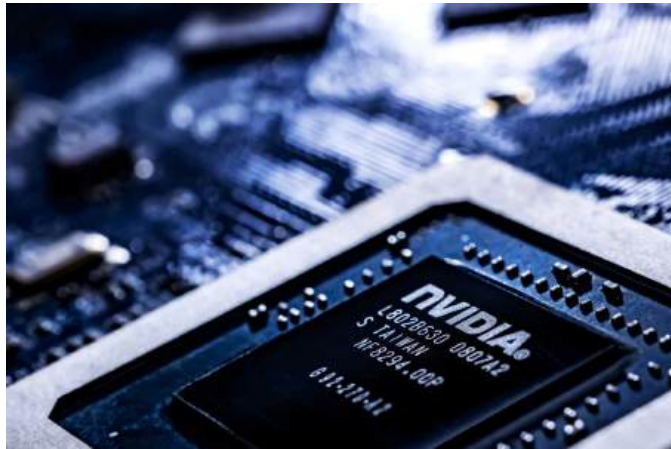
Innovate
UK



Science and
Technology
Facilities Council

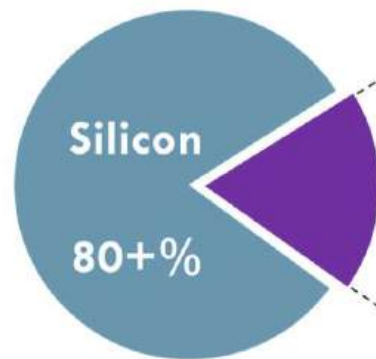


What I'm NOT Going to Discuss



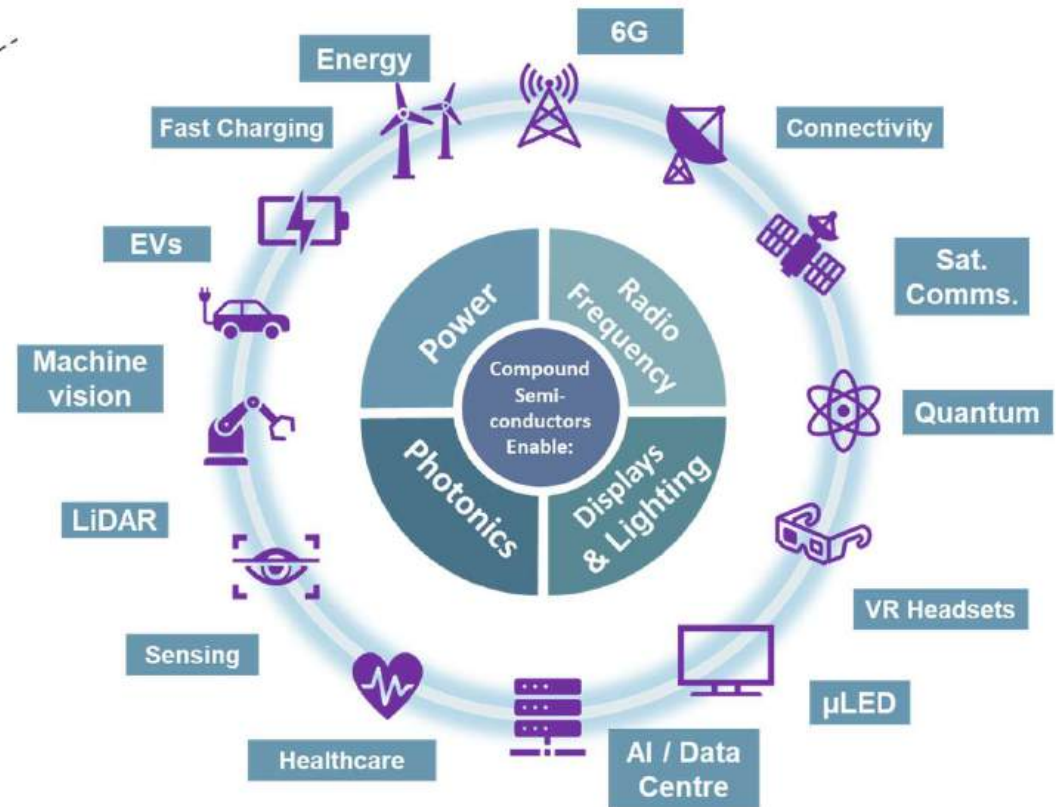
Semiconductors – a \$Tn industry 2030: Unstoppable

The Global Semiconductor market is \$600Bn (exc. Equipment)



Compound semiconductors enable critical functionality in many important areas

...Moore's Law, more transistors, smaller and cheaper, processing & storage



Why It's Important in South Wales

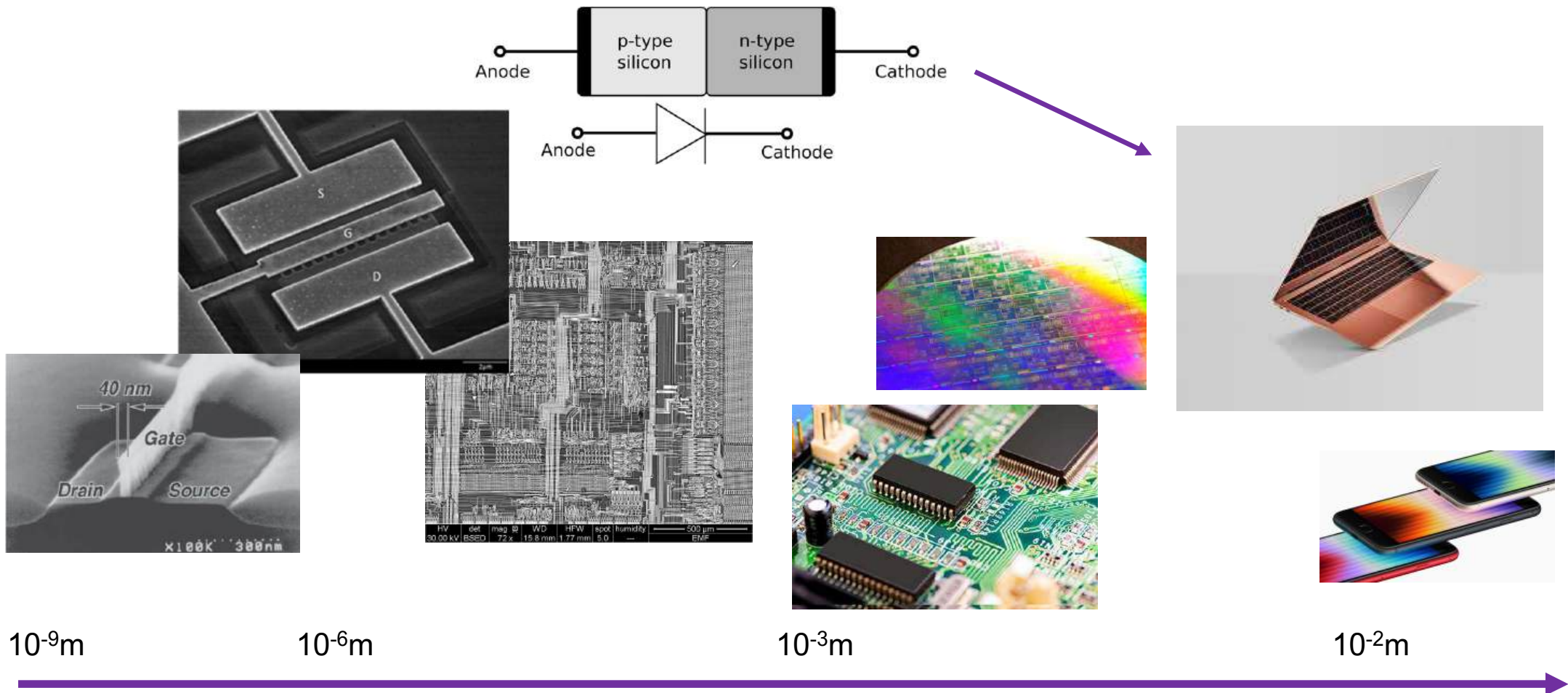
Key Metrics

- *Approx. 2800 employees (32% growth since 2020)*
- *Over £350M in GVA contribution (122% growth since 2020)*
- *Over £600M in annual sales (90%+ export)*
- *~£1B investment commitment since 2018*
>2 : 1 Private : Public

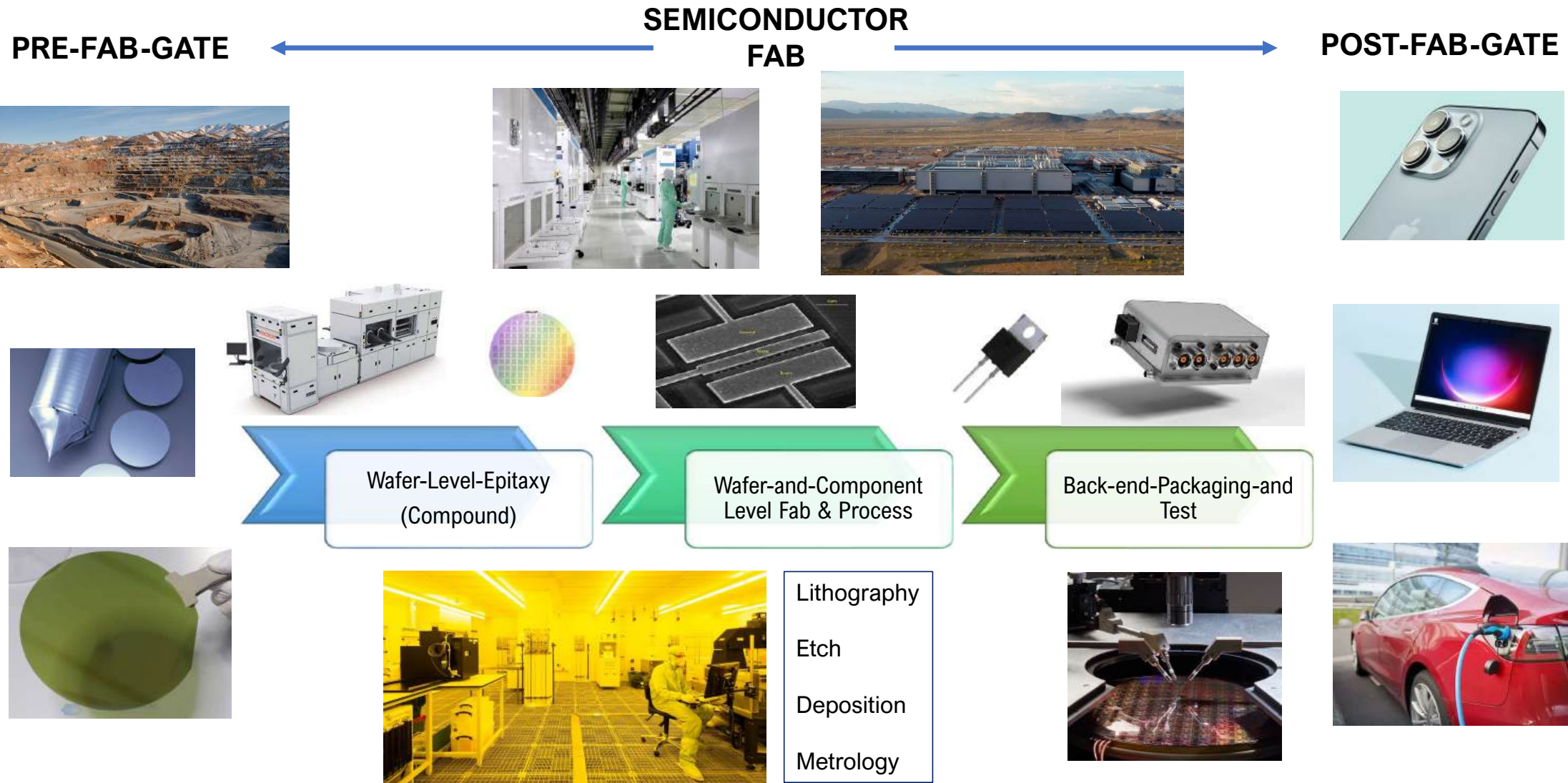


*Data from WERU CSconnected [reports](https://csconnected.com/resources/reports/) at: <https://csconnected.com/resources/reports/>

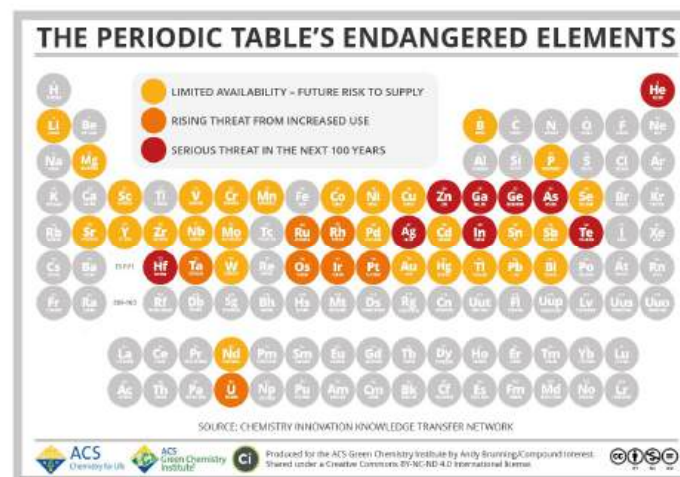
Challenge 1: The Complexity of Semiconductor Devices



Challenge 2: The Complexity (&\$) of the Supply Chain



Challenge 3: Input Vectors – Energy, Water, Raw Materials



Facts



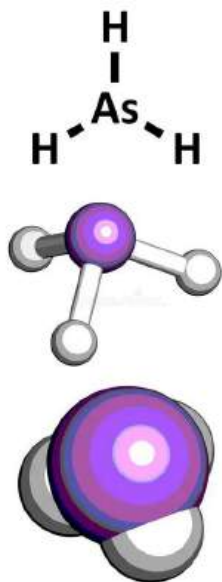
~1 MWh per 12" 3 nm node wafer (c.f. 2.5 MWh/yr UK <household>)
 3nm node fab 2 TWh/yr (c.f. I-EAF 1M tonnes/yr ~ 0.5 TWh/yr)
 TSMC (2024) total consumption ~ 25 TWh (16.7 million households)
 25% of Taiwanese electricity use by 2030



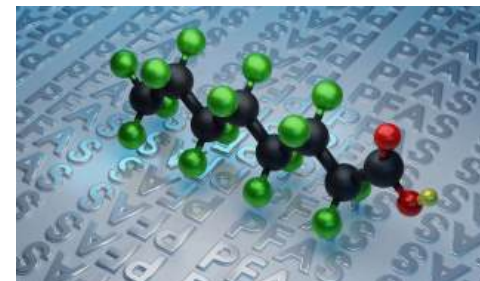
~30 million litres of water / day in a single fab
 TSMC Phase 1 in Arizona ~ 18 million litres a day, 65% recycled



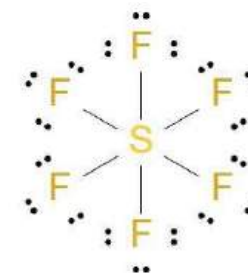
Challenge 4: Input & Output Vectors – Toxicity and Waste!



'Arsine is an inorganic compound with the formula AsH₃. This flammable, pyrophoric, and highly toxic pnictogen hydride gas is one of the simplest compounds of arsenic. Despite its lethality, it finds some applications in the semiconductor industry



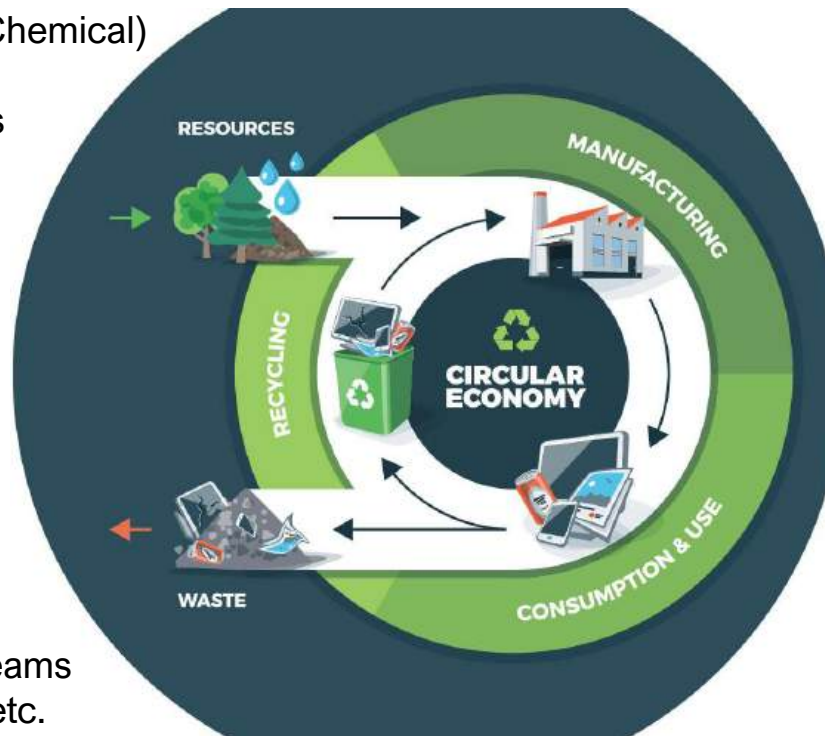
'PFAS (per- and polyfluoroalkyl substances) are a large group of thousands of man-made synthetic chemicals used in industry and consumer goods since the 1940s and 1950s. They are widely known as "forever chemicals" because their strong carbon-fluorine bonds ... now used extensively in the semiconductor industry ..'



Semiconductor Manufacturing Sector Circular Economy

Input Vectors:

- Energy (Electrical, Thermal, Chemical)
- Mined Raw Materials
- Synthetic Petroleum Products
- PFAS
- Process Gases & Liquids
- Water (including DI)



Output Vectors:

- Devices
- Gas, Liquid, Solid Waste Streams
- F-gases, slurries, HF, PFAS, etc.
- Large thermal waste

Particular Issues:

- High embodied manufacturing energy
- Some of the most toxic raw materials on the planet (arsine, phosphine, etc.)
- Toxic & high CO₂ equivalent process materials (e.g. HF, SF₆, organic solvents, PFAS)
- High water consumption and need for ultra-pure water
- Yields >99% crucial
- \$Bn assets with decadal depreciation (semiconductor fabs are sticky)
- Endangered periodic table!
- Large manufacturing footprints with complex services needs: ultra-stable power (> 100MVA)
- Fully packaged and difficult to recycle component products (mixed material)
- Industry 'looks' clean but is high emissions

Sustainable Semiconductor Manufacturing Action

SEMI S23 - Guide for Conservation of Energy, Utilities and Materials Used by Semiconductor Manufacturing Equipment



<https://www.semi.org/en/standards-watch-2024-sep/energy-efficiency-standards-initiative>



[https://www.europarl.europa.eu/RegData/etudes/BRIE/2026/791444/EPRS_BRI\(2026\)791444_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2026/791444/EPRS_BRI(2026)791444_EN.pdf)



Centre for Integrative Semiconductor Materials – One of a Kind in the UK



1. Industry Ballroom Cleanroom 24x7x365
2. Islanded fab – on-site energy generation, on-site gas production, on-site waste handling. etc.
3. Fab-of-the-future – integrating across semiconductor platforms for efficiency & input material replacement
4. Fully monitored at the individual tool level to measure electrical consumption per process (SEMI S23 framework)



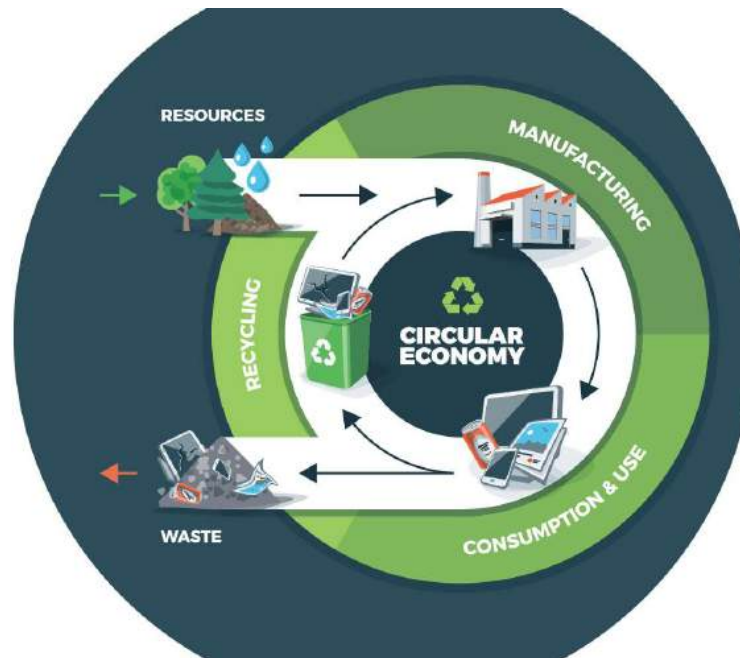
Semiconductor Manufacturing Sector Circular Economy (Opportunities)

Input Vectors:

- Accurately monitor electricity consumption (circuit and tool level)
- Establish emissions baselines
- Electrify processes (dry etch)
- Replace raw materials with earth abundant
- Improve efficiency of processes
- Reduce process steps
- On-site generation of power
- Heat capture and use
- On-site gas and solvent generation and regeneration
- No-site water purification and reuse

Output Vectors:

- Extended product lifecycle & design for recycle
- On-site waste treatment of all streams (efficient abatement)
- Carbon, capture and use
- Heat capture and use
- On-site gas and solvent generation and regeneration
- On-site water purification and reuse



General Strategies:

- Intrinsically higher yield processes & platforms
- LCA sector specific frameworks (e.g. SEMI S23) core element of quality measures
- Larger, more efficient fabs
- Larger wafer platforms
- Focus on process simplification
- Focus on material innovation
- Advanced heterogeneous integration concepts
- THE ISLAND FAB CONCEPT



Swansea
University
Prifysgol
Abertawe

Centre for Integrative Semiconductor
Materials
Y Ganolfan Deunyddiau Lled-ddargludol
Integreiddiol

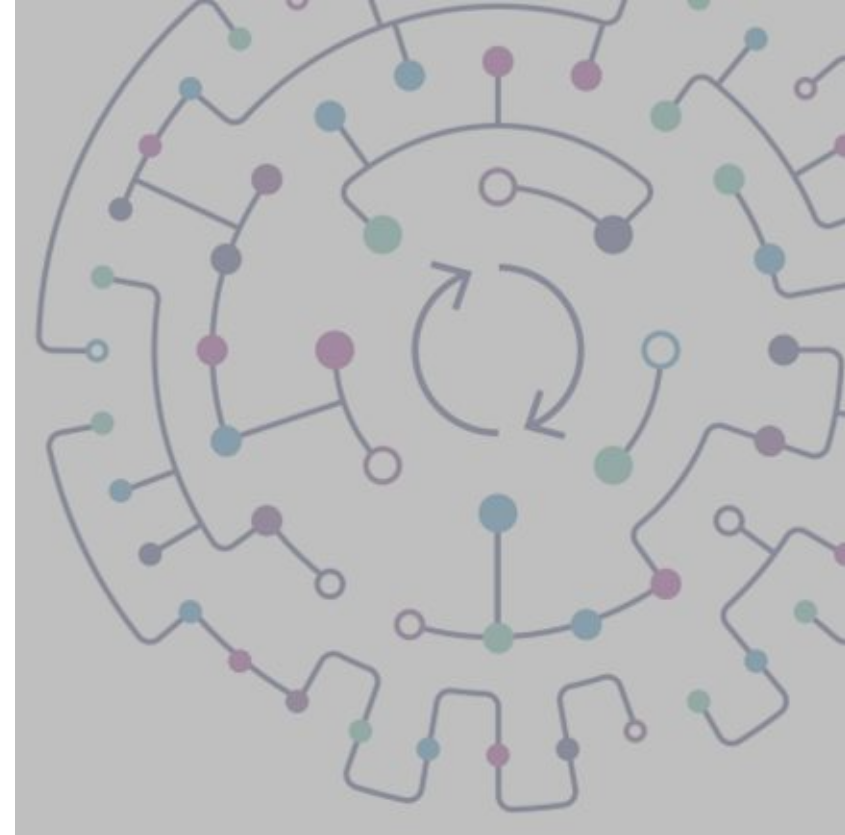


Thanks for Listening &
Thanks to all our colleagues at CISM



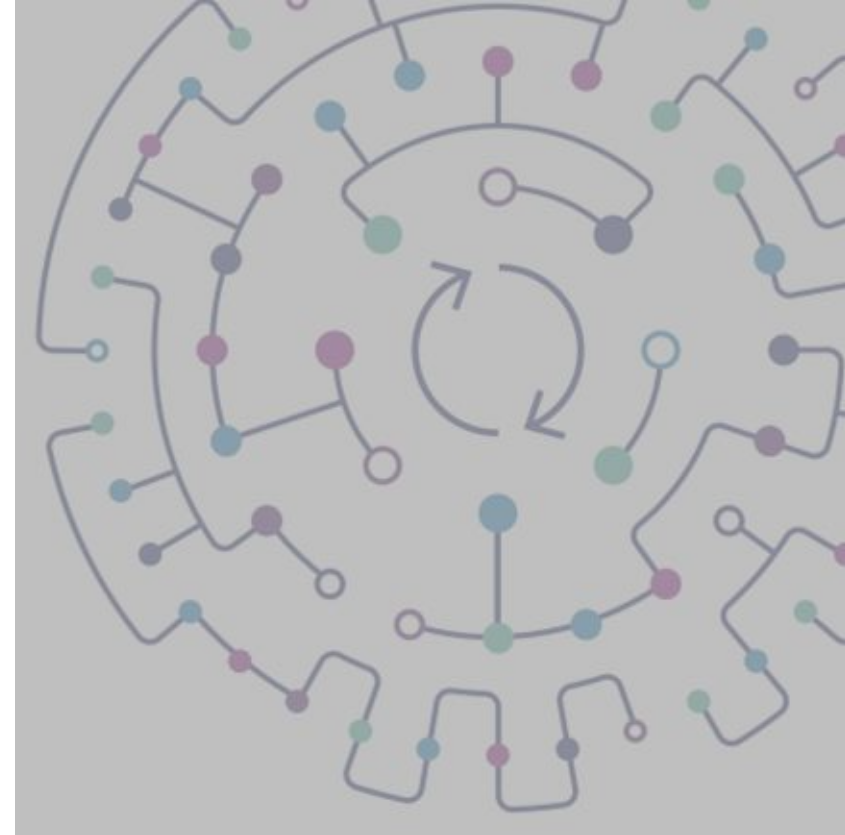
The Outer Loops: Resource Security, overcoming the Feasibility Gap

Chair: Professor Gosia Swadźba-Kwaśny



Closing the Rare Earth Loop: Circular Hydrometallurgy from Lab to Plant

Prof Peter Nockemann, Queen's University Belfast





**QUEEN'S
UNIVERSITY
BELFAST**

QUEEN'S UNIVERSITY
IONIC LIQUID
LABORATORIES

QUILL

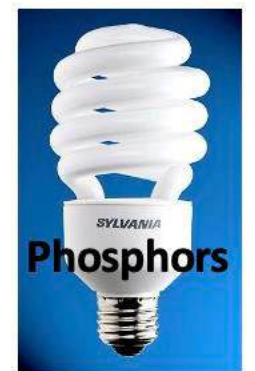
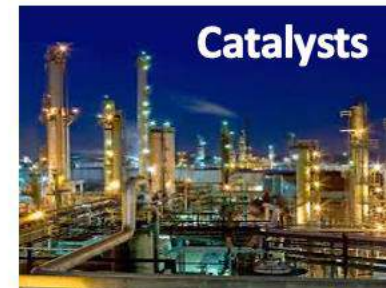
Sustainable Rare Earth Separation for Recycling of Permanent Magnets.

Research Group
Prof. Peter Nockemann

Research Challenge

21 Sc Scandium	39 Y Yttrium	57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
Light Rare Earth Elements (LREE)										Heavy Rare Earth Elements (HREE)						

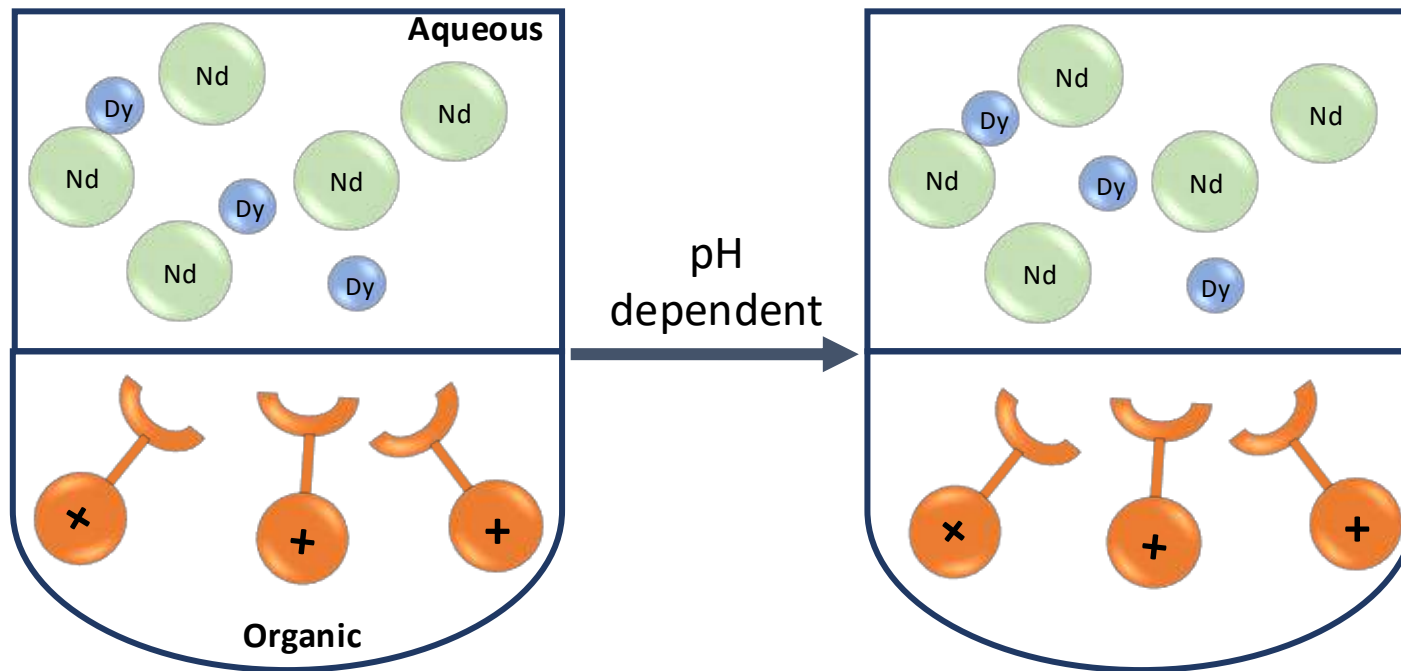
- Rare earth metals (REMs) are crucial for clean energy technologies, but global supply is concentrated in China, posing risks
- Traditional REM recycling methods are often inefficient, costly, and do not produce high-quality materials
- A new, cleaner and more efficient approach to REM recycling is needed to ensure adequate supply for growing demand



Sustainable Metal Recycling

21 Sc Scandium	39 Y Yttrium	57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
Light Rare Earth Elements (LREE)										Heavy Rare Earth Elements (HREE)						

Developing new highly selective extractants for the separation of rare earth elements



Separation Factors (Nd/ Dy) > 25 × higher
Patent: WO/2019/239149A1
EU & Industry funding

Impact achieved

Patented technology for the separation and purification of rare earth magnets going commercial



- Seren Technologies acquired by Ionic Rare Earths in 2022; built a REM recycling plant in Belfast using QUB's patented process
- The plant has been operating continuously since Jan 2024, cementing UK's position in securing alternative REM supply
- High-purity separated REMs produced, supporting the UK's EV and clean energy sectors and reducing reliance on China
- Environmental benefits through increased recycling vs. mining; economic benefits through new skilled jobs in Belfast
- Hiring of QUB graduates at Ionic Technologies strengthens the local REM supply chain

Path to Commercialisation

ionic
technologies



DRIVE35 Collaborate
CircularEconomy



ADVANCED
PROPULSION
CENTRE UK



Innovate
UK

Scale-Up Readiness
Validation & CLIMATES



ADVANCED
PROPULSION
CENTRE UK

Technical Developer
Accelerator Program



QUEEN'S
UNIVERSITY
BELFAST



2022
Lab Scale



2022
Pilot Scale



2023/24
Demonstration Plant
10tpa REO capacity



2025/28
Supply Chain Validation



2027/28
Commercial
Plant¹
400tpa REO
capacity

1. Facility Render, planned construction expected to be completed late 2027, subject to financing and approval being received.

iRECYCLE-Malaysia: Innovative Recycling of E-waste for Critical Metals and Sustainable Economy in Malaysia



Transforming E-waste Management in Malaysia

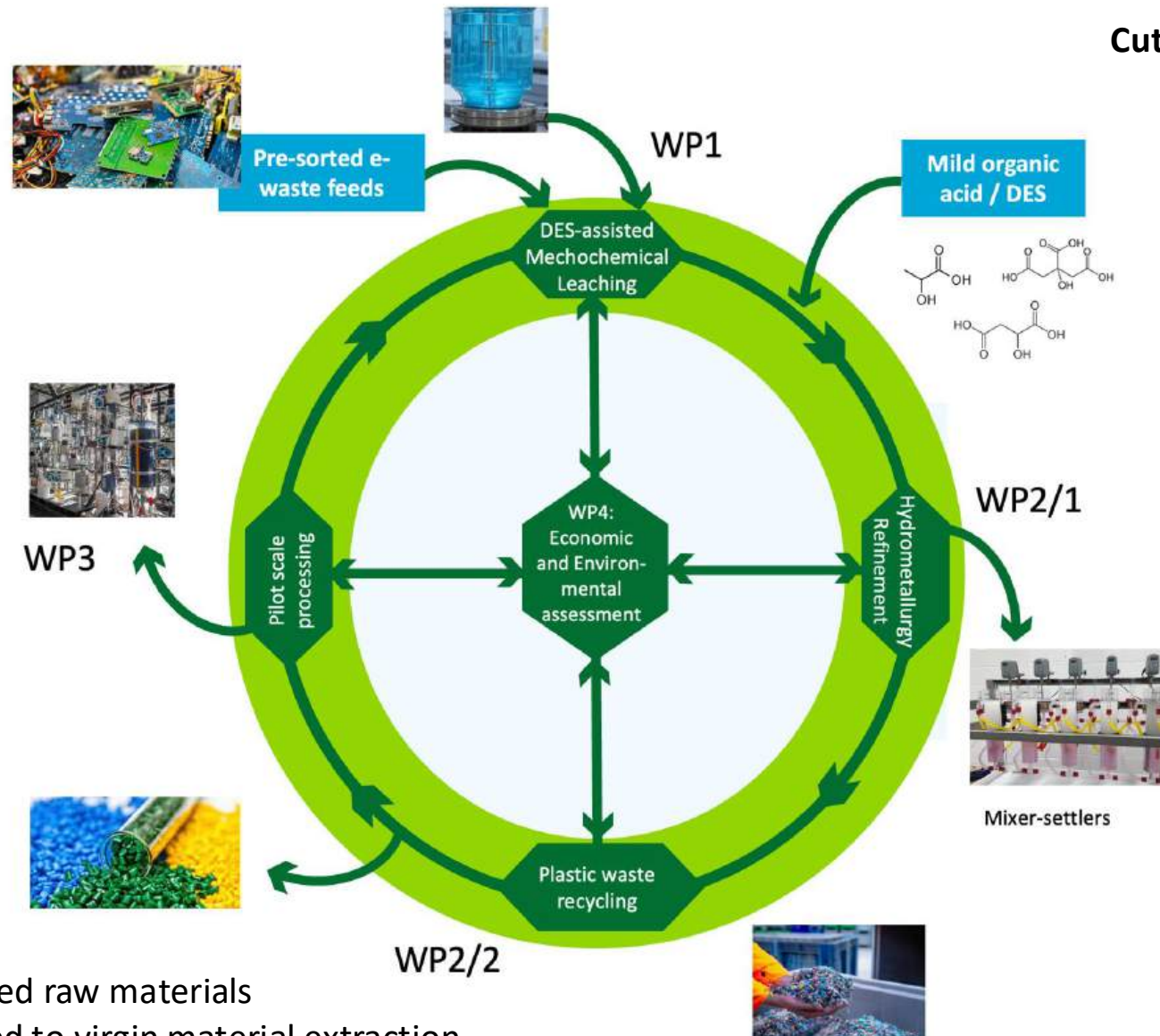
- Malaysia's e-waste projected to reach 1.4 million tonnes by 2030
- Only 25% currently undergoes formal recycling

Environmental & Economic Impact

- Creation of green technology jobs in formal recycling sector
- Improved worker health and safety
- Economically viable processes designed for local implementation

Circular Economy Benefits

- Reduced dependency on imported raw materials
- Lower carbon footprint compared to virgin material extraction
- Support for clean energy technologies requiring critical minerals



Cutting-Edge Recycling Solutions

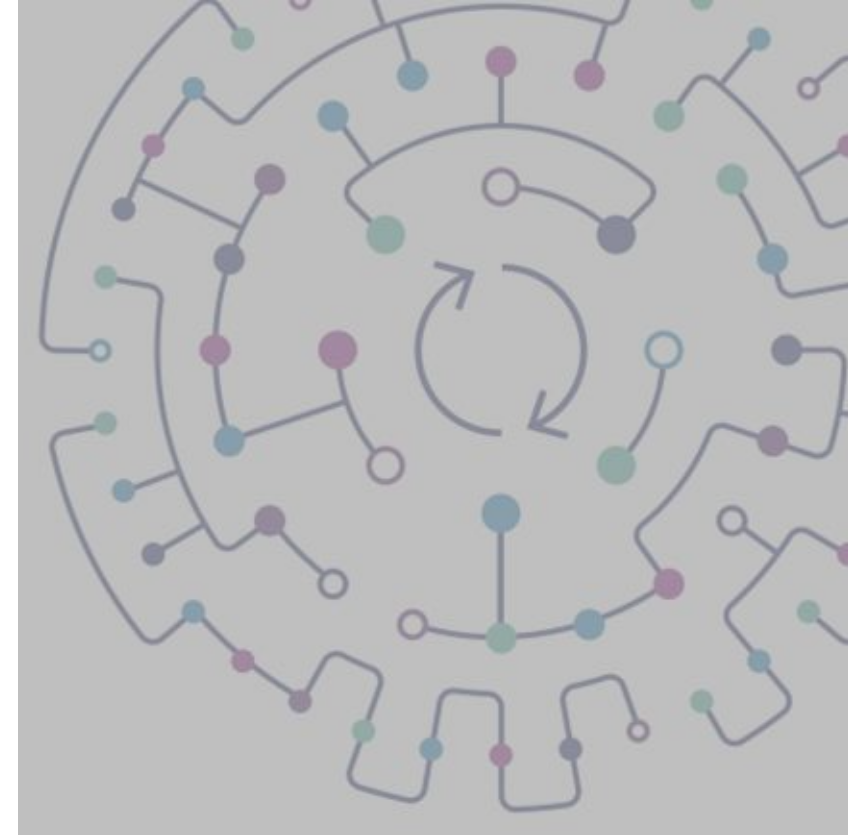
- Hydrophobic deep eutectic solvents replacing hazardous acids
- Supercritical fluids for plastic separation without toxic emissions
- Novel flowsheets maximising critical metals recovery
- Pilot-scale demonstration for pre-commercial validation

Supporting Malaysia's Sustainable Development

- Addresses development challenges in upper middle-income DAC-listed country
- Engages government, industry and communities
- Training programs for sustainable practices adoption
- Contributes to UN Sustainable Development Goals

Industrial Symbiosis: the easiest route to net zero

Jacqueline Gibson, Industrial Synergies



An industrial ecosystem where unused or residual resources from one company are used by another.

Resulting in **increased**

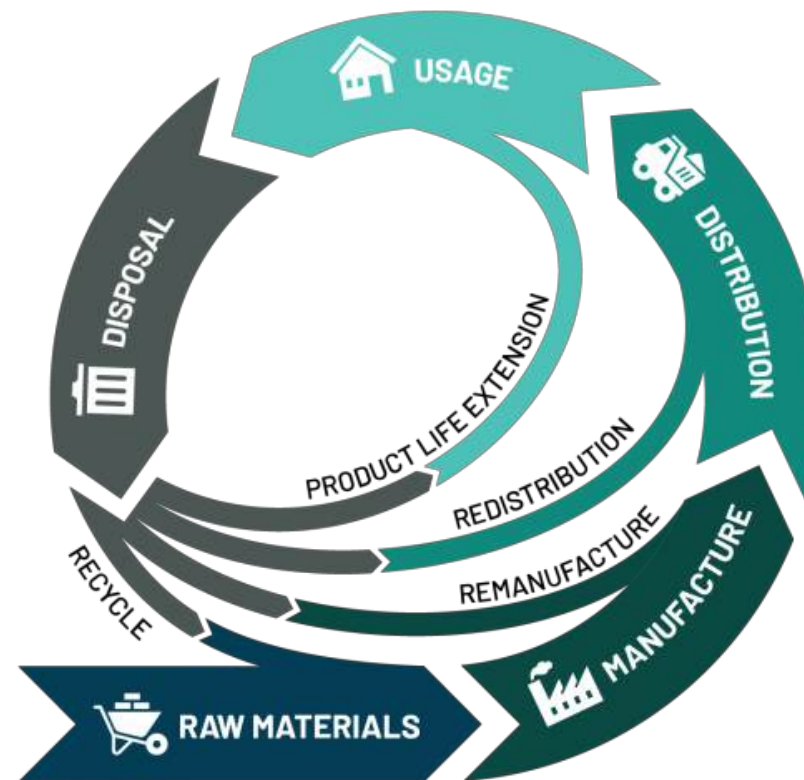
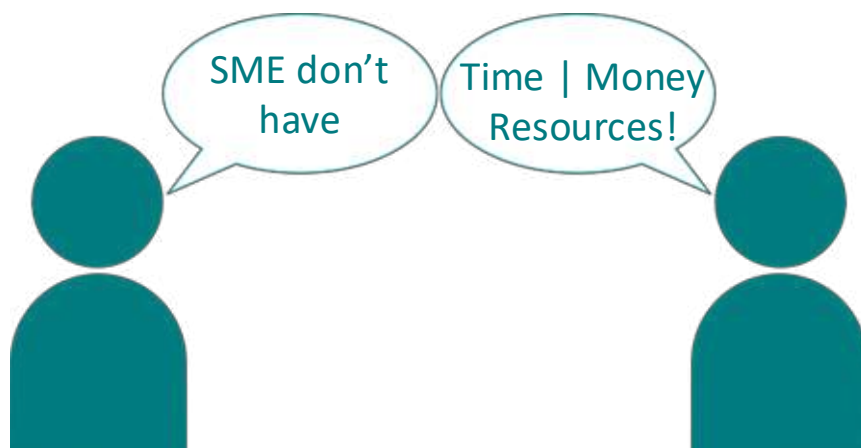
 business opportunities

 business collaborations

And **reduced**

 environmental impact

 operating costs



SYNERGie 4.0

Advisor

Ian Humphreys

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Advanced Resource Search

UK

Northern Ireland

Any

City

Category

Site Classification

From Workshop

Category

Site Classification

Any Workshop

Distance

Latitude

Longitude

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0

0

Search

Export

Search returned 3,161 results

List View

View on Map

Showing 1 to 20 of 3161

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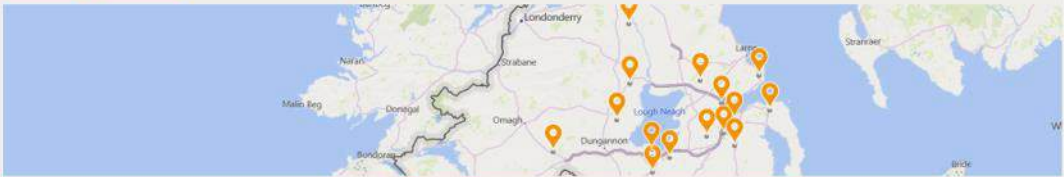
5

6

7

8

...



Reports

FAQ

Contact Us

Powered by SYNERGie 4.0

Version : 2.1.11 International Synergies Limited ©

Resource Name	Description	Site Name	IC Cod	SIC Description	Address 1
ABS welding wire reels	ABS welding wire reels collected from	TERECO LIMITED	38320	Recovery of sorted materials	286 Drummakilly Road
Alternative recycled aggregate	Alternative recycled aggregates as inl	Admsn Civil Projects	42220	Construction of utility projects for electricity and telecommunications	4 Bankmore Way East,
Aluminium Trihydrate	Aluminium Trihydrate	RecyCo	38110	Collection of non-hazardous waste	102 Barony Rd
Animal feed waste	Out of date & out of spec products	RecyCo	38110	Collection of non-hazardous waste	102 Barony Rd
Automation Solutions	Automation Solutions for moving pro	Telestack Ltd	28390	Manufacture of other special-purpose machinery n.e.c.	Bankmore Rd
Bags Polypropylene - 1Ton		RecyCo	38110	Collection of non-hazardous waste	102 Barony Rd
Baled cardboard	Baled cardboard	RecyCo	38110	Collection of non-hazardous waste	102 Barony Rd
Baled Cardboard (Egg Box)		RecyCo - NI	38320	Recovery of sorted materials	102 Barony Rd
Barrels - Steel		Telestack Ltd	28390	Manufacture of other special-purpose machinery n.e.c.	Bankmore Rd
Bathroom equipment and fit	Bathroom equipment and fittings from	Hosey Gardening Service	81300	Landscape service activities	13 Glenselly Gardens
Cable reels and timber pallete	Cable reels and timber pallets from m	Admsn Civil Projects	42220	Construction of utility projects for electricity and telecommunications	4 Bankmore Way East,
	materials, currently disposed of in general waste.				
	Solution :				
	Segregate and offer for potential rebate to specialist timber, plastics				
	and cardboard recycling companies	JMG Systems	27900	Manufacture of other electrical equipment	66-68A Derry Road
Cable reels, various sizes and cons/metals	Automotive 11/11/08	RecyCo - NI	38320	Recovery of sorted materials	102 Barony Rd
Capacity to supply	Capacity to supply new and used card	Cardboard Boxes NI Ltd	82320	Packaging activities	3 Golan Road
Capacity training room for t		GLOBAL HORIZON SKIL	85530	Other education n.e.c.	24
Capacity waste management		RecyCo	38110	Collection of non-hazardous waste	102 Barony Rd

Export

Search returned 259 results

Showing items 1 to 20

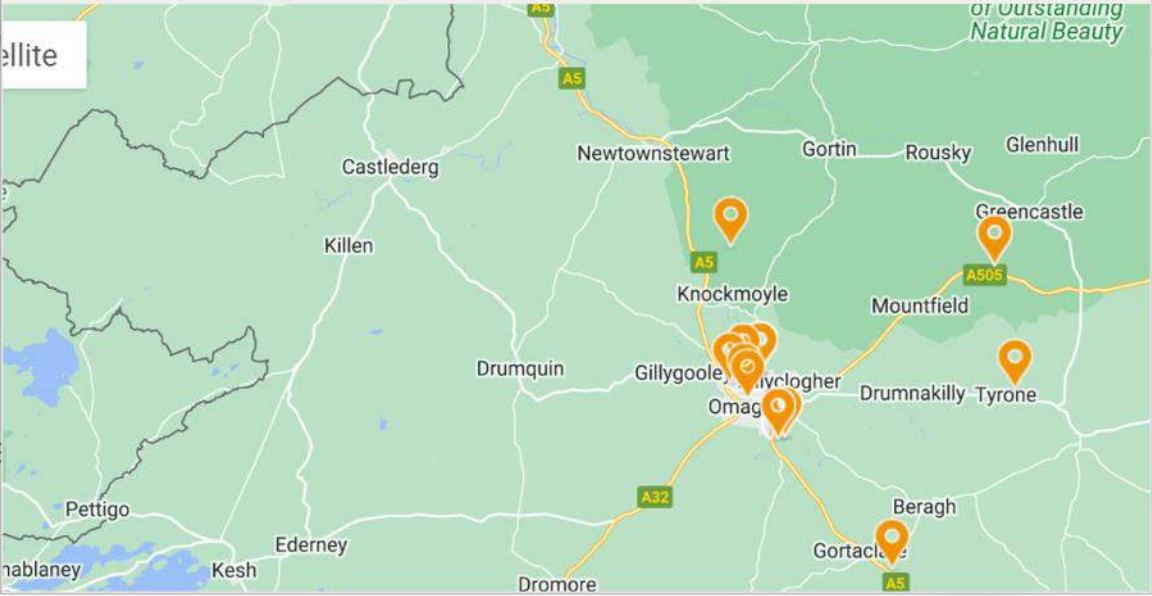
1

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2007 - 2025

OVERVIEW

The Invest NI Resource Matching Service is the longest running facilitated industrial symbiosis programme in the world. It has been delivered by International Synergies NI Ltd since inception in 2007 and to date our team have worked with over 3000 NI companies to achieve significant impact.

Cost
Savings



£32m

Additional
Sales



£18m

Private
Investment



£2.3m

Jobs



130

Virgin Material
Savings



308,000 T

Waste diverted
from landfill



405,000 T

CO2
Savings

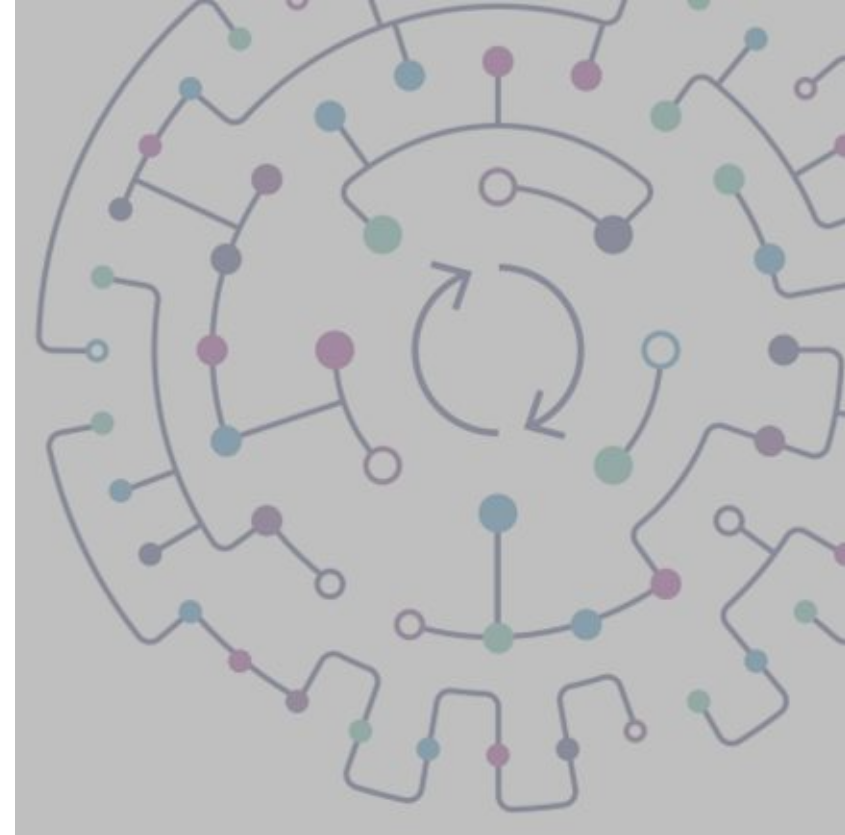


439,000 T



From Scarce to Sufficient: Synthesis Rules for Resource- Secure Nanomaterials in Energy Conversion

Dr Shalini Singh, University of Limerick



Panel Discussion



Prof. Peter Nockemann
Queen's University Belfast



Jacqueline Gibson
International Synergies

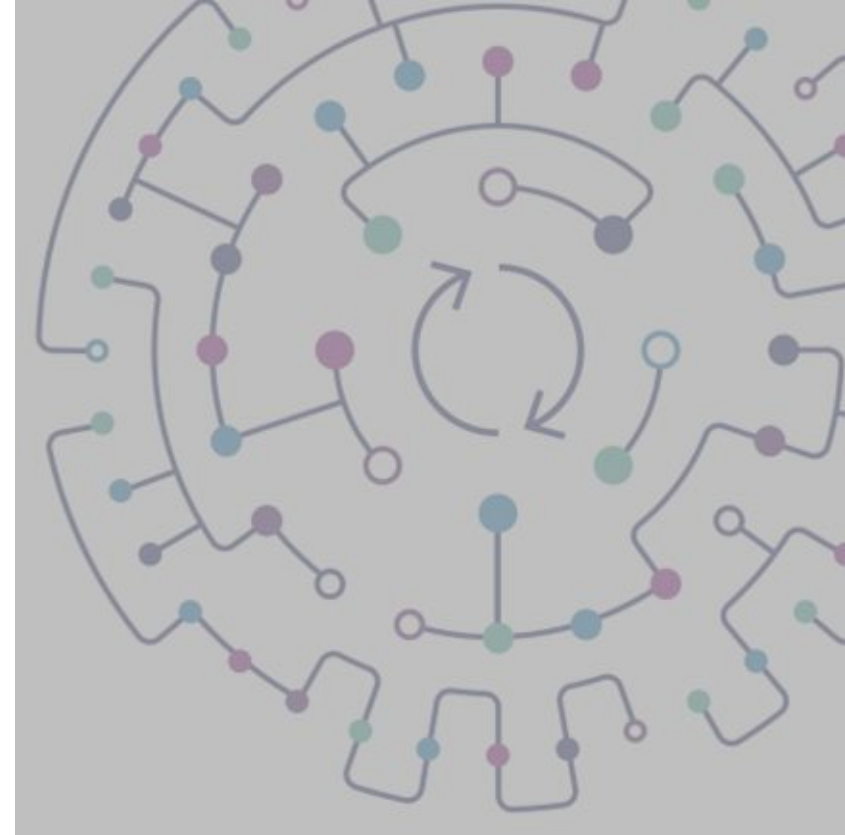


Dr. Shalini Singh
University of Limerick



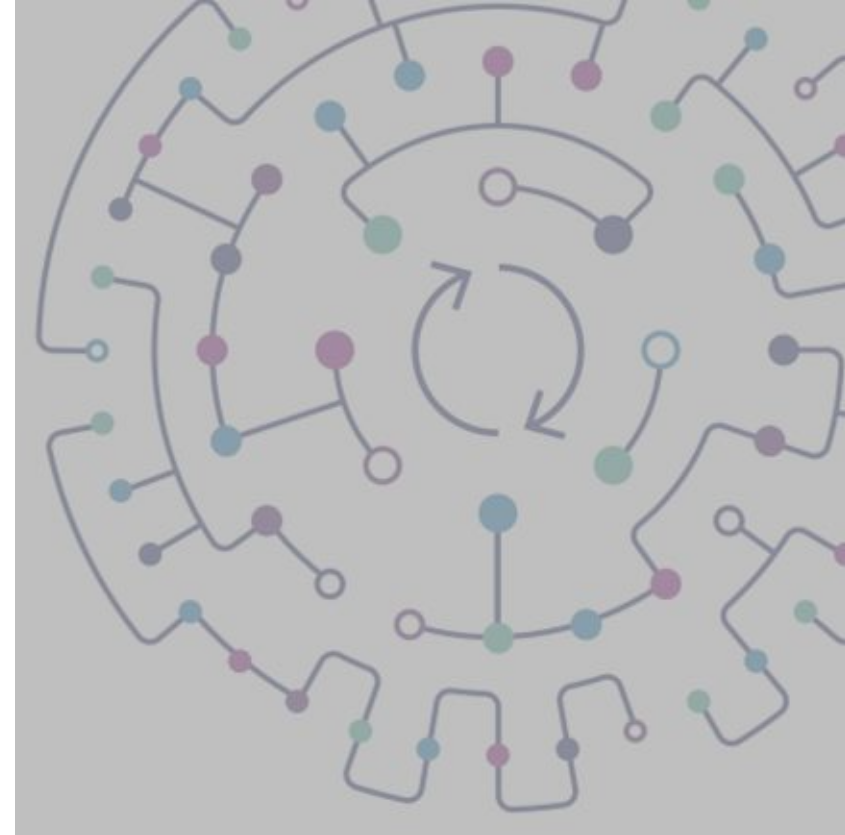
Professor Paul Meredith
DICE Network+ Co Lead
Swansea University

Coffee break



The Inner Loops: Retention, Life Extension & Standardisation

Chair: Diego Bermudez, PhD



Fireside chat



Josh Watts

Sustainable Ventures



Alastair Winner

TechBuyer

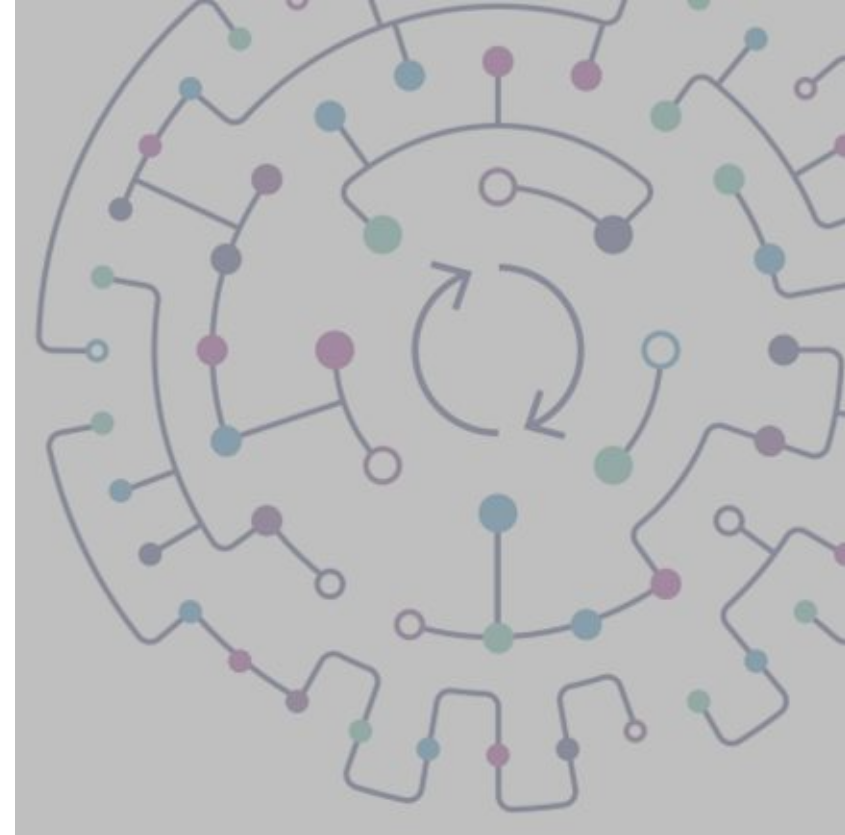


Cormac O'Prey

**Kestrel Technology
Consulting / BSI**

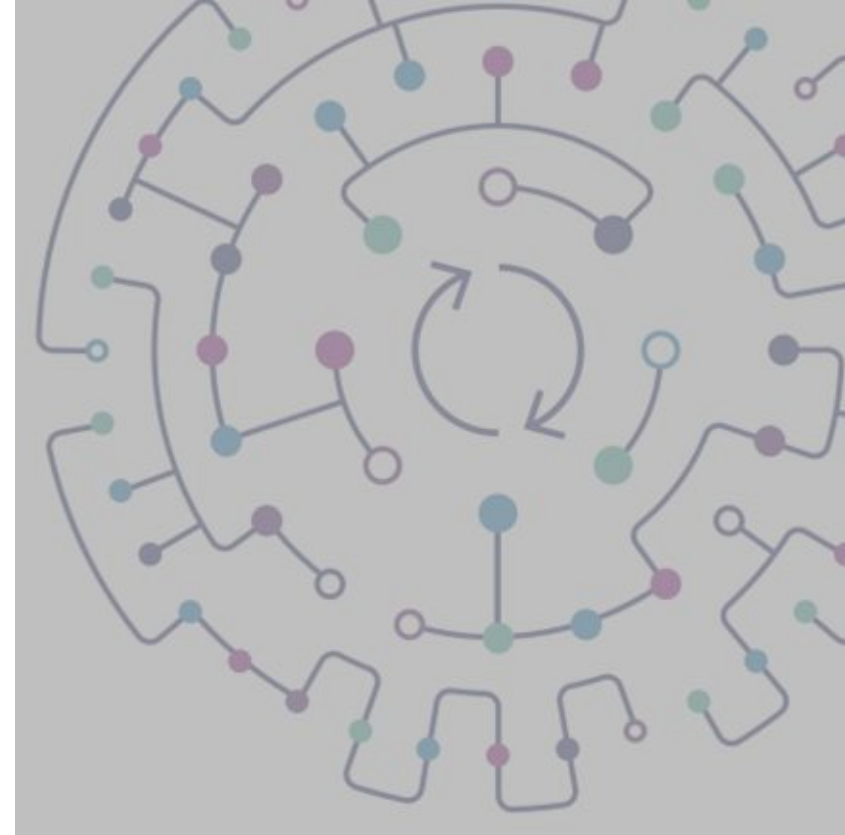
Networking Lunch

Restart at 1pm



Solutions-focused workshop

Led by ReJig

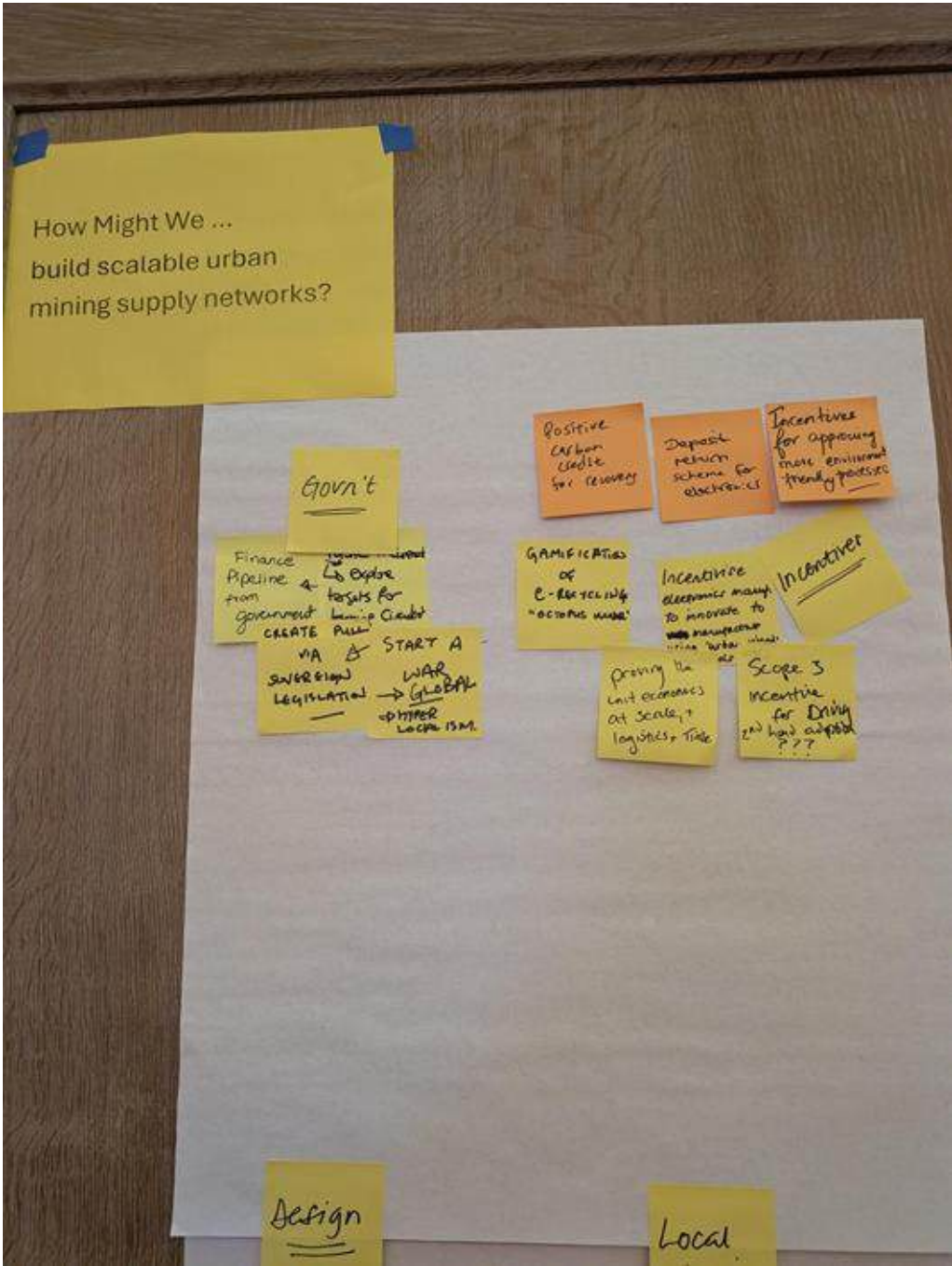








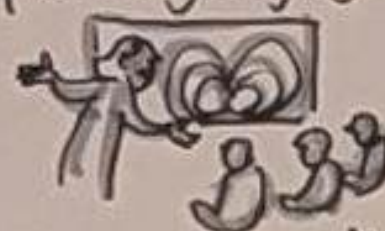
How might we build scalable urban mining supply networks?





Up Skill & Training programme
from a young age

Skills for the
Future



Change the
curriculum
from primary
age

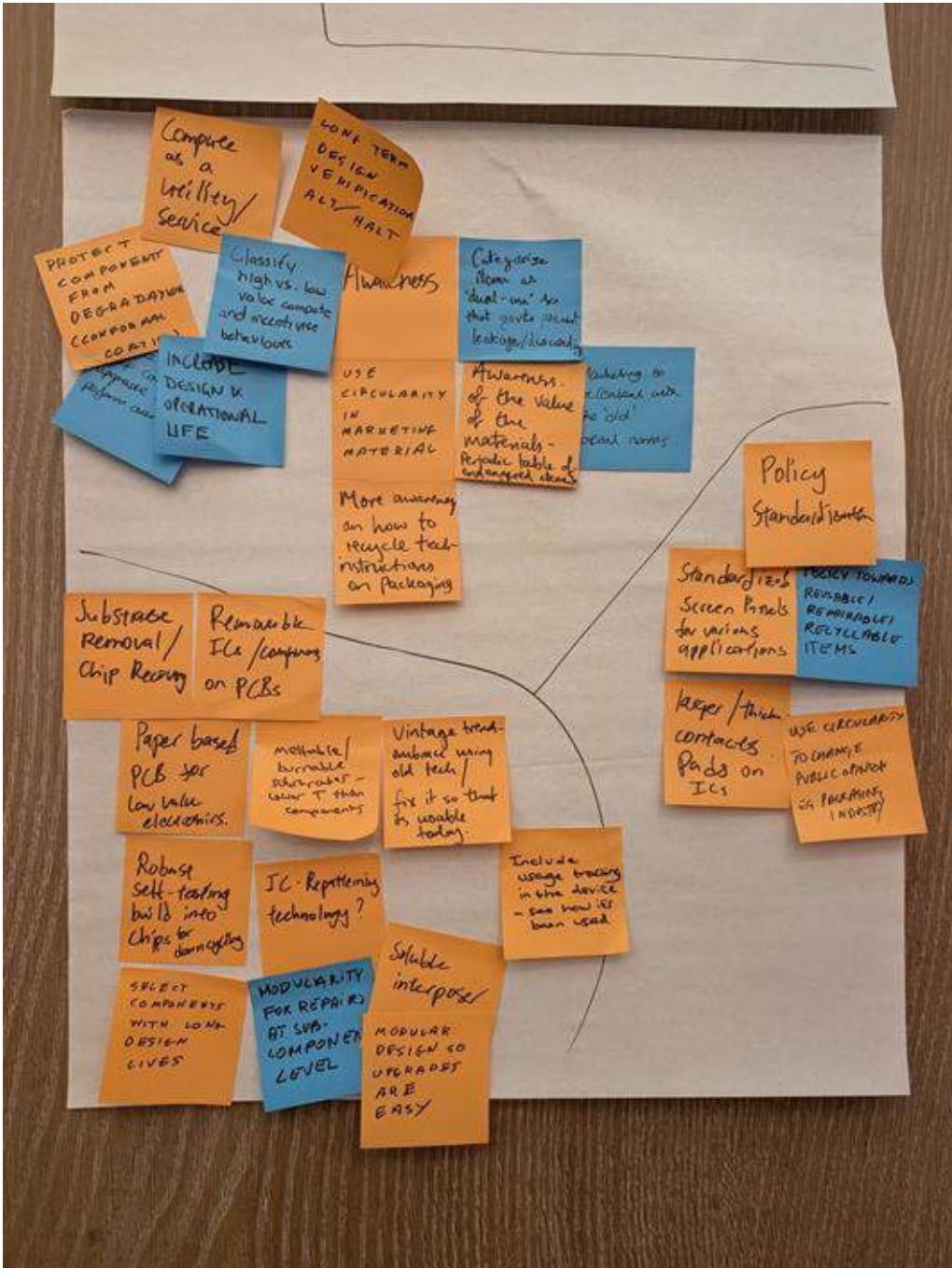
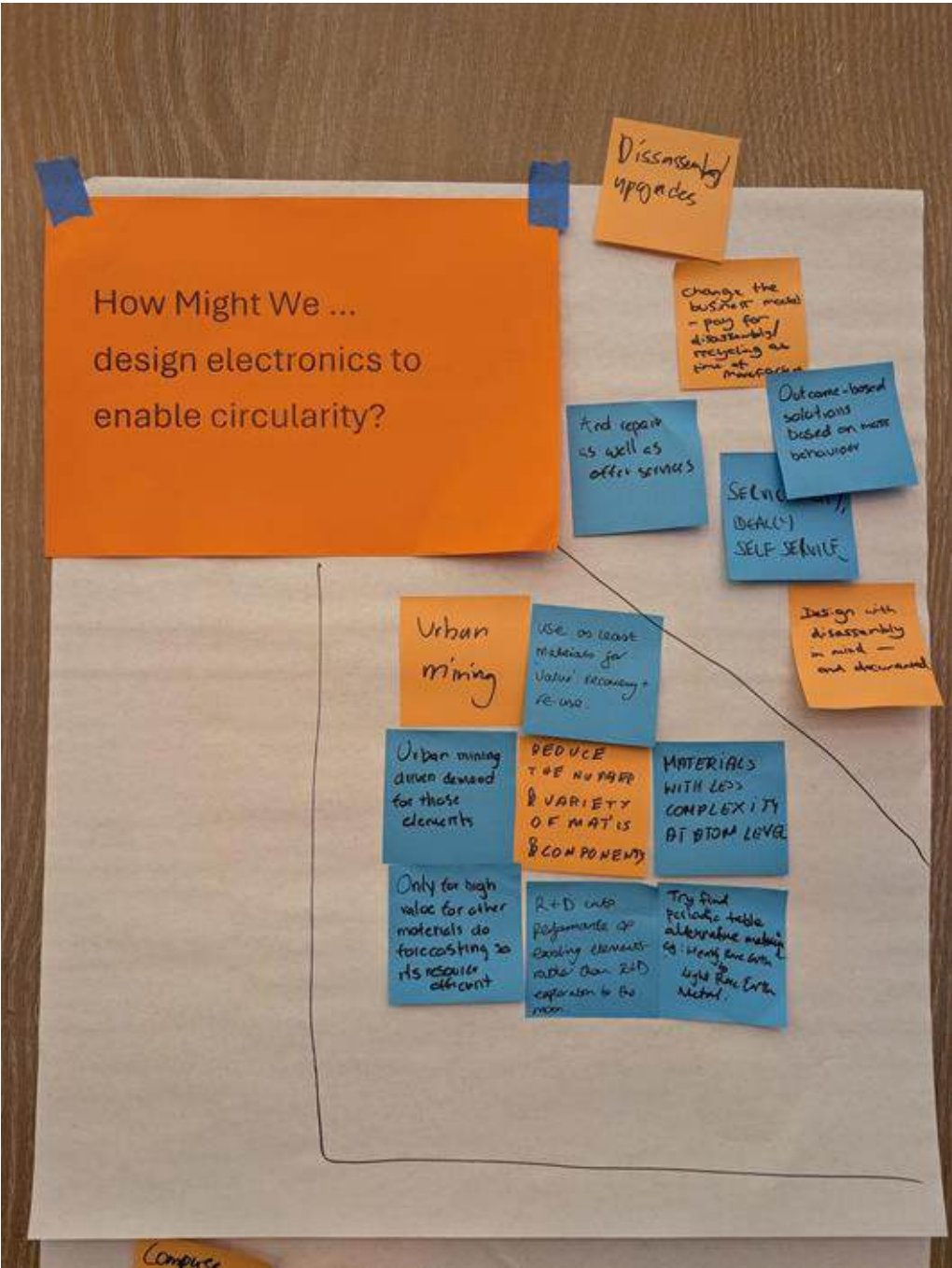
→ apprentice
level
a generation
ready for 2030
and beyond

New jobs that
AI can't do

How might we
build scalable urban
mining supply networks?

Challenge
Workshop

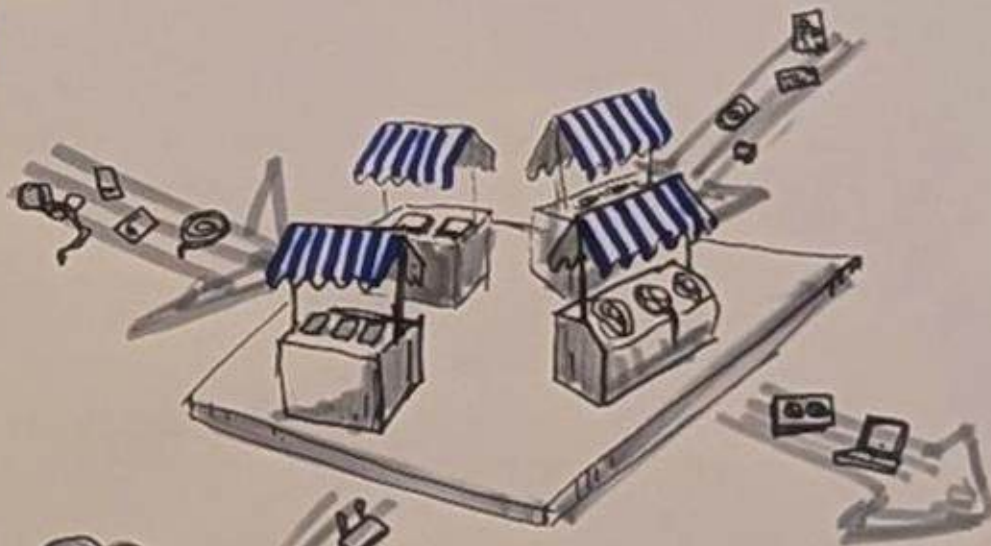
How might we design electronics to enable circularity?



Challenge Workshops



How might we
design electronics to
enable circularity?



Mandatory
Design for Recovery

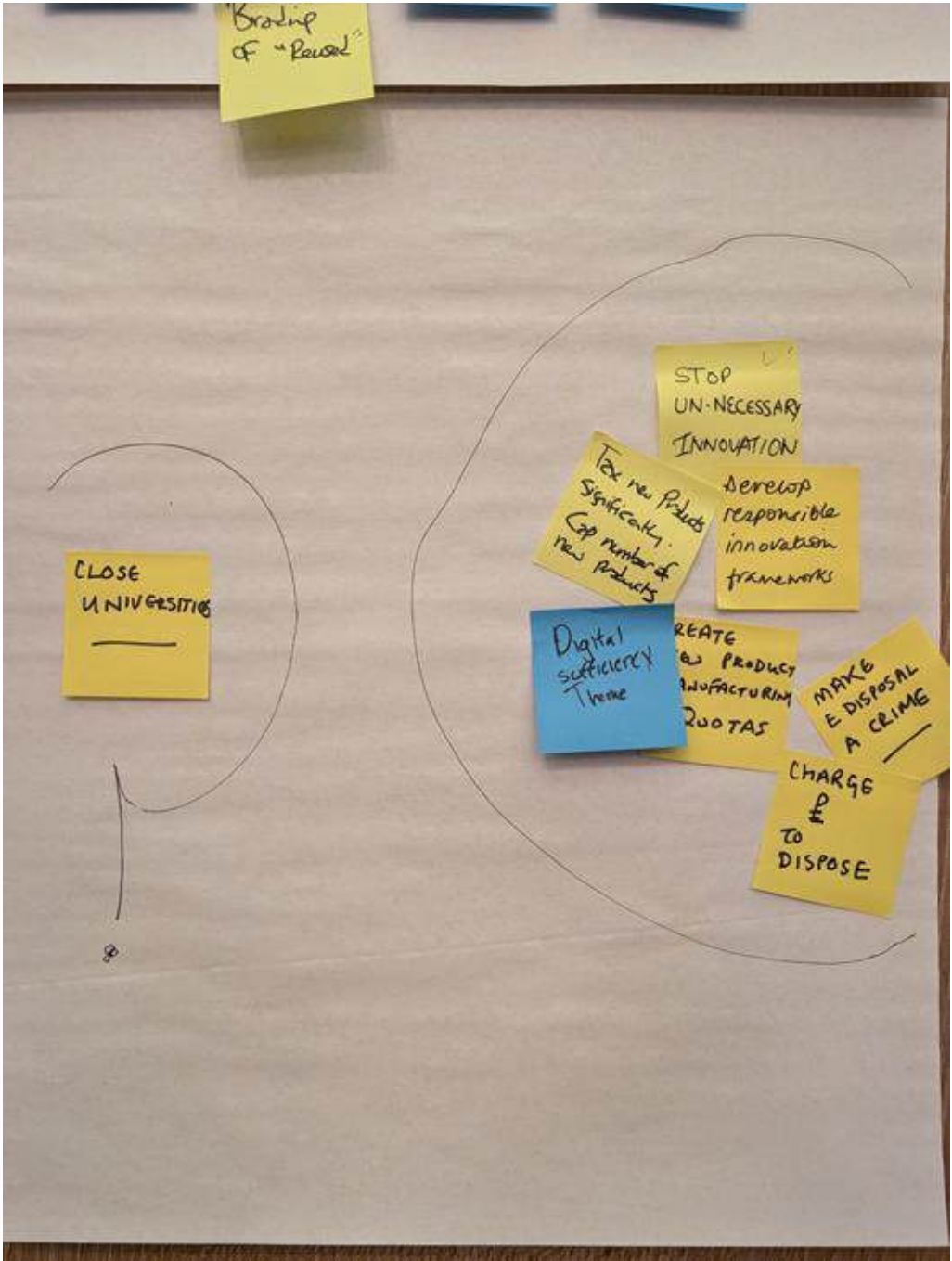
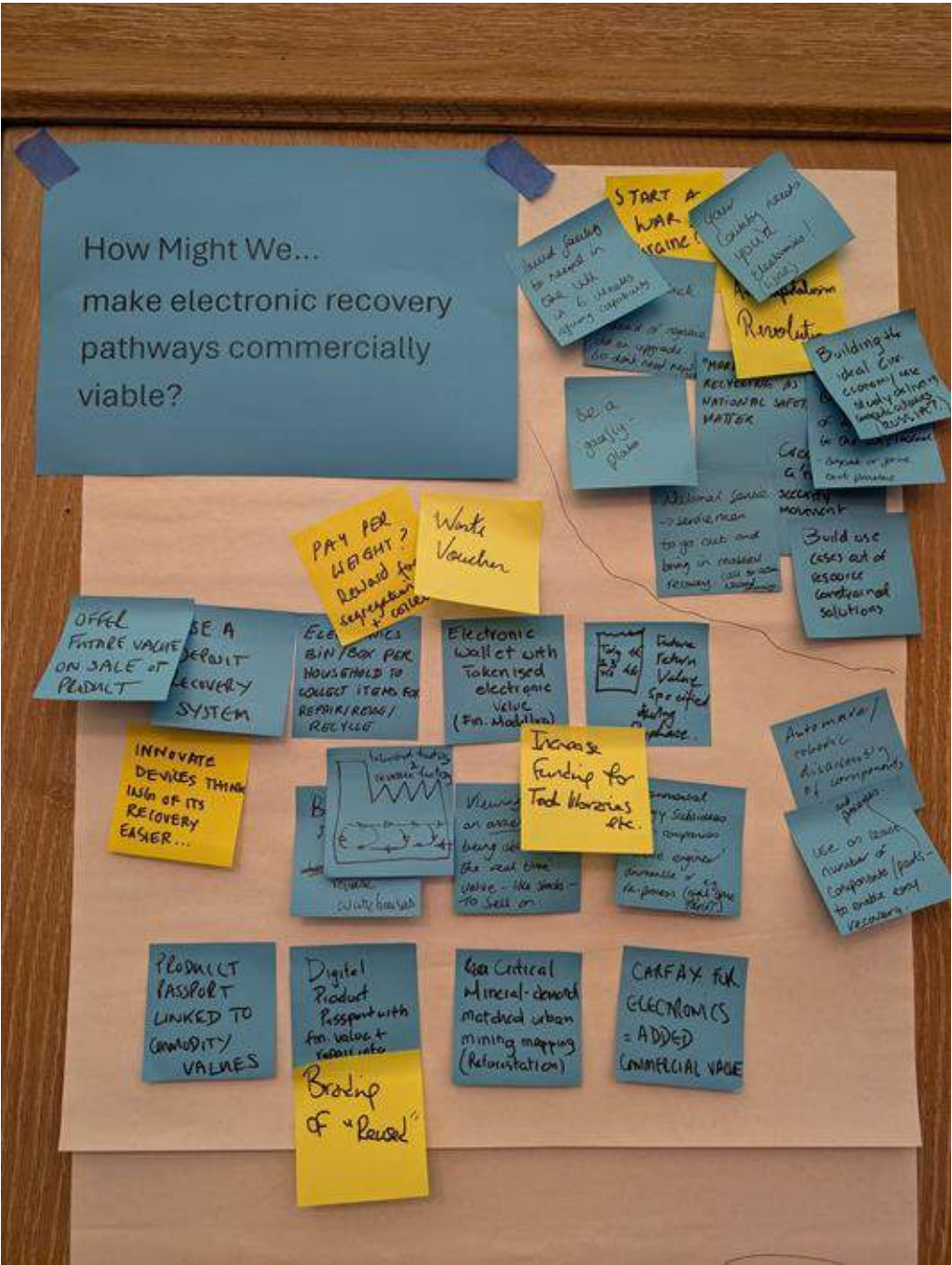


Industry guidelines
for design

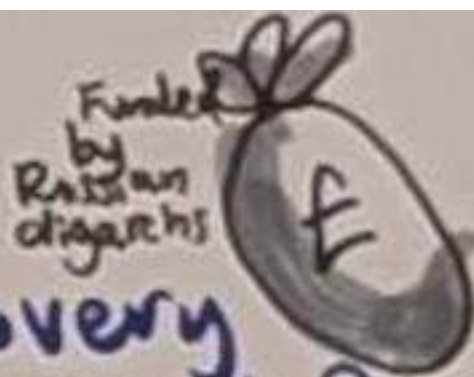
Regulation & standards



How might we make electronic recovery pathways commercially viable?



How might we
make electronic recovery
pathways commercially viable?



In a situation of
emergency
we
value critical
elements



Thank you for joining us

Please share your reflections



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