Circular Economy: Boom or bust?

Dr. Kieren Mayers
Executive in Residence, INSEAD

(also Director of Environment and Technical Compliance, Sony Interactive Entertainment)

The views presented in this presentation are those of the author and not necessarily those of Sony Interactive Entertainment

Presentation outline

* Concepts versus practice
* Government policy and circular economy
* Industrial Ecology, the science of the circular economy

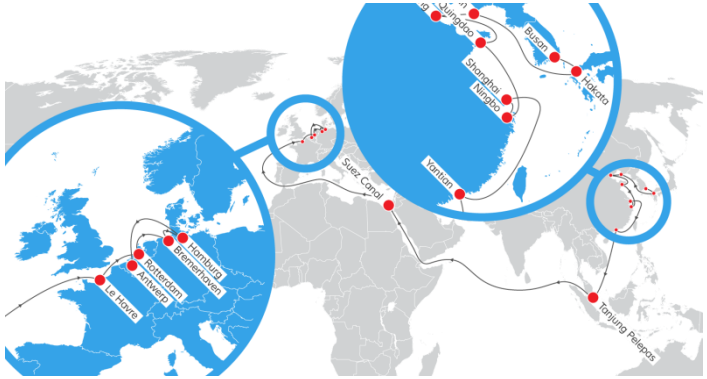
Does closed loop recycling always make sense?

How can waste be sorted by brand / specific product? ***Does it need to be for recycling to be possible?***

How would you organise so many different collection services for different manufacturers / types of product? ***Does the waste need to be bulked for efficient collection?***

How can sufficient volumes by ensured processed into sufficient quality for new production? ***Does the waste need to bulked and mixed to provide enough volume?***

How far does the product need to be shipped to for production? ***Is there another possibility somewhere closer?***



How can society move from product to service systems?

- Products shared to reduce consumption eg city bikes
- Dematerialise products eg streaming video instead of discs
- Producer leases products and manages end of life eg photocopiers

Are service-systems intrinsically better than products for society and environment?

Does car leasing reduce car ownership and use?

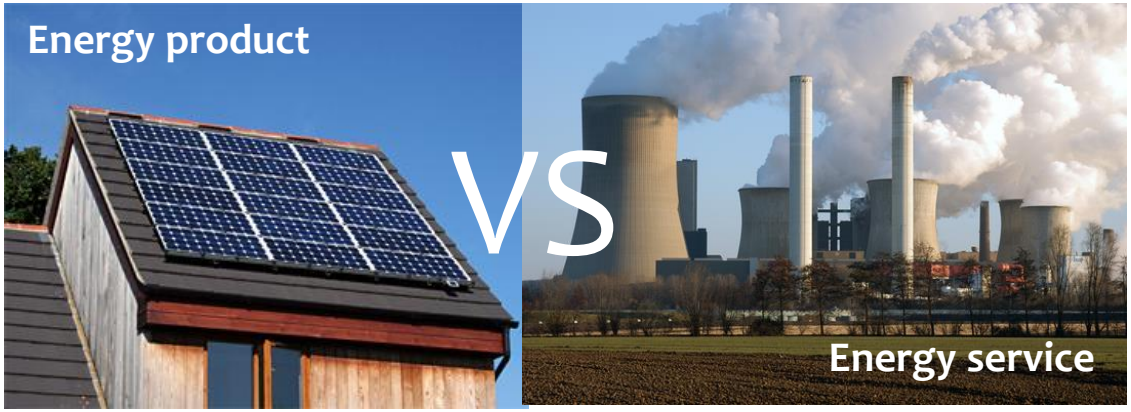
The cloud has environmental impact too

NATURE WORLD NEWS

Gaming's Carbon Footprint: Are Downloaded Games Actually Worse Than Disks?

By Brian Stallard — Sep 04, 2014 04:34 PM EDT

Here's something that you probably didn't see coming. The amount of greenhouse gases emitted during the production of a hard Blu-ray disk is actually *less* than the carbon released during the download of a single videogame.



How can producers be encouraged to develop longer lasting products?

Some producers do provide premium products that will last longer, so can't they all?

Should producers declare expected lifetime of their products?

Does it always make sense to invest energy and materials to make products last longer?

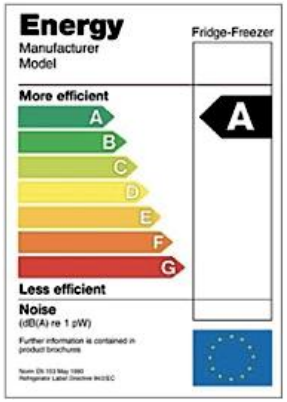
What if we want technology to advance and offer new types of experience and service?

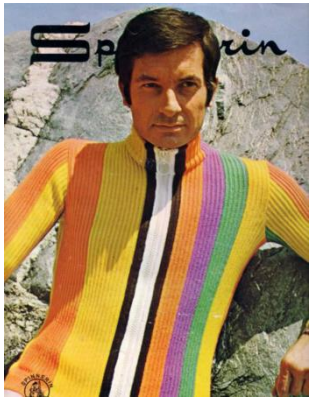
If consumers expect their products to last as long any stated ‘average’ life span, will they also pay higher prices for resulting extended warrantees?

How can the expected lifetime of new products be measured in advance?

What happens if consumers don’t want to pay premium prices for longer lasting products?

What if new products become more energy efficient in use?



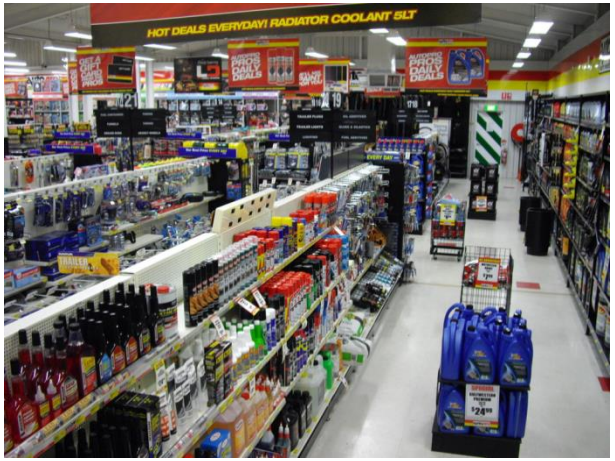


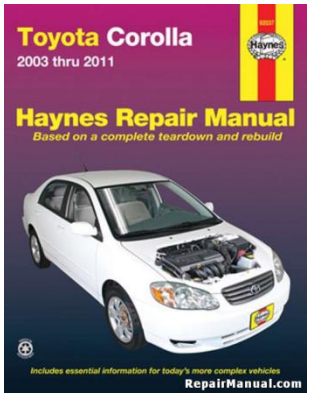
What if tastes change?

How can products be made more repairable / reusable?

Can components easily be replaced?

Are spare parts available?





Is there information available on how to repair?

Repair and reuse are practicable way to extend product life, but…

Will repairing and reusing a particular product avoid products being replaced with new, of result in more products being used overall?

Could there be important reasons why producers would wish to maintain control of information, parts, and services for repairing their products?

How many parts should be produced and kept in warehouses (both energy consuming processes) for how long in case they might one day be needed for repair?

How can products be designed to be more recyclable?

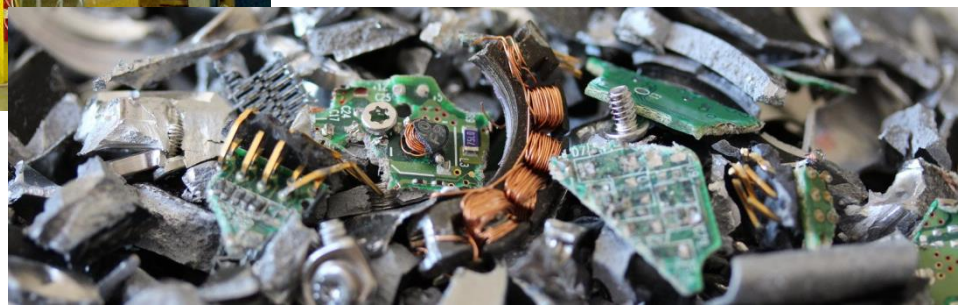
Ensuring ease of disassembly?

Providing information on materials in products?

ITEM	QUANTITY
6" channel, 7/16" thick	20 feet
Grade 8 bolts, washers, nuts, 1/2"x2"	48
Main cylinder[1], 5", surplus	1
Hopper cylinder, 1.5"x15"[3]	1
Control Valve, open center, 2 spool[4]	1
Hopper sheet metal, 3/16"	24 square feet
Hydraulic fittings	various
Hydraulic hoses[6]	4
Cylinder mounting metal rods and angle	various
Main press plates, 1"x6", 1"x8"	3 pieces, 3 feet total
Pressing plate sides, 1/2"x6"	3 feet
Nylon 6/6 liner	5 square feet
Rubber for press plate[7], 6"X12"	1
Hopper table 1/4" steel: 2" tubing and plate	10' & 6 square feet
Hopper alignment rail: 2"x1/4" angle	2 feet
3-point mount for a tractor, 2"x4"x1/4" tubing	4 feet
Legs, 2"x1/4" square tubing	12 feet

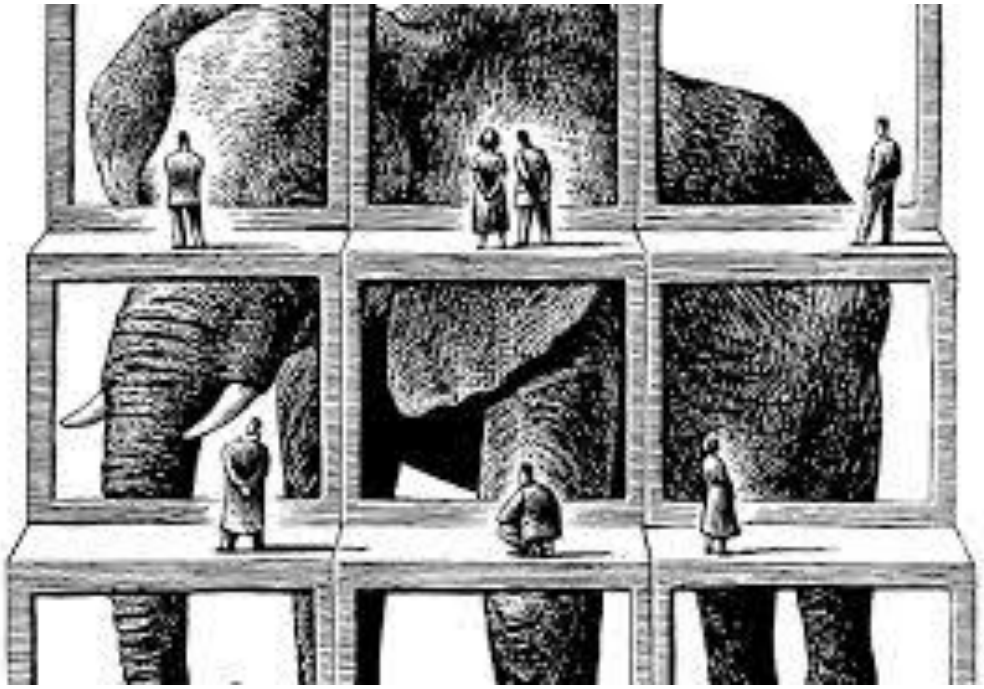
Design for recycling should not lose sight of *how* products are recycled

Product-specific bill of materials doesn't help bulk recycling



Efficient bulk recycling is automated, similar to mining ore

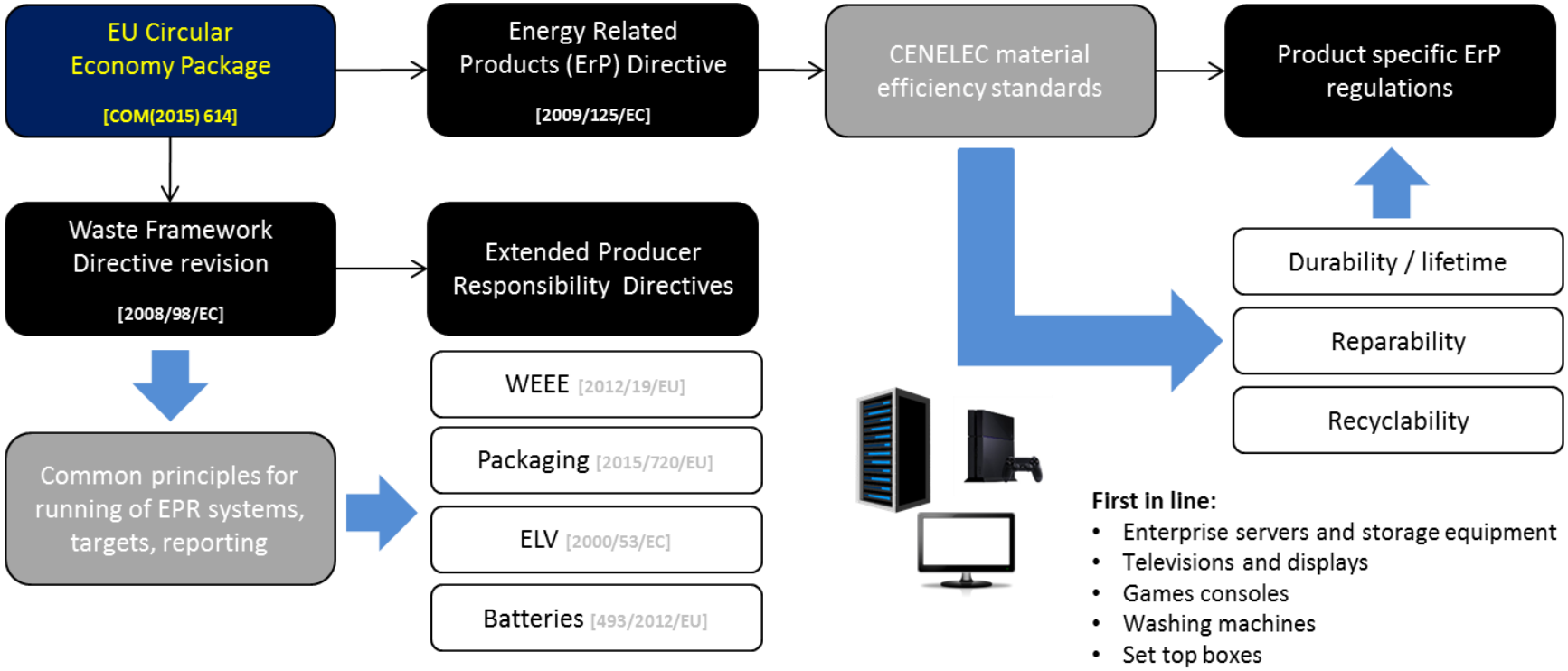
Context is important



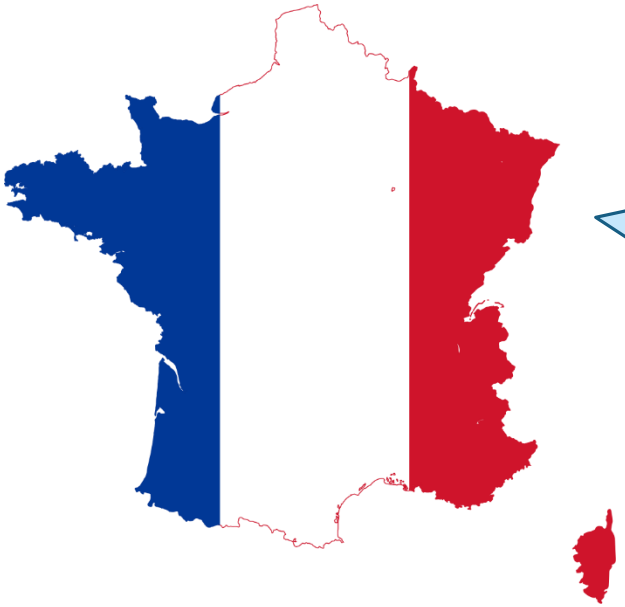
Is my idea for circular economy any good?

- Is it possible?
- Is it practical?
- Will consumers buy it?
- Will it cause other environmental problems?
- How will it reduce materials consumption?
- **Is my knowledge based on my own assumptions, what someone told me, or actual evidence**?

The EU is creating a mandatory policy framework for Circular Economy



France is also creating national legislation



- Draft French Circular Economy law expected 2021
- Mandatory repairability labelling & scoring: including parts availability
- EPR WEEE fee modulation linked to repair scoring and recycling of plastics up to 30% of product price!

Is stockpiling parts inventory for a fixed number of years material efficient?

Device	Random Policy	YOF Policy	OOF Policy	Sampling Policy
A	0.163	0.042	0.034	0.023
B	0.124	0.025	0.022	0.014
C	0.316	0.065	0.060	0.040
D	0.256	0.052	0.061	0.040
E	0.302	0.068	0.083	0.044
Average	0.232	0.050	0.052	0.032

Table 3 **Expected out-of-OEM repair costs weighted by the total number of devices sold of each model for different assignment policies. The unit of the values in the table is $/device sold.**

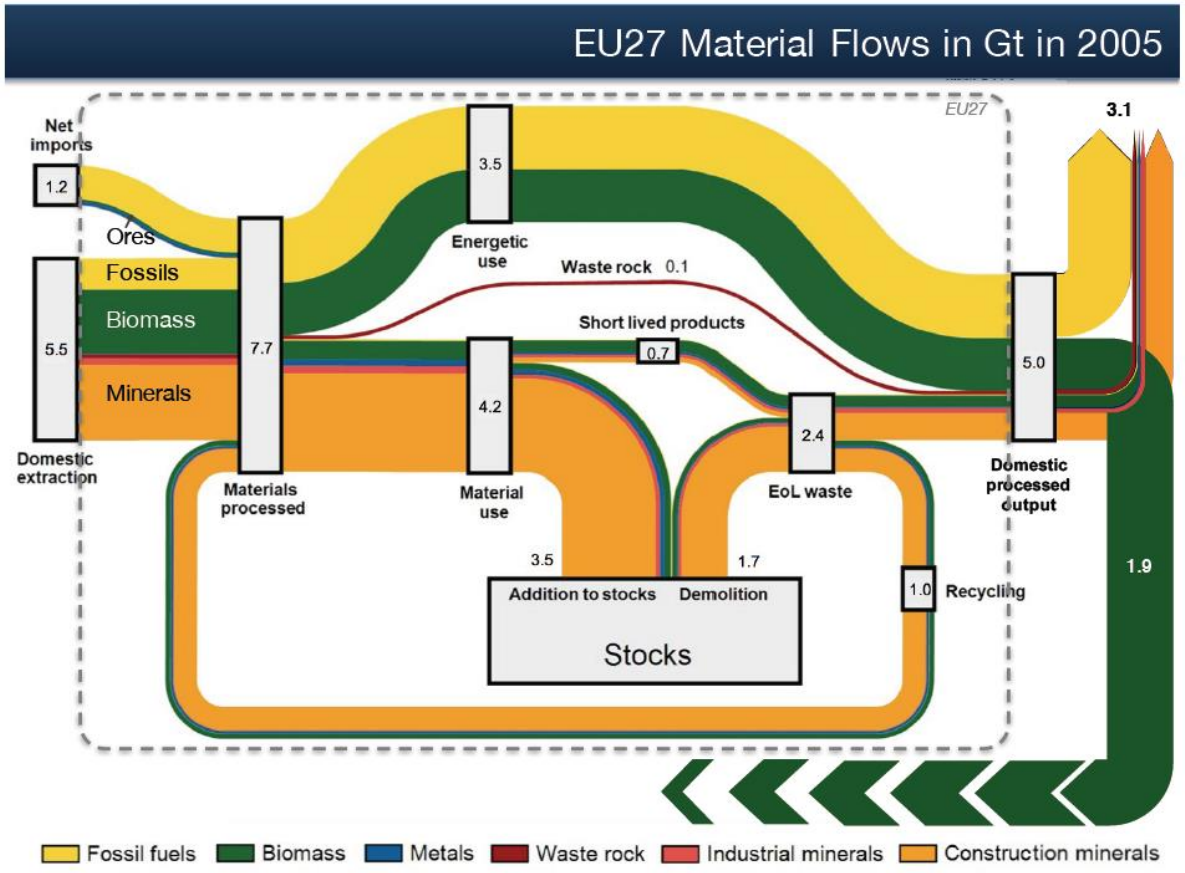
	Random Policy	YOF Policy	OOF Policy	Sampling Policy
Total Expected cost in millions of $	11.61	2.51	2.60	1.62

Table 4 **Total expected cost per year (in millions of $ per year) assuming 50 million device sales per year**

'there might be other dynamic optimization problems with a cost and state-space structure that leads to simple farsighted policies performing better than myopic policies.'

Calmon, A. P., Graves, S.C., and F. Lemmens, "*Warranty Matching in a Consumer Electronics Closed-Loop Supply Chain*", INSEAD *Working Paper 2019/36/TOM: Fontainebleau, September 2019*

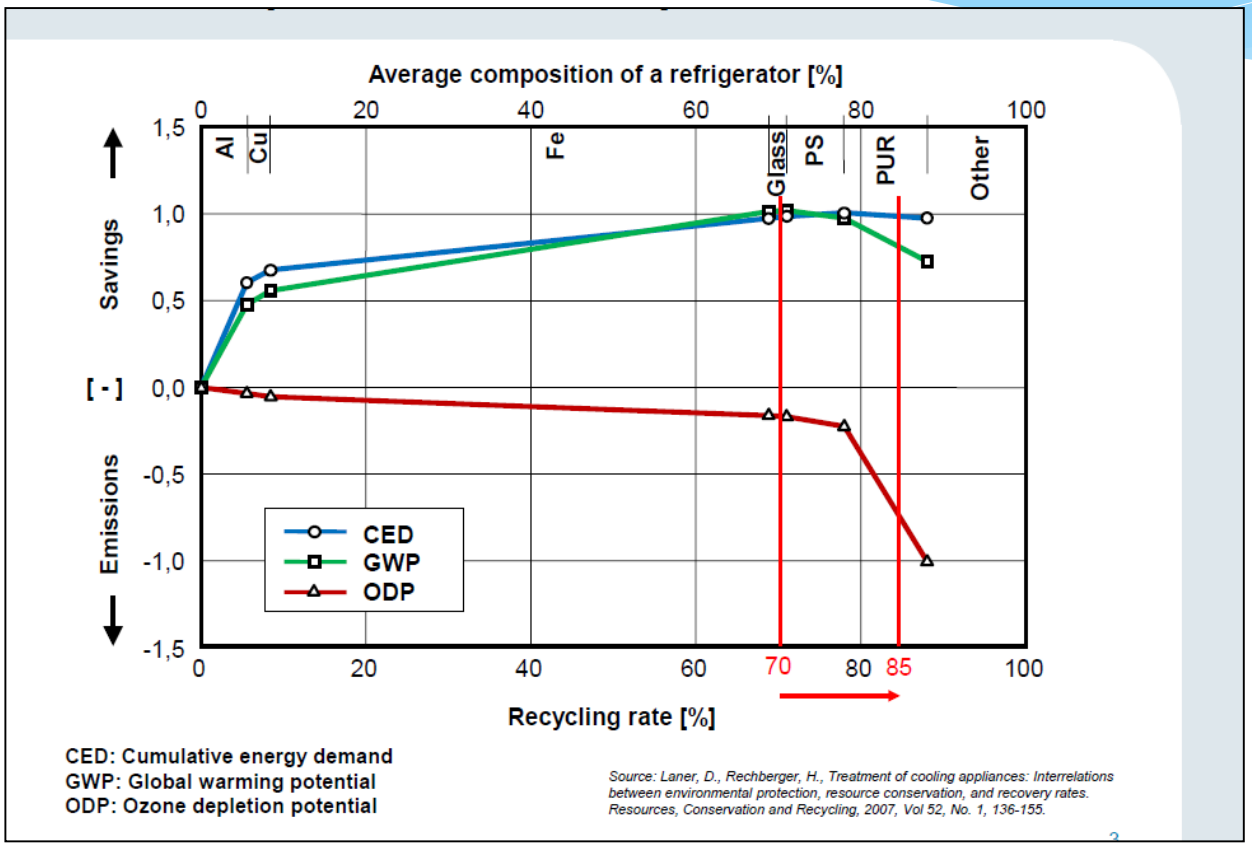
Stocks of materials in use are growing: waste volumes are not sufficient to supply new production



- Processed materials = 7.7 Gt
- Energetic use & Stock additions = 89%
- Potential degree of circularity: 38%

Haas, W., "Global economy's circularity: Current state and future options", *Industrial Ecology: Science of the Circular Economy*, Brussels 2016

When is circularity more environmentally beneficial, and when is it not?



'A higher recycling rate is not *per se* better. To find the optimal recycling rate requires profound understanding of the system.'

Rechberger, H., "How to find optimized recycling rates and more to establish a Circular Economy", *Industrial Ecology: Science of the Circular Economy*, Brussels 2016

Circular economy is a means to a end, not an end it itself

* Methods are needed that work in practice to reduce the environmental impact of materials use: be wary of over-generalised ‘Circular Economy’ doctrine
* The EU is implementing circular economy requirements already: this is an opportunity for research, which provides methods based on science
* Expect unexpected results, and be happy that the answer to the question ‘what is the best outcome?’ is often ‘it depends!’

99PLAS DIGITAL PLATFORM

- Building closed-loop plastic recycling solution-

Established in 2012, Minder Technology is a dynamic and passionate team of talented designers, developers and marketing professionals that loves helping business deliver their value to the world. We provide solutions in a highly competitive marketplace and it's our technology that ensures our standing-out. It is really exciting to try out new technology and find the best one to help you accelerate your business.

Established in 2007, buying and selling most types of plastics. Through the company's annual growth, it has become now a leading name in the plastic recycling industry

Recycling Industry Supply Chain

Industry Challenges

Reverse Supply Chain

- Difficult to implement quality standard
- No guarantee of quantity

Lack of connections and interactions between all concerned parties

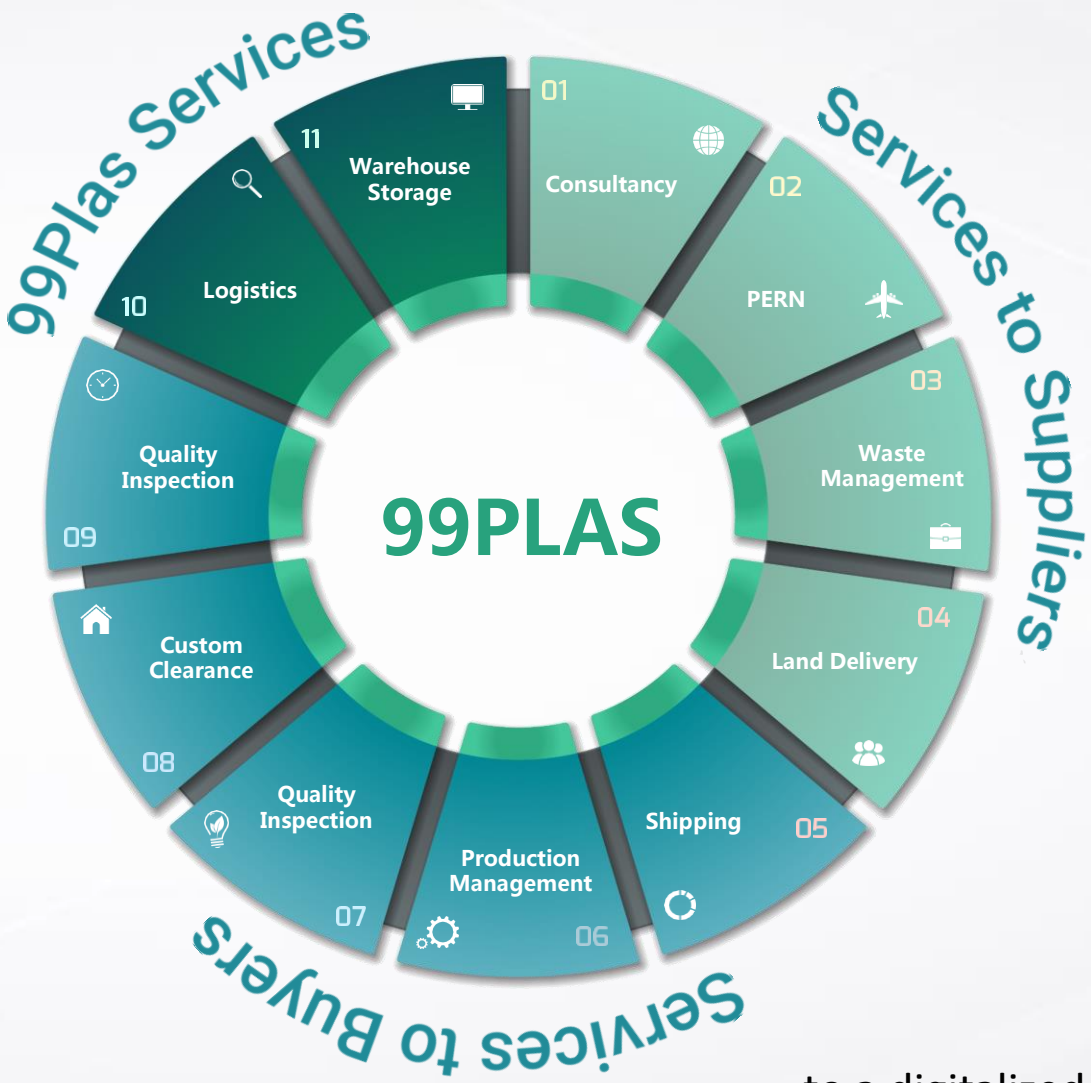
- Retailer - produce waste
- Recycler – store/sort/transport waste
- Manufacturer – process waste
- University / Policy maker / Media

The plastic recycling supply chains in the UK are weak when facing international competition

- UK EA system slowing down the exporting process
- China close door for solid waste importing

99Plas Objective

From a classical Supply Chain...



...to a digitalized Knowledge based Supply Chain

99Plas Objective

Create a Cloud Computational Interactive Trading System

Develop innovative data-based services

Build a novel B2B2B business model archetype

Core Services

01 Information - Online Trading

99Plas will be free for certified users.

02 Logistics

Our logistics collaboration with professional service providers allow us to operate at the optimum level regarding transport solutions.

03 Quality Inspection

Our well-experienced inspectors provide on-site inspection to ensure loading process and quality of material hold up to the standards given.

04 Paperwork

99Plas will help users to complete the required paperwork for in/export trading.

05 PERN

99Plas offers trading with PERN, with all grades producing evidence to guide and identify packaging meeting the required UK obligations.

06 Price Pattern

99Plas will monitor price trend to offer and make calculated decisions for future actions.

07 Bespoke Services

In addition to our core services, 99Plas keeps open-minded to provide bespoke services as our customers request

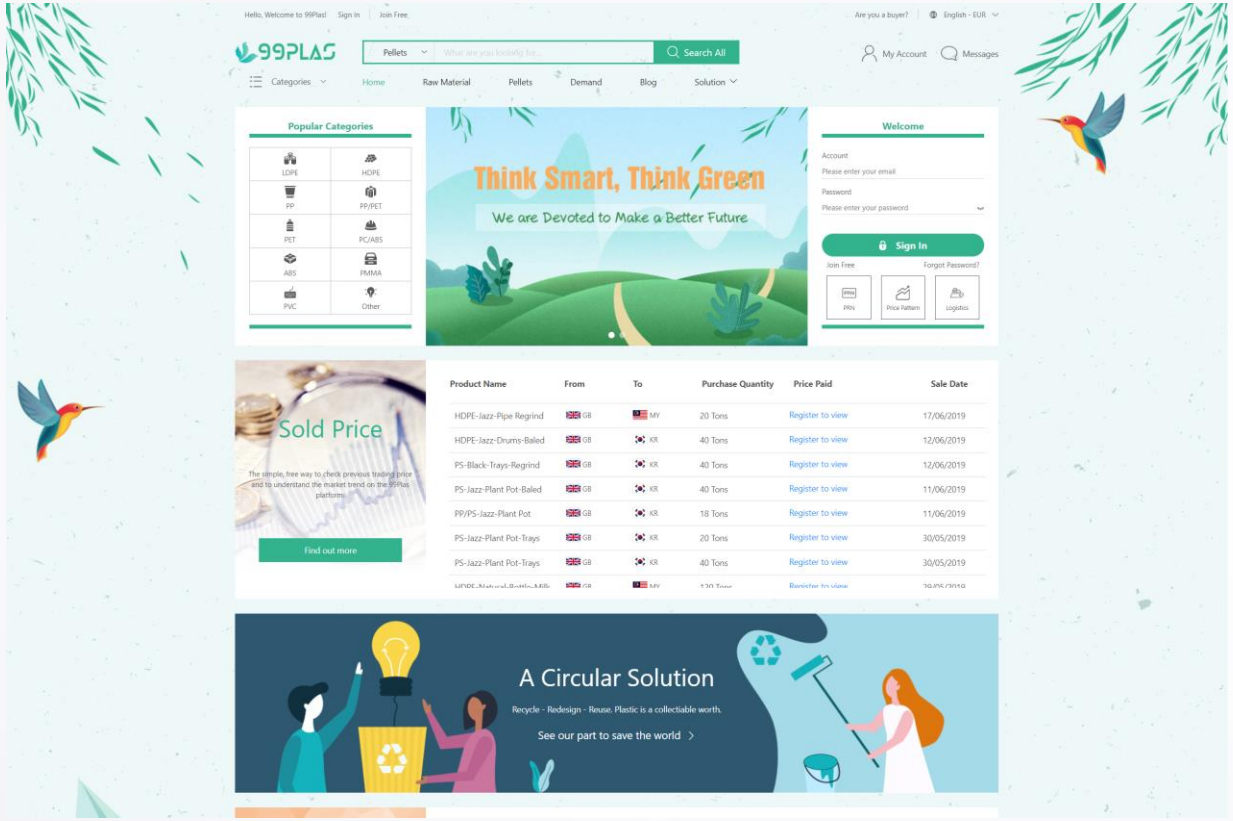
+ Consultancy + Education

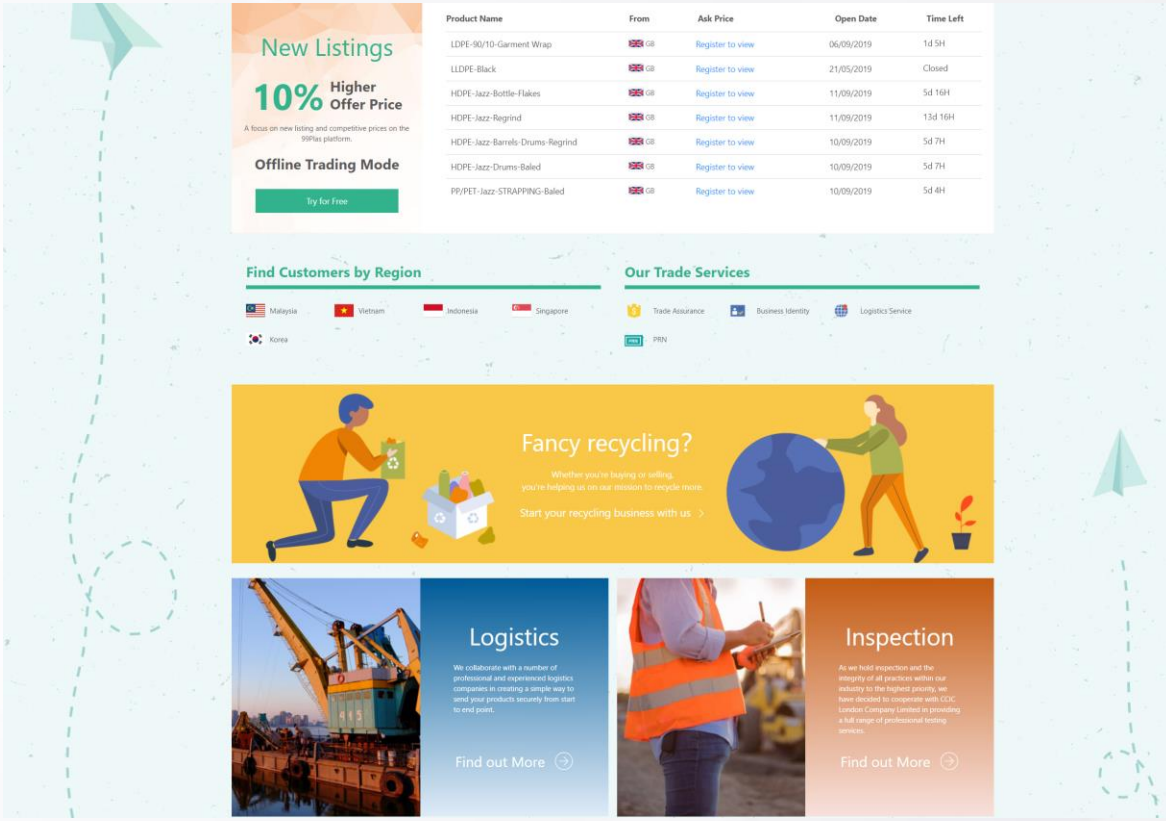
+ Insurance + Finance

Plaspedia

Implementation Framework

99Plas.com





What next.....


Thank you
Contact via Linkedin
Welcome to take a look at 99Plas

NORTH EAST
AUTOMOTIVE
ALLIANCE

The North East Automotive Sector

A globally significant region

- Nissan, Sunderland – the UK's most productive car plant
  - 30% of all UK passenger vehicles
  - 20% of all EV production across Europe
- Other OEMs - Komatsu, Caterpillar, Cummins & Erwin Hymer
- World-class supply chain - 28 Tier 1's and over 200 <tier 2
- Europe's largest battery facility
- UK's largest automotive cluster – the NEAA
- £11bn sales and 30,000 direct employees

NORTH EAST AUTOMOTIVE ALLIANCE

European Union
European Regional Development Fund

Industry Leadership

Executive Board

Steve Marsh	Nissan & NEAA Chair
Mike Mathews	NEAA Vice Chair
Paul Butler	NEAA CEO
Martin Porton	RTC & NEAA Comp Sec
Matt Boyle	Driving the Electric Revolution
Stephen Irish	Hyperdrive
Peter Howe	Komatsu

About the NEAA

- Established in March 2015
- Industry led cluster
  - 240+ member companies
  - Supported over 190 SMEs through ERDF
  - Engaged with over 1,400 companies
- 13 industry working groups covering 5 key thematic areas
- £500,000 p.a. in-kind support for cluster activities

Advisory Board

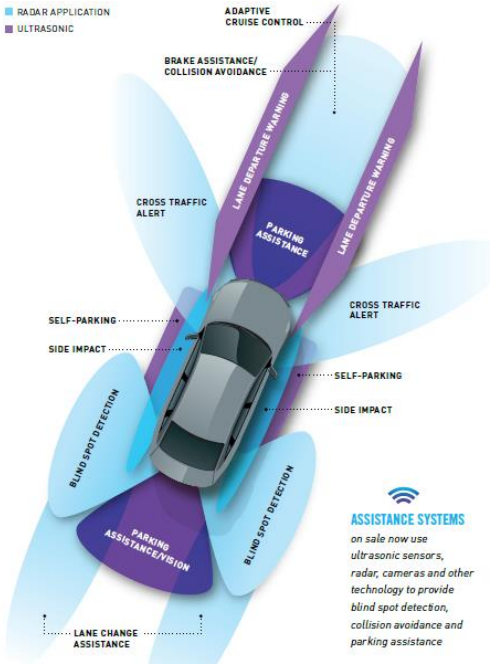
NISSAN, KOMATSU, kasai, UNIPRES, NIFCO, Calsonic Kansei, HYPERDRIVE, snop, ZF TRW, ADIENT, elringklinger, Gestamp, LEAR CORPORATION, Cummins, SEWS-E, NOVARES Beyond plastics, FALTEC EUROPE LIMITED, Sunderland City Council, ZERO CARBON FUTURES, RTC NORTH

BRONZE Cluster Management Excellence
STRIVING FOR CLUSTER EXCELLENCE

The automotive sector will see more change in the next 10 years than its entire history to date

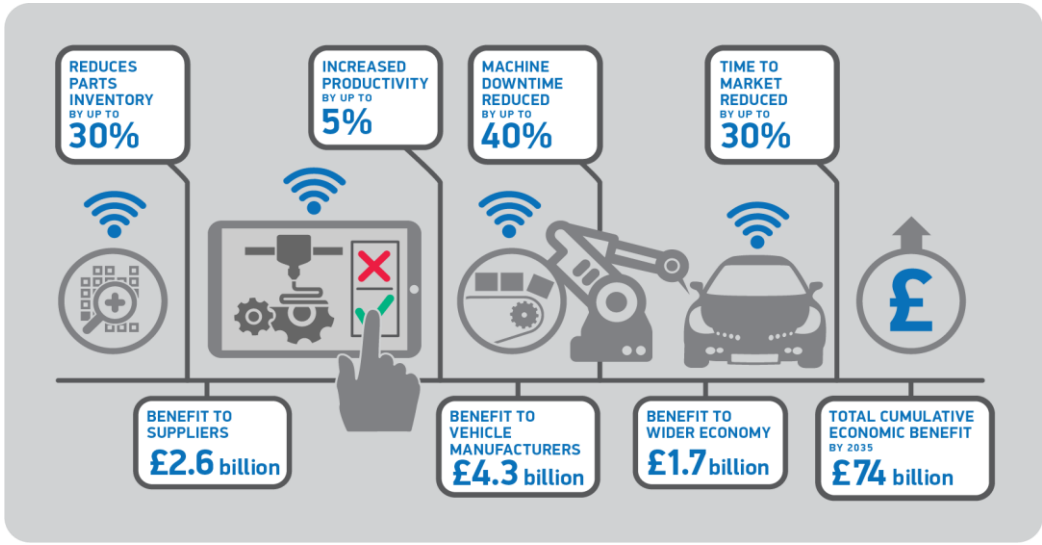
The Automotive Technology Revolution

"Almost half of the world's top 20 "Most Innovative Companies" are automakers. In fact, for the first time this year's (2014) top 20 list included more automobile manufacturers than technology companies. "
The Boston Consulting Group (BCG)



Manufacturing Processes

- CMF
- Customisation
- Shorter lead times
- Automation
- Industrial Digitalisation



On Vehicle

- Light weighting & advanced materials
- Driver assists
- Advanced propulsion – EV & hydrogen
- Connected and autonomous vehicles,
- Infotainment
- Codaholics
- Changing consumer use

NORTH EAST AUTOMOTIVE ALLIANCE

European Union
European Regional Development Fund

What is Industry 4.0?

Factory of Now

Automation, but machines are isolated and specifically programmed. Maintenance is reactive. Data islands exist between zones, shops and factories.

Integrated Supply Chain
Transparency and connectivity in supply chain allows for automatic and highly optimised supply decisions

Intelligent Products
The vehicles themselves carry and emit information to support the manufacturing and logistics process

End-to-End Traceability
Fully transparent view of all n-tier suppliers supports risk modelling, supply chain optimisation and quality assurance

Autonomous Logistics
Self-driving lorries, drones and car transporters allow automated JIT delivery between factory and supply chain

Smart Robots
Robots are adaptable to changes in circumstance, allowing high degree of production line agility.

Smart Maintenance
Predicative algorithms and on-board sensors support integrated machine maintenance leading to zero downtime.

Connected Workforce
Employees have immediate access to information at the point of need, through context-aware interfaces such as wearables

Defect Detection
Use artificial intelligence to detect abnormalities in parts or on the vehicle itself, thereby improving output quality

Digital Twins
Virtual representations of physical assets allows real-time analysis and low-risk simulations of new scenarios

Build to Customer Order
Sales systems tightly integrated with scheduling & parts ordering systems; smart robotics allows high degree of customisation

Factory of the Future

Connected, Data-rich factories with fully integrated, transparent supply chains. Highly-automated, smart machinery which can self-diagnose and quickly adapt to change.

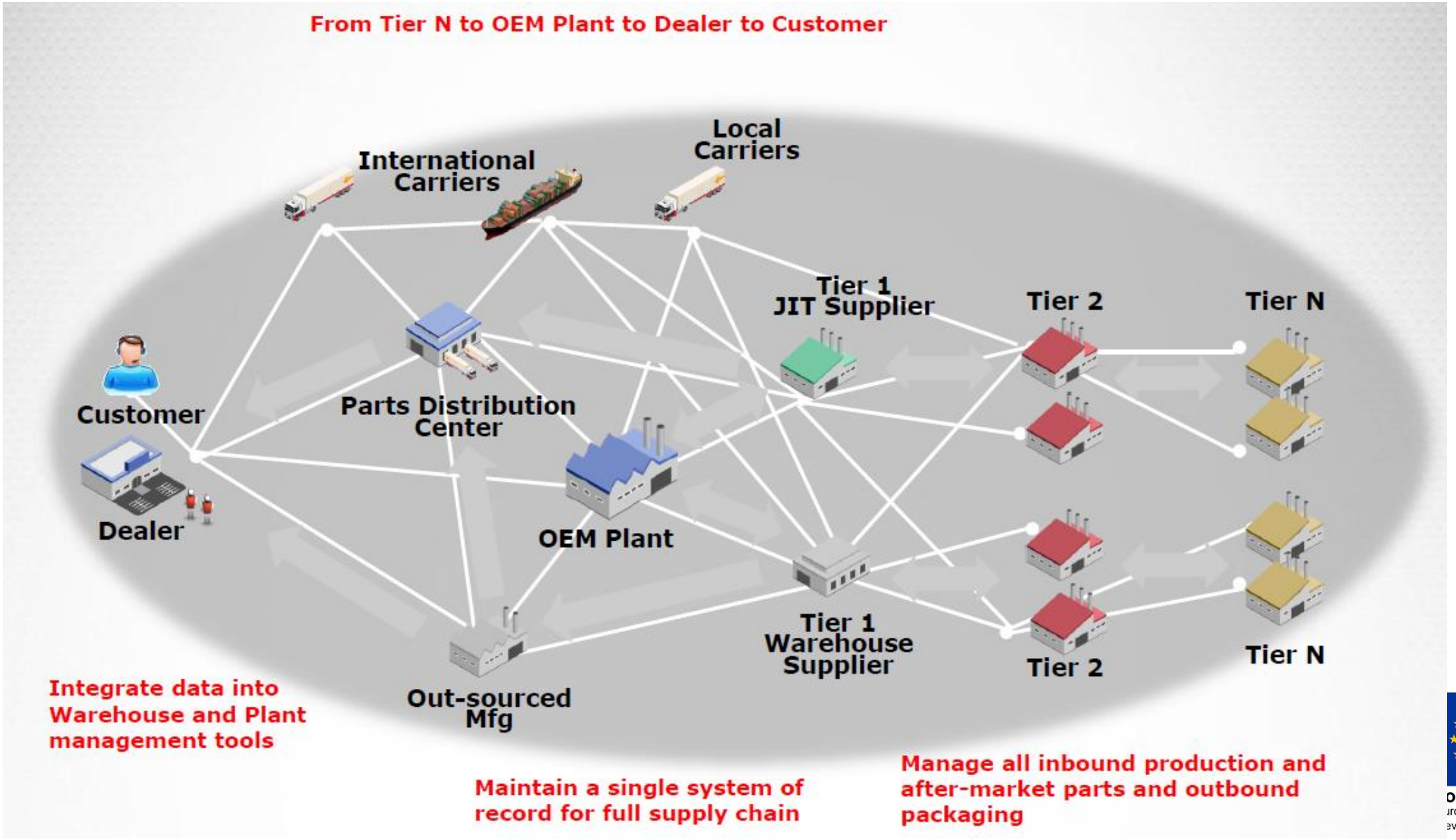
Enabled by

Cloud • Cyber Security • Data Analytics • IOT • Blockchain • xReality • Machine Learning • DevOps

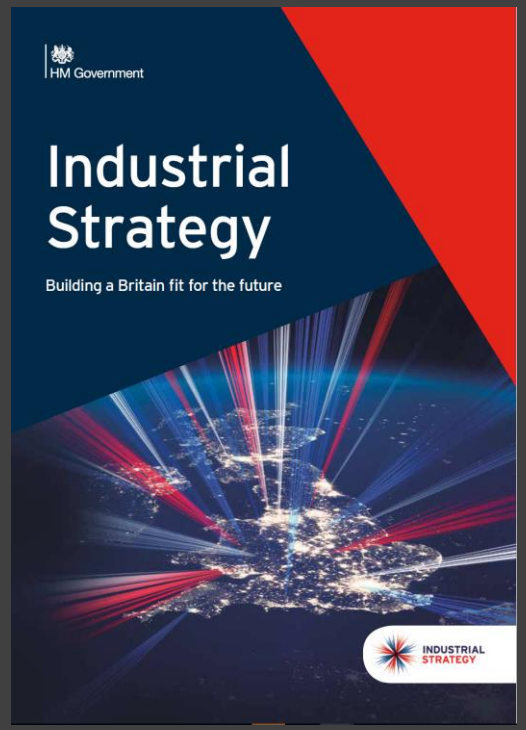
NORTH EAST AUTOMOTIVE ALLIANCE

European Union
European Regional Development Fund

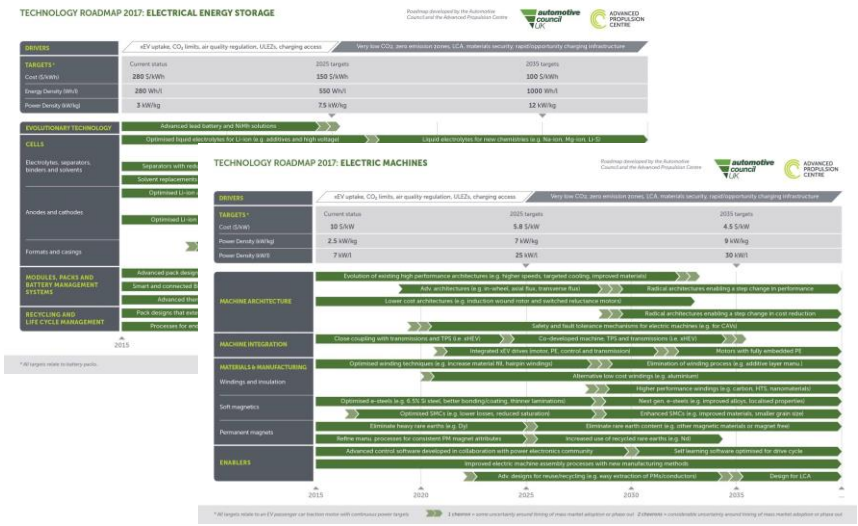
Integrated Digital Supply Chain



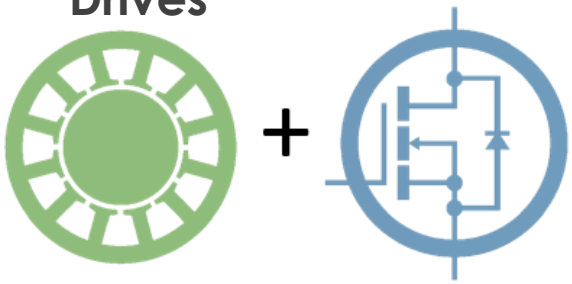
The Opportunity…



Technology Roadmaps



Power Electronics & Electric Machine Drives



Battery

RESEARCH + INNOVATION + SCALE UP

The Faraday Institution

A new, virtual research institute comprising a headquarters at the Harwell Science and Innovation Campus and a series of research projects carried out in UK universities to accelerate fundamental science and its translation directly related to batteries.

Research and Innovation Projects

An innovation programme to support collaborative research and development with co-investment from industry (led by Innovate UK).

UK Battery Industrialisation Centre

An open access facility with technology scale-up capabilities to ensure solutions are ready for manufacturing technologies at high volume (led by APC).

Made Smarter

Made Smarter Adoption:

- £20m secured for NW pilot from treasury via BEIS
- Pilot:
  - Engage 3000 SMEs
  - 600 receiving diagnostic assessment
  - 480 accessing £20k grant to purchase specialist services and equipment

Manufacturing Made Smarter:

- Deliver 30% increase in manufacturing productivity by 2030
- £147m Industrial Strategy Challenge Fund (ISCF) secured, plus industry match
- Key themes
  - Smart Factories
  - Connected Supply Chain
  - Adaptable, Flexible Manufacturing & Skills
  - Design, Make and Test

NORTH EAST AUTOMOTIVE ALLIANCE

European Union
European Regional Development Fund

RTH EAST
UTOMO
ALI

Questions?

recirclerecycling.com

ReCircle.

Don’t let your recycling
go to waste

Northumbria University
NEWCASTLE

Closed Loop Supply Chain Management Workshop 13th September 2019

Many thanks for the invitation!

Aldous Hicks
CEO
ReCircle Recycling Ltd
recirclerecycling.com
aldoush@recirclerecycling.com

What is Closed-Loop Supply Chain Management?

Traditionally:

- Supply Chain is a set of activities that includes purchasing, manufacturing, logistics, distribution, marketing, that perform the function of delivering value to end customer. (Turan Paksoy, 2011)

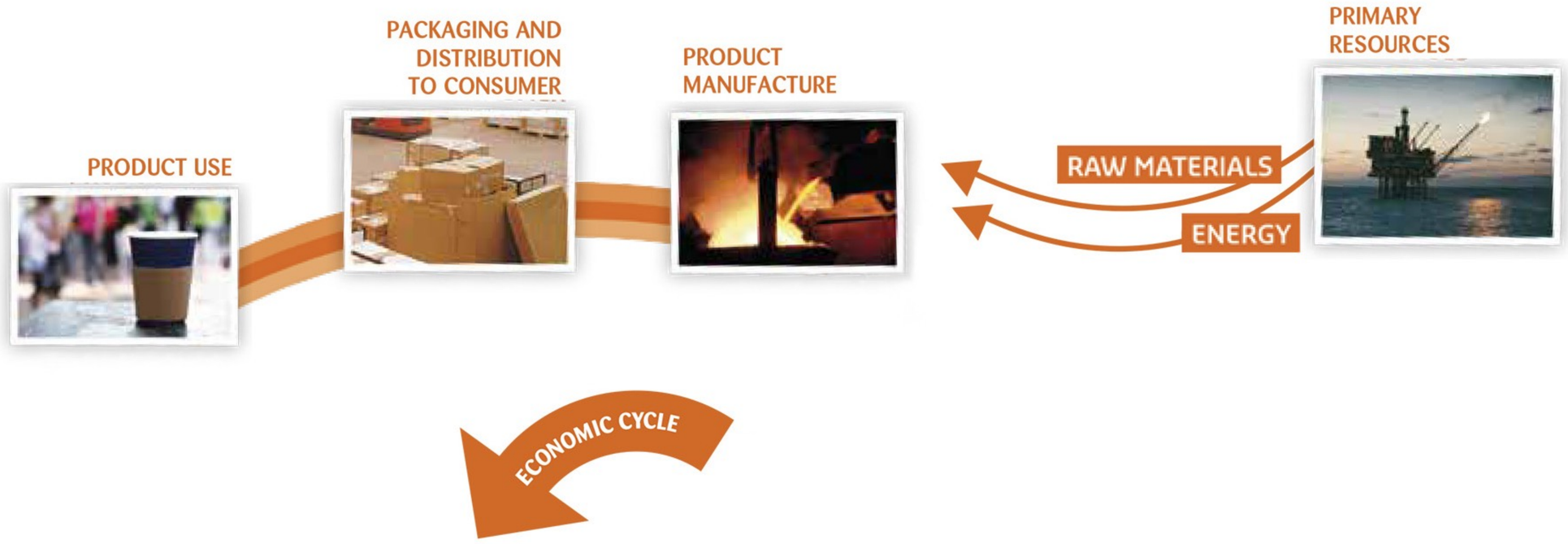
More Recently (last two decades):

- Focus on sustainable development and green economics … with a great deal of research performed in the fields connected with supply chains and logistics. (Kumar and Kumar, 2013)

Terms include:

- Green Supply Chain Management (GrSCM)
- Closed Loop Supply Chain Management (CLSCM)
- Reverse Supply Chain Management (RSCM)
- Reverse Logistics (RL)
- Sustainable Supply Chains (SSC)
- Sustainable Transport (ST)

SCM

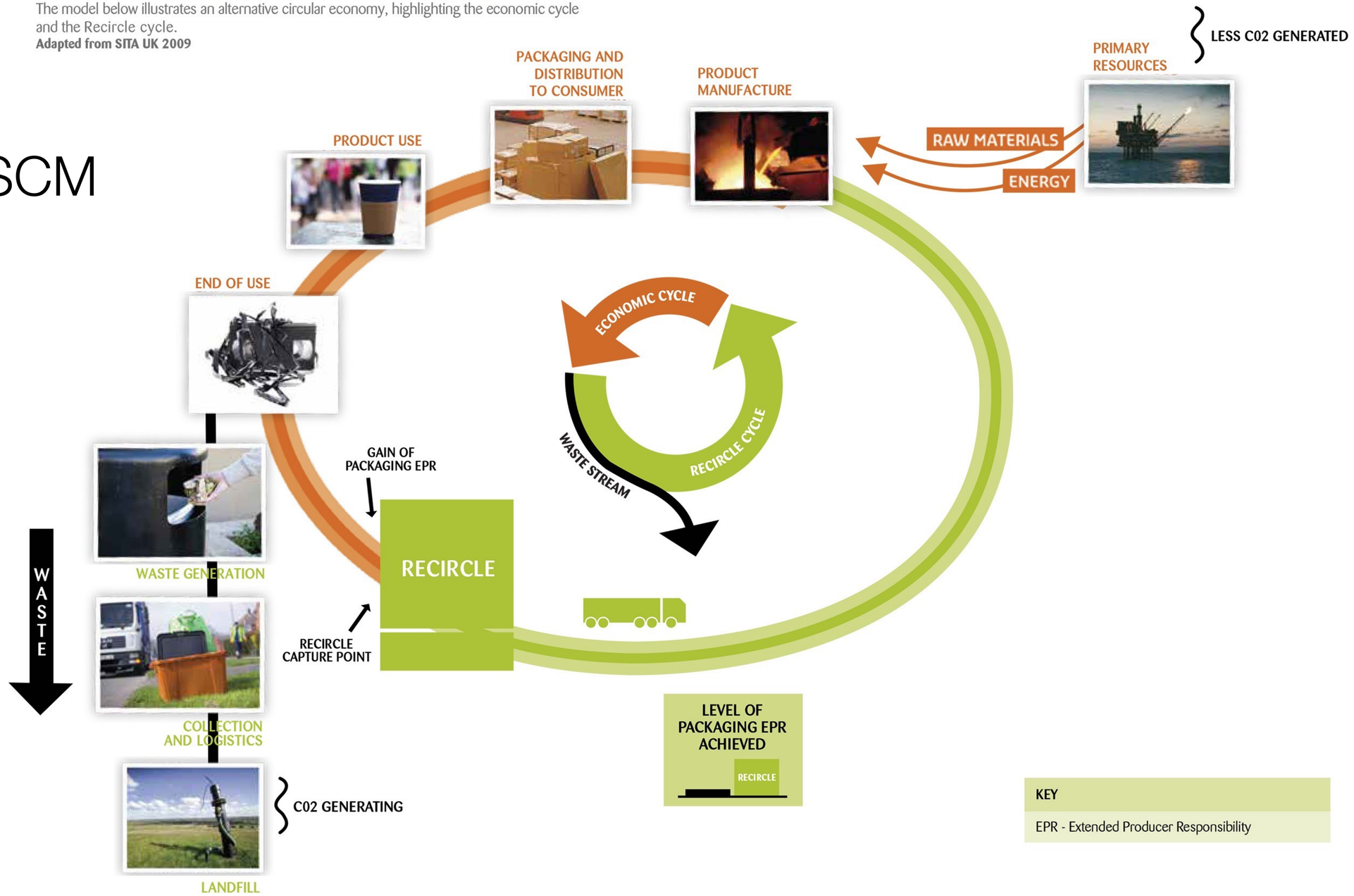

PRODUCT USE
PACKAGING AND DISTRIBUTION TO CONSUMER
PRODUCT MANUFACTURE
PRIMARY RESOURCES
RAW MATERIALS
ENERGY
ECONOMIC CYCLE

C-L SCM

DIAGRAM 4 - THE CIRCULAR ECONOMY MODEL - WITH RECIRCLE CYCLE

The model below illustrates an alternative circular economy, highlighting the economic cycle and the Recircle cycle.

Adapted from SITA UK 2009



Delivering the Closing the Loop part of the CLSCM

Existing recycling does not work. Why?

Flawed process concept which maximises:

- material throughput at minimum cost

Rather than:

- material purity at minimal cost

Increasing material purity trumps increasing scale.

Terminology

Waste - what is it?

- 2 or more materials of a different substance in a receptacle is waste
- We humans make the decision to create waste

Used-material - highly valuable if different substances not put together?

Zero-Waste - minimising a bad!

Maximise Used-Material - maximising a good!

Our Mission

ReCircle Recycling Ltd (RRL) is developing the world's first 100% closed-loop domestic recycling appliance.

Our mission is to transform how society reuses its used-materials and empower households and businesses to actively contribute, deliver and benefit from the circular economy.

The Problem

- Recycling is not working
- Globally only 2% of packaging is recycled into a material of the same quality (Ellen MacArthur Foundation 2018)
- 38% of packaging leaks into the environment (Ellen MacArthur Foundation 2018)

ReCircle Recycling

- ReCircle is a paradigm-changing product that will transform the way we reuse our $-cash valuable used-materials
- The ReCircle system bypasses issues faced by existing recycling models by never allowing two used-materials made from different substances (or colour) to be put together (in the home, workplace, hospital, factory etc.)
- This allows everyone to play a part in managing their own valuable used-materials effectively – ultimately delivering commercial and environmental benefits for individuals, the economy and the planet

ReCircle.

We're developing the world's first **100% closed-loop domestic recycling appliance**

The **ReCircle** is revolutionary and completely disrupts the current recycling system by giving you total control and complete confidence that what you recycle goes back to make more products and stays away from landfill.

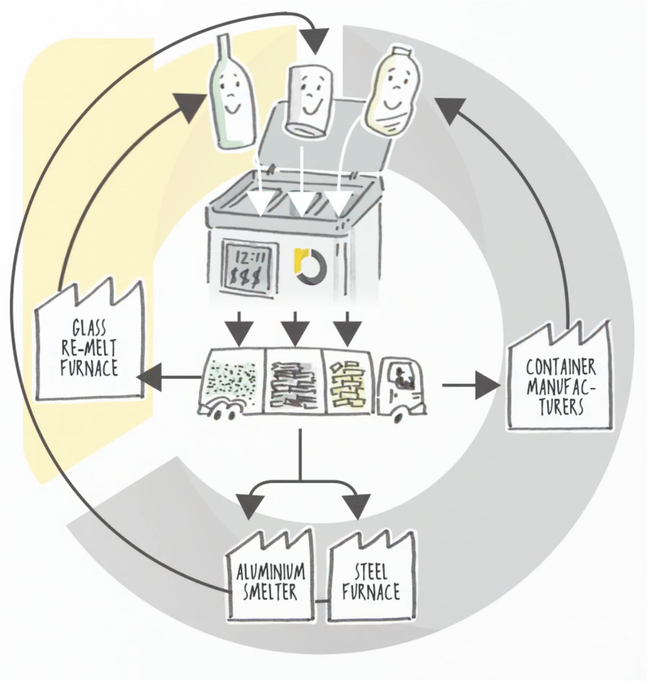
recirclerecycling.com

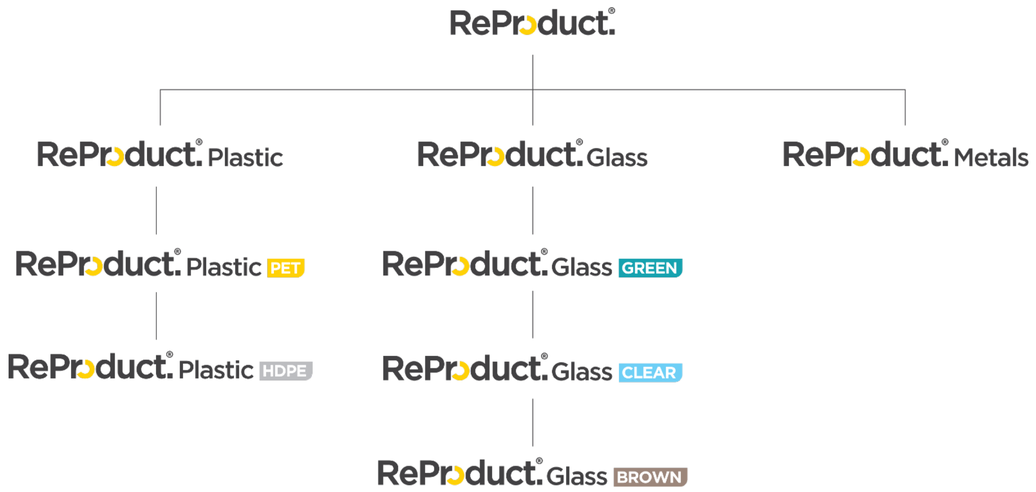
The Appliance

- The ReCircle will sensor check and identify, wash, dry, granulate plastic (PET, HDPE, mixed plastics), grind glass (clear, green, brown) and compact metal (steel and aluminium) packaging and containers
- The ReCircle will separately store the eight compacted space-saving $-cash valuable close-loop ReProduct®s
- All the while keeping used-materials separate to guarantee purity

RePr◔duct.®

- ReCircle will provide a free pick up service via an Uber-style mobile app
- The logistics and on-sale of closed-loop products will be a key aspect
- There is a great opportunity to integrate with deposit return schemes and extended producer responsibility (EPR) systems





Technology

The key components of the ReCircle Appliance are;

Sensors - near infrared camera technology & spectral imaging.

Granulators - glass crushing and plastic shredding.

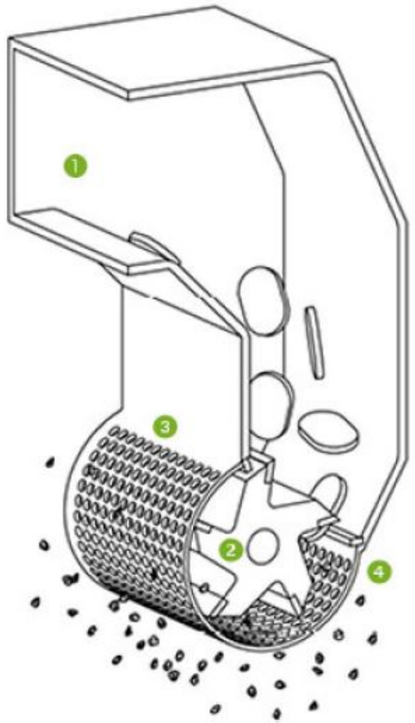
Washing - high pressure spray bars and jets.

Electronics - hardware, software, consumer interface app & IOT.

Storage - robust, compact storage and using smart rollers.

Manufacturing - high speed additive robotic manufacturing.

Product Logistics – household pick-up, weighing and pneumatic bulk handling.



ReCircle's technical experts will **re-engineer and apply existing readily available industrial equipment** to the appliance on a reduced scale, suitable for hi-tech, robot controlled and operated assembly line manufacturing. The product pick-up logistic system will be state-of-the-art.

Benefits

Individual

- Empowers consumers to -
    1. Closed-loop recycle
    2. Contribute to and benefit from the circular economy
- Saves time and hassle

Manufacturers

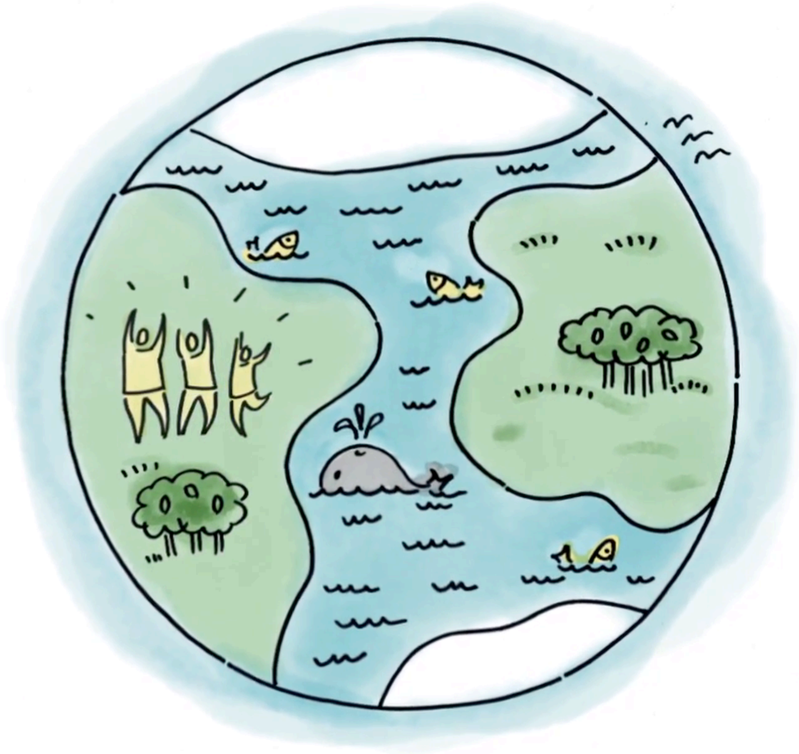
- Access to high quality closed-loop RePr◑duct®

Environment

- Greater utilisation of used-materials
- Less raw materials required
- Educates consumers
- Negative C02
- Less waste and pollution

Economy

- Deliver circular economy



ReCircle.

THE RECIRCLE APPLIANCE

ReCircle's home and business appliance uses sensors to guarantee zero contamination and **100% closed-loop recycling** of materials.

Zero contamination means high purity, ensuring maximum value of the RePr◑duct.®

New ReCircle process.

Current industrial process modified for ReCircle.

Existing process.

* A ReCircle will process PET, HDPE, clear/green/brown glass and aluminium and tin cans with further materials to follow in future.

9. Tankers collect individual ReProduct® materials from the bulk transfer station and deliver direct to manufacturers.

MANUFACTURER

10. ReProduct® material used to produce new containers with up to 100% recycled content.

APPLIANCE OWNER

RECIRCLE LOGISTICS

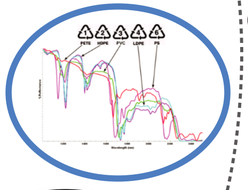
8. The collection vehicles separately unload ReProduct® materials into silos at a bulk transfer station.

START

1. Used containers * are loaded into specific areas of the ReCircle. Similar to the compartments in your dishwasher.

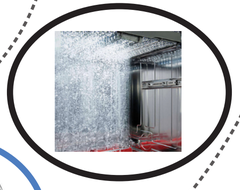
ReCircle.

7. The ReCircle collection vehicle individually weighs ReProduct® materials before depositing them into separate bins in the vehicle.

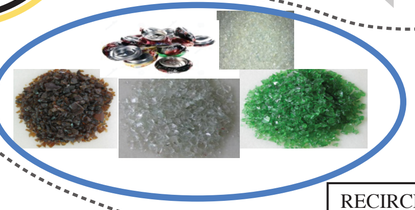


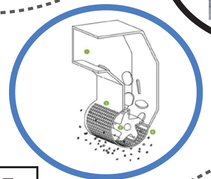
2. Sensors check the material classification of each used-container to ensure it is placed in the correct receptacle. Similar sensors are currently used in industry.

6. The ReCircle app is used to book a free pick-up when storage bays are full. Easily remove and wheel the bays to the curbside, as with your recycling bin.



3. Detergent is added and the ReCircle cleans used-containers like a household dishwasher.



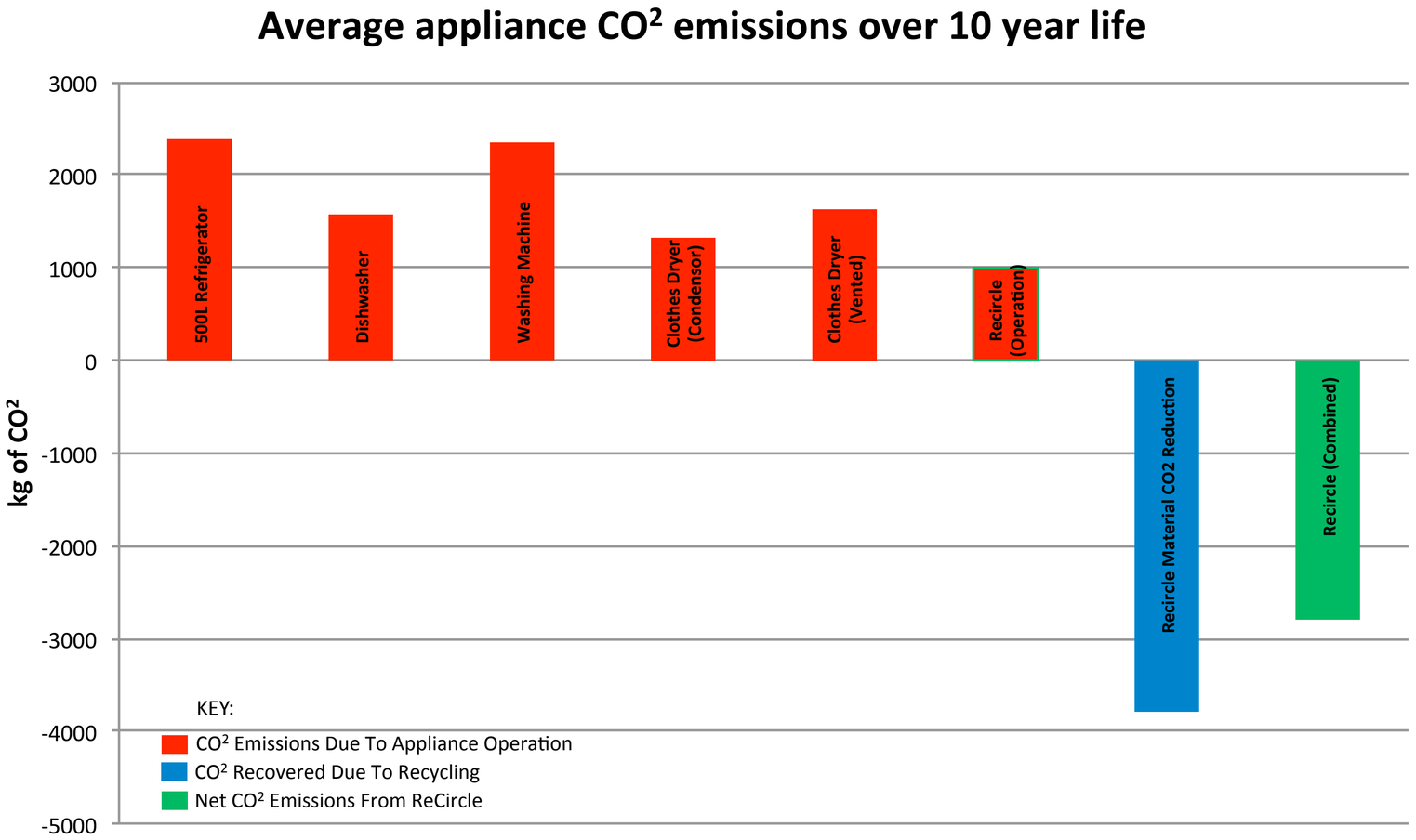


RECIRCLE APPLIANCE

5. Each material is individually processed into its optimum form (ReProduct®) and stored separately in the ReCircle's storage bays.

4. The glass and plastic used-material is processed separately through grinders and granulators respectively, equipment currently used in industry.

Carbon Emissions



ReCircle estimates based on latest LCA (Life Cycle Assessment) energy use, CO2 emissions and material recovery figures.

Northumbria University
NEWCASTLE

Closed Loop Supply Chain Management Workshop 13th September 2019

Seeking experts:

- Near infra-red (NIR) spectroscopy
- Life Cycle Assessment (LCA)

Questions welcomed!

recirclerecycling.com
aldoush@recirclerecycling.com

Appendix

Technology Patents

USA, Canada, Japan, China, Hong Kong and South Korea, representing more than 70% of the world’s GNP. References available upon request subject to an NDA.

ReCircle.

Royalty Revenue

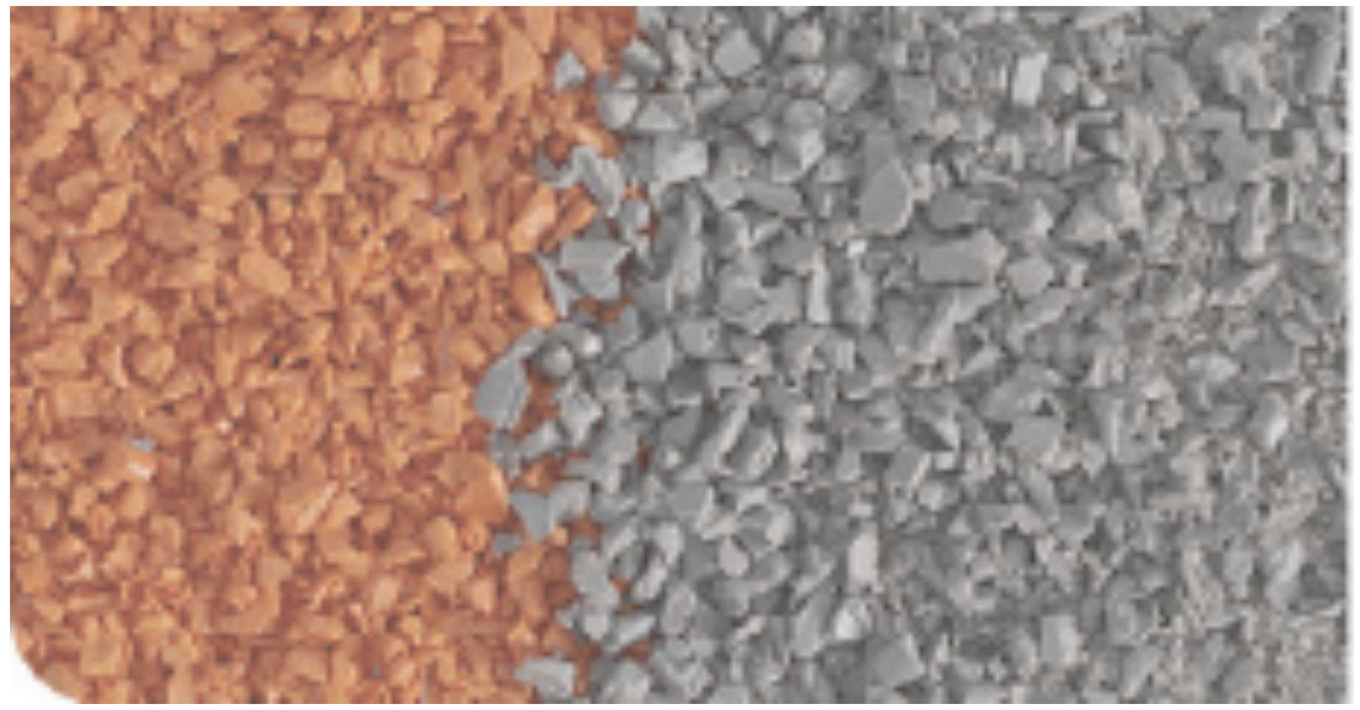
ReCircle has developed a pre-early-stage B2C 10 year sales forecast with Year 1 equal to the year 2022. At this very early stage of the appliance and logistics system development, this predictive model can only deliver **ballpark figures.** Furthermore the (what we think is) huge potential of the B2B closed-loop product market has been excluded in these calculations due to concern for best application of our currently limited resources.

ReCircle's projections are based on a royalty model - where ReCircle will develop the appliance and logistics system prototypes, before selling the manufacturing, distribution, marketing, selling and appliance rights to a major, emerging or diversifying white-goods manufacturer. ReCircle also plans to licence the logistics system that will pick-up, aggregate and deliver the recyclable products (called **Re**Product™) from household to manufacturer.

In the first five to seven years of the full-scale roll-out, the revenue generated from sales of **Re**Product™ to manufacturers will ensure that the **Re**Product™ **collection service will be free-of-charge to the appliance owner** (household, university, stadium etc).

The predicted growth of sales of Re Product™ **will eventually outgrow the cost of collection - ensuring further downstream royalty cashflows to RRPL**, some of which may be passed onto the appliance owner, further incentivising appliance sales.

ReCircle predicts the collection and sale of **Re**Product™ will become cash flow positive between year five and year seven.



ReProduct.

5 Year Key Objectives

1.	Raised £500,000 (Stage 1 - Funding) for the development of the prototype ReCircle appliance.	Q2 2019
2.	Complete the development of the ReCircle prototype.	Q3 2020
3.	Raise £8 million (Stage 2 - Funding) for the development of systems, processes and toolage for hi-tech, robot controlled and operated assembly line manufacturing.	Q4 2020
4.	**Deliver exit opportunity for original and Stage 1 - Funding ReCircle shareholders based on share valuation following capital raising in Objective 3 above.**	**Q4 2020**
5.	ReCircle appliance ready for manufacture for first full-scale roll-out.	Q4 2021
6.	Trial 100 ReCircle appliances in households, along with associated logistic systems for assessment and proof of operation.	Q4 2021
7.	Obtain accreditation by relevant US State statutory bodies to process bottle deposits on behalf of ReCircle owners.	Q4 2021
8.	Update the US target market projections.	Q4 2021
9.	Sell manufacturing, distribution, marketing and appliance rights to a major, emerging or diversifying white-goods manufacturer in return for agreed royalty (~ minimum 6%).	Q4 2021
10.	**Deliver exit opportunity for original, Stage 1 - Funding and Stage 2 - Funding ReCircle shareholders based on valuation delivered by agreed royalty in Objective 9 above.**	**Q4 2021**
11.	Manufacturing capacity in train in US.	Q1 2022
12.	Roll-out (sold) 4,200 ReCircle appliances into the first targeted US market and generate £500,000 royalty revenue for ReCircle ReCycling Pty. Ltd.	Q4 2022
13.	Become cash flow positive.	Q4 2023

THE TEAM

ALDOUS HICKS
CO-FOUNDER

BSc (Phys) BEng (Mech) (Syd.)
Over 30 years' experience as a technology and software developer, project manager and mechanical engineer, including developing water and material recycling technology. Developed SOHO custom PC database software.

ALISON RICHARDSON
CO-FOUNDER

BA, Dip Ed (Tas.), National Certificate Training Journalism (UK), Dip. Museum Studies, Master of Health Studies (Syd.)
Alison uses her interpersonal skills when travelling between Australia and the UK to ensure ReCircle is at the forefront of industry developments, promoting awareness and fund raising.

PHIL SANDERS
ENGINEERING & TECHNICAL

BEng (Hons) (Birm.City)
Almost 20 years' experience in the field of Product Design and Development working as a Mechanical Engineer and Project Manager. Worked for Hella Manufacturing developing automotive lighting solutions primarily for Jaguar and Spent 10 years in Australia working for Electrolux in country NSW as a senior R&D Project Manager.

VINCENT NEATE
NON-EXECUTIVE DIRECTOR

B.A. (Phil, UoL), CPA
More than twenty-five years' experience as an auditor, consultant and general business advisor as a chartered accountant. Former partner of KPMG. Vincent runs his own consulting business and is a non-executive director on the board of a number of charities and non-profits.

GILLES POELTINGER
ENGINEERING & TECHNICAL

Bus. Man. HF. GM Akademie (St. Gallen, Switz.) Gilles began his professional career as a senior engineer at Nuga AG in Switzerland, designing the Centricut high-performance, minimal footprint range of plastic cutting & grinding systems. He has over 9 years experience in the technical development & design of these systems and equipment.

STUART CHATER
MARKETING & COMMS

BA Communications - Broadcast Journalism (CSU)
Seven years' experience as a social media consultant working in creative and media advertising agencies. Representative clients include Facebook, Coca-Cola, Red Bull, Volvo, Air New Zealand, ANZ Bank and GlaxoSmithKline. Stuart joins ReCircle in London to assist with commercial and marketing.

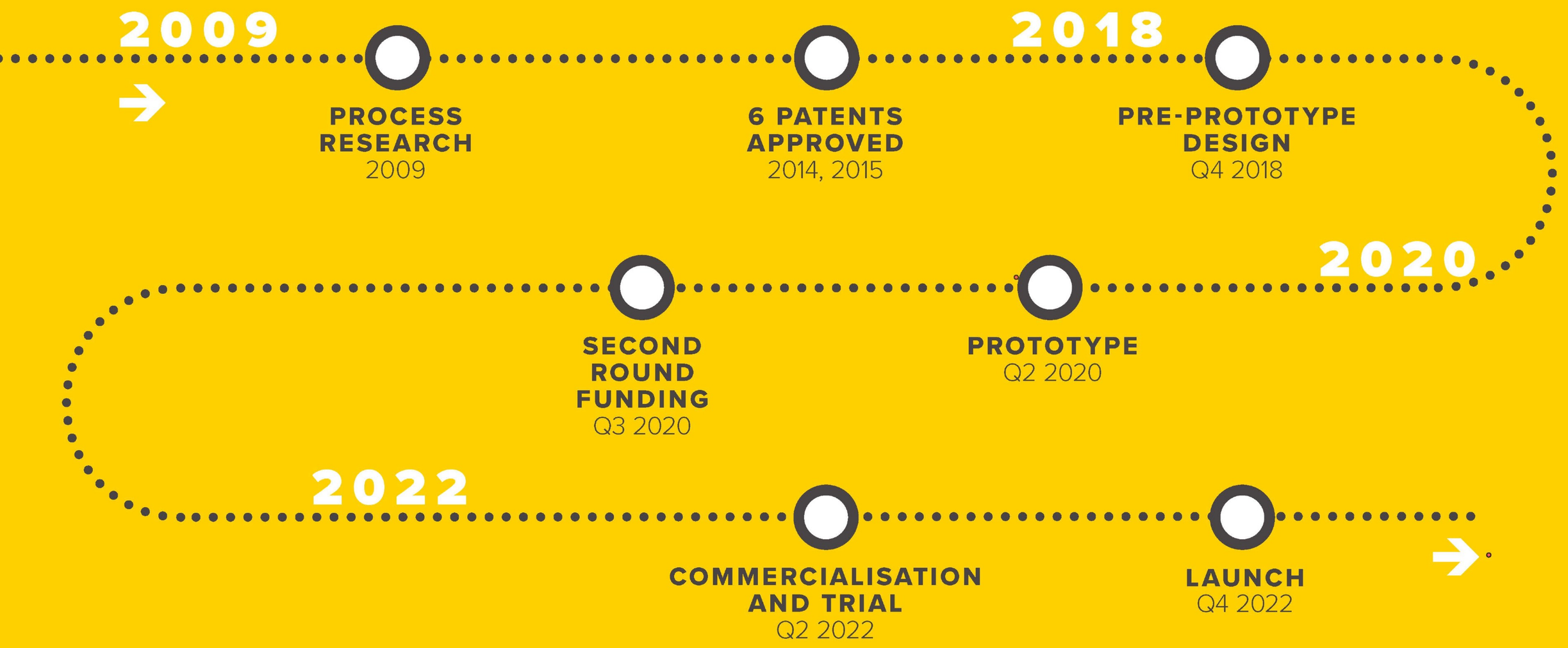
TRISTAN TAYLOR
PROJECT MANAGER

BA (Hons) Int. Bus., European School of Economics (Lond.)
Tristan has 14 years experience working in startups and SMEs as an account and project manager, director and co-founder. He is passionate about bringing new solutions to broken systems. Tristan has worked in niche retail, mobile technology, online hospitality, renewable energy, consumer product and edtech industries.

recirclerecycling.com

ReCircle.

ROADMAP



CLSC, Newcastle upon Tyne - 2019

Circular economy implementation in the south-west agri-food sector:

implications for practice & theory

Prof Mickey Howard

Professor of Supply Management

m.b.howard@exeter.ac.uk

Exeter Centre for Circular Economy

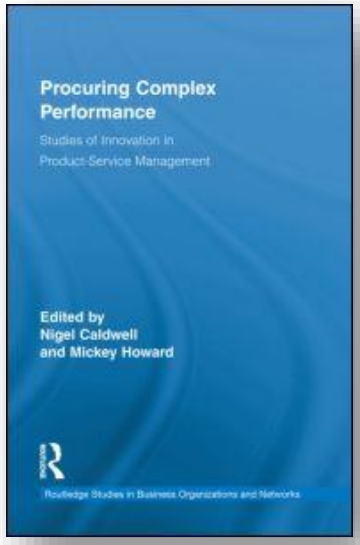
http://business-school.exeter.ac.uk/research/centres/circular/

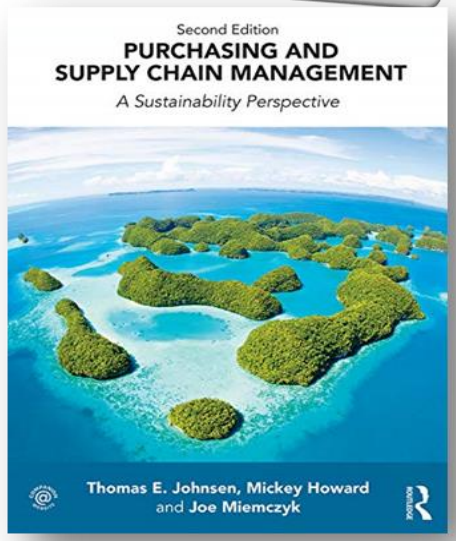
UNIVERSITY OF EXETER | BUSINESS SCHOOL

EPSRC

Engineering and Physical Sciences Research Council

My background





A circular perspective

- **Waste elimination**
- **Value recapture**
- **System resilience**

Introduction - *the project*

- EPSRC project (2016-19) **£483,000**: '*Modelling supply chain optimisation in the food and beverages industry: Helping SMEs in South West England work towards the Circular Economy*'.
- **Multi-disciplinary** collaboration between Business School, Engineering and S. Sciences.
- Dairy & baking sector SMEs: **9 firms** selected.
- We started by looking at the challenges around waste i.e. the lost value of **materials, energy, water** and labour.

- RQ1: *How effectively can circular economy (CE) principles be applied to the food and farming sector?*
- RQ2: *How can small-medium enterprises (SME) access opportunities given their limited resources?*

Theoretical foundations

- **Triple bottom line** (TBL) – Elkington 1998; 2004.

  Failure of TBL to realise benefit to society i.e. '..*broken promise*' (p81).

- **Natural resource based view** – Hart 1995; Hart & Dowell 2011.

  Firms start with basic 'pollution prevention' then move towards 'sustainability'

  Response to change implies role for dynamic capabilities?

- **Systems perspective links with resilience** – Bansal 2005.

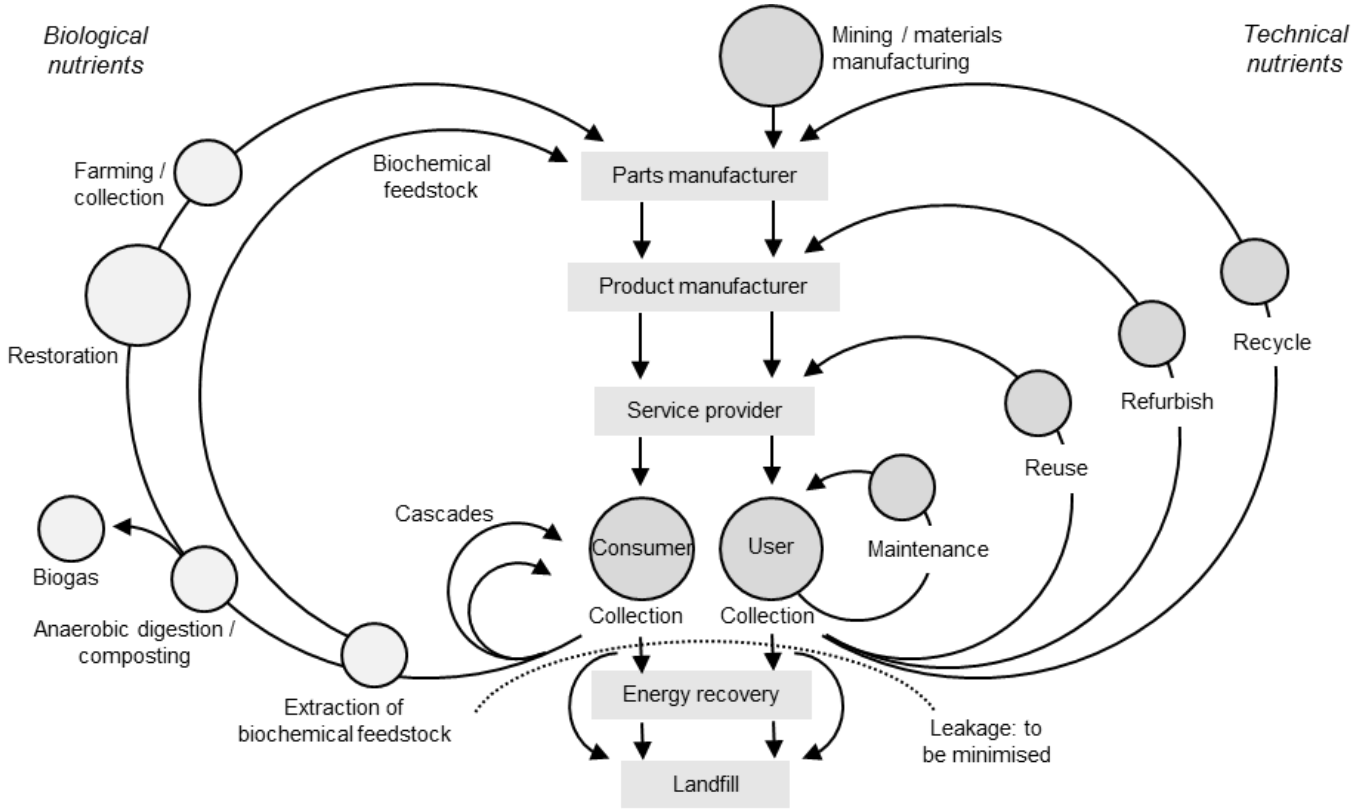
  Corporate sustainable development needs to look beyond firm boundaries

- **Industrial symbiosis** – Chertow 2007.

  Rethink competition between firms toward a more collaborative model based on value and product & knowledge sharing for mutual gain.

Circular economy (CE) - *definition*

'An industrial economy that is producing ***no waste and pollution,*** *by design or intention, and in which* ***material flows*** *are of two types,* ***biological nutrients,*** *designed to re-enter the biosphere safely, and* ***technical nutrients****, which are designed to circulate at high quality in the production system without entering the biosphere as well as being* ***restorative and regenerative by design****'.*



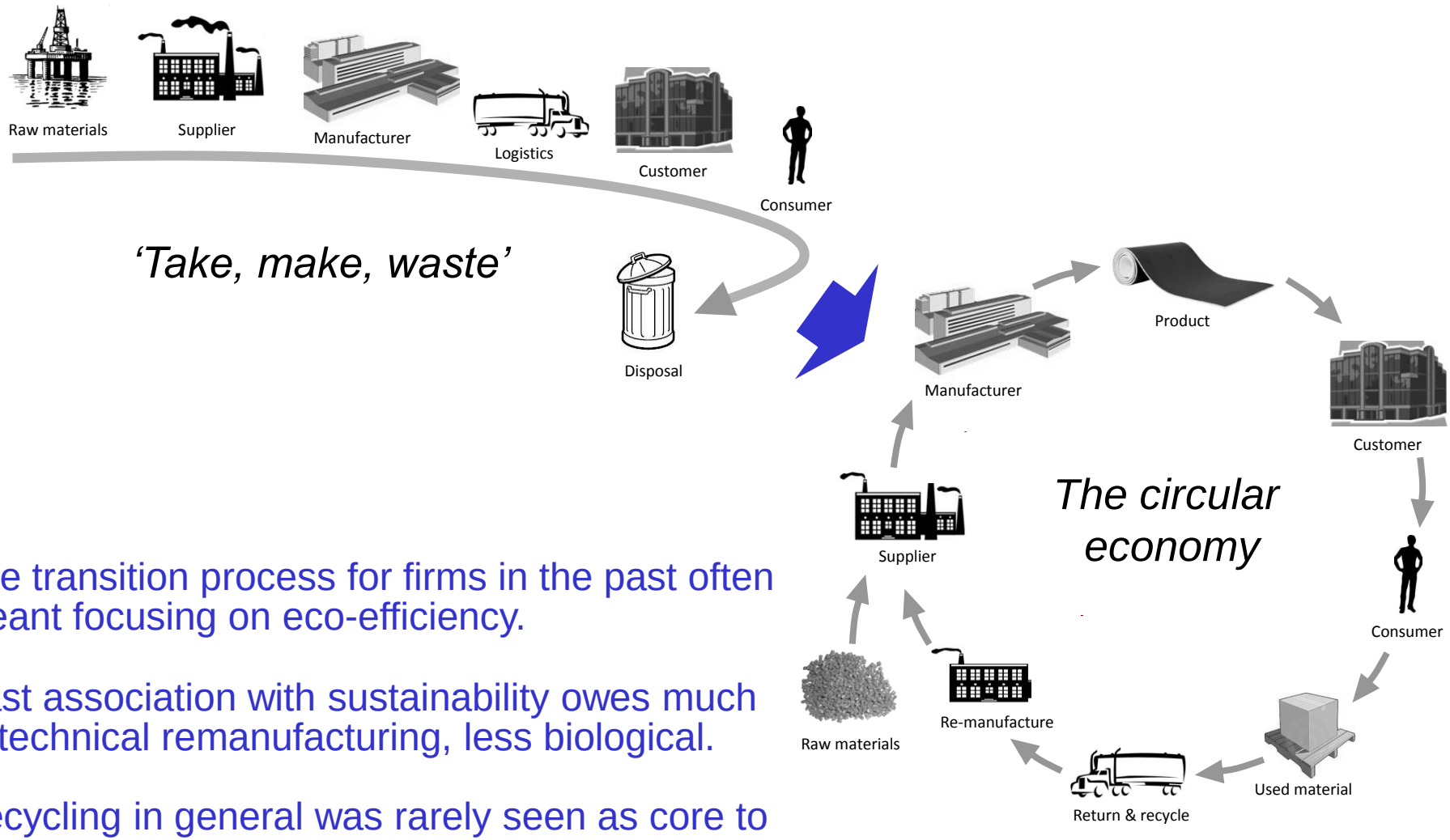
Source: Ellen MacArthur Foundation (2012).

Why circular - *and why now?*

- CE envisions a **system** designed by humans and inspired by nature.
- CE principles could not only address environmental & social challenges, but generate a net benefit of **€1.8 trillion** across Europe by 2030.
- CE aims to go beyond resource efficiency to achieve **resource effectiveness**, requiring radical **systemic change** rather than just incremental improvement.
- CE is gaining traction in many countries such as **China, Europe & UK** (i.e. BS 8001 - 2017).
- CE is delivered through new business models designed to ensure environmental protection while offering firms a competitive advantage - we call this ***circular business advantage.***

Howard & Webster (2018) https://medium.com/circulatenews/circular-business-advantage

Transition from linear to circular



- The transition process for firms in the past often meant focusing on eco-efficiency.
- Past association with sustainability owes much to technical remanufacturing, less biological.
- Recycling in general was rarely seen as core to business success.

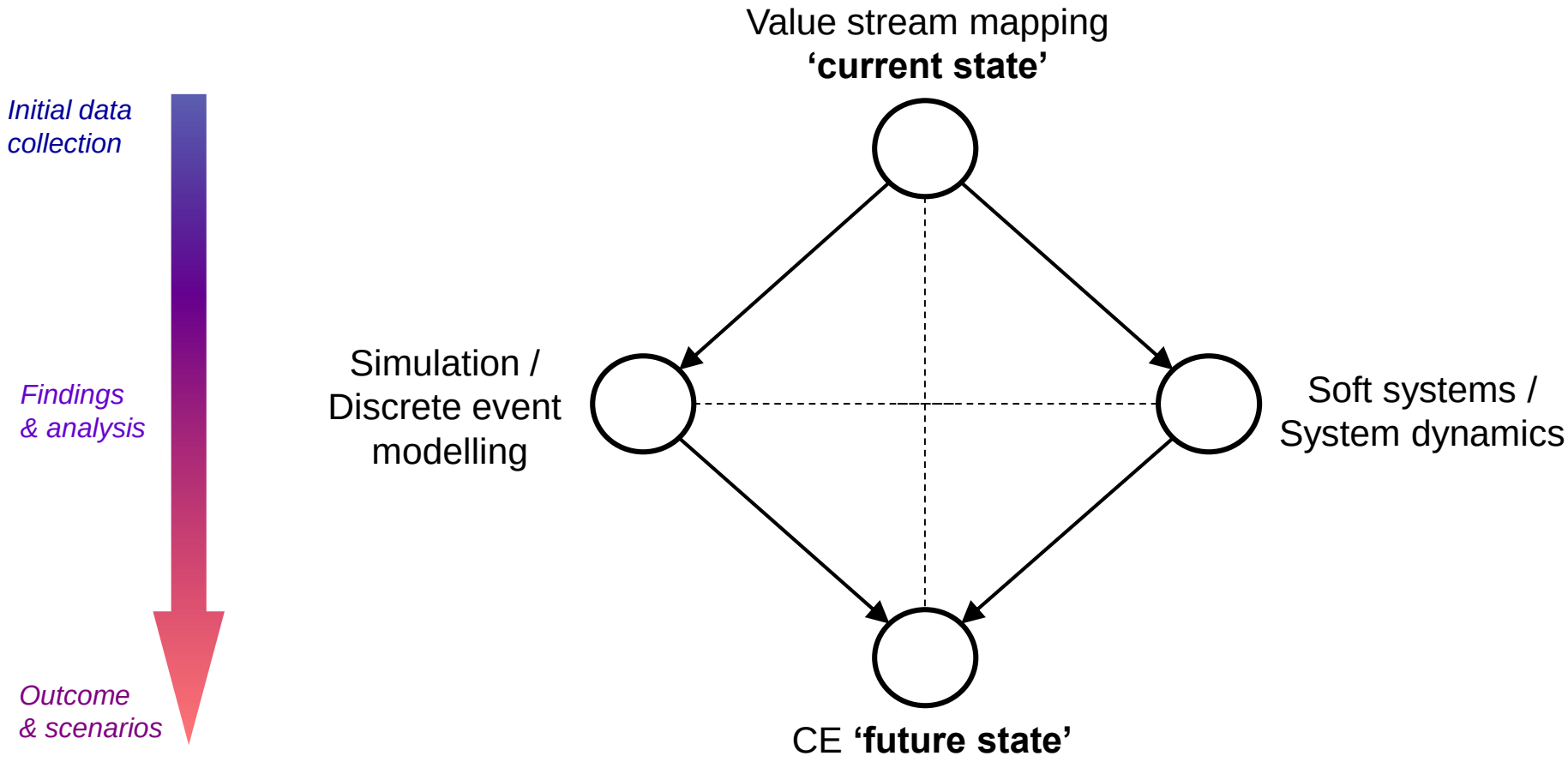
Johnsen, Howard & Miemczyk (2014, 2018)

Research method

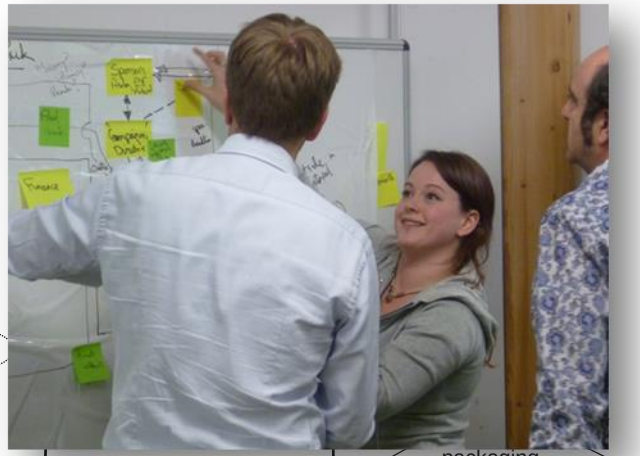
- Started with onsite consultation process around the issues of waste at dairy and baking SMEs.
- Built up a ‘current state’ picture of what was working well and less well at each firm.
- Use of value stream mapping, systems modelling and simulation to understand a circular economy ‘future state’.
- Feedback to & from partners at private project workshops.
- Dissemination of wider findings via public events (e.g. Westminster).

Research method - *mapping & modelling*

- Use of soft and hard modelling techniques throughout the project to capture data required to understand the barriers & enablers for SMEs adopting CE. This involved some adaption or hybrid modelling.



Value stream map - *dairy process*



Milk from 35 local farmers

Milk from 'spot market'

4 x per day

Tanker transport 3PL

Cold Raw Milk silo storage

Raw cold Cream silo storage

700 Solar Panels 230kW

Soon to provide up to 30% energy requirements

Minimise CIP by 'running up the fats'

Switch off glycol saves energy when pre-heating straight away

Cream at 60°C

Cream 18% fat

Cold Finished Skim Milk silo storage

SR30 Pasteurizer (Regen side) 55-58°C

(Hot side) Pasteurised: 72.5°C, 20s

Milk separator

Skim milk

Standardising tank 20-30 mins

SR20 Pasteurizer (Regen side)

(Hot side) Pasteurised: 72.5°C, 20s

Homogenizer 15kW

Holding tubes

Cooling (Glycol)

Cream tank

packaging

Finish tank

Packaging: Plastic buckets film & bottles

Packing (Filmatic machine 2lt cream

Palletizing

Chilled Store <3°C; 30kW

100 B2B customers (mainly food mfrs)

Industrial symbiosis

Digestate (to another AD plant)

Reverse Osmosis (30kl cream to 15lk water & concentrated cream

CIP rinsings

Concentrated Skimmed milk

Finished Skim conc silo Storage then used for base preparation

Cooling (Glycol)

Holding tubes

CIP rinsings

Cream at 60°C

CIP rinsings

AD Water storage tank To be utilised & not wasted !!

polymer & ferric

Energy generation

sludge

AD plant

DAF Units

Permeate (3rd party)

Water to drains

Aim: 20% reduction in water usage

"Water is the 'low hanging fruit' from the basic requirements of energy, water and materials" ()

Key to symbol:

Waste

Agent, stakeholder dept. or product

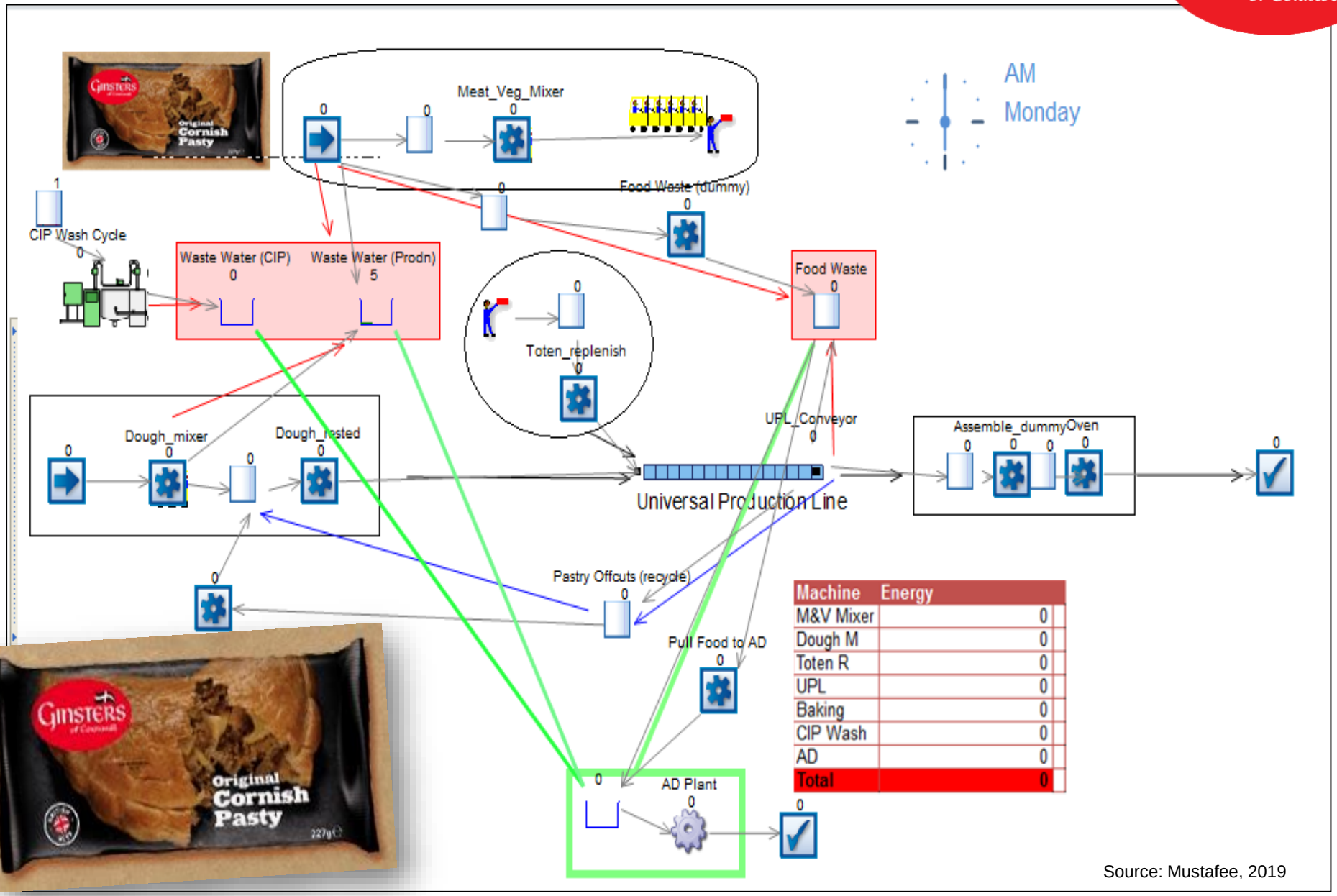
Process, activity or workstation

IT system

Flow of material, water or energy

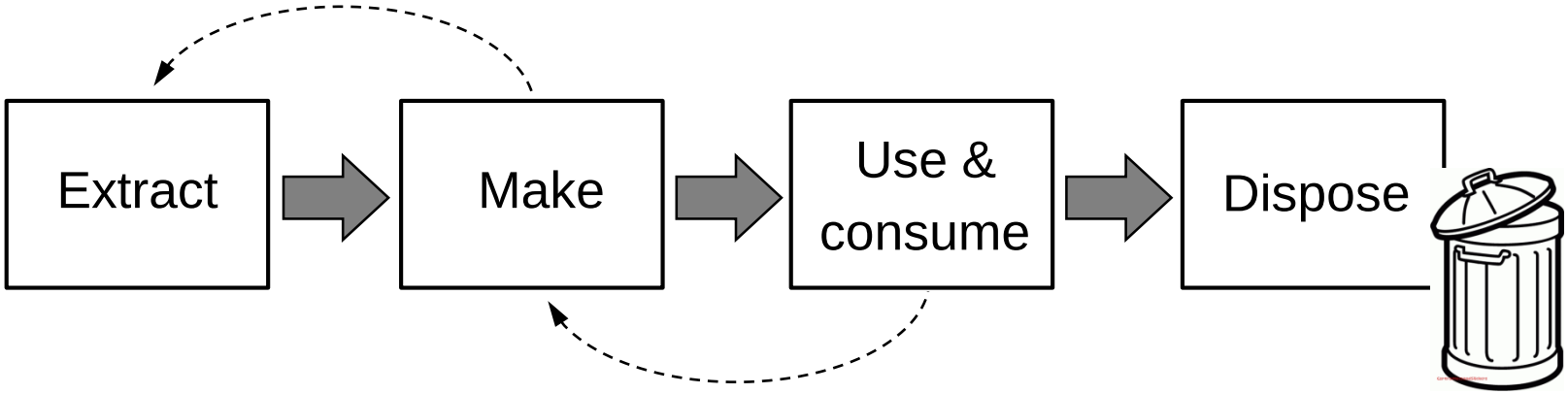
Good practice

Simulation - *Ginsters production line*



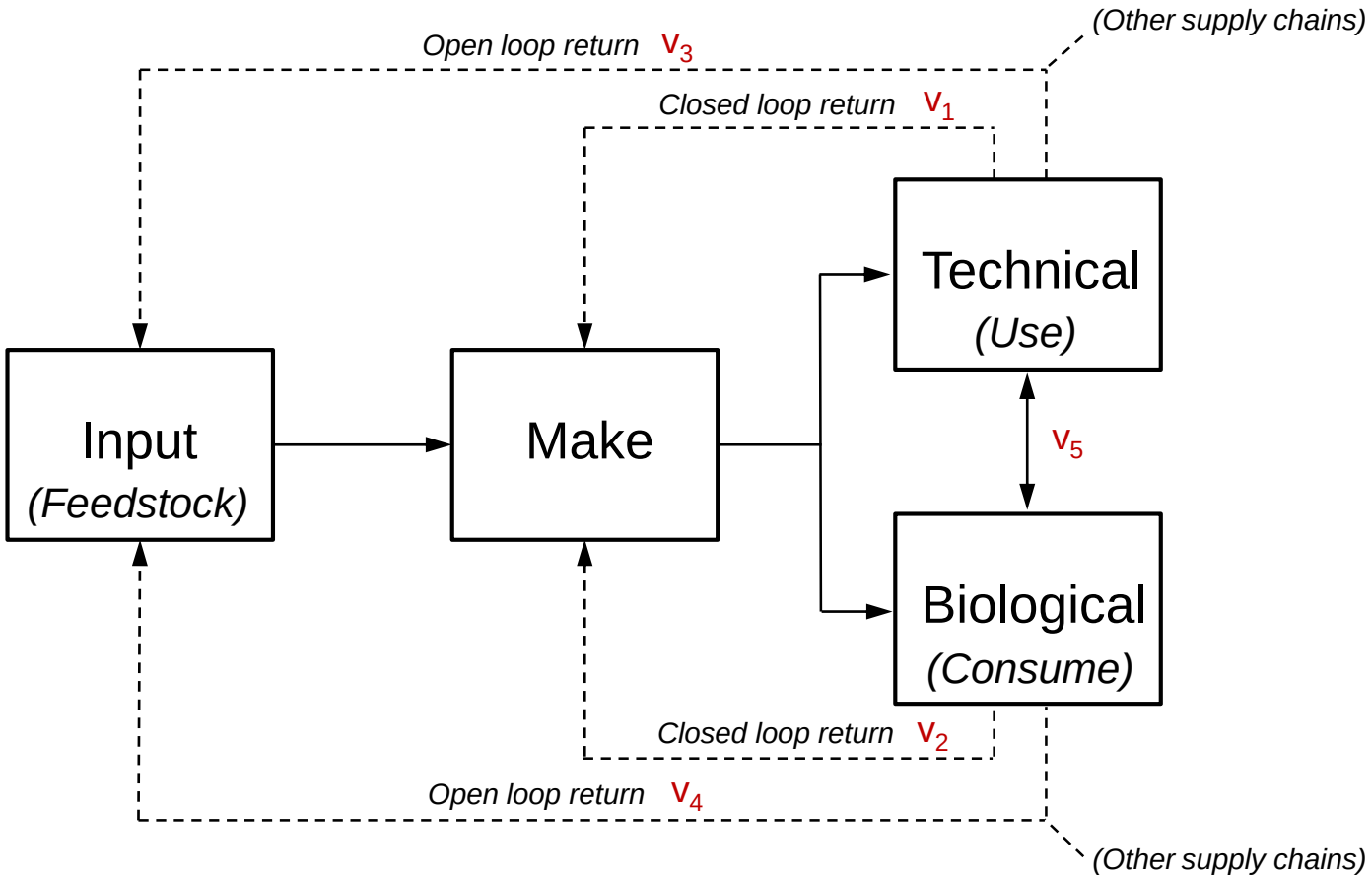
Source: Mustafee, 2019

Current state - *efficiency & cost focus*



- Linear.
- Isolated and *ad hoc* return loops.
- Recycling processes often added later, perhaps the result of new regulation, with little thought over lost value.

Future state - *double loop design*



- Circular business models must distinguish between nutrient type.
- Requires both closed and open return loops.
- Circular indicator emphasis on **value** (v) recapture.

Howard, Hopkinson & Miemczyk (2019)

Some evidence of SME good practice

- **Surplus pastry re-used in production**

  Example of ‘biological closed loop return’

- **Whey re-used in the onsite anaerobic digester (AD) plant**

  Or given to a local AD plant

- **Wet solids from production sold as fertiliser to farmers**

  Grey water is separated and re-used

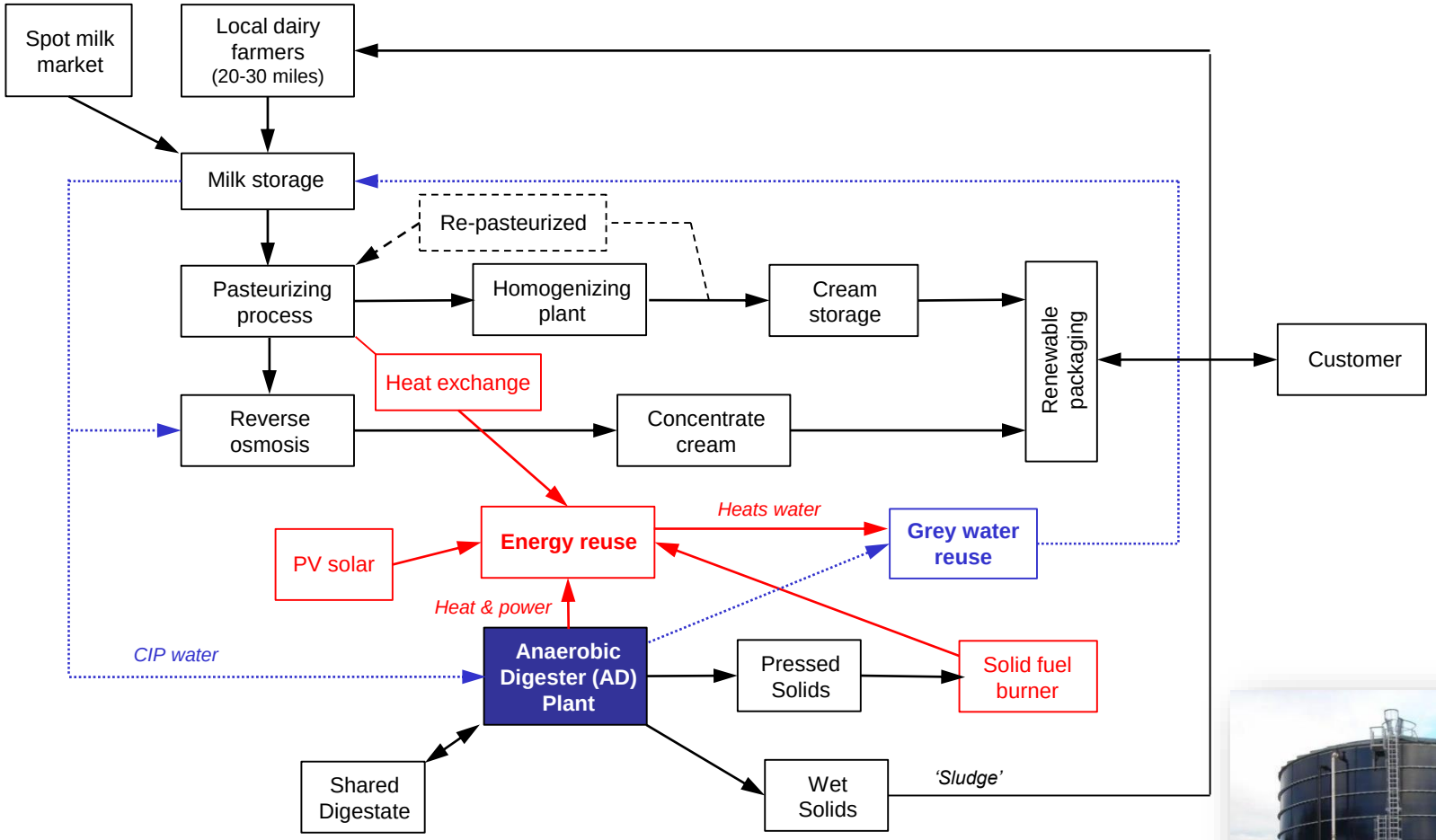
- **Solids from production pressed into briquettes for onsite thermal energy generation**

  An example of technical nutrient closed loop return

  Briquettes can also be sold to a third party

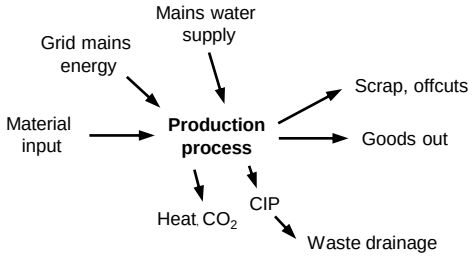
NB: Some of these practices are not new!

Future state dairy - *CE enables resilience!*



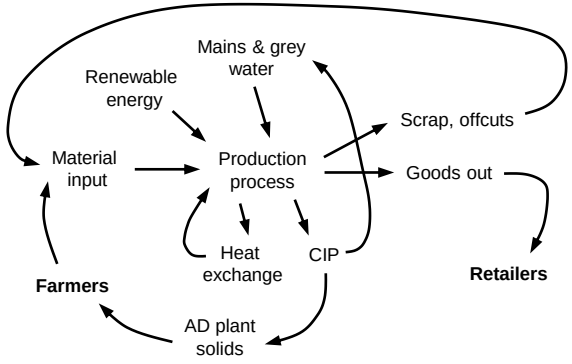
- Circular systems are better able to resist shocks & shortages.
- ***Material-water-energy*** flows work best when interlinked.
- Role of anaerobic digester plant technology is important.

Systems view - *levels of analysis*



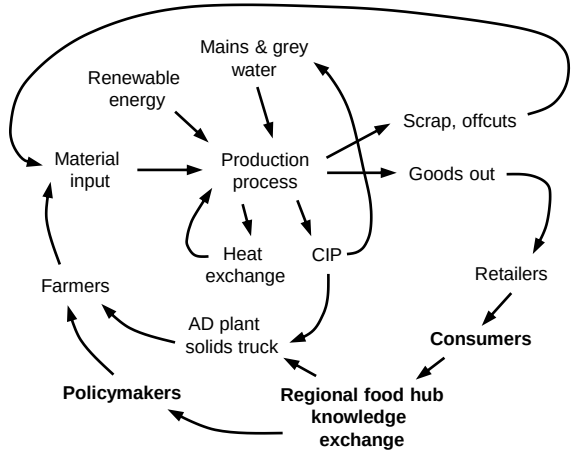
1. Within firm

'Inputs - outputs'



2. Supply chain

Sharing with key partners & stakeholders



3. Whole system integration

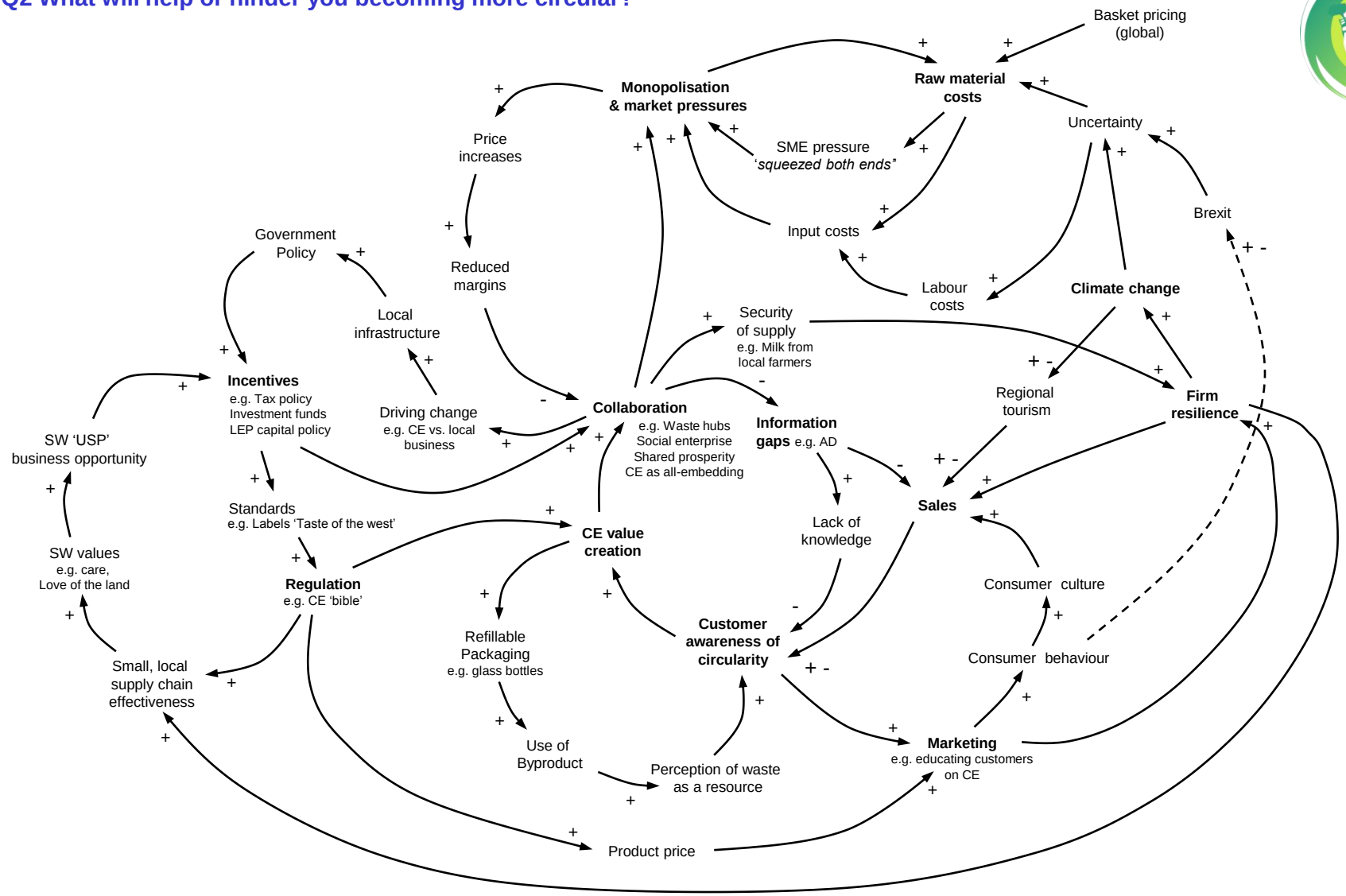
Policy development & knowledge hubs

Lanhydrock, Bodmin, 9th November 2018

Circular Economy partners workshop - systems map

Q1 What is hindering your business?

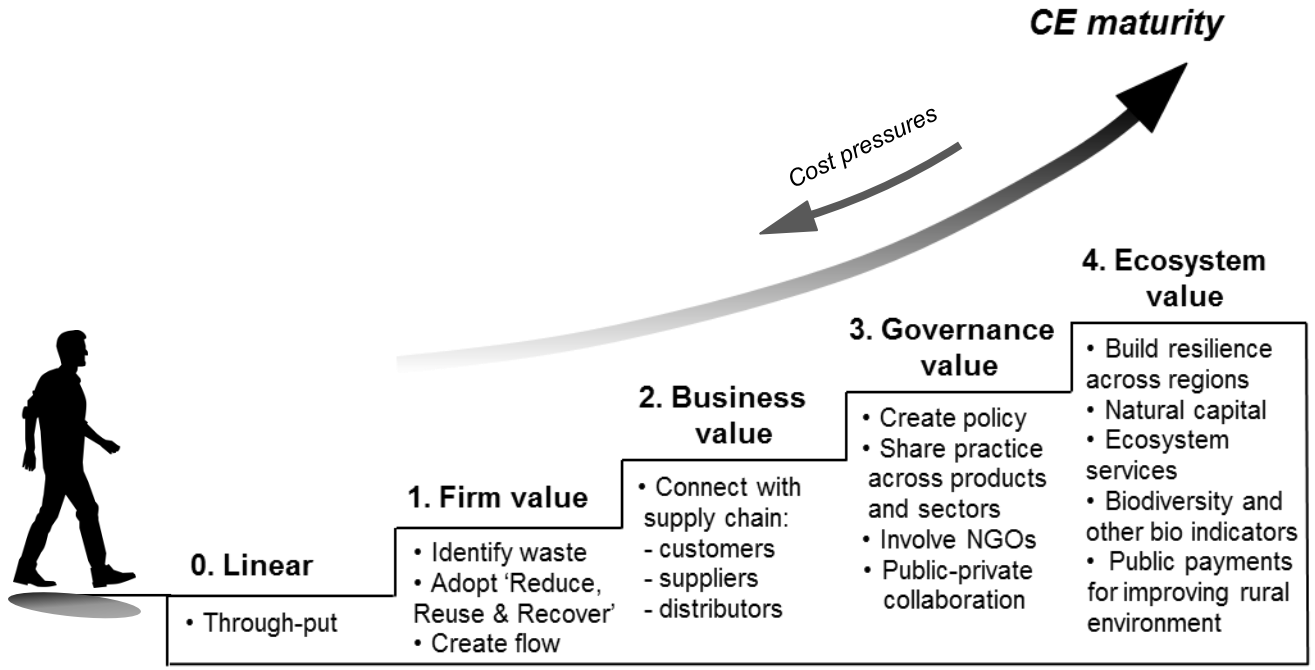
Q2 What will help or hinder you becoming more circular?

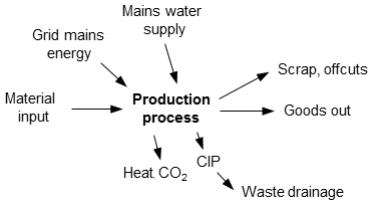


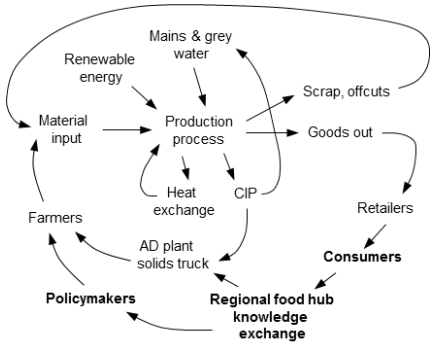
Drawn: MH 13.11.18

The path to CE maturity

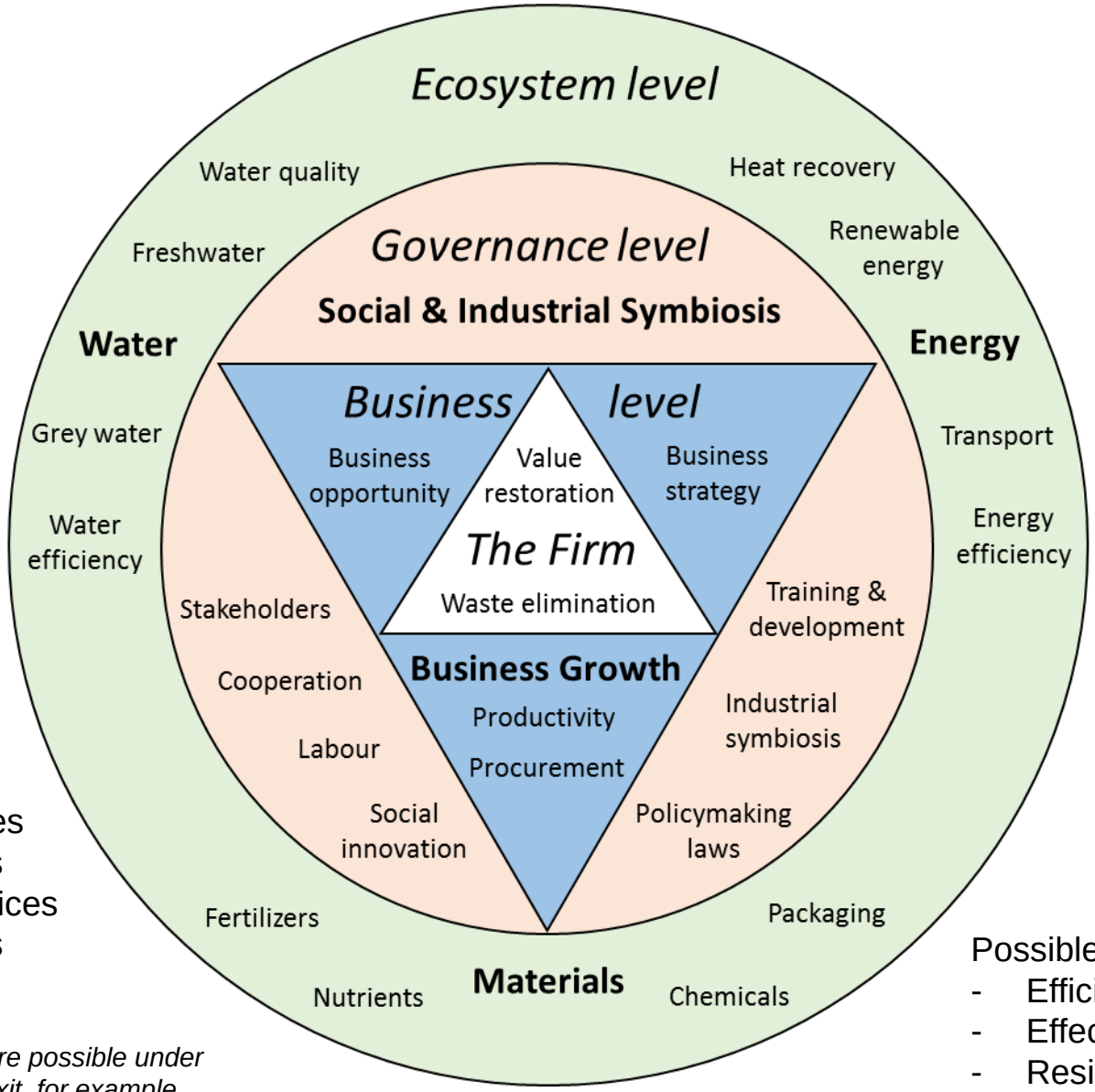
- Our 4 step model develops idea of circular economy maturity.
- Emphasis is on <u>restoring value to the system</u> not just waste elimination.







Circular economy model for clean growth



Possible scenarios:

- Hike in energy prices
- Hike in water prices
- Hike in materials prices
- Hike in labour costs
- New CE legislation

A combination of the above are possible under hard or softer versions of Brexit, for example.

Possible model optimization for:

- Efficiency
- Effectiveness
- Resilience

Project outputs / events

- 9 participating SME (4 dairy, 4 baking, 1 drinks) reports
- 4 private project events for participating industry delegates 2016-2019
- Special public event in 2018 at Westminster with selected MPs - '*Can the Circular Economy Save Britain's Food and Farming Industry?'*
- Keynote speaking at CE related events across the UK & Europe
- Trade articles on CE, agri-food and the role of AD plant technology
- Academic and peer review articles on the CE (wip)
- Social media / twitter updates, project website and 20min video.

UNIVERSITY OF EXETER | BUSINESS SCHOOL

The team:

HOUSES OF PARLIAMENT

Prof Matt Lobley Dan Eatherley Prof Steffen Boehm (Pi) Phil Ugalde (project partner)

Dr Lydia Vamvakeridou-Lyroudia Prof Nav Mustafee Prof Mickey Howard

Conclusions

Implications for theory

- Our CE maturity model emphasizes value recapture and moving beyond ‘waste & recycling’ at level of the firm.
- Benefit of a systems perspective means greater resilience to shocks such as shortages, drought, rising energy prices etc.
- CE implementation barriers: time, financial, technical, staff turnover. Enablers: CE tools, anaerobic digester plant technology.

Implications for practice

- Opportunities for new markets post-Brexit e.g. selling ice cream to the southern hemisphere during the UK winter low season.
- Some good practice already exists e.g. reusing food surpluses.

Further work

- Merits further questions around role of regional knowledge hubs
- Circular economy implementation toolkit – ‘seven tools for CE’
- Clean growth model development

CLSC, Newcastle upon Tyne - 2019

Circular economy implementation in the south-west agri-food sector:

implications for practice & theory

Prof Mickey Howard

Professor of Supply Management

m.b.howard@exeter.ac.uk

Exeter Centre for Circular Economy

http://business-school.exeter.ac.uk/research/centres/circular/

UNIVERSITY OF EXETER | BUSINESS SCHOOL

EPSRC

Engineering and Physical Sciences Research Council

Selected references

EMF - Ellen MacArthur Foundation (2012). Towards the Circular Economy Volume 1: An economic and business rationale for an accelerated transition. Cowes, UK: Ellen MacArthur Foundation.

EMF (2014). Towards the Circular Economy Volume 3: Accelerating the scale up across global supply chains. Cowes, UK: Ellen MacArthur Foundation.

Hopkinson, P., Zils, M., Hawkin, P., and Roper, S. 2018. Managing a complex global circular economy business model. *California Management Review.* Forthcoming.

Howard, M. and Webster, K. 2018. Circular business advantage: what organisations need to know. Circulate – online publication of the Ellen MacArthur Foundation. October 24th. https://medium.com/circulatenews/circular-business-advantage

Howard, M., Hopkinson, P. and Miemczyk, J. 2019. The regenerative supply chain: a framework for developing circular economy indicators. *International Journal of Production Research.* DOI: 10.1080/00207543.2018.1524166. Forthcoming.

Miemczyk, J., Howard, M. and Johnsen, T. 2016. Dynamic development and execution of closed-loop supply chains: a natural resource-based view. *Supply Chain Management: An International Journal.* 21 (4), 453-469.

Johnsen, T., Howard, M. and Miemczyk, J. 2018. Purchasing & Supply Chain Management: A Sustainability Perspective (2nd Edition). Routledge, Taylor & Francis Group: UK.

www

https://business-school.exeter.ac.uk/about/people/profile/index.php?web_id=Mickey_Howard

https://business-school.exeter.ac.uk/research/centres/circular/

https://www.ellenmacarthurfoundation.org/

https://medium.com/circulatenews/

Fashion clothing returns: Can machine learning help?

Chee Yew Wong[1] & Nitin Jain[2]

CLSC 2019 Newcastle

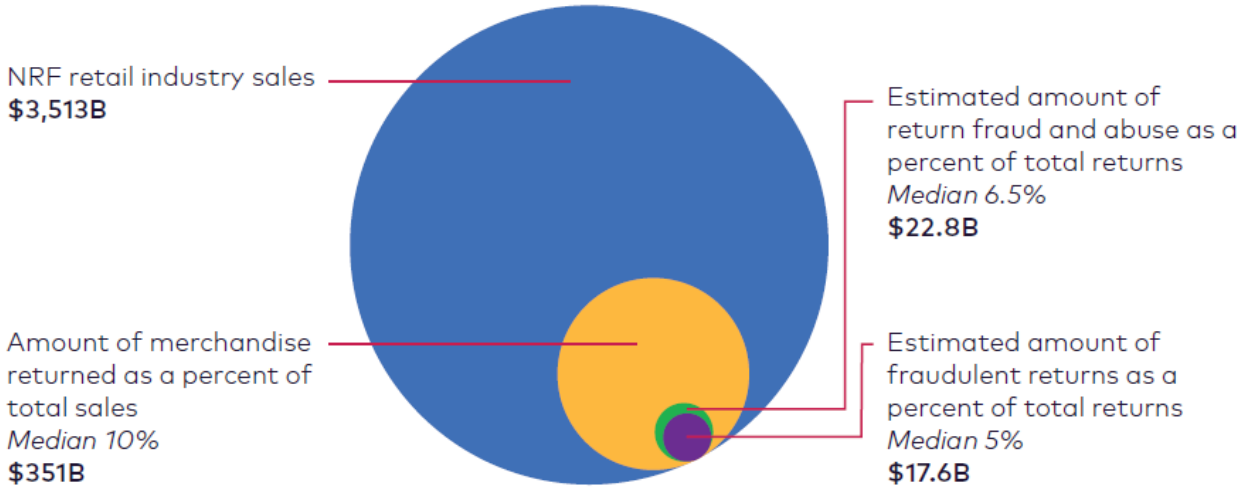
[1]Leeds University Business School, Leeds, UK. (c.y.wong@leeds.ac.uk)

[2]Leeds University Business School, Leeds, UK (KTP associate)

The economic impacts of merchandise returns[1]

UNIVERSITY OF LEEDS

Annual US Merchandise Returns and Return Fraud

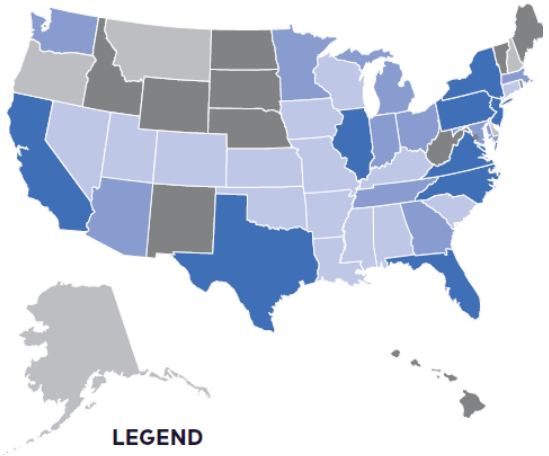


Impacts of returns:

- Retailers: Lost sales
- States: Lost VAT tax
- Planet: Energy, virgin materials, emission…

Lost US Sales Tax Impact of Return Fraud and Abuse

MAP OF LOST STATE SALES TAX BY STATE



LEGEND

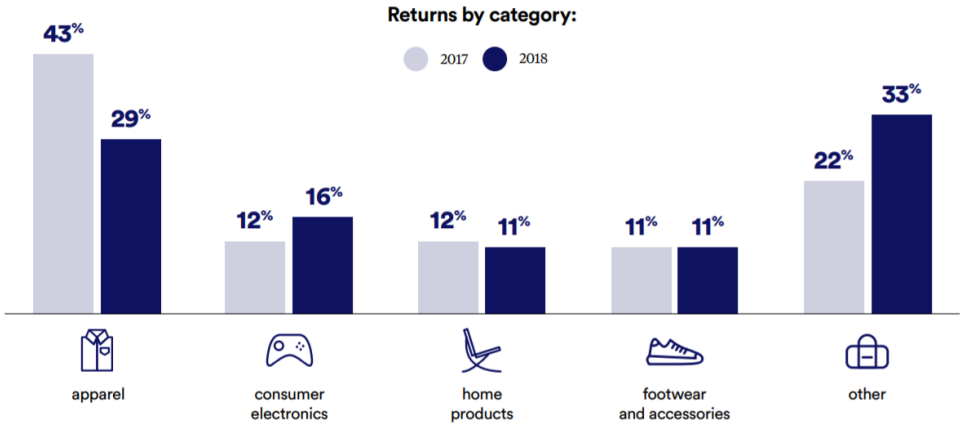
- $0 Lost sales tax revenue
- <$10 Lost sales tax revenue
- $10–$24 Lost sales tax revenue
- $25–$49 Lost sales tax revenue
- $50> Lost sales tax revenue

Sales tax revenue in millions, based on right-hand estimates from table.

Return rates vary across product categories[1]

UNIVERSITY OF LEEDS

RETAIL CATEGORY	BLENDED RETURN RATE(1)
Apparel	12.69%
Auto Parts	22.78%
Beauty	7.04%
Department Stores	13.90%
Drug/Pharmacies	1.98%
Footwear	9.63%
Hard Goods	11.70%
Home Improvement	11.76%
Housewares	12.53%
Sporting Goods	8.92%
NRF Survey Median(2)(3)	10.0%



[4]Narvar Consumer Report 2018 — The State of Returns: What Today's Shoppers Expect

Merchandise returns as fraud and abuse[1]

UNIVERSITY OF LEEDS

Which examples of return fraud has your company experienced in the past year?

RETURN FRAUD EXAMPLES	2017
Return of stolen merchandise (shoplifting)	68.3%
Employee return fraud or collusion with external sources	65.1%
Return of merchandise purchased with fraudulent or stolen tender	57.1%
Returns made by organized retail crime groups	54.0%
Wardrobing or renting (returns of used, non-defective merchandise)	39.7%
Returns using counterfeit receipts	28.6%
Returns using e-receipts	19.1%
Other	3.2%
None of the above	11.1%

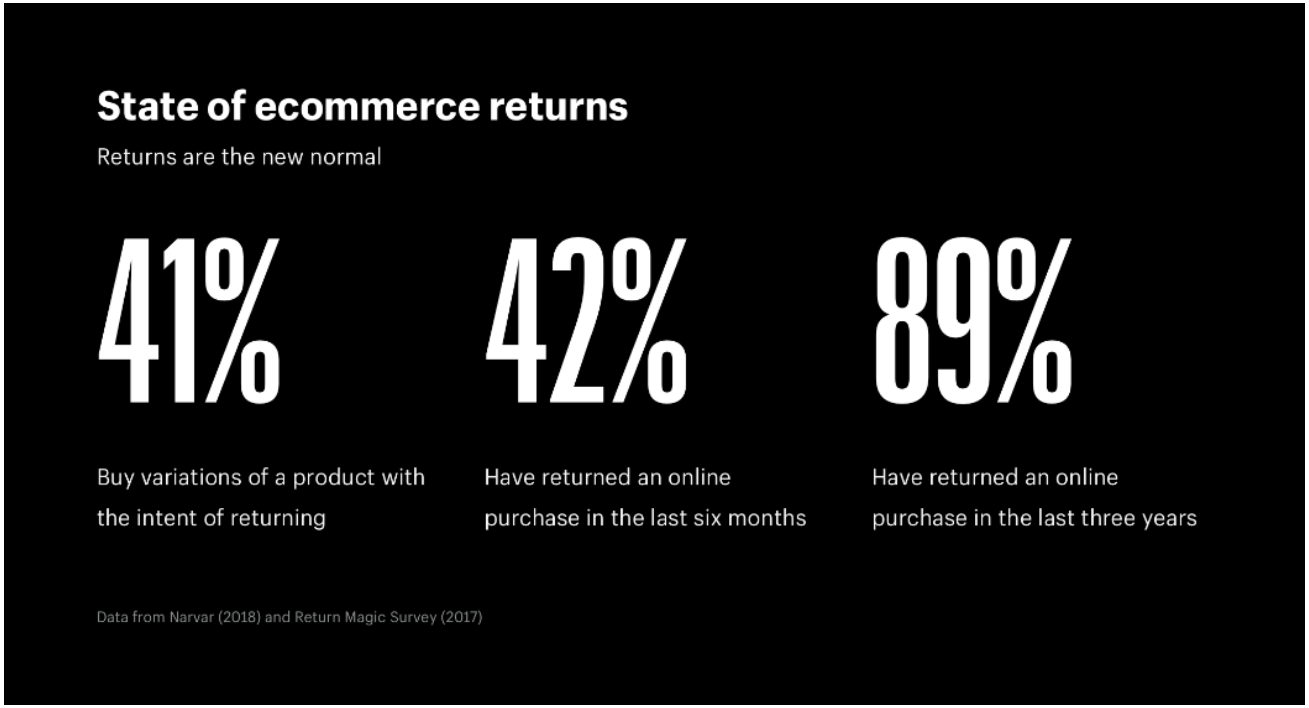
Source: National Retail Federation 2017 Organized Retail Crime Survey. November 2017.

See reference [1]

An emerging behaviour: buy variations of products with the intent of returning

UNIVERSITY OF LEEDS

In USA, nearly 2/3 consumers returned at least 1 item during the past holiday (2017), and 23% bought items with the intention to return them later [1]



- Wardrobing*
- Serial returners
- Return frauds
- Retail crime groups

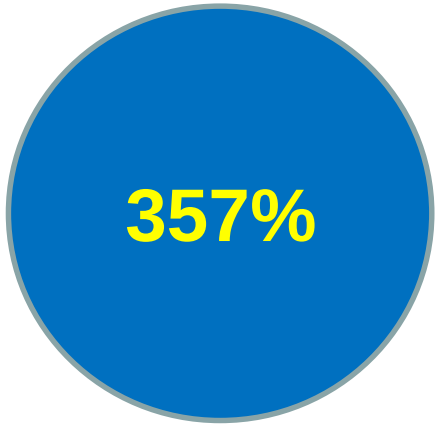
[4]Narvar Consumer Report 2018 — The State of Returns: What Today's Shoppers Expect

*See reference [6] for an example of optimal return policy for wardrobing

Can lenient return policy, e.g. “Free returns” boost sales?

UNIVERSITY OF LEEDS

- It is claimed[3] that a free return policy can massively boost sales by up to…



- Free returns “league board”[11]

FREE RETURNS WORLDWIDE	Burberry	Kenzo	Pull & Bear	The Outnet
	Farfetch	Massimo Dutti	Puma	Vans
	G-Star Raw	Mulberry	Reebok	Zara
	Gucci	Net-A-Porter	Selfridges	
FREE RETURNS IN 20+ COUNTRIES	Agent Provocateur	Bershka	Espirit	Paul Smith
	ASOS	Calvin Klein	Jimmy Choo	Reiss

NO FREE RETURNS			
Abercrombie & Fitch	Forever 21	Mothercare	Ted Baker
Anthropologie	Fred Perry	Myprotein	The Edinburgh Woolen Mill
Arco	Gabor	Office	The Hut
Armani	Getthelabel.com	Orvis	The North Face
Blacks	Go Outdoors	Outdoor & Country	The White Company
Blue Inc	Hollister	Peacocks	Toast
Boden	J Crew	Pro-Direct	Tommy Hilfiger
Bonmarché	Jack & Jones	QVC	Urban Industry
Brand Alley	Jaeger	Ralph Lauren	Vente-Privee
Cath Kidston	JoJo Maman Bébé	Rapha	Vivienne Westwood
Charles Clinkard	Joy	Regetta Outdoor Clothing	Whistles
Cotswold Outdoor	Kitbag.com	Rohan	Wynsors World of Shoes
Cotton Traders	Lands' End	Roman Originals	
Craghoppers	Liberty	Route One	
Crew Clothing	Lipsy	Schuh	
Cycle Surgery	Long Tall Sally	SecretSales	
Ellis Brigham Moutain Sports	Mamas & Papas	Snow + Rock	
Everything5pounds.com	MandM Direct	Sole	
Flannels	Millets	SportsDirect.com	

Research: Lenient return policy generally increases purchase more than returns. Effects of return policy factors (time, money, effort, scope, exchange) on purchase and return vary[5].

Lenient return policies: pressures to give more time to return & less time to refund

UNIVERSITY OF LEEDS

ITV REPORT 5 April 2019 at 1:31pm

Asos launches new returns policy in bid to block 'serial returners'

WE'VE UPDATED OUR RETURNS POLICY

We know free returns are one of the (many) reasons you shop with us, so we've increased the time you can return stuff from 28 days to 45 days. If you return anything within 28 days, we'll refund you as normal... and after that (up to 45 days), you'll now get an ASOS gift e-gift card for the amount you spent.

We also need to make sure our free returns remain sustainable for us and for the environment, so if we notice an unusual pattern, we might investigate and take action. It's unlikely to affect you, but we wanted to give you a heads up (more deets below). Thanks for being a great ASOS shopper!

https://www.itv.com/news/2019-04-05/asos-launches-new-returns-policy-in-bid-to-block-serial-returners/

極度乾燥(しなさい) Superdry®

How long does the Return take?

Please allow 7-10 working days from our receipt of your goods, for your return to be processed.

ebay

If your item arrives damaged or faulty, you can return it for a refund. If you've changed your mind and want to send it back, you can ask the seller if they'll accept a return.

If the item you received doesn't match the description in the original listing, or if it arrived faulty or damaged, you're covered under the eBay Money Back Guarantee. You can return it even if the seller's returns policy says they don't accept returns.

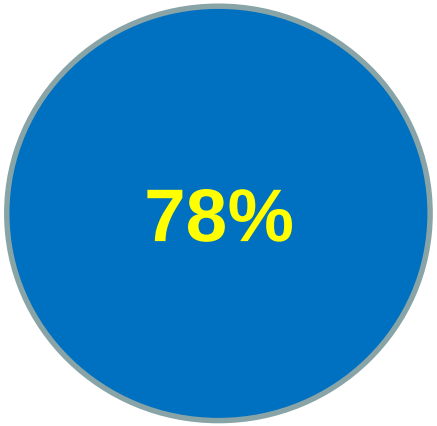
If you no longer want an item, you'll be able to see in the listing if the seller offers returns, how long you have to request a return, and any other conditions. You can check the listing by selecting the item in your Purchase history.

Once you start a return, the seller has 3 business days to resolve your issue. If your problem isn't solved at the end of those 3 days, you can ask us to step in and help.

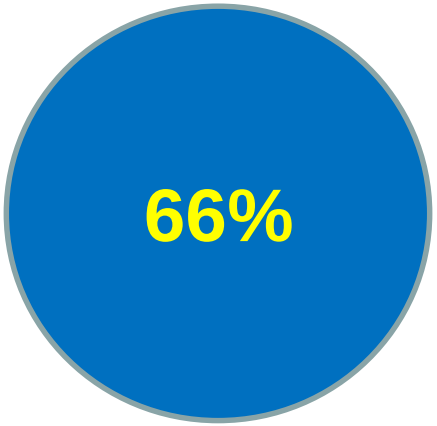
https://www.ebay.com/help/buying/returns-refunds/return-item-refund?id=4041

Cross road in between lenient return policies and escalating return costs

UNIVERSITY OF LEEDS



of online shoppers rate easy or free returns as important[2]



of online shoppers are put off by unclear or complicated return process[2]

of goods sold are returned[2]

- Shop direct handled 250 million returns annually[2]
- A large online fashion brand owner received 120,000 returns / day

Restocking fees is not as common as thought

UNIVERSITY OF LEEDS

Large retailers are better able to absorb the costs of a return item, so they don't usually charge a restocking fee. In fact, the only large retailers known to apply a restocking fee to some items are Home Depot and Best Buy. Both are buried in the fine print, but nonetheless, are there if either store wants to apply them.

eBay, on the other hand, lives in its own universe with its own rules, protocols, and opinions—and the issue of restocking fees divides eBay sellers. Because many sellers are solo operators and every dollar counts, they charge restocking fees for all returns, regardless of the reason. Other sellers feel that a restocking fee is bad for business. These are the sellers that aren't penny-pinching but end up making other penny-pinching eBay sellers look bad.

https://www.thebalancesmb.com/should-ebay-sellers-charge-a-restocking-fee-for-returns-4051833

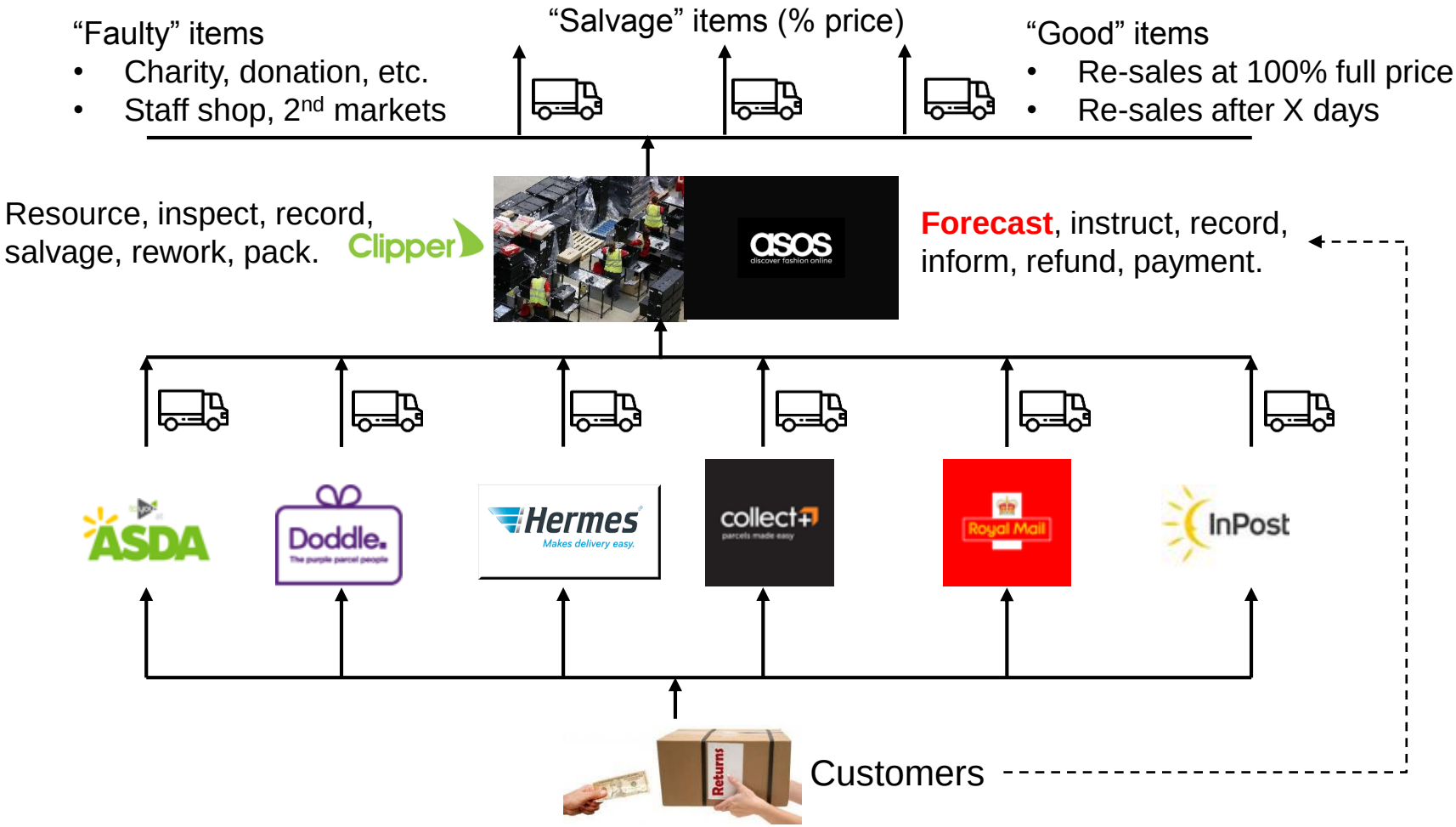
Research on consumers and retailers (brand owners)

UNIVERSITY OF LEEDS

- **Consumers**
  - Ordinary consumers face ex-post fit & valuation uncertainty[6]
  - Opportunistic consumers face restocking fee[6,7, 9] in exchange for partial consumption of products
  - Purchase decision affected by selling price[6,7], delivery cost, return policies[5], restocking fees[6,7,8], etc.
  - Return decision[5] affected by selling price, delivery cost, return policies, restocking fees[6,7,8], etc.
- **Retailers**
  - Decide on selling price, return policies[6,9], restocking fees, etc. and estimate sales / profits, policy for consumer to opt out of free returns for a discount[10], etc.
  - **Predicting return rates**[10], re-selling (salvage) value[7], and return logistics cost implications
  - Consider forward and reverse logistics capability[9]
  - Cost-benefits between retailer and manufacturer depending on who salvages the returns

Return logistics for fashion retailers: Prediction of returns matters

UNIVERSITY OF LEEDS



Predicting returns: can machine learning help?

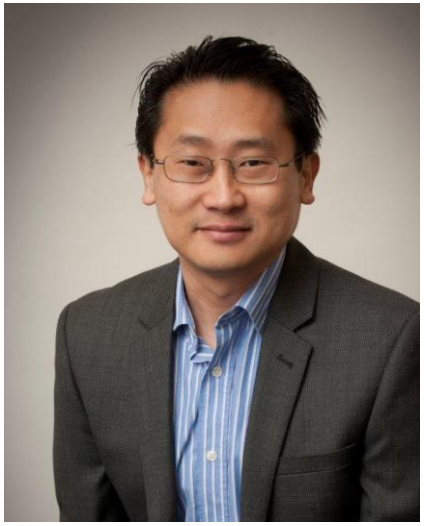
UNIVERSITY OF LEEDS

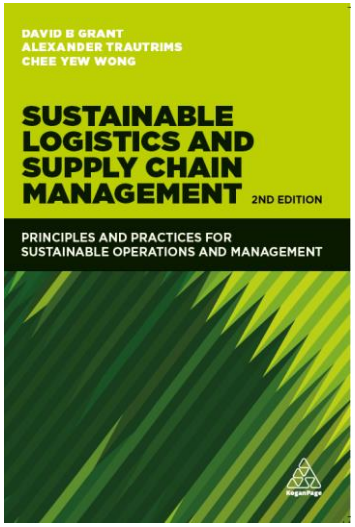
- Cui et al. (2019)[10]
  - Factors: sales, order date, retailer, product type, production details, ship date, return date, return policies, etc.
  - Consider main effects, 2nd and 3rd order interaction effects
  - Found Least Absolute Shrinkage and Selection Operator (LASSO) best for predicting future return volume (compared LARS-OLS hybrid, Smooth Clipped Absolute Deviation, Elastic Net).
  - Explored two tree-based ML methods: Random Forest & Gradient Boosting to capture non-linear structure in the data, but failed to improve prediction accuracy of LASSO
- The KTP project: aim to develop predictive analytics solutions
  - Expand known factors[10] including manufacturer/product characteristics, weather, seasonality (holidays, events, festival, etc.), consumer demographics, etc.
  - Combine data from fashion brand owners/retailers and return logistics service providers
  - Develop training data, optimize prediction using historical and real-time data

Thank you!

UNIVERSITY OF LEEDS

Professor Chee Yew Wong
Leeds University Business School
University of Leeds
Maurice Keyworth Building
Leeds LS2 9JT
T: 0113 3437945
E: c.y.wong@leeds.ac.uk
W: www.greensupplychains.org
W: http://lubswww.leeds.ac.uk/coscr/





ISBN: 9780749473860

Centre for Operations and Supply Chain Research (COSCR)
LEEDS UNIVERSITY BUSINESS SCHOOL

UNIVERSITY OF LEEDS

Major references

UNIVERSITY OF LEEDS

1. Appris Retail (2017) 2017 consumer returns in the retail industry, 1-6.
2. Retail week (2014) The future of returns, 1-7. www.retail-week.com
3. CNBC (2012) Offering free returns can boost online purchases 357%
4. Narvar Consumer Report 2018 — The State of Returns: What Today's Shoppers Expect
5. Janakiraman et al (2016) The effect of return policy leniency on consumer purchase and return decisions: a meta-analysis review. Journal of Retailing, 92(2), 226-235.
6. Zhang et al. (2017). Optimal return policies with wardobing. Production and Operations Management 26(7), 1315-1332.
7. Ketzenberg and Zuidwijk (2009). Optimal pricing, ordering, and return policies for consumer goods. Production and Operations Management 18(3), 344-360.
8. Shulman et al. (2011). Managing consumer returns in a competitive environment. Management Science 57(2), 347-362.
9. Shulman et al. (2009). Optimal restocking fees and information provision in an integrated demand-supply model of product returns. MSOM 11(4), 577-594.
10. Cui et al. (2019). Predicting product return volume using machine learning methods. EJOR, *in press*.
11. Rebound (2017) The great returns race: Benchmark 2017, 2nd Ed.

University of Brighton

Remanufacturing-Status of the Art

By Dr. Yan Wang

University of Brighton

E-mail: y.wang5@brighton.ac.uk

1.About University of Brighton

- Over 21,00 students
- Strong in remanufacturing, automotive, design, art, medicine, pharmacy etc.

Contents

Overview of Remanufacturing in UK

Innovation in Remanufacturing

Conclusions

Contents

What is Remanufacturing?

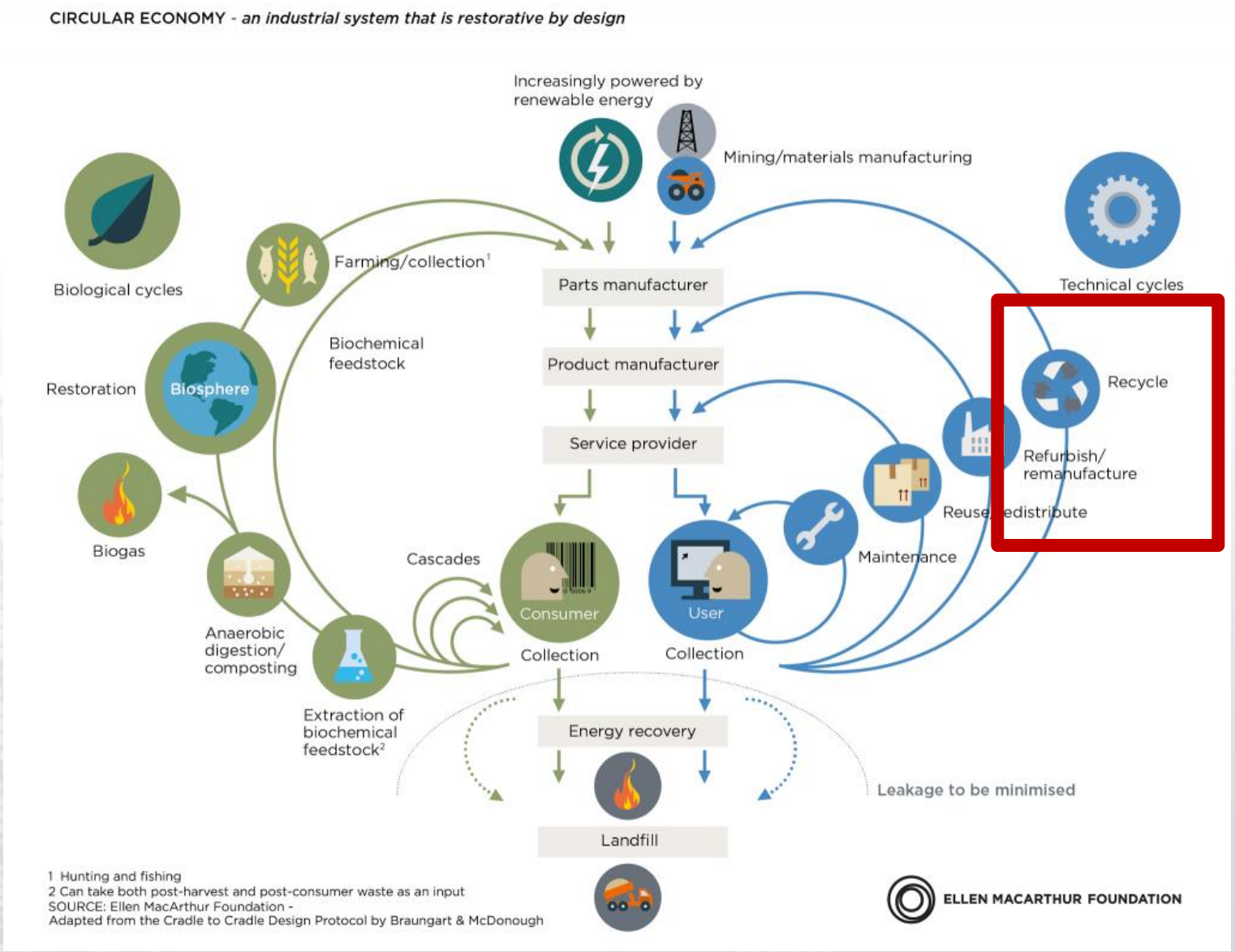
BS 8887-2(2009)

- **Remanufacture** returns a used product to **at least as new performance specification** and gives the resultant product a warranty that is at least equal to that of a newly manufactured equivalent.
- **Reconditioning** returns a product to a **satisfactory working condition** that may be inferior to the original specification and **a gives a warranty less than the newly manufactured product**.
- **Repair** corrects specified faults in a product and gives a warranty less than the newly manufactured product that may not cover the entire product.
- **Recycle**: Recovers materials for the original purpose or a new purpose.

!

http://www.remanufacturing.org.uk/pdf/story/2p221.pdf

Remanufacturing and circular economy



How to remanufacture?

Used products

Disassembly

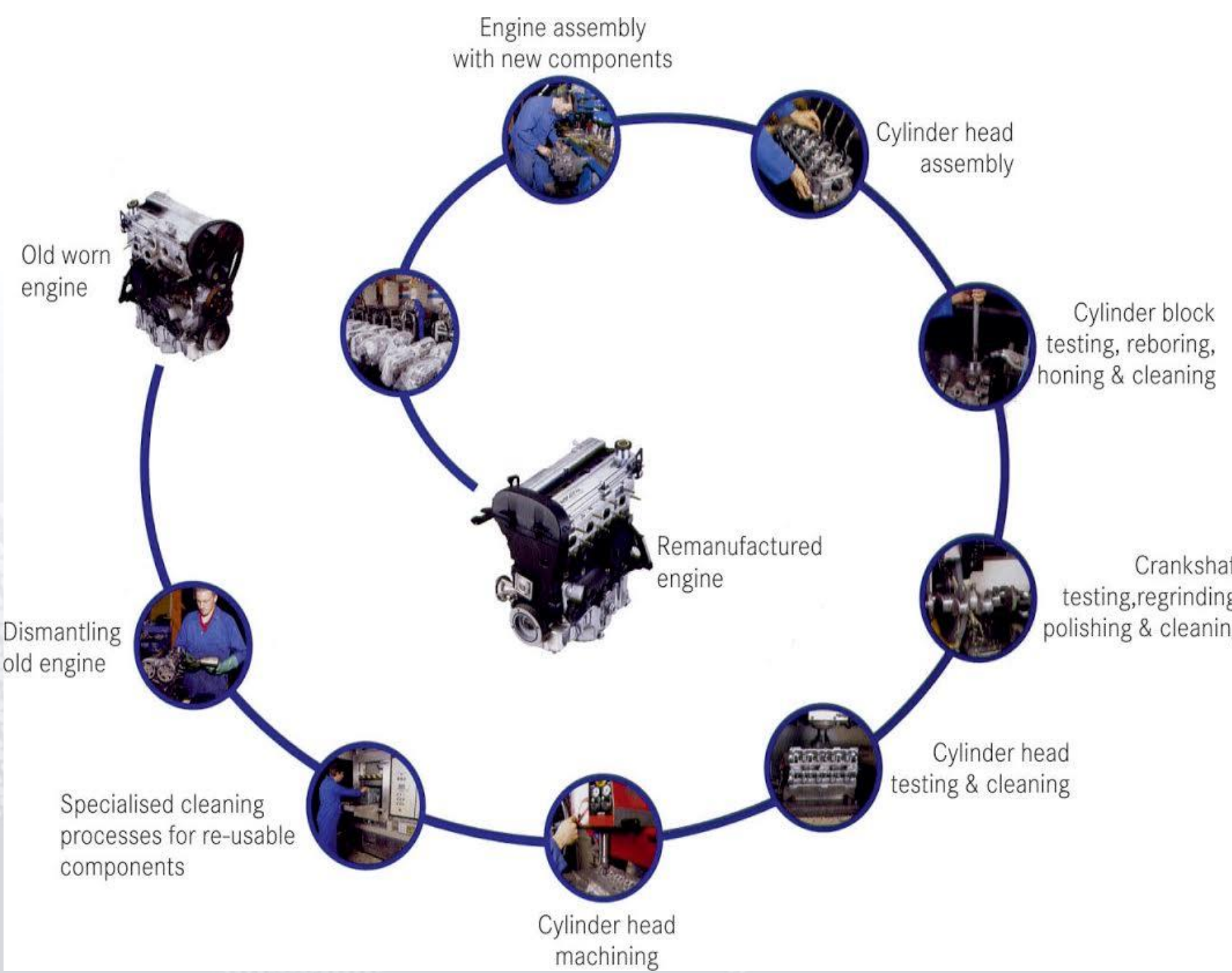
Cleaning

Part Inspection

Part replacement | Part reuse | Part repair

Reassembly

Inspection of remanufactured products



Why remanufacturing?

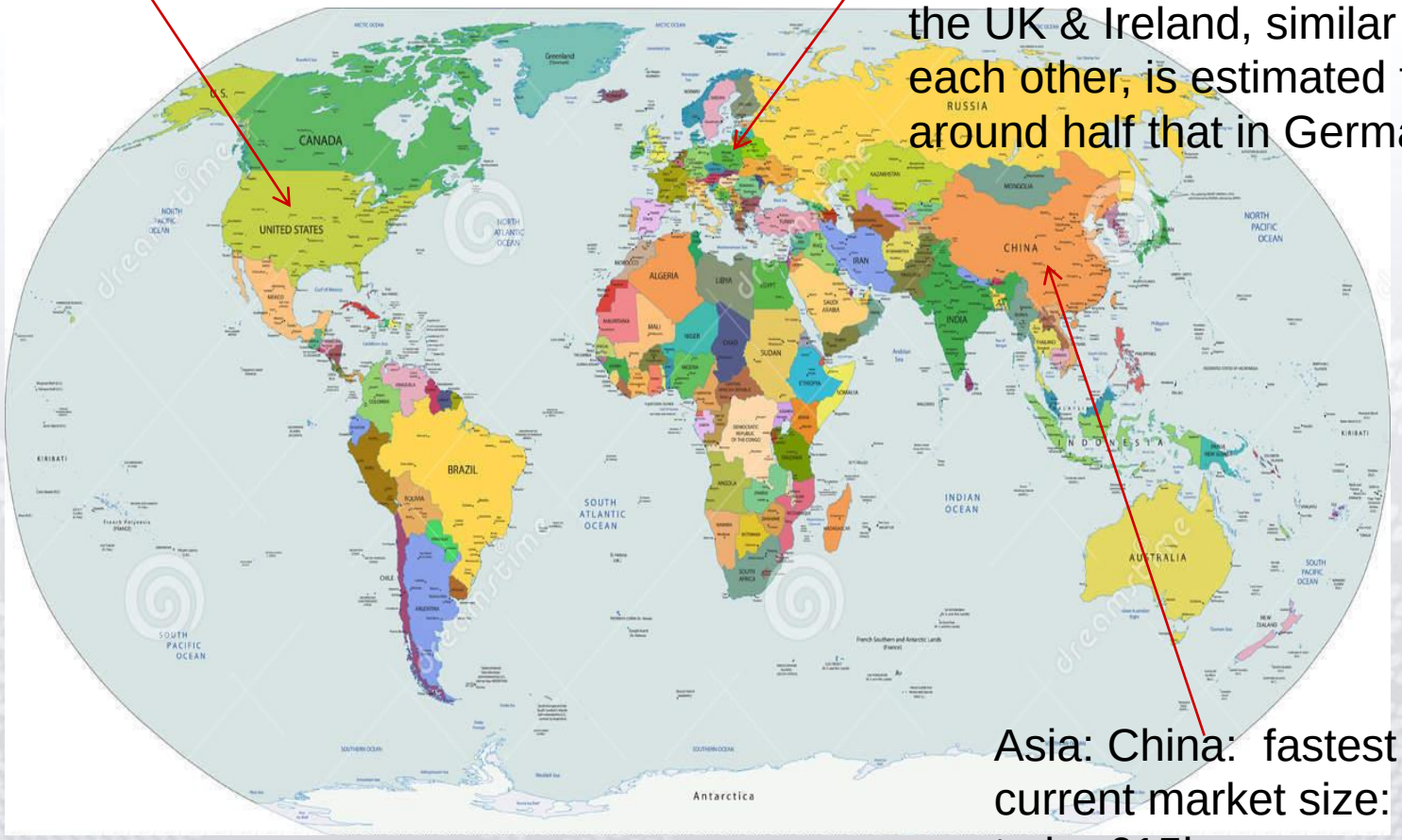
- The European Union produces up to **3 billion tonnes** of waste every year[1]
- Remanfuacturing returns End-of-Life products back to use, **reducing waste**;
- Saves up to **80% of the material and energy** required to manufacture a new product [2]
- *Retaining a client base.* Remanufacturing also presents a strong business opportunity and it can be **twice** as profitable as manufacturing[3]
- Benefits to the end user; 80% price of new products, when the customer returns a product **they can receive an identical remanufactured product with no waiting time**.[3]

[1] http://ec.europa.eu/environment/waste/pdf/WASTE%20BROCHURE.pdf
[2] PEARL, “Reconditioning: The Ultimate Form of Recycling”, 2010
[3] http://www.policyconnect.org.uk/apsrg/sites/site_apsrg/files/apsrg_-_remanufacturing_report.pdf

Global Remanufacturing market

US: Largest market, $43 billion (£27.4 billion) in 2011

EU: €30bn, 70% in Germany, the UK & Ireland, France and Italy, Remanufacturing in France and in the UK & Ireland, similar in size to each other, is estimated to be around half that in Germany



Asia: China: fastest growing, current market size: estimated to be £15b

Japan: up to €3.8 billion

Remanufacturing in the UK

Even the most conservative estimates suggest that the potential of remanufacturing in the UK is £5.6billion[1]

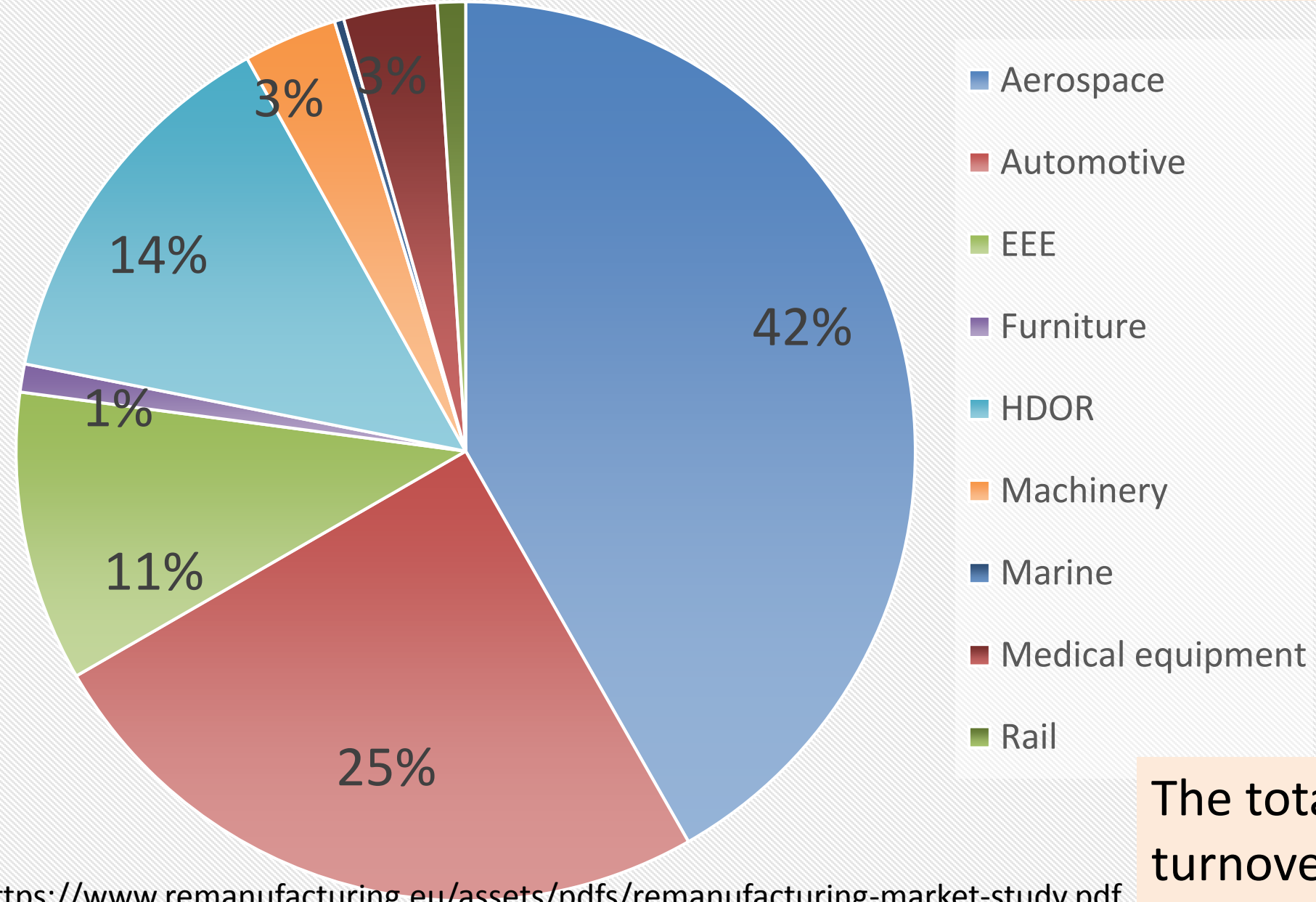
This could potentially be increased by a factor of 10 by 2020, therefore increasing its percentage of total manufacturing turnover from the current 1% to 10%, leading to £5bn of additional profit per annum for manufacturers, over 300,000 jobs, £3bn of savings from avoiding landfill cost and the retention of resource value[2]

The over- emphasis on **recycling** in the UK has actually hindered the development of remanufacturing. Although the recycling and remanufacturing industry were the same size in 2005, remanufacturing has only grown by 15-20% since then, in comparison to the UK recycling industry which has grown by 300%[1]

[1]http://www.policyconnect.org.uk/sites/site_pc/files/report/604/fieldreportdownload/apsrgapmg-triplewin.pdf
[2] http://telllaura.org.uk/resource/2020%20Report.pdf

Sector of remanufacturing in EU

HDOR :Heavy-Duty and Off-road Equipment
EEE: Electrical, Electronical Equipment



https://www.remanufacturing.eu/assets/pdfs/remanufacturing-market-study.pdf

The total remanufacturing turnover is about 30b euro

Remanufacturing still at its infancy

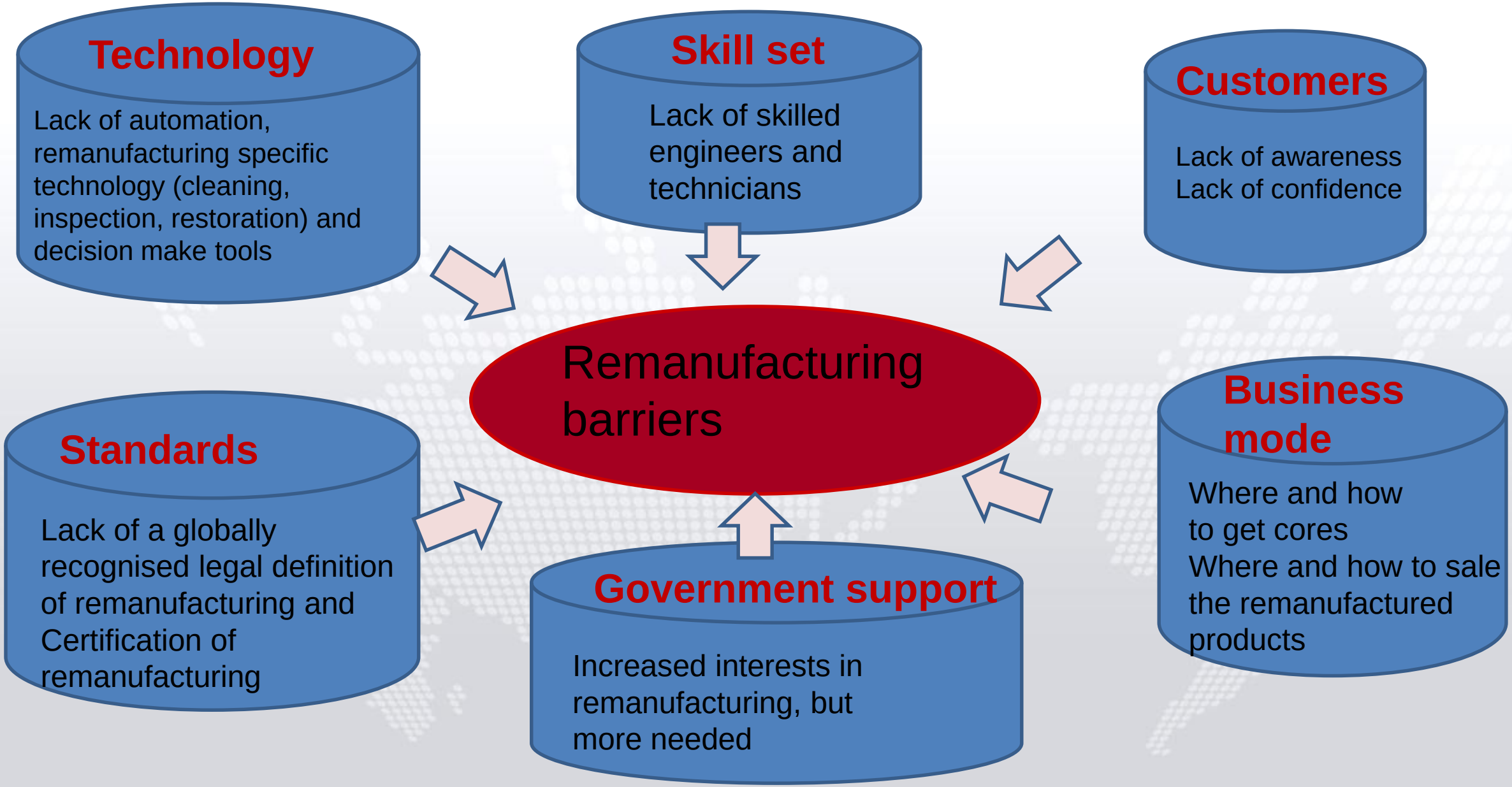
Sectors	Turnover (€bn)	Firms	Employm't ('000)	Core[2] ('000)	Intensity
Aerospace	12.4	1,000	71	5,160	11.5%
Automotive	7.4	2,363	43	27,286	1.1%
EEE	3.1	2,502	28	87,925	1.1%
Furniture	0.3	147	4	2,173	0.4%
HDOR	4.1	581	31	7,390	2.9%
Machinery	1.0	513	6	1,010	0.7%
Marine	0.1	7	1	83	0.3%
Medical equipment	1.0	60	7	1,005	2.8%
Rail	0.3	30	3	374	1.1%
Total	**29.8**	**7,204**	**192**	**132,405**	**1.9%**

Remanufacturing sectors across the EU.

These are substantial numbers but represent an intensity (ratio of remanufacturing to new manufacturing) of only 1.9%.

https://www.remanufacturing.eu/assets/pdfs/remanufacturing-market-study.pdf

Barriers for Remanufacturing



Regulatory Frameworks barriers

- **WEEE Directive-**End-of-life products for remanufacturing are classified products as **waste** which needs **certificates** to handle
- **The Freedom of Information (FOI) Act-T**here is currently little scope for remanufacturers to access product design or in-service data or specifications.
- **The End of Life Vehicles (ELV) Directive**-**Recycling** more attractive to some manufacturers than **remanufacturing**.
- **Restriction of the Use of Certain Hazardous Substances in Eelectrial and Electronic Equipment (RoHS**) Directive -if part of a product is replaced, the **whole product will have to be reassessed** in order to be awarded a CE mark
- IPs:

Standard barrier

http://www.bbc.co.uk/programmes/articles/5mzXMVhR19L47jS2SSrntBL/ideal-engines-and-gearboxes

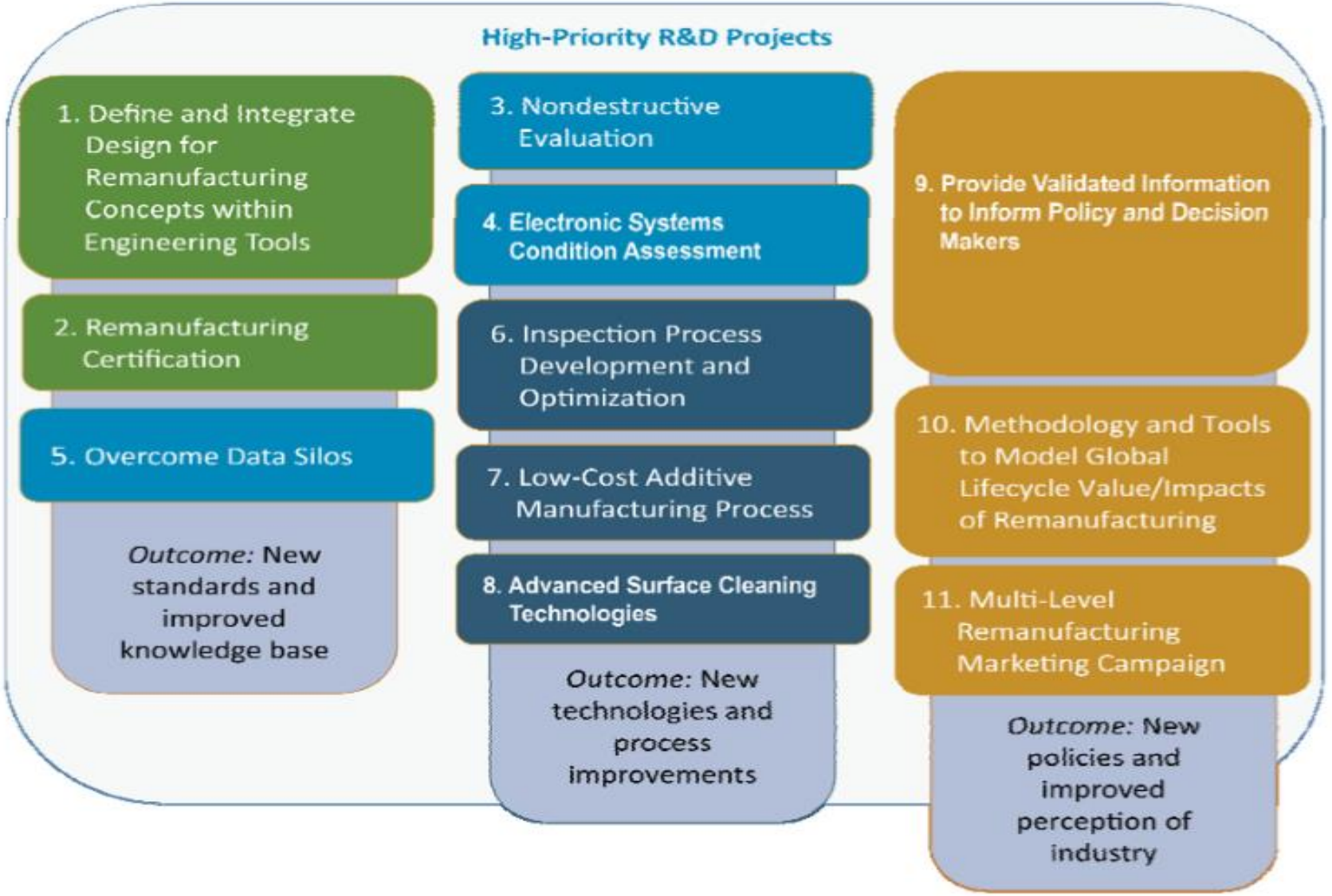
Lack of standards for remanuf. Products, public awareness, accreditation have led to the problem!!!

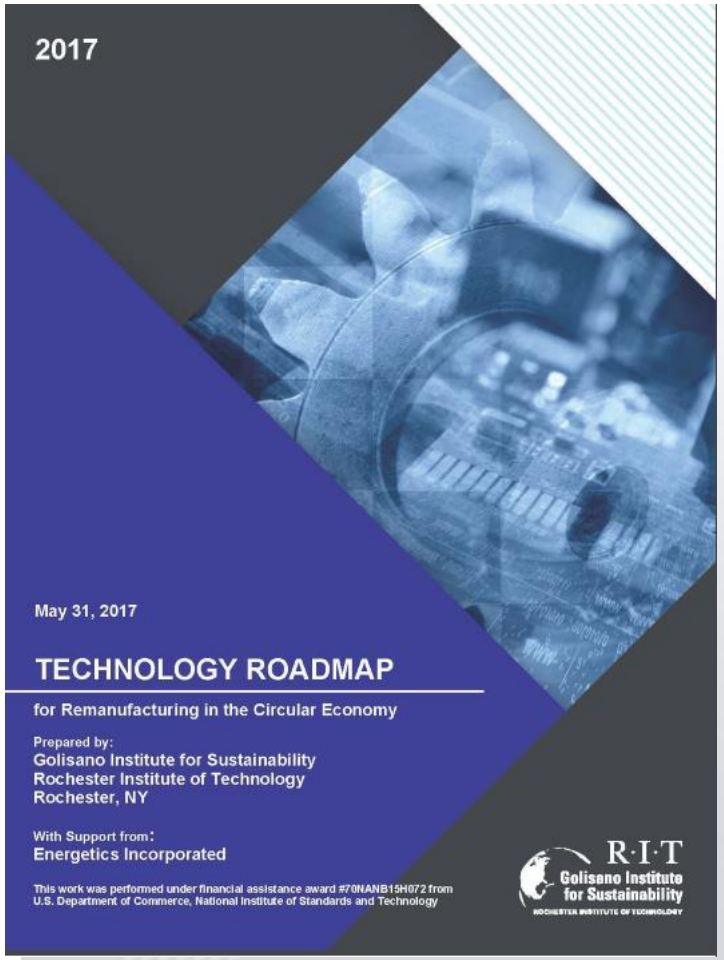
Technical barrier for remanufacturing

- Currently the labour cost for remanufacturing is around **3-6 times** of that for production of virgin production.
- This is led from **differential quality** of returned End-of-Life products, thus remanufacturing is often **one off**.

Contents

Technology road mapping for remanufacturing in Circular Economy





Scottish Institute for
REMANUFACTURE
Reuse, Repair and Reconditioning

www.scot-reman.ac.uk

Scottish Funding Council
Promoting further and higher education

ZERO WASTE SCOTLAND

University of Strathclyde Glasgow

HERIOT WATT UNIVERSITY

SMAS
Scottish Manufacturing Advisory Service

Example project:
Removal of carbon residue from cylinder heads

Cummins

AFRC
ADVANCED FORMING RESEARCH CENTRE
UNIVERSITY OF STRATHCLYDE

From presentation by Ben Peace, KTN, China mission, 2016

EPSRC

Engineering and Physical Sciences Research Council

"Autonomous Inspection in Manufacturing & Remanufacturing (AIMaReM)"

- £2m
- May 2016-April 2020

University of Strathclyde Glasgow

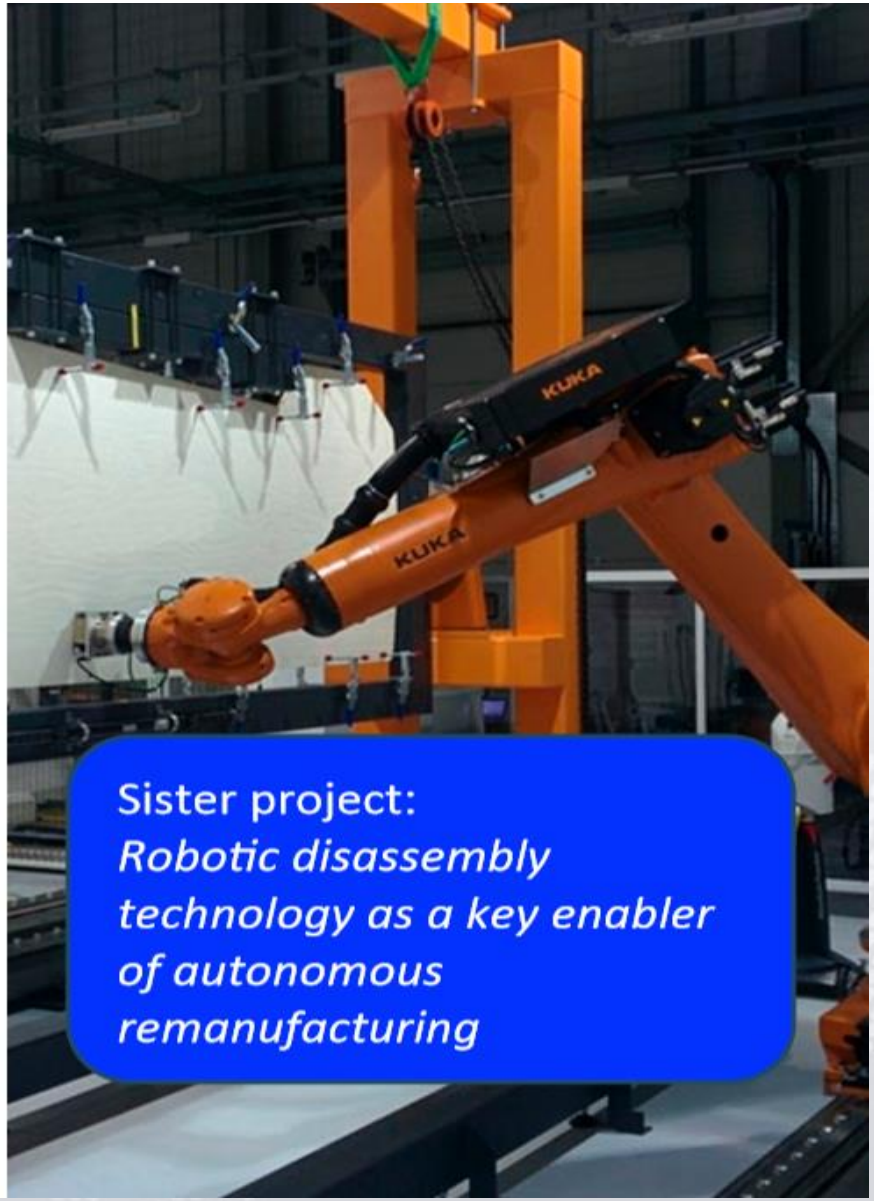
AUTOCRAFT Drivetrain Solutions

SPIRIT AEROSYSTEMS

Association for Robots in Architecture

KUKA

http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?



Remanufacturing processes :

Automated inspection and disassembly

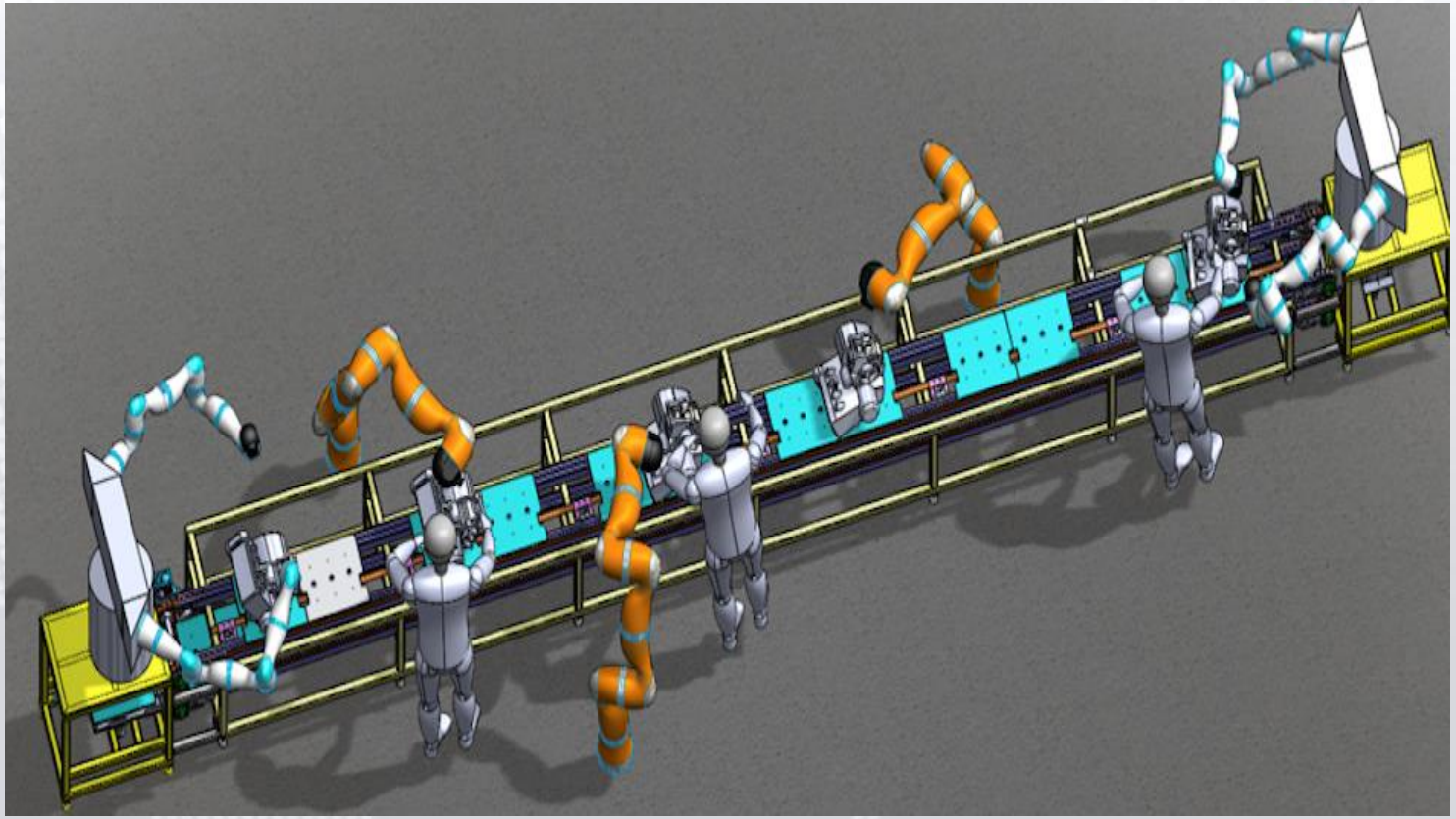
From presentation by Ben Peace, KTN, China mission, 2016

EPSRC: Robotic disassembly technology as a key enabler of autonomous remanufacturing

Caterpillar Limited (UK)	Hi Speed Sustainable Manufacturing Inst	Manufacturing Technology Centre
Meritor HVBS (UK) Ltd	SAIC Motor UK Technical Centre Ltd	

University of Birmingham

£2m 01 May 2016-30 April 2021



Resilient remanufacturing networks: forecasting, informatics and holons

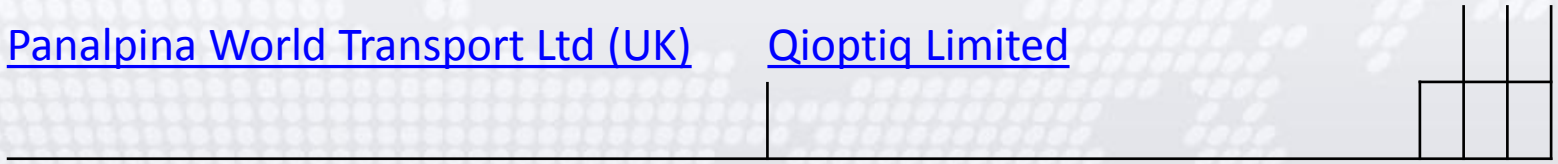
01 January 2017 -30 April 2019

Brother International Europe Limited

Panalpina World Transport Ltd (UK)

Qioptiq Limited

WRAP



look at returns forecasting and how such forecasts can be integrated in a systemic way with inventory and production optimisation procedures

Resource efficient business models

REBus

European programme developing 30 exemplary pilots

www.rebus.eu.com

MSTLN

Network of UK businesses exploring servitization

www.mstln.com

Innovate UK

Nearly 100 projects exploring circular economy

tinyurl.com/Circular-Chains

EPSRC Centre for INDUSTRIAL SUSTAINABILITY

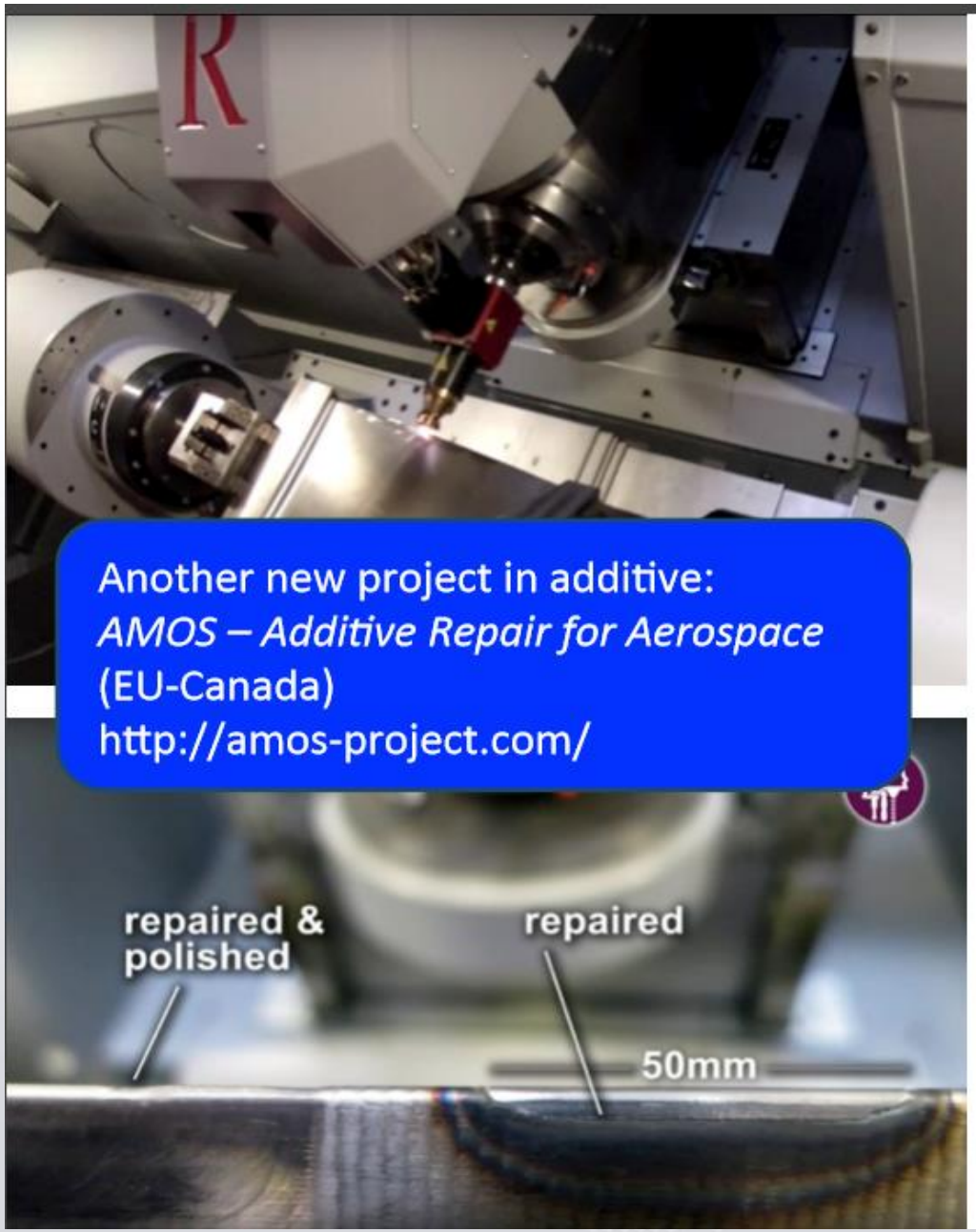
Business model toolkit

www.industrialsustainability.org/tools/

Remanufacturing business models

Remanufacturing processes :

Adaptive repair



Innovate UK

"Reclaim" project

- Additive manufacture (laser cladding)
- £1m

mtc Manufacturing Technology Centre

Delcam

Cummins

TWI

RENISHAW apply innovation™

DE MONTFORT UNIVERSITY LEICESTER

- Spinout formed in 2012:

HYBRID MANUFACTURING TECHNOLOGIES

www.hybridmanutech.com

From presentation by Ben Peace, KTN, China mission, 2016

Blume – remanufacturing LED bulbs

-Partially funded by Innovate UK

https://thefuturescentre.org/signals-of-change/106195/first-light-bulb-last-lifetime

- An open ring structure providing ample air circulation around the LEDs, 40% cooler than the competition- Run for 100,000 hours.=70 years of light.
- Releasing a single screw at the bottom of the product allows the bulb to be completely disassembled and every component to be separated.- remanufacturing and technology upgrades.
- Long term ambition is to provide lamps as a service, with online monitoring and regular upgrades.

Remanufacturing print heads

funded by Innovate UK

- Industrial inkjet printhead failures due to missing/deflected nozzles are a major source of financial loss to PSPs and result in tens of millions of pounds worth of high value electronics being scrapped.
- This project aims for the industrial development of a novel cleaning process and materials for the remanufacturing industrial printheads (value £1,500 - £6,000)

Refurbishment of torpedo ladle and locomotion axles through Laser Applied Surface Engineering (Re-LASE)

Tata, Wal Colmonoy , LASE and TWI

http://www.relaseproject.co.uk/about/

- Deliver a process that offers a coating which benefits from increased wear and fatigue resistance, coupled to an inspection method that ensures and validates the safety of the part prior to service.
- Such a coating would allow for refurbished axles to be in service for longer than the original un-coated components

Project ABACUS & AMPLiFII

Through development of new business models and innovative approaches for the EV battery reverse logistics value chain and remanufacturing process, waste stream reduction of up to 70% is possible.

Flexible Restoration for Remanufacture of Rolling Stock Components

Innovate UK funded

Targeted at one-off production resulting from the differential quality of used rolling stock components, the project aims to assess and validate a framework for customised restoration for remanufacture through the concept of remediation features based on a digital approach (CAD/CAM, Reverse Engineering, database and computer programming).

tecforce®
tried > tested > trusted

University of Brighton

Remanufacturing standards (UK and USA)

RIC001.1-2016: Specifications for the Process of Remanufacturing

The Remanufacturing Industries Council announced a new accreditation programme that allows remanufacturers to acknowledge and validate that their remanufacturing processes conforms to RIC001.1-2016: Specification for the Process of Remanufacturing.

BS 8887-Design for Manufacture, Assembly,. Disassembly and End-of-life

BS (ISO) 8887-220:2010- The process of remanufacture. Specification

BS 8887-3:2018- Guide to choosing an appropriate end-of-life design strategy

Remanufacturing standards developed

No.	STANDARD NO	Name	category	Date
1	GB/T 27611-2011	General requirements and labeling for recycled and remanufactured products	Base	2012-05-01
2	GB/T 28615-2012	Green manufacturing: The technology specification for metal-cutting machine tool remanufacturing	Procuct	2012-12-01
3	GB/T 28618-2012	Remanufacturing: General technical requirements for mechanical products	Base	2012-12-01
4	GB/T 28619-2012	Remanufacturing: Terminology	Base	2012-12-01
5	GB/T 28620-2012	The calculating methods of remanufacturing rate	Base	2012-12-01
6	GB/T 28672-2012	The technical specifications for remanufacturing of automotive components: Alternator	Procuct	2013-01-01
7	GB/T 28673-2012	The technical specifications for remanufacturing of automotive components: Starter	Procuct	2013-01-01
8	GB/T 28674-2012	The technical specifications for remanufacturing of automotive components: Steering gear	Procuct	2013-01-01
9	GB/T 28675-2012	Remanufacturing of automotive components: Disassembly	Methods	2013-01-01
10	GB/T 28676-2012	Remanufacturing of automotive components: Classification	Methods	2013-01-01
11	GB/T 28677-2012	Remanufacturing of automotive components: Cleaning	Methods	2013-01-01
12	GB/T 28678-2012	Remanufacturing of automotive components: Pre-delivery inspection	Methods	2013-01-01
13	GB/T 28679-2012	Remanufacturing of automotive components: Assembly	Methods	2013-01-01
14	GB/T 29796-2013	Laser repairing general specification	Methods	2014-04-15
15	GB/T 30462-2013	Remanufactured non-road internal combustion engines: General specifications	Procuct	2014-10-01
16	GB/T 31207-2014	Quality management requirements for machinery products remanufacturing	Base	2015-05-01
17	GB/T 31208-2014	The methods of quality evaluation for remanufacturing core	Base	2015-05-01

Contents

Overview of Remanufacturing in UK

Innovation in Remanufacturing

Conclusions

Summary

- Remanufacturing is a triple win industry in the UK, yet still at its infancy (only 1.9% of mass production)
- Barriers include: standards, legislation, customer recognition, remanufacturing process technology, business mode etc.
- R&Ds in Remanufacturing technology the UK cover: automation for inspection and disassembly, adaptive repair, coating, design for disassembly, Artificial intelligence, business mode etc.
- R&Ds in remanufacturing in the UK cover industries including automotive, railway, battery for EV, office, lighting, service

Opportunities

- Technical development of standards (BSI and SAC)
- Potential collaboration and partnership between the UK and Chinese research funding agencies could be established to tackle common problems facing by both the UK and Chinese remanufacturing industry.
- Improved trading arrangement
- Joint investment
- Digital platform for remanufacturing to increase the availability of cores for remanufuacturing
- Areas of growth: wind turbine, e-vehicle, WEEE, composite, robotics and AI

Thank you for your attention!

Reverse supply chain design optimisation for circular economy applications

Athanasios Rentizelas

14 September 2019

University of Strathclyde Engineering

DMEM Design, Manufacture & Engineering Management

www.strath.ac.uk/dmem

Delivering Total Engineering

Profile

- Mechanical Engineer, specialisation in Energy
- MSc in Operations Management
- PhD in Reverse Supply Chain Optimisation
- Lecturer in Engineering Management, Supply Chain @ DMEM, University of Strathclyde, since 2013

Research Interests

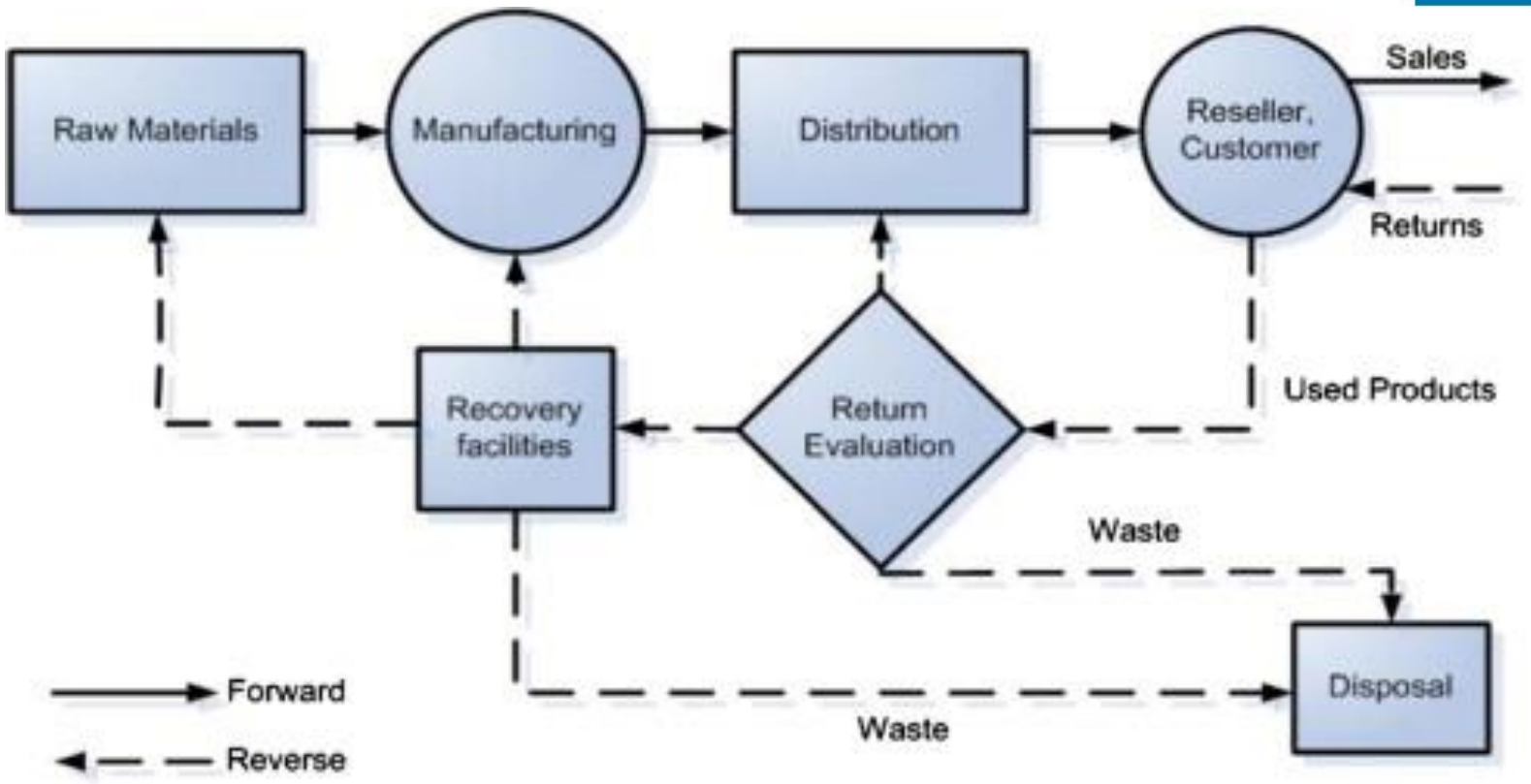
Adopting a systems approach to:

- **Circular economy**-enabling supply chain design and optimisation
- **Sustainability assessment** of extended supply chains

Plus

- Decision support models to support small farmers in developing countries

Closed Loop Supply Chains – some thoughts



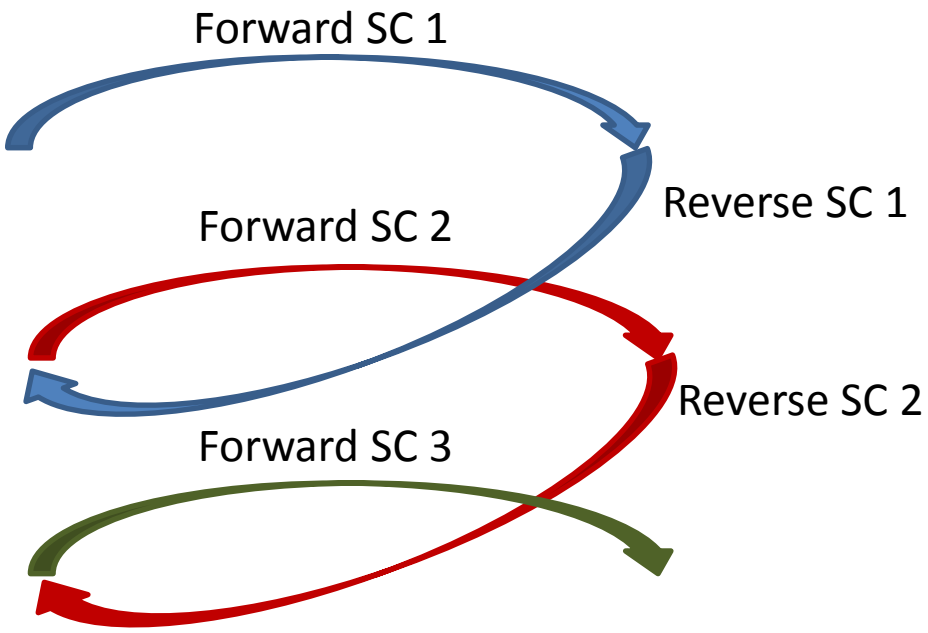
Tonanont et al., 2008

- Feeding into the 'same' forward supply chain?

Closed Loop Supply Chains – some thoughts

- Feeding into the ‘same’ forward supply chain?

Closed Loop Supply Chains – some thoughts



- Feeding into different forward supply chains… (Circular Economy)
- Reverse Supply Chain efficiency key enabler for circularity (costs, environmental impact)

FiberEUse

Large scale demonstration of new circular economy value-chains based on the reuse of end-of-life fiber reinforced composites

T7.2: Reverse logistics network architecture

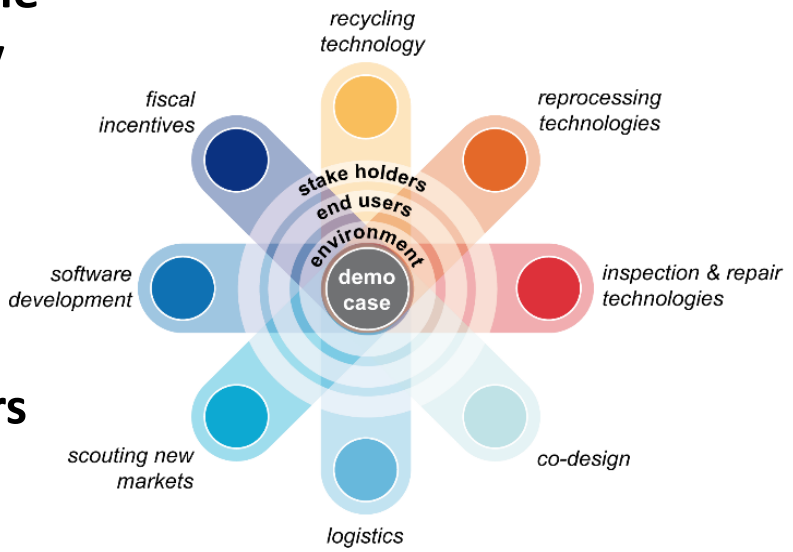
Introduction – What is FiberEUse

- Funding body: **EU Horizon 2020** (Grant Agreement No. H2020-730323-1)
- Grant: **€9.8 million**
- Duration: **4 years** started on June 2017
- Consortium: **20 partners**, from **7 EU countries**.
- Aim: **Integrating different innovation actions through a holistic approach to enhance the profitability of composite recycling and reuse in value-added products.**

Project objectives

FiberEUse aims to develop and demonstrate a large scale reuse of end-of-life (EoL) composites materials via:

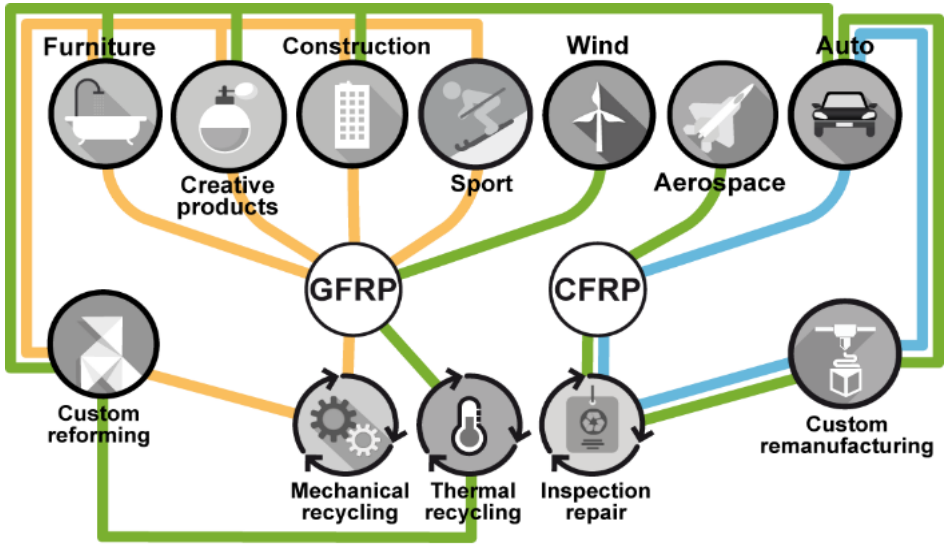
- **Integration of innovative remanufacturing technologies addressed to develop profitable reuse options for mechanically or thermally recycled EoL GFRP and CFRP composites** - enabling ease of operation, significant cost reduction, compliance with EU Directives
- **Development of an innovation strategy for mobilization and networking of stakeholders from all the sectors related to composites** - from original equipment manufacturers (OEMs) to tier 1 suppliers, logistical operators, technology providers and exploiters, designers, and end-user associations



FiberEUse Concept

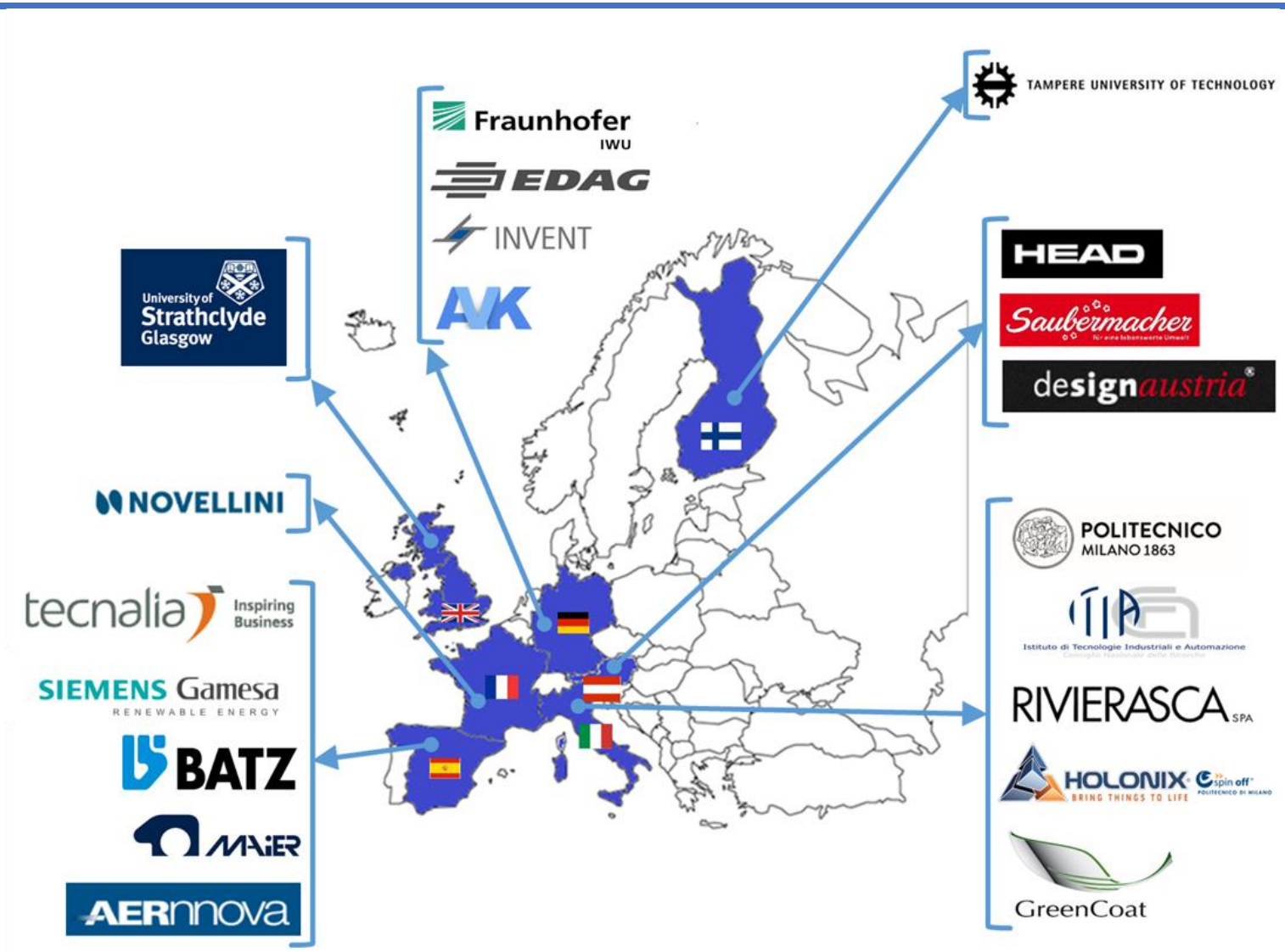
FiberEUse is based on the realization of three macro use-cases, further detailed in eight demonstrators:

- **Use-case 1:** Mechanical recycling of short GFRP and re-use in added-value customized applications, including furniture, sport and creative products
- **Use-case 2:** Thermal recycling of long fibers (glass and carbon) and re-use in high-tech, high-resistance applications
- **Use-case 3:** Inspection, repair and remanufacturing for EoL CFRP products in high-tech applications

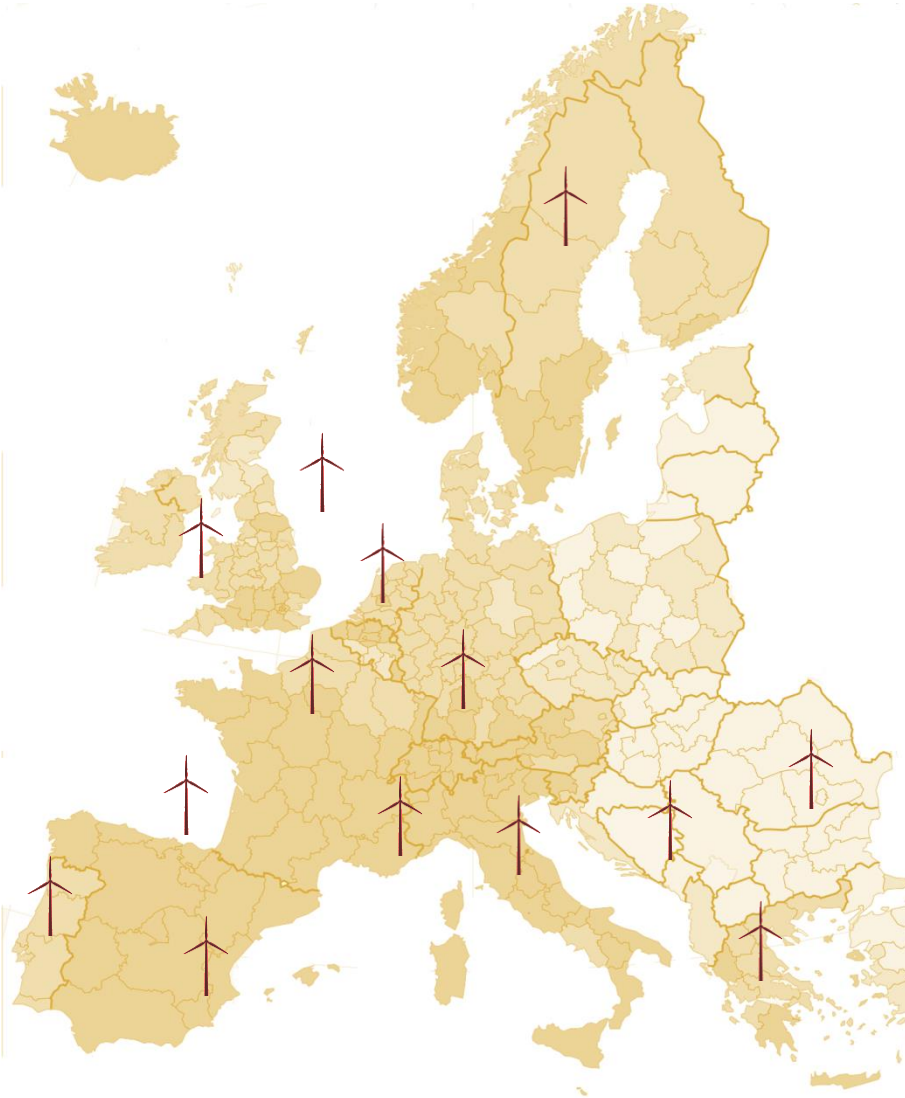


FiberEUse Use-Cases and involved industrial sectors

Project partners



FiberEUse: Design & optimisation of reverse logistics network for end-of-life fiber reinforced composites



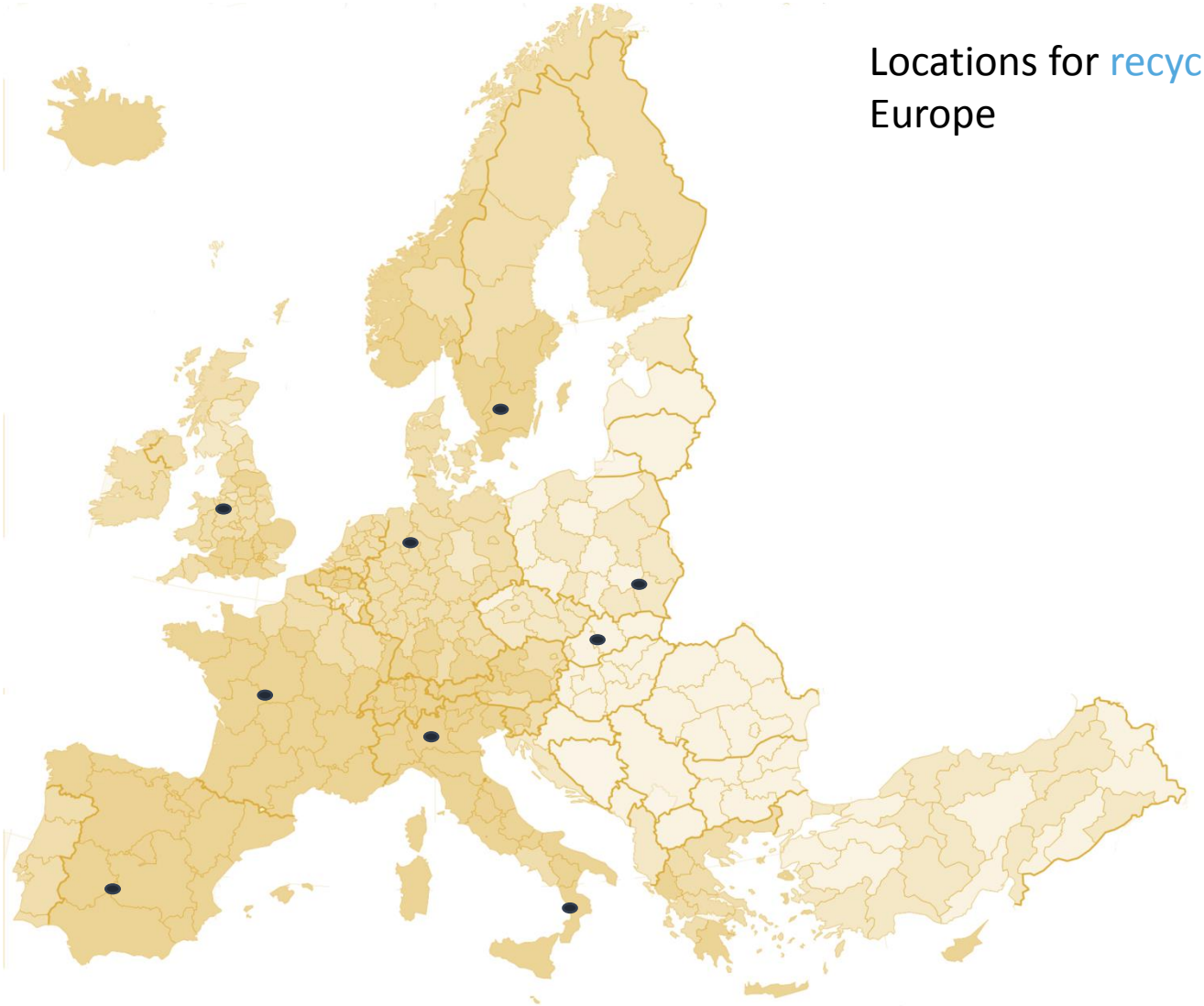
SUPPLY - Waste material suppliers location

Locations for onshore & offshore wind farms in Europe for waste material availability

Optimisation/simulation model characteristics

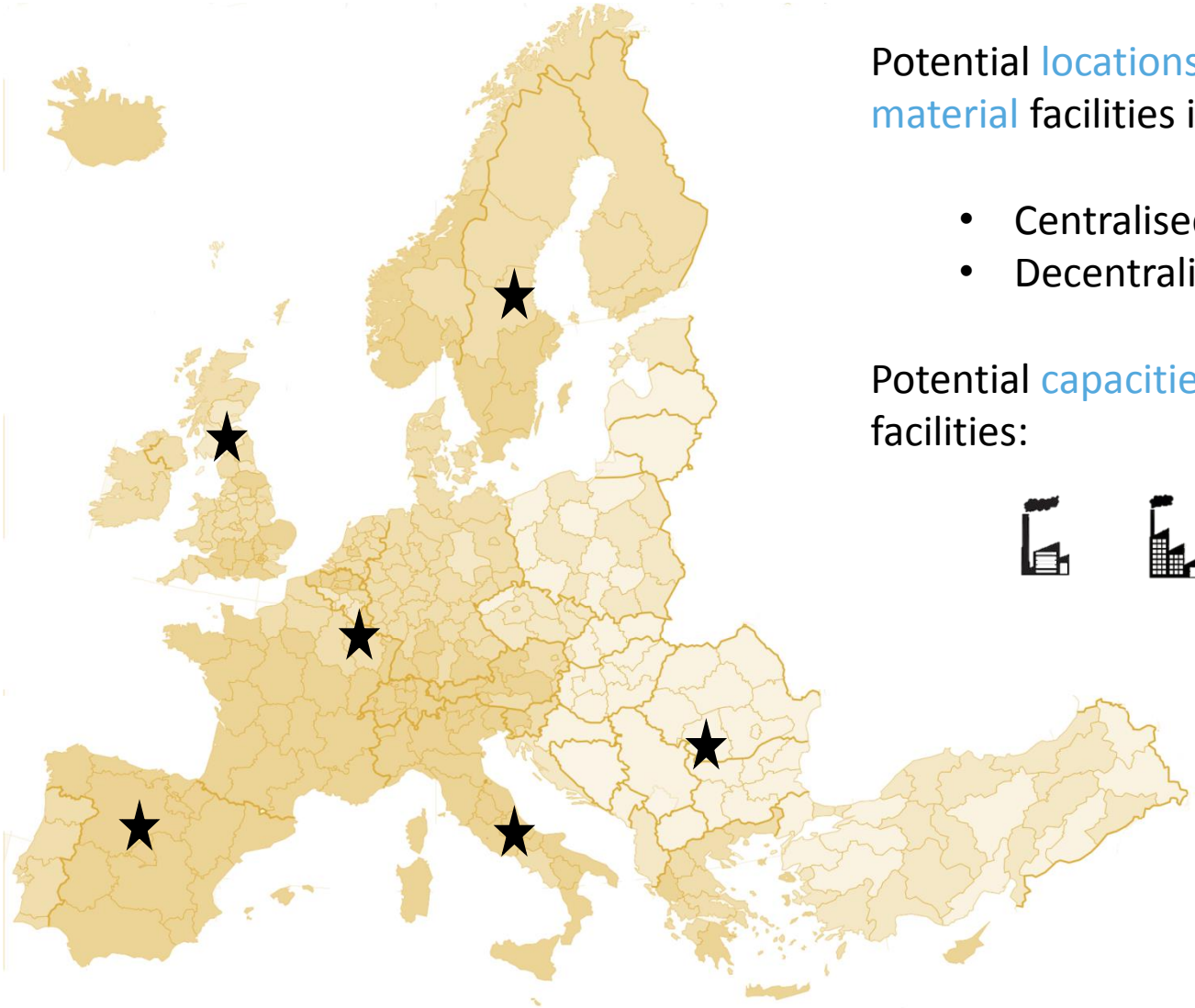
- **Supply-driven** model
- Capability to deal with various end products
- Centralised/decentralised facilities
- Spatially explicit
- **Large scale**
- Economies of scale vs logistics costs
- System-wide cost optimisation

DEMAND - Recycling material end users location



Locations for recycled material demand in Europe

Potential processing facilities location & capacities

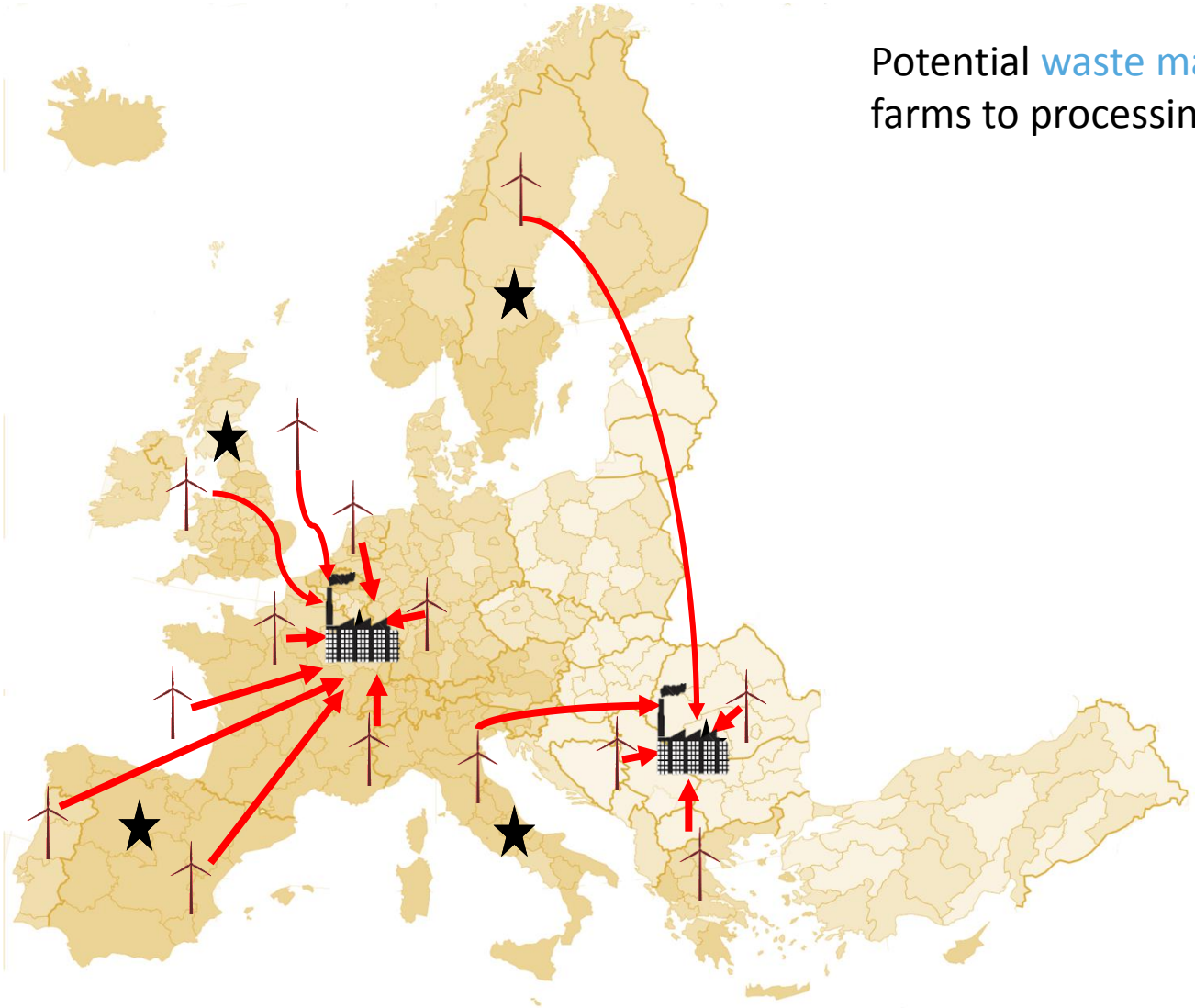


Potential locations for processing of waste material facilities in Europe:

- Centralised facilities
- Decentralised facilities

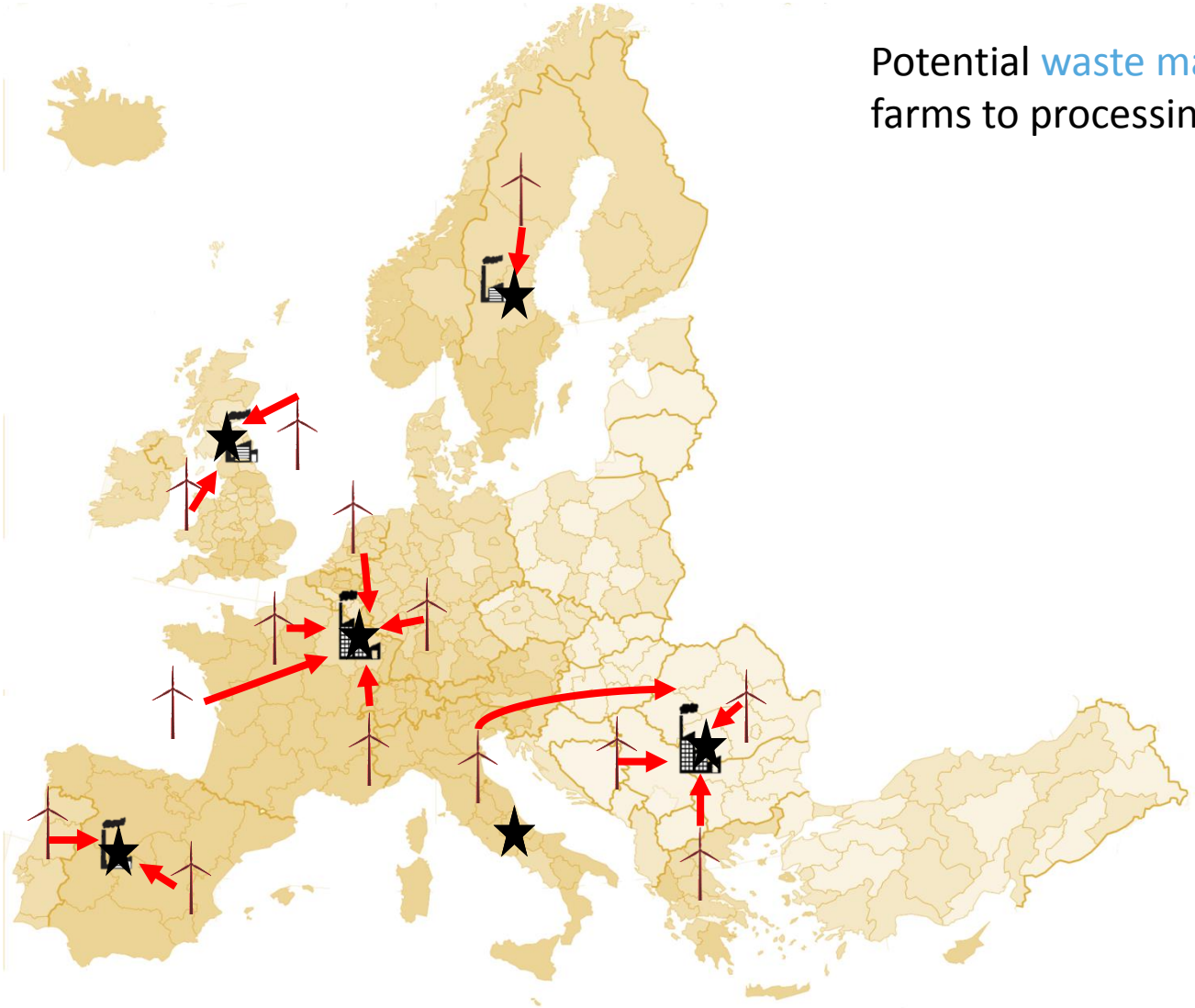
Potential capacities for the waste processing facilities:

Potential inbound material flow: Centralised approach



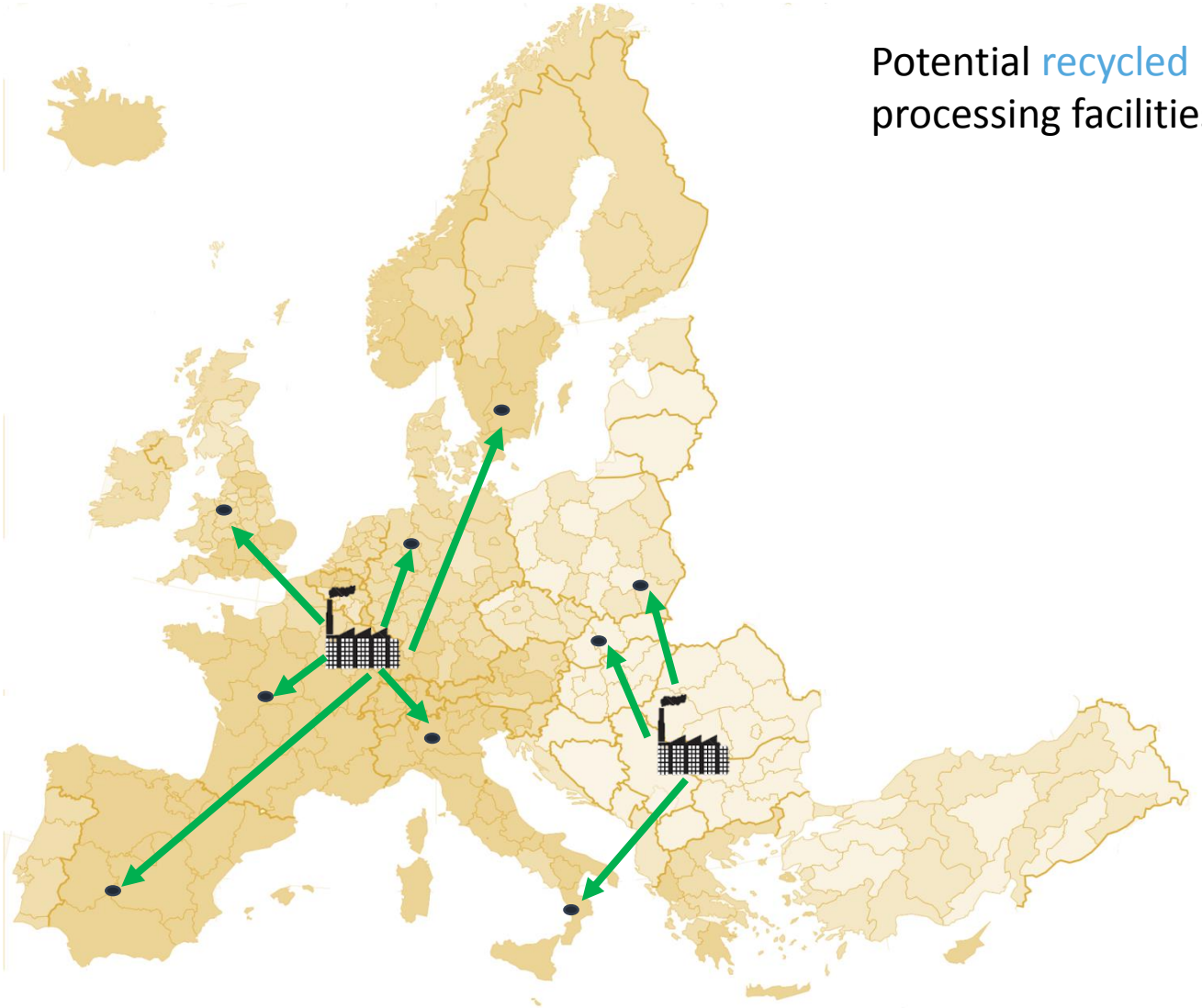
Potential waste material flow from wind farms to processing facilities

Potential inbound material flow: Decentralised approach



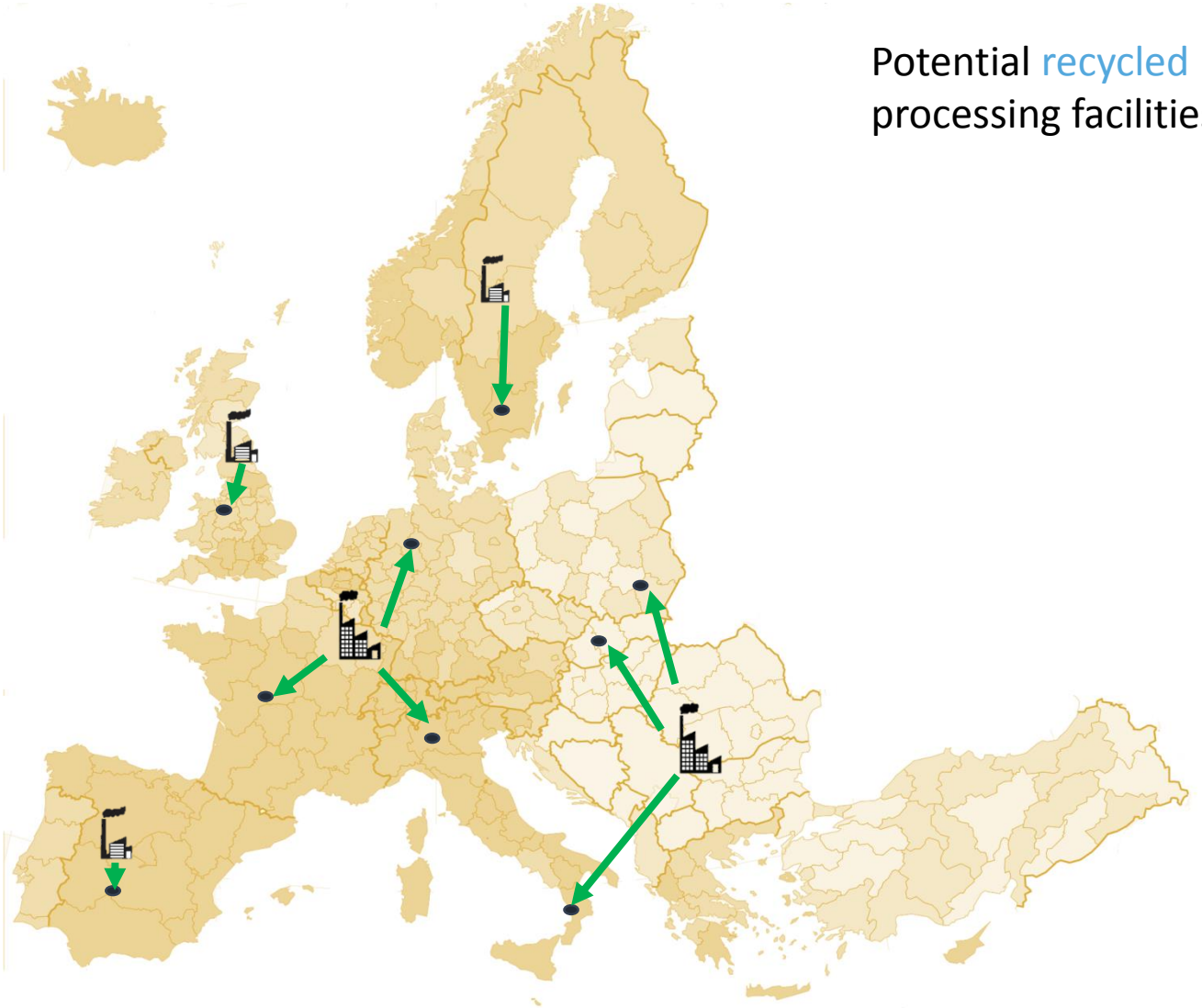
Potential waste material flow from wind farms to processing facilities

Potential outbound material flow: Centralised approach



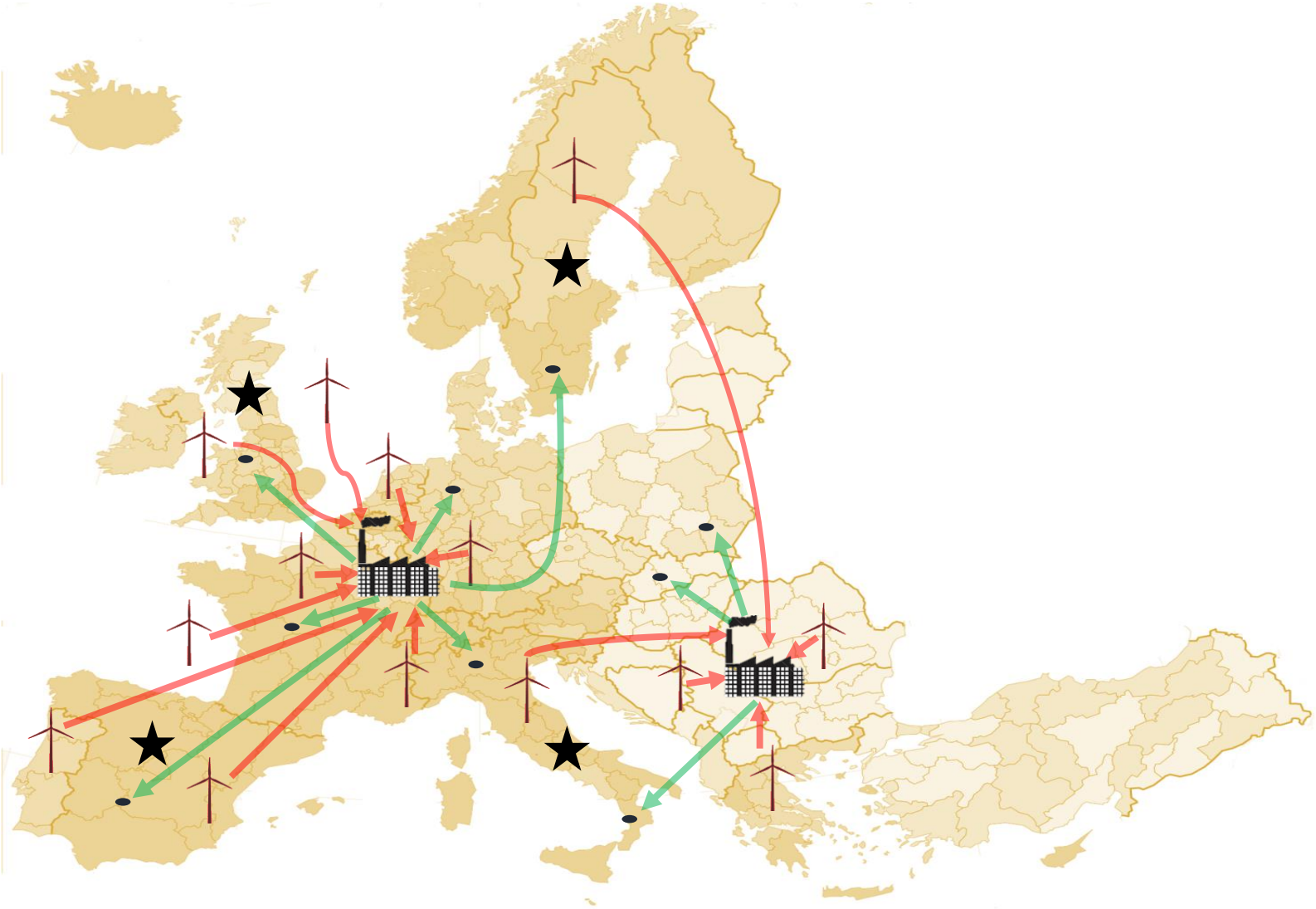
Potential recycled material flow from processing facilities to end users

Potential outbound material flow: Decentralised approach

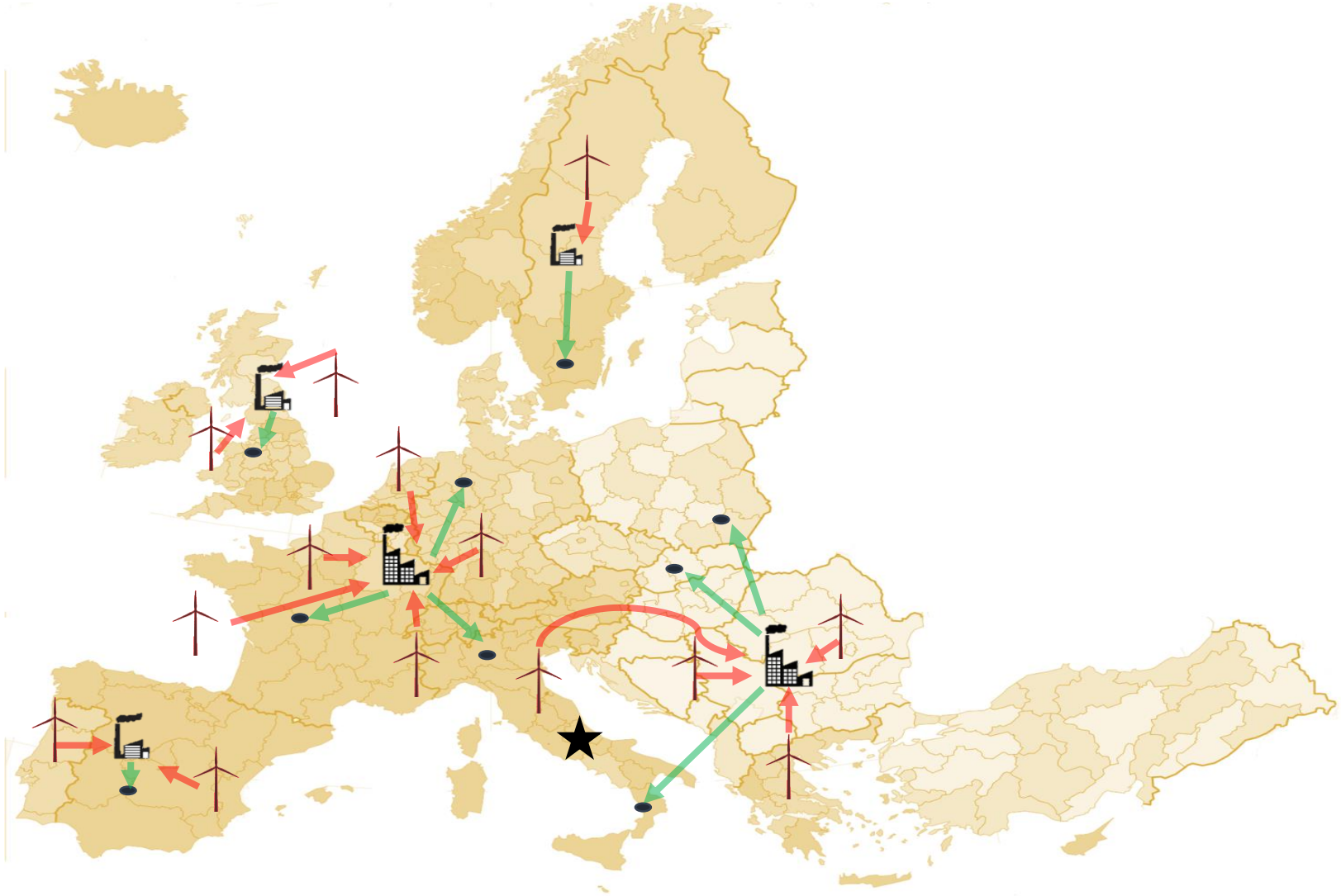


Potential recycled material flow from processing facilities to end users

Optimised reverse logistics supply chain: Centralised approach



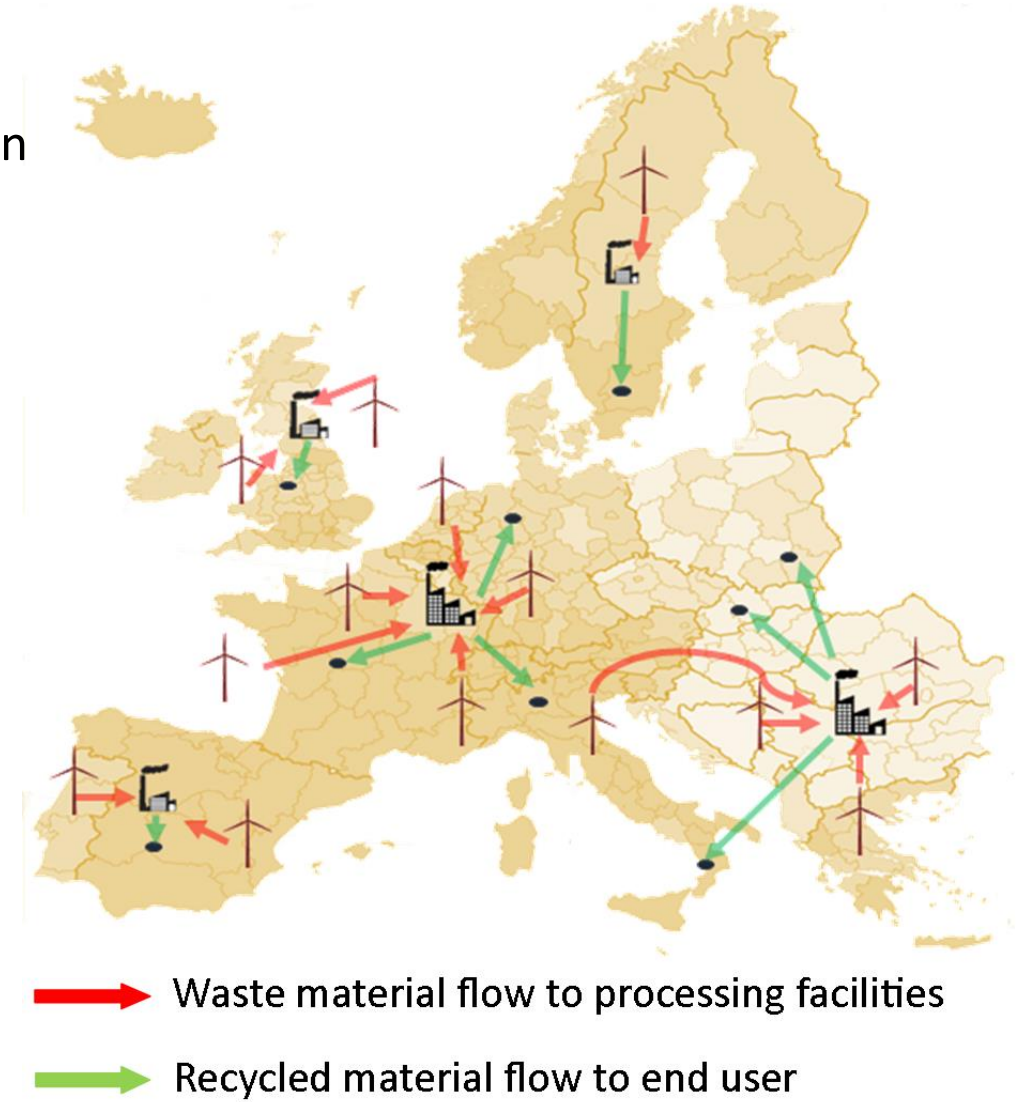
Optimised reverse logistics supply chain: Decentralised approach



Output of the optimisation

Reverse logistics network configuration

- Facilities location
- Facilities capacity
- Material flows inbound (to processing facilities)
- Material flows outbound (to end users)

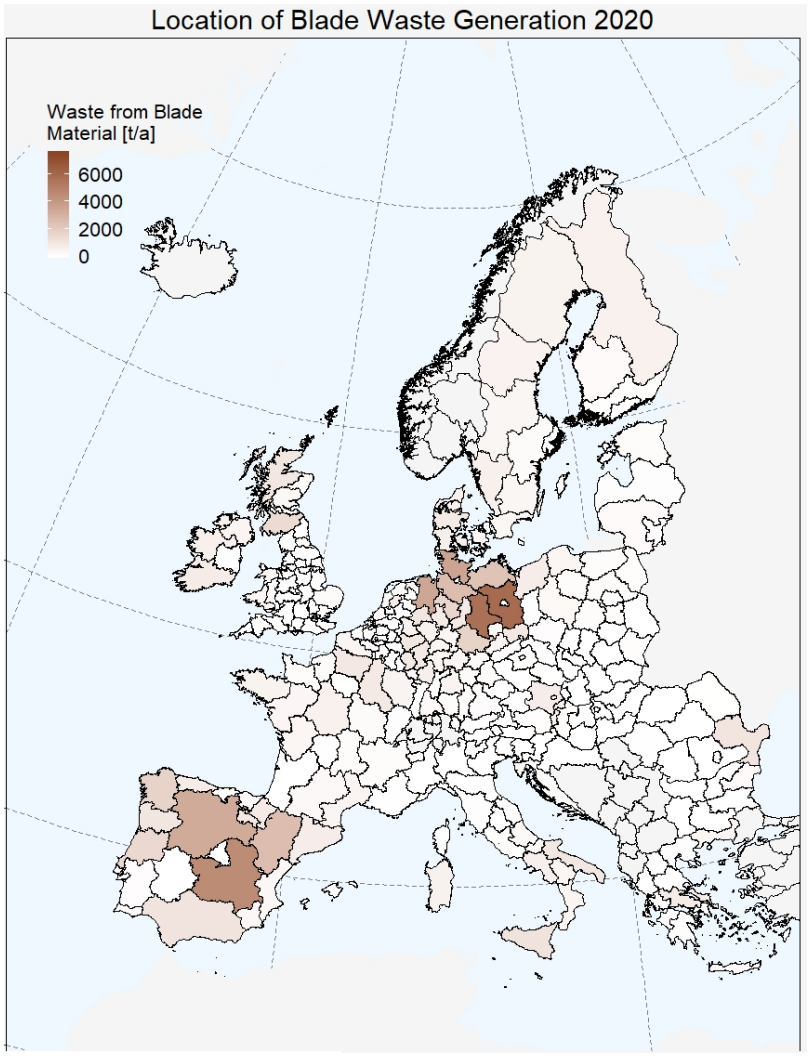


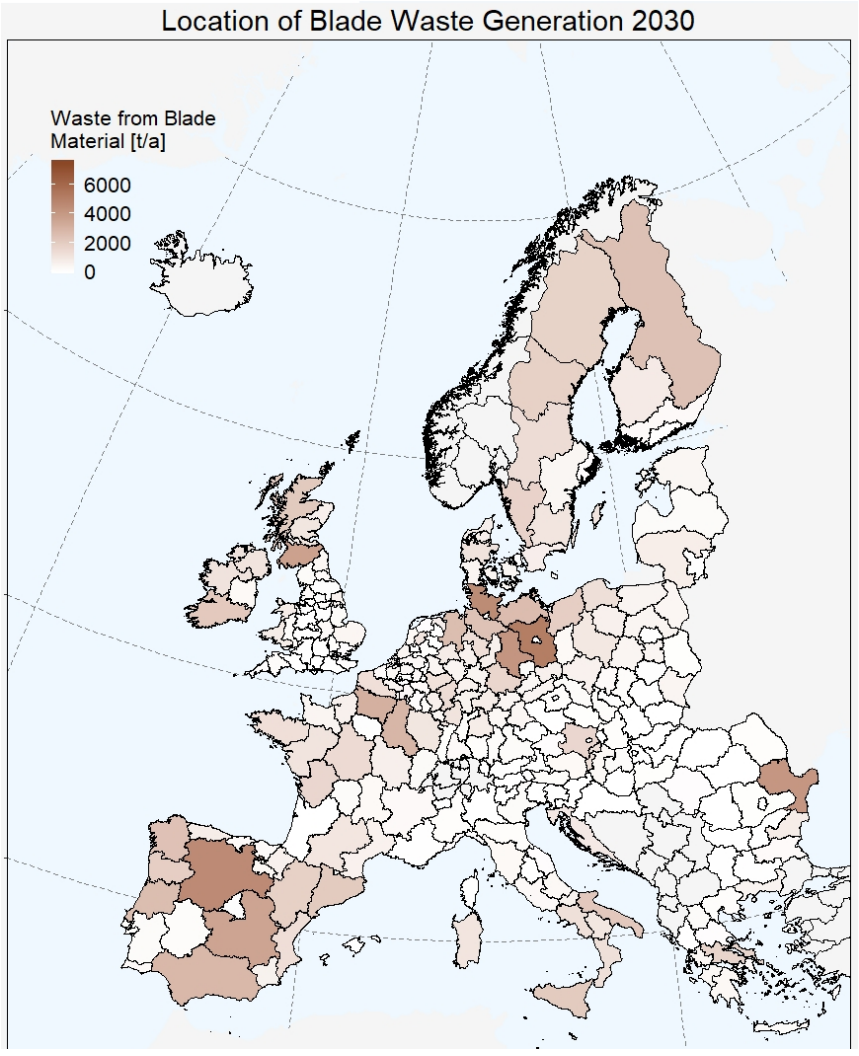
Task 7.2 progress

Applications
1st application: Mechanically Recycled GF Supply→ Wind Sector Demand→ SMC/BMC manufacturers
2nd application: Thermally Recycled CF Supply→ Automotive, Aerospace, Wind Sector Demand→ Automotive Sector etc.
3rd application: Inspection Repair Supply→ Automotive & Aerospace Sector Demand→ Automotive Sector

1st application: Mechanical recycling of Glass Fibers

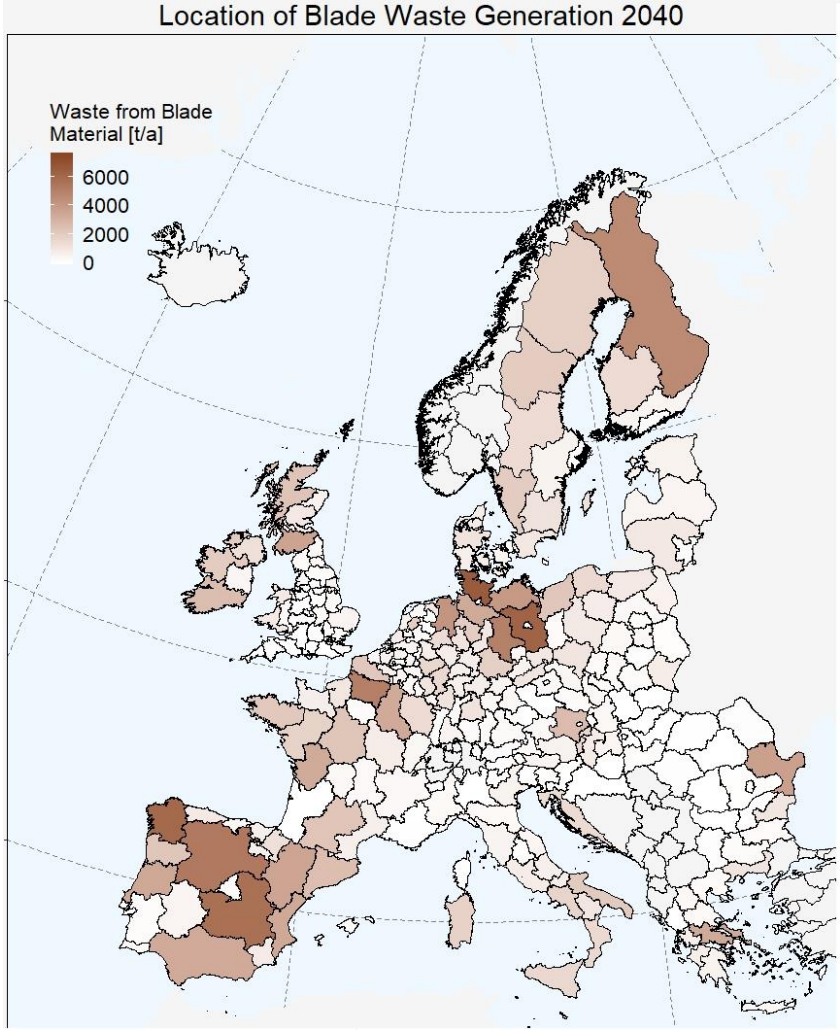
Prognosis of blade waste material from onshore

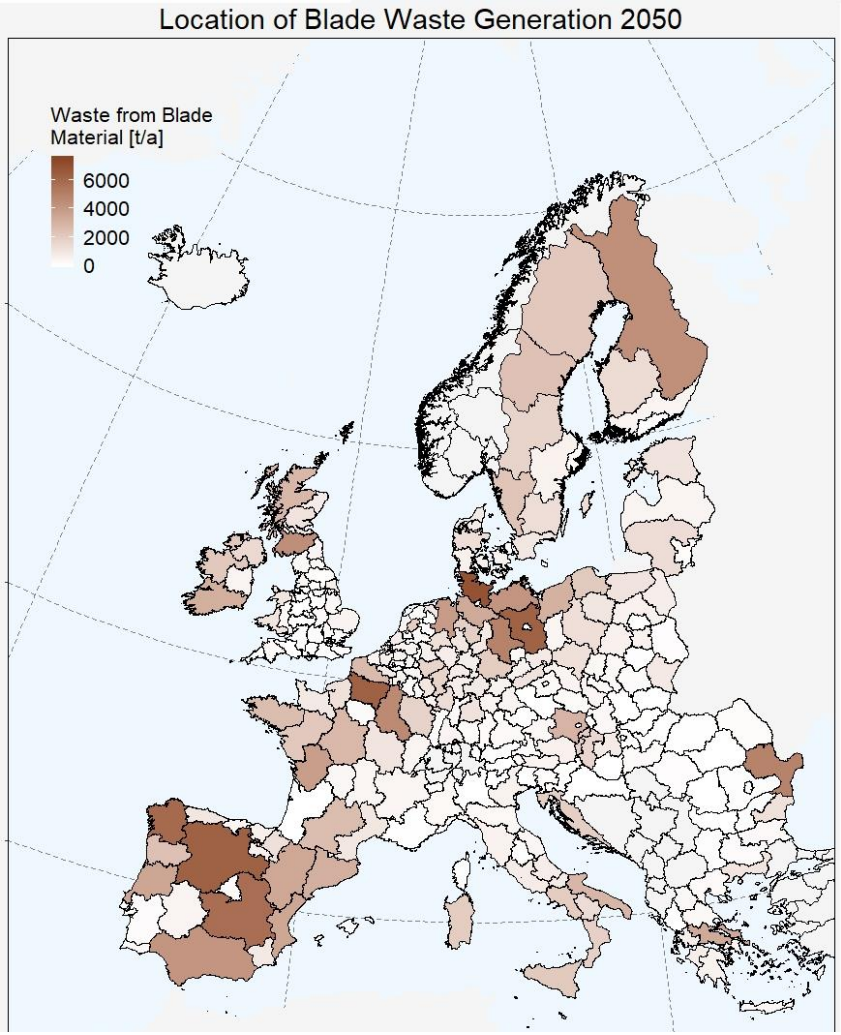




1st application: Mechanical recycling of Glass Fibers

Prognosis of blade waste material from onshore

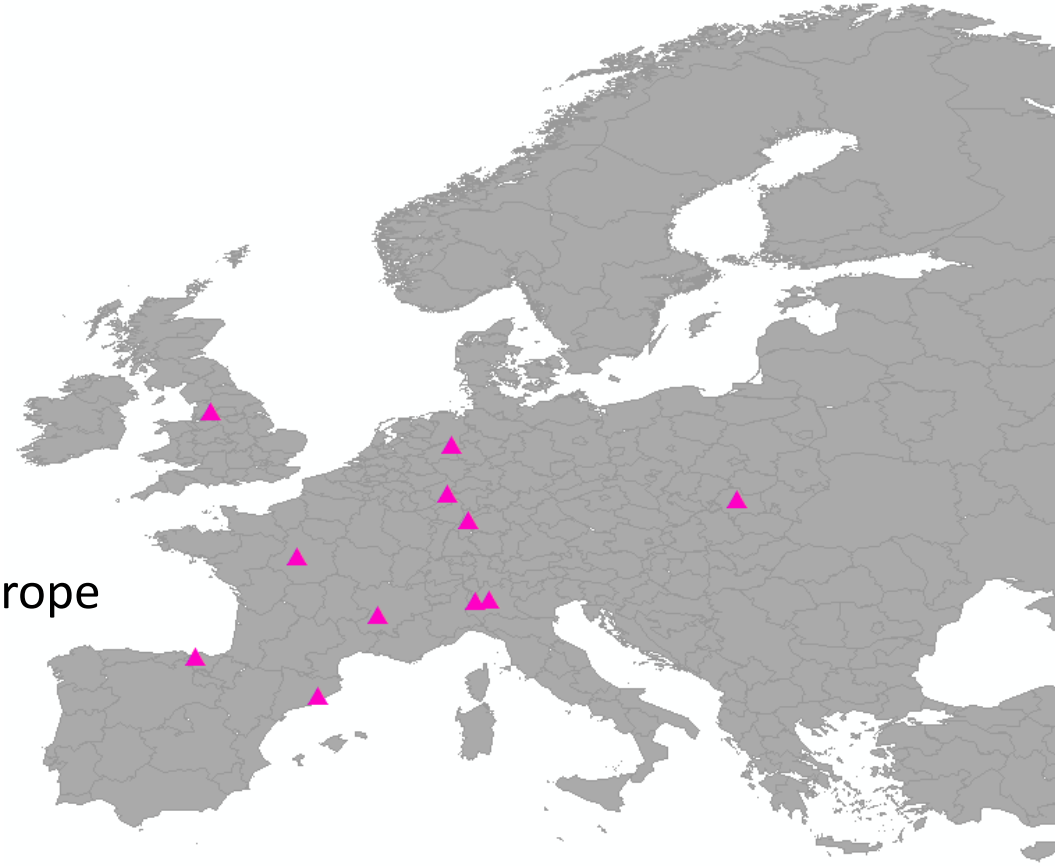




1st application: Mechanical recycling of Glass Fibers

Demand Side (2020):

- SMC/BMC used in automotive, transportation, electronics and building sector
- 11 SMC/BMC manufacturers in Europe
- Substitution of filler material on SMC/BMC (40%-50%)



1st application: Mechanical recycling of Glass Fibers

Results: Proposed facilities and capacity for 2020

Facility location	Capacity (t)
Germany	16000
Italy	16000
Poland	16000
United Kingdom	16000

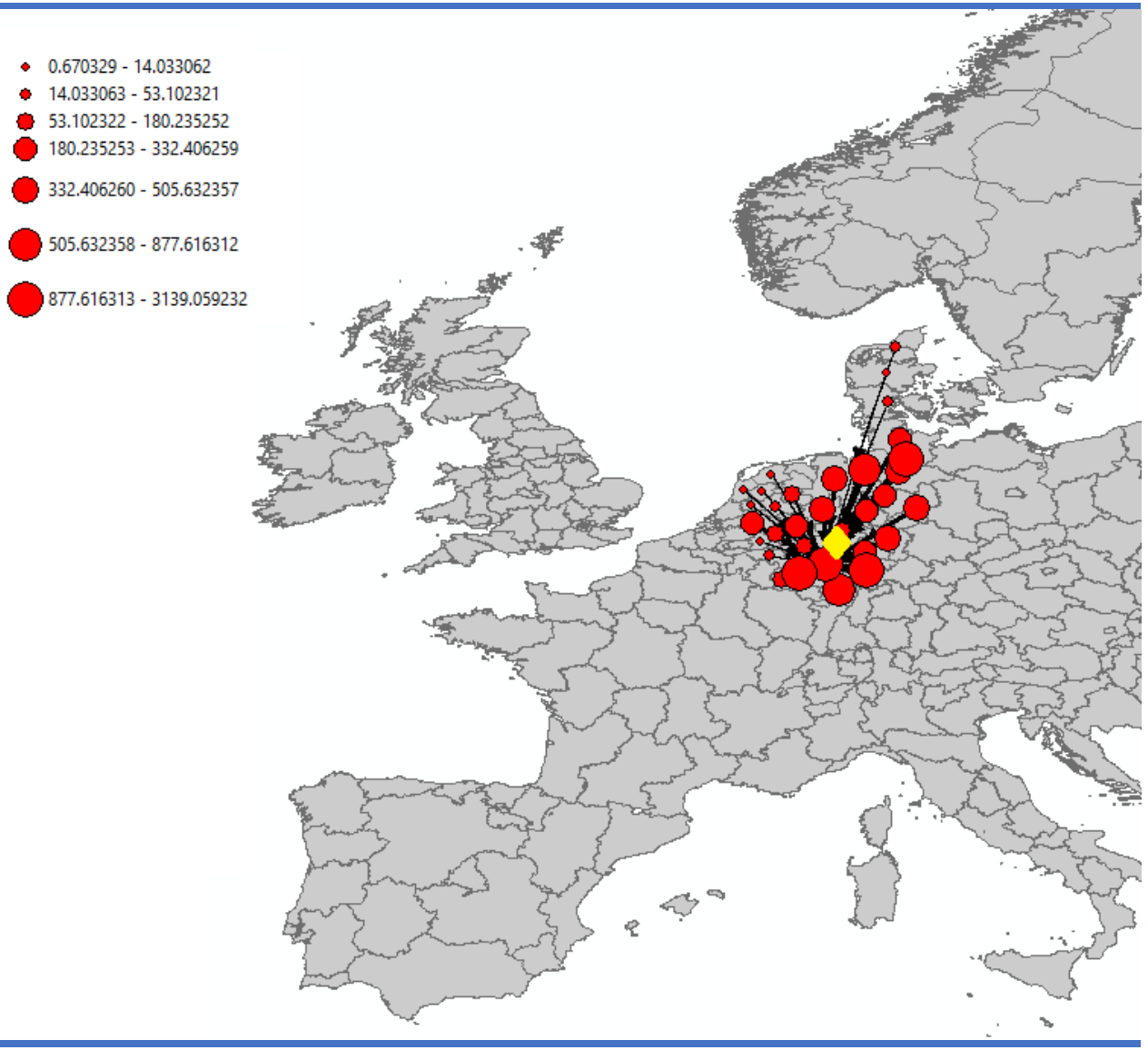
1st application: Mechanical recycling of Glass Fibers

Results: Supply flow for

2020

- Facility in Germany
- Facility Capacity:

  16,000 t per annum

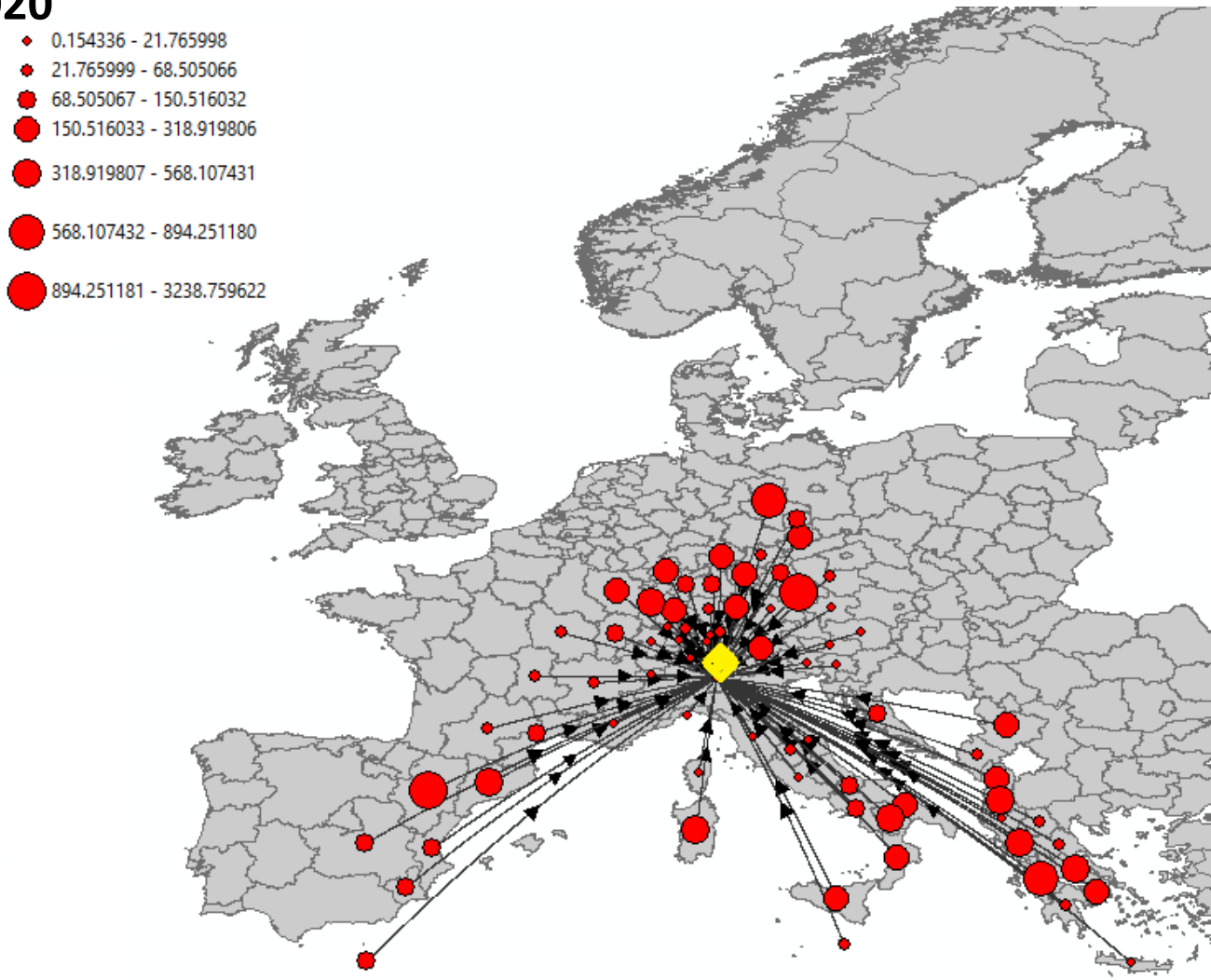


1st application: Mechanical recycling of Glass Fibers

Results: Supply flow for 2020

- Facility in Italy
- Facility Capacity:

  16,000 t per annum

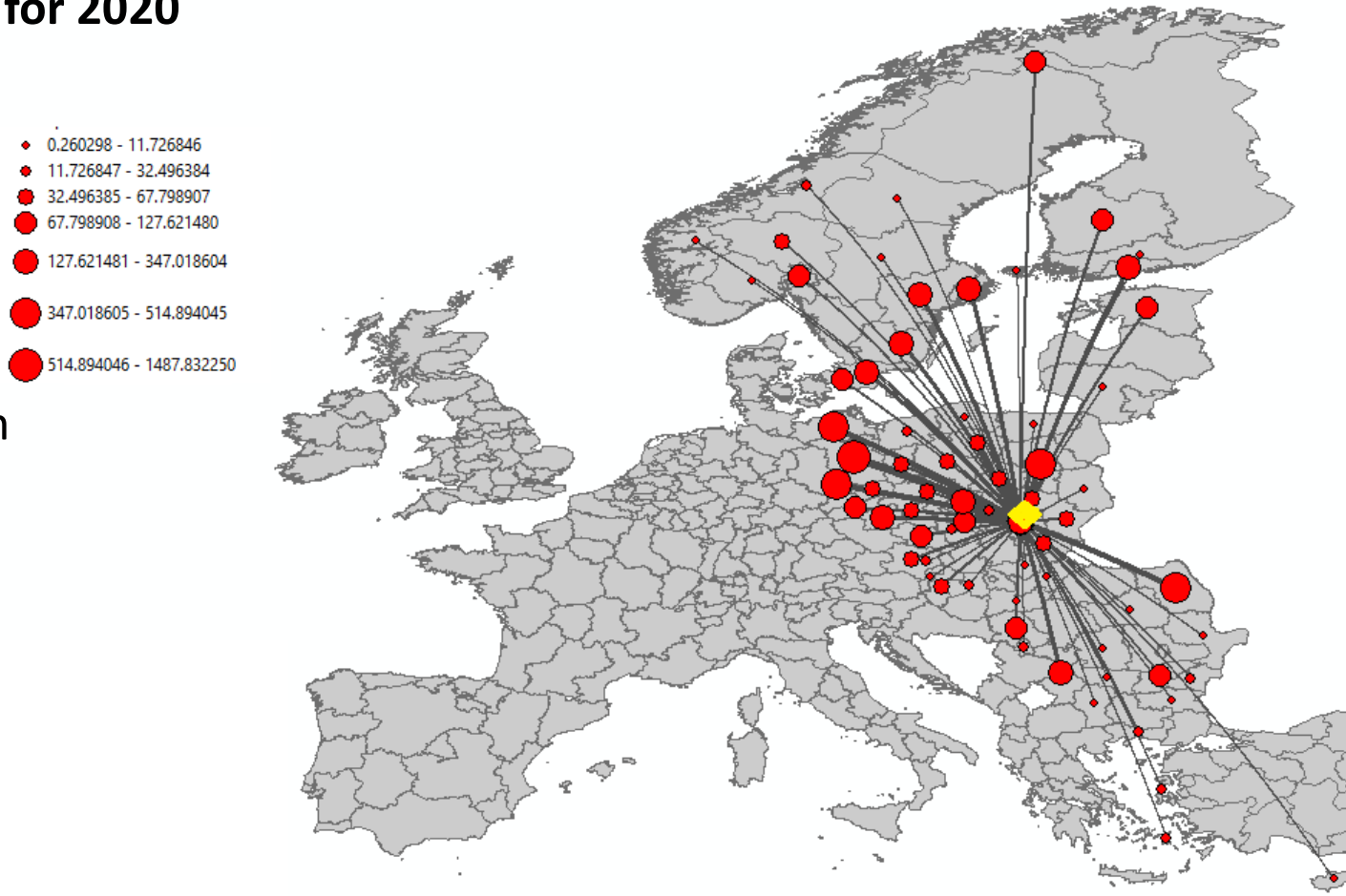


1st application: Mechanical recycling of Glass Fibers

Results: Supply flow for 2020

- Facility in Poland
- Facility Capacity:

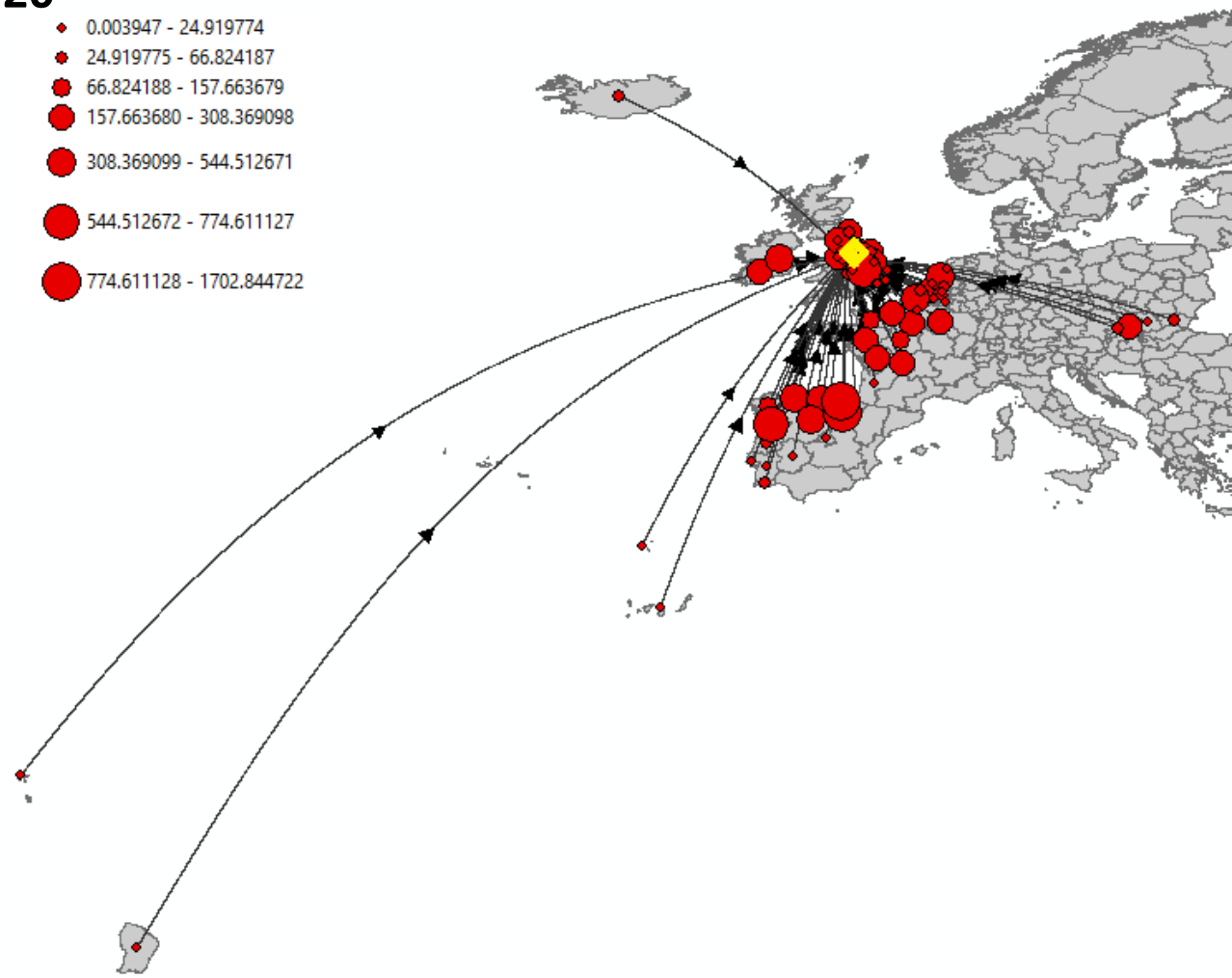
  16,000 t per annum



1st application: Mechanical recycling of Glass Fibers

Results: Supply flow for 2020

- Facility in United Kingdom
- Facility Capacity: 16,000 t per annum



1st application: Mechanical recycling of Glass Fibers

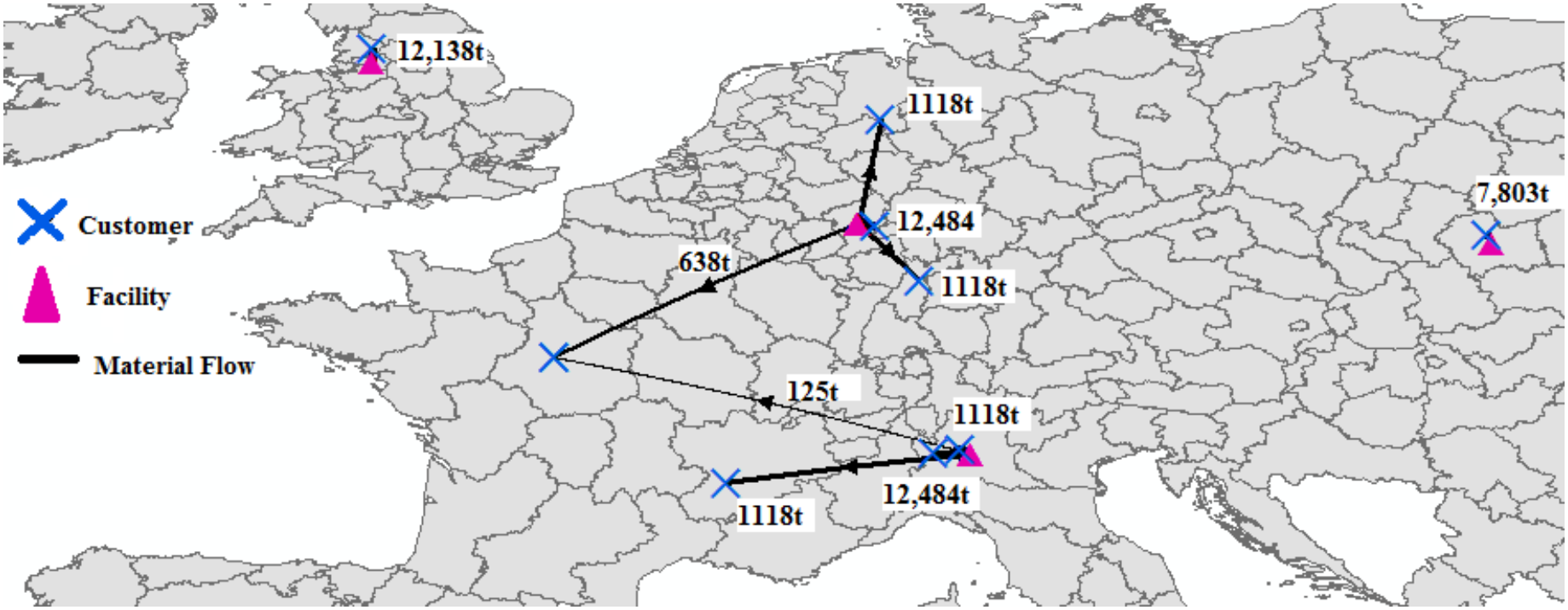
Results: Proposed facilities capacity use for 2020

Facility location	Capacity (t)	Percentage of capacity used
Germany	16000	96%
Italy	16000	93%
Poland	16000	49%
United Kingdom	16000	76%

1st application: Mechanical recycling of Glass Fibers

Results: Demand flow for 2020

- 11 SMC/BMC manufacturers
- 4 facilities



Use case 3 (Inspection & Repair): Car Sharing platform – Car seats

- Service-oriented: multiple use cycles of the product; revenue mostly coming from repair/reuse/upgrade
- Focus on car sharing: clear take-back systems; short product life-cycles; lightweighting
- Novel gluing/attaching technologies (enhanced detachability) to avoid structural damage
- Much more expensive to manufacture; revenue from repair/reuse cycles
- Environmental benefit only achieved after several re-use cycles

Project 2

Recovering value from waste agricultural plastics from the Scottish vegetable and soft fruit industry

Project Aim: to investigate utilisation of pyrolysis to convert agricultural plastic waste to added value products; fuel, energy or platform chemicals.

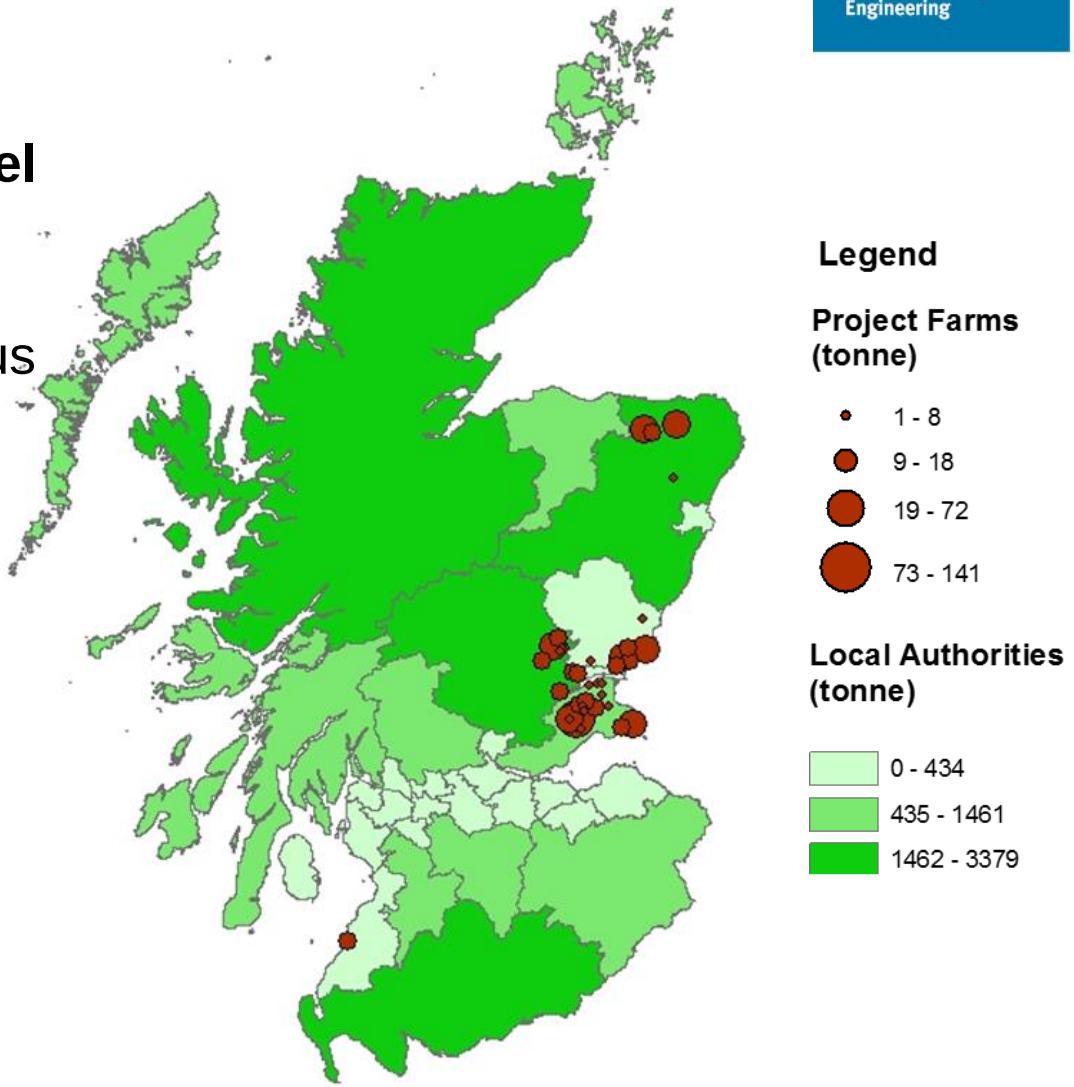
Role: Design & optimisation of reverse logistics network for waste agricultural plastics

Agricultural Plastic Waste arising distribution

University of Strathclyde Engineering

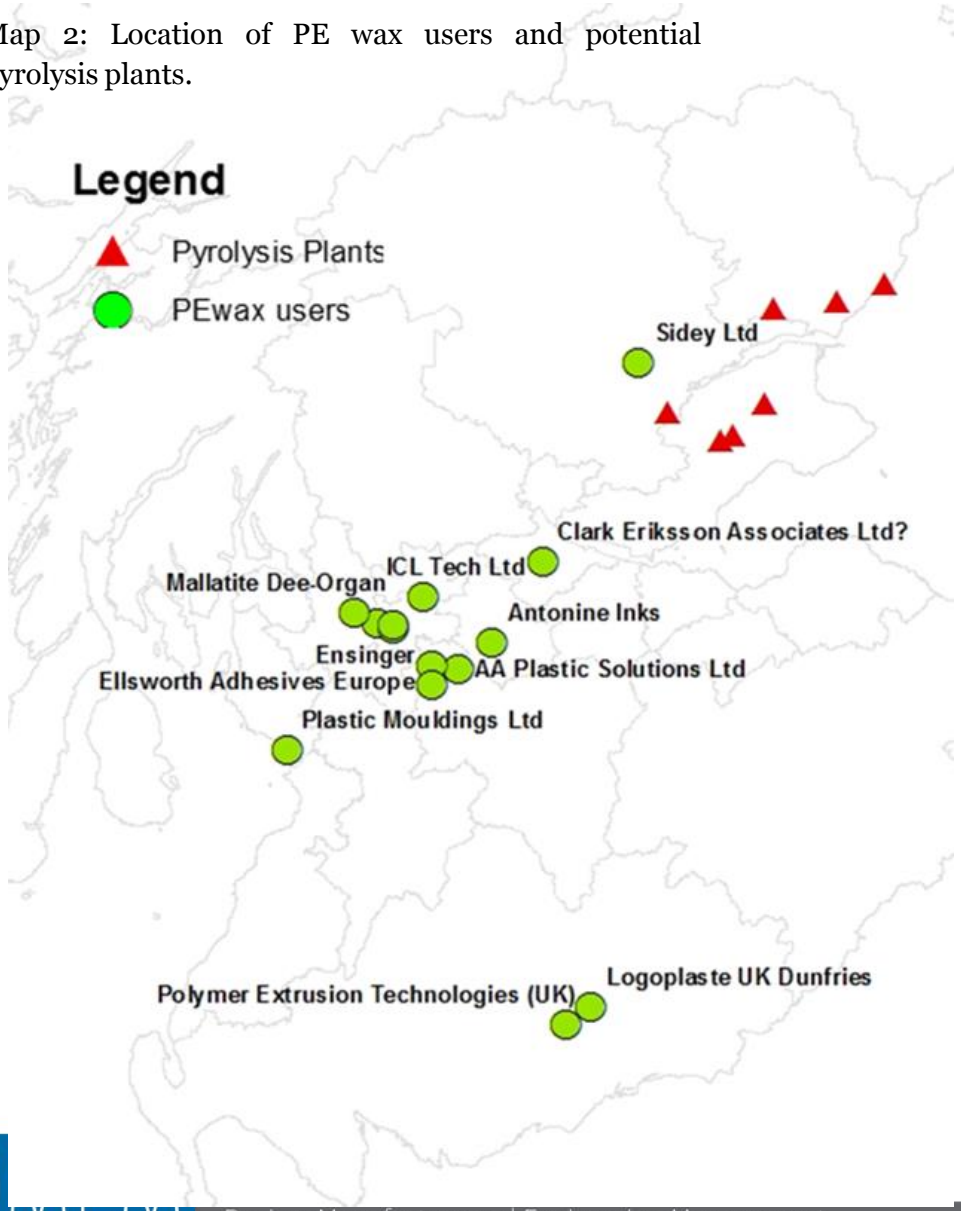
Optimisation/simulation model characteristics

- **Supply-driven** model
- Capability to deal with various end products
- Centralised/decentralised facilities
- Spatially explicit
- **Local to national scale**
- System-wide profit optimisation



Polyethylene Wax- (PE wax)

Map 2: Location of PE wax users and potential pyrolysis plants.



Polyethylene Wax (PE wax) has many commercial uses including candles, packaging, wood and fire logs, plastic additives& lubricants, rubber, adhesives, coating, cosmetics, polishes.

Project 3

Arran Hospitality Sector Circular Economy model

Project Aim: to identify and optimise circular economy pathways for the food waste from the hospitality sector in Arran.

TOPOLYTICS™

ARRAN
The Island
Island time .... in no time

University of Strathclyde Glasgow

University of Strathclyde Glasgow