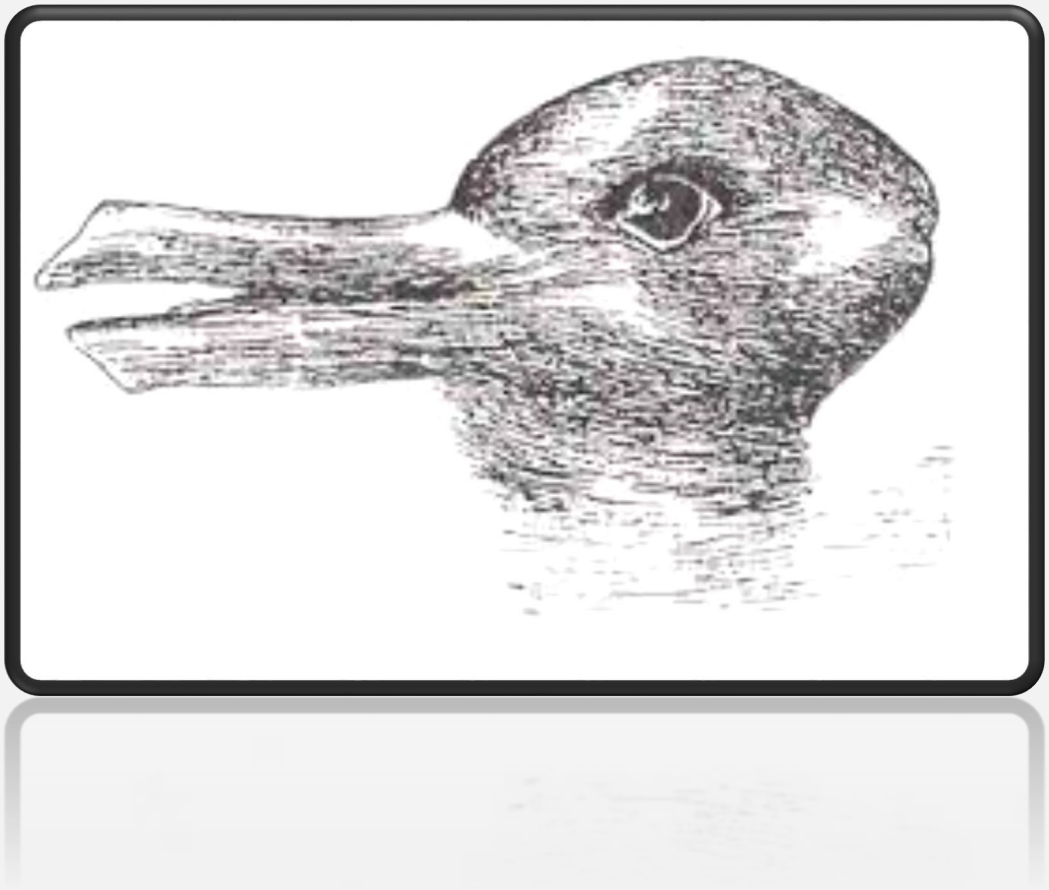
A Good Disruption –
Redefining growth in the 21st century

CONCAWE

Prof. Dr. Martin R. Stuchtey
March 18th 2019

SYSTEMIQ

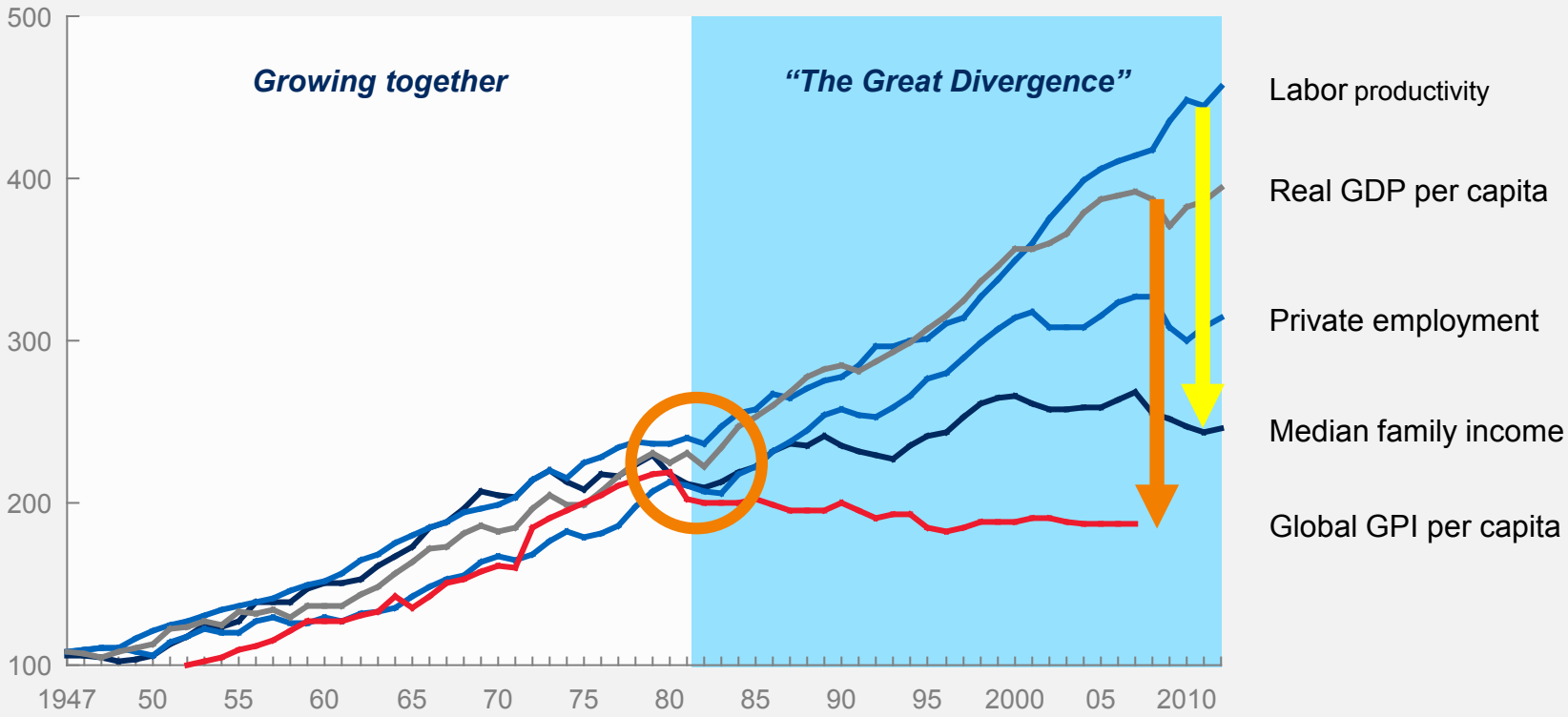
Congruence, anomaly, or new paradigm?



SOURCE: Thomas Kuhn, Structure of a Scientific Revolution (1964)

We are seeing a “great divergence”

U.S. labor productivity, GDP per capita, employment, median income, and Global GPI per capita
Indexed to 1947



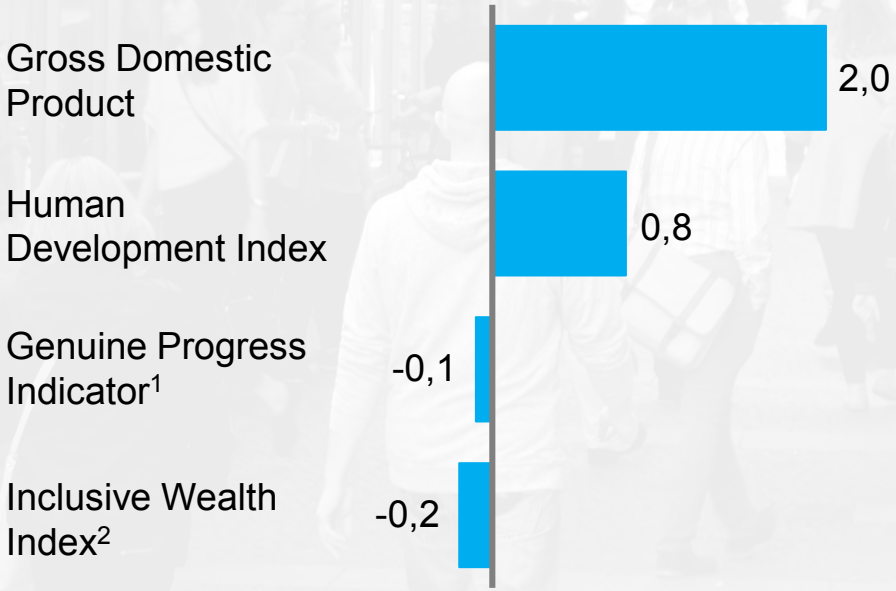
SOURCE: Stuchtey, et al (2015), Federal Reserve Bank of St. Louis, Brynjolfsson and McAfee , Kubiszewski et al. (2013)

Annual GDP Growth rates in Germany, France, and the USA

SOURCE: Insee, Statistisches Bundesamt, U.S. Bureau of Economic Analysis

Measures of societal development that include natural capital depletion grow much slower than GDP

Progress per capital, globally, 1990 – 2010, real terms



Considerations

	Economic Capital	Social	Natural
Gross Domestic Product	✓		
Human Development Index	✓	✓	
Genuine Progress Indicator[1]	✓	✓	✓
Inclusive Wealth Index[2]	✓	✓	✓

1 1990-2005, as later data not available globally,
2 IWI exists in two versions, one unadjusted, and one where adjustments are made for environmental damage, oil capital gains, and total factor productivity. The adjusted version is shown here,
3 Global population growth was 1.6 percent per year during the period

SOURCE: UNEP (2014a), Kubiszewski et al. (2013)

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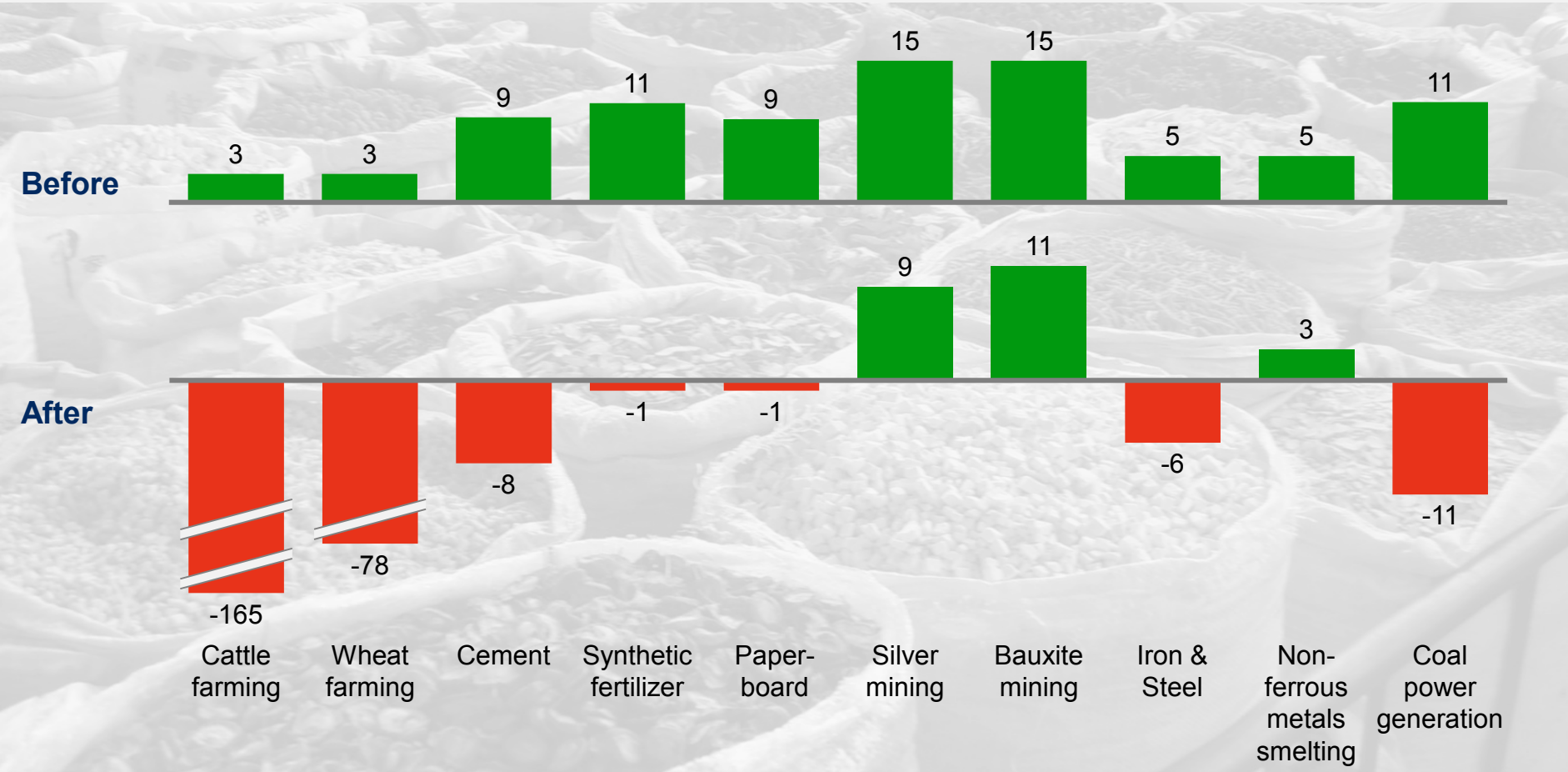
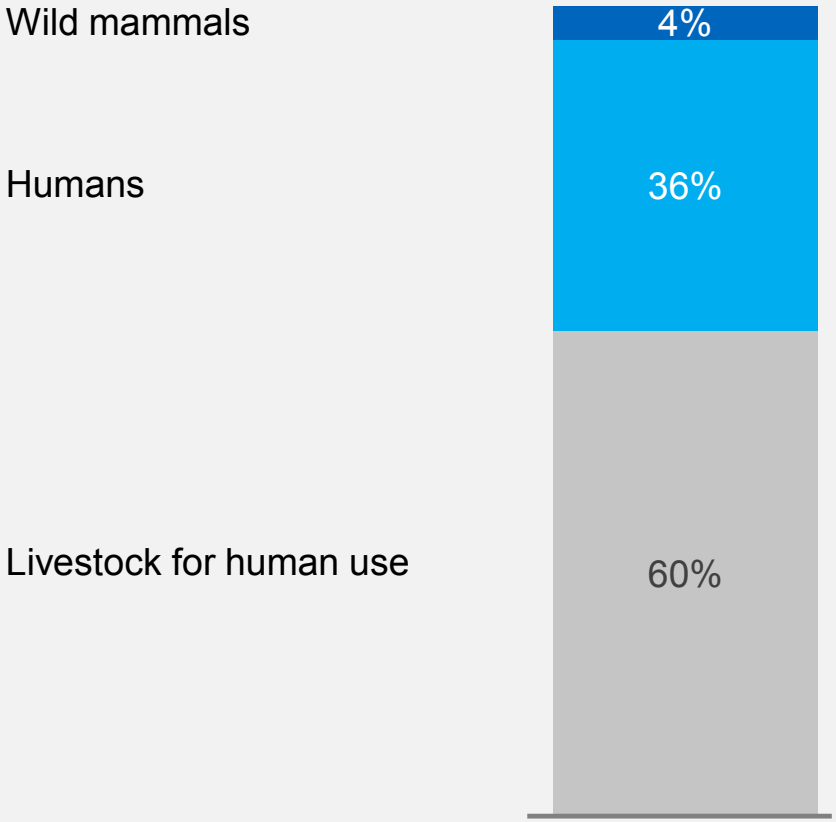
Paradigm shift: Most of the world's resource using industries negative

Profit margin (EBIT) before and after natural capital costs, based on top-2 companies in each Morgan Stanley Composite Index category, %, 2012



Paradigm shift: wild vertebrates reduced to 4%

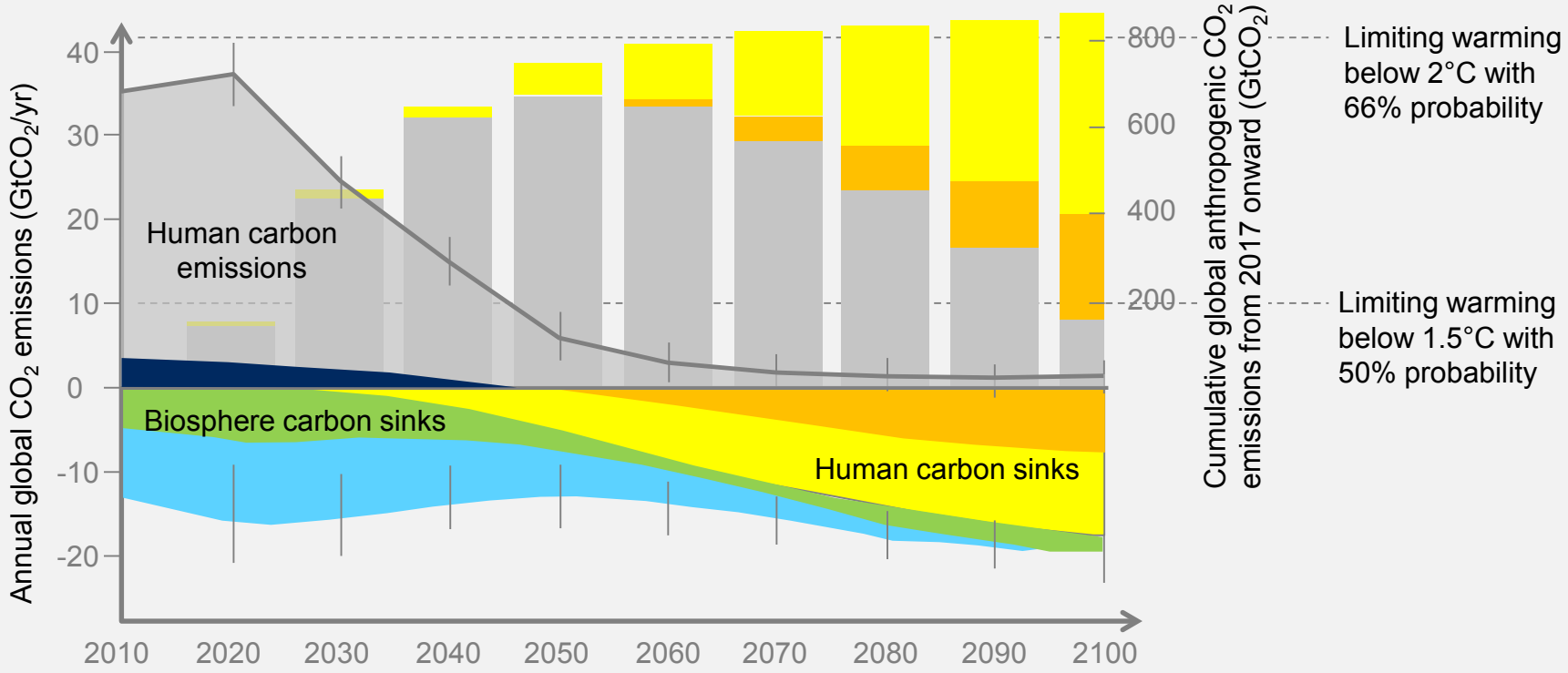
Biomass weight of vertebrate population 2016



- Mass of humans and livestock **23 times** that of wild mammals
- Livestock outweighs wild mammals and birds by **factor 11**
- Biomass of wild marine/ terrestrial mammals reduced **six times**
- Wild plant biomass reduced by **half**
- Cows are the world **key predator**: 90% of small fish catch is ground up for animal feed

SOURCE: Bar-On, Philips, and Milo, 2018. The biomass distribution on Earth. PNAS Latest Articles ** Philip Wollen, 2012

Paradigm shift: 15 Gt CO_2 removal required to stay on Paris track



Anthropogenic CO^2 emissions (gross)

- Fossil fuel and industry
- Land use and land-use change

Anthropogenic CO^2 removals

- Land use and land-use change
- Engineering CO_2 sink (BECCS)

Biosphere carbon sink

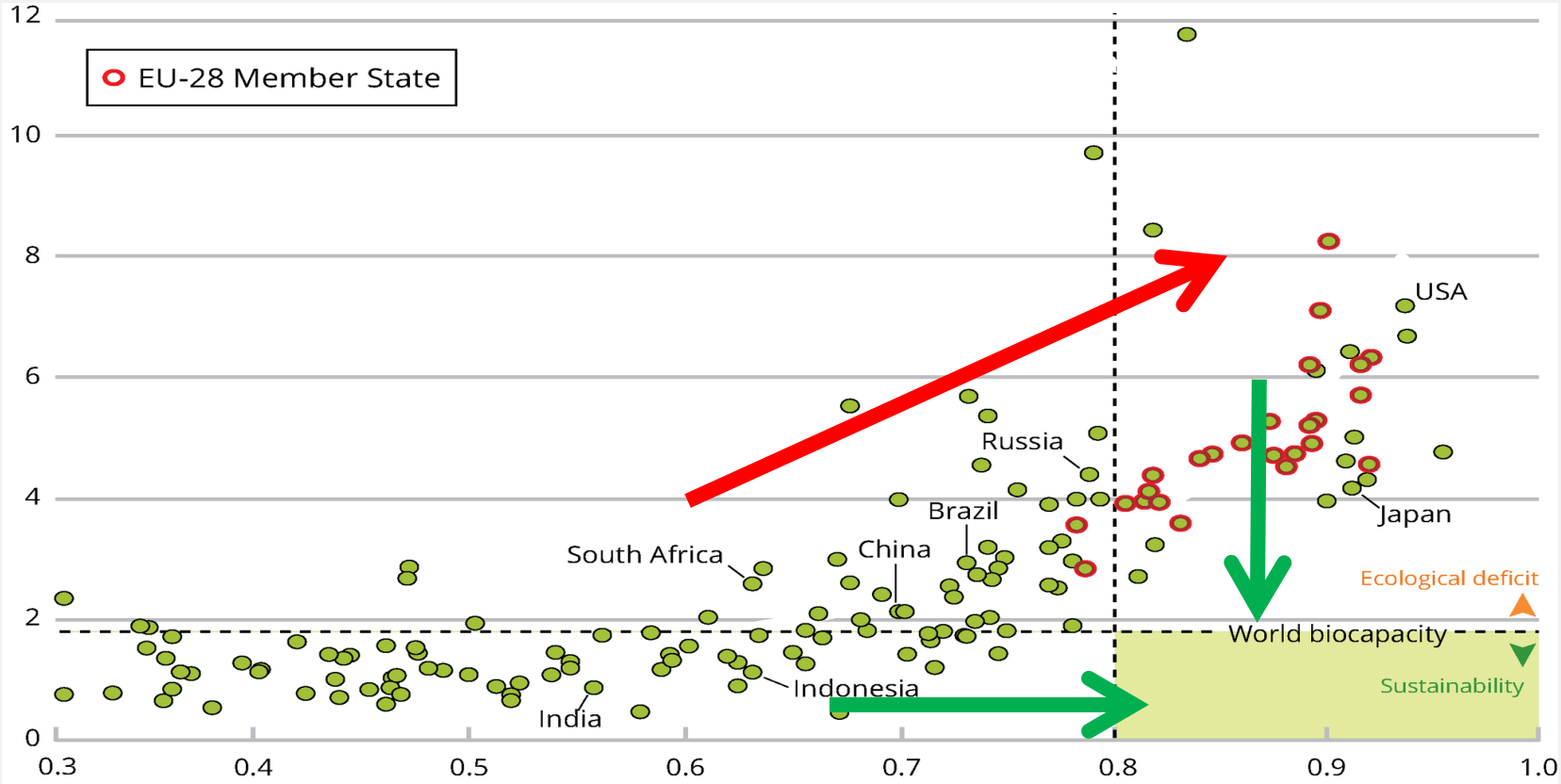
- Land carbon sink
- Ocean carbon sink

Whiskers on total natural sinks: the 90% range of modeled uncertainties

Paradigm shift: 1 kg of plastic for 1 kg of fish

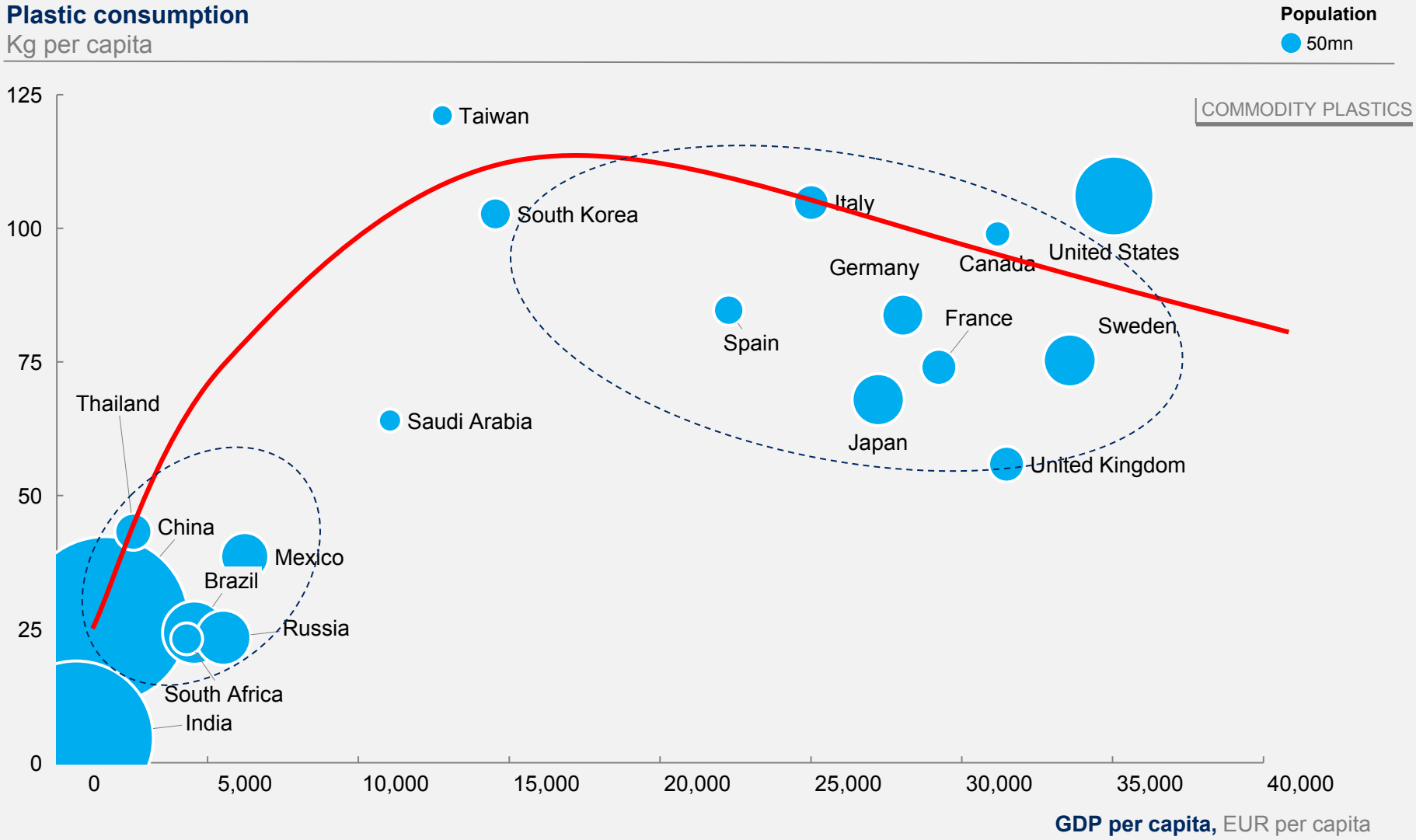
Our future operating space – uncharted

hectares per person per year



SOURCE: Global Footprint Network, 2012; UNDP, 2014a

Waiting for Kuznets – example commodity plastics



1 Includes EPS, HDPE, LDPE, LLDPE, PET Resins, PP, PS, and PVC

SOURCE: Global Insight

The vision of a decoupled, net positive industry model

Good, not less bad – as a **new norm**
Decoupled growth as an economic standard **4**

Abundant clean energy **1**

Highly productive systems **3**

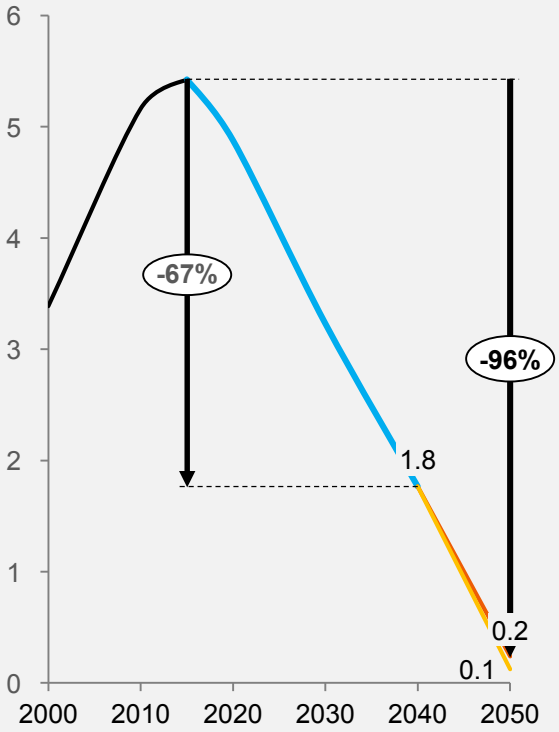
Material backbone **2**

SOURCE: Stuchtey et al. : A Good Disruption (2015)

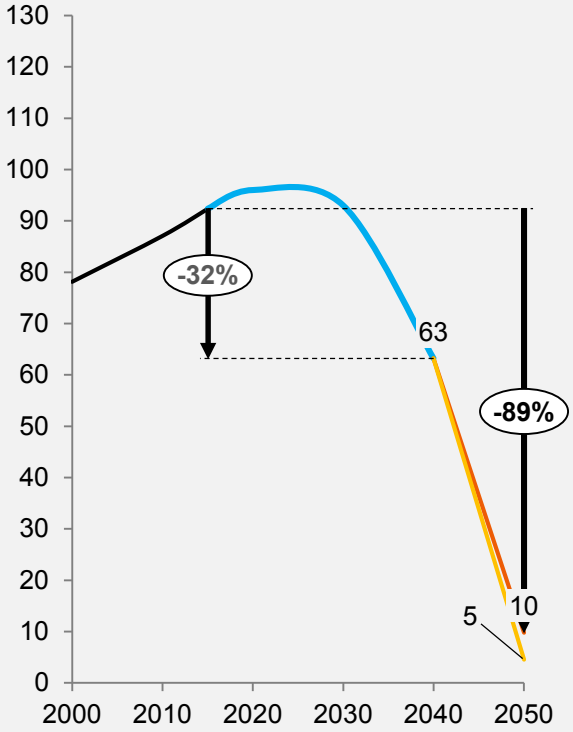
Towards a 1,5°C-compatible energy system – fossil consumption pathways

Central scenario
Supply-side decarbonization illustrative pathway
Supply-side decarbonization and efficiency illustrative pathway

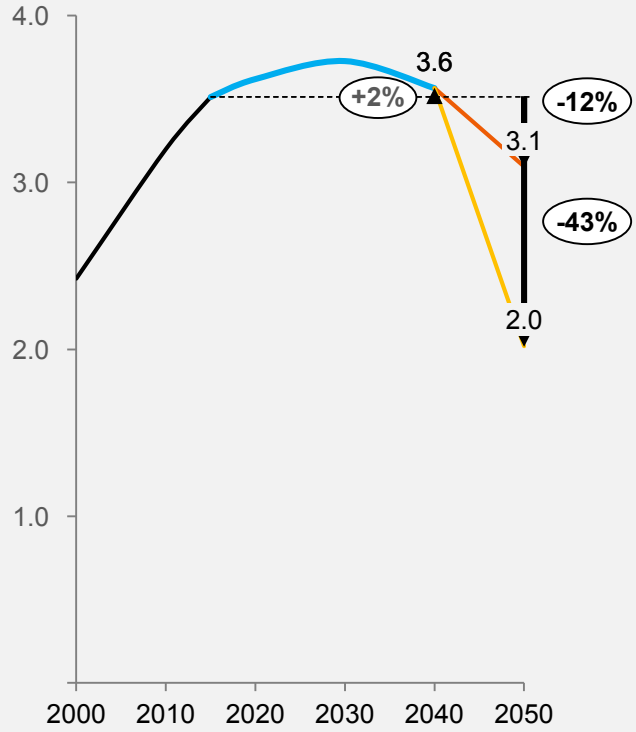
Coal consumption
Billion tonnes per year



Oil consumption
Million barrels per day



Natural gas consumption
000 bcm per year



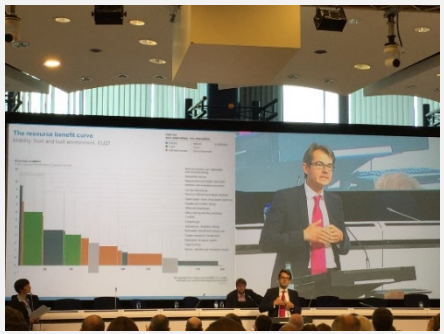
In the ETC decarbonization pathways, all emissions from remaining fossil fuel use are abated with CCS/U

Notes: All fossil fuel trajectories are based on scenarios reaching a 2°C objective with at least two-thirds probability. The charts show median fossil fuel use in 21 scenarios with less than 15 $GtCO_2$ removal in any given year. Average removals 2050-2100 are 3 Gt/year through CCS on fossil fuels and 8 Gt/year through BECCS or other negative emissions.

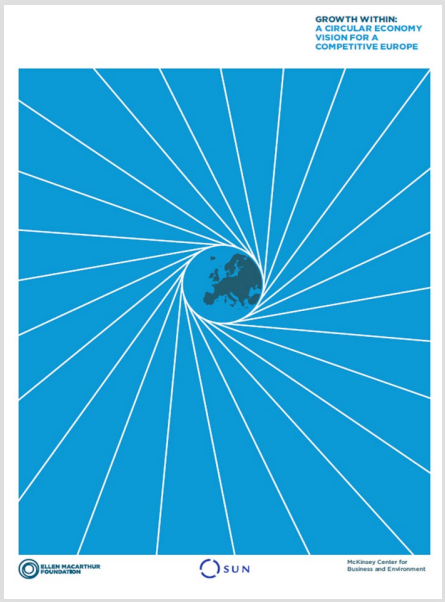
SOURCE: Historic data from BP. Projects are Copenhagen Economics calculations on data from IIASA AR5 database; SYSTEMIQ analysis for the ETC (2018)

SYSTEMIQ

Towards a circular economy: 2016, at the European Commission



"Circular economy will be a similar mega trend in economy as globalization. I'm convinced that the circular economy can enable a triple win: economic, environmental and social."
Jyrki Katainen - EU Vice President Jobs, Growth, Investment and Competitiveness

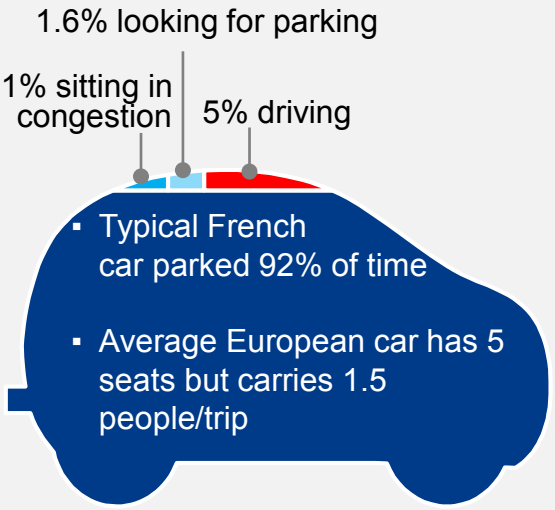


"I am very impressed by the findings of Growth Within report, looking forward to developing our shared agenda"
Karmenu Vella, EU Commissioner Environment, Maritime Affairs and Fisheries

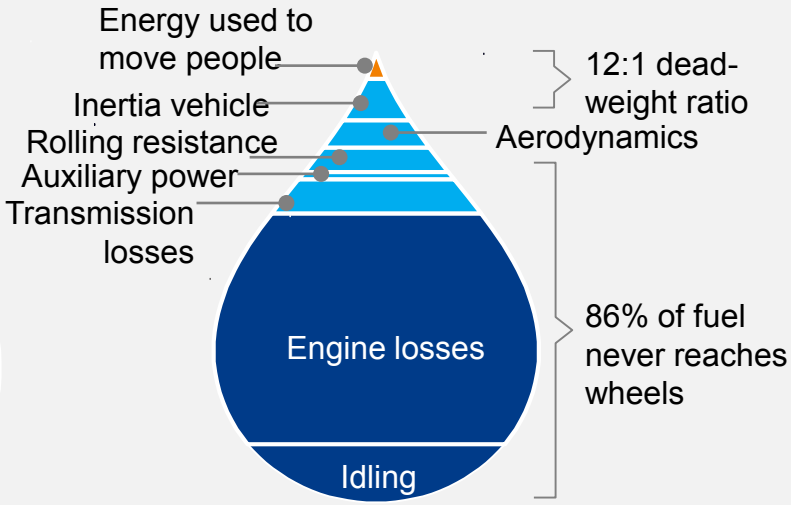
"I passionately believe in the opportunities of the circular economy. The future is not making things with finite components."
Frans Timmermans, EU Commission First Vice President

Major structural waste in the mobility system

Car utilization

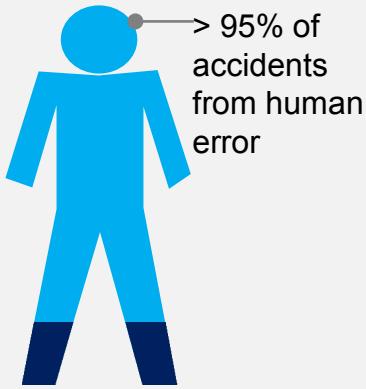


Tank-to-wheel energy flow - gasoline



Deaths and injuries per year on road

30,000 deaths in accidents and 4x as many disabling injuries



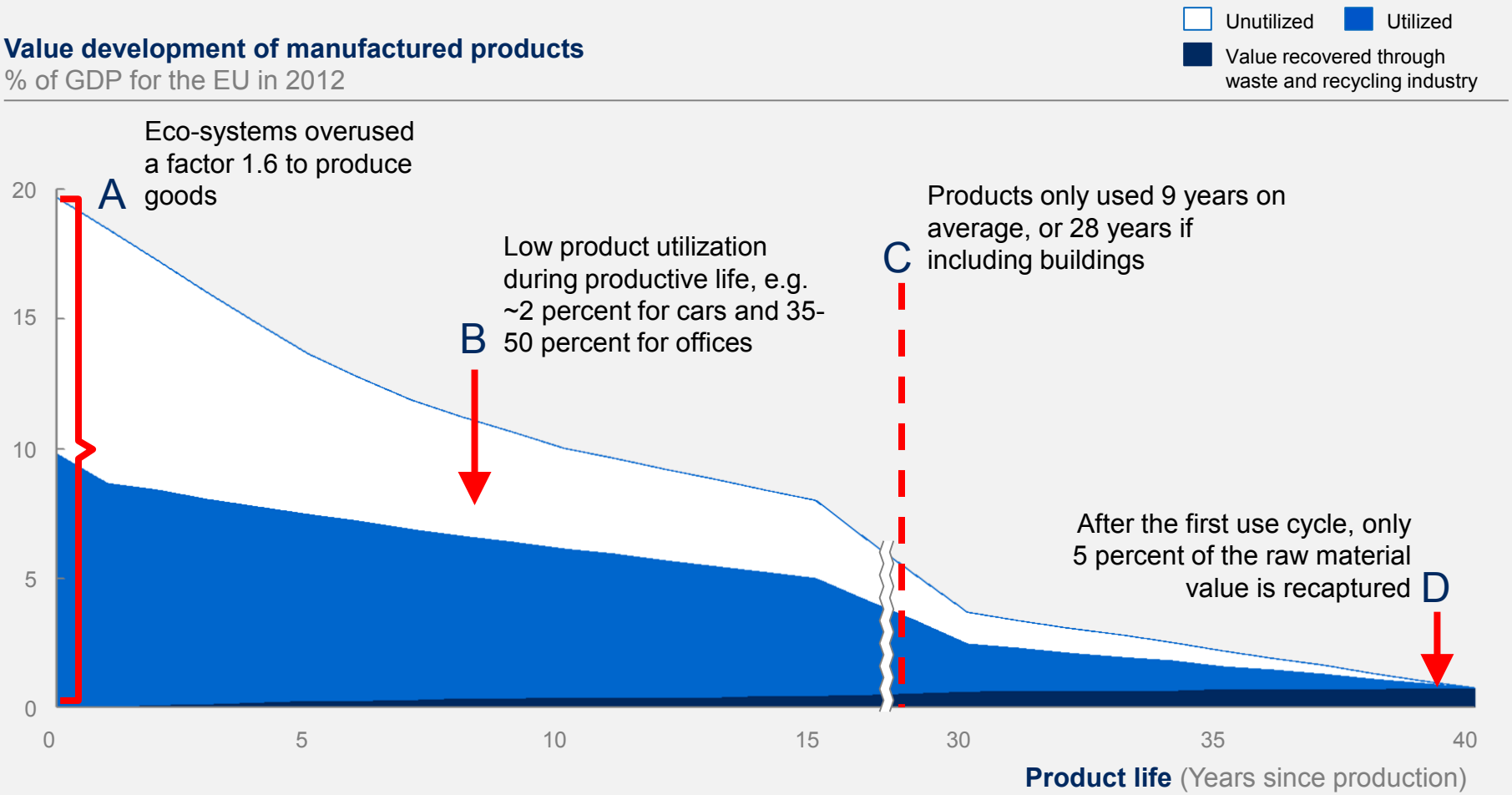
Land utilization

- Road reaches peak throughput only 5% of time and only 10% covered with cars then
- 50% of most city land dedicated to streets and roads, parking, service stations, driveways, signals, and traffic signs

SOURCE: McKinsey Center for Business and Environment, Ellen MacArthur Foundation & SUN (2015)

Waste, waste, everywhere – example Europe

Value development of manufactured products
% of GDP for the EU in 2012



SOURCE: McKinsey Center for Business and Environment, Ellen MacArthur Foundation & SUN (2015)

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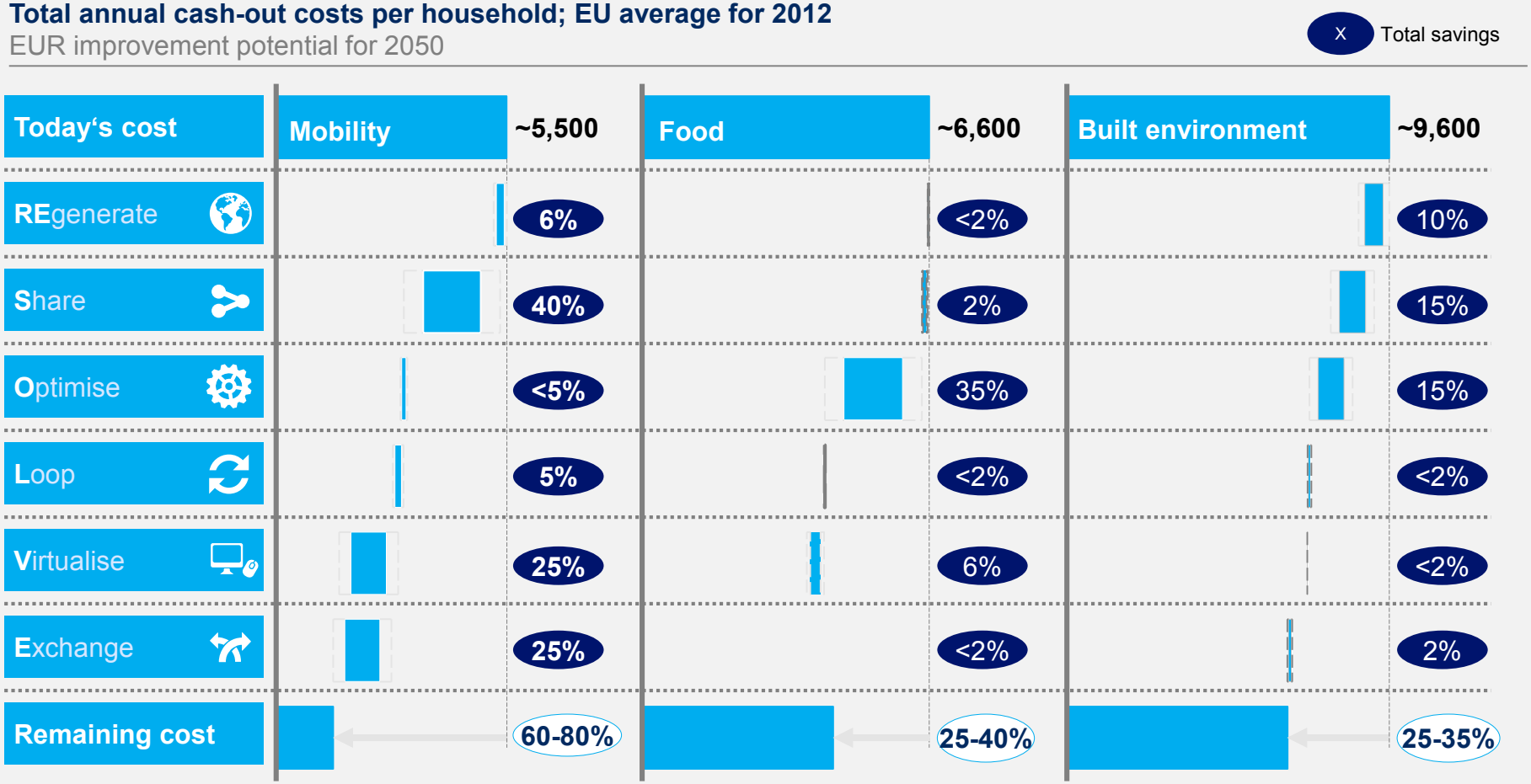
Cost-reduction potential in the three real life systems

Total annual cash-out costs per household; EU average for 2012
EUR improvement potential for 2050



SOURCE: McKinsey Center for Business and Environment, Ellen MacArthur Foundation & SUN (2015)

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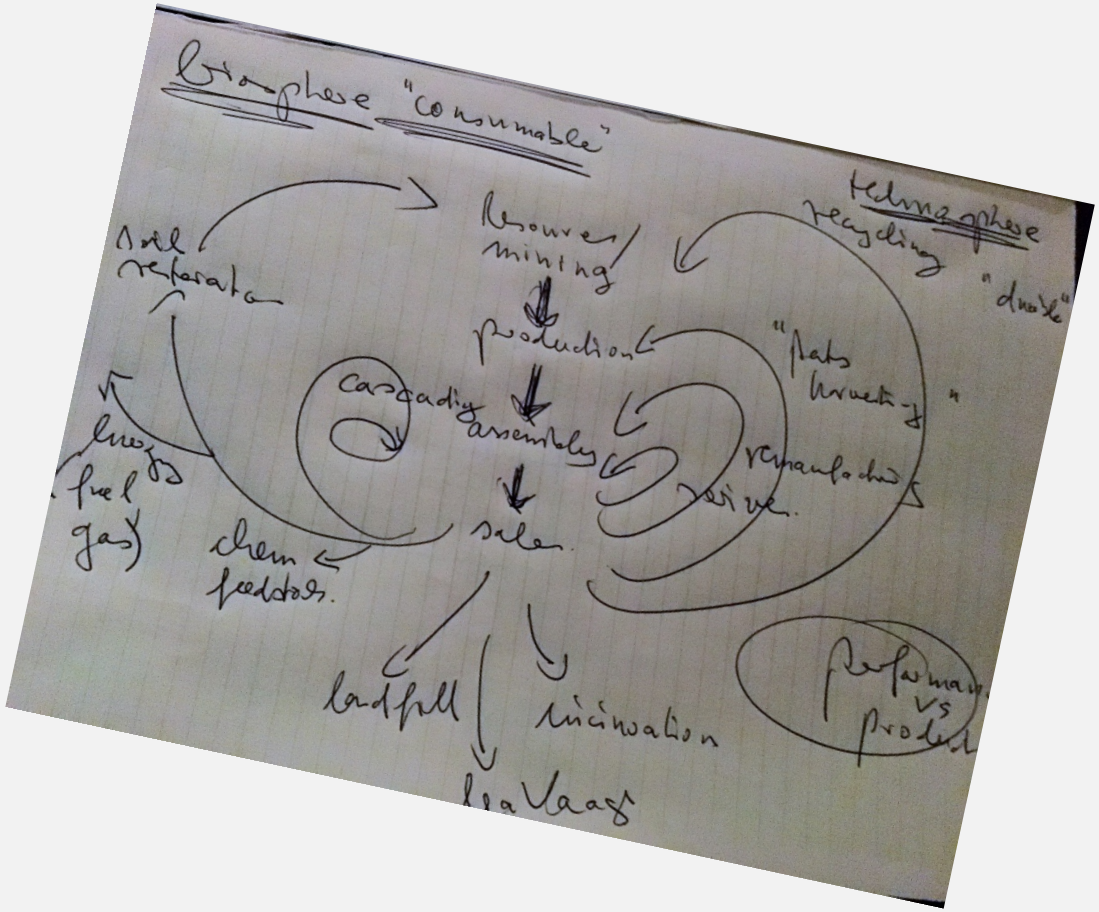
ReSOLVE – a menu of business actions for a better economy

	Examples
REgenerate	▪ Shift to renewable energy and materials ▪ Reclaim, retain, and restore health of ecosystems ▪ Return recovered biological resources to the biosphere
Share	▪ Share assets (e.g. cars, rooms, appliances) ▪ Reuse/secondhand ▪ Prolong life through maintenance, design for durability, upgradability, etc.
Optimise	▪ Increase performance/efficiency of product ▪ Remove waste in production and supply chain ▪ Leverage big data, automation, remote sensing and steering
Loop	▪ Remanufacture products or components ▪ Recycle materials ▪ Digest anaerobic ▪ Extract biochemicals from organic waste
Virtualise	▪ Books, music, travel, online shopping, autonomous vehicles etc.
Exchange	▪ Replace old with advanced non-renewable materials ▪ Apply new technologies (e.g. 3D printing) ▪ Choose new product/service (e.g. multimodal transport)

SOURCE: McKinsey Center for Business and Environment, Ellen MacArthur Foundation & SUN (2015)

In search of a new logic



In search of a superior design - outline of a circular economy system (75 million downloads)

Principle 1

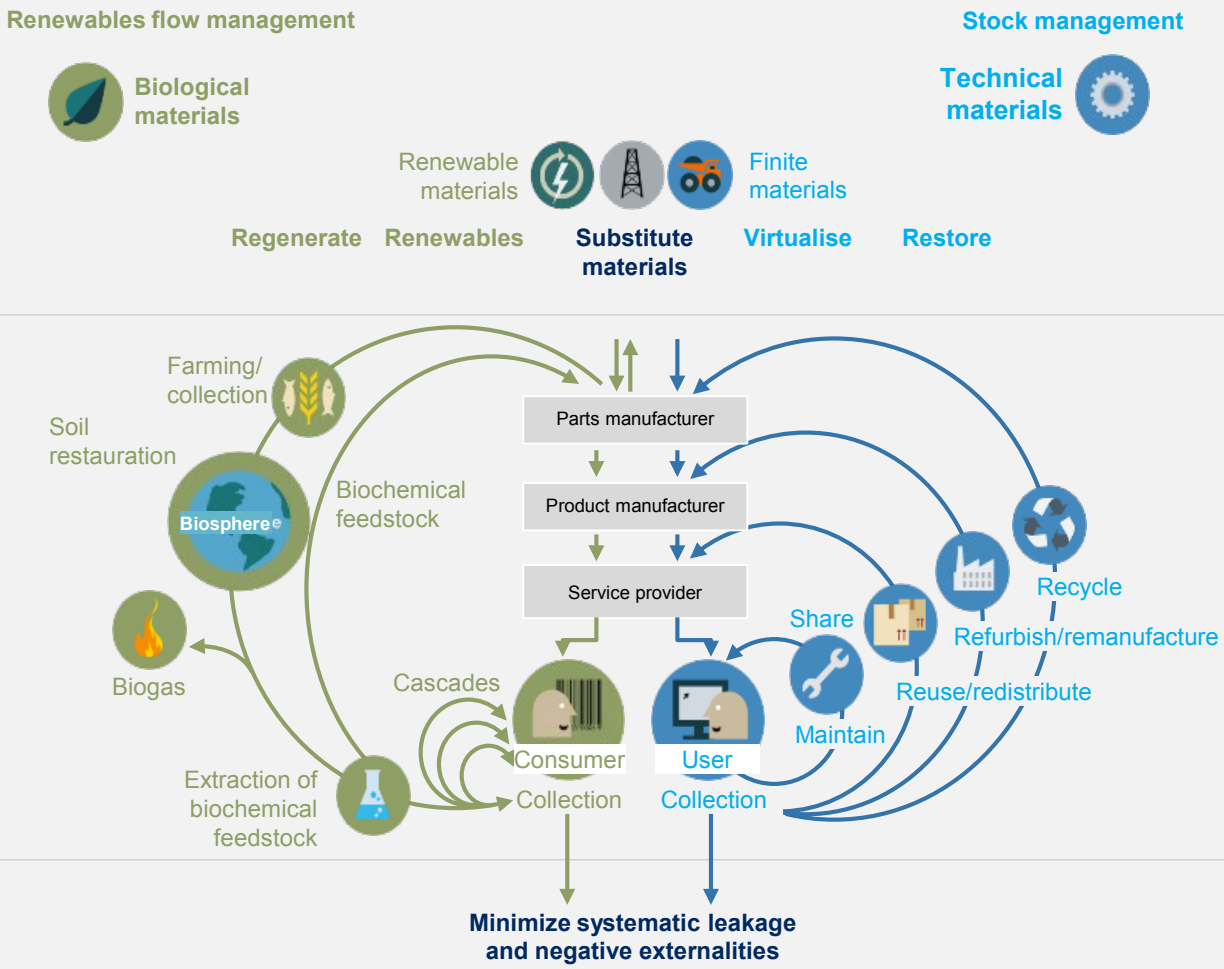
Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows

Principle 2

Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles

Principle 3

Foster system effectiveness by revealing and designing out negative externalities



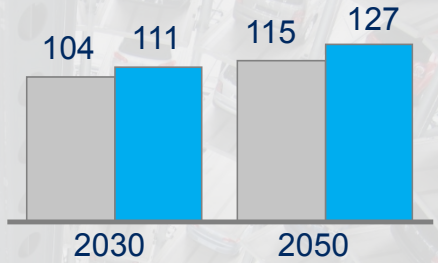
SOURCE: Ellen MacArthur Foundation & SUN (2013)

“Growth Within” developed the vision of a circular European economy – with better etter economic and environmental outcomes

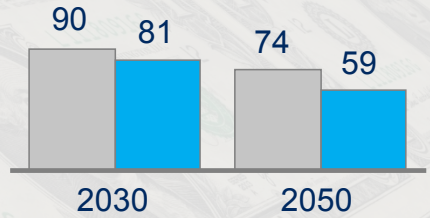
Indexed (2012 = 100)

Current development scenario
Circular scenario

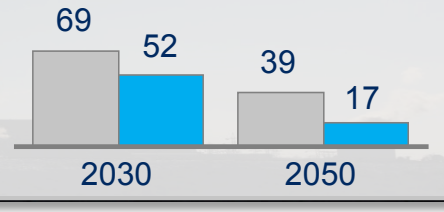
GDP
EU-27, indexed (2012 = 100)



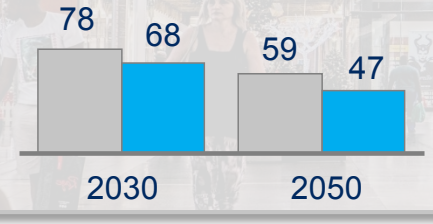
Direct user cash out costs
EU-27, indexed (2012 = 100)



CO2 emissions
EU-27, indexed (2012 = 100)

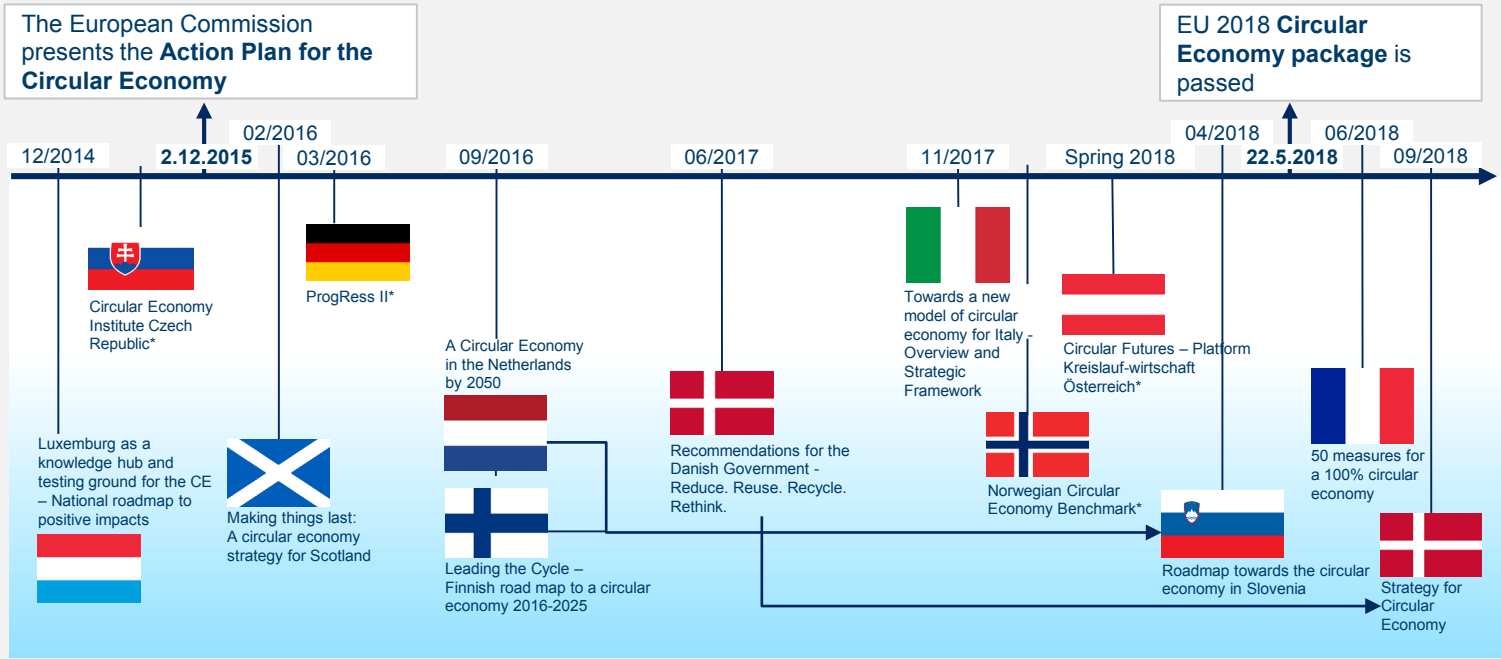


Primary material consumption
EU-27, indexed (2012 = 100)



Countries are making the circular economy part of national policy priorities

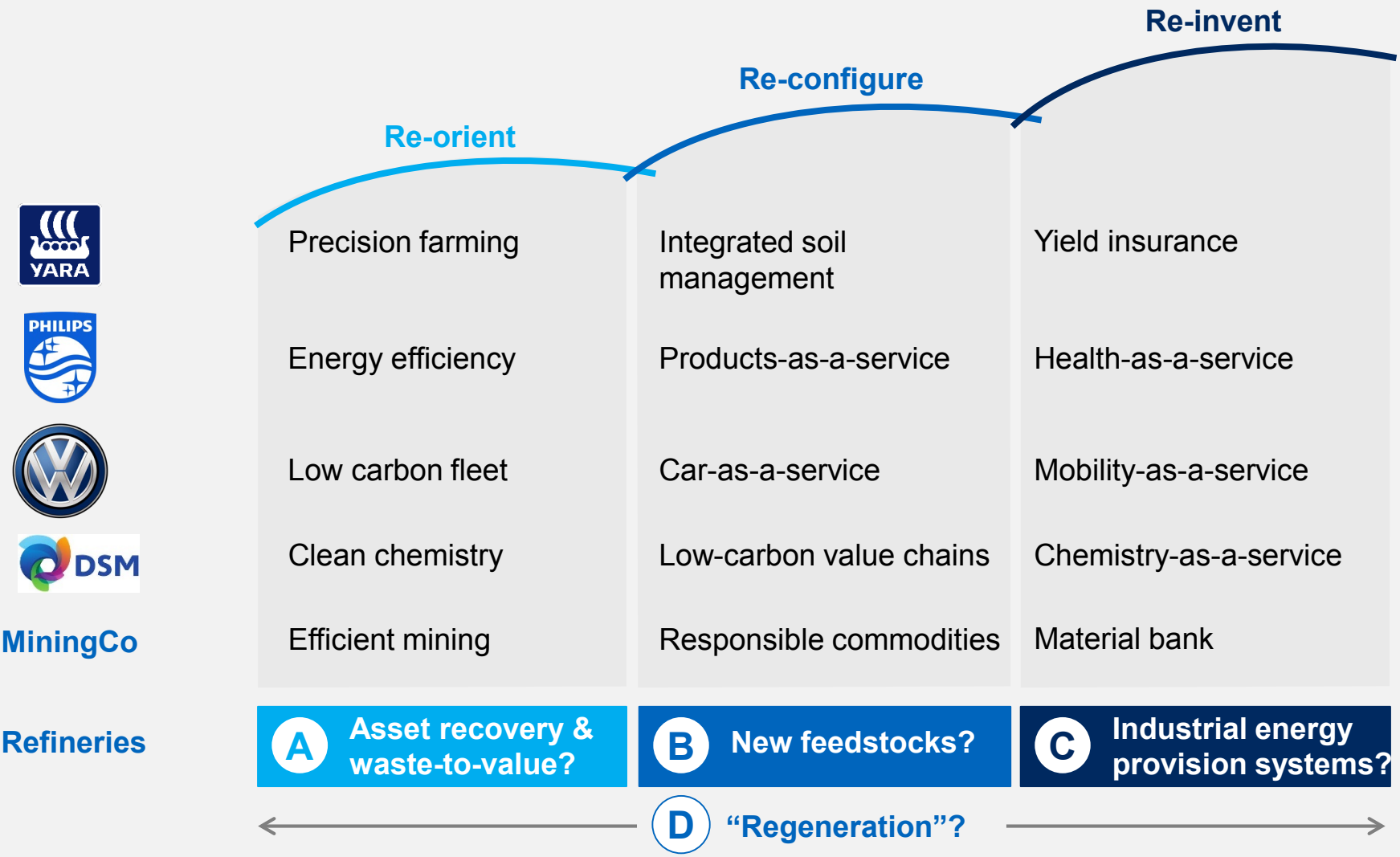
Circular economy roadmaps and relevant initiatives



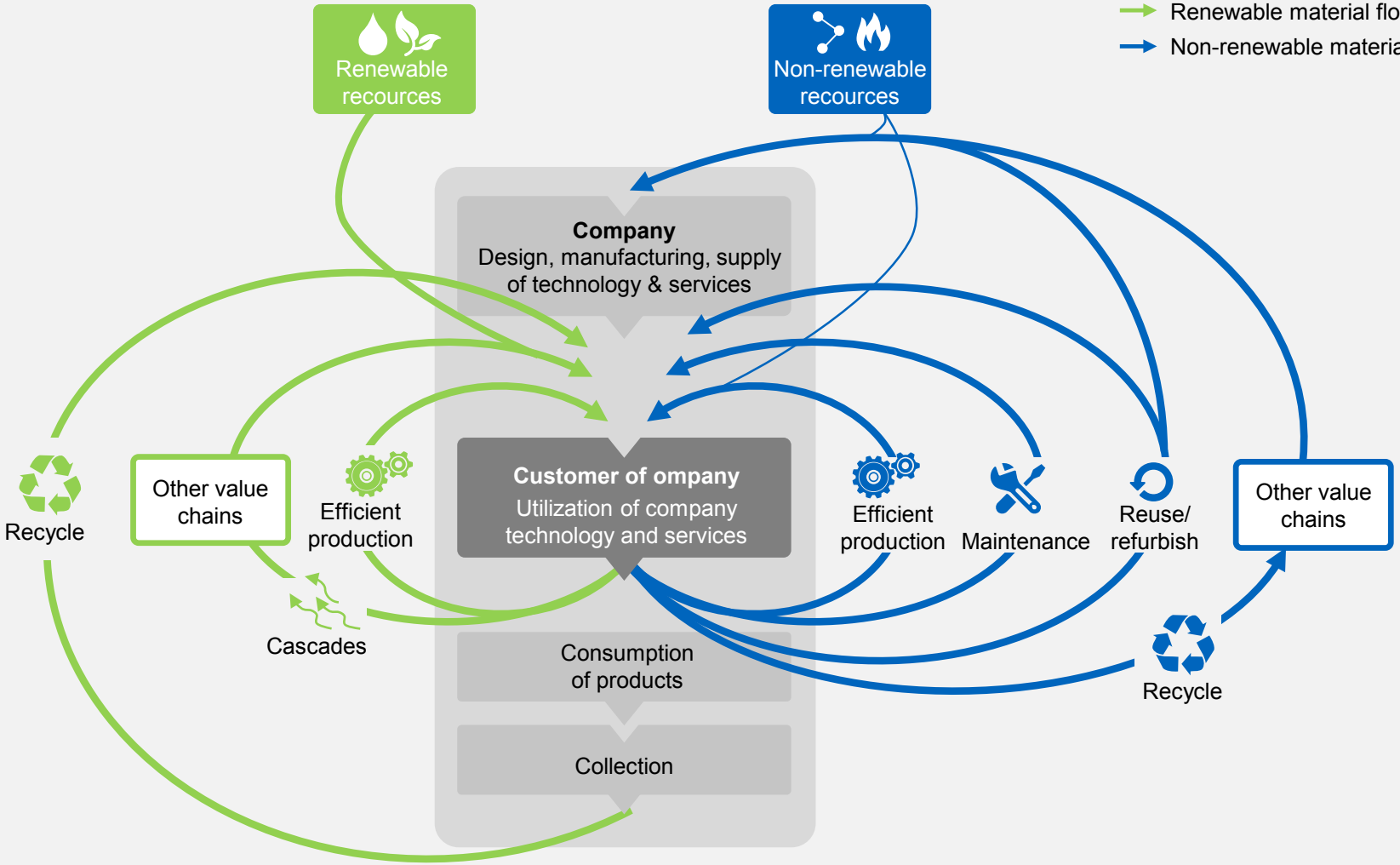
International development:

- CHINA 2017 release of a circular economy policy portfolio - "**ecological civilization**"
- JAPAN focus on **resource efficiency** and recycling potential;
- CANADA thematic integration via the logic of sustainable value creation (**"smart prosperity**")

Industries are starting to react to the new global context and avoid “stranded asset” risks



A Asset-intense industries can massively benefit from equipment recovery now enabled by digital “material banks”



B Plastic is the workhorse material of the global economy and growth engine of the petrochemical industry – facing massive headwinds

Plastic, one word, thousands of different materials developed by chemists over 70 years for different applications and different fields.

As of 2015, 7.8 bn tons of plastic material was produced globally.[1] Plastic has become ubiquitous thanks to extremely low production cost.

With >400m tons output and 600 bn dollar revenues yearly, the plastic industry has grown into one of the biggest sector of the chemical industry.

Polymer research globally shows that interest in this material has never been higher: new polymers, new catalysts, new processes, new properties etc.

SOURCE: (1) G. Roland, J. Jambeck, K. Law. 2017, Science advances

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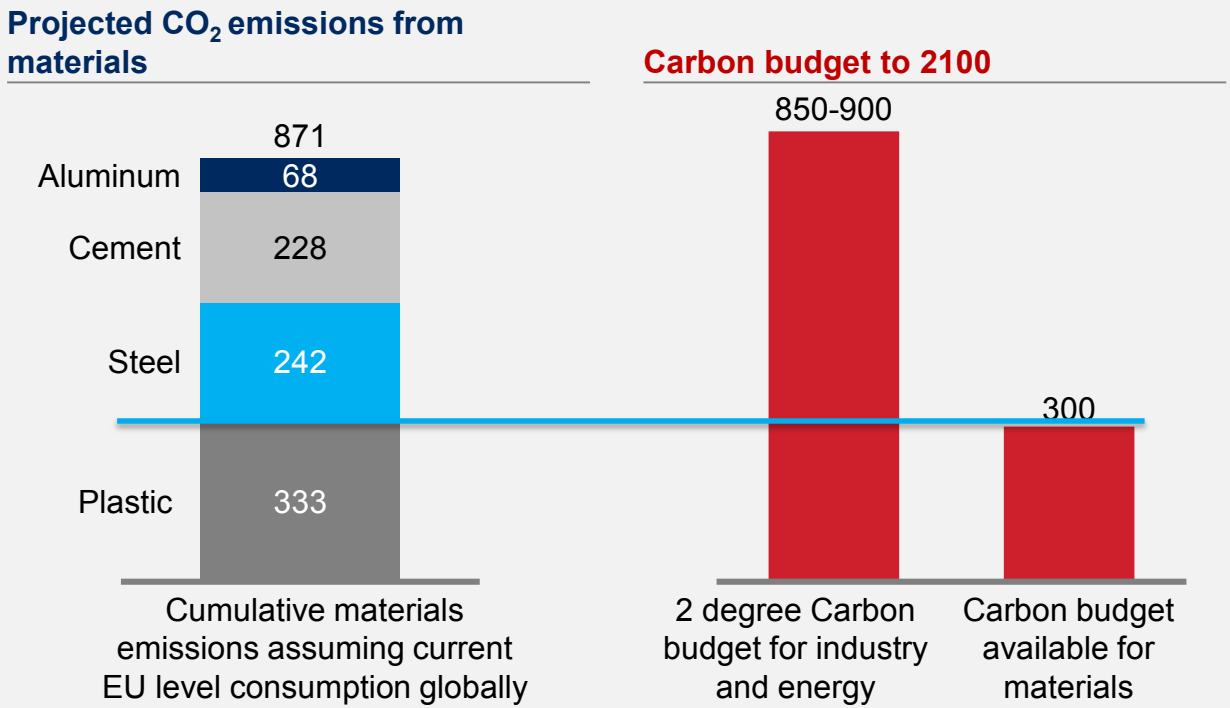
B There is a newly emerging imperative to keep plastic out of the atmospheric carbon cycle

Cumulative emissions to 2100
$GtCO_2$, global, 2015-2100

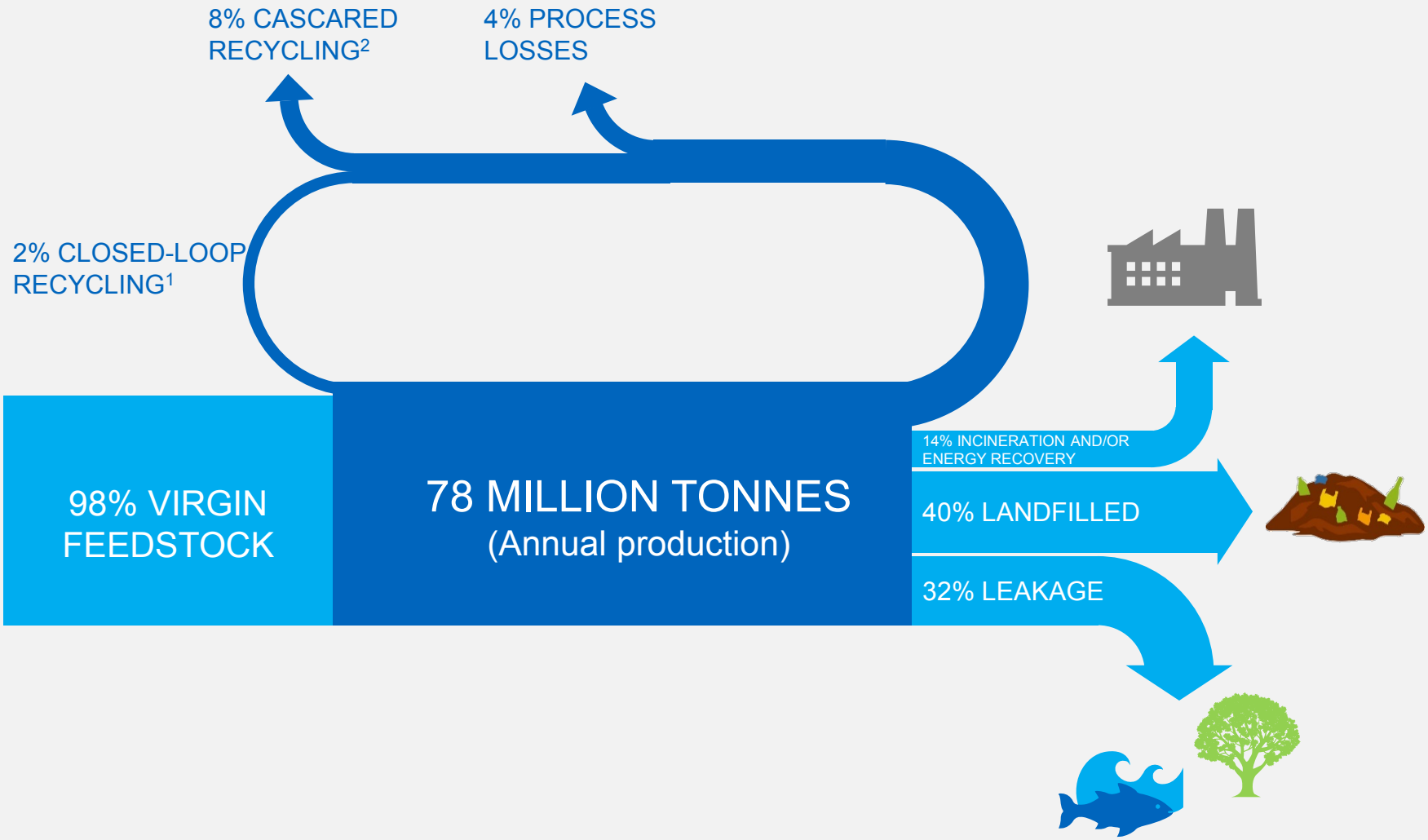


SOURCE: Material Economics 2018

B Over the last 2 years plastics leakage into eco-systems has been elevated to the global agenda – and starts to reshape the value chain

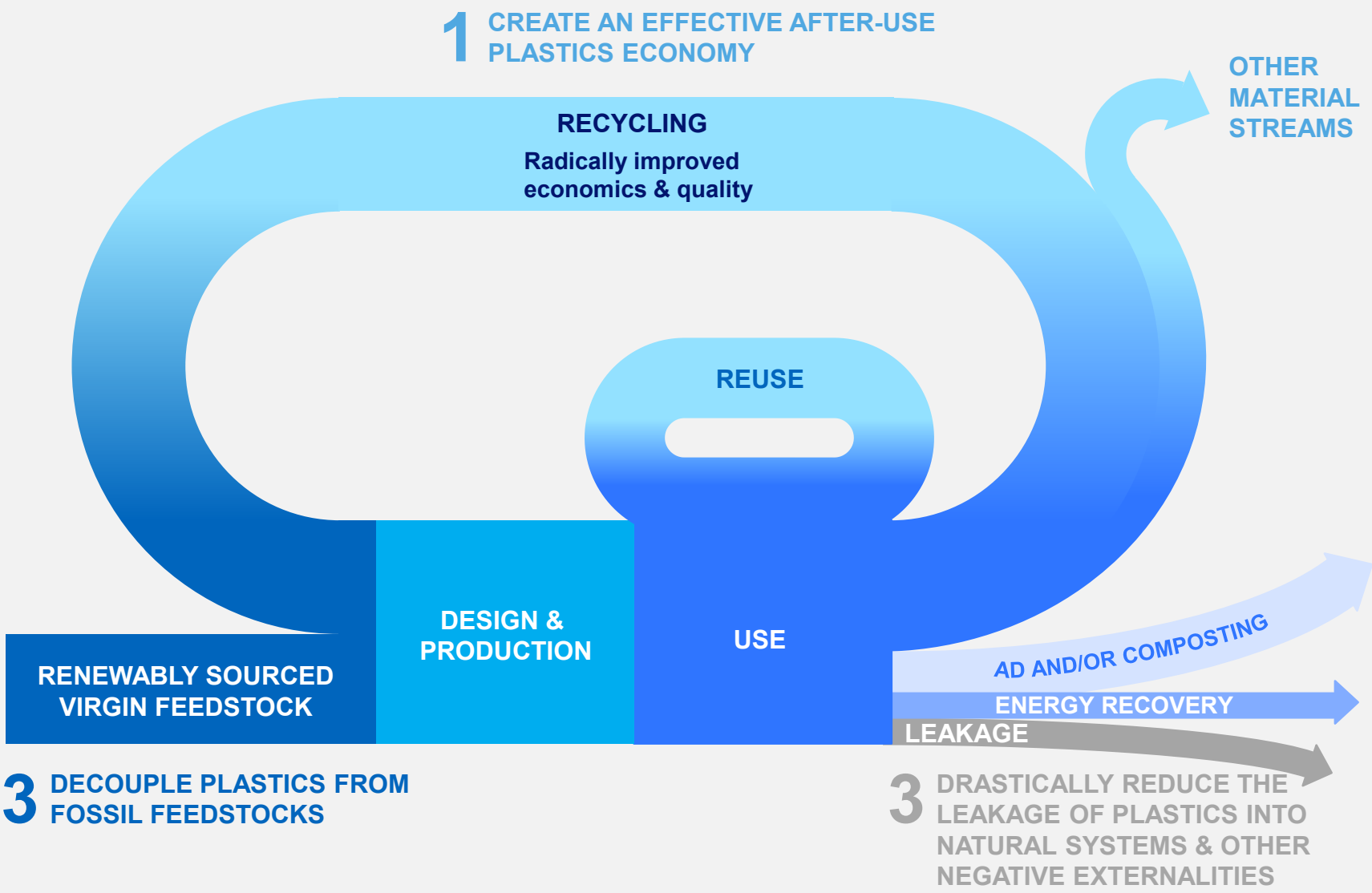
SOURCE: Ocean Conservancy; Rochman et al., 2013; Davison and Asch, 2011; Jacobsen et al., 2011; Raum-Suryan et al., 2009; Hanni and Pyle, 2000; NOAA; Environmental Investigation Agency

B The global plastic packaging value chain is starting to move into a major disruption



1 Closed-loop recycling: Recycling of plastics into the same or similar-quality applications
2 Cascaded recycling: Recycling of plastics into other; lower-value applications
SOURCE: Project Mainstream analysis – for details please refer to Appendix A

B The target plastic system – recoupled, looped, high-value

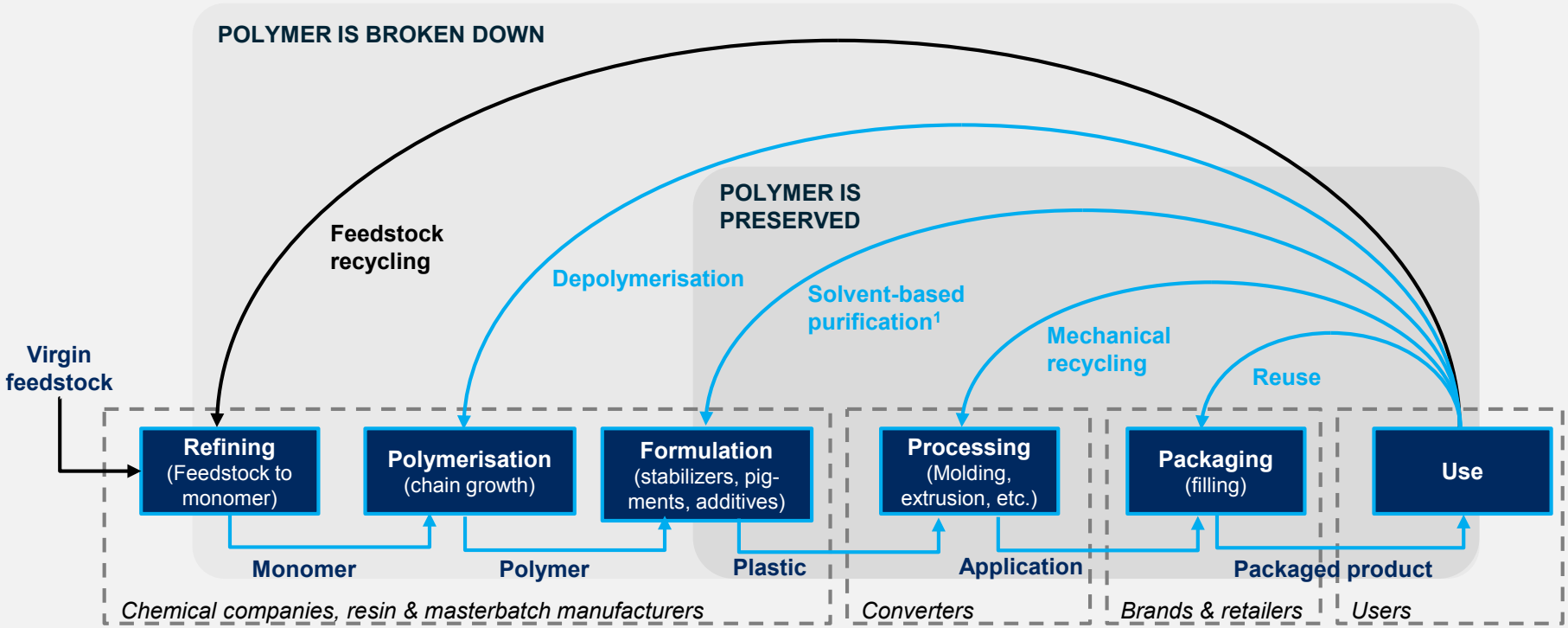


SOURCE: McKinsey Center for Business and Environment

B Oct 29th 2018 in Bali – 200 businesses commit to 100% recyclability & recycled content, shifting market dynamics

B Mechanical vs. feedstock recycling – an emerging competitive battle field

ILLUSTRATIVE



When polymer is broken down:

- Infinite reprocessing cycles possible
- Loss of material integrity and value
- High energy use
- Multiple unit operations
- Multiple options for material applications

When polymer is preserved:

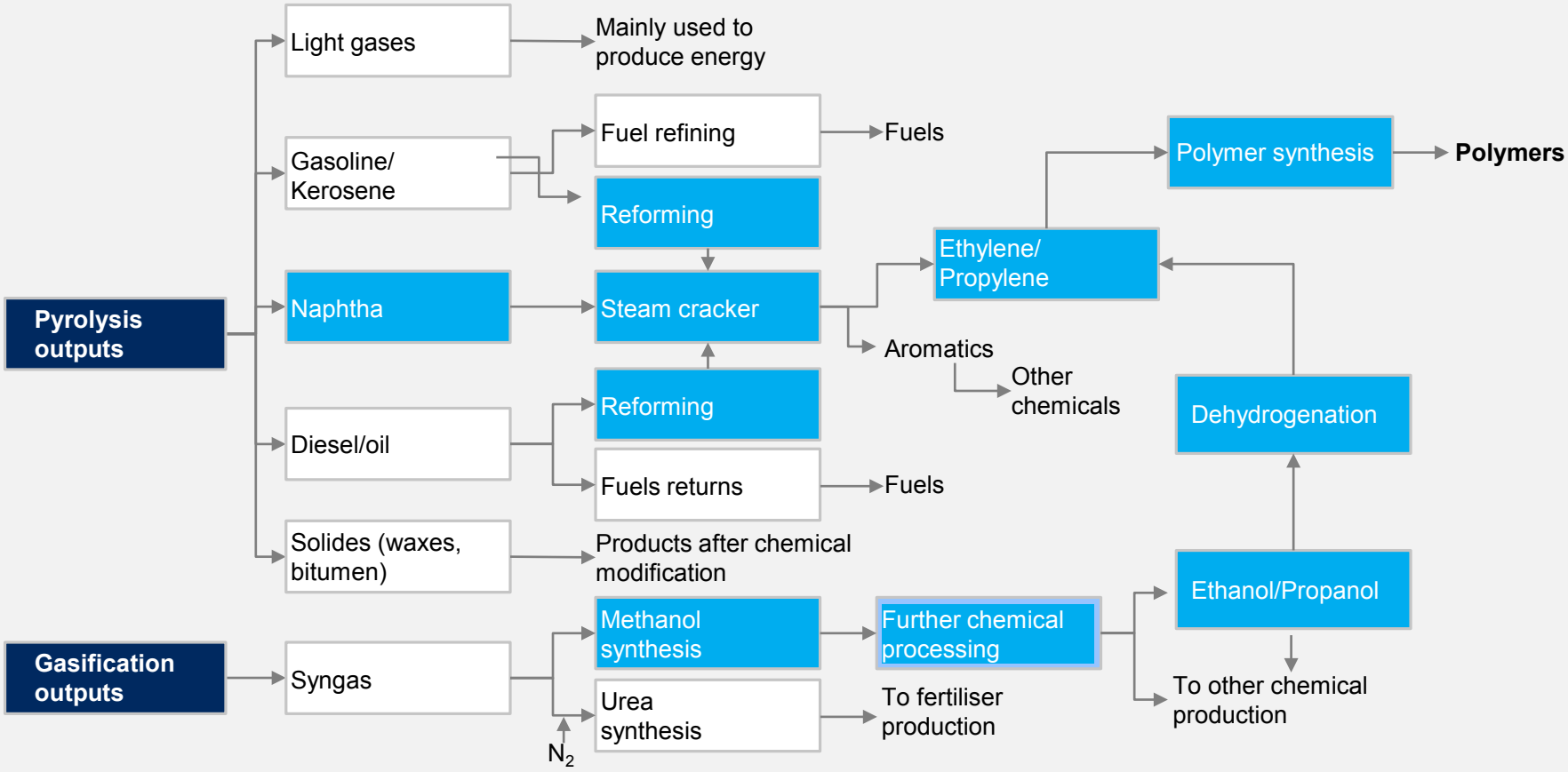
- Preserved material integrity and value
- Each reprocessing cycle degrades material
- Low energy use
- Few unit operations
- Few options for material applications

1 Also called 'solvolysis'

SOURCE: De Smet, M. & Linder, M. (Eds.), *A circular economy for plastics – Insights from research and innovation to inform policy and funding decisions*. European Commission, Brussels, Belgium (2019 –forthcoming)

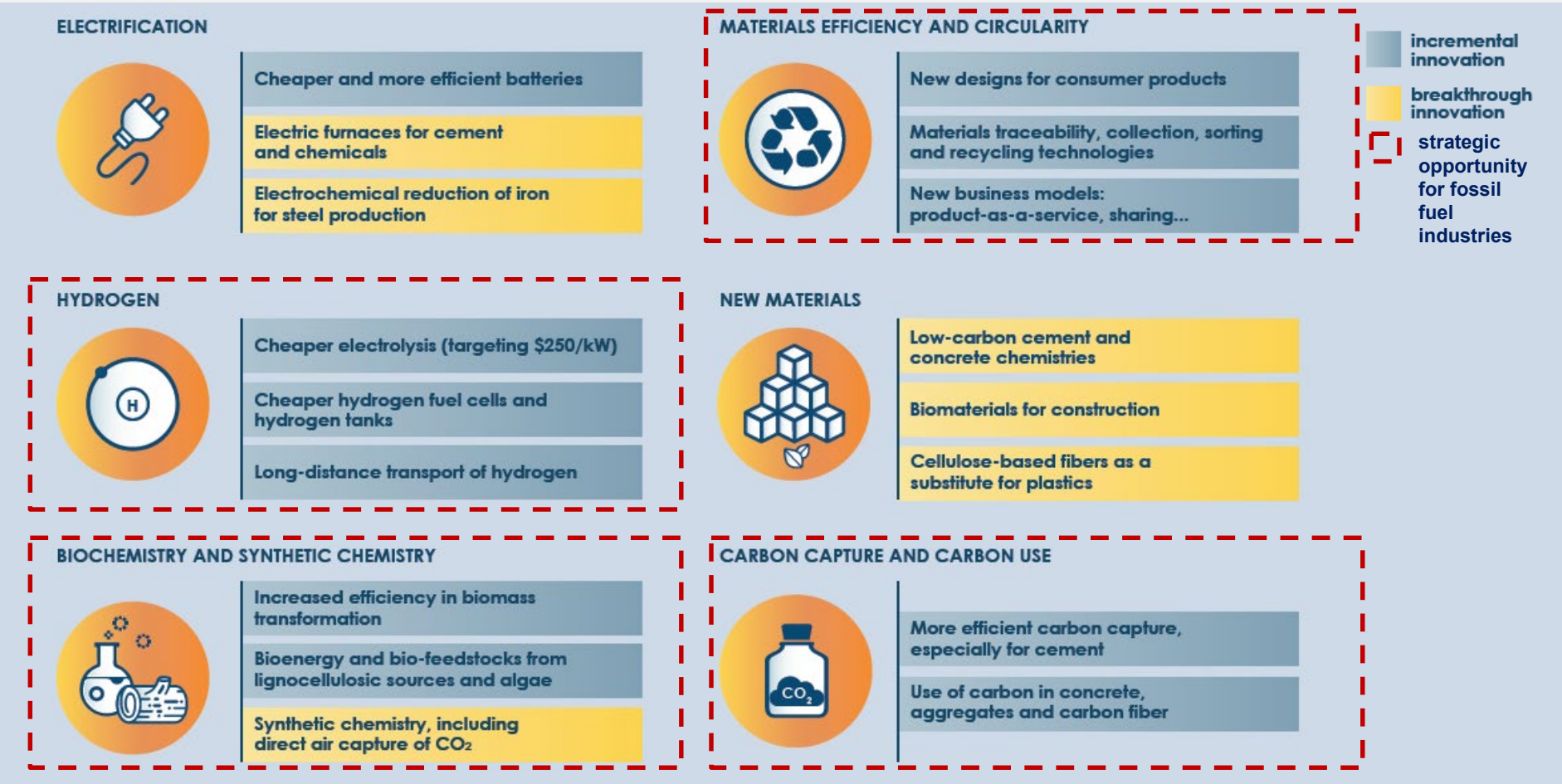
B We are seeing new market entrants developing the feedstock recycling space

With existing petrochemical infrastructure, the likely outcome is a mix of fuel, polymer and chemical products

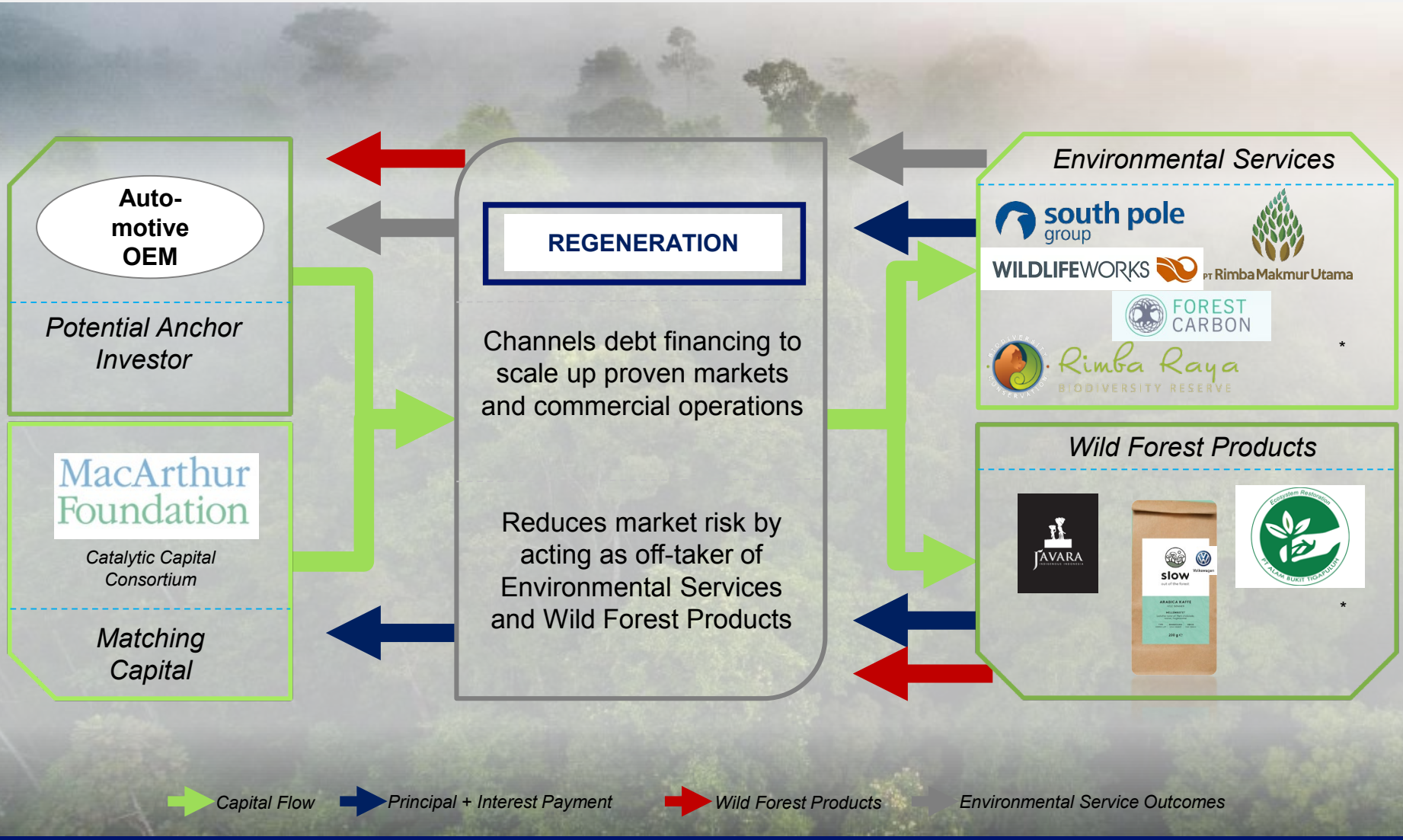


SOURCE: Team Analysis; Centi et al. (2017); Butler, E. *et al.*, *Waste Biomass Valor.* (2011); Richards, T. *et al.*, *Feedstock recycling of polymers,* RE:Source (2018)

C Hydrogen, biochemistry, carbon capture and circularity represent attractive zero-carbon business development opportunities for refinery players



D REGENERATION could be a central pillar of an industry transition strategy – now explored by the automotive industry



*non-exhaustive

The next 20 years – towards an economy that prospers whilst natural systems thrive

First economy
(1820 – 2017)

Second economy
(2018 – 2038)

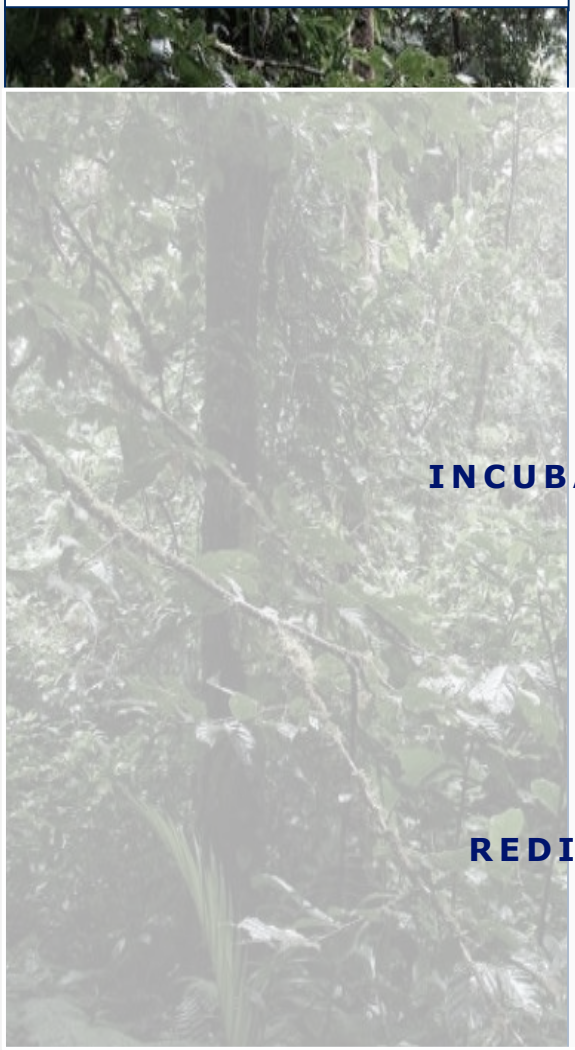
TRANSFORM

RETHINK

SOURCE: SYSTEMIQ

We need a theory of change – for every economic system

LAND USE	MATERIALS	ENERGY



BUILDING COALITIONS

Energy Transitions Commission
Blended Finance Task Force
New Plastic Economy
Made_in_Germany_2.0

TRANSFORMING PIONEERS

Europe's Largest Fertilizer Group
World Largest Environmental Service Company
Two Oil Majors
Largest Enzyme Producer

INCUBATING PROJECTS AND COMPANIES

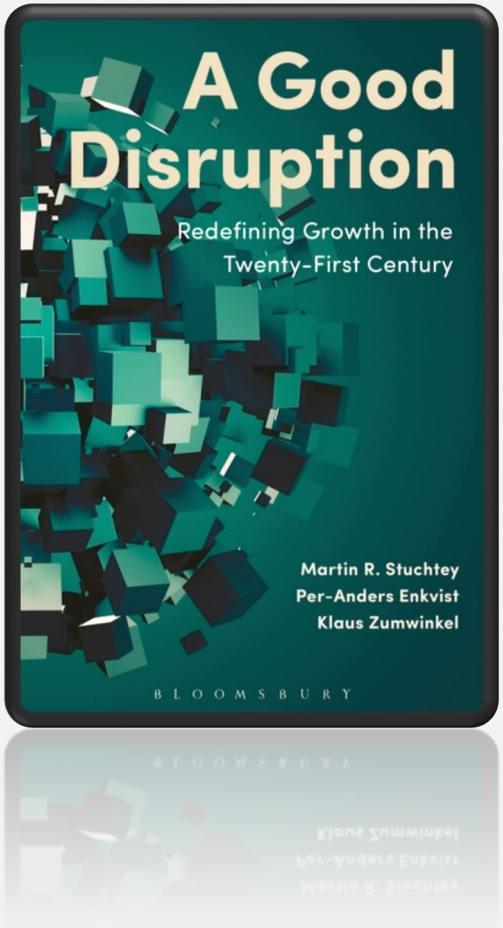
Building the "Grüner Punkt" in Indonesia
The Uber of Waste
STOP
Rebuild

VENTURING

BioCarbon engineering
Electron
Upside Energy
Open Invest

REDIRECTING LARGE-SCALE CAPITAL

Temasek
Blackrock
IFC
Green Finance Institute
Open Invest



Thank you!

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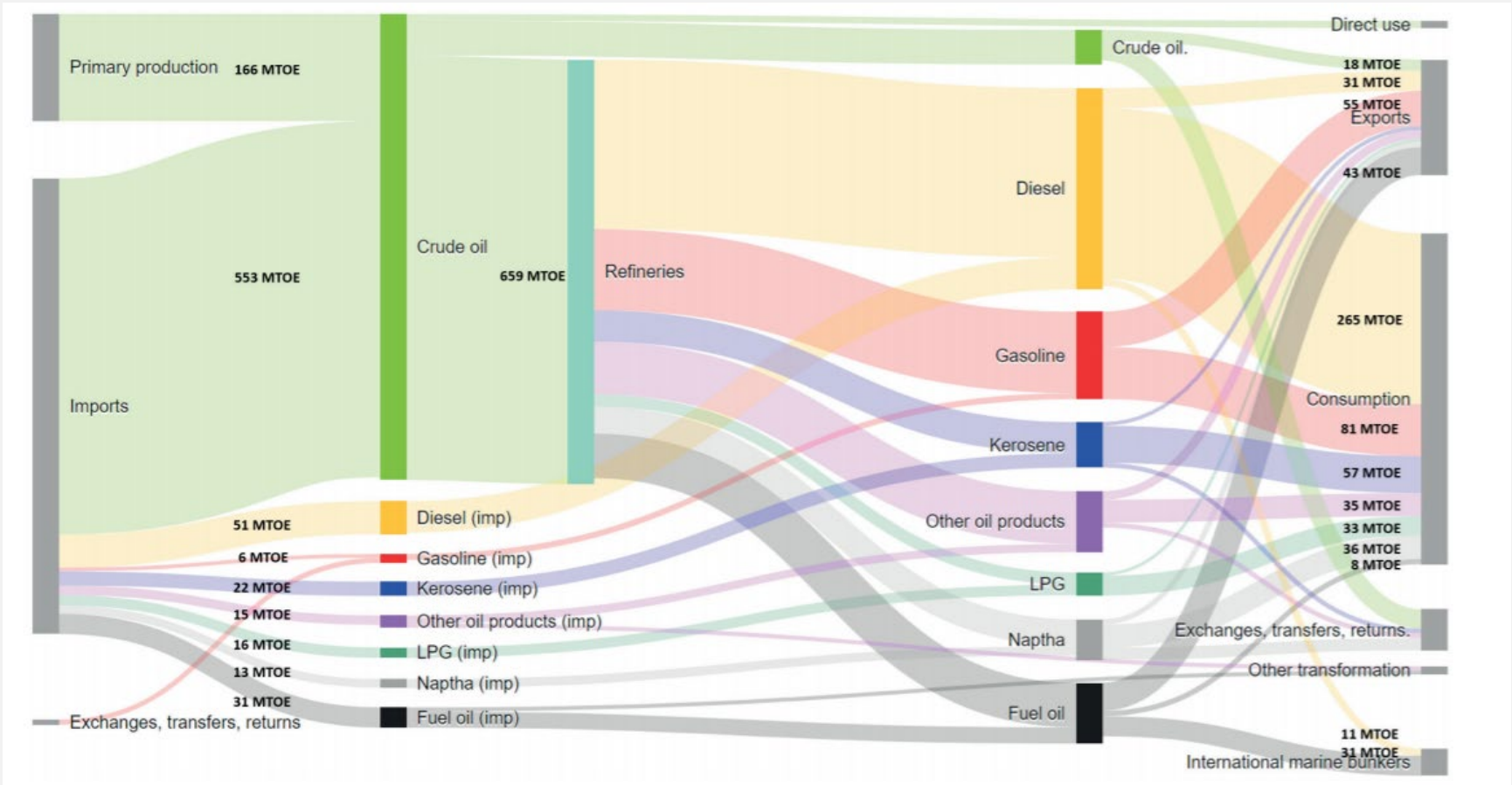
A challenge to the European refinery industry

Europe's petroleum input and output flow



Source: CIEP (2017), *The European Refining Sector: A Diversity of Markets?*

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B The petrochemical industry has started to explore circular polymer opportunities but there is so much more to explore

Bio-based monomer feedstock
Bio-based chemical
- *Butamax (butanol from high value crops)*
- *Bioskoh (ethanol from 2nd gen. feedstocks)*
- *First2Run (integrated biorefinery from dry crops)*
- *Funguschain (chemical and new materials from mushrooms)*

Designing recycling friendly materials
- *Cradle –to-Cradle methodology*
- *Additive flows*

AI empowered chemistry
- *Citrine*
- *ChemAlive*
- *Sustainalyze*

Depolymerization
PA (at industrial scale)
- *Aquafill*

PET (scaling)
- *Demeto*
- *PerPETual*

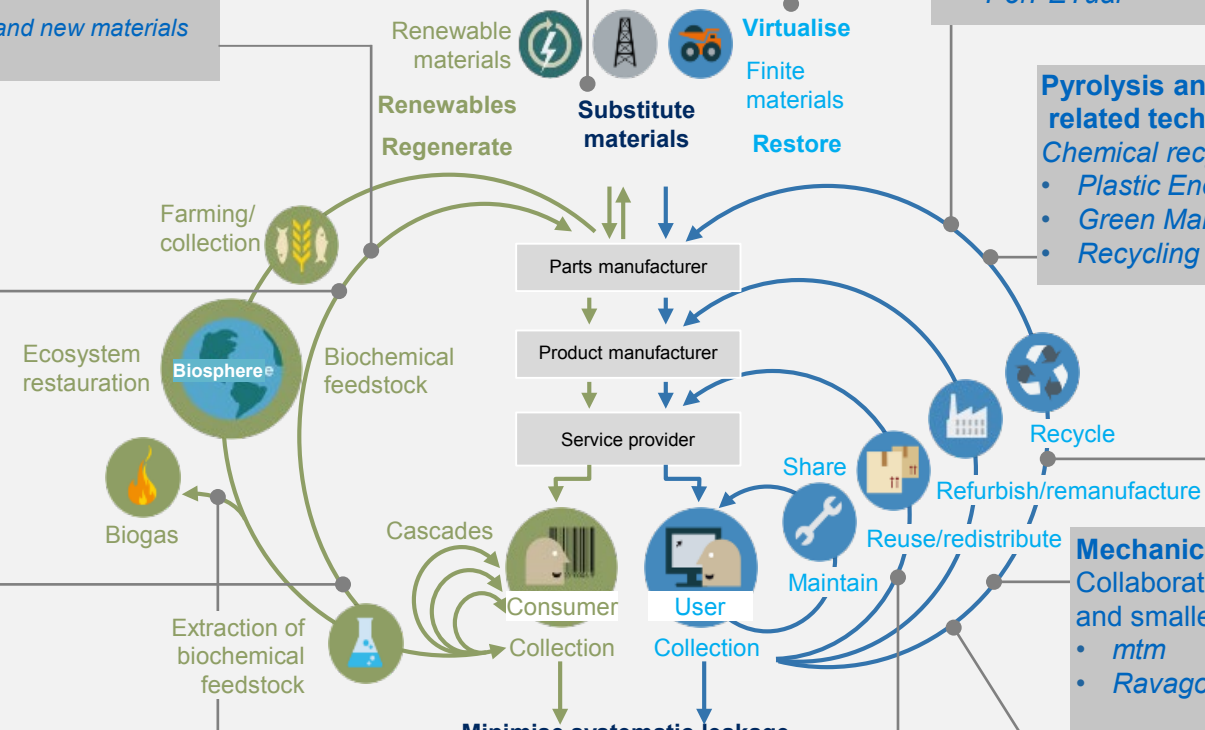
PS (scaling)
- *Agilyx*
- *Pyrowave*

Biogas valorization technologies
Biogas to bio-based biodegradable plastics
- *Full cycle bioplastic*
- *Mango Materials Biogas to proteins*
- *StringBio*

Pyrolysis and related technologies
Chemical recycling for polyolefins
- *Plastic Energy*
- *Green Mantra*
- *Recycling Technologies*

Waste to Resources
Mixed waste to chemicals
- *Consortium Enerkem, AkzoNobel, Air Liquid, City of Rotterdam*
- *Shell (IH² Technology)*
- *Various gasification start-up (Synova, Klean industries)*

Selective extraction
Addressing multi-layer packaging
- *Creasolv*
- *APK recycling*
- *Cleyond*



Mechanical Recycling
Collaborating with large players and smaller innovative start-ups
- *mtm*
- *Ravago*
- *UBQ*
- *Integrico*
- *MacRebur*

Innovative biogas technologies
- *Nexterra (gasification)*
- *Carbonlites (anaerobic digestion)*

Chemicals a service
What can we learn from other industries?
- *SafeChem*
- *EcoLab*

New sorting technology
Empowering the recycling industry
- *Urban mining Corp.*
- *Tomra*

SOURCE: Ellen MacArthur Foundation & SUN (2013)

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