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Prototype for a Carbon Productivity Tool: Framework, metrics and methodologies

ANNEXES TO METHODOLOGY DOCUMENT

Annex 1: Suite of Carbon Productivity metrics considered in prototype

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Measuring carbon productivity – prototype metrics

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Carbon productivity metrics are defined according to the purpose and application

CARBON PRODUCTIVITY	PURPOSE / APPLICATION	METRICS
$\textbf{Carbon productivity} = \dfrac{\text{Value created}}{\text{Non-renewable carbon as input for energy and feedstock}}$	**Measure financial value derived from fossil fuel carbon** *Product life cycle, company*	**Financial Return on Carbon Employed** $\dfrac{\text{Revenue (€)}}{\text{Non-renewable carbon input (Barrels of oil equiv.)}}$
	Measure environmental value derived from fossil fuel carbon (carbon saving in use/after-use) *Product life cycle*	**Environmental Return on Carbon Employed** $\dfrac{\text{Non-renewable carbon use avoided compared to “industry standard” (BOE) *100}}{\text{Non-renewable carbon input (Barrels of oil equiv.)}}$

Note: Non-renewable carbon includes fossil fuel carbon as well as non-renewable biomass (e.g. biomass use that causes net deforestation)
Source: SYSTEMIQ analysis.

Measuring carbon productivity – a suite of metrics for different applications (1)

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Additional metrics are proposed for different applications and for further development

PURPOSE / APPLICATION	METRICS	Notes
Measure financial value derived from fossil fuel carbon *Product life cycle, company*	**Financial Return on Carbon Employed - Revenue** Revenue (€) / Non-renewable carbon input (Barrels of oil equiv.)	• Selected metric for prototype tool • Accessible and comparable basis for FROCE • Includes costs, wages and taxes that can be considered as wider benefits to society, employees and supply chain • Not measuring value (profit) for a company
	Financial Return on Carbon Employed - Earnings EBIT (€) [1] / Non-renewable carbon input (Barrels of oil equiv.)	• Widely used measure for company earnings (profit) that could provide a basis for internal company analysis on value created per unit of fossil carbon • Not always accessible or comparable between companies and does not include wider benefits to society (wages and supply chain)
	Financial Return on Carbon Employed – Revenue + Social Cost Revenue + monetised social cost (€) / Non-renewable carbon input (Barrels of oil equiv.)	• Monetises environmental cost of product life cycles e.g. via open source Environmental Profit and Loss (EPL) accounting • Complete measure of net societal benefits derived from fossil carbon • High effort and cost to compile data

1. EBIT = Earnings before Interest and Tax Note: Non-renewable carbon includes fossil fuel carbon as well as non-renewable biomass (e.g. biomass use that causes net deforestation). Source: SYSTEMIQ analysis.

Measuring carbon productivity – a suite of metrics for different applications (2)

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Additional metrics are proposed for different applications and for further development

PURPOSE / APPLICATION	METRICS	Notes
Measure environmental value derived from fossil fuel carbon (carbon saving in use/after-use) *Product life cycle*	**Environmental Return on Carbon Employed – Relative Over Absolute** Non-renewable carbon use avoided compared to "industry standard" (BOE) * 100 ——— Non-renewable carbon input (Barrels of oil equiv.)	• Selected metric for prototype tool • Widely applicable metric: >0 means product has lifetime carbon benefits; >100 means it is net positive • Consistent with LCA approach • Relies on choice of comparison product • Relative / Absolute metric not consistent with common financial metrics
	Environmental Return on Carbon Employed – Relative Over Relative Non-renewable carbon use avoided in use and after-use compared to "industry standard" ——— Additional non-renewable carbon consumption in production (Barrels of oil equiv.)	• Where this is applicable, it provides a clear and intuitive metric that is consistent with common financial metrics • However, only applicable to products that have a higher consumption of fossil carbon during production phase
	Environmental Return on Carbon Employed – Absolute over Absolute Net non-renewable carbon consumption in use and after-use ——— Non-renewable carbon consumption in production (Barrels of oil equiv.)	• Highlights major driver of carbon consumption in life cycle to target improvement initiatives • As a stand-alone ratio, it does not provide information on magnitude of carbon consumption in either phase of life cycle

Note: Non-renewable carbon includes fossil fuel carbon as well as non-renewable biomass (e.g. biomass use that causes net deforestation)
Source: SYSTEMIQ analysis.

Measuring carbon productivity – a suite of metrics for different applications (3)

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Additional metrics are proposed for different applications and for further development

PURPOSE / APPLICATION	METRICS	Notes
Measure environmental value derived from fossil fuel carbon (carbon saving in use/after-use) *Product life cycle*	**Environmental Return on Carbon Employed – Net Life Cycle Consumption** Net consumption of non-renewable carbon attributable to product across its full life cycle (production + use + after-use)	• Comparable metric that does not rely on choice of “industry standard” comparison • Risk that this is perceived as “shifting blame” or double-counting between companies - not consistent with guidelines on reporting avoided emissions, which recommend differentiation by stage of value chain
	Environmental Return on Carbon Employed – Carbon Payback Period (Relative) $\dfrac{\text{Additional non-renewable carbon consumption in production, relative to industry standard}}{\text{Non-renewable carbon consumption avoided per year of use, relative to industry standard}}$	• Clear and intuitive metric for communicating about use phase benefits of a product • However, only applicable to products that have a higher consumption of fossil carbon during production phase • Does not capture benefits in after-use however could be developed further
	Environmental Return on Carbon Employed – Carbon Payback Period (Absolute) $\dfrac{\text{Non-renewable carbon consumption in production (Barrels of oil equiv.)}}{\text{Non-renewable carbon consumption avoided per year of use, relative to industry standard}}$	• Clear and intuitive metric for communicating about use phase benefits of a product • Only applicable to products that repay their total carbon consumption during use phase • Does not capture benefits in after-use however this metric could be developed further

Note: Non-renewable carbon includes fossil fuel carbon as well as non-renewable biomass (e.g. biomass use that causes net deforestation)
Source: SYSTEMIQ analysis.

Measuring carbon productivity – a suite of metrics for different applications (4)

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Additional metrics are proposed for different applications and for further development

PURPOSE / APPLICATION	METRICS	Notes
Measure environmental value derived from fossil fuel carbon (carbon saving in use/after-use) *Product life cycle*	**Environmental Return on Carbon Employed – <u>Productivity of fossil carbon input</u>** $1 + \left(\frac{\text{Non-renewable carbon use avoided compared to “industry standard” (BOE)}}{\text{Non-renewable carbon input (Barrels of oil equiv.)}} \right)$	• Alternative method to calculate and communicate the relative over absolute ratio, expressed as a percentage • Industry standard product would have 100% return on carbon employed and improved product would have a return above 100% • >200% indicates a “net positive” product that repays its own carbon debt during use and after-use • Consistent with LCA approach • Relies on choice of comparison product

Note: Non-renewable carbon includes fossil fuel carbon as well as non-renewable biomass (e.g. biomass use that causes net deforestation)
Source: SYSTEMIQ analysis.

Annex 2: Carbon productivity framework in the context of the natural carbon cycle

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Maintaining global climate change below 2°C requires a radical shift

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To meet 2°C target and Global Goals (SDGs), we need to derive more value from less fossil carbon

Global Carbon Budget
Based on Paris Agreement

900 Gigatons of CO_2
or equivalent GHG gases

Total emissions between now and 2100

Usable Fossil Fuels
Based on 900 GTCO2e

2,083,690,261,758 Barrel

20-25 years at current consumption rates

Energy required
Good standard of living

100 GJ per person per year

78% per capita increase required in non-OECD countries

Sources: Carbon Tracker Initiative (2013). Unburnable Carbon 2013: Wasted capital and stranded assets. Carbon Tracker and Grantham Research Institute; EIA (2016). Monthly Energy Review; EPA (2015). Inventory of U.S. Greenhouse Gas Emissions and Sinks; The Energy Transition Commission (2017); icons made by Freepic from www.flaticon.com.

Benefits from applying a resource productivity approach to fossil fuel carbon

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FROM...."Carbon is the enemy"	TO..."Carbon as a source of value"
Decarbonisation	Carbon management
Mitigation and reduction	Productivity, value creation and re-coupling to new sources of carbon
Narrow view of GHG emissions from company-owned facilities[1]	Life-cycle and circular view of carbon flows related to a product, including use-phase benefits
Concept divide between climate change mitigation and circular economy	Coherent efforts reconciling climate mitigation and circular economy
One-company carbon efficiency focus	Innovation and collaboration between companies along a product value chain
Zero growth as ultimate recourse	Growth de-coupled from fossil carbon as ultimate recourse

1 Analysis of ET Global 100 data shows that Scope 1 and 2 GHG emissions (emissions related to company-owned facilities and direct energy sourcing) make up less than 30% of the life-cycle emissions of a product, and even for those companies reporting, only one-third report more than five Scope 3 emissions categories

A resource productivity approach to carbon: Introduction

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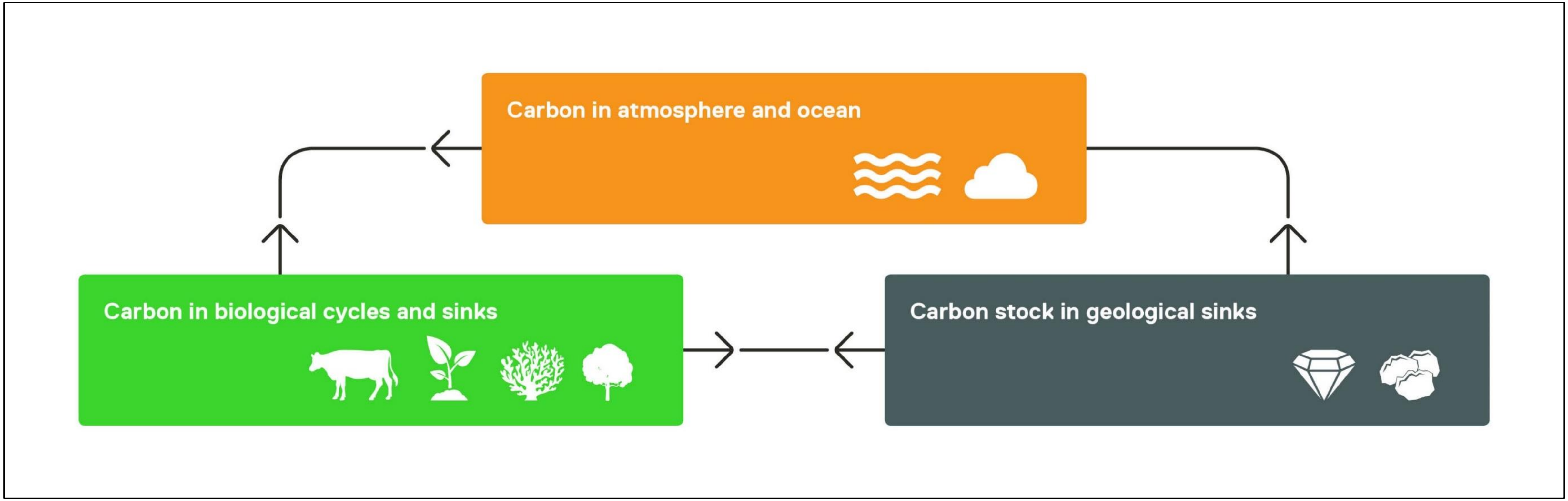
Applying a well-tested concept to fossil fuel carbon

Elements of a resource productivity approach	Benefits	Practical application
❑ Input-based (e.g. barrels of oil rather than emissions) ❑ Measures value generated per unit of resource ❑ Seeks to decouple value creation from resource use	✓ Prioritises high value uses of a resource, or uses with high cost of decoupling ✓ Does not penalise business growth when measuring performance ✓ Takes a life-cycle view of resource use and after-use	▪ Assess and manage risks from dependence on scarce resources ▪ Anticipate market shifts towards substitute resources ▪ Guide and prioritise innovations for decoupling or resource efficiency

References: Eurostat (2017) http://ec.europa.eu/eurostat/statistics-explained/index.php/Resource_productivity_statistics; McKinsey Global Institute (2011): Resource Revolution; Meeting the World's Energy, Materials, Food and Water Needs

A resource productivity approach to carbon: Using the natural carbon cycle as a model (1)

The natural carbon cycle has carbon stocks and flows in balance



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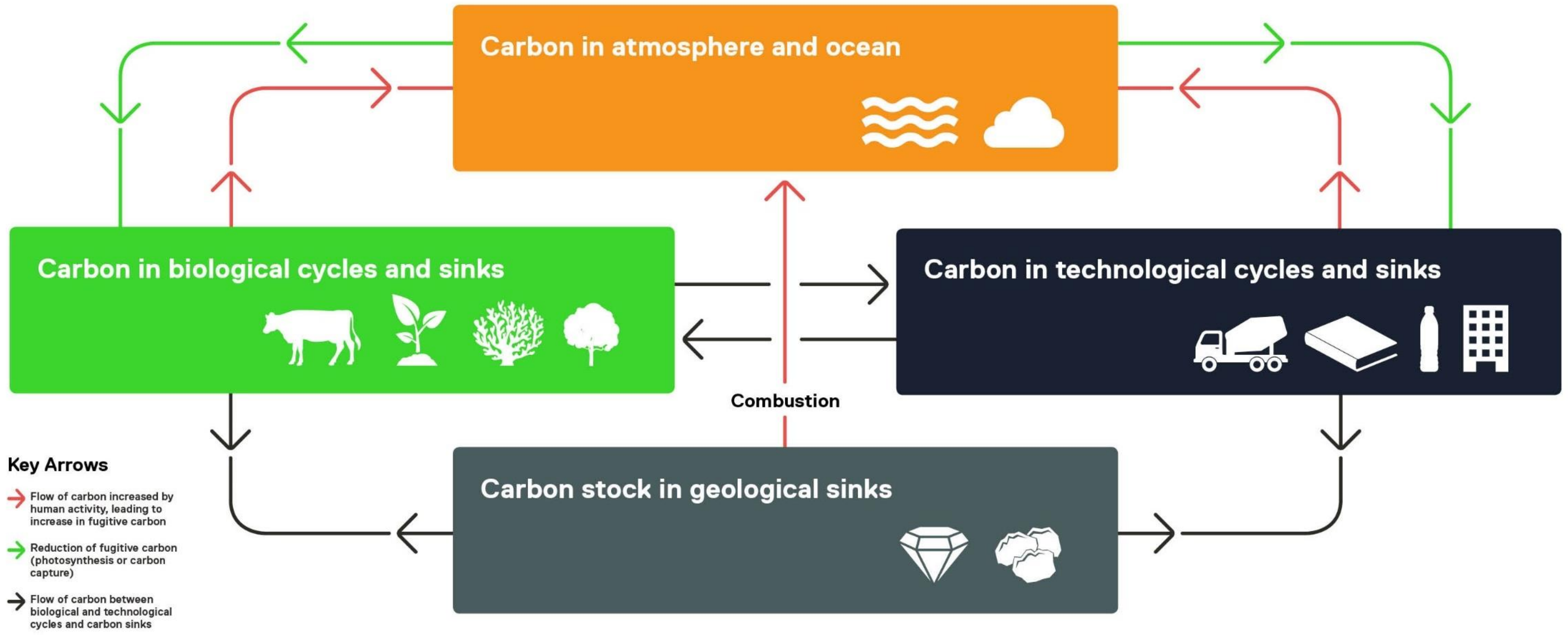
Source: Braungart and Engelfried (1992, Fresenius Envir. Bulletin) *An intelligent product system to replace waste management* / Also draws on McDonough (2016, Nature) *Carbon is not the enemy.*

A resource productivity approach to carbon: The natural carbon cycle provides a model (2)

Human activities increase fugitive carbon through fossil fuel use and impacts on biological cycles



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Source: Braungart and Engelfried (1992, Fresenius Envir. Bulletin) *An intelligent product system to replace waste management* / Also draws on McDonough (2016, Nature) *Carbon is not the enemy.*

Nine levers to improve carbon productivity (1)

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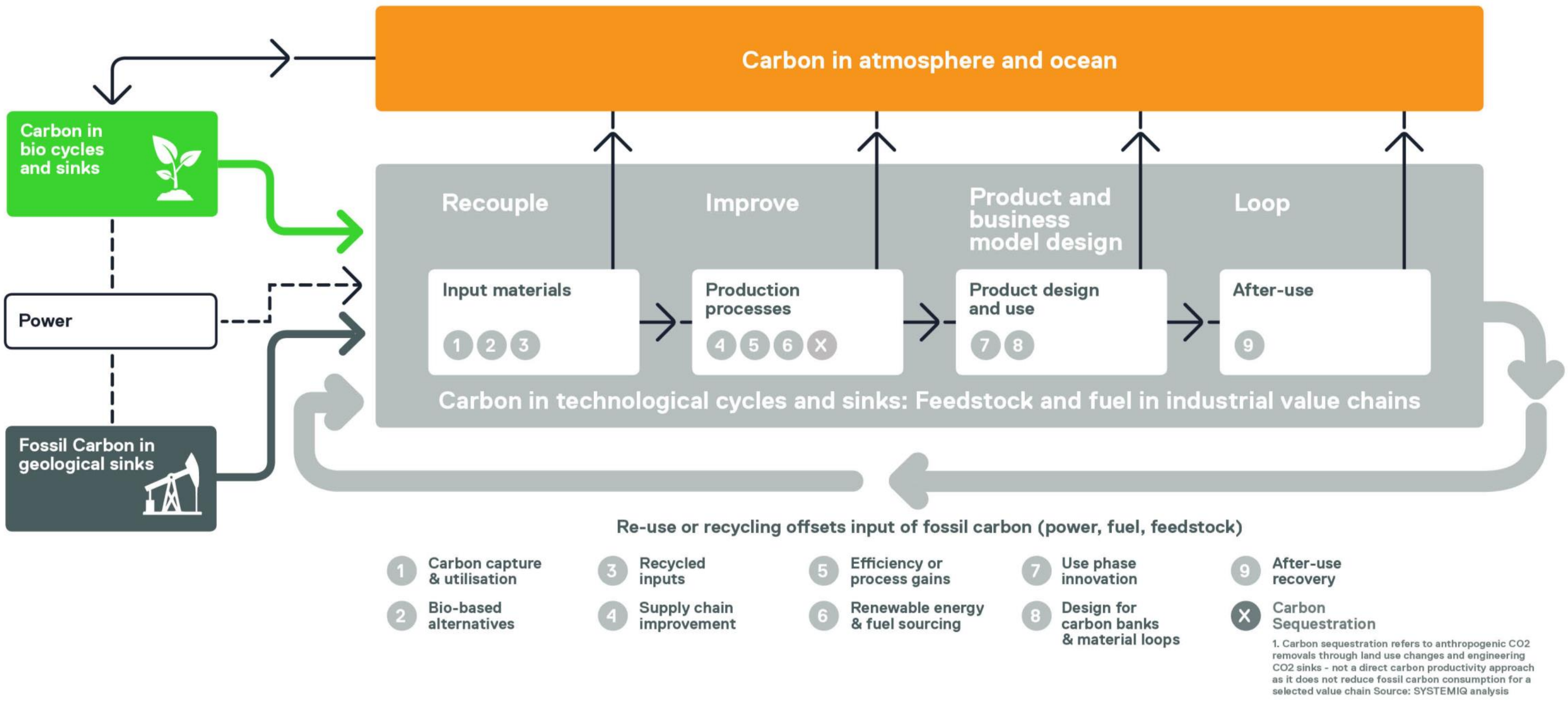

Source: SYSTEMIQ analysis

Nine levers to improve carbon productivity (2)

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	Lever	Description	Examples
1	**Carbon capture and utilisation**	Divert carbon from atmosphere or industrial waste stream into **useful products** (e.g. polymers, construction materials)	CCU into cement, polymers, soda ash, fuels
2	**Recycled inputs**	**Replace virgin with recycled inputs**, reducing fossil fuel required for energy and feedstock	Use of recycled metals, fibres, plastics
3	**Bio-based alternatives**	Substitute fossil carbon feedstock with **sustainable bio-based alternatives**	Bio-based plastics
4	**Supply chain improvements**	Improve energy and material efficiency in **supply chain companies**	Selection of suppliers Supplier engagement
5	**Efficiency or process gains**	Increase energy and material **efficiency in production processes**, or improve processes	Energy efficiency improvements in factories
6	**Renewable energy sourcing**	Increase the share of low-carbon energy in **power/fuel** for production	Switch to renewable electricity or bio-fuels
7	**Use phase innovation**	New or improved **products or business models** that reduce carbon emission reductions in use phase	Business models innovations; renewable energy products; energy-saving products
8	**Design for carbon banks and material loops**	**Product and system design** to enable “carbon banking” and closed material loops	More durable and long-lasting materials and products; design for re-use / recycling
9	**After-use recovery**	Recovery of **after-use products and materials** to enable re-use or recycling	Product or material take-back schemes
x	**Carbon Sequestration[1]**	Divert carbon from atmosphere or industrial emissions into **durable sinks** (e.g. sub-surface storage reservoirs, forests)	Industrial carbon capture and storage (CCS)

1. Included for completeness but not considered a direct carbon productivity approach. Source: SYSTEMIQ analysis

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Collaborative methodology: Applying carbon productivity across value chains

		Input materials	Manufacturer	Retailer	Recovery and recycling
R	1 Carbon capture and utilisation	✓			
	2 Bio-based alternatives	✓			
	3 Recycled inputs	✓	✓		
I	4 Supply chain improvement	✓	✓	✓	
	5 Efficiency or process gains	✓	✓	✓	
	6 Renewable energy and fuel sourcing	✓	✓	✓	
P	7 Use phase innovation – products & business models	✓	✓	✓	
	8 Design for carbon banks and material loops	✓	✓		✓
L	9 After-use recovery			✓	✓

Source: SYSTEMIQ analysis

Annex 3: Worked example of measuring Environmental Return on Carbon Employed

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Example: Environmental return on carbon employed (polycarbonate car windscreen)

Environmental ROCE demonstrates that PC glazing has lifetime carbon benefits relative to industry standard

Polycarbonate windscreen compared to laminated glass:

- Light-weighting reduces fuel consumption by 0.11 BOE over life
- After-use recovery of polycarbonate saves 0.02 BOE
- 0.12 BOE to produce one windscreen; 0.05 BOE for glass

Environmental Return on Carbon Employed (EROCE)

Fossil carbon use avoided
Barrels of oil equivalent
= [**0.11** Use-phase fuel saved compared to glass + **0.02** After-use recovery compared to glass + **-0.07** Adjusted for higher prodn. footprint[1]] *100

Fossil carbon input
Barrels of oil equivalent
= **0.12** Barrels of oil equivalent to produce

=>

EROCE=50

Conclusion:

- Product has lifetime carbon benefits relative to the industry standard
- Half of the total fossil carbon consumed in production is "repaid" during use and after use

1. Polycarbonate production has higher fossil fuel consumption than glass during production. Source: Covestro internal life-cycle analysis data

Applying "suite" of alternative carbon productivity metrics (1)

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Application to polycarbonate windscreen (new product) compared to laminated glass windscreen (standard)

PURPOSE / APPLICATION	METRICS	CALCULATION
Measure environmental value derived from fossil fuel carbon (carbon saving in use/after-use) *Product life cycle*	**Environmental Return on Carbon Employed – Relative Over Absolute** Non-renewable carbon use avoided compared to "industry standard" (BOE) * 100 ――――― Non-renewable carbon input (Barrels of oil equiv.)	• EROCE = 50 • Product has lifetime carbon benefits relative to the industry standard • Half of its total fossil carbon consumption is "repaid" during use and after use
	Environmental Return on Carbon Employed – Relative Over Relative Non-renewable carbon use avoided in use and after-use compared to "industry standard" ――――― Additional non-renewable carbon consumption in production (Barrels of oil equiv.)	• EROCE (Relative over Relative) = 1.9 • The "additional" carbon investment in making a polycarbonate windscreen, compared to the industry standard, is repaid 1.9 times during use and after-use
	Environmental Return on Carbon Employed – Absolute over Absolute Net non-renewable carbon consumption in use and after-use ――――― Non-renewable carbon consumption in production (Barrels of oil equiv.)	• Fossil carbon consumption for a PC windscreen in use and after-use is 2.2x production footprint; Glass windscreen is 7.8x • This ratio would provide some guidance on where to target innovation / improvement activities for different products

Note: Non-renewable carbon includes fossil fuel carbon as well as non-renewable biomass (e.g. biomass use that causes net deforestation)
Source: SYSTEMIQ analysis.

Applying "suite" of alternative carbon productivity metrics (2)

DRAFT

Additional metrics are proposed for different applications and for further development

PURPOSE / APPLICATION	METRICS	CALCULATION
Measure environmental value derived from fossil fuel carbon (carbon saving in use/after-use) *Product life cycle*	**Environmental Return on Carbon Employed – <u>Net Life Cycle Consumption</u>** Net consumption of non-renewable carbon attributable to product across its full life cycle (production + use + after-use)	▪ Net life-cycle fossil carbon consumption forced by PC windscreen is 0.37 BOE ▪ Laminated glass is 0.44 BOE ▪ Net life cycle consumption of fossil carbon is 16% higher for laminated glass, compared to polycarbonate
	Environmental Return on Carbon Employed – <u>Carbon Payback Period (Relative)</u> $\frac{\text{Additional non-renewable carbon consumption in production, relative to industry standard}}{\text{Non-renewable carbon consumption avoided per year of use, relative to industry standard}}$	• Time to payback the additional fossil carbon consumption required to make a polycarbonate windscreen is 7.6 years, compared to industry standard
	Environmental Return on Carbon Employed – <u>Carbon Payback Period (Absolute)</u> $\frac{\text{Non-renewable carbon consumption in production (Barrels of oil equiv.)}}{\text{Non-renewable carbon consumption avoided per year of use, relative to industry standard}}$	• Polycarbonate windscreen does not repay the total carbon consumption for its production during use phase

Note: Non-renewable carbon includes fossil fuel carbon as well as non-renewable biomass (e.g. biomass use that causes net deforestation)
Source: SYSTEMIQ analysis.

Measuring carbon productivity – a suite of metrics for different applications (3)

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Additional metrics are proposed for different applications and for further development

PURPOSE / APPLICATION	METRICS	Notes
Measure environmental value derived from fossil fuel carbon (carbon saving in use/after-use) *Product life cycle*	**Environmental Return on Carbon Employed – <u>Productivity of fossil carbon input</u>** $1 + \left(\frac{\text{Non-renewable carbon use avoided compared to “industry standard” (BOE)}}{\text{Non-renewable carbon input (Barrels of oil equiv.)}} \right)$	• EROCE = 150% • Product has lifetime carbon benefits relative to the industry standard • Half of its total fossil carbon consumption is “repaid” during use and after use

Note: Non-renewable carbon includes fossil fuel carbon as well as non-renewable biomass (e.g. biomass use that causes net deforestation)
Source: SYSTEMIQ analysis.

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