Prototype for a Carbon Productivity Tool: Framework, metrics and methodologies
Developed by SYSTEMIQ, Future-Fit Foundation and the Carbon Productivity Consortium
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This prototype tool is intended for intended for companies involved in product value chains, and others that have an interest in improving the climate impacts of product life-cycles. Interested parties are invited to provide feedback, join a working group to develop and apply the tool, or to adapt and develop for their own use (contact: ben.dixon@systemiq.earth).

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1. Overview

What is Carbon Productivity?

Carbon productivity measures the value created from carbon resources, just as labour productivity measures the value created from human resources. Carbon resources can come from geological sources (e.g. fossil carbon in the form of coal, oil and gas) or biological cycles (e.g. from plants and soils). This prototype tool focuses on value creation from fossil carbon.

In 2015, the Paris Agreement and the Global Goals for Sustainable Development framed three critical and inter-linked challenge for society:

- **Drastically reducing consumption of fossil carbon** (coal, oil and gas) in order to reduce the flow of greenhouse gases into the atmosphere
- **Maintaining and growing healthy and productive economies** around the world, to increase human well-being, alleviate poverty and deliver the Global Goals
- **Protecting, enhancing and creating natural or man-made sinks for carbon** (e.g. forests, soils, and useful products containing captured CO_2), to remove greenhouse gases from the atmosphere

Balancing the three challenges above to restrict global climate change to well below 2˚C requires us to wean our economy off fossil carbon, and to achieve a huge leap in the value generated from each unit of fossil carbon that we use – in other words, we need a breakthrough in carbon productivity.

Why do we need a new tool?

This prototype complements existing tools for understanding, reporting and improving the climate impact of a company or product – for example Life Cycle Assessment (LCA), the Greenhouse Gas Protocol, the Carbon Disclosure Project, Science-Based Targets and many others. It does not replace any of these existing tools.

A carbon productivity tool can provide value for private sector companies and other audiences, in three ways:

- Providing a fresh perspective on carbon as a valued input rather than a waste product (CO_2), which gives actionable insight for companies to reduce their climate impact and grow their business by generating more value from less fossil carbon
- Enabling a life-cycle and circular economy view on industrial processes and products to guide carbon productivity improvements – including innovation and design of products that have a positive impact on fossil fuel consumption during their use phase
- Proposing metrics and templates to measure carbon productivity and guide innovation and improvement activities by a company or multiple companies across a product value chain and life cycle.

Use of a carbon productivity concept and tool should be grounded in a commitment to reduction in fossil carbon use in line with the Paris Agreement and a well below 2˚C climate target. As with the emissions intensity metrics used by many companies, year-on-year improvements in carbon productivity are meaningful only in the context of this absolute trajectory.

Why should we optimise our use of fossil carbon?

In general, a resource productivity approach is applied when a resource is scarce or supply is threatened.

Fossil carbon is not scarce in nature, however burning of fossil carbon produces CO_2 and other greenhouse gases (GHGs). The Paris Agreement places tight limits on GHG emissions and under a 2˚C climate target it restricts us to around 20-25 years of fossil fuel consumption, at current consumption levels, before we exceed the total limit for emissions between 2015-2100[1].

Without large scale carbon capture and storage (CCS) most of the fossil carbon in nature is "unburnable", so the usable portion should be considered as a scare and valuable resource to be optimised.

What is the purpose and audience for the prototype tool?

The prototype tool is intended for companies involved in product value chains, and others that have an interest in improving the climate impacts of product life-cycles.

A carbon productivity tool can provide companies with new actionable insights as they seek to manage risks of new regulations and shifts in investor and customer expectations on climate change and to identify and take advantage of breakthrough business opportunities in key markets including energy generation, efficiency and storage, transportation and the built environment.

The purpose of the prototype tool is threefold:

1. To measure carbon productivity at company and product level, through prototype **metrics**
2. To enable a circular life-cycle perspective on carbon productivity, through a prototype **improvement framework** that draws on the natural carbon cycle and identifies the levers that can be pulled to effect productivity gains

[1] 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.

3. To support collaboration on carbon productivity, between companies in a value chain, through a prototype **collaboration methodology**

What are next steps in development of the prototype tool?

The prototype tool has been developed by the Carbon Productivity Consortium with input from representatives of companies, consultancies, academic institutions and NGOs actively working on climate change mitigation and life cycle assessment. It will be discussed at the Carbon Productivity Basecamp event on June 14th 2017, in London.

Companies, consultancies, academic institutions and NGOs are invited to provide input on the prototype tool, join a working group that will further develop the tool during Q3 2017, and volunteer to pilot use of the prototype tool for one or more product value chain(s).

2. Carbon productivity metrics

Carbon productivity measures the value created from fossil carbon resources (coal, oil and natural gas). Applying this concept to specific companies or products requires robust and insightful metrics that can be practically applied by companies.

A metric design process carried out for this project identified a number of options (outlined further in Annex 1). Two prototype metrics are proposed for two different applications of the carbon productivity concept (Exhibit 3), although other options can be used and further developed where appropriate. The metrics draw on data from life cycle assessment methodologies.

Financial Return on Carbon Employed (FROCE):

- measures the financial value (revenue) derived per unit of fossil carbon used;
- uses the most widely available measure of financial value (revenue), but other measures of value could be considered in future developments of the tool;
- includes energy and feedstock carbon (e.g. for chemicals or materials produced from oil) and does not differentiate between different sources of fossil carbon (oil, coal or gas), as it is intended to give a clear and simple perspective on fossil carbon use.

Environmental Return on Carbon Employed (EROCE):

- measures the environmental value (fossil carbon consumption avoided) derived per unit of fossil carbon used
- applies to a new or improved product that avoids fossil carbon consumption during its use or after-use, compared to an existing product;
- guides innovation towards "net positive" products - since an EROCE score greater than 100 indicates that a new or improved product avoids more fossil carbon consumption (in use and after-use) than the consumption required to create it. An EROCE score greater than zero indicates that the product has life-cycle carbon benefits relative to the industry standard.

The EROCE calculation and concept depends on comparison of a new or improved product, to an existing product that is generally accepted as widely used or the "industry standard" for the product. It is aligned with existing methodologies[2] and is applicable to guiding innovation / improvement programmes rather

[2] For example: WBCSD (2013): Addressing the avoided emissions challenge. http://wbcsdpublications.org/project/addressing-the-avoided-emissions-challenge/

than static measurements, since the new or improved product could soon become the “industry standard”, at which point the metric is no longer applicable.

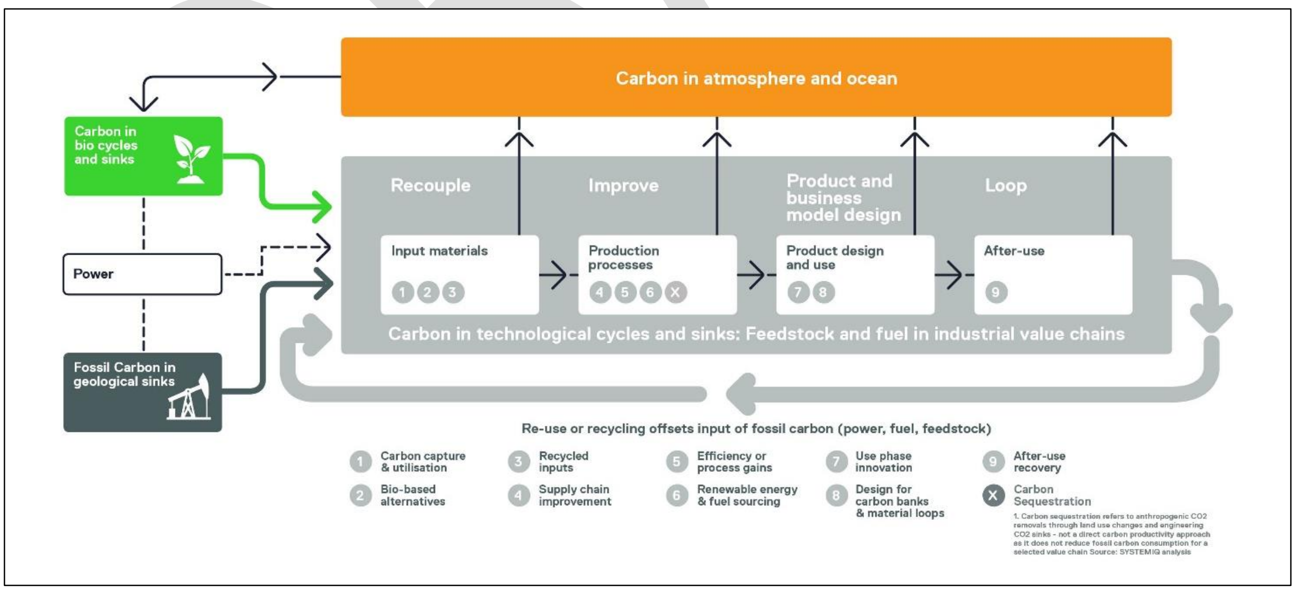
Exhibit 3: Prototype carbon productivity metrics

CARBON PRODUCTIVITY	PURPOSE / APPLICATION	METRICS
Carbon productivity = Value created / 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** Revenue (€) / 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** Non-renewable carbon use avoided/forced in use & after-use (BOE) / Non-renewable carbon input (Barrels of oil equiv.)

3. Framework for improving carbon productivity

The purpose of the carbon productivity **framework** is to provide insight for companies to improve the carbon productivity of their processes and products. The framework identifies nine “improvement levers” that represent the full set of options available to improve carbon productivity, across four areas: **R**ecouple > **I**mprove > **P**roduct and Business Model Design > **L**oop (Exhibits 1 and 2).

Exhibit 1: The RIPL framework for improving carbon productivity



The RIPL framework is rooted in an understanding of the natural carbon cycle – with balanced flows of carbon between geological sinks, biological cycles and sinks, and the atmosphere and ocean – and the influence of human activity on the carbon cycle - dramatically increasing the flow of "fugitive" carbon into the atmosphere and ocean, and creating new technological cycles and sinks for carbon. The connection to the natural carbon cycle is explained further in Annex 2.

The framework can be used to facilitate strategic conversations about innovation and carbon productivity improvement strategies within companies and between companies at different stages of the value chain. A prototype collaboration methodology for collaborative innovation is described below.

Exhibit 2: Improvement levers for improving carbon productivity

	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

4. Applications of carbon productivity

As a concept, carbon productivity – creating more value from less fossil carbon – can be applied broadly to guide planning and action by companies, government agencies and other institutions working on climate change mitigation.

Carbon productivity metrics are designed for companies involved in product value chains, and others that have an interest in improving the climate impacts of product life-cycles. Three applications are proposed:

1. **Guiding innovation and improvement:** Metrics can be used by companies to guide innovation towards "net positive" products that avoid fossil carbon consumption in their use and after-use phases (Environmental Return on Carbon Employed). They can also be used to facilitate collaborative innovation between companies across a product value chain and life cycle (see below).
2. **Setting targets and tracking performance:** Carbon productivity targets and tracking over time (based on Financial Return on Carbon Employed) allow companies to measure and communicate their progress in generating more value from less fossil carbon. Carbon productivity targets could be aligned with Science-Based Targets that set GHG emission targets aligned with global climate goals (2˚C target).

3. **Comparing products and companies (with care):** The Environmental Return on Carbon Employed compares a new or improved product to an existing product. Other **product comparisons** could also be made using both metrics - for example within an overall product portfolio - however this should ensure a “fair” comparison that takes into account the nature of the product, position in value chain, and cost of decoupling the product from fossil carbon. Similarly, the metrics could be used to **compare companies** on their financial return on carbon employed, but this comparison is confounded by differences in the product portfolio and position in the value chain – comparing companies on their targets and improvements over time is likely to be more insightful.

For all applications of carbon productivity, users are encouraged to consider potential unintended consequences on other social and environmental values, that might result from application of carbon productivity improvement levers. Guidance is provided in the prototype methodology.

Exhibit 3: Environmental Return on Carbon Employed (Polycarbonate Car Windscreen)

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)

Life cycle saving of fossil carbon (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 / after-use**

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

5. Applying carbon productivity to a product value chain and life cycle

The potential for collaborative innovation between companies in a product value chain has been highlighted by studies and examples of improved environmental and social performance[3]. Companies working alone tend to focus on improvements through efficiency, procurement and energy switching, whilst collaborative approaches can unlock breakthrough innovation on new feedstocks, product and business model design and circular economy approaches.

Collaborative innovation approaches require a common framework, language and measurement methodology to enable effective and well-targeted strategies and a fair allocation of efforts between companies. The carbon productivity framework and metrics provide a template for collaborative innovation, based on life cycle assessment, that can quantify opportunities, identify “hotspots” for reducing fossil carbon consumption across a product value chain and life cycle, and track performance over time.

[3] For example: WBCSD (2011), Collaboration, Innovation, Transformation. http://www.wbcsd.org/Clusters/Sustainable-Lifestyles/News/How-to-guide-launched-to-increase-business-competitiveness-with-sustainable-value-chains

Application of this methodology provides a baseline assessment of carbon productivity and allows companies to quantify and prioritise improvement levers and set targets, based on the RIPL framework. Principles and implementation steps for applying the framework and metrics to a product value chain and life cycle are outlined in Exhibit 4.

Exhibit 4: Principles and implementation steps for application of framework

Application to a product value chain and life cycle	Principles for application	Implementation steps
Tool is applied to guide companies in a value chain to apply the levers in the RIPL framework and achieve three goals: 1. Increase the value derived from each unit of fossil carbon used 2. Reduce the consumption of fossil carbon attributable to the production, use and after-use phases of a product 3. Avoid unintended consequences from applying the levers, on other environmental and social values	Application is based on a Life Cycle Assessment (LCA) • Fossil fuel consumption (abiotic depletion – fossil) for all inputs, production processes and after-use • After-use of products (e.g. recycling) is based on a realistic assessment of after-use pathway and "avoided burden" of fossil carbon consumption in next production cycle • Other environmental and social impacts assessed where they may be altered by improvement levers Complementary to other climate-related metrics • "Global warming potential" can be assessed alongside carbon productivity Practical and cost-effective • Greatest attention to the steps with the highest fossil carbon consumption and/or highest potential for absolute improvement	1. Assemble collaborative group of companies working in value chain, with agreement on objectives, confidentiality and cost sharing for assessment 2. Define product and base year 3. Define value chain 4. Conduct life cycle assessment (baseline) 5. Identify solutions and targets using the RIPL framework 6. Screen for potential unintended consequences 7. Implement solutions and measure improvements over baseline

6. Limitations and topics for further development

Three topics are noted for further work and consultation, in future developments of this prototype tool:

1. Application of the concept and tool to companies or products that are "fully decoupled" from fossil carbon

Along with other resource productivity metrics, carbon productivity cannot measure the performance of companies or products that are fully decoupled from the resource (fossil carbon). This means that companies or products achieving a target state of 100% renewable energy and feedstock would effectively "break" the metric. Whilst this is a limitation that warrants further work, it is not considered a high priority as mainstream industrial production is far from this target state today.

2. Application of the concept and tool to understand and improve carbon flows in biological cycles and sinks

The prototype tool focuses on uses of fossil carbon in industrial systems. Carbon flows in biological cycles and sinks also have a significant impact on climate change and will play a significant role in solutions to maintain global climate change within 2˚C – for example, protecting, restoring and enhancing natural sinks for carbon (e.g. forests) and protecting or restoring the carbon storage capacity of soils by adopting improving agricultural practices. Developing the concept and tool to support improvements in this area could be the subject of a second prototype tool and methodology.

3. Calculating time horizons, defining industrial carbon sinks and assessing "net present value" of carbon productivity improvements

The prototype tool does not include an assessment of the relative timing of fossil fuel consumption and GHG emissions across a product life cycle. For example, fossil carbon consumption (and emissions) avoided by a lightweight gasoline-powered car would accrue over a lifetime of c. 12 years, compared to consumption of fossil fuels (and emissions) in the production of that car. Materials that contain carbon and have a long lifetime, flow in closed loop circular systems, or are never likely to be incinerated (e.g. some building materials) could also be considered as long-term industrial carbon sinks and this concept is not currently considered in the tool.

7. Methodologies and Annexes

Methodologies:

- Calculating Financial Return on Carbon Employed
- Calculating Environmental Return on Carbon Employed
- Applying carbon productivity to a product value chain and life cycle
- Screening unintended consequences on other environmental and social values

See attached Microsoft Excel file

Annexes:

- Annex 1: Suite of Carbon Productivity metrics considered in prototype
- Annex 2: Carbon productivity framework in the context of the natural carbon cycle
- Annex 3: Worked example of measuring Environmental Return on Carbon Employed

See attached Microsoft PowerPoint file