Net zero product discovery

A framework for the future

cambridgeconsultants

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1 Executive summary

The race towards net zero is well and truly on. As momentum gathers pace, businesses everywhere are facing up to the challenge of an ever pressing global imperative for change.

Innovative minds attuned to the threat of environmental catastrophe are turning their attention to the opportunities offered by transformative products and services. More specifically, they are targeting solutions that not only provide sustainability benefits but deliver highly competitive and differentiating customer value propositions.

The challenge demands a radical reworking of traditional and increasingly outdated approaches to product development. This whitepaper explores such a way forward. It guides you through the complexities of net zero product innovation and presents a clear framework for the future, founded on a broad and robust working methodology.

We examine the potential rewards of sustainable yet multidimensional business growth and reveal why whole system mapping is a prerequisite for driving essential system-level – not just product-level – innovation. Detail is of course crucial, so we also take you, step-by-by step, through the four phases of the product discovery framework: Research, Define, Ideate and Develop.

2 Introduction: embracing net zero

The course is set. Businesses and nations are now alive to the diverse opportunities that will flow from transforming and contributing to a global society with net zero emissions. 50% of global GDP is covered by net zero initiatives set by regions or countries committed to achieving the goal by 2050, if not before. (Race To Zero Campaign, 2020).[1]

Wide-reaching cross-sector initiatives by multinational corporations are springing up to encourage and support other companies on the journey. In one example, Danone, Nike, Unilever, Microsoft and others have launched Transform to Net Zero – offering guidance and frameworks to accelerate the global transition towards a net zero economy (Microsoft & PwC, 2020).[2] More than 340 companies – including Astra Zeneca, Vodafone and Diageo – have set net zero targets in line with a 1.5°C future (Science based targets, 2020).[3] The ambition is clear. Our whitepaper sets out to explain the vital role that systemic net zero product development will play in realising it.

Any lingering debates about the urgency to halve greenhouse gas (GHG) emissions this decade or become a net zero society by 2050 are over. Action is essential to limit global warming to 1.5°C and avoid devastating impacts on humanity and nature. Threats include – but are not limited to – rising sea levels, biodiversity loss and increasingly frequent and severe weather events. The spectres of destroyed livelihoods, increased resource scarcity and reduced food security loom. Forty-six per cent of people say they are now personally affected by environmental problems, with climate change being their primary concern (Kantar, 2020).[4]

Previously, minimising climate change had been considered synonymous with sacrifice and compromise – in terms of consumer experience as well as profitability. This lens is now outdated. 67% of consumers across the world are actively trying to buy products produced in an environmentally friendly way (Microsoft & PwC, 2020).[5] Meanwhile, swathes of multinationals are declaring ambitious net zero goals that are consistent with Paris Agreement emission reduction targets. Growth in VC investment in climate tech is currently three times the growth in artificial intelligence (PwC, 2020).

50% of global GDP
is now covered by leading net zero initiatives

Over 340 companies
have set net zero targets in line with a 1.5°C future

Growth in VC investment in climate tech is currently
3x the growth in artificial intelligence

46% of people
state that they are now personally affected by environmental problems

An average company has **5.5x greater** supply chain emissions to direct emissions

91% of Apple's carbonfootprint
is attributed to the manufacturing and use of its products

Figure 1: Infographic - 2020 statistics

Emissions reduction targets extend beyond a company's direct emissions and include those associated with the manufacture and use of their products. Quite rightly so. The average company's supply chains emissions are five and a half times greater than their direct emissions (CDP, 2019).[6] No less than 91% of Apple's carbon footprint, for example, is attributed to the manufacturing and use of its products (Apple, 2020).[7] Net zero product development, abating emissions from across a product's life cycle, is absolutely integral in realising companies' net zero goals.

Net zero products cannot be developed in isolation of the system that will ultimately support their manufacture, distribution and disposal; nor the consumers who will use them. Yes, most consumers will be seeking sustainable products. But these must differentiate themselves over incumbent competition by improving the customer value proposition beyond environmental benefits alone. Right now, sustainable products appeal mostly to early adopters who are often willing to sacrifice affordability, efficiency and performance. But this is not a sustainable commercial strategy.

We believe that net zero product development demands a radically new product discovery framework. It should include multidisciplinary teams focused on system-level transformation, consumer-centred design and innovation that places the system and consumer – not just the product – at the core of the process.

This paper presents our vision for the framework, which integrates research, analysis, clearly defined sustainability goals and design to develop net zero product systems. It will allow teams to deliver products that are not just net zero, but also respond to environmental concerns such as plastic waste, water and air pollution, and deforestation.

3 The opportunity for sustainable, multidimensional growth

Developing net zero products using a framework that focuses on system-level innovation provides inherent benefits to companies and consumers alike. And it readily accommodates additional sustainability goals beyond reduction in GHG emissions. This ensures that net zero products will stimulate multidimensional growth for companies and societies, realising immediate positive impacts in addition to the harm-minimisation strategy of limiting global warming to 1.5°C.

Our approach provides the opportunity and necessity to deliver products with improved consumer experiences. System-level innovation will invariably impact at least one form of consumer interaction with the product (purchase, use, transportation and disposal, for example) to deliver on its sustainability goals. Most consumers will be eager to purchase environmentally friendly products. But few are willing to make sacrifices to consumer experience compared to that offered by existing, less sustainable competitive products. Improved consumer experience is therefore a requirement to deliver a commercially sustainable product.

This fact promises to empower more employees in innovation. It demands a broader, more diverse product development team compared to those used in traditional product development. Integrating user-centred design, system-level design and product technical design will engage employees from multiple departments in the process of developing net zero products.

Additional opportunities for improved sustainability can be identified and captured alongside targeting zero GHG emissions. The triple bottom line is a valuable approach of identifying and categorising these additional goals considering people, planet and profit:

PEOPLE

Social bottom line considers benefits and costs across multiple stakeholders, striving to improve social and equity conditions. Key stakeholders include end consumers, employees, local communities and communities impacted by company operations. Some examples? Abolishing child labour, improving working conditions, safety and wellbeing and improving the status of women

PLANET

Environmental bottom line considers the impact that businesses have on the environment. While limiting global warming to 1.5°C is essential to minimise environmental harm, other environmental goals promise immediate benefits to the local and global environment. Examples include reducing fossil fuel energy use, eliminating plastic waste, reducing use of toxics, and preventing deforestation, soil loss, erosion and ecosystem destruction

PROFIT

Economic bottom line considers not only company commercial profit but also the impact on the health of the local economy and stakeholders along the global value chain. Choice of suppliers, employee salaries, fair prices for commodities and raw materials, and longevity of a product to thrive in the market are all examples of factors that contribute to this metric

Figure 2: The triple bottom line

Nine categories of impact provide comprehensive coverage of sustainability issues which can be mapped against the triple bottom line (Schöggl et al., 2016[8]): lowering negative environmental impacts from waste, resource deficiency, transport and logistics, economic efficiency and profitability, resource consumption, optimisation of end-of-life, selection of low impact materials, health and safety, and social and ethical considerations. These categories should form a checklist against which the system can be evaluated during ideation and subsequent development. Explicit consideration of the system against each category can expose system strengths and weaknesses, informing areas of focus during concept development activities.

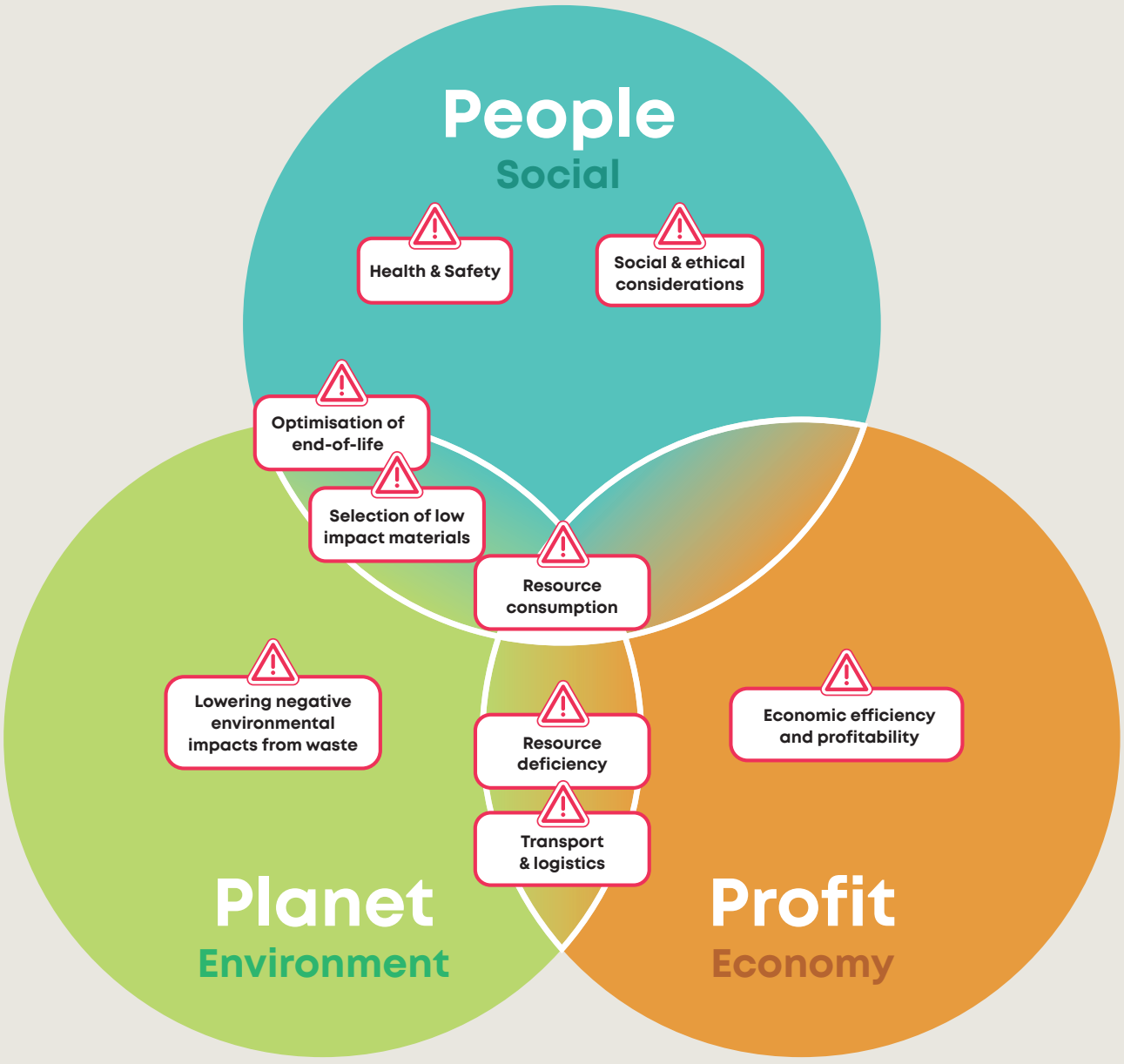


Figure 3: The nine categories of impact

4 Using whole system mapping to drive system-level innovation

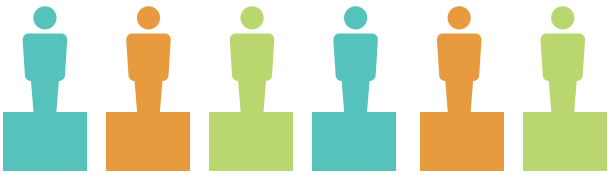
Net zero product development requires innovation across a product's entire value chain. Crucially, it must consider supply chain and consumer use, both typically the key sources of Scope 3 GHG emissions which often outweigh all other sources of corporate GHG emissions. Emissions associated with consumer use and end-of-life, for instance, can contribute up to 66% of the total emissions associated with consumer packaged goods (CPG) companies (Unilever, 2020).[9]

Companies committed to reducing these sources may look to address individual value chain nodes independently. For example, the supply chain department may conduct extensive assessment of their current supply chain, potentially introducing initiatives to incentivise suppliers to reduce their emissions. This is often challenging due to limited data or visibility of supply chain beyond tier 1 and 2. In parallel, R&D and product development may use their existing product development process to explore new products that introduce new technologies and user experiences to reduce consumer use emissions.

The risk of a segmented approach is that key opportunities will be missed. It is also less likely to deliver a product that delivers consistent environmental, societal, commercial and consumer benefits. Segmented teams are often constrained or restricted by requirements imposed by value chain functions beyond their remit. These might include manufacturing constraints imposed on product development, or distribution constraints imposed on the supply chain due to assumed consumer purchasing patterns. A systemic approach, empowering employees from across the value chain to form a cross-functional, collaborative development team, breaks down the barriers between functions and provides an engaging platform for truly disruptive successful net zero innovation.

A segmented approach

Key opportunities could be missed and teams are often constrained by value chain requirements



A systemic approach

A cross-functional, collaborative team breaks down function barriers and can enable disruptive innovation

Figure 4: The benefits of a systemic approach

Cambridge Consultants' process is customised to each client, depending on their economic and operational requirements. It uses the principles of Whole System Mapping, first developed for the Autodesk Sustainability Workshop in 2010 by Jeremy Faludi, now at TU Delft, and used by dozens of companies and universities around the world.[10] This facilitates innovation by the creation of invaluable visual maps of the product's system. They not only capture the flow of materials, energy, money and/or emissions within a product system, but also how individuals and societies both influence and are influenced by the same system. This approach will identify products that sufficiently reduce GHG emissions – and achieve supplementary sustainability goals.

"The risk of a segmented approach is that key opportunities will be missed. It is also less likely to deliver a product that delivers consistent environmental, societal, commercial and consumer benefits."

A system level approach, using whole system maps as a visual tool, enables product development teams to:

Engage and empower employees from across their company to work together to collaboratively develop products. A whole system map provides a clear vision across the company of the system required to sustainably achieve net zero

Help identify technological, social and cultural factors that can act as either levers for change or challenges to be de-risked and overcome before implementation

Identify and explore system-level issues. The goal of achieving net zero must be evaluated alongside other objectives including impact on the earth, on society and on the company. The cross-functional development team must have authority to negotiate across competing priorities and drive through difficult decisions. Senior stakeholder engagement and trust is key to success

Identify risks and mitigation strategies to reduce the impact of unintended consequences

Embrace the flexible, experimental and iterative approach to developing a sustainable net zero product

Monitor the iterative development and evolution of a concept system map throughout development

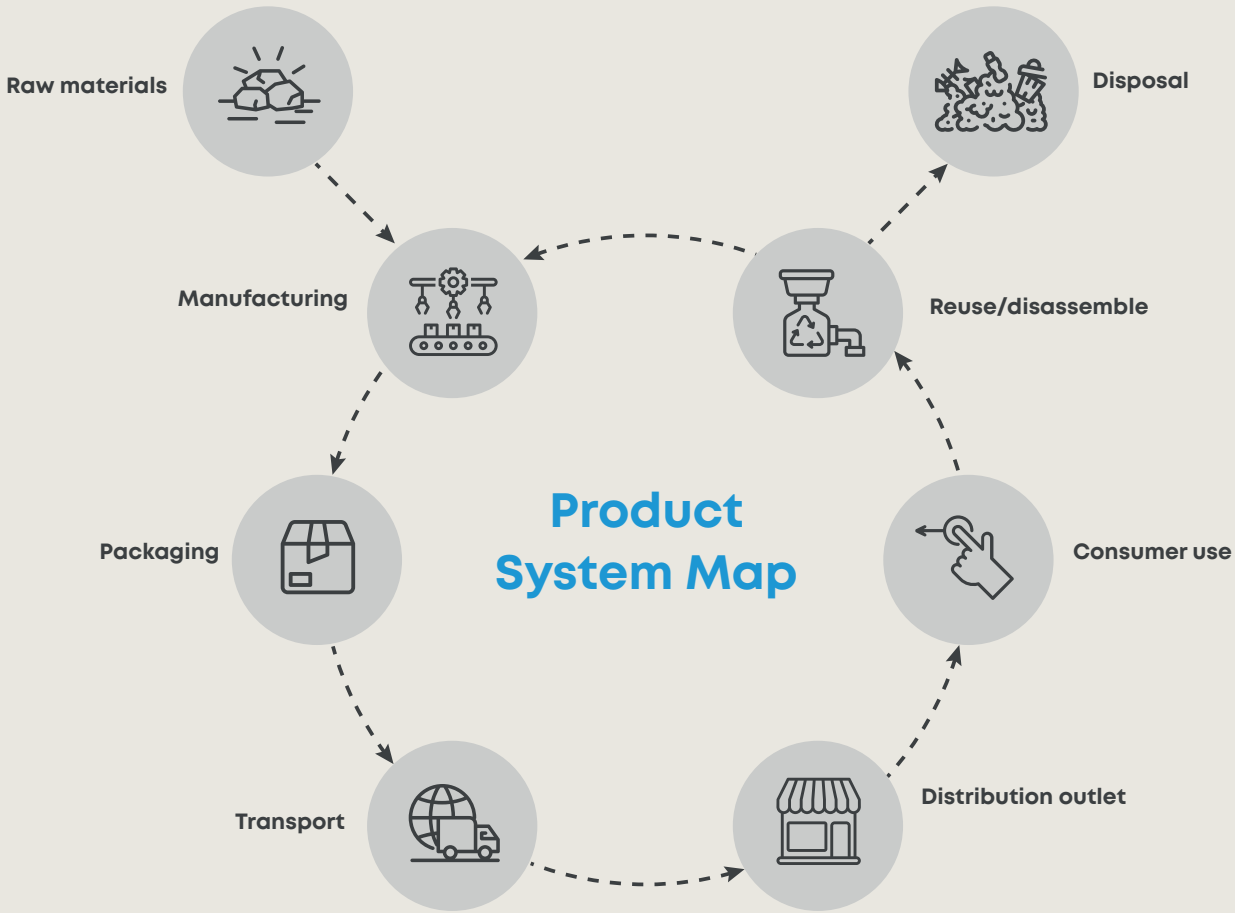


Figure 5: The product system map

5 The product discovery framework explained

Let's be clear. The framework presented in this paper is specifically designed to facilitate net zero product innovation. It integrates stakeholders from across departments into a cross-functional development team that is able to approach product innovation from a system level. And it places the entire system that supports a product as 'in scope for innovation'. This is vital, because it is the source of many GHG emissions and adverse environmental impacts associated with companies and their products.

Our framework goes against the grain of traditional product development processes where engineers and designers address a problem by breaking it down into pieces. While a fragmented node-centric approach can be useful for developing topical expertise or local solutions, considering product development initially at the system level provides an opportunity for much greater impact.

The framework is founded on a number of imperatives. To be successful, a programme must:

Engrain product whole system maps at its core. They elegantly capture and visually communicate complex product systems. They encourage both thorough system-level innovation and node-based de-risking and development. And they provide live snapshots of the concept system as it continually evolves and develops. This graphical approach facilitates senior stakeholder engagement and offers a common language between the many disciplines that are involved in net zero product development

Engage companywide stakeholders and experts in the product discovery process. System-level disruption will require engagement and support from across corporate departments. Involving multiple stakeholders from the outset of innovation will improve critical engagement, generate more creative solutions, and uncover and support entrepreneurial employees from across organisations. Key departments to involve are R&D, product development, supply chain and marketing

Embrace uncertainty and learning with iterative learning cycles. Net zero product development is challenging. There are initially many unknown unknowns. Iterative timeboxed learning cycles, focused on a common goal of developing a concept product system map, ensures teams focus on the highest cross-functional risks. Iterative development promotes the value of learning and encourages findings to be woven back into the new product system

Continually evaluate sustainability performance and alignment with other requirements. Regular evaluation of the concept system's performance against GHG emission and other environmental targets will ensure alignment with sustainability goals and potentially unlock opportunities for further design improvements. Systematic measurement will help ensure that the system meets the required net zero aligned sustainability goals

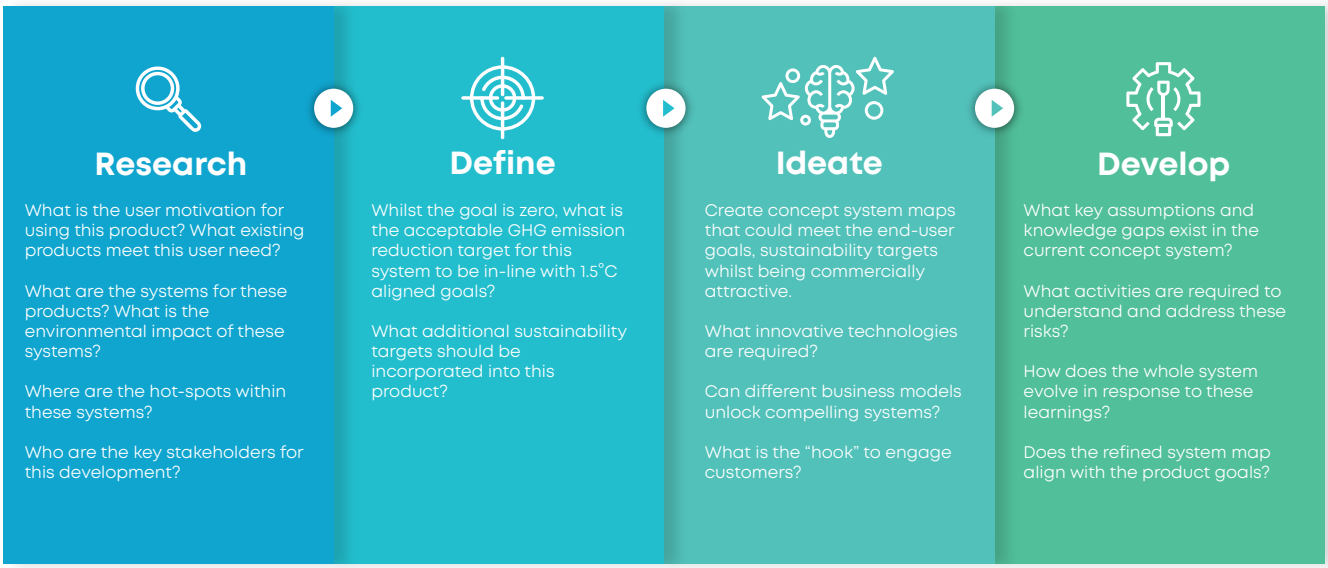


Figure 6: The four phases of the framework

5.1 Research

Radical innovation demands sound understanding and clearly defined goals. Traditional product development processes can be too constrained to allow the freedom required to create net zero products. A different approach is needed, which should begin with research right at the outset to focus and align product development teams.

User story focus should initially spotlight user motivation, not the product. What is the purpose of the product? What are the consumers trying to achieve? Defining this early in product development anchors and motivates the development team to achieve a common goal. This goal must be inherently solution agnostic – ensuring that it does not constrain innovation.

Traditional product development will typically begin with drafting a product requirements specification, which is inherently solution specific. It makes various assumptions that act to define and constrain the product system map. These assumptions are usually related to technologies, materials, manufacturing processes or technical expertise associated with incumbent products. Focusing only on the end user motivation during research will not inhibit innovation and ideation.

"Radical innovation demands sound understanding and clearly defined goals. Traditional product development processes can be too constrained to allow the freedom required to create net zero products."

Product discovery

System map analysis introduces maps and quantifiable analysis into the process at the beginning – starting with existing products that achieve the same end user goal. The environmental impact of these systems should be quantified by literature research or appropriate use of life cycle assessments (LCAs). This will identify hotspots in a product's system to focus innovation and set a benchmark against which concept systems can be analysed. This analysis can highlight key differences that exist between product ranges within a company. For example, a cosmetics company is likely to find that the hotspots for haircare, skincare and makeup are all likely to differ between consumer use, raw materials and packaging.

The sources and details of these system maps will be company specific, with different strategies being relevant to start-ups and mature enterprises. The latter are likely to be able to create system maps based on existing products, assuming close alignment to the end user goal, whereas a start-up will probably have to generate system maps based on competitor or similar products that meet a similar goal.

System map generation will require cross-functional involvement. It is the first opportunity to identify stakeholders who may be peripheral to a traditional product development process but integral to net zero innovation. Purchasing and supply chain departments will be required to fully interrogate the supply chain, diving deep beyond tier 1 and 2 suppliers.

Marketing and sales will be needed to highlight the different consumer purchasing and use patterns, all of which are likely to have different environmental impact. End-of-life considerations are crucially in scope as a concern and responsibility for the product development team. There will be opportunities to engage circular economy principles, eliminating waste and unnecessary emissions, while unlocking transformative business models and new sources of insights or revenue.

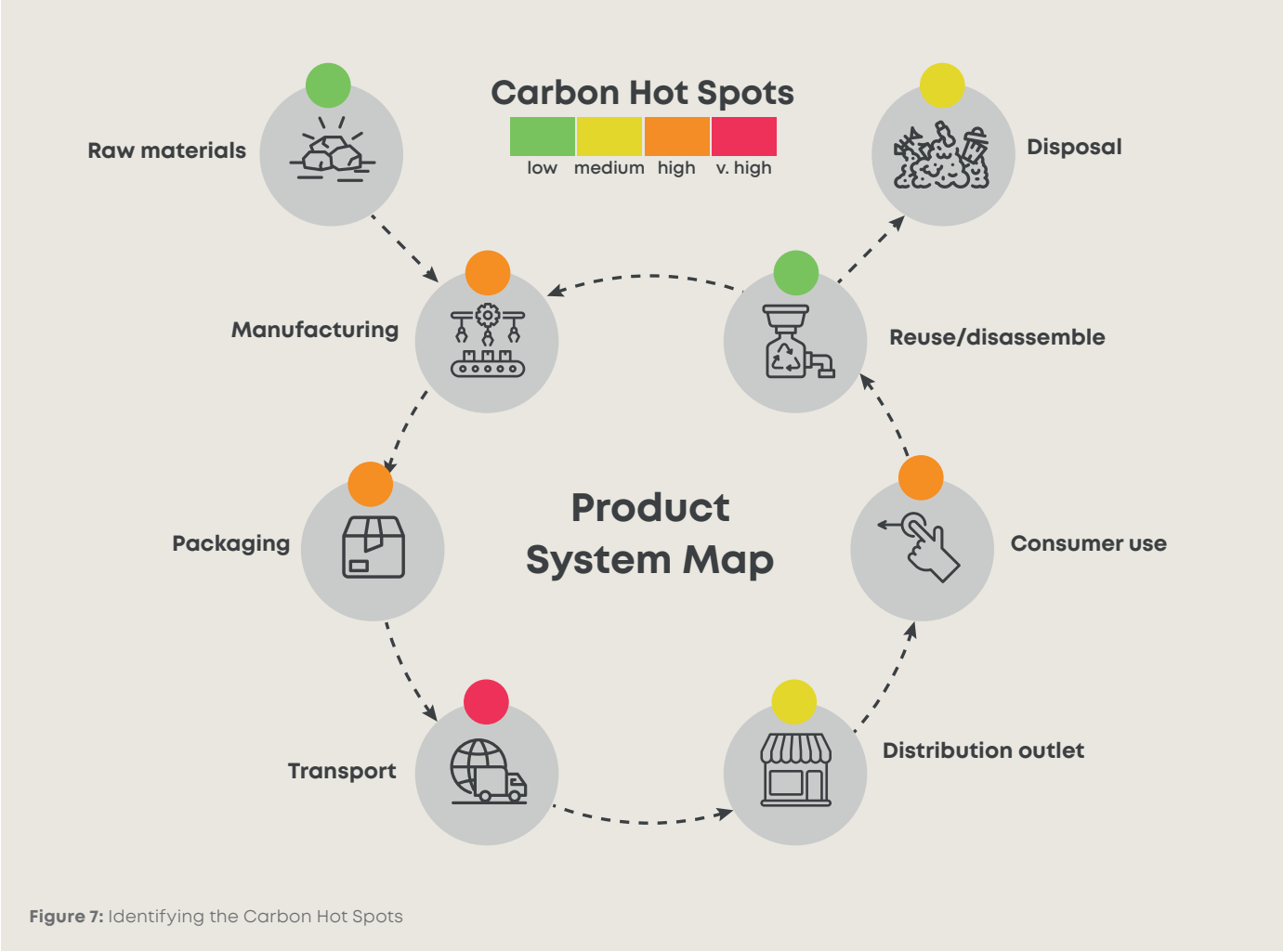


Figure 7: Identifying the Carbon Hot Spots

5.2 Define

With the focus of product development pinpointed on net zero goals, it's important to identify other appropriate sustainability objectives that should be incorporated. These additional goals can be diverse, depending on industry, and can be gathered from multiple sources. The hotspots identified by the whole system maps of current product systems will often identify other sustainability related objectives such as land use and plastic waste. Additionally, corporate sustainability goals will often extend beyond net zero goals and can provide sources for further objectives that a new product system should align with.

It's crucial that society focusses on accelerating towards net zero CO_2 emissions. All development teams should set true net zero GHG as the ultimate goal for their product system. But it is important to appreciate technological, commercial and regulatory limitations that may, in the short-term, mean products still have residual net-CO_2 emissions. The acceptance of this temporary transient should not be exploited during early-stage product system ideation.

It could be tempting to adopt a minimum viable approach to sustainable product development, implementing the bare minimum required to meet corporate level sustainability goals. But this approach introduces risk rather than eliminating it. It also kerbs innovation, restricts ideation and stops companies and societies fully benefiting from the opportunities that net zero products provide.

Translating corporate net zero goals directly onto all products within a company's portfolio assumes that the challenges to achieve the goals are of equal magnitude for each product

Minimum viable goals restrict innovation and ideation. Concept systems identified today, while perhaps too immature to be incorporated into a product system for immediate launch, stimulate valuable research projects, unlocking differentiating technology for subsequent products

Limitations in a system's ability to achieve true net zero in required launch timescales is assessed and accounted for later in the development cycle (the Develop stage). Identifying and understanding company-level CO_2 reduction goals, especially Scope 3 goals and how the product timescales and lifetime will be impacted by them, will be important to consider during concept system development. Residual unabated emissions should be quantified and compensated in the transition to net zero.

While key stakeholders may have been identified during Research, to define and quantify system maps, their involvement should be cemented by involving them in Define too. Company level sustainability goals may be broken down into function-specific goals and strategies. It is essential that the product development team has full exposure to them. The most efficient approach embraces the involvement of employees from different departments in key aspects of product system innovation to leverage their expertise and consolidate their investment in the programme. This will act to mitigate the risk of anti-sponsors for the disruption that a net zero system is likely to necessitate.

A workshop – involving the extended cross-functional team to explore and confirm relevant sustainability goals – is a highly effective tool. It helps achieve alignment, support and direction ahead of system-level innovation. The goals should be integrated into the consumer attractiveness and business fit criteria that are often weighted and used to score concepts systems to assist in down-selection.

Sometimes sustainability can conflict with wider aims or criteria, which need to be teased out and identified separately. Sustainability can no longer be regarded as just another criterion, as this has a damping or averaging effect on concept scoring. Detailed sustainability criteria need to be both integrated alongside the important consumer and business criteria for relative weighting but subsequently filtered and mapped on separate axis. This enables development teams to interrogate the degree of alignment or conflict between the consumers and business between the relative sustainability goals. Mapping on a separate axis forces important questions to be faced: what are we NOT going to do and what are we going to do instead?

Broader sustainability goals should be used to define sustainable system objectives in addition to achieving net zero CO_2 emissions. These will then be used as supplementary objectives during system-level ideation. Concept systems will continually be assessed against these objectives.

What company-level sustainability goals exist?

- Does the company have a science-based CO_2
- reduction target?
- Do these align with any of the 17 UN Sustainable
- Development Goals (SDG's)?
- What residual CO_2 emissions are acceptable for this product to maintain alignment with 1.5°C global warming?

What aspects of sustainability are most important to target consumers?

What aspects of society are currently most impacted by existing products (as identified during *Research*)?

Figure 8: Key questions to be considered

5.3 Ideate

Ideation workshops are the ideal environment for radical innovation. They ease the creation of concept system maps that focus on meeting both net zero and the supplementary sustainability system objectives defined during Define. The ultimate goal of the workshops is to create concept system maps for subsequent development. It is crucial that creativity and innovation should is not stifled or restricted… system-risks will be identified, prioritised and addressed during subsequent development.

Research conducted in producing and assessing product system maps of existing products during Research should not inhibit creativity during the workshops. But insights on key hotspots will be valuable in identifying key hurdles that could exist in future concept systems. Ideation should initially focus on developing solutions to the user story defined during Research and subsequently focus on developing a whole system map that meets the defined sustainability objectives.

Whole system maps present an ideal framework for structuring system-level ideation:

1. Ideate and prioritise attractive user stories
2. Ideate and capture a visual representation of a system that can enable an attractive user story while meeting sustainable objectives
3. Conduct further system-level ideation on draft product systems, focusing on developing alternative approaches for nodes within the system map and approaches that could eliminate nodes from the system
4. Assess concept system maps against sustainable system objectives for down-selection and further subsequent development and de-risking

"A workshop – involving the extended cross-functional team to explore and confirm relevant sustainability goals – is a highly effective tool. It helps achieve alignment, support and direction ahead of system-level innovation."

5.4 Develop

Concept system maps should be developed and de-risked using an iterative sprint-based approach. Iterative development is best because of the high-level of uncertainty when evolving and de-risking radical net zero maps. Development activities will reveal opportunities and challenges that were not considered during initial ideation. Iterative development provides a framework that allows these learnings to be captured and incorporated back into the system for future cycles. This approach also elevates the value of learning, ensuring that it is captured for use in subsequent development cycles or future products.

It is during this stage of net zero product innovation that further requirements should be integrated into the development process:

- Timescale to launch
- Anticipated product lifetime throughout the system. For example, how many years will this product be manufactured for? And how many years will consumers use this product?
- End-of-life considerations

Throughout development, it will be essential to analyse the viability of a system to reach a balance between CO_2 emissions and removals within the context of these additional product requirements. Depending on the specific source of emissions, compensation of unabated CO_2 emissions may be an appropriate approach to enable this product to be net zero. These decisions should be grounded in science. Research into suitable residual emissions for different sectors of the economy where emission abatement is infeasible, is currently being completed by organisations such as Science Based Targets (Science based targets, 2020).[11]

A cross-functional development team can effectively de-risk and develop key functions of this system using an integrated approach. This ensures that all stakeholders remain involved in developing the product system and that overall product risk is managed across all disciplines. Key challenges and unknowns associated with the current concept product system will be identified and de-risked using a systematic process:

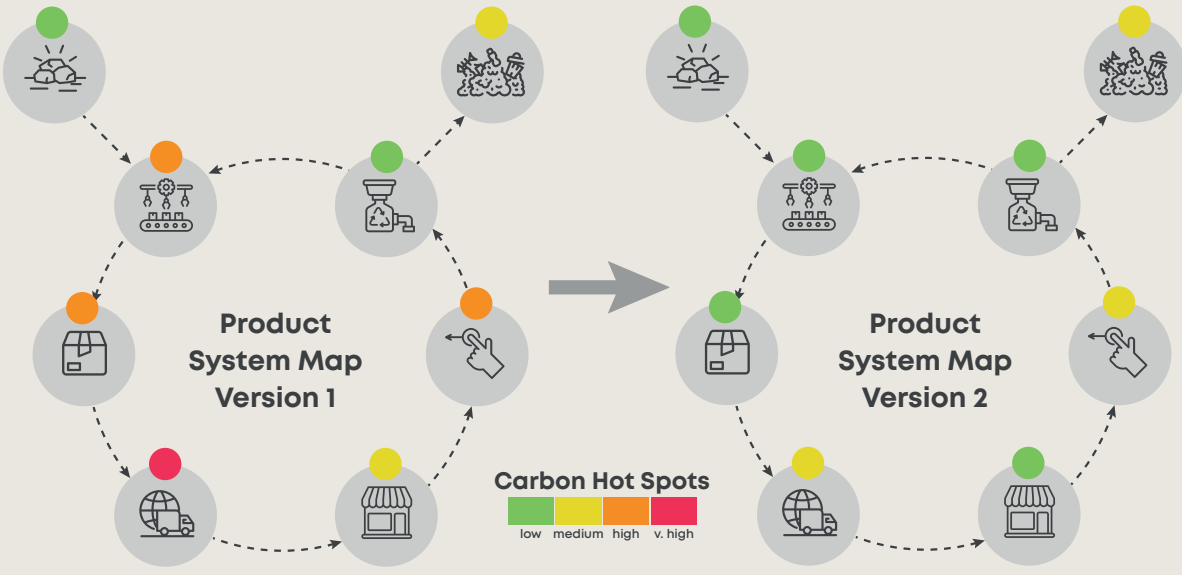


Figure 9: Potential improvement using an iterative approach

Identify

Identify assumptions and key knowledge gaps that exist in the current concept system map. These should be populated in a risk-register/backlog, and classified as commercial, technical, user-centred or environmental knowledge gaps – and then prioritised.

Plan

Each iterative cycle should focus on addressing the highest risk knowledge gaps in the backlog. The goal of a learning cycle should be to present an updated product system map that incorporates the learnings from the highlighted knowledge gaps.

Evolve

Specific activities should be grounded in seeking an answer to the specific knowledge gap with subject matter experts from across the team. All disciplines are equally important in ensuring a successful product is developed and learnings in one discipline are likely to impact other aspects of the system. So it is essential that all disciplines are developed simultaneously during development.

- Confidence in commercial viability should be interrogated alongside all other activities. Net zero system maps may require unconventional business models (e.g. converting products to services)
- Net zero products may require innovative technology deployment in any aspect of the system (e.g. raw ingredient manufacture, disassembly, logistics). Technical knowledge gaps can focus on identifying and developing enabling technologies for these products
- Elevated consumer experience is likely to be key for successful adoption of a net zero product. The consumer journey/experience should be continually evaluated and evolved throughout this phase.
- The ability of the system to meet the sustainability goals identified in Define should be continually assessed (e.g. can glass ampules be manufactured using renewable electricity? Will users accept having to shake their product for 5 mins to activate a key reaction?)

Update

The answers to each knowledge gap should make a recommendation about the current product system map. These recommendations should be integrated into an updated system concept map. The environmental impact of this updated product system should be continually updated to quantifiably understand both its absolute environmental impact and relative evolution versus previous cycles and existing systems evaluated during the Research stage. This will ensure that the system remains grounded in science-based environmental impacts.

This iterative process will increase product maturity, reduce risk and capture learnings that will be valuable for future product development cycles. The product system will converge to a state where (alongside identified outstanding assumptions and risks) the development team can validate that the product system will:

- **Meet the sustainability goals captured in Define**
- **Meet the user-needs identified in Research**
- **Be commercially viable**
- **Be technically feasible**

This level of maturity enables product teams to transition from product discovery into product execution where conventional product development processes are suitable for further development. These processes should be supplemented with additional feedback loops that ensure continued alignment with the sustainability goals as the system continues to mature.

Figure 10: An iterative sprint-based approach

Case study – The framework in action: shampoo concept

The framework for net-zero product discovery has been applied to shampoo. It is an example that demonstrates how the framework presented in this paper can be used to develop concepts that reduce Scope 1, 2 & 3 CO2 emissions. This is a key requirement if companies are to realise their net-zero aligned emission reduction goals while addressing multiple additional sustainability impact areas.

The approach integrates sustainability goals into the needs of both the consumers and the business. It focuses on ensuring that user experience is elevated and enhanced compared to competitive products, while still being a commercially compelling concept for the business. Shampoo is a consumer-packaged goods (CPG) product that combines a challenging use-case and diverse range of adverse sustainable impacts on societies.

The system map of shampoo below highlights its relative carbon emissions hotspots and additional identified sustainability impact areas. This analysis shows that water heating, water treatment, packaging manufacture and distribution have the largest impact on CO2 emissions, predominantly due to the use of fossil fuels as the source of energy for the processes at each of these nodes.

In addition to identifying carbon hotspots, research identified the need to improve the adverse environmental impacts of deforestation to source materials, poor air quality due to particulates from distribution pollution and minimising the harm of waste by reducing single use plastics.

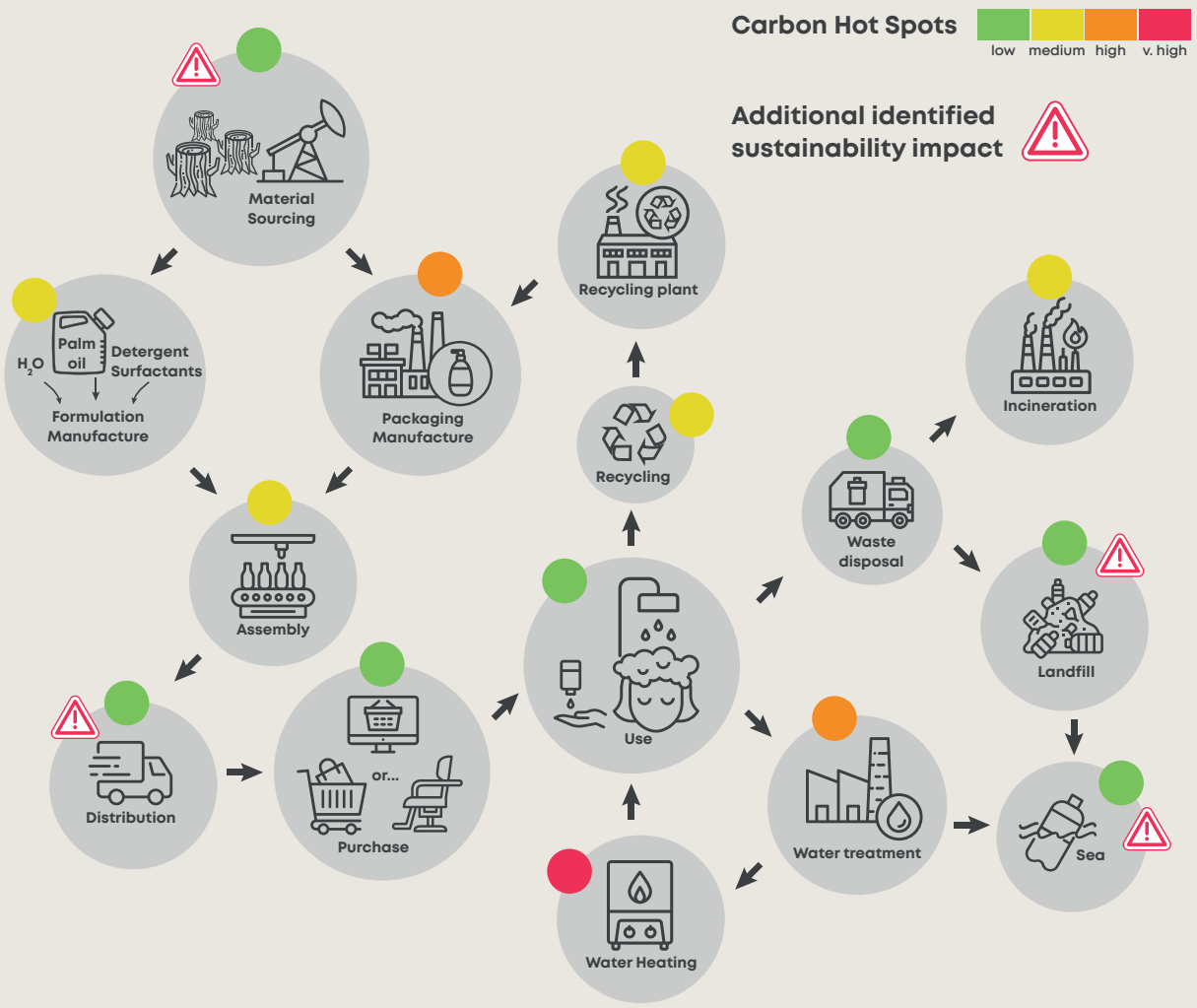


Figure 11: Shampoo system map showing carbon hot spots and additional impacts

It is important to note that the results listed above would not be highlighted by a product-centric approach, nor one that does not look beyond the boundaries of what is done inside the company alone. Yet these are the very areas that need to be investigated and understood to successfully create a net zero product that meets a company's ambitions.

These insights can be used to define sustainability goals that are integrated into the business and consumer objectives that will also be defined to frame concept innovation. Ideation workshops are subsequently the ideal environment to explore and uncover concept systems that aim to meet the defined sustainability goals as well as satisfying the key product goals.

A potential design solution

This concept replaces the recyclable, yet still widely incinerated or landfilled PET shampoo bottle with a durable wooden container, embodying CO_2 through in its fabric and demonstrating a shift in the value proposition and design approach for CPG consumables. It demonstrates a dramatic move away from the status quo of a 'low value – okay to dispose' consumable. Instead, it provides differentiation by designing for permanence and longevity, and with the added benefit of increased visual aesthetic.

Here, the vessel – reusable and repairable by design – can be refilled at local retail locations using a bespoke dispense system that mixes ingredients at the point of dispense. This paves the way for new opportunities to engage consumers with enhanced, personalised shampoo products and experiences. The physical aspects of the vessel, shampoo and dispense system can be fused with a digital service that offers data-driven customisation, improved product recommendations, differentiated propositions and – ultimately – heightened brand loyalty.

Also, crucially, this means that the water (which forms >80% of shampoo product) can be added at the point of dispense. This drastically reduces the distribution volume to retailers, cutting CO_2 emissions and adverse impacts on air quality due to particulates arising from distribution. This reduction in emissions could be further improved with an electrified fleet charged from renewable electricity sources.

The environmental impacts of the surfactants in the shampoo – coming under increasing consumer scrutiny because of habitat destruction and deforestation from coconut and palm oil production – can be mitigated by using algae. This can produce the fatty acids that can be further processed into these bases, which could reduce deforestation and inefficient land use.

This concept could involve a business model where the business retains responsibility for replacement, restoration, and end-of-life disposal of the container. This could be achieved, for example, by incentivising consumers to return containers via a deposit scheme.

When containers are no longer suitable for continued use or repair, the maintained control of end-of-life for the containers means any adverse environmental impacts can minimised. For instance, the choice of wooden materials means that containers could be used as feedstock for bioenergy with carbon capture and storage (BECCS), a net-negative emissions energy technology.

In addition to being a luxury consumer product, the container can now act as an energy vector for net-negative electricity generation. Energy that is captured during growth via photosynthesis is converted into electricity via incineration at end-of-life, crucially capturing and storing the resulting CO_2 generated during combustion. The sustainability impact and CO_2 emissions associated with manufacture can be reduced by selecting suppliers and manufacturers based on their use of renewable energy sources.

Although this concept wouldn't actively reduce emissions associated with consumer use of the shampoo inside the bottle, it is very feasible to consider a situation where emissions are reduced by electrification of domestic water heating, the use of heat pumps to displace gas fired boilers or – longer term – the use of green hydrogen instead of gas, with associated transition towards renewable energy for water treatment. Earlier concept systems explored dry shampoo, eliminating the need for hot water to feature within the system map. But this sacrifice in user experience is one that the mainstream environmentally conscious consumer is unlikely to entertain, thus threatening the profitable sustainability of the concept.

6 Conclusion

A radically new kind of product development procedure is essential if a company is to meet its net zero goals. Emissions associated with products and their supply chains are often the dominant factor in a carbon footprint. This is why system-level innovation is needed to successfully abate the GHG emissions of a product. Such an approach allows additional environmental and social goals to be considered, while preserving commercial growth during product discovery.

The framework we've outlined represents the vital new methodology required for successful net zero product discovery. It enables sustainable, multi-dimensional growth by using whole system mapping to drive system-level innovation. In the process, it breaks down the barriers between corporate functions and promotes systemic innovation.

Whole system maps drive areas for research and analysis, help identify opportunities for additional goals and provide a launchpad for collaborative ideation. Once concept systems have been identified and down-selected, multidisciplinary development teams can focus on addressing key remaining risks and unknowns. Concept system maps are constantly evolved in multiple sprints as learning processes and understanding mature.

Our framework will develop concept systems to a maturity and level of managed risk where product teams can transition from product discovery into product execution. From here, conventional product development processes are appropriate for further development. Additional feedback loops can ensure continued alignment with the sustainability goals as the system continues to be perfected.

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