

Building Momentum for Decarbonisation

Deliverable 6.2

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1. Introduction

While often considered as different terms for the essential challenge of mitigating climate change, ‘reducing greenhouse gas emissions’ and ‘decarbonisation’ frame the problem in different ways, and with different implications for how it can be addressed. The impetus to reduce greenhouse gas emissions is an essentially ‘end of pipe’ problem framing, with attention drawn to those parts of economy and society with direct atmospheric emissions, where the problem is one of creating either efficiencies or alternatives to drive the number down. Decarbonisation, on the other hand, signals a more systemic challenge across the economy as a whole, where the matter at hand is one of undoing the carbon dependency of multiple areas of social and economic life.

From this perspective, climate mitigation as decarbonisation requires that we consider not only how the ongoing dependence on fossil fuels can become undone, but also how alternatives can be made durable, ‘sticky’, or what Bernstein and Hoffmann (2018) term ‘entrenched’. Across the fields of Science and Technology Studies (STS) and Political Science, different approaches have been used to explain how and why political systems, large technical infrastructures, social practices and economic modes of production and consumption have come to endure. Broadly speaking, those writing from a more institutionalist perspective tend to focus on *path dependency* as the key dynamic that maintains administrative structures, bureaucracies, policy systems and political administrations, as self-reinforcing dynamics set in such the costs of changing existing approaches rises, positive feedback occurs and social and economic returns are generated (Kotilainen et al. 2019; Levin et al. 2012). With a different emphasis, those drawing on STS approaches focus on *lock-in* as the critical dynamic through which stability is achieved, as different elements of socio-technical systems—including institutions, practices, cultural norms, operating procedures, technological components and so on—come to be so tightly woven and interdependent as to generate stable socio-technical regimes. Drawing on Hughes’ (1983, 1987) study of the electricity network as a large technical system, the term *momentum* is used to describe the apparent ‘life of their own’ that such systems possess (van Lente et al. 2003: 264), where “numerous interrelationships develop over time between social actors and technologies, which serve to reinforce the status quo: choices and decisions are influenced by past investments and established practices, and thus there is a bias against new innovations” (Lovell 2005: 817).

Most research that has come to consider how path dependency, lock-in and momentum matter for low carbon transitions has focused on the ways in which existing forms come to be disrupted and alternatives come to take hold (Geels 2007; Fuenfschilling & Truffer 2016). A large and influential body of work has been developed on the potential for ‘niche innovations’ to break through existing regimes, the conditions under which this can take place, and the means through which such innovations might ‘scale up’ (Smith et al. 2010). Other research has sought to understand how forms of governance experimentation and policy initiatives come to be established, grow and take root, and to explore how new forms of cultural and material practice

come to be normalised and taken up within society (Bulkeley and Castán Broto 2013; Bouzarovski and Haarstad 2016; Evans et al. 2018). In each case, attention has been largely directed to the means through which novelty is generated in the face of dominant, ‘locked-in’ socio-technical, institutional and cultural high carbon systems. Yet, as these studies show, generating novelty is not sufficient. Instead, low carbon interventions and initiatives need to acquire their own momentum and durability.

Taking this approach in turn changes how we approach the question of the worth or significance of specific initiatives. Rather than asking (only) about their direct impact on reducing greenhouse gas emissions, the analytical challenge is to understand their potential for catalysing decarbonisation, either in terms of disrupting existing systems or through gathering sufficient momentum such that they become newly established (Bernstein and Hoffman 2018; van Lente et al. 2017). In this report, we first expand on the concept of momentum and its significance as a means of understanding the dynamics of decarbonisation, before turning to consider how far the case-studies investigated in REINVENT can be considered as having the potential to generate momentum, and with what consequences for how we understand the possibilities for decarbonisation across the REINVENT sectors.

2. Conceptualising Momentum

Of the three related concepts of path dependence, lock-in and momentum, we focus on momentum as a means of understanding the dynamics of decarbonisation both because it encompasses elements of each of the other key concepts—path dependence mechanisms are essential to the means through which momentum is acquired and those systems which gather sufficient momentum in turn come to achieve ‘lock-in’—but also because it conveys the active, dynamic means through which such forms of stability are achieved. As a physical property momentum is calculated from the mass and velocity of a moving object, while in social terms it also refers to the driving force or impetus gained by a process or course of events. While in the conceptual sense in which it is being used here momentum is used to signify that a socio-technical system has gained sufficient force, weight and traction through the interconnection and reinforcement of its diverse elements so as to appear to have an irreversible life of its own (van Lente et al. 2003), as Lovell (2005) reminds us such systems are always at least partially open and require continually work to maintain; furthermore, as observed by Mattern (2018), “[a]greements about what things deserve repair—and what “good repair” entails—are always contingent and contextual”. While we therefore draw from the underpinning work on momentum within studies of socio-technical systems, which regards it as the status acquired at the end point of a trajectory when stability and durability have been achieved, we turn also to the term’s meaning as a physical property and its etymology in order to focus more on the processes through which momentum comes to be gathered or acquired. Understanding how and why particular initiatives are able to gather momentum therefore requires that we examine how they come to hold such potential, as well as the work required to acquire and maintain this over time.

2.1 A Life of Their Own? Momentum in Large-Technical Systems

In his pioneering work on the electrification of cities in the US, Hughes (1983) developed an account of how such large technical systems came to be established which stressed that not only were technical innovations, political developments, social change and individual agents significant, but they were also inexorably tied into one another, forming what he termed a ‘seamless web’ through which the trajectory of, in this case, lighting provision came to be governed and normalised. For Hughes, momentum is the ‘end stage’ of the development of such systems, signalling that they have become embedded in society through establishing multiple linkages between actors and entities, such as regulatory bodies, firms, social practices, norms and so on. As Geels (2007: 124) summarises, “in the momentum stage, large technical systems possess direction and display a rate of growth that suggests velocity. This momentum and directionality are not autonomous but stem from the alignments of many social and technical elements.” Central therefore to an understanding of momentum are both the notion of the *directionality* of interventions— a term that is largely left unexplored in the literature to date—and their *growth*, the latter of which is regarded as taking place through the cumulative effect of linkages that form between multiple different social and technical components. Indeed,

it has been this focus on how far and much interventions grow that has led many to consider trajectories of socio-technical system change in terms of matters of scale (see Deliverable 6.1). Yet if we understand momentum primarily not as the finished, end-state of those socio-technical systems that have gathered sufficient weight and force, but instead as the dynamic through which potential is realised, new avenues for inquiry are opened.

For Hughes, system change, such as it is conceived to take place, emerges through a “punctuated evolutionary pattern of growth, with stable periods of ‘momentum’ interrupted periodically by the emergence of system-wide critical problems that can be solved only by radical innovations” (Lovell 2007: 2501). Yet in regarding such systems as inherently stable and open only to radical and external interventions, the concept of momentum has been critiqued for ‘black boxing’ socio-technical systems and failing to consider the ongoing dynamics through which they are maintained and contested (Lovell 2007; Geels 2007; Graham & Marvin 2001). Further critiques have also been levelled at the way in which the concept of momentum tends to presume that, where system change *does* occur, this is a matter of substitution—whereby one large technical system replaces another—and at the implied sense of technological determinism that emerges from the focus on technological innovation as paving the way for the development of alternatives. Nonetheless, the concept remains an intriguing one for those concerned with understanding how, why and with what implications system-wide change, of the kind implied by decarbonisation, can be accomplished.

2.2 Building Momentum through Niches, Experiments and Novelty

Despite the centrality of the concept of momentum to early work on socio-technical systems and their dynamics over time, as interest in low carbon transitions has grown over the past three decades it has faded from view, in favour of the more frequently debated question of how emerging niches, experiments and novel forms of social practice or cultural norms can be ‘scaled up’ (see Deliverable 6.1). Nonetheless, across three bodies of work that have been broadly concerned with understanding low carbon transitions—work on socio-technical transitions, on governance experimentation, and on the material and cultural politics of low carbon life—the question of how momentum emerges remains at least of implicit importance.

When it comes to the debate on socio-technical transitions, various iterations of the ‘multi-level perspective’ have dominated our understanding, demonstrating through multiple examples in diverse contexts how innovations in protected niches emerge and, under different conditions of the external environment, are able to challenge or transform existing socio-technical regimes: the established, stable arrangements through which systems of provision and consumption operate (Smith et al. 2010). As Geels and Schot (2007: 400) explain, a central part of the dynamics of (low carbon) transition is that “niche-innovations build up internal momentum, through learning processes, price/performance improvements and support from powerful groups.” Drawing on a combination of insights from path dependency theory—the importance of increasing economic and social returns on innovation—as well as those derived from Hughes’ work establishing the importance of ‘linkages’ in providing the impetus required for momentum to build, analyses of how niche innovations build momentum have focused on the

the ways in which their protected environments lower their risks and costs, whilst also stressing the ways in which *social* networks and coalitions of actors are built around emerging innovations.

Work on governance experimentation, and on the emergence of multiple interventions operating at the transnational, national and sub-national level to address climate change, have tended to focus more on the *political* dynamics through which momentum might be built (Hoffman 2011; Bulkeley et al. 2014; Bulkeley 2019). Here too there has been a focus on the ways in which such interventions come to generate linkages and coalitions, with research suggesting that new kinds of governance complexes are being formed, both internationally and regionally, as different interventions come to be related to one another and joined up, thus generating new kinds of institutional structure, forms of learning, and norms about how governance can be conducted (Abbott 2012; Betsill et al. 2015). At the same time, Castán Broto and Bulkeley (2018) point to the importance of understanding the *circulation* of experimentation not as an extractive process, through which particular elements of experimentation are transferred to new contexts, but rather as a set of dynamics through which experimentation comes to be embedded within the circulatory processes and practices that comprise, in this case, the urban milieu. As they go on to explain, “experimentation brings about an *unruly* dynamic of new configurations and potential circulations which may be more or less successful in opening up existing obdurate socio-material regimes. In this sense, the transformative potential of the experiment is always and already part of the intervention and its capacity for transformation relates both to the ‘stickiness’ of the regime within which it is inserted and its immanent capacity to assemble, enrol, and transform the socio-technical configurations of which it is a part.” (Castán Broto and Bulkeley 2018). Across the breadth of literature on climate governance experiments then, both serve as a means through which either coalitions and/or new socio-material configurations are built and rely on these as a means through which to build momentum. In drawing attention to the ‘immanence’ of such configurations—their capacity to generate power and effect through the act of being drawn together—Castán Broto & Bulkeley’s (2018) account of how experiments come to circulate also provides one perspective on how such interventions might come to hold the ‘directionality’ needed to build momentum.

The importance of objects, artefacts and devices as a means through which socio-material configurations are built and maintained also comes to the fore in the literature that considers the possibilities of generating transitions towards decarbonisation from the perspectives of material and cultural politics. In these approaches, “culture is explicitly recognized as (re)produced through the assembling and mobilization of material objects and the kinds of actor networks and sociotechnical configurations through which they are constituted” (Bulkeley et al. 2016: 8). Low carbon transitions start with the emergence of cultural novelty—new meanings, ways of being, forms of identity—established through particular devices, technologies and mechanisms, desires, and dissent from existing practices or socio-material orders. For Bulkeley et al. (2016:12) “it is in the interweaving and recursive reconfiguration of devices, desires, and dissent that the situated politics of climate change emerges and takes effect.” it is through processes of constructing individual responsibilities, of normalising

particular forms of identity, consumption or visions of the good life, and/or of sustaining particular routines or operating procedures, that existing forms of high carbon socio-material conditions and cultural life are given momentum. At the same time, this work shows “the contingent nature of the obduracy of high-carbon society and the ways in which moments of fluidity are opened and closed in the interrelation between devices, desires, and dissent” as “opportunities for transformation emerge in the flux of the relations between devices, desires, and dissent” (Bulkeley et al. 2016: 23). According to Stripple and Bulkeley (2019), the analytical task then becomes one of “seeking to understand how and why particular kinds of socio-material relations are assembled, held together and create momentum through the productive capacity to generate power and the ways in which this is contested.” Momentum here is thus generated through the ways in which entities become configured in relation with one another, in a form of network-building or expansion that takes place not through coalition building, but rather through an emergent process of enrolment and circulation.

Overall, and despite their different takes on the issue, the work that has grown around the question of how niches, experiments and novelties come to generate momentum points to three key dynamics: 1) how particular configurations generate emergent/immanent forms of power that provide both directionality and force; 2) the significance of alliances, coalitions and enrolment as different means through which linkages are generated which come to give interventions weight and stability; and 3) the ways in which through processes of circulation and normalisation novel interventions come to be embedded and taken for granted. Critically, in each case, momentum is regarded as an open process requiring ongoing work that is never settled—a precarious accomplishment that is subject to reversal.

2.3 Momentum as Entrenchment

Building on the literature on socio-technical systems in transition and the politics of climate experimentation, as well as institutional theory regarding path dependency, a recent body of work by Steven Bernstein and Matthew Hoffmann and their team at the University of Toronto has made a series of interventions which have sought to provide a systematic account of the ways in which low carbon interventions might provide the potential for decarbonisation. They argue that pathways to decarbonisation are an inevitably political affair, requiring shifts in political systems that can be generated by subnational experiments or interventions through three key mechanisms: “normative change (normalization); building capacities to act differently, whether by mobilising resources directly or via institutional change; and coalition building” (Bernstein & Hoffman 2018: 191). These three mechanisms in turn “determine whether and how the policies and practices that experiments promote scale up and entrench in the jurisdictions and systems being targeted for disruption (direct effects), as well as how they influence other jurisdictions and systems beyond the direct scope of the intervention (interdependent effects)” (Bernstein & Hoffman 2018: 191). Rather than being sufficient in themselves to enabling scaling up and entrenchment, these dynamics give interventions the *potential* for catalysing decarbonisation.

These two processes—scaling up and entrenchment—are thus seen as key to the ways in which decarbonisation can be catalysed. While the debate on scaling up has been extensively covered in the literature to date (see Deliverable 6.1), the notion of entrenchment as advanced by Bernstein and Hoffmann has close parallels with the debate on momentum, which has received much less attention. As they suggest, the notion of entrenchment “focuses attention on how interventions might not only focus on achieving immediate ‘stickiness’ but also how they gain durability, expand the populations they cover, and change behaviours through largely unexplored progressive incremental forces whereby a number of small policy changes can have significant transformative effects if they trigger path-dependent processes” (Bernstein & Hoffman 2018: 202). Indeed, it is primarily from the literature on path dependency that the notion of entrenchment is developed in this account, drawing on the work of Levin et al. (2012) to suggest that this can be generated through the immediate ‘lock-in’ of policies or practices (e.g. through legislation), which become self-reinforcing as the costs of reversal start to become prohibitive, as positive feedback occurs with interventions accruing new and diverse supporters, and as increasing returns come to be generated over time (Bernstein and Hoffman 2018: 202). Here, their focus is especially on how such dynamics generate “processes that make new initiatives and/or the policies or practices they promote ‘sticky’ or difficult to reverse by triggering or reinforcing coalition building or broadening, normalization and capacity building” (Bernstein and Hoffman 2018: 202). Yet despite its attraction as a term which signals that new forms of decarbonisation have become firmly rooted, entrenchment itself (with its military connotations of ‘digging in’) carries also a focus on an end-state that is fixed and complete, stubborn or even obdurate.

2.4 Gathering Momentum

Rather than focusing on momentum as a concept through which we can further understand how decarbonisation can itself become entrenched, locked-in or obdurate, we find it helpful instead to focus on the dynamics of momentum as a means through which to understand how new forms of potential are gathered together, coming to have force and meaning that are *durable*—able to withstand wear, pressure or damage—and *enduring* over time. Here, the three core dynamics identified by Bernstein and Hoffman (2018)—of capacity building, coalition building and normalisation—together with the insights generated from the original accounts of large technical systems and the burgeoning literature on experimentation within socio-technical systems, leads us to identify three essential features of momentum which help us to understand the potential for decarbonisation.

First, we turn back to the notion of *directionality*, a term that conjures both the potential and capacity for an intervention to take form and acquire momentum. It is a term that closely resembles Easterling’s concept of *disposition*, what she describes as “the character or propensity of an organization that results from all its activity. It is the medium, not the message.... Not the object form, but the active form.” (Easterling 2014: 21). As she further explains:

“The ball at the top of an inclined plane possesses a disposition. The geometry of the ball and its relative position are simple markers of potential agency. Even without rolling down the incline, the ball is actively doing something by occupying its position. Disposition, in common parlance, usually describes an unfolding relationship between potentials. It describes a tendency, activity, faculty or property in either beings or objects—a propensity within a context” (Easterling 2014:72)

Even without rolling down the incline, the ball has the *capacity* to do so, a capacity generated both by the ‘geometry of the ball’ (its *inherent* capacities, if you like) and its *relative* position, such that “disposition [*or directionality, in our terms*] is “immanent, not in the moving parts, but in the relationships between the components” (Easterling 2014: 72). Rather than thinking of capacity as something that is conferred from an external actor to an intervention, working with Easterling’s notion of disposition helps to unpack the ways in which the capacity and directionality that such interventions may hold is due in part to their essential composition and form (e.g. those interventions undertaken by actors with significant resources may hold more ‘capacity’ than others), but is also *relational*, in terms of being acquired through the way in which it travels and the degree of friction it encounters. Understanding the momentum of decarbonisation interventions therefore requires that we move beyond capacity as seen only in terms of singular or autonomous properties of technologies, individual agents and so on, and work to include considerations of the disposition and directionality of interventions, as well as their immanent and relational potential.

The second core dynamic of momentum comes from the focus on *growth* in the original accounts of large-technical systems, which has been compounded upon by subsequent studies of socio-technical innovation and experimentation. While there has been a relatively extensive debate on the ways in which ‘scaling’ can take place (see Deliverable 6.1), here we suggest that growth can be seen in different ways, and that this perspective in turn helps us to understand the dynamic of momentum. For Bernstein and Hoffmann (2018), growth takes place through the building of coalitions and the gathering of (diverse) interests around decarbonisation interventions and the creation of new constituencies. Yet the original conception of momentum within large-technical systems points to the importance of many other kinds of *linkages* through which interventions come to *expand* and *enrol* multiple social and material entities, which in turn increase their potential.

Finally, a concern with momentum as an established, end-state across the literature also suggests that processes of *normalisation* are of significance. For some, this is a matter of norm change, of the replacement of one set of norms with another (Bernstein & Hoffmann 2018; Tozer 2020); yet it is equally relevant to examine how things come to be normal in the first place—the processes of normalisation that allow certain kinds of potential to be realised. Normalisation is often associated with certain narratives or visions coming to be held in common, but it can also apply to the routinisation of everyday practices, ways of knowing, or the giving of meaning to entities and experiences. (Bernstein & Hoffman 2018; Shove 2003a)

Taken together, the concepts of directionality/disposition, expansion and normalisation provide a means through which to start to unpack what it is that the gathering of momentum for decarbonisation might involve. In the next section, we further unpack these concepts and work with three of the REINVENT case-studies—HYBRIT, Oatly and Zero Waste Supermarkets—to test and probe their utility in developing our understanding of the dynamics of deep decarbonisation.

3. Momentum for Decarbonisation: Analysing REINVENT Cases

As discussed above, the concept of momentum has to date received relatively limited attention, especially when compared to the extensive debates which have taken place as to how the ‘scaling’ of diverse interventions might generate new pathways for decarbonisation (see Deliverable 6.1). In this context, our analysis of the REINVENT cases is exploratory—we seek to use a selection of the cases to scrutinise the conceptualisation of momentum we have developed in Section 2, whilst at the same time drawing on the insights offered by this approach to further our understanding of the case-studies in question.

3.1 Directionality & Disposition

Drawing on the different threads of the concept of momentum discussed in Section 2, we found that there are three aspects of the dynamic of *disposition and directionality* that appear to be especially significant when it comes to understanding how interventions come to hold the potential for decarbonisation.

The immanent capacity of interventions

The *immanent* capacity of interventions lies both in their technical or material constitution (and the possibilities this yields), as well as in the way that the intervention itself serves to make some things possible and others not, potentially leading to redundancy in existing socio-technical systems and generating new potentials.

Taking first the issue of technical capacity, we find an example of how the capacity for momentum is established in our case of fossil-free steelmaking, HYBRIT (see Appendix). The steel industry is usually considered hard-to-abate, leading to carbon-capture and storage (CSS) technology (formerly) dominating the suggested solutions for its mitigation. By presenting a hydrogen-based steelmaking technology, HYBRIT promotes a fossil-free alternative. While ‘climate neutrality’ or ‘net zero carbon’ narratives leave space for remained greenhouse gas (GHG) emissions, which then are compensated by negative-emissions (e.g. through CSS), being fossil-free instead urges decarbonisation at the core. Thus, HYBRIT renders deep decarbonisation of the steel industry possible, which might shift notions of steel industry being hard-to-abate. A central infrastructural change of hydrogen steelmaking is a shift to electric arc furnaces, which fit better with smaller production units. Thus, the material properties of the electric arc furnaces configure a more decentralised mode of steelmaking.

In the case of oat-based dairy substitutes, Oatly (see Appendix), we also see how material properties of the innovation are crucial to its transformational potential. The potential of oat milk substituting for dairy milk serves to re-organise the value chain: instead of using oats for

cattle feed, it becomes instead the main resource for making the product. Although dairy has not to date been displaced by oat-based products, this potential is inherent to the innovation. An imagined displacement of dairy products by oat-based counterparts would signify major changes in the value chain, and in the distribution of economic power. However, as it aligns well with dominant business models, Oatly has the potential to change some parts of the system, while others stay the same. Nevertheless, the initiative has a strong immanent potential, if released.

However, the inherent potential of an intervention is not only due to its materiality, but the ways in which its presence re-organises the socio-technical systems of which it is a part and hence opens up new possibilities. A key element here are their roles as ‘multipliers’ and ‘switches’, as Easterling would have it, and how these roles serve to generate disposition. If we consider a pilot-project of a zero-carbon house, such a one-off innovation will have little impact in and of itself. But, as Easterling says, “designing something to be multiplied within a population of houses has the potential to recondition the larger suburban field or hack the suburban software”; a city “grows or changes because of the multipliers that circulate within it – cars, elevators, mobile phones, laws, real estate formulas, structural innovations and security technologies among them” (Easterling 2014: 74). The elevator is an example of one such multiplier that has transformed the urban built environment. Multipliers make some things possible and others not: some socio-technical systems become redundant, while new potentials arise from the innovation replicating across the urban. ‘Switches’ are another “active form in the infrastructural space”, exemplified by a dam in a hydrological network, a terminal in a transit network, or an internet service provider: “Like the ball on the inclined plane they establish potentials. Like a valve they may suppress or redirect. The switch may generate effects some distance down the road or the line. It is a remote control of sorts – activating a distant site to affect a local condition or vice versa. Exceeding the reach of a single object form, the switch modulates a flow of activities”; however, the ‘switch’ “cannot control all of its own consequences any more than one could account for every use of the water flowing through a dam.” (Easterling 2014: 75)

Drawing from Easterling, we can thus view steel as a ‘multiplier’. Together with the elevator—which is also deemed a ‘multiplier’—structural steel skeletons made the construction of vertical buildings possible, and were crucial in the emergence of the modern skyscraper (Easterling 2014). HYBRIT’s low-carbon steel can also be seen as a ‘multiplier’ to be replicated and standardised. It might not rewrite the urban in the way that steel and the elevator did; nonetheless, it operates as something to be installed which could “hack the suburban software” (Easterling 2014:74), and thus has a broader reach than a ‘one-off innovation’.

Applying these concepts to the case of Oatly suggests that the innovation takes the roles of both a ‘multiplier’ and a ‘switch’. The innovation consists of a patented enzyme process for making an oat base, from which a variety of oat-based products are derived. Although this does not necessarily rewrite the urban space, a similar analysis can be applied to consider oat milk not as a one-off innovation, but instead as a design to be, to reiterate Easterling’s wording, “multiplied in a field of houses”. (Easterling 2014: 74) Oat-based products also take the role of

‘switch’, as they have the potential to trigger a new flow of activities. It is possible to imagine a diet in which dairy products are simply replaced with oat products, while the other animalistic components (e.g. eggs, meat etc.) remain. However, since the most important of characteristic of Oatly is its emphasis on being low-carbon by comparison to dairy herds, it is possible to imagine the innovation fostering adjustments towards a more generally plant-based diet, in order to further lower its carbon footprint.

It is illuminating to think of the supermarket (and its core innovation of self-service) as a ‘multiplier’. When it emerged in the 1950s, it quickly became the dominant form of organisation between ‘the farm’ and ‘the work’. The supermarket became an obligatory passage point, where food had to be wrapped and packed in certain ways (increasingly involving plastics) in order that customers could serve themselves. In the same way, the idea of a ‘zero-waste store’ has transformative potential because it is a standardised form that can be replicated: when inserted into the urban field, ‘zero-waste’ can be reproduced. A zero-waste store also works as a ‘switch’, something which “exceeds the reach of a single object, and modulates a flow of activities” (Easterling 2014: 75). Zero-waste is not only about being package-free, but also about a more just mode of consumption, and the seeking out of a more minimalistic and sustainable lifestyle. As one zero-waste store owner said, “[o]ur mission is to change mindsets, change lifestyles. It cannot be reduced to plastics or packaging.” Thus, such stores encourage sustainable habits which exceed those practiced within the store itself. Moreover, placing a zero-waste store in a neighbourhood shifts that local environment: to shop for groceries at a zero-waste store is to become locally involved, by contrast to buying at placeless multinational retail franchises. As zero-waste supermarkets are connected together through networks of knowledge sharing, the local also becomes tied to the transnational.

Capacity

A second key element is regarded as *capacity*: interventions are regarded as generating potential for entrenchment, according to Bernstein & Hoffman (2018), through mechanisms of capacity building, which they regard as a matter of mobilising *resources* or *institutional change*. Tozer (2020: 3) extends this to suggest that capacity building can take *material, institutional or cognitive forms*, as interventions alter “the means to act by providing support through funding, training, technology etc.”

HYBRIT consists of several parallel elements. Hybrit Development AB is a joint venture by Swedish companies SSAB (a privately-owned steel company), LKAB (a state-owned mining company), and Vattenfall (a state-owned energy company). The research programme RP1 is another component, in which many universities (KTH Royal School of Technology, Lund University, and Luleå Technical University), research institutes (e.g. RISE, Swerim), and industry partners (Sandvik) also participate. The HYBRIT initiative is organised as a public-private partnership with substantial governmental support, mainly financed through the Swedish Energy Agency, and has mobilised massive resources around fossil-free production of steel, which has come to be framed as a matter of securing the future of Swedish steel-making. Although still at pilot project stage, the initiative has become a central part of the Swedish

strategy for international climate action. The capacity building at work here takes many forms: mobilising funding for decarbonisation, initiating research, and shaping policy.

One interesting cognitive capacity identified in the case of Oatly is the capacity to assess and calculate the carbon footprint of a product, and how that allows for product differentiation. Life-cycle assessments (LCAs) is a technique to determine the environmental impacts associated with all stages of a product's life cycle, from raw material extraction, through manufacturing and distribution, to disposal or recycling; LCAs are now globally recognised as the pre-eminent tool for calculating environmental impact. The standardisation of LCAs by actors such as the ISO and EU has done much to provide the technique with a scientific credibility and appearance of objectivity that have allowed it to become an indispensable tool of governance. In 2015 Oatly made the music festival Way Out West 'milk-free', and since 2019 the impact of the entire event has been quantified in CO₂-equivalents as part of Oatly's "Show us your numbers" campaign, in which they urge food producers to display their LCA results on their food packaging and lobby for a law that would require them to do so.

Such quantification provides Oatly with its main *raison-d'être*. Their latest campaign "Spola mjölken" (trans. "Flush the milk", which is a nod to a famed Swedish anti-alcohol campaign "Spola kröken", trans. "Flush the booze") displays a dripping milk bottle with the text "switch to oat drink to reduce greenhouse gas emissions by 75%". By veiling the marketing device in an affective slogan with historic ties to a health-promoting initiative, Oatly limits consumers' decision space to being either for or against climate action. However, it is crucial to note that GHG emissions of oat-based products are relatively easy to calculate. Dairy production involves co-products such as meat, which can complicate the assessing carbon footprints with LCAs. While LCA has been developed specifically for the sector of food and agriculture supply chains, there are issues inherent in the question of where one should draw the boundaries around the system that is being measured (e.g. Freidberg 2018, 2019). Thus the cognitive capacity at work here appears as immanent to oat milk *as a product*, since its ability to be assessed in climate impact enables the initiatives potential to be enhanced; however, it also appears as a cognitive capacity developed by Oatly *as an organisation*, since they have introduced the labelling dynamic to the dairy sector, thus making it a key factor to be taken into account when choosing between dairy and plant-based products.

A related cognitive capacity can be found in Oatly's concept of "the Oatly way". This demonstrates the different production processes of dairy and oat milk, and is usually displayed in a graphic through which the different production processes is illustrated: on one side there are arrows connecting oat with production facilities via a cow ("the cow way"), while on the other side arrows connect oats directly to production facilities ("the Oatly way"). The illustration has been criticised for being a simplified model: for instance, it excludes the grazing of animals, and leaves out regional differences in dairy production. However, in a similar manner to the employment of LCAs, "the Oatly way" shows the innovation's capacity to demonstrate (or perform) its potential in a simple (because simplified) yet powerful way.

One of the pioneers of the zero-waste lifestyle is Bea Johnson, who has been called the priestess of waste-free living' by the New York Times. Johnson started blogging around 2010, offering her readers tips on how to shop with refillable jars, how to organise their kitchen to reduce household waste, and other such lifestyle topics; she also shares the results of her family's waste reduction over the period of a year. When she revealed that her family could fit a year's worth of waste into a single mason jar, this resulted in massive media attention, inspiring many to join what later became the zero-waste 'movement'. Central in the cognitive capacity of Johnson's intervention is the mason jar's ability to demonstrate the *absence* of waste: in the context of well-circulated pictures of landfills and plastic-filled beaches resulting from poor waste management, fitting your waste into a mason jar signifies your non-contribution to these environmental impact issues. The mason jar thus became a powerful and sensational symbol of the zero-waste lifestyle and its potential, which served as a strong imaginary around which to build the movement.

Relational potential

A third aspect of the ways in which disposition and directionality are established is the 'relational potential' immanent to the alignment/configuration created through the intervention. This is about how socio-material configurations open up new possible ways of acting, generating meaning, and forming attachments (e.g. consider how new devices generate new desires, e.g. around electric cars, vegan food); these reconfigurations thus serve to bring tensions into existing forms—or frictions, if you will.

In the case of Oatly, the work of alignment between the innovation and the wider society—through its presence in schools, supermarkets, and festivals etc.—is critical. As mentioned briefly under *capacity*, Oatly helped the music festival Way Out West to become 'milk free' in 2015. In conjunction with the cultural event, Oatly ran a campaign that urged the people living in Gothenburg to become milk free for 72 hours (the same duration as the festival), which according to their estimations would save 325 tons of CO₂-equivalents. As such, the festival area (and to some extent also the city of Gothenburg) became a space for demonstrating what a milk-free society could look like. Oatly has been present at Way Out West for several years. In 2016, their "google milk" campaign, which urged people to google in order to bust myths about milk, was brought to a climax by the two popular podcasters, Axel Schulman and Sigge Eklund, hosting a talk on the subject at one of the festival stages. By aligning their product with cultural events and public personalities, Oatly has sought to create associations of their product with popular culture and a hip lifestyle. As such, (responsibility for) climate action through food sustainability expands to the cultural sphere, thus expanding scope for (climate) responsible societal actors.

Packaging is necessary for the mass transportation of food products, as it helps to avoid food spoilage. Thus, package-free food products portray the currently dominant internationally-extensive food supply chains as impossible, and a shifted reliance upon more local food supply chains as necessary. Eliminating packaging therefore does not merely change the grocery habits of individuals; it also implies systematic changes regarding how, where, and when food is produced. A dominant source of friction encountered by zero-waste stores are cultural notions

of convenience: zero-waste store owners, a WWF representative, and a policy officer interviewed in our study all stressed that consumers have become accustomed to convenience. The zero-waste store is neither time-saving nor effective; instead the stores offer a slower, but more meaningful, shopping experience. Moreover, they have a limited product variety, thus offering less freedom of choice, although this is a conscious decision linked to their striving for sustainable models. However, owners of zero-waste stores argue that zero-waste is not *necessarily* inconvenient, and stress that shopping in your own neighbourhood is convenient in a compensatory way. That argument is limited by the limited spread of the innovation: not every neighbourhood has their own store, at least not yet. meanwhile, zero-waste bloggers interviewed in the study state clearly that there are trade-offs in the lifestyle when it comes to convenience, though the compromises may not be as numerous as initially supposed: the main issues raised are staying on a budget, finding zero-waste stores, and finding all you want once you get there; as such, patronising more than one store is often necessary (and may thus result in a higher transportation footprint for the shopper).

3.2 Expansion: linkages and networks

As discussed in Section 2, much of the literature that has stemmed from initial accounts of the importance of momentum in fostering socio-technical change has focused on *scale* as the means through which the growth of innovations which in turn generate transitions take place. Focusing on the notion of momentum brings into view other dynamics through which interventions expand and come to gather force.

Momentum as growth/how entities come to be attached

The notion of linkages in the original conceptualisation of large technical systems is used to signal the growth of interventions as they came to enrol more, and more diverse, social and material elements. The dynamics of enrolment, in terms of how/which entities come to be attached to interventions, is thus important in terms of understanding how momentum is acquired. Similarly, analysis of socio-technical systems has pointed to the importance of linkages in the evolution of innovations though it is worth noting that in that tradition linkages are more often associated with developing stability and a new form of ‘lock-in’ than the focus on *durability* which we suggest is a more productive way to understand why momentum matters for decarbonisation.

Oatly was initially linked to dairy production, as they partnered with the dairy company Skånemejerier to produce a product intended to solve the issue of lactose intolerance. Through this partnership Oatly were able to grow their business and produce larger quantities of oat milk. However, this partnership also held them back, as it sustained the market framing of oat milk as an alternative product for those *unable* to drink cow’s milk. When they broke with Skånemejerier, they were able to reframe oat milk as a product for those *unwilling* to drink cow’s milk, but they retained their established contacts with supermarkets, making it possible to sell their product directly. This thus enabled Oatly to instead compete with dairy milk, and to link their product—and dairy more generally—to climate action, through framing it as a solution to the high GHG emissions related to dairy production. Thus, a crucial linkage formed

through this shift from being solely attached to issues of health and allergy, to becoming connected to issues of climate action and impact.

As outlined earlier, the zero-waste store is a little bit different from the traditional supermarket, but there are many things that remain the same. What defines them is less their material and symbolic structure, and more the central role that imaginaries play: they are known primarily through the imaginaries they invoke, which are conscious attempts to invoke a future that resists the present in some way, and which may indeed invoke new social relations. In organisation studies, such invocations of resistance are referred to as prefiguration, a phenomenon which has usually been studied in relation to explicitly anti-capitalist examples of alternative organisation, such as collectives or social movements, to which non-hierarchical and participatory practices are key (Daskalaki & Kokkinidis, 2017; Reinecke, 2018). Zero Waste stores are usually run by one or several individual entrepreneurs, and thus tend to lack this emphasis on participatory processes or explicitly radical politics; nonetheless, solidarity can still be a key feature of such organisations if they are driven by values such as helping society, closeness to the social problem, and a non-monetary focus (Germak & Robinson, 2014).

In zero-waste stores we can observe prefiguration in processes both within and beyond the organisation, such as finding new ways to avoid plastics, selling local and organic food, and creating a space for learning and communication about waste. This can also manifest in the nurturing of affective bonds of friendship with buyers, suppliers and volunteers, thus facilitating the prefiguration of alternative ways of living (cf. Farias, 2017). By running a zero-waste store, social entrepreneurs might be seen to be acting as a part of the larger zero-waste movement, inspired by the global community and different actors within it, such as social media influencers, as well as inspiring others. They can be said to be engaging in *prefigurative partaking*, i.e. “forms and processes of everyday activism that are incremental and consisting of comparatively small efforts arising out of dissociation and ruptures in the taken-for-granted” (Skoglund & Böhm, 2019:6–7).

Zero-waste supermarkets thus take a fairly different approach towards growth compared to Oatly, as they reject its most common meaning (i.e. expansion of the organisation): instead of aiming for expansion (or ‘scaling up’), they seek instead to become embedded in their local communities. This more horizontal form of replication is usually made by someone attached to each area/neighbourhood, although some store owners have opened up another store in a neighbourhood close by. Many stores are realised through crowdfunding in their communities, or are organised as cooperatives which are ultimately owned by their members. Observing the thriving number of supermarkets, and at the strong zero-waste networks enabling that growth, this linkage-building strategy is shown to be durable—though there is a long way to go before they are challenging the big chains in every neighbourhood.

Coalition Building

Most work on both socio-technical regimes, niches and experimentation focuses on *coalition building* as central to the growth of interventions, which is seen to be particularly important when this process involves non-like-minded organisations (Hajer 1995). Especially in cases where new interventions attract support from those who were formerly connected to

dominant/incumbent regimes, such coalition-building can be interpreted as signalling a ‘shrinking’ of the dominant socio-material configuration (and hence a disruption or slowing of its momentum). At the same time, it is important to recognise that such coalitions can be matters of convenience, allowing dominant actors to either claim credentials for green innovation, or to ensure that any threat to their position is contained.

Oatly’s partnerships with incumbents (see above) have been central in establishing themselves as an actor at the dairy market. However, this has not been the only form of coalition building that has taken place. A critical aspect of this case-study relates to how the food company situated themselves in a coalition on food as a sustainability pathway. Oatly, along with SimrisAlg, Food for Future, and Astrid & Aporna, created the lobby organisation *Växtbaserat Sverige* (trans. “Plant-based Sweden”) in 2017, with the purpose of advocating for plant-based foods. An articulated requirement for becoming a part of the group was to not be owned by dairy companies producing meat or/and dairy, thus separating companies producing plant-based products merely for business interests from those with a genuine desire to advance the agenda. Oatly has also engaged in partnerships with the Swedish University of Agricultural Services (SLU) and various farmers, within which sustainability experiments have been carried out to gain knowledge: for instance, Oatly initiated a research project with the sustainable farmer Adam Arneson, who—according to the projects results—increased his caloric output per CO₂ by increasing the ratio of plants grown. Such partnerships can be seen as an intention to create coalitions with farmers, who (at least in a Swedish context) have traditionally aligned themselves with livestock producers. However, the lasting successfulness of this attempt at coalition building is an open question: their 2019 campaign “Spola mjölken” (trans. “flush milk”) left many farmers upset, claiming they would stop supplying Oatly with oats. Many farmers produce both for Oatly and dairy companies, and felt attacked by the ad. (Resumé 2019a; 2019b) Thus, rather than building coalitions with farmers, Oatly’s communicative style might have reinforced the agricultural sector’s resistance towards them, which may potentially slow their momentum.

However, it is important to note that Oatly has gathered a remarkable force behind their cause. A critical node was the lawsuit filed by Svenska Mjölken (Dairy Sweden), charging Oatly for malicious marketing practices. This event initiated the notorious (and still ongoing) ‘Milk War’, and led to a large fine and a ban on some of Oatly’s marketing formulations. However, the CEO of Oatly has reportedly claimed that this was one of the best things that had happened to them. Once the lawsuit started, many things unfolded overnight, according to the Oatly employee Sofia Eldhe, interviewed in our study: magazines featured editorial pieces supporting the cause of either side; people picked a side, and took to social media to speak up; researchers published reports of the negative impact of milk. It appears that the lawsuit actually initiated positive feedback loops, and was thus crucial in gathering force around the initiative.

In the case of zero-waste supermarkets, coalition building has been fostered through social movement formation. By mobilising criticism towards the unsustainable use of packaging, plastic use (especially downstream) has become highly politicised, initiating political regulations on single-use plastics (e.g. plastic bag bans and taxes). We can also see how story-

lines (Hajer 1995) of packaging as ‘waste’ are produced by the zero-waste movement, which gather together actors such as activists, non-governmental organisations (NGOs) and zero-waste grocery stores, but also alliances such as Zero Waste International Alliance and regional umbrella organisations like Zero-waste Europe. However, the zero-waste store goes beyond merely being plastic-free: it also connects to story-lines of consumer awareness, just consumption and the strengthening of local communities. Following Hajer’s (1995) concept of discourse-coalitions, we can identify a discourse-coalition on ‘ecological citizenship’ (cf. Seymore 2005), engaged in assembling these various story-lines. This discourse coalition is crucial to the building of momentum around zero-waste supermarkets, since it gathers force behind the initiative.

However, this discourse-coalition has met significant resistance from incumbents, which construct a counter-narrative of packaging as ‘protection’. This story-line has been connected to the circular economy approach, in which ‘closed loops’ are promoted, and also to story-lines depicting the modern supermarket as exemplifying convenience and choice among a variety of products. The discourse coalition on circular economy, as identified in the conducted case study, gathers officers of the European Union, WWF Denmark, and various conventional retail companies. Being for the most part a reaction to the zero-waste movement and its politicisation of plastics, the discourse-coalition could also be seen as a countercoalition (Bernstein & Hoffman 2018) employed by incumbents to reinforce their positions and burnish their green credentials, which serves to slow momentum of the zero-waste supermarkets.

The dynamics of incumbents attending to discourse coalitions to ensure their positions have also been found in other innovations examined in our case-studies, one of which is HYBRIT. Incumbent actors—such as the state, the state-owned mining company LKAB, and the state-owned energy company Vattenfall—are gathering around ‘fossil free’ rather than ‘climate neutral’ or ‘net zero carbon’. This has political implications, as being fossil-free puts the focus upon the decarbonisation of core emissions, whereas climate neutrality frames GHG emissions as an issue of post-production mitigation; this shifts the solution discourse away from CSS strategies and towards deep decarbonisation measures. Situating HYBRIT in the future of Sweden is crucial for boosting the initiative’s potential and momentum; it is also crucial for the survival of not just future Swedish steelmaking, but also the incumbent actors’ continuing role in such. Hence, the coalition is as much about the initiative itself as it is a way for the state and company to improve their green credentials.

The formation of desire

To date, analyses of the linkages created by interventions has focused on their most obvious social and material dimensions, with less attention paid to the ways in which linkages are generated through forms of cultural resonance and emotional attachment. Work on the cultural politics of decarbonisation (Bulkeley et al. 2016) suggests that the formation of desires is an important means through which momentum is built.

Oatly invite consumers to become a part of the “post-milk generation” and promotes practising “planetary stewardship”. In their narrative, consuming oat milk is about daring to make a

choice, and to work (consume?) for a better world. The desire for consuming Oatly's oat milk thus becomes a matter of being rebellious and advocating for change. Oatly have also come to be associated with hip barista culture, which may be derived from their witty copy-writing, contemporary graphics, and their barista-specific version of Oatly. For instance, during the company's expansion, the production capacity for unable to match the large demand. Notoriously, a black market of Oatly Barista emerged in New York during this time, demonstrating the strong desire for the cappuccino-compatible oat milk. However, Oatly has built emotional linkages on being a (self-proclaimed) 'good' company, which has been increasingly criticised since they were partly acquired by the state-owned Chinese company China Resources, who now together with a Belgian company holds the majority of shares; there is a possibility that this new ownership structure harms their image as an independent 'underdog, and a 'good' company. Maybe even more importantly, it might also delegitimise their green credentials (e.g. as China has significant investments in coal); this could influence and decrease the support for Oatly, especially from customers seeking to consume in 'good' ways. (However, the demand for their products seems to not have dropped since this business deal was done in 2016.)

The desires formed by Oatly are deeply contested by the dairy company Arla; by appealing to taste and cultural norms, Arla seeks to limit the emotional linkages of Oatly. Moreover, there is a central theme in Arla's advertisements, which aims to trigger active resistance against (low-carbon) consumption of oat milk. This is evident in the advertising that was put up in conjunction with the (cow's) milk free music festival Way Out West in 2015, which contained the text "forbidden milk is the sweetest", and picture with a person pouring cow's milk in a hip flask. This is also evident in Arla's video campaign featuring the slogan "only [cow's] milk tastes like milk", which featured several situations in which cow's milk was replaced by the plant-based milk "*pojlk*"—a wordplay on *mjolk*, the Swedish word for milk, and an obvious jab aimed at Oatly: the person in the advert who is offered or served *pojlk* (e.g. at a café, at home at breakfast, at a festival) asks if it tastes like (cow's) milk, and then shows signs of disgust when receiving no as an answer.

Zero-waste stores embody the desire of becoming a 'good' citizen, as they allow consumers to construct an identity which coheres with environmental and sustainability values. Zero-waste supermarkets 're-enchant' the grocery shopping experience and make it a meaningful practice, where social relations are formed and sustainability is practiced. Predominantly supplying vegan or vegetarian products, zero-waste goes beyond promoting low-carbon to become a matter of consuming locally-produced and 'just' food. A reoccurring motto of the interviewed owners of ZW stores is: "consume only what you need"; thus the stores promote reduced consumption, rather than solely seeking to replace 'like for like' what you already consume. This suggests that zero-waste stores do not merely seek to form desires for a product or service, much as a desire for a low-carbon and just lifestyle which reaches far beyond food consumption. This imaginary has been widely contested by conventional retail: rather than rejecting the desire of consuming sustainably, conventional supermarkets instead reject zero-waste as a means for fulfilling such desire. One packaging expert interviewed in our case study said: "I don't dispute that people have the opinions and desires they have regarding zero waste, but I have to work

from a scientific foundation. And the science says that while they may think they are doing something good, in reality they might not be.” In this framing, practicing a zero-waste lifestyle is perceived as being driven by emotions, as opposed to the ‘rational’, scientifically-based position of improving packaging: by drawing on rationalistic ideals, incumbent actors seek to hinder the desire for zero-waste by framing it as ‘irrational’. A representative for WWF points out how zero-waste stores are “asking a lot of costumers”, as it requires a degree of planning and forethought that makes spontaneous grocery shopping hard. Thus, the zero-waste stores are also contested by their inconvenience, and framed as ‘unrealistic’.

3.3 Normalisation: Making the New Normal

This property of interventions can also be seen as taking three different forms, depending on the conceptual entry point used. From the original Large Technical Systems perspective, embedding is evident when the system itself is not evident—i.e. it has become invisible, hardly perceptible as a system, taken for granted, ordinary. Here we need to attend to the process of normalisation, which is linked to discursive framings of how we view the world, but which also involves everyday practices (Bernstein & Hoffman 2018; Tozer 2020). Shove (2003a) shows how these two aspects are intimately linked: practices and routines shift when notions of normality do, but everyday habits can also serve to uphold such normative notions. Some things are so bound up with routine and habit that they seem invisible: the air conditioning machine is linked to perceptions of ‘normal’ inside temperatures and to appropriate clothing in the workplace (e.g. suits), but it is also wired to infrastructure; meanwhile natural ventilation functions are increasingly left out from the design of living and working spaces, taking the installation of an air conditioner for granted. Thus the three forms of normalisation are: a standardised and invisible system; the acceptance of an idea or change in norms; and the establishment of everyday practices. However, in line with Shove et al. (2007: 11), we attend to these processes “without supposing that these necessarily result in stabilization or closure.”

Momentum as system being invisible

When a perception of normality has been standardised, it goes unseen. Hughes saw momentum as the ‘end stage’ of stabilisation of a system, when it has become embedded in society (Geels 2007) to the extent that it becomes invisible. Shove (2003a) states that things can be so bound up with routine and habits that they seem invisible, and exemplifies this with energy use—the use of energy in itself, but also the ways in which it is acquired and enrolled by tools and household infrastructures. This can also be exemplified through the way in which the car has come to be taken-for-granted as the main means of transportation: it has become interwoven into networks of highways, sociotechnically normalised while also rendering alternatives (e.g. bicycling) as deviant (Böhm et al. 2006). As Shove (2003b:68) puts it, “[c]ars depend upon and generate co-requisite arrangements including networks of roads, garages and petrol stations, driving skills, regulatory systems and laws. Such systems in turn produce and maintain societies that presume and rely upon high levels of automobility.” Thus, constructing highways enforces car driving as a normal practice, but equally the car itself, and the practice of driving it, shapes the design and extension of such infrastructures. Here it is helpful to add

Easterling's (2014: 76-77) concept of 'wiring/topologies', which "model the wiring of an organization". As she goes on to suggest, "just as an electronic network is wired to support specific activities, so can space be 'wired' to encourage some activities and routines over others." (Easterling 2014: 77) We thus seek in the following to attend to the material and infrastructural aspects of normalisation.

The innovation of Oatly has come to be integrated into the infrastructure of supermarkets: it is commonly placed in the refrigerated dairy section alongside dairy products, and is thus to some extent a standardised product. Crucial to this integration was creating and releasing the 'device' of *chilled* oat milk: while aseptic oat milk can be stored on shelves, fresh oat milk needs to be refrigerated. Here the material properties of oat milk may play a role: as it resembles (mimicks?) milk in its packaging, colour, and function, it seems reasonable to place it next to its dairy counterparts. Shove (2003a) argues that the use of air conditioners becomes more distanced or passive, or even invisible, when integrated into infrastructure, which fosters further routinisation; similarly, picking up oat products is more of a passive act, and thus appears more as a natural part of grocery shopping, when found in the refrigerated dairy section rather than at shelves in a different part of the store. This serves to demonstrate how Oatly as a device adopts to the prevailing infrastructural arrangements. It is possible to imagine that the infrastructure in turn needs to adjust to fresh oat milk—for instance by requiring more cooling machines. However, this has not been evident in the study and needs further investigation.

Oat milk has now become a part of the 'typical' basket of goods through which the UK Consumption Index is accounted, indicating a status of ordinary (ONS 2020); moreover, you can increasingly have your coffee with oat milk when buying take away or at a café. On its website, Oatly has launched a function called "the oat-finder", through which you can find cafés serving coffee with Oatly Barista. We note that Oatly Barista can be found in many places in the ten countries that they to date deliver to (Oatly, n.d.a); however, being 'fully' standardised would mean that oat milk is so ordinary that it can be found at every café, which the existence of "the oat-finder" indicates is not yet the case.

Packaging is strongly interwoven into the food system, illustrated by the fact that "most food companies have invested more in packaging machines than in food production", as stated by a packaging expert interviewed in our study. Packaging thus seems to be taken-for-granted, not the least as its material properties enable long-distance food logistics, upon which global supply chains rely. The zero-waste stores are also interwoven into infrastructure, but in a different matter. Instead of becoming a part of a global supply chain, zero-waste stores attempt to create, sustain and embed themselves in a food system which is local, organic, seasonal, and predominantly vegetarian. In that sense, zero-waste stores prefigure a sustainable transformation of the food system at the local scale. We found that the connection to small and local producers is a question of showing *solidarity* towards these and other like-minded organisations: the relationship to the suppliers of the food products is important, and prefigures the material reconfiguration of the food system that zero-waste stores envision. Thus, by being embedded in neighbourhoods, they 'wire' (Easterling 2014) the local space, and by eliminating packaging, new practices are encouraged. We also see how material elements and the design of

zero-waste supermarkets resemble the conventional store to a certain extent; the self-service dynamic, the ways in which goods are organised and placed, which goods are available. In this regard, they also closely resemble the small-scale grocers that used to exist in abundance before the advent of the modern supermarket; this resembling, or rather mimicking, can be seen as a way of constructing practices which are not too different to those which are already familiar. As such, they seek to establish zero-waste grocery shopping as a part of ordinary life.

Normalisation/Norm change

Other approaches focus on *normalisation*, and see it as a much more active and ‘visible’ thing, achieved through visions, discursive framings and so on; Tozer (2020) suggests it includes discursive shifts in what is regarded as being in the public interest, or the reframing of problems so that new solutions are seen as viable.

A crucial part of Oatly’s strategy has been becoming visible as an alternative to dairy milk; a milk, which at the same time distinguish themselves from cow’s milk. Throughout Oatly’s campaigns and marketing narratives, establishing consumption of oat-based products as normal is closely interlinked to making the consumption of dairy seem *abnormal*. This has been made most evidently in the campaign that concluded that oat milk is “like milk, but made for humans”—later banned after a legal dispute—implying that cow’s milk is not for human consumption. In their campaign “Spola mjölken” (trans. “Flush milk”), consuming cow’s milk is compared to driving a car without seatbelt and other (as they put it) “stupid things we use to do before”, thus framing dairy as outdated. The normalisation of oat milk is also related to desires; normalising the desire for oat milk itself, but also more generally for the low-carbon lifestyle. Rather than normalising the desire for vegan food, they have focused on oat milk’s lower carbon footprint, thus making oat milk desirable for broader group of people.

However, although cow’s milk to some may be perceived as the opposite of oat milk, Oatly uses many of the traits of the (production of the) former to make the latter seem more normal. Swedish dairy is by tradition sold fresh, and thus refrigerated in supermarkets. While many former plant-based milks have been sold in ambient packaging, Oatly is mimicking the way dairy is sold; at the refrigerated section (although they also have some oat milks in ambient packaging). Thus, by appealing to the cultural habit of buying fresh dairy, Oatly has succeeded in becoming culturally accepted: the introduction of the chilled series of skinny, standard and deluxe oat milk in 2019 is a reference to the traditional series of low-fat, reduced-fat and whole milks, and yet another example of how Oatly mimics dairy products to be perceived as normal. It also seeks to resemble milk in colour and function to be a seamless substitute, the success of which can most easily be illustrated with Oatly’s oat milk for coffee. Many were initially reluctant to substitute cow’s milk with oat milk in their coffee, simply because it didn’t blend well; once the company released Oatly barista, which blends very well, many former sceptics have been willing to shift. It also seeks to be seen as normal by bearing the same name, although Oatly’s right to call its products ‘milk’ has been contested by dairy companies, and even led to ban of using the name in some countries. This contestation extends beyond the judicial, to become an ideological debate on the meaning of milk: is it a beverage with a certain function,

with a certain nutritional content; or is it a beverage specifically situated in an ecosystem involving cows?

Zero-waste supermarkets seek to be visible by positioning themselves as different to modern supermarkets, as a place which gives meaning to the shopping routine, and as a form of everyday activism: it is not just about the food you eat, but rather a part of a lifestyle which promotes a more sustainable and just world. Zero-waste supermarkets, alongside the associated social movement, have framed packaging as ‘waste’, rendering packaging as something unnecessary that should be removed rather than improved. As such, plastic has come to be a huge concern receiving a lot of attention in policy, and the idea of removing and/or reducing the use of plastics has come to be more widely accepted, illustrating a successful norm change. The stores themselves seek to be seen as normal by resembling conventional supermarkets when it comes to how goods are placed and organised, and what kind of products are sold. As highlighted in our case-study, the stores also very closely resemble the small-scale grocery stores that used to exist before modern supermarket emerged; thus nostalgia, mixed with contemporary presentation styles (e.g. in the stores’ logos and instructions) plays an important role in building momentum. This suggests that the stores seek to be seen as normal through being seen as new and modern, yet also familiar and nostalgic. However, the zero-waste stores encounter friction in the form of established notions of convenience: the (modern) supermarket as a service where we can buy what (food) we want, when we want it. A Danish WWF representative stated that not being able to grocery shop spontaneously—due to the need for bringing bags, jars, etc.—means that zero-waste supermarkets are “asking a lot of costumers”. Thus, standardised views on convenience slow the momentum of the initiative, making it seem ‘unrealistic’.

Becoming normal to do (practices)

A third perspective might focus on what it becomes normal *to do*—on how low carbon experiments come to be ‘lived’ (Bulkeley et al. 2014), or how new everyday practices or cultural norms come to be established as routine (e.g. virtualised meetings in the pandemic period). This aspect is crucial since “the build-up of everyday action on climate change—practices—can shift perceptions of the necessity and appropriateness of climate action” (Bernstein & Hoffman 2018: 198). Several key dynamics here cluster around normalising individual behaviour, institutionalising new kinds of professional practice (Tozer 2020), and ways that these may sustain notions of normality (Shove 2003a).

Historically cow’s milk in Swedish schools has been subsidised by the national government, which played a crucial role in setting taste preferences and establishing the routine of drinking cow’s milk at a young age: drinking milk frequently is directly linked to notions of taste. Oatly has sought to counter this by being present in schools. For instance, Oatly provides “oat stations” in schools, where oat milk is refrigerated to enable substitution for cow’s milk as meal beverage; they have also arranged half-day courses on how to make vegan school meals. Although it is hard to tell how much this has fostered new practices, it clearly seeks to encourage new routines of milk drinking. Looking at the end-user side, we see how Oatly has shaped their product to make a seamless substitute, which can be seen as a strategy to make shifting practices

easier: for instance, baristas using Oatly Barista can make cappuccinos in a similar way as before, but with oat milk. This suggests that something can be normalised not merely by establishing new practices, but also by seeking to align that thing as close as possible with current practises or routines.

However, if we instead look at the production side of Oatly, we see a different picture. Although the logistics of production, distribution and sales resemble those of dairy companies, production of oat milk requires significantly different practices at farms, as they entail a shift away from livestock farming. The case-study shows how the farmer Adam Arnesson (who had traditionally grown oats for feed, which he both sold to the market and used for his own animals) cooperated with Oatly to create a model for increasing the output of his farm without investing in more livestock. This was made by growing more oats intended for human consumption. According to a study based on the experiment, this resulted in the farm reducing its carbon footprint by half while doubling its caloric output.

In one of Oatly's most recent campaigns, they encourage the industry to "show their numbers", referring to climate footprint; this was accompanied by a new series of products on which their carbon footprint is labelled. This initiation of labelling dairy products has potential for the normalisation of professional practices of evaluation and labelling of (dairy) products' carbon footprint, although consensus around a standardised approach and method for measuring the carbon footprint has not yet been established. Life-cycle assessments (LCAs) are emerging as the most important technique for determining the environmental impacts associated with all stages of a product's life cycle, from raw material extraction to final disposal or recycling. LCAs were used in many of the cases studied in this project, such as oat milk, fossil-free jackets, and zero-waste retail; in these cases, LCAs were mainly used as a 'market device' to either position their innovation favourably (oat milk, bioplastic textiles) or to protect their product from market entrants (plastic packaging). Interestingly, LCAs seem to have become 'that which is normal to do'; they are emerging as an 'obligatory passage points' in the practice of sustainable consumption, though their use tends to instigate scientific and public controversy.

While the zero-waste movement in general, including the stores, normalises the idea of zero-waste, the physical stores enable people to practice their ideals. However, it seems as not all of those who go to the store keep the habit. As one zero-waste store owner puts it, "[i]t's easy to get people, but it's hard to keep them.". Shopping at grocery stores involves establishing various new everyday practices; it does not solely involve changing the store you go to, it also involves establishing routines such as bringing your own bags and jars. These practices are enforced through pedagogical instruction boards in the stores, and personnel who are eager to help and guide. However, carrying around various items in order to shop clearly goes against taken-for-granted convenience: normalised expectations of freedom of choice—that is, the ideal that we expect to be offered a wide assortment of products to choose between, but also different labels of choice for each kind of product—also play a crucial role here. Zero-waste stores usually hold a smaller selection and sell groceries unlabelled; these are adaptations to a small operational scale, but also to a reliance on shorter supply chains. Here it is evident that issues around the

routinisation of habits required for zero-waste shopping are bound to standardised ideas of normality and necessity, and thus to perceptions and practices, but also emotions and desires.

4. Generating Momentum?

The cases explored in this report demonstrate varying degrees of momentum. While each exhibits the three facets of this dynamic that our conceptual framework unpacks, they do so to different degrees. Further, they do so in ways that have varied consequences for the nature of the pathways to decarbonisation that they are able to carve out, and for the traction that they hold within wider socio-technical system. In this section, we bring our findings together for each case and consider the implications of how momentum is being realised for the ways in which decarbonisation is being navigated.

4.1 HYBRIT: contradictory immanent potential?

HYBRIT is the innovation that has been able to gather least momentum amongst those attended to in this work; however, that does not mean that it has gathered none at all. Most notably, the innovation has a huge (albeit seemingly) *immanent potential*, since it enables making steel production fossil-free. Steel is usually considered a hard-to-abate industry, which is why CSS strategies formerly have been dominant within the discourse; rendering deep decarbonisation of the steel industry possible, and the non-abatable abatable, is thus a big deal. We also see how HYBRIT has been able to gather massive *capacity* for the intervention: it has mobilised large amounts of funding, leading to an institutional capacity best expressed in the way that HYBRIT is commonly mentioned by the Swedish government as an example of its national measures for climate action. However, the innovation has encountered a few highly significant frictions. As the project has unfolded—although still at pilot stage—future competitiveness and sustained financial support remain as challenges, despite the large amount of governmental funding already received.

If we instead examine the initiative's linkage-building, we see how some linkages are in place while others are clearly absent. HYBRIT has been able to gather a strong coalition around 'fossil-free steelmaking', supported by many actors: the framing of the initiative being 'fossil-free' rather than 'climate neutral' is crucial since it is a discursive act that puts focus on deep decarbonisation rather than post-production mitigation. However, this also appears as a strategy employed by incumbents to improve their green credentials in order to ensure their position in a future steel industry. HYBRIT has also been able to create emotional linkages, as there is a strong desire for fossil-free steel; through being used as an example of the Swedish government's climate action, it becomes a part of the desire to position Sweden as "the world's first fossil-free welfare country" (The Swedish government 2015). The initiative has successfully established a discourse of fossil-free steel, through which a steel industry without GHG emissions is imagined. Moreover, the shift from the formerly dominant discourse of CSS strategies indicates a norm shift; this also indicates that 'low-carbon' policy is increasingly considered to be 'good' policy (cf. Tozer 2020). Thus, the initiative can be seen as a part of (or

alternatively a consequence of) climate action targets increasingly appearing to be both inevitable and expected among governmental policy and sector-specific visions alike.

However, the initiative still lacks a few critical infrastructural linkages. The capacity of Swedish fossil-free electricity production is estimated to be enough to provide sufficient supply to HYBRIT, the estimated future supply of wind power is crucial here (see Svensk Vindenergi 2020). However, there might be some issues related to *distributing* electricity. This requires expansion of the electricity grid, which is hindered by lengthy and complicated permission processes. A new full-scale demonstration plant is now planned to be built in Norrbotten County (northern Sweden), whose availability of fossil free electricity was very important in the placement decision. Thus, HYBRIT has established a few infrastructural linkages, although some are still missing. Establishing these are critical in making HYBRIT a part of ‘the new normal’, and normal ‘to do’, which has not yet been achieved. Practices are inherently hard to evaluate in this case since the project is still at pilot-project phase; nonetheless, this provides an example of how an innovation cannot solely become discursively accepted, but must also be realised and interwoven into everyday practices.

HYBRIT, whose goal is to produce 100 % fossil-free steel by 2035, is a crucial part of SSAB’s goal of becoming 100% fossil-free by 2045. (SSAB, n.d.) As a part of the measures to be implemented in order to achieve this, SSAB will replace the two active blast furnaces in their Oxelösund production site with an electric arc furnace. The ambition is to use fossil-free produced electricity, but biogas is also seen as a possible alternative when such fuel has become more affordable. As a temporary solution, the initiative will be fuelled with natural gas, which will be supplied by SSAB’s to-be-built liquefied natural gas (LNG) terminal in Oxelösund, Sweden. Building the LNG terminal is mainly to supply the Oxelösund production site and to enable its conversion and is thus not directly a part of the HYBRIT project, neither is HYBRIT production planned to be fuelled by natural gas. However, both Oxelösund and HYBRIT are critical in SSAB’s road to decarbonisation. Although it is definitely too early to draw any conclusions regarding potential entrenchment effects of building the LNG-terminal, we may note a parallel to Bernstein & Hoffman’s (2018) example of reinforcing of a carbon lock-in in Colorado: in their example, a project initially aiming for establishing renewable energy ended up using natural gas, which resulted in a reinforcement of carbon lock-in rather than an improvement of the system. Building infrastructure for natural gas could incentive further use of the fossil fuel in Oxelösund—instead of later replacing it with renewable energy as planned—, and therefore possibly initiate carbon lock-in-effects of SSAB’s decarbonisation plan at the site, and thus also their goal of becoming 100 % fossil-free by 2045. Since HYBRIT’s goal is to make all steelmaking fossil-free at industrial level by 2035, lock-in effects may too affect the initiative’s potential. However, how, and if, this may affect SSAB’s decarbonisation plan—and in extension HYBRIT—remains to be seen, and merits further investigation at a later stage of the innovation.

Thus, HYBRIT appears to be an initiative with a huge potential, a hard-hitter— but it struggles to realise that potential. While some linkages are in place, mainly emotional and coalition building behind ‘fossil-free steelmaking’, crucial linkages to the current infrastructural system

are still missing. This is also reflected in infrastructural aspects of normalisation, which HYBRIT has not been able to acquire. This is critical in explaining why the successful normalisation of fossil-free steel *as an idea* has not yet been materialised into practices. Again, it is hard to establish practices while still being at pilot project stage: it is simply too early to say how the initiatives somewhat contradictory potentials will play out. What can be said based on our analysis of the case, however, is that HYBRIT demonstrates the importance of building many different aspects of momentum in order to successfully realise decarbonising potential.

4.2 Oatly: the force of new desires?

We see how the inherent material properties of Oatly's innovation is crucial in the innovation's transformation potential: the potential of oat milk to substitute for dairy milk serves to re-organize the value chain, and may also redistribute economic power. (However, since Oatly aligns well with dominant business models, it is questionable to what extent the initiative could transform broader structures of power.) Nevertheless, the initiative's immanent potential is strong, not least as oat milk takes the role of a 'multiplier' to be replicated and standardised across the food sector; it also works as a 'switch', as it may foster further flow of low-carbon activity, in the form of diets trending toward a more plant-based composition. An interesting cognitive capacity identified in the case of Oatly is the capacity to be assessed, and the ability to calculate the carbon footprint of the product, and how that allows differentiation. Through campaigns urging the industry to "show their numbers", and through labelling their own product's carbon footprint, Oatly rhetorically limits consumers' decision space to being for or against climate action: this reflects oat milk's capacity to be assessed in this way, which enables making climate impact the main criteria when choosing between dairy and plant-based alternatives. Similarly, "the Oatly way" shows a capacity to demonstrate their potential in a simple (and, according to many, simplified) yet powerful way. Oatly has been able to align their initiative to the wider society through its presence in schools, at festivals etc., which illustrates a strong relational potential. One example is their collaboration with the music festival Way Out West, in which they made the festival area milk free; as such, the festival became a space for demonstrating what a milk-free society could look like. Moreover, climate action through food sustainability expands to the cultural sphere, expanding scope for (climate) responsible societal actors.

Oatly has been able to create strong linkages in many respects. Through their many collaborations with dairy incumbents, they have been able to create the connections necessary to get the product into supermarkets, which was deemed the highest hurdle by an Oatly employee. By later ending such partnerships, they could re-frame their product to become attached to climate action and impact, a critical linkage building for the innovation's gathering of momentum. Oatly has also been able to gather force around 'sustainable food', both in terms of production and consumption; crucial in doing so was the lawsuit around their marketing practices, which ended with a ban, but also with a strong support for their cause. However, they have had a hard time building coalitions with farmers who traditionally align themselves with livestock producers: if the product's full potential is to be released, in the form of a shift from dairy to oat-based products, Oatly needs to the farming sector 'on board'. The way they have

communicated risks reinforcing resistance towards their low-carbon initiative, and thus hindering the momentum thereof. Moreover, they have succeeded in creating a desire for their oat-based products on the grounds of sustainability, and thus also a desire for low-carbon lifestyles; these desires have, however, been widely contested by incumbents. For instance, during the milk free festival of Way Out West, the dairy company Arla ran an ad saying that ‘forbidden milk is the sweetest’ featuring a picture of a person with a person pouring cow’s milk in a hip flask, as if seeking to trigger active resistance towards Oatly. The force Oatly has gathered has thus been met with significant resistance, some of which has served to push the initiative further, however equally pushed groups—whose support they need to attract—further away.

The innovation of Oatly has now become invisible to some extent, as it is placed in the refrigerated dairy section alongside dairy products, and has thus to some extent become interwoven in the infrastructure of supermarkets. Creating and releasing the ‘device’ of chilled oat milk was central to acquiring this position. We can also see how Oatly seeks to resemble milk, in its packaging, colour, and function: by resembling, or mimicking, cow’s milk’s material properties, it appears as a seamless substitute, enabling oat-based products to increasingly become a part of ordinary life. A crucial part of Oatly’s strategy has been becoming visible as an alternative to dairy milk; it is ‘a milk’, but at the same time distinguishes itself from *cow’s* milk. Throughout their campaigns, the message they seek to convey is that cow’s milk is ‘natural’ and high-carbon; by revealing consumption of oat milk as a constructed practice, oat milk has increasingly come to be seen as normal. As cow’s milk is subsidised to set preferences at a young age, Oatly has struggled to establish the habit of consuming oat milk, or other oat-based products, to the same degree. However, by using the school as a battleground to establish new preferences, cow’s milk’s given role has been questioned; once again, resembling cow’s milk has been crucial in making consuming oat milk a part of everyday practices. Most notable is the example of Oatly Barista, which provided a plant-based product which blends well with coffee, and thus makes substitution easy. By introducing carbon footprinting, they can potentially normalise professional practices of LCAs; thus, by becoming ‘new yet familiar’, oat milk has become normalised. Oatly has been able to gather momentum by coming to be seen as normal *as an idea*, but also *as an element of established practices*. However, Oatly becomes most successful when it is seen as equivalent to any other dairy products, to be used in cooking or in your morning coffee. Although the innovation has not fully been taken-for-granted, some elements of invisibility are evident. Moreover, although their antagonistic relationships with dairy companies seem to increase the initiative’s force, souring relationships with farmers might serve to hinder the realisation of their full potential.

The case of Oatly demonstrates synergistic effects between different dynamics of momentum. Oat milk takes the role of a ‘multiplier’ with the potential to be circulated and replicated, but in order to actually become circulated, it was necessary to create a strong desire for the innovation. This formation of desire is in turn strengthened by the innovation’s immanent potential of disrupting the value chain, and its capacity to be assessed (and thus also valued) according to its climate footprint. Linking this to processes of normalisation, it is evident that creating linkages within the food sector was crucial in becoming a part of the dairy section in

supermarkets. Becoming seen as a viable alternative to cow's milk was supported by a strong coalition building behind the initiative supporting their cause. Moreover, in order to establish new practices it was crucial to be present at schools and cultural events, which also served as a ground to dismantle cow's milk's given position in society. This is far from an exhaustive examination of all the ways in which the dynamics intervene; however, it shows that the realisation of Oatly's potential, the ball rolling down the incline, is a process requiring all the different dynamics of momentum attended to in this work.

However, it is evident that Oatly struggles with gathering momentum in some respects. For example, their oat milk has become interwoven into the infrastructure of supermarkets, but it has not yet become a taken-for-granted part of ordinary life. As Shove (2003a) demonstrates with the air conditioner and construction design, things and practices are co-constructive; the air conditioner changes infrastructure, since building designs are adopted to the device to be installed, and infrastructure further encourages the practice of using the device, thus making it an unseen part of ordinary life. Practices need to be manifest at a certain scale to be interwoven into the infrastructure, which in turn further enables scaling of the innovation. We can see such dynamics, or at least tendencies thereof, in the case of Oatly. As the initiative has scaled up (see Deliverable 6.1)—here referring to the process of breaking through the socio-technical regime of dairy, and establishing as a new technology—we see how the products have been more tightly integrated into supermarkets, involving multiple aspects momentum building. Equally, the initiative has *rescaled* (see Deliverable 6.1) the meanings of dairy milk, which is fostering normalisation of oat milk. Rescalings through material configuration and politicisation of dairy also play a crucial role in building momentum for the initiative.

It is also interesting to examine the case according to Bernstein & Hoffman's (2018) second system effect: entrenchment, and to what extent the initiative is made *durable*. Important here is how Oatly has successfully built linkages: making oat milk a question of climate action rather than one of lactose intolerance; assembling a strong coalition behind the cause; creating a desire. Here, 'low-carbon' comes to be a sought-after quality of products, which normalises 'low-carbon' as 'good' (cf. Tozer 2020); this fosters a "sticky" practice of consuming oat-based products, and an equally "sticky" desire for doing so, but also for decarbonising actions more broadly. As they have realised its immanent (decarbonising) potential, dairy milk has become less of a matter of course, and Oatly has become more bound up to everyday practices, indicating a partial undoing of high-carbon orders and the creation of a low-carbon trajectory. However, though the introduction of chilled oat milk seems to have been crucial in normalising the innovation, and thus fostering the entrenchment thereof, we can also see how it may reinforce assumptions of food needing to be 'fresh' and 'natural'. Mylan (2016: 213) explores "the momentum in the wrong direction for transition to lower carbon societies" through orange juice, which is kept on a high-carbon trajectory involving desires and perceptions of 'quality'. Mylan (2016: 232) explains how an attempt to carbon footprint-label orange juice failed to shift consumption habits of orange juice towards less carbon-intensive as "[t]he new quality of 'carbon intensity' faced an uphill struggle to be incorporated into consumers' perceptions of quality, against deeply embedded qualities, including freshness, and taken-for-granted associations such as cooling and not-from-concentrate." In this light, Oatly's oat milk being

chilled can be seen to enhance a desire for the product, and thus a shift to a less carbon-intensive practice (compared to cow's milk); nevertheless, it also reinforces high-carbon practices of refrigerating goods, which in this case signify refrigerating both in *en route* to the store, and to a larger extent in homes (pasteurised oat milk needs refrigerating at home, though not until opened). Just as the frozen food sector relies on the standardised practice of having a freezer at home (Shove 2016), chilled oat milk relies on having a (large) refrigerator at home. Thus, although the general entrenchment effects of the initiative lead to making decarbonisation durable, we can in this aspect also talk about negative feedback loops (Bernstein and Hoffman 2018), which risks leading to increased durability of some more carbon-intensive practices.

Oatly meets a lot of frictions, which take many different forms. The strong coalition building around 'food sustainability' and the desire therefore has been met with a 'countercoalition' (Bernstein & Hoffman 2018) from incumbents who emphasise the environmental benefits of dairy production, and who contest desires for oat milk in terms of the taste of cow's milk; however, these contestations seem to serve to gather rather than hinder momentum for the initiative. Haarstad & Wanvik (2016: 433) conceptualise socio-technical regimes as unstable and unpredictable, and read regimes as assemblages of entities "held together in more or less impermanent relationships"; this "enables us to appreciate changes and ruptures that may not overthrow 'the system as a whole', but nevertheless represent significant change." In line with this, the contestations seen in the case of Oatly suggest that processes of change are not taking place by 'breaking through' regimes of permanence, but rather by rendering regimes and their inertia as contingent. Going back to the discussion of which 'parts' of the system Oatly changes (e.g. the dairy value chain), and which 'parts' that they reinforce (e.g. hegemonic business models), assemblage thinking might help us identify how Oatly reinforces some systems of power, even as they are closely involved with significant change-making.

4.3 Zero Waste Supermarkets: how friction reduce the power of momentum

In terms of disposition, the initiative of zero-waste supermarkets has been able to gather momentum, but also encounters frictions along the way. It can be seen both as a 'multiplier' to be circulated in order to rewrite the urban space, emphasising the local community, but it also takes the role as a 'switch', leading to a flow of activities as it promotes sustainable practices exceeding those practices at the store. It has also been able to gather momentum through relational potential: as it removes packaging from the imaginary assemblage, it renders long global supply chains impossible, thus making more local ones necessary. Perhaps the most striking gathering of momentum in this dynamic is the initiative's capacity as demonstrated by the mason jar. Fitting one family's year's worth of waste really spread the word of the zero-waste movement and became an exceptionally powerful symbol of the potential of the lifestyle, posing the question: if one family could reduce their waste to this extent, what would it mean if we all lived this way? However, it is evident that the initiative encounters frictions in the form of established notions of convenience: it is seen as (and *is*, to a certain degree) a more time-consuming way of grocery shopping. This makes zero-waste grocery shopping seem unrealistic to deploy at scale, which renders it unfeasible and thus hinders the directionality of the initiative.

The growth of zero-waste supermarkets has increased rapidly in recent years. The stores employ a growth model which differs from mainstream ones, through replicating small-scale stores rather than building large stores included in franchises: this is a part of their set of values the stores seek to practice' according to which consuming sustainable (package-free, organic), just (predominantly vegetarian or vegan) produce, and consuming only as much as you really need, is crucial. The stores have not become fully scaled (in the way they are seeking to become), as many neighbourhoods still lack a zero-waste store; this leads to inconveniences—for instance, costumers needing to search for stores—not inherent to the initiative itself. Regardless, the stores have been able to create strong linkages. Crucial in this work is the building of discourse coalitions around 'ecological citizenship'; moreover, they appeal to and embody the desire for being a 'good' citizen. Thus, although the stores come with some compromises (e.g. with time taken, or with keeping a budget), they do offer a meaningful experience, and a space where social relations can be built and new food systems imagined. Thus, although more physical expansion (i.e. opening more stores) is needed, momentum has successfully been gathered.

Zero-waste supermarkets are interwoven into infrastructure, but in a different manner. Instead of being interwoven into a global food system, they are embedded in local societies, and shorter supply chains; they thus reconfigure transformation in food systems at a local scale, while 'wiring' the local space. They have a few 'ordinary' elements; for instance, the self-service dynamic, or the organisation and display of goods. However, they have evidently not become taken-for-granted: going to such stores appears more as an alternative activity, rather than a part of ordinary life. Zero-waste stores have evidently come to be visible as an alternative to modern supermarkets; they are emphasised as a place which gives meaning to the shopping routine, and as a means to practice everyday activism. It is not just about the food you consume, but about the different world you imagine. As such, zero-waste, including the stores and the movement, has succeeded in bringing about a shift in the public perception of packaging, from being taken-for-granted and invisible, to being a sustainability issue in need of address. However, the zero-waste paradigm has also been contested, deemed 'unrealistic' by incumbents, which hinders the innovation's being fully seen as 'normal'. Moreover, as stated by a zero-waste store owner, people are hard to keep, which suggests that the initiative has not yet been able to make zero-waste grocery shopping a part of ordinary life. It is thus clear that while the idea of zero-waste has shifted norms, it is still not seen as nor been made 'normal to do'. Neither has the initiative become interwoven into infrastructure to the degree that it goes unnoticed.

The aspects of momentum where zero-waste supermarkets have been able to gather momentum are interlinked, and seem to all be connected to the strong social movement behind the initiative. The immanent capacity of the zero-waste stores has been strongly communicated with the mason jar filled with a Bea Johnson' family's years' worth of waste; serving a powerful imaginary of the potential of zero-waste lifestyles, it triggered an enormous attention to the paradigm, leading to many joining the movement. Both of these aspects also seem to be crucial to the successful establishment of the discourse of packaging as 'waste': Bea Johnson's mason jar illustrated the possibility of living without packaging—which thus appeared as

‘unnecessary’—and the strong coalition of zero-wasters further frame this lifestyle as feasible, thus further legitimising the packaging-as-waste discourse.

However, expected and taken-for-granted convenience runs like red thread through the aspects of momentum which the zero-waste stores has either not been able to gather, or has been obstructed from doing so. Making use of Shove’s (2003a:16) understanding of convenience as “to describe arrangements, devices, or services that helped save or shift time”, we see how the inconvenience(s) of zero-waste grocery shopping is emphasised by incumbents, making the lifestyle seem ‘unrealistic’, which reduces the initiative’s (perceived?) potential. Convenience is also crucial in the successfully established discursive coalition of ‘circular economy’: while zero-waste requires compromising with consumption habits, lifestyle and dominant business models, the circular economy paradigm does not. Moreover, inconvenience seems to be a critical component in understanding why the zero-waste store has not come to be routinised: most notably, it is seen as time-consuming to bring your own jars, difficult to find a store, and then difficult to finding what you want once you get there. Although some of these inconveniences are inherent to values of the stores—removing packaging is non-negotiable, and a smaller selection of products often results from sourcing only local food—some of these inconveniences are linked to the limited growth of the initiative. While they have increased remarkably in recent years, many neighbourhoods still do not have a zero-waste store of their own; if this were not the case, shopping in your own neighbourhood could actually be more convenient, as one zero-waste owner said. This also emphasises the importance of further scaling of the initiative—in the sense of being diffused horizontally into a new context—for positive feedback loops to be fostered. Moreover, rescaling as in politicisation of packaging plastics (see Deliverable 6.1) may be crucial in processes of normalisation, since shifting the discourse of such has been a crucial part in making zero-waste an acceptable idea. Rescaling in terms of material configuration, meanwhile (see Deliverable 6.1), may also intervene with momentum building, as the configuration of global supply chains are critical in the immanent and relational potential of the initiative. This suggest that scaling and momentum are two co-constructing processes, both necessary in the making of change.

Thus, the zero-waste initiative has successfully built momentum in some respects, but struggles in many others. A question that remains to be answered is what can be said about the *durability* and the *entrenchment* (Bernstein & Hoffman 2018) of the innovation, and what decarbonisation trajectories it might construct. As attended to earlier, the innovation has a strong capacity, reflected in its ability to demonstrate its potential through Bea Johnson’s mason jar. Moreover, the zero-waste stores have been able to build a strong coalition around the initiative, and also embodied the desire to become a ‘good citizen’. Zero-waste shopping has thus to some extent become “sticky”, in terms of being bound to new forms of identity (cf. Bulkeley et. al. 2016). However, the innovation has been contested by incumbents forming a counter-coalition around the notion of the ‘circular economy’, through which the initiative itself, as well as the desire for it, have been contested as being ‘unrealistic’ and too inconvenient. As a result, while public opinions on packaging plastics have been shifted, the zero-waste supermarket is not fully seen as ‘normal’. This is echoed in the question of whether zero-waste shopping has become normal ‘do to’. As mentioned above, zero-waste supermarkets struggle with keeping customers coming

back, indicating that for many this seldom results in a habit that lasts; thus, although the zero-waste stores successfully employ many of the political processes (e.g. capacity, coalition building, normalisation) that may lead to entrenchment according to Bernstein & Hoffman's (2018) framework, the frictions it encounters continue to hinder the extent to which this innovation can become entrenched.

5. Conclusions

The concept of momentum has been an essential but often neglected building block in the conceptualisation of socio-technical systems and their transitions. Fundamental to initial work on large-technical systems and seen as a critical component of how path-dependency is established, we suggest that an analytical focus on the nature and dynamics of momentum will be essential if we are to fully comprehend the potential for decarbonisation. Building on the early writings in the field and drawing on the more recent advances in the debate made by Bernstein and Hoffmann (2018) as well as Easterling's (2014) account of the 'extrastatecraft' involved in the generation of infrastructural space, we suggest that the concept of momentum can usefully be disaggregated as comprising of three interwoven dynamics—directionality/disposition, expansion, and normalisation—each of which in turn involves multiple components. While such a composite account of momentum is rather complex, it is helpful in analytical terms, for it allows for a detailed examination of how, why and to what effect different interventions may or may not be able to gather momentum.

Our analysis of three of the REINVENT case-studies—HYBRIT, Oatly and Zero Waste Supermarkets—demonstrates that momentum does indeed take many forms. While HYBRIT is only at the pilot stage, and hence the extent to which it has gathered momentum is likely to be limited, our assessment suggests that while it has significant immanent potential to date it has not yet been able to garner sufficient linkages, capacity or normalcy for this to be realised. The case speaks to why so many apparently promising technological solutions are never successful: while often posed as a matter of 'technical capacity' that needs to overcome 'social realities', taking the concept of momentum allows us to see that the possibilities for decarbonised steel lie in the ways in which its socio-technical momentum can be established.

In contrast, both Oatly and zero-waste supermarkets have been able to garner momentum, generating multiple forms of directionality/disposition, expansion and normalisation, as discussed extensively in Section 4; yet both have also encountered *friction* in various forms. For Oatly, this has arisen in terms of both how it has established linkages and expanded within the mainstream supermarket sector, and also with the challenge of both remaining distinct and normal at the same time. For zero-waste supermarkets, the challenge is also one of becoming enmeshed within the normal routines and forms of everyday life.

However, the nature of these frictions are in each case different, and have resulted in Oatly having established more momentum than zero-waste supermarkets. Comparing the cases, first we can see that they have adopted different approaches to the fundamental issue of *convenience* (Shove 2003a). Oatly has sought to align their product and the practices of which it is an intimate part closely with existing forms of consuming milk, and hence have been able to both 'slip into' networks and infrastructures whilst also challenging existing conventions about what it is that milk is, does, and becomes. Zero-waste supermarkets on the other hand seek purposively to be a 'misfit' with existing supermarket shopping practices, requiring different

practices to be learnt and old ones discarded, creating a slower experience which is intended to be thick with meaning and intentional in its effect on bringing what are often routine acts to a new kind of presence in everyday life. The small number of stores—their limited capacity as a multiplier—further exacerbates the idea that the zero-waste supermarket is an exception rather than the rule.

A second key point of comparison concerns the extent to which each intervention has encountered resistance from existing incumbents. In the case of Oatly, it appears that the friction that has been found between the intervention and incumbents as they seek to establish oat milk as a viable, desirable alternative and to generate expansion has generated new coalitions and provided the means through which oat milk has come to carry particular desires. In contrast, zero-waste supermarkets have encountered opposition and derision, with the alternative discourse of the ‘circular economy’ and its attendant interventions being able to claim both more rationality and more sensibility. Zero-waste supermarkets are neither seen as effective nor as efficient, and here rather than their experimental qualities being lauded they come to be used against them to generate a resistance based on the idea that they will ‘never catch on’.

These cases appear to suggest that the Goldilocks principle holds true. Interventions can be ‘too cold’: the HYBRIT project has potential, but it has not been able to gather enough energy to start to roll. Interventions can also be too hot: the directionality of the zero-waste supermarket and all that it conveys about what it would mean to pursue deep decarbonisation in everyday life generates too much friction. Oatly is just right: neither too hot nor too cold, it gains sufficient energy to start to make a difference to the hunger for decarbonisation, but not so much that it is unpalatable to digest. This in turn raises interesting questions about how momentum creates pathways for decarbonisation. It is clearly not a matter of the substitution of one socio-technical configuration with another, but instead multiple configurations are in play at the same time and the potential of one has significant implications for the others. Our analysis also suggests that it may be possible for an intervention to scale but not to gather momentum, and vice versa: these are two different sets of dynamics governed by different functions and attributes.

While the Goldilocks principle considers the set of circumstances that create the ‘just right’ conditions for decarbonisation, we also need to bear in mind that the conditions are never just right, and maybe never will be; furthermore, the conditions are always changing. What is understood as ‘deviant’ in any point in time (too hot, or too cold) might be able to gather momentum at a different moment, when new opportunities emerge, or new frictions form. Living through a pandemic, as the authors are at time of writing, reminds us that options for decarbonisation that were heretofore seen as impossible might be reconsidered, and with an alarming suddenness. The American author William A. Feather noted that “people who delay action until all factors are favorable do nothing”. Goldilocks, at least, tried all the bowls.

6. Appendix: background of the REINVENT cases

6.1 Oatly

The negative environmental impact of livestock has been increasingly understood and documented during the past two decades, leading to a questioning of the dairy industry. According to FAO (2019), livestock industries represents 14.5% of all anthropogenic GHG emissions. Although GHG emissions per gallon of milk has fallen due to increased productivity, dairy emissions still increased by 18% between 2005 and 2015 (FAO & GDP 2019).

The Swedish food brand Oatly produces oat-based dairy analogues for an international market. Through a patented enzyme process, they manufacture an oat base which is then processed into a diverse set of products (milks, yoghurts, cream, etc.). Their innovation was developed in the early 90s in conjuncture with research findings on lactose intolerance. It was not until 2012 that Oatly really took off, after a rebranding. They have become known for their cocky copywriting, bold ads, and the legal dispute with Swedish dairy (actually a consequence of the former). The Oatly brand is available in 20 countries throughout Europe and Asia. (Oatly, n.d.b)

6.2 Zero-waste supermarkets

Plastic packaging represents 40% of plastic demand and over 60% of plastic waste in Europe (European Commission, 2018). Most plastic packaging is single-use, meaning that 95% of the value of packaging is lost to the economy after a short first use (Ellen MacArthur Foundation, 2016). Any attempt to address the challenges of plastic pollution and decarbonisation will have to tackle plastic packaging.

Zero-waste grocery stores depart radically from the standard practices of conventional supermarkets by offering their range of goods without any plastic packaging whatsoever. They rely on shoppers to bring their own bags, jars, and containers from home and fill them up at the store, buying only as much as they need. There is no complicated technology or infrastructure that enables them. Neither is the organisational and business model of the zero-waste store overly innovative in comparison to supermarkets. These are not novel forms of arranging the sale of groceries, as they very closely resemble the small-scale grocers that used to exist in abundance before the advent of the modern supermarket with its economies of scale, efficient logistics, and extensive range of product offerings. Opening of zero-waste supermarkets has increased significantly recently. Despite the rapid growth, zero-waste retail still makes up a minuscule niche of overall retail, catering primarily to affluent, urban neighbourhoods.

6.3 HYBRIT

The steel industry is the single biggest emitter of greenhouse gases across all of industry, mainly due to the production of primary steel, for which coke in particular, but also natural gas, coal, and sometimes oil are used (see D2.2). In Sweden, steelmaking accounted for 11% of national emissions in 2016. Innovation in the steel sector in the past has focused on productivity gains on energy use and material efficiency, but in recent years research on decarbonising primary steel production has emerged.

HYBRIT, acronym for Hydrogen Breakthrough Ironmaking Technology, is a development project with the aim of implementing fossil-free primary steelmaking through direct reduction of iron ore using hydrogen as reductant (H-DR) and fossil-free mining and palletisation of iron ore. The project consists of two parts: Hybrit Development AB, which is a joint venture by Swedish companies SSAB (steel company), LKAB (state-owned mining company), and Vattenfall (state-owned energy company). HYBRIT RP1 is a research project that includes academia, research institutes, and industry, with financial support from the Swedish Energy Agency. The initiative was publicly announced in April 2016. The pilot phase will last from 2018 to 2024, which includes having the pilot plant in Luleå (north Sweden) built by 2020. The demonstration phase will last from 2025 to 2030, leading to the production and commercialisation of fossil-free steel by 2030.

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