Meeting human needs within planetary boundaries – a provisioning systems perspective on clean transitions

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BACKGROUND PAPER

May 2022

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This Background Paper supports the scientific report, *Stockholm+50: Unlocking a Better Future*

Summary

Beginning during the industrial revolution and then rapidly accelerating since the end of the Second World War, human civilization has undergone a massive transformation with profound implications not just for humans but for the planet more broadly. While this development has enabled great improvements in living conditions for billions, it has come at the cost of massive overexploitation of natural resources. The key challenge for the global community moving forward is thus how to meet human needs and continue to improve human welfare without transgressing the boundaries of sustainable use of natural resources. In other words, keeping within what has been called **the sustainability corridor.**

Staying within this corridor can be achieved through different means, including changing which natural resources are used – such as going from fossil fuel to renewable energy – or changing human needs – by reducing excessive consumption. Central to any changes is also the configuration and set-up of the actual structures that link human needs with use of natural resources. These **provisioning systems** include not only the physical infrastructure and machinery that enable extraction, processing and transport of natural resources into products and services that meet human needs but institutional and social systems as well.

In this paper, we draw upon the provisioning systems framework to illuminate and better understand the central characteristics of different sustainability challenges, pros and cons of corresponding solutions and why particular policy actions that are effective in one context are infeasible in another. We focus particularly on issues related to climate change mitigation and apply the provisioning systems framework to two examples. The first looks at how one particular human need (charging a cellphone) can be met through two provisioning systems (grid electricity and a portable solar panel) that have almost nothing in common. The second example concerns the same basic problem (greenhouse gas [GHG] emissions and mobility) but with different modes of transport (air and road).

The overarching argument we make is that truly effective policies aimed at more sustainable production and consumption will often require a thorough understanding of specific contexts of sectors, geographical conditions and political realities. This is especially important in the light of the radical and rapid changes needed to transition the global economy to net zero by 2050. This process has the potential to be disruptive not just technologically but for society more generally – it is essential that this complexity is addressed head on. Instead of overly relying on piecemeal approaches like carbon pricing or consumer scapegoatism, policymakers need to make sure to coordinate measures across provisioning systems.

1. Introduction – balancing human needs and planetary boundaries

1.1 The pros and cons of human civilization

Over recent centuries, human civilization has developed into something that seems completely natural to us today but would have been completely unthinkable before it actually came into being. On the one hand, human well-being has reached the point where billions now have a standard of living that is far beyond what even royalty could aspire to only a few hundred years ago. On the other hand, these achievements have come at enormous costs in terms of exploitation of not only people but nature as well (Raworth, 2017).

Awareness of the extent of the damage done to our planet was first brought on to a truly global agenda at the UN Conference on the Natural Environment in 1972 (United Nations, 1973). The almost 50 years since have seen an enormous increase in our understanding of how human activities shape and damage our ecosystems and, perhaps most worryingly, disturb the geophysical cycles upon whose function all life on Earth, including our own, is based.

The fact that the Earth's climate is now changing because of human activities is arguably the most telling example of our power to manipulate our surroundings. The consequences of this could become not only catastrophic on a planetary scale but also possibly irrevocable, if we continue emitting carbon dioxide and other GHGs into the atmosphere (Intergovernmental Panel on Climate Change, 2021). This is especially so as we are at the same time decreasing the capability of natural systems to remove carbon from the atmosphere and impairing the capacity of human and natural systems to adapt to a changing climate (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2019).

A central challenge for humanity moving forward is therefore to find an approach by which billions of people can live decent lives but **within** the boundaries of sustainable resource utilization. In other words, balancing human needs and the planetary boundaries and staying within the **sustainability corridor** (Bringezu, 2015; Raworth, 2017).

1.2 Rethinking required?

In addition to being used as a concept around which to frame ambitions of environmentally sustainable development, the sustainability corridor approach can also be used as an analytical starting point to discern what such a development could look like in practice. In addition to focusing on how to transform current systems to be compatible with ambitions around sustainability, it is important to zoom out and think more broadly on the core of the matter. Fundamentally, it can be framed as something like this: humans have a set of needs, nature has a set of resources – taking away everything else, how could a system be designed that enables human needs to be met without overexploiting natural resources? Which are the key aspects that need to be taken into account? And how do specific system characteristics determine how actual change can play out in practice? In this paper, we explore how the **provisioning systems concept** (Fanning et al., 2020; O'Neill et al., 2018) can be used to explore these questions. The remainder of the paper is structured as follows. In Section 2, we present the provisioning systems concept, including some key analytical components of the framework. In Section 3, we present and analyse two examples. Section 4 concludes with a discussion and policy recommendations.

2. The provisioning systems concept

2.1 Introducing provisioning systems

The question of how to change to systems that deliver more sustainable consumption and production has been proposed by Geels et al. (2015) as a '**reconfiguration**' of systems, focusing on social–technical transitions and changes to social practices. Mont (2019) advocates for '**systems transformation**', which includes alternative consumption and business models and exploration of processes that govern transformations to these new forms of consumption and provisioning. At a more practical level, the United Nations Environment Programme (UNEP) (2021) suggests applying a **systems lens to a value-chain approach**, considering the complex drivers and feedback loops that determine and influence the operations and behaviours of actors along the value chain. The aim is to engage actors along the value chain and identify promising solutions and a common agenda for system transformation. Several other authors who have reviewed and synthesized recent sustainable consumption and production (SCP) literature agree with taking a systems perspective on the problem and solutions (see Bengtsson et al., 2018; Blok et al., 2015; Cohen, 2019; Geels et al., 2015; Laakso et al., 2021; Shibin et al., 2016; Tukker, 2008; Vergragt et al., 2014).

Most recently, and building upon the sustainability corridor concept to structure thinking around the connection between human needs and the associated resource use patterns, researchers have suggested a concept called **provisioning systems** (O'Neill et al., 2018). A provisioning system is defined as *'a set of related elements that work together in the transformation of resources to satisfy a foreseen human need… This definition establishes the system boundary of a provisioning system, and the elements, relationships, and purpose that comprise it.'* (Fanning et al., 2020).

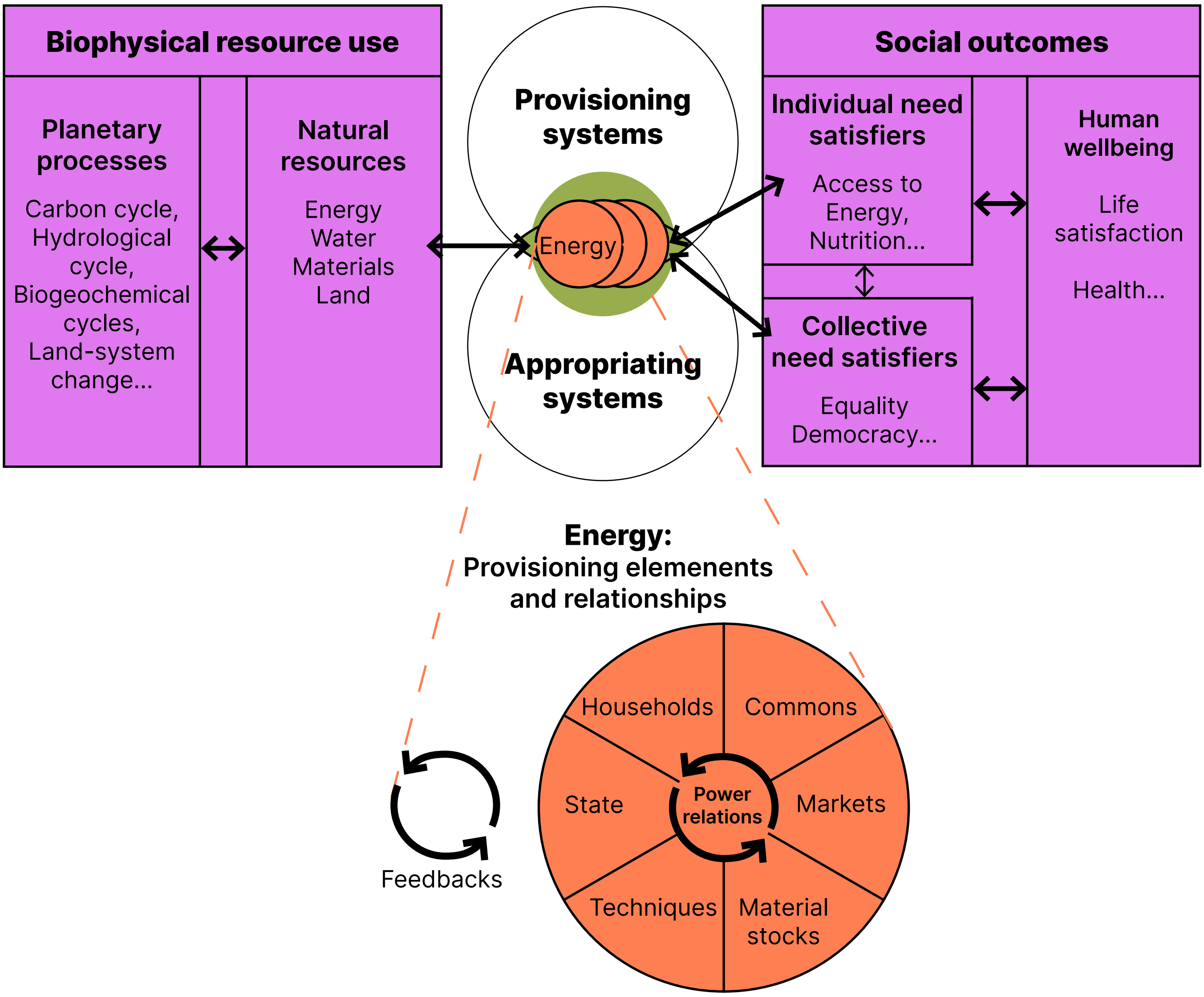

Figure 1: Illustration of the provisioning systems concept
Source: adapted from Fanning et al., 2020

In other words, provisioning systems are everything that lies between the biophysical resource base and the social outcomes. Importantly, and as is illustrated in Figure 1, the provisioning system does not just include all the physical equipment and infrastructure used in the processing and transport parts of any given supply chain but is *'formed by an interconnected set of institutional and technological elements that generate feedbacks and reproduce power relations'*. It is framed around needs – each need satisfier (e.g., a car to satisfy the need for mobility) can be mapped to a provisioning system, while elements of different provisioning systems may be shared (Fanning et al., 2020). By examining needs and the purpose of a system it is possible to explore entirely new pathways or systems to meet needs, not constrained by the existing systems in place, as is often the starting point for policy, technical or efficiency improvements.

As shown in Figure 1, the framework also takes account of **appropriating systems**, where rents are extracted to satisfy the wants of a small section of society (e.g., a wealthy elite), which can be at the expense of efficient social provisioning. Fanning et al. (2020) suggest that these appropriating systems deserve special attention, and that while there will likely always be some degree of rent extraction, the strength and legitimacy of appropriating systems must be explored because they maintain powerful actors who are invested in the status quo. These must be better understood to overcome obstacles to transformative change.

The provisioning systems framework can also be used to conceptualize different approaches to reducing environmental impacts. Whereas one particular measure may entail changes in patterns of the biophysical resource base – such as moving from fossil fuel to renewable energy – another may entail changes pertaining to the social outcomes – such as adjusting one's lifestyle to lower environmental impact activities. While all such changes in one way or another are bound to also affect the central component in the framework – the provisioning systems themselves – the extent of this change will vary from context to context, as we shall see in our examples in Section 3.

2.2 Frameworks for analysis of provisioning systems

There is no clear consensus on how to more directly operationalize analysis of provisioning systems. To date, a couple of different approaches are discussed by, for example, Vogel et al. (2021) and Plank et al. (2021). We will build our analysis around the framework presented by Fanning et al. (2020), who divide provisioning systems into six different **elements**. These are in turn categorized into the **TECHNOLOGICAL** elements **material stocks** and **techniques** and the **INSTITUTIONAL** elements **households**, **markets**, the **commons** and the **state**, with the latter four drawing upon Raworth (2017). For the sake of clarity, we will need to briefly explain how these are defined and their respective functions in provisioning systems.

- **Material stocks** are all the physical artefacts and equipment used in provisioning systems, such as buildings, machinery and infrastructure.

- **Techniques** are the different skills and competencies needed to build, operate and maintain the material stock.

- **Households** are all the (unpaid) activities done within the realm of our private lives.

- **Markets** are all economic transactions of monetarily priced goods or services.

- **The commons** are all the ways in which humans collaborate without formal transactions or monetary exchange, everything from community gardens to open-source software.

- **The state** supports the other three institutional elements by providing public goods but also sets the formal rules under which they operate.

It is important to note that these six elements do not by themselves make up the provisioning systems – the systemic aspects truly emerge only when one considers the interactions between these elements. In other words, how the elements influence and feed back to each other, and the power relations involved in these interactions, have profound implications for the characteristics of the provisioning system as a whole. The underlying values and principles of institutions also matter – they allow some societies to take environmental limits into account more than others (Fanning et al., 2020).

In light of this, in the next section, we review the concept of provisioning systems from an empirical perspective, building on two examples. We subsequently discuss these examples using the elements framework as a starting point. We do not attempt to provide a comprehensive analysis of each provisioning system, for a specific context, but rather highlight some of the elements of different systems and the needs that they satisfy and, through this, draw some insights into similarities, differences, fundamental tensions or roadblocks to change. We investigate common principles, questions or actions that could be taken to transform these systems. We follow the suggestion of Fanning et al. (2020) for some initial questions for the elements, such as:

- What are the different roles of **households**, the **commons**, **markets** and the state in the provisioning system? Which institutions **dominate provisioning**?

- What are the existing **techniques**? What are the **material stocks?**

And in terms of interactions, feedback, power relations and the purpose of the system, we ask questions such as:

- How can we characterize the **path-dependent relations** linking institutions and technologies?

- What are the different **sources of power** and how are they **wielded**?

- How do existing need satisfiers and/or the **subsystems** of different institutional elements **conflict with the overall purpose** of the provisioning system?

3. Concretizing provisioning systems – two examples

In this section, we present two examples that showcase the provisioning systems perspective. Each example examines how similar, or almost identical, needs can be met through provisioning systems that are very different from each other.

- The **first** example takes as a starting point the provisioning of one single specific human need – the charging of a cellphone – and how this can be met through the use of two distinctly different provisioning systems: grid power or a portable solar photovoltaic (PV) panel.
- The **second** example is focused on mobility and compares the provisioning systems of road transport and air transport. In particular, we discuss how their similarities and differences influence what measures can be taken to reduce emissions in the two sectors.

3.1 Example 1: There is more than one way to charge a cellphone

3.1.1 Description of the systems: grid power or portable solar

As our first example showcasing the value of the provisioning systems perspective, we will discuss two drastically different ways of providing a service that is an everyday activity for most people around the world: charging a cellphone.

In advanced economies, the typical way of doing this would be to simply attach the cellphone to a charger and attach the charger to a wall socket. The electricity in the wall socket typically comes into the building from a part of the local power distribution grid, which in turn connects to the main transmission grid – the 'highways' of the electricity power grid. The grid itself is – despite rapid global growth in wind and solar generation – in most countries fed electricity predominantly from large concentrated production units in the form of thermal (including coal, natural gas and nuclear) or hydro power plants. This is a highly intricate networked system with plenty of interlinkages between generators and consumers, with interactions that take place over very large distances and essentially in real time. In order to make sure that the system functions properly in spite of all these intricate activities, national transmission system operators (TSOs) have the responsibility to make sure that, at each given moment in time, electricity supply matches electricity demand.

Another way of charging a cellphone would be to plug it into a portable solar PV panel, of which there are many variations, ranging in size from tens to hundreds of watts. The electricity flowing into the cellphone now comes from the solar PV panel, which converts light to electricity. There is no physical connection to a broader physical network and no TSO that takes responsibility to oversee things. However, that portable solar PV panel did not just materialize out of thin air. On the contrary, it is the result of a highly complicated and global supply chain that starts with mining of the raw materials, then processing into semi-finished components that are fed into very large mass-production facilities producing millions of solar panels every year[1]. Downstream from the actual production of the solar panel is a complicated network of traders, distributors, shipping companies, retailers and then, finally, the consumer who has chosen to buy the solar panel at, say, a local hardware store.

1. Chinese manufacturer GCL Systems has announced plans to construct a 60GW production facility. This would be a facility that produces 200 million individual 300W solar panels every year or more than 500 000 solar panels per day (Scully, 2021).

3.1.2 *Applying the provisioning systems framework to the cellphone charging example*

As our description above illustrates, the portable solar PV system and the socket-grid system are both quite complicated, but complicated in different ways. In order to analyse this more closely, we will look at this example from the provisioning systems perspective.

Starting with the **material stocks** and **techniques** elements of the respective provisioning systems, the two are so different that they can be said to belong to distinct techno-economic paradigms (Perez, 2010). Except for the fact that the two systems provide the same service, they have almost nothing in common. The socket-grid system is based on a classic utility model with centralized large-scale generation of electricity, which is then distributed to the end user via an intricate, technologically sophisticated and very capital-intensive physical network. The portable solar system, on the other hand, is more like a consumer appliance, mass-manufactured and purchased through retail. One could argue that the portable solar panel approach has more similarities to the provisioning system for something like a TV set than to the socket-grid approach.

The techno-economic differences between the two systems are reflected in their respective institutional elements as well. The state and the market are very dominant actors in the socket-grid system, where technological as well as economic aspects are highly regulated through standardization and legal frameworks. The power of households has historically been quite limited, although this has changed somewhat in regions with deregulated electricity markets that allow consumers to choose between different suppliers of electricity. Even in these contexts, however, the transmission and distribution systems tend to be monopolies, run either by the state or by highly regulated private companies. In the portable solar PV example, the first part of the provisioning system is highly interwoven by different kinds of private, public and international governance frameworks, pertaining to things like raw material sourcing, manufacturing standards and international trade rules. However, once the portable solar panel is transferred to the end consumer, institutional linkages are largely severed, with the operational phase being completely within the mandate of the household realm.

As we have now shown how different the two systems are, one may question the value in comparing them at all. The reason why this is important is that while electricity provisioning systems globally are predominantly of the socket-grid type, much of the innovation and market growth is in technologies that have characteristics that are more similar to the portable solar PV model. Obviously, a portable solar panel is not a direct substitute for grid-socket when it comes to the quality of energy services more broadly. However, it is still worthwhile to consider in the light of the rapid development and cost reductions of energy technologies like solar PV and battery storage. Deployed in combination, these are becoming capable of providing more challenging energy services and are emerging as increasingly competitive alternatives to grid-based power supply, especially in regions with weak or non-existing electricity infrastructure. While this is promising in that it opens up new opportunities to improve energy access for communities that otherwise would remain unserved, understanding the differences in provisioning systems to the traditional grid-based model of electricity provision is key. It is not that one system is necessarily better than the other, but inherent differences mean that market mechanisms, user behaviour and institutional frameworks may function according to different sets of logic than what has typically been the case for electricity provisioning systems. This is especially important as electricity provisioning will in the future increasingly be a blend between these two, as solar PV becomes an important source of the grid electricity mix in many countries as well.

3.2 Example 2: Two flavours of mobility pie

3.2.1 Description of the systems: road transport and air transport

For our second example, we compare two provisioning systems for mobility: road transport and air transport. Mobility is a key societal service, but one whose provision tends to come with plenty of negative externalities. These include noise pollution, air pollution and traffic accidents with material as well as human damages, but our focus here will be on how mobility leads to GHG emissions. Our objective is to discuss how the characteristics of the respective provisioning systems have important consequences for the composition of the mitigation toolset.

The services provided through the two systems are similar though not quite identical. There are key differences that have important implications for the effectiveness of different levers that we can pull on to mitigate mobility-related emissions. These levers include reducing demand for mobility, shifting to more emissions-efficient modes of travel and shifting to lower-emission vehicle technologies. These are all relevant for both road transport and air transport, but, as we will see, not equally relevant.

We first briefly review what the two provisioning systems have in common. One key technological and institutional aspect is that equipment supply for manufacturing of airplanes and road vehicles involves intricate networks of vast geographical extent. Large volumes of material are processed and transported long distances, with components produced by suppliers in different parts of the world and then shipped to select locations for final assembly. Another thing that the two have in common is that, despite these large material flows and component transports, the vast majority of the life cycle GHG emissions occur in the use phase, arising from the fact that operations are completely dependent on combustion of fossil fuels.

The **differences** between the two systems include – of course – many different aspects. One that can be mentioned is the network structure, where commercial aviation is built around a relatively small number of key nodes (airports), whereas road networks are a lot more fine-grained. Another is the number of operated vehicles, where there are many more road vehicles in operation than there are air vehicles. However, the most important difference for our purpose here is the simple fact that road transport takes place on the ground and air transport takes place in the air. While an obvious fact, it is one that has vital implications for the technological emissions reduction opportunities available.

Despite many decades of gradual improvements in both internal combustion engines (ICE) and jet engines, the inherent limitations of combustion-based engines mean that they remain quite inefficient. Even the most efficient diesel engines use only around 40% – at best – of the energy in the fuel to actually propel the vehicle, with the remainder lost as heat in the conversion process (Xin & Pinzon, 2014). In contrast, a battery electric vehicle (BEV) drivetrain has an efficiency of around 90% (US Department of Energy (DOE), 2018) – a key reason why BEVs tend to be a lot cheaper to operate. They are, however, still more expensive to purchase, but with manufacturing scaling up, BEVs are expected to soon reach 'sticker-price parity' with ICE vehicles (McKerracher, 2021). Adding to this the favourable policy landscape based on the environmental benefits of electric vehicles – especially as electricity generation increasingly shifts to low-carbon technologies – electrification of road transport is looking increasingly inevitable.

The same is not true for air transport, where battery electrification looks to be a feasible option only for small aircraft and over short distances. The high energy density needed for transatlantic flights, for example, will not be possible to mirror by any other means than liquid fuels. These are currently produced from fossil resources, but it is technologically possible to produce these from either biomass or by capturing CO2 from the atmosphere and combining this with hydrogen to synthesize so-called electrofuels or e-fuels. Both the biofuel route and the e-fuel route look, however, to be substantially more costly than the fossil route (Dahal et al., 2021).

3.2.2 What can a provisioning systems perspective tell us about decarbonization of mobility?

A key difference between the road transport and air transport systems thus lies in the technological pathways available for deep decarbonization. For road transport, there is for most use cases – even heavy trucks (Nykvist & Olsson, 2021) – the possibility to shift to a different techno-economic paradigm: battery electrification. In addition to enabling drastic emissions reductions, BEVs can come with clear and tangible monetary benefits for the user. As noted above, operational costs of BEVs are already much lower than for ICE vehicles and sticker-price parity is within reach.

In terms of broader implications in the provisioning system, the shift to the BEV techno-economic paradigm is expected to be a cornerstone in eliminating emissions (International Energy Agency, 2021), but the transition process is causing substantial turbulence in the market element of the provisioning system. BEVs and ICE vehicles may look similar from the outside, but the drivetrain is such an integral part of the industry that a radical technological change in this particular subsystem has ripple effects across the entire provisioning system. This is because when it comes to material stock and techniques, the technological parts of the BEV provisioning system are in many ways quite different from those of the ICE. As a consequence, in a sector where successful start-ups have been extremely rare, plenty of new all-BEV vehicle manufacturers are coming into the market. At the same time, established actors face needing to almost rebuild much of their existing operations, having to make massive investments in new manufacturing facilities. In addition, supply chains for batteries are rapidly scaling up, with implications for the material stock element of the provisioning system in the form of strongly increasing demand for battery minerals like lithium. There is also the need to set up an infrastructure system for charging of BEVs and making certain that the associated electricity system can manage this new load. Exactly what the role of different actors in this should be and to what extent this is a responsibility of the market or the state are still a matter of debate.

For households, the transition entails changes in that the upfront cost of a BEV is higher and the operational range is typically a lot shorter than for an ICE vehicle. At the same time, most charging can be done at a parking facility without much additional investment, and operational costs are, as we noted, substantially lower. However, while the latter is beneficial for the household, it may not be beneficial for the system as a whole, as it incentivizes more driving in order to make the most of the large initial capital investment. In other words, this could make BEV owners even less interested in other approaches to reduce mobility emissions, such as switching to public transport or cycling, and associated planning that would increase accessibility. This is potentially problematic, because while the shift to a BEV can enable drastic GHG emissions reductions, other externalities from road transport, like congestion, could remain unmitigated or even worsen.

For air transport, the exceptional demands placed on energy carriers used in aviation mean that there are only limited possibilities to switch to a new techno-economic paradigm in terms of propulsion technology. In other words, most of the emissions reductions will have to take place within the existing paradigm. Technological decarbonization pathways building on alternative fuels will be more expensive, and may still not be sufficient from a climate change mitigation perspective. This is because combustion of non-fossil hydrocarbons in high altitudes still contributes to climate change through the formation of contrails, whose effects make up a considerable portion of the total warming from aviation (Jungbluth & Meili, 2019). The consequence from this for policymaking is that the opportunities for technological change to resolve emissions from the system are more limited.

In a situation such as air transport where emissions reductions can come either through demand reduction or through changes to other fuels, it seems likely that incumbent companies and existing regulatory frameworks will remain relevant. Furthermore, this means that the pace of change will largely be based on what is decreed by the state and public policy. The role of the market and its actors is not eliminated though. Public policy is not decided by objective arbitration but is on the contrary highly influenced by all kinds of societal interests and power structures – including, and importantly, the incumbent sectors whose emissions need to be reduced.

Moving to a higher-cost fuel and passing these costs on to travellers would have the added 'benefit' of increasing costs leading to reduced demand. This would, however, introduce serious issues of equity where aviation may be clean but also a luxury. Therefore, demand reduction would preferably have to be induced via other means. Here, shifting values and norms can play an important role, as seen in the 'flight shame' phenomenon in 2019. Obviously, the Covid-19 pandemic has disrupted patterns of air travel at an unprecedented scale and it is highly likely that this will have long-term effects in terms of behavioural changes as well, though exactly how this plays out is too early to tell.

4 Discussion

4.1 System-wide measures required for systemic change

An implicit argument made here is that, instead of addressing environmental problems through means that seem conceptually very appealing and then becoming disappointed that these do not work in practice, practical realities need to be addressed head on. This means acknowledging the flawed assumptions that underlie many of the approaches that have aimed to steer provisioning systems and consumer needs to more sustainable patterns in the past. Carbon pricing is a telling example of a conceptually appealing but often practically very challenging approach (Rosenbloom et al., 2020), and similar points can be made about consumer roles in driving towards more sustainable systems. The ability of consumers to influence the systems and drive sustainability via their individual choices has been continuously overestimated and even put forward as a convenient excuse for other actors to do less (cf. Akenji, 2014; Röös et al., 2020; Willett et al., 2019).

4.2 Policy options

4.2.1 Traditional approaches aimed at sustainable production and consumption have proved insufficient

The typical policy approach to sustainable consumption and production over past decades has been to focus efforts on **eco-efficiencies in production and the consumption of 'green' or sustainable products**. This means waste reduction, resource efficiency, cleaner production, eco-innovation, green design and renewable technologies on the production side, leading to **'greener' products** for consumption at the end (Cohen, 2019). Consumers were then expected to **shift their lifestyles and choices accordingly**, relying on information and labelling of products. Focus was (and often still remains) placed on increasing market uptake of green technologies and the behaviours and preferences of individuals (Geels et al., 2015). Yet, **these approaches have not and will not bring about the desired and necessary changes**. One fundamental reason for this is that while there have been substantial improvements over time in terms of energy and material efficiencies, these improved efficiencies have been outweighed by increases in absolute demands. The eco-efficiency and consumer choice shift was too small to address unsustainable patterns of production and consumption and the associated environmental and social issues at the scale and urgency required (Geels et al., 2015).

It was therefore argued that **greater policy emphasis must be put on reducing levels of consumption, and altering consumption patterns and lifestyles** linked to sustainable and unsustainable consumption (Berg, 2011; Defila & Di Giulio, 2020; Lorek & Fuchs, 2013; Sandberg, 2021). This field of work investigated consumerism, materialism, consuming less and changing lifestyles and, in some cases, a complete overhaul of existing politico-economic structures. Policies and activities that focused in these areas were termed **'strong'** sustainable consumption, where a shift to more sustainable consumption is about reducing overall resource consumption, instead of individual consumption, and recognizing the social embeddedness of consumption decisions. Example activities include the sharing economy, a shift in cultural values, local initiatives or self-sufficiency (Geels et al., 2015), exploring non-material contributions to a 'good life', neighbourhood exchange, community or subsistence work and attempts to increase human well-being through social structures (Lorek

& Fuchs, 2013). Yet, these types of 'strong sustainable consumption' activities are noted as **more contentious than sustainable production-related activities** (Cohen, 2019), **politically unpalatable, as well as at risk of being elitist** (Geels et al., 2015; Hobson, 2013). These options can also appear abstract, might not necessarily lead to significantly more sustainable (or happier) societies and it is not obvious how they might remedy environmental problems at scale (Geels et al., 2015). Mont et al. (2019) make a similar critique of what they term 'system optimization' (like weak/reformist) and 'system reorientation' (similar to strong/revolutionary).

4.2.2 Systemic change requires systemic policies

In response to these critiques, policy measures based on a systems approach to sustainable consumption and production have been proposed. Welch and Southerton (2019), for example, suggest policy measures that seek to address the systemic connections between consumption and production. These types of measures would take greater account of connections between those agents involved in the production and delivery of goods and services and those that consume or seek to influence the consumption of those products. They should also address **social, cultural, material and economic** aspects of the system simultaneously, and feature **multi-scalar** and **reflexive governance** approaches. Multi-scalar policy initiatives seek to align the interaction of agents delivering policy measures at different scales of intervention, such as the household, the city or the production–consumption system. Reflexive governance approaches recognize ongoing sequences of intervention, monitoring and adjustment, rather than focus on a single moment of intervention (Welch & Southerton, 2019).

In another example, the value-chain approach of UNEP (2021) also focuses on identifying intervention points within economic systems and suggests that through consultation and collaboration with actors within a value chain, policymakers should aim to (1) **understand specific value chains and identify hotspots,** then (2) **consolidate existing action** and **identify opportunities** to address the identified hotspots, and lastly (3) define a **common agenda and prioritize actions** through a participatory process.

While these approaches apply a systems thinking lens, by bringing in a provisioning system perspective at the policy level it is also possible to explore more deeply the **purpose** of value chains or existing systems and more closely **examine the needs** that are or should be met, balanced by the resources available and environmental limits. This opens up possibilities to understand and shift the current system, but also to reimagine the provisioning system and alternative ways of meeting societal needs, with different constellations of actors, institutions or technologies. As Fanning et al. (2020) acknowledge, **redefining the purpose of a system** is one of the most **effective** ways to create transformative change, though also one of the hardest. In their definition of a provisioning system, the purpose is to satisfy a foreseen human need, but they note that this is particularly challenging due to the low resource efficiency of existing need satisfaction in high-consuming societies and conflicting subpurposes among provisioning system elements.

One example from Dillman et al. (2021) on urban mobility compares policies to enhance mobility or accessibility. Certain provisioning systems for transport might make a type of need satisfier (e.g., a private car) essential for satisfying one's needs (access services, earn money). But changes in both physical and social structures might **escalate or de-escalate specific need satisfiers**. Policy that aims to enhance mobility might lead to an increased reliance on private cars, but policy that aims to enhance accessibility might focus on de-escalating need satisfiers and reducing the amount of travel required to meet human needs.

4.3 Policy recommendations

The general policy messages coming from these perspectives is that policymakers must look to intervene at multiple parts of the system – whether that is addressing social, cultural, material and economic aspects of consumption (Welch and Southerton, 2019) or ensuring that policies are integrative, cross-sectoral and population-wide, tackling connected issues with a range of different measures simultaneously (Reisch et al., 2013). Critically examining and understanding the elements in existing systems, along with the relationships, feedback and power structures, as the provisioning system framework suggests, helps identify multiple policy intervention points. Policy recommendations that draw inspiration from this would therefore be in the form of recommended policy **portfolios** rather than individual measures, with policies that target both the barriers to and opportunities for change.

Examples of activities to identify and undertake this work include:

- Bring necessary partners together, to acknowledge the need for multiple interventions at different stages and scales.
- Measure resource use and social outcomes relative to the sustainability and sufficiency conditions of the sustainability corridor. Map provisioning systems onto individual need satisfiers in order to identify opportunities for, and barriers to, achieving the specific changes needed (Fanning et al., 2020).
- Identify points in the existing system that might hinder or prevent change (Vergragt et al., 2014); that is, different kinds of lock-in in the form of:

  - existing legal or regulatory requirements
  - decision-making policy tools
  - models or data structures that reflect existing systems and restrict more transformative change
  - powerful actors invested in the status quo, particularly in appropriating systems
  - dominant cultural values and activities that promote those values – such as competitive work, advertising, appealing to status or financial success as achievement.

- Address points of lock-in simultaneously and through multi-scalar policies and reflexive governance (Welch & Southerton, 2019).
- Open up discussions about how to meet individual and collective needs and any conflicts between provisioning systems and appropriating systems (Fanning et al., 2020). This may involve various trade-offs that may be highly contested and moral or values-based in nature (Elgert, 2018; Mccool & Stankey, 2004). Deliberative, inclusive discussions are therefore essential.
- Utilize government investment and financial mechanisms to support the transition, such as de-risking demonstration or commercialization of new innovations, dealing with stranded assets, delivering sustainable public procurement or reorganizing tax and subsidy structures. While the state has a key function in leading this change, there is also a role for the financial sector to coordinate and have sustainability

strategies that are coherent across full portfolios (Maltais et al., 2021), which can also be supported by policy action.

- Ensure that any transition is just – both for consumers and producers. Government assistance (transition assistance policy), in the form of retraining workers, supporting consumers with adopting new technologies, increasing costs or changes to lifestyles, for example, should be put in place. Ensuring that this support is communicated, available, accessed and acknowledged will be essential to ensure buy-in to the transition from a large share of the population (Mildenberger et al., 2022).

- Perform careful anticipatory analysis of the full provisioning system to understand the ripple effects from different policy measures and make sure to pre-emptively address adverse side effects.

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This background paper was written as part of a collection supporting the scientific report *Stockholm+50: Unlocking a Better Future*.

Suggested Citation: Olsson, O., & Dawkins, E. (2022). Meeting human needs within planetary boundaries - a provisioning systems perspective on clean transitions. *Stockholm+50 background paper series*. Stockholm Environment Institute.

The report and background papers have been independently produced with funding provided by the Swedish Ministry of the Environment. They also received funding from the Swedish International Development Cooperation Agency (Sida) core support to SEI, and the Swedish Foundation for Strategic Environmental Research (MISTRA). The content of this paper lies with the authors and does not necessarily reflect the positions or opinions of the funding organizations.

IN ASSOCIATION WITH STOCKHOLM+50

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Editor: Scriptoria
Layout and Graphics: Richard Clay and Mia Shu, Stockholm Environment Institute; Hayley Alter and Miriam Sturdee