Ref. Ares(2023)5458776 - 07/08/2023

Economic and Social Considerations for the Future of Nuclear Energy in Society

Project Number: 101060920

Deliverable 3.1: SoP systematic review

Work Package 3

Lead Beneficiary: University of Cassino and Southern Lazio

Due date: 31/07/2023 Released on: 31/07/2023

Author(s):	Giacomo Dei, Professor Giorgio Locatelli, Dr Benito Mignacca, Professor Paolo Trucco, Professor Marco E Ricotti

For the Lead Beneficiary	Reviewed by Work package Leader	Approved by Coordinator
Dr Benito Mignacca	**Professor Giorgio Locatelli**	**Daniela Diaconu**

Dissemination Level		
PU	Public	**X**
RE	Restricted to project partners and EC	
SEN	Sensitive (EU-restricted)	

Funded by the European Union

Project information

Project full title:	Economic and Social Considerations for the Future of Nuclear Energy in Society
Acronym:	ECOSENS
Funding scheme:	CSA
ECGA number:	101060920
Call/topic	HORIZON-EURATOM-2021-NRT-01-14
Coordinator:	Regia Autonoma Tehnologii pentru Energia Nucleara (RATEN) – Daniela Diaconu
EC Project Officer:	Maria Papadopoulou
Start date – End date:	1 October 2022 - 30 September 2025 (36 months)
Coordinator contact:	+40 744 701 476, daniela.diaconu@nuclear.ro
Administrative contact:	+40 744 701 476, daniela.diaconu@nuclear.ro
Online contacts (website):	https://ecosensproject.eu

Document information

Deliverable Title	SoP systematic review
Deliverable No.	D 3.1
Work Package No.	3
Work Package Title	A System of Provision approach for nuclear power
Lead Beneficiary	Politecnico di Milano
Contractual Delivery Date	31/07/2023
Actual Delivery Date	31/07/2023
Type	R
Dissemination level	RE
Authors	Giacomo Dei (PoliMi), Professor Giorgio Locatelli (PoliMi), Dr Benito Mignacca (UNICAS), Professor Paolo Trucco (PoliMi), Professor Marco E. Ricotti (PoliMi).
To be cited as:	Dei G. et al, (2023): SoP systematic review Deliverable D3.1

Funded by the European Union

Status of deliverable		
	By	Date
Delivered (Lead Beneficiary)	UNICAS	14.07.2023
Verified (WP Leader)	PoliMI	17.07.2023
Reviewed (Reviewers)	Project partners	29.07.2023
Approved (PC)	RATEN	31.07.2023
Submitted to EC (PC)	RATEN	06.08.2023

Disclaimer

The document is proprietary of the ECOSENS consortium members. No copying or distributing, in any form or by any means, is allowed without the prior written agreement of the owner of the property rights.

Acknowledgement

This project has received funding from the Euratom Research and Training programme, a complementary funding programme to Horizon Europe, under grant agreement No 101060920. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union, European Commission or European Atomic Energy Community (granting authority). Neither the European Union nor the granting authority can be held responsible for them.



Funded by the
European Union

Table of Contents

Executive Summary 2
1 Introduction 3
2 Method 5
3 Findings 8
3.1 Complementarities with the Multi-Level Perspective 8
3.2 Definition of Boundaries 9
3.3 Theories 11
3.3.1 Horizontal vs vertical perspective 11
3.3.2 Theoretical lenses 12
3.3.3 Engaged vs Detached approaches 13
4 Using the SoP Approach to Tackle Grand Challenges 14
5 Case study: SoP application to the nuclear industry 16
5.1 Nuclear beyond electricity production 16
5.2 SoP and Nuclear hydrogen 17
5.2.1 Hydrogen market 17
5.2.2 Insights using the SoP approach 18
6 Conclusions 22
7 References 23
Annex 1 – Documents Included in The Analysis 28

Executive Summary

This paper introduces a novel approach, called the System of Provision (SoP), to sense-making the role of nuclear technology across socio-technical systems (ST-systems). The SoP approach offers a new perspective on the relationship between ST-systems (e.g., electricity, food, transportation) and nuclear technology, including its tangible (e.g., power plants) and intangible (e.g., culture, workforce education) elements. The SoP approach would enable analysis at the "system level" precluded by traditional approaches such as cost-benefit analysis. At the core of the SoP approach lies the notion that consumption behaviours are contingent upon the specific system through which a good or service is provided. The SoP approach considers the context-specific nature of each provision system and how it is influenced by the materiality of what is provided. This perspective is potentially relevant because of the possibility of using nuclear technology for electricity, district heating, naval propulsion, hydrogen production, etc.

The methodology adopted in this report is a systematic literature review with a two-stage process. The first stage was a systematic search conducted on Scopus, which utilized Boolean operators to identify all relevant documents containing the keywords "System* of Provision*" OR "SoP approach*" in the title, abstract, or keywords fields. All the retrieved 215 documents were included in the initial sample for further analysis. The second stage was the filtering phase, where inclusion and exclusion criteria were applied. The filtering phase excluded 174 documents (81%), leaving 41 documents to be analysed. Simultaneously with the filtering phase, we performed an iterative snowballing approach. In this phase, we added 24 documents, resulting in a final sample of 65 documents. We abductively conducted a thematic analysis of the documents leading to three key conclusions:

1) The SoP approach lacks a clear definition of systems, particularly regarding their boundaries. The adoption of the concept of "ST-systems" can overcome the issue of defining boundaries;
2) The SoP approach has explanatory power and theoretical flexibility to adapt to various theoretical lenses;
3) The SoP approach can be complemented by the multi-level perspective (MLP).

Therefore, together with the MLP theoretical framework, the SoP approach can be used to sensemaking the role of nuclear technology by providing a holistic perspective on the complex interactions involved in and across ST-systems. By applying the SoP approach to the study of nuclear technology, stakeholders - including decision-makers - can better understand the various agents involved in the provision chain, their priorities, and their power dynamics. This will help to identify the challenges and opportunities associated with nuclear technology, as well as potential solutions that consider the diverse perspectives and priorities of relevant stakeholders. In summary, our work provides three main scientific contributions:

1) Policies, projects and consumption behaviours are tightly interconnected, and the SoP approach can be used to investigate such links in the context of nuclear technology;
2) Under the conditions and assumptions presented in the reviewed literature, we conclude that nuclear technology can be pivotal in addressing some of the so-called Grand challenges, in particular thanks to its potential to significantly reduce the carbon footprint of ST-systems, such as the ST-systems related to food and transport;
3) Policies are a key element in supporting nuclear technology by (A) directly fostering investments across ST-systems and (B) shaping consumption behaviours and indirectly supporting vertical provisioning structures.

In our future research, under the ECOSENS project, we will leverage the SoP approach to map existing nuclear-dependent scenarios with the five elements of the SoP approach: agents, relations, structures, processes, and material culture. This will enable us to understand drivers and enabling factors of existing ST-sytems leveraging nuclear technology, thereby proposing policy recommendations to expand the applications of nuclear technology further when and where appropriate.

1 Introduction

The System of Provision (SoP) is a comprehensive approach to studying consumption behaviours (Fine and Leopold, 1993). The SoP approach originated in the 1990s as a response to the shortcomings of individual and collective efforts within the social sciences to establish a comprehensive understanding of consumption behaviours (Bayliss and Fine, 2020). This approach evolved into a systematic framework incorporating elements deriving from various social sciences disciplines such as anthropology (Callon and Caliskan, 2005), sociology (Gay et al., 2013) and psychology (Bayliss and Fine, 2020).

The SoP approach emphasises the importance of understanding how different actors and factors interact to shape a system. It recognises that systems are complex, interconnected, and shaped by economic, social, cultural, political, geographical, historical, and technological factors (Bayliss and Fine, 2020; Mattioli et al., 2020). Consequently, interactions of several interrelated factors lead to unique consumption cultures specific to each commodity. These cultures encompass a range of practices, ideas, and meanings that collectively influence consumption patterns (Bayliss et al., 2017). By examining the commodity chains involved in the production, delivery, access, use, and disposal of goods and services, the SoP approach sheds light on the diverse institutional, organisational, and technical systems that have the potential to shape the construction and management of demand (Chappells, 2008).

The core principle of the SoP approach is that individual demand for specific products/services and the mere existence of a specific commodity chain or production structure are not the only determinants of consumer choice. Rather, consumer choice is historically shaped and influenced by a broader social context, characterised by horizontal interactions and factors that extend beyond immediate consumer desires (Brooks, 2015). The SoP approach considers the vertical integration of production and consumption while recognising significant horizontal factors that shape and contextualise consumption on a societal level (Bayliss and Fine, 2020) (see section 3.3). Traditionally, the horizontal perspective to the study of the dynamic of consumption relies on the notion that there is a specific utility function that encapsulates the preferences of individuals (Fine and Leopold, 1993; Spaargaren and Van Vliet, 2007). Demand is then shaped by rationality, simplified to the maximization of the utility function incorporating constraints of prices and income (Fine, 2002). Of note, this perspective does not consider the linkages along the value chain that connect production to the consumption of goods. This shortcoming highlights the need to emphasize the relevance of horizontal and vertical perspectives. By integrating horizontal and vertical perspectives, on the one hand, the SoP approach allows us to investigate significant shifts of historical proportions as well as global influences, such as the commodification of production, globalisation, neoliberalism, and financialisation. On the other hand, the SoP approach considers the specific and contextual factors associated with individual consumers, objects, and consumption practices (Bayliss and Fine, 2020).

The SoP is defined by (Fine, 2002, p. 79) as *''an inclusive chain of activity that attaches consumption to the production that makes it possible"*. The SoP refers to the integration of economic and social elements that influence the extent and nature of consumption (quantitative aspect) and the associated meanings and significance attached to it (qualitative aspect) (Fine, 2002). According to (Bayliss and Fine, 2020), identifying a SoP depends on the research questions and areas of investigation. The subjectivity in the adoption of the SoP approach, depending on the understanding of the context under investigation, makes the SoP approach flexible and versatile in many different empirical contexts (Atkins and Gastoni, 1997; Brooks, 2015; Chappells and Shove, 2000; Júlíusson et al., 2020). This is because the SoP approach is founded on the empirical and inductive identification of interconnected systems comprising material and

cultural factors that mutually influence one another. The overall direction of inquiry depends on the specific area under investigation in conjunction with the empirical aspects of the SoP. Given their nature, the boundaries of SoP are determined during the research process rather than relying on preconceived analytical templates (Bayliss and Pollen, 2021; Mattioli et al., 2020; Williams et al., 2019).

We have, therefore, two ontological objects. The first is the SoP which is empirical and related to the provision of specific goods (e.g., cars) or services (e.g., transportation). The second is the SoP approach which is a theoretical framework developed by Leopold and Fine to investigate SoP (Fine and Leopold, 1993).

The systematisation of the SoP approach into a framework includes five main themes, identified by (Bayliss and Fine, 2020) as the main drivers to consumption: *Agents*, individuals or groups (structured or unstructured) of individuals that participate in the system; *Structures*, forms of provisioning of goods or services (e.g. institutional, social, organisational); *Processes*, the sequences of activities that take place at a systemic level within the SoP or around the SoP; *Relations*, connections between agents and distribution of power (e.g. social classes, ages, income levels); *Material Cultures*, the meaning that the agents attribute to a product or a service. To better illustrate the concept of material culture, let's take the example of cars. Cars can be seen as mere tools to go from A to B. Yet, often people see cars as a way to express their personality (e.g., "sports cars") or as status symbols (e.g., "luxury cars"). Additionally, many Hollywood movies give cars an idea of "freedom". Therefore, purchasing a car is not just buying a tool to go from A to B, but an experience where several factors (e.g., cultural, economic, social) play a role. Similarly, a nuclear reactor is not just a "machine to make electricity". For some consumers, nuclear power symbolises evil or a "Chernobyl" like scenario, while for others, it could represent a step forward for their nation to become a modern country by modernising its tangible and intangible assets.

Despite the theoretical richness of SoP, there is no structured literature review on it. This document aims to present the state of the art of the SoP literature, its integration within the narrative of sustainable transition and a pilot application to nuclear technology.

By leveraging a systematic literature review, we identified three main results. First, the SoP approach lacks a clear definition of systems, particularly regarding their boundaries. The adoption of the concept of "ST-systems" can overcome the issue of defining boundaries. Second, the SoP approach has explanatory power and theoretical flexibility to adapt to various theoretical lenses. Last, the SoP approach can be complemented by the multi-level perspective (MLP).

2 Method

The methodology adopted in this paper is a Systematic Literature Review (SLR). The main goal of a SLR is to answer a specific research question, identifying and analysing all the relevant empirical studies that meet predetermined inclusion criteria (Snyder, 2019). The contributions of SLRs reside in the capacity of critically examining extensive bodies of literature and subsequently reinterpreting them (Petticrew and Roberts, 2008). Researchers adopt this systematic approach aiming to collect and consolidate evidence to inform policy and practice within a particular discipline (Tranfield et al., 2003). With this SLR, we examine the entire body of literature on the SoP approach, investigating both the theoretical debates (past and ongoing) and its application in empirical studies. The systematic search, performed using Scopus (February 2023) and leveraging Boolean operators, collected all documents containing "System* of Provision*" OR "SoP approach*" in the title, abstract, or keywords. We selected only papers written in English in the systematic search. This search led to 215 documents, including 160 articles, 21 book chapters, 14 conference papers, 12 reviews, 5 books, 2 short surveys, and 1 editorial. Despite the general and inclusive research string and due to the limited number of documents identified, all the retrieved documents were included in the initial sample.

The screening process of the 215 documents included two distinct phases. In the first phase, we selected the documents based on reading the title, abstract and keywords. To increase the validity of the research, this phase was carried out, in parallel, by two authors. We applied the following inclusion and exclusion criteria:

Inclusion criteria: the document discusses the "System of Provision" as an approach to the study of consumption as intended by (Fine and Leopold, 1993) and developed further by (Bayliss and Fine, 2020; Fine, 2002).

Exclusion criteria: the document mentions the "System of Provision" as a broad concept used as a synonym for other concepts such as value chain, large system, and supply chain.

Regarding the books and reports, we examined the table of contents and the introductory chapter of each book to implement the first filtering phase applying inclusion and exclusion criteria. Regarding the book chapters, if they had not an abstract, they were moved to the second filtering phase.

After the first filtering phase, 100 documents were excluded (46%), leaving 115 documents to be further examined. In the second phase, all the documents were read in full by at least one author. We implemented the second filtering phase based on the inclusion and exclusion criteria adopted in the first filtering phase. The documents were labelled as "relevant" if they were included, "not relevant" if they were excluded, and "undecided" if the author had doubts about the relevance of the document. In this last case, a second author was in charge of reading in full "undecided" documents and making a decision based on inclusion and exclusion criteria. The second filtering phase excluded 74 documents (64%), leaving 41 documents to be reviewed.

Simultaneously with the full-text reading, we performed an iterative snowballing approach. In this phase, we added 24 documents to our sample, resulting in a final sample of 65 documents. We performed a thematic analysis on peer-reviewed articles (45 out of the 65 total documents). The remaining 20 documents (4 books and 16 large reports) were fully read and used to inform the research. Figure 1 summarises this process.

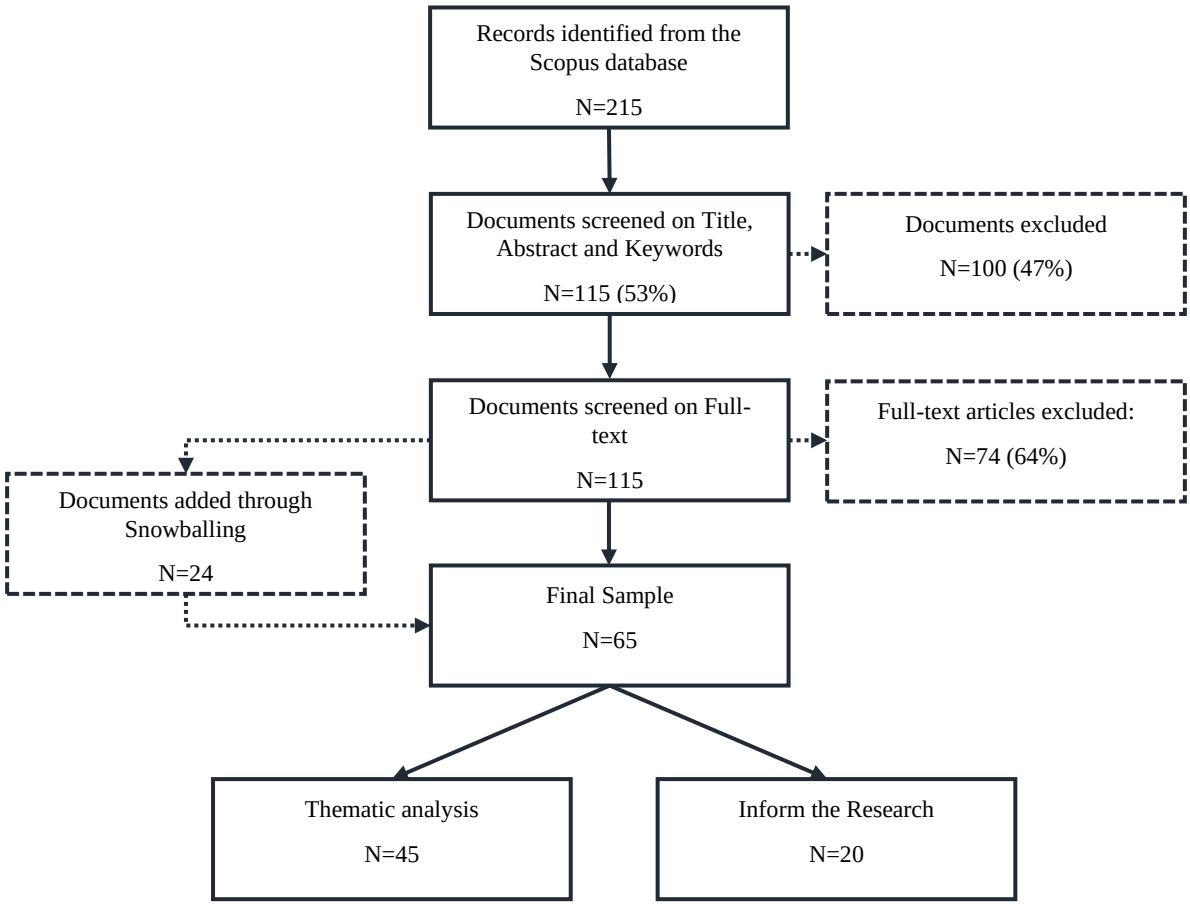


Figure 1 Overview of the selection process of the documents

We conducted a thematic analysis of the collected documents to perform a rigorous analysis. Thematic analysis is a method for *"identifying, analyzing and reporting patterns (themes) within data"* (Braun and Clarke, 2006, p. 79). In conducting a thematic analysis, different from a content analysis, a theme's frequency is unrelated to its relevance (Vaismoradi et al., 2013). Considering the relatively low quantity of information about the SoP approach and the fact that the SoP approach incorporates insights from numerous disciplines, we conducted a thematic analysis to avoid missing potentially relevant concepts. In conducting the thematic analysis, we followed the six-phase process suggested by (Braun and Clarke, 2006): data familiarization, generating initial code, searching for themes across the data, reviewing themes, defining themes, and producing the report. However, the analysis is conducted abductively (Thompson, 2022). For this reason, the six-step guide from (Braun and Clarke, 2006) is then complemented by one of the steps proposed by (Thompson, 2022) in its eight-step-process for thematic analysis, i.e., the creation of a codebook. All the documents have been imported into "Atlas.ti" software to support the coding process. Through the thematic analysis, 5 themes and 30 codes have been identified, as shown in Table 1.

THEMES	CODES	DESCRIPTION
SoP adoption	Agents	Participants in the System
	Relations	The way in which two or more Agents are connected
	Processes	How the consumer engages with provisioning in terms of how consumption is accessed
	Structures	Historically and socially specific forms of provisioning
	Material Cultures	The meanings that agents in SoP attribute to goods or services
Context	Location	Geographic area (e.g. nations, regions, continents, cities)
	Period	Historical moment (e.g. year, decade)
	Sector	Businesses and organisations involved in similar economic activities, sharing common characteristics and serving specific market needs
	Boundaries	The scope and limits within which the system operates, defining its interactions, inputs, outputs, and the elements it includes or excludes
Change	Economic	Significant alteration in the production, distribution, or consumption of goods and services within an economy
	Political	Any significant alteration in the structure, processes, or policies of a political system or government
	Environmental	Any significant alteration of the environment
	Technological	The idea of improving existing technologies and developing new ones
	Social	The alteration of mechanisms within the social structure
	Historical	A transformation or evolution that occurs over a period of time (e.g. Industrial Revolution)
Analysis	Detached	Having or showing no bias or emotional involvement; disinterested
	Engaged	Involvement in the context under investigation
	Generalizability	The degree to which the results of a study can be applied to a broader context
	Intended auditor	Individuals, organisations or groups of people to whom the analysis is directed
	Explicit onto-epistemological position	The philosophical stance that emphasises the interdependence of ontology and epistemology
	Theoretical lens	The theoretical perspective that explains the nature of the observations
	Retrospectivity	Directed to the past; contemplative of past situations
	Prospectivity	Relating to or effective in the future
SoP debate	Alternative approaches	Approaches proposed as an alternative to the SoP approach
	Area of application	The research area in which the SoP approach has been proposed
	Framework	Structuration of the SoP approach in a framework
	Future researches	Research directions suggested
	Integrations	Proposals to integrate the SoP approach with other concepts/models/approaches
	Strengths	The advantages identified in adopting the SoP approach
	Weaknesses	The disadvantages identified in adopting the SoP approach

Table 1 Themes and Codes identified through the Thematic analysis.

3 Findings

Analysing the aforementioned 45 documents thematically and using the books and the reports to inform the study, we identified three key findings.

3.1 Complementarities with the Multi-Level Perspective

The SoP approach is a structured framework for studying consumption, bringing together insights from various disciplines across social sciences (Bayliss and Fine, 2020). At the core of the SoP approach lies the notion that consumption behaviours are contingent upon the specific system through which a good or service is provided (Fine, 2017). Due to its explanatory power, the SoP approach is gaining popularity across epistemological communities. Following (Markard et al., 2012) recommendations, our analysis shows that the SoP approach can further enhance and complement the MLP theoretical framework. As stated in (Köhler et al., 2019), the MLP requires two main enhancements that the SoP addresses as follows:

- The macro analyses level of the MLP *"evoked critiques underlining the need for detailed micro-level investigations of underlying actors, technologies, infrastructures and institutional contexts"* (Köhler et al., 2019, p. 18). The SoP can explore the relationship between macro and micro perspectives acting as a bridge between macro-level policies (e.g. financing and provisioning systems) and the micro-level actions of individual producers and consumers (Bayliss and Fine, 2020).
- *"Calls for better integration between practice theory approaches to consumption and the MLP"* (Köhler et al., 2019, p. 13). The most commonly adopted theoretical lens with the SoP approach is "Practice theory" (Hansen, 2017; Wahn, 2020; Williams et al., 2019). In particular, (Warde, 2014) stresses understanding social practices to understand better consumption patterns rather than focusing solely on individual choices.

Remarkably, also the MLP can complement the SoP approach by, for instance, advancing the concept of a "Sociotechnical system (ST-System)" as the ontological object to be investigated (Geels, 2004). The SoP approach has emerged as a powerful analytical framework with high explanatory power, enabling scholars to understand complex systems (Hansen, 2018; Mattioli et al., 2020). However, the literature surrounding this approach is characterized by dispersed and multidisciplinary contributions (Bayliss and Fine, 2020). Consequently, there is a need to consolidate and structure the SoP approach, providing clear and actionable insights to researchers interested in adopting this framework.

3.2 Definition of Boundaries

The SoP literature lacks a clear rationale for defining the system's boundaries. Consequently, based on the purpose of their research, different researchers adopted different boundaries, leading to different levels of understanding, rigour and scientificity. To clarify this concept, we present three articles investigating the transport sector through the SoP approach.

(Mattioli et al., 2020) analyse the political economy of car dependences drawing from the SoP approach as a specific method of concrete examination derived from the political economy tradition. Mattioli and co-authors identify five main elements responsible for the existence of a transport system strongly dependent on car usage: i) the culture of car consumption, ii) the automotive industry (both in terms of characteristics of the industry and lock-in effects on consumers), iii) the provision of car infrastructures, iv) the urban development, and v) the public transportation system. Mattioli and co-authors highlight the importance of adopting a proactive and historically conscious political agenda encompassing research and practical measures for the transition from the car-dependent system.

(Hansen, 2017) investigates the two transitions from bicycles to motorcycles first and from motorcycles to cars then, in the Vietnamese context. (Hansen, 2017) identifies as the main drivers to changing consumption behaviours the large-scale transformations brought about by *"doi moi"*, the local context of mobility, the physical infrastructure, and the practices of mobility and consumption. Moreover, other elements are identified as drivers concerning the usage of cars, such as health and safety reasons, together with social structures and conditions. Through the analysis, (Hansen, 2017) successfully explains, at least partially, the two transport transitions that Vietnam faced over the last decades.

(Williams et al., 2019) investigate the institutional policy-making processes that influence mobility behaviours. Williams and co-authors aimed to understand how government funding creates opportunities for sustainable travel to emerge and how theories of practice can be used to analyse mobility and shape travel behaviour. They analysed the local sustainability transport funds from the UK as a case study and identified how practices within national governments and local authorities shape consumption patterns.

All three studies examine the transport sector, reaching relevant conclusions and providing valuable insights. In all cases, the SoP approach has demonstrated significant explanatory power, despite being applied in different empirical contexts and paired with different theoretical lenses (see also the "theories" section). Yet, it is extremely challenging to cross-compare or generalise from those three cases as they fail to have a similar system. Although the three studies focus on the transport sector, the system's boundaries differ.

Regarding the definition of boundaries, (Mattioli et al., 2020) explicitly follow three key principles of the SoP approach:

- The "vertical" analysis framework, as presented by (Fine et al., 2018, p. 39), is the *"idea that consumption (needs) to be understood more closely in relation to its attachment to production".*
- The attention to historical developments to understand the evolution of material and cultural aspects of provision.
- The inductive selection of the key elements of the system.

(Mattioli et al., 2020) specify that the article is not focused on any specific spatial and temporal context. Also, (Mattioli et al., 2020) explicitly draw the boundaries of the system, e.g. *"While external suppliers*

can account for a large share of vehicles' value, here we focus mostly on vehicle manufacturers, given their key position in the structure of the industry, both in strategic and economic terms" (Mattioli et al., 2020, p. 4) *"Our review is inevitably selective. Most notably, the paper does not address directly the political economy of the oil industry even though cars and oil have a symbiotic relationship that can be traced back to early twentieth-century US"* (Mattioli et al., 2020, p. 2).

Differently from (Mattioli et al., 2020), (Hansen, 2017) specifies temporal and spatial boundaries but does not focus on the vertical structures. Specifically, (Hansen, 2017) does not consider the characteristics of the automotive industry, such as the economies of scale, the high capital intensity, and the overcapacity and over production. Yet, (Hansen, 2017) considers import and export factors in the system's boundaries analysed, which are instead considered by (Mattioli et al., 2020).

In contrast with (Mattioli et al., 2020) and (Hansen, 2017), (Williams et al., 2019) focus on a narrower sub-system, i.e., the "transport planning system of provision". Moreover, despite defining temporal and spatial boundaries, the SoP is mainly adopted to identify and explain "relations" in the system. The system is limited to practices of Governments, Civil service, Transport planning and Travelling; however, agents, structures, processes or material cultures presented in the other papers are not considered.

In these examples, it is evident that the systems analysed were not the same. Despite all these studies being meaningful when individually taken, a more comprehensive understanding, for example, at the sector level, is precluded. In addition, more generally, several articles do not explicitly state and discuss the system's boundaries. Despite the clear area under investigation (e.g. household consumption, energy retrofit provision, meat consumption), the system's boundaries are not explicitly presented and discussed (de Feijter et al., 2019; Hansen, 2018; Wahn, 2020). To overcome this issue in defining the boundaries of a system, we propose the adoption of the concept of "Socio-Technical Systems" (ST-systems) as defined by (Geels, 2004). (Geels, 2004) applied the concept of ST-systems in the area of systems of innovation, starting from a critique of the existing approaches to describe the systemic nature of innovation, e.g. technological systems (Carlsson, 1997), sectoral systems of innovation (Malerba, 2002) and large technical systems (Hughes, 2019). Therefore, for instance, future research on car dependency or train development or aeroplane market structure could use the ST transport system, as detailed in (Geels, 2018). A key reason that makes the ST-system an ideal level of analysis for the SoP approach is the conception of the system as *"the linkages between elements necessary to fulfil societal functions"* (Geels, 2004, p. 900).

Similarly to the SoP, in fact, (Geels, 2004) includes both the supply and the demand side in ST-systems. Moreover, ST-systems consider the key role played by the actors of the system and the material culture (Geels, 2004). However, despite recognising the relevant role played by social systems, differently from the SoP (Geels, 2004) highlights the importance of material aspects of systems such as physical infrastructures. The identification of such elements would be beneficial in the definition of boundaries when adopting the SoP approach. In fact, (Geels, 2004) provides a clear framework for identifying the basic elements and resources of ST-systems, making a distinction between the production and consumption sides.

Therefore, we highlight the potential of the SoP approach as a sense-maker framework for ST-systems for two main reasons. First, there is a lack of definition of what "system" is in SoP, and ST-systems present all the key elements to be considered in the SoP approach. Despite (Geels, 2004, p. 901) recognises that *"boundary definition is more an empirical issue than a theoretical one"*, ST-systems have, contrarily to SoPs, distinguishable elements such as knowledge, capital, labour and human actors. Second, after mapping the ST-systems, the explanatory power of the SoP approach can answer the question *"Who has What, How and Why"* (Bayliss and Fine, 2020) in ST-systems. The SoP approach can provide valuable support to the quest of scholars examining the relationships between strategic decisions, policies, and consumption

behaviours. Scholars have already adopted the SoP to explain different contexts from a sectorial (e.g. water, food, waste), geographical (e.g. UK, USA, Vietnam) and temporal point of view (Bayliss, 2017; Fine and Davidson, 2018; Hansen, 2018, 2017; Júlíusson et al., 2020; Lee, 2018; Schelly, 2014). However, these studies could better define the object under investigation and enhance the rigour of the analysis by adopting the ST-system concept.

3.3 Theories

3.3.1 Horizontal vs vertical perspective

The SoP approach departs from the reductionist and individualistic theories characterizing mainstream economics under a neoclassical perspective. (Bayliss and Fine, 2020) criticize the wide range of horizontal theories related to specific disciplines, identifying the impossibility of generating a holistic understanding of consumption behaviours through integrating these theories. According to (Bayliss and Fine, 2020), to answer the question "Who gets what, how and why?" horizontal intra-disciplinary theories developed in sociology, anthropology, psychology, and other disciplines are insufficient. Therefore, while recognizing the relevance of horizontal factors that can characterize different SoPs, (Fine and Leopold, 1993) underline the necessity of including a vertical perspective. (Fine and Leopold, 1993, p. 8) identify the vertical structure underlying the consumption analysis as *"the chain of activities that connects production to consumption (and even disposal) across the life of the commodity"*. The agents involved in the supply chain of commodities, as well as the specific characteristics of goods and services produced or provided, how they are supplied, and the consumers that are targeted, are different according to the typology of the commodity. Each commodity is characterized by its distinctive system of interconnected structures, relations, processes, and agents (Bayliss and Fine, 2020). Therefore, the SoP approach investigates consumption as both shaped by the vertical system linking production to consumption and by horizontal characteristics such as gender, status and income level. (Fine, 2013) highlights how the SoP approach can trace its origins back to the Marxist theory of value. In particular, the SoP approach shares with this theory the fundamental concept that a commodity cannot reveal the relationships, processes, structures, and agents behind the act of sale. When purchasing the commodity in a market predominantly characterized by impersonal relations, the consumer is blind to the chain that connects production, distribution, consumption, and disposal. However, going back to the relevance of vertical systems, according to the Marxist political economy, social relations of production are the reason why commodities can be priced, sold and used passing through the market (Bayliss and Fine, 2020).

To propose a practical distinction between horizontal and vertical perspectives, we elaborate on (Mattioli et al., 2020) that investigate the transport ST-system. While recognizing the importance of horizontal elements like the emotional and psychological attachment to the car, its cultural role or status symbol, (Mattioli et al., 2020) present many elements proper of the vertical transport ST-system. The authors describe the characteristics of the automotive industry, the provision of car infrastructures, land use patterns and the provision of public transportation. In adopting the SoP approach, (Mattioli et al., 2020) do not consider one element more or less relevant than the others but focus on investigating how they are interconnected.

3.3.2 Theoretical lenses

Starting from the critique of horizontal intra-disciplinary theories, (Bayliss and Fine, 2020, p. 18) state that *"just as there is no general theory of consumption, so there can be no general theory of SoPs in the sense that the application of the approach will be dependent upon the particular system under consideration"*. Our findings from the thematic analysis support this idea. In the SoP literature, there is no shared theoretical background for explaining the dynamics in the systems analysed. Part of the SoP literature does not explicitly state any theoretical lens (Bayliss and Pollen, 2021; Brooks, 2015; Chappells and Shove, 2000; Santos et al., 2018). However, also the studies that do not state any theoretical lens provide meaningful results or can explain and interpret the phenomenon observed and interpreted through the SoP approach. For example, (Chappells and Shove, 2000) criticize demand-side management approaches, underlining the overlooked relation between energy providers and consumers. Starting from the "organisational interdependency" concept, the authors investigate modes of co-provision in the UK, emphasizing that different configurations involve different agents, relations and structures. (Chappells and Shove, 2000) come to the insightful and based-on-evidence conclusion that *"approaches to reconfiguring energy demand need to be set in the context of the energy system of provision as a whole"*. Another example is the study conducted by (Santos et al., 2018), who investigated the relation between financialization and social reproduction in Portugal through three different systems of provision: pensions, housing and water. (Santos et al., 2018) explain how the role played by agents, relations and processes at international level furthered the raise of inequalities in semi-peripheral Portuguese areas. By reporting these examples, we want to emphasize the high explanatory power of the SoP approach, independently from adopting theoretical lenses. The SoP approach allows scholars to investigate consumption behaviours tracing back their causes not only to the individualistic perception but mainly to the structure of the upstream value chain of the good or service provided. In so doing, scholars can individuate agents, relations, structures and processes distinctive of each SoP that would otherwise remain concealed.

However, most scholars adopting the SoP approach clearly state the theoretical lens they adopted. The most frequently adopted theoretical lens is practice theory (Hansen, 2017; Rinkinen et al., 2019; Schelly, 2014; Williams et al., 2019). According to (Warde, 2014, p. 284), *"The most common explanation of the emergence of theories of practice is that they were a response to a number of fundamental problems of social theory at the point of the passing of economism and Marxism in the 1970s"*. (Warde, 2014) stresses the concept of social practices to understand better consumption patterns rather than focusing solely on individual choices. Practice theory moves away from the desires of individuals towards the established norms of collective culture (Warde, 2005). The primary focus in practice theory shifts towards the arrangement of the practice and the connected instances of consumption (Warde, 2005). Elaborating on this concept, investigating meat consumption in Vietnam, (Hansen, 2018) identifies a change in the moments and location of consumption (i.e. eating away from home) as one of the main factors leading to increasing meat consumption in the country. Similarly, according to (Thongplew et al., 2021), SoP and consumption practices are interdependent and mutually influence one another. (Thongplew et al., 2021) explore plate waste in university canteens in Thailand, and identify that shared practices (e.g. leaving food on the plate to feed stray dogs), together with other characteristics of the SoP (e.g. size of the canteen, quality of food, price), impede to reach the ambitious goal of zero waste.

Other theoretical lenses are adopted by scholars using the SoP approach, such as care theory (Fine and Davidson, 2018), the theory of food systems (Atkins and Gastoni, 1997), and the social practices model (Schelly, 2014). (Fine and Davidson, 2018) draw on care theory in describing the transition from public health-care services toward the marketization of the SoP in Australia. (Atkins and Gastoni, 1997) overcome the limitations of food system theory through the SoP approach in investigating the characteristics of the

Maltese food system. (Schelly, 2014) builds on (Spaargaren, 2003) and adopts the social practices model to investigate two different incentive structures in Wisconsin and Colorado, aiming at fostering the adoption of PV technologies. According to (Schelly, 2014, p. 7), these incentive policies are structures *"that influence the social setting in which patterns of human practice emerge and become meaningful."*. Therefore, the author suggests that a proper focus on social practices shaped by the SoP and its elements can improve the design and implementation of energy policies.

These examples of theoretical lenses adopted together with the SoP approach highlight the flexibility of this approach. The SoP approach can be interpreted through general theoretical lenses for the study of consumption (e.g., practice theory) but also with theories belonging to the specific ST-system under investigation (e.g., care theory).

3.3.3 Engaged vs Detached approaches

Scholars adopted engaged and detached approaches to apply the SoP framework to case studies. In a few cases, the approach was required by the temporal dimension of the study, e.g. (Júlíusson et al., 2020) investigating the tenant-based system in Iceland between the 17th and the 18th century. However, in the majority of empirical studies, scholars decided either to conduct detached analysis merely based on secondary and primary data such as reports, scientific literature, and interviews (de Feijter et al., 2019; Fine and Davidson, 2018; Robertson, 2017; Schelly, 2014); or to be engaged in the process through log-term fieldwork, participated observations and direct consumption of the good or service under investigation (Hansen, 2022, 2018, 2017; Thongplew et al., 2021). To provide some examples, (de Feijter et al., 2019), investigating governance structures for housing retrofitting in China and Netherlands, based their detached analysis on semi-structured interviews with local government officials, housing association officials, construction companies, and private developers. Moreover, the authors triangulated the data through direct observation and policy documents. Similarly, (Bayliss and Pollen, 2021) analysed the Zambian SoP of electricity and relied on stakeholders' interviews, publicly available documents from energy companies and other secondary data. In contrast, (Hansen, 2022, p. 1445), analysing the ST-system of food in Vietnam states, "*The research combined interviews with an ethnographically inspired approach to food practices. This aligns with practice approaches' emphasis on going beyond 'sayings' to also study 'doings' to understand practices"*. This implied that the author lived in Hanoi experiencing places such as markets, supermarkets, and restaurants.

With these examples, we are not providing any judgement regarding the preferrable approach to the research for scholars adopting the SoP approach. Contrarily, we highlight that the approach adopted by scholars strongly depends on the nature of the good or service investigated. Still, the depth of the analysis and the specific actors, relations, structures, processes or material culture that a scholar wants to investigate deeply influence the approach to the research to be preferred.

4 Using the SoP Approach to Tackle Grand Challenges

In this section, we show how SoP can be used in discussing Grand Challenges. Grand Challenges (i.e. *"Specific critical barriers that, if removed, would help solve an important societal problem with a high likelihood of global impact through widespread implementation"* (George et al., 2016, p. 1881)) demand extensive resources, collaborations, and efforts to tackle them (Coenen et al., 2015). Addressing grand challenges requires efforts from diverse fields such as science, technology, engineering, and social sciences. The escalation of long-term phenomena like climate change, depletion of natural resources, and energy supply instability is becoming prominent in policy and academic debates. Adapting to this evolving reality requires countries to not depend on the status quo of "business as usual" (European Commission, 2013). Aligned with this view, sustainability transition researchers (Köhler et al., 2019, p. 2) argue that addressing grand challenges requires *"radical shifts to new kinds of socio-technical systems"*.

Similarly, (Andersson et al., 2021) state that grand challenges require significant transformations in the ST-systems governing production and consumption. The ST-system and grand challenges have a relationship in that the former must be transformed to address the latter. From an ST-systems perspective, policymakers are placing greater efforts on addressing grand challenges. This concern is being promoted especially by supranational entities such as the OECD and the EU but is slowly being adopted by local and regional authorities (Coenen et al., 2015).

In light of this, there are at least two levels of analysis: the first one, rather superficial, is that ST-systems affect and are affected by grand challenges. The electricity ST-system emits a considerable amount of greenhouse gasses affecting climate change. In turn, climate change affects the electricity ST-system by changing weather patterns, e.g., weather availability for thermal or hydropower plants. Yet, there is a second, more profound and meaningful level of analysis that is worth discussing and represented in Figure 2. The key insight here is that ST-system is linked to policy, projects and consumer behaviours. Let's go back to the example of the electricity ST-system. A certain government might have a policy to decarbonise the country using nuclear technology. So, the government might implement several policies to promote "nuclear projects". Such projects include, among others, constructing nuclear power plants, manufacturing facilities for the critical components and opening new schools/university departments to train the workforce. Installing new nuclear plants shapes consumption behaviour because, for instance, a lower price of electricity promotes a wider adoption of electric stoves (like in France) over gas-fired stoves (like in Italy). So, in general, in our analysis of the ST-systems, we focused mainly on Policies, Projects, and Consumption Behaviours (see Figure 2):

- **Policies**. Policies are shaped or should be shaped by the urgency of addressing grand challenges. Consequently, policies have a double effect, promoting specific project typologies and directly shaping consumption behaviours. For example, the introduction of restrictions on car emissions in certain areas of major cities can: i) push the automotive industry to develop R&D projects on more efficient engines, alternative fuels or technologies (e.g. electric and hybrid cars); ii) force consumers (e.g. car owners) to change their purchasing decisions toward less polluting vehicles, or to change the transportation behaviours, for example switching from private mobility to public transportation or shared vehicles.
- **Projects**. In ST-systems, projects have a twofold effect. Projects can directly affect grand challenges and/or shape the consumption behaviours of the actors in the ST-system. For example, investing in a modern and large electrified transport system can, on the one side, directly reduce "Scope 1" emissions of transportation companies. On the other side, refurbishing and extending a fleet could change people's perception regarding public transportation, incentivizing them to increase their consumption.

- **Consumption behaviours**. The consumption patterns of actors participating in ST-systems directly impact grand challenges and can also shape new projects. For example, changes in mobility behaviours such as shifting from the usage of private vehicles to public transportation or shared mobility could: i) Directly affect grand challenges through a decrease in the demand for private vehicles, the increase of the utilization rate of shared or public vehicles and the reduction of direct emissions from the usage of vehicles; ii) Shape and incentivize new projects in the ST-system of transport, such as metro lines, high-speed train railways, or expanded fleets.

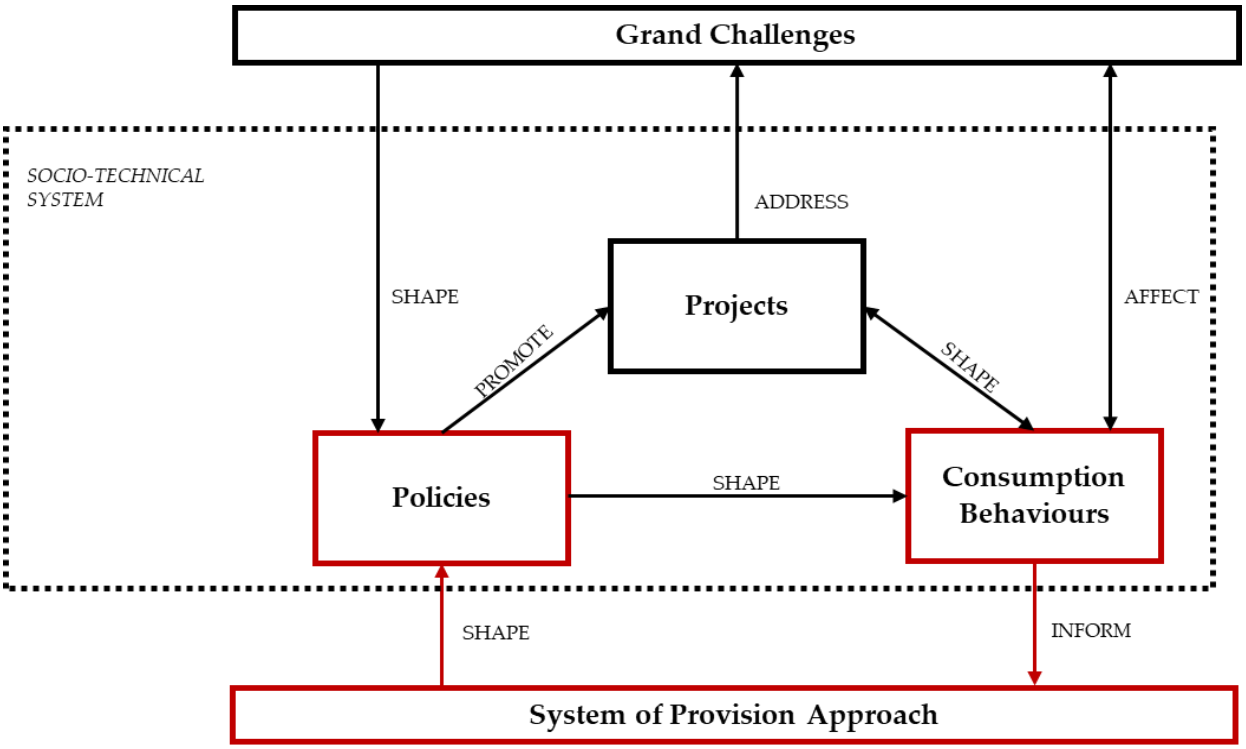


Figure 2 Relations between Grand Challenges and ST systems and the role of the SoP approach

Within this framework underlying relationships between policies, projects and consumption behaviours, we highlight the SoP approach's role in sense-making the dynamics occurring in ST-systems between these three key elements. As a bottom-up approach, the SoP can sensemake the consumption behaviours of particular agents (i.e. consumers), searching for the main relations, processes, structures and material cultures that influence consumption patterns. The SoP approach can inform and shape policy-making processes by studying consumers as a unit of analysis. In the next section, we operationalise the application of the SoP using the case study of nuclear technology, particularly the production of hydrogen from nuclear power plants.

5 Case study: SoP application to the nuclear industry

5.1 Nuclear beyond electricity production

The narrative surrounding the civil application of nuclear power primarily focuses on its role in electricity production through nuclear power plants. Traditionally, electricity production from nuclear power has yielded numerous social and economic benefits (Choi et al., 2009). Nuclear power has played a key role in driving the industrialization of entire countries (e.g. South Korea), promoting energy independence (e.g. France), and fostering social equity by facilitating broader access to affordable electricity (Kwak and Yoon, 2020). Additionally, nuclear power can be a valuable electricity source for countries seeking to decarbonize their electrical systems, as it is a low-carbon source of electricity. However, electricity production is not the only application of nuclear power. There are at least 3 other key existing applications:

1. **District heating.** In 2008, 59 units across nine countries, namely Bulgaria, the Czech Republic, Hungary, India, Romania, Russia, Slovakia, Switzerland, and Ukraine, were employed for district heating and process heat (Locatelli et al., 2017). According to (International Atomic Energy Agency, 2008), district heating requires mainly: i) a temperature range of 80-150°C; ii) consumption within 10-15 km from the heat source; iii) a backup capacity to ensure a reliable heat supply. In addition, heat generation capacity depends on the collective demand (600-1200 MWth, usually for large cities), and heat is mainly supplied in the colder parts of the year. A valid example of district heating from nuclear is the Beznau NPP in Switzerland, supplying more than 150 GWh/y of carbon-free heat to several surrounding municipalities and reducing the plant's effects on the water temperature of the Aar River.
2. **Desalination**. The viability of integrated nuclear desalination plants has been demonstrated through extensive experience totalling over 150 reactor-years, primarily in Kazakhstan, India, and Japan (World Nuclear Association, 2023). The widespread implementation of nuclear desalination for commercial purposes will largely hinge on economic considerations. (Locatelli et al., 2015) also analysed the possible adoption of Small Modular Reactors (SMR) for Multi Effect Desalination (MED). According to the authors, the advantages of desalination plants are i) the possibility of switching on and off the plant and the easy storability of water; ii) the simplicity and robustness of the process; iii) the modularity of the desalination plant. (Locatelli et al., 2015) conclude that desalination plants can represent a flexible buffer for excess power generated. Yet, according to (World Nuclear Association, 2023), estimated costs range from 70 to 90 US cents per cubic meter, comparable to fossil-fuelled plants in the same context, making nuclear desalination a competitive alternative. An excellent example is the BN-350 fast reactor at Aktau in Kazakhstan, which supplied 80.000 m^3/d over 27 years.
3. **Naval propulsion**. Naval propulsion solutions include mainly:
    a. **Military aircraft carriers and submarines**. The first application of nuclear propulsion on a submarine was in 1955 (Ragheb, 2010). Since then, hundreds of nuclear-powered submarines and aircraft carriers have been built and operated. This is mainly due to the necessity of operating these ships for a long period without refuelling so as not to disclose the vehicles' position (Bayraktar and Pamik, 2023). Nuclear reactors power many aircraft of the US military fleet, creating great expertise and technological advancements.
    b. **Icebreakers**. Over the last decades, nuclear propulsion systems have been successful in icebreaker applications (Bayraktar and Pamik, 2023). Nuclear-powered icebreakers are usually

more powerful than fossil-fuelled ones, present fewer issues with refuelling and rely on a carbon-free energy source. However, Russia is the only country operating nuclear icebreakers (Henderson, 2019).

c. **Civil commercial boat**. In this area, the experience level is far more limited than the previous two solutions. However, approximately 2% of energy-related CO2 emissions can be attributed to international maritime freight transportation (International Energy Agency, 2023). According to (Walsh et al., 2017), nuclear-powered ships could play a key role in decarbonising the freight transportation sector. Technological developments in the nuclear industry (e.g. SMRs), new regulations, and increased public acceptance could facilitate the transition from fossil-fuelled to nuclear propulsion systems. Nowadays, the only operating nuclear-powered cargo ship is the Russian Sevmorput, commissioned in 1988.

From a technological perspective, nuclear power proved a high technological readiness level (TRL) in many applications to assume a key role in various ST-systems outside electricity generation. Desalination plants are fundamental in the water provision ST-system of many countries. District heating from nuclear power plants heavily impacts the ST-system of housing, dramatically reducing CO2 emissions. Nuclear power for naval propulsion is a proven and standard technology in the military sector but could have a broader role in the ST-system of transport.

5.2 SoP and Nuclear hydrogen

In this section, adopting the SoP approach in two case studies, we highlight nuclear technology's role in producing hydrogen to decarbonise ST-systems. In doing this, nuclear power can substantially contribute to addressing a grand challenge that is recognised worldwide[1]: climate change.

5.2.1 Hydrogen market

Hydrogen consumption is about 95 million tons (Mt) per year (IEA, 2022). Over the past 50 years, the hydrogen demand steadily grew by 1.6 % per year. (Energy Transition Commission, 2021; Hydrogen council, 2021; IEA, 2022; IRENA, 2022) provide a range of scenarios for 2050; in all these scenarios, there is a faster exponential growth over the next decades. Historically the largest share of the hydrogen produced today is produced and consumed in refinery and chemical production. The opportunity for nuclear hydrogen in these markets is to substitute the existing hydrogen produced from fossil fuels leading to a relevant decarbonisation. On the downstream side of the supply chain this switch will not require substantial infrastructural changes since hydrogen (from fossil fuel) is already used in their operations. The change will occur only in the upstream side of the supply chain, where hydrogen will be produced with nuclear power replacing fossil fuels.

Today, most hydrogen is produced near the consumption site due to the high transport and storage cost and the possibility of producing hydrogen on demand from fossil fuels (Ahmed et al., 2022). Industrial applications are the main markets for hydrogen. The first industrial application is in refineries which

[1] Other grand challenges can be local: e.g. aging population is a grand challenge in many EU country (E.g. Italy), while it is not in several African countries.

accounts for 42% of the total production (40 Mt), where hydrogen is mainly used for hydrodesulfurization and light hydrocarbons from heavy hydrocarbons. The second sector is ammonia production (34 Mt, 36 % of the total), where hydrogen is used to fix nitrogen pumped from the air. Ammonia is the main feedstock for several sectors, such as nitrogen-based fertilisers, refrigerant gasses and pharmaceuticals. Methanol is the third sector, consuming 15Mt per year of hydrogen (16% of the total). Methanol is currently used to produce plastics and fuel additives. Finally, direct reduction iron (DRI) accounts for 5% of the total hydrogen consumption (5Mt per year). DRI is a process where iron ore is reduced to produce sponge iron, which will later be transformed into steel. In this sector, hydrogen is used as a reducing agent. Other sectors that use hydrogen are transport and residential heating, which account for less than 1% of global consumption. The global push to move toward a net-zero economy should increase the hydrogen demand as, for instance, an energy vector. In this scenario(s), hydrogen should be produced by low-carbon energy sources (e.g., nuclear) and used as chemical feedstock and energy vector playing an essential role in deep decarbonization.

The value that nuclear hydrogen can generate goes beyond economic and financial performance, including:

- Security of supply. Differently from hydrogen obtained from fossil fuels, nuclear hydrogen can rely on a reliable supply chain. First, storing enough nuclear fuel to ensure the continuity of operations for a long period is possible. Second, it is possible to adopt differentiation strategies regarding suppliers for nuclear fuel (several politically stable countries produce raw uranium), thus reducing the dependence on market scarcity and fluctuations.
- Price stability. Nuclear Hydrogen has less exposition to price volatility compared to fossil fuels. Furthermore, nuclear power plants are capital-intensive, and almost all their costs are fixed or sunk. From this perspective, nuclear hydrogen guarantees high price stability over time.
- Low-carbon emission. Nuclear is a competitive energy source to produce low-carbon hydrogen at a large scale. IAEA's net-zero scenario highlights the need to coexist variable (renewables) and stable (nuclear) sources(IAEA, 2021). This represents a competitive advantage for nuclear, compared to fossil fuels.
- Production schedule. Nuclear hydrogen production is schedulable, while renewable sources are not. The possibility of planning hydrogen production is essential to align demand and supply to reduce storage costs.
- Co-generation. Co-generation is a valuable alternative to switch from hydrogen production (e.g. during the night, when hydrogen can be stocked) to electricity production.
- First mover advantage. Nuclear Hydrogen can represent an opportunity for countries to be the first mover on the market. Developing new competencies and know-how can allow countries to export their technology worldwide.

5.2.2 Insights using the SoP approach

The goal of this and the next sections is to show the role of the SoP approach in examining the process of decarbonizing supply chains leveraging hydrogen produced by nuclear facilities (in short, "nuclear hydrogen"). We will focus on the food and transport ST-system. The key points are the following:

- Nuclear hydrogen can reduce the carbon intensity of the Food ST-system by substituting existing ammonia plants for fertilizers.
- Nuclear hydrogen can reduce the carbon intensity of the transport ST-system by substituting oil for large shipping boats.
- There is a "push logic" (i.e., the arrow "Policy Promote projects") in this substitution that has two components:
    - Governments provide incentives to support the design and construction of NPP and Hydrogen facilities. This decreases the cost of nuclear hydrogen.
    - Governments establish disincentives for using alternatives. Typical examples include legislation forbidding certain kinds of fuel and emission and/or higher tax on fossil fuels (these two approaches are very common in, e.g., the car sector)
- There is a "pull logic" (i.e. the arrow consumer behaviour shape projects) promoted by policies shaping consumer behaviour.

For instance, the creation of nutritious score labels is already happening in the food industry, as in Figure 3. The Nutri-Score is a nutritional rating system that uses five colours to demonstrate the overall nutritional value of food products. It rates products using a letter from A (best) to E (worst) and assigns a corresponding colour from green to red. The French government chose this system in March 2017. The Nutri-Score has received recommendations from several European Union countries, the European Commission, and the World Health Organization. In short, consumers should be incentivized to buy healthy "A" products instead of unhealthy "E" products. This willingness to buy would shape the supply chain accordingly. We propose the adoption of a similar label but for the CO_2 intensity of food and mass-produced goods.

Similarly, with what has been done for home recycling (increasing) and cigarette smoking (decreasing), public institutions should educate the public to consume more responsibly, i.e. food and mass-produced goods with a lower carbon intensity. So, demand for lower carbon-intensity food and mass-produced goods will push producers to reduce the carbon intensity of their supply chains. Food producers can therefore reduce their supply chain using fertilizers based on nuclear hydrogen, while food and goods produced overseas can reduce their intensity using maritime transportation fuelled by nuclear hydrogen. We will focus now on these two ST systems.

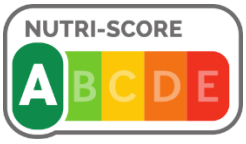


Figure 3 Example of a possible label to inform consumers

5.2.2.1 Food ST system: the Fertilizers supply chain

In this first case study, we investigate, through the SoP approach, the potential role of nuclear hydrogen in the food ST-system. Aiming to address the grand challenge of climate change by decarbonizing food consumption, we focus on the specific role that nuclear hydrogen can play in producing fertilizers used in

agriculture. Fertilizers are fundamental for ensuring a stable and reliable production of food. One key component necessary for producing fertilizers is ammonia derived from hydrogen. In this supply chain, the main steps are the production of hydrogen from nuclear energy, the chemical transformation of hydrogen in ammonia, the production of fertilisers and the consumption of these fertilisers by farmers. In this supply chain, nuclear power can guarantee a stable production of low-carbon hydrogen in terms of supply and price. Substituting fossil-based hydrogen with nuclear hydrogen can represent a key step for decarbonising the fertilizers supply chain and, in general, the food ST-system. Figure 4 represents a schematic analysis of the fertilizers supply chain in the food ST-system. Table 2 shows the case of three ammonia plants and the size of a nuclear power plant required to decarbonise them. As the table shows, this is about the scale of a large nuclear reactor (or a few SMRs).

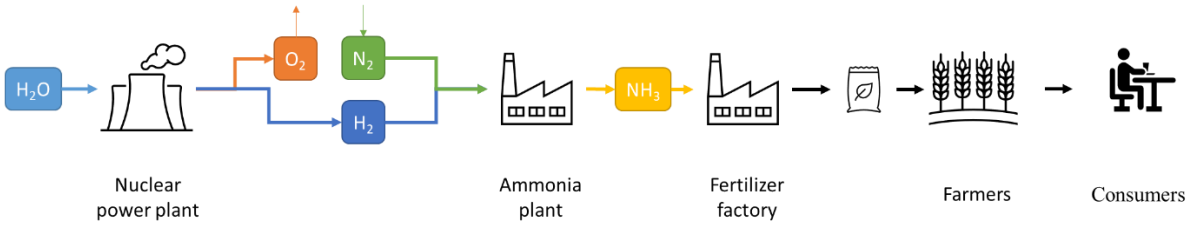


Figure 4 Fertiliser supply chain

Ammonia Plant	NH3 Production [tonnes/year]	H2 production required [Nm³/year]	MWt Sulfur–iodine (VHTR)	MWe Electrolysis (PWR)
SAFCO, Al-Jubail	1.300.000	2.552.848.242	1.940	1.425
CF Industries, Port Neal	1.200.000	2.356.475.300	1.790	1.315
KAPSOM, Shangdon	600.000	1.178.237.650	895	658

Table 2 Relevant examples of ammonia plants

5.2.2.2 Transportation ST-system: decarbonising bunker fuel

According to (Energy Transition Commission, 2021; IEA, 2021), power storage, shipping and aviation represent future markets which will need a heavy reconfiguration to foster hydrogen use. The future demands for these sectors are 84 Mt yearly of hydrogen for power storage and 141,5 Mt for sea shipping (this amount refers to the overall pure hydrogen required; however, it can be consumed as pure hydrogen or under the form of hydrogen-based synthetic fuels), and 97,5 Mt for aviation (using hydrogen-based synthetic fuels). The technologies necessary for these markets are different, and clear decarbonisation pathways are still to be defined. For example, shipping industries could be powered by several hydrogen-based fuels using internal combustion engines, pure hydrogen using fuel cells, and electric hybrid solutions. These new markets are clear opportunities for hydrogen to penetrate traditional fossil-fuel-based markets. Therefore, while the actual market uses hydrogen only as a chemical compound to obtain a specific chemical reaction, future markets will still see hydrogen as a chemical compound, but a large amount of hydrogen will be utilised as an energy carrier to couple low-carbon energy (e.g. nuclear) with other sectors.

The supply chain for using nuclear hydrogen as a shipping fuel is one of the potential future markets for hydrogen. Hydrogen could be produced within bunker ports and then used as fuel for heavy shipping vehicles to limit the cost of transport. Placing the nuclear power plant within the bunker port is ideal due to the availability of cooling water and water for the electrolysis, and the power plant will also be useful to feed the bunker port. In doing this, it would be necessary to liquefy and store hydrogen in specific vessels located within the bunker port. Then the liquified hydrogen could then be transported to the end user through bunkering ships. Also, in this supply chain, several stakeholders should be aligned. Figure 5 shows the supply chain and places it in the wider ecosystem context. Table 3 shows the impact on the bunker port and the amount of MWt and MWe necessary to decarbonise the entire port. Obviously, total decarbonisation is not a near-term goal, but even shifting 10% of the total fossil fuel to hydrogen would require at least the construction of a large NPP.

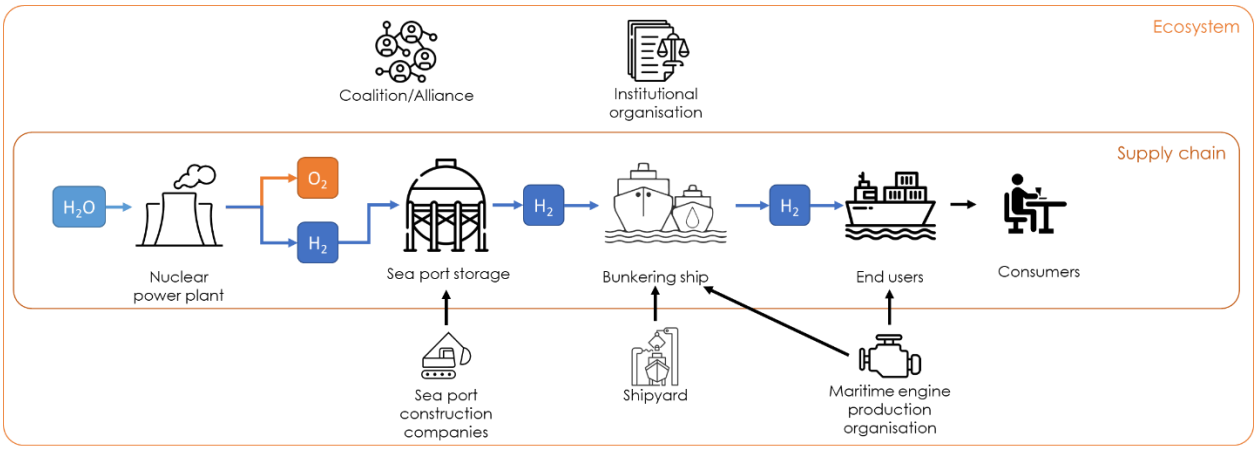


Figure 5. Nuclear hydrogen sea shipping value chain

Bunker port	Bunker Fuel Sold [tonnes/year]	H2 production required [Nm³/year]	MWt Sulfur–iodine (VHTR)	MWe Electrolysis (PWR)
Rotterdam	13.000.000	40.272.830.821	30.598	22.476
Fujairah	9.500.000	29.430.145.600	22.360	16.425
Hong Kong	5.500.000	17.038.505.347	12.945	9.509

Table 3 Bunker port demand

In summary, adopting the SoP approach in a prospective way in transport and food ST-systems allows identifying and examining horizontal and vertical structures, uncovering opportunities that would be neglected otherwise.

6 Conclusions

The SoP approach is a structured framework for studying consumption, bringing together insights from various disciplines across social sciences. At the core of the SoP approach lies the notion that consumption behaviours are contingent upon the specific system through which a good or service is provided. Due to its explanatory power, the SoP approach is gaining popularity across various epistemological communities. Based on a systematic literature review, this paper aims to present the state of the art of the SoP literature, its integration within the narrative of sustainable transition and a pilot application to nuclear technology.

We performed a systematic literature review based on a systematic search and a snowballing process. We abductively performed a thematic analysis of 45 out of 65 documents of our final sample (Braun and Clarke, 2006; Thompson, 2022), identifying 30 codes grouped into five themes. The remaining 20 documents (4 books and 16 long reports – more than 2000 pages) were fully read and used to inform the research.

By leveraging a systematic literature review, we identified three main results. First, the SoP approach lacks a clear definition of systems, particularly regarding their boundaries. The adoption of the concept of "ST-systems" can overcome the issue of defining boundaries. Second, the SoP approach has explanatory power and theoretical flexibility to adapt to various theoretical lenses. Last, the SoP approach can be complemented by the multi-level perspective (MLP).

We discuss how the SoP approach can address Grand Challenges. Grand Challenges require extensive resources, collaborations, and efforts from diverse fields such as science, technology, engineering, and social sciences. Sustainability transitions of ST-systems play a crucial role in addressing Grand Challenges, and policymakers are placing greater efforts into addressing them. This paper highlights the SoP approach's role in the sense-making of the dynamics occurring in ST-systems between policies, projects, and consumption behaviours. The application of the SoP approach is operationalized using the case study of nuclear technology and hydrogen production from nuclear power plants. In particular, we focus on the potential of using nuclear technology to produce hydrogen to decarbonize supply chains in two case studies: the food and transport ST-systems. Nuclear hydrogen can reduce the carbon intensity of the food ST-system by providing low-carbon hydrogen for fertilizers, and it can reduce the carbon intensity of the transport ST-system by substituting oil for large shipping boats. This paper proposes a "push logic" and a "pull logic" to promote substitution, consisting of government incentives, disincentives, and policies shaping consumer behaviour. Furthermore, this paper reflects on the significance of the SoP approach from both a phenomenological perspective and nuclear technology. This study contributes to advancing the SoP approach and its implications for understanding consumption patterns by critically evaluating the existing literature and offering new insights applied to the nuclear sector.

7 References

Ahmed, S.F., Mofijur, M., Nuzhat, S., Rafa, N., Musharrat, A., Lam, S.S., Boretti, A., 2022. Sustainable hydrogen production: Technological advancements and economic analysis. International Journal of Hydrogen Energy. https://doi.org/10.1016/j.ijhydene.2021.12.029

Andersson, J., Hellsmark, H., Sandén, B., 2021. The outcomes of directionality: Towards a morphology of sociotechnical systems. Environmental Innovation and Societal Transitions 40, 108–131. https://doi.org/10.1016/j.eist.2021.06.008

Atkins, P.J., Gastoni, M., 1997. The Maltese food system and the Mediterranean. GeoJournal 41, 127–136. https://doi.org/10.1023/A:1006880723291

Bayliss, K., 2017. Material cultures of water financialisation in England and Wales. New Political Economy 22, 383–397. https://doi.org/10.1080/13563467.2017.1259300

Bayliss, K., Fine, B., 2020. A Guide to the Systems of Provision Approach: Who Gets What, How and Why. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-54143-9

Bayliss, K., Fine, B., Robertson, M., 2017. Introduction to special issue on the material cultures of financialisation. New Political Economy 22, 355–370. https://doi.org/10.1080/13563467.2017.1259304

Bayliss, K., Pollen, G., 2021. The power paradigm in practice: A critical review of developments in the Zambian electricity sector. World Development 140. https://doi.org/10.1016/j.worlddev.2020.105358

Bayraktar, M., Pamik, M., 2023. Nuclear power utilization as a future alternative energy on icebreakers. Nuclear Engineering and Technology 55, 580–586. https://doi.org/10.1016/j.net.2022.10.033

Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qualitative Research in Psychology 3, 77–101. https://doi.org/10.1191/1478088706qp063oa

Brooks, A., 2015. Systems of provision: Fast fashion and jeans. Geoforum 63, 36–39. https://doi.org/10.1016/j.geoforum.2015.05.018

Callon, M., Caliskan, K., 2005. New and old directions in the anthropology of markets. Wenner-Gren Foundation for Anthropological Research, New York, April 9.

Carlsson, B., 1997. Technological Systems and Industrial Dynamics. Springer Science & Business Media.

Chappells, H., 2008. Systematically sustainable provision? The premises and promises of "joined-up" energy demand management. International Journal of Environmental Technology and Management 9, 259–275. https://doi.org/10.1504/IJETM.2008.019037

Chappells, H., Shove, E., 2000. Organising energy: Consumption, production, and co-provision. Proceedings ACEEE Summer Study on Energy Efficiency in Buildings 8, 8.39-8.50.

Choi, S., Jun, E., Hwang, I., Starz, A., Mazour, T., Chang, S., Burkart, A.R., 2009. Fourteen lessons learned from the successful nuclear power program of the Republic of Korea. Energy Policy 37, 5494–5508. https://doi.org/10.1016/j.enpol.2009.08.025

Coenen, L., Hansen, T., Rekers, J.V., 2015. Innovation Policy for Grand Challenges. An Economic Geography Perspective. Geography Compass 9, 483–496. https://doi.org/10.1111/gec3.12231

de Feijter, F.J., van Vliet, B.J.M., Chen, Y., 2019. Household inclusion in the governance of housing retrofitting: Analysing Chinese and Dutch systems of energy retrofit provision. Energy Research and Social Science 53, 10–22. https://doi.org/10.1016/j.erss.2019.02.006

Energy Transition Commission, 2021. Making the Hydrogen Economy Possible: Accelerating Clean Hydrogen in an Electrified Economy.

European Commission, 2013. Europe 2020: Europe's Growth Strategy. Brussels: European Commission.

Fine, B., 2017. The material and culture of financialisation. New Political Economy 22, 371–382. https://doi.org/10.1080/13563467.2017.1259299

Fine, B., 2013. Ephemera. Consumption matters.

Fine, B., 2002. The World of Consumption: The Material and Cultural Revisited, 2nd ed. Routledge, London. https://doi.org/10.4324/9780203095553

Fine, B., Bayliss, K., Robertson, M., 2018. "The Systems of Provision Approach to Understanding Consumption." pp. 27–42.

Fine, B., Leopold, E., 1993. The World of Consumption. Routledge.

Fine, M., Davidson, B., 2018. The marketization of care: Global challenges and national responses in Australia. Current Sociology 66, 503–516. https://doi.org/10.1177/0011392118765281

Gay, P. du, Hall, S., James, L., Madsen, A.K., Mackay, H., Negus, K., 2013. Doing Cultural Studies: The Story of the Sony Walkman. SAGE Publications.

Geels, F.W., 2018. Low-carbon transition via system reconfiguration? A socio-technical whole system analysis of passenger mobility in Great Britain (1990–2016). Energy Research & Social Science 46, 86–102. https://doi.org/10.1016/j.erss.2018.07.008

Geels, F.W., 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. Research Policy 33, 897–920. https://doi.org/10.1016/j.respol.2004.01.015

George, G., Howard-Grenville, J., Joshi, A., Tihanyi, L., 2016. Understanding and tackling societal grand challenges through management research. Academy of Management Journal 59, 1880–1895. https://doi.org/10.5465/amj.2016.4007

Hansen, A., 2022. Negotiating Unsustainable Food Transformations: Development, Middle Classes and Everyday Food Practices in Vietnam. European Journal of Development Research 34, 1441–1459. https://doi.org/10.1057/s41287-021-00429-6

Hansen, A., 2018. Meat consumption and capitalist development: The meatification of food provision and practice in Vietnam. Geoforum 93, 57–68. https://doi.org/10.1016/j.geoforum.2018.05.008

Hansen, A., 2017. Transport in transition: Doi moi and the consumption of cars and motorbikes in Hanoi. Journal of Consumer Culture 17, 378–396. https://doi.org/10.1177/1469540515602301

Henderson, I.M., 2019. Cold Ambition: The New Geopolitical Faultline [WWW Document]. The California Review. URL https://calrev.org/2019/07/18/cold-ambition-the-new-geopolitical-faultline/ (accessed 7.13.23).

Hughes, R.M., Thomas, 2019. The Development Of Large Technical Systems. Routledge, New York. https://doi.org/10.4324/9780429309991
Hydrogen council, 2021. Hydrogen decarbonization pathways.
IAEA, 2021. Nuclear Energy for a Net Zero World. IAEA, Vienna.
IEA, 2022. Global Hydrogen Review 2022. IEA, Paris.
IEA, 2021. Global Hydrogen Review 2021. IEA, Paris.
International Atomic Energy Agency, 2008. Advanced Applications of Water Cooled Nuclear Power Plants (Text), Advanced Applications of Water Cooled Nuclear Power Plants. International Atomic Energy Agency.
International Energy Agency, 2023. International shipping [WWW Document]. IEA. URL https://www.iea.org/energy-system/transport/international-shipping (accessed 7.13.23).
IRENA, 2022. Global hydrogen trade in a 1.5°C scenario.
Júlíusson, Á.D., Lárusdottir, B., Lucas, G., Pálsson, G., 2020. EPISCOPAL ECONOMICS: Property and power in post-reformation Iceland. Scandinavian Journal of History 45, 95–120. https://doi.org/10.1080/03468755.2019.1625436
Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M.S., Nykvist, B., Pel, B., Raven, R., Rohracher, H., Sandén, B., Schot, J., Sovacool, B., Turnheim, B., Welch, D., Wells, P., 2019. An agenda for sustainability transitions research: State of the art and future directions. Environmental Innovation and Societal Transitions 31, 1–32. https://doi.org/10.1016/j.eist.2019.01.004
Kwak, K., Yoon, H. (David), 2020. Unpacking transnational industry legitimacy dynamics, windows of opportunity, and latecomers' catch-up in complex product systems. Research Policy 49, 103954. https://doi.org/10.1016/j.respol.2020.103954
Lee, K.C.L., 2018. Grocery shopping, food waste, and the retail landscape of cities: The case of Seoul. Journal of Cleaner Production 172, 325–334. https://doi.org/10.1016/j.jclepro.2017.10.085
Locatelli, G., Boarin, S., Pellegrino, F., Ricotti, M.E., 2015. Load following with Small Modular Reactors (SMR): A real options analysis. Energy 80, 41–54. https://doi.org/10.1016/j.energy.2014.11.040
Locatelli, G., Fiordaliso, A., Boarin, S., Ricotti, M.E., 2017. Cogeneration: An option to facilitate load following in Small Modular Reactors. Progress in Nuclear Energy 97, 153–161. https://doi.org/10.1016/j.pnucene.2016.12.012
Malerba, F., 2002. Sectoral systems of innovation and production. Research Policy, Innovation Systems 31, 247–264. https://doi.org/10.1016/S0048-7333(01)00139-1
Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: An emerging field of research and its prospects. Research Policy, Special Section on Sustainability Transitions 41, 955–967. https://doi.org/10.1016/j.respol.2012.02.013
Mattioli, G., Roberts, C., Steinberger, J.K., Brown, A., 2020. The political economy of car dependence: A systems of provision approach. Energy Research & Social Science 66, 101486. https://doi.org/10.1016/j.erss.2020.101486
Petticrew, M., Roberts, H., 2008. Systematic Reviews in the Social Sciences: A Practical Guide. John Wiley & Sons.

Ragheb, M., 2010. Nuclear Naval Propulsion | IntechOpen [WWW Document]. URL https://www.intechopen.com/chapters/19667 (accessed 7.13.23).
Rinkinen, J., Shove, E., Smits, M., 2019. Cold chains in Hanoi and Bangkok: Changing systems of provision and practice. Journal of Consumer Culture 19, 379–397. https://doi.org/10.1177/1469540517717783
Robertson, M., 2017. (De)constructing the financialised culture of owner-occupation in the UK, with the aid of the 10Cs. New Political Economy 22, 398–409. https://doi.org/10.1080/13563467.2017.1259303
Santos, A.C., Rodrigues, J., Teles, N., 2018. Semi-peripheral Financialisation and Social Reproduction: The Case of Portugal. New Political Economy 23, 475–494. https://doi.org/10.1080/13563467.2017.1371126
Schelly, C., 2014. Implementing renewable energy portfolio standards: The good, the bad, and the ugly in a two state comparison. Energy Policy 67, 543–551. https://doi.org/10.1016/j.enpol.2013.11.075
Snyder, H., 2019. Literature review as a research methodology: An overview and guidelines. Journal of Business Research 104, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039
Spaargaren, G., 2003. Sustainable consumption: A theoretical and environmental policy perspective. Society and Natural Resources 16, 687–701. https://doi.org/10.1080/08941920309192
Spaargaren, G., Van Vliet, B., 2007. Lifestyles, consumption and the environment: The ecological modernisation of domestic consumption. Environmental Politics 9, 50–76. https://doi.org/10.1080/09644010008414512
Thompson, J., 2022. A Guide to Abductive Thematic Analysis. The Qualitative Report 27, 1410–1421. https://doi.org/10.46743/2160-3715/2022.5340
Thongplew, N., Duangput, N., Khodkham, S., 2021. Addressing plate waste and consumption practice at university canteens: realizing green university through citizen-consumers. International Journal of Sustainability in Higher Education 22, 1691–1706. https://doi.org/10.1108/IJSHE-02-2021-0056
Tranfield, D., Denyer, D., Smart, P., 2003. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. British Journal of Management 14, 207–222. https://doi.org/10.1111/1467-8551.00375
Vaismoradi, M., Turunen, H., Bondas, T., 2013. Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. Nurs Health Sci 15, 398–405. https://doi.org/10.1111/nhs.12048
Wahn, I.-L., 2020. The Organization of Practices for Instituting Economic Processes: Alternative Food Networks in Beijing. Cultural Sociology 14, 357–378. https://doi.org/10.1177/1749975520935756
Walsh, C., Mander, S., Larkin, A., 2017. Charting a low carbon future for shipping: A UK perspective. Marine Policy 82, 32–40. https://doi.org/10.1016/j.marpol.2017.04.019
Warde, A., 2014. After taste: Culture, consumption and theories of practice. Journal of Consumer Culture 14, 279–303. https://doi.org/10.1177/1469540514547828
Warde, A., 2005. Consumption and Theories of Practice. Journal of Consumer Culture 5, 131–153. https://doi.org/10.1177/1469540505053090

Williams, D.G., Spotswood, F., Parkhurst, G., Chatterton, T., 2019. Practice ecology of sustainable travel: The importance of institutional policy-making processes beyond the traveller. Transportation Research Part F: Traffic Psychology and Behaviour 62, 740–756. https://doi.org/10.1016/j.trf.2019.02.018

World Nuclear Association, 2023. Nuclear Desalination - World Nuclear Association [WWW Document]. URL https://www.world-nuclear.org/information-library/non-power-nuclear-applications/industry/nuclear-desalination.aspx (accessed 7.13.23).

Annex 1 – Documents Included in The Analysis

Year	Authors	Title	Journal	Abstract
1994	Fine B.	Towards a political economy of food	Review of International Political Economy	A political economy of food is proposed by drawing critically upon existing literature. First, food is understood in terms of a system of provision in which the connection between production and consumption is viewed as a chain of activities, vertically integrated. Different foods give rise to different systems of provision, and these are distinguished relative to other non-food systems by their heavy dependence upon organic properties throughout the linkages from production to consumption. While emphasis is placed upon the tendencies to vertical (dis)integration along the food chain and to industrialization of food processing and agriculture, these are not interpreted as empirical trends within the confines of given structures, as is standard in the most recent food systems literature, but as potential supports to the reproduction or transformation of those structures. In particular, the structural relationships between agriculture and industry are interpreted as the historically contingent outcome of tendencies and countertendencies associated with capital accumulation. These will vary across food products, undermining the validity of a general theory of the rise and fall of Fordist agriculture.
1996	Fine B., Heasman M., Wright J.	Consumption in the age of affluence: the world of food	Book	Over recent years there have been extensive and dramatic changes in the world of food. Developments include biotechnology, large supermarkets, all-year round exotic fruits and vegetables, fast food, and ethnic restaurants. This book argues to study these phenomena requires an interdisciplinary approach from across the social sciences. Insights around the nature of food systems are explored and an argument is made for a number of propositions that build upon and reconstruct existing food systems theory. Food system theory is developed further by defending the system-of-provision approach. Applications of food system theory are presented for the UK sugar system, showing how it has shifted over time and how it is distinctive relative to other sugar producers. A critical examination is given of the application of standard neoclassical demand theory to the determination of diet, specifically assessing the evolution of its use empirically with UK National Food Survey (NFS) data. A technique for consumer durables is used to calculate from NFS data patterns of food purchase. Calculations are then given for food norms for a variety of meat products, class and food preferences, and dairy products by level of food expenditure.
1997	Atkins P.J., Gastoni M.	The Maltese food system and the Mediterranean	GeoJournal	The paper seeks to understand the Maltese food system in the context of its history and its geographical position within a broad Mediterranean setting of food production, processing, marketing and consumption. Although it has characteristics in common with Spain, Italy and Greece. Malta has some unusual features derived from its colonial heritage and its long-standing dependence upon imported foodstuffs. The future is uncertain because full membership of the European Union might threaten agricultural prosperity and indigenous food manufacturing. A 'systems of provision' approach to the study of the Maltese food system would be an appropriate framework for further research.
2000	Spaargaren G., Van Vliet B.	Lifestyles, consumption and the environment: The ecological modernisation of domestic consumption	Environmental Politics	Ecological modernisation theory has been developed so far mainly with respect to the production sphere. In order to apply the theory to the sphere of consumption, it needs to be enriched with some of the central concepts from the sociology of consumption. What results is a contextual model of (domestic) consumption which combines an actor-oriented approach with a system-of-provision perspective of consumer behaviour. In conclusion, the relevance of the proposed model for research on the ecological modernisation of domestic consumption is discussed.

2000	Chappells H., Shove E.	Organising energy: Consumption, production, and co-provision	Proceedings ACEEE Summer Study on Energy Efficiency in Buildings	The fragmentation of utility networks and the emergence of new energy providers, including community-based organisations, calls for a more consumer-oriented examination of utility systems management. Although demand-side management (DSM) approaches have claimed to draw the consumer more into energy network planning, this has often involved only a partial understanding of consumer interests in the energy field, which are still seen from a largely provider-oriented perspective. Such a position ignores not only the importance of issues such as consumer comfort in setting energy schedules, but also the scope for consumers to act as joint 'scripters' of energy network arrangements. This paper calls for a re-examination of the organisation of utility "systems of provision" and of the technologies involved in the provision of domestic energy. Drawing on examples from the UK, we explain how particular storage systems and devices are strategically configured along utility supply chains in order to frame how and when energy can be consumed. As well as providing an overview on how energy is controlled and organised, the paper will reveal the range of actors (utility companies, community organisations and households) involved in the tactical configuration of what amounts to the "co-provision" of energy at various levels. This is important since such configurations shape the distribution of individual and organisational responsibility across the network and so influence the points and possibilities for intervention in the cause of energy efficiency.
2002	Guthman J.	Commodified meanings, meaningful commodities: Re-thinking production-consumption links through the organic system of provision	Sociologia Ruralis	Agro-food researchers have yet to systematically theorize how the social life of food intersects with a political economy of food production. Yet without such understanding, activists are unlikely to affect the politics of production in intended ways. It is crucial to understand how the meanings that animate the politics of consumption are translated and distributed as surplus value and rent, and, for that matter, how surplus value and rent value are translated into meanings. This paper is a preliminary attempt to further that understanding by considering these translations in organic food provision. It begins with some recent interventions in conceptualizing taste and then explores their significance in value creation and distribution. It then considers what they offer in understanding the taste for organics specifically. Ultimately, I argue that certain of these tastes present considerable, if different, problems for the commodification of organic food, which are only resolved by a re-making of organic meanings together with unintended distributions of value.
2004	Fine B.	Debating production-consumption linkages in food studies	Sociologia Ruralis	Recent contributions to the journal have commendably sought to extend agro-food studies from production to consumption in line with the consumption turn across the social sciences. In doing so, and inspired by actor-network theory, exception has been taken to the systems of provision approach to food studies. This approach is defended by suggesting that it has in part been misinterpreted as comprising an extension of agro-food studies to consumption rather than a general approach to consumption per se applied to food in particular. In addition, the later turn of such agro-food studies to consumption is shown to continue to lag behind the understanding of the culture of consumption that has evolved over the past decade. A plea is made for more constructive and informed dialogue with the literature on consumption.
2006	Jackson, P., Russell, P., & Ward, N.	Mobilising the commodity chain concept in the politics of food and farming	Journal of Rural Studies	Focusing on the concept of ‘commodity chains’ within the food industry, this paper analyses the term's widespread and variable usage in both academic and policy-orientated work. Despite recent criticisms, the concept has retained its popular appeal alongside competing metaphors such as networks, circuits and assemblages. Examining the concept in more detail demonstrates a range of diverse and inconsistent definitions such that ‘commodity chains’ are in danger of becoming, in Andrew Sayer's terminology, a chaotic conception. The paper pursues Sayer's suggestion of making such conceptions the object of academic study where the proliferation of diverse uses may throw light on the political interests of those who mobilise the term in different ways. The argument is illustrated with case studies from the UK Government's Department for Environment, Food and Rural Affairs, the Countryside Agency (a statutory body) and Sustain (a campaigning group). The analysis draws on secondary sources and on interviews with representatives of these agencies. The paper concludes that the different mobilisations of the concept by these agencies provide valuable insights into

				the politics of food and farming in contemporary Britain. Specifically, we argue that the concept objectifies social relations, fore-grounding certain (technical and economic) features and back-grounding other (social and environmental) issues.
2007	Ben Fine	From Sweetness to McDonald's: How Do We Manufacture (the Meaning of) Foods?	The Review of Social & Economic Studies	/
2012	Foster, C., McMeekin, A., & Mylan, J.	The entanglement of consumer expectations and (eco) innovation sequences: The case of orange juice	Technology Analysis & Strategic Management	Prospects for future innovation to reduce the carbon intensity of everyday consumer products rest significantly on the path dependent processes that have caused current products with their associated modes of provision and practices of consumption to be as they are. We use the history of orange juice to examine the dynamics of innovation sequences that have emerged to solve a series of 'problems' associated with the production and consumption of orange juice, the latest being the carbon problem. In particular, we focus on the interdependencies between consumer expectations of what constitutes 'good orange juice', changes in the product itself and in the system through which it is provisioned. We conclude with a discussion of how historical, path dependent processes lead to alternative framings of the new problem to be solved and different strategies for pursuing innovative solutions.
2013	Hall C.M.	Framing behavioural approaches to understanding and governing sustainable tourism consumption: beyond neoliberalism, "nudging" and "green growth"?	Journal of Sustainable Tourism	Three different sets of approaches to understanding behaviour with respect to sustainable tourism mobility and consumption are identified in this paper: the utilitarian, social/psychological and the systems of provision/institutional approach. Each is based on different sets of assumptions on the factors that affect consumer sustainability behaviour. These assumptions not only affect the selection of policy tools to change behaviours but are also related to different modes of governance. Assumptions with respect to human behaviour and behavioural change and modes of intervention and governance are interrelated and mutually reinforcing and act as policy paradigms. Failure to recognise the importance of social structures in affecting behaviour has created a path dependency in which solutions to sustainable tourism mobility are only accepted within the dominant governance and behavioural paradigm. Other policy options and academic research that identify structures and institutions in systems of provision as a sustainability problem that requires non-market intervention and/or significant system change are regarded as marginal to the policy process or are ignored. It is concluded that all three different ways of approaching consumer behaviour are required if a sustainable transition to the socio-technological system of tourism mobility is to be made in a timely manner.
2013	Head L., Farbotko C., Gibson C., Gill N., Waitt G.	Zones of friction, zones of traction: The connected household in climate change and sustainability policy	Australasian Journal of Environmental Management	Households are increasingly addressed as a focus of environmental policy, with varying degrees of success in achieving more sustainable outcomes at the domestic level. Part of the problem is black boxing, in which the inherent complexity of households tends to be taken for granted. Here we draw on cultural environmental research to put forward a more sophisticated conceptualisation - the connected household approach. The connected household framework uses the themes of governance, materiality and practice to illustrate and explain the ways everyday life, and the internal politics of households, are connected to wider systems of provision and socioeconomic networks. We introduce zones of friction and zones of traction to illustrate different pathways of connection between the spheres. Friction and traction can help decision-makers think through the possibilities and constraints of working at the household scale. The approach is illustrated using the example of water, with a focus on the variable success of water tanks in reducing mains water consumption during the millennium drought.

2013	Ben Fine	Consumption matters	Ephemera	Somewhat indulgently, I have met the request both to explain my approach to consumption and how it came about. I do so by first indicating the origins of the system of provision [SOP], approach to consumption and, then, its attachment to cultural systems. I follow this by attending to some debates around the SOP approach and close by seeking to bring out some implications for the nature of consumer politics.
2013	Jennifer Churchill	Towards a framework for understanding the recent evolution of pension systems in the European Union	FESSUD	/
2013	Kate Bayliss, Ben Fine, Mary Robertson	From Financialisation to Consumption: The Systems of Provision Approach Applied to Housing and Water	FESSUD	/
2014	Schelly C.	Implementing renewable energy portfolio standards: The good, the bad, and the ugly in a two state comparison	Energy Policy	Understanding how household practices with regard to energy usage change and how to most effectively encourage the adoption of technologies that utilize renewable energy sources at the residential scale are important issues for addressing the environmental impacts of energy use. Here, the social practices model (Spaargaren, 2003) is applied to examine solar technology adopters in two U.S. States who were interviewed about adopting residential solar electric technology and specifically about their experiences with the rebate and incentive programs available to them. Examining the policies and interrogating their potentially unintended consequences from the perspective of the user sheds light on how residential solar incentive programs act as systems of provision, shaping the practices of solar technology adopters, in hopes of improving these incentive programs and effectively encouraging increased residential solar technology adoption. Findings suggest that feed-in tariffs offer additional positive outcomes related to broadening the context for adoption and encouraging future energy conservation while size restrictions, wholesale pricing in net metering agreements, and inconsistent policy mechanisms across utilities in the same state all have potentially unintended negative consequences. Utilizing a perspective attentive to social practice offers a means of improving the design and implementation of energy policy.
2014	Todorova Z.	Consumption as a social process	Journal of Economic Issues	This article discusses consumption as a social process that is part of social provisioning and is in an evolutionary interplay with other social processes. The analysis provides grounds for a context-specific research that explores consumption in the context of a culture-nature life process, and draws on material from various disciplines. The article seeks to contribute to the literature on social provisioning as an organizing concept in heterodox economics. The first section explains what is meant by social process and delineates its elements. The second section formulates a categorization of social processes, and locates a consumption process within a system of culture-nature life processes. The rest of the article delineates the elements of the consumption process, providing illustrations based on literature from various disciplines. Specifically, the third section discusses consumption activities. The fourth section discusses institutions and systems of provision of goods and services. The fifth section applies the concept of habits of life and thought to the consumption process. Finally, the article concludes that the formulated analysis transcends dualisms such as social-economic, cultural-material, society-nature, and micro-macro, and draws implications for heterodox economics.
2014	Spaargaren G., Van Vliet B.	Lifestyles, consumption and the environment: The ecological	Ecological Modernisation Around the World:	Ecological modernisation theory has been developed so far mainly with respect to the production sphere. In order to apply the theory to the sphere of consumption, it needs to be enriched with some of the central concepts from the sociology of consumption. What results is a contextual model of

		modernisation of domestic consumption	Perspectives and Critical Debates	(domestic) consumption which combines an actor-oriented approach with a system-of-provision perspective of consumer behaviour. In conclusion, the relevance of the proposed model for research on the ecological modernisation of domestic consumption is discussed.
2014	Ben Fine	The Continuing Enigmas of Social Policy	FESSUD	/
2014	Kate Bayliss	Case study: the financialisation of water in England and Wales	FESSUD	/
2014	Mary Robertson	Case Study: Finance and Housing Provision in Britain	FESSUD	/
2015	Brooks A.	Systems of provision: Fast fashion and jeans	Geoforum	Using the example of jeans and the fast fashion sector, this critical review explores how systems of provision analysis can be used to understand geographical connections between spaces of production and places of consumption. The study of global commodity chains and production networks has proliferated in economic geography, yet the focus on transactions between places frequently omits to consider the material culture that surrounds processes of making and buying. In contrast, in cultural geography the meanings and transformations associated with 'following things' has explored the shifting meanings of commodities as well as personal experiences of shopping with a focus on signifying culture. Ben Fine's systems of provision approach can offer a more comprehensive analysis. Fine considers how the role of the consumer has emerged as well as the economic processes through which value is established in goods and is an inclusive way of examining the activities that connect consumption and production. Through discussing some of the recent and emerging work on denim jeans this review shows how a systems of provision approach can effectively map a 'fast fashion' system and provides a framework that can be applied to other economic geographies.
2015	Gill N., Osman P., Head L., Voyer M., Harada T., Waitt G., Gibson C.	Looking beyond installation: Why households struggle to make the most of solar hot water systems	Energy Policy	This paper examines household responses to sustainability issues and adoption of energy saving technologies. Our example of solar hot water systems highlights the complexity and variability of responses to low-carbon technologies. While SHW systems have the potential to provide the majority of household hot water and to lower carbon emissions, little research has been done to investigate how SHW systems are integrated into everyday life. We draw on cultural understandings of the household to identify passive and active users of SHW systems and utilize a model that illustrates how technology use is dependent on inter-relations between cultural norms, systems of provision, the material elements of homes, and practice. A key finding is that households can be ill-prepared to make the most of their SHW systems and lack post-installation support to do so. Thus, informed and efficient use of SHW systems is hit and miss. Current policy is largely aimed at subsidizing purchase and installation on the assumption that this is sufficient for emission reduction goals. Our analysis provides evidence to the contrary. Areas we highlight for policy and practice improvement are independent pre-purchase advice, installation quality, and practical guidance on system operation and interaction with patterns of hot water use.
2015	Gilad Isaacs	The commodification, commercialisation and financialisation of low-cost housing in South Africa	FESSUD	/
2015	Nuno Teles	Financialisation and neoliberalism: The case of water	FESSUD	/

		provision in Portugal		
2015	Ana Santos, Nuno Serra, Nuno Teles	Finance and Housing Provision in Portugal	FESSUD	/
2015	Piotr Lis	Financialisation of the system of provision applied to housing in Poland	FESSUD	/
2015	Çelik, Ö., Topal, A., & Yalman G.	Finance and System of Provision of Housing. The Case of Istanbul, Turkey	FESSUD	/
2016	Fine B.	The world of consumption: The material and cultural revisited: Second edition	Book	*Consumption has become one of the leading topics across the social sciences and vocational disciplines such as marketing and business studies. In this comprehensively updated and revised new edition, traditional approaches as well as the most recent literature are fully addressed and incorporated, with wide reference to theoretical and empirical work. Fine's refreshing and authoritative text includes a critical examination of such themes as: * economics imperialism and globalization * the world of commodities * systems of provision and culture * the consumer society * public consumption. This book presents an updated analysis of the cluttered landscape of studies of consumption that will make it required reading for students from a wide range of backgrounds including political economy, history and social science courses generally.
2016	Kate Bayliss	Neoliberalised water in South Africa	FESSUD	/
2016	Nuno Teles	Prospects for financialised water provision: going beyond public/private ownership debates	FESSUD	/
2016	Gaye Yilmaz, Ozlem Celik	Finance and System of Provision of Water; The Case of Istanbul	FESSUD	/
2016	Kate Bayliss	The System of Provision for Water in Selected Case Study Countries	FESSUD	/
2016	Robertson, M.	The System of Provision for Housing in Selected Case Study Countries	FESSUD	/
2016	Kate Bayliss	The financialisation of health in England: lessons from the water sector	FESSUD	/

2016	van der Walt, K.	Thorough-bread? A study of the system of provision of bread in South Africa	University of the Witwatersrand	Over one billion people in the world are under-nourished, and over two billion suffer from malnutrition of micro-nutrients – known as 'hidden hunger'1. This is largely due to the fact that two thirds of the world's population depend on cereal or tuber based diets (e.g., wheat, maize, potatoes) which tend to satisfy energy demands but not essential micro-nutrients2. The industrialisation of food production systems that occurs as part of the process of economic development has been linked to great improvements in access to food on the one hand, but this has also resulted in major transitions in population-level food consumption and lifestyle patterns. The changes affecting both dietary and physical activity have been termed the 'nutrition transition'3, which signals the change from consuming large amounts of fibre and low amounts of fat, to a diet comprised of highly processed, high-energy foods. Developing countries now face a 'triple burden' in terms of overcoming under-nutrition of micro and macro nutrients, as well as addressing over-consumption related to the 'nutrition transition' that accompanies economic development4. Given this setting, this paper sets out to understand how the industrialisation of the wheat to bread chain in South Africa has influenced population consumption patterns and to what extent consumer interests have been marginalised in the pursuit of industrial efficiencies during the development of this chain. This will be done using a 'Systems of Provision' approach which enables a vertical analysis of the processes leading up to consumption, whilst allowing for the incorporation of historically defined, context-specific influences on chain development and consumption patterns, including political, socio-economic and cultural factors, which other vertical approaches, such as the Global Value Chain framework do not enable.
2017	Iacovidou E., Millward-Hopkins J., Busch J., Purnell P., Velis C.A., Hahladakis J.N., Zwirner O., Brown A.	A pathway to circular economy: Developing a conceptual framework for complex value assessment of resources recovered from waste	Journal of Cleaner Production	The transition to a circular economy, where the value of resources is preserved in the technosphere, must be supported by policies and operational decision-making based on evidence. Existing methods used to provide this evidence (e.g. LCA, LCSA, CBA) are not robust enough to adequately address the creation and dissipation of systemic and multidimensional value that spans the social, environmental, economic and technical domains. This study proposes a novel, conceptual approach that seeks to assess how complex value is created, destroyed and distributed in resource recovery from waste systems. This approach expands beyond conventional methods of estimating value. It combines scientific and engineering methods with a socio-political narrative grounded in the systems of provision (sop) approach, and provides a comprehensive, analytical framework for making the transition to a resource-efficient future. This framework has the potential to connect bottom-up and top-down approaches in assessing resource recovery from waste systems, and address systemic challenges through transparency and flexibility, while accounting for the dynamic and non-linear nature of commodities flow and infrastructure provision in the overall system. This creates the pathway towards circular economy, and lays the foundations for future advances in computational and assessment methodologies in the field of RRfW.
2017	Hansen A.	Transport in transition: Doi moi and the consumption of cars and motorbikes in Hanoi	Journal of Consumer Culture	The rapid developments in Vietnam since the economic reforms (doi moi) initiated in 1986 have led to a transformation of urban mobility. In less than 20 years, motorbike ownership in the country increased tenfold, and there are now 4 million motorbikes in Hanoi alone. While the two-wheelers dominate traffic, car ownership has increased rapidly in the last decade. This article approaches the consumption of cars and motorbikes in the Vietnamese capital from a social practice theory perspective. It particularly emphasises material conditions for practices in terms of systems of provision, available technology and infrastructure. This emphasis, the article argues, is necessary to account for large-scale changes in consumption in a context of rapid economic development. These conditions, however, have co-evolved with mobility practices and the local geography of consumption. Private cars in many ways represent a break with the dominant two-wheeled conditions and practices, but bring along social distinction, safety and comfort. In turn, a new automobility regime is emerging in the outskirts of Hanoi. The article analyses these material, social and bodily pillars of practices, and based on fieldwork in Hanoi approaches the changing urban mobility in the interplay between development and everyday life.

2017	Bayliss K., Fine B., Robertson M.	Introduction to special issue on the material cultures of financialisation	New Political Economy	This paper offers a wide-ranging introduction to the symposium on the material culture of financialisation. It begins by addressing the nature of financialisation itself, drawing on a tight definition in order to distinguish the phenomenon of financialisation from its effects and from the looser associations prevalent within much of the literature such as the presence of credit or even simply (more extensive) monetary relations. In order to locate financialisation within economic and social reproduction, of which material culture is a part, close attention is paid to the distinctive forms of financialisation arising from commodification, commodity form and commodity calculation. The differences in the extent to which, and how, these prevail are addressed through the system of provision approach and its framing of material culture through its use of 10 distinctive attributes of such cultures, known as the 10Cs (Constructed, Construed, Conforming, Commodified, Contextual, Contradictory, Closed, Contested, Collective and Chaotic). The analysis is then illustrated by reference to the papers that follow in this volume which demonstrate the diverse ways in which shifting cultures have served to embed financialisation in our daily lives. The first is on the material culture of financialisation itself and this is followed by a number of case studies that include the promotion of financial literacy and financial inclusion, well-being, the media and finally two sector examples are provided on housing and water.
2017	Bayliss K.	Material cultures of water financialisation in England and Wales	New Political Economy	The ownership structure of the water and sewerage sector has changed substantially in England and Wales (EW) since the 10 companies were listed on the London Stock Exchange in 1989. The majority of firms are now delisted and a number of companies are now owned by financial investors via special purpose vehicles. In some cases, revenue streams from customer water bills have become securitised for decades into the future not only to raise funds for investment, but also for finance distributions to shareholders. The high financing costs associated with these highly leveraged corporate structures are passed on to customers. The regulator, Ofwat, tasked with protecting the interests of consumers, operates largely within a system of price controls intended to mimic a competitive market in the absence of financial speculation. This means that regulation steers away from intervening in the financialised corporate structures that have emerged around some of the water utilities. These manifestations of financialisation are considered to be 'market outcomes'. This paper explores the discourses and narratives that have developed in the provision of water in EW to create a situation where such rentier transfers are normalised. Using the systems of provision approach, the paper shows that the material culture of water finance has been constructed along narrow lines with superficial consumer consultation, while extensive financial engineering to increase shareholder returns continues unimpeded.
2017	Fine B.	The material and culture of financialisation	New Political Economy	This paper provides a framework for understanding the material cultures of financialisation. It does so through a tight definition of financialisation itself (as the spread of interest bearing capital across economic and social reproduction) but also attaches financialisation to broader influences through commodification, commodity form and commodity calculation. These in turn are used to frame the material culture(s) of financialisation through deploying the 10Cs derived from the System of Provision approach: that the material cultures of financialisation are Constructed, Construed, Conforming, Commodified, Contextual, Contradictory, Closed, Contested, Collective and Chaotic. Some emphasis is placed upon the 'distance' of financialisation as such from most everyday practices and the systemic lack of knowledge of the financial system however it is represented and experienced.
2017	Robertson M.	(De)constructing the financialised culture of owner-occupation in the UK, with the aid of the 10Cs	New Political Economy	Taking owner-occupation as the quintessential form of financialised housing provision, this paper investigates how housing cultures, understood as a set of shared behaviours and beliefs about housing, have been (re)shaped in the UK in a way that favours owner-occupation, and the implications of this shift for agents' subjectivities. Utilising the systems of provision/10Cs approach, which takes as its starting point that the norms and meanings associated with homeownership are complex and conditioned by the contradictory interaction of cultural and material factors, the paper shows how the rise of owner-occupation reflected changes in socially shared images and meanings around housing as well as material benefits associated with the tenure. However, the

				complex analysis of material culture facilitated by the 10Cs reveals that the culture of owner-occupation is not hegemonic. While housing policy since the 1980s has given material and cultural impetus to owner-occupation in Britain, the reflexive and resistive capacities of consumers, when coupled with the competing meanings attached to housing and the growing dysfunctionality of the current housing model, have constrained the dominance of the ethos of owner-occupation and render its future vulnerable.
2018	Hansen A.	Meat consumption and capitalist development: The meatification of food provision and practice in Vietnam	Geoforum	The global consumption of meat and animal products has increased dramatically in recent decades, particularly due to rising consumption in so-called developing countries. This increase has popularly been explained as part of a "nutrition transition" driven by rising income, urbanisation and foreign culinary influences. From the supply side, the increase has been approached as part of a "livestock revolution" or alternatively as the outcome of capitalist agricultural processes. This paper argues, however, that these explanations have given insufficient attention to how and why consumption of meat changes. The paper analyses the case of Vietnam, where meat consumption has increased very rapidly since the initiation of market reforms in 1986. In understanding how meat consumption and development have co-evolved, the paper argues that consumption should be approached at the intersection between systems of provision and everyday practices. With this backdrop – and partly combining, partly going beyond standard explanations – the paper locates four main contributing factors towards increasing meat consumption in Vietnam: (1) changes in systems of provision for meat, (2) the meat intensification of traditional meals and the import of meat-intensive eating practices from abroad, (3) the increasing prevalence of eating out; and (4) the positive social connotations attached to meat as a symbol of development and progress. The paper goes on to argue that the dramatic meatification of food provision and practice in Vietnam should be understood as the result of capitalist development processes and their associated economic and social changes, rather than the 'natural' and inevitable outcome of development.
2018	Fine M., Davidson B.	The marketization of care: Global challenges and national responses in Australia	Current Sociology	Care is a social necessity for life. Ensuring access to appropriate care at crucial points in the life course became a political necessity soon after the mid-20th century, as the right to suitable care became recognized as a fundamental entitlement of citizenship in most advanced capitalist economies. Over recent decades there has been a shift away from more traditional welfare state forms of public services towards increasingly marketized systems of provision. Changes in the provision of care in the public domain are associated with an increasing reliance on private capital and competition between a variety of providers, with public agencies competing alongside private for-profit and not-for-profit agencies. Drawing on care theory, historical sociology and political economic analysis, this article examines the conflicting tensions that shape aged care under marketization. Using Australia as a case study, it is argued that as private capital and resources take the place of scarce public resources and enable expenditure cuts to be presented as innovation, better services and more 'consumer choice', it is not the market but the finance, regulation and management work of the state that is the essential determinant of the assistance previously provided through non-market processes.
2018	Sonnberger M., Gross M.	Rebound Effects in Practice: An Invitation to Consider Rebound From a Practice Theory Perspective	Ecological Economics	Rebound effects are the unintended consequences of improvements in energy efficiency. They refer to situations in which efficiency improvements are reduced or even reversed by changes in behavior. In many cases these effects stem from small behavior changes rooted in cultural values or from the interconnectedness of everyday practices. Practice theory has established itself in many social science disciplines, including ecological economics, and its focus on routinized activities in everyday life promises to provide beneficial insights to debates on rebound. Since this has not been done to date, this article aims to fill the gap by offering suggestions as to how practice theory can complement and enhance existing explanations of rebound effects. Drawing on existing practice theory research on energy consumption, we identify and discuss a number of starting points for practice theory-inspired research on rebound effects. These include the pivotal role of distributed agency between humans and non-humans (e.g. technical devices),

				the co-dependence of practices, the co-evolution of practices with systems of provision, as well as a general trend towards the acceleration of everyday life.
2018	Wheeler K.	The moral economy of ready-made food	British Journal of Sociology	The aim of this paper is to develop and apply a framework to explore how moralities of consumption are constituted in and through markets. Using the case of ready-made foods, this paper argues moral economies are comprised through interactions between micro-, meso- and macro-level processes in the form of instituted systems of provision, state regulation, collective food customs promoted though media, NGOs and lifestyle practitioners, and the everyday reflections of consumers. Building on a theoretical framework developed to understand the moral economy of work and employment (Bolton and Laaser 2013), this paper explores how markets for ready-made food are incessantly negotiated in the context of moral ideas about cooking, femininity and individual responsibility. It focuses on 'new' market innovations of fresh ready-to-cook meal solutions and explores how these products are both a response to moralizing discourses about cooking 'properly', as well as an intervention into the market that offers opportunities for new moral identities to be performed. Using data gathered from interviews with food manufacturers and consumers, I advocate for a multi-layered perspective that captures the dynamic interplay between consumers, markets and moralities of consumption.
2018	Santos A.C., Rodrigues J., Teles N.	Semi-peripheral Financialisation and Social Reproduction: The Case of Portugal	New Political Economy	Portugal, a semi-peripheral country within the world economy, has followed financialisation processes similar to and distinct from those of core countries. This article reflects on the factors that have shaped social reproduction in Portugal by examining the differentiated ways through which finance has interacted with the provision of housing, pensions and water and their variegated impacts. Based on these three case studies, the article discusses the constraints on, and pressures for, continued expansion of finance in the aftermath of the Global Financial Crisis. It underlines the subordinated and uneven nature of Portuguese semi-peripheral financialisation, the role of European integration in its unfolding, and concludes that the promotion of the interests of finance located in major advanced capitalist countries, and of the national and international institutions under their influence, has resulted in growing social and spatial inequalities.
2018	Kate Bayliss, Giulio Mattioli	Privatisation, Inequality and Poverty in the UK: Briefing prepared for UN Rapporteur on extreme poverty and human rights	Sustainability Research Institute	Since the late 1980s, successive governments have increased the role of the private sector in the provision of basic services in the UK, particularly in England. In addition, shifting global trends have led to financial innovation, providing more imaginative methods of sweating capital assets and extracting revenue. As a result, the provision of services to meet fundamental human needs has become a source of profit for international financiers, diverting revenue streams from potentially progressive provision and infrastructure investment. Households, many of which struggle to make ends meet, are in some cases financing interest and dividend payments to the world's richest via their consumption of basic essentials (here, water, energy and local buses). Privatisation has been driven by an ideological attachment to the supposed efficiency of private markets. In reality, the result has been upward pressure on prices and restructuring of services, in ways that disadvantage the poorest in society, contributing to inequality, both in the UK and globally. In addition, policies are contributing to a culture of individual responsibility for disadvantage and deprivation, thus weakening the scope for a coherent approach to social policy. These privatised structures have promoted the needs of investors, and the "market", over the population. This paper shows that where essential and monopolistic public services are provided by private investors, there are inevitable tensions between the priorities of shareholders and the needs of society. Social provision within the water, electricity and public transport sectors fails to reach millions of households for whom many basic services are unaffordable (or non-existent in the case of transport). Furthermore, social policy tends to focus on

				affordability and consumption while the regressive structures which underpin these outcomes are often neglected.
2019	de Feijter F.J., van Vliet B.J.M., Chen Y.	Household inclusion in the governance of housing retrofitting: Analysing Chinese and Dutch systems of energy retrofit provision	Energy Research and Social Science	One of the most important governance challenges in terms of energy saving is the physical upgrading of apartment buildings via housing retrofitting. In urban studies, little focus has been applied to the shape and character of the retrofit governance frameworks to realise inclusion of householders. Little is known about how these different frameworks, and the systems of provision they represent, impact on householders to achieve energy saving in their retrofitted houses. By recognising the importance of the relationship between provision and consumption, this study aims to analyse household inclusion in Chinese and Dutch systems of energy retrofit provision to suggest strategic improvements for intermediation. The empirical data is gathered in qualitative case studies of housing retrofitting in Amsterdam, Beijing and Mianyang (Sichuan province, China) by interviewing local retrofit providers, combined with site observations and reviews of policy documents. This paper shows how the formation of sustainable retrofit practices is co-constituted in shifting constellations of retrofit governance along the public-private-community divide. Public and private modes of housing retrofit provision seem to converge in Beijing, Mianyang and Amsterdam. The findings point to how regulations, processes and technical infrastructures should be adjusted to realise sustainable retrofit practices. The paper concludes that energy housing retrofitting in both Chinese and Dutch contexts requires co-management among householders and social intermediaries.
2019	Williams D.G., Spotswood F., Parkhurst G., Chatterton T.	Practice ecology of sustainable travel: The importance of institutional policy-making processes beyond the traveller	Transportation Research Part F: Traffic Psychology and Behaviour	Changing mobility behaviour towards activities and actions that have a less detrimental impact on the environment, public health and society is an objective of transport policy jurisdictions globally. In line with a burgeoning body of research examining behaviour and social change, this paper explores the governmental systems that influence mobility behaviours through a social practice lens. This paper blends two social practice theoretical models, the '3-Elements Model' and 'Systems of Provision' as a means of understanding the delivery of the Local Sustainable Transport Fund (LSTF), a central government grant scheme for English local authorities. We examine how the meanings, materials and competences within the practices of bid writing by local authorities and scheme selection by government influenced the distribution of funding to local authorities. The research starts from the principle that, where funding is provided by central government, in the case of this research that of the UK, an opportunity is created for mobility practices to change. The significance of funding is not easily theorised by the 3-Elements model but is more helpfully explained when that model is blended with the wider Systems of Provision model to create a model of practice ecology. Our theorisation allows for a rigorous exploration of the 'practice scaffolding' which shapes how people travel. Policymakers are recommended to consider a practice ecology approach when developing mobility management schemes to tackle air quality, climate change and obesity issues more effectively.
2019	Rinkinen J., Shove E., Smits M.	Cold chains in Hanoi and Bangkok: Changing systems of provision and practice	Journal of Consumer Culture	We know that patterns of domestic consumption are situated within broader systems of provision and that home appliances like the fridge freezer bridge between practices of cooking, shopping and eating, on one hand, and increasingly global systems of food production, distribution and diet on the other. In analysing the uses of fridge freezers in Hanoi and Bangkok as expressions, in microcosm, of complex and evolving processes of urbanisation and food provisioning, this article provides new insight into how specific configurations, dependencies and patterns of consumption take hold and how they vary and change. Our analysis of systems and practices in flux

				has the dual function of showing how household strategies reflect and contribute to more extensive transformations, and of demonstrating how these are shaped by ongoing tensions and relations between new and established forms of urban food supply and associated concepts of freshness and safety. The result is a subtle account of the multiple routes through which consumer 'needs' evolve.
2019	Serrano A., Brooks A.	Who is left behind in global food systems? Local farmers failed by Colombia's avocado boom	Environment and Planning E: Nature and Space	Work on global food systems has focused on the livelihoods of farmers directly affected as growers of agricultural export goods and has paid less attention to those who are left behind by new patterns of production and consumption. The connections between pre-existing agricultural livelihoods and the new systems of provision associated with fashionable products are poorly understood. Global trends in food culture have wide ranging local impacts. In this paper, we argue that researchers need to look beyond linear commodity chains and the goods that travel from producers in one country to consumers in another and expand global food systems analysis to understand what regional livelihoods are modified or displaced by globalized agriculture. Avocados are a popular health food among millennials. Colombia is experiencing a boom in exports. Avocados have long been grown in the Santander region, but global demand has turned them into a politically important crop. Using food systems analysis, our field research illuminates how new opportunities for capital accumulation are transmitted through global markets and shape regional agricultural practices. Large investors have profited, while small-scale farmers have been impoverished. We demonstrate how the interplay of requirements for homogenous fruit from local supermarkets, demand for the export Haas variety, as well as the government's export-oriented policies have modified local livelihoods.Our contribution examines the broader social space in which agriculture is located. We argue for the need to study food systems beyond the vertical relations that constitute linear supply chains and examine the horizontal context of systems of provision.
2019	Wheeler K.	Moral economies of consumption	Journal of Consumer Culture	The aim of this article is twofold: first, to bring together debates about enduring normative concerns surrounding the morality of consumption with more recent concerns about the ways specific moralities are constituted in and through markets. The second aim is to develop the concept of 'moral economy' and call for an approach to its study, attentive to how moralities of consumption develop through interactions between instituted systems of provision, forms of state regulation, customs within communities and the everyday reflections of consumers about the things that matter to them. As consumers are increasingly asked to factor environmental and fair labour concerns into their purchase and post-purchase habits, there is a real need to understand how moralities of consumption are both formatted through institutional frameworks and shaped everyday by actors from within. After developing a framework for the study of moral economies, this article explores in depth the experiences of one couple in relation to the cessation of a cardboard recycling collection in Shropshire (England) to show why a multilevel perspective is needed to appreciate the place of morality within the market.
2019	Foden, M., Browne, A., Evans, D., Sharp, L., & Watson, M.	The water–energy–food nexus at home: New opportunities for policy interventions in household sustainability	The Geographical Journal	The nexus of water–energy–food (WEF) is as apparent at the household scale as it is anywhere else. We introduce the "Nexus at Home" as a starting point for exploring the dynamics of WEF resource use and household sustainability. Drawing on two research projects we focus specifically on domestic kitchens as a site where practices of cooking, eating, cleaning and disposing of waste come together. While these practices have long been targets for policy intervention, existing approaches draw on a limited range of perspectives from the social sciences. Reflecting on our work with four non-academic partners (Defra, BEIS, FSA, Waterwise), we consider how social practice and geographies of household sustainability research might be combined with the dictum of "nexus thinking" to re-imagine the framing of policy and intervention to reduce the resource intensity of everyday life. Synthesising existing "home practices" literature in the context of the "live" policy problems raised by our partners, we seek to provide clear guidance for intervening in kitchen practices. We draw on one topic which has not yet been the subject of social practices research: fats, oils and grease (FOG) going down the kitchen plughole and contributing to widespread sewer

				blockages. In doing so we document the sequence of interrelated food provisioning activities through which WEF is put to use in domestic kitchens and contributes to FOG blockages in sewers. We reflect upon the multiple ways these practices are shaped by the rhythms of daily life, dynamics within the home, wider cultural conventions, and infrastructures. This paper contributes to the nascent transdisciplinary research agenda of translating home practices research into wider conceptualisations of "intervention," with a specific orientation towards academic and non-academic stakeholders who are interested in influencing systems of sustainable consumption and production within, and across, the WEF sectors.
2020	Mattioli G., Roberts C., Steinberger J.K., Brown A.	The political economy of car dependence: A systems of provision approach	Energy Research and Social Science	Research on car dependence exposes the difficulty of moving away from a car-dominated, high-carbon transport system, but neglects the political-economic factors underpinning car-dependent societies. Yet these factors are key constraints to attempts to 'decouple' human well-being from energy use and climate change emissions. In this critical review paper, we identify some of the main political-economic factors behind car dependence, drawing together research from several fields. Five key constituent elements of what we call the 'car-dependent transport system' are identified: i) the automotive industry; ii) the provision of car infrastructure; iii) the political economy of urban sprawl; iv) the provision of public transport; v) cultures of car consumption. Using the 'systems of provision' approach within political economy, we locate the part played by each element within the key dynamic processes of the system as a whole. Such processes encompass industrial structure, political-economic relations, the built environment, and cultural feedback loops. We argue that linkages between these processes are crucial to maintaining car dependence and thus create carbon lock-in. In developing our argument we discuss several important characteristics of car-dependent transport systems: the role of integrated socio-technical aspects of provision, the opportunistic use of contradictory economic arguments serving industrial agendas, the creation of an apolitical façade around pro-car decision-making, and the 'capture' of the state within the car-dependent transport system. Through uncovering the constituents, processes and characteristics of car-dependent transport systems, we show that moving past the automobile age will require an overt and historically aware political program of research and action.
2020	Blue S., Shove E., Forman P.	Conceptualising flexibility: Challenging representations of time and society in the energy sector*	Time and Society	There is broad agreement that the need to decarbonise and make better use of renewable and more intermittent sources of power will require increased flexibility in energy systems. However, organisations involved in the energy sector work with very different interpretations of what this might involve. In describing how the notion of flexibility is reified, commodified, and operationalised in sometimes disparate and sometimes connected ways, we show that matters of time and timing are routinely abstracted from the social practices and forms of provision on which the rhythms of supply and demand depend. We argue that these forms of abstraction have the ironic effect of stabilising interpretations of need and demand, and of limiting rather than enabling the emergence of new practices and patterns of demand alongside, and as part of, a radically decarbonised energy system. One way out of this impasse is to conceptualise flexibility as an emergent outcome of the sequencing and synchronisation of social practices. To do so requires a more integrated and historical account of how supply and demand constitute each other and how both are implicated in the temporal organisation of everyday life. It follows that efforts to promote flexibility in the energy sector need to look beyond systems of provision, price, technology, and demand-side management narrowly defined, and instead focus on the social rhythms and the timing of what people do.
2020	Wahn I.-L.	The Organization of Practices for Instituting Economic Processes: Alternative Food Networks in Beijing	Cultural Sociology	Recurrent food safety scandals have prompted Beijing consumers to organize farmers' markets and buyers' clubs as a way to access organic food. This article draws on practice theory to understand the way in which these networks use the idea of "good food" to reorganize practices of farming, food purchase, cooking, and eating. The article uses the Polanyian concept of "instituted economic processes" to analyze specific modes of orientation and exchange between organic farmers and urban consumers and specific instituted forms of production and consumption. The article illustrates that

				"good food" became a shared element in practices and the system of provision. Through the qualification of food and associated discourse relating good food to practices and the food system, practices from production to exchange and consumption share an orientation and institute distinctive economic processes.
2020	Júlíusson Á.D., Lárusdottir B., Lucas G., Pálsson G.	EPISCOPAL ECONOMICS: Property and power in post-reformation Iceland	Scandinavian Journal of History	It has been common to view the Icelandic economy either from the perspective of the individual farm in terms of its productivity or at the national scale in terms of trade and the role of imports/exports. Given the fact that the economy was largely a tenant-based system with a small number of landowners, there is an important middle ground between the household economics of individual farms and the state-sanctioned trade structures that needs to be explored. The objective of this paper is to examine this middle ground and the way the economy was structured in relation to property ownership and tenancy using the case study of the bishopric of Skálholt during the 17th and 18th centuries. Adopting a modified system of provision approach, three scales of analysis are adopted: the settlement itself, the immediate environs and finally the wider regional property network. Tracing the connections outward at successive scales reveals the complex nature of the economic infrastructure behind one of the largest landowners in Iceland at this time. © 2019, © 2019 the Historical Associations of Denmark, Finland, Iceland, Norway and Sweden.
2020	Kate Bayliss , Ben Fine	A Guide to the Systems of Provision Approach Who Gets What, How and Why	Book	/
2021	Mathai M.V., Isenhour C., Stevis D., Vergragt P., Bengtsson M., Lorek S., Mortensen L.F., Coscieme L., Scott D., Waheed A., Alfredsson E.	The Political Economy of (Un)Sustainable Production and Consumption: A Multidisciplinary Synthesis for Research and Action	Resources, Conservation and Recycling	Despite widespread recognition of the need to transition toward more sustainable production and consumption and numerous initiatives to that end, global resource extraction and corresponding socio-ecological degradation continue to grow. Understanding the causes of this persistent failure is a necessary step towards more effective action. This article contributes to that understanding by synthesizing theory and evidence that links unsustainable production-consumption systems to power and inequality. While sustainable consumption and production research and action mostly focuses on technological or behavioral change, the socio-ecological inequalities driving production-consumption systems built into the organization of our global political economy, remain largely overlooked. In response, we propose a structural political economy orientation that seeks explicitly to reduce these inequalities and advance environmental justice and, thus, create the conditions for sustainable production-consumption systems. We then propose three important arenas of research and action towards sustainable production-consumption systems: justice, governance, and co-production of knowledge and action. These arenas, collectively and individually, can serve as entry points to study and act on the dynamics of (un)sustainable production-consumption systems. This can be done at the micro level, with respect to specific commodity chains or systems of provisioning, or at meso and macro levels with respect to national and global production networks. Our proposed orientation helps distinguish research and practice proposals into those emphasizing management and compensation resulting often in persistence of unsustainability, from those proffering structural changes in unsustainable production-consumption systems. We invite critique and collaboration to develop this research and action agenda further.
2021	Bayliss K., Mattioli G., Steinberger J.	Inequality, poverty and the privatization of essential services: A 'systems of provision' study of water, energy and local buses in the UK	Competition and Change	This paper is concerned with the distributional effects of the deregulation and privatization of essential services in Britain since the 1980s, based on a cross-sector study of water, energy and local bus transport. Our approach locates end users within the structures and processes, and prevailing narratives that underpin both production and consumption. This framework highlights the ways that the provisioning of these vital services is contested, contradictory and underpinned by power relations. We show that, at one end, investors in these sectors have made generous returns on their investments but their methods of profit maximization are often not in the public interest. Meanwhile these profits are financed by end users' payments of bills and

				fares. Many lower-income households face challenges in terms of affording, and even accessing, these essential services. Regulation has failed to provide adequate social protection. We argue that adverse social outcomes emerge from systemic factors embedded in these modes of provision. A narrative of politically-neutral, technocratic solutions belies the underlying contested nature of privatized monopolistic shared essential services. Moreover, a policy preoccupation with markets and competition obscures the inequality embedded in the underlying structures and processes and undermines more collective and equitable forms of provisioning.
2021	Bayliss K., Pollen G.	The power paradigm in practice: A critical review of developments in the Zambian electricity sector	World Development	Sub-Saharan Africa lags behind the rest of the world in electricity access and consumption. Infrastructure deficiencies are framed in terms of a "financing gap", with policy oriented around attracting global private capital. Recent calls for increased private infrastructure investment follow three decades of market-oriented sector reforms. This paper explores the way that this standard policy paradigm has unfolded in Zambia. Drawing on the Systems of Provision approach we focus on three core interconnected segments of the electricity system: the performance of the state utility, Zesco; private sector participation and cost-recovery pricing. The paper shows that Zesco has run into major difficulties since 2015 due to a crisis in hydro resources and adverse currency movements. In line with the policy paradigm, the utility has signed up to a number of agreements with international independent power producers (IPPs) to diversify power sources, and tariffs have been raised to improve Zesco's financial situation. However, closer inspection reveals contradictions, biases and inconsistencies in this standard policy package when applied in practice. Zesco's acutely debilitating financial position is a relatively recent occurrence. Short-term fluctuations in hydro power, for which intermittent back-up is needed, have instead been addressed with new decades-long contracts for fossil fuel generation. IPPs have provided generous returns for foreign investors but have created long-term, dollar-denominated liabilities for Zesco, contributing to a weakening financial position. Tariffs have been raised but households cannot afford to pay a price that covers Zesco's increased costs. The proliferation of IPPs appears to have worsened the situation.The paper shows that energy sector policies organised around the entry of private capital are problematic and likely to contribute to a dynamic of unequal global capital accumulation. Greater attention is needed to social equity, with policies oriented around domestic circumstances and the specific challenges faced.
2021	Shin H., Chappells H.	The making of energy consumers: From mutual provisioning to mass markets and beyond	Book Chapter	This chapter critically engages with the concept of the energy consumer, which is often assumed to be an uncontroversial and self-evident category in research and practice. Drawing on recent humanities and social science research, historically and geographically contingent manifestations of energy consumers are highlighted. As well as considering how ideas of the energy consumer took shape within distinctive socio-material arrangements, the chapter explores the diverse roles consumers took on within systems of provision. This narrative moves through periods of mutual provisioning, to mass consumption, to decentralised co-provision or 'prosumption'. In so doing, the chapter raises new sets of questions about the energy consumer that have been largely neglected in conventional energy studies, including: how we understand the construction and continuation of socio-spatial differentiation in user roles, what the reconfiguration of sustainable energy practice entails and how active civic engagement might be restricted in an energy systems context.
2021	Thongplew N., Duangput N., Khodkham S.	Addressing plate waste and consumption practice at university canteens: realizing green university through citizen-consumers	International Journal of Sustainability in Higher Education	Purpose: This study aims to explore ways to minimize plate waste at university canteens by studying plate waste and consumers at three main canteens of a university, Thailand. Design/methodology/approach: Using university canteens in Thailand as a case, plate waste was characterized and quantified and consumers' insights concerning food consumption practices were examined through focus group discussion. Findings: The results revealed that each consumer wasted edible food around 19 grams/meal. The generation of plate waste is affected by the food provision system, including canteen setting, food purchasing procedure and food quality. In addition, the presence of stray dogs in the canteens inhibited consumers from finishing up their food. Thus, improving the food provision system is crucial to engage consumers in achieving zero plate waste. Originality/value: This research

				sheds some light on ways to engage consumers in sustainable consumption and contributes to the knowledge on plate waste and sustainable consumption in university settings. Improving food quality and canteen settings are of importance to better engage consumers. In addition, this research revealed that concepts of system of provision and citizen-consumers are practical to analyze sustainable transformations for green university initiatives.
2022	Hansen A.	Negotiating Unsustainable Food Transformations: Development, Middle Classes and Everyday Food Practices in Vietnam	European Journal of Development Research	Amidst calls for making food systems more sustainable, new unsustainable food transformations unfold alongside economic development. Explanations for unsustainable food transformations in emerging economies vary greatly, but there is widespread agreement that demand from new middle classes play a crucial role. Yet this demand is to a large extent co-created by systems of provision, and middle-class consumers are constantly navigating food transformations in a search for healthy and safe food. Focusing on Vietnam's dramatic food transformations, and combining attention to the political economy of food with a social practice approach to consumption, the paper zooms in on the how middle-class households in Hanoi negotiate the rapid transformations of food systems and food environments. The paper concludes that new thinking on sustainable food systems is urgently needed and argues that vital insights can be gained by studying food practices and their interaction with everyday geographies of consumption.