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Conceptual Clarifications of the Process-Based System Model

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Abstract
While global development seems to be moving in the right directions in some areas, like decreasing global poverty and securing access to basic education for all, the mismanagement of natural resources and human affected climate change should be clear indicators for the unsustainable development of our global society. Change is needed. Without any global governance mandated with the management of the global sustainable development others need to step up to the challenge and take responsibility for the current and future survival and equality of our society. Organizational management systems have been suggested to be described through its purpose, principles, practices and tools. As a tool and practice for systematic improvements in quality and sustainability a process-based system model has been developed over the last 20 years. Originally aimed for visualizing the relations between key performance indicators for organizational sustainability, it has evolved towards a generic system model template with several use cases. In this paper the development of the process-based system model is reviewed and revisited for the purpose of identifying further areas of development and highlighting any ambiguities and weaknesses in the model. The key findings are the ambiguity around input, drivers and their relation to external system resources. Future research is suggested to test the usability of the model with its intended audience, used as a sense-making tool, and explore the relation to previously defined system levels with relation to the process view in focus.

Keywords
process-based system model, sense making, sustainable transition, cement-based building materials, system performance

1. Introduction to Tools for Quality and Sustainability

The idea of a sustainable development has been traced back to the ancient Greek society with philosophers noting the pace in which lumber was being harvested exceeded the pace of regeneration of forests. Today, several decencies later our planet and society are faced with similar challenges due to mismanagement of natural resources as well as the unprecedented consumption of fossil fuel. Following the commonly cited 'Brundtland definition' of sustainable development from the OECD conference in 1987, the concepts could be said to be about the survival and equality among current and future generations of people on planet earth.

While global development seems to be moving in the right directions in some areas, like decreasing global poverty and securing access to basic education for all, the mismanagement of natural resources and human affected climate change should be clear indicators for the unsustainable development of our global society. Change is needed. Transition from fossil fuels to renewable energy, from harvesting and polluting our natural life on land and sea to regeneration and purification.

Without any global governance mandated with the management of the global sustainable development others need to step up to the challenge and take responsibility for the current and future survival and equality of our society. The majority of goods and services provided by our society stems from businesses who engage in value creating processes in complex and often global value chains. These businesses and their value chains also come with a footprint, both environmental and social. The concept of corporate social sustainability (CSR) has been around for some 40 years, placing parts of the responsibility of sustainable development with the business organizations. In recent years the concept of sustainability has become a buzz word hyped by research (Kirchherr, 2022) and embraced without any definition nor explicit understanding by business and society (Isaksson and Rosvall, 2020). Introducing sustainability as a dimension of performance in organizations is a challenge receiving increasing attention. Parallels to the quality hype in beginning of 2000s could be made.

The similarities between quality and sustainability are several. Both research and practice have been struggling to agree on definitions of the two concepts. Quality and sustainability both refer to a state of being for some other product or process (e.g. service). With a high-level of quality as the goal, quality development is the journey towards the goal where processes are improved through various interventions in the system. Similarly, we can think of sustainability as a level, describing a state on a scale from low to high, where something sustainable is above a threshold on this scale. Sustainable development is then the journey of improvement towards this goal of sustainability.

Research on quality management has suggested that a management system can be described through a set of system elements such as a purpose, principles, practices, and tools (Fredriksson and Isaksson, 2018). Attempts to expand quality principles and develop new tools and practices to enable systematic improvement work for increased sustainability performance of organizations are several. Key expansions are the change in scope from a customer centric principle to a stakeholder focus as well as the emphasis on processes and systems thinking (Garvare and Isaksson, 2001; Isaksson and Garvare, 2003; Isaksson, Hallencreutz and Garvare, 2008). Part of the suggested management system for sustainable development is the Process-Based System Model (PBSM) first introduced in 2003 by (Isaksson and Garvare, 2003). The model was initially used as a tool to visualize the relation between certain key indicators for measuring organizational sustainability. With several iterations the model has evolved into a tool to be used for several purposes and in other practices such as the Sustainability Opportunity Study (Isaksson, Ramanathan and Rosvall, 2021).

In a deep-dive reviewing the evolution of the process-based system model as both a tool and practice this paper revisits the inherent logic, conceptual relations and the consistency of the model.

2. Method

This paper is mainly conceptual, developing theory based on previous literature. The selection of literature has been conducted using a snowballing approach from the latest published version of the process-based system model. In this review nine papers were identified as both applying and developing the model during the period of 2003-2019. This review adds to the overarching development of a generic model for visualizing key system elements for organizational sustainability performance. The development has previously been suggested to follow the meta-methodology innovation action research used for the development of the balance score card (Kaplan, 1998), see references in (Isaksson, 2006). Main contribution to the action research cycle is the summary of what has been done and what are to be done regarding the development of the PBSM.

3. Key elements in a process-based system

The process-based system model was first introduced in 2003 and has evolved through a series of papers developing the model based on superficial application on cases from cement manufacturing, higher education and mobile communication. The visual model has emerged and the difference from the first version from 2003 and the updated version from 2019 is illustrated in figure 1.

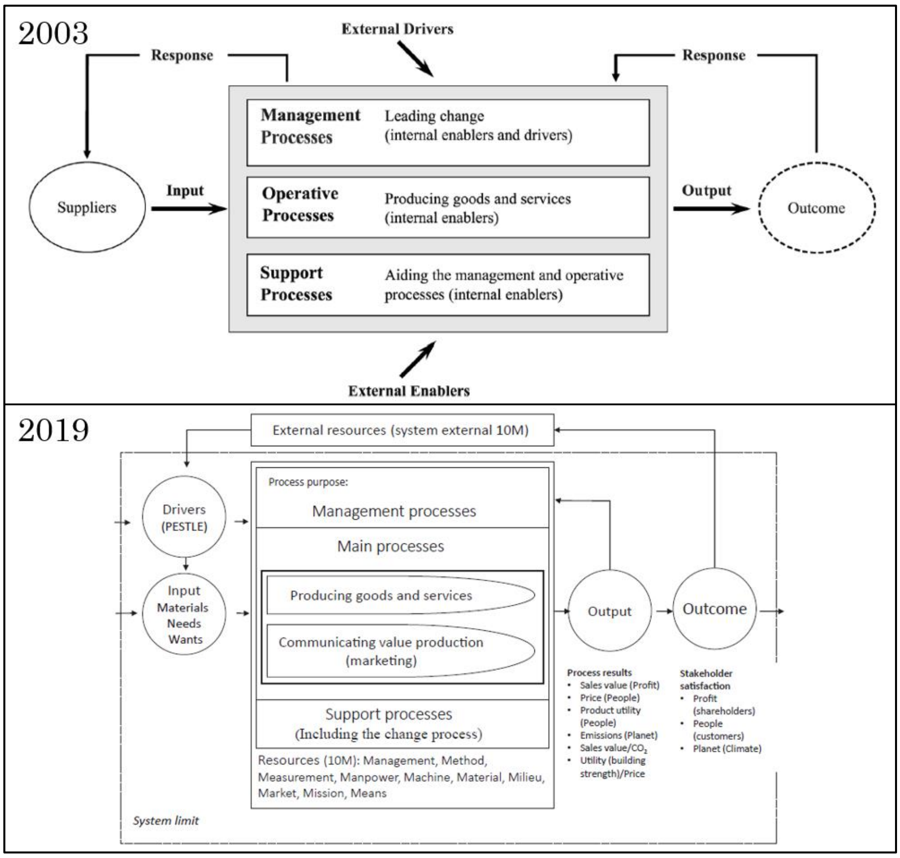

Figure 1: showing the process-based system model in its visual representation from 2003 (on top) and the later version from 2019 (in bottom). Source (Isaksson and Garvare, 2003; Isaksson, 2019a)

Over the period of development of the PBSM there have been some system elements that have been replaced and introduced. The schematic logic has also evolved with new boxes, circles and arrows. The main system elements and schematic logic has remained. Key system elements in the PBSM are processes, process measurements, resources and drivers. Each set of these elements are reviewed and current understanding of their relations and interconnectedness are clarified here.

3.1. Processes

There are several definitions of processes, after reviewing the core values of TQM and extending the scope from customers to stakeholders (Isaksson, 2006) defines processes as "a network of activities that, by the use of resources, repeatedly converts input to an output for stakeholders". This definition has followed the PBSM development and is reused in later work (Isaksson, 2016). Processes in the model are divided into three types based on their purpose and customer, main processes, management processes and support processes.

- Main (also core or operative) processes are those that deliver output to external stakeholders (Isaksson, 2006).
- Support processes are those that provide support to the main processes, having only internal stakeholders (Isaksson, 2006).
- Management processes covering strategy, planning and control over the main and support processes, and thereby also having only internal stakeholders (Isaksson, 2006).

The process definition and the categorization with main, support and management processes have remained similar during the cycles of evolution.

3.2. Process measurements

In (Garvare and Isaksson, 2001) the scope of business excellence models, as part of the larger TQM management system, was extended through five core values for organizational excellence in sustainable development. As part of the expansion four types of indicators for sustainable development based on (Compton *et al.*, 1998) were introduced, namely; driving forces, state, reactive response and active response. These categories were used in the initial version of PBSM to introduce the process measurements input, output, outcome, drivers and enablers.

Input is defined in an organizational context in (Isaksson and Garvare, 2003, p. 650) as "process input is directly controlled by the organization and consists of the services and goods bought. They continue with "we separate inputs in the form of goods and services from drivers that stand for demand related to the goods and services" (Isaksson and Garvare, 2003, p. 651). Further "in an organizational context both input and demand could be seen as driving forces creating enough voltage to push or pull the flow through the organization." (Isaksson and Garvare, 2003, p. 650). The idea that input is only material in form of goods and services is echoed in (Isaksson, 2006) and the abstract demand 'driving' the process is something else. However, in (Isaksson, Johansson and Fischer, 2010) housing needs and capacity to pay is used as input, including abstract demands (stakeholder needs) to the process measurement category. Further 'building demand' and 'cement demand' is used in figure 3 and 4 in (R. Isaksson, 2016). In figure 2 in (Isaksson, 2019a) input encapsulates materials, needs and wants indicating that the development has arrived in a use of input measurements as being the combination of concrete material input, as well as abstract stakeholder needs and wants. From this review there seems like the term driver has changed from initially referring to stakeholder needs and wants, which together with goods and services bought by the organization created the voltage to push or pull the process flow through the organization.

Output is defined in (Isaksson, 2015, p. 782) as “the result of the process”. No further elaboration is made specifically around output but there are several papers mentioning the distinction between output and outcome.

Outcome is the perceived stakeholder satisfaction of the output. This is mentioned in the initial paper (Isaksson and Garvare, 2003) and then echoed in similar ways throughout the development of PBSM. Key here is the conceptualization of stakeholders which is reviewed in a later section.

Relating this to the four categories of indicators driving force, state, and response initially introduced in (Isaksson and Garvare, 2003), the input indicators are the driving force, output and outcome describe the state while response indicators are not clearly matched with any of the system elements in the 2019 version, while being illustrated as the response loop in the 2003 version, see figure 1. Response indicators are defined as “the measurements taken to handle problems caused by the output” (Isaksson and Garvare, 2003, p. 651).

3.3. Resources

In the working definition for PBSM processes are said to be ‘enabled’ by resources, “…by the use of resources converting input to output”. Resources are first introduced to the PBSM in (Isaksson, 2006) where they are referring to internal resources of an organization used interchangeably with internal enablers. External enablers holds the place where later external resources are used in figure 2 in (Isaksson, 2019a) (also 2019 version in figure 1 here). A transition from only enablers in (Isaksson and Garvare, 2003), to a mix of enablers and resources in (Isaksson, 2006; Isaksson, Hansson and Garvare, 2007) and then to only using resources in (Isaksson, Hallencreutz and Garvare, 2008; Isaksson, Johansson and Fischer, 2010; Isaksson, 2015, 2019a; R. Isaksson, 2016) has taken place during the development. Enablers are defined in (Isaksson and Garvare, 2003) in terms of internal and external enablers, in an organizational context. From the notes to table 1 in (Isaksson and Garvare, 2003, p. 653), “internal enablers include processes and systems that make work with the 3E-dimensions[1] easier. Examples of external enablers are branch organizations, and the general level of education within a region or country.” The introduction of resources started with the 7M list from (Bergman and Klefsjö, 2007) where “enablers could be seen as resources for the organization” (Isaksson, 2006, p. 635). The 7M list is a list of generic causes for quality problems which can be described in a cause-and-effect diagram. In its original form the 7Ms are management, man, method, measurement, machine, material and milieu which all serves as categories for common problem identification searching for root causes. This list has later been expanded to 10M with the addition of market, mission and means, see (Isaksson, 2015).

When applying the 9M list for a group of cement plants the authors notes that in retrospect the qualitative assessment of the root causes is mainly intended for knowledge management (Isaksson, Hallencreutz and Garvare, 2008). This is interpreted as relating to the systems ability to understand its internal and external resources, defined as the M-list combining both concrete resources like machine, man, and material as well as abstract resources like method, management, and measurement. Here an analysis of maturity of the measurement system is suggested to provide insight in how well the system conducts knowledge management, i.e. understands itself based on the information about its internal and external resources (Isaksson, Hallencreutz and Garvare, 2008). The resources are of varying importance depending on what the main processes of the system are. It is clear that the internal resources are enabling the processes to occur, both main, management and support processes. If key resources are lacking, say for example a tractor for a small farmer, the lack of resources becomes a barrier for process

[1] 3E is a version of the triple bottom line with Economy, Environment and Ethics – see (Isaksson and Garvare, 2003).

performance. The knowledge management system in the system, partly consisting of the measurement resource, monitors and manages the internal resources.

The external resources of the system are not as clearly described in relation to the systems processes. In the first paper to use external resources instead of enablers they are introduced as external resources that affect performance, with examples such as level of corruption, competition, and possibilities to buy materials and services (Isaksson, Hallencreutz and Garvare, 2008). “The external resources will affect how the information from different interested parties and stakeholders is interpreted” (Isaksson, Hallencreutz and Garvare, 2008, p. 218). This idea is further explained in (Isaksson, Johansson and Fischer, 2010) where the relation between stakeholder feedback and processes is described as passing through a filter of external resources that describe the organizational environment. The feedback then turns into drivers for the system in terms of stakeholder needs or wants and is either dampened or amplified based on the ‘filter’ of external resources (R. Isaksson, 2016). The 10M list for external resources is interpreted as being used for a checklist for the larger (external) system of which the studied system (internal) is part of, where the main purpose is to detect qualitative root causes for what types of drivers (stakeholder wants and needs) affect the (internal) system processes.

3.4. Drivers

Drivers have been a part of the PBSM since the initial versions, described in (Isaksson and Garvare, 2003) as both demand for the products and requests for restrictions regarding undesired outputs such as social problems and pollutants. Drivers are later described as external forces that either are dampened or amplified feedback signals from stakeholders, or resulting forces from external processes ‘enabled’ by the external resources (R. Isaksson, 2016). In (R. Isaksson, 2016) the PESTLE model from (Burnes, 2009) is introduced as a tool to map these driving forces that ‘provides the voltage that pulls or pushes the flow through the processes’. PESTLE is an acronym for Political, Economical, Social, Technological, Legal and Environmental factors which affect an organization (Burnes, 2009, p. 434). When input is including both materials, stakeholder needs and stakeholder wants, there seems to be an overlap in the model when using PESTLE to describe the driving forces that provides the static tension that holds the system processes in place. A clarification on what each dimension of the PESTLE includes and how that relates to stakeholder needs and wants, as well as to how input in the form of materials, stakeholder wants and needs is called for. This will in large part be affected by how stakeholders are defined and how their needs and wants are distinguished. The resulting interpretation of drivers is illustrated in figure 2 where the drivers are force holding the system processes in a static state of tension, i.e. repeatedly converting input to output by use of system resources.

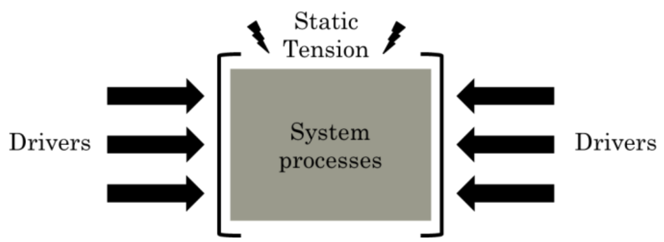

Figure 2: representation of how drivers are forces creating the static tension that hold the system processes in place. Source own elaboration.

The drivers are in turn the final feedback connection from the process results (output) via a filter of stakeholders who provide feedback based on their perception of the process results (outcome). The stakeholder feedback is then filtered through the external system resources which either amplifies, dampens or replicate the feedback signals into the driving forces (drivers), illustrated in figure 3.

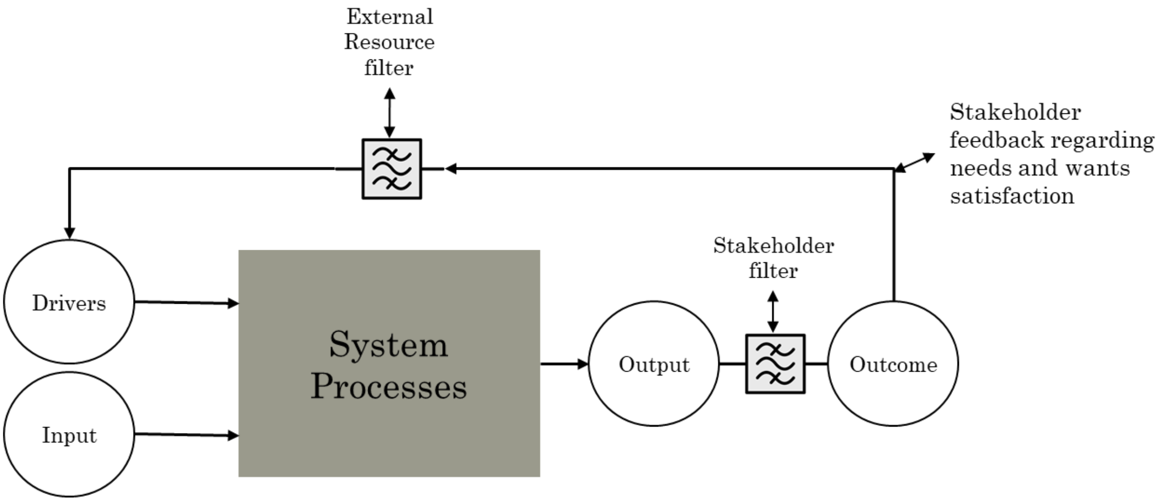

Figure 3: a process-based system model with feedback loop and indicated filters altering the relations between system elements. Source own elaboration based on (Isaksson, 2006)

3.5. System Stakeholders

Identifying the key stakeholders has been a central task of the PBSM through out the development. Initially stakeholders are defined by the categories of actors that it includes, namely customer, suppliers, shareholders, employees, current and future societies and the nature in general (Isaksson and Garvare, 2003). In (Isaksson, Johansson and Fischer, 2010) the concept of stakeholders deviates and gets a more specific, confirming to a stakeholder theory for managing sustainable development by (Garvare and Johansson, 2010). In this theory stakeholders “are those actors that provide essential means of support required by an organization and who can withdraw their support if their wants or expectations are not met, thus causing the organization to fail or inflicting unacceptable level of damages” (Isaksson, Johansson and Fischer, 2010, p. 427). Three types of actors are introduced, primary stakeholders, secondary stakeholders, and interested parties.

Primary stakeholders are those actors that have a direct control of essential means of support required by the organization. Examples for an organization would be customers, employees in form of management and co-workers, suppliers of essential goods and services, shareholders and government.

Secondary stakeholders are individuals or organizations that, in one way or another are able to influence primary stakeholders to withdraw their essential support if their wants and needs are heavily violated, leading to unacceptable levels of damage for the organization. Examples could be non-governmental organizations, academics, media, fair-trade bodies.

Interested parties are those individuals and organizations, as well as natural environment that are affected by the organizations activities but do not have the possibility nor power to react and sanction the organization.

In parallel to the development of the PBSM is work relating to identifying key stakeholders for sustainable development from an organizational perspective. This work partly takes off in the expanded scope for business excellence models (Garvare and Isaksson, 2001) and is presented as a criteria for an organization to keep its license to operate in the long run in (Isaksson, 2019b). The main idea is to use people and planet as the key stakeholders to focus initial organizational efforts on improving sustainability performance (Isaksson, Garvare and Johnson, 2015). This counters the anthropocentric stakeholder theory with primary, secondary stakeholders and interested parties and places equal focus on social issues (people) and the environment (planet) and argues that the profit dimension of the triple bottom line (represented by the business-oriented stakeholder perspective) is over emphasized in organizations. For identifying and selecting a systems key stakeholders the pareto principle, also known as the law of the vital few, is suggested to be used (Isaksson, Garvare and Johnson, 2015; Isaksson, 2019a).

There is much to say about how to define, identify and prioritize stakeholders for organizations, and any generic process-based system. The current proposed method to work with stakeholders for PBSM is the pareto principle based on People and Planet as key sustainability stakeholders.

3.6. System Levels

The PBSM has evolved from an organizational bound model to a generic structure intended to be applicable from a global perspective (Isaksson and Garvare, 2003; Isaksson, Hallencreutz and Garvare, 2008), over supply chains (Isaksson, Hansson and Garvare, 2007; Isaksson, Johansson and Fischer, 2010), to organizations and sub-organizational levels (Isaksson, 2006, 2015; Isaksson, Yamamoto and Garvare, 2016). Mainly one effort has occurred in trying to connect the system level in a system-of-systems where the PBSM in focus is placed, being the introduction of the viable system model from (Beer, 1995). In the paper (Isaksson, Johansson and Fischer, 2010) the system model with its five levels of system management is used to draw the conclusion that the level five (highest system management level) is not being achieved which is what holds back supply chain innovation potential. This analysis overlaps with the idea of using the stakeholder feedback and other drivers as main forces affecting the system. It is clear that the scope of the PBSM is intended to fit any system of processes, working like a box-in-a-box model where it is possible to zoom in and out regardless of organizational, industry, regional and national boundaries. If and how the levels in the system-of-system needs to be specified for the PBSM remains unanswered.

3.7. Use cases, applications and intended audience of PBSM

The PBSM is interpreted to initially focus on providing a mental model for which types of indicators that were key for reviewing sustainability performance of organizations, see (Isaksson and Garvare, 2003; Isaksson, 2006). In later versions (Isaksson, Hansson and Garvare, 2007; Isaksson, Johansson and Fischer, 2010) the use case were moving towards illustrating supply chain improvement potential related to sustainability performance. In (Isaksson, 2015) the purpose of the PBSM we described as creating the framework for an opportunity study through partly a generic change model and a steady state description based on PBSM. Here the use case splits into both being a mental model for how organizations can work with change for sustainable development, and also relating to its initial use case of visualizing the relationship between key process indicators for sustainable development. In the following work the PBSM is mainly referred to as being used to visualize and identify opportunities, which are assumed to contribute to an urgency of change as the initial step in (Kotter, 1995) eight step process for change (R. Isaksson, 2016; Isaksson, 2019a). A third suggested use case for the PBSM is as describing the 'perfect process' as a visionary state from where an organization can use backcasting for strategic planning (Isaksson, Yamamoto and Garvare, 2016).

The review on how the PBSM has been tested empirically shows that there are cases from both cement manufacturing, building value chain, mobile connection value chain, higher education as well as a global system view based on (Meadows and Club of Rome, 1982).

Initially the PBSM had a clear focus on the organization and identifying the key performance indicators to monitor and improve sustainability performance. The model has continuously been part of an ambition to describe how TQM could be used for working with sustainable development as well as quality, which is also the title of (Isaksson, 2006) 'Total quality management for sustainable development – process based system models'. Total quality management, sometimes shortened to quality management, has been historically been connected to business life, commercial and industrial organizations for manufacturing and production. Research and development related to TQM naturally have the organization and more specifically the management of the organization as their key audience. In (Fredriksson and Isaksson, 2018) a model for describing quality philosophies is developed and used on TQM, Six Sigma, Lean Management and ISO 9000. The fundamental elements of any management system are proposed to be principles, practices, tools, purpose, roll-out process and management process in steady-state. With regards to this the PBSM has been developed as a tool with several use-cases but the practice of applying the PBSM for each specific use-case has not been clearly formulated into a method description or similar checklist. In later versions the PBSM is used as a tool in the practice of DAS opportunity study (Raine Isaksson, 2016).

With the generic configuration with focus on processes in systems, the model could be used by an audience beyond business organizations. Essentially all system actors with an interest of understanding how their internal and external system affects their processes should be able to structure their thinking and mapping with the PBSM. This goes for researchers who are interested in why systems behave like they do, activists looking for root causes on a higher system level to their main concern, government officials looking to understand the connection between the local organizational environment and the regional and national etc. The interpreted key contribution of the PBSM is that allows for 'taking the elevator' between different system levels while keeping its generic structure only to be updated with content depending on which part of the system that is in focus.

3.8. Previously suggested future research

With some 20 years of development the key modifications to the PBSM are described in this review. During the evolution several suggestions for future research has also been presented.

- In the initial development of PBSM as a structure for sustainability indicators, (Isaksson and Garvare, 2003) suggest further research on introducing the 3E model (version of triple-bottom-line) for sustainability reporting of small and medium sized businesses. Further, as a call for ethic business operations a product value scale, based on something similar to Maslow's hierarchy of needs is suggested as area of future research.
- (Isaksson, 2006) discusses the usability of the model and calls for testing of usability stating that the model should be easy to understand and unambiguous, suggesting a test based on (Ould, 1995) where the model should be grasped within 10 minutes. PBSM as a sense-making model has not yet been tested by any of the potential audiences.
- As part of the co-evolving ideas on excellence models for sustainable organization, see e.g. (Garvare and Isaksson, 2001; Garvare, Hallencreutz and Isaksson, 2007), (Isaksson, Hallencreutz and Garvare, 2008) note that using a maturity scale for a systems measurement resources to indicate the level of focus on knowledge management would be an interesting area for future research. This is done in (Isaksson and Hallencreutz, 2008).
- In (Isaksson, Johansson and Fischer, 2010) the identification and application of appropriate value per harm indicators to raise public awareness about supply chain innovation potential is suggested to be continued through further iterations and fact

finding. This is partly done in iterations with the building supply chain and cement manufacturing in (Isaksson, 2015; Raine Isaksson, 2016).

- The hypothesis that willingness to change is inversely proportional to the magnitude of the improvement potential is raised in (Isaksson, 2015) and further research to test the hypothesis is called for.
- Relating to the challenge of creating a sense of urgency for change through use of the two models PBSM and PPT, (Isaksson, 2019a) concludes that future research should involve testing of the strategy (i.e. the suggested method for identifying gaps) by presenting findings to persons in leading positions in the studied value chain. Again, calling for validation of the sense-making ability of the system models.

In reviewing the key articles of the evolution of the PBSM future development is suggested to carefully consider the use-case and audience for the PBSM before attempting further development. It is clear from this review that the model has evolved from its original purpose of providing a structure for sustainability indicators towards a more generic system model that could have several use-cases. Key conceptual clarifications to consider, regardless of the intended use-case and audience are suggested as:

- Defining input, especially in relations to drivers (previously enablers).
- Defining drivers and the specific relation to external resources and internal processes. Also providing a complete visual presentation of how 'stakeholder feedback', as an information input, is converted/filtered via external resources to become drivers.
- How system levels are to be interpreted and handled in the model. Should there be a system element to keep track of what level of the system the visualization is focusing on? This could possibly be depending on the use-case and intended audience.
- Criteria for validation, how do we know that the model is working?

4. Updating the process-based system model

In this section suggestions based on the identified needs for conceptual clarification of the PBSM are presented. In short, the definition for input is revised, the idea of drivers and the relation to system resources and system stakeholders is scrutinized and developed. Based on this, an example from the housing value chain is used to illustrate the proposed logic. The challenges regarding system levels and PBSM as well as the criteria for validation is left outside the scope of this paper.

4.1. Input

The main confusion regarding input relates to the distinction or fusion between material (described as purchased goods and services) with stakeholder (e.g. customer) needs and wants. Using the PBSM for any application beyond or within the organizational boundaries, i.e. at a different system level than encompassing a whole organization, the idea of defining input as purchased goods and services can be misleading or incorrect. The suggestion here is that input, and the related indicators for monitoring process input, are limited to the resources in terms of goods and services that are consumed directly in the value creating (main) process that converts input to output. This is to be distinguished from the internal resources that are not directly consumed by the main processes but rather lasts for several process cycles. Here stakeholder needs and wants are distinguished from input to be consistent with the following definition of drivers.

Using the example of a production process we can imagine a ball mill for cement milling. Input for the milling process would be the clinker which is milled into a new product i.e. cement, and kWh representing the energy consumed in the milling process. The ball mill itself, and the balls rolling and crushing the clinker in the mill are identified as internal resources for the milling process, since they last for several process cycles (assuming some cycle definition on an hourly basis). The customer demand for cement is here considered among the drivers for the process, rather than input.

An example of a service process could be the cyber security service provided by a software consultant firm. Where the process 'provide secure it-systems' with an assumed cyclical period of a month, assuming a business model using a monthly subscription, would take as input the kWh for running the computers and servers as well as the hours of labor put into maintenance, development and customer relations.

4.2. Drivers, external resources and stakeholder feedback

Drivers are interpreted as the forces that combined creates the static tension that holds the processes together, ensuring the repeatability of conversion of input to output for several cycles. Going back to our definition of processes as 'a network of activities that, by the use of resources, repeatedly converts input to an output for stakeholders', drivers are not explicitly referred to. Here the drivers would be the answer to questions like 'why would a network of activities be repeated over and over again?'. Stakeholders needs and wants are in the definition the receivers of the value created in the processes. Stakeholders can be internal and external, depending on the type of processes.

In (Isaksson and Garvare, 2003) the idea of a driver either pushing or pulling the process flow is introduced. This is never revisited in the following papers, however the idea of distinguishing between drivers that pull or push the process flow could make sense. The illustration to envision how drivers are related to system processes and how they can be distinguished as either pull or push drivers is presented in figure 4.

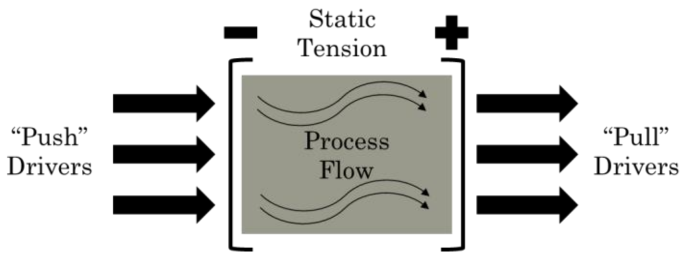

Figure 4: Revised visalization of how drivers are either pushing or pulling the process flow. Source own elaboration.

Driver are essential to understand if the system management, or other stakeholders, desires to change the system processes. In the PBSM the relation between stakeholder satisfaction (outcome) and potential changes in the system has been described thorough various forms of feedback loops inspired by systems theory. The relation between stakeholder feedback (stakeholder needs and wants) and drivers is here presented in figure 4. The system processes result in output. Between output and outcome is a filter where we can imagine the stakeholders of the system receiving the information of the output. The stakeholders then compare the output to their expectations and arrives in a perception about wheter the output was good, bad or neutral. This perception underlies the feedback (information) regarding how the stakeholder would like to receive another or the same type of output from the process. I.e. any potential urges for change start with stakeholder's perception of output. The resulting feedback is then filtered through the external systems resources. The idea is here that depending on the external context of the system processes, different stakeholder needs and wants become stronger in their driving force.

The external context is suggested to be described qualitatively through the 10M checklist. For the filer analogy to work the 'maturity level' of each system resource related to each stakeholder want and need would be measured. With such an indicative level of external resources, the magnitude of driving forces could be explained. Going back to the insight that in order to change the output of the processes, the driving forces must be reconfigured. Modifications in input and internal resources could result in different output, but the underlaying question why input or internal resources would be modified would be answered by the changes in driving forces. With this described logic, the idea that drivers would be both ‘filtered stakeholder feedback’ as well as other external driving forces is rejected. In the suggested logic all stakeholders are included in the feedback loop from outcome, via the external resource filter, into the drivers, which makes ‘any other external driving forces’ excessive. All drivers are assumed to be filtered feedback from stakeholders.

Previous papers have introduced some tools for mapping and listing these system elements. Drivers are suggested to be listed by PESTLE in (Raine Isaksson, 2016), external resources are mapped with the 10M checklist in (Isaksson, 2015), and key stakeholders are suggested to be identified by using the Pareto approach in (Isaksson, Yamamoto and Garvare, 2016). Where these tools are to be applied in the constructed logic for stakeholder feedback is illustrated in figure x.

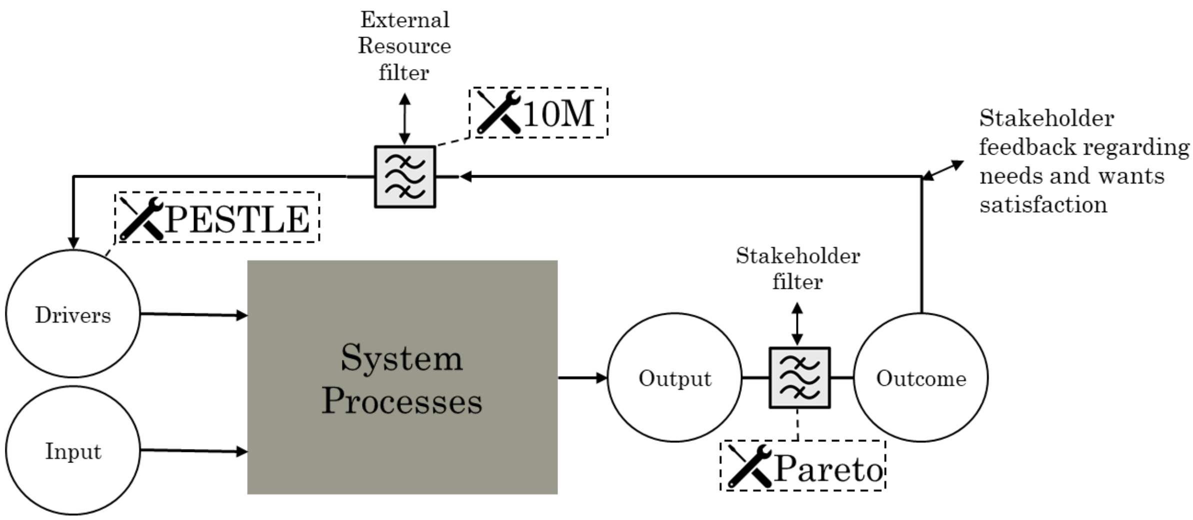

Figure 5: Process based system model with feedback loop and filters altering the feedback signals, with indicated tools for selected system elements. Source own elaboration based on (Isaksson, 2006).

Going back to the initial ideas of using PBSM for mainly structuring the indicators for measuring sustainable development, we return to the indicator categories driving force, state, active/reactive response. Mapping our system elements and related indicators it is here suggested that indicators for drivers are the driving force. Input, output and outcome are state indicators and any measured changes in external or internal resources or input are active/reactive response indicators. Exactly how to set up indicators for stakeholder satisfaction, external resource filtering and drivers is not yet described in the previous development of PBSM. Indicating an area for future work.

Working through the suggested framework PESTLE in regards to listing drivers for the PBSM, it is suggested here to distinguish between push and pull drivers, relate each identified driver to the resources from the 10M list and the underlaying stakeholder feedback. This would highlight the explanation for each driver and potentially provide better decision support for system management.

5 Cement innovation in Sweden

Globally cement production accounts for 7-8% of carbon dioxide (CO_2) emissions. Cement production in Sweden is done by the company Cementa AB, owned by Hiedelberg Cement.

Cementa is Sweden's second largest single source emitter of CO_2 (Nyheter, Zachrisson Winberg and Sima, 2021). The market for cement is characterized as a monopoly and the business model of Cementa, as the other global producers of Cement (Raine Isaksson, 2016), is based on maximizing tons sold cement. Sweden has a national target for net-zero CO_2 emissions until 2045 which includes all major industries like the cement and concrete business. Undoubtedly there are going to be major changes in the processes along the housing value chain in order to reduce the carbon footprint within the set timeframe. A national roadmap for the cement and concrete industry, targeting net-zero emissions by 2045 suggest several areas for improvement and concludes that innovation and new technology is required for the industry to transition towards a net-zero state (Fossilfritt Sverige, 2018). The national process for producing cement can be illustrated as a process-based system with input, system processes, internal system resources, output, outcome (based on stakeholders' perception), external resources and drivers. As a way of illustrating the conceptual clarifications relating to the PBSM done in this paper, the process for producing cement in Sweden is visualized with PBSM.

5.1. System purpose

The purpose of the system in focus is to produce cement to meet the demands of the Swedish market.

5.2. System stakeholders

The scope is limited to the stakeholder "Planet" which needs are interpreted as mainly balance in the carbon cycle, i.e. a concentration of CO_2e in the atmosphere limited to 280ppm. Here environmental impacts from cement production like exploiting quarries and potential impacts on ground water is delimited.

5.3. System processes

Main system processes for producing cement are 'Raw material preparation', 'Raw milling', 'Clinker burning', 'Cement milling', 'Dispatching', and 'marketing cement' (Raine Isaksson, 2016). Support processes could be described as 'managing improvement', 'measuring performance', 'maintaining resources' and 'managing input'. Management processes are bundled into 'managing cement producing organization'.

5.4. System state measurements

Input for cement manufacturing are the raw materials like lime, sand, fly ash and kWh hours needed to run the factory. Further input for the system is the hours of labor put into by the employees working in the system, as well as fuels consumed during the production process.

Output from the system is tons produced cement, tons CO_2 emissions, tons waste produced in the processes, revenue and profit produced by the system (yearly financial reporting).

Outcome is limited by the previous focus on the stakeholder "Planet" which is increased dissatisfaction for each ton CO_2 added to the imbalance of CO_2 concentration in the atmosphere.

5.5. System drivers

System drivers can be categorized as Political, Economic, Social, Technological, Legal, and Environmental (PESTLE). Conducting only a superficial analysis for illustrative purposes the following drivers, related to the stakeholder need of and output of 0 CO_2 emissions, can be identified:

Political drivers are the recent 'Fridays for future' movement which is calling out politicians and leaders to start acting for a net-zero society and slow down climate change. This could result in politicians introducing incentive schemes for reduced emission rates among industry actors, working as a pull driver.

Economic drivers are the price of carbon emission trading rights, which are traded within the European union. A higher price of carbon will pull the system towards lower emission rates.

Social drivers are information about the negative effects on people that climate change has globally. News about extreme wildfires, droughts, flooding and other type of extreme weather that cause people harm could create pressure to reduce emissions.

Technological drivers are innovation and development around carbon capturing and storage (CCS) and electrification of the burning process of clinker. New technology works as a pull driver in enabling new processes.

Legal drivers are potential regulations in carbon emissions where excessive emissions are punishable by law. No such regulations are in place today, resulting in this driver being a lacking push driver.

Environmental drivers would be the threat of raising sea levels as an effect of climate change and increased CO2 concentration. Where current production processes would risk damages due to their geographical location. This would be a pull driver.

5.6. System resources

The internal and external system resources can be described using the categorization 10M:

- Mission
- Management
- Method
- Manpower
- Measurement
- Machine
- Material
- Milieu
- Market
- Means

In the analysis of the internal and external resources and the connection to the identified drivers it became apparent that it is not a straight forward exercise. Previous literature does not provide any generic guideline for how to go about with this challenge and further explanations and examples are called for. For the sake of illustration this example was limited to the stakeholder need of CO2 concentration in the atmosphere, the struggle to do the analysis could be due to the reduced format since the PBSM in its design is holistic. Identifying all relevant stakeholders and mapping their interconnected relations to drivers and system resources could possibly be done, but this task will be left for future studies. An illustrative PBSM with the identified system elements for producing cement in Sweden is presented in figure 6.

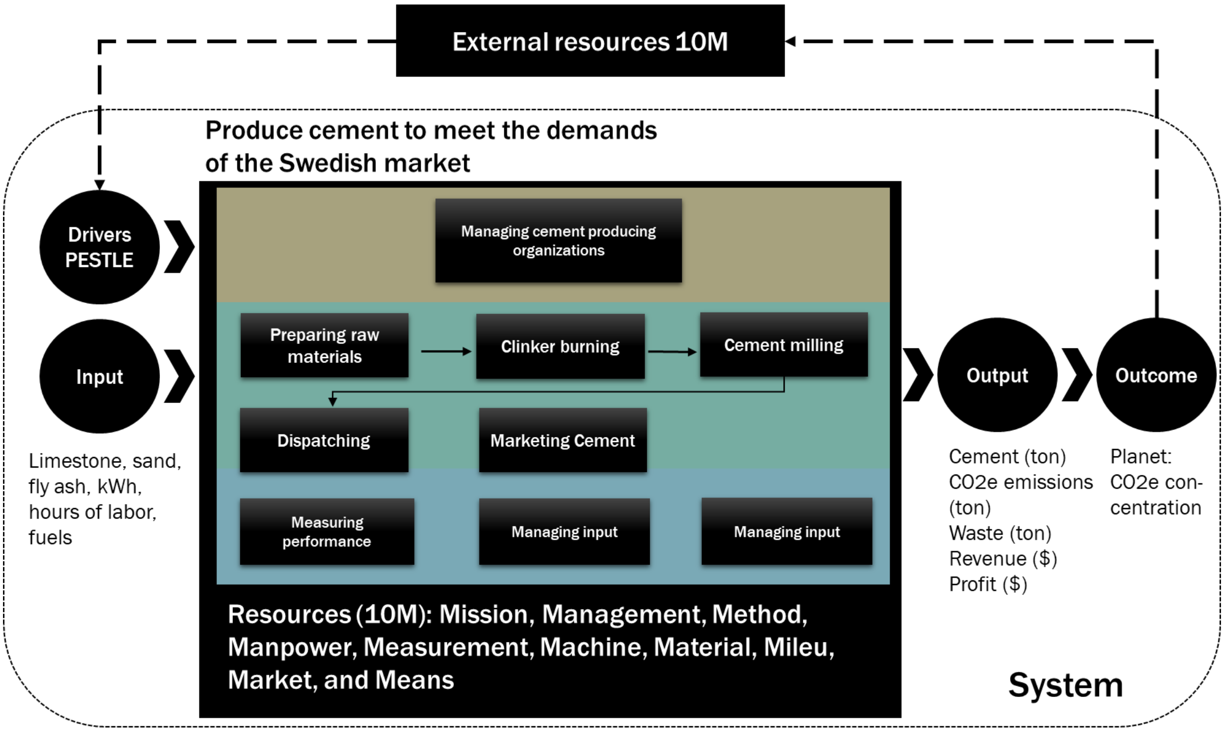

Figure 6: Process-based system model with key processes, inputs, outputs, and outcomes for the Swedish cement production system. Source own elaboration based on (Isaksson, 2016).

6 Discussion and conclusion

In this review and illustrative example several ideas for future development and some inconsistencies have emerged. It is clear that the use case of the PBSM have expanded from visualizing the relations between certain key indicators for organizational sustainability towards being a generic system model with a range of different applications. Used as a tool and practice in the developing Sustainability Opportunity Study method it is being integrated in the process of creating a sense of urgency for change.

The main purpose of this paper has been to ‘flush out’ any inconsistency in the explanations and definitions of the system elements and their relation in the PBSM. The key findings are the ambiguity around input, drivers and their relation to external system resources. Input is here defined as ‘the resources in terms of goods and services that are consumed directly in the value creating (main) process that converts input to output’. Drivers are revisited and understood as the forces holding the processes in their static configuration assuring repeatability over several process cycles while pulling or pushing the process flow. In the illustrative example from cement production in Sweden it becomes apparent that the idea of stakeholder needs, wants (and possibly demands) require a holistic analysis since the needs of one dimension, here limited to environment, cannot in itself describe the driving forces that enables a certain system performance. This might also entail that the theory for stakeholder (Garvare and Johansson, 2010) used in (Isaksson, Johansson and Fischer, 2010) should be revisited and compared to the reduced focus on People and Planet as main stakeholders. Here the model should be tested with a thorough analysis from a real case, for use case and audience the model is partly targeted.

Further need for development and clarification is identified regarding the system level and the relations between the process-based systems on different system levels, initially introduced in (Isaksson, Johansson and Fischer, 2010).

Following the cycle of innovation action research the fourth and final step before improving and advancing a model ‘implement concept in new organization’ (Kaplan, 1998), is lacking from the development of PBSM. There are no studies conducted testing the utility of the model, as a sense-making tool, among any of the intended audience. This also relates to the lack of criteria for how the model is to be evaluated. So far there the PBSM has only been tested in cases conducted by the same authors developing the model. I.e. the sensemaking ability of the visual model and related tables with information. This calls for further research and any future development should be guided by the results from such experiments.

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