SYSTEM INNOVATION: CASE STUDIES

BELGIUM - System innovation
for sustainable materials use in Flanders

OECD

OECD Working Party on Innovation and Technology Policy

System innovation for sustainable materials use in Flanders

A case study on system innovation for sustainable development

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Contents

1. The context of this report

This case study (report) was developed as part of the OESO Committee for Scientific and Technological Policy (CSTP) activity on 'System innovation' carried out under the auspices of the Working Party on Innovation and Technology Policy (TIP). The goal of this trajectory was a) to improve policy maker's understanding of the concept of system innovation as a tool for orienting innovation policy and decision making and b) to foster mutual learning between policy makers, researchers, business representatives based on case studies of a system innovation in specific sectors/technologies in areas such as e-mobility, sustainable building and housing, smart cities and technology platforms for health and green growth initiatives. The case studies commissioned for the project were considered as a way to learn how other countries are using concepts and policies based on system innovation thinking to meet societal challenges.
Additionally, we consider this case study as a reflexive exercise and as such, as an element of further elaboration of sustainable materials programmes/transitions in a Flemish context. That very perspective explains the handled approach of a stakeholder-supported learning history, of which some additional steps still need to be executed. In that, the present report is seen as a first tangible outcome of a work in progress and to be continued.

We handled a methodological approach of the 'learning history', a method developed by MIT (Roth and, Kleiner, 1995) in a tradition of 'organizational learning' (e.g. Roth and Senge, 1996) and action research (Argyris et al., 1985). With this method, a collective history is created, as a reflection and documentation process in which researchers and stakeholders work together as an insider/outsider team. Learning histories are meant to engage and influence readers, because of the extensive use of participants' own narratives to capture their own coherent stories about complex realities.

The current stage (and hence this report) of our learning history is to be considered as the 'Concept Learning History', developed by combining desktop research and interviews with 12 stakeholders.

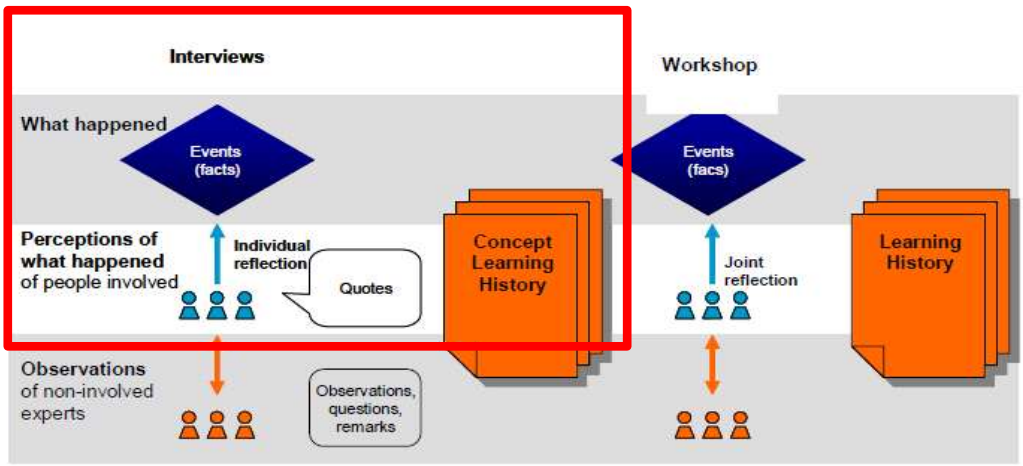


Figure 1. 'Learning history' as the overarching approach

In a next stage, a joint reflection will consolidate the findings and enrich the analysis with the combination of the different viewpoints of the stakeholders.

Studying societal/socio-technical systems is a work of co-creation; diverse perspectives on a system and its functioning not only helps the convergence towards a joint understanding; it is also a reflection of the drivers for real life systems' functioning and evolution. And as a consequence, it is quintessential when considering (steered/guided/influenced) systemic change.

2. The use of materials: is there a case for change?

2.1. The world is growing and developing

In the past centuries and decades, the overall welfare of the growing human population on planet Earth has increased, from a perspective of individuals as well as of a continuing geographic spread of human development (Figure 2). This welcome evolution was enabled by a growth of worldwide economic activities. Yet, this same growing economy was coincided by an increasing 'footprint', up to a level of resource appropriation that currently already exceeds the Earth's carrying capacity. In this context, the growing world economy has also drastically increased the demand and use of material resources (Table 1).

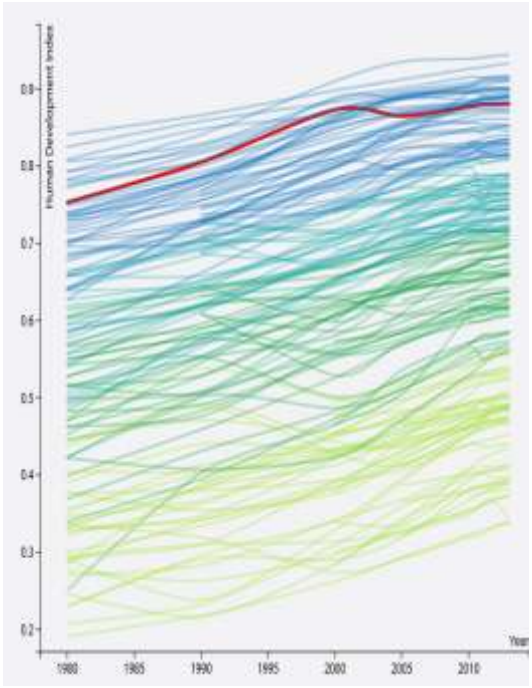


Figure 2. Evolution of the UN Human Development Index for worldwide countries (Belgium = red line)

Table 1. Indicative data on growth of materials use

World growth in consumption of principal raw materials, 1961 – 2012

Steel	Cement	Aluminum	Plastics	Wood
X 4.26	x 11.10	x9.45	x48.33	x1.60

Population growth during this period: x 2.28

Source: Data for wood from FAO (2013); for cement, steel, and aluminum;from the U.S. Geological Survey (2013); and for plastics from the Association of Plastics Manufacturers in Europe (2013).

Further envisaged evolutions will only increase the use of materials. A number of impacts resulting from this progress in resource appropriation are becoming ever more clear and tangible.

2.2. Environmental degradation

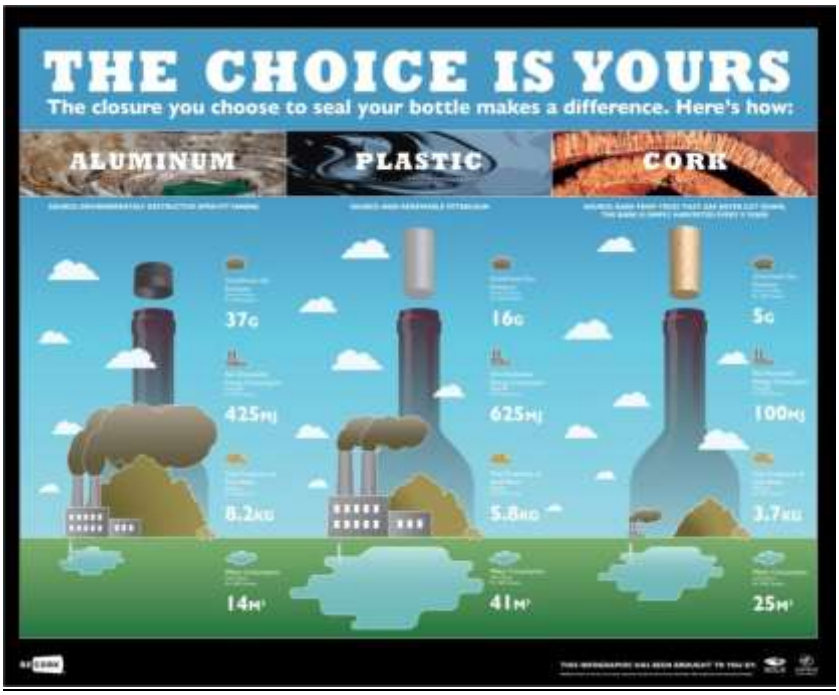


Figure 3. An illustrative message on the environmental impacts related to material resource use
Source: ASUCD EPPC

The increasing environmental impacts, caused by increased materials appropriation and exploitation, draw back on aspects of water use, energy use and coinciding greenhouse gas emissions, waste generation (Figure 3).

2.3. Scarcity is getting tangible

A number of basic material resources have a limited stock/availability; for some of them the time to depletion (at continued current extraction rates) is already within the perspective of a current human lifetime (Figure 4).

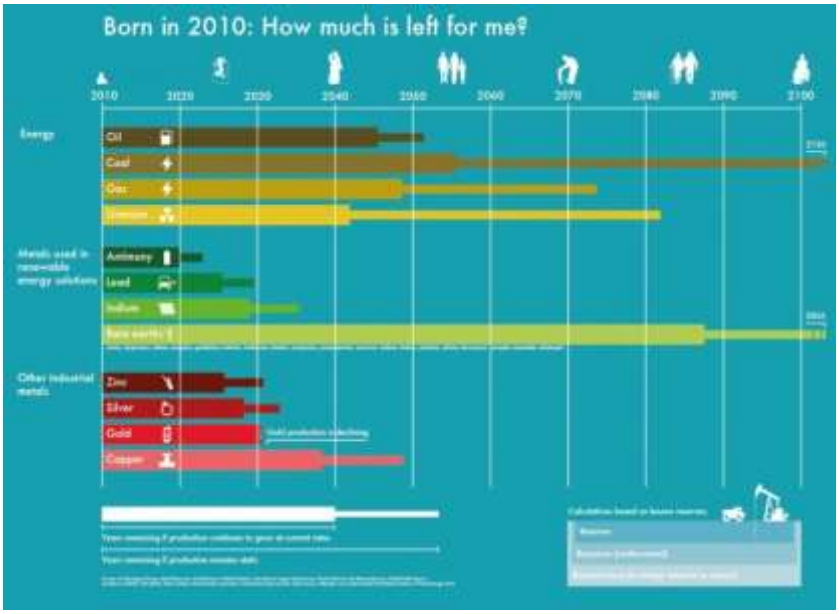


Figure 4. How much is left? Resource scarcity in a time perspective
Source: www.coolinfographics.com

The need for extracting of more difficultly recoverable ores and sources increasingly reflects in high and volatile prices (Figure 5).

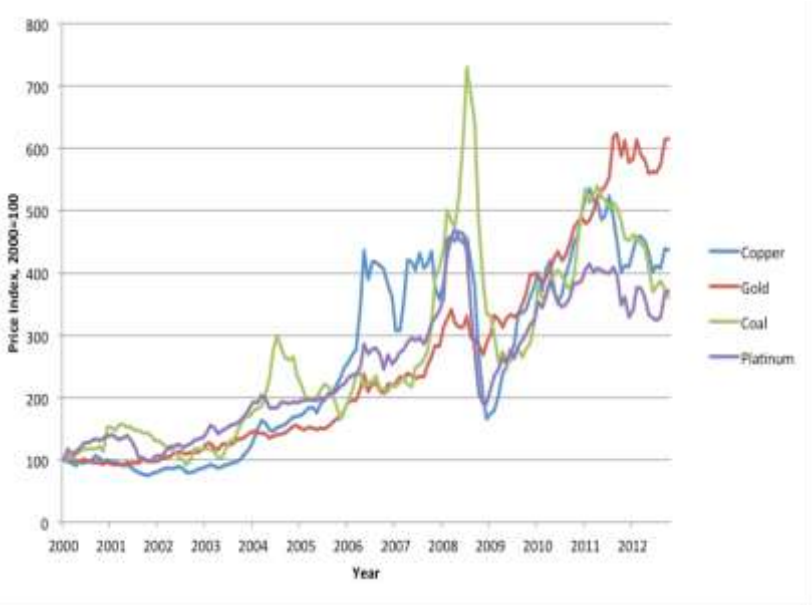


Figure 5. Evolution of indexed mineral prices, 2000-2012.
Source: World Bank

2.4. International strategic issues

Geopolitical tensions and appropriation insecurities in supply induce strategic positions with regard to remaining resource stocks and even stir up discussions and discourses in the sense of 'conflict minerals' (Figure 6). An aspect in the same range is that of the 'resource curse': the paradox that countries and regions with abundance of natural resources tend to have less economic growth and worse development outcomes than countries with fewer resources (Shao and Lang, 2014).

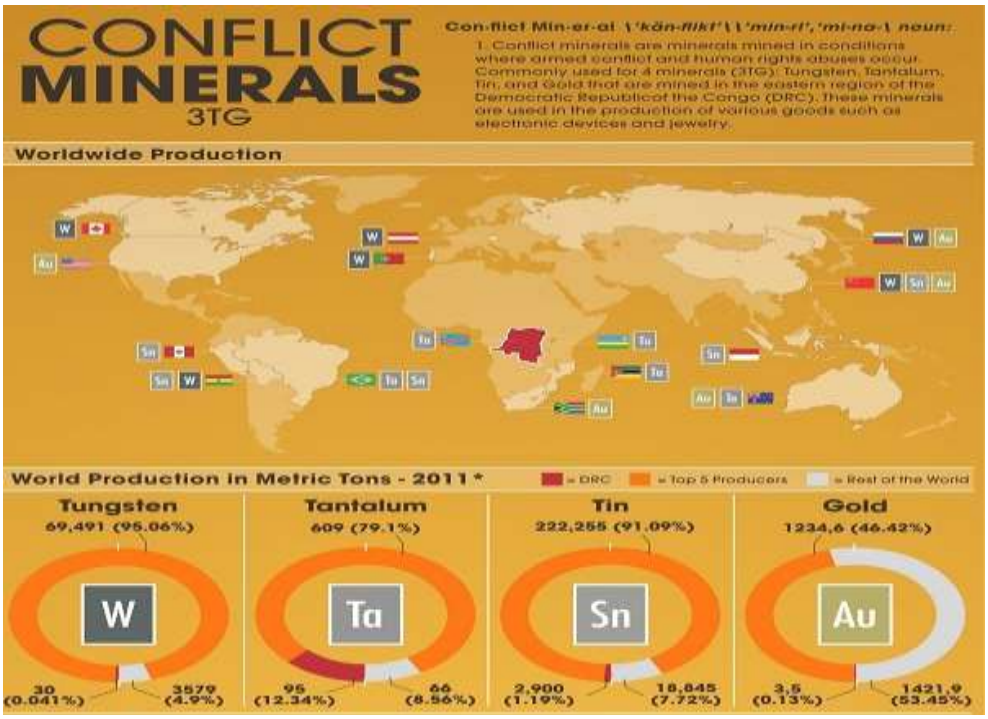


Figure 6. Materials as conflict agitators?
Source: Venkel Ltd.

2.5. A sense of urgency! Is there?

There is an increasing awareness that materials and their use in sustainable products and production processes asks for rethinking (Crabbé et al., 2013). It seems that we near an abandonment of a notion of a 'myth of superabundance' (Udall, 1963). Natural resources and their exploitation need more careful management (Holden, 2013). There is more and more dispute with regard to practices such as planned obsolescence (or built-in obsolescence) (e.g. Miao, 2011) in industrial design - a policy in which a product's useful lifetime is deliberately limited, making it unfashionable or no longer functional after a certain period of time.

It seems acknowledged that over-exploitation of natural capital goes at the cost of environmental and economic consequences. Yet, the still quite dominant dogma of blind economic growth encourages extraction and degradation of stocks that appear to be free (Dong et al., 2014). And even well intended strategies for more circular economies appear not to hold up to other preferences…

How can we turn waste into resources and jobs? How can we break our reliance on new materials? How can we re-use, re-manufacture and recycle? How can we change the way we produce and consume?
Key questions of the EU Green Week 2014 June 2014

… December 2014

There is apparently a perceived dichotomy between a greener and more circular economy and a growth inspired economy. Yet, are they as antagonistic as that? Resource efficiency might offers plenty of opportunities , also from a viewpoint of (international) competition and concurrent development of jobs (Rohn et al., 2014).

3. Why systems innovation?

3.1. It's simple: it's complex!

A prominent characteristic of the generic challenge in tackling a myriad of unsustainability symptoms in contemporary Earth societies is complexity: the multiple issues at stake relate to diverse activities and actors, combine multiple topics and functionalities and address many structures and institutions, all of them strongly interrelated and interwoven. Aspects such as the rise of networked societies may on the one hand explain the increase in wickedness of problems (Castells, 2011); on the other hand, the awareness of the 'wicked' nature (Rittel en Webber, 1973) has risen during the last decades; and with it the acknowledgement of the need for holistic approaches and systems innovation (Foley et al., 2011; Gallopin, 2003; Senge, et al., 2008; Tukker et al., 2008; Waddell et al., 2013). The dominant paradigm of mechanical, reductionist and linear solving of emergent problems – that we have been conditioned to love and accept - no longer (solely) seems to match. Something else is needed for the reality of the 'VUCA-world' we live in, characterised by volatility, uncertainty, complexity and ambiguity. Many things happen in non-linearity, based on what emerges between people, unsmooth, random and unpredictable. As such, societal settings are all about complex adaptive systems (Holland, 2006), plenty of connections and feed backs and constantly co-evolving and adapting continuously.

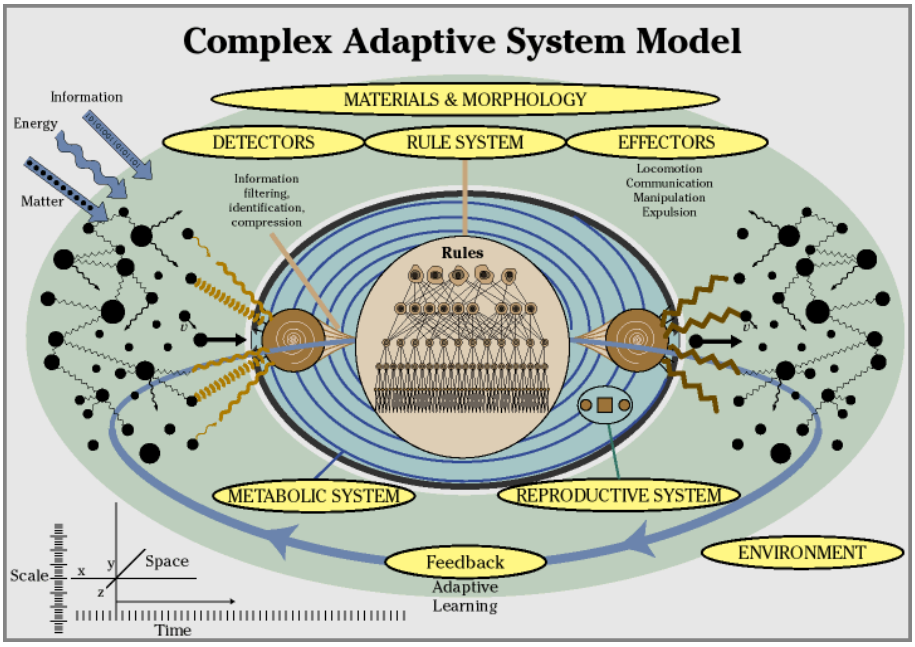


Figure 7. Complex adaptive systems…

Source: Marshall Clemens - Idiagram - NECSI

Complexity science/practice offers a way of going beyond the limits of reductionism, because it starts from an understanding that much of the world is not machine-like and comprehensible through a cataloguing of its parts; but consists instead mostly of organic and holistic systems that are difficult to comprehend by traditional (scientific) analysis (Lewin, 1999). We face a quest for the necessary shift from systematic solutions to systemic approaches.

3.2. System innovation?

Emerging system innovation discourses draw on concepts such as 'transitions' (as fundamental changes in cultures, structures and practices; Freibauer et al., 2011; Loorbach, 2007; Rotmans et al., 2001) and their governance (Grin et al., 2010). Acknowledging multiple inter-relations between multiple 'sectors' (Wallgren and Höjer, 2009). A basic precondition for systemic action is the very understanding of systems' functioning (Kalaugher et al., 2013; Soroczynski, 2002) and a concurrent development of attitude/competence of systems thinking and education of holistic professionals (Waddock, 1998).
Without any negative appreciation, a starting point of the presented work is that even when terms 'systems', 'systemic', 'systems innovation', etc. are used in research and practice, the actually considered entities keep drawing back on still limited approaches such as (e.g.) 'technological artefacts in local languages or incremental sustainable 'practices'.
Exercises in genuine systems analysis (and subsequent systemic acting) should be instrumental for some essentials of effective transition dynamics:
- mapping and relating multiple relevant issues and thereby inspiring a broader viewpoint than the one from specific 'topics' at hand (Meadows, 1994; Rotmans and Loorbach, 2009);
- making explicit the loci of conflict in and between current practices and related institutions (Van Mierlo et al., 2010);
- informing and inspiring various system scenarios, including discontinuities and surprises (Shaw et al., 1992);
- inspiring the envisioning of desired, sustainable system configurations (Rotmans and Loorbach, 2009);
- enabling skills in understanding systemic relations and concepts such as tipping points, leverages and resilience (Blackmore and Ison, 2012);
- enhancing reflexivity in system innovation projects and encouraging system(ic) learning (Van Mierlo et al., 2013).

A major 'advice' from the start: continuous reflection on the actual systemic and disruptive nature of the changes that are being questioned/envisaged is necessary; it is clear that no matter how well the intentions for sustainable and systemic change, discussions tend to slide down to contemporary concerns, organisations, stakes, very specific problems… and immediate 'cures'.

4. Studying the case: methodological grips

4.1.Transition thinking

A major conceptual framework that shores up the study at hand is the one of transitions and their 'management'. Transitions are societal processes of fundamental change in culture, structure and practices. In that context, transition management is a governance approach that includes a portfolio of tools that have as a common objective to enable change in practices and structures (institutions) directed towards sustainable development targets (Frantzeskaki et al., 2012). Transition management can be described as a deliberative process to influence governing activities in such a way that they enable societal processes of change towards sustainability (Loorbach, 2007). It is thus defined as a new process-based technique that raises the following issue: how do we coordinate, bring together and influence actors and their activities in such a way that they reinforce each other to such an extent that they can compete with dominant actors and practices (Frantzeskaki et al., 2011). Transition Management process methodology includes a combination of mutually reinforcing steps and associated activities that should enable the understanding and whenever possible steering/guiding/facilitating of systemic innovations towards sustainability (Figure 8):

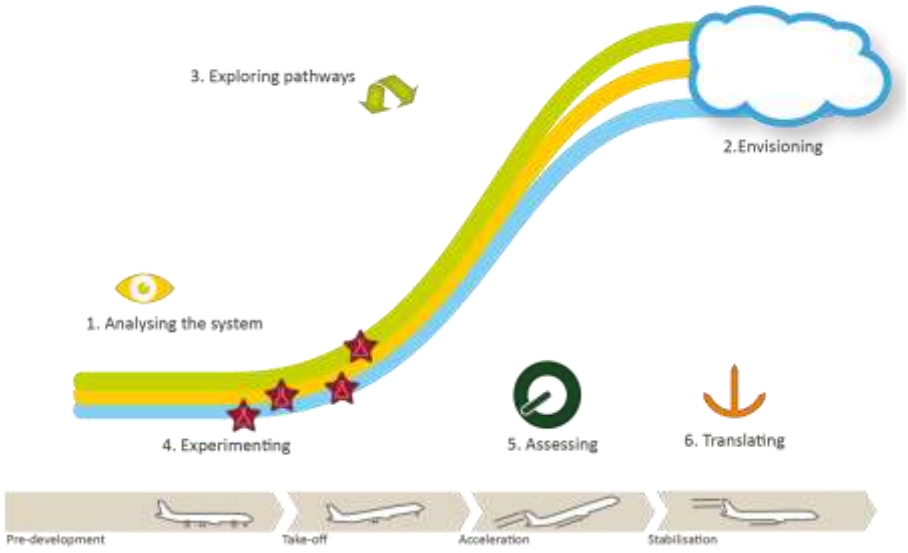


Figure 8. A pragmatic framework for sustainability oriented transitions
Source: Nevens et al., 2012

a) Analysing the system

A first step in changing a system is getting to know it; a systems analysis is a method to attain an overview and integrated perspective of the system under study. Determining the relevant players and their interrelations, the key system functions, formal and informal institutions are the elements of a comprehensive system description and outline. A balanced mix of quantitative data (statistics, historical data) and qualitative information (about values and norms, stakeholders, interrelations, routines, power and empowerment) are needed for a comprehensive understanding of the considered system. An instrumental system analysis stimulates an integral (holistic) thinking and a long-term perspective. It provides actors with a systematic mapping of the situation and problem that can enable them to look beyond their own expertise and perspectives and to understand the interconnectedness of the system(s).

b) Envisioning

A change trajectory towards a more sustainable society can be initiated by an appealing and inspiring vision. A vision entails images and a narrative of desirable systems based on shared principles of sustainable development. Coherent visions provide long-term orientation and guidance (Quist, 2007; Farley and Costanza, 2002), mobilize support and enrol resources for the subsequent phases of a transition management cycle (Van der Helm, 2009; Smith and Stirling, 2008). A vision connects and commits actors with different backgrounds and stakes (Smith et al., 2005). A process of imaginary scenario building (envisioning) is employed to create a vision by engaging community and local change agents (Newman and Jennings, 2008, p.4-5; Nevens et al., 2008).

c) Exploring pathways

Starting from an inspiring vision, different strategies on how to realise the desired future situation can be outlined. This backcasting exercise (Lovins, 1976; Robinson et al., 2011; Dreborg, 1996) results in different strategic transition pathways that include the actions that will progressively build-up in pursuing the desired vision. Backcasting breaks down the long-term sense of direction into mid- and short-term targets and actions. In this way, backcasting allows negotiations and sharing of prioritization of the pathways in a participative way (Holmberg, 1998; Kanyama et al., 2007).

d) Experimenting

Defined as ‘practical experiments with a high level of risk (in terms of failure) that can make potentially large contribution to a transition process’ (Rotmans, 2005), transition-experiments are real-life developments of drastically alternative ways of working and/or thinking, fitting into envisaged new system approaches. Such experiments link an established future vision with action potential and hence can me major triggers to enable take-off and acceleration of transition. Through a series of 'transition experiments' in different niches, social innovations can be improved and eventually replace dominant practices (Raven et al., 2010). Transition experiments are characterised by (a) their connection to a societal challenge, (b) illustrating a radical change of practices and/or culture and/or structures and (c) their inherent relation to learning (as an interactive process of obtaining new knowledge, competences or norms and values) (Van den Bosch, 2010; Van Buuren and Loorbach, 2009). Vreugdenhil et al. (2012) argue that transition experiments are designed to be and deliver innovative practices, have a strong knowledge orientation (produce knowledge and assist learning), require an open and inclusive governance context to be initiated and can be employed to provide feedback to policy-making and to an innovation process. Genuine transition experiments are conducted in a real-life societal context and involve multi-actor alliances (including private or public organisations, end-users, researchers, government, consultants, etc.).

e) Assessing

During the course of the different trajectories towards the envisaged future system, instruments can be designed for an effective follow-up of actions that are undertaken. These instruments can and should be based on the same principles that were employed to envision the future. Products, processes, and technologies can all be the subject of different types of monitoring and assessment, examining their compliance with the diverse sustainability criteria of the new systems. Methods based on indicators (whether or not merged into an index), cycle assessments, multi-criteria analyses can all fit into assessment toolboxes. Also in a city context, assessment tools enable comparison of municipalities and urban areas, and supports decision-making processes (Tanguay et al., 2010). Therefore, just as important as the tools themselves, is their effective use; monitoring instruments are not designed to ‘measure’ but to trigger action, to enhance system change in a desired direction. This type of transition monitoring focuses on the transition process itself and involves measuring the modulation of slow macro-level changes up to faster micro-level changes, from niche emergence to regime resilience (Grin et al., 2010). A key question is the final interest of assessing and certifying tools: genuine interest in sustainable urban development or mere profiling and benefiting (‘Green washing’) (Haapio, 2012).

A second aspect is the monitoring of the transition management process, involving the follow-up and reflection on all actions, events, policies and strategies that influence the transition in question; and hence feed a process of social learning, which is a prerequisite for eventual success.

f) Translating

In order to actually initiate system change, experiences from the different typical transition activities have to be incorporated and multiplied in actions of the relevant system stakeholders, varying from policy and legal changes to new corporate strategies, citizen behaviour. In that way, the lessons learned from experiments, backcasting or scenario and envisioning efforts result in an effective dynamic process of change. Thereby, ‘stakeholders’ includes governments, industry, consumers, researchers, entrepreneurs, and the more. By translating the lessons learned into change-inducing actions, the whole system is incrementally displaced (‘transitionised’ or transformed), closer to a dynamic sustainable equilibrium (Nevens et al., 2012).

4.2. System analysis devices

In the presented case study on system innovation, we applied two supporting heuristic 'devices' that help structuring and representing societal 'systems' from a historical, present and desired future viewpoint and configuration.

4.2.1. The transition theory multi-level perspective

The transition theory multi-level perspective basically assumes that a societal system's functioning develops/changes as a co-evolution of events at landscape, regime and niche level; this multi-level perspective was used before in studies on transitions for sustainable material innovation (Crabbé et al., 2013)

The theory of sustainability transitions (Grin et al., 2010), assumes that transformative changes of societal systems develop as a co-evolution and acceleration of dynamics at such different scales; within this 'multi-level perspective' (MLP; Rip and Kemp, 1998; Schot, 1998; Geels, 2002; Geels and Schot, 2007), the following elements are considered (Figure 9):

- on a 'landscape' level, major gradients of force are in play: dominant, exogenous trends and developments exert different kinds of pressure on the ruling systems, and trigger a sense of urgency (Bindraban and Rabbinge, 2012);

- 'regime' indicates the dominant cultures, structures and practices that establish the 'incumbent' system's functioning. Lock-in, inertia and path dependencies (Hagelskjaer Lauridsen and Stissing Jensen, 2013) are elements of the typical rigidity that prevents from altering the regime fundamentally; in fact, the capability of (temporarily) response to changing external drivers and internal processes allows the regime to survive within it's safe stability domain (Folke et al., 2010);

- 'niches' are loci where radical and systemic novelties emerge, by co-evolution of entrepreneurial impulses and in heterogeneous networks (Garud and Karnøe, 2001). Essentially they are embryonic societal systems of which the culture, structures and activities clearly deflect from those of the incumbent system (Raven et al., 2010). Often, niches develop from radically innovative transition 'experiments' (Brown and Vergragt, 2008; van den Bosch, 2010).

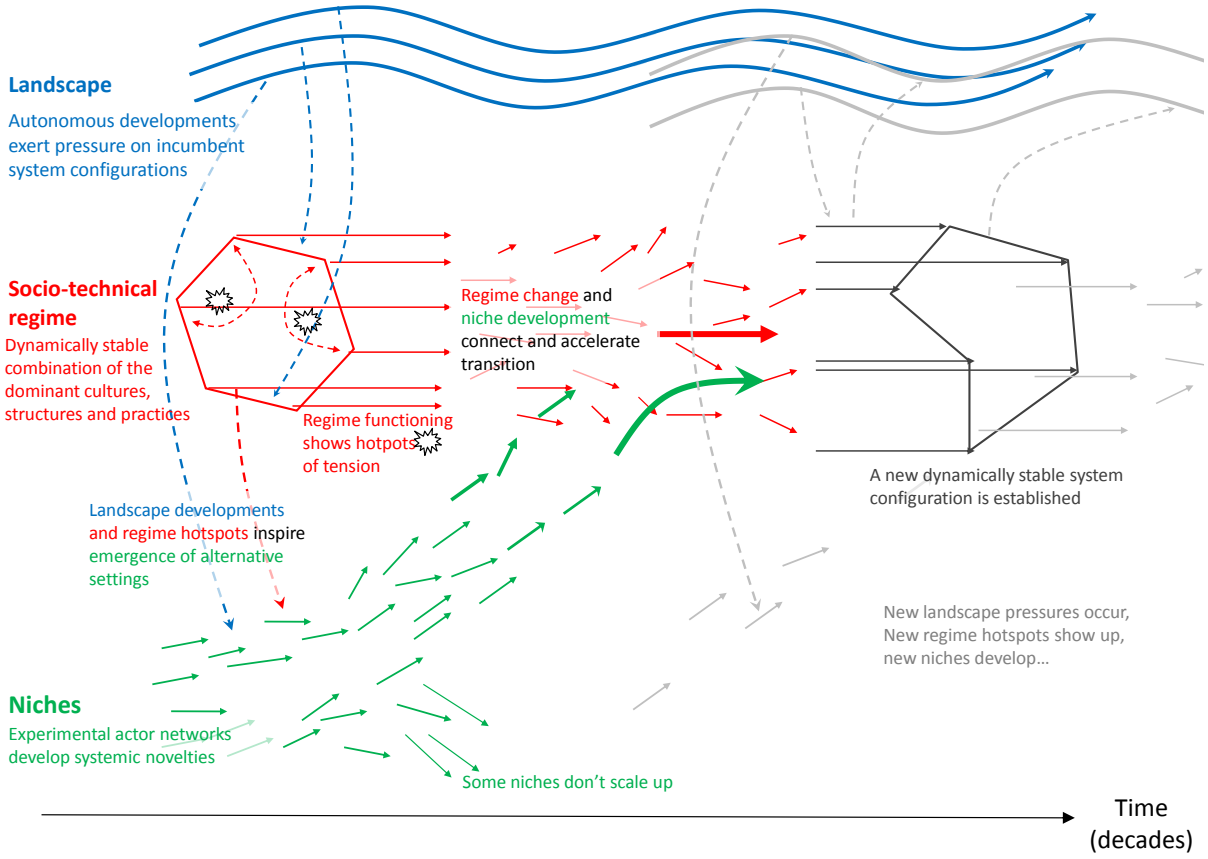


Figure 9. The dynamic multi-level perspective of transition theory
(own interpretation inspired by Geels and Schot, 2007)

4.2.2. Causal loop diagrams

Visual models incorporate major potential to capture inherent systems complexity to a level that allows for the enlightenment of tensions, trade-offs, leverages and intervention options; for that supporting capacity of articulating systems' architecture and functioning, visuals are frequently deployed as a typical 'language' for system description and analysis (Checkland and Scholes, 1990; Kim, 1995; Senge, 1994). Diagram-like devices reduce endless complexities to manageable simplicities with focus on the essential issues while avoiding endless searches for more details while drowning in ever proliferating useless information (Pagani and Otto, 2012). An often used format is the causal loop diagram or influence diagram (Coyle, 2000; Kirkwood, 1998) , which originates from the field of system dynamics (Forrester, 1958) and has proven to enable a workable externalization of mental models (Wolstenholme, 1999). In the systems analysis we present, we deployed a causal loop diagram that represents the dominant system configuration ('regime in the MLP) was annotated by a generic metaphor and a number of 'hotspots', indicating major issues/loci of tension in the currently dominant system configuration. In the following sections, we represent the systems analysis in the format of the MLP and causal loops; in a more elaborate version, the diverse elements are illustrated (whenever possible) by numerical data/timelines (Mathijs et al., 2013). Causal loop diagrams allow a condense representation of the elements, interrelations and mechanisms that explain the dominant functioning of a specific system; accompanied by a narrative that clarifies the type and the roles of actors, the underlying discourses, mental models and driving values as well as elements of power and other tacit or intangible factors that co-determine a system's actual functioning.

4.2.3. …in a timeline perspective

To establish our case study, we employed these devices into a 'learning history' trajectory: based on two 'archetype system configurations (a historical one and a desired future), key stakeholders were interviewed, allowing us to adapt/enrich the system archetypes and narratives. A next, envisaged step is to converge the diverse inputs and combine/confront them in a joined discussion with all the previously interviewed stakeholders (work in progress).

Surely, there is no one silver bullet methodology to describe systems and to initiate systemic thinking and systemic solution development. Therefore, choices with regards to methods are very often pragmatic and fitting into a practice that resembles more to craft work than to 'exact science'. Most important is an attitude of purpose before method: as long as actual systemic thinking is reinforced, the methodological choice is of second order.

5. Results

5.1. The system at stake

Delineating a system is an oxymoron: drawing 'borders' inevitably cuts of parts of larger systemic coherence. It's essential to find an equilibrium between parsimony and sufficiency: embracing as much simplicity as possible and as much complexity as necessary.

We studied the 'waste and materials system', as it shows in Flanders, but of course taking into account the transnational context and dimensions in which the relevant matters take place. This case is considered rich enough to document and inspire learning with regards to:

- encountered challenges of sustainable development;
- envisaged need for multi-scale, multi-level, multi-actor and multi-function change;
- interconnectedness with other 'sectors';
- historical development/transition of the system;
- substantial -past and future- policy involvement;
- high societal benefits as well as business opportunities.

To purify the rationale that we build, we chose to describe and study this waste and material system based on two system 'archetypes':

- a 1970's linear system of 'take-make-use-discharge', producing waste;
- a desired 2050's 'circular' system, using materials in closed loops.

We position the current situation (2010 as symbolic 'midterm' point) on this timeline: looking back on what has already happened since the 70's and what is needed to evolve towards a desired 'leitbild' of a sustainable system configuration.

5.2. In hindsight: from waste to recycling (1970 – 2010)

5.2.1. The 1970's system archetype (v1.1)

The 1970 starting point illustrates a linear system model that, supported by evolution of (technological) intellect and inspired by a credo of economic growth and material consumption, allowed for effective progress and of individual welfare. A major consequence of this consumption encouraging system was a drastically growing amount of waste per capita (Figure 10).

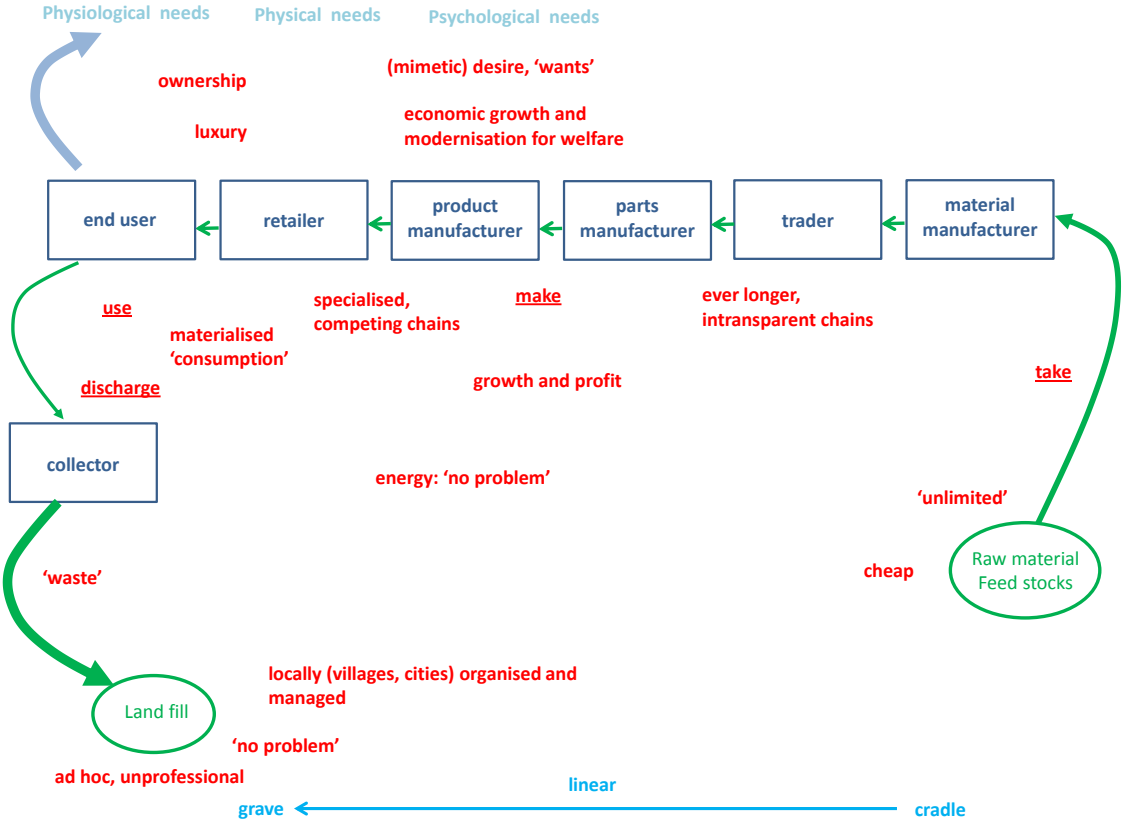


Figure 10. The 1970s archetype: a linear take-make-use-discharge system. In red: the typical discourse vocabulary.

Increasingly, this linear system experienced pressure:

Landscape scale: EU concerns about pollution, translated in obligations for member states with regards to waste management (most dominantly pronounced in the 1975 EU Waste Directive), worldwide environment-related events and initiatives stirring up a growing public awareness (e.g. 1971 Club of Rome Report; 1986 Tjernobil nuclear disaster; 1987 Our common Future, etc.)

Regime level: rising amounts of waste (typically land filled on municipal scale, unprofessionally organised) in confrontation with limited landfill space and/or processing capacity; increasingly tangible side effects of odour and toxicity.

Niche level: local environmentalist actions against polluting and health threatening waste infrastructures and practices.

5.2.2. Dealing with 'waste' (1980…)

The pressures on the incumbent system initiated a response that was predominantly anchored in the assignment of a newly established Flemish 'state' actor. Although initially retarded by political and state reform struggles, the Flemish Public Waste Agency (OVAM, °1981) got the legally embedded assignment to prevent and manage waste. In a first movement to create order of the existing chaos, (legal) instruments such as reporting duties, environmental permits and landfill bans were developed and deployed to optimise waste removal and processing. At the same time, collaboration of the government with industry was initiated, in particular for the management of industrial waste streams. In this way, a genuine 'waste sector' was gradually institutionalised. Further on, landfill and incineration levies were introduced to discourage waste disposal. Intensive sensitising of Flemish inhabitants with regards to the issue was focussed on sorting and recycling of waste, a practice in which citizens could actually engage, aided by a system of selected waste collection at home and the establishment of municipality container parks for selective waste fraction collection. At the same time, the selective collection system also instigated in Flemish citizens a certain culture of consciousness with regard to waste generation. The recycling practice was also reinforced by '(extended) producer responsibility', a government imposed approach that obliges producers to accept (products) or take back (packaging) end-of-life products and as such makes producers accountable for their products even beyond the phase of 'end-use'. This assignment is commonly complied with by sector/specific waste-oriented plans, covenants and agreements with the government, resulting in selective collection channels; paid for by producers, yet discounted in the consumer's product price. As such, a well organised industry could be organised. In parallel with the recycling track, a policy was conducted to minimise land filling and to put incineration (later on with energy recovery) central for residual waste processing.

Measurable indicators illustrate the run of this initial change trajectory (Figure 11): in an almost archetypical transition S-curve, a switch was made from a residual waste system to a selective collection and recycling system, a process that took about 20 to 30 years. Compared to an overall EU situation, this happened at high pace and hence Flanders is acknowledged as a frontrunner in waste management.

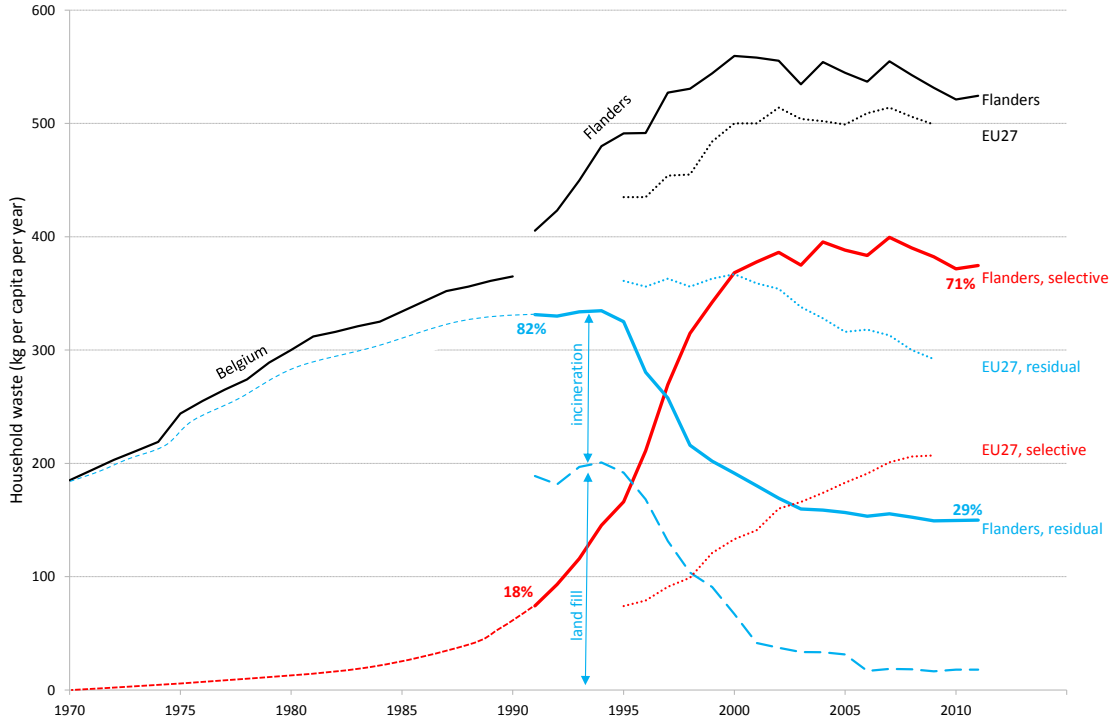


Figure 11. 1970 – 2010: selective household waste collection shifts the system towards 'recycling'
Data sources: VMM, OVAM

5.2.3. ... and establishing a system v1.2

During and in spite of the switch to a 'recycling system' (Figure 12), the total amount of household waste continued to rise. Apparently, the pull of rising welfare and its close connection with material consumption persisted and possibly even reinforced this major trigger of material intense production and consumption processes. Opinions are there saying that the 'good report on recycling' might have caused a reassuring contentment of being sustainable/environmentally friendly and hence did not (yet) trigger incentives at the highest rungs of the Lansink waste/materials hierarchy (*prevention, re-use*, recycling, energy, incineration, land fill). In fact, it looks like the first steps that were taken, away from the linear land fill waste dominated system were still the least preferable on that very materials hierarchy. An important aspect of this move is that a renewed system was established in which a waste industry developed, firmly anchored by own legislation, (infra)structures and business models; which can be regarded as a new (niche)-regime that has its typical assets of self-preservation, inertia and resistance to change (e.g. with regards to initiatives in relation to re-use; see later). On the other hand, and organically grown during the 30 preceding years, the by now 'normal' selection culture, experience and volumes were/are considered as a major potential (local) trump to kick start from towards a future, more sustainable (and worldwide) system. In particular with regards to the consumer/citizen, selective collection entailed a mental switch towards more consciousness about waste. As such, the trajectory is also considered as a 'pedagogical' process that established a mental shift that could be very important for further steps towards even more sustainable systems, in which the role of consumers/citizens is ever increasingly emphasized.
One might say that this first move boiled down to operationally (and successfully) tackling an impact related problem (landfill waste) by a governmental actor using rather classic instruments; yet, without a prominent long term vision nor much co-creative solution development. In that, it can be considered as only a first step towards genuine system innovation; major mechanisms of the initial archetype remained in place or were even reinforced (cf. total household waste increased and later on stabled at still high levels, economic growth and waste/materials used remained coupled).

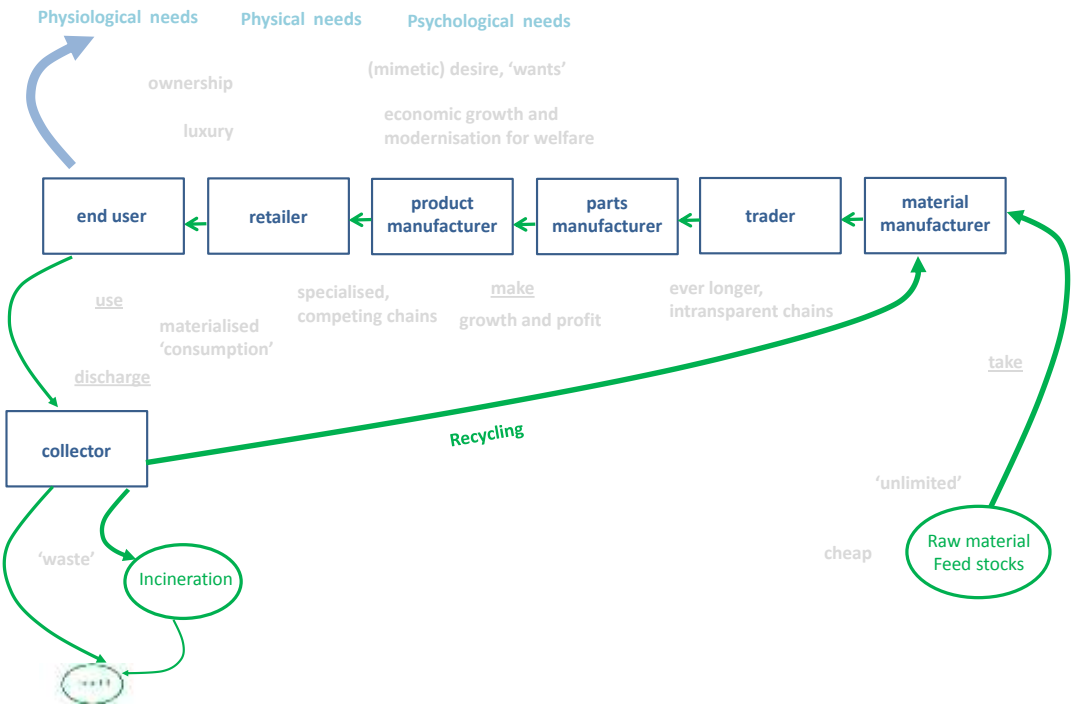


Figure 12. The 2010 system: v1.2., 'recycling' as a modified version of the initial archetype

5.2.4. The future comes in sight

In the context of a more and more pronounced sustainability discourse, inspired by (e.g.) the 2002 Johannesburg Summit on Sustainable Development, the issue of a sustainable use of materials from an holistic and integrated point of view gradually developed in the early years of the 21st century. This evolution was reinforced by a number of inter-linked pressures on the evolved system:

Landscape scale: the rising world population and its concurrent increase in welfare levels by material consumption entails an ever growing awareness and reality of the scarcity of a number of essential resources, for many of which we (EU) are strongly geographically dependent. This materials scarcity is closely intertwined with peak oil and climate change concerns in the energy system, with the limited availability of space on Earth and its desirable use for different purposes (cf. food-feed-fuel-fibre-dilemmas). Events like the Rio +20 hindsight nurture a feeling of having made but few genuine progress with regards to sustainability issues.
Regime level: businesses that depend on material resources experience price increases and high volatilities and hence uncertainty about future supply increases. Material intensive industrial sectors do not longer flourish in our regions. Certainly from a EU perspective, the amounts of generated waste are still higher than some decades ago and they do not actually decline.
Niche level: multiple and diverse initiatives emerge in which new concepts of dealing with material use and consumption are explored: sharing communities, re-use circuits, product service systems, etc. Also in production businesses, concepts like Cradle-to-Cradle find fruitful soil in front running companies.

In that context of more systemic challenges of sustainability, and in Flanders, a number of front running policy officers got acquainted with the emerging theory and practice of 'transitions' and 'transition management'. They embodied what might be called policy entrepreneurs that enabled themselves and/or were enabled to engage in 'entrepreneurial discovery' that targeted content as well as institutional innovation. Within their own policy-organisation(s) they succeeded to create 'niche-space' to experiment with the transition/system innovation approach. In the case of OVAM, a 'Plan C' transition trajectory was develop since 2006, as a self-organising network that inspires radical innovation in the waste and materials system. The involved and diverse group of stakeholders developed a long term vision of a sustainable system with closed material loops, aided by smart (infra)structures, renewable, multifunctional and flexible materials and components, tailor-made production technologies, product service business models and conscious consumers. It is generally acknowledged that this vision played a decisive role in the shift from a waste to a materials discourse. As a network, Plan C strived for a broker and incubator function for innovation trajectories. From 2009 onwards, the role of the Plan C arena diminished, owing to frantic attempts to structure the initiative, finding funds and deploy 'labelled' projects; elements that were opposite to the initially intended innovative and informal approach with a rather minimal structure and building on shared ambition and engagement.
At the same time, other evolutions reinforced a catch up of more actors with the conceptual and long term leitbild of Plan C: the EU resource efficiency strategy and the ever more tangibles from the real world landscape (resource availability and prices). At the same time, a growing number of front running companies embraced sustainable materials use as a corporate strategy, based on economic reasons but just as well starting from leadership and intrinsic motivation for socially and environmentally more acceptable/justifiable business models.

Create policy-niches for policy-entrepreneurs (recognise them and/or recruit them); allow experimenting and guts, allow 'failure' as an asset to learn; create space for creativity. Be aware of the potentially negative effects of structuring/institutionalising niche/experiential space too quickly.

5.2.5. In foresight: up to a circular economy as the new system archetype (v.2.0.)

Inspired by vision-type processes in Flanders and abroad, an image/narrative on a desired future system of connected, closed and lean material loops is boiling down, fitting a generic discourse of a 'circular economy' (Figure 12). Going beyond the initial shift towards 'recycling' (with a connotation that recycled means 'not lost', yet still a lot of products are produced from virgin materials), this new setting represents systemic change:

- drawing back on the very essential function/purpose of the system: addressing human behaviour for fulfilling needs (not necessarily 'wants') and the yes-or-no necessity of (possession of) material 'stuff' to do this;
- re-designing a linear process of take-make-use-discharge into a more networked and circular setting in which diverse and smart connections and short-cutting practices support efficiency, sufficiency and resilience;
- including major principles such as no waste and full recycling of material resources;
- holding opportunities for successful yet radically innovative value creation and hence economy; without catastrophe or welfare loss.

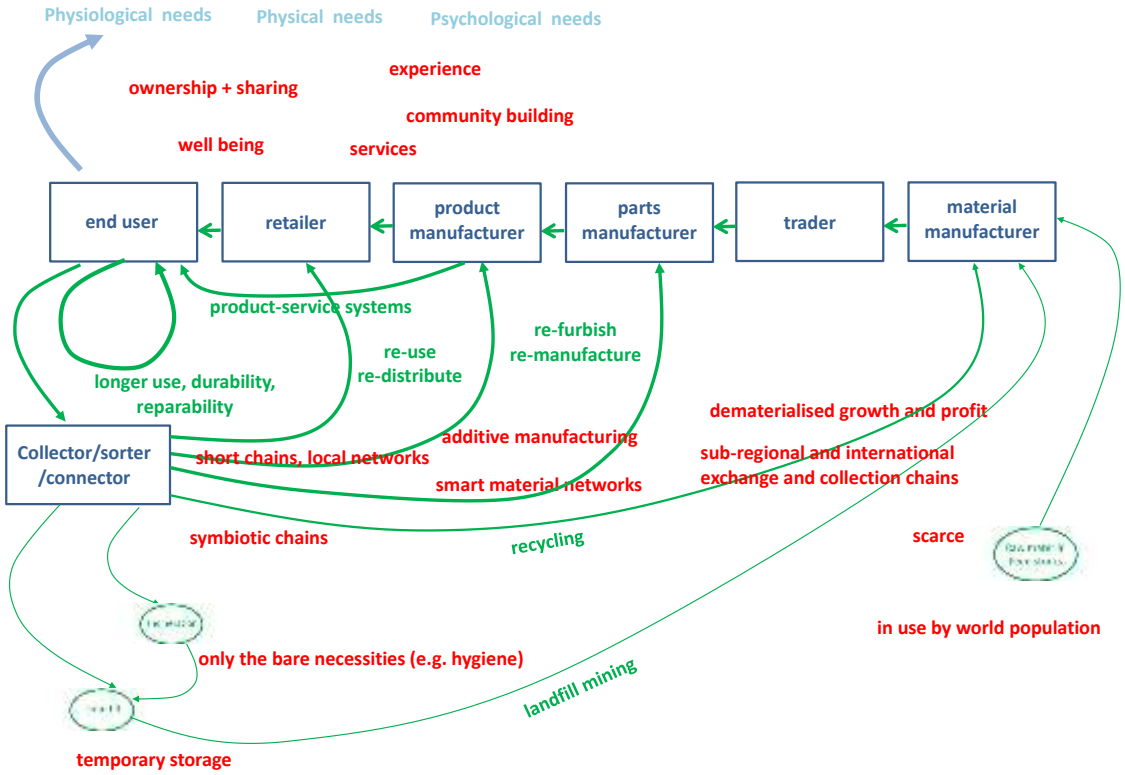


Figure 12. The 2050s system archetype: a circular economy system. In red: the typical discourse vocabulary.

6. Critical success factors to innovate the system

Medio 2011, Flemish government decided to embrace 'Sustainable Materials' as a spearhead policy related to the major societal challenges of the region. Legislatively anchored by the Flemish Material Decree and in an explicit discourse of transition (management), the Flemish Materials Programme should be a unique approach that connects policy, industry, science and civil society to steer a coherent programme, establish an agenda and collaborate on the necessary actions. The ultimate ambition of co-creating a circular economy translates in three pillars of a) long term vision and disruptive experiments, b) policy research and c) an agenda of 45 actions.
In order to establish the desirable/desired circular system, there is agreement that more disruptive changes will be needed. The simple tools are used out (landfill bans, producer responsibility…), the 'usual' set of instruments alone will not suffice. And although there is no single silver bullet solution/methodology, a coherent combination of multiple strategies/attitudes/roles seems indispensable:

- **connecting** different levels reinforces and accelerates, hence combine bottom-up and top-down initiatives: transitions are not 'started' at a high level, they as well emerge in societal undercurrents; grass root initiative should be recognised, acknowledged and included in a broader story;

- establish a coherent, inspiring and positive image/narrative of future opportunities, 'brand' a **vision** process towards an appealing circular economy; develop and communicate concrete, exemplary 'icon' initiatives/opportunities;

- redefine organisations with regard to their future roles/functions (organisational survival is no objective) and consequently derive structures and intra- and extra-organisation orientations; there will be specific need for roles that boil down to connection, brokerage, communication and facilitation;

- connect different actors into pro-active and collaborative platforms that design whole-chain logics and opportunities; find and/or educate competent 'brokers' that are able to detect and connect people, knowledge and elements of solutions;

- make a coherent combination of local/regional focus areas (e.g. product service approaches, 3D printing, re-use, sharing…) and 'cross-border focus areas (establishing clustered streams for efficient and/or complex recycling businesses);

- deploy **appreciative inquiry** for 'individual' initiatives (in business, civil, policy, science…) that embody systemic change and that work; detect and welcome new-comers with good ideas (not solely vested players that renew/innovate themselves);

- inspire and support creative, new value creation models that can be translated in sustainable business models/logics; empower specific actors to detect existing 'good practices' and to bring them tailor made to potential 'followers';

- recognise and give visibility to business leadership in sharing systems, product service models, re-use, re-distribution…

- establish **demonstrators/pilots** and give them visibility; make demonstrators out of initiatives that emerge 'en cours de route';

- don't over-regulate, learn to let go of; too much regulations hinder genuine innovation;

- work towards transversal policy, going beyond noncommittal interdepartmental consultation and towards genuine inter- and transdisciplinary co-creation; allow for policy entrepreneurship on that matter; a same

logic counts for industry, in getting over sectorial boundaries and in considering whole-chain and cross chain symbiosis;

- enrich science with roles of actor connection, actual participation (action research) and triggering profound reflection (asking the right questions, inspiring systemic thought and action); thereby also appreciating and valuing the more intangible, subtle outcomes that draw back on social processes, mind-sets, etc.
- use well informed communication to stir up the sense of urgency, yet at the same time illustrating the attractiveness and opportunities of creating a more sustainable system;

- integrate sustainable societal system configurations in **education and training** since younger generations tend to be more open to new patterns and since changing mental models takes time; let younger generations inspire the 'old' ones and not always the other way round, as is now often the case;

- peer-to-peer communities and bottom up revolutions aided by e-platforms are expected to play a major role in new paradigms of de-centralised power and agency; use the tacit and practical knowledge that is inside them and the transformative potential that they represent;

- enrich operational progress and tangible results with **reflexive monitoring** on the very essences of the grand challenges and of the envisioned systemic changes;

- identify transformative leadership and allow it to stimulate organisation transcending collaborations and entrepreneurship;

- learn not to eliminate uncertainty and complexity, yet learn how to deal with it; allow failure;

- focus on those assets for which a strong position is already acquired; look for good collaboration elsewhere.

An essential element that counts for of all of these elements is consistency: the 'strategies' mentioned typically take ample time to get established in settings that anchor in the necessary trust, comprehension and willingness. They are build up with patience, belief, perseverance and most often there is a great deal of (intangible) social capital behind them. Sudden break offs in policy strategies (e.g.) can cause these fragile constructions to fall behind or even collapse; causing the previous investments to lose a significant part of their potential benefits.

7. ‘Co’ is key: acting in a system’s perspective is co-creating

It is clear that this collection of assets needed for systemic and disruptive change itself disrupts a classic ‘iron triangle’ approach of (technological and economic) innovation (Figure 13).

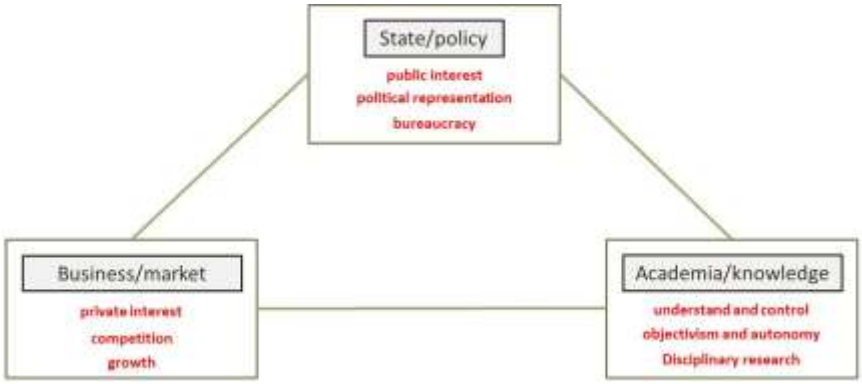


Figure 13. The ‘iron triangle’/’triple helix’: no longer the sole innovation model…

In fact, besides the explicit inclusion of civil society (organisations) and citizens as actors, it also illustrates that a strict delineation of roles and functions no longer prevails. Systemic change asks for systemic approaches, in which connection and collaboration in a societal pentagon are key (Figure 14). In that, it is a challenge for each of the actors (also policy) to act from a position within the system and to genuinely participate in the processes, rather than playing a more ‘exogenous’ role and deploying exogenous leverages. Effective/successful collaborations are those in which the collaborators show genuine engagement i.e. they mobilise resources (not solely financial ones). Additionally, the new kinds of systemic multi-actor settings no longer solely deal with rather linear ‘transaction’ logics between the partners but they adhere to a more co-creation model with concurrent contribution *and* access/use issues.

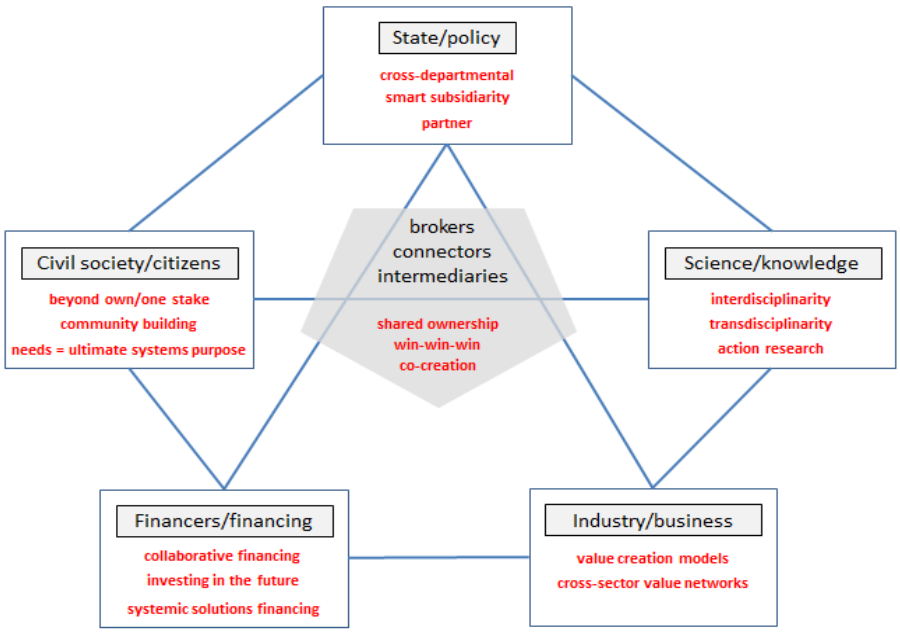
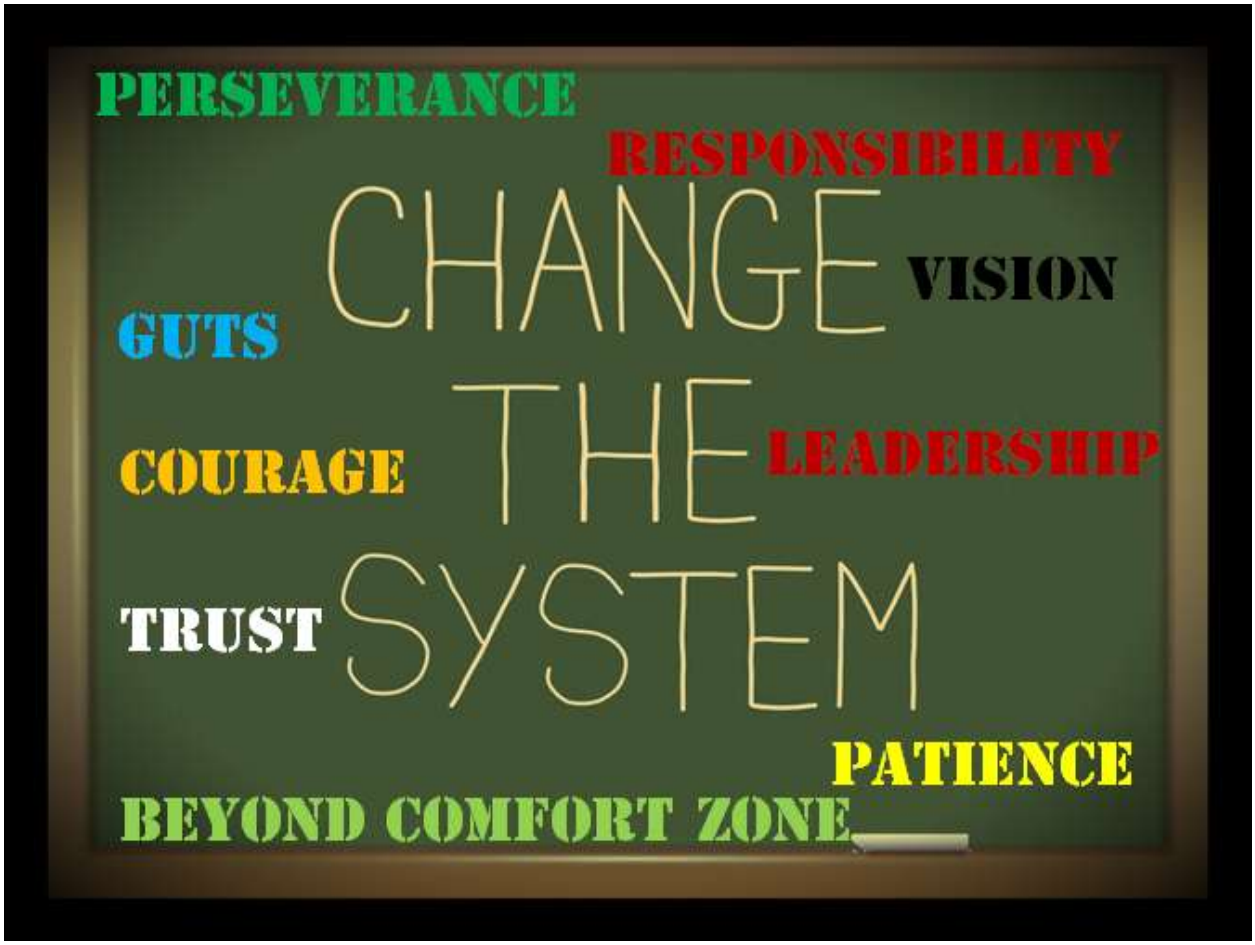


Figure 14. The societal pentagon: a lens for looking at actors and their roles for system innovations/ sustainability transitions.

8. Putting some things into perspective

- It is clear that we need to accept a natural and inherent dose of randomness when studying and tackling system innovations and transitions: there is no such thing as a smooth S-curved transition trajectory; a system doesn't exactly and predictably work in the way that diagrams depicture; not all relevant aspects can be categorised in landscape-regime-niche discourses…
- System innovations or transitions cannot be 'managed' in a classic connotation of command and control, at the very best they can be more or less understood and based on that understanding be guided, steered, influenced. The most important however is to establish a culture/mindset of systemic thinking or transition thinking, that nurtures an legitimate experimenting climate that copes with the issues of uncertainty and complexity.
- Working on systems innovations is a matter of learning: a) because we are typically not used of tackling that kind of change or innovation and b) because the paradigm of learning-by-doing and doing-by-learning is an inherent precondition for successful trajectories.



References

Argyris, C. Putnam, R. & Smith, D. 1985. Action Science: Concepts, methods and skills for research and intervention. San Francisco: Jossey-Bass.

Bindraban, P. , Rabbinge, R., 2012. Megatrends in agriculture – Views for discontinuities in past and future developments. Glob. Food Secur. 1, 99-105.

Blackmore, C., Ison, R., 2012. Designing and developing learning systems for managing systemic change in a climate change world, in: Wals, A., Blaze Corcoran, P. (Eds.), Learning for sustainability in times of accelerating change. Wageningen Academic Publishers, The Netherlands, pp. 347-363.

Brown, H., Vergragt, P., 2008. Bounded socio-technical experiments as agents of systemic change: the case of a zero-energy residential building. Technol. Forecast. Soc. 75, 107-130.

Castells, M., 2011. The rise of the network society: The information age: Economy, society, and culture (Vol. 1). Wiley. com.

Checkland, P., Scholes,P., 1990. Soft Systems Methodology in Action. John Wiley & Sons Ltd, Chicester,UK.

Coyle, G., 2000. Qualitative and quantitative modelling in system dynamics: some research questions. Syst. Dynam. Rev. 16, 225-243.

Crabbé,A., Jacobs, R., Van Hoof,V., Bergmans,A., Van Acker,K., 2013. Transition towards sustainable material innovation: eveidence and evaluation of the Flemish case. Journal of Cleaner Production 56, 63 – 72.

Dong,X., Yu,B., Brown, M., Zhang,M., Jin,Y., Zhang,X., Ulgiati,S., 2014. Environmental and economic consequences of the overexploitation of natural capital and ecosystem services in Xilinguole League, China. Energy Policy 67, 767 – 780.

Dreborg, K.H., 1996. Essence of back casting. Futures 28: 813–828.

Farley, J., Costanza, R., 2002. Envisioning shared goals for humanity: a detailed, shared vision of a sustainable and desirable USA in 2100. Ecol. Econ. 43, 245 – 259.

Foley, J., Ramankutty, N., Brauman, K., Cassidy, E., Gerber, J., Johnston, M., Mueller, N., O'Connell, C., Ray, D., West, P., Balzer, C., Bennett, E., Carpenter, S., Hill, J., Monfreda, C., Polasky, S., Rockström, J., Sheehan, J., Siebert, S., Tilman, D., Zaks, D., 2011. Solutions for a cultivated planet. Nature 478, 337-342.

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Chapin, T., Rockström, J., 2010. Resilience thinking: integrating resilience, adaptability and transformability. Ecol. Soc. 15, 20. <http://www.ecologyandsociety.org/vol15/iss4/art20/> (accessed June 2013).

Forrester, J., 1958. Industrial Dynamics-A Major Breakthrough for Decision Makers. Harvard Bus. Rev. 36, 37-66.

Frantzeskaki, N., Henneman, P., Loorbach, D., Roorda, C., van Steenbergen, F., Wittmayer, J., 2011. Urban Transition Management manual. Navigator of the MUSIC project. DRIFT (Dutch Research Institute for Transitions, Rotterdam, the Netherlands. URL : www.themusicproject.eu

Frantzeskaki, N., Loorbach, D., Meadowcroft, J., 2012. Governing transitions to sustainability: Transition management as a governance approach towards pursuing sustainability, Intern. J. Sustainable Development 15, 19-36.

Freibauer, A., Mathijs, E., Brunori, G., Damianova, Z., Faroult, E., Girona i Gomis, J., O'Brien, L., Treyer, S., 2011. Sustainable food consumption and production in a resource-constrained world. European Commission – Standing Committee on Agricultural Research (SCAR), The 3rd SCAR Foresight Exercise. <http://www.scp-knowledge.eu/sites/default/files/knowledge/attachments/Umwelt-Wissenschaft-EU-Landwirtschaft2050.pdf> (Accessed May 2013).

Gallopin, G., 2003. A systems approach to sustainability and sustainable development. CEPAL – SERIE Medio ambient y desarrollo. United Nations Publication, Santiago, Chile.

Garud, R., Karnøe, P., 2001. Path creation as a process of mindful deviation, in: Garud,R., Karnøe,P. (Eds.), Path dependence and creation, Lawrence Earlbaum Associates, pp. 1-38.

Geels, F., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case study. Res. Policy 31, 1257-1274.

Geels, F., Schot, J., 2007. Typology of socio-technical transition pathways. Res. Policy 36, 399-417.

Grin, J., Rotmans, J., Schot, J., 2010. Transitions to sustainable development, New directions in the study of long term transformative change. Routledge, New York, London.
Haapio, A., 2012. Towards sustainable urban communities. Environ. Impact Assessment Rev. 32, 165-169.
Hagelskjaer Lauridsen, E., Stissing Jensen, J., 2013. The strictest energy requirements in the world: an analysis of the path dependencies of a self-proclaimed success. Energ. Policy 53, 97-104.
Holden, S., 2013. Avoiding the resource curse in Norway Energy Policy 63, 870 – 876.
Holmberg, J., 1998. Backcasting: a natural step in operationalising sustainable development, Greener Manage. Int. 23, 30–51.
Holland, J., 2006. Studying Complex Adaptive Systems. Journal of Systems Science and Complexity 19, 1-8.
Jessop, B., 1995. The regulation approach, governance and post-Fordism: alternative perspectives on economic and political change, Economy and Society 24, 307 – 333.
Kalaugher, E., Bornman, J., Clark, A., Beukes, P., 2013. An integrated biophysical and socio-economic framework for analysis of climate change adaptation strategies: the case of a New Zealand dairy farming system. Environ. Modell. Soft. 39, 176-187.
Kanyama, A., Dreborg, K., Moll., H., Padovan, D., 2007. Participative backcasting: a tool for involving stakeholders in local sustainability planning, Futures, 40,34-46.
Kim, D., 1995. System Thinking Tools; The Toolbox Reprint Series. Pegasus Communications, Cambridge, Mass.
Kirkwood, 1998. System Behaviour and Causal Loop Diagrams, in: System Dynamics Methods: a quick introduction. <http://www.public.asu.edu/~kirkwood/sysdyn/SDIntro/ch-1.pdf> (accessed March 2013)
Lewin, R., 1999. Complexity: Life at the Edge of Chaos. Chicago: Chicago University Press.
Lovins, A., 1976. Energy strategy: the road not taken? Foreign Aff. 55, 63–96.
Loorbach, D., 2007. Transition management, new mode of governance for sustainable development. International Books, Utrecht, the Netherlands.
Mathijs, E., Nevens, F., Vandenbroeck, P., 2013. Transition to a sustainable agro-food system in Flanders: a system analysis. MIRA – AMS 2012 Topic Report. <http://www.milieurapport.be/Upload/main/0_topicrapporten/Topicrapport_Eng_webC2.pdf> (accessed July 2013)
Meadows, D., 1994. Envisioning a Sustainable World. Third Biennial Meeting of the International Society for Ecological Economics, October 24-28, 1994, San Jose, Costa Rica. <http://www.oasisdesign.net/design/legalizesustainability/files/D_Meadows_Envisioning.pdf> (accessed March 2013)
Monstadt, J., 2007. Urban governance and the transition of energy systems: institutional change and shiftingenergy and climate policies in Berlin. International Journal of Urban and Regional research 31, 326 – 343.
Miao, C.-H., 2011. Planned obsolescence and monopoly undersupply. Information Economics and Policy 23, 51 – 58.
Nevens, F., De Weerdt, Y., Vrancken, K., Vercaemst, P., 2012. Transition in research, research in transition. When technology meets sustainability. VITO (Flemish Institute for Technological Research), 'Vision on Transition'- series, n°1. VITO, Mol, Belgium.
Newman, P., Jennings, I., 2008. Cities as sustainable ecosystems: Principles and Practices, Island Press, London.
Pagani, M., Otto, P., 2012. Integrating strategic thinking and simulation in marketing strategy: seeing the whole system. J. Bus. Res. 66, 1568-1575.
Quist, J., 2007. Backcasting for a sustainable future. The impact after 10 years. Eburon Academic Publishers, Delft, the Netherlands.
Raven, R., Van den Bosch, S., Weterings, R., 2010. Transitions and strategic niche management: towards a competence kit for practitioners. Int. J. Techn. Manage. 51, 57-74.
Read, A., 1999. Making waste work: making UK national solid waste strategy work at the local scale. Resources, Conservation and Recycling 26, 259 – 285.
Read,A., 2001. Delivering sustainable waste management – a UK perspective. Resources, Conservation and Recycling 32, 173 – 179.
Rip, A. , Kemp, R., 1998. Technological Change, in: Rayner S., Malone E. (Eds.), Human Choice and Climate Change, Volume 2. Batelle Press, Columbus Ohio, pp. 327-399.

Rittel, H., Webber, M., 1973. Dilemmas in a General Theory. Policy Sci. 4, 155-169.
Robinson, J., Burch, S., Talwar, S., O'Shea, M., Walsh, M., 2011. Envisioning sustainability: Recent progress in the use of participatory backcasting approached for sustainability research. Techn. Forecasting Soc. Change 78, 756-768.
Rohn,H., Pastewski,N., Lettenmeier,M., Wiesen, K., Bienge,K., 2014. Resource efficiency potential of selected technologies, products and strategies. Science of the Total Environment 473 – 474, 32 – 35.
Roth, G., Kleiner,A., 1995. Learning Histories, a formal process for organizational learning. Systems Thinking in Action Conference Proceedings, 18-20 September, Boston, MA, p. 195-206
Roth, G., Senge,P., 1996. From theory to practice: research territory, processes and structure at an organizational learning centre, Journal of Organisational Change Management, vol. 9 (1), p. 92-106
Rotmans, J., 2005. Societal Innovation: between dream and reality lies complexity. Erasmus university of Rotterdam, inaugural address. Research in management series, 2005, reference number EIA-2005-026-ORG. URL : http://papers.ssrn.com/sol3/papers.cfm?abstract_id=878564
Rotmans, J., Kemp, R., Van Asselt, M., 2001. More evolution than revolution: transition management in public policy. Foresight 3, 15-31.
Rotmans, J., Kemp, R., Van Asselt, M., 2001. More evolution than revolution: transition management in public policy. Foresight 3, 15-31.
Rotmans, J., Loorbach, D., 2009. Complexity and transition management. J. Ind. Ecol., 13, 184-196.
Schot, J., 1998. The usefulness of evolutionary models for explaining innovation: the case of the Netherlands in the nineteenth century. Hist. Technol. 14, 173-200.
Senge, P., 1994. The Fifth Discipline: the art and science of the learning organisation. Currency Doubleday, Ney York, USA.
Senge, P., Smith, B., Kruschwitz, N., Laur, J. and Schley, S., 2008. The Necessary Revolution, How individuals and organisations are working together to create a sustainable world. Nicholas Brealey Publishing, London.
Shao, S., Yang,L., 2014. Natural resource dependence, human capital accumulation, and economic growth: a combined explanation for the resource curse and the resource blessing. Energy Policy, in press.
Shaw, R., Gallopin, G., Weaver, P., Öberg, S., 1992. Sustainable Development. A systems approach. International Institute for Applied Systems Analysis, Satus Report SR-92-6; Laxenburg, Austria.
Smith, A., Stirling, A., 2008. Socio-ecological resilience and socio-technical transitions: critical issues for sustainability governance. Working papers from the STEPS Centre. URL :http://www.steps-centre.org/PDFs/STEPS%20Working%20Paper_Transitions.pdf
Smith, A., Stirling, A., Berkhout, F., 2005. The governance of sustainable socio-technical transitions. Res. Policy 34, 1491 – 1510.
Soroczynski, T. 2002, Integrated Systems Analysis and Sustainable Development, in: Rizzoli, A., Jakeman, A., (Eds.), Integrated Assessment and Decision Support, Proceedings of the First Biennial Meeting of the International Environmental Modelling and Software Society, Volume 3, pp. 133- 138.
Stoker, G., 1998. Governance as theory: five propositions. International Social Science Journal 50, 17 – 28.
Tanguay, G., Rajaonson, J., Lefebvre, J., Lanoie, P., 2010. Measuring the sustainability of cities: an analysis of the use of local indicators. Ecol. Indicators 10, 407 –
Tebbatt Adams, K., Phillips,P., Morris, J., 2000. A radical new development for sustainable waste management in the UK: the introduction of local authority Best Value legislation. Resoources, Conservation and Recycling 30, 221 – 244.
Tukker, A., Charter, M., Vezzoli, C., Stø, E., Munch Andersen, M. (Eds.), 2008. System Innovation for Sustainability.1: Perspectives on Radical Change to Sustainable Consumption and Production Greenleaf Publishing, Sheffield, UK.
Udall,S., 1963. The Quiet Crisis. Holt Rinehart and Winston, New York, Chicago, San Francisco, USA.
Van Buuren, A., Loorbach D., 2009. Policy innovation in isolation? Public Manage. Rev. 11, 375-392.
Van den Bosch, S., 2010. Transition experiments. Exploring societal changes towards sustainability. PhD Thesis. Erasmus University Rotterdam, the Netherlands.
Van Mierlo, B., Arkestijn, M., Leeuwis, C., 2010. Enhancing the reflexivity of system innovation projects with system analyses. Am. J. Eval. 31, 143-161.

Van Mierlo, B., Janssen, A., Leenstra, F., van Weeghel, E., 2013. Encouraging system learning in two poultry subsectors. Agr. Syst. 115, 29-40.
Vreugdenhil, H., Taljaard, S., Slinger, J.H., 2012. Pilot projects and their diffusion: a case study of integrated coastal management in South Africa. Int. J. Sustainable Development 15, 148-172.
Waddell, S., McLachlan, M. and Dentoni, D. , 2013. Learning & Transformative Networks to Address Wicked Problems: A GOLDEN Invitation. International Food and Agribusiness Management Review, 16(A), 23-32.
Wallgren, C., Höjer, M., 2009. Eating energy – Identifying possibilities for reduced energy use in the future food supply system. Energ. Policy 37, 5803-5813.
Wolstenholme, E., 1999. Qualitative v. Quantitative modelling : the evolving balance. J. Oper. Res. Soc. 50, 422-428.