Combining Foresight and Systems Dynamics in the project - Scenarios for a Sustainable Europe 2050

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Abstract
This study showcases the use of Causal Loop Diagrams (CLD) analysis in the foresight project *Scenarios for a Sustainable Europe in 2050 (SSE2050)* and how CLDs can be used in the context of the *Scenario Method* in foresight. The project *SSE2050* is part *EIONET NRC FLIS (Forward Looking Information and Services)*. The results show that the *solution scenarios* vary slightly in how the framing of system boundaries and the point of departure in the narratives are treated. The CLDs analysis show that the key factors evolution in the scenarios are either generic or highly specific, influencing the interpretation of the scenarios. This illustrates the necessity to be explicit in the description of the solution scenarios since the factors derived for the CLDs need explicit language. CLDs constitute one additional lever to critically reflect and visualize complex interdependencies that are conveyed in the written text of scenario narratives. This will aid in enriching and identifying key factors of influence in the scenarios and validating the results for further communication. The study shows that scenario CLDs can be part of enriching scenarios further and complement the foresight method.

Keywords: System dynamics, foresight, qualitative analysis, Sustainable Europe 2050, causal loop diagrams, scenario analysis, EIONET

1 Introduction and purpose

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This article is an attempt to abridging the foresight *Scenario Method* with the *system dynamic qualitative approach* using the *Causal Loop Diagramming* method. This article is a summary in part of the project *European Environment Information and Observation Network* (EIONET) *National Reference Centre* (NRC) *Forward Looking Information and Services* (FLIS). Scenarios for a Sustainable Europe in 2050 (SSE 2050), part 2, reported by the Swedish Environmental Protection Agency, report 6975 (Haraldsson and Bonin, 2021). The main purpose of this study was to showcase the use of Causal Loop Diagrams (CLD) analysis on the scenarios developed in the project (SSE 2050). The CLD analysis draws upon the main results of the project SSE 2050 (EEA/EIONET NRC FLIS, 2020). In Haraldsson and Bonin (2021), the narratives form the SSE 2050 project were interpreted and contextualised by the authors to develop the CLDs (figure 1).

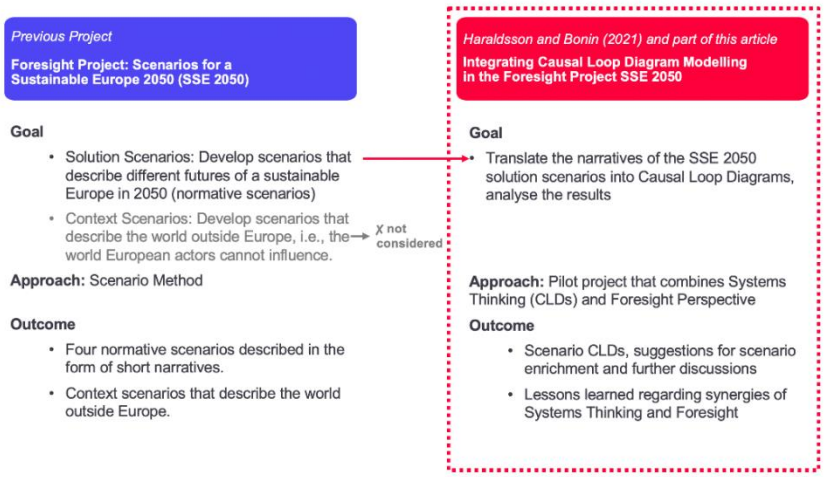

Figure 1: Overview of the project SSE 2050 and the report on scenario CLDs

A total of four *solution scenarios* were developed during the project SSE 2050 (figure 2): *1) Ecotopia, 2) A Pragmatic Path, 3) Green Growth Paradigm, 4) Utilitarian Technocracy for Good*. This article will show an in-depth analysis and comparison of two solution scenarios, *Ecotopia* and *A Pragmatic Growth.*

Figure 2: This article focuses on two scenarios of the scenarios developed in the SSE2050.

The scenario narratives developed in the project SSE 2050 are imaginative qualitative descriptions of possible futures and not based on quantitative assessments. It is important to note that scenarios are not predictions, they make no assertion about probabilities. The CLDs are therefore based upon a set of assumptions and limitations derived from the authors. In this article, the scenarios *Ecotopia* and *A Pragmatic Path* were chosen to illustrate the differences

between the scenario narratives in terms of their internal complexity and logic, as well as internal social dynamic and external forces of environmental shocks and regulation.

The overall goal of the project was to:

1) Illustrate how scenario narratives are dictated by feedback loop behaviour that shows the evolution of different key factors over time.
2) Show possibilities and limitations through identification and analysis of leverage points.
3) Analyse and enhance the plausibility of each scenario as a function of time and improve the scenario consistency by enriching the scenarios.
4) Show how systemic change can be facilitated in the normative scenarios being studied.

Combining the results of the *Scenario Method* from SSE 2050 with systems dynamics modelling was a special feature of this project. The *Scenario Method* is an established tool in the context of foresight analysis, which aims to broaden the perspective on different possible future developments. The goal of Foresight is to support decision-making by systematically analysing plausible and possible futures and in some contexts also normative, preferable, futures. Foresight helps with identifying transformations and to understand a world that is perceived as volatile, uncertain, complex and ambiguous. Policymakers are turning to foresight methods, for instance, the European Commission recently published its first annual Strategic Foresight report (European Commission, 2020, 2019). The Scenario Method has seen evolution and application in numerous studies for the private and public sector (Deutsche Post, 2012; Lorenz and Veenhoff, 2013; Schnurr *et al.*, 2018; SDC, 2019). Scenarios are about developing different, alternative futures, not to make predictions or show the most likely outcome. In the context of foresight projects, other methods and techniques can be applied, like environmental scanning, trend analysis, the Futures Wheel, Causal Layered Analysis or Delphi method (Millenium Project, n.d.; UNDP, 2018)

Haraldsson and Bonin (2021) show that a CLD analysis can be performed on the results coming out from the *Scenario Method*. The qualitative system dynamics uses the Causal Loop Diagramming and behaviour over time (BOT) as the primary method of describing cause and effect and feedback-loops in order to assess the direction of the potential impact of an explorative or normative scenario in a non-numerical way (see (Binder et al., 2004; Burns and Musa, 2001; Haraldsson, 2004; Haraldsson and Ólafsdóttir, 2018; Haraldsson and Sverdrup, 2021; Kim and Senge, 1994; Lorenz and Haraldsson, 2014; Maani and Cavana, 2007)). In the context of this study, CLDs are used as a tool to frame boundaries around each scenario and to convey the core feedback loop description of that scenario. Furthermore, each scenario was analysed to observe possible implications of feedback loop behaviour over time of the key factors under observation. This approach was pioneered at the Swedish EPA during the work on the State of the Environment reporting 2015 (Haraldsson, 2020).

2 Methods

Qualitative modelling is an approximate science that interpret a narrative from a set of assumptions. When developing CLDs a key approach is to find the appropriate level of detail that address the questions posed. A challenge in this project was to convey the story of the scenario narratives as understood from its basic description in SSE 2050 and capture the projections that supported the narratives. The approach adopted in the study was based on the KISS (keep it simple, straightforward). Meaning that the number of elements per scenario were limited to 15 to 20 in order to maintain overview and coherence (Haraldsson, 2004). . Keeping

the KISS principle in mind greatly helped to manage the process how a collection of items can be collapsed into a single simplified factor to maintain an overview.

Combing system dynamics and CLDs (SEPA) and foresight methods (Z_punkt) allowed for overlapping complementary modes of thinking and tools to reduce complexity. Thus, combining the two approaches allowed leverage synergies between the project participants and showed where overlap enhanced the understanding of developing proper framing of the scenarios and CLDs (Figure 1). In short, Foresight pointed to the direction where the proper framing should occur in space and time, and systems dynamics set the rules on how the framing should be done in respect of space and time.

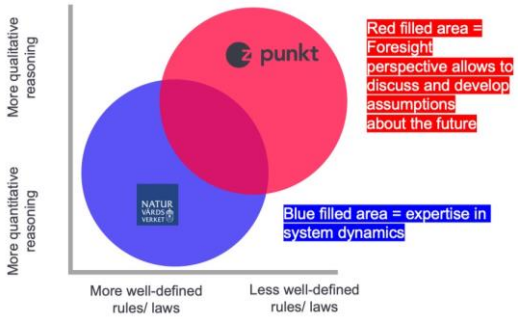

Figure 1: Foresight shows in what direction the framing should occur and system dynamics set the rules on how the farming should be done in space and time.

2.1 Work procedure for combining foresight and system dynamics

In system dynamics, there are two approaches to conduct a qualitative modelling, an explorative and descriptive approach (Abdelbari and Shafi, 2017; Barlas, 1996; Neumann, 2015). The main difference between the two approaches is the nature of dealing with boundary definitions and constructing feedbacks. The descriptive approach is focused constructing loops and keeping track of observing combined loop behaviour with an initial question as focus. The explorative approach focuses on identifying link structure between factors where loops evolve through the process and questions arise along the way that are interesting to the task. Both processes have their usefulness in a CLD analysis but combining the methods can give a good balance between understanding a non-structured task and pre-defined questions that set the boundary conditions for the analysis (Haraldsson, 2020; Haraldsson and Ólafsdóttir, 2018; Lorenz and Haraldsson, 2014).

The type of outcome coming from SSE 2050 project saw the use of the combined (explorative and descriptive) approach useful. This is because scenario narratives are framed with a set of conditions that "tell the story" of the situation picture in the distance future. However, the narratives do not contain specific, detailed indicators that reflect the objectives of the scenario nor how success is defined in terms of obtaining or maintaining the conditions being described. Here the combined CLD approach explores the framing of the boundaries and descriptively identifying specific success and limiting feedback parameters that influence the scenario evolution. During the project workshops it was found that this combination stimulated creative thinking with respect to different questions posed for the scenarios:

- How can scenarios be framed without losing the information in the narrative description and be represented in a simplified CLD?
- What are important cause and effect relationships and feedback-loops identified?

- What are the success and limiting factors that enable the scenario in its current form?
- What items need to be added to enable continuity/plausibility of the scenario?
- What dynamic behaviour does the scenario express when analysing loop behaviour over time?
- How does energy, food and mobility connect to each scenario, do they point to new paradigms for production-consumption systems?

The *Scenario Method* applied by Z_Punkt has defined its methodological steps with a combination of methods where the impact-uncertainty analysis, consistency analysis or morphological box is combined into one process (Deutsche Post, 2012; Schnurr et al., 2018; SDC, 2019). Figure 4 shows the common steps of a scenario process and highlights at which stage Causal Loop Diagrams entered the process.

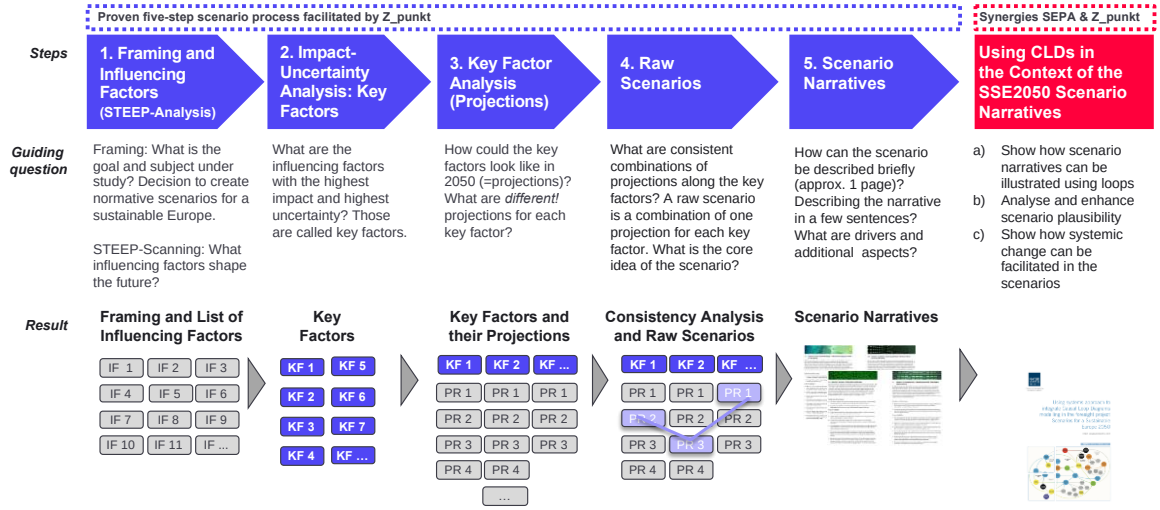

Figure 4: Overview on the scenario process

Scenario development may focus on a specific focal topic and in the context of SSE 2050 it is sustainability. The project SSE 2050 describes normative scenarios for Europe, i.e., desirable futures of how a sustainable Europe could look like. Moreover, context scenarios that describe the world outside were developed. However, for this research project on CLD, only the solution scenarios for Europe 2050 were used.

The scenarios SSE 2050 provide a broad frame of reference on how the room of manoeuvre of sustainability looks like under different hypothetical solutions. This results in two important aspects that had been considered for developing the scenario CLDs:

a) there is no in-depth knowledge about every possible aspect for each solution scenario and
b) the short narratives focus on describing solution space in desirable futures rather than challenges that have been overcome within each scenario.

A structured participatory exchange between the project members was used involving brainstorming based on the existing scenario narratives and key factors. The process of developing the scenario CLDs follows the method described in (Haraldsson and Sverdrup, 2021) but adapting for this project can be broken down into three major steps.

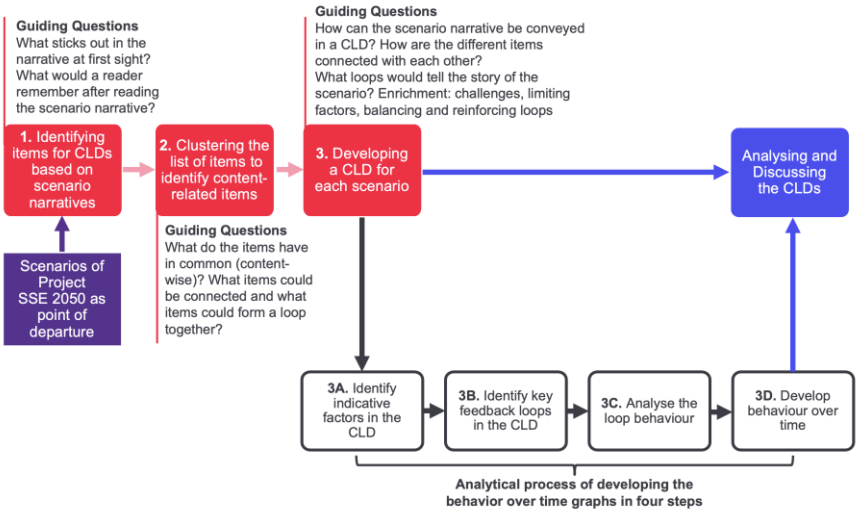

Figure 5: The process of developing and analysing and discussing CLDs

The framing of the scenarios already provided the system boundaries and issue definition where the items of interest could be extracted. As discussed earlier, the scenario process does not focus on defining what aspects within each scenario create the condition for its existence. Therefore, in the CLD process, a guiding question for defining the main actors and what defines the overall success for the scenario was necessary. Furthermore, asking guiding questions on what feedback-loops and driving forces "drive" the scenario, as well, what the opportunities and limiting factors maintaining the existence of each scenario. Each step was summarised by guiding questions. A more detailed description of each of the three main steps can be found at the end of this section. After the scenario CLD had been developed, the narrative overall impression was assessed and a behaviour over time (BOT) graph was developed for selected elements of the CLDs. The analytical process of developing the BOT was divided into four steps as shown in (3A-3D in Figure 5) and uses the method as described in (Haraldsson, 2004; Haraldsson and Ólafsdóttir, 2018; Haraldsson and Sverdrup, 2021). The BOT development process ultimately illustrates what feedback cycles are interesting over time and consequently the archetypical behaviour or the scenario. Once the CLD is completed, the "core" story of the scenario is expressed through behaviour over time (BOT) according to the following process: 3A) indicative factors from the CLD are chosen which are intended to communicate the story through the CLD. 3B) main feedback loops (reinforcing and balancing) that drive the core behaviour of the indicative factors in the CLD are identified. 3C) loops are analysed as combined reinforcing and balancing behaviour and drawn as cyclic behaviour. 3D) behaviour over time is drawn as repeated cyclic intervals of the indicative factors.

While developing CLDs based on the scenario narratives, it was possible to explore additional questions relating to what exists outside the narratives, i.e. impact of global drivers and interaction of subsystems. The questions posed were:

- What links can be identified between the scenario CLDs to basic modules for production-consumption systems (e.g. mobility, food, energy)?
- What links can be identified between the scenario CLDs to general aspects of sustainability of Europe and the global context?

2.2 Specific steps to develop CLDs from the scenario narratives

The process of developing the CLDs from the scenario narratives followed three steps:

Step 1: Identifying important items based on the scenario narrative

- What sticks out in the narrative at first sight? What would a reader remember after reading the scenario narrative? What is defined as success in the narrative? For instance, success in each narrative is the story of what is being maintained as a desired state, e.g. no/low environmental infringement, high degree of efficiency etc.
- A list of items was extracted from the description of the solution scenario. Items may be single nouns, a combination of an adjective and noun or also a half-sentence. The list of items constitutes a starting basis for developing causality links between items and the start of building loops for the scenario CLDs. The process is inherently iterative, and it was understood that the CLDs would evolve during the process.

Step 2: Clustering the list of items

- What do the items have in common (content-wise) in relation to what is defined as success? What items could be connected and what items could form a loop together?
- By sorting and clustering the list of items, finding topics and umbrella terms, the number of items can be greatly reduced. The key factors and projections of the solution scenarios were used to identify additional items and connections. It is not required to include all projections but the objective is to have a narrower set of items that can be used to develop the CLDs.

Step 3: Developing individual scenario CLDs

- How can the scenario narrative be conveyed in a CLD? How are the different items connected with each other in relation to the defined success of the scenario? What loops would tell the story of the scenario? What could be challenges or limiting factors (elements)? What could be additional (balancing) loops?
- The different clustered items provide the starting basis to construct a scenario CLD. For this step, it is important to keep the KISS principle in mind. At this stage, items may be renamed, or additional items may be added to construct loops and to aid comprehensibility. When there is fit, items are connected, and their polarity is defined. It is not mandatory to include all items of the list or to show every connection. Above all, a scenario CLD should reflect the core idea of the scenario with a limited number of items and a sufficient number of loops.
- The solution scenarios SSE 2050 describe desirable futures. Therefore, due to the narrative description, the CLDs have tendencies to show excess of reinforcing loops that work towards a sustainable Europe and less of what constitute limiting factors. Therefore, it was necessary to identify the limiting factors that "balance out" the reinforcing loops. Generically in the CLD development process, it is common initially to identify only the reinforcing loops since the balancing loops are often not obvious to identify. In the systems approach the reinforcing loops are a temporary state and balancing loop ultimately regulate the system. All CLDs need to illustrate how the system is regulated through reinforcing and balancing factors. In this case, it was needed to identify and insert regulating factors that would make the scenario narrative logically work. During the project, it became evident that it is not possible nor desirable to show all possible challenges and limiting factors in the CLD as this would increase the complexity too much, but the necessary aggregation was assessed in order to challenges and limiting factors. The results point to policy levers given that the solution scenarios constitute desirable futures for Europe in 2050.

3 Results – developing CLDs for the scenario narratives

The constructing of a CLD follows a specific structure where cause and effect are variables that either change in the same direction (indicated with a "plus") or change in opposite direction (indicated with a "minus"). Processes that feedback in the same direction are called reinforced processes (indicated with R) since they amplify the condition. Similarly, the processes that feedback to give a change in opposite direction (indicated with B) balance (dampen) out a condition (Haraldsson, 2004). Part of framing the system boundaries for the SSE 2050 solution scenarios into CLDs was analyzing the key factors as categorized according to the STEEP (figure 2). Each of the scenario narratives was initially derived based on these key factor projections during the project SSE 2050.

The scenario CLDs follow a similar structure (Figure 2). The report focuses on the most important parts of each CLD. Four types of elements (E) and two types of connections (>) are depicted in scenario CLDs:

- Parts of the scenario narrative and key factor projections (colours of the circles according to STEEP)
- Challenges, barriers and limits identified during workshops (black circles)
- First ideas for links to production consumptions systems (energy, food, mobility) are indicated (grey circles).
- First ideas for links to the context scenarios are indicated (purple circles)
- In Kumu, the graphical expression given is as follow (figure 6). A positive polarity (+) indicates that more of "A" goes along with more of "B" (solid line). For a negative polarity (-) it holds that the more of "A" the less of "B" (dashed line). Major balancing loops and reinforcing loops are indicated in each scenario CLD.

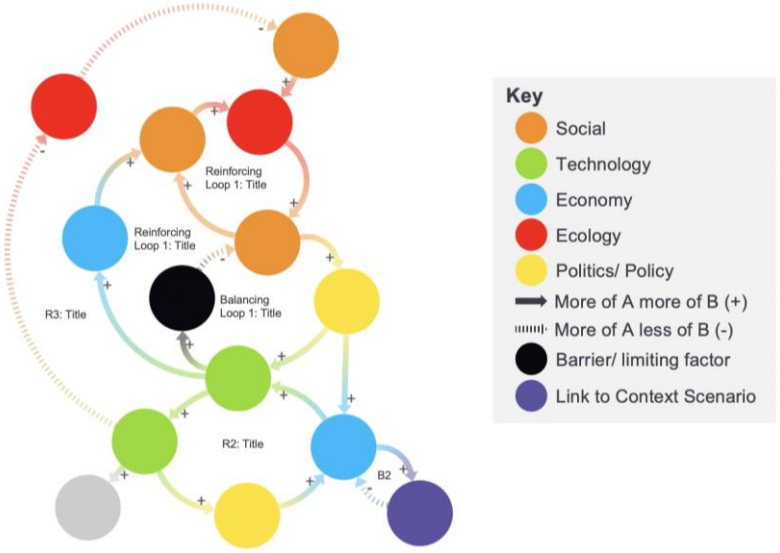

Figure 2: Schematic overview of the scenario CLDs setup and categorisation according to STEEP and system boundary definition.

Each scenario of the two scenarios presented in a separate section. The major characteristics of each scenario CLD are summarised. The behaviour over time (BOT) is shown in a diagram for selected elements of the CLDs and described briefly.

3.1 A Pragmatic Path: Transformation within planetary and regulatory limits

The following CLD in figure 7, shows the result from the work process developing CLD for the solution scenario "A Pragmatic Path: Transformation within planetary and regulatory limits".

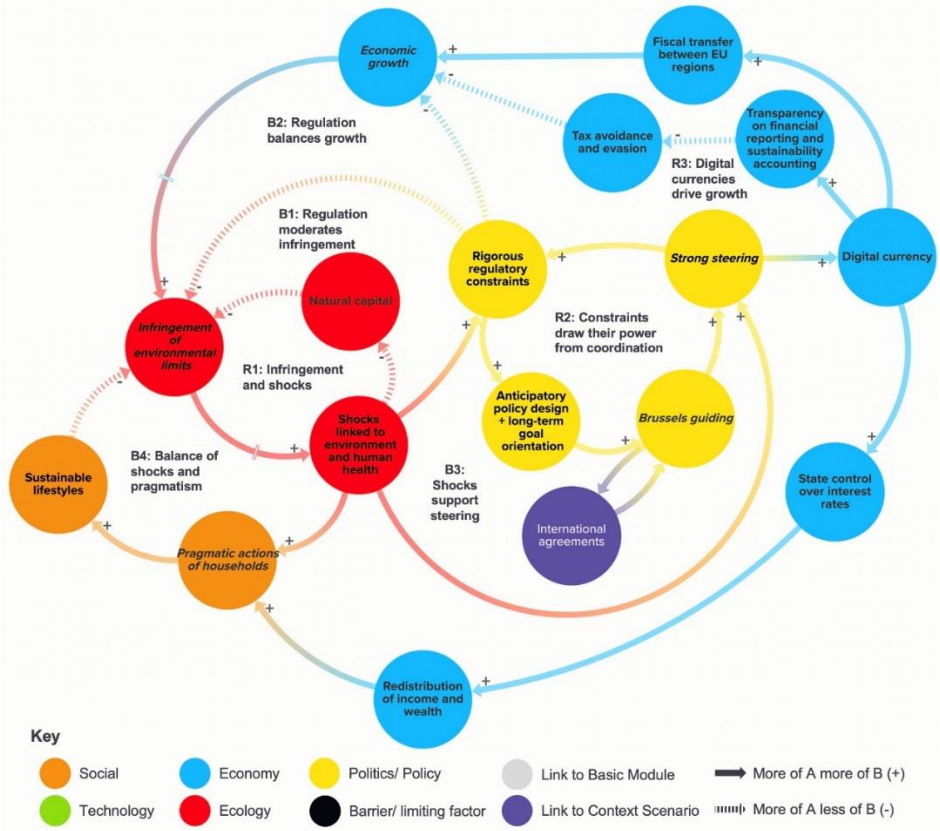

Figure 7: Scenario CLD: A Pragmatic Path: Transformation within planetary and regulatory limits

The solution scenario *Pragmatic Path* can be summed up as *infringement of environmental limits drives 'strong steering'*. Steering and pragmatic actions are a reaction to shocks linked to environment and human health. Shocks are a long-term effect caused by the infringement of environmental limits. In short, the scenario CLD and discussions can be summarised as follows:

- Short-termism jeopardises natural capital and reduces future leeway for growth.
- *Infringement of environmental limits* leads to shocks that drives the *regulatory constraints* and *pragmatic actions*.
- Introducing a digital currency has an equivocal effect on *infringement of environmental limits*: it *increases economic growth* (increased infringement) but also stimulates *pragmatic actions of households* in the end (reduced *infringement on environmental limits*).
- The BOT diagram shows that *infringement of environmental limits* illustrates an oscillating behaviour in concert with strong steering (Figure 8).

Developing the CLD for the scenario *A Pragmatic Path* made additional questions and challenges explicit that could aid the enrichment of the scenario:

- What is the dependence on context scenarios? Guidance of Brussels is important to reinforce regulatory constraints but depending on the context scenario, the future of the

global situation outside Europe in 2050 might challenge the power structure of Brussels or even undermine it.

- What could the impact of transparency on financial reporting and sustainability accounting on business activity and infrastructure investment look like in a strong steering situation?
- How can the increased state control over interest rates (via digital currencies) additionally be used to stimulate a sustainable transition?

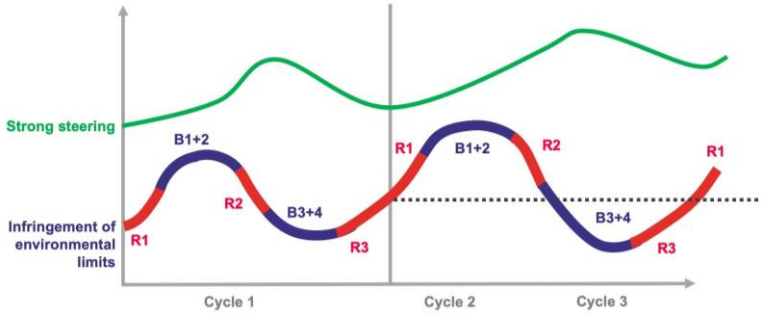

Figure 8: Behaviour over time diagram: A Pragmatic Path

A Pragmatic Path: Telling the story of the scenario CLD

The initial cycle starts with economic growth in near term that leads to infringement of environmental limits, where it builds up and leads to shocks to the environment and human health *(R1)*. Shocks erode natural capital and in turn expedite the infringement of environmental limits. With shocks present, rigorous regulatory constraints are put into play in order to limit the pressure on environmental limits directly *(B1)*. Moreover, constraints weaken economic growth, which balances the infringement of environmental limits *(B2)*. Regulatory constraints are drawing their power from anticipatory policy design and long-term goal-orientation. Brussels is guiding and steering the regulatory efforts, which in turn reinforce the regulatory constraints *(R2)*. Amid shocks, steering receives more support and power, thereby reinforcing regulatory constraints even more *(B3)*. Based on strong steering, a digital currency is introduced and becomes accepted. The digital currency allows to control interest rates and therefore employment. As a consequence redistribute income and wealth is a possibility. The increased financial leeway is used by pragmatic households to live a sustainable lifestyle given the environmental shocks. The pragmatism of households means sustainable lifestyles and therefore the infringement of environmental is reduced *(B4)*. But the digital currency also reinforces the infringement of environmental limits: The digital currency increases the transparency on financial reporting and sustainability accounting which reduces tax evasion and avoidance. This in turn increases economic growth and thus the infringing environmental limits is stronger. The end of second cycle starts a shift towards a lower level of infringement of environmental limits. This CLD does not contain a barrier/limiting factor since these already exist indirectly in the loop description. That said, it does not indicate that these do not exist in the scenario, but rather that it was not necessary in order to communicate the scenario behaviour.

In summary, this scenario is maintained through strong steering that is reinforced through anticipatory policy design (*R2*). This allows for a flexible combination of "agile" planning and regulatory constraints. The key to further develop this scenario would be to explore in-depth what items in anticipatory policy design create a positive driving force and win-win setup towards strong steering and regulatory constraints.

3.2 Ecotopia: Post-growth collaboration

The following CLD in figure 9, shows the result from the work process developing CLD for the solution scenario "Ecotopia: Post-growth collaboration".

Figure 9: Scenario CLD Ecotopia, a post-growth collaboration.

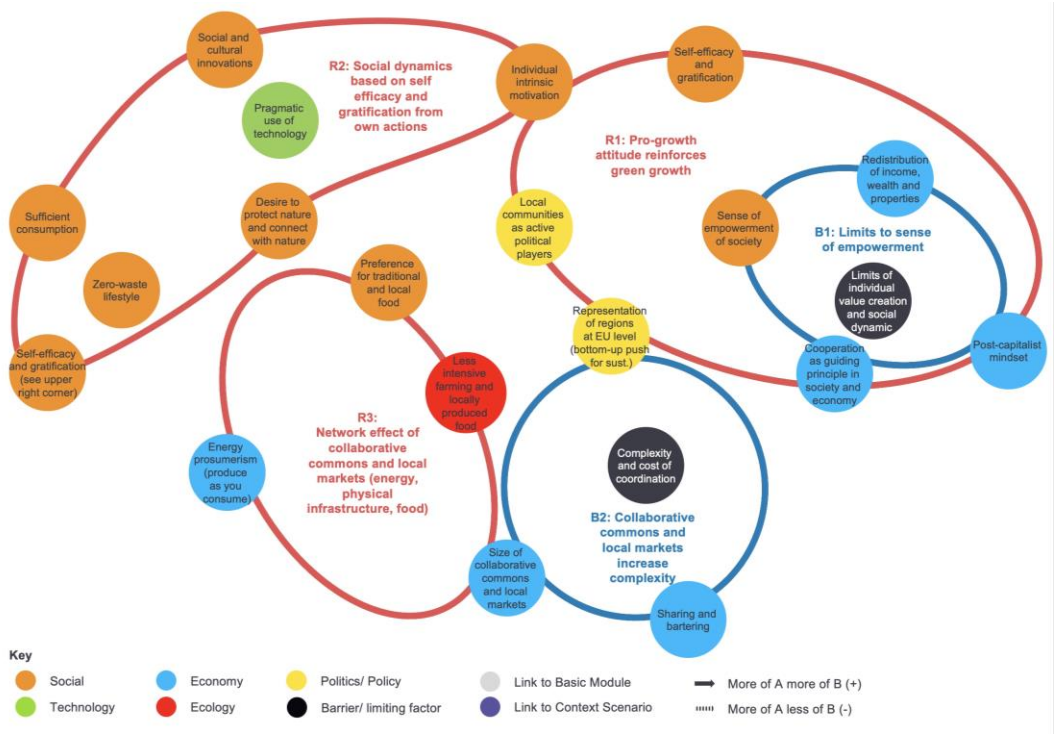

Figure 10: Aggregated loops of the scenario Ecotopia

The solution scenario *Ecotopia: Post-growth collaboration* can be summed up as self-empowerment individual behaviour drives a change regarding the way society, politics and the economy function. The CLD in figure 9 shows that different connections from green market-based incentives and to pro-growth attitude and libertarian ethos merge into the loop behaviour that drive "empowerment". Figure 10 shows the aggregated influence from reinforcing loops (R1, R2, R3) and balancing loops (B1, B2) that impact the "empowerment" in the scenario description. In short, the scenario CLD and discussions can be summarised as follows:

- Self-efficacy and gratification reinforce individual intrinsic motivation and therefore the fundamental shift towards the Ecotopia scenario.
- There is an emergence of the collaborative commons paradigm and local markets based on desire to protect nature and reconnect with nature and a post capitalist mindset.
- Main limiting factors that steer the evolution of the scenario is "complexity and costs of coordination" that regulate administration, and "limits of individual value creation and social dynamics" that regulate self-empowerment
- Self-empowerment shows cyclical evolution towards saturation of how much value creation is possible (limits of individual value creation and social dynamics), BOT shown in Figure 12.

Developing the CLD for the scenario *Ecotopia* generates additional questions and challenges explicit that could aid the enrichment of the scenario. These questions arise from the influence of the sub-system upon Ecotopia (Figure 11).

- If complexity and costs of coordination cooccur with a pragmatic attitude to technology: How can technologies or social innovation reduce transaction costs?
- Local land availability could put a limit to sustainability of the scenario Ecotopia. The competition for local land increases as different production consumption systems would

consume local land (Figure 11). For instance, food and energy, and also the development of "Ecocities" require local land.

- How would the production consumption system look like given this profound change in society, politics and economy?
- Local demand for materials and resources increases as the size of the collaborative commons increases (Figure 11). How can this demand be sustained? Do circular economy approaches provide a sufficient answer? Are more imports from outside Europe and exchange between Europe required?
- Sufficient consumption could reduce state revenue and economic growth. How can the necessary level of public services and innovation activity be achieved and be sustained?

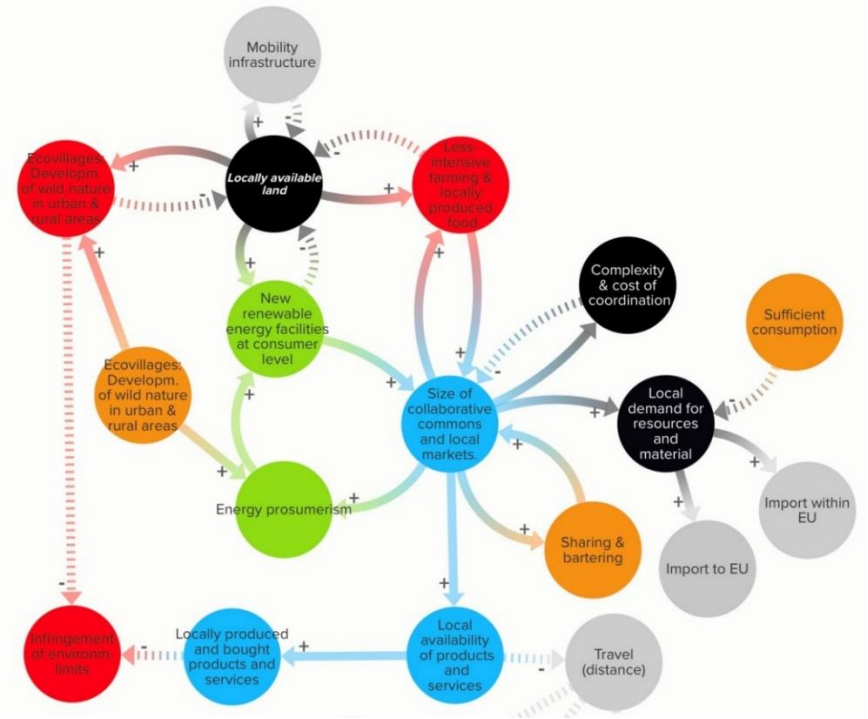

Figure 11: Locally available land and local demand for resources and material (simplified representation of the CLD to highlight the importance of both items)

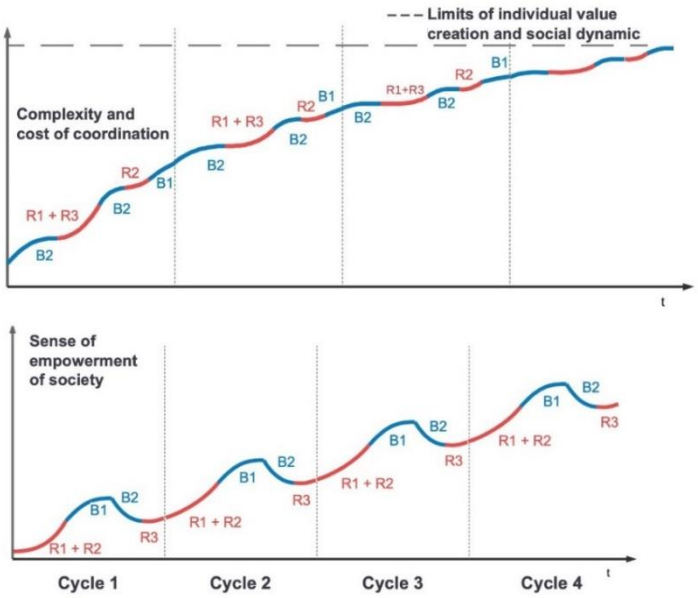

Figure 12: Behaviour over time diagram for Ecotopia. The sense of empowerment of society is limited by the complexity and cost of coordination in administration and limits to individual value creation (and social dynamic), driven with absence of AI technology.

Ecotopia: Telling the story of the scenario CLD

The BOT in figure 12 shows that here are basically 5 main loops creating the behaviour of the Ecotopia scenario. The scenario has a strong reinforcing behaviour but the main limiting factor is the "Limits of individual value creation and social dynamics" that puts a cap on how much "sense of empowerment of society" is possible for the scenario. This is indicated with the loop B1. The second limiting factor is the "Complexity and cost of coordination", indicated with the loop B2, which links two systems together, i.e. the physical (energy, agriculture, physical infrastructure etc, indicated with the loop R3) system and the social/politic system (loop R1 and R2). Lack of AI technology drives the complexity and cost of coordination indicates how "bottom up/local communities" management increases in complexity with increased shift towards society that is self-sufficient but is an active player in a global context. Pragmatic use of technology (or lack of use) means more mechanisation and increased administrative labour efforts. This is antithesis to high technological society that use digitalisation to offload administration tasks from the labour population to AI-management. In short, defining carrying capacity for social conditions, as well as technological conditions would define the limits to growth of the Ecotopia scenario in the current scenario description.

This is due to the vision and the goal posts for *Ecotopia* future is farther away from todays world setting than *A Pragmatic Approach* (Figure 13). The scenario Ecotopia is a bottom-up approach in terms of technology, economy and social mindset thus aligning different unique requirements for transformation of the society. The *A Pragmatic Approach* on the other hand is more aligned with current conditions and transformation of the society is perceived to be better understood. Both scenarios show a vision of a post-growth future where sustainable hard conditions are met but from a different mindset. The difference in mindset is in principle difference in how social sustainability is perceived.

The development of the CLDs illustrated the importance of have a clear understanding of the underlying principles of the *Solution Scenarios*. The *Ecotopia* scenario required explanations of social dynamics and psychology to help to validate and enrich the scenario ecotopia and its CLD. The authors conclude that such expertise would aid to clarify the principles dictating the

reinforcing loops and the necessary balancing loops that govern the social dimension of the scenario. This shows that Interdisciplinarity does not only play an important role during the development of scenarios but also at the stage of the development of scenario CLDs, especially when the "distance of a future scenario to today" is rather large.

3 Analysing the differences between scenarios Ecotopia and A Pragmatic Path

The scenarios *Ecotopia* and *A Pragmatic* Path envision different futures of a sustainable Europe in 2050. This difference stems from the point of departure of the framing of the initial question and how much it deviates from the current conditions. The vision and the goalposts for Ecotopia future are farther away from today's world setting than A Pragmatic Approach (Figure 13). The scenario Ecotopia is a bottom-up approach in terms of technology, economy and social mindset thus aligning different unique requirements for the transformation of the society. The A Pragmatic Approach on the other hand is more aligned with current conditions and the transformation of the society is perceived to be better understood. Both scenarios show a vision of a post-growth future where sustainable hard conditions are met but from a different mindset. The difference in mindset is in principle difference in how social sustainability is perceived.

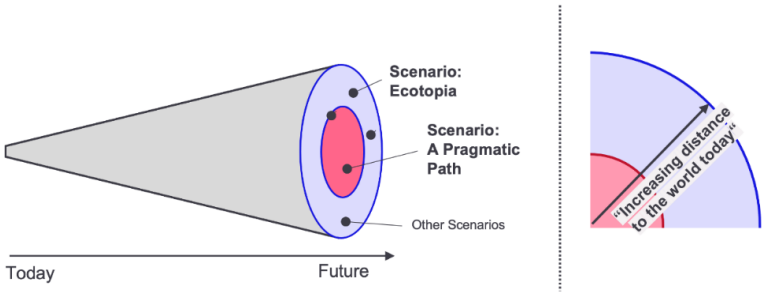

Figure 13: Comparison of the deviation of the scenario Ecotopia and the scenario Pragmatic Path from today's perspective.

The scenario ecotopia describes a future where changes in the mindset and leading sustainability paradigm are strongly driven by the *intrinsic motivation* of individuals and society. This is in contrast to the scenario pragmatic path, where *extrinsic motivation*, i.e., shocks to the environment and regulation are reactive actions that lead to a more sustainable future. In Ecotopia, the societal dimension can therefore be considered as a driver, i.e. forming the Ecotopia future, whereas, in the scenario A Pragmatic Path, societal change is the result of the environmental and economic conditions and regulation.

The development of the CLDs illustrated the importance of having a clear understanding of the underlying principles of the *Solution Scenarios*. The *Ecotopia* scenario required explanations of social dynamics and psychology to help to validate and enrich the scenario ecotopia and its CLD. The authors conclude that such expertise would aid to clarify the principles dictating the reinforcing loops and the necessary balancing loops that govern the social dimension of both scenarios. This shows the importance of having a proper participatory process during both the development of the scenarios as well as the CLDs.

4 Concluding remarks

The project shows that applying CLDs in the context of the *Scenario Method* provides an added value with respect to two dimensions, the processes level and the content level.

On a process level, CLDs constitute one additional lever to critically reflect and visualize complex interdependencies that are conveyed in the written text of scenario narratives. In that sense, CLDs complement the presentation of scenarios from a different angle as Scenario CLDs and the BOT diagrams can be used to aid presentation and understanding of scenarios when presenting scenarios to third parties or developing a report on scenarios.

On a content level, it has become clear that the novel approach of combining CLDs and scenario narratives is helpful not only to critically reflect scenario narratives but to enrich them by thinking through balancing and reinforcing loops. This mode of creative systemic thinking helps to uncover new aspects that help to make a scenario more plausible and consistent. This is because developing CLDs creates awareness for the challenges, barriers to change and limiting factors of scenarios that might not be derived if only the scenario method was applied. For instance, in scenario projects where normative scenarios are developed, i.e., scenarios that describe desirable futures, CLDs can help to better understand the plausibility and conflicting interests. In the context of the scenario project, SSE 2050, normative scenarios for a sustainable Europe in 2050 were developed based on key factors that European actors can influence. However, the future of Europe depends also on the state of the rest of the world in 2050. Thus, the actions of actors outside Europe would have an impact on the room of manoeuvre of Europe. Using the scenario CLDs that depict scenarios for a sustainable Europe in 2050 can help to identify interdependencies with the state of the world outside Europe, potential discrepancies between long-terms goals and policies, as well as the possible stakeholder conflicts and how to intervene for reconciliations.

The results indicate that the solution scenarios produced from the SSE 2050 vary slightly in how the framing of system boundaries and the point of departure in the narratives are treated. Furthermore, the CLD can either be generic or specific in describing the scenario. For instance, Ecotopia has a specific focus on the induvial level and the scenario CLD description serves to fulfil the individual needs on a personal level. The CLD factors are abstract and value-laden to illustrate the social values and their dynamic behaviour, showing a clear distinction between the personal level and the generic level. The solution scenario A Pragmatic Path shows factors that are more generic in the CLD descriptions (e.g., society being affected vs the individual level etc).

All the solution scenarios required support factors to show barriers/limitations to have the CLDs work in terms of appropriate reinforcing and balancing behaviour. The solution scenarios tended to highlight reinforcing behaviour in the narratives and omit the description of limiting factors, therefore showing unlimited growth. This illustrates the difference between the Scenario Method and the CLD approach. The narratives produced from the Scenario Method describe a situation picture of the desired state without going into details about how the scenarios work internally, whereas the CLD approach investigates how the makeup of the scenario is constructed through feedbacks. From the system dynamic approach, reinforcing loops are temporary and limiting factors will ultimately constrain growth in all systems. Therefore, during the analysis, it was necessary to identify and insert specific barriers/limitations to create balancing feedback loop behaviour within the solution scenarios.

Apart from the scenario, A Pragmatic Growth, all the scenarios required adjustment to illustrate feedback constrains, and the scenario Ecotopia required the most adjustment.

One of the conclusions from the study points toward the necessity to be explicit in the description of the solution scenarios (and its supporting projection description) since the factors derived for the CLDs need explicit language. This will aid in enriching and identifying key factors of influence in the scenarios, and furthermore validating and preparing the results for further communication is the next step. The study shows that scenario CLDs can be a point of departure to enrich the scenarios further and complement a foresight process (here: scenario analysis). Haraldsson and Bonin (2021) show how CLDs can be developed based on the results of a foresight process. Future research and pilot projects could analyse how Foresight and System Thinking can be integrated more closely from the beginning (Figure 15).

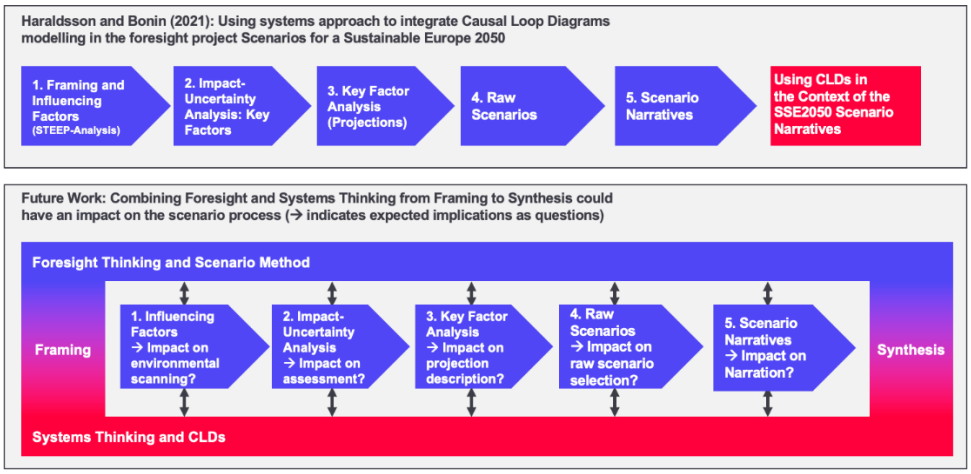

Figure 15: Integrating Foresight and Systems Thinking more closely

This study points towards five different use cases of the CLDs that warrant further consideration for follow-up activities in the context of SSE 2050 and beyond:

1. Giving an understanding of the solution scenario narratives by creating dynamic storytelling.
2. Identifying challenges and shortfalls in the solution scenario narratives that need to be addressed to enhance robustness and reliability.
3. Stimulating the discussion on how external systems influence the scenario narratives, i.e. production and consumption systems (energy, food, mobility).
4. Connecting solution scenarios and context scenarios: Reconciling the goals and actions of Europe and the goals and actions of other actors outside Europe
5. Identify and integrating additional sustainability indicators into scenarios through the CLD building process.

Further work

In addition to the aforementioned follow-up activities related to qualitative modelling, translating the scenario CLDs or parts of them into simplified numerical models could be another option. For instance, the scenario CLDs can be rebuilt in iMODELER for further qualitative indexing analysis (QIA) Figure 16. The qualitative indexing analysis has been demonstrated to show loop behaviour and BOT for selected factors (Haraldsson, 2020;

Haraldsson and Ólafsdóttir, 2018). In figure 16, the first trial run for QIA on the Solution scenario Green Growth Paradigm is shown.

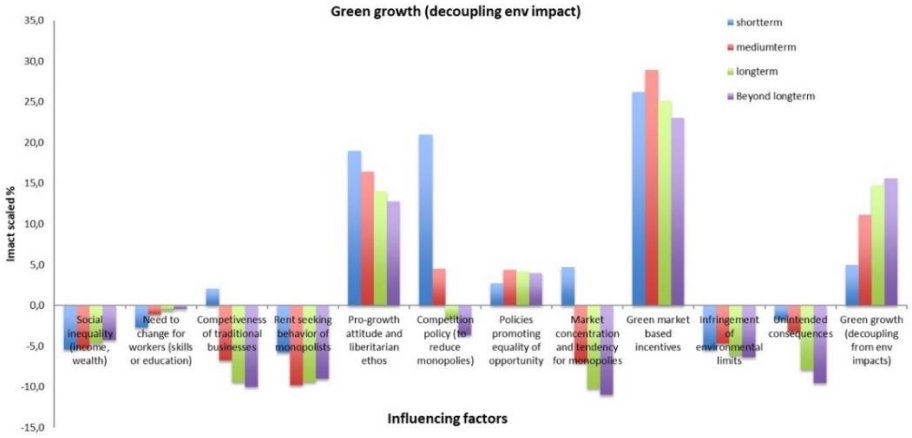

Figure 16: Analysing the scenario CLDs with qualitative indexing analysis. Example of solution scenario - Green Growth Paradigm: The great decoupling of growth in free markets

References:

Abdelbari, H., Shafi, K., 2017. A computational Intelligence-based Method to 'Learn' Causal Loop Diagram-like Structures from Observed Data. System Dynamics Review 33, 3–33. https://doi.org/10.1002/sdr.1567

Barlas, Y., 1996. Formal Aspects of Model Validity and Validation in System Dynamics. System Dynamics Review 12, 183–210.

Binder, T., Andreas Vox, Salim Belyazid, Hordur V. Haraldsson, Mats G. Svensson, 2004. Developing System Dynamics Models from Causal Loop Diagrams.

Burns, J.R., Musa, P., 2001. Structural Validation of Causal Loop Diagrams. Presented at the Proceedings of the 19th International Conference of the System Dynamics Society, System Dynamics Society.

Deutsche Post, 2012. DELIVERING TOMORROW Logistics 2050- A Scenario Study. Bonn, Germany.

European Commission, 2020. Strategic Foresight - Charting the course towards a more resilient Europe.

European Commission, 2019. Mission Letter – Vice-President for Interinstitutional Relations and Foresight. (Mission Letter).

Haraldsson, H.V., 2020. Multi-Criteria Policy Options Analysis of the Swedish Environmental Goals Using Indexed Causal Loop Diagram Modelling Method, in: Enabling Collaborative Governance through Systems Modeling Methods. Springer, pp. 175–190.

Haraldsson, H.V., 2004. Introduction to Systems Thinking and Causal Loop Diagrams (Technical Report). Lund University, Department of Chemical Engineering.

Haraldsson, H.V., Bonin, D., 2021. Using systems approach to integrate Causal Loop Diagrams modelling in the foresight project Scenarios for a Sustainable Europe 2050 (No. 6975). Swedish EPA, Stockholm.

Haraldsson, H.V., Ólafsdóttir, R., 2018. Evolution of Tourism in Natural Destinations and Dynamic Sustainable Thresholds over Time. Sustainability 10. https://doi.org/10.3390/su10124788

Haraldsson, H.V., Sverdrup, H., 2021. Systems Science and System -Thinking in practice- How to develop qualitative and numerical models for evolving under-standing of challenges

and responses for complex policies and com-municating insights (No. Forthcomming). Swedish EPA.

Kim, D.H., Senge, P.M., 1994. Putting Systems Thinking into Practice. System Dynamics Review 10, 277–290.

Lorenz, U., Haraldsson, H.V., 2014. Impact Assessment of Global Megatrends: Two Case Studies Connecting Global Megatrends to Regional Topics. Swedish Environmental Protection Agency.

Lorenz, U., Veenhoff, S., 2013. Integrated scenarios of sustainable food production and consumption in Germany. null 9, 92–104. https://doi.org/10.1080/15487733.2013.11908118

Maani, K.E., Cavana, R.Y., 2007. Systems Thinking, System Dynamics: Managing Change and Complexity, 2nd ed. Pearson Education NZ (Prentice Hall), Auckland.

Millenium Project, n.d. Futures Research Methodologies 3.0.

Neumann, K., 2015. KNOW WHY: Systems Thinking and Modeling: Gain insights for a happier life, more intelligent management and a better world. BoD–Books on Demand.

Schnurr, M., Glockner, H., Berg, H., Schipperges, M., 2018. Erfolgsbedingungen für Systemsprünge und Leitbilder einer ressourcenleichten Gesellschaft: Abschlussbericht. Band 3: Leitbilder einer ressourcenleichten Gesellschaft. (No. UBA-FB 002646/3). Umweltbundesamtes.

SDC, 2019. TREND RESEARCH FOR THE POSTAL SECTOR IN 2030 (EC grant agreement 2017/2019 VS/2017/0374), EUROPEAN SOCIAL DIALOGUE COMMITTEE FOR THE POSTAL SECTOR I 2017–2019. The European Social Dialogue Committee for the Postal Sector (SDC).

UNDP, 2018. Foresight Manual – Empowered Futures for the 2030 Agenda.