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A ROADMAP FOR SUSTAINABLE SUPPLY MANAGEMENT

Hiilineutraali yhteiskunta YAMK
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Toimitusketjujen vastuullisuuden varmistaminen on vähitellen tulossa pakolliseksi kaikille yrityksille. Opinnäytetyön tavoitteena on luoda hankinnan kestävän kehityksen tiekartta. Tehtävänä on tunnistaa, mitä toimitusketjussa pitäisi muuttaa, miten sitä muutetaan ja miten havaitut parannukset toteutetaan, mikä mahdollistaa hankinnan kestävän kehityksen muutoksen.

Hankinta on osa valmistavan teollisuuden toimitusketjua mahdollistaen tuotannon oikea-aikaisen virtauksen oikealla laadulla ja oikealla kustannuksella. Lakisääteiset vaatimukset, kuten CSRD, REACH ja RoHS, edellyttävät hankinnan tukea komponenttien hankinnassa. Kokonaiskustannusmallia (TCO) voidaan käyttää toimittajien hallinnan tukena. Hankinnan muutosten tunnistaminen ja tiekartan luominen toteutettiin looginen ajatusprosessi (The Logical Thinking Process) -strategian ja ongelman ratkaisu metodologian avulla.

Hankinta käsiteltiin kokonaisuutena asiakastoimitusten mahdollistajaksi määritellyin kriteerein. Tunnistetut muutettavat asiat liittyivät tiedonkulkuun ja vastuullisuus teemojen hallintaan sekä riittävään resursointiin. Tärkein tekijä toimitusketjun muuttamisessa kestäväksi on ylimmän johdon tuki. Ilman tukea on erittäin vaikea saada aikaan muutoksia muutosvastuksen vuoksi.

Avainsanat	Hankinta, toimitusketju, vastuullisuus, tiekartta

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ABSTRACT

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Ensuring the sustainability of supply chains is gradually becoming mandatory for all companies. The aim of the thesis was to create a roadmap for the sustainable development of procurement. The task was to identify what should be changed in the supply chain, how to change it, and how to implement the identified improvements, enabling the sustainable development of procurement.

Procurement is part of the supply chain in the manufacturing industry, enabling the timely flow of production with the right quality and at the right cost. Statutory requirements, such as CSRD, REACH, and RoHS require procurement support for component purchases. The total cost model (TCO) can be used to support supplier management. The identification of procurement changes and the creation of a roadmap were implemented using The Logical Thinking Process (LTP) strategy and problem-solving methodology.

Procurement was handled as a whole with criteria defined as an enabler of deliveries. The identified issues to be changed were related to the flow of information and responsibility for managing the themes, as well as sufficient resourcing. The most important factor in transforming the supply chain into sustainable is top management support. Without support, it is very difficult to accomplish changes due to resistance to change.

Keywords Procurement, supply chain, sustainability, roadmap

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1 INTRODUCTION

The world is struggling with social, environmental, and economic crises and striving to make supply chains sustainable. There are government-driven sustainability initiatives to make the transition mandatory, rather than purely driven by market forces. The EU has multiple laws that force companies to make changes and expand the scope of sustainability initiatives to cover the entire value chain, not just their own operations. Sustainability reporting will become a part of every company's agenda and their supply chain.

Supply chain and supply management play a critical role in driving sustainable change with their suppliers. Supply management operates across organizations throughout the supply chain and requires sufficient information flows and policies to ensure sustainable procurement. Sustainability change initiatives need to be planned and executed while considering dependencies on supply chain information flow and needs. Change requires a systems approach. The systems approach sees everything to be connected, if operating in the same system – the company. A system-level sustainability roadmap provides a concrete action plan in the best-case scenario. It visualizes all critical dependencies in a lean manner, with actions that are aligned with the company's ambitions and requirements.

1.1 Research Problem

A case study is done for a company operating in Europe that offers manufacturing services for other businesses. The company aims to improve its sustainability performance by transforming its supply chain and management to be guided by sustainability themes. The company's sustainability management assessment indicated improvement needs, and now supply management would need a concrete action plan in the form of a sustainability roadmap with clear priorities to execute during a three-year period.

1.2 Research Questions

The research objectives are to investigate supply management sustainability practices and create a roadmap for transformation by answering the following questions:

1. What is the Supply Management Goal?
2. What to change in a company to transform supply management into sustainable supply management?
3. What to change in a company to transform supply management into sustainable supply management?
4. How to change company supply management into sustainable supply management?

The research questions are first approached from a theoretical perspective by conducting a literature review on sustainable supply management practices in manufacturing companies. Change management requires defining action plans, and to arrive there, it is necessary to conduct a holistic mapping of the status, what needs to be changed, and how to make the change happen.

1.3 Research Model

The research approach is a practice-based research study, which aims to understand the current practices in the organization and determine which new practices should be adopted. Practical action research involves giving voice to researchers and others who will have to deal with the long-term consequences. This encourages practitioners to act wisely and prudently to ensure that the outcomes are

supportive.[1] Researchers act as active participants in understanding current practices and identifying what needs to be corrected before an actual strategic roadmap can be developed and implemented successfully.

The objective of the thesis is to develop a sustainability roadmap by utilizing systems thinking and logical thinking to map the supply management status of sustainability management, and improvement actions. This will create a strategic roadmap with detailed project plans. The Logical Thinking Process builds the whole produced outcome according to logical rules and syllogisms.[2] Aristotelian syllogism consists of major premises, minor premises, and a conclusion. An additional syllogism used simultaneously involves means, method, and motivation to achieve the objective conclusion. The theoretical framework provides the necessary basis for understanding sustainable supply chain and supply management key factors and capabilities to operate within economic, social, and environmental legal requirements while satisfying current and future customer needs. The development of an actual roadmap is based on the requirements of the case company.

Research problems are approached by first answering research question 1: define what the goals and requirements for sustainable supply management are within the boundaries of the supply management system in manufacturing operations. The second question addresses the deviations between the desired system requirements and existing practices, and simultaneously identifies what needs to be changed for system improvement. The third question answers how identified deviations should change to in supply management. The fourth question answers

[1] Kemmis, S, 2009

[2] Dettmer H. William, 2007

how to make these changes through a strategic roadmap and detailed project plans.

2 THEORETICAL FRAMEWORK

2.1 Supply Chain Management

Supply chain management views the supply chain and the organizations in it as a single entity. This single entity acts as a system (**Figure 1**) to understand and manage the different activities needed to coordinate the flow of products and services to best serve the ultimate customer. The system provides the framework to align all functions to best respond to business requirements that otherwise would seem to conflict with each other. Companies are systems made up of interdependent parts, functions. All the functions within the same company work together to achieve targets or work separately in silos and fail to meet targets. It is important to understand how each driver operates and how it directly affects the supply chain, enabling certain capabilities.[3]

Figure 1. Supply chain.

Production includes activities such as creating master schedules that consider plant constraints, resource availability, quality control, and equipment maintenance. Inventory buffers are used to protect against uncertainties in the supply

[3] Hugos, Michael H. 2018

chain. Depending on demand, inventory should be optimized considering factors such as location and readiness level (raw material, semi-finished, or finished goods). The location of facilities and inventory is influenced by the company's needs, which are determined based on the product's path to the final consumer. The company must optimize its facilities according to its future needs. Transportation plays a crucial role in the supply chain by moving inventory from one location to another. Transportation usually focuses on cheaper options, but then it takes more time to reach our destination and requires larger stock inventories to mitigate uncertainty. Information is gathered on supply needs, which allows effective decisions on production volume, where to locate inventory, and how to transport it to the final customer.[5]

In a company, the trade-off between responsiveness and efficiency (**Figure 2**) involves weighing the benefits of useful information against the cost of acquiring it. Accurate information can lead to efficient decisions and better forecasts, but the cost of obtaining and delivering this information can be high. Companies must decide how much information to share with others and how much to keep private. Sharing more information allows for greater responsiveness, but there is a concern about revealing information that could be used by competitors. Increased competition can negatively impact a company's profitability.[5]

Efficient supply chain network with a well-designed distribution network, effective transportation systems, and reliable suppliers are important for the timely availability of items and a quick response to changes in demand. Accurate demand forecasting is crucial for supply chain management as it helps in planning production, managing inventory levels, and coordinating with suppliers. It allows organizations to align their supply chain activities with customer demand, reducing the risk of stockouts or excess inventory. Supplier capability is a crucial factor in supply chain

management. It involves assessing supplier performance, establishing strong relationships, and implementing effective supplier management practices to ensure the timely and adequate delivery of required items.[4]

Theory of Constraints defines the goal of the supply chain as increasing throughput while simultaneously reducing both inventory and operating expenses.[5] To achieve the goal, each part needs careful planning to keep supply chain flow and deliveries aligned with customer needs. Customer requirements need to cascade to each function to enable effective operations planning. The key factor is information flow. Information is the basis upon which to make decisions regarding the other four supply chain drivers. It is the connection between all the activities and operations in a supply chain. Supply management is part of supply chain management procuring the required raw materials, services, and items to enable manufacturing operations to manufacture and deliver products to the customer according to customer requirements. [5]

[4] Wallace, W et al, 2014

[5] Schragenheim Eli, et al, 2000 page 43

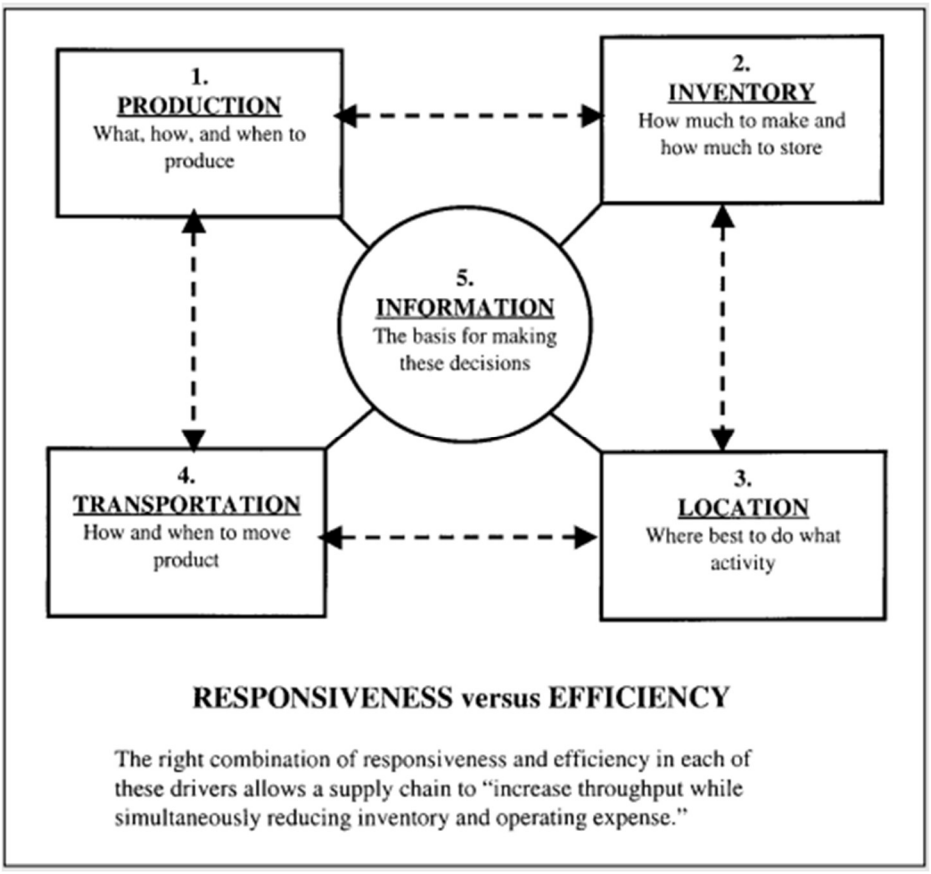

Figure 2. Supply chain planning.[5]

2.2 Supply management

Managing suppliers in today's highly networked environment is a greater challenge than in the past. The role of the supply management function in most companies has evolved significantly and requires far more participation by senior management. Executive leadership must signal the importance of the supply management function to the organization and be involved in establishing the appropriate supply chain structure and proactively participate in the design of the supplier management process.[7]

Effective supplier management requires a strong procurement team, IT support, and performance measurement. Procurement organizations must think strategically, develop strong supplier relationships, negotiate contracts, and integrate the supplier base deeper into the company. Active management of the procurement organization and strategic sourcing will develop the most efficient supply network for the organization.[7]

Issues may arise if the supply management is not considered from a process perspective, including the flow of information, materials, services, and capital throughout the supply management process. If the supply chain is managed from a functional-oriented view, the focus will only be on the steps for which each function is responsible. Procurement personnel and internal business partners may miss opportunities for the supply side to add value in the organization's recognition and description stages if they are not involved. Operating in functional silos and managing the process sequentially rather than concurrently can result in waste, such as unnecessary costs, long cycle times, queues, waits, and missed opportunities.[7]

2.3 Sustainable supply management

The concept of sustainability has gained significant attention in recent years, with a global aspiration to achieve a society, economy, industry, supply chain, business, and individual alignment with sustainable principles. This vision necessitates the implementation of specific actions to attain a harmonious state. It is imperative to address the progressive buildup of substances extracted from the earth's crust, such as heavy metals and fossil fuels, which have long been relied upon. Phasing

out these materials is crucial to mitigate the environmental impact associated with their extraction.[6]

The accumulation of chemicals and compounds produced by society requires attention. Toxic substances such as dioxins, Polychlorinated Biphenyls (PCBs), and dichlorodiphenyltrichloroethane (DDT) pose risks to both the environment and human health. Prioritizing the identification and utilization of safer alternatives, as well as reducing the production of these harmful substances is crucial for the future.[15]

The degradation and destruction of natural processes also demand urgent consideration. Activities such as overharvesting forests, encroaching upon critical wildlife habitats, and contributing to climate change have detrimental effects on the delicate balance of nature. Reversing these trends and safeguarding the environment for future generations is imperative.[15]

Sustainability extends beyond environmental concerns and encompasses social aspects as well. It is crucial to eliminate social conditions that systematically undermine individuals' capacity to avoid injury and illness. Unsafe working conditions and non-livable wages must be eradicated to ensure the well-being of all individuals.[15]

It is essential to address social conditions that hinder individuals' participation in shaping the social systems they are part of. Suppression of free speech and ne-

[6] Sroufe, R. P. et al, 2017

glecting diverse opinions impedes progress and hinders collective decision-making. Fostering an inclusive environment that values and incorporates diverse perspectives is vital.[15]

Education and personal development play pivotal roles in achieving sustainability. Removing obstacles to learning and developing competencies, both individually and collectively, is necessary. Equal access to education and opportunities for personal growth should be ensured for all individuals.[15]

In the pursuit of sustainability, it is crucial to eliminate social conditions that imply partial treatment. Discrimination and unfair selection to job positions have no place in a society striving for equality and fairness. Upholding principles of equal opportunity and meritocracy is essential.[15]

The creation of individual meaning and the co-creation of common meaning are fundamental for a sustainable society. Celebrating cultural expression and removing obstacles to the co-creation of purposeful conditions enable individuals to find fulfillment and contribute to the greater good.

Sustainable supply chain management with focus on environmental, social, and financial dimensions requires systems thinking to understand big picture of interaction with one's own and external environment. When the operating environment is understood, a sustainability strategy can be made. [2]

2.4 Integrating Sustainability into Supply Management Operations

The supply chain is a chain of interdependent functions creating value for the customer according to applicable laws that impact the operations with legal requirements.[6] [7] Sustainable supply management change requirements come from customers' requirements and laws. Change requires a favorable organizational environment, sustainable procurement initiatives, compliance with sustainability standards and external environmental pressures, often from customers and society.[8]

Favorable organizational environment comes when the whole supply chain is acting sustainably by ensuring human rights, working conditions and environmental performance throughout the supply chain.[19] It is crucial for success to have top leadership commitment and support to environmental and occupational health and safety activities within their organizational control. Compliance requires resources and if financial returns are not sufficient to cover the costs, it is not done properly.[9] Therefore, sustainability requires clear governance and well-defined practices to monitor and adjust sustainability activities applied to one's own supply chain.[17]

To achieve a truly sustainable supplier supply chain, it is a prerequisite to have transparency to enable sustainable supply chain success.[10] Suppliers supply chains

[7] Company law and corporate governance

[8] Prasad D. et al, 2018

[9] Venkatesh V. et al, 2020

[10] Fraser I. et al, 2020

for items may be using mineral sources with connections to conflict zones or otherwise poor social conditions, poor working conditions, and corruption.[11]

Sustainable supply management requires supply chain knowledge. Supply chain knowledge builds on experience, and it may be necessary for the company to utilize internal and external resources by applying governance mechanisms to learn different complexity levels of supplier supply chain.[12] Companies may build their knowledge of the supplier supply chains by mapping and auditing what is happening and strengthening trust, collaboration, and governance of strategic suppliers. Such endeavor can be costly to do alone so one option is to collaborate with different businesses using the same raw materials to lower their due diligence costs.[19]

Sustainable supply management, which involves multi-tier collaboration, enables lower costs and fewer delays in deliveries. This is accomplished through strategic alignment and mutual trust in corporate social responsibility (CSR) and operational alignment throughout the entire supply chain.[13] Supplier selection plays a crucial role in achieving a sustainable supply chain. Creating and maintaining sustainable and close relationships with suppliers leads to better performance and reduces waste by using less energy and resources, as well as lowering investment costs on inventory and replenishment volume. Close cooperation allows suppliers to enhance their knowledge on sustainability.[14] In a multi-tier sustainable supply chain, lower-tier suppliers must comply with cascaded sustainability requirements from

[11] Sancha C. et al, 2019

[12] Gong Y. et al, 2018

[13] Yan M. et al, 2016

[14] Debnath B. et al, 2023

higher-tier suppliers. This can be achieved by carefully selecting aligned suppliers or by having sufficient power and influence over suppliers.[15] Suppliers may receive conflicting requirements from their environment if, for example, a higher power actor requests low-cost products, while another is willing to pay more for better risk management within the supply chain. In unclear situations, organizations might choose to decouple from such requirements that remain uncertain as an investment – not committing to them and, in the worst case, treating sustainability as a mere paper exercise.[16] Suppliers are more likely to adopt sustainability requirements when they are compelled to do so by the operating environment or when the supplier is already practicing sustainability - in line with the focal firm.[25] Suppliers respond better to compliance requirements if they are also compensated fairly and have a strategic partnership.[26] Unfair financial compensation from the supply chain will push towards non-compliance.[26]

Managing sustainable supply management has a better probability of succeeding when resources and management attention are focused on areas that have direct control over what is done in suppliers' premises or have a good influence basis.[25] Priority sustainability initiative activities should focus on strategic items that have a high overall business impact. The second priority should be given to suppliers who are aligned with the company. Suppliers who provide bottleneck items with critical resources or non-critical items that face cost pressure are experiencing performance issues and have low negotiation power, which reduces the likelihood of success for sustainability programs.[25]

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[15] Marttinen K. et al, 2022

[16] Sauer P. et al, 2018

Companies may manage this risk by focusing their attention on the most critical material supply chains that could have profound consequences for the company, such as loss of business and reputation. Whichever comes first due to supply chain uncertainty.[19] It is possible to directly engage suppliers in a complex supply network, and this is usually done through a "direct" approach when the company does not have enough knowledge.[20]

Suppliers that have a small impact on supply chain sustainability may not be the focus of management attention. When there is low uncertainty in the material supply chain, it is appropriate to use low effort practices to ensure supplier compliance. On the other hand, when there is high uncertainty, it is necessary to further develop the relationship to have a greater influence on company objectives. This can be achieved through direct or indirect approaches, with frequent, long-term, and trustful interactions.[22] At the time knowledge is sufficient, companies tend to use "indirect" or simply "don't bother".[20]

When a firm has multi-tier supplier power sources, they will have a greater influence on cascading sustainability requirements throughout the entire supply chain. If they only focus on the first tier, it will not be successful in making the supply chain sustainable.[24]

If a firm has a high dependency on its suppliers' items, the firm is weak in negotiation power. Firms that have critical resources and knowledge have greater power over the supply chain at all levels.[24]

2.5 Sustainable supply chain risk management

Sustainability risk management consists of three different areas: social dimension, environmental dimension, and economic dimension. Each of these has its own legal compliance requirements that companies must comply with. When operating

in the EU area, legal compliance acts as the minimum requirement for risk management. Legal requirements are the same for customers who are also operating in the EU area. EU legal requirements provide minimum customer sustainability requirements and therefore also impact risk management. Customers can also request separate actions to minimize supply chain sustainability risks impacting the three dimensions. These requirements have an impact on the economic aspect through the Total Cost of Ownership, such as additional certification costs or other documentation costs. The supply chain might need to change its logistics strategy to minimize environmental impact while simultaneously increasing the economic burden with additional costs from more environmentally friendly transportation. Each supply chain step needs to be economically sustainable to enable an overall robust and sustainable supply chain. Major risks that have an impact on the environment, humans, and society are counterbalanced with monetary risk values at the accounting level. Deciding which actions are good for an overall sustainable supply chain requires initiatives that create additional revenue through new business or reduce costs within the supply chain.

2.5.1 REACH - regulation of the Registration, Evaluation, Authorization and Restriction of Chemicals

REACH is the main EU law to protect human health and the environment from the risks of chemical use. The REACH Regulation (EC 1907/2006) entered into force in 2007. The regulation requires the EU industry to identify, report, and provide safety information on the substances in the European database SCIP, which is managed by the European Chemicals Agency (ECHA). ECHA is the central point managing the database system, coordinating in-depth evaluations of informed chemicals, and maintaining a public database for the convenience of consumers and professionals seeking hazard information. Article 33 specifies that consumers have the right to receive a report on substances within 45 days (about 1 and a half months) from the inquiry. Business-to-business transactions do not have this time

limit and are therefore required to provide a REACH declaration specifying the substances the item(s) contain for each delivered item.

The REACH Regulation aims to:

- ensure a high level of protection of human health and the environment against harmful substances
- assess the safety of chemical substances in use in the EU
- promote innovation and competitiveness
- promote alternative (non-animal) methods for the assessment of the hazards of substances

REACH Registration requires companies to register their chemical substances if they exceed 1 ton per year per company. Companies need to identify the risks of handling chemicals and inform how to handle them and how they handle the chemicals. Not all usage is required to be registered, but there is an obligation to inform when using SVHC in company products. Information needs to be shared when concentration levels are over 0.1% of the item weight to the item concerned. This requires a company to report in detail which parts substances can be found in, down to the smallest part of the assembly if it has SVHC concentrations above the threshold, such as a spacer or O-ring. The SVHC list is updated every 6-month period.[17]

[17] European Commission. REACH Regulation.

2.5.2 RoHS - Restriction of Hazardous Substances Directive

The RoHS Directive aims to prevent risks to human health and the environment by restricting the use of certain hazardous substances in electronic and electrical waste. It promotes recyclability and ensures a level playing field for manufacturers and importers in the European market.

EU laws restrict the use of hazardous substances in electrical and electronic equipment through the RoHS Directive. The WEEE Directive promotes the collection and recycling of such equipment. The RoHS Directive currently restricts the use of ten substances in electrical and electronic equipment.

The RoHS Directive currently restricts the use of ten substances:

- lead
- cadmium
- mercury
- hexavalent chromium
- polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE)
- bis(2-ethylhexyl) phthalate (DEHP)
- butyl benzyl phthalate (BBP),
- dibutyl phthalate (DBP) and di-isobutyl phthalate (DIBP).[18]

[18]Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS)

2.5.3 CSRD – Corporate Sustainability Reporting Directive

Corporate Sustainability Reporting Directive (EU) 2022/2464 requires companies to report their sustainability information on social and environmental issues supported by an economical view on the risks social and environmental issues present to the company. The key point is to help interested parties evaluate companies' sustainability performance (part of the European Green Deal). The first companies to apply the new rules are current large public-interest listed companies currently reporting according to the Non-Financial Reporting Directive (NFRD). NFRD requires companies to report on environmental matters, social matters and treatment of employees, respect for human rights, anti-corruption and bribery, and diversity on company boards (in terms of age, educational and professional background).

CSRD is built as an overarching directive with multiple standards as part of the delegated act named European Sustainability Reporting Standards (ESRS). ESRS Annex I include a total of 12 standards, of which two are cross-cutting standards mandatory for all companies. In addition to the two cross-cutting standards, 10 reporting standards are applied to the extent that they are relevant to sustainability matters in the company's operations and value chain. Relevancy is determined through a double materiality assessment, which consists of assessing the impact materiality of sustainability matters and financial materiality. From a metrics perspective, each materiality can be positive or negative.[19]

The ESRS standards are the following:

[19] ESRS Annex I

Cross-cutting standards:

- ESRS 1 General requirements
- ESRS 2 General disclosures

Standards on Environmental, Social and Governance matters:

- ESRS E1 Climate change
- ESRS E2 Pollution
- ESRS E3 Water and marine resources
- ESRS E4 Biodiversity and ecosystems
- ESRS E5 Resource use and circular economy
- ESRS S1 Own workforce
- ESRS S2 Workers in the value chain
- ESRS S3 Affected communities
- ESRS S4 Consumers and end-users
- ESRS G1 Business conduct
- ESRS2 General disclosure is the minimum reporting requirement for disclosures and defines also what is needed to do in 10 social and environmental reporting standards.[20]

General reporting areas on ESRS's are:

- Governance (GOV) describing governance processes, controls, and procedures to monitor and manage impacts, risks, and opportunities

[20] European Commission, Corporate sustainability reporting;

- Strategy (SBM) describing company's strategy and business model(s) interacting with material impacts, risks, and opportunities as well as strategy on addressing materiality
- Impact, risk, and opportunity management (IRO) describing the process(es) used to identify impacts, risks, and opportunities, and assessed and managed through policies and actions
- Metrics and targets (MT) describe how a company is measuring its progress towards the targets it has set.[21]

2.5.4 Corporate Sustainability Due Diligence Directive

The Corporate Sustainability Due Diligence Directive (CSDDD) (EU commission proposal Feb 22nd, 2022) aims to foster sustainable and responsible corporate behaviour and integrate human rights and environmental considerations into companies' and corporate governance. CSDDD ensures that businesses address the impacts of their actions within their value chain inside and outside of the EU.[22]

The Due Diligence requires companies to include various risk-based due diligence measures in their operations, such as:

- Drafting an internal due diligence policy and including the due diligence obligation in the company's essential operating principles and risk management systems
- Identification and prioritization of actual or potential adverse effects
- Prevention, mitigation, and termination of adverse effects

[21] EFRAG European Sustainability Reporting Standards

[22] The Corporate Sustainability Due Diligence Directive

- Implementation of corrective measures related to realized adverse effects
- Consultation and involvement of relevant stakeholders
- The introduction of a procedure for reporting actual or potential adverse effects and a non-judicial complaint mechanism
- Implementation of regular follow-up measures
- Public information on due diligence measures for companies that do not report in accordance with the Corporate Sustainability Reporting Directive (CSRD).[23]

Companies with more than 1000 employees must develop a policy to promote the implementation of the transition plan. Companies could be liable for damages if they fail to comply with the obligations of the directive and cause harmful impacts. The injured party would have the right to full compensation, but the company's liability for damages would be limited by its business partners in the value chain. The limitation period for a damages claim would be at least five years. The directive would also provide for other sanctions, such as inspections and penalties. According to the directive, companies must comply with effective, proportionate, and dissuasive sanctions. Sanctions should include at least a financial penalty and a public announcement of the company's name and the nature of the violation. The maximum penalty for a financial sanction should be at least 5% of the company's global turnover.[23]

[23] Holmström T. et al, 2024

2.5.5 Human rights

Universal Declaration of Human Rights consists of 30 articles that outline the fundamental rights and freedoms that all individuals are entitled to. These rights include the right to life, liberty, and security of person; the prohibition of slavery and torture; the right to recognition as a person before the law; the right to a fair trial; the right to privacy; the right to freedom of movement, thought, and religion; the right to work and social security; the right to education; and the right to participate in cultural life. The Declaration emphasizes the importance of equality, non-discrimination, and the protection of human dignity. It also recognizes the responsibilities of individuals to the community and the limitations that can be placed on rights and freedoms to protect the rights of others and maintain public order.[24]

2.5.6 Conflict minerals

The EU passed a new regulation in May 2017 to stop the trade in conflict minerals. The law requires EU companies to import minerals and metals from responsible sources only. The requirements started to apply on 1 January 2021.[25]

The minerals trade in politically unstable areas can finance armed groups, while increasing forced labour and other human rights abuses, and supporting corruption and money laundering. These 'conflict minerals' such as tin, tungsten, tantalum, and gold can be found in everyday products like mobile phones and cars or in jewellery. It is difficult for consumers to know if the products they buy are funding violence, human rights abuses, or other crimes overseas.[32]

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[24] Human rights

[25]Conflict minerals

Companies have due diligence requirement to investigate and manage risks in their supply chain. Companies must check that the minerals they buy are sourced responsibly and do not contribute to conflict or illegal activities. By checking their supply chains, companies can ensure that they manage these risks responsibly.[34]

EU importers of tin, tantalum, tungsten, and gold must follow a five-step framework to ensure that their imports have not been produced in a way that funds conflict or other illegal practices. The steps include:

- Establish strong company management systems
- Identify and assess risk in the supply chain
- Design and implement a strategy to respond to identified risks
- Carry out an independent third-party audit of supply chain due diligence
- Report annually on supply chain due diligence.[34]

2.6 Total cost of ownership

Total cost of ownership (TCO) is an integral part of managing supply management. TCO extends from traditional item price focus to all other major cost issues that affect critical purchases. TCO is proactive approach to purchasing. [26]

All purchased items are part of doing business and therefore part of the total cost of ownership, including the supplier's item price, performance, compatibility, and value added. Price and compatibility are the most important aspects when evaluating the total cost. Price is self-explanatory, but compatibility refers to the buyer-

[26] Ellram L, 1994

supplier relationship and how well the supplier meets the buyer company objectives. It also considers how well the supplier is coping with the focal company's operational needs, creating added value for the end customer. What is needed is the lowest total cost of ownership, which provides the best value.[27]

When the total cost of ownership is kept at an optimal level, both internal and external cash flow are minimized for the overall costing of the system. This is achieved by ensuring that cost elements are at a sufficient level, which involves identifying supplier-generated costs throughout the lifecycle of the system.[28]

In a simplified way, total costs are part of the overall system's net profit as a component of costs. Companies invest money in inventory that is used to manufacture end products. Everything done inside the company to produce the product incurs an expense.

Net profit = Sales – Expenses[29]

Supply management and total cost of ownership have a substantial impact on net profit, as they involve purchasing materials and the costs generated from using these materials.[10]

Total cost of ownership uncovers details generated by supplier performance and supports further analysis and decision-making. There is no one-size-fits-all approach, as the data used varies a lot because each business has specific business

[27] Snelgrove T. 2011

[28] George A. et al, 2003

[29] Schragenheim, E. et al, 2019

conditions. The total cost of ownership model will evolve after the first model is used. Unique models might be needed to track, analyze, and use in decision-making.[24]

The total cost of production is the sum of the costs of labor, materials, and overhead minus any return from the successful sale of surplus materials. The disposition of surplus materials is important to the environmental movement and to profit maximization. Such materials include: 1) scrap and waste; 2) surplus, obsolete, or damaged stock; and 3) surplus, obsolete, or damaged equipment. Supply chain managers who often hold diverse views on environmental issues (ranging from active environmentalists to those merely sympathetic to the cause or those who view it as a radical conspiracy against big business) frequently overlook this fact.[30]

TCO main benefits are improved supplier performance measurement, improved purchasing decision making, improved internal and external communications, better insight and understanding into purchased goods/services and supplier performance, and support company continuous improvements efforts.[31]

[30] Handfield R. et al, 2002

[31] Ellram L, 1994

3 DEVELOPMENT OF SUPPLY MANAGEMENT SUSTAINABILITY ROADMAP

3.1 Strategic roadmap

"*Strategy is the art and science of developing and employing skilled people, technology, marketing and sales, and other instruments of organizational power in a synchronized fashion to achieve the corporate goal and objectives."*[32]

Company strategy points the direction and course of action for the whole organization. Strategic objectives trickle down in a hierarchical way. Depending on where a person is in the organization, they can have strategic objectives that are at a tactical level higher in the organization. Strategy formation and planning answer the question of what type of business the company is by defining the company mission, where the company expects to go with their business by defining the vision, and the principles and concepts that are important to the company by defining the values. In addition to this, the strategy defines the long-term growth and profitability objectives. These objectives will require incremental steps for execution to achieve them in the company's specific operating environment. [30]

A complete strategy analysis depends on the level of knowledge of the company's internal and external environment, and with a sufficient level, it produces solutions quickly. Another factor is understanding the complexity of the system. System complexity depends on the ability to control the system. Managing the system

[32] Dettmer W. 2003, p. 136

is easier when there are only a few variables to control – fewer degrees of freedom. Managing is also easier when there is a full view of dependencies as cause-and-effect relationships in the system. [30]

3.2 Change Management Method – Logical Thinking Process

Logical thinking process (LTP)[2] is a systems-level problem-solving methodology with five specific phases (**Figure 3**) to create an action plan for a defined system goal. The action plan is also a strategic roadmap. Each phase can be used separately but works best as a whole LTP analysis. The phases are:

- Goal tree
- Problem tree - Current reality tree
- Conflict resolution diagram - Evaporating Cloud
- Solution tree - Future reality tree
- Implementation tree – Prerequisite tree

The goal tree describes the future state with goals, critical success factors, and necessary conditions. The current reality tree identifies the current state compared to the future state and critical root causes. The evaporating cloud develops solutions to the critical root causes and lays the starting point for the future reality tree. The future reality tree is a desktop simulation that identifies all the needed actions to achieve the future state as defined in the goal tree. The prerequisite tree is a detailed action plan for each action identified during the future reality phase. The outcome is a list of all actions to implement changes aiming to reach the future state defined in the goal tree phase.[2]

The goal tree, evaporating cloud, and prerequisite tree are necessity-based trees. Necessity-based trees are read in the form "In order to ... we must ... because...".

The validity of necessity-based trees' cause-effect relationships depends on meeting minimum necessary requirements. For the necessity-based trees, they cannot realize the resulting entity without the preceding entity. [2]

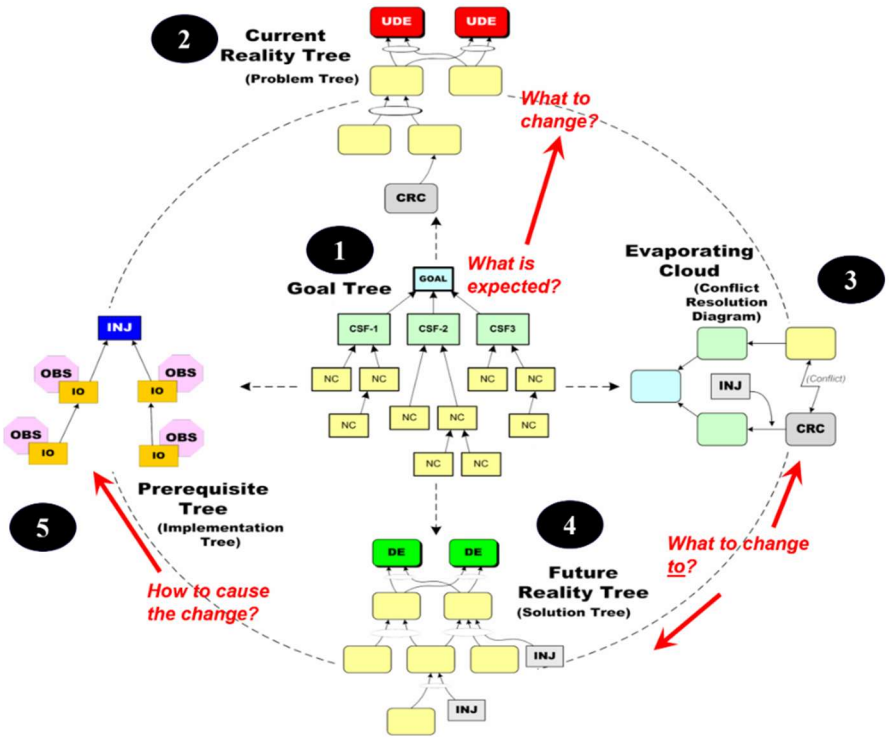

Figure 3. The Logical thinking process wheel.[33]

The current reality tree and future reality tree are sufficiency-based trees. Sufficiency-based trees are read in “If - then” form. The validity of cause-effect depends on sufficiency. Sufficiency comes from the ability of causes to actually produce the effect. Sufficiency logic is based on Aristotle's view in logic to present causes that are linked and causing the studied effect. The causal factors are:

[33] Siglaugsson Thorsteinn, 2024 The logical thinking process wheel

- Means (resources)
- Method (a way to act)
- Motivation (the desire or determination to act)

The second logic tool is syllogism, which has three parts with their own roles. A major premise describes the nature of the situation, while the minor premise consists of statement(s). There can be more than one minor premise. Each statement follows a grammatical subject-verb-object structure.[2]

The Categories of Legitimate Reservation (CLR)[2] are rules of logical thinking. CLR is used to analyze logic trees. It is a framework consisting of eight specific tests or proofs that are used to validate cause-effect logic. The CLR consists of:

1. Clarity
2. Entity existence
3. Causal existence
4. Cause insufficiency
5. Additional cause
6. Cause-effect reversal
7. Predicted effect existence
8. Tautology

The CLR can be partially used for necessity-based tree self-scrutinization, and fully for sufficiency-based trees. Each CLR and question is explained in appendix 1.

LTP is a logic-based approach to problem solving, and the analysis requires accurate and verifiable data to produce the correct outcome. Systems are usually complex by nature and require extensive knowledge of how the system functions.

LTP sets a clear focus and defines what is important for the success of the system. A company is a system with interdependencies between all the activities carried out in various functions to operate the company.[2]

Goal tree

The first step in Logical Thinking Process[2] methodology is the Goal tree, which answers the question of what systems should do to achieve their goals. The goal tree serves as a reference to compare operational performance. The tree is built hierarchically based on the necessity of actions, using the phrase "In order to.... I must...." Each layer represents a lower-level action that needs to occur before higher levels can be achieved. Lower levels do not generate the conditions for the next level. The goal tree can be constructed by listing the company's mission and value statements. [31]

The goal is whatever the system owner decides it to be. The goal has multiple preconditions to be satisfied if it is to be achieved. These are called critical success factors and necessary conditions. Critical success factors do not guarantee success but require a group of additional necessary conditions for success. There are two types of necessary conditions: internal and external. The internal necessary conditions are self-defined conditions for operations/systems. Company value statements are often self-imposed necessary conditions, which are choices and realized in the form of policies. Policies can ultimately be the constraint limiting company success. The external necessary conditions are imposed by the environment, outside the organization. These conditions include natural laws, laws of science, legislative laws, basic knowledge as common sense, and individuals who have the power to shut down the system/company. Other external conditions include the competitive environment, the nature of the product/service, and changes in the industry paradigm, which render other conditions unnecessary and create new ones.[30]

From all the necessary conditions, only a few are critical, varying from 1 to 5. Possible sources of necessary conditions include mission, vision, and values statements, as well as laws, governmental regulations, or the board of directors' mandate. [30]

Current reality tree

Current reality tree (CRT) [2] answers the question of where we currently stand compared to the future state of the goal tree and what needs to change. A well-defined problem is more than half solved.[34] Building the goal tree helps us understand the system dependencies that contribute to undesired effects (UDE), which in turn assists in building the Future Reality Tree.

CRT begins by identifying visible deviations from the benchmark goal tree, which are referred to as undesired effects (UDE). The CRT then constructs a logical structure based on logical rules from the UDE, until the critical root cause and the dependencies between logical branches emerge. The current reality tree uses sufficiency logic ("If... then..."). The logic tree is built top-down syllogistically (**Figure 4**) one layer at a time. The construction of the tree only stops when the critical root cause is identified at the bottom of the tree. [2]

[34] Dettmer W. 2019

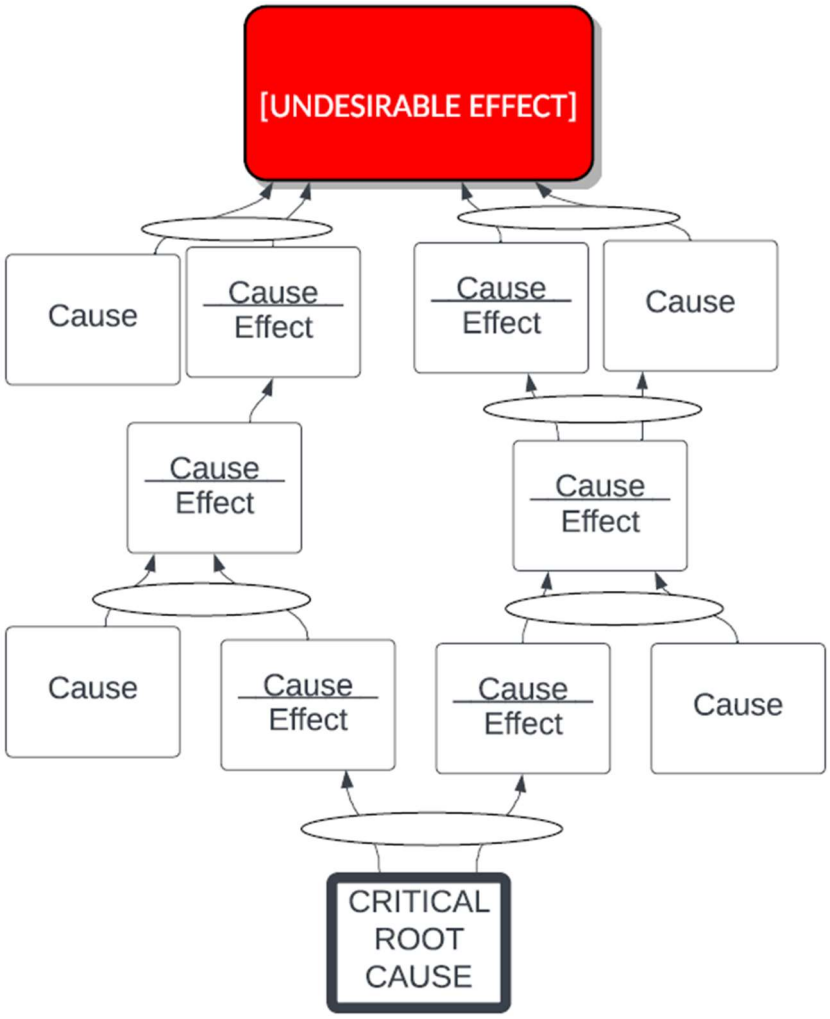

Figure 4. Current reality tree logical structure.

Evaporating cloud

Not all critical root causes will need to be handled in the conflict resolution phase called the evaporating cloud (**Figure 5**) phase, only the most important ones. The identified biggest contributor critical root cause or multiple contributors require the underlying conflict to be resolved. The organizational conflict could be internal or external, either clearly noticeable or hidden conflict. A conflict arises from deviating needs that one side currently wants to do, and another party does not want to do. These are prerequisites to fulfill the requirement. From these two sides,

both views have different needs to fulfill, a requirement to achieve the objective common for both views but cannot be achieved without fulfilling both needs.[2]

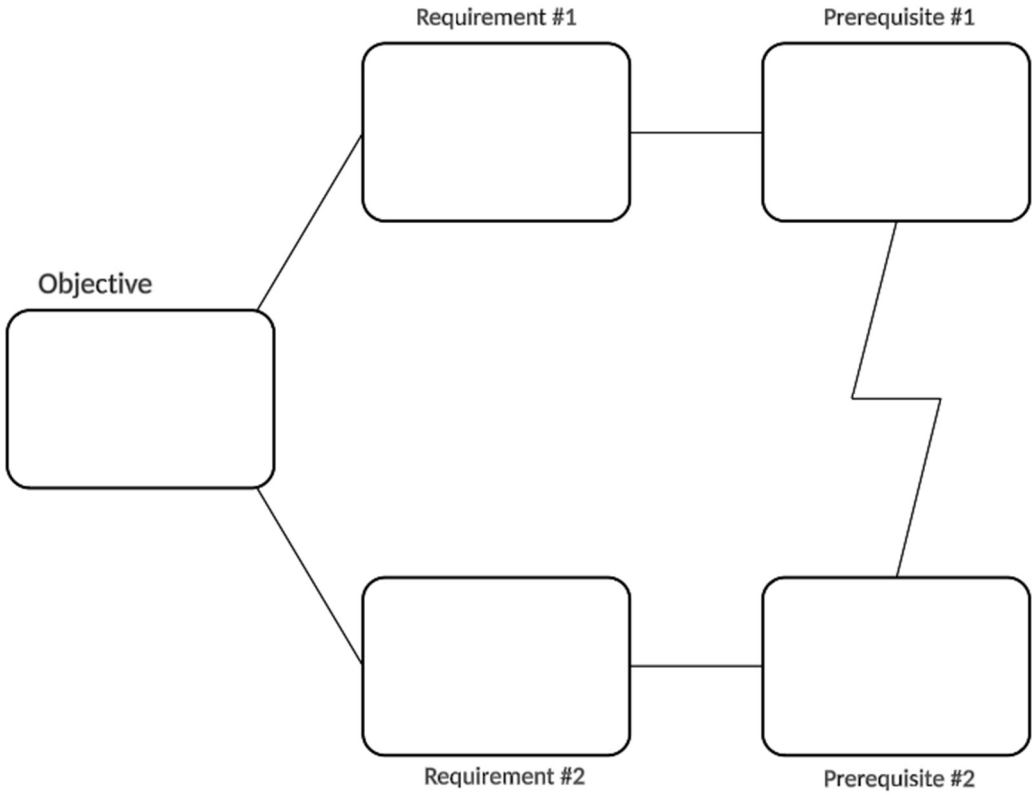

Figure 5. Evaporating Cloud.

Between each connection from objective to requirements #1 and #2, there are their own assumptions for the defined requirement. The connections between requirements #1-2 and prerequisites #1-2 have underlying assumptions that create the conflict. A solution is developed to address the assumption that is not valid by creating a win-win solution. Conflict resolution can require multiple solutions or injections to remove the conflict.[2]

As all undesired effects will originate within the same system, critical root causes resolved in the solution development phase are the ones as low as possible in the tree. This ensures the biggest possible improvement to the system with solutions named as injections. A solution is created originating from conflicting activities or

policies in the system/organization, which is the critical root cause for the system-level problem. The critical root cause is the starting point for generating a solution for the obstacle or showstopper, which, if left in its current state, will make persons' change efforts frustrating and, optimistically stated, result in suboptimal outcomes. The critical root cause is usually a conflict between two activities trying to satisfy their own needs connected to the organizational goal. [2]

Future reality tree

Future reality tree (FRT) starts from injections (actions) developed with evaporating cloud. In CRT, UDEs are the deviations from critical success factors. Injections aim to achieve Desired Effects – Goal tree necessary conditions. FRT can be either done without a CRT analysis or by using the current reality tree structure by placing injection(s) where critical root causes were. This changes the logic from negative CRT to positive FRT. The future reality tree uses sufficiency logic "If… then…" in a syllogistic way. FRT is built from bottom-up, one layer at a time, until desired effects are reached to fulfill the goal tree reference state. Tree building requires supporting actions to get the right direction. Also, deviations from expected reactions from changes, injections, are simulated with the future reality tree and counteractions to mitigate negative outcomes. FRT verifies that the created injections do produce the intended future reality. The logical structure from bottom-up is also the sequence for execution for the future reality. [2]

Prerequisite tree

The prerequisite tree collects all defined injections and generates supporting actions to define the concrete steps to take in order to achieve the defined deliverable. Activities are brainstormed, categorized, and placed on a timeline in the correct sequence to highlight what needs to be done first. The categories can include development, training, and implementation, all of which are part of the overall

execution plan to achieve the defined objective. Once all actions have been defined, the tree is rotated 90 degrees to the right, showing what needs to be done from left to right. [2]

4 CREATION OF SUPPLY MANAGEMENT SUSTAINABILITY ROADMAP

The supply management sustainability roadmap was developed using the Logical Thinking Process methodology. The roadmap work was completed digitally in the Lucidchart application.[35]

Understanding the organization's structure, governance, and processes must be sufficient to evaluate how the organization works and how to make changes happen. For this reason, in the initial stages, this area was studied in detail by mapping all available and reasonable data on how the organization manages its inputs and outputs to generate throughput. At this phase, the focus is on the overall view of what the organization manages from a supply management perspective and interactions.

The development of an organization is mandated by the system owner, who has their own sphere of control and sphere of influence. This provides a view of what decisions can be made directly by the system owner and where they can only influence the decisions on how the system will work. If corrective actions fall within the sphere of influence, there is a need to obtain decision-making power from someone else to support the changes. This view will establish the boundary conditions for the study and improvements, in the form of a roadmap, and set the stage for the upcoming challenges in making changes happen.[2]

[35] Lucichart, n.d. www.lucidchart.com

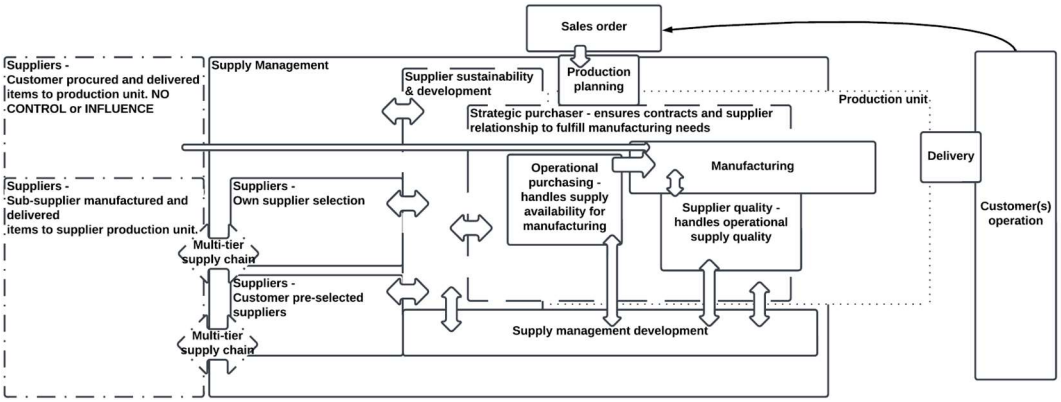

Figure 6. Supply management boundaries.

The supply chain is the overall delivery process (**Figure 6**) from customer order to customer delivery, meaning everything that happens inside the company at the operational level. The supply chain has sufficient governance and processes to enable customer delivery.

Creating a strategic roadmap with concrete action plans requires interaction with the system owner and impacted main stakeholders. The goal and goal tree should be aligned with the company's goal and ensure that the supply management strategy will not deviate from the company's strategy, but rather support it and improve company profitability.

4.1 Goal Tree

The creation of a strategic roadmap with a concrete action plan began with a desktop goal tree using a cloud-based diagramming application called Lucidchart. The initial goal tree was prepared based on the company's public information, gathering inputs from the company's mission, vision, and strategy to understand what the company's goal tree would look like. This provided a better understanding of what is important in supply management towards the company's goals and served as the starting point for the supply management goal tree. The actual goal for Supply Management was defined by the system owner. The Supply Management goal

tree was complemented by a theoretical framework on supply chain management and taken into consideration in the context of the case company when building the initial tree. Proposed entities were brainstormed with the Supply Management Director. Once all requirements were documented, the entities were categorized as necessary conditions and critical success factors below the goal. The critical success factors were evaluated as guiding conditions that must be realized to achieve the goal. Each critical success factor was discussed in detail to determine the actual need and ensure that the entity was clear and understandable to all. The critical success factor has a series of necessary conditions as requirements using necessity-based logic. After the goal tree reached an acceptable level of accuracy in all areas, it was reviewed with the Quality Director to improve quality and sustainability requirements necessary to achieve success in the supply management operating environment. The Goal tree was developed in an iterative way, with a total of four versions, to arrive at the approved goal tree. (**Figure 7**).

The supply management goal was defined as *Efficient, Effective and Sustainable Supply chain.* The goal is to further clarify the meaning: to achieve maximum productivity with minimum wasted effort and expense using readily available resources while maintaining a certain level of performance (economic, social, and environmental).To achieve the goal, there needs to be four conditions (critical success factors) satisfied:

- CSF#1 Supply meets defined quality criteria
- CSF#2 Item available at right time
- CSF#3 Optimal total cost
- CSF#4 Minimized sustainability risk in supply chain.

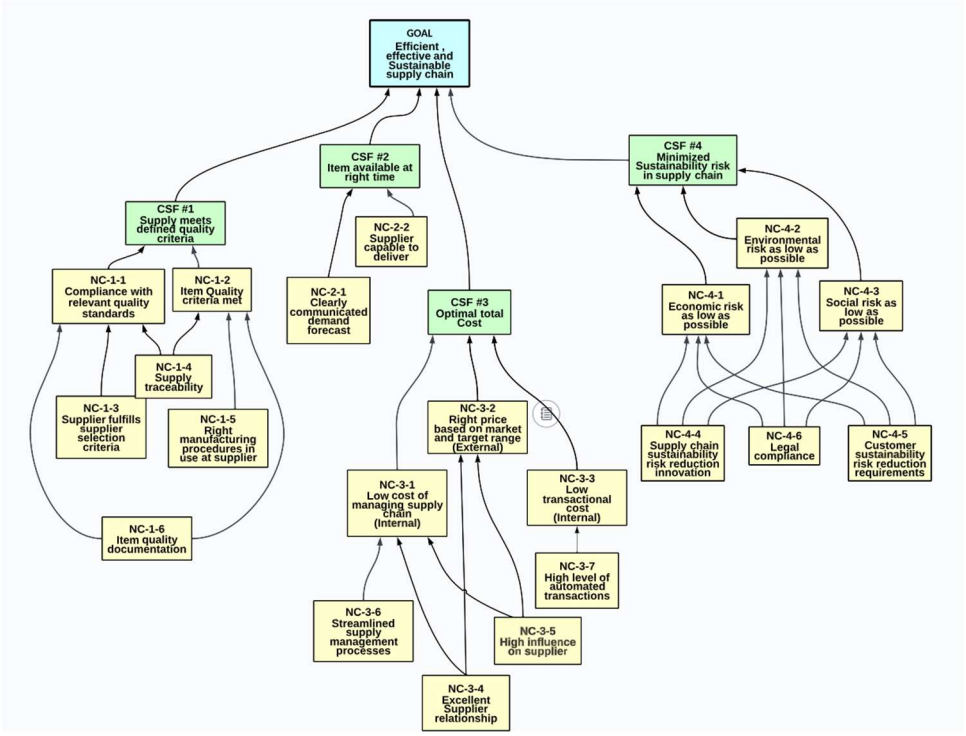

Figure 7. Goal tree.

Quality Criteria for Efficient and Sustainable Supply Chain

Suppliers need to possess the necessary capabilities and resources to meet the supply chain demands. Suppliers must comply with relevant quality standards, thereby guaranteeing that their products and services meet the established benchmarks of excellence.

Item quality criteria are impacted by utilizing appropriate manufacturing procedures. By utilizing the right techniques and processes, suppliers can enhance the overall quality of their output, thereby contributing to the attainment of item quality criteria. Suppliers are also expected to provide comprehensive item quality documentation and ensure supply traceability, enabling transparency, accountability, and effective monitoring and evaluation of the supply chain. By fulfilling the criteria, suppliers demonstrate their commitment to maintaining high standards of quality.

Compliance with quality standards and the utilization of appropriate manufacturing procedures directly influence the attainment of item quality criteria. Item quality documentation and supply traceability support the overall supply quality.

Ensuring Timely Availability of Items with Clear Communication and Supplier Capability

To guarantee the availability of items at the appropriate time within a supply chain depends on two necessary conditions. The first necessary condition entails the clear communication of a demand forecast. By effectively communicating the anticipated demand, the supply chain can engage in proactive planning and ensure that the appropriate quantity of items is ordered. This facilitates the optimization of inventory levels and minimizes the risk of shortages or excesses.

The second necessary condition is the supplier's capability to deliver the ordered items. It is crucial that the selected supplier possesses the necessary resources, expertise, and operational capabilities to fulfill the order within the specified period. This includes factors such as production capacity, transportation logistics, and inventory management. By ensuring the supplier's capability to deliver, the supply chain can mitigate the risk of delays or disruptions, thereby maintaining a seamless flow of items.

The successful fulfillment of clearly communicated demand forecast and the supplier capable of delivering is paramount in achieving the critical success factor of making the item available at the right time. If items are not available at the right time, then delays or shortages within the supply chain can have negative effects as not capable to deliver items in time to customers. As deliveries have shortages, it can create a negative effect in the form of dissatisfied customers and potential revenue loss. By ensuring that the item is available when needed, the supply chain

can enhance customer satisfaction, maintain operational efficiency, and maximize revenue generation.

The clear communication of the demand forecast is essential for the supplier to adequately plan and allocate resources, while the supplier's capability to deliver is dependent upon the accuracy and timeliness of the demand forecast.

Optimizing Total Cost

The factors that contribute to achieving optimal total cost highlight the necessary conditions that play a role in achieving this goal. Three necessary conditions are a low cost of managing the supply chain, the right price based on the market and target range, and low transactional costs.

A high level of automated transactions and streamlined supply management processes, along with an excellent supplier relationship and high influence on suppliers, are necessary conditions that contribute to a low cost of managing the supply chain. The interconnectedness between these necessary conditions is of great importance in leveraging technology and efficient processes to minimize costs and improve operational efficiency within the supply chain.

An excellent supplier relationship and high influence on suppliers are crucial in achieving the right price based on the market and target range. By fostering strong relationships with suppliers and exerting influence, the organization can negotiate favorable pricing terms and ensure that costs align with market conditions and the target range.

A high level of automated transactions (internal) leads to the necessary condition for low transactional costs and, ultimately, to the critical success factor of optimal total cost.

Minimizing Sustainability Risk in Supply Chain

The main objective of minimizing sustainability risk in the supply chain is to reduce economic, environmental, and social risks to the lowest possible level. Necessary conditions encompass several key components that contribute to achieving critical success factor in minimizing sustainability risk in the supply chain.

Legal compliance is identified as a crucial factor in minimizing sustainability risk. By complying with relevant laws, regulations, and industry standards, the organization can ensure that its operations align with legal requirements and mitigate potential risks associated with non-compliance.

Meeting customer sustainability risk reduction requirements is another important aspect of minimizing supply chain sustainability risk. This emphasizes the organization's commitment to addressing the specific sustainability concerns and expectations of its customers. By aligning with customer requirements, the organization can enhance its reputation, build stronger relationships, and reduce potential risks associated with customer dissatisfaction.

Supply chain sustainability risk reduction innovation is the third necessary condition in the goal tree sustainability branch, which emphasizes the importance of continuously seeking innovative solutions and practices to minimize sustainability risks within the supply chain. By embracing innovation, the organization can identify and implement innovative approaches that reduce risks and enhance sustainability performance, including the economical aspect.

Each necessary condition is connected to economic, environmental, and social risks and must be addressed collectively to achieve the desired outcome, the main objective of minimizing sustainability risk in the supply chain.

4.2 Gap Analysis

The gap analysis phase was conducted by comparing the current reality to the set goal and hierarchical requirements to identify deviations. The case company has multiple manufacturing locations in two different countries in the EU, each with a different customer base and issues at hand. In addition to this, the company has two different ERPs in use, creating additional complexity in the analysis. Due to the complexity of different manufacturing locations having different deviations compared to the goal tree and underlying requirements, the scope of the Master's thesis was adjusted to cover the total cost of ownership and sustainability risk management. With the used methodology LTP, all critical root causes need to be solved to achieve the system goal.

Mapping started with reviewing existing documentation and more specifically how it can be found in processes and procedures. Understanding what exists and what does not provide background for overall mapping of the current reality. The quality of the gap analysis depends on the studied system knowledge.[36] To have the necessary system knowledge for current reality analysis, mapping was conducted with a total of 6 individuals from all three locations. The purpose was to understand the major deviations and the connected causes for the identified undesired effects. After deciding to focus the study on CFS#3 *Optimal Total Cost* and CSF#4 *Minimized Sustainability Risk in the supply chain*, the number of active contributors involved in the analysis was reduced to three individuals who possessed the most expertise on the topic and the surrounding environment. In this case the se-

[36] Dettmer H. William, Strategic Navigation 2003

lected critical root cause was *High influence leaders are not organizationally responsible to comply with sustainability legal requirements*. The critical success factor for successful change is the top management support for change. Without it, creating a strategic roadmap will only lead to improvements in the system, but there is a risk of reverting back to the old way of working due to pressure to maintain the current status quo.

The identified undesired effects were that *supply management is unable to optimize the total cost of ownership* (TCO) and *systematic supply chain sustainability risk management* is missing. A logic tree is read from bottom up, starting from the critical root cause (CRC) and moving upwards at each level until all undesired effects and root causes have been logically connected based on what is happening.

Challenges in Prioritizing Legal Sustainability Compliance

High-influence leaders within the organization do not recognize their personal accountability in complying with legal sustainability requirements (**Figure 8**). These leaders tend to prioritize tasks for which they are directly accountable, often neglecting legal sustainability compliance. Furthermore, these leaders are not organizationally responsible for ensuring compliance with sustainability legal requirements, magnifying the issue.

Sustainability leaders within the organization understand the significance of legal compliance for the future. However, there is a disagreement within the company regarding the potential impact of sustainability risk management on the company's business prospects (**Figure 9**). This disagreement hinders the prioritization of legal sustainability compliance, as differing perspectives on the importance of sustainability risk management create obstacles for investments.

These challenges encompass a lack of personal accountability among high-influence leaders, the absence of organizational responsibility for compliance, and a

disagreement regarding the potential impact of sustainability risk management. Addressing these challenges is crucial for organizations to effectively prioritize and ensure legal sustainability compliance.

This disagreement blocks the prioritization of supply chain sustainability. The lack of priority leads to the company's failure to acknowledge the necessity of having a dedicated sustainability expert or manager (**Figure 9**). This lack of recognition has given rise to several challenges that impede progress in sustainability and risk management. Internal disagreement has resulted in a failure to initiate supply chain sustainability training. The supply management personnel lack the necessary knowledge and understanding of the supply chain sustainability requirements. No-one in the company's personnel has the capability to immediately assume the role of a sustainability expert. As supply management does not have the needed training nor sustainability expertise, it lacks full awareness of current and future supply chain sustainability requirements (**Figure 13**) relevant to the company. This lack of awareness poses a significant hindrance to the successful implementation of supply chain sustainability practices and capability to effectively manage supply chain sustainability risks.

Challenges in Ensuring Supplier Compliance with Sustainability Requirements

The challenges faced by a company in ensuring supplier compliance with sustainability requirements (**Figure 12**) encompass various aspects, including the company's failure to act when suppliers fail to meet sustainability requirements and the inability to ensure full compliance.

One of the key issues identified is the lack of knowledgeable resources (**Figure 10**) available within the company to effectively manage sustainability requirements and sustainability assessment tool, hindering the company's ability to ensure sup-

plier compliance. While the company does require suppliers to comply with relevant legislation, it is evident that some suppliers are not meeting the necessary sustainability requirements. This highlights the need for the company to have the capability to identify and verify supplier compliance, ensuring that sustainability standards are met throughout the supply chain.

As the supply management team lacks full awareness of all the relevant current and future supply chain sustainability requirements, it poses a significant challenge to effectively manage supplier compliance with sustainability requirements.

Challenges in Integrating Customer Sustainability Requirements into Supply Chain Management

The organization does not integrate customer sustainability requirements into supply chain management (**Figure 11**). One of the primary issues identified is the lack of effective procedures and integration of customer requirements. Currently, the supplier quality requirements are derived from the customer requirements, but the existing procedures do not adequately support the supply chain sustainability management. The organization lacks a system to integrate customer general requirements into the order specification tool, and the usual information flow to the supply management does not include customers' general sustainability requirements.

It is acknowledged that customers do not include mandatory sustainability requirements in their product orders, and there is no established procedure for handling general customer requirements. This lack of integration and procedure impairs the organization's ability to effectively address customer sustainability requirements (**Figure 14**). The organization does not have a knowledgeable resource available to initiate supply chain sustainability risk identification separately from customer orders. The identification of sustainability risks is only done when the

customer specifically requests it, thus limiting proactive sustainability management.

Challenges in Implementing Sustainability Risk Management

Primary obstacles for implementing sustainability risk management are the lack of agreement among management regarding the potential impact of sustainability risk management on business prospects (**Figure 13**). The lack of consensus obstructs the prioritization and effective integration of sustainability risk management practices within the organization. Without a systematic approach in place, the organization struggles to effectively address sustainability-related risks. Additionally, there is a shortage of expert resources and investment dedicated to sustainability risk management.

The organization lacks a comprehensive approach to managing sustainability risks across the organization, and there is a notable absence of supply chain sustainability risk management practices and resources. Therefore, sustainability risk identification is only initiated when it becomes mandatory to fulfill customer requests, indicating a reactive rather than proactive approach. The organization's supply management function faces challenges in ensuring that all suppliers comply with sustainability requirements, highlighting the need for enhanced supply chain sustainability management practices (**Figure 12**).

Challenges in Customer Requirement Management and Supply Chain Sustainability

The organization faces challenges in managing general customer requirements and integrating supply chain sustainability requirements (**Figure 14**). The organization's customer requirement management process primarily focuses on technical requirements, often overlooking general customer requirements and supply

chain sustainability considerations. Most of the customers do not explicitly communicate their specific supplier requirements including sustainability requirements. The organization primarily captures technical requirements from customers, which reinforces the emphasis on technical aspects while neglecting supply chain requirements.

The identification of supply chain sustainability requirements only occurs when customers explicitly request it. Therefore, as a result supply management personnel have limited awareness of relevant customer supply chain sustainability requirements. This lack of awareness impedes the organization's ability to proactively address and integrate customers' supply chain sustainability considerations into its operations.

The organization has not implemented a systematic approach to identify and manage supply chain sustainability requirements and associated risks (**Figure 15**). This lack of a structured framework hinders the organization's ability to effectively address and mitigate supply chain sustainability risks while considering the cost impact of the actions. The indirect costs associated with the supply chain remain hidden or not visible within the organization's current processes (**Figure 16**).

Challenges in Integrating Total Cost of Ownership into Supplier Performance Management

The organization has not initiated the development of Supply Management Total Cost of Ownership (**Figure 16**, **Figure 17**), and there is no designated individual responsible for mapping the indirect costs within the supply chain. To accurately calculate the total cost of ownership, data from each step of the internal supply chain is essential. Identifying the sources of indirect costs necessitates mapping the actions within the supply chain and their associated costs.

To effectively measure supplier performance, it is crucial to have a comprehensive understanding of the concept of total cost of ownership. Currently, the organization only follows the identified supply chain cost elements, the prioritization of measures that serve the stakeholders' individual interests and the focus of supplier performance metrics on operational requirements, while the supply chain indirect costs remain hidden or not visible within the organization's processes. Furthermore, the costs associated with fulfilling general customer requirements are not tracked after delivery, further complicating the integration of TCO into supplier performance management. Supply management is not able to achieve optimal total cost (**Figure 18**).

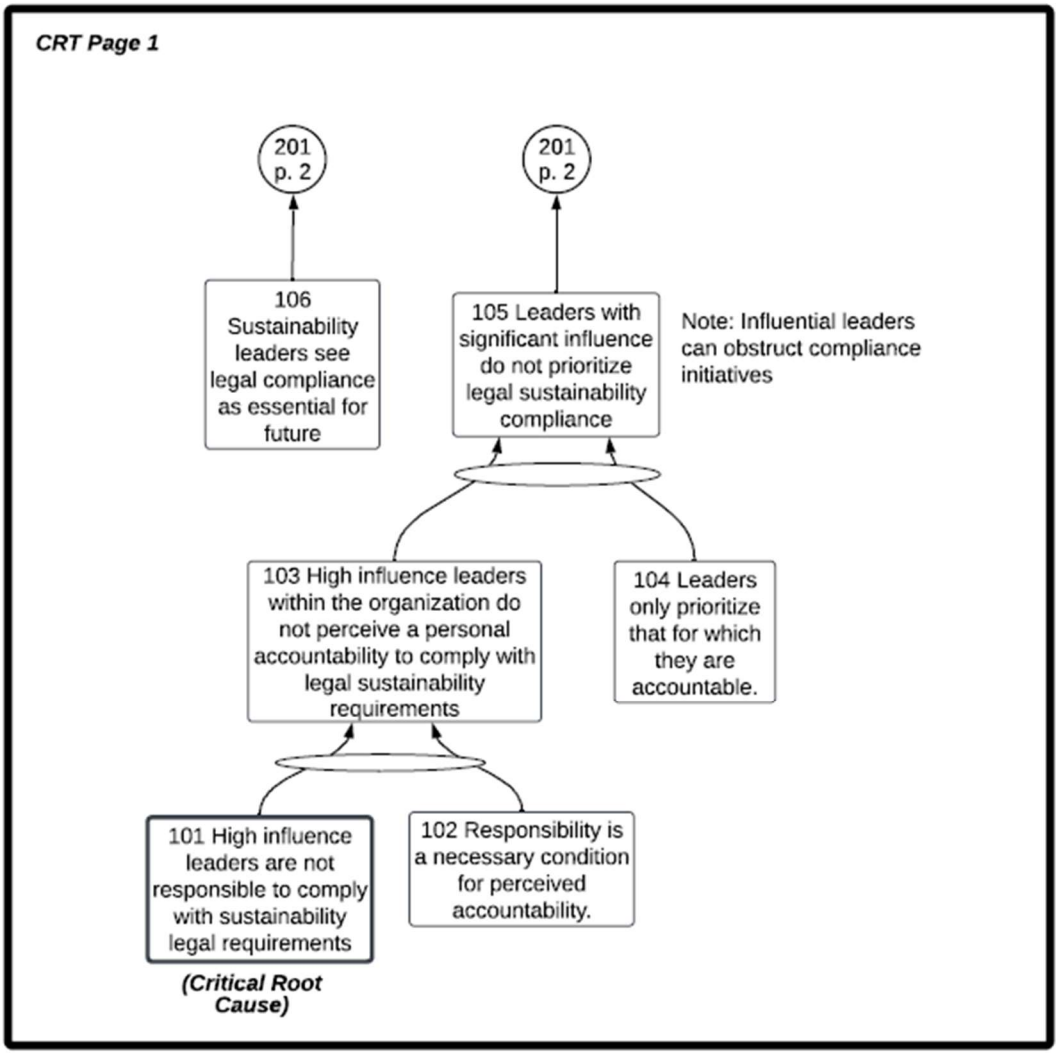

Figure 8. Current Reality Tree page 1.

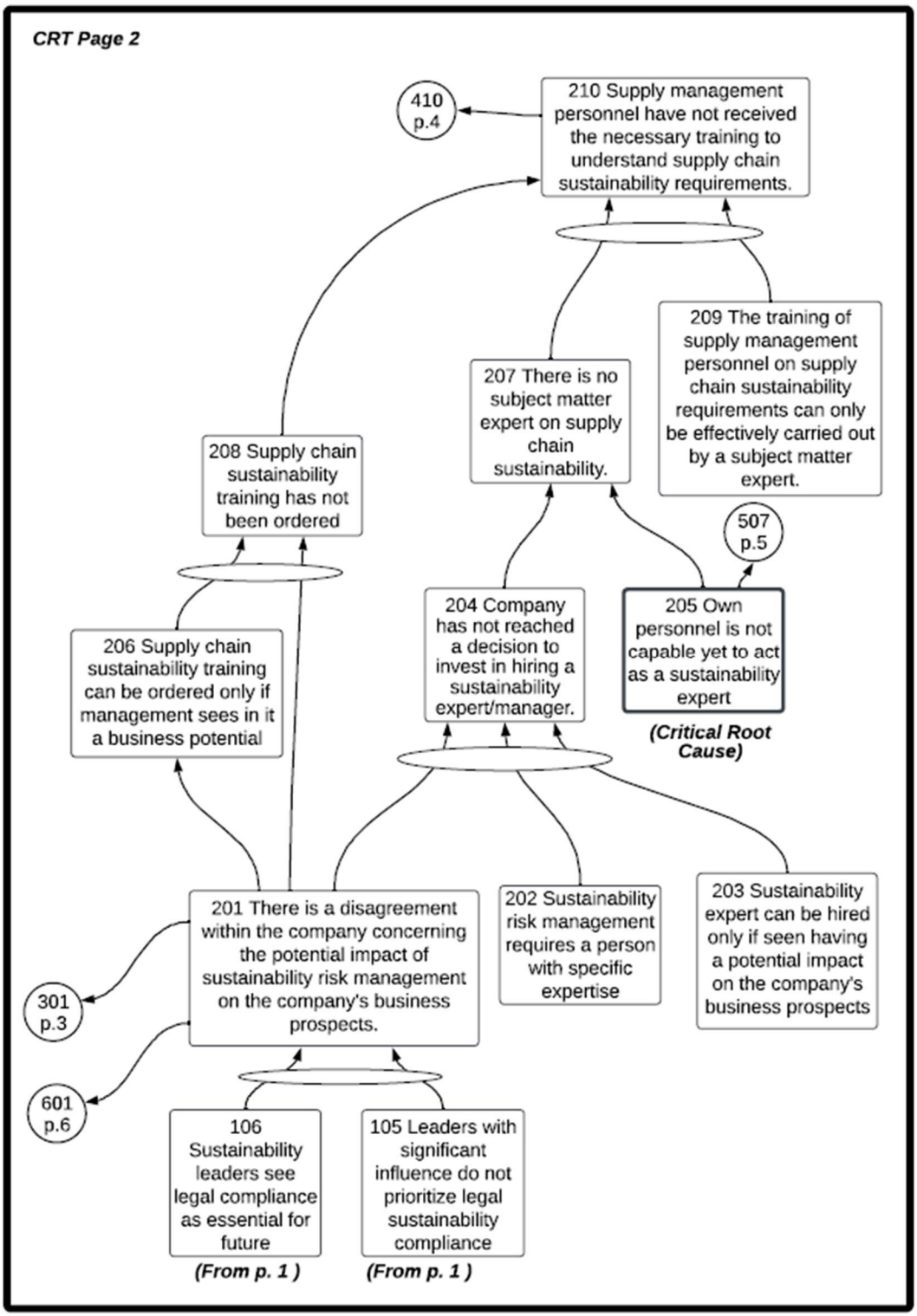

Figure 9. Current Reality Tree page 2.

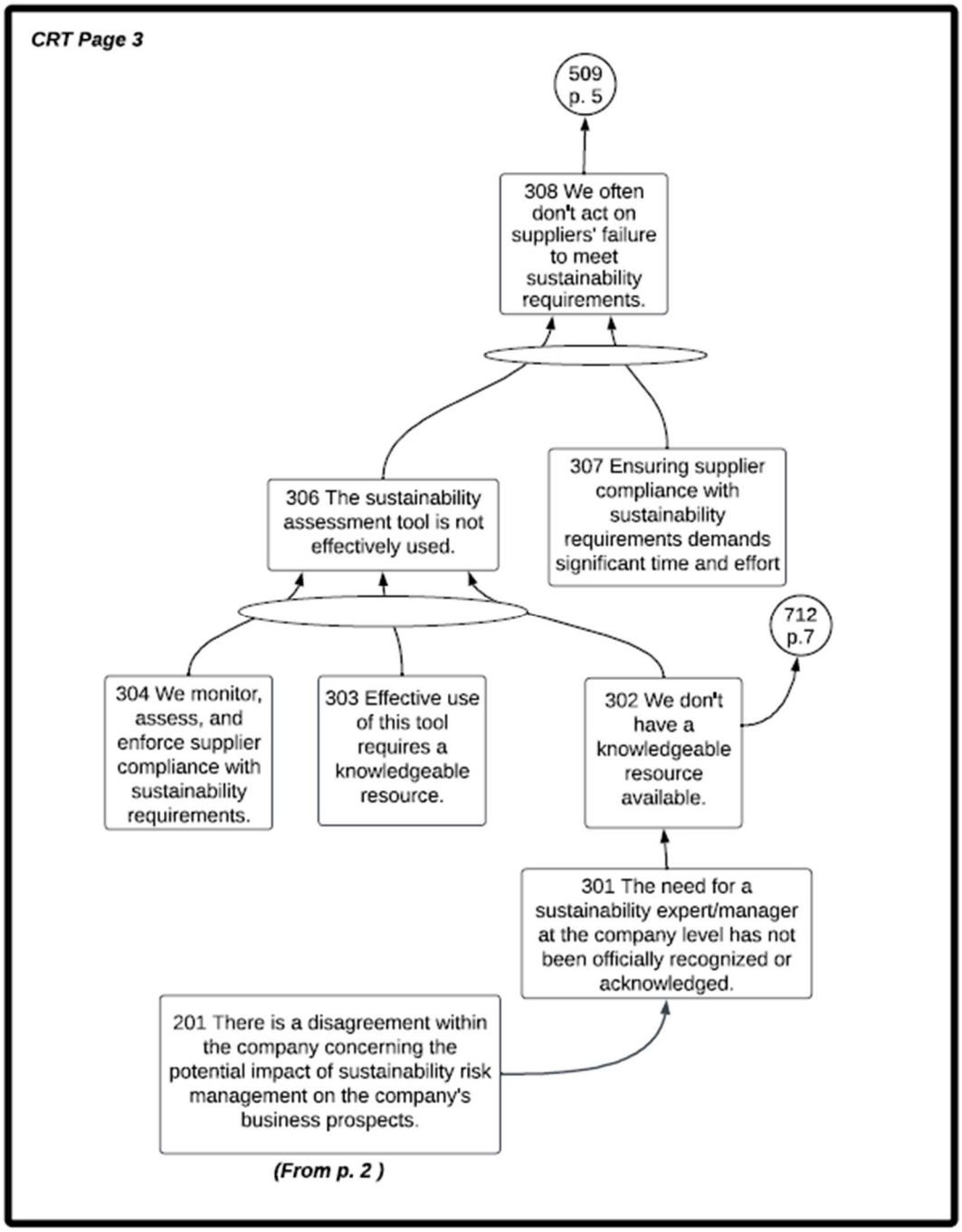

Figure 10. Current Reality Tree page 3.

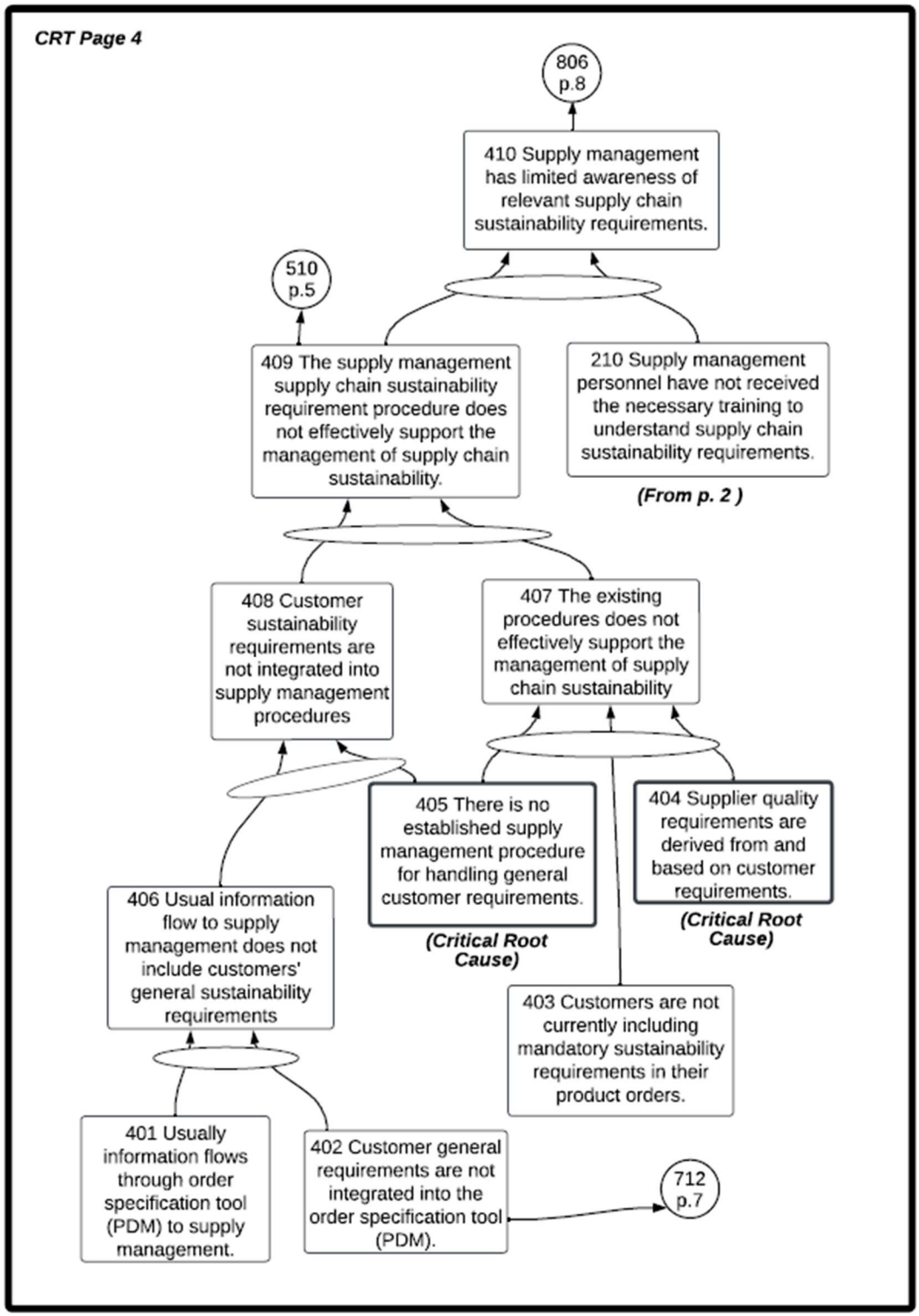

Figure 11. Current Reality Tree page 4.

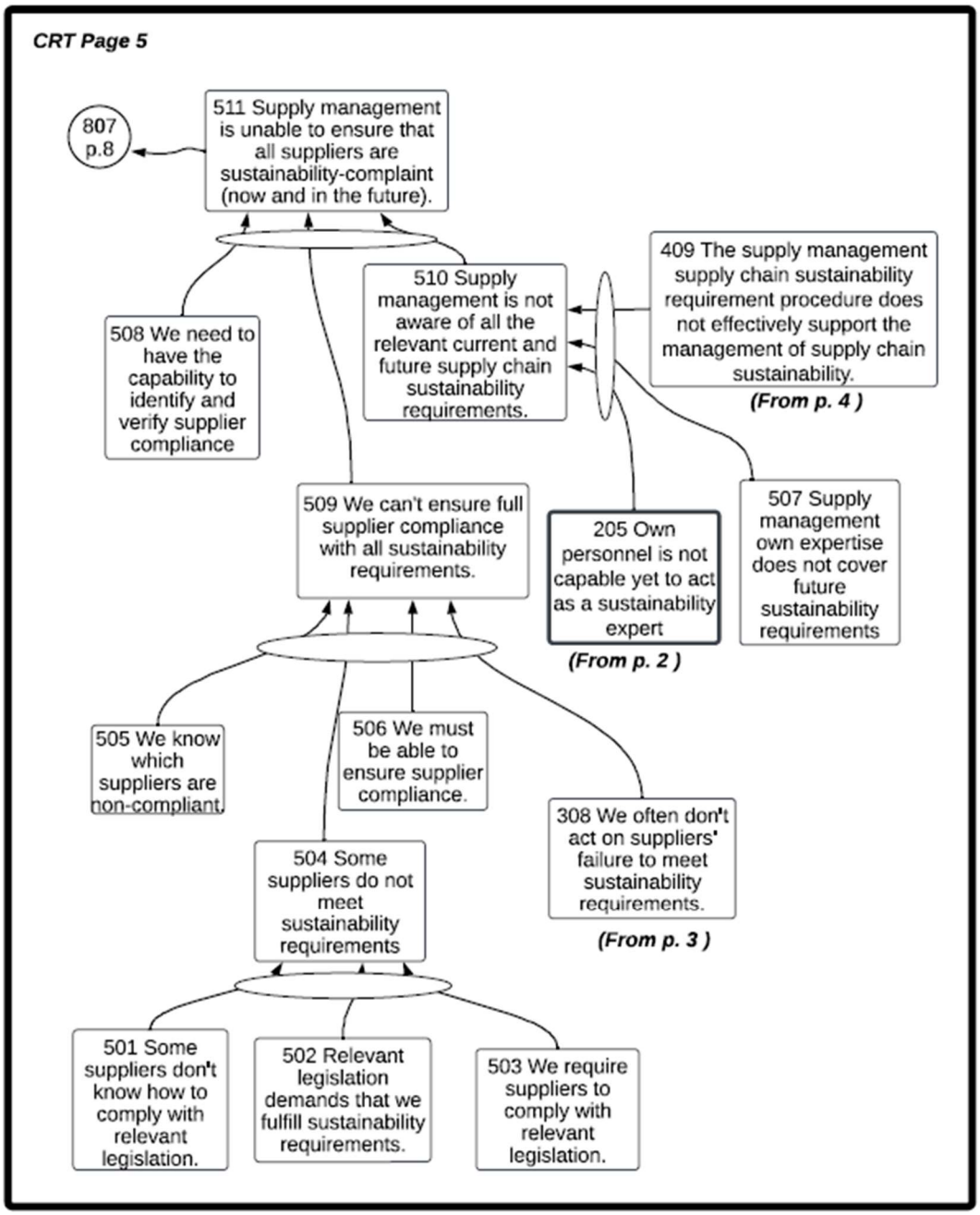

Figure 12. Current Reality Tree page 5.

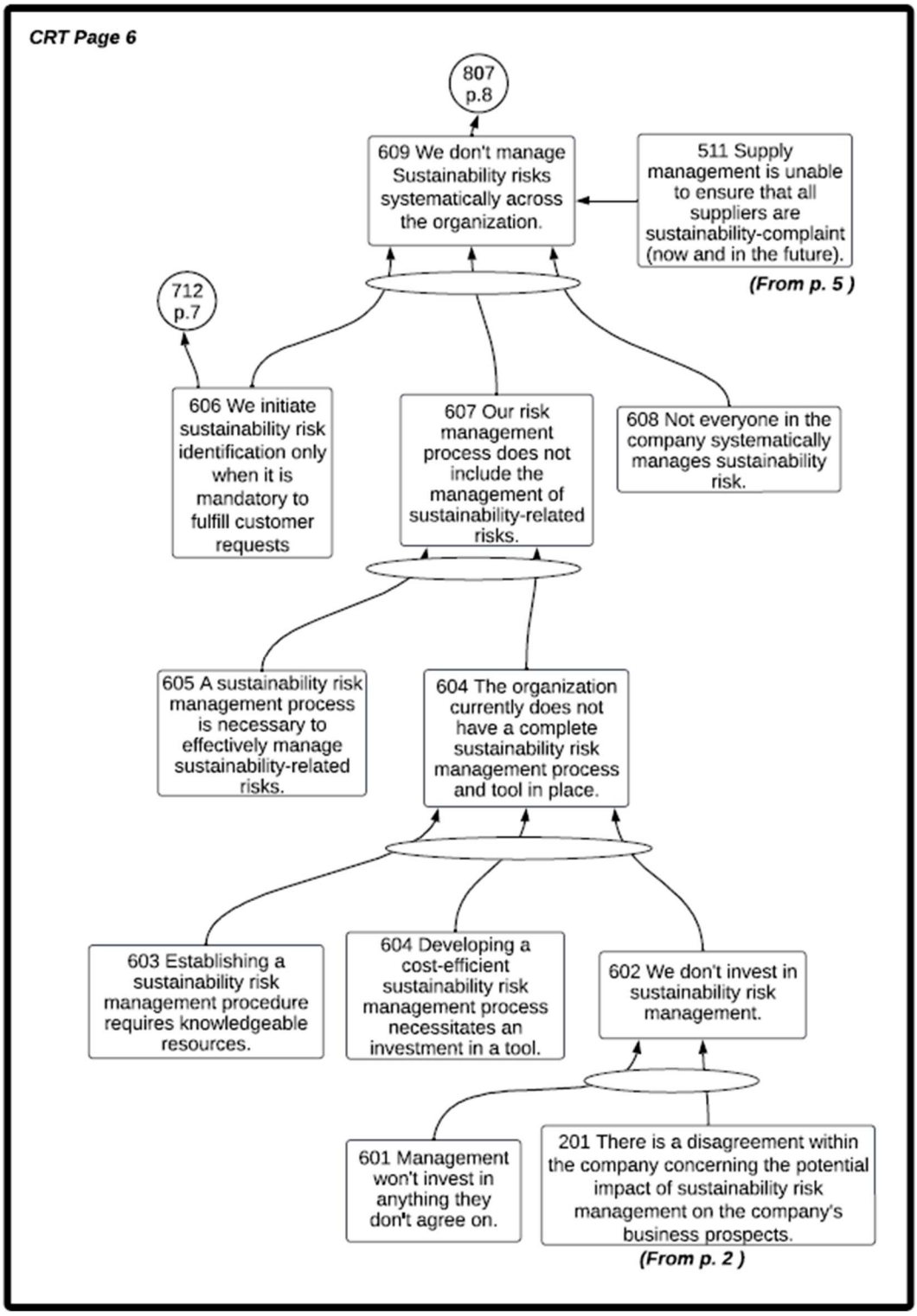

Figure 13. Current Reality Tree page 6.

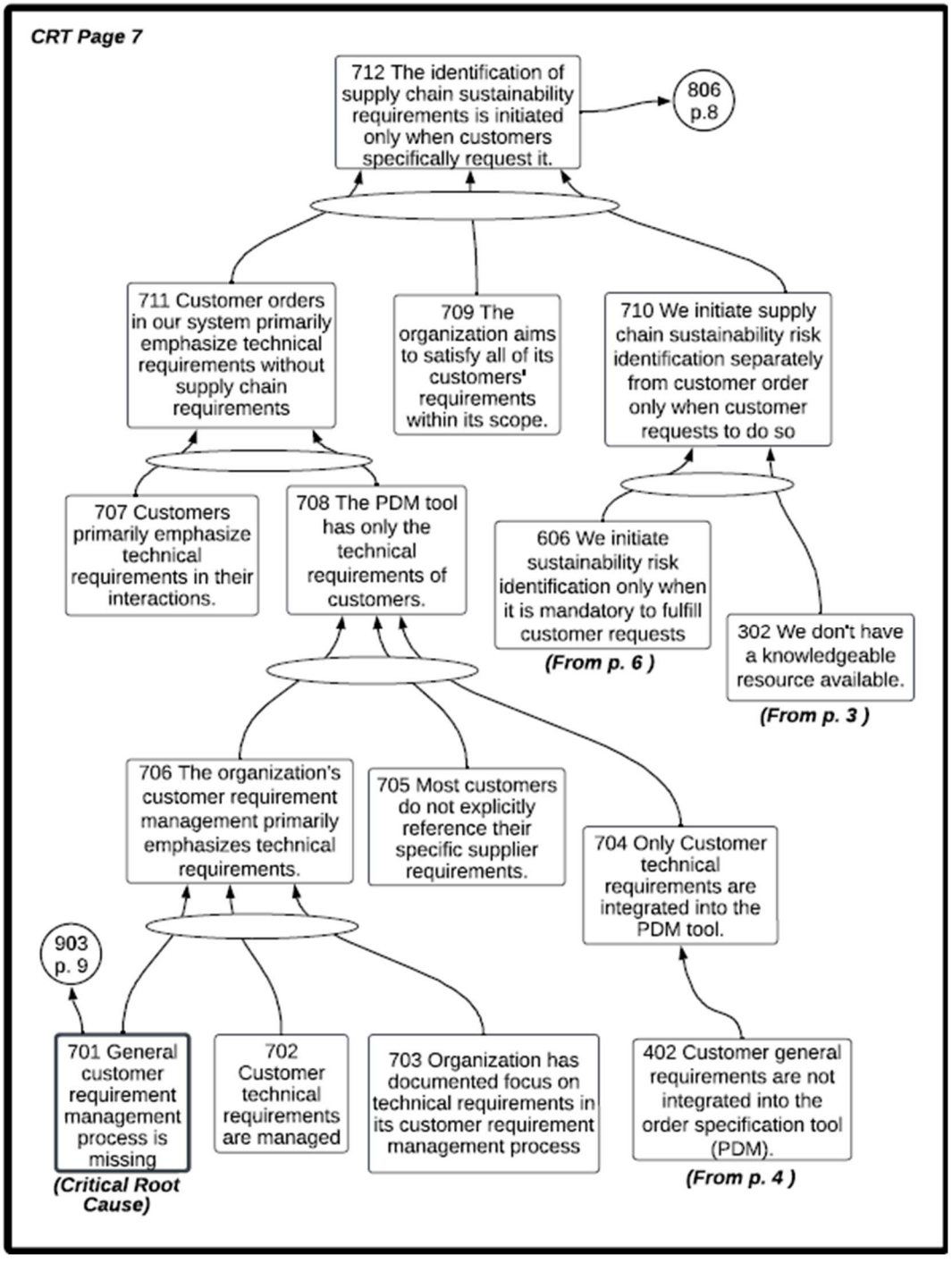

Figure 14. Current Reality Tree page 7.

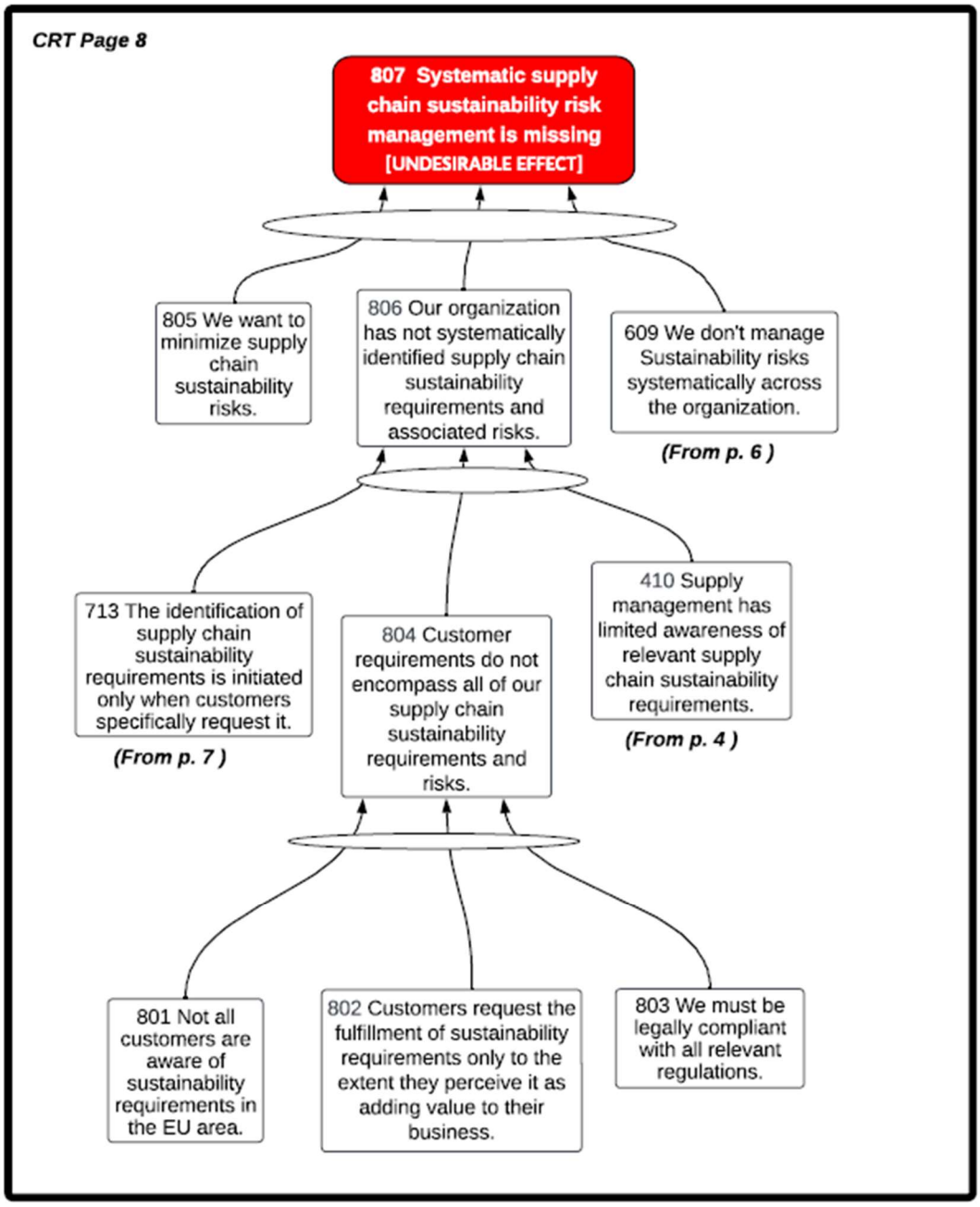

Figure 15. Current Reality Tree page 8.

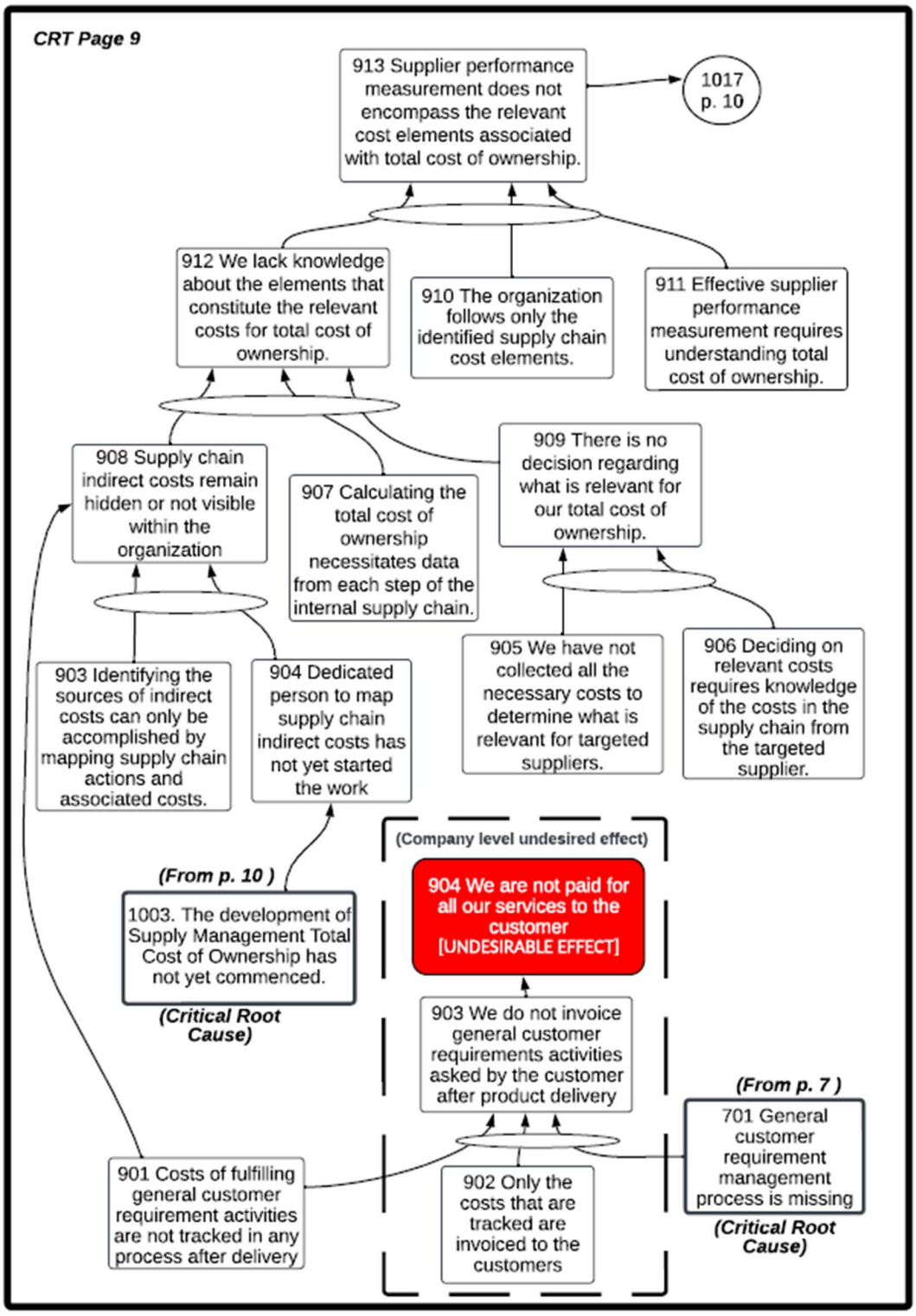

Figure 16. Current Reality Tree page 9.

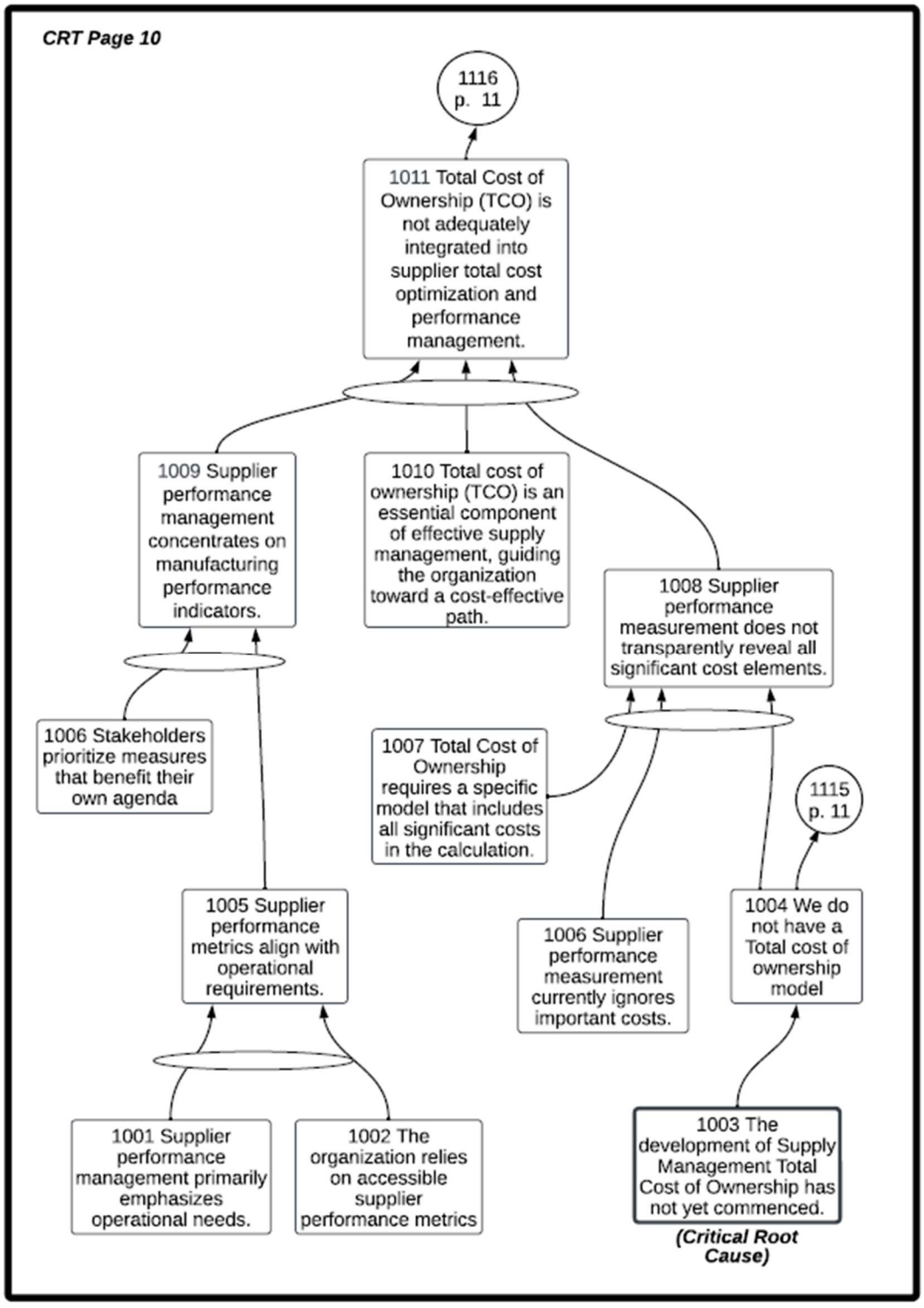

Figure 17. Current Reality Tree page 10.

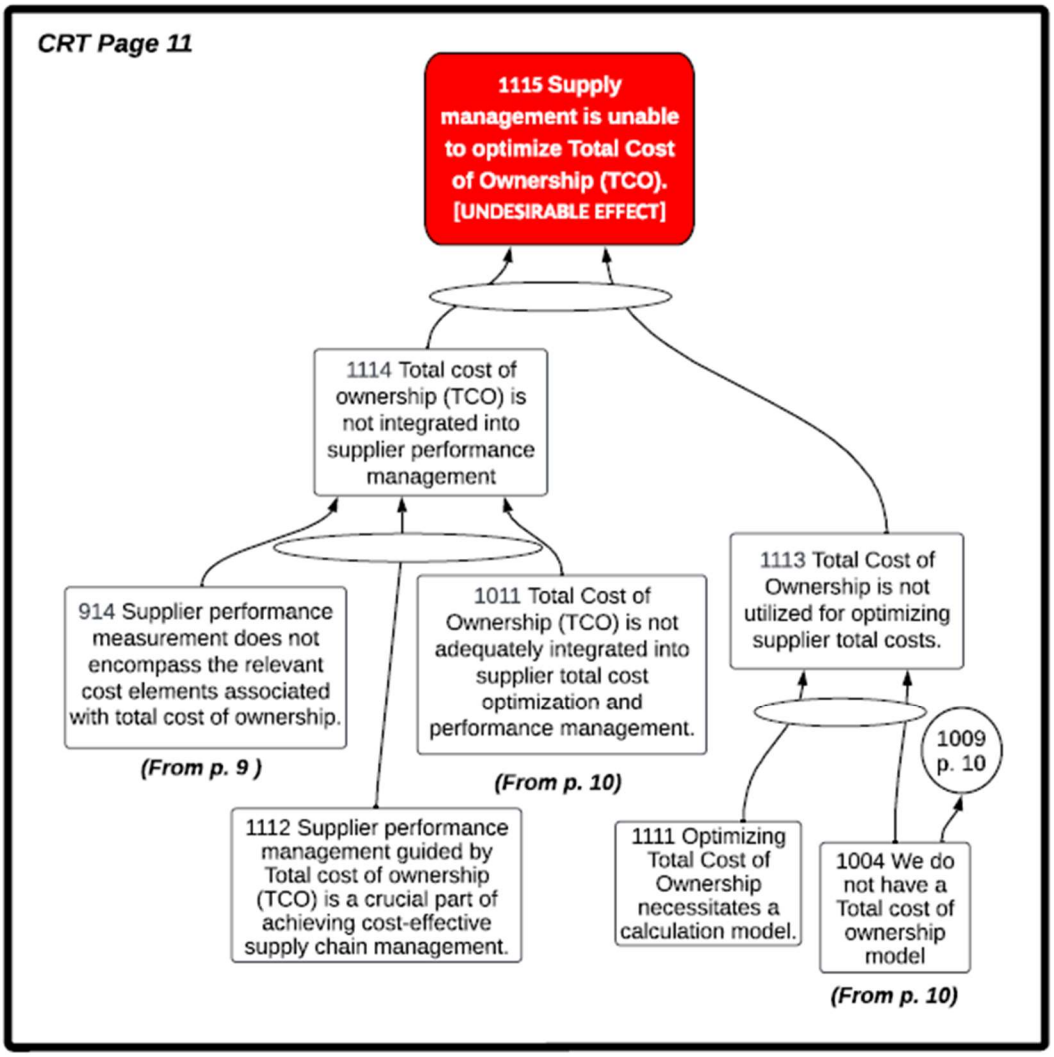

Figure 18. Current Reality Tree page 11.

4.3 Solution Development

The critical root cause for the successful strategy execution was management support with entity *High influence leaders are not responsible to comply with sustainability legal requirements,* which is a visible effect of conflicting high influence leaders' views on the benefits of sustainability activities. The conflict was described as *Do supply chain sustainability activities* and *Skip supply chain sustainability activities* (**Figure 19**). An initial evaporating cloud was built based on knowledge from the system and established goal tree. As the most important task

of the supply management is to enable the success of manufacturing operations, they must prioritize activities according to the needs of manufacturing.

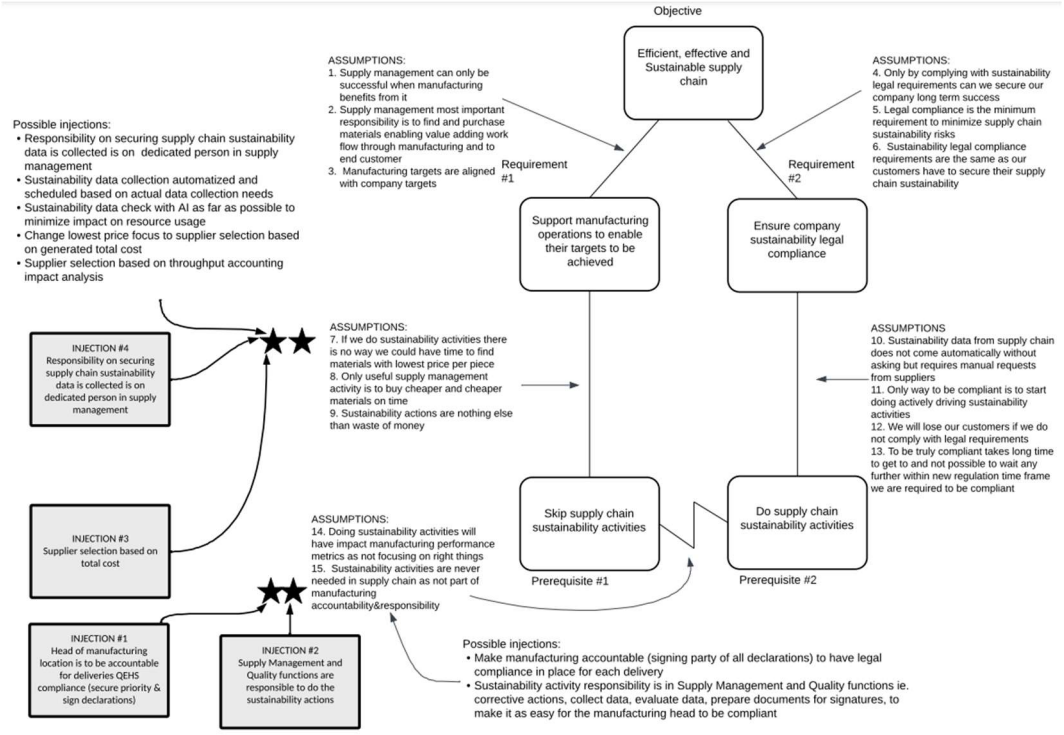

Figure 19. Evaporating Cloud.

Conflicting views arose from assumptions about the role of company resources and what is crucial for success. The right side of the evaporating cloud (Figure 6) highlights the realities necessary for a sustainable company, while the left side represents the reasons why sustainability is deemed unnecessary. Manufacturing does not perceive sustainability as a responsibility within its organizational context, and therefore does not view it as a facilitator for successful manufacturing operations. This lack of recognition negatively impacts the activities of Supply Management and Quality functions, as their actions are not considered important. One key assumption that needs to be addressed is the belief that engaging in sustainability activities would leave no time to find materials with the lowest price

per piece. Another assumption states that sustainability activities are never necessary, as supply chain sustainability is not part of manufacturing's accountability or responsibility.

The total cost is aligned with the critical success factor of total cost in the goal tree. Focusing solely on the lowest purchase item price often leads to larger batch sizes and subsequently requires a larger investment in items, resulting in a higher total cost despite a lower price per item.

Since sustainability for deliveries falls under manufacturing responsibility, legal compliance must be prioritized as it becomes part of the process. Therefore, there needs to be sufficient expertise to carry out all sustainability activities, and as a result, the responsibility for acting was placed on Supply Management and Quality functions to ensure a cost-efficient execution of sustainability actions.

Developed injections:

- Injection #1 Head of Manufacturing is responsible for deliveries and QEHS/sustainability compliance (secure priority & sign declarations) Injection.
- Injection #2 Supply management and Quality functions are responsible to do the sustainability actions.
- Injection #3 Supplier selection based on total cost.
- Injection #4 Responsibility on securing supply chain sustainability data is collected is on dedicated person in supply management.

Injections #1-4 are the foundations for the future reality tree, serving as starting points towards desired outcomes.

4.4 Future to be Status – Strategic Roadmap

Future reality tree (FRT) was the fourth step in the logical thinking process methodology. The logical process defined the FRT goal as a desktop simulation in which identified solutions to critical root causes are simulated to be effective in changing the earlier analysis in the form of CRT into an all-positive FRT. CRT focused only on the negative, with some neutral entities supporting the logical premises. The creation of CRT took 2/3 of the overall effort and made FRT creation much less intensive, as the logical structure is mostly the same within the same system. This means that one can use the logical structure done during gap analysis. It was a matter of having the system knowledge available to create the right injections to ensure that FRT has the necessary injections to transform the system into the desired state. Identified injections at the root of FRT needed supporting injections to ensure a path to Goal tree requirements.

FRT was built from bottom up, and whenever a created injection changed the upper part of the reality, logical steps were adjusted or removed to match the syllogistic cause-and-effect structure. CRT was almost fully utilized in FRT. Only small areas of CRT were removed. Through created injections, additional aspects of future requirements were added to the logic tree. Injections identified to have a probable alternative outcome than planned were developed with additional injections to support the original injection. Supporting injections prevent undesired outcomes.

Legal Compliance and Sustainability Risk Management

Non-compliance (**Figure 31**) with legal requirements can have detrimental consequences, including reputational damage and financial penalties. A Combination of loss of reputation and financial penalties may in turn impact profitability and customer retention.

It is crucial that high influence leaders within the organization take accountability for legal sustainability compliance and prioritize their responsibilities accordingly (**Figure 20**). This emphasizes the need for leadership commitment and engagement in driving compliance efforts. The head of manufacturing has been identified as having a crucial role in ensuring deliveries comply with quality, environment, health, and safety (QEHS) standards. This also includes sustainability legal requirements that are delivery-based requirement. Sustainability needs to be integrated into manufacturing operations, but it does not mean all actions need to be taken by the head of manufacturing. Supporting injection (**Figure 30**) was to place needed sustainability actions responsibility on Supply management and Quality functions, while Head of manufacturing needs to ensure there is enough priority to keep legal compliance in high priority. This was seen as necessary to keep the cost of managing the supply chain as low as possible.

Sustainability risk management was recognized as a specialized area requiring specific expertise. Resource constraints and a lack of active demand from authorities or customers may impede timely compliance efforts. Effectively managing sustainability risks may generate additional costs associated with supply chain management. To counterbalance the negative effects of additional costs, an additional injection was created to develop a lean compliance process and procedure. This is the aligned with the goal tree optimal total cost and streamlined supply management processes and therefore includes efficient systems to facilitate compliance with legal sustainability requirements.

To keep top management support and favoring sustainability actions a positive reinforcing loop was created with an incentive for management by linking sustainability to profitability, aligning sustainability goals with financial performance.

Supply Chain Sustainability Training and Expertise

The consensus within the company regarding the potential impact of sustainability risk management on the organization's business prospects enables sustainability initiative progress (**Figure 21**). Comprehensive training was identified as a need in supply management. Face-to-face training sessions are arranged and conducted for all supply management personnel to educate them on supply chain sustainability requirements. It is important to note that every activity in a supply chain impacts at least one of the three sustainability themes: economic, environmental, or social, which requires in-depth knowledge to provide sufficient training. Therefore, sustainability training and risk management requires a person with specific expertise. The company has the option to hire a sustainability expert or train their own personnel to act as sustainability experts. Supply management opted to build sustainability expertise by appointing person to become a sustainability expert by prioritizing 'learning by doing' sustainability activities and arrange supporting training on supply chain sustainability legal compliance requirements.

Sustainability data collection and analysis

Improving supply management sustainability requires the development and effective utilization of proper supplier sustainability assessment tools (**Figure 22**) These tools should encompass both item-level sustainability data and supplier overall Environmental, Social, and Governance (ESG) data. By streamlining the data collection process, the associated compliance costs can be minimized, and non-compliant suppliers can be easily identified. The goal is to have a lean compliance process that sets clear conditions for adherence. This can be achieved by leveraging automation to reduce the efforts required for data collection and analysis (**Figure 32**). Implementing automated processes allows the organization to streamline the overall sustainability assessment procedure, thereby enhancing efficiency and effectiveness.

The responsibility for securing the collection of supply chain sustainability data lies with a dedicated individual within the supply management function – subject matter expert. This individual serves as a key resource, possessing the necessary knowledge and expertise to oversee and ensure that suppliers comply with the established sustainability requirements. If suppliers fail to meet compliance requirements, appropriate actions are taken to address the non-compliance.

Managing Supply Chain Sustainability Requirements

Supply management needs to develop procedures and processes (**Figure 23**, **Figure 24**) to effectively manage supply chain sustainability requirements. Suppliers are obligated to comply with relevant legislation. In cases where suppliers are found to be non-compliant, critical measures are taken to coach and guide them towards meeting the required quality and sustainability standards. Supply management plays a key role in ensuring supplier compliance and takes appropriate actions when suppliers fail to meet sustainability requirements (**Figure 33**). To ensure supplier compliance a dedicated individual is assigned with the responsibility of addressing overall non-compliance issues among suppliers.

The organization demonstrates a proactive approach by staying informed about all relevant current and future supply chain sustainability requirements. Supply management personnel undergo training to enhance their understanding of these requirements. Sustainability requirements serve as the minimum requirement for legal compliance. It is important to ensure the flow of information, starting from customers' sustainability requirements, which are then transmitted through the order specification tool to the supply management function.

To ensure the effectiveness of the supply management procedures, periodic updates are implemented. This ensures that the processes remain current and aligned with evolving sustainability standards.

Sustainability Risk Management Process

The consensus within the company regarding the potential impact of sustainability risk management on the organization's business prospects (**Figure 27**) has utmost importance for realizing investment in sustainability risk management initiatives and implementing a comprehensive process and tool to effectively manage sustainability-related risks, which are crucial for the overall sustainable supply chain.

The sustainability risk management process is considered essential for the organization to proactively address and mitigate sustainability-related risks. Systematic identification of sustainability risks covers both existing and emerging legal requirements. By following a yearly clock schedule, the organization ensures that sustainability risks are regularly assessed and managed.

To enable the sustainability risk management process in a cost-efficient manner, a cost-efficient tool is developed and utilized. The tool enables the organization to streamline the identification, assessment, and mitigation of sustainability risks cost-effectively. A sustainability expert is responsible for developing a detailed sustainability risk management procedure, ensuring that the process is well-defined and effectively implemented.

The role of supply management is to ensure chosen suppliers meet both current and future sustainability requirements. By actively managing the sustainability performance of suppliers, the organization can mitigate risks and promote sustainable practices throughout the supply chain.

Supply Chain Sustainability Requirements Management Process

The customer requirement management process (**Figure 26**) encompasses both general and technical customer requirements, including sustainability requirements. This comprehensive approach ensures that all customer expectations, including those related to sustainability, are effectively managed, and addressed.

A systematic approach to identifying and understanding the various supply chain sustainability requirements ensures that the customer requirement management process encompasses all customer requirements, including those related to sustainability. The order specification tool plays a crucial role in capturing and documenting all customer order requirements, specifically identifying, and addressing the supply chain sustainability requirements associated with each customer order. Having all necessary information flowing through the supply chain functions enables the organization to fulfill all customer requirements within its defined scope while simultaneously minimizing supply chain sustainability risks.

Only the costs that are actively tracked and monitored are invoiced to the customers. Having all needed customer requirements included in offers ensures that the organization is appropriately compensated for the activities it provides its customers.

Optimizing Supplier Performance and Costs through Total Cost of Ownership

Total cost of ownership (**Figure 28**, **Figure 29**) serves as a crucial component in effective supply management, guiding the organization towards a path of cost-effectiveness. To effectively manage TCO, the identification of relevant costs is based on their impact on total cost. This ensures that the organization focuses on the costs that have the most significant influence on overall TCO. As a prerequisite there must be a TCO model to optimize TCO and supplier total costs, enabling the organization to make informed decisions regarding cost optimization.

Supplier performance evaluation is conducted using costs as the basis for all performance measures. By incorporating costs into the evaluation process, the organization can assess supplier performance holistically, considering both quality and cost factors. Previously hidden sustainability activity costs are made visible to all and presented to top management as an indicator of how much sustainability requires time and resources.

There are risks (**Figure 34**) associated with total cost of ownership as a tool to identify cost reductions areas through supply chain. If flow is not the priority for operations, cost reduction activities may result in sub-optimizing supply chain flow leading to poor business performance. The organization's supplier performance metrics require integration of flow and TCO metrics into supplier performance management, to highlight both flow and TCO as a key factor in supplier evaluation and decision-making processes.

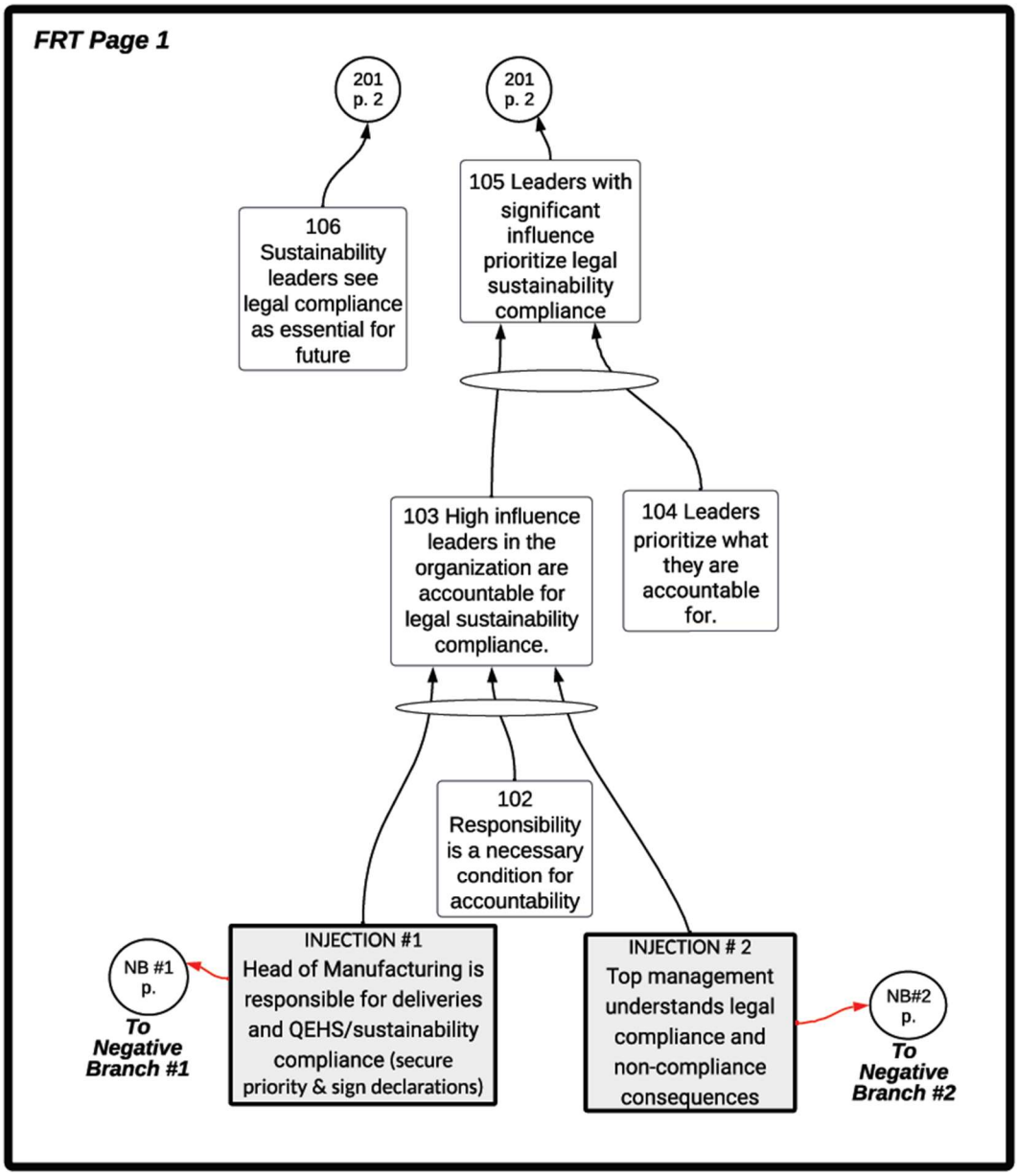

Figure 20. Future reality tree page 1.

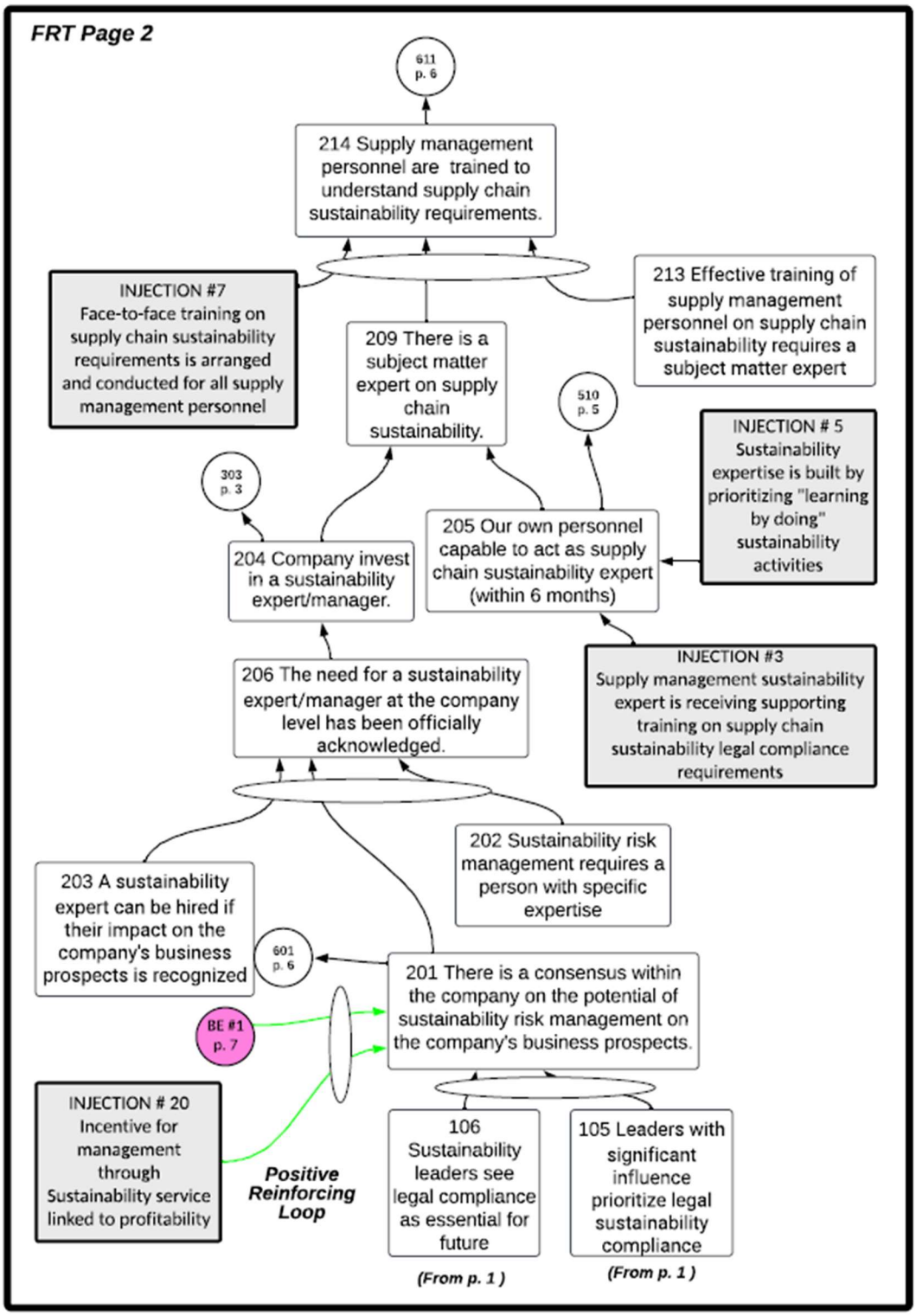

Figure 21. Future Reality Tree page 2.

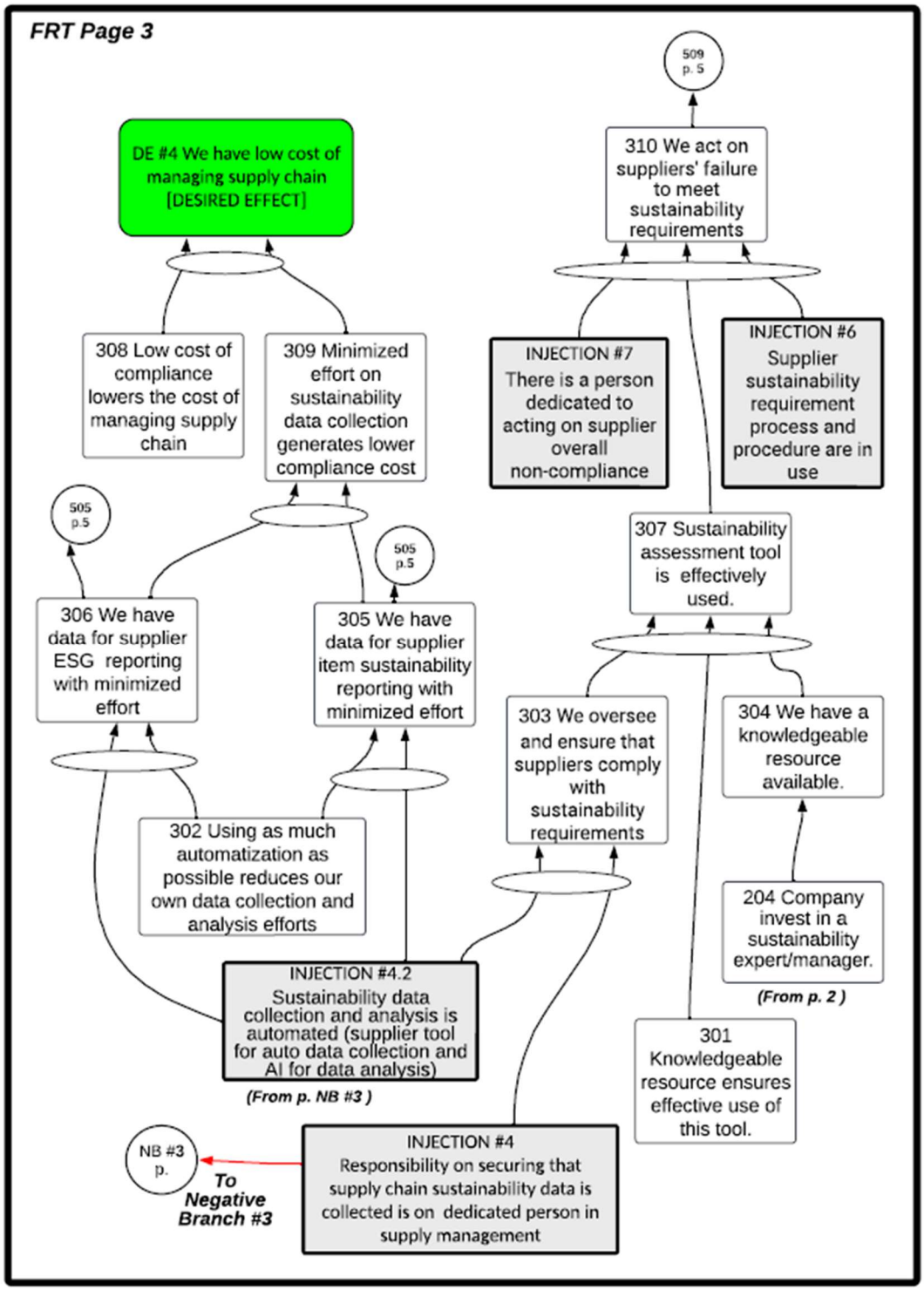

Figure 22. Future Reality Tree page 3.

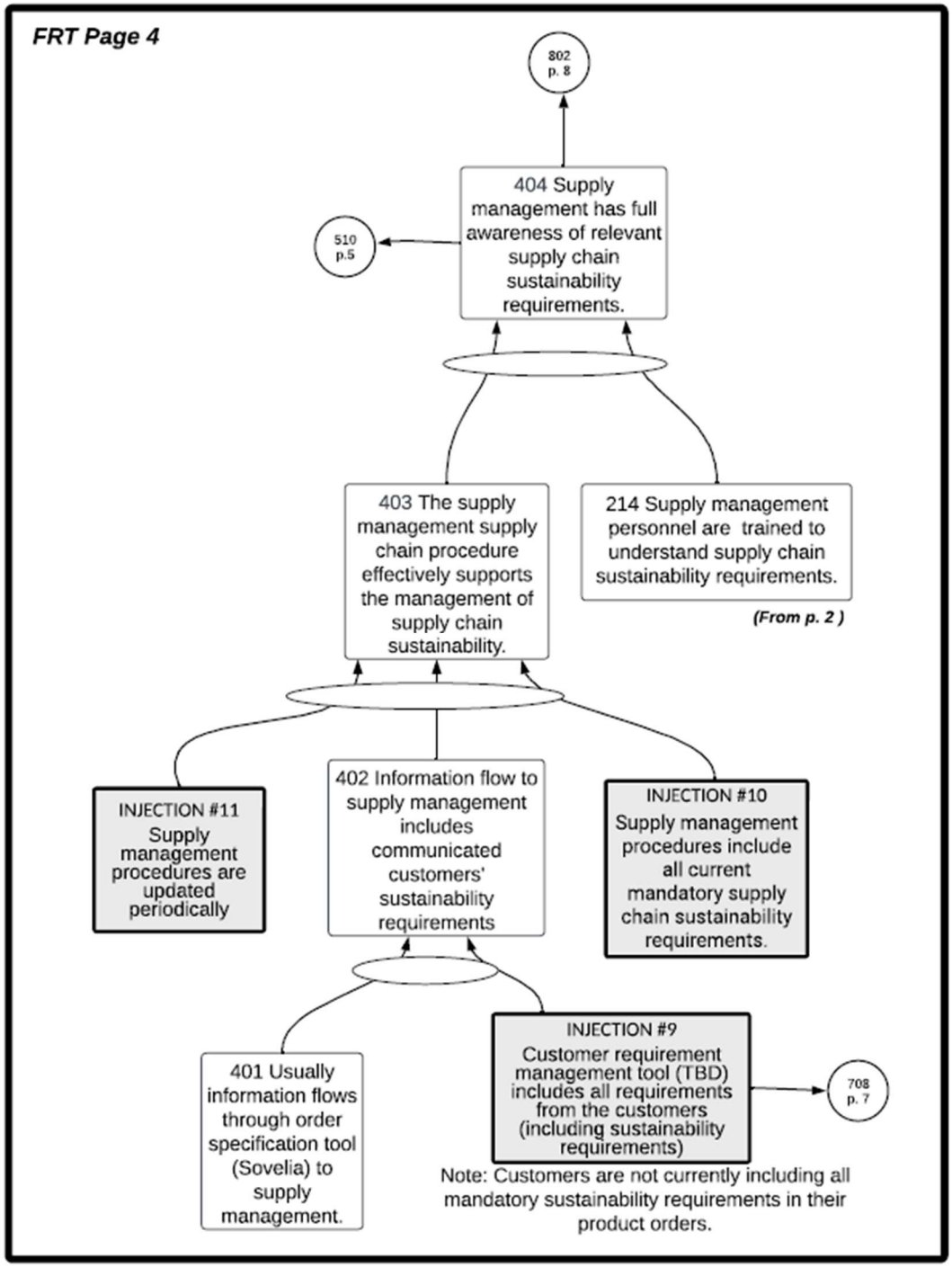

Figure 23. Future Reality Tree page 4.

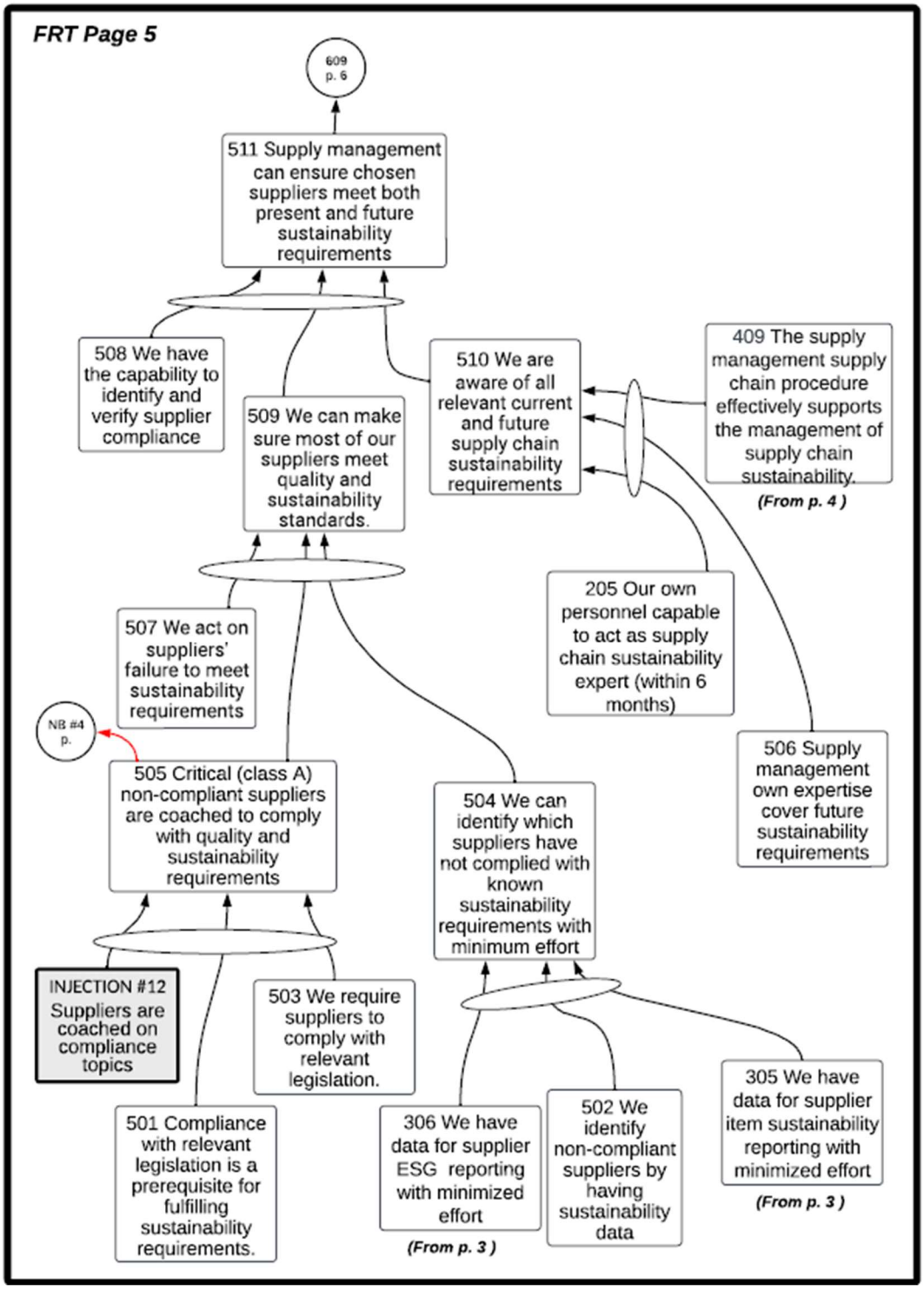

Figure 24. Future Reality Tree page 5.

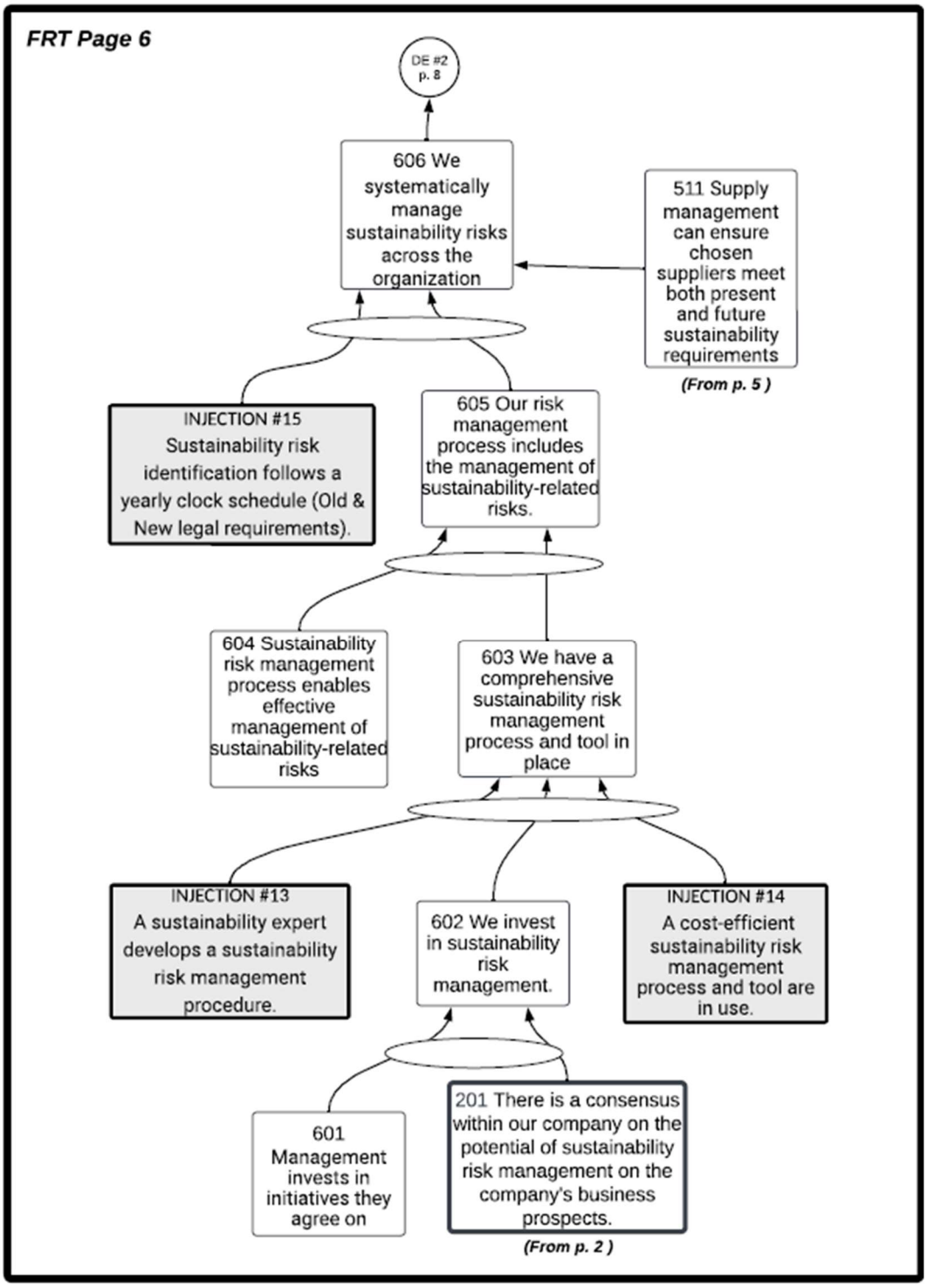

Figure 25. Future Reality Tree page 6.

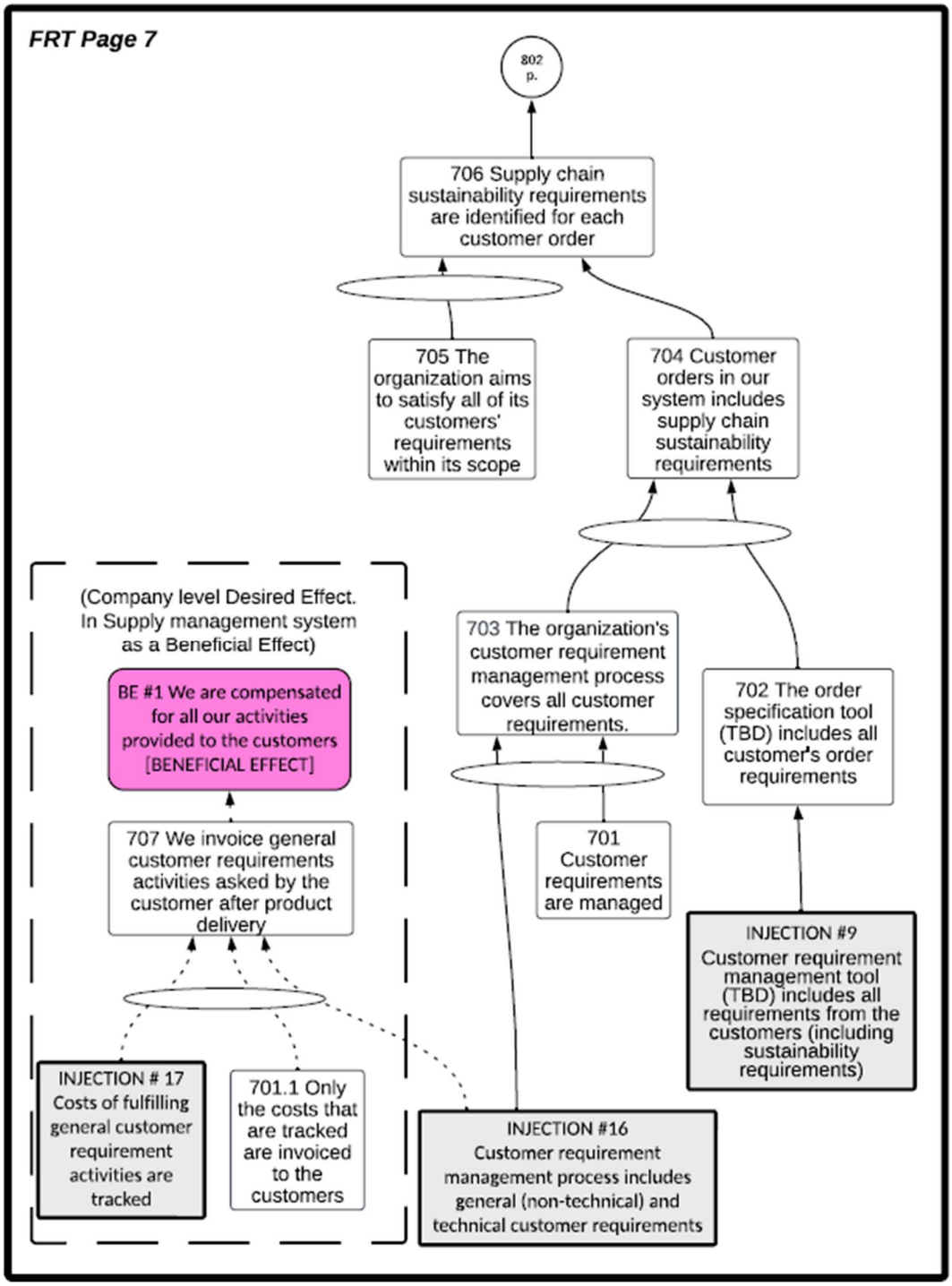

Figure 26. Future Reality Tree page 7.

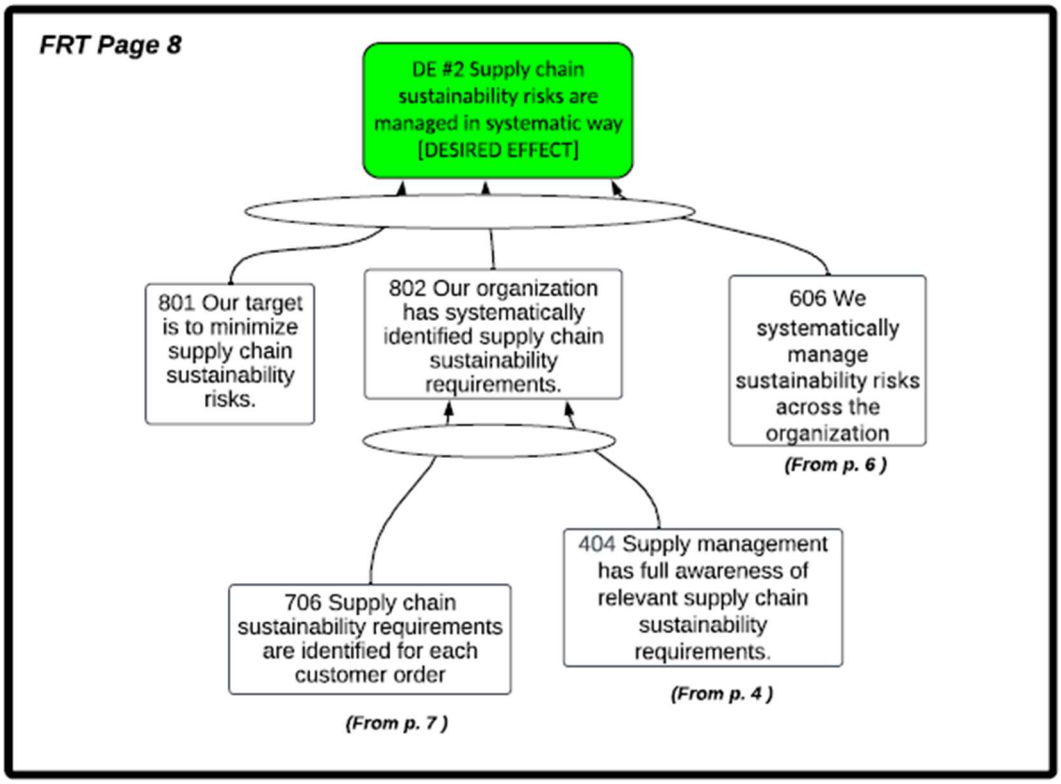

Figure 27. Future Reality Tree page 8.

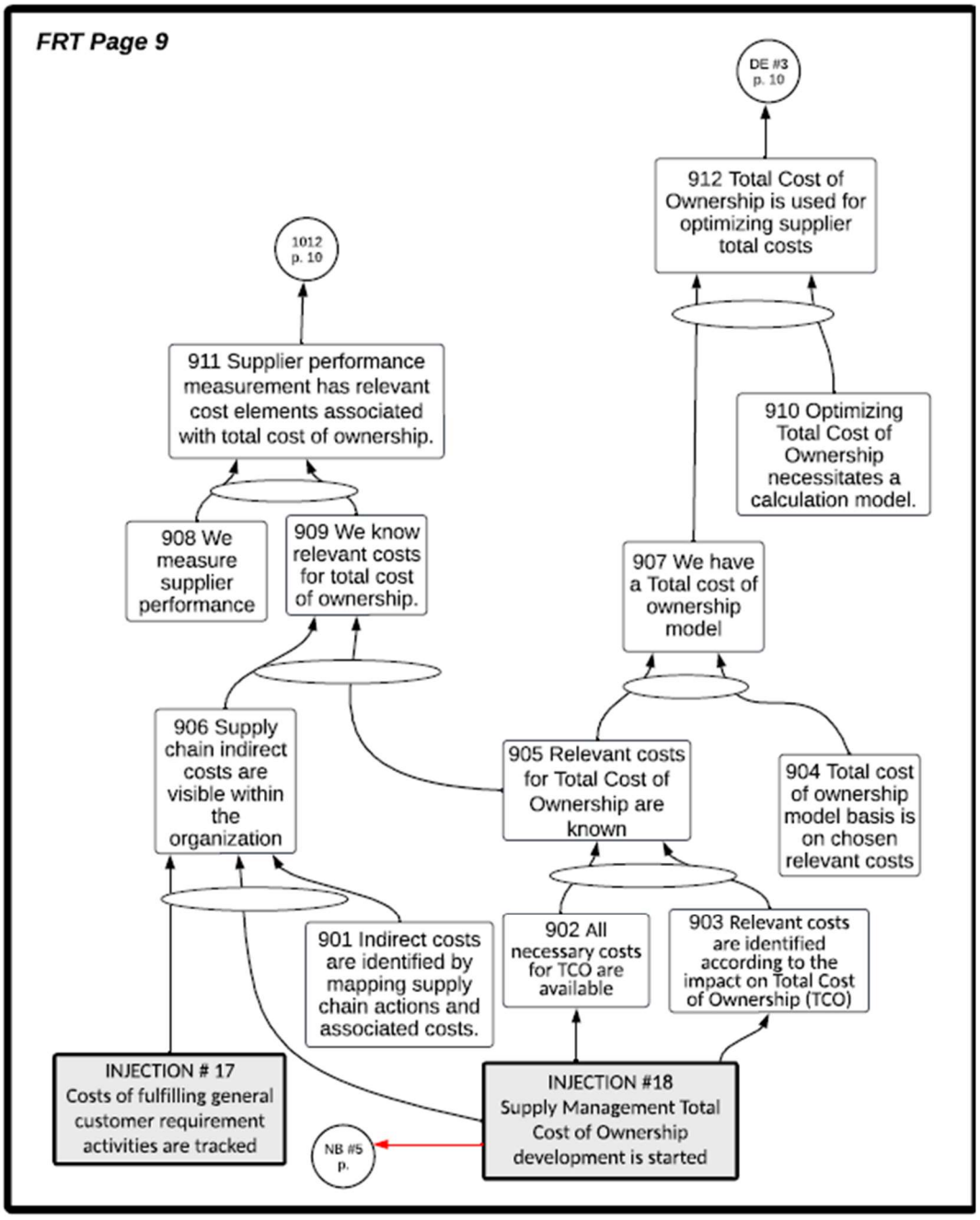

Figure 28. Future Reality Tree page 9.

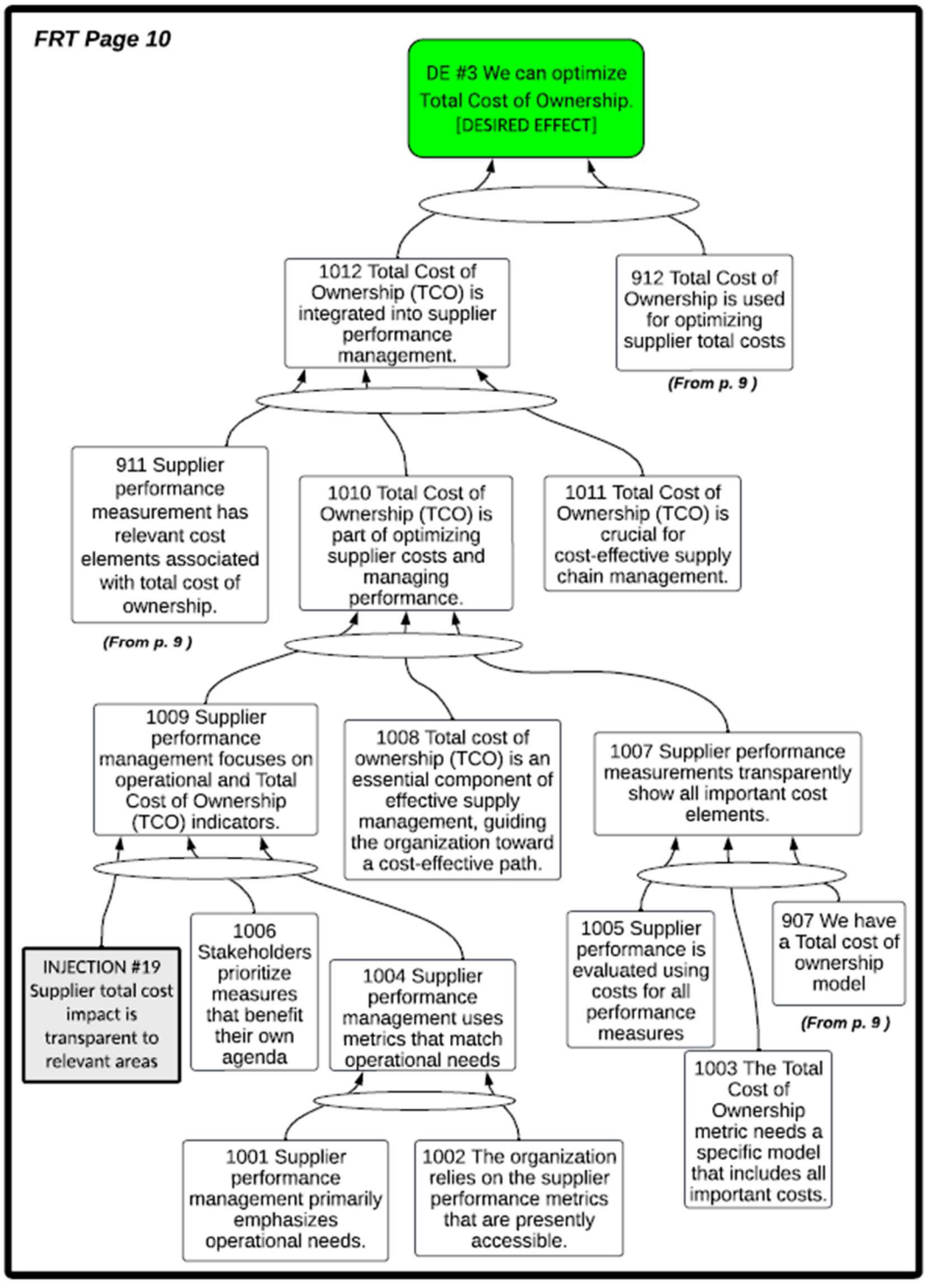

Figure 29. Future Reality Tree page 10.

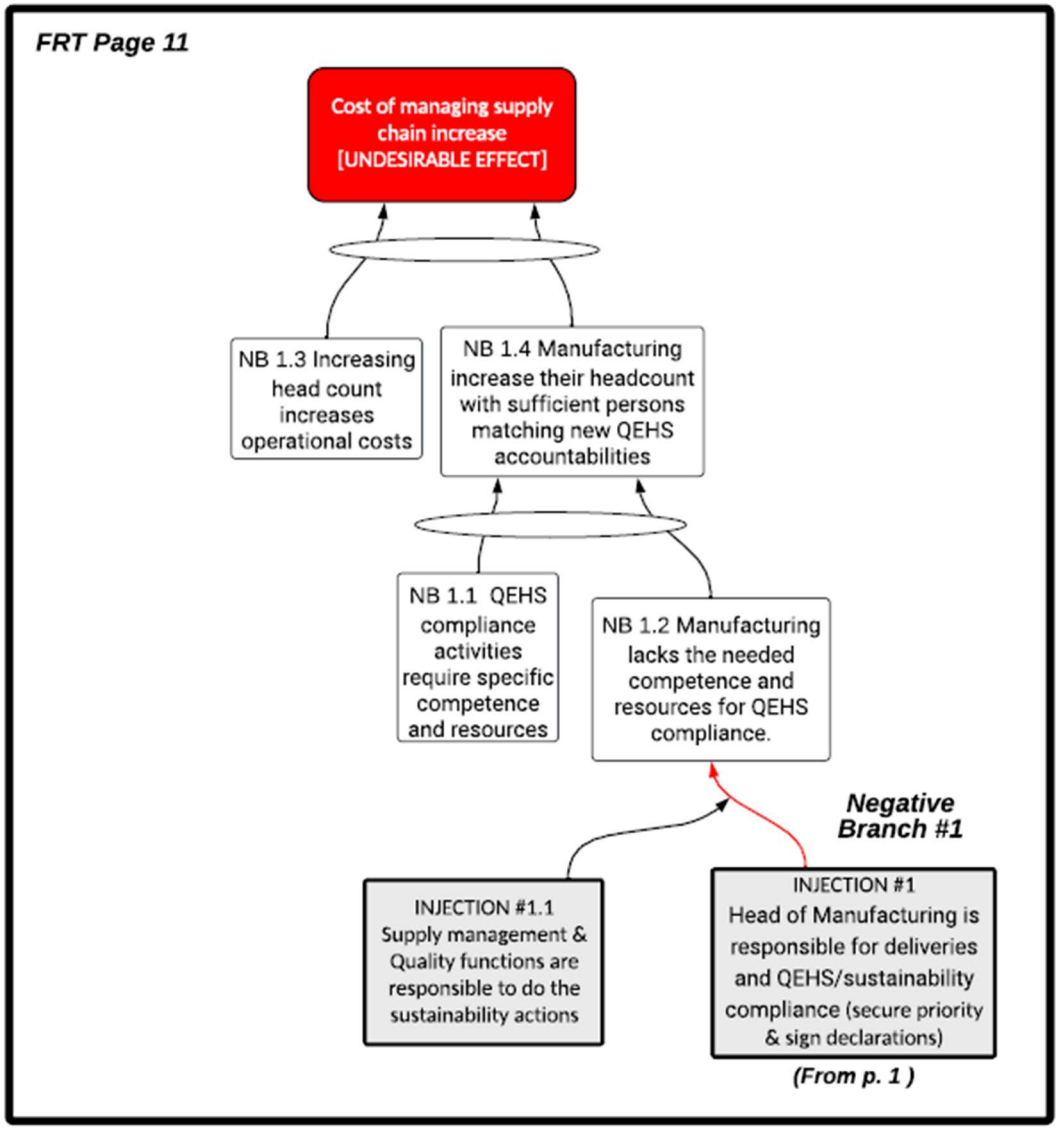

Figure 30. Future Reality Tree - Negative Branch #1.

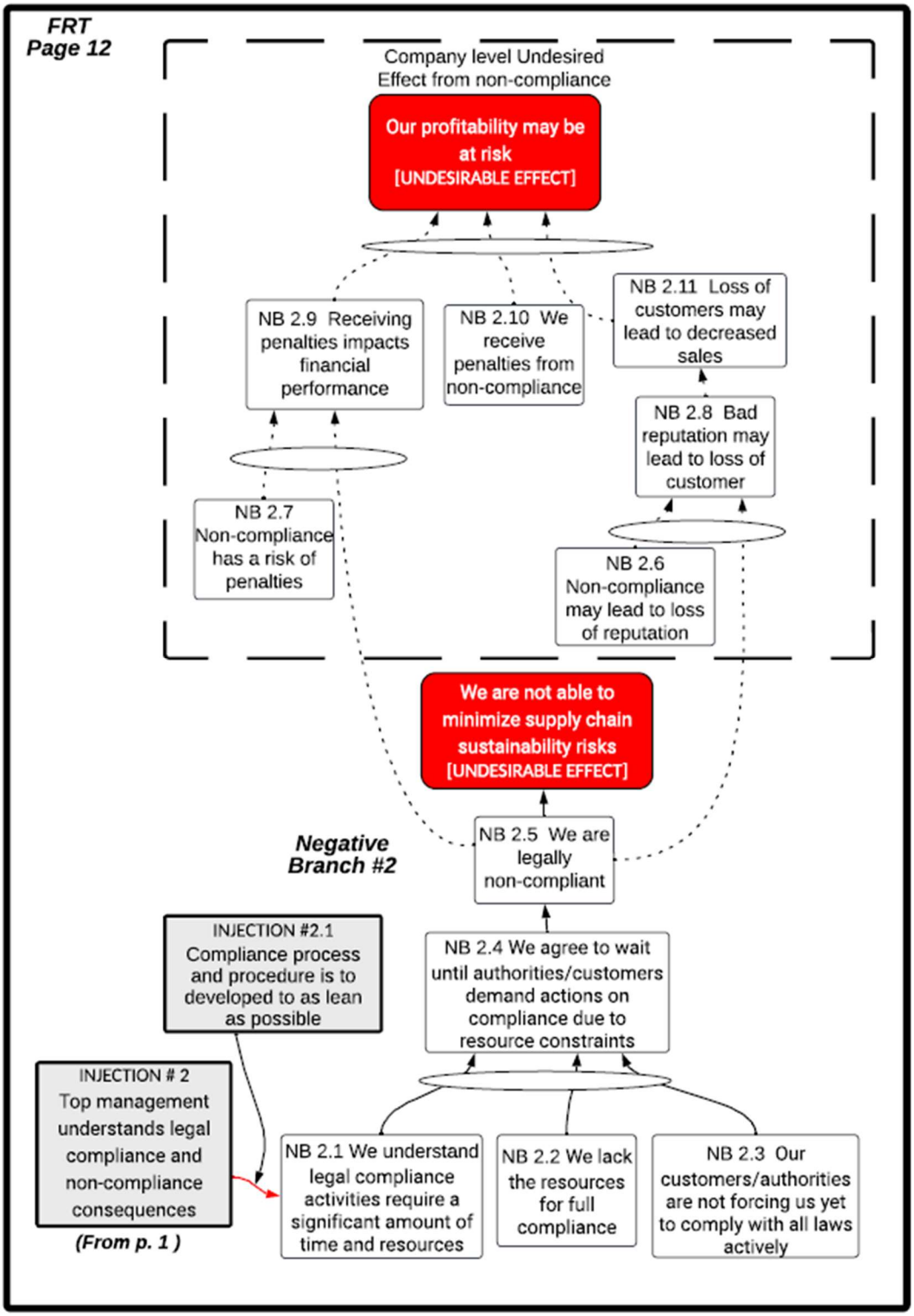

Figure 31. Future Reality Tree - Negative Branch #2.

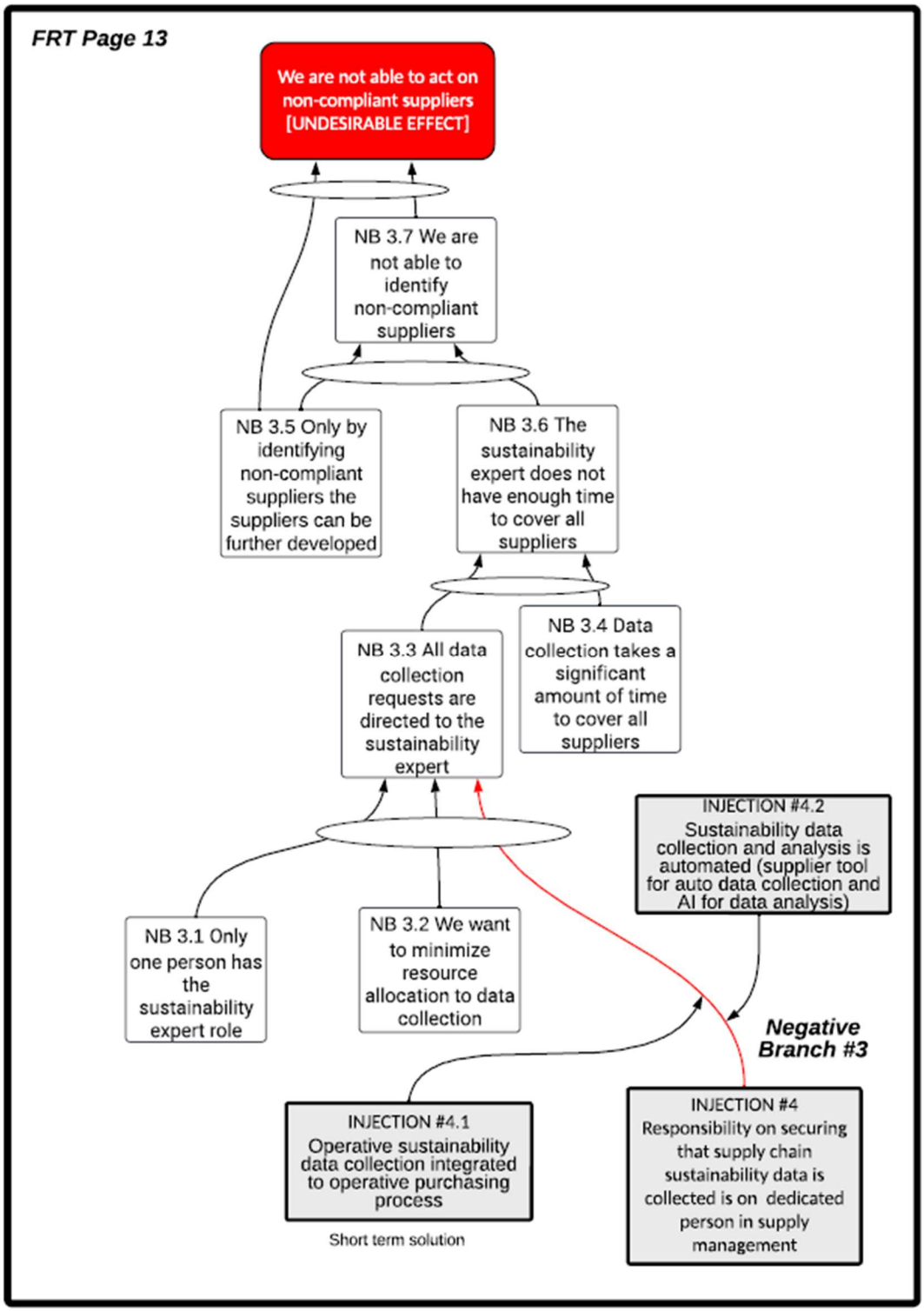

Figure 32. Future Reality Tree - Negative Branch #3.

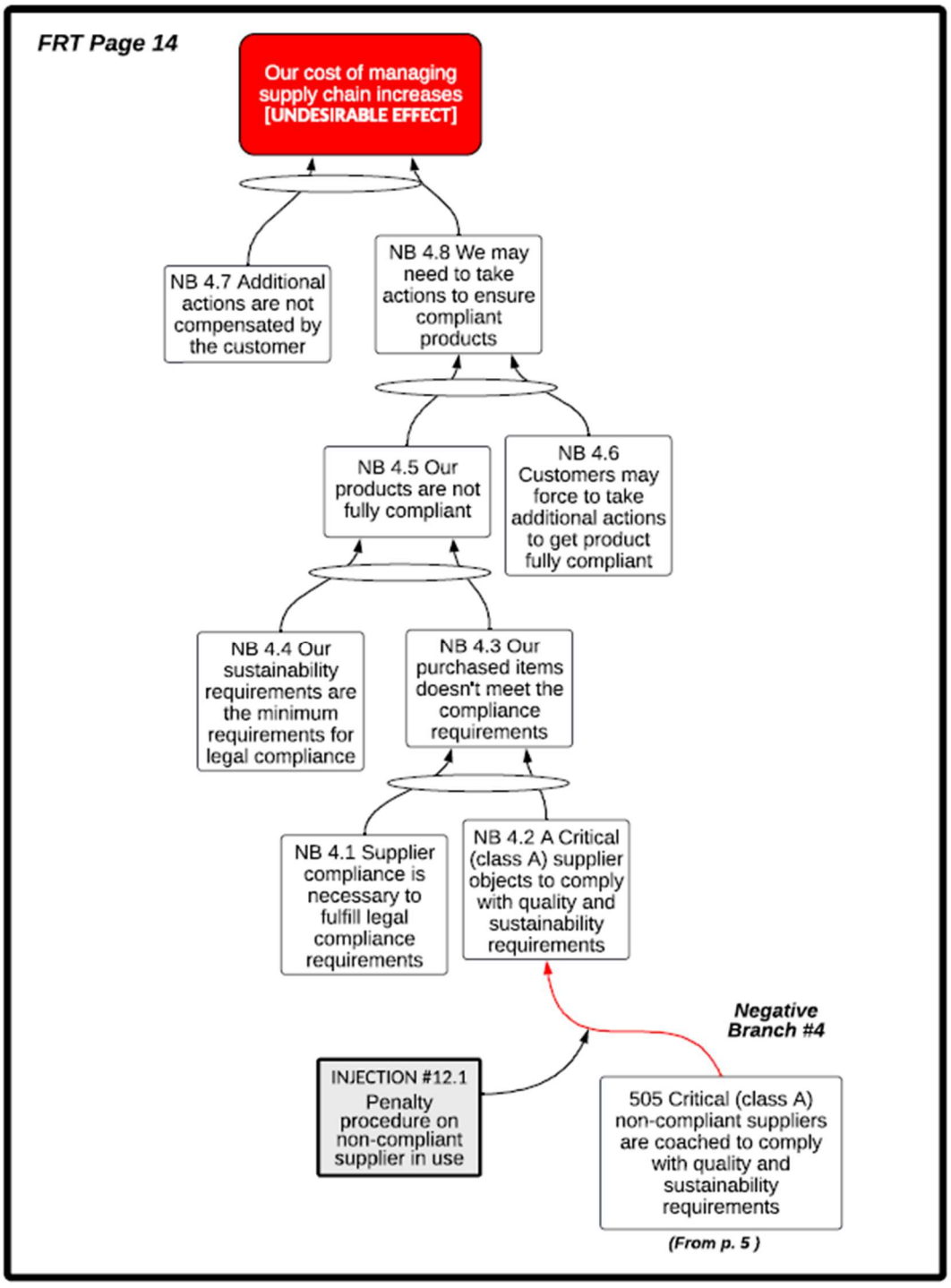

Figure 33. Future Reality Tree - Negative Branch #4.

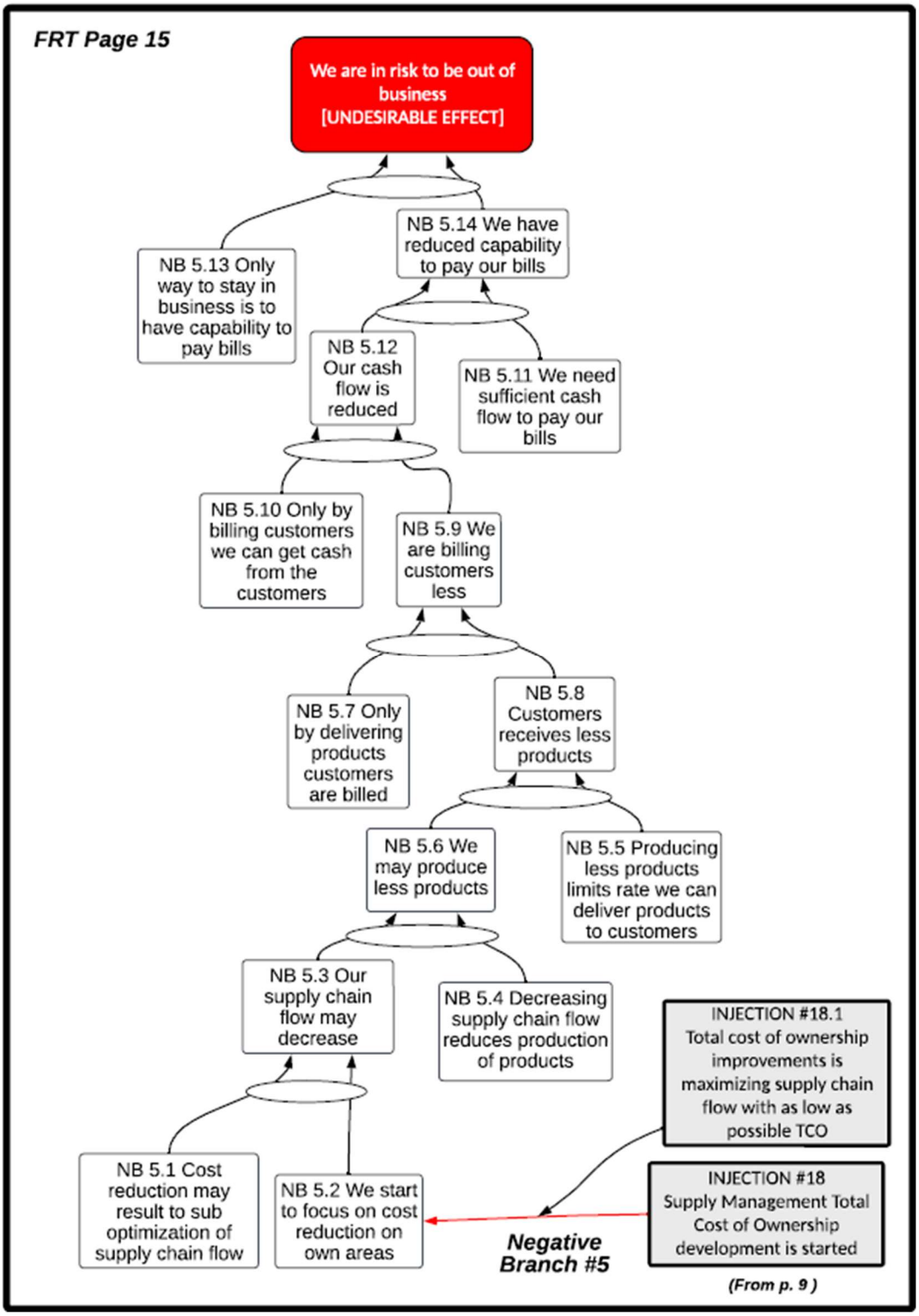

Figure 34. Future Reality Tree - Negative Branch #5.

4.5 Roadmap Action Plan – Detailed Action Plan

A detailed action plan was formed by creating detailed action plans for each injection developed during the future reality tree phase. Actions were defined in brainstorming sessions with individuals who have the role and knowledge to execute the change. The participants included a supply management sustainability expert, quality director, supply management director, and company CEO.

Each of the identified injections requires an action plan in the form of a project. Some injections are intricately connected and therefore addressed in the same plan. Out of a total of 20 injections identified in the future reality tree to achieve the goal, 14 require separate project plans.

The needed actions, named Intermediate Objectives, were brainstormed with individuals impacted by each injection. With all steps identified, it was also discussed if there are obstacles for change to realize for a specific injection, and actions to bypass the obstacles. Brainstorming took multiple hours to identify each injection's intermediate objectives. As there was only very limited time with top management, injections to clusters (**Figure 35**) Sustainability commitment and resourcing, and Systematic Supply Chain Sustainability Risk management were done with a different approach than previous ones. Brainstorming was replaced with the Crawford Slip Method[37] in which each participant answered the presented three questions by themselves in limited time and gave the answers by email only to the author, thus keeping each participant's own views hidden, uninfluenced by

[37] Dettmer H. William, 2003 Brainpower networking

others' thinking. The questions followed the logical thinking process instructions for developing a prerequisite tree. After all inputs were received, all PRTs were built and reviewed with all participants.

Cluster	Projects to Execute Change
Sustainability Commitment and Resourcing	INJECTION #1 Head of Manufacturing is responsible for deliveries and QEHS/sustainability compliance (secure priority & sign declarations)
	INJECTION #1.1 Supply Management and Quality functions are responsible to do the sustainability actions
	INJECTION #2 Top management training
	INJECTION #5 Supply Management Sustainability expert training
	INJECTION # 20 Incentive for management through Sustainability service linked to profitability
Total Cost of Ownership	INJECTION #18 Total Cost of Ownership in use
	INJECTION # 18.1 Total cost of ownership improvements is maximizing supply chain flow with as low as possible TCO
	INJECTION # 17 Costs of fulfilling general customer requirement activities are tracked
Sustainability Tools and Procedures	INJECTION #6 Objective: Our supplier sustainability requirement process and procedure are in use
	INJECTION #4.1 Operative sustainability data collection integrated to operative purchasing process
	INJECTION #4.2 Sustainability data collection and analysis is automated (supplier tool for auto data collection and AI for data analysis)
	INJECTION #12 Suppliers are coached on compliance topics
Systematic Supply Chain Sustainability Risk Management	INJECTION #14 A cost-efficient sustainability risk management process and tool are in use.
	INJECTION #16 Customer requirement management process includes general (non-technical) and technical customer requirements

Figure 35. Prerequisite tree - Implementation roadmap.

4.6 Validity

LTP Methodology has clear instructions on how and what to do through the five steps while complying with the rules of logic (CLR) to keep the logic tight and understandable to readers. To ensure the logic was right, ChatGPT 3.5 was also utilized for checking that no premises were missing in a specific context. Only a very few connections had missing premises. The logic trees were scrutinized according to the Categories of Legitimate Reservation and reviewed with case company participants to check if entities are true in the environment – validity check. In addition to this, GT, CRT, EC, and FRT logic quality was reviewed by LTP experts H. William Dettmer (partially) and Thorsteinn Siglaugsson for the tree to be logically tight and supporting the conclusions with a constructed tree.

5 CONCLUSIONS

Sustainable supply management requires sufficient skillset and personnel supported by a built-in information flow and the necessary policies, processes, and guidelines to enable supply chain sustainability within company sustainability requirements. Supply management is connected to almost the entire supply chain. Sustainability requirements come from legal compliance and customer requirements, and it is impossible to fulfill them without minimizing sustainability risks. Sustainability requirements must be integrated into the supply chain. If sustainability activities are not part of the customer requirement process and are not integrated into supply chain activities, fulfilling customer sustainability requirements will not be visible in company costs and will remain hidden. By considering the total cost of ownership, all relevant costs become visible to the organization, enabling cost tracking and resource utilization. The most important factor in transforming the supply chain into a sustainable is top management support. Without support, it is very difficult to accomplish changes due to resistance to change.

The roadmap development was done with supply management boundary conditions in the supply chain. It was noticed that boundary conditions should have been set at the company level in the supply chain and involve more people in the roadmap work to minimize future resistance to change.

The logical thinking process is an excellent method to improve system performance as it provides a clear goal, identifies what needs to be changed, resolves conflicts, validates future reality to achieve desired outcomes with logic, and creates action plans with built-in risk mitigation for successful execution. The logical thinking process methodology depends on systems knowledge and data accuracy. Getting the right knowledgeable individuals to participate in roadmap development was crucial. If the data used were invalid, the outcome would be a plan that does not reflect the real system reality. The logical thinking process methodology

enabled the creation of a concrete action plan for implementation, which was easy to convert into a project plan.

If I could start roadmap development from the beginning, it would be done at the company level. Work would be involving all the main actors from the company, especially those who can obstruct the initiative. Actual change for the roadmap creation would have been mostly on a goal tree. Persons involved in building logic trees would be mostly the same persons having knowledge in sustainability and total cost of ownership. This would ensure that key individuals would see for themselves what the organizational issues are, resolve conflicts, and be part of the team designing the future, leading to better acceptance and support for the initiative. As the roadmap was not done with this approach, there is a risk of passive resistance from head(s) of manufacturing.

The logical thinking process methodology was very motivating to use, as I could simultaneously learn about what is happening in the supply chain and why sustainability is not yet integrated into daily work. Using the logical thinking process put me in a facilitator role with sufficient background knowledge to support tight logical trees. In the future, I will use the logical thinking process as my main methodology for continuous improvement.

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APPENDIX 1 CATEGORY OF LEGITIMATE RESERVATION, RULES OF LOGIC

	1. Goal Tree	2. Current Reality Tree	3. Conflict Resolution Diagram	4. Future Reality Tree	5. Prerequisite Tree
Purpose	**Define a goal, critical success factors and necessary conditions for achieving it.**	**Define the symptoms and determine critical root causes behind them. A root cause will often consist in a faulty assumption or in a conflict.**	**Structure, then analyse conflicts that may lie behind critical root causes and come up with injections to solve them**	**Analyse if injections to conflicts and/or direct solutions to critical root causes are sufficient to achieve the goal**	**Define precisely, when needed, all the steps necessary to realise each entity in step 4**
Questions asked and actions taken	What is the goal? What is truly necessary to achieve it (no nice-to-haves)? If some of the critical success factors or necessary conditions are not in place, go to step 2 to analyse why.	What are the root level causes behind the symptoms identified and are they sufficient to produce them? How, precisely, do the root causes lead to the symptoms? If there is a conflict, go to step 3. If not, go directly to step 4.	What are the conflicts behind critical root causes? Do the conflicts really exist? What are the logical connections between the entities in the CRD and are all those connections valid? What may be done differently to eliminate the conflicts? Use those suggestions as inputs in step 4.	Are the injections or direct solutions really sufficient to achieve the goal or is something more needed? How precisely will they lead to this? Are there any negative effects resulting from the solutions? If some entities need further step-by-step analysis, go to step 5.	What are the necessary steps to realise each entity? Are there obstacles on the way? How can those obstacles be removed? When done, use the Prerequisite Tree as a basis for a project plan.
Type of reasoning	**Necessity logic (In order to ... We must)**	**Sufficiency logic (If ... Then)**	**Necessity logic (In order to ... We must)**	**Sufficiency logic (If ... Then)**	**Necessity logic (In order to ... We must)**
Validity checklist (categories of legitimate reservations): Follow this list to check the validity for each entity and each connection in the logic trees.	Is any additional explanation required for the cause, or effect, as written?	Is any additional explanation required for the cause, or effect, as written?	Is any additional explanation required for the cause, or effect, as written?	Is any additional explanation required for the cause, or effect, as written?	Is any additional explanation required for the cause, or effect, as written?
	Is the connection between cause and effect convincing at face value?	Is the connection between cause and effect convincing at face value?	Is the connection between cause and effect convincing at face value?	Is the connection between cause and effect convincing at face value?	Is the connection between cause and effect convincing at face value?
	Are any intermediate effects missing between cause and effect?	Are any intermediate effects missing between cause and effect?	Are any intermediate effects missing between cause and effect?	Are any intermediate effects missing between cause and effect?	Are any intermediate effects missing between cause and effect?
	Is the statement in each entity a complete idea?	Is the statement in each entity a complete idea?	Is the statement in each entity a complete idea?	Is the statement in each entity a complete idea?	Is the statement in each entity a complete idea?
	Is the statement structurally sound; that is, does it express only one idea in a single entity, is there no embedded if-then statement within the entity?	Is the statement structurally sound; that is, does it express only one idea in a single entity, is there no embedded if-then statement within the entity?	Is the statement structurally sound; that is, does it express only one idea in a single entity, is there no embedded if-then statement within the entity?	Is the statement structurally sound; that is, does it express only one idea in a single entity, is there no embedded if-then statement within the entity?	Is the statement structurally sound; that is, does it express only one idea in a single entity, is there no embedded if-then statement within the entity?
	Does the statement seem valid?	Does the statement seem valid?	Does the statement seem valid?	Does the statement seem valid?	Does the statement seem valid?
	Does the cause really result in the effect when read out as an if-then statement?	Does the cause really result in the effect when read out as an if-then statement?	Does the cause really result in the effect when read out as an if-then statement?	Does the cause really result in the effect when read out as an if-then statement?	Does the cause really result in the effect when read out as an if-then statement?
		If the cause is intangible, can an additional predicted effect be identified?	If the cause is intangible, can an additional predicted effect be identified?		
	Is the cause sufficient to produce the effect or are other causes needed too?	Is the cause sufficient to produce the effect or are other causes needed too?	Is the cause sufficient to produce the effect or are other causes needed too?	Is the cause sufficient to produce the effect or are other causes needed too?	Is the cause sufficient to produce the effect or are other causes needed too?
	Is the cause really necessary to produce the effect; is it certain that the effect will not be produced if the cause does not exist?		Is the cause really necessary to produce the effect; is it certain that the effect will not be produced if the cause does not exist?		Is the cause really necessary to produce the effect; is it certain that the effect will not be produced if the cause does not exist?
	Is the cause the only possible cause or could something else produce the effect by itself?	Is the cause the only possible cause or could something else produce the effect by itself?	Is the cause the only possible cause or could something else produce the effect by itself?		
	Is the cause really causing the effect, or is the stated effect in fact causing the stated cause?	Is the cause really causing the effect, or is the stated effect in fact causing the stated cause?	Is the cause really causing the effect, or is the stated effect in fact causing the stated cause?	Is the cause really causing the effect, or is the stated effect in fact causing the stated cause?	
		What other effects should lead from the cause, and do they exist?	What other effects should lead from the cause, and do they exist?	What other effects should lead from the cause, and do they exist?	
	Is there circular logic in the cause-effect relationship?	Is there circular logic in the cause-effect relationship?	Is there circular logic in the cause-effect relationship?	Is there circular logic in the cause-effect relationship?	Is there circular logic in the cause-effect relationship?

Category of Legitimate Reservation, rules of logic.

https://thorsteinnsiglaugsson.substack.com/p/rules-of-logic. Accessed 9.5.2023