

MULTI STAKEHOLDER SUPPORT - METHODOLOGY



Willem Manders, Bartje Alewijnse



This Deliverable report DXXX is part of the INITIATE project, that has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°958318

Executive Summary

This report details a structured approach developed within the European INITIATE project, aimed at fostering industrial symbiosis between the steel and chemical industries to reduce greenhouse gas emissions. The goal is to create a circular economy by reusing residual steel gases to manufacture urea with a reduced carbon footprint. This report presents the methodology used to support this transition and outlines how it can be applied to other industrial transformations.

The INITIATE project aims to tackle the complex challenge of creating a sustainable and circular value chain by enabling collaboration between industries with diverse interests and objectives. To achieve this, the methodology supports decision-making among stakeholders and guides the transition from conceptual ideas to investment decisions in more sustainable processes. Key aspects of this process include reducing uncertainties, building trust, and narrowing down strategic options to select the most feasible and profitable pathways.

The report consists of the following elements:

1. **Method Development:** The methodology evolved through three phases:
 - Version 1: Based on interviews and existing methodologies.
 - Version 2: Refined using two real-world use cases.
 - Version 3: Further adjustments after an 18-month review by the exploitation team.
2. **Challenges Addressed:** Industrial transitions face multiple challenges, such as dealing with new technologies, uncertainties, regulatory environments, and building collaboration between industries that traditionally do not work together. This method helps streamline decision-making and commitment-building to overcome these hurdles.
3. **Framework:** The methodology operates on three levels:
 - **Ecosystem Level:** Identifies the necessary system changes.
 - **Value Chain Level:** Establishes collaborations between partners in specific locations.
 - **Actor Level:** Focuses on the needs and interests of individual partners, driving their investment decisions.
4. **Two Key Movements:**
 - From ecosystem-level exploration to actionable use-cases and investment decisions.
 - From initial collaboration to firm commitment, leading to the final investment in scaling up symbiotic industrial solutions.
5. **Roadmap & Stakeholder Engagement:** The method emphasizes iterative steps, including stakeholder identification, understanding their ambitions, analyzing use-cases, and addressing key uncertainties. It culminates in designing a decision-based roadmap to secure long-term investments.
6. **Orchestration:** The methodology requires facilitation by an independent, trusted party who can navigate the diverse interests and complex data inputs to ensure the success of the collaborative effort.
7. **Further Recommendations:** Future research should focus on improving the understanding of market mechanisms, managing uncertainties, and refining value networks. It is also suggested to enhance individual business cases for stakeholders to strengthen long-term commitment.

The methodology is designed to be flexible and adaptable to other industrial contexts, promoting sustainable, cross-sectoral innovation while supporting decision-making in uncertain environments.

Contents

Executive Summary.....	1
1. Introduction	3
2. Approach followed to develop methodology.....	4
2.1. Version 1: based on interviews and existing methodology frameworks.....	4
2.2. Version 2: based on two use-cases and overall roadmap review	4
2.3. Version 3: based on the experience of the exploitation team	4
3. Key challenges	5
4. Methodology framework.....	6
4.1. Two key movements.....	6
4.2. Facilitation by independent party	8
4.3. Types of activities	8
4.4. Steps	9
5. Approach – steps	10
5.1. PMC and stakeholder identification, selection and onboarding	10
5.2. Stakeholder ambitions and strategic options	11
5.3. Stakeholder use cases.....	12
5.3.1. Physical flows and volumes	12
5.3.2. Value network	13
5.3.3. Policy analysis.....	15
5.3.4. Business case.....	16
5.4. Key drivers and uncertainties	17
5.5. Roadmap design.....	18
5.6. Decision roadmap	21
5.7. Exploitation roadmap	21
5.8. Investment decisions	22
6. Further activities / research	23

1. Introduction

In order to cut greenhouse gas emissions and meet (other) climate targets, industries need to change to a more sustainable way of doing business. This includes a transition towards more sustainable and circular value chains. Due to extremely complex ecosystems with many uncertainties (different stakeholders, changing rules and regulations, risky markets etc.) this is a difficult task.

This is also the case for the European INITIATE project. The aim of the INITIATE project is to advance the implementation of circular economy and industrial symbiosis by re-using residual steel gases as a resource for the cross-sectorial, more efficient and less wasteful manufacture of urea, at a significantly reduced carbon footprint. In the project all necessary steps are taken to come to a bankable business case for a first commercial size demonstrator.

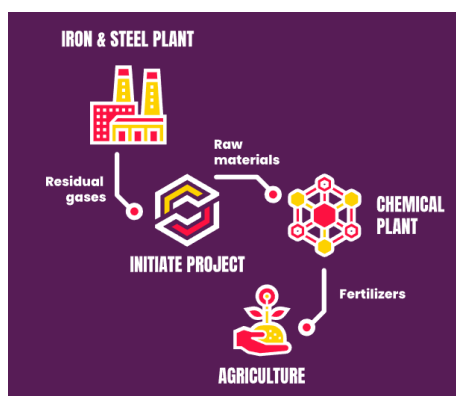


Figure 1: graphical overview of industrial symbiosis in INITIATE project

For more information about the INITIATE project please visit the following website: [INITIATE Project | A stepwise project \(initiate-project.eu\)](https://initiate-project.eu)

Within the INITIATE project, focusing on symbiosis between the steel and chemical industry, a methodology was developed to lead the start and upscaling of such transitions in a structured manner. The method focuses on finding the biggest uncertainties, building trust between the partners, and reducing the options to the most feasible and profitable pathways. Moving from a general ecosystem level towards a value chain and finally actor level. This method was developed and applied in the INITIATE project, but is aimed to be suitable for other industrial transitions as well.

This document first elaborates on how the framework for this methodology was established. After this the different steps and how they were executed in practice are explained into more detail. Lastly, recommendations for future use (e.g. in other industries) and further research are given.

2. Approach followed to develop methodology

This methodology was developed in a number of steps with different prototype versions, as shown in Figure 2 below.

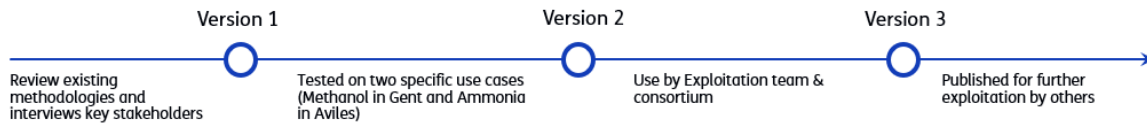


Figure 2: development of methodology over time

2.1. Version 1: based on interviews and existing methodology frameworks

The first version of the methodology described in this document was developed based on interviews and compiling an overview of existing methodologies.

The interviews were held with key stakeholders within the INITIATE consortium. Purpose of the interviews was to identify the key challenges with regards to realizing the INITIATE potential. The insights were then used to review existing methodologies to see how they could help address the identified challenges.

2.2. Version 2: based on two use-cases and overall roadmap review

The first version of the methodology was then tested on two use-cases and a consolidation session with the whole consortium. The underlying key insight from the testing was that we needed to build the methodology with elements on three levels: eco-system level (roadmap, portfolio of Product Market Combinations), the value chain level (concrete use-cases) and the actor level (proposition for individual partners).

The two use-cases helped to really test the methodology and see how applicable it was for the INITIATE program. Due to time constraints and maturity of the INITIATE program, it was not possible to test all the individual tools and process steps at this stage.

Based on the insight from the two use-cases a final review session was done with the whole consortium to see how the insights from the use-cases could be used to build a roadmap. This version was handed over to the exploitation team for further development and implementation.

2.3. Version 3: based on the experience of the exploitation team

After 18 months the methodology will be reviewed again together with the exploitation team. The insights from that review will be included in the methodology that is presented in this document. (Note: to be completed)

3. Key challenges

The motivation behind this methodology is to support the transformation towards more sustainable industries. In this case, this consists of both the steel industry as well as the chemical industry through a possible symbiotic relation regarding the reduction of CO2 emissions. This is challenging from a number of perspectives as is indicated in the next table.

Table 1: Key challenges

Challenge	Possible implications	Methodological requirements
Opportunity to support raw material transition through novel industrial symbioses between industries	Connecting industries that are not used to working together in the same value chain and have different interests, business models, etc.	- Dealing with multiple actors from different industry sectors (e.g. steel, chemicals) with multiple values / objectives (public & private) - Building trust / collaborative approach - Creating information transparency between partners (data driven)
	Range of possible routes to make this work	- Recognizing different stakeholder strategic options and identifying possible overlap & synergies - Portfolio approach (roadmap / portfolio level & specific opportunities)
Number of key constraints	Existing markets & products Available capital Existing rules and regulations	- Systemic approach to deal with key constraints - Collaborative process
Involves novel technologies / Innovation	High level of uncertainty Scaling challenges	- Dealing with uncertainties & risks - Iterative / road-mapping / adaptive approach

In other words, the focus of the methodology is to see how to:

- on the one hand reduce the complexity (e.g. number of strategic options, different stakeholders with different values and objectives) and uncertainties (e.g. novel technologies);
- and on the other hand build trust (e.g. collaborative process, information transparency) and commitment in order for the key stakeholders to make important choices and agree a joint way forward (e.g. roadmap, adaptive approach).

4. Methodology framework

4.1. Two key movements

In order to overcome the challenges mentioned earlier, a methodology framework was developed as depicted in Figure 3 below. The framework consists of two main directions:

- From (eco)system perspective to individual actor perspective (from 'top' to 'bottom' in the picture), focused on reducing complexity and uncertainties. This means the move from the INITIATE concept of industrial symbioses between the steel industry and the chemical industry, to a selection of possible product & market combinations to the development of specific use-cases in specific locations. The goal here is to, together, work towards a concrete solution in a broad solution space.
- From commitment to investigate together to actual commitment towards investments (from 'left' to 'right' in the picture), focused on building trust and enabling stakeholders to make important choices and agree on a joint way forward. This means moving from participating in the INITIATE consortium, to committing to possible first applications in specific locations, to ultimately agreeing to make investments to scale-up.

The idea is to on the one hand reduce the number of uncertainties, options and choices and on the other hand increase the level of commitment of the involved stakeholders throughout the process, ending with final investment decisions regarding the upscaling of the newly developed, more sustainable value chain.

To do so, we move from a general (eco)system level in which we explore the system and its boundaries, to a value network level in which we work with a specific value chain to be transformed, and finally to investment decisions on an actor level. As mentioned before, this method focuses on finding the **biggest uncertainties** on all levels, **building trust** between the partners, and **reducing the options** to the most feasible and profitable transformation pathways.

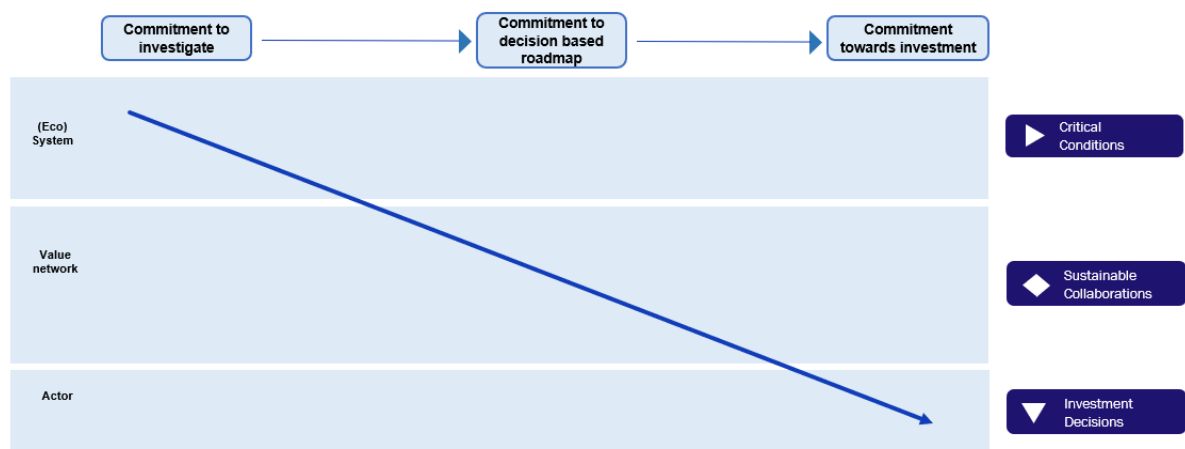


Figure 3: framework of developed methodology

From system perspective to individual actor perspective

The three level approach is based on transition theory. Through combining literature on transition management with providing support on decision making for sustainability innovations, three perspectives for decision makers to consider when implementing and realizing innovations and adapting existing value chains were identified.



Sustainable innovations impact society, potentially changing existing practices, standards and beliefs. Need to understand ecosystem



Sustainable innovations can affect existing value chains and collaboration forms between organizations. Need to understand impact for value chains



Sustainable innovations should be motivated by internal decision making and fit strategic purposes of organizations. Need to understand actor perspective

Figure 4: the different transition levels

The system perspective is about identifying required system changes. This is typically more conceptual. This involves a number of actual ideas (e.g. possible different value chains / product – market combinations). This is often guided by portfolio management and road mapping.

The value chain perspective is all about establishing specific value chains at a specific location with identified partners. The intended outcome is all about sustainable collaborations between trusted partners.

The actor perspective is about the proposition for individual partners in the value network. Key is to see what is required for individual partners to be interested to participate and take their final investment decision for scaling the innovation.

The focus of the multi stakeholder decision support process in the INITIATE project iteratively moves from the boundary conditions on an ecosystem level towards obtaining commitment on an actor level. The value chain level serves as a connecting factor and common ground between these two.

From exploration / idea to commitment (scaling)

The second important direction is to get from a broad exploration of the opportunity to concrete steps (e.g. investments) and scaling of the opportunity.

At the system level this means that critical conditions need to be in place (e.g. investment climate, policies, etc.). At value network level this means that there need to be sustainable collaborations with trust between the partners. At actor level this means a commitment to scale (e.g. final investment decisions).

The first (exploration) stage entails commitment to investigate together. Here, the partners of the consortium commit to spending money and time to explore the concept of this new value chain. When willing to continue with this transition, after an elaborate analysis of the opportunities, the partners are asked to commit to a (developed) decision based roadmap in order to finally work towards the last level of commitment: investment decisions. This final (exploitation) phase starts within the INITIATE project, but is aimed to continue afterwards.

4.2. Facilitation by independent party

As an Innovation Orchestrator TNO Vector has led this process and brought together all the analyses and stakeholders in order to guide the process.

In future projects where this methodology is intended to be used, the recommendation is that an independent party operates as orchestrator of the process. Key characteristics of the orchestrator are:

- independent: so no own interest as a stakeholder in the value network (neither existing nor future);
- dealing with complexity: ability to deal with a range of different stakeholders with different intentions and interests;
- credible & trustworthy: a person that is trusted by all parties involved;
- ability to research / organize / validate relevant data which is being brought to the table by any of the stakeholders.

This method as described in this document is intended to support the independent and experienced orchestrator. Therefore this method is not covering basic stakeholder management skills, facilitation skills, etc.

4.3. Types of activities

The proposed approach is a combination of a number of elements, introduced in Table 2 below. Everything, as mentioned earlier, being facilitated by an Innovation Orchestrator.

Table 2: application of methodology

Element	Objective	Practical
Sessions with individual stakeholders	• Deep understanding of stakeholder needs and objectives • Building trust in the process and facilitators • Gathering data and input/feedback on use case(s)	• Regular contacts between process facilitator and individual stakeholders • Physical attendance helps to build a relationship
Data analysis	• Creating information transparency • Make the process data driven	• Leverage existing literature, public information
Multiple stakeholder sessions	• Sharing perspectives • Building relationships and trust	• Use set of tools to capture key insights and conversations (included in methodology as described later in this document) • Regular physical meetings help to build a relationship

Over the course of the INITIATE project these different elements were applied to the subsequential steps introduced earlier. The main goal was to build trust and increase the level of commitment from and between the stakeholders. For each specific case it is required to find the right mix of the elements described above.

In the beginning, for the Product Market Combinations (PMC) and stakeholder selection, it works well to start with a combination of data analysis and individual sessions with stakeholders to understand ambitions, perspectives and collect relevant data (both from the stakeholders and public data which can then be checked with the stakeholders).

In the next phase (from use cases towards roadmap) an iterative process of first data analysis (as a preparation), then individual sessions to check and include the correct information and perspectives, and lastly multi stakeholder sessions to share and discuss insights was followed. The latter can consist of different combinations of stakeholders.

At a system level it is recommended to include all consortium stakeholders. For specific sessions (e.g. specific use-case / value network analysis) it is better to limit the group to relevant stakeholders for that specific experiment in order to keep the conversations focused.

Important is to hold regular meetings (preferably physical meetings) to build a relationship, which is crucial for the partners to be willing to work together in the future.

In order to obtain and increase the anticipated level of commitment it is recommended to, after the Product-Market Combination and stakeholder selection, execute the use case analysis and roadmap development in sprints of 3-4 months.

4.4. Steps

In Figure 5 the different steps to be taken are shown. The commitment to investigate is related to the proposal phase of the INITIATE project, where the different consortium partners agree to investigate the industrial symbiosis options together. Within the project, a use case analysis is performed on a value chain level, analyzing a representative use case of industrial symbiosis in a specific location between selected partners. This use case analysis then leads towards a general and a decision based roadmap. The selected stakeholders are closely involved in this analysis, increasing the level of trust from and between them. After this a new level of commitment is expected (i.e. stakeholders commit to the next steps formulated in the decision based roadmap). This is followed by an exploitation phase that finally leads towards final investment decisions. This phase is partly led, within the INITIATE project, by an appointed exploitation team. However, the related negotiations will most likely not be finished within the project timeline and continue afterwards.

An elaboration on the different steps is given in the next chapter (5). Step 1 – 8 will be discussed in the respective sections 5.1 – 5.8.

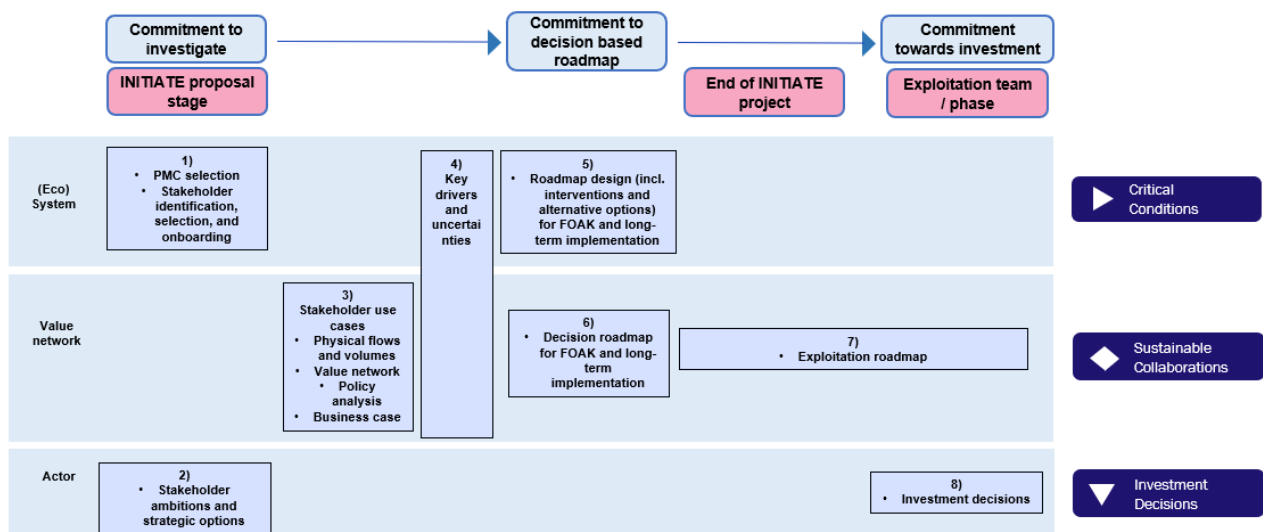


Figure 5: framework of the developed methodology including process steps

5. Approach – steps

In this chapter the proposed steps at system level, value network level and actor level are described in more detail. For each step the following components are discussed:

- **Objective**
Description of the objective of the step. Including a link back to explain the relevance of this step in relation to the identified challenges earlier in this document.
- **Description and approach**
Elaboration on what this step consists of and how this was executed.
- **Analysis and reflections**
Description of the type of data and analysis relevant in that step, including a graphical representation of how this analysis was performed/visualized. In addition, a set of reflection questions was included used to critically review the case during the sessions and gather key insights (uncertainties, drivers, risks).

5.1. PMC and stakeholder identification, selection and onboarding

Objective

To select the most promising product-market combinations (PMCs) for symbiosis between the steel and chemical industry using the INITIATE technologies. This is an important first step to further narrow down the number of possible options. Key is to do this jointly with the key stakeholders so that it aligns with their ambitions (step 2, section 5.2). The selected PMCs will help determine the specific use-cases to be analyzed.

Description and approach

First, an inventory of the possible PMCs was made, together with a set of (economic, societal, business model, and ecosystem related) KPIs on suitability for industrial symbiosis. These KPIs received a qualitative ranking to be able to compare the PMCs. Going from a long-list to a short-list, finally three PMCs were selected to further investigate. This was done by a combination of desk research and interviews with stakeholders.

This is also the first phase of creating a minimum viable ecosystem needed to continue with the next steps. In the case of the INITIATE project, a consortium of stakeholders from both the steel and chemical industry was already formed. However, if this is not the case, it is needed to select and onboard partners that are needed to further develop the PMC value chain.

Analysis and reflections

A detailed elaboration on this analysis can be found in the report of INITIATE D6.4: Inventory of successful symbiotic relationships. The selected PMCs in INITIATE are shown in Figure 6 below.

Product	Market
Hydrogen	Energy – external
	Energy – internal
	DRI
	Feedstock
Urea	Fertilizer
	Animal feed
	Diesel Exhaust Fluid
	Resins
Methanol	(Syn-)fuels
	Chemical
Ammonia	Fertilizer
	Fuel
	Energy
	Chemical

Figure 6: selected product-market combinations (PMCs) INITIATE

5.2. Stakeholder ambitions and strategic options

Objective

Simultaneously with step 1 (section 5.1), the objective of this step is to get clarity on the stakeholder ambitions and strategic options of the different stakeholders. Key part of this process is to make this explicit between the stakeholders in order to create a joint understanding of how decisions might be made (in line with the ambition) and what the acceptable solution space is for the different stakeholders.

This clear articulation helps in a number of ways:

- Helps to identify any potential mismatches. This is something which then needs to be addressed early in the process.
- Helps with specific decisions. For example it will help to make explicit the criteria for the PMC selection (see section 5.1).

Description and approach

First, the stakeholders are asked to think about their ambitions and share this in individual sessions. Next, they share these ambitions with each other in a multiple stakeholder session and discuss whether/where they can find common ground. The strategic options that stakeholders have (different routes to achieve these ambitions) should also be taken into account here.

Analysis and reflections

Have a discussion, led by the independent party, to see whether it is realistic for the different stakeholders to work together towards a shared goal. The ambitions can be clearly formulated using the Value Proposition Canvas (Figure 7) or Business Model Radar (Figure 8).

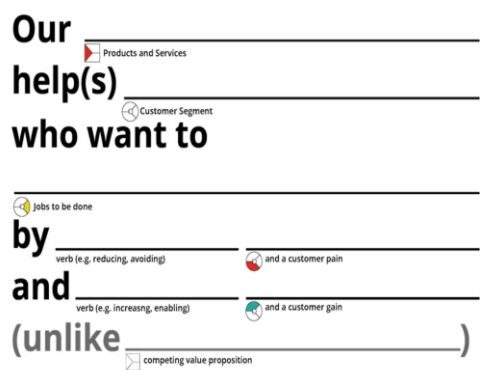


Figure 7: Value Proposition Canvas

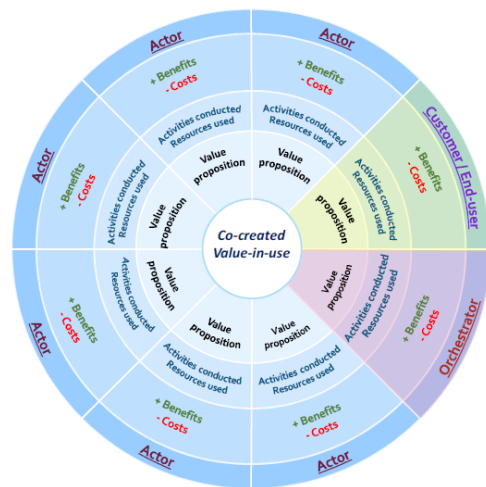


Figure 8: Business Model Radar

This also means finding overlap between their alternative options/routes. On an actor level the different stakeholders always have several different options/routes that are possible on their way to achieve their ambition.

This methodology aims to explore and develop one selected symbiosis opportunity. However, in order to stay realistic, the alternative options and their likeliness per stakeholder should also be taken into account. Therefore, these alternative routes are introduced here (Figure 9) and included in the use case analysis and roadmap development steps that follow. Finally, when working towards final investment decisions, the individual actors will compare their options and choose the most beneficial one. The option circled in red is the INITIATE option for both the steel industry and the Chemical industry. Potential mismatches need to be discussed / addressed. This can also mean to get more specific as certain options might work in specific situations (e.g. locations, markets).

Steel	Scenario
Do nothing (BFG/BOFG)	- Free allowances decrease, pay penalties/ETS - Possible cap on production (emissions)
CCS (SEWGS)	- Invest in SEWGS and storage - No penalties/ETS
CCU internal hydrogen (SEWGS)	Use hydrogen to replace coal/iron ore internally
CCU MeOH, ammonia, urea (SEWGS)	- Steel industry sells hydrogen and CO₂ to chemical industry to produce methanol. - Until when does this count as 70% GHG reduction for RED compliance?
CCU outside EU (e.g. Brasil)	- Possibility to receive (tax) advantages and CCU subsidies (e.g. US) - Higher bio-feedstock and storage availability - Green product classification (→ increased market size) and no ETS
Hydrogen DRI (NG as back-up)	- Reduce iron by either green hydrogen or natural gas - Limited availability green hydrogen
Chemical	Scenario
CO ₂ and H ₂ from natural gas	- Emit CO₂ - Pay ETS price - Decrease in free allowances
CO ₂ and H ₂ from steel industry	- Available - Continuity within EU unclear (RED -70% GHG reduction)
Biogenic CO ₂ and H ₂	- More expensive - Green

Figure 9: alternative routes steel and chemical industry

5.3. Stakeholder use cases

Objective

Purpose of this step is to get more specific in identifying concrete use-cases. In this case specific steel manufacturing plants at specific locations with specific products & markets for the chemical manufacturer. The purpose is to get more specific, while at the same time increase the understanding the stakeholders have of the key cost & value drivers and uncertainties. Making the cost drivers, value drivers and uncertainties explicit for the whole opportunity also helps to see how these could potentially be managed by the group of stakeholders. The insights will for instance be used to design the roadmap, starting with the next scaling step in a location where potentially the cost are the lowest, the benefits are the highest and/or the uncertainties are the smallest. This understanding will help to increase commitment.

Description and approach

The use cases consist of a number of steps. A first iteration is done by collecting data from the public domain in order to create a shared understanding of the potential value chain. Next, individual sessions with the stakeholders were held to check, complete and review the use cases, followed by multiple stakeholder sessions with the same goal. The next (sub)sections elaborate on the different elements of the use case analysis.

An important part of the use case analysis is determining the scope of the use case. This scope was set to the delta case. This means that for every step, the scope comprises the difference between the current (as is) and new (to be) situation and all elements related to that.

5.3.1. Physical flows and volumes

Description

Purpose of this step is to make a graphical representation of the physical flow of materials and energy both qualitatively and quantitatively. Often it makes sense to do this for the existing situation as well as the new proposed solution. The goal is to get a common set of data so all stakeholders are aligned on the physical system boundaries and related data points (and/or ranges). This provides clear communication regarding the scope of the value chain. This representation is focused on the total system, not yet looking at the interests of different stakeholders.

Analysis and reflections

Data to include and analyze (when relevant):

- material & energy flows;
- material and flow compositions (this refers to things like specifications, possible contaminants, etc.);

- process steps (e.g. continuous or batch);
- technology (maturity, availability, alternatives);
- volumes (e.g. modelled against a certain reference facility, linked to the overall ambition);
- physical layout & required logistics / infrastructure (e.g. amount of land required, storage and transport requirements, etc.).

Ideally this is developed for the:

- current situation;
- proposed solution (with possible options);
- next best alternative / other options (if relevant, in less detail).

An example of a graphical representation is given in Figure 10 below.

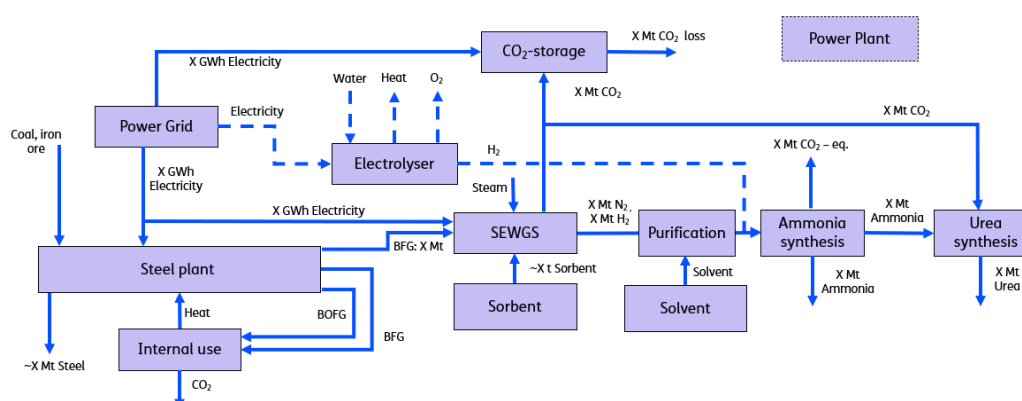


Figure 10: graphical representation of physical flows and volumes

After drawing up the physical flow and volumes graph it is important to reflect on that jointly with the key stakeholders. Typical reflections include the material / energy balance, the amount of change between the current situation and the proposed solution as well as possible risks & uncertainties which can already be identified at this stage. See an example below.

Table 3: reflection guidance - physical flows and volumes

Review topic	Reflection questions	Examples INITIATE
Material & Energy Balance / circularity	• Balance: is the material & energy balance correct in terms of conversion rates, required energy, etc.? • Circularity: are the material flows circular? Are there remaining rest streams or rest energy (e.g. heat)?	In the INITIATE example SEWGS will produce both CO2 and H2. If these will be converted to for instance Methanol, one of the quantities will be leading (in most cases H2). Additional H2 by adding electrolyzers might be an interesting option.
Impact of the change	• Markets: Is there an existing or new market for the product(s)? • Materials: Impact of change on existing use of materials & flows?	The different exhaust gasses are currently being used for energy supply to the steel mill. If these gasses are going to be used to produce chemicals, additional energy will be required for the steel mill. The potential market volumes of new products is potentially very large. This will have an impact on existing markets and associated market prices.
Risk & uncertainties	• TRL: how mature are the technologies in the different conversion steps? • Critical materials: Are there critical materials / choke points? • Constraints: Any critical constraints in terms of required space, logistics, etc.?	Different process steps are at different levels of technology maturity (e.g. some are in the demo phase, others already commercially available). This is important to take into account when scaling up. A key requirement for this model to work is the storage availability of CO2.

5.3.2. Value network

Description

Purpose of this step is to make a graphical representation of the value exchanges and dependencies between different potential stakeholders, building on the physical flow representation (see Figure 11). Different physical steps can be

grouped under the responsibility of certain stakeholders. In this representation also additional relevant stakeholders outside the consortium (like governmental bodies, financiers, etc.) need to be added.

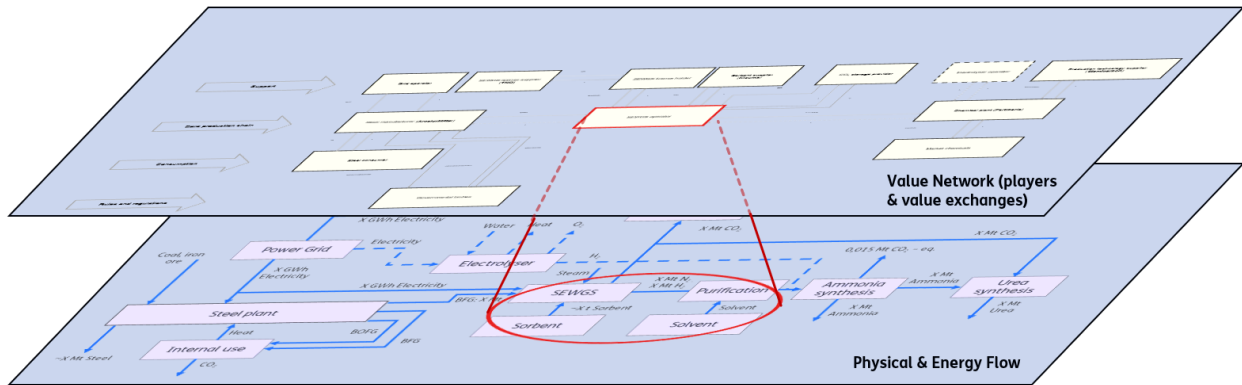


Figure 11: link between physical & energy flow view and value network (with value exchanges)

Analysis and reflections

Key data to analyze (when relevant):

- key activities and associated actors in the network;
- value exchanges between actors;
- (first) division of activities and costs/benefits between actors;
- total system perspective / possible models and alternatives for each party.

Ideally this is developed for the:

- current situation;
- proposed solution (with possible options);
- alternative options for the different stakeholders (if relevant, in less detail).

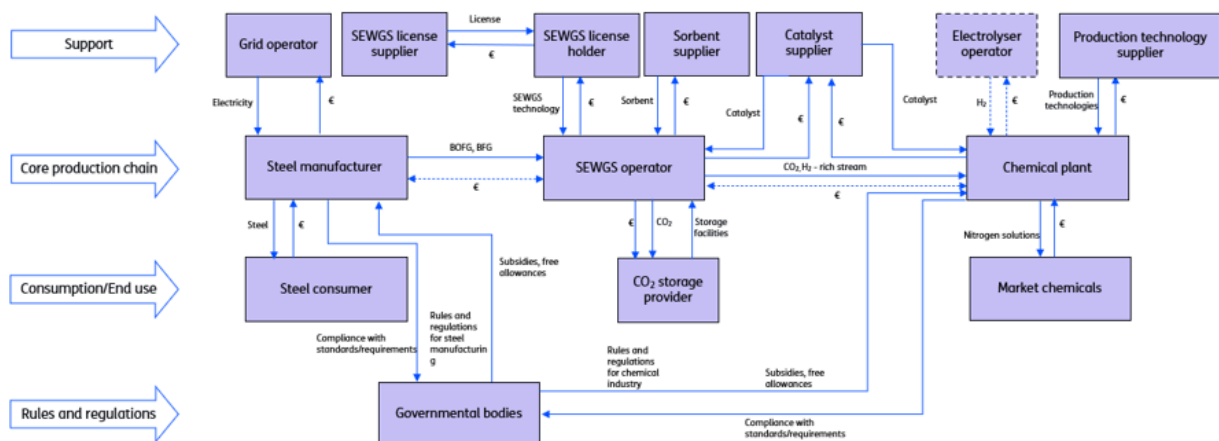


Figure 12: example graphical representation of value network (to be)

After the visualization of the value network it is important to have a reflection session on the value network (Table 4).

Table 4: reflection guidance - value network

Review topic	Reflection questions	Examples INITIATE
Completeness	Are all activities and potential actors identified or are there actors missing?	In the INITIATE program there are currently no CO2 storage providers included. This is however a critical stakeholder for the model to work.
Actor perspective	Alternatives: what are there alternative options or solutions for the different parties? And how favorable are these options?	In the INITIATE setup there are different possible options on who could operate the CO2 capture technology (SEWGS). Is it a separate operator (as is depicted in the picture above) or could it be operated by the steel manufacturer or chemical plant?
Role of Government	Influence: where does the government have an impact on the value network (in terms of mandates, regulations, subsidies, etc.)	In the INITIATE example the government plays a critical role in driving the change (e.g. through ETS regulations, product classifications) and potentially enabling the change (e.g. through subsidies). See also next paragraph.
Impact of the change	Network of actors: what is the change from the current model to the new model? What is the impact on the different existing (and new) actors?	In one of the possible cases the powerplant will no longer be required as the BFG/BOFG will be used to make chemical products, not electricity. This will have an impact on the powerplant stakeholder.
Risk & uncertainties	- Power balance & dependencies: who are the key players? What are the critical dependencies? Who has the power in the network? - How is the strategic autonomy balanced?	To make this use case possible, the steel and power plant at the same location need to be willing to continue with the same plans. They are very much dependent on each other.

5.3.3. Policy analysis

Description

It is important to understand the role of the Government in the value network. Often the Government is a key driver of the change. Therefore it is important to identify and analyze the policies, rules and regulations that impact the use case. Consequently, the feasibility of different scenarios can be mapped and stakeholders can work on strategies to deal with or influence these rules and regulations where possible.

Analysis and reflections

Research should identify what relevant policies or rules and regulations exist (e.g. Table). Next, it should be examined where and how these regulations impact the value chain (13).

Table 5: identified policies INITIATE

Policy	Description	Impact
RED	Companies will need to indicate the percentage of renewable energy used in the raw material acquisition and pre-processing of industrial products. RED2 is now effective, RED3 in process. The EU sets targets, member states need to set up own legislation to reach these targets. RFNBOs, RCFs, and low-carbon fuels must meet a -70% GHG emission target.	RED3 will include penalties. Also, after 2041 the use of fossil CO2 will not count for the 70% GHG reduction. This means the offtake will shift to biogenic CO2.
CBAM	CBAM will ensure the carbon price of imports is equivalent to the carbon price of domestic production, and that the EU's climate objectives are not undermined. Phase-in period until 2034.	Pay ETS equivalent of CO2 if produced outside of EU.
ETS	Cap and trade system for emissions allowances. Targets for emission reduction increase, and number of (free) allowances will be reduced.	Currently the ETS price is around 90 euros/ton, this price will increase. Also, the free allowances will phase-out as CBAM phases in.
Net Zero Industry Act	This Act will attract investments and create better conditions and market access (permits, subsidies) for clean tech in the EU.	Applicable to CCS, but not to CCU and advanced biofuels.
IRA	The Inflation Reduction Act (US) contains new spending and tax breaks to boost clean energy, such as CCU/CCS compensation. Only applicable when located in the US.	Tax advantages when located in the US.

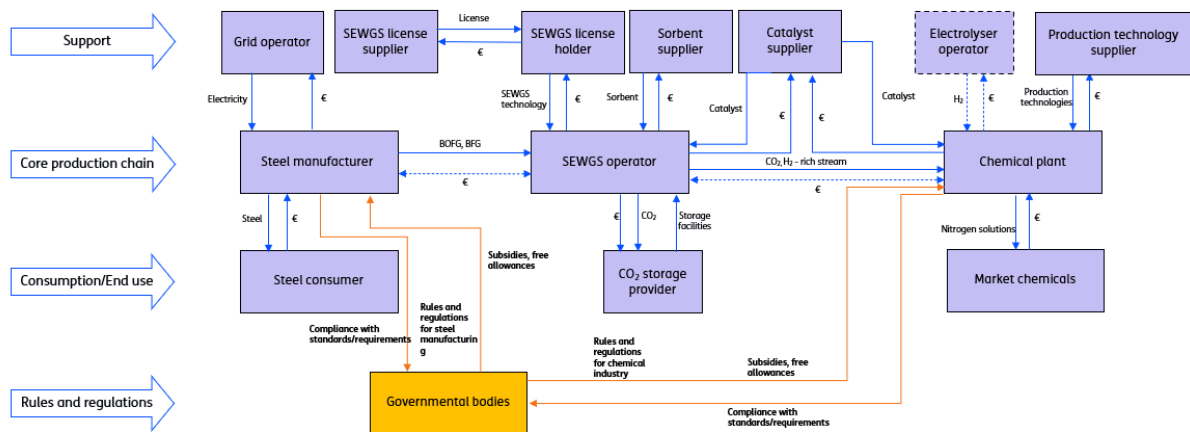


Figure 13: graphical representation of how and where the policy makers impact the value network

5.3.4. Business case

Description

The objective of this step is to understand whether the business case makes sense as a whole and for the individual stakeholders. This is done by quantifying the cost, benefits and uncertainty ranges.

This will provide insight into:

- Whether / when / where the business case will work as a whole (e.g. depending largely on the different uncertainty ranges).
- Whether / when this model could work for individual stakeholders (in the INITIATE program the individual perspectives were not taken reviewed).
- Comparing the opportunity with the alternative options for the different stakeholders (e.g. the steel manufacturer can compare the INITIATE option with the option of just paying the ETS price or going for CCS).

It is important to note that in this stage a first order analysis was enough to meet this objective. Therefore it was not required to share confidential information. At a later stage this might be required.

Analysis and reflections

Adding up all costs and benefits on a value chain level to have an overview of the total business case (see Figure 14 for graphical representation):

- Costs: both CAPEX investments as well as OPEX. Based on the volume case as mapped in the physical flow scenario. Exclude any possible subsidies that are not 100% certain, if a gap remains (for the business case to become positive) it can be discussed at a later stage how this can be filled. In the next picture the costs are shown in blue bars, with the green arrows highlighting the uncertainty margins. In the picture the most likely costs add up to a total number.
- Benefits: both product sales (e.g. using market price information) as well as potential other benefits like avoided costs (e.g. ETS prices). In the next picture the benefits are shown in red (including uncertainty ranges indicated with the green arrows). In this picture the most likely benefits are used and they are moving down on the right side of the picture, showing how they will recover the costs. The last red bar ending below the zero line therefore indicates a possible profit. Key in this picture was not to build an exact business case or NPV, but to highlight the biggest costs elements, key benefits and the big uncertainty ranges.
- Uncertainties / sensitivities: use (publicly) available data to show ranges of costs & benefits (e.g. based on price scenarios, cost estimate scenarios, etc.). Include internal risks (chance & impact) as well as risks outside the network (political, economic, social, technical, legal, ecological) that have an impact on the feasibility. Include uncertainties that can be quantified (e.g. using ranges / sensitivities) in the picture (as explained before), but also include additional potential risks which cannot be quantified.
- Broader impacts: important to also include possible broader impacts (e.g. CO2 reduction, impact on biodiversity, implications for being able to sustain the steel industry in a sustainable way, etc.). In the INITIATE example the biggest driver (CO2 reduction) was included in the calculations using the ETS price. Other considerations need to be taken into account as well in order to make balanced decisions.

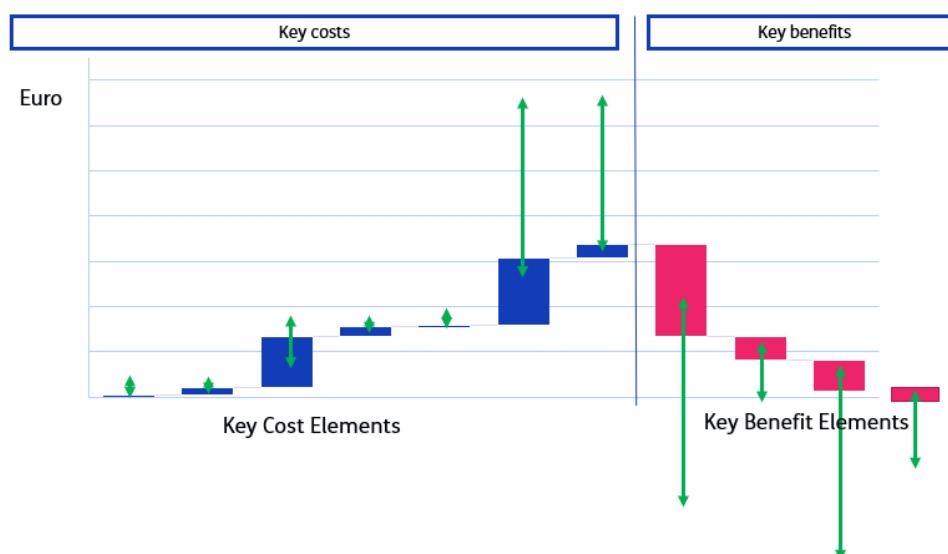


Figure 14: graphical representation of costs and benefits overview value chain

Similar overviews were made for alternative scenarios (e.g. do nothing, move outside the EU, or to compare different PMCs) , to compare the use case with alternative routes for the different stakeholders.

The table below presents a set of questions / reflections which can be used with the stakeholder group to deepen the understanding.

Table 6: reflection guidance - costs and benefits

Review topic	Review questions	Examples INITIATE
Completeness	Is the business case complete? Are there any additional costs? Or additional benefits which can possibly be quantified?	It was clear that there are other considerations (e.g. importance of keeping the steel industry in Europe) that were not quantified in this case.
Total Business Case perspective	- Is it a positive business case? Under what conditions? - Effect of uncertainties in costs / prices? Most impactful costs?	It is clear from the picture above that there are number of key cost elements (e.g. the sixth blue bar) which are a big cost component of the business case, which also have a huge uncertainty range. If the highest uncertainty range number would become reality the business case would become highly unprofitable.
Individual actor perspective	- Is it a good business case for all individual parties? - If not, is there a way to redistribute costs / benefits?	The individual business cases were not made.
Comparison with alternative routes	- How is the business case of alternative routes (per stakeholder)? - Is it feasible and/or profitable to continue with this use case compared to other options?	For the steel and chemical industry, the total business case (on a value chain level) was also calculated for their alternative options for comparison.
Towards next steps	- What is required to make this business case fly as a whole and for each party? - What are possible interventions to create a (more) positive business case (either by reducing costs, increasing benefits or reducing uncertainty)? Is it possible to make a positive business case (e.g. with government subsidy)? - How to mitigate risks, by individual parties or within the network?	Certain cost / benefit ranges could be reduced if agreements are made between the stakeholders in the INITIATE consortium. Especially for the next step of the scaling journey. Other ranges (for instance product prices) might be more difficult to mitigate.

5.4. Key drivers and uncertainties

Objective

The purpose of this step is to better understand what drives the key uncertainties in order to build a roadmap based on dealing with / reducing those uncertainties. Key is therefore to determine the key drivers and uncertainties of the use case in order to determine the feasibility and focus points of the next steps.

Description and approach

The uncertainties and drivers can be deduced from the costs and benefits ranges in the business case. After analyzing these costs and benefits, the outcome is discussed in multiple stakeholder sessions, in combination with the next (roadmap design) steps.

In Figure 15 a graphical representation of the key costs/benefits and drivers/uncertainties is given. This overview can serve as an effective starting point to facilitate discussions with and between the stakeholders about the feasibility, future scenarios and possible pathways regarding the aspired transition.

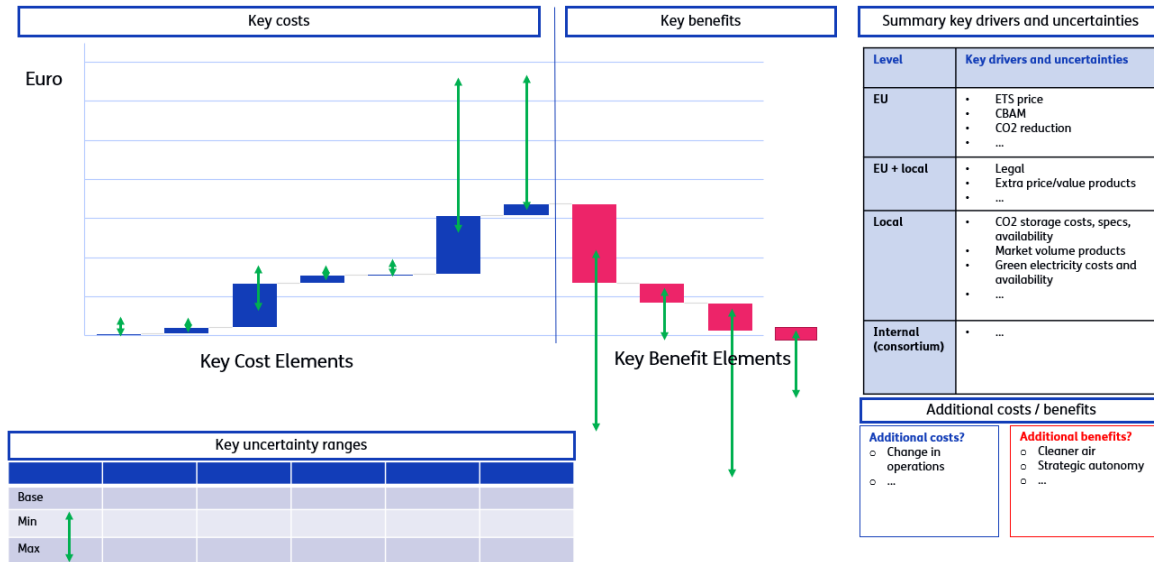


Figure 15: graphical representation of costs and benefits translated to key drivers and uncertainties

Analysis and reflections

What costs/benefits have or can have (when looking at the ranges) the biggest impact on the viability of the use case?

Table 7: reflection guidance – key drivers and uncertainties

Review topic	Review questions	Examples INITIATE
Conditions	- Under what conditions do we have a positive business case? - Under what conditions do we have a negative business case?	In the INITIATE program it became visible that we could identify options where the costs are likely to be low, uncertainty ranges small and an existing market with a potential price premium would be available.
Order of magnitude	- Which factors are most important to determine the way forward? - What are the ranges there? How likely will those costs/benefits fluctuate?	At some point in the INITIATE program a more detailed analysis of a certain CAPEX element was requested by multiple stakeholders. Through the overall analysis however it became clear that that specific cost element was not the most critical for the overall business case.

5.5. Roadmap design

Objective

Purpose of this step is to take the insights from the business case (costs, benefits and uncertainty ranges) and setup a way forward based on those insights. An explicit insight into key costs, benefits and uncertainty ranges helps to make choices on when & where & with whom the next steps would make sense. It helps to identify the key decisions that need to be made in order to make the next steps concrete and make it possible for stakeholders to commit to the next steps. Key is to go through a set of logical steps with the stakeholders to make the options, choices and key decisions / milestones explicit building on the insights of the previous steps in the process.

Description and approach

As a first step, the key drivers and uncertainties are translated to the necessary roadmap dimensions, as shown in Figure 16. Basically the cost / value drivers which are the biggest and/or with the highest uncertainty range are shown on the left of the picture. The second column in the picture highlight the key factors that drive those. These influencing factors are then grouped into five key roadmap dimensions (Geography, Market, Product, Technology,

Ecosystem) on which decisions can be made. For the next step (building a first of a kind factory) this would for instance mean: where to build the first of a kind factory (geography), making what product for what market, achieving what specific technology maturity (Technology) and with what partners (ecosystem).

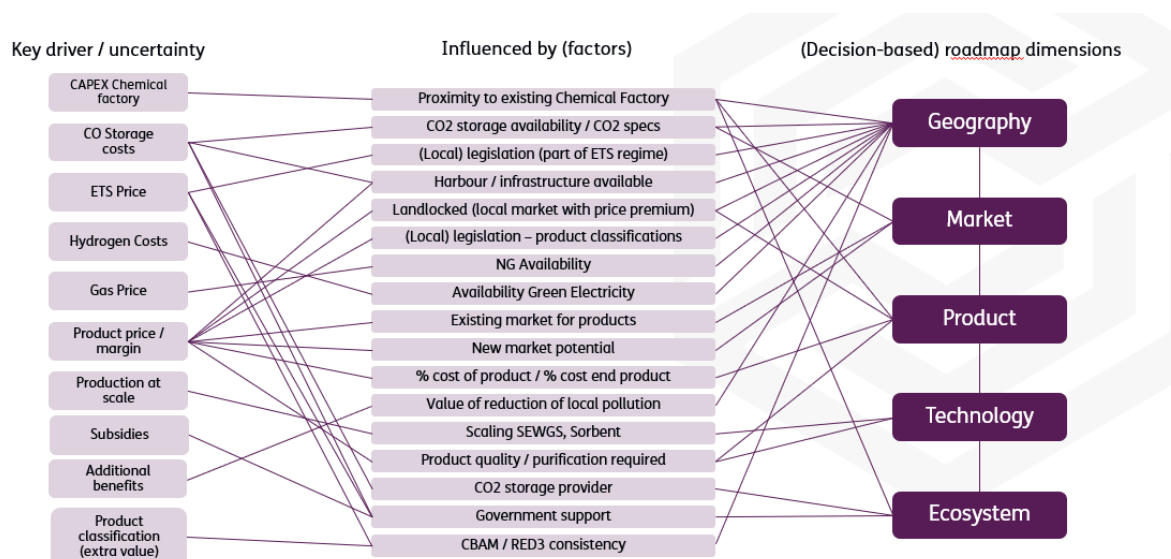


Figure 16: translation of key drivers/uncertainties to roadmap dimensions

These five dimensions can then be used to design the roadmap structure. They form the X and Y axis of the framework. The framework below than also brings in the time dimension. In the INITIATE program the roadmap was organized according to the time dimensions depicted in Table 8.

Table 8: time dimensions roadmap framework

Time dimension	Typical questions	Key inputs
Ultimate Potential	What is the maximum potential applicability? How far can the business case be scaled?	Link back to the ambition statements of the stakeholders
Scaling Pathways	What are possible pathways towards the ultimate potential? How are the pathways going to combine choices on geography and products / markets?	Link back to the strategic options each of the stakeholders has
Niche markets to start	Where will the next scaling step take place (e.g. lowest costs, highest benefits, lowest uncertainties)	Link back to business case
Next steps	What is the best way to take the next steps? What are the key decisions that need to be made to move forward (e.g. build exploitation team)?	Link back to the individual stakeholder timelines
Key current building blocks	What is already in place? What can be leveraged? Where can existing stakeholders already build on?	Link back to existing assets, existing markets, lead customers, etc.

This framework (see Figure 17) can then be completed with (different, so also alternative routes included) **options** and **requirements** (what is needed to be able to continue?).

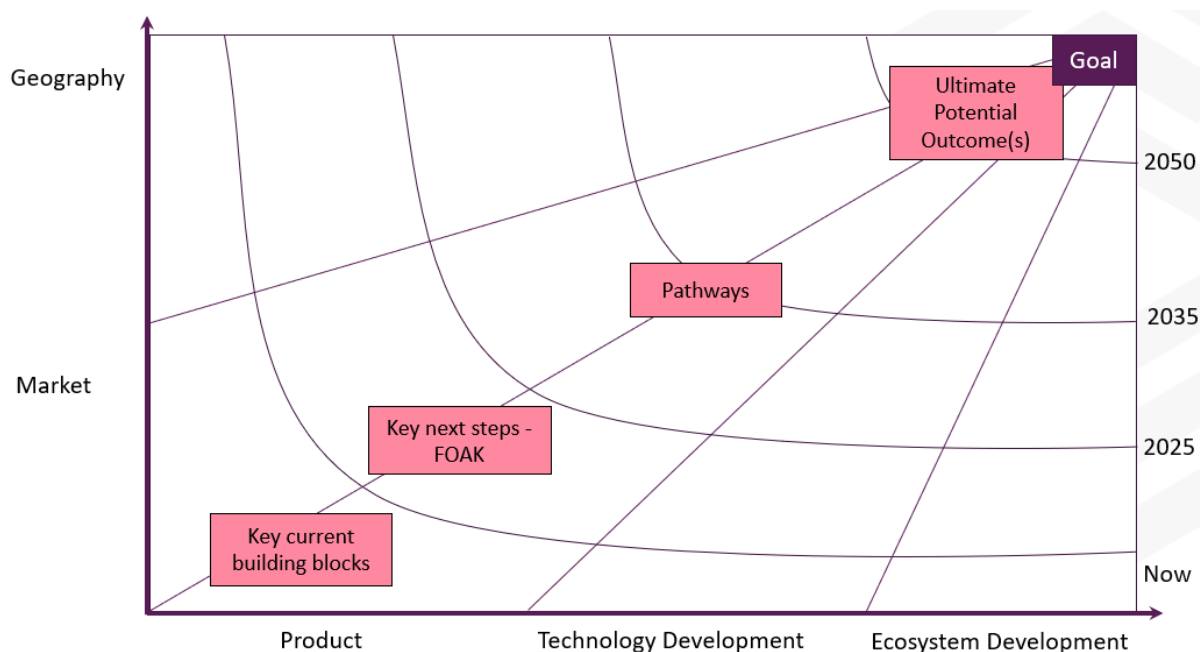


Figure 17: roadmap framework

Using this structure, individual and multiple stakeholder sessions were held to fill out this roadmap as much as possible. This was first done for every dimensions separately (including selected experts on that dimension), see Figure 18. Followed by completing the roadmap as a whole with the entire consortium.

Relevant background information and data was collected to base (ultimate) potential scenarios on, such as:

- market sizes;
- production numbers (from both the steel and chemical industry);
- locations of plants, potential clients, logistical hubs etc.

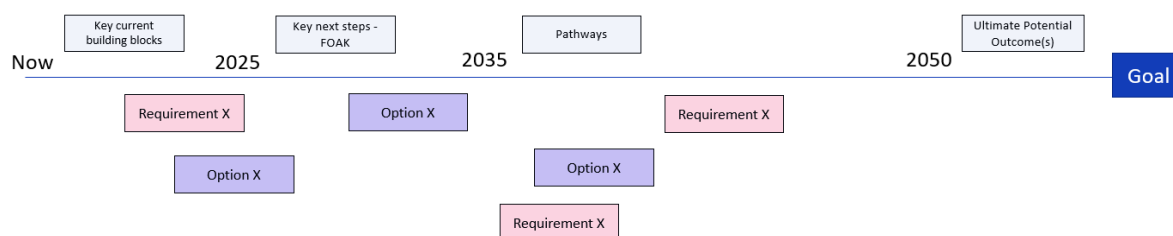


Figure 18: roadmap for 1 dimension

Analysis and reflections

Together with the different stakeholders one can analyze the direction(s) that the roadmap visualizes. Example questions are given in Table 9.

Table 9: reflection guidance - roadmap

Review topic	Review questions	Examples INITIATE
Level of clarity of direction	• To what extent is the roadmap specific enough in terms of choices related to the key roadmap dimensions? •	It was clear in the INITIATE program that there was increased clarity on the key roadmap dimensions. As a first step the next scaling step (building a FOAK) was being investigated in terms of a specific geographic location and product / market combination.
Level of commitment	• Does the roadmap fit with the ambition of each stakeholder? • Is the roadmap credible for each stakeholder? • Is it feasible for each stakeholder?	From discussions it was clear that there are different levels of commitment within the consortium.

5.6. Decision roadmap

Objective

Purpose of this step is to make the roadmap more specific by creating a decision based roadmap for the next 18-24 months for the key stakeholders in the INITIATE consortium.

Description and approach

To create a decision roadmap for the next step in the scaling journey (in this case the building of the First-of-a-Kind (FOAK) plant) and the long-term commercialization of the value chain, working towards final investment decisions. The idea is that if all partners agree (also weighing their alternative options) on this value chain, they can follow the steps in this decision roadmap to work towards a FOAK and long-term commercialization.

Again, this was first created (based on the general roadmap) and discussed with the individual actors, and afterwards with the complete consortium. Through these discussions commitment and trust should be gained from all stakeholders, to increase willingness to continue with the formulated steps.

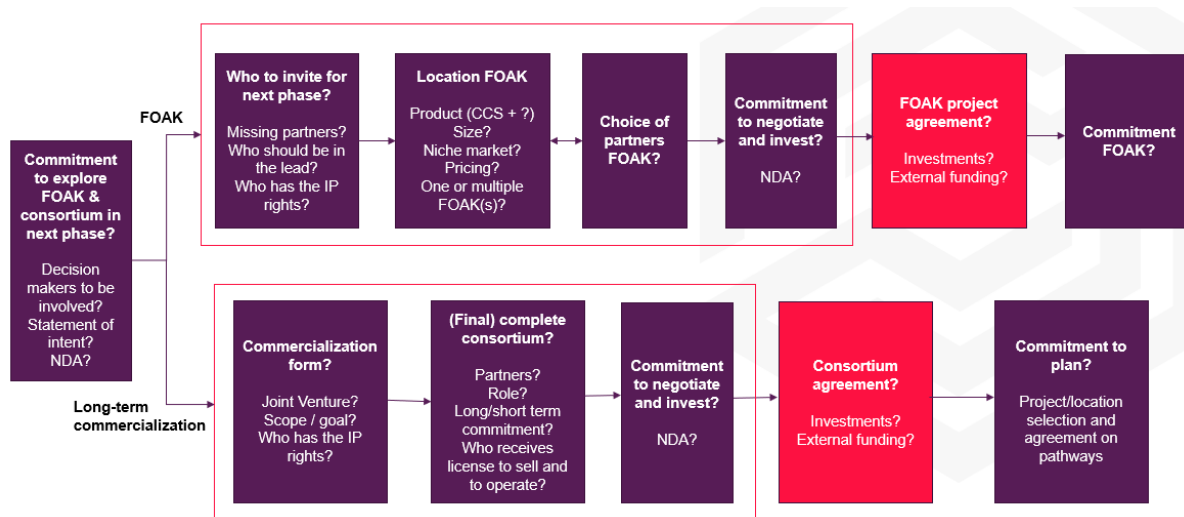


Figure 19 : decision-based roadmap FOAK and long-term commercialization

Analysis and reflections

The main questions to start with following this decision-based roadmap (Figure 19) are given in Table 10.

Table 10: reflection guidance – decision-based roadmap

Review topic	Review questions	Examples INITIATE
FOAK and pathway project / location selection	- What are the selection criteria (production, availability, logistics, market etc.)? - Risks and highest change of success?	When comparing locations, different selection criteria (gas prices, availability biomass, differences in legislation in and outside the EU, etc.) were identified to decide upon the location of the FOAK. Further research was needed to collect all the necessary data.
Commercialization options	- What are the options (joint venture, licensing, project development etc.)? - What are the pros, cons, and considerations per option?	This is aligned with the license negotiations regarding the SEWGS technology.

5.7. Exploitation roadmap

Objective

To increase commitment and work on the exploitation of the first steps of the general and decision roadmap.

Description and approach

To form an exploitation team that takes the lead in executing the first steps of the decision roadmap.

In the INITIATE project the exploitation team consists of:

- the SEWGS technology business developer, in charge of the SEWGS license negotiations;
- an independent consultant with an expertise in value chains in the chemical industry.

One of the most important aspects here is to, again, check whether a minimal viable ecosystem is in place. This is essential to be able to continue on a realistic pathway. If stakeholders are missing, the first step should be to get them on board. Also, at this stage it is crucial to include the decision makers within the involved parties, since the project is moving from an exploration stage towards final investment decisions.

5.8. Investment decisions

The methodology described in this document works towards an exploitation phase that ends with final investment decisions. This entails that the partners of the selected PMC/value chain all decide to continue with a FOAK and/or long-term commercialization and make the necessary investments. For now, this method facilitates the process up to creating a decision based roadmap (Step 5.6, after which it is up to the exploitation team to execute the next steps.

6. Further activities / research

This document describes the first version of the methodology based on the application in INITIATE. Based on learnings from the INITIATE project there are a number of key suggestions for additional activities in the INITIATE program and some suggestions for further research to further develop the methodology.

Potential additional activities INITIATE program

- **Logistics**
To get a more complete picture of the value chain, the logistical processes needed for the physical flows should be included to the physical flows and value network. This might mean that a logistic provider becomes part of the INITIATE program. As discussed earlier in this document that could also include a CO2 transport and storage provider.
- **Importance of strategic autonomy (scarcity feedstock)**
One of the reasons to drive forward the INITIATE program might be because of a strategic autonomy perspective. This might be in terms of sustaining steel industry in Europe and/or from the perspective of CO2 as a feedstock for the Chemical Industry. The value of strategic autonomy has not been included in the current analysis done as described in this report. A broader reflection on the value / importance of strategic autonomy and the impact on this case might be very helpful. This could also include conversations about the key findings in INITIATE with key European representatives.
- **Individual business case**
The business case for the INITIATE program is currently only calculated for on a value chain level. To increase more insight for and therewith commitment from the stakeholders the business case should also be calculated on an individual actor level (e.g. business case for steel manufacturer/chemical company). This might be a logical next step as part of the decision based roadmap that is suggested in this document.
- **Value division between partners**
In addition to business cases on an actor level, more attention could go to the division of costs and benefits between the partners. One of the strengths of this methodology and the role of the innovation orchestrator is to have an (independent) overview of the entire value chain. Even if the complete business case is positive, this might not mean the same for all individual stakeholders. To continue, a fair distribution of all costs and benefits should then be facilitated. Again this is a logical next step to do as part of the decision based roadmap.

Potential further research to enhance the methodology

Besides additional activities for INITIATE as described above, this project also highlighted some potential areas for further research on the methodology.

- **Dealing with Uncertainty**
In this methodology the identification of uncertainty ranges was used to develop the roadmap. This approach could be expanded to see how uncertainties could be managed within the consortium. This could help mitigate some of the risks and uncertainties and make the business case more attractive. A clear separation should then be made on how to deal with uncertainties that are system uncertainties (which the value network partners cannot manage but can define a collaborative response to) and value network uncertainties which can be mitigated within the network.
- **Control Points**
This methodology is focused on building new value networks. Important is to also make sure that the new value network is economically sustainable in the long term. Classically this is looked at on an actor level to identify sustainable competitive advantage. An area for further research is to see how this could be looked at at a value network level to identify 'control points'.
- **Market Mechanisms**
In the INITIATE program it became clear that a few of the biggest risks / uncertainties have to do with the range of potential market prices (e.g. price of CO2 / ETS, price of products being produced). These have a

very big impact on the potential business case. A methodology to better understand the key factors behind how these prices develop can help to develop a more robust roadmap.

TNO Vector has recently started to explore these three additional research areas.