

# Syngas value chains in the Rotterdam Harbor Industrial Cluster *Go Big or Go Home?*

THE IMPORTANCE OF SCALE ON OUR WAY TO STRATEGIC AUTONOMY

WHITE PAPER



INDUSTRY'S  
DRAWING ROOM

16 april 2026  
Andreas ten Cate  
Tijs Beek

# Voorwoord



## Arne Weverling

PROVINCIE ZUID-HOLLAND

“Go big, or go home!':  
dat spreekt mij aan.”

De Rotterdamse haven is een van de grootste en belangrijkste doorvoerpunten van grondstoffen in Noordwest-Europa. De chemische industrie produceert er op grote schaal materialen voor ons dagelijks leven. Maar onze afhankelijkheid van fossiele grondstoffen maakt ons kwetsbaar, dat merken we elke dag. De overstap naar duurzame en circulaire koolstofketens is daarom geen keuze meer, maar een noodzaak én een strategische kans.

Ik heb de Tekenkamer van de Industrie gevraagd hoe we deze transitie in het Haven-Industrieel Complex (HIC) kunnen versnellen en tegelijkertijd onze economische kracht behouden. Dat duurzaam syngas in verschillende toekomstscenario's economisch aantrekkelijk is voor het HIC, bleek al uit de **scenariostudie**<sup>1</sup> die we in 2025 samen met de gemeente Rotterdam hebben laten uitvoeren. Naar aanleiding van deze studie heb ik gevraagd hoe we een syngasketen kunnen ontwikkelen en relevante investeringen naar Zuid-Holland kunnen aantrekken. Een grootschalige, duurzame syngasketen blijkt - hoewel een immense uitdaging - veel kansen te bieden: economische robuustheid, strategische autonomie en een schaal die van grote waarde is voor de Nederlandse en Europese economie.

“Een grootschalige, duurzame syngasketen blijkt  
veel kansen te bieden.”

Het advies van de Tekenkamer luidt: 'Go big, or go home!'. En dat spreekt mij aan. Grote vraagstukken vragen om richting, regie en lef. Als provincie verbinden we ruimte, economie en leefomgeving om deze transitie mogelijk te maken. Ik nodig partijen uit om samen de volgende stap te zetten en het idee van een syngasketen in Zuid-Holland verder uit te werken, zodat we de haven van morgen hier laten ontstaan én behouden.

*Arne Weverling (VVD)  
Gedeputeerde Haven en Industrie  
provincie Zuid-Holland*

# Meindert Stolk

PROVINCIE ZUID-HOLLAND

“Samenwerken in circulaire ketens is cruciaal om onze ambitie van een volledig circulaire samenleving in 2050 waar te maken. Dit onderzoek laat zien dat een grootschalige syngasketen in Zuid-Holland echte kansen biedt om circulariteit in de chemie van idee naar praktijk te brengen. Die stap juich ik van harte toe.”

*Meindert Stolk*

*gedeputeerde Economie en Innovatie,  
provincie Zuid-Holland*

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## Nico van Dooren

Een grootschalige duurzame syngasketen lijkt een serieus perspectief te bieden voor het toekomstbestendig en duurzaam maken van de Rotterdamse industrie. Als we die sprong voorwaarts echt willen maken, moeten we niet om de knelpunten heen lopen: alleen door barrières in regelgeving, infrastructuur, ruimte en financiering, gericht en gezamenlijk op te lossen, kan deze transitie op de schaal plaatsvinden die Nederland en Europa nodig hebben.”

*Nico van Dooren*

*Executive manager Strategy & Portfolio  
Havenbedrijf Rotterdam*

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## Michiel Spits

“Syngas uit afval, biomassa en industriële reststromen is noodzakelijk om afhankelijkheid te reduceren en weerbaarheid te vergroten. Onze technologie is klaar om te schalen!”

*Michiel Spits*

*CEO, DOPS Recycling Technologies B.V.*

# Executive Summary

The goal is clear: sustainable, circular, and strategically autonomous carbon conversion at the scale of the Rotterdam Harbor Industrial Cluster (R-HIC). What is not clear is how to get there — the route from ambition to industrial reality remains uncharted.

Syngas, or synthesis gas, is an elementary chemical building block and platform, a gas consisting of a mixture of carbon monoxide (CO) and hydrogen (H<sub>2</sub>). Historically made from coal or gas, it can also be produced from waste or biomass. In this way, it can play a key role in shaping clean carbon conversion, bridging between various renewable feedstocks replacing crude oil, and the products and fuels we use in society daily.

The exploration of how this route can play a role in a future clean and circular Rotterdam Harbor Industrial Cluster was carried out as an assignment from the Province of South-Holland. Three fundamentally different development versions were constructed, each defined by a different scale of development: 100 thousand tons per year (100 kton/yr), 1 million tons per year (1 Mton/yr) or 10 million tons per year (10 Mton/yr) renewable carbon. Analyzing the consequences of *choosing* a scale, and stress-testing them against geopolitical drivers, showed that size matters if we want to move successfully forward to meet our goals in these uncertain times. The 8 key messages (KM) below summarize what was found:

## A. THE SCALE OF THE CHALLENGE | PAGE 9

### **KM1 | The HIC Is Europe's Carbon Conversion Anchor**

The Rotterdam Harbor Industrial Cluster handles around 200 Mton/yr carbon-based materials annually. What makes it strategically irreplaceable is its own conversion capacity of 50 Mton/yr — locally processing the crude into fuels and chemicals at scale, making the HIC an essential node in Europe. That domestic crude conversion capacity gives the region an important degree of strategic autonomy. *No alternative cluster in Europe can realistically take over this role at scale within the timeframe that matters.*

In the next decades consumption of fuels will inevitably change and a transition to renewable and circular feedstocks is necessary; non-sustainable carbon is not a viable long-term option. The direction is set, but the question is how fast and effective we can get there. As one of the main European refinery hubs, getting this transformation right ripples far beyond Rotterdam:

- With the HIC ensuring a stably supply of sustainable fuels and feedstocks, manufacturing industry in Germany and the wider hinterland can continue to operate and compete.
- A competitive manufacturing base sustains the economic health of the ARRRRA region and the broader European economy.
- A stable European economy underpins the political cohesion and security of the Union.
- The Netherlands, deeply integrated with and dependent on this system, is a direct beneficiary of getting this right.

### **KM2 | The Scale We Aim for Determines the Actions We Take Today**

The R-HIC is one of Europe's largest industrial complexes with four major refineries, a substantial chemicals cluster, and deep integration with local power, hydrogen and CO<sub>2</sub> value chains. Any serious transition plan must start here: this is the scale of the challenge. Deciding what we want this cluster to look like in the future is not a detail to be worked out later, it is the starting point for every decision that follows.

Focusing on the size of the challenge has system wide implications. Transformation at the required pace, and at this scale, involves actors across the full width of the system from project developers, infrastructure operators, regulators, to financiers, permitting authorities, and more. These actors can only move together if they know what they are moving towards. Without that shared direction, each actor optimizes towards their own objectives without clarity on how or when the R-HIC as a whole could reach its goal. With a shared vision and a plan, the dynamic shifts: focus emerges, choices become possible, and forward movement becomes real.

## **B. THREE VERSIONS, THREE FUTURES** | PAGE 14

### **KM3 | Planning for Large-Scale Development Gives Us Control over Our Transformation**

To make a plan is to make decisions, and deciding on the scale of development is crucial. To assess how scale influences outcome, three distinctly different scale value chain versions were developed: Version 1 (Circular Carbon Niche), Version 2 (Industrial Scale), and Version 3 (Renewable Carbon Megahub). In the analysis, these versions were polarized against each other to understand the differences that surface when building these value chains. This uncovers the role of scale on the shape of the path forward.

And it shows that choices have consequences. A Version 1 development leads to early action but ultimately leaves us import-dependent. Version 2 and Version 3 take time to plan but lead to a scale that matches operations and can secure our strategic autonomy while reaching our sustainability goals.

#### **KM4 | Version 2 and Version 3 are fundamentally different in character**

Version 2 is built up out of a large, centrally developed industrial facility that reaches refinery scale and operates as a single integrated unit. It is a known development model, executed by large industrial players or joint ventures, and it delivers at scale. The challenge is that to reach HIC-wide scale, Version 2 needs to be built multiple times and only a limited number of such integrated sites can fit within the HIC. Each requires dedicated space and integration with one or more existing refineries, creating significant continuity risks during the transition between scrap and build phases.

Version 3 is something different altogether. At the core is a dedicated syngas infrastructure network that decouples generation from use and integrates different operations across the cluster. This enables organic evolution which starts with an initial development and grows over time. As existing factories slowly phase out, new units are added to the ecosystem in their place, and the space they free up becomes available for the next addition. Rather than building one large asset, Version 3 orchestrates the gradual buildout of an interconnected ecosystem integrating with surrounding value chains in hydrogen, power, CO<sub>2</sub> and chemicals. The cluster becomes the unit of development, coordinated from the onset and built incrementally over decades.

### C. WHAT IT TAKES TO GET THERE | PAGE 19

#### **KM5 | Increasing Scale Shifts Who Leads and Who Supports the Transformation**

Who needs to take initiative shifts fundamentally across the three versions. In Version 1, project developers drive development in an entrepreneurial, distributed, and bottom-up way. In Version 2, large industrial players and joint ventures take the lead coordinating large capital-intensive developments that require stable long-term policy support. In Version 3, the national government must set direction to ensure the systemic transformation of the HIC. This creates the mandate needed to unlock cross-border alignment with the ARRR cluster and European Commission that transformation at this scale demands.

The burden on bureaucracy shifts too. Permitting, spatial planning, infrastructure development and enforcement all require attention regardless of which version we pursue. The counterintuitive reality is that supporting twenty distributed small projects near Rotterdam and across the country likely demands as much, or more, from authorities, ports, municipalities and province as coordinating one large national priority. The difference is that at Version 3 scale, this can be planned for and managed by design. At Version 1 and Version 2 scale, it remains largely uncontrolled.

## **KM6 | Version 3 Builds for Transition**

Transforming the HIC is not a single event but a decades-long process of change, during which the system must keep running. Imperfections are inevitable and require hybrid operations in which old and new coexist, timing mismatches between asset retirement and new development are managed, and resource constraints require flexibility. Version 3 is designed to handle this. The syngas backbone and cluster-wide coordination facilitate phased development, absorbing delays and maintaining continuity.

Investments can be phased to match system readiness, and delays absorbed without stranding assets. And crucially, each addition to the ecosystem builds on what came before while technology matures, operations are better understood, and the cluster learns how to develop and integrate at scale as it evolves.

Version 3 will not be perfect or fully circular quickly, but it is the only version that puts us firmly on the right path.

## **KM7 | Stress-Testing Sharpens the Conclusion**

Strategic autonomy does not equal full self-sufficiency, but securing our future carbon need does require our own conversion capacity and diversified feedstock sourcing. Testing the versions against execution realities and geopolitical conditions reveals how far each version gets us toward that goal. In a world of increasing geopolitical instability, increased focus on resilience and strategic autonomy are not aspirations — they are requirements:

- **Version 1** — domestic production covers less than 10% of future carbon demand; the remainder must be imported; strategic autonomy is not achieved
- **Version 2** — reaches meaningful scale but replication limitations within the HIC constrain total volume to about 20% of what is needed; supports strategic autonomy only marginally
- **Version 3** — designed to create substantial strategic autonomy through a deliberate feedstock hierarchy and system integration with domestic offshore wind, hydrogen and CCS infrastructure; its aims for 50% of carbon demand. Its scale and resilience make it the only version robust enough to withstand geopolitical pressure while driving transformation

## KM8 | The Province of Zuid-Holland, the Mobilizing Force in the Middle

The Province of Zuid Holland has high stakes in a long-term development of the R-HIC and a strategic role to play. It governs amongst other things: spatial planning, permitting, and enforcement, making it an unavoidable actor in any version. Governing the execution will land on the Provinces' plate. Better to shape the path than to be shaped by it. It also has a central role in within the multi-level governance system in between EU, national, provincial, municipal, and port authorities, and is uniquely positioned to align these parties. From that position, the Province activates, aligns and accelerates the stakeholders, turning its governance position into a true mobilizing force.

The recommended next steps are:

- **Leadership from the institutional top:** Large scale developments need institutional leadership - drive consensus on the vision and development plan of the R-HIC with **key governance stakeholders**.
- **Know where you come from:** to go from vision to masterplan to action, create an up-to-date coherent digital reference map of the current port sites and energy flows.
- **Look at the complete picture:** syngas is a crucial piece of the puzzle and a key system element, but not the only one. Explore **how to scale all key ingredients** and develop their **scaling pathway staircases** in the same way.
- **Learn to think big, build the masterplan, make it concrete:** take the step to design Version 3.
- **Build broad support:** start shaping support for the masterplan through focused multi-stakeholder engagements.

# A.

## The Scale of the Challenge

 **KM1 | The HIC Is Europe's Carbon Conversion Anchor**

 **KM2 | The Scale We Aim for Determines the Actions We Take Today**

### INTRODUCTION

“What can we do to stimulate the development of circular and renewable carbon investments in the Rotterdam Harbor Industrial Cluster?” This question was raised at the Province of Zuid Holland after reviewing the outcome of the feedstock transition scenario study<sup>1</sup> for the Rotterdam Harbor Industrial Cluster (R-HIC) published in early 2025. That question leads to a harder one: do we know what our choices are? And do we understand what forces influence these choices? Who needs to take which decisions and do we understand which are within our control? We know what we want to achieve. What we do not yet have is a common picture of how to get there.

This paper is a first step into uncovering what it takes to develop a syngas-based value chain in the Rotterdam Harbor Industrial Cluster. The exploration was carried out by Tekenkamer van de Industrie and Sproule ERCE, commissioned by the Province of Zuid-Holland.

To understand how scale and the size of development influence our ability to reach our goals, a staircase of increasing scale was constructed as the basis for the analysis. The versions in this staircase are deliberately polarized. They are not sequential steps on a growth path, but fundamentally different development approaches designed to expose what different choices imply in practice. Three versions were defined: Version 1 (Circular Carbon Niche), Version 2 (Industrial Scale), and Version 3 (Renewable Carbon Megahub). Each grows from a different size building block but has the ambition to grow. For all three versions, as scale increases complexities grow. Version 0 (Do Nothing) is the baseline. When policies don't converge and certainty stalls investments, this is the decline scenario that emerges. The analysis behind the versions was built up in four steps:

- Archetypical value chains establish what a syngas-based system looks like from feedstock to product (Deliverable 1)
- A staircase of increasing conversion scale, comparing each version against the challenge of supplying future renewable carbon demand (Deliverable 2)
- Stakeholder interviews, policy analysis, and a feedback workshop testing the versions against a broad set of actors (Deliverable 3)
- A decision-based roadmap per version, summarizing the order and ownership of key decisions (Deliverable 4)

The full underlying analysis is available in the project deliverables, published as appendices and accessible online.

This paper takes the reader on a strategic exploration of the logic of scale, the realities of development, and the consequences of different choices. It sharpens the questions that matter. Along the way, it becomes clear that the choices involved touch actors across the full width of the system, from project developers and infrastructure operators to regulators, financiers, and national government, and that alignment between them is as much part of the challenge as the technology itself. The paper is structured in four sections: (A) establishes the scale of the challenge; (B) introduces the versions and what distinguishes them; (C) examines what it takes to get there; (D) sets out the path forward.

## A System Under Pressure

The R-HIC is one of Europe's largest industrial complexes, handling around 200 Mton/yr of carbon-based materials annually (see the text box). Four major refineries currently process about 25% of that total flow, converting crude into fuels and base chemicals at scale. That scale is both its strength and the measure of the challenge ahead. The HIC is not just a Dutch asset, it is the gateway to the ARRA hinterland, deeply integrated with the industrial clusters that stretch from Antwerp through the Rhine and Ruhr to Northwestern Europe.

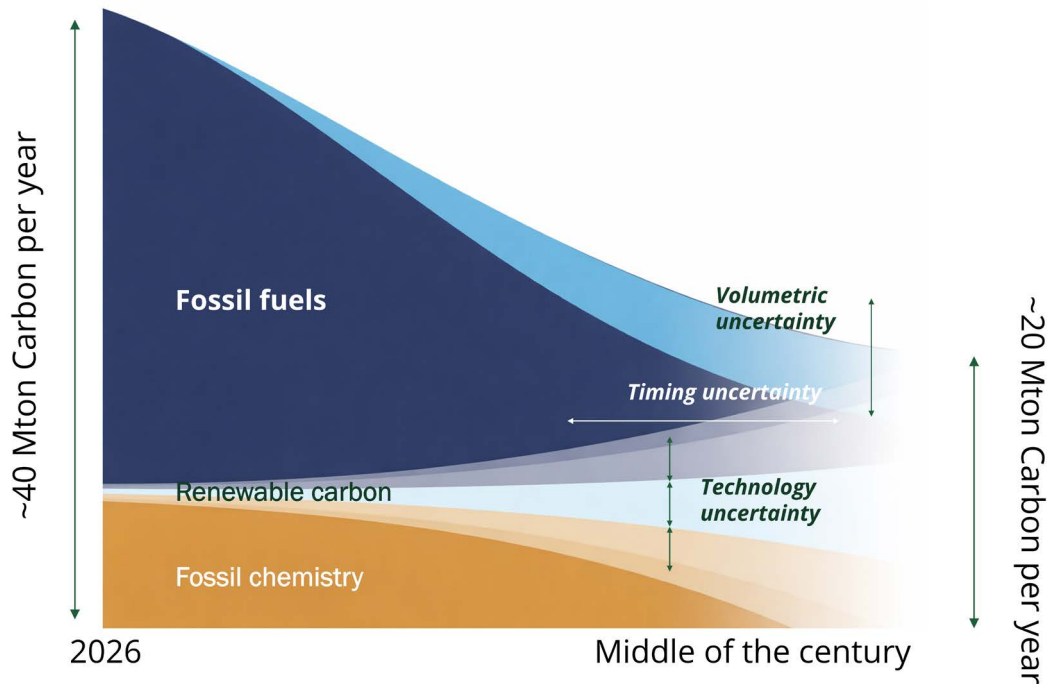
Figure 1 illustrates the expected future trends and uncertainties: demand for carbon-based products will decline significantly as electrification and alternative fuels take hold, but a residual of 15–20 Mton/yr carbon is expected to remain in the long run — and that part must come from renewable sources. This paper does not address that gap directly; it explores how to close it, based on industrial expertise and experience, with a realistic view of what can actually be developed.



### CRUDE OIL AND OIL PRODUCTS IN ROTTERDAM – SOME BACKGROUND TO THE NUMBERS

Rotterdam is the port with the largest number of refineries in Europe. Its liquid bulk throughput amounts to approximately 200 Mton/yr. Of this, roughly 100 Mton/yr is crude oil intake, of which approximately half is converted by the local refineries. The remaining half is transported by pipeline as crude to refineries in Vlissingen, Antwerp, and Germany. Of all crude oil imported into the EU-27 by sea, approximately 20% passes through Rotterdam, more than any other single port. Around 100 Mton/yr of oil products in throughput is a mix of locally refined output and imported products entering for storage, blending, and onward trading. The products are distributed to Germany, Belgium, and Switzerland as the dominant outlet, with secondary maritime flows to the UK and global markets. Roughly 80% of the Dutch domestic market is served from Rotterdam — approximately 35–40 Mton/yr covering transport fuels, industrial feedstocks, heating oil, maritime bunkering, and aviation fuel.

## Conversion volume Rotterdam HIC



**Figure 1:** *The future of carbon demand and conversion in The Netherlands<sup>2</sup>. 15-20 Mton/yr of Carbon is still required by 2050.*

The pressure to change is real and felt across the board. It is not just driven by the push towards a sustainable low emissions future. Strategic autonomy is at the heart of it as we depend on others for our carbon supply, now and in the future. This is a key vulnerability, and we need to find ways to stay in control of our own choices. The Draghi report placed it on the European agenda, and the Dutch action plan for industrial competitiveness presented by Peter Wennink in late 2025 formulated a national answer. Beyond competitiveness, climate targets are binding and geopolitical instability is deepening the case for autonomy further.

Strategic acceleration requires clear-eyed judgment about where things are heading. Urgency alone does not point to the right action, analysis can. Pragmatically defining the steps to take and in what order is exactly what this exploration sets out to do. The starting point is the realization that the ideal transition of the R-HIC does not exist.

Figure 1 makes the scale of this transition concrete. It shows the anticipated decline in need for carbon conversion in The Netherlands over the coming decades driven by electrification, alternative fuels, and shifting consumption patterns. The figure also shows key uncertainties: the timing of the decline, the volume that ultimately remains, the technologies that must fill the gap, and the balance between what we can produce domestically and what must come from imports. The distinction between fuels and chemicals is visible: fuel volumes decline, while chemical volumes persist. The figure does not give a precise answer, but it frames the size of the task: 15–20 Mton/yr carbon, from renewable sources, by 2050.

Systemic change involves many actors across the economy, such as project developers, infrastructure operators, regulators, financiers, and national government. None of whom can move this forward alone, and all need a shared direction to align. What we know clearly is what we do not want: CO<sub>2</sub> emissions, import dependency, industrial decline. What we lack is a shared positive vision of what we do want to build. Without that, even well-intentioned efforts pull in multiple directions, and the cumulative effect is a system that is hard to navigate and harder to move. And beneath all of this lies the most fundamental challenge: this is not a single project to be managed. It is a decades-long redesign of one of Europe's most complex industrial systems, while keeping it going throughout that period. A key factor in this transition is the role of governance. In our liberal democracy, the government is a factor that has often proven a source of uncertainty rather than stability. While this is understandable, it is incompatible with the transformation ahead and might ask for a different role for our multi-level governance system.

Working through these dimensions systematically is exactly what this exploration does. And in doing so, we find that the choices we face are not arbitrary, instead they follow an unavoidable logic. Systemic transformation of this magnitude is not something a bottom-up, market-led system will likely produce by itself. The first decision, what we want the transition of this cluster to look like, shapes every decision that follows. Who should take which decision is exactly what the next sections set out to uncover.

## Why Syngas?

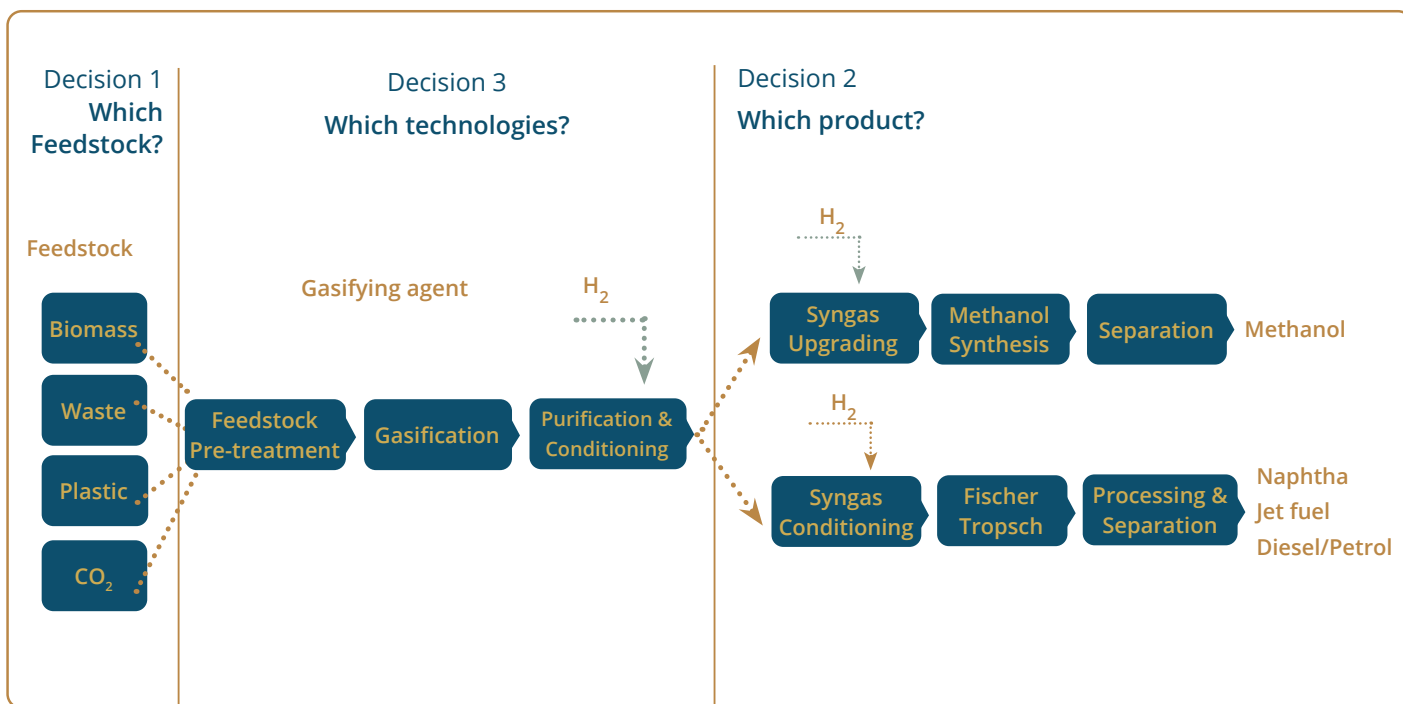
Closing a 15–20 Mton/yr carbon gap requires a conversion route capable of operating at scale — one that can handle the diversity of available feedstocks and serve the diversity of products the HIC supplies. This study focuses on syngas value chains as that route, for two reasons.

The first is focus. The Province of Zuid-Holland commissioned this exploration to understand what a specific, developable value chain could mean for the HIC, not to map every possible route. Syngas provides that focus without pretending to be the total answer. The final recommendation acknowledges this explicitly: syngas is crucial, but not the only route.

The second reason is strategic. Syngas, a mixture of hydrogen and carbon monoxide, is a uniquely flexible intermediate. Figure 2 shows that it can be produced from a wide range of carbon-rich feedstocks: waste, biomass, plastics, CO<sub>2</sub>. It can be converted into an equally wide range of products: methanol, synthetic fuels, and base chemicals. This flexibility is not just a technical property, it is a strategic one. A syngas-based system at scale can absorb feedstock uncertainty, serve multiple downstream markets, and integrate with hydrogen and carbon dioxide value chains as green hydrogen supply grows. It is able to act as a bridge between the carbon-rich inputs the HIC currently handles and the sustainable products it needs to supply in the future.

To assess these features of syngas value chains from renewable feedstocks, archetypical value chains were developed, showing the basic building blocks needed for a complete value chain from feedstocks to chemical products and fuels. Deliverable 1 includes a basic assessment of feedstock availabilities for the different routes explored.

The proposed role for syngas as a scalable platform for the R-HIC is not merely a theoretical exercise. Syngas has the proven capacity to operate at scale, albeit so far mostly based on fossil feedstocks. There is a long history of syngas in society, from city gas where coal gasification was used to provide light in the streets in the 19<sup>th</sup> century, to forming the basis of modern chemistry in early ammonia and chemicals production. Across the globe there are running syngas factories at multi-million tons per year scale today. It has proven to operate at scale in South-Africa, where Sasol has been producing fuels from coal for a long time, and in China where it is widely used to produce methanol from coal. In Qatar Shell's Pearl GTL project produces a range of fuels and lubricants from natural gas.



**Figure 2:** Archetypical syngas value chain from various carbon feedstock to methanol and hydrocarbons.

# B.

## Three Versions, Three Futures

 **KM3 | Planning for Large-Scale Development Gets Us in Control of Our Transformation**

 **KM4 | Version 2 and Version 3 Are Fundamentally Different in Character**

### The importance of scale

To understand how scale shapes outcome, three versions were constructed which each show a fundamentally different approach to building and scaling up a syngas value chain from today into the future. It is important to compare this to the baseline, no development at all, which is shown in Version 0. These versions form a development staircase and are described in detail in Deliverable 2.

**Version 0** is the absence of a syngas-based value chain. Under high uncertainty and lack of coordinated action, investments stall and decline kicks in. Without conditions for development there is just the contraction of the cluster. The Sustainable Industry Lab described this as the “wegklijn scenario”, a perishing industry. In Version 0, society will change, electrification progresses, fossil fuel consumption drops, but the conditions to support development of new industry and manage turndown are lacking. Facilities close in an uncontrolled way, giving shocks in supply that will be felt across Europe. Feedstock flows may reroute, but the strategic position that took decades to build erodes. Gunvor’s recent departure and the cancellation of Shell’s biofuels plant are early signals of this dynamic. Version 0 is the default and shows that not doing anything is not neutral. It is a choice not to act in a coherent and strategic manner. This paper focuses on the development path of the three versions and what it takes to build them. Version 0 is not elaborated on, but is shown as the reference against which every version is measured.

Version 1 (Circular Carbon Niche), Version 2 (Industrial Scale), and Version 3 (Renewable Carbon Megahub) are three fundamentally different approaches for developing a syngas value chain in the HIC. They are different in the size of their building blocks, the level of coordination, and their potential for reaching scale:

- **Version 1:** starts from single-feedstock gasification plants on an industrial plot, producing around 250 thousand tons of methanol per year (kton/yr). These plants can be co-located with a feedstock provider. It creates scale through a portfolio of independent projects across.

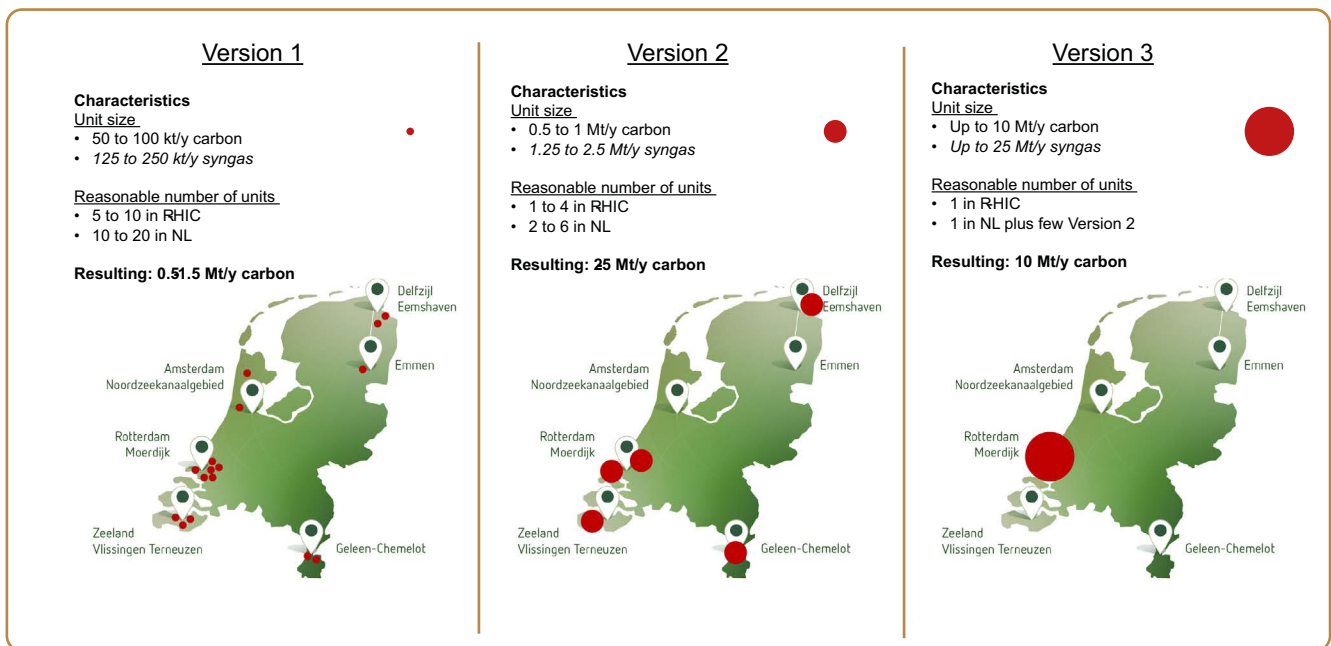
- **Version 2:** starts from refinery-scale integrated facilities processing around 1 million tons per year (1 Mton/yr) of carbon from biomass and waste and producing 2.2 Mton/yr of methanol or sustainable fuels. These projects require a coordinated hydrogen supply, have a large footprint, and will typically be governed through a joint venture structure between major industrial players and technology start-ups.
- **Version 3:** takes a cluster-wide approach in which small and large sites are built around a central syngas infrastructure network. Over the coming decades, it targets 10 Mton/yr of carbon and is able to produce 22 Mton/yr of methanol or hydrocarbon equivalents. The key is to create a new value chain by integrating sites across the R-HIC. This requires coordination at a cluster level under national supervision.

Figure 3 shows what each may look like at HIC scale.



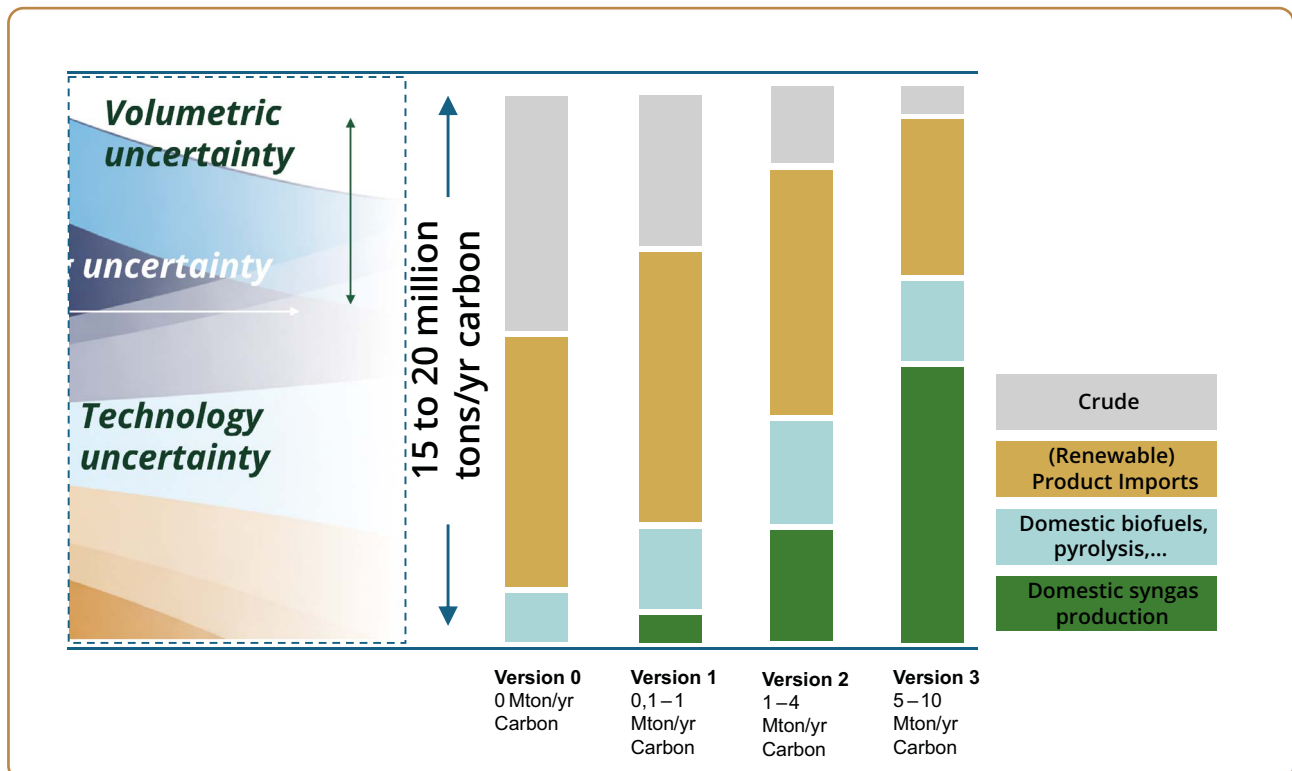
**Figure 3:** Impression of a Version 1 plot, a Version 2 site, and Version 3 cluster-wide ecosystem of distributed sites connected by syngas infrastructure, projected on the HIC.

For Version 1 to reach a million-ton per annum scale requires 10 to 20 individual projects mostly close to the R-HIC, but also across The Netherlands. Each of these will require its own plot, permits, and feedstock supplies. There are limits to how many can be placed in the R-HIC and how many can realistically be developed across the country, by need of space but also by need of safety and environmental requirements, which puts a ceiling on the number of appropriate sites across the country. Version 2 concentrates development into a small number of large integrated sites, no more than a handful across The Netherlands, each a major undertaking. Replicability is limited by available space and industrial conditions. Version 3 is different: there is one plan, spanning the entire HIC, with a ceiling set by the cluster itself and coordinating the allocation of available space. Figure 4 shows these replication limits and the production ranges they imply.



**Figure 4:** Replication potential and production ranges of Version 1, 2 and 3 across The Netherlands — from distributed small-scale projects to a single cluster-wide ecosystem in the HIC.

The ranges in Figure 4 are estimates based on physical and logistical limits of each version: how much feedstock is available, how many sites can realistically be developed, and how much space can the HIC accommodate. These scale estimates have consequences. Below the scale of Version 3 means accepting a lower domestic production and higher imports. The impact is estimated and presented in Figure 5.



**Figure 5:** Impression of the staircase build-up from Version 0 to Version 3 of domestic carbon supply with syngas, other biogenic routes and imports of renewable and residual fossil carbon.

Figure 5 presents a view on how total carbon supply to the Netherlands could develop in the different versions. It takes the feedstock transition study carried out for the Province of Zuid-Holland as a starting point for a version-specific assessment of how different strategic choices play out over time. Each version implies a different degree of syngas development and a different growth trajectory for alternative biogenic routes such as HVO and plastic pyrolysis. Both face their own scaling challenges and limitations. The result is a different balance between renewable imports and residual fossil crude. The extent to which imports can be renewable is highly uncertain and dependent on global supply growth that is outside our control. Figure 5 is not a forecast; it is an illustration of the possible consequences we face when choosing a specific version.

In summary, Version 0 includes no syngas development but a small basis of existing biodiesel production and growing demand for imports of (fossil based) products as conversion capacity in the R-HIC inevitably drops over time. In Version 1 domestic syngas supply develops but remains far below the scale needed, and dependency on product imports still grows. Version 2 and Version 3 both reach a scale that meaningfully grows domestic production of sustainable products and fuels, renewable feedstock imports grow, and residual fossil crude shrinks as a fraction of total supply. The difference between Version 2 and Version 3 is not whether they contribute substantially but how much headroom they create. Even at Version 3 scale, what we are building remains a significant but partial answer to a very large demand. That tension is not a reason to hesitate, it is a reason to be clear-eyed about what we are choosing, and why scale matters.

While Version 2 and Version 3 both reach meaningful scale, the question which to pursue does not end there. How they are built is as consequential as what they deliver. Version 2 is built through a small number of standalone mega-projects which deliver industry scale that must integrate with the existing cluster to ensure its stability as it continues to operate. Integration itself brings real continuity risks. Coordinating new construction with live operations is complex, and the stakes grow with every iteration. To reach HIC-wide scale, this sequence must be repeated three or four times with each consecutive project starting from less optimal conditions. This creaming curve is driven by more difficult sites resulting in higher cost and inevitable competition for feedstocks and demand with the other sites.

Version 3 starts off from a different premise. The cluster itself is the unit of development, not the individual plant. A central syngas infrastructure network connects distributed specialist sites, each optimized for one part of the value chain, like the Botlek steam network, where some parties supply steam and others are offtakers. As the transition includes reducing demand, a degree of closure is unavoidable. The real challenge is still how to best organize this re-development, but it creates the opportunity of utilizing the space made available from closing factories within existing refinery complexes. In a Version 3 transformation, these plots can be used to develop new assets as they only need a partial value chain and connection to the syngas infrastructure. This creates the opportunity to grow the syngas system organically, without forced disruption of entire sites. Every addition builds on the last, technology matures, and the cluster learns as it goes. A master plan guides this evolution from day one.

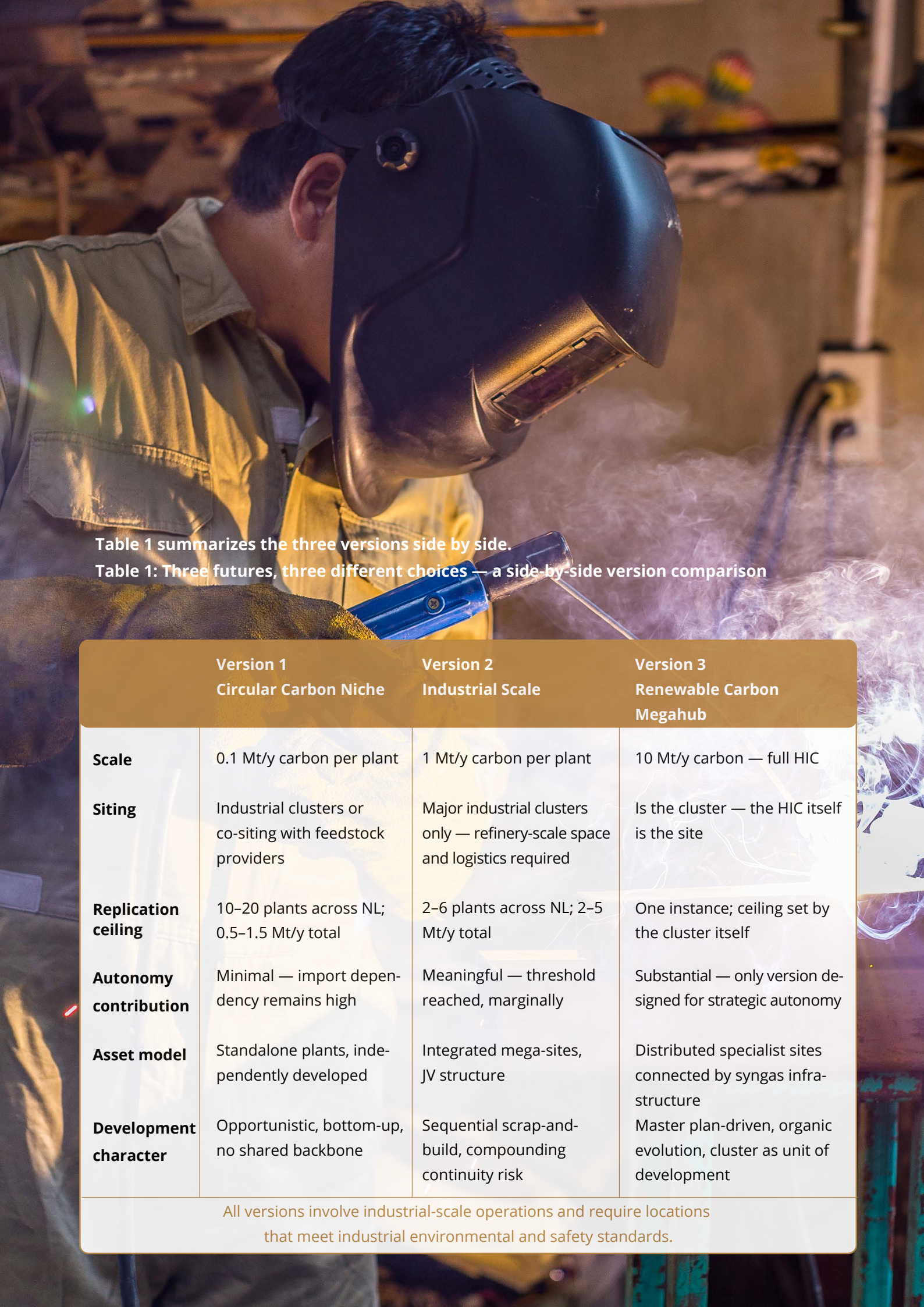


Table 1 summarizes the three versions side by side.  
 Table 1: Three futures, three different choices — a side-by-side version comparison

	Version 1 Circular Carbon Niche	Version 2 Industrial Scale	Version 3 Renewable Carbon Megahub
<b>Scale</b>	0.1 Mt/y carbon per plant	1 Mt/y carbon per plant	10 Mt/y carbon — full HIC
<b>Siting</b>	Industrial clusters or co-siting with feedstock providers	Major industrial clusters only — refinery-scale space and logistics required	Is the cluster — the HIC itself is the site
<b>Replication ceiling</b>	10–20 plants across NL; 0.5–1.5 Mt/y total	2–6 plants across NL; 2–5 Mt/y total	One instance; ceiling set by the cluster itself
<b>Autonomy contribution</b>	Minimal — import dependency remains high	Meaningful — threshold reached, marginally	Substantial — only version designed for strategic autonomy
<b>Asset model</b>	Standalone plants, independently developed	Integrated mega-sites, JV structure	Distributed specialist sites connected by syngas infrastructure
<b>Development character</b>	Opportunistic, bottom-up, no shared backbone	Sequential scrap-and-build, compounding continuity risk	Master plan-driven, organic evolution, cluster as unit of development

All versions involve industrial-scale operations and require locations that meet industrial environmental and safety standards.

# C.

## What It Takes to Get There

**KM5 | Increasing Scale Shifts Who Leads and Who Supports the Transformation**

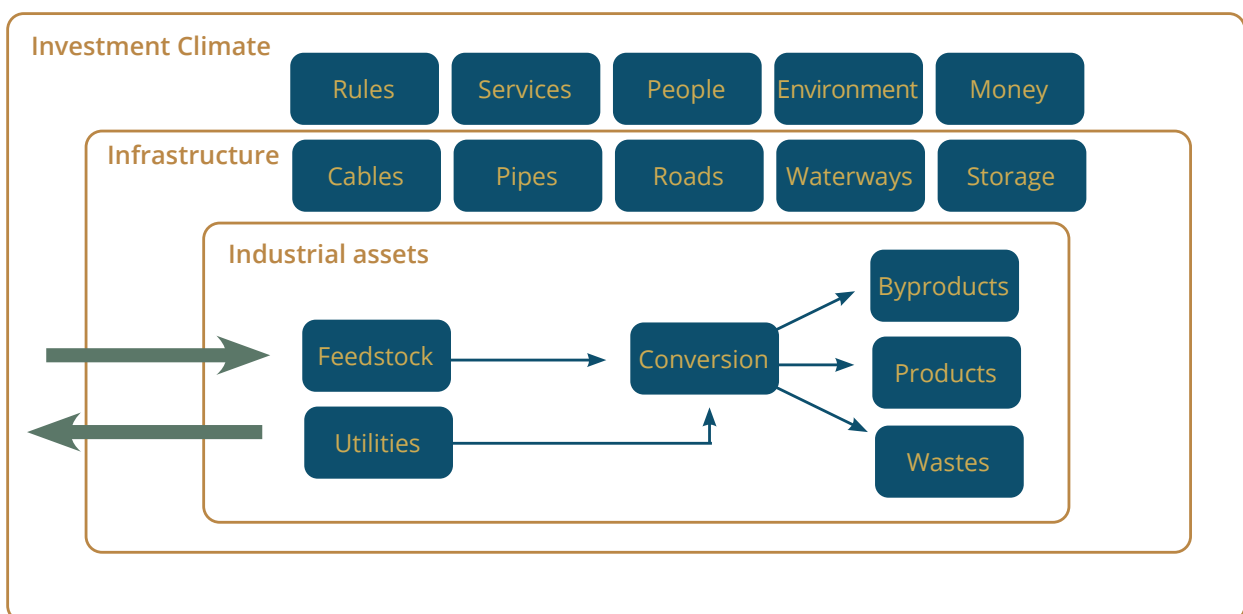
**KM6 | Version 3 Builds for Transition**

**KM7 | Stress-Testing Sharpens the Conclusion**

It is now clear that scale is a decisive variable which will require us to also move at scale. Things move when decisions get made in the right order, by the right people. That requires alignment across a landscape of stakeholders all fundamentally different in their role, their time horizon, and what they need to commit to. This section works through what that alignment demands — across three dimensions: who is in the lead to take the initiative, how will governance hold over the course of a decades-long transformation, and can the system withstand internal volatility and external pressures during that period and hence remain stable. This analysis is presented in more detail in Deliverable 4.

### Decisions in a multi-stakeholder jungle

The key to action, and to getting investments going, is rooted in understanding who the actors are that play a role in the development, and which decisions they need to take. For this purpose, we categorize the stakeholder landscape into three segments, schematically presented in figure 6.



**Figure 6:** Three key stakeholder domains – Assets, Infrastructure and Investment Climate.

## The three categories:

- **Industrial Assets** are the parties involved in developing, building, owning and operating the value chain assets, the factories converting feedstock to products, but also for utility assets such as waste processors, hydrogen producers, or even windfarms if we go fully upstream, and refineries and chemical plant operators downstream.
- **Infrastructure** operators own and manage the physical systems that make operations possible at scale: power, gas, hydrogen or CO<sub>2</sub> networks, logistics, storage, and waterways.
- **Investment Climate** is defined by the essential boundary conditions through local, regional, national and EU authorities. Together they form our multi-level governance system which sets out the rules and regulations that open up business opportunities and protect these against geopolitical stress. Beyond the governance system, the Investment Climate also includes access to capital providers, training, innovation and research institutions, and the networks that build lobbying power and public support.

For developments to move, all three domains must point roughly in the same direction to align decision making. A project developer building a gasification plant needs permits from authorities, subsidies and support from government, a convincing long-term business case for investors, and infrastructure available at the right scale, at the right time, at a cost that keeps the business viable. Each of these depends on actors in a different domain, and each domain moves at a different pace, responds to different incentives, and is accountable to different principals. Alignment between them is not automatically achieved, especially in a transforming system. This must be organized.

The current investment climate operates on governments that set the boundary conditions, and the market takes care of the rest. Assets get built by those who see opportunity, infrastructure follows demand, and regulation steers behavior towards societal goals. This works in a stable system but doesn't work when we must drive systemic change. It cannot, by design, produce coordinated and simultaneous transformation of an entire industrial cluster.

We tried to organize change through tailor-made bilateral agreements (maatwerkafspraken), but these got stuck as governments and companies in these bilateral negotiations needed to consider the value and risks associated in the rest of the changing value chain across assets, infrastructure and investment climate. Policymakers are now searching for a new approach at a cluster value level. The combination is more likely to succeed in combination with integration of the accelerators and blockers from across the three domains.

There are many policies in place to stimulate or enforce the transition. But often, policies coming from different regulators touch on the same domain or value chain with conflicting messages. These mixed signals create unclarity and uncertainty, making it difficult for project developers to move ahead, and often Version 0 is the outcome. The current system cannot coordinate a transformation at this scale without a fundamentally different approach to governance. This gap is recognized and proposals such as the Bold Ideas<sup>3</sup> report, the Rapport Wennink<sup>2</sup>, and the Special Economic Zone<sup>4</sup> for Rotterdam-Moerdijk aim to offer solutions.

Figure 7 shows how each of the three versions would move through the three key phases in project development (Initiation, feasibility and execution) are shaped, leading up to taking a Final Investment Decision (FID). This comparison shows that the versions differ fundamentally. Deliverable 4 includes more details on these project development roadmaps.



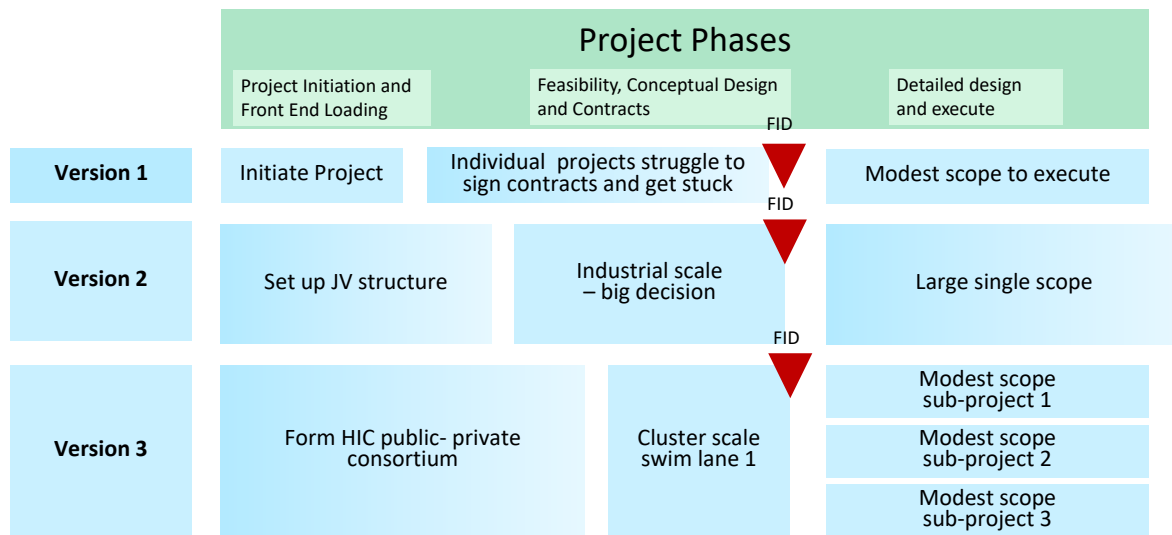
### **WHEN GOOD POLICY PRODUCES BAD OUTCOMES**

Reaching net-zero emissions by 2050 is the urgent, and broadly supported goal. The ETS was designed to get us there by putting a hard cap on emissions and tightening it year by year. The 2023 Fit for 55 reforms accelerated that from 2050 to 2039.

The physical reality of industrial transformation does not automatically follow these policy timelines. Building infrastructure, retraining workforces, and rebuilding value chains at the scale of clusters like the R-HIC takes decades, and if emissions cannot fall fast enough, shrinking ETS allowances against sustained demand will drive carbon prices to a spike that makes investment impossible, leaving closure the only remaining option.

On top of this, net-zero also requires sequestering large volumes of biogenic carbon permanently underground to compensate for unavoidable emissions. This pulls carbon away from the feedstock streams that circular and renewable value chains need.

The combined effect is a system under extreme tension. When that becomes visible, political pressure to relieve the 2039 deadline becomes inevitable, introducing a new round of uncertainty for anyone trying to make long-term investment decisions.



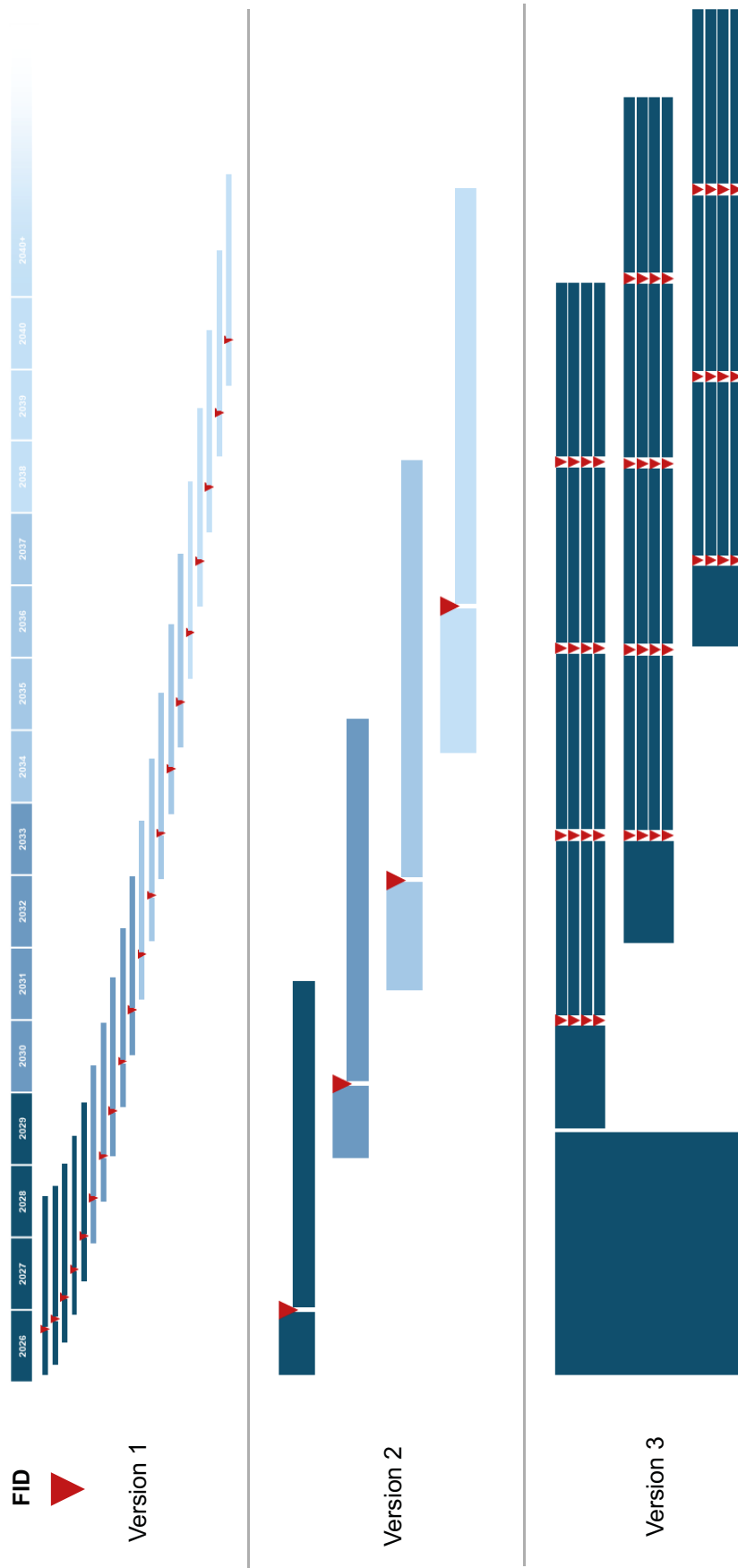
**Figure 7:** Sketch of project phasing for the three different versions, distinguishing start-up Front-end loading and feasibility phases leading up to FID and detailing and execution after FID.

In **Version 1**, development is driven by project developers who see a business opportunity. The project developer takes the initiative and designs, plans and executes the project. The path to FID aims to solidify the business case by sourcing feedstock, selecting product and technology, fixing a location, permits and infrastructure all pulled together in a FEED study, used to secure financing, offtake contracts, and more. This pre-FID phase takes three to five years during which changing circumstances will likely result in delays or disruption. Following the FID, the project is executed. Recent experience inside the HIC shows that even then changing circumstances can still create delays or even kill the project.

In **Version 2**, individual project decisions involve a much larger scope indicated in the diagram by a wider swim lane. The first phase of the project focuses on building a consortium, or joint venture, consisting of large and small industrial players that develop a much larger site. As these projects expand to refinery scale, their scope also grows in complexity requiring coordinated hydrogen supply, large spatial footprints, long-term offtake contracts, and alignment with one or more refineries in the HIC and across multiple infrastructure providers simultaneously. The JV formation takes substantial time, and the increased complexity requires time to assess feasibility and select a concept before taking FID. Support for the initiative with regional and national policy makers is secured upfront, and offtake contracts are easier to get as large industrial players can embed some of the fuel or product into their portfolio.

In **Version 3**, the logic inverts entirely. No project developer or JV can initiate this version; the national government must act first. And this structural governance renewal is probably the hardest part. The transformation of the entire HIC requires a mandate at cross-ministerial level, alignment with the EU, and a public-private consortium to coordinate space allocation, a diversified feedstock strategy, infrastructure planning, and market creation across the cluster.

Version 3 does not ask governments to support a market. It asks governments to create the conditions for a transformation the market alone will never produce. Without national leadership as the starting point, Version 3 will never get started. Preparation of plans is phased and managed through so-called swim lanes. Each swim lane aims to develop a full value chain at a pre-defined scale, securing alignment between parties who each carry out their task, to build together the first *minimal viable system*, limiting the scope and risks of each sub-project. Planning includes asset owners and infrastructure operators, who can commit once the framework is in place. Version 3 allows for a phased approach to investments, accelerating when possible while taking a step back when needed. The ultimate scale of Version 3 is difficult to predict but it would have the potential to grow to a size that is of a similar order of magnitude to the current R-HIC.



**Figure 8:** Schematic impression of the planning Gantt-charts of the three versions at total system level, showing their distinctly different characteristics. The green triangles indicate the moment individual projects take FID. Version 1 is a set of small projects building up over time, Version 2 is a limited set of large projects, and Version 3 a program with initial planning phase and systematic coordinated build-out.

## Reaching scale...

To reach scale, a portfolio of projects will have to be executed in a short time. Figure 8 schematically depicts such a pipeline of projects across the versions. **Version 1** consists of independent projects creating scale through a large set of similar kinds of projects. Each project manages its own scope, secures a plot and permits, hydrogen, feedstock and offtake contracts. The first project takes benefits from the best circumstances and all following project will find it more difficult to progress resulting in longer timelines and higher cost, indicated in the figure by longer timelines and fading colors.

In **Version 2** it is visualized that the preparatory phase expands compared to Version 1, and execution timelines also expand as the scope is significantly larger. Similar for the smaller Version 1 projects, the timelines are likely to become longer with successive projects as these Joint Ventures compete. With space limitations in the HIC and best places taken, each next project's chance of success declines.

**Version 3** deviates significantly from these two pathways. The extensive planning and stakeholder alignment in the beginning paves the way for a coordinated and aligned execution of large sets of projects with smaller scopes. This clearly asks for smart planning of infrastructure aligned with the asset level project portfolio. Once the first swim lane is being built, a second swim lane is initiated to expand and secure continuous development. With strong policy alignment to national and even EU level, the risk profile for long-term development in principle can be significantly reduced, securing progress and managing costs of the development.

## ...and building at scale

Building at scale introduces challenges that are version specific. They fall into two categories: front-end development and execution.

Development challenges center on project leadership and the interface with government. At this scale, every project requires active navigation of infrastructure planning, permitting procedures, and — where decisions are contested — the possibility of legal pressure. The executive branch of government becomes a primary counterpart, not an actor in the background.

Execution challenges are the practical consequences of building many large projects simultaneously. Process plants of this scale demand laydown areas, heavy transport logistics, and temporary engineering facilities on site. Sustained delivery requires a pipeline of specialized contractors, engineers, and tradespeople — resources that are scarce, cannot be easily scaled up, and will be competed for across projects.

In **Version 1**, each project manages its own development and construction independently. There are no shared logistics, no coordinated contractor planning. The aggregate demand across the group of projects running alongside each other competing in the same labor and equipment market is real but unmanaged at system level — cost pressure and scheduling friction are the inevitable result. Permitting authorities, grid operators, and infrastructure providers face many parallel,

uncoordinated demands. To ensure continuity and progress you would want to optimize operation. The lack of coordination means amongst others that companies compete for the same resources in a limited, constrained, offering (from financing, from contractors, for feedstocks and customers etc) that risks progress, while also the capacity to learn is fragmented across projects and not organized centrally, further reducing the opportunity to go forward fast. In Version 1 acceleration is only achieved by making all the individual segments as efficient as possible and especially by streamlining the authorities, making them fast, predictable, and accessible to all. Beyond that all projects are on their own.

In **Version 2**, execution concentrates on a small number of large projects and construction sites. The burden of development and execution concentrates as each project is a major undertaking with high execution complexity and a long development cycle. Getting Version 2 coordinated requires a lead developer with the mandate and capacity to drive a JV. It requires regional authorities actively securing space and stakeholder alignment. And it requires national government to provide long-term policy stability to this scale projects bankable. Without all three in place, the JV-scale development will be hard to materialize. Specialistic teams and equipment are largely the same from site to site, which makes sequencing rigid: the contractor ecosystem built for one site disperses before the next begins and must be reassembled at higher cost each time. Building single integrated sites on large plots requires dedicated space, which possibly requires demolition and clearance before the main site can be erected. With inclusion of cleaning the soil and preparing for building this may take much costly time. High stakes and an uncontrolled environment with high risks can make this kind of project fragile. At the same time, the stakes for society are high, risking that this kind of development becomes “too big to fail”, potentially risking the need for costly government bailouts.

In **Version 3** space for laydown of materials, equipment, and logistics are features of the master plan. Specialist capacity is contracted and the coordinated program justifies a deliberate build-up of a human ecosystem to support design and construction. International workforce training, housing, healthcare, and social infrastructure are prerequisites that can be planned for and funded as part of the program.

The scale of the investment is where the execution argument becomes an economic argument. Building the human and physical capability ecosystem needed to deliver Version 3 does not just serve the HIC — it rebuilds something The Netherlands has largely lost: the capacity to plan, finance, and execute industrial development at scale. The trained workforce, the contractor networks, the knowledge base, the governance model — these accumulate over decades of sustained construction and become assets in themselves. Other European clusters face the same challenge. Being first means being positioned to export not just sustainable fuels and feedstocks, but the capability to build the systems that produce them. The Netherlands is known for building dikes and waterways – the Deltawerken strengthened this expertise. A Version 3 transformation of the R-HIC has the potential to become the European reference for large-scale renewable carbon conversion as the logical consequence of choosing Version 3 and executing it well.

## Geopolitical Sensitivity Scan

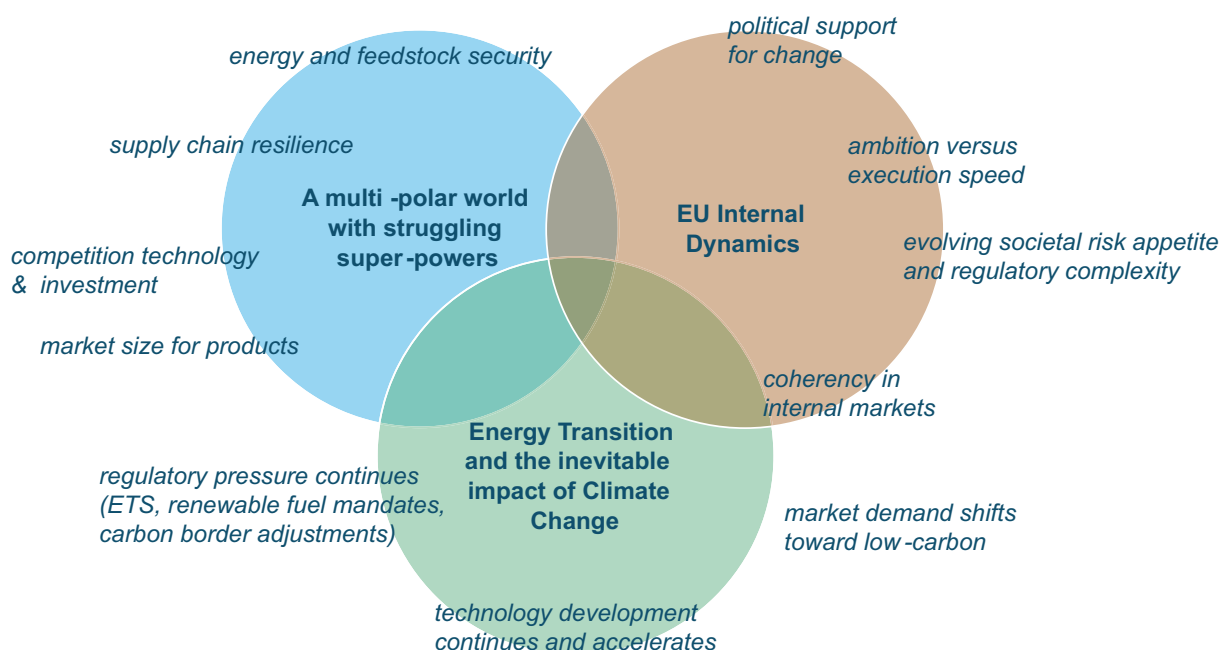
It is important to assess to what extent a version contributes to reaching our goals and ambitions together with the associated risks. In a complex setting such as the Rotterdam-HIC, there are many limitations to shaping large scale change especially in a short period of time. No-regret options and easy choices are hardly available in an integrated and connected system. Therefore, the approach taken is to identify the trade-offs and **minimize the maximum regret**. How do we keep the risks under control, and what benefits weigh against them?

To get a first impression of the robustness of each version under geopolitical uncertainty, an initial exploratory sensitivity scan was done. The analysis is shared in Deliverable 4. The versions are measured by a set of 5 KPIs for ambitions and 4 KPIs for risks, summarized in table 2 below.

**Table 2: Overview of Ambitions and risks for stress-testing the three different versions.**

	TYPE	DESCRIPTION
<b>Ambitions</b>  How do versions support reaching our R-HIC, national and EU ambitions?	<b>Climate Change - CO<sub>2</sub> emission reduction</b>	How much does the Version contribute to achieving CO <sub>2</sub> emission reduction? EU targets are 55% emission reduction in 2030 and effectively net-zero by 2040.
	<b>Circular Economy contribution</b>	How much does the Version contribute to achieving circularity of carbon-based products (chemicals, plastics, etc.)? Target 55% by 2035 and 100% in 2050.
	<b>Role of HIC in the Dutch Economy</b>	How much does the Version contribute to the economic development of R-HIC, the NLD economy and securing its position in the ARRR cluster?
	<b>Activity of process industries in the HIC (investments)</b>	How much does the Version contribute to the ongoing development of industrial activity in the Rotterdam HIC? Based on rough investment estimates.
	<b>Strategic autonomy</b>	How much does the Version contribute to strategic autonomy? (Reducing crude oil, increasing feedstock diversification, increasing feedstock sourcing hedge.
<b>Risk Themes</b>  What risk-exposure give the versions to R-HIC?	<b>Policy uncertainty / indecisiveness</b>	Conflicting and constantly changing policies with mixed signals are a prime risk for capital-intensive industry development.
	<b>Level playing field (global competition)</b>	Uncertainty of market position and ROI due to competition risks in immature markets. Risks of unfair competition with oil or state-supported dumping.
	<b>Transition system risk (continuity &amp; stability)</b>	Risks associated with systemic transformation of industrial cluster structure, large multi-party value chains, and (un)controlled turn-down.
	<b>Execution risk (permits, contractors, resources, space)</b>	Risk of pressure on large-scale building process (coordination, use of space, manpower, financial means, public support, supply of goods and services).

The performance and risks of each version are tested against the world they will be built in. Figure 9 shows the driving forces this world is shaped by: a **global multi-polar world with struggling superpowers**, the **accelerating energy transition**, and the **internal dynamics of the European Union**. Each of these forces acts differently and interacts in complex and uncertain ways outside our control. They strongly influence the performance of the HIC as a whole and the syngas value chains within it. As such they create both opportunities and constraints for industrial clusters. Analyzing these driving forces reveals **critical uncertainties and inevitable truths**. As a geopolitical sensitivity scan these three driving forces are applied to each version to identify their response against each force to reveal their potential long-term strengths and weaknesses.



**Figure 9:** External geopolitical driving forces that influence industrial development in the HIC.

The main outcome of this analysis is summarized in table 3. The table shows the highest value each Version can give, the risks associated with each, and a trade-off between those. As can be expected, the highest value comes with increasing scale. Larger investments are made, more product is produced and we come closer to our ambitions. But the risk profiles change as well.

Version 0 – no development – is a situation that needs to be **avoided at all costs**. It gives tremendous risks of uncontrolled turndown, making The Netherlands and Europe extremely vulnerable and product-import dependent.

With Version 1 we expect that up to 10 scattered isolated value chains of limited size can be deployed over time in or near the R-HIC. This might feel like a good start but ultimately does little to achieve our overall goals and increases the risk profile of the R-HIC, as it still implies **increasing long-term risks**, dependence on imports, and high susceptibility to wavering policies similar to Version 0.

Scaling up to **Version 2** brings us closer to our ambitions, but risks also increase disproportionately. Large greenfield sites that need to integrate with existing refineries result in exposure to continuity. This period of exposure can easily grow to 10-15 years per site taking into account demolition of the fossil site, build-up of the new circular facilities and integration with the wider system. A small number of large scale stand-alone projects also requires support against external and internal shocks creating a risk of these projects becoming **too big to fail**. Finally, the aggregated scale of a small number of Version 2 type sites is still much smaller than the current HIC increasing import dependency over the short to long-run.

**Version 3** brings a balanced long-term infrastructure-based coordinated approach to build out at full R-HIC scale. This balanced approach and long-term vision enables a phased turn-around of the hub, managing build-out and decline at the same time. This both brings us much closer to our goals, and at the same time manages risks increasing robustness against the external geopolitical but also internal driving forces. One crucial pre-condition for this version is **long-term leadership, support and commitment**.

**Table 3:** *Minimizing maximum regret – summary overview of the trade-off between value and risk for three versions (see Deliverable 4 for full analysis).*

RISK SCALE		
Low	Medium	High

	Version 0 — No Development	Version 1 — Circular Carbon Niche	Version 2 — Industrial Scale	Version 3 — Renewable Carbon Megahub
Highest Value	No value, no scaled circularity - only loss	Up to 10 isolated syngas value chains	Up to 4 new JVs create a significant step towards ambitions.	A balanced approach to reach goals and maintain a stable strategic R-HIC.
Largest Risk	Uncontrolled downturn, loss of stability and strategic market position	No long-term stable hydrocarbon supply, uncontrolled decline of industry	Still significant import dependence and long periods of transition with high risks.	Long transition requires sustained support and solid coordinating leadership.
Trade-offs between value and risk	Avoid it at all costs	Does not reach ambitions at high strategic and societal risks	Controlling downturn possible but may lead to 'too big to fail' dynamic.	Highest potential value when commitment and cluster wide coordination are in place

To close this section, table 4 summarizes what each version demands across governance, geopolitical resilience, and execution.

Table 4: What it takes to get there across governance, resilience and execution across versions

**Table 4:** *What it takes to get there — governance, resilience and execution across versions*

	<b>Version 1</b> <b>Circular Carbon Niche</b>	<b>Version 2</b> <b>Industrial Scale</b>	<b>Version 3</b> <b>Renewable Carbon Megahub</b>
<b>Who leads</b>	Project developers — entrepreneurial, bottom-up	Large industrial players and JVs — coordinated, capital-intensive	National government — cross-ministerial mandate required
<b>Governance requirement</b>	Fast, predictable, accessible permitting at volume	Long-term policy stability; regional space security; bankable JV conditions	Public-private consortium; cross-border ARRRR and EU alignment; national coordinator
<b>Support burden</b>	Diffuse but high — volume of parallel uncoordinated demands on authorities	Concentrated — fewer projects but each a major undertaking requiring full-stack alignment	Planned by design — burden is large but anticipated, coordinated, and manageable
<b>Geopolitical resilience</b>	Exposed — import dependency remains high; sustainability and strategic autonomy not achieved	High risk — meaningful scale but resilience under stress, replication limits constrain total volume	Robust — deliberate coordination, system integration, and scale designed for transformation and strategic autonomy
<b>Execution character</b>	Fragmented — each project its own construction bubble; aggregate resource competition unmanaged	Sequential mega-sites — rigid sequencing; contractor ecosystem disperses between builds	Permanent construction state — laydown, logistics and specialist capacity maintained continuously
<b>Workforce and capability</b>	No shared investment possible — each project too small	Episodic — capacity built per site, dispersed between projects	Sustained pipeline — training, housing, social infrastructure justified and planned at program level

# D.

## Wrapping It Up

 **KM8 | The Province of Zuid-Holland, the Mobilizing Force in the Middle**

### Bringing It Together

Rotterdam's role in oil markets is that of a strategic node: it imports crude, converts carbon at scale, provides storage and system flexibility, and enables arbitrage between crude and product markets to keep the hinterland supplied efficiently. It is the single largest carbon conversion hub in the region. Securing and maintaining this position is crucial to the Northwest European economy. Europe is the second export market globally, and we achieve this position due to our strong industrial manufacturing base, our high productivity and high degree of well-trained and educated workforce. Energy and feedstock security are the basis of this manufacturing industry and our global market position. The R-HIC carbon conversion hub is not a nice-to-have, it is a must!

Our goals are clear: reduce CO<sub>2</sub> emissions and build a circular economy at scale. For both goals syngas from circular and biogenic sources is crucial. It serves as the platform for carbon conversion and as the feedstock that can progressively replace fossil-based refining as the backbone of the HIC. That substitution must be managed as a stable, coordinated transition: one declines, the other growing, in step with each other and with the forces shaping the system from outside.

That kind of transition requires coordination, planning, and execution at a scale that matches the role of the R-HIC in the wider ARRRRA economy. It does not emerge by accumulation of smaller initiatives. Only Version 3 has that potential — it is the only path that can match the scale required while keeping the complexity of the transformation manageable.

The one ingredient it cannot do without is leadership: in vision, in coordination, and in the willingness to commit. That is why we say: Go Big or Go Home.

Go Big is the conclusion, but each version contains important lessons that can make Version 3 succeed. The three versions were polarized to sharpen the analysis but when we bring them together, what do they tell us about the way forward?

- **Building the Cornerstone Today** | Version 1 is where action is live right now. Innovators are taking risks, making miles in learning, proving the technology and the business case. This is essential, a critical puzzle piece of the transformation, but it only delivers real value when it is part of a bigger plan. Project developers deserve support, and finding their role as part of a bigger plan gives them the perspective to know what they are building toward.
- **Focus Corporate Action at Scale** | Version 2 is where the industrial system must answer a fundamental question about its own future. Oil majors and chemical industrials are essential. Planning, building and operating at scale is exactly what they do and those capabilities are irreplaceable if the transformation is to succeed. Each of them will need to define their role as part of the large plan and start building the bridge toward it. Those who see the challenge need to step up.
- **Direction from the Top** | Version 3 is where it all comes together, not from the bottom up, but from a top-down plan, requiring governance innovation. The government must learn to play its role in building the vision, setting the direction, coordinating the actions, creating the conditions, finding the right mix of market and guidance that fits our liberal economy. This does not start later. It starts today.

Each version contributes essential ingredients, it is our choice to bring them together and set out our path to a clean, sustainable and stable future on our own terms and conditions. This is what strategic autonomy is about, making the difficult choices when we want it rather than when they are forced upon us.

# Recommendations: Build a vision for transformation of the R-HIC – together!

We recommend that building **a solid long-term development masterplan together with the key stakeholders** is essential to unlocking progress at pace – *go slow in the beginning to go fast in the end!* We must come to terms with the complexity of transforming the R-HIC into the clean, circular, low-emission hub we need. The key learning from this study is that when we accept these complexities, and value the role of carbon conversion in the R-HIC as the key regional node in a global system, we need to learn to think, talk and act at the full scale of this cluster. The understanding lacks **how** to move forward together, coherently managing decline and growth at the same time in a hub that is already there and full. The story must be built; the insights must be shared. The recommended next steps are:



**Leadership from the institutional top:** Large scale developments need institutional leadership - drive consensus on the vision and development plan **with key governance stakeholders** (Ministries, Province, Municipality, Port Authority, Tennet and GasUnie, and EU representatives). Create the leadership needed, develop the coordination framework.



**Know where you come from:** Transforming the HIC starts with understanding today's baseline. A no-regret action is to **create an up-to-date coherent digital reference map** of the current port. What does the full set of energy and feedstock flows look like today? Which areas will likely be impacted by significant reductions in fossil conversion? How can these play a role in the required development of renewable carbon value chains? This is **the basis for going from vision to masterplan to action** and creates clarity on what we want and where we want it.



**Look at the complete picture, develop scaling pathways for all the ingredients:** syngas is a crucial piece of the puzzle to unlock circular carbon at scale, but it is not the only route to sustainable carbon. Laying this first piece of the puzzle makes it easier to develop:

1. similar archetypes for other sustainable carbon conversion value chains (like pyrolysis and HVO fuels),
2. the associated offshore wind and hydrogen value chains to create an integral vision of future carbon conversion aligned with an energy plan in the HIC, and
3. the other interacting value chains and infrastructure in the R-HIC (e.g. downstream materials and chemicals, the chlorine cluster, the use of land and water, the importance of logistics).



**Learn to think big, build the masterplan, make it concrete:** take the step to **design the ecosystem buildout** of Version 3 to FEL 0 level (Front End Loading, Identification phase – see “FEL explained”) identifying the developments needed along all three dimensions: Assets, Infrastructure and the supportive regulations in the Investment Climate.



**Build broad support:** start shaping for the masterplan through focused multi-stakeholder engagements. Build on the syngas value chain versions and their impact assessments. Investigate the balance between economic and societal benefits and trade-offs between higher-cost carbon products and regained strategic autonomy, circularity and sustainability.

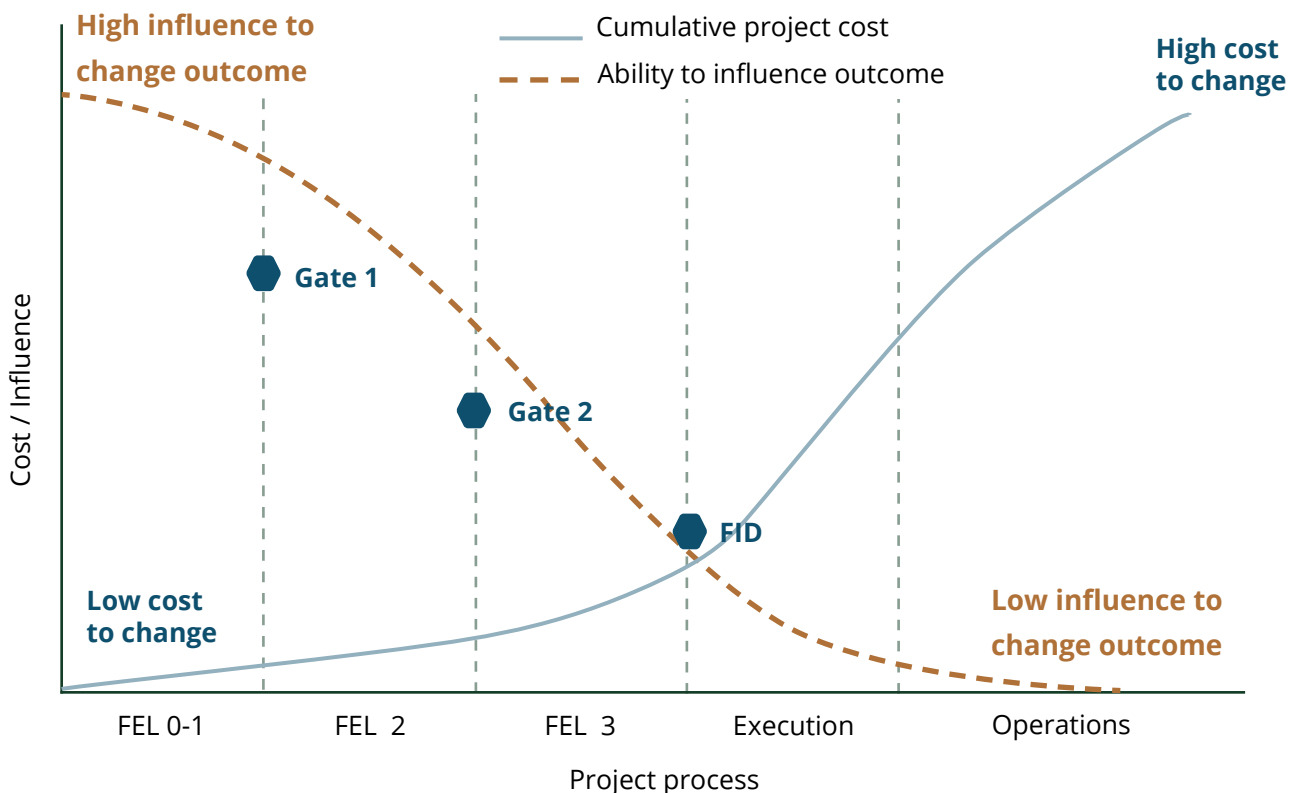


## FEL EXPLAINED

**Front End Loading (FEL)** is a structured project planning methodology used in capital-intensive industries. Figure 10 shows the project execution model, indicating the progressive definition of scope, cost, and schedule using a phased approach, leading stakeholders to address risks and commit additional resources at well-defined approval milestones. Each stage ends with a **gate review** — go, revise, or stop.

The term was coined by **DuPont** in the 1980s — the name is literal: you “load” the hard thinking onto the **front end** before construction commits the budget. In the 1990s it was formalized through benchmarking across thousands of capital projects, making it a de facto standard in oil & gas, petrochemicals, mining, and large infrastructure

- **FEL 0 – Conceptualization/Identification:** Is there an idea worth exploring?
- **FEL 1 – Feasibility:** Does this idea make business sense?
- **FEL 2 – Scope Development:** Which option are we pursuing, and what does it involve?
- **FEL 3 – FEED / Project Definition:** How exactly do we build it, and what will it cost?
- **FEL 4 – Execution:** Construction and commissioning begins.



**Figure 10:** Front-end loading visualized.

As FEL phasing progresses, costs go up and influence to change scope go down.

# Nederlandse samenvatting



# Management Samenvatting

Het doel is helder: duurzame, circulaire en strategisch autonome koolstofconversie op de schaal van het Rotterdamse Haven Industrieel Complex (R-HIC). Wat niet duidelijk is, is hoe we daar komen — de route van ambitie naar industriële realiteit is nog onontgonnen terrein. Syngas, of synthegas, is een elementaire chemische bouwsteen, een gasmengsel van koolmonoxide (CO) en waterstof (H<sub>2</sub>) dat kan functioneren als platform. Van oudsher wordt het gemaakt uit kolen of gas, maar het kan ook geproduceerd worden uit afval of biomassa. Op die manier kan het een sleutelrol spelen in schone koolstofconversie, als brug tussen diverse hernieuwbare grondstoffen die ruwe olie vervangen, en de producten en brandstoffen die we dagelijks gebruiken.

De verkenning hoe deze route een rol kan spelen in een toekomstig schoon en circulair Rotterdamse Haven Industrieel Complex is uitgevoerd in opdracht van de Provincie Zuid-Holland. Drie fundamenteel verschillende ontwikkelversies zijn geconstrueerd, elk gedefinieerd door een andere ontwikkelschaal: 100 duizend ton per jaar (100 kton/jr), 1 miljoen ton per jaar (1 Mton/jr) of 10 miljoen ton per jaar (10 Mton/jr) hernieuwbare koolstof. De keuze voor de schaalgrootte van ontwikkeling heeft consequenties, en het analyseren, en toetsen daarvan tegen geopolitieke krachten, laat zien dat omvang ertoe doet als we succesvol vooruit willen komen in onzekere tijden. De 8 kernboodschappen (Key Messages - **KM's**) hieronder vatten de bevindingen samen:

## A. DE SCHAAL VAN DE OPGAVE | PAGE 9

### **KM1 | Het HIC is het anker van Europese koolstofconversie**

Jaarlijks vloeien circa 200 Mton/jr koolstofhoudende materialen door het Rotterdamse Haven Industrieel Complex, hiervan wordt 50 Mton/jr verder verwerkt in het HIC zelf. Deze grootschalige verwerking van ruwe olie tot brandstoffen en chemicaliën maakt het HIC een essentieel knooppunt in Europa. Deze binnenlandse conversiecapaciteit geeft de regio een belangrijke mate van strategische autonomie. **Geen ander cluster in Europa kan deze rol realistisch overnemen op deze schaal en binnen de korte termijn die voor de energie- en circulaire transitie noodzakelijk is.** De komende decennia zal het verbruik van brandstoffen onvermijdelijk veranderen en is een transitie naar hernieuwbare en circulaire grondstoffen noodzakelijk; niet-duurzame koolstof is op

de lange termijn geen houdbare optie. De richting staat vast, maar de vraag is hoe snel en effectief we daar kunnen komen. De impact van een succesvolle transformatie binnen het belangrijkste raffinagecentrum van Europa reikt ver voorbij Rotterdam:

- Met het HIC als stabiele leverancier van duurzame brandstoffen en grondstoffen kan de maakindustrie in Duitsland en het bredere achterland blijven opereren en concurreren.
- Een concurrerende maakindustrie draagt de economische gezondheid van de ARRA-regio en de bredere Europese economie.
- Een stabiele Europese economie ondersteunt de politieke samenhang en veiligheid van de Unie.
- Nederland, diep verweven met en afhankelijk van dit systeem, profiteert direct wanneer dit goed gaat.

## **KM2 | De schaal die we nastreven bepaalt de stappen die we vandaag zetten**

Het R-HIC is een van de grootste industriële complexen van Europa, met vier grote raffinaderijen, een substantieel chemisch cluster en diepe integratie met lokale waterstof-, energie- en CO<sub>2</sub>-waardeketens. Elk serieus transitieplan moet hier beginnen: dit is de schaal van de opgave. Bepalen hoe dit cluster er in de toekomst uit moet zien is geen detail dat later uitgewerkt wordt — het is het vertrekpunt voor elke beslissing die volgt.

Focussen op de omvang van de opgave heeft systeembrede implicaties. Transformatie in het vereiste tempo, en op deze schaal, raakt actoren over de volle breedte van het systeem: van projectontwikkelaars, netbeheerders en toezichhouders tot financiers, vergunningverleners en meer. Deze actoren kunnen alleen gezamenlijk bewegen als ze weten waar ze naartoe bewegen. Zonder die gedeelde richting optimaliseert elke actor naar eigen doelstellingen, zonder helderheid over hoe of wanneer het R-HIC als geheel zijn doel kan bereiken. Met een gedeelde visie en een plan verandert de dynamiek: er ontstaat focus, het wordt mogelijk om keuzes te maken en vooruitgang wordt reëel.

## **B. DRIE VERSIES, DRIE TOEKOMSTEN** | PAGE 14

### **KM3 | Planning voor grootschalige ontwikkeling geeft ons controle over onze transformatie**

Om een plan te maken moeten er beslissingen genomen worden, en de keuze voor de schaal van ontwikkeling is daarbij cruciaal. Om te beoordelen hoe schaal de uitkomst beïnvloedt zijn drie fundamenteel verschillende waardeketenversies ontwikkeld: Versie 1 (Circulaire Koolstof Niche), Versie 2 (Industriële Schaal) en Versie 3 (Hernieuwbare Koolstof Megahub). In de analyse zijn deze versies tegenover elkaar gezet (gepolariseerd) om de verschillen die dit geeft bij het bouwen van deze versies zichtbaar te maken. Dit maakt het belang van de schaal van ontwikkeling op de keuze van het pad vooruit goed zichtbaar.

En het laat zien dat keuzes consequenties hebben. Een Versie 1-ontwikkeling leidt tot vroege actie maar maakt ons uiteindelijk importafhankelijk. Versie 2 en Versie 3 kosten tijd om te plannen maar leiden tot een schaal die past bij de huidige operaties in de haven, en die onze strategische autonomie kan helpen borgen en onze duurzaamheidsdoelen binnen handbereik brengt.

#### **KM4 | Versie 2 en Versie 3 zijn fundamenteel anders van karakter**

Versie 2 is opgebouwd uit een grote, centraal ontwikkelde industriële site die de schaal van een raffinaderij benadert en opereert als één geïntegreerd geheel. Het is een bekend ontwikkelmodel, uitgevoerd door grote industriële spelers of joint ventures, en het presteert op de schaal die we van zo'n site kennen. De uitdaging is dat Versie 2, om HIC-brede schaal te bereiken, meerdere malen gebouwd moet worden en dat slechts een beperkt aantal van zulke geïntegreerde locaties in het HIC past. Elke locatie vereist eigen ruimte en zal moeten integreren met een of meer bestaande raffinaderijen, wat aanzienlijke continuïteitsrisico's met zich meebrengt tijdens de transitie tussen sloop- en bouwfasen.

Versie 3 is wezenlijk anders. De kern is een syngas-infrastructuurnetwerk dat productie en gebruik van syngas ontkoppelt en verschillende operaties over het cluster integreert. Dit maakt organische evolutie van het systeem mogelijk die begint met een eerste ontwikkeling en in de loop der tijd groeit. Naarmate bestaande fabrieken door afname van de vraag naar olieproducten geleidelijk worden uitgefaseerd, worden nieuwe eenheden aan het ecosysteem toegevoegd. Deze nemen de plaats in van fabrieken die sluiten en zo wordt de ruimte die vrijkomt, ook binnen grote geïntegreerde sites zoals raffinaderijen, nuttig ingezet voor iedere volgende toevoeging. In plaats van één groot asset te bouwen, orkestreert Versie 3 de geleidelijke opbouw van een onderling verbonden ecosysteem dat integreert met omliggende waardeketens in waterstof, energie, CO<sub>2</sub> en chemicaliën. Het cluster wordt de eenheid van ontwikkeling, gecoördineerd vanaf het begin en incrementeel opgebouwd over decennia.

### C. WAT NODIG IS OM ER TE KOMEN | PAGE 19

#### **KM5 | Bij toenemende schaal verschuift de rol van wie leidt en wie ondersteunt**

De partij die het initiatief neemt verschilt fundamenteel tussen de drie versies. In Versie 1 zijn het de projectontwikkelaars die de ontwikkeling aanjagen op een ondernemende, gedistribueerde manier, van onderop. In Versie 2 nemen grote industriële spelers en joint ventures het voortouw bij het coördineren van grote, kapitaalintensieve ontwikkelingen die stabiele langetermijnbeleidsondersteuning vereisen. In Versie 3 moet de rijksoverheid richting geven om de systemische transformatie van het HIC te borgen. Dit creëert het mandaat dat nodig is om grensoverschrijdende afstemming met het ARRRRA-cluster en de Europese Commissie te borgen die transformatie op deze schaal vereist.

De last op het overheidsapparaat verschuift eveneens. Vergunningverlening, ruimtelijke ordening,

infrastructuurontwikkeling en handhaving vragen aandacht, ongeacht welke versie we nastreven. Het lijkt misschien tegenstrijdig, maar het ondersteunen van twintig verspreide kleine projecten bij Rotterdam en door het land vraagt waarschijnlijk evenveel, of meer, van autoriteiten, havens, gemeenten en provincie, als het coördineren van één grote nationale prioriteit. Het verschil is dat op Versie 3-schaal dit gepland en beheerst kan worden. Op de schaal van Versie 1 en Versie 2 blijft het grotendeels onbeheerd.

## **KM6 | Versie 3 bouwt voor transitie**

Het transformeren van het HIC is geen eenmalige gebeurtenis maar een decennialang proces van verandering, waarin het systeem moet blijven draaien. Imperfecties zijn onvermijdelijk en vragen om hybride operaties waarin oud en nieuw naast elkaar bestaan, timing-mismatches tussen het sluiten van bestaande en de ontwikkeling van nieuwe fabrieken worden beheerst, en beperkte middelen flexibiliteit vereisen. Versie 3 is hiervoor ontworpen. De syngas-leiding en clusterwijde coördinatie faciliteren gefaseerde ontwikkeling, waarbij vertragingen worden opgevangen en continuïteit behouden blijft.

Investerings kunnen gefaseerd worden naarmate het systeem zich uitbreidt, en vertragingen worden geabsorbeerd zonder dat assets stranden. En cruciaal: iedere toevoeging aan het ecosysteem bouwt voort op het voorgaande, terwijl technologie doorontwikkelt, de operatie beter begrepen wordt, en we in het cluster leren hoe we op schaal tegelijk ontwikkelen en integreren terwijl het evolueert.

Versie 3 zal niet snel perfect of volledig circulair zijn, maar het is de enige versie die ons stevig op het juiste pad zet.

## **KM7 | Stresstesten scherpt de conclusie aan**

Strategische autonomie is niet hetzelfde als volledige zelfvoorzienendheid, maar om onze toekomstige koolstofbehoefte veilig te stellen is eigen conversiecapaciteit en toegang tot gediversifieerde grondstofvoorziening noodzakelijk. Door de versies te toetsen aan de complexiteit van de uitvoering, en aan de onzekerheid van geopolitieke omstandigheden, krijgen we inzicht in hoe iedere versie ons dichterbij dit doel brengt. In een wereld van toenemende geopolitieke instabiliteit zijn weerbaarheid en strategische autonomie geen ambities — het zijn vereisten:

- **Versie 1** | binnenlandse productie dekt minder dan 10% van de toekomstige koolstofvraag; de rest moet worden geïmporteerd; strategische autonomie wordt niet bereikt
- **Versie 2** | bereikt betekenisvolle schaal maar beperkingen voor meerdere sites binnen het HIC begrenst het totale volume tot circa 20% van wat nodig is; ondersteunt strategische autonomie slechts marginaal

- **Versie 3** | ontworpen om substantiële strategische autonomie te creëren door een bewuste grondstofhiërarchie en systeemintegratie met binnenlandse offshore wind-, waterstof- en CCS-infrastructuur; richt zich op 50% van de koolstofvraag. De schaal en weerbaarheid maken het de enige versie die robuust genoeg is om geopolitieke druk te weerstaan en tegelijkertijd de transformatie vooruit te stuwten.

## **KM8** | **De Provincie Zuid-Holland, de mobiliserende kracht in het midden**

De provincie Zuid-Holland heeft grote belangen bij een langetermijnontwikkeling van het R-HIC en speelt daarin een strategische rol. Zij bestuurt onder andere ruimtelijke ordening, vergunningverlening en handhaving, waardoor zij een onvermijdelijke actor is in elke versie. De uitvoering zal op het bord van de provincie terechtkomen dus is het verstandig om het pad te vormen in plaats van erdoor gevormd te worden. De provincie heeft daarnaast een centrale rol binnen het meerlaagse bestuursstelsel tussen EU, Rijk, provincie, gemeente en havenbedrijf, en is uitstekend gepositioneerd om deze partijen op één lijn te brengen. Vanuit die positie activeert, verbindt en versnelt de provincie de belanghebbenden, en maakt zij van haar bestuurlijke positie een daadwerkelijk mobiliserende kracht.

De aanbevelingen voor vervolgstappen zijn:

- **Leiderschap vanuit de institutionele top:** grootschalige ontwikkelingen vragen institutioneel leiderschap — werk aan consensus over de visie en het ontwikkelplan van het R-HIC **met de essentiële institutionele partijen en staatsdeelnemingen**.
- **Ken je vertrekpunt:** maak een actuele, samenhangende digitale referentiekaart van de huidige havensites en energiestromen om van visie naar masterplan naar actie te komen.
- **Kijk naar het complete beeld:** syngas is een cruciaal puzzelstuk en een belangrijk systeemelement, maar niet het enige. Verken hoe **alle essentiële elementen** opgeschaald moeten worden en ontwikkel hun **transitieladder** op dezelfde manier.
- **Leer groot te denken:** ontwikkel het masterplan, maak het concreet, **ontwerp** Versie 3.

**Bouw breed draagvlak:** begin met het vormen van draagvlak voor het masterplan door gerichte bijeenkomsten met belanghebbenden.



# Appendices

## Syngas Value Chain in Rotterdam HIC

All project information can be found here:  
[industrys-drawing-room.com/syngas-rotterdam](https://industrys-drawing-room.com/syngas-rotterdam)

The deliverables that support this research are appendices to this report and can be downloaded at the project webpage.

1. Deliverable 1: Archetype value chain
2. Deliverable 2: Syngas Staircase
3. Deliverable 3: Staircase assessment by external stakeholders
4. Deliverable 4: Decision-based Roadmap

# References | footnotes

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# Colophon

**Title:** Syngas value chains in the Rotterdam Harbor Industrial Cluster –  
Go Big or Go Home? The importance of scale on our way to strategic autonomy

**Publication date:** 16 april 2026

**Authors:** Andreas ten Cate, Tijs Beek

**Assignment:** This document is a deliverable of the project “Ontwikkeling Synthesegasketen HIC”, assigned by Provincie Zuid Holland, registered under number PNR20085654. The project is carried out by Tekenkamer van de Industrie and Sproule ERCE. The project ran from October 2025 to March 2026.

**Project execution:** This project was carried out in a joint effort by Tekenkamer van de Industrie and Sproule ERCE



**Layout & Design:** Designmix

**Cover image:** Generated using OpenAI ChatGPT (DALL-E)

**AI-assistance:** Interview transcriptions were processed using Fireflies.ai. Anthropic Claude was used to assist in the analysis and processing of interview transcripts. All AI-generated outputs were reviewed and edited by the authors.

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**Acknowledgement:** The authors kindly extend their gratitude for the support and good partnership with the Province of Zuid Holland. The research was done with the active participation of many stakeholders who voluntarily shared their time and expertise during the project, we are very grateful for their support and time. An overview of consulted stakeholders and parties is shared in Deliverable 3.

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**Suggested citation:** Ten Cate, A. & Beek, T. (2026). Syngas value chains in the Rotterdam Harbor Industrial Cluster – Go Big or Go Home? The importance of scale on our way to strategic autonomy. Tekenkamer van de Industrie / Sproule ERCE, commissioned by Provincie Zuid-Holland. Available at: [industrys-drawing-room.com/syngas-rotterdam](https://industrys-drawing-room.com/syngas-rotterdam)



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