BRIEFING NOTE
June (No. 2023/02)

LARGE EMITTING ASSET DECARBONISATION STUDY METHOD:

Demonstrated in the case of the south African petrochemicals value chain

Authored by Emily Tyler, Brett Cohen and Lonwabo Mgoduso

1 INTRODUCTION

In 2022/23, Meridian Economics undertook a project to better understand the decarbonisation options available to the high emitting coal-to-liquid assets of Secunda and Sasolburg in South Africa. A key objective of the project was to experiment with methodology for decarbonisation analysis.

In our Briefing Note 'Analytical requirements to support decision making and implementation of just decarbonisation in South Africa' (Meridian Economics, 2022a), we observe that the majority of analysis in this space focuses on techno-economic, continuous and near-linear pathways to 2050, and that additional conceptual views, knowledges and ways of integrating these will be important for deepening our understanding of the complexity and uncertainty of the just decarbonisation challenge. The method developed for the Secunda and Sasolburg project was borne from this observation.

Although demonstrated through a particular case study, the method was intended as replicable to other high emitting assets in South Africa and in other jurisdictions.

2 OBJECTIVES

The methodology is aimed at enhancing an understanding of large emitting assets in their highly interconnected contexts, in order to promote optimal decision-making and governance of these assets in the public interest.

It is anticipated that the outcomes of the project can be used for guiding policy, strategy development and implementation.

3 THINKING ORIGINS

The method followed in this project is grounded in three closely related thinking traditions:

- Complex systems thinking
- Multi-criteria analysis
- Scenario planning

Taken together, these approaches allow for the inclusion of stakeholder perspectives; systematic consideration of multiple dimensions of the decarbonisation challenge; and active engagement with uncertainty, complexity, and long-term systemic challenges.

Complex systems thinking foregrounds 1) the relationships between units rather than units themselves (moving away from a siloed / sectoral approach), 2) that uncertainty is a central feature of the evolution of complex systems, rather than an afterthought, and 3) that exploring different perspectives on a problem affords valuable insights and opportunities.

Multi-criteria analysis offers various approaches to problem structuring and analysis. Such approaches have been developed with the purpose of taking systemic approaches to options analysis that are more holistic, creative, replicable and defensible, and have buy-in from a wide range of stakeholders.

In the **scenario planning** tradition, narrative scenarios are often developed to complement the analysis and outputs of a quantitative modelling framework. Scenario planning allows for simultaneous consideration of quantitative and qualitative elements towards identifying enabling conditions, options and decision points which are relevant and robust to different futures.

> Guided by these thought-traditions, understanding the challenge of decarbonizing Secunda, Sasolburg and their value chains can be characterized as follows:
>
> Secunda and Sasolburg are deeply embedded in the socio-economic system of which they are a part. Together with their upstream and downstream value chains they can be thought of as a **complex system.**

Complex systems have particular characteristics. Their evolution is non-linear and path dependent. The starting characteristics of the system both constrain and enable the pattern of systemic evolution. Decisions made by actors at points in time, including in the value chains, will lock in or lock out future action and outcomes. There will be tipping points in markets, societies, politics and the environment along the way which will impact (constrain and create) future options. Understanding these complex interconnections is critical for good decision making.

Different constituents have **different perspectives** on the decarbonisation challenge, and different conversations happen within different constituencies, using different languages and concepts – all of which are relevant to meeting the challenge.

Furthermore, there is value in considering **knowledge from different societal dimensions**, such as political, environmental, social, technological, economic, and legal (referred to hereafter as “PESTEL”) to better understand how the complex system may evolve. An integrated and transparent framework for considering different perspectives and knowledges with equal weighting provides the opportunity to engage the problem in a more holistic and comprehensive way, as compared to that offered by traditional techno-economic models which tend to abstract from drivers of real-world complexity.

The future, in particular one as rapidly evolving as is that being driven by the urgency of decarbonisation, is highly uncertain. **Uncertainty considerations**, and building resilience in the face of uncertainty, must be central to systemic decarbonisation analysis.

4 CORE METHOD TERMINOLOGY

This section provides working definitions for key terms central to the methodology:

High emitting assets: Physical techno-economic assets that represent point sources of emissions that contribute materially to South Africa’s national greenhouse gas inventory. These are placed at the centre of the study’s focus.

Value chains: Activities that are techno-economically linked to the high emitting assets. These can be further characterised as upstream and downstream, relative to how they are situated to the high emitting assets.

Complex system: The emitting assets plus their value chains comprise the 'complex system' of the study. A complex system is an open system, where the implications of a change in one of the system components for the remainder of the system cannot be pre-determined, and the system under study is not isolated from the broader environment in which it is located.

Decarbonisation route: A detailed qualitative and, where relevant, quantitative description of the changes to the high-emitting assets and their value chains between now and 2050 that conform to a particular degree of decarbonisation ambition. The route is a projection, an example of a possible pathway forward for the assets and value chains.

5 METHOD STEPS

The method comprises seven main steps:

1. Identification of the emitting assets relevant to the study, and their value chains – the 'complex system'
2. Definition of the extent of decarbonization ambition appropriate to the study, including identification and interrogation of the decarbonization modelling studies that assist in understanding the extent of decarbonatization required.
3. Mapping of stakeholders that will be impacted by decarbonisation of the high emitting assets and value chains, and identifying a prioritised sub-set of stakeholders to engage in the study.
4. Engaging representative stakeholders in focus groups (e.g. civil society; business; government) to capture PESTEL dimensions of the complex system's decarbonisation from each grouping's perspective.
5. A PESTEL analysis, detailing the implications of the complex system's decarbonisation under each of the PESTEL dimensions, drawing from the stakeholder engagements together with literature,.
6. Extracting and synthesizing key insights for decision-makers.
7. Communication with attention to the logic of equating knowledges and perspectives, and rendering complex information accessible.

STEP 1: DEFINITION OF THE STUDY FOCUS

A high emitting asset is defined as follows for the purposes of this methodology:

- A source of emissions with long lasting physical and economic characteristics.
- Systemically significant, including in emissions and economically (central to both supply and demand in its value chain).
- Subject to a central point of control (rendering it a complicated system as opposed to an open, complex system; a single economic agent).

For the South African project, we chose to focus on assets in the petrochemicals sector, because they:

- Are less well understood in terms of their systemic interactions and options in the current policy / decision discourse.
- Lend themselves to analysis and method demonstration, and have sufficient data available for meaningful conclusions to be drawn.
- Are a priority for policymakers.

Similar contextual factors will likely determine the area of focus in other jurisdictions.

To refine the asset set, the following criteria were applied to the assets in the sector:

1. Centrality – how important is the role the asset plays in both supply and demand in its value chains?
2. Interlinkages – what is the extent of technical interlinkages with other significant assets in the sector, in terms of material and energy flows?
3. Greenhouse gas (GHG) emissions – how material is the asset's contribution to (South Africa's) national GHG inventory?
4. Lifetime – what are current expectations of the future economic lifetime of the asset?
5. Governance – to what extent is the asset subject to one central point of control?
6. Fossil fuel dependence – to what extent are fossil fuels are used for both feedstock and energy inputs?

Activities that are techno-economically linked to the identified assets were then mapped as a value chain, with both upstream and downstream components. Given the focus on the asset's decarbonisation, both the fossil intensive and decarbonised attributes of this value chain are mapped.

In the South African project, the asset identification analysis was captured in the following matrix (see Table 1 below) using traffic light colours to indicate 'yes – maybe – no'. Sasol's Secunda and Sasolburg assets emerged as warranting focus in the study, with the company's joint-owned Natref facility a close runner-up. Natref was therefore considered more peripherally in the analysis.

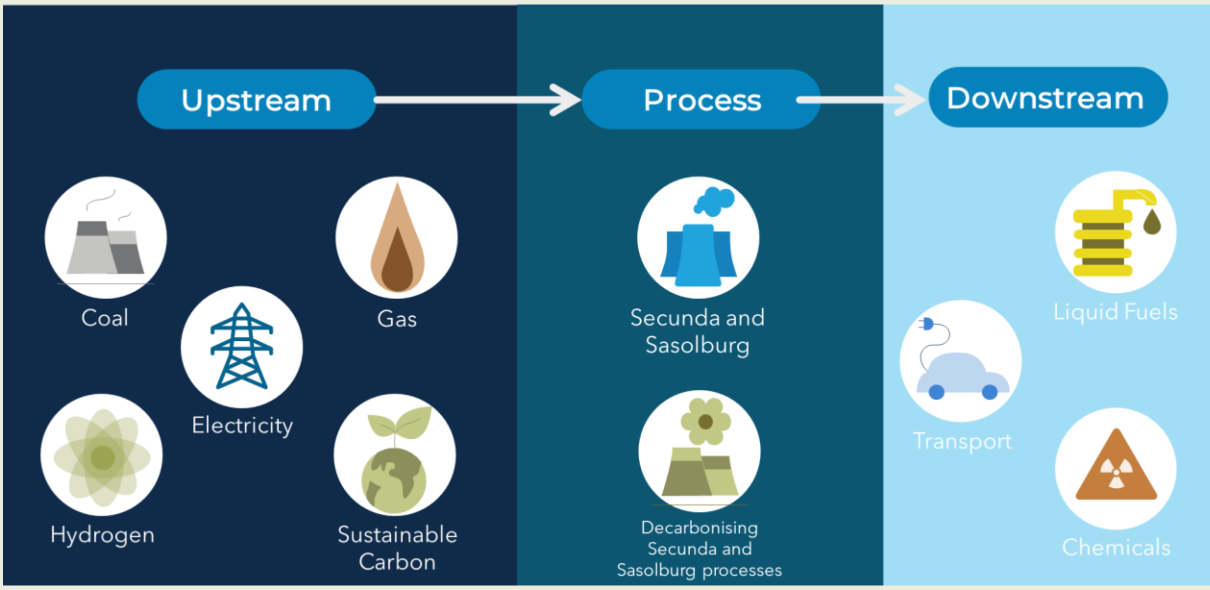
The reason crude oil refineries and PetroSA's facility were not included as key assets is that: they are low emissions contributors relative to Sasol's operations; many are likely to be retired in the very near future; and they are not subject to the central point of control.

Table 1: Screening for key assets

Screening criteria	Secunda	Sasolburg	Natref	Crude refineries	PetroSA
Centrality					
Interlinkages					
Relative GHG emissions					
Lifetime					
Governance					
Fossil dependence					

The different value chain components for South Africa's Petrochemicals value chain are presented in Figure 1 below.

Figure 1: Secunda, Sasolburg and their value chain



Project resourcing (budget and time) ultimately determines the breadth and depth of the analysis, and containing the scope was a constant challenge in the project. The following criteria / principles / questions can be used to guide decision-making on which of the value chain components to subject to more detailed analysis:

- Does it influence a tipping / bifurcation point relating to the asset's performance?
- Does it materially undermine the coherence of a decarbonisation pathway identified by the modelling studies?

- Might it trigger a tipping point in another upstream or downstream subsystem?
- Does it emerge as important from the stakeholder analysis?

STEP 2: DEFINING DECARBONISATION AMBITION

The political process of agreeing and apportioning decarbonisation efforts is a work in progress at both the international and national levels, and the definition of decarbonisation ambition is therefore dependent on the context in which the assets being studied are located.

The Paris Agreement temperature goal requires translation into global greenhouse gas emissions reduction targets. The total volume of remaining greenhouse gas emissions that can be emitted into the atmosphere while containing global temperature rise (termed the global "carbon budget") is projected by complex climate models and is subject to **high levels of uncertainty**.

When trying to understand what Paris Alignment means for a region, country, sector or, in the case of this project, the Secunda and Sasolburg facilities and their value chains, this uncertainty is further compounded (Meridian Economics, 2022b). The first key contributor to this additional uncertainty links to the politics involved in dividing up the budget between states at different levels of development, who come from different starting points, and have different **historical responsibilities for the stock of emissions already in the atmosphere**. The second arises in trying to establish the proportion of the global and national effort, once established, that the facilities and their value chains will need to take.

With decarbonisation, the journey is as important as the end point. Greenhouse gas emissions are cumulative in the atmosphere, and so the total quantity of emissions over time is important. Slow and partial decarbonisation over a century would have very different implications to rapid and total decarbonisation over a decade.

There is also a spatial element. Climate change is a global problem. The impacts of greenhouse gases are not linked to where they are emitted – nor are their impacts uniformly experienced. Often those least responsible for emissions are most adversely affected by climate change. At the same time, very rapid decarbonisation can have adverse economic and social impacts as our systems transition. Finding the balance between the pace of transition in different locations and sectors, and managing and adapting to the negative impacts of climate change, has to be grappled with at a global level.

Global political decarbonisation signals - together with those from climate science and analysis - are further translated through markets, organisations, technologies and behaviours. This translation may increase or decrease the pace and extent of decarbonisation at particular points over time. Markets work in non-linear ways, bringing in the potential for to rapidly 'tip', potentially accelerating decarbonisation.

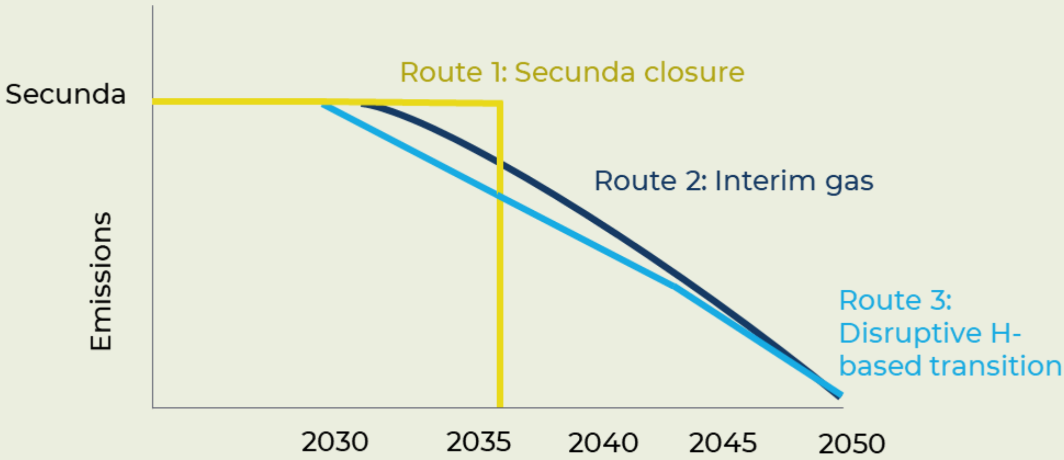
In South Africa, the process to apportion sector, emitter or activity level effort is just beginning. There have, however, been a selection of techno-economic modelling studies which offer a key contribution to the political process of apportioning decarbonisation effort, for guiding the future direction of travel, and for evaluating progress towards achieving decarbonisation goals.

Given the absence of a mandated level of effort being placed on individual emitters, this project takes as a departure point that the decarbonisation goal for Secunda, Sasolburg and associated value chains will need to at least be aligned with the Paris Agreement.

To provide some indication of what this "Paris-alignment" could imply quantitatively for the facilities and their value chains, the project interrogates two of the most comprehensive and credible modelling analyses in South Africa. It also draws on Sasol's own decarbonisation communications to help understand decarbonisation opportunities and plans for Secunda and Sasolburg. Whilst Sasol's communications are from a corporate as opposed to national policy perspective, they contain valuable insights into what decarbonisation might technically be possible over time.

The modelling studies were used to identify stylised decarbonisation routes for Sasol's Secunda facility, which are illustrated in **Error! Reference source not found.**[1].

Figure 2: Decarbonisation pathways in existing modelling analyses



The three stylized decarbonisation routes for Secunda can be described as follows:

- Route 1: Overall closure of the Secunda facility over a 1-2 year period. This could occur in the early to mid-2030s depending on the drivers for closure.
- Route 2: Utilisation of natural gas instead of coal as both an interim feedstock and interim energy carrier, to reduce emissions whilst economic supplies of green hydrogen and sustainable carbon feedstocks are secured at scale.
- Route 3: Direct transition from using coal as feedstock to using green hydrogen and a sustainable source of carbon as feedstocks. This route would avoid any potential lock-in to gas infrastructure as per Route 2.

In addition to the identification of high-level stylised decarbonisation routes, the modelling studies also provided quantitative information on the transition paths of the value chains, which provide a sense of the scale of the decarbonisation challenge in each area.

[1] Given that the future of Sasolburg is heavily dependent on Secunda, and its modelling treatment unclear from the modelling reports (chemicals were not modelled in detail by either study), the focus of the graphic is Secunda, with potential implications for Sasolburg described in the following text.

STEP 3: STAKEHOLDER MAPPING

A stakeholder mapping exercise was undertaken to understand and describe all the stakeholders that may be implicated by the decarbonisation of the assets and their value chains.

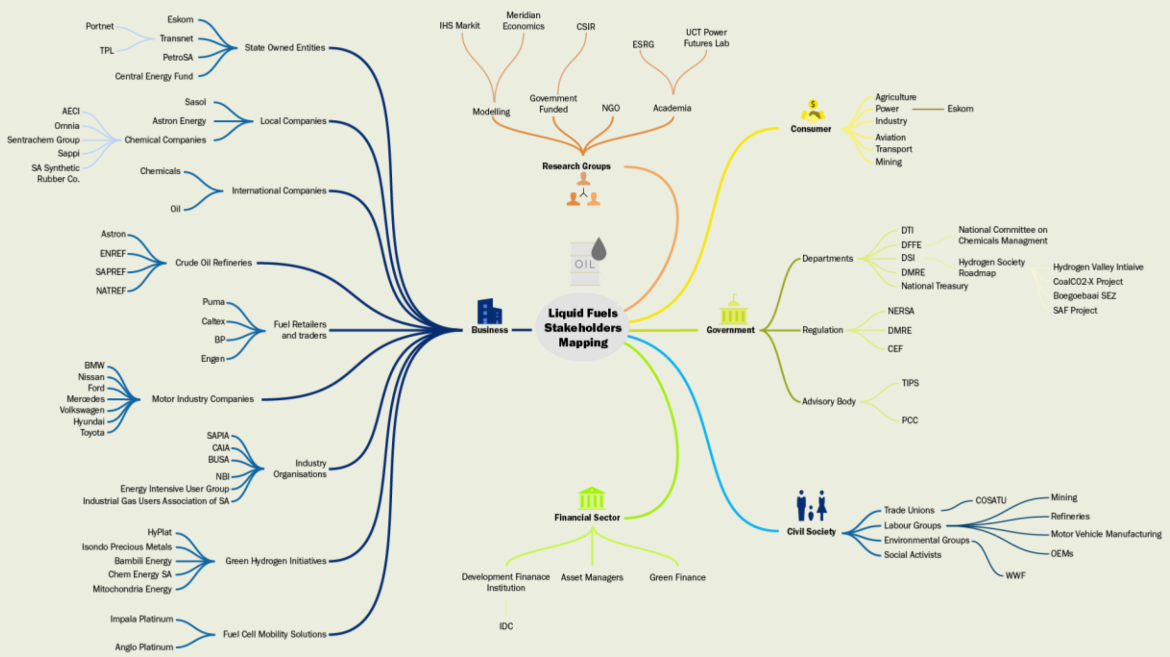
From this grouping we reached out to specific representative stakeholder groups for focus group engagement. These were chosen according to the following criteria:

1) Stakeholders who are critical to successful decarbonisation.
2) Vulnerable stakeholders with unacceptable levels of potential negative future impacts.
3) Accessibility given the time and resource constraints of the project.

Consideration should also be given to the spatial distribution of stakeholders as far as possible.

The South African stakeholder map is represented below, showing the extent of this initial exercise.

Figure 3: Key Liquid Fuels Stakeholders Map



The constituent groups engaged with in the project were as follows:

- Civil Society, with a focus on just transition and the environment.
- Labour, with an interest in worker rights in the transition.
- Grassroots, representing underprivileged communities in the vicinity of large emitting facilities.
- Government, with a focus on national government.
- Business, who have an interest in existing and future evolution of the space.
- Asset Management, who are responsible for directing investment flows and managing investor risks associated with the transition.

STEP 4: STAKEHOLDER ENGAGEMENTS

A series of engagements was held with constituents with an interest in Sasol's operations and the linked value chains. The groupings of stakeholders were determined based on their involvement in specific areas of the value chain. In some of the constituent groupings, more than one engagement was held to capture a more diverse set of perspectives.

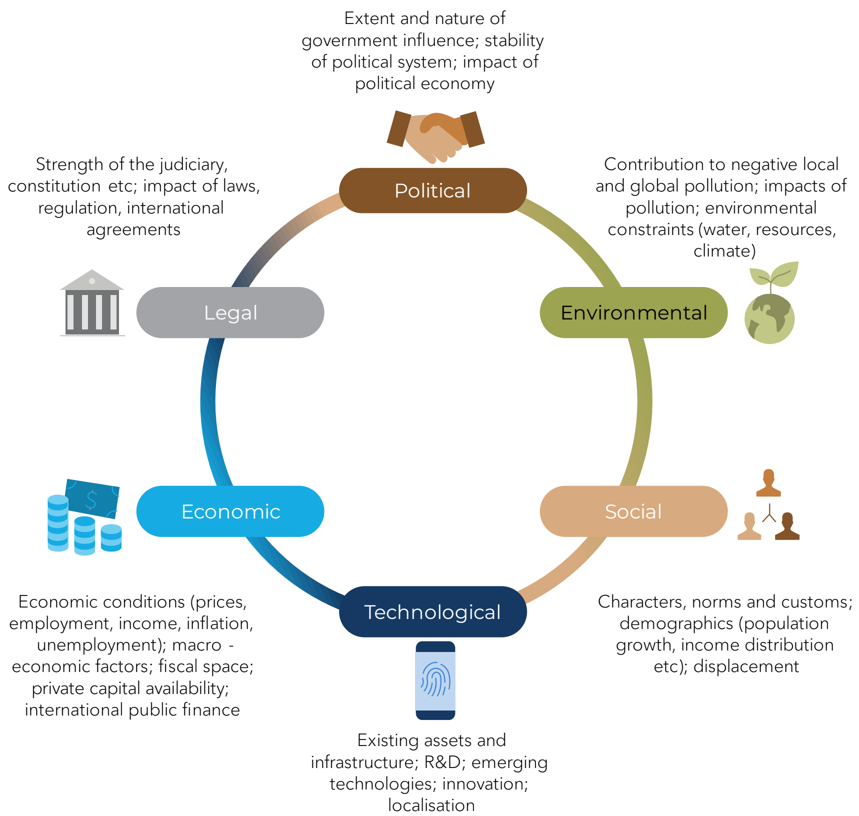
Constituents were contacted via email to set up the engagements for each grouping. In-person meetings were prioritised where possible, however, most engagements were through video conferencing platforms. These engagements started with a brief description and presentation of the project, its objectives and methodology. This was followed by a semi-structured discussion framed around the PESTEL dimensions and how they relate to the representative constituent grouping. Minutes were taken for each engagement and were summarised.

As the final outputs of the study were produced, constituents were invited to provide any additional feedback.

STEP 5: PESTEL DESCRIPTION OF THE DECARBONISATION OF THE ASSETS AND THEIR VALUE CHAIN

The core analytical component of the project was conducted using the PESTEL framework. This framework originates from business planning and has been widely used to help structure understanding perspectives that have the potential to impact on organisations and industries in a range of contexts. This framework of analysis studies the key external dimensions (Political, Environmental, Social, Technological, Economic and Legal) that influence an organisation (CIPD, 2021), as shown below.

Figure 4: Pestel Analysis Dimensions



For this project, PESTEL was used to expand the dominant climate policy view on the decarbonisation challenge beyond the techno-economic, describing the decarbonisation challenges facing the facilities and their value chains from each separate PESTEL dimension. Despite the imbalance in the detail of each, the intention is to highlight the need to place these on an equal footing in terms of importance and relevance, in recognition of the intricate interactions between them which co-determine the transitional direction of the complex systems of interest in this study.

> In the South African case, substantially more information was gathered on the techno-economic perspective than the others. This reflects the overwhelming focus on techno-economic analyses in the literature, and the disciplines making up the project team. It does not, however, mean that there are not a range of meaningful analysis of decarbonisation from other perspectives – just that these tend to remain in separate conversations, with little consideration of how different dimensions could be brought into conversation with each other (a sentiment expressed in the civil society engagement).

As with the rest of the study, the focus of the PESTEL analysis is first and foremost on the facilities, with secondary consideration of value chain activities. The approach attends to breadth above depth, attempting to at least flag significant issues from any one perspective. It is acknowledged that each area represents a study in and of itself, and the review of the literature might be far from exhaustive.

The description of the decarbonisation ambition outlined in Step 2 is used as a checkpoint throughout the PESTEL analysis, routes to ensure that the analysis is situated against the ambition requirements outlined by the modelling.

The analysis also considered existing structural legacy constraints (e.g. skills, government capacity, contractual relationships etc), and their durability, given the significance of these in system change.

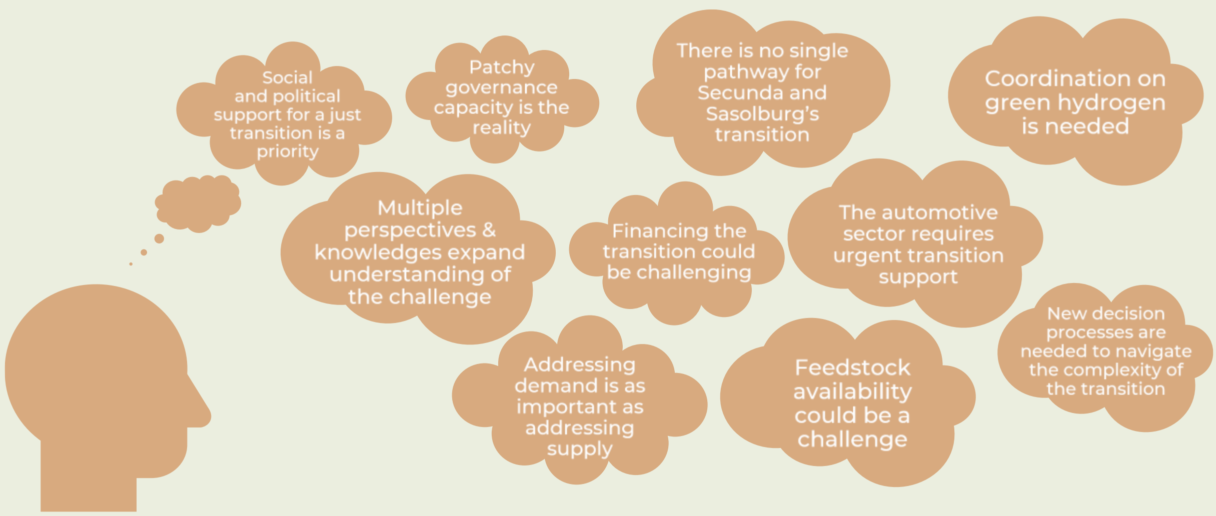
STEP 5: EXTRACT AND SYNTHESIZE KEY FINDINGS FOR DECISION MAKERS

From the PESTLE description of the decarbonisation of the assets and their value chains, key findings were extracted and synthesised.

This process focused on the inter-connections between areas that are typically considered in silo's (such as individual sectors, or particular types of knowledge), as this is the value added by the broad rather than deep methodology of the project. Further, the process tried to identify key areas that held the potential to tip the system in a positive or negative direction, or aspects that would lock-out or lock-in particular pathways forward.

The following are a distillation of what the author team of the project found most significant for policy and decision-makers engaging with the decarbonization of Secunda, Sasolburg and their value chains.

Figure 5: Key insights for decision makers in the petrochemicals value chain



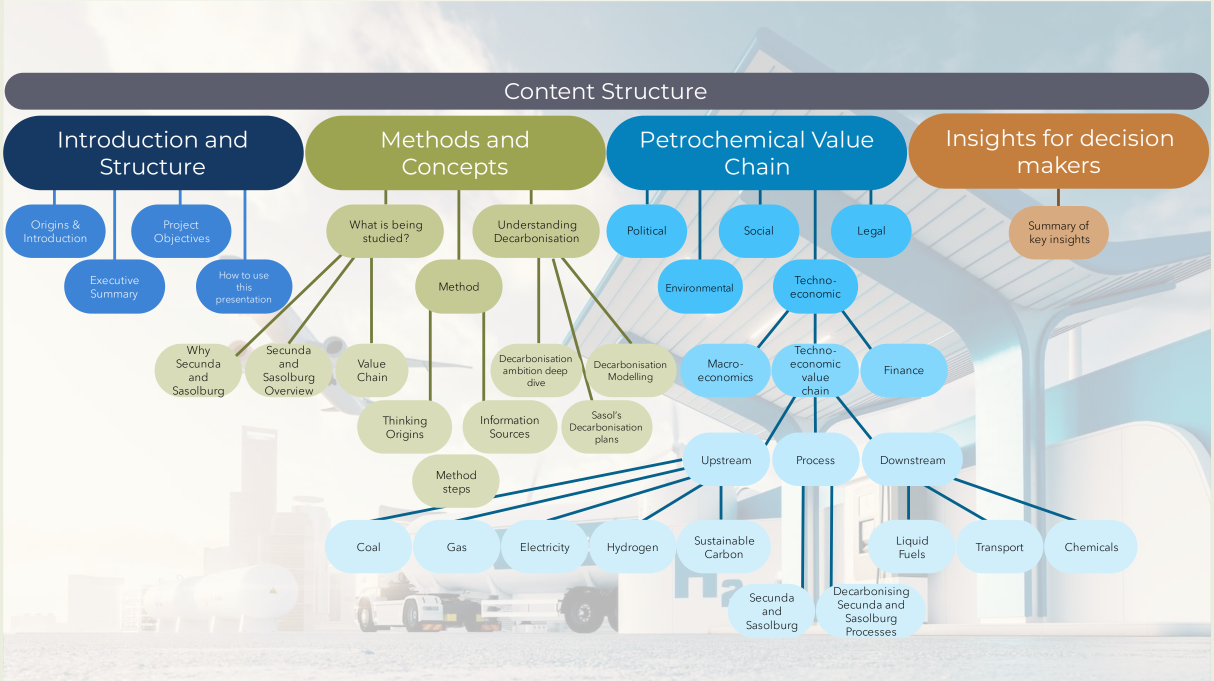
STEP 6: COMMUNICATION OF OUTPUTS

The standard way of communicating research and analysis in the climate and other arenas is through the production of linear reports. A decision was taken early in this project to attempt something different: presenting the findings in a non-linear format. Thus, while still text-dominant, the output of this project was designed to be visually appealing, and to allow the reader to easily navigate to sections of interest to them rather than having to progress through a linear report structure. Further, the non-linear format was used to portray and emphasise an analytical logic. Most significantly, all PESTEL knowledge dimensions sit on the same hierarchical level, implying equality of importance, even if the techno-economic dimensions dominate in terms of quantity.

This **novel non-linear communication tool** is aimed at providing an accessible and engaging experience for the reader, enhancing communication of complex specialist territory. Visualisation and interactive techniques within the standard Microsoft PowerPoint package were employed to enable engagement with the content. It is thus hoped that it will be used as a dynamic tool, rather than a static report that could remain, on the whole, unread, providing new ideas on how studies in this area might be communicated in future.

The resulting content structure for the non-linear presentation output for this project is depicted in the figure below.

Figure 6: Content structure map in the context of South Africa



6 INFORMATION SOURCES

The use of multiple knowledge dimensions and perspectives as information sources are integral to complex system thinking methodology and ensuring that analysis foregrounds current realities and future uncertainties. This project draws on information from existing techno-economic decarbonization models, open-source literature, and stakeholder perspectives from constituents and key experts across the value chain.

Two existing South African modelling studies, that have played an important role in informing South Africa's policy discourse, were chosen to assist in understanding possible Paris-aligned futures for the decarbonisation of the petrochemicals and transport sectors. The first was produced by the Energy Systems Research Group at the University of Cape Town, and the second by BCG for the NBI as part of their Just Transitions study. Where possible, the project team analysed the underlying data, and engaged with the modelling teams in order to better understand how the models have treated the petrochemical and chemical assets and their related activities.

A deep dive **technical paper** on production processes at Sasol was prepared under this study. This formed the basis of a critical understanding of the highly complex interlinkages between Secunda and Sasolburg, feedstock requirements and process linkages with utilities, production units and other external facilities. The **open literature** used included company reports, research studies, media articles and other publicly available information.

A series of **engagements were conducted with selected constituents** with an interest in Sasol's operations and the linked value chains, as discussed above. Constituents included Civil Society; Labour; Grassroots; Government; Business; Asset Management. **Interviews were also conducted with selected experts** on the topics of transport, the Sasol production processes, electric vehicles and gas.

7 METHODOLOGY LIMITATIONS

Limitations were identified during the course of this project, which the study design attempted to counter.

Because a key principle of the complexity thinking underpinning the study is that of the importance of interlinkages in complex systems, the scope of the study is very broad. This has necessarily meant its depth is, in parts, limited. Each of the areas represented in the 'Decarbonising the SA petrochemicals value chain' description has been the subject of many prior studies, and this one does not claim to uncover anything new at this level, nor provide a comprehensive consolidation of the findings of these studies. Rather, the insights this study does claim are those relating to the connections between the knowledges, perspectives and technical areas covered.

One aim of the study was to equate knowledge areas, and the PESTEL device was used to this end. However, both the author team composition as well as the literature are **biased towards the techno-economic.** This bias was countered in the study structure, particularly the use of a non-linear communication format, to emphasise equality of knowledge dimensions.

The study is based on information contained in the literature, as well as verbal communication with stakeholders. Given the complexity of every element of the value chain, and the fact that the authors are not experts in all of these, there are potential areas where interpretations may have been incorrect. The reader was recommended to cross-check information prior to making any specific decisions based on the information presented.

8 CONSIDERATIONS FOR REPLICATION

The method in this project was developed iteratively through application to particular emitting assets and their associated value chain, in a certain developing country context. However, the approach developed here is readily applicable to other emitting assets in both developed and developing country contexts.

Innovative components of the method that are readily transferable include:

1. **Focusing on the asset** in the context of its value chain as opposed to setting economic or sectoral analytical boundaries, or looking at assets in isolation.

2. **Stakeholder input and perspectives** are integral to the project method, as a source of knowledge upon which the findings are based, rather than incorporating stakeholder engagement later in the analysis to test findings.
3. **The use of the PESTEL framework (or similar)** to ensure a wide range of ways of understanding the decarbonization challenge are considered.
4. The **novel non-linear communication tool** that allows readers to navigate their own way through study findings, rather than having to progress through a linear report structure.

9 REFERENCES

Meridian Economics. 2022a. The evolving analytical requirements to support decision-making and implementation of decarbonisation in South Africa. (2022):12. Available: https://meridianeconomics.co.za/our-publications/analytical-requirements-to-support-decision-making-implementation-of-just-decarbonisation-in-south-africa/.

Meridian Economics. 2022b. The meaning of "net zero" for South Africa and its power sector. (2022):30. Available: https://meridianeconomics.co.za/our-publications/defining-net-zero-for-analysis-of-the-south-african-power-sector/.

CIPD, 2021. "PESTLE Analysis", Available at: https://www.cipd.org/uk/knowledge/factsheets/pestle-analysis-factsheet/#gref.