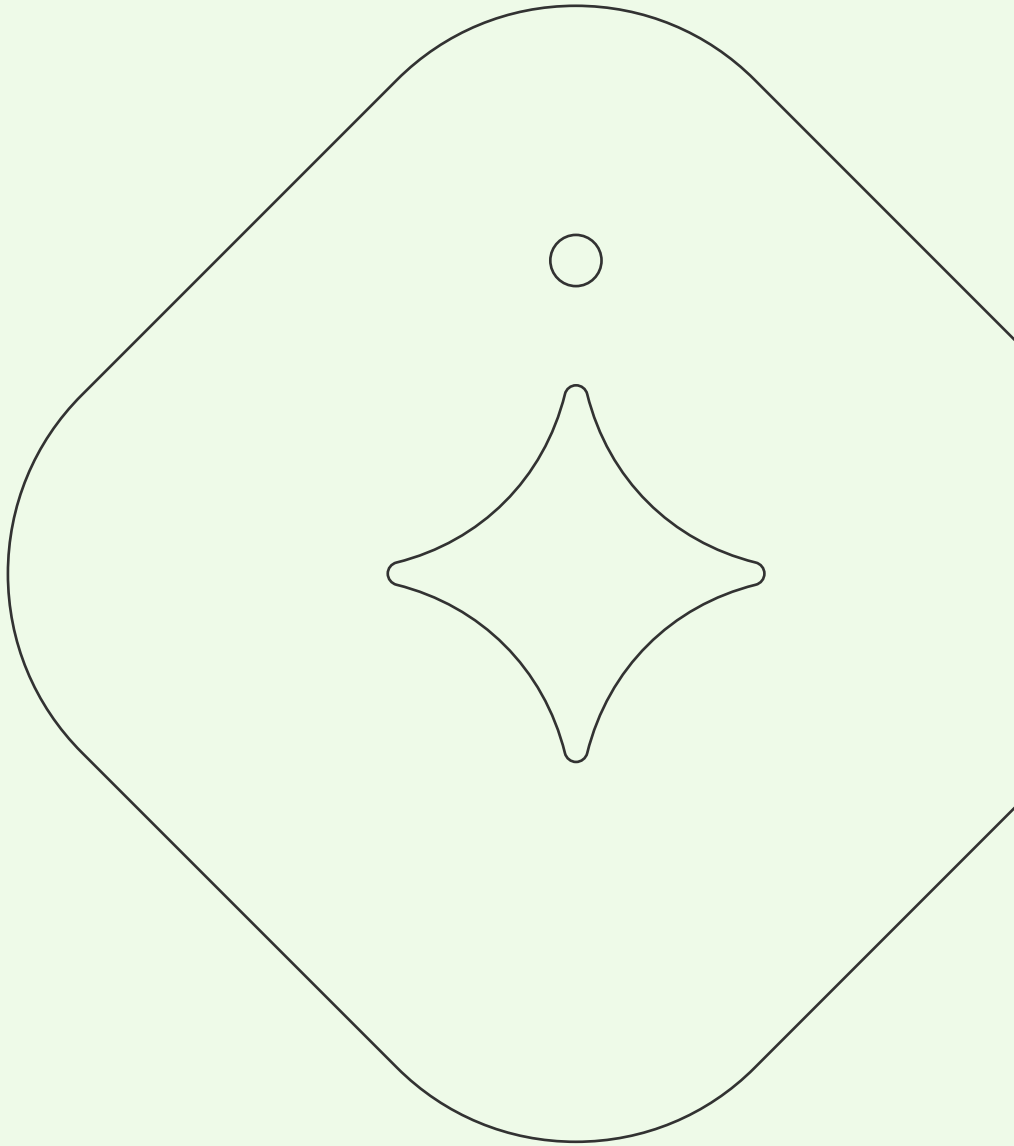
METHODOLOGY

Green Corridors
Feasibility Study Phase

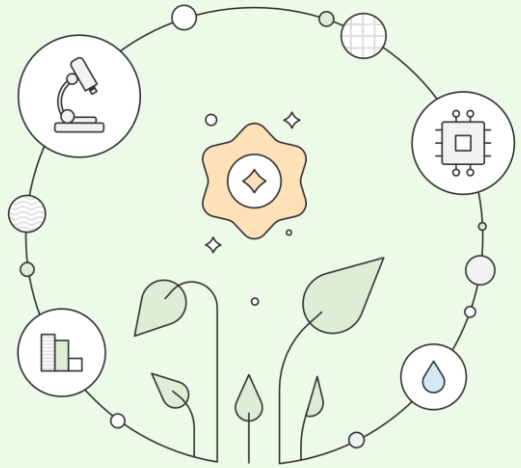


Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

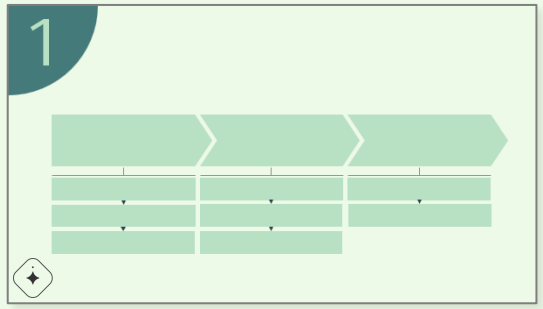
Expected outcomes of Feasibility Study phase

During the Feasibility Scoping phase, as well as before and during the Pre-feasibility Study, thorough work has been carried out to establish a solid project baseline across all dimensions. The management of some projects may commence at the Feasibility Study phase; however, the purpose of this phase is to gather essential information to form the foundation for a comprehensive feasibility assessment — encompassing technical, financial, and regulatory aspects — and to enhance the existing work.

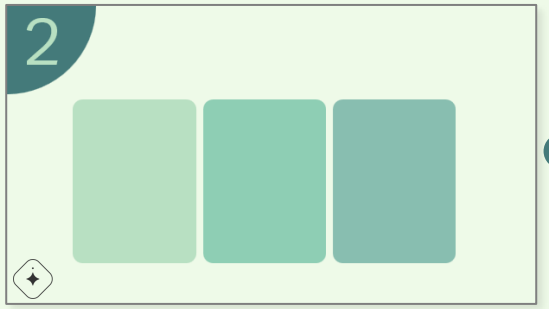
Subsequently, project team members will develop a comprehensive roadmap for advancing to the next stage. This entails selecting the final project concept, defining commercial and financing frameworks, and initiating the solution-building process.



How this document is constructed

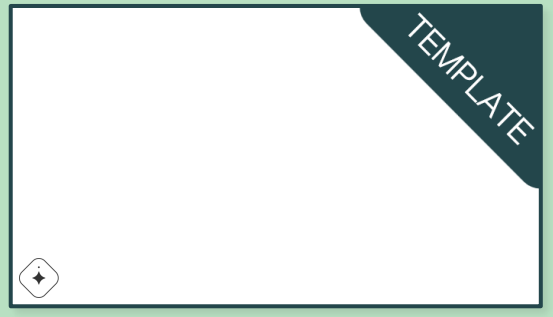


Navigation through the document



What's the purpose, key questions and importance of the subject

Summary of chapter findings and outcomes



Templates

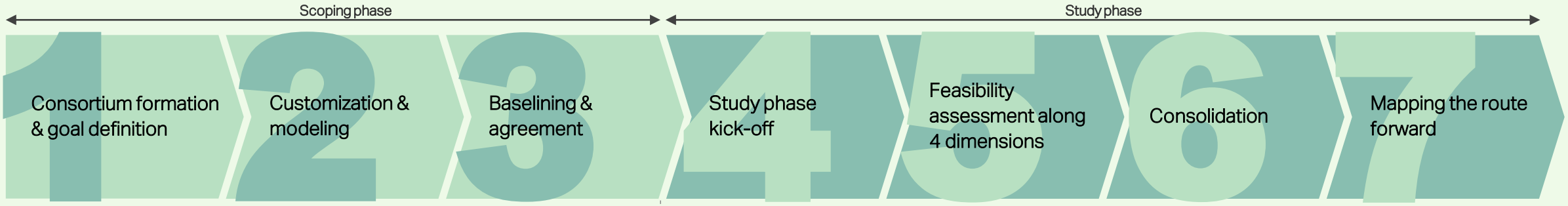
To be noted:

If a thorough Pre-feasibility phase and/or feasibility scoping have been conducted earlier, certain aspects of workstreams 2-5 may have been addressed to some extent. In such instances, it's advisable to conduct a gap analysis to determine which remaining tasks need to be completed.

Further detailing of proposed activities

Examples

The Feasibility Phase



The Feasibility Scoping Phase enables participants to **form a consortium** and project team members to **agree on roles** as well as **ways of working** in the upcoming Feasibility Study. It also aims at clearly **defining the focus and goals of the Feasibility Study** as well as the **work that needs to be done** for the specific corridor to reach these goals.

The Feasibility Study aims at **assessing the technical and regulatory feasibility of a specific green corridor** along the fuel, port, vessel, and cargo dimensions as well as **defining the residual cost gap**. It further includes a **risk registry** and **roadmap**, all of which are outlined together with the **consolidated findings** of the Feasibility Study.

Project Commitment Letter

The Center methodology for Feasibility studies is structured around seven workstreams

Workstreams	1 Corridor baselining	2 Alternative fuels supply chain	3 Port and bunkering infrastructure	4 Vessel decarbonization pathway	5 Cargo demand dynamics	6 Consolidation	7 Mapping the route forward
Stakeholders	All stakeholders	Fuel producers	Port and bunkering operators	Shipowners and operators	Cargo owners	All stakeholders	All stakeholders
Scope	**High-level assessment:** • Shortlist of potential alternative fuels • Vessel and voyage characteristics • Trade flows • Regulatory framework	**Feasibility assessment for each decarbonization pathway along value chain:** Technical feasibility Regulatory feasibility Cost assessment *Steps 2-5 run in parallel*				**Feasibility assessment** summary, highlighting: • **Technical and regulatory** feasibility • Main gaps to reach feasibility and the cost of closing them • **Residual cost gap** assessment, including cost sharing in project • Proposed options for additional funding of project • Risk registry and potential mitigation action	Development of **roadmap** and **required commitments** for the next phases of the project, up to operation

4 Study phase kick-off

- I Corridor baselining 1

5 Feasibility assessment along 4 dimensions

- J Alternative fuels supply chain 2
- K Port and bunkering infrastructure 3
- L Vessel decarbonization pathway 4
- M Cargo demand dynamics 5

6 Consolidation

- N Residual cost gap analysis 6
- O Consolidation of Feasibility assessment 6

7 Mapping the route forward

- P Roadmap 7

4l. Corridor baselining

Purpose

- Conduct a **corridor project baselining** to create an initial view on relevant **fuel, ports, and bunkering infrastructure**, relevant **vessel** characteristics and **trade flow** as well as just and equitable specifics.
- Summarize **key insights** into a **corridor project baseline** that can serve as the starting point for the Feasibility assessment (max 10 pages).
- Include **scope drawing.**

Key questions

- What are the **key characteristics** of the green corridor at hand?
- What are the **initial positions** on choice of fuel, port(s), and vessel segment for the Feasibility Study?

Importance

- Typically, corridor project baselining is conducted in Feasibility Scoping, but may in some cases be conducted at the beginning of the Feasibility Study instead.
- A common **baseline document** for all project members outlines **all relevant parts of the project** and ensures the **study is conducted in an efficient and swift process.**
- The scope drawing ensures that the project team always knows what the project is about and where the interfaces are located.

4I. Corridor baselining

Summary of chapter findings and outcomes

01

- Description of the **target state —** including **vision, goals, and requirements** for the green corridor
- Conceptual drawing of scope and workstream delineation

02

Technical:

- Recommendation of the **alternative fuel** to be used in the green corridor, including its required volume, if possible, its **source / feedstock** and its **production location**
- Description of **current port, storage, and bunkering infrastructure** along the green corridor, including current capacity, as well as the future **target port, storage, and bunkering infrastructure**, including necessary capacity
- Overview of current and expected **vessels** in the corridor, including their specific **characteristics** and **emissions**
- Understanding of **trade flows, cargo type, volume and value, cargo owners** and **consumers**

03

Regulatory:

- Overview of the administrative scheme in place within the green corridor

04

Cost:

- Preliminary cost assessment for **alternative fuels supply chain, port and bunkering infrastructure, vessel decarbonization pathway**
- Potential CO_2 abatement, initial total **cost estimate** (CapEx and OpEx over 25 years) as well as an initial view on the **incremental cost of green**

05

- Initial thoughts and findings on just and equitable aspects

4 Study phase kick-off

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5J. Alternative fuels supply chain

Purpose

- Assess the technical and regulatory feasibility of **delivering the amount and type of fuel needed** for the green corridor at the required timeline, and quantify related **costs (CapEx and OpEx)** (insights from workstream 4)
- Define **expected production center(s)** for alternative fuel
- Outline measures related to the alternative fuel supply chain to ensure a **just and equitable implementation** of the project
- Identify cost and **cost-down trajectories** for drivers of fuel costs (e.g., technology CapEx, electricity prices)
- Perform just and equitable assessment for the fuel supply chain (Matrix)

Key questions

- Can the **alternative fuel supply** meet the **demand for the specific green corridor?**
- What is the **required volume of alternative fuel** for this corridor and **range of expected production?**
- What are the main **drivers impacting the cost of alternative fuels** and how will they evolve over time?
- What is the **investment/financing required** to match the expected demand in the specific green corridor?
- Which **workers, communities and ecosystems** are affected by the transition to a low/zero emission fuel supply chain?
- What are the **socio-economic opportunities and risks**, and how can they be maximized/minimized, respectively?
- How do we ensure a **just and equitable** alternative fuel production?

Importance

- There are 3 critical cost elements to be considered for the technical and regulatory feasibility for the green corridor:
  - Delivering the **amount and type of fuel**
  - Meeting the **timeline**
  - **Quantifying** related costs

5J. Alternative fuels supply chain

Summary of chapter findings and outcomes

01	• **Proposed source of alternative fuels** for the specific green corridor (source of renewable energy, feedstock, and fuel production centers) and **evolution of alternative fuel supply and demand** over time for regions relevant to the corridor (local or international/ imported)
02	**Technical feasibility** of alternative fuel production for the specific green corridor, including: • Expected feedstock production locations and capacity • Fuel production locations and capacity • Transportation of fuel to relevant region in corridor
03	**Regulatory feasibility** of alternative fuel production projects and permits related to their development for a specific green corridor: • Regulatory and policy structure to allow/enable alternative fuel and feedstock production, storage and distribution (e.g., for hydrogen, carbon capture, storage, and transport) • Regulations on scale of alternative fuel production, and health and safety guidelines on handling, storage, and use • Carbon credits and other tailwinds • Measures to ensure a just and equitable alternative fuel production
04	**Cost assessment** of alternative fuel production project development relevant to the specific green corridor, including: • Resulting CapEx requirements • Expected cost of production and potential price of alternative fuels, and their evolution over time • Financing and funding options
05	**Just & Equitable:** • An analysis from a J&E perspective will provide insights on how workers, communities and ecosystems might be affected by the offtake of alternative fuels within the green corridor. There might be socio-economic opportunities and risks. It is important that work is done to maximize the opportunities and minimize the risks

Estimate fuel demand for the specific green corridor

	1	2
Steps	Estimate ability to deliver alternative fuel for the specific corridor at time and capacity outlined	Assess expected competition for fuels to be used in the green corridor – high-level alternative fuel requirements from other sectors and availability for shipping
Inputs	• Input from corridor project baselining, e.g., applicability of fuels by vessel type • Fuel characteristics (e.g., density, calorific value) • Workstream 4	• Sectors to use alternative fuels by 2030 • Expected capacity of alternative fuels (per fuel) to be used by each sector until 2050[1]

1. Depending on project timeline

Define expected production centers for alternative fuels, assess their technical and regulatory feasibility

Steps	1	2	3	4
	Estimate total fuel capacity available for the specific green corridor over time	Define and describe where energy and fuel for the green corridor will come from and can relevant land areas be secured	Identify permittings required to produce alternative fuels.	Outline main safety and regulatory aspects for the production of alternative fuels
Inputs	• Capacity of alternative fuels expected to be produced • Capacity from announced projects excluding committed volumes • Fuel demand estimates for green corridor	• Renewable energy potential (e.g., solar and wind capacity factors) • Mapping of feedstock sources • Land surfaces available	• Different alternative fuels (e.g., biodiesel, hydrogen, ethanol) may have varying permit requirements • Zoning laws and land use regulations • Permittings for energy supply, feedstock, electrolyzers, fuel synthesis, etc. • Relevant government agencies	• Safety assessment for specific fuels • Supportive regulation • Policies announced to incentivize development of alternative fuel production infrastructure

Identify and quantify fuel cost and downward cost trajectories

	1	2
Steps	Identify main drivers of costs for alternative fuel across the value chain and quantify starting points for costs. This includes, as applicable: • Fuel/feedstock production technology cost (CapEx, OpEx) • (Renewable) electricity price • Fuel storage costs (e.g., H_2 liquefaction) • Fuel transportation costs	Define cost evolution for key cost drivers of alternative fuel until 2050[2] based on similar downward cost trajectories for comparable technologies (e.g., evolution of hydrogen fuel cells vs. solar panel cost evolution); include evolution of transportation costs for fuel sourced from other locations vs. produced locally
Inputs	• Value chain and supply chain for each alternative fuel • Maturity and deployment of fuel production technology, and feedstock production technology (e.g., new R&D technologies for fuel cells, more mature technology for solar/wind power) • Key drivers of cost – variable costs/costs that are expected to evolve	• Examples of similar technologies and their downward cost trajectories over time • Estimated starting points for costs across value chain of relevant alternative fuels

2. Depending on project timeline

Quantify CapEx and OpEx requirements

	1	2	3	4
Steps	List new infrastructure/CapEx investments required for each step of the alternative fuel value chain, for example: • Feedstock production CapEx • Feedstock storage, transportation CapEx • Fuel production CapEx • Fuel storage, transportation CapEx	Assess fuel cost evolution during the project development	Assess financing and funding options (including cost of capital) to support investments	Identify players for each step of the value chain (including manufacturing, utilities, energy, logistics) and identify each player's ability to invest at required scale and pace by player, based on their size and decarbonization commitments
Inputs	• Value chain and supply chain for each alternative fuel • Green Corridor Scenario Modeling tool	• Projection for evolution of drivers of cost for alternative fuels	• Public and private financing options, including cost of capital estimate and "green" investment subsidies • Local funding/subsidy programs for alternative fuel projects	• Players for each step of the fuel value chain • Decarbonization/ESG commitments and involved partnership

J&E assessment – Alternative fuels supply chain

Steps

1	2	3
Identify the communities, workers and ecosystems potentially affected by specific corridor	With the identified groups and ecosystems in mind, go through the questionnaire and identify the risks and opportunities	Consider the ESG / Sustainability Strategies of commercial stakeholders involved in Workstream 2

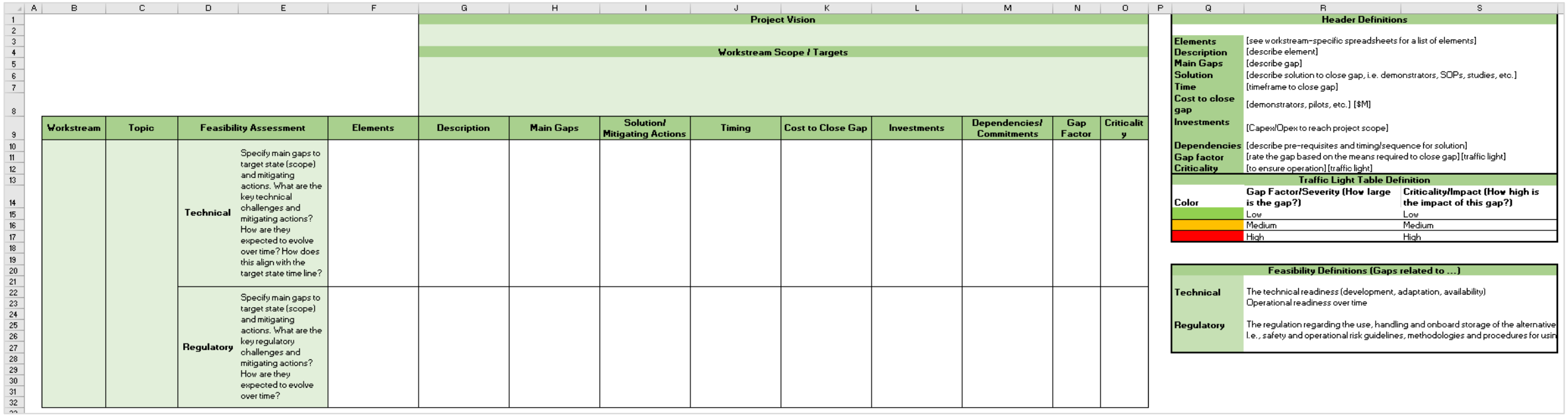
Further explanation

- **Communities:**
  Affected communities such as those close to new fuel plants or power plants, those connected to the same energy grid as the green corridor, or communities living in the vicinity of water resources or land area that are affected by the new fuel or energy infrastructure.
- **Workers:**
  Affected workers such as those working across the alternative fuel supply chain (e.g., workers in fuel plants or solar parks) and those whose jobs might be at risk or change significantly because of the green corridor (e.g., workers in fossil energies).
- **Ecosystems:**
  Affected ecosystems such as those in the vicinity of new fuel infrastructure or energy infrastructure developments associated with the corridor or those impacted by land use change, water use, or biochemical flows related to these developments.

- Use the questionnaire provided in the J&E Data Collection Sheet.
- If relevant, highlight risks that should go into the risk matrix.

- Identify synergies between project objectives and the ESG / sustainability strategies for stakeholders involved in Workstream 2. For inspiration, consult the ESG questions provided in the Pre-feasibility data collection Excel tool Tab 5.2.

Workstream gap analysis – Alternative fuels supply chain



Project Vision

Workstream Scope / Targets

Workstream	Topic	Feasibility Assessment		Elements	Description	Main Gaps	Solution/ Mitigating Actions	Timing	Cost to Close Gap	Investments	Dependencies/ Commitments	Gap Factor	Criticality
		Technical	Specify main gaps to target state (scope) and mitigating actions. What are the key technical challenges and mitigating actions? How are they expected to evolve over time? How does this align with the target state time line?										
		Regulatory	Specify main gaps to target state (scope) and mitigating actions. What are the key regulatory challenges and mitigating actions? How are they expected to evolve over time?										

Header Definitions

Elements	[see workstream-specific spreadsheets for a list of elements]
Description	[describe element]
Main Gaps	[describe gap]
Solution	[describe solution to close gap, i.e. demonstrators, SOPs, studies, etc.]
Time	[timeframe to close gap]
Cost to close gap	[demonstrators, pilots, etc.] [$M]
Investments	[Capex/Opex to reach project scope]
Dependencies	[describe pre-requisites and timing/sequence for solution]
Gap factor	[rate the gap based on the means required to close gap] [traffic light]
Criticality	[to ensure operation] [traffic light]

Traffic Light Table Definition

Color	Gap Factor/Severity (How large is the gap?)	Criticality/Impact (How high is the impact of this gap?)
	Low	Low
	Medium	Medium
	High	High

Feasibility Definitions (Gaps related to …)

Technical	The technical readiness (development, adaptation, availability) Operational readiness over time
Regulatory	The regulation regarding the use, handling and onboard storage of the alternative I.e., safety and operational risk guidelines, methodologies and procedures for usin

Throughout the Feasibility assessment, fill the table with insights on **technical and regulatory feasibility**[3] – specifically, use this table to highlight **gaps and ways to close them**

Legend and definitions

3. Cost assessment is covered under the residual cost gap analysis methodology

4 Study phase kick-off

I Corridor baselining 1

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P Roadmap 7

5K. Port and bunkering infrastructure

Purpose

- **Identify potential ports** for the specific green corridor.
- For the ports of choice, identify:
  - Capacity for storing and bunkering alternative fuels
  - Existing and planned infrastructure
  - Regulatory frameworks for storage and bunkering
- Estimate the required **investments for retrofitting/building** new storage and bunkering infrastructure (CapEx/OpEx over 25 years) to meet corridor demand.
- **Assess the feasibility** of developing storage and bunkering infrastructure for alternative fuel.
- Perform **just and equitable assessment** for port and bunkering infrastructure.

Key questions

- What are the **expected port and bunkering sites** for this specific corridor?
- What does the current **fuel storage and bunkering infrastructure** look like and what **additional investments** are required?
- How much of the required capacity can be covered by **retrofitting existing infrastructure?**
- How much **extra infrastructure** is required?
- Will it be **feasible from a regulatory perspective to develop** the storage and bunkering infrastructure?
- What are the **required investments and financing potential** for retrofitting/developing the required infrastructure?
- What will be the running cost for these facilities?
- Which **workers, communities and ecosystems** are affected by port, storage and bunkering infrastructure for low/zero emission fuels?

Importance

- The ports play an important role in the green corridor, but the **activities related to the corridor** are often **managed by several stakeholders**.
- As the new fuel (chemical) will be stored and bunkered at the port (most likely the most-populated port along the green corridor), the **safety, permits and regulation** are crucial items to map in the early phases.
- There might be **socio-economic opportunities and risks**. Therefore, it is equally important that work is done to maximize the opportunities and minimize the risks.

5K. Port and bunkering infrastructure

Summary of chapter findings and outcomes

01

- **Overview of required port and bunkering infrastructure** to meet the specific corridor's demand for alternative fuel (location, capacity, technologies)

02

Technical feasibility of alternative fuel bunkering, storage, and logistics connected to the green corridor ports, including:

- Potential for **conversion/retrofitting** of infrastructure for alternative fuels
- Logistics solution for transporting alternative fuel to storage sites
- **Potential availability of land** for new infrastructure (if required)
- **Operational capacity** based on fuel type (e.g., required skills to handle fuel)

03

Regulatory feasibility, including the ability to **store/bunker** fuel at green corridor ports; **health and safety guidelines** for storage, bunkering, logistics; and fuel handling **process definitions,** as well as measures to ensure a **just and equitable** development of the alternative fuel along the entire storage/bunkering process.

04

Cost assessment for conversion/retrofitting and development of the infrastructure required for the specific green corridor, including:

- Resulting CapEx requirements
- OpEx costs (for storage tanks, ports, new bunkering barges, etc.)
- Opportunities to share bunkering and storage infrastructure based on demand from vessels outside the corridor
- Financing capacity and potential

05

Just & Equitable:

- An analysis from a J&E perspective will provide insights on how workers, communities and ecosystems might be affected by the development of fuel storage and bunkering facilities. There might be socio-economic opportunities and risks. It is important that work is done to maximize the opportunities and minimize the risks.

Estimate the demand and capacity for storage and bunkering of alternative fuels for the specific green corridor, and identify potential ports

Steps

1. Map current and expected storage and bunkering ports relevant to the specific green corridor, including their infrastructure and capacity
2. Assess the ability of the green corridor port and bunkering sites to handle the low/zero carbon emission vessel segment and alternative fuels from a technical and regulatory perspective. Develop necessary measures for storage and bunkering infrastructure to ensure a just and equitable implementation of the project
3. Assess potential gaps between existing/ expected storage and bunkering infrastructure and fuel demand and estimate potential to retrofit or build new infrastructure

Inputs

1. Voyage characteristics (location of bunkering) – Input from corridor project baselining
- Storage requirements given the expected fuel volume and physical state of the fuel (i.e., refrigerated, pressurized, etc.)
- Overview of current and planned infrastructure/capacity for bunkering and storage sites (including barges, storage tanks)
- Location and potential capacity of new bunkering sites along the corridor
- Stakeholders of bunkering sites used by vessels in the corridor
- Readiness of fuel storage/bunkering systems and safety standards for handling alternative fuel (e.g., ammonia, hydrogen)

2. Regulations for handling alternative fuels
- Permitting processes for handling alternative fuels
- Safety standards and verification of fuel suitability related to LCA

3. Combination of the previous steps

Useful information
Another area of consideration is the size of relevant ports in terms of employee count; handling, storage and bunkering of alternative fuel might require additional employees.

Estimate the investment required to retrofit/build new storage and bunkering infrastructure to meet corridor demand

	1	2	3
Steps	Assess the infrastructure required to store alternative fuels at the green corridor bunkering sites and estimate investment required to retrofit/develop the necessary infrastructure	Assess the infrastructure required to bunker alternative fuels at the green corridor sites (same sites as Step A) and estimate investment required to retrofit/develop infrastructure	Create an overview of the total infrastructure required for the specific green corridor and cost implications, and identify financing capacity for required investments
Inputs	• Technical feasibility of converting existing infrastructure • Regulatory readiness of storage and bunkering sites (safety aspects and permits for e.g. ammonia, hydrogen, etc.) • Expand demand for storage • Land available for alternative fuel storage and estimate of its storage capacity • Cost estimate (CapEx and OpEx over 25 years) of storage facilities for alternative fuel, including economies of scale and sharing infrastructure with other demand sources	• Technical feasibility of converting existing infrastructure • Regulatory readiness of storage and bunkering sites (safety and permitting for e.g. ammonia, hydrogen, etc.) • Expand demand for bunkering • Estimate the number of bunkering barges required for given storage capacity • Cost estimate (CapEx and OpEx over 25 years) of bunkering facilities for alternative fuel, including economies of scale and sharing infrastructure with other demand sources	• Combination of the previous steps

J&E assessment - Port and bunkering infrastructure

Steps

1	2	3
Identify the communities, workers and ecosystems potentially affected by the specific corridor.	With the identified groups and ecosystems in mind, go through the questionnaire and consider the identified risks and opportunities.	Consider the ESG / Sustainability Strategies of commercial stakeholders involved in Workstream 3

Further explanation

- **Communities:**
  Affected communities such as those living close to port, storage or bunkering infrastructure, or communities living in the vicinity of water resources or land area that are impacted by the port, storage or bunkering infrastructure.
- **Workers:**
  Affected workers such as those at existing and new port, storage and bunkering facilities.
- **Ecosystems:**
  Affected ecosystems can include those in the vicinity of existing and new port, storage and bunkering infrastructure associated with the corridor but can also include those impacted by land use change, water use, or biochemical flows related to that infrastructure.

- Use the questionnaire provided in the J&E Data Collection Sheet
- If relevant, highlight risks that should go into the risk matrix

- Identify synergies between project objectives and the ESG / sustainability strategies for stakeholders involved in Workstream 3. For inspiration, consult the ESG questions provided in the Pre-feasibility data collection Excel tool Tab 5.2

Workstream gap analysis – Port and bunkering infrastructure

						Project Vision								
						Workstream Scope / Targets								
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Legend and definitions

4. Cost assessment is covered under the residual cost gap analysis methodology

Workstream 4

4 Study phase kick-off

- I Corridor baselining 1

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- P Roadmap 7

5L. Vessel decarbonization pathway

Purpose

- Assess the technical and regulatory feasibility of **delivering the required number of vessels** within the specified timeline.
- Estimate the number and specification of vessels required including type and size.
- Assess if the vessels are to be **newbuilds or retrofitted vessels with modifications (or a mix).**
- Create the **timeline to deliver the vessels.**
- Identify regulations that impact the handling of **alternative fuel on vessels along the specific green corridor**, and define workstream-related measures to ensure a safe and just operation of the vessels.
- Quantify the **CapEx and lifetime OpEx** (for 25 years of operation) requirements for newbuilds and retrofitted vessels and review financing potential.
- Perform just and equitable assessment for the vessel decarbonization pathway.

Key questions

- **How many vessels are needed** and what are their required **characteristics** (e.g., vessel type, fuel, cargo, volumes, engine)?
- Can the **shipyards** deliver the required type and number of vessels and what is the **timeline to make the vessels operational**?
- How **many of the required vessels are** expected to be **newbuilds or retrofitted** over time to meet the decarbonization ambition?
- Which **additional modifications** can be applied to the vessels (e.g., energy efficiency, onshore power) to reduce the amount of alternative fuel required?
- What are the **regulatory requirements to be fulfilled to** make the vessels operational according to the specified vessel characteristics/timeline?
- What are the resulting **investment requirements** (CapEx and OpEx) and potential financing opportunities?

Importance

- Vessels are the **ultimate vectors** to meet the corridor's **CO_2 abatement targets**.
- It is important to **thoroughly analyze the existing and future fleets** operating within the green corridor and understand what **changes** will be **needed** in terms of upgrading, retrofitting and/or newbuilds.
- Analysis from a J&E perspective will provide insights on how **workers, communities and ecosystems might be affected** by the transition to vessel decarbonization pathway.

5L. Vessel decarbonization pathway

Summary of chapter findings and outcomes

01

- **Current and future vessel availability and timeline** taking into consideration the availability of alternative fuels based on technology maturity
- **Modifications required for existing vessels and characteristics of new vessels** (i.e., alternative fuels, onboard storage, technologies)

02

Technical feasibility of vessel newbuild/conversion to use alternative fuels, including:

- Impact of usage of alternative fuels on vessel, voyage range, and cargo payload
- Fuel and technology availability and maturity over time
- Vessel renewal/new ordering timelines

03

Regulatory feasibility of vessel conversion to use alternative fuels:

- Regulations regarding use and onboard storage of alternative fuels
- Measures to ensure a just and equitable conversion and operation of the vessels, including relevant ESG ambitions

04

Cost assessment of vessel conversion to use alternative fuels, including:

- CapEx and OpEx for existing and new vessels' incremental cost of green
- Resulting financing needs and funding sources

05

Just & Equitable:

- Analysis from a J&E perspective will provide insights on how workers, communities and ecosystems might be affected by the change/addition of new operating vessels and their related new technologies. There might be socio-economic opportunities and risks. It is important that work is done to maximize the opportunities and minimize the risks.

Estimate the number of vessels required and define the green corridor's future vessel requirements, including type and size of vessels

	1	2	3
Steps	Estimate the number of vessels required for the green corridor	Define the vessel requirements needed for the vessels to operate on the specific green corridor (i.e., capacity, type, size) over time, including requirements to decarbonize the vessels	Determine the technology available for newbuilds and retrofitting vessels (e.g., engine, energy efficiency retrofit kit, onshore power connection panel, other equipment) to enable the vessels to operate on the green corridor
Inputs	• Input from Feasibility Scoping and corridor project baseline	• Evolution of the corridor's shipping demand for vessels • Expected utilization of vessels	• Technology availability, and approval from classification society and flag state

Define the number of newbuilds and retrofitted vessels that can operate in the specific green corridor over time

	1	2	3	4
Steps	Define technologies (including onboard fuel storage) for new vessels and the required/available modifications to retrofit the vessels expected to operate on the green corridor	Assess cost, technology availability and shipyard readiness for newbuilding and for retrofitting the vessels	Compare costs, capacities, and readiness (e.g., expertise available from shipyards, engine manufacturers, etc.) and define most economic pathway	Make high-level assessment of mix between newbuilds and retrofit
Inputs	• Information from shipbuilders' classification societies	• Capacity constraints for shipbuilding value chain players (e.g., shipyards, engine manufacturers)	• Cost and capacity to deliver newbuilds • Cost and capacity to retrofit existing vessels	• Step 3 • Factors such as shipyard capacity, technology advancements, regulatory trends, and economic factors influencing costs.

Create the timeline to decarbonize the selected vessels based on vessel technology and fuel availability, as well as fuel maturity

	1	2
Steps	Define timeline required to reach the corridor's target of operating on low/zero emission vessels based on vessel requirements and possibilities for newbuilding and retrofitting vessels	Compare the high-level sequencing of fuel available with the sequence of selected vessels on an incremental basis (e.g., per year) based on fuel availability
Inputs	• Matching of fuel maturity, availability and requirement • Technology availability	• Alternative fuel availability

Identify regulations that impact the availability of the vessel decarbonization pathway

	1	2
Steps	Identify regulatory frameworks that could impact the development, conversion, and/or operation of conventional vs low/zero emission vessels in the specific green corridor, either acting as drivers or barriers to the green corridor project	Assess the regulatory feasibility of converting existing vessels vs building new vessels and the operation of the same on the specific green corridor
Inputs	• Input from the Pre-Feasibility Study • Local and international policies, regulations, and guidelines issued by regulatory institutions, e.g., regulations regarding the use and onboard storage of alternative fuels	• Combination of the previous steps

Quantify the CapEx and lifetime OpEx requirements for newbuilds and retrofitted vessels and review financing potential

	1	2	3
Steps	Quantify the expected CapEx, on the basis of tech maturity, financial environment, etc.	Quantify the lifetime OpEx (for 25 years of operation)	Assess financing and funding options (including cost of capital) for ship operators and ship owners
Inputs	• New building, and modifications to existing/new vessels • Green Corridor Scenario Modeling tool	• Vessel operating cost for newbuilding or retrofitted vessel • Assumptions on new crewing requirements (additional training, more automation, safety requirements, etc.) • Green Corridor Scenario Modeling tool	• Public and private financing options, including cost of capital estimate and “green” investment subsidies • Local funding/subsidy programs

J&E assessment - Vessel decarbonization pathway

	1	2	3
Steps	Identify the potentially-affected communities, workers and ecosystems.	With the identified groups and ecosystems in mind, go through the questionnaire and consider the identified risks and opportunities	Consider the ESG / Sustainability Strategies of commercial stakeholders involved in Workstream 4
Inputs	• **Communities:** Affected communities such as those in the vicinity of vessel operations such as port- and/or coastal communities. • **Workers:** Affected groups such as seafarers • **Ecosystems:** Affected ecosystems such as marine ecosystems along the green corridor in question	• Use the questionnaire provided in the J&E Data Collection Sheet • If relevant, highlight risks that should go into the risk matrix	• Identify synergies between project objectives and the ESG / sustainability strategies for stakeholders involved in WS4. For inspiration, consult the ESG questions provided in the Pre-Feasibility data collection Excel tool Tab 5.2

Workstream gap analysis – Vessel decarbonization pathway

Project Vision												
Workstream Scope / Targets												
Workstream	**Topic**	**Feasibility Assessment**	**Elements**	**Description**	**Main Gaps**	**Solution/ Mitigating Actions**	**Timing**	**Cost to Close Gap**	**Investments**	**Dependencies/ Commitments**	**Gap Factor**	**Criticality**
		Technical Specify main gaps to target state (scope) and mitigating actions. What are the key technical challenges and mitigating actions? How are they expected to evolve over time? How does this align with the target state time line?										
		Regulatory Specify main gaps to target state (scope) and mitigating actions. What are the key regulatory challenges and mitigating actions? How are they expected to evolve over time?										

Header Definitions

Elements	[see workstream-specific spreadsheets for a list of elements]
Description	[describe element]
Main Gaps	[describe gap]
Solution	[describe solution to close gap, i.e. demonstrators, SOPs, studies, etc.]
Time	[timeframe to close gap]
Cost to close gap	[demonstrators, pilots, etc.] [$M]
Investments	[Capex/Opex to reach project scope]
Dependencies	[describe pre-requisites and timing/sequence for solution]
Gap factor	[rate the gap based on the means required to close gap] [traffic light]
Criticality	[to ensure operation] [traffic light]

Traffic Light Table Definition

Color	Gap Factor/Severity (How large is the gap?)	Criticality/Impact (How high is the impact of this gap?)
	Low	Low
	Medium	Medium
	High	High

Feasibility Definitions (Gaps related to …)

Technical	The technical readiness (development, adaptation, availability) Operational readiness over time
Regulatory	The regulation regarding the use, handling and onboard storage of the alternative I.e., safety and operational risk guidelines, methodologies and procedures for usin

Throughout the Feasibility assessment, fill the table with insights on **technical and regulatory feasibility**[5] – specifically, use this table to highlight **gaps and ways to close them**

Legend and definitions

5. Cost assessment is covered under the residual cost gap analysis methodology

Workstream 5

4 Study phase kick-off

5 Feasibility assessment along 4 dimensions

6 Consolidation

7 Mapping the route forward

I Corridor baselining 1

J Alternative fuels supply chain 2

K Port and bunkering infrastructure 3

L Vessel decarbonization pathway 4

M Cargo demand dynamics 5

N Residual cost gap analysis 6

O Consolidation of Feasibility assessment 6

P Roadmap 7

5M. Cargo demand dynamics

Purpose

- Examine expected growth and development, trade patterns, and the cargo value chain
- Assess the cargo's **sensitivity to changes in shipping/transportation costs** over time, including share of shipping as part of overall product cost and emissions.
- **List possible alternatives** of transporting the cargo and identify **competing routes and transportation modes.**
- Evaluate the cargo owners' and end-consumers' willingness to pay.
- Identify **mechanisms and regulations** that likely impact the cargo owners' and/or end consumers' **willingness to pay.**
- Perform just and equitable assessment to identify communities, workers and ecosystems potentially affected by the shift in cargo transportation mode and/or demand dynamics.

Key questions

- What are the **trade patterns** for the cargo types in the specific green corridor? Who **owns the cargo**?
- What is the **value of the cargo** and what is the cost of the green transportation per cargo unit?
- What are the **alternative** routes outside the green corridor or alternative means of transportation?
- How much of the incremental cost can be covered by **cargo owners** and through the **full customer chain**?
- Which **levers** will have an expected positive or negative impact on the cargo owners' and/or end consumers' willingness to pay?
- How might the use of alternative fuels affect the cargo beyond emissions?
- Are there any **socio-economic opportunities and risks**, and how can they be maximized/minimized, respectively?

Importance

- While work on fuel, ports and vessels aggregates the total cost of the green corridor, the cargo assessment addresses the **options of closing the cost gap with the price on cargo**.
- Within the supply chain, one central dimension is the **willingness of cargo owners and end-customers** to pay for green transportation.

5M. Cargo demand dynamics

Summary of chapter findings and outcomes

01 Description of the **nature of the cargo** in its current configuration and **future developments** (e.g., growth, trade patterns)

02 Description of the **cargo value relative to the incremental cost of green transportation** under current and expected developments

03 Identification and description of the **alternatives and competing options** for green transportation of the cargo

04 **Quantitative and qualitative assessment** of the cargo owners' and end consumers' **willingness to pay** for decarbonized shipping, mapped vs volume of cargo transported in the corridor per stakeholder

05 Overall **drivers**, such as ESG focus areas, which **impact the cargo owners' and end consumers' willingness to pay** (e.g., regulatory mechanisms, industry drivers and constraints) and workstream-related measures to ensure a **just and equitable implementation** of the project

Examine expected growth and development, trade patterns, and cargo value chain

	1	2	3	4
Steps	Describe the selected cargo's origin and basic characteristics (e.g., weight, necessary safety measures, temperature requirements, etc.)	Identify current volume, expected growth and volume fluctuations in the cargo trade	Describe the cargo industry's sustainability ambition and decarbonization adoption levels	Outline the cargo value chain, including the cargo's end usage
Inputs	• Market research reports (raw material, final goods, etc.) • Historical shipping services sales data	• Inbound/outbound products/commodities per segment over time (fronthaul-backhaul) • Historical intra-year volume development (seasonality)	• Industry decarbonization maturity level and investor/consumer pressure • Total industry emissions • Total life cycle emissions per unit of cargo • Just and equitable questionnaire including ESG- related considerations	• Market reports for downstream cargo/final goods

Assess the cargo's value

	1	2	3	4	5
Steps	Estimate the cargo's value (e.g., sales revenue, retail value)	Describe and estimate the future price and growth basics of the cargo (consider also green shipping potential for value adds)	Assess shipping costs relative to cargo value	Determine the cargo owners' and/or end consumers' ability to absorb additional green transportation costs	Estimate the shipping emissions and costs in comparison to the total emissions of the cargo
Inputs	• Cargo owner and end consumer value chain mapping • Cargo market sales reports • Retail value per unit for most relevant cargo types	• Future price and value estimation • Market sizing of sectors/industries that can potentially consume or use the cargo as input	• Cost breakdown to understand the potential to absorb additional green transportation cost • Scenario modeling of 'locked-in' costs from empty handling, commitments or alternative trading	• Cost breakdown of downstream products and final goods, including their retail value	• Breakdown of total emissions in the value chain • High-level cost estimate of decarbonizing the full value chain

List potential alternatives for transporting the cargo and identify competing routes and transportation modes

	1	2	3	4
Steps	Assess alternatives and substitutes to the cargo in the value chain – Can the cargo be substituted ?	Identify alternative transportation options and sourcing or production methods that become more competitive in light of increased green transportation costs in the green corridor – Will cargo be moved via other modes of transport?	Assess the feasibility of cargo bypassing the corridor's trade route	Identify opportunities to bundle demand from multiple cargo owners and end consumers (e.g., options for combining cargo types and optimization of fronthaul-backhaul) in the green corridor
Inputs	• Downstream market analysis	• Insourcing/outsourcing alternatives • List of alternative sources • Alternative production methods	• Trade flows	• Cost estimation and splits of bundling services

Make a quantitative and qualitative estimation of the willingness to pay (WTP) for sustainable shipping

Steps	1	2	3	4	5
	Assess the quantitative willingness to pay for decarbonized shipping services in the corridor	Specify the retail value of the cargo and establish the relative monetary cost and impact of transitioning to green transportation	Map monetary outcome of commercial alternatives, either for transportation or production / development	Identify monetary value and impact from transition mechanisms (e.g., tax / subsidies, book and claim, etc.)	Estimate the quantitative and qualitative willingness to pay of cargo stakeholders
Inputs	• Historical transportation data, market trends, growth projections, and competitive landscape. • Consumer chain surveys to assess the WTP of stakeholders for decarbonized shipping services	• Cost for moving cargo on fossil fuels and cost of green transportation • Green corridor scenario modelling tool • Incremental cost of green per cargo unit	• Identification of relevant key financial metrics • Definition of the commercial alternatives being evaluated • Evaluation of the revenue potential of each alternative	• Potential subsidies, grants, tax incentives, book and claim, green tax or market mechanisms that may influence stakeholders' willingness to pay.	• Cost and pricing models, including subsidies development as well as add-on value from green shipping transition

Identify mechanisms and regulations that likely impact the cargo owners' and/or end consumers' willingness to pay

	1	2	3	4	5
Steps	Identify the drivers of willingness to pay for decarbonized shipping and create an overview of stakeholder decarbonization commitments and commercial alliances relevant to the green corridor	Identify other stakeholders' ability to influence the energy transition and assess high-level abatement opportunities for non-shipping emissions of the specific cargo	Assess contract / charter dynamics to understand potential commercial or contractual constraints related to the corridor	Assess opportunities from longer-term offtake agreements that de-risk alternative fuel costs in the green corridor	Identify regulatory frameworks which could influence the fuel transition and assess how other ESG principles will impact the decarbonization focus, and define workstream-related measures to ensure a just and equitable implementation of the project
Inputs	• Industry decarbonization maturity level and investor / consumer pressure • Cargo owner / end consumer surveys • Published reports detailing Scope 3 emission targets • Consumer chain surveys to assess the willingness to pay for decarbonized shipping services	• Membership of decarbonization alliances (e.g., Sustainable Freight Buyers Alliance, First Movers Coalition, coZEV Coalition)	• Contractual review	• Estimate cost savings from longer-term offtake agreements • Regulatory/commercial frameworks for offtake agreements	• Overview of regulatory factors on cargo and transportation • Green Corridor Scenario Modeling tool • Just and equitable assessment including overview of relevant ESG focus areas and evaluation of their impact on decarbonization

J&E assessment - Cargo demand dynamics

Steps	1	2	3
	If relevant, identify the potentially-affected communities, workers and ecosystems.	With the identified groups and ecosystems in mind, go through the questionnaire and consider the identified risks and opportunities	Consider the ESG / Sustainability Strategies of commercial stakeholders involved in Workstream 5
Further explanation	• **Communities:** Affected communities such as port communities, coastal communities or communities in the vicinity of new fuel or energy infrastructure. • **Workers:** Workers handling cargo who are affected by the shift in cargo transportation mode and/or demand dynamics. • **Ecosystems:** Affected ecosystems on land and ashore such as those in the vicinity of new fuel or energy infrastructure developments, and port and bunkering facilities associated with the corridor but also those affected through land use change, water use, or biochemical flows related to these developments.	• Use the questionnaire provided in the J&E Data Collection Sheet • If relevant, highlight risks that should go into the risk matrix	• Identify synergies between project objectives and the ESG / sustainability strategies for stakeholders involved in WS2. For inspiration, consult the ESG questions provided in the Pre-Feasibility data collection Excel tool Tab 5.2

Workstream gap analysis – Cargo demand dynamics

						Project Vision								
						Workstream Scope / Targets								
Workstream	Topic	Feasibility Assessment		Elements	Description	Main Gaps	Solution/ Mitigating Actions	Timing	Cost to Close Gap	Investments	Dependencies/ Commitments	Gap Factor	Criticality
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Throughout the Feasibility assessment, fill the table with insights on **technical and regulatory feasibility**[6] – specifically, use this table to highlight **gaps and ways to close them**

Legend and definitions

6. Cost assessment is covered under the residual cost gap analysis methodology

Workstream 6

4 Study phase kick-off

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O Consolidation of Feasibility assessment 6

P Roadmap 7

6N. Residual cost gap analysis

Purpose

- **Cost assessment :**
  Estimate the total corridor cost as well as the residual cost gap throughout the value chain of green shipping and outline potential actions/measures to close the cost gap.

Key questions

- What is the **incremental cost of green**?
- How can the cost gap be closed?
- What are the **financing requirements** and the funding sources to enable the green corridor?
- What are the **potential risks** for the implementation of the green corridor and how can they be **mitigated?**

Importance

- This is a crucial step in **evaluating the trajectory of a green corridor**. It helps determine if the project is receiving **sufficient funding** to move towards execution.
- Based on the **results of the cost gap analysis**, the project team will take the next steps.
- The project team will **engage stakeholders outside the consortium**. The goal is to identify options to **close** the residual cost gap. These options could include subsidies or loans.
- The accuracy of the cost assessment and its relevance depends on the quality of the technical and regulatory assessment. This implies that a **thorough and accurate technical and regulatory assessment is essential** for a valid cost assessment.

6N. Residual cost gap analysis

Estimate the incremental cost of green

Continuously refine with more data

A. **Estimate costs** of fuel, port and bunkering infrastructure, vessel for **fossil fuel-based** corridor

B. **Estimate costs** of fuel, port and bunkering infrastructure, vessel for **alternative fuel-based** corridor

C. **Incremental cost of green**.

I. Calculate the **incremental cost** based on (A) and (B). Estimate the high-level cost pass through on cargo and the CO_2 price, to cover the incremental cost of green

II. Assess any **pre-investments done** amongst consortium members to update **incremental cost of green**

III. Update the **incremental cost of green** based on technical insight during Feasibility Study

Reduce the incremental cost of green through the consortium

D. **Reduce costs among consortium members** through business development opportunities and synergies

E. **Assess the willingness to pay** of cargo owners (E1) & customers (E2)

Assess funding options to close the remaining cost gap

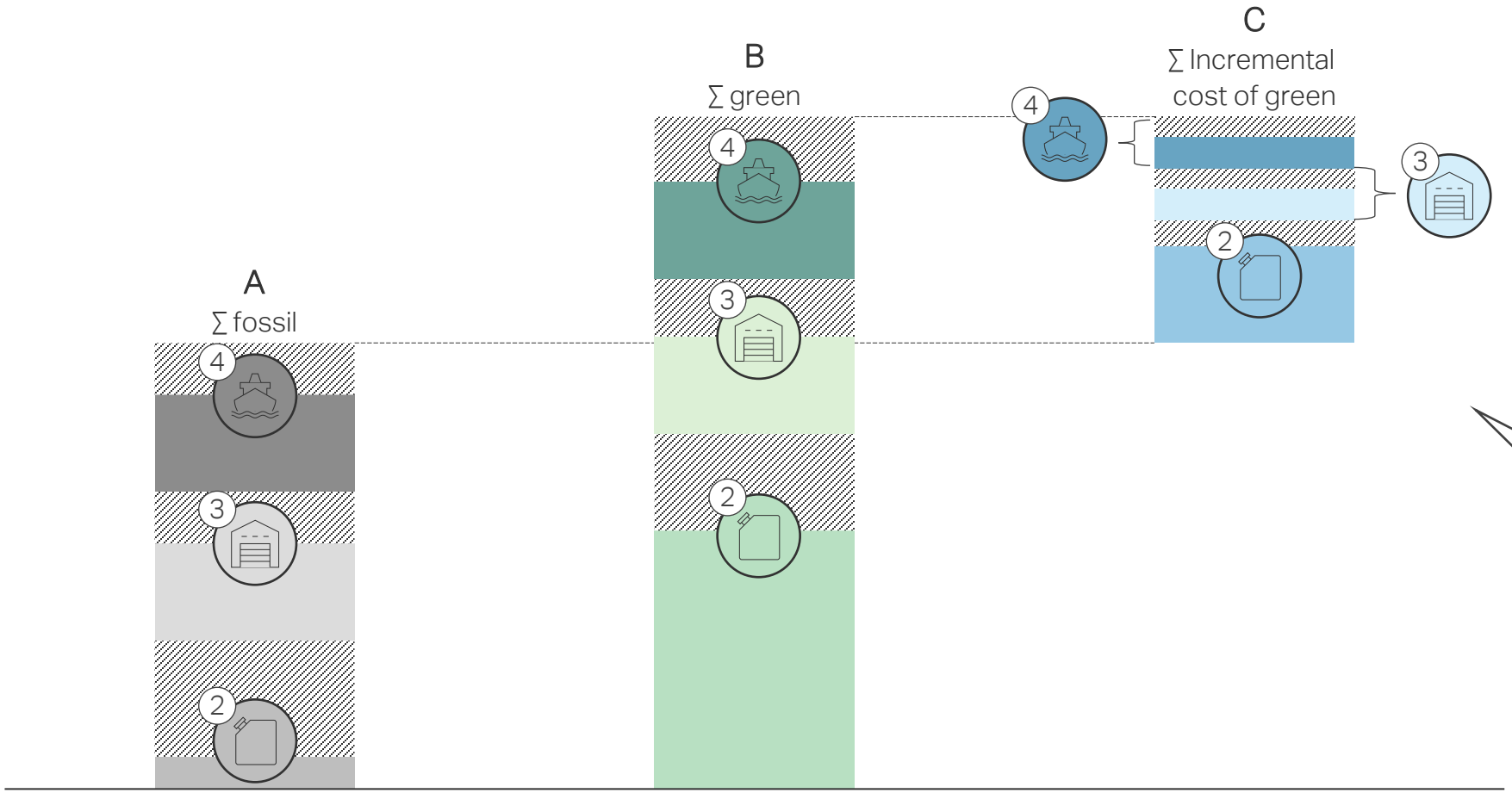
F. **Identify the remaining cost gap = residual cost gap** to be covered by other stakeholders

- **Identify sources of funding** to close the remaining cost gap
  - Subsidies
  - Attractive loans
  - Repayment of ETS
  - Philanthropic organizations
  - Guaranteed minimum auctions
  - Other financial instruments

Project Commitment Letter

Feasibility Documented

Initial estimates on the incremental cost of green for a green corridor



Legend

Costs

- OpEx
- CapEx

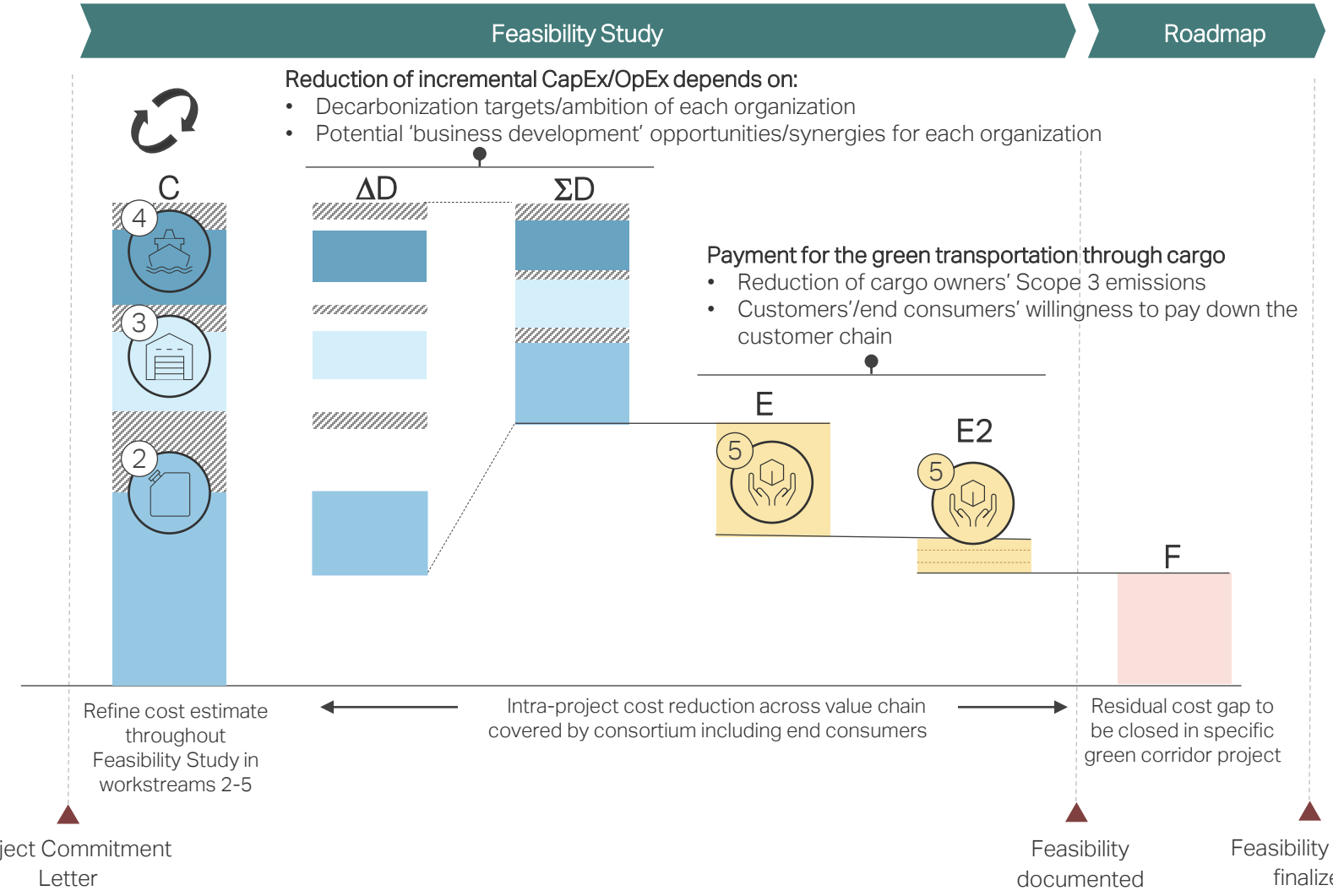
Workstreams (WS)

- WS 2: Fuel producers
- WS 3: Port and bunkering operators
- WS 4: Shipowners and operators

Cost pass through for green transportation = Σ Incremental cost of green / Cargo volume moved in the period

7. Estimate to be further refined with cost inputs received from consortium members after the Project Commitment Letter has been signed

Estimating and addressing the incremental cost of green in Feasibility



Legend

Costs

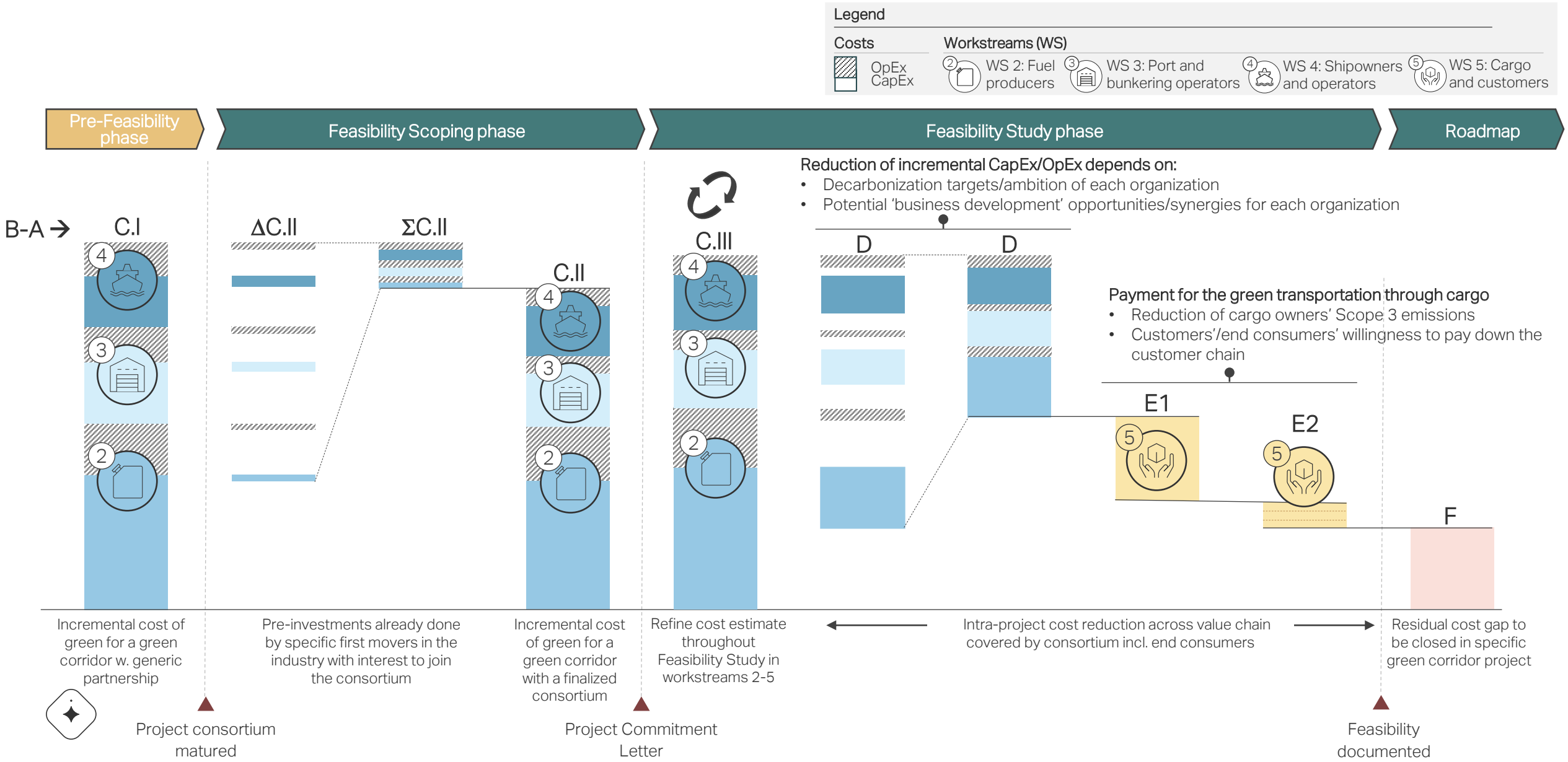
- OpEx
- CapEx

Workstreams (WS)

- WS 2: Energy & Fuel producers
- WS 3: Port and bunkering operators
- WS 4: Shipowners and operators
- WS 5: Cargo and customers

Refinement during Feasibility Study

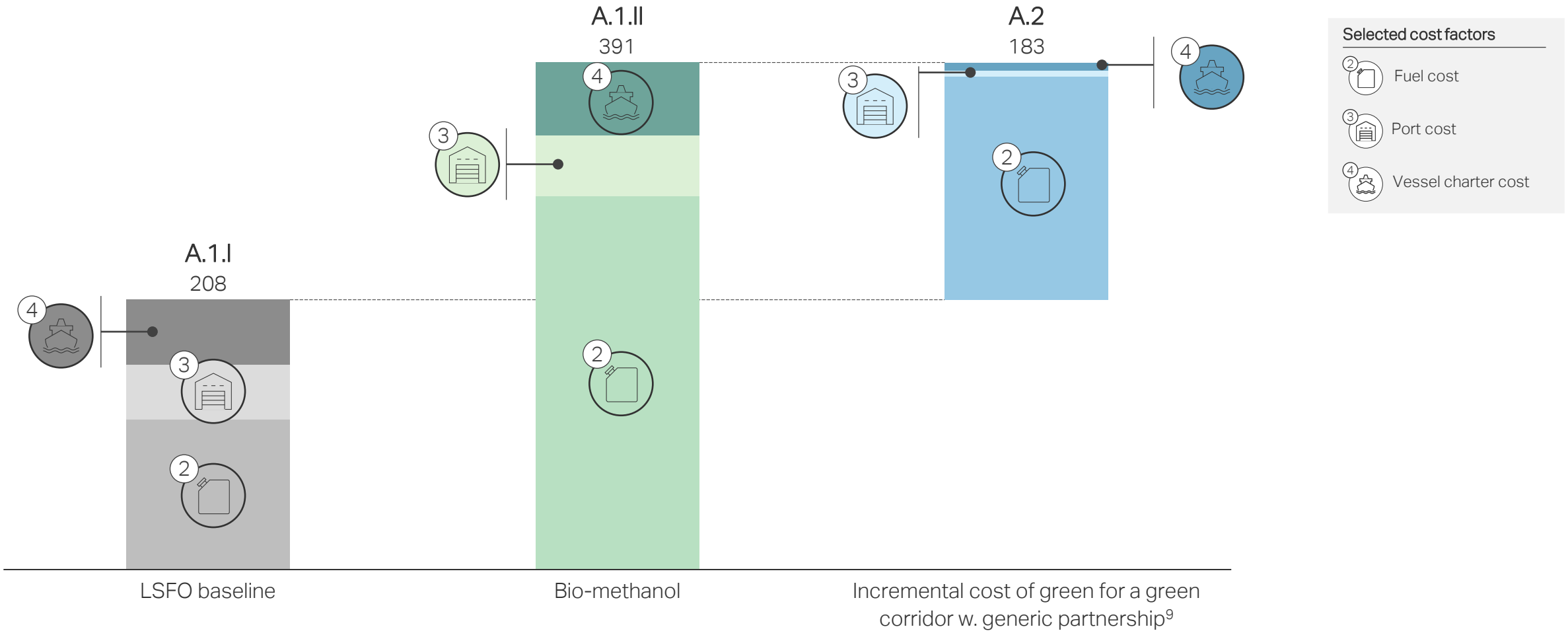
The incremental cost of green – full overview



EXAMPLE

A. Calculating the incremental cost of green – Example

Incremental decarbonization cost along the value chain compared to LSFO (selected cost factors), USD/TEU[8]



8 Cost per TEU for a 1,500 TEU ship sailing on different fuel types from Hamburg, Germany to Kotka, Finland. Source: Maritime Decarbonization Strategy 2022

9 Estimate to be further refined with cost inputs received from consortium members after the Project Commitment Letter has been signed

Workstream 6

4 Study phase kick-off

5 Feasibility assessment along 4 dimensions

6 Consolidation

7 Mapping the route forward

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M Cargo demand dynamics 5

N Residual cost gap analysis 6

O Consolidation of Feasibility assessment 6

P Roadmap 7

6O. Consolidation of Feasibility assessment

Purpose

- Consolidate findings from the Feasibility assessment along the green corridor.
- **Technical feasibility assessmen**t: Identify technical challenges and define actions to accelerate the implementation of the corridor.
- **Regulatory feasibility assessment:** Regulatory and policy changes for the green corridor to go ahead.
- Estimate the total corridor **incremental cost of green** as well as the **residual cost gap.**
- **Just and equitable assessment:** Consolidate J&E assessments across workstreams 2 to 5 with the general J&E assessment (performed by Project Lead in scoping phase).
- Develop a **risk register** and identify potential **mitigation actions.**
- Summarize insights on **technical, regulatory and J&E feasibility** as well as **costs.**

Key questions

- What are the **technical challenges** (if any) for the implementation of the green corridor? What **actions are required to reach technical feasibility?**
- What are the **regulatory and policy constraints**? What **actions are required to reach regulatory feasibility?**
- What are the **costs** (CapEx and OpEx) **through the value chain** to deliver the development, construction and operation of the green corridor?
- What are the **options for cost reduction** in the value chain elements?
- Are there **synergies** that can be realized across these steps?
- What needs to be addressed to create a **just and equitable** corridor?

Importance

- **Quantifying** the residual cost gap is essential to **evaluate the trajectory** of a green corridor in terms of receiving sufficient funding to move towards execution. Based on the outcome of the analysis, the project team will engage stakeholders outside the consortium to identify options to close the residual cost gap (e.g., subsidies or loans).
- The validity of the cost assessment as well as the relevance relies on the **quality of the technical and regulatory feasibility assessments.**
- About **Just and Equitable**, this step enables stakeholders to **make informed decisions and facilitates necessary policy changes** for the green corridor.
- The just and equitable assessment ensures that the **benefits** of the green corridor are **distributed fairly among all stakeholders**, including affected communities and worker groups.

6O. Consolidation of Feasibility assessment

Summary of chapter findings and outcomes

01

Technical feasibility:

- Identify the main gaps between baseline status and aligned project scope per chapter (see Feasibility matrix), evaluate and rank them

02

Regulatory feasibility:

- Identify the main gaps and hurdles to achieve the aligned project scope per chapter (see Feasibility matrix in Appendix 6.5), evaluate and rank them

03

Cost assessment:

- Calculate residual cost gap of green shipping using CapEx and OpEx (for 25 years of operation) results of Workstreams 2-5 (list pre-project investments also)
- Identify possibilities to eliminate residual cost gap and sequence them (starting with cost reduction measures within the project consortium)

04

Risk register and a list of potential mitigation actions:

- Develop respective mitigation actions and sequence them

05

Just and equitable assessment:

- Summarize which communities, workers and ecosystems are most likely to be affected by the green corridor. Consider how to ensure their representation in the project going forward. In addition, ensure transparent project governance systems
- Develop an overview of the socio-economic risks and opportunities throughout the corridor. Develop mitigation actions for risks that are not included in the risk register and consider how the opportunities can be maximized

Consolidate technical feasibility results, specifying main gaps between assessments and target state throughout value chain

	1	2	3	4	5
Steps	Identify technical challenges (if any) across the value chain, and develop a risk register	Define how technical challenges are expected to evolve/be resolved over time (e.g., timing for availability of ammonia-fueled engines) and how this aligns with the project timeline, and include these mitigation actions in the risk register	Categorize technical challenges based on their severity and impact on the green corridor (critical vs. lower-priority challenges) as well as a high-level estimate of the cost associated with resolving the technical challenge	Define scenarios for timing the resolution of main technical challenges, assessing project timeline implications and actions required	Define actions and their sequencing to accelerate the technical enablement of green corridors, highlighting stakeholders who should be involved and ensuring critical actions are prioritized
Inputs	• Technical assessment – Input from Workstreams 2-4	• Technical assessment – Input from Workstreams 2-4 • Technical/technological trends and outlook based on market reports • Overall project timeline – Input from Pre-Feasibility Study	• Technical challenges	• Technical assessment – Input from Workstreams 2-4 • Current proposed decarbonization pathway – Input from Workstream 4	• Technical assessment – Input from Workstreams 2-4 • Current proposed decarbonization pathway – Input from Workstream 4 • Scenarios for the resolution of technical challenges

Consolidate regulatory feasibility of the green corridor

	1	2	3	4	5
Steps	Identify potential regulatory challenges across the value chain and relevant levels of governance (international, regional, national, local) and compliance with applicable sustainability conventions and guidelines, including: • Regulatory/policy constraints • Permitting • Areas with lacking policy/regulatory structure or guidelines • Compliance with conventions and guidelines, such as UN Global Compact, Just Transition, and individual stakeholder commitments	Categorize regulatory challenges based on their severity and impact on the green corridor (critical vs. less urgent challenges) into a risk register and estimate the costs associated with resolving the regulatory challenges	Identify required policy changes across the value chain and levels of governance to realize or accelerate the green corridor (e.g., policies to expedite safety measures) and map the timing for expected policy changes	Map and prioritize policy and regulatory changes by expected feasibility and impact, identifying timeline implications (e.g., actions to put policy changes on appropriate agendas)	Assess the overall regulatory feasibility for the green corridor, highlighting areas of concern
Inputs	• Input from Workstreams 2-4 • UN Global Compact commitments • Just Transition targets and commitments • Commitments from partners/stakeholders	• Current regulatory challenges	• Current regulatory challenges	• Expected feasibility and impact of policy/regulatory changes	• Combination of the previous steps

Consolidate cost assessments throughout value chain, estimate the total corridor incremental cost of green as well as the residual cost gap

	1	2	3	4
Steps	Aggregate the total value chain cost for establishing (CapEx) and operating (OpEx) the specific corridor and compare with a similar fossil-fuel corridor	Estimate the cost of the green corridor in absolute terms, incremental cargo unit cost, as well as the cost per ton of abated CO_2, and compare with similar projects/options. Identify options for cost reduction through synergies, ESG value and business development along the value chain	Identify the 'willingness to pay' for green transportation in the specific green corridor: • Cargo owners • Customers through the downstream chain	Identify the residual cost gap to be closed for the green corridor at hand and identify options for closing the cost gap (see Appendix 6.3) for the residual cost gap guideline)
Inputs	• Input from 6N • Dialogue with consortium members to understand options for cost reduction through synergies, ESG value and business development	• Insights from cargo owners specific to the project • Specific and/or general view on the end customers' willingness to pay	• Input from Workstream 5 • Insights from cargo owners specific to the project • Specific and/or general view on the end customers' willingness to pay	• Combination of the above • Public and private funding options available in region, segment, etc.

Develop a risk register and identify potential mitigation actions

	1	2	3A	3B	4
Steps	Aggregate risks across dimensions, incl.: • Technical • Regulatory • Costs	Identify risks for • Executional • Organizational • Commercial • Just & Equitable workstreams 2-5	Estimate the high-level probability and impact of each risk, quantifying the project's probability-adjusted risk	Identify mitigation actions to either reduce risk probability or impact on the green corridor, prioritizing risks with a high impact and/or high probability	Propose metrics/indicators to identify and measure risks throughout the project as it moves forward
Inputs	• Identified challenges	• Implementation and completion of tasks • Individuals or teams responsible for execution • KPIs, progress, timelines • Market research • Activities related to diversity, equity, and inclusion	• Past examples of comparable projects • Stakeholder interviews	• Risks identified	• N/A

J&E assessment - Consolidation

Steps	1	2	3
	If relevant, identify the potentially-affected communities, workers and ecosystems.	With the identified groups and ecosystems in mind, go through the questionnaire and consider the identified risks and opportunities	Consider the ESG / Sustainability Strategies of commercial stakeholders involved in Workstream 5
Further explanation	• **Communities:** Affected communities such as port communities, coastal communities or communities in the vicinity of new fuel or energy infrastructure. • **Workers:** Affected workers such as those handling cargo or low/zero emission fuels etc. • **Ecosystems:** Affected ecosystems on land and ashore such as those in the vicinity of new fuel or energy infrastructure developments, and port and bunkering facilities associated with the corridor but also those affected through land use change, water use, or biochemical flows related to these developments.	• Use the questionnaire provided in the J&E Data Collection Sheet • If relevant, highlight risks that should go into the risk matrix	• Identify synergies between project objectives and the ESG / sustainability strategies for stakeholders involved in WS2. For inspiration, consult the ESG questions provided in the Pre-feasibility data collection Excel tool, Tab 5.2

4 Study phase kick-off

I Corridor baselining 1

5 Feasibility assessment along 4 dimensions

J Alternative fuels supply chain 2

K Port and bunkering infrastructure 3

L Vessel decarbonization pathway 4

M Cargo demand dynamics 5

6 Consolidation

N Residual cost gap analysis 6

O Consolidation of Feasibility assessment 6

7 Mapping the route forward

P Roadmap 7

7P. Roadmap

Purpose

1. Build an **integrated roadmap for each value chain participant,** considering the sequencing and lead time of projects and risk scenarios, and map relevant **milestones:**
   - Select and Define phases:
     - Detailed roadmap
     - **Project governance** and resources
     - **Communications and engagement plan** for internal and external stakeholders
   - Execute and Operate phases:
     - High-level timeline including lead times
2. **Create** a **comprehensive roadmap** with required investment decisions and outline funding options to close the incremental cost of green.
3. **Outline initial thoughts** regarding commercial arrangements, offtake agreements, etc.
4. **Sign off** on the integrated roadmap

Key questions

- What are the **short and long-term steps** to **operationalize** the green corridor?
- What are the **steps needed for a final investment decision (FID) of the project?**
- What are the **commitments and investments/projects required** from each stakeholder to close part of the incremental cost of green and enable the integrated business case?
- What is the **overall roadmap toward operationalizing the green corridor** and what **actions does each stakeholder** need to take?
- What is the required **project governance** to deliver the roadmap for the next phases (Select and Define)?
- What are the **resources and capabilities required to complete the next phases** (Select and Define) of the project?
- What is the **internal and external stakeholder communications plan?**

Importance

- The roadmap is a **key decision tool** for these project participants both for planning to move the project forward, and for discussing public **funding options**.
- **Public funding (along with private funding)** will be **required** to ensure that the first green corridor will move forward.
- For **public funding** to be unlocked, thorough documentation validating the green corridor's decarbonization potential is needed.

7P. Roadmap

Summary of chapter findings and outcomes

01	**Summary of feasibility study**
02	**Statement of feasibility**, a summary of the Feasibility Study output considering technical and regulatory aspects - CO_2 abatement
03	• Summary of incremental and residual cost gaps • Funding options • $/t CO_2
04	Proposed **integrated roadmap** and milestones for each stakeholder for each upcoming phase including **investment decisions/**CapEx requirements
05	• **Immediate next steps and investment** requirements for next phases (Select and Define) • **Potential commercial arrangements** and **commitments**
06	**Communication plan**

Build an integrated roadmap for each value chain participant and map relevant milestones

Steps

1

For the Select and Define phases:

- Define the list of activities/projects required across the value chain, outlining interdependencies and considering sequencing and lead times
- Overlay risk assessment onto roadmap (e.g., high-probability execution risks built into the timeline)
- Create a detailed list of milestones planned over time, linked to above activities

2

For the Execute and Operate phases, develop a high-level view on the main milestones per phase and associated timeline for each activity

Inputs

- From Section 6
- Risk register – Input from Workstream 6

- Decarbonization potential, ambition and timeline (if available) for the corridor
- Lead time for key equipment

Catalog investment decisions, expected lead times, and required commercial arrangements planned over time by value chain participant

	1	2	3	4
Steps	Catalog investments required by each element of the value chain over time per concept (e.g., alternative fuel, propulsion engine), and identify expected lead times per investment/project	Review commitments outlined by stakeholders to partly close the incremental cost gap and enable the integrated business case for the green corridor for each feasible concept, including CapEx investments	Summarize the financing needs over time to secure sufficient funding for the project	Catalog the dependencies and commercial arrangements required with partners outside the consortium (e.g., engineers, manufacturers, shipyards, financial institutions) • Offtake commitments (e.g., for fuel producers from shipping, other sectors) • Contracting commitments (e.g., from cargo owners)
Inputs	• CapEx requirements per stakeholder over time – Input from Workstreams 2-5 • Feasible solutions for corridor – Input from Workstream 6	• Commitments required per stakeholder – Input from Workstream 6	• Financing requirements and sources (e.g., public and private financing options, "green" investment subsidies, local funding/subsidy programs) – Input from Workstream 6	• Commitments and capacity requirements for external stakeholders – Input from Workstreams 2-6

Define the project governance and resourcing requirements to complete the Select & Define phases (1/2)

	1	2	3
Steps	Map all relevant stakeholders (internal and external) for the green corridor, and define their roles in the project, e.g., core consortium participants, knowledge partners, external stakeholder	Define groups and capabilities required for the project governance and their responsibilities, participants, resources, and cadence, for: • Decision making (steering committee) • Central coordination/PMO[10] group • Engineering teams from stakeholders • Central regulatory affairs group • Central business case analytics group • Legal / contractual activities • NGOs or local civil society groups	Determine the processes (i.e., cadence of meetings, participants, forum, escalation management) and ways of working/reporting lines within the project
Inputs	• List of stakeholders	• Examples of other consortia • Engagement with consortium members	• Consortium format – Input from Pre-Feasibility • Examples of other consortia • Engagement with consortium members

10 : Project Management Office

Define the project governance and resourcing requirements to complete the Select & Define phases (2/2)

	4	5	6
Steps	Outline possible consortium configuration and structure, considering the option to establish a legal entity structure, and define implications for project funding	Estimate investments required to complete the next phases (Select and Define) of the project, based on outstanding steps toward FIDs and required project governance	Identify stakeholder appetite and funding availability to enter next phases (Select and Define), given investment requirements
Inputs	• Discussion with stakeholders • Legal and economic considerations	• Roadmap for Select and Define phases • Resources for project governance	• Next-phase investment requirements • Discussion with stakeholders

Develop a communication and engagement plan for internal and external stakeholders in the Select and Define phases

	1	2	3	4
Steps	Map all stakeholders (internal and external – e.g., government, national/international regulators, industry leaders, industry coalitions, general public) for the green corridor and assess prioritization of engagement by level of criticality and level of urgency to contact	Identify project milestones that require/prompt external communications	Develop core messages per external stakeholder for each phase of the green corridor project, syndicating with project team and consortium stakeholders	Build an action plan for each stakeholder group, incl. mode, timing and cadence of communication, and person/group responsible for communication per stakeholder group
Inputs	• List of stakeholders – 7.1 output	• Project phases and respective milestones • Map of stakeholders	• Communication milestones	• Combination of the previous steps

Activities to be included in the roadmap for next project phases

NOT EXHAUSTIVE

Select

- Agree on **criteria to rank project concepts** along value chain (e.g., timing, cost)
- Identify and **gather additional insights** required for ranking
- **Select final concept** based on project concept ranking

Define

- Create **detailed design plans & schedule** for the technical work required for each step in value chain, **highlighting interdependencies**
- Detail **regulatory and policy changes required** (e.g., ammonia handling)
- Create **implementation plan for required regulatory and policy changes**
- Draft **commercial frameworks** (e.g., offtake agreements)
- Detail **financing frameworks** for FID (e.g., subsidies, local funding)
- Define the **consortium legal structure** for the execution and operation of the green corridor (e.g., asset ownership, project funding)

Execute

Operate

- **Execute project** in a safe and cost-efficient way, with **all testing, validation, training, and frameworks completed** (further details per project needed)
- **Hand over to operators** on corridor

Congratulations on successfully completing the Feasibility Study phase of your green corridor project!

Thanks to the collaborative efforts across various workstreams, the project team has achieved a comprehensive understanding of the key components comprising the green corridor: fuel, ports, vessels, and cargoes, considering their technical, financial, and regulatory aspects.

This culmination is presented in a comprehensive final report, complete with a **risk matrix and mitigation plan**, offering a holistic view of the **global feasibility** of the green corridor project.

What comes next?

With all essential elements now assembled, stakeholders are poised to determine the project's direction, establish a **roadmap**, define **governance** structures, and allocate **resources** for the next critical phase: the engineering and commercial design of the green corridor.

Disclaimer

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