REPORT

Green hydrogen derivatives export – logistic analysis

Final Report

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ADMINISTRACIÓN NACIONAL DE PUERTOS
República Oriental del Uruguay

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This consultancy report was prepared by the Port of Rotterdam and Royal HaskoningDHV. The opinions and recommendations expressed do not necessarily reflect the positions of the commissioning and/or counterpart institutions, nor do they bind the Uruguayan state. The export scenarios analysed are solely hypotheses considered for the studies conducted, and do not imply any commitment by the Uruguayan state regarding production and export volumes

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Executive Summary

Competitive advantages

Uruguay has several key competitive advantages compared to other countries exploiting the production and export of hydrogen, such as:

- Institutional stability
- Potential to develop new renewable energy generation capacity
- Current electrical grid already almost completed (>95%) decarbonized
- Availability of biogenic CO_2 thanks to the pulp industry

It is expected that the production capacity of hydrogen derivatives, such as methanol, SAF and urea, will develop and grow in Uruguay over the coming years, capitalizing on the availability of biogenic CO_2.

Logistic strategies

Hydrogen derivatives will be produced in various regions in the county with potential for production of renewable energy, availability of fresh water and CO_2, and logistic opportunities.

The products will be transported from the production facility to a port for exports to international markets. The logistic solution selected for a certain export flow will depend on location, availability of equipment, price levels, reliability, etc. It is likely that a mix of options will be selected, including the use of rail, barge, and different types of tankers.

Uruguay is accessible by water along the west side of the country by the Rio Uruguay, along the south side of the country by the Rio de la Plata, and to the Atlantic Ocean through Montevideo. The maximum vessel size is limited by the water depth as shown in Table 0-1.

Table 0-1 Maximum vessel sizes used for the maritime supply chain.

River / site	Water depth	Vessel type	Maximum vessel size
Montevideo	13m (14m planned)	Large tanker	50,000 ton
Rio de la Plata	10m	Medium tanker	25,000 ton
Rio Uruguay	7m	Barge Small tanker	2,500 ton 7,500 ton

It is expected that the central rail corridor will be used for products from the central / North Eastern parts of the country. Production facilities in the western side of the country are likely to use barge or tanker transport on Rio Uruguay and Rio de la Plata. It is likely that a mix of options will be selected, including the use of rail, barge, and different types of tankers. The resulting export supply chain is schematized in Figure 0-1.

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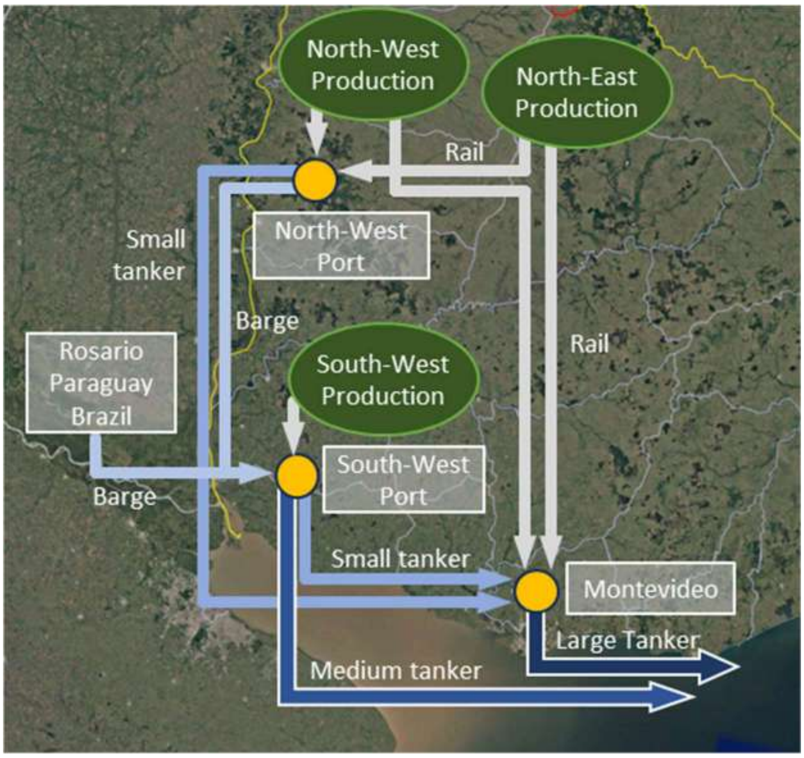

Figure 0-1 Schematisation of export logistics

Terminal capacity

Export of hydrogen derivatives will require marine terminals in ports where product can be received (by rail, vessel or pipeline), stored in tanks, and exported using ocean-going tankers. Key considerations for the location of the marine terminal are space availability, safety zones, hinterland connections, maritime accessibility, environmental impact, scalability, and cost of development.

The required capacity of each of the terminals will depend on the total production volumes and locations. Initially one berth and a terminal area of 1 or 2 hectares will suffice. When volumes grow and operations expand, multiple berths and larger terminal areas are required.

Initially, terminal operations may use existing infrastructure as much as possible to reduce initial investments, and leverage on other cargo flows to share required general investments. Later, when volumes grow and shipping increases, the terminal can be converted to a dedicated terminal with additional capacity.

Marine terminal sites

Key ports include Montevideo, a North-West port along the Rio Uruguay, and a South-West port at the mouth of the Rio Uruguay / Rio de la Plata.

There are different options for the development of a marine terminal in Montevideo. The main port basin of Montevideo has deep water allowing the use of larger tankers. In addition, the port is well connected by rail. However, available space for a terminal is limited and safety needs to be considered in areas close to populated areas.

Promising options for a terminal in Montevideo are the East basin reclamation, reclamation along the Dique de cintura, or a site at ANCAP / Capurro, as shown in Figure 0-2.

Figure 0-2 Potential marine export terminal sites in Montevideo.

A possible terminal layout for the East basin reclamation, with a berth along the Digue de Cintrura, is shown in Figure 0-3.

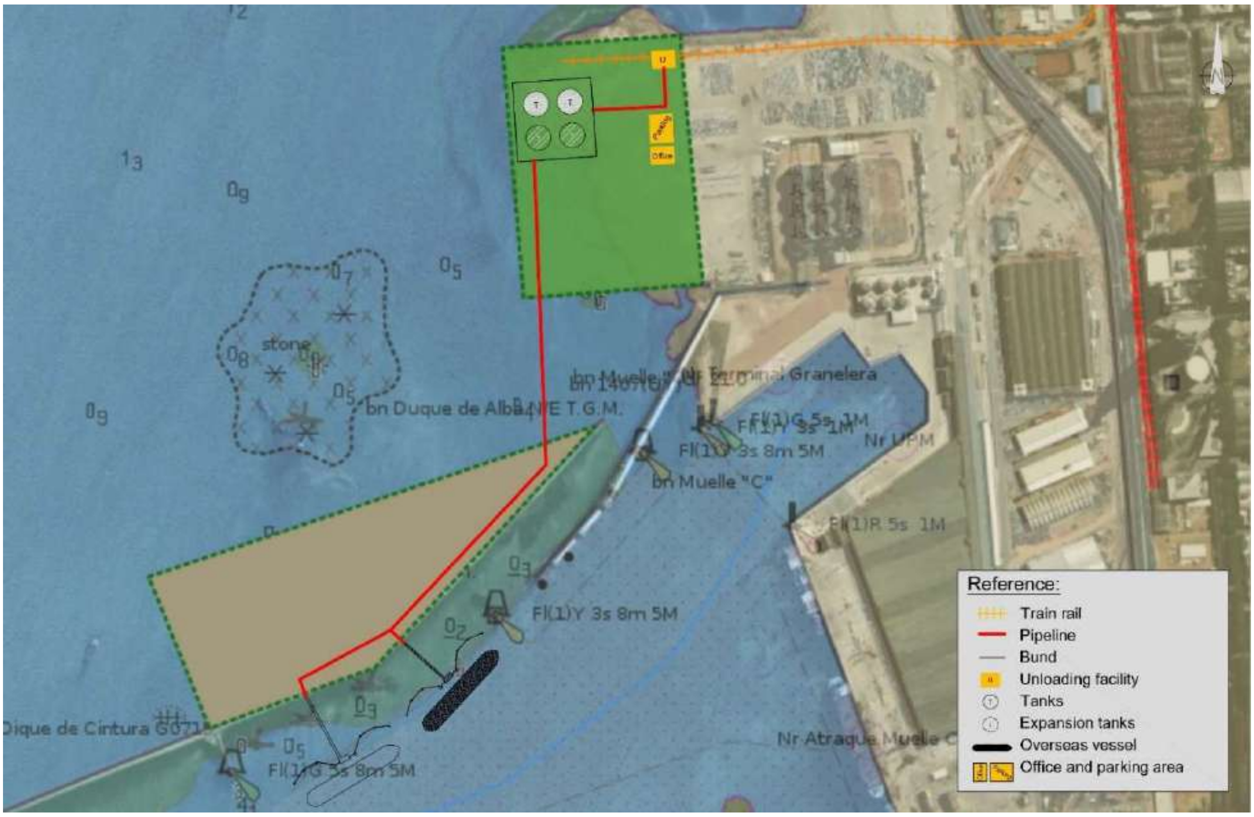

Figure 0-3 Potential marine export terminal layout in Montevideo

The North-West port will likely be in Paysandú. The ALUR site in Paysandú is well- suited for a marine terminal for barges and small tankers thanks to its space availability and connectivity (refer Figure 0-4).

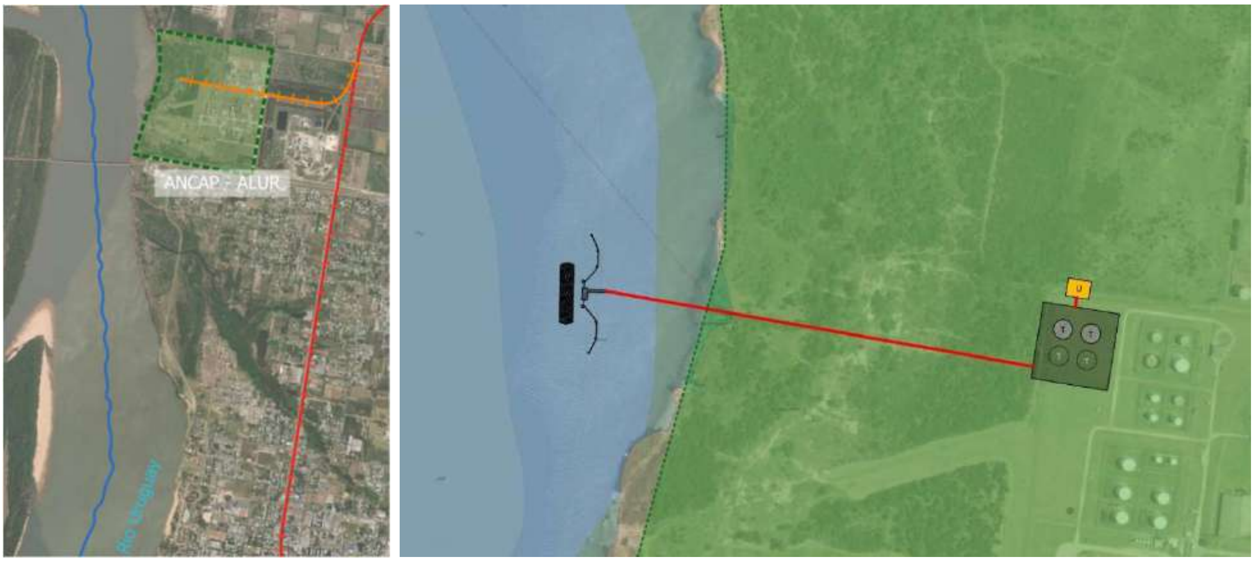

Figure 0-4 Potential marine export terminal layout in Paysandú

For the South-West port Nueva Palmira could be suitable. A port in this locations could also grow into a transshipment hub for the hinterland of Brazil, Paraguay and Argentina. A possible terminal layout at Nueva Palmira is shown in Figure 0-5.

Figure 0-5 Potential marine export terminal layout in Nueva Palmira

1 Introduction

1.1 Project background

Uruguay has competitive advantages for the development of green hydrogen and its derivatives. The quality, abundance and complementarity of wind and solar resources would allow reaching competitive costs for hydrogen production at scale. By 2030, as per the studies developed, production costs in Uruguay could reach 1.2-1.4 USD/kg with a total capacity of more than 90 GW of power based on renewable energy in the sites with the greatest potential.

In turn, the country has hydroelectric power plants, power transmission grid infrastructure, easy access to biomass and high availability of fresh water that would allow for low-cost synthetic fuel production of e-fuels and other hydrogen related products. Uruguay has ports with access to the Atlantic Ocean. Also, the country has the intention to further develop important infrastructure and internal logistics capacities. Based on the potential of its resources, hydrogen production could be around 1 Mt H2/year by 2040 or even earlier. An export terminal would be required to export such volume; this export terminal is the main subject for this project.

This study focuses on the maritime facilities required for the export of green hydrogen derivates such as e-methanol, e-fuels and urea, while the export of pure hydrogen, or in the form of ammonia, is not considered in this study. The study considers various potential sites in Montevideo Bay area and along the Río de la Plata and Río Uruguay. Sites along the Atlantic coast are not considered in this study.

The project is focused on the identification of a long list of options for an export terminal of hydrogen products, both in the Montevideo Bay area and the greater area along the coast of Río de la Plata and Río Uruguay. Based on a high-level qualitative assessment/comparison, as well as the inspections and interviews done during the site visit, the long-list has been reduced to a short-list of preferred and potentially attractive locations. For the short-listed site an overview per location was created with main characteristics and recommendations.

1.2 Project organisation

Port of Rotterdam and Royal HaskoningDHV were asked to carry out an analysis of the logistics at the port of Montevideo and other alternative ports for the export of green hydrogen derivatives. The study was completed in the period February – May 2024.

The study is financed by the United Nations Industrial Development Organization (UNIDO) and sponsored by the Uruguay Ministry of Industry, Energy and Mining (MIEM), the Ministry of Transport and Public Works (MTOP) and the national port authority (ANP).

1.3 Objective of this report

The study includes the following main milestones:

- Task 1 – Inception stage (Feb-2024)
- Site visits and stakeholder meetings (Mar-2024)
- Task 2 – Site evaluation (Apr-2024)
- Task 3 – Site development plans (Apr-2024)
- Task 4 – Logistic analysis (this report)

This Logistic analysis report is the final report that combines results from all milestones into a one complete document.

2 Production of green hydrogen derivatives

2.1 Global hydrogen market

On the road to meet the goals of the Paris agreement, the role of hydrogen will grow in multiple sectors. The bulk of future hydrogen demand will result from the power, industry, and transport sector. The total global demand is expected to grow to 300 million ton per annum (mtpa) if the current trajectory is followed or up to 660 mtpa to achieve all global commitments (McKinsey 2023, Deloitte 2023). The growth and distribution per sector are presented in Figure 2-1. In industry, hydrogen is a vital feedstock to produce green steel and green fertilizer and it can be used to reduce the carbon footprint of conventional fossil fuels by replacing grey hydrogen in refineries. In transport, hydrogen or its derivatives can be used where electrification is not an option. It is unlikely that medium to long-haul flights will ever be able to switch to electricity, and the production of synthetic fuels with hydrogen is a way to decarbonize these flights.

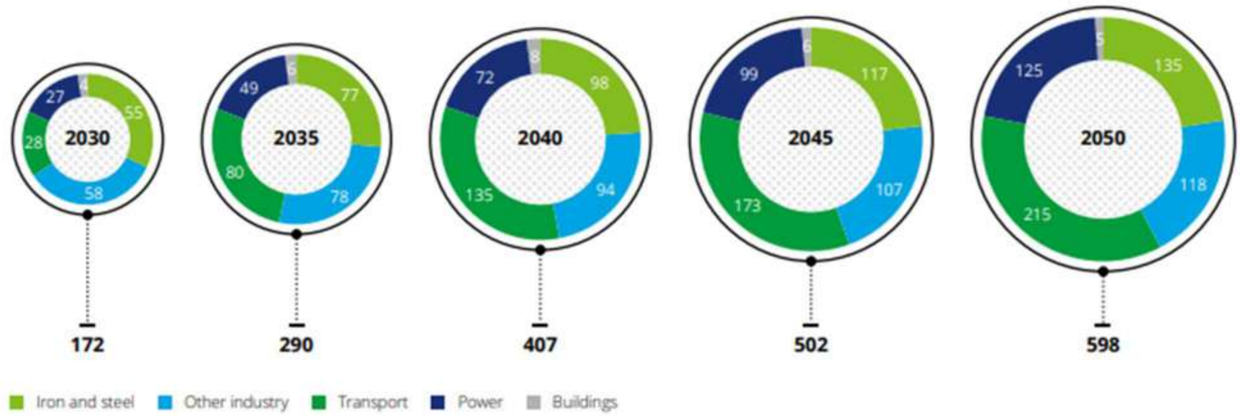

Figure 2-1 Growth of global hydrogen demand in mtpa (Deloitte 2023)

In the shipping sector ammonia is expected to be the fuel of choice due to scalability and costs in the long-term future, but methanol currently makes up a larger portion of the order book of new vessels. In the power sector hydrogen can be used as a storage medium of renewable energy, to decarbonize location with no access to renewable energy, or to supply renewable energy when there is no wind or sun to supply complete demand.

End-users will not all use hydrogen. A significant portion of all hydrogen is used to produce derivatives that are easier to handle or necessary feedstocks for industry. Figure 2-2 displays that of the total 600 Mton by 2050, 130 Mton H2eq of ammonia will be produced, 32 Mton H2eq of methanol and 115 Mton H2eq of SAF.

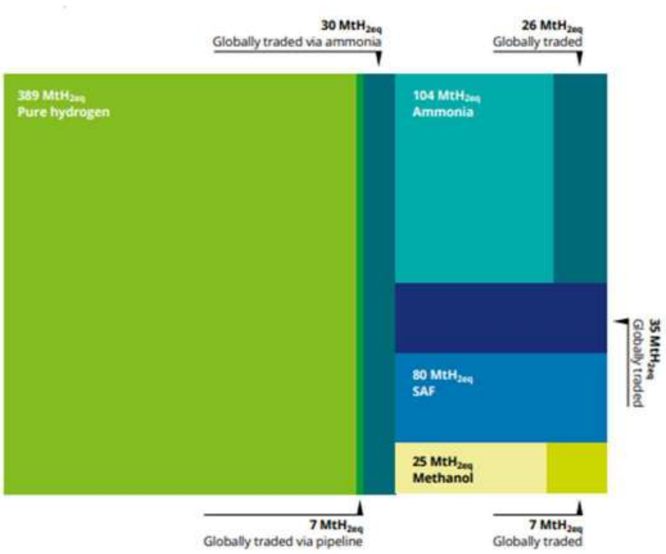

Figure 2-2 Breakdown of global hydrogen production per carrier (Deloitte 2023)

For Uruguay, especially the SAF (Sustainable Aviation Fuel) and methanol markets are interesting. The production of both SAF and methanol (and other e-fuels such as e-diesel) requires green hydrogen as well as carbon. Uruguay has abundant bio-genic CO_2 supply, being produced as byproduct from pulp mills. By

2050, 38 Mton of Methanol and 59 Mton of SAF will be traded globally, suggesting there is a substantial potential market for Uruguay to serve. Apart from SAF also other e-fuels (which can be derived from e-methanol) will be an important market.

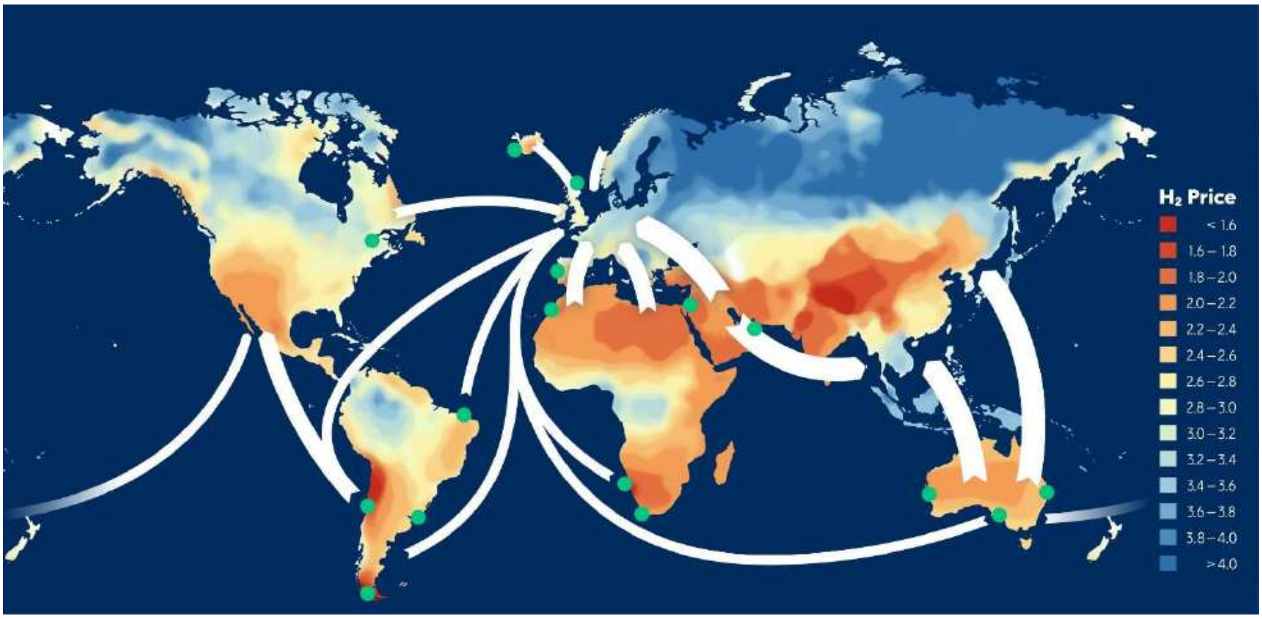

Figure 2-3 Major Hydrogen flows 2030 (Source: iea.org & PoR internal study)

In July 2023, Uruguay and the EU signed a Memorandum of Understanding with the aim to cooperate closer in the field of renewable hydrogen, and its derivatives. In Figure 2-3 the major hydrogen flows by 2050 are displayed. The EU and possibly India are the most interesting markets for Uruguay. Although the EU does not have the highest demand as a region, it does lack the necessary conditions to be self-sufficient.

The EU is also one of the first jurisdiction to develop legislation that does provide an outlook on early demand growth from 2030 onwards. The effects of legislation, both from the EU as well as global institutions, are discussed in section 2.3. Uruguay has also signed specific government-to-government MoUs with dedicated countries that could play an important role in this supply-chain, like the Netherlands. Port of Rotterdam can serve as the import-Hub for these derivatives into North-West Europe.

2.2 E-fuel production

As mentioned in the previous section, Uruguay is well positioned to produce different kinds of e-fuels. In this section, a brief description of different e-fuel production pathways is presented.

The common feature of the listed e-fuels is that green hydrogen is required for the fuel to classify as renewable. The classification, and the use of the term 'green', differs per jurisdiction. Here the EU definition of Renewable Fuels of Non-Biological Origin (RFNBO) is used.

For green hydrogen to classify as RFNBO it must have a carbon intensity of 3.4 kg CO2/kg H2 or lower. This means that the hydrogen must be produced with electricity that has a carbon intensity of 68 g CO2/kWh or lower, assuming 50 kWh/kg hydrogen.

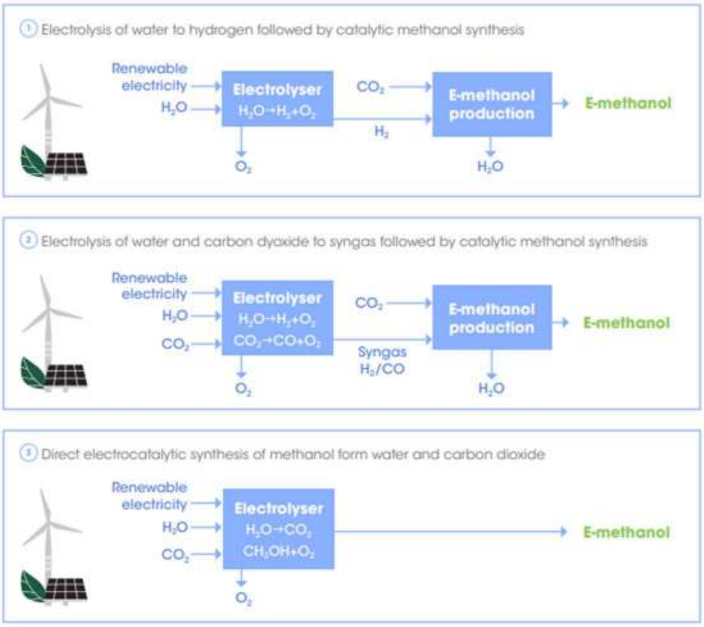

Figure 2-4 Production pathways e-methanol (IRENA 2021)

In the last year, the grid carbon intensity of Uruguay was below this threshold for 8 of the 12 months (Electricity Maps 2024), with an average grid carbon intensity of 78 g CO2/kWh. This means that hydrogen production with grid electricity is possible, when taking proper measures to ensure a carbon intensity below the threshold. Potential measures include energy storage, additional renewable energy generation or switching off when the carbon intensity threshold is surpassed.

There are two distinct categories of renewable methanol, i.e. bio-methanol and e-methanol. The pulp mills have bio-methanol as a byproduct, but this is usually used in the production process. The main focus of this report is e-methanol.

E-methanol is produced by combining green hydrogen and green carbon. There are three pathways to produce e-methanol, listed in Figure 2-4. The most mature and simplest production pathway is the direct reaction of CO_2 and H_2. For every ton of methanol, 0.19 ton of hydrogen and 1.38 ton of CO_2 is required. The other production pathways theoretically have a higher conversion efficiency but have yet to be proven feasible on a large scale.

For SAF, there are also two distinct production pathways, biogenic and synthetic. The difference here being that for the most important biogenic production pathway, HEFA, large quantities of green hydrogen are required. SAF production through the Hydrotreated Esters and Fatty Acids (HEFA) process does not scale well, due to the lacking availability and decentralised sourcing of the most important feedstock: cooking oil.

The alcohol-to-jet SAF pathway is gaining momentum, with several companies announcing significant production capacity. There are also other biological feedstock options available, but to classify as sustainable these sources may not compete with food production or harm the environment.

The synthetic power-to-liquid pathway theoretically has a limitless supply available, as the only resources required for the production are electricity, water, and carbon. The CO2 is used to produce CO, which can be combined with hydrogen through the Fischer-Tropsch process to form complex hydrocarbons. This process can be seen as the reverse of conventional fuel burning.

This process is not only used for SAFs but is also used to produce other synthetic hydrocarbons such as e-methane or e-diesel. The biggest advantage of SAFs is that they can be used as drop in fuels, requiring little engine adaptation.

2.3 Regulations

2.3.1 Introduction

The demand of e-fuels is driven by legislation and regulation set out by governments and international institutions, due to the price difference between conventional fuels and e-fuels. Multiple institutions and countries are implementing rules to move towards a net zero society. Below, the relevant legislation of the EU and the IMO are discussed.

2.3.2 European Union

Legislation can be divided along two lines. Market regulation, developing a market despite unfavourable economics, and classification, making sure that definitions are aligned.

The EU is actively building the market for e-fuels by focusing legislation on the development of demand and supply. ReFeul EU mandates the uptake of biobased and synthetic SAFs, by implementing a step-by-step SAF blend percentage obligation. The step-by-step approach is illustrated in Figure 2-5.

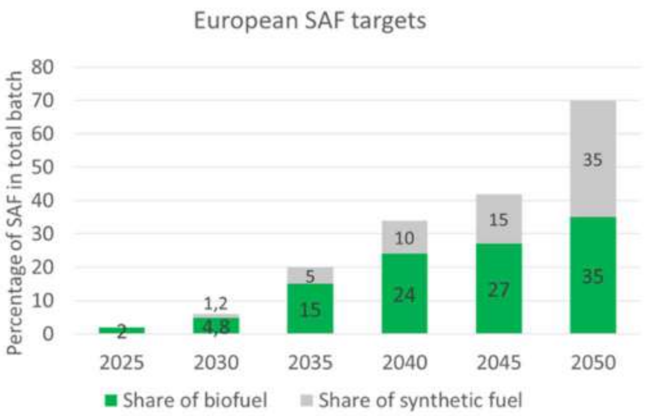

Figure 2-5 ReFeul EU blending requirements

Through Fuel lEU Maritime (FEUM) the shipping sector is required to lower its weighted carbon intensity of its energy demand. Starting at a 2% reduction by 2025 and working towards an 80% reduction by 2050. The severeness of the penalties for non-compliance are a clear incentive for ship operators to transition towards alternative fuels. This is further strengthened by the inclusion of the shipping sector in EU ETS, further penalizing GHG emissions.

The development of necessary infrastructure for the fuel transition of road, sea and air transport is supported by the Alternative Fuel Infrastructure Regulation (AFIR). Transport hubs are required to develop the necessary infrastructure to facilitate the fuel transition.

The EU has alternative fuel classification legislation in place to enhance transparency for industry and ensure a level playing field between different countries. Fuels are classified by the EU as Recycle Carbon Fuels (RCFs) or Renewable Fuel of Non-Biological-Origin (RFNBOs) when the footprint is below the threshold of a 70% reduction with respect to the benchmarked fossil fuel footprint of 95 gCO2e/MJ (EU Regulation 2023/1185, supplementing RED). This means that methanol can have a footprint of 0.56 kg CO2/ kg. If the e-methanol exceeds this threshold, the combustion emissions will be equal to fossil methanol under the FEUM legislation, not counting towards reduction goals.

According to the EU Regulation 2023/1185, carbon dioxide from industrial CCS is classified as 'avoided emissions' until 2041, if the used CO2 is accounted for under ETS, or a similar CO2 pricing system. CO2 stemming from the energy sector is classified as 'avoided emissions' up to 2036. Therefore, green methanol production with carbon from industry can be used up to 2040 for the EU market, if the industries are covered under a CO2 pricing mechanism. Uruguay has the highest carbon price world-wide, in the form of a carbon tax of 156 USD/tCO2 (World Bank 2023).

Whether the combustion of RFNBOs and RCFs will require surrendering emission allowances is still unclear. This will be decided in the course of 2024 (FAQ Maritime Transport in EU Emissions Trading System). Currently the combustion of sustainable biomass is exempt from ETS. If RFNBOs and RCFs will get the same treatment, a strong incentive to switch to these fuels would be created, but if the emissions will fall under ETS, there will be little reason to switch to these more expensive fuels.

2.3.3 Shipping

The International Maritime Organisation is the UN Maritime regulatory body. In 2023 the IMO passed, through unanimous vote, the ambition of a net zero shipping sector by or around 2050. The IMO is currently in the process of drafting legislation to support this ambition. This legislation is likely to get a similar structure to FEUM.

The IMO's Marine Environment Protection Committee (MEPC) is working on the IMO alternative fuel classification system. This classification system will be the foundation on deciding whether vessels comply to the IMO ambitions. During the coming MEPC 82, 30 September - 4 October 2024, an Intersessional Working Group will present its findings, on the GHG impact assessment.

2.3.4 Aviation

The American Society for Testing and Materials (ASTM) approved the use of SAF up to a 50% blend in aviation in 2011. The actual blend that planes can use is likely much higher, but due to stringent safety standards this limit is still in place. The International Civil Aviation Organisation (ICAO) is establishing several goals and schemes to demonstrate commitment to the global decarbonisation efforts of the aviation industry by 2050. Legislation is in place to obligate airlines with emissions above a certain threshold to reduce and offset these emissions.

SAF is seen as the primary instrument to drive the sector's emissions down. During the third Conference on Aviation and Alternative Fuels (CAAF/3), the vision of a 5% emission reduction by 2030 was formulated. The ICAO is working on global coverage of SAF accounting methodologies to increase transparency, ensure a level playing field, and guarantee the environmental integrity of emission reduction efforts.

2.4 E-fuel production in Uruguay

2.4.1 Competitive advantages Uruguay

Uruguay has some key competitive advantages compared to other countries exploiting the production and export of hydrogen.

- Institutional stability
- Potential to develop new renewable energy generation capacity
- Current electrical grid already almost completed (>95%) decarbonized
- Availability of biogenic CO_2 thanks to the pulp industry

Renewable energy for the production of hydrogen and e-fuels can be generated onshore or offshore in the Rio de la Plata, as shown in Figure 2-6. The potential capacity of renewable energy in Uruguay is estimated to be as follows:

- Onshore wind 30 GW
- Solar 60 GW
- Offshore wind 275 GW

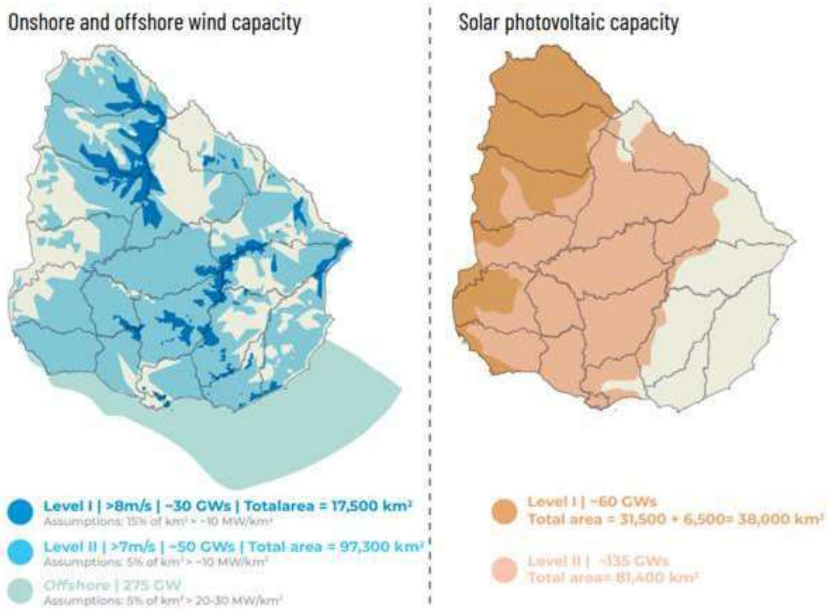

Figure 2-6 Wind and solar photovoltaic capacity (Source: McKinsey)

Biogenic CO_2 can be captured from the three large pulp mills at Paso de los Toros in the North-East (UPM) of the country, Fray Bentos (UPM) in the West, and Montes del Plata in the South-West.

Based on the availability of biogenic CO_2, the production of e-fuels in Uruguay has the potential to reach an estimated 7 mtpa. New industries that generate more biogenic CO2 could be created in the future.

2.4.2 Assumed production regions

This study assumes there will be three main production regions, i.e., North-East, North-West and South-West as shown in Figure 2-7. Each area will have different logistic preferences and solutions for product export, which are discussed in this report.

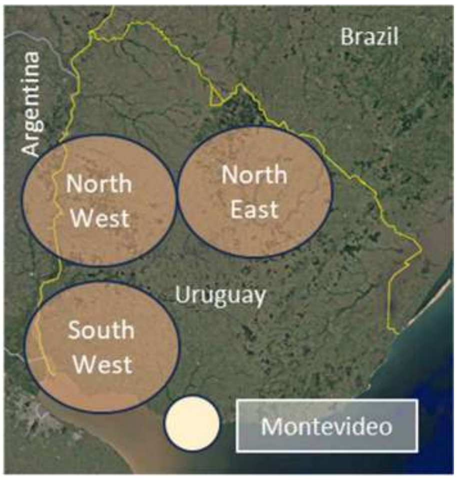

Figure 2-7 Assumed production regions of e-fuels

3 Project premises and general information

3.1 Products

Four possible scenarios are considered for exports of e-methanol and e-kerosene by 2040:

- Scenario A: 1 million tons of product per year (Mtpa)
- Scenario B: 3 million tons of product per year (Mtpa)
- Scenario C: 5 million tons of product per year (Mtpa)
- Scenario D: 10 million tons of product per year (Mtpa)

In addition to the export of e-methanol and e-kerosene, also urea may need to be exported. The potential export volume of urea for the different scenarios cannot been confirmed at this time.

Export of ammonia is not considered as part of this project.

Some product characteristics of e-methanol, e-kerosene (SAF) and urea are listed below.

Table 3-1 Products characteristics

Main characteristics	e-methanol	e-kerosene (SAF)	urea
Form	liquid in ambient temperature	liquid in ambient temperature	1-4 mm granules
Energy density	20 MJ/kg	43MJ/kg	-
Flashpoint	9.7°C	29-70°C	-
Density [kg/m3] at 20°C	790	790-840	Relative density: 1.33 (1330)
Angle of repose	-	-	28°-45°
Class	IMDG code class 3 substance, flammable liquid GHS02: Flammable GHS08: Serious Health Hazard GHS06: Acute Toxicity	IMDG code class 3 substance, flammable liquid GHS02: Flammable GHS07: Health Hazard GHS09: Hazardous to the environment	IMSBC cargo group: C (cargoes which are neither liable to liquefy nor possess chemical hazards) ECHA/GHS: No hazards
Health hazard	Toxic if swallowed, is toxic in contact with skin, is toxic if inhaled, causes damage to organs and is a highly	May be fatal if swallowed and enters airways, may cause cancer, is a flammable liquid and vapour, causes skin irritation and may cause	No hazards

Main characteristics	e-methanol	e-kerosene (SAF)	urea
	flammable liquid and vapour.	drowsiness or dizziness.	
Port environmental hazard	Not dangerous for aquatic environment.	Toxic to aquatic life with long lasting effects.	No hazards
Shipping and storage hazard	Toxic, highly flammable liquid and vapour	Toxic, highly flammable liquid and vapour	Corrosive when moist
Fire hazard	Highly flammable, ATEX relevant	Highly flammable, explosive atmospheres	Non combustible
Typical port storage	cylindrical tanks	cylindrical tanks	silos (if exposed may require insulation for products sensitive to heat, no ventilation required)
Main handling methods	pipeline	pipeline	conveyors, bucket elevator, trucks
Typical stockyard stacking	-	-	overhead conveyor stacker or truck dump
Typical stockyard reclaim	pump	pump	FEL to hopper and conveyor, pneumatic, gravity (silos)
Typical ship loading methods	pipeline	pipeline	direct bulk with load chute

3.2 Safety zones

The site-specific risk (PR) contour indicates the probability that a fatal accident occurs at a certain place in a period of one year as a direct consequence of an incident with hazardous substances if a person were to be present 24 hours a day and unprotected at that location. There are two risk contours that are of importance:

- The 10^{-6} contour is the PR-contour where the chance of death is 0.0001% per year. *Vulnerable objects* should not be located or enter within this contour, and *objects with limited vulnerability* preferably should not be located within this contour.
    - *Vulnerable objects* are for example houses, hospitals, schools, campsites, and large shopping malls.
    - *Limited-vulnerable objects* are for example small office buildings, shops, sport facilities and restaurants.
- The 10^{-5} contour is the PR-contour where the chance of death is 0.001% per year. Inside this contour it is allowed for certain people to be present if they are informed about the risks, mitigations, and evacuation routes; buildings can be located here if the ventilation can be promptly deactivated; people are allowed which will not be in that area for a full 24 hours.

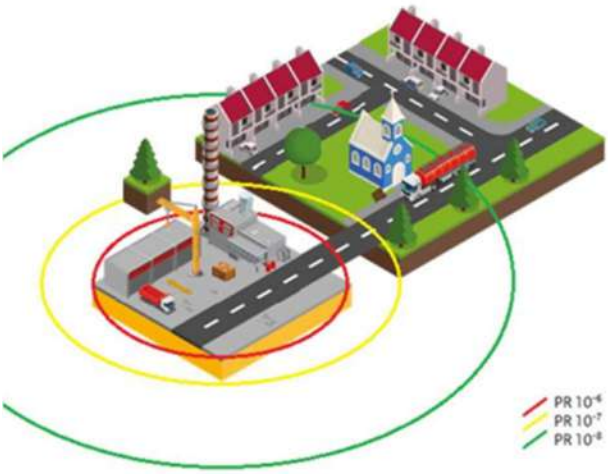

Figure 3-1 Example safety zones including the PR-contour 10^{-4}, 10^{-7} and 10^{-8} (for illustration only)

All scenarios involve the risks of the production of H_2 in an electrolyser. Depending on the design of product pipes and process properties, a distance of several tens to 100 meters from the pipe to the PR $1x10^{-6}$ contour must be considered. This also applies to storage.

Below calculation is based on the medium scenario B of 3 Mtpa, typical values, for PR 10^{-6} includes. The table includes typical values based on similar projects in different countries. In more advanced study stages, site specific calculations should be made to take account of the volumes, storage, operations and conditions at the site.

	e-fuels	Methanol	Hydrogen
Storage	100-200 m	NA	100-200 m
Pipelines	100-200 m	100-200 m	50-100 m (very much depending on aboveground or underground)
Production facility	200-300 m	200-300 m	300-400 m
Loading	200-300 m	200-300 m	300-400 m

Urea is the safest substance in terms of environmental safety. No risks are expected for the immediate environment.

The safety contours for a specific site need to be calculated using a risk assessment taking into account the actual products and volumes, operations, and local conditions. An example of a site specific safety contour for a project site in Rotterdam (The Netherlnads) is shown in Figure 3-2 (this example is for different products, volumes and conditions and serves as an illustration only).

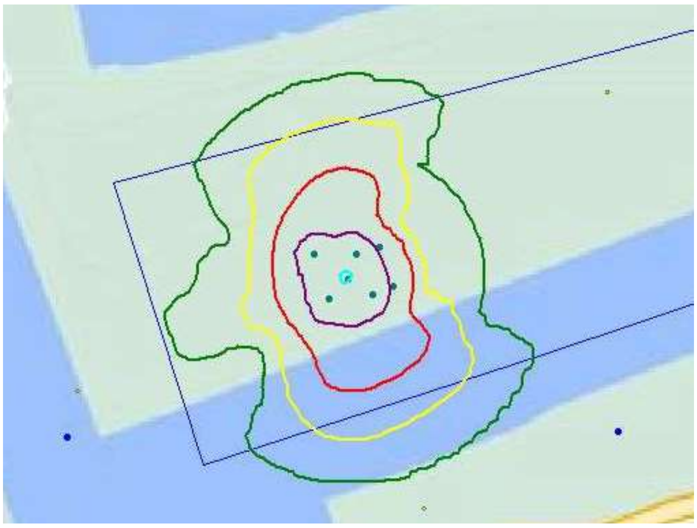

Figure 3-2 Example of site specific safety contour (for illustration only)

3.3 Design vessels

It is considered that the ships exporting product will be drawn from the international fleet, considering seagoing product tankers. Typically maximizing the cargo parcel size results in the most economic transport mode and lowest transport emissions per ton. For exports to Europe and other cross-ocean destinations, larger tankers with a capacity of about 50,000 tons would ideally be used. Alternatively medium sized vessels with a capacity of about 25,000 tons could be used, but this would result in higher costs and emissions per ton. Regional trade in South America could be carried out in small tankers with a capacity of about 7,500 tons.

For the port of Montevideo, the draft of the vessels is currently restricted to 13m, and is planned to be deepened to 14m by 2025, allowing use of larger tankers. The depth in the channels of the Rio de la Plata is currently 10m, allowing medium-sized tankers or partially loaded larger tankers. The depths of navigation channels to ports located more inland along the Rio Uruguay is limited to 7m, allowing access by barge or small tanker only.

Table 3-2 Design vessels: tankers

Type	Cargo capacity (DWT)	Draft (m)	LOA (m)	Beam (m)
Barge	2.500	3	60	15
Small tanker	7.500	7	100	17
Handy (medium tanker)	25.000	10	170	27
MR2 (larger tanker)	50.000	12	190	32

3.4 Road network

According to the Geoportal of the MTOP, the main roads are highlighted in the following map along with the relevant sites under study. Road transport will be supplementary for the inland logistics, but is not expected to be the main mode of transport for larger volumes of e-fuels due to the large number of trucks that would be required and the associated emissions and pressure on the road infrastructure.

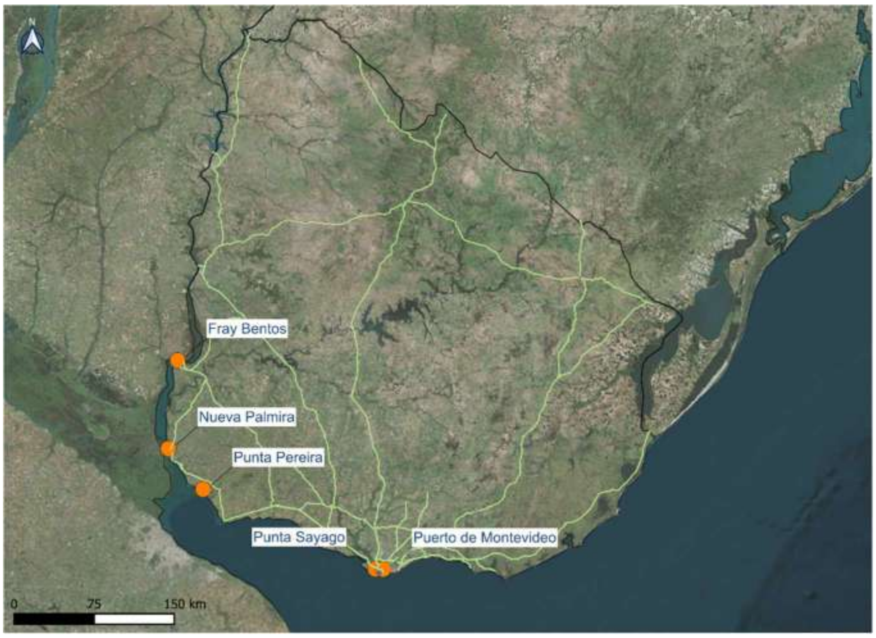

Figure 3-3 Road network

3.5 Rail network

According to the Geoportal of the MTOP, the rail network is highlighted in the following map along with the relevant sites under study. The central corridor is currently being completed and will be operational by 2025. The corridor will connect the port of Montevideo with destinations in the North of the country. and will have a branch to Paysandu. Rail transport may be used for transport of e-fuels from the production locations to the port of Montevideo.

Figure 3-4 Rail network

4 Maritime development strategy for export of e-fuels

4.1 Growth scenarios

As it was mentioned before, the development scenarios considered for this study are the following:

- Scenario A: 1 million tons of methanol / e-fuels per year
- Scenario B: 3 million tons of methanol / e-fuels per year
- Scenario C: 5 million tons of methanol / e-fuels per year
- Scenario D: 10 million tons of methanol / e-fuels per year

The supply chain required to export these volumes from various locations in the country will not rely on a single concept but will be a mix of solutions best suited for the production location and available storage and transport modes.

The different scenarios are seen as a timeline, where Scenario A (1 mtpa) is the initial target, and other scenarios represent models for further growth. Scenario B (3 mtpa) will therefore expand on the initial development of Scenario A, Scenario C will expand from Scenario B, and Scenario D will expand from Scenario C.

Scenario A (1 mtpa) is seen as a realistic target for the next 10-15 years. Starting point are the two initial projects from Enertrag and HIF, which are assumed to be operational around 2030. Together they would account for 0.2-0.3 million ton of products per year.

Depending on global demand for green fuels, and on Uruguay’s competitive position, growth beyond 1 mtpa may be possible. Scenario D (10 mtpa) is considered as a long-term potential target and can be used as a roadmap to give direction to immediate investments.

4.2 Key considerations for maritime export

4.2.1 Overview

Some key considerations need to be taken into account for the maritime export strategies:

- Onshore supply chain
- Maritime supply chain
- Common user infrastructure
- Leveraging on existing infrastructure
- Leveraging on other cargo potential
- Permitting

4.2.2 Onshore supply chain

The onshore supply chain of e-fuels to the port for export by ship can be setup by road, rail or pipeline.

Road transport is the most flexible modality. Trucks are generally widely available, and no specific infrastructure is required. However, with larger volumes, the number of trucks would put a large claim on the capacity of the public road network, resulting in potential congestion and delays. For example, transporting 1 million tons per year by 30t trucks would result in about 100 trucks per day, or 4 per hour.

Rail connection is available between Montevideo to Northern Uruguay (Tambor and beyond), with a planned branch to Paysandú. Most of the rail is single track. The rail system will be used mostly for cargo, although some passenger rail services may be developed around Montevideo. Of the total capacity of the central railroad a part is reserved for UPM's mill in Paso de los Toros that will use it to transport mainly pulp to the port of Montevideo. The remaining capacity, assuming methanol or synthetic fuels transport using 500m trains, is about 5 million tons per year.

Pipeline transport is the most efficient transport modality for larger volumes, but implementation is complex due to the high investment costs and required procedures related to land ownership and permitting. Pipeline transport of e-fuels over longer distances is not expected to be feasible. Pipeline transport over shorter distances could be considered. At the port terminal, storage tanks are connected to the jetty by pipeline to allow loading of the vessel.

4.2.3 Maritime supply chain

Uruguay is accessible by water along the west side of the country by the Rio Uruguay, along the south side of the country by the Rio de la Plata, and to the Atlantic Ocean through Montevideo. The maximum vessel size is limited by the water depth as shown in Table 5-1.

Table -1 Maximum vessel sizes used for the maritime supply chain.

River / site	Water depth	Vessel type	Maximum vessel size
Montevideo	13m (14m planned)	Large tanker	50,000 ton
Rio de la Plata	10m	Medium tanker	25,000 ton
Rio Uruguay	7m	Barge Small tanker	2,500 ton 7,500 ton

The port of Montevideo has access channels and port basins with a depth of 13m, and are expected to be dredged to a depth of 14m by 2025. This will allow access by medium sized vessels with a capacity of 40,000 to 50,000 tons. Such vessels are suitable for use on international shipping routes. Larger vessels can be used if partially laden for top off in a deepsea port outside Uruguay.

Rio de la Plata has a 250km long and 90m wide channel system maintained at a depth of 10m. This allows access by small and (partially laden) medium sized tankers of up to 20,000 to 30,000 tons. This size is typically used for regional trade or small volumes, but could be used for international exports. Ports along the Rio de la Plata include Nueva Palmira,.

Ocean tankers can sail up on the Rio Uruguay, but due to the limited depth of the river (7m) only small tankers can be used. Such small tankers with a capacity of 5000-8000 tons are typically used for small regional trades, and are not suitable for larger scale international exports. The Rio Uruguay can also be used for barges, typically with a capacity of about 2500 tons. Multiple barges can be connected and pushed by a single push boat. Ports along the Rio Uruguay include Paysandú and Fray Bentos.

4.2.4 Common user marine terminal

Storage of the liquid bulk, in this specific case Methanol and E-fuels, is an essential part of the logistical chain. At the specific production site storage tanks are needed in order to store the liquid bulk before it can be distributed. It is assumed that this is in general part of the investment of the specific production projects. Storage of Methanol and specific fuels like SAF (kerosine) needs to be done in dedicated tanks with specific characteristics for each liquid, however these are existing standards. Looking at the specific characteristics of these it is assumed that also existing storage tanks can be used, possibly with adjustments.

The storage capacity on each site needs to be sufficient to provide a buffer between the incoming flow and the export flow. The storage capacity therefore needs to be at least as large as the largest single shipment (train or vessel) plus a buffer capacity to allow for disruptions in the supply chain.

Initially, when only one or two parties will be producing e-fuels, investments in storage tanks can be made by the specific producer, owning and operating its own tanks. However, when multiple parties require storage capacity at a certain location, the concept of a common-user marine terminal (multi-client) needs to be considered.

In a common-user marine terminal, the tank storage terminal is owned and operated by a dedicated terminal operator. Multiple users can book storage capacity at the terminal, paying for guaranteed availability of a certain volume and for specific use of the tanks. Tanks and infrastructure connections to the tanks including jetties can be shared in this way, creating efficiency and reducing overall investment and space requirements. This type of operation is a well-proven concept in many port or industrial complexes worldwide.

Specific tanks can be used to store “generic” liquids e.g. methanol from different ownership, provided that strict quality controls are applied. Alternatively, each (large) company uses its dedicated tanks. Depending on expected volumes and logistic requirements, smaller tanks can be built to create more flexibility.

In case land availability is scarce, which is the case in Montevideo port, a common (multi-client) marine terminal should be considered in order to maintain enough flexibility for new future users. Such a terminal can be operated by a third party. There is sufficient expertise in the market and willingness to invest in such terminal worldwide (companies like e.g. Vopak, Advario, Koole, Evos, etc.). In Uruguay also ANCAP could take this role.

It is important that user-tariffs for such a terminal can be considered as fair and according to market standards. In large ports like Port of Rotterdam, with multiple common multi-client terminals, this will be guaranteed by competition in the private market. In the case of a single common-user terminal in a port, fair pricing can be guaranteed by specific regulations which can be part of the concession contract.

It can be considered to float a tender for the concession to build and operate such a terminal. Port of Pecem (Brazil, in which Port of Rotterdam is a shareholder) has adopted such a model.

Considering the needed amount of land to be allocated for a tank farm, the following needs to be considered:

- Minimum volume of two times the volume of the largest ship-size
- Additional size to support tanks of different liquids (producers want to be flexible between the production of Methanol or E-Fuels)
- Additional space to use multiple smaller tanks to support multiple clients.

4.2.5 Leveraging on existing port infrastructure

To ease start of operations with limited investments, it is recommended to use existing port infrastructure as much as possible. The market for e-methanol and e-fuels is a new market, with many uncertainties, which creates a high barrier for investment for early movers. Based on the possible future scenarios a dedicated investment in port infrastructure will need to be made to support the future volumes, but existing infrastructure could be used as much as possible to support the initial projects. In this case the projects can be de-risked by lowering the needed initial investments, but also the timeline of the project will be de-risked by not being dependent on complex investments with uncertainties and risks. Specifically for green-field location the development time for financing, permitting and construction can be long.

For the initial years volumes will be too small to justify big investments in port infrastructure, both in Montevideo port and ports along the river Uruguay.

To use the existing infrastructure also (smaller) investments need to be done for supporting infrastructure like transport pipes and tank storage. This should be done in a way that it can be expanded over time with volumes increase, according a specific “grow-in model” supported by the defined scenarios.

Uruguay is also strategically located for handling cargo from neighbouring countries, thereby generating critical volume for development of port infrastructure. The mouth of Rio Uruguay, where Río Uruguay and Río Paraná-Guazú (with connections to Argentina, Brazil, and Paraguay) meet Rio de la Plata could become a hub for transshipment of barge traffic into ocean vessels.

4.2.6 Permitting of maritime infrastructure

Any infrastructure developments along Río Uruguay, which forms the western border between Uruguay and Argentina, require permission from all riparian states. The approval process can be difficult and lengthy, and has even resulted in international dispute in the past[1].

The Rio de la Plata, which forms the southern border between Uruguay and Argentina, is much wider than the Rio Uruguay. Here, states may decide on development within the coastal zone without permission from others. This may lead to faster permitting procedures.

[1] https://en.wikipedia.org/wiki/Uruguay_River_pulp_mill_dispute (website visited19 April 2024)

4.3 Export logistics strategies

4.3.1 Overview of logistic nodes and strategies

The setup of a supply chain very much depends on the location of the production facility. Only two production locations are currently identified, i.e. in Tambor and Paysandú. Other facilities are expected to develop, but the location of these facilities is currently not known. It is therefore important that the export strategies allow for flexibility.

Potential logistic nodes for maritime exports have been identified which could take a strategic position in the export strategy for hydrogen derivatives, as shown in Figure 4-1. These include the following:

- Planned production centres (Tambor and Paysandú),
- Montevideo
- Potential ports along the Rio Uruguay (Paysandú and Fray Bentos)
- Potential ports at the mouth of the Rio Uruguay / Rio de la Plata (Nueva Palmira)

Figure 4-1 Potential maritime logistic nodes

Two principal logistic options for maritime exports can be identified:

- Montevideo as central export hub
- Transshipment hub at the mouth of Rio Uruguay

These options are discussed in the sections below.

4.3.2 Montevideo as central export hub

In this option all product is brought to a central export terminal in Montevideo, where it is loaded into an ocean tanker. Inland transport is by rail or barge / small tanker. This option can be characterized as follows:

- From Paysandú, e-fuels can be shipped by rail or by barge. Transport costs for rail are likely to be more expensive than for barge.
- From the North-West production areas, e-fuels are brought to Montevideo by rail.
- Barges sail down Rio Uruguay and across Rio de la Plata to Montevideo. A typical size of barges is 2500 tons, and multiple barges may be combined to form a block pushed by a single push boat. During part of the year, wind and wave conditions on the Rio de la Plata are rough and barges cannot always safely reach Montevideo. Barges need to wait for better conditions, which leads to a disruption of the logistic flow (this is the current situation for the barges that go from Paysandú towards the ANCAP refinery in Montevideo bay). Additional storage may be required at Paysandú to minimize disruption of the production process, and at Montevideo to minimize disruption of the ocean export.
- Alternatively, small tankers (or customized seagoing barges) may be used between Paysandú and Montevideo. These tankers are available on the market, but are generally more expensive to operate than barges.
- Products are collected at a multi-user terminal in Montevideo and stored in the terminal tanks. From there the ocean tanker is loaded. With an expected depth of 14m, tankers with a capacity of up to 50,000 tons can be loaded.

The option is schematically visualized in Figure 4-2.

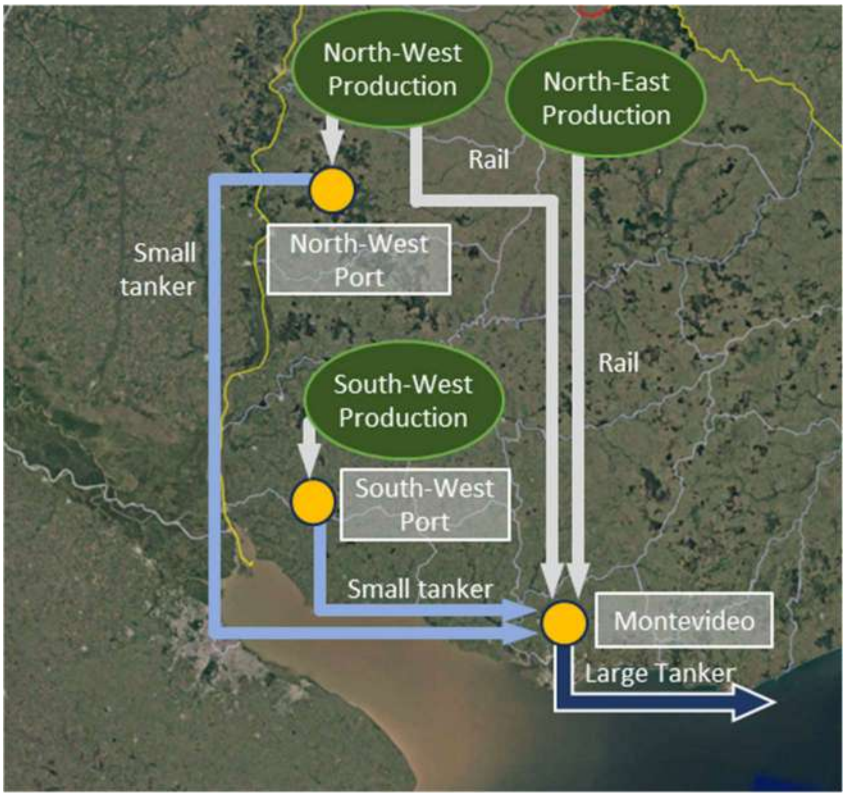

Figure 4-2 Logistic scheme using Montevideo as central hub for maritime exports

Other production locations are expected to develop in future. Depending on their location, these locations can be fitted into the same scheme when product can either be transported to a barge hub along the Rio Uruguay / Rio de la Plata or can be connected by rail. This is schematized in Figure 4-3.

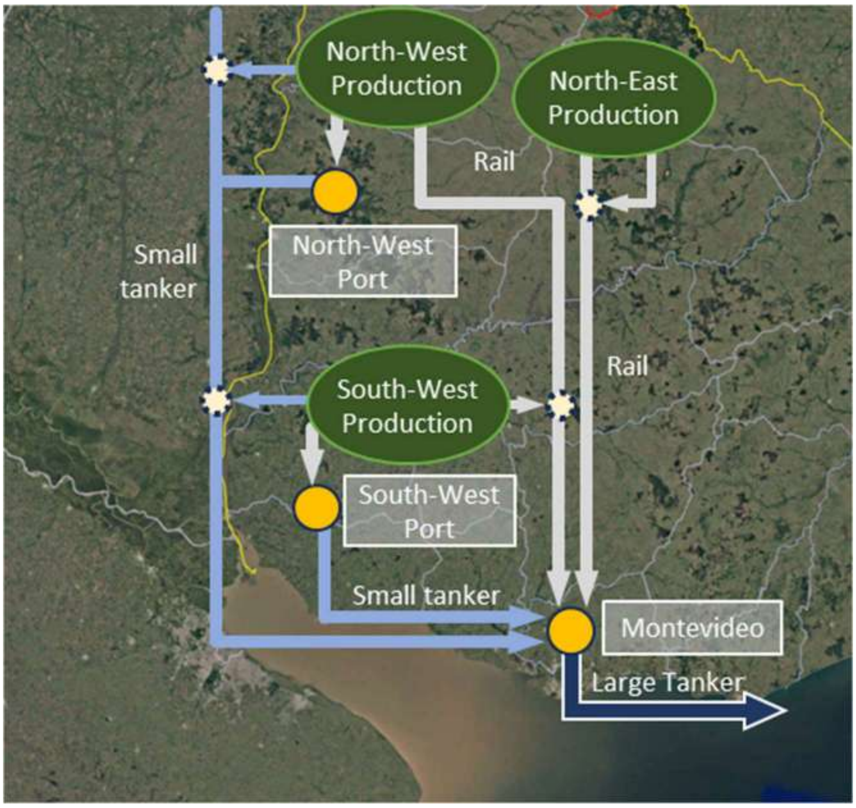

Figure 4-3 Future production expansion, using Montevideo as central hub

4.3.3 Transhipment hub at mouth of Rio Uruguay

This concept uses a transhipment hub at the mouth of the Rio Uruguay. This transhipment hub could be realised in Nueva Palmira, or along Rio de la Plata. There the cargo is loaded into ocean tankers. Rail cargo is routed to Montevideo, where it is loaded into ocean tankers. This option is characterized as follows:

- From Paysandú, barges transport the e-fuels to the transhipment hub, where the cargo is stored in storage tanks.
- At the transhipment hub, the product is loaded into medium-sized ocean tankers. Considering the depth of the Rio de la Plata of 10m, the maximum parcel size at the transhipment hub is 20-30,000 tons, using (partially laden) Handy-size tankers.
- The tankers sail directly to their international destinations, or top-off at a deep-sea port in the region, which could be Montevideo or Argentinian or Brazilian ports.
- Cargo from North-West production areas is transported by rail to a terminal Montevideo, where it is loaded into ocean tankers.

This option is schematically shown in Figure 4-4.

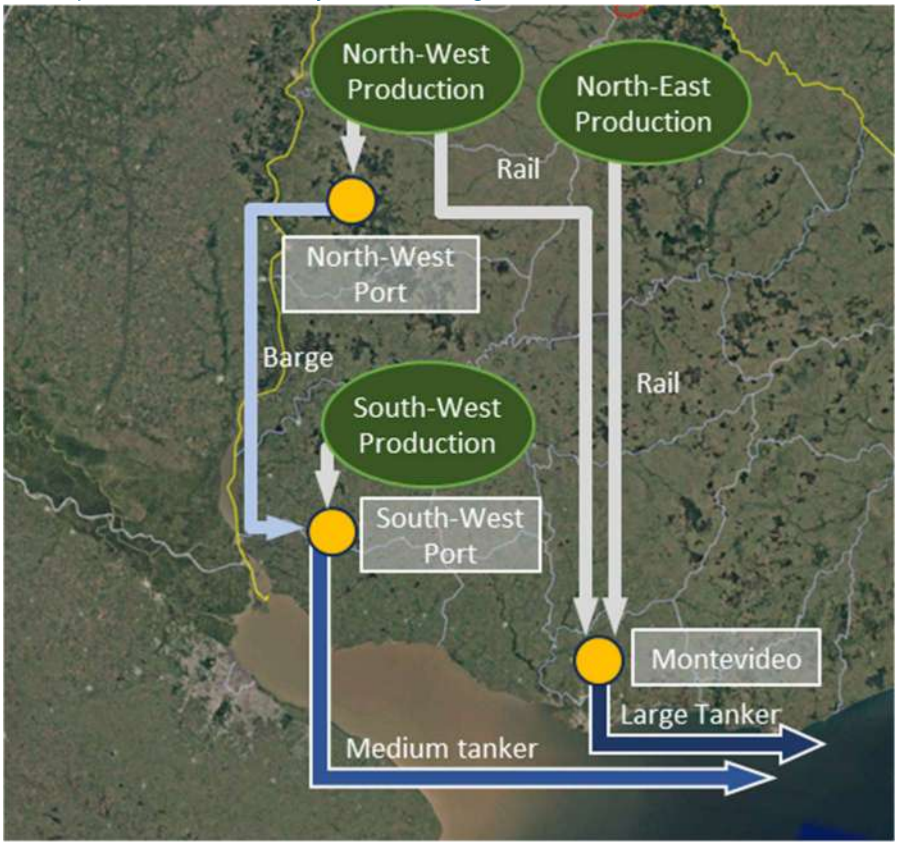

Figure 4-4 Logistic scheme using Montevideo and transshipment hub at mouth of Rio Uruguay

Other production locations can be fitted into the same scheme when product can either be barged to the transhipment hub or can be connected by rail.

The transhipment hub could also benefit from other cargoes from hinterlands in Argentina (Rosario), Brazil and Paraguay. These cargoes could include e-fuels, but also other products such as grains, agricultural products, ores, and project cargoes. The additional cargo potential could generate critical mass to justify investments.

This is schematized in Figure 4-5.

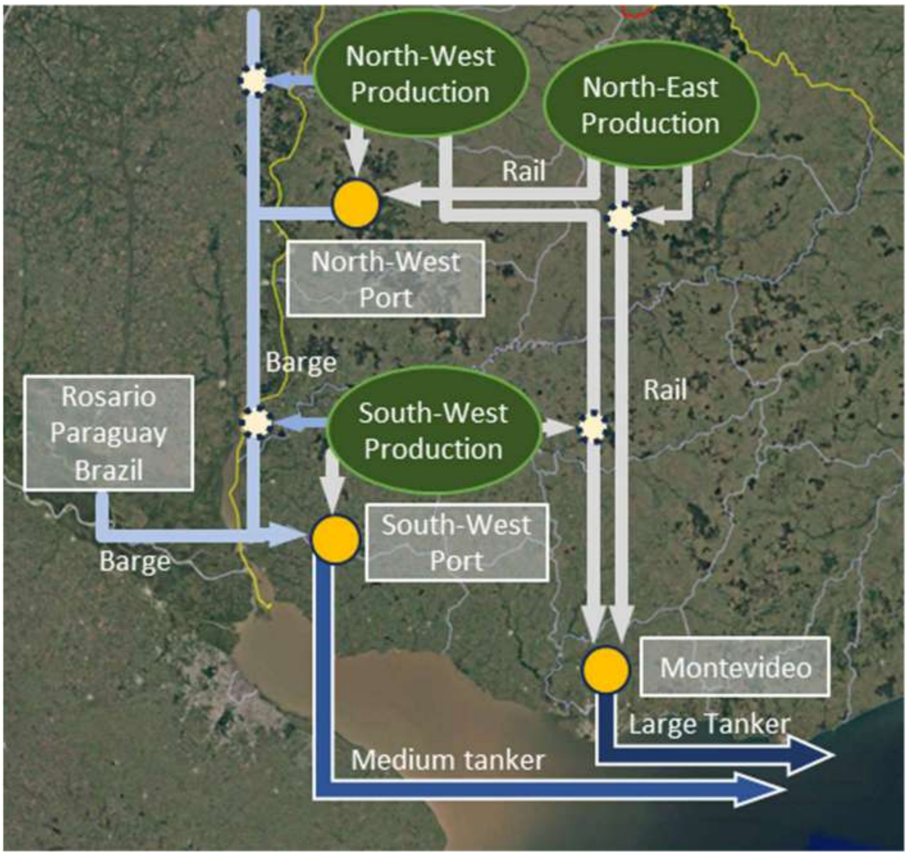

Figure 4-5 Future production expansion, using transshipment hub at mouth of Rio Uruguay

As this transshipment Hub requires significant investments in either of the ports; it is assumed that this investment will only be made when there is a significant (guaranteed) volume of cargo. The initial volume from the HIF project in Paysandú would possibly not be enough to justify this investment. Investments should be phased to match growing volumes.

4.3.4 Combination Logistic strategies assumed for capacity calculation

The logistic solution selected for a certain export flow will depend on location, availability of equipment, price levels, reliability, etc. It is likely that a mix of options will be selected, including the use of rail, barge, and different types of tankers.

Key ports will include Montevideo, a North-West port along the Rio Uruguay, and a South-West port at the mouth of the Rio Uruguay / Rio de la Plata. The North-West port will likely be in Paysandú, but also other locations could be developed. For the South-West port, Nueva Palmira could be suitable.

The resulting strategies are schematized in Figure 4-6.

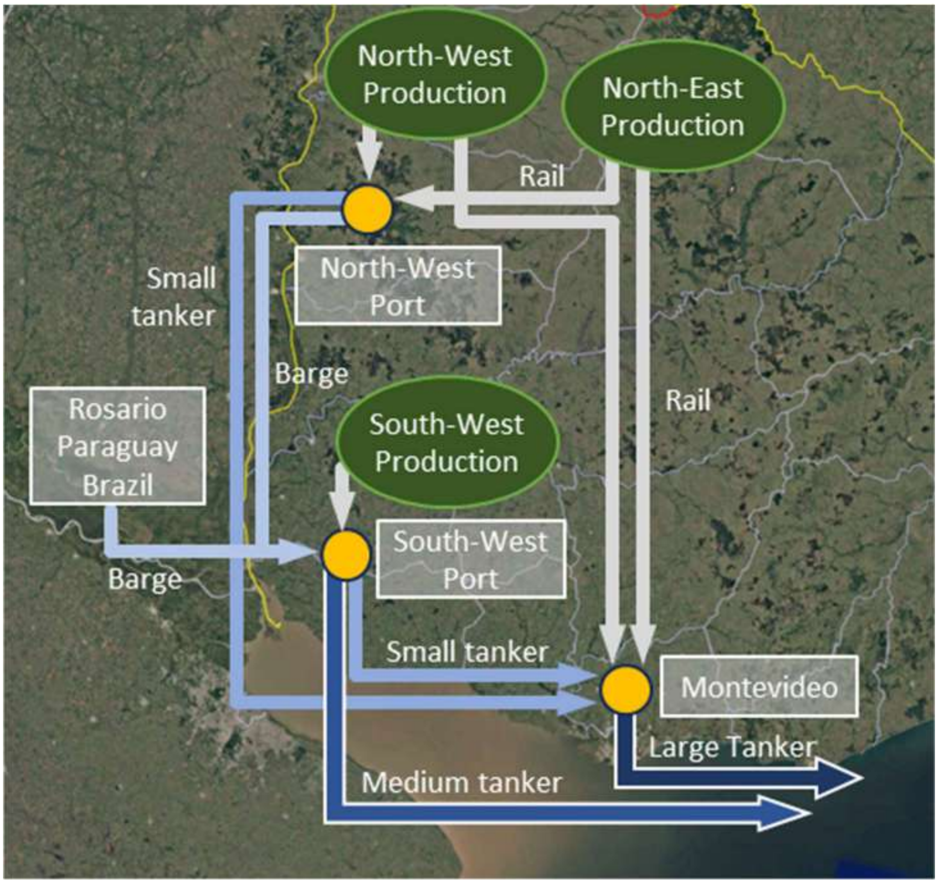

Figure 4-6 Logistic strategies assumed for capacity calculation

4.4 Port capacities

4.4.1 Calculation method

Capacity calculations were made for each of the volume scenarios as discussed in Section 4.1. For each of the ports, the number of berths and the required storage terminal area were estimated.

To determine the required capacity, various assumptions need to be made on production volumes, modal split, loading capacity, etc. The estimate for the required storage capacity is based on the capacity of the design vessel in addition to an allowance for multiple products and for delays.

It is however uncertain how the production and export of e-fuels is going to develop in Uruguay, and the assumptions can therefore not be based on existing industry data. Instead, typical industry values were used to give an indication of possible outcomes.

The detailed calculation sheet is included in Attachment A. Key results are summarized below.

4.4.2 Montevideo port capacity

The estimated capacity of Montevideo Port for e-fuels for the different scenarios is shown in Table 5-2. The port receives small tankers originating from ports along the Rio Uruguay and Rio de la Plata. In addition, a large volume is received by rail. Products are stored on the marine terminal and exported by large tankers. For Scenario 1 and 2, the small and large tankers can be combined on one berth. For scenarios 3 and 4 a second berth would be required. Total terminal area would be about 2 ha for Scenario 1 and up to 14 ha for Scenario 4.

Table -2 Port capacity Montevideo

Port of Montevideo	Unit	Scenario 1 1,000,000 tpa	Scenario 2 3,000,000 tpa	Scenario 3 5,000,000 tpa	Scenario 4 10,000,000 tpa
Assumed volumes					
• Small tanker (import)	mtpa	460,000	1,400,000	2,140,000	3,020,000
• Large tanker (export)	mtpa	960,000	2,600,000	3,540,000	5,020,000
Number of vessels					
• Small tanker (import)	vessels/year	61	187	285	403
• Large tanker (export)	vessels/year	19	52	71	100
Berth capacity					
• Small tanker (import)	berths	0.2	0.5	0.8	1.1
• Large tanker (export)	berths	0.1	0.2	0.3	0.4
• Total	berths	1	1	2	2
Terminal capacity					
• Tank capacity	ton	120,000	360,000	720,000	900,000
• Number of tanks	No.	2	6	12	15
• Terminal area	m2	20,000	60,000	110,000	140,000

4.4.3 North-West port capacity

The estimated capacity of the North-West Port is shown in Table 5-3. This port receives cargo by rail and from regional production sites, and exports by barge and small tankers. A single berth would be sufficient to handle the required volumes in Scenarios 1, 2 and 3, and a second would be required for Scenario 4. In addition, lay-by berths are required for empty barges and tankers, and for loaded barges waiting for transport. Total terminal area is about 1ha up to 3ha.

Table -3 Port capacity North-West Port

North-West Port	Unit	Scenario 1 1,000,000 tpa	Scenario 2 3,000,000 tpa	Scenario 3 5,000,000 tpa	Scenario 4 10,000,000 tpa
Assumed volumes					
• Barge (export)	mtpa	100,000	400,000	930,000	2,220,000
• Small tanker (export)	mtpa	300,000	800,000	1,170,000	1,780,000
Number of vessels					
• Barge (export)	vessels/year	40	160	373	889
• Small tanker (export)	vessels/year	40	107	156	237
Berth capacity					
• Barge	berths	0.0	0.1	0.3	0.7
• Small tanker	berths	0.1	0.3	0.4	0.7
• Total	berths	1	1	1	2
Terminal capacity					
• Tank capacity	ton	20,000	60,000	120,000	150,000
• Number of tanks	No.	2	6	12	15
• Terminal area	m2	10,000	10,000	20,000	30,000

4.4.4 South-West port capacity

The estimated capacity of the South-West Port is shown in Table 5-4. This port receives cargo by barge and from regional production sites, and exports by small tankers to Montevideo or medium tanker to international markets. A single berth would be sufficient to handle the required volumes in Scenarios 1 and 2, and a second would be required for Scenario 3 and a third one for Scenario 4. In addition, lay-by berths are required for empty barges and tankers, and for loaded barges waiting for transport. Total terminal area is about 1ha up to 7ha.

Table -4 Port capacity South-West Port

South-West Port	Unit	Scenario 1 1,000,000 tpa	Scenario 2 3,000,000 tpa	Scenario 3 5,000,000 tpa	Scenario 4 10,000,000 tpa
Assumed volumes					
• Barge (import)		100,000	400,000	930,000	2,220,000
• Small tanker (export)		160,000	600,000	970,000	1,240,000
• Medium tanker (exp.)		40,000	400,000	1,460,000	4,980,000
Number of vessels					
• Barge (import)	vessels/year	40	160	373	889
• Small tanker (export)	vessels/year	21	80	130	166
• Medium tanker (exp.)	vessels/year	2	16	58	199
Berth capacity					
• Barge	berths	0.0	0.1	0.3	0.7
• Small tanker	berths	0.1	0.2	0.4	0.5
• Medium tanker	berths	0.0	0.1	0.4	1.4
• Total	berths	1	1	2	3
Terminal capacity					
• Tank capacity	ton	60,000	180,000	360,000	450,000
• Number of tanks	No.	2	6	12	15
• Terminal area	m2	10,000	30,000	60,000	70,000

5 Site evaluation

5.1 Approach

In this study several export site options are compared with the objective to converge to the best feasible option. A Multi-Criteria Analysis (MCA) was made to compare the options, considering the following key characteristics:

- Space available, for onshore storage and facilities. Available space is restricted due to the need of safety zoning around hydrocarbon facilities.
- Safety zones. Typically, Oil and Gas and renewable product have significant safety implications for the surroundings. The typical external risks relate to fire, explosion, toxicity, etc. Since the public is not trained to act in case of emergency, people will need to remain outside of physical areas carrying high risks. Remote locations are therefore preferred.
- Hinterland connection, vicinity to existing and accessible infrastructure with sufficient capacity.
- Accessible water infrastructure, with sufficient draft and sheltering for waves and currents. Both the access conditions and the moored conditions are important.
- Environmental considerations, the impact on the environment., as well as on the surrounding public.
- Scalability, as four scenarios are being analysed, the possibility of expansion is well rated.
- Vicinity to production plant and CO_2, the distance to the production facility plays a significant role in cost and disturbance.
- Cost (qualitative), parameter includes both marine and onshore investment for port facilities and storage.

Different weights were given to the criteria to reflect their importance (A=very important; B=important; C=less important) and scores were given for each of the criteria (1=small/unfavourable; 2=average; 3= large/favourable). The overall evaluation for each site is defined as higher potential, average potential and lower potential sites.

The following potential sites have been identified and are evaluated in this section:

- Montevideo Bay
  - Punta Sayago
  - ANCAP refinery
  - Capurro plant
  - East basin reclamation
  - Dique de cintura reclamation
  - West breakwater reclamation
- Rio de la Plata and Rio Uruguay
  - ANCAP – ALUR Paysandú
  - Public Port Paysandú
  - Public Port Fray Bentos
  - Public Port Nueva Palmira

5.2 Montevideo Bay

5.2.1 Site overview Montevideo Bay

Figure 5-1 Site selection Montevideo Bay

No.	Site	Space available	Safety zones	Hinterland connection	Water infrastructure	Environmental considerations	Scalability	Vicinity to production – CO2	Cost (qualitative)	Level
		A	A	A	B	B	C	B	A	
1	ANCAP Refinery	2	3	3	2	2	2	1	2	Average potential
2	Capurro Plant	1	2	3	2	3	1	1	2	Average potential
3	East basin reclamation	3	3	3	3	2	2	1	2	Higher potential
4	Dique de cintura reclamation	3	3	2	3	2	3	1	2	Higher potential
6	West breakwater reclamation	3	3	1	3	1	3	1	1	Lower potential
7	Punta Sayago	3	3	1	1	1	3	1	1	Lower potential

Table -1 MCA Montevideo Bay site options
Weight: **C** less important – **B** important – **A** very important
Score: **1** small/unfavourable – **2** average – **3** large/favourable

5.2.2 ANCAP refinery

Figure 5-2 ANCAP Refinery

General description	La Teja Refinery is the sole oil refinery in Uruguay. It is situated in Montevideo Bay and is owned by ANCAP. The refinery can unload, and store additives received in bulk. Additionally, it comprises three berths, namely North, South, and West, which can accommodate vessels up to 190m in length (first two berths) and 110m in the last one. It has seven manifolds to load and unload refined liquid petroleum fuels and lubricating oils and one manifold to receive and load LPG. The terminal also serves as an export hub and provides fuel supply (bunker) to ships operating in the Port of Montevideo and the surrounding areas of the River Plate.	
Space available	There is no space available for additional storage tanks within the plant area. Eexisting tanks could be redefined, or land could be reclaimed towards the Montevideo Bay	Average potential
Safety zones	The storage can be situated at a safe distance from nearby urban areas, in compliance with regulatory guidelines.	Higher potential
Hinterland connection	Montevideo Port is connected to the centre and north of the country by the new Ferrocarril Central line.	Higher potential
Water infrastructure	The refinery has three berths that are connected to the main channel in the bay via a 7m deep channel, accessible for small tankers only. Deepening of the channel to allow larger tankers is possible but would require significant investments. Alternatively a deep-water berth can be constructed in the main port basin along the Dique de Cintura (refer also Section 5.2.4 and 5.2.5), connected to the terminal by a 5km long pipeline.	Average potential
Environmental considerations	The development of storage tanks on the site is not expected to have a significant environmental impact. However, land reclamation could generate an impact.	Average potential
Scalability	There is space in the bay for further land reclamation to allow expansion of storage tank capacity.	Average potential
Vicinity to production plant and CO2	The site is not situated near existing e-fuel production projects or biogenic CO_2 production sites in the country. However, there would be synergy with refinery utilities and systems.	Average potential
Cost (qualitative)	Required investments are expected to be average.	Average potential

5.2.3 Capurro plant

Figure 5-3 Capurro Plant

General description	Capurro Plant is a property owned by ANCAP-ALUR, which is situated close to ANCAP refinery La Teja in Montevideo Bay. It is a biodiesel plant that spans roughly 20 hectares and has the capacity to store 60 million litres per year, although some of it is currently not in use. The plant cannot accommodate new tanks due to limited space, and there are no berths or river connections available.	
Space available	There is no space available within the plant area, existing tanks could be redefined or demolished to build new ones.	Lower potential
Safety zones	The plant is located near the city. However, the storage could be placed in the southwest corner, keeping a safe distance from the city.	Average potential
Hinterland connection	Montevideo Port is connected to the centre and north of the country by the new Ferrocarril Central line.	Higher potential
Water infrastructure	In the case of storing the products in the Capurro plant and exporting them through the ANCAP refinery berths, the maximum available depth would be 7m. Alternatively a deep-water berth can be constructed in the main port basin along the Dique de Cintura (refer also Section 5.2.4 and 5.2.5), connected to the terminal by a 5km long pipeline.	Average potential
Environmental considerations	The development of storage tanks on the site is not expected to have a significant environmental impact.	Higher potential
Scalability	There is not much space for future storage expansion.	Lower potential
Vicinity to production plant and CO2	The site is not situated near existing e-fuel production projects or biogenic CO_2 production sites in the country.	Average potential
Cost (qualitative)	Required investments are expected to be average.	Average potential

5.2.4 East basin reclamation

Figure 5-4 East basin reclamation

General description	Some land at the eastern side of Montevideo Bay that has been reclaimed and is owned by ANP. The land is approximately 6 hectares in size and is located near Darsena III.	
Space available	The site has enough space for e-fuel storage.	Higher potential
Safety zones	The storage can be situated at a safe distance from nearby towns, in compliance with regulatory guidelines.	Higher potential
Hinterland connection	Montevideo Port is connected to the centre and north of the country by the new Ferrocarril Central line.	Higher potential
Water infrastructure	A dedicated berth could be constructed along the Dique de Cintura adjacent to the grain berth, just outside the port basin to maintain safe manoeuvring for all vessels. The basin is planned to have a depth of 14m when dredging works are completed in 2025.	Higher potential
Environmental considerations	The development of storage tanks on the site is not expected to have a significant environmental impact. However, land reclamation could generate an impact.	Average potential
Scalability	There is room for land reclamation for storage tank construction. A dedicated berth may be needed if volumes grow.	Average potential
Vicinity to production plant and CO2	The site is not situated near existing e-fuel production projects or biogenic CO2 production sites in the country.	Lower potential
Cost (qualitative)	Required investment are expected to be average.	Average potential

Royal HaskoningDHV

Port of Rotterdam

5.2.5 Dique de cintura reclamation

Figure 5-5 Dique de cintura reclamation

General description	Land reclamation on the north side of the internal breakwater in Montevideo Bay, in shallow water. A dedicated jetty could be constructed adjacent to the port basin, outside the manoeuvring areas to ensure safe navigation in the entire port.	
Space available	There is enough space for land reclamation in the area.	Higher potential
Safety zones	The storage can be situated at a safe distance from nearby housing, in compliance with regulatory guidelines.	Higher potential
Hinterland connection	Montevideo Port is connected to the central and north part of the country by the new Ferrocarril Central line. A rail connection to the site itself may be difficult, and a rail unloading station would need to be developed onshore.	Average potential
Water infrastructure	The available depth in the port basin is 13 meters and expected to be deepened to 14m by 2025. A berth can be located adjacent to the grain berth, just outside the port basin to maintain safe manoeuvring for all vessels. A second berth can be added if required to expand capacity.	Higher potential
Environmental considerations	The development of storage tanks on the site is not expected to have a significant environmental impact. However, land reclamation could generate an impact.	Average potential
Scalability	There is sufficient space for further land reclamation for additional storage tank construction in future if required.	Higher potential
Vicinity to production plant and CO2	The site is not situated near existing e-fuel production projects or biogenic CO2 production sites in the country.	Lower potential
Cost (qualitative)	Investment costs are rated average.	Average potential

5.2.6 West breakwater reclamation

Figure 5-6 West breakwater reclamation

General description	Land reclamation on the west side of the extension of the breakwater “Escollera oeste”, along with a jetty to receive overseas vessels. The terminal would be located in deep water adjacent to the entrance channel.	
Space available	A terminal could be constructed on a reclaimed area adjacent to the breakwater, where there is enough space for land reclamation. Alternatively the terminal could be placed in Punta Sayago (refer Section 5.2.8), connected to the berth by subsea pipeline.	Higher potential
Safety zones	The terminal is at a safe distance from nearby urban areas, in compliance with regulatory guidelines.	Higher potential
Hinterland connection	The terminal is not directly connected to land (other than by subsea pipeline). An onshore unloading facility for trucks and rail is required. Montevideo Port is connected to the centre and north of the country by the new Ferrocarril Central line. However, the project would be away from the coastline. A rail and truck unloading area, as well as storage tanks, could be located in Punta Sayago.	Lower potential
Water infrastructure	A jetty to be constructed with an available maximum depth of 14m. The jetty would need to be located outside the port entrance in sheltered water, requiring extension of the breakwater and dredging of a berth pocket.	Higher potential
Environmental considerations	The development of storage tanks on the site is not expected to have a significant environmental impact. However, the impact of land reclamation and dredging on the coastal processes and marine life would require further assessment.	Lower potential
Scalability	There is sufficient space for additional land reclamation for expansion of the storage tanks, either by expanding the reclamation or on Punta Sayago.	Higher potential
Vicinity to production plant and CO2	The site is not situated near existing e-fuel production projects or biogenic CO2 production sites in the country.	Lower potential
Cost (qualitative)	Required investment for this facility would be very high.	Lower potential

5.2.7 Punta Sayago

Figure 5-7 Punta Sayago

General description	Punta Sayago is a property belonging to ANP, located 6 kilometres away from the Port of Montevideo. The site covers approximately 90 hectares and has plans for a logistics area development. Most of the land is currently available for development, except for a recently built warehouse and some old buildings located near the coast. Small scale ship demolition / scrapping activities take place at the southern tip of the peninsula. There are no berths or river connections.	
Space available	The site has enough space for e-fuel storage and associated activities.	Higher potential
Safety zones	Storage can be situated at a safe distance from nearby towns, in compliance with regulatory guidelines.	Higher potential
Hinterland connection	There is no rail connection. A connection to the main rail lines would require ~10km long new rail through a populated area, which will be difficult and costly. Development of a rail connection in future is therefore unlikely.	Lower potential
Water infrastructure	Although it is located on the Rio de la Plata coast, the maximum available depth is 3 meters. Extensive dredging work would be required to allow barge or tanker operations in the area. Alternatively marine facilities could be constructed further offshore or along the Western breakwater (refer Section 5.2.6), but this would require long pipelines and offshore structures.	Lower potential
Environmental considerations	Development of marine jetties and dredging could have significant environmental impact. Due to the lack of a rail connection, trucks would be the primary mode of transportation, resulting in a greater impact.	Lower potential
Scalability	The site has enough space for future storage expansion.	Higher potential
Vicinity to production plant and CO2	The site is not situated near existing e-fuel production projects or biogenic CO2 production sites in the country. Although space is available at the site, it is unlikely that any green hydrogen derivatives production would develop around Montevideo due to the limited space in the hinterland and lack of water and green CO2.	Lower potential
Cost (qualitative)	Development of the site would require high investment.	Lower potential

5.3 Rio de la Plata and Rio Uruguay

5.3.1 Site overview Rio de la Plata and Rio Uruguay

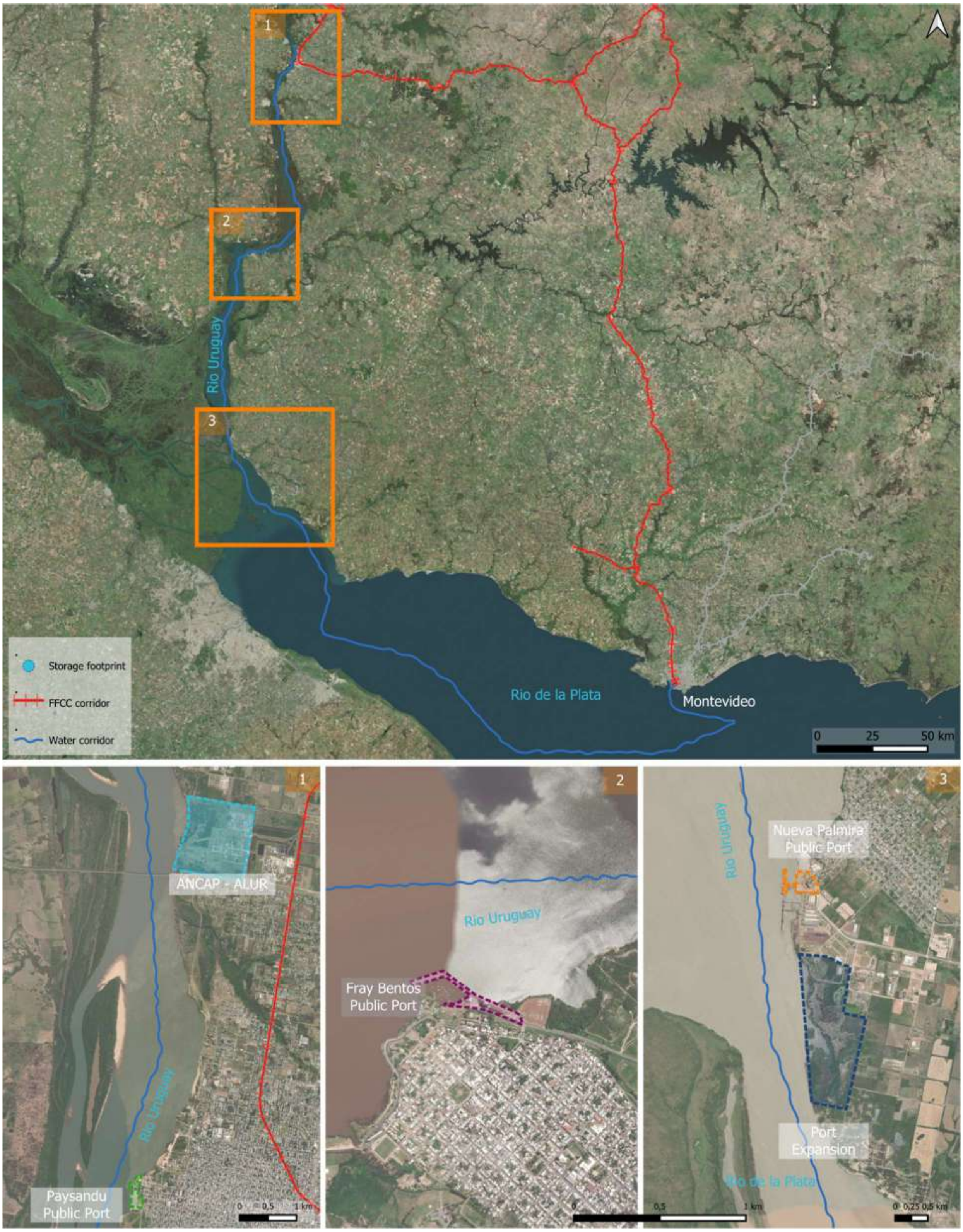

Figure 5-8 Site selection Rio de la Plata and Rio Uruguay

No.	Site	Space available	Safety zones	Hinterland connection	Water infrastruct	Environmental	Scalability	Vicinity to production	Cost (qualitative	Level
		A	A	A	B	B	C	B	A	
1	ANCAP - ALUR	3	3	3	2	2	3	3	3	Higher potential
2	Public Port Paysandú	2	1	2	2	2	1	2	3	Lower potential
3	Public Port Fray Bentos	1	1	2	2	3	1	2	3	Lower potential
4	Public Port Nueva Palmira	2	2	2	3	3	2	1	3	Higher potential
5	Port expansion Nueva Palmira	3	3	2	3	2	3	1	1	Higher potential

Table -2 MCA Rio Uruguay and Rio de la Plata site options.
Weight: **C** less important – **B** important – **A** very important
Score: **1** small/unfavourable – **2** average – **3** large/favourable

5.3.2 ANCAP-ALUR Paysandú

Figure 5-9 ANCAP and ALUR plant in Paysandú

General description	The ANCAP Paysandú Plant is situated, next to the Uruguay River, on the north side of the General Artigas-Paysandú Colón Bridge. The plant is supplied via river by a buoy located north of the General Artigas Bridge, and via pipeline to the storage tanks. ALUR, which is also located in the same area, is a sustainable agro-industrial company that produces a range of products including biodiesel, bioethanol, chemicals, animal feed, energy, and sugar. The planned HIF e=-fuel facility will be located about 6km north of this site and can be connected by pipeline.	
Space available	The site has enough space for e-fuel storage.	Higher potential
Safety zones	The storage can be situated at a safe distance from nearby towns, in compliance with regulatory guidelines.	Higher potential
Hinterland connection	Rail connection to the site is currently being developed. When completed, the site will be connected by rail to the centre and the south of the country, and to Montevideo Port.	Higher potential
Water infrastructure	Current marine infrastructure includes a mooring buoy near the bridge, connected to land by pipeline. This facility is planned to be replaced by a fixed jetty, which will be located further north along the river. The depth at the jetty will be 7m.	Average potential
Environmental considerations	The development of storage tanks on the site is not expected to have a significant environmental impact	Average potential
Scalability	The site has enough space for future storage expansion.	Higher potential
Vicinity to production plant and CO2	Availability of biogenic CO2 from ALUR and close to HIF project (6km to the north)	Higher potential
Cost (qualitative)	It implies a low investment.	Higher potential

5.3.3 Public Port Paysandú

Figure 5-10 Public Port in Paysandú

General description	The Paysandú public port, located on the Uruguay River in the city of Paysandú, is 125km from Fray Bentos and almost 450km from Montevideo. It has a berth for handling dry bulk, which is administered by ANP.	
Space available	The site has some available space where e-fuel storage could be located.	Average potential
Safety zones	The area is near the city, and safety zones overlap with populated areas.	Lower potential
Hinterland connection	There is no rail connection. The possibilities of connection with the hinterland are by truck or barges / small tankers along Rio Uruguay.	Average potential
Water infrastructure	The public port has a berth with an available depth of 7 m.	Average potential
Environmental considerations	The development of storage tanks on the site is not expected to have a significant environmental impact.	Average potential
Scalability	The site is enclosed by the town, and there is no space for future storage expansion.	Lower potential
Vicinity to production plant and CO2	The site is close to the HIF project, but connection would require construction of a pipeline through the city where a suitable alignment would be difficult.	Average potential
Cost (qualitative)	Required investments would be relatively low because most marine infrastructure is already existing.	Higher potential

5.3.4 Public Port Fray Bentos

Figure 5-11 Public Port in Fray Bentos

General description	The Fray Bentos public port, located on the Uruguay River, is 317km from Montevideo and 92km from Nueva Palmira. It has a berth for exporting grains, which is administered by ANP.	
Space available	The port is located inside the city, with limited space available for development of a storage terminal.	Lower potential
Safety zones	The port is located inside the city, with existing urban areas close to the port and potential transport routes and storage areas. Ensuring sufficient safety zones would be challenging.	Lower potential
Hinterland connection	There is no rail connection. The possibilities of connection with the hinterland are by truck or barges and small tankers along Rio Uruguay.	Average potential
Water infrastructure	The public port has a berth with an available depth of 7 m.	Average potential
Environmental considerations	-	
Scalability	There is not enough room for future storage expansion.	Lower potential
Vicinity to production plant and CO2	-	
Cost (qualitative)	-	

5.3.5 Public Port Nueva Palmira

Figure 5-12 Public Port in Nueva Palmira

General description	The port area of ANP in Nueva Palmira has an Ultramar Quay, 370 m long, that is divided into two positions called Ultramar Sur and Norte. Ultramar Sur has two manifolds that are used for the unloading of liquid fertilizers, while Ultramar Norte has equipment for bulk cargo. Additionally, there is a barge quay that is 196 meters long and can accommodate three barges operating simultaneously. The barge quay also has a manifold to load barges.	
Space available	The port area lacks sufficient space for e-fuel storage; however, the nearby hinterland has enough space.	Average potential
Safety zones	The area is near the city. However, the storage could be placed in the south, keeping a safe distance from the city.	Average potential
Hinterland connection	There is no rail connection. The possibilities of connection with the hinterland are by truck or barges and small tankers along Rio de la Plata and Rio Uruguay.	Average potential
Water infrastructure	The public port counts with two berths with 10m depth. The berth occupancy is approximately 55% in both berths. The grain terminal has a very high utilisation during the 6-month peak season.	Higher potential
Environmental considerations	The development of storage tanks on the site is not expected to have a significant environmental impact.	Higher potential
Scalability	There is some room for future storage expansion.	Average potential
Vicinity to production plant and CO2	The site is not situated near existing e-fuel production projects or biogenic CO2 production sites in the country.	Lower potential
Cost (qualitative)	Required investment would be relatively low because existing infrastructure can be used.	Higher potential

5.3.6 Port expansion Nueva Palmira

Figure 5-13 Port expansion area in Nueva Palmira

General description	The port expansion area of Nueva Palmira's public port is approximately 150 Ha and located in the south of the city. This area is reserved for port projects and could be used by ANP as required.	
Space available	The site has enough space for e-fuel storage.	Higher potential
Safety zones	The area is near the city. However, the storage could be placed in the west side, keeping a safe distance from the city.	Higher potential
Hinterland connection	There is no rail connection. The possibilities of connection with the hinterland are by truck or barges and small tankers along Rio de la Plata and Rio Uruguay.	Average potential
Water infrastructure	There is currently no infrastructure available. The depth in the channel is 10 meters and accessible by medium sized ocean tankers. The site is located near the connection of the Rio Uruguay and Rio Parana Guazu from Argentina, and safety of shipping traffic in the river must be carefully considered.	Average potential
Environmental considerations	The development of land and new jetties may have some environmental impact.	Average potential
Scalability	The site has enough space for future storage expansion.	Higher potential
Vicinity to production plant and CO2	The site is not situated near existing e-fuel production projects or biogenic CO2 production sites in the country.	Lower potential
Cost (qualitative)	Investments for development of the site are expected to be high	Lower potential

5.4 Site evaluation

5.4.1 Site evaluation Montevideo Bay

In Montevideo Bay, the reclaimed sites in the eastern basin and north breakwater score most favourable, having sufficient space, access to deep water, and sufficient safety clearance from populated areas. Other sites, such as ANCAP refinery, Capurro and the liquid bulk terminal, have some restrictions related to available space, access to deep water or safety zones, but could be feasible options. Punta Sayago and the West breakwater reclamation are considered less viable options due to the large investments required to connect the sites to the hinterland and to provide vessel access to deep water.

	Montevideo Bay	
3	East basin reclamation	Higher potential
4	North breakwater reclamation	Higher potential
1	ANCAP Refinery	Average potential
2	Capurro Plant	Average potential
7	Punta Sayago	Lower potential
6	West breakwater reclamation	Lower potential

5.4.2 Site evaluation Rio Uruguay and Rio de la Plata

In Rio Uruguay and Rio de la Plata, the port of Nueva Palmira (existing port and expansion area) is well suited to develop an e-fuel terminal thanks to its accessibility for medium sized ocean tankers, and potential as a transit point for barge traffic from Rio Uruguay and the larger region.

The ANCAP / ALUR site at Paysandú is well positioned to handle exports from HIF and any other production facilities that may develop in the northern part of the country, and can connect to Paysandú by rail. However, due to limited depth in the river, the site can only be accessed by barge and small tanker, requiring cargo transfer into ocean carriers in another port.

The public ports of Paysandú and Fray Bentos are not favoured for development of an export terminal due to the lack of space and proximity to urban areas.

	Rio Uruguay and Rio de la Plata	
1	ANCAP – ALUR Paysandú	Higher potential
5	ANP Nueva Palmira	Higher potential
6	Port expansion Nueva Palmira	Higher potential
2	Public Port Paysandú	Lower potential
4	Public Port Fray Bentos	Lower potential

6 Concept plan for potential sites

6.1 Montevideo

An overview of potential sites in Montevideo is shown in Figure 6-1.

Figure 6-1 Port of Montevideo – potential sites

A marine terminal for export of e-fuels could be developed at any of these sites.

Instead of a berth in the port of Montevideo, the option of a Single Point Mooring (SPM) could be considered when volumes increase. An SPM can however not be located close to Montevideo because of shallow water. A suitable location for an SPM is at the existing crude import SPM near Punta del Este. If in the further future there is no more need for import of crude, the existing buoy and existing pipelines could be converted and used for export of e-methanol. Alternatively, a new SPM system could be developed in this location. For this study, the SPM is mentioned as a potential future option but not further detailed.

Potential terminal development in Montevideo is illustrated for one site, for which the eastern reclamation is selected. A typical layout for this terminal is shown in Figure 6-2. Key features include the following:

- A storage terminal can be developed on the existing reclamation, which is currently not used and can easily be levelled and developed. A number of storage tanks would be built, with number and size depending on the number of owners, number of products and logistic requirements. Alternatively, tank storage can also be realised at the ANCAP refinery or at Capurro. However, this requires a longer pipeline connection with multiple lines.
- The terminal area is located away from populated areas, reducing any safety risks.
- A rail terminal can be constructed on the terminal to receive rail cargo, or alternatively a pipeline connection to a nearby rail terminal can be constructed.

- If additional berth capacity is required, a dedicated berth can be constructed adjacent to the grain terminal along the separation dam. The berth should be located directly outside the navigation area of the port basin to ensure that sufficient space is available for safe manoeuvring. The jetty can be connected to the marine terminal by pipeline.
- By increasing the size of the reclamation, the terminal can be expanded if additional tank storage is required.

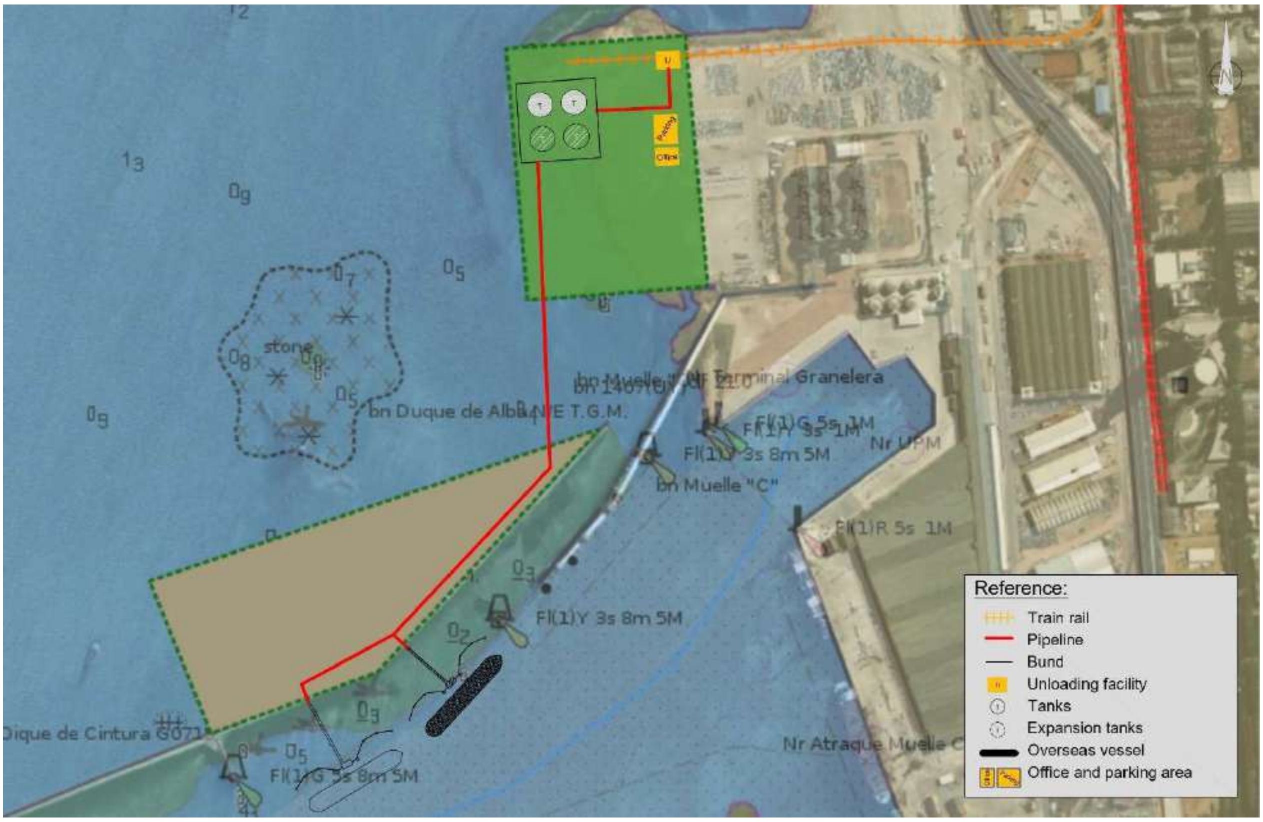

Figure 6-2 Potential layout of Montevideo East Reclamation marine terminal

6.2 North-West Port - Paysandú

The existing ALUR terminal at Paysandú is a feasible location for the development of a marine terminal for e-fuel export. The location of this site is shown in Figure 6-3. A possible layout of the facility is shown in Figure 6-4. The site has the following main features.

- The existing tank storage area can easily be expanded as required for development of additional tank storage.
- A new fixed jetty is planned to be constructed on the river adjacent to the existing terminal. This jetty is planned to be completed by 2025 and will have the capacity to handle barges and small tankers. This jetty can also be used for export of e-fuels.
- The terminal will be connected to HIF Paysandú.
- A rail connection on the terminal is planned to be completed.

Figure 6-3 Location of ALUR terminal in Paysandú

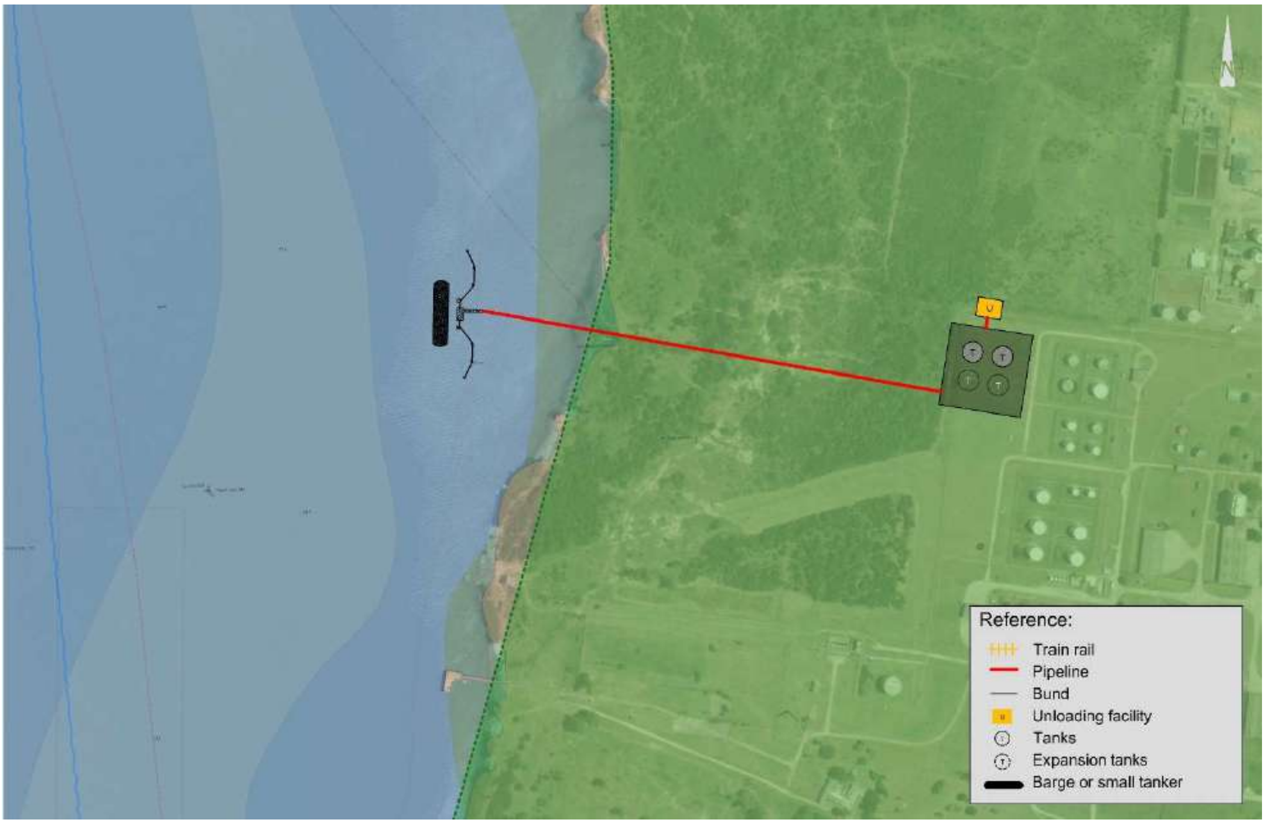

Figure 6-4 Potential layout of Paysandú Marine Terminal

6.3 South-West Port - Nueva Palmira

There are different possibilities for development of a port In South-West Uruguay, of which the existing port of Nueva Palmira seems promising. The location of these ports is shown in Figure 6-3.

Figure 6-5 Location of Nueva Palmira

Nueva Palmira is an existing port with three terminals. Two terminals (the grain terminal and UPM pulp terminal) are private and not suitable for use for e-fuels. The public terminal is currently used for grain and general cargo, but would have some spare capacity for handling e-fuels. For larger volumes a new e-fuel jetty would need to be developed in the expansion area south of the port.

A possible layout of the marine terminal in Nueva Palmira is shown in Figure 6-6.

- A tank storage area could be developed in the direct hinterland of the existing port, where land is available in the port expansion area. This land is located away from housing areas to avoid safety risks.
- Initially unloading and loading of e-fuels could be handled at the existing public berth, connected by pipeline to the tank storage area.
- When volumes grow a dedicated jetty could be constructed south of the existing jetties. This area is earmarked as expansion area for the port. The new jetty is near the junction of Rio Uruguay and Rio Parana Guazú from Argentina, but can be developed outside shipping lanes to ensure safe navigation on the river. A new pipeline connection to the tank farm could be established, so that there is no need to move the tanks.
- The new site has the potential to develop multiple berths for barges and medium sized tankers, allowing the facility to develop as a transhipment hub for cargoes from Northern Uruguay and also for neighbouring countries.

Figure 6-6 Potential layout of Nueva Palmira marine terminal

6.4 Cost estimates

Rough order-of-magnitude CAPEX cost estimates have been made for three potential sites, two in Montevideo (East Basin reclamation and Dique de Cintura reclamation) and for the expansion of Nueva Palmira Public Port. This estimate is a Class 5 estimate (rough order of magnitude) with an expected accuracy of -50%/+100%, consistent with a low level of definition at this stage.

These estimates have been made for the principal components of the marine development, namely:

- Marine Works: including reclamation, revetment and jetty. Estimated based on initial quantity estimates and similar projects.
- Civil Works: Onshore civil works associated with the marine development. Estimated based on project experience.

Investments for tank storage and pipeline systems will be made by the terminal operator and are not included in this estimate.

A summary of the CAPEX estimates is shown in Table 6-1. Further details are included in Appendix B.

Table 6-1 CAPEX estimation (order-of-magnitude)

Item		Total cost (million USD)
East basin reclamation		
	Marine works (excluding jetty)	5.3
	Civil works terminal	1.6
	Total	**6.9**
Dique de cintura reclamation		
	Marine works	47.8
	Civil works terminal	2.0
	Total	**49.8**
Nueva Palmira Expansion		
	Marine works	25.7
	Civil works terminal	1.6
	Total	**27.3**

7 Recommendation for future studies

Further studies and engineering design will be required for the development of a marine terminal.

As a first step, the ongoing study on onshore logistics will complement and support this study for the marine facilities, providing a complete view on the development and logistics of hydrogen derivatives. On the policy side, a view should be developed on the role of public and private parties in the supply chain.

Further development will depend largely on the location and the scale of the production sites that will be developed. Each facility will seek an optimal logistic mix for their exports based on cost optimization and reliability. The marine facilities required to facilitate these exports need to be developed in anticipation of acutal demand. Over-capacity should be avoided to minimize over-investments, while under=capacity would limit export potential. A solid market forecast for the production and export of hydrogen derivatives, with a 5-year and long-term outlook, should therefore be produced and updated regularly.

Initial exports may be facilitated through existing facilities to minimize the initial investments. Once volumes grow and expansion is required, a dedicated marine terminal may be developed. This would involve additional studies and design, including:

- Feasibility studies to determine the capacity, layout and concept of the terminal
- Environmental impact studies to determine any environmental impact and mitigation measures
- Safety studies to determine safety contours
- Permitting and approvals from the various authorities
- Site surveys to determine local site conditions (e.g. bathymetry, geotechnical)
- Engineering studies for the required facilities

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Appendix A – Maritime terminal capacity calculation

Uruguay e-fuel maritime export

Port requirements

	Unit	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Scenario	-	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Volumes					
Total production e-fuels (e-methanol, e-diesel, SA	ton/year	**1,000,000**	**3,000,000**	**5,000,000**	**10,000,000**
Share of total production					
North-East		40%	40%	30%	20%
North-West		50%	40%	40%	40%
South-West		10%	20%	30%	40%
Production volumes					
North-East	ton/year	400,000	1,200,000	1,500,000	2,000,000
North-West	ton/year	500,000	1,200,000	2,000,000	4,000,000
South-West	ton/year	100,000	600,000	1,500,000	4,000,000
Modal split					
North-East					
Rail to Montevideo		100%	90%	80%	80%
Rail to Paysandu		0%	10%	20%	20%
North-West					
Rail to Montevideo		20%	10%	10%	10%
Barge to NP / MC		20%	30%	40%	50%
Small tanker to Montevideo		60%	60%	50%	40%
South-West					
Small tanker to Montevideo		80%	60%	40%	20%
Medium tanker international export		20%	40%	60%	80%
Volumes					
Rail to Montevideo					
From North-East	ton/year	400,000	1,080,000	1,200,000	1,600,000
From North-West	ton/year	100,000	120,000	200,000	400,000
Total	ton/year	500,000	1,200,000	1,400,000	2,000,000
Barge to NP / MC					
From North-East	ton/year	-	40,000	133,333	222,222
From North-West	ton/year	100,000	360,000	800,000	2,000,000
Total	ton/year	100,000	400,000	933,333	2,222,222
Small tanker to Montevideo					
From North-East	ton/year	-	80,000	166,667	177,778
From North-West	ton/year	300,000	720,000	1,000,000	1,600,000
From South-West	ton/year	160,000	600,000	973,333	1,244,444
Total	ton/year	460,000	1,400,000	2,140,000	3,022,222
Export volume					
Large tanker from Montevideo	ton/year	960,000	2,600,000	3,540,000	5,022,222
Medium tanker from NP/MC	ton/year	40,000	400,000	1,460,000	4,977,778
Assumptions					
Vessel cargo capacity					
Barge	ton	2,500	2,500	2,500	2,500
Small tanker (7m depth)	ton	7,500	7,500	7,500	7,500
Medium tanker (10m depth)	ton	25,000	25,000	25,000	25,000
Larger tanker (14m depth)	ton	50,000	50,000	50,000	50,000
Operation times					
Days per year	Days/year	350	350	350	350
Hours per day	Hours/day	20	20	20	20
Hours per year	Hours/year	7,000	7,000	7,000	7,000
Productivity					
Barge	ton/hour	600	600	600	600
Small tanker	ton/hour	600	600	600	600
Medium tanker	ton/hour	800	800	800	800
Larger tanker	ton/hour	2,500	2,500	2,500	2,500
Maximum allowable berth utilisation					
Barge	-	80%	80%	80%	80%
Small tanker	-	65%	65%	65%	65%
Medium tanker	-	65%	65%	65%	65%
Larger tanker	-	65%	65%	65%	65%

Ports

Montevideo

Import volume					
Rail	ton/year	500,000	1,200,000	1,400,000	2,000,000
Small tanker	ton/year	460,000	1,400,000	2,140,000	3,022,222
Export volume					
Large tanker (export)	ton/year	960,000	2,600,000	3,540,000	5,022,222
Number of vessels					
Small tanker (import)	vessels/year	61	187	285	403
Large tanker (export)	vessels/year	19	52	71	100
Berth capacity					
Time at berth					
Small tanker	hours/year	767	2,333	3,567	5,037
Large tanker	hours/year	384	1,040	1,416	2,009
Berth requirements					
Small tanker	berths	0.2	0.5	0.8	1.1
Large tanker	berths	0.1	0.2	0.3	0.4
Total	berths	1	1	2	2
Terminal capacity					
Tank capacity					
Number of users	No.	2	3	4	5
Number of products	No.	1	2	3	3
Tank size (1.2xlargest vessel)	ton	60,000	60,000	60,000	60,000
Total tank capacity	ton	120,000	360,000	720,000	900,000
Number of tanks	No.	2	6	12	15
Terminal area					
Tank storage density	ton/m2	8	8	8	8
Tank area	m2	15,000	45,000	90,000	112,500
General areas	%	20%	20%	20%	20%
Total terminal area	m2	20,000	60,000	110,000	140,000

North-West Port

Import volume					
Local production by pipeline	ton/year	400,000	1,080,000	1,800,000	3,600,000
Rail from North-East	ton/year	-	120,000	300,000	400,000
Export volume					
Barge	ton/year	100,000	400,000	933,333	2,222,222
Small tanker	ton/year	300,000	800,000	1,166,667	1,777,778
Number of vessels					
Barge	vessels/year	40	160	373	889
Small tanker	vessels/year	40	107	156	237
Berth capacity					
Time at berth					
Barge	hours/year	167	667	1,556	3,704
Small tanker	hours/year	500	1,333	1,944	2,963
Berth requirements					
Barge	berths	0.0	0.1	0.3	0.7
Small tanker	berths	0.1	0.3	0.4	0.7
Total	berths	1	1	1	2
Terminal capacity					
Tank capacity					
Number of users	No.	2	3	4	5
Number of products	No.	1	2	3	3
Tank size (1.2xlargest vessel)	ton	10,000	10,000	10,000	10,000
Total tank capacity	ton	20,000	60,000	120,000	150,000
Number of tanks	No.	2	6	12	15
Terminal area					
Tank storage density	ton/m2	8	8	8	8
Tank storage area	m2	2,500	7,500	15,000	18,750
General areas	%	20%	20%	20%	20%
Total terminal area	m2	10,000	10,000	20,000	30,000

South-West Port

Import volume					
Local production by pipeline	ton/year	100,000	600,000	1,500,000	4,000,000
Barge from Paysandu	ton/year	100,000	400,000	933,333	2,222,222
Export volume					
Small tanker	ton/year	160,000	600,000	973,333	1,244,444
Medium tanker	ton/year	40,000	400,000	1,460,000	4,977,778
Number of vessels					
Barge	vessels/year	40	160	373	889
Small tanker	vessels/year	21	80	130	166
Medium tanker	vessels/year	2	16	58	199
Berth capacity					
Time at berth					
Barge	hours/year	167	667	1,556	3,704
Small tanker	hours/year	267	1,000	1,622	2,074
Medium tanker	hours/year	50	500	1,825	6,222
Berth requirements					
Barge	berths	0.0	0.1	0.3	0.7
Small tanker	berths	0.1	0.2	0.4	0.5
Medium tanker	berths	0.0	0.1	0.4	1.4
Total	berths	1	1	2	3
Terminal capacity					
Tank capacity					
Number of users	No.	2	3	4	5
Number of products	No.	1	2	3	3
Tank size (1.2xlargest vessel)	ton	30,000	30,000	30,000	30,000
Total tank capacity	ton	60,000	180,000	360,000	450,000
Number of tanks	No.	2	6	12	15
Terminal area					
Tank storage density	ton/m2	8	8	8	8
Tank area	m2	7,500	22,500	45,000	56,250
General areas	%	20%	20%	20%	20%
Total terminal area	m2	10,000	30,000	60,000	70,000

Appendix B – Capex estimate

CAPEX

	Unit	Quantity	Rate US$/Unit	Total cost US$	Notes
East basin reclamation					
Marine works				5,300,000	
Reclamation works	m3	90,000	30	2,700,000	*From -0.5 to 4m - Area=2 Ha*
Revetment	m	1,300	2,000	2,600,000	*Perimeter in contact with water*
Civil works terminal				1,575,000	
Paving	m2	5,000	125	625,000	*Area= 50% 10Ha*
Lighting	m2	5,000	10	50,000	*Area= 50% 10Ha*
Drainage	m2	5,000	40	200,000	*Area= 50% 10Ha*
Main Utilities	sum	1	500,000	500,000	*Electricity and water supply*
Auxiliary buildings	sum	1	200,000	200,000	*Parking and offices*
Total				**6,875,000**	
Dique de cintura reclamation					
Marine works				47,780,000	
Dredging berthing area					
Berthing pocket	m3	203,000	20	4,060,000	*From -0.5 to -14 - Area=40,000m2*
Turning basin	m3	226,000	20	4,520,000	*From -12 to -14 - Area=113,000m2*
Reclamation works	m3	540,000	30	16,200,000	*From -0.5 to 4m - Area=12 Ha*
Revetment	m	1,500	2,000	3,000,000	*Perimeter in contact with water*
Jetty large vessels	no	1	20,000,000	20,000,000	*Design vessel 50,000 ton - 14m depth*
Civil works terminal				2,012,500	
Paving	m2	7,500	125	937,500	*Area= 50% 15Ha*
Lighting	m2	7,500	10	75,000	*Area= 50% 15Ha*
Drainage	m2	7,500	40	300,000	*Area= 50% 15Ha*
Main Utilities	sum	1	500,000	500,000	*Electricity and water supply*
Auxiliary buildings	sum	1	200,000	200,000	*Parking and offices*
Total				**49,792,500**	
Nueva Palmira Expansion					
Marine works				25,700,000	
Levelling works	m3	200,000	30	6,000,000	*From 2 to 4m - Area=10 Ha*
Revetment	m	850	2,000	1,700,000	*Coast protection*
Jetty medium vessels	sum	1	15,000,000	15,000,000	*Design vessel 25,000 ton - 10m depth*
Jetty barges		1	3,000,000	3,000,000	*Design vessel 2,500 ton - 4m depth*
Civil works terminal				1,575,000	
Paving	m2	5,000	125	625,000	*Area= 50% 10Ha*
Lighting	m2	5,000	10	50,000	*Area= 50% 10Ha*
Drainage	m2	5,000	40	200,000	*Area= 50% 10Ha*
Main Utilities	sum	1	500,000	500,000	*Electricity and water supply*
Auxiliary buildings	sum	1	200,000	200,000	*Parking and offices*
Total				**27,275,000**	