

**A GOOD PLACE
FOR OUR FUTURE.**

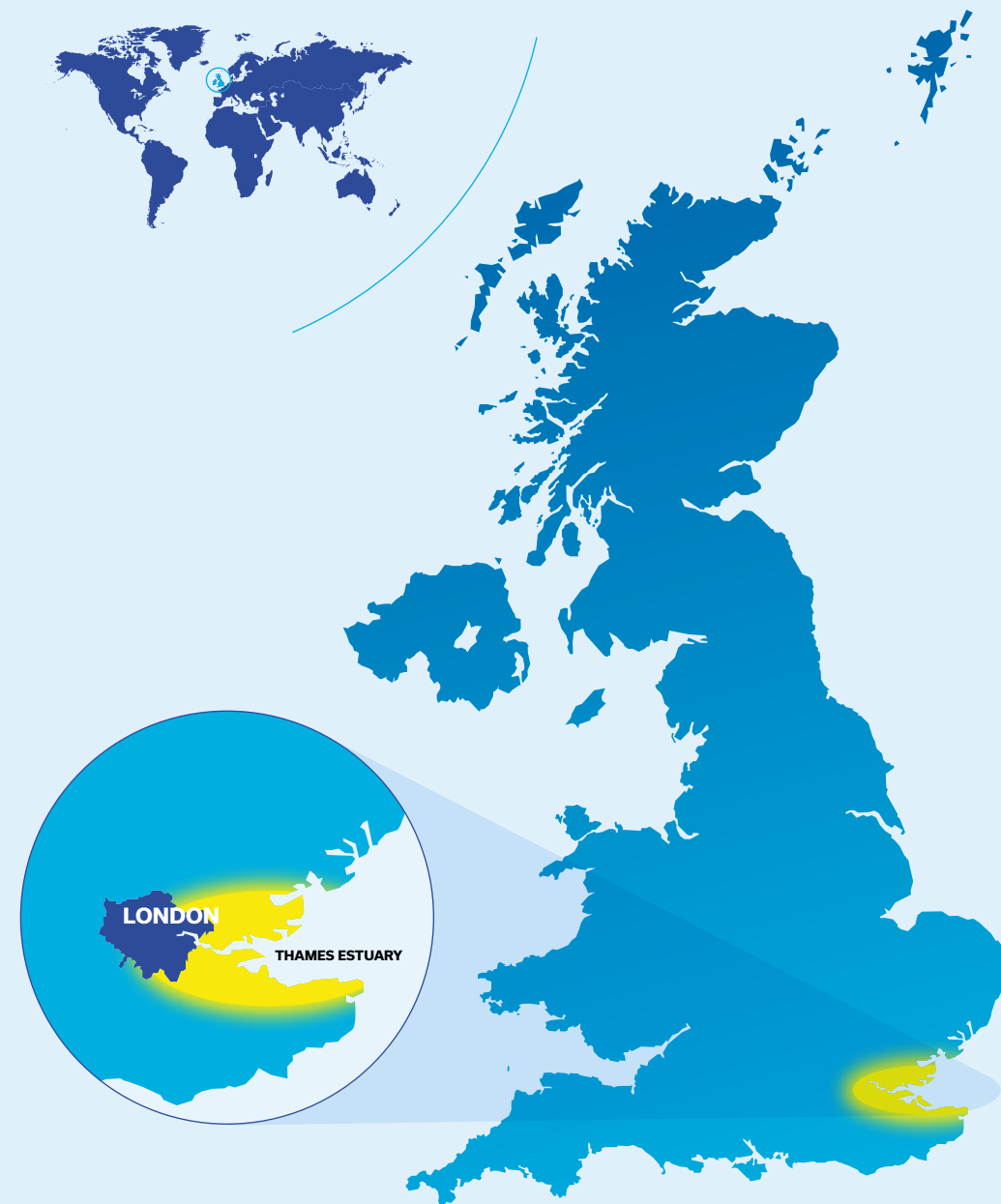
**WE'RE IN A
GOOD PLACE.
JOIN US.**

HYDROGEN ROUTE MAP

A SUMMARY



THAMESESTUARY.ORG.UK



IN THEIR OWN WORDS.

“The Thames Estuary Growth Board is unique and timely. Its capacity to convene **public and private** stakeholders across an **entire region** to speak with **one voice** to policy makers and drive forward **short, medium and long-term investment** is exactly what the hydrogen agenda needs.”

“This is by far the most **comprehensive and well thought out approach** to hydrogen investment that we’ve seen.”

“[We are now] convinced there is a huge potential for **Thames Estuary to be the global reference site** for this and agree completely with the clusters and ground-up project development as well as top-down investor engagement.”

Comments from various stakeholders consulted on this project.

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- Hydrogen ecosystem route map and investment plan

This summary document has been produced to provide a snapshot of our comprehensive report.

We can provide that report on request. If you would like it, please contact Thames Estuary via email at enquiries@thamesestuary.org.uk

FOREWORD.



Kate Willard OBE

Thames Estuary Envoy and
Chair of Thames Estuary Growth Board.

We are proud and excited to launch
The Thames Estuary's Hydrogen Route Map.

The Thames Estuary is the most
exciting growth region in the UK with the
potential to generate **£190 billion** for the
UK economy by 2050.

Through our Green Blue vision, our
objective is to achieve that growth by
capitalising upon the unique built and
natural assets of this place by identifying and
catalysing new opportunities. We also want
to create the cleanest and greenest river-side
region anywhere on the planet.

The Thames Estuary has the capability to
turbo-charge the Government's ambition to
become a global player in hydrogen energy
and its net zero goal.

Over the past six months we've looked
across the Estuary to understand the needs
and opportunities and articulate the scope
for a hydrogen ecosystem which is
compelling and capable of attracting
multi-billion-pound investment.

A hydrogen ecosystem in the Estuary would
have far reaching, positive implications for
the region and the UK.

The Estuary would set the UK on its path
to zero carbon by 2050 reducing carbon
emissions by up to 5.9 million tons per year.

Across the region itself, it would unlock
incredible benefits for people and local
economies supporting its levelling up through
9,000 new jobs and generating **£3.8 billion**
by 2050. The transition away from fossil fuels
will help address issues of poor air quality and
improve health and wellbeing.

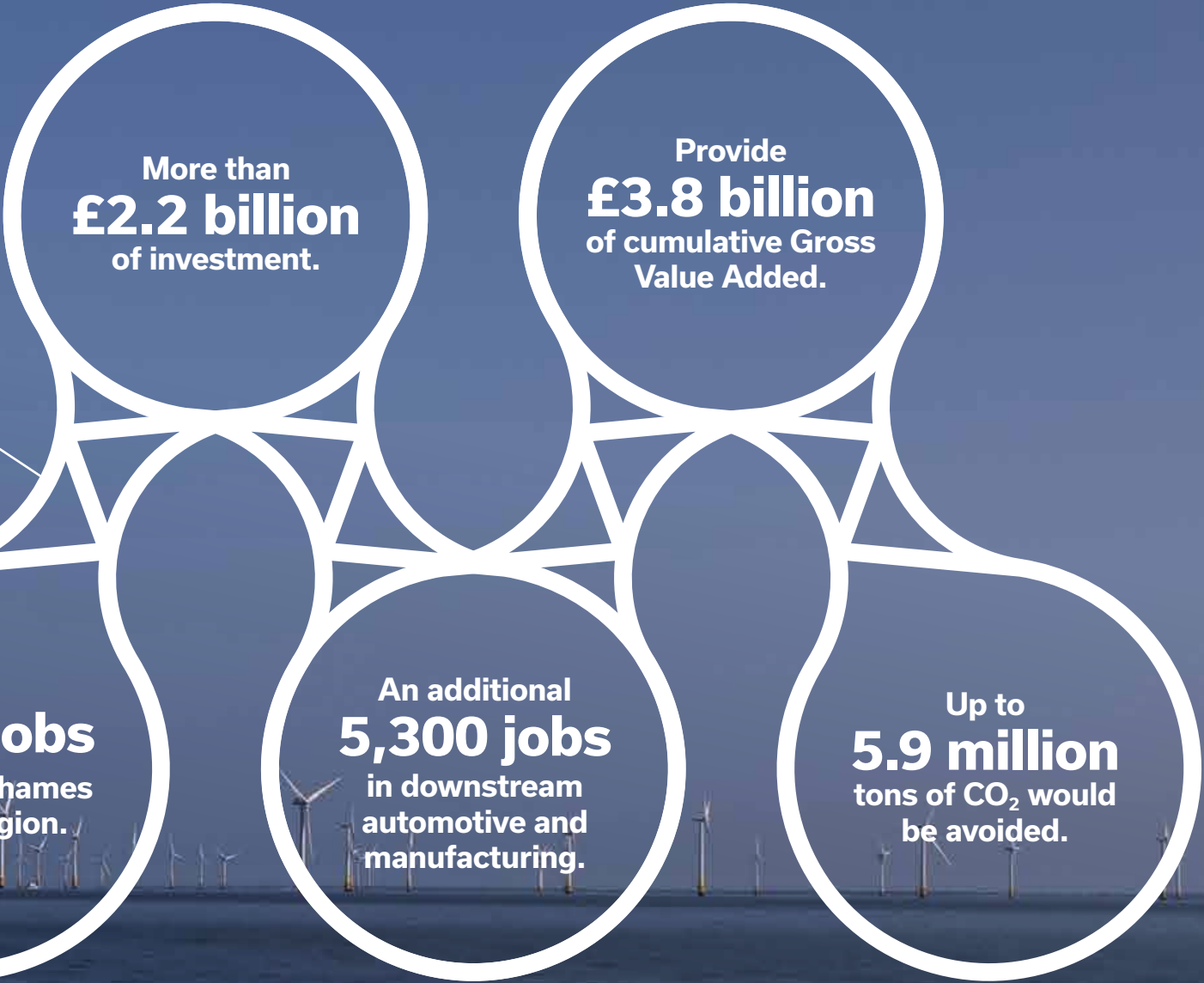
It would also set a course for the Estuary
to become a global leader in research
and development trialling cutting-edge
technologies and innovation.

The Thames Estuary Growth Board is a
strategic investment partner to Government
and by commissioning bankable investment
plans like this, we are unlocking the potential
of this place, supporting the levelling up
agenda and our national recovery from Covid.

This is a compelling opportunity for investors
to become part of the most amazing hydrogen
project anywhere on the planet. **Join us.**

**THE ECONOMIC
DESIRABILITY OF A
HYDROGEN ECOSYSTEM
IN THE ESTUARY.**

It is estimated that, by 2035, demand for hydrogen
manufacture and supply could support up to:



SECTION 1.

INTRODUCING THE THAMES ESTUARY.

The Thames Estuary region

The Thames Estuary is backed by Government as the UK's best growth opportunity.

It has the potential to catalyse 1.3 million jobs, build 1 million new homes and add £190 billion to the nation's economy by 2050. It will play an integral part in the UK's trade with Europe post-Brexit and support the country's bounce-back from Covid and the wider levelling-up agenda.

In 2018, The Thames Estuary 2050 Growth Commission published an ambitious vision for growth in this beautiful place of blurred boundaries which includes parts of east London, north Kent, south Essex and the River Thames. The Government backed it and hailed it as an amazing opportunity in their response.

The Thames Estuary Growth Board

Kate Willard OBE was appointed Thames Estuary Envoy in December 2019 to deliver the 2050 Commission's vision and selected a dedicated private-public Thames Estuary Growth Board made up of stellar talents from government, politics, energy, law, planning, infrastructure, transport, energy, and creative industries to work with her to drive it forward.

The Growth Board launched its vision, called "The Green Blue" in July 2020, to begin the task of realising the amazing potential of the Thames Estuary. It's called "The Green Blue" because it's about creating good, green, sustainable growth using the important, blue waterway of the Thames that connects the UK with the rest of the world.

Since then, the Board have been getting on with the job of making great things happen in the Estuary.

The Board recognises its purpose is to add new value to the Estuary and not interfere or duplicate anything already happening. It wants to use its influence, networks and relationships to find new opportunities to benefit people, communities and businesses across the entire region.

It has made huge strides forward developing multi-billion-pound investment projects that are already stimulating the interest of national and international investors in sectors as diverse as hydrogen, digital infrastructure, waterborne freight, and housing and infrastructure. By the end of this financial year (2021/22) it will have finalised investible propositions from these projects targeting initial investments into the Estuary during 2022/23 and beyond.



GREATER LONDON

CITY OF LONDON

ESSEX

KENT

THAMES ESTUARY

THE FUTURE THAMES ESTUARY

The Thames Estuary is an amazing place.

While it clearly boasts enormous advantages situated close to the City of London with international transportation hubs, world-class universities, thriving creative and cultural quarters and acres of brownfield sites ripe for development on its doorstep, it will also be transformed over the next 30 years thanks to various projects across sectors including transport, infrastructure, leisure and culture.

The Thames Estuary Growth Board is backing many large-scale projects and will work to identify and unlock further benefit from each.

They include:

The Lower Thames Crossing – a 2.6-mile tunnel (the longest in the UK) connecting communities in Kent and Essex - this is the most ambitious UK road project since the M25 improving connectivity across the territory to key ports.

The London Resort in Swanscombe, Kent, will be one of Europe's largest construction projects and three times larger than any other resort park in the UK, transforming 535 acres into two theme parks, a water park, 3,500 hotel rooms. Creating 30,000 jobs, this will be one of the largest immersive experience centres in the world.

The historic **London markets** of Smithfield, Billingsgate and New Spitalfields are being consolidated into one market, located in Dagenham Docks, by 2023. This 42-acre site will be the country's largest wholesale food destination, bringing a huge economic boost to the area and creating employment opportunities for local people.

There will also be a boom in the creative industries with new Hollywood-rivalling film studios built in **Dagenham and Purfleet-on-Thames**.

Other cultural projects planned will position London and the south-east as a world leader for the creative industries on a scale never seen before.

The Thames Estuary is also host to one of the UK's first freeports which will have different customs rules to other UK ports. As well as tariff flexibility, customs facilitations and tax measures, **Thames Freeport** will offer wider benefits for businesses such as planning reforms, funding for infrastructure improvements and innovation incentives.

The Thames Freeport will generate jobs and opportunities for the whole area, benefitting communities along the Estuary that need it most.

SECTION 2

THE THAMES ESTUARY AND THE HYDROGEN OPPORTUNITY

The Thames Estuary Growth Board understands the region presents a unique opportunity for investment in hydrogen at scale like nowhere else in the UK.

THE POTENTIAL FOR HYDROGEN IN THE THAMES ESTUARY

Demand:

The Estuary is next to one of the world's leading cities, with a large demand on its energy and transport infrastructure. Initial research by the University of Kent identified significant demand for hydrogen across the region. The Thames Estuary Growth Board saw the potential for an internationally significant cluster across a range of uses such as transport, industry, heating, and power and undertook this work to understand how we could deliver an investment led ecosystem. The Estuary has the key ingredients (brownfield sites, access to water, need, reliance on fossil fuel energy) to create a compelling case for investment in hydrogen.

Contribute to Net Zero:

In addressing the root cause of climate change, reducing the impact of greenhouse gases, our promotion of a hydrogen-driven economy would support decarbonisation and UK net zero targets.

Legacy:

We already have locations within the Estuary where progress is being made. A transition to incorporating hydrogen in the domestic gas supply and new plants to manufacture hydrogen for public transport are already happening, but this is just the beginning.

Scale:

We also have critical mass that will enable adoption at scale, as well as large opportunities in air and port side uses, public transport, other municipal uses and a significant logistics sector to service.

Decarbonisation:

The Thames Estuary region as a whole emits roughly 11.8 million tonnes of CO₂ equivalent per year. This is higher than any of the UK's six industrial clusters (Grangemouth, Teesside, Merseyside, Humberside, South Wales and Southampton). Hydrogen presents a huge decarbonisation opportunity for the region, contributing to the UK's greenhouse gas emissions reduction targets.

Opportunity to co-ordinate:

We want to ensure the industrial, oil, petrochemical, energy and maritime activities on both banks of the Thames and beyond, and into the communities across the counties of Essex and Kent, feel the economic, environmental and societal benefits that a coordinated hydrogen economy could bring to the region. Moreover, an effective, coordinated strategy has the capability of feeding those benefits right into the marketplace in the heart of London.

UK Hydrogen Strategy:

The Government is committed to delivering hydrogen at scale. As a strategic investment partner to Government, we are in a position to support that ambition.

Health and wellbeing:

The positive impact a hydrogen future would have on the health of our Estuary communities cannot be overstated. The development of an Estuary-wide hydrogen vision would present an opportunity to re-dress some of the environmental and health inequalities and improve outcomes for people living here.

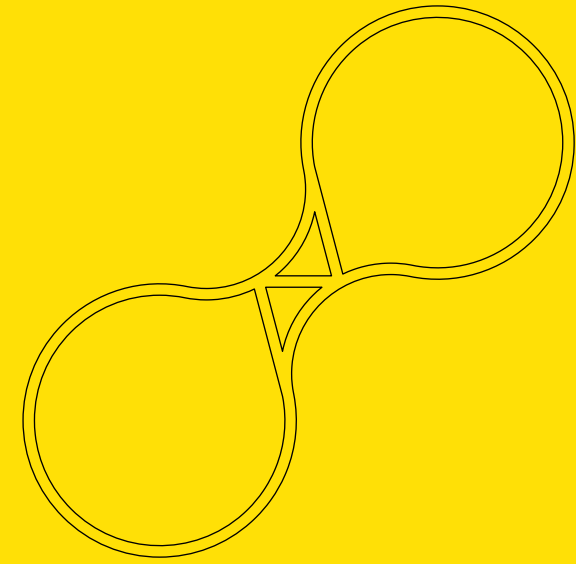
The case for a hydrogen ecosystem in the Thames Estuary is compelling.

The Thames Estuary Growth Board recognised that and understood it would need the right support and backing from investors to make it happen.

This vision is our roadmap for the next ten years to enable it.

It sets out the work we have done up to this point to comprehensively understand the opportunities and how we can begin to deliver.

SECTION 2.



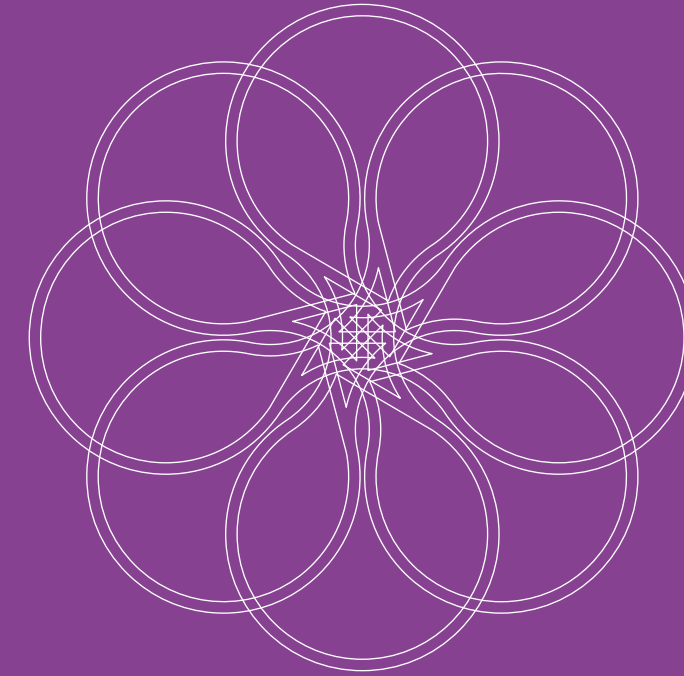
HYDROGEN SUMMIT



In November 2020, we held a hydrogen summit which brought together leaders and experts from industry, academia, transport and energy to begin debating a hydrogen strategy for the Estuary and a plan for the future.

The wide-ranging discussion concluded that as well as environmental benefits, there was an opportunity to unlock economic growth and create new green jobs across the Thames Estuary.

This would be key for the levelling up agenda and promoting economic growth post-Brexit and post-Covid.



HYDROGEN ROUTE MAP

Following the summit, which revealed a clear appetite and demand for hydrogen in the Thames Estuary, the Growth Board commissioned Ikigai and DNV to develop our route map.

The rest of this document sets out the findings of this study and next steps.

IKIGAI
CAPITAL

Ikigai Capital is a Net Zero bankability consultancy focused on clusters, city and industrial decarbonisation. They bridge the gap between investors, tech, demand and Government to unlock capital investment for sustainable and inclusive regional growth.

Ikigai Capital are developing the hydrogen ecosystem route map.

DNV

DNV is a global assurance and risk management company with market leading experience advising on the transition to a low carbon economy, including the sourcing, distribution, storage and application of hydrogen.

The the route map is being informed by a technoeconomic study by DNV.

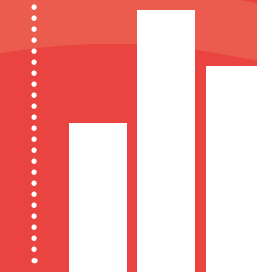
SECTION 3.

OUR STUDY TO CATALYSE A HYDROGEN ECO-SYSTEM IN THE THAMES ESTUARY.

OBJECTIVES.

The Thames Estuary Hydrogen Route Map has identified and evaluated the potential for an investable hydrogen generation, distribution, storage and usage infrastructure within the region. This section describes the methodology for it.

PHASE 1.



To quantify the scale of the Thames Estuary hydrogen opportunity.



To create a route map to capital investment.



To balance broader objectives of affordability, inclusivity, systems-thinking and skills growth.

PHASE 2.



To develop a pipeline of investable projects.



To attract funding and deploy projects.

SECTION 3.

STAKEHOLDER
ENGAGEMENT.

200+
INTERVIEWS



£10.9
TRILLION
ASSETS UNDER
MANAGEMENT



More than 200
interviews with
local stakeholders.

A region-specific
hydrogen workshop with
over 50 representatives
from industry.

One-to-one
discussions with
multiple local
authorities.

An investor workshop with
130+ financial institutions and
organisations with more than
£10.9 trillion of Assets Under
Management (AUM).

Cross-government engagement with the
Departments for Business, Energy, and
Industrial Strategy (BEIS), International Trade
(DIT), Transport (DFT) and the Infrastructure
and Projects Authority (IPA).

International and
nation-wide cooperation
with universities and
other industrial areas.

SECTION 3.

THE APPROACH.

The approach has been:

TOP-DOWN

The techno-economic assessment has mapped:



Challenges of hydrogen infrastructure delivery.



Sources and uses of hydrogen.



Other low carbon alternatives vis-à-vis hydrogen.



Filtering criteria for an optimal hydrogen cluster.



The current and future policy landscape.



The approach has been:

BOTTOM-UP

The focus now will be on attracting immediate investment through value-creation:



Alignment with core business strategies of local demand (decarbonisation, revenue diversification and operational optimisation).



Identifying potential for long-term contracted cash flows from the hydrogen ecosystem.



Looking at cross-subsidisation opportunities to accelerate hydrogen infrastructure development.



DEFINING CHARACTERISTICS OF THE THAMES ESTUARY

The study considered the region's current situation regarding hydrogen.

A dispersed and diverse place bringing together 18 local authority areas.

Not formally recognised as one of six industrial clusters by the UK government – yet, an area with higher overall carbon emissions.

No current large-scale hydrogen production or infrastructure, but two major projects in development, namely Cavendish and Ryze.

Multiple offshore wind farms and more in development, but with competing uses and decoupled from local demand.

Lack of underground/ geological storage potential for CO₂, particularly with regards to blue hydrogen production.

One of the most densely populated regions of the UK with high value land.

SECTORAL APPLICATIONS.

We have compartmentalised potential hydrogen demand under a series of sectors, capturing existing sites and new projects where demand could come from in the region.



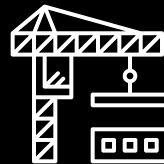
Ports, maritime & river transport:

Multiple ports (London Gateway, Tilbury, Thamesport, Purfleet, Sheerness). A complementary study is underway by the Port of London Authority to calculate river-transport demand and optimal refuelling sites.



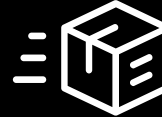
Airports and aviation:

London City Airport, London Southend Airport, a proposed new cargo airport at Manston (subject to planning) and existing jet fuel pipelines to Heathrow.



Construction:

Major infrastructure projects with ambitious green objectives (Thames Tideway, Lower Thames Crossing, London Resort).



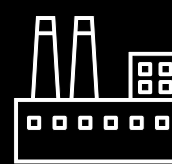
Distribution & logistics:

A major logistics and distribution hub (rail, river, shipping and road) including the London Markets Relocation site.



Residential:

Plans for 25,000+ new homes by 2030, with ambitions to deliver low-carbon heat.



Industry:

A variety of large emitters with high-temperature heat and hydrogen vehicle requirements (Ford, Tate & Lyle, Cory and others).

POTENTIAL HYDROGEN BUSINESS MODELS IN THE THAMES ESTUARY.

The following business models are some of those that have been identified, through stakeholder engagement, to facilitate accelerated implementation of a hydrogen ecosystem in the Estuary. These models are designed to take advantage of existing and announced UK Government revenue support for hydrogen production, transport and storage applications.

Long term concession agreements to provide 'mobility-as-a-service':

- Well-suited to dedicated corporate HGV and vessel fleets and public buses, emergency vehicles and refuse collection vehicles.
- Would include all aspects of service delivery: vehicles (whether fuel cell electric vehicle or hydrogen combustion engine), hydrogen production (whether from new or, subject to meeting additionality criteria, existing generation), distribution, storage and captive refilling infrastructure.

Captive hydrogen refuelling hubs:

- Well-suited to locations with a high proportion of back-to-base HGV and/or river vessel demand, as well as non-road mobile equipment such as conveyors, cranes, tugs and forklifts.
- Will require long term bilateral agreements with anchor haulage companies or vessel operators or 'obligations to refuel' imposed by ports or distribution centres, subject to price caps, in order to for such investments to be investable.

Sustainable multi-fuelling service stations:

- Well suited to high HGV traffic motorways around ports, distribution or industrial zones, and to existing truck-parking areas. Could also be implemented as an upgrade to existing service stations.
- A multi-fuel model (EV charging, biomethane and hydrogen refilling capacity) has been successfully deployed in other countries to take advantage of regional feedstocks, facilitate cross-subsidisation of hydrogen revenues by more established fuels, reduce utilisation risk and maximise flexibility as fleets convert over time.

Target cost 'Net Zero Construction':

- Designed to incentivise the lowest cost solution for decarbonisation of construction of major, long term projects in the Thames Estuary and investment in legacy infrastructure.
- Rather than specifying a single technology or fuel solution for equipment, vehicles and vessels required to be provided by contractors, the project sponsor would instead set a target cost for achieving Net Zero (and security of supply) during the construction and operational period of the project.

Multi-technology vehicle public/private financing platform:

- Designed to bridge the gap between the current capital cost of hydrogen vs fossil-fuelled HGVs, and accelerate uptake of hydrogen vehicles by large fleets on an OEM-neutral basis through a public-private match funding facility.
- A model successfully deployed in the US, in that case to provide funding to support individual OEMs to offer "pay-per-use" or finance leases to their customers on a turn-key basis (i.e. including all maintenance, insurance and in some cases, hydrogen supply).

Combined industrial fuel-switching and carbon reutilisation:

- Well-suited to industrial high temperature heat users currently dependent on natural gas, where heat recovery or current heat pump technology does not meet operational requirements.
- The solution could incorporate a certain proportion of onsite carbon capture and reutilisation given the strong demand for carbon in the Thames Estuary, in advance of permanent storage becoming available backed by Government support. The concept design should also be able to accommodate scale up of usage over time, as further sources of hydrogen become available to the Estuary, including from imported or UK produced e-ammonia.

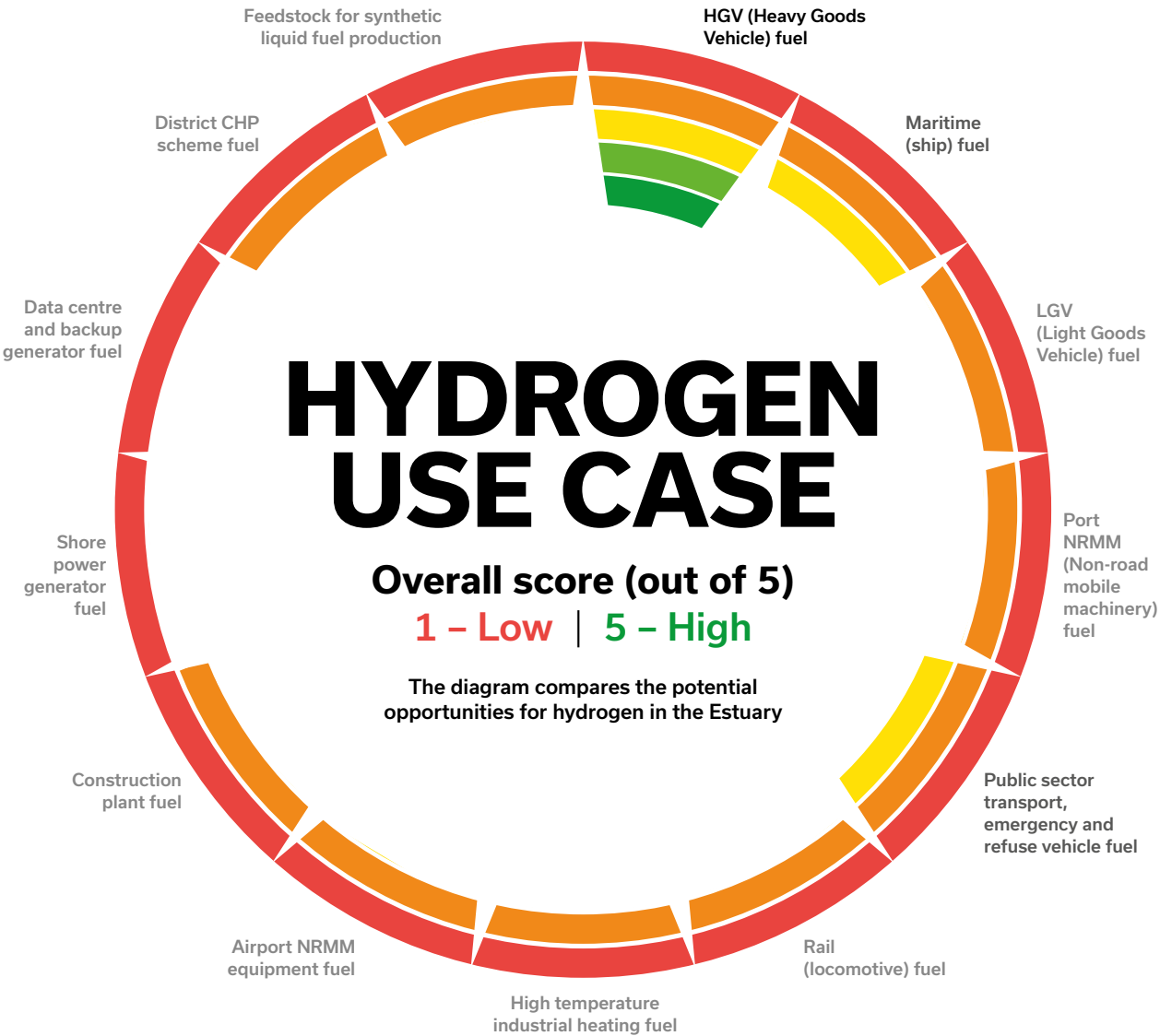
'Pay to save' models:

- Suited to locations where there are growing power demands or the necessity for long periods of critical load back-up power, concerns about air pollution and significant grid constraints.
- Customers share in the savings associated with switching from diesel generators to hydrogen-fuelled generation barges, or avoided costs associated with grid upgrades associated with delivery of, for example, ship-to-shore power.

SECTION 3.

OUR AMBITION IS TO DELIVER PROJECTS IN A SHORT TIME SCALE (2-3 YEARS) THEREFORE, POTENTIAL HYDROGEN APPLICATIONS FOR THE THAMES ESTUARY WERE **ASSESSED BASED ON THE FOLLOWING BANKABILITY CRITERIA,** IN LINE WITH INVESTOR EXPECTATIONS:

Size of potential market.
Technology readiness.
Competitiveness and capacity of supply chain.
Competition from alternative fuels/technologies.
Policy support.
Flexibility/inertia to transition, for example, capital intensity.



Hydrogen is an energy carrier that can be used in a wide range of final use applications without contributing to greenhouse gas emissions in the form of carbon dioxide.

DNV has reviewed a number possible hydrogen uses, with detailed explanation available in the techno-economic report. DNV has also scored these based on a set of key bankability criteria.

Uses that initially appear to be the most promising are all transport related and include hydrogen for heavy good vehicles (HGVs), public sector transport and non-road vehicles at ports and airports. This is not altogether surprising, as these uses can be difficult to decarbonise using other means such as electrification.

THE UK HYDROGEN STRATEGY AND THE THAMES ESTUARY

The Hydrogen Strategy published by the UK government in August 2021 can further support the Thames Estuary Hydrogen ecosystem via these opportunities:

£240m for the Net Zero Hydrogen Fund.	Up to £60m under the Low Carbon Hydrogen Supply 2 competition.	CfD business model for hydrogen production, to be finalised in 2022.	Up to £68m for the Longer Duration Energy Storage Demonstration competition, with storing hydrogen produced from excess electricity in scope.	Grant funding to support fuel switching technologies, including low carbon hydrogen, through Phase 2 of the £315m Industrial Energy Transformation Fund.	£55m Industrial Fuel Switching 2 competition.
£40m Red Diesel Replacement competition.	£120m this year through the Zero Emission Bus Regional Areas (ZEBRA) scheme towards 4,000 new zero emission buses.	Up to £20m this year to design trials for both electric road system and hydrogen long haul heavy road vehicles (HGVs).	Up to £20m this year for the Clean Maritime Demonstration competition.	Up to £15m this year for the 'Green Fuels, Green Skies' competition.	Support for hydrogen innovation as one of the ten key priority areas in the £1bn Net Zero Innovation Portfolio.

WHAT IS THE SCALE OF THE OPPORTUNITY?

Because of the uncertainty in speed, depth and breadth of penetration of hydrogen into transport and other sectors, a scenario-based approach was used to model the opportunities a hydrogen ecosystem might bring to the Thames Estuary.

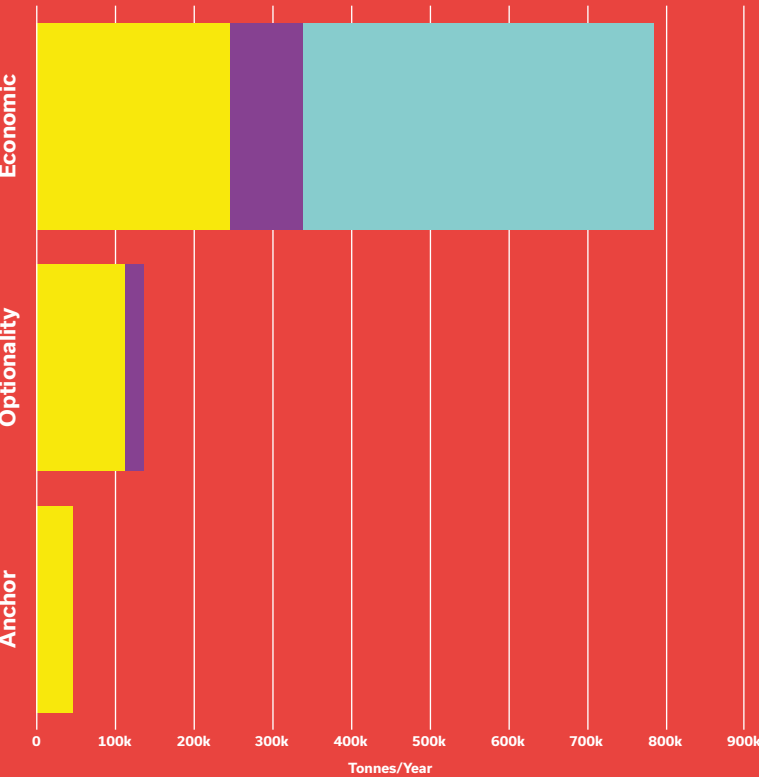
The three scenarios modelled were:



SECTION 3.

HYDROGEN DEMAND

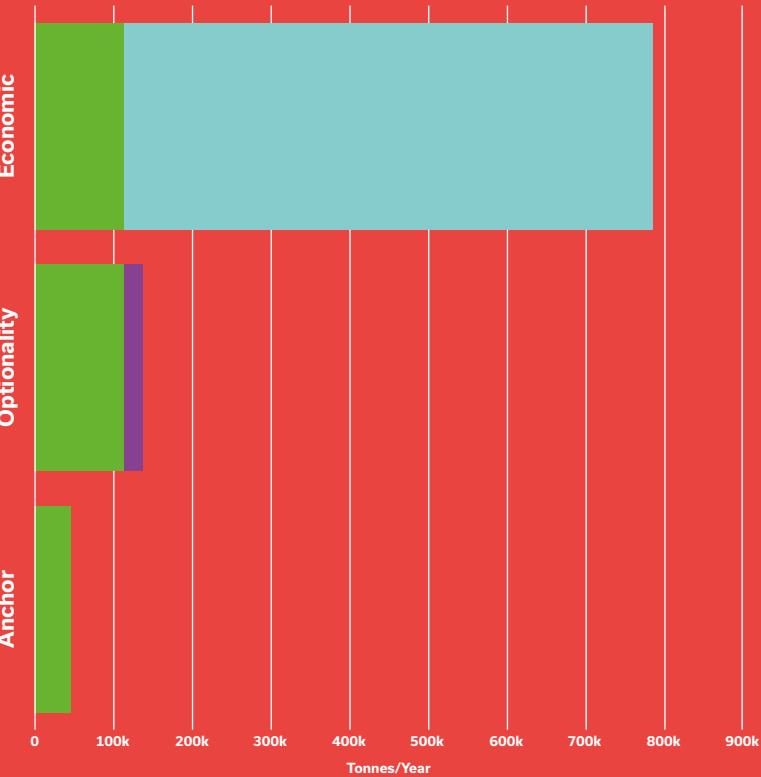
Estimated hydrogen demand within the Thames Estuary for each of the three scenarios modelled.



Transport Industry (heat & power) Domestic & Commercial (heat)

HYDROGEN SUPPLY

Estimated hydrogen supply within the Thames Estuary for each of the three scenarios modelled.



Green H2 Electrolysis Blue/Green Ammonia Blue H2 (reformer)

Only low-carbon sources of hydrogen were considered as part of study, including blue/green ammonia (NH₃) as low-carbon hydrogen carriers, and these were stress-tested against the demand scenarios modelled in order to consider how these could match up.

Green hydrogen supply has been prioritised for those applications requiring a high degree of hydrogen purity, particularly fuel cell equipped vehicles.

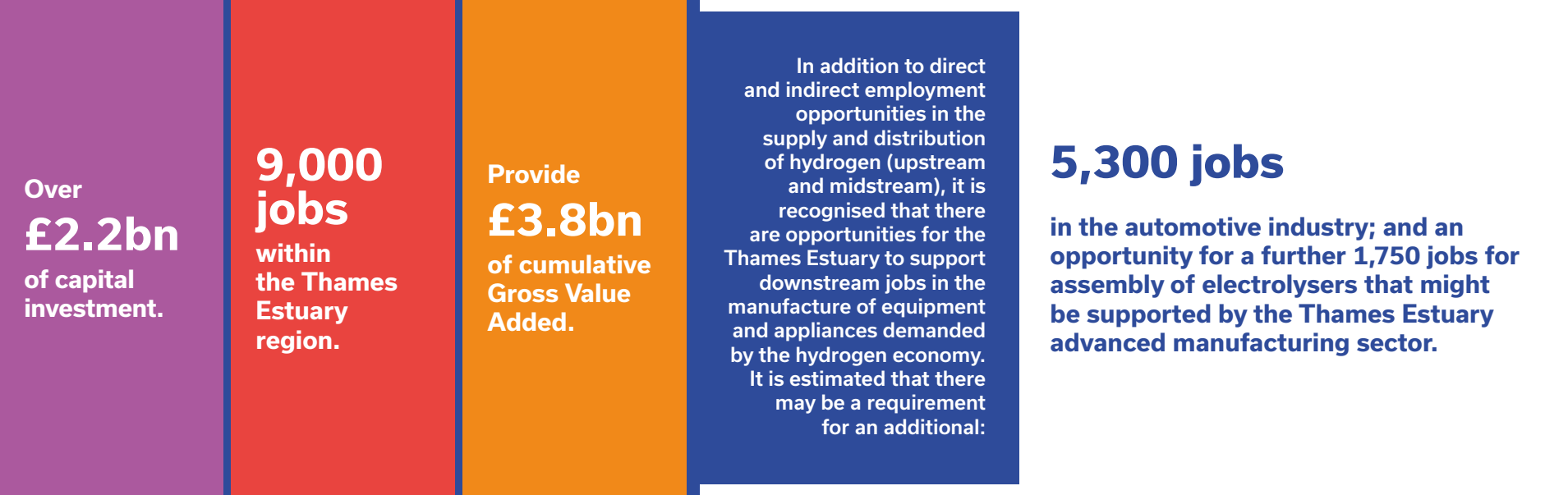
Due to capacity constraints for local green hydrogen production, blue hydrogen as well as imported green/blue ammonia have also been considered. These lend themselves to industrial high heat applications as well as commercial and residential heating.

SECTION 4.

OUR STUDY IDENTIFIED THE IMPACT AND BENEFITS OF A HYDROGEN ECOSYSTEM IN THE THAMES ESTUARY.

CONCLUSIONS AND WHAT WE NEED TO DO NEXT.

It is estimated that, by 2035, demand for hydrogen manufacture and supply could support up to:



THE STEPS WE NEED TO ACHIEVE TO MEET THE ANTICIPATED SCALE.

HYDROGEN SUPPLY, STORAGE AND DISTRIBUTION:

- Installation of new renewable power generation capacity balancing other land uses and long-term storage.
- Identification of available COMAH (Control of Major Accident Hazards) sites.
- Managing health and safety considerations.
- Installation of hydrogen generation, distribution and storage infrastructure vis-a-vis populated areas.
- Exploring options for CO₂ shipping and long-term storage, supporting blue hydrogen production, due to limited geological storage.
- Balancing the additionality criteria of renewable generation for green hydrogen production against the ability to optimise existing generation assets.
- Guaranteeing a certain level of purity for hydrogen fuel-cell applications.



THE UK HYDROGEN STRATEGY SETS OUT THE GOVERNMENT'S **AMBITION TO ADVANCE THE HYDROGEN AGENDA.** GOVERNMENT SUPPORT IS ESSENTIAL, AND CAN PLAY A VARIETY OF ROLES:

Local authority concessions to provide hydrogen fuel/fuelled vehicles for public services.

Obligations to use alternative fuels into specifications.

Changing policy to create markets. For example, the Contracts for Difference scheme for low-carbon hydrogen production, and 'development fuel' certification incentivising hydrogen production for use in transport-related applications.

Tax concessions and upfront grants for vehicles and refuelling infrastructure.

Breaking the 'chicken and egg' problem. In other words, what comes first the demand or the supply/refuelling infrastructure?

Reducing high upfront costs/capital expenditure.

Understanding the residual value of hydrogen vehicles at the end of their operational life.

Supplying hydrogen fuel at a competitive cost at the dispenser (i.e., the all-inclusive price of hydrogen delivered at the pump, which includes distribution and storage).

Providing tax breaks such as exemption from fuel duty.

HYDROGEN DEMAND AND ADOPTION:

- Balancing conversion of existing vehicles/equipment vs. new purchases.
- Increasing the availability of operation and maintenance services.
- Managing fleet flexibility requirements, such as refuelling time, range, etc.
- Matching local manufacturing capacity with demand scale up over time.
- Accelerating progress through government support.

SECTION 4.

HYDROGEN 'CLUSTERS' ACROSS THE THAMES ESTUARY

A series of **hydrogen 'clusters'** have been identified across the Thames Estuary.

A hydrogen cluster is defined as: 'a geographic region where one large or a co-operative of smaller potential demand exists or alternatively a site which is advantaged through access to land and infrastructure such that it has the potential to become a hydrogen hub and distribute hydrogen to outlying consumers'.

In order to identify the potential hydrogen demand-led 'clusters', the following demand, supply, storage and distribution filtering criteria were mapped out across the Thames Estuary using GIS software.

As a result of this exercise, a total 14 clusters were identified. Nine of these clusters are portrayed in the 'hydrogen cluster map'.



Demand (based on hydrogen use cases reviewed):

Priority given scale, timeline and geography

- High temperature heat process industry
- Commercial HGVs (haulage companies, captive industry fleets, RORO sites at ports, existing truck parking areas, service stations on major motorways/A-road junctions)
- Emergency vehicles (ambulances and police), local authority refuse collection vehicles, long-haul buses and taxis
- Markets and distribution warehouses (continuous use equipment)
- Long-term construction sites (non-road mobile machinery and gensets)
- Ferries and other river vessels (bunkering)

Second tier

- Cruise terminals (where ship-to-shore power is constrained)
- Airports (short-haul passenger and cargo)
- Critical loads with onsite diesel back up
- Existing / new district heat networks
- Marine bunkering opportunities
- Freight rail lines unable to be electrified
- Large existing / planned residential schemes (one or more national/regional developers)

Supply (supporting the identified demand in each cluster):

- Existing oil ports and refineries
- Existing/planned gas-fired power stations
- Existing/planned EFW/biomass power stations
- Existing/planned renewable power
- Access to water/WWTF (incl. for generation capacity)

Distribution and storage (enabling infrastructure required):

- Electrical substations
- Gas grid (high / medium pressure)
- Electrical interconnectors
- Existing / disused fuel pipelines
- River access
- Jetty infrastructure
- Min. river draught (>11m at low tide)
- Disused / existing fuel or gas terminals
- Sites with appropriate regulatory designations such as COMAH
- Large brownfield industrial zone land banks not suitable for more valuable uses

CASE STUDY: WHAT DOES THE HYDROGEN OPPORTUNITY LOOK LIKE WITHIN A SPECIFIC CLUSTER?

Using an East London Cluster as a case-study, the specific hydrogen opportunity was analysed at a more granular level.

This included the use of public domain data and information collected through the stakeholder engagement exercise to come up with a more accurate estimate of an anchor hydrogen demand.

From this, a build out plan for the hydrogen supply was developed, with a capital expenditure estimate for the required facilities.

Finally, the avoided NOX and CO₂ emissions were calculated and factored into the cost-benefit analysis.

Sector	Hydrogen demand (tonnes/day)	CAPEX (£ million)	Primary input cost per unit output	Societal value of avoided NOX (£ million/year)	Avoided CO ₂ emissions (tonnes/year)
HGV transport	7.3	96	£ 3.13 /kg H2	9.0	23,477
LGV transport	0.6	7.2	£ 3.52 /kg H2	1.2	3,127
Industry	34.4	170	£ 3.95 /kg H2 equiv	6.7	75,000

FROM CONCEPT TO PROJECTS

As part of the next phase of the project, we will convert the hydrogen opportunity into bankable projects. This entails:

- Deep dive analysis into ‘showcase’ clusters.
- Further local stakeholder engagement to refine hydrogen demand assumption.
- Stress-test shortlisted technical applications with stakeholders.
- Decide on optimal technical solutions.
- Refinement of business models (if required) to get stakeholder support for a specific project.
- Outline business case development for identified projects, outlining nature of parties sought to deliver the project.
- Presentation of projects to investors, where third-party/external financing is sought.

SECTION 4.

OUR TIMELINE.

Early April 2021 Hydrogen cluster boundaries defined on the basis of aggregated complementary demand, technical constraints and strategic cooperation opportunities.	Late April 2021 Confirmation of key stakeholder willingness (but not commitment) to explore hydrogen ecosystem opportunities, timeframes and constraints, subject to due diligence etc.	Early May 2021 Identification of optimal locations for “store-front” projects on the basis of bankable business models within each cluster.	Late May 2021 Funder workshop.	June–July 2021 Finalisation of the cost-benefit analysis (CBA) model and completion of the techno economic report.	June–September 2021 Initial bilateral engagement with interested investors post funder workshop.	August–October 2021 Completion of the government strategy report and engagement with various departments (DfT, BEIS, Innovate UK, KTN & DLUHC).
OCTOBER 2021 Launch of the Thames Estuary Hydrogen Route Map Executive Summary. 		November 2021–February 2022 Bilateral meetings with local authorities, key local demand sources, landlords, OEMs, and developers.	November 2021–March 2022 Preparation of outline business cases for projects spanning the entire hydrogen value chain within clusters, and on a regional basis, working with relevant stakeholders.	February–April 2022 Early engagement with investment community to seek input on outline business cases and further shaping of project pipeline.	May 2022 Release of project investment pipeline for initial clusters.	May 2022–onwards Delivery.

THE INVESTOR ASK.

Proven technologies (TRL 9+).	Projects now - 2-5 years to commencement of construction (in advance of upgrade of the gas network).	Portfolio approach (demonstrator must be replicable and scalable).	Minimised interface and utilisation risk through demand-led clusters.	Contracted, stable long-term cash flows.
Creditworthy counterparties.	Support for industrial investment in vehicle uptake and conversion.	Expansion of the RTFO to incentivise liquification, retail infrastructure and the use of hydrogen in green construction (and certainty post-2032).	Recognition of the role of existing private wire green generation in reducing hydrogen production costs.	

HOW TO GET INVOLVED?



INVEST.



If you are an investor with appetite for any part of the Thames Estuary Hydrogen Ecosystem value chain, we would like to understand your requirements vis-à-vis the proposed hydrogen business models, in order to structure projects accordingly.

INNOVATE.



If you are a clean technology company, UK-based or international, and are looking for more than just flexible office space, but also shared industrial lab quality testing, accreditation and prototyping facilities and 'technology sand-pits', to commercialise your technology.

COLLABORATE.

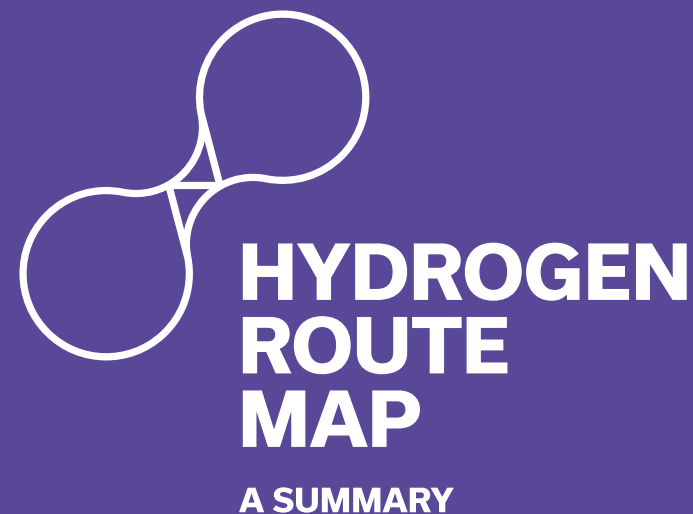


If you are a university, industrial player, OEM, tech provider, developer, or any other party, and are interested in discussing opportunities for collaboration with the Thames Estuary Hydrogen Ecosystem project.



**This summary document has been produced
to provide a snapshot of our comprehensive report.**

**We can provide that report on request.
If you would like it, please contact Thames Estuary
via email at enquiries@thamesestuary.org.uk**



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GOOD PLACE.
JOIN US.**

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