KONGSTEIN

Agentur für Wirtschaftsförderung
Cuxhaven
Landkreis Cuxhaven
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KONGSTEIN GmbH

Hydrogen as new part of the DNA of the municipality Cuxhaven – Positioning 2020

Further development of the hydrogen strategy for the municipality Cuxhaven (CuxH_2aven Maritime Hydrogen)

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Stadt Cuxhaven
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List of abbreviations

CO_2	Carbon Dioxide
CTV	Crew-Transfer-Vessel
SOV	Service-Operation-Vessel
JUHLV	Jack-Up-Heavy-Lift-Vessel
COP	Conference of the Parties
IMO	International Maritime Organization
BSH	*Bundesamt für Seeschifffahrt und Hydrographie*
LOHC	Liquid Organic Hydrogen Carrier
PtG	Power-to-Gas
ZIM	*Zentrales Innovationsprogramm Mittelstand*
NIP	*Nationales Innovationsprogramm Wasserstoff & Brennstoffzelle*
LH_2	Liquid Hydrogen
NOK	Norwegian Krone

1. Preamble

As part of the initiative by the “Agentur für Wirtschaftsförderung” in Cuxhaven during 2018 and 2019, as well as the developed concept for the usage of hydrogen in Cuxhaven and neighboring areas, KONGSTEIN was commissioned to further develop Cuxhaven’s journey into the hydrogen future. Within the assignment, the following questions should be answered:

- How is the market developing in Germany, Europe and worldwide?
- What should be developed in Cuxhaven and does the existing include the most relevant focuses?
- What are the key characteristics of Cuxhaven?
- What is really required in Cuxhaven?
- Is there a market for hydrogen in Cuxhaven and what form should it take?

2. We are KONGSTEIN

The KONGSTEIN GmbH is located in Hamburg and is a subsidiary of Norwegian KONGSTEIN AS in Bergen, founded in 2016. KONGSTEIN's vision "Enabling the Green Shift in Shipping and Energy" refers to advisory support of major projects in the offshore renewables and maritime industries. KONGSTEIN is involved in marine engineering, project and risk management, as well as maritime operations and asset management. The key clients include well-known manufacturers of offshore wind turbines, wind energy operators as well as leading contractors in Germany, Denmark, the U.S. and Norway.

The KONGSTEIN team is comprised of experienced project managers, engineers and commercial specialists with strong maritime background. Their backgrounds include decades of experience in leading positions in ship building, special purpose vessel operations, offshore wind and oil & gas. Hence, a variety of KONGSTEIN personnel has extensive experience in the design of vessels and offshore structures, as well as experience in developing offshore logistic concepts and the respective requirements. Our partners accumulated many decades of hands-on experience in major projects within the offshore energy and maritime industries and connect with a pool of highly qualified specialists world-wide.

For hydrogen, KONGSTEIN can rely on the Norwegian expertise and project experience and is working closely together with the classification society *DNV GL*. In addition, KONGSTEIN has an extensive network of associate partners and suppliers along the Norwegian west-coast cluster. For our clients we focus on the development of maritime transport concepts for green hydrogen produces by offshore wind (Power-to-Gas) as well as on concepts for the reduction of CO_2 emissions of offshore wind farms and vessels (i.e. CTVs, SOVs, JUHLVs).

3. Further developing the hydrogen concept

3.1 Regulatory environment

In addition to the increasing public awareness of emissions and the consequential pressure on politics, administration and companies, the regulatory environment is one of the key drivers for the reduction of CO_2 emissions. Those can be separated into regulations, strategies and targets both on a national and international level:

Table 1: Overview of international and national regulations, strategies and targets

International	National
• Paris Agreement as result of the COP21 (signed in November 2016) • International climate conferences by the COP • Targets set by the IMO to limit CO_2 emissions by 2030 and 2050 within the shipping industry	• National hydrogen strategy • Northern German hydrogen strategy • "Flächenentwicklungsplan" for offshore wind farms by the BSH

In order to meet the targets set in the Paris Agreement across the 195 signing countries, projects with maximum impacts will be required. The current increase in temperature is visually demonstrated in Figure 1 – the target is to limit the average temperature increase to a maximum of +2°C compared to pre-industrial levels.

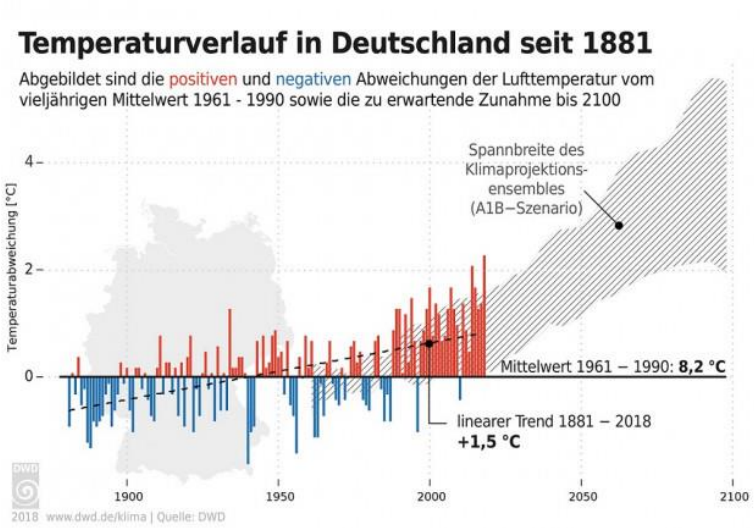

Figure 1: Temperature course in Germany since 1881 [1]

Furthermore, local regulations are already being implemented. One example is in Norway for the west coast Geiranger and Nærøy fjords, where vessels are not allowed to emit any emissions starting in 2026. Such regional restrictions could also become relevant for Germany before 2050 and would assist in meeting the targets from the IMO and the Paris Agreement.

3.2 Market potential for hydrogen applications

In order to identify the market potential of hydrogen applications for Cuxhaven, it is of high importance that the following three criteria are met:

a. Potential applications should bring an economical added value for Cuxhaven or play an important role in Cuxhaven's future,
b. Potential applications should fit into the local conditions – be these strengths or weaknesses,
c. The hydrogen strategy should preferably provide a unique, differentiating position within Germany and northern Europe.

The potential economic value across different sectors can be derived from various market studies until 2050. Figure 2 represents potential value in the five main sectors (power

generation, mobility, industry, heating, industrial raw material), for which the bubble size indicates the potential market for hydrogen in 2050.

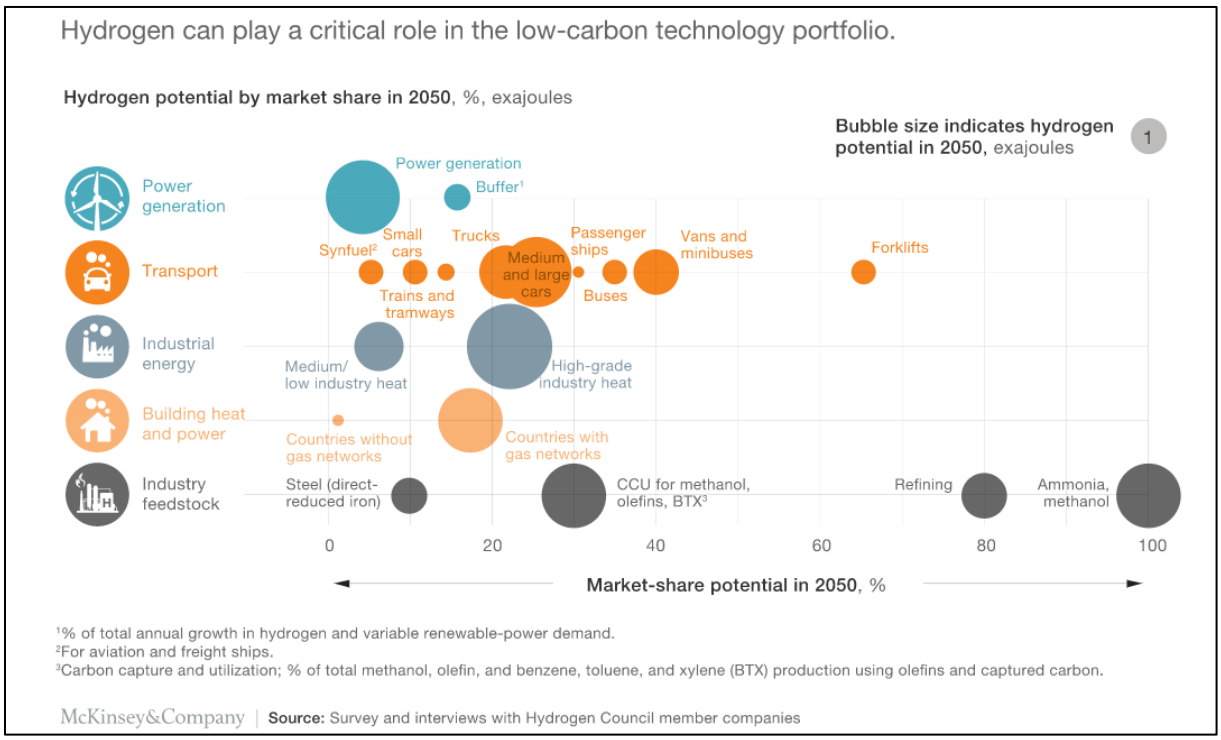

Figure 2: Market potential for hydrogen applications in 2050 [2]

From this figure it can be derived that the largest potential for hydrogen applications lie within the power generation, heavy haul trucking, maritime applications, as well as industry applications.

From these defined, economically valuable industries for hydrogen, it can be derived which, based on Cuxhaven's local conditions, which may be fitting for future applications in Cuxhaven.

It is suggested that Cuxhaven identify flagship projects to strongly differentiate and create a unique position for Cuxhaven from other regions pursuing hydrogen, as well as to gain a competitive advantage through technology or knowledge. Applications that are already in commercial use play a minor role, as their use in other regions would limit them from being considered a flagship project. These include:

- KeroSYN – Production of aviation fuel from green Hydrogen for the Hamburg Airport at the refinery Heide
- HyWheels – Implementation of a hydrogen fleet in Fulda, which comprises trucks, busses, vans and cars
- Wind-hydrogen Salzgitter – Usage of hydrogen generated through onshore wind energy for the production process of steel

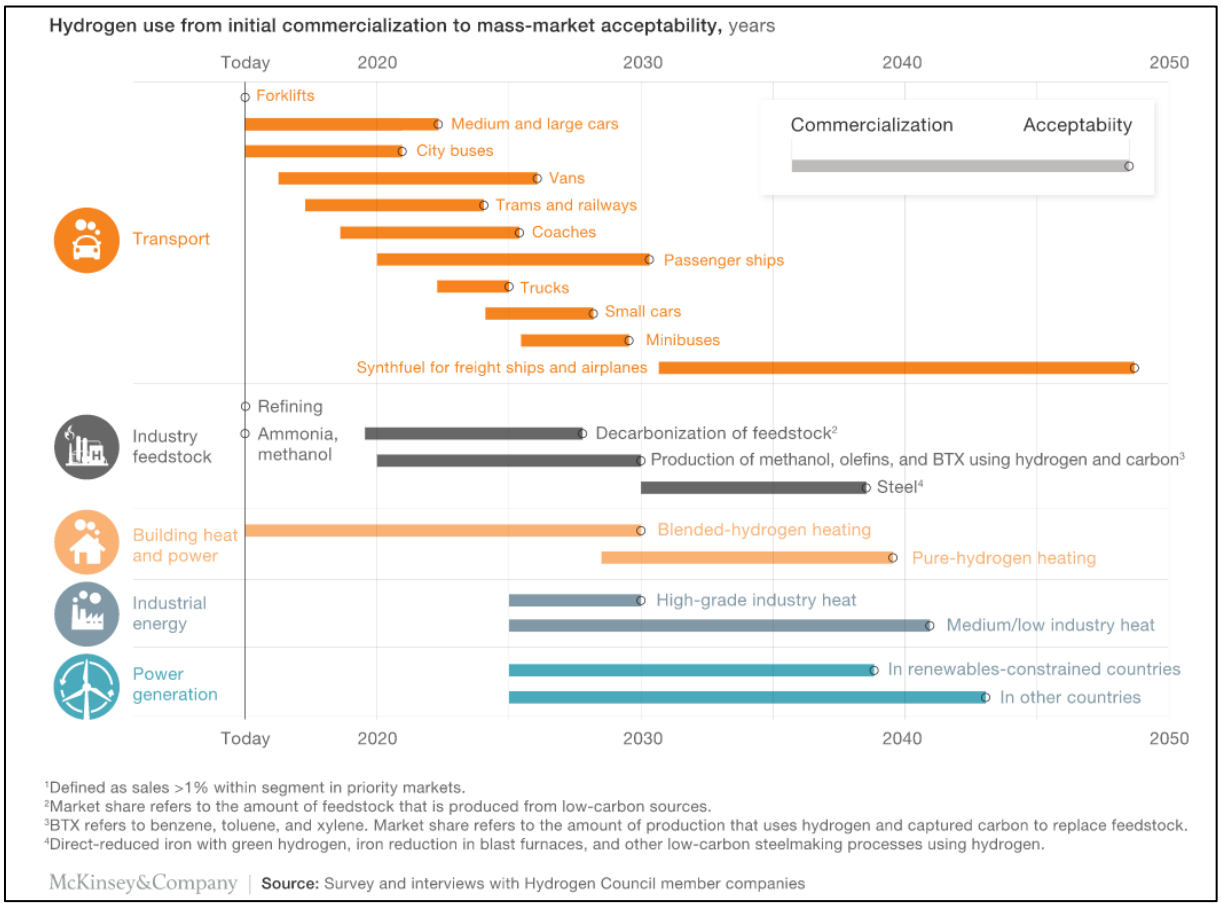

Figure 3: Estimated time from initial commercialization to mass-market acceptability [2]

Figure 3 further underlines which applications are already commercially available, and which are developing their potential within the next year or respectively decades. In summary, the biggest potential for hydrogen applications in regard to a unique position include maritime applications, synthetic fuels and industry applications.

3.3 Prioritization for Cuxhaven

3.3.1 Local conditions

One of Cuxhaven's key targets is economy growth, which can be measured through the gross national product, the trade tax income and the unemployment rate. At Cuxhaven's economic forefront are the tourism industry, the renewable energy industry, as well as their port.

The port is gaining importance to Cuxhaven as well as broadened its scope over the past few years, including:

- Freight increase of 2% in 2018 and roughly 35% in 2019 compared to the respective prior year,
- New container routes to and from Iceland and Faroe Islands,
- Planned investment of roughly 250 million Euro for new port berths (5, 6 & 7) located next to the river Elbe with deep-water fairway. [3]

Additionally, Cuxhaven relies on its local expertise and economy in the offshore wind industry, which developed its own cluster along the Elbe favored by the "Deutsches Offshore-Industrie Zentrum".

In summary, Cuxhaven's economy is unique in its strengths. For both offshore wind as well as port / maritime applications, Cuxhaven can rely on experienced local experts as well as a strong economic position with significant growth potential. Additionally, Cuxhaven holds large potential for further development opportunities in either maritime solutions or power-to-gas applications in combination with offshore wind energy. Such development would place Cuxhaven in a clear leading region position within Europe. Two flagship projects offer such a chance:

- Conversion of offshore wind energy to hydrogen (power-to-gas) and the transport in gaseous, liquid or bound (i.e. LOHC) form to Cuxhaven, where the energy would be temporarily stored and further distributed within Germany,
  Maritime applications for ferries with a fixed operational profile. For which round-trip vessels and ferries are ideal, such as for the connection between Cuxhaven and

Brunsbüttel. This ferry connection would distinguish itself by being the world's first open-sea ferry operating utilizing hydrogen.

3.3.2 Evaluation

For the evaluation of existing and future potential applications for hydrogen, KONGSTEIN recommends a criteria matrix that mainly evaluates the value to Cuxhaven and the potential economic growth. Secondarily, such a criteria matrix could evaluate ideas, suggestions and projects on their potential to reduce CO_2 emissions, their visibility and their unique position.

Figure 4 illustrates such an evaluation as initial draft for Cuxhaven, where the market potential until 2050 is illustrated on the vertical axis and the importance for Cuxhaven derived from the local conditions (section 3.3.1) on the horizontal axis. Furthermore, the hydrogen potential in 2050 is portrayed in the bubble size.

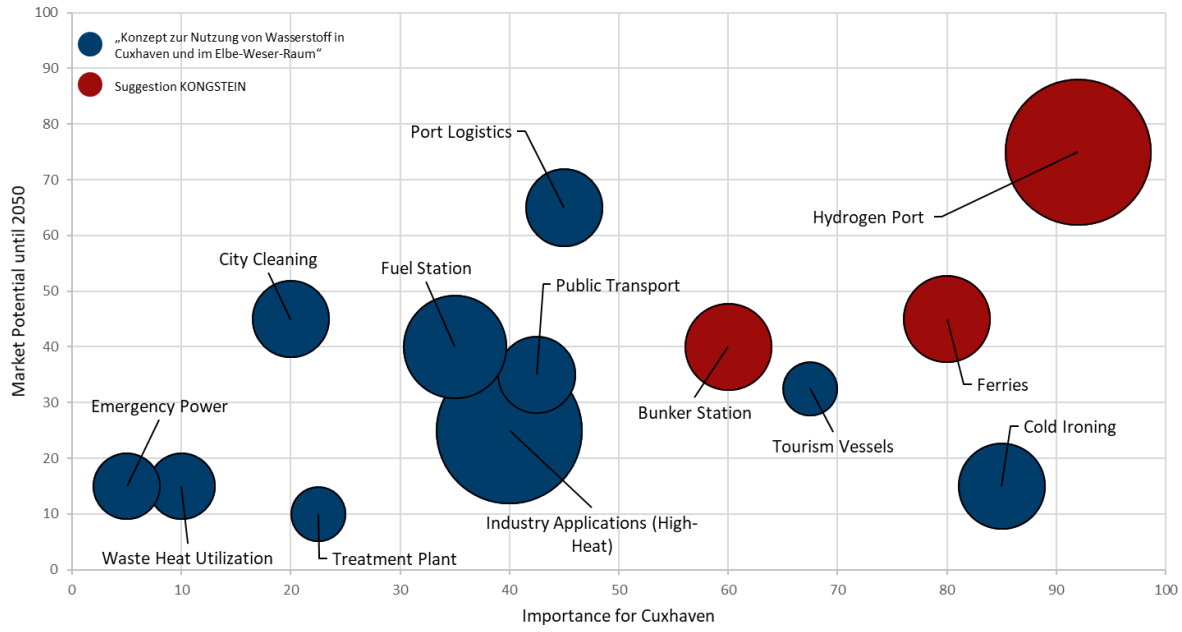

Figure 4: First draft of the evaluation of potential hydrogen applications in Cuxhaven

KONGSTEIN recommends the exact verification of ideas, suggestions and projects based on the pre-defined criteria.

3.3.3 Knowledge hub

By investing early in adopting hydrogen as new technology, Cuxhaven could have the potential to gain a unique position in knowledge transfer. Primarily this should focus on PtG through offshore wind and vessel propulsion. To begin, the knowledge hub of Cuxhaven could utilize and further develop existing programs:

- Extension of the prestigious „Seefahrtsschule", where the nautical patent could receive additional courses in the handling of hydrogen (i.e. safety).
- The maritime apprenticeship "Mac Azubi" could gain increased appeal by offering courses or trainings. Especially ship mechanics based in safety and maintenance for hydrogen vessels could be examples for unique positioning.
- These programs could be extended by cooperating with local companies in order to offer hands-on experience. Such industry cooperation could also bring in international interest as well.

Furthermore, KONGSTEIN recommends Cuxhaven select international partnerships, for example building upon the historical connection to Bergen. This is an ideal example as the west coast of Norway is currently pushing maritime hydrogen solutions.
Other partner cities like Pila in Poland or Hafnarfjödur in Iceland could become strategic partners as well.

3.3.4 Funding programs

In order to achieve a unique position within hydrogen applications, Cuxhaven could potentially receive support through national or international funding programs. We suggest creating one central contact point to be able to evaluate project ideas and to evaluate them on their respective relevance for Cuxhaven.
Cuxhaven can potentially use the following funding programs:

- Ministry of economics Lower Saxony,
- Ministry of the environment Lower Saxony,
- NBank,
- Metropolitan region of Hamburg,
- BMWi (z.B. ZIM, NIP),

- BMVI (z.B. Hyland),
- EU (z.B. Horizon, Poseidon),
- Multinational programs (z.B. MarTERA).

An evaluation of these funding programs is necessary in order to identify best-fits for any Cuxhaven maritime flagship projects.

3.4 International reference projects

We consider the following reference projects for the prospective presentation as potentially relevant.

3.4.1 Offshore-Wind / Power-to-Gas

Hydrogen port Kobe, Japan

Japan has committed themselves to implement hydrogen as new energy carrier and will start the import of liquefied hydrogen from Australia in fall 2020. The transport requires vessels designed to handle the hydrogen at -253°C, in addition to port infrastructure at Kobe Airport Island (see Figure 5) comprising of bunker and storage technology. The hydrogen is then used to produce electrical and thermal energy for the local applications.

Figure 5: Conceptional design of the hydrogen port in Kobe, Japan [4]

Together with the IMO, new interim regulations were developed in order to ensure safe handling and transfer of the LH_2. Cuxhaven can utilize the operational experience for their own project development. [5]

LH_2 Supply Chain Norway

A consortium led by the *NorSea Group* has received 33,5 Million NOK from the Norwegian government to develop a supply chain for liquefied hydrogen for the maritime industry in Norway. The main focus is set on the development of a terminal in order to safely bunker and temporarily store LH_2. This plays also a key part in the operation of ferry lines as mentioned in chapter 3.3.1. [6]
Cuxhaven can potentially use the important findings to further the development for their own port infrastructure.

3.4.2 Shipping

There are several shipping projects worldwide utilizing hydrogen for propulsion already, although they almost exclusively focus on ferries due to the small size, limited travel distances and fixed routes. The latter is a major advantage for the implementation of a hydrogen bunker infrastructure as well. As discussed in 3.3.1, ferries could be a substantial opportunity for Cuxhaven as well.
Following is a list of relevant projects in the shipping industry, their characteristics and relevance for Cuxhaven.

Ferries Norway

There are currently two ferries under construction in Norway which are utilizing hydrogen for propulsion. One of the ferries is utilizing gaseous hydrogen as part of the EU funded FLAGSHIPS project, while the second ferry will be using LH_2. Hence, this is a unique project receiving international recognition (see Figure 6).

Figure 6: Norwegian Ferry utilizing LH_2 for propulsion [7]

Due to the fixed route profile, these two ferry connections were identified as optimal pilot projects. In close cooperation with the Norwegian classification society *DNV GL*, new standards and regulations are being developed.

Other maritime applications

Next to the two Norwegian projects, several other hydrogen ferries are worldwide in development or already in operation utilizing the advantage of a fixed operational profile, including the following:

Table 2: Other ferry projects and their unique characteristics

Project	Region	Unique characteristics
SF Breeze	San Francisco, USA	High-speed ferry
HySeas III	Orkney-Islands, Scotland	Limited open-sea capabilities
Hydroville	Antwerp, Belgium	Hydrogen combustion engine
Nemo H2	Amsterdam, The Netherlands	In operation since 2011

The HySeas III projects represents in particular the potential and a technical feasibility profile for Cuxhaven to implement an open-sea ferry between Cuxhaven and Brunsbüttel. In addition, the concept of only using green hydrogen for the ferry could be implemented in Cuxhaven, as well as the potential hydrogen port infrastructure described previously.

While the previously described projects are exclusively limited to ferries, there are several projects and concepts in Europe to implement hydrogen onto other vessel types. The

Belgium project “Hydrotug” and the FLAGSHIPS tugboat project in Lyon, France could play a key role for the port of Cuxhaven as both tugs and pilot boats have potential to reduce CO_2 emissions as well.

Figure 7: Ulstein construction support vessel [8]

The Norwegian vessel designer *Ulstein* recently published their conceptual offshore wind construction support vessel SX 190 (see Figure 7), which, next to a conventional propulsion system, will have the option to operate for multiple days on hydrogen. Due to the connection to the offshore wind industry in Cuxhaven there are potential overlaps, including bunkering hydrogen in Cuxhaven’s port for this or future similar vessels.

4. Implementation

4.1 Preparation

The implementation of specific hydrogen projects in Cuxhaven require four essential steps:

1. Identification of **flagship projects** that fit into the local economy (i.e. hydrogen port for offshore wind hydrogen or hydrogen powered ferries),
2. Identification of specific **funding opportunities** for flagship projects,
3. Drafting of a **master plan** which describes the intentions, potential partners and the time schedule,
4. Identification of **local support** by politics, administration, institutions, companies and citizens.

These are the initial steps suggested to the client.

4.2 Initial draft for positioning and marketing

Based on the identified potential applications for Cuxhaven, a marketing slogan can be developed for further usage. KONGSTEIN recommend a short, precise slogan which comprises the maritime and the hydrogen side of Cuxhaven:

CuxH_2aven Maritime Hydrogen

In addition, a potential link to the offshore wind driven reference “Cuxhaven Offshore” can be identified:

C/O CUXHAVEN OFFSHORE C/H CUXHAVEN HYDROGEN

Figure 8: Point of reference to “Cuxhaven Offshore”

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[1] F. Lachmayr, "Südkurier," 6 März 2018. [Online]. Available: https://www.suedkurier.de/ueberregional/wissenschaft/Es-wird-waermer-in-Deutschland-Klimabilanz-belegt-das-Zeitalter-der-Extreme;art1350069,9645687. [Accessed 28 Januar 2020].

[2] B. Heid, M. Linder, A. Orthofer and M. Wilthaner, "McKinsey Insights," McKinsey & Company, November 2017. [Online]. Available: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/hydrogen-the-next-wave-for-electric-vehicles. [Accessed 6 Januar 2020].

[3] "Cuxhavener Nachrichten," 13 02 2020. [Online]. Available: https://www.cnv-medien.de/news/cuxhavens-grosse-rolle-als-ausgangshafen-fuer-short-sea-verkehre.html. [Accessed 17 02 2020].

[4] J. Sampson, "H2 View," 22 Oktober 2019. [Online]. Available: https://www.h2-view.com/story/abb-to-support-australia-japan-hydrogen-project/. [Accessed 28 Januar 2020].

[5] Kawasaki, "Global Kawasaki," Oktober 2018. [Online]. Available: https://global.kawasaki.com/en/stories/articles/vol74/. [Accessed 28 Januar 2020].

[6] I. Taylor, "Bunkerspot," 17 Dezember 2019. [Online]. Available: https://www.bunkerspot.com/europe/49564-europe-3-7-million-funding-for-norwegian-maritime-liquid-hydrogen-supply-chain. [Accessed 28 Januar 2020].

[7] R. Moore, "Riviera Maritime Media Ltd.," 16 Juli 2019. [Online]. Available: https://www.rivieramm.com/news-content-hub/news-content-hub/norwayrsquos-first-hydrogen-powered-car-ferries-take-shape-55559. [Accessed 28 Januar 2020].

[8] Ulstein, "Ulstein," 18 November 2019. [Online]. Available: https://ulstein.com/news/2019/zero-emission-operations-in-offshore-construction-market. [Accessed 28 Januar 2020].