



Hydrogen
Europe

LOHC Industry Transformation – LOHC IT

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Industrial Hydrogen Supplier
(e.g. steam methane reforming, etc.)



StoragePLANT



ReleasePLANT /
ReleaseBOX



Industrial Hydrogen Consumer
(e.g. fuels, chemicals, fertilizers,
metal refining, food, etc.)



Energy
(e.g. on-grid, off-grid)



Renewable Energies
(e.g. via electrolysis)

Hydrogenation

Exothermic ($\sim 250^{\circ}\text{C}$, 25 – 50 bar)



Dehydrogenation

Endothermic ($\sim 300^{\circ}\text{C}$, 1 – 3 bar)



Mobility
(e.g. cars, buses trucks,
trains, ships, etc.)

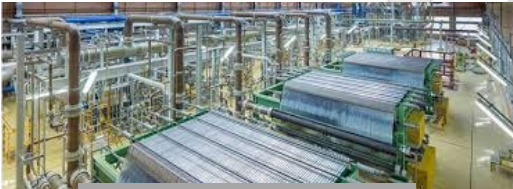
LOHC Technology uses *conventional oil infrastructure*
to connect *hydrogen supply and demand*

Sustainable hydrogen sourcing



Renewable hydrogen

- Wind & hydro @ <3 ct./kWh
- >5.000 h/year production



By-product hydrogen

- Chlor-Alkaline electrolysis
- others

Global hydrogen distribution

1 Ship Transport *International*



- Use of existing oil tankers / fuel storage infrastructure
- International trans-ocean transport

2 Rail Transport *(Inter)-national*



- Multi-ton transport on existing infrastructure
- Flexibility of rail network

3 Road Transport *National / regional*



- High capacity road delivery to distributed customers

Diversified demand sites

1 Pipeline hubs *International*



- Green hydrogen from international sources for pipeline distribution

2 Large industry *International*



- Large-scale industrial customers with renewable heat demand
- Green hydrogen as base chemical

3 HRS & industry *Distributed national*






























- High-capacity HRS
- Hydrogen as base chemical and utility

Hydrogenious LOHC Technologies' vision is the establishment of a **global LOHC infrastructure** to enable a **hydrogen fuelled society**

LOHC IT – State of the art and comparison



	Compressed Hydrogen  CGH2_{250bar}	Cryogenic Hydrogen  LH2	Liquid Organic Hydrogen Carrier  LOHC
Process and technology maturity			
Storage	 Low storage density	 Very high storage density but not suited for long term storage	 High storage density
Transport	 Transport through tunnel and by ship restricted	 Transport through tunnel and by ship restricted	 No transport restrictions
TRL	 TRL 9	 TRL 9	 TRL 6
Cost	 Low CAPEX	 Very high CAPEX at source	 High CAPEX at consumer
Hazards	 Flammable and no smell or flame visibility	 Flammable and no smell or flame visibility	 Only water hazard
Energy demand	 Low energy demand	 Very high electricity consumption	 High process heat demand
Handling	 Large safety zones	 Large safety zones	 Easy handling and storage
Technology improvement needs	 Low net storage and transport capacity	 Production plant efficiency and boil-off management	 Scale up and storage cycle efficiency

Development focus for LOHC includes **scale-up**, **efficiency increase** and **cost reduction**

LOHC IT – Participants and location

LOHC Transport Mechanisms

1 Ship Transport

Large scale



- Use existing oil tankers / fuel storage infra-structure for trans-ocean transport at minimal cost

2 Rail Transport

Medium scale



- Large reduction in on-land transport cost
- Multi-ton transport on existing infrastructure

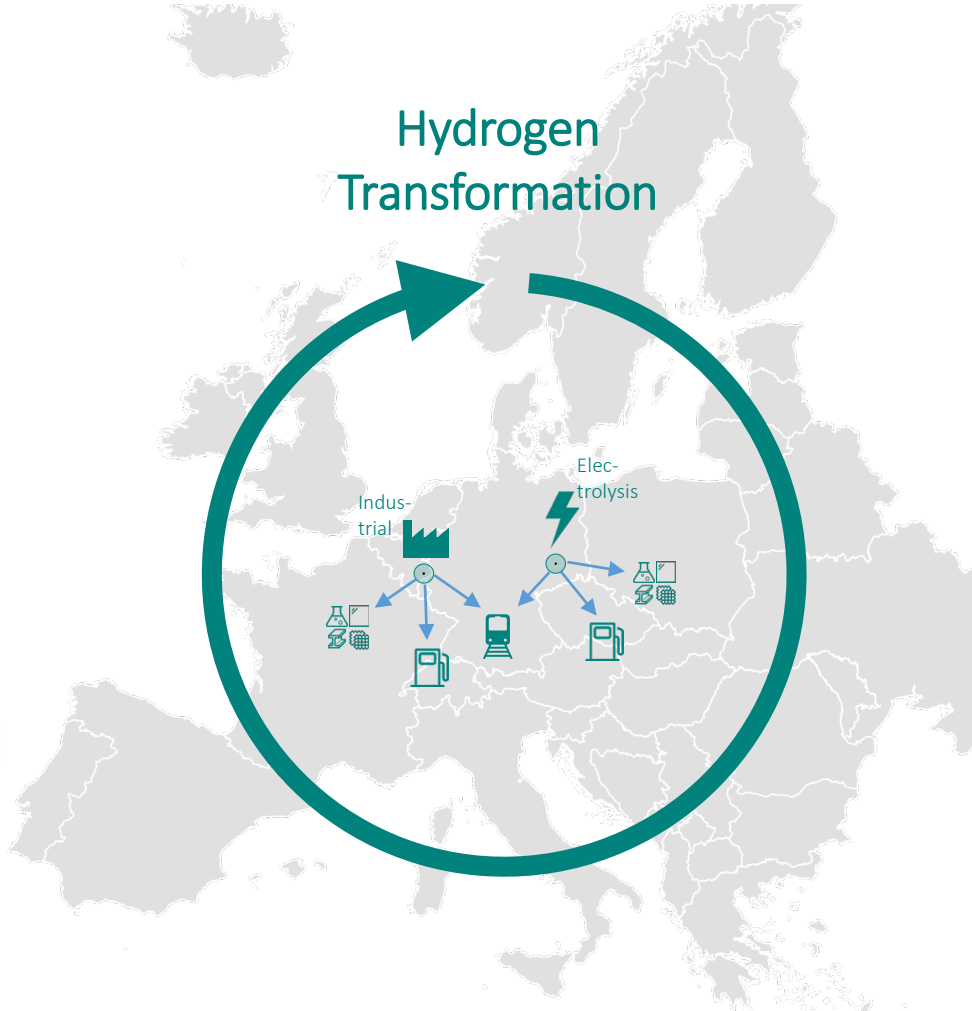
3 Road Transport

Small scale



- High flexibility for hydrogen distribution through easy loading / unloading of LOHC

Hydrogen Transformation



Decentralized LOHC Dehydrogenation

Industry



- High storage capacity at on-site production facilities (e.g. chemical, glass, steel, etc.)
- On-demand release of hydrogen

Mobility



- High storage capacity at HRS
- Compatible with existing fuel station infrastructure (e.g. storage tanks)
- On-demand release of hydrogen

LOHC IT - Budget and maturity

Project example



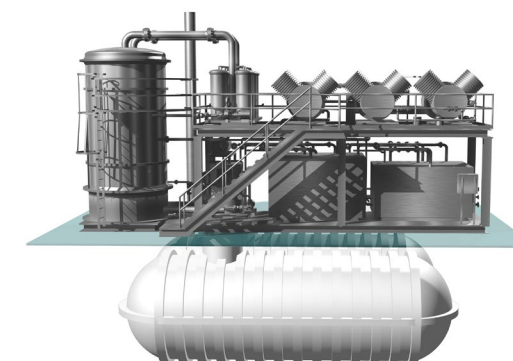
- a. StoragePLANT 5tpd in Germany
- b. ReleasePLANT 1.5 tpd in the Netherlands
- c. HRS in Erlangen, Germany planned for 2020

Potential for further subsequent expansion to >20 tpd H₂ planned to facilitate bulk hydrogen import via sea transport

- 5 tpd StoragePLANT
- By-product hydrogen on ChemPark
- Road, Rail and Ship connection available

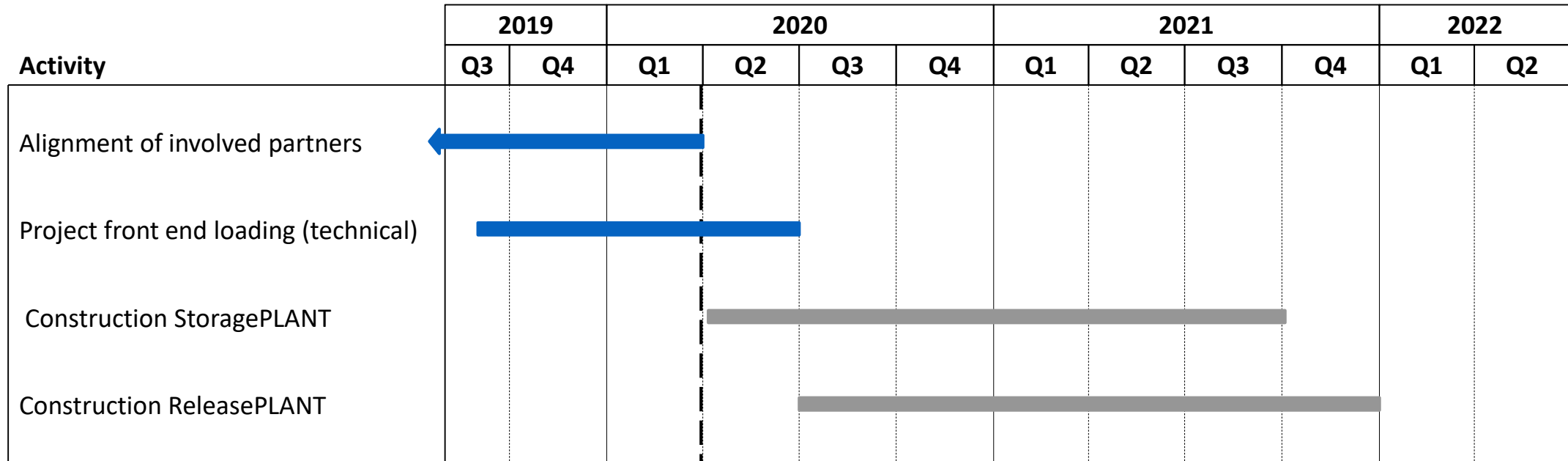
- 1.5 tpd ReleasePLANT
- Feed-in of hydrogen into existing hydrogen pipeline
- LOHC delivery by truck, rail and ship under assessment

- GHG emission reduction by replacing conventional SMR
- Up to 15,000 tons of CO₂ emission reduction at full scale rollout



- Capex: ~ 10 Mio €
- Cash Flows: ~4 Mio € (10 year basis)
- Key influencing variables: Permitting, cost of heating, hydrogen price

LOHC IT - Budget and maturity

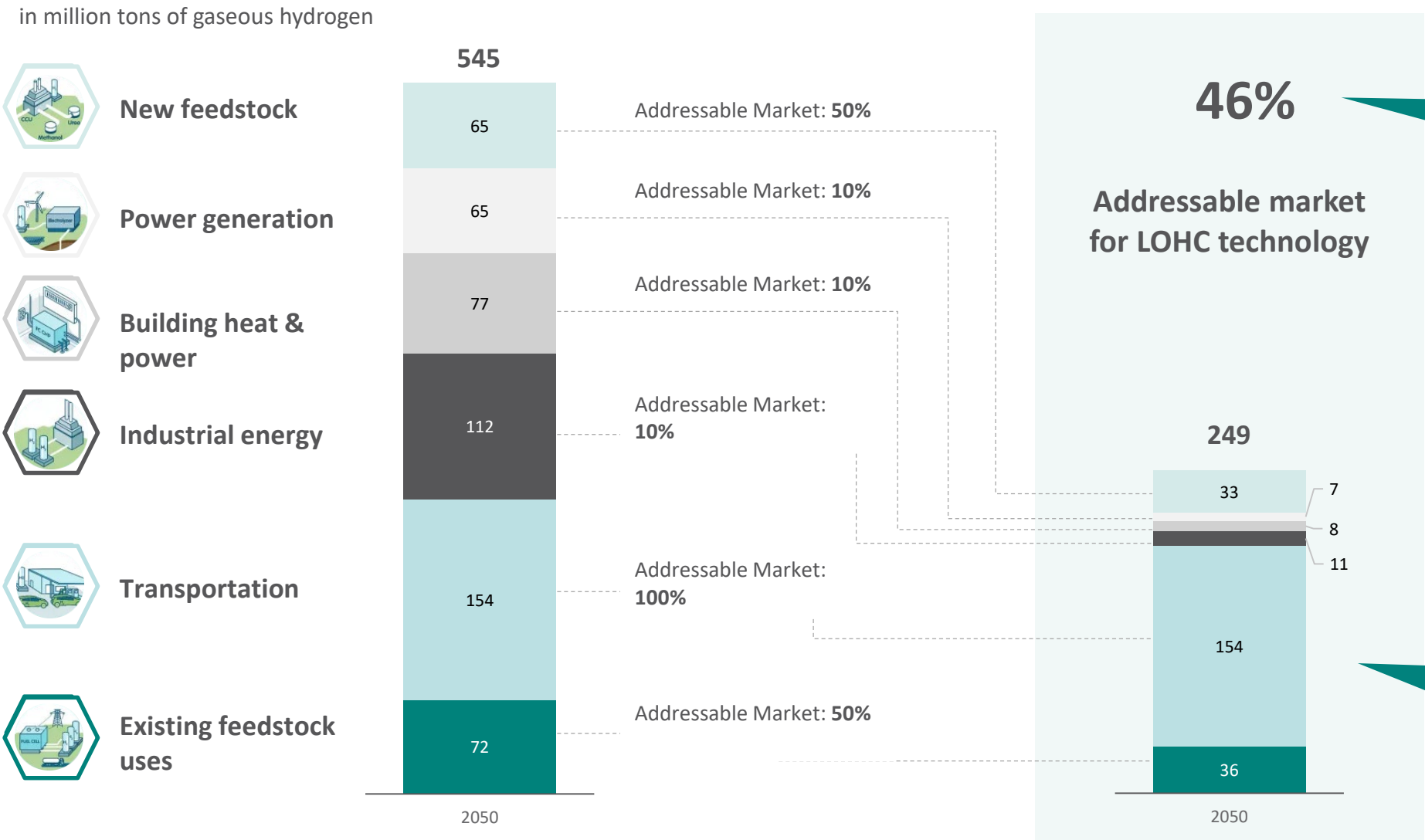


Contract closure and funding planned until end of Q1 2020

Project under negotiation, level or certainty +/- 25%, key variables: *Permitting* and *availability of suppliers*

Large-scale project planned to be on-stream by *end of 2021*

LOHC IT – Market and Impact



Large addressable market for LOHC technology

Hydrogen vehicles will be a *core vector* in a de-carbonized, mobile future