

Wärtsilä

2. Online-Workshop

Bio-LNG

Dezentrale versus zentrale Verflüssigung

29. April 2021 | 10:00 - 12:00 Uhr

LNG.AGENTUR
Niedersachsen

Sven Fischer
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Wärtsilä Gas Solutions

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FOUNDED IN 1834

GLOBAL LEADER

in sustainable solutions for the marine and energy markets

COMPARABLE OPERATING
RESULT

275 MEUR

ORDER INTAKE

4,359 MEUR

NET SALES

4,604 MEUR

OPERATIONS IN OVER

200 LOCATIONS

OUR PERSONNEL APPROX.

17,800

NATIONALITIES

139

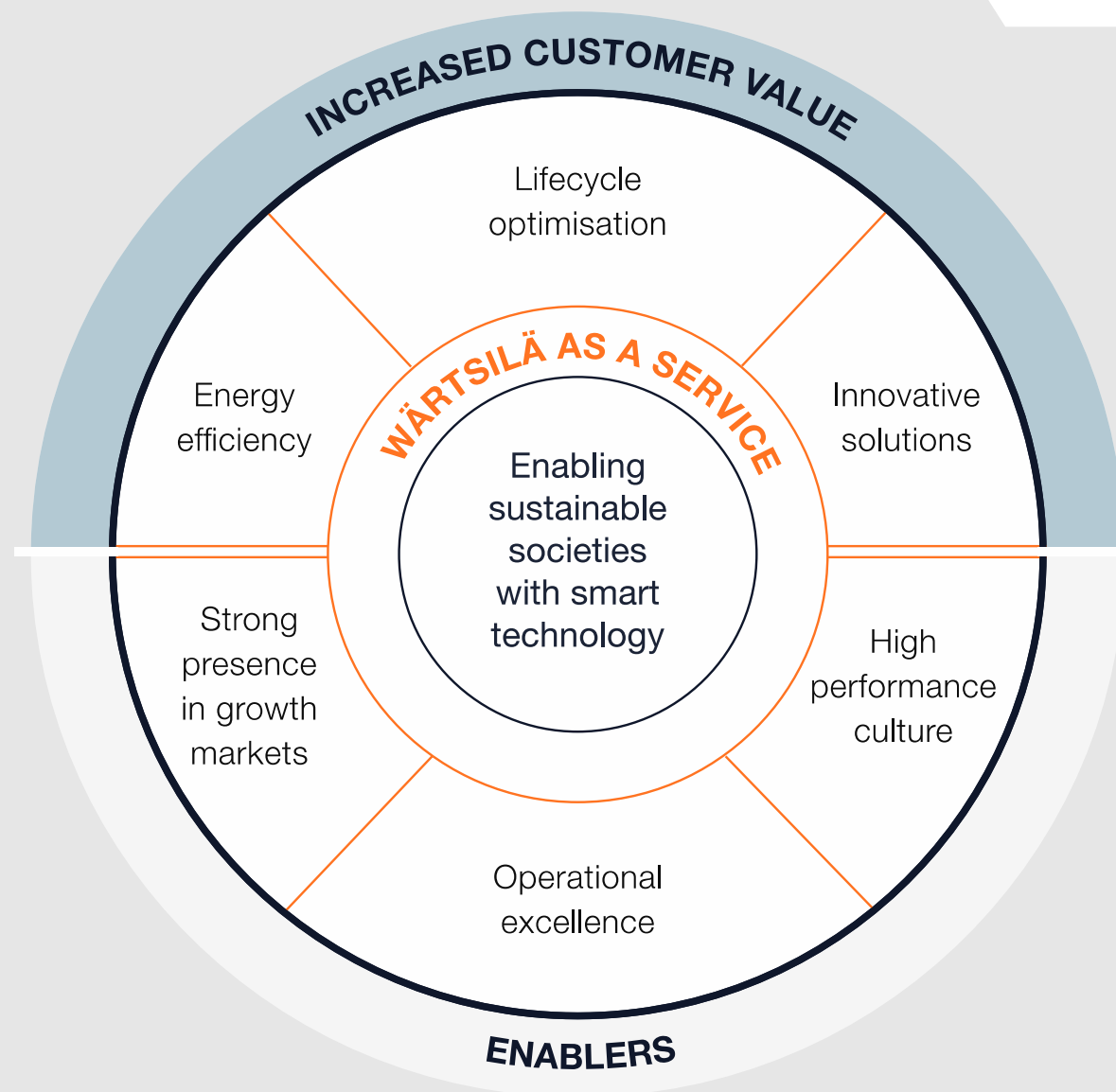
OUR INDUSTRIES

ENERGY

Leading the path towards a 100% renewable energy future

MARINE

Leading the industry transformation towards a Smart Marine Ecosystem





OUR GLOBAL PRESENCE

62%

Europe

22%

Asia

11%

Americas

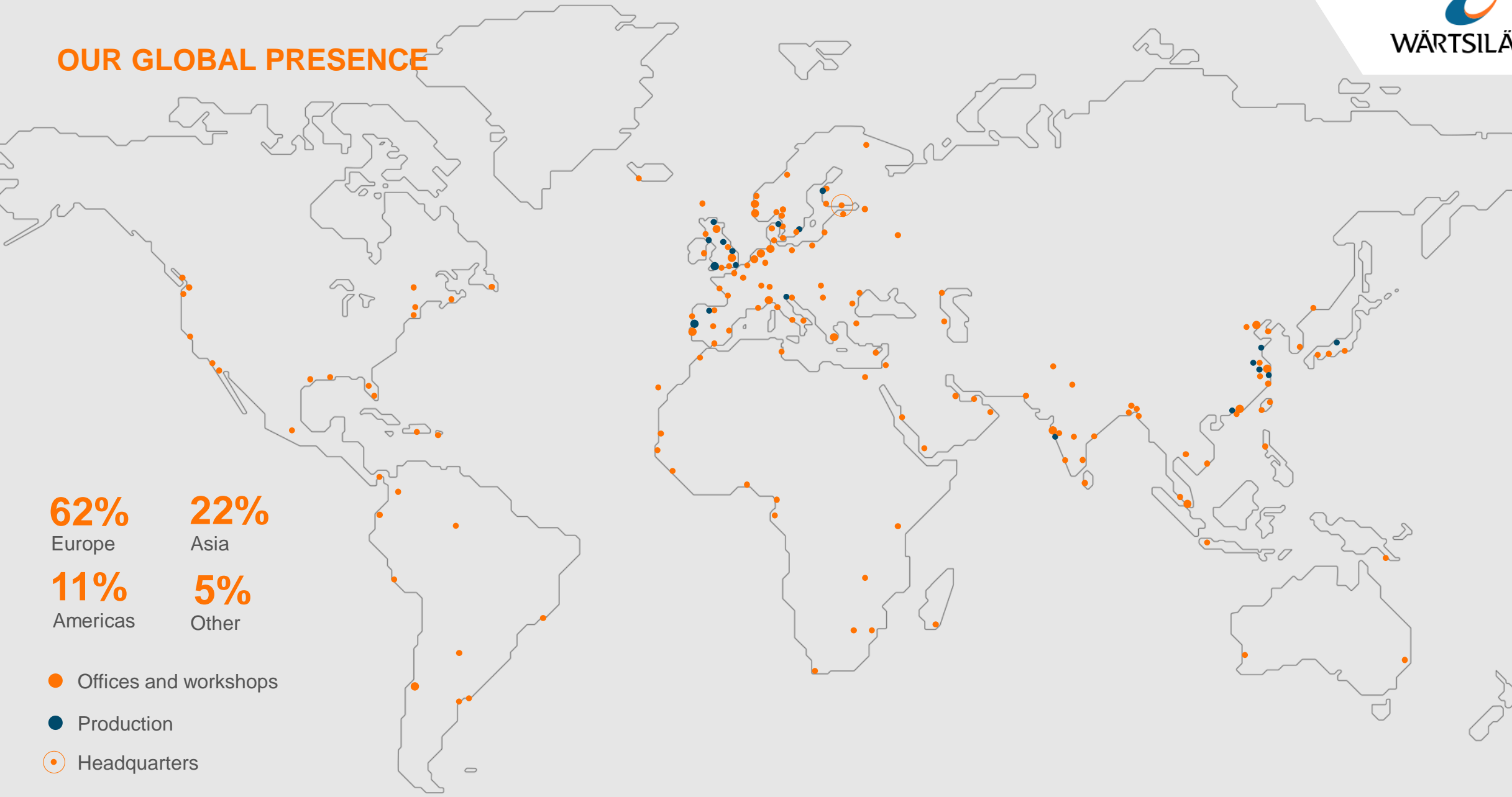
5%

Other

● Offices and workshops

● Production

○ Headquarters



OUR 139 NATIONALITIES



This figure tends to evolve throughout the year, therefore this number is an approximation.

GAS SOLUTIONS

Wärtsilä's gas solutions bring carbon neutral or transition fuels to the market and minimise emissions from the gas infrastructure. In so doing, Wärtsilä helps customers on the journey towards a sustainable future through a focus on lifecycle support innovation, and digitalisation.

KEY FACT:

500 gas solution projects, almost **3,000** inert gas systems and **45** biogas solutions delivered by Gas Solutions



Decarbonisation



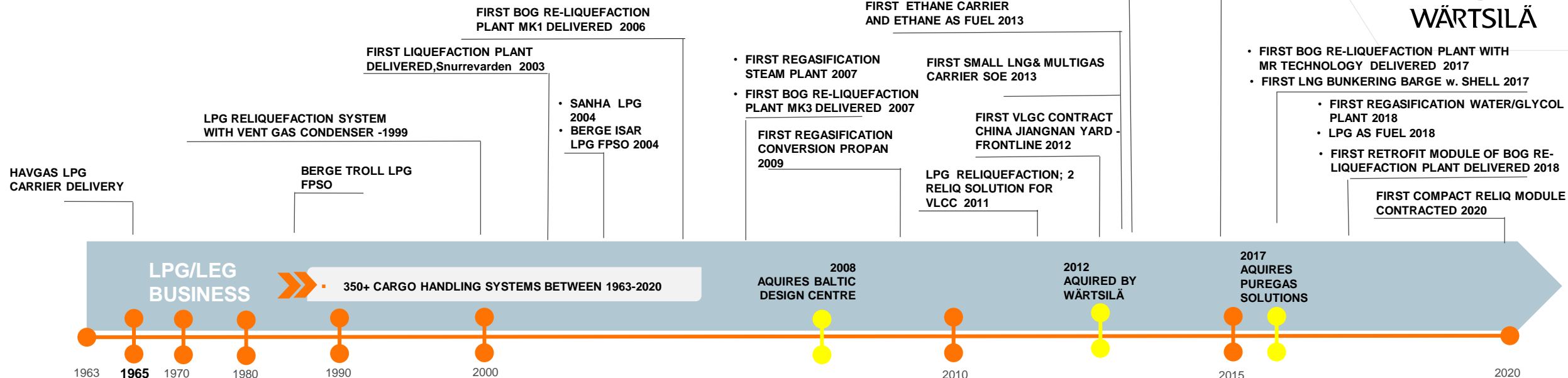
Lifecycle solutions



Remote monitoring



Operational efficiency



50+ years of experience on gas handling systems, including:

- ✓ systems and process design
- ✓ Hardware design / manufacture/ assembly
- ✓ naval architecture (ship integration)
- ✓ installation, commissioning & start-up



- FIRST LPG CARGO HANDLING DELIVERED IN 1965
- 350+ CARGO HANDLING SYSTEMS LPG/LNG/ETHANE
- 2 LPG RELIQ SOLUTIONS
- FIRST IN INDUSTRY LPG AS FUEL SOLUTION
- 12 VOC RECOVERY SYSTEMS

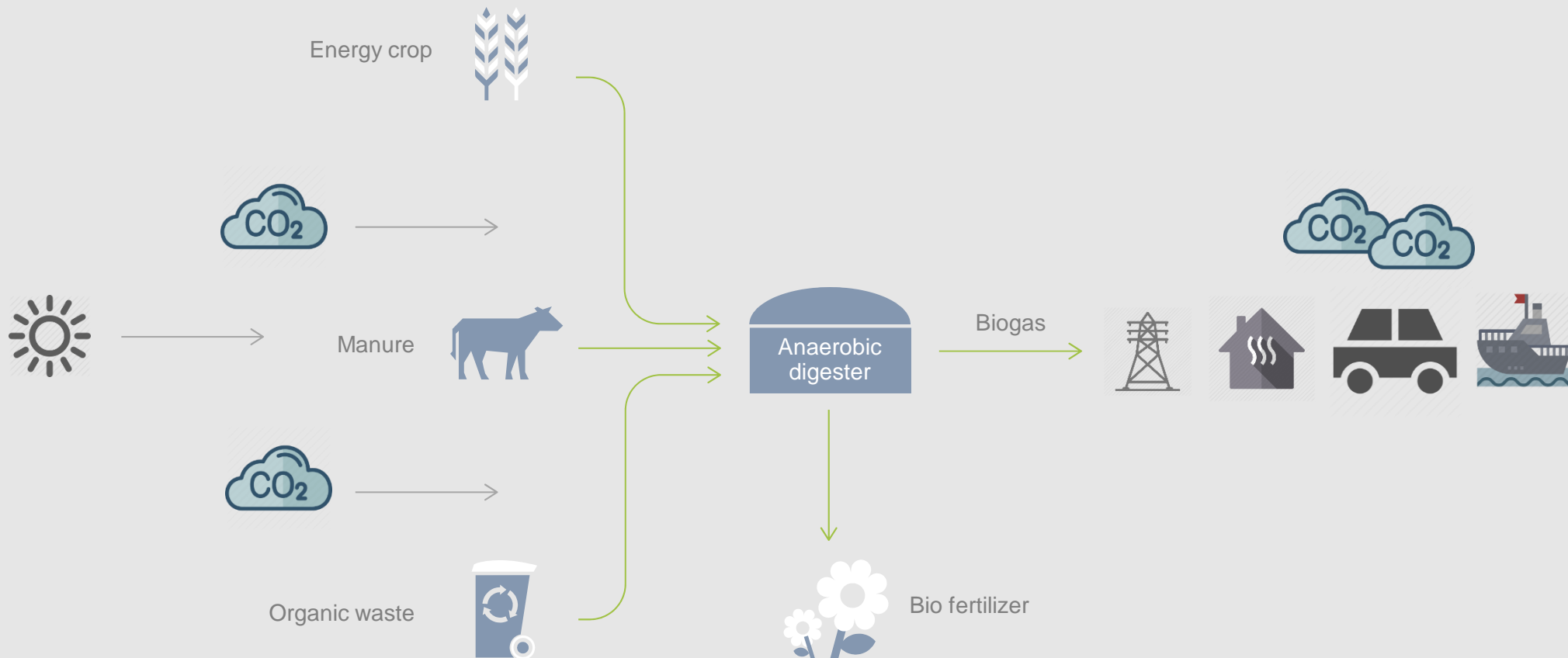
LPG BUSINESS since 1965

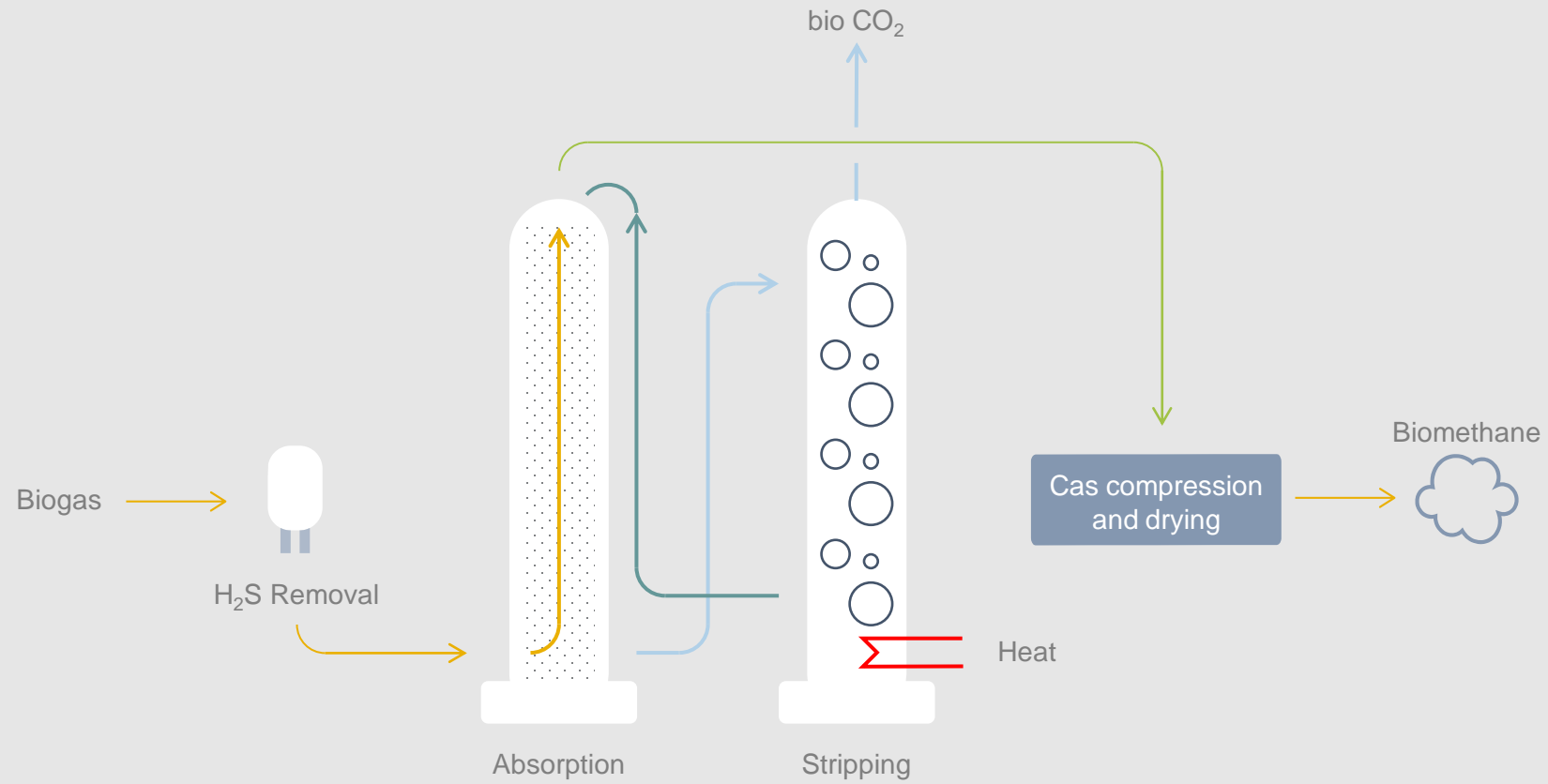


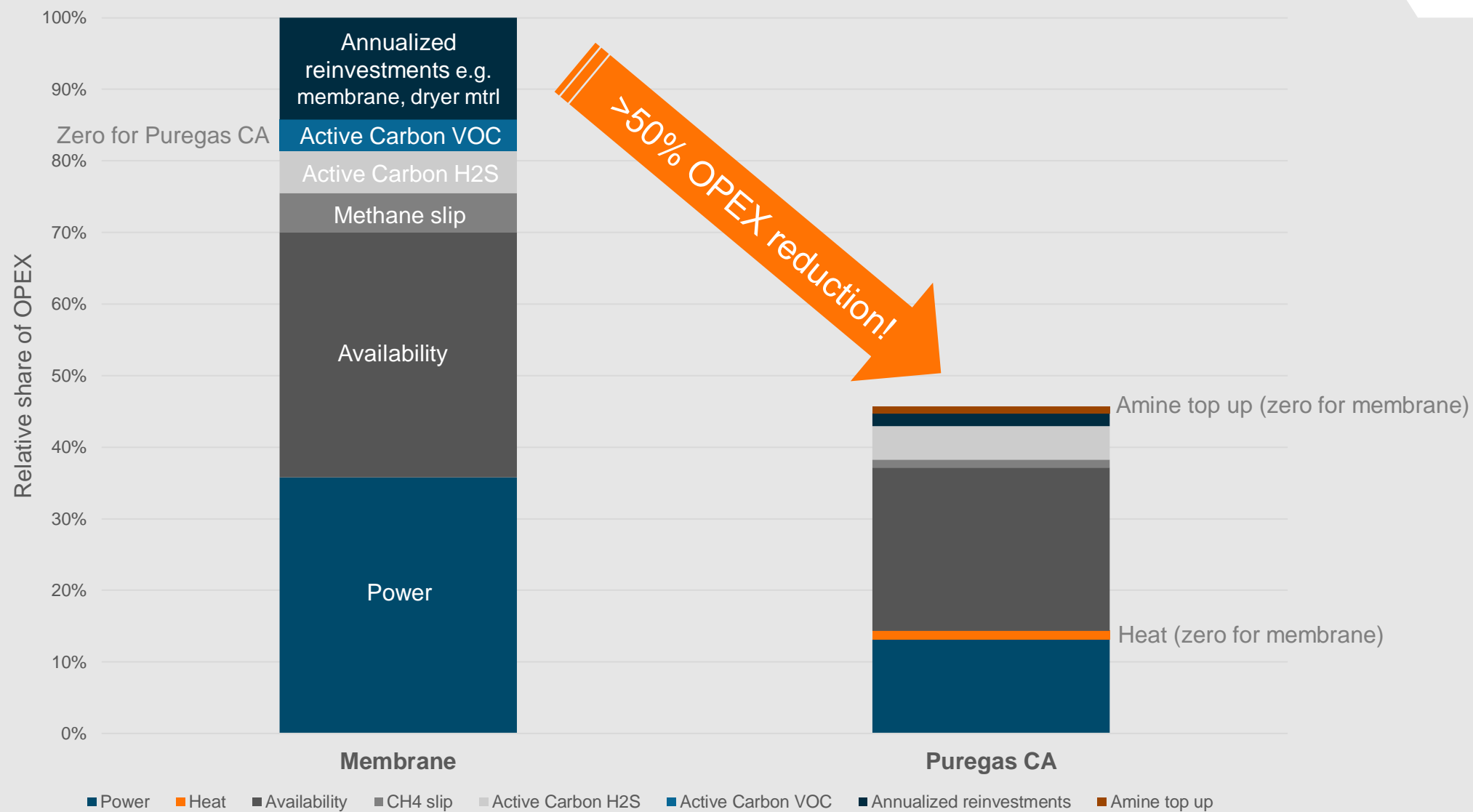
- 59 LNG RELIQUEFACTION PLANTS
- 23 REGASIFICATION PLANTS
- 2 TERMINALS
- 6 BIOGAS LIQUEFACTION PLANTS
- 47 BIOGAS UPGRADING PLANTS

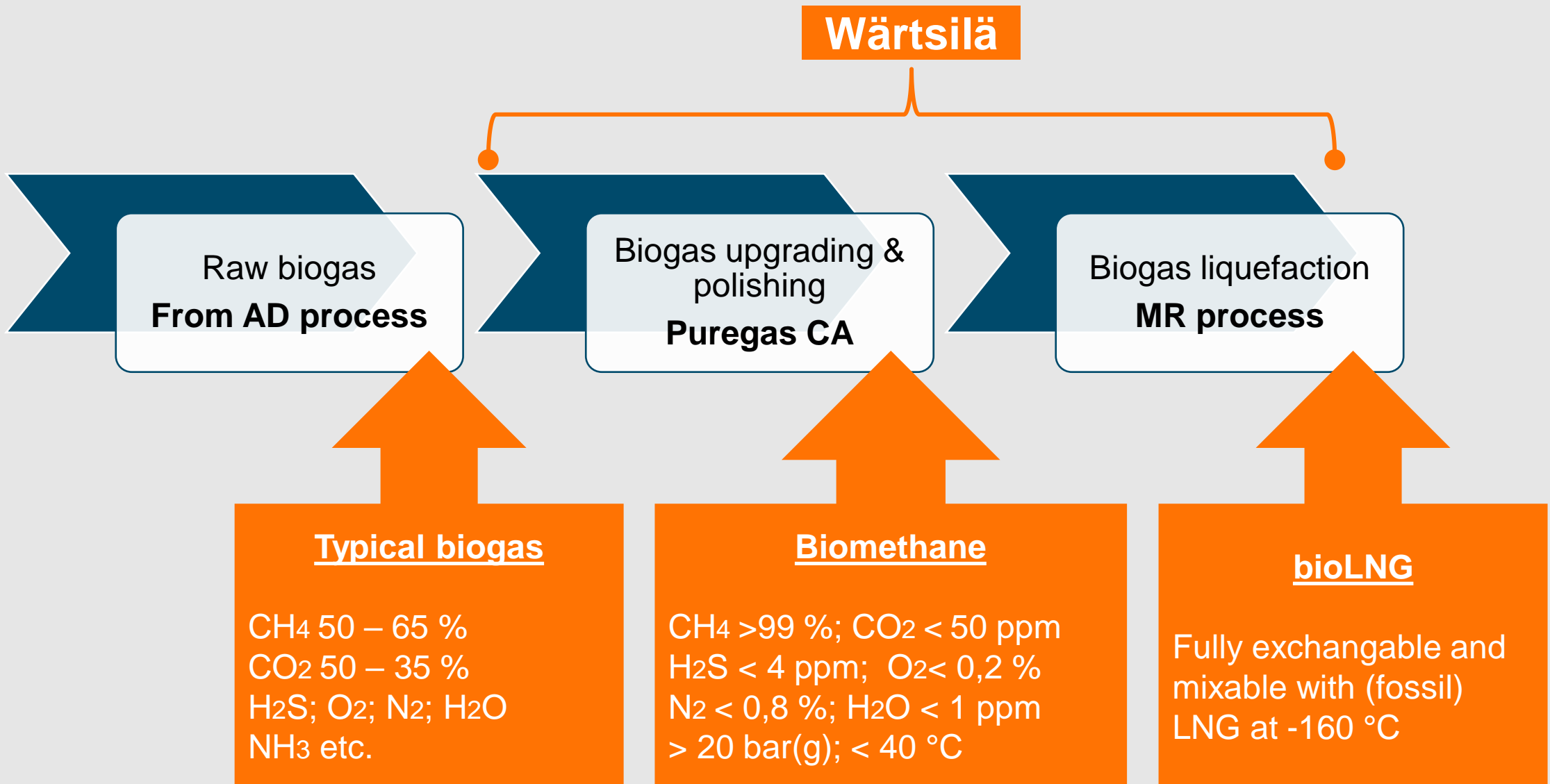
LNG BUSINESS since 2002

| Biogas | Biomethane |
|--|---|
| Renewable, CO ₂ neutral and circular business model | Connect to existing infrastructure for natural gas and LNG |
| Waste to high value energy and fertilizer | Energy storage for base and peak loads |
| Local energy supply and security | Unlock potential for CO ₂ neutral/negative vehicle fuels |
| Local job creation | Domestic energy supply security |



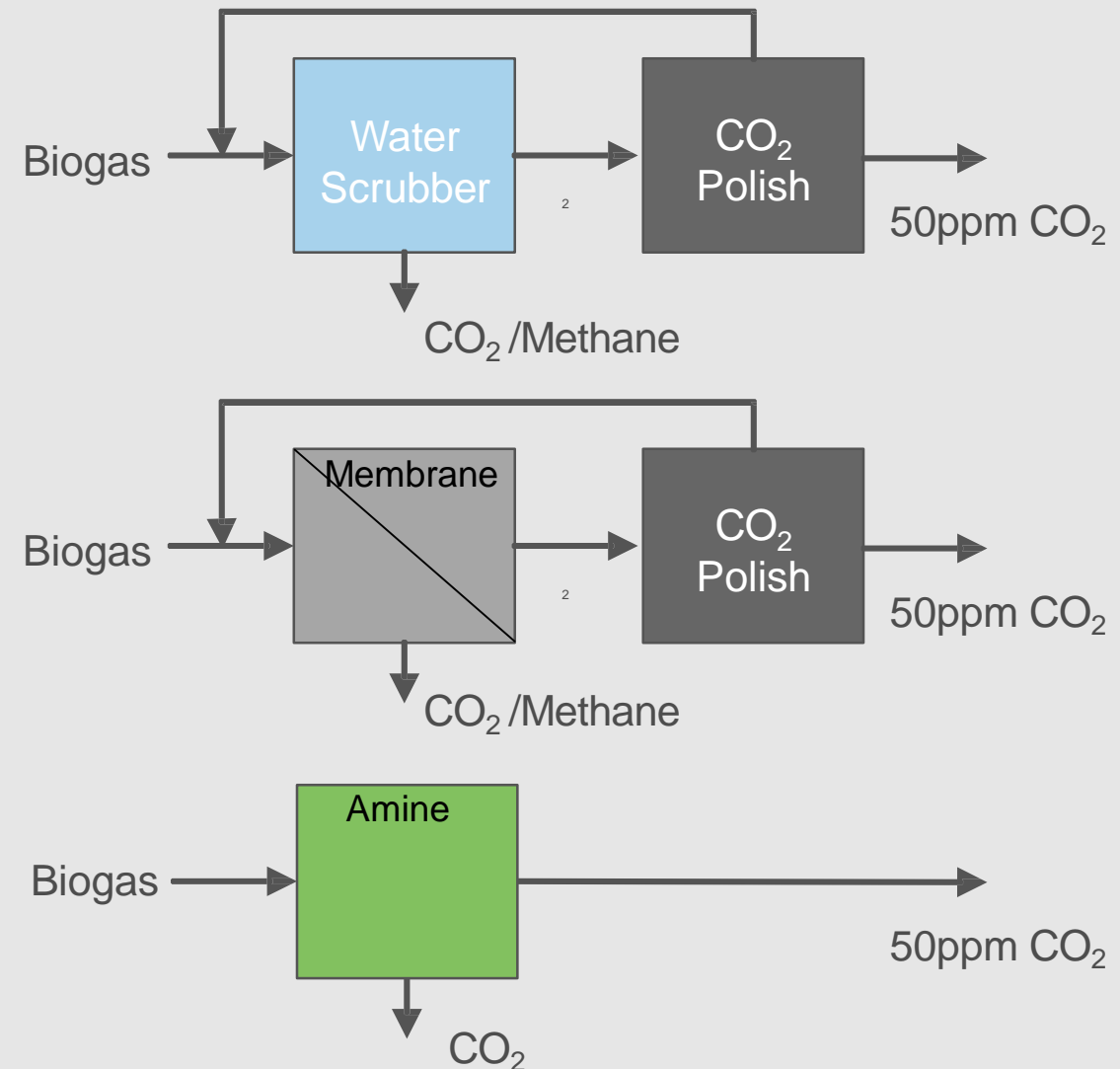






Wärtsilä Biogas Cleaning Alternatives

- Water Scrubber in combination with Polishing System
 - Risk of biological growth (Fouling)
 - Two process steps
 - By-Product: Regeneration Gas from Polishing
 - Methane slip
- Membrane in combination with Polishing System
 - Sensitive to raw gas impurities
 - Two process steps
 - By-Product: Regeneration Gas from Polishing
 - Methane slip
- Amine System
 - One process step
 - Very low methane slip
 - Requires heat. If heat can be recovered, net heat demand very low.



Manufactured and fully tested
(FAT) before delivered to site

High-Grade Stainless Steel
used throughout

Built-in redundancy of key
components such as
compressors and blowers

Easy access for maintenance

6 months lead-time from
order to Ex Works, Sweden

>40 references in operation



Small-scale liquefaction plants

INPUT

Gas sources

- Pipeline gas
- Biogas
- Associated gas
- Coal seam gas
- Shale gas

PLANT

2000 – 300 000 TPA

(3 400 – 510 000 GPD)

Gas pre-treatment

- Removing H_2O , CO_2 , H_2S , C_2+

Liquefaction

- Mixed Refrigerant:
2 000 – 30 000 TPA
(3 400 – 51 000 GPD)
- Nitrogen cycle:
20 000 – 300 000 TPA
(34 000 – 510 000 GPD)

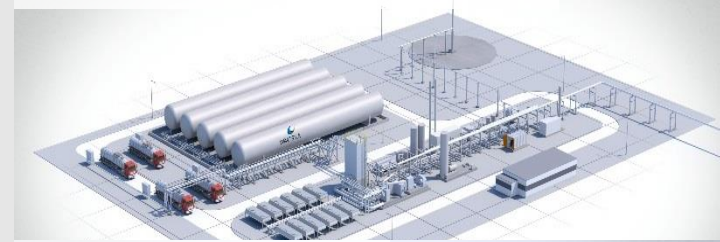
Storage tanks

Export systems

Biogas liquefaction plants



Small-scale liquefaction plants



Peak shaving plants



OUTPUT

LNG transport

- Carriers
- Trucks
- Containers
- Rail cars

Peak shaving gas send-out

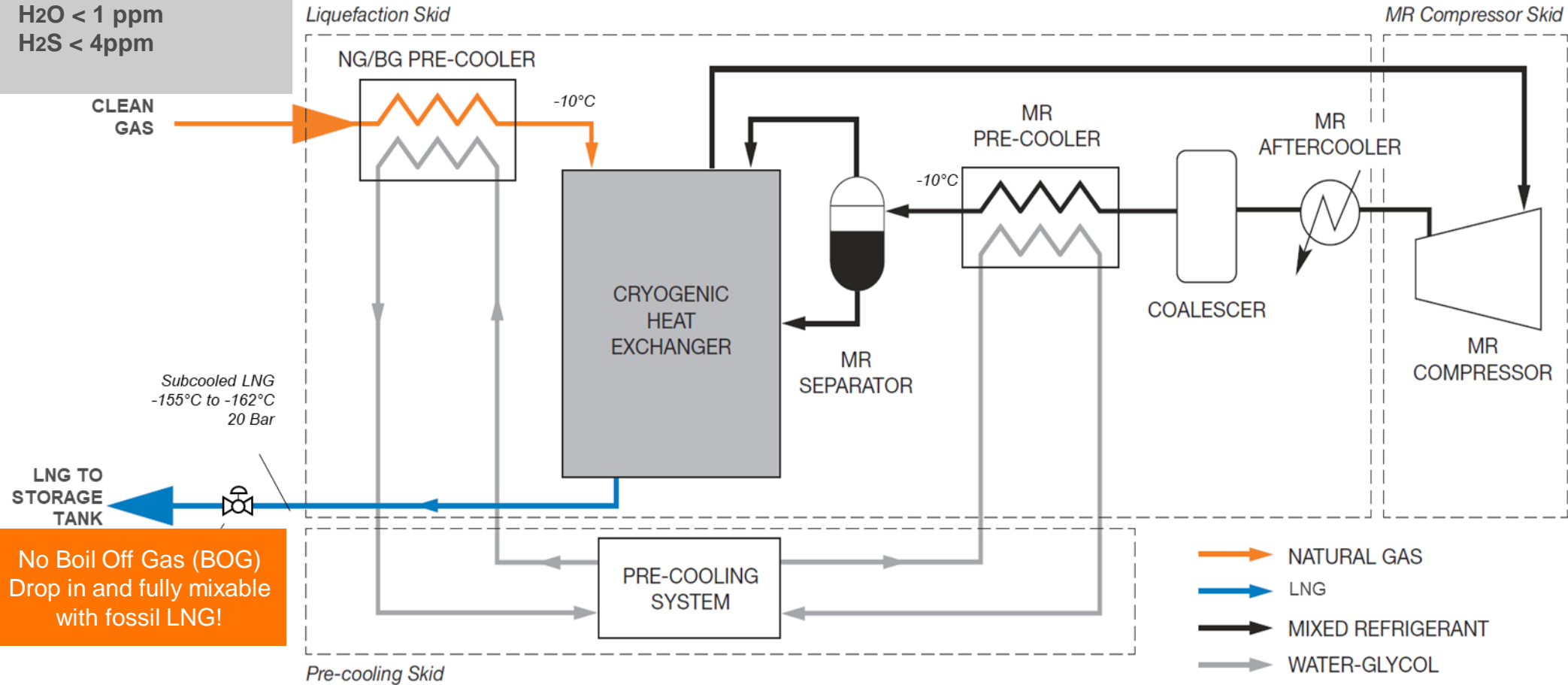
Ship bunkering

Wärtsilä Liquefaction technology with two different processes

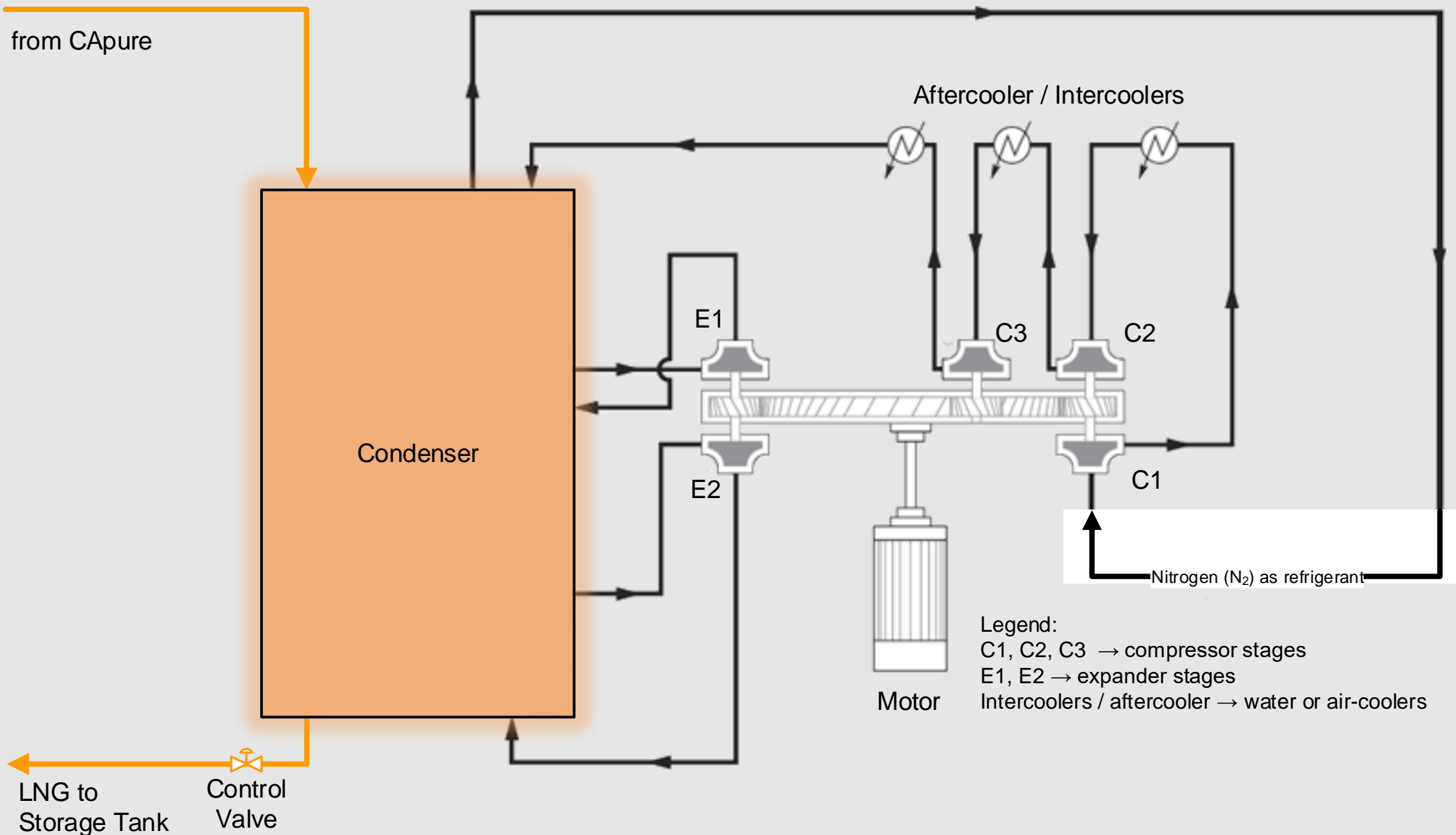
| Technology | MR Process | N ₂ Brayton Process |
|----------------------------|---|--|
| Production capacity | 2000 to 18,000 TPA | 18,000 to 300,000 TPA |
| Refrigerant system | Proprietary mix of hydrocarbons in a closed loop | Nitrogen produced from air on-site |
| Energy consumption | As low as 0.70 kWh/kg conditional to design priorities | As low as 0.35 kWh/kg conditional to design priorities |
| Technology features | Off-the-shelf components that enable a less expensive solution, quick delivery and simplified maintenance | Robust technology that allows for quick and simple start-up/shutdown & ramp up/ramp down compared to competing technologies. |
| Installation | Plug-and-play design with standard capacities 10, 17 and 25 TPD delivered within 12 months | Reduced installation time and small footprint through a modularized design |
| Delivery time | ~ 10 months DAP site | ~ 18 months DAP site |

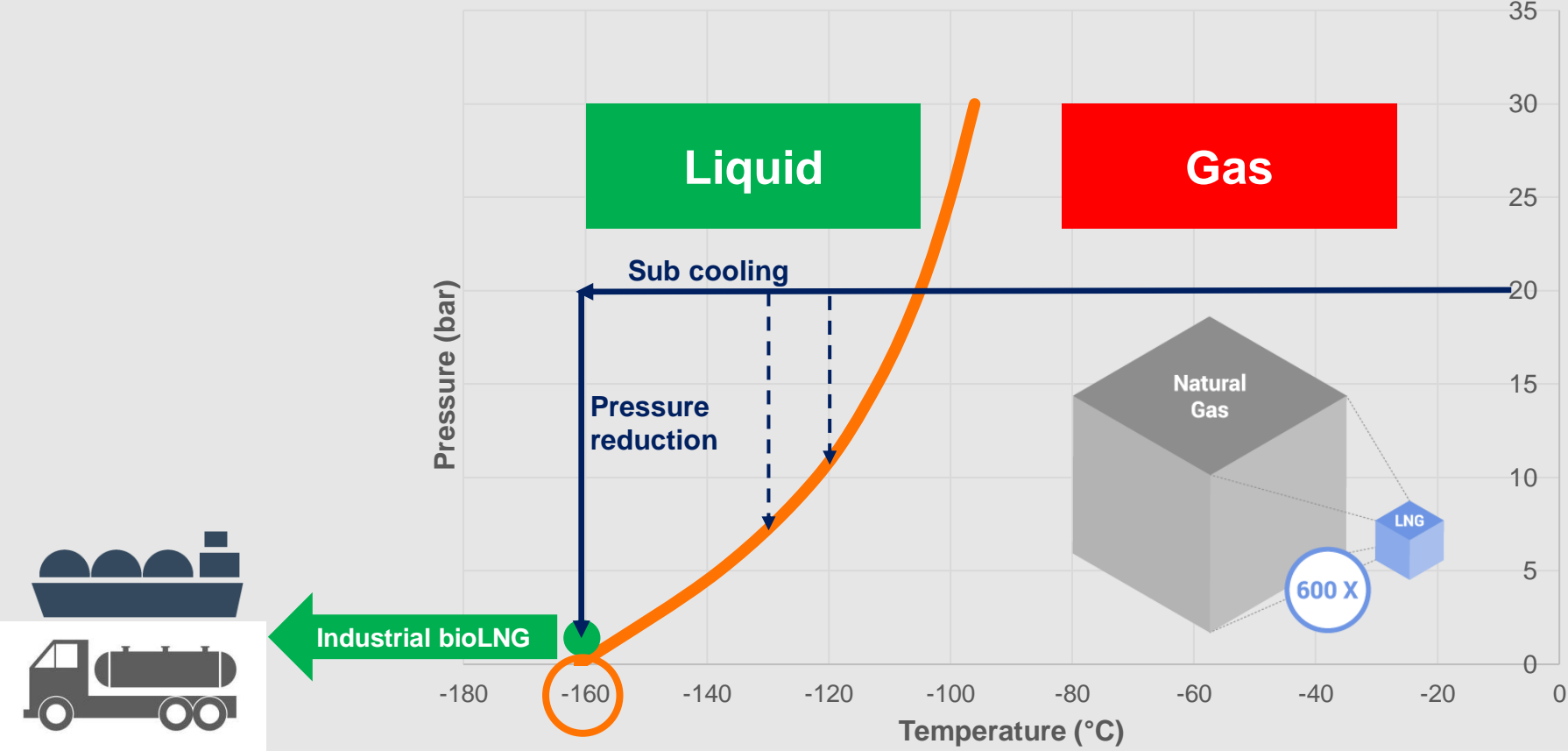
CApure polishing step:

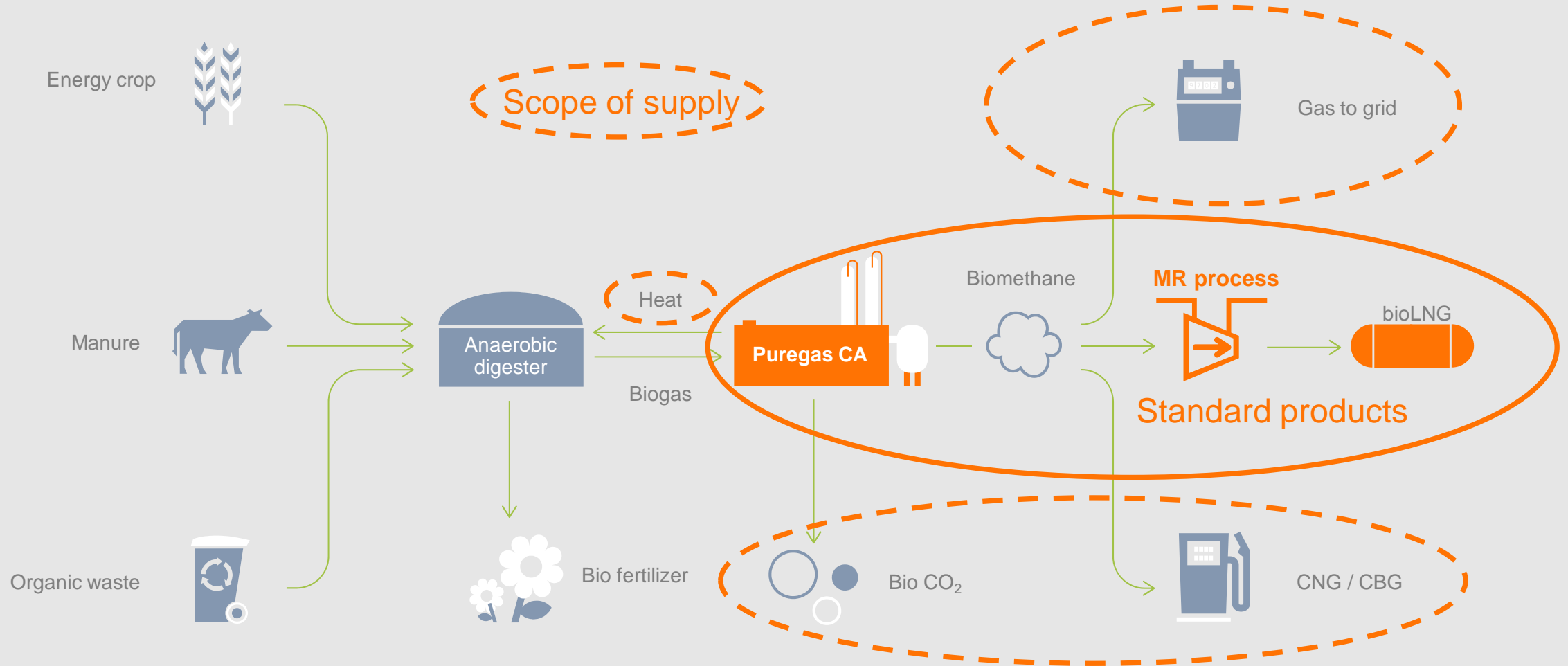
- CO₂ < 50ppm
- H₂O < 1 ppm
- H₂S < 4ppm



No Boil Off Gas (BOG)
Drop in and fully mixable
with fossil LNG!







| | Equipment Supply | Process EPC | EPC |
|--------------------------|-----------------------------------|---------------------|---------------------|
| Engineering | ✓ | ✓ | ✓ |
| Procurement | ✓ | ✓ | ✓ |
| Construction of Skids | ✓ | ✓ | ✓ |
| Transport | Either: FOB, CIF, CIP, DAT or DAP | DAP to project site | DAP to project site |
| Installation Works | Provide Supervision | ✓ | ✓ |
| Comissioning & Gas Trial | ✓ | ✓ | ✓ |
| Civil Works | NO | NO | ✓ |

Experience and recent success

A person wearing a bright yellow jacket and dark pants is rappelling down a thin rope that stretches across the frame. The background features a dramatic mountain landscape with steep, rocky peaks partially obscured by thick, white mist or clouds. The overall atmosphere is one of adventure and high-altitude exploration.

Snurrevarden

| | |
|----------------------------------|---|
| Customer | Gasnor (part of Shell) |
| Type | Small scale liquefaction plant |
| Tank net volume | 2 x 250 m ³ |
| Capacity | 60 TPD / 22,000 TPA |
| Size of liquefaction unit | 16 m x 18 m |
| Gas source | Pipeline gas Inlet pressure 120-150 bar |
| Details | <ul style="list-style-type: none"> LNG transported to customers by tanker truck |
| Scope of supply | Complete plant, incl. <ul style="list-style-type: none"> Gas pre-treatment Cooling system (Ambient air) Reversed Brayton liquefaction process Storage tanks Electrical and control systems Truck loading system Gas engine Excl. Substructures |
| Delivery method | EPCIC |
| Delivered | 2003 |



“The first stand-alone small scale LNG plant in Northern Europe.”

Kollsnes II

| | |
|----------------------------------|---|
| Customer | Gasnor (part of Shell) |
| Type | Small scale liquefaction plant |
| Tank net volume | 4,000 m ³ |
| Capacity | 240 TPD / 87,600 TPA |
| Size of liquefaction unit | 12 m x 38 m |
| Gas source | Pipeline gas. Inlet pressure typically 70 bar. |
| Details | Extension to Kollsnes I. Includes two truck loading stations and existing loading jetty for small LNG carriers. |
| Scope of supply | Complete plant, incl. <ul style="list-style-type: none"> • Gas pre-treatment • Cooling system (Seawater) • Double Reversed Brayton liquefaction process • Storage tank • Electrical and control systems • Civil works |
| Delivery method | EPCIC |
| Delivered | 2007 |



“Twice the capacity,
half the footprint!”

Gasum Kilpilahti

| | |
|---------------------------|--|
| Customer | Gasum |
| Type | Mini liquefaction plant |
| Tank net volume | 3 x 700 m ³ |
| Capacity | 55 TPD / 20,000 TPA |
| Size of liquefaction unit | 16 m x 20 m |
| Gas source | Pipeline gas |
| Details | <ul style="list-style-type: none">Utilization of excess nitrogen from adjacent oxygen plant.No rotating machinery |
| Scope of supply | <ul style="list-style-type: none">Pre-treatmentLIN liquefaction processStorage tanks Excl. substructures |
| Delivery method | EPCIC |
| Delivered | 2010 |



“LIN consumption reduced by 60% compared to old liquefaction plant.”

EGE Biogas

| | |
|----------------------------------|--|
| Customer | Cambi AS |
| Type | Mini liquefaction plant |
| Tank net volume | 180 m ³ |
| Capacity | 11 TPD / 4,000 TPA |
| Size of liquefaction unit | 8 m x 14 m |
| Gas source | Biogas from 50,000 TPA of food waste |
| Details | Fuel production for 135 buses in the city of Oslo |
| Scope of supply | Complete plant, incl. <ul style="list-style-type: none"> • Gas pre-treatment • Cooling system (Ambient air) • MR liquefaction process • Storage tank • Electrical and control systems • Service agreement Excl. Civil works and installation |
| Delivery method | EPC |
| Delivered | 2013 |



“135 Oslo region buses will be able to run on biogas which means 10,000 tonnes emission reduction per year.”

Biokraft LBG

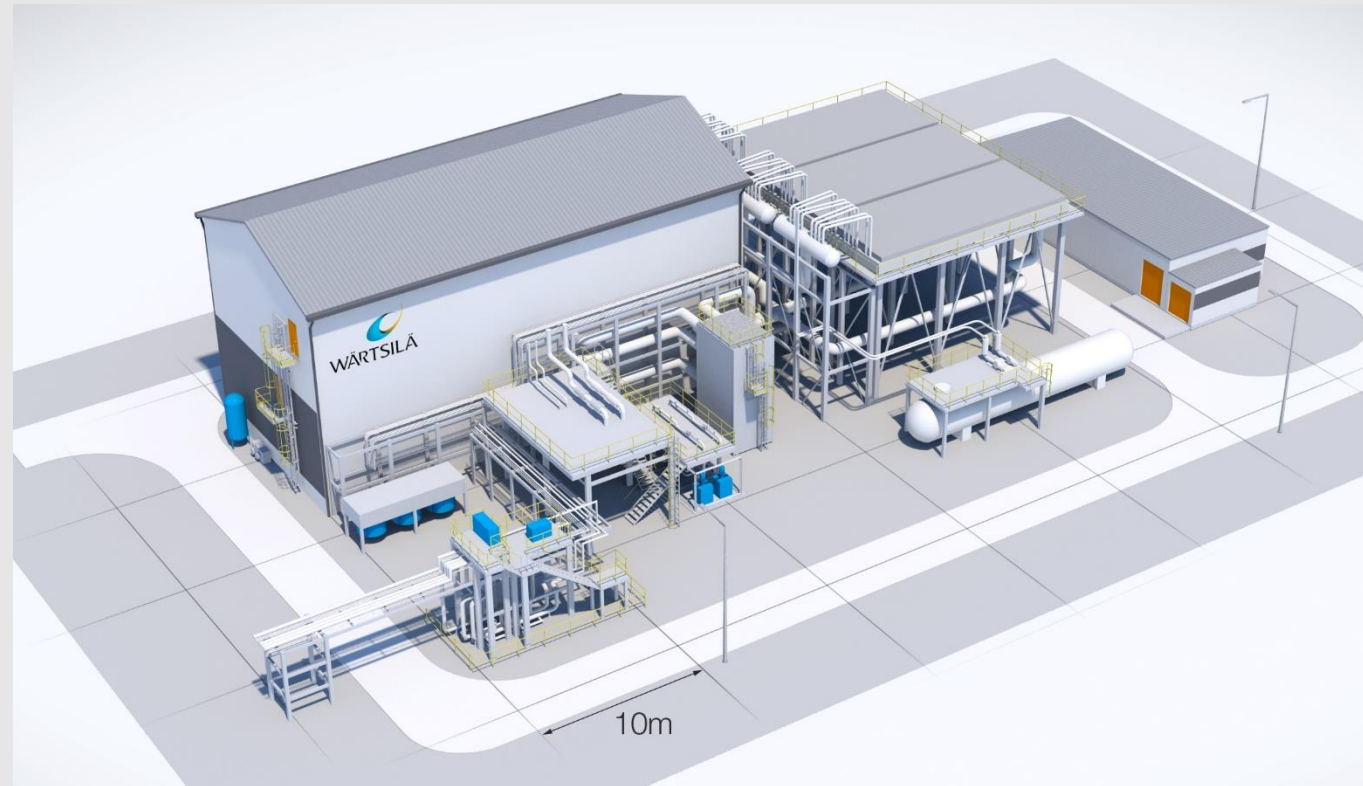
| | |
|----------------------------------|---|
| Owner | Biokraft AS |
| Type | Mini liquefaction plant |
| Tank net volume | 350 m ³ |
| Capacity | 25 TPD / 9,125 TPA |
| Size of liquefaction unit | 30 m x 40 m |
| Gas source | Biogas from fish industry and paper mill waste |
| Details | Biogas to be used on city buses in Trondheim |
| Scope of supply | Liquefaction plant, incl. <ul style="list-style-type: none"> • Gas Cleaning • Cooling system (Ambient air) • MR liquefaction process • Storage tank • Electrical and control systems • Service agreement • Installation of plant Excl. Civil works |
| Delivery method | EPC |
| Delivered | 2018 |



“We expect strong demand for liquefied biogas as fuel. Wärtsilä’s biogas liquefaction solution represents an important step forward in realising this potential.”

Dragon LNG, Wales, UK

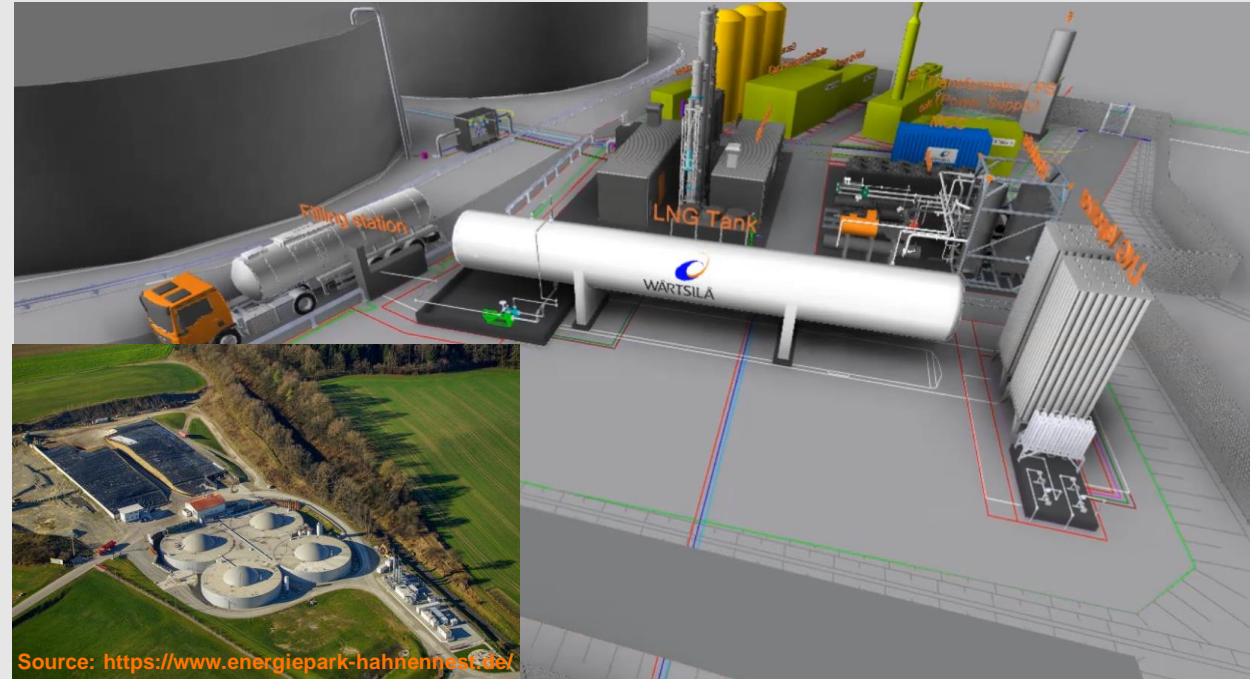
| | |
|------------------------|---|
| Customer | Dragon LNG (JV between Petronas and Shell) |
| Type | BOG (boil-off gas) re-liquefaction package for large scale LNG terminal |
| Capacity | 320 TPD / 112 000 TPA |
| Scope of supply | <ul style="list-style-type: none">• Coldbox• Air coolers• N2 Brayton cycle liquefaction process• LNG pumps• Instrument air compressors/dryers• Instruments and valves• Control system• Supervision• Commissioning |
| Delivery method | Engineering & Procurement |
| Delivered | 2018 |



“Our terminal operates at the highest levels of efficiency using commercially proven technology, equipment and materials.”

biohybrid Hahnennest bioLNG, Germany (on hold)

| | |
|------------------------|---|
| Owner | Erdgas Südwest GmbH |
| Type | Liquefaction plant |
| Tank net volume | 105 m ³ |
| Capacity | 10 TPD / 3 500 TPA |
| Footprint | 12 m x 20 m |
| Gas source | Biogas from bio waste and/or pipeline gas |
| Details | Advanced biofuel (bioLNG) and LNG production |
| Scope of supply | <ul style="list-style-type: none"> • Gas cleaning by CAPure • MR liquefaction process • Storage tank • Export system • Electrical and control systems • Installation of plant Excl. civil works |
| Delivery method | EPC |
| Delivered | Building Permit received, project not executed |



“Biogas and pipeline gas compositions can vary substantially, and Wärtsilä’s advanced technology can handle both.”

Tornio LNG Terminal

| | |
|-------------------------|--|
| Customer | Manga LNG |
| Type | Mid scale LNG Terminal |
| Tank net volume | 1 x 50 000 m ³ |
| Capacity | 936 TPD / 342 000 TPA at 99.9% availability |
| Size of terminal | 1000 m x 300 m |
| Gas source | LNG delivered by LNG carrier |
| Details | NG supply via local pipe line, truck loading and ship bunkering |
| Scope of supply | Complete plant, incl. <ul style="list-style-type: none"> • Ship unloading 3000 m³/h • Ship bunkering (350 m³/h) • LNG storage (50 000 m³) • Gas sent-out and metering (39 T/h @ 6.5 barg) • Regasification • Truck loading (2 x 45 m³/h) • Electrical systems, starters and all cables • Control systems and safety • All civil works and backfilling • All piping and structural steel • All buildings |
| Delivery method | EPCIC |
| Delivered | 2018 |

“The largest LNG Terminal in Finland”

99.9 % availability



Tekniska verken i Linköping

| | |
|----------------------------------|--|
| Owner | Tekniska verken |
| Type | MR liquefaction plant |
| Tank net volume | 177 m ³ |
| Capacity | 20 TPD |
| Size of liquefaction unit | 30 m x 40 m |
| Gas source | Biogas |
| Details | The plant will produce bioLNG |
| Scope of supply | Liquefaction plant, incl. <ul style="list-style-type: none">• Gas Cleaning• MR liquefaction process• Storage tank• Export system• Electrical and control systems• Installation of plant Excl. Civil works |
| Delivery method | EPC |
| Delivered | 2019 |



“with this project, Tekniska verken, the Swedish pioneer in biogas, will reach new markets and thereby increase the biogas production.”

VEAS bioLNG, Norway

| | |
|------------------------|---|
| Owner | VEAS |
| Type | Liquefaction plant |
| Tank net volume | 300 m ³ |
| Capacity | 20 TPD / 7 400 TPA |
| Footprint | 12 m x 20 m |
| Gas source | Biogas from waste water |
| Details | Advanced biofuel (bioLNG) production for buses in the city of Oslo |
| Scope of supply | <ul style="list-style-type: none"> • Gas cleaning by CApure • MR liquefaction process • Storage tank • Export system • Electrical and control systems • Installation of plant Excl. civil works |
| Delivery method | EPC |
| Delivered | 2019 |



“VEAS, the largest wastewater treatment plant in Norway will produce LBG for buses and heavy duty trucks.”

Pori

| | |
|----------------------------------|--|
| Owner | Gasum |
| Type | MR liquefaction plant |
| Tank net volume | Tank integrated with LNG terminal |
| Capacity | 25 TPD |
| Size of liquefaction unit | 20 m x 20 m |
| Gas source | Boil Off Gas (BOG) from LNG terminal |
| Details | Reliquefaction of BOG to LNG |
| Scope of supply | Liquefaction plant, incl. <ul style="list-style-type: none"> • MR liquefaction process • Electrical and control systems • Installation of plant Excl. Civil works |
| Delivery method | EPC |
| Delivered | 2020 |



“Short lead time, proven technology and low OPEX were key parameters for selection Wärtsilä.”

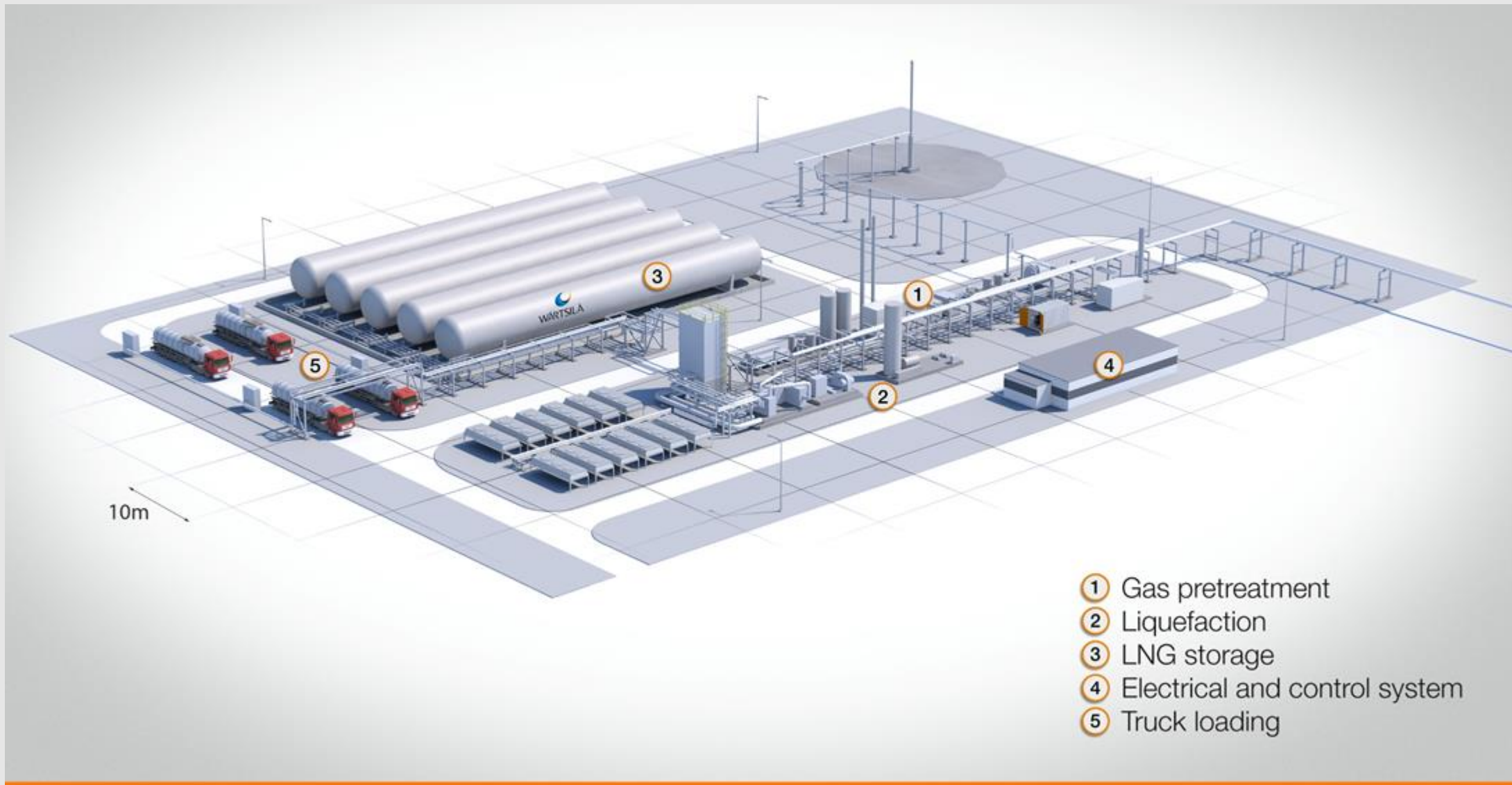
**DE, undisclosed, 285tpd pipeline gas cleaning & liquefaction
Status: Building Permit process**

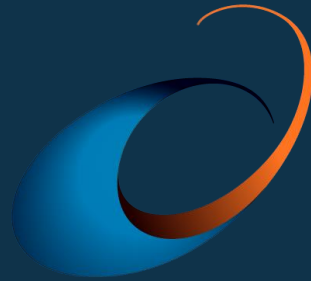
**AT, undisclosed, 25tpd pipeline gas cleaning & liquefaction
Status: Building Permit process**

**NL, undisclosed, 25tpd biogas upgrading & liquefaction
Status: Building Permit process**

NO, undisclosed, Extension of a 25tpd biogas upgrading & liquefaction plant

Indicative 3D model Liquefaction Plant





WÄRTSILÄ

Look forward to do business together!