

Towards a 100% renewable energy future: WÄRTSILÄ in the BioGas (LBG) MARKET

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THIS IS WÄRTSILÄ

A global leader in smart technologies
and complete lifecycle solutions for
the marine and energy markets



CLEAN ENVIRONMENT

A future without emissions
or pollution



MARKET SHAPING & INNOVATION

A union of new technology
and business models



ENERGY INTELLIGENCE

An optimised way of producing
and using energy

WÄRTSILÄ'S PURPOSE
is to enable sustainable
societies with smart
technology.



Smart Marine Vision

Wärtsilä's aim is to lead the industry's transformation towards a Smart Marine Ecosystem by **new ways of collaboration and smart technology**.

By applying smart technology and performance optimisation services, Wärtsilä aims to deliver greater efficiencies, minimise climate impact and a higher safety to the shipping industry.



Smart Energy Vision

The energy landscape is in transition towards more flexible and sustainable energy systems. **We envision a 100% renewable energy future.**

Wärtsilä is leading the transition as the **Energy System Integrator** – we understand, design, build and serve optimal power systems for future generations.

We provide all the essential technologies, lifecycle services and optimised solutions for future energy systems.

ENERGY SOLUTIONS

We are a leading global energy system integrator offering a broad range of environmentally sound solutions. We deliver value to our customers by integrating all the essential technologies, services and solutions for sustainable and reliable energy systems. Our flexible and efficient solutions provide customers with superior value and enable a transition to a more sustainable and modern energy system for future generations.

**ECONOMIC
GROWTH,
ELECTRIFICATION
AND IMPROVING
STANDARD
OF LIVING**

**RAPIDLY
INCREASING
RENEWABLES**

**DECLINING
INFLEXIBLE
BASE LOAD
GENERATION**

**EMERGING
DISRUPTIVE
STORAGE
TECHNOLOGY**

**THE ROLE
OF **GAS** IS
INCREASING**



A leader in the global energy industry



ENERGY EFFICIENT SOLUTIONS

- Smart Power Generation combining energy efficiency, fuel and operational flexibility
- Most complete offering of marine products and integrated solutions, including a broad portfolio of environmental products
- Optimized asset performance over the lifecycle



GAS-BASED TECHNOLOGY

- A forerunner in gas and multi-fuel engines, fuel systems, technology and services
- Offering that covers gas value chain from exploration to end consumers
- Wide offering in small scale LNG



INNOVATIVE SOLUTIONS

- Global track record in distributed energy
- Project management and engineering competence create customer value
- Making use of digital technology



ENGINE POWER PLANTS

Ultra-flexible internal combustion engine based power plants



ENERGY STORAGE AND INTEGRATION

Utility-scale energy storage solutions and advanced software



RENEWABLES

Utility-scale solar power plants, solar-engine, storage+ hybrid solutions



LNG INFRASTRUCTURE

Small and medium scale liquefaction plants, terminals and distribution

67 GW INSTALLED POWER PLANT CAPACITY IN 177 COUNTRIES

OVER 70+ GLOBAL ENERGY STORAGE SYSTEMS INSTALLED

WE HAVE BUILT THE LARGEST LNG TERMINAL IN THE NORDIC REGION

FIRST COMPANY IN THE WORLD TO OFFER **UTILITY-SCALE HYBRID POWER PLANTS THAT UNITE LARGE FUEL-BASED POWER STATIONS WITH UTILITY-SCALE SOLAR PV POWER PLANTS**

Natural gas is conquering new markets

Global interest in LNG is driven by

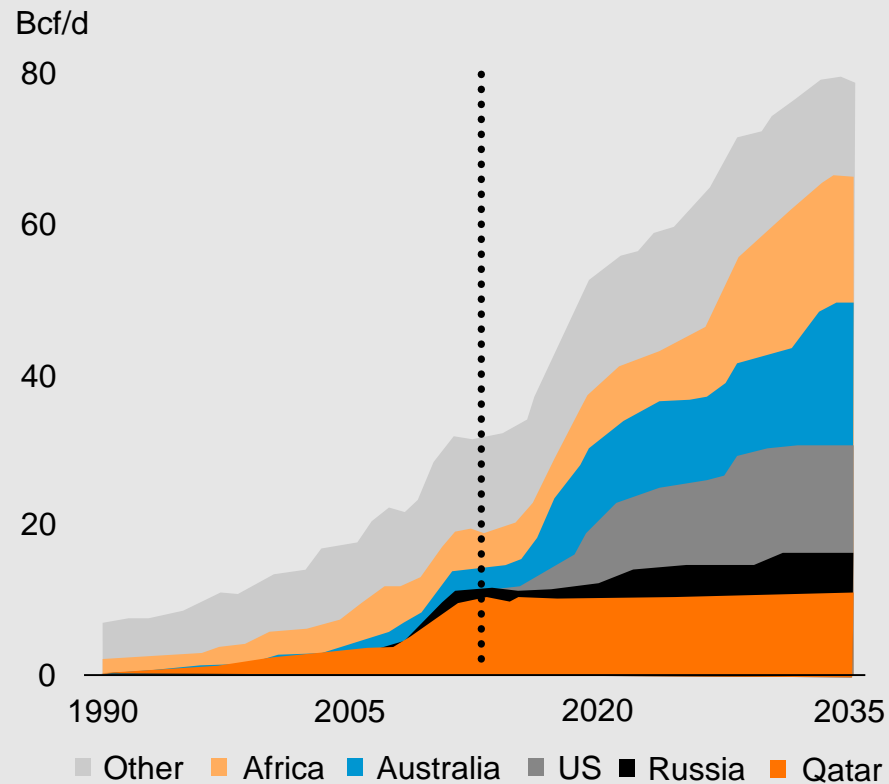
- Energy security considerations and lower energy costs
- Requirements for emission reduction in power generation, industry and shipping
- Rapid growth of intermittent renewable power generation and escalating demand fluctuation. LNG/gas is a perfect balancing fuel.

By 2035 LNG will have overtaken pipelines as the dominant form of traded gas – BP Energy Outlook 2035

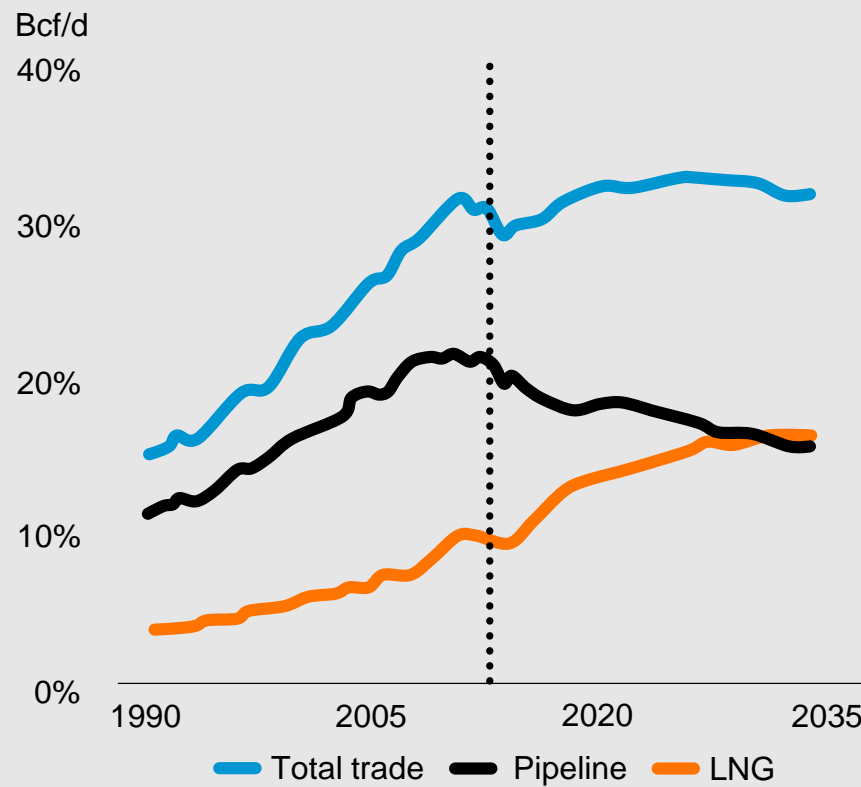


LNG Trends - BP Energy Outlook 2035

- LNG supply



- Shares of global gas consumption

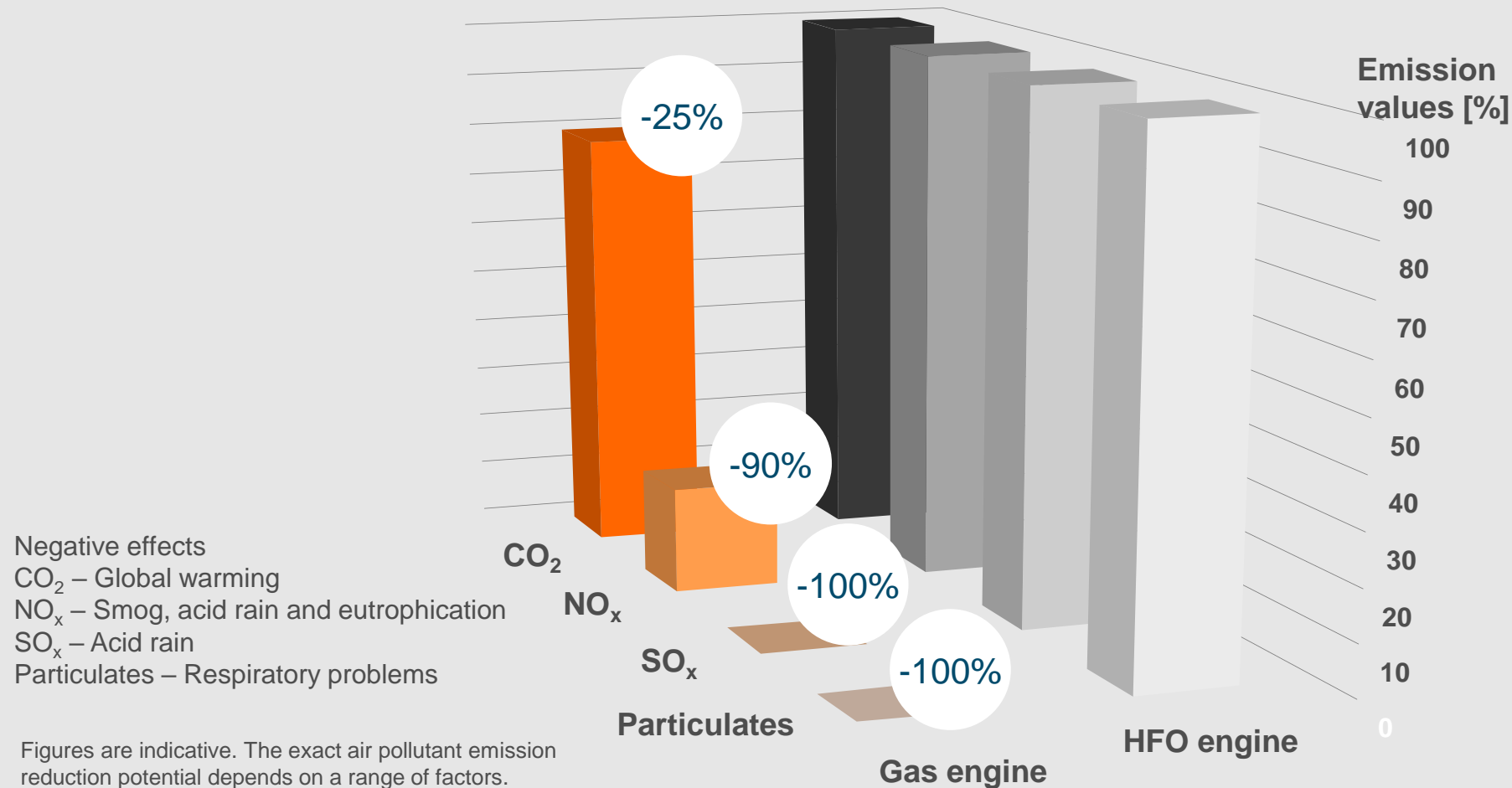


EU is driving the development of LNG infrastructure out of two reasons

- **Environmental** and the EU clean fuel strategy mainly related to the transport sector both at sea and at land with stricter emission legislation.
- **Security of Supply**, with the largely dependence on Russia for EU's natural gas imports, EU wants to diversify its natural gas imports by both promote new pipeline like TAP and TANAP as well as increase the number of LNG receiving terminals.



Emission reduction potential with LNG



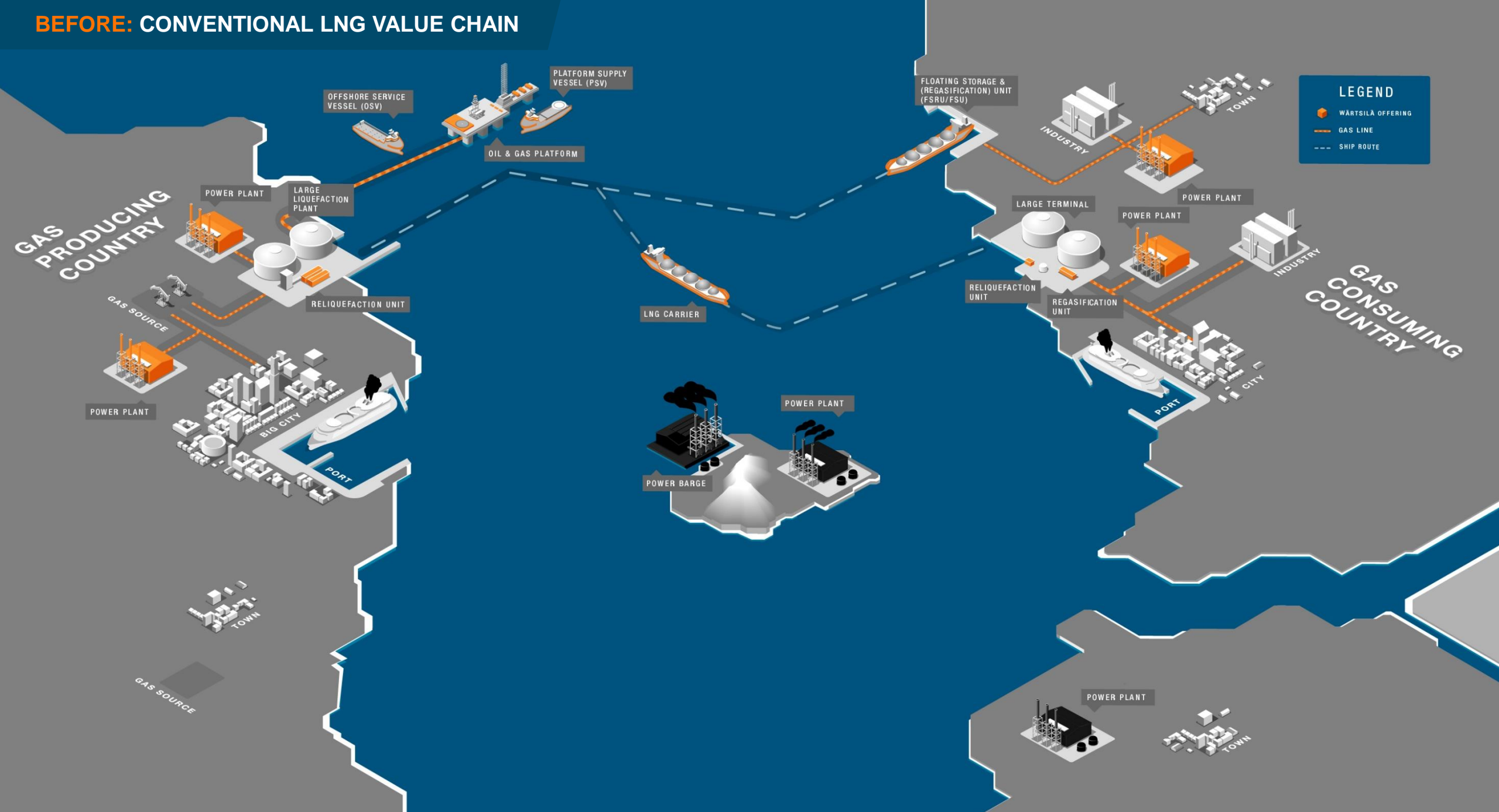
Wärtsilä developing LN(B)G infrastructure

As a forerunner in gas and multi-fuel engines, fuel systems, technology and services, Wärtsilä participates in the global shift to gas also with LNG infrastructure projects.

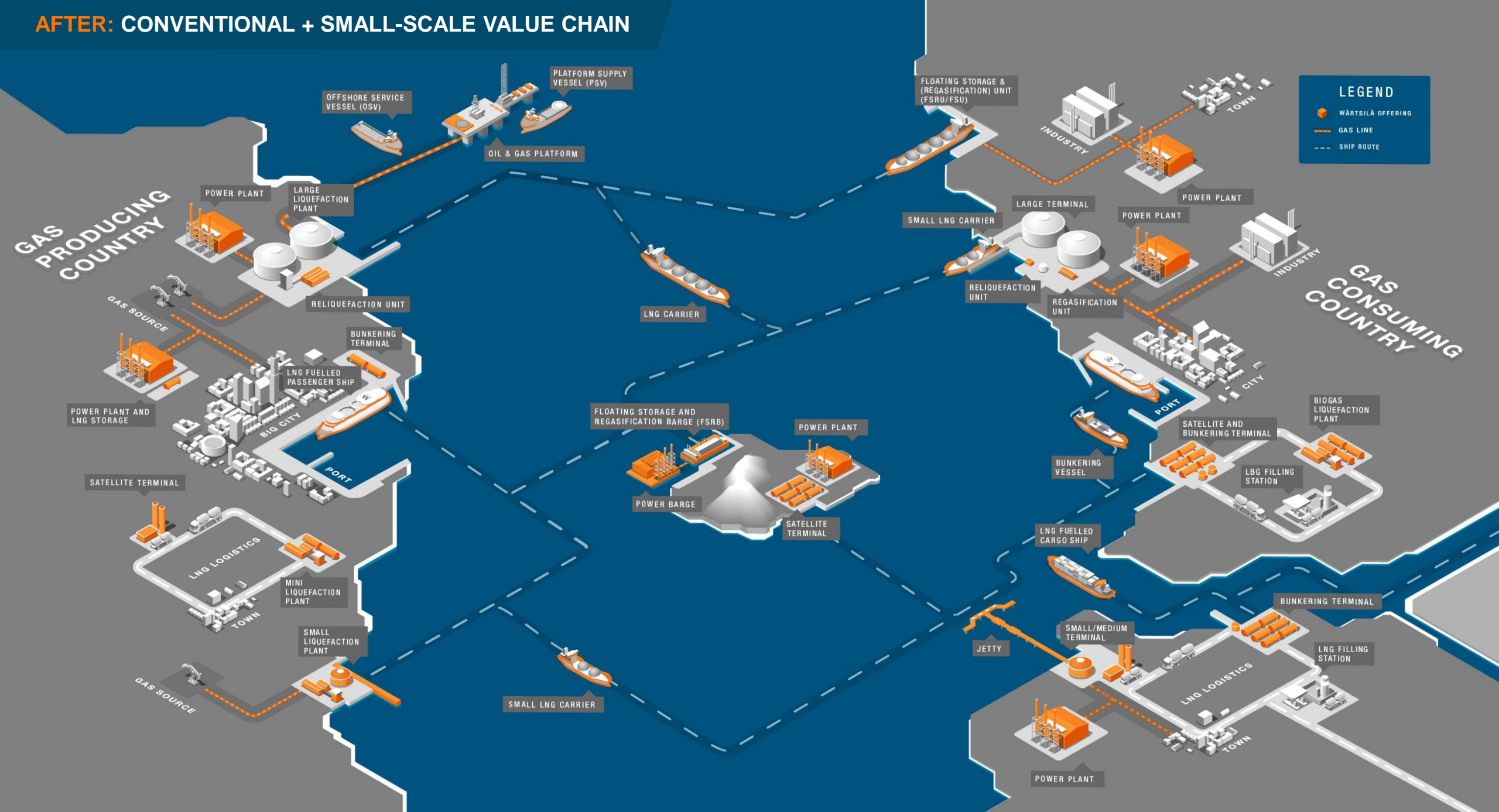
- We provide our full range of **project and lifecycle support** to LNG liquefaction plants & terminals to deliver EPC projects worldwide.
- We have the capability to **develop the entire LNG value chain** in partnership with our customers.
- Also, we provide similar services for **LEG (ethane) and LPG (propane)** infrastructure.



BEFORE: CONVENTIONAL LNG VALUE CHAIN



AFTER: CONVENTIONAL + SMALL-SCALE VALUE CHAIN



Wärtsilä Gas Solutions

50+ years of gas system delivery references



LPG/LEG BUSINESS 1963-

1963-1999
• 125 CARGO HANDLING SYSTEMS

2000->
• > 300 CARGO HANDLING SYSTEMS



GAS RECOVERY BUSINESS 1998-

- > 30 HC BLANKET & FLARE GAS RECOVERY SYSTEMS
- >10 SHIP/FSU BASED VOC RECOVERY SYSTEMS
- 4 SHORE TERMINAL VOC RECOVERY SYSTEMS
- > 150 FLARE GAS IGNITION SYSTEMS



LNG BUSINESS 2002-

- 43 LNG RELIQUEFACTION PLANTS
- >13 REGASIFICATION PLANTS
- 2 TERMINALS
- 4 SMALL SCALE ONSHORE LNG PLANTS



LNGPac BUSINESS 2009-

- >100 TOTAL NO. OF LNGPAC™

- VOC Recovery (VOCRS)
- LPG Carriers (LPGC)
- Small Scale Carriers & Bunkering
LNG vessels (SSLNG)
- Fuel Gas Supply (FGSS)
- LNG Carriers (LNGCS)
- Floating Storage (FSRUS)
- Terminals & Liquefaction (TERMLS)
- Inert Gas Systems (IGS)
- Flare Gas Ignition (FGIS)



Mini and small-scale liquefaction plants

INPUT

Gas sources

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

PLANT

2000-300,000 TPA
(3400-510,000 GPD)

Gas pre-treatment

Liquefaction

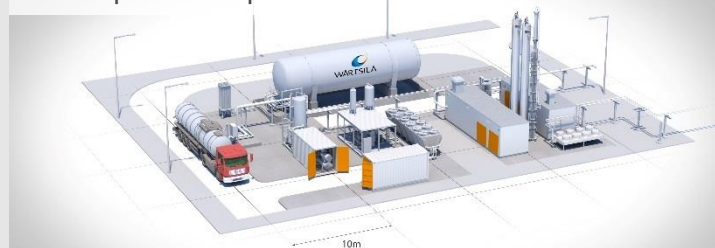
- Mixed Refrigerant: 2000-30,000 TPA
(3400-51,000 GPD)
- Reversed Brayton: 20,000-300,000 TPA
(34,000-510,000 GPD)

Storage tanks

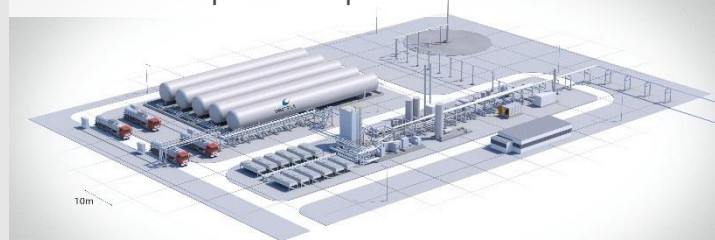
Jetty & marine facilities

Export systems

Mini liquefaction plants



Small-scale liquefaction plants



Peak shaving plants



OUTPUT

LNG transport

- Carriers
- Tanker trucks
- Containers
- Rail cars

Peak shaving gas send-out

Ship bunkering

Wärtsilä's mini and small-scale liquefaction plants

- Modular skids based on proven design are quality checked in the factory, easy to transport and quick to install, thereby reducing **risk and cost**
- Load variation is easy to handle, which gives **flexibility** of operations while maintaining **efficiency**
- State-of-the-art control system **automates** the plant and makes it easy to operate. Even unmanned operation is possible.
- Easy maintenance through simple designs and readily available spares ensures high **availability** throughout years of operation, thus maximizing **earnings**.



Small- and medium-scale terminals

INPUT

LNG transport

- Carriers
- Tanker trucks
- Containers
- Rail cars

TERMINAL

Tank capacity

100-160,000 m³

(26,400-42 million gallons)

Jetty & marine facilities

Unloading systems

Storage tanks

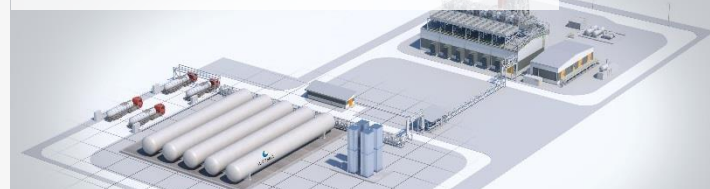
Boil-off gas handling

Regasification

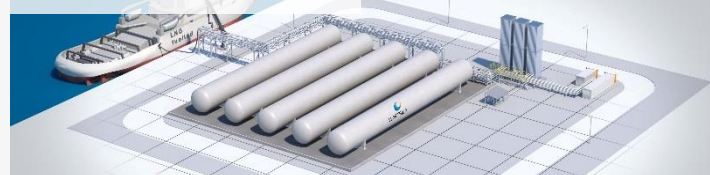
- Up to 1000 TPH
(1000 MMSCFD)

Export systems

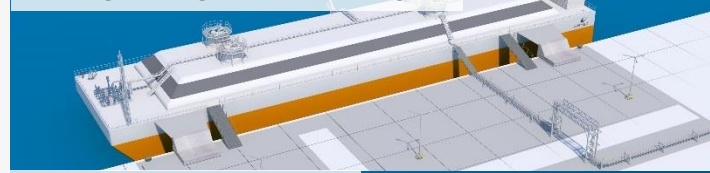
Satellite terminals for gas power plants



Small satellite terminals



Storage & regasification barges



Medium-scale terminals



OUTPUT

LNG transport

- Carriers
- Tanker trucks
- Containers
- Rail cars

Gas send-out

Ship bunkering




Wärtsilä's small- / medium-scale terminals



- Specifically adapted for the requirements of small-scale LNG through **elimination of complexity** and **increase of flexibility**
- **Single use** (e.g. providing fuel for a power plant) or **multi use** (e.g. gas send-out, ship bunkering, truck loading)
- Available for both **hub and spoke operations**
- **Onshore and near shore** (barge) concepts
- **Stringent safety regulations** during both construction and operation

Going Green

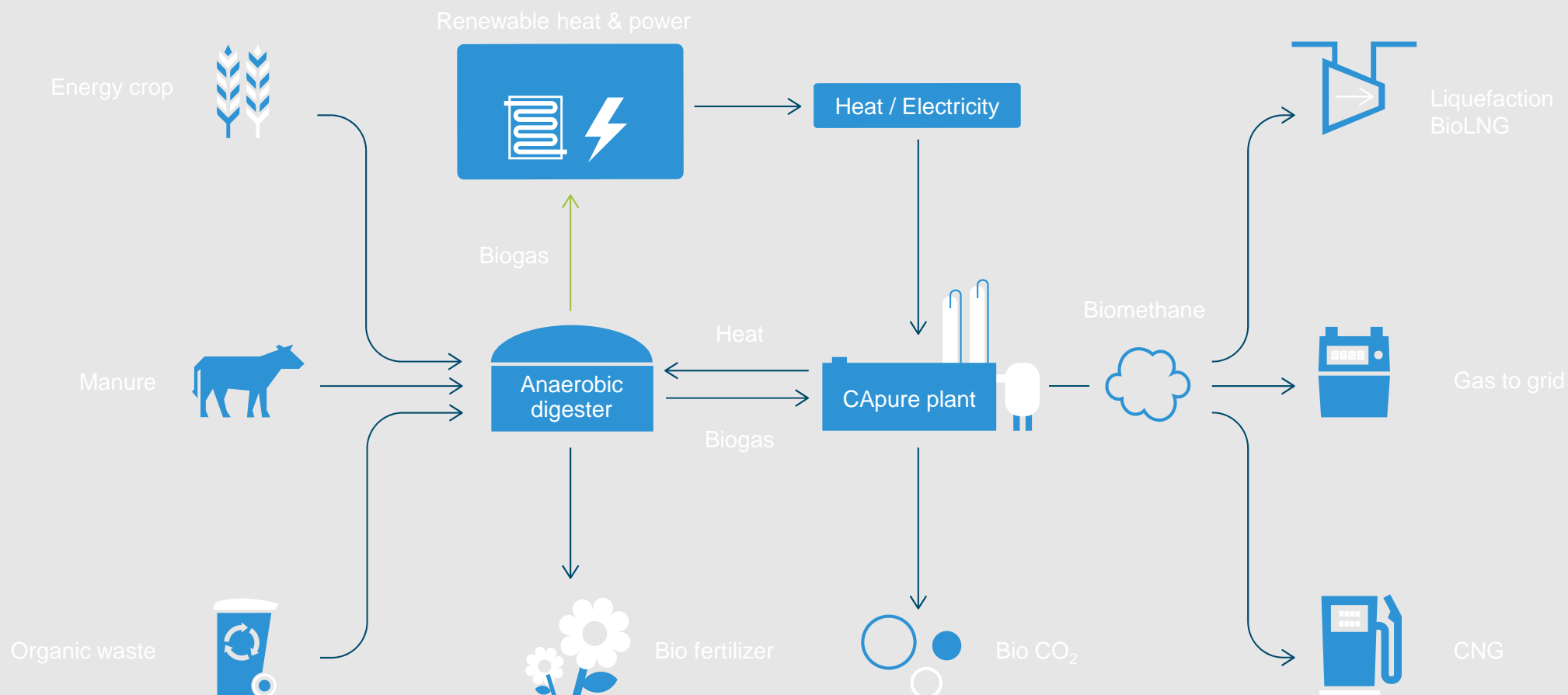


All human activity creates waste. However, waste can also be a valuable resource. Excess agricultural produce, manure, wastewater sludge, industrial and restaurant food waste are all perfect raw materials for biogas production. Biogas can then be upgraded to pure biomethane, which can be used as a low carbon vehicle fuel or injected into the natural gas grid to provide renewable energy to both homes and businesses.

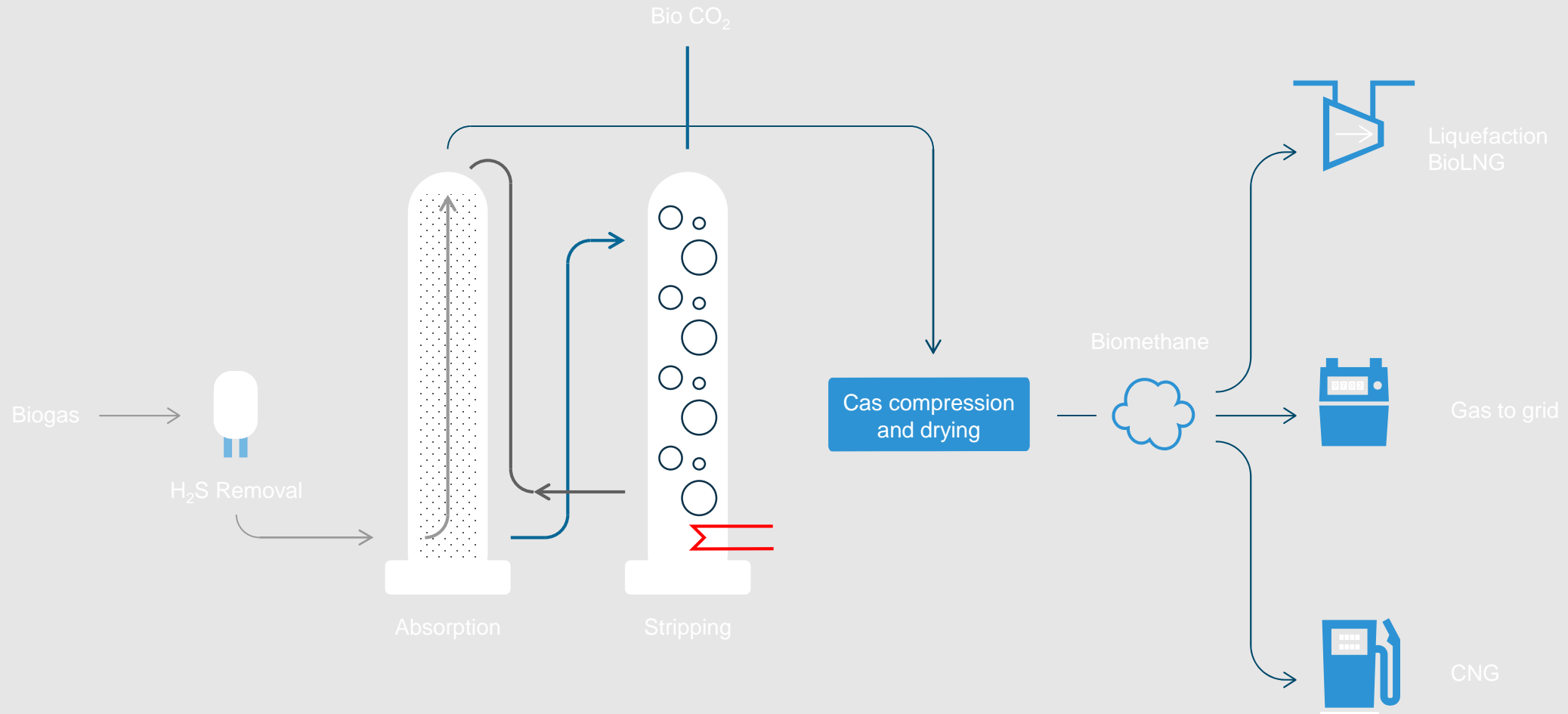
- VOC Recovery (VOCRS)
- LPG Carriers (LPGC)
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- LNG Carriers (LNGCS)
- Floating Storage (FSRUS)
- Terminals & Liquefaction (TERMLS)
- Inert Gas Systems (IGS)
- Flare Gas Ignition (FGIS)
- **Biogas Upgrading (BUS)**
- **Biogas Liquefaction (BLS)**

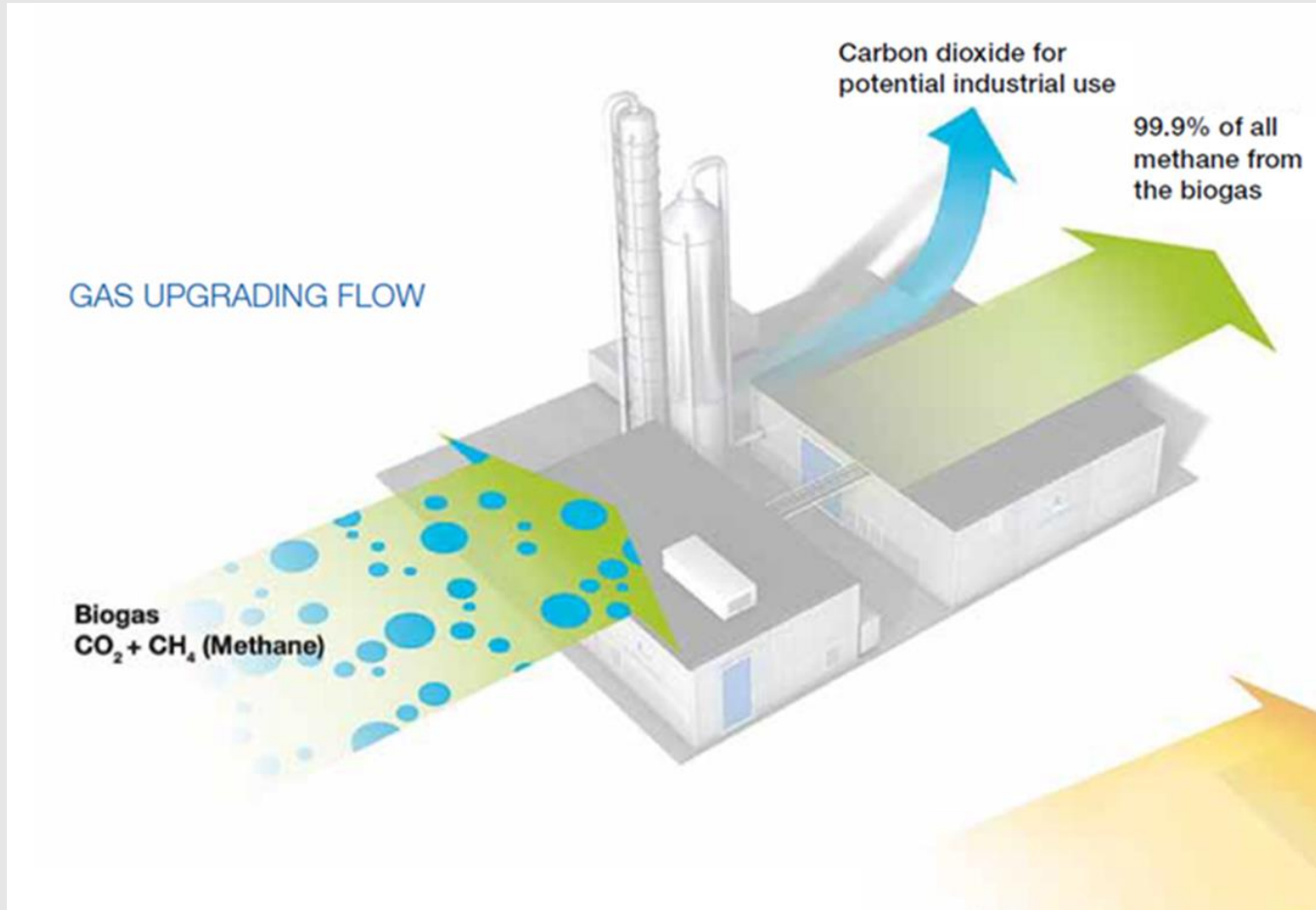


Biogas Process



CApure Process





- Less than 0.1% methane slip
 - **Protecting our environment**
- 99.9% of the methane in the biogas can be sold
 - **Always the highest revenue**
- Low electricity consumption

CApure Core model	Max Capacity (Nm ³ /h biogas)
CA30	700
CA40	900
CA50	1.250
CA60	2.000
CA70	3.000
CA75	4.500
CA80	6.000

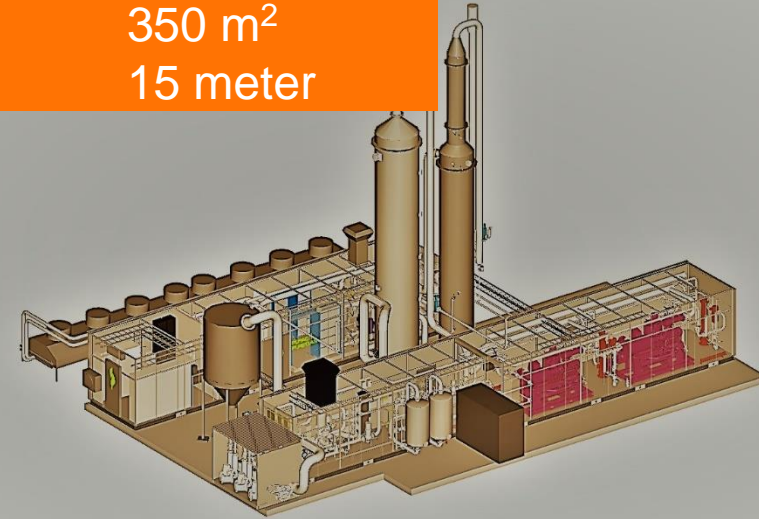
7 core models - available in 4 versions

- Standard
- Vacuum models for lower temperature requirement (< 95°C)
- LBG models (< 50 ppm CO₂)
- H₂S models (< 3'000 ppm H₂S)

CA80 – standard version

Foot print: 350 m²

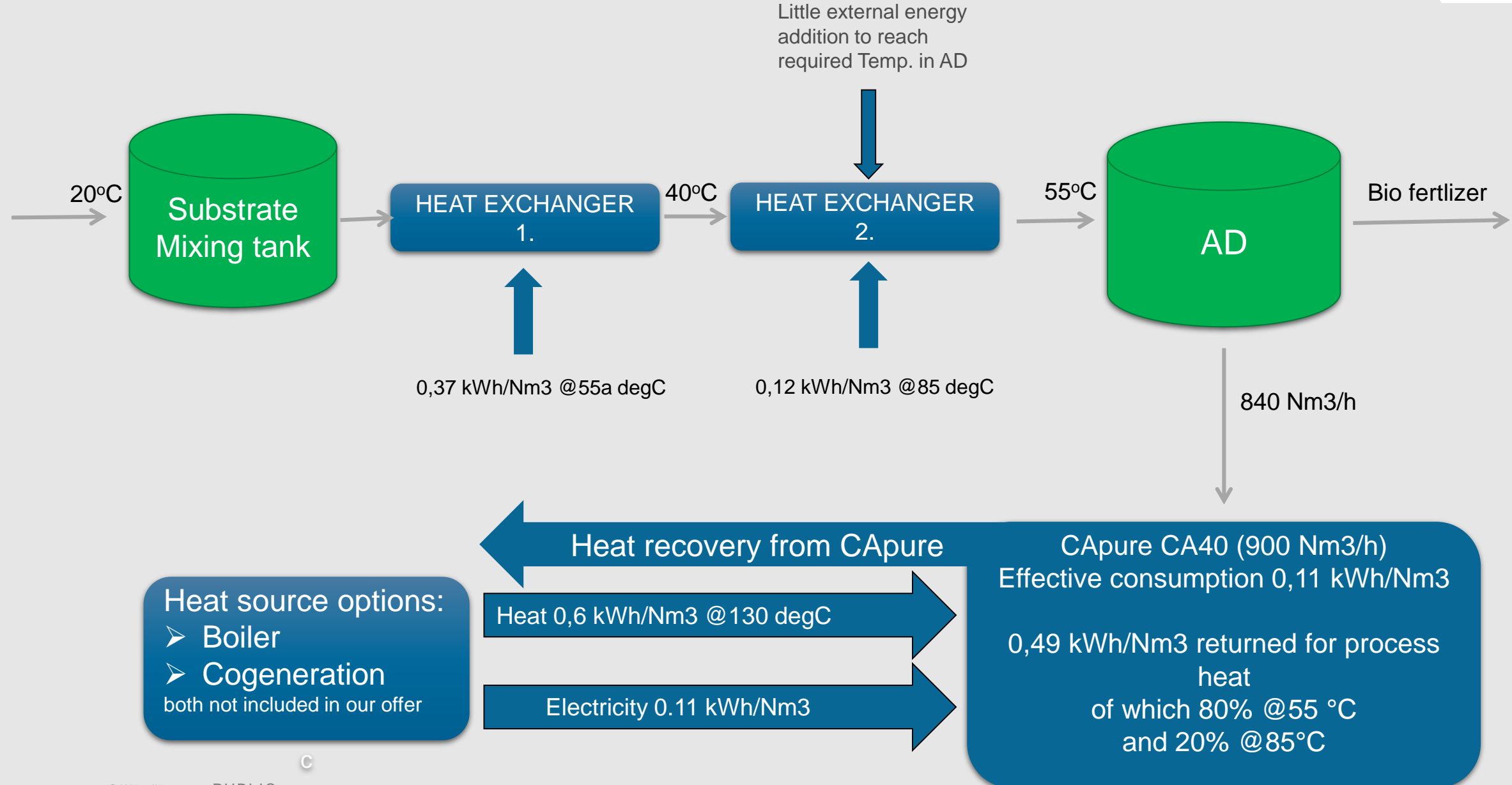
Height: 15 meter

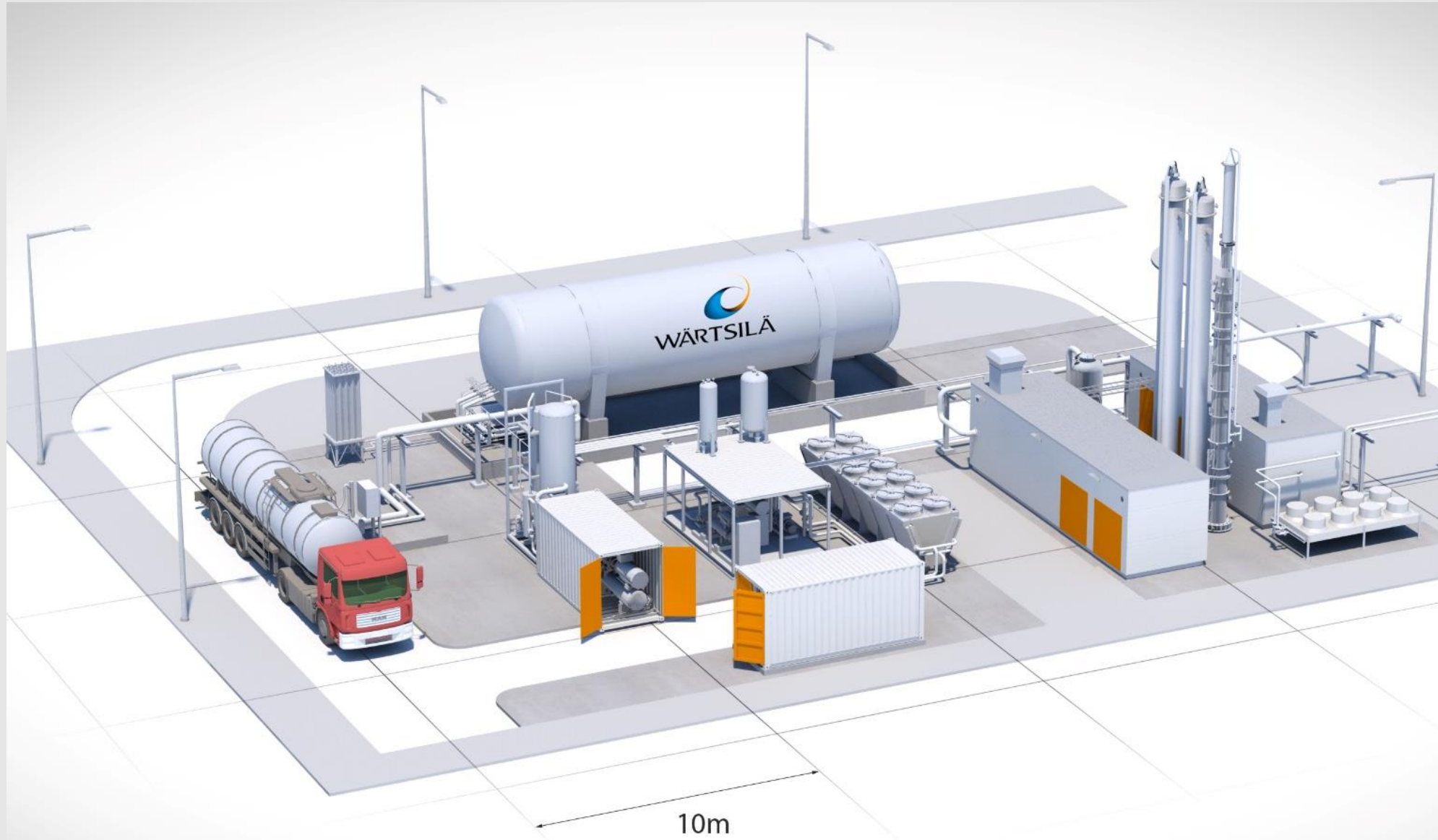


Certificate of compliance to

- Machinery Directive 2006/42/EC
- Pressure Equipment Directive 2014/68/EU requirement
- Low Voltage Directive 2014/35/EU
- Electromagnetic Compatibility Directive 2014/30/EU
- Equipment for potential explosive atmospheres (ATEX) Directive 2014/34/EU









Main Technical data:

- Energy consumption: ~ 0.7 kWh/kg LNG
- Capacities up to 50 tons/day
- Based on Mixed Refrigerant technology
- Designed for unmanned operation
- Footprint for liquefaction system: 15x15 m²
- Delivery time: 12 months
- Standard capacities: 10, 17,5 and 25 ton LNG/day

On-Going Project

Biokraft bioLNG

Owner	Biokraft AS
Type	Mini liquefaction plant
Tank net volume	350 m ³
Capacity	25 TPD / 9,125 TPA
Size of liquefaction unit	12 m x 20 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">• 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	2017



Skogn 21. august 2017



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

Wärtsilä LNG solutions

ONSHORE



Small LNG liquefaction plants



Mini LNG liquefaction plants



Medium-scale LNG terminals



Small satellite LNG terminals



LNG storage & regasification barge

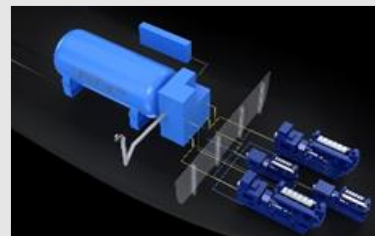
OFFSHORE



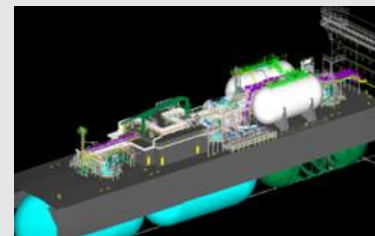
LNG regasification



BOG reliquefaction

Cargo handling system
Gas and LNG carriers

Fuel gas handling system



Ship and cargo tank design

LIFECYCLE



Lifecycle services



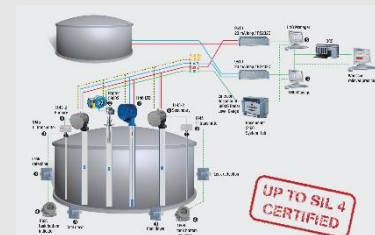
Start-up support



Product and technical support



Spares



Tank control systems

Solutions adapted to **small-scale LNG**

- **Simplicity and flexibility** are necessary for the small-scale business model:
 - Ability to ramp-up/ramp-down according to supply/demand variation
 - Multiple LNG/gas loading/unloading options
- **CAPEX reduced** by:
 - Elimination/simplification of equipment that is unjustified or impractical for small-scale LNG
 - Maximizing the use of standard components & modularization
- **OPEX reduced** by:
 - Optimal trade-off between process efficiency and simplified operation (high availability / high level of automation) that enables low lifecycle costs
- **Safety measures** taking into consideration that the consequence of potential incidents in small-scale LNG are smaller



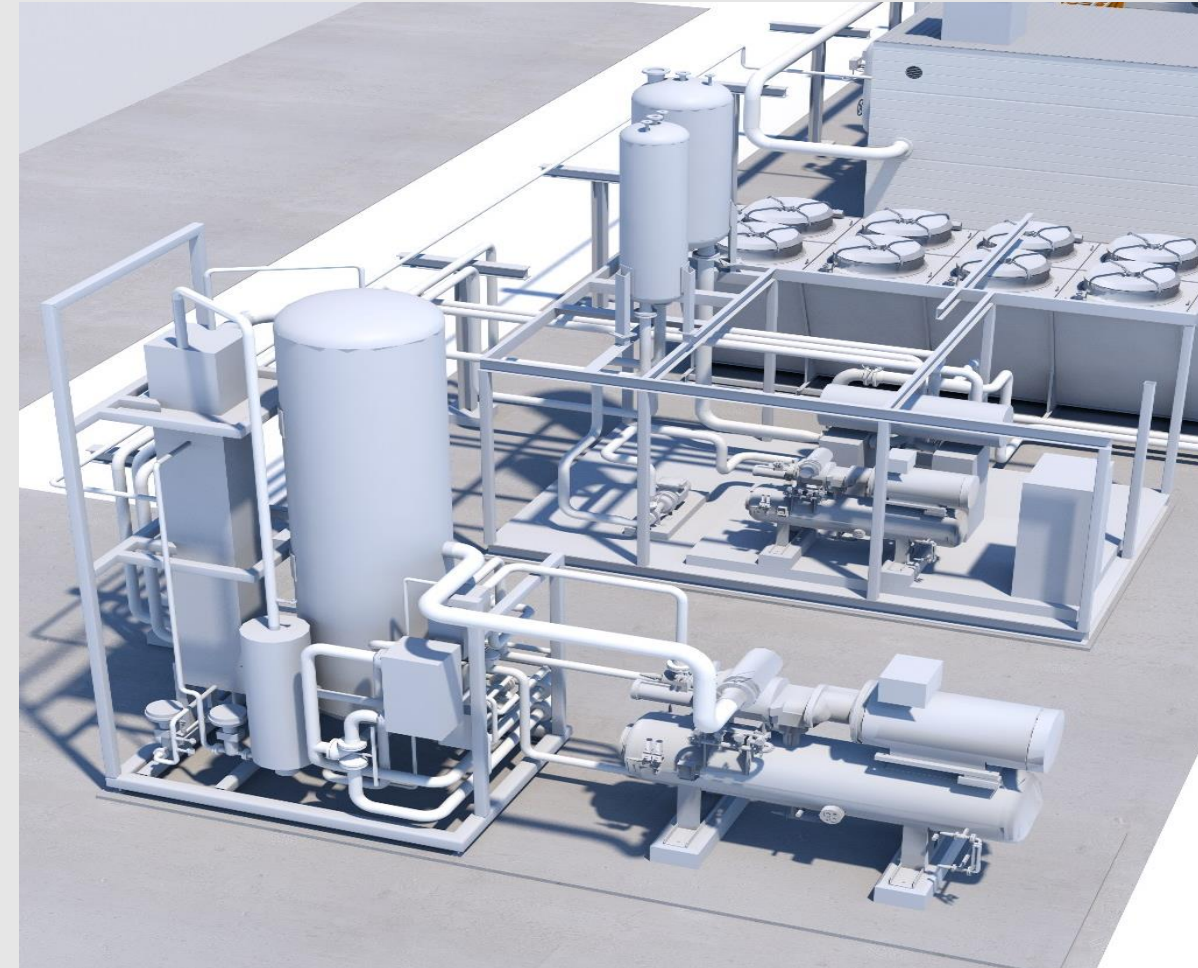
Modularisation and standardisation

Modular skids are built and quality checked under factory conditions

- All critical components are tested in the factory before delivery
- Modules are easy to transport and quick to install
- Modules can be added to increase capacity/redundancy

Standardization of functionalities, choice of components and modularization principles

- Utilisation of proven designs lowers design, purchasing and installation costs as well as ensures a high level of quality



Complete solutions that bring value to customers

**Project
Development
& Financing**

Technology

EPC

**Operations &
Maintenance**

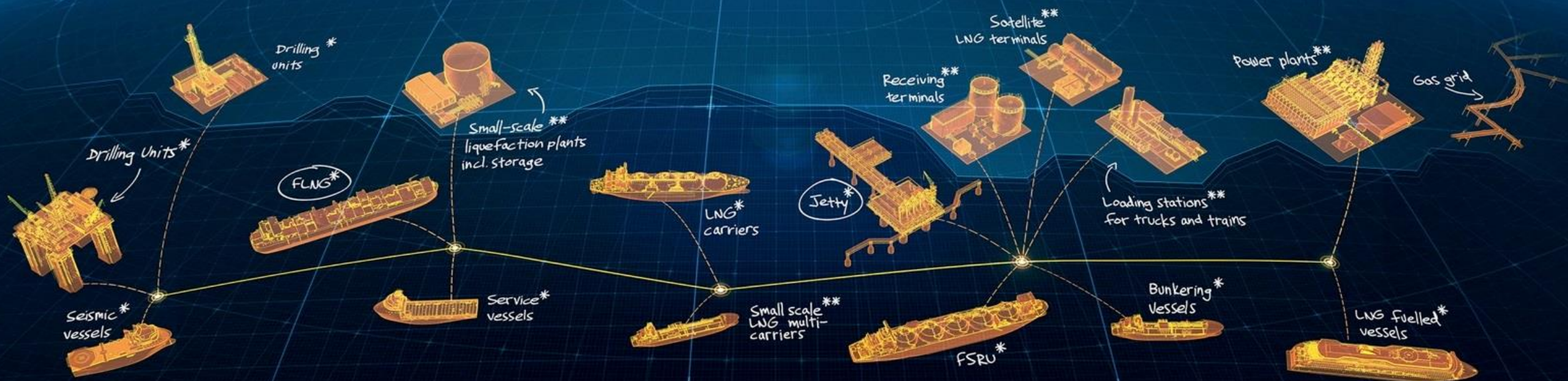
LNG terminal or liquefaction plant

Gas / dual-fuel power plant

WÄRTSILÄ

YOUR SHORTER ROUTE TO THE GAS AGE

Let the leader in LNG enable your smooth transition to gas. We have the expertise, experience and offering you need. Our offering covers integrated solutions*, EPC turnkey delivery**, services and products for all phases of the LNG lifecycle.



EXPLORATION
AND DRILLING



PRODUCTION AND
LIQUEFACTION



TRANSPORT



STORAGE AND
DISTRIBUTION



END CONSUMERS



WÄRTSILÄ