



nordsol

The future is liquid.

INTRODUCTION TO BIO-LNG

TECHNOLOGY, PROJECT REALIZATION, BUSINESS CASE

Kristjan Leppik

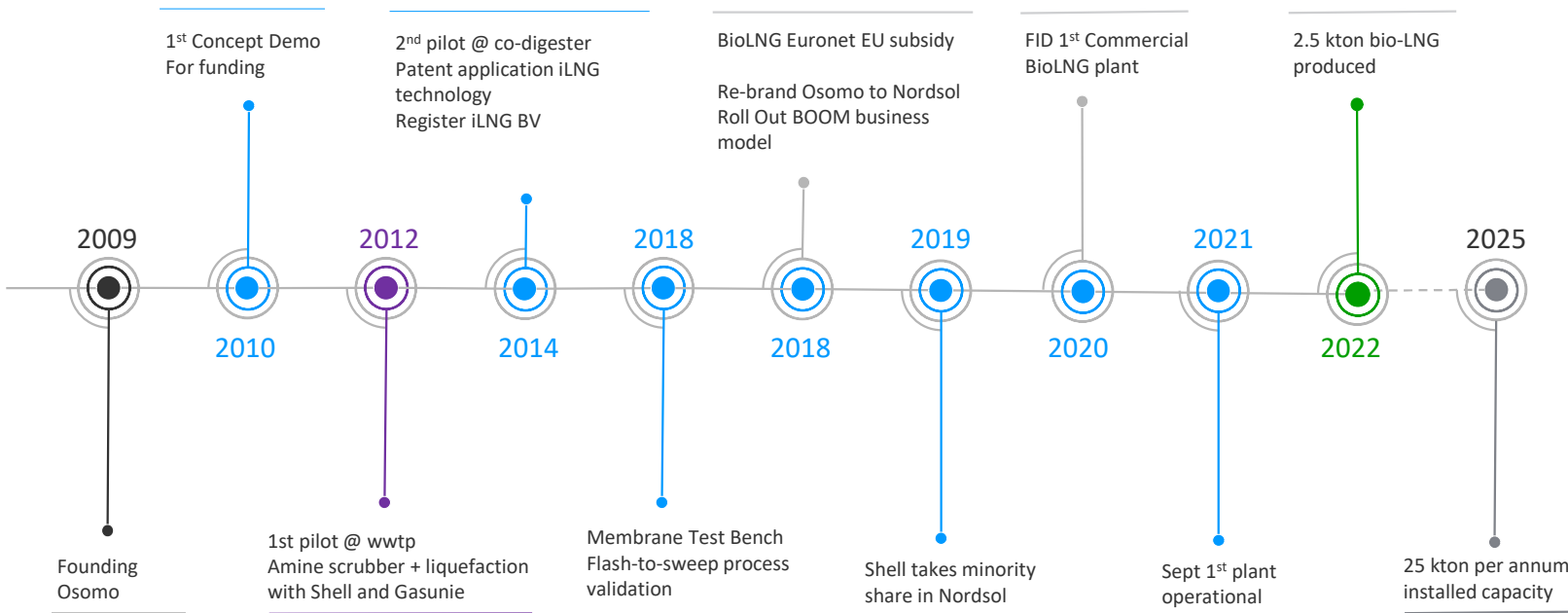
Project Manager

Biometaani ja biovesiniku foorum

19/09/2023



Nordsol's **journey** to bio-LNG technology





About Nordsol

- ▶ Installations for onsite bio-LNG production
- ▶ Frontrunner in technology
- ▶ All-round bio-LNG expertise
- ▶ Make bio-LNG mainstream
- ▶ Contribute to a local, circular economy

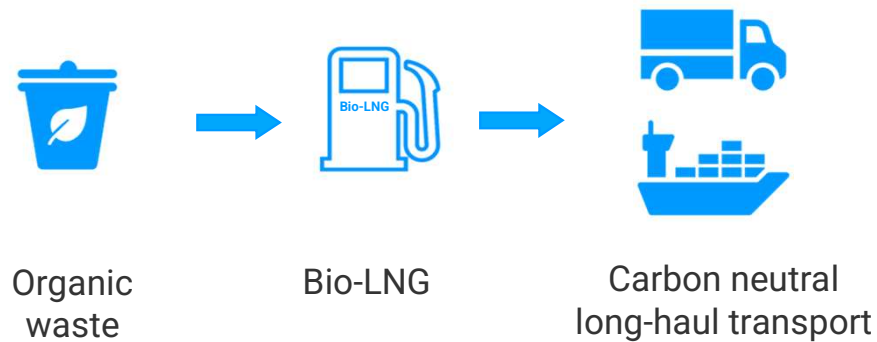
Global CO2 emissions from transport



Source: IEA, last updated November 2021

What is **bio-LNG**?

Bio-LNG is the carbon neutral, drop-in alternative for LNG, made from biogas. Bio-LNG is essential for the decarbonization of long-haul, heavy-duty transport and the achievement of global climate targets.



Bio-LNG: creating the **most value from biogas**

► More green value

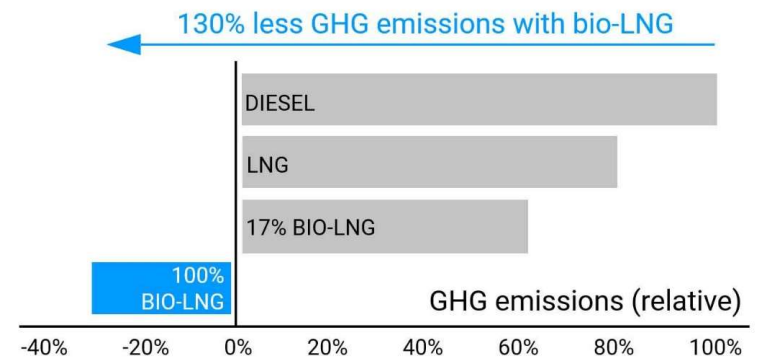
- ◊ Zero emission transport
- ◊ Decreased CO₂ emission for biogas with bio-LNG vs. electricity
- ◊ Additional CO₂ recovery in the production process

► More social value

- ◊ Sustainable business model based on real market drivers instead of government subsidy
- ◊ Local circular economy

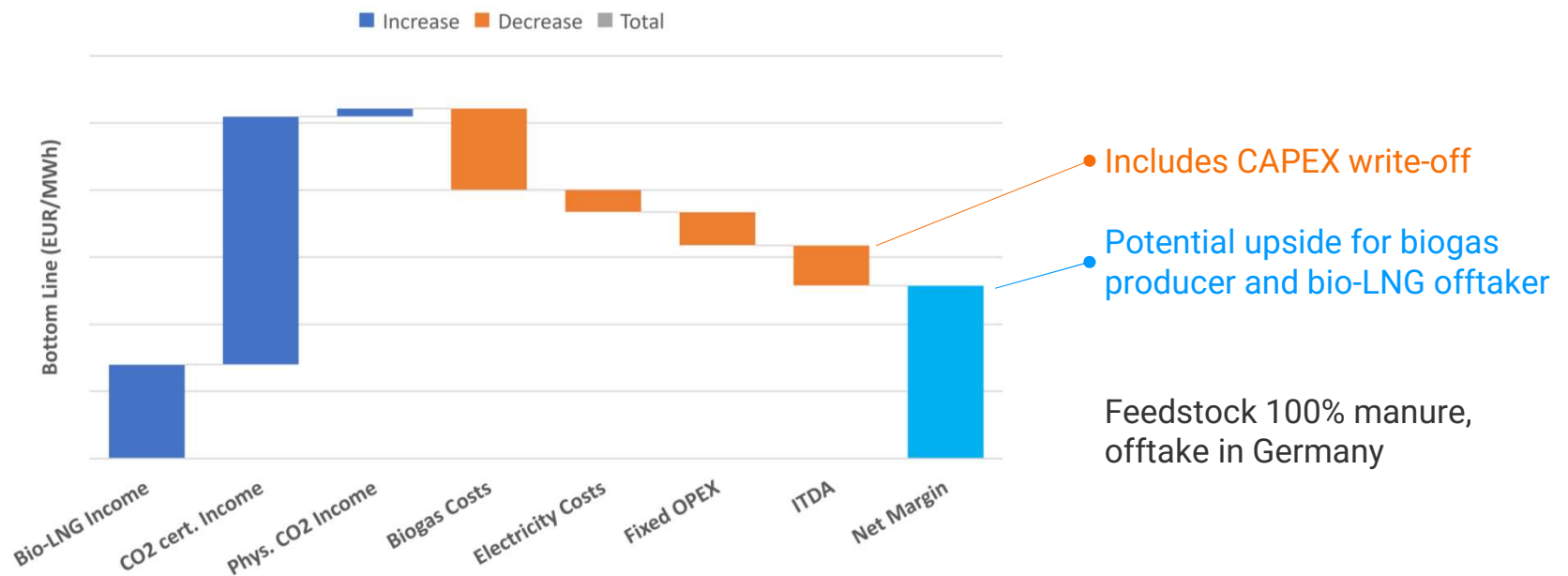
► More financial value

- ◊ Competitive to biomethane
- ◊ Long-term market outlook for bio-LNG



Bio-LNG production is economically viable

Bio-LNG Income/Cost Waterfall



Biogas upgrading and liquefaction **reinvented**

Key differences between natural gas and biogas offers an opportunity for maximizing economic viability

LNG from natural gas

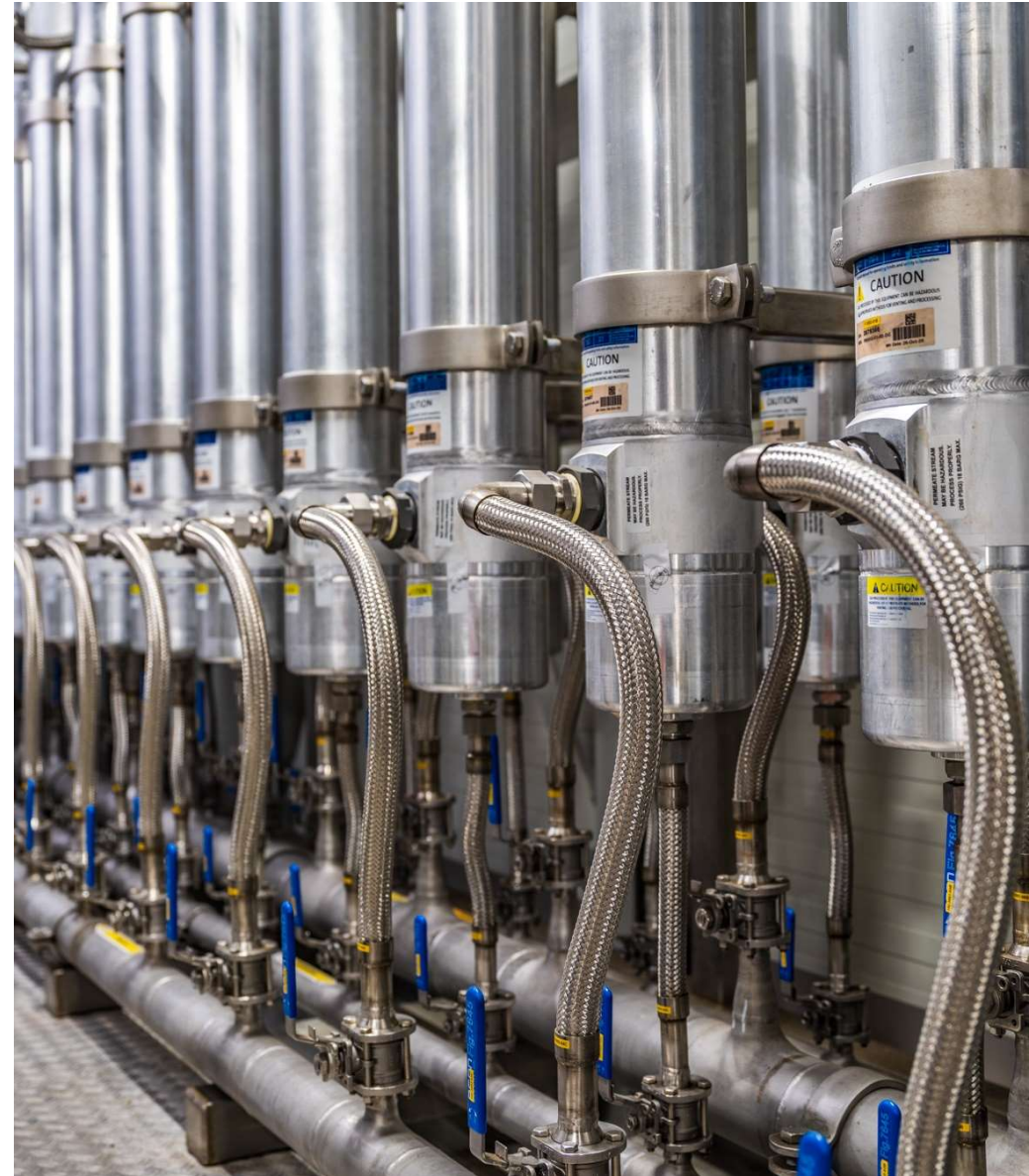
- ▶ Capacity 3 – 15 Mtons/year
- ▶ Consistent flow and composition of gas
- ▶ Complex gas composition
- ▶ Gas is a cheap source of energy for the plant

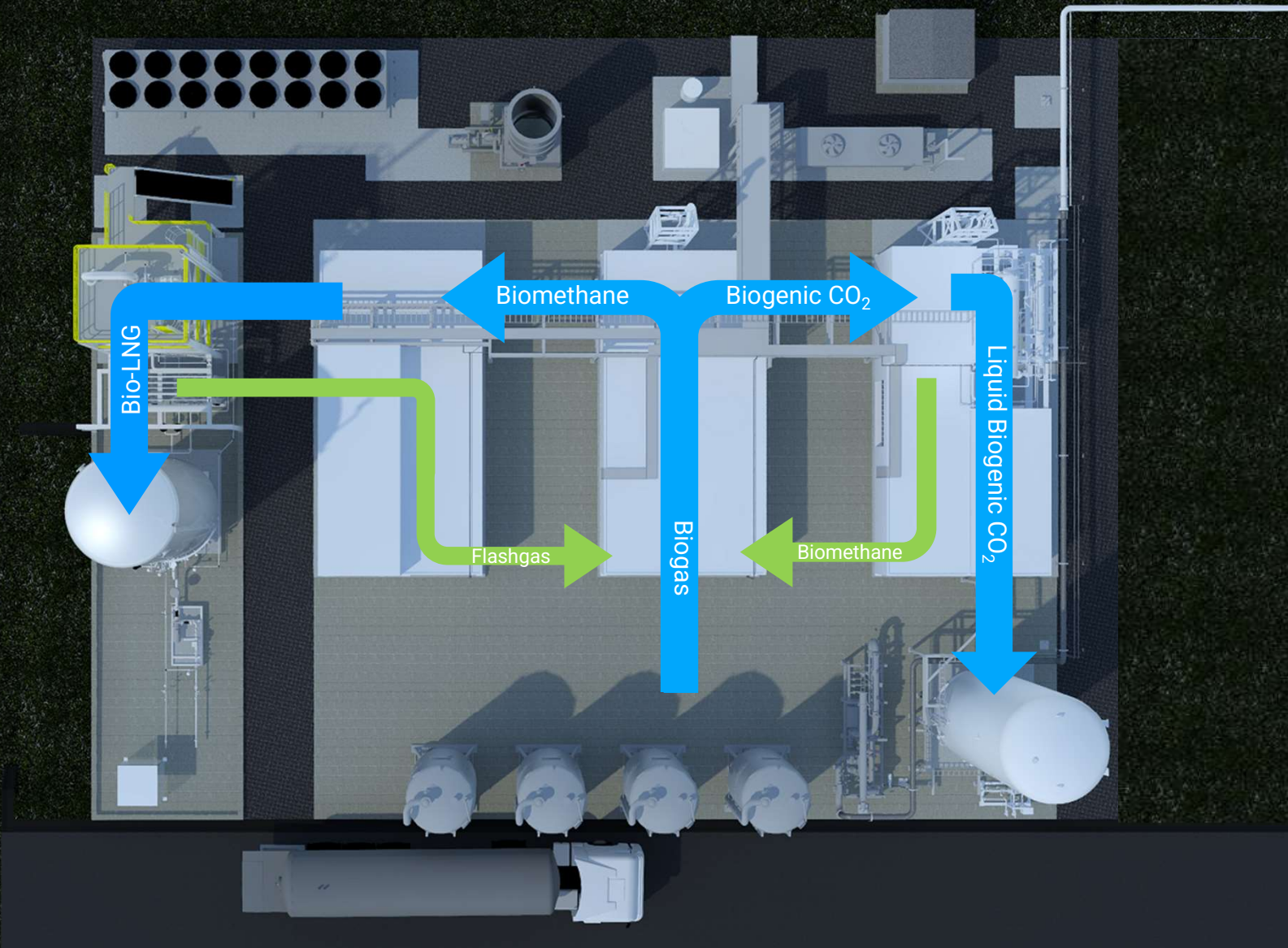
LNG from biogas (bio-LNG)

- ▶ Capacity 3 – 100 ktons/year
- ▶ Fluctuating flow and composition of gas
- ▶ Simple gas composition
- ▶ Biogas is an expensive source of energy for the plant

Technology highlights

- ▶ 30% lower TCO, low energy consumption
- ▶ Membranes only - no polishing needed between upgrading and liquefaction
- ▶ Zero methane slip
- ▶ Integrated CO₂ liquefaction
- ▶ Ease of operation, 24/7 unmanned









Bio-LNG plant Amsterdam

3,4 kton bio-LNG from 8M Nm3 biogas per year

- ▶ Initiated by Nordsol, Renewi and Shell
- ▶ Built, owned, operated and maintained by Nordsol
- ▶ Stable production 8-10 tpd bio-LNG
- ▶ Unmanned operation
- ▶ ±4 kilotons bio-LNG produced (Sept 2023)
- ▶ Bio-LNG and biogenic liquid CO₂ truck loadings every 1-2 days
- ▶ High quality bio-LNG - well above client specs



nordsol

The future is liquid.



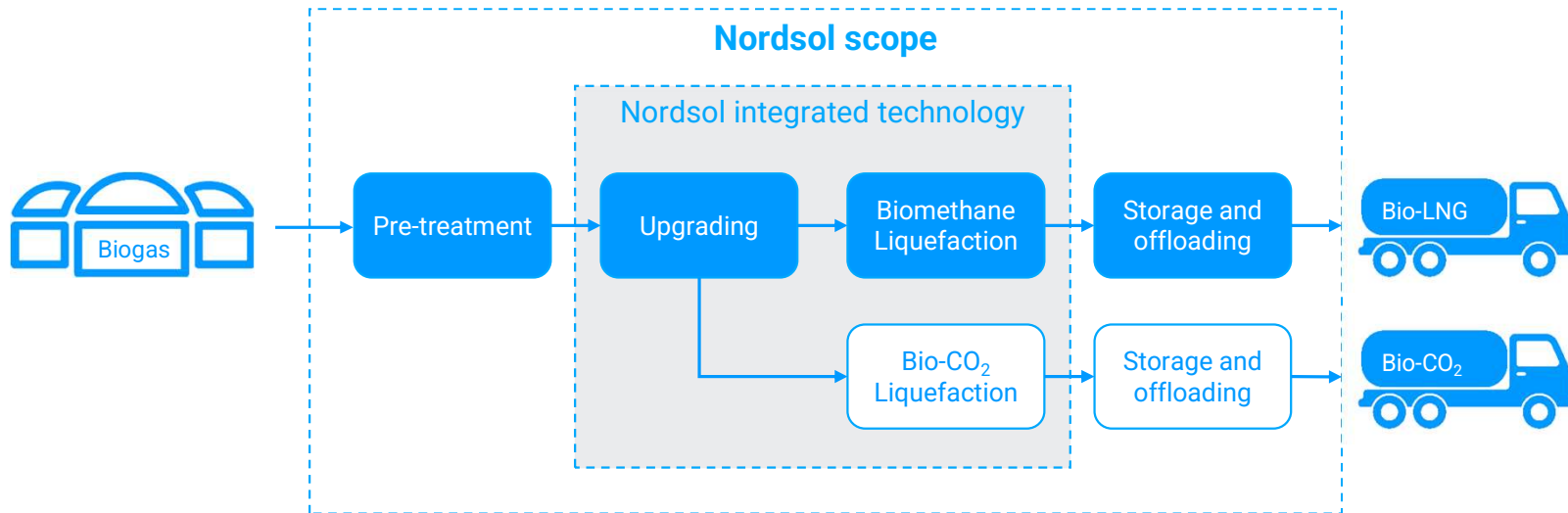
Co-financed by the Connecting Europe
Facility of the European Union

Bio-LNG is the best possibility to decarbonize the hard-to-abate long-haul, heavy-duty transport sector today.

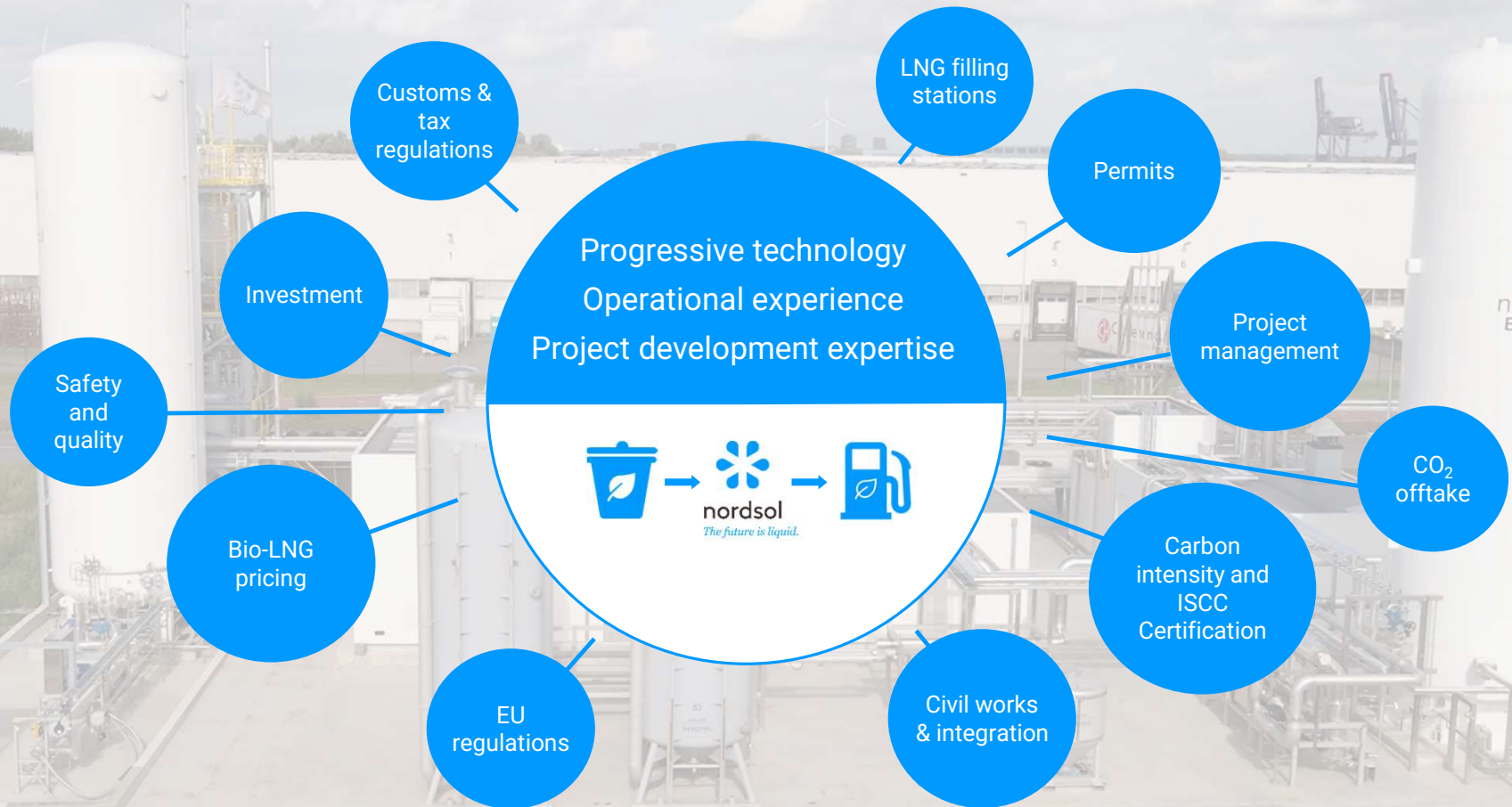


Bio-LNG production offers the highest value for biogas.

Integrated technology for **economic viability**

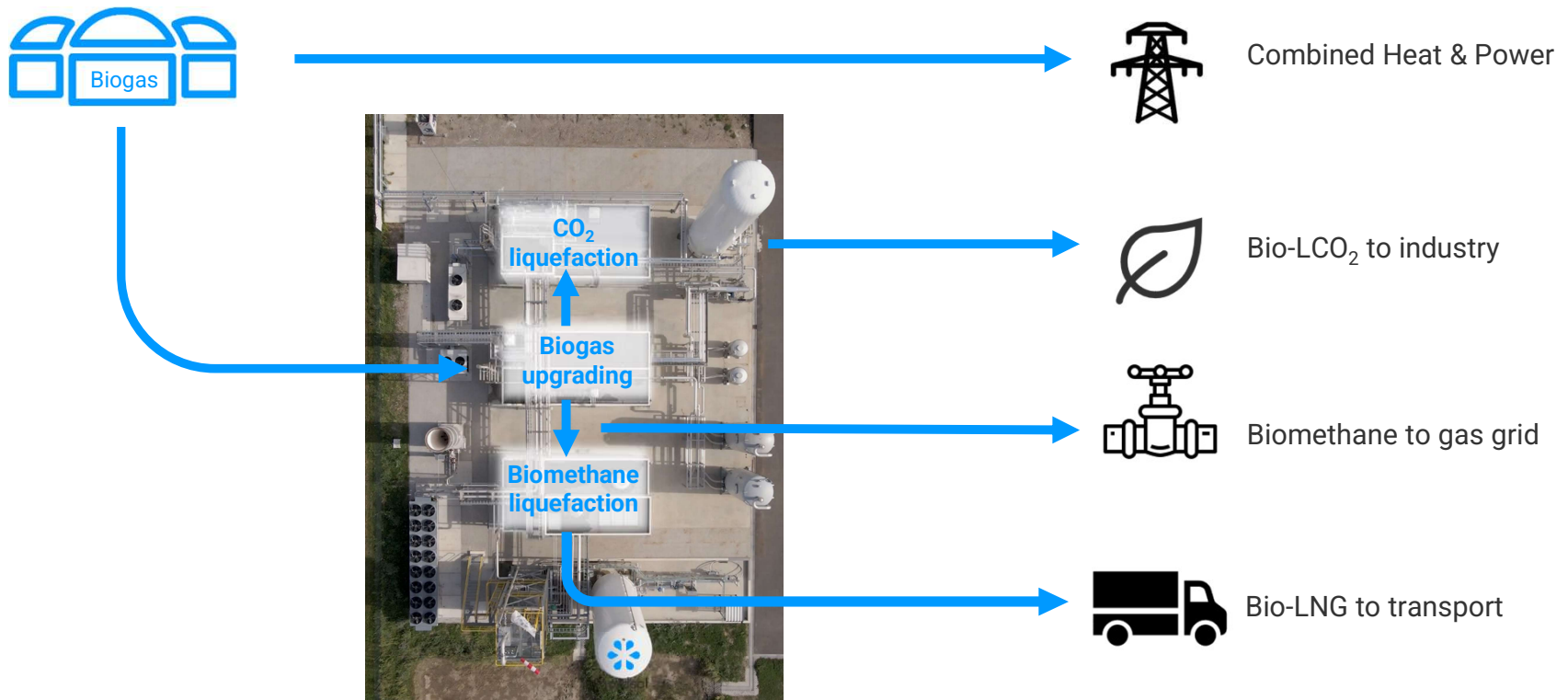


From technology company to **all-round bio-LNG expert**



Flexibility to serve a dynamic market for 25 years

Multiple valorization routes



Bio-LNG technology references



Bio-LNG Amsterdam, NL

- ▶ 10 tpd
- ▶ Q4 2021



Bio-LNG Wilp, NL

- ▶ 7 tpd
- ▶ Q1 2024



Bio-LNG UK

- ▶ 10 tpd
- ▶ Q4 2023

6 additional projects in final stages of development

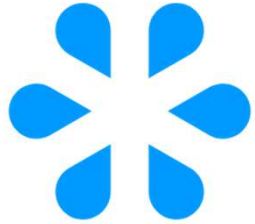
- ▶ Nordics, Belgium, Poland, Netherlands
- ▶ 5/10/20/45 tpd

Key take aways

Onsite bio-LNG production

- ▶ Highest value for biogas
- ▶ Scalable and economically viable
- ▶ Technology designed for the best CI and low TCO
- ▶ Flexibility in valorization routes
- ▶ How Nordsol can help
 - ◊ Technology
 - ◊ Permitting
 - ◊ Certification
 - ◊ Bio-LNG offtake






nordsol

The future is liquid.

Kristjan Leppik

 +31 651 440 785

 kristjan@nordsol.com

 www.nordsol.com

