

Boosting the biomethane value chain

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Milan • May 23th 2019

GLOBAL MARKETS
& TECHNOLOGIES

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Advanced Business & Technologies



The Air Liquide Group

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AIR LIQUIDE, THE WORLD LEADER IN GASES, TECHNOLOGIES AND SERVICES FOR INDUSTRY AND HEALTH

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Boosting the bioCH₄ value chain

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A World Leader in Gases, Technologies, and Services for...

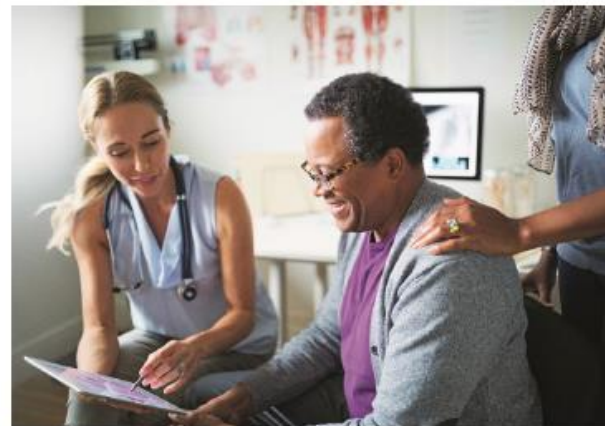
INDUSTRY

- A wide range of industrial processes for our customers: energy, metals, food, chemicals, automotive, pharmaceuticals, etc.



HEALTH

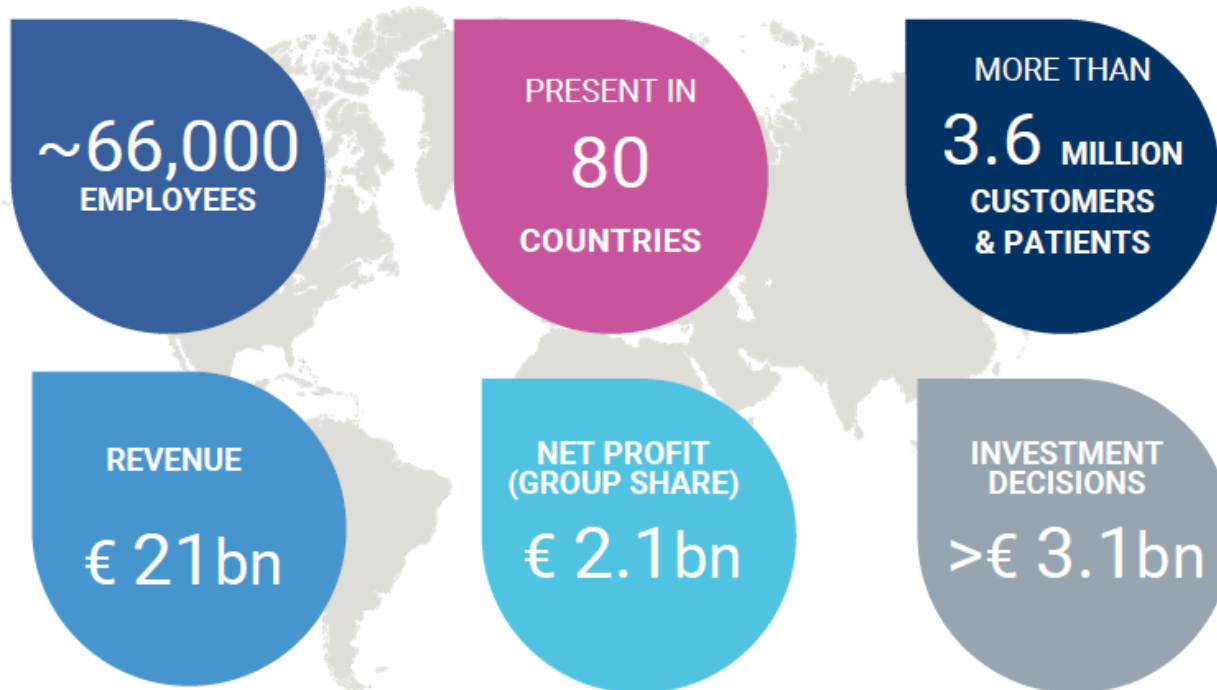
- Patients at home
- Hospitals
- Hygiene and specialty ingredients



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AIR LIQUIDE, THE WORLD LEADER IN GASES, TECHNOLOGIES AND SERVICES FOR INDUSTRY AND HEALTH

2018 Key Figures



Our Activities

DESIGNING INDUSTRIAL GAS PRODUCTION UNITS FOR AIR LIQUIDE AND CUSTOMERS PRODUCING DIRECTLY

SUPPLYING GASES AND SERVICES FOR ALL INDUSTRIES AND HEALTH

DEVELOPING NEW MARKETS AND BREAKTHROUGH TECHNOLOGIES



LARGE QUANTITIES by pipelines

MEDIUM QUANTITIES by tanker trailers

SMALL QUANTITIES in cylinders



BIOMETHANE PRODUCTION UNITS, HYDROGEN CHARGING STATIONS AND OTHERS

CUSTOMERS CHOOSING TO INSOURCE THEIR GAS NEEDS

CHEMICALS
REFINING
METALS

MATERIALS & ENERGY
AUTOMOTIVE & MANUFACTURING
FOOD & PHARMACEUTICALS
TECHNOLOGY & RESEARCH
PROFESSIONALS & RETAIL

HOSPITALS
HOME HEALTHCARE
HYGIENE/SPECIALTY INGREDIENTS

SEMI-CONDUCTORS
FLAT PANELS
PHOTOVOLTAIC

ENERGY TRANSITION
MARITIME LOGISTICS
DEEP-TECH^(a)

ENGINEERING & CONSTRUCTION
Building plants and equipment for gas production



LARGE INDUSTRIES
Producing and delivering gases in large quantities



INDUSTRIAL MERCHANT
Serving a wide range of customers thanks to the Group's expertise in gases and processes



HEALTHCARE
Providing gases, medical products and services to support our clients and patients, in the hospital and at home



ELECTRONICS
Designing, manufacturing, and providing molecules and equipment for this sector

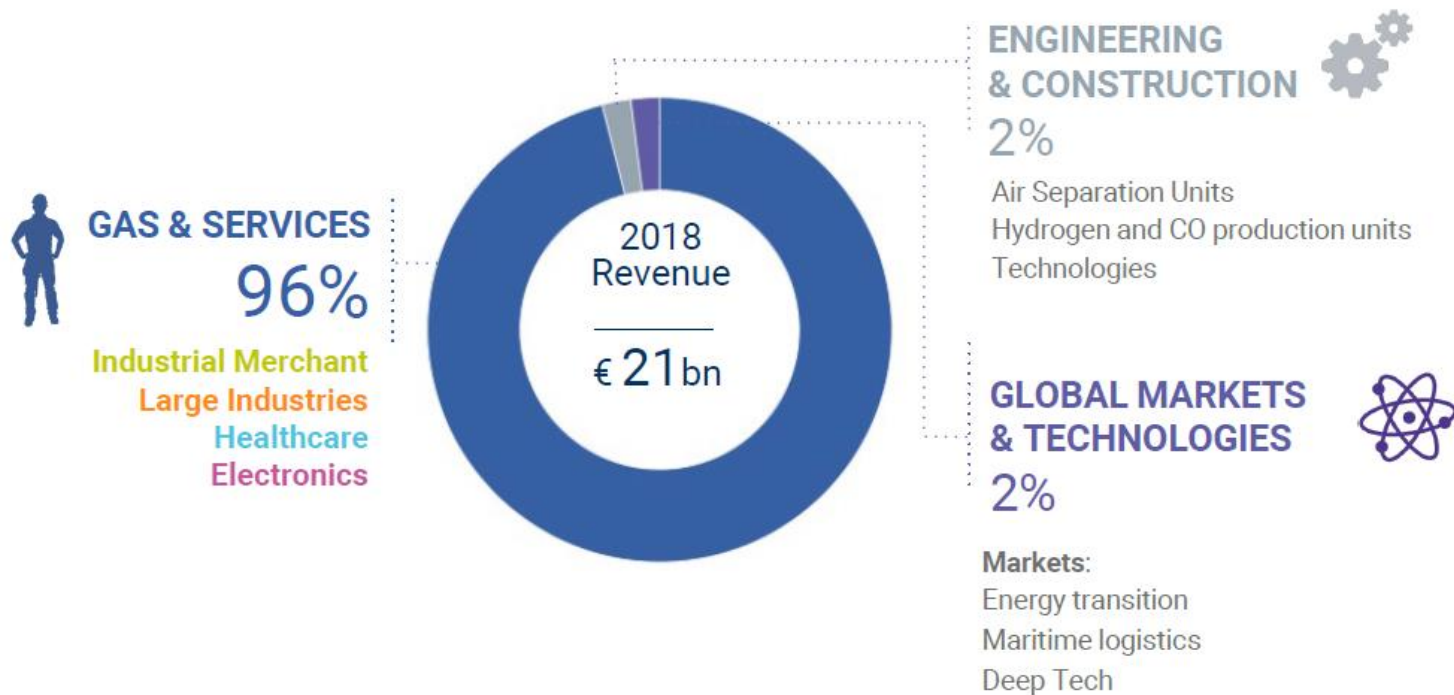


GLOBAL MARKETS & TECHNOLOGIES
Providing technological solutions (molecules, equipment and services) for new markets



(a) Scientific breakthroughs and disruptive technologies that can fundamentally change design and production methods.

Group Revenue at € 21bn



Global Markets & Technologies

A World Business Unit focusing on new markets requiring a global approach

Deep Tech

Equipment and services for:

- Big science and fusion
- Space
- Aerospace
- Advanced separations
- Industrial solutions
- Support to clean mobility

Energy transition

- Biomethane
- Hydrogen

Maritime

- Maritime Energy
- Maritime Cryogenic Transport
- High added value molecules

GLOBAL MARKETS & TECHNOLOGIES

> 450 M€ sales (2018)



Double digit growth since its creation



1,800 people

12 countries



Disruptive & entrepreneurial mindset

Energy transition key figures



**More than
60 bio-NGV
filling stations** in
Europe



**More than
10 multi-energy stations**
(CNG, LNG, liquid nitrogen)
already opened in France



**More than
120 hydrogen stations**
designed and installed
in the world

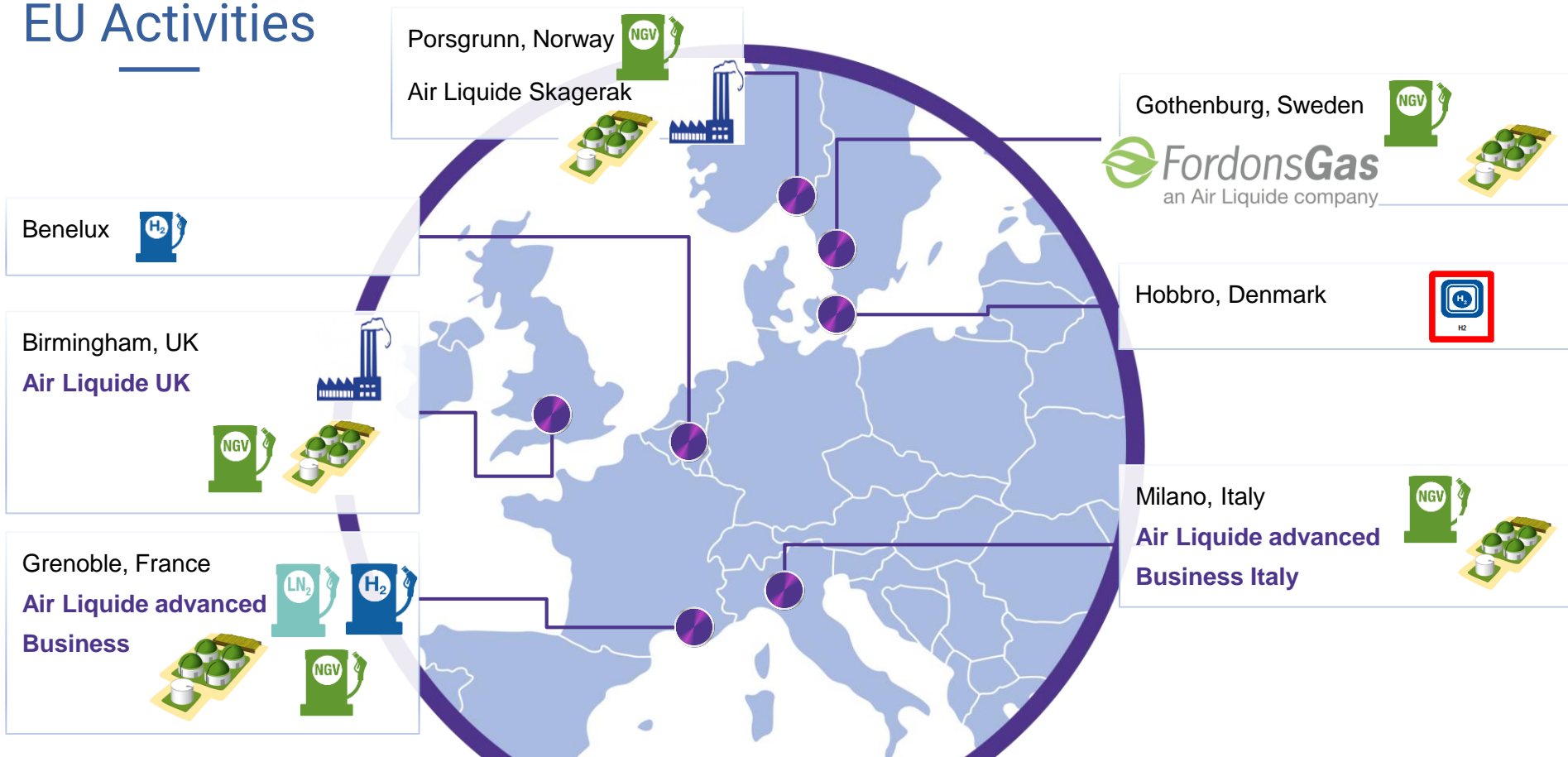


**12 biomethane
production
units** worldwide



**More than 100
years of experience**
in gas separation

EU Activities



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AL Technology insight into a circular bioeconomy scheme

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Boosting the bioCH₄ value chain

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Biogas upgrading units geographies

Americas



- 20 Biogas Upgrading Units in the **US**
- 2 BUU in **Latin America**
- Focus on **landfill** biogas
- First reference in **2006**
- Upgrading from **2500 to 20 000 Nm³/h** of raw biogas

Europe & Asia

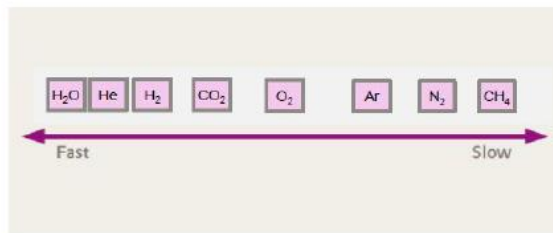


- 20 BUU in the **UK** for **grid injection**
- 17 BUU in **France** for **grid injection**
- 6 BUU in **Germany, Hungary & Austria** for **grid injection**
- 4 BUU in the **Nordics** for **liquid mobility & grid injection**
- 3 BUU in **China** for **local use & grid injection**
- 1 BUU in **Italy** for **bio-LNG**
- Focus on **AD gas**
- First reference in **2011**
- Upgrading from **100 to 1840 Nm³/h** of raw biogas

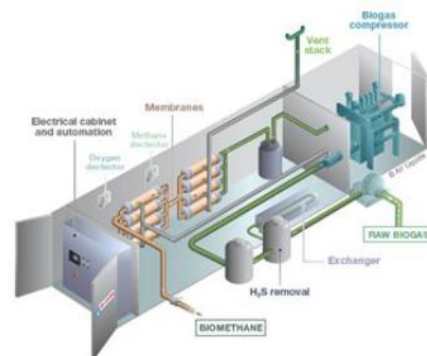
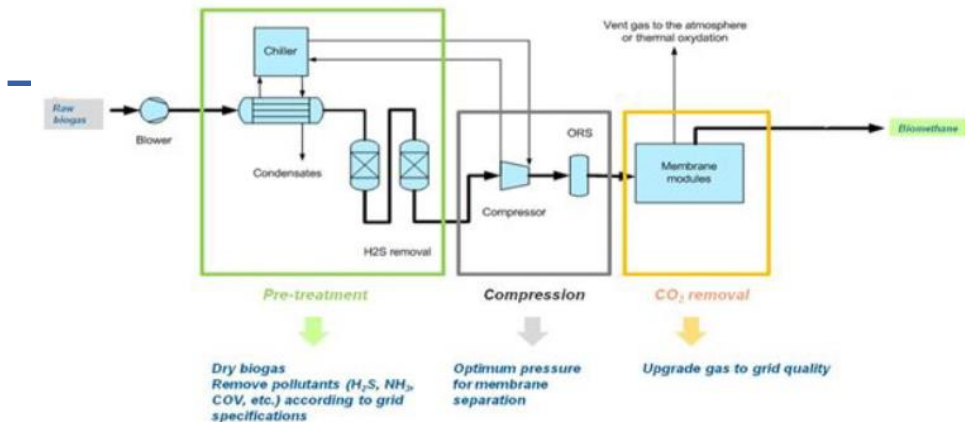
Membranes technology



- Membranes used in AL process are made by AL MEDAL (AL advanced Separations), Delaware USA
- Membranes are made of hollow polymeric fibers
- MEDAL has a 30-year experience in gas separation
- Two sizes of membranes available : 6" & 12" reducing the number of membranes & the corresponding footprint of the unit



Upgrading unit – Main steps



- A pre-treatment step allows to have a “clean” biogas, H₂S (hydrogen sulfide), VOC (Volatile Organic Compounds), Ammonia & Water free
- A compression step allows to rise biogas pressure to ~14 barg
- A membrane separation step allows to separate the CO₂ & CH₄ in order to have a CH₄-rich biomethane stream
- The biomethane can either be injected into the grid with or without a compression, or liquified in for mobility use
- Option with regenerative PSA for high concentration of VOC
- The CO₂ can be either sent to the vent, or recovered via a liquefaction unit

How does it looks...

Kaposvar



- First DTC unit
- Beetroot pulp used for feedstock
- Flexibility to production seasonality
- 99.5% of recovery rate
- 1500 Nm³/h of raw biogas

Rybjerg



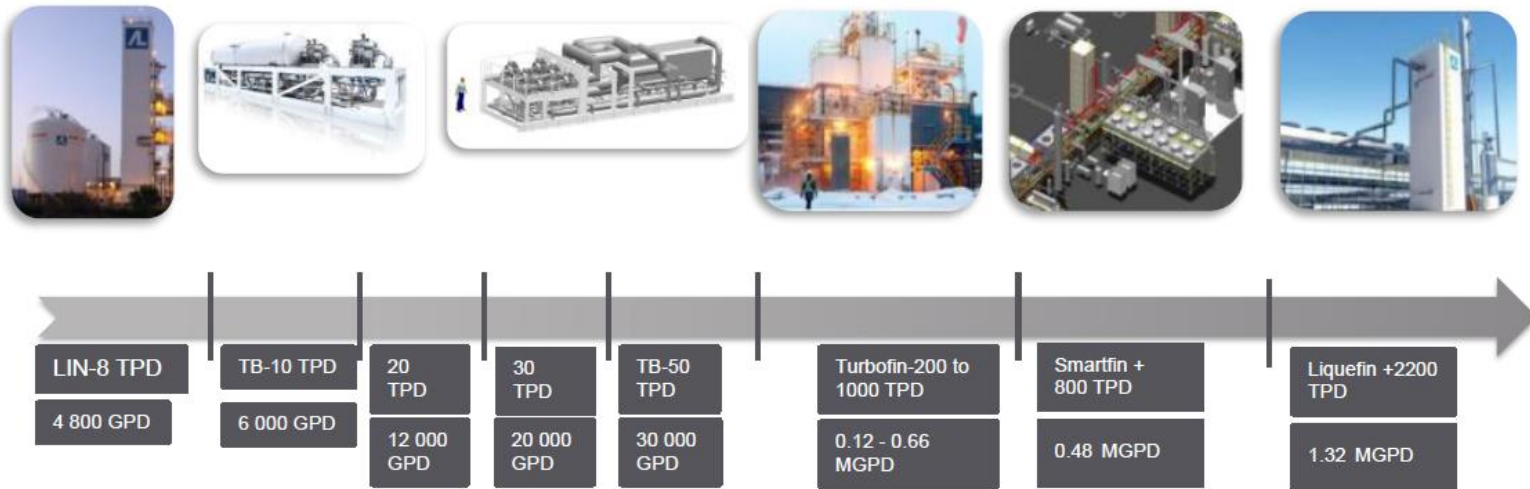
- First reference in Denmark
- Agricultural waste
- 99.5% of recovery rate & [CH₄] > 97%
- 900 Nm³/h of raw biogas

Biovilleneuve



- Biggest plant in France
- Agricultural waste
- HP compressor installed - Possibility to compress to 60 barg
- 99.5% of recovery rate
- 900 Nm³/h of raw biogas

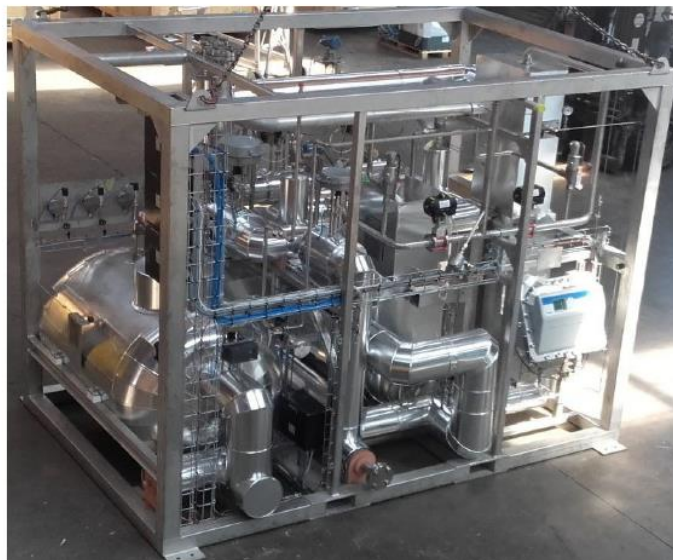
Air Liquide LNG Liquefaction units portfolio



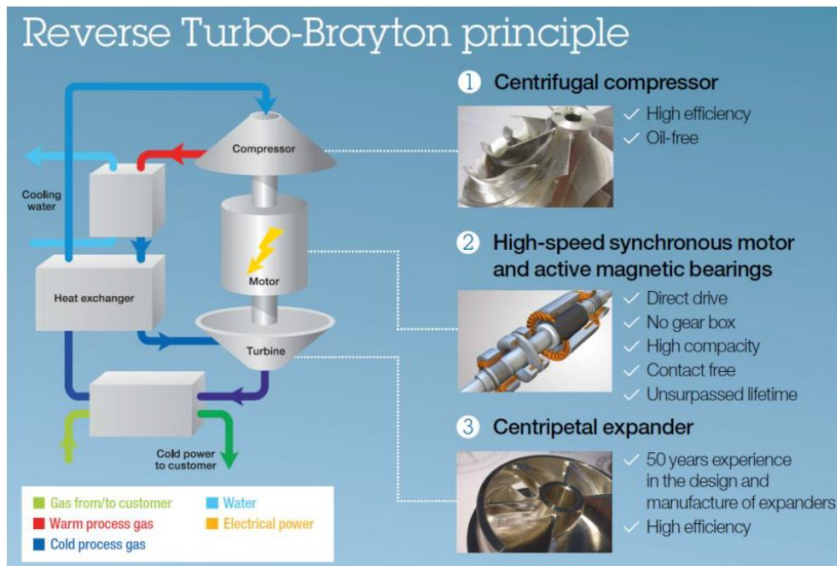
Open cycle liquefiers (up to 8 TPD)

■ Liquid nitrogen cryogenic liquefiers

- Availability rate 98%
- Min/max liquefaction rate : from 1,4 to 2 Nm3 LIN / Nm3 biomethane
- Inlet and outlet biomethane temperature: 25 / -153 °C
- Inlet and outlet LIN temperature : -195 / -70 °C



Turbo Bryton Liquefiers (from 10 to 50 TPD)



Multi-energy fueling stations and Blueeze

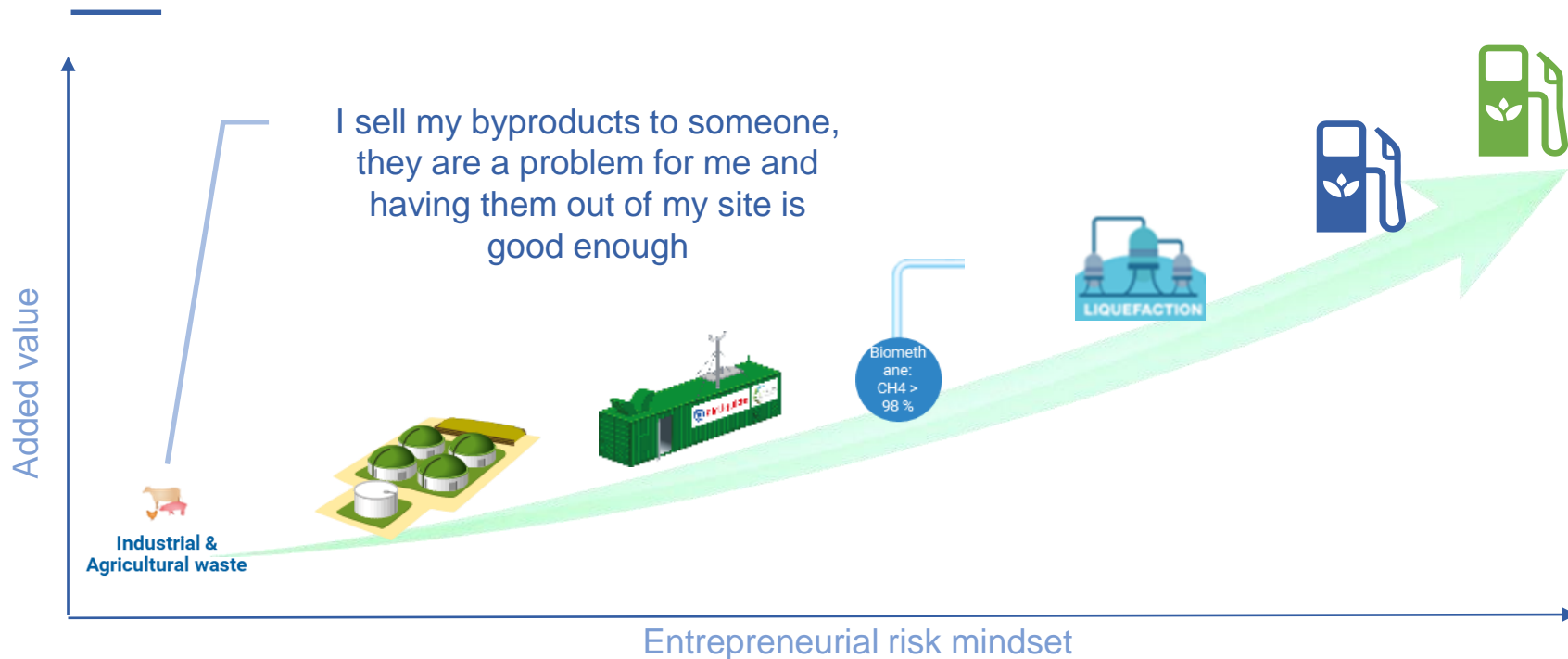




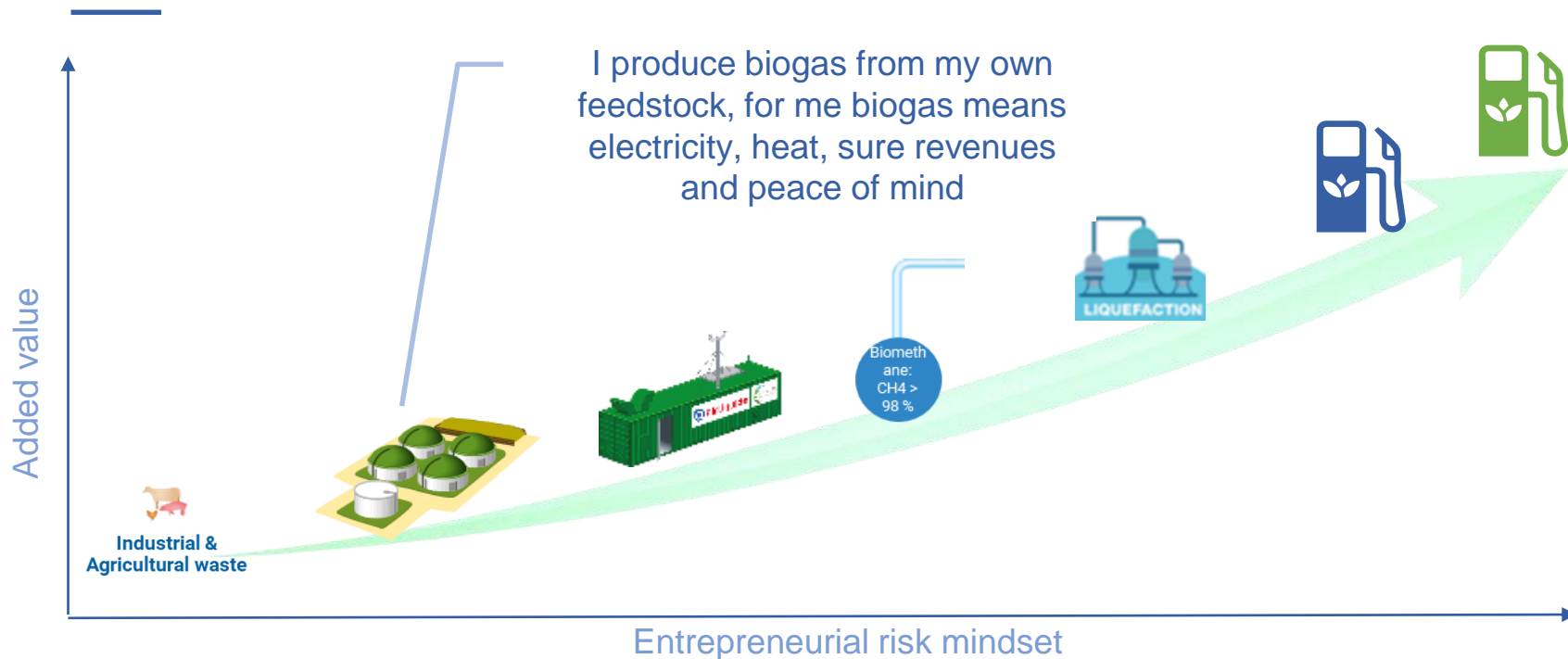
- solving conflict with diesel cooling unit's very high pollution emission
- Noise, Carbon footprint & local emissions reduction
- Better management of cold chain

Boosting the bioCH₄ value chain : The farming and industrial ecosystem

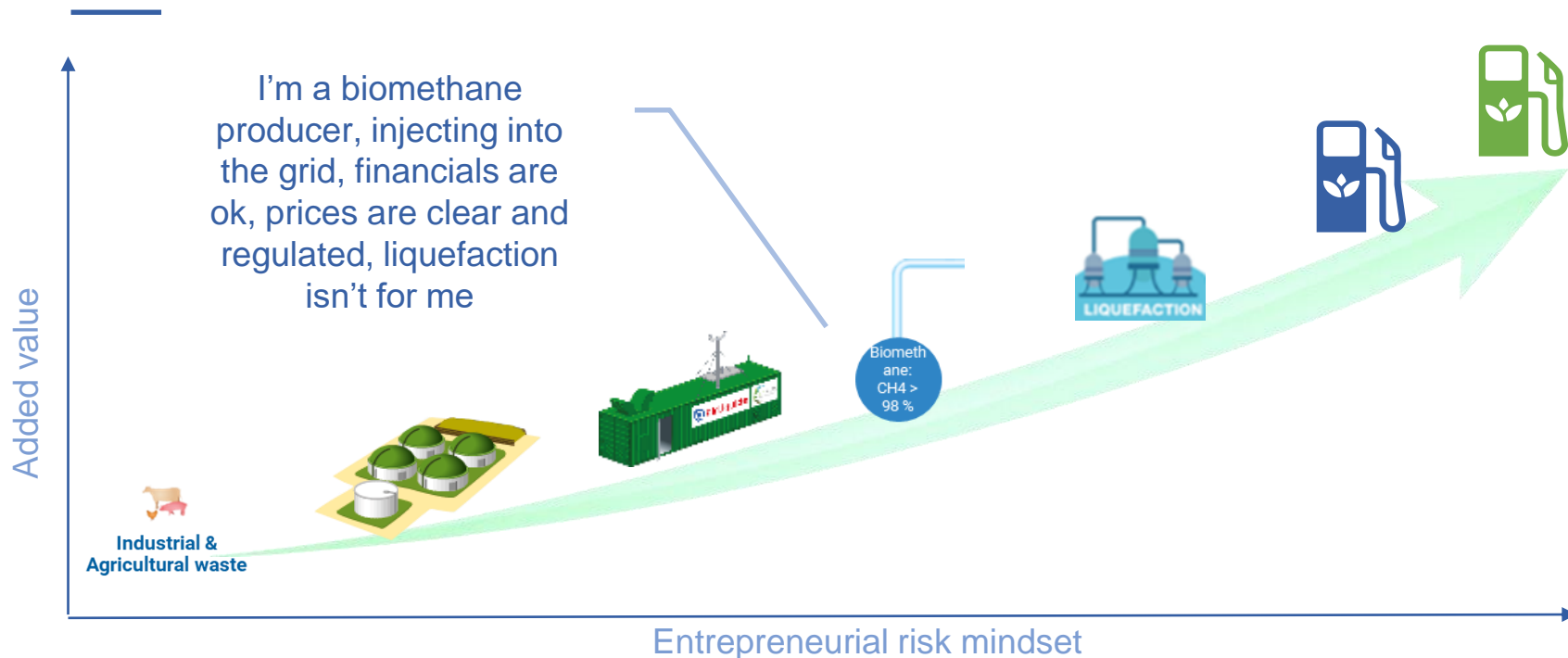
Business models comparison – Where are you ?



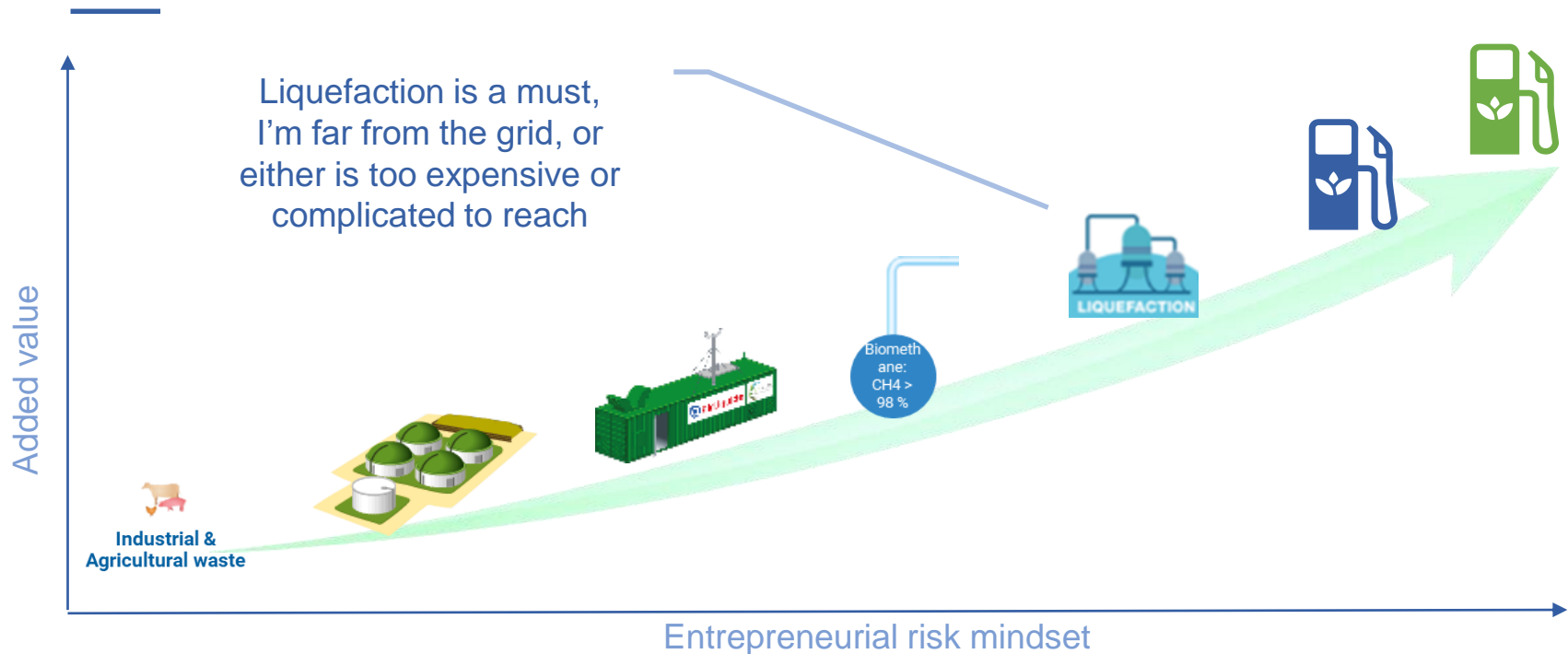
Business models comparison – Where are you ?



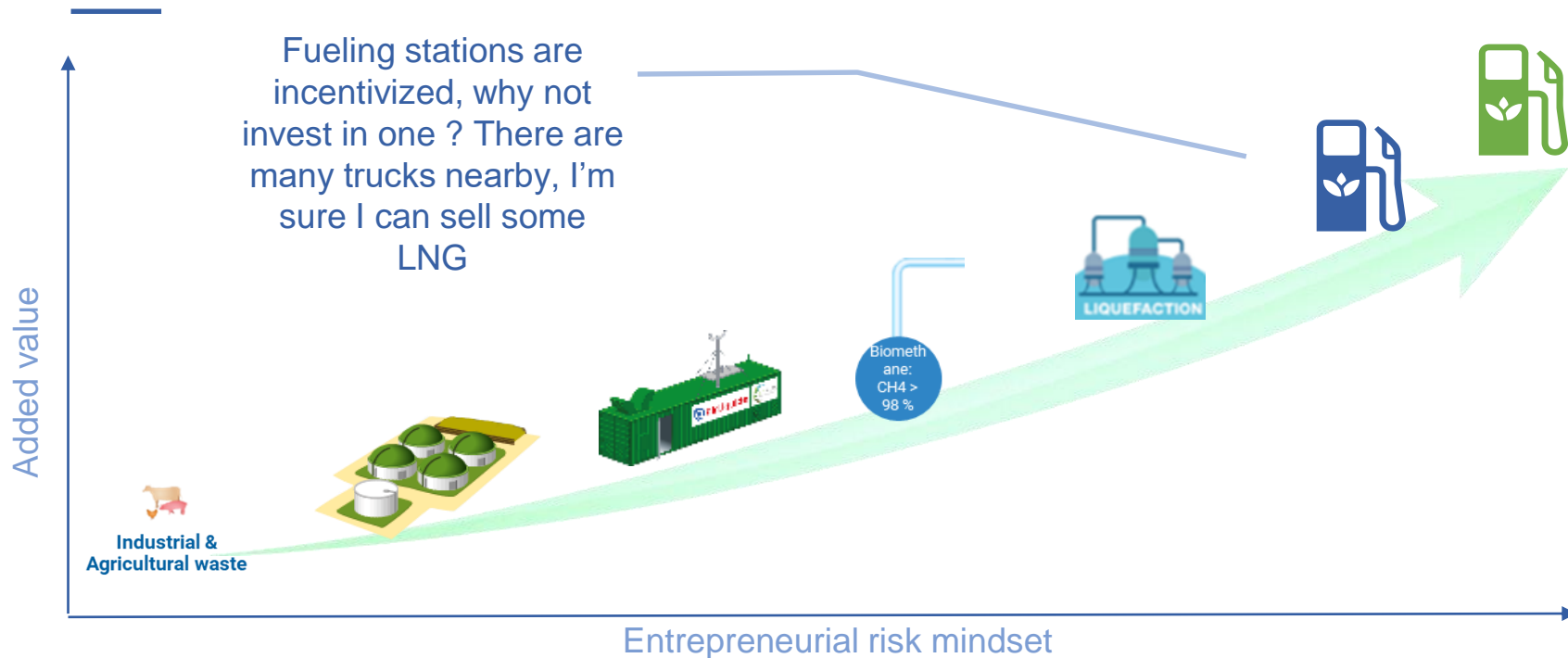
Business models comparison – Where are you ?



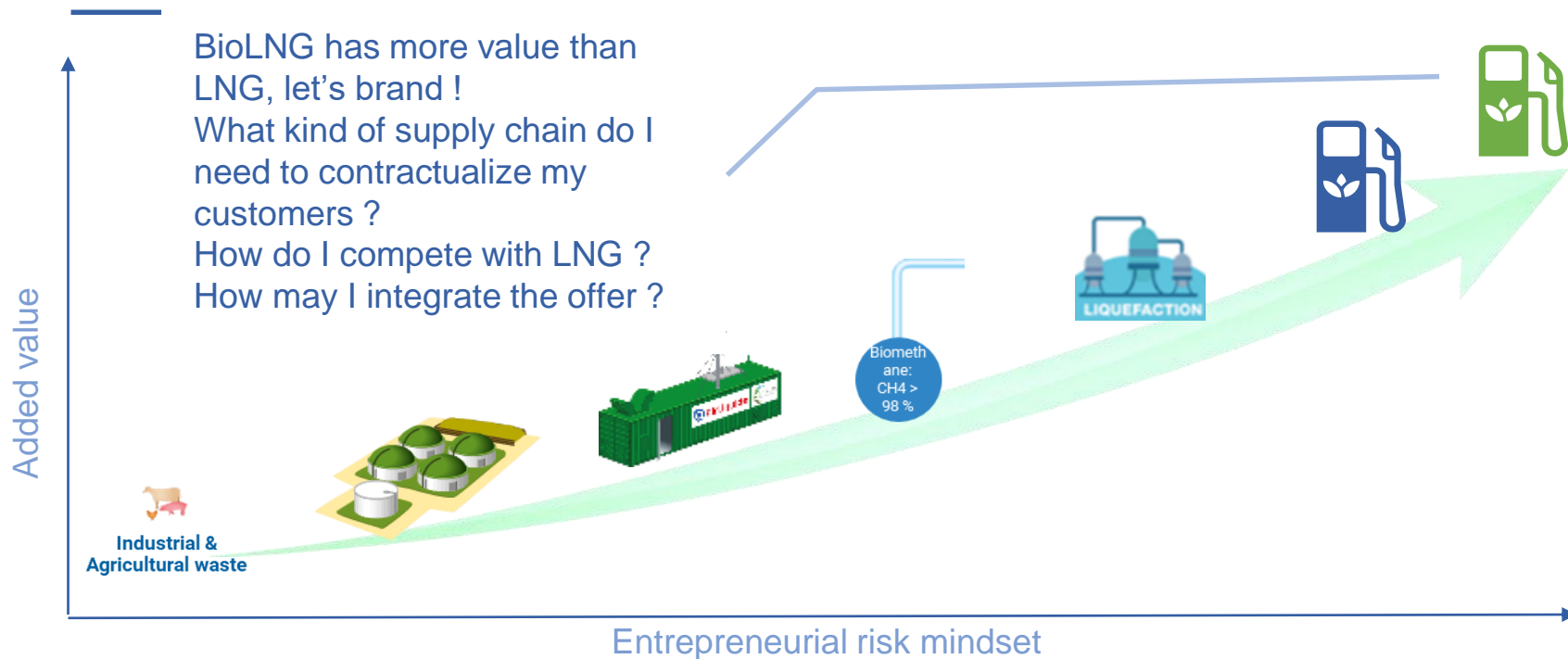
Business models comparison – Where are you ?



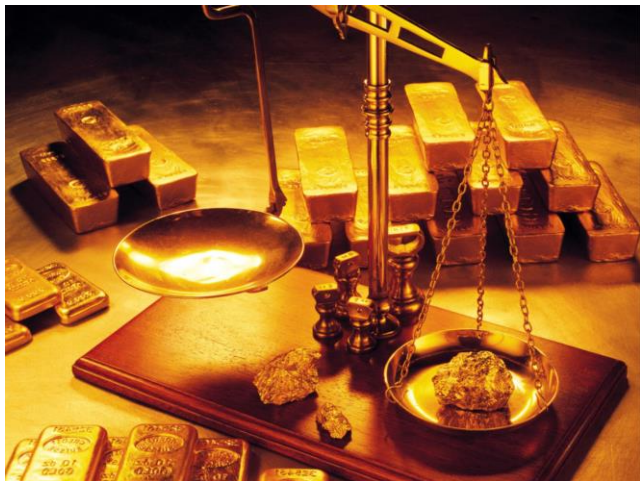
Business models comparison – Where are you ?



Business models comparison – Where are you ?



Business models comparison – The extended value chain



The focus on incentivizing system and technology create the illusion of working for producing plain METHANE exactly as it was Electricity or even simpler... “Energy”

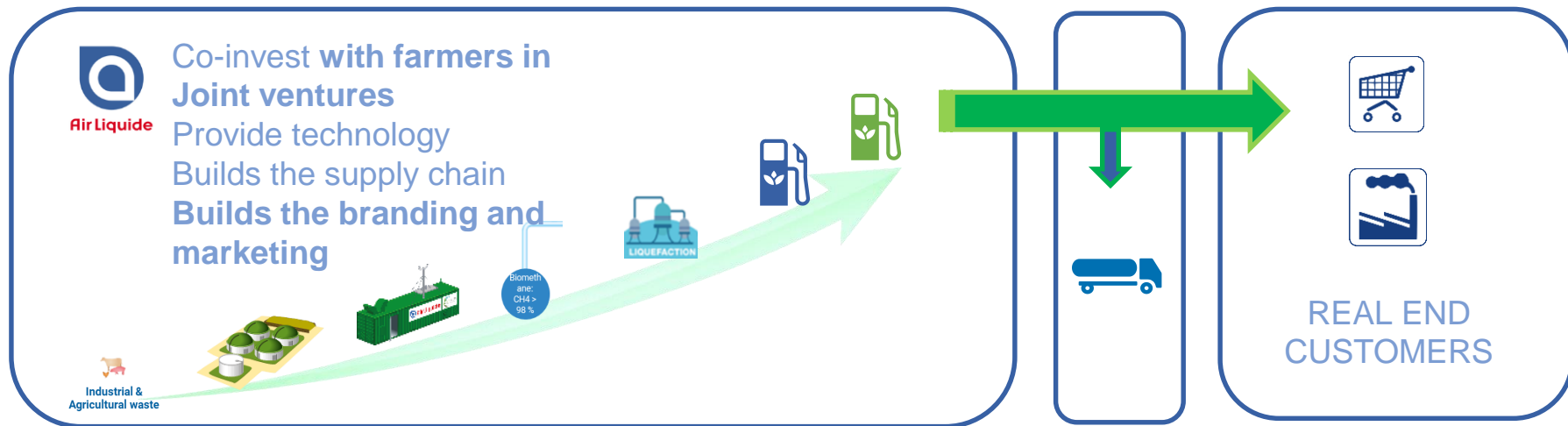
Biomethane has an intrinsic value that goes further than plain energy driver.

- Because drives decarbonisation of supply chain
- Because eases logistics in regulated traffic areas
- Because may lead to customer retention for fleets
- Because there won't be enough for everyone

The question is WHO TAKES this value in the value chain ?

Move on together – ecosystem wise business model

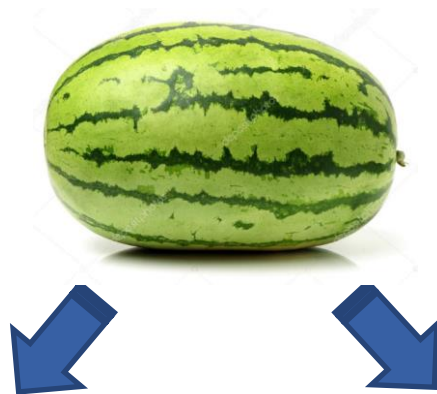
The highest level of value is created **together** through SPVs with farmers, the risk is lowered and shared, moreover final customers are addressed with an integrated offer been not only local but Nation wide or at European level.



Conclusions

- A business model that **cares for the farming and industrial ecosystem** is possible
- A better **distribution of the created value** is possible through collaborative partnership instead of traditional customer/supplier relationships
- Full investment **risk is lowered** through partnerships **driven by market initiatives** and not by opportunistic try-outs.
- Air Liquide promotes such kind of business model in Italy and is able to implement it

One last image...



Thanks for your
attention !

