From prototype to serial production

manufacturing hydrogen fuelling stations

LeadIng.

THE LINDE GROUP

DI Markus Mayer

A3PS Conference 2014

Content

THE LINDE GROUP

Linde Vienna – ATZ

Technology development

Linde hydrogen refuelling systems

Linde small serial production of hydrogen fuelling stations

Linde Vienna – Application Technology Center (ATC)

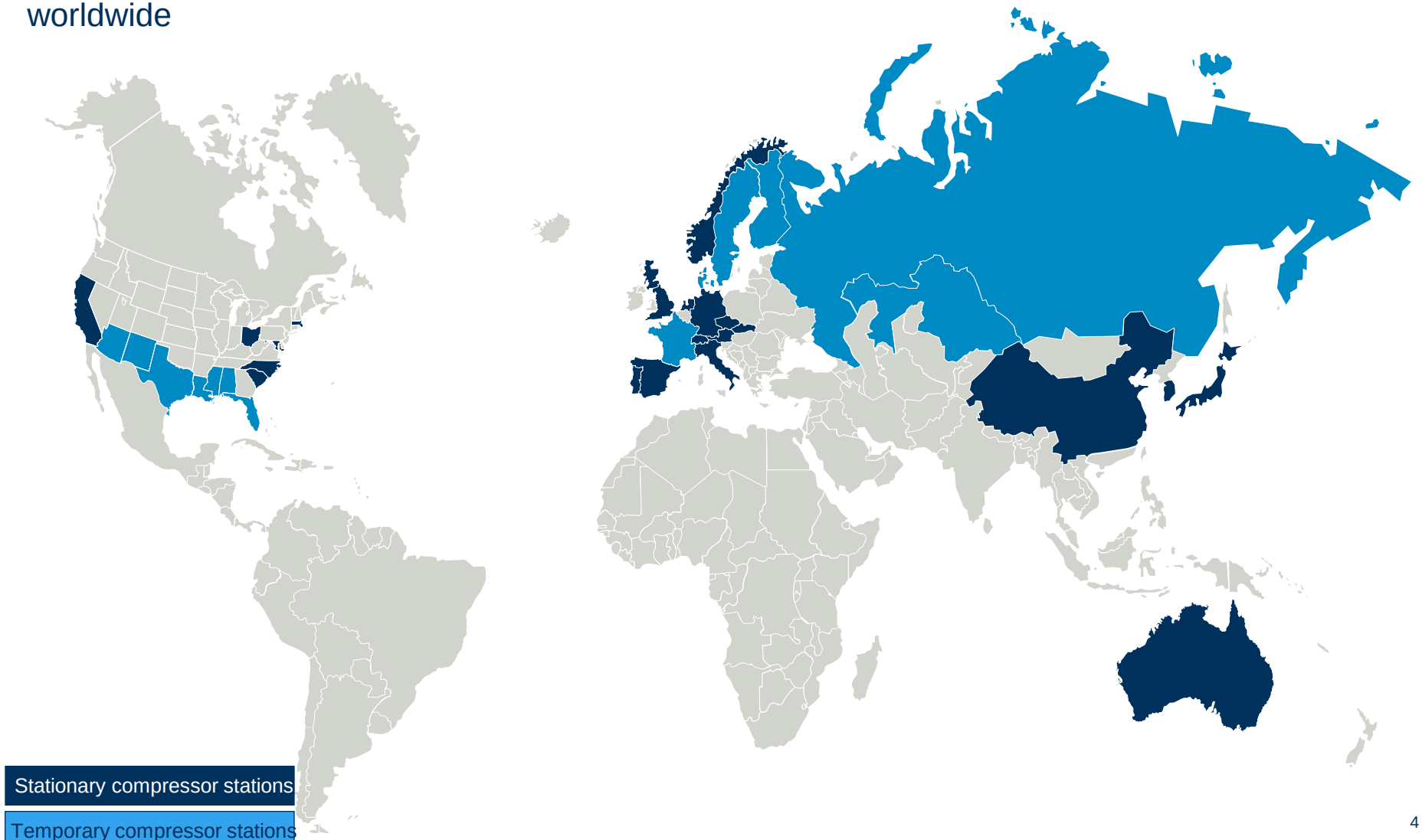
The ATZ develops and brings **breakthrough innovations** to market in a **unique collaboration** with internal and external customers.
It is renowned as a world leading competence center for **advanced hydrogen & CNG fuelling** and for its thermodynamic- and compression solutions

Since 2012 the ATZ has had a department that deals with production transfer into serial and the related **small serial production.**

ATC projects – worldwide

THE LINDE GROUP

More than **120 H2 compressors** and over 380 compressors for other gases like CNG, Ar or N2 worldwide

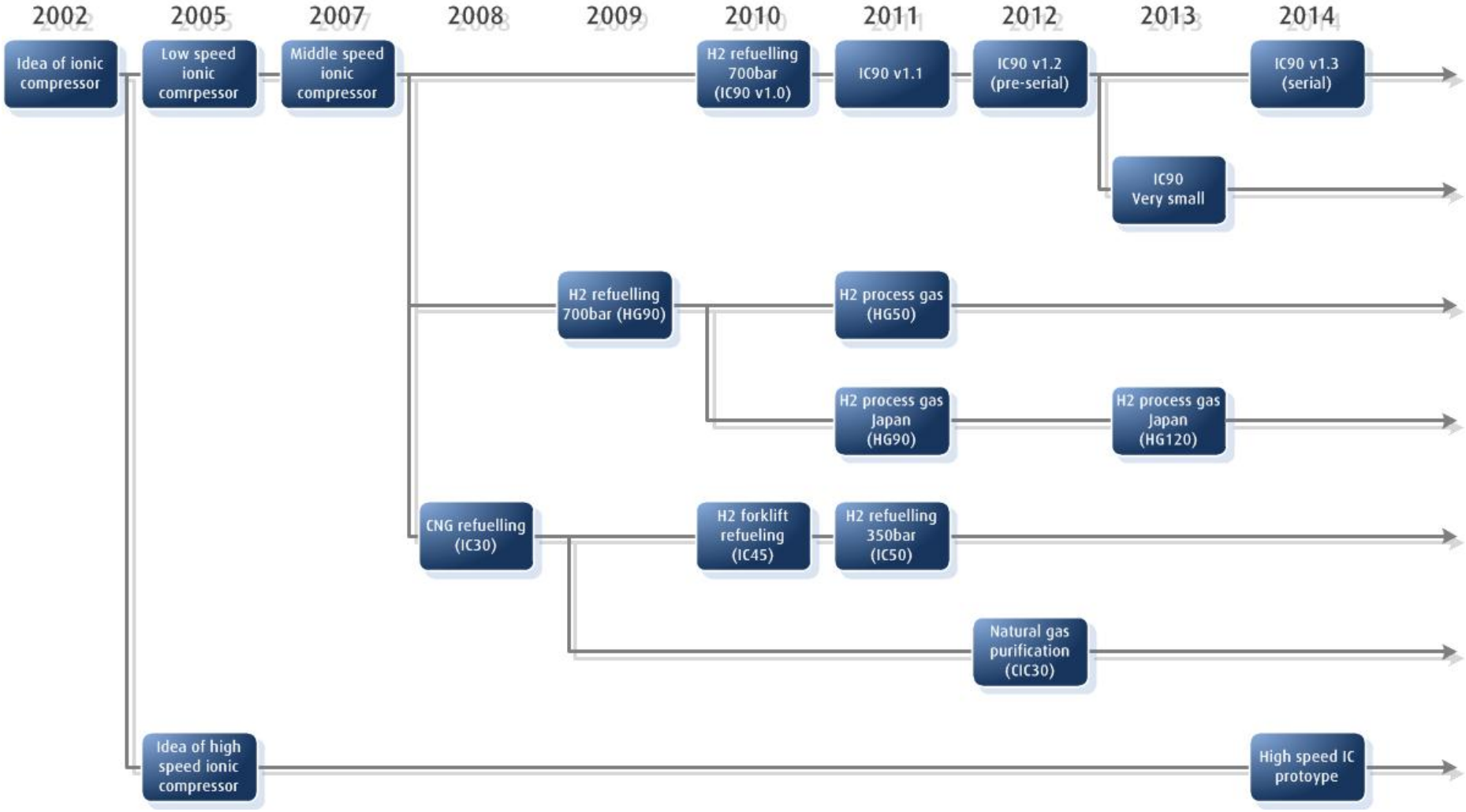


Content

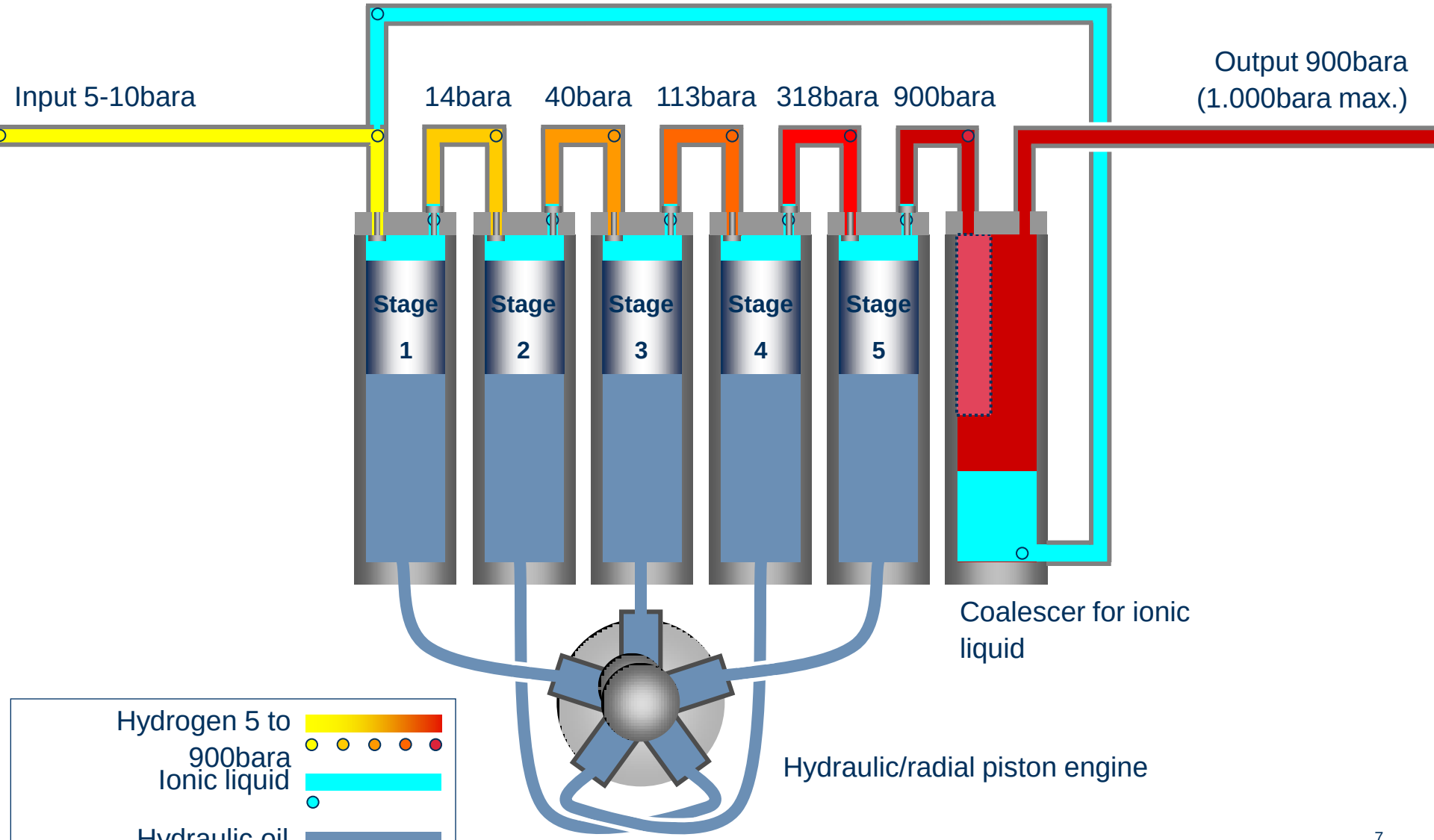
THE LINDE GROUP

Ionic compressor: development history

THE LINDE GROUP



Ionic compressor 90MPa - IC90
functionality

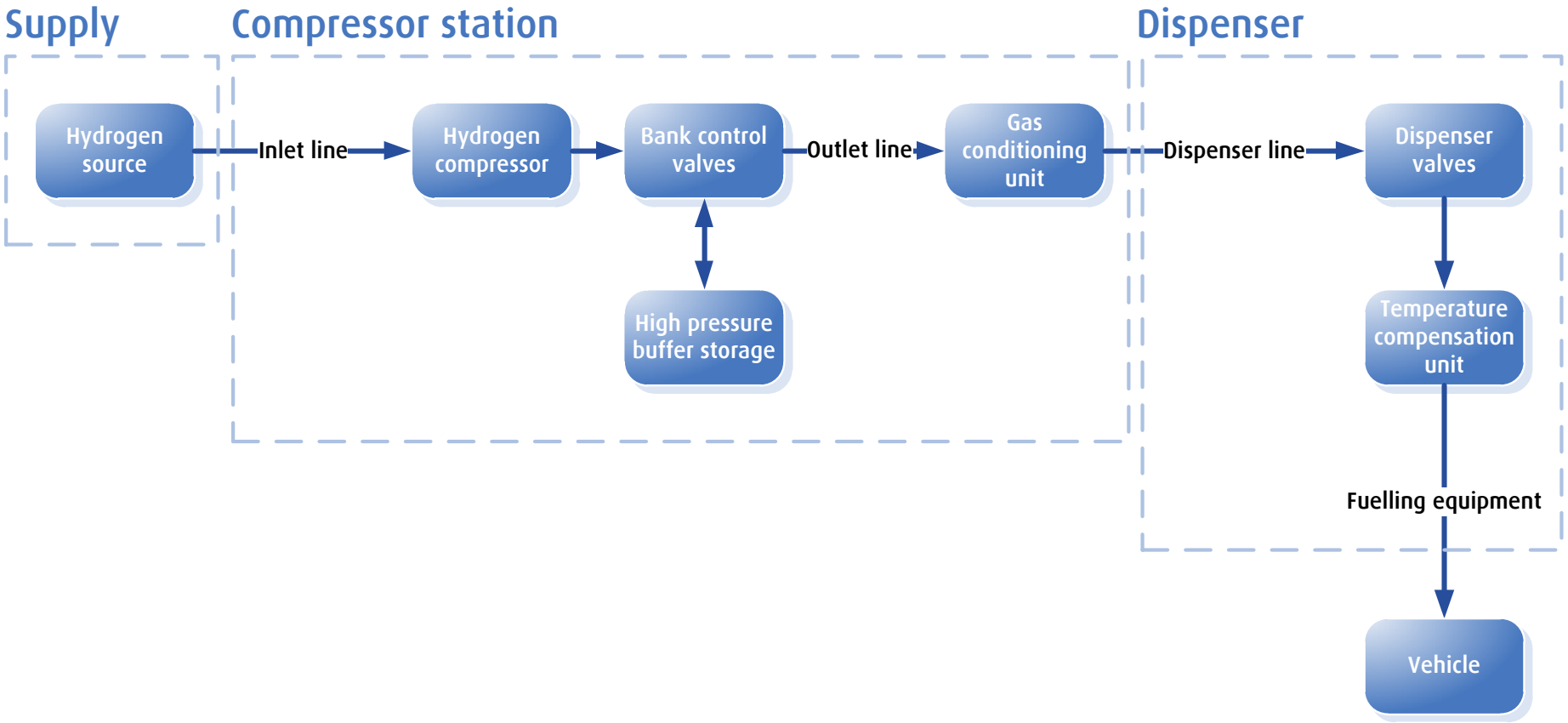


Content

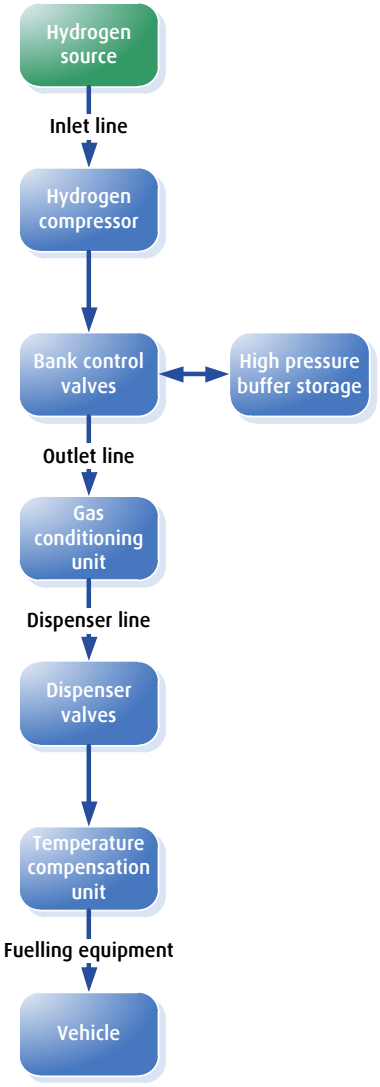
THE LINDE GROUP

Layout – 700bar hydrogen fuelling with compressor

Overview



Basic layout
Hydrogen source



Options:

Gaseous supply

—Onsite 45bar standard tank

—Onsite 200bar/200kg tubes (Fig. 1)

—GH2 trailer supply (Fig. 2)

—Onsite steam reformer

—Onsite electrolyser

Liquid supply

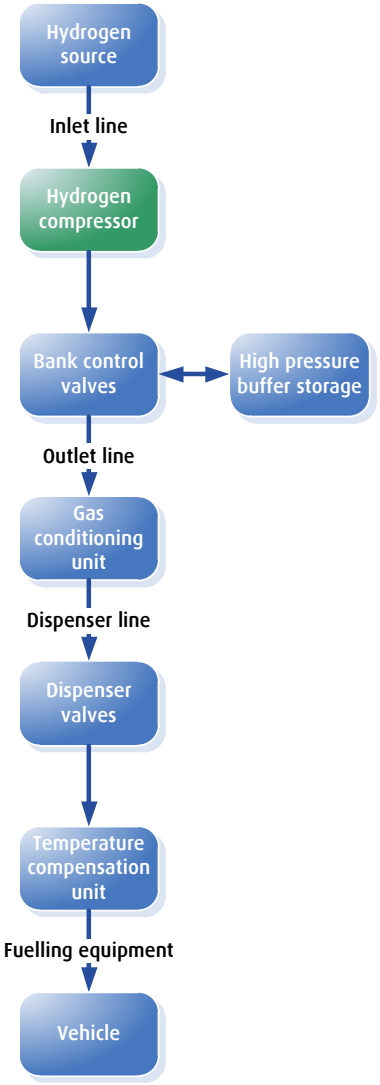
—Liquid tank

—LH2 trailer supply

Fig. 1: 200bar tubes with caps for underground installation

Fig. 2: 200bar trailer (Type T 7228 – 38m³)

Basic layout
Hydrogen compressor



Options:

—**Very small:** Downsized IC90 (Fig. 1)

—**Small:** 1 standard IC90 in one standard container (Fig. 2)

—**Medium:** 2 standard IC90s in one standard container (Fig. 3)

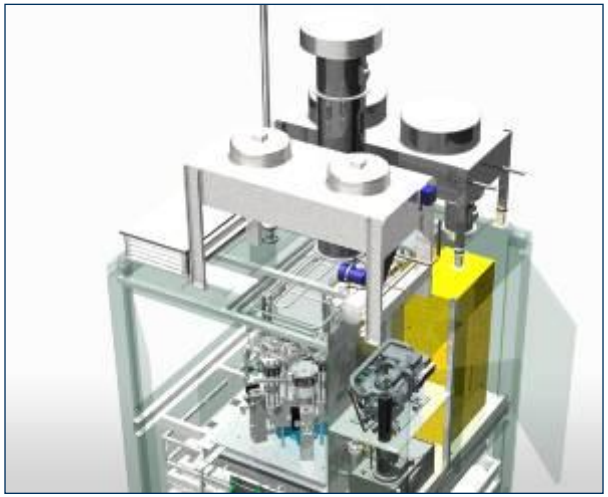


Fig. 1: IC90 very small

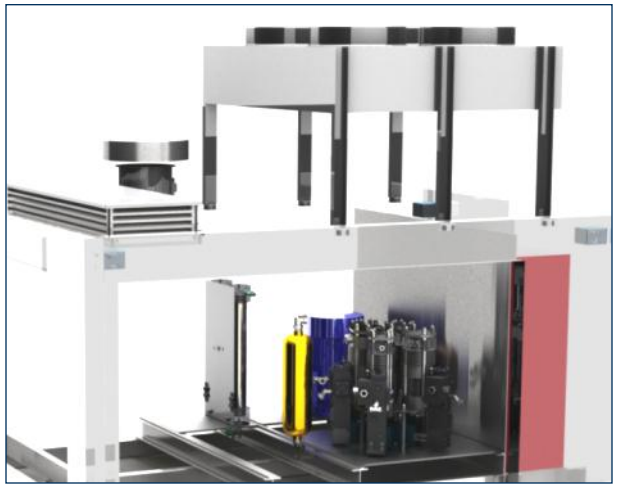
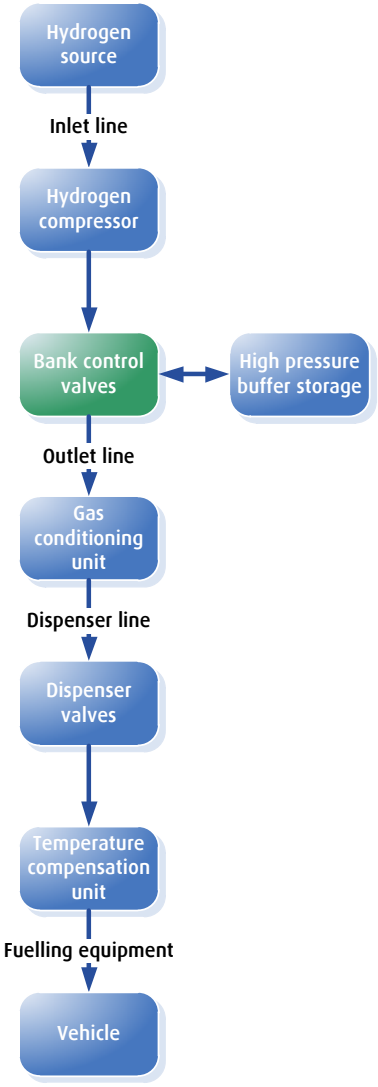


Fig. 2: IC90 small

Fig. 3: IC90 medium

Basic layout
Bank control valves



Options:

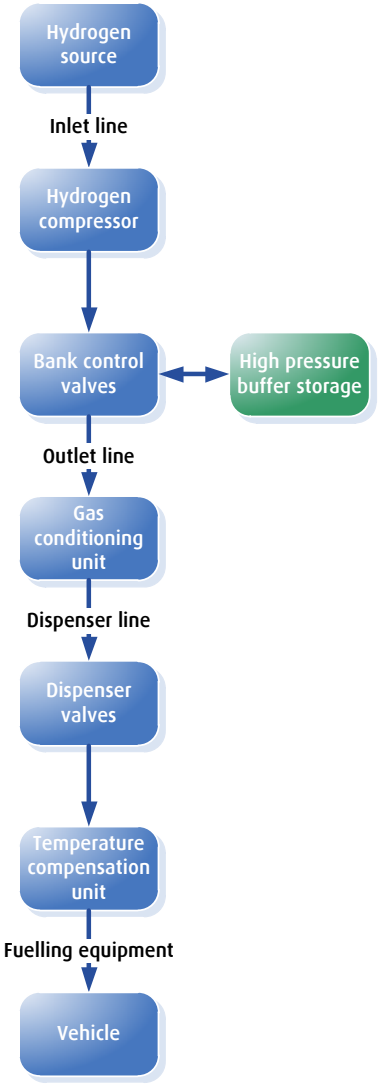
—Modular 3 Bank block for one dispenser line (Fig. 1)

—Modular 3 Bank block for two dispenser lines (Fig. 2)

Fig. 1: 3 Bank block for one dispenser line

Fig. 2: Bank block for two dispenser lines

Basic layout
High pressure storage



Options:

—Modules of 5 or 8 cylinders for 1000bar (Fig. 1)

—Up to 26 cylinders in one standard IC90 container (Fig. 2)

—External bundle container

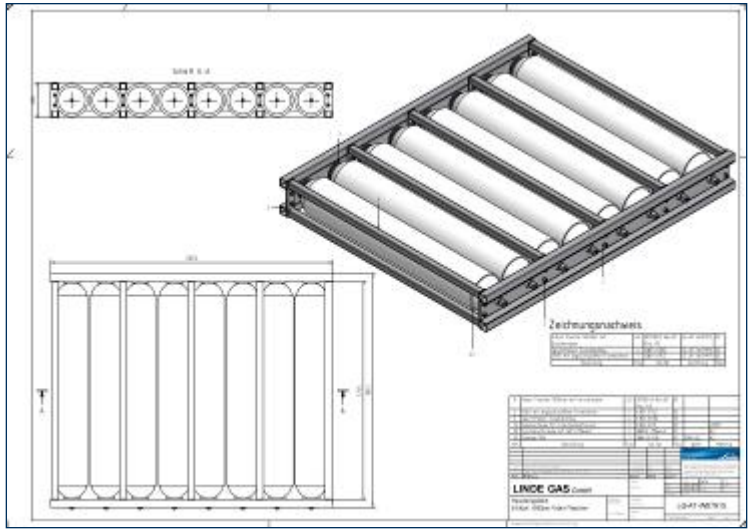
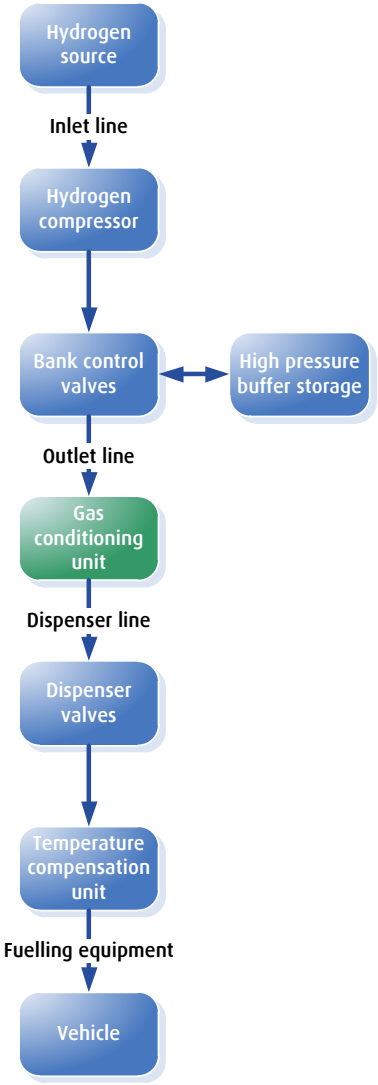


Fig. 1: Bundle for 8 bottles

Fig. 2: Installed bottles – EU standard station

Basic layout
Gas conditioning unit (Cold Fill)



Patented layout:

—Standard cooling unit with option for temperature compensation unit (Fig. 2)

—Maintenance free solid cold accumulator (Aluminium) with several heat exchanger lines (Fig. 1)

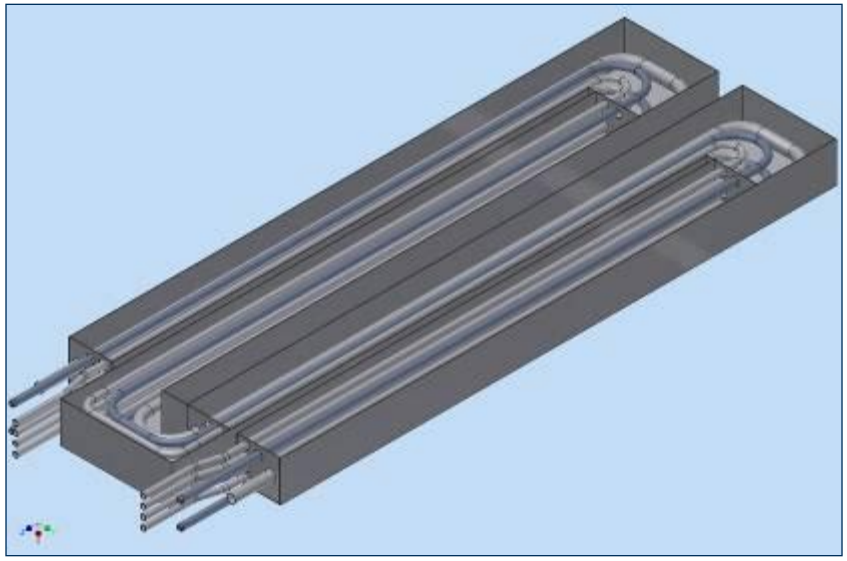
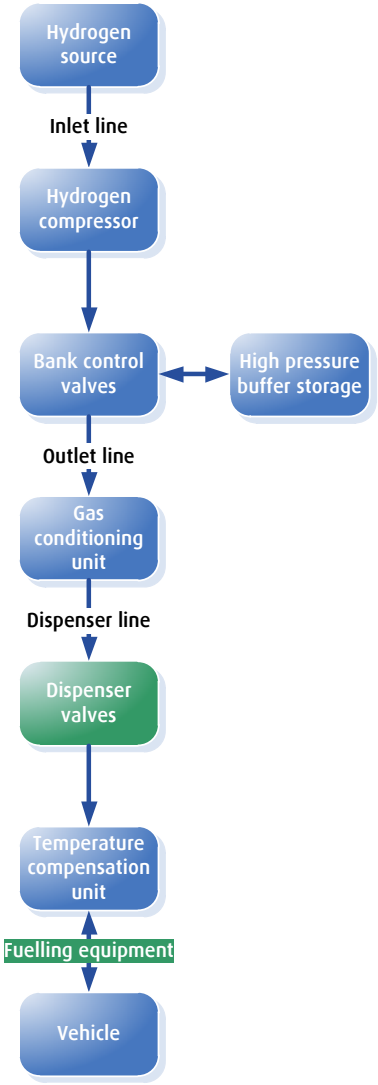


Fig. 1: Solid coldfill heat exchanger module (w.o. Aluminium)

Fig. 2: Standard cooling unit

Basic layout
Dispenser



Options:

—Dispenser: 1 hose – 700bar (Fig. 1)

—Dispenser: 2 hoses – 700bar (Fig. 2)

—Dispenser: 1 hose – 700bar; 1 hose – 350bar

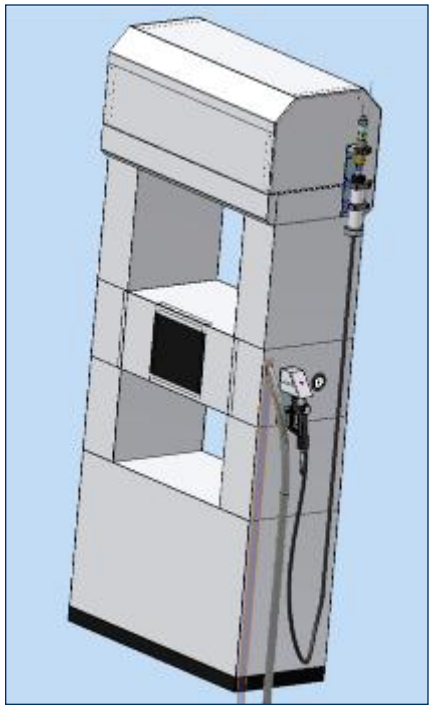


Fig. 1: Dispenser 1 hose-700bar

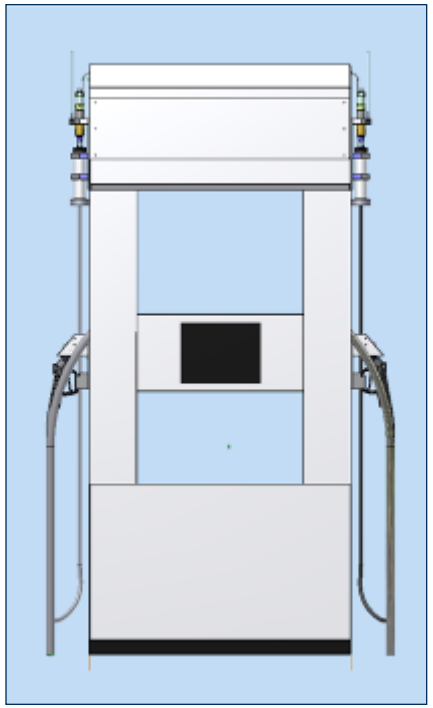
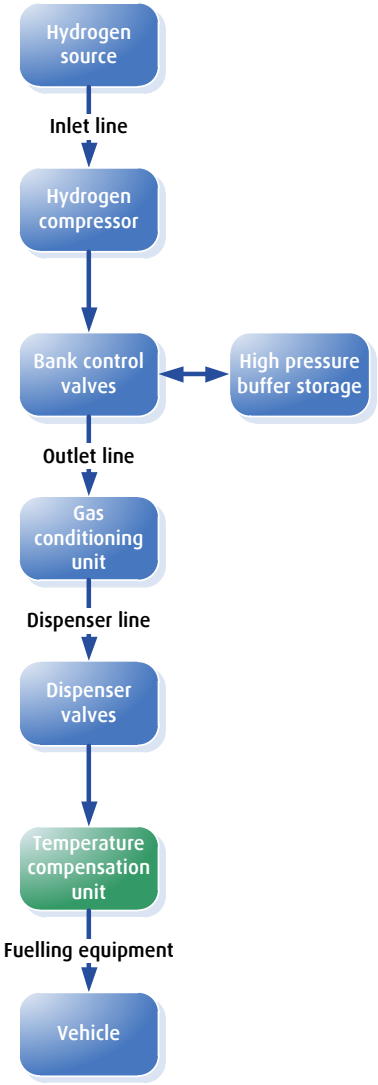


Fig. 2: Dispenser 2 hoses-700bar

Basic layout
Temperature compensation unit (TCU)



Patented layout:

—Used to compensate the warm dispenser line up to 50m (with standard TCU)

—Supplied by standard cooling unit in container (minimal losses)

—Maintenance free solid cold accumulator (Aluminium) for 1 dispenser line (Fig. 1)

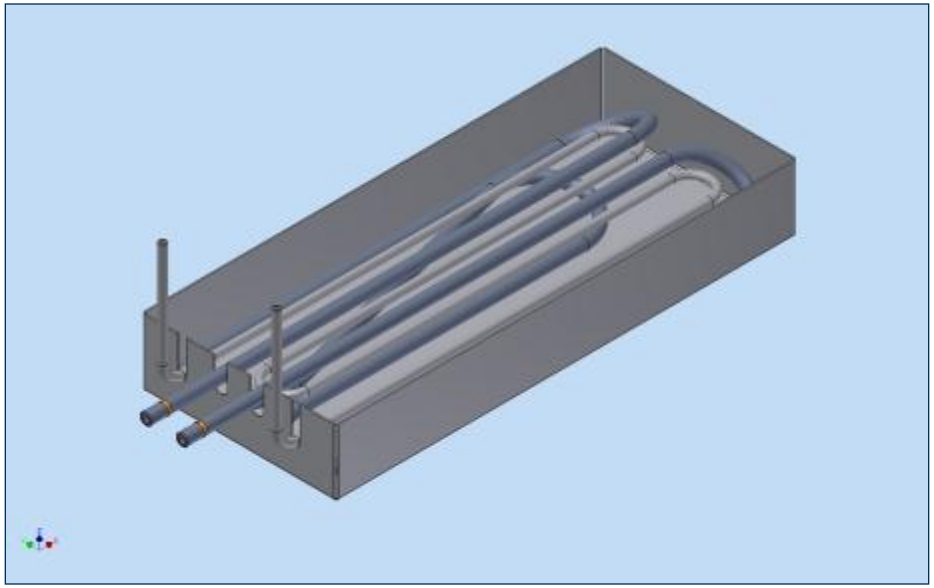
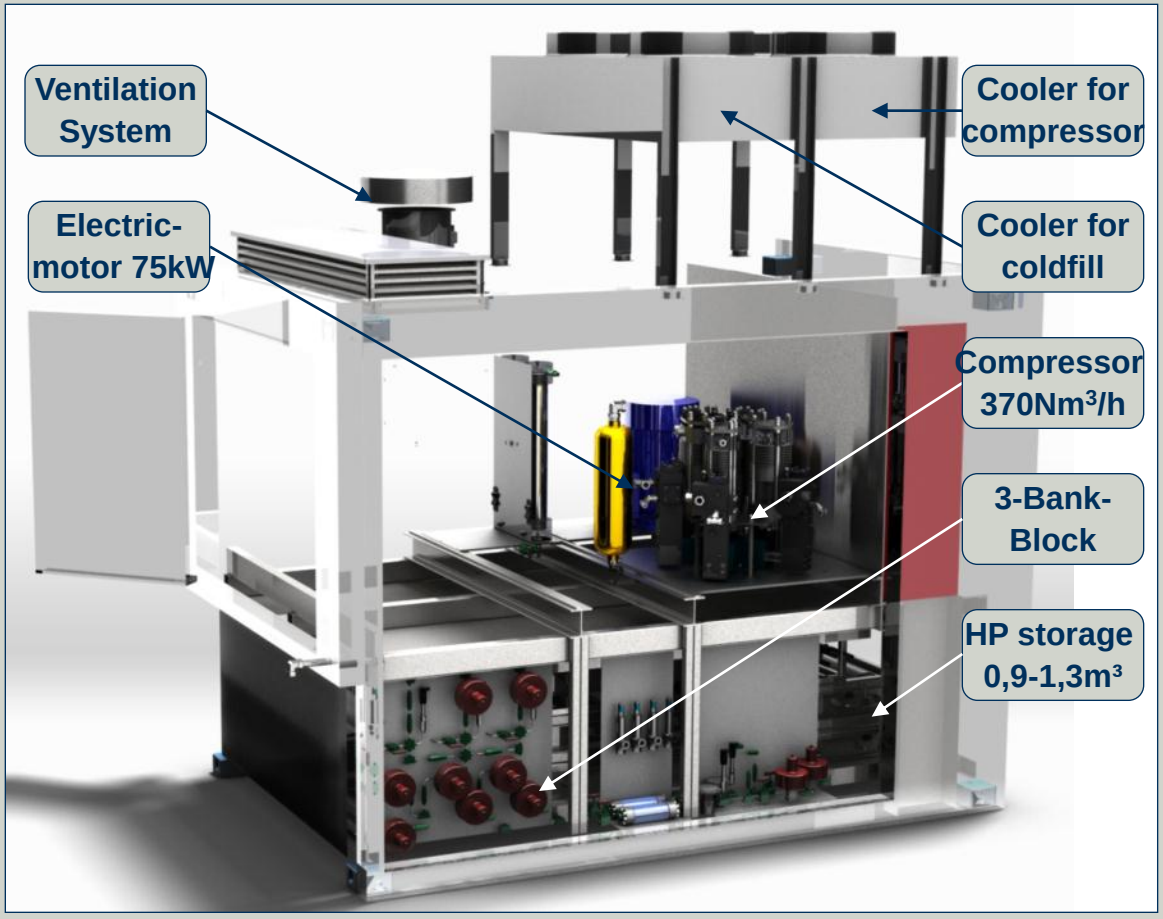


Fig. 1: 3D model - standard TCU (without Aluminium)

Content

THE LINDE GROUP

Hydrogen fuelling station for serial production

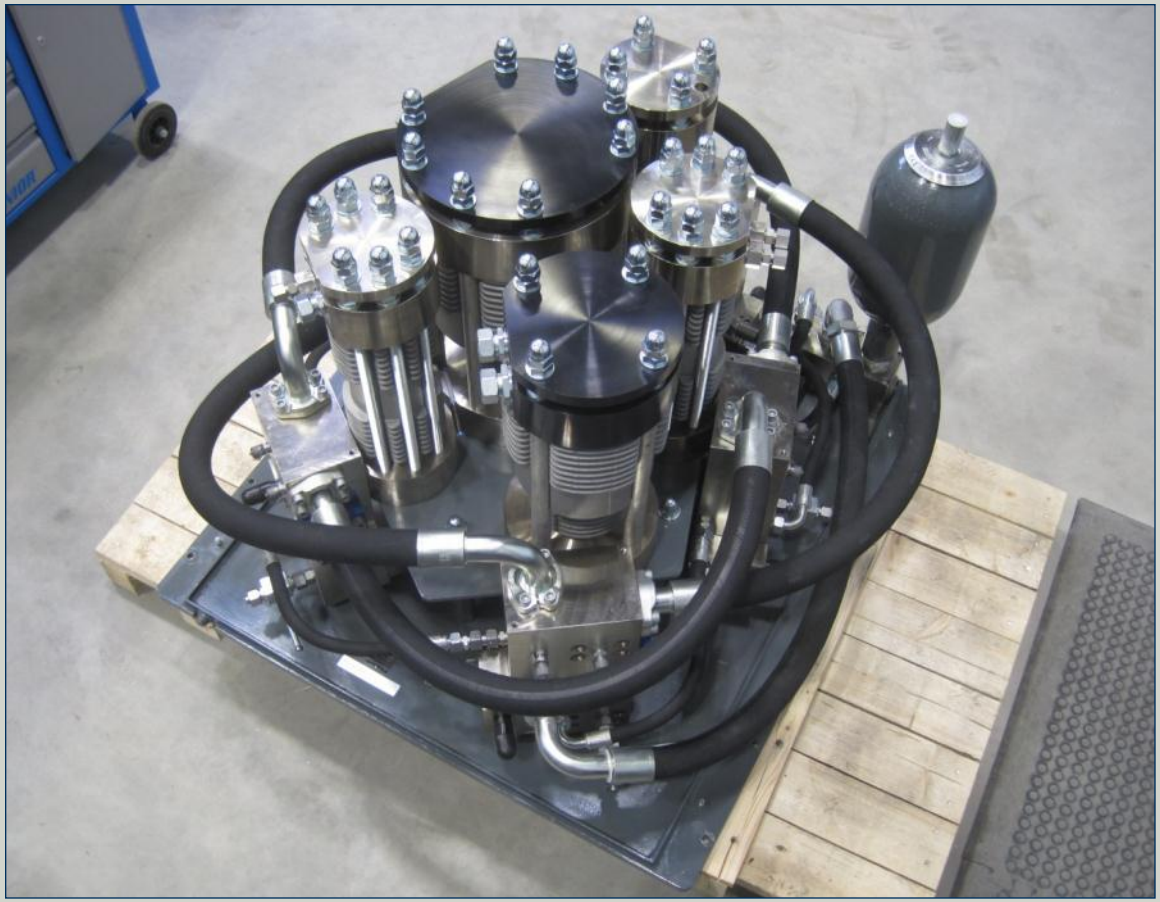


Example: New design of IC90 (US+EU Version)

Layout & performance

- Small footprint: **2,7m x 4,3m**
- Connected load: 105kW
- Compressor type: **Ionic compressor for H2 – IC90**
- Noise emission: <75dB(A)
- Supply: **gaseous or liquid**
- Option for capacity upgrade (**33,6kg/h => 67,2kg/h**)
- Fuelling protocol: **SAE J2601-A70**
- Same container for **US** and **EU** model

Ionic compressor 90Mpa
"IC90"



Ionic compressor 90MPa – IC90

Performance

- Ionic compressor for H2
- **5-stage** compression
- Stage compression ratio: **1:2,8**
- Max. delivery rate: **370Nm3/h ~ 33,6kg/h**
- Min. input: **5bara**
- Max. output: **1.000bar**
- Power consumption at 5bara inlet pressure: **75kW**
- Stroke frequency: **5,8Hz**
- **Specific energy consumption: 2,7kWh/kg H2** (= energy saving of around 40%)[1]

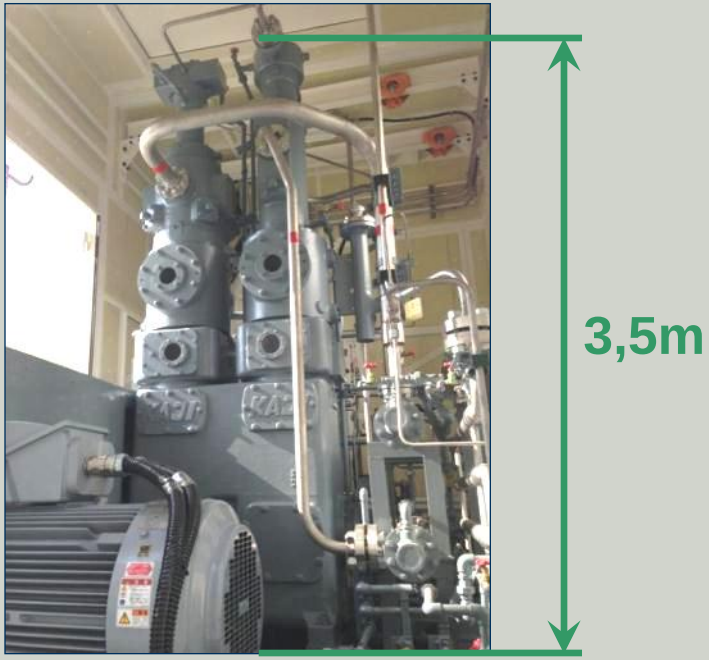
1 compared to conventional dry running piston compressor for 90MPa

Benchmark

Hydrogen compressor of competitor and Linde IC90

THE LINDE GROUP

Hydrogen compressor of competitor



Manufacturer: ---

Technology: 4-stage piston compressor

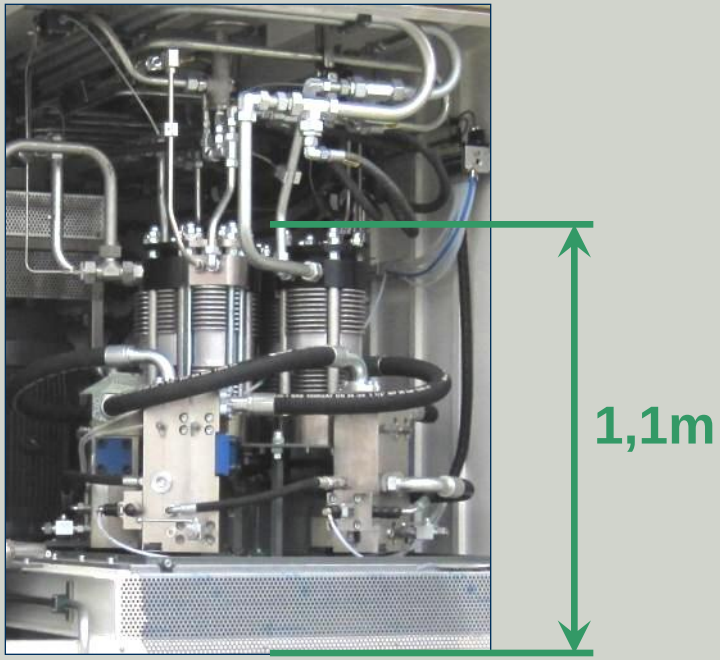
Delivery rate: **100 Nm³/h**

Max. outlet: **440bar**

Inlet range: **4 – 7bar**

VS.

Linde ionic compressor – IC90



Manufacturer: Linde Gas – Austria

Technology: 5-stage ionic compressor

Delivery rate: **370 Nm³/h**

Max. outlet: **900bar**

Inlet range: **3,3 – 200bar**

Small serial production of hydrogen fuelling stations

Work shop and assembly area


Ware house


EU station at test facility

Overview and Outlook

Actual[1]:

- Capacity: 50 stations/a
- Avg. lead time: 8 months
- Testing capacity: 2 boxes on test stand for testing activities

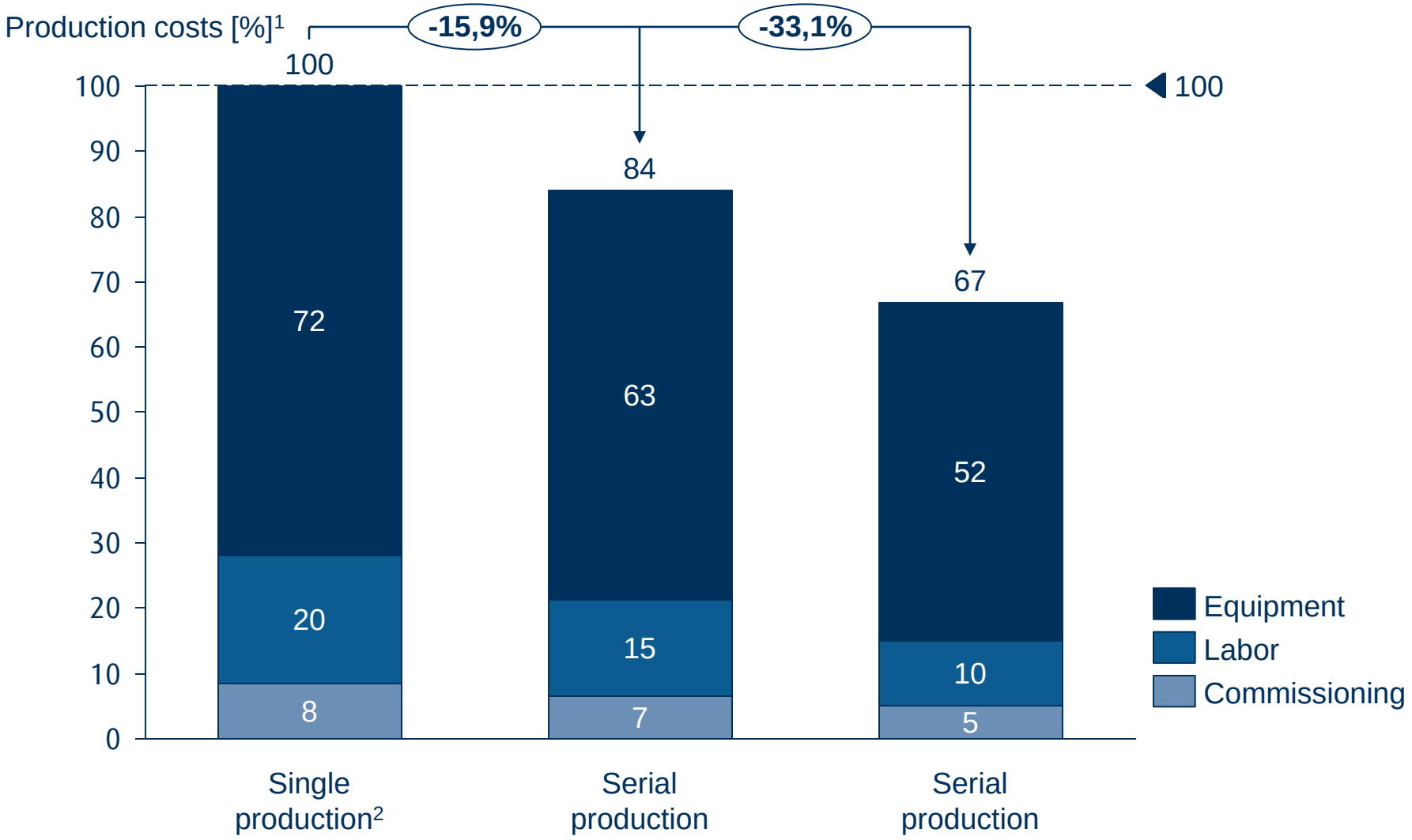
Outlook[1]:

- Capacity: 100 stations/a (second shift)
- Avg. lead time: 5 months
- Testing capacity: 4 boxes on test stand

1 based on EU stations with similar scope of supply

Cost reduction potential

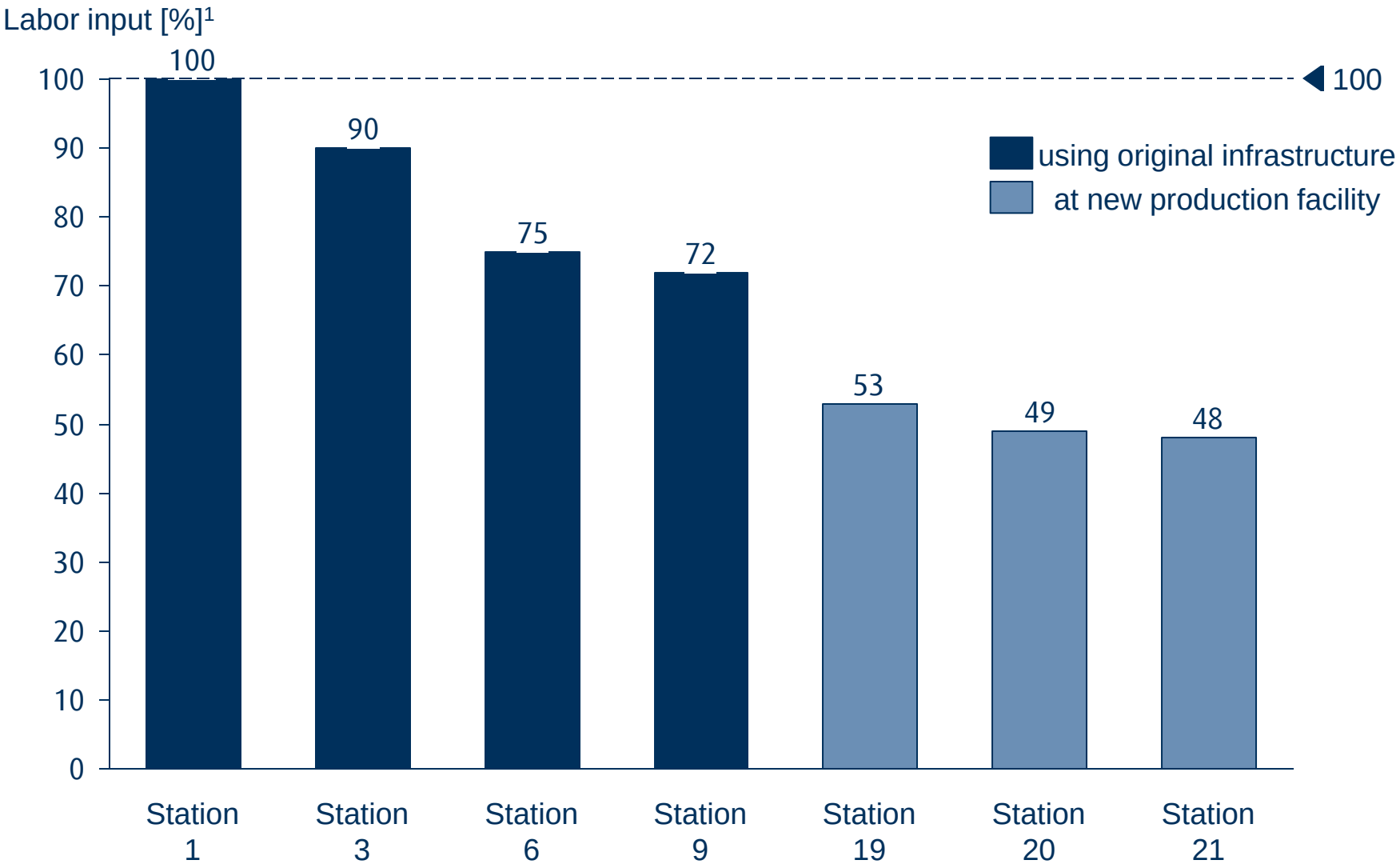
Advantage of small serial production



1 based on EU stations with similar scope of supply

2 base is production cost of IC90 stations in 2010, costs are inflation adjusted

Economies of scale
Labor input



1 labor for assembly only, based on EU stations with similar scope of supply

Thank you

THE LINDE GROUP