

Air Liquide Group and China presentation

THIS DOCUMENT IS PUBLIC

March 2017

Air Liquide Group



Data as per year 2016

Approximately

68,000

employees

Present in

80

countries

Revenue

16.4

€ billion

More than


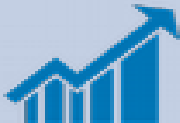








3 million

customers
and patients

Delivering Greater Value Together



Air Liquide in China: brief history

1990-2003 Initial Stage	2004-2006 Acceleration	2007-2013 Tengfei	2014-now Zhuoyue
 <p>Shanghai Caohejing Plant, Air Liquide's first plant in China, started</p>  <p>Electronics, Industrial Merchant, Engineering & Construction, and Large Industries activities successively rolled out</p>	 <p>Air Liquide China Holding founded</p>  <p>Major contracts signed, with business mainly in coastal areas</p>	 <p>Launch of Tengfei Plan</p>  <p>Major contracts signed, with business expanding into the center, west and south</p>  <p>74 plants</p>	 <p>Launch of Zhuoyue Plan</p>  <p>Major contracts signed, with business further expanding into the west and south</p>  <p>Nearly 90 plants</p>

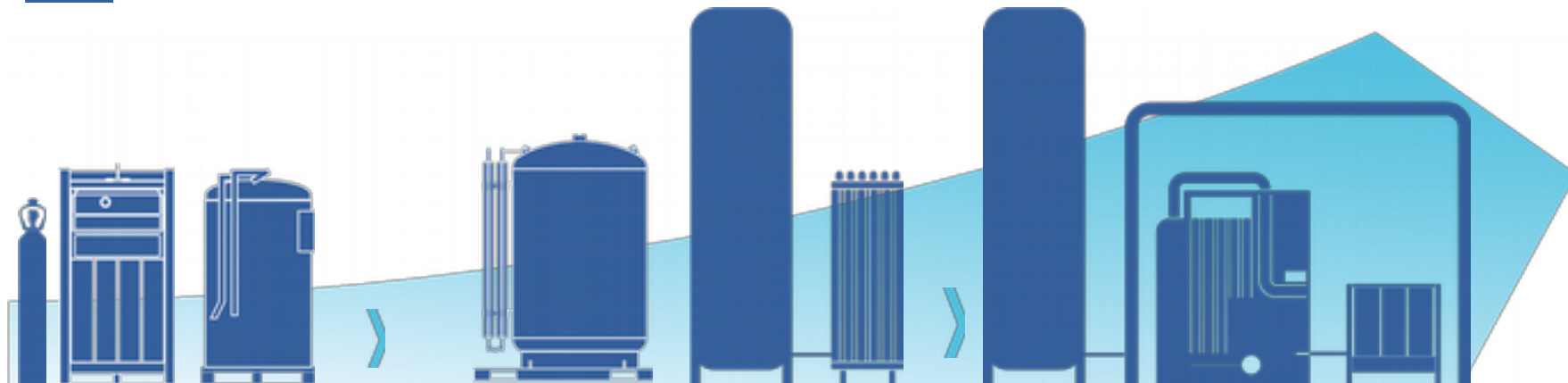
THIS DOCUMENT IS PUBLIC

March 2017

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

Group and China presentation

We offer flexibility in supply to match customer needs



Packaged gases supply

**Compressed gases for cylinders,
liquid form for dewars**

- For small and medium volumes
- Available in bundles or dewars for larger consumption
- For mobile use

Bulk & microbulk supply

By trailers, in liquid form

- For large volumes
- When cryogenic use is required

On-site supply

(FLOXAL™ offer)

- For even larger volumes, from 10 to several thousand Nm³/h
- At customer's premises, even in remote locations
- Only for nitrogen, oxygen and hydrogen

THIS DOCUMENT IS PUBLIC

May 2017

IM WBL Knowledge, Branding & Communication

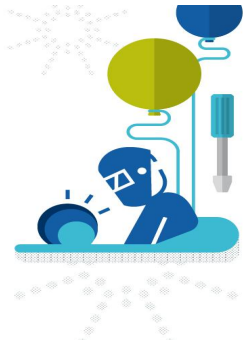
AIR LIQUIDE, THE WORLD LEADER IN GASES, TECHNOLOGIES AND SERVICES FOR INDUSTRY AND HEALTH

IM More about 2017

**INDUSTRIAL
MERCHANT**

Across all industries

Professionals & Distributors



Professionals and craftsmen, involved with metal fabrication, heating, construction and repair.

Automotive & Fabrication



Small to large companies that transform primary materials (metal) into finished products or advanced fabrications.

Materials & Energy



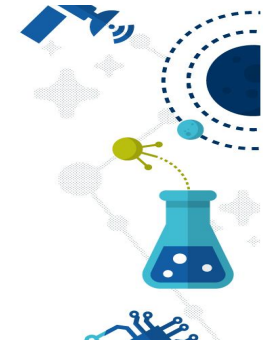
Industries engaged in activities from the extraction of ores and oil to the transformation of raw materials into added-value products.

Food & Pharma



Companies engaged with food, beverage and pharmaceutical production and processing activities.

Technology & Research



Advanced technology industries (optoelectronics, electronics manufacturing, space), research centers and analytical labs.



Automotive & Fabrication

Our products:

Packaged gases in majority

- **Ar + Ar Mix** Arc and laser welding
- **N₂** Heat treatment / Laser cutting
- **O₂** Cutting and Heating
- **C₂H₂ + other fuel gases** Oxy-cutting and Heating
- **H₂** Heat treatment
- **He** Welding / Diving / Heat treatment
- **CO₂** Surface cleaning / Welding
- **Specialty gases** Calibration / Emission control

Leading brands:

Premium products

- **ARCAL™**: dedicated range for arc welding
- **LASAL™**: products for laser welding and cutting
- **FLAMAL™**: dedicated range for flame applications
- **ALPHAGAZ™**: pure and calibration gases for engine emission testing

Process solutions

- **ALNAT™**: process solutions for high performance heat treatment
- **Nexelia** for Laser Welding



Technology & Research

Our products:

- **H2** Polysilicon and LED manufacturing, rocket engine testing
- **He** Fiber optics drawing
- **N2** Inert atmosphere for soldering of electronic components / Fiber optics / LED and polysilicon manufacturing
- **NH3** LED manufacturing
- **Ar** Ingot pulling
- **Spec gases:** Calibration for analytical equipment (pure gases)
- **Rare gases:** Lighting

Leading brands:

Premium products

- **ALPHAGAZ™** : specialty gases for analysis, calibration and quality control

Process solutions

- **Nexelia:** All-in-one solutions for electronics manufacturing (formerly ALIX™)

Our strengths: Innovative technologies for China

E&C

- Build production units, mainly **air gas separation and hydrogen production units**
- Cover the entire project lifecycle: license engineering services / proprietary equipment, high-end engineering & design capabilities, as well as project management & execution services.
- Its industrial gas, energy conversion and gas purification solutions enable customers to optimize the use of natural resources.

SRTC

- Inaugurated in February 2016, **SRTC** will become a major center for the Group's innovation in the Asia-Pacific region.
 - Investment of € 25 million
 - Capacity of 250 employees
 - Covering 18,400 m²
- The center address issues such as **energy transition, CO₂ emissions reduction, waste water treatment, urban air quality, food safety, and healthcare.**

aB&T

- Launched in 2013, advanced Business & Technologies (Asia) supports the coming transitions in providing turn-key solutions in the following markets:
- **Renewable Energy**
 - Biogas Upgrading
 - Hydrogen Mobility
- **High Tech**
 - Scientific Research
 - Space

Air Liquide advanced Technology (AL-aT)

Since 1962, AL-aT is the **high technology** subsidiary of the Group dedicated to **innovation** and industrial solutions in the field of **cryogenics** and **gas engineering**

More than **600** employees; about **140 m€** turnover



AL-aT's site in Sassenage, France

Aeronautics



Gas&Cryogenics



Space



Energy





Solar Impulse



E-fan

© EIVL - 2013 - All rights reserved



330 LE



Grease Lightning



HY4

Electrical power trains enable innovative architectures

The distributed power



Extremely efficient

Quiet

Green



Fuel Cells & Hydrogen : the Next Revolution Onboard

Non Propulsive Energy Aboard Airliners



Galley

How to store the energy?



APU



RAT

10 -100 kW power range 50 – 1000 kWh energy range
Similar needs for general aviation power trains

Comparison of gravimetric indexes of various energy storages

example for the sake of clarity (public data)

(*) energy available at propeller input

For a **1 ton** aircraft flying **6 hours** at a speed = **120 kt** (*) public data for SIMBA / Issoire Aviation

Shaft brake power to be generated $\approx 70 \text{ kW}$; $\approx 460 \text{ kWh}$ to be stored; elec. motor eff. **90%**

AVGAS tank
3300 Wh/kg
engine eff. 37%



$\approx 140 \text{ kg}$



Liquid Hydrogen
3500 Wh/kg
Fuel cell eff. 45%

 **Air Liquide**
creative energies



$30 \text{ kg } (\Phi 0,95 \text{ m})$

Liquid Hydrogen Tank : a possible Spin-off from Space



ARIANE V Helium tank



110 flown to date
vacuum insulated, 100% aluminum
1200 L of liquid Helium
qualified for harsh environment

Could contain up to **84 kg of liquid Hydrogen**



70% scale

Courtesy Issoire AVIATION



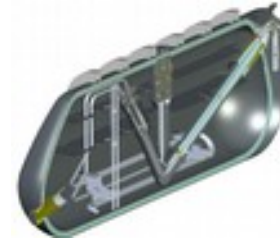
Other types of liquid H₂ tanks made by Air Liquide for the automobile

Could be adapted for specific aircraft integration



Complex processes

Innovative solutions



Any shape



12 kg, 15% gravimetric index

Innovative realizations



conformable LH₂ tank (8 kg)

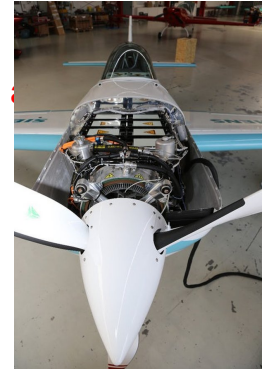
Valorizing the boil-off on ground (there is no boil off in flight)

- When on parking, the boil-off can be valorized in the FC (1 – 2 kW) :

- for either recharging the battery
- Or for providing power back to the airport via a simple battery electrical vehicles



al plug



- If the FC is off, no loss up to 2 to 5 days, depending on the liquid level

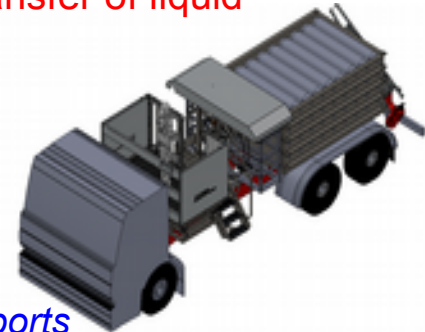
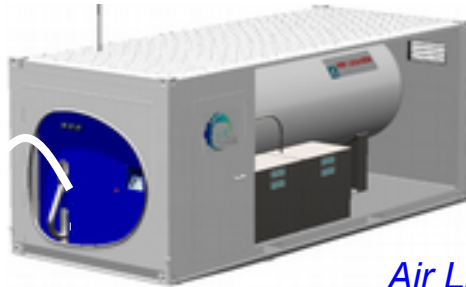
Should the maximum pressure be reached,

-the BO can be burnt into a small and safe catalytic system (only H₂O vapors are released)

- The hydrogen refueling station will depressurize the tank, recool it and refill it
 - All boil-off to be recovered by the station (for further recompression/re-liquefaction)

Liquid Hydrogen and Logistics are coming

- 1 Liquid Hydrogen will become widely available for the automotive market at short term (2020)
investments on liquefiers and Hydrogen Recharging Station (HCS) are in progress
- 2 Logistics & infrastructure for airports will benefit from synergies with the automotive market
- 3 Station for aircrafts are much simpler than for cars : no pressure, just a transfer of liquid



Air Liquide's concepts for mobile liquid H2 station for airports

Conclusions

- 1 Electrical aircrafts : a promising future for a cleaner and quieter aviation
Energy onboard airliners and power trains for GA (similar power&energy)
- 2 Liquid Hydrogen : the best solution for storing large amounts of energy
- 3 The liquid molecule will soon become widely available thanks to the automotive market
- 4 Technologies are there : electrical motors, fuel cells, hydrogen tanks, refueling stations

*All this combined with the distributed power : **a revolution is in progress***

Refueling hydrogen

electric aircrafts...



will soon be as simple as that!

For more information on Air Liquide



WU Silu

ALC IM Markets and Added Value Business Development

No.1820 Guanghai Road, Minhang District, Shanghai,
201108, P.R.China
Email address: silu.wu@airliquide.com



Visit our website: airliquide.com

THIS DOCUMENT IS PUBLIC

21

May 2017

IM WBL Knowledge, Branding & Communication

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

IM More about 2017

INDUSTRIAL
MERCHANT

Follow us

