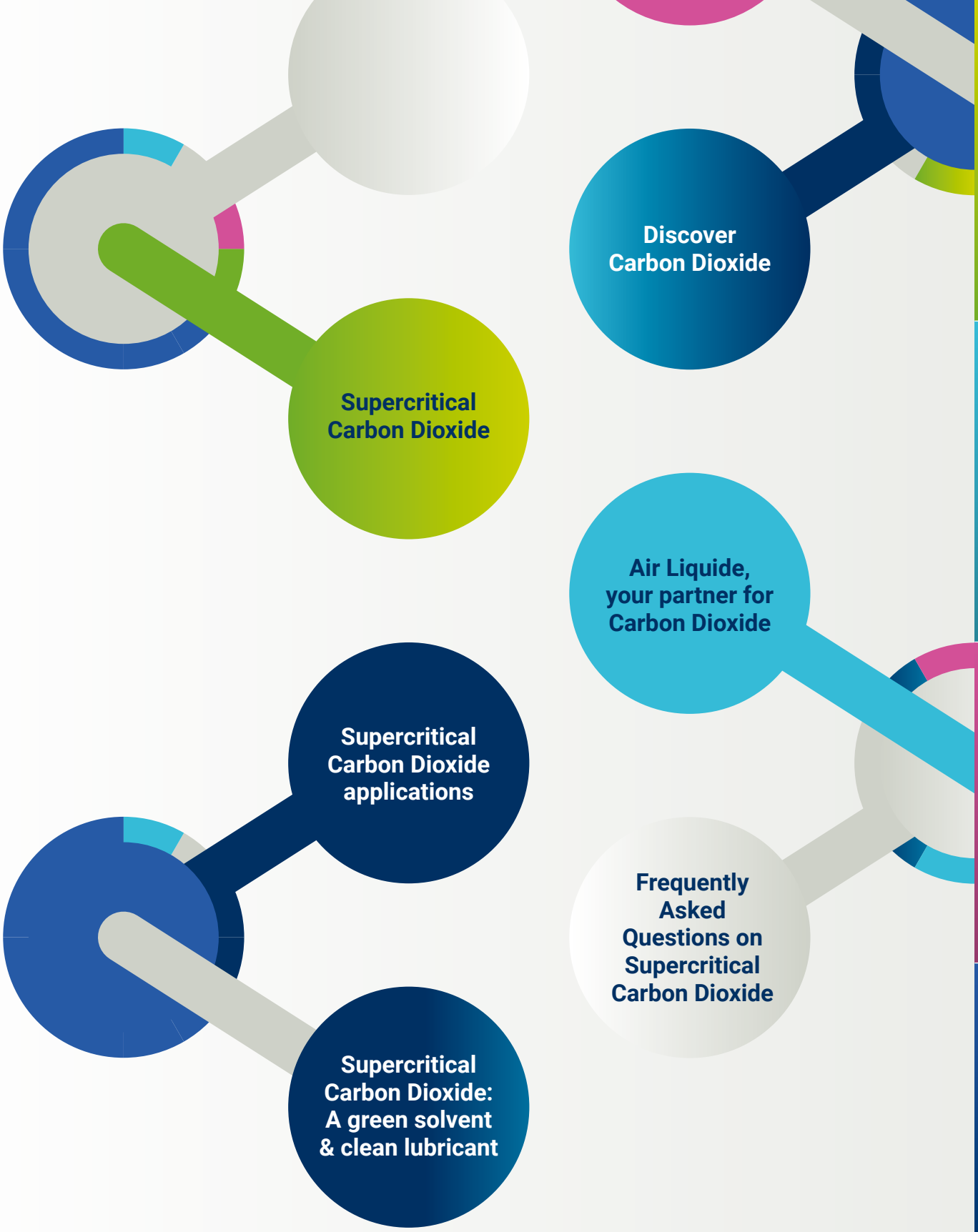


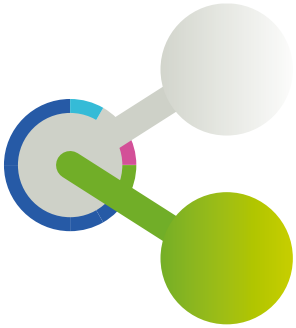
Carbon Dioxide CO_2

Air Liquide

What is Carbon Dioxide?

Carbon dioxide (CO_2) is an odorless, tasteless, colourless, non flammable gas, naturally present in the atmosphere and indispensable for life. It is necessary for the photosynthesis process of the plants, to produce oxygen and to sustain life on earth.

TO LEARN MORE



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Air Liquide, your partner in Europe

Since several year Air Liquide recovers and purifies the CO_2 to offer a product with high purity in respect of our planet and of customers need.

TO LEARN MORE

- **Reliable sourcing**
- **Dedicated knowledge & expertise**
- **European presence**
- **Continuous innovation**

NEXT ›

What is the Supercritical Carbon Dioxide?

A fluid is said "supercritical" when it is heated above its critical temperature (Tc) and compressed above its critical pressure (Pc). Several fluids like water, ethane, propane or carbon dioxide can go supercritical.

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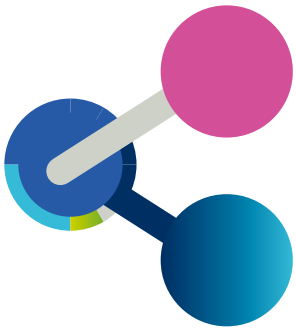


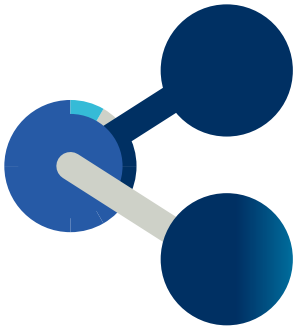
NEXT ›

Industrial applications for the supercritical carbon dioxide

The supercritical carbon dioxide (sCO_2) is widely used in many industrial applications.

- FOOD & BEVERAGE
- PHARMACEUTICAL & COSMETICS
- ELECTRONICS
- METAL WORK
- ENERGY PRODUCTION
- CHEMICAL
- WOOD / PULP AND PAPER INDUSTRY
- TEXTILE INDUSTRY

TO LEARN MORE



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A green solvent and a clean lubricant

Supercritical carbon dioxide is an attractive alternative to traditional organic solvents and lubricants.

TO LEARN MORE

NEXT

FAQ about carbon dioxide

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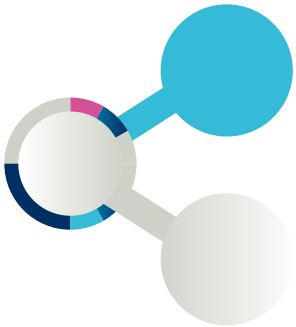

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What is a supercritical fluid?

Do all materials go supercritical?

Is supercritical carbon dioxide (sCO_2) a new fluid?

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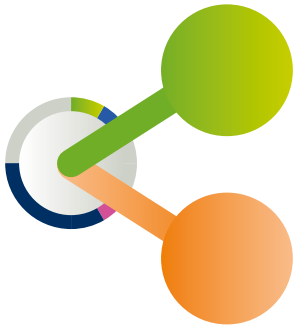

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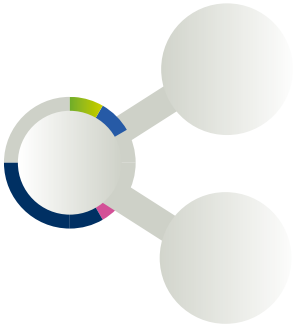
From recovered to pure product

Most of the Carbon Dioxide (CO_2) delivered to customers by Air Liquide in Europe has been captured from bioethanol, fertilizer and Hydrogen production.

TO LEARN MORE



Biogenic CO_2

Recovered CO_2

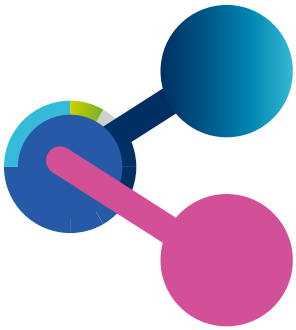
Generated CO_2

NEXT ›

Supply chain from sourcing to customer

The CO_2 is captured at the source, purified and conditioned in liquid, gas or solid phase with the appropriate packaging to satisfy the final needs.

TO LEARN MORE



NEXT ›

Concentration and effects on human physiology

EIGA SOURCE

- 300-400 ppm: fresh air composition
- 600-1000 ppm, acceptable indoor air

- 5000 ppm (0,5%) uncomfort for sensitive people
- 1-1,5% headache for sensitive people, effect on metabolism after hours

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Carbon dioxide: safety @usage

The use of CO_2 for industrial applications in confined spaces undergoes specific laws. The limit of the human exposure to high concentrations of CO_2 during a fixed lapse of time is given by the EIGA* and the OSHA**.

TO LEARN MORE

EIGA* (european gas Industrial association)
OSHA** (Occupational Safety and Health Administration)

What is Carbon Dioxide?

Carbon dioxide (CO_2) is an odorless, tasteless, colourless, non flammable gas, naturally present in the atmosphere and indispensable for life.
It is necessary for the photosynthesis process of the plants, to produce oxygen and to sustain life on earth.

CO_2 is generated both by natural and industrial activities. The principal natural sources of CO_2, called also biogenic, are human and animal respiration, decomposition of organic matter, volcanic eruption, natural combustion, forest fires etc; whilst industrial activities like electricity production, combustion of coal or hydrocarbons, fermentation, cement production or oil refining account for an important amount of CO_2 released in the atmosphere.
Emissions from the burning of petrol and diesel for transports is another large source of CO_2 generated by human activities.

Use and valorisation of recovered carbon dioxide :
For many years, Air Liquide has been developing solutions to recover and purify the CO_2 emitted by industrial and natural activities, to propose to the customers a high purity CO_2 in respect of our planet and its sustainability.

CO_2 is largely used in all industries at different degrees of purities.

Among many usages, the CO_2 industrial quality. is used for cleaning, degreasing, welding; the food grade quality is fundamental to freeze or to prepare food, as well as very high purity for labs or as refrigerating gas for climatisation.
Air Liquide proposes CO_2 in cylinders, bundles, or in liquid form with the required level of purity and for all activity sectors.

NEXT ›

Air Liquide, your partner in Europe

Since several year Air Liquide recovers and purifies the CO_2 to offer a product with high purity in respect of our planet and of customers need.

Reliable sourcing

Dedicated knowledge & expertise

European presence

Continuous innovation

Reliable sourcing

- **Largest production network in Europe;**
- **Sustainable portfolio** of sources: fermentation, fertilizers, biomass, steam methane reforming;
- **Strong investment in biogenic environmental friendly sources** over last years;
- **Continuous improvement** of our capacity (+40% in 5 years).

Dedicated knowledge & expertise

- **Global Supply Chain** from capture to customer applications;
- Diversified **application portfolio;**
- **Know-how and experience:** dedicated experts;
- **Engineering and maintenance teams:** to implement the caputre and purification processes.

European presence

- **Dedicated organization** to manage production, distribution, quality, business development;
- **Preferred supplier** for key players in several fields, like the food industries and the metal and plastic industries.

Continuous innovation

- **100 active patents** in CO_2;
- Co-development with **customers & partners;**
- Direct involvement in **major international R&D projects;**
- Leading **innovation in CO_2 capture** (several pilot operations) and CO_2 valorisation.

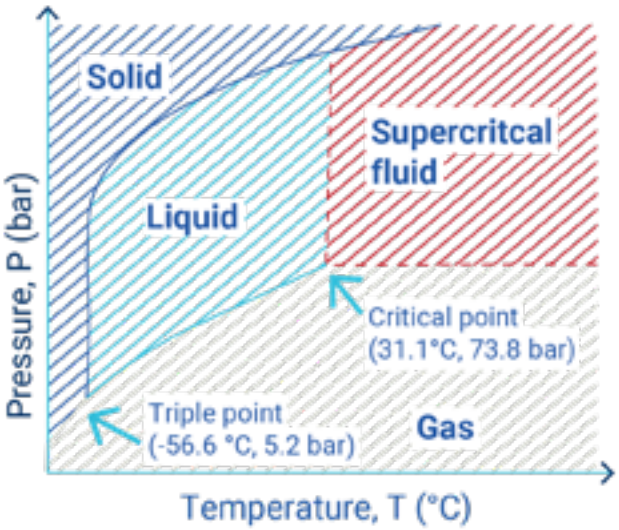
NEXT ›

What is the Supercritical Carbon Dioxide?

A fluid is said "supercritical" when it is heated above its critical temperature (Tc) and compressed above its critical pressure (Pc). Several fluids like water, ethane, propane or carbon dioxide can go supercritical.

Supercritical fluids have properties that are intermediate between gas and liquid, exhibiting both high diffusivity and low viscosity.

Carbon Dioxide is the most widely used supercritical fluid because of the easily accesible critical point (Tc= 31°C, Pc=74 bar). Moreover the supercritical CO_2 is chemically inert, non-flammable and available at high purities and at fair costs.
Beside having the density of a liquid and the diffusivity of a gas, supercritical CO_2 has also the unique property to be a natural solvent of oils; varying the pressure and the temperature it is possible to adapt the solvation power of sCO_2 to different oils.



At supercritical conditions, CO_2 has:

- Gas-like viscosity
- Liquid-like density
- Enhanced solubility
- High msicibility (with organic solvents)

NEXT ›

Industrial applications for the supercritical carbon dioxide

The supercritical carbon dioxide (sCO_2) is widely used in many industrial applications.

- FOOD & BEVERAGE
- PHARMACEUTICAL & COSMETICS
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- ENERGY PRODUCTION
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- TEXTILE INDUSTRY

Some examples of industrial uses:

FOOD & BEVERAGE:
Decaffeination of coffee beans, extraction of natural essences from plants (ex: hops, aromas), dairy products processing (milk sterilization and pasteurisation, milk fat fractionation, extraction of cholesterol in butter, cheese, cream), sterilization of fruit juice, elimination of pesticides,...

PHARMACEUTICAL & COSMETICS:
Extraction of active components from plants, production of drugs loaded medical implants for locally drug releasing (ex: antibiotics, hormones), extraction of oils and vegetal components for perfumes and beauty products.

ELECTRONICS:
Cleaning and degreasing of optronic element sand electronic cards after soldering and assembly.

METAL WORK:
Replacing of oil and wet lubricants with sCO_2 for machining operations: drilling milling, turning. Degreasing and deep cleaning of plastic parts, ceramic elements and metal working.

ENERGY PRODUCTION:
Working fluid in compressor and turbines for power generation.

CHEMICAL:
Extrusion of elastomers, synthesis and purification of polymers and composites, catalysis.

WOOD / PULP AND PAPER INDUSTRY:
Lignin extraction, extraction of contaminant from waste paper for recycling.

TEXTILE INDUSTRY:
Cleaning and degreasing of functional textiles, ecological dyeing of textiles, tanning of leather.

NEXT ›

A green solvent and a clean lubricant

Supercritical carbon dioxide is an attractive alternative to traditional organic solvents and lubricants.

Cleaning and lubrication are two fundamental parts of industrial production processes, but the use of traditional solvents and oils has some invonvenients:

- Pollution of water and soil, dermatitis or respiratory problems for humans;
- Strict regulations for storage and recycling of exhausts oils and lubricants;
- Some solvents and oils are under investigation to evaluate their toxicity and carcinogenicity.

Supercritical carbon dioxide is therefore an attractive alternative to traditional fluids.

Cleaning: the parts to be cleaned are immersed in a bath of supercritical carbon dioxide. The sCO_2 enters in each anfractuosity like a gas and flush out the dirt like a liquid. The solvation strength of sCO_2 can be adapted by variating the supercritical temperature and pressure.

Lubrication for machining processes: the supercritical fluid is projected between the metal part and the cutting tool, where it expands, it generates cold and it acts as a dry lubricant.

Although CO_2 is a greenhouse gas, Air Liquide CO_2 is captured from the environment and purified, then used in the processes and eventually it is returned to the environment. this virtous cycle have a very low impact on the greenhouse effect.

Applications	Methods	Alternative technical solutions	Use of water / water vapour	Risk to pollute soil or water, Volatile Organic Compounds emissions	Risk of allergies, dermatitis for operators	Possibility to mix sCO_2 with additives
Degreasing	Immersion in sCO_2 baths	Solvents, water vapour, manual wiping	No, dry cleaning	No	No	Yes, if required
Lubrication	Projection of sCO_2	Oils or additives with water	No, dry lubrication	No	No	Yes, if required

NEXT ›

FAQ about carbon dioxide

How Air Liquide's CO_2 is produced?

How can I buy CO_2, which is the supply mode?

Is the use of CO_2 safe for the operators?

Are there any regulations/ safety standards on the use of CO_2?

What is the limit of 5000 ppm (parts per million) or 0,5% of CO_2?

How Air Liquide's CO_2 is produced?

Air Liquide's CO_2 is not produced, it is captured and purified from the emission of other industries like bioethanol, fertilizers, petrochemical who produces the CO_2 during their processes.

How can I buy CO_2 and which is the supply mode?

Air Liquide offers Carbon Dioxide in solid, gaseous or liquid phases. The solid phase, also called dry ice, is delivered in pellets or in blocks, while the gaseous or the liquid CO_2 can be delivered in bottle / bundles of bottles for small consumption or in liquid phases and stored in a tank. Air Liquide proposes distribution systems including booster pumps, heaters, buffer tanks, etc to satisfy your technical specifications.

Are there any regulations/safety standards on the use of CO_2?

Yes. The CO_2 is naturally present in the fresh air. We breathe in a concentration of 300-400 ppm. However if the concentration of CO_2 is too high, more than 50 times the concentration in fresh air, the CO_2 starts having negative effects on human physiology. For this reason, the use of CO_2 undergoes some safety rules especially for its usage in a closed space. The room has to be equipped with anoxia and CO_2 detectors connected with visual and sound alarms. The working space must be well ventilated and possibly equipped with an exhaust CO_2 extraction system.

Is the use of CO_2 safe for the operators?

The use of CO_2, in respect with the safety regulations, doesn't present any risk for the operators.

What is the limit of 5000 ppm (parts per million) or 0,5% of CO_2?

Two major institutions the EIGA (European Industrial Gas Association) and the OSHA (Occupational Safety and Health Administration) have fixed the limit values: the Permissible Exposure Limit (PEL) is 5000 ppm (parts per million) or 0.5% of CO_2 for a maximum exposure time of 8 hours. This means that a human can not stay for more than 8 hours in a room with a CO_2 concentration of 5000 ppm.

NEXT ›

FAQ about Supercritical Carbon Dioxide

What is a supercritical fluid?

Do all materials go supercritical?

Is supercritical carbon dioxide (sCO_2) a new fluid?

Can traces of supercritical carbon dioxide (sCO_2) remain in the treated material?

Is supercritical carbon dioxide (sCO_2) a lubricant agent or a degreasing?

What is a supercritical fluid?

A gas or a liquid can go supercritical when it is compressed above its critical pressure and heated above its critical temperature. In those conditions, the molecules have a high kinetic energy to act like a gas (or to fight against intermolecular forces) and they are very close to each other due to the high pressure to act like a fluid, therefore a supercritical fluid has both the characteristic of a gas and a liquid at the same time.

Do all materials go supercritical?

No, not all the materials can pass in the supercritical condition. Some liquids like water and gases like CO_2 or can go supercritical.

Is supercritical CO_2 a new fluid?

No, it has been used for industrial processes since the end of the XX century, initially for coffee decaffeination, in cork treatment to remove cork taint, in oil extraction from plants, and later in medical domains to impregnate implants with drugs, in manufacture industries as cleaning and degreasing agent for almost all materials (metal, plastic, fabrics..), in energy generation and as lubricant fluid for machining.

Can traces of supercritical CO_2 remain in the treated material?

No, Supercritical Carbon Dioxide exists only at high pressure and temperature (Tc= 31°C, Pc=74bar). At atmospheric pressure and temperature CO_2 exists in a gaseous state and it doesn't rest inside the material.

Is supercritical CO_2 a lubricant agent or a degreasing?

Currently, it is the two, depending on its setting up, it can be used to degrease. In this case, it is used as a fluid to flush out the dirts from the smallest holes, or as a dry lubricant to reduce the friction between two or more parts in movement.

NEXT ›

From recovered to pure product

Most of the Carbon Dioxide (CO_2) delivered to customers by Air Liquide in Europe has been captured from bioethanol, fertilizer and Hydrogen production.

AL is committed to develop only recovered CO^2 new units
The recovery and purification process gives the CO_2 a second useful life. In fact it reduces the CO_2 emissions in the atmosphere while the molecule, initially considered as a fatal emission, is transformed into a raw material indispensable for several applications.

Biogenic CO_2

We preferentially source green/biogenic CO_2 from environmental friendly processes using renewable feedstock.

Recovered CO_2

We also source from **by-product CO_2** emitted by certain industries (“fatal emissions”) like Fertilizer and Petrochemical.

Generated CO_2

No project from processes with the sole purpose being to generate CO_2.

- CO_2 geological wells
- Hydrocarbons combustion

Biogenic CO_2

Recovered CO_2

Generated CO_2

NEXT ›

Supply chain from sourcing to customer

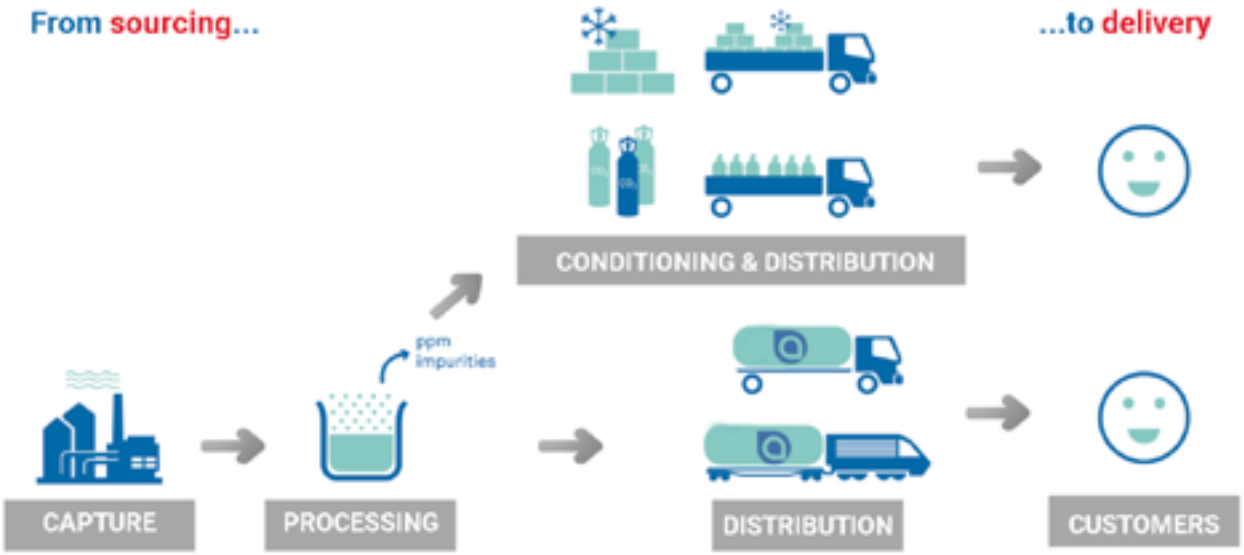
The CO_2 is captured at the source, purified and conditioned in liquid, gas or solid phase with the appropriate packaging to satisfy the final needs.

The dry ice is CO_2 in solid phase, delivered in pellets or in blocks, usually delivered in boxes.

Bottle or bundles of bottles are suitable for an usage of CO_2 in gaseous form. The gas is pressurized at 50 bars for quantities up to 300kg for packaging.

Bottle or bundles with dip tube are dedicated for application requiring a small amount of liquid CO_2.

For bigger consumption, CO_2 is delivered in liquid form. Air Liquide assures the transport and the rental of the storage tank installed at the customer's working site .



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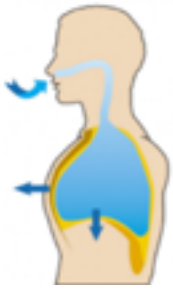
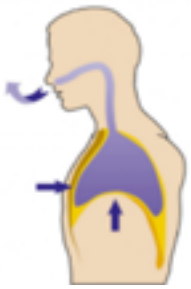
Concentration and effects on human physiology

Composition
O_2=21%
CO_2=0,03%
(300 ppm)



Composition
O_2=16,5%
CO_2= 4,1%
(41000 ppm)



EIGA SOURCE

- 300-400 ppm: fresh air composition
- 600-1000 ppm, acceptable indoor air

- 5000 ppm (0,5%) uncomfort for sensitive people
- 1-1,5% headache for sensitive people, effect on metabolism after hours

- 3%: narcotic effect, headache, increase of pulse rate after few hours
- 3-5%: Difficult in breath, transpiration, intoxication after 30 min

- 5-10% loss of judgment, breath issues, in few minutes, risk of death
- 10%: unconsciousness in 1 minute, death if longer exposure time
- >10% immediate convulsions and death

0,03-0,04% of gaseous CO_2 composes the fresh air we inhale. At higher concentrations, CO_2 has a negative effect on human physiology; the gravity depends on the CO_2 concentration and on the exposure time.

The EIGA* and the OSHA** have fixed a Permissible Exposure Limit (PEL) for CO_2 of 5000 parts per million (ppm) (0.5% CO_2 in air) averaged over an 8-hour work day.

5000 ppm (0,5%) of CO_2 corresponds to.. 9g of CO_2 in 1m^3

Human emits CO_2: an adult at rest emits 0,8-1Kg of CO_2 in 24 hours only with the breath, while an adult doing an intense physical activity can emit 4 to 6 times more of CO_2.
5000 ppm of CO_2 are generated by 7-8 people seating for 1 hour in a room of 33m^3 (10-12m^2 meeting room) with no air changing, or when one person sleeps for 8 hours in a 33m^3 bedroom (small hotel room) with no air changing. A longer permanence in confined spaces with no air chaigning, can generate a sense of uncomfort or headache.
All those effects are reversible and disappears in few minutes after leaving the room.

EIGA* (european gas Industrial association)
OSHA** (Occupational Safety and Health Administration)

NEXT ›

Carbon dioxide: safety @usage

The use of CO_2 for industrial applications in confined spaces undergoes specific laws. The limit of the human exposure to high concentrations of CO_2 during a fixed lapse of time is given by the EIGA* and the OSHA**.

The exposure limit ant exposure time to CO_2 is fixed to 5000 ppm and 8 hours, that means that an adult can not stay for more than 8 hours in a room with 5000 ppm of CO_2. to avoid depassing the treshold limits, any close space where CO_2 is used must have a correct air revewal, a CO_2 detector with alarm and sometimes an exhaust CO_2 extraction.

There is a second treshold limit for CO_2 concentration and exposure time. The values changes from country to country and they depends on the type of CO_2 application.

Carbon Dioxide is a heavy gas and it accumulates on the floor. The CO_2 detectors must be installed taking into account the non uniform composition of atmosphere.

CO_2 CONCENTRATION	TIME EXPOSURE LIMIT	EFFECTS	REQUIRED OR RECOMMENDED ACTIONS
First CO_2 threshold: 5000 ppm (0,5%)	8 hours	Uncomfort, light headache	Notification with a visual alarm. Obligation to detect and fix the problem immediately, no need to evacuate the room if the CO_2 concentration is quickly reduced.
Second threshold between 1% and 3% of CO_2, depending on local laws and type of applications.	Few minutes	Headache, breathing acceleration	Notification with a sound alarm and a visual signal, immediate stop the CO_2 source and evacuation of the room.

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OSHA** (Occupational Safety and Health Administration)