



STANDARD PRESENTATION – Last revision July 2019

## Vapour Recovery Units (VRU) for petroleum application

Adsorption–Absorption systems based on activated carbon and dry screw vacuum pumps

- 1 Company presentation
- 2 Why installing a VRU?
- 3 The VRU by CARBOVAC
- 4 Design and implementation
- 5 Some references

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Companies and participations in industrial activities



**Our activities**

35 years of expertise

1980

ALMA designs, develops and manufactures high-accuracy metering instruments dedicated to petroleum distribution. Thanks to its experience and expertise in manufacturing of turbines, sensors and electronics, as well as legal metrology, ALMA offers a wide and comprehensive range of products and solutions for your refined petroleum metering equipment needs.

2005

CARBOVAC specializes in hydrocarbons vapour recovery using an innovative technology that combines an adsorption process on activated carbon & regeneration by means of dry screw vacuum pumps. This unique know-how makes CARBOVAC a key player in the VRU market.

2015

ALMA & CARBOVAC have decided to share expertise and resources to strengthen its international presence around 4 business units; thus covering the whole of the transport & distribution petroleum chain:



**VAPOUR RECOVERY UNITS**

- Feasibility studies
- Development of customized solutions
- Basic engineering & design
- Turnkey solutions
- Local service



**OIL TERMINAL LOADING & METERING**

- Hydrocarbons loading / unloading (LPG included)
- Truck, wagon, ship
- Pipeline
- Additivation
- Coloration
- Blending
- Calibration and verification
- Supervision & management system



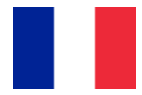
**TRANSPORT METERING**

- Tank trucks (rigid, semi), rail tankers and aircraft refuellers
- Gravity - pump - mix delivery solutions
- Diesel - gasoline - fuel - jet - LPG - AdBlue
- Data communication interface
- Master meter for calibration & repair
- Mobile flow meter for reception control



**AFTER-SALES SERVICE**

- Legal metrological verification of metering equipment
- Maintenance of loading arms instrumentation
- Mechanical maintenance of loading arms
- Maintenance of hydrocarbons Vapour Recovery Units
- Preventive, curative intervention contract
- Audit, upgrading, training
- Storage tank gauging

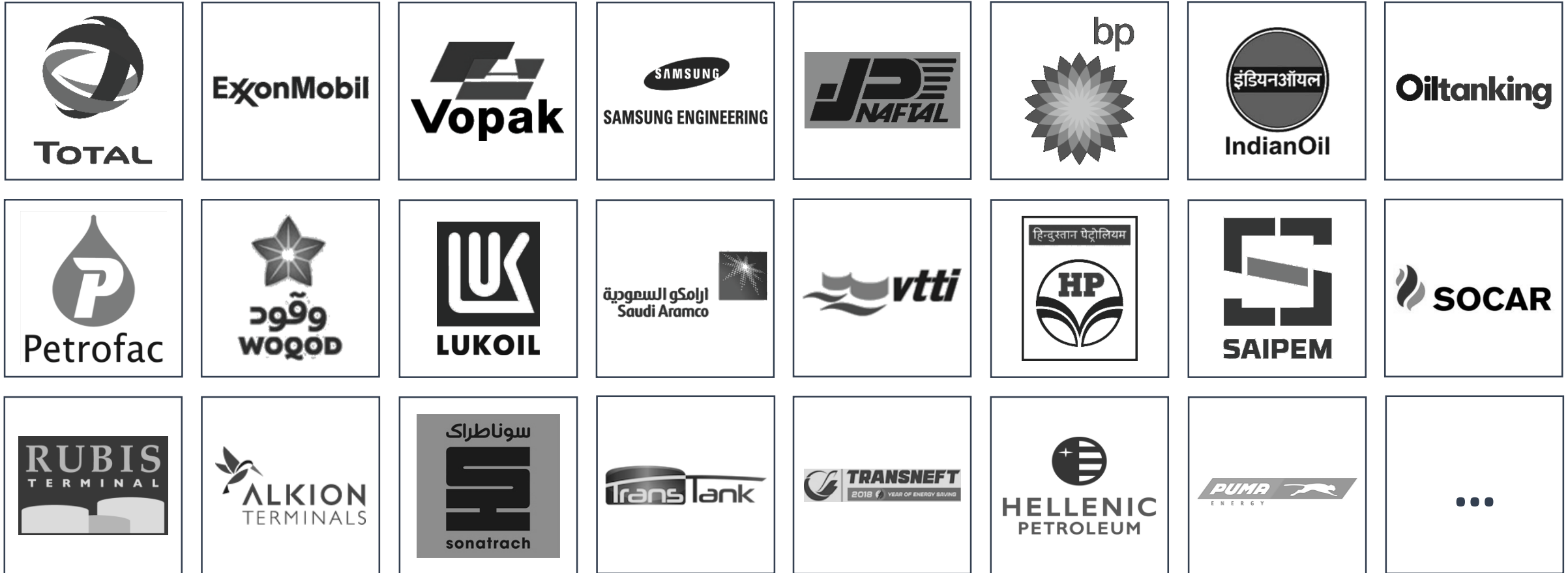


ALMA CARBOVAC: 100% owned by LE GARREC

230 employees / +35 M€

Headquarters in Paris area (Boissy Saint-Léger)

More than a 100 projects conducted through the world, in 25 countries



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## ENVIRONMENT

Meeting environmental laws and regulations  
Reduce pollution due to VOC releases  
Smell inconvenience



## HEALTH

Protection of human health (neighbourhood, operators)  
Protection of wildlife



## SAFETY

Reduction of hazardous environment in day-to-day operations at site (drivers, operators...)



## VALUE

Recovery of a valuable product

## European Parliament and Council Directive 94/63/EC (20<sup>th</sup> of December 1994)

ON THE CONTROL OF VOLATILE ORGANIC COMPOUNDS (VOC) EMISSIONS RESULTING FROM THE STORAGE OF PETROL AND ITS DISTRIBUTION FROM TERMINALS TO SERVICE STATIONS

For the purpose of this Directive:

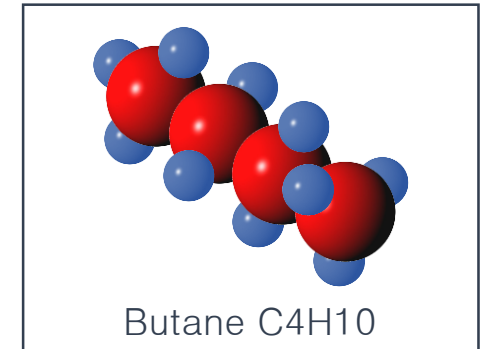
- a) “petrol” shall mean any petroleum derivative, with or without additives, having a reid vapour pressure of 27.6 kilopascals or more, which is intended for use as a fuel for motor vehicles, except liquefied petroleum gas (LPG);
- b) “vapours” shall mean any gaseous compound which evaporates from petrol;



# Vapour's concentration & hydrocarbons composition

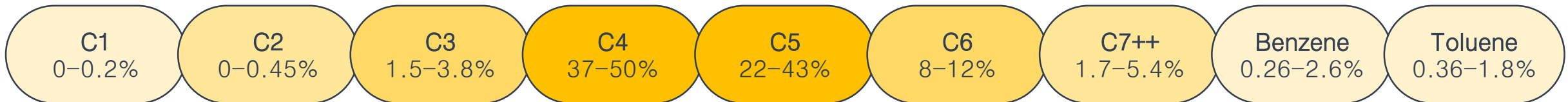
Vapour's concentration in hydrocarbons is influenced by:

- The type of products loaded
- Site conditions of exploitation (temperature...)
- The type of loading operations
- The recovery configuration at gas stations (trucks application)

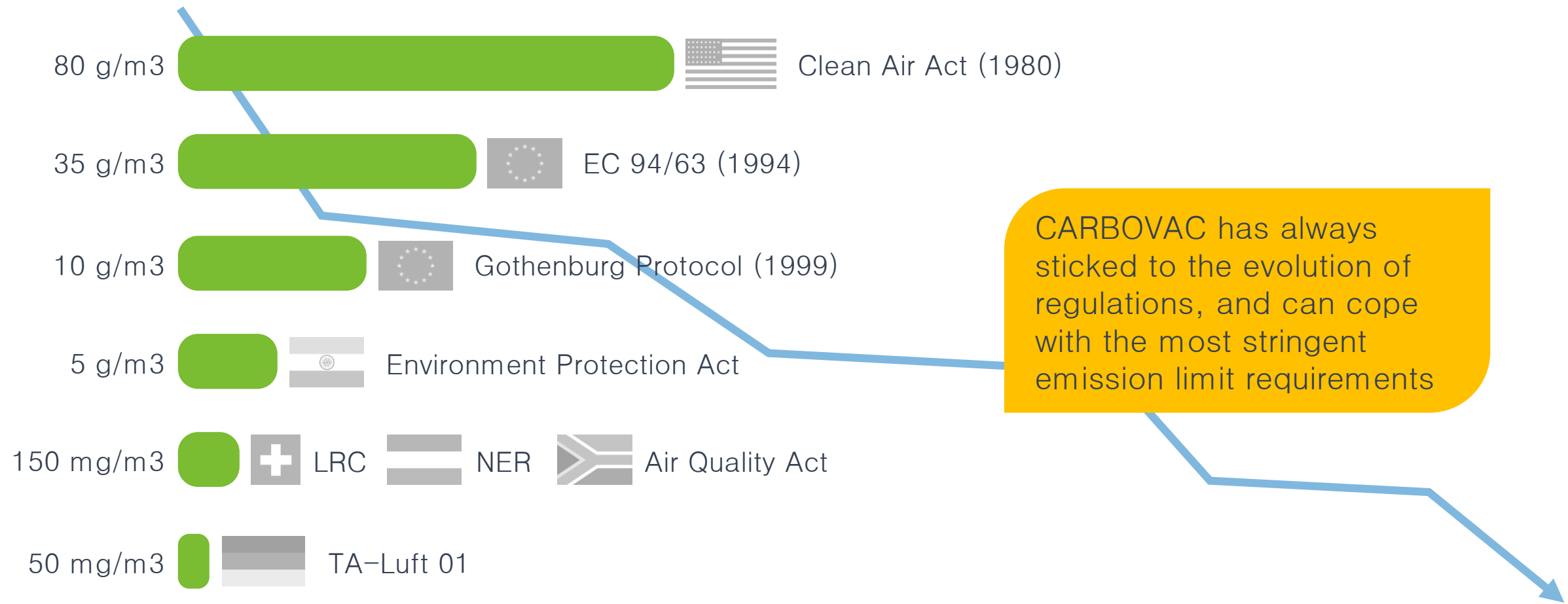


Concentration may vary **between 0 to 50% vol.** (av. mole weight 65 g):

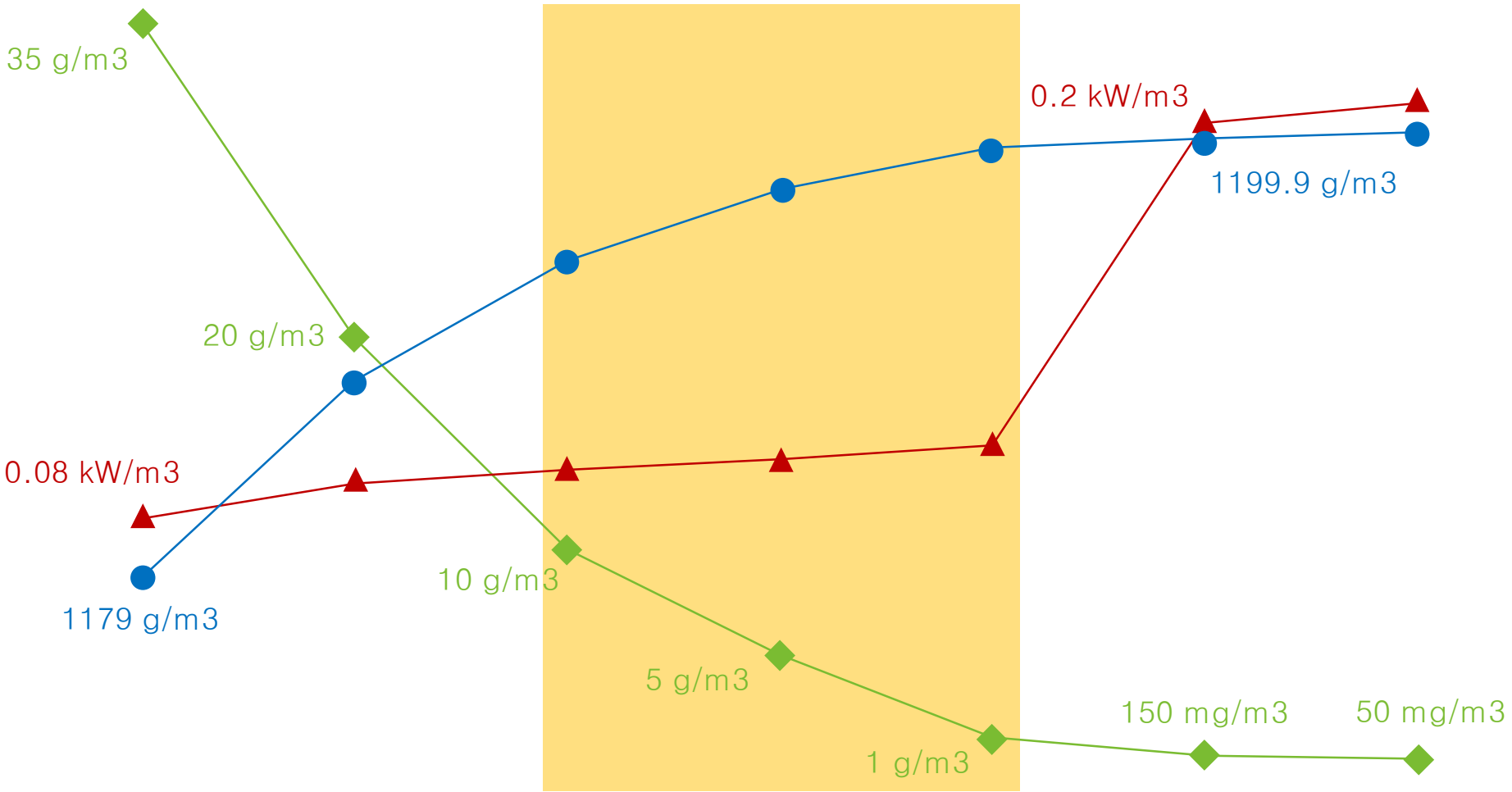
(typical hydrocarbons composition for gasoline vapours)



Improvement in vapours treatment technology has led to more stringent laws and regulations



Finding the optimum ratio between “emission limit”, “recovery rate” and “energy consumption”



Energy consumption increases with lower emissions level

Energy consumption difference between 1g/m<sup>3</sup> and 150 mg/m<sup>3</sup> is 2x more important

Extra 0.5 gram recovered costs 0.1 kWh

## VRU recovery calculation and monitoring

With the example of:

an inlet HC concentration of	40% vol.
an average outlet concentration of	2 g / m <sup>3</sup>
an average mole weight of	65 (gasoline)

Calculation of the mass of HC at VRU inlet / m<sup>3</sup>:

$$(0.4 \times 65) / (22.4 \times 10^{-3}) = 1160.7 \text{ g/m}^3$$

Mass of HC recovered = 1158.7 g / m<sup>3</sup> of inlet vapours

→ Effective recovery rate = **1.49 L / m<sup>3</sup>** of vapours

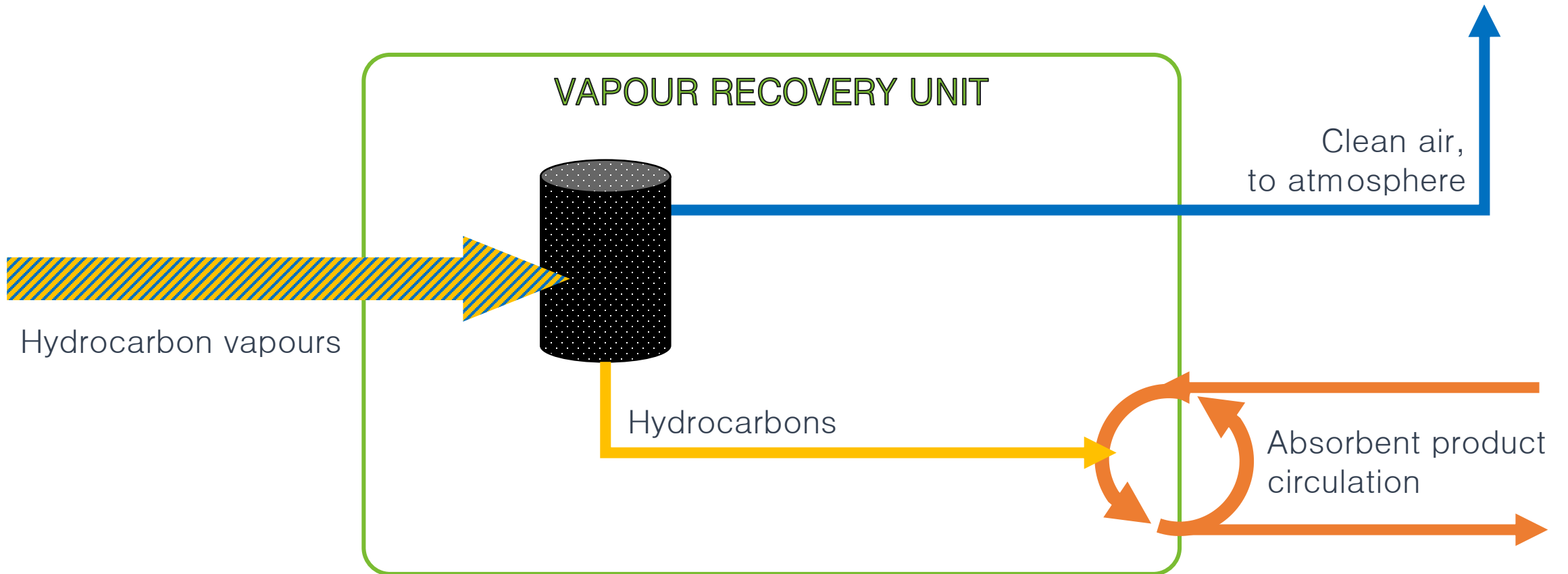
→ Vapour recovery rate = **99.9%**

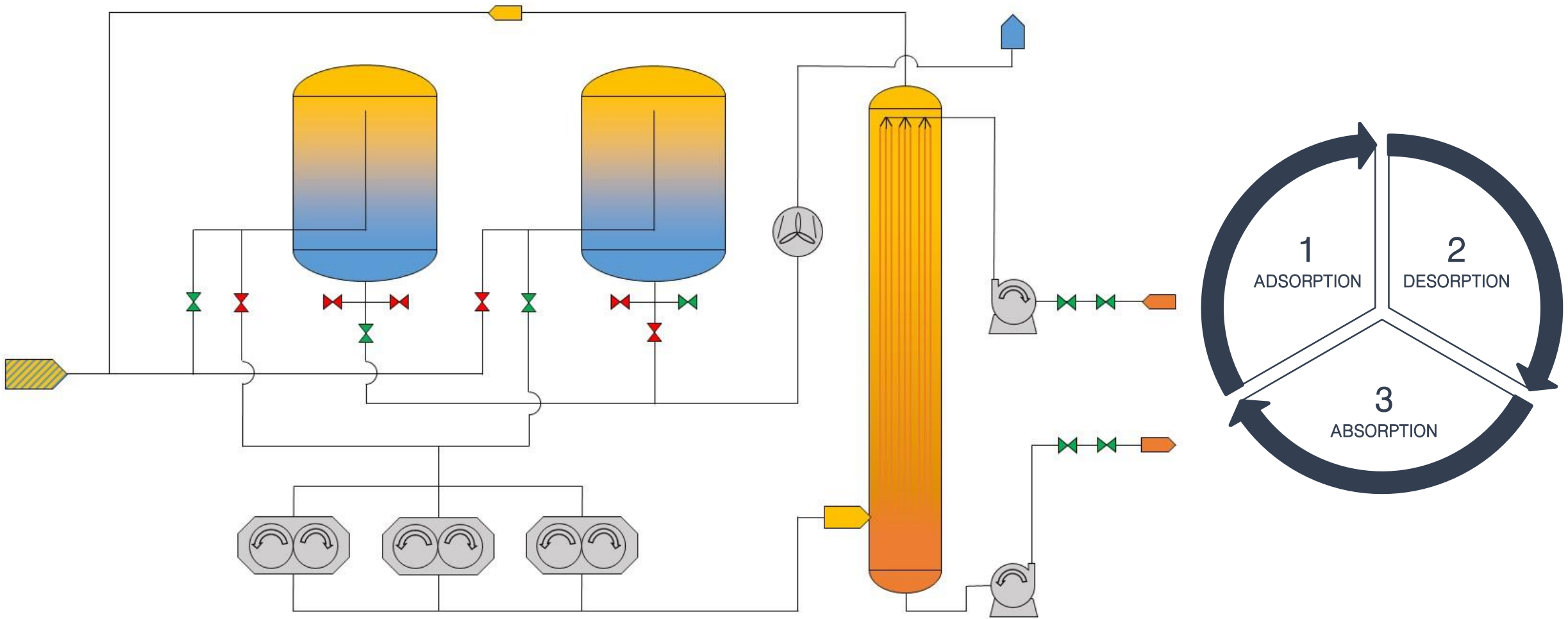
### DID YOU KNOW?

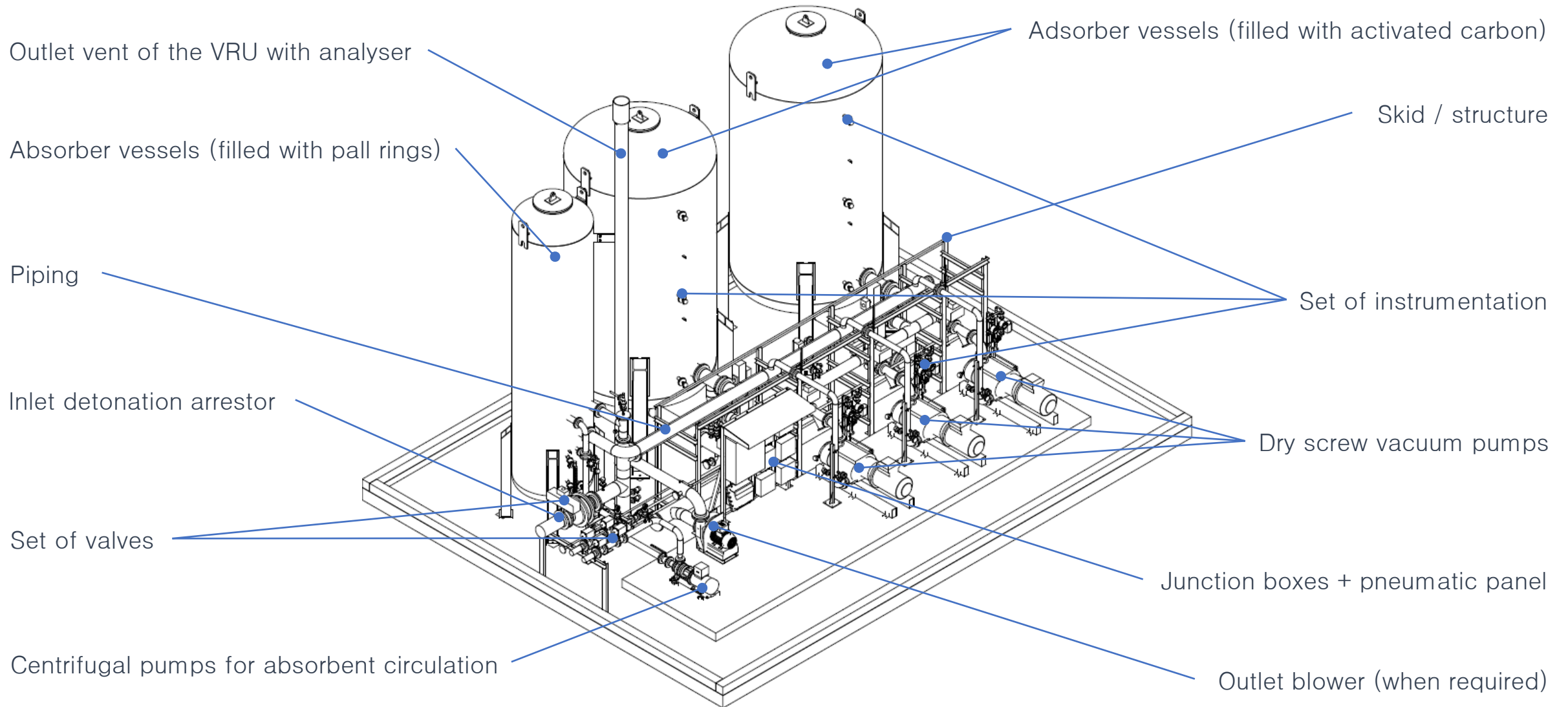
Out of a 30 m<sup>3</sup> gasoline tank truck, a VRU can permit to recover up to 45 L of gasoline.

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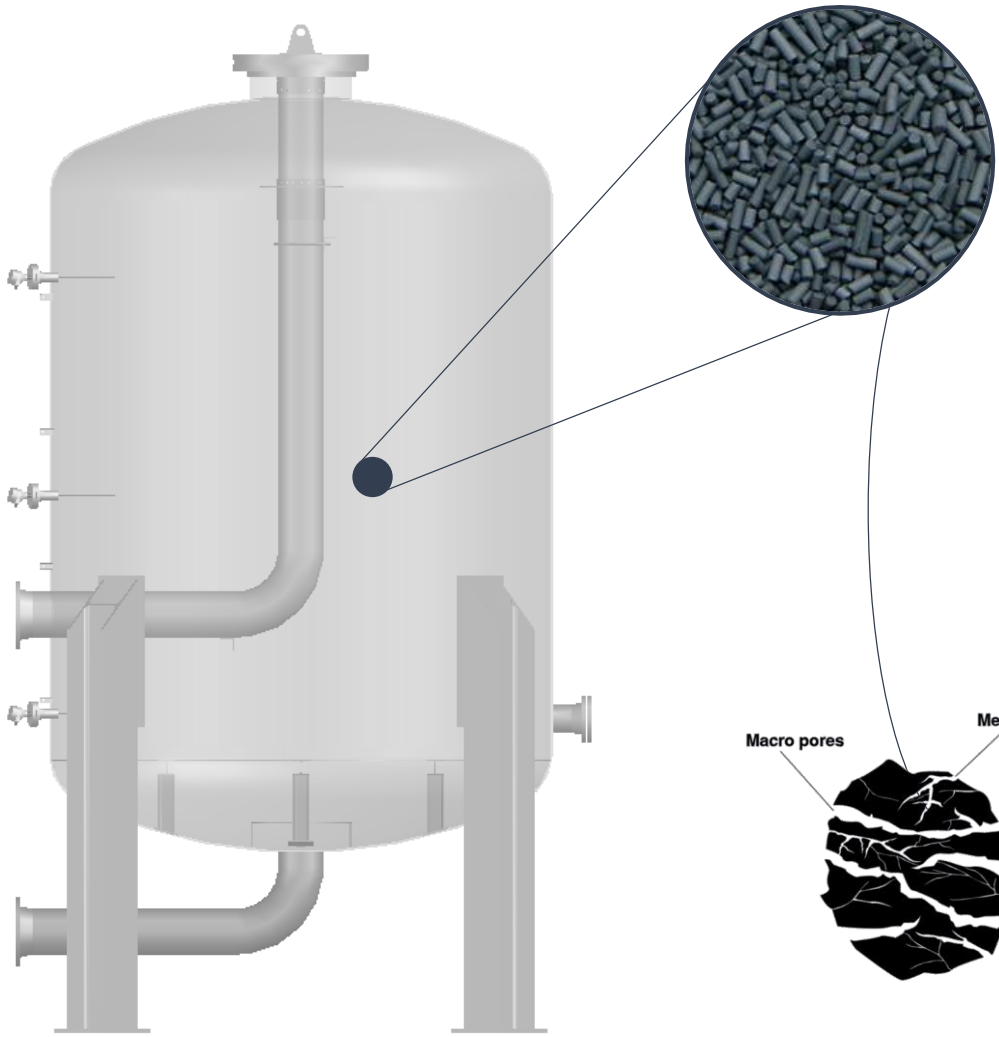
## What is a Vapour Recovery Unit (VRU)?









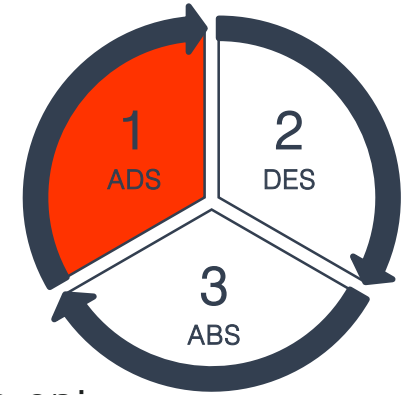


## Activated carbon beds

Most used absorbent through the World, obtained from carbonization and activation of natural products.

The adsorption capacity of the carbon depends on:

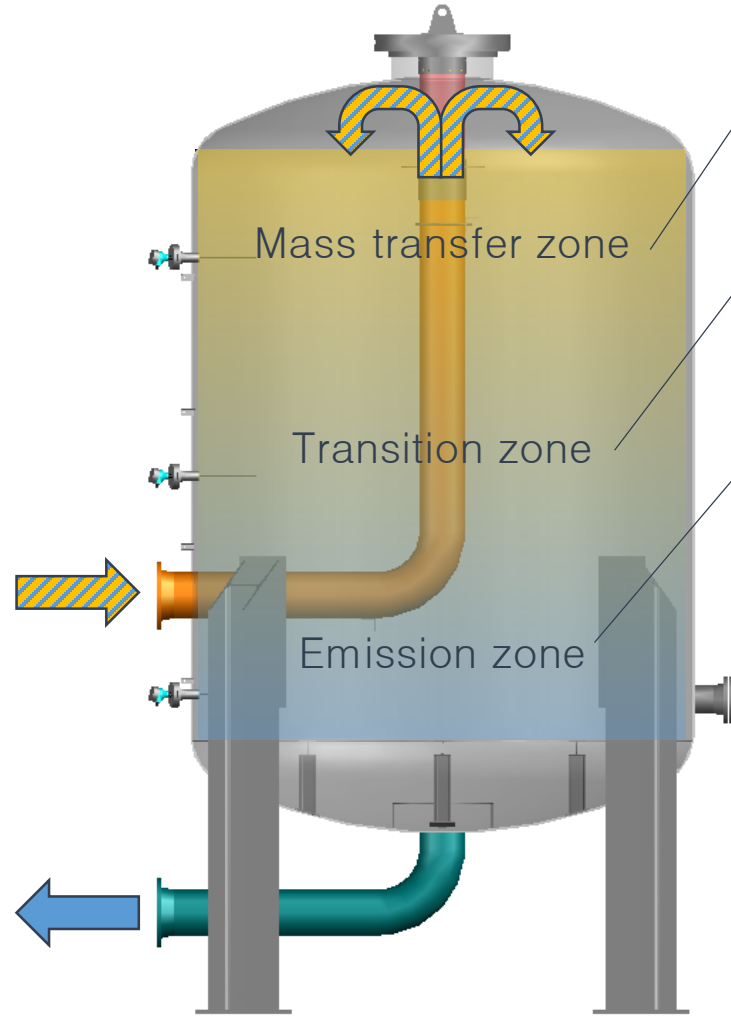
- Specific internal surface (up to 1200 m<sup>2</sup>/g)
- Pores size and distribution
- Base material properties and hardness



### DID YOU KNOW?

CARBOVAC uses mineral coal activated carbon, water steam activated.

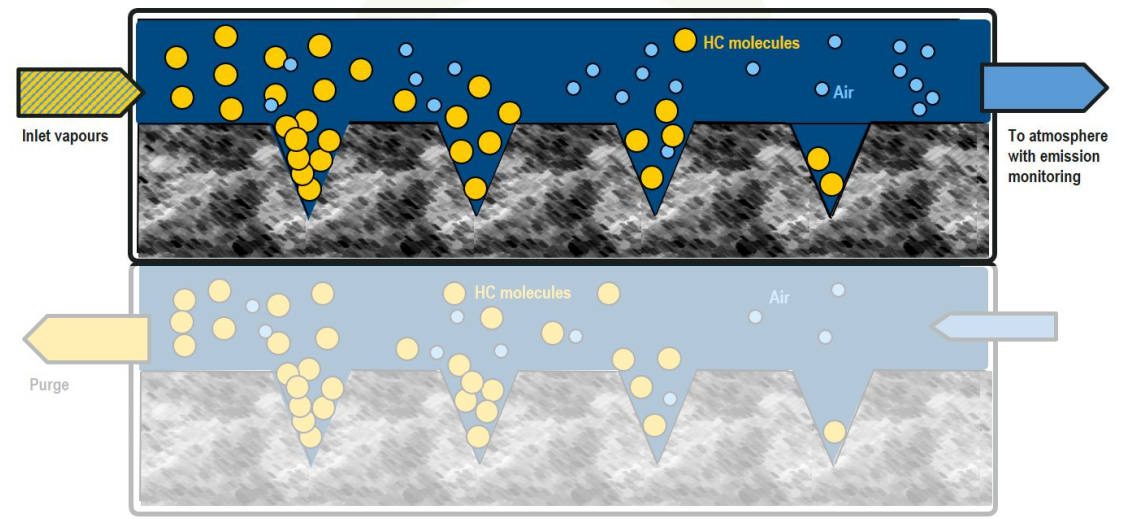
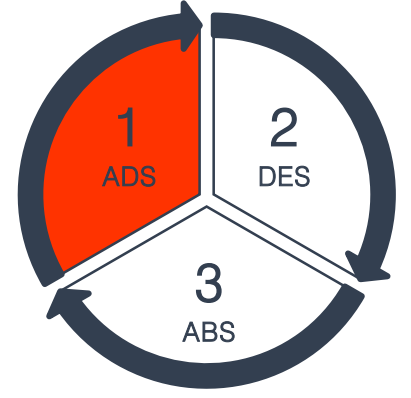
VRUs have been observed working with the same activated carbon for almost 20 years!

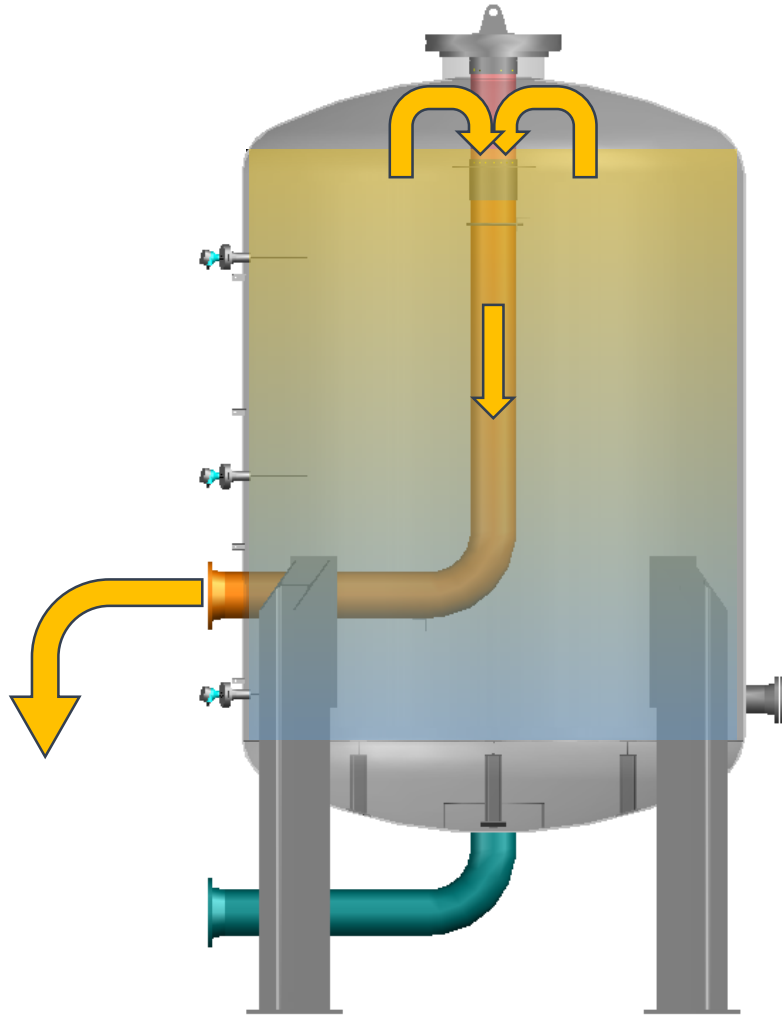


The mass transfer zone removes the bulk of the hydrocarbons.

The transition zone of the carbon bed provides a buffer for variations in flow rate and concentration.

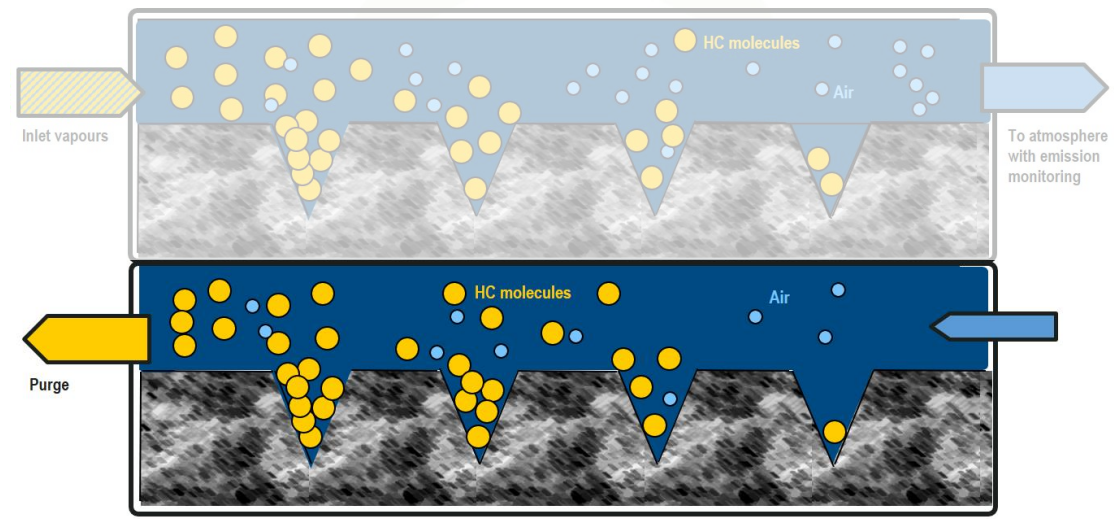
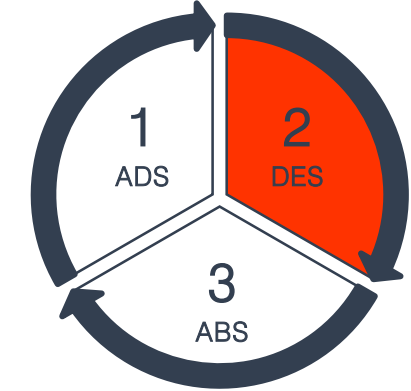
The saturation rate of the “outlet” layer (emission zone) of carbon must always stay low.





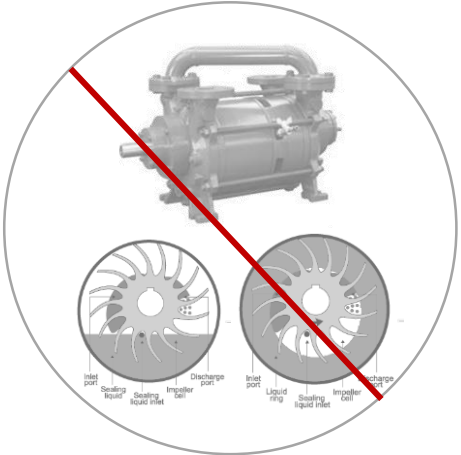
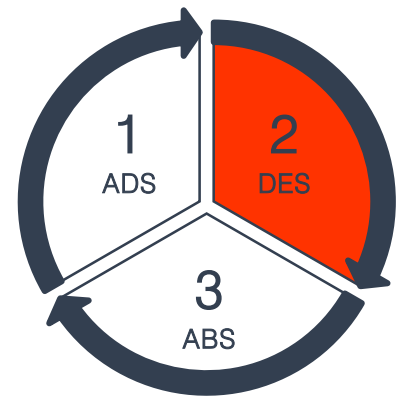
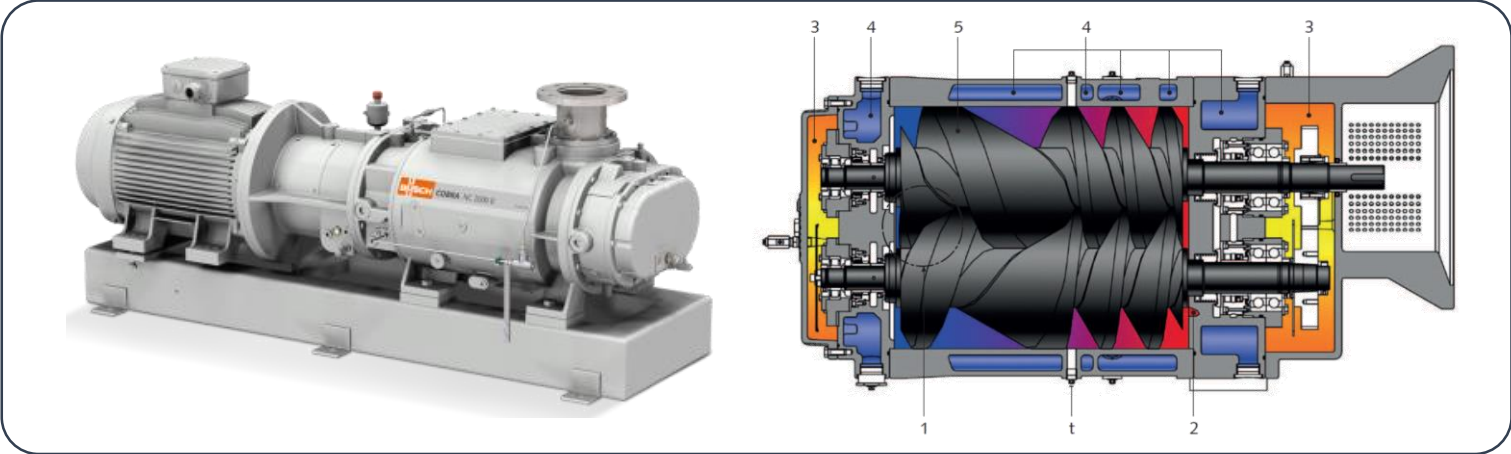
During desorption phase, the activated carbon bed is “cleaned” of its hydrocarbons content, by removing it through vacuum.

The need in vacuum (capacity, level of vacuum...) mainly depends on the type of hydrocarbons molecules stuck into the activated carbon, and on the level of emissions requested.

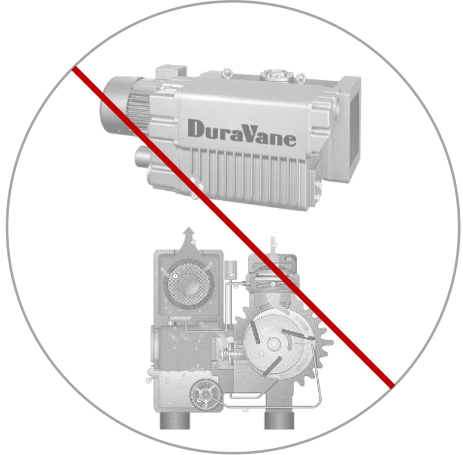


DRY SCREW  
VACUUM PUMPS

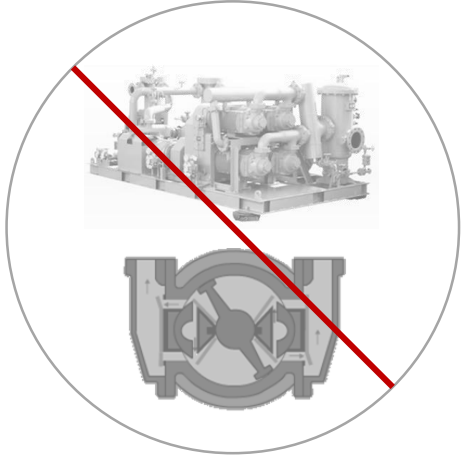
CARBOVAC is the specialist of VRUs using dry screw vacuum technology.



Liquid ring vacuum pump



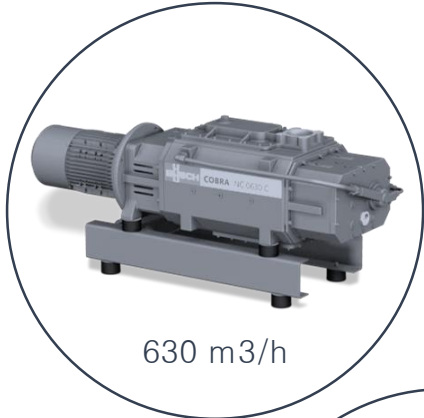
Rotary vane vacuum pump



Wing vacuum pump



COBRA industry range  
Made in Switzerland



630 m3/h



1500 m3/h



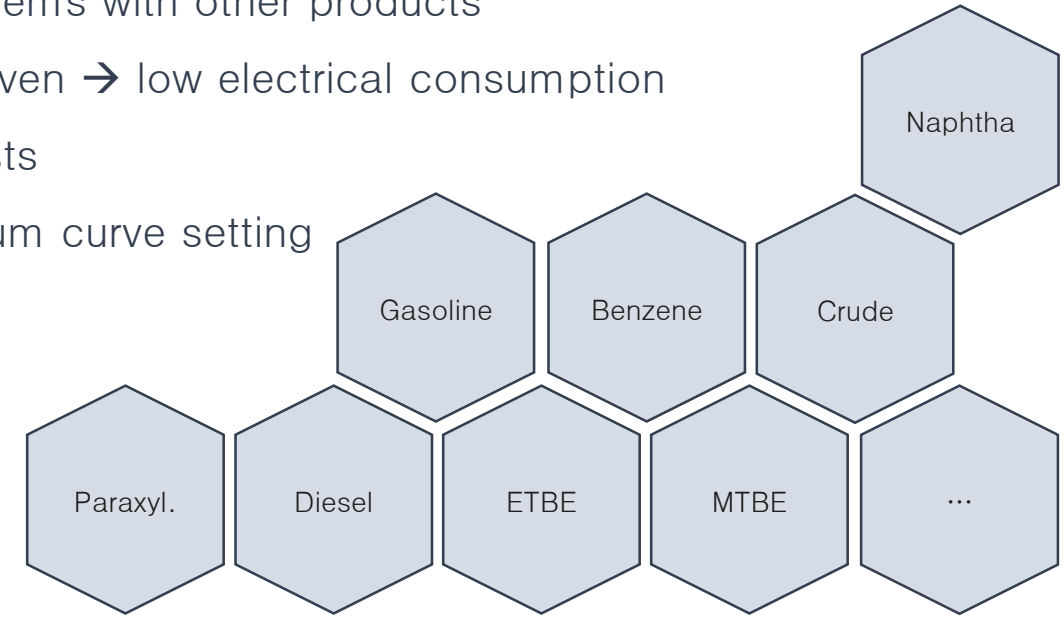
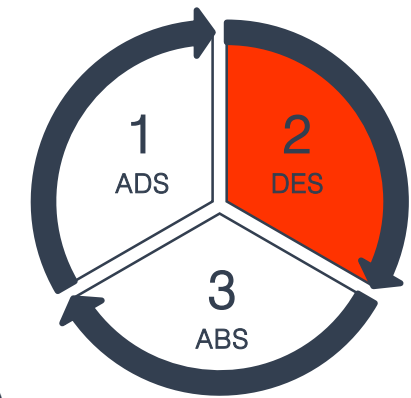
2500 m3/h

## Dry screw vacuum pumps

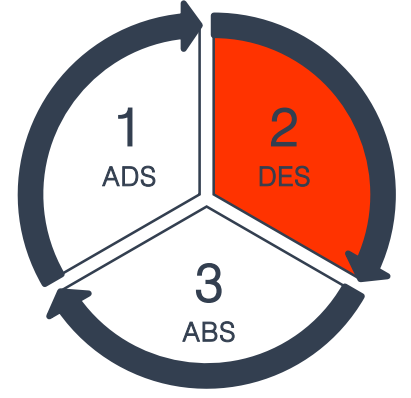
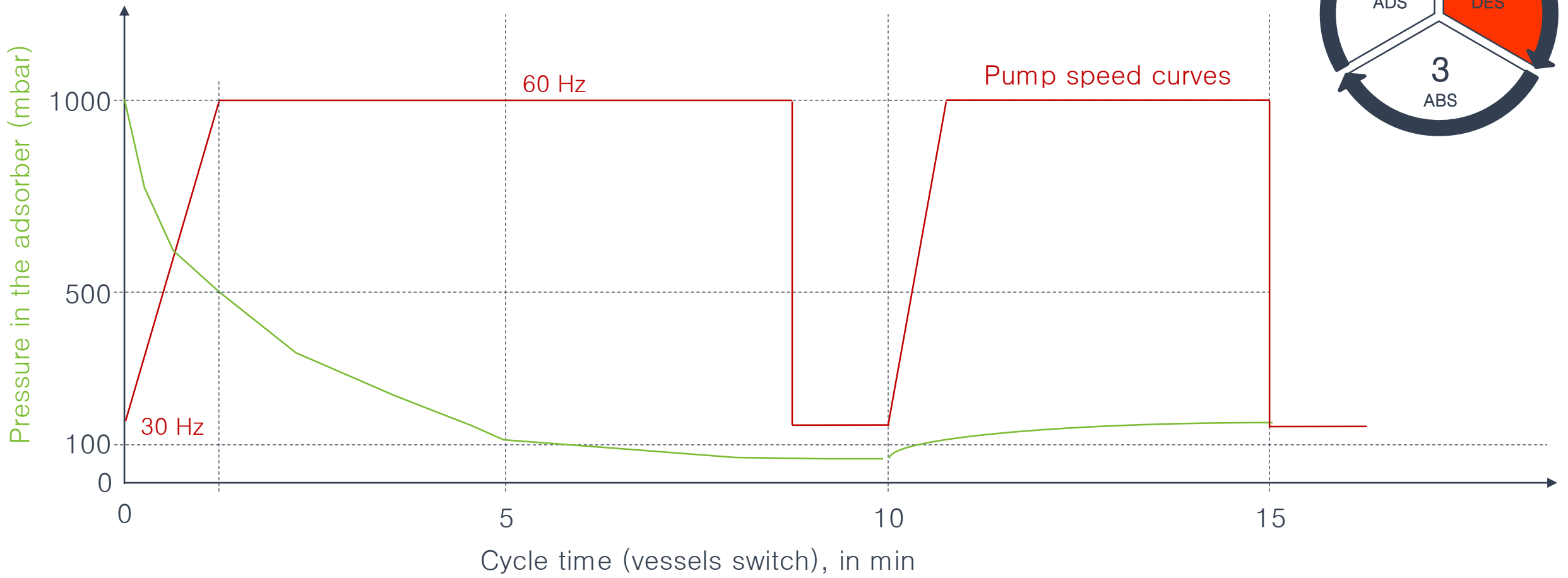
- Simple equipment
- Robust material (steel cast, monobloc screws)
- No internal touching parts
- No corrosion/no abrasion (compared to glycol system)
- No compatibility problems with other products
- Variable frequency driven → low electrical consumption
- Low maintenance costs
- Precision of the vacuum curve setting

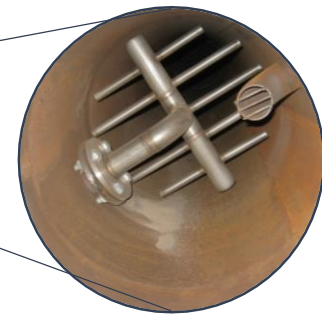
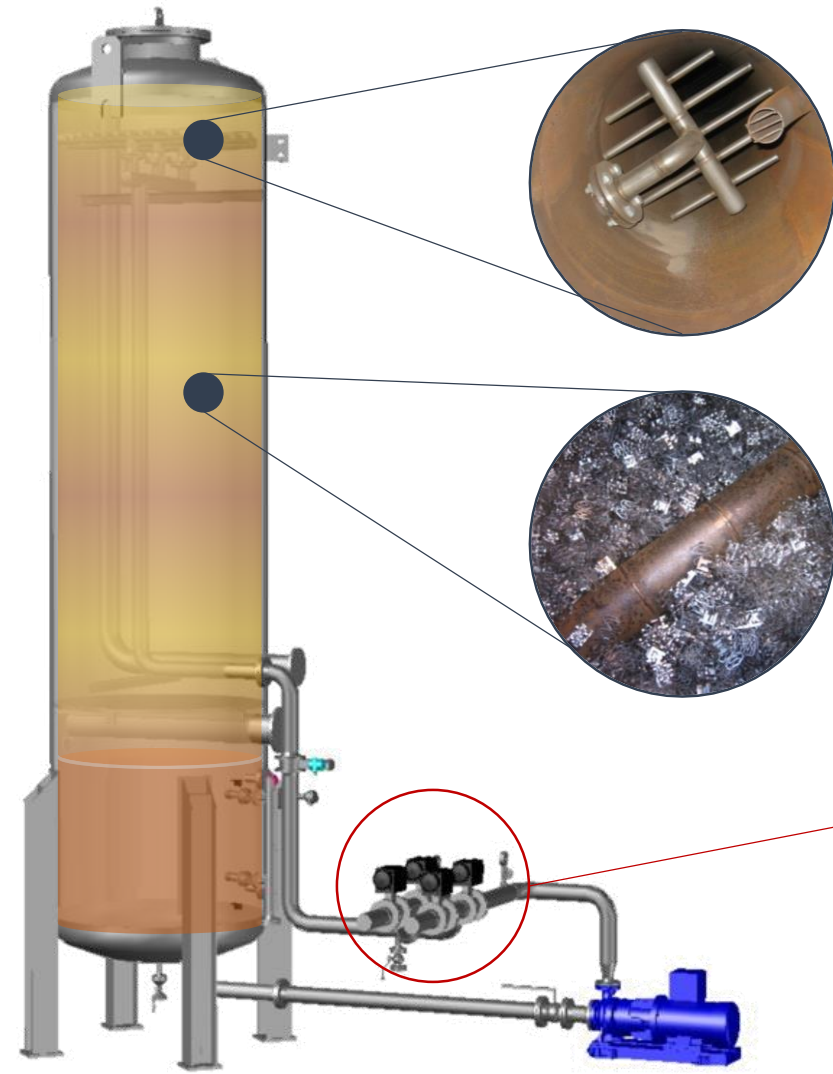
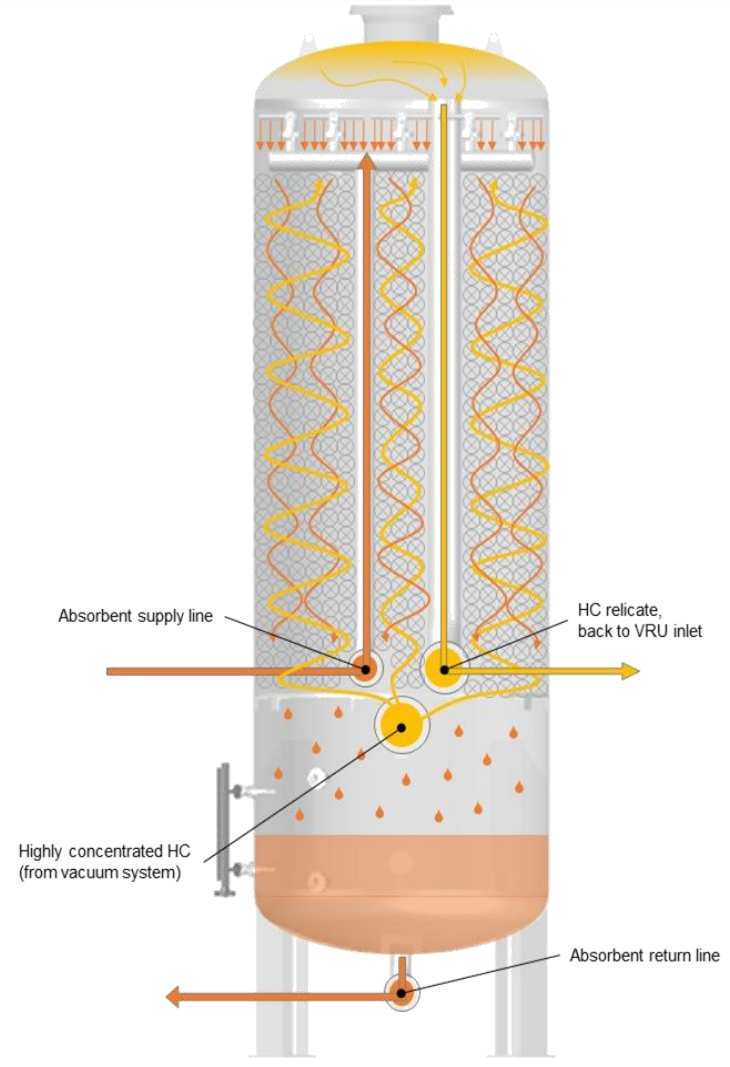
### MOTORS RATING:

- 22 kW
- 30 kW
- 55 kW



### Typical desorption/vacuum curve

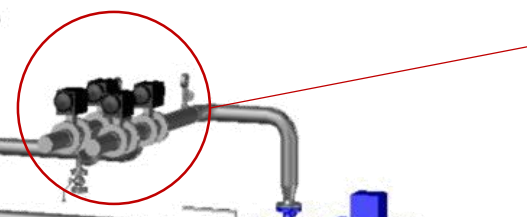




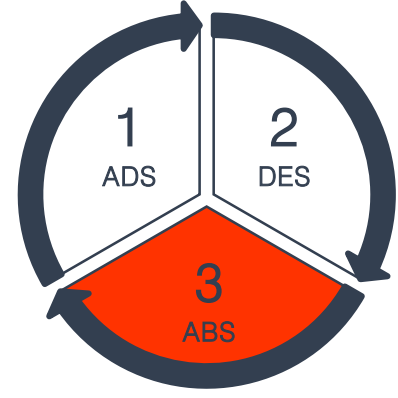
Absorbent shower” distribution



Column filled with aluminium packing rigs



A standard by CARBOVAC:  
2 positive closing valves  
(1 process + 1 safety)



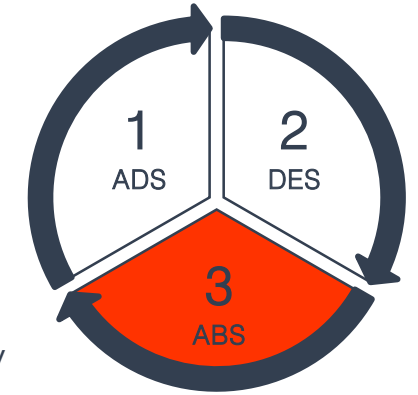
## Focus on the absorbent circulation circuit

The VRU process, and especially the **re-absorption phase** (column), introduces a **limitation** in terms of **absorbent product maximum vapour pressure** → 680 mbar

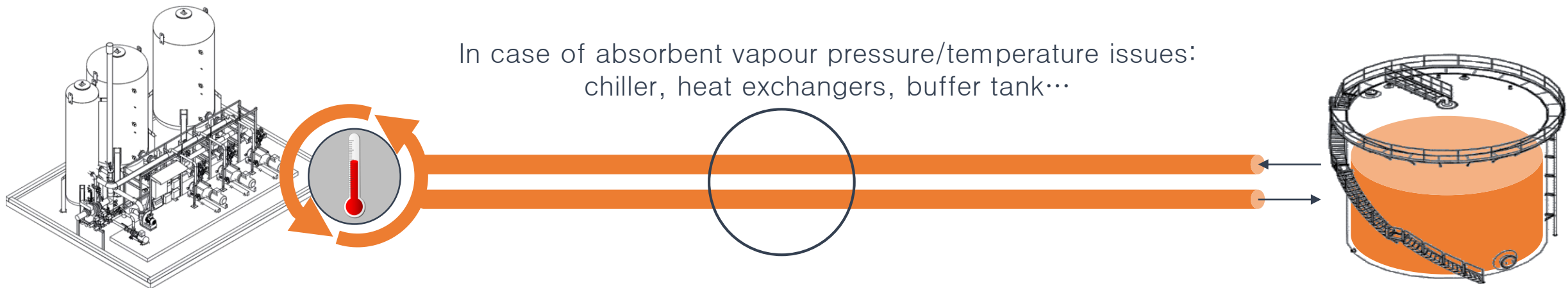
The recovered hydrocarbons being mainly **“light” components**, the absorbent product supplied to the VRU and the one returned to the storage are **not quite the same**: returned product is enriched with light components, and the temperature is slightly above (a few °C).

The philosophy behind the absorbent:

- Biggest volume available
- Highest product turnover frequency
- Who benefits from the VRU recovery?
- Main absorbent circuit / auxiliary circuit

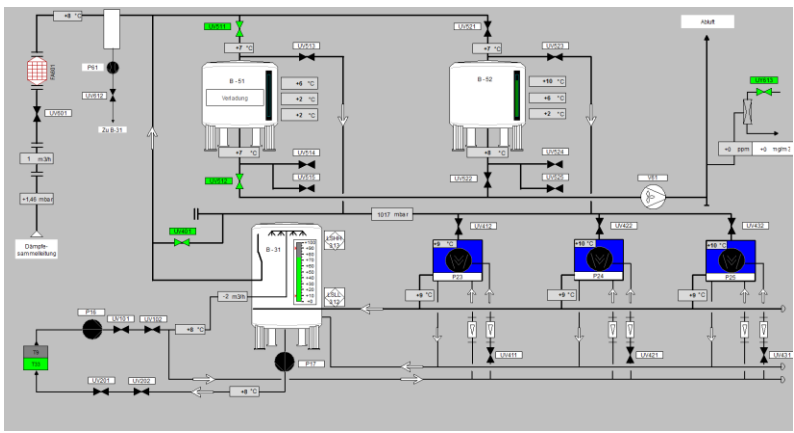


In case of absorbent vapour pressure/temperature issues:  
chiller, heat exchangers, buffer tank...





## Typical SCADA view of a CARBOVAC vapour recovery unit supervisor



B01 - Values				Electrovalve	
UV010	UV012	UV013	UV014	UV015	UV016
UV017	UV018	UV019	UV020	UV021	UV022
UV023	UV024	UV025	UV026	UV027	UV028

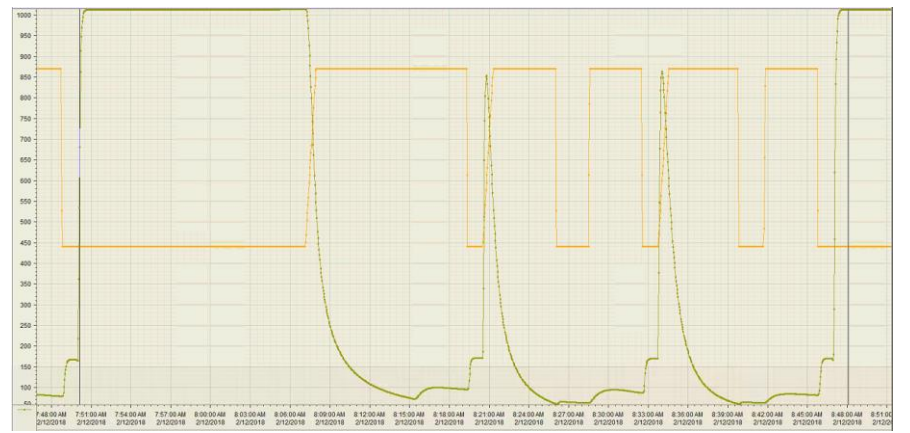
  

B02 - Values				Absorbent's Values	
UV029	UV030	UV031	UV032	UV033	UV034
UV035	UV036	UV037	UV038	UV039	UV040
UV041	UV042	UV043	UV044	UV045	UV046

PID	VAPOUR	VACUUM	CURVES	PARAMETERS	SYSTEM	STATUS	RESET
ABSORBENT			567	mbar	0	g/m3	

Process + shutdown safety signals monitoring



Curves checking (emission, elec. consump.)  
Historical reports

HAZOP, Explosion Protection Document,  
EC Declaration of conformity

The whole system is  
explosion shock proof  
to 9 barg

All valves with limit switches

Gasoline pumps installed  
below liquid level

High-high and low-low level  
switches on the re-absorber



Temperature monitoring in  
the activated carbon beds

Outlet temperature of the  
vacuum pumps < 50°C

Detonation arrestor at the  
inlet of the VRU

Two positive closing valves  
in each gasoline circulation  
line

“Watch dog” PLC  
For shut down function

With CARBOVAC, make the choice of:

▶ **Optimized / higher lifetime of vacuum pumps**

Robust design

No internal touching parts, no internal wears

Overhaul of the pumps only after 40 000 operating hours

▶ **Lower energy consumption <0.12 kWh/m<sup>3</sup> of vapours**

Regeneration energy proportional to the real mass of HC adsorbed

All motors equipped with VFDs to adjust the consumption to the mass HC to be treated

▶ **Higher lifetime of activated carbon**

Reverse flow (no dusting of the carbon)

Pressure controlled desorption process

Optimized pore size distribution

Low pressure drop

▶ **A real partner for your project**

Engineering (basic + detailed), expertise advising

Project management

Procurement

Delivery

Supervision of installation

Commissioning, start-up, training

▶ **Lower maintenance costs**

No corrosion or abrasion (absence of glycol)

Simple process: system limited to its mere elements

Selection of high quality equipment

## What we offer for your VRU project?

We accompany you at every stage of your VRU implementation project ...



Consulting & feasibility



Basic & detailed engineering



Project management



Sourcing & procurement



Manufacturing subcontracting



F.A.T. and inspections



Supervision of installation



Pre-commissioning & start-up



Training

... and VRU life-time, through competent contractors (LUVÉBA, local partners...)



Maintenance contracts



Tele-maintenance



Spare parts/bulk material



Testing/compliance



Rewamping/upgrades

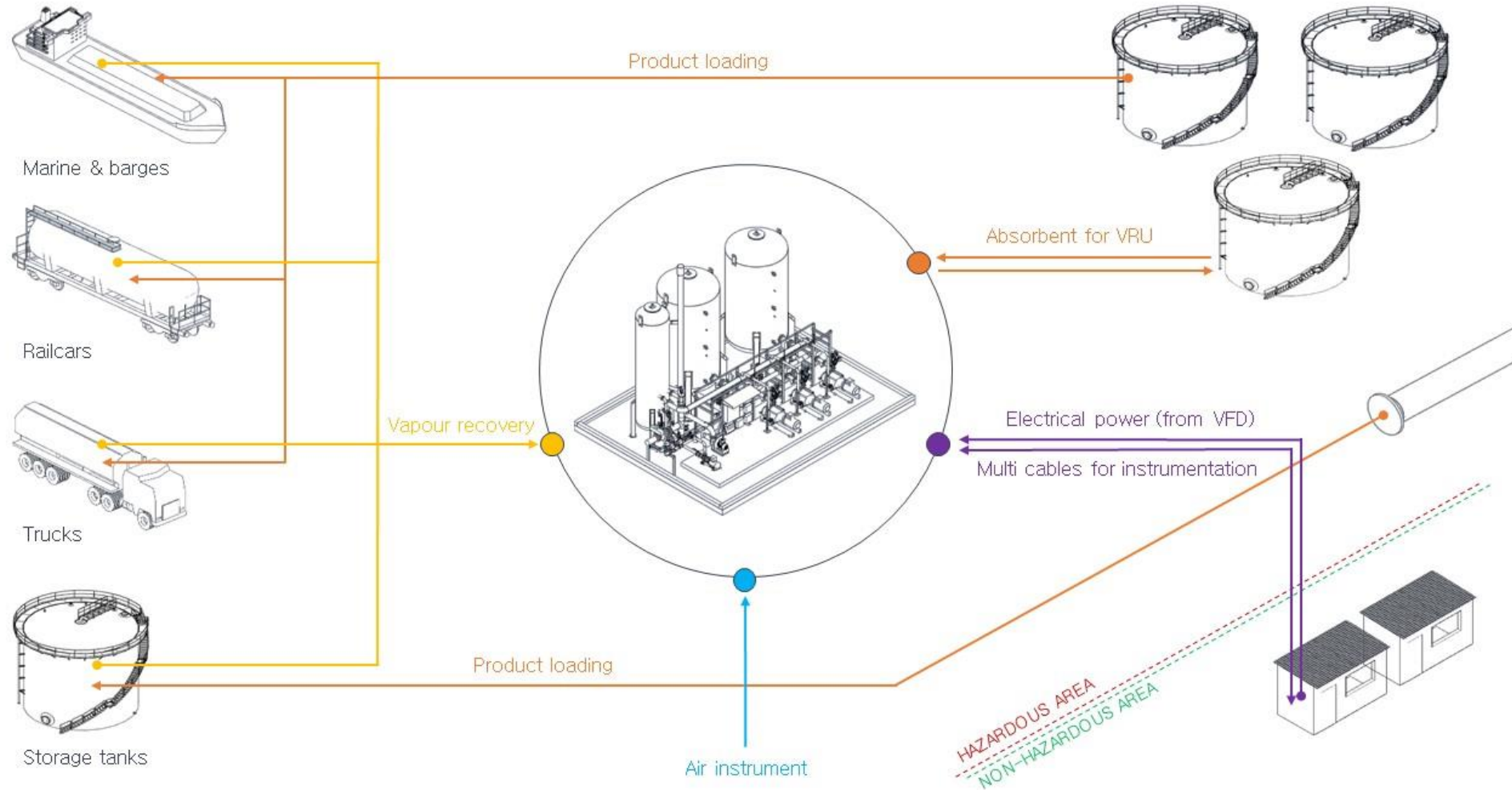
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main parameters to be considered to design a VRU

Q(i)	in m <sup>3</sup> /h	<b>Maximum instantaneous flowrate</b> mainly affects: inlet line size / pressure drop of the VRU
HC	in % vol.	<b>Vapours' hydrocarbons relative hydrocarbon concentration</b> mainly affects: all VRU design configuration
Q(c)	in m <sup>3</sup>	<b>Volume of vapours to be treated per "cycle"</b> mainly affects: activated carbon volume + vessels diameter
Q(4)	in m <sup>3</sup>	<b>Volume of vapours to be treated over a 4 hours' period</b> mainly affects: required vacuum capacity and configuration
Q(d)	in m <sup>3</sup>	<b>Volume of vapours to be treated per operating day</b> mainly affects: "overall adjustment factor"

# How does a VRU interacts with its environment?





Fabrication



Preparation for shipment



Shipment / transportation



Blank assembly

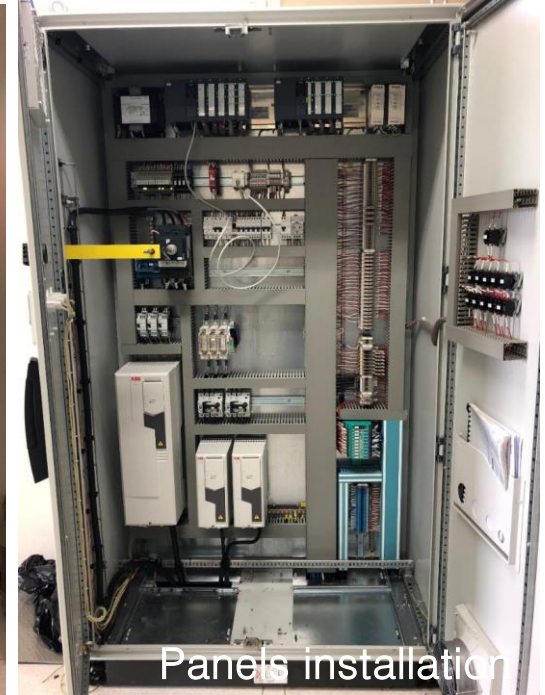


Preparation for shipment



Shipment / transportation





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CLIENT: OILTANKING

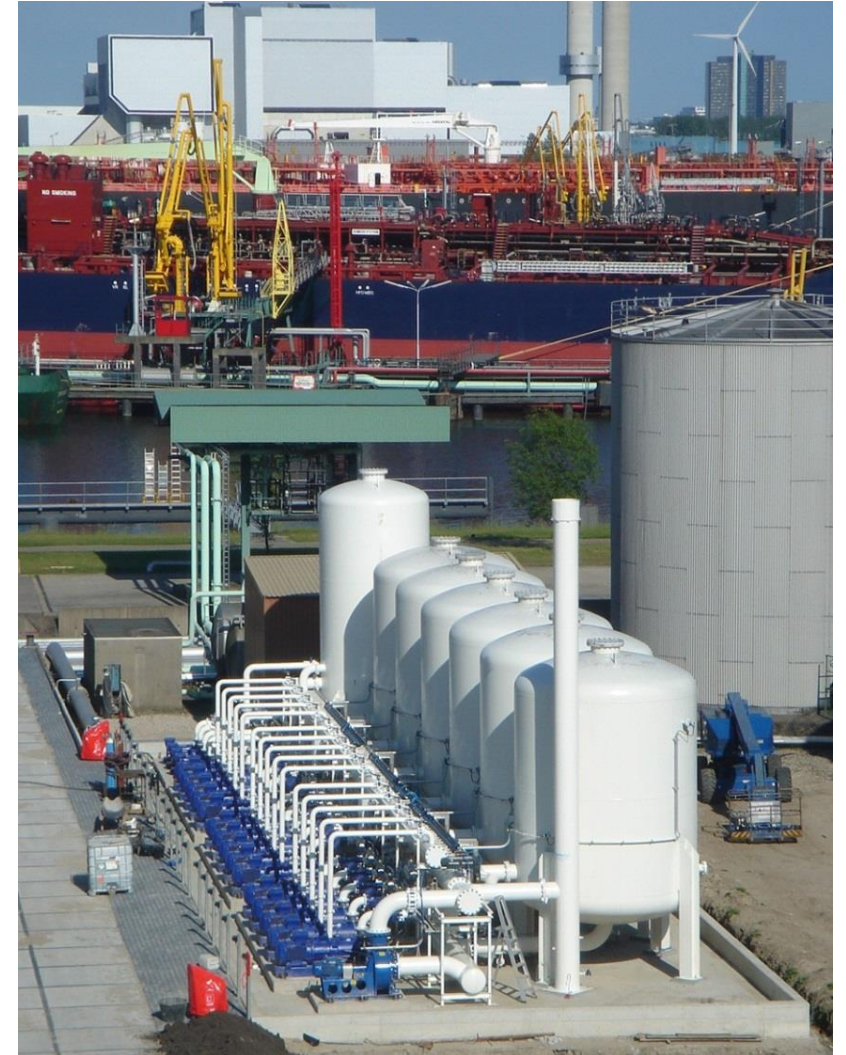
LOCATION: Amsterdam (The Netherlands)

APPLICATION: Marine loading operations

PRODUCTS: Gasoline / Diesel / Crude / BTX

CAPACITY: 7500 m<sup>3</sup>/h

E.L.R.: 150 mg/m<sup>3</sup>



CLIENT: TRANSNEFT

LOCATION: Kosmino (Russia)

APPLICATION: Marine loading operations

PRODUCTS: Crude

CAPACITY: 14 000 m<sup>3</sup>/h

E.L.R.: 10 g/m<sup>3</sup>



CLIENT: EXXONMOBIL

LOCATION: New Caledonia (France)

APPLICATION: Trucks loading operations

PRODUCTS: Gasoline

CAPACITY: 1000 m<sup>3</sup>/h

E.L.R.: 10 g/m<sup>3</sup>



CLIENT: UFA

LOCATION: Ufa (Russia)

APPLICATION: Trucks loading operations

PRODUCTS: Gasoline

CAPACITY: 2000 m<sup>3</sup>/h

E.L.R.: 35 g/m<sup>3</sup>



CLIENT: TOTAL (SMSPP)

LOCATION: Mayotte (France)

APPLICATION: Trucks loading

PRODUCTS: Gasoline / Diesel

CAPACITY: 480 m<sup>3</sup>/h

E.L.R.: 10 g/m<sup>3</sup>



CLIENT: BP TRANSTANK

LOCATION: Germany

APPLICATION: Storage tanks (F+B)

PRODUCTS: Gasoline / Diesel

CAPACITY: 2000 m<sup>3</sup>/h

E.L.R.: 50 mg/m<sup>3</sup>





CLIENT: VENTAMONJAKS

LOCATION: Venspils (Latvia)

APPLICATION: Marine loading

PRODUCTS: Naphtha

CAPACITY: 5000 m<sup>3</sup>/h

E.L.R.: 10 g/m<sup>3</sup>



CLIENT: ARAMCO – SATORP

LOCATION: Jubail (Saudi Arabia)

APPLICATION: Marine loading

PRODUCTS: Gasoline / Paraxylene

CAPACITY: 3 x 3000 m<sup>3</sup>/h

E.L.R.: 10 g/m<sup>3</sup>



CLIENT: VOPAK

LOCATION: Amsterdam (The Netherlands)

APPLICATION: Marine loading

PRODUCTS: Multi-products

CAPACITY: 5000 m<sup>3</sup>/h + 2500 m<sup>3</sup>/h

E.L.R.: 150 mg/m<sup>3</sup>



CLIENT: LUKOIL

LOCATION: Macedonia

APPLICATION: Trucks loading

PRODUCTS: Gasoline / Diesel

CAPACITY: 480 m<sup>3</sup>/h

E.L.R.: 10 g/m<sup>3</sup>



CLIENT: ALEXELA

LOCATION: Norway

APPLICATION: Marine loading

PRODUCTS: Gasoline

CAPACITY: 1800 m<sup>3</sup>/h

E.L.R.: 35 g/m<sup>3</sup>



Thank you for your attention.