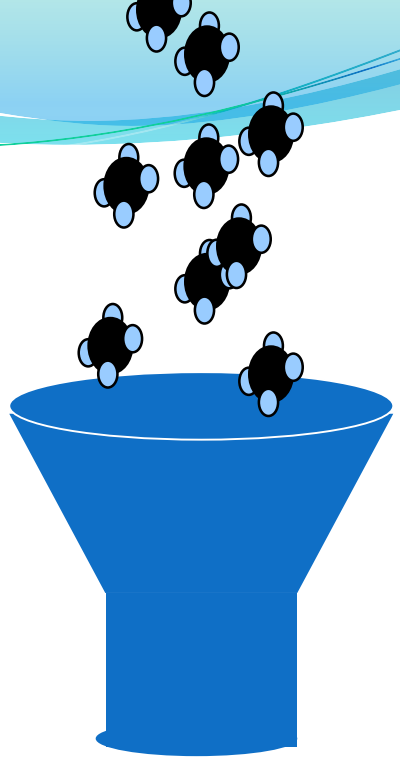
# BEST PRACTICE IN VAM PROCESSING

Bogota 24 July 2018

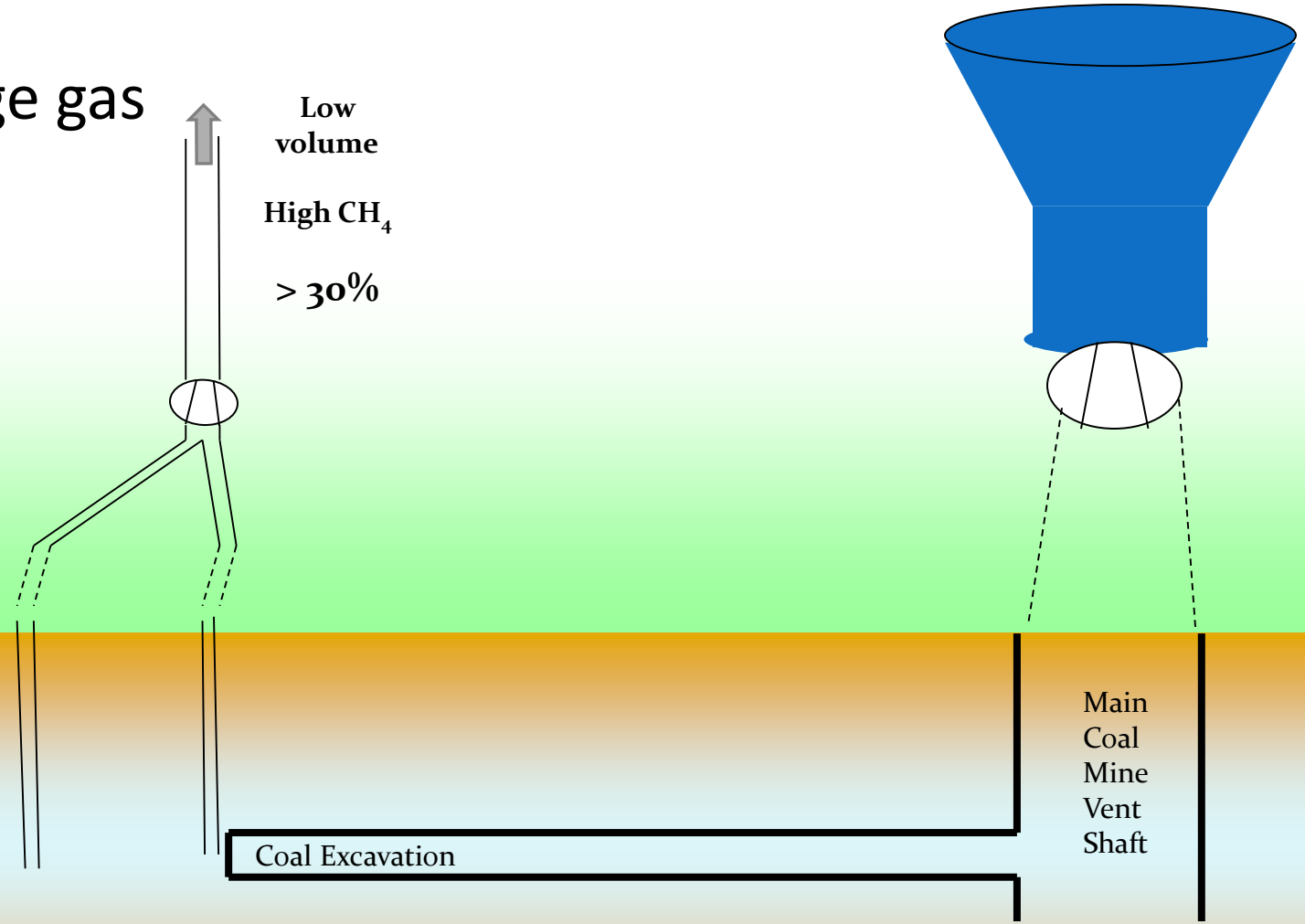
Richard Mattus



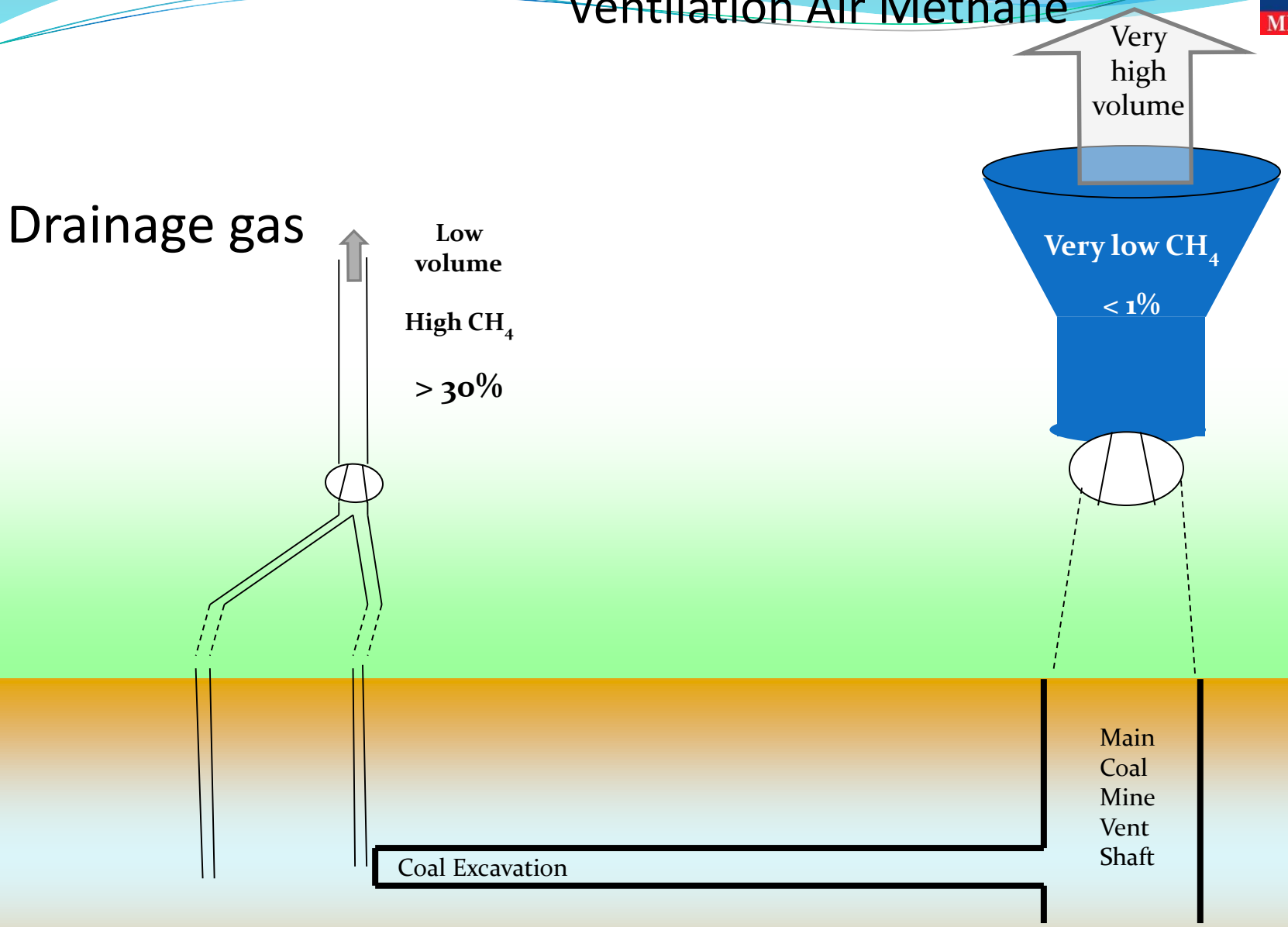
- Why is VAM an issue?

- Technologies for processing VAM
- Proven technologies so far
- Successful installations
- Guide lines for feasibility

# Drainage gas



# VAM, Ventilation Air Methane



# TECHNOLOGIES FOR PROCESSING VAM

CONDITIONS:

Very large volumes of air with extremely low $CH_4$ content.

*~1 000 000 $Nm^3/hr$* *<1% to <<1%*

| TECHNOLOGY | SPECIFICS | ISSUES | COMMENTS |
|---|---|---|---|
| COMBUSTION AIR with VAM as supplementary fuel | For power plants, turbines, boilers | Very large air volumes. | Hard to find large user nearby a ventilation shaft. |
| LEAN GAS TURBINES | Have managed to come down to 2-3%. | Typically combined with drainage gas. Very large air volumes. | So far only lab scale installations. |
| CONCENTRATORS | Increase $CH_4$ concentration. | Technical difficulties. Very large air volumes. | No successful installations or trials officially reported yet. |

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| INDUSTRIAL OXIDIZERS | | | |
| RTO, Regenerative Thermal Oxidizers | Need only 0.2% $CH_4$ for self sustaining oxidation process. | No major issues for experienced suppliers. | Proven technology for VAM with several long time installations. |
| RCO, Regenerative Catalytic Oxidizers | Catalyst lowers the temp needed for oxidation. | Catalyst can be "poisoned" by e.g. S. Catalyst needs at some point to be exchanged. | Several RCO solutions in trial. No success officially reported yet. |
| Recuperative Thermal Oxidation | Passes pollutant ($CH_4$) by an open flame. | Most traditional industrial oxidizer. Very costly to operate. | No serious attempts due to low financial feasibility. |

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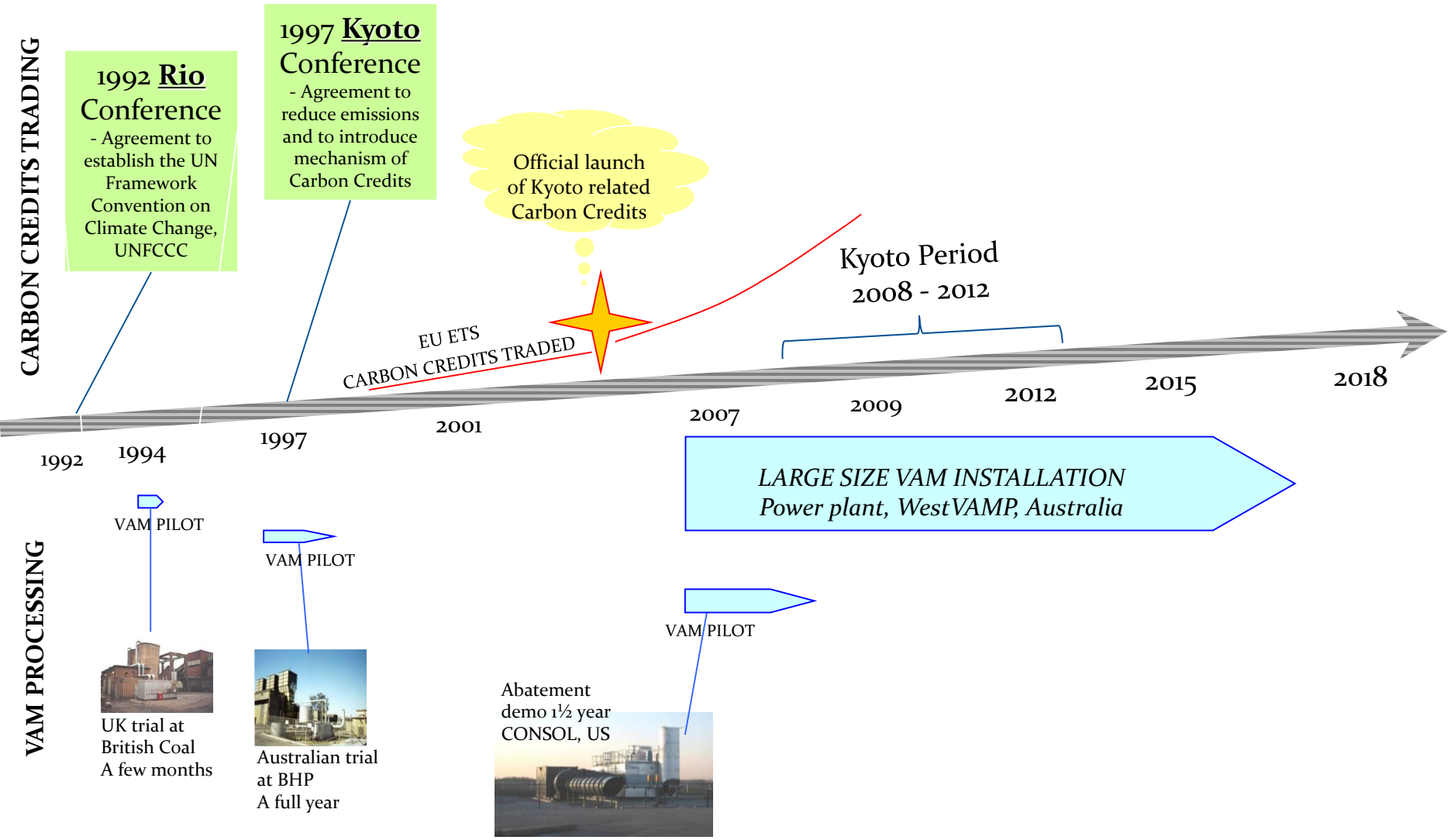
# VAM PROCESSING AND CARBON CREDITS



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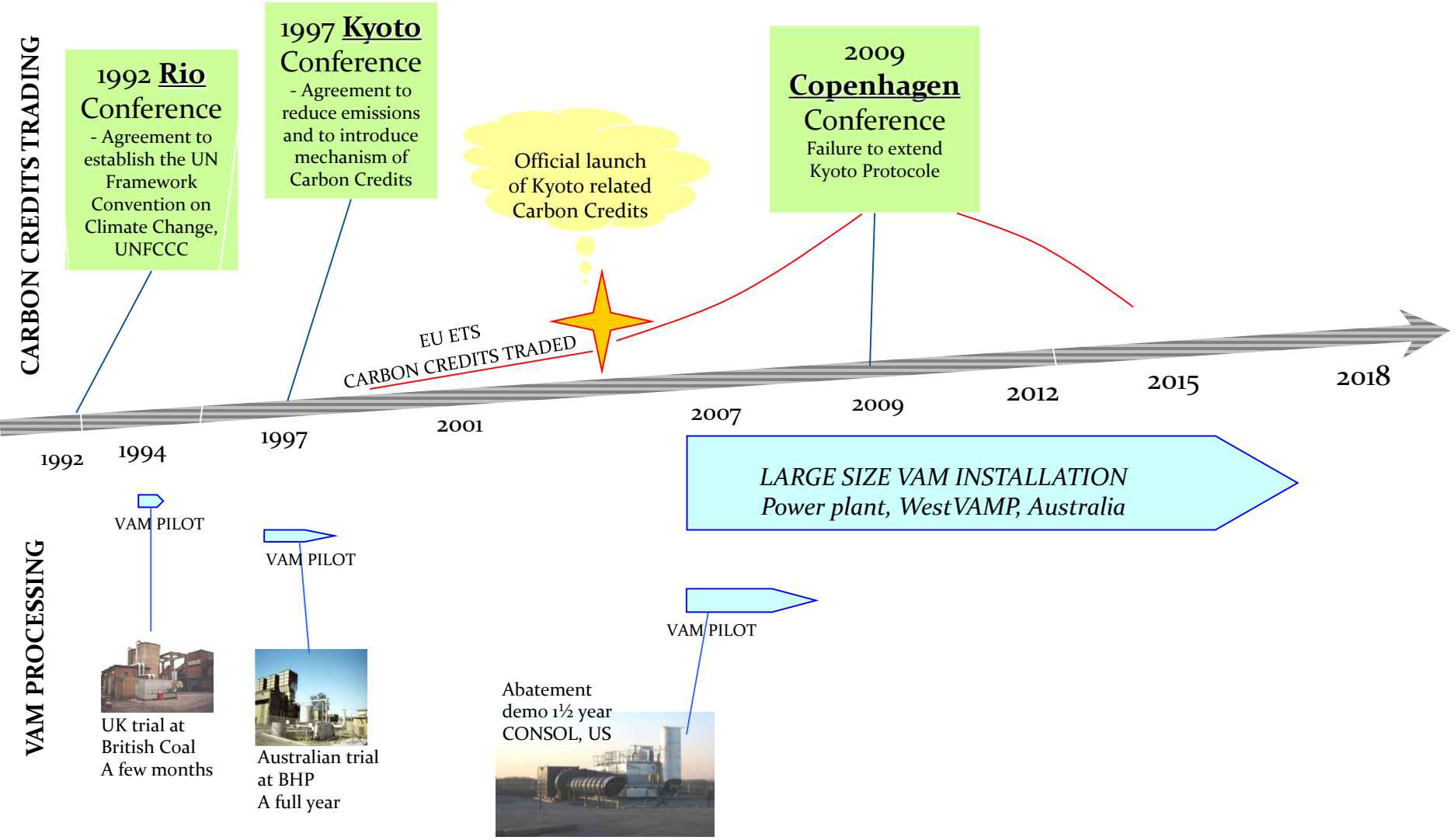

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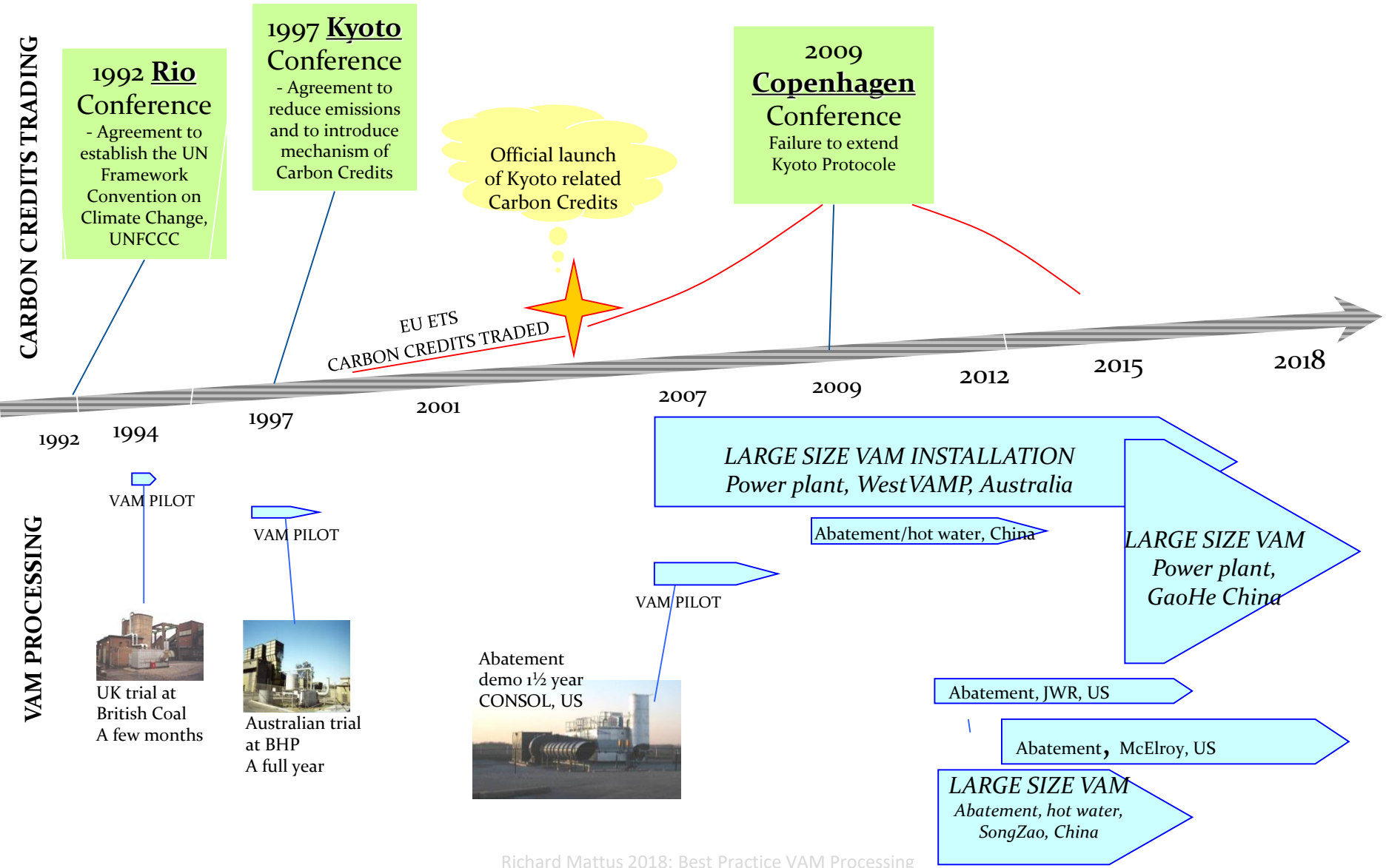

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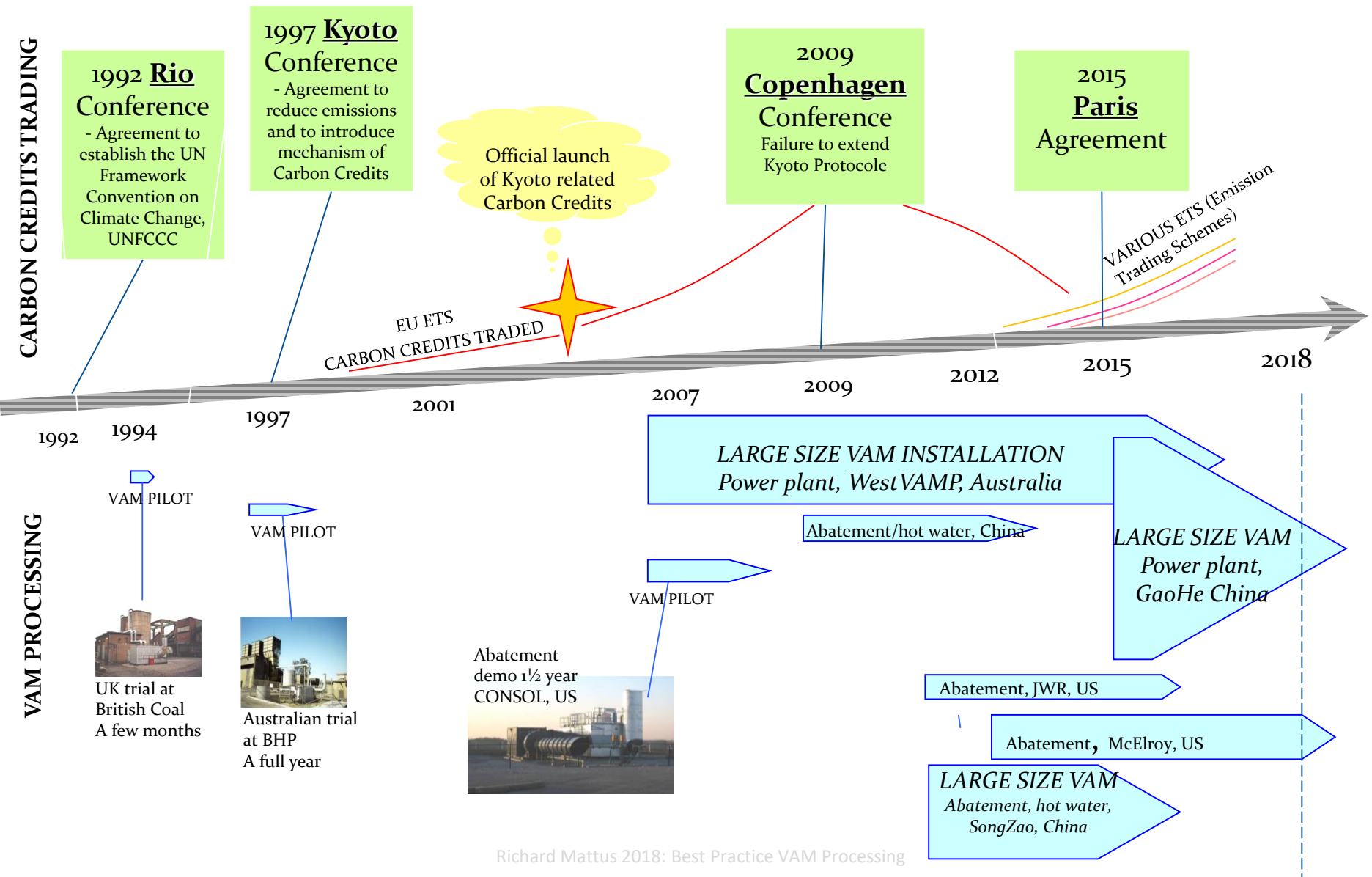


# COMMERCIAL SIZE VAM PROCESSING

BY EXPERIENCED RTO-SUPPLIERS

# COMMERCIAL SIZE VAM PROCESSING

OFFICIALLY STILL IN OPERATION BY JUNE 2018

McElroy,
180 000 $Nm^3/h$
Since 2012

VAM Power Plant GaoHe
1 080 000 $Nm^3/h$
Since 2015

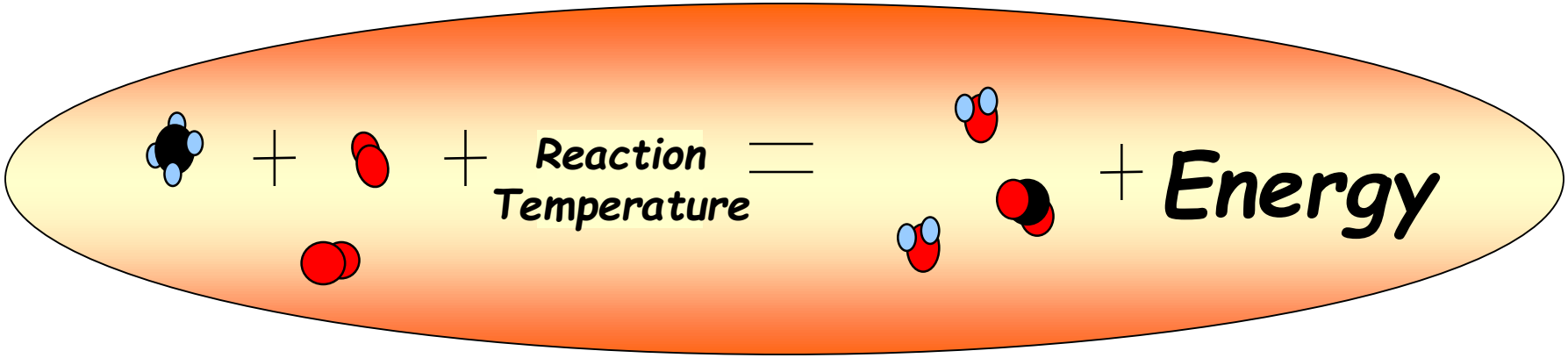
<u>Closures of others due to :</u>

- Moving of mining activities
- Failing values of carbon credits

# RTO technology

## - How does it work?

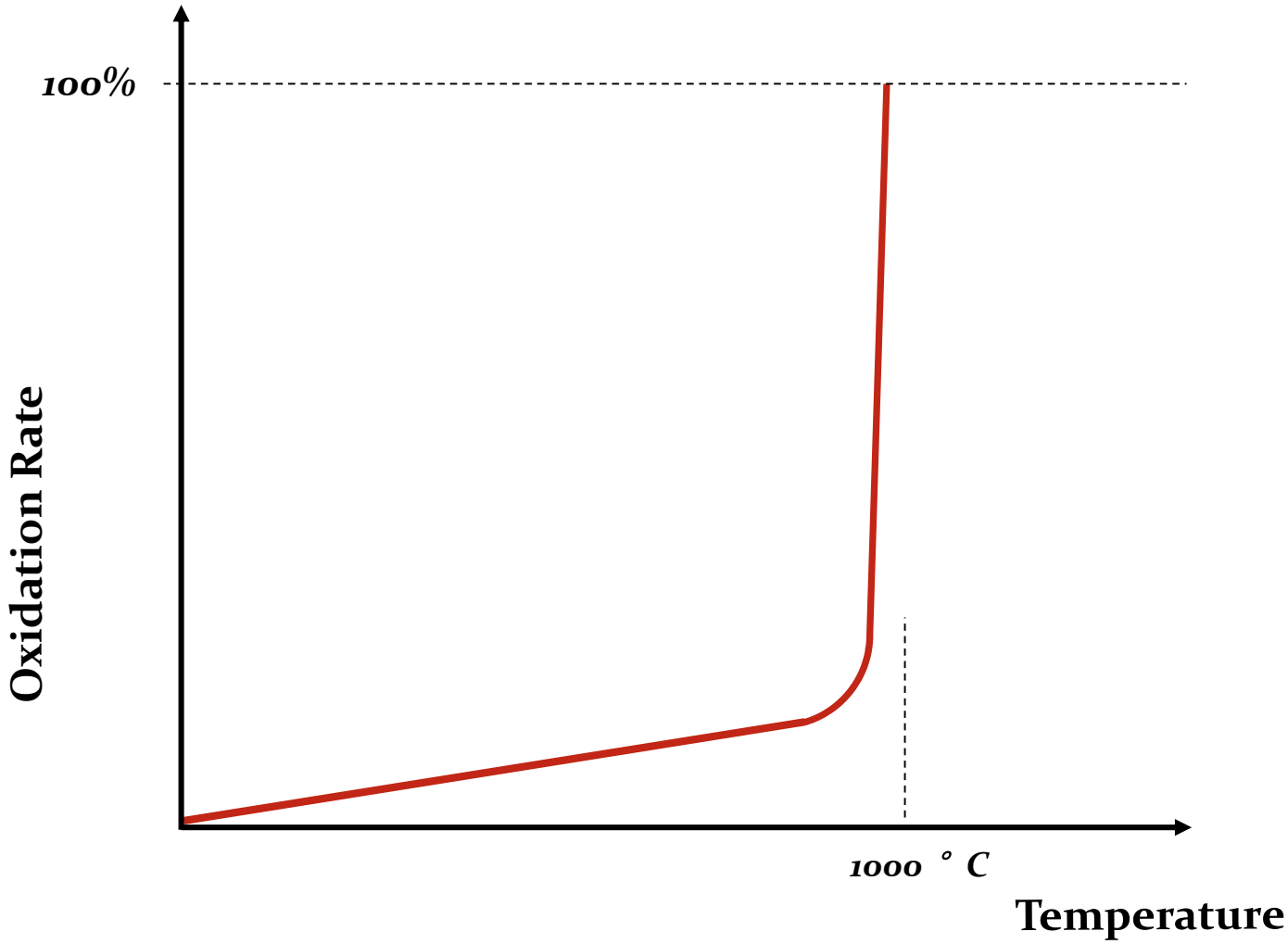
# Principle of RTO reaction




Like all VOC gases,
methane oxidize at 850-900°C
to form water and $CO_2$.

And release Energy!

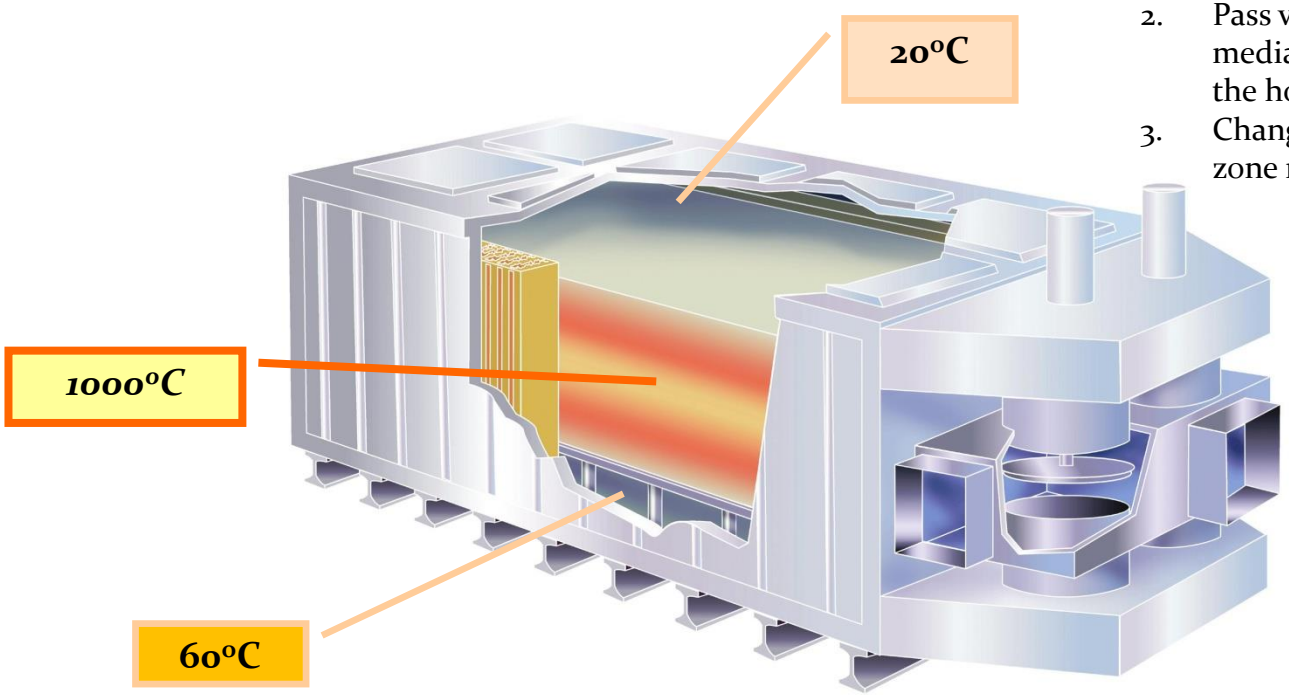
# VOC Oxidation Rate



# Single can RTO

**RTO FUNCTION:**

1. Heat center cross section of ceramic bed to 1000°C.
2. Pass ventilation air through, heating media, oxidizing all VAM in air passing the hot zone.
3. Change direction of flow, making hot zone remain in center bed section.

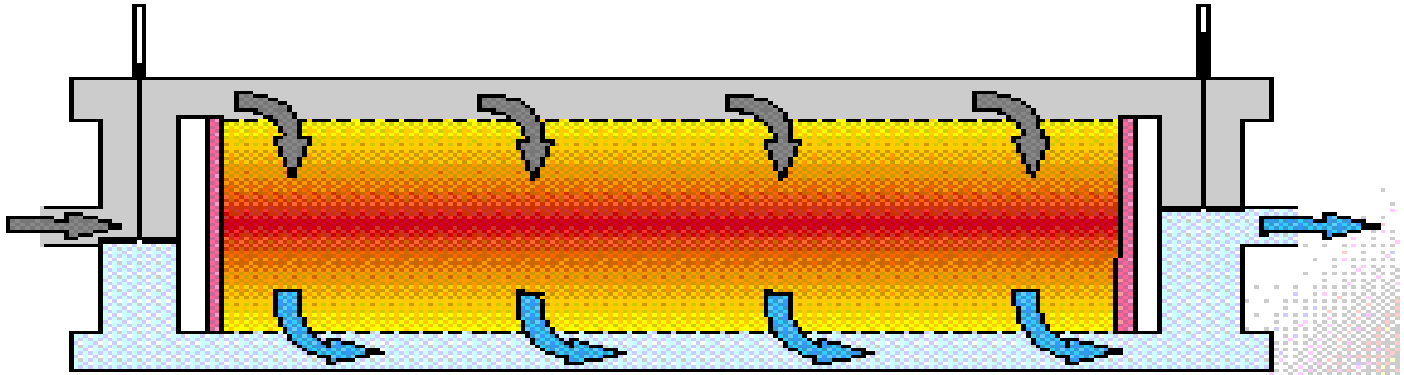



**No catalyst**

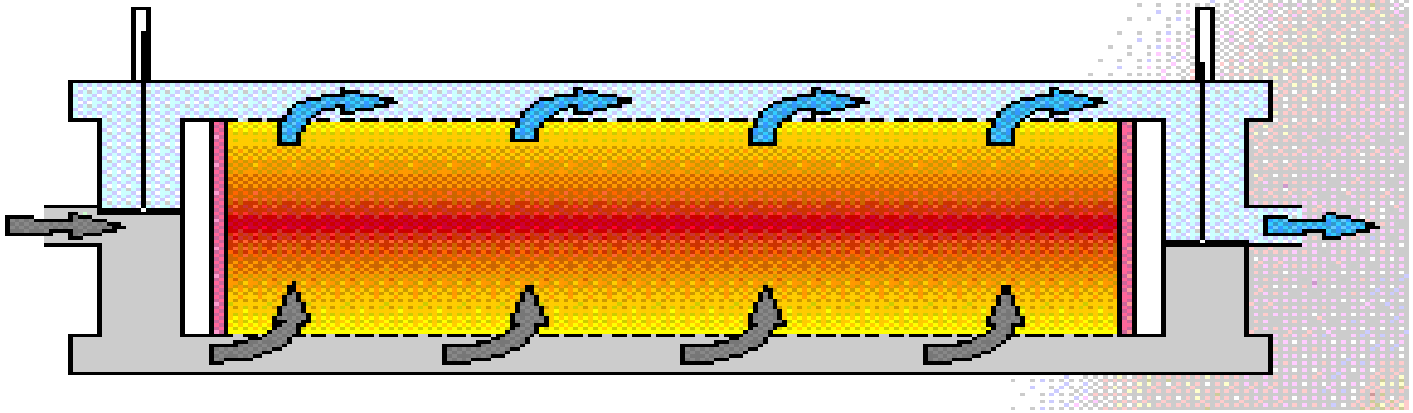
operate at natural oxidizing temperature

# Single can RTO

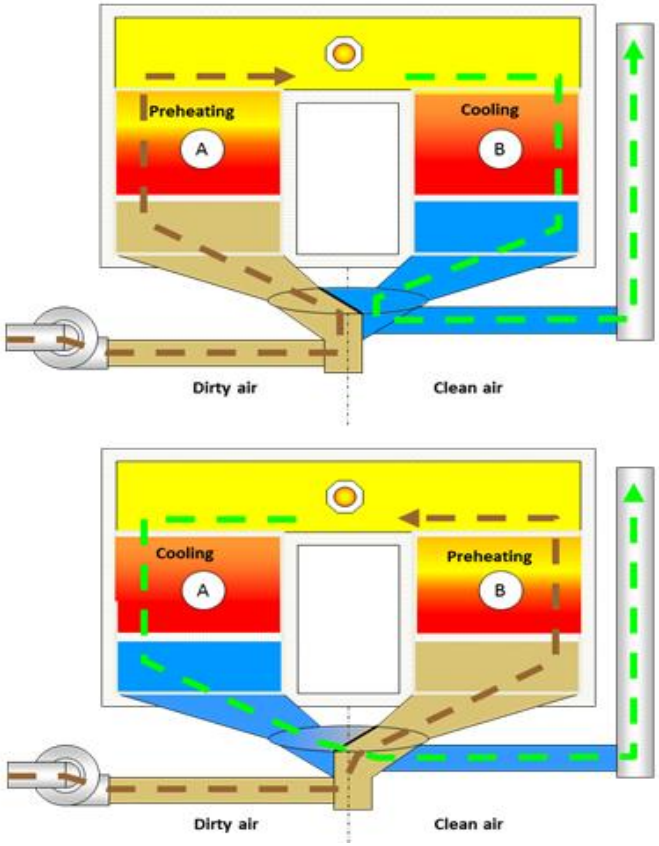
Flow down



Flow up

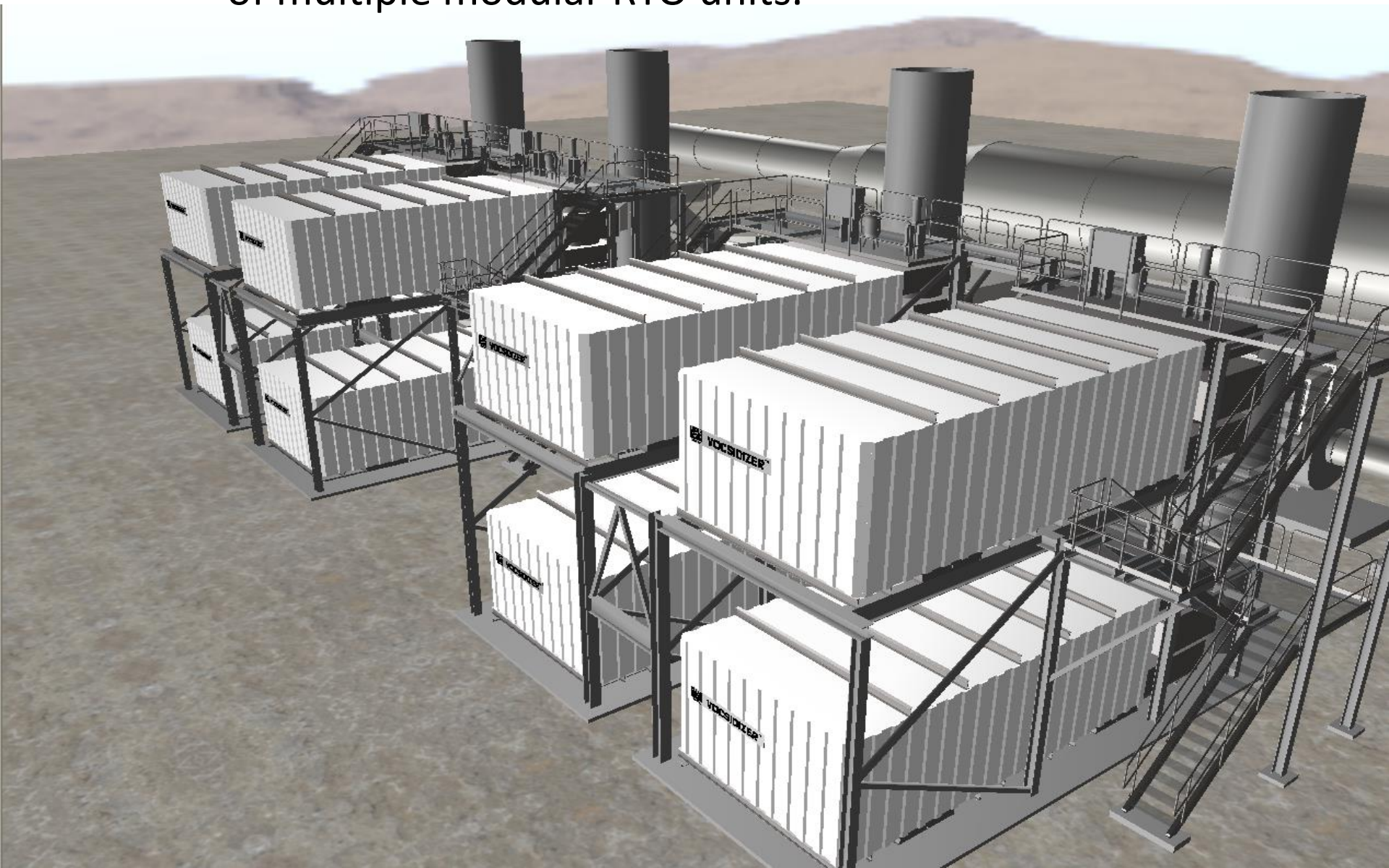


# 2 Can (or more) RTO

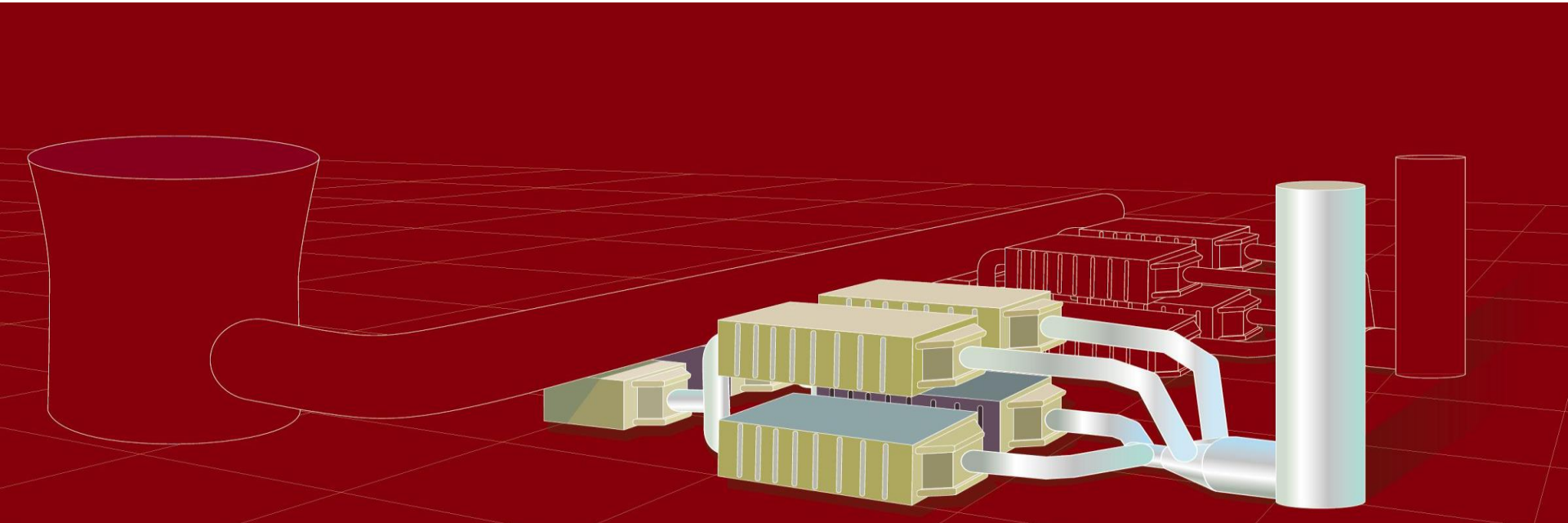



Main difference between the single can RTO and 2 can or multiple can RTO's: Oxidation in a combustion chamber instead of in the ceramic bed.

RTO installations typically consists of multiple modular RTO units.



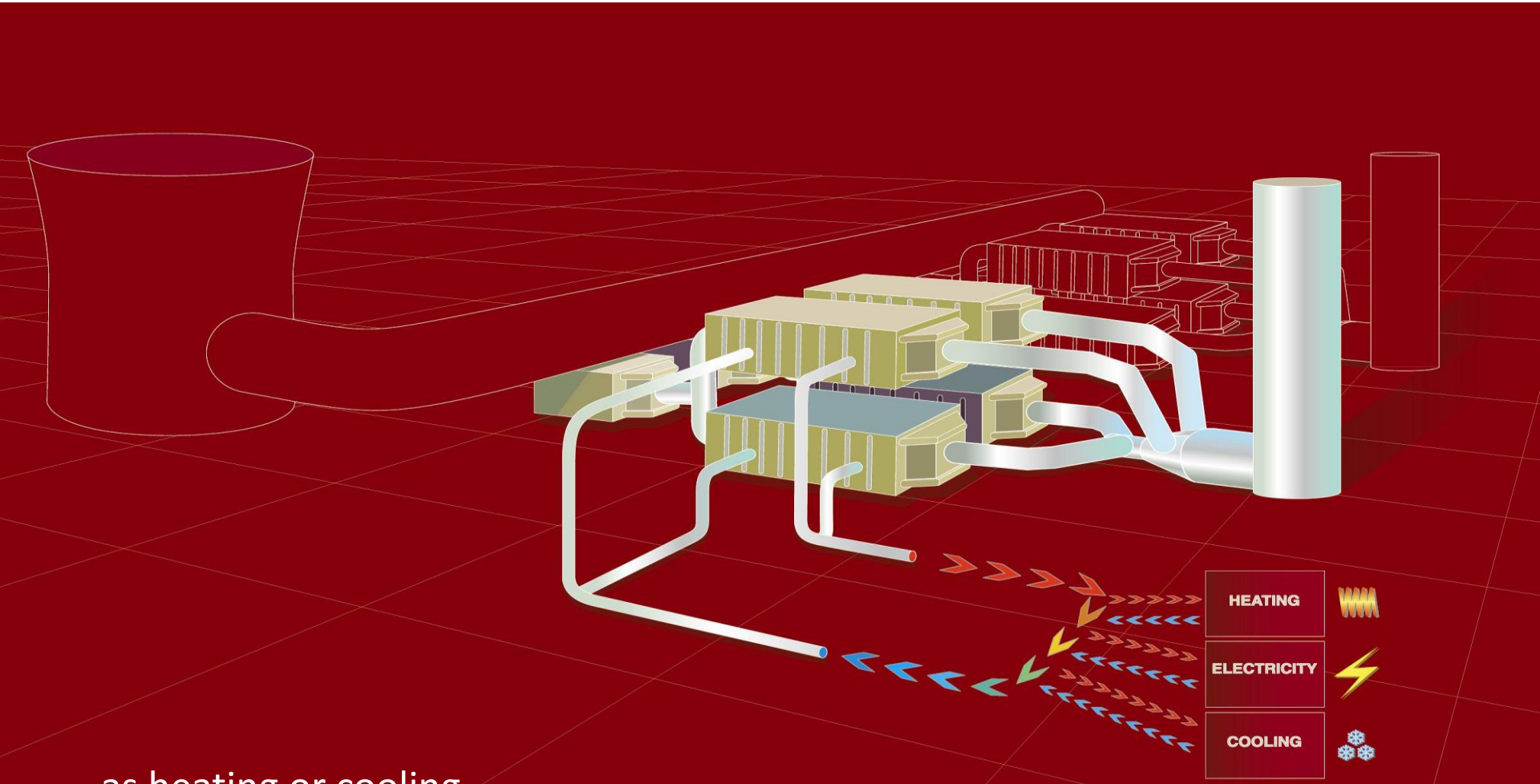
# PURE VAM ABATEMENT



Min 0.2% $CH_4$ to keep oxidizing going .

If higher, the excess can be utilized..

# CONVERTING ENERGY OF VAM INTO USEFUL ENERGY




.. as heating or cooling,
or as electricity.

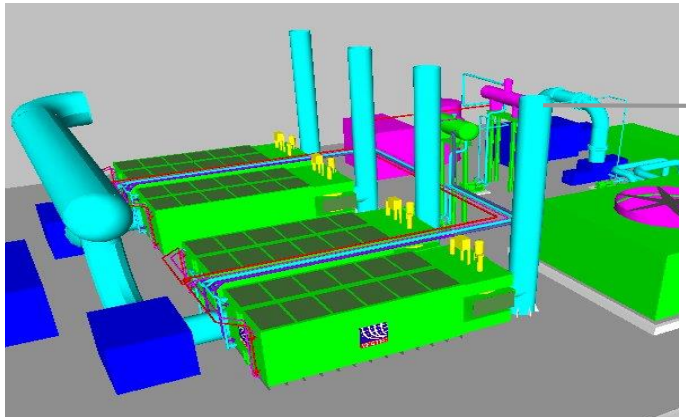
GUIDE LINES

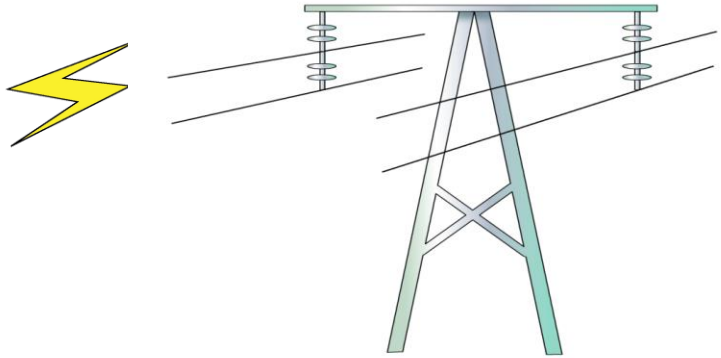
# Indications of VAM project economics

- The project economics of a VAM processing installation will largely depend on;
  - Total costs for investment, operation and maintenance.
  - Average VAM concentration of the ventilation air being processed.
  - The value of reducing the emissions.

GUIDE LINES

# VAM Energy Recovery with RTO's as boiler units





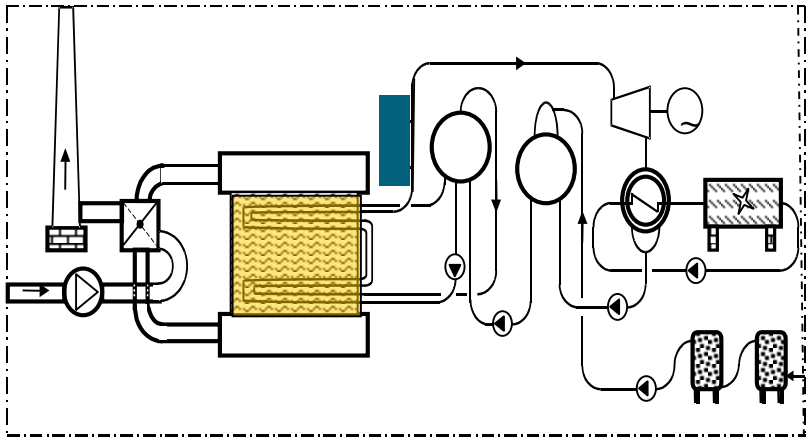
0.2 % methane needed to maintain oxidation.
Energy of concentrations above 0.2 % can be recovered.

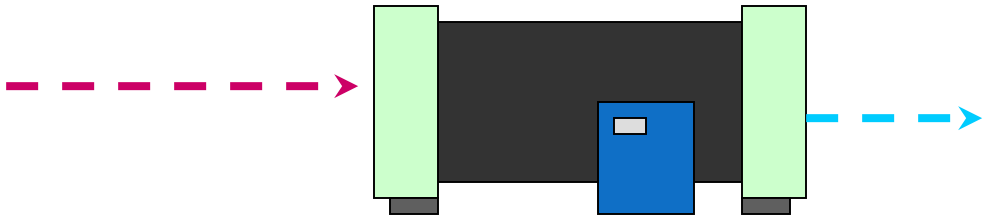
***Example:*** *800 000 m³/h*, *1 % $CH_4$* → *72 MW(th)* → *21 MW(el)* *(at 30% efficiency)*

***Example:*** *800 000 m³/h*, *0.6 % $CH_4$* → *36 MW(th)* → *10 MW(el)* *(at 30% efficiency)*

GUIDE LINES

# Cogeneration of electricity and heating – plus cooling





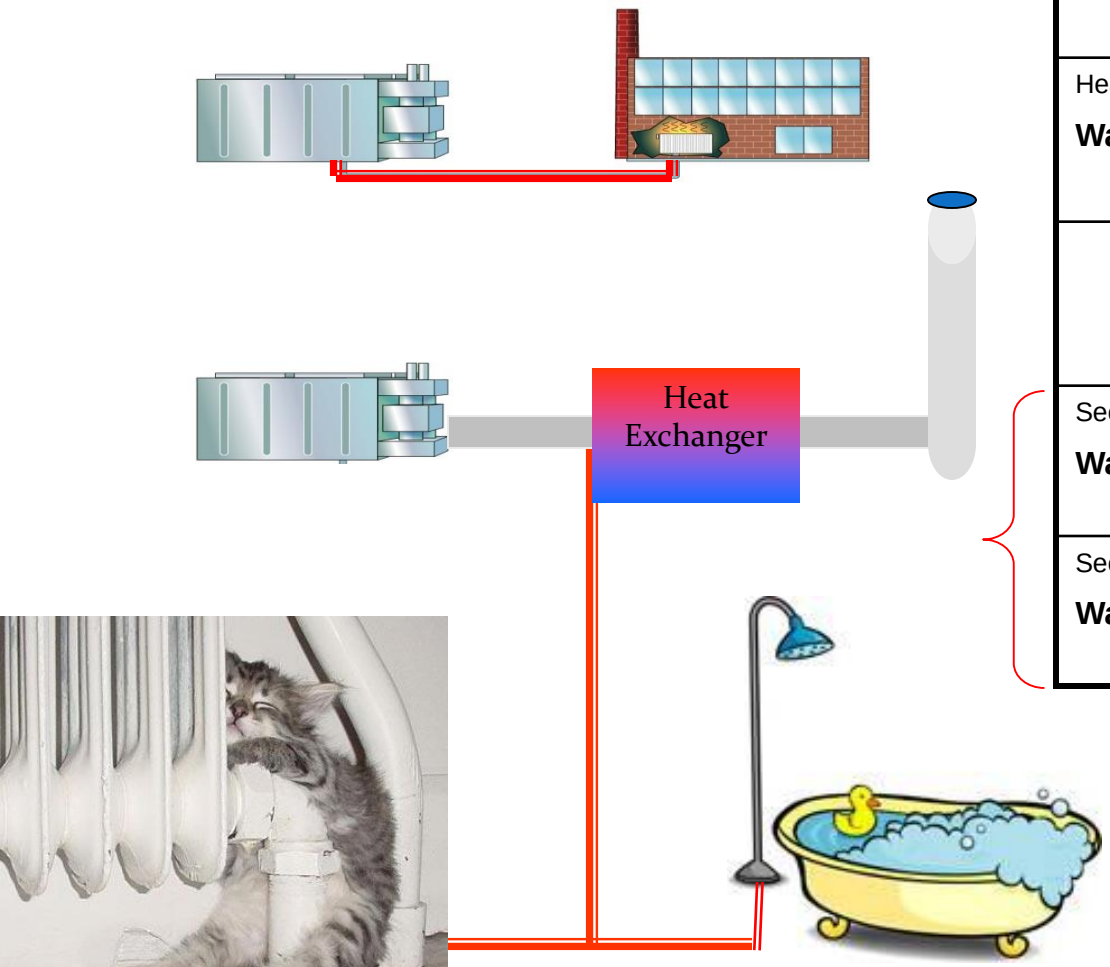
Cooling water from electricity generation drives absorption chiller

***Example:***

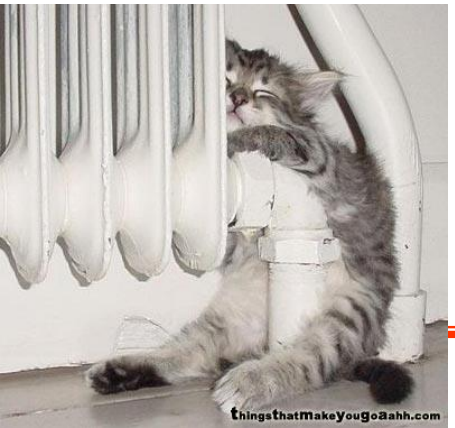
*800 000 m3/h*
*1% methane* → *72 MW(th)* → *21 MW(el)* → *19 MW(el) + 38 MW(cool)*

GUIDE LINES

# *Hot water* from VAM (thermal energy)




| | 0.3% | 0.6% | 0.9% |
|---|---|---|---|
| Heat straight from bed.<br>**Water at 70 - 150$^{oC}$** | 3 MW | 11 MW | 18 MW |
| -- - *For each 250 000 Nm3/h of ventilation air* - - - | | | |
| Secondary heat-exchanger.<br>**Water at 70oC** | 1 MW | 8 MW | 15 MW |
| Secondary heat-exchanger.<br>**Water at 150oC** | - | 2 MW | 10 MW |



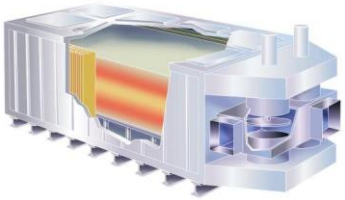
GUIDE LINES

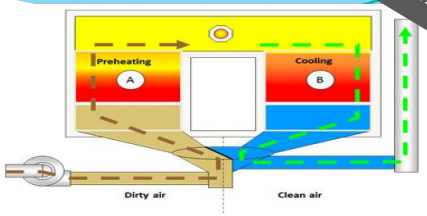
# *Electricity* from VAM (electrical energy)

| | 0.3% | 0.6% | 0.9% |
|---|---|---|---|
| Heat straight from bed.<br>**Water at 70 - 150$^{oC}$** | 3 $MW_{th}$<br>=<br>½ -1 $MW_e$ | 11 $MW_{th}$<br>=<br>3 -4 $MW_e$ | 18 $MW_{th}$<br>=<br>5 - 6 $MW_e$ |
| -- - *For each 250 000 Nm3/h of ventilation air* - - - | | | |

For large size plants (min ½ million m3/h of ventilation air), conversion from thermal to electrical energy can be expected to be around 30%, and lower for smaller plants.

# Calculations of $CO_{2e}$ from VAM processing






GUIDE LINES

Examples:
250 000 Nm3/h @ 0.9 % VAM comes to 240 000 tonnes of CO2e
125 000 Nm3/h @ 0,9 % VAM comes to 120 000 t CO2e
125 000 Nm3/h @ 0,3 % VAM comes to 40 000 t CO2e

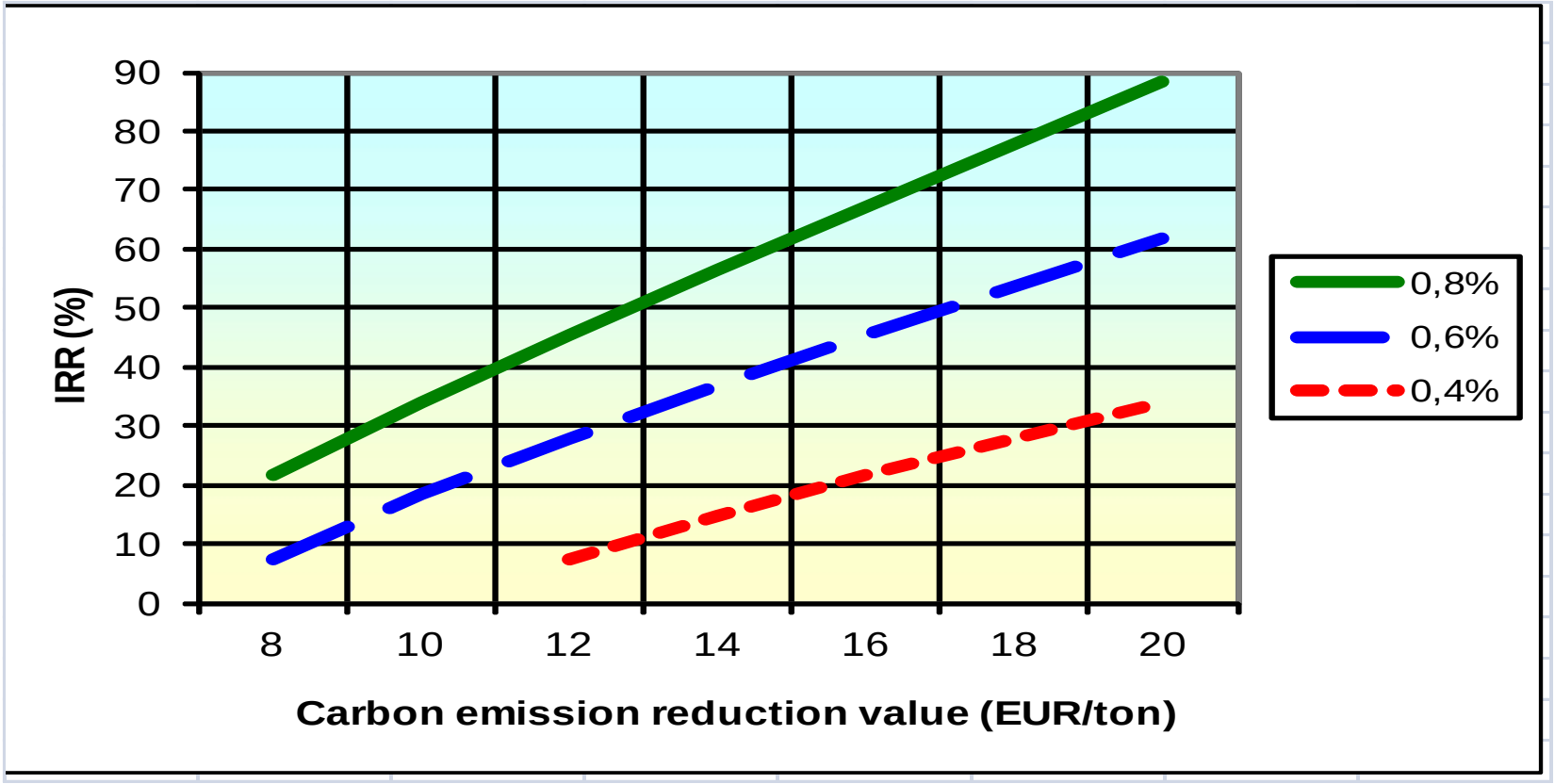
| VAM conc'n / Nm3/h vent air | 0.3 % | 0.6 % | 0.9 % |
|---|---|---|---|
| 125 000 | ***40*** | ***80*** | ***120*** |
| 250 000 | ***80*** | ***160*** | ***240*** |
| 500 000 | ***160*** | ***320*** | ***480*** |
| 1 000 000 | ***320*** | ***640*** | ***960*** |

*Annual emission reductions in thousand tons of CO2e*

# VAM Project Financial Feasibility

GUIDE LINES

## VAM project economics indications



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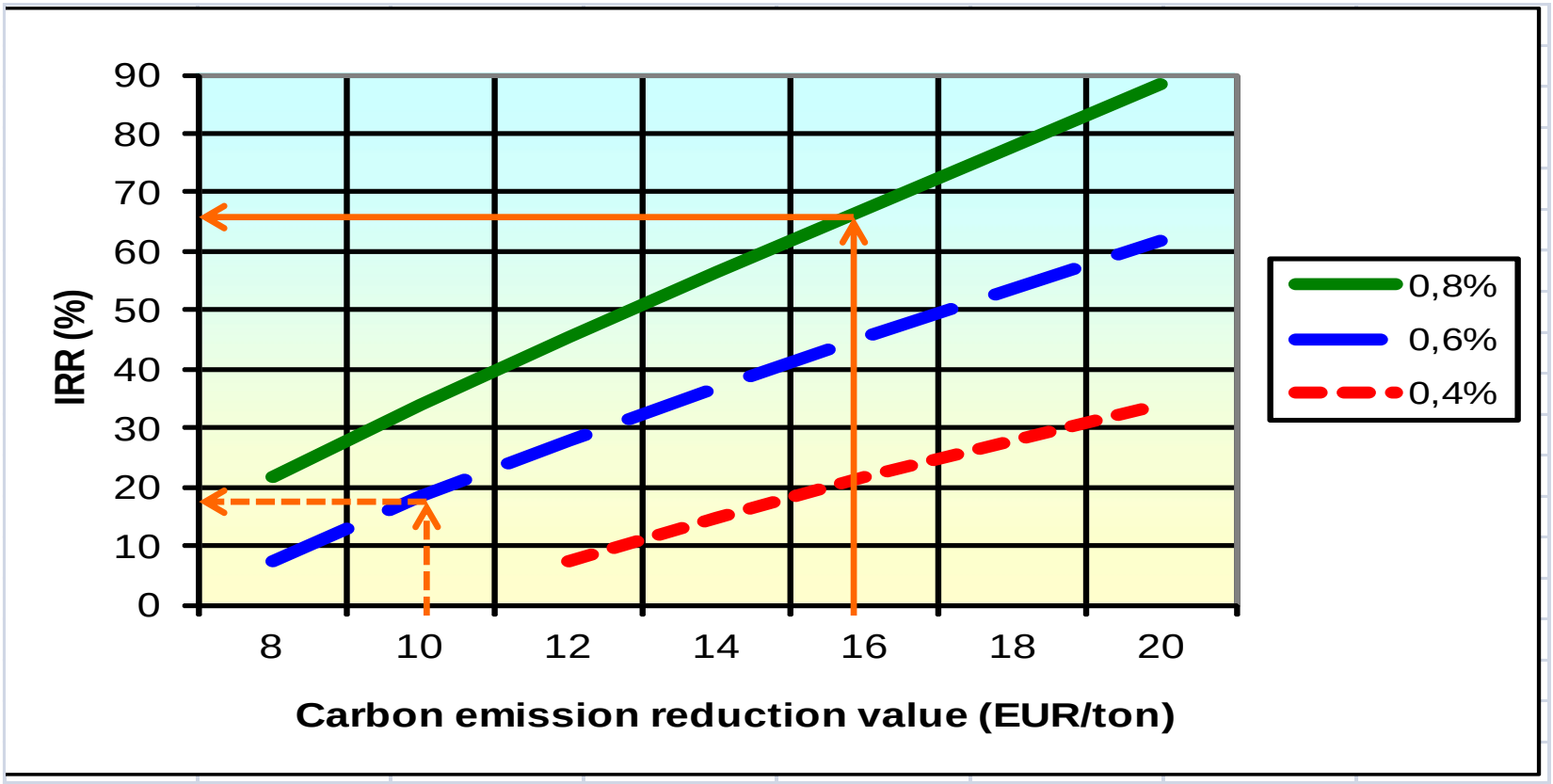


Examples:

- An emission reduction value of EUR 16/t $CO_{2e}$ and a 0.8% VAM concentration would yield an IRR of approx 65% - i.e. an expected pay back of less than 2 years.
- A value of EUR 10/t CO2e and a 0.6% VAM concentration would yield an IRR of approx 20% - i.e. an expected pay back of around 5 years.

# VAM Project Financial Feasibility

GUIDE LINES

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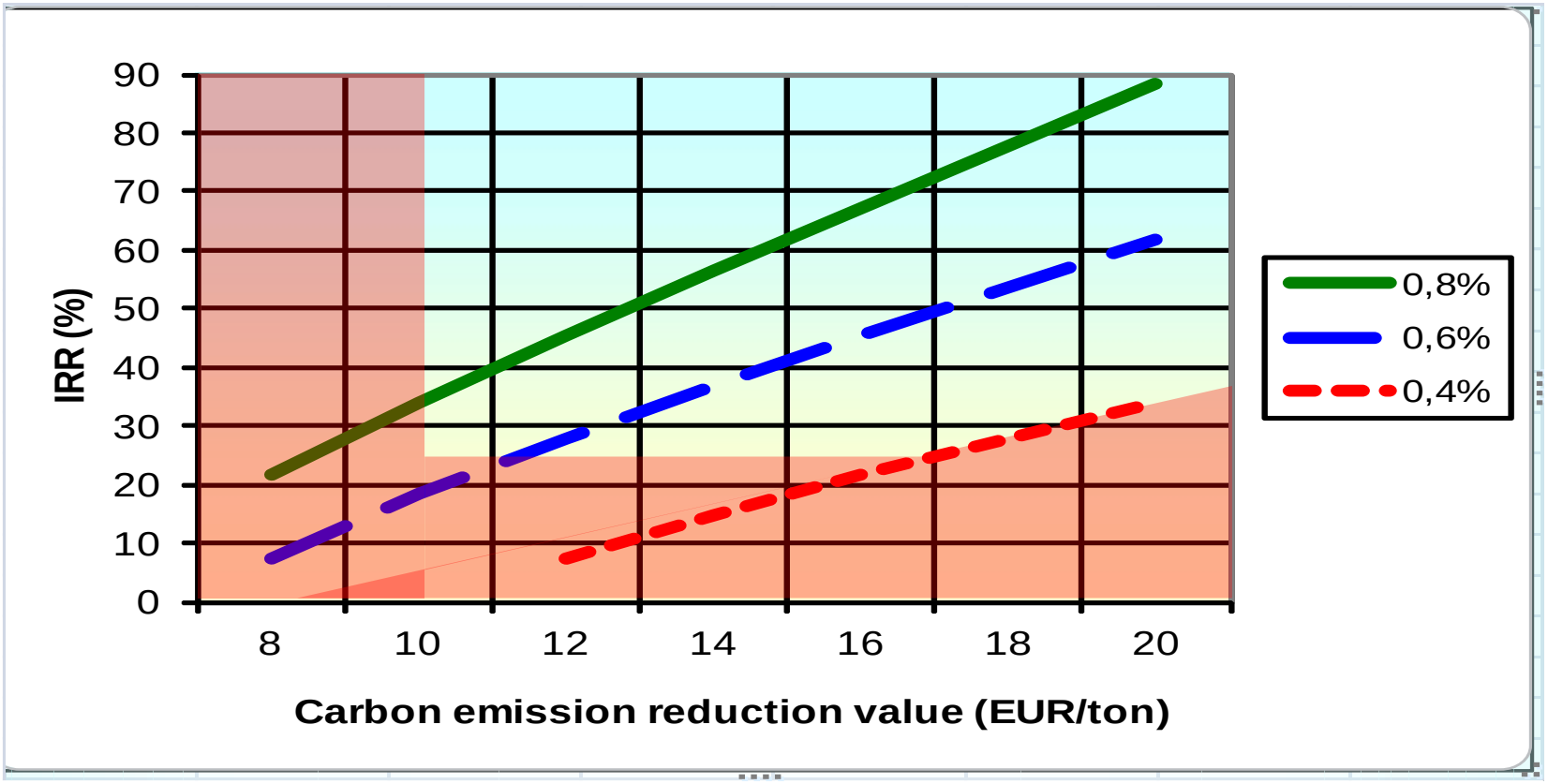



CONCLUSIONS for reasonable/good pay back:

- VAM concentrations should be min ½ percent
- Carbon emission reduction value (Carbon Credits/Carbon Tax etc) should be minimum EUR 10/t $CO_{2e}$

# Carbon Credits Trading

The world's largest trading scheme is the

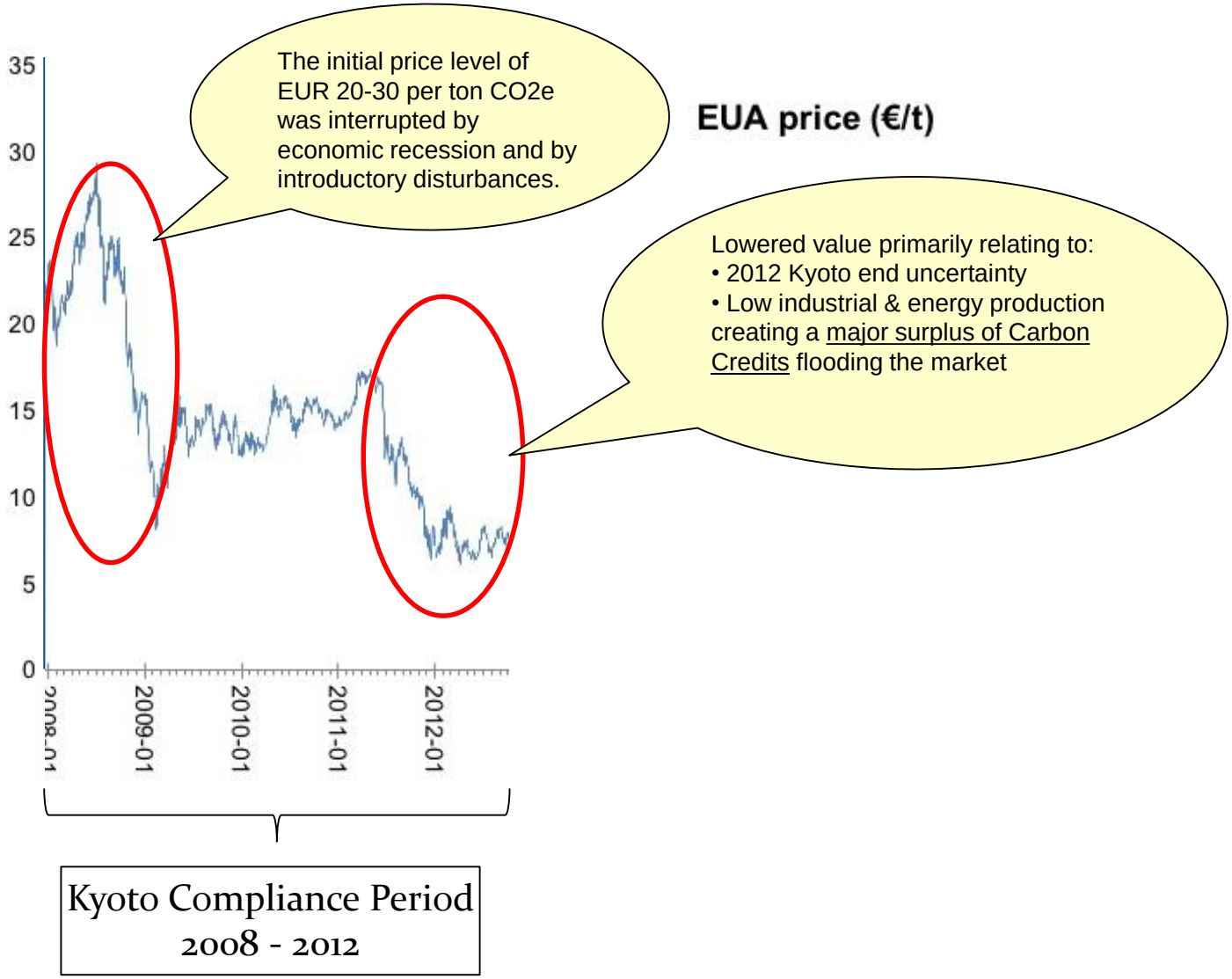
EU ETS

= The EU carbon credits Emissions Trading Scheme

# Carbon price overview EU


Kyoto Compliance Period
2008 - 2012

# Carbon price overview EU



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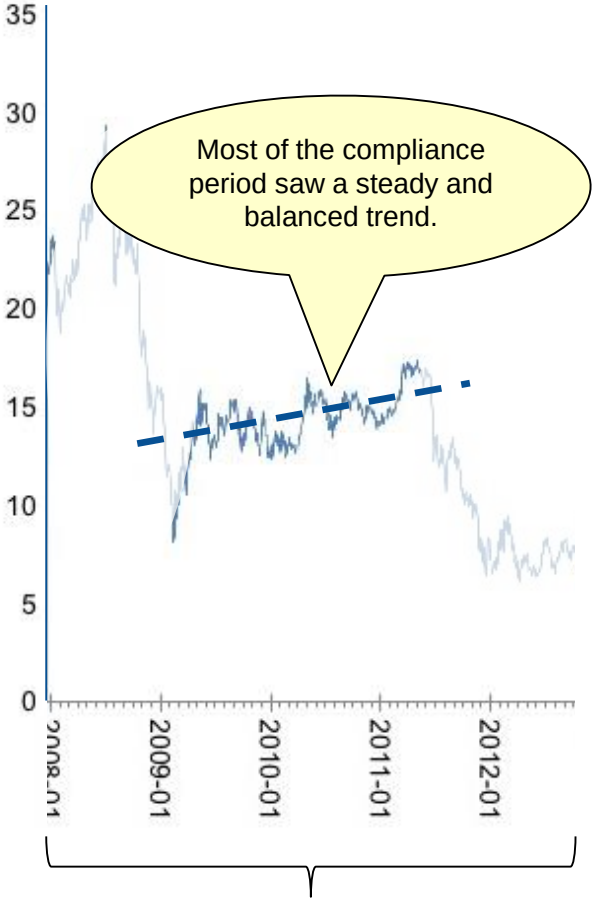
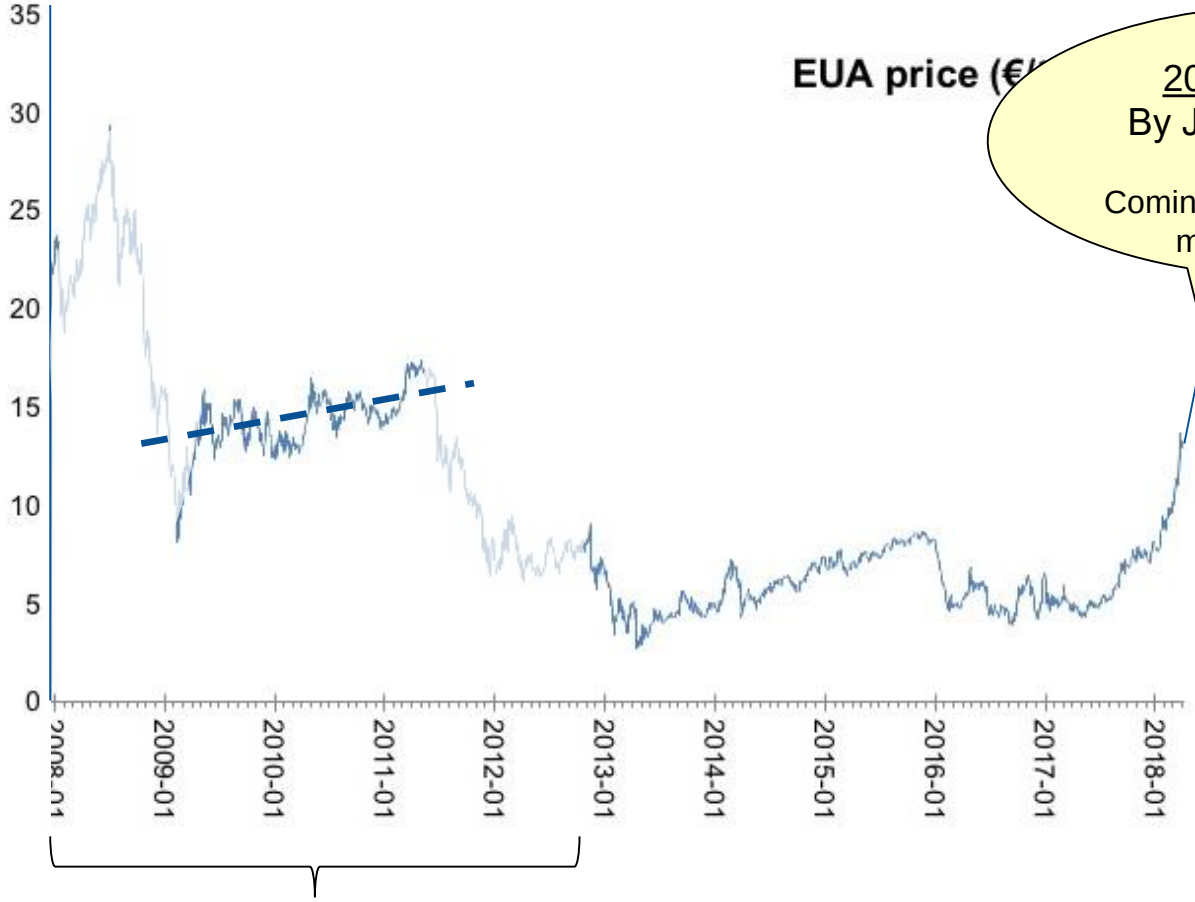



**EUA price (€/t)**

Kyoto Compliance Period
2008 - 2012

# Carbon price overview EU



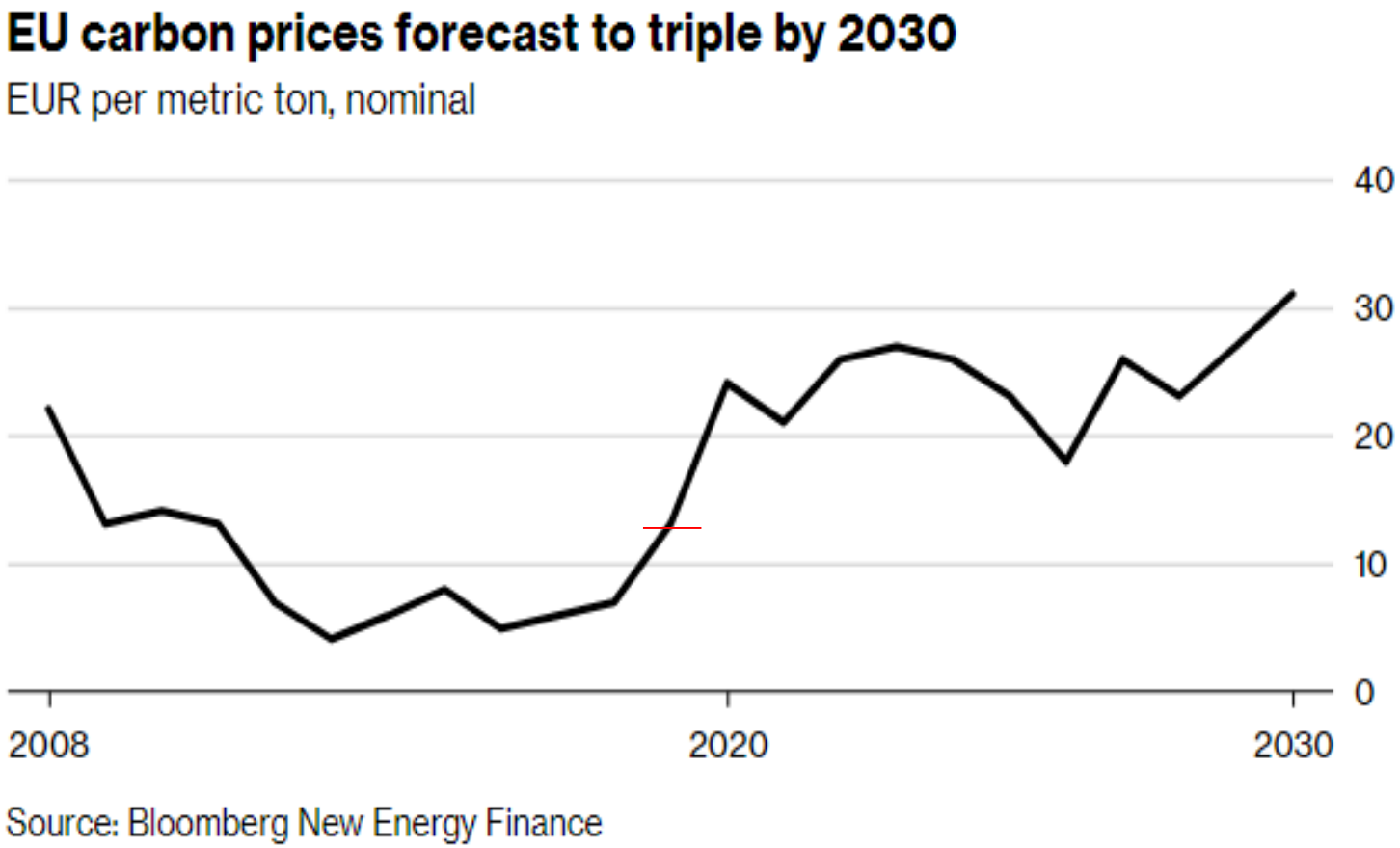

2018 EUA price:
By June above € 15.

Coming back to a balanced market situation?

Kyoto Compliance Period
2008 - 2012

# FORECAST PUBLISHED IN FEBRUARY 2018

(- when EUA at €13 EUR)



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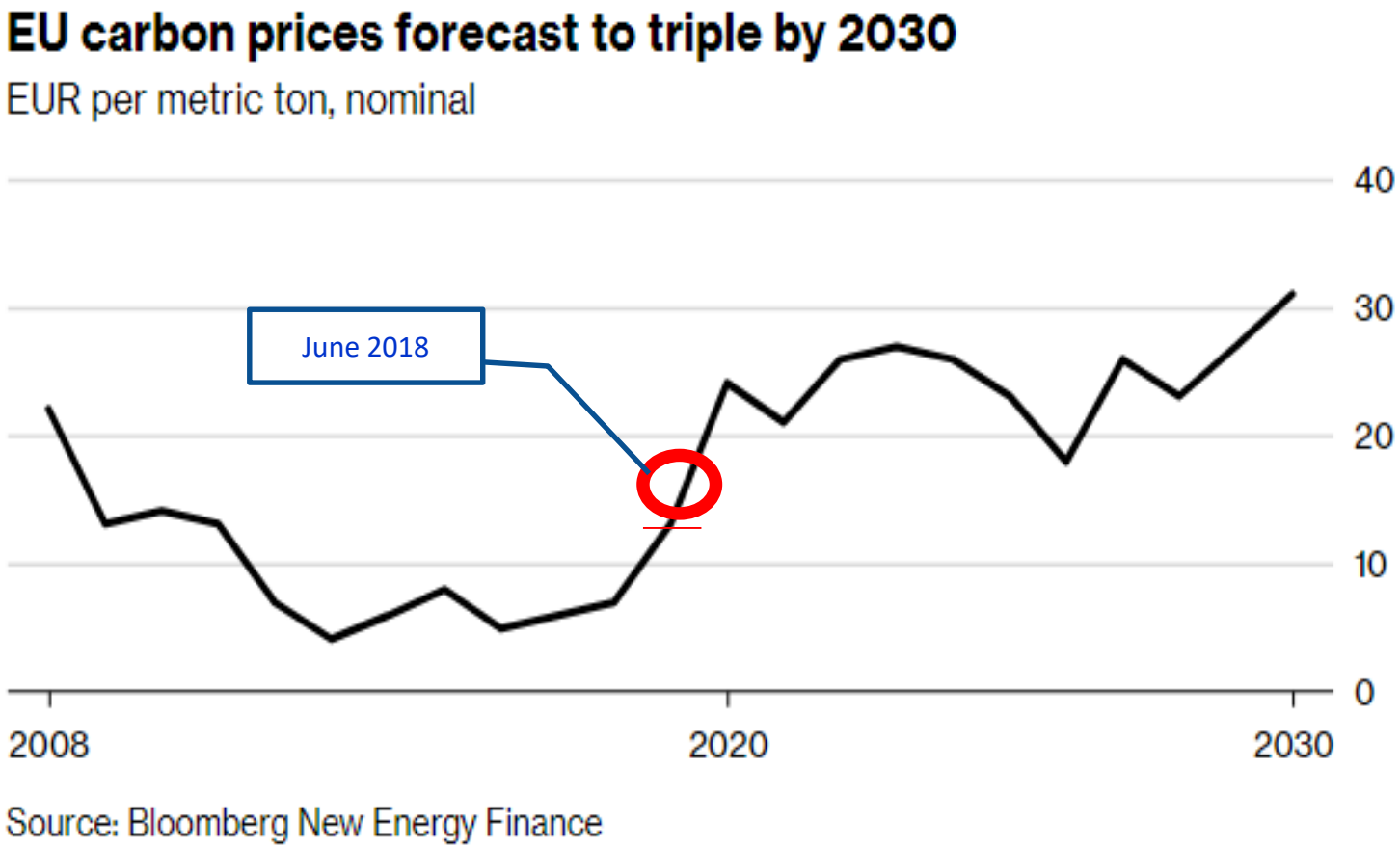
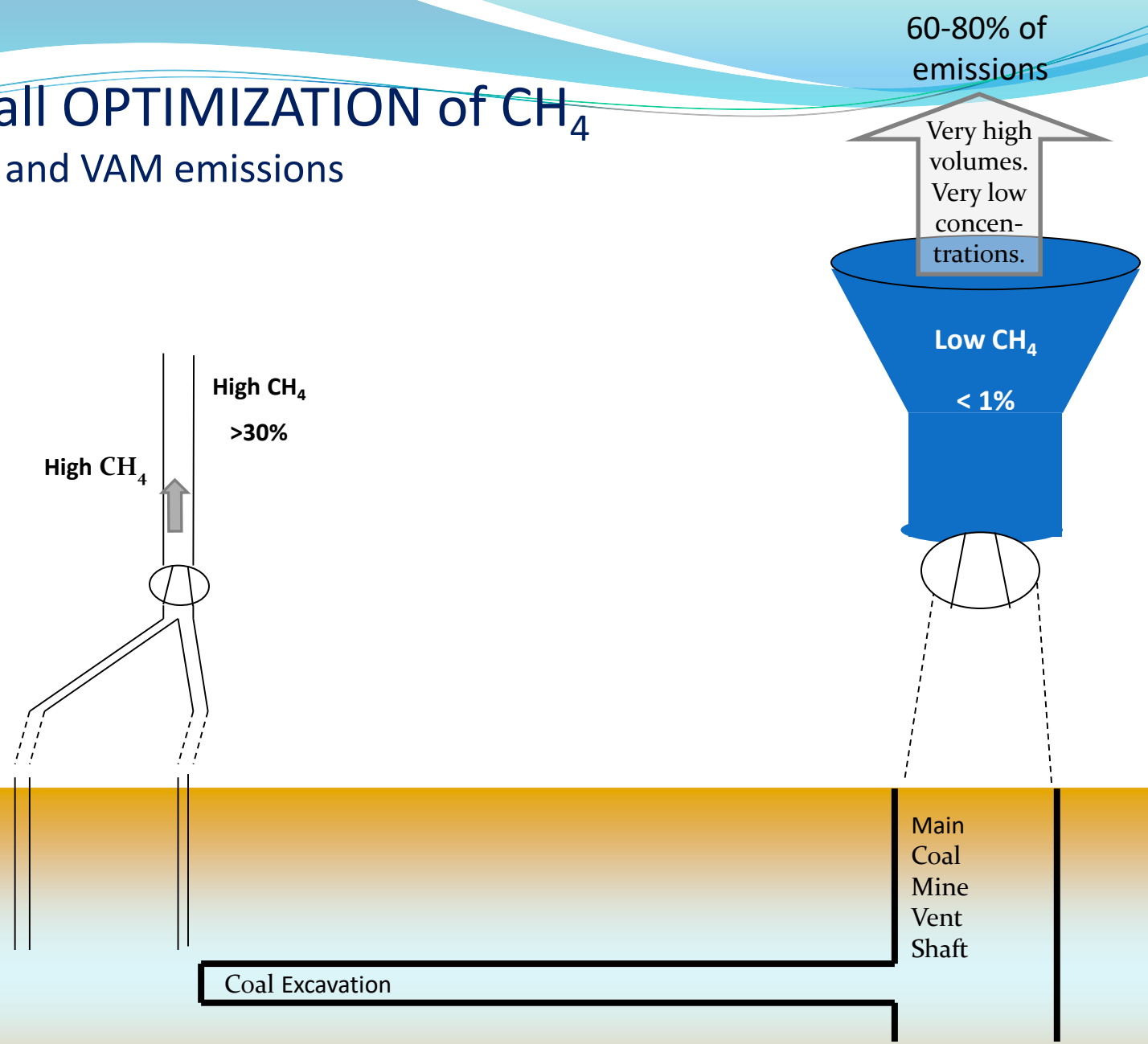


# Overall OPTIMIZATION of $CH_4$

## - CMM and VAM emissions



# Overall OPTIMIZATION of $CH_4$

## - CMM and VAM emissions


**High $CH_4$**

**>30%**

60-80% of emissions

**Low $CH_4$**

**< 1%**

Main Coal Mine Vent Shaft

Coal Excavation

# Overall OPTIMIZATION of $CH_4$

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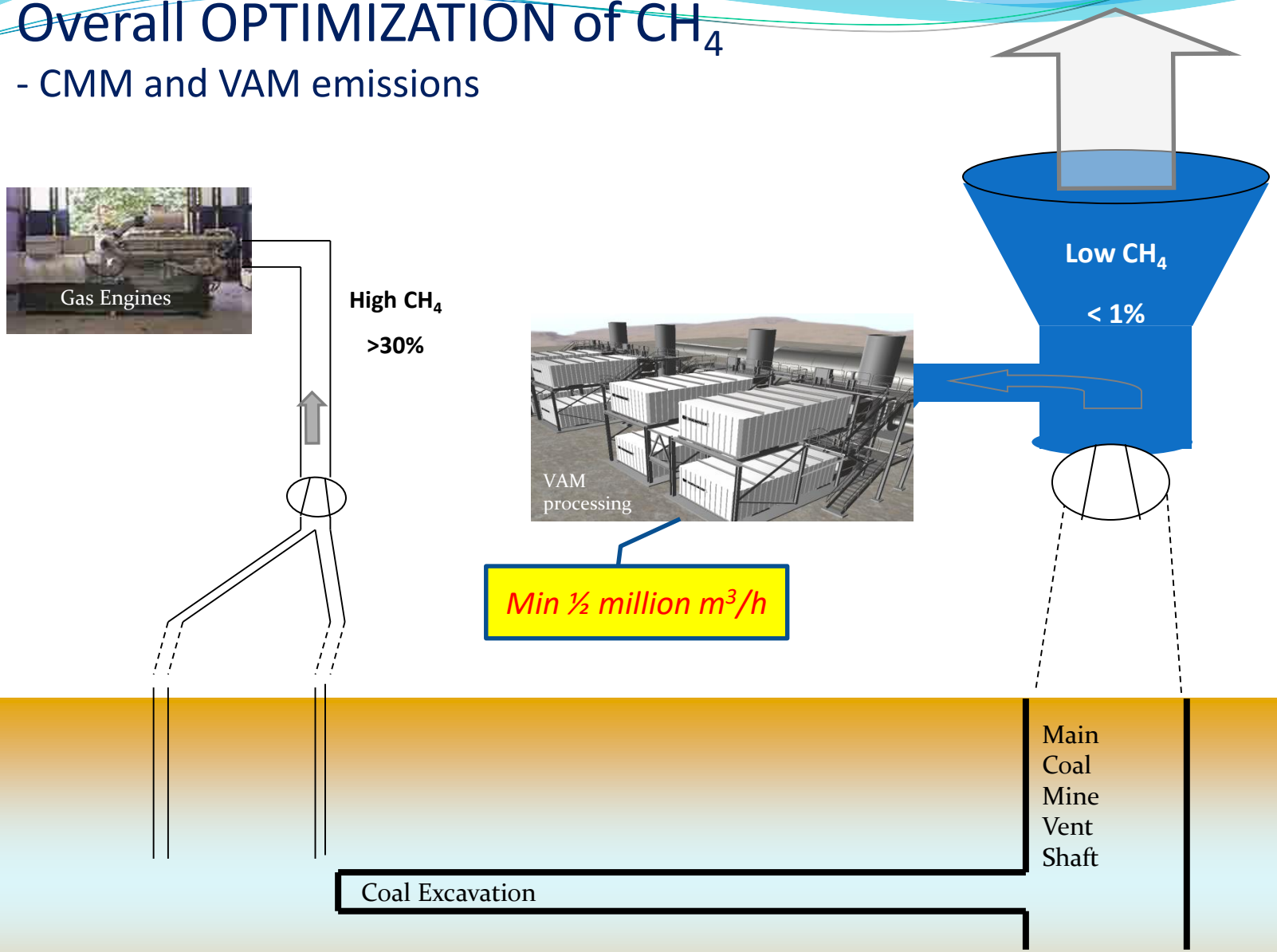

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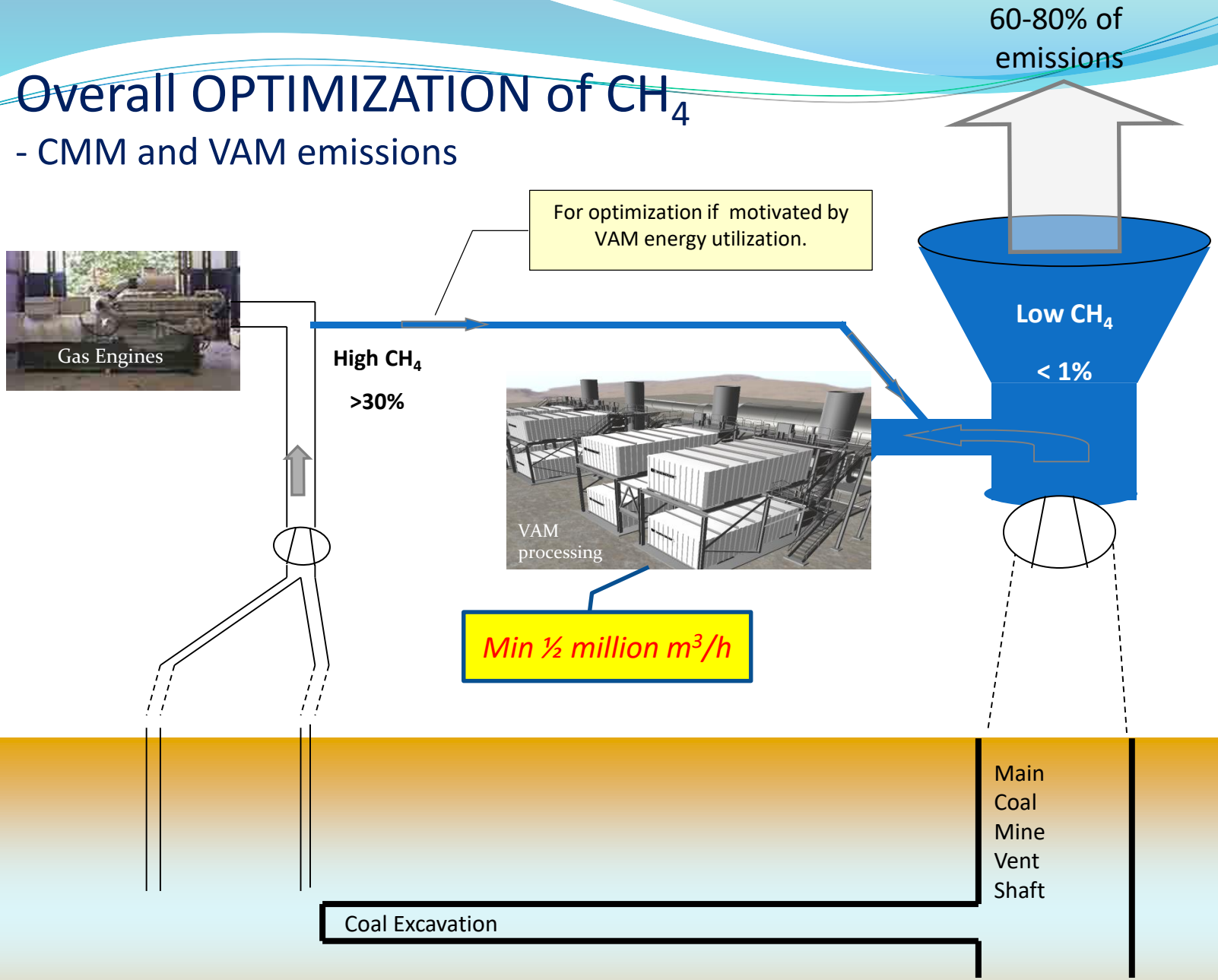

# CONCLUSIONS

VAM PROCESSING

- Experienced RTO suppliers can provide proven VAM processing solutions
- There will in time be more suppliers and more technical solutions to VAM processing

- For best feasibility of VAM projects, look for:
  - VAM concentrations of ~½ % or more
  - Possibility to enrich the ventilation air (into VAM processing) to min ½%
  - Possibilities to utilize thermal energy close to ventilation shaft (Heating? Cooling?)
  - Look for good value of reducing VAM emissions (Carbon Credits or similar)

For very large mines: Optimize your overall emission strategy between processing of drainage gas and processing of VAM for power generation.

Richard.Mattus@gmail.com
VAM specialist
UN Group of Experts on CMM