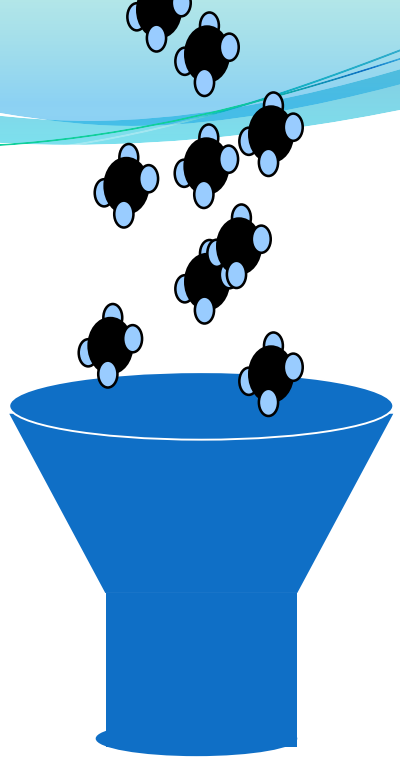
BEST PRACTICE IN VAM PROCESSING

Astana 20 June 2018

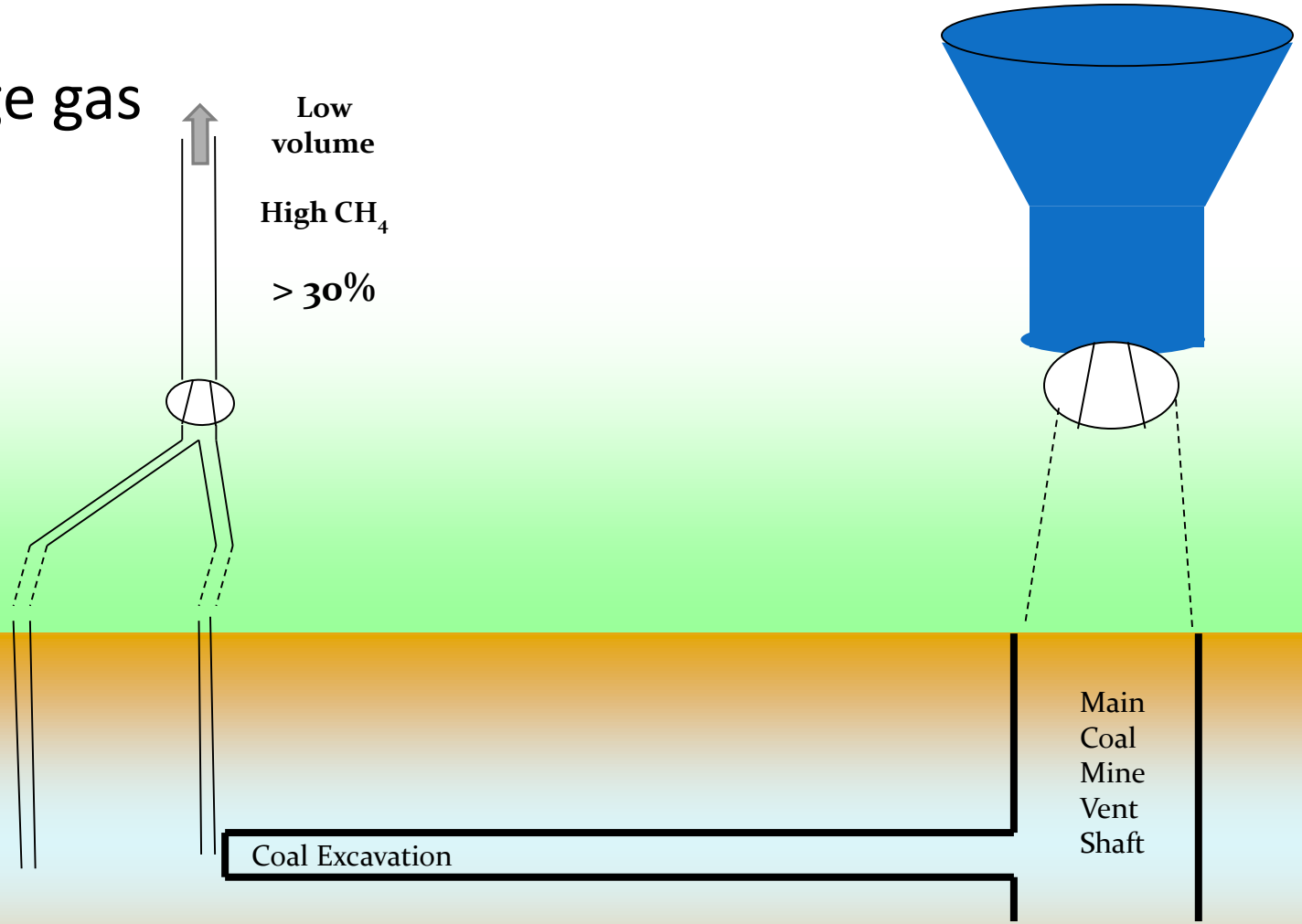
Richard Mattus



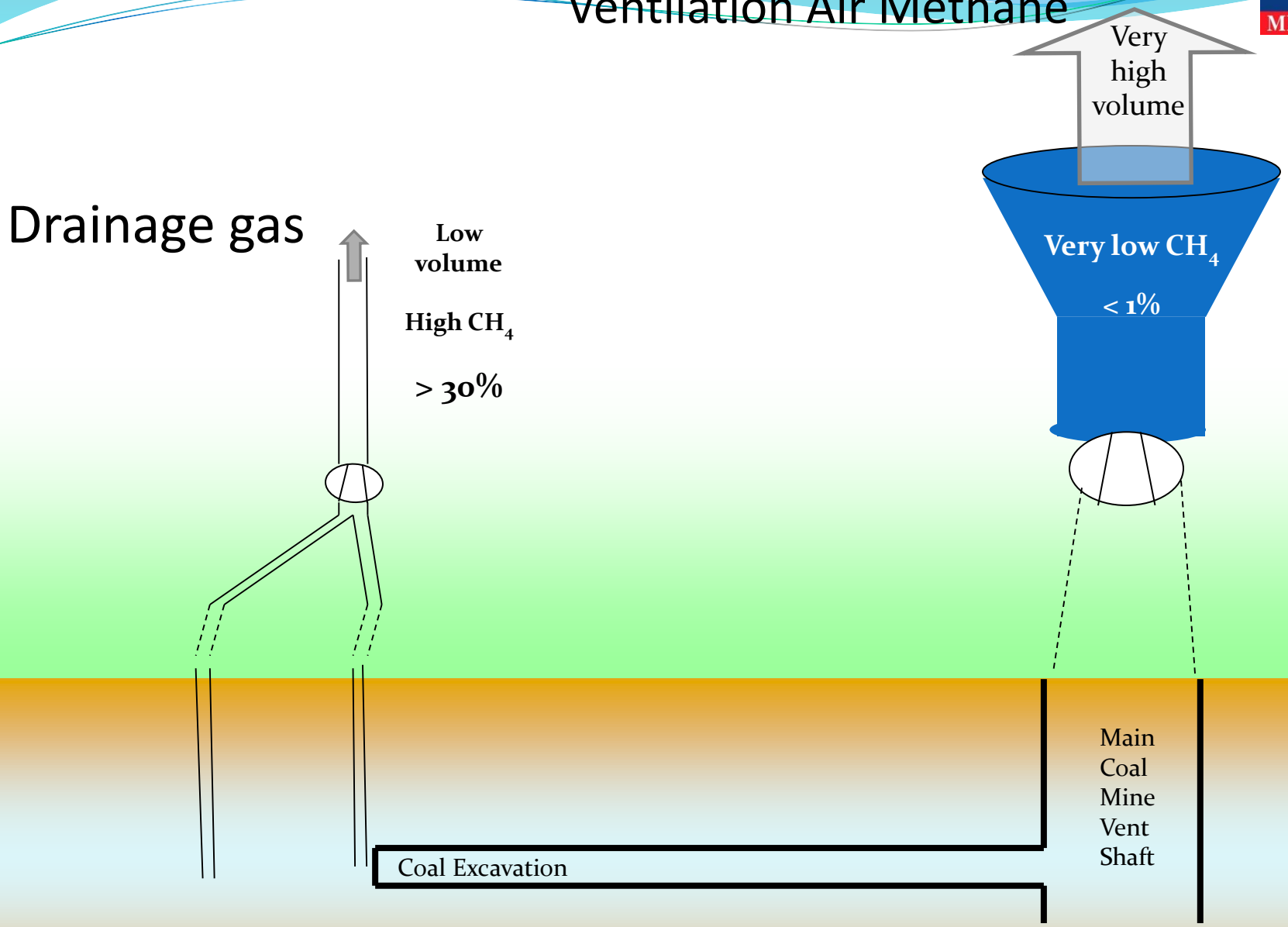
- Why is VAM an issue?

- 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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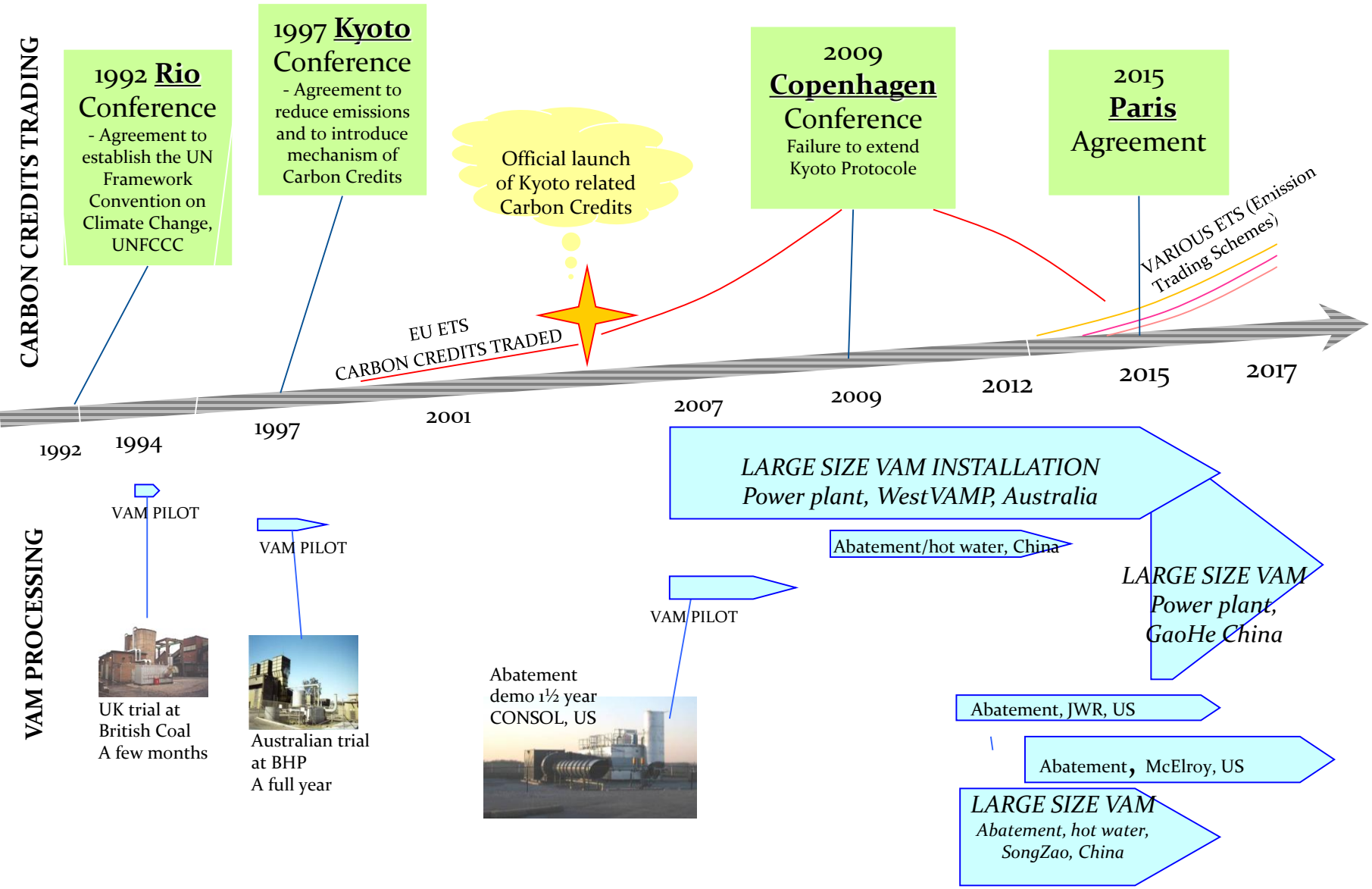
INDUSTRIAL OXIDIZERS

VAM PROCESSING AND CARBON CREDITS



COMMERCIAL SIZE VAM PROCESSING

EXPERIENCED RTO-SUPPLIERS

COMMERCIAL SIZE VAM PROCESSING

IN OPERATION BY JUNE 2018

McElroy,
180 000 Nm³/h
Since 2012

VAM Power Plant GaoHe
1 080 000 Nm³/h
Since 2015

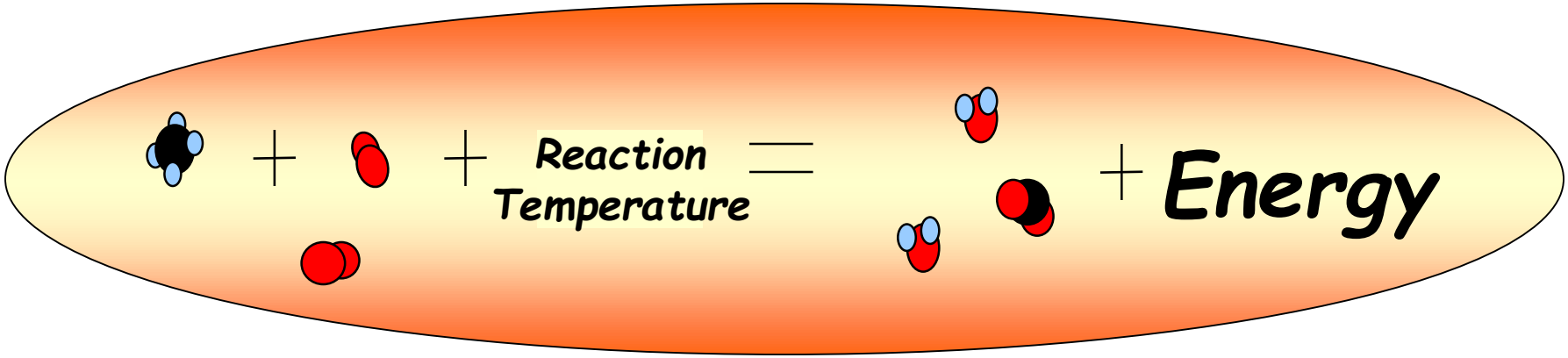
<u>Closures of others due to :</u>

- Moving of mining activities
- Failing values of carbon credits

RTO technology

- How does it work?

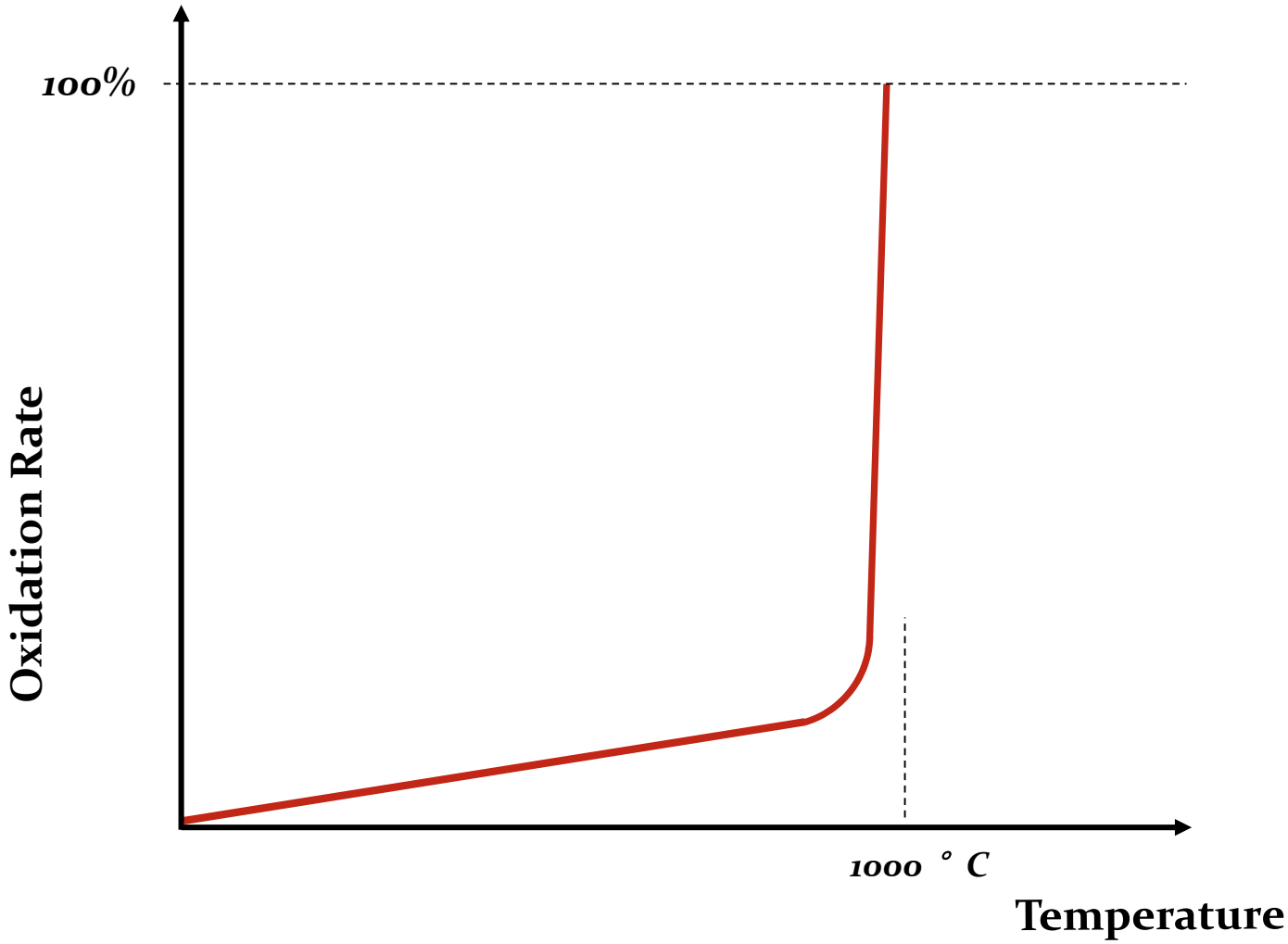
Principle of RTO reaction



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

And release Energy!

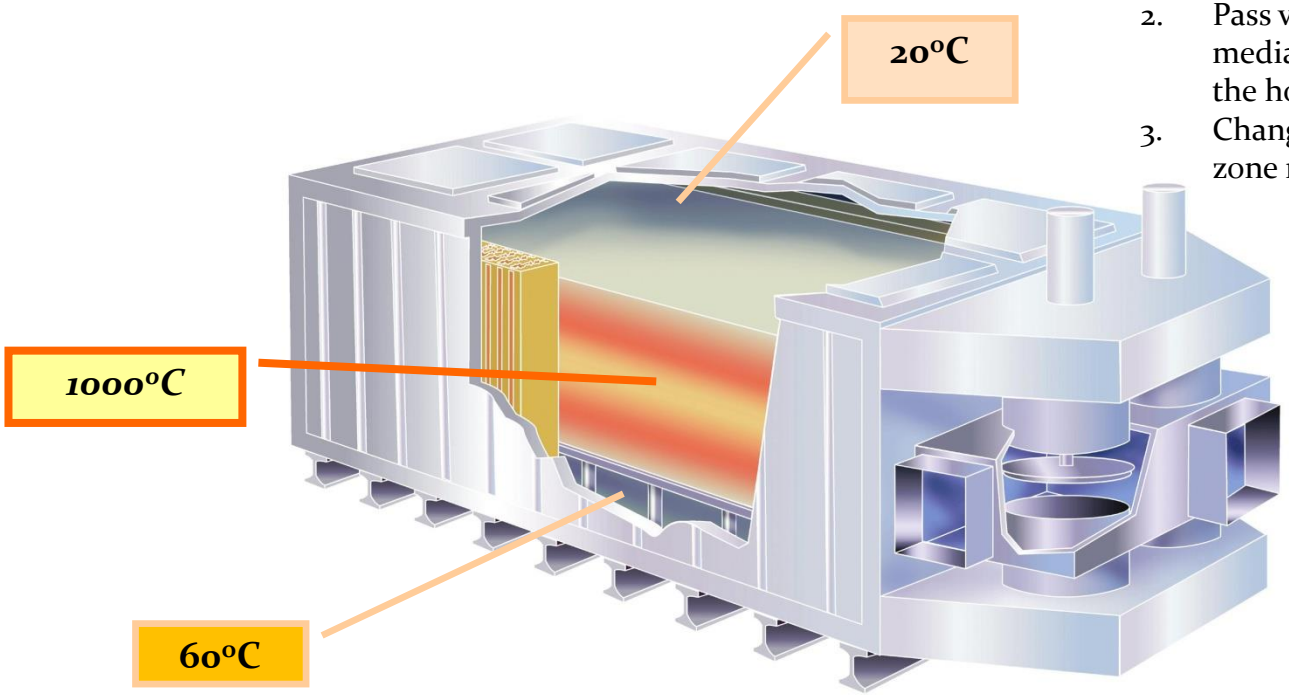
VOC Oxidation Rate



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.

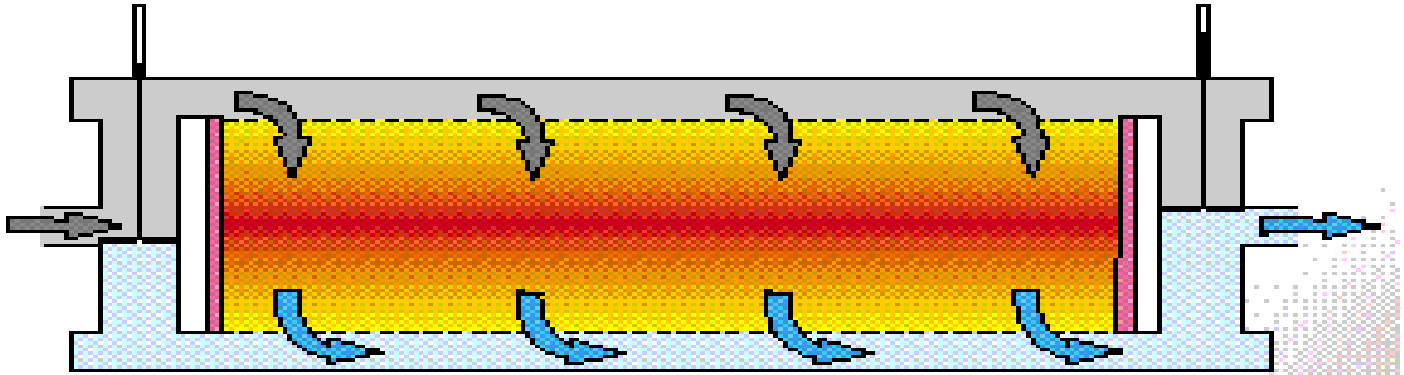


No catalyst

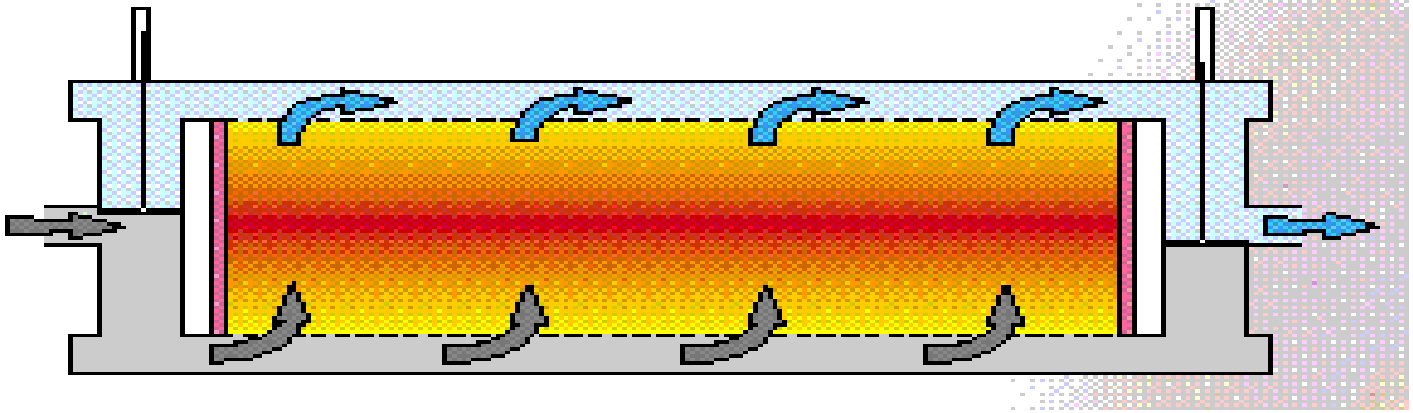
operate at natural oxidizing temperature

Single can RTO

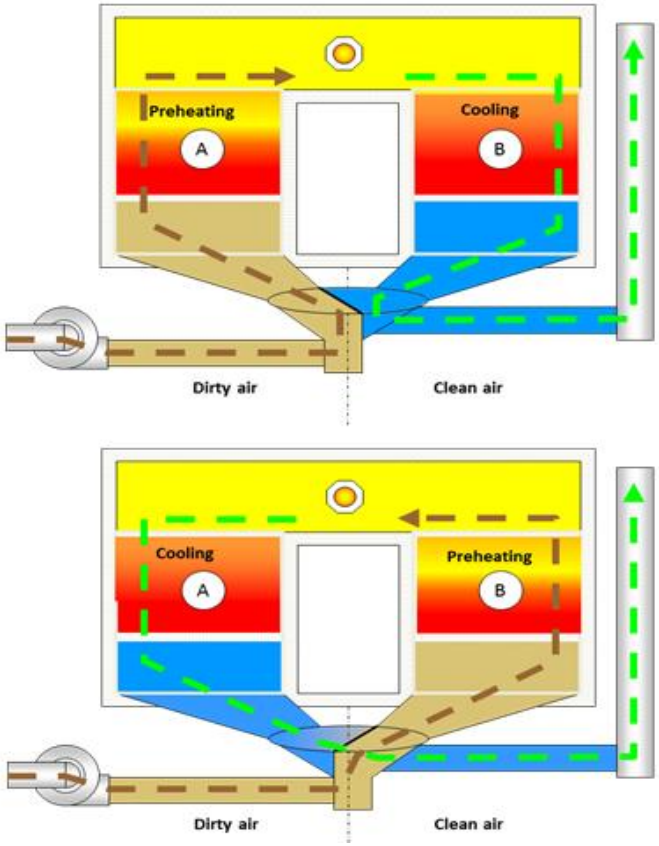
Flow down



Flow up

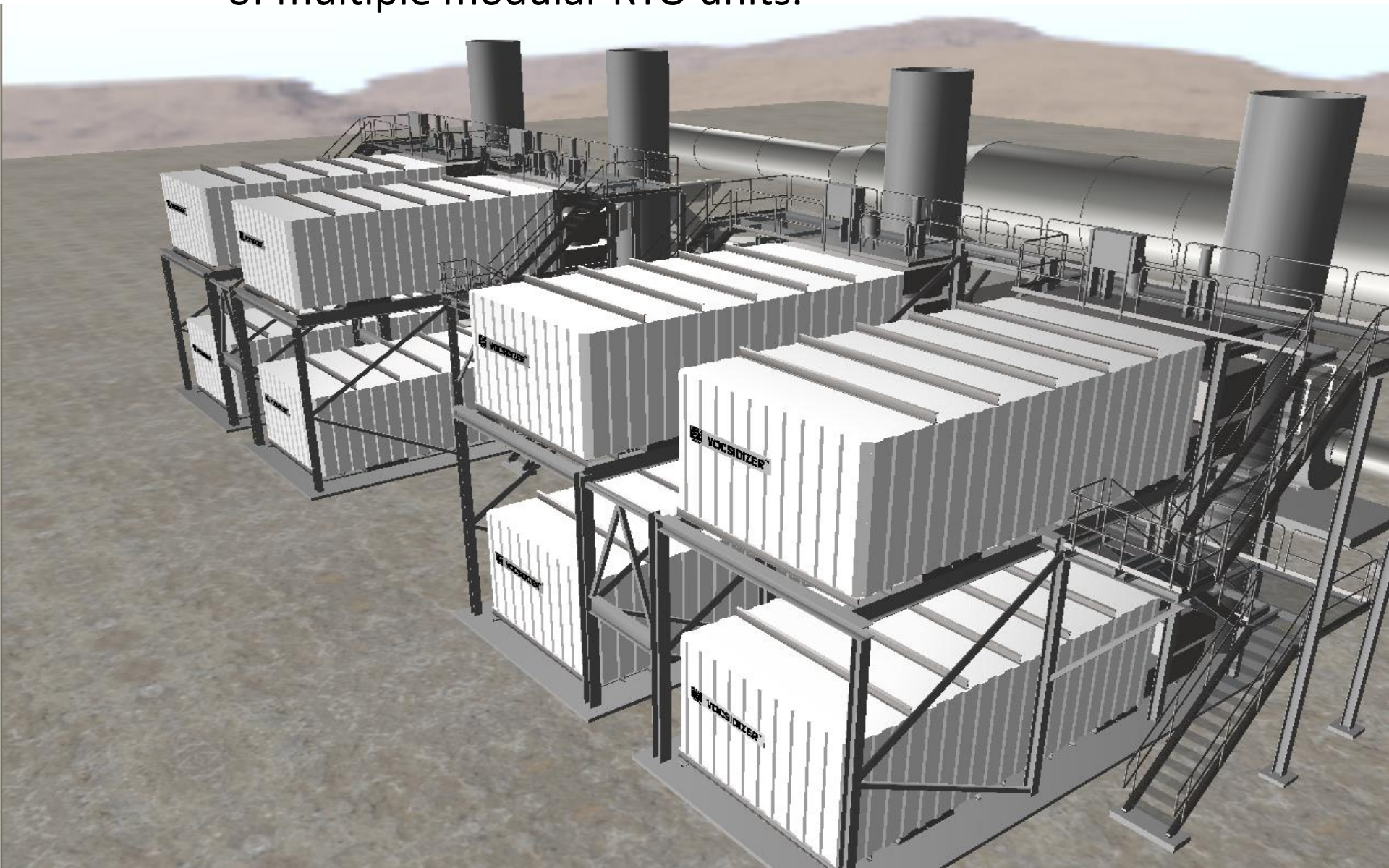


2 Can (or more) RTO

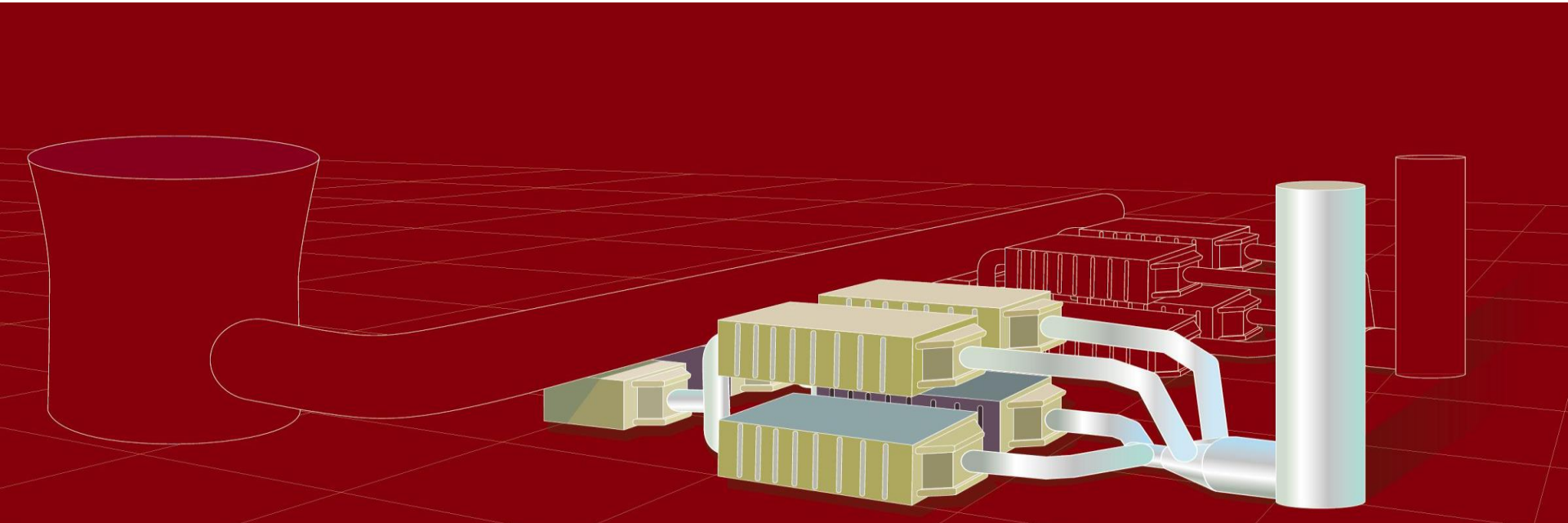


Main difference between the single can RTO and 2 can or multiple can RTO's: Oxidation in a combustion chamber instead of in the ceramic bed.

RTO installations typically consists of multiple modular RTO units.



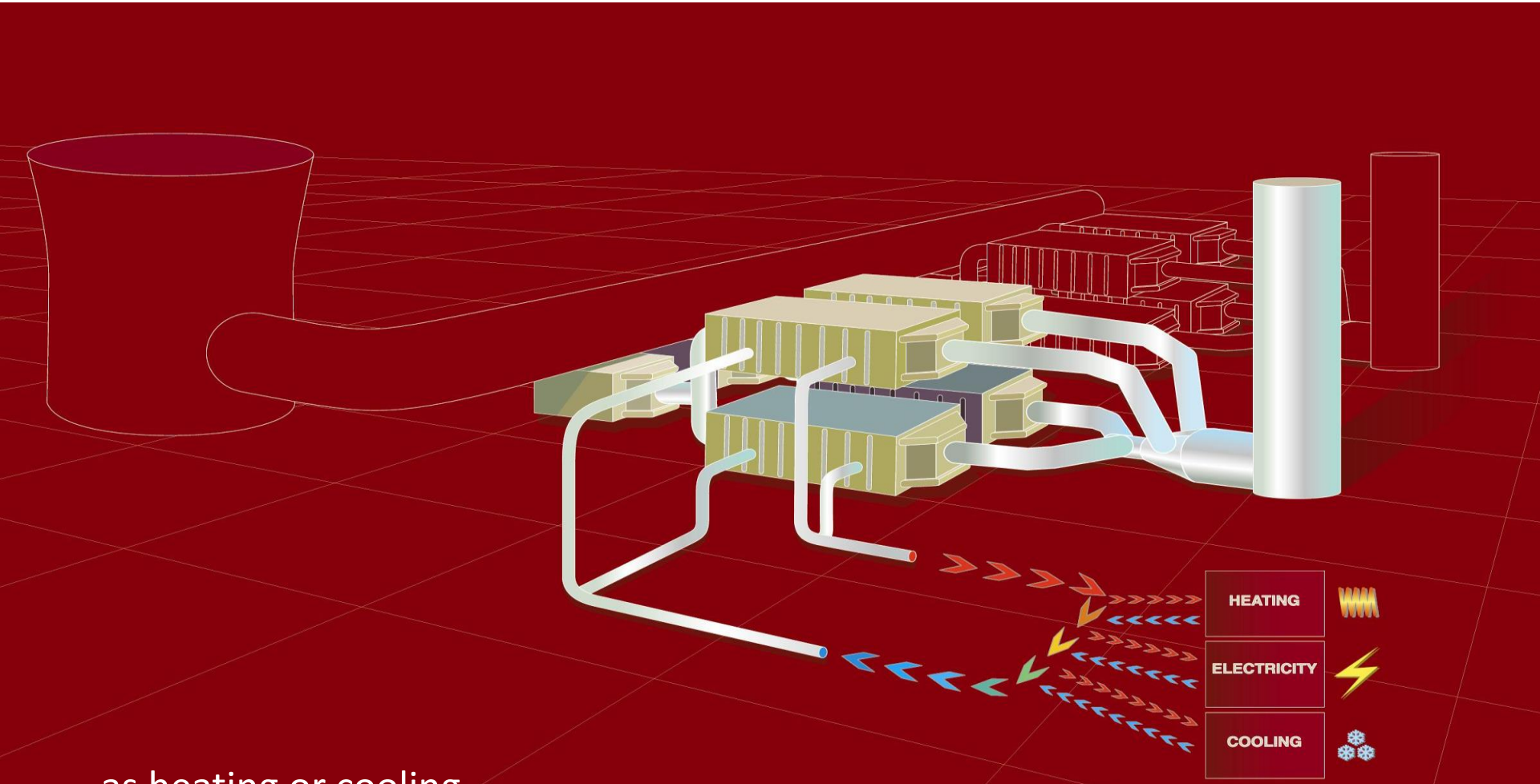
PURE VAM ABATEMENT



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.

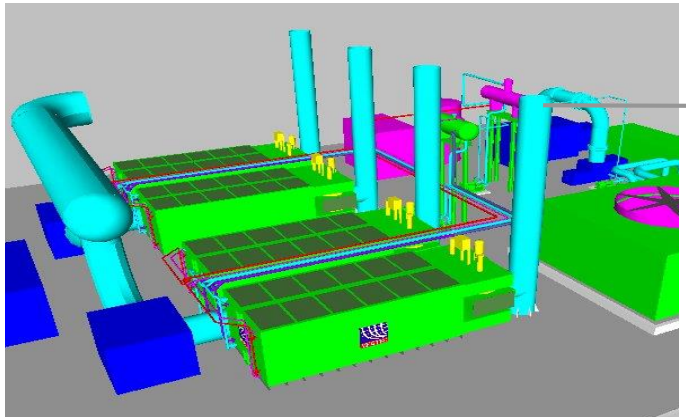
GUIDE LINES

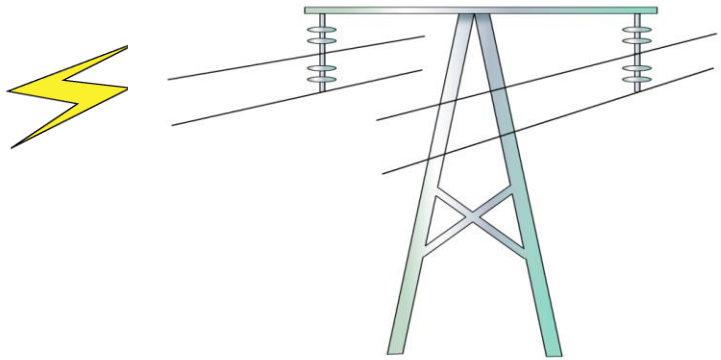
Indications of VAM project economics

- 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





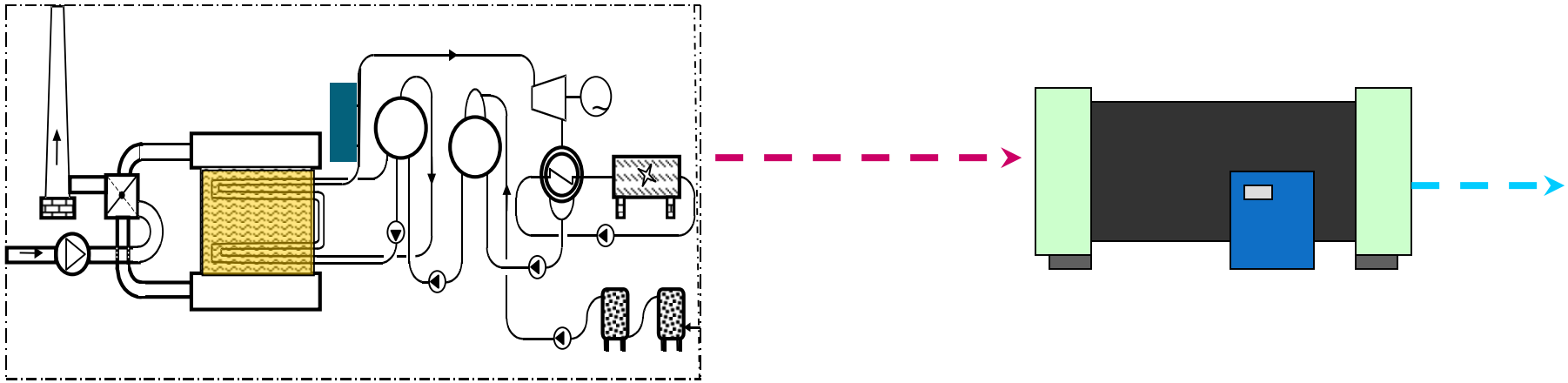
0.2 % methane needed to maintain oxidation.
Energy of concentrations above 0.2 % can be recovered.

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



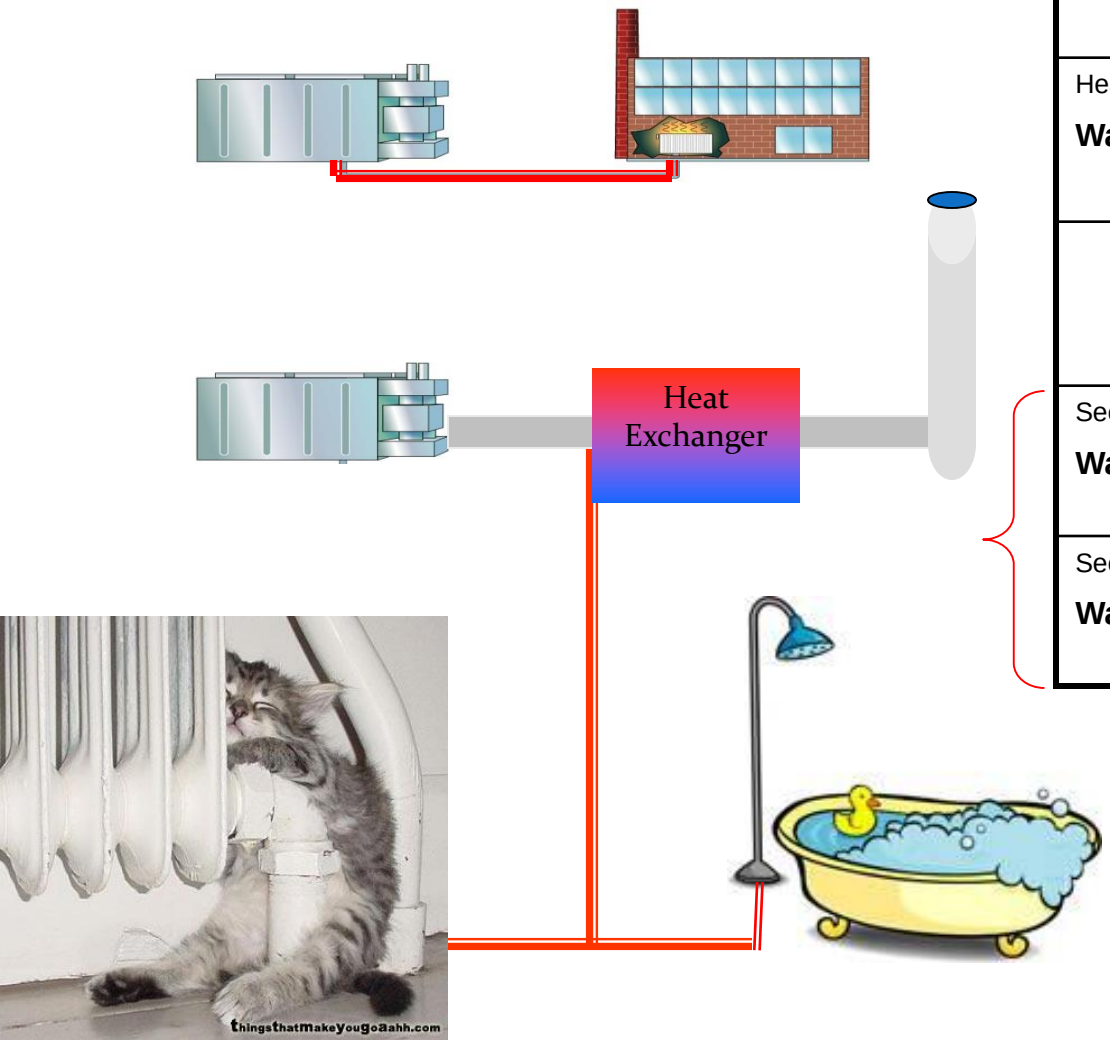
Cooling water from electricity generation drives absorption chiller

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. **Water at 70 - 150^{oC}**	3 MW	11 MW	18 MW
-- - *For each 250 000 Nm3/h of ventilation air* - - -			
Secondary heat-exchanger. **Water at 70oC**	1 MW	8 MW	15 MW
Secondary heat-exchanger. **Water at 150oC**	-	2 MW	10 MW

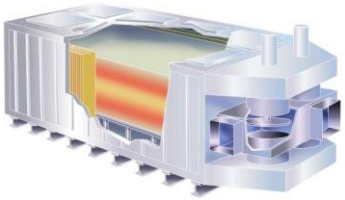
GUIDE LINES

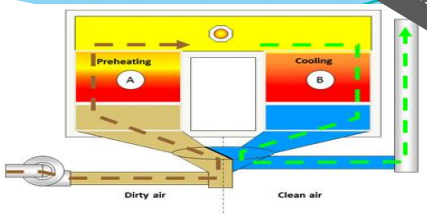
Electricity from VAM (electrical energy)

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

For large size plants, 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

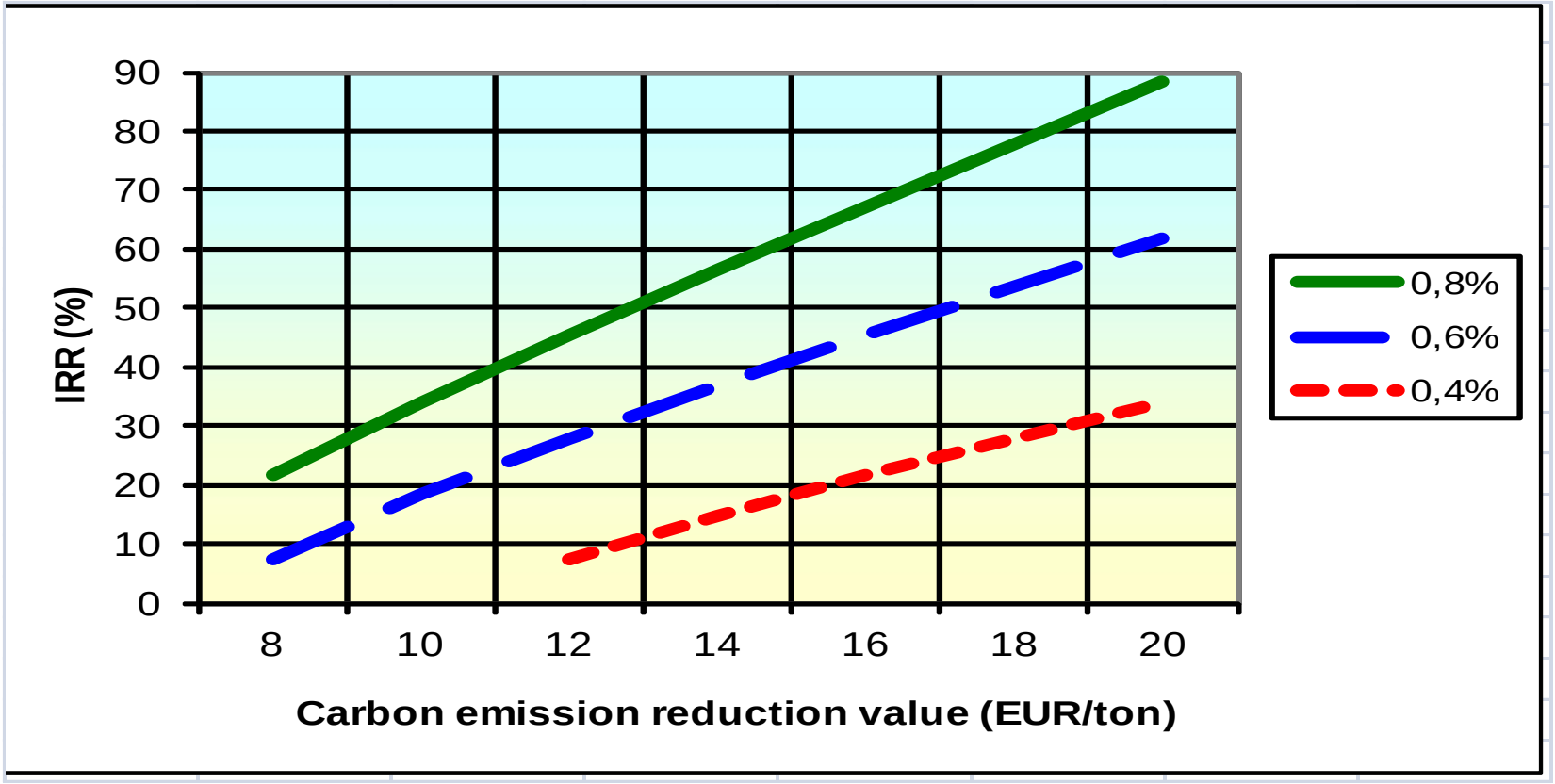
VAM conc'n / Nm3/h vent air	0.3 %	0.6 %	0.9 %
125 000	***40***	***80***	***120***
250 000	***80***	***160***	***240***
500 000	***160***	***320***	***480***
1 000 000	***320***	***640***	***960***

Annual emission reductions in thousand tons of CO2e

VAM Project Financial Feasibility

GUIDE LINES

VAM project economics indications



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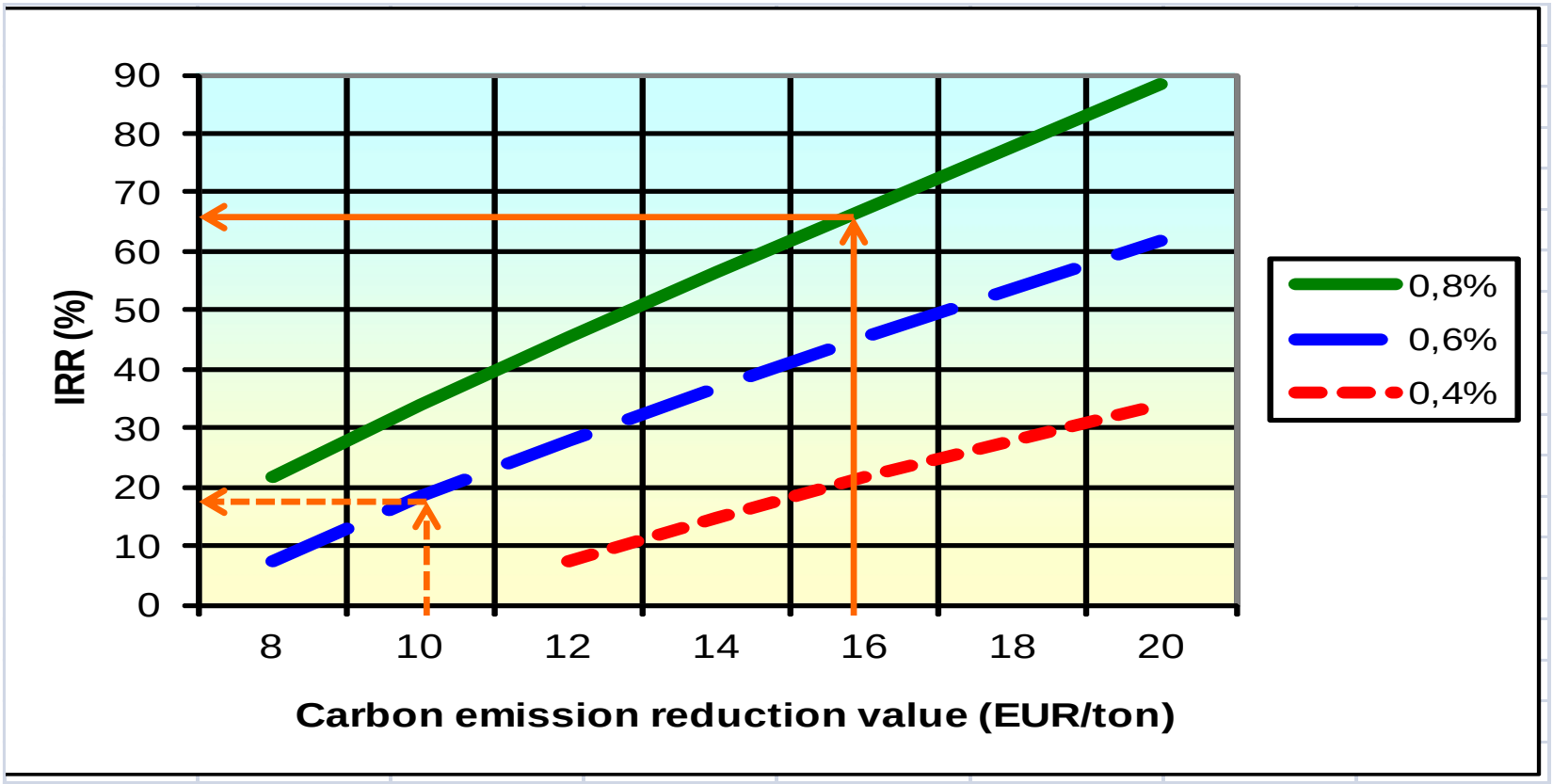


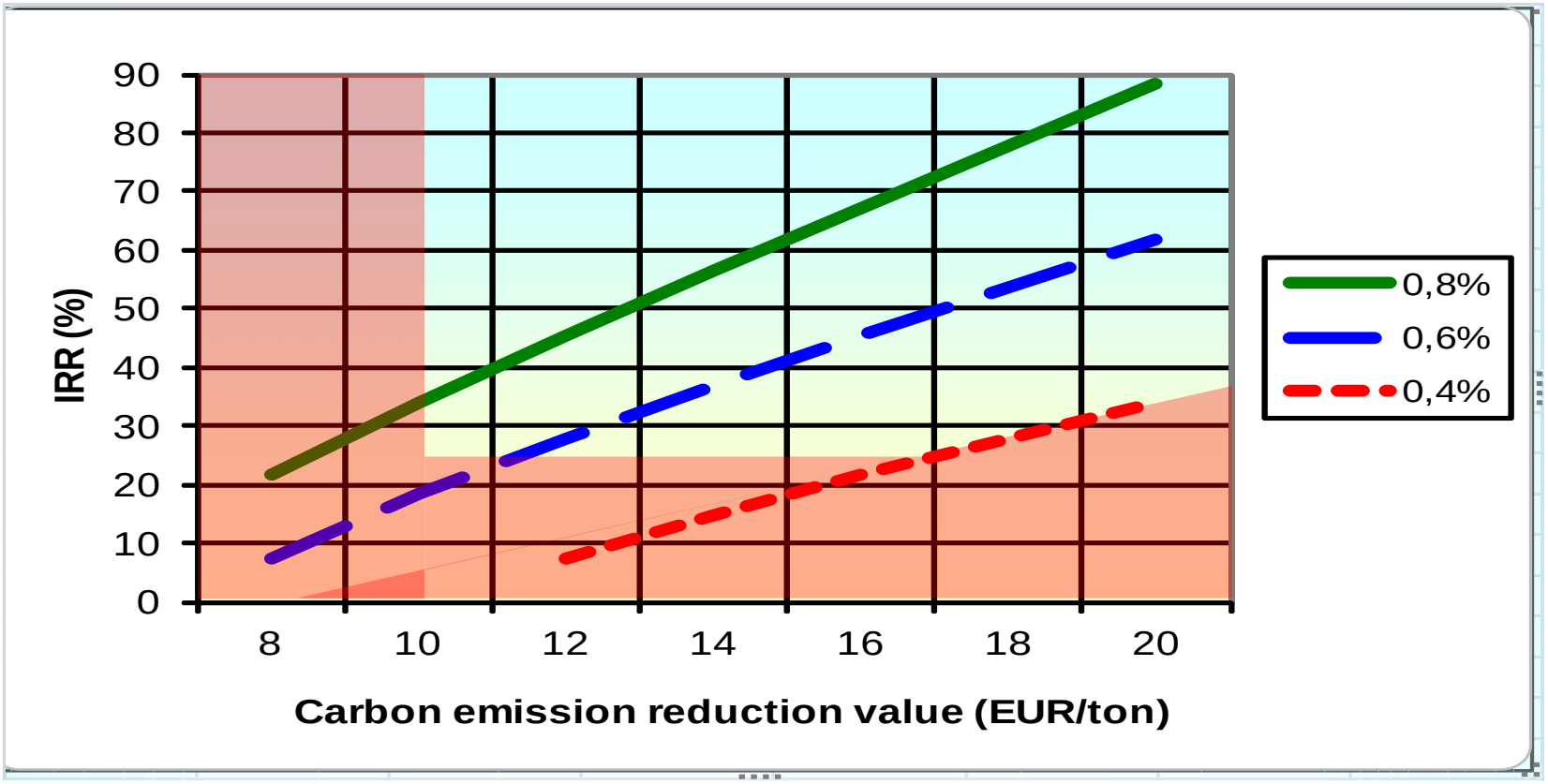
Examples:

- 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

VAM project economics indications



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 price overview EU

Kyoto Compliance Period
2008 - 2012

Carbon price overview EU

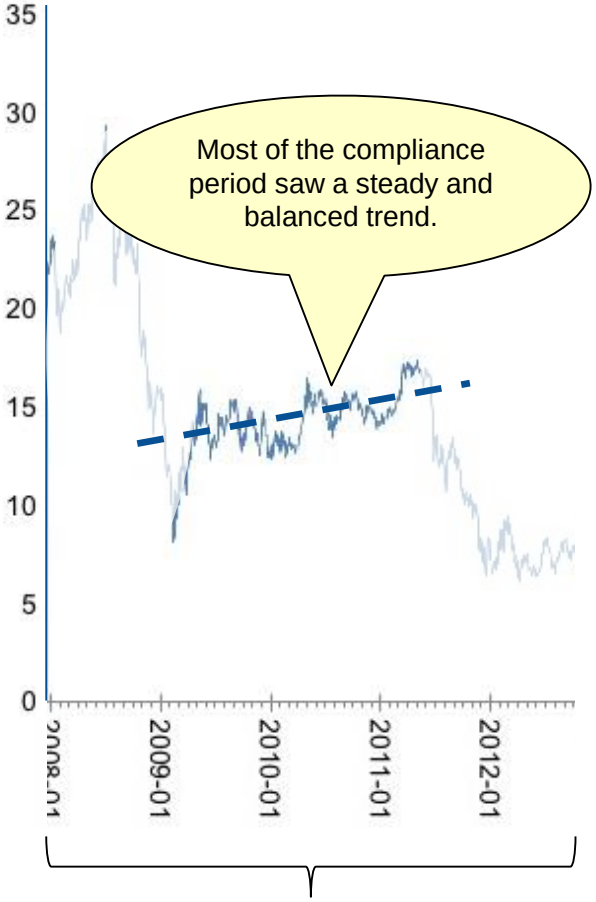
EUA price (€/t)

The initial price level of EUR 20-30 per ton CO2e was interrupted by economic recession and by introductory disturbances.

Lowered value primarily relating to:
- 2012 Kyoto end uncertainty
- Low industrial & energy production creating a major surplus of Carbon Credits flooding the market

Kyoto Compliance Period
2008 - 2012

Carbon price overview EU



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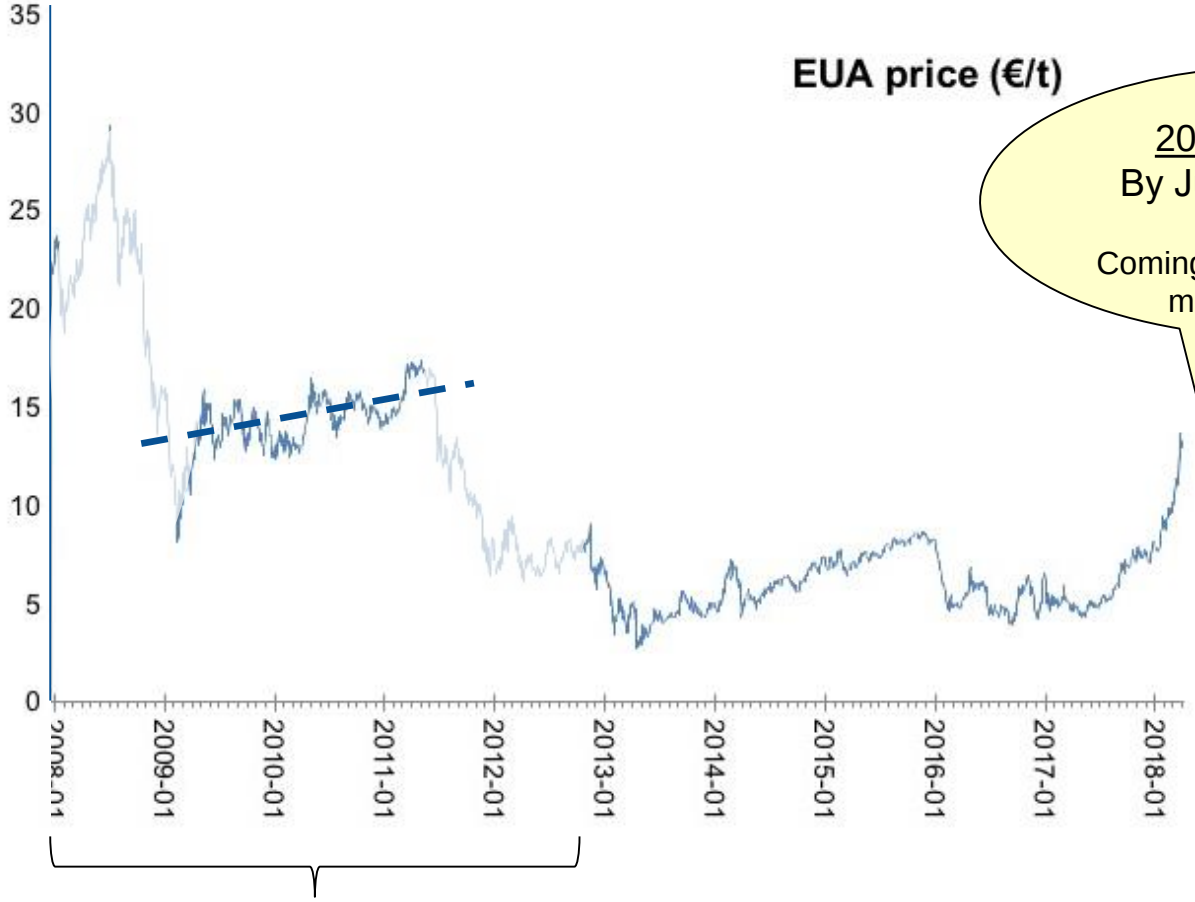

2018 EUA price:
By June above € 15.

Coming back to a balanced market situation?

Kyoto Compliance Period
2008 - 2012

Carbon price overview EU

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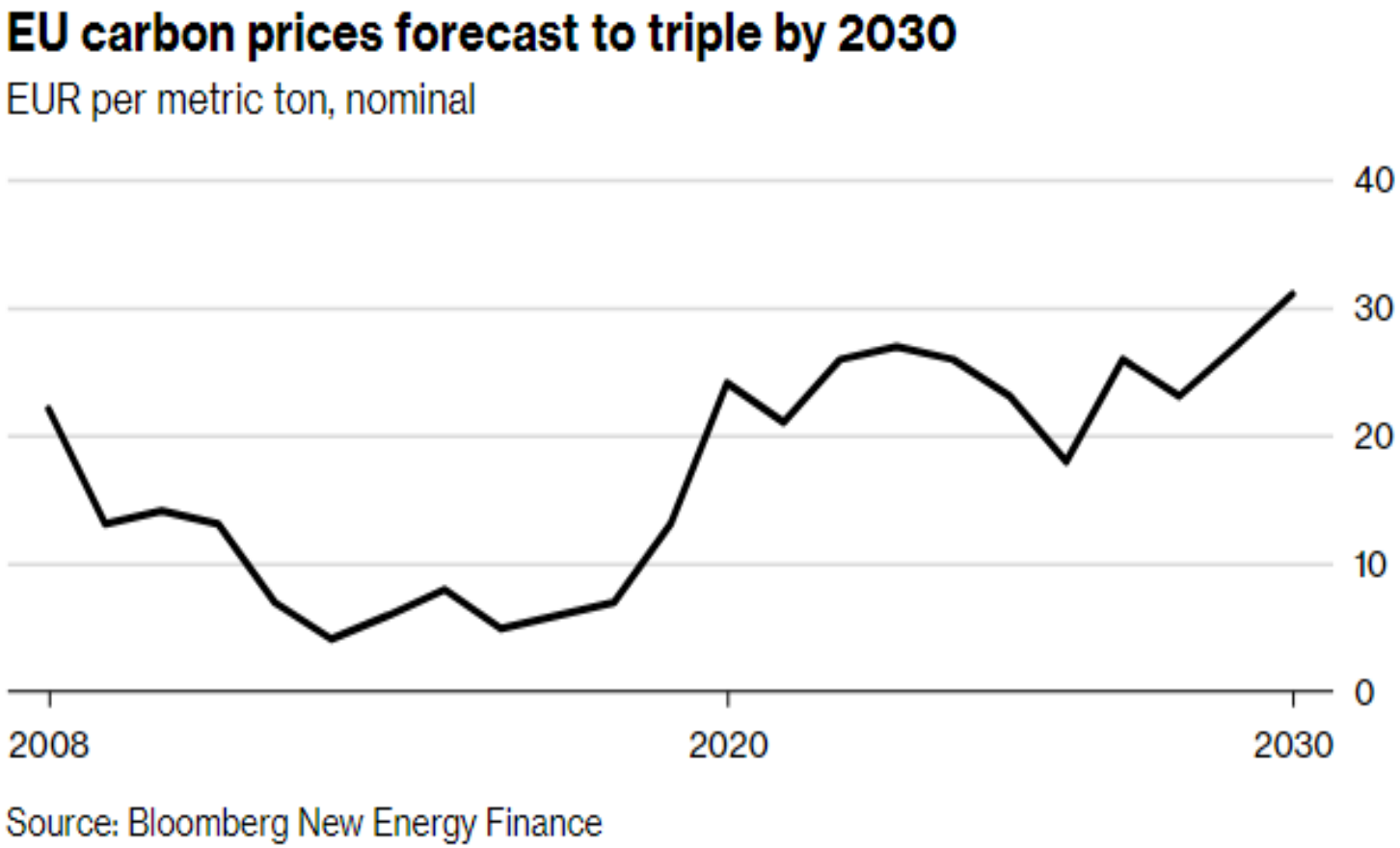
Carbon price overview EU

Kyoto Compliance Period
2008 - 2012

FORECAST PUBLISHED IN FEBRUARY 2018

(EUA at €13 EUR)



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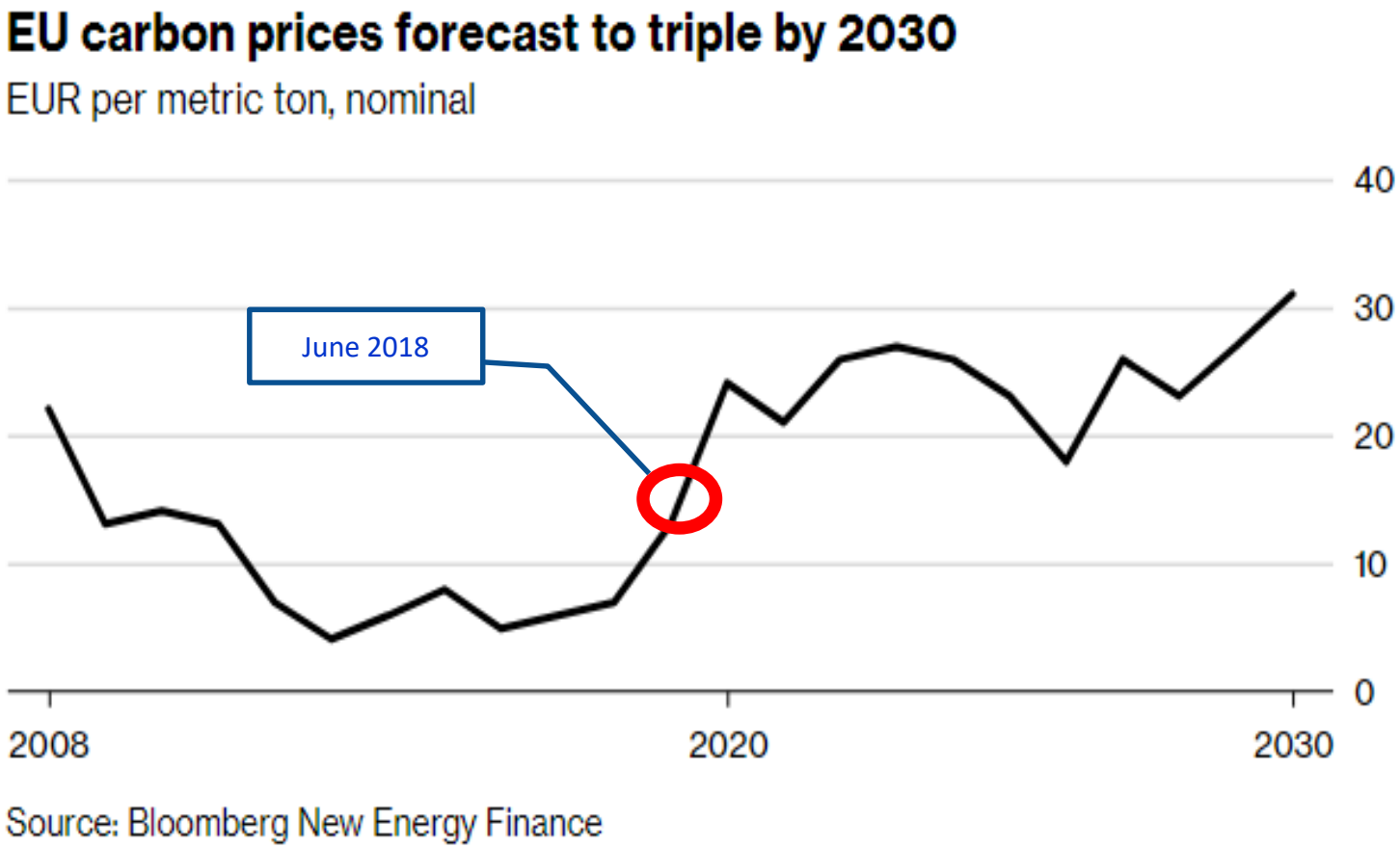
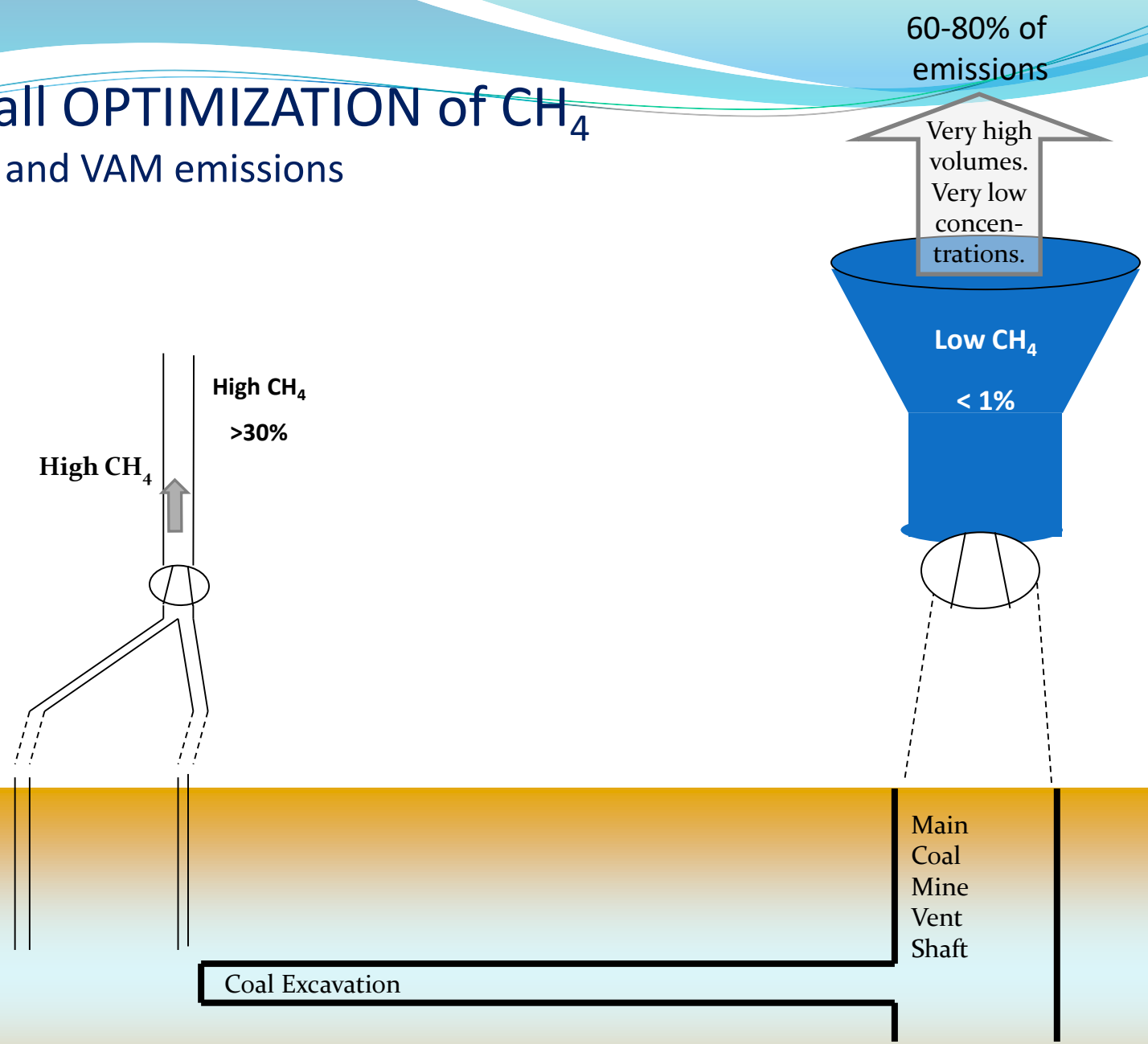


Overall OPTIMIZATION of CH_4

- CMM and VAM emissions



Overall OPTIMIZATION of CH_4

- CMM and VAM emissions

High CH_4

>30%

60-80% of emissions

Low CH_4

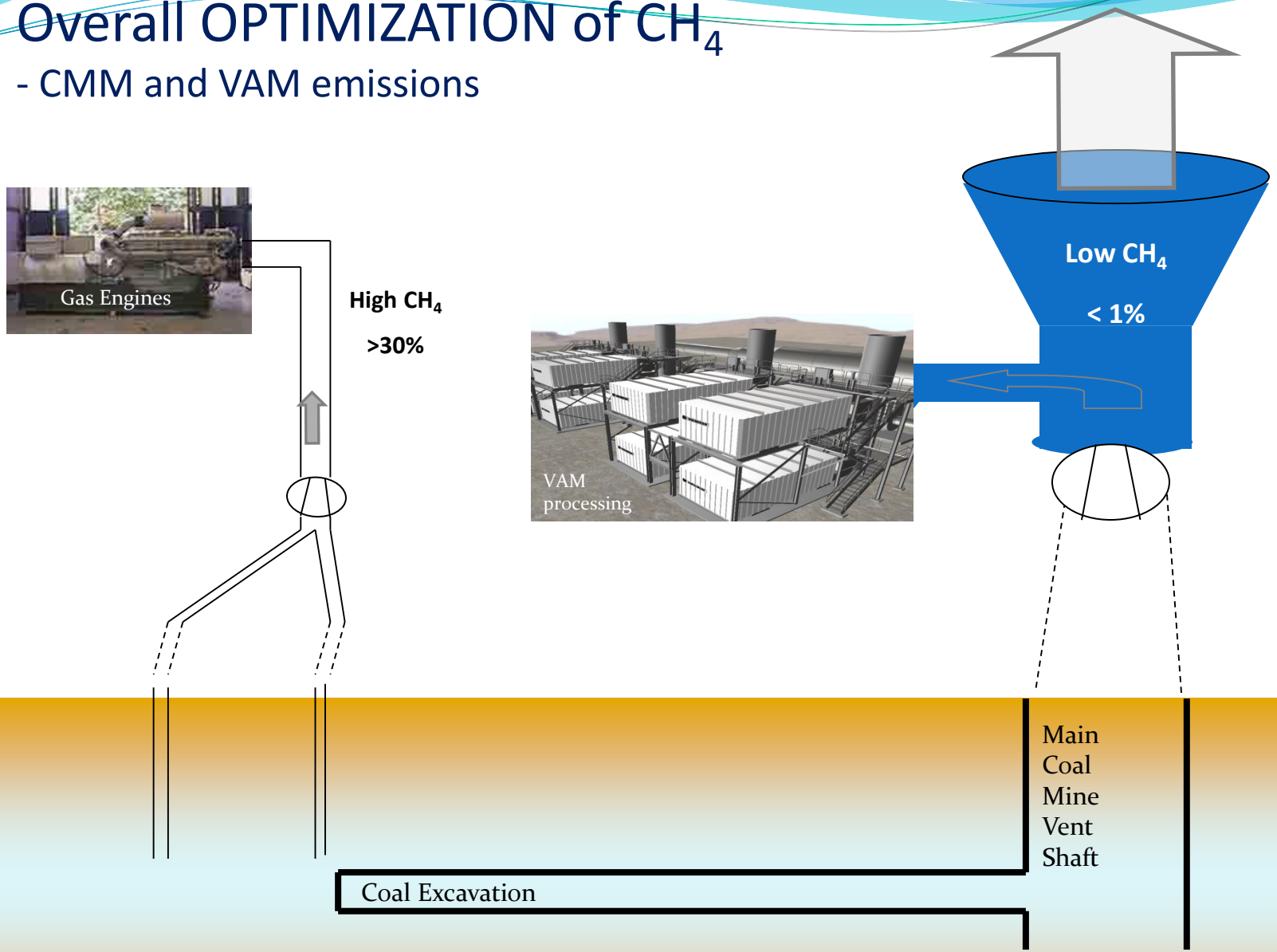
< 1%

Main Coal Mine Vent Shaft

Coal Excavation

Overall OPTIMIZATION of CH_4

- CMM and VAM emissions



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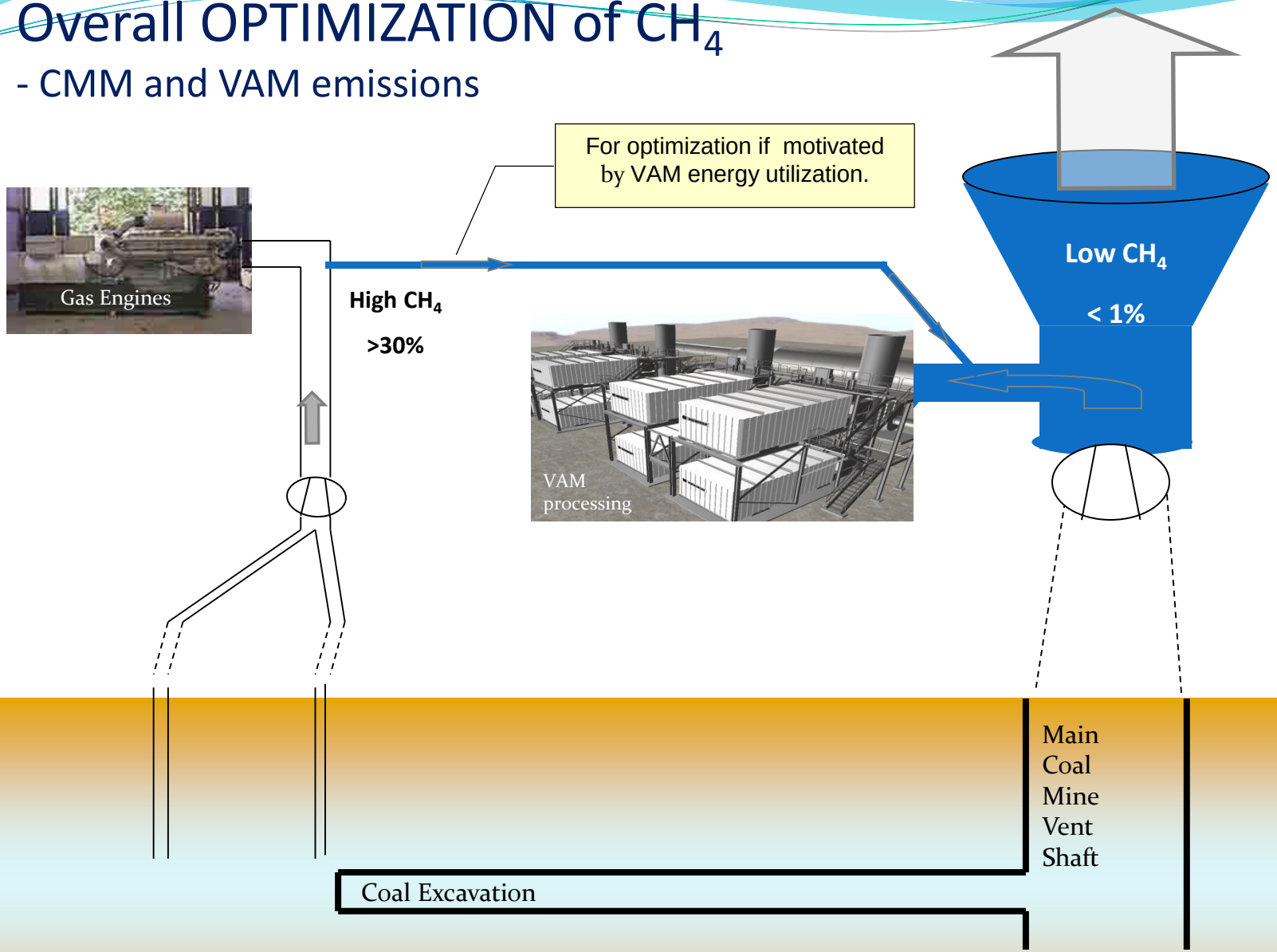

CONCLUSIONS

VAM PROCESSING

- Experienced RTO suppliers can provide proven VAM processing solutions
- There will 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 (cooling?)
  - Look for good value of reducing VAM emissions (Carbon Credits or similar)
- Optimize your overall emission strategy between processing of drainage gas and VAM

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