In full operation – the world's first VAM Power Plant

Presented at Methane to Markets Partnership Conference & EXPO in Beijing
30 Oct 07 by Richard Mattus, MEGTEC

WestVAMP IN FULL OPERATION

- At the WestCliff Colliery of BHP Billiton in Australia
- Based on (patented) technology from MEGTEC Systems
- VOCSIDIZERs from MEGTEC are made part of the power plant steam cycle

WestVAMP IN FULL OPERATION

Fuel contains ~ 99% air

- **250 000 Nm3/h** (150 000 scfm) of ventilation air with
- **0.9% CH4** concentration (VAM + drainage gas) generating
- **High pressure, superheated steam** driving a
- **Conventional 6 MWe power plant steam turbine**

WestVAMP HOOD CONNECTION

- Open connection having no influence on ventilation system

WestVAMP IN FULL OPERATION

- In full operation since April 2007
- Officially opened on 14 September by the honorable Morris Iemma, Premier of NSW, Australia

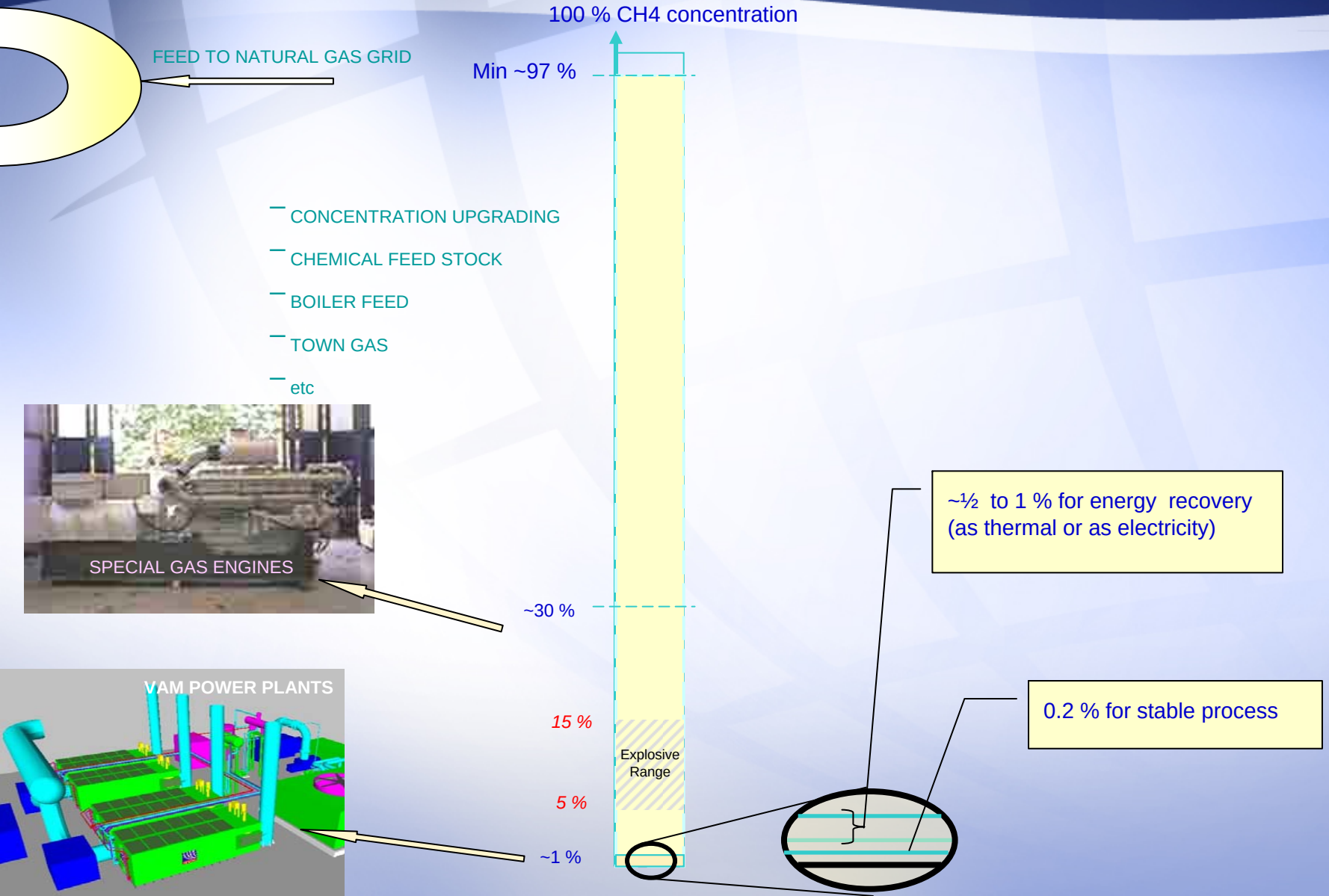
.. national Australian news of that date

PRESENTATION OUTLINE

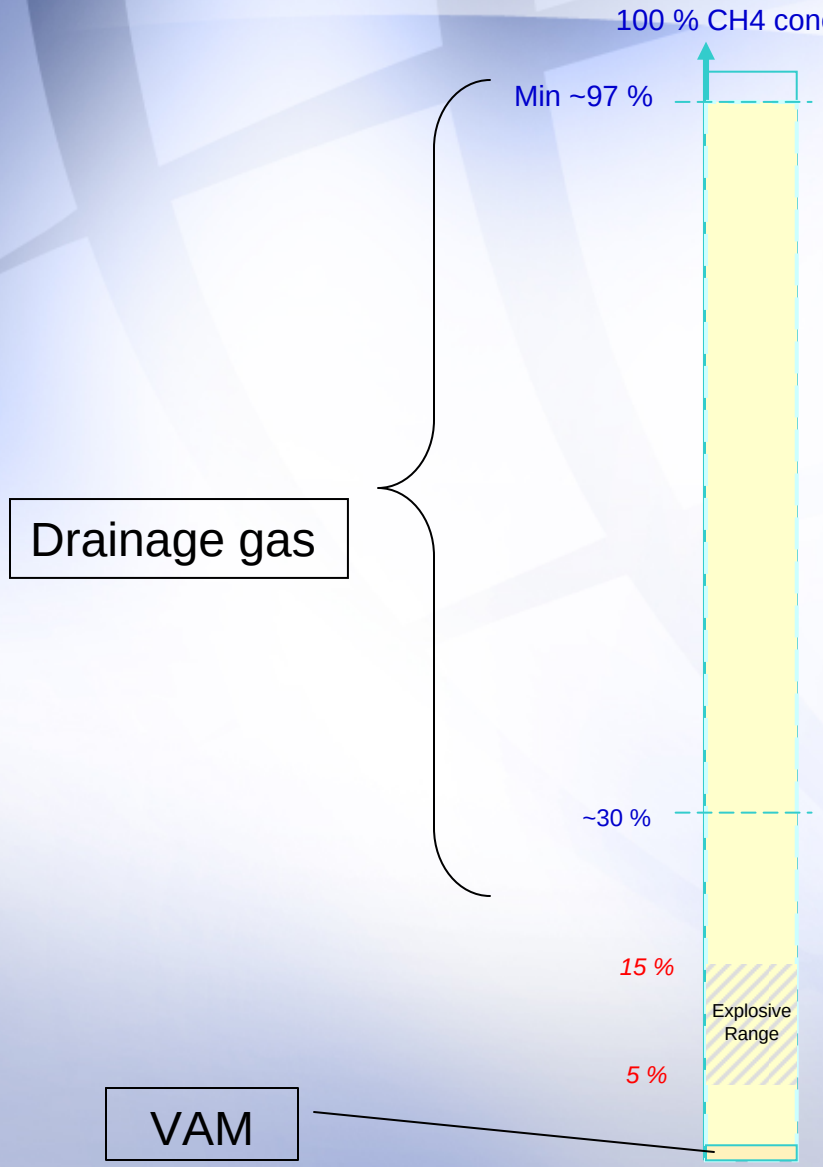
Key Topics covered:

- 4 Coal Mine VAM site demo's of MEGTEC
- Who is MEGTEC and how did MEGTEC solve the VAM dilemma (utilizing large volumes of extremely lean gas as fuel) ?
- Why is reducing VAM emissions of high interest?
- VAM Project economics

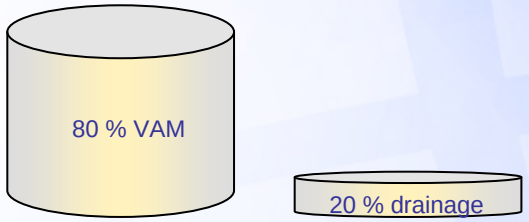
REFERENCES OF CONCENTRATION - CMM



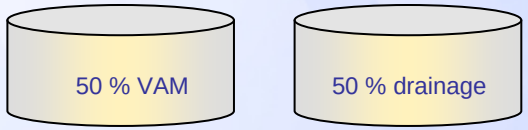
CMM EMISSIONS – VAM vs DRAINAGE



Distribution of total methane emissions



- from typical coal mine in China



- from mine (anywhere) with extensive drainage

GLOBAL CONCLUSION :
Most CMM is emitted as VAM

MEGTEC Systems

.. belongs to

SEQUA Corporation

US industrial corporation
noted on NYSE
USD >2 billion (2006 Sales)

MEGTEC Systems

USD >0.2 billion in sales

Over 800 employees worldwide

SEQUA Corporation

Aerospace

Chromalloy Gas Turbine

Automotive

Arc Automotive

Casco Products

Metal coating

Precoat Metals

Speciality chemicals

Warwick Intenational

Industrial machinery

MEGTEC Systems

Other products

After Six

MEGTEC Locations Worldwide

De Pere, WI

Columbus, OH

Vero Beach, FL

Manchester, UK

Maidenhead, UK

Ingre, France

Evry (Paris), France

Åmål, Sweden

Göteborg,Sweden

Maintal (Frankfurt) Germany

Shanghai, China

Pune, India

Singapore

Melbourne, Australia

MEGTEC Systems Worldwide Headquarters

MEGTEC Systems Regional Offices

MEGTEC Systems

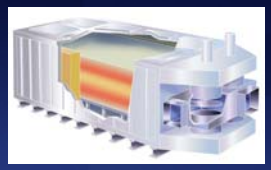
Globally leading supplier

of emission control equipment

+

In house competence and experience of boilers and boiler design.

MEGTEC VOCSIDIZER INSTALLATIONS

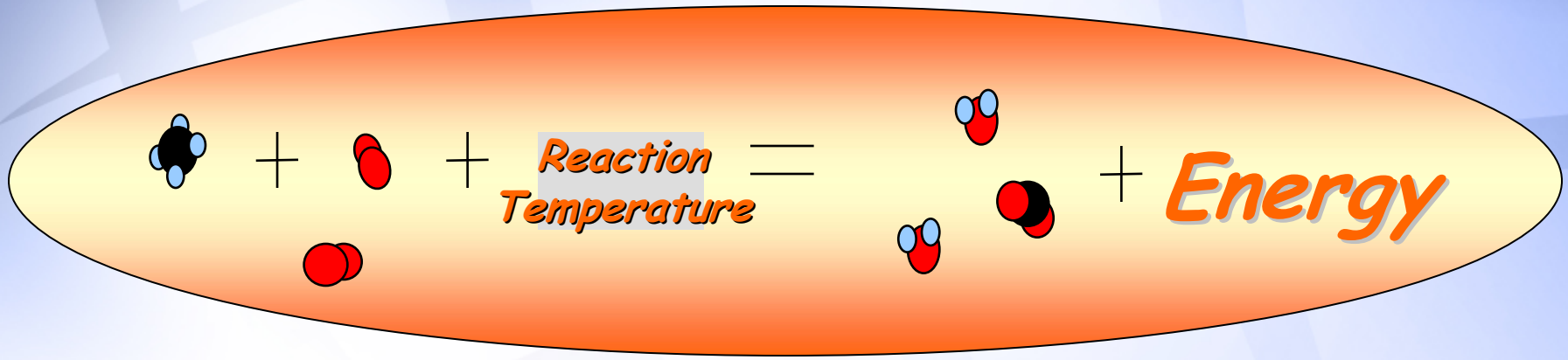


MEGTEC has delivered over 800 VOCSIDIZERs

in many different industrial applications, now including ..

- Coal Mine Ventilation Air Methane

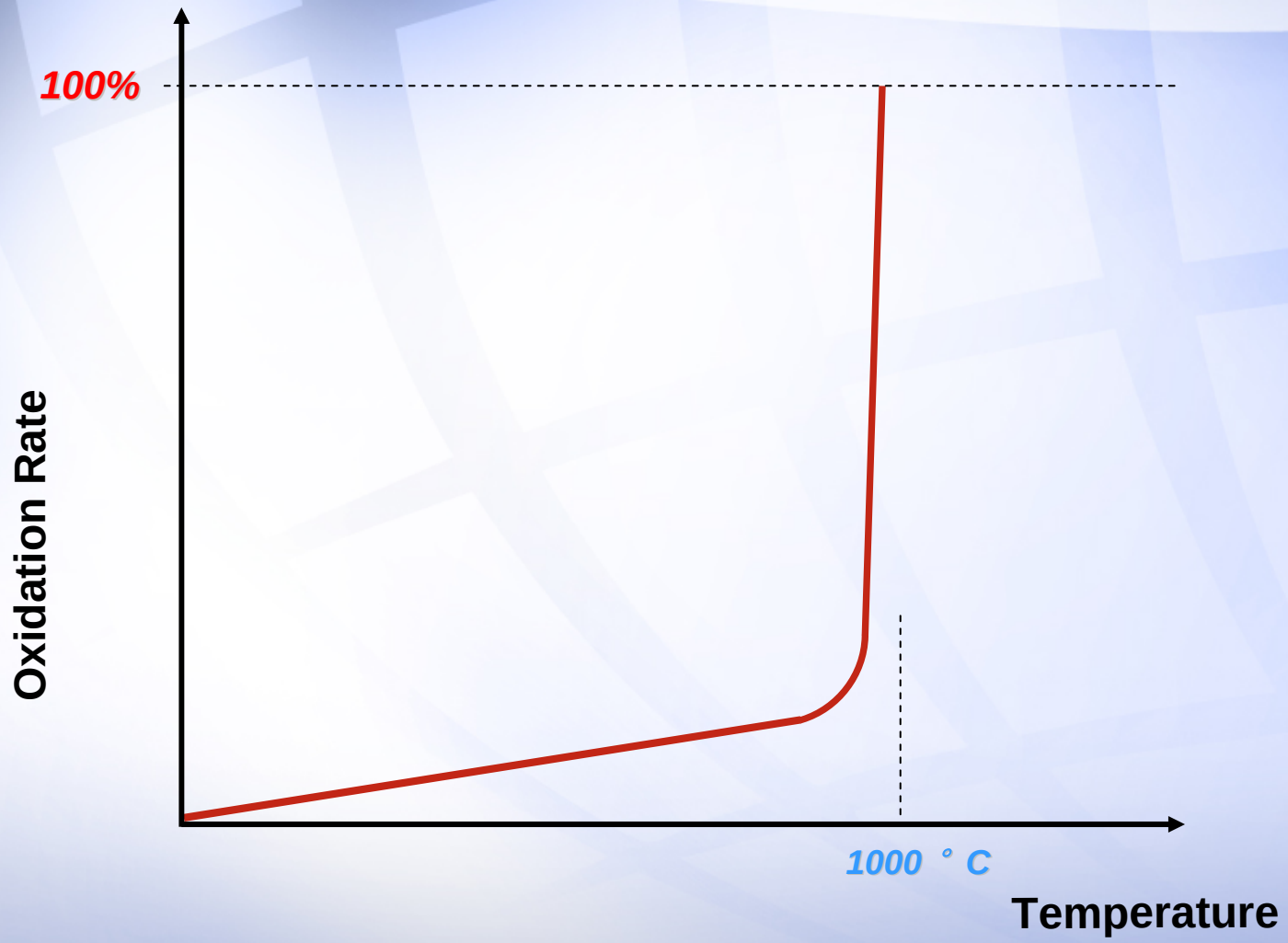
VOCSIDIZER - Principle of reaction



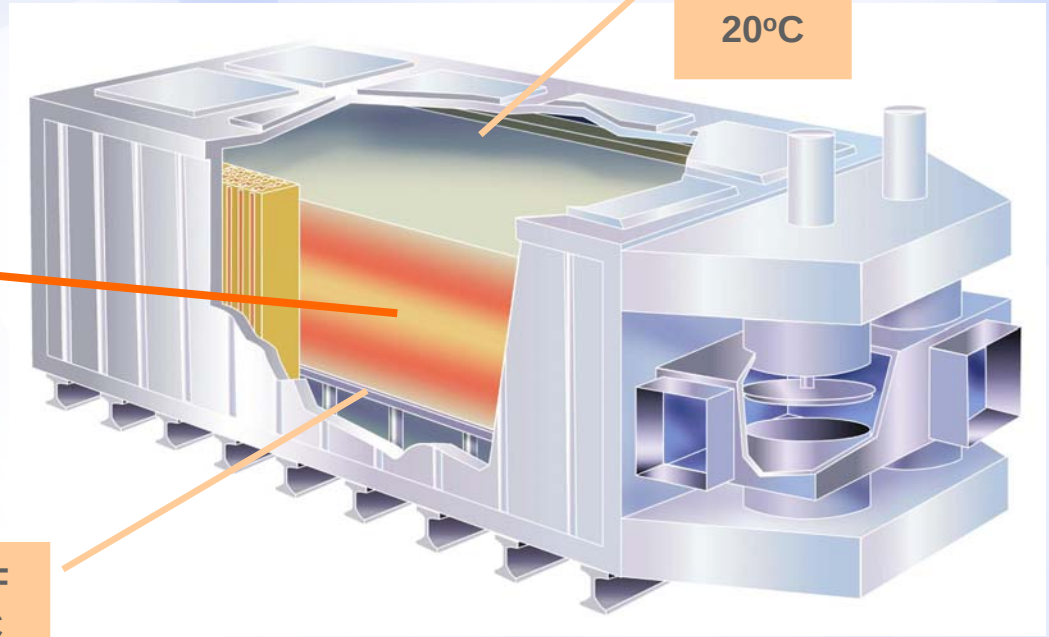
Like all VOC gases, methane oxidize at 850-900°C to form mainly water and CO_2.

And release Energy!

VOC Oxidation Rate



The Flameless VOCSIDIZER



No catalyst

operate at natural oxidizing temperature

Flameless: Oxidation completely in-bed.

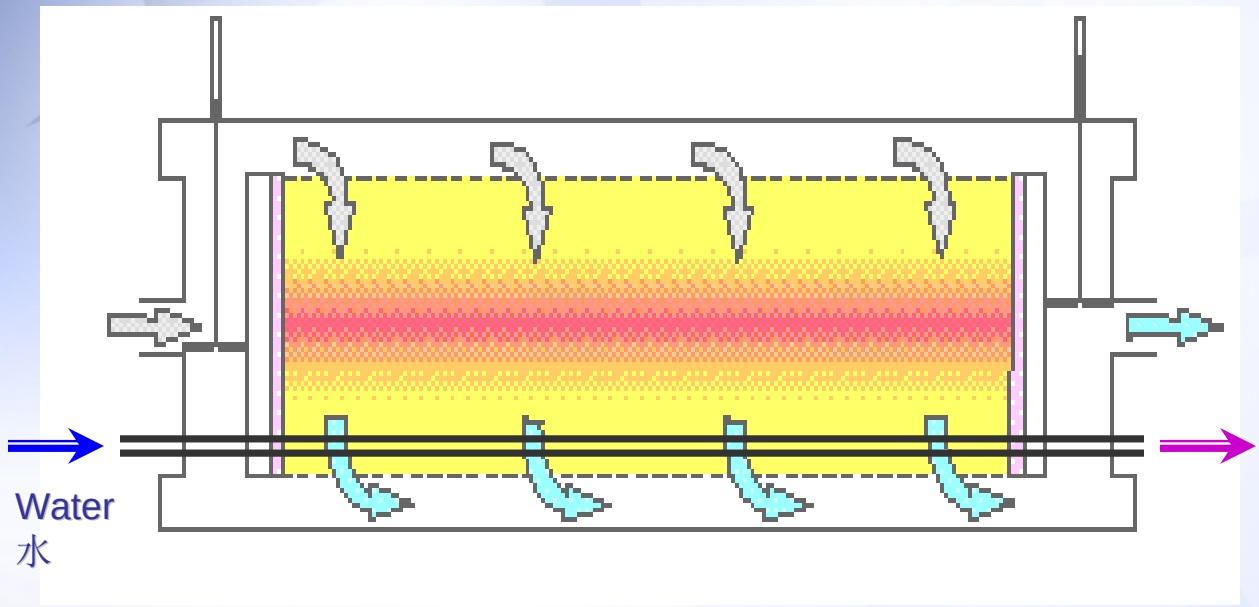
No NOx: No flame. Even though temp is high, it is not near where thermal NOx is generated.

PROVEN TECHNOLOGY

First coal mine site demonstration
Thorseby Coal Mine, British Coal, UK

1994:
Demonstrated ***efficient VAM Abatement***

Efficient Energy Recovery from VOCSIDIZER bed



VAM FOR ***THERMAL*** USE

PROVEN TECHNOLOGY

First coal mine site demonstration
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Second coal mine site demonstration
Appin Colliery, BHP, Australia

2001 - 2002:
Demonstrated, by boiling water during 12 months,
- ***Efficient Heat Recovery***
- ***Ability to handle variations in VAM concentration***

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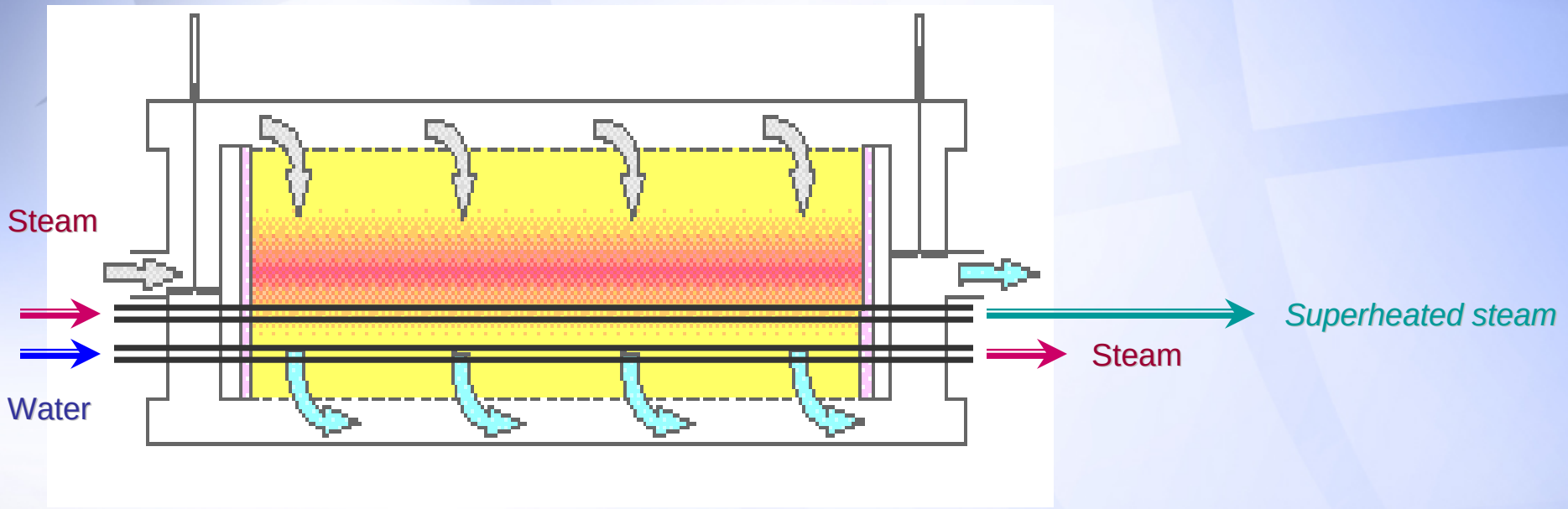
- ***Efficient Heat Recovery***
- ***Ability to handle variations in VAM concentration***

Awarded in April 2005 as ACARP's best Greenhouse Gas Project

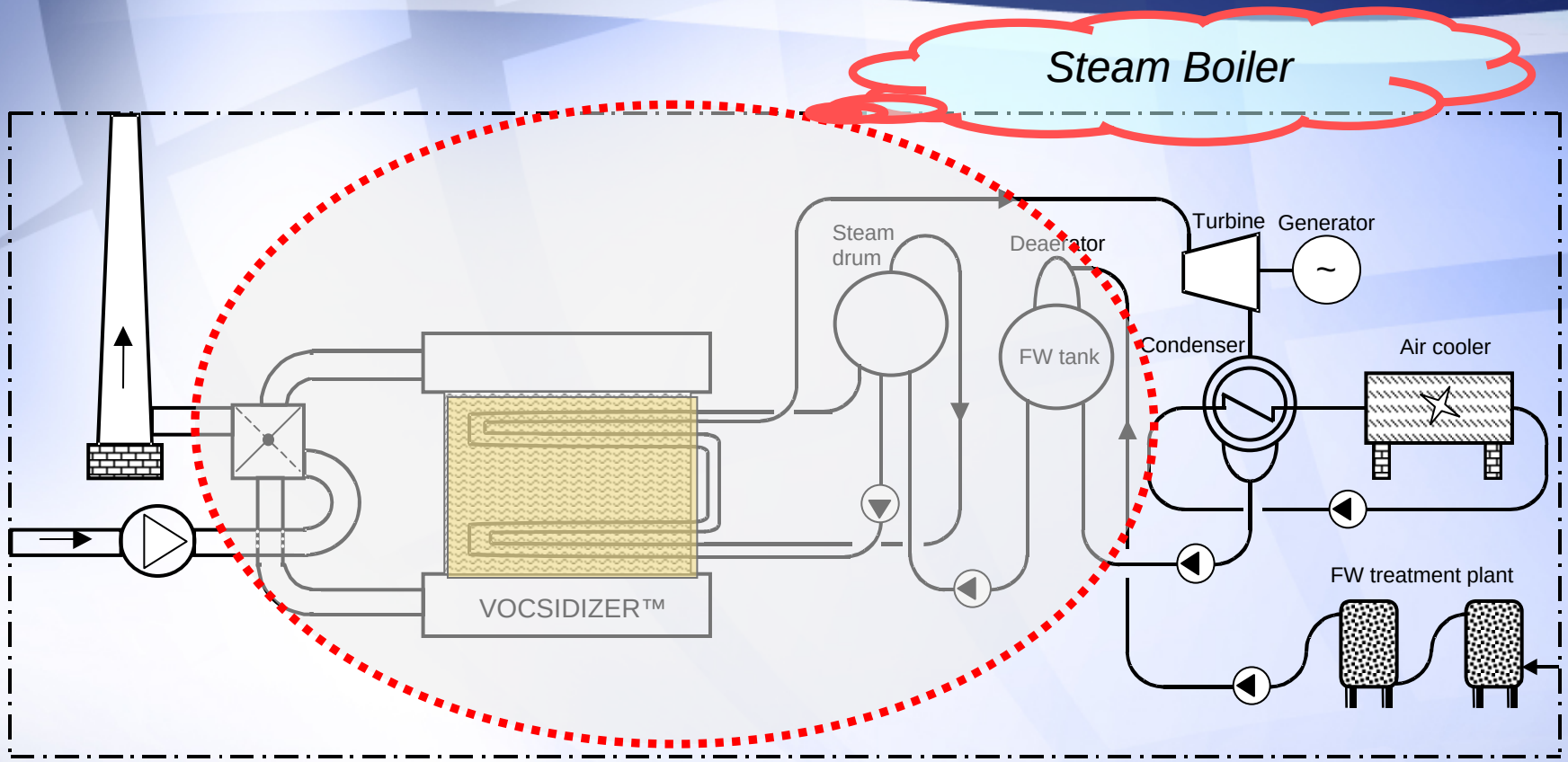
The Appin Project was partly Government funded by ACARP - Australian Coal Association Research Programme

VOCSIDIZER Energy Recovery as Superheated Steam

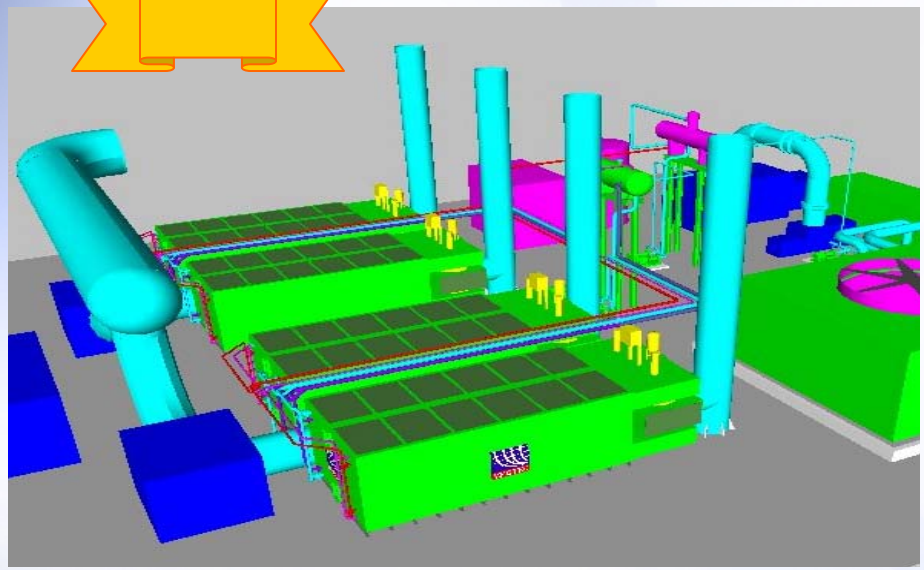


PRINCIPLE DIAGRAM FOR :

VOCSIDIZER STEAM CYCLE FOR POWER GENERATION



VAM Power Plant - VAM AS PRIMARY FUEL FOR THE GENERATÍON OF ELECTRICITY



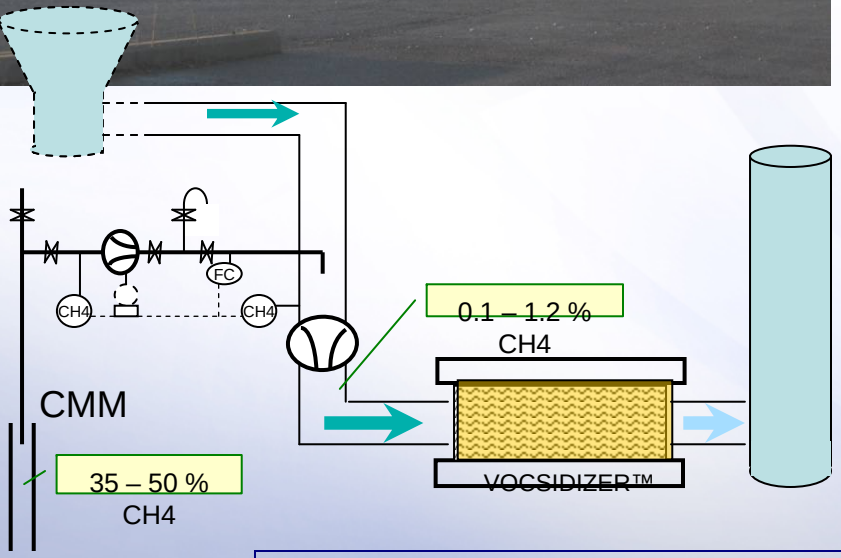
Third coal mine site demonstration:

VAM Power Plant in successful operation since April 2007.

- *In August 2007, Highly Commended in the Excellence Awards 2007 by the NSW Minerals Council.*
- *In September 2007, receiving the Excellence in Energy Award by the Australian Institute of Energy*

The WestCliff Project was partly Government funded by AGO – Australian Greenhouse Office

US VAM Project at CONSOL Energy



Fourth coal mine site demonstration:

Windsor mine, CONSOL Energy, USA

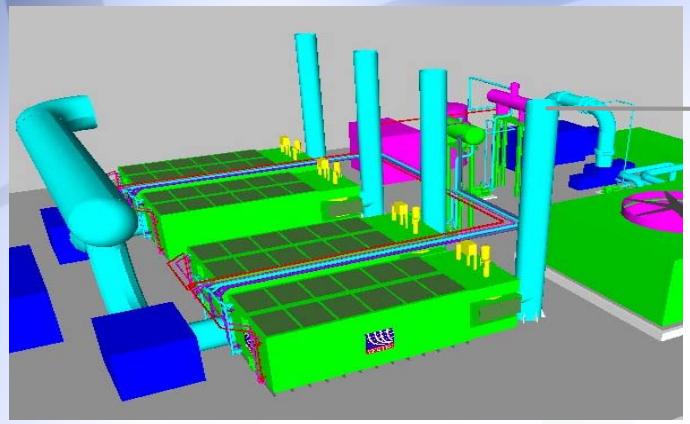
- 50 000 m^3/h (30 000 scfm) of ventilation air
- 0.1 – 1.2 % methane (abandoned mine gas)
- Unmanned operation since May 2007

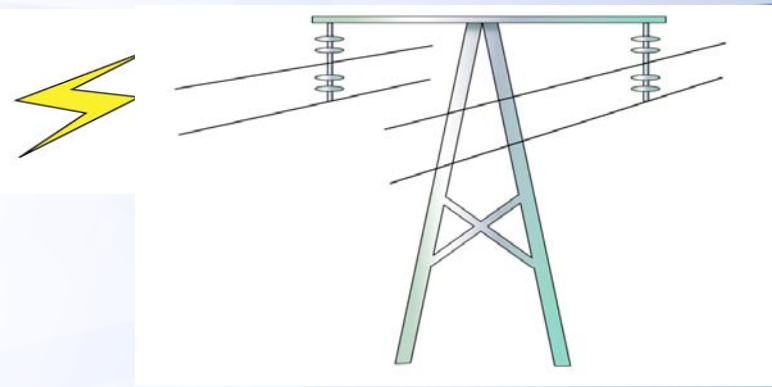
PROJECT DESIGN:

Injecting high concentration mine gas into a large flow of fresh air in order to simulate various concentrations of VAM, then to evaluate abatement in the VOCSIDIZER.

The Project is partly Government funded by the US EPA and the US DOE

VOCSIDIZER technology for VAM Energy Recovery





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

Example: *800 000 m^3/h*

1 % CH_4 → *72 MW(th)* → *21 MW(el)*

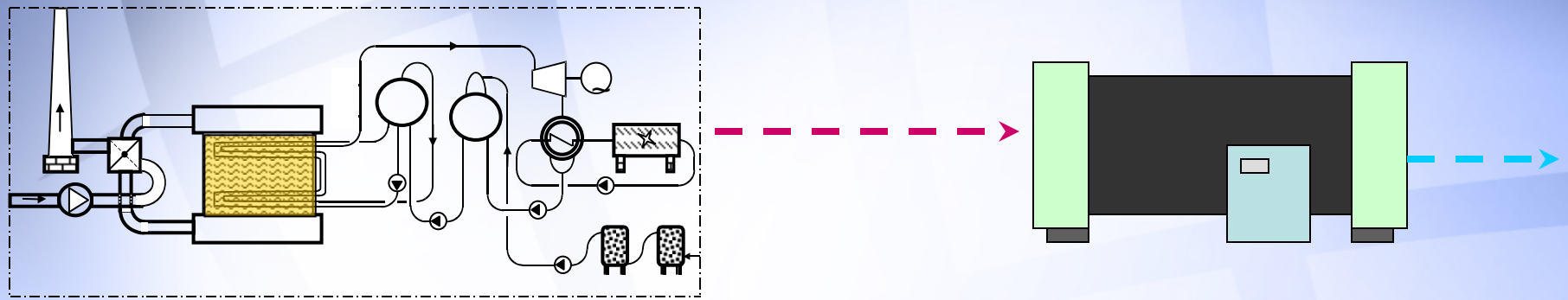
(at 30% efficiency)

Example: *800 000 m^3/h*

0.6 % CH_4 → *36 MW(th)* → *10 MW(el)*

(at 30% efficiency)

Cogeneration of electricity and heating – plus cooling

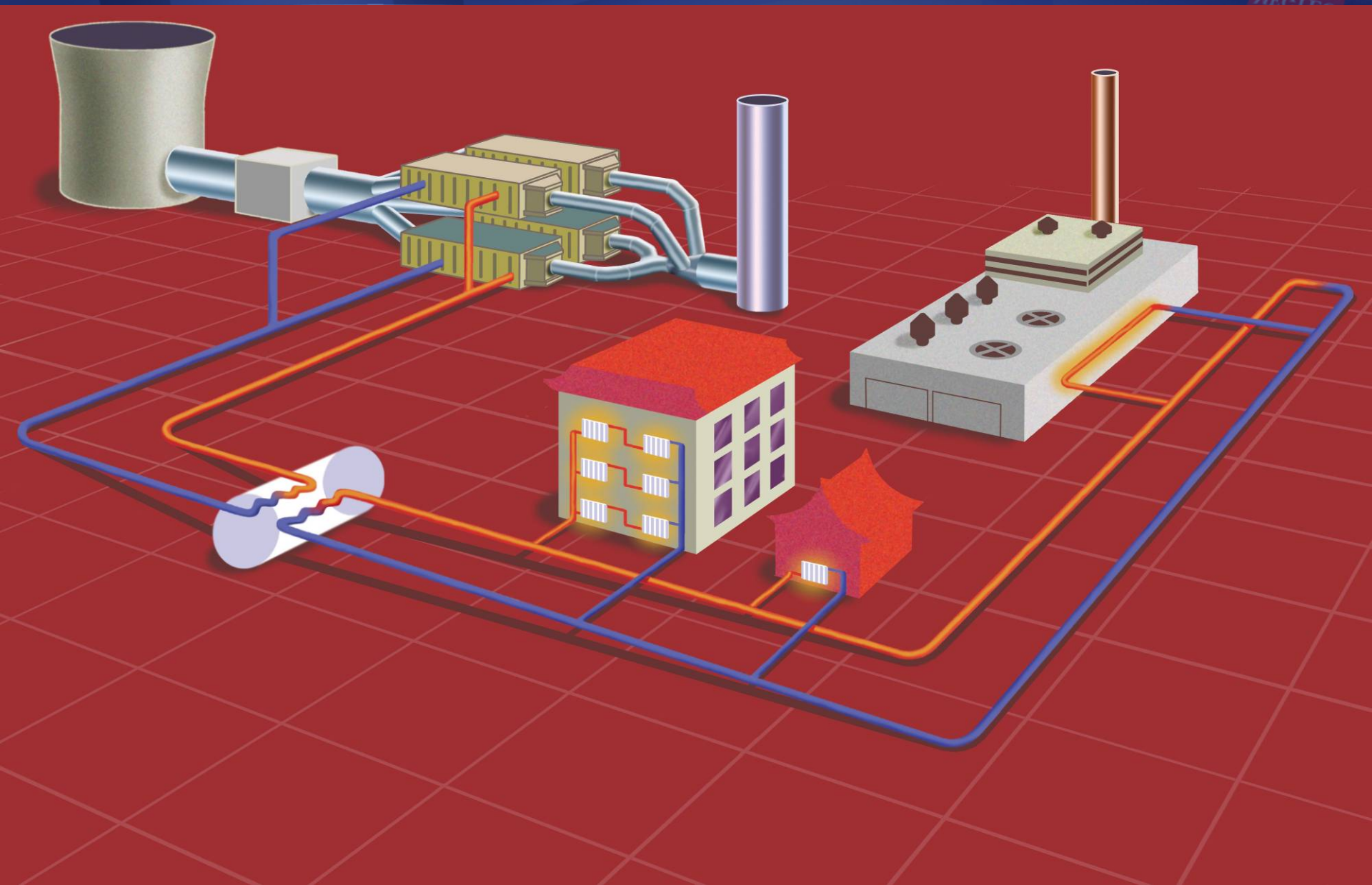


Cooling water from electricity generation drives absorption chiller.

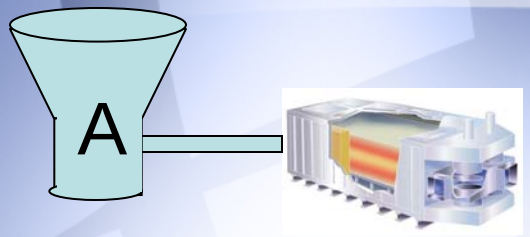
Example:

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

VAM Energy Recovery for District Heating / cooling

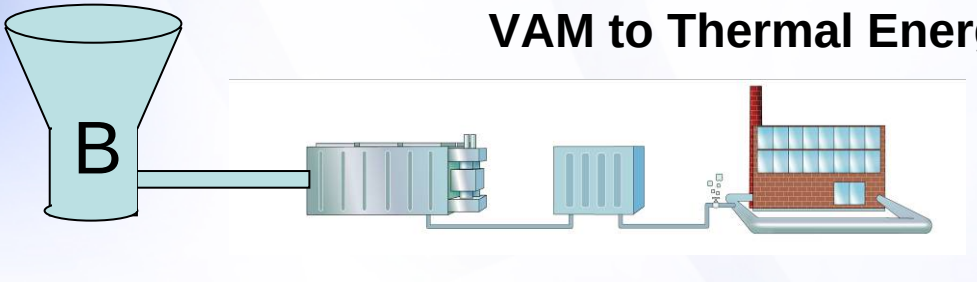


THREE OPTIONAL VAM VOCSIDIZER CONCEPTS

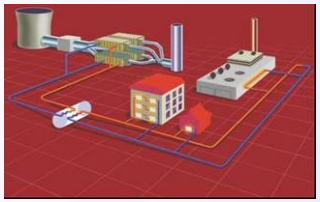


VAM Abatement Only

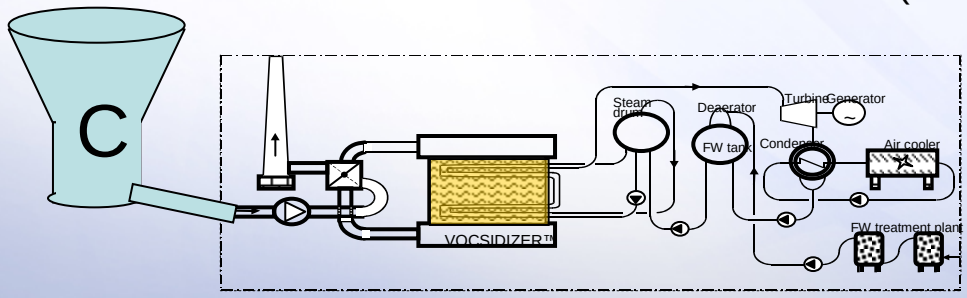
A type of ”flaring”.



VAM to Thermal Energy



VAM to Energy

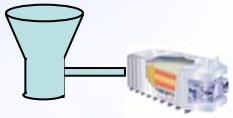


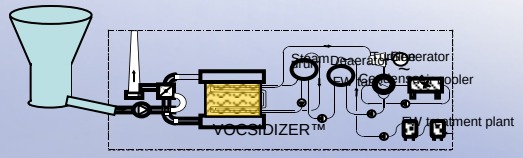
VAM Power Plant (VAM to Electrical Energy)

PRESENTED IN CHINA SINCE 2004

The technology and concept of oxidizing and utilizing VAM has been

presented by MEGTEC at Work Shops and Conferences in China since 2004.





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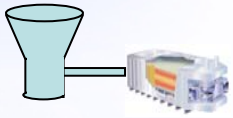
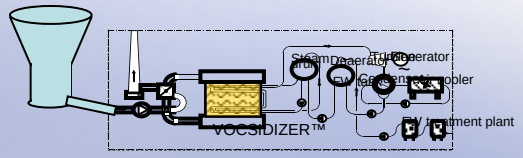
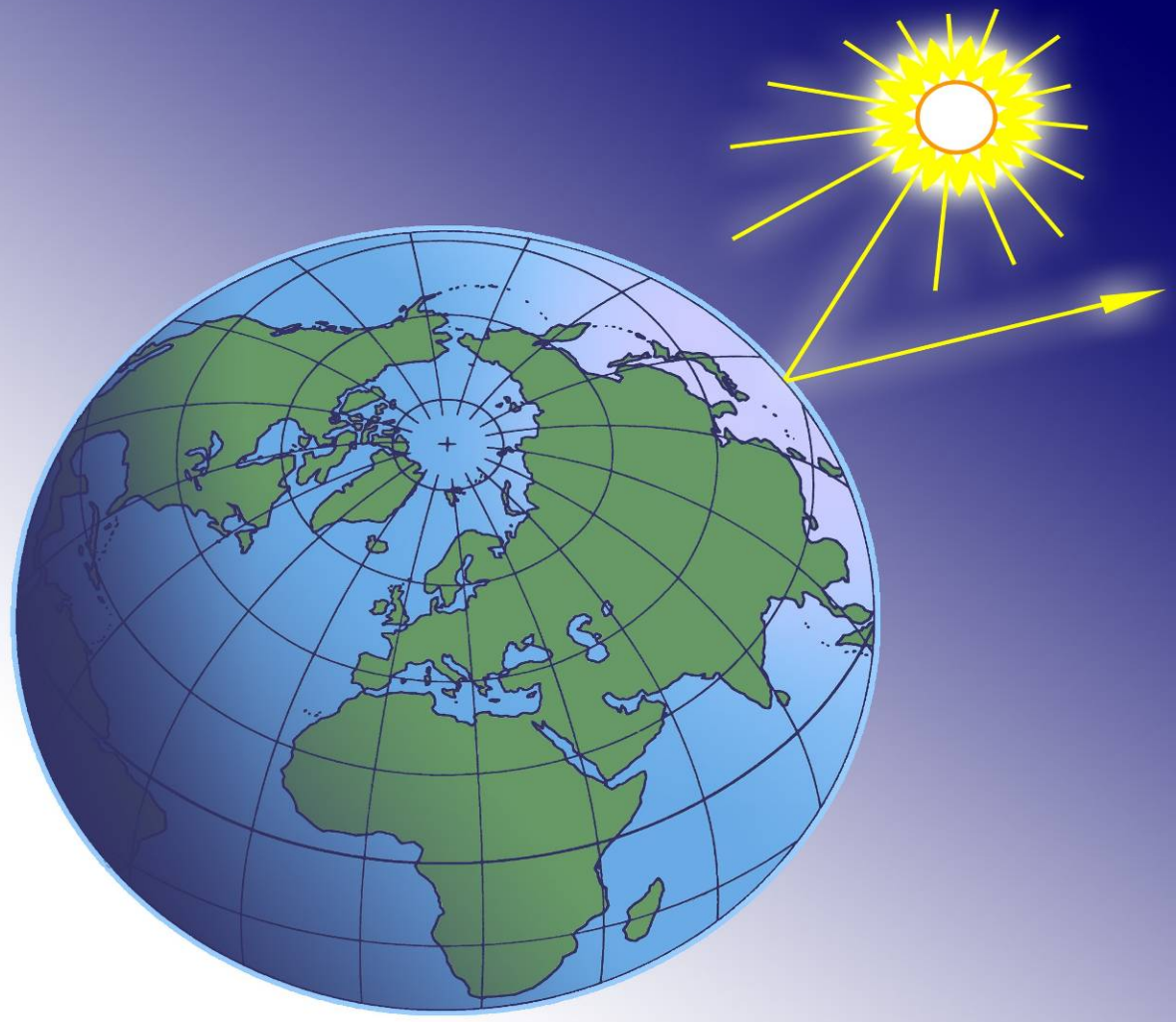




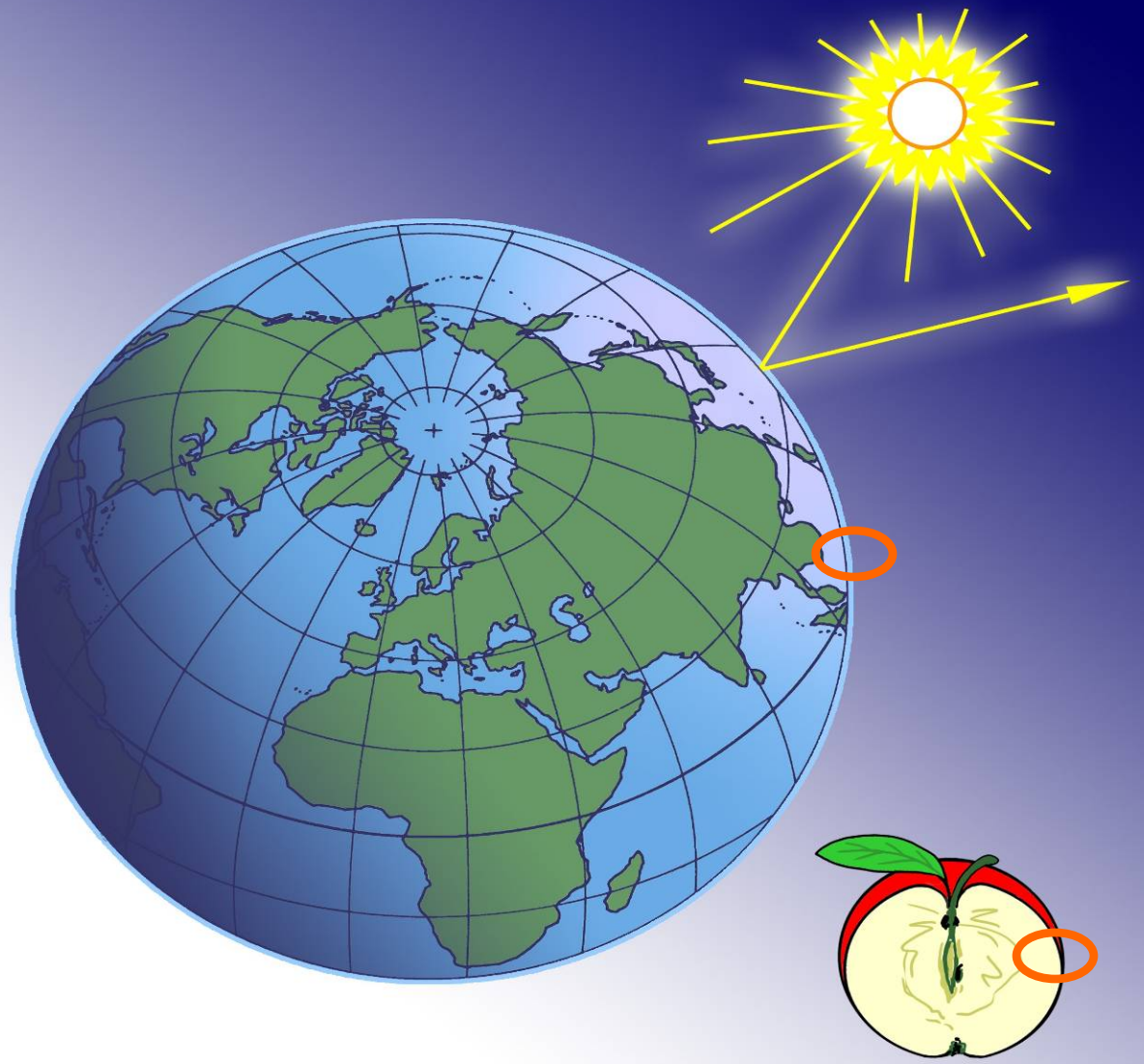
WHY ALL THIS INTEREST TO REDUCE VAM EMISSIONS ?

- What is carbon credits financing?

One bubble of atmosphere

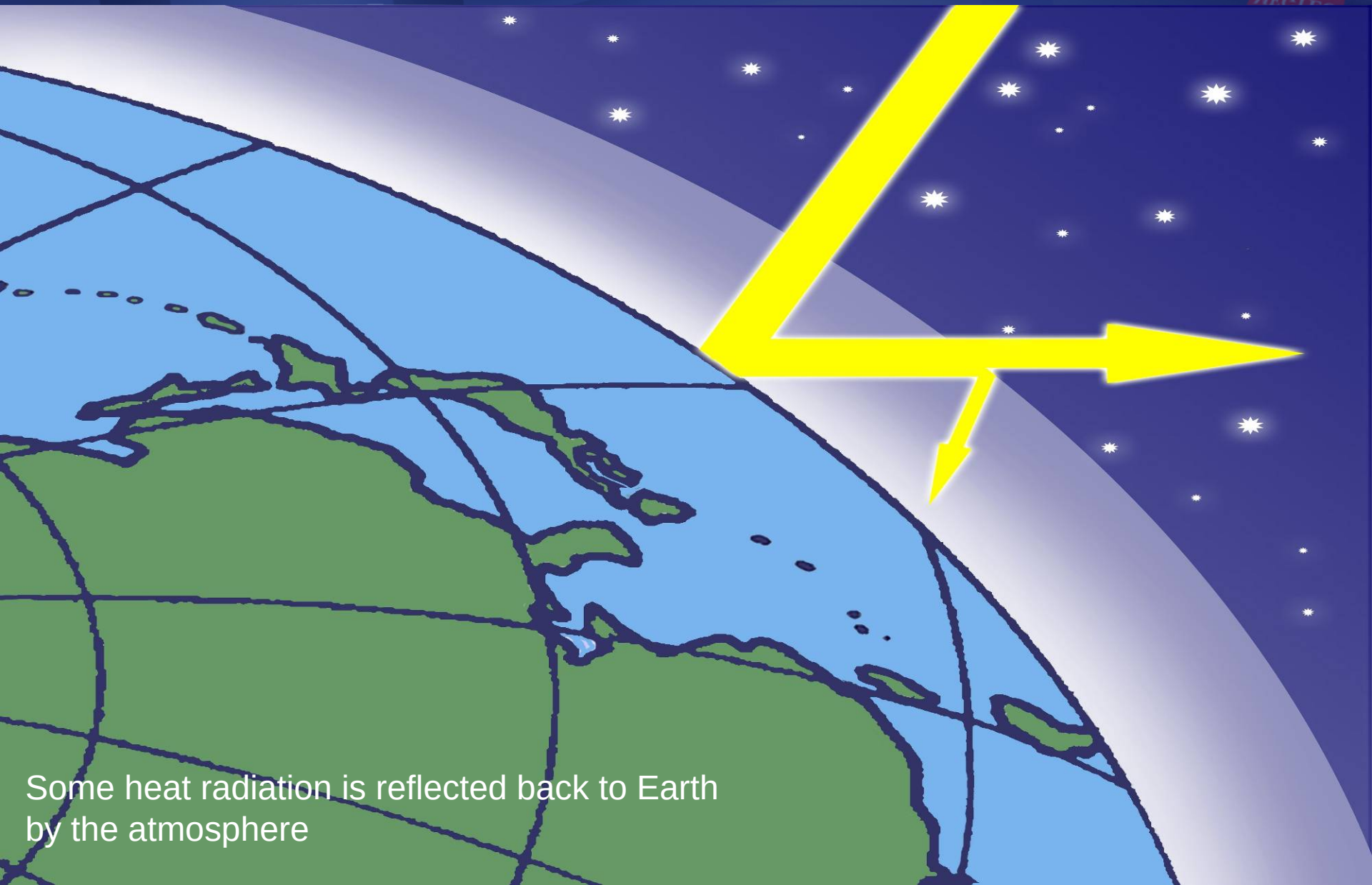


One bubble of atmosphere



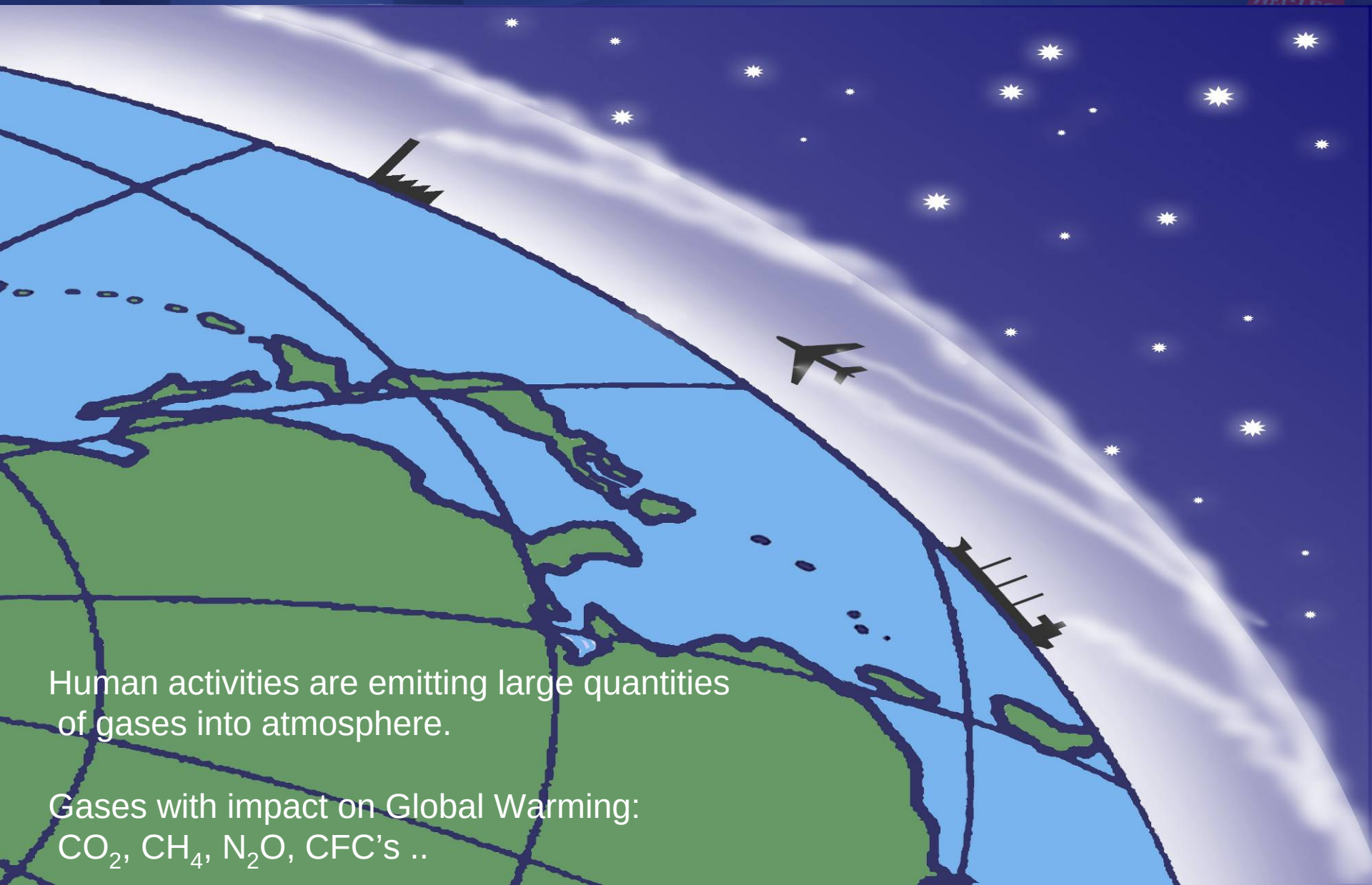
Atmosphere thickness to the Earth is **like the skin to the apple**

One bubble of atmosphere



Some heat radiation is reflected back to Earth by the atmosphere

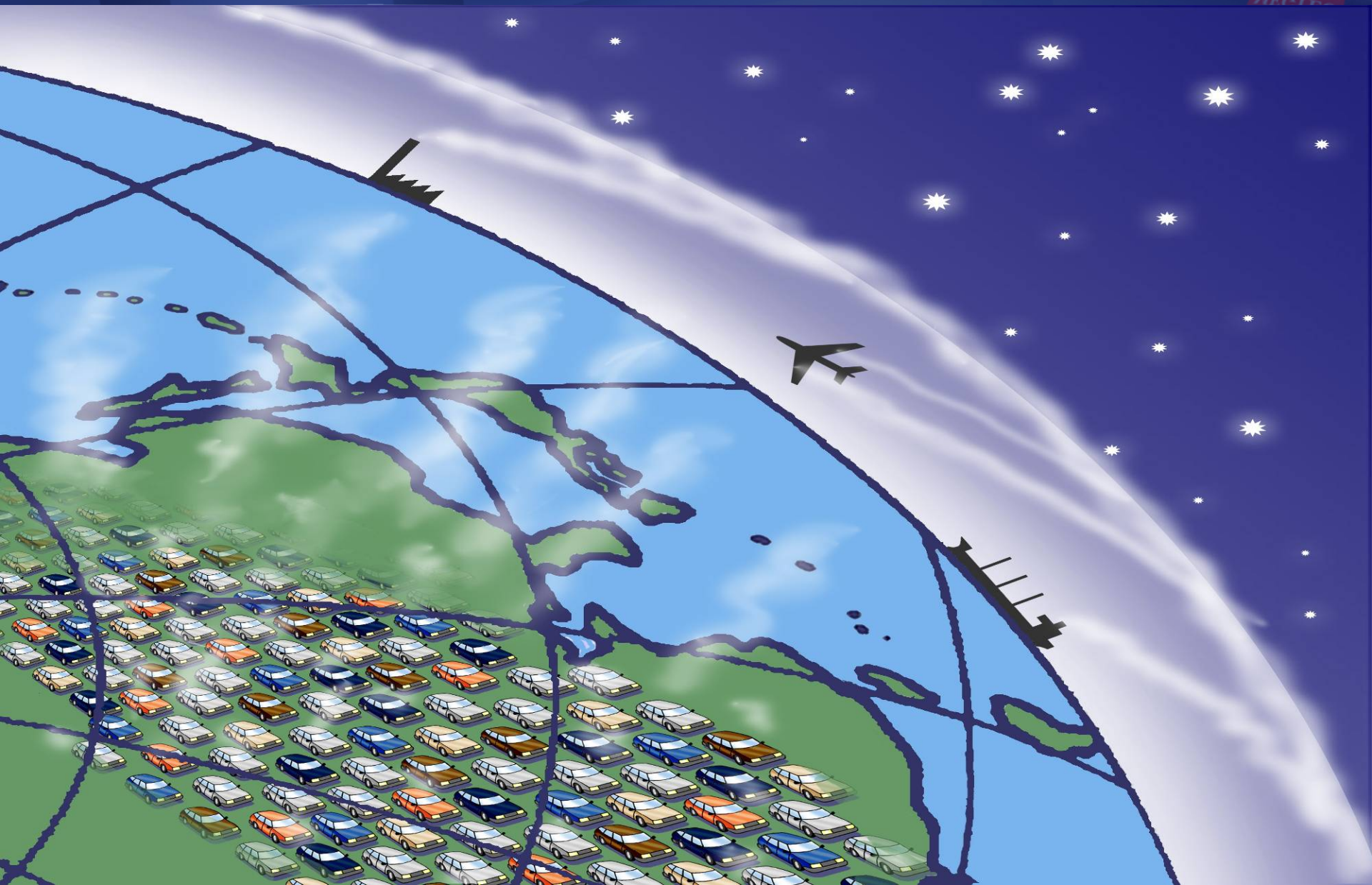
One bubble of atmosphere



Human activities are emitting large quantities of gases into atmosphere.

Gases with impact on Global Warming:
CO_2, CH_4, N_2O, CFC's ..

One bubble of atmosphere



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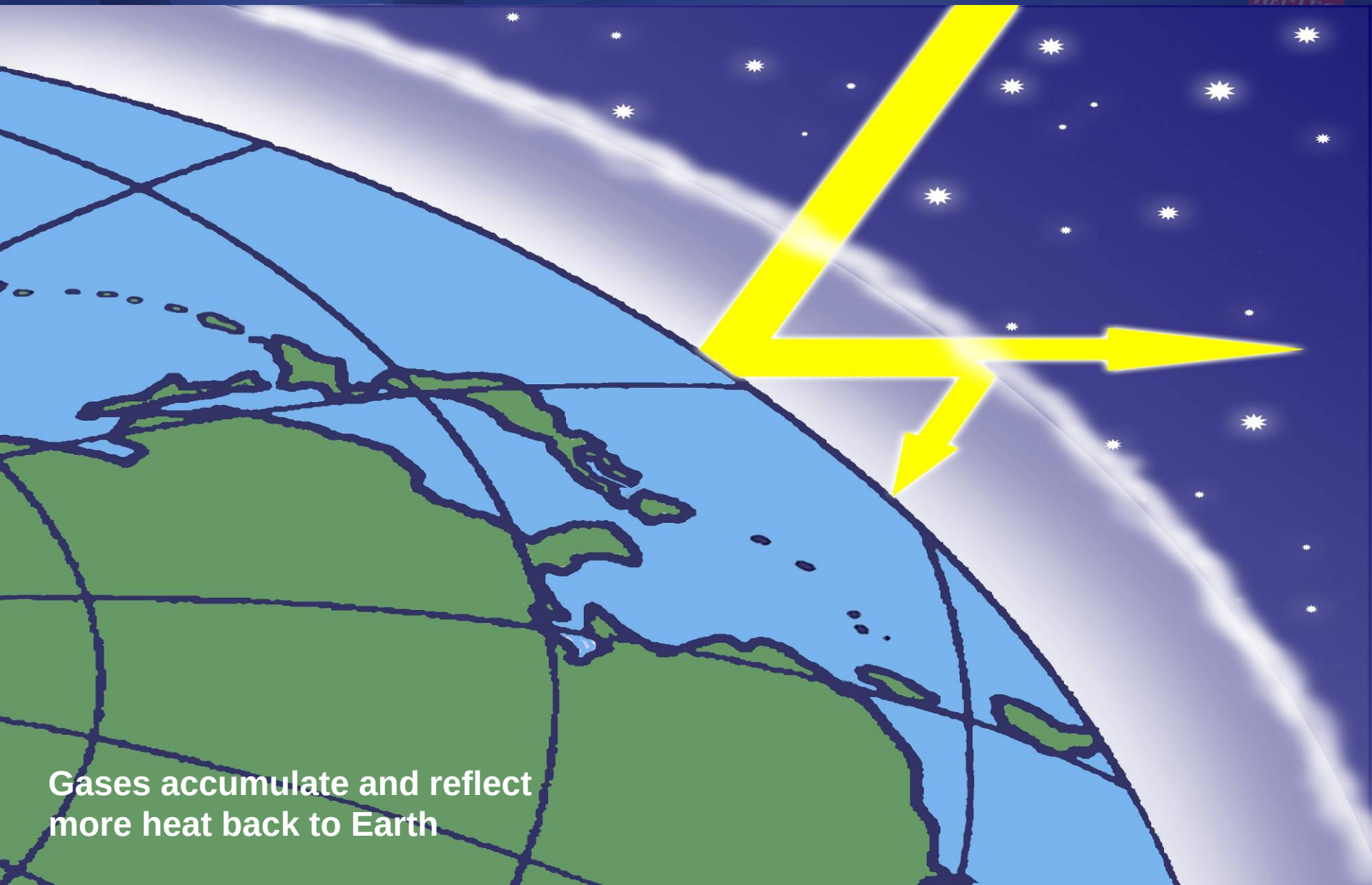

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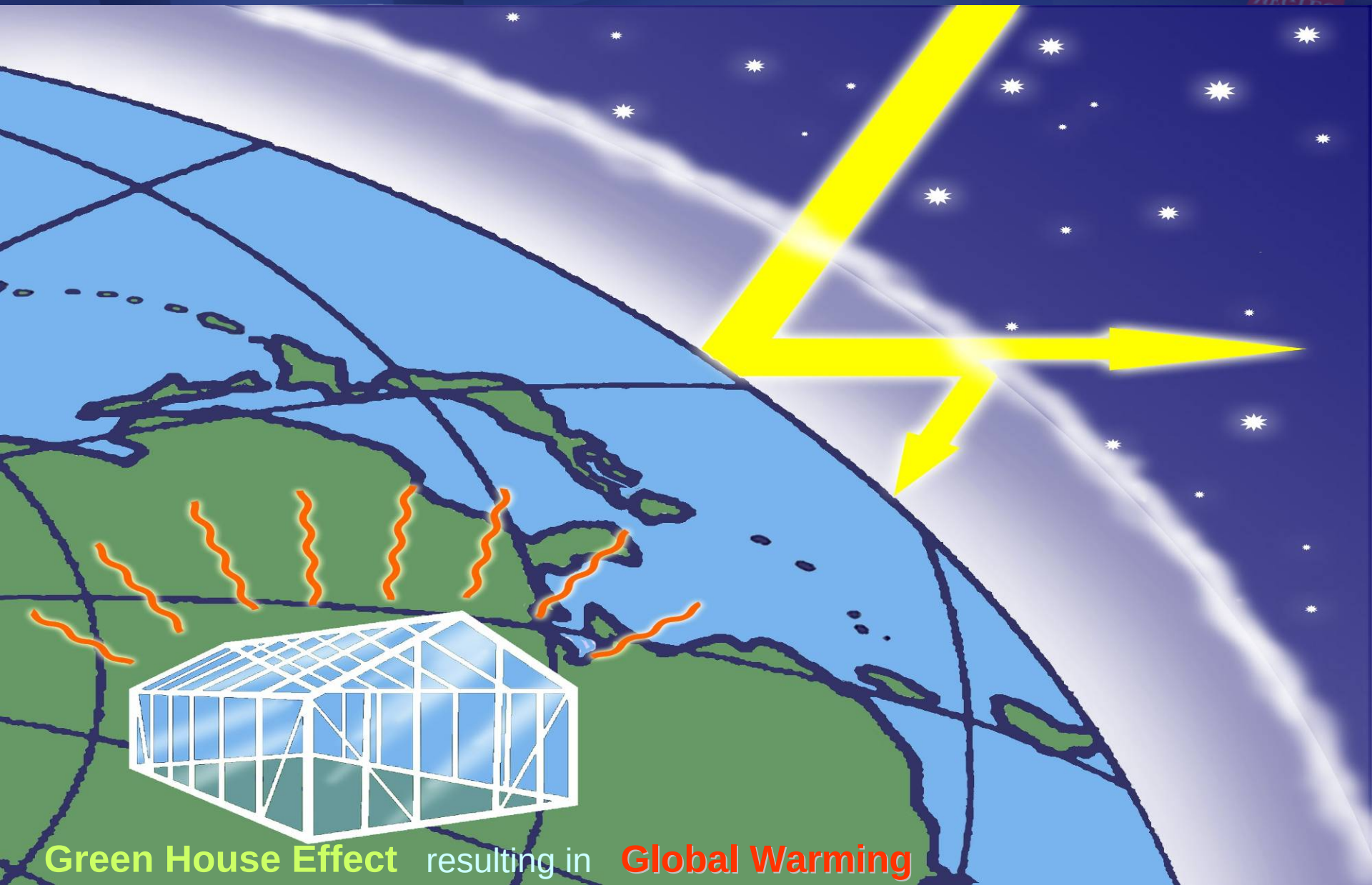


Green House Effect resulting in **Global Warming**

One bubble of atmosphere

CO_2 remains 100 years in the atmosphere, continuously accumulating at ***accelerating*** rate.

- Governments of the World agree this trend must be broken
- The Kyoto Protocole introduced **a system of emission caps for industrialized countries**, and **a system of trading emission allowances** – promoting investment in emission reductions **where investment is most efficient** in reducing GHG (Green House Gas) emissions. All emissions are into the same thin bubble of atmosphere.

Besides Kyoto, now also local emission reduction schemes
Recent trend is companies and individuals buying Voluntary Emission Reduction credits

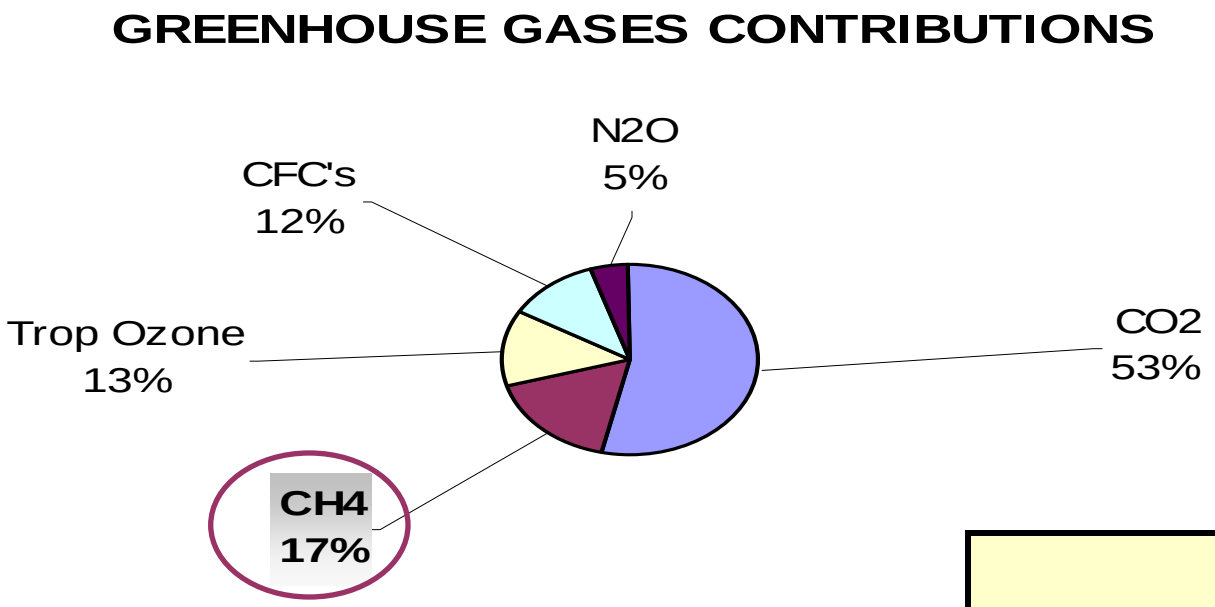
One bubble of atmosphere

CONCLUSIONS:

- Structures of trading schemes of “carbon credits” (CER / ERU / VER / NGAC ..) are now established
- Trading is increasing quickly and becoming globally integrated
- Media attention as well as public awareness and concern are very high and increasing

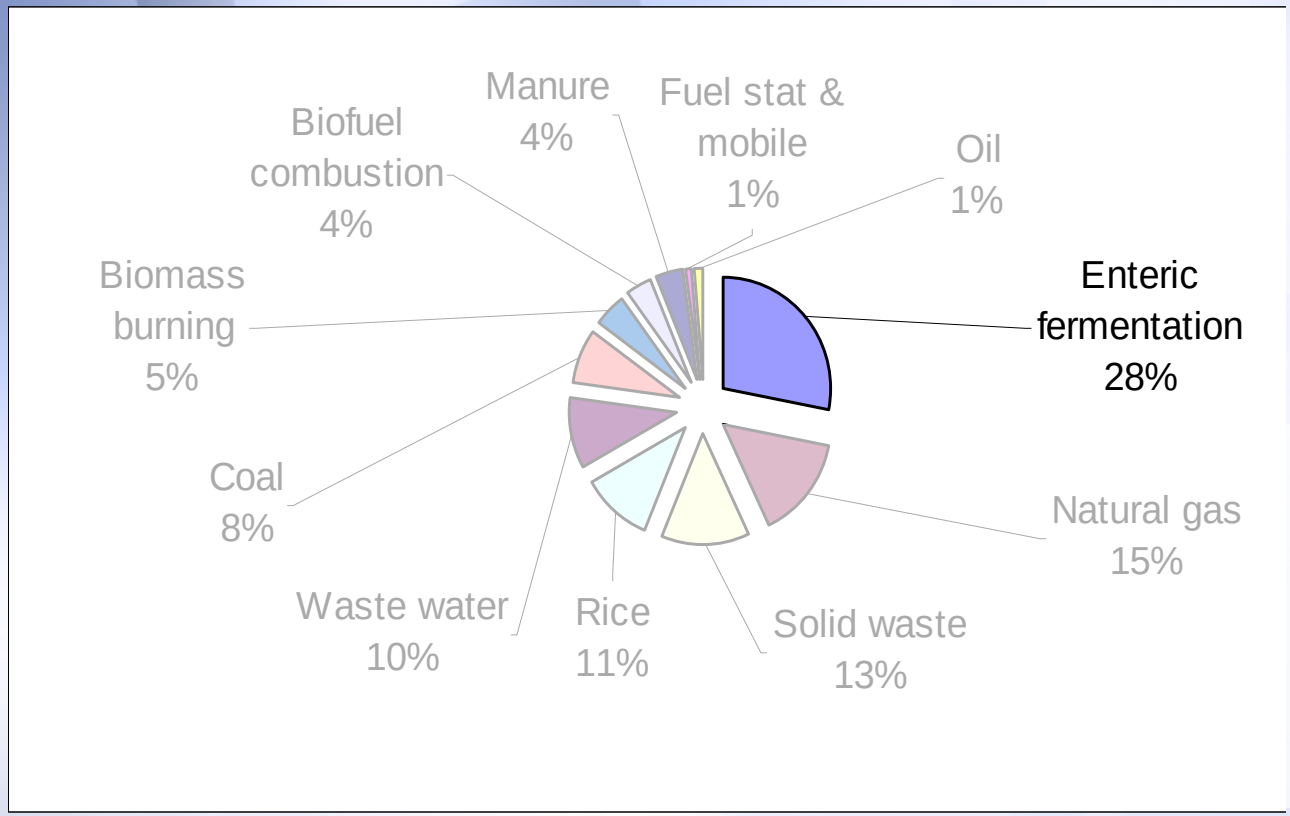
➢ **Carbon credit financing of successful emission reduction projects is here to stay**

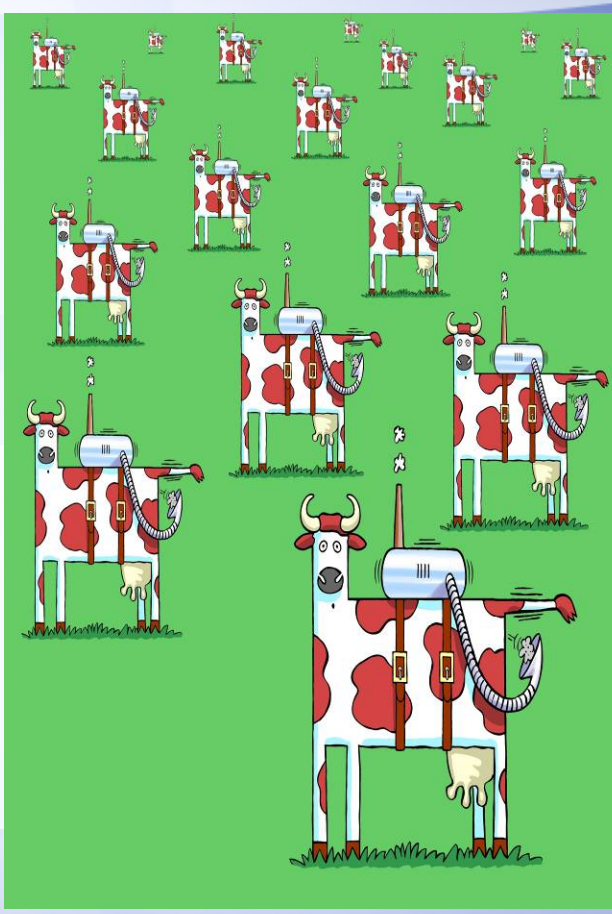
Green House Gas METHANE



	CO2	CH4
Global Warming Power	1	23 (21 in the first Kyoto Period)
Life time in atmosphere	100	12 ½

Global Methane Emissions - by source





BIGGEST TOTAL SOURCE:
Cows, sheep etc

PROBLEM:
Each source is very small

50-100 kg per cow 1-2 t CO2e per year

ANNUAL GREENHOUSE EFFECT on Global Warming

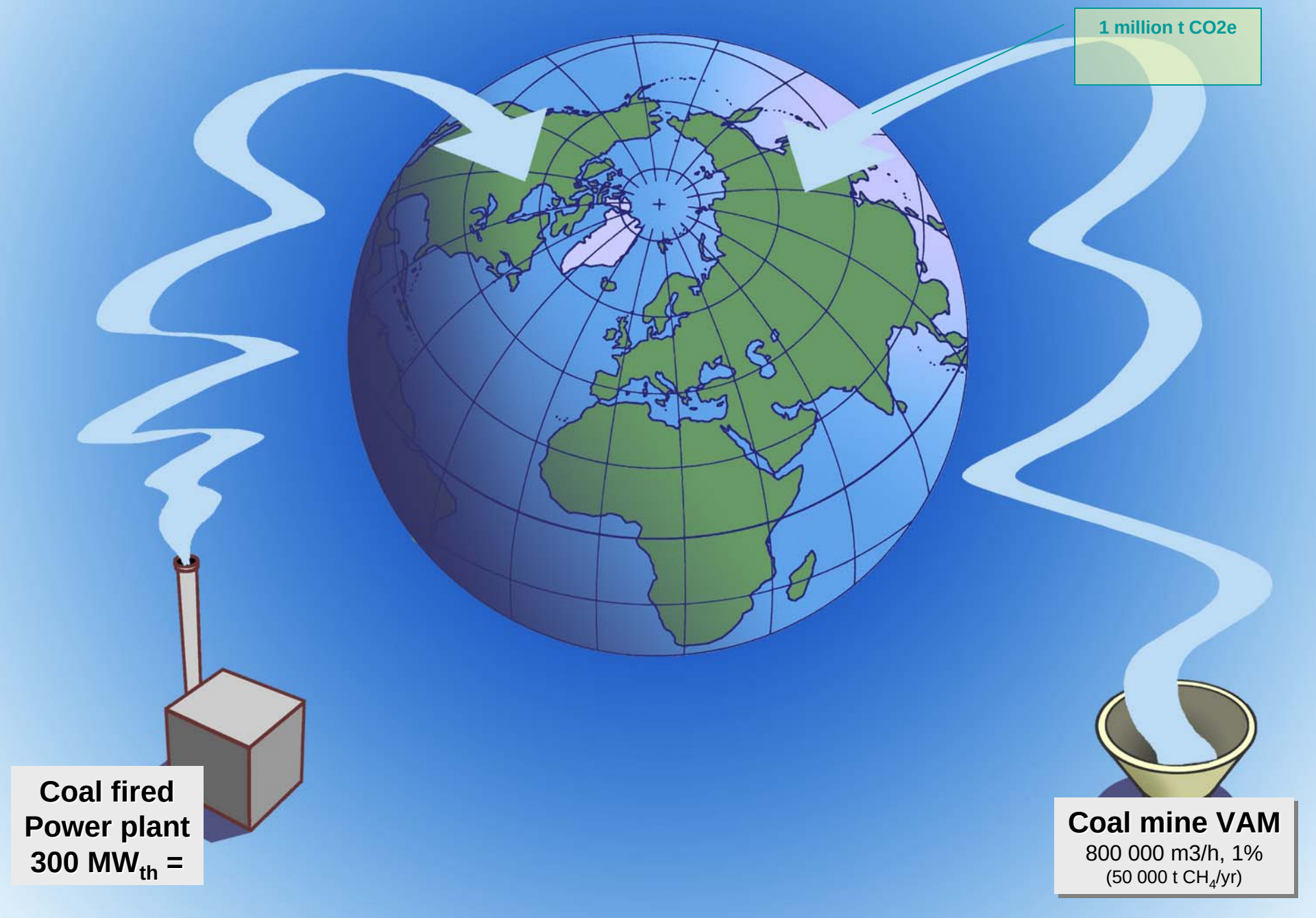
1 million t CO2e

Coal mine VAM

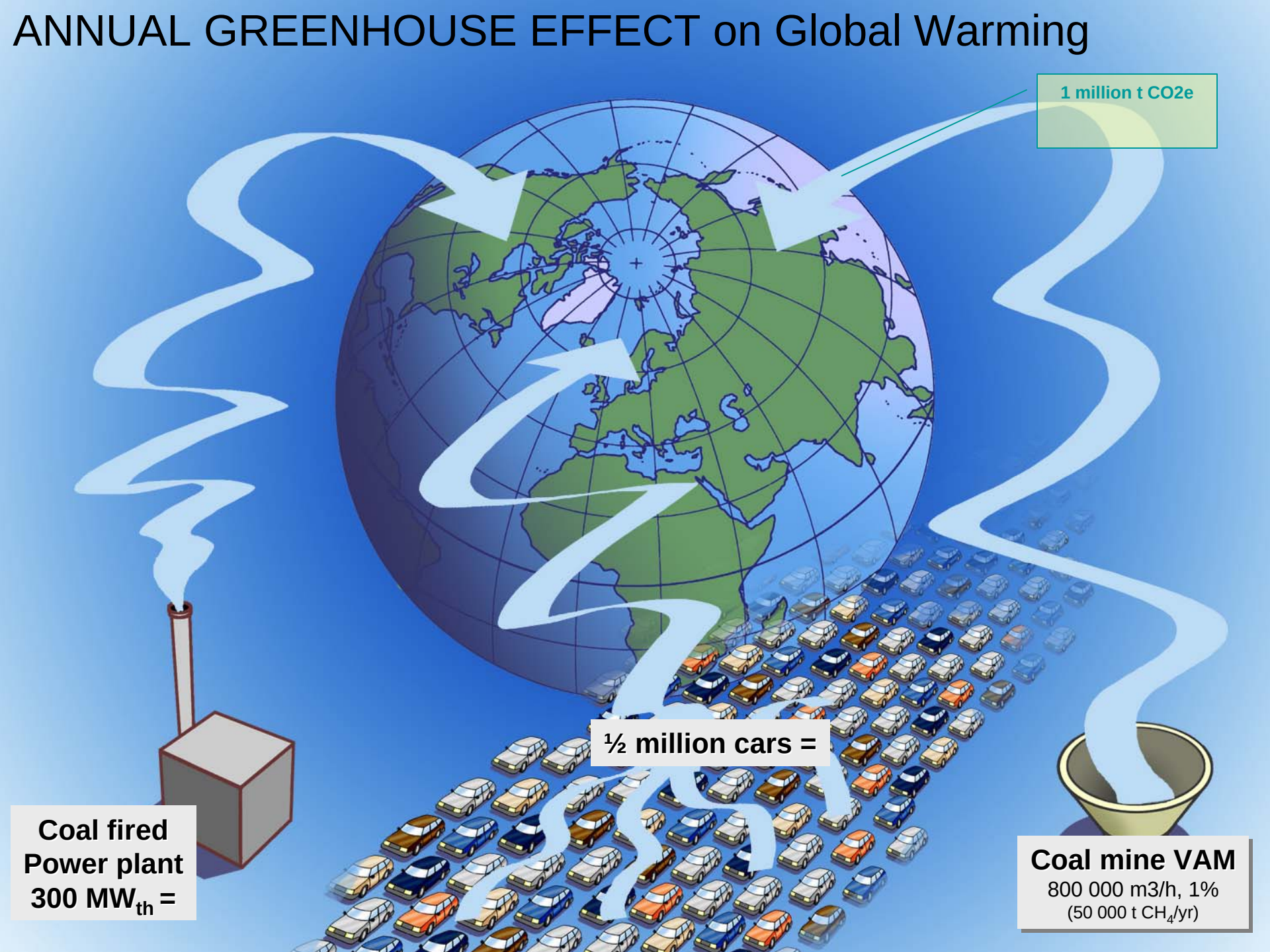
800 000 m3/h, 1%

(50 000 t CH_4/yr)

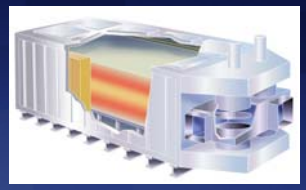
ANNUAL GREENHOUSE EFFECT on Global Warming



ANNUAL GREENHOUSE EFFECT on Global Warming



Calculations of CERs



For calculation of amount to CERs, consider:
- Vocsidizer cleaning efficiency and availability
- conversion rate of CH4 into CO2e.

The formula will be:
[Cleaning Efficiency] x [Hours of availability] x [Volume flow of ventilation air] x [VAM concentration] x [(CH4 weight) x Global Warming factor – (CO2 weight)]

which comes to:

0.97 x [8760x0.97] x [Flow of ventilation air] x [VAM concentration] x [0.71 x (21 – 2.75)]

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

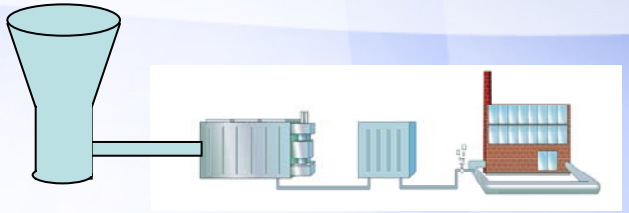
	0.3	0.6	0.9
125 000	***40***	***80***	***120***
250 000	***80***	***160***	***240***
500 000	***160***	***320***	***480***
1 000 000	***320***	***640***	***960***

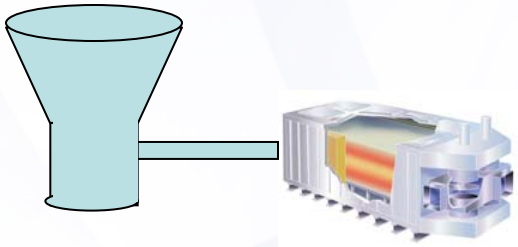
Thousand tons of CO2e per year

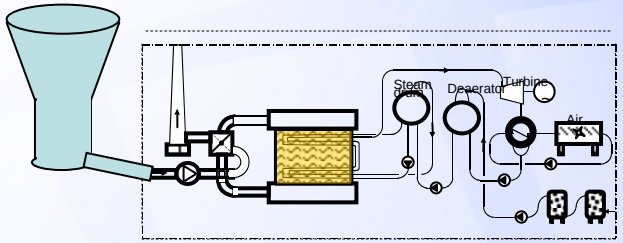
IN ADDITION at energy recovery :
If carbon based energy is replaced, the effect on Global Warming is ~20% better.

VAM Project Economics

- ETS €15 – 20/t CO2e for 2008
- CDM in China $ 10/t CO2e
- VERs 3 – 4 $/t CO2e







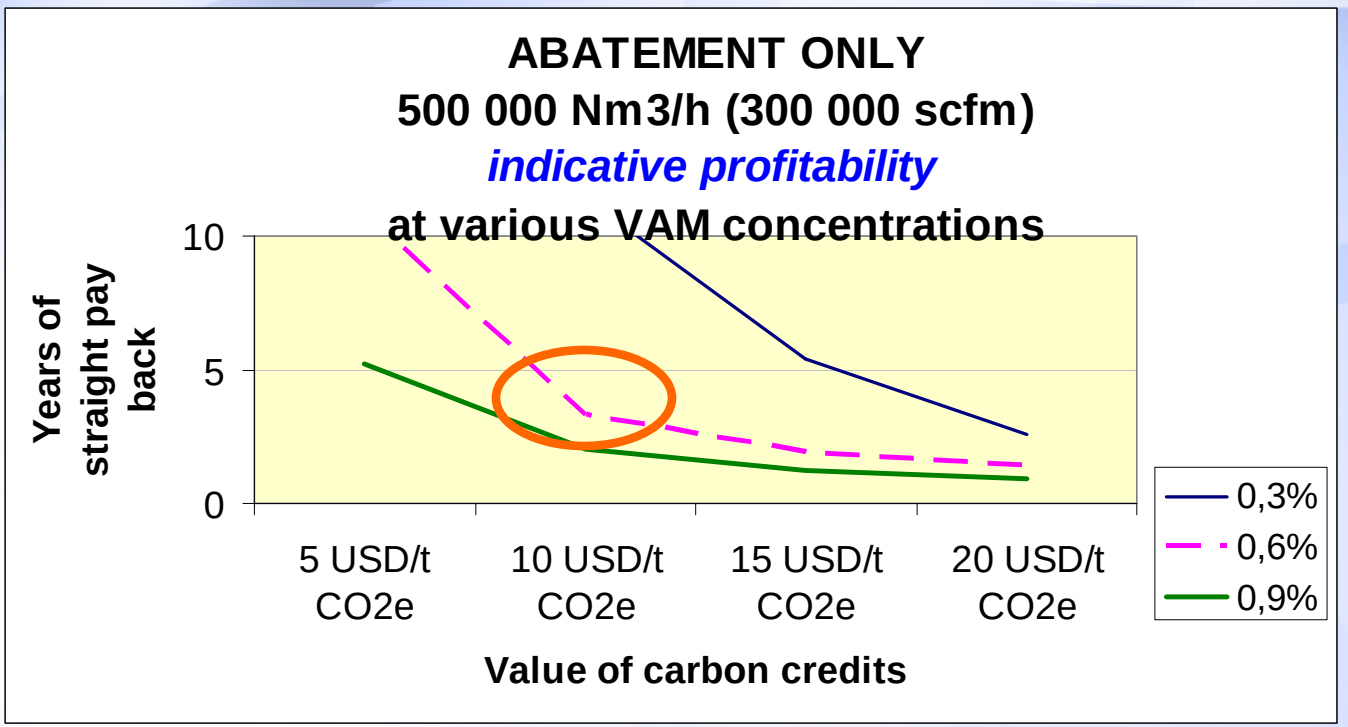
- Many parameters – especially for VAM Power Plants
- Each site must be evaluated separately
- The new market for carbon credits is still very volatile

FOLLOWING PAGES:

Indications to estimated levels, trends and critical values.

Please note that these are indicative only.

VAM Project Economics - *indications*

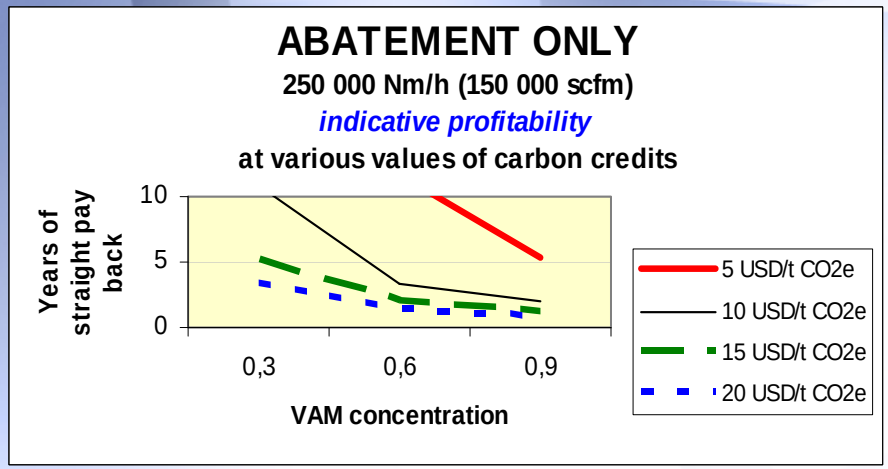


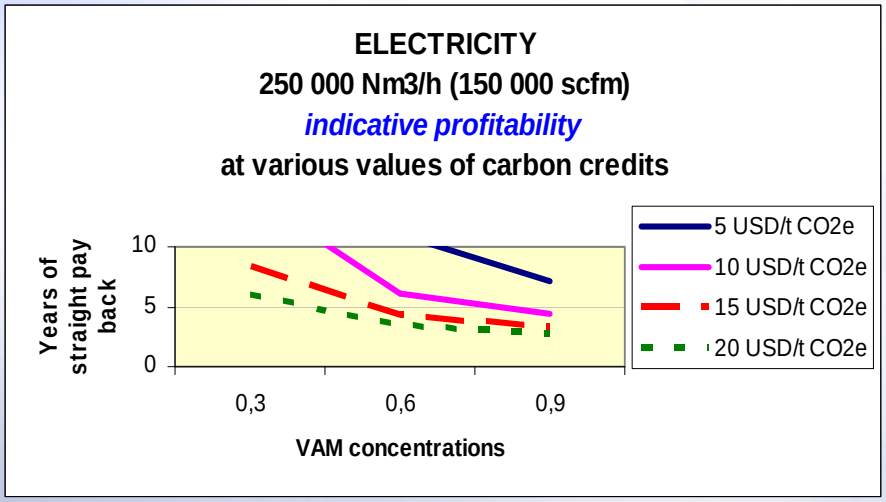
CONCLUSIONS:

- VAM should be min 0.6 %
- Carbon credits should be min 10 USD/t CO2e

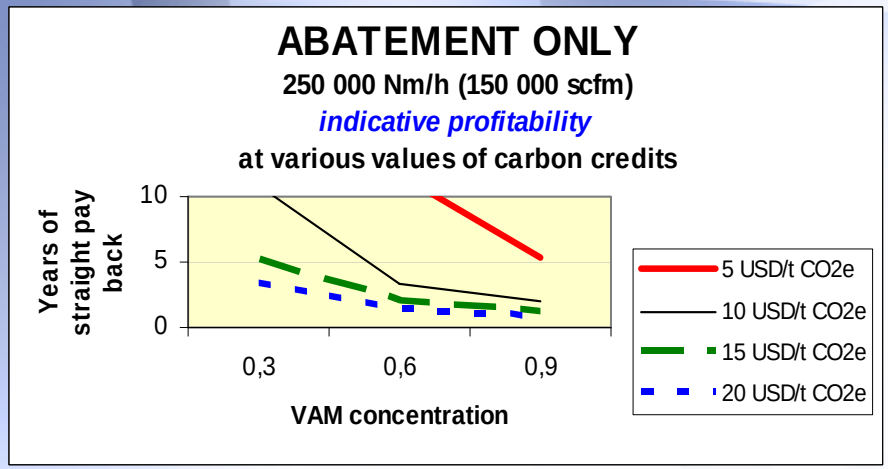
.. then the straight pay back time is only a few years - provided approved

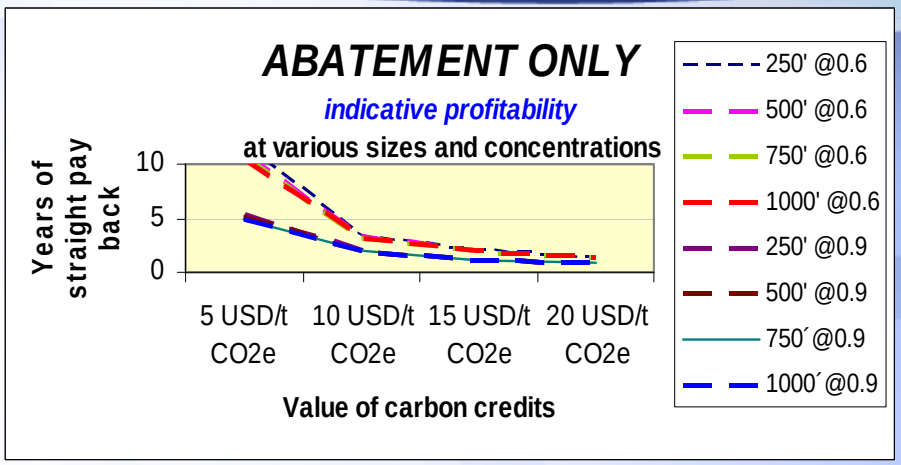
VAM Project Economics - *indications*

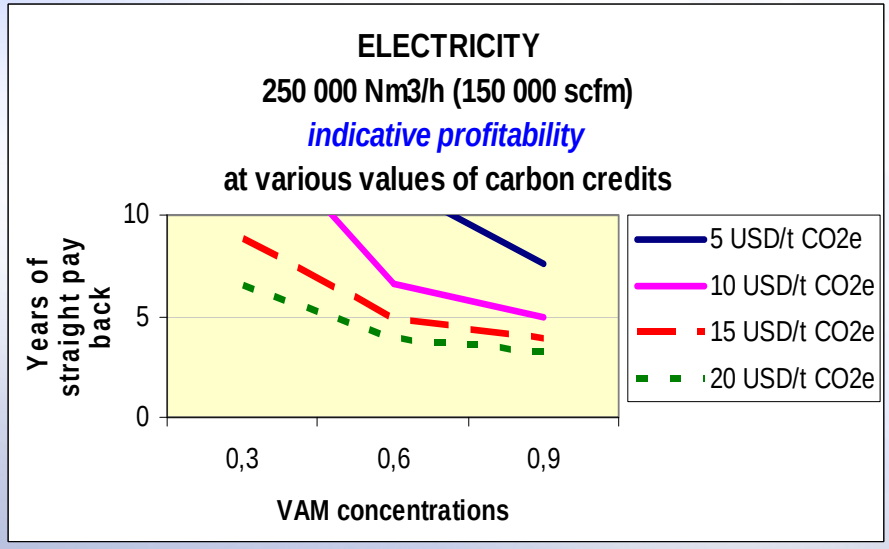


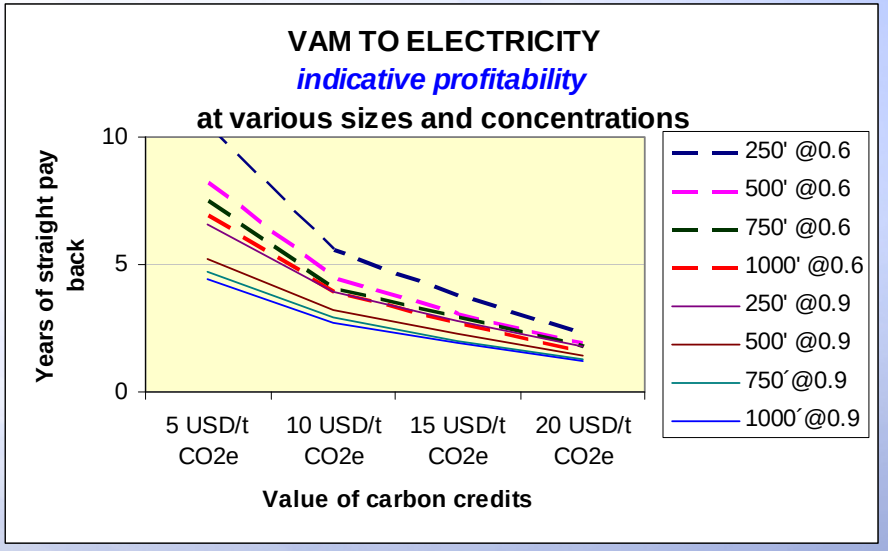


VAM Project Economics - *indications*





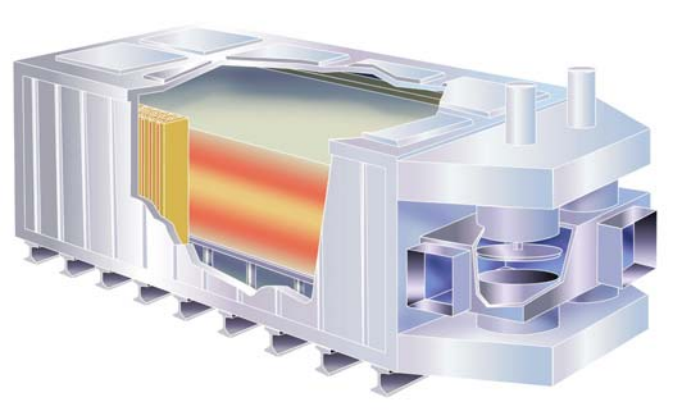




- VAM Power Plants have higher CAPEX and higher revenues

4 CONCLUSIONS on VAM **(Ventilation Air Methane)**

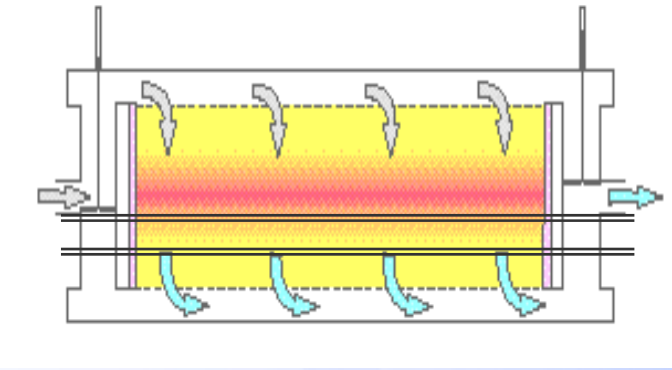
1. VOCSIDIZER *can abate* VAM



4 CONCLUSIONS on VAM (Ventilation Air Methane)

1. VOCSIDIZER *can abate* VAM

2. VOCSIDIZER *can convert* VAM into useful energy



4 CONCLUSIONS on VAM (Ventilation Air Methane)

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3. Project WestVAMP in Australia is the *World's first* large scale *VAM Power Plant* - using VAM as primary fuel

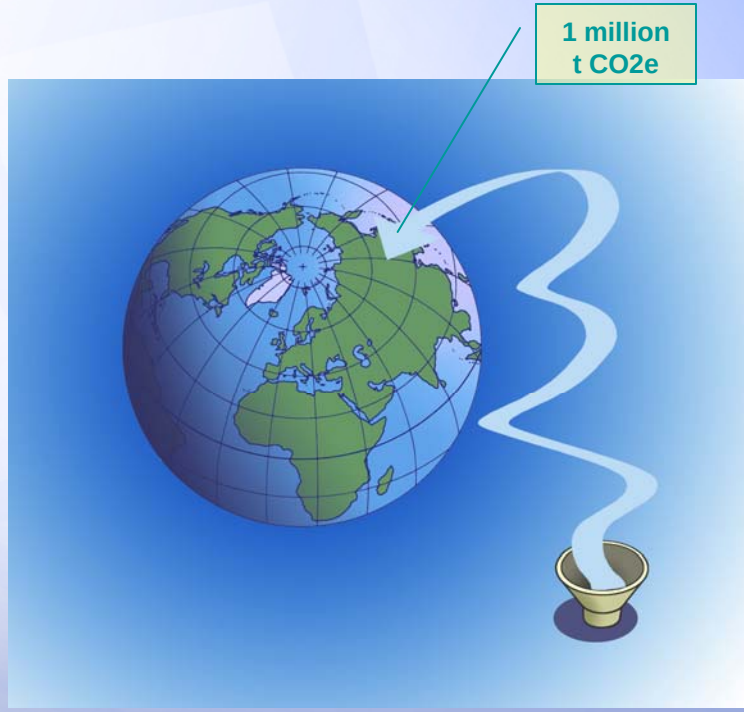
4 CONCLUSIONS on VAM (Ventilation Air Methane)

1. VOCSIDIZER *can abate* VAM

2. VOCSIDIZER *can convert* VAM into useful energy

3. Project WestVAMP in Australia will be the *World's first* large scale *VAM Power Plant* - using VAM as primary fuel

4. A full scale VAM Power Plant can reduce annual emissions of 1 million tons CO_{2e} - providing significant positive impact on Global Warming



ADDITIONAL CONCLUSION on VAM

At:

- > ½ percent CH4 and
- > 10 USD/t in value of Carbon Credits,

VAM projects can have pay back time of a few years only !

The World's first VAM Power Plant is

IN FULL OPERATION

RMATTUS@MEGTEC.SE