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Amine scrubbing for CO_2 capture from power plant flue gas

Nick Booth

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Overview

- UK Electricity production by fuel type
- Reducing power station CO_2 emissions
  - Track 1: Efficiency
  - Track 2: Carbon capture and storage
- Amine scrubbing process and chemistry
- Advantages and challenges
- Development activities
- Conclusions

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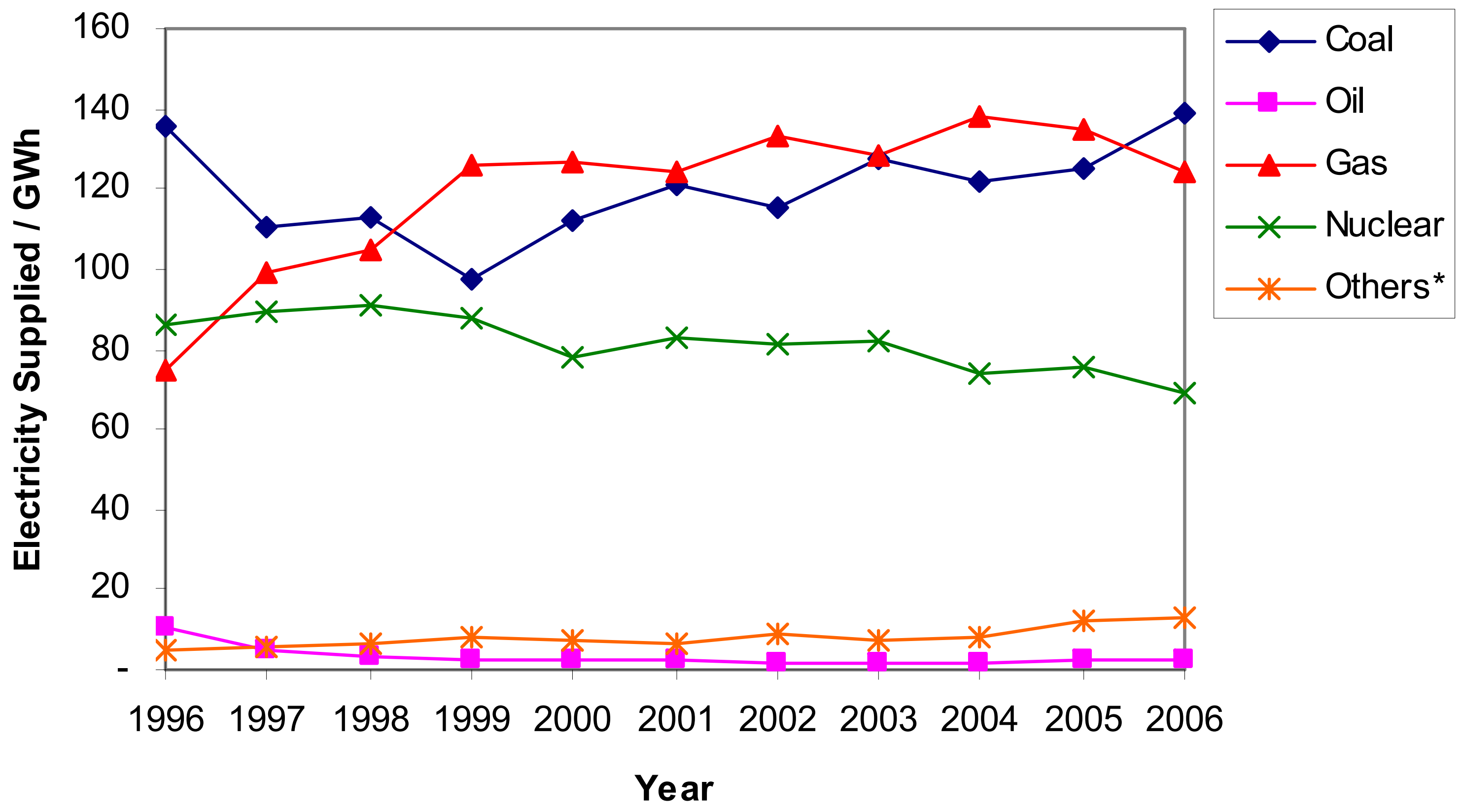
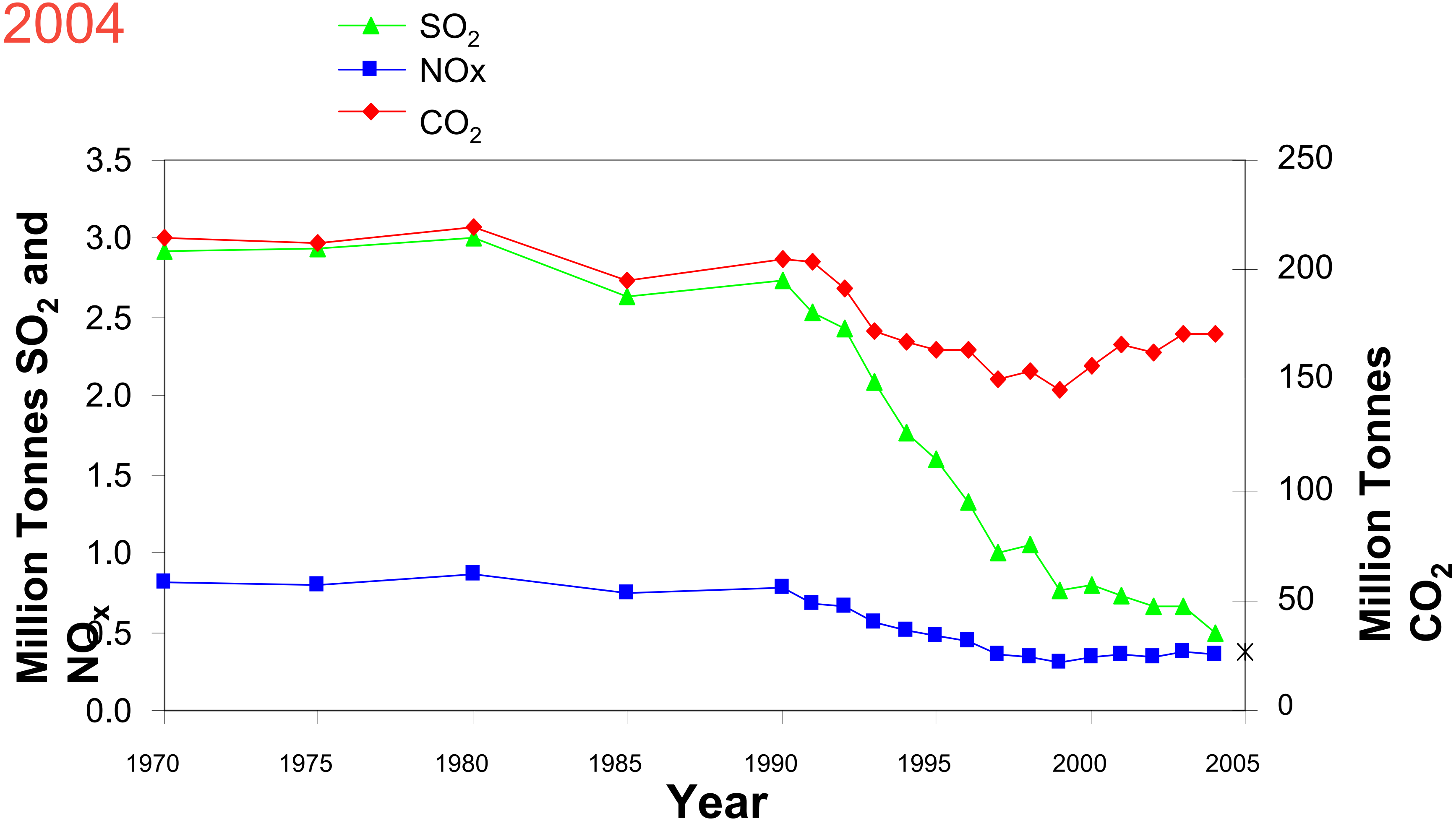
UK electricity supply 1996 – 2006 by fuel type



Source: http://stats.berr.gov.uk/energystats/dukes5_6.xls

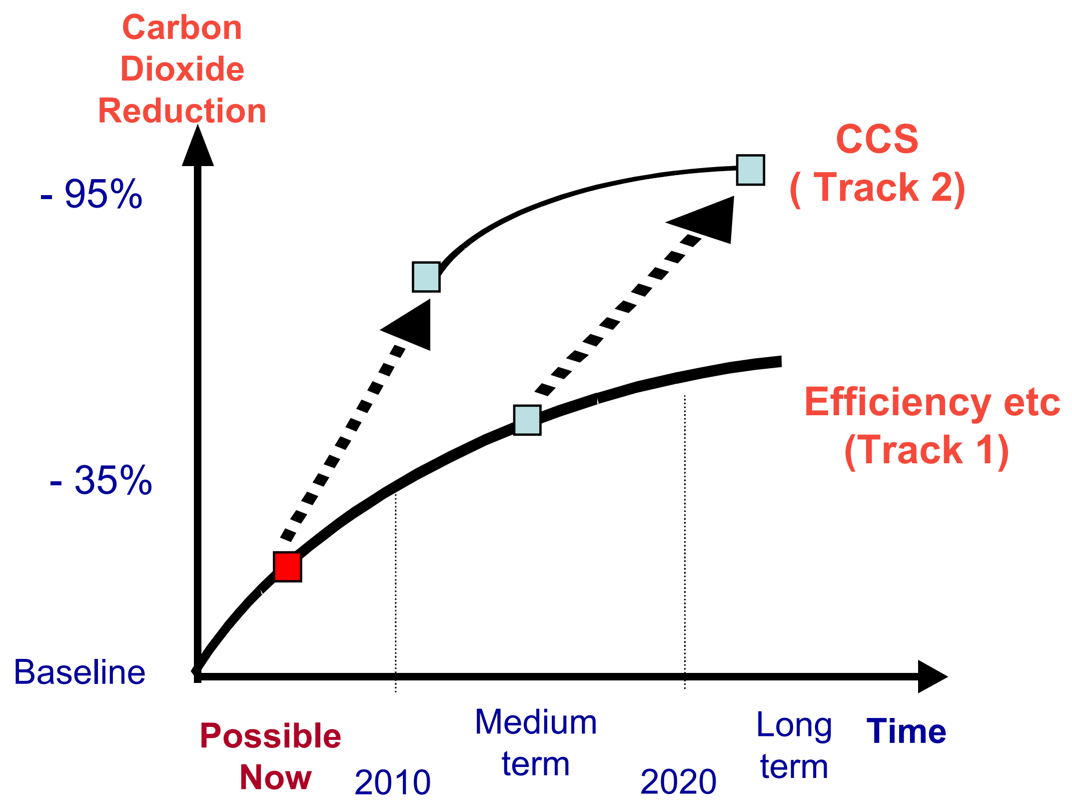
UK power station emissions of SO_2, NO_x and CO_2 1970-2004



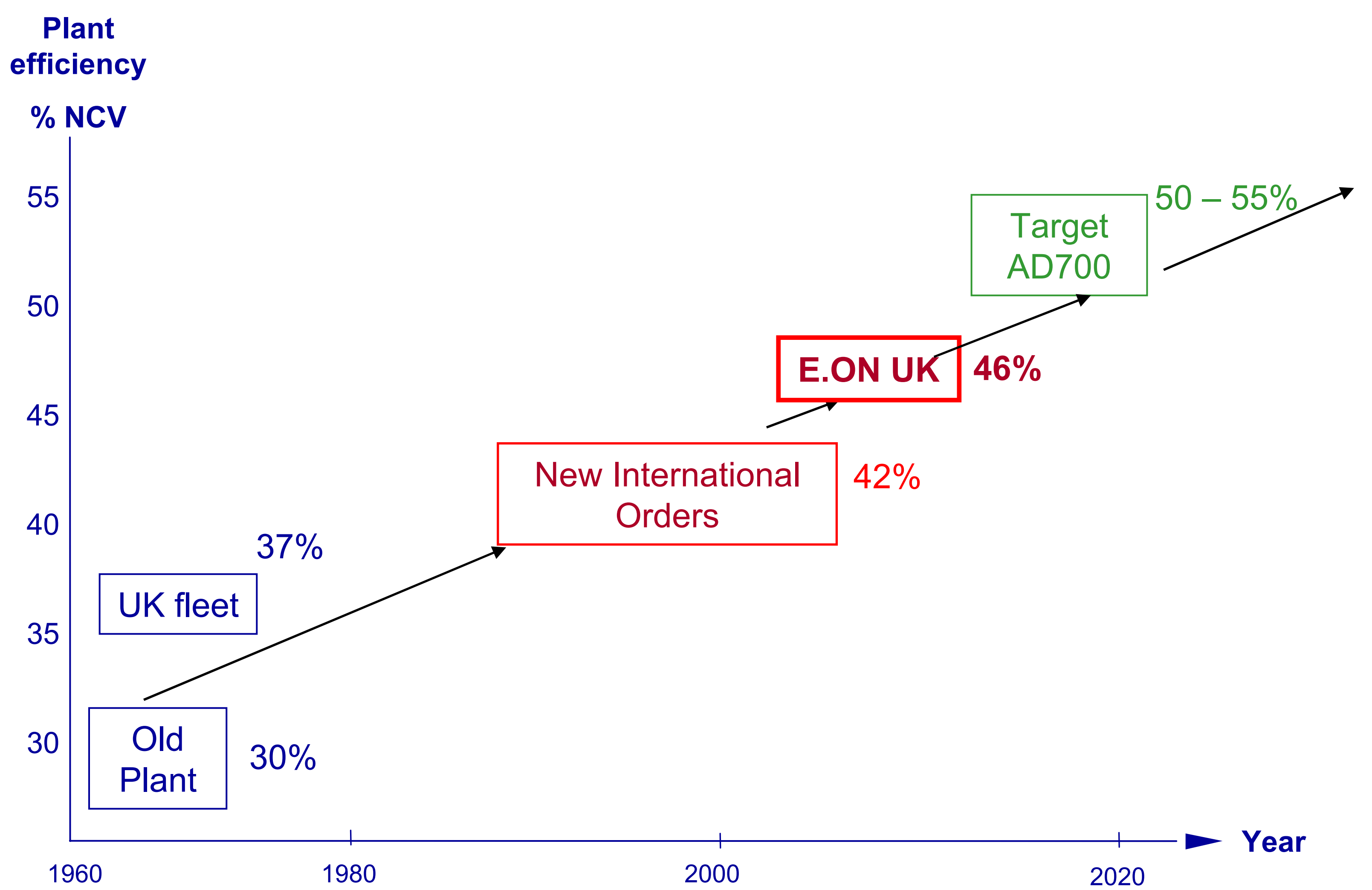
Carbon dioxide abatement from fossil fuels

Twin track Approach:

- Track 1
  - Fuel switch
  - Biomass
  - Efficiency improvements
- Track 2
  - Carbon Capture and Storage Technology



Track 1: Efficiency Improvement - Coal fired plant



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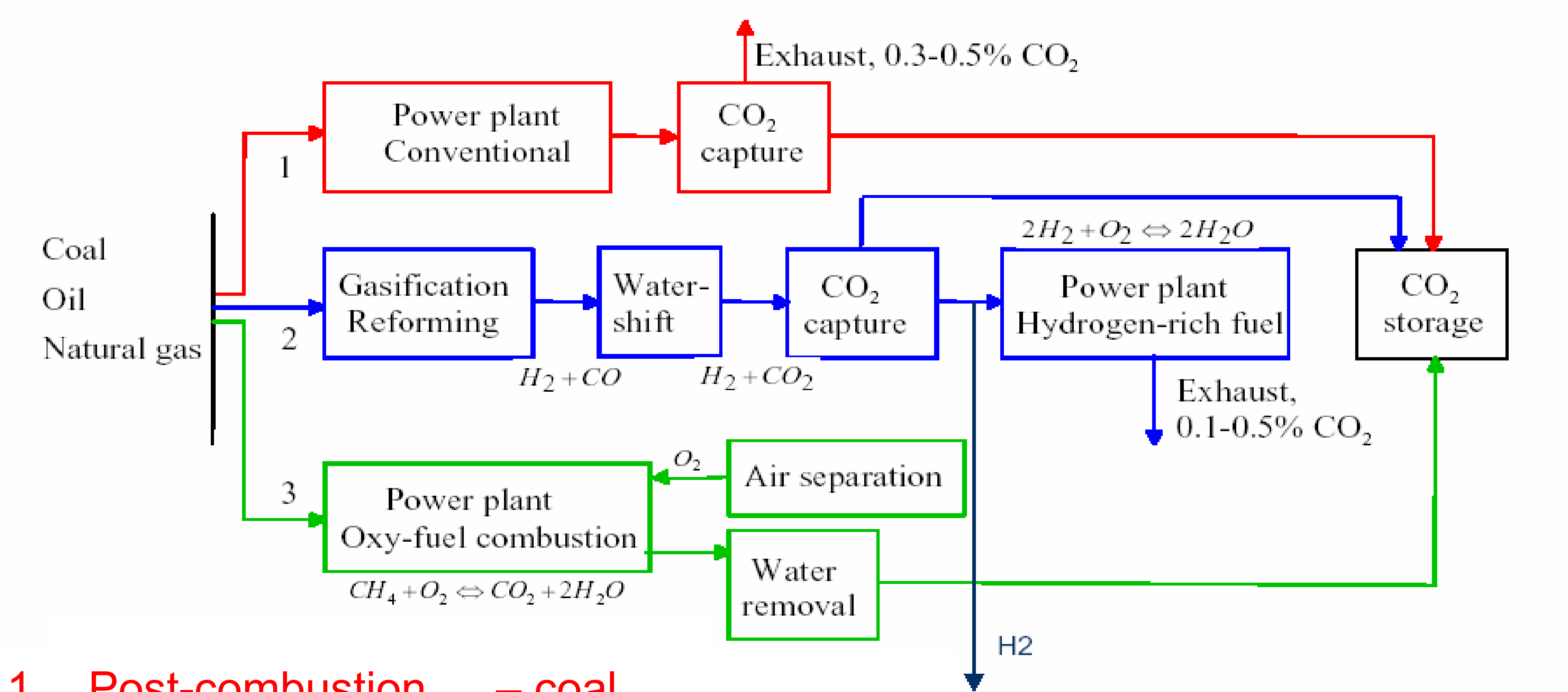
Kingsnorth 5 & 6 – Artist's Impression (expected ~2013)

Track 2: Options for power plant CO_2 capture



1. Post-combustion – coal
2. Pre-combustion – coal, natural gas
3. Oxy-fuel – coal

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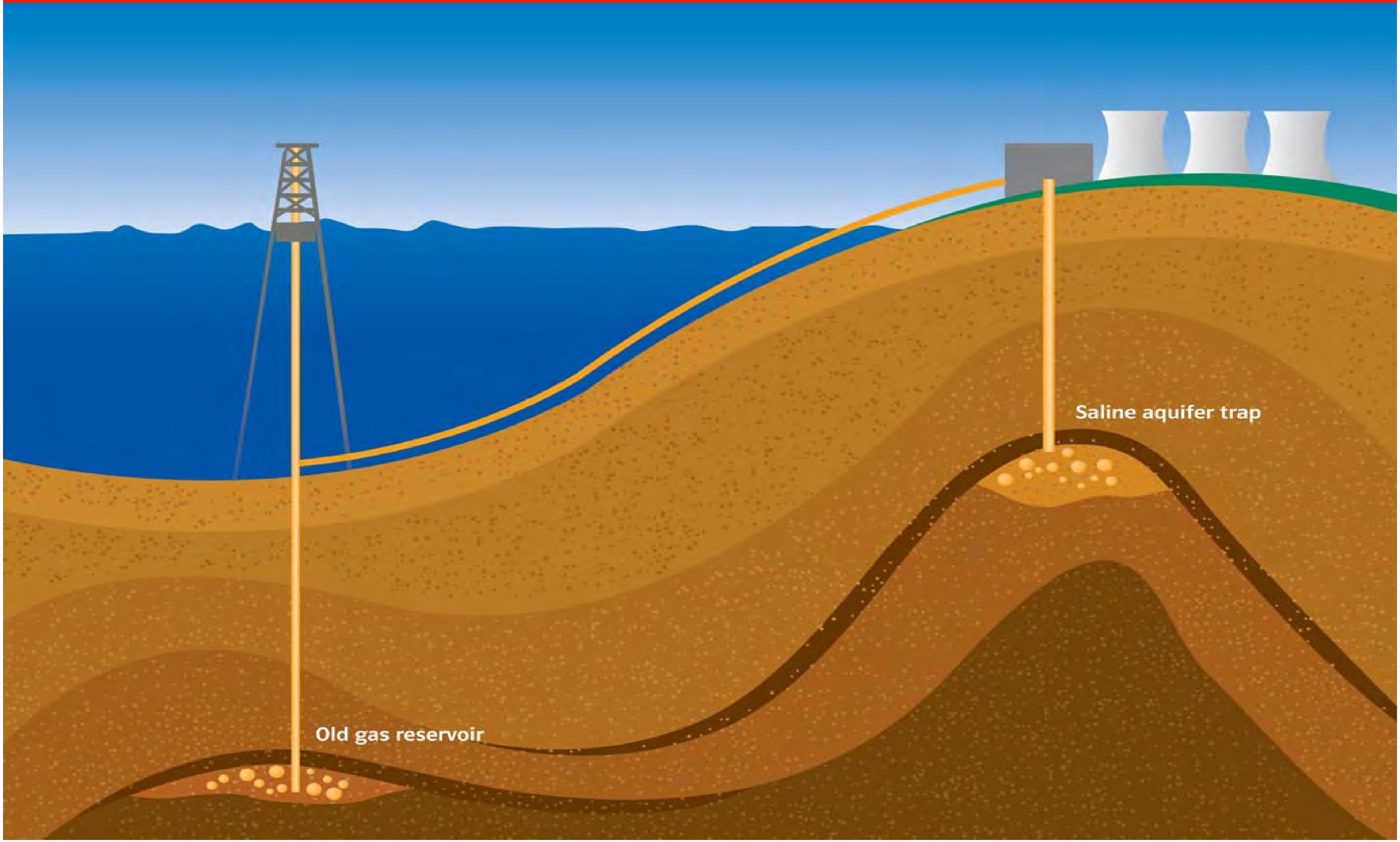

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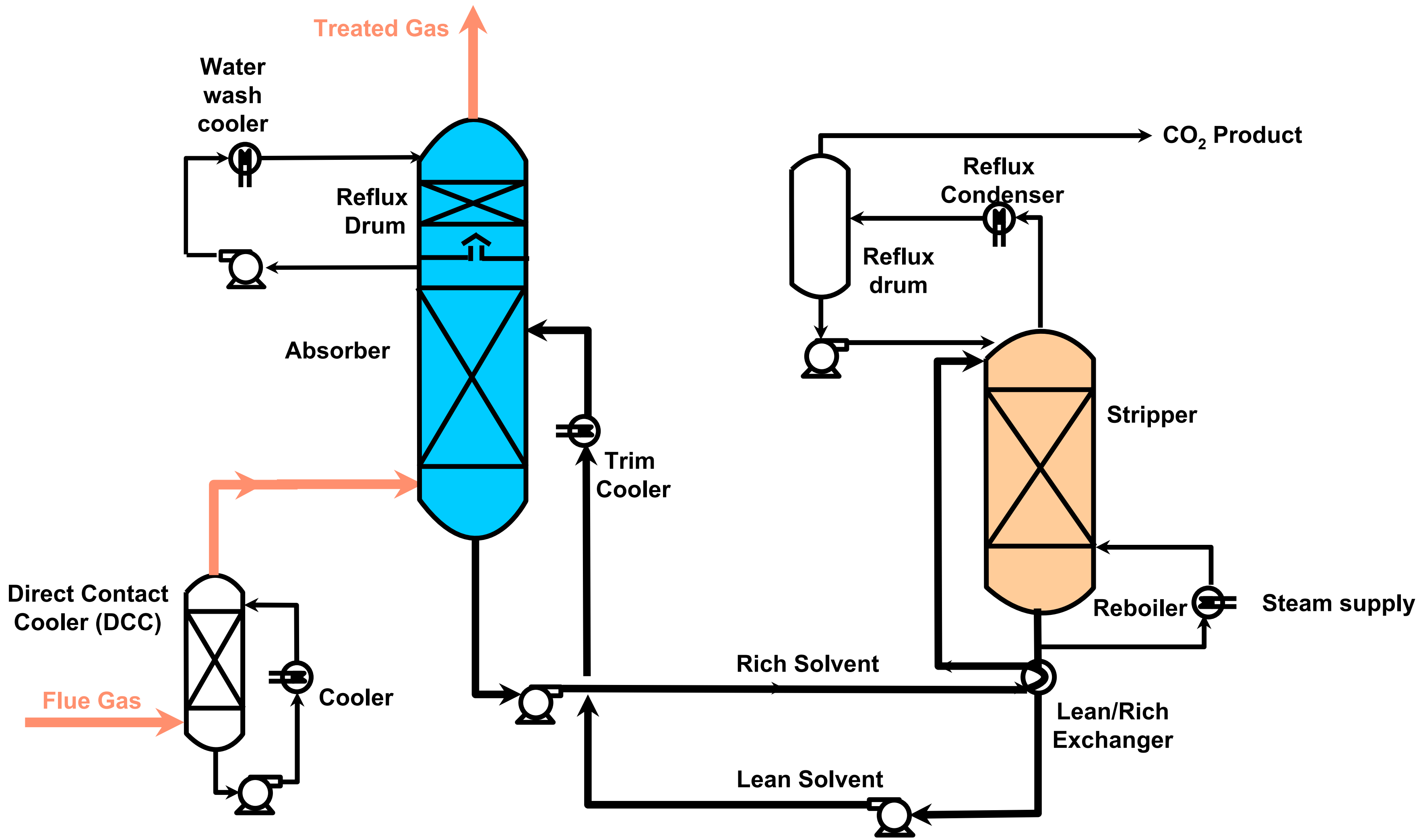
Amine Scrubbing for CO_2 Capture



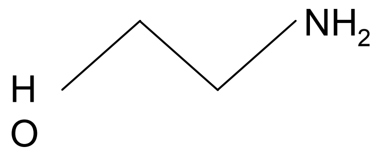
Process Chemistry

- Primary and secondary amines react directly with CO_2

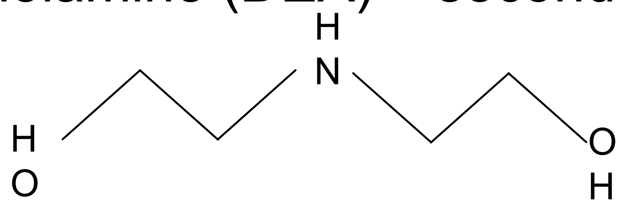
$$CO_2 + 2\,R_1R_2NH \leftrightarrow R_1R_2N^+H_2 + R_1R_2NCOO^-$$

then, $R_1R_2NCOO^- + H_2O \leftrightarrow R_1R_2NH + HCO_3^-$ [but K<<1]

- Monoethanolamine (MEA) – primary amine



- Diethanolamine (DEA) – secondary amine



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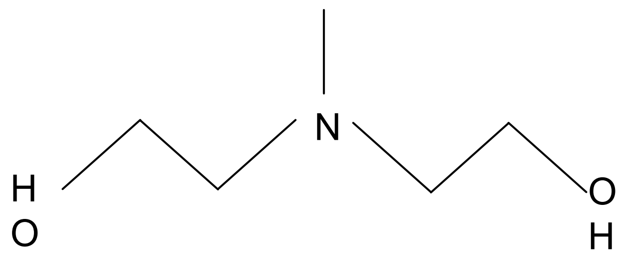
Process Chemistry

- Tertiary amines react indirectly with CO_2
  - Base catalysed hydrolysis of CO_2

$$CO_2 + R_1R_2R_3N + H_2O \leftrightarrow R_1R_2R_3N^{+}H + HCO_3^{-}$$

- Methyl diethanolamine (MDEA) – tertiary amine



Process Chemistry

- Reaction rate and reaction enthalpy for common amines

	Reaction rate constant	Reaction Enthalpy	Stoichiometry
	m^3/kmol.s	kJ/mol	mol/mol
MEA	**~ 7000**	**90**	**0.5**
DEA	**~ 1000**	**80**	**0.5**
AMP	**~ 700**	**75**	**1**
MDEA	**~ 7**	**60**	**1**

Amine scrubbing advantages and disadvantages

- Advantages
  - 70+ years of experience with industrial gas streams
  - Retro-fit to existing and new conventional plant
  - Bypass
  - Pure CO_2 stream for storage
  - One of most developed CO_2 capture options (1000te/day)

- Challenges
  - High energy penalty (~10% points)
  - High cost - capital and operating
  - Footprint
  - Scale-up (13,000te/day)
  - Corrosion & degradation (SO_2, O_2, particulate, etc)

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Development activities

- Issues to address
  - Cost and energy penalty – advanced amines/reagent and engineering
  - Power plant integration – gas path and heat/steam
  - Corrosion – new materials
  - Degradation – flue gas pre-treatment
  - Scale-up – build & operate pilot, demo, full scale plants

- E.ON UK activities
  - CASTOR EU project – www.co2castor.com
  - International Test Centre (ITC) sponsor – www.co2research.ca
  - CAPRICE EU/Global project – www.caprice-project.eu
  - Ammonia process demonstration – E.ON Nordic/Alstom
  - 6te/day CO_2 pilot plant - E.ON Benelux
  - Others…

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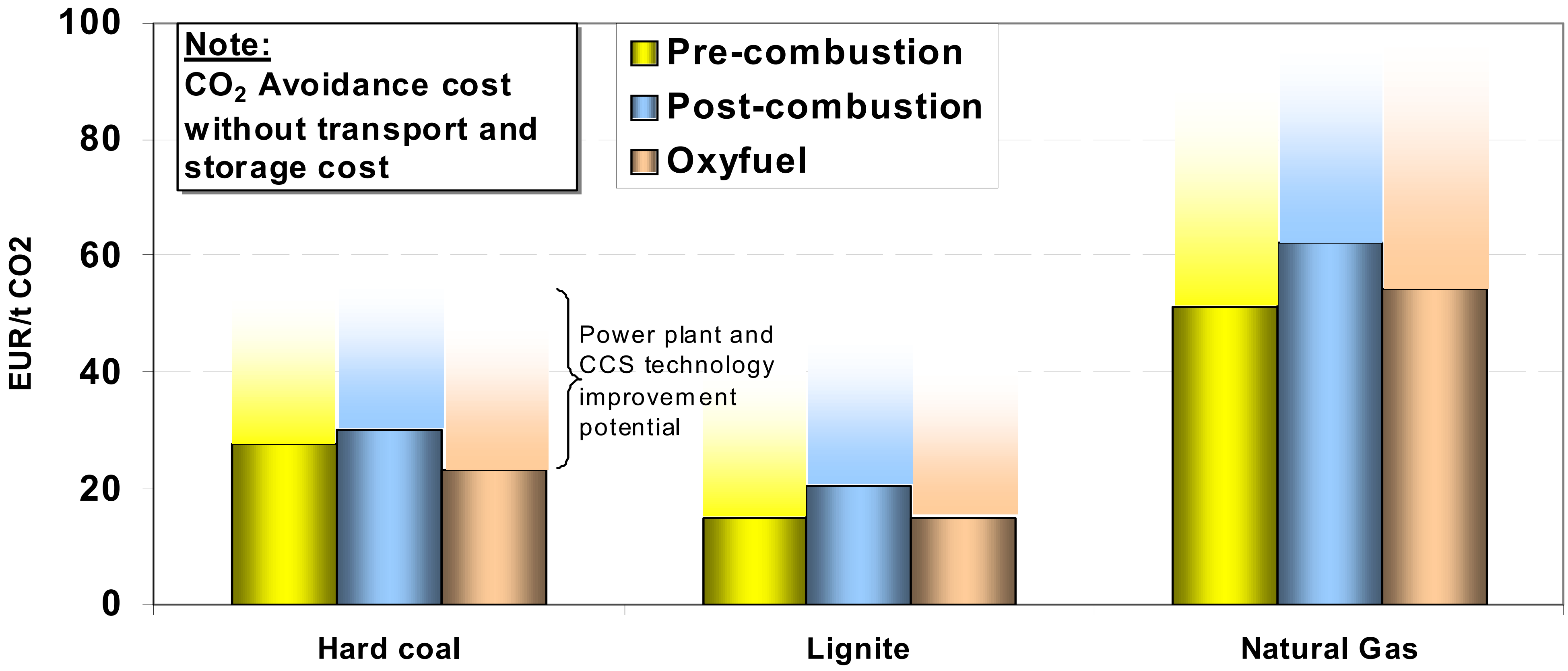
Conclusions – Amine scrubbing of CO_2

- Ongoing requirement for fossil fuel fired power plant
- Cleaner fossil fuel plant technically feasible
- Two track approach to reducing CO_2 emissions
  - Track 1: Efficiency, fuel selection (35% reduction)
  - Track 2: Carbon capture and storage (90-95% reduction)
- Amine scrubbing is a leading capture option, but needs
  - Amine chemistry development
  - Engineering development
  - Scale-up
  - Integration into power plant
- Leading technologies at similar stage of development and demonstration
- Uncertainty over cost of carbon capture technologies
- Uncertainty over future value/cost of carbon credits

Comparison of Costs Associated with CO_2 Capture Technologies

Expected CO_2 avoidance cost for large-scale power plants in operation by



Source: Technology Platform Zero Emission Power