E.ON | UK

# E.ON’s Activities on IGCC and Zero Emissions Plant

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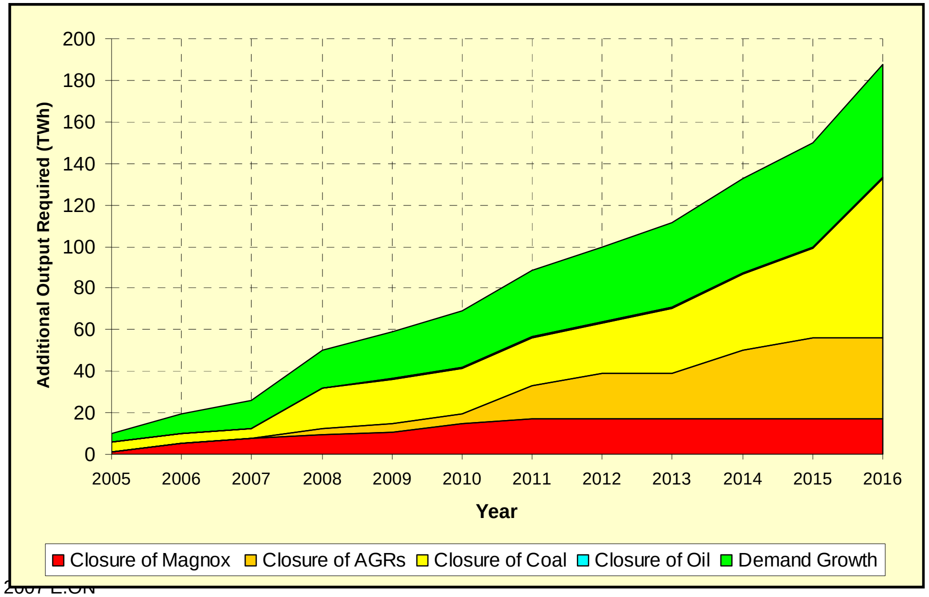
Rugeley - 20 June 2007

# The Need for New Capacity

- By 2015 the UK will see up to 26GW of plant closures (LCPD and nuclear life expiry)

- With no new build, demand may exceed supply in winter peaks by about 2011




•Estimated 36 GW of new capacity needed by 2020 ~ 45% of UK capacity

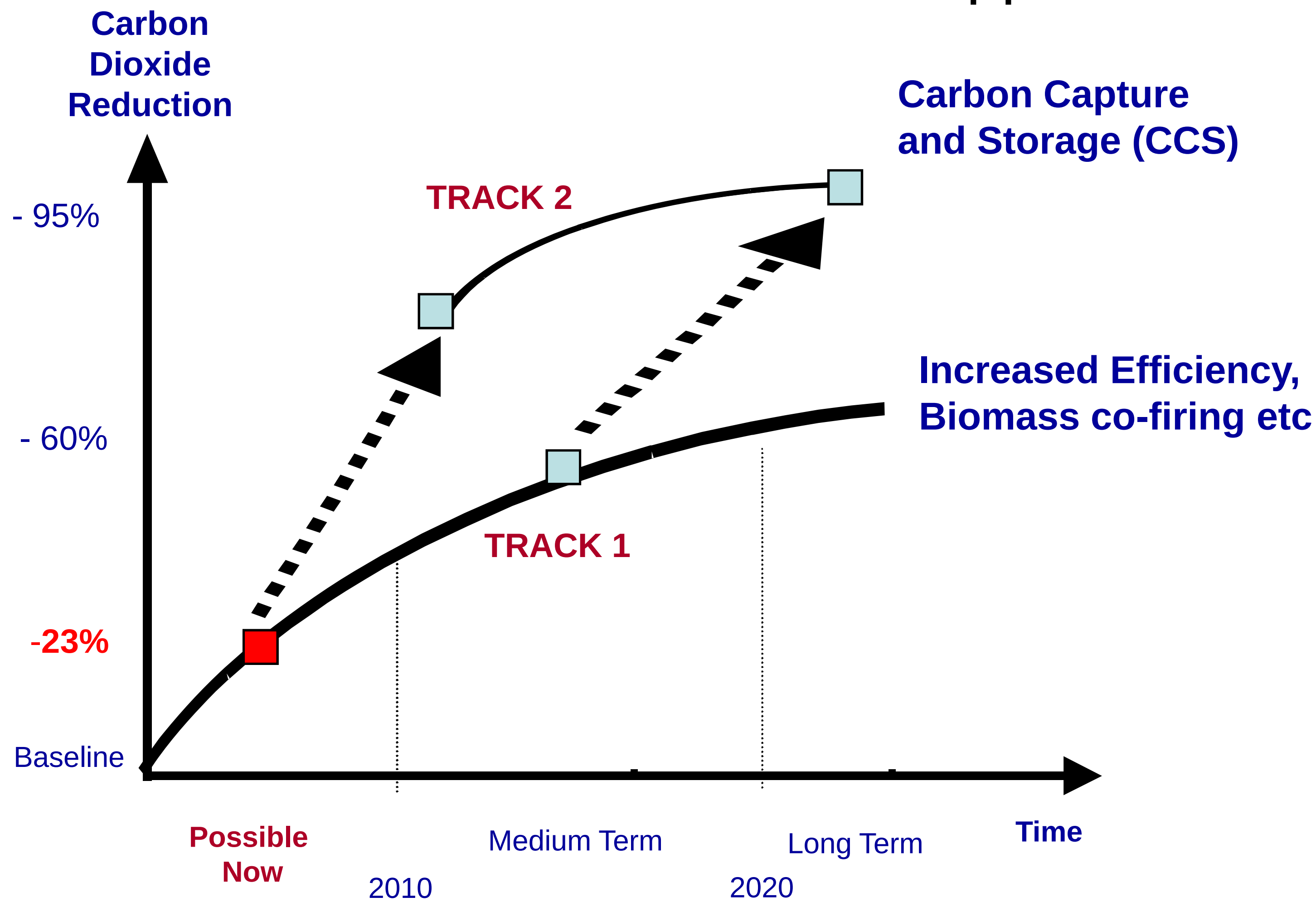
Replacement with gas-fired CCGTs will not reduce overall $CO_2$ emissions – and lead to ~70% gas dependency.

# Replacement Generation Options

**Considerations include:**

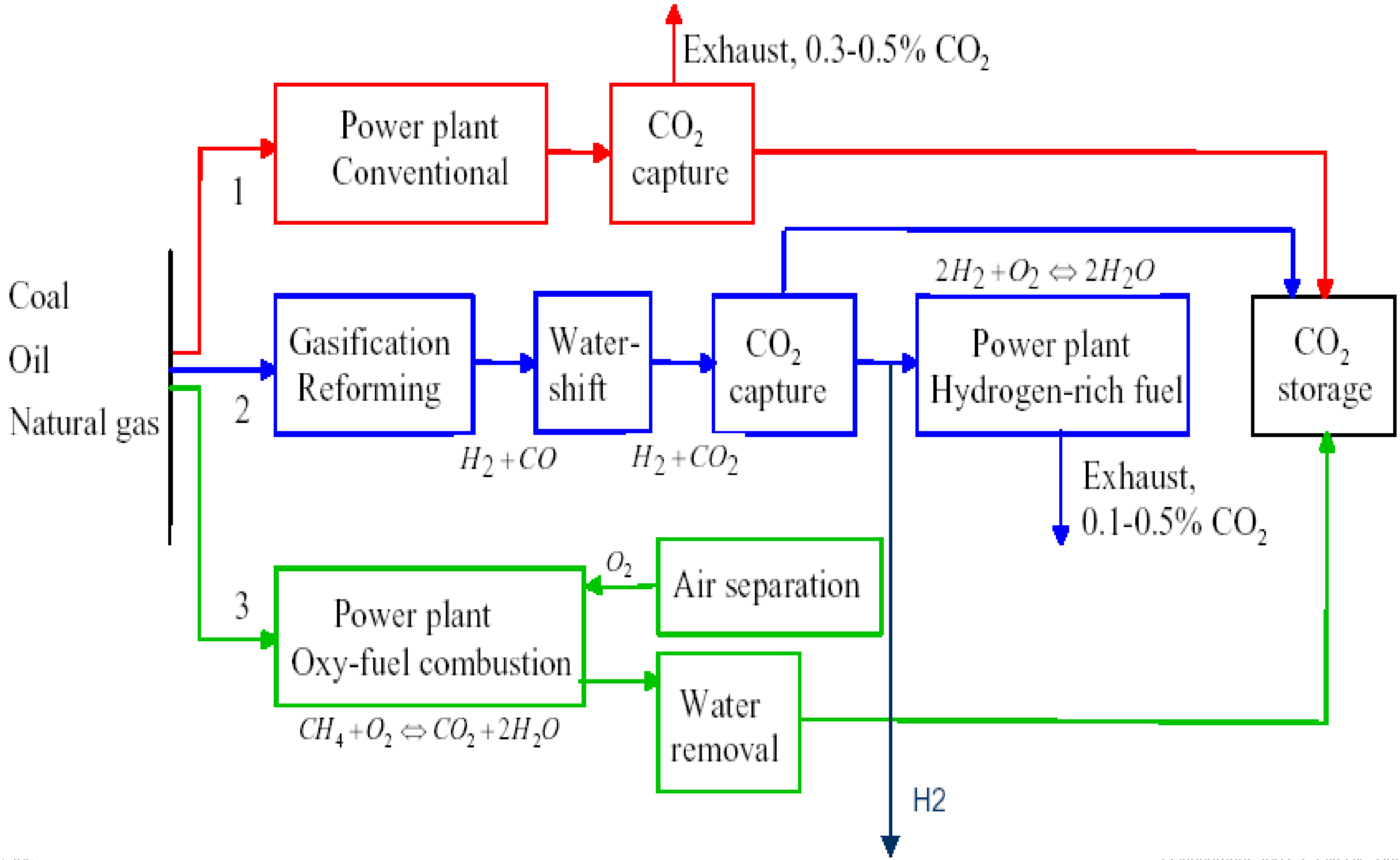
•Government Policy (including post-Kyoto position, Security of Supply) – the Energy White Paper, EC Policy Initiatives, G8 ..........
•Environmental Performance
•Commercial Viability (including cost of fuel and carbon)
•Public Acceptability (a factor for new nuclear?)
•Technology maturity (clean coal technologies, marine?)
•Reliability (e.g. the intermittency of wind)
•Extent of Deployment (can enough be built in time; e.g small scale CHP, nuclear consenting)

# $CO_2$ abatement from coal – twin track approach



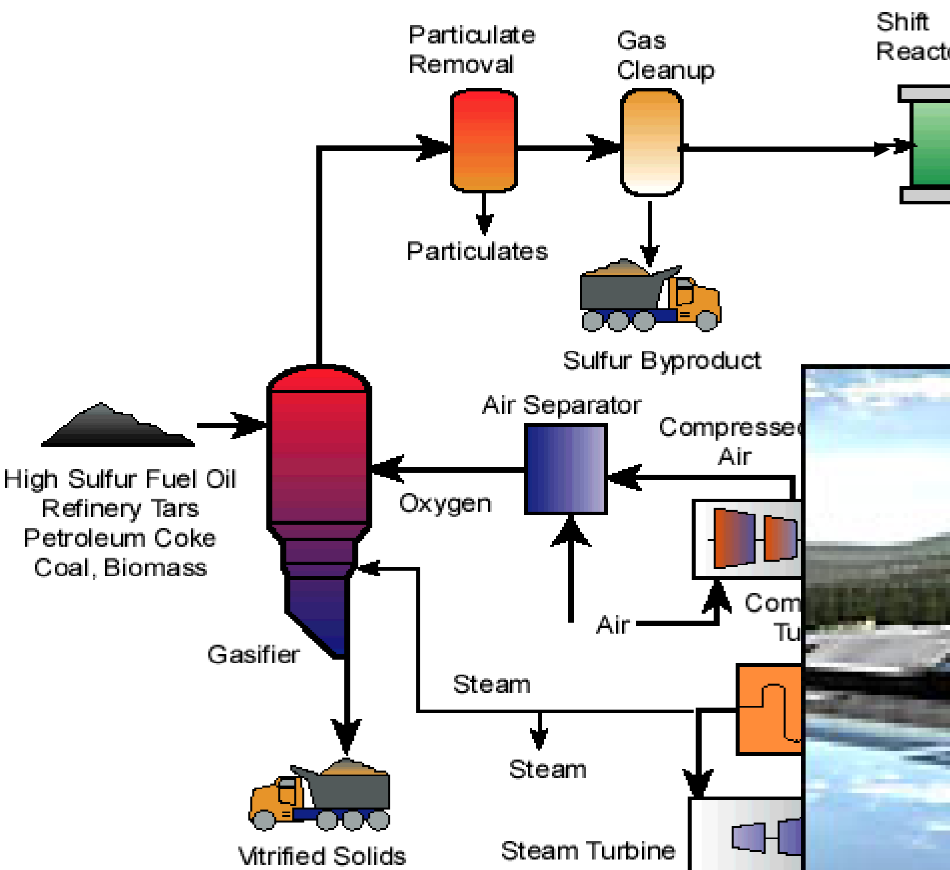

Source: IEA

# CO2 Capture Options



# GASIFICATION WITH CAPTURE

# IGCC with $CO_2$ Capture




## Current Position

- Killingholme
- Essence of the $1B US FutureGen project
- EU Hypogen/Dynamis project has similar goal

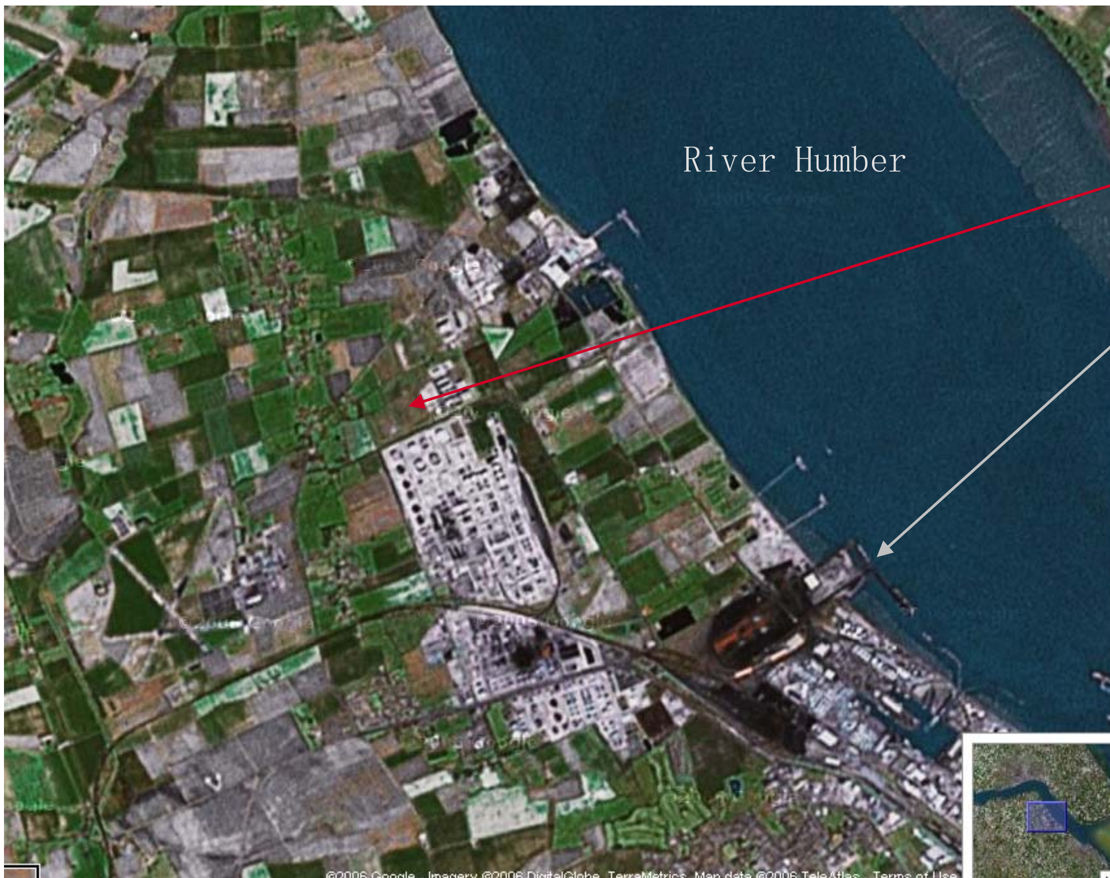
E.ON UK' s CCS project at Killingholme

**Overview**

- Killingholme will nominally be a 450MW IGCC+CCS fuelled on coal
- Built on or close to the existing Killingholme site
- Multiple $CO_2$ storage options identified in the Southern North Sea (SNS)

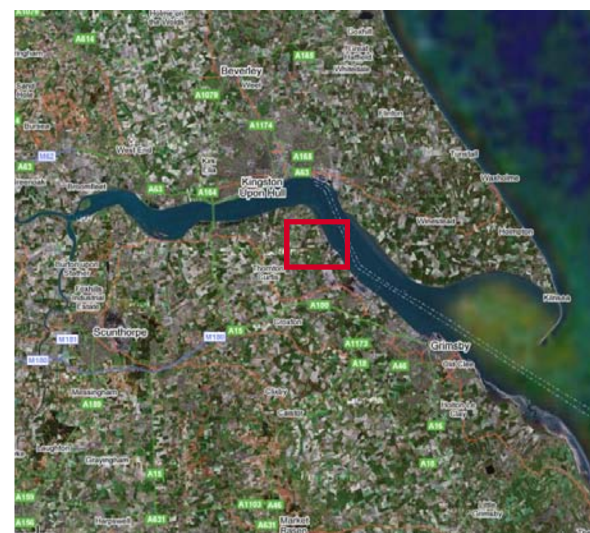
**Killingholme could be operational by late 2011**

The existing E.ON site is the front running site on which to build Killingholme IGCC



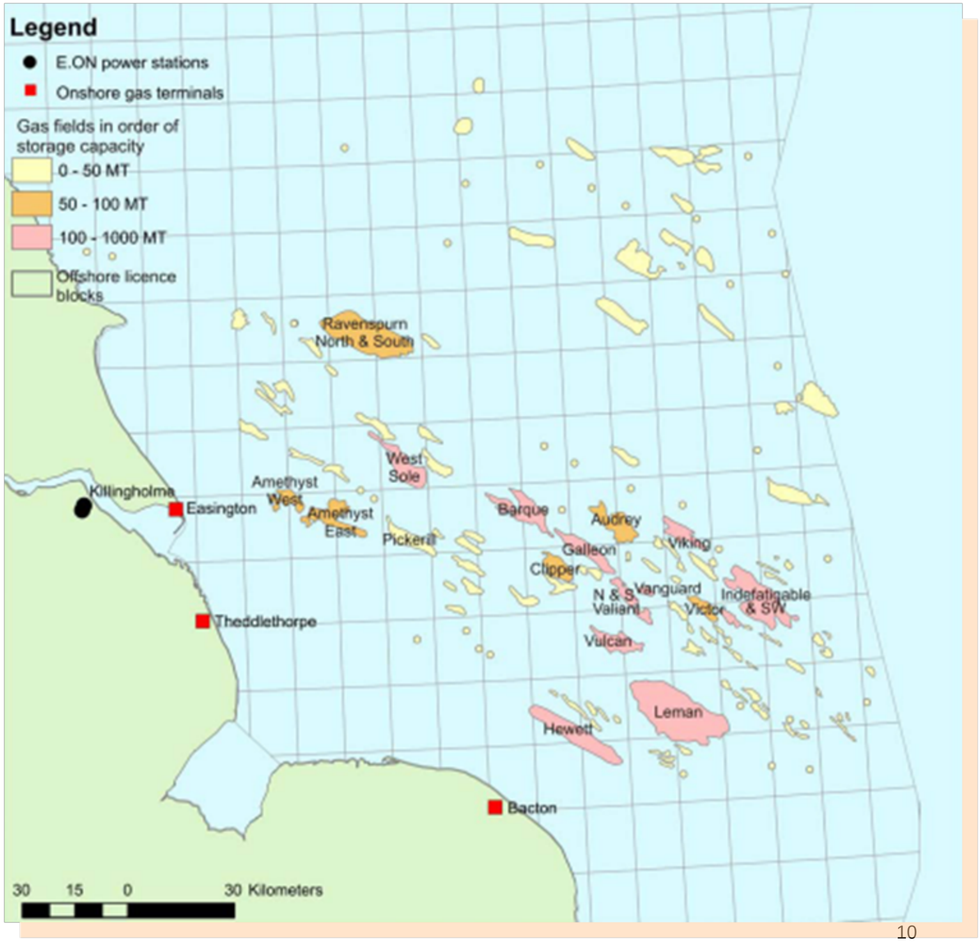

E.ON site

Immingham dock



# Multiple $CO_2$ storage sites identified in the SNS

- Killingholme is well positioned for $CO_2$ evacuation from Easington and Theddelthorpe
- The vast majority of gas fields in the SNS are capable of storing $CO_2$
- The SNS is capable of storing 2.8BT of $CO_2$, Killingholme will produce 3MT of $CO_2$ pa.

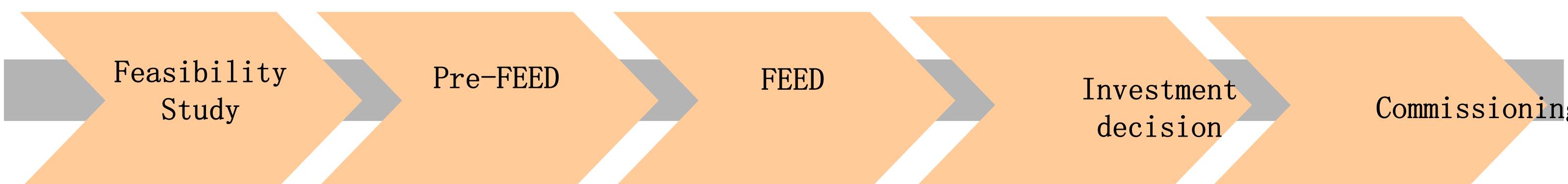


UK

# Killingholme could be operational by 2011

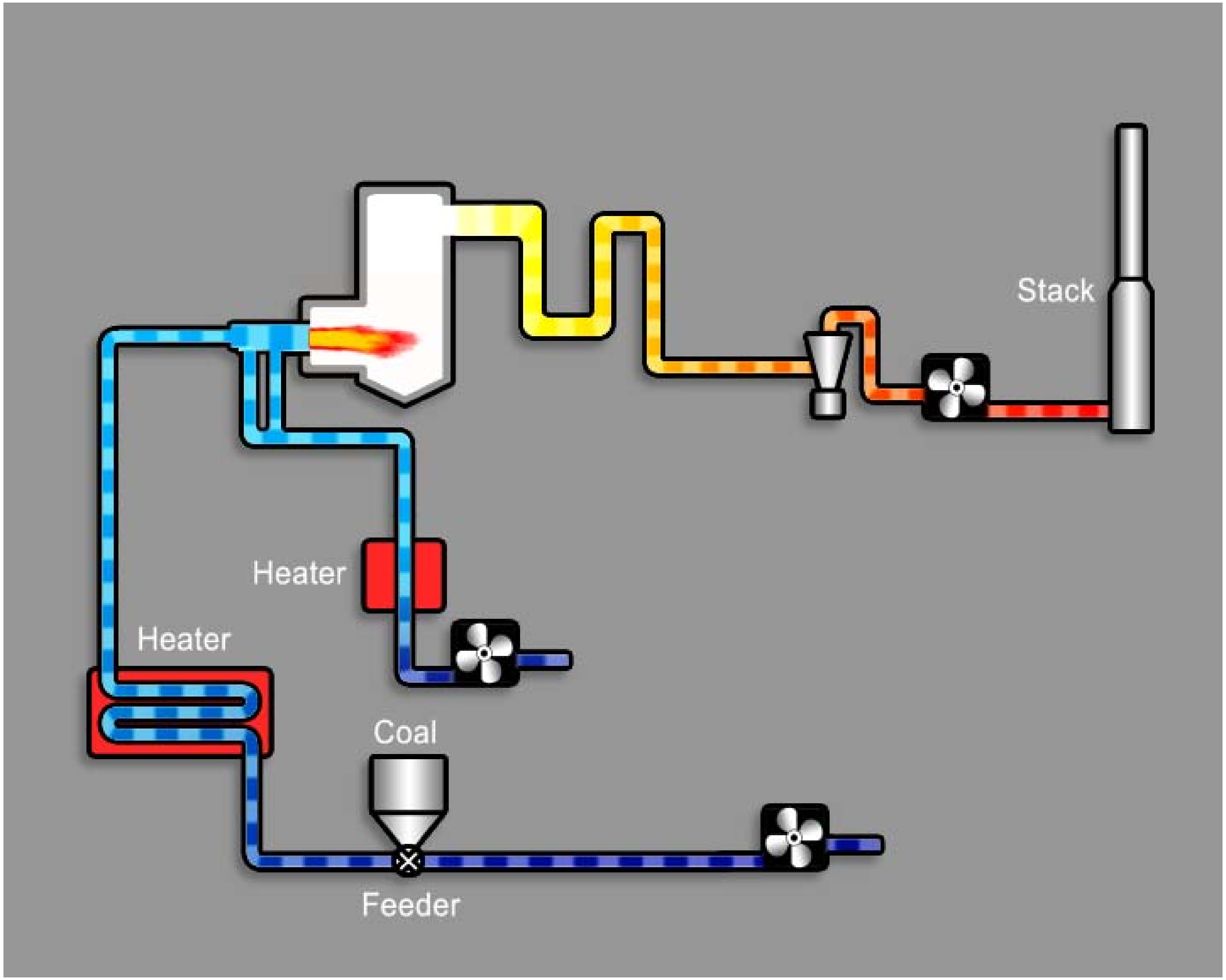
## Milestones

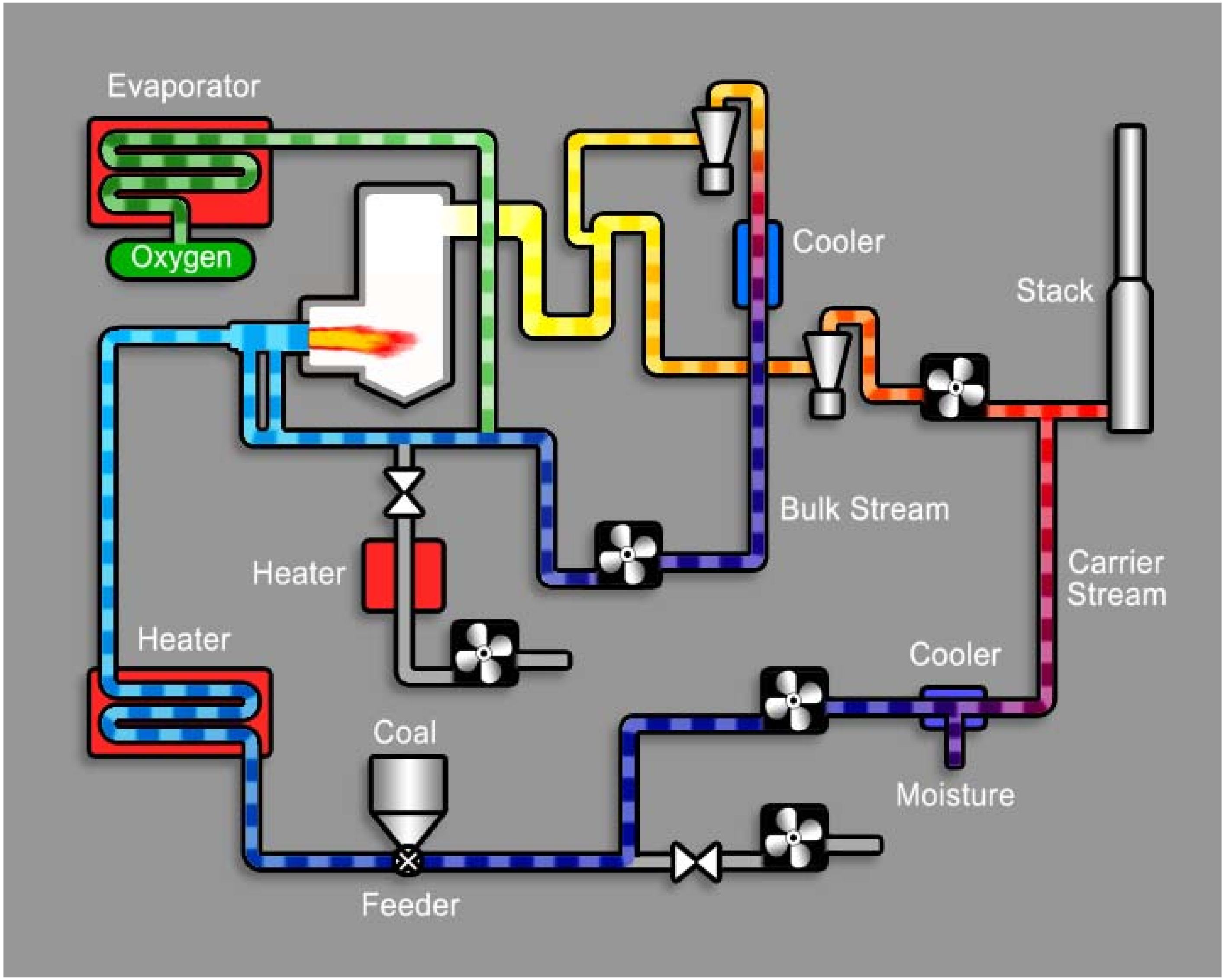
- Sept 2006 — Feasibility study reports
- Jan 2007 - July 2007 — Pre-FEED study
- Aug 2007 - May 2008 — Full FEED study
- **June 2008 — Investment decision**
- July 2008- Sept 2011 — Construction
- **Dec 2011 — Plant commissioning**




This timetable is ambitions but is designed to ensure E.ON remains front-running utility on coal based carbon capture. Clearly there are factors that could cause delay

# OXYFUEL


Stack
Heater
Heater
Coal
Feeder


Evaporator
Oxygen
Cooler
Stack
Bulk Stream
Carrier
Stream
Heater
Heater
Cooler
Coal
Moisture
Feeder

# Oxygen tank and evaporator

# Carrier stream – ground floor

# Civil works for bulk stream tower

# Testing: results

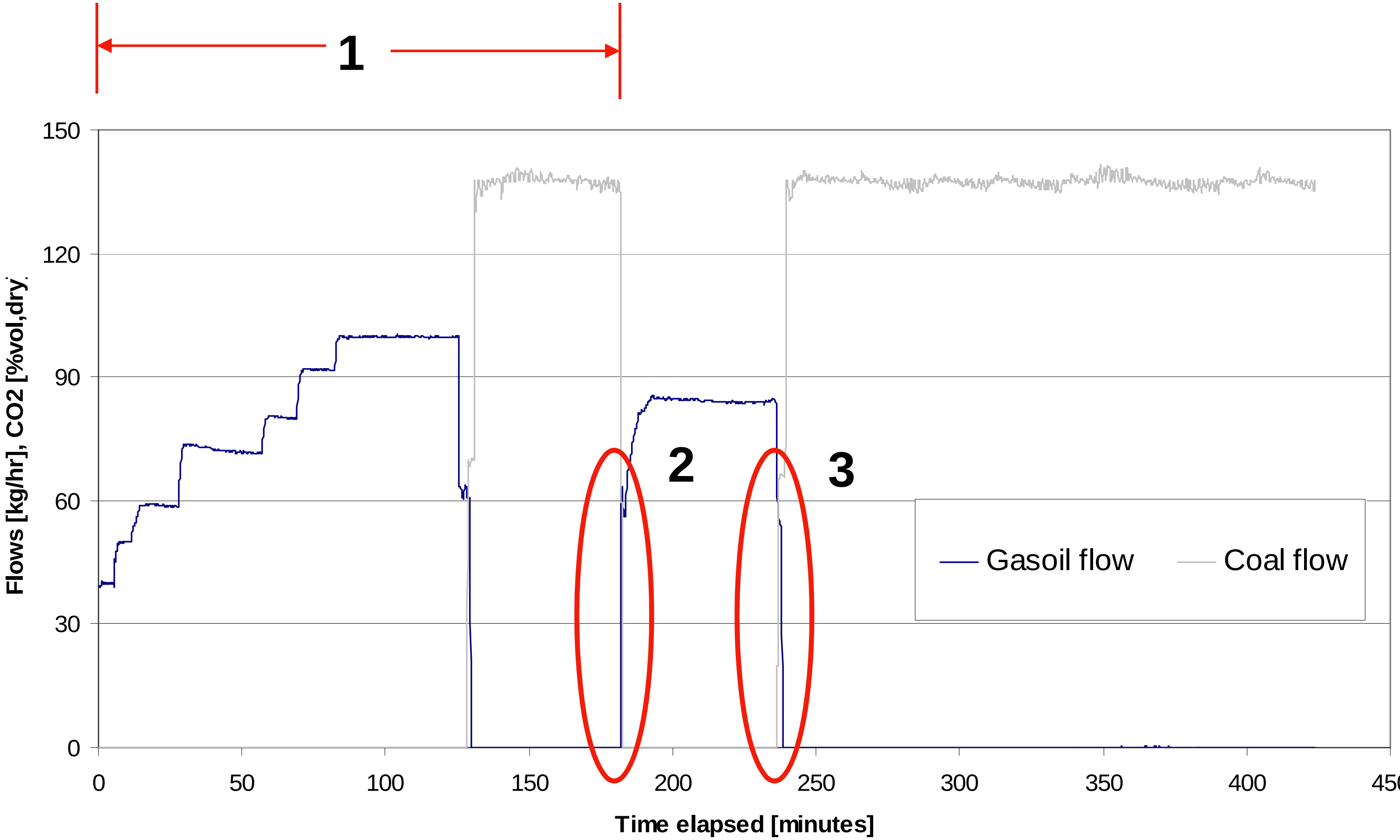
Reduction in net flow

Operation: changeover

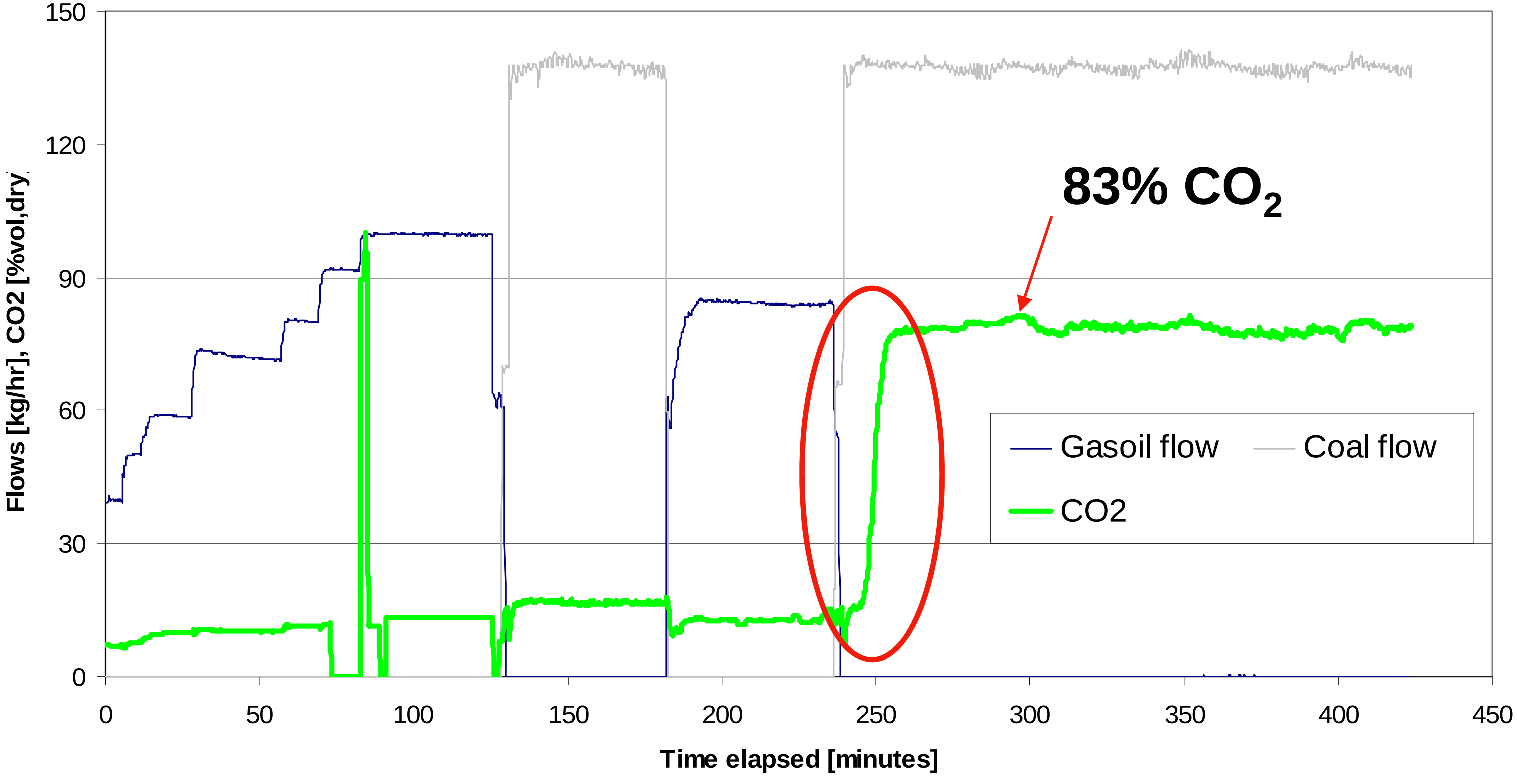
Emissions ($CO_2$, NO, $SO_2$, CO) and C burnout

Combustion stability

# Changeover



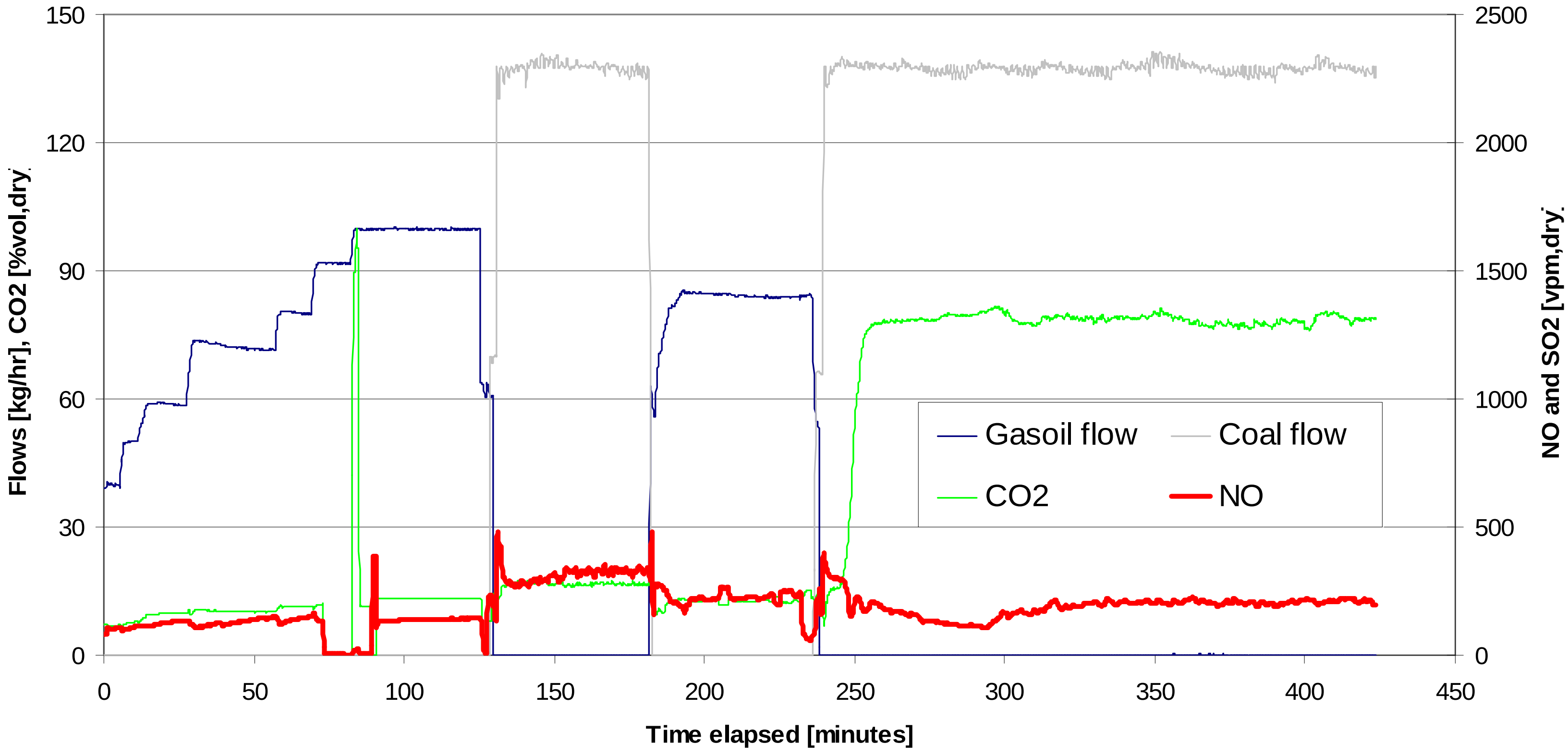

1. Warm up on gasoil, then switchover to coal for air baseline test
2. Revert to gasoil during switchover of carrier stream
3. Revert to coal for full switchover (bulk)




| $CO_2$ [%vol,dry] | Gasoil, air = 14 | Coal, air = 17 | Coal, oxyfuel = 80 |
|---|---|---|---|

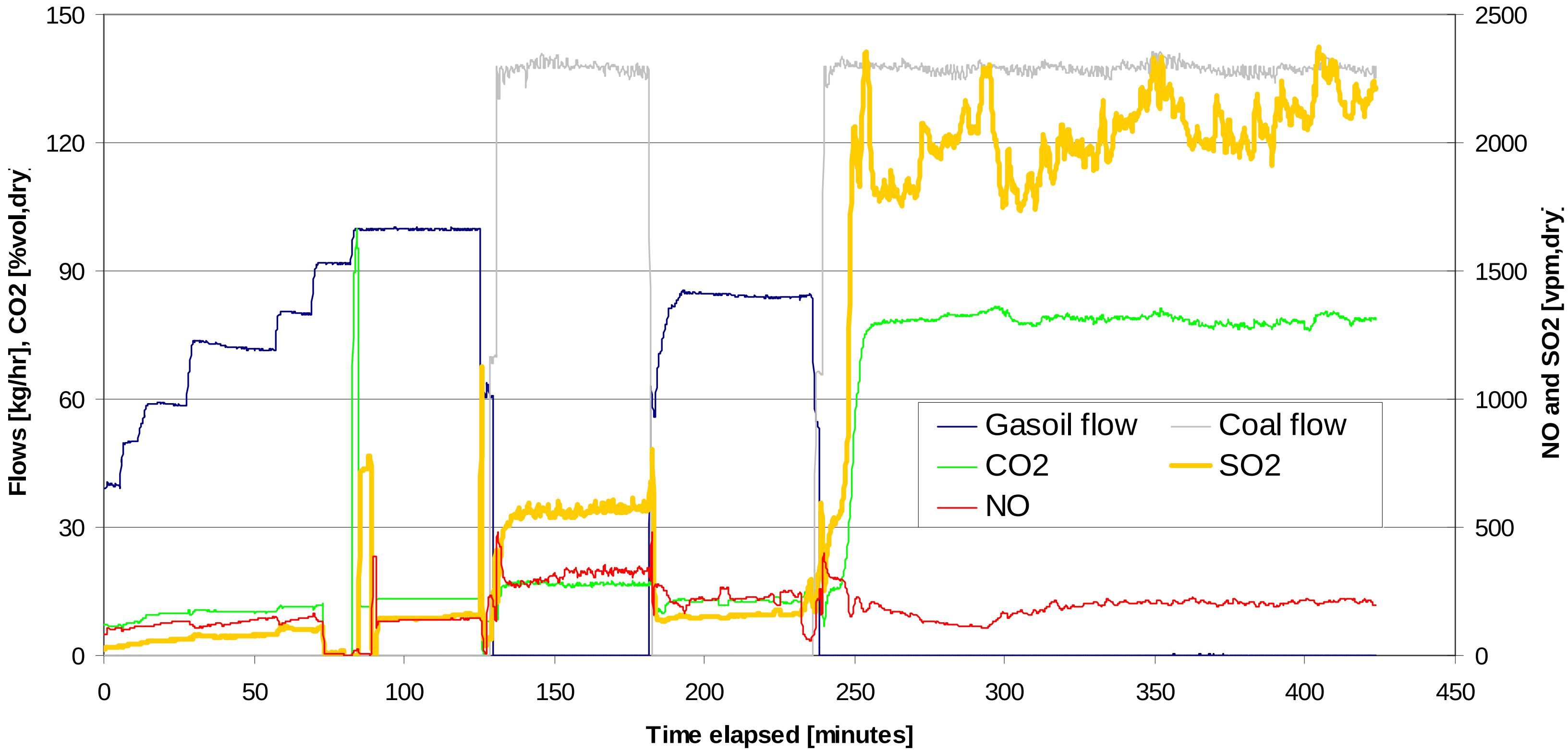
Changeover and $CO_2$ concentration response time <10 minutes

# Changeover



150
120
90
60
30
0
2500
2000
1500
1000
500
0
Flows [kg/hr], CO2 [%vol,dry]
NO and SO2 [vpm,dry]
0
50
100
150
200
250
300
350
400
450
Time elapsed [minutes]
Gasoil flow
Coal flow
CO2
NO

# Changeover



150
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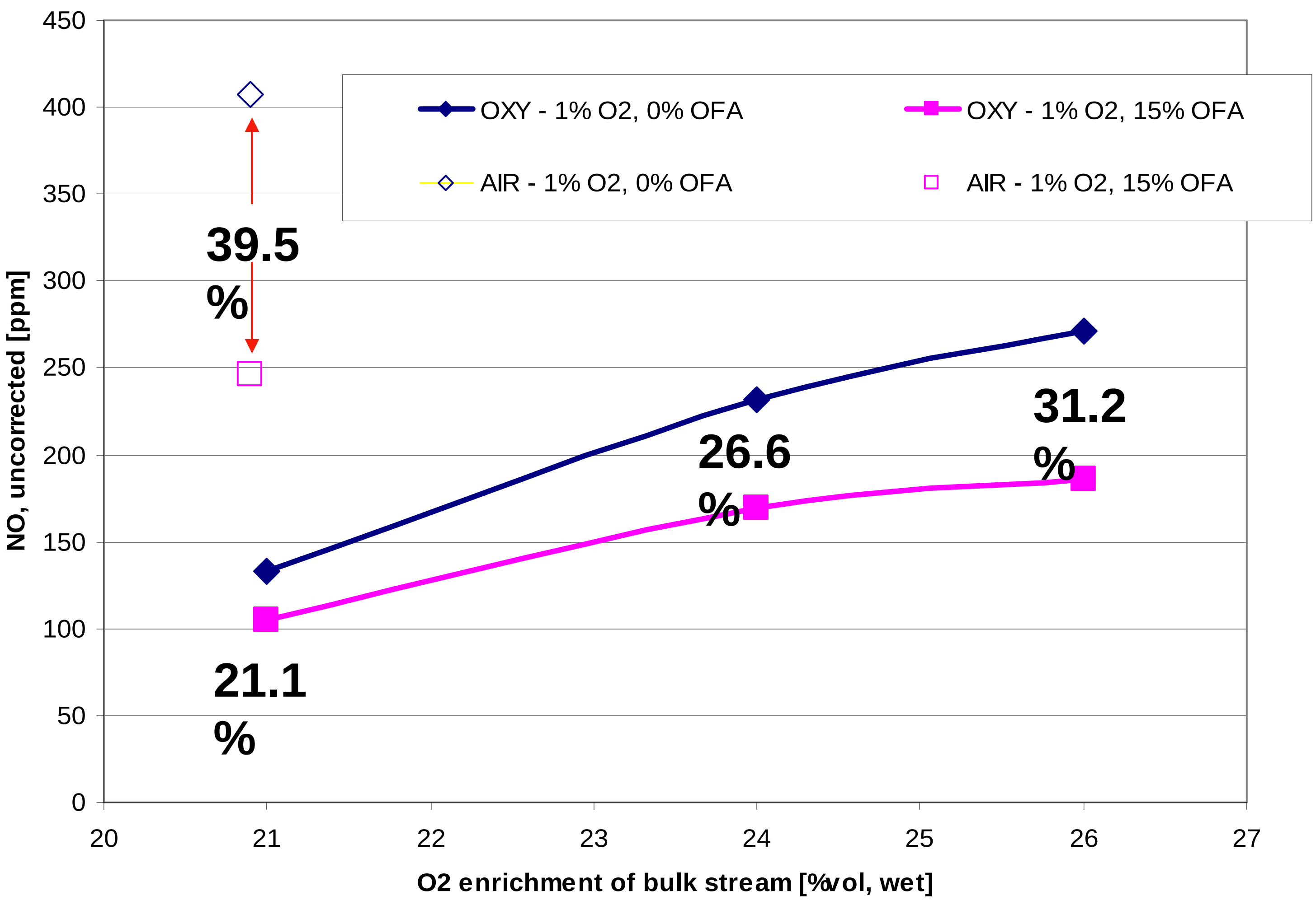
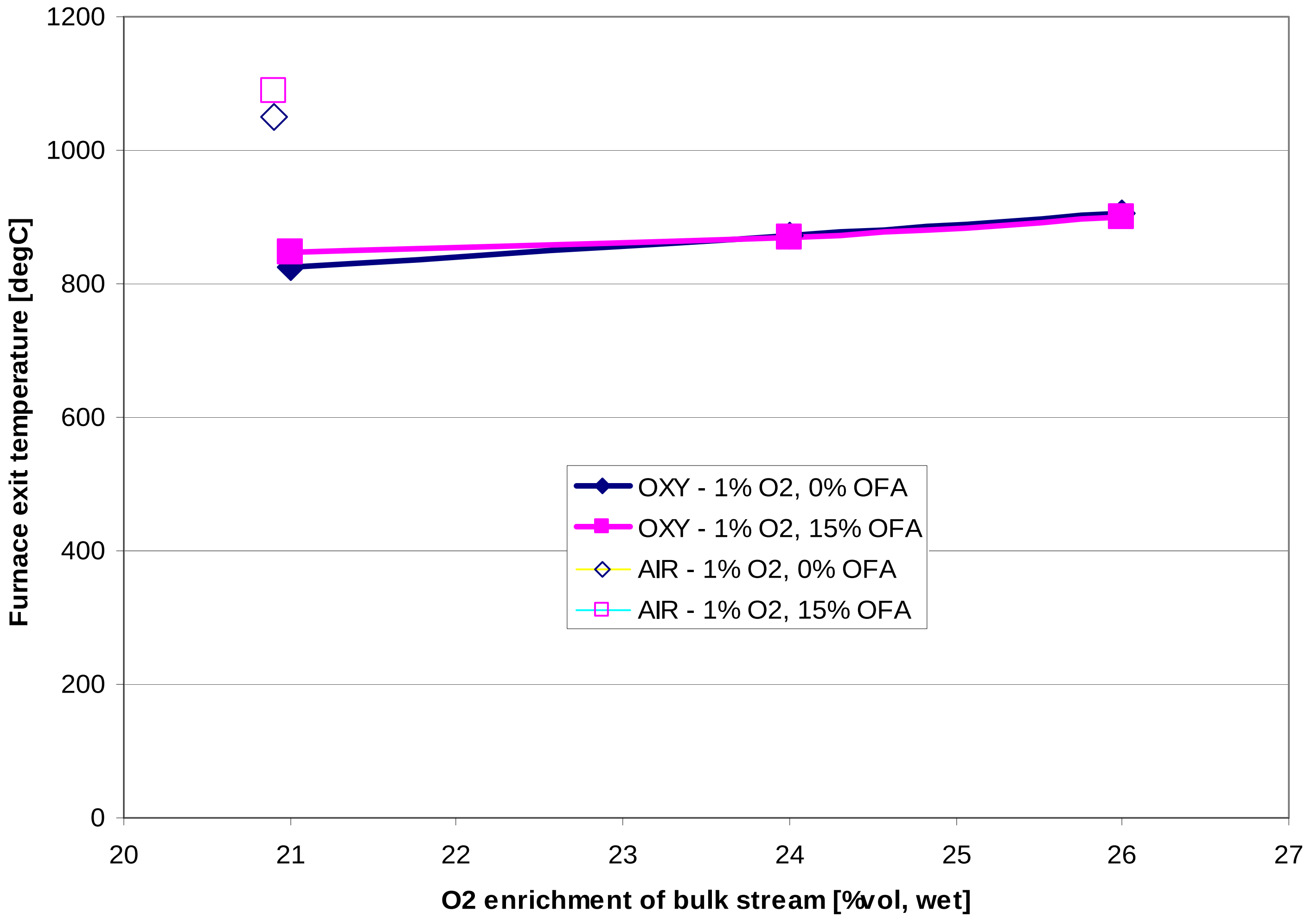
Flows [kg/hr], CO2 [%vol,dry]
NO and SO2 [vpm,dry]
Time elapsed [minutes]
Gasoil flow
Coal flow
CO2
SO2
NO

# Emissions - NO



# Furnace exit gas temperature



# Conclusions

~75% reduction in exhaust gas requiring treatment

~80% $CO_2$ content in dry exhaust gas

Reduction in NO concentration

Increase in CO, $SO_2$ concentration

Reduction in absolute levels of all emissions

Burnout degraded at low $O_2$ enrichment

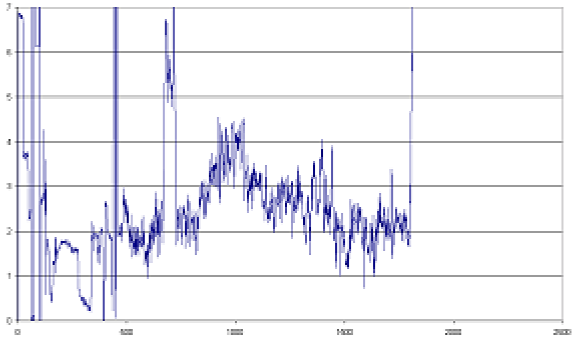
Flame stability degraded

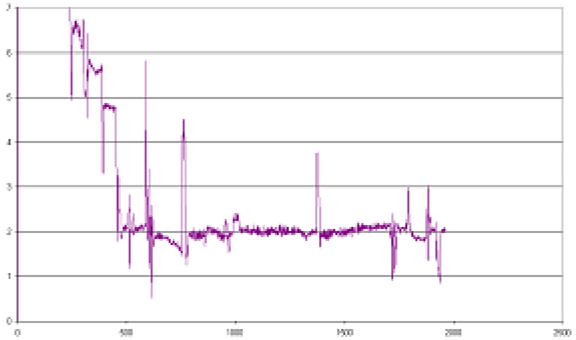
Reduced flame and gas temperatures

Increasing $O_2$ enrichment = closer to air

# Achievements to date

- >50 hours of operation in full oxyfuel mode
- Improved stability during operation
- Flame detection issues resolved
- One man operation
- Optimised controller response paramete
- Recalibration of instruments
- Fuel feed arrangements – difficult coal
- >80% (dry) $CO_2$ concentration
- Proof of trips and interlocks





# Remaining issues/further R&D

$O_2$ enrichment – higher levels, enrichment of primary

Heat transfer

Fuel feeding and conveying

Flame detection

Tramp air ingress

Ash behaviour/fate of trace elements

Fouling behaviour

Corrosion

# Implications for full scale

Oxyfuel combustion achievable

Staged combustion can reduce NO emissions, if required

Combustion efficiency similar to air can be achieved

Optimum $O_2$ enrichment likely to result in lower volume flow than air

$SO_2$ (and others?) concentrated by ~4 times

Attention needs to be paid to control and instrumentation

Scope for increased enrichment (>26%) without exceeding materials constraints, whilst reducing shaft work

Safety and efficiency improvements possible in milling