# HYDROGEN AND POWER PRODUCTION WITH INTEGRATED CARBON DIOXIDE CAPTURE BY CHEMICAL-LOOPING REFORMING

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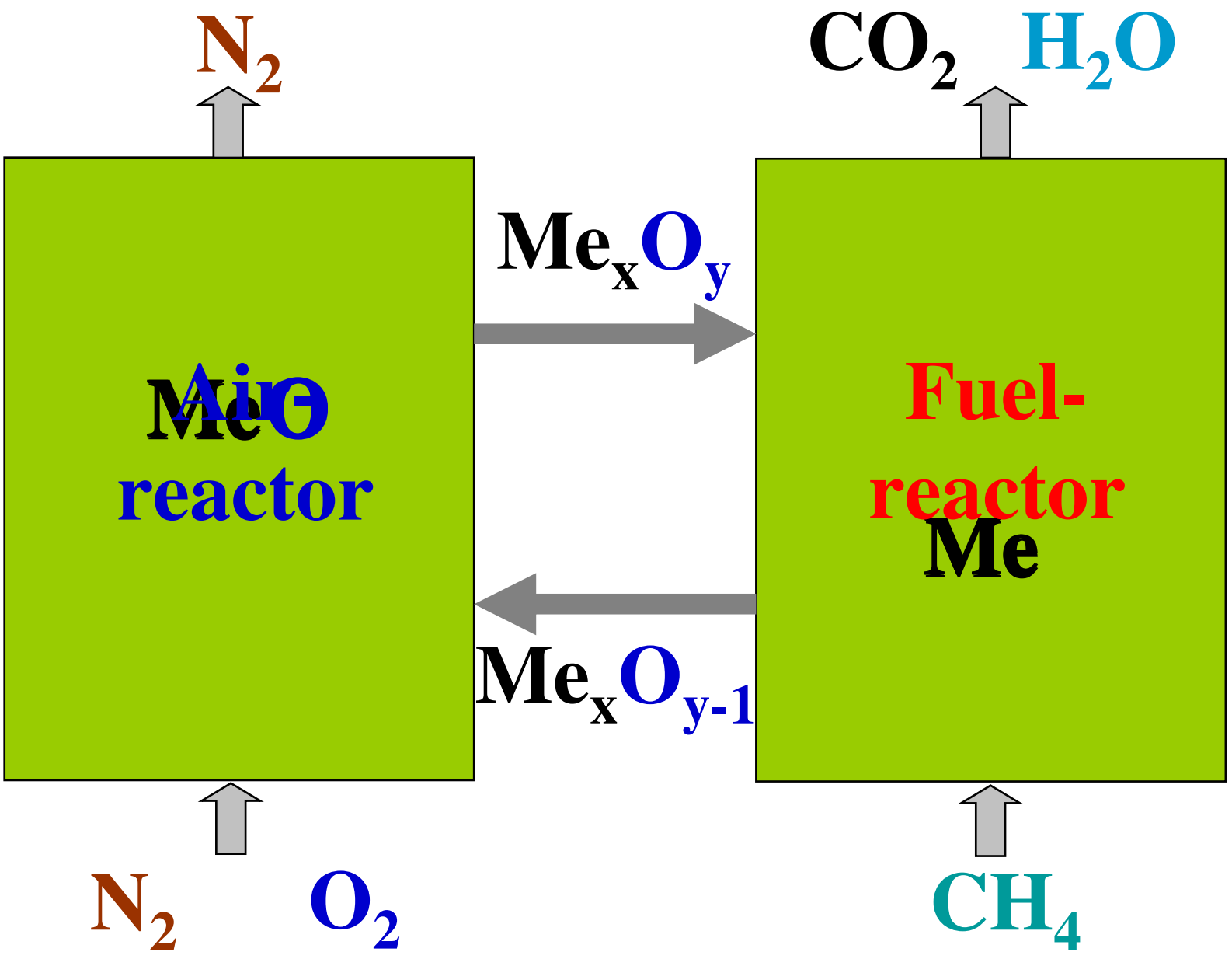
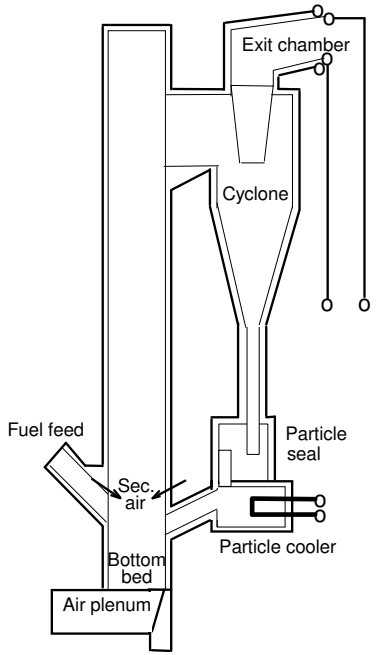

$N_2$
$CO_2$ $H_2O$
$Me_xO_y$
Air-
Me-O
reactor
Fuel-
reactor
Me
$Me_xO_{y-1}$
$N_2$ $O_2$
$CH_4$

## circulating fluidized-bed combustion of solid fuels

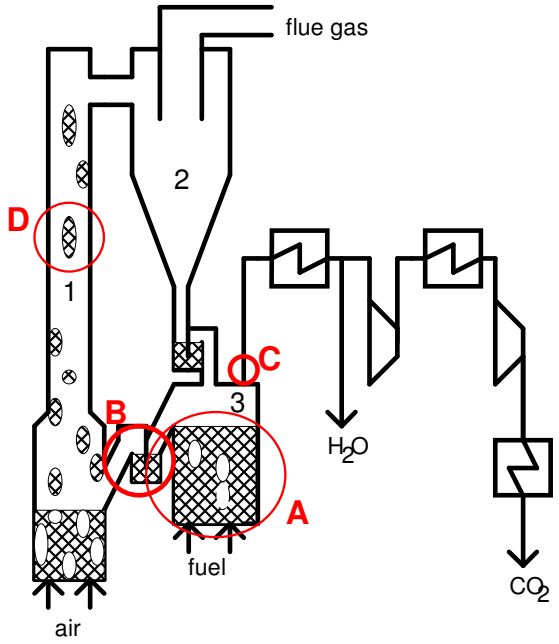



commercial:

250 MWe in operation

600 MWe designed

## chemical-looping combustion



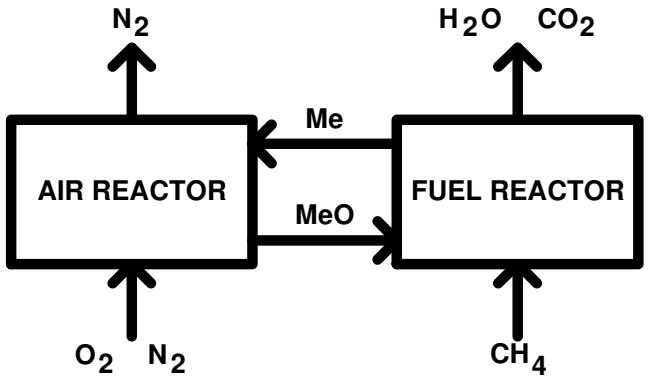

A extra fluidized-bed

B extra particle lock

C additional gas outlet

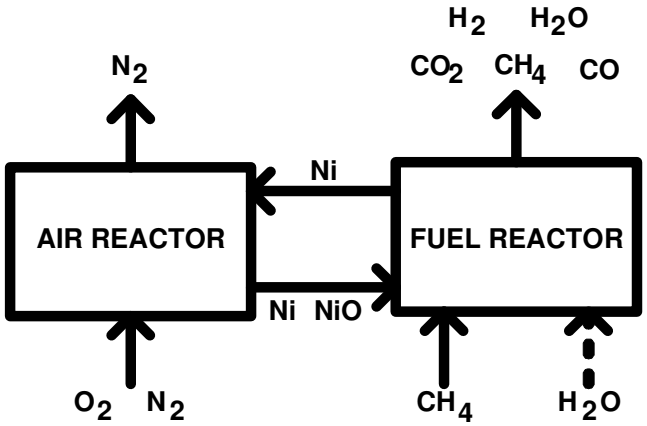
D no gas residence time criteria

## chemical-looping combustion




full fuel conversion

## chemical-looping reforming



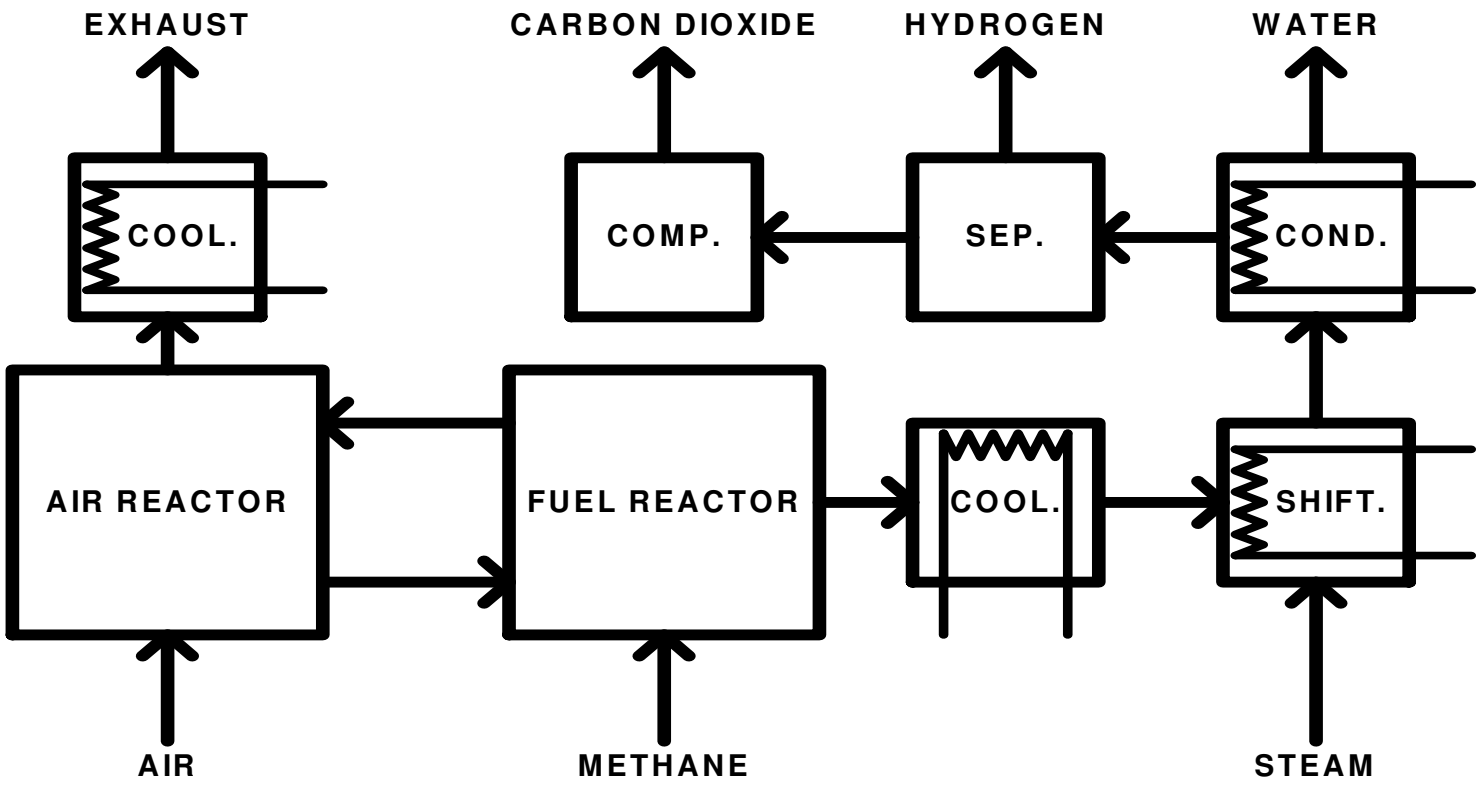

partial fuel conversion

3 × added fuel

(~1/3 cost/MW fuel)

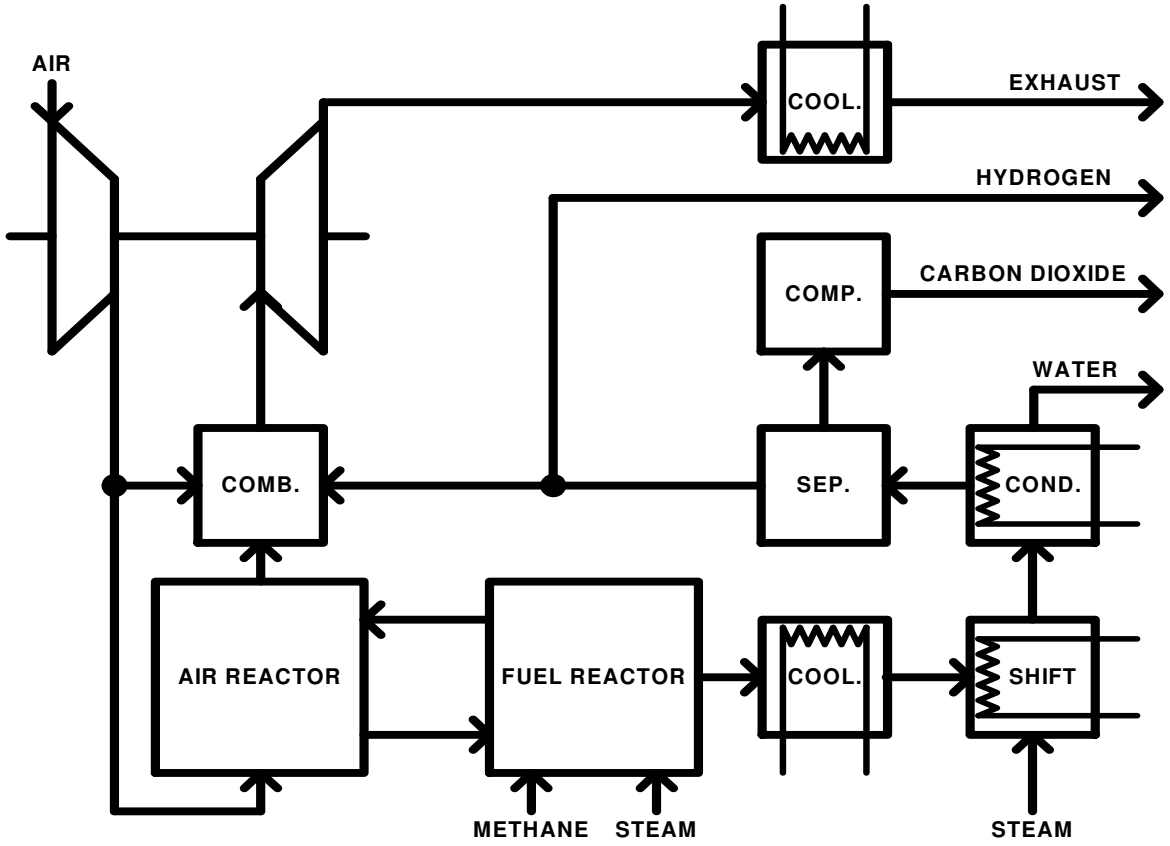
| chemical-looping reforming | conventional reforming |
| --- | --- |
| suitable for scaling-up | in use |
| undiluted $CO_2/H_2$ | |

# ATMOSPHERIC CLR




Simplified process scheme for case 1A, atmospheric CLR by partial oxidation. Preheating of fuel, air and steam is not shown.

# PRESSURIZED CLR




Simplified process scheme for case 2B, pressurized CLR with internal H2 combustor. Integration with steam cycle and preheating of fuel and steam is not shown.

## chemical-looping reformation cases

**atmospheric**

1A partial oxidation

1B autothermal, (partial oxidation and some steam added)

1C autothermal, heat used in steam cycle

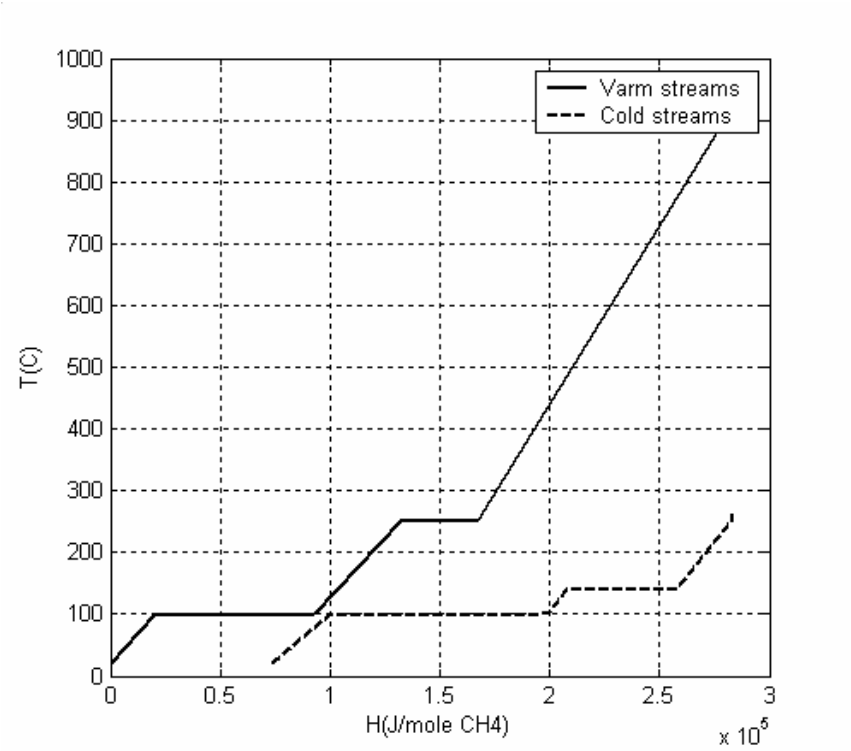
**pressurized+combined cycle**

2A autothermal, turbine inlet 1017 C

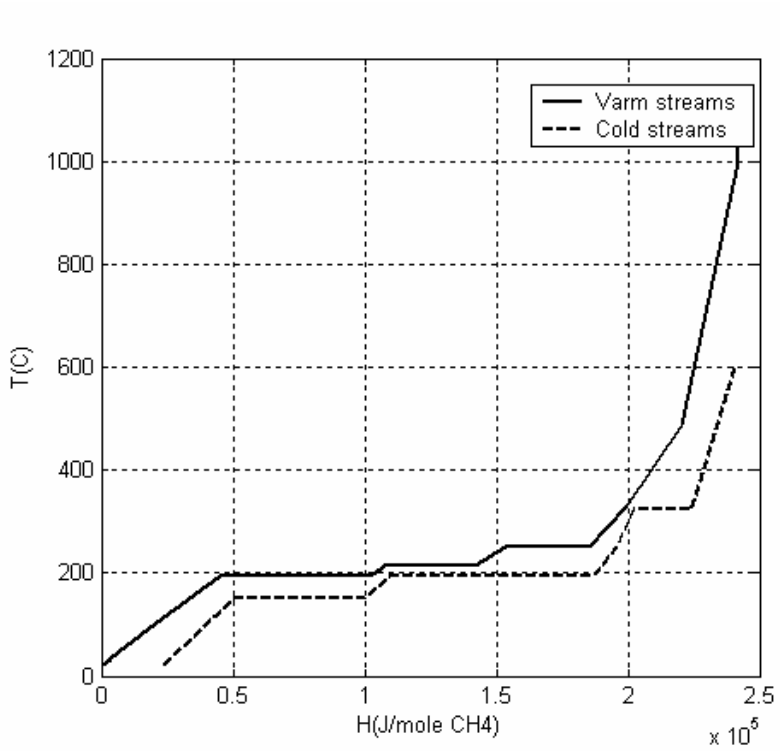
2B autothermal, $H_2$ used for temperature increase

2C autothermal, high temperature air reactor 1172 C

# THERMAL PERFORMANCE

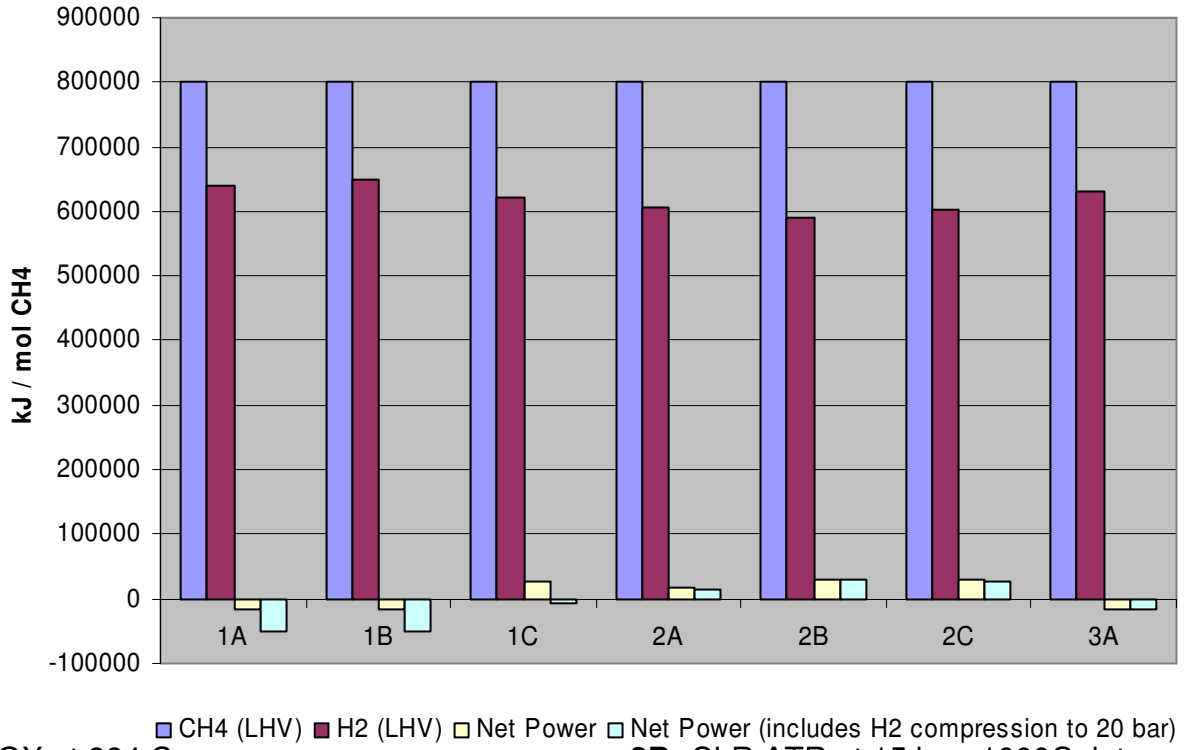



**Case 1A**
Atmospheric CLR
Partial oxidation




**Case 2B**
Pressurized CLR 15 bar
Autothermal Reforming
Combined cycle with
internal H2 combustor

# HYDROGEN AND POWER




**1A:** Atmospheric CLR, POX at 884 C

**1B:** Atmospheric CLR, ATR at 888 C

**1C:** Atmospheric CLR, ATR at 872C, steam cycle

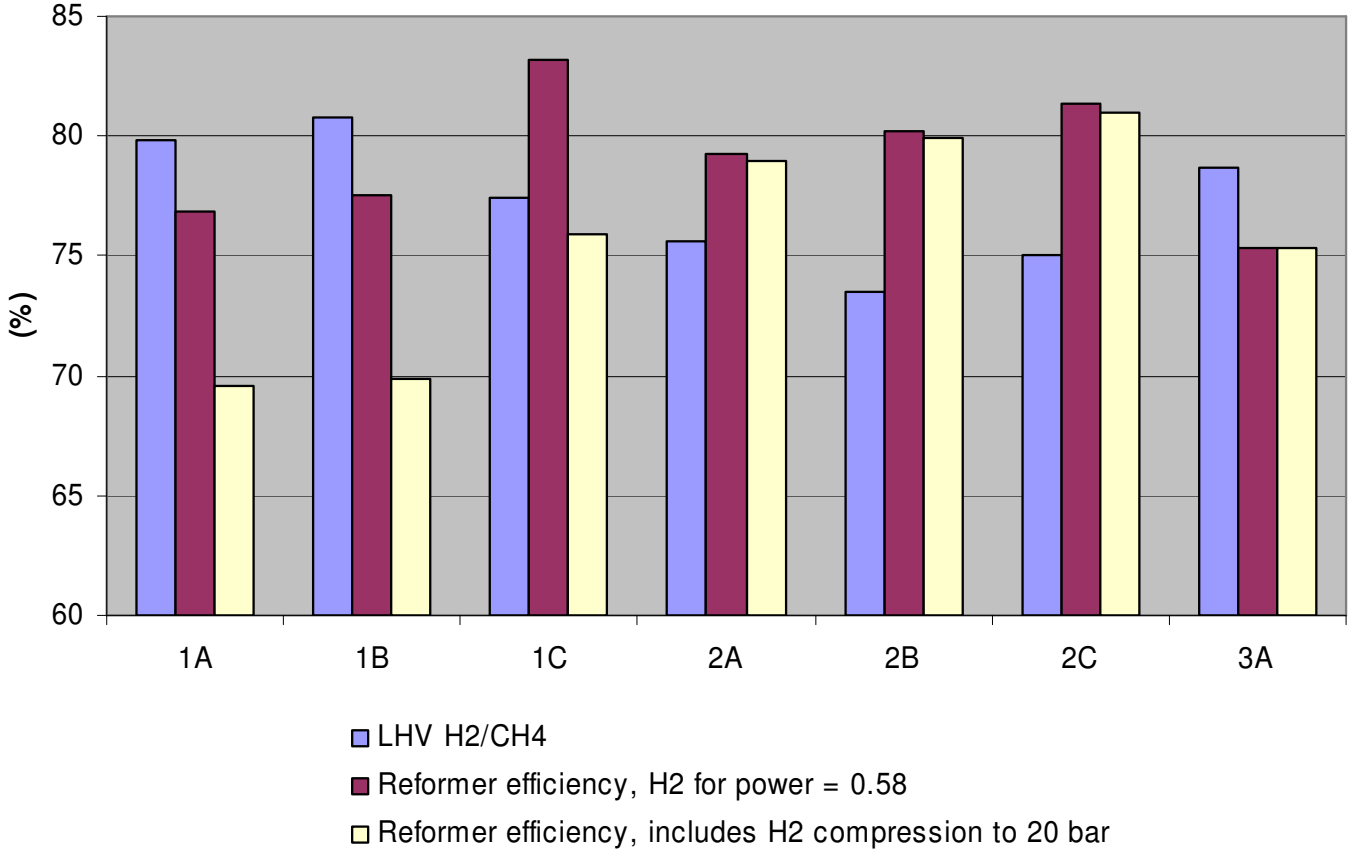
**2A:** CLR ATR at 15 bar, 1017C, combined cycle

**2B:** CLR ATR at 15 bar, 1000C, internal H2 combustor and combined cycle (0.11 H2 to internal combustion)

**2C:** CLR ATR at 15 bar, 1172C, combined cycle

**3A:** Steam reforming at 20 bar, 800C, with amine scrubbing (0.43 H2 and 0.14 CH4 to internal combustion)

# REFORMER EFFICIENCY




**1A:** Atmospheric CLR, POX at 884 C
**1B:** Atmospheric CLR, ATR at 888 C
**1C:** Atmospheric CLR, ATR at 872C, steam cycle
**2A:** CLR ATR at 15 bar, 1017C, combined cycle
**2B:** CLR ATR at 15 bar, 1000C, internal H2 combustor and combined cycle
**2C:** CLR ATR at 15 bar, 1172C, combined cycle
**3A:** Steam reforming at 20 bar, 800C, with amine scrubbing