Methane pyrolysis, gasification and combustion

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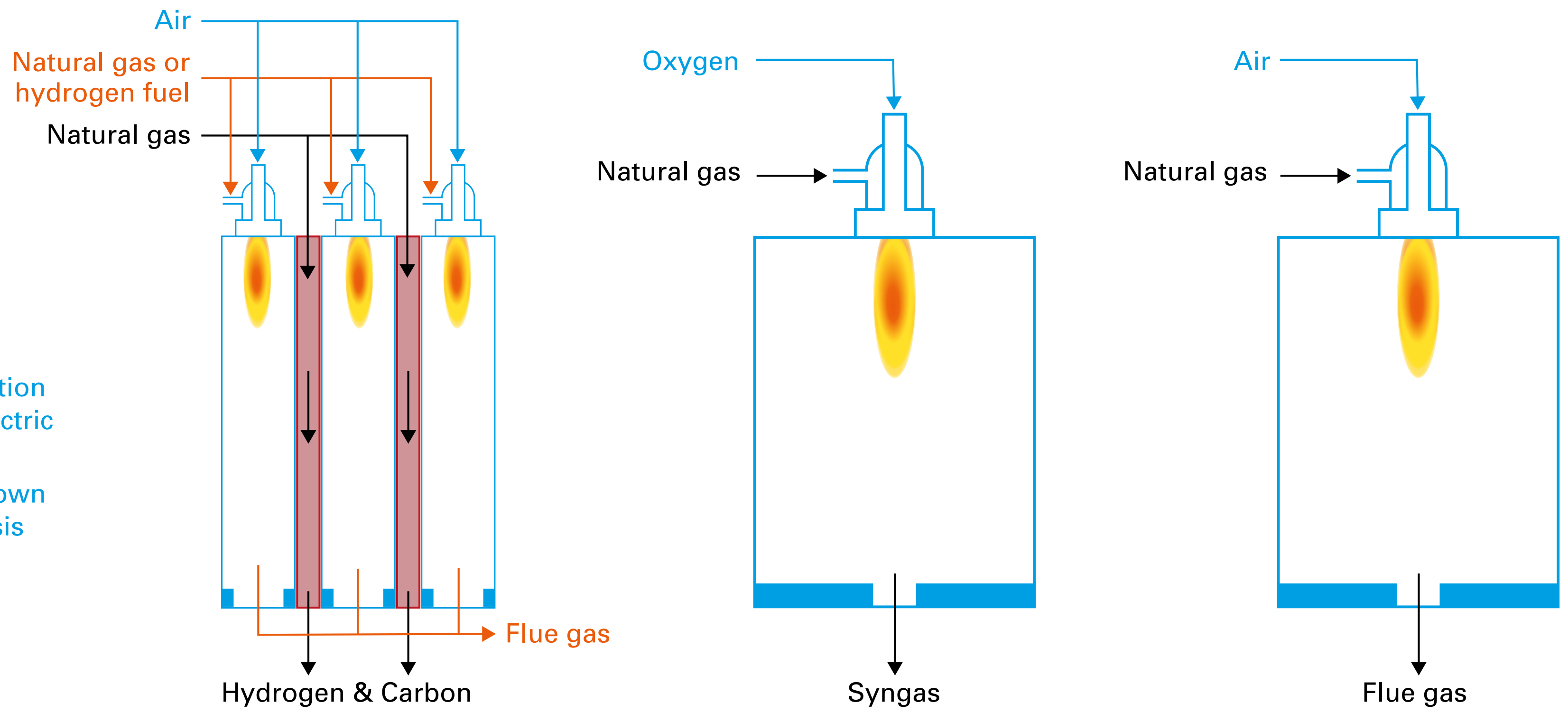
Notes:
- Shaded area denotes catalyst bed
- Energy for pyrolysis may be from combustion of fuel, or from an electric plasma arc
- Pyrolysis diagram shown is for catalytic pyrolysis



Process	Pyrolysis (Methane splitting or cracking)	Partial Oxidation – POX (Gasification)	Combustion (Thermal oxidation)
Oxygen feedstock	None, oxygen-free process	Oxygen from ASU fed with controlled stoichiometry to limit CO_2 generation	Air fed in excess to ensure full conversion to CO_2 (oxygen from ASU in Allam cycle)
Catalyst required	Yes (Carbon, Nickel or Iron) for catalytic, no for thermal and plasma	No for thermal POX, yes for catalytic POX	No
Energy required / released	Endothermic, requires heat input	Exothermic, steam generation	Exothermic, ideal for steam generation
Chemical reaction	$CH_4 \rightarrow C + 2H_2$	$2CH_4 + O_2 \rightarrow 2CO + 4H_2$ (ideal case)	$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ (ideal case)
Carbon product	Carbon black powder	CO and CO_2 from side reactions	CO_2
Hydrogen content in product gas	100 %	~ 60 %	Zero, complete oxidation to CO_2 & H_2O is ideal case
Product gas pressure	Atmospheric pressure	40 to 80 bar	Atmospheric pressure
Product gas temperature	500 to 900 °C catalytic, 1100 to 1400 °C thermal, 1500 to 2000 °C plasma	~ 1400 °C	~ 1400 °C