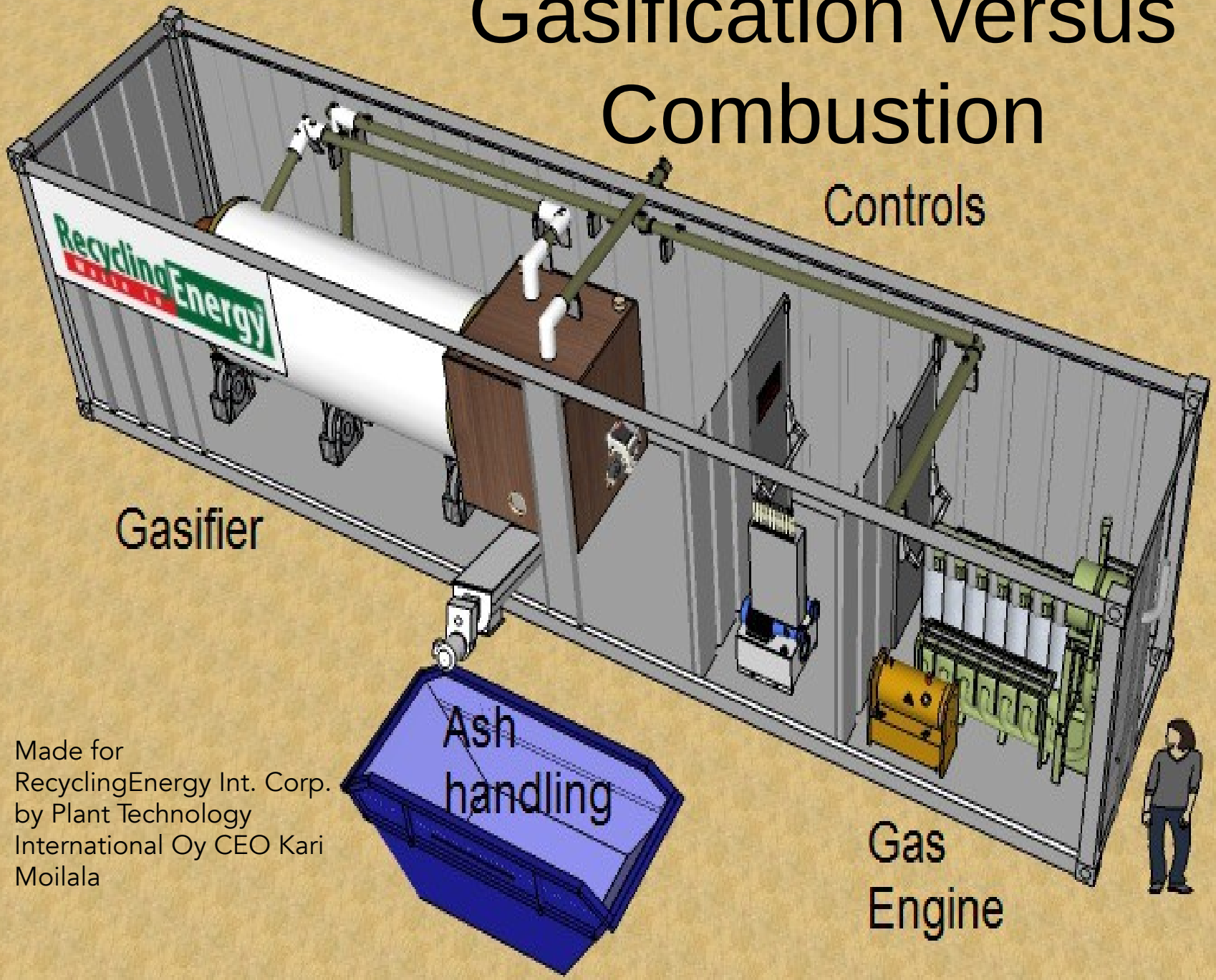
Gasification versus Combustion



Made for RecyclingEnergy Int. Corp. by Plant Technology International Oy CEO Kari Moilala

Background

Gasification	Combustion
· Based on conversion of liquid and/or solid fuel into combustible gas · Gas can be cleaned and used as a raw material or for energy production → gas engine, gas turbine, boiler · Reduction reactions require external energy and/or an oxidant → partial combustion · Part of the fuel energy available as heat → heat recovery is necessary · Suits well in small-scale CHP production	· Based on conversion of gaseous, liquid and/or solid fuel into flue gas · Energy utilization is based on heat recovery → hot air, hot water, steam, hot oil, hot organic liquid → tesla turbine, steam engine, steam turbine · Flue gas needs to be cleaned → large units, in waste combustion may be one third of investment

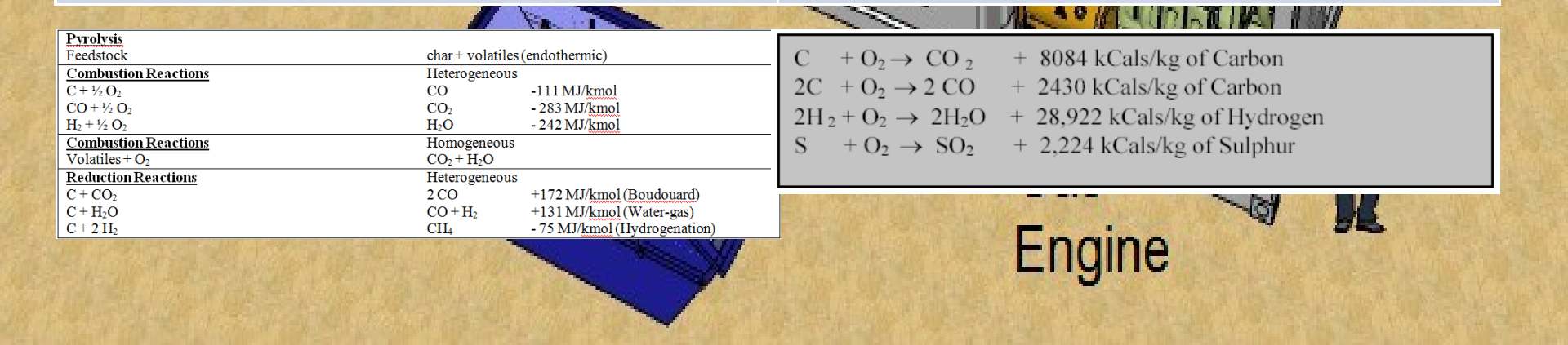
Pyrolysis		
Feedstock	char + volatiles (endothermic)	
Combustion Reactions	Heterogeneous	
$C + ½ O_2$	CO	-111 MJ/kmol
$CO + ½ O_2$	CO_2	- 283 MJ/kmol
$H_2 + ½ O_2$	H_2O	- 242 MJ/kmol
Combustion Reactions	Homogeneous	
Volatiles + O_2	$CO_2 + H_2O$	
Reduction Reactions	Heterogeneous	
$C + CO_2$	2 CO	+172 MJ/kmol (Boudouard)
$C + H_2O$	$CO + H_2$	+131 MJ/kmol (Water-gas)
$C + 2 H_2$	CH_4	- 75 MJ/kmol (Hydrogenation)

$C + O_2 \rightarrow CO_2$ + 8084 kCals/kg of Carbon

$2C + O_2 \rightarrow 2 CO$ + 2430 kCals/kg of Carbon

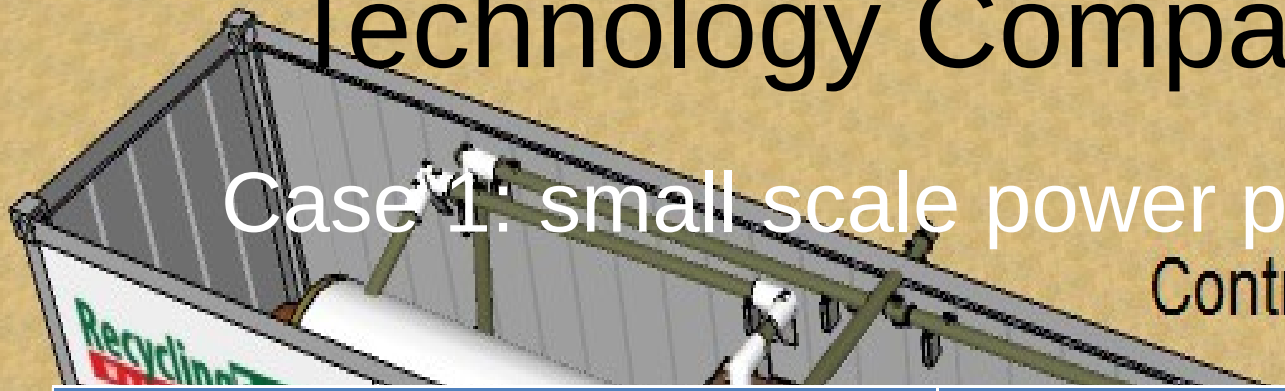
$2H_2 + O_2 \rightarrow 2H_2O$ + 28,922 kCals/kg of Hydrogen

$S + O_2 \rightarrow SO_2$ + 2,224 kCals/kg of Sulphur



Technology Comparison

Case 1: small scale power production



Gasification	Combustion
· Biomass or residue → gas production→ gas cleaning → gas use in a gas engine → heat recovery · Efficiencies: · Power up to 35 % · Heat up to 55 % · **Investment for 1 MWe:** · Drum gasifier 3 MWfuel, 400 k€ · Gas cleaning, 100 k€ · Gas engine, 500 k€ • Boiler, 300 k€ • **TOTAL: 1 300 k€**	· Biomass or residue → combustion → steam generation in a boiler → steam turbine + flue gas cleaning · Efficiencies: · Power up to 25 % · Heat up to 65 % · **Investment for 1 MWe**: · Grate combustor 4 MWfuel, 500 k€ · Boiler, 900 k€ · Steam turbine, 800 k€ • Gas cleaning, 300 k€ • **TOTAL: 2 500 k€**

Technology Comparison

Case 2: medium scale WTE

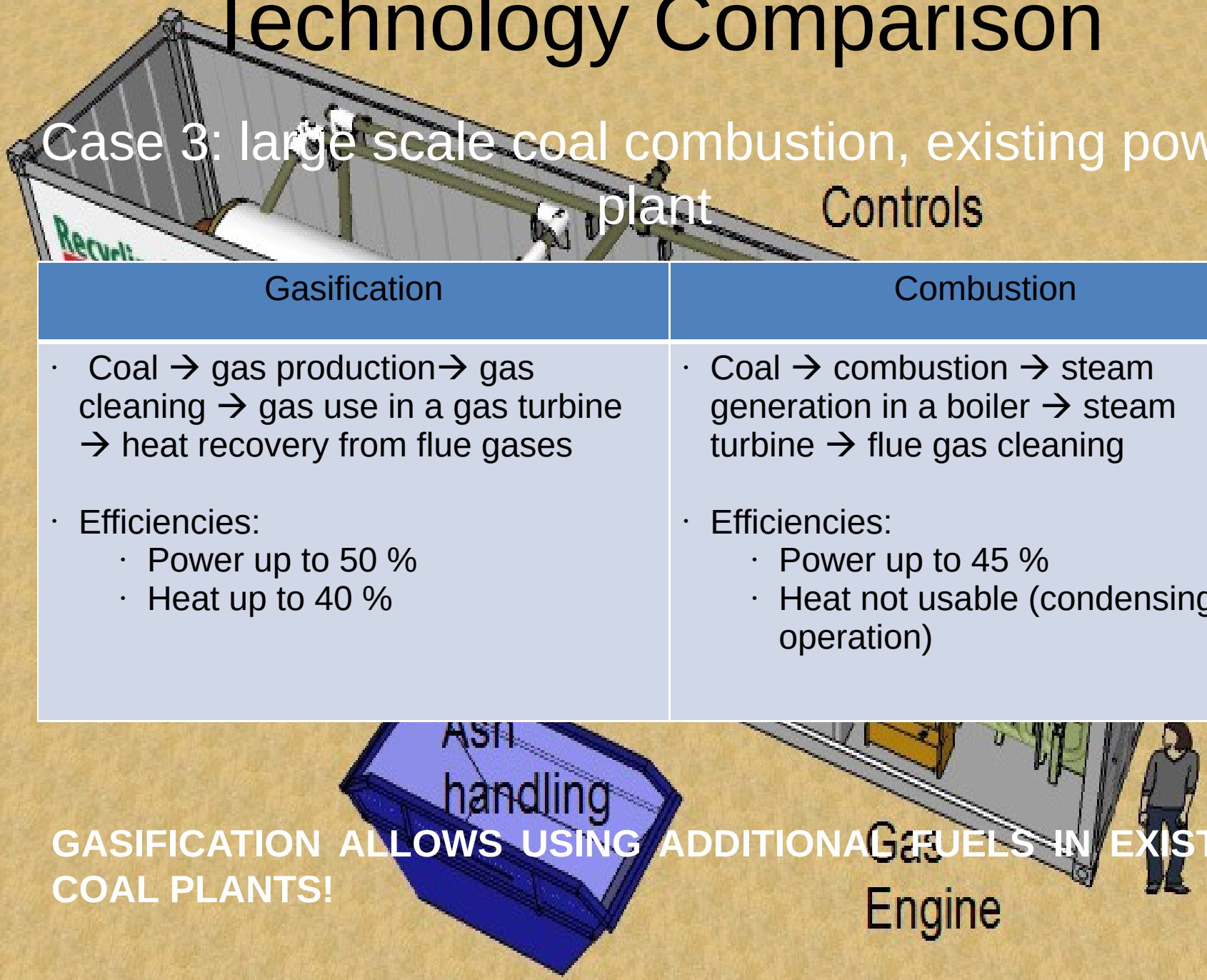
Gasification	Combustion
· Waste → gas production→ gas cleaning → gas use in a gas engine → heat recovery · Efficiencies: · Power up to 40 % · Heat up to 45 % · **Investment for 10 MWe:** · 6 * Drum gasifier 5 MWfuel, 6 M€ · Gas cleaning, 2,5 M€ · 5 * 2 MW gas engine, 8 M€ • Boiler, 4.5 M€ • **TOTAL: 21 M€**	· Waste → combustion → steam generation in a boiler → steam turbine → flue gas cleaning · Efficiencies: · Power up to 20 % · Heat up to 65 % · **Investment for 10 MWe**: · Grate combustor 50 MWfuel, 12 M€ · Boiler, 10 M€ · Steam turbine, 6 M€ • Gas cleaning, 18 M€ • **TOTAL: 46 M€**

NO LIMIT IN POWER PLANT SIZE: AMOUNT OF MODULES CAN BE INCREASED!

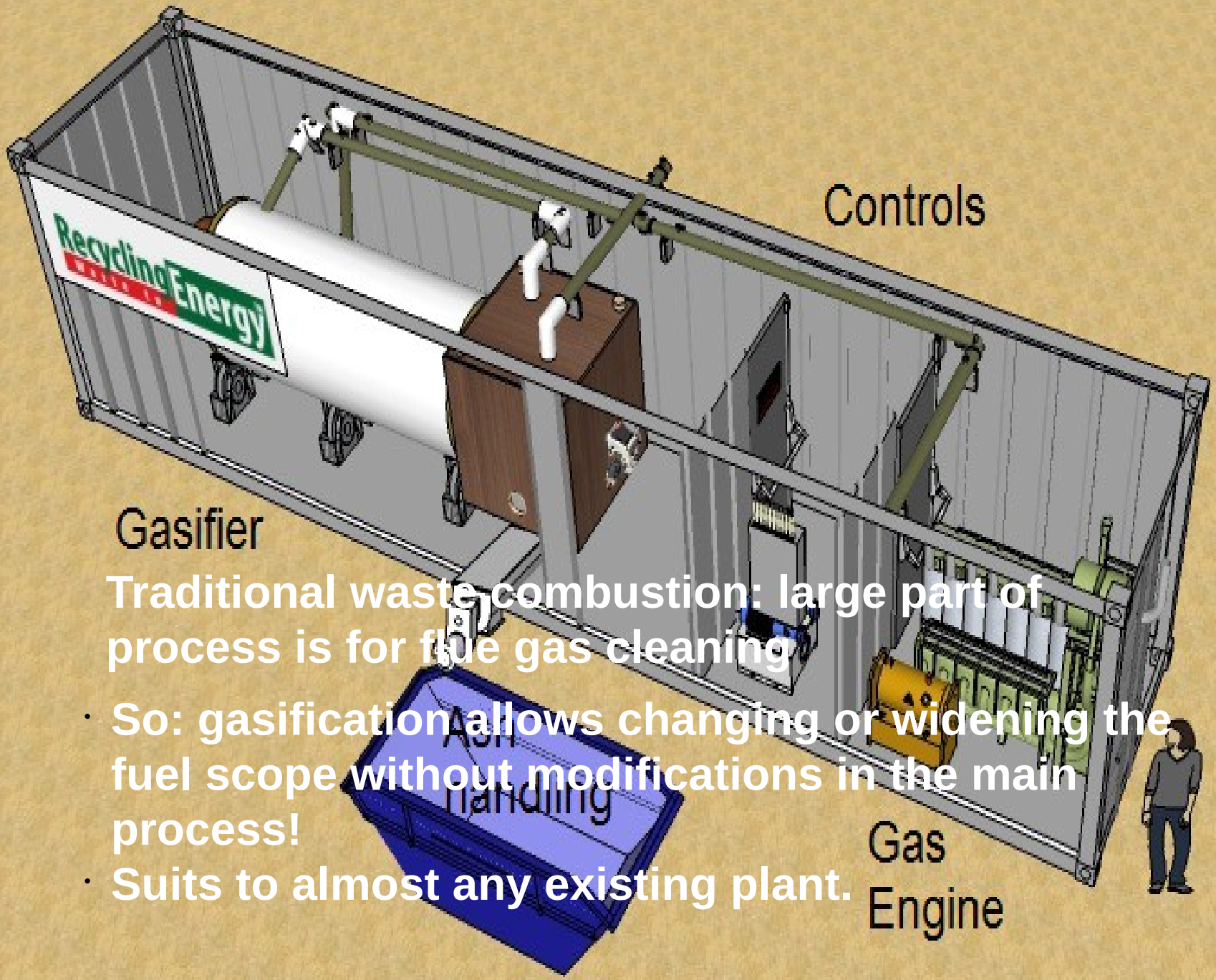
Technology Comparison

Case 3: large scale coal combustion, existing power plant

Gasification	Combustion
· Coal → gas production→ gas cleaning → gas use in a gas turbine → heat recovery from flue gases · Efficiencies: · Power up to 50 % · Heat up to 40 %	· Coal → combustion → steam generation in a boiler → steam turbine → flue gas cleaning · Efficiencies: · Power up to 45 % · Heat not usable (condensing operation)



GASIFICATION ALLOWS USING ADDITIONAL FUELS IN EXISTING COAL PLANTS!



Traditional waste combustion: large part of process is for flue gas cleaning

- **So: gasification allows changing or widening the fuel scope without modifications in the main process!**
- **Suits to almost any existing plant.**