

LIFE CYCLE EMISSIONS FROM FOSSIL FUEL POWER PLANTS WITH CARBON CAPTURE AND STORAGE

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Outline

- **OBJECTIVE:** LIFE CYCLE EMISSIONS FROM POWER PLANTS WITH CCS
- **LIFE CYCLE ANALYSIS:** AN INTRODUCTION
- **CURRENT METHODOLOGY:** BOUNDARIES AND DATA COLLECTION
- **RESULTS:** RESOURCE CONSUMPTION, GHG AND OTHER EMISSIONS AND SENSITIVITY ANALYSIS
- **CONCLUSIONS**

OBJECTIVE

Life Cycle Analysis of Carbon Capture and Storage

- For a 90 % capture plant, are GHG emissions really reduced by 90 %?

-Extensive research has been undertaken on life cycle GHG emissions from power generation technologies including renewables and nuclear

-The current work investigates life cycle emissions from power generation technologies with and without CCS

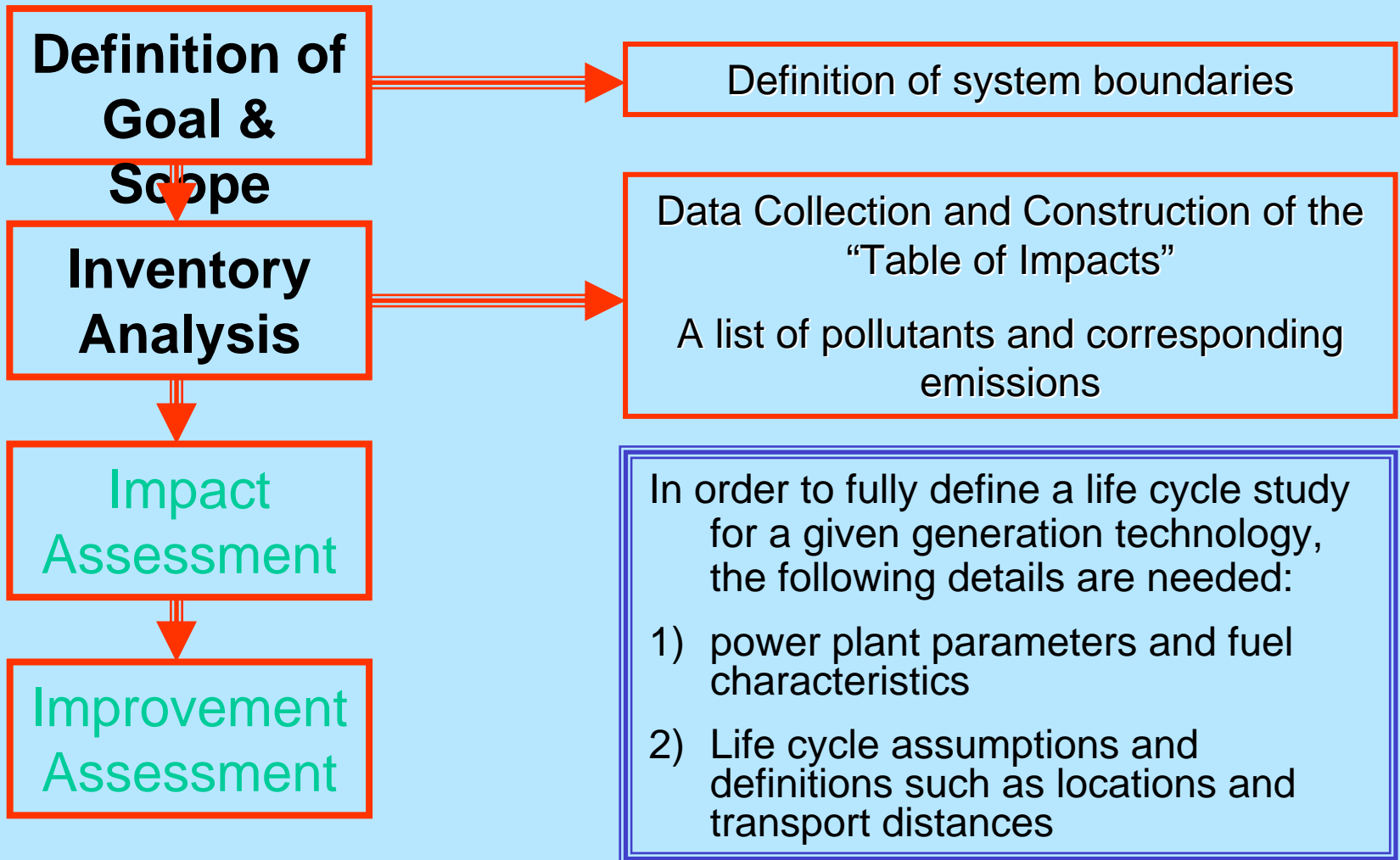
- Percentage reductions of GHG emissions due to CCS are compared for several technologies against a reference technology

LIFE CYCLE ANALYSIS

Life Cycle Analysis - Introduction

- An account of product flows to the environment
 - Air, water and solid waste emission
 - Energy resources
 - Resource consumption
- A comprehensive analytical tool: “Cradle to Grave”
- A means for comparing the environmental impacts of different options

Life Cycle Analysis - Methodology

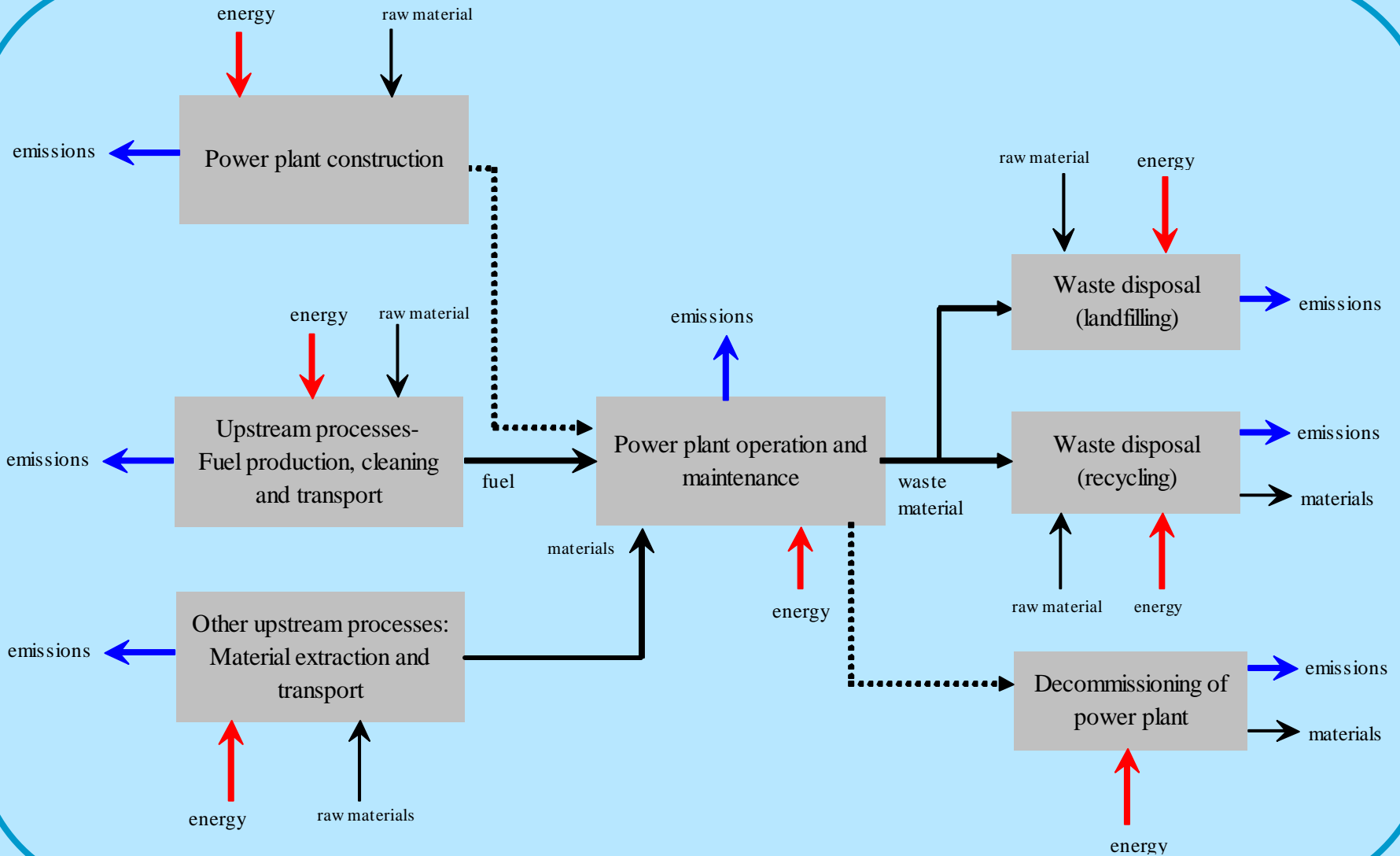


CURRENT METHODOLOGY

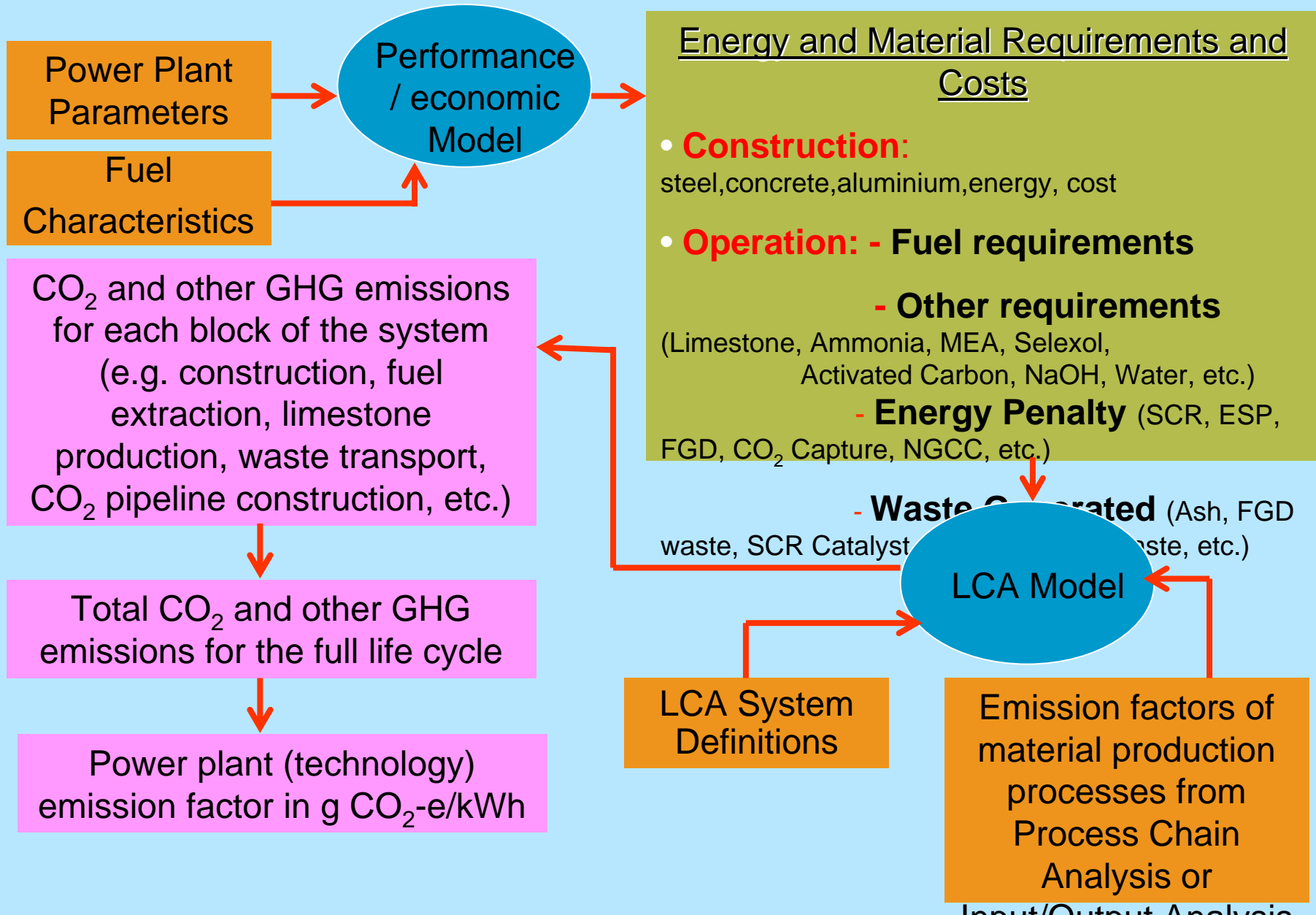
Technologies considered for Analysis

- **The following technologies are analysed in detail**
 - Supercritical PC with SCR, ESP & FGD (No CCS)
 - Supercritical PC with SCR, ESP, FGD and CCS
 - Natural Gas Combined Cycle (NGCC) without CCS
 - Natural Gas Combined Cycle (NGCC) with CCS
 - Integrated Gasification Combined Cycle (IGCC) with CCS
 - Integrated Gasification Combined Cycle (IGCC) with CCS
- **Compared to reference**
 - Subcritical PC with SCR, ESP & FGD (No CCS)

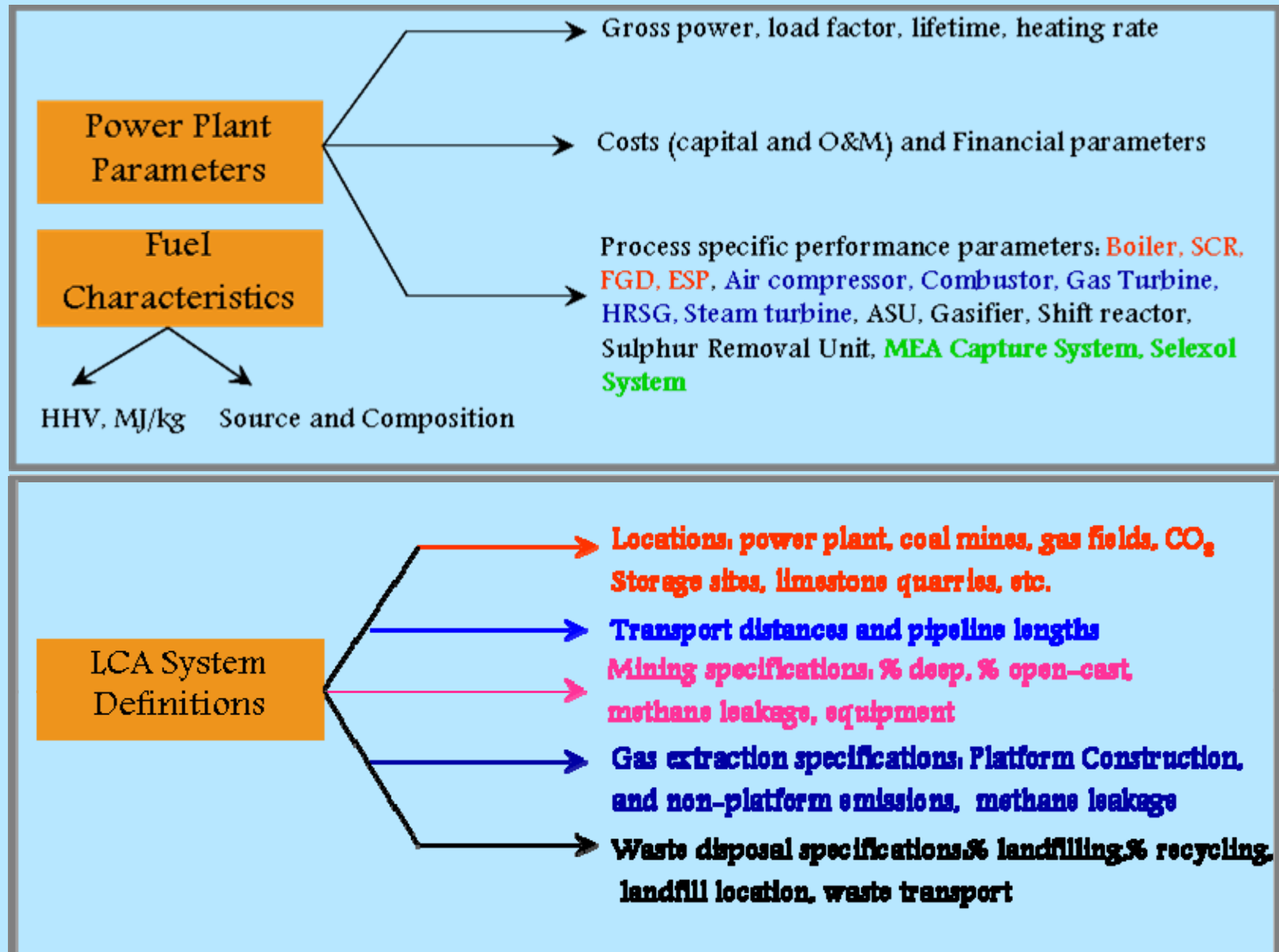
Life Cycle Boundaries



Analysis Strategy



Performance/Economic Model - Data



LCA Model : Process vs. I/O Analysis

Process Analysis

kg / MW
(Construction)

or

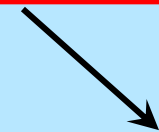
kg / hr (Operation)

×

Material	kg CO ₂ /kg	MJ/kg
concrete	0.2	1.5
Limestone	1.3	12
aluminum	23	250
Copper	13.9	150
Ammonia	2.4	25

×

MW or hr/year



Total kg CO₂-e and
MJ (Construction)

or

kg CO₂-e/year and
MJ/year (Operation)

Input/Output Analysis

£ / MW
(Construction)

or

£ / hr (Operation)

×

Material	kg CO ₂ /£	MJ/£
Rail transport	6.8	74.8
Water	3.2	27.5
Organic Chemicals	7.9	80.0
Ceramics	4.7	54.6

×

MW or hr/year



RESULTS

Resource Consumption

Technology	Coal *	Nat Gas *	Limestone *	NH ₃ *	MEA *	Selexol *	Water **
Reference: Sub PC	329.7	-	19.0	0.68	-	-	3.1
Super PC	294.9	-	16.9	0.61	-	-	3.1
Super PC + CCS	390.1	-	27.2	0.80	3.6	-	4.1
Super PC+CCS - FGD	379.2	-	-	0.78	56.3	-	3.9
NGCC	-	130.1	-	0.20	-	-	na
NGCC + CCS	-	151.9	-	0.23	1.33	-	na
IGCC	314.9	-	-	-	-	0.02	0.6
IGCC + CCS	365.9	-	-	-	-	0.03	0.9

* in g/kWh units ** in l/kWh units

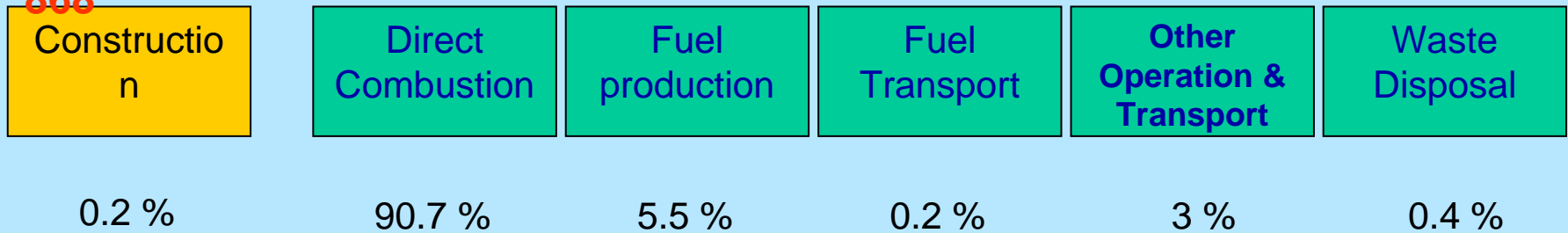
GHG Emissions: PC vs. NGCC

Supercritical

PC

Total GHG emissions (g CO₂-e / kWh):

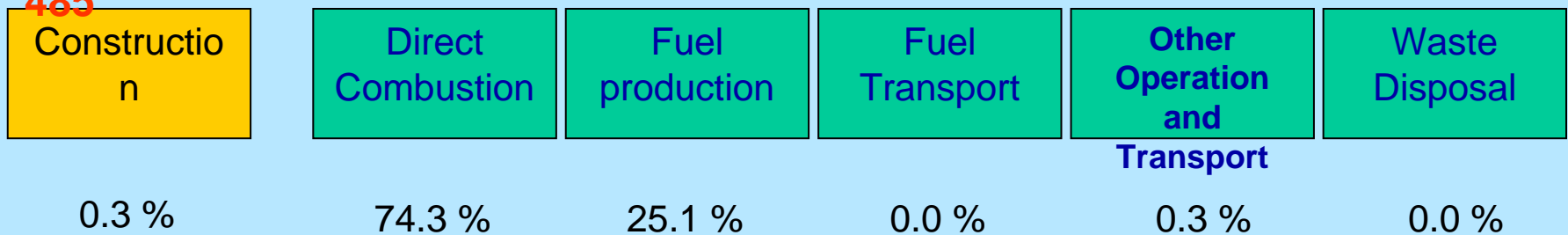
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NGCC

Total GHG emissions (g CO₂-e / kWh):

485



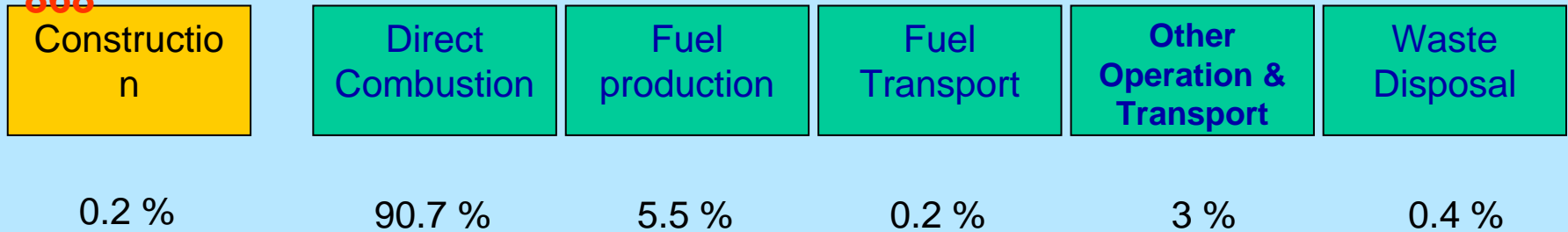
Methane leakage from transport is included with Fuel production emissions

GHG Emissions: Non-CCS vs. CCS

Supercritical PC without CCS

Total GHG emissions (g CO₂-e / kWh):

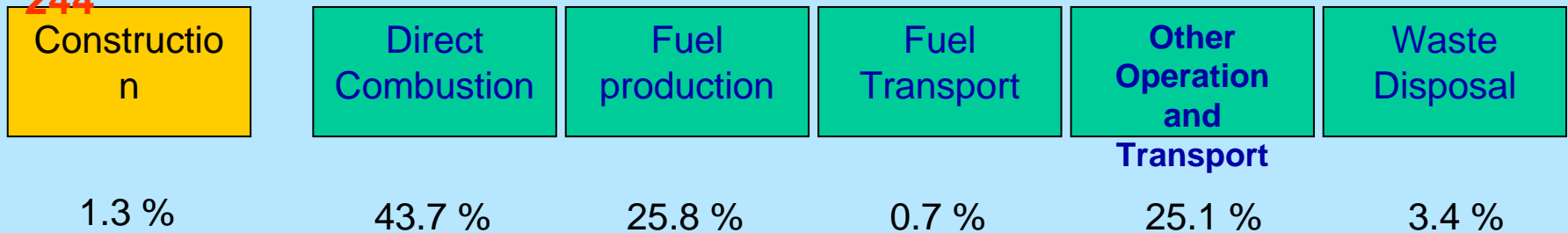
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Supercritical PC with CCS (90 % capture)

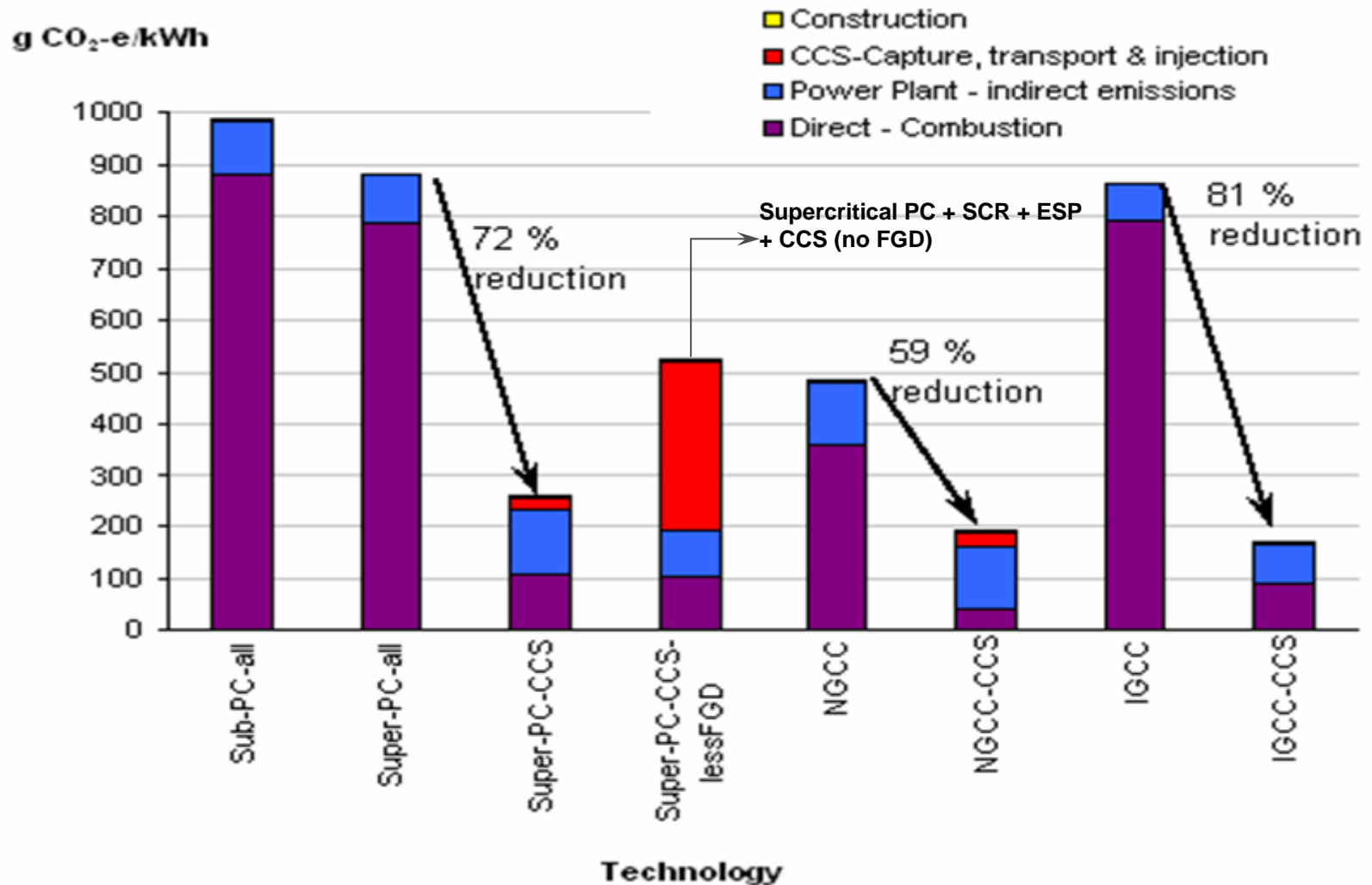
Total GHG emissions (g CO₂-e / kWh):

244



Production of MEA in addition to other materials

GHG Emissions in g CO₂-e/kWh



Other Air Pollutants

Technology	NO _x (as NO) (g/kWh)	SO ₂ (g/kWh)	Particulates (g/kWh)	NH ₃ (g/kWh)
Super PC	0.410	1.250	0.058	0.005
Super PC +	0.590	0.009	0.030	0.470
NGCC	0.140	-	-	Not available
NGCC + CCS	0.160	-	-	Not available
IGCC	0.120	0.300	0.004	-
IGCC + CCS	0.100	0.330	0.004	-

Sensitivity Analysis of GHG Emissions

Technology	A	B	C	D	E
Reference: Sub PC	+3.5%	NA	-0.09%	NA	NA
Super PC	+3.5%	NA	-0.09%	NA	NA
Super PC + CCS	+16.9%	NA	-0.50%	+0.05%	+14.8%
NGCC	NA	+10.9%	NA	NA	NA
NGCC + CCS	NA	+33.2%	NA	+0.07%	+11.3%
IGCC	+3.3%	NA	-0.06%	NA	NA
IGCC + CCS	+24.4%	NA	-0.4%	+0.08%	+25.6%

A: All coal imported from Russia instead of locally mined

B: Natural gas losses increase from 1% to 3 %

C: 50 % of waste (Ash and FGD) recovered and used in construction materials

D: CO₂ pipeline length increases by 100 km

E: Capture efficiency decreases by 5 percentage points

Conclusions

- Life cycle GHG emissions from UK fossil fuel power stations with CCS (90 % CO₂ capture) can be reduced by 75-84% (compared to the reference technology)
- IGCC is favorable with GHG emissions reducing to less than 160 g/kWh.
- For coal power plants, importing coal (coal transport distance) and capture efficiency have the most significant effects on GHG emissions from power plants with CCS.
- For gas power plants, methane leakage from the extraction and transport of natural gas has the most significant effects on GHG emissions from plants with CCS
- Other factors such CO₂ pipeline length have no significant effects

QUESTIONS