

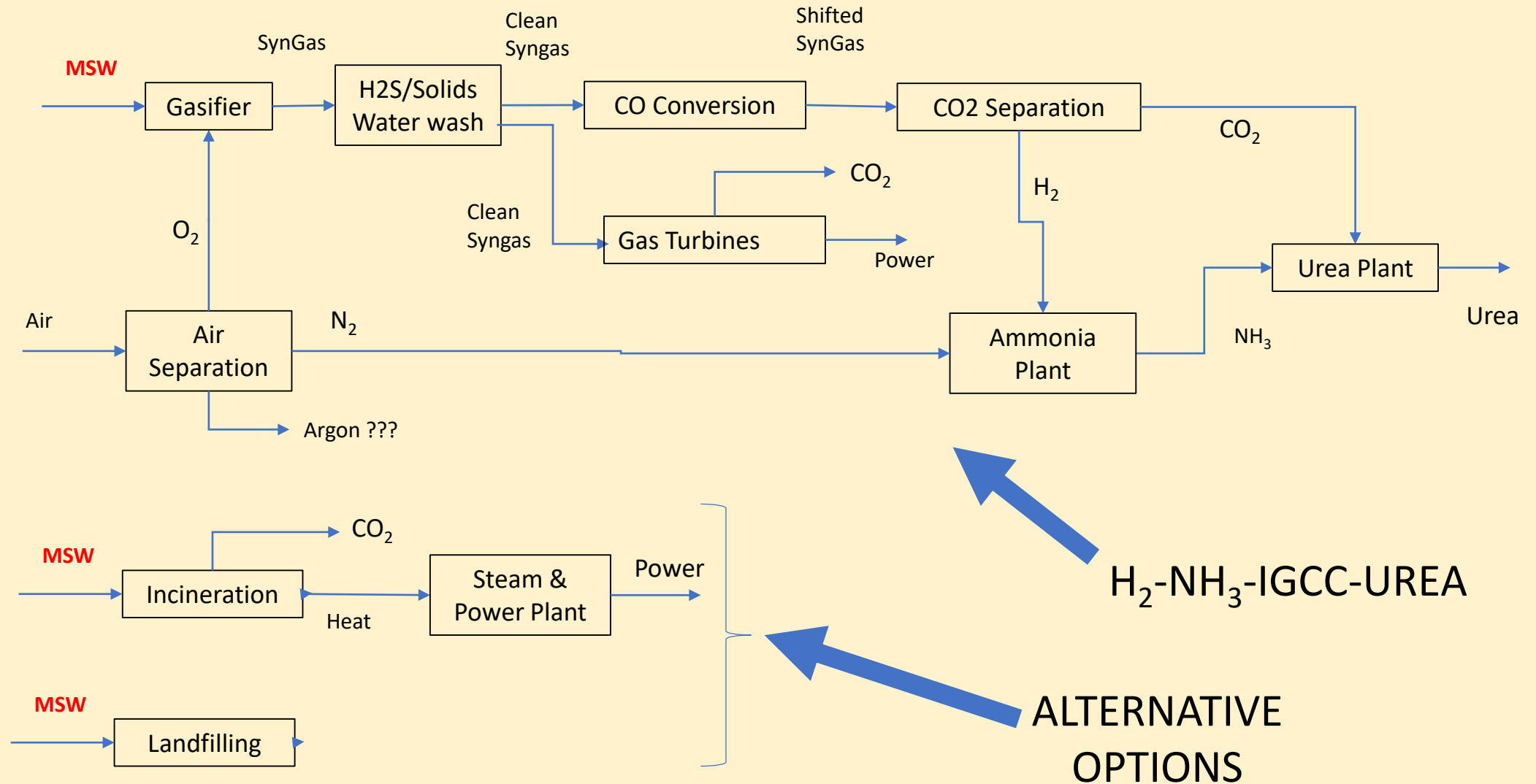
CHEMICAL ENGINEERING DESIGN & SAFETY

CHE 4253

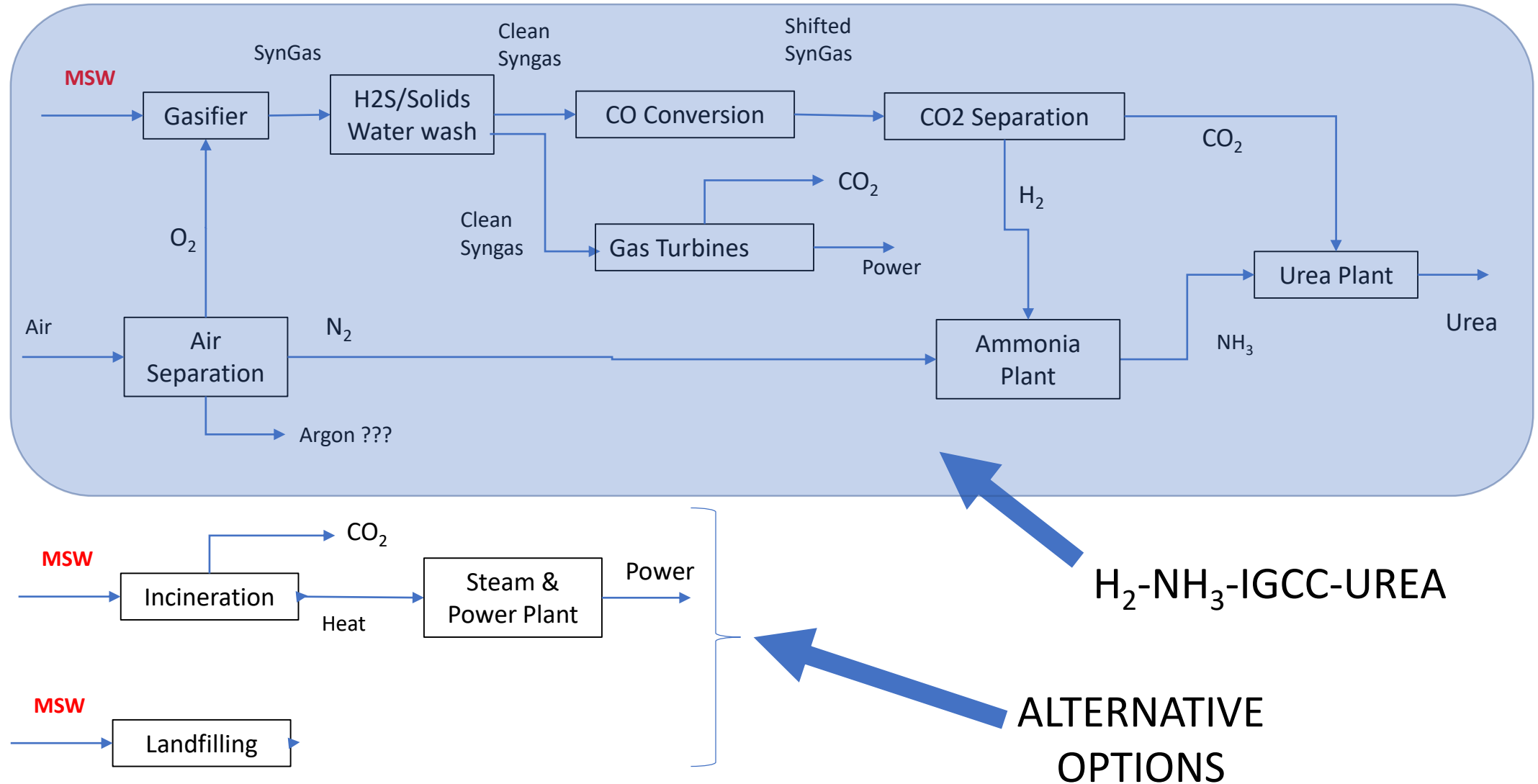
Prof. Miguel Bagajewicz

MSW Project-2. Supplemental Material
General Issues

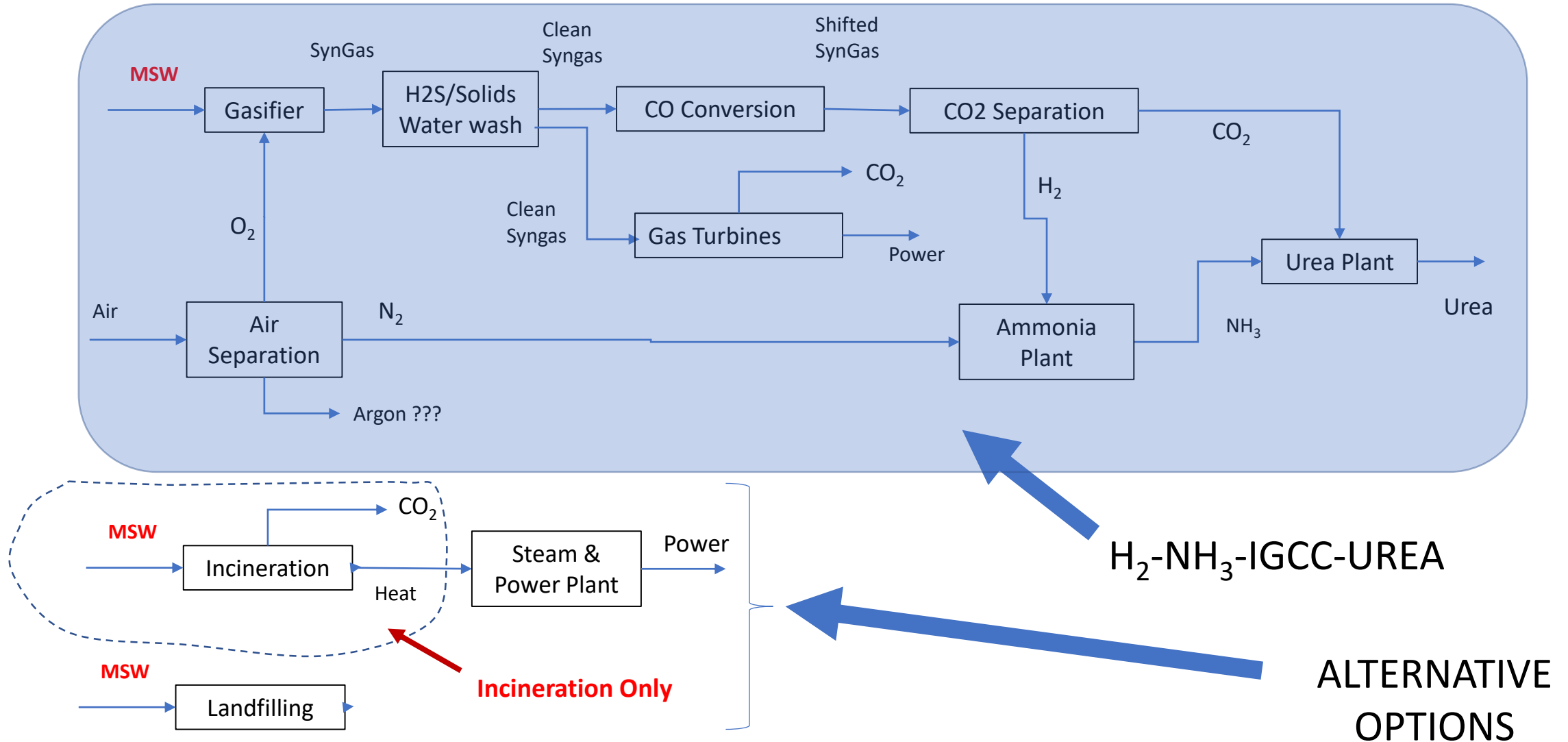
MSW Processing Options



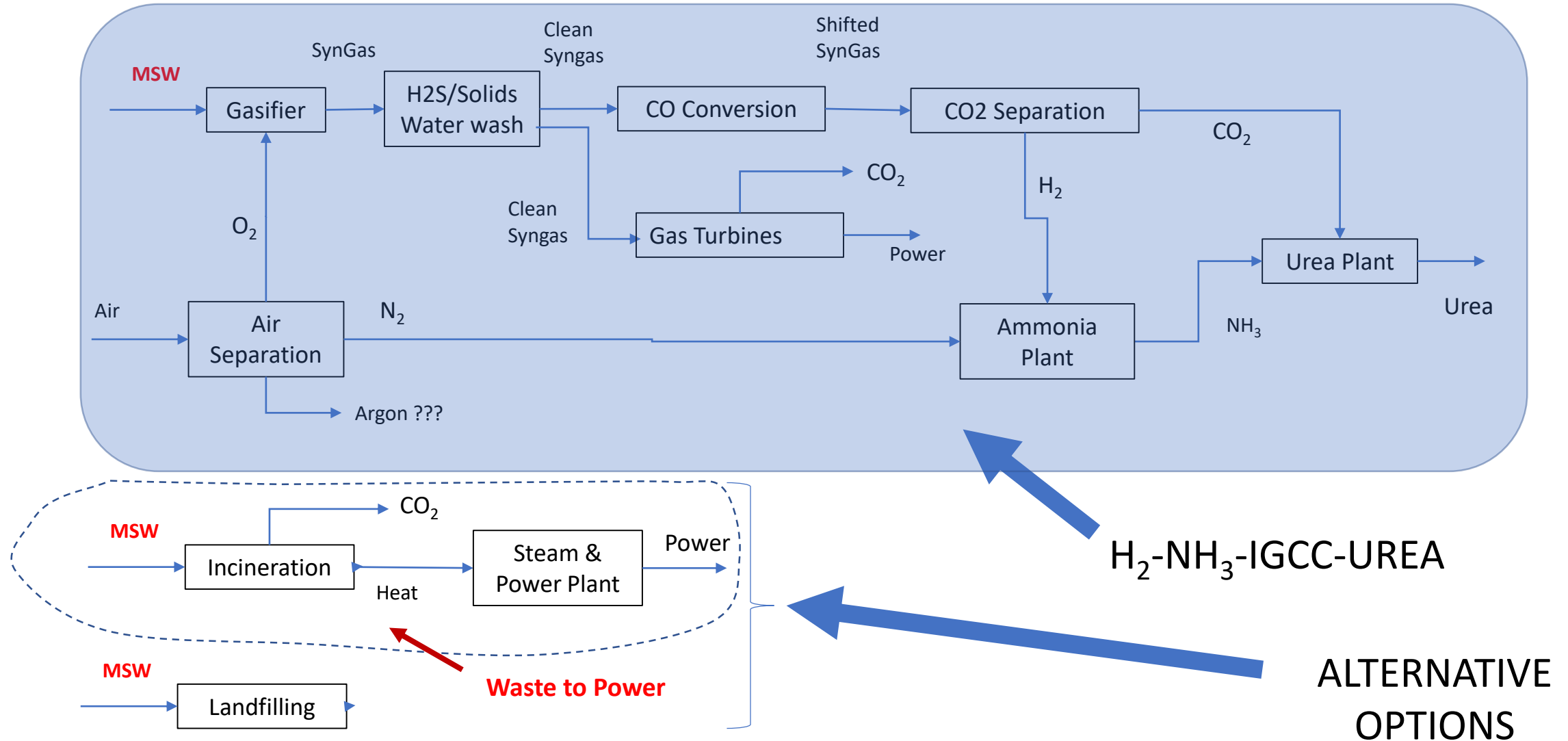
MSW Processing Options



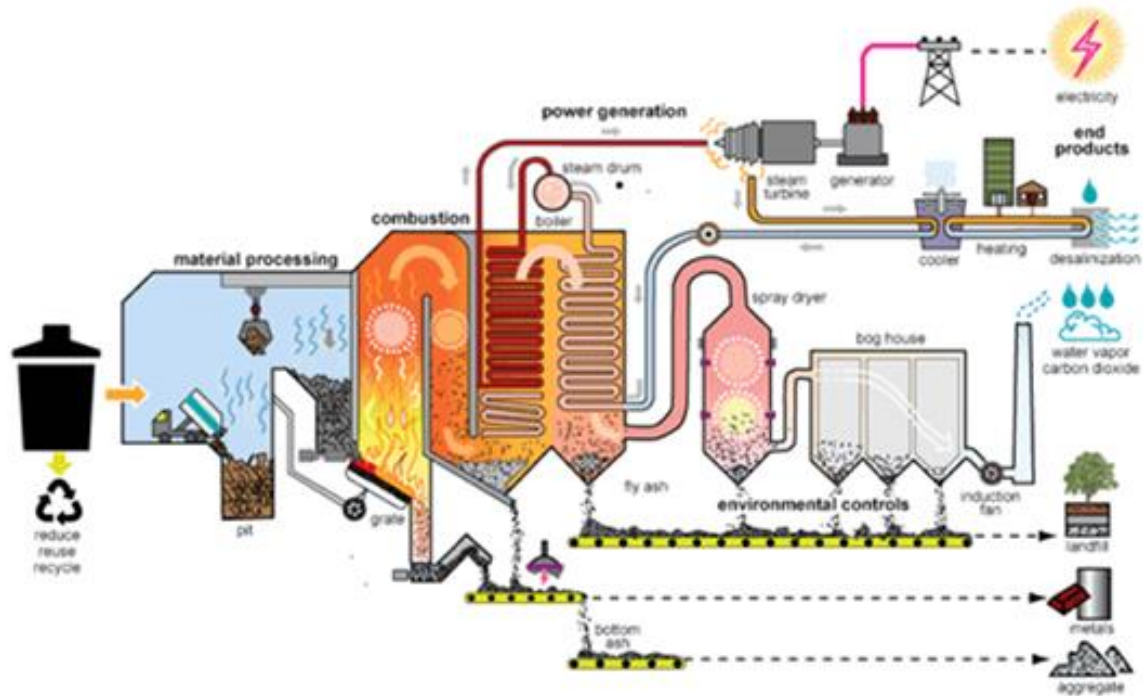
MSW Processing Options



MSW Processing Options

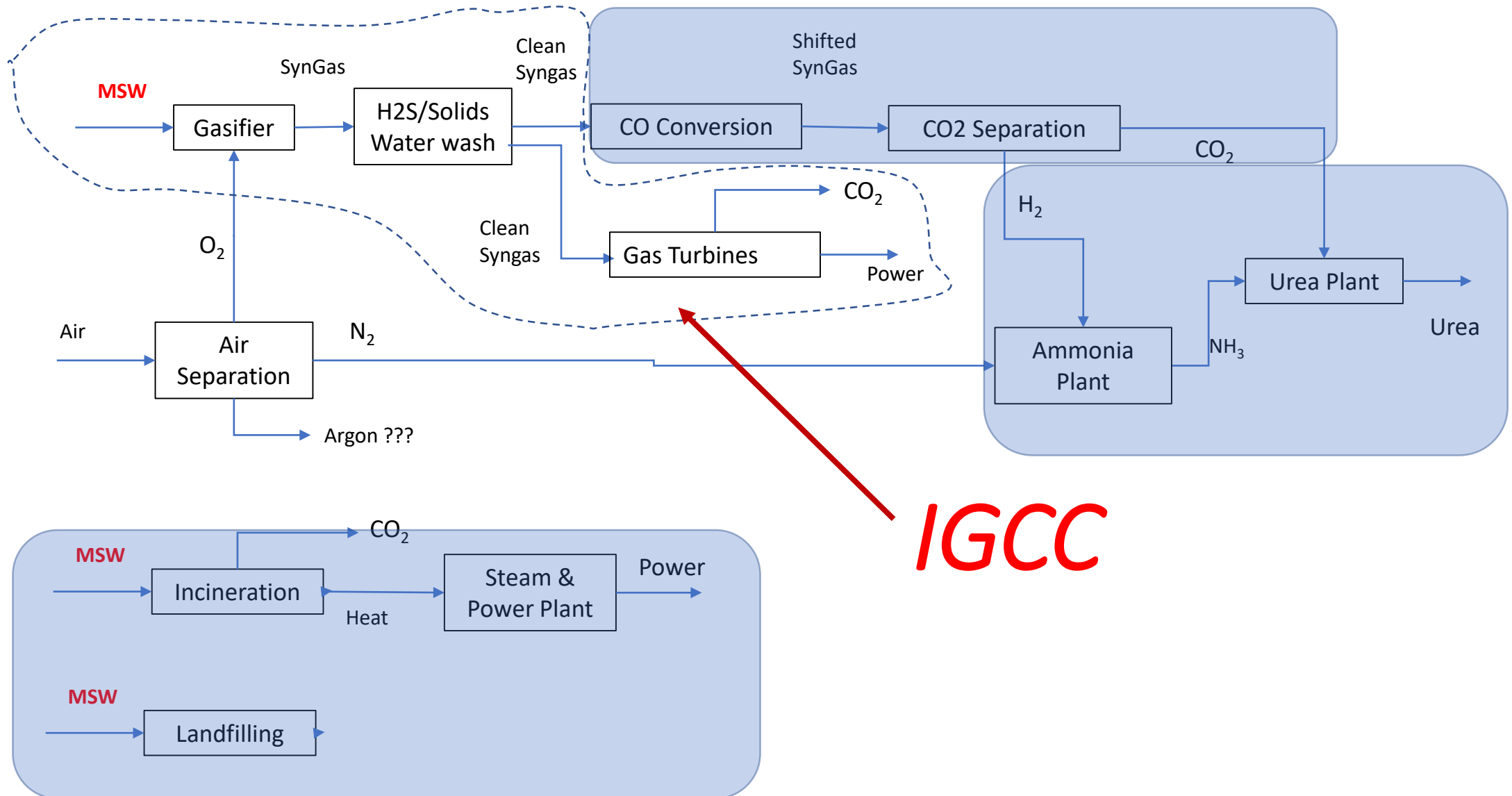


Incineration to Power

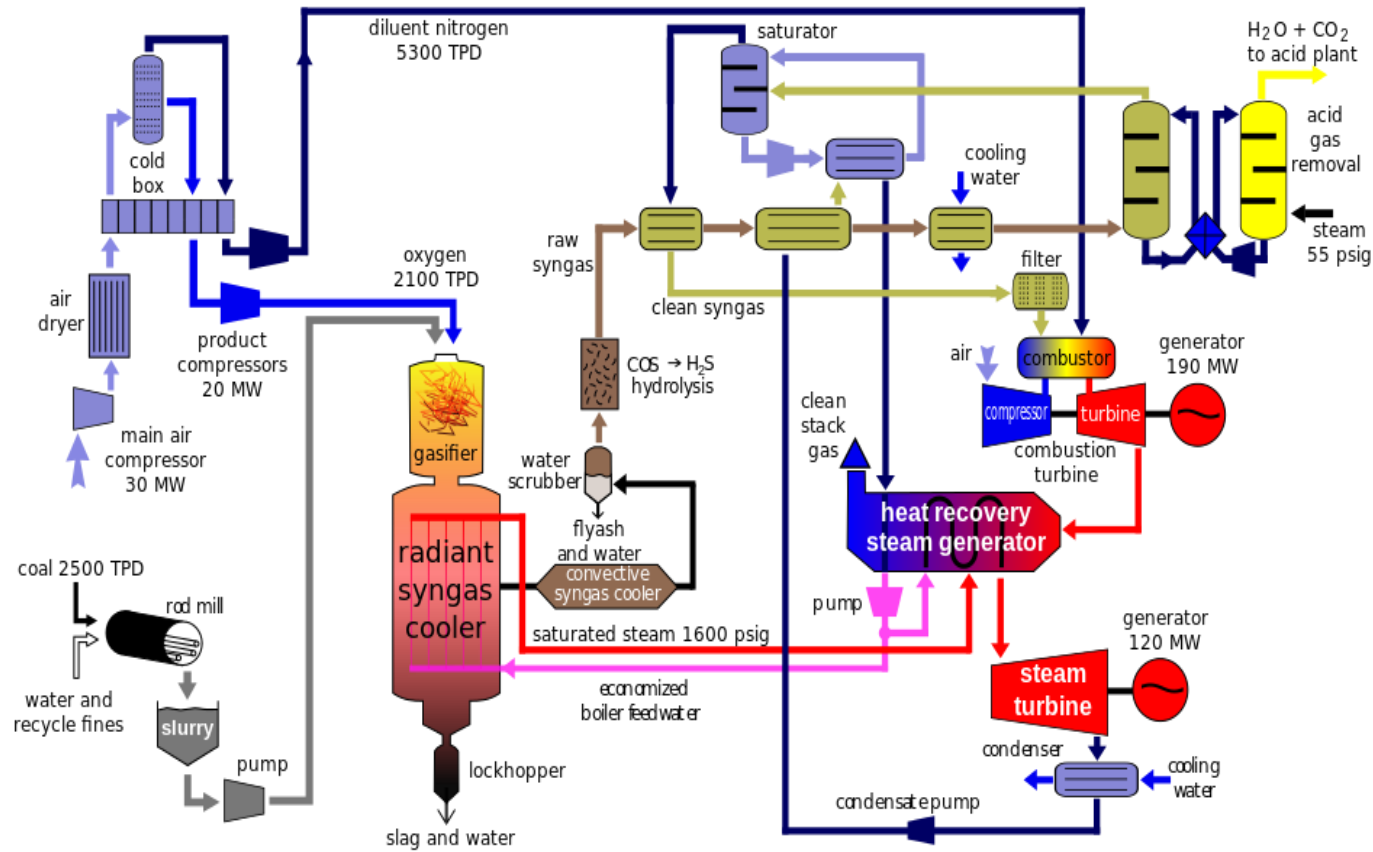


- Incineration Chamber has alternative designs
- Boiler only needs make-up water due to leaks.
- Cooling tower arrangement can have alternative designs.

MSW Processing Options

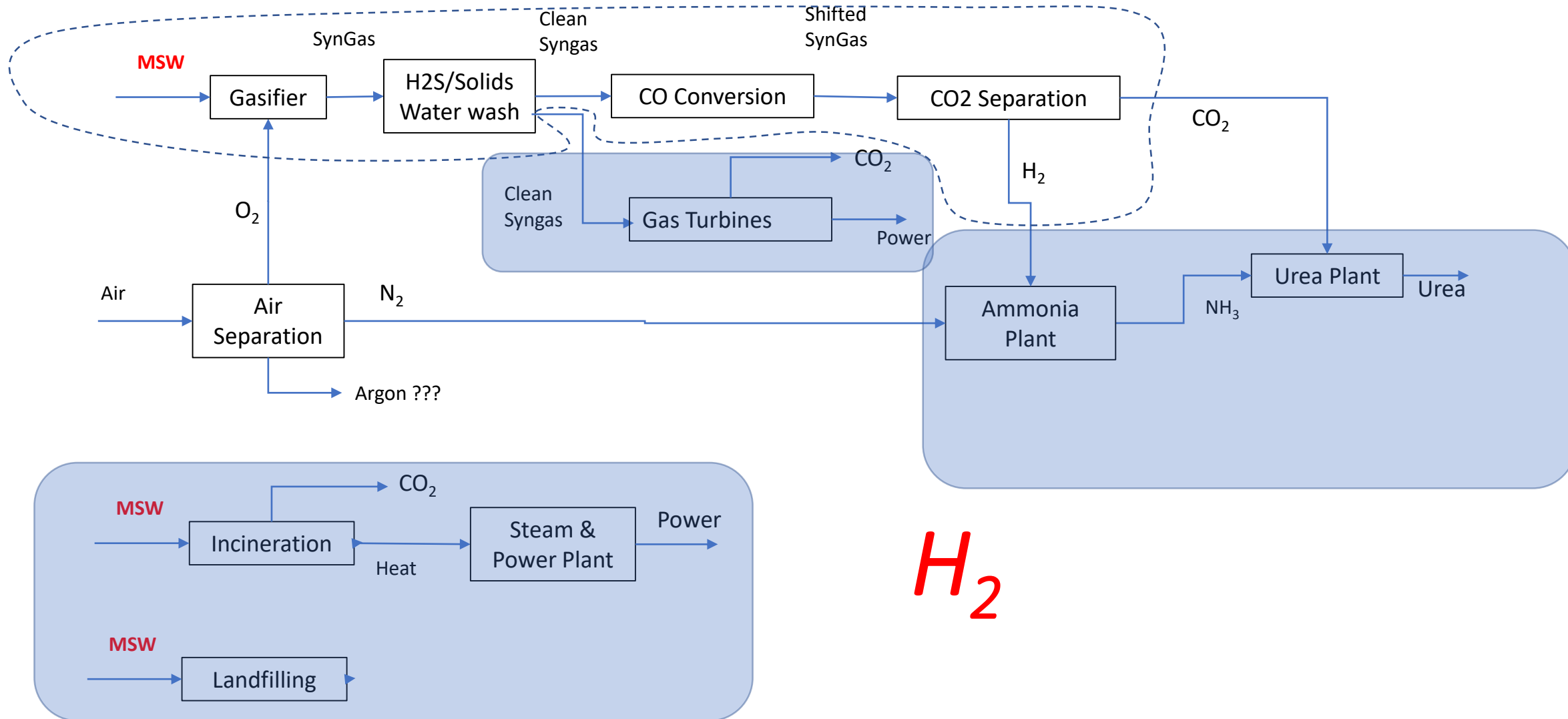


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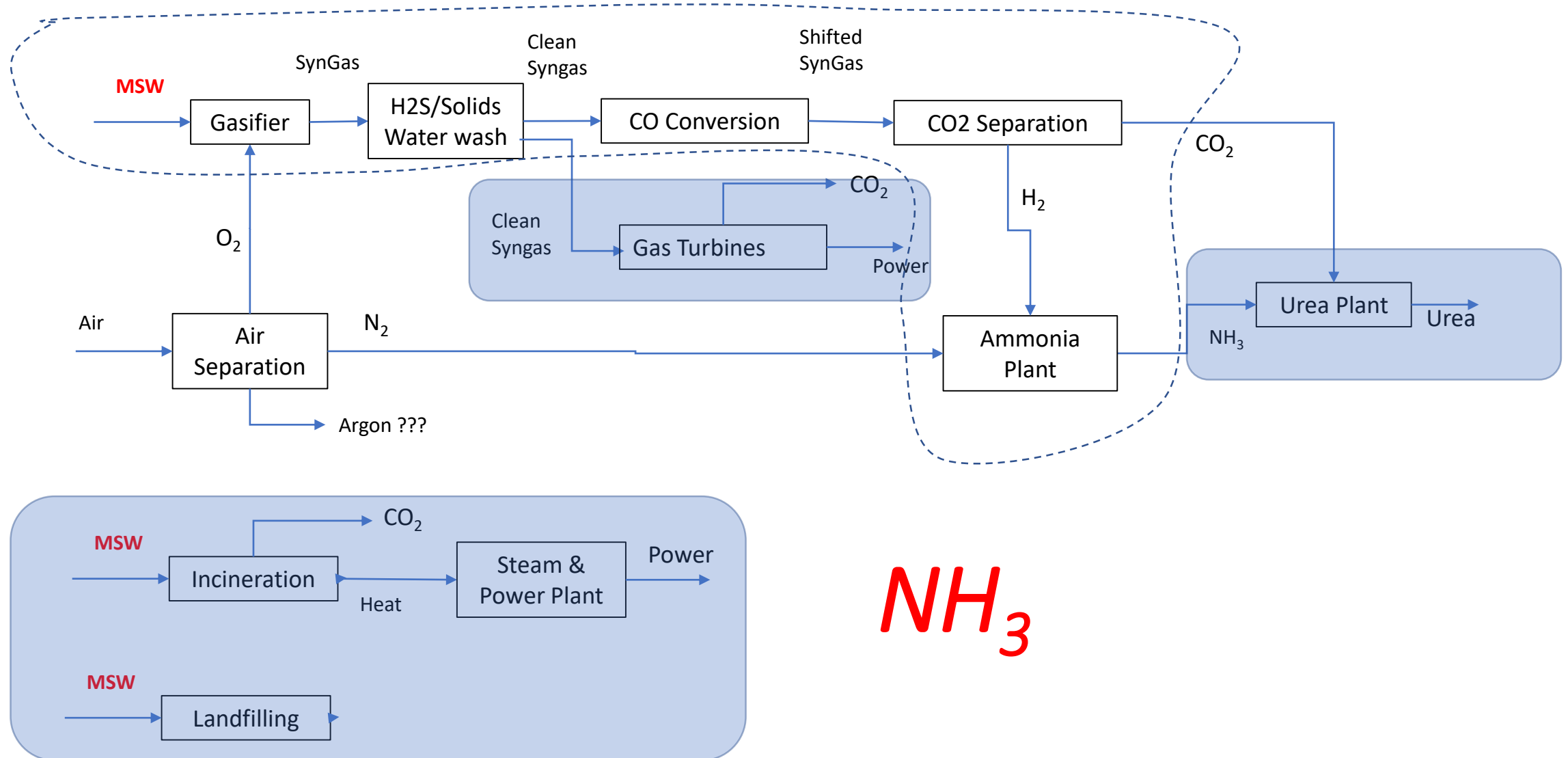


- Gasifier is a combustor with low oxygen. Basically an incomplete combustion.
- Slurry based feed to gasifier. Alternative is solid pellets.
- Acid gas removal to eliminate residual H₂S and bulk CO₂ to reduce volume.
- Syngas combustor followed by turbine
- Heat recovery generates vapor.

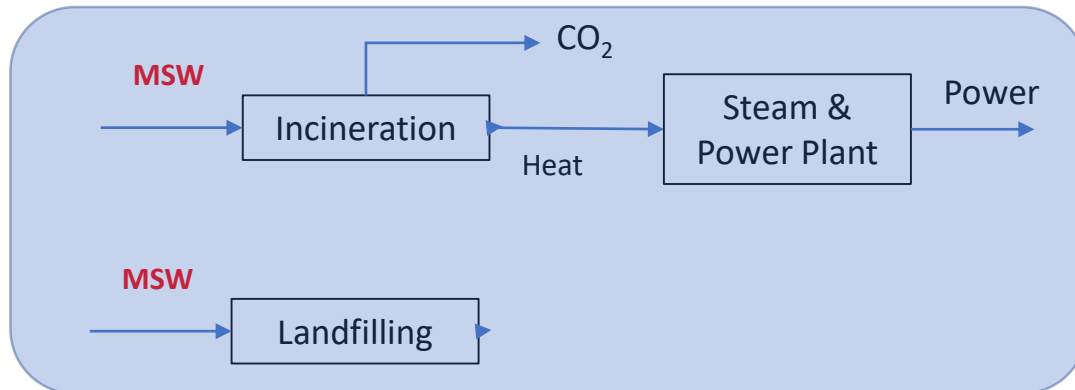
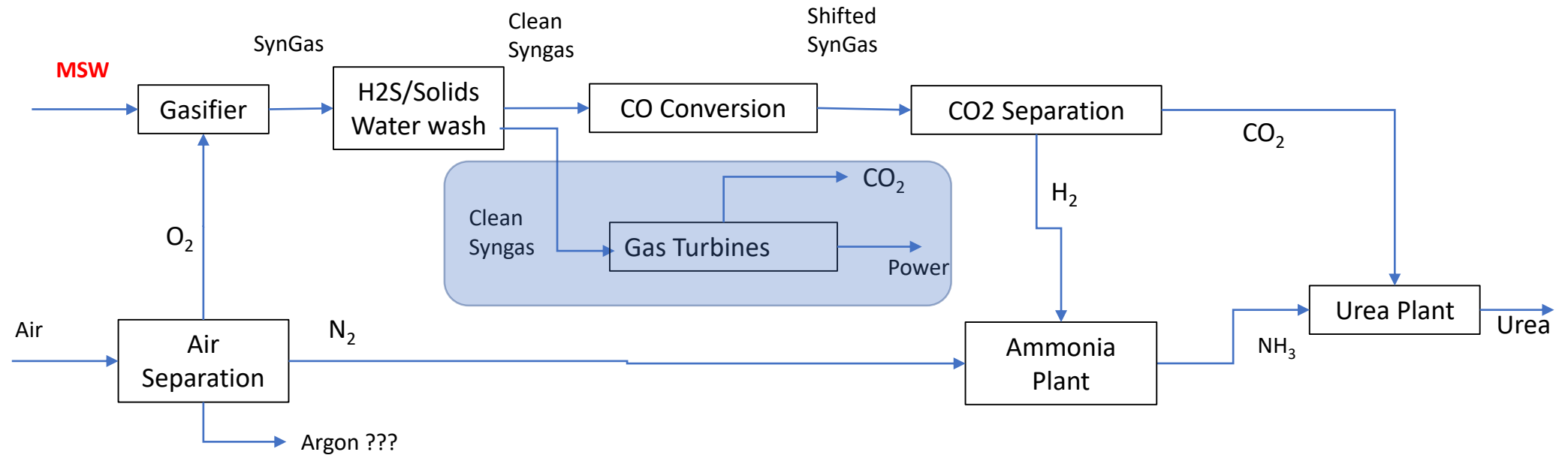
MSW Processing Options



MSW Processing Options



MSW Processing Options



UREA

YOUR JOB

- Start from the overall MSW processing capacity decided.
- Adjust the capacity of each plant in the chain to the MSW capacity of reference. The output of one is equal to the input of the next.
- Scale up the equipment to the appropriate plant capacity.
- Make sure that you consider equipment maximum sizes. Duplicate equipment if scaled up size is larger than the maximum.
- Product Cost can be scaled linearly
- Use the percentages wisely. Revise them for sanity and realism.

EQUIPMENT COST

- P&T graphs.
- Matches

Make sure it is 2018 value!!
Use indices if needed.



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COMPARE!!!!

YOUR JOB

- Inspect items carefully. For example, electrical, is 10% of cost. What electricals are you going to use? Can you break it down and see if it amounts to that 10%?

	Percent of delivered-equipment cost for		
	Solid processing plant [†]	Solid-fluid processing plant [†]	Fluid processing plant [†]
Direct costs			
Purchased equipment delivered (including fabricated equipment, process machinery, pumps, and compressors)	100	100	100
Purchased-equipment installation	45	39	47
Instrumentation and controls (installed)	18	26	36
Piping (installed)	16	31	68
Electrical systems (installed)	10	10	11
Buildings (including services)	25	29	18
Yard improvements	15	12	10
Service facilities (installed)	40	55	70
Total direct plant cost	269	302	360
Indirect costs			
Engineering and supervision	33	32	33
Construction expenses	39	34	41
Legal expenses	4	4	4
Contractor's fee	17	19	22
Contingency	35	37	44
Total indirect plant cost	128	126	144
Fixed-capital investment	397	428	504
Working capital (15% of total capital investment)	70	75	89
Total capital investment	467	503	593

ESTIMATION OF CAPITAL INVESTMENT BY PERCENTAGE OF DELIVERED EQUIPMENT METHOD					
(See Table 6-9)					
The fractions in the cells below are approximations applicable to typical chemical processing plants. These values may differ depending on many factors such as location, process type, etc.					
Required user input	Default		Subtotal		Result
Required, from a linked sheet or entered manually			Notes & comments		
Project Identifier: Illustration 101	Fraction of delivered equipment			User: copy from values at left or insert	Calculated values, million \$
	Solid-processing plant	Solid-fluid processing plant	Fluid processing plant		
Direct Costs					
Purchased equipment, E'					8.800
Delivery, fraction of E'	0.10	0.10	0.10	0.10	0.880
Subtotal: delivered equipment					9.680
Purchased equipment installation	0.45	0.39	0.47	0.47	4.550
Instrumentation&Controls(installed)	0.18	0.26	0.36	0.36	3.485
Piping (installed)	0.16	0.31	0.68	0.68	6.582
Electrical systems (installed)	0.10	0.10	0.11	0.11	1.065
Buildings (including services)	0.25	0.29	0.18	0.18	1.742
Yard improvements	0.15	0.12	0.10	0.10	0.968
Service facilities (installed)	0.40	0.55	0.70	0.70	6.776
Total direct costs	1.69	2.02	2.60	2.60	34.848
Indirect Costs					
Engineering and supervision	0.33	0.32	0.33	0.33	3.194
Construction expenses	0.39	0.34	0.41	0.41	3.969
Legal expenses	0.04	0.04	0.04	0.04	0.387
Contractor's fee	0.17	0.19	0.22	0.22	2.130
Contingency	0.35	0.37	0.44	0.44	4.259
Total indirect costs	1.28	1.26	1.44	1.44	13.939
Fixed capital investment (FCI)					48.787
Working capital (WC)					8.615
Total capital investment (TCI)					57.402
Sent to 'Evaluation' and 'Year-0 \$', there adjusted as described below					

Sent to 'Evaluation' and 'Year-0 \$', there adjusted as described below

P&T

- Use similar scrutiny for Product

UTILITY COSTS

See Table 6-14 and Table B-1 for ranges of utility unit costs and sources of information. Default values are rough averages and may be changed. Utility costs can differ widely with location.

Process Identifier: Illustration 101

Required user input	Notes & comments
Result	Default, may be changed

TOTAL UTILITY COST =	2.025	million \$/y
Sent to sheet 'Annual TPC'		

Utility	Default unit cost	Default cost units	Annual utility requirement, in appropriate units	Default units of utility requirement	Annual utility cost, million \$/y
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Air, compressed

Process air	0.45	\$/100m ³ *		100 m ³ /y	
Instrument air	0.90	\$/100m ³ *		100 m ³ /y	

Electricity

Purchased, U.S. average	0.045	\$/kWh	1800000	kWh/y	0.081
Self-generated	0.05	\$/kWh		kWh/y	

Fuel

Coal	1.66	\$/GJ		GJ/y	
Fuel oil	3.30	\$/GJ		GJ/y	
Natural gas	3.00	\$/GJ	360000	GJ/y	1.080
Manufactured gas	12.00	\$/GJ		GJ/y	

Refrigeration, to temperature

15 °C	4.00	\$/GJ		GJ/y	
5 °C	5.00	\$/GJ		GJ/y	
-20 °C	8.00	\$/GJ		GJ/y	
-50 °C	14.00	\$/GJ		GJ/y	

Steam, saturated

3550 kPa	8.00	\$/1000 kg		1000 kg/y	
790 kPa	6.00	\$/1000 kg	40000	1000 kg/y	0.240
Exhaust (150 kPa)	2.00	\$/1000 kg		1000 kg/y	

Waste water

Disposal	0.53	\$/m ³		m ³ /y	
Treatment	0.53	\$/m ³	400000	m ³ /y	0.212

Waste disposal

Hazardous	145.00	\$/1000 kg		1000 kg/y	
Non-hazardous	36.00	\$/1000 kg		1000 kg/y	

Water

Cooling	0.08	\$/m ³	2500000	m ³ /y	0.200
Process					
General	0.53	\$/m ³	400000	m ³ /y	0.212
Distilled	0.90	\$/m ³		m ³ /y	

* measured at 101.3 kPa and 15°C.

Title:	Date:			
Product:	Capacity, kg/h:			
Operating time, h/yr:	Capacity, kg/s:			
Capacity, kg/yr:	Fixed Capital Investment (FCI)			
User variables				
	Suggested factor	Rate or quantity per year	Cost per rate or quantity unit	Calculated values, \$M
Raw materials				
1				
2				
3				
4				
Operating labor [†]				Total
Operating supervision	0.15	of operating labor		
Utilities [†]				
Water				
Cooling				
Process				
Electricity				
Fuel				
Refrigeration				
Steam				
Waste treatment and disposal	0.07	of FCI		
Maintenance and repairs	0.15	of maintenance and repairs		
Operating supplies	0.15	of operating labor		
Laboratory charges	0.15	of operating labor		
Royalties (if not on lump-sum basis)	0.04	of TPC without depreciation		
Catalysts and solvents				
Total variable production costs				
Depreciation—calculated separately below				
Taxes (property)	0.02	of FCI		
Financing (interest)	0.00	of FCI		
Insurance	0.01	of FCI		
Rent	0.00	of FCI		
Depreciation [†]				
†Calculated according to MACRS 5-year schedule. (See Chap. 7 for details.)				
Year	Depreciation % of FCI	d _f , \$/yr	TPC = (d _f + c _o), \$/yr	
1	20			
2	32			
3	19.2			
4	11.52			
5	11.52			
6	5.76			
7	0			
⋮	⋮			
20	0			

Fixed charges (without depreciation)	
Plant overhead costs	
Administrative costs	
Distribution + marketing costs	
Research and development costs	
General expenses	
Total product cost (without depreciation)	

SCALING

- Intensive properties (P,T) remain the same
- Capacity of plant (usually throughput or production) changes.
- Columns: # trays stay the same, diameter scaled maintaining special velocity
- Reactors: CSTR, scale volume with capacity, PFR: Length is the same, scale diameter maintaining spatial velocity.
- Heat exchangers. Scale area with exchanged heat.
- Compressors & pumps: scale power with capacity