Advanced Gas Cleaning for Biomass Gasification

Thermal Gasification of Biomass

Workshop on Raw Gas Clean-up, Gas Conditioning and Synthesis Gas Conversion

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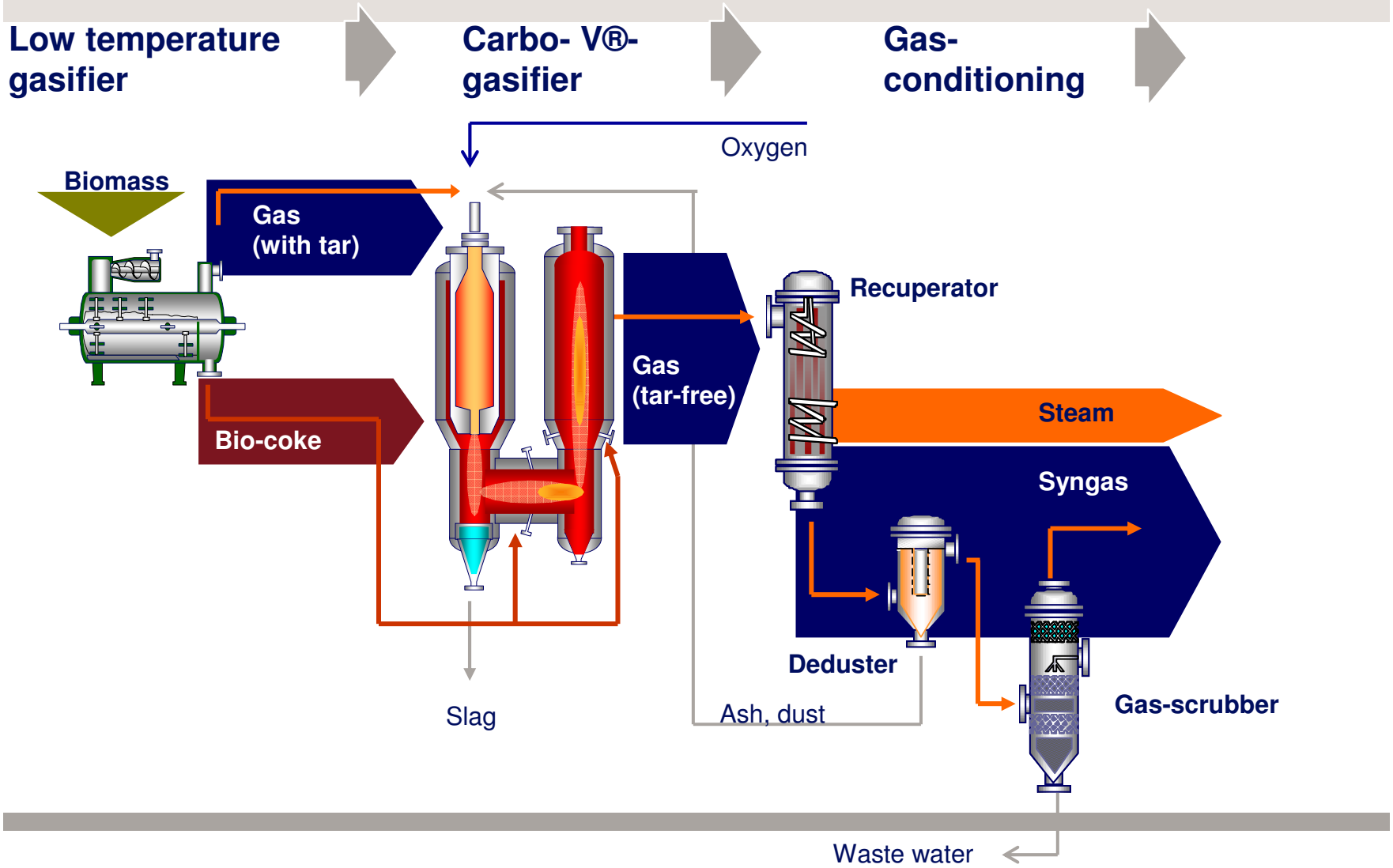
Development Goals of Carbo-V®

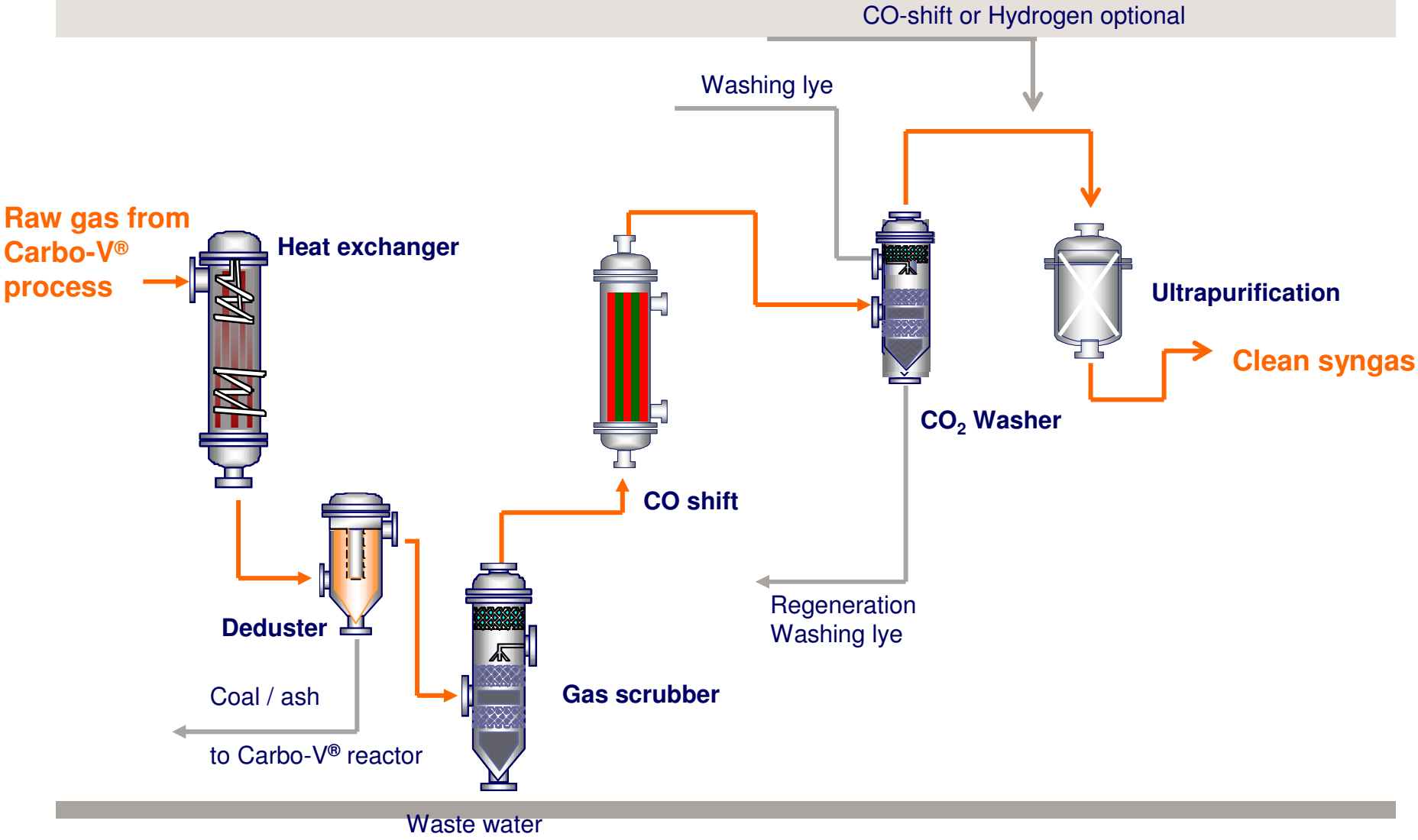
Carbo-V®-Gasification aiming for

- high feedstock flexibility (for all dry and carbon-containing materials)
- high efficiences
- gasification power range up to 200 MW
- high syngas quality
- **tar free gas**

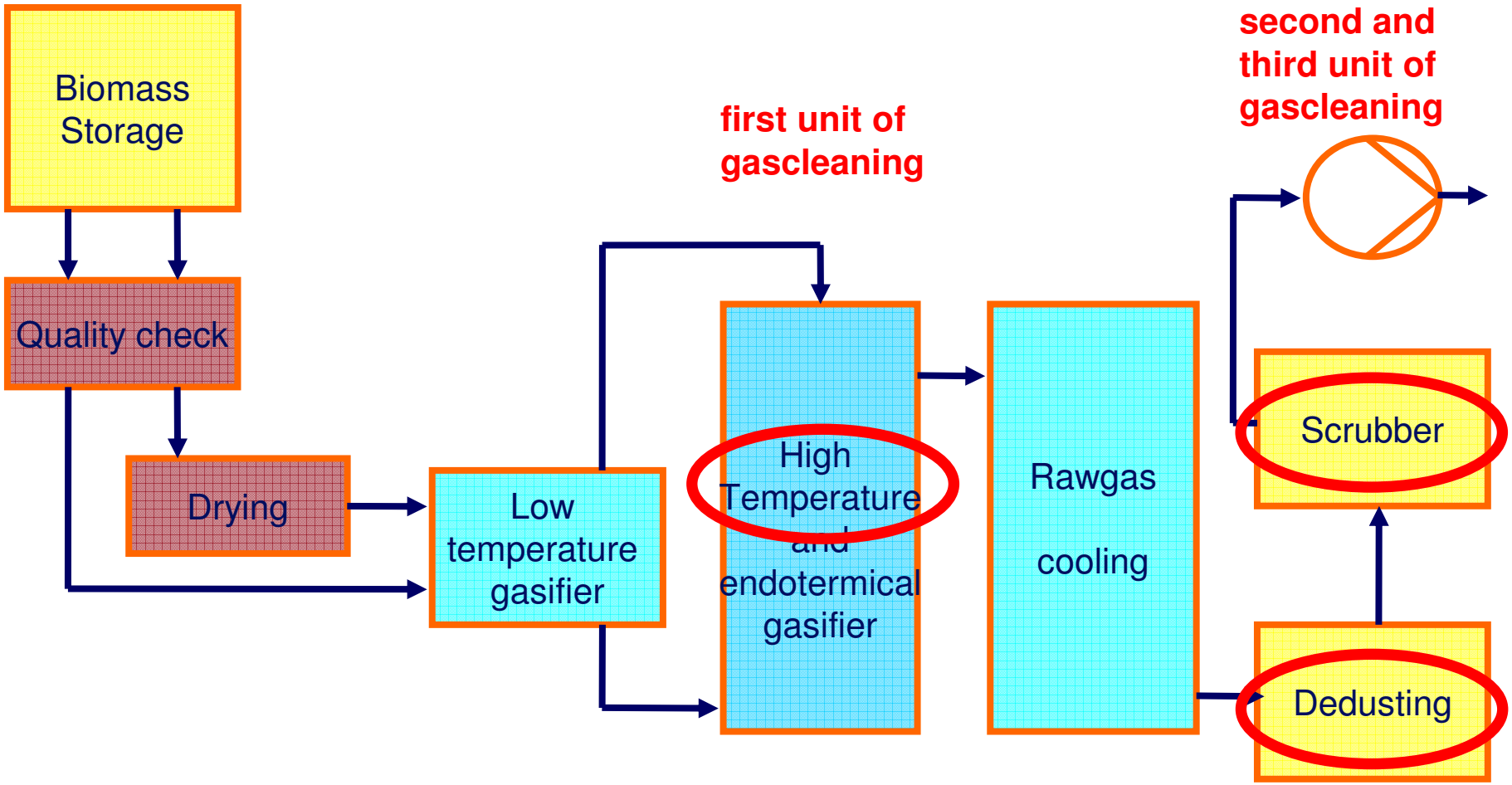
Carbo-V® -Process, simplified



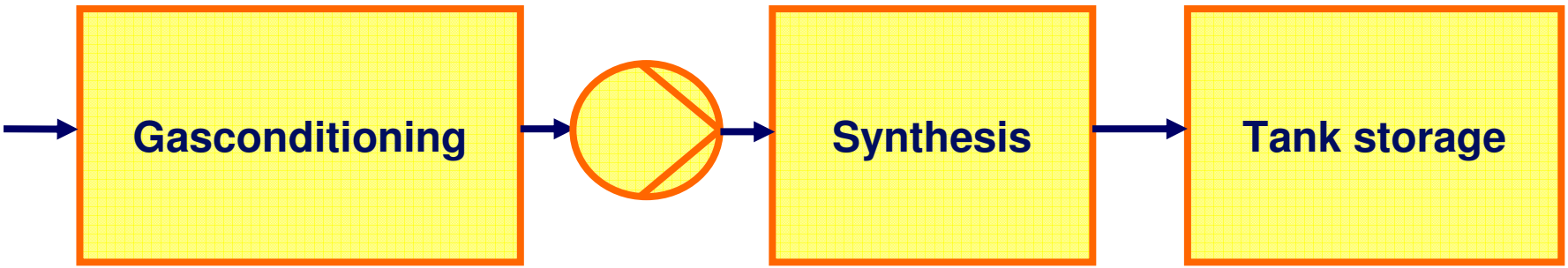
Gas cleaning process, simplified



Multi stage raw gas cleaning - block diagram



Multi stage raw gas cleaning - block diagram



Composed of

- CO-shift
- CO_2-Washing

fourth unit of gascleaning

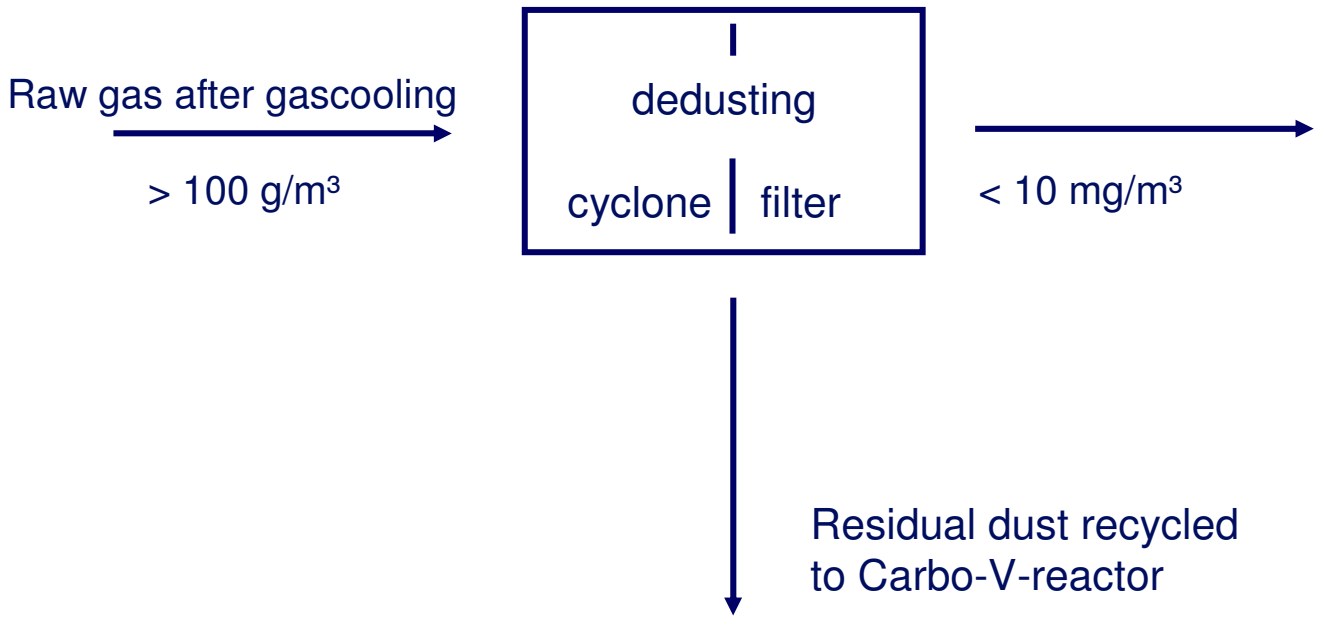
Composed of

- ultrapurification
- Fischer-Tropsch-Synthesis
- Hydrocracking
- Destillation

fifth unit of gascleaning

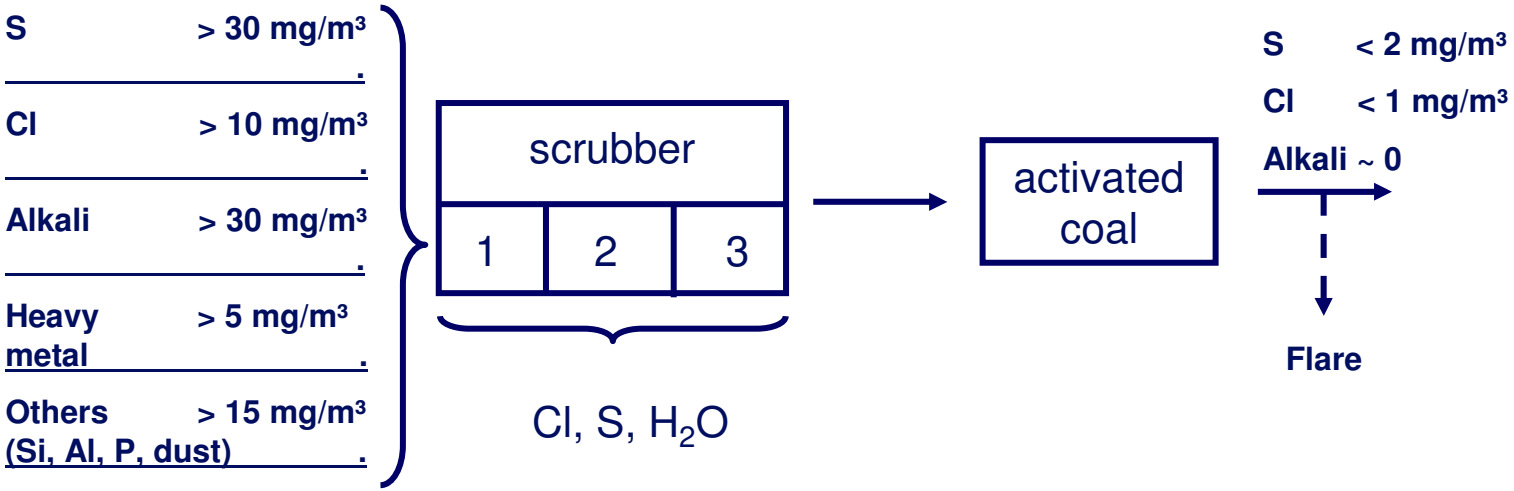
Targets for several units

second unit of gascleaning - dedusting



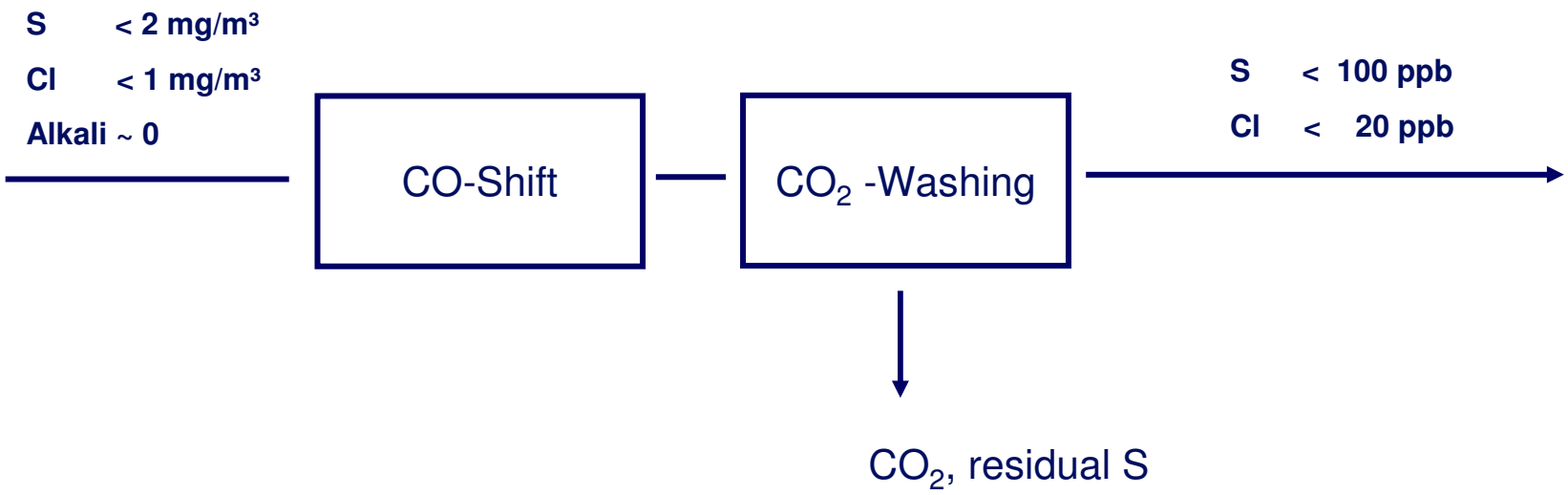
Targets for several units

third unit of gascleaning - scrubber



Targets for several units

fourth unit of gascleaning – CO_2-washing



Targets for several units

fifth unit of gascleaning - ultrapurification

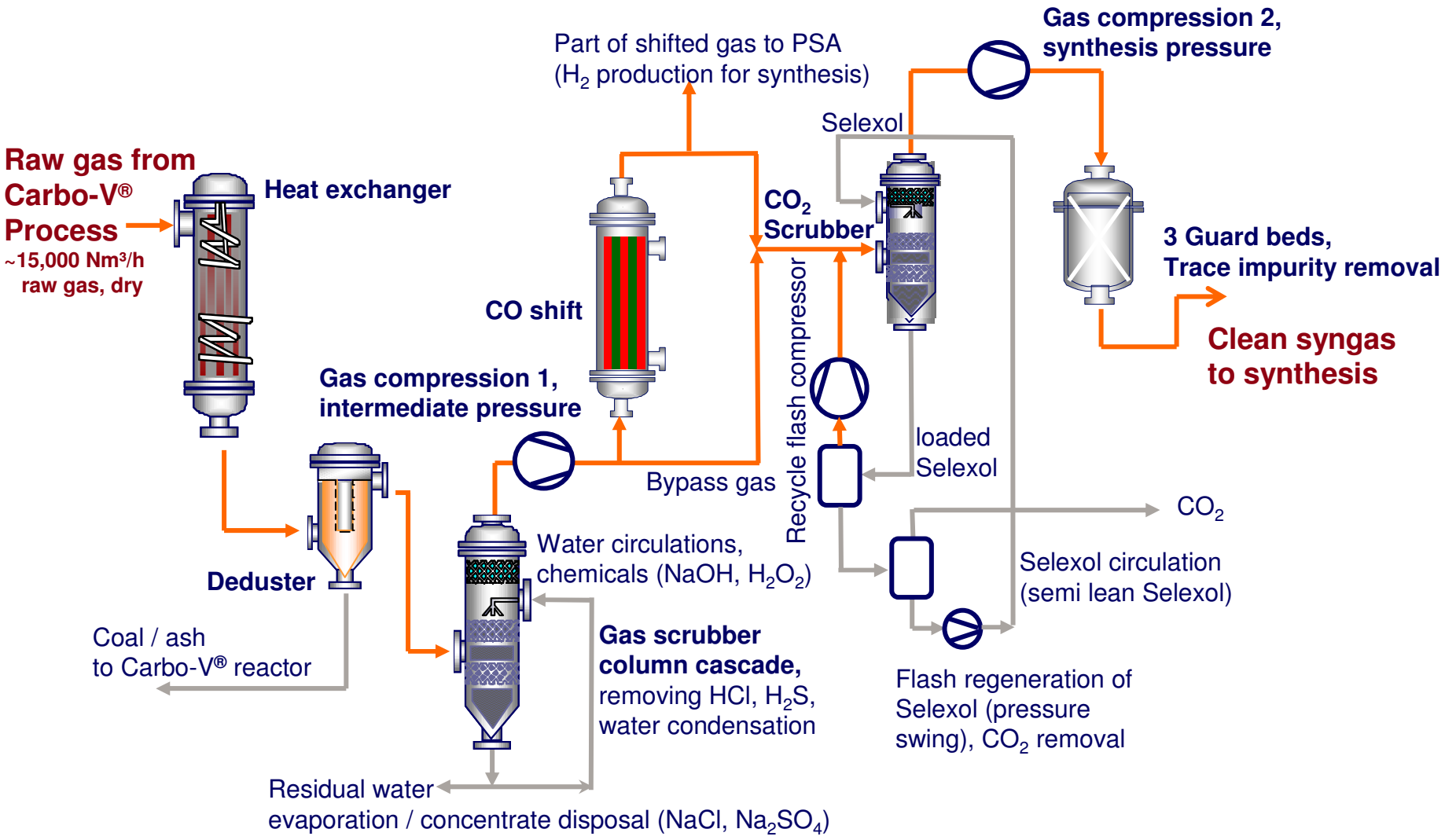
Summary: in detail eleven steps in five units to produce a clean syngas

Comparision gas cleaning - overview

Beta vs. SIGMA

	Beta	SIGMA
Capacity	45 MW_{th}	640 MW_{th}
Raw gas volume	~ 15,000 Nm^3/h, dry	~250,000 Nm^3/h
Gasification	One line	Multi line
Pressure gas cleaning	Intermediate level	Synthesis level

Beta plant gas conditioning process 1/2



Beta plant gas conditioning process 2/2

Specifics of Beta plant gas conditioning process:

1. Relatively high consumption of chemicals for water wash stages (NaOH, regulation of relatively high pH- value, H_2O_2) → high OPEX

2. Relatively high amount of concentrate incl. consumed chemicals to dispose (concentrate with NaCl, $NaSO_4$) → high OPEX

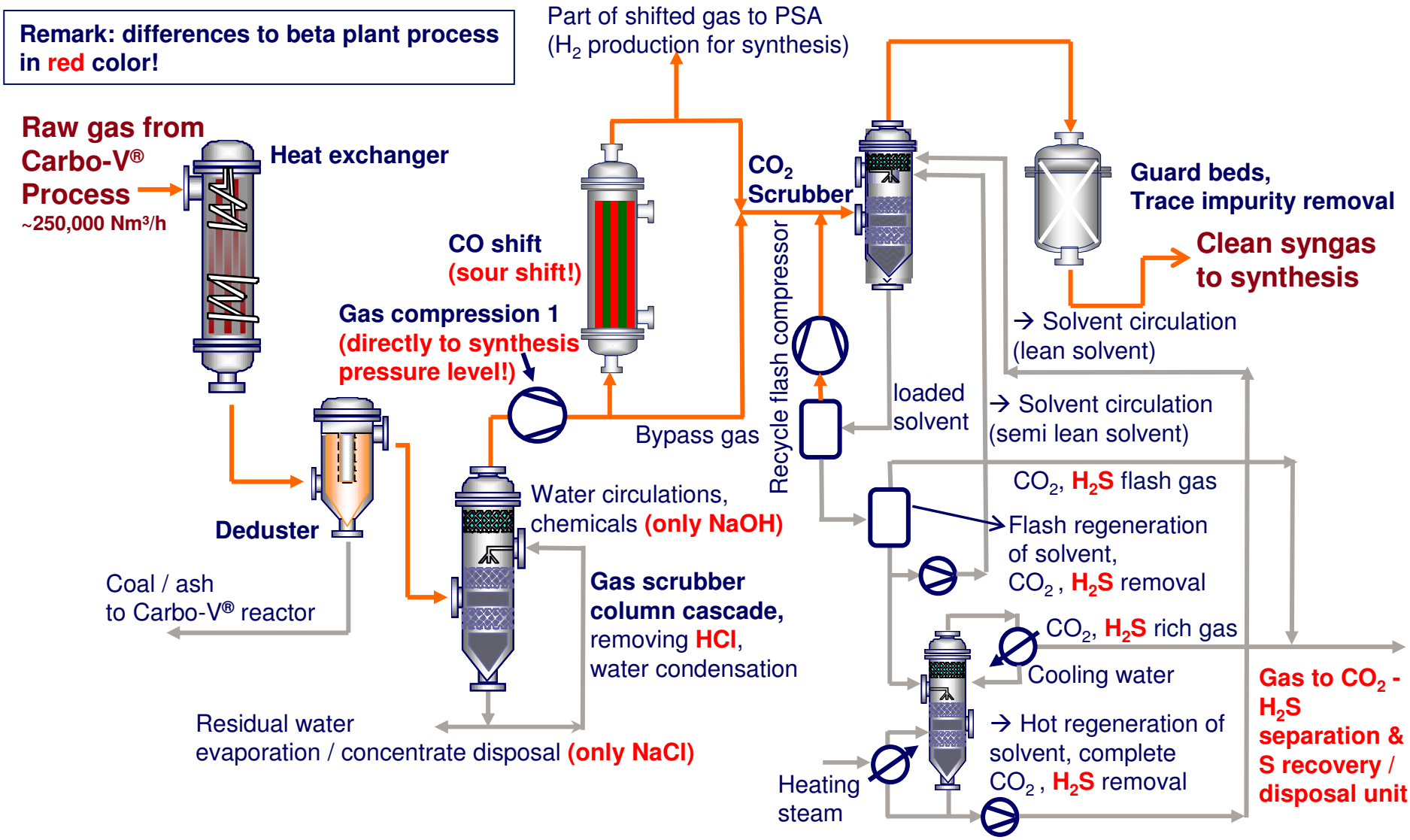
3. 2 gas compressors (relatively high CAPEX).
   Intermediate pressure level for gas conditioning. High pressure level for synthesis.

   Intermediate pressure level for gas conditioning → higher pressure level would be more favorable for pressure swing regeneration of solvent (CO_2 absorption at high pressure, CO_2 desorption / solvent flash regeneration at low pressure level)

4. Selexol scrubber column: organic solvent (like Selexol) coabsorbs (in lesser quantities) valuable gas compounds (H_2, CO) too → recycle flash to minimize H_2, CO loss → CAPEX and OPEX for recycle gas compressor

Sigma plant gas conditioning process 1/3

Remark: differences to beta plant process in red color!



Sigma plant gas conditioning process 2/3

Sigma plant gas conditioning process, comparison with Beta plant:

1. Relatively lower consumption of chemicals for water wash stages, only and lower NaOH consumption for regulation of (lower) pH – values and HCl removal.

2. Relatively lower amount of concentrate incl. consumed chemicals to dispose (concentrate with NaCl).

3. Only 1 gas compressors (relatively lower CAPEX).
   High pressure level for gas conditioning and for synthesis.

   → High pressure level is more favorable for pressure swing cycle of the solvents (CO_2 absorption at high pressure, CO_2 desorption / solvent flash regeneration at low pressure level)

4. Besides pressure swing solvent regeneration there is a hot regeneration resp. inert gas (N_2) stripping regeneration for the generation of lean solvent (solvent without H_2S) needed → CAPEX, OPEX.

5. Unselective CO_2 – H_2S removal (AGR – acid gas removal) with physical organic or aqueous amine solutions → following CO_2 – H_2S separation and S recovery unit needed → CAPEX.

Sigma plant gas conditioning process 3/3

Considered solvents for unselective AGR (acid gas removal), in limbo!:

CAPEX / OPEX to be supplied by sigma scouting phase supervisor else!

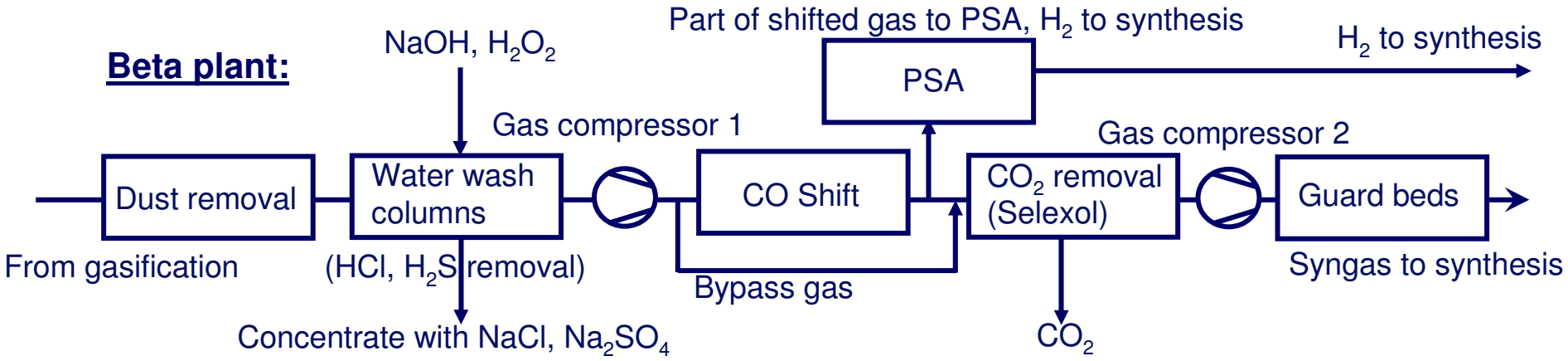
[1 – 3: Organic solvents (physical solvents),
4 – 6: Aqueous amine solutions (chemical solvents)]

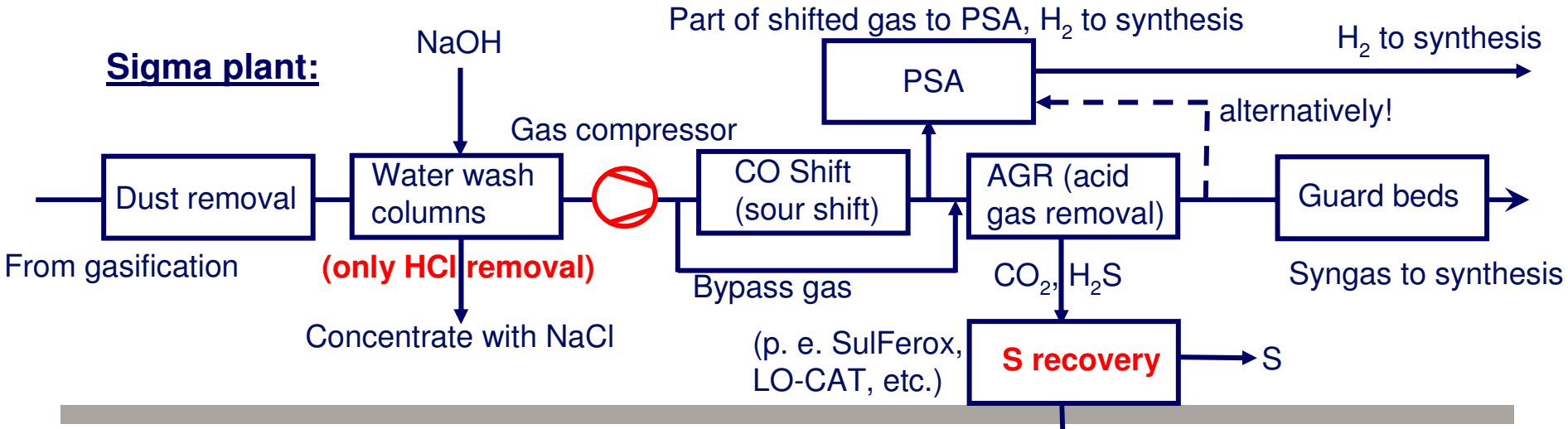
1. **Rectisol®**
2. **Genosorb®**
3. **Selexol®**
4. **aMDEA**
5. **ADIP-X**
6. **Remark: alternatively other solvents / supplier possible, par example aMDEA / sMDEA.**

Further remark: organic solvents imply greater coabsorption of valuables (H_2, CO) then aqueous solutions → greater amount of recycle gas for loss compensation needed, but organic solvents imply lesser residual CO_2 / H_2S in the clean synthesis gas to the guard beds too.

Beta plant gas conditioning process, Sigma plant gas conditioning process

Summary: Block diagrams (simplified):





Remark: AGR (acid gas removal): choice of solvent in limbo else!

Thank you!

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