PEGASUS FINAL WORKSHOP

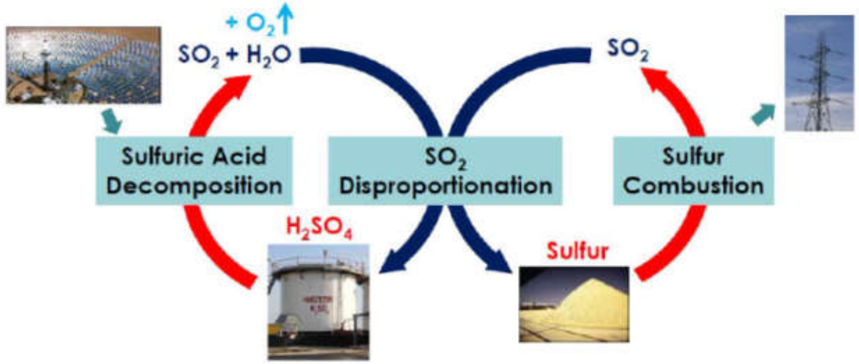
NextChem
Maire Tecnimont for Energy Transition

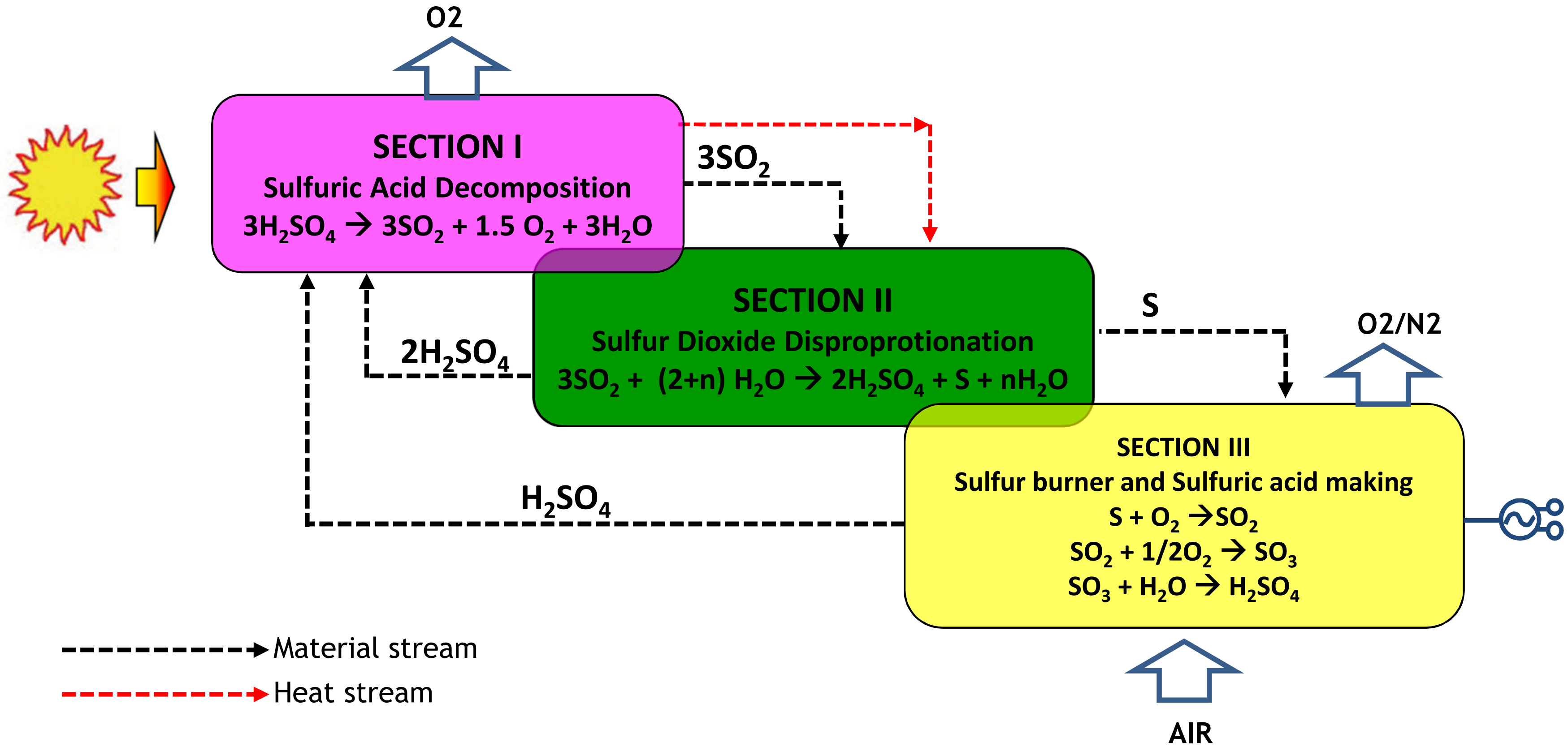
PEGASUS 36 MEETING| January 2020

PROCESS FLOW SHEET

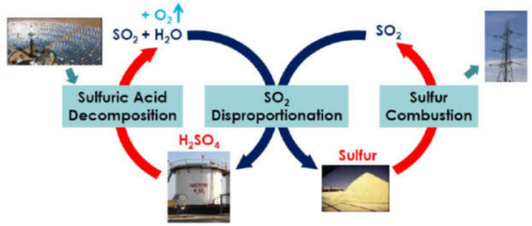
The overall flow sheet may be devided into three sub sections:

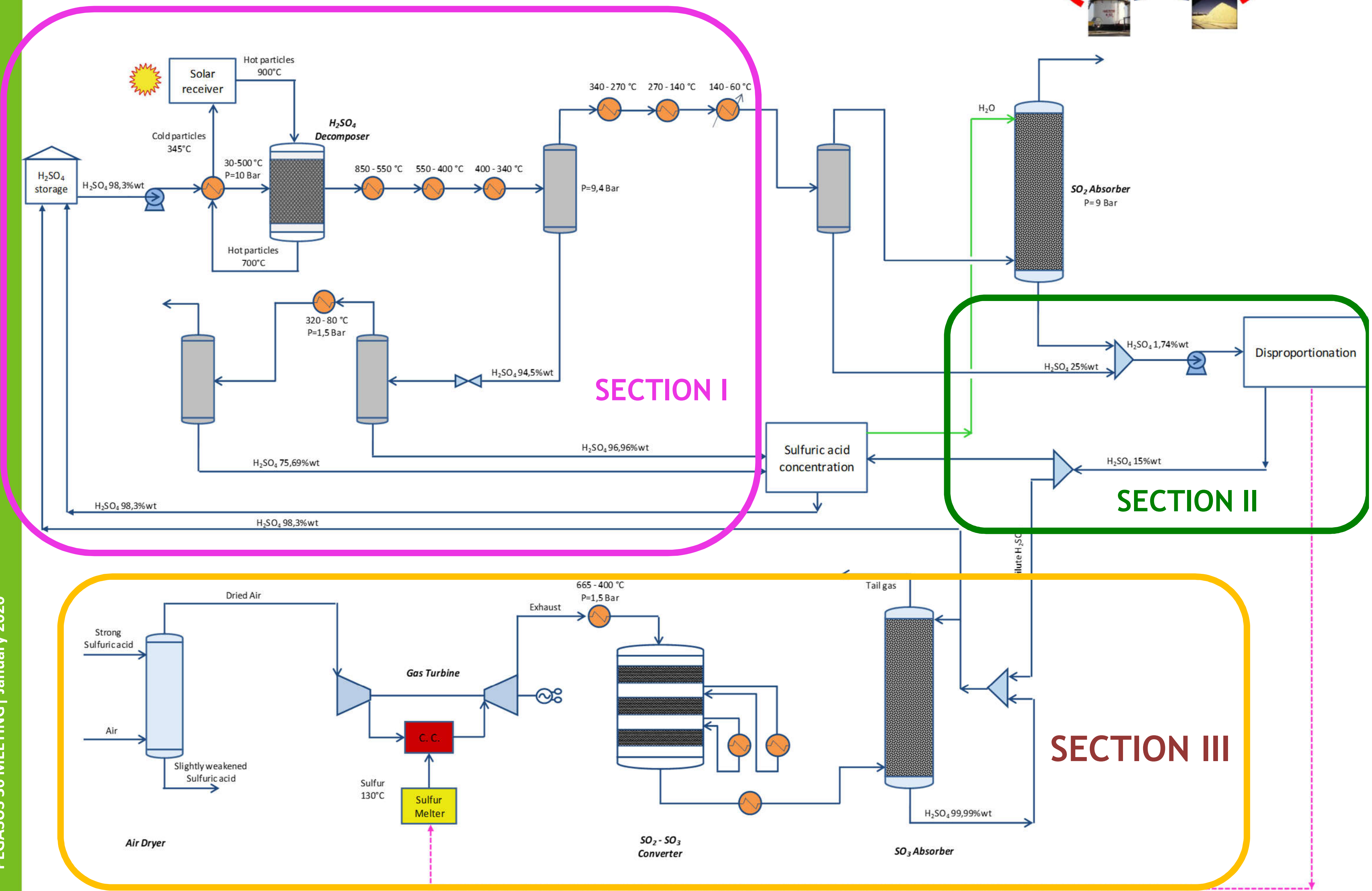
- SULFURIC ACID DECOMPOSITION;
- SULFUR DIOXIDE DISPROPORTIONATIO
- SULFUR COMBUSTION





OVERALL FLOWSHEET





TO BE ELABORATED.

FOCUS ON BUILT IN MODELING FOR SOLAR FIELD

AND Aspen plus model for the chemical plant including

- **the high non ideality of the system**
- **THE NON-CONVENTIONAL EQUIPMENT (receiver and reactor for SO3 decompoasition)**

RESUMING MAIN RESULTS OF D 6.5

COMPLETE FLOWSHEET

The below process description has to be read in conjunction with following Process Flow diagram:

- Process Flow diagram - Solar receiver, H_2SO_4/SO_3 decomposition and SO_2 separation;
- Process Flow diagram - Disproportionation and H_2SO_4 storage;
- Process Flow diagram -03 - H_2SO_4 concentration;
- Process Flow diagram -04 - Sulfur burner and SO_3 contact process;
- Process Flow diagram -05 - Steam cycle;

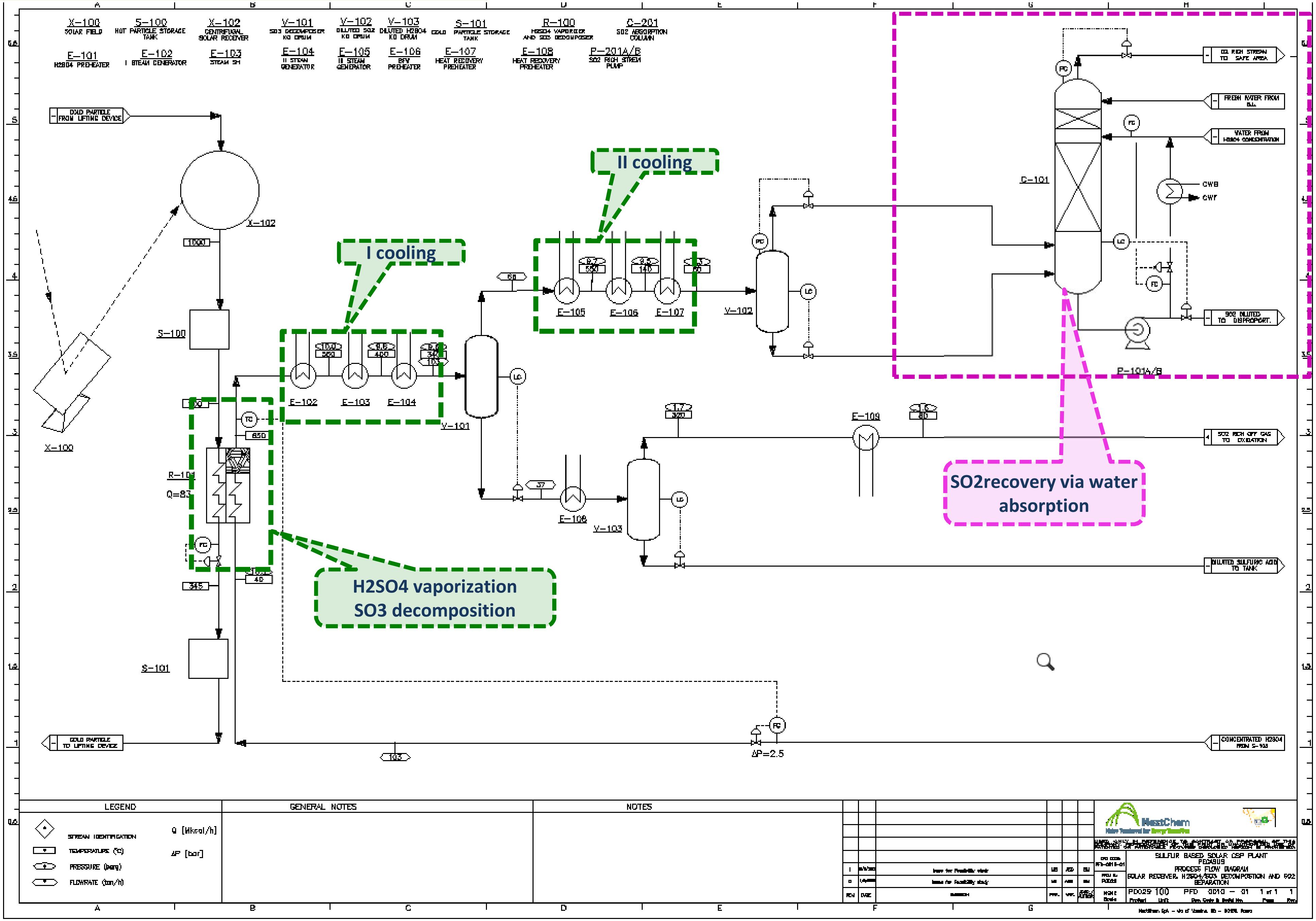
The drivers for process optimization are the:

- Maximization of heat integration;
- Minimization of material loss through vent/off gas;
- Maximization of process efficiency

Reference capacity for the chemical plant was a base load thermal duty of 96MWht being the second one identified (12MWth) within D.6.1 too detrimental for the economy of scale for the chemical plant.

SOLAR RECEIVER, H2SO4/SO3 DECOMPOSITION AND SO2 SEPARATION

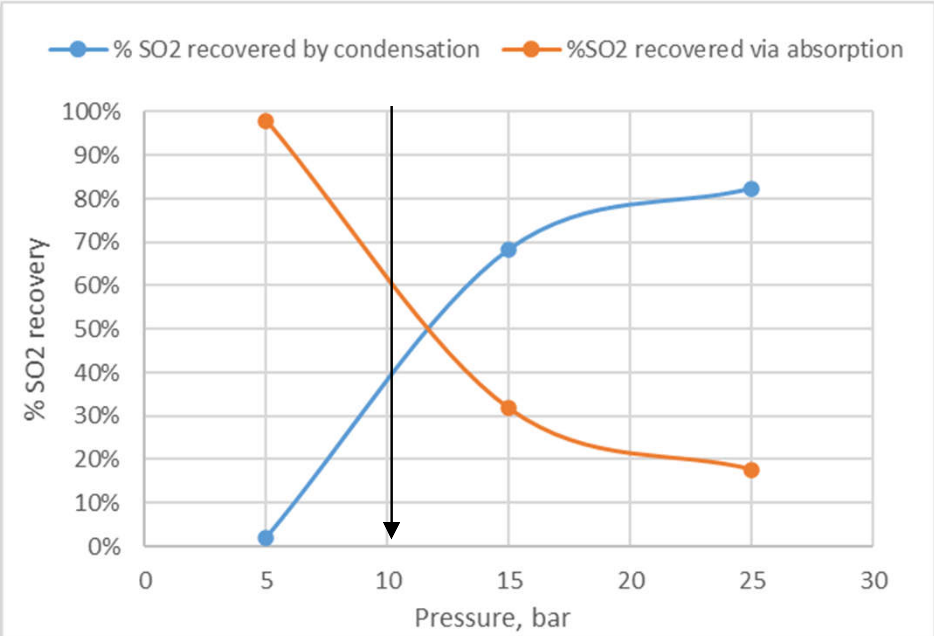
SECTION I
Sulfuric Acid Decomposition
$3H_2SO_4 \rightarrow 3SO_2 + 1.5\ O_2 + 3H_2O$



The SO3 decomposition section is promoted by **High TEMPERATURE AND LOW PRESSURE.**

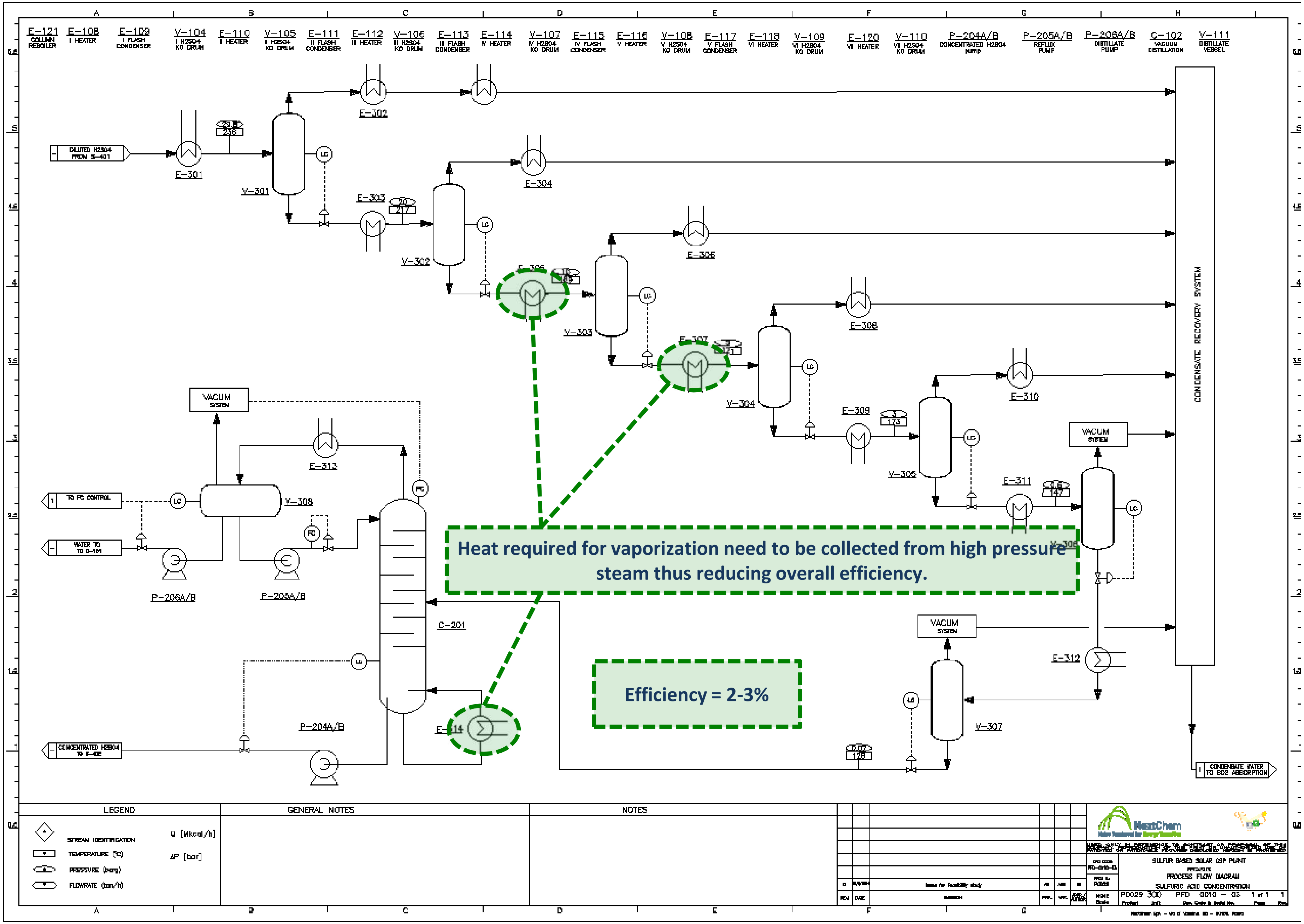
At increasing pressure SO2 is mainly recovered via condensation reducing the load of the absorption column.

It derives that at increasing pressure a lower content of water is introduced into the downstream disproportionation and following H2SO4 concentration step.



Although increasing pressure at around 10 barg in order not to be too detrimental for the SO3 decomposition, the amount of water is too high for the downstream section.

UNIT 300 - H2SO4 CONCENTRATION



SOLAR RECEIVER, H_2SO_4/SO_3 DECOMPOSITION AND SO_2 SEPARATION

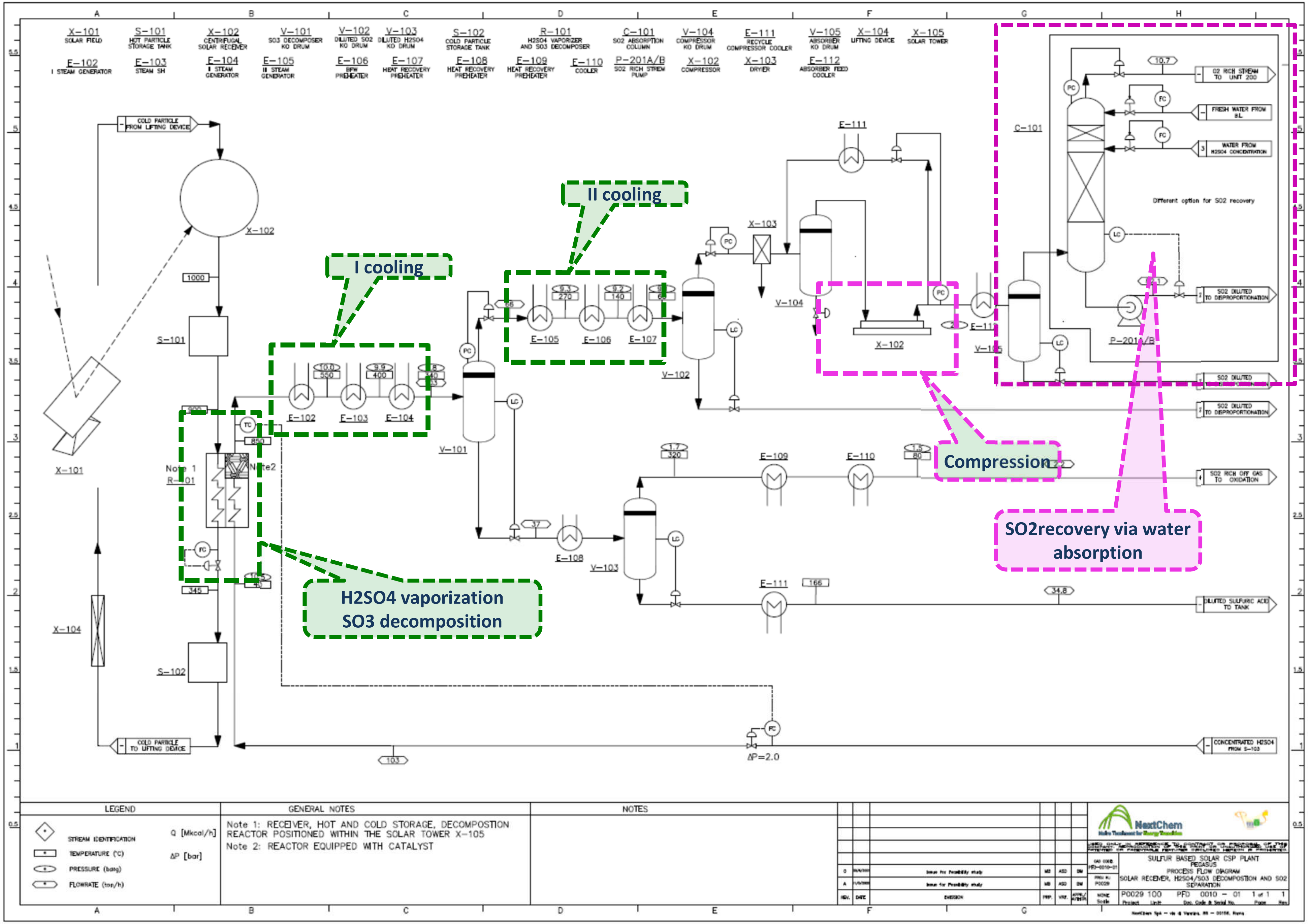
To increase di efficiency of downstream H_2SO_4 concentration, as process optimization it has been decoupled pressure of the reaction section and pression of the SO_2 absorption unit.

By introducing a compression stepo of the SO_2-O_2 mixture, the Water/SO_2 ratio of the absorption colum may be consistenlty reduced.

The resulting sulfuric acid solution is doubled moving from 16.5% to 36%w.

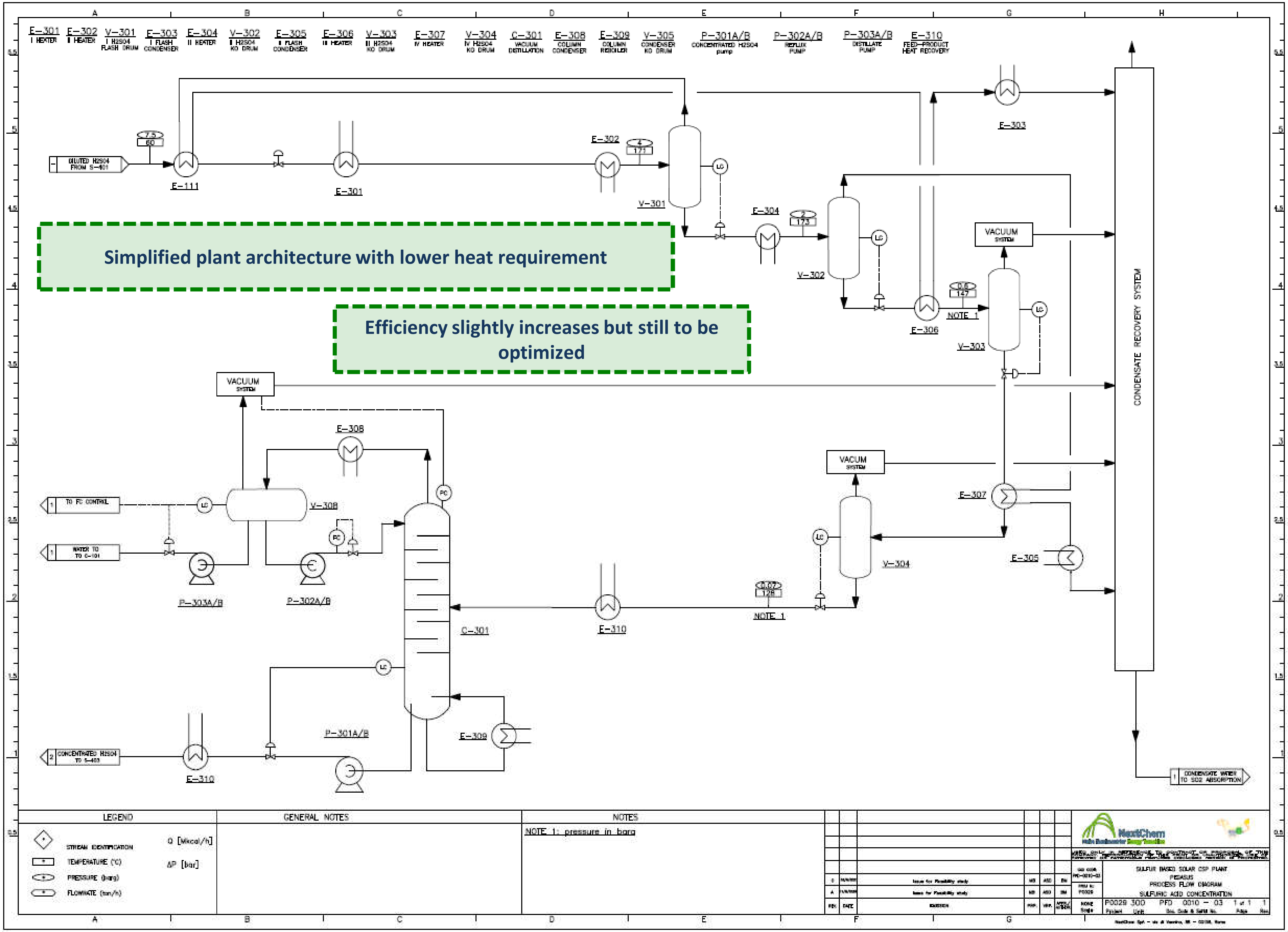
Simplified plant architecture with lower energy requirements.

SOLAR RECEIVER, H2SO4/SO3 DECOMPOSITION AND SO2 SEPARATION



H2SO4 CONCENTRATION SECTION

From 7 stage towards
4 concentration stages



Simplified plant architecture with lower heat requirement

Efficiency slightly increases but still to be optimized

A further optimization of SO_2 recovery has to be carried out in order not to penalize the overall process efficiency:

Despite the reduction in steam consumption due to increased pressure, a solution based on absorption with pure water still accounts for the downstream disproportionation step an excessive amount of water that consumes to much steam for concentration via vaporization with a consequent penalty on global efficiency.

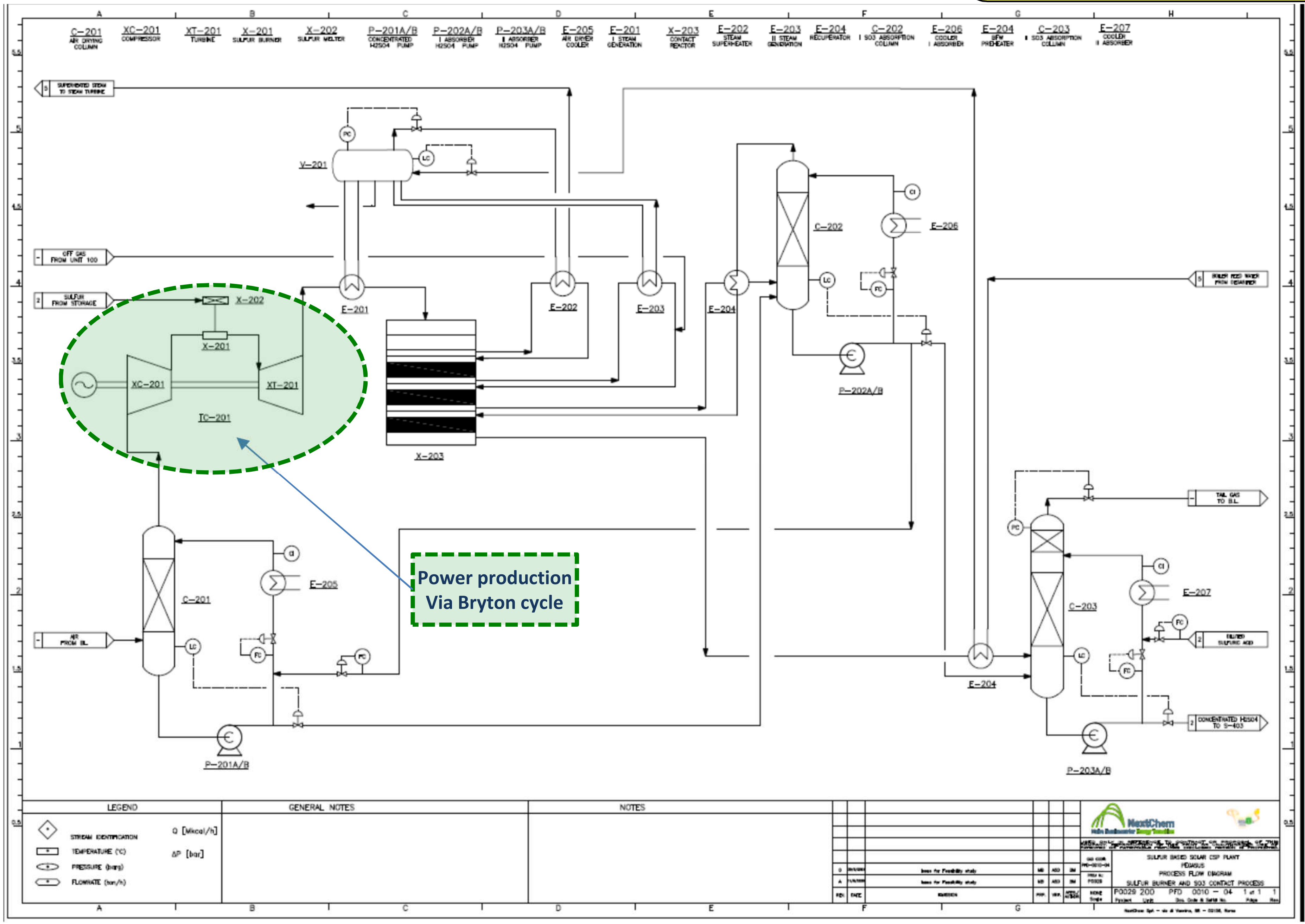
This suggests to move towards a REGENERATIVE ABSORPTION that means an architecture based on absorption and stripping column. Moving towards a regenerative scheme, SO2 may be recovered without diluting SO2. Several industrial applications are available on the market mainly for flue gas treatment application.

Estimated consumption available from literature is in order of 3,5 - 9 kg LPS/kg SO2 recovered, depending on adopted conditions (DuPont. 2012). Although still using steam, the latter is a low-pressure steam that can be easily recovered as waste heat with a reduced impact on the overall power production.

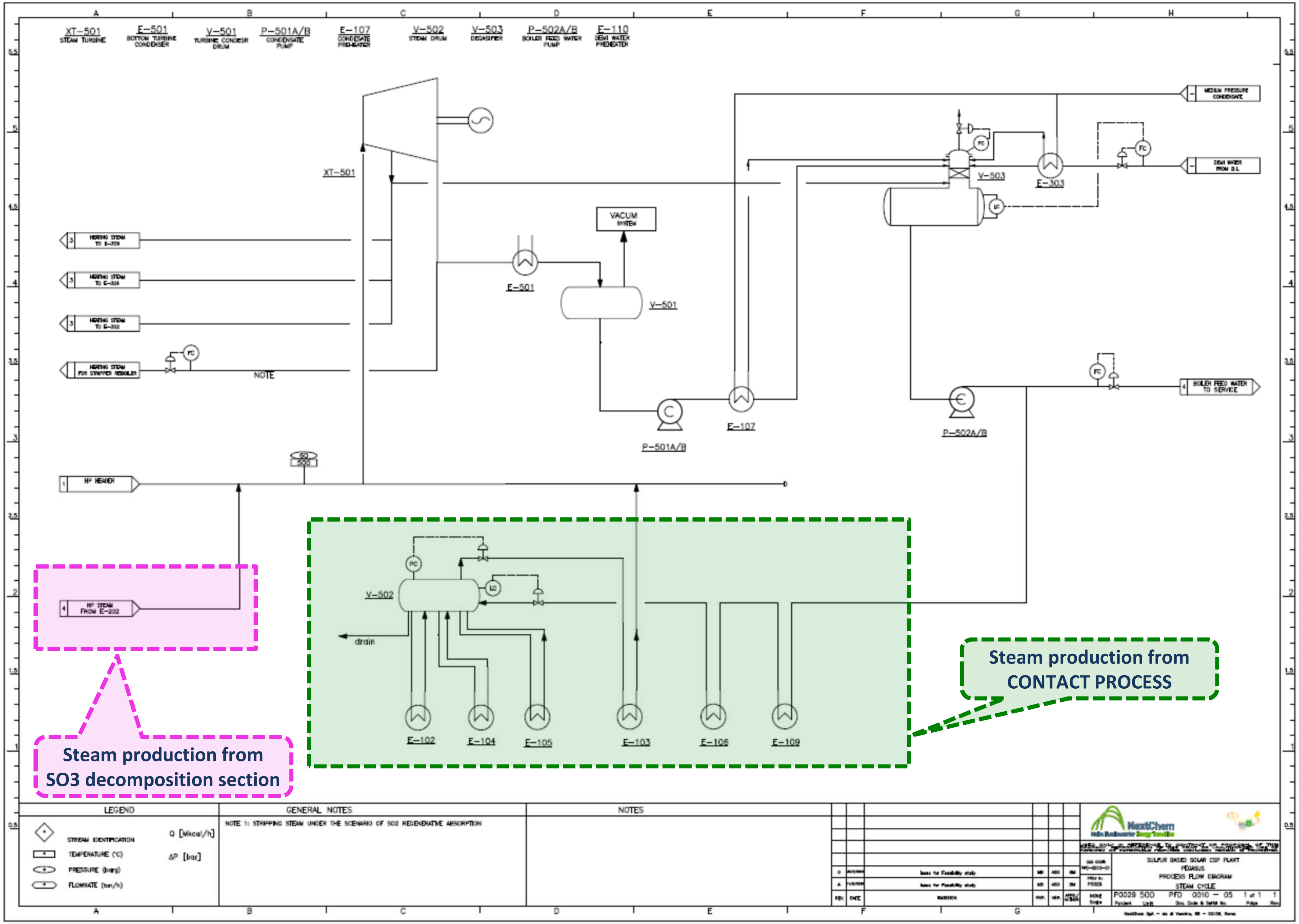
Under this figure steam requested for SO2 stripping is collected as spillage from turbine thus with a lower impact on process efficiency.

UNIT 200 - DOUBLE ABSOPRTION PROCESS, SULFUR BURNER

SECTION III
Sulfur burner and Sulfuric acid making
$S + O_2 \rightarrow SO_2$
$SO_2 + 1/2O_2 \rightarrow SO_3$
$SO_3 + H_2O \rightarrow H_2SO_4$



UNIT 500 - STEAM CYCLE



OVERALL PROCESS EFFICIENCY

OVERALL PROCESS EFFICIENCY

the achievable net overall power production resulting from Rankine cycle is around 15.1MWe. The spillage of LPS (3barg) from steam turbine is diverted to SO2 regenerative reboiler. The low pressure at which spillage is carried out have a limited impact on power production lowering in the meantime the turbine condenser load. Under the above scenario adding the power production from Bryton Cycle and deducting around 1,1MWe for internal consumption, resulting overall net power production from combined cycle is in order 19.1 MWe. Resulting efficiency in converting solar energy into power is thus around 19.9%.

ROOM FOR PROCESS EFFICIENCY INCREASE

The latter is an interesting result once compared with target for CSP technology, also in relation to further improvement that can be achieved by the use of novel solvent for SO2 absorption, such as ionic liquid, characterized by a high SO2 loading combined to low regeneration heat. This figure can improve the overall power production from Rankine cycle thus increasing the overall efficiency.

NextChem S.r.l

Sede Legale:
via Guido Polidoro 1,
67100 L'Aquila, Italia
T +39 0862 763411
F +39 0862 763547

Sede Operativa:
Via di Vannina 88/94,
00156 Roma, Italia
T +39 06 9356771

www.mairetecnimont.com

NextChem
Maire Tecnimont for Energy Transition

NextChem

Maire Tecnimont for Energy Transition