Feedback on CAPE-OPEN use in implementing Gas Treatment components

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ifP *Energies nouvelles*

Content

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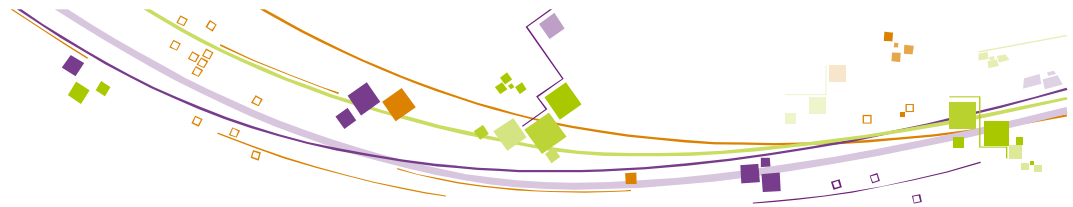
IFP Energies nouvelles in brief

- Public-sector research, innovation and training center
- In the fields of energy, transport and the environment
- Five strategic priorities
  - Renewable energies
    - Producing fuels, chemical intermediates and energy from renewable sources

  - Eco-friendly production
    - Producing energy while mitigating the environmental footprint

  - Innovative transport
    - Developing fuel-efficient, environmentally-friendly transport

  - Eco-efficient processes
    - Producing environmentally-friendly fuels and chemical intermediates from fossil resources

  - Sustainable resources
    - Providing environmentally-friendly technologies and pushing back the current boundaries of oil and gas reserves
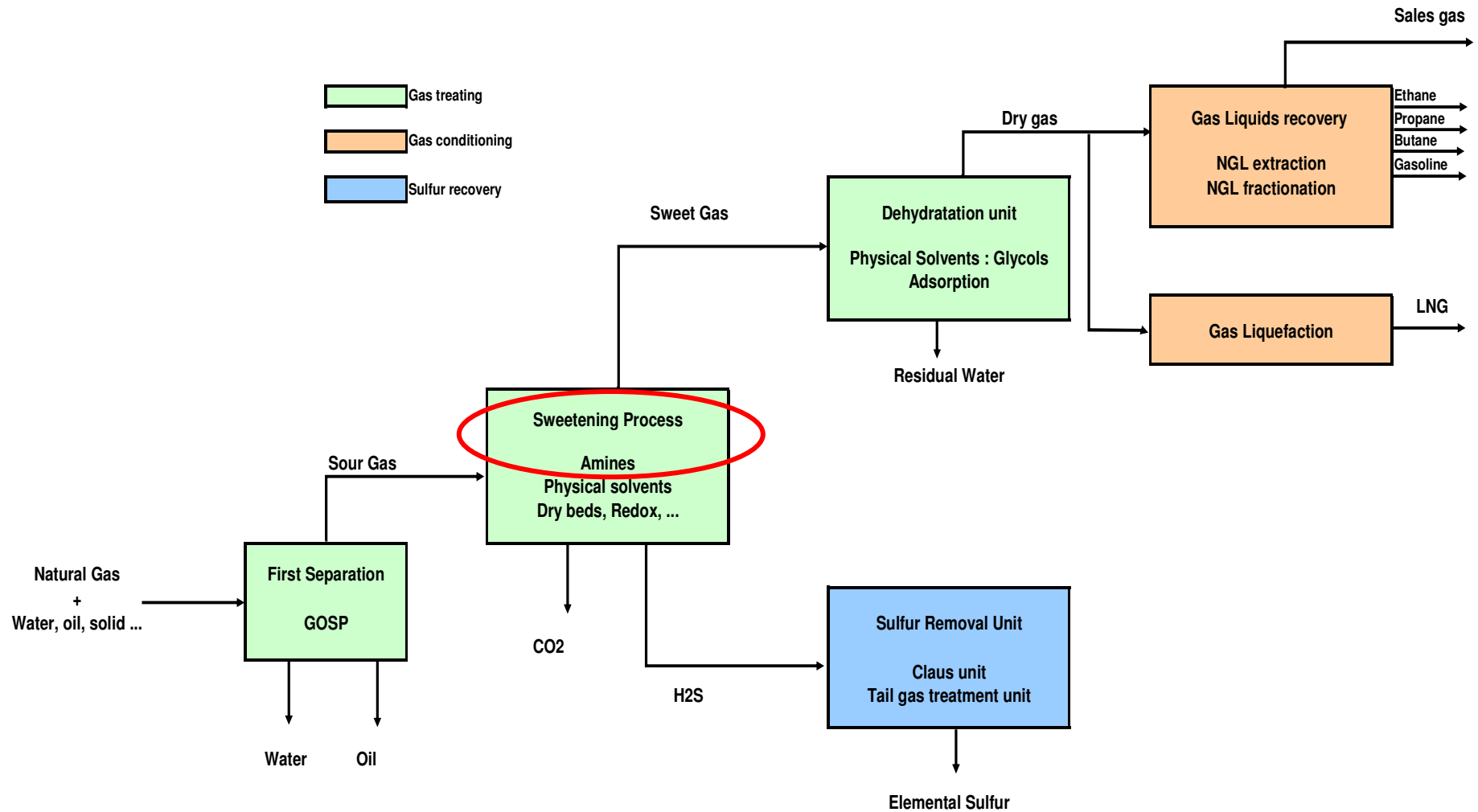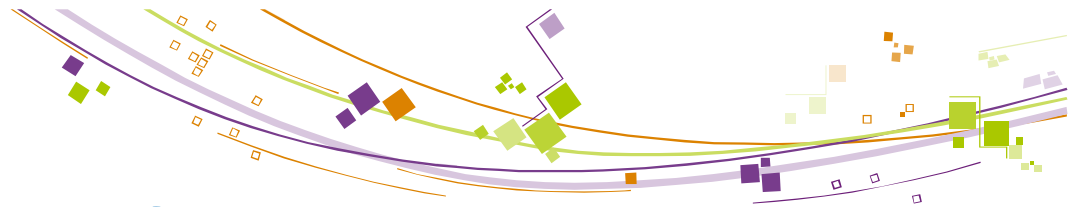
Content

- **IFP Energies nouvelles in brief**
- **Context and Objectives**
  - Gas Treatment
  - Amine based process for gas sweetening
  - Desulfo+ Project
- **Implemented components**
  - Unit Operations
  - Thermo system and Physical Properties Package (PPP)
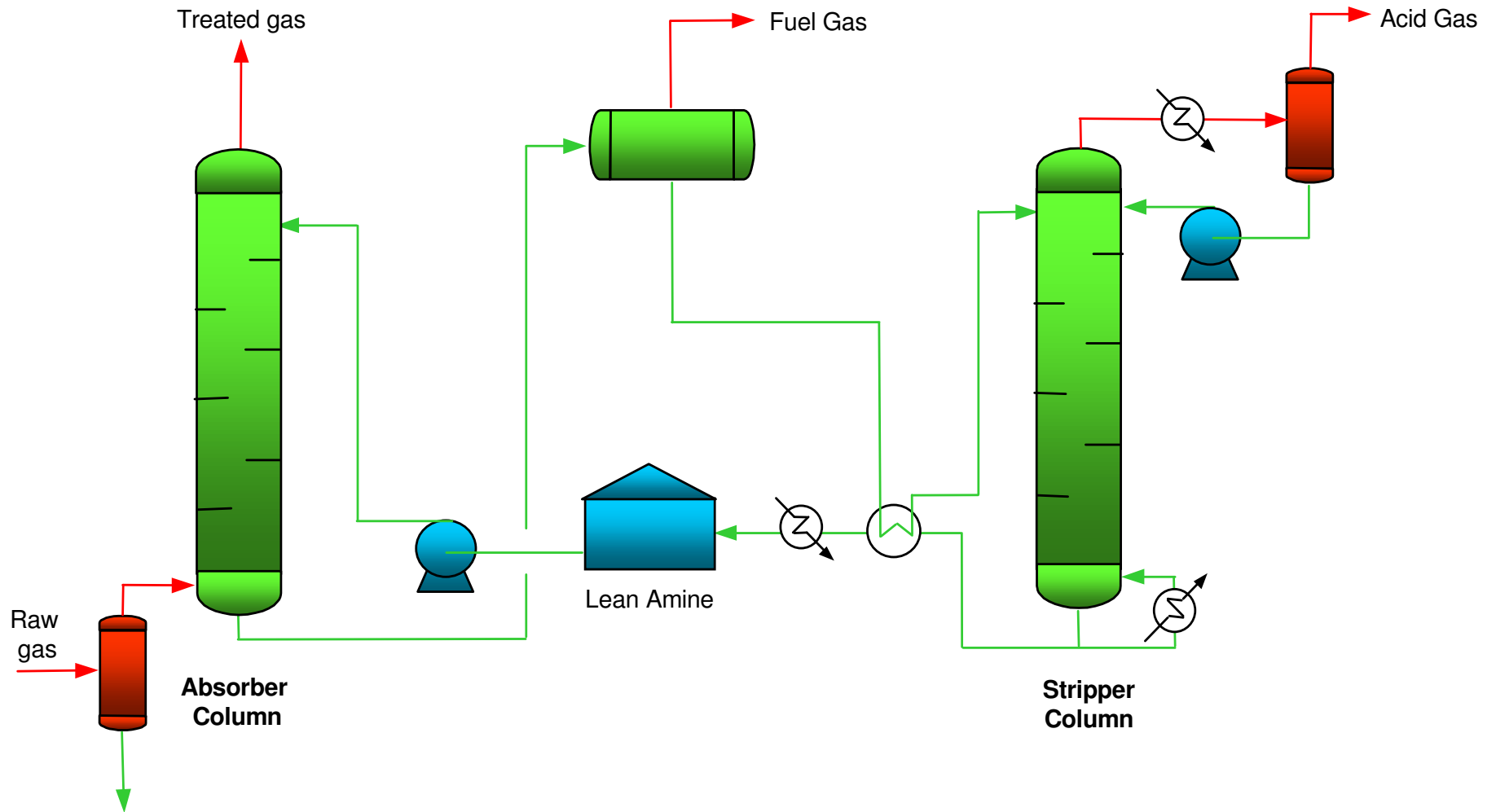 - Advanced development
- **Conclusion**

Natural Gas Processing

Legend:
- Gas treating (green)
- Gas conditioning (orange)
- Sulfur recovery (blue)

Flow diagram:

Natural Gas + Water, oil, solid ... → **First Separation / GOSP** → Water, Oil

First Separation → Sour Gas → **Sweetening Process / Amines / Physical solvents / Dry beds, Redox, ...** (circled in red)

Sweetening Process → CO_2

Sweetening Process → H_2S → **Sulfur Removal Unit / Claus unit / Tail gas treatment unit** → Elemental Sulfur

Sweetening Process → Sweet Gas → **Dehydratation unit / Physical Solvents : Glycols / Adsorption** → Residual Water

Dehydratation unit → Dry gas → **Gas Liquids recovery / NGL extraction / NGL fractionation** → Sales gas, Ethane, Propane, Butane, Gasoline

Dehydratation unit → **Gas Liquefaction** → LNG

Amine based process for gas sweetening

Treated gas

Fuel Gas

Acid Gas

Raw gas

Absorber Column

Lean Amine

Stripper Column

Desulfo+ Project: Advamine^{TM}

- **Partnership**
  - **TOTAL**
    - Engages in all aspects of the petroleum industry
      - Upstream operations (oil and gas exploration, development and production, LNG)
      - Downstream operations (refining, marketing and the trading and shipping of crude oil and petroleum products).
    - One of the world's largest integrated chemical producers

  - **PROSERNAT**
    - Subsidiary of HEURTEY PETROCHEM and IFP Energies Nouvelles
    - Supplies equipments and technologies to natural gas industry
      - Process Licensor of Acid Gas Removal units and Sulfur plants
      - Supplier of Modular Units in O&G Processing facilities

Desulfo+ Project: Advamine[TM]

- **What is Desulfo+**
    - Amine based processes for gas sweetening simulator
    - Inclusive of mass transfer rate-based models for acid gas reactions with liquids
    - Upgraded version of in-house software "Desulfo", initially developed by TOTAL
    - Models rated by more than 40 years experience of plant operation and process data from on-running Gas Sweetening Units

- **Existing Standalone software "Desulfo"**
    - Implemented in Fortran
    - No user interface (input and output as keywords file)
    - No interoperability with other process tools

- **Existing software needs:**
    - More user-friendly GUI
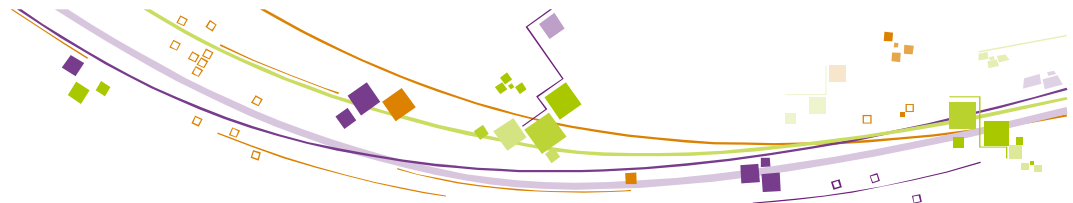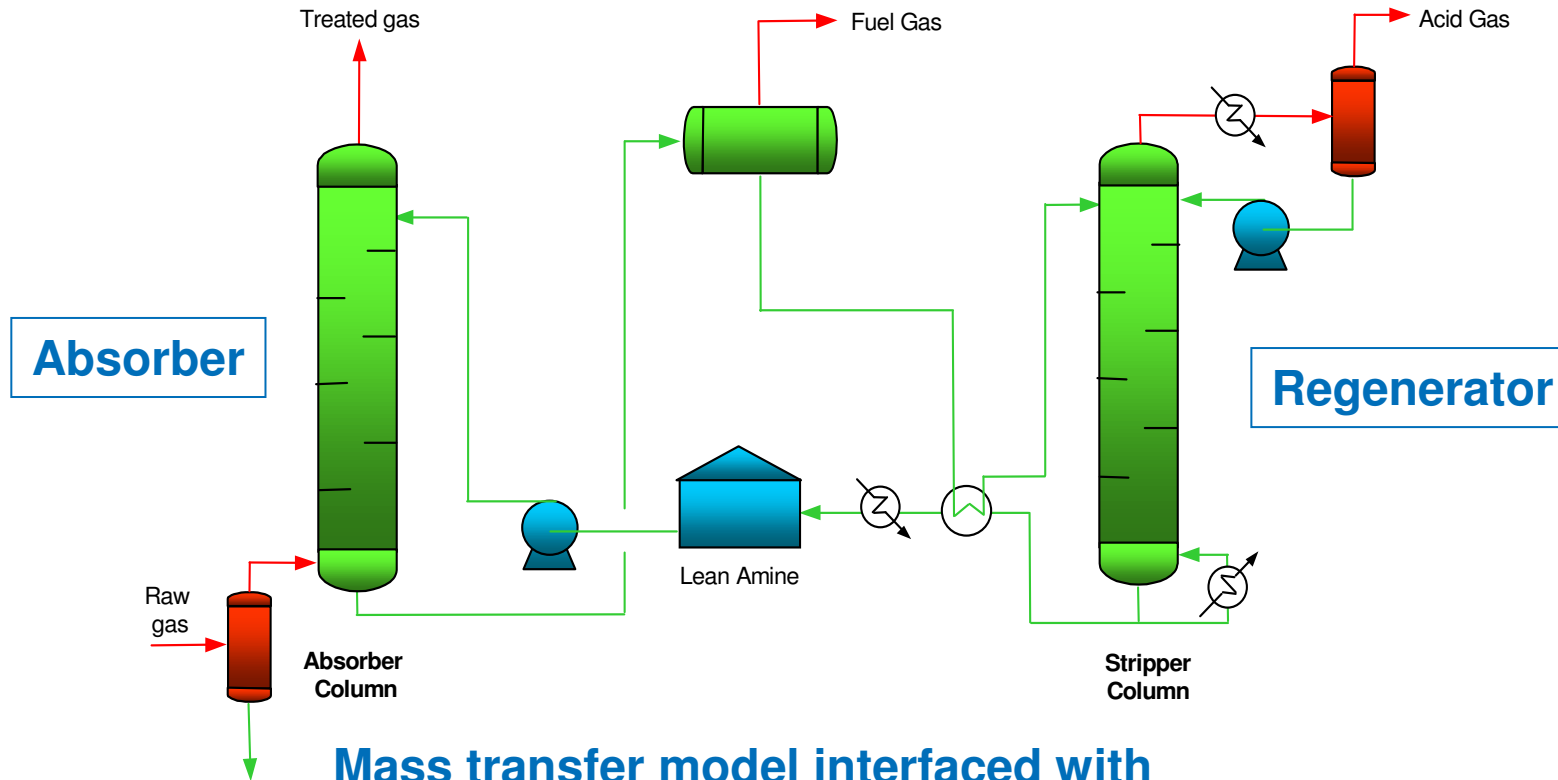   - Advanced features (eg. controller / optimizer / reporting / ...)

Desulfo+ Project: Advamine^{TM}

- **Why CAPE-OPEN Standard ?**

  - Interoperability with process tools

  - Portability in most of process simulation environment

  - Modularity / Maintainability

- **New software "Desulfo+"**

  - Keeps the proprietary models from Desulfo

  - Uses the PME Interfaces for input (GUI) and outputs (reporting facilities)

  - Uses some native UO from PME (Flash drum, HX, Pumps, ...)

 - Offers more interoperability with other process tools
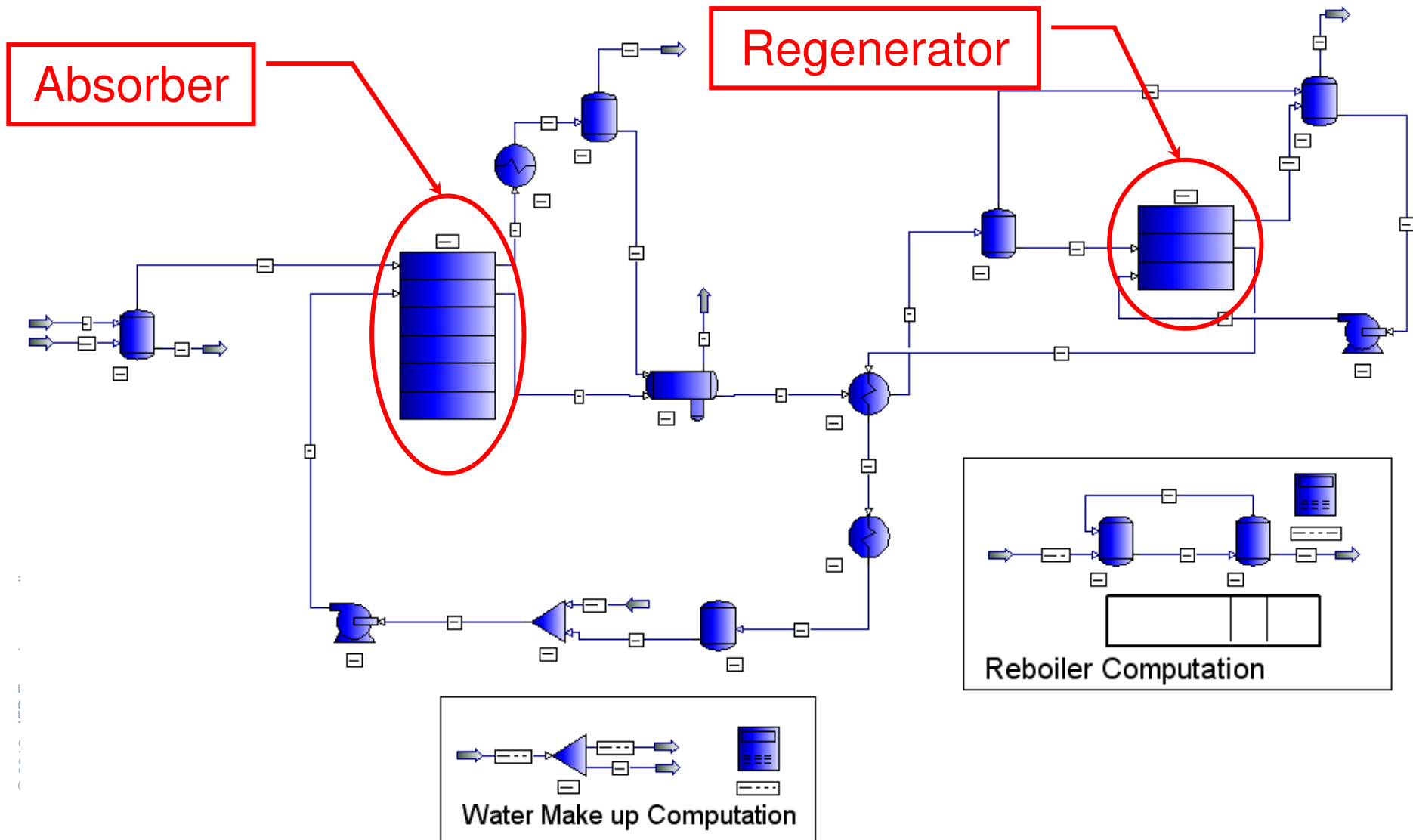
Desulfo+ in simulation of amine based process

Treated gas

Fuel Gas

Acid Gas

Absorber

Regenerator

Lean Amine

Raw gas

Absorber Column

Stripper Column

Mass transfer model interfaced with thermodynamics:
- **Consider thermal transfer models**
- **Consider rated calculations of hydraulics on various types of tower internals**
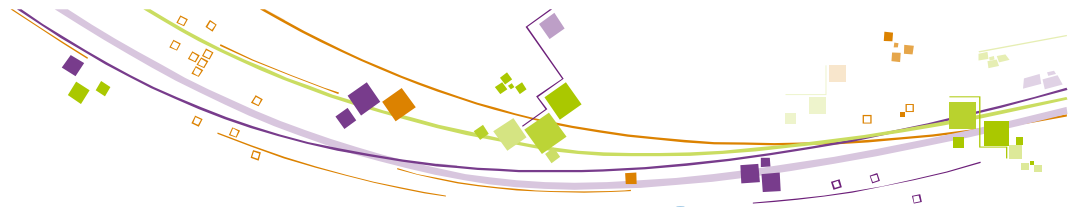
Absorber

Regenerator

Reboiler Computation

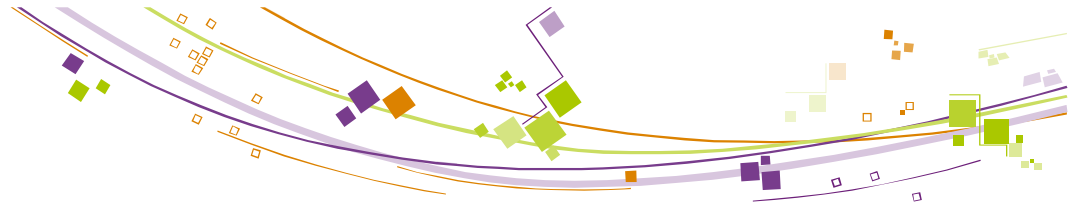Water Make up Computation

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    - Advanced development

- **Conclusion**

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Implemented Components

- **Unit Operations**
    - Regenerator
    - Absorber

- **Thermo System / Physical Property Package (PPP)**
    - Extended in-house thermodynamic server (CARNOT)
    - Delegate equilibrium computation to PME built-in thermo using properties computed by our PPP
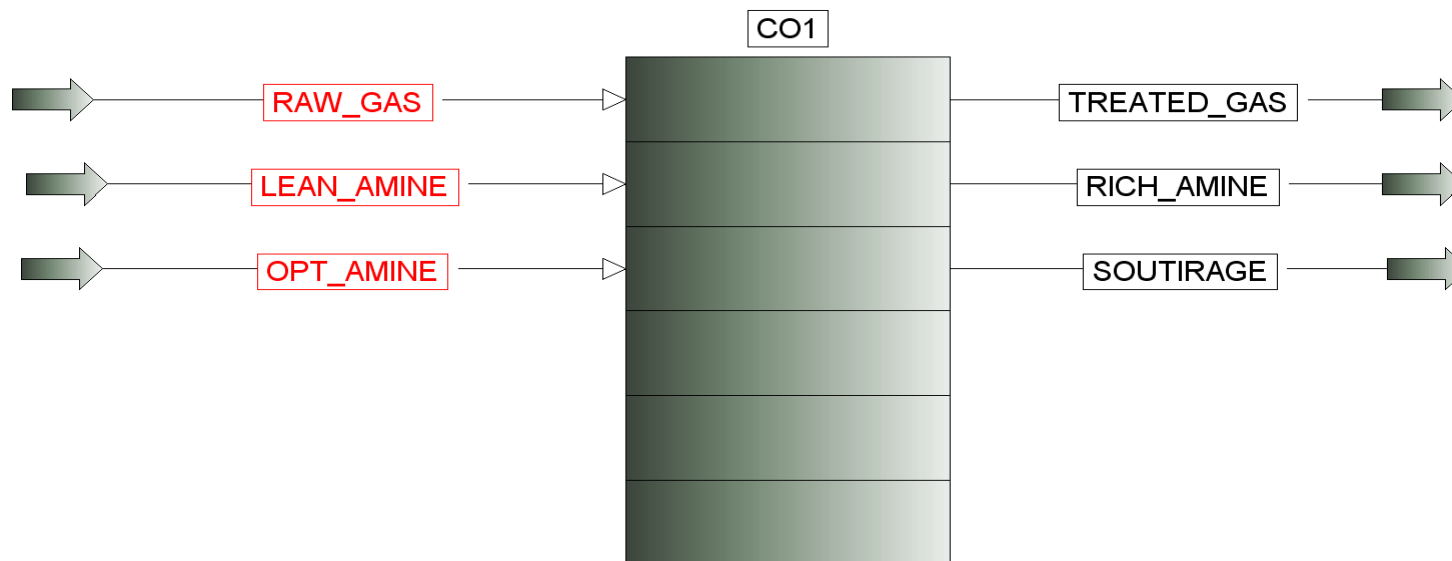   - CAPE-OPEN thermodynamics v1.0
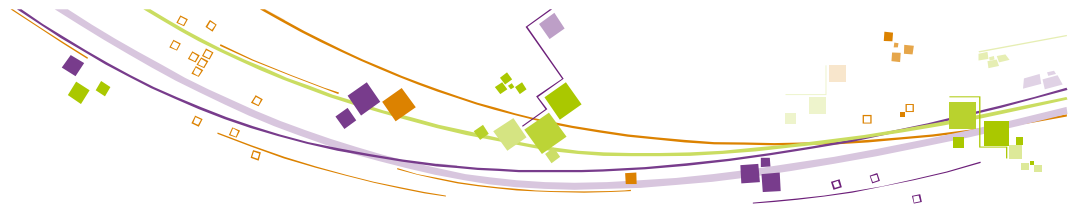
Unit Operations

Absorber

- **3 input ports**
  - Raw Gas (mandatory)
  - Lean Amine (mandatory)
  - Other Amine (optional)

- **3 output ports**
  - Treated Gas (mandatory)
  - Rich Amine (mandatory)
  - Draw off (optional)

CO1

RAW_GAS → TREATED_GAS

LEAN_AMINE → RICH_AMINE

OPT_AMINE → SOUTIRAGE
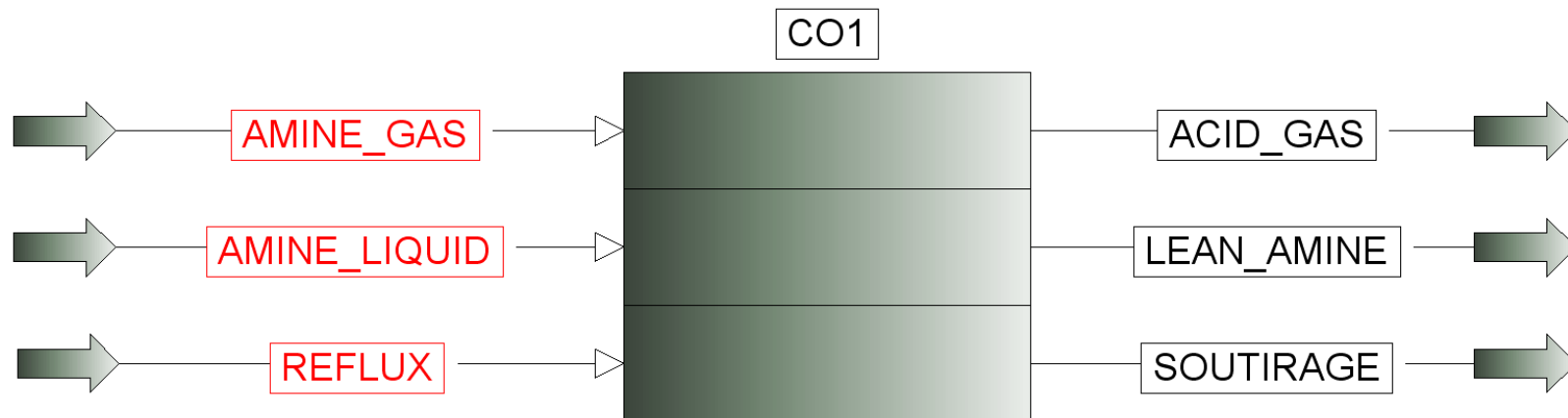
Unit Operations

Regenerator

- **3 input ports**
  - Rich Amine Gas phase (mandatory)
  - Rich Amine Liq. phase (mandatory)
  - Reflux (mandatory)

- **3 output ports**
  - Acid Gas (mandatory)
  - Lean Amine (mandatory)
  - Draw off (optional)

CO1

AMINE_GAS → ACID_GAS

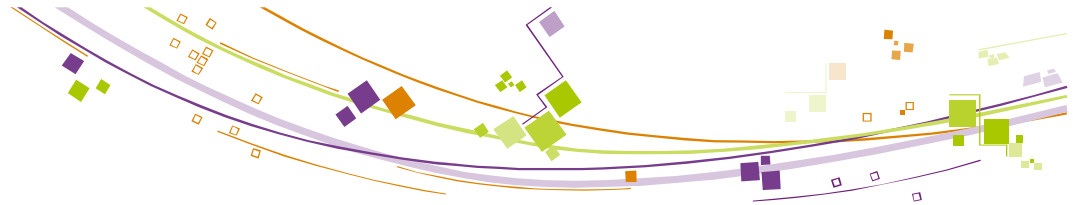AMINE_LIQUID → LEAN_AMINE

REFLUX → SOUTIRAGE

Interoperability within PME

- **PRO/II (Invensys)**
  - Begin project with v8.x
    - Some CAPE-OPEN defects
  - Currently, using Pro/II v9.1.1
    - Better CAPE-OPEN compliance

- **Aspen HYSYS (AspenTech)**
  - Tests in progress with v7.3

Advanced Development

- **Performance**
  - Cached computation in calcProp from PPP
    - No computation if input thermodynamics conditions are the same

- **Dynamic ports**
  - Pro/II allows dynamic ports management on editing UO GUI

- **Future developments**
  - Multithreading

Feedback

- **Not so difficult**
    - Business approach (Modular in terms of business entities)
    - Only few methods to implement
    - Some tools to spy on what happen (eg, COLTT)

- **Not so easy**
    - Integration into black box software
        - Where is the bug?
    - How to implement specifications?
    - Management of supporting industrial simulator, itself under upgrade and delivery of new releases of CAPE-OPEN compliant simulator
    - Delay to fix bugs if from third-party supplier
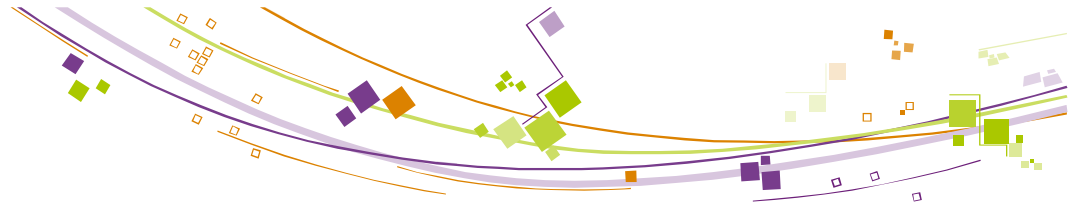   - Not same delay from owner company (few days) to third-party (few months)

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- **Conclusions and perspectives**

Conclusions and perspectives

- IFPEN and its partners have developed models and tools for Amine based processes for Gas Sweetening simulation
  - Based on CAPE-OPEN Standard
  - Gain
    - User Friendly software
    - Improved flexibility to implement adds
  - Difficulties
    - Interface with third party supplier and management of support software
    - Need lot of time
      - Development / Testing (compare to monolithic codes)

Conclusions and perspectives

- **Perspectives**
  - Use in design of gas sweetening plants & analysis of industrial logs
  - New developments
    - New Unit Operations models
    - New Thermodynamic models
    - Multithreaded computation
  - Portability studies (Aspen Plus, ProSimPlus, ...)

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