



Interoperability with CAPE-OPEN.

A demonstration to re-use a MATLAB® unit model in different process simulators.

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Anlagen- und Prozesstechnik

Linde

Agenda



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1. Motivation
2. What is CAPE-OPEN?
3. Who is CO-LaN?
4. How does interoperability work with CAPE-OPEN?
5. Why is CAPE-OPEN important for Linde Engineering?
6. Why is CAPE-OPEN important for you?



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Current Situation

- CO-LaN develops and promotes the CAPE-OPEN standard
- CAPE-OPEN standard allows interoperability between different engineering tools
- CAPE-OPEN is actually implemented in many commercial and academic engineering tools
- Industrial engineers have a rather low awareness about CAPE-OPEN
- Linde is member of the non-profit organization CO-LaN
- CAPE-OPEN is part of Linde Engineering's IT strategy

Objective

- Create awareness about CAPE-OPEN and CO-LaN
- Introduce into capability and applicability of CAPE-OPEN
- Introduce into business cases for Linde Engineering
- Show up business cases for industrial and academic engineers

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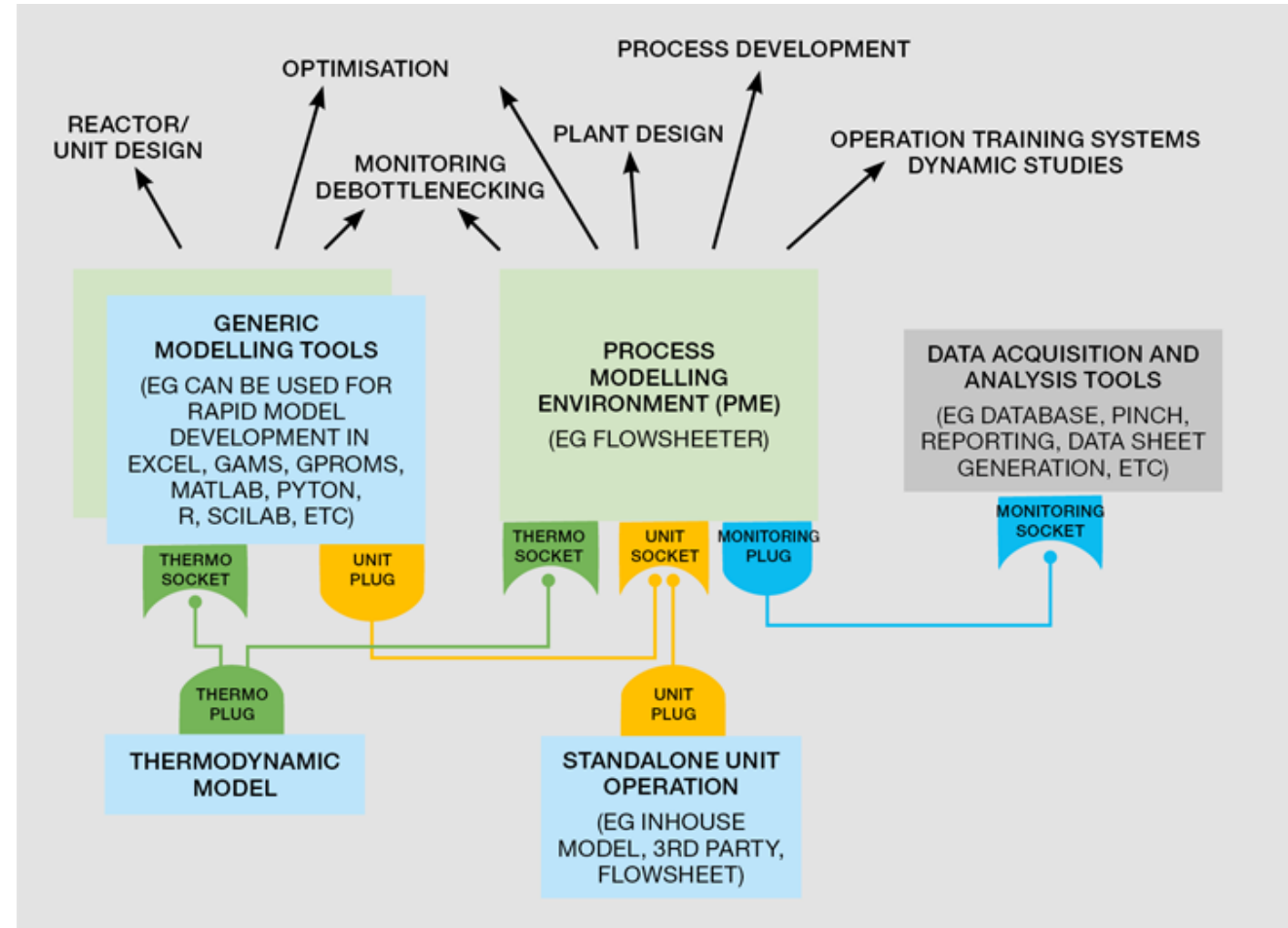


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What is CAPE-OPEN?



- The CAPE-OPEN standard defines rules and interfaces that allow CAPE (Computer-Aided Process Engineering) applications or components to interoperate
- CAPE-OPEN defines currently these (business) interface specifications:
 - Partial Differential Algebraic Equations
 - Numerical solvers
 - Thermodynamics and Physical Properties interface specification
 - Unit Operation interface specification
 - Petroleum Fractions
 - Chemical Reactions
 - Physical Properties Data Bases



Picture from The Chemical Engineer (11th January 2019)
<https://www.thechemicalengineer.com/features/better-together/>

Where is CAPE-OPEN implemented?



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Process Modeling Environments (selection)

- Scilab
- Aspen HYSYS
- COFE
- IndissPlus
- ProMax
- Simulis Thermodynamics
- BatchReactor
- gPROMS
- BatchColumn
- ProSimPlus
- Petro-SIM
- COMSOL
- UniSim Design
- VALI
- PRO/II
- Aspen Plus
- MOSAICmodeling
- XChanger Suite

Process Modeling Components (selection)

- MATLAB® Unit Operation
- REFPROP CAPE-OPEN
- MEMSIC
- CAPCO2
- VMGThermo
- COUSCOUS
- TEA
- Simulis Thermodynamics
- Aspen Properties
- Gas-Liquid Cylindrical Cyclone
- MultiFlash
- ChemSep
- IK-CAPE
- Shortcut
- Cosmotherm
- Scilab Unit Operation
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Who is CO-LaN?



- CO-LaN is a non-profit organization founded in 1995 (EU project)
- Membership is free for associate members (software vendors, universities and individuals)
<http://www.colan.org/category/member/2-corporate-associate-member/>
<http://www.colan.org/category/member/3-individual-associate-member/>
- Corporate full members (“industrial CAPE-OPEN users”) pay an annual fee and are represented in the management board
<http://www.colan.org/category/member/1-corporate-full-member/>



The missions of CO-LaN are:

1. Promote cooperation among CAPE software vendors to ensure that the CO standards actually translate into commercially valuable interoperability according to users priorities
2. Promote CAPE-OPEN standard to end-users and distribute CAPE-OPEN information and technology internationally
3. Maintain and develop CAPE-OPEN interface specifications
4. Supply testing facilities to support development of components and interoperability of PMC and PME vendors
5. Provide training, guidelines and tools for CAPE-OPEN development

Selected Additional References to CO-LaN and CAPE-OPEN



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- CAPE-OPEN on Wikipedia
https://en.wikipedia.org/wiki/CAPE-OPEN_Interface_Standard
- CO-LaN Homepage
<http://www.colan.org>
- MATLAB® Unit Operation potential improvements for academic use
<http://www.colan.org/presentation/matlab-uo-in-aspen-plus/>
- A Rate-Based Equation-Oriented Parallel Column Model: Application to Dividing Wall Columns
<http://www.colan.org/presentation/chemsep-dwc/>
- AmsterCHEM
<https://www.amsterchem.com/>

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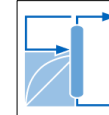
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Software components needed for demonstration:

1. CAPE-OPEN compatible process simulator
<http://www.colan.org/category/process-modeling-environment/>
2. MATLAB® CAPE-OPEN Unit Operation
<https://www.amsterchem.com/matlabunitop.html>
License needs to be requested, but free-of-charge for non-commercial use
3. MATLAB®
www.mathworks.com

MVP Lesson 4: Kinetic Reactor Unit in MATLAB®



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Input to MATLAB® model

Feed Conditions

$$T = 392\text{ °C}$$

$$p = 1.013\text{ bar}$$

$$\dot{N}_{\text{CO}} = 0.0025 \frac{\text{mol}}{\text{s}}$$

$$\dot{N}_{\text{H}_2\text{O}} = 0.0015 \frac{\text{mol}}{\text{s}}$$

$$\dot{N}_{\text{CO}_2} = 0.0001 \frac{\text{mol}}{\text{s}}$$

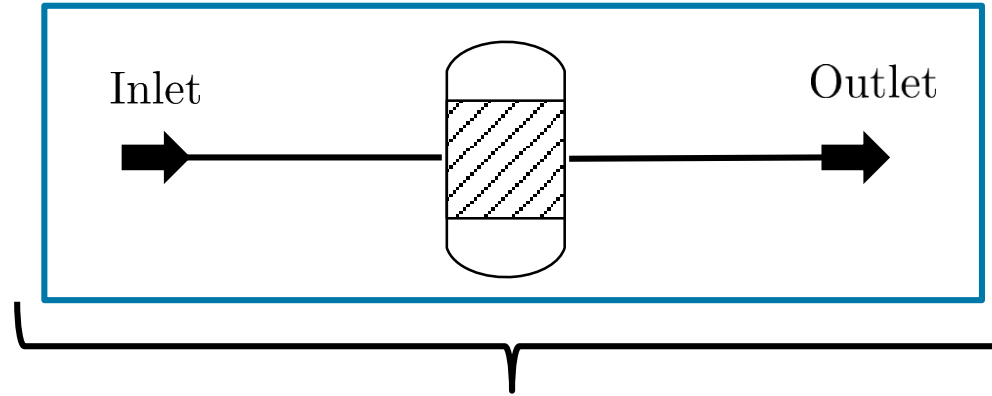
$$\dot{N}_{\text{H}_2} = 0.0002 \frac{\text{mol}}{\text{s}}$$

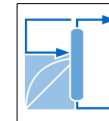
Reactor Geometry

$$d = 2.54\text{ cm}$$

$$L = 7.5\text{ m}$$

$$\rho_{\text{Sch}} = 4.6 \times 10^6 \frac{\text{g}_{\text{Kat}}}{\text{m}^3}$$





Input to MATLAB® model

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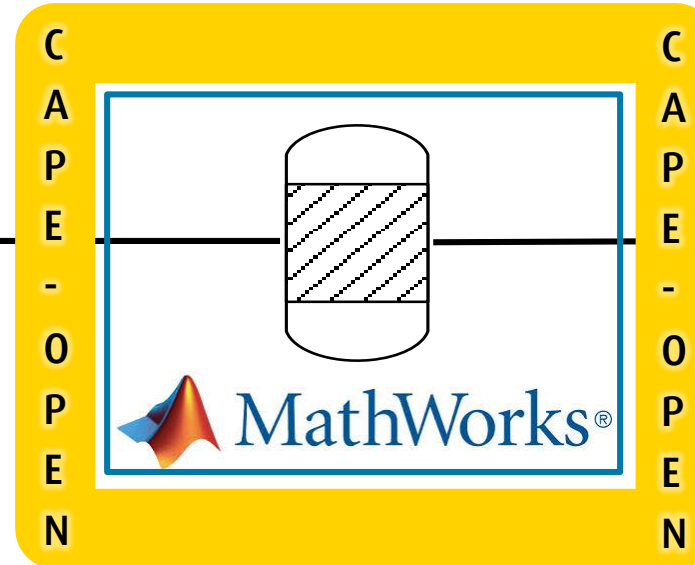
$$L = 7.5\text{ m}$$

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Honeywell

Inlet



Outlet

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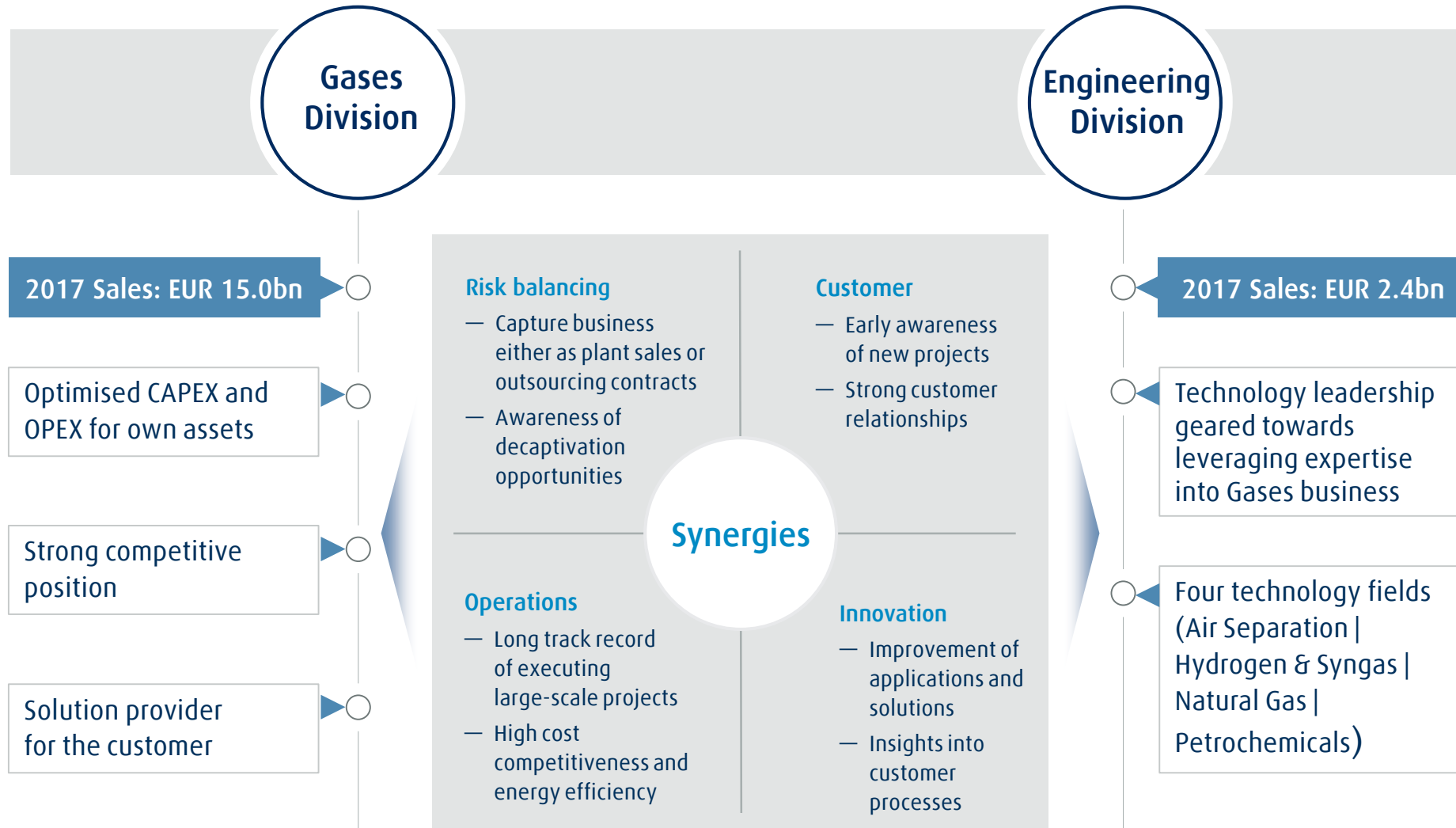
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Integrated Gases & Engineering model

Synergies built on strong Engineering foundation



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Engineering Division

Core competence in gas processing applicable to full portfolio



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6,144 employees*

3,000 engineers

1,000 process engineering patents
Expertise & experience

4,000 completed plant projects

Feedstock

Air
Hydrocarbons
Tail gases
Natural gas
Exhaust gases

Liquefaction

Separation

Thermal Cracking

Products

Hydrogen
Rare gases
Carbon dioxide
Nitrogen
Carbon monoxide
Olefins
Oxygen
Synthesis gas

Offerings

Components

Standardised plants

Customised plants

Services

Air separation plants



Hydrogen and Syngas plants



Petrochemical plants



Natural gas plants



For Linde Gas & third-party customers

For the chemical & energy-related industries

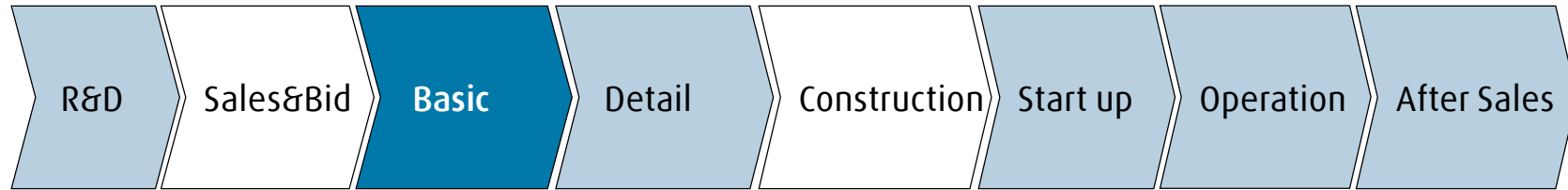
*Status: 31/12/2017

Process Simulation

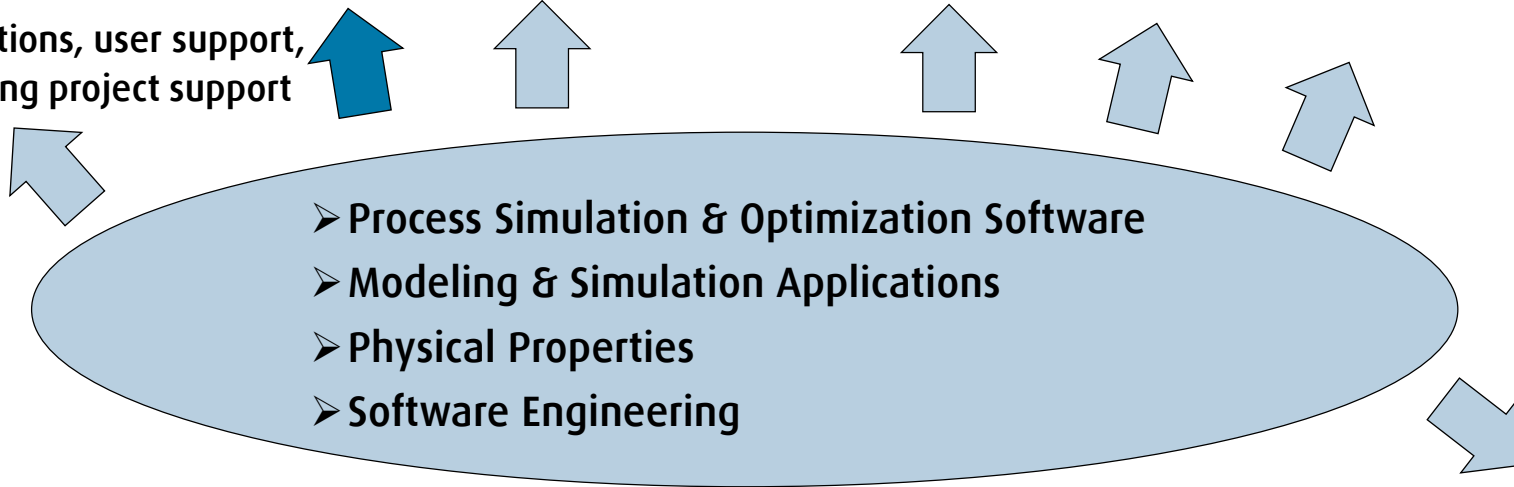
Overview – IT for Process Design & Control



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IT applications, user support,
engineering project support



Linde Engineering

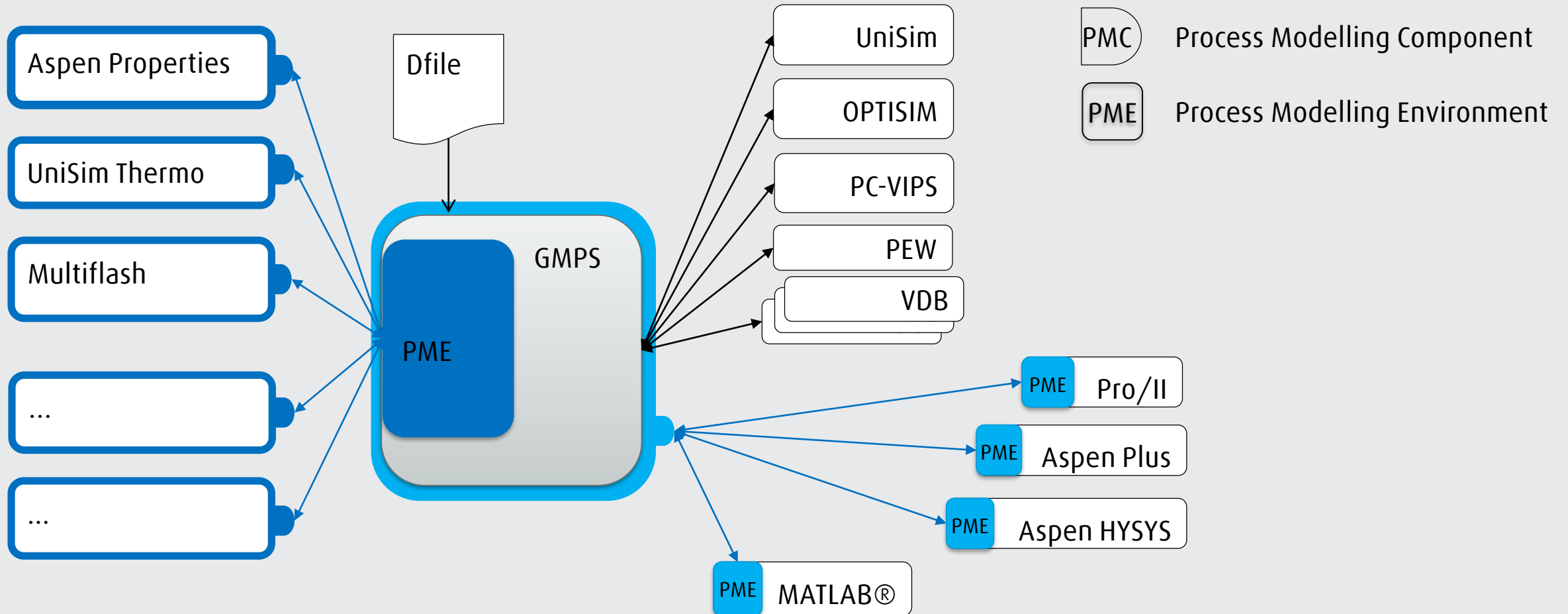
Linde Gas



CAPE-OPEN Thermo Interfaces to Linde's Thermo Package



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Applications
&
Process simulation tools

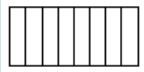
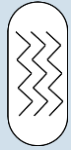
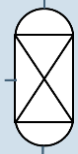

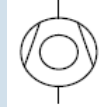
PdM

OPTISIM

PC-VIPS

UniSim & OTS



Process unit models
&
Physical properties









GMPS

Plate Fin Hex, Coil Wound Hex, Column, Membrane, Turbo compressor,
Cracking furnace, Cracked gas heat recovery, Reformer

Modeling software








SW engineering tools




Microsoft





Microsoft





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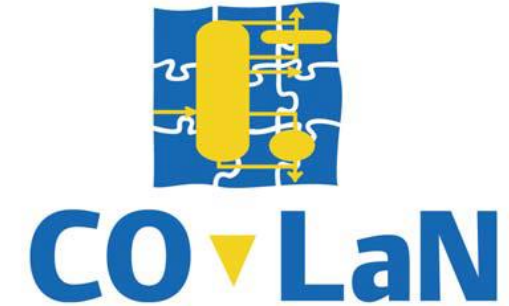


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Why is CAPE-OPEN important for me?



- CAPE-OPEN is the bridge to attach your unit or thermo model to other platforms
https://en.wikipedia.org/wiki/CAPE-OPEN_Interface_Standard
- CO-LaN maintains and develops CAPE-OPEN standard
<http://www.colan.org>
- CAPE-OPEN allows to create even more complex models based on existing pieces
- CAPE-OPEN can save you a lot of time and money by avoiding to re-invent the wheel





The whole is more than the sum of its parts
Aristotle (384 – 322 BC)



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