The benefits of Digital Twins and VR for greenfield projects

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AGENDA

- Intro to CEPSA and Inprocess
- PEP & DETAL Process
- Challenges & Solutions
- The OTS and 3D VR Models
- Benefits to CEPSA

inprocess

independent from any provider (process simulator or ICSS)

our **core business** is Process Simulation

keen to **share its knowledge** with clients

2006 est. in Barcelona by domain experts	**55 countries** worldwide presence	**60+** simulation engineers
3000+ years experience	**400+** executed projects	**330+** training courses

Mission

accompany our clients in their success in achieving **safer**, **greener**, more **reliable** and more **profitable** industrial operations

Inprocess Solutions & Services

Lifecycle Modelling and Operator Training Simulators

Process Simulation Studies

Professional Development & Training

Applications and Software Products

About CEPSA

Cepsa is a **global, integrated** company operating across **the entire oil and gas value chain** and with over 90 years of experience.

Chemicals is one of the engines that is driving our internationalization and one of the areas where we are growing the most.

We are the **world leading producer** in **Alkylbenzene** (600 kMT/y total capacity)

Three LAB* Production sites located in San Roque (Spain), Becancour (Canada) and Camaçari (Brazil)

10,000 PROFESSIONALS

Who work with technical excellence, an ability to adapt, and an innovative spirit. They help us to stay competitive and are the key to face and overcome future challenges.

EXPERIENCE

We are supported by 90 years' experience in the oil world, making us a leading and robust company.

FIVE CONTINENTS

We operate across the entire oil value chain in five continents through our businesses in Exploration and Production, Chemicals, Refining, Distribution and Marketing, Gas & Power, and Trading.

INTERNATIONAL OUTLOOK

Our leadership in chemicals, combined with our broad experience in project execution across the world, helps us to grow internationally.

INTEGRATED BUSINESS

The physical integration of our production plants strengthens our model, reduces logistical costs and increases synergies.

SUSTAINABLE ENERGY

Our main priorities are to provide society with a safe, reliable and sustainable energy and contribute to the economic and social development of the communities where we work.

CUSTOMER SATISFACTION

Our commitment to the quality of our products and services and to the satisfaction of consumers forms the base of our customer relationship.

CHEMICALS LEADERSHIP

We are world leaders in LAB production (the raw material used to make biodegradable detergents), and in cumene. We are also the second world producer of phenol, used to make high performance materials, and acetone.

INNOVATION AND TECHNOLOGY

Innovation underpins everything we do. We have a Research Center that helps us to create value, optimize processes and improve the quality of operations and products.

CEPSA is an integrated oil & gas Company and the largest Linear Alkylbenzene producer in the World (600 kMT/y)

*LAB- Linear Alkylbenzene

Puente Mayorga Petrochemical Plant produces LAB, raw material for biodegradable detergents. It supplies around 50% of the African and 25% of Western Europe markets

250 kt/y LAB

80 kt/y LABSA

400 kt/y Paraffins

100 kt/y Solvents

- Began operations in 1969 to produce LAB, raw material for Biodegradable Detergents
- Located at Algeciras Bay
- First plant ever to retrofit to Detal Technology (2021)
- Betting on quality: First company in Spain to achieve ISO 9001 certification (year 1992)

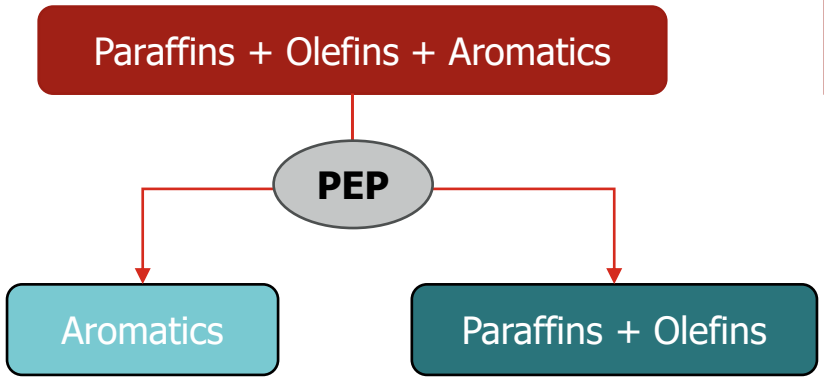
Source: Corporate Strategy

The capacity expansion and technology revamp

- Cepsa implemented a new upgrade project to expand production at its Puente Mayorga Chemical Plant in San Roque (Cadiz). The revamping process covers the installation of the new Detal technology, co-licensed by Cepsa and UOP, the most modern and efficient technology for the production of linear alkylbenzene (LAB), as well as increasing production capacity at the plant from 200 to 250 Kt/yr

https://www.youtube.com/watch?app=desktop&v=uDaLeUb0ij8

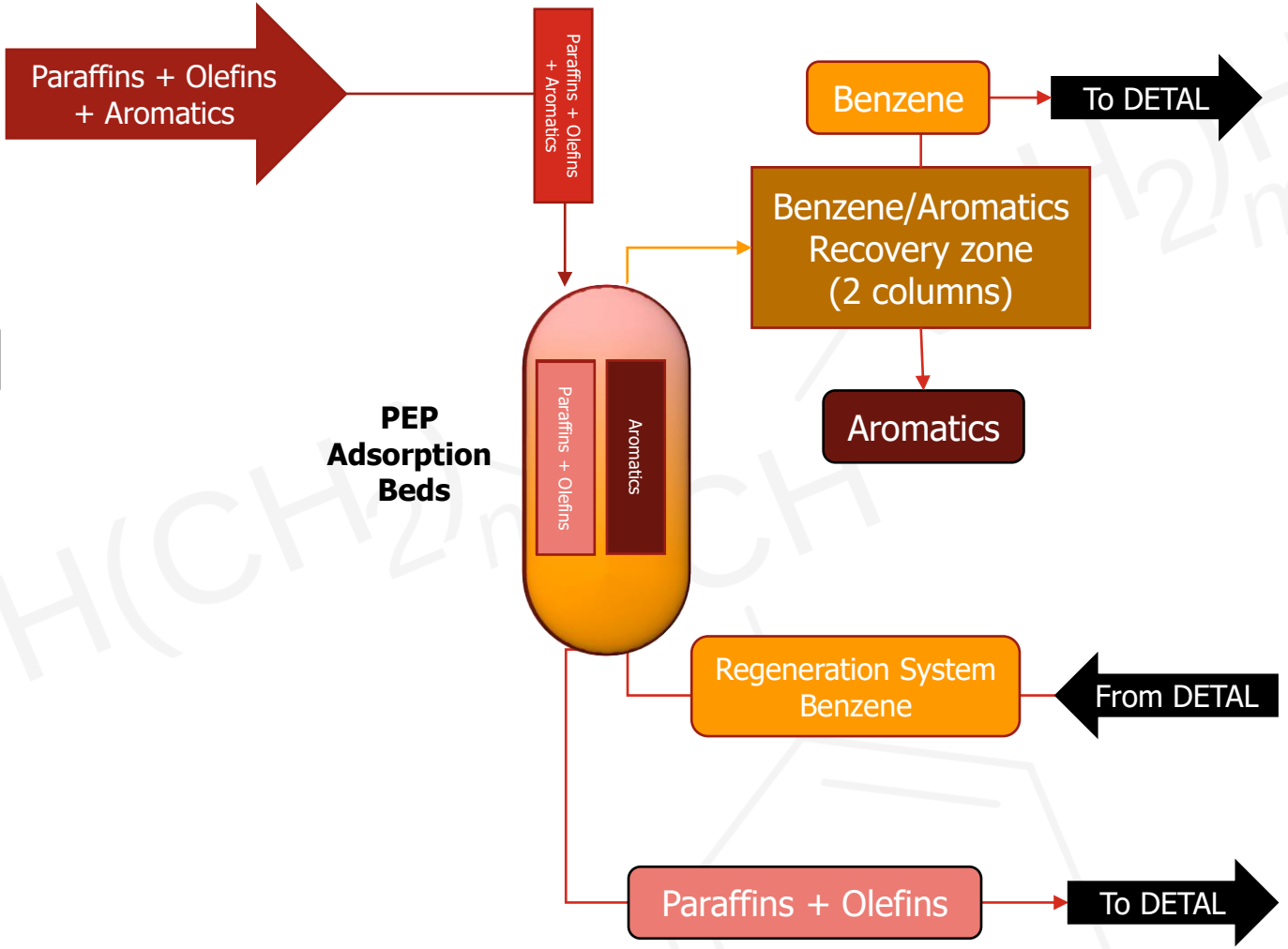
DETAL Process Description



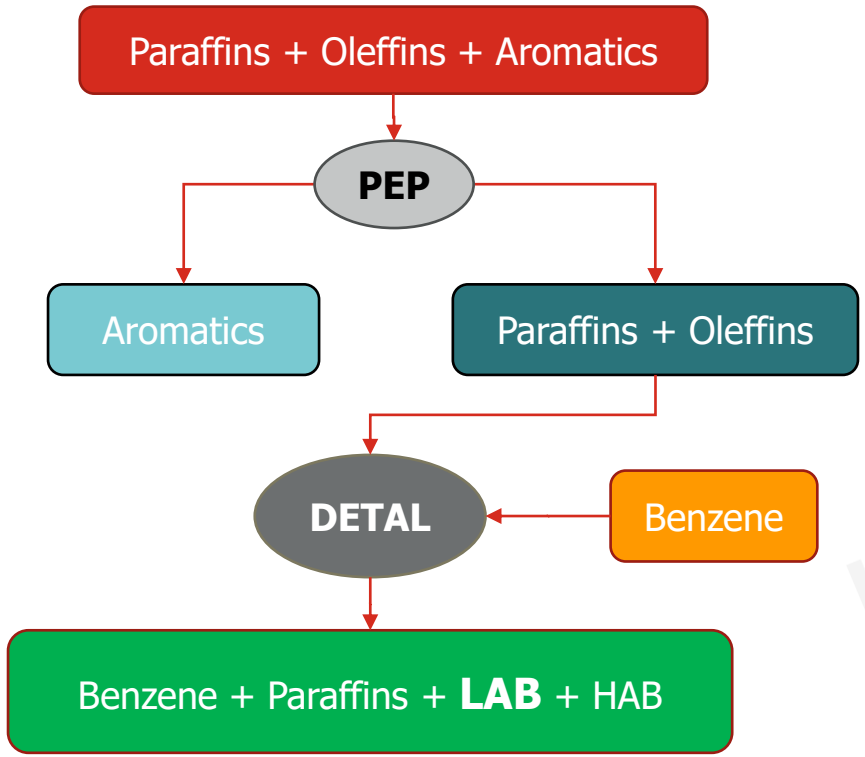
PEP Unit: Objective

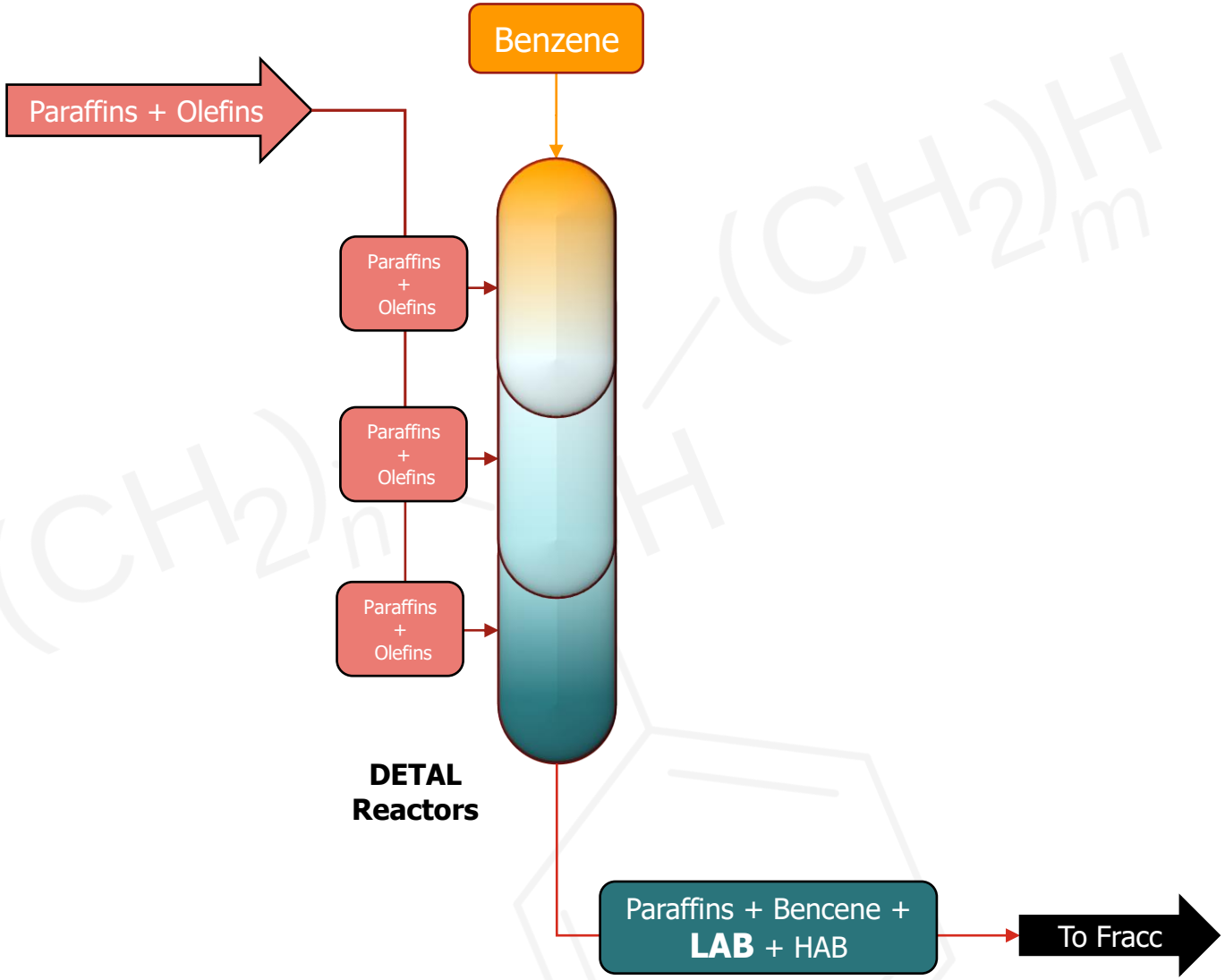
The feed stream is composed of Paraffins, Olefins and Aromatics These aromatics have to be eliminated to avoid the HAB formation in DETAL reactors, which reduced the LAB performance.

PEP Adsorption beds is used to do the Aromatics separation



DETAL Process Description

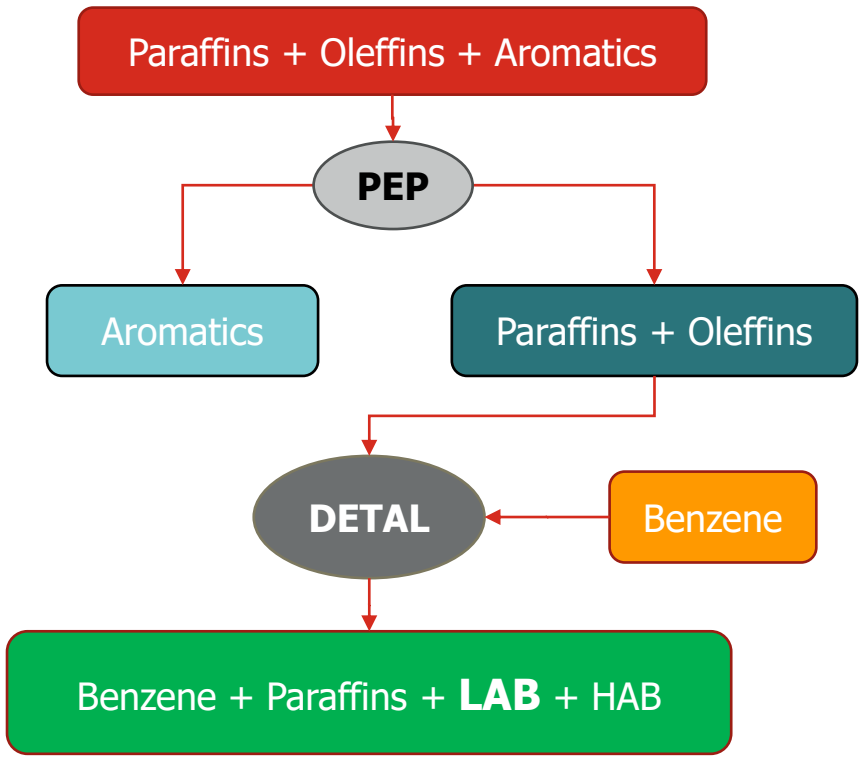




DETAL Unit: Objective

LAB (**L**inear **A**lkyl **B**enzene) is obtained in the DETAL reactors. Olefins fed from PEP Unit react with Benzene in DETAL selective catalytic reactors to obtain LAB mainly

DETAL Process Description



DETAL Unit: Objective

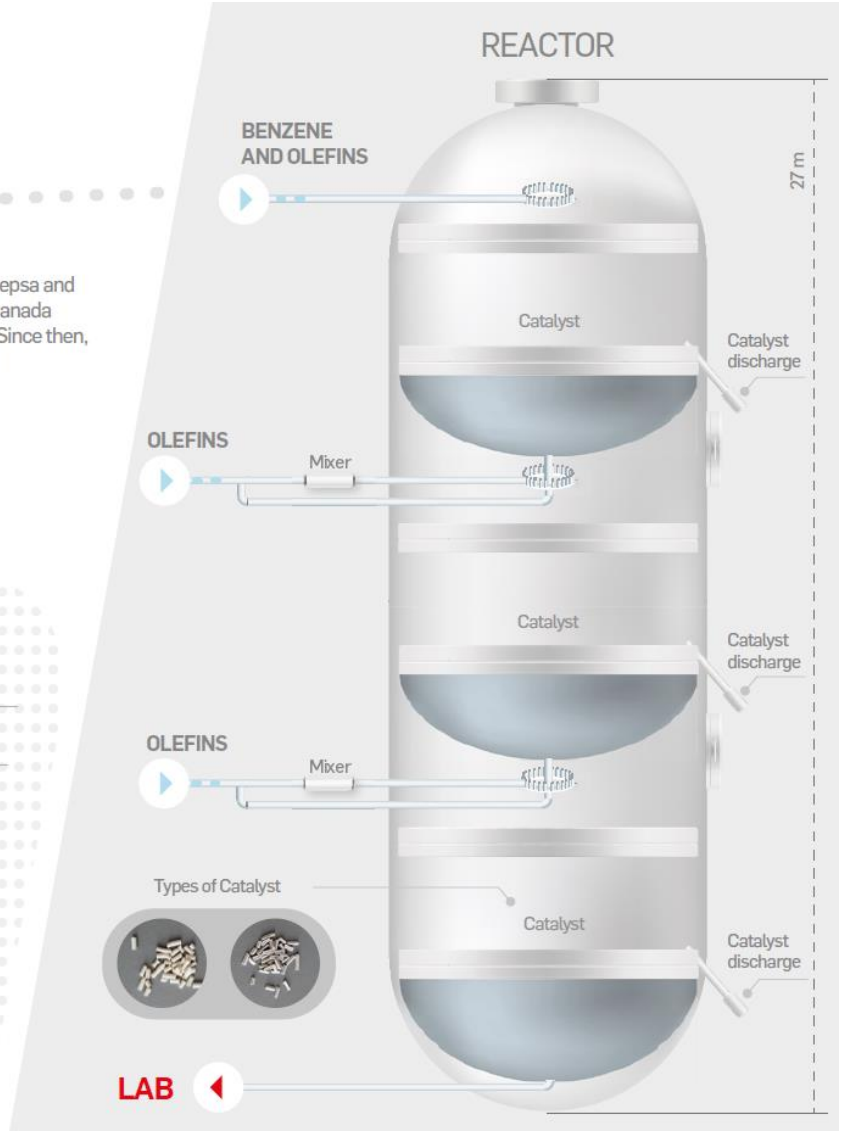
LAB (**L**inear **A**lkyl **B**enzene) is obtained in the DETAL reactors. Olefins fed from PEP Unit react with Benzene in DETAL selective catalytic reactors to obtain LAB mainly

DETAL Technology

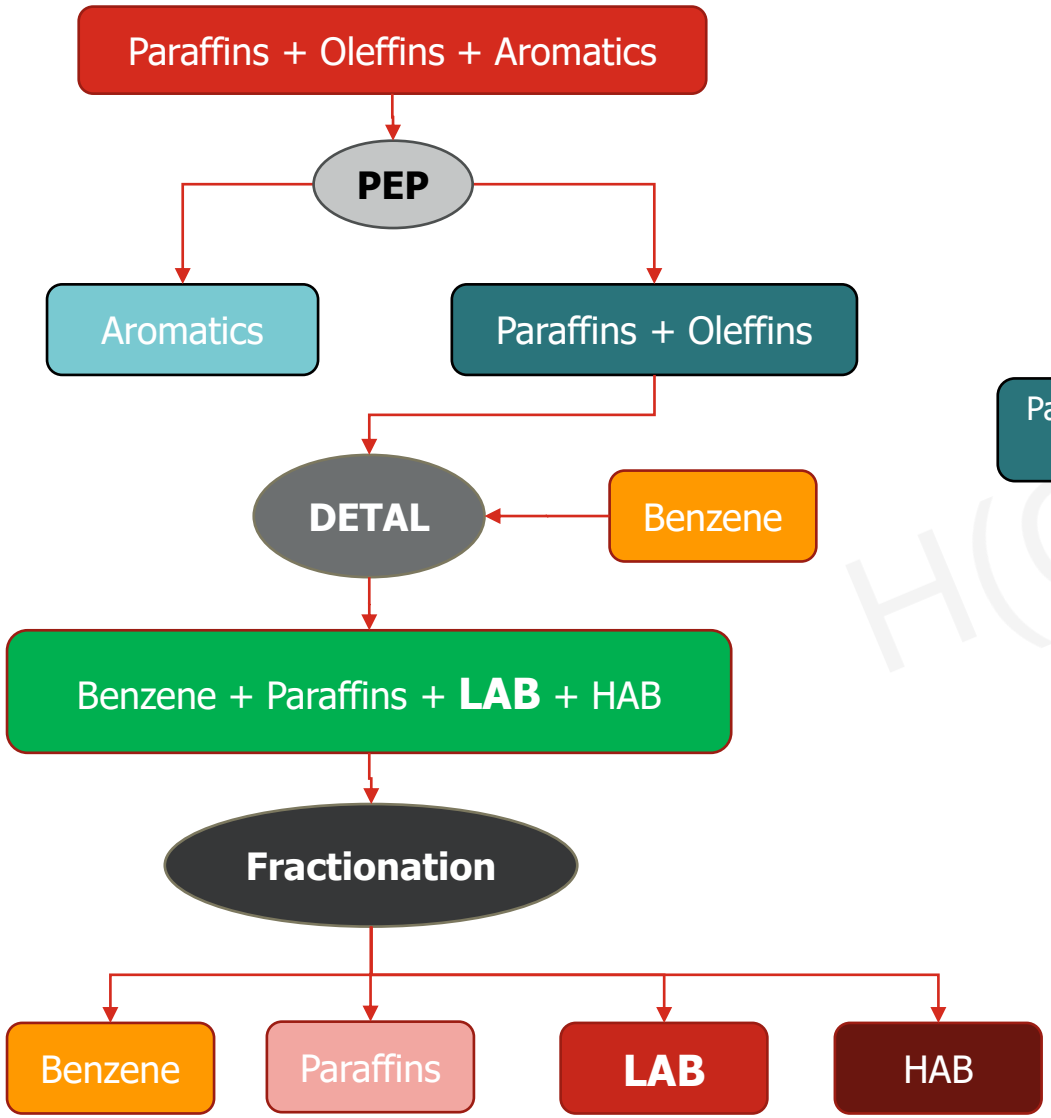
A pioneering technology in the sector developed by Cepsa and Universal Oil Product (UOP). Our chemicals plant in Canada was the first in the world to use this process in 1995. Since then, 85% of new LAB capacity added use this technology.

THE ADVANTAGES OF DETAL TECHNOLOGY

- Improves quality of final product
- Optimizes raw material consumption (increasing efficiency and lowering emissions)
- Reduces fixed and associated costs
- Improves safety and lowers environmental impact
- Simplifies maintenance shutdowns and start-up, and optimizes production processes

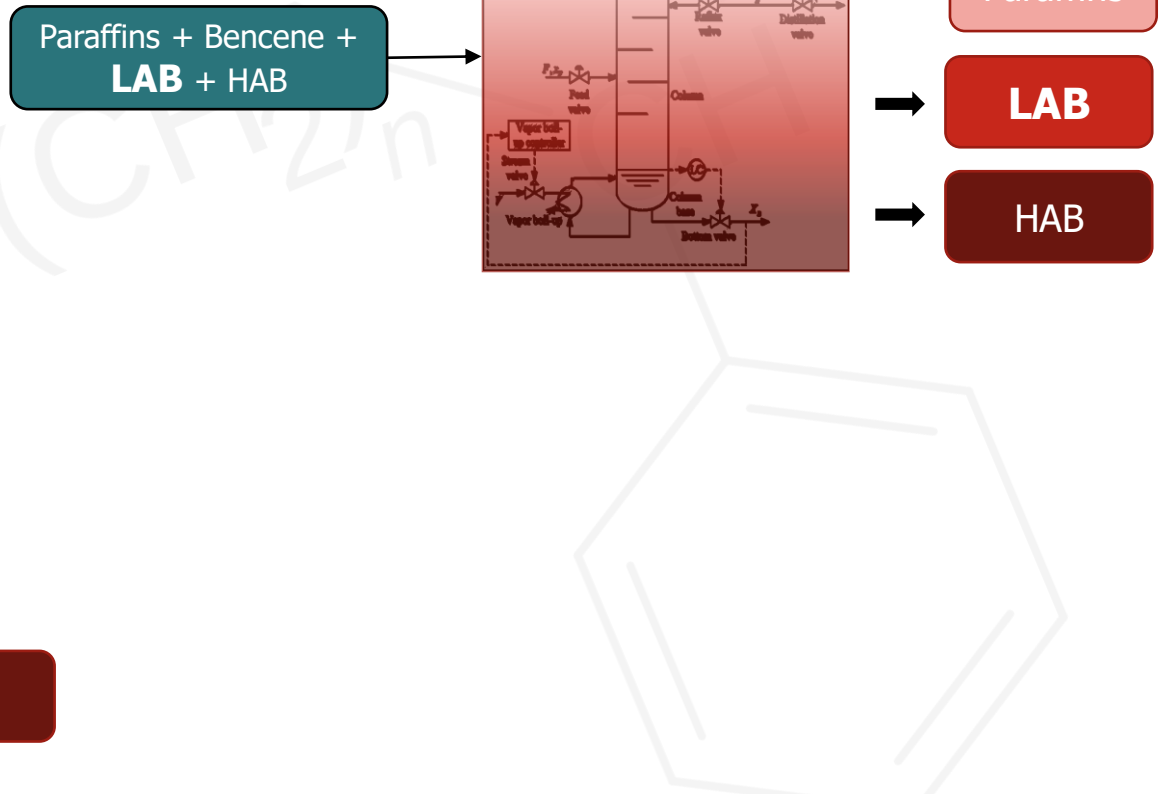


DETAL Process Description



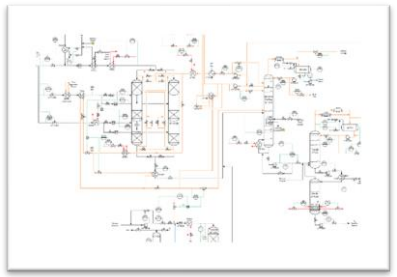
Separation Unit

7 distillation columns



Challenges & Solutions – 1.Process Simulator

Design Chemical Process



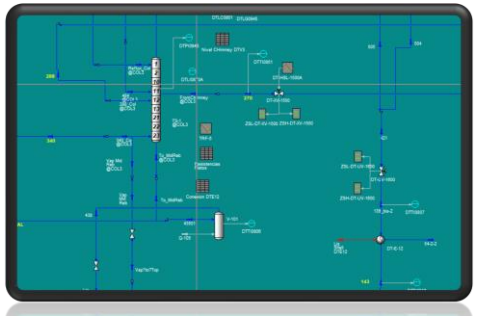
The first stage of a new process is the design of the configuration and operating conditions to obtain the desired products with the required quality level

Real Plant

Existing Units

New Units

Simulated Process



The process model simulator has to be able to reproduce the chemical process with accuracy and robustness

Process Simulator Requirement:

- Chemical Process
  - Defined Components: 33
  - Hypo Components (HAB): 5
  - Chemical Reactions
- Dynamic Simulation
- Easy communication ability
- Robustness
- Widely known software
- Easy maintenance

Aspen HYSYS®

Challenges & Solutions – 2. Size

Columns **11**

Reactors **6**

Vessels **27**

Shell & Tube
Heat Exchanger **28**

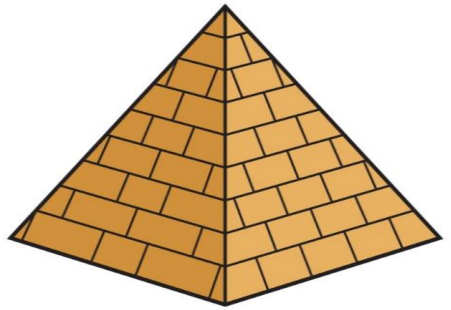
Air-Cooler
Heat Exchanger **12**

Pumps **55**

Controllers
Control Valves **114**

Instruments **354**

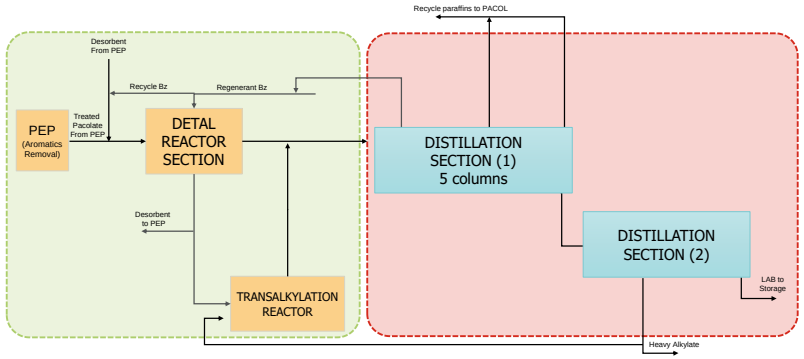
Communication
Nº TAGs **3261**



BIG MODEL

The main performance requirement for an OTS is Time Real Factor > 1
Due to the high number of equipment and communication signal, this value was in danger

2 interconnected independent models

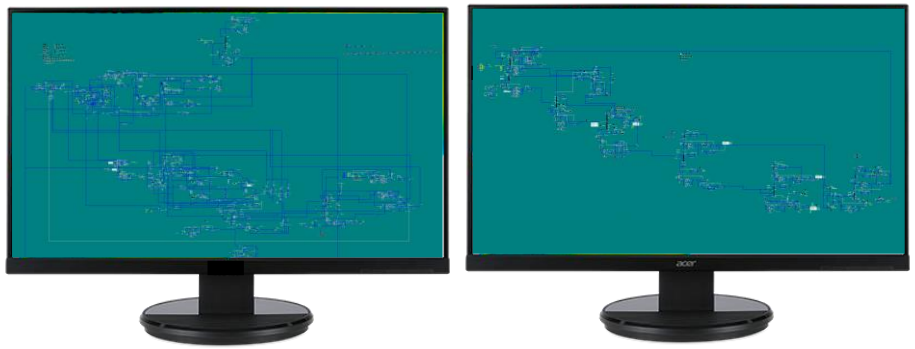


HYSYS MODEL 1

PEP & DETAL

HYSYS MODEL 2

FRACTIONATION



Challenges & Solutions – 3. Process Details

Adsorption Beds

MAIN CHALLENGES

- Adsorption as Unit Operation is not include in HYSYS
- Plug Flow Simulation in Beds
- Regeneration Process is carried out done in counterflow

Solution: Use of Spreadsheets

Hysys is flexible enough to develop custom items

Spreadsheets

This tool lets the user to operate with:

- selectivity (to program and modify the amount of each component adsorpted in each bed independently)
- realism (it is possible to program the adsorption relationship against other variables like pressure and temperature)

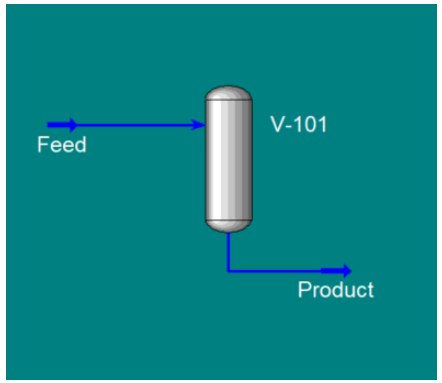
Challenges & Solutions – 3. Process Details

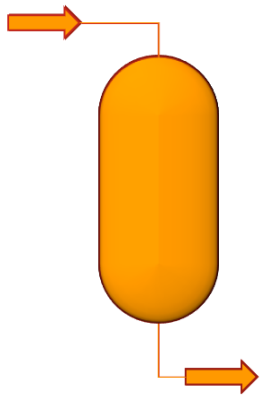
Adsorption Beds

MAIN CHALLENGES

- Adsorption as Unit Operation is not include in HYSYS
- Plug Flow Simulation in Beds
- Regeneration Process is carried out done in counterflow

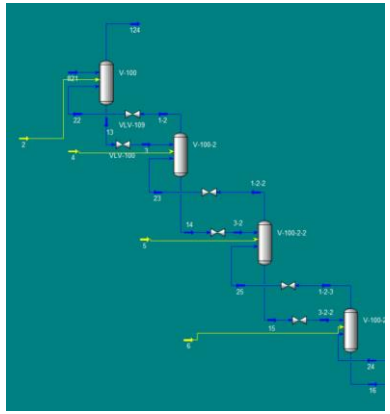
Vessel Volume is represented like an unique homogeneous volumen.
This fact prevents the slug flow simulation

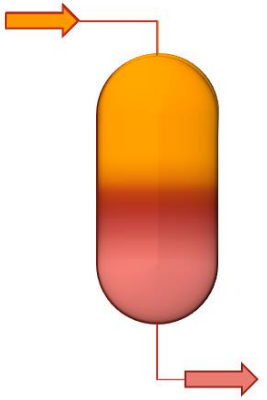




Solution: Segmented beds volume

Volume Segmentation let the user to evaluate the slug Flow. The perfect slug Flow is obtained with infinite number of vessel in series. It is necessary to evaluate the minimum number of vessel to reproduce the expected plug flow





Challenges & Solutions – 3. Process Details

Adsorption Beds

MAIN CHALLENGES

- Adsorption as Unit Operation is not include in HYSYS
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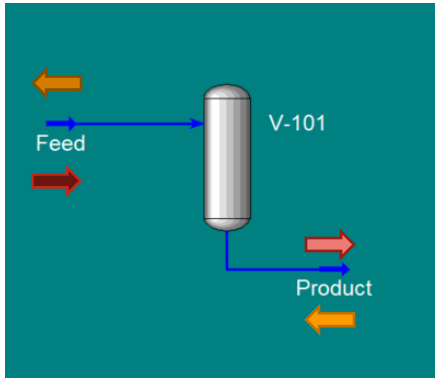
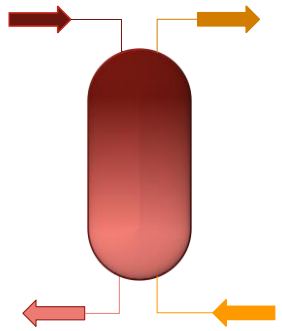
- Regeneration Process is carried out done in counterflow

Reverse flow direction causes instabilities in Hysys when working with negative flows

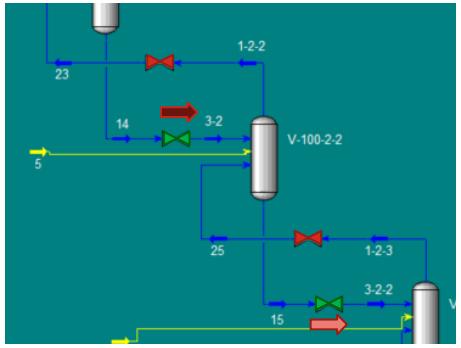




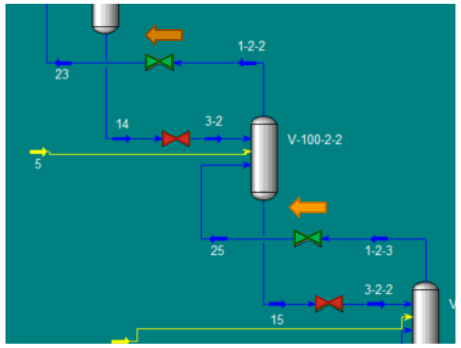
Solution: Implement parallel paths

The installation of parallel paths prevents the negative flows. This architecture requires a logic strategy to open/close the desired paths during each procedure

Adsorption Mode
From Top to Bottom

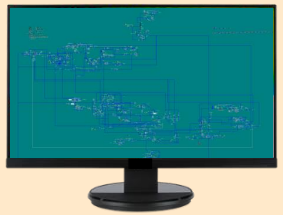


Desorption Mode
From Bottom to Top



Challenges & Solutions – 4. Communication

2 Independent Hysys Model



PEP & DETAL

FRACTIONATION

2 Independent ICSS

Honeywell

YOKOGAWA CENTUM VP

PLC

DCS

Animated & Customized Screens

Inprocess Infrastructure Suite (IIS)

Data Treatment (Graphics)

3D VR Model

Different Stations

Instructor Station

Operator Station

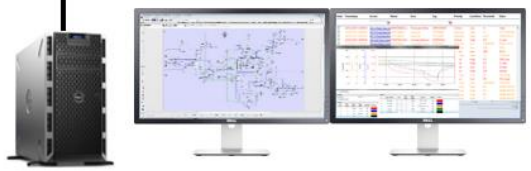
The OTS

CEPSA contracted Inprocess to develop OTS based on a rigorous dynamic process simulation model of the revamped plant, which is also connected to a detailed 3D Virtual Reality model of the plant.

Operator Station:

- *IIS for Operator Station*

Ethernet Network



Instructor Station and Simulation Server:

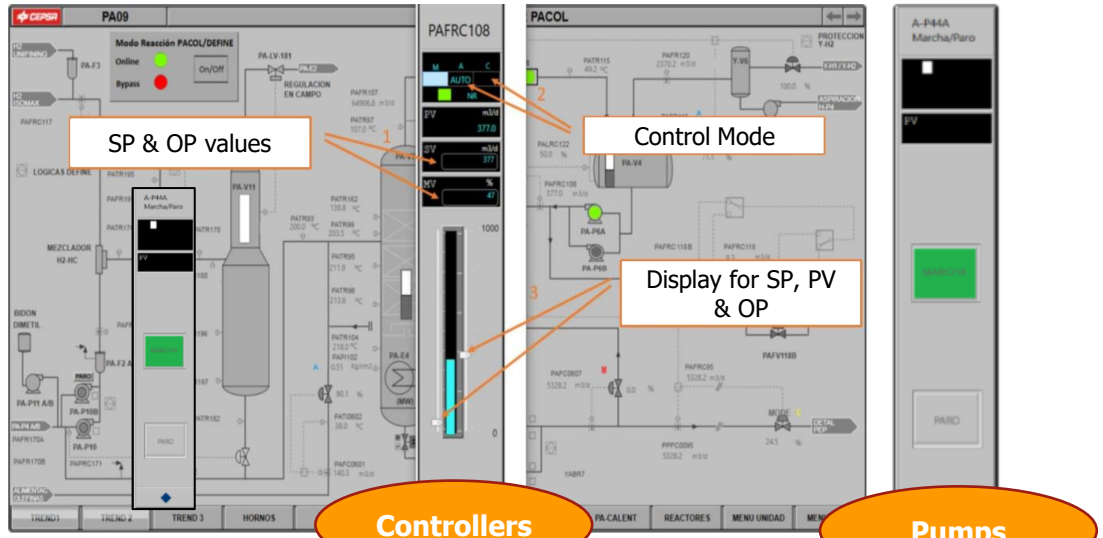
- *Inprocess Infrastructure Suite(IIS) for Instructor Station*
- *Aspen HYSYS® Dynamics Run-time*

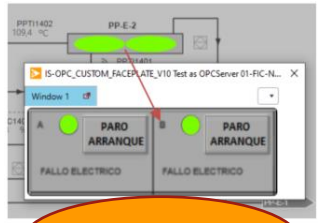
Virtual Reality Station:

- *High-End Nvidia graphic card*
- *Virtual Reality Headset*

Totally customized to reproduce the real environment for the operators:

Yokogawa Centum VP emulated faceplates & Navigation





3D MODEL – Virtual Reality

"Game" 3D engines

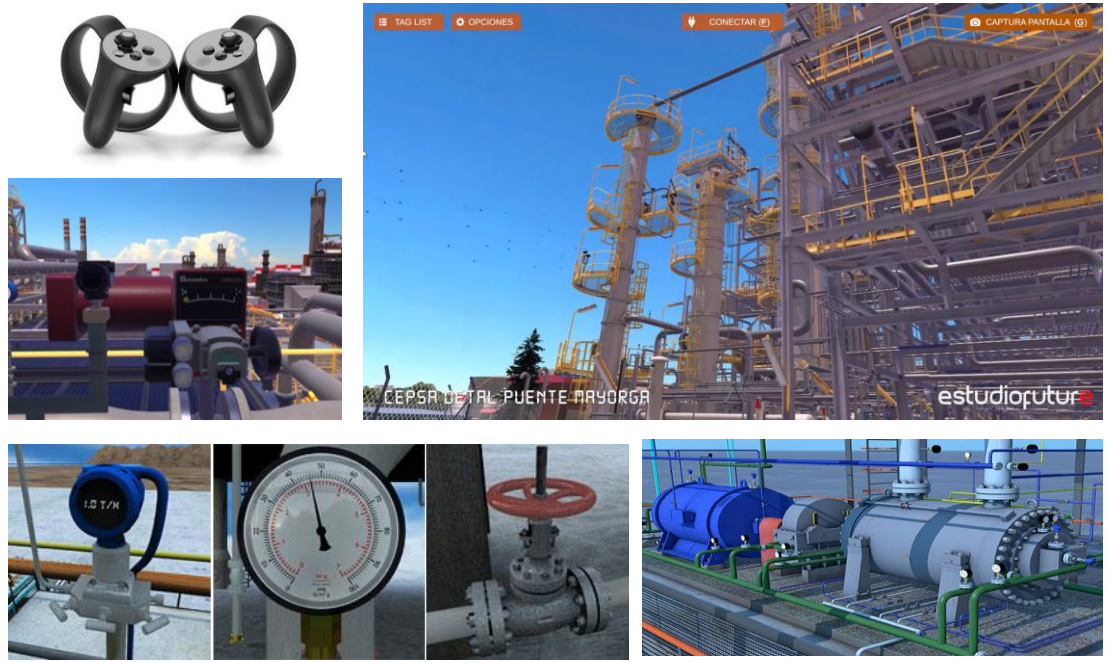
Most of the 3D CAD software is not designed to run in real-time at 90Hz fps, required for comfortable VR. For that purpose, "Game Engines" are used instead.

Smartplant3D models were converted, refined and optimized to Unity 3D models.

3D CAD plant design & piping modeling software			
#	Product	Company	native file format
	PDS (Plant Design System)	Intergraph	.dgn, .dri
	SmartPlant 3D (SP3D)	Intergraph	.vue
	CADWorxs	Intergraph	
	PDMS (Plant Design Management System	AVEVA	.rvm
	Everything 3D (E3D)	AVEVA	
	Microstation v8i	Bentley	.dgn
	AutoPlant v8i	Bentley	
	OpenPlant 3D	Bentley	
	AutoCAD Plant 3D	AutoDesk	.dwg, .dxf

3D Realtime Render Engines (Game Engines)			
#	Product	Company	read files
	Unity3D	Unity Technologies	.fbx, .obj, .3ds
	UnReal Engine 4	Epic Games	
	CryEngine	Crytek	

You are allowed to manipulate any field device or manual valve with your hands or VR-hand controller



Operating companies have found advantages in:

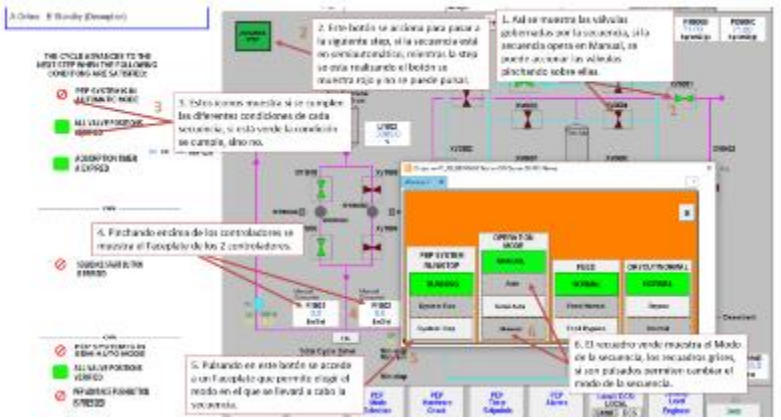
- Deeper involvement of field staff in understanding the process
- The full operations team can practice critical events such as startups, shutdowns and emergency responses in a fully realistic manner
- "Best field practices" can be designed and communicated to all staff
- Field Operator performance can be fully tracked and documented, for evaluation and compliance purposes
- This type of learning is extremely motivating
- Reduce travel and living costs associated with on-the-job training

Benefits to CEPSA

OTS Usage by CEPSA

1. Training of panellists for plant start-up
   - Process Engineering Department: Analysis & Preparation of Start-up & Shutdown Procedures
   - Process Engineering Department: Analysis & Preparation of Emergency Procedures

Benefits to CEPSA



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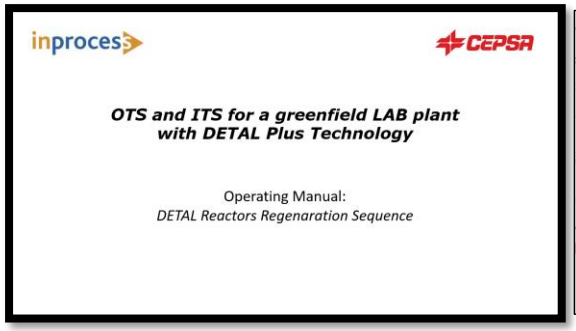
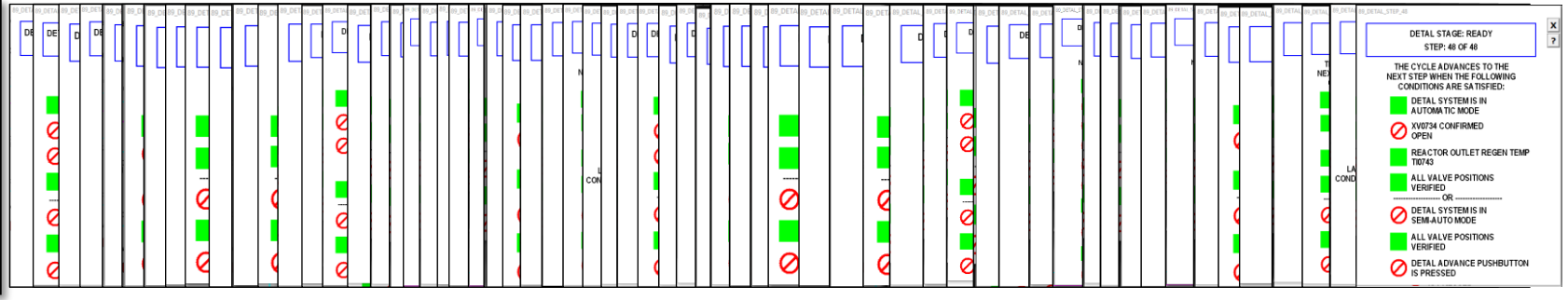
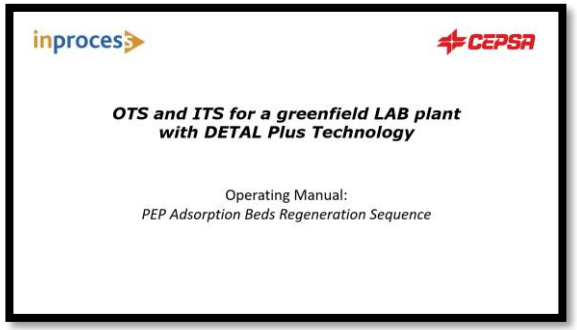
2. Training of panellists for PEP & DETAL regeneration sequences

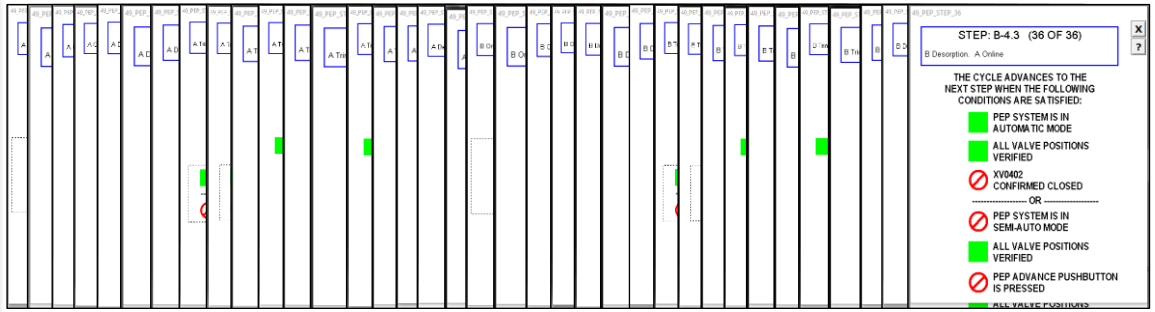
DETAL Reactors Regeneration sequence: 60 stages





PEP Adsorption Beds Regeneration sequence: 36 stages





Benefits to CEPSA

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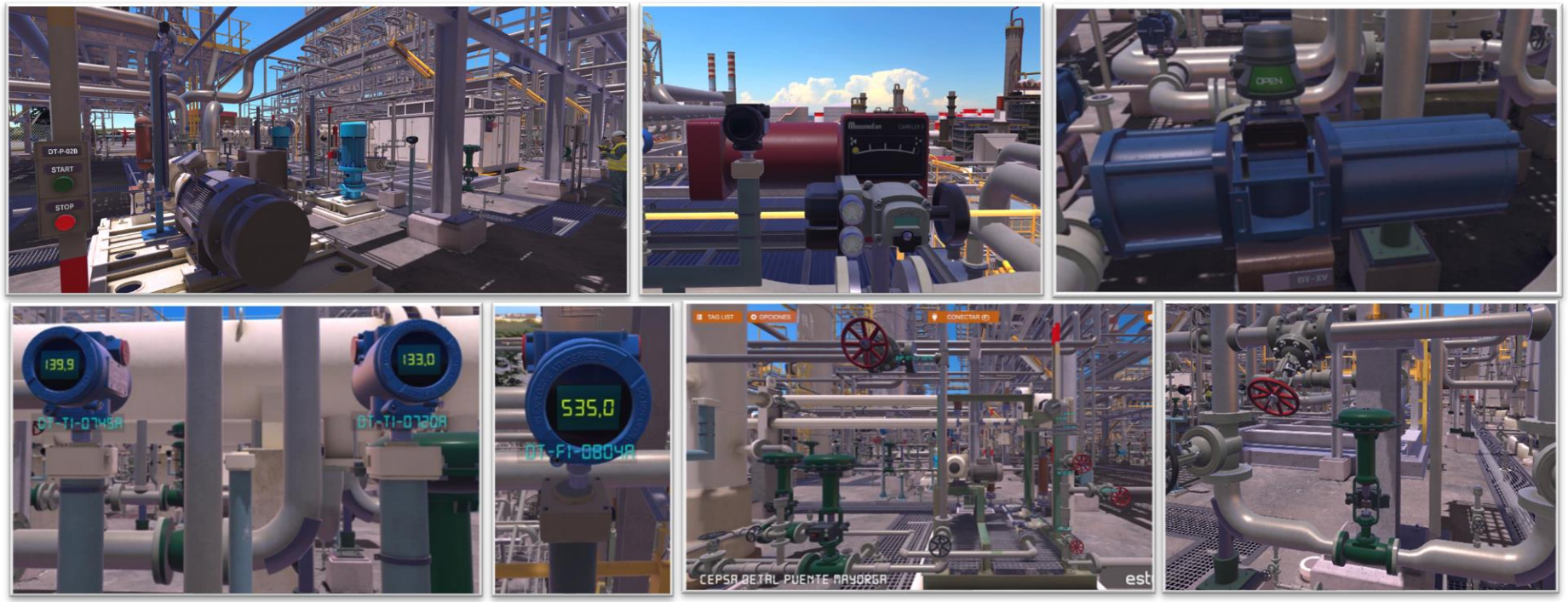
2. Training of panellists for PEP & DETAL regeneration sequences
3. OTS (VR): Location of equipment and hand valves for subsequent labelling in the field

3D Models



Real Life

Benefits to CEPSA

OTS Usage by CEPSA

1. Training of panellists for plant start-up
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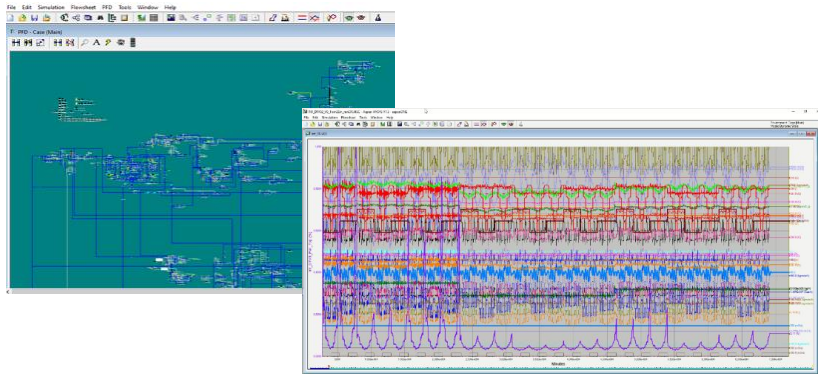
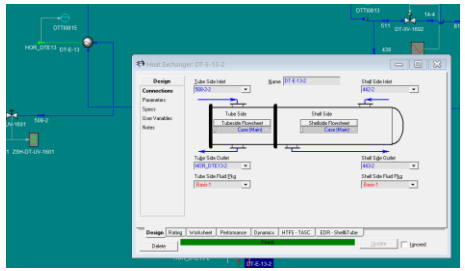
2. Training of panellists for PEP & DETAL regeneration sequences
3. OTS (VR): Location of equipment and hand valves for subsequent labelling in the field

Other and parallel uses

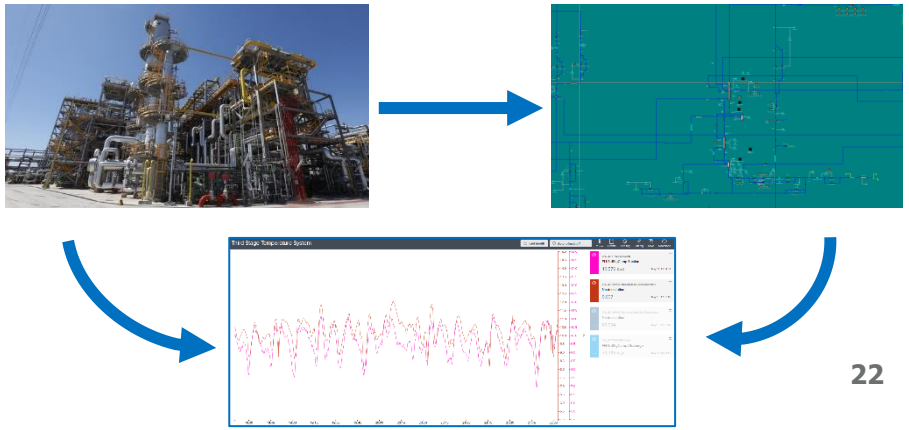
1. Dynamic Models
   - Performance check of units with different operating conditions
   - Tuning of control loops
   - Adjust of temperature controllers (temperature-pressure compensation)
   - Generation of Dynamic Data for Inferentials



2. Static Models
   - Rigorous analysis of equipment design
   - Reuse for revamping studies



3. Future
   - Online Digital Twin.
   - Installation of a “Button” for automatic update of Simulation input data from DCS
   - Use of 3D VR models for training in other specific scenarios




inprocess
CEPSA
Thank you
Q&A