



Brine Purification Project

PMDI Estarreja

June 2017



Agenda:

- Dow Portugal Introduction;
- Brine Purification Project:
 - Drivers;
 - Project Goals;
 - Project Value Statement;
 - Project Key Milestones;
 - Project Execution Plan;
- Next Steps....





Dow Portugal



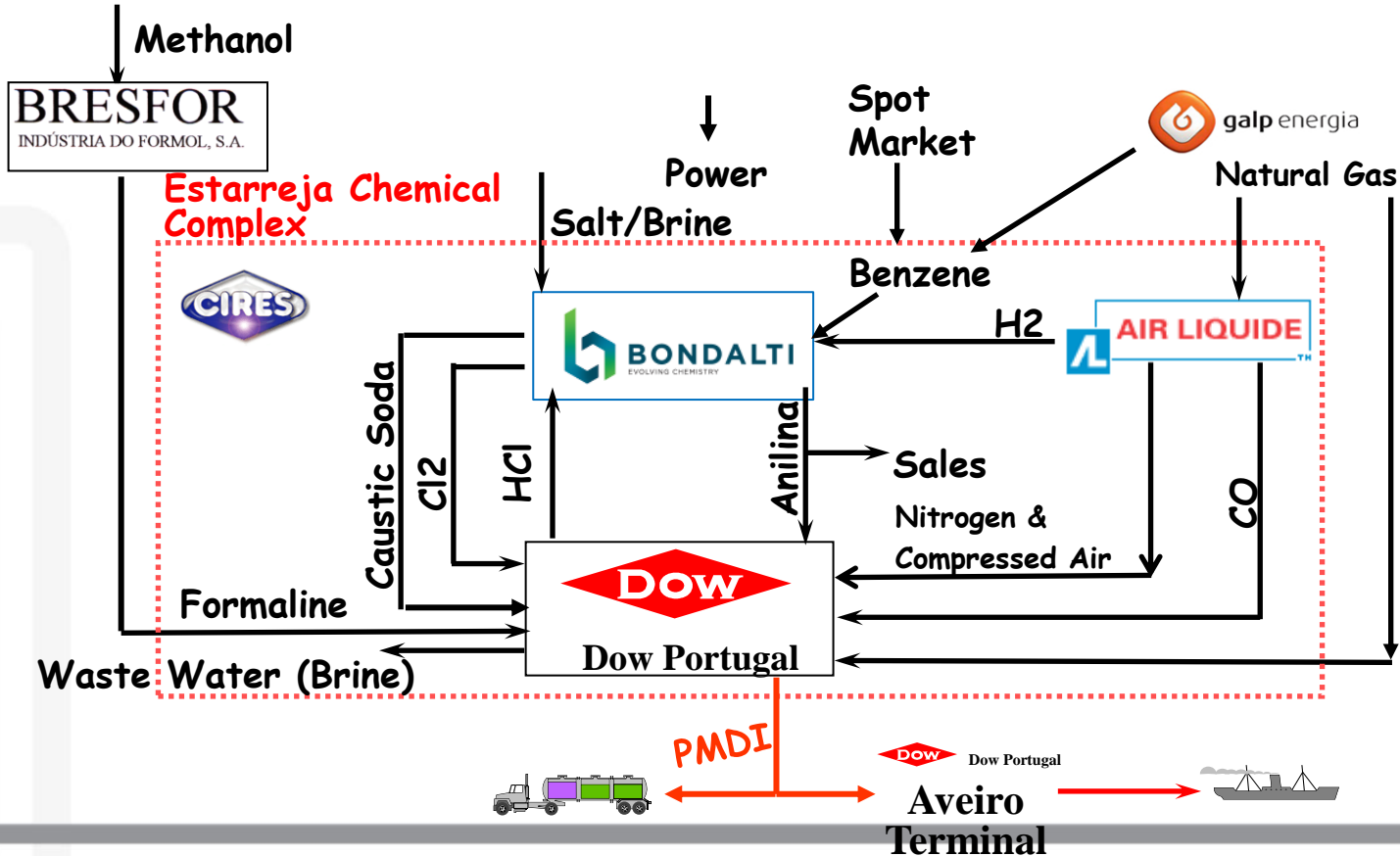
Total Area = 218,000 m²
Building Area = 150,000 m²





Dow Portugal Integration

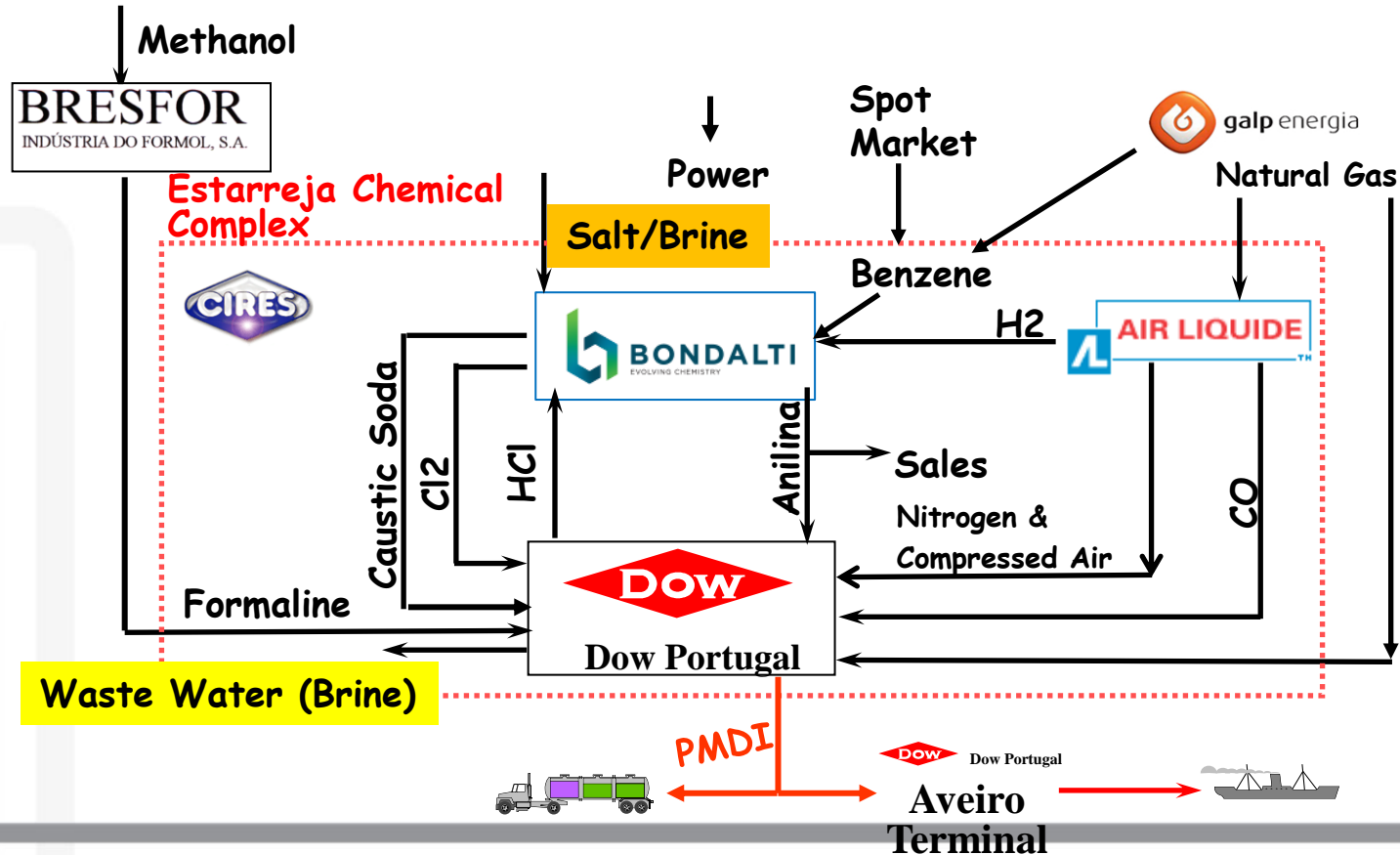
- ❑ Polymeric Isocyanates production (PMDI)
- ❑ Plant start-up 1982
- ❑ Capacity Expansion in 2009





Dow Portugal Integration

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Brine Study Drivers

BRESFOR
INDÚSTRIA DO FORMOL, S.A.

Estarreja Chemical Complex



Power

Salt



HCl

Anilina



Dow Portugal

Formaline

Waste Water (Brine)

Caustic Soda



Brine

Cl₂

Estarreja is disposing a high volumetric stream of dirty brine to a centralized Biox Unit (SIMRIA) and Sea (Atlantic Ocean);

Estarreja uses chlorine and caustic soda in the manufacturing of PMDI that generates the brine stream;

Global and European effort pushing for green chemical industry are intending to reduce chemical wastes and CO₂ emissions to the environment;

Innovative solutions tested at lab and pilot scales indicate that the wasted brine can be purified to quality levels required by the Chloro Alkali Technology to make chlorine and Caustic

Industrialization of the tested solutions could reduce drastically the liquid emissions of the Estarreja Complex, salt transportation CO₂ emissions, while reverting salted wastes to value added reusable chemicals.



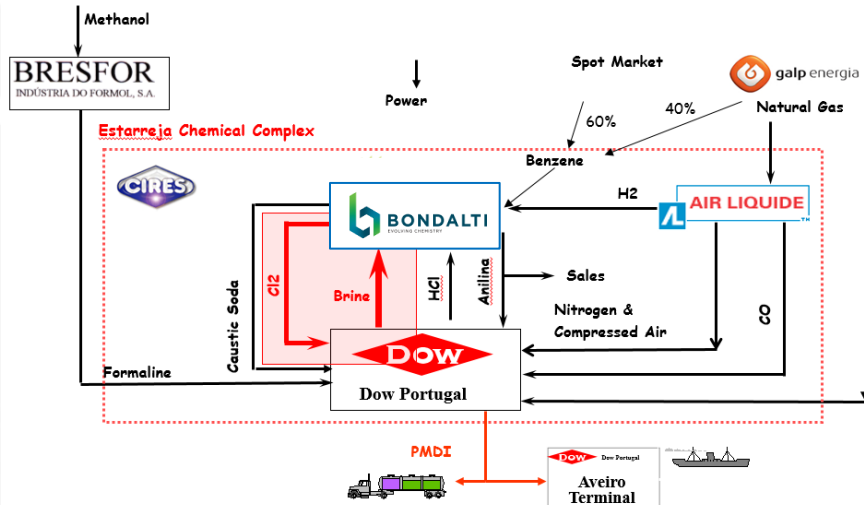


Brine Study Project

Project Goals

Evaluate new innovative solutions capable of purifying and recycling a wasted brine stream to make value added products and reducing significantly the amount of wastewater disposed by the Estarreja Complex to the Centralized Wastewater System (ADRA/SimRia), Sea and Environment.

Develop the best Innovative technologies to remove brine impurities and recovery Brine Recycling to Chlor-Alkali Process.



Project Goals

- 80 % of Organics Removal;
 - TOC < 10 ppm in the permeate;
 - Higher Salt Recovery ($\geq 90\%$);
 - DCF > 60%
-
- Integrate PMDI and Bondalti CA Technologies;
 - 2025 Sustainability Goals;



Value statement

Through the use of Innovative Solutions the project has the potential to:

- Generate up to 1.6MM Eu/y savings in salt /water reduction/reuse;
- Reduce the Estarreja Complex Wastewater disposal to the Ocean by 200 -220 Mm³/y;
- Reduce river water usage in the Complex by 100 - 120 Mm³/y;
- Reduce rock Salt extraction in nature by 26000 Tons/y;
- Eliminate 1200 truck round trips (80Km) for salt transportation;
- Enable the development and proofing of new technologies for the wide Industry;
- Set a new Global Integrated Standard for the PMDI/CA Industry Integration.





Project Key Milestones Summary

● Secret Agreements and Contracts between University of Aveiro, University of Porto (FEUP) and Dow;

● **Laboratory Key Plan Steps:**

Brine **Characterization** (Organics and Inorganics) with different analytical methods;
Brine **Purification** - selection of the most effective technology to purify the brine stream;
Lab Sensitive **analysis**;

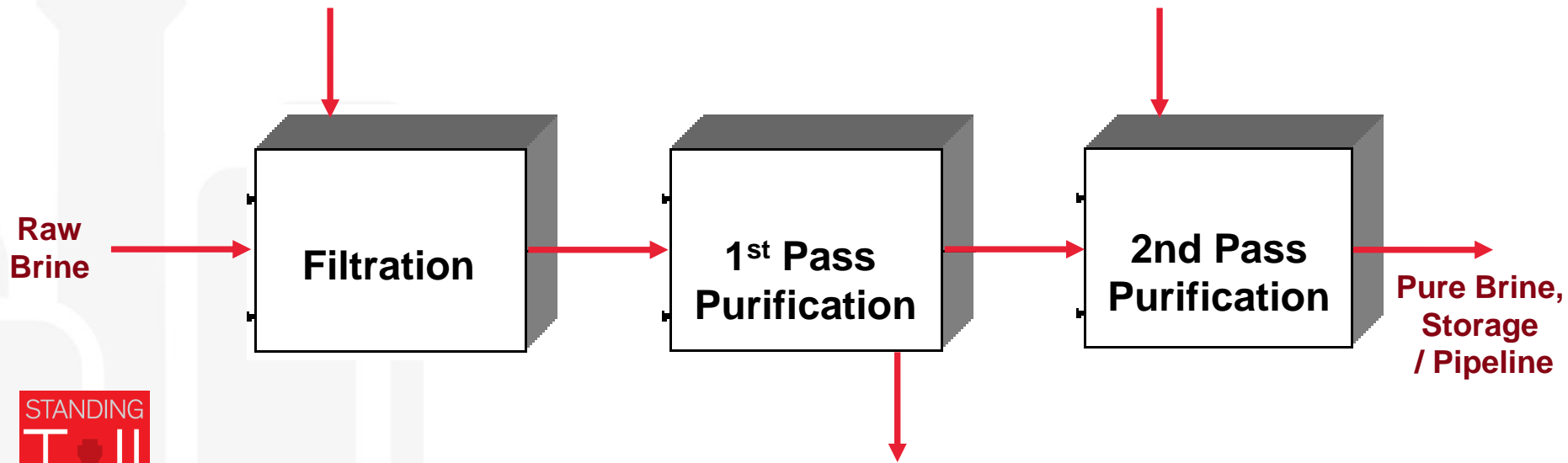
● **Pilot Unit Key Plan Steps:**

Pilot Unit configured, specified and built (based on lab sensitivity tests);
Pilot Unit **start up**;
Pilot Unit **tests** - Completion of 30 DOE / Definition of process design correlations for an industrial unit;
Integration studies with Bondalti and agreement on quality specs;
Aspen model simulation for different process alternatives;
Project identification and scoping
Cost and economic evaluation for an industrial installation.





Project Unit Block Diagram





Pure Brine Quality Data Summary

Inorganic & Organic Analysis by **Customer** and Dow Labs

- All CA Brine specs are met;
- %NaCl, %H2O in the Integrated Optimization Approach needed;
- Water Removal Opportunities needed by both Companies.

Quality Specification

Parameter	Units	range	target	comments
pH	---			
NaCl	% W			
Sulfatos	mg/l			
NaOH	mg/l			
Na2CO3	mg/l			
NaHCO3	mg/l			
Mg	micg/l			
Ca	micg/l			
Sr	micg/l			
Ba	micg/l			
Al	micg/l			
Fe	mg/l			
Mn	micg/l			
Ni	micg/l			
SiO2 Met.Ad.Pad.	mg/l			
Iodo mg/l	micg/l			
Insolubles	mg/l			
Pb	micg/l			
TOC	mg/l			
C4 +	mg/l			
Cl1---Cl3, bp<80°C	mg/l			
Cl1---Cl3, bp>80°C	mg/l			

*Reviewed and
accepted by
Customer*





Project Execution Plan

Brine Purification Project	2010-2020					2021					2022					2023					2024				
	Project Scope Identification & Definition	[Yellow]					[White]					[White]					[White]					[White]			
Project Detail Eng	[White]					[Yellow]					[Yellow]					[White]					[White]				
Construction	[White]					[White]					[White]					[Yellow]					[White]				
Release to Operations	[White]					[White]					[White]					[White]					[Yellow]				





Project Next Steps

... advance with project
Industrialization!





Dow Operations

Standing for excellence.