OTTOBRE 2021

DALLE BASI LUBRIFICANTI ALL'IDROGENO : OLTRE 50 ANNI DI SOSTENIBILITA'

ITELYUM

Il nome dell'economia circolare

Itelyum è la realtà italiana con più di mezzo secolo di storia, riconosciuta a livello internazionale per tecnologia, esperienza e qualità nella rigenerazione di oli lubrificanti, nella purificazione di solventi e reflui chimici e nei servizi ambientali per l'industria.

Con la forza di **23 società**, **26 siti operativi** e oltre **850 persone**, Itelyum offre soluzioni sostenibili a oltre **30.000 clienti** in più di **60 paesi**.

% circolarità sul totale dei rifiuti (oltre 1 milione t) e delle materie prime (~40.000 t) gestite dal gruppo

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Processi, prodotti e servizi integrati

REGENERATION SOLUTIONS	PURIFICATION SOLUTIONS	ENVIRONMENT SOLUTIONS
Leader nella produzione di basi lubrificanti rigenerate, utilizzate dai più importanti produttori di lubrificanti al mondo e con prestazioni equivalenti a quelle delle basi ottenute da materie prime vergini.	Leader nella produzione di solventi ad alta purezza da stream vergini e nella purificazione di reflui chimici e solventi usati provenienti dall'industria chimica e farmaceutica.	Provider di servizi integrati per i produttori di rifiuti speciali: raccolta, stoccaggio, trasporto, pretrattamento, intermediazione, consulenza, analisi chimiche e trattamento delle acque industriali.

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+850 persone / 23 società / 26 sedi operative

Una struttura industriale solida e flessibile

Oltre 1,8 milioni di tonnellate di rifiuti industriali gestiti

REGENERATION SOLUTIONS

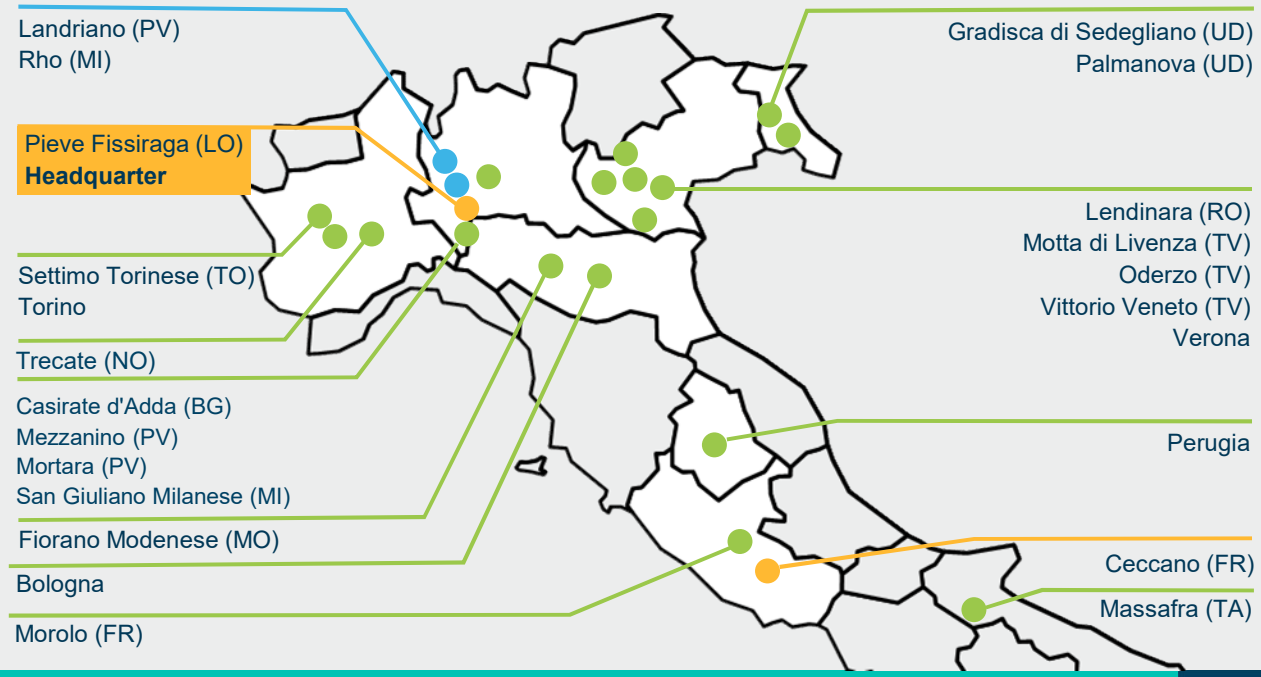
tratta
180.000 t/anno oli lubrificanti usati
produce
120.000 t/anno basi lubrificanti
40.000 t/anno altri rigenerati

PURIFICATION SOLUTIONS

tratta
100.000 t/anno solventi e stream chimici usati
40.000 t/anno solventi e stream chimici vergini
produce
70.000 t/anno solventi e altri rigenerati
30.000 t/anno solventi e altri da stream vergini

SOLUZIONI PER L'AMBIENTE

gestisce
1.500.000 t/anno rifiuti industriali
Di cui **handling** e **servizi** 500.000 t/anno



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REGENERATION SOLUTIONS

Rigenerazione degli oli lubrificanti
Eccellenza circolare

Due impianti per la rigenerazione di oli usati, dotati di tecnologie e processi proprietari evoluti, capaci di produrre basi lubrificanti di alta qualità.

Le basi prodotte sono ideali per l'impiego nelle diverse applicazioni di lubrificazione nei settori automotive e industriale, soddisfacendo i più severi requisiti prestazionali e ambientali.

La ridotta impronta ambientale delle basi rigenerate crea valore sostenibile per il mercato.

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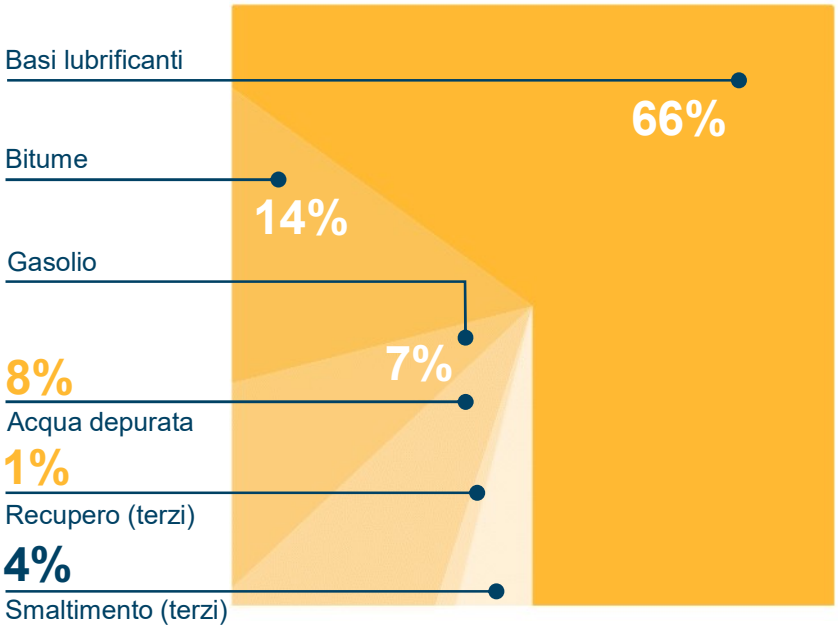
Rigenerazione degli oli lubrificanti
Eccellenza circolare

Confrontate con la produzione primaria, le basi lubrificanti rigenerate generano:

- la **metà** delle emissioni di CO_2
- **4 volte meno** emissioni di polveri sottili
- **5 volte meno** emissioni di acidificanti (NO_x, SO_2 e NH_3)

Inoltre, almeno il **95%** dell'olio lubrificante trattato viene trasformato in prodotti, restituito all'ambiente come acqua depurata o valorizzato da terzi.

Circolarità > 95%



% sull'olio lubrificante usato trattato

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Pillars della strategia di sviluppo tecnologico di Itelyum

L'**economia circolare** si compie attraverso il concetto di rigenerazione estesa sviluppando verticali paralleli (Waste to finished products - End of Waste) e integrati/interconnessi (bridges crossing different waste management supply chains) attraverso le seguenti linee di azione:

1) Utilizzare i processi consolidati di **rigenerazione** (i.e. olio usato, solventi) come piattaforme aperte per sviluppare e realizzare nuovi EoW :

- utilizzo del polverino da PFU per la produzione di rubberized asphalt da olio usato;
- devulcanizzazione del polverino da PFU per ottenere idrogeno e zolfo (SACS);
- utilizzo del polverino da PFU e del plasmix per ottenere idrogeno e lubrificanti (Plasbreaker);
- utilizzo di H_2S e CO_2 per ottenere H_2, syngas e zolfo (AG2S);

2) **Open Innovation** attraverso la collaborazione con i centri di competenza universitari per sviluppare nuovi processi, nuovi prodotti ed eventuali impatti su salute e ambiente: Politecnico di Milano, Università della Calabria, Università Federico II di Napoli, Università di Milano.

3) **Digital Transformation**:

- IoT e Cloud implementation
- business platformization
- digital twin

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First recovery proposal of waste materials: process based on the use of the Itelyum Re-Refined Engine Oil Bottom (REOB) (Viscoflex 1000 or 2000), Intra and Extra Itelyum wastes

Viscoflex 1000/2000
Produced from used oils

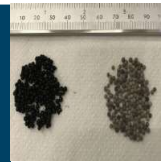
Crumb Rubber waste or non Vulcanized Rubber waste from rubber Industries
(e.g: Michelin, Goodyear etc.)

cellulose from waste paper

Oil mill's wastes after a sieving process

Exausted Celite Waste from Oil filtration plant

Exausted Alumina
("greened" waste, $\gamma-Al_2O_3$



Dehydrated sediments from plant centrifugation process

New finished Bitumen product (EoW) ITELPLUS 1

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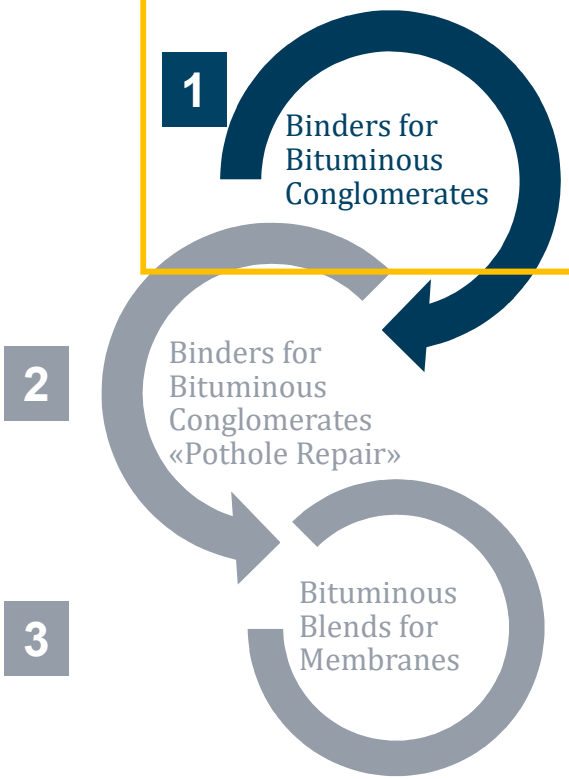
FIRST WASTE RECOVERY PROPOSAL



BINDER CHARACTERIZATION:
- Chemical-physical study– **NMR** & **DSC**
- Rheological study– **DSR**

CONGLOMERATE CHARACTERIZATION:
- Mix design study– **Gyratory method**
- Classical mechanical study- **ITS** & **ITSR**
- Dynamic mechanical study– **ITSM**, **RLAT** & **ITFT**

BINDER CHARACTERIZATION:
- Chemical-physical study– NMR & DSC
- Rheological study– DSR

CONGLOMERATE CHARACTERIZATION:
- Mix design study– Gyratory method
- Classical mechanical study- ITS & ITSR

BINDER CHARACTERIZATION:
- Chemical-physical study– NMR & DSC
- Rheological study– DSR

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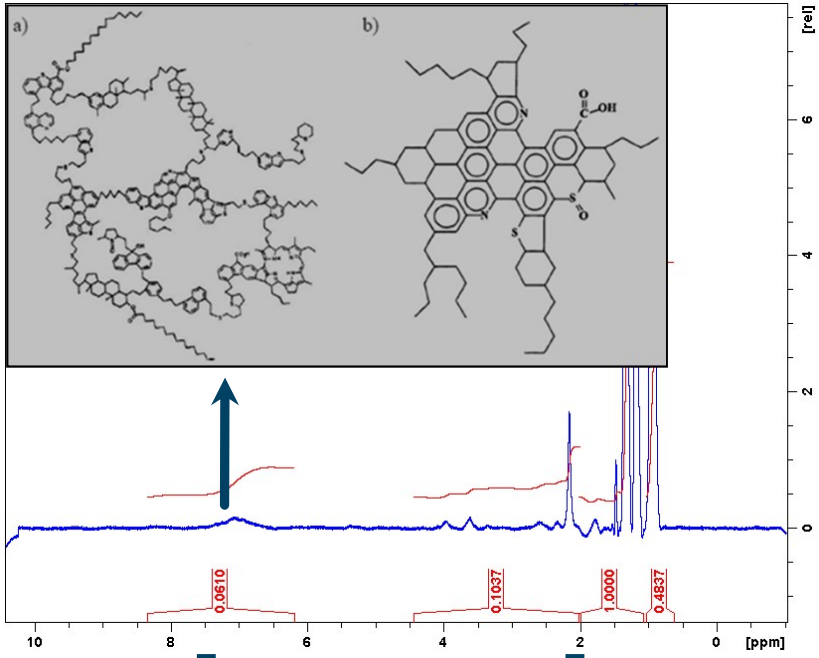
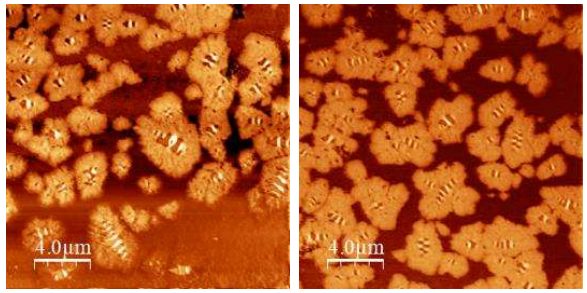
Mix of Aliphatic Hydrocarbons and low percentage of polyaromatic molecules

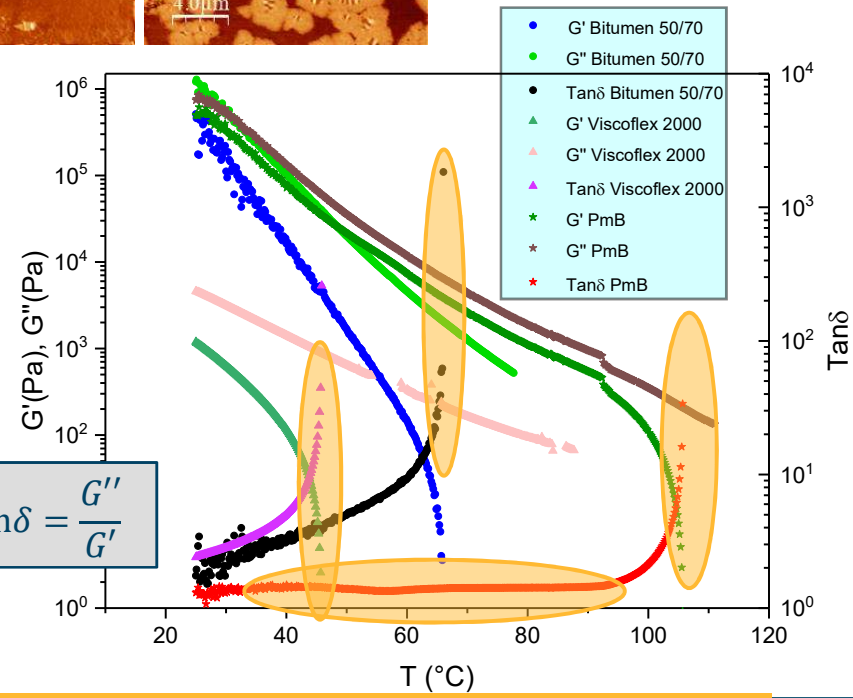


Aromatic zone

Aliphatic zone



AFM pictures of Asphaltenes molecules



$$\mathrm{Tan}\delta = \frac{G''}{G'}$$

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Mixture for binder formation

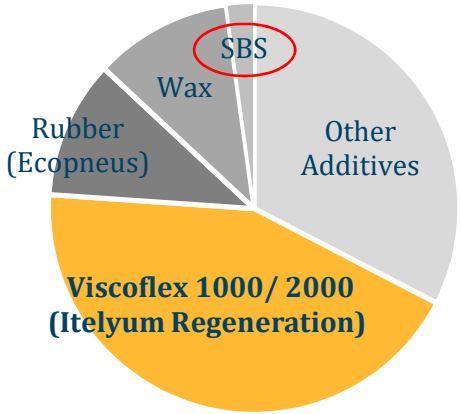

Table 1: various Blend so far prepared*

Mixture	Bitumen	V1000	V2000	RUBER	WAX	SBS	Adhesion Promoter	P2	C2	CdN	CNC	RP	Nt	LiS
								Cellulosic materials				Other additives		
B23	/	/	60	15	10	0	0.3	14.7	0	0	0	0	0	0
B23 C2	/	/	60	15	10	0	0.3	0	14.7	0	0	0	0	0
B23 CDN	/	/	60	15	10	0	0.3	0	0	14.7	0	0	0	0
B23 CNC	/	/	60	15	10	0	0.3	0	0	0	14.7	0	0	0
B26	/	/	40	10	10	0	0	20	0	0	0	20	0	0
B27	/	/	60	5	10	0	0	15	0	0	0	10	0	0
B29	/	/	40	10	10	0	0	0	0	0	0	40	0	0
B30	/	/	40	0	15	0	0	14.7	0	0	0	25	0.1	5
B26 D**	/	/	40	10	10	0	0	20	0	0	0	20	0	0
B27 D	/	/	60	5	10	0	0	15	0	0	0	10	0	0
B29 V1	/	40	/	10	10	0	0	0	0	0	0	40	0	0
B27-1	/	/	60	5	10	1	0.3	13.7	0	0	0	10	0	0
B29-1	/	/	50	10	10	0.5	0.3	0	0	0	0	29.2	0	0
CAM 26	/	/	40	10	10	0	0	20	0	0	0	20	0	0
CAM 29	/	/	40	10	10	0	0	0	0	0	0	40	0	0
CAM 29 V1	/	40	/	10	10	0	0	0	0	0	0	40	0	0

** Values expressed as percentages - ** D means Dense Viscoflex 2000*

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Asphalt concrete specimens Prepared using various blends Presented in Table 1

Blend	ITMS (MPa)	ITS (MPa)
PmB (HARD)	4578	0.90
Bitume 50/70	9558	2.12
B 23	3179	0.40
B 23 C2	2704	0.37
B 23 CdN	3146	0.39
B 23 CNC	3388	0.38
B 26	8852	0.89
B 27	6186	0.85
B 29	8319	1.73
B 30	7769	0.99
B26 D	10402	1.06
B27 D	5875	0.66
B 29 D	14020	1.96
B 30 D	9937	1.36
B 29 V1	12382	1.07
B 27-1	4376	0.53
B 29-1	5978	0.62
CAM 26	4042	0.40
CAM 29	6540	0.67
CAM 29 V1	6178	0.57

ITMS

Indirect Tensile Stress Modulus

ITS

Indirect Tensile Stress

Most promising blends chosen for further enhancements

All Bituminous conglomerates except the CAMs (for which were used aggregates composed by 50% virgin and 50% recycled materials), have been prepared by using 100% of RAP

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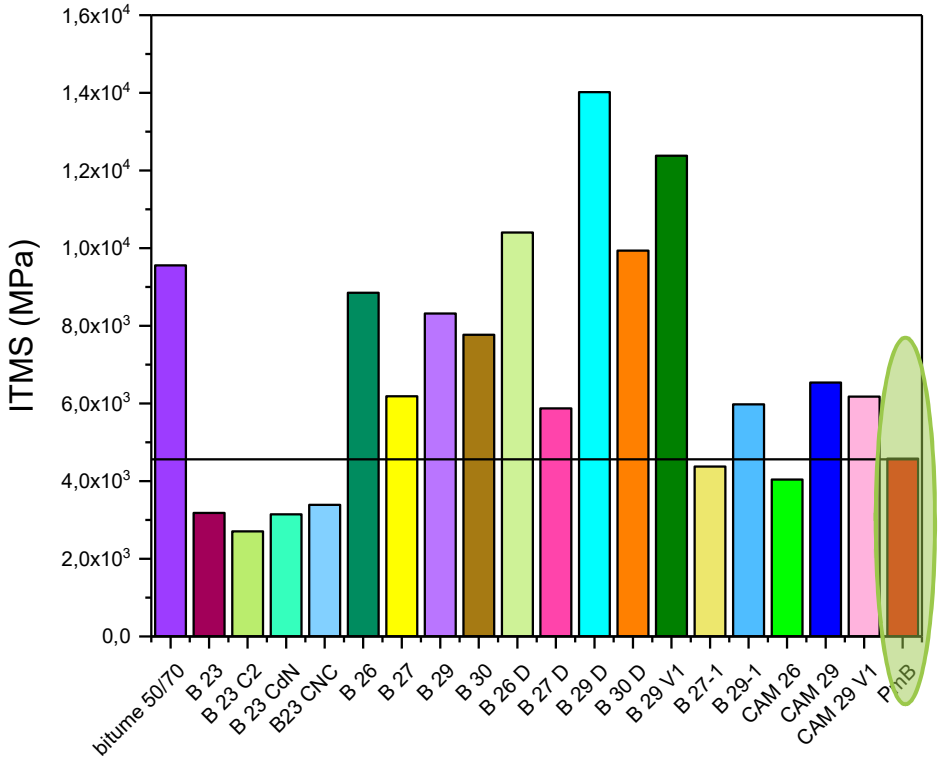
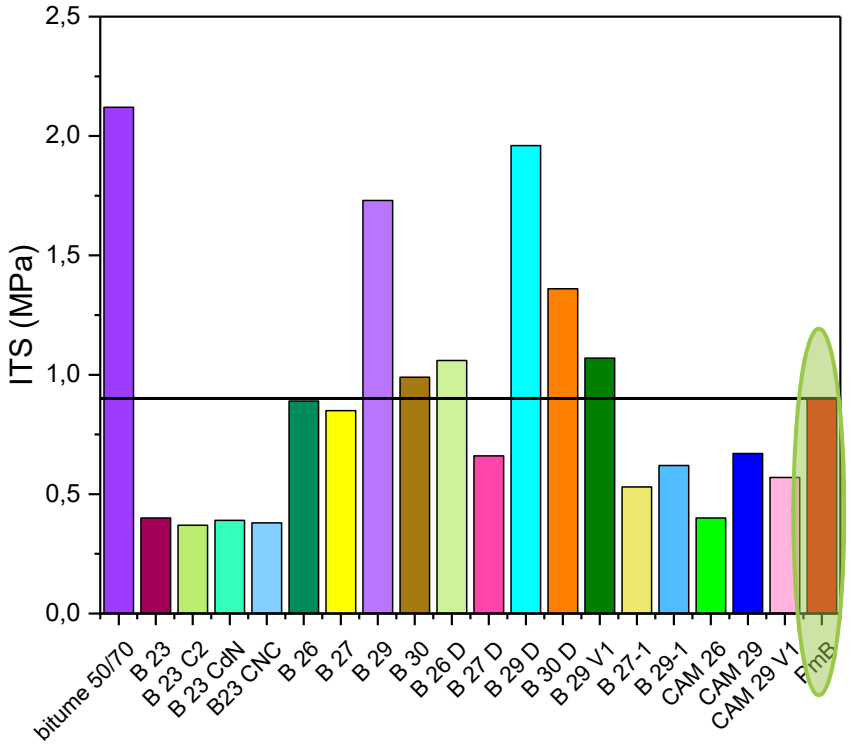
Objective:
ITSM @20°C > 4000 MPa



Objective:
ITS > 0,7 MPa @ 20 °C [ANAS requirement]



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R&D

Work in progress

- New Blend complying with ANAS standard Parameters
- Substitute the elastomeric polymers with new thickening agents from natural sources
- Obtain new low-cost and eco-friendly blends

PmB like blend
ideal for paving asphalt

50/70 bitumen like
ideal for cold asphalt production

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La Tecnologia AG2S™

Da emissioni acide a syngas: la trasformazione è sostenibile

A seguito dei promettenti risultati ottenuti nelle fasi sperimentali e pilota e nonostante il rallentamento dovuto alla pandemia, Itelyum Regeneration ha avviato il "Laboratorio Dimostrativo Permanente (LDP)" presso lo stabilimento di Pieve Fissiraga (LO), che permetterà di affinare la tecnologia Acid Gas to Syngas™ (AG2S™) utilizzando direttamente le stream industriali di campo.

DI ANNA DELL'ANGELO[1], MASSIMO BARBIERI[2], FRANCESCO GALLO[3], FLAVIO MANENTI[1]

[1] POLITECNICO DI MILANO, DIPARTIMENTO CMIC "GIULIO NATTA", CENTRE FOR SUSTAINABLE PROCESS ENGINEERING RESEARCH (SUPER)
[2] POLITECNICO DI MILANO, TECHNOLOGY TRANSFER OFFICE
[3] ITELYUM REGENERATION SRL

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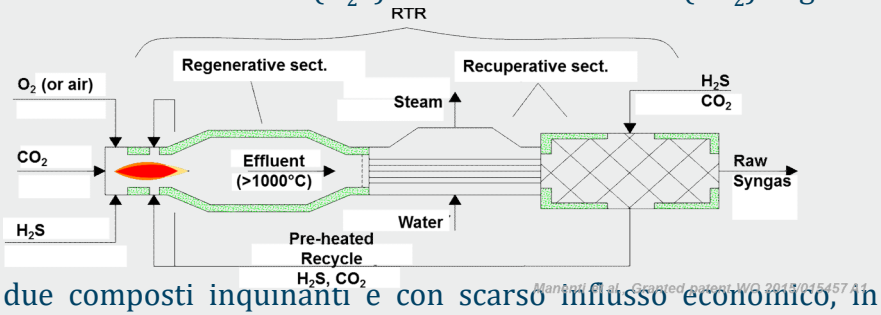
La Tecnologia AG2S™

Open Innovation con il Politecnico di Milano

La tecnologia Acid Gas to Syngas™ (AG2S™) consente la conversione di acido solfidrico (H_2S) e anidride carbonica (CO_2) in gas di sintesi (CO e H_2) secondo la reazione complessiva:

$$2\ H_2S + CO_2 = CO + H_2 + S_2 + H_2O$$



L'importanza di tale reazione risiede nella valorizzazione di due composti inquinanti e con scarso influsso economico, in autosufficienza energetica e senza alcun ulteriore sfruttamento di risorse (fossile e rinnovabili).
La tecnologia trova applicazione sia in ambito fossile (campi gas, raffinerie, *shale*, gassificazione del carbone) sia rinnovabile (geotermia, biomasse), offrendo una nuova via di utilizzo della CO_2 e dell'H_2S, la cui potenzialità idrogenante ne ha notevolmente amplificato l'interesse, per la produzione alternativa di syngas ed altre sostanze chimiche derivanti da esso (ammoniaca, metanolo e dimetil etere per citarne alcune).

L'H_2S, infatti, è la molecola più ricca di idrogeno dopo il metano e gli idrocarburi, il metanolo e l'ammoniaca. Con contenuto di idrogeno al pari dell'acqua, ma con una ridotta energia di legame molecolare, l'acido solfidrico non dovrebbe essere considerato solo un'inquinante da bruciare in un impianto Claus per ottenere zolfo elementare e acqua, bensì una risorsa per produrre idrogeno a bassa richiesta energetica.

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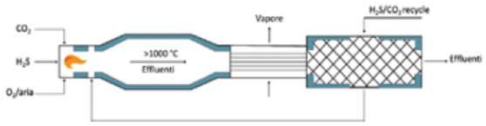
Open Innovation con il Politecnico di Milano

AG2S™, UNA TECNOLOGIA PROMETTENTE

La tecnologia AG2S™ nasce abbinando in maniera sinergica il potenziale rispettivamente riducente e ossidante di queste emissioni acide per la produzione di syngas, senza l'utilizzo di alcuna nuova fonte fossile, ma nemmeno rinnovabile, e in maniera energeticamente autosostenibile.
La tecnologia si applica a qualsiasi impianto in cui sono co-presenti emissioni di H_2S e CO_2. Gli esempi più classici sono i processi di idrodesolforazione presenti nelle raffinerie che oggi, attraverso il processo Claus, convertono l'H_2S in zolfo elementare ed acqua, prodotti di scarso interesse economico.
Sono in corso anche progetti nell'ambito del gas naturale, con conversione dei gas acidi a bocca di pozzo, dello shale oil, della geotermia, dl trattamento degli oli esausti e della produzione del gas naturale sintetico.
In particolare, si segnala il progetto "CO_2-free coal-to-methanol process" secondo cui la tecnologia AG_2S sarà in grado di recuperare tutte le emissioni CO_2 dell'intera filiera di sintesi.



AG2S™ TECHNOLOGY: SCHEMA DI PROCESSO

FIGURA 3 - LE FACILITIES DEDICATE AI LABORATORI PERMANENTI DEL POLITECNICO DI MILANO PRESSO ITELYUM REGENERATION. A DESTRA, VISTA ESTERNA DEI LABORATORI IN CUI OPERERANNO RICERCATORI DEL CENTRE FOR SUPER DEL POLITECNICO E DI ITELYUM REGENERATION. A SINISTRA, VISTA INTERNA CON I REFERENTI DI RICERCA E SVILUPPO, IL PROF. FLAVIO MANENTI (POLITECNICO DI MILANO,) E L'ING. FRANCESCO GALLO (ITELYUM REGENERATION)

Laboratorio permanente del Politecnico di Milano nell'impianto Itelyum a Pieve Fissiraga

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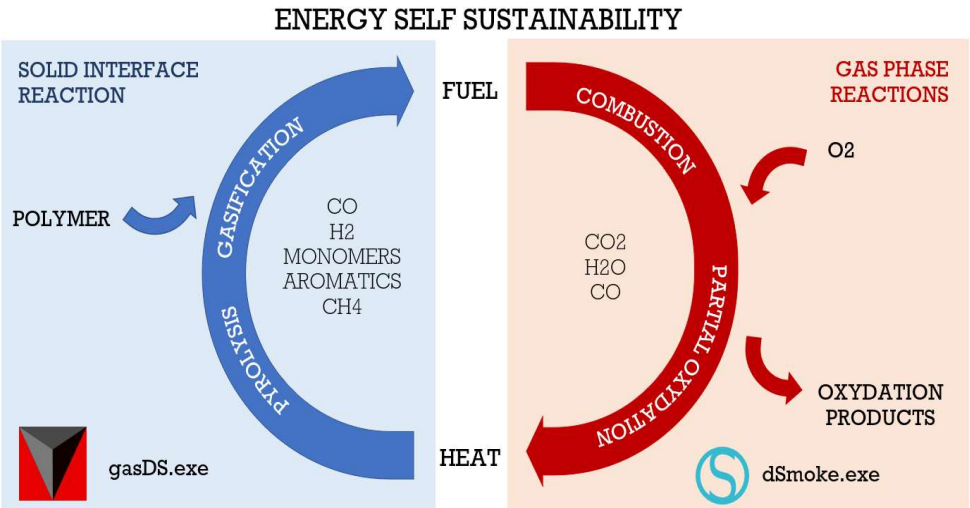
La Tecnologia PLASTBREAKER

Pyrolysis is the process of plastic thermal cracking thanks to rapid heating in the absence of oxygen, reducing the plastics long polymer chains into shorter hydrocarbons. The process takes place in four stages, namely initiation, transfer, decomposition and termination, resulting in the production of vapours and char. Pyrolysis vapours include both condensable and non-condensable gases. The condensation of the condensable vapours forms the pyrolysis wax/oil, which is a complex combination of the thermal cracking. Inter-reactions between these primary thermal cracking products results in the production of secondary products and char and non-condensable gases as by-products of the pyrolysis process.

The pyrolysis process occurs in a thermal reactor, in inert atmosphere, at atmospheric pressure and at a fixed reaction temperature. Usually, thermal cracking of plastics occurs within the temperature range of 300 – 650°C, depending on the heating rate and plastics type with the reaction temperature strongly influencing the pyrolysis product yields.



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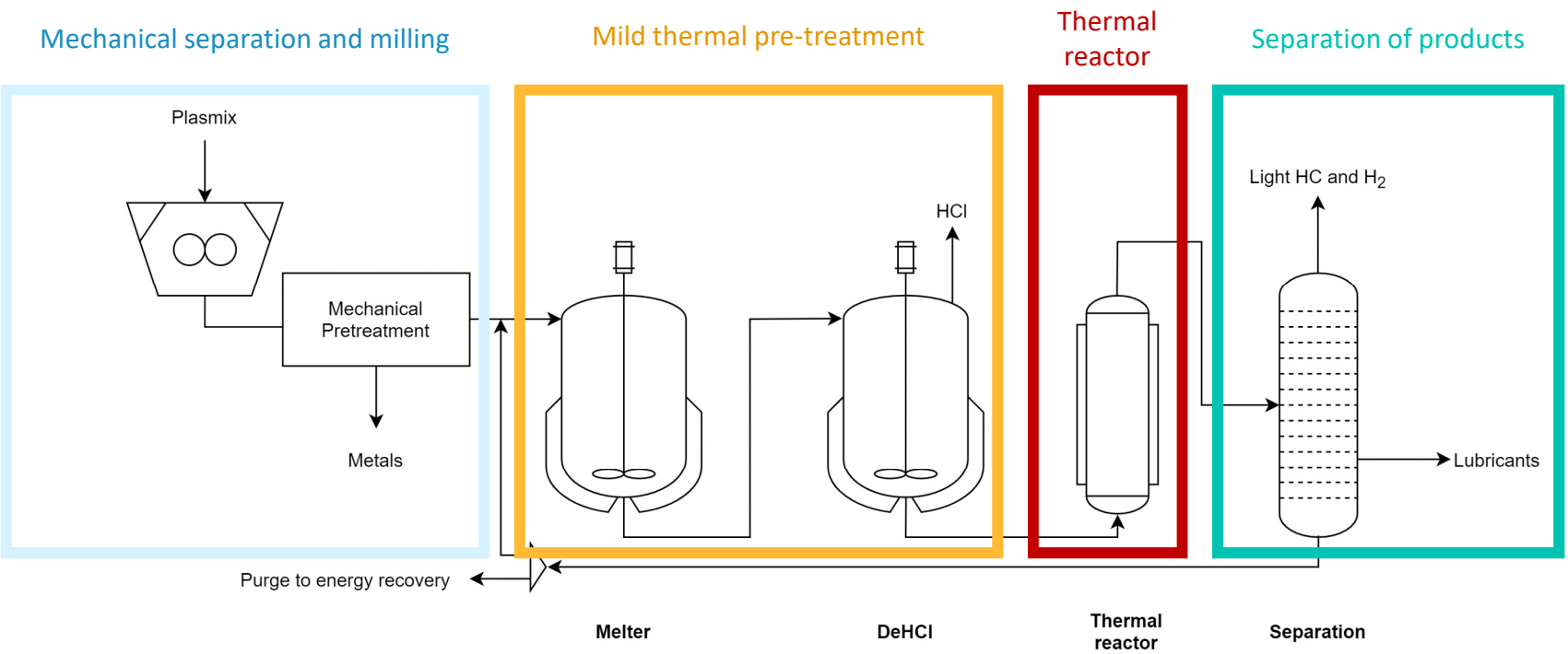
La Tecnologia PLASTBREAKER

Open Innovation : Hydrogen Strategy



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IPCEI Hydrogen – Project Overview

Open Innovation : IPCEI Hydrogen

Development of a **blue/green hydrogen production specific hub** in Itelyum Regeneration refinery in Pieve Fissiraga, Lodi, Italy

Hydrogen production initiatives

- **Steam-reforming unit, with CO2 capture plant**, producing 1000 Nm3/h of Hydrogen from natural gas and. Capturing CO2 emissions will allow to reduce the environmental impact of the hydrogen produced enabling its classification as blue hydrogen
- **Plastbreaker unit**, which converts plasmix material into green hydrogen and lube base using an innovative technology:
  - pilot unit with annual treatment capacity of ca. 1000 t of plastic, for the production of more than 150 t/year hydrogen, is already in place on Itelyum facilities;
  - The project includes the industrialization of the unit with an annual treatment capacifit of ca. 80.000 t of plastic, for the production of more than 12.000 t/year hydrogen production;
- **Electrolysis unit**, with a capacity of 20MW allowing for more than 2.000 t/year hydrogen production. The electrolysis unit will be fed with 100% renewable electricity, sourced with specific PPAs and origin certificate, to produce green hydrogen

Hydrogen use destinations

- **Replacement of current natural gas** as a fuel for boilers and cogeneration units of the production site;`
- **Use as a process feed** to the hydrofinishing unit of the used mineral oil re-refinery unit on-site
- **Hydrofinishing of vegetable used oil**, to produce sustainable 2nd and 3rd generation biofuels
- **Injection into national natural gas network**
- **Bottling**, together with CO2 and O2 (byproducts of the project), in a specific **bottling and refuelling station** to be realized on-site

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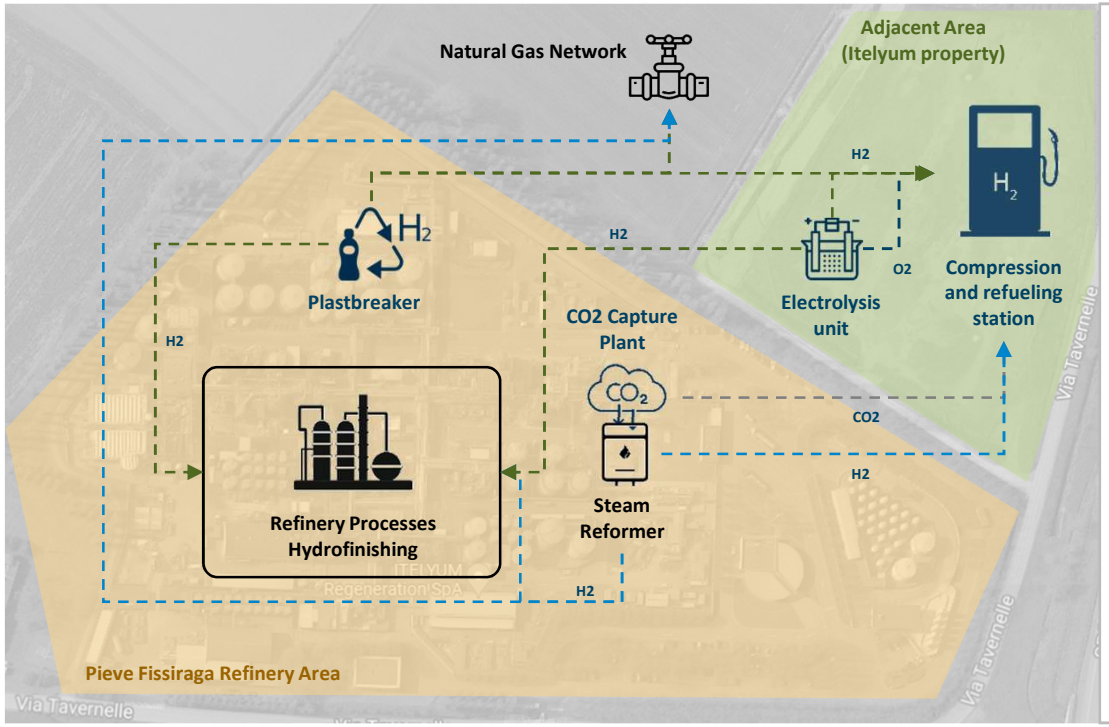
Project Conceptual Scheme and key metrics

Open Innovation : IPCEI Hydrogen



- Plasmix treatment capacity: ca. **80.000 t/year**
- Hydrogen Production ca. **14.000 t/year**:
  - ca. 2.000 t/year from electrolysis
  - ca. 12.000 t/year from plasmix
- Byproducts from continuing treatments:
  - Biolubricant: **8.000 t/year**
  - 2nd and 3rd generation biodiesel: **8.000 t/year**
  - Base lube (group II, group III, white), ultra-low sulphur gasoil and bitume: **48.000 t/year**
- CO_2 impact abatement **126.000 t/year**:
  - 85.000 t/year from complete switch of Itelyum facility from natural gas to hydrogen combustible, which of 5.000 t/year from steam reformer CO2 capture
  - 41.000 t/year from plastics wastes treatment compared to incineration

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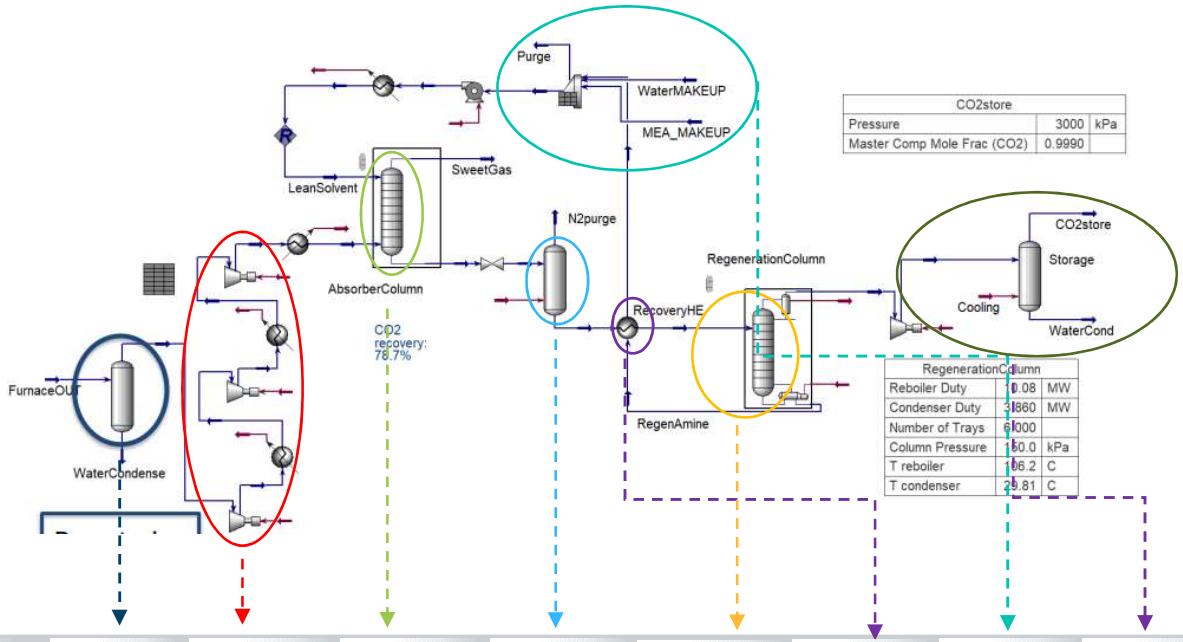
Focus on CO_2 Capture

Open Innovation : IPCEI Hydrogen



CO2store		
Pressure	3000	kPa
Master Comp Mole Frac (CO2)	0.9990	

RegenerationColumn		
Reboiler Duty	10.08	MW
Condenser Duty	31860	MW
Number of Trays	61000	
Column Pressure	150.0	kPa
T reboiler	106.2	C
T condenser	25.81	C

Input data:
70,000 Nm3/h
Max 12% (vol/vol) of CO2
Ambient Condition (1 atm and 25°C)

1 **Dewatering** → **Compression : 1 bara to 16 bara and with inter-refrigeration post-cooling** → **Absorber column with MEA solution at 37-50°C and 16 bara** → **Depressuriz atopm amd purge N2 (preserve product purity** → **Stripping CO2 and MEA solution regerenation at 1.7 bara (feed at 90°C)** → **Heat Recovery** → **Make-up & Purge ricycle** → **Compressio n (30 bara), dewatering & storage**

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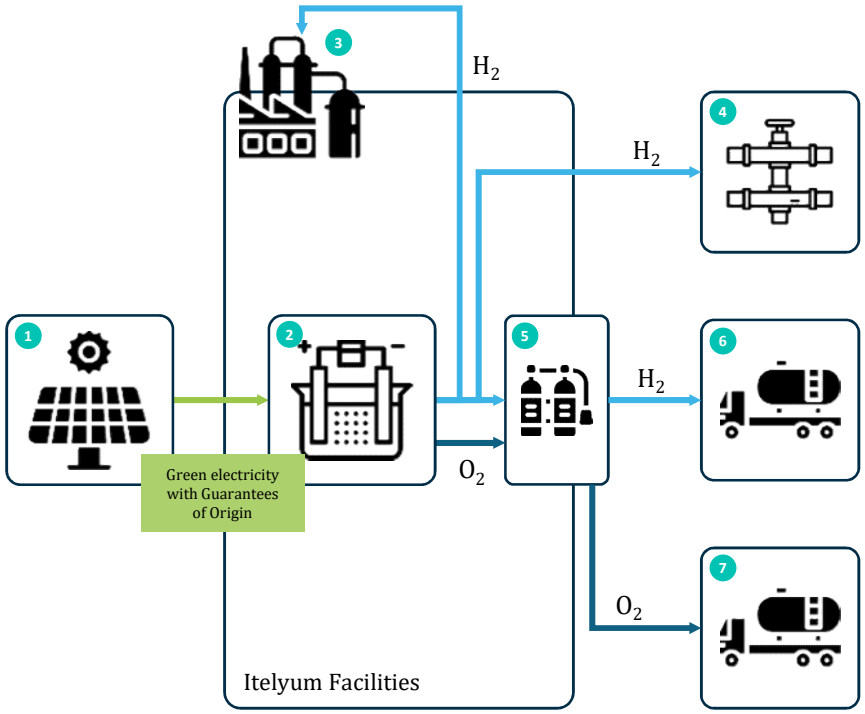
Focus on Electrolysis Unit

Open Innovation : IPCEI Hydrogen



ID	Description
1	▪ Green Electricity PPA with guarantees of origin
2.1	▪ Financing for electrolysis plant and refineries conversion to hydrogen
2.2	▪ Provision of electrolysis technology and agreements with international players
2.3	▪ EPC and project management for electrolysis plant implementation and operation
3	▪ Hydrogen and Oxygen consumption in refineries production processes
4	▪ Hydrogen injection in natural gas transportation pipeline network
5	▪ Hydrogen and Oxygen compression and bottling plant
6	▪ Hydrogen offtaking by third parties
7	▪ Oxygen offtaking by third parties

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Partners involved

Open Innovation : IPCEI Hydrogen

POLITECNICO MILANO 1863

Politecnico di Milano: Plastbreaker technology is today at TRL6 and further consolidation. Activities are planned in a dedicated laboratory under construction at Itelyum facilities in order to advance pilot phase and to strengthen data needed for the industrial scale up

Scouting ongoing

Electrolyser manufacturers: Itelyum is scanning state-of-the-art technologies by relevant manufacturers in order to consolidate electrolysers' understanding in terms of productions yields, hydrogen output specifics, energy consumption profiles, maintenance costs and capex needed for its implementation

preliminary

Hydrogen compressors and CO_2 liquefaction suppliers: both electrolyser and steam reformer output hydrogen and CO_2 at near-to-atmospheric pressure. Itelyum is evaluating partnership with compressor developers to implement a compression and bottling station within an Itelyum-owned land with different profit-sharing schemes

Scouting ongoing

CO_2 capture technology suppliers: amine-based CO_2 capture represents primary technology to be adopted for CO_2 capture and Itelyum is studying its best application to refinery facilities, starting from steam reforming unit

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Key Positive Effects on the Market

1

The proposed implementation covers the whole H_2 ecosystem, and the implementation of the project will also bridge the gap between the latter and the circular economy. Plastbreaker and electrolysis are two complementary technologies that will produce hydrogen from green sources and waste, and the same H2 will be used in the refinery processes to:

- Regenerate used mineral oil to obtain base lube
- Produce biofuels and biolubricants

2

The project would result in the following further positive side effects on market:

- First industrial-scale application of Plastbreaker technology, which could provide a sustainable and green alternative for plastic recycling
- Viability of a reliable source of hydrogen for hydrogen-intensive industries, to be eventually supplied directly through the existing pipeline infrastructure
- Progressive roll-out of a refuelling infrastructure and supply chain for hydrogen mobility, starting form heavy duty vehicles

3

These spill-over effects could be amplified with

- Green electricity reaching stability of supply or origin certificates mechanisms even out volatility of renewable sources
- Reliable plastic waste supply chain, and sustainable plastic recycling overcomes incineration
- Hydrogen policy promoting broad H2 use and conversion of fossil-fuels equipment
- Hydrogen transportation network being scaled to supply hydrogen to H2-intensive utilizers
- Hydrogen mobility expansion at retail scale and sustained by distribution network

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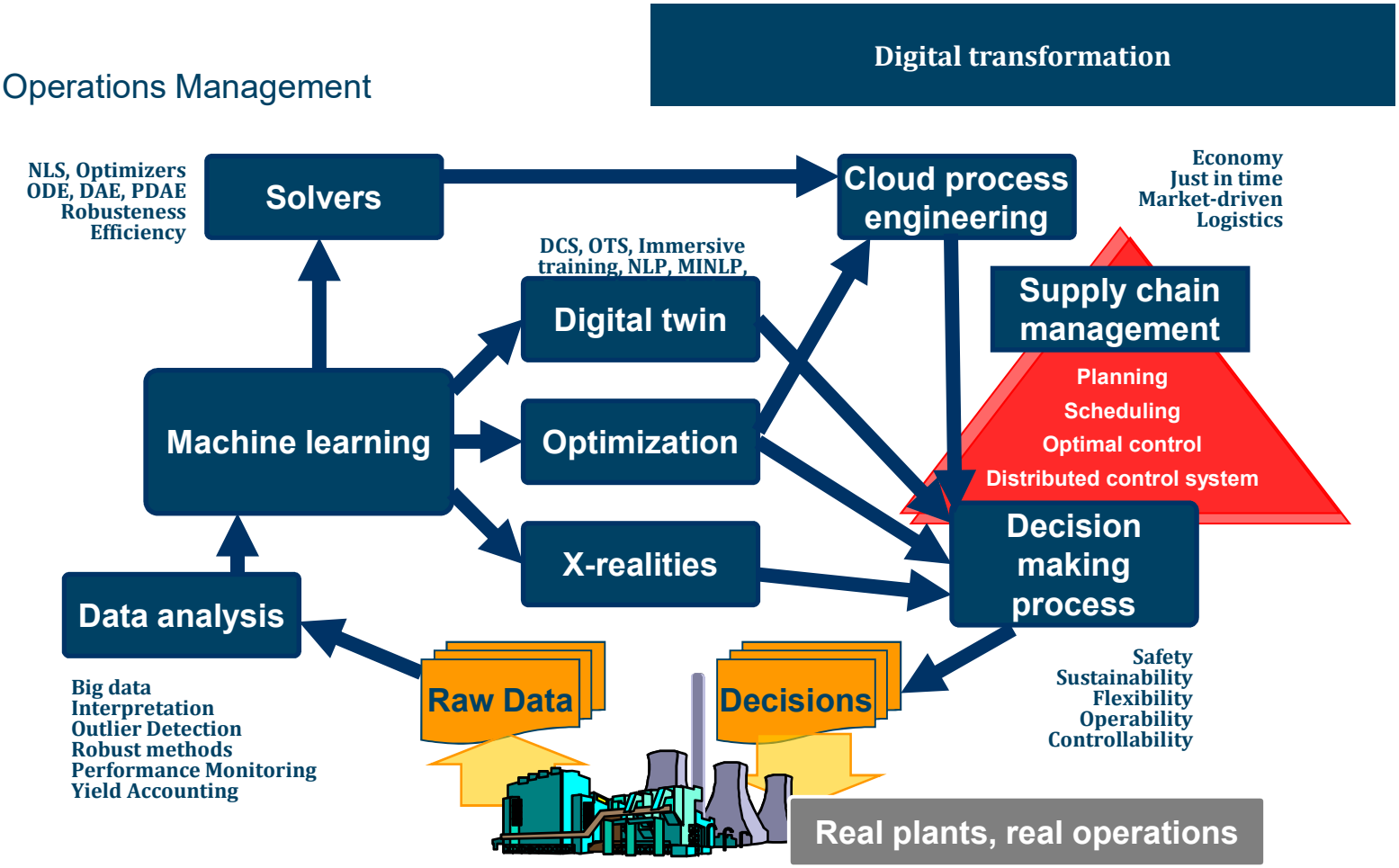
Process Operations Management



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