ReWaCEM
Resource recovery from liquid Waste streams in metal industry by Cutting Edge Membrane technologies

Dr.-Ing. Joachim Koschikowski
Fraunhofer Institut für Solare Energiesysteme

ReWaCEM
14 Project Partners

R&D Institutes and Univeristies	SMEs	Industry
Fraunhofer ISE	SolarSpring membrane solutions	TecnoZinco zincatura a caldo centro lavorazione acciaio
BFI Excellence in Applied Research VDEh-Betriebsforschungsinstitut GmbH	DEUKUM	ELECTRONIQUEL
Gobierno de España, Ministerio de Economía, Industria y Competitividad; Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas	AEE INTEC	DEUTSCHE EDELSTAHLWERKE
Università degli Studi di Palermo	PSE Powering Scientific Exchange	AT&S
University of Stuttgart Chair of Building Physics (LBP) Life Cycle Engineering (GaBi)	aIz	

ReWaCEM Resource recovery from industrial waste water by cutting edge membrane technology

SPIRE PROJECT

ReWaCEM

Objectives of the Project

The overall objective of the project is to reduce the :

- fresh water demand
- demand for make up acids
- ammount of disposed waste water and
- amount of disposed valuable metals

in metall plating industry by a combiantion of innovative membrane separation technologies as Diffusion Dialysis (DD), Membrane Distillation (MD) + advanced filtration systems for pre treatment

Source:DEW

ReWaCEM

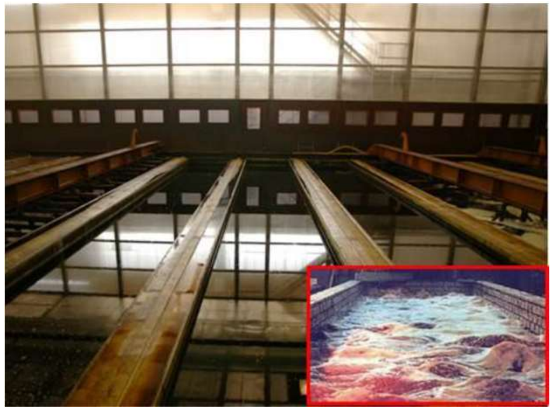
The 4 Different Demonstration Cases

Case 1: Recovery of **hydrochloric acid** (HCl) pickling solutions in zinc plating processes

Case 2: Recovery of **sulfuric acid** (H_2SO_4)from rinsing water in copper and silver coating + Recovery of **fresh water** from precipitation

Case 3: Recovery of **mixed nitric + hydrofluoric acid** (HNO_3+ HF) **pickling solutions** in the stainless steel industry

Case 4: Recovery of **gold and Paladium** in printed circuit board industry



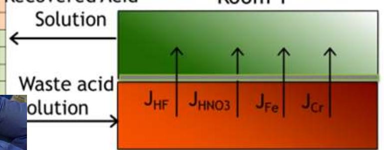
ReWaCEM
Core Activities

Process Analysis and process design

BFI Excellence in Applied Research
University of Stuttgart
Chair of Building Physics (LBP)
Life Cycle Engineering (GaBi)
UNIVERSITÀ DEGLI STUDI DI PALERMO

[HNO3]	[g/lt]	88.9
[HF]	[g/lt]	29.8
[Fe]	[g/lt]	6.1
[W_tot]	[Kg/h]	86.8
[HNO3]	[g/lt]	129.6
[HF]	[g/lt]	29.3
[Fe]	[g/lt]	5.8
[W_tot]	[Kg/h]	90.5
[HNO3]	[g/lt]	167.8
[HF]	[g/lt]	28.9
[Fe]	[g/lt]	5.6
[W_tot]	[Kg/h]	94.2

-J_{HNO3}[7], J_{HF}[8], Fe_pass(%)[5] and Cr_pass(%)[5] resulted from literature

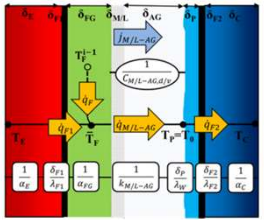


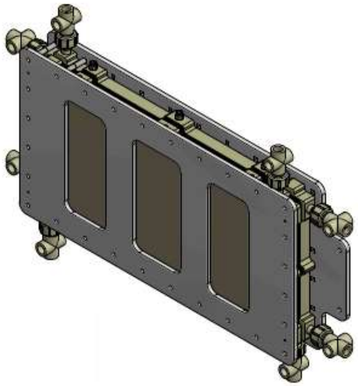
RR_max_HNO3	%	89%
RR_max_HNO3	%	92%
RR_max_HNO3	%	94%
RR_max_HF	%	62%
RR_max_HF	%	61%
RR_max_HF	%	59%

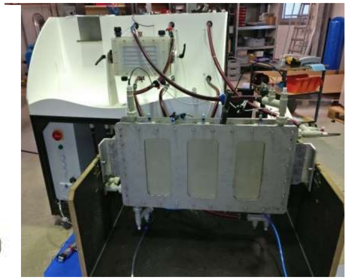
ReWaCEM
Resource recovery from industrial waste water by cutting edge membrane technology

DD and MD module design and construction

Fraunhofer ISE
DEUKUM
SolarSpring membrane solutions

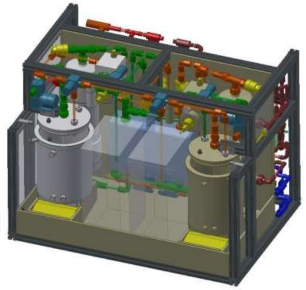


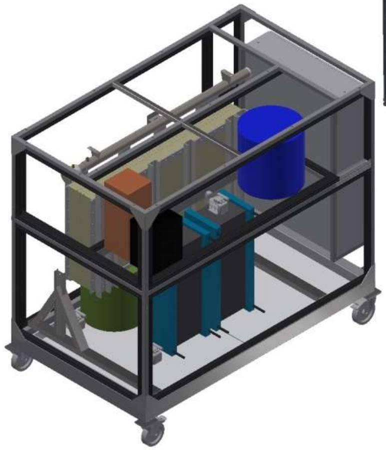




Construction and installation of 4 Demonstration plants

Fraunhofer ISE
AEE INTEC
UNIVERSITÀ DEGLI STUDI DI PALERMO
BFI Excellence in Applied Research
GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas





SPIRE PROJECT

ReWaCEM

Core Activities

Operation, assessment and optimization of Demo- plants

BFI Excellence in

GOBIERNO DE ESPAÑA | MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

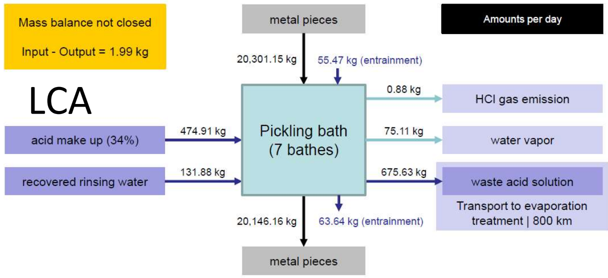
Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

AEE INTEC

UNIVERSITÀ DEGLI STUDI DI PALERMO

University of Stuttgart
Chair of Building Physics (LBP)
Life Cycle Engineering (GaBi)

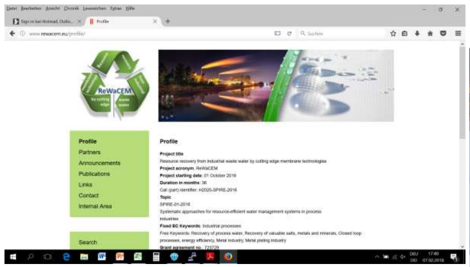
LCA



Dissemination and market introduction

aiz

PSE Powering Scientific Exchange

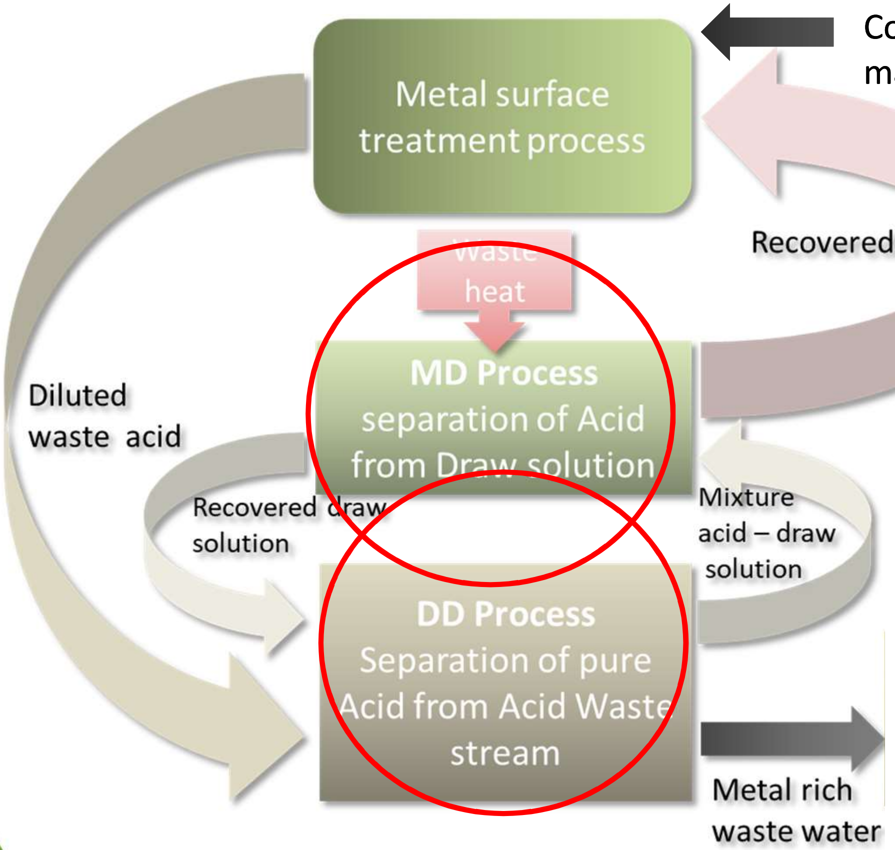


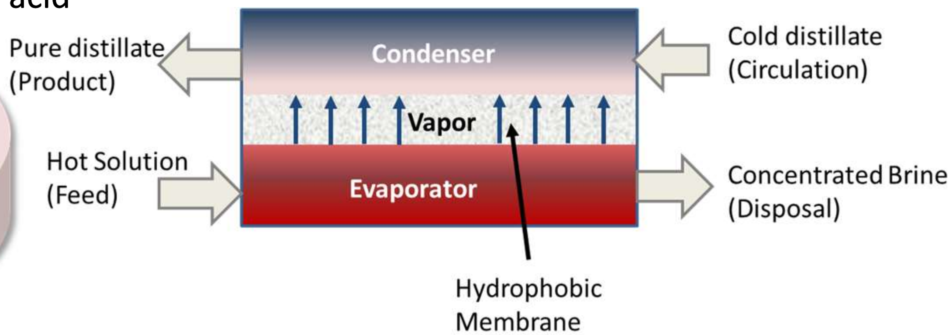
ReWaCEM Resource recovery from industrial waste water by cutting edge membrane technology

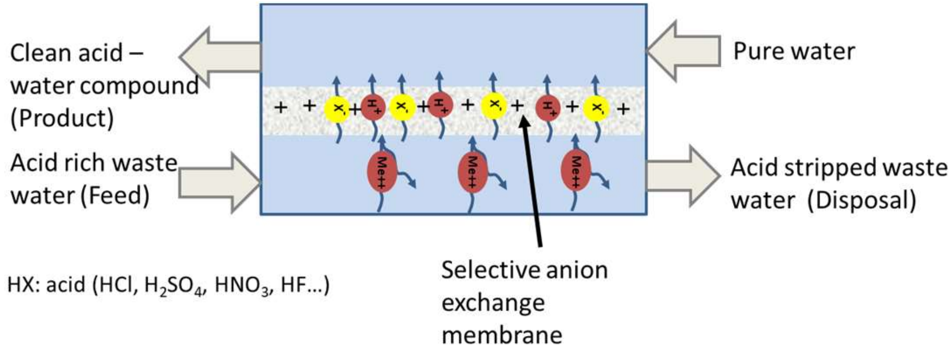
SPIRE PROJECT

ReWaCEM

Core technologies case 1: Recovery of HCl and **Case 3:** Recovery of mixed (HNO_3, HF)

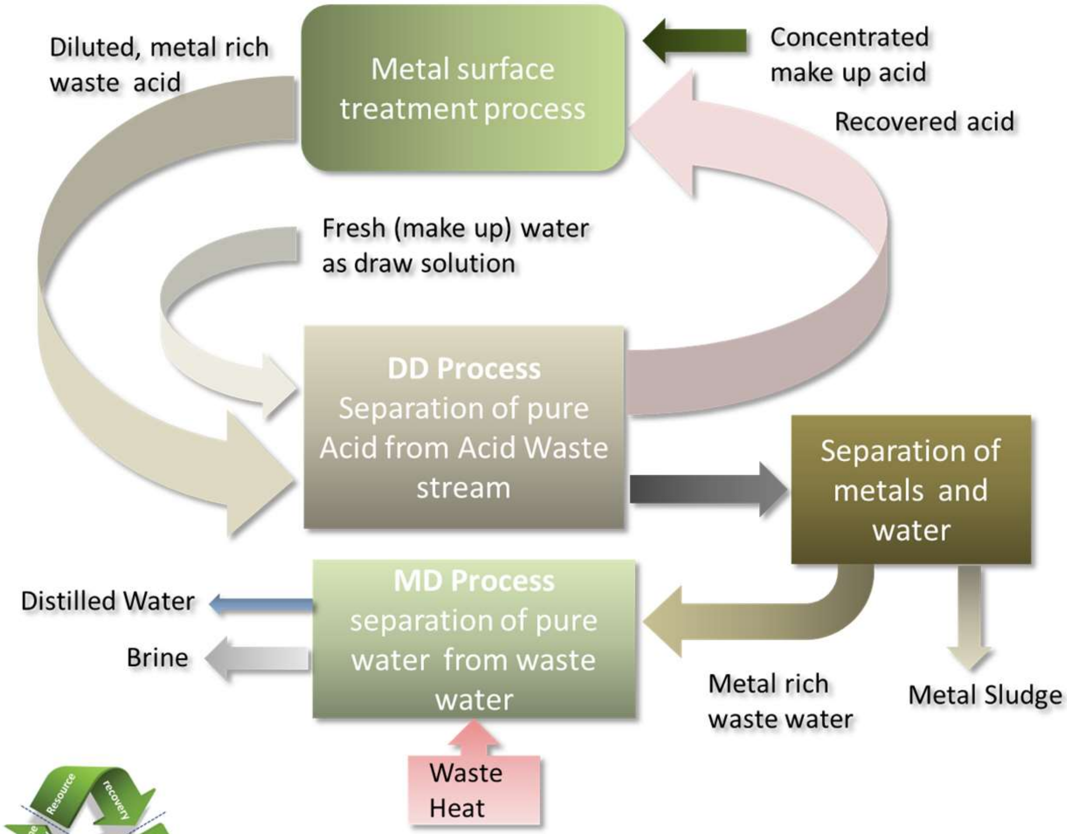


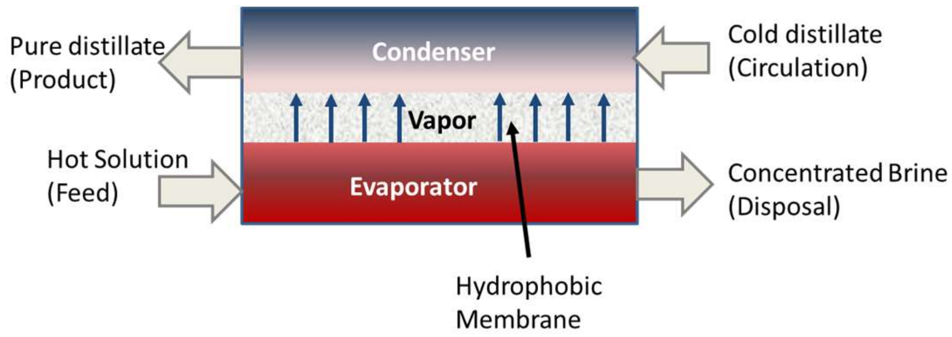


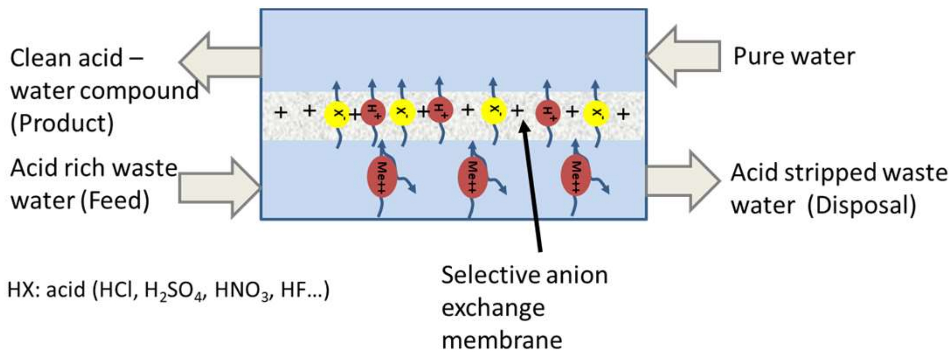


ReWaCEM

Core technologies case 2: Recovery of H_2SO_4

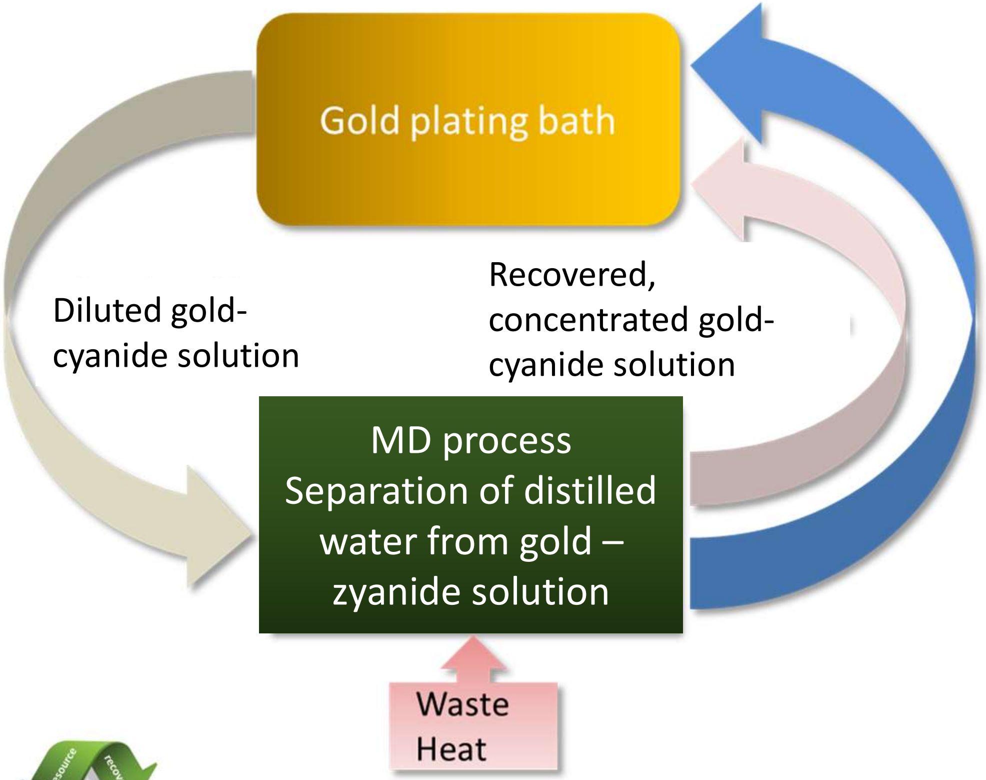


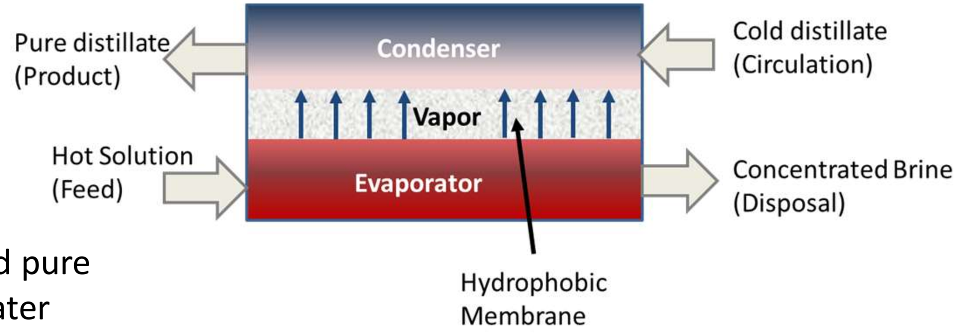




ReWaCEM

Core technologies case 4: Gold-Cyanide recovery



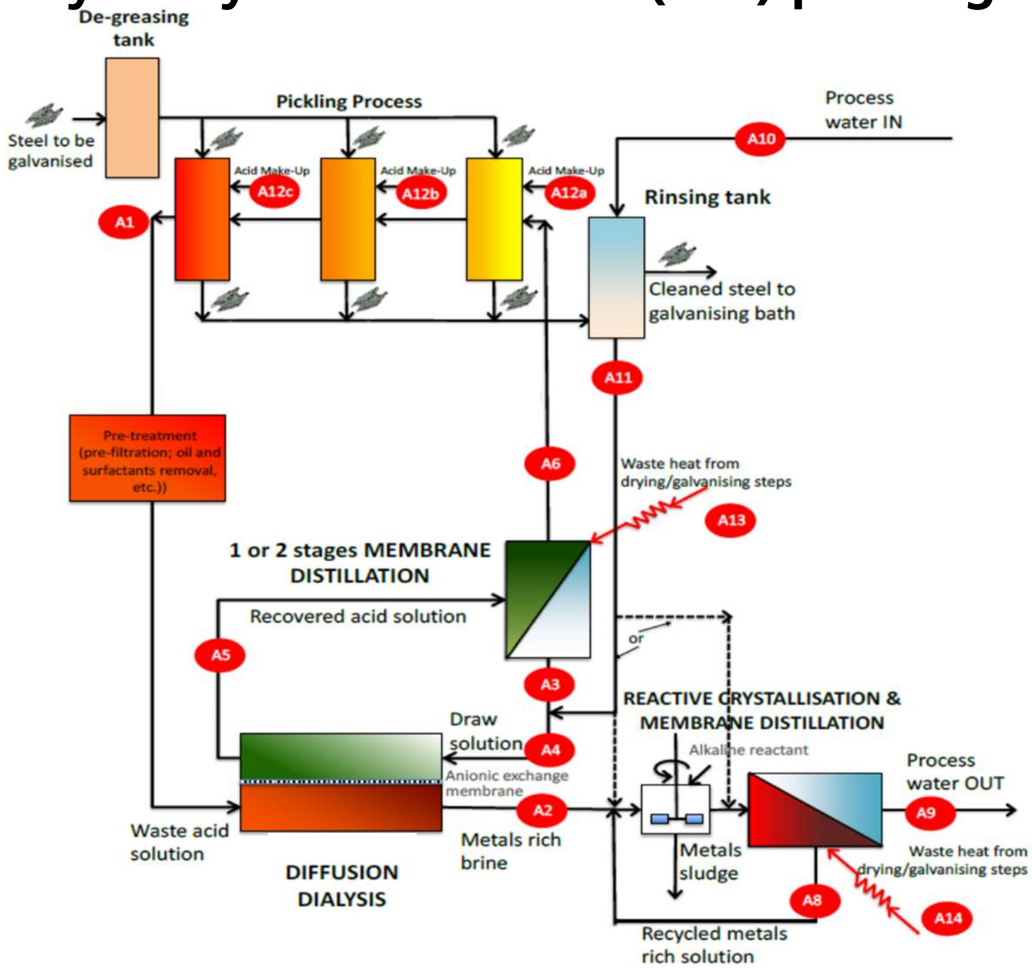


ReWaCEM

Example case 1: Recovery of hydrochloric acid (HCl) pickling solutions in zinc plating processes

Simulation results validated with lab experiments

Initial feed flow rates 15, 17 and 20kg/h



ReWaCEM

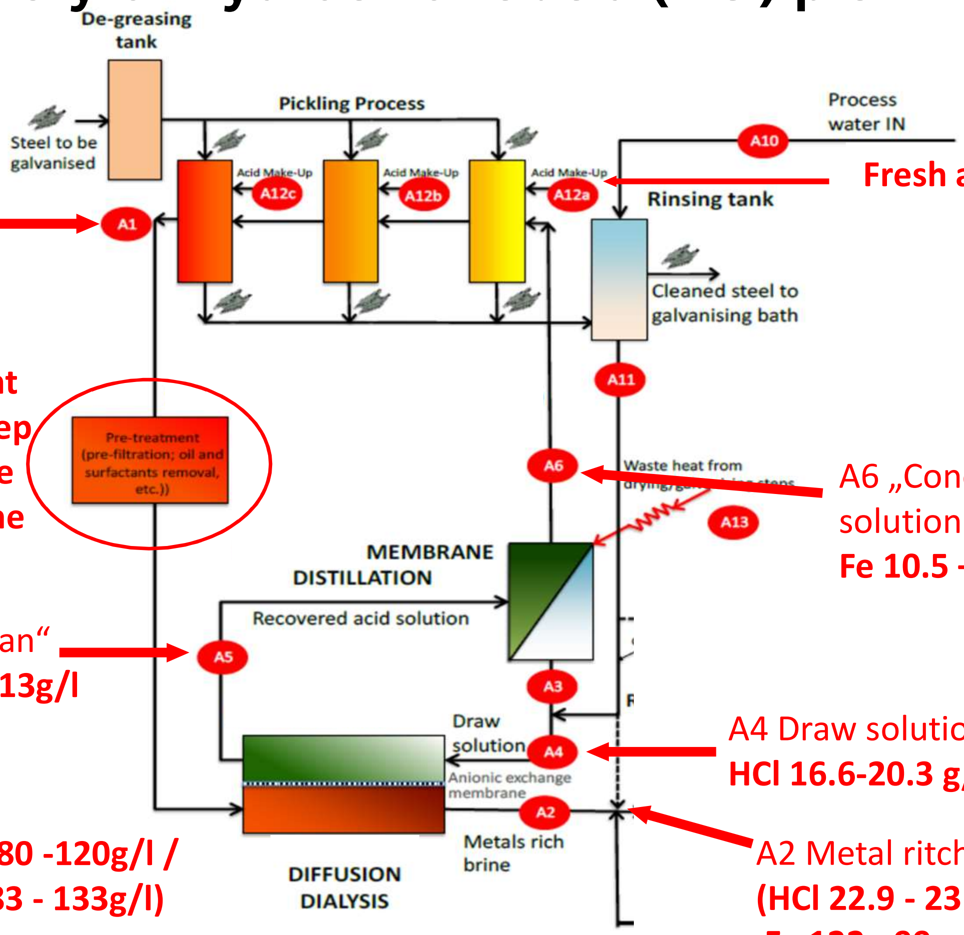
Example case 1: Recovery of hydrochloric acid (HCl) pickling solutions in zinc plating processes

A1 „Less effective“ waste pickling solution **(HCl 80 -120g/l / Fe 183-133g/l)**

Pre treatment Important step to protect the DD membrane

A5 „Low concentrated clean“ acid solution **(HCl 76.5 - 113g/l / Fe 5.6 – 4.7g/l)**

(HCl 80 -120g/l / Fe 183 - 133g/l)



Fresh acid HCl 33%

A6 „Concentrated clean“ acid solution **(HCl 111 - 156g/l / Fe 10.5 – 7.8g/l)**

A4 Draw solution **(water-HCl 16.6-20.3 g/l - Fe 0 g/l)**

A2 Metal ritch brine **(HCl 22.9 - 23.7 g/l / Fe 122 - 99 g/l)**

ReWaCEM

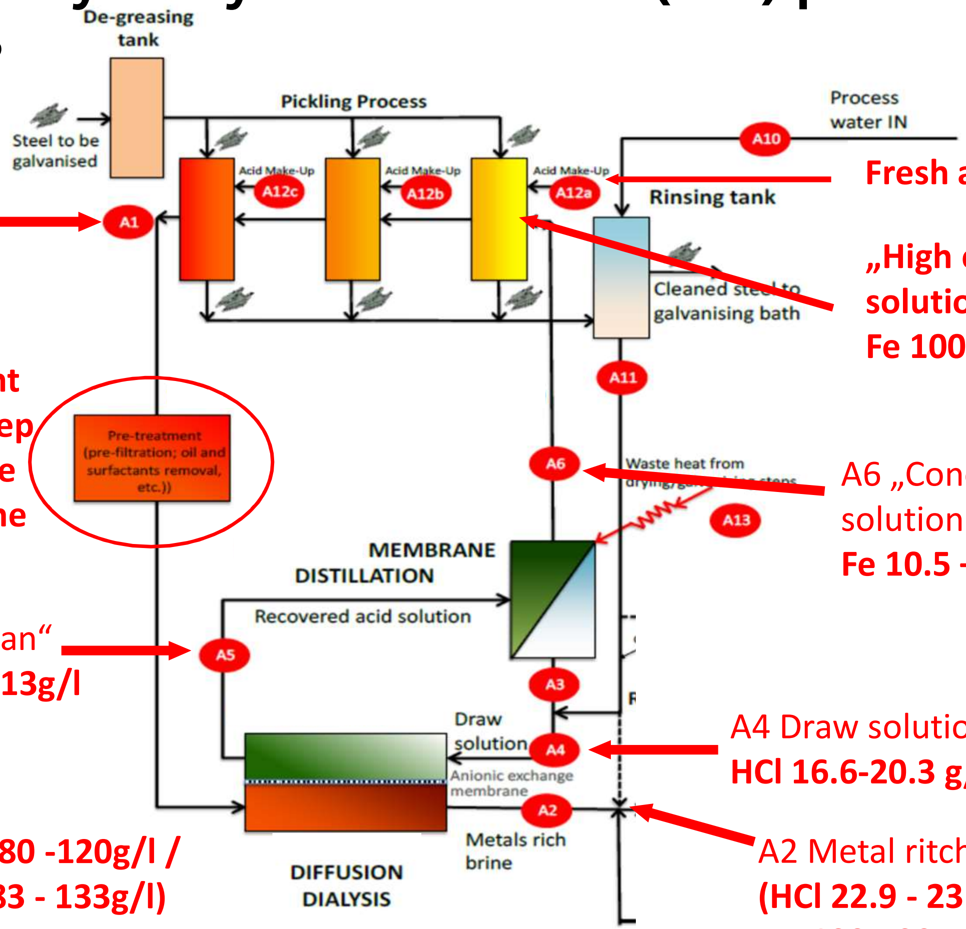
Example case 1: Recovery of hydrochloric acid (HCl) pickling solutions in zinc plating processes

A1 „Less effective“ waste pickling solution **(HCl 80 -120g/l / Fe 183-133g/l)**

Pre treatment Important step to protect the DD membrane

A5 „Low concentrated clean“ acid solution **(HCl 76.5 - 113g/l / Fe 5.6 – 4.7g/l)**

(HCl 80 -120g/l / Fe 183 - 133g/l)



Fresh acid HCl 33%

„High effective“ pickling solution HCl 120-150g/l- Fe 100-75 g/l)

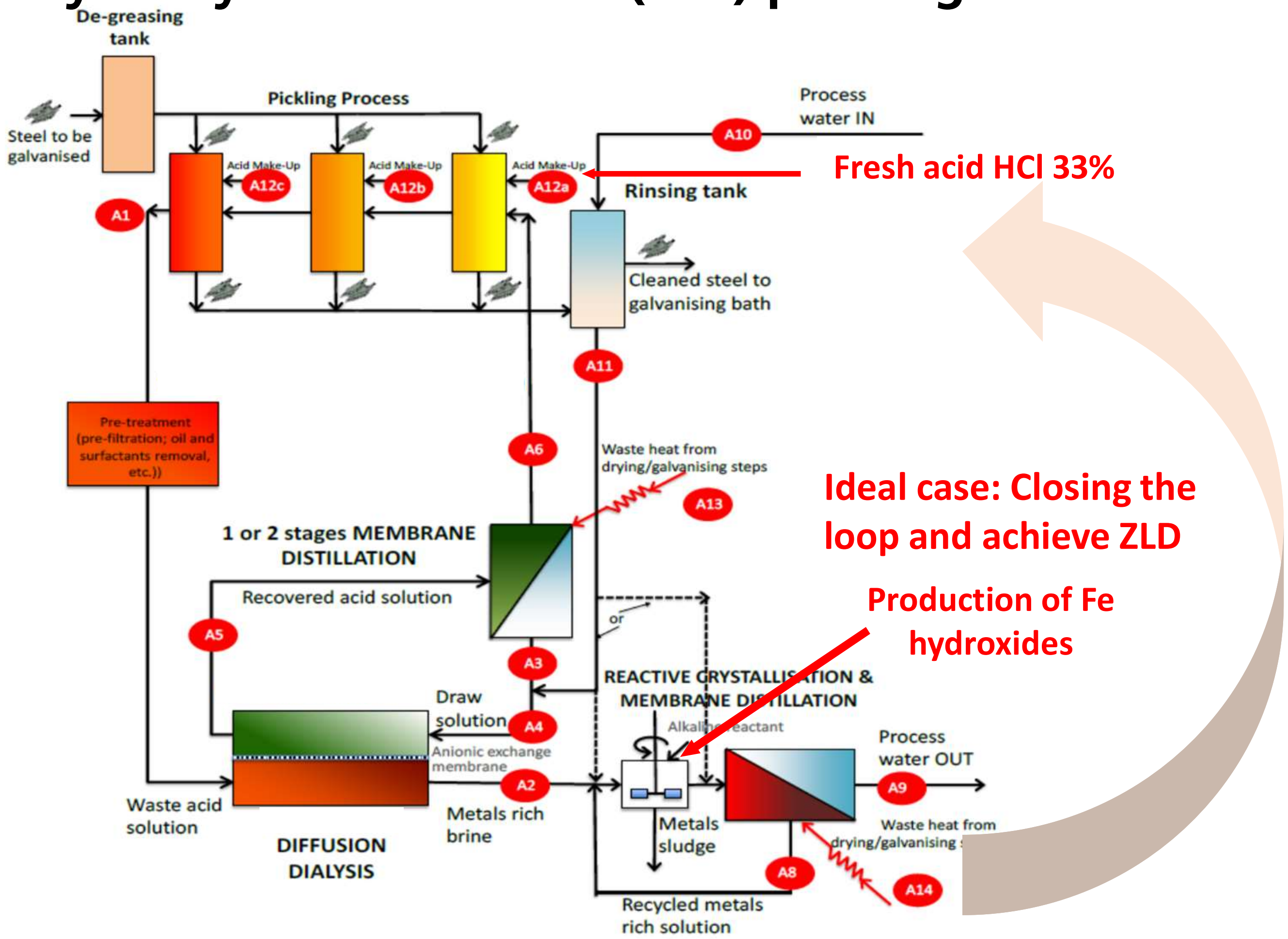
A6 „Concentrated clean“ acid solution **(HCl 111 - 156g/l / Fe 10.5 – 7.8g/l)**

A4 Draw solution **(water-HCl 16.6-20.3 g/l - Fe 0 g/l)**

A2 Metal ritch brine **(HCl 22.9 - 23.7 g/l / Fe 122 - 99 g/l)**

ReWaCEM

Example case 1: Recovery of hydrochloric acid (HCl) pickling solutions in zinc plating processes



Conclusions

- The significant reduction of waste water disposal is condition precedent by legislation to operate factories particular in Asia already today
- The reduction of waste water disposal is economically viable in many cases where transportation and disposal costs are high
- Experimental and simulation investigations in the ReWaCEM project show promising technical results and the feasibility of the DD - MD approach
- First economical evaluation in the project show that the recovery of valuable resources (acids, gold-cyanide,…) from waste streams can be profitable

Source: Jul.s Pic.s

Project coordinator email:
joachim.koschikowski@ise.fraunhofer.de