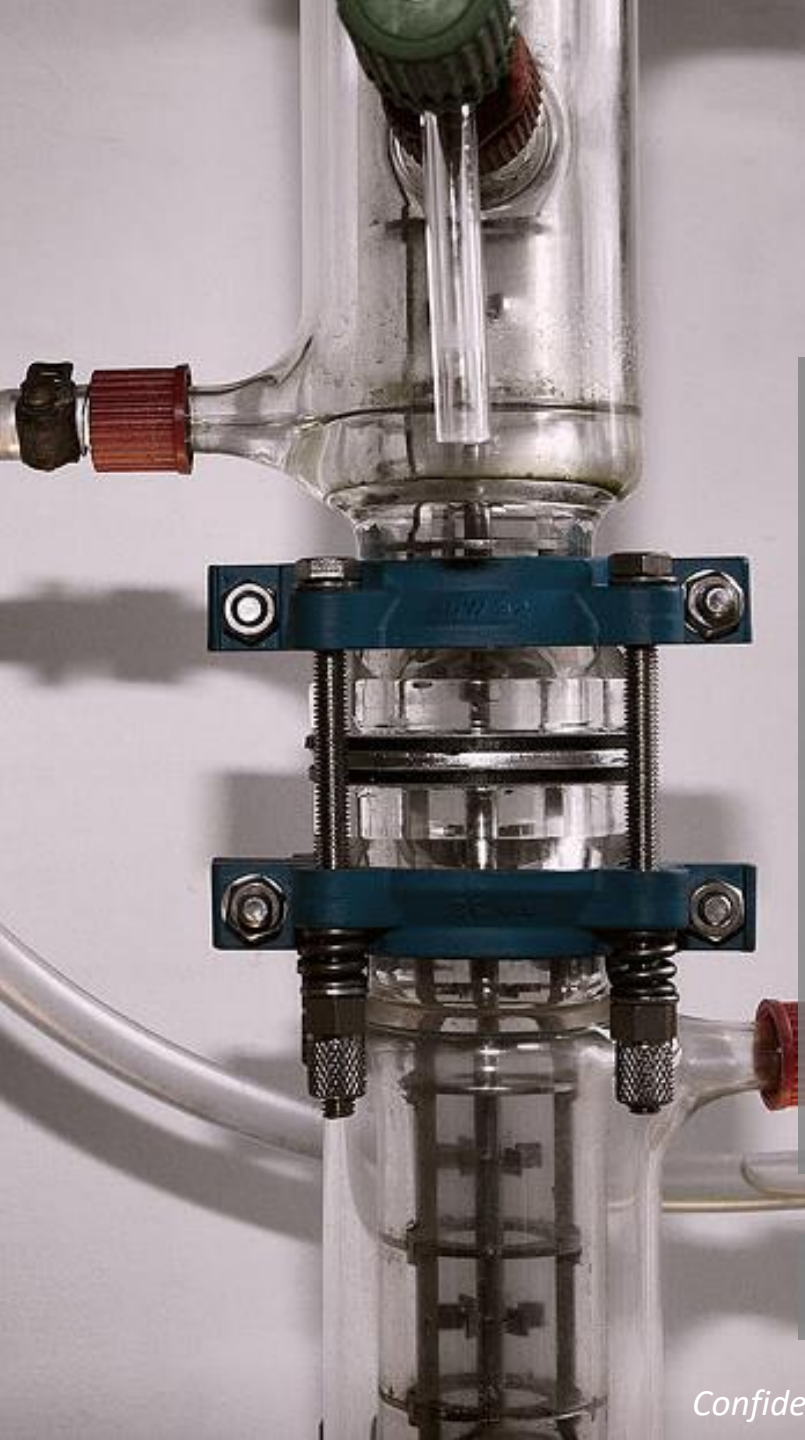


processium
Process & Product Design

Journées Techniques
SCALE-UP 2017
Adebiotech – Pôle IAR

Aides à la conception du procédé et incertitudes (design et aspect économique), cahier des charges et données critiques

21 novembre 2017, Romainville

Confidential. Not to be copied, distributed or reproduced without prior approval

processium
Process & Product Design

Contents

Confidential. Not to be copied, distributed or reproduced without prior approval

processium

Process & Product Design

1. Processium

Confidential. Not to be copied, distributed or reproduced without prior approval

Processium General Overview

Who we are

25% PhDs

15% turnover dedicated to R&D

20% turnover outside France

917 m² of laboratories

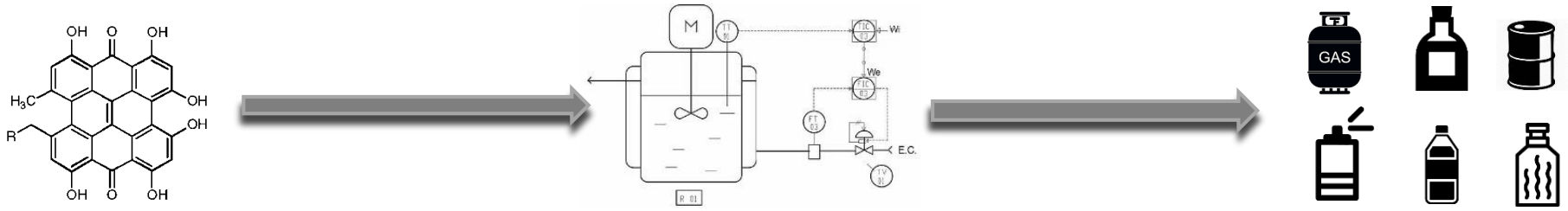
processium

processium do Brasil
Process & Product Design

Confidential. Not to be copied, distributed or reproduced without prior approval.

Processium General Overview

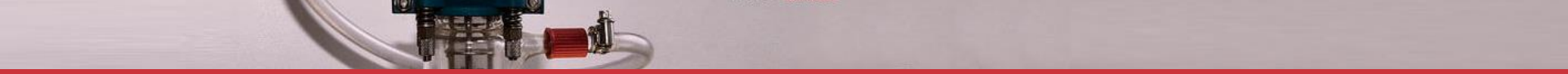
What we do



CLIENT PROJECT DEVELOPMENT

Research	Process Conception	Process Scale-up	Industrialization & production	Commercialization
	PROCESSIUM SERVICES		PROCESSIUM SERVICES	

Confidential. Not to be copied, distributed or reproduced without prior approval.



Processium General Overview

How we work

Laboratory dedicated to products

processium
Process & Product Design

Laboratory dedicated to processes

Analysis and measurements

Scientific computing

Process engineering

Confidential. Not to be copied, distributed or reproduced without prior approval.

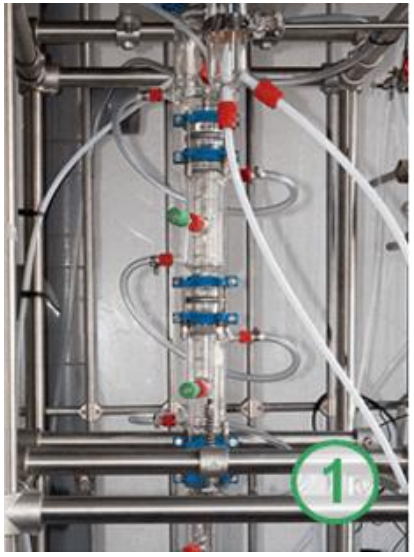
Laboratory equipments

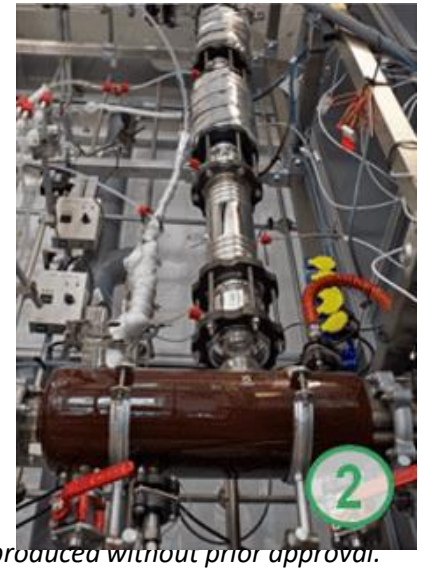
Liquid separation

1- Liquid-Liquid extraction
(continuous and stirred column)
5 to 25 l/hr, up to 150°C

2- Continuous distillation
1 to 3 l/hr, 20 to 250°C, 10 to 1,000 mbar

3- Thin layer evaporation
(short pass available)
1 to 3 l/hr, 20 to 250°C, min 1 mbar or 10-3 mbar for short pass





processium

Confidential. Not to be copied, distributed or reproduced without prior approval.

Laboratory equipments

Reaction & Separation

1- Tangential filtration (ceramic)
MF, UF – Max 4 bar

2- Ball mills

3- Batch reactor
1 bar, up to 200°C

4- Tangential filtration (organic)
MF, UF, NF, RO – Max 60 bar

5- Continuous reactor
1 l, micro-wave heating system, up to 40 bar, up to 250°C

6- High pressure distillation
1 to 20 bars
Continuous or batch distillation
Reactive distillation

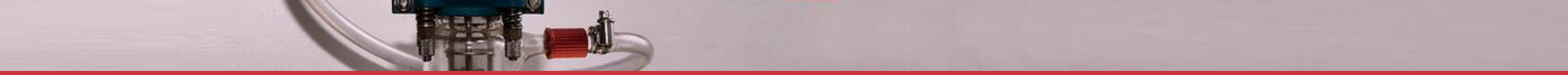
processium
Confidential. Not to be copied, distributed

processium

Process & Product Design

2. Feedback from Chemical Industry

Confidential. Not to be copied, distributed or reproduced without prior approval

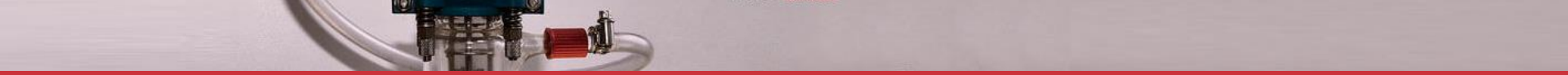


Process Scale-up

Basic Data Errors

Outcome Variable	Projects without Basic Data Errors	Projects with Basic Data Errors
Percent of successful projects	44	0
Average production months 7-12 vs plan (%)	87	38
Time required for start-up (months / deviation regarding forecast)	7 / +40%	22 / +140%
Slip in execution schedule (%)	16	30

Confidential. Not to be copied, distributed or reproduced without prior approval.



Process Scale-up

Key scale-up items

External: Market, people and environment

Critical Scale-up Item
New product ?
Performance product?
New market?
New customers?
New country? New safety, health, environmental aspects
New suppliers of technology?
New feedstocks? New suppliers?

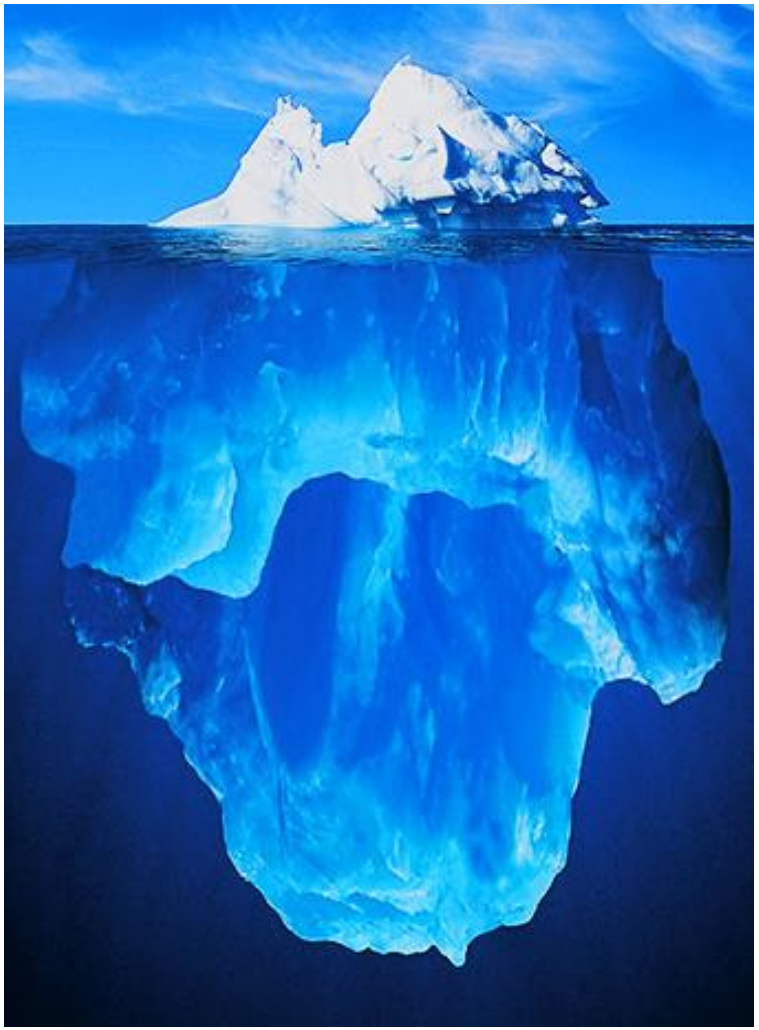
Process

Critical Scale-up Item
New chemistry?
Novel process?
Novel unit operation? Novel equipment?
Recycle streams?
Solids processing?
New control?
Process operation experience
Phases mass transfer?
Hydrodynamics scale-up?
G/L or L/L mass transfer?
Residence time distribution?
Heat transfer?
New construction materials for streams?

Confidential. Not to be copied, distributed or reproduced without prior approval.

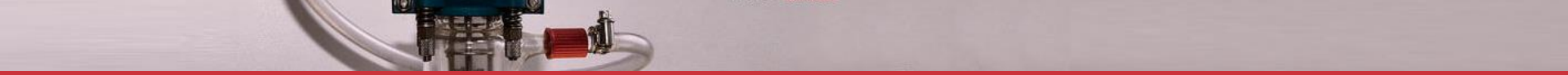
Process Scale-up

Technology Readiness Levels (TRL)



TRL 9	N^{th} of a kind	TRL 9	Proven Industrial scale
TRL 8	A first-of-a-kind application, large-scale production facility	TRL 7-8	Demo-industrial scale
TRL 6-7	Demo scale production facility		
		TRL 5-6	Pilot-scale
TRL 3-5	Development and Validation of technology		
		TRL 3-4	Lab-scale
TRL 1-2	Concept	TRL 1-2	Research

Confidential. Not to be copied, distributed or reproduced without prior approval.

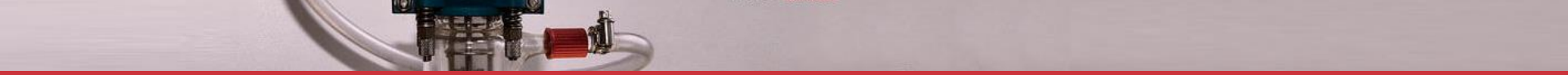


Process Scale-up

Key steps

	Production rate (kg/h)	Scale Up Factor
Industrial Plant	100-10,000	-
Pilot Plant	1-100	1-10000
Miniplant	0.1-1	100-100,000

Confidential. Not to be copied, distributed or reproduced without prior approval.



Process Scale-up

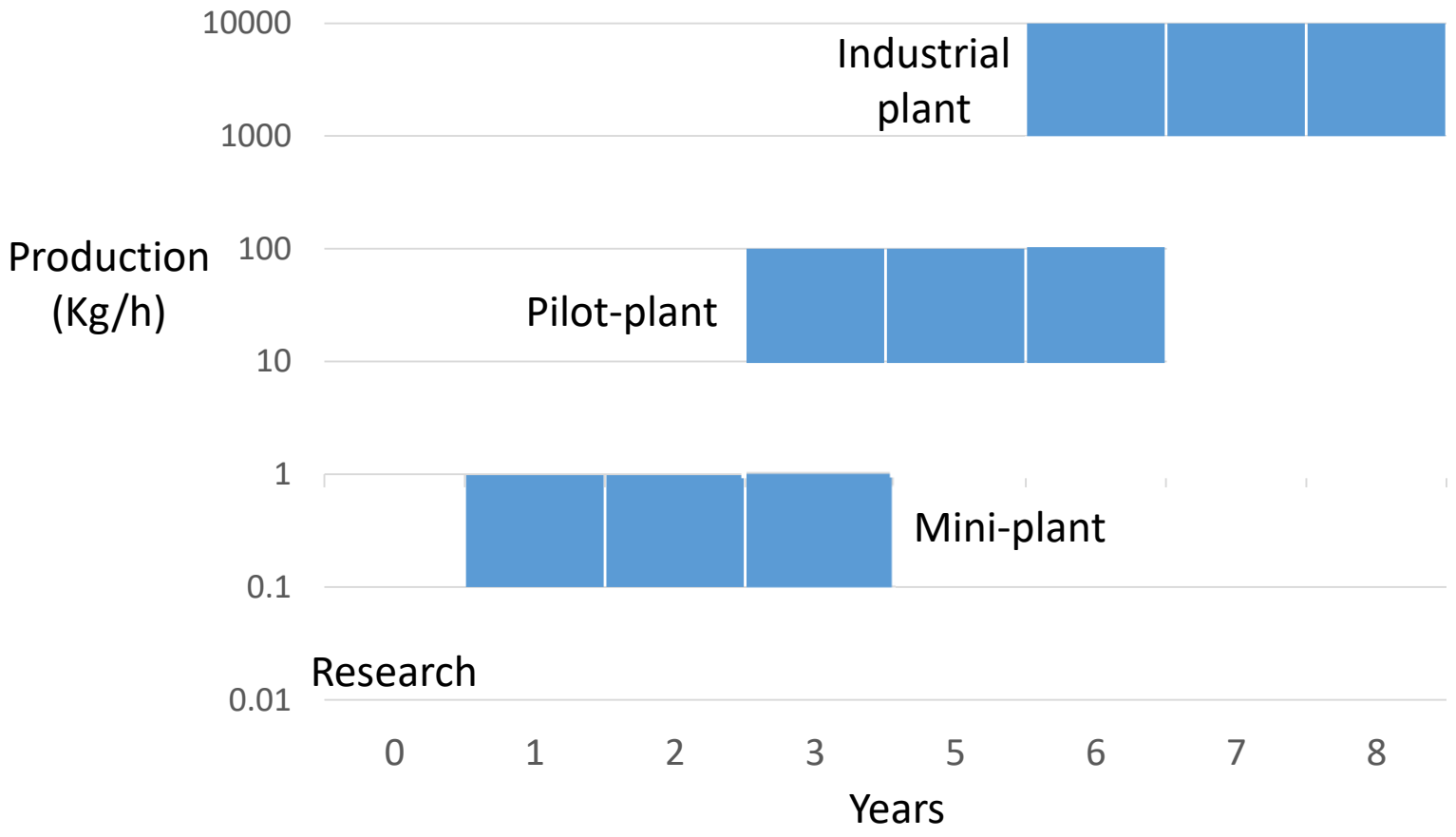
Scale-up factors

Process Step	Maximum Scale-Up value
Reactors **Multi-tubular & adiabatic Fixed-Bed reactor**	> 10 000 (50 000 achieved)
Homogeneous Tube and Stirred Tank	> 10 000
Bubble Column	< 1 000
Gas-solid Fluidized bed	50 - 100
Separation processes **Distillation and Rectification**	1 000 – 50 000
Absorption	1 000 – 50 000
Extraction	500 – 1 000
Drying	20 - 50
Crystallisation	20 - 30

Confidential. Not to be copied, distributed or reproduced without prior approval.

Process Scale-up

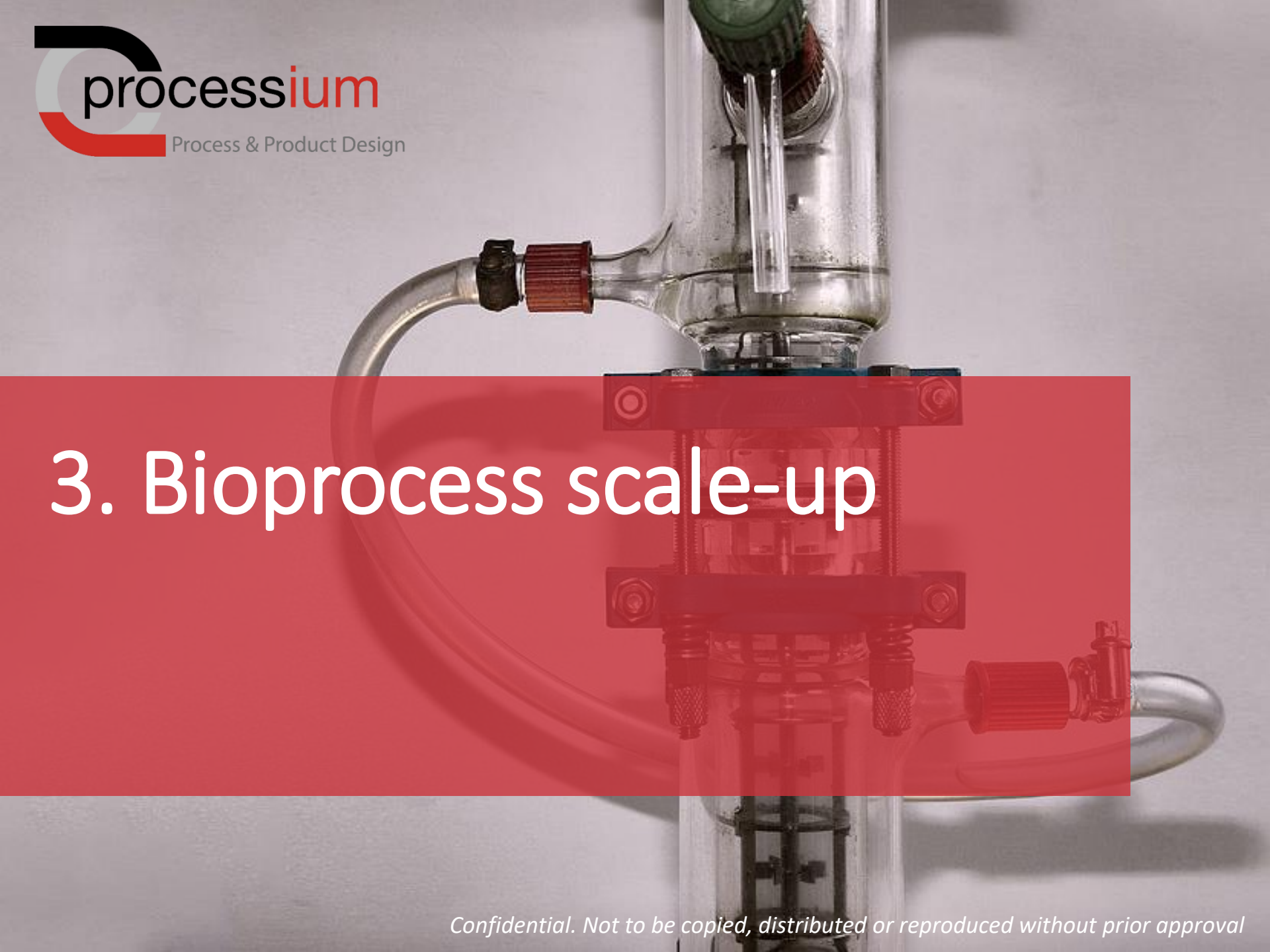
Time scale



Confidential. Not to be copied, distributed or reproduced without prior approval.

processium

Process & Product Design



3. Bioprocess scale-up

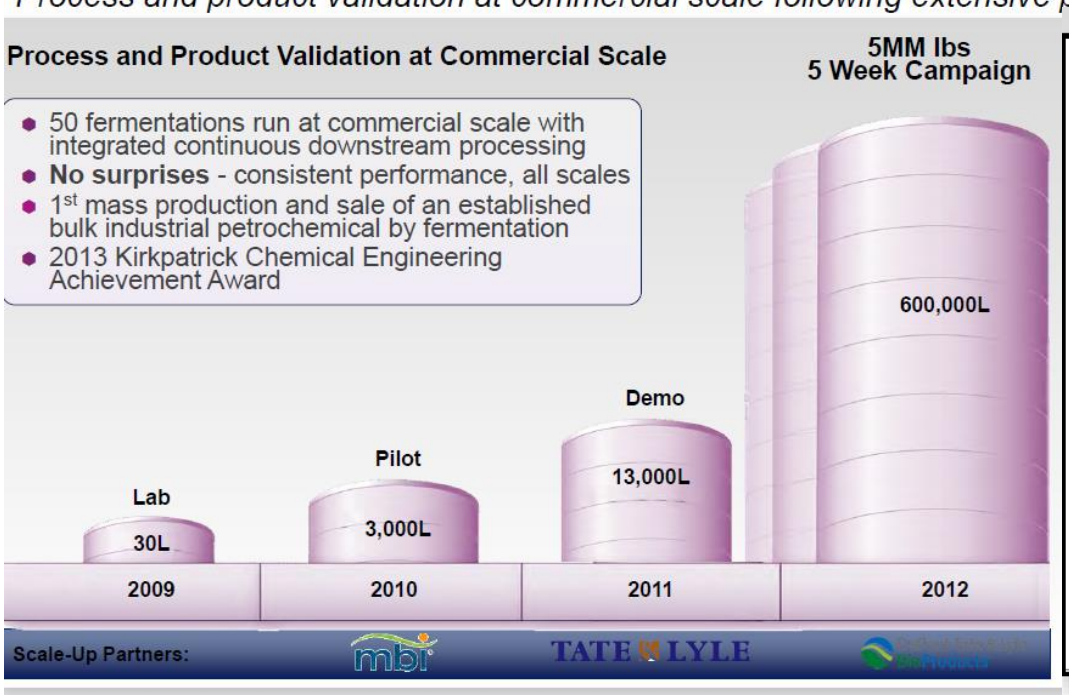
Confidential. Not to be copied, distributed or reproduced without prior approval

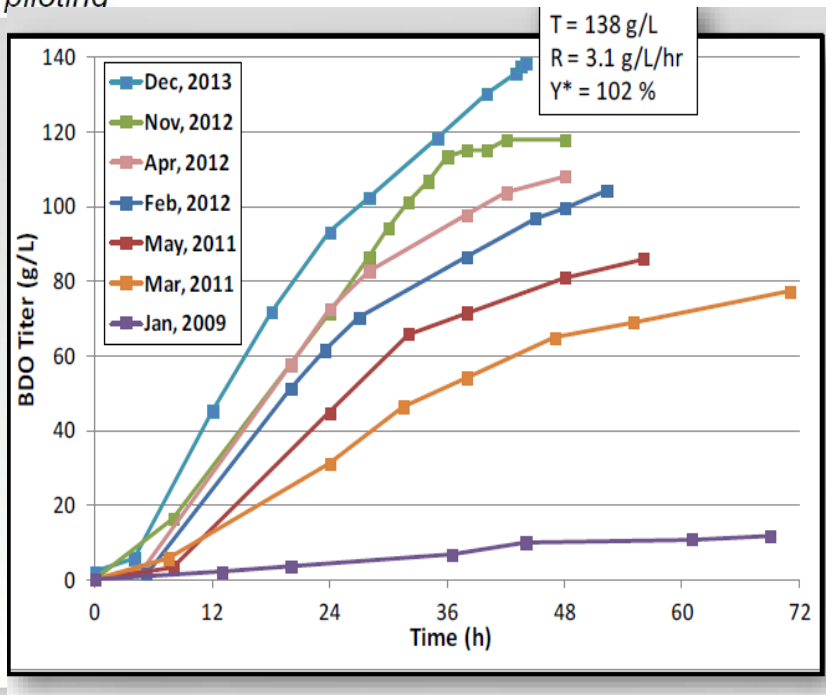
Industrial bioprocess scale-up

A case study : 1,4 BDO

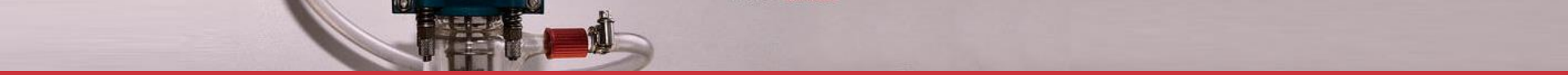
1,4-Butanediol: 5 years from concept to commercial (0.5X 1,3-PDO)

Process and product validation at commercial scale following extensive pilotina





Confidential. Not to be copied, distributed or reproduced without prior approval.

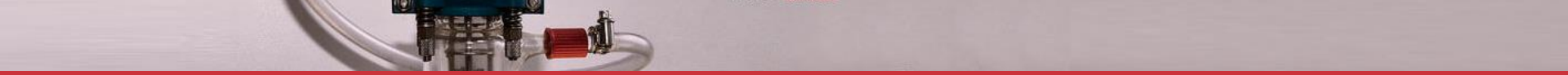


Industrial bioprocess scale-up

Biotech vs Chemicals

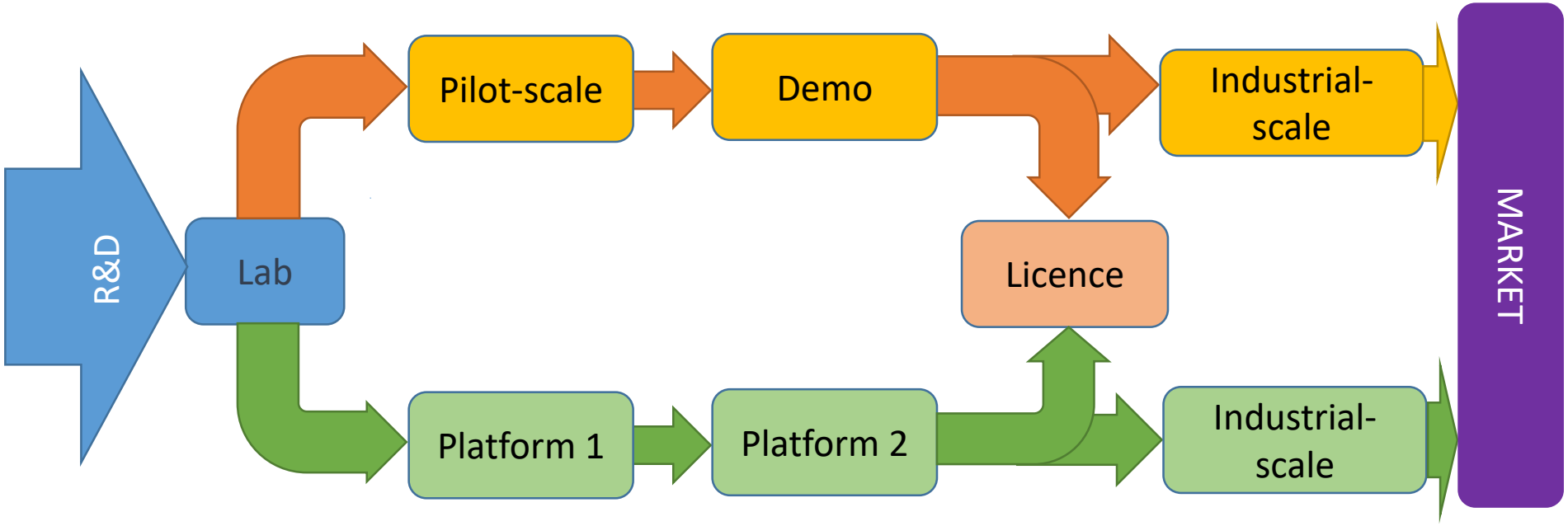
- Microbes
- Aseptic operation of fermenters
- Control of the fermentation process
- Natural feedstocks
- Low product concentration in aqueous phase
- Selectivity
- Impurities

Confidential. Not to be copied, distributed or reproduced without prior approval.



Product & Process Scale-Up

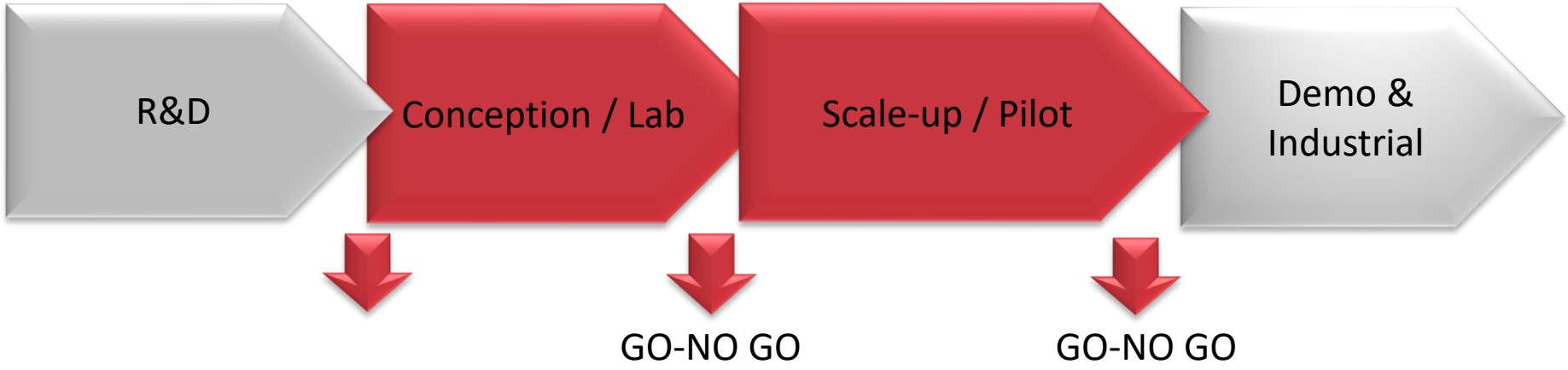
Two main routes for Process/Product Scale-Up



Confidential. Not to be copied, distributed or reproduced without prior approval.

Industrial bioprocess scale-up

Main steps of the conception and scale-up stages



Deliverables

- Either process book of the demo plant and V1 of the process book of the target industrial unit
- Or update production package
- Risk analysis

Confidential. Not to be copied, distributed or reproduced without prior approval.

Industrial bioprocess scale-up

Main results of the conception and scale-up stages

Development → Conception / Lab → Scale-up / Pilot → Demo & Industrial

- Process flowsheet
- Mass & heating balances
- Operating conditions
- Sizing of unit operations
- First optimization of the process regarding
  - CAPEX/OPEX
  - Product quality, productivity, yields
  - Environmental impact

Confidential. Not to be copied, distributed or reproduced without prior approval.

processium

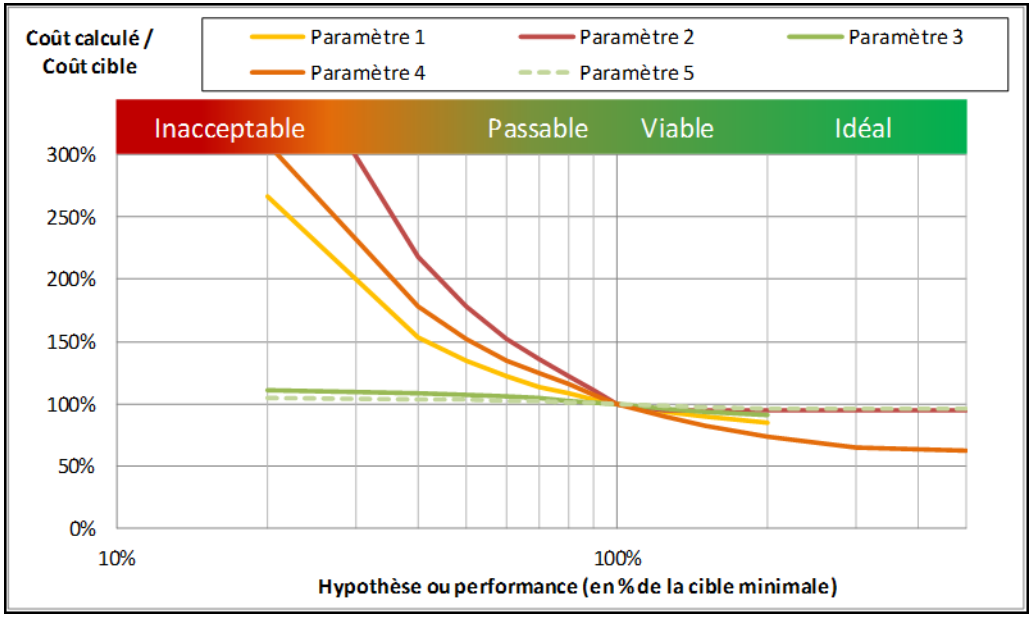
Process & Product Design

4. Case studies

Confidential. Not to be copied, distributed or reproduced without prior approval

Case study 1

Preliminary Techno-economical study



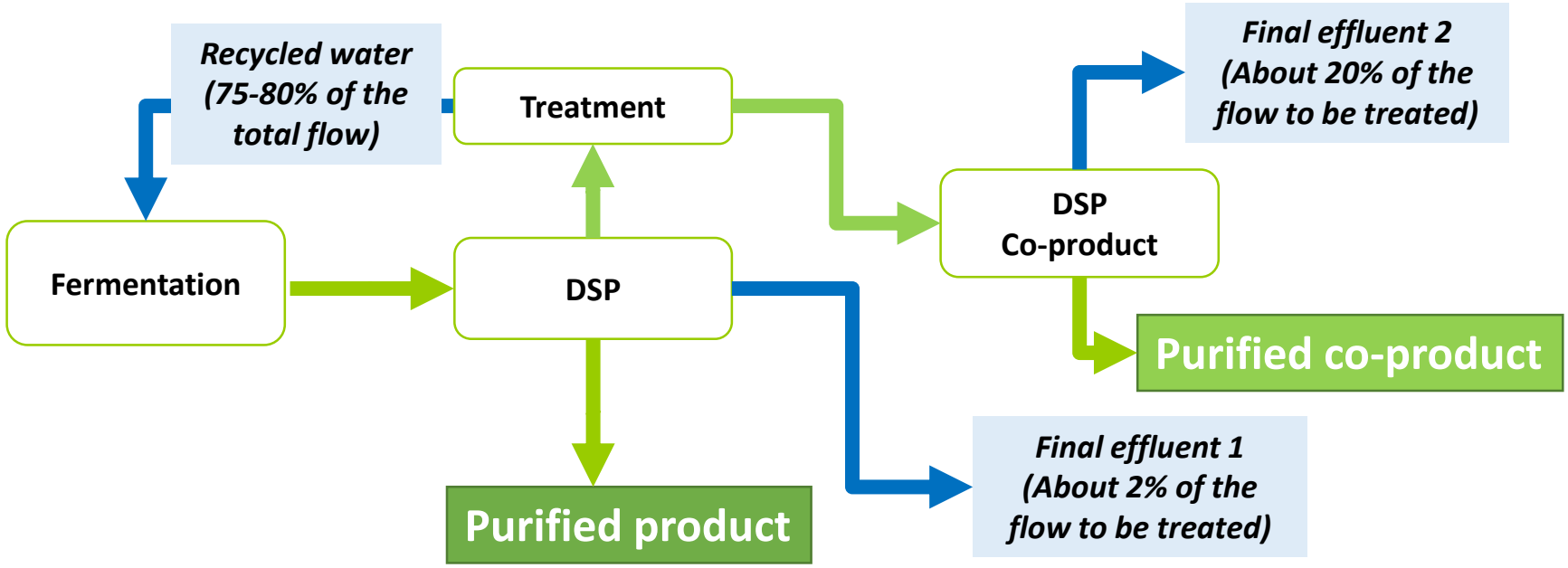
Results	• First technical and economical estimation of the project • Fermentation development defined in connection with purification and separation requirements

Confidential. Not to be copied, distributed or reproduced without prior approval.

Case study 2

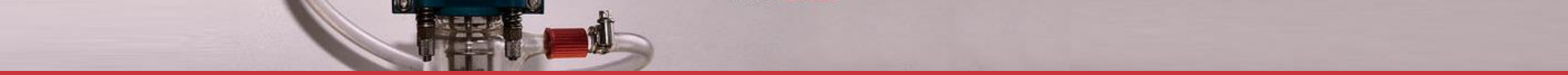
Process development

Joint development of DSP / USP



- Minimization by fermentation of the most penalizing impurity in purification
- Valorization of a co-product: economy of work in fermentation
- Recycling water with sufficient quality for fermentation

Confidential. Not to be copied, distributed or reproduced without prior approval.



Case study 3

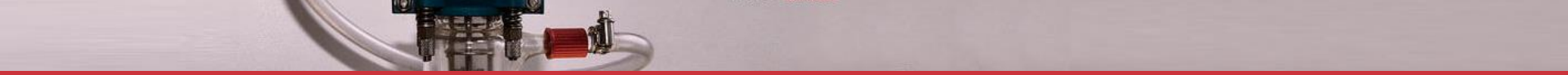
Feedstock impact

- One of the key step in the process is to separate the noble product from the salts and sugars

- Development of a DSP with 1G sugars :
  - PCD A (1G): Performance and robustness. Yield 97%
  - PCD B (1G): Low performance, and limited robustness due to fouling problems. Yield ≈ 80%
- Development of the same DSP with 2G sugars :
  - PCD A (2G): Low performance and limited robustness
  - PCD B (2G): Good performance, and robustness. Yield 95%

→ Necessity to have a global approach : raw material/USP/DSP

Confidential. Not to be copied, distributed or reproduced without prior approval.



Case study 4

Downstream process optimization

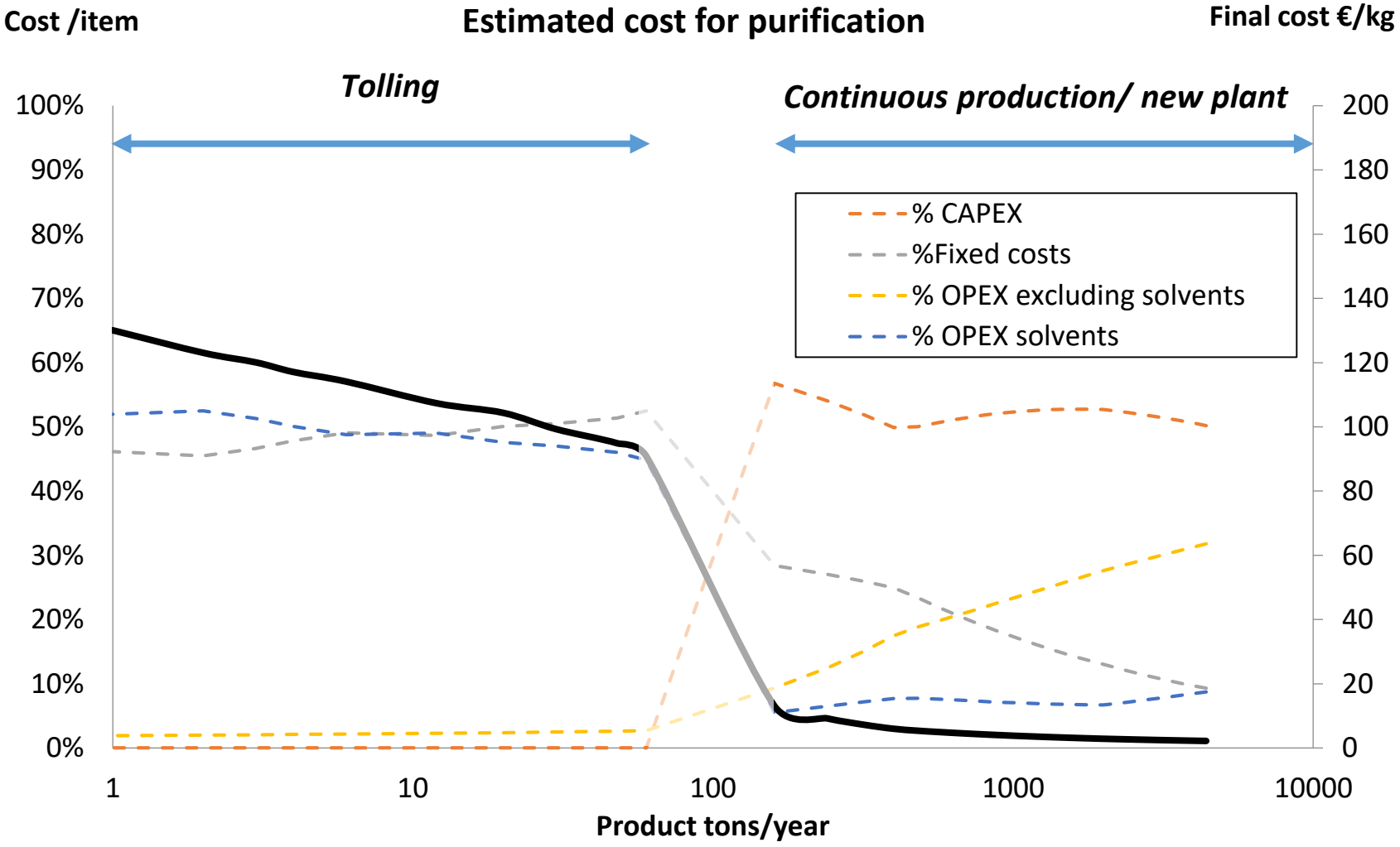
Estimation for a 30 KT/year plant

	Reference solution	Energy integration solution	Difference
Vapor consumption t/h	44.5	12.5	-72%
Cooling water Consumption m3/an	2630	730	-73%
Power consumption (compressor) GWh/an	-	13.56	-
Number of exchangers	16	18	+2
OPEX k€/an	8480	3173	-62%
K€/ t final product	0.28	0.10	-62%
Return on investment time		< 2 ans	

Confidential. Not to be copied, distributed or reproduced without prior approval.

Case study 5

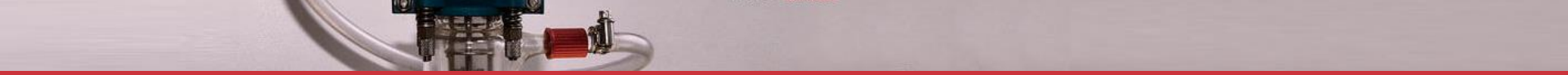
Toll manufacturing



processium
Process & Product Design

5. Conclusions

Confidential. Not to be copied, distributed or reproduced without prior approval



Conclusions

Process scale-up

- Objectives
  - To limit the risks
  - To save time
  - To manage CAPEX/OPEX
- How?
  - Identifying market targets
  - Implementing adapted industrial methodologies
  - Looking for key partners
  - Working in parallel, anticipate
  - Defining GO/NO-GO milestones

Confidential. Not to be copied, distributed or reproduced without prior approval.

processium
Process & Product Design

Contact

CEI – CS 52132
62 boulevard Niels Bohr
69603 Villeurbanne - France

Pascal ROUSSEAUX
+33 4 78 17 37 00

pascal.rousseaux@processium.com
www.processium.com