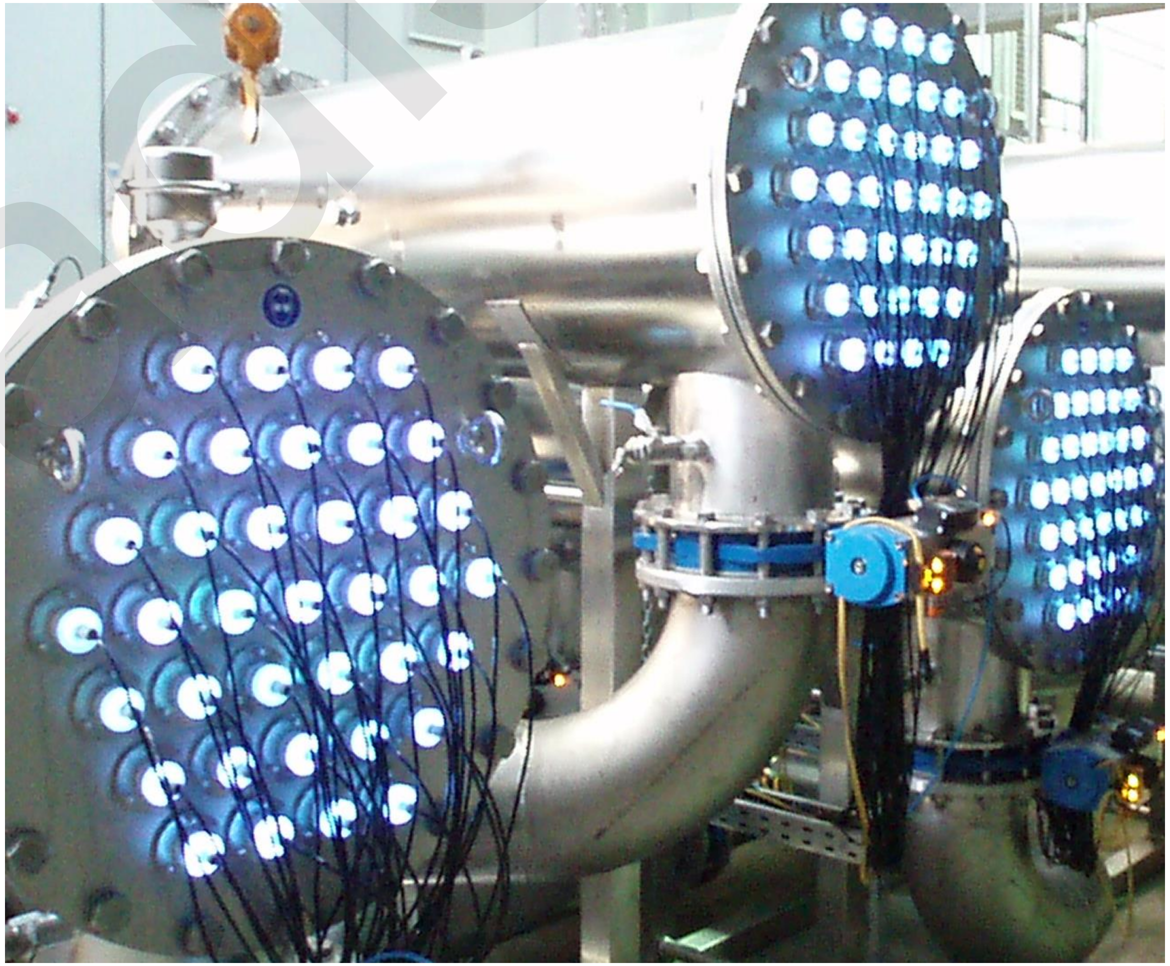
ARCADIS

Water and Vapour Treatment

Carolin Klauer

Parallels between process engineering planning and the preparation of an excellent lunch meal

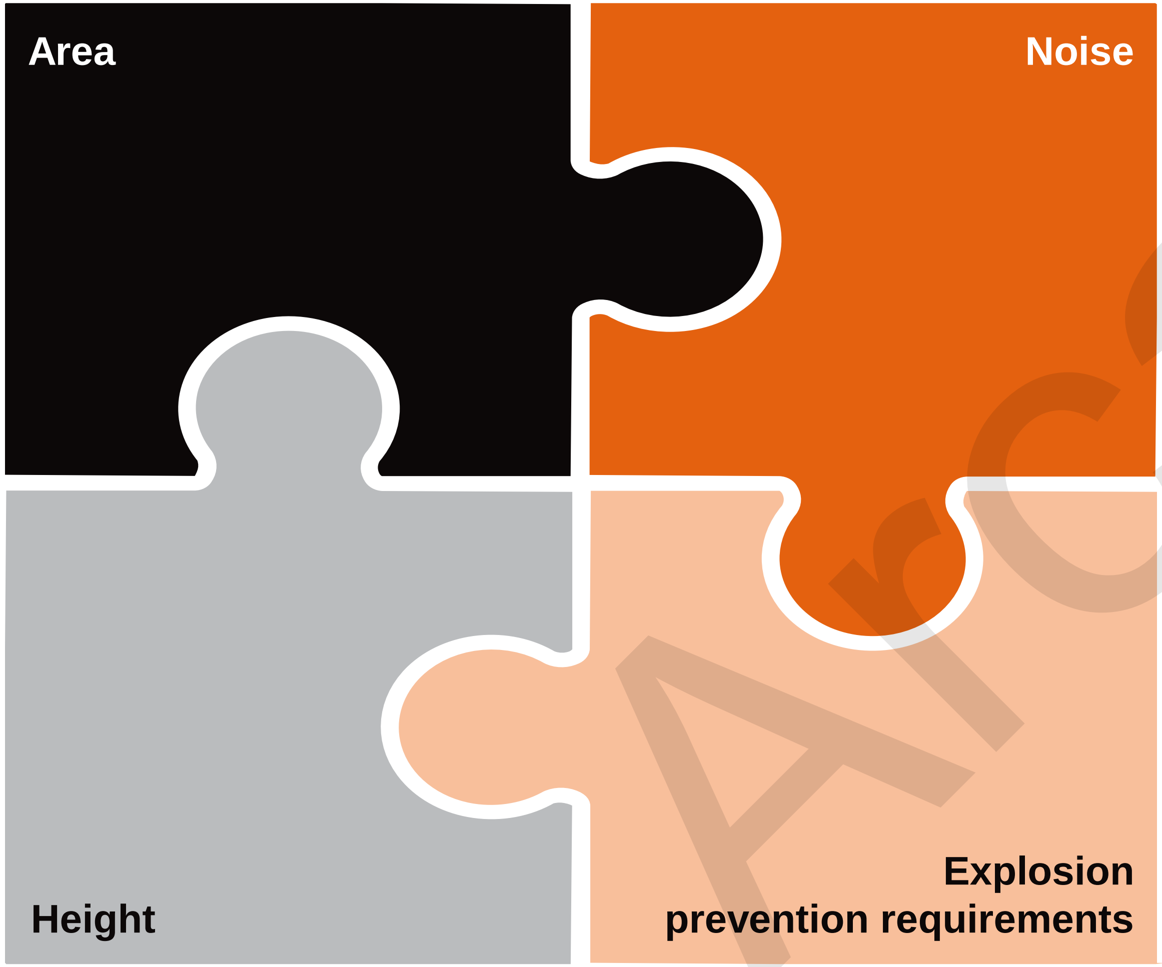


Part 1

Design parameters - ingredients

and their influence on general design decisions

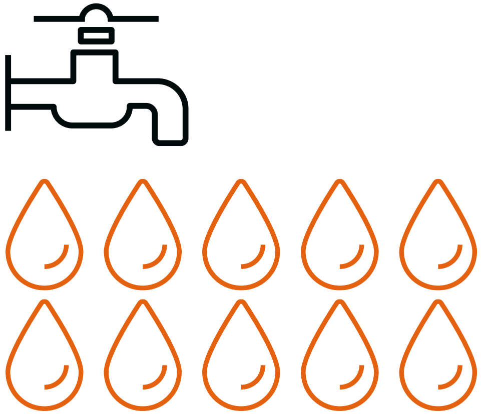
Design parameters . site conditions



ARCADIS

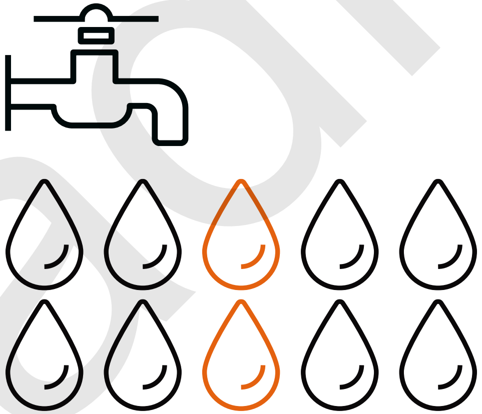
Design parameters . flow rate

Flow rates influence treatment sizing and costs



Influence of **Maximum flow rate**

- The size of the treatment system depends hereon.
- The influence on capital expenditure is non linear.



Influence of **Average flow rate**

- Operational expenditure depends on it,
- Influence is partial linear (operating resources) and partial non linear.

Design parameters . contaminants concentration

Treatment process	IRON	PFAS	MTBE	ANILINE
Adsorption with GAC	-	+	(+)	+
Desorption	-	-	+	-
Filtration	+	-	-	-
Precipitation/Sedimentation	(+)	-	-	-
Precipitation/Flotation	(+)	-	-	-
AOP	-	-	(+)	+
Reverese Osmosis	(+)	+	(+)	(+)

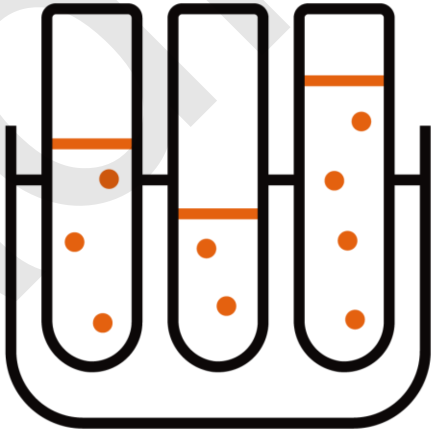
Maximum concentrations influence the choice of treatment technique and the capital expenditure, influence is non linear.

Average concentrations influence the choice of treatment technique and the operational expenditure, influence is linear.

Design parameters . general hydrochemistry

List of general hydrochemical parameters

- pH, conductivity, temperature, oxygen, redox potential, acid capacity, base capacity,
- COD, DOC, TOC,
- total suspended solids (TSS), settable solids,
- Calcium, magnesium, sodium, potassium, ammonia, iron^{2+}, iron (total), manganese, chloride, nitrate, nitrite, phosphate, sulfate,
- heavy metals,
- relevant contaminants.



It is important that the parameters are analyzed at least in one qualified round of sampling

TSS - Iron - Manganese - pH - Carbonate balance - Ammonia:
Often require additional treatment steps and cause related costs (CAPEX and OPEX).

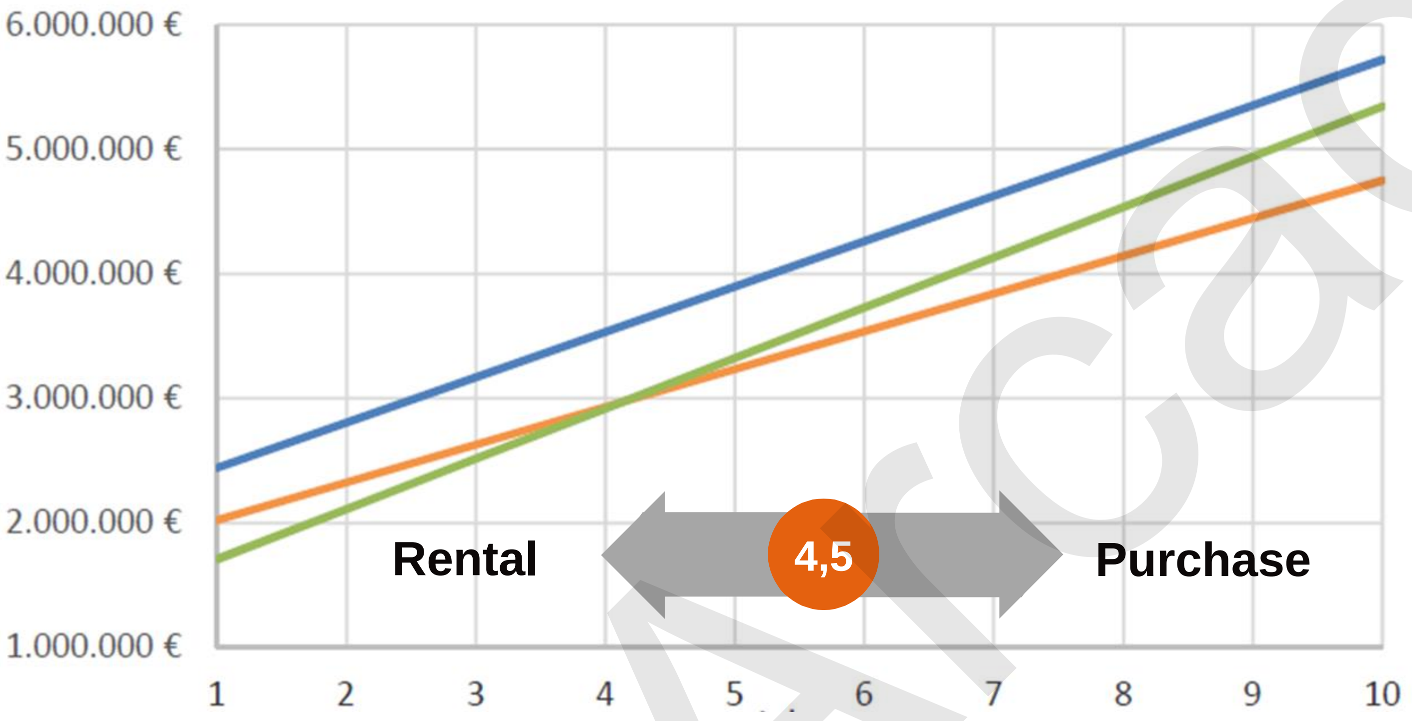
ARCADIS

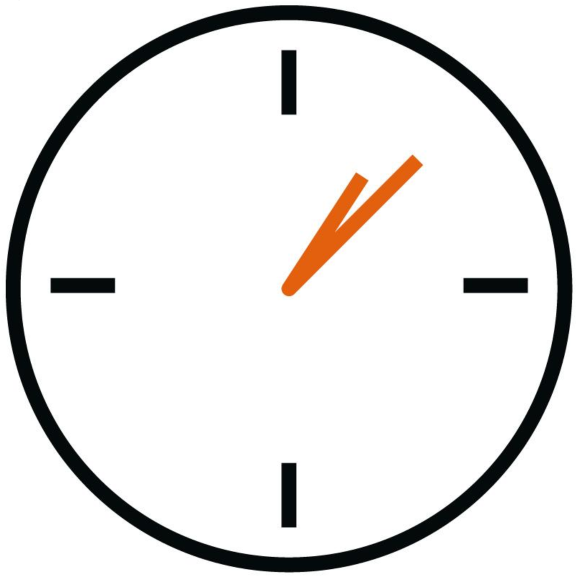
Design parameters . client requirements

	Criteria	Low						High	Weighting
A	Capital Expediture (CAPEX)		X						7%
B	Operational Expediture (OPEX)			X					11%
C	Totel costs in 15 years				X				14%
D	Time to start operation					X			18%
E	Compliance / Licensable by authorities							X	25%
F	Demand for land	X							4%
G	Liability / Suspectance to failure						X		21%
	Total								**100%**

Design parameters . Operating duration

Operating duration often decides about rental or purchase of the treatment system





But: It is an individual decision of our client based on their individual requirements

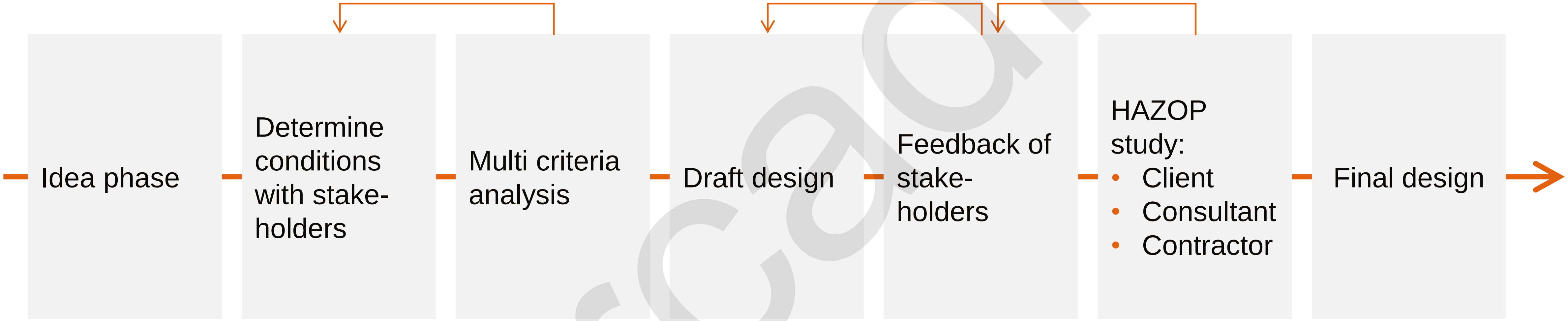
Part 2

Design process - preparation method

From first sketch to full running treatment system

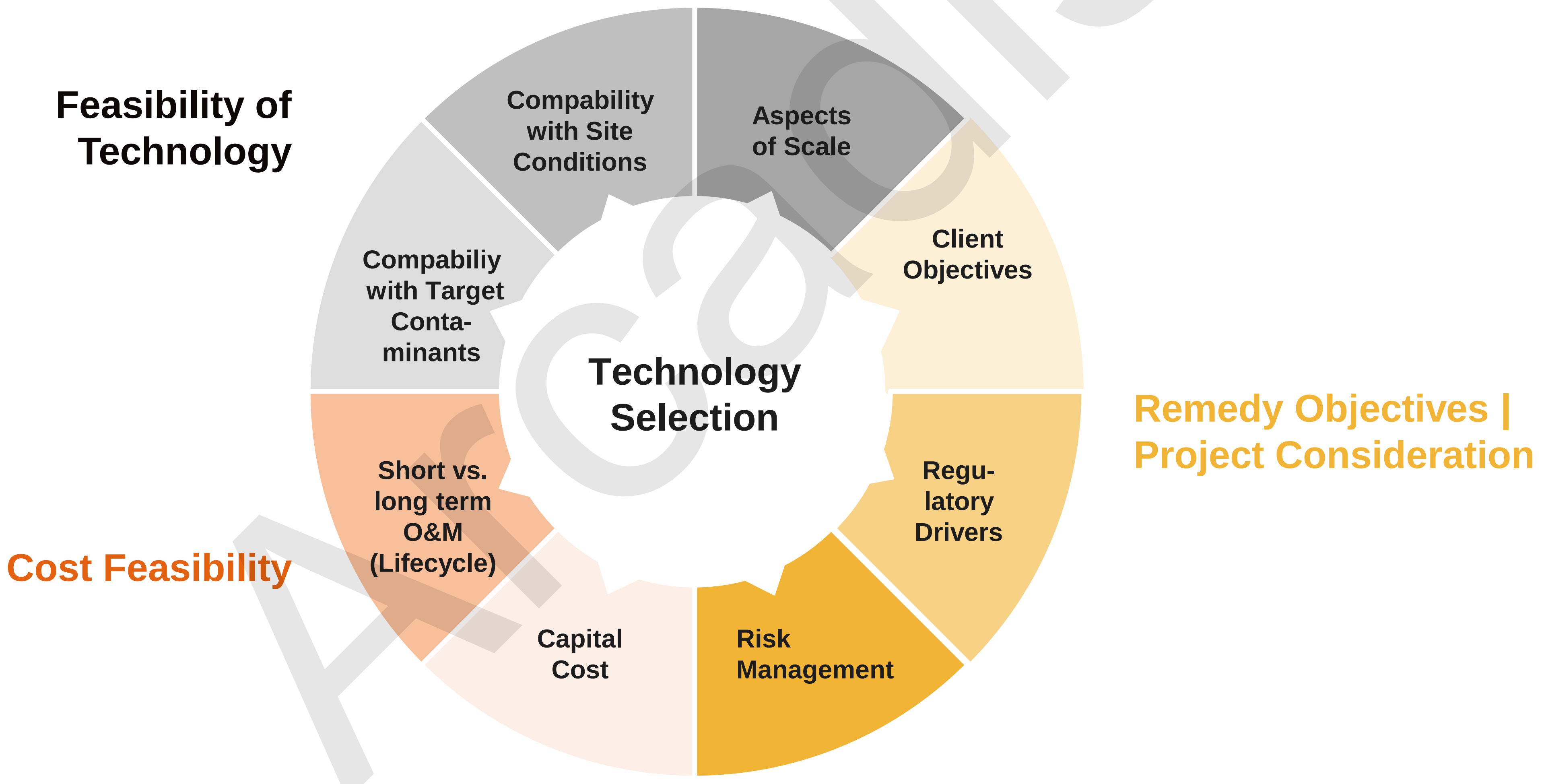
ARCADIS

Design process . block flow



Different stakeholders and HAZOP studies effect design, budgets and planning

Design process . technology selection



Design process . multi criteria analysis

Var.	Variante / Kriterium: Bezeichnung	Durchsatz [m³/h]	Investitionskosten A1: Invest.-Kosten (ohne Leitungsbau)	Investitionskosten A2: Invest.-Kosten für den Leitungsbau	Betriebskosten B1a: Betriebsstoff-verbrauch	Betriebskosten B1b: Abfallauf-kommen	Betriebskosten B2a: Personalbe-darf unter Berücksichti-gung der Anlagen-standorte	Betriebskosten B2b: Personalbe-darf unter Berücksichti-gung der Anlagenauto-matisierung	Betriebskosten B3: Betriebs-kosten	Gesamt-kosten C: Gesamtkosten in 15a	Zeitbedarf D1: Stillstandszeit der Wasser-aufbereitung	Zeitbedarf D2a: Zeitbedarf für die Planung	Zeitbedarf D2b: Zeitbedarf für die Umsetzung	Gene migu E: Geneh gungsfä keit
1	Erweiterung der bestehenden WAA am bisherigen Standort	50												
2		35												
3	Neubau am bisherigen Standort ohne Interimsbetrieb	50												
4		35												
5	Neubau am bisherigen Standort mit Interimsbetrieb	50												
6		35												
7	Zweite WAA am bisherigen Standort	50												
8		35												
9	Neubau am Standort A oder B	50												
10		35												
11	Zweite WAA am Standort A oder B	50												
12		35												

Bewertung: KO | ausreichend | befriedigend | gut | sehr gut

Var.	Version / Criteria: Treatment process	1-stage / 2-stage	without client reqirements: sum	without client reqirements: position	with client requirements: sum	with client requirements: position
1	relocation, old site	2-stage				
2	relocation, new site	2-stage	3,00	67%	2,81	63%
3	partial reuse/new old site	2-stage				
4	partial reuse/new new site	2-stage	3,18	89%	2,9	75%
5	new system, old site	1-stage without second treatment				
6		1-stage with second treatment				
7		2-stage				
8	new system, new site	1-stage without second treatment				
9		1-stage with second treatment	3,12	78%	3,0	88%
10		2-stage	3,35	100%	3,39	100%

Multi criteria analysis can help to tailor the design to the clients' individual needs!

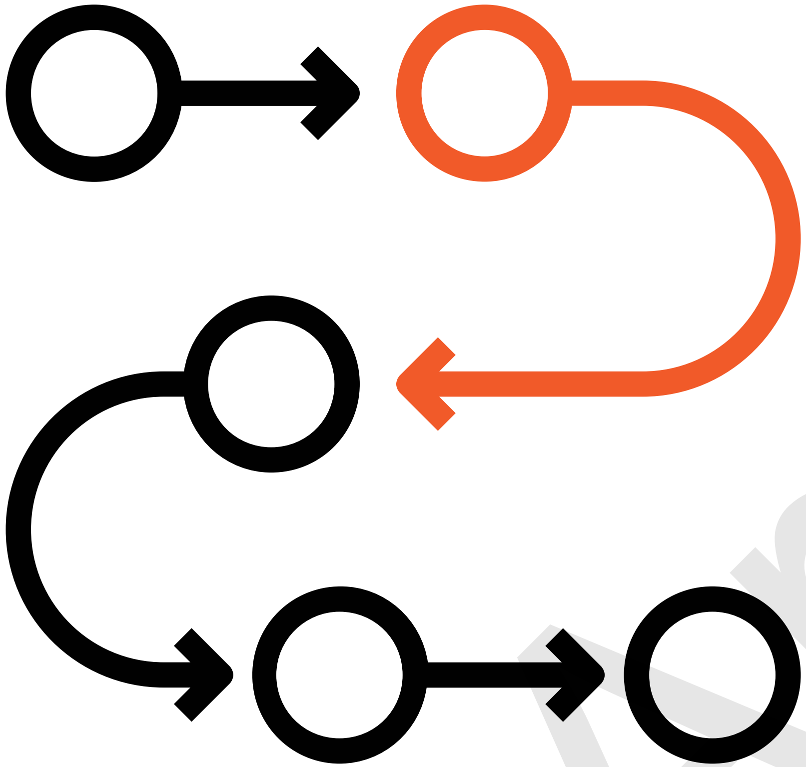
Part 3

Benefit of modelling and testing - special kitchen utensils

Numeric hydrochemical modelling and different lab and scale test

Benefit of modelling & testing . modelling

Numeric hydrochemical modelling is a crucial element in design and optimization



With numeric hydrochemical modelling, technical remediation systems and running processes (flows or reactions) can be characterized, analyzed, and especially optimized.

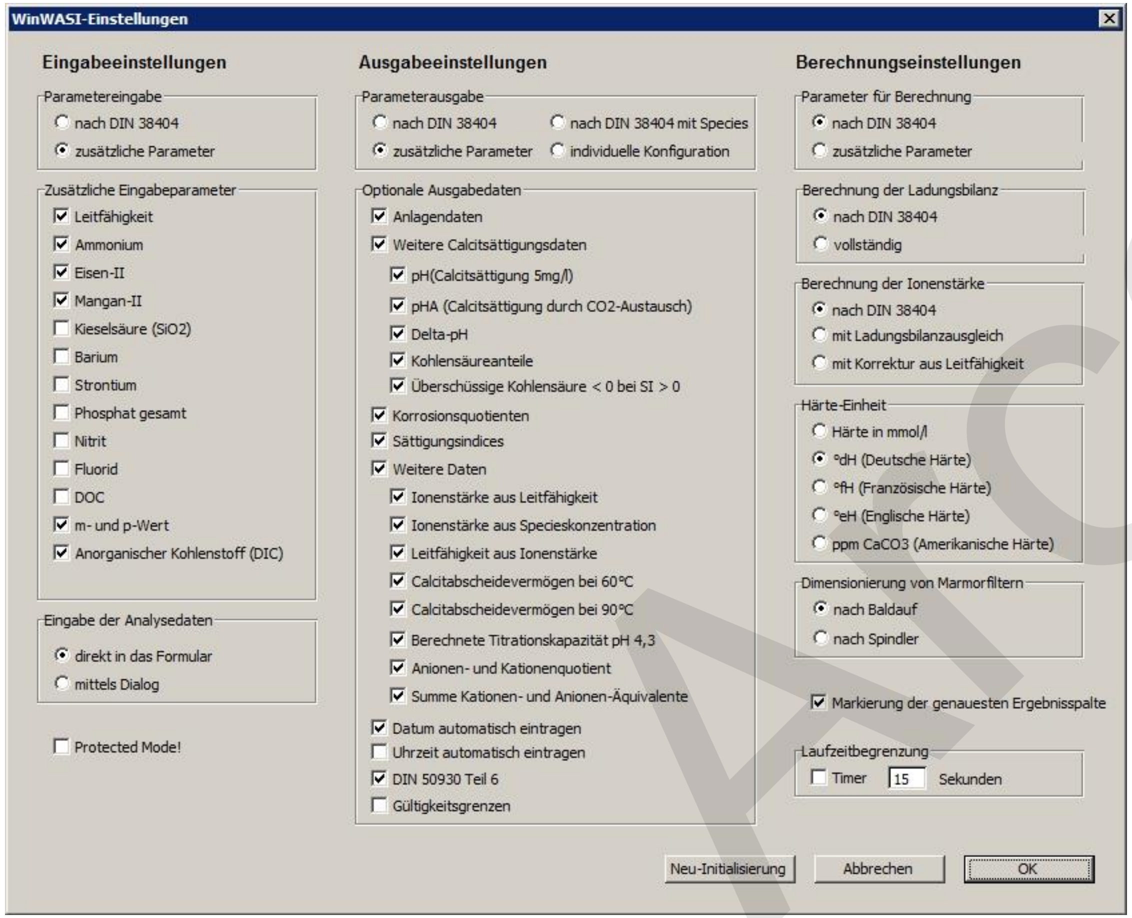
The effects of technical interventions (for example oxygen injections, substance dosing, etc.) can thus be predicted and optimized for the remediation.

Numeric hydrochemical modelling is used for multiple applications

ARCADIS

Benefit of modelling & testing . modelling

Numeric hydrochemical modelling is a crucial element in design and optimization

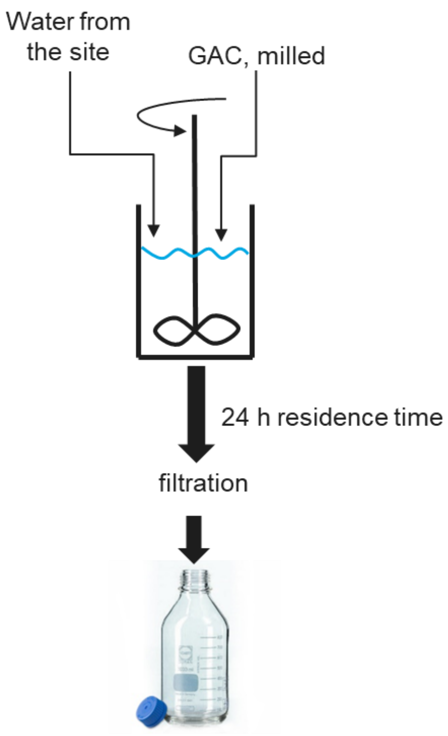


- Simulation and evaluation of the dissolution and **precipitation processes** which develop after infiltration of active substances
- Determining the dosing rates of e.g. carbon dioxide to **prevent colmation** processes in infiltration wells
- Modelling of the **influence of the pH-value** on the optimal retention of arsenic in a fixed bed adsorber and determination of optimal dosing rates
- Forecast of the impact of **mixing different waters** from several wells on the behavior of the mixed water (separating, corroding, etc.)

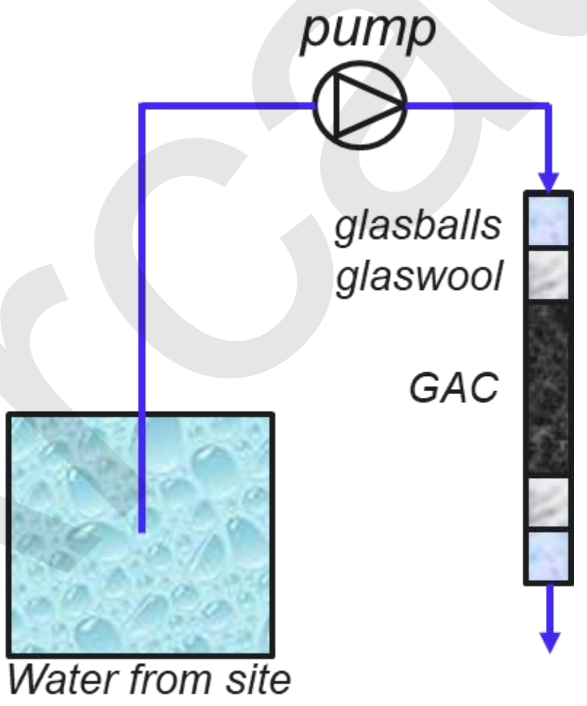
Benefit of modelling & testing . testing

Test settings

Batch tests



Small scale column test



Pilot test on site

Benefit of modelling & testing . testing

Duration, Significance and Costs of different test settings

Test setting	Test duration	Significance of the test	Costs, € net
Batch-Test (lab)	2 days	No breakthrough curve, but good comparison of many, different GAC possible.	~ 5,000 to 8,000 for 10 GAC
Small-Scale Column-Test (lab)	2 to 6 weeks	First breakthrough curves, good comparison of a different GAC.	~ 15,000 to 20,000 for 3 GAC
Pilot-Test on site	3 to 4 months	Accurate breakthrough curves, very reliable comparison of a few GAC, Strategic use 'on site'-effect.	~ 100,000 to 130,000 for 3 GAC

Benefit of modelling & testing . testing

Step by step approach

1) Batch tests	• up to 10 types of media • representing all suppliers and their relevant products • technical quality assessment
2) Request for quotes	• Economical assessment
3) Scale test of preselection	• Up to three media that have the best price-performance ratio
4) Final selection	• final selected suppliers quote • selection of the most economical media for the specific site

Batch tests, small scale column tests and pilot tests help to minimize OPEX in long-term remediation projects

Part 4

Optimization - the power of spices

Examples of pitfalls & successes

Optimization . Example I

Design pitfall, resulting action and continuous improvement

Technical data

Contaminants:
CHC, FHC, C6 aromatic HC
iron, calcium carbonate

Volume:
up to 15 m³/h

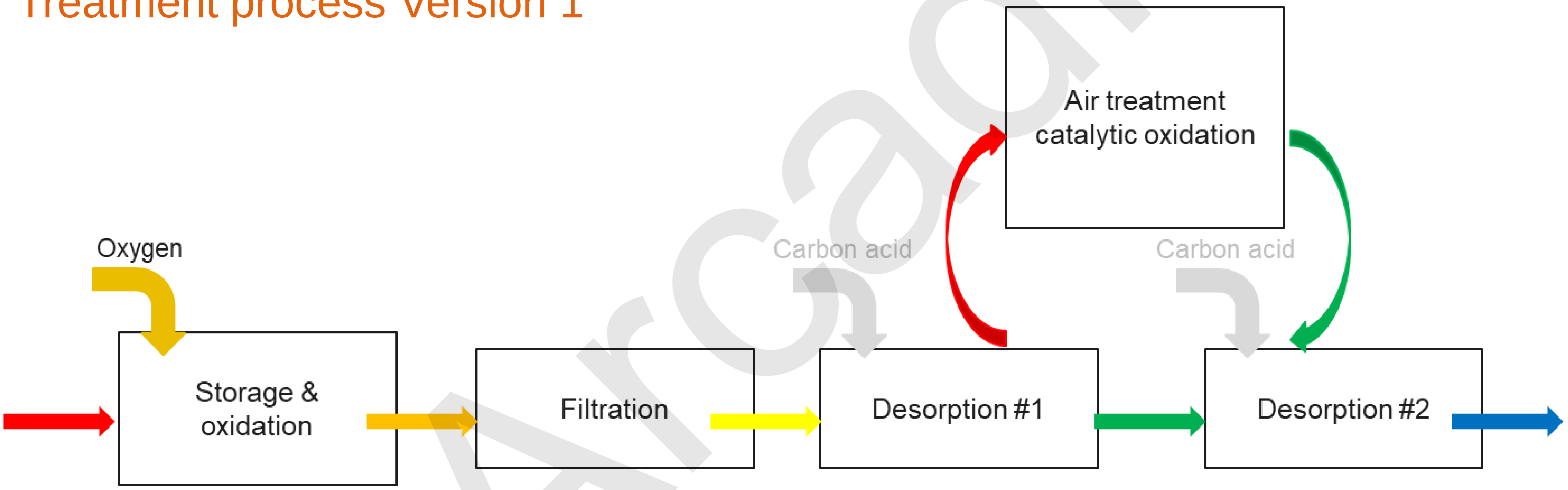
Treatment technology

oxidation, filtration, desorption, catalytic oxidation

Multiple technical optimization required

Optimization . Example I

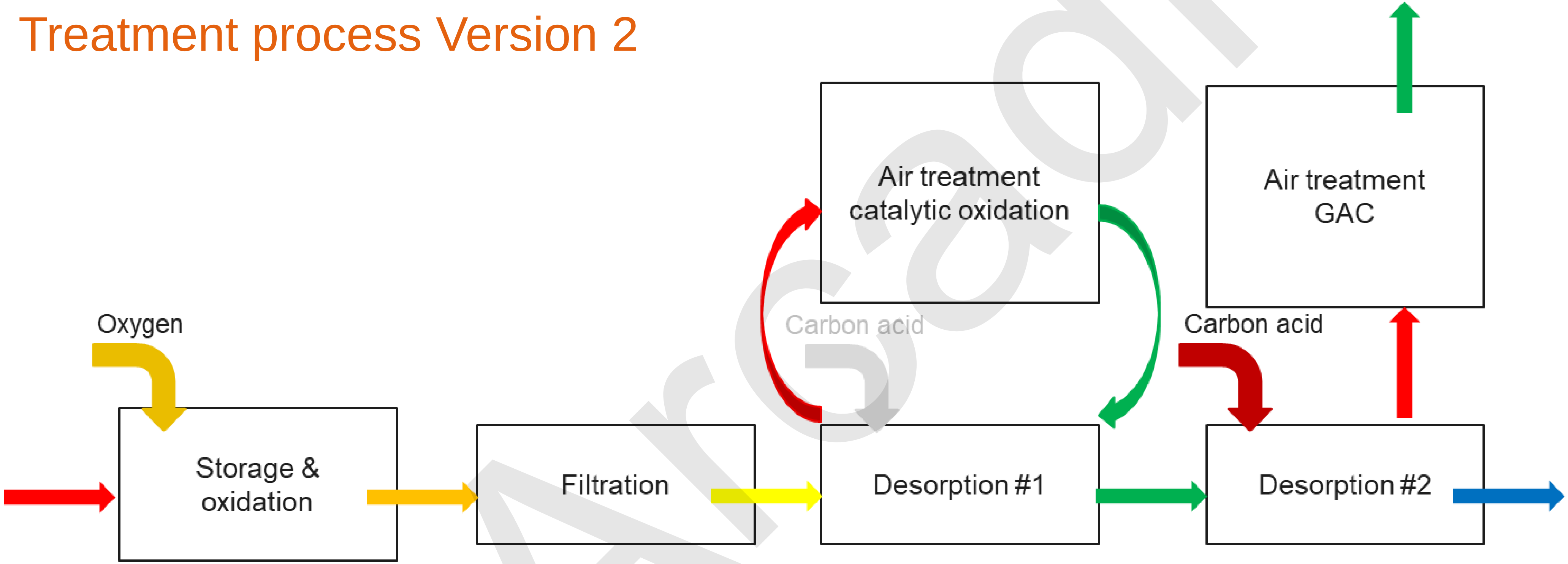
Treatment process Version 1



Design according to analytical data with 25% contingency.
During 1st on site operation: not sufficient to reach the limits for discharge

Optimization . Example I

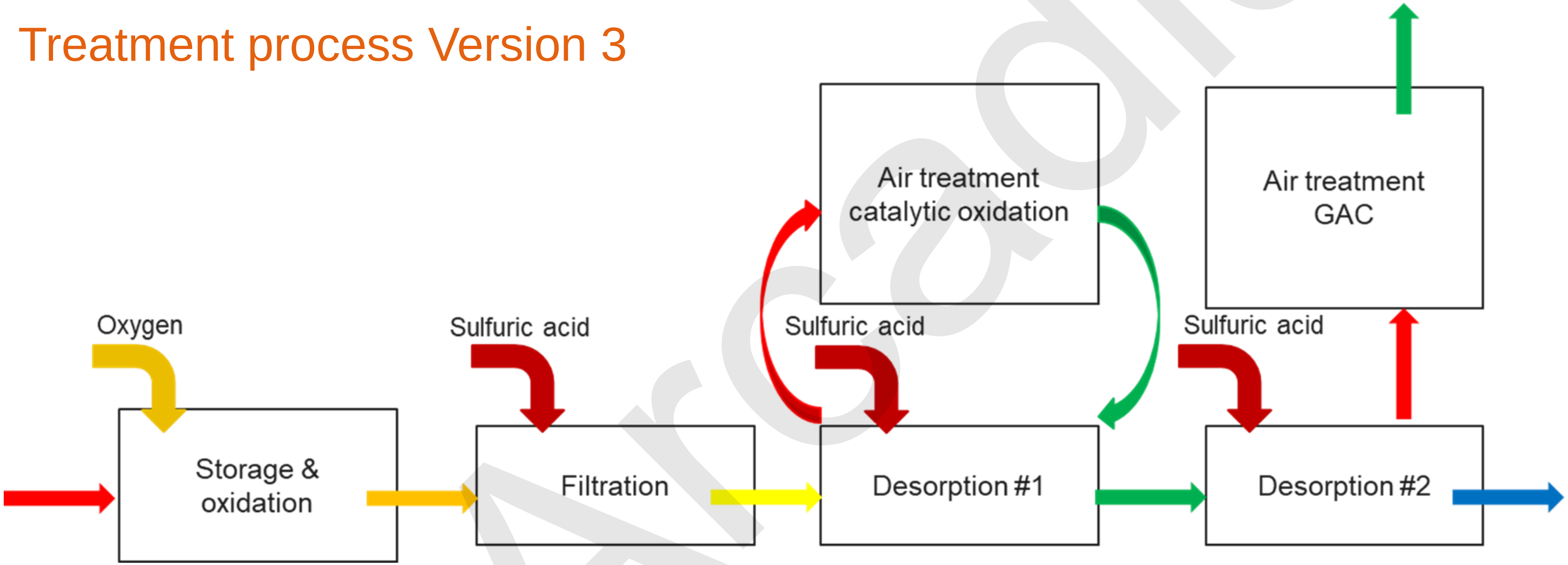
Treatment process Version 2



Design sufficient & proof in full scale,
reaches the limits for discharge at any time

Optimization . Example I

Treatment process Version 3



Substitution of acid:
use of “production waste acid” of the client instead of an external product

Optimization . Example II

OPEX optimization

Technical data

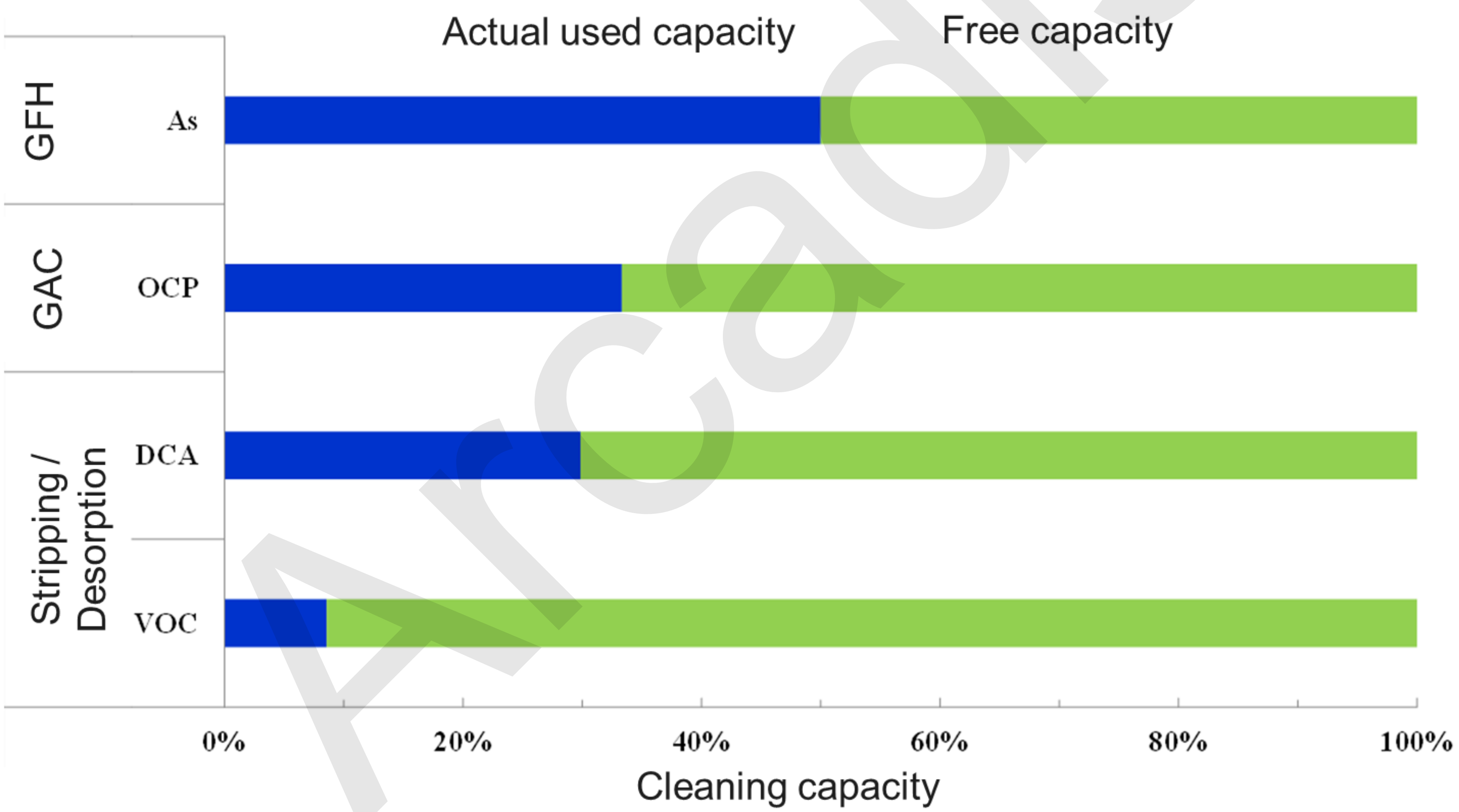
Contaminants:
CHC, BHC, C6 aromatic HC, OCP, Arsenic, iron, calcium carbonate

Volume:
up to 50 m³/h

Treatment technology
oxidation, filtration, desorption, catalytic oxidation, adsorption, chemisorption

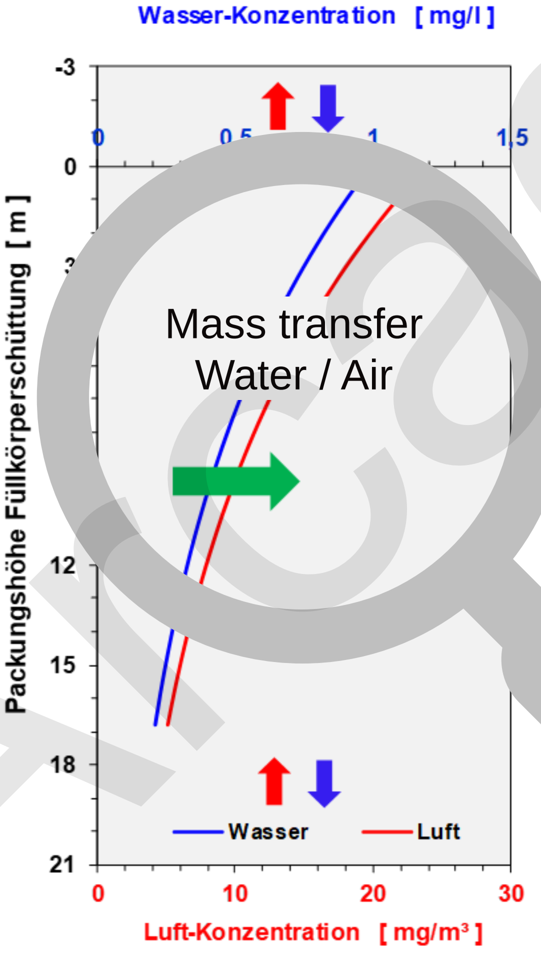
Multiple technical optimization required

Optimization . Example II



Optimization . Example II

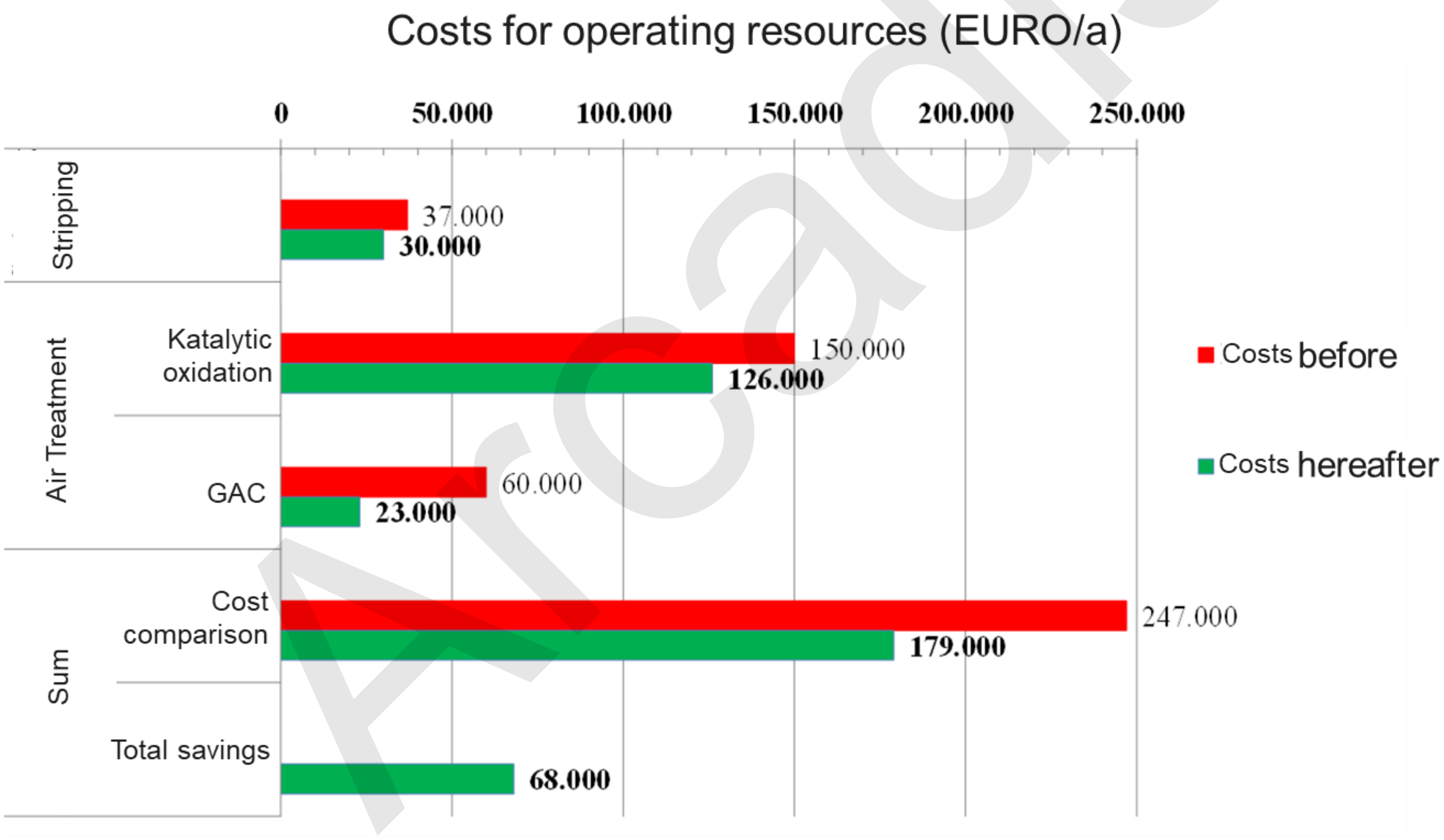
Modellierung der DCA-Strippung			Ein	Aus
Strippmodul		1		
Desorptionskolonnen		K1.1 + K1.2		
System- und Prozessparameter				
Packungshöhe	[m]	17		
Kolonnendurchmesser	[m]	1,0		
Wasserdurchsatz	[m³/h]	24		
Luftdurchsatz	[m³/h]	1.000		
Luft-/Wasserverhältnis	[-]	42		
Konzentration Wasserphase	[µg/l]		990	210
Konzentration Luftphase	[mg/m³]		5	24
Stoffeigenschaften				
Henrykoeffizient	[-]	4,0E-02		
Stofftransportparameter				
Stoffdurchgangskoefizient	[1/s]	5,0E-02		
Stoffbilanz				
Wasserphase	[g/h]		24	5
Luftphase	[g/h]		5	24
Reinigungsleistung	[g/h]	19		
Raumleistung	[g/m³/h]	1,4		
Wirkungsgrad	[-]	79%		



Kolonnenkopf
Eintritt Rohwasser
Austritt Prozessluft

Kol
Eintritt Prozessluft
Austritt Reinwasser

Optimization . Example II



ARCADIS

Enjoy your lunch!

Thank you for your attention!