

A TOOL FOR PRE-SELECTING BENEFICIAL USES OF FINE DAM SEDIMENT

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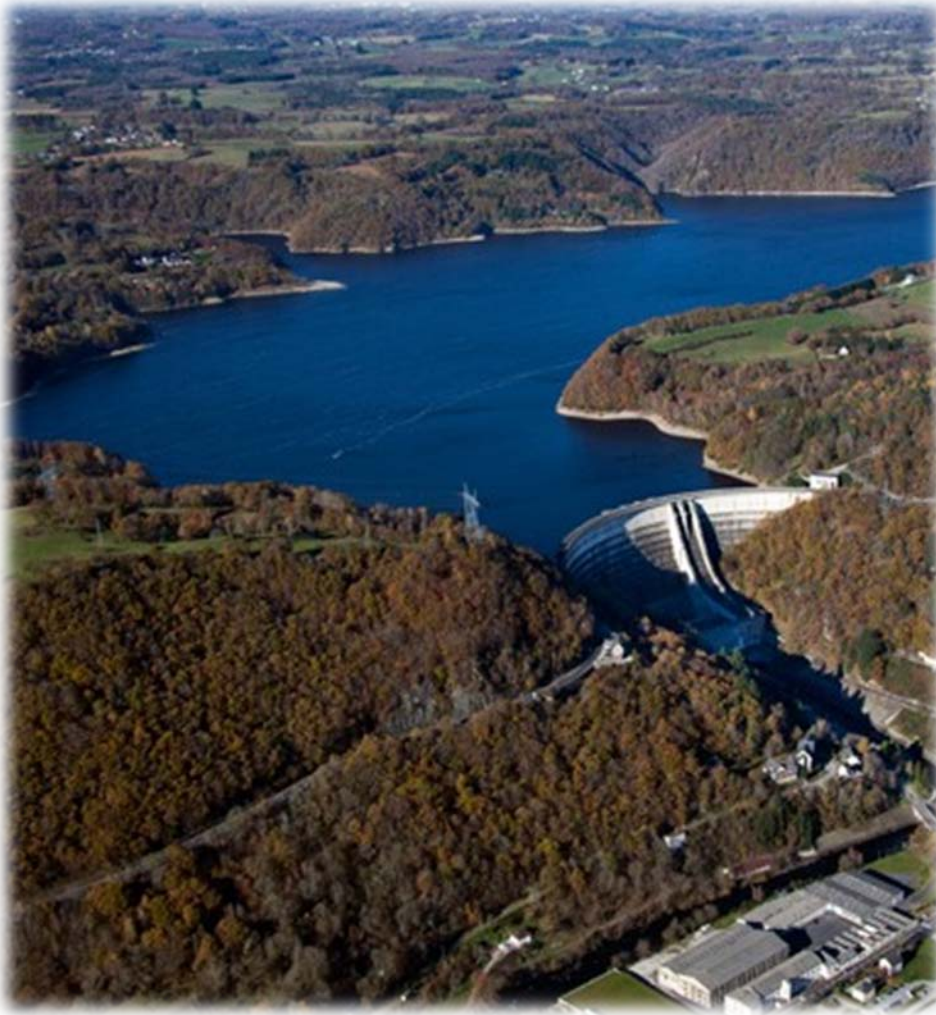
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ORGANISATION



I. Context

- Hydroelectricity in EDF Group
- Impacts of sediment accumulation in dams
- Waste legislation context

II. Materials and their beneficial reuse solutions

III. Pre-selecting tool: methods and design

- Key-criteria
- Interpretation of criteria
- Production of Sediment Suitability Indexes

IV. Spatial adequacy

V. Conclusion and outlook

- Conclusion about the tool
- Outlook: Focus on a reuse option with a new PhD project

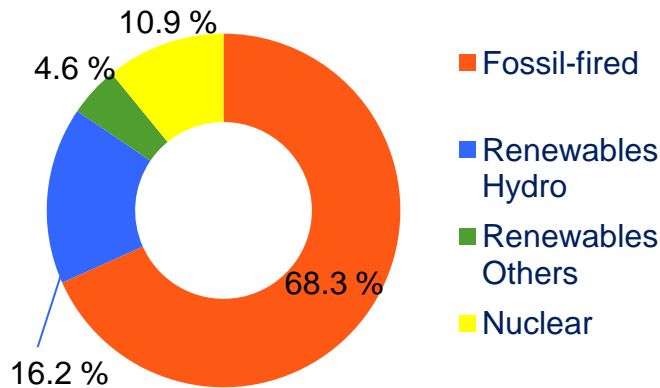
CONTEXT (I)



HYDROELECTRICITY PRODUCTION

Global outlook

Global Mix



- 2nd electricity source in the world
- First source among renewables

EDF in France



= 20 GW of installed capacity in metropolitan France

Facilities all over the French territory
→ Various geographical, geological and industrial contexts

9.6%

of EDF's electricity output in France
Main role: Production adjustment according to the demand

439

Hydropower plants operated by EDF in France with an average age of 60 years

640

Dams operated by EDF in France, 150 of them are more than 20 meters high

CONTEXT (II)



SEDIMENT ACCUMULATION IN DAMS: IMPACTS

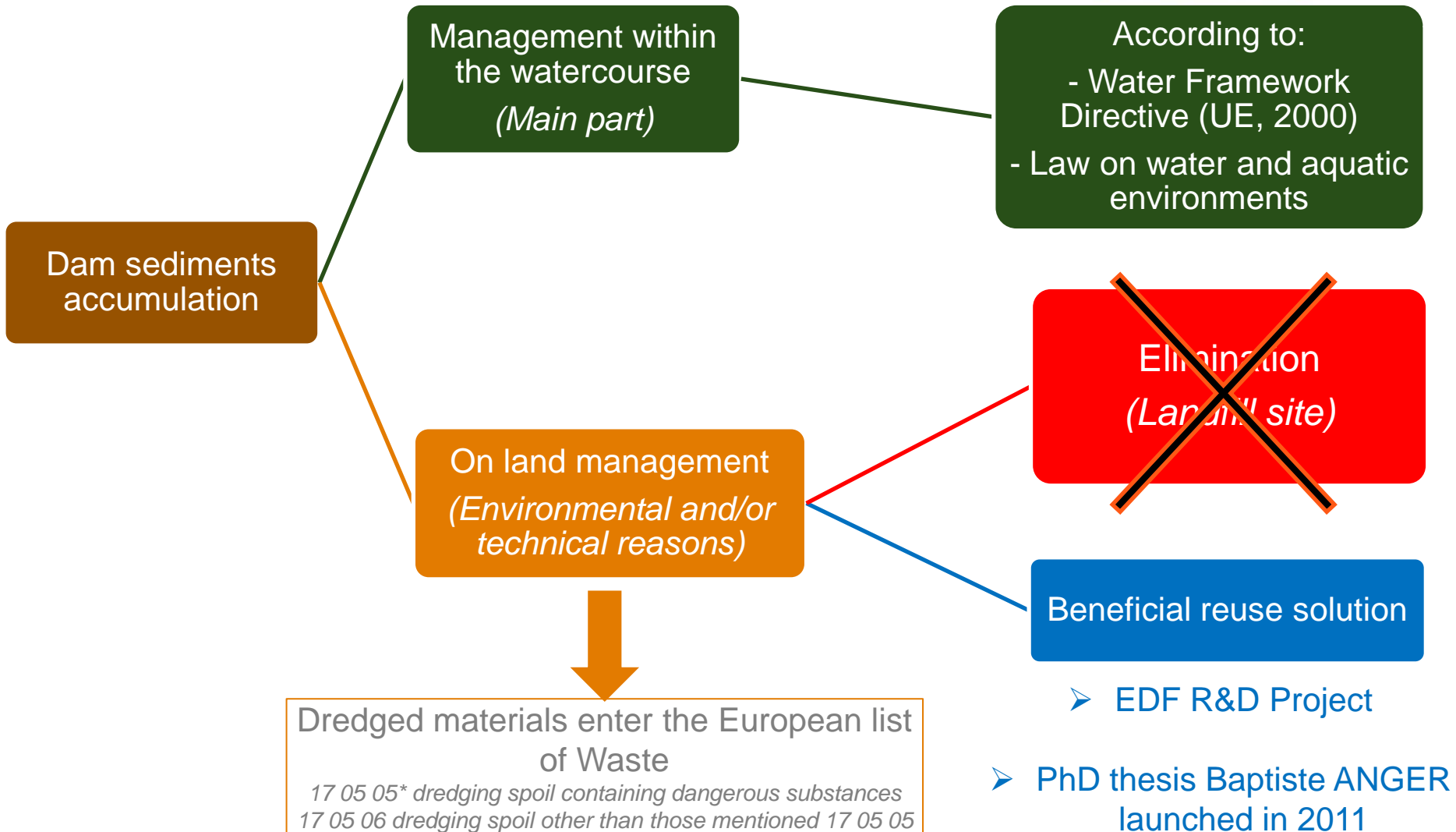
EDF as operator	Users and neighbours	Environment
<ul style="list-style-type: none">- Storage capacity loss→ Power loss- Reservoir more limited	<ul style="list-style-type: none">- Flood risks due to higher water level- Landscape impact- Drawbacks for recreational activities	<ul style="list-style-type: none">- Algae and vegetation development- Lack of sediment downstream: hydromorphology can be modified, potential impact on aquatic life (especially fish reproduction),....

→ Sediment management is a real issue for EDF Group in hydroelectricity production



CONTEXT (III)

WASTE LEGISLATION CONTEXT



MATERIALS AND REUSES OPTIONS (I)

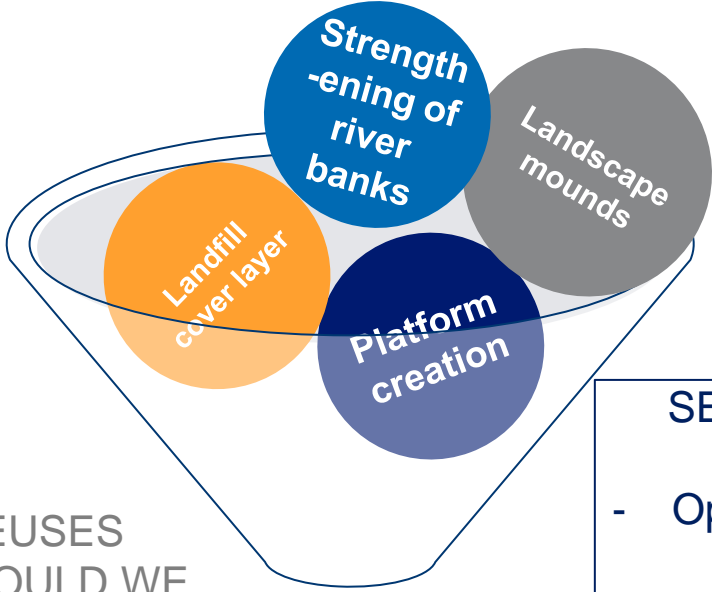
WHAT MATERIAL ARE WE TALKING ABOUT ?

Coarser particles (> 2mm) can be reused easily as opposed to finer ones



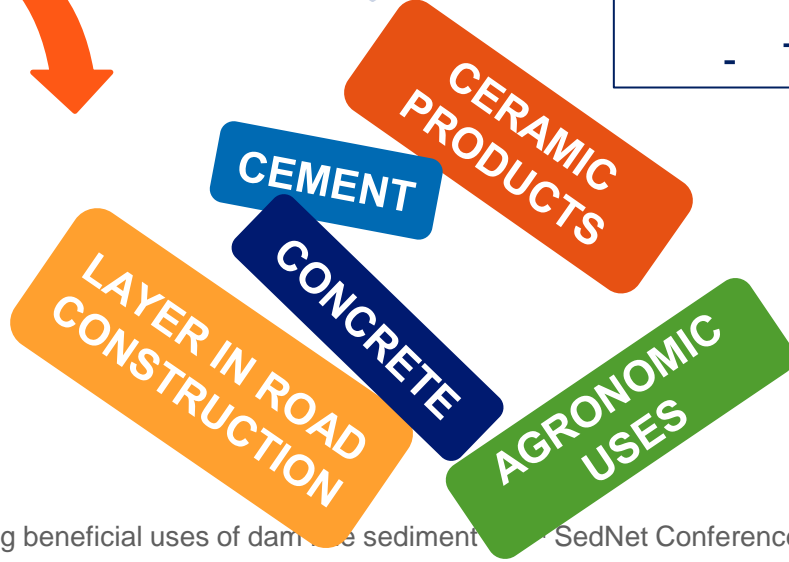
Studies focused on fine-grained sediments
→ particles with diameters < 2mm and $d_{50} < 63\mu\text{m}$
Mainly SILTS and CLAYS

WHICH REUSES OPTIONS SHOULD WE CONSIDER ?



SELECTION BASED ON :

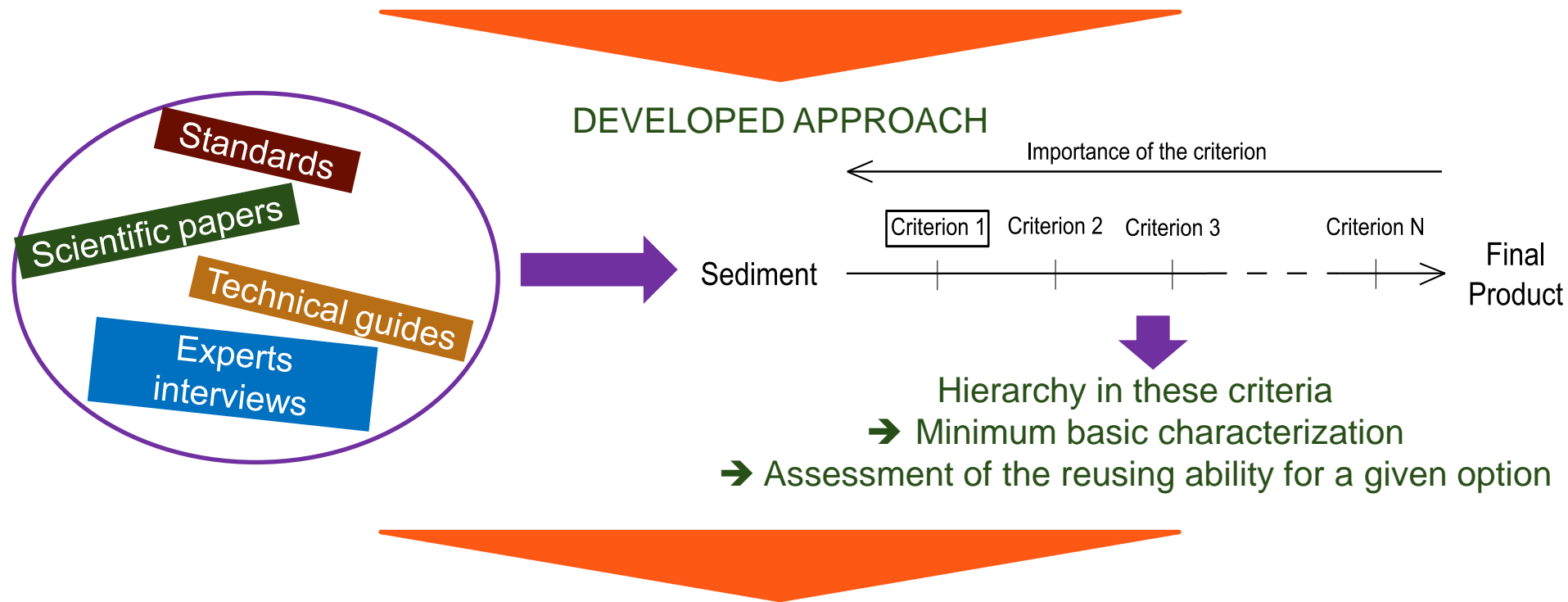
- Options that could potentially use large volumes
- Economical viability
- Technical feasibility



MATERIALS AND REUSES OPTIONS (II)

STATE OF THE ART & STATE OF THE SITUATION (in 2011)

- No guidelines for beneficial reuses of sediment: lack of regulations and standards dedicated to this material
- Mainly studies focusing on one reuse option and a reduced number of dredged materials
- Variability in sediment characteristics but exhaustive characterizations are impossible



PRE-SELECTING TOOL (I)

1

Basic criteria identification
+
Prioritization

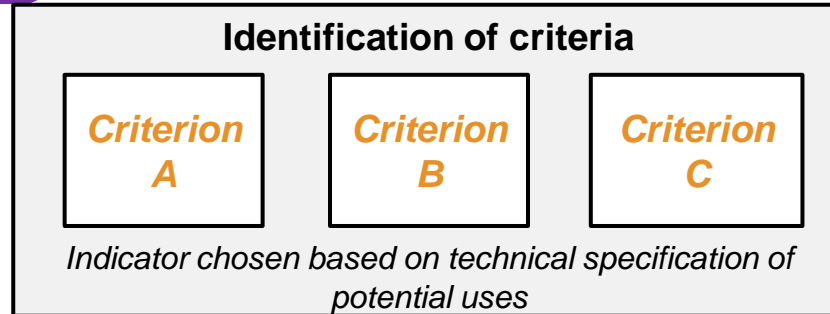
2

Lab test
confirmations

3

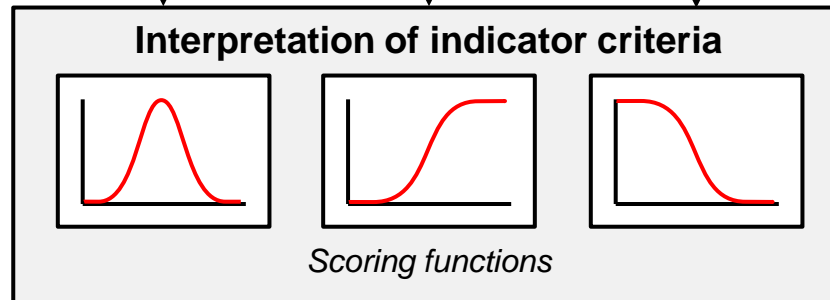
Pre-selecting tool
conception

STEP n°1



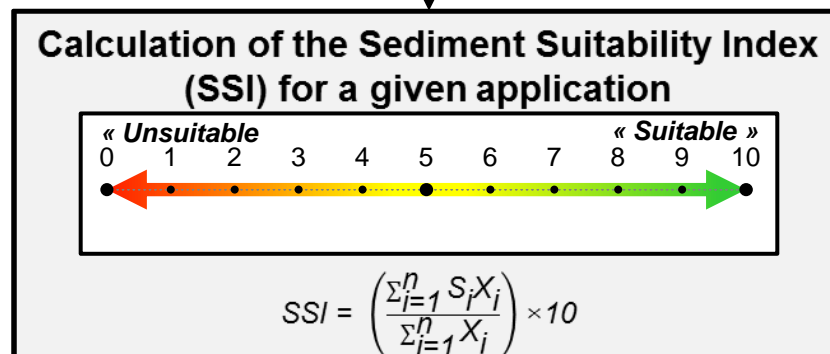
Relevant parameters
→ basic criteria e.g.
*median diameter, organic
matter content, Atterberg
limits,...*

STEP n°2



“More-is-better”
“Less-is-better”
“Optimal values”
→ Scores

STEP n°3



Weighted scores sum
(Weight according to the
criterion importance)

PRE-SELECTING TOOL (II)

1

Basic criteria identification
+
Prioritization

2

Lab test
confirmations

3

Pre-selecting tool
conception

- Criteria are selected according to:
 - application specification
and/or
 - comparison between sediment characteristics
and traditional raw materials
- Criteria come from:
 - scientific papers,
 - standards,
 - technical guidelines,
 - experiments at the laboratory scale,
 - consideration of expert opinions.

Example: road sub layer

3 criteria selected :

- PSD
- %OM
- Atterberg limits

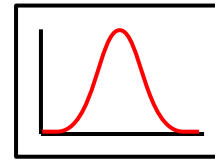
→ *These criteria are required in all geotechnical classifications for fine grained soil*



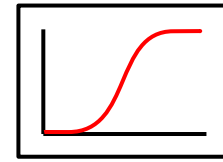
PRE-SELECTING TOOL (III)

STEP n° 1: Identification of criteria ✓

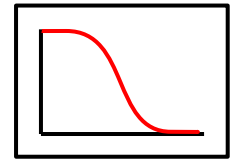
Different cases



Optimum value



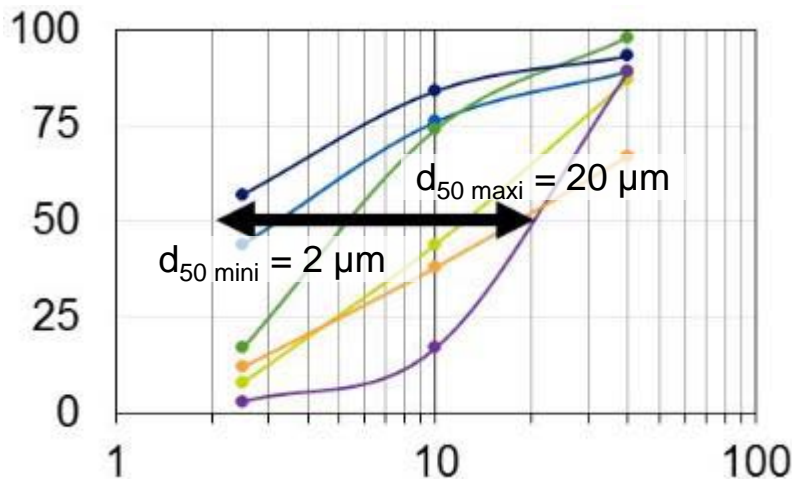
"More-is-better"



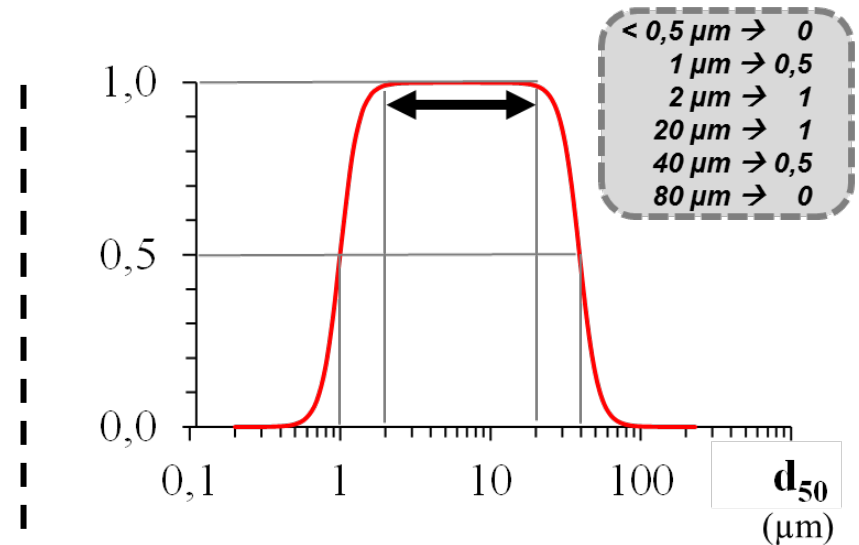
"Less-is-better"

STEP n° 2: Interpretation of indicator criteria

- Curves role: Transformation of criteria value (%OM, Atterberg limits, d50...) into a score in a [0;1] interval.
- Key values + adjustment curve software (*CurveExpert*) → Curves and mathematical functions
- Obtained score give an idea of suitability between criterion and expected value (by industrial process)



Examples of granulometric curves of raw mixes for bricks and tiles production (according to Kornmann et al. 2005)



- Reuse option: Raw material in ceramic products
- Scored criteria: Median diameter

PRE-SELECTING TOOL (IV)

- STEP n° 1: Identification of criteria ✓
- STEP n° 2: Interpretation of indicator criteria ✓
- STEP n° 3: Calculation of Sediment Suitability Indexes (SSIs)

- For each relevant criteria, a weight between 1 and 4 is given.

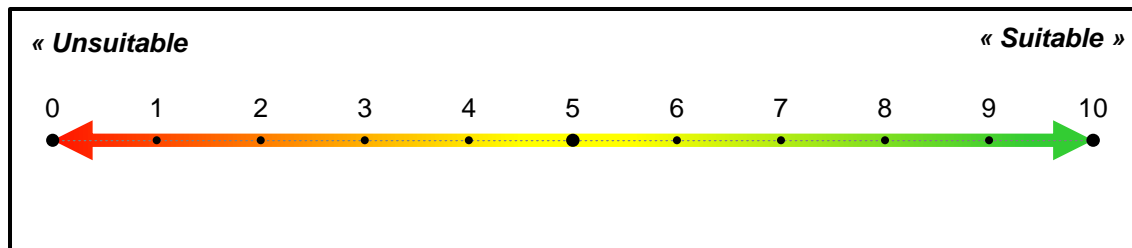
Example: Clinker reuse	Criteria	Silica ratio	Quartz Content	d ₉₀	Lime Saturation Factor
	Weight	3	2	1	1

- Calculation of Suitability Indexes : 1 sediment for 1 reuse option

$$SSI = \left(\frac{\sum_{i=1}^n S_i X_i}{\sum_{i=1}^n X_i} \right) \times 10$$

→ Weighted average

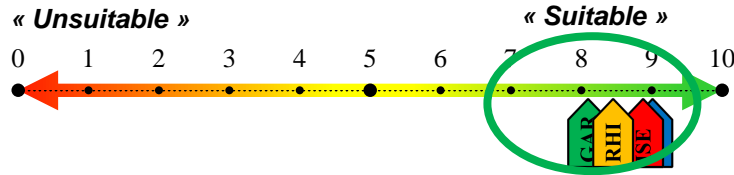
- SSI scale: between 0 and 10



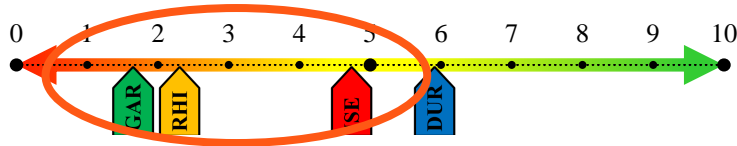
PRE-SELECTING TOOL (V)

TRIALS OF THE TOOL ON DAM SEDIMENTS

CLINKER RAW
MEAL



FILLER (MORTAR
and CONCRETE)

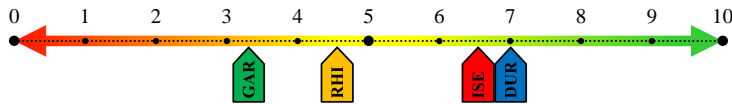


Options with highest SSIs:

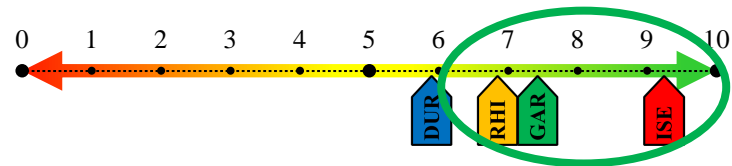
- Clinker
- Ceramics
- Agricultural spread

And lowest SSIs for mineral additions in concrete: fine, clay and organic sediments do not suit requirements of this option

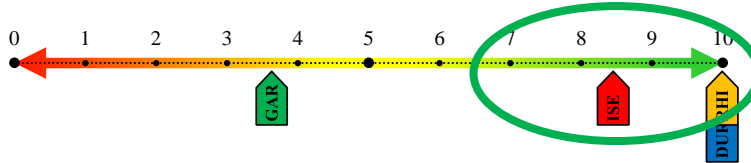
ROAD MATERIALS



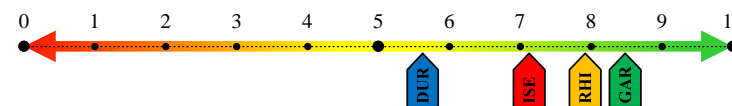
RAW MATERIAL IN
CERAMIC
PRODUCTS



AGRICULTURAL
SPREAD



ARTIFICIAL SOIL
CREATION

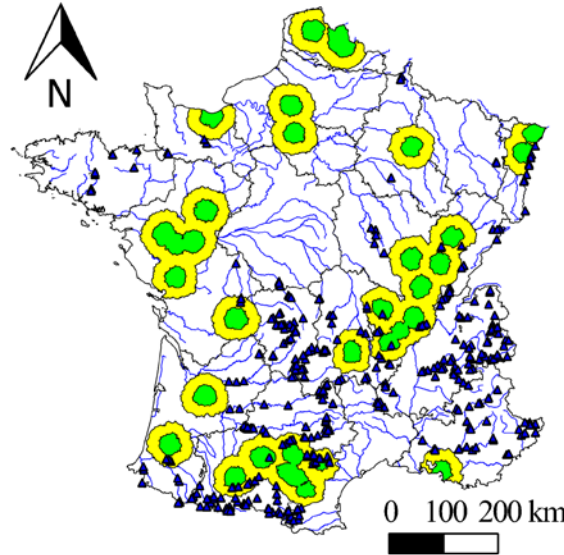


Lab confirmation

SPATIAL ADEQUACY

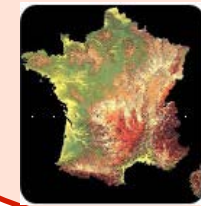
Technical adequacy

Sediment characteristics
Indicator criteria & SSIs



Spatial adequacy

Location of the reuse
industrial sites



Main clay roof tile / brick manufacturing plants vs dams



Potential synergy between sediment
from one dam and an industrial site

Requires:

- Geographical data collection and organization
- GIS analyses on case studies: in particular taking into account road network (ArcGIS 10 and Business analyst add-on)

CONCLUSION & OUTLOOK

CONCLUSION ABOUT THE TOOL

- Technical specifications identified for 5 reuse options
- After lab tests, construction of a preselecting tool based on these specifications:
 - ✓ Methodological framework
 - ✓ Scoring functions and Suitability Indexes created
 - ✓ Requirement of a minimal characterization

OUTLOOK

- Deployment of the tool
- Many possibilities to develop it: changes in the criteria, additions of new beneficial reuse solutions, adaptation to new wastes
- Strengthening of the studied reuse options → New PhD projects

THANK YOU FOR YOUR ATTENTION.

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Baptiste ANGER's thesis manuscript (in french):

<http://chercheurs.edf.com/fichiers/fckeditor/Commun/Innovation/theses/TheseAnger.pdf>

