

# Decision Support Tools for Landfill Reclamation



Eddy Wille  
Michaël Van Raemdonck, Peter Nagels  
OVAM

# OVAM

- Public Waste Agency of Flanders
- Environmental Agency headed by the Flemish Minister of Environmental Affairs
- Established in 1981 (State reform of 1980 in Belgium)
- Competent Authority for:
  - Waste Management;
  - Sustainable Material Management;
  - Circular Economy;
  - Soil Remediation.
- Staff: approx. 310 FTE
- Offices : Mechelen – Belgium
- [www.ovam.be](http://www.ovam.be)



# Overview



- Making decisions about what & why ?
- Trends & Boundary conditions
- Conceptual Site Model
- The myth of Orion, Cedalion & Eos
- DST 1 : Cedalion
- Interim use : finding the light Eos
- DST 2 : Orion

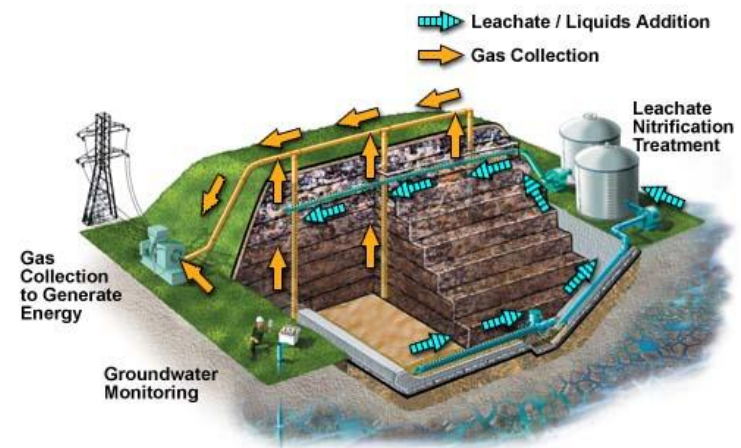
# Making decisions about what & why ?

Facts & Figures :  
According to EU  
Landfill Mining  
Consortium  
EURELCO the North-  
West Europe region  
has ~ 100,000  
landfill sites.



# Making decisions about what & why ?

Many of these sites are not engineered multibarrier landfill systems and lack state-of-the-art **environmental protection systems**, leading to local pollution, land-use restrictions and global impacts. Fortunately, these volumes of resources can be recovered through **Landfill Mining**.

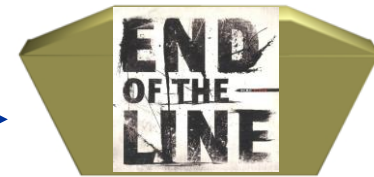


Courtesy of Waste Management

# Making decisions about what & why ?



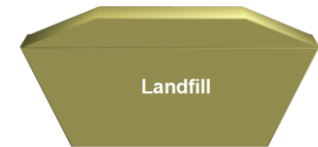
Landfilling : final waste disposal sites as the end of the line in a linear economy



Is this the end of story ?



Risk based approach ( source – pathway – target ) : install a safe infinite containment



Guarding the status quo :  
 is this static concept robust to environmental changes ?



**Report on mapping**  
 Analysis of the March 2017  
 COCOON Questionnaire  
June 2018



## COCOON-analysis :

we are lucky people : there is quite a lot of room for improvement !

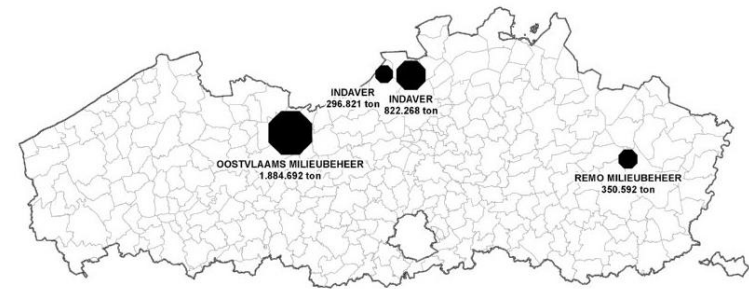
## Introduction of Dynamic Landfill Management

# Trends & Boundary conditions

Number of landfills		
	1985	2017
Cat 1 (Hazardous waste)	11	4
Cat 2 (Non-hazardous waste)	34	9
Cat 3 (Inert waste)	73	4

## Former landfills:

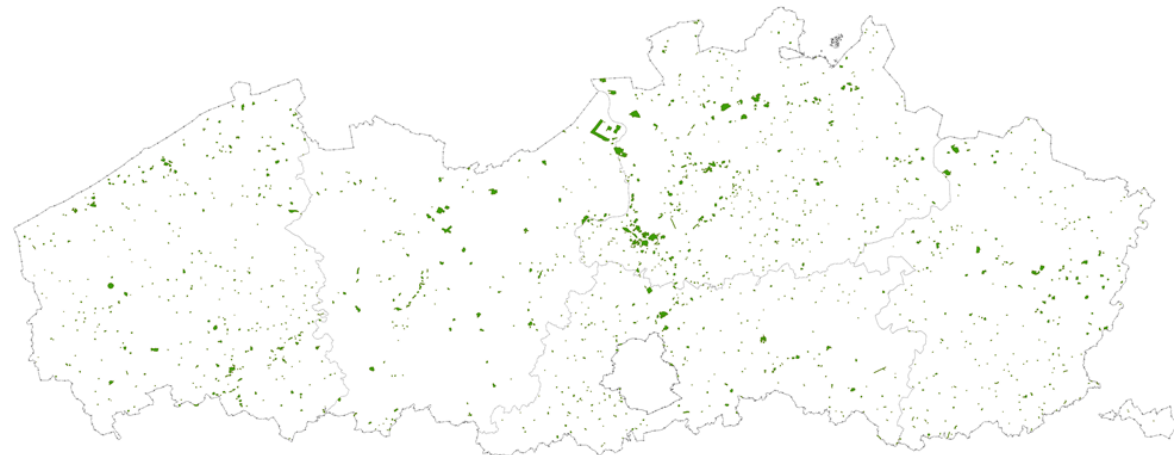
- Flanders :
  - 3.300 sites identified (2018) (163 Km<sup>2</sup>)
  - > 2% waste landfilled
- EU :
  - 150 – 500.000 (estimation)
  - 40% waste landfilled



Cat. 1

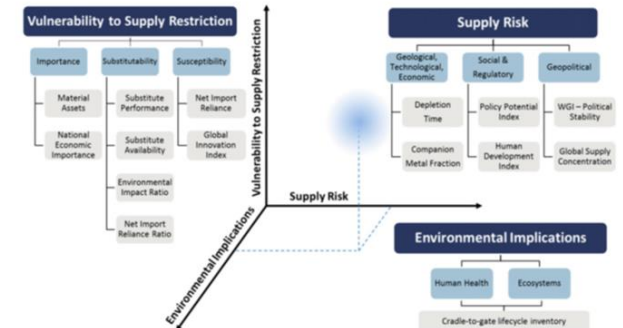
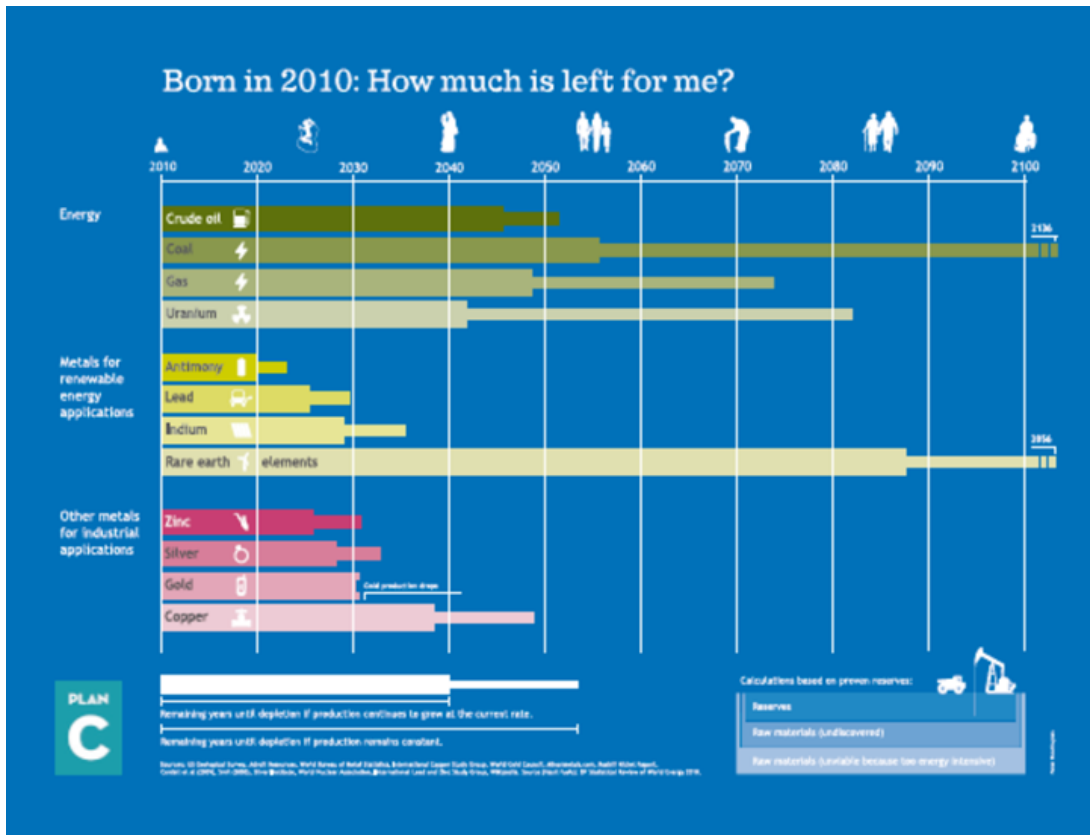


Cat. 2 - MSW

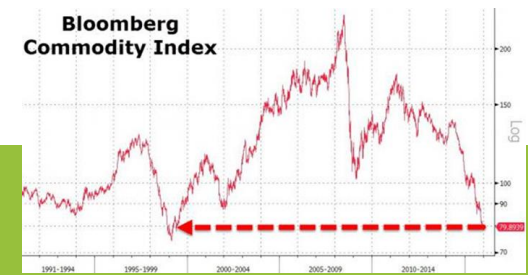
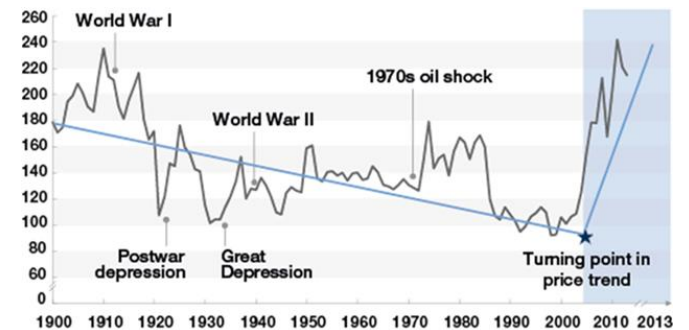


# Trends & Boundary conditions

Resources and commodity markets



Material criticality : geological, technological and economic components of supply risk (Graedel)





# Trends & Boundary conditions

## Climate change & Flooding risks

AP JASON DEAREN AND MICHAEL BIESECKER, ASSOCIATED PRESS  
 SEP. 2, 2017, 3:08 PM



At the Highlands Acid Pit on Thursday, August 31, 2017, the No Trespassing sign on the barbed-wire fence encircling the 3.3-acre Superfund site barely peeked above the churning flood water from the nearby San Jacinto River.



3rd March 2016  
**Toxic timebomb from landfill site flood risk**

COASTAL AND ESTUARY LANDFILL DUMPS

SITES AT RISK OF COLLAPSE, COLLAPSE IN ENGLAND AND WALES

**1,264** landfill sites are located in coastal areas and estuaries at risk of erosion (shown on map)

**2,946** additional landfill sites are located in flood plains



## Waste Erosion Assessment and Review (WEAR)

Final Report



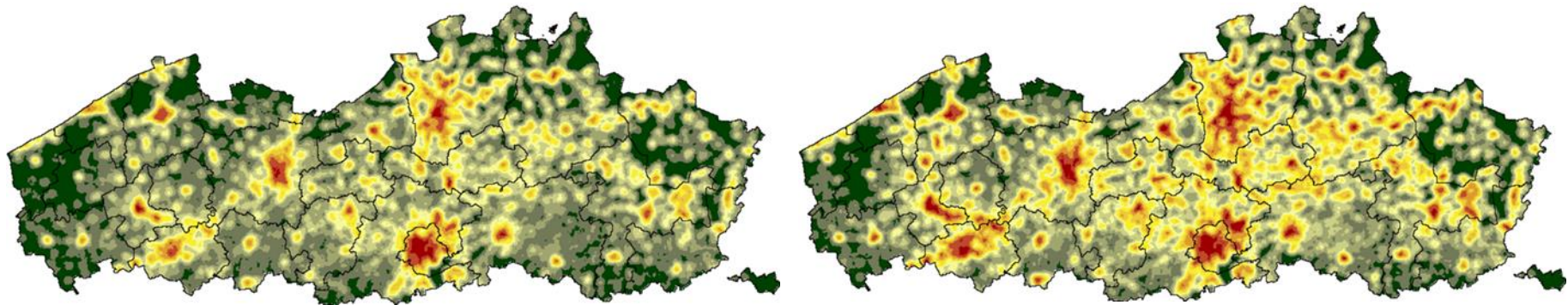
May 2015

Solid Waste Program,  
 Alaska Department of Environmental Conservation



# Trends & Boundary conditions

Land use and soil sealing



2010

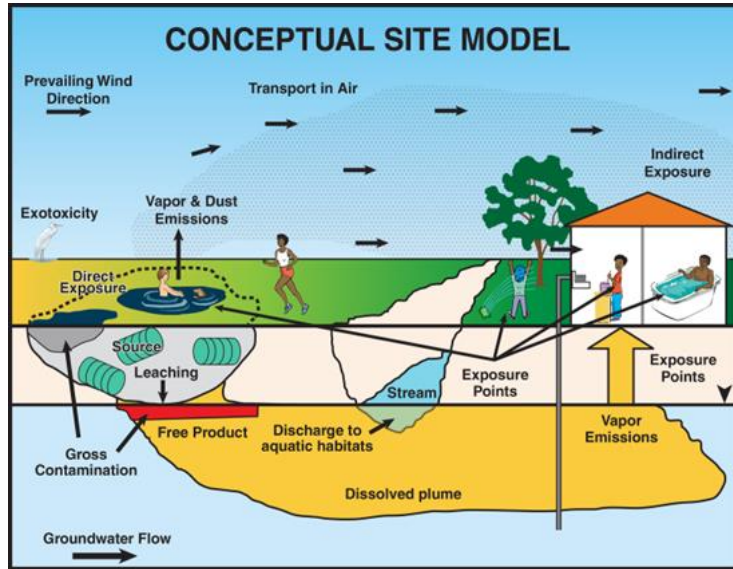
2050

Increase of urban areas in Flanders: in total 7 ha/day; 5 ha/day transformed in residential landuse.

Simulation made by Vito for the period 2010 – 2050 shows the impact of urbanisation in Flanders. According to the Planning Agency: population will rise significantly and assessments indicate the need of over 630.000 new dwellings by 2050.

'Ageing cities' is not limited to its inhabitants; infrastructure also requires retrofitting to become more sustainable and ready for the future.

# Conceptual Site Model



Traditional Conceptual Site Model sets focus mainly on impacts and risks. Seldom data on waste (quality and quantity), infrastructure, geotechnical characteristics,... Often limited scale (spatial, timing,...)

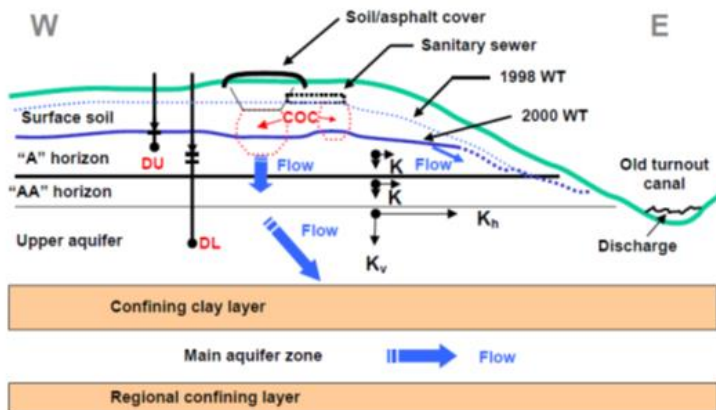
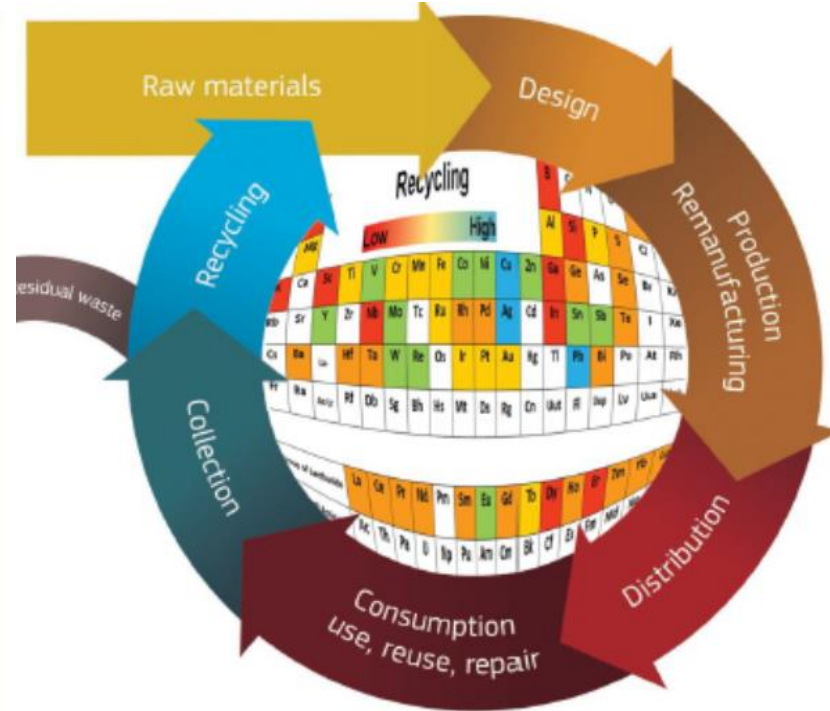
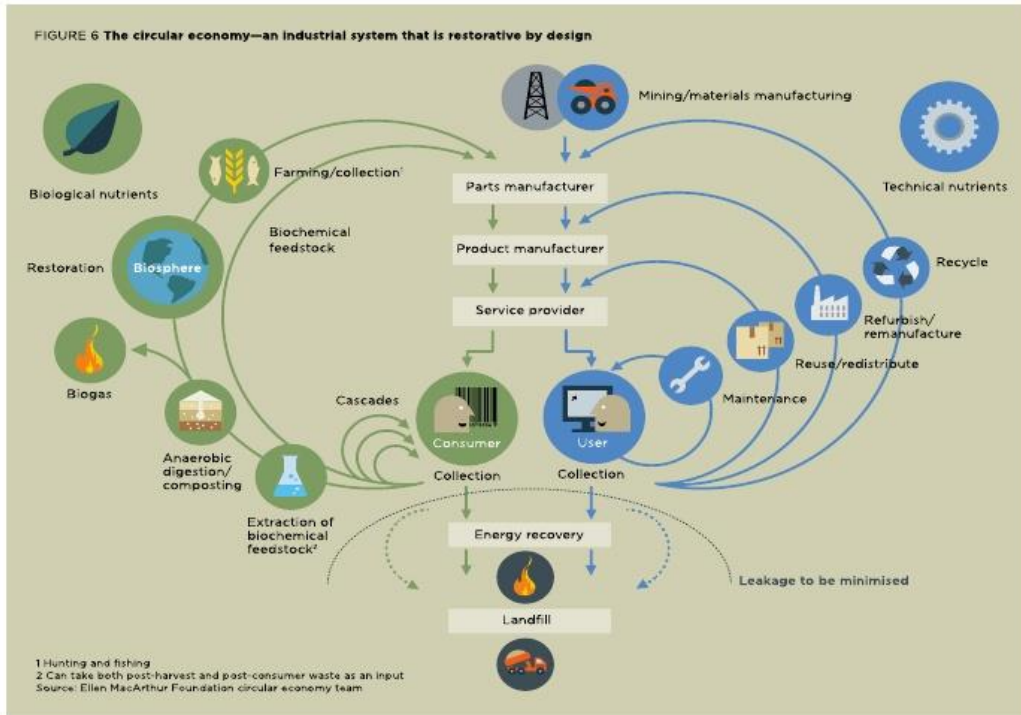


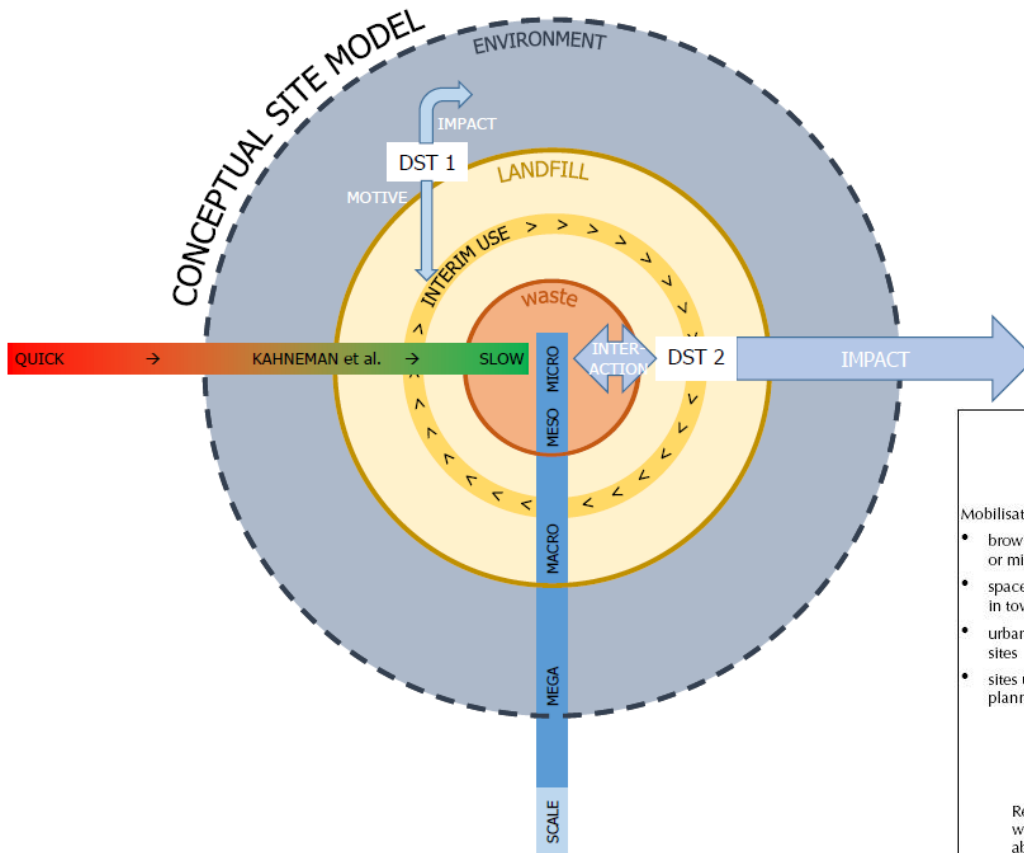
Figure 3-1. Initial conceptual site model showing a confining layer between two aquifers.

# Conceptual Site Model

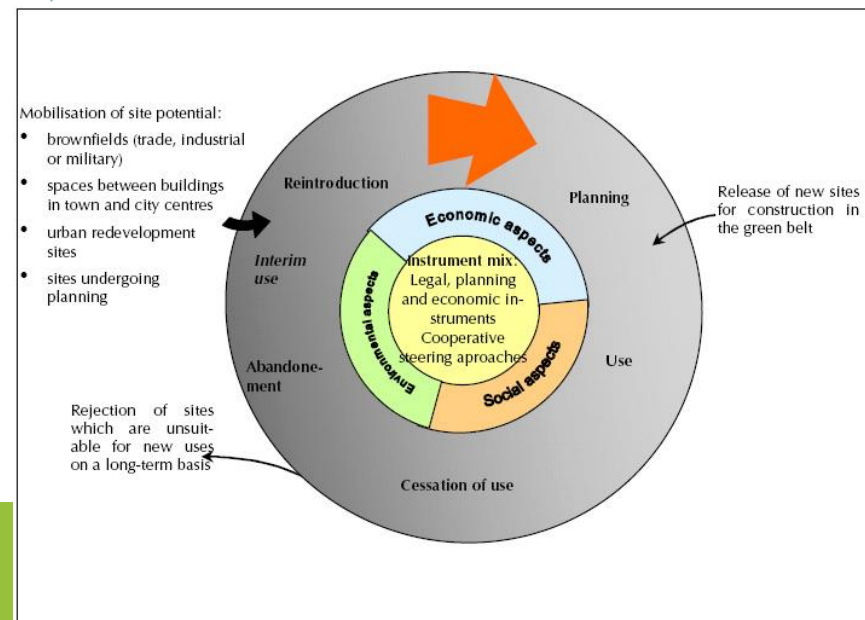


Broader Concepts available but ...  
landfills have no place in them !

# Conceptual Site Model

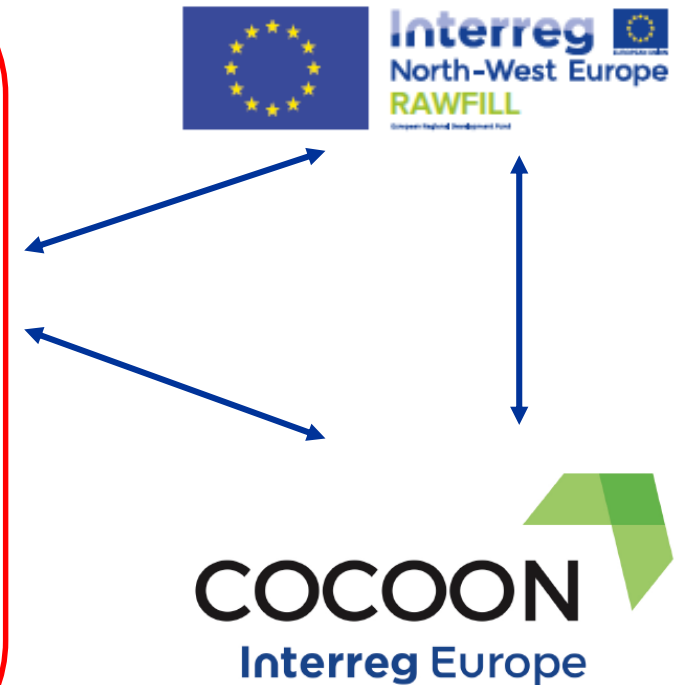


Onion-model :  
 First attempt of linking  
 landfills with their  
 (eco)systems & time in  
 the broadest sense



# Conceptual Site Model

- Setting up a Conceptual Site Model :
  - Integrating multiple dimensions
  - Defining its purpose and applicability
- Feeding the model : Enhanced Inventory Framework
  - Detecting sources of data
  - Collecting data (Geophysical prospection)
  - Data quality control (**Guidelines**)
- Developing the Decision Support Tool :
  - Defining the output and outcome
  - Constraints for use
- Testing the DST in practice
- Feed back loops :
  - Adjustments DST, CSM, data requirements
  - **Interactions** (policies, legal aspects, economy,...)



# The myth of Orion, Cedalion & Eos



Servant Cedalion is leading the temporary blinded giant Orion to the light Eos.

The metaphor of dwarfs standing on the shoulders of giants (Latin: *nanos gigantum humeris insidentes*) expresses the meaning of "discovering truth by building on previous discoveries".

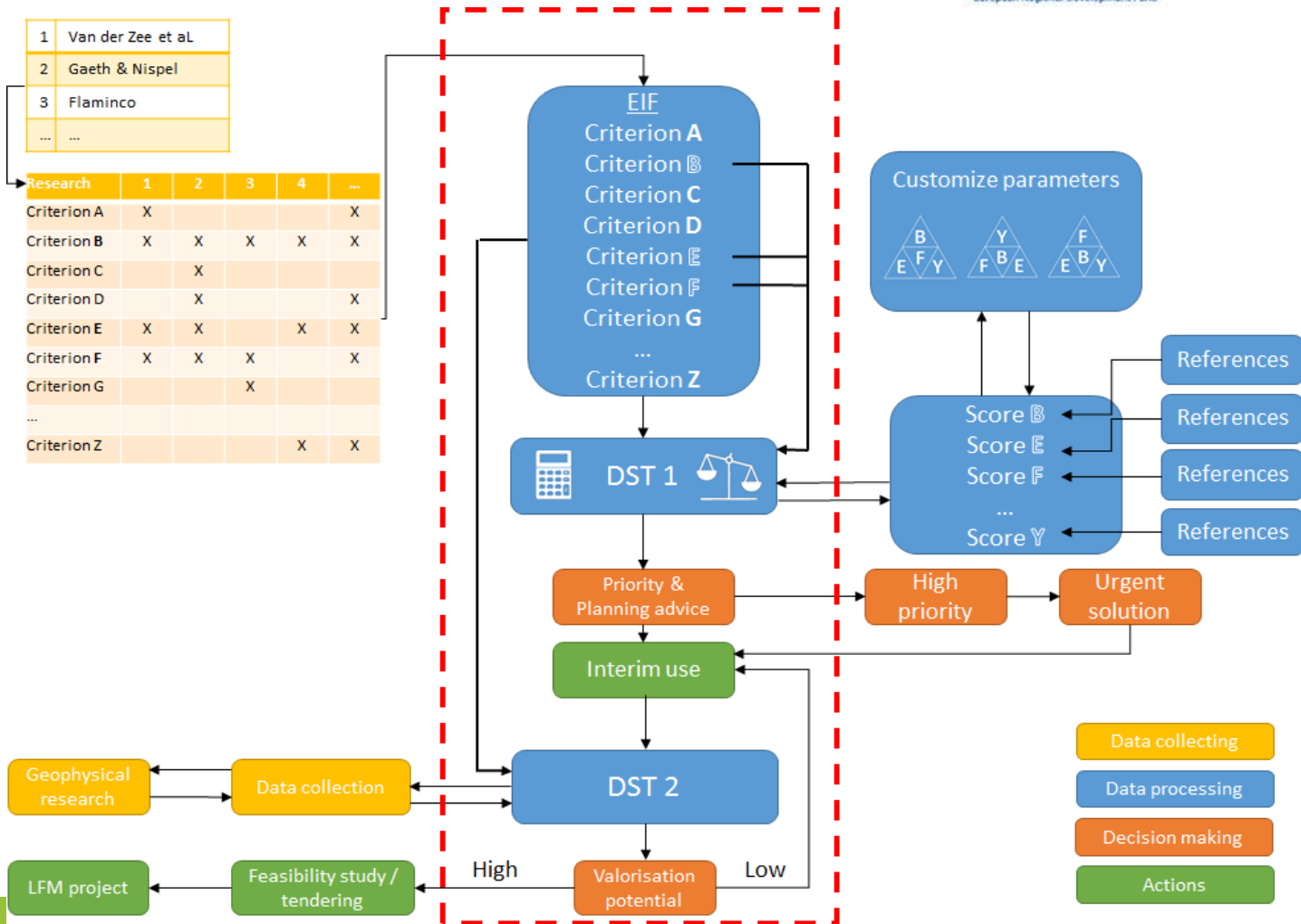
Isaac Newton in 1675: "If I have seen further it is by standing on the shoulders of Giants."

# The myth of Orion, Cedalion & Eos

1	Van der Zee et al
2	Gaeth & Nispel
3	Flaminco
...	...

Research	1	2	3	4	...
Criterion A	X				X
Criterion B	X	X	X	X	X
Criterion C		X			
Criterion D		X			X
Criterion E	X	X		X	X
Criterion F	X	X	X		X
Criterion G			X		
...					
Criterion Z				X	X





# The myth of Orion, Cedalion & Eos



DST 1 : Cedalion

Easy, straightforward application usable by everyone

➤ guidance

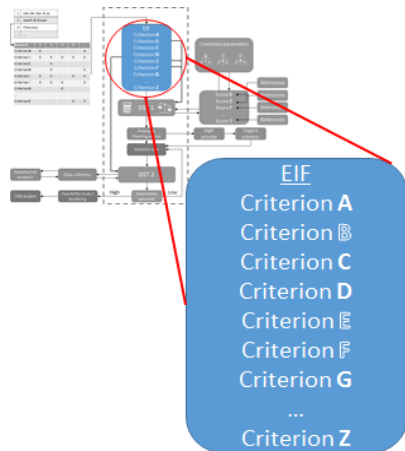
DST 2 : Orion

Complex, only for most promising landfills

➤ Business case

# DST 1 : Cedalion Screening & classification

Sections	Criteria
Generic information	n/a
Landfill ID-card	Ranking number
	File number (if applicable)
	Location (address, coordinates, land plots)
	Owner
	Operator
Surroundings	Permits
	Groundwater
	Land use type
	Flooding areas
Geometry	Transport by road, train and ship
	Surface area
	Depth
	Volume
	Surface texture
	Landfill type
	Age

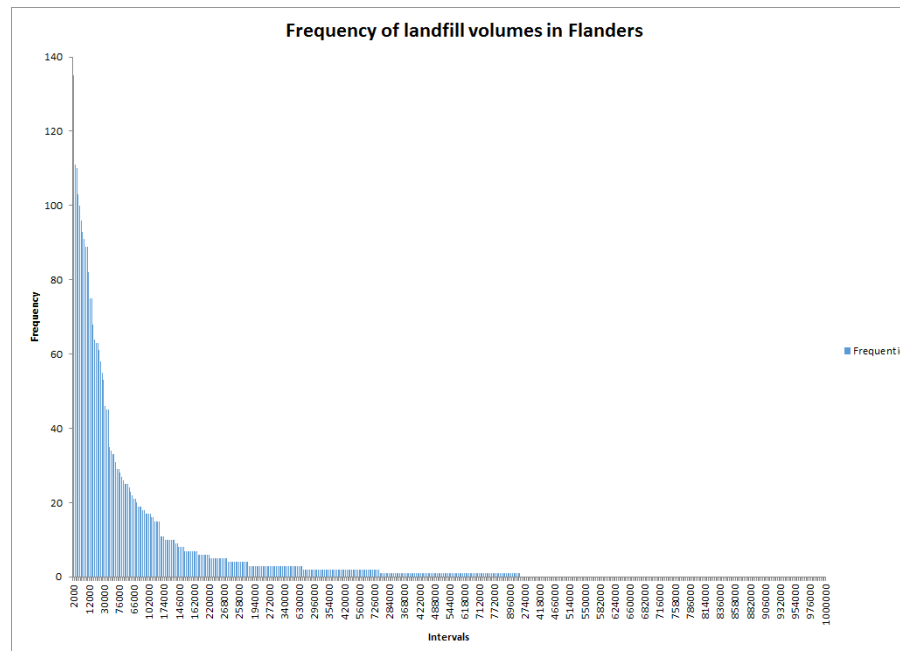


# DST 1 : Cedalion

## a “small” problem

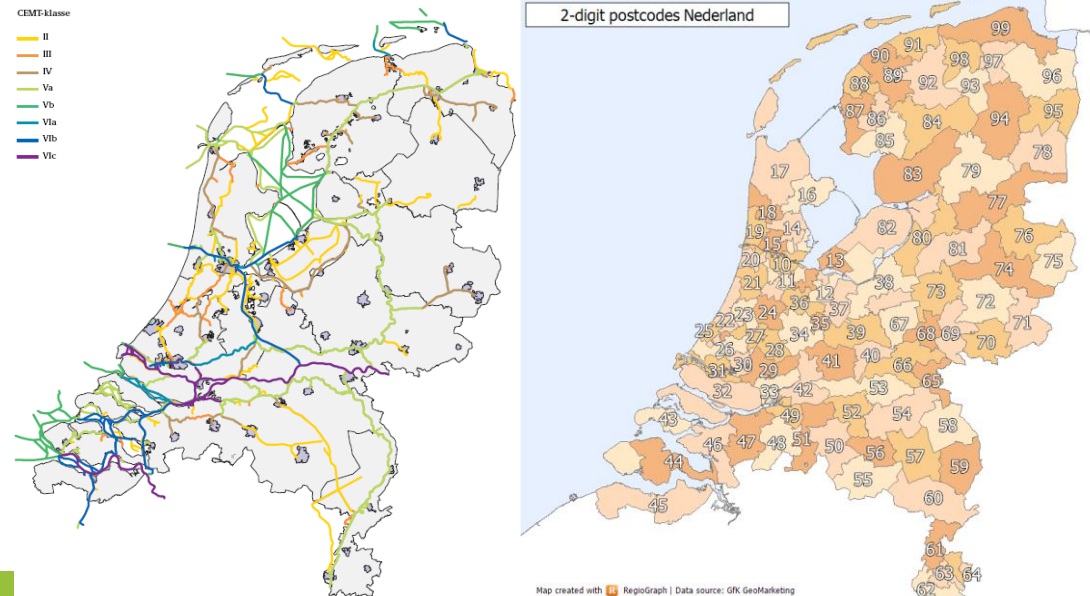
50% of all landfills < est. only 41.000 m<sup>3</sup>

- “Big” = upper 10% → default > 350.000 m<sup>3</sup>
- “Average” = 50% of total → default 35.000 – 350.000 m<sup>3</sup>
- “Small” = lower 40% → default < 35.000 m<sup>3</sup>



# Transport (1)

- Train
  - Open dataset of 27.000 EU stations
  - 3 nearest stations are advised using coordinates
- Ships
  - Open data on CEMT classification for inland waterways
  - Advises are given on waterways within the two-digit postal code zone of the landfill



# Transport (2)



- Roads based on site visit
- Interlink with DST 2: calculation of carbon foot print for different scenarios:
  - Truck only
  - Truck + train
  - Truck + boat

# Waste types

- Typology:

Municipal solid waste	Asbestos
Industrial waste	Metal slag
Dredging materials	Mining waste
Waste water sludge	Mixed waste
Inert materials	Other
Fly ash	

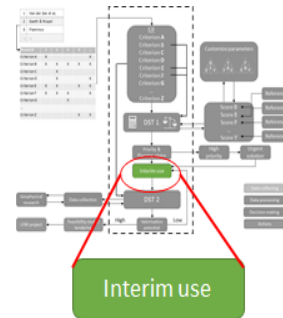


- Interlink: does it concern a mono landfill?

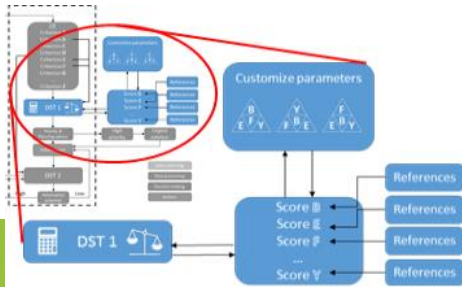
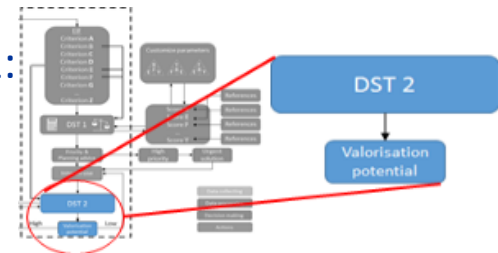
# Weighing (1)

- Criterion selection = standard weight
- Interlinking questions will or won't add weight
- Criterion + interlinking questions = basket which adds to the total, resulting in:

- One or more ways of interim use



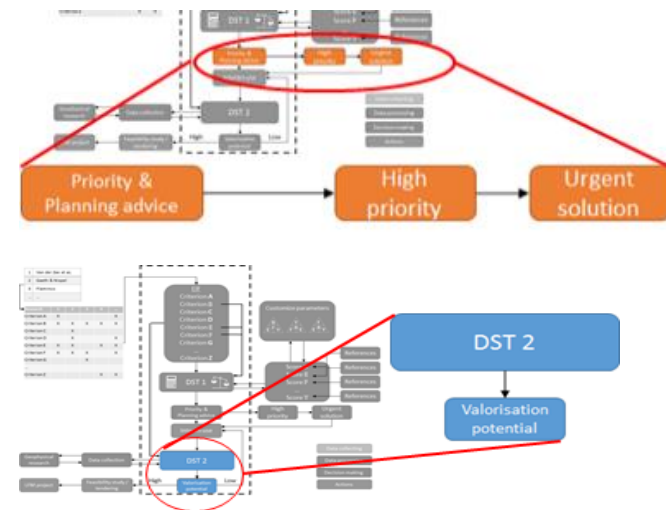
- Best scores (apart from quick responses) to DST 2:



# Weighing (2)

Certain answers on interlinking questions can trigger quick responses before the final result:

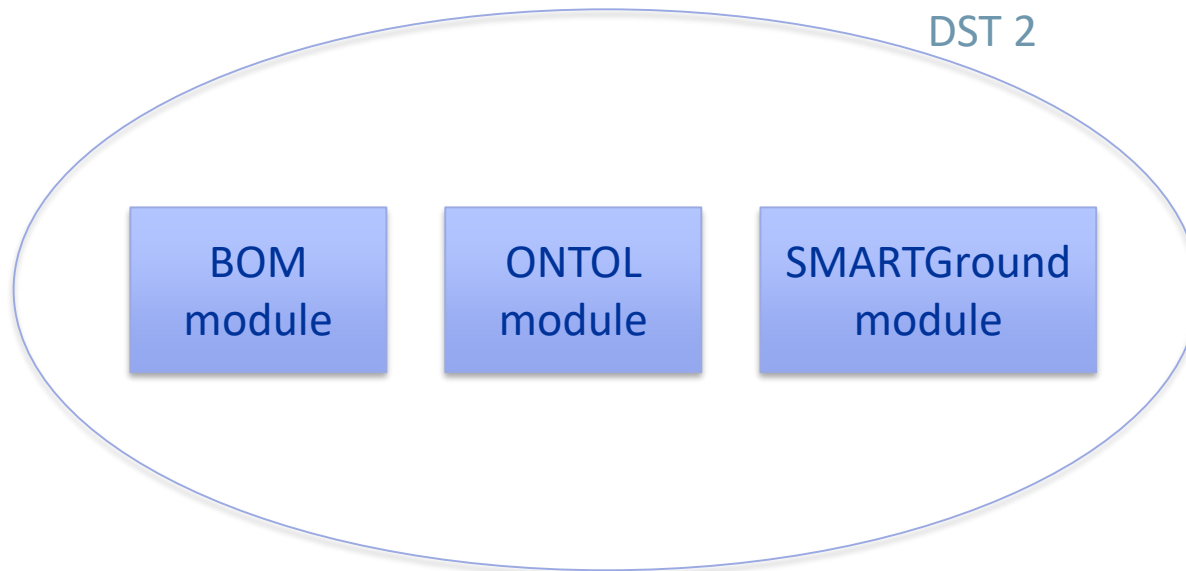
- High priority that need urgent solutions:
- Bypasses to DST 2:





# DST 2: optimizing good ideas

- Not reinventing but reusing
- Existing tools have each strong points and shortages



# Viability of the LFM-Project

DST 2 must be a tool used during the evaluation process of a possible Land Fill Mining Project.

Main Question :

**Will the LFM-project be viable?**

3 families of criteria must be evaluated :

- Technical criteria. Is the project technically feasible?
- Socio-economic criteria. Is the project sustainable and economically viable?
- information-quality criteria. Is there enough info to make a reliable evaluation ?

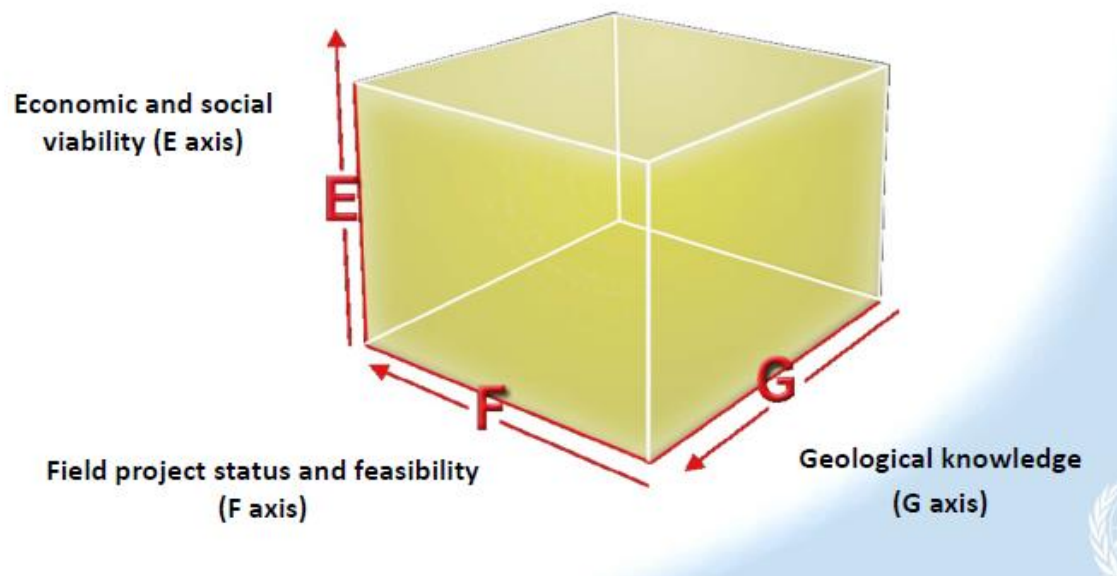
# Viability of the LFM-Project



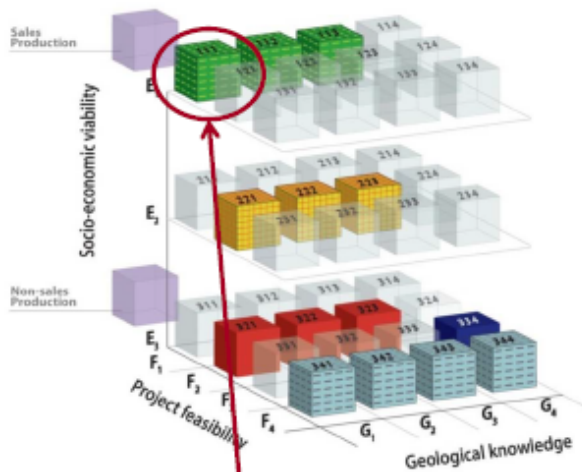
- A multi-criteria analysis is needed;
- TU-Wien refers to the evaluation frameworks used in the mineral deposit mining industry (TU –Wien , Doppler-institute Prof. Fellner);
- UNFC United Nations Framework Classification-system :
  - Used in the mining –industry ;
  - International agreed methodology;
  - Standardized evaluating procedures for technical and economic criteria;
  - Output : 3 dimensional diagram;
  - Ranking: Positioning of a project in this 3 dimensional reference system;

# UNFC-2009 Criteria

## UNFC – The three criteria



## UNFC – How it works



**UNFC Class: 111**

Category	Definition
E1	Extraction and sale has been confirmed to be economically viable.

Category	Definition
F1	Feasibility of extraction by a defined development project or mining operation has been confirmed.

Category	Definition
G1	Quantities associated with a known deposit that can be estimated with a high level of confidence.

# UNFC 2009 extended to Ifm-projects -Results

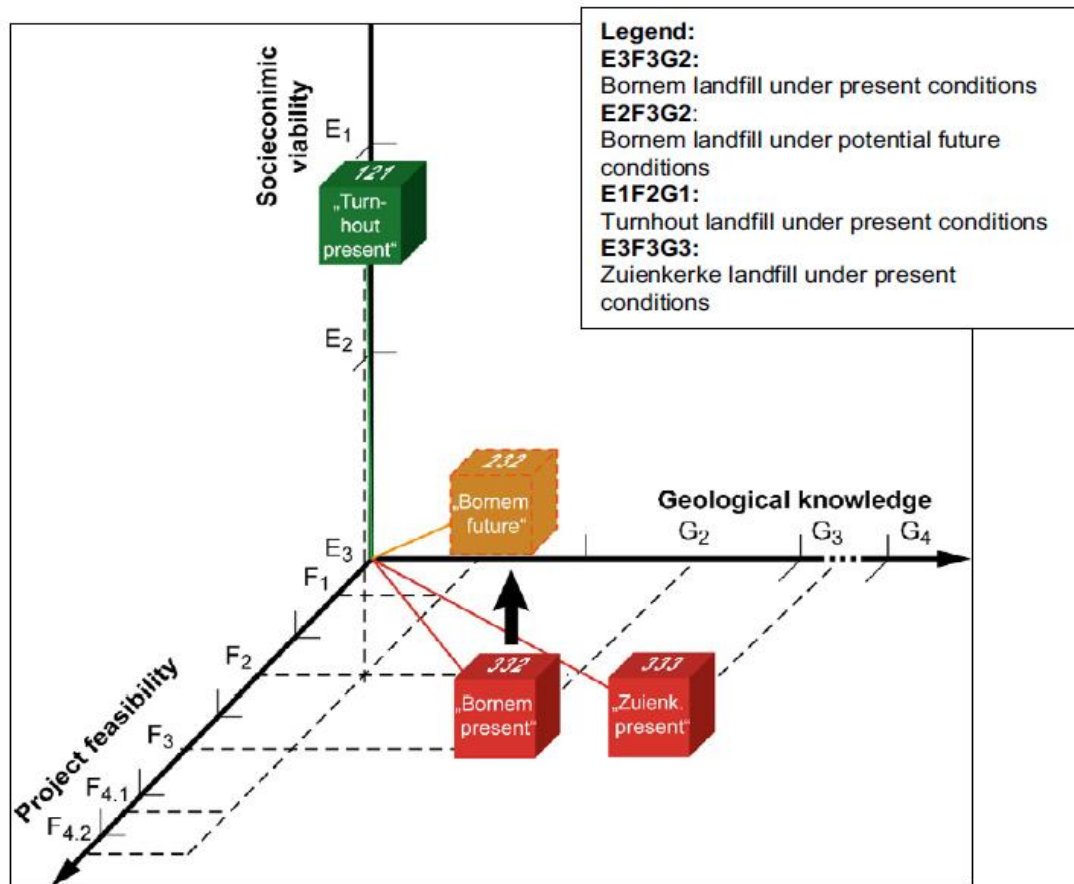


Fig. 6. Classification of the three landfill-mining projects under UNFC.

# Context DST2 in RAWFILL



## Second level: ranking

### What?

rank pre-selected and fully investigated LFs of economic interest for raw material recovery purposes

### Result

integrating the LF in its physical, economic and social environment

### Proposal

Multicriteria –Evaluating RAWFIL- system based on UNFC-2009 (anthropogenic-ressources/reserves)

# DST state of the art



- Cost-benefit scheme- (Van der Zee)
- Introduction modern investment techniques  
NPV, sensitivity analysis, scenario's
- Internalization of external environmental effects
- Integration physical and economical model-  
Material Flow Analysis



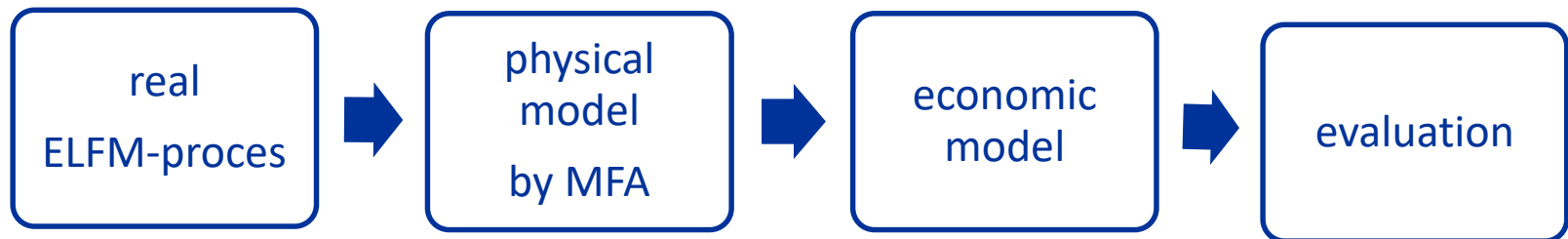
# DST -ONTOL



- **Fast environmental and economic evaluation** of LFM- projects;
- Facilitating of **prioritization of LFM-projects**;
  
- **Comparison of different scenarios** for implementing a LF-mining project;
  
- Streamlined format (e.g. agreed economic calculation methods)
  
- **Provision of default data sets** (e.g. waste composition, sorting technology efficiencies, waste-to-energy efficiencies, etc.)
  
- screening assessments without the need for extensive data generation

# Evaluation & classification of anthropogenic resources

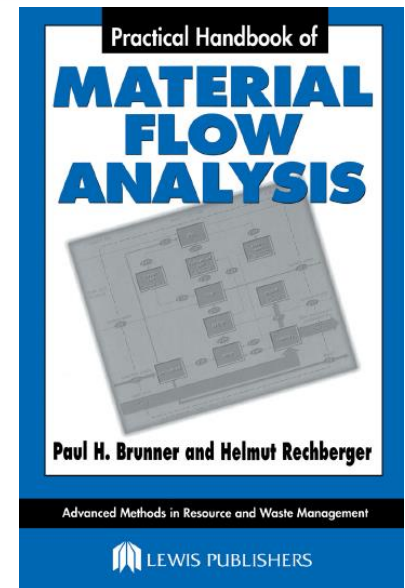
Integrated evaluation of the technical and socio-economic feasibility of the project



# Physical model based on Material Flow Analysis -MFA

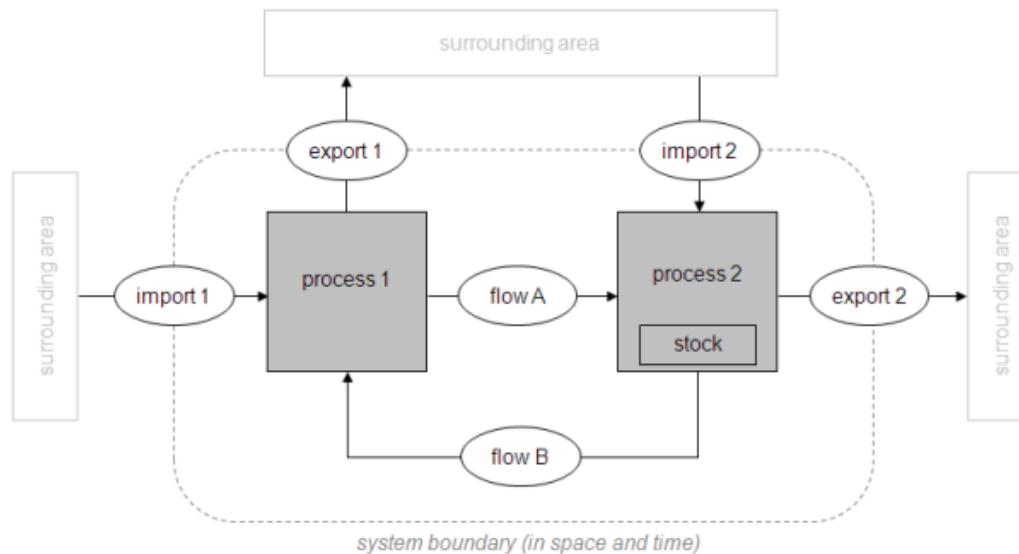
MFA variant is developed by TU-Wien and ETH Zürich  
Prof. Brunner Prof. Rechberger

- Establish Mass/energy balance-equations to control the total Material Flow Analysis.
- Real LFM-process is partitioned in modules
- For each module material and energy balances are created
- Development of open-source software STAN by TU-Wien (substance flow analysis)



# Building a MFA-model of a project

- For each procesmodule a balance of material- and energyflows is simulated;
- Inputs = Outputs – Changes of stock;
- The modules are interconnected by the material and energyflows;

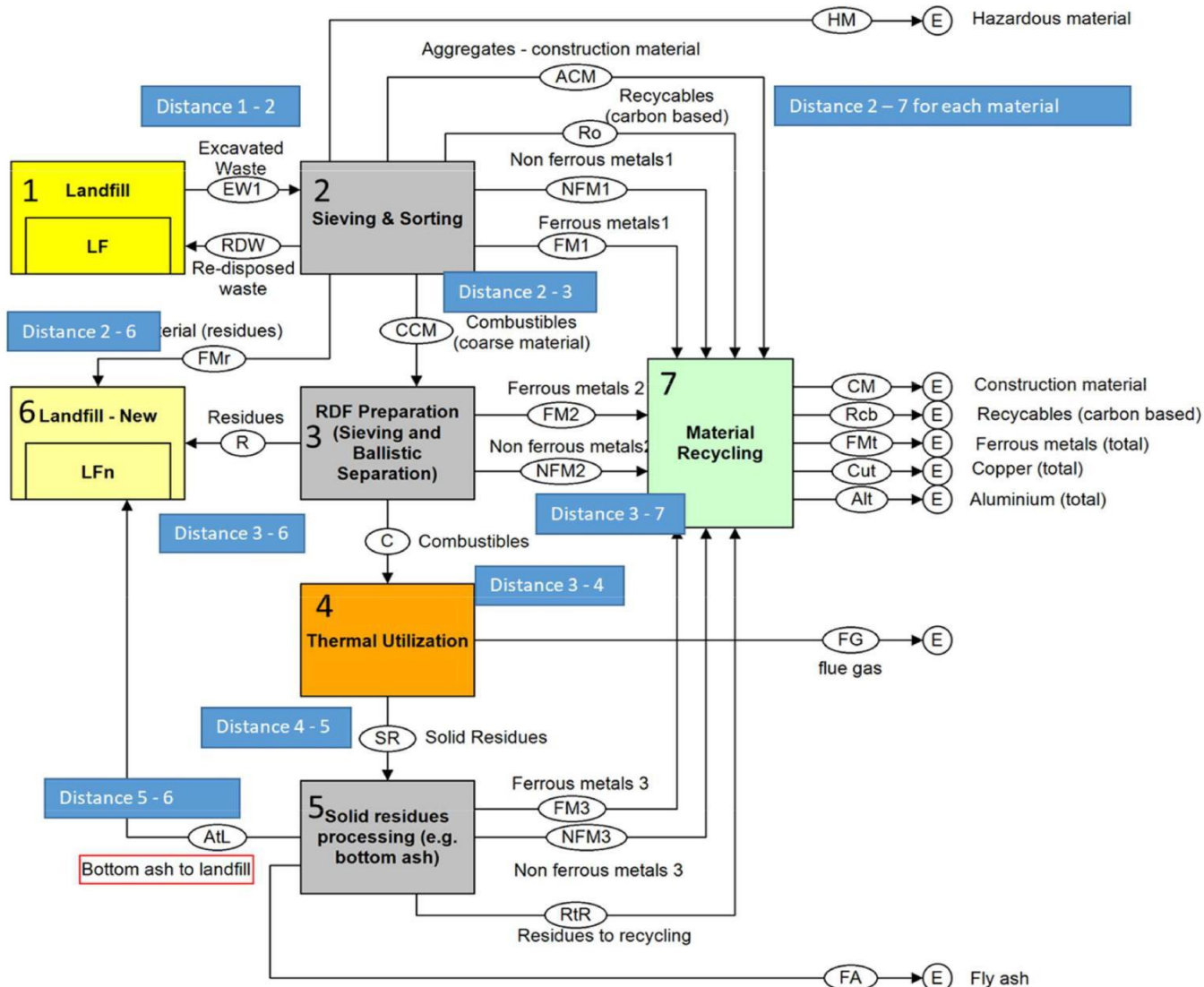


# Standard MFA-scheme



- Physical simulation starts from a standard scheme ;
- This standard scheme is composed of modules which represent the possible LFM-operations (excavating, sieving, incineration etc.);
- Individual projects are associated with specific MFA-schemes
- Specific schemes are modifications of standard MFA-scheme
- Differences in the set-up of LFM-projects are implemented by e.g material-flows, prices ,separation efficiencies, energy demands, transport

# Standard MFA-scheme



# Inputs and outputs of the DST2-tool



1 choice which type of analysis :  
ecological/economic/ecological+economic

## 2 Input

- general landfill data;
- data for the reference case = no landfill mining;
- data for the landfill mining case;
- technical information;

## 3 Results calculated for both reference and LFM-case

- material flows : MFA-scheme;
- cash flows;
- Impact on Green House Gas

# Interreg



EUROPEAN UNION

# North-West Europe

# RAWFILL

European Regional Development Fund

# Thank you!