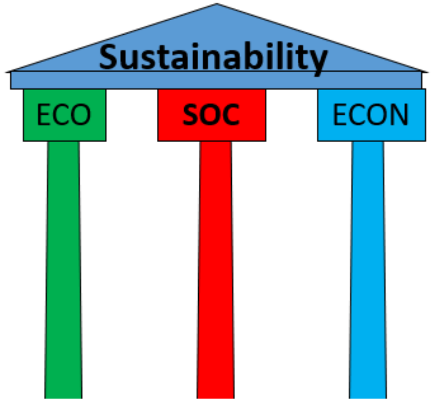
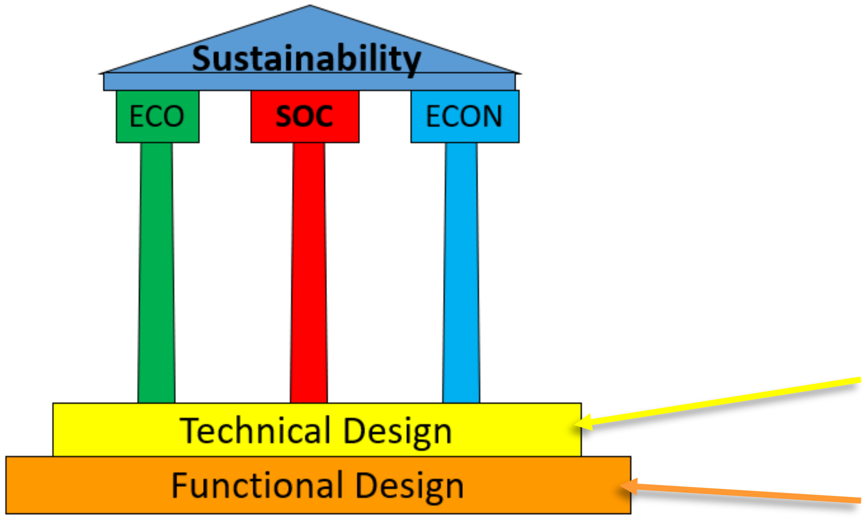
Sustainable Constructions with Geosynthetics

2024-04-09
Henning Ehrenberg

Sustainability and Construction Products Regulation (CPR)



Sustainability and Construction Products Regulation (CPR)



Basic requirements (CPR) for sustainability for Construction Works

- Without meeting the technical needs there is no sustainability
- Without meeting the functional needs there is no sustainability

UN Sustainable Development Goals

The United Nations' 17 Sustainable Development Goals are designed to be a "blueprint to achieve a better and more sustainable future for all".

The goals address issues on how to provide a safe and healthy sustainable environment for humankind.

Many relate to resource preservation, access to clean water, emission reduction, climate change and other environmental issues.

UN Sustainable Development Goals

The UN has defined several “sustainable development goals/SDGs” where some of them, depending on the application, are clearly supported by geosynthetics with

1. Ecological Aspects

UN Sustainable Development Goals

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1. Ecological Aspects
2. Economic Aspects

UN Sustainable Development Goals

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1. Ecological Aspects
2. Economic Aspects
3. Social Aspects

UN Sustainable Development Goals

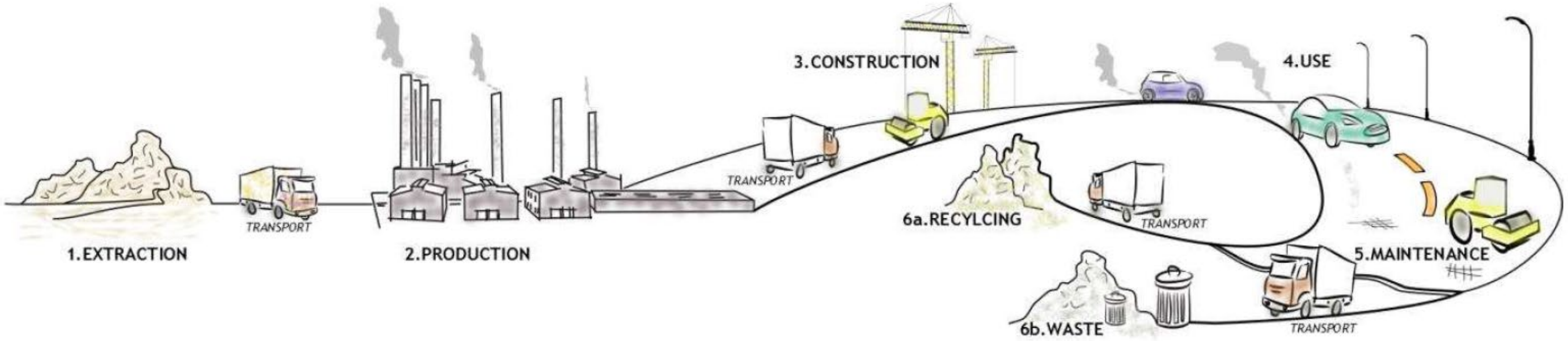
The UN has defined several “sustainable development goals/SDGs” where some of them, depending on the application, are clearly supported by geosynthetics with

1. Environmental Aspects
2. Economic Aspects
3. Social Aspects

Not all SDGs are supported by geosynthetics in every application and not to the same extent, but some of the SDGs are always supported by construction methods with geosynthetics.

What is a LCA (of products or constructions)

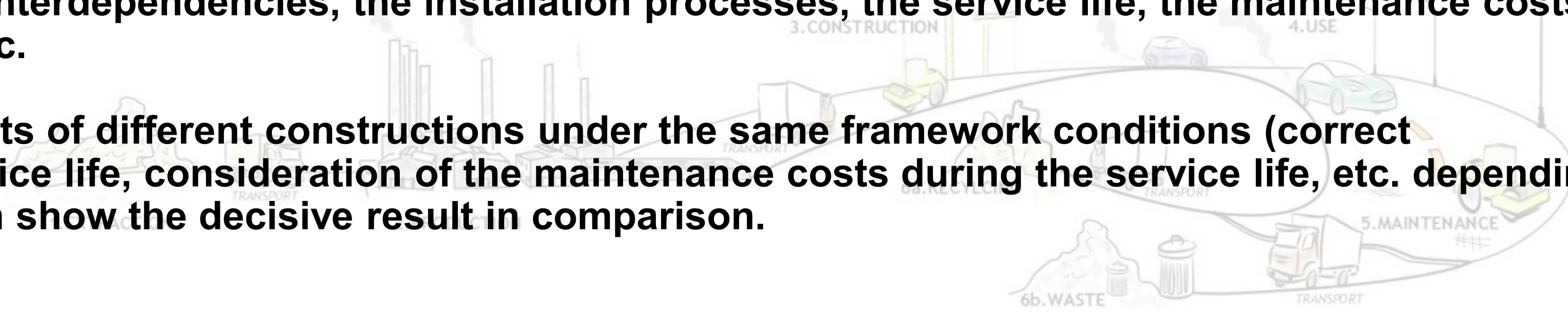
- **LCA looks for product life cycle and compares different product life cycles or life cycle of constructions**



- **earlier ones often until use (cradle to gate, 1-4)**
- **newer ones more up to waste (cradle to cradle, 1-6a) or**
- **up to recycling (cradle to grave, 1-6b)**

What is a LCA (of products or constructions)

- **An EPD for a single construction product „alone“ could guide you in a wrong direction**
- **An EPD of a single product is usefull as part of a LCA of a whole construction, it gives the needed data for evaluating the LCA of a construction**
- **Only the life cycle assessment of a complete construction gives you the true picture, as it summarises the entire construction with all its interdependencies, the installation processes, the service life, the maintenance costs during the service life, etc.**
- **The life cycle assessments of different constructions under the same framework conditions (correct consideration of the service life, consideration of the maintenance costs during the service life, etc. depending on the construction) then show the decisive result in comparison.**

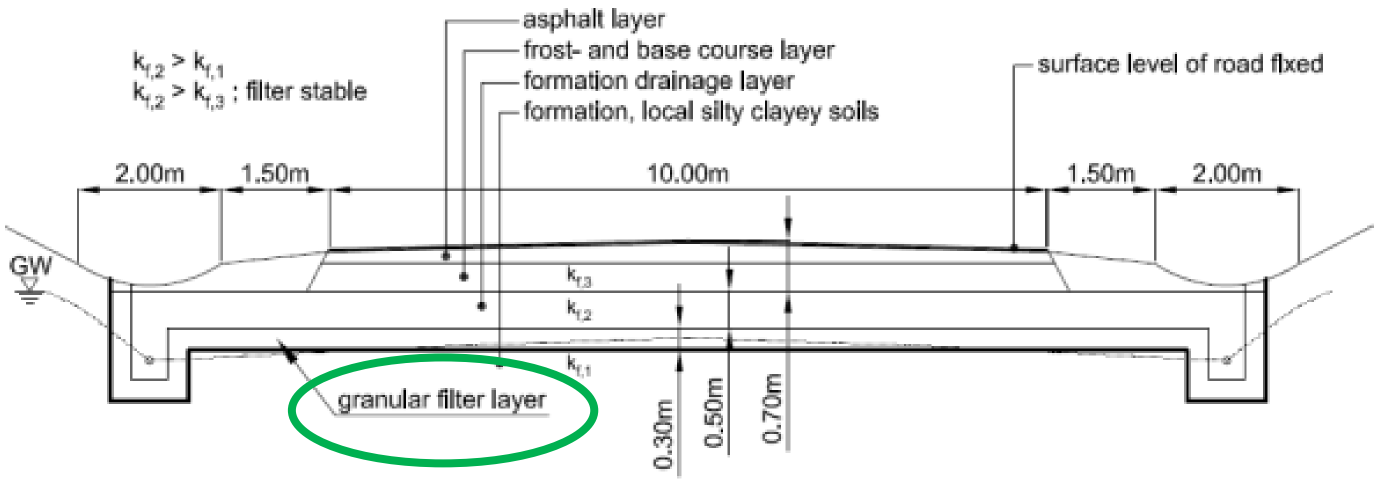


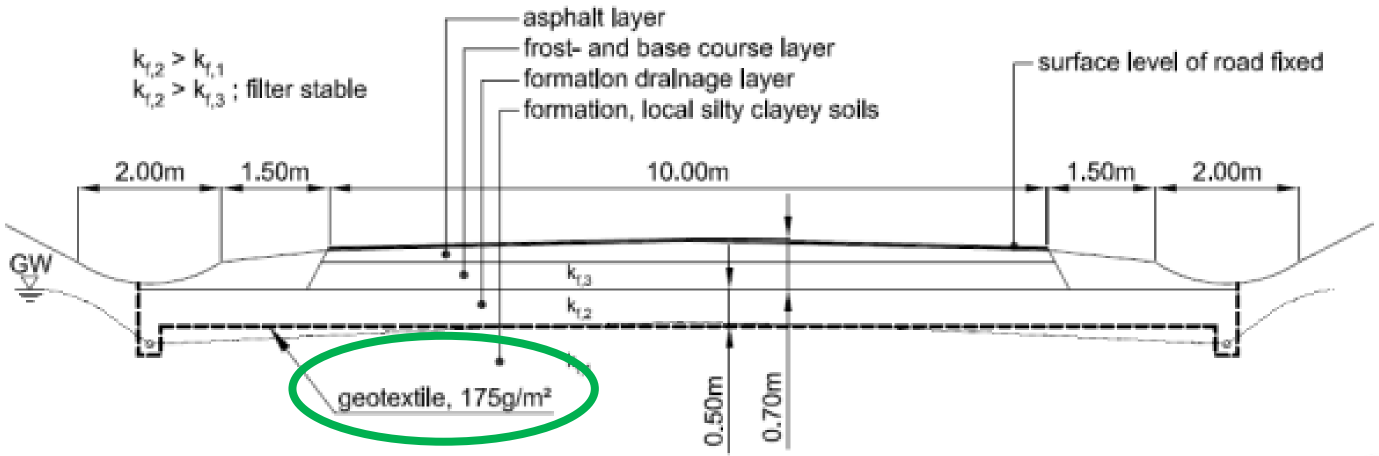
EAGM LCA Case 1

Geosynthetic filter system below a road

Drainage trench construction

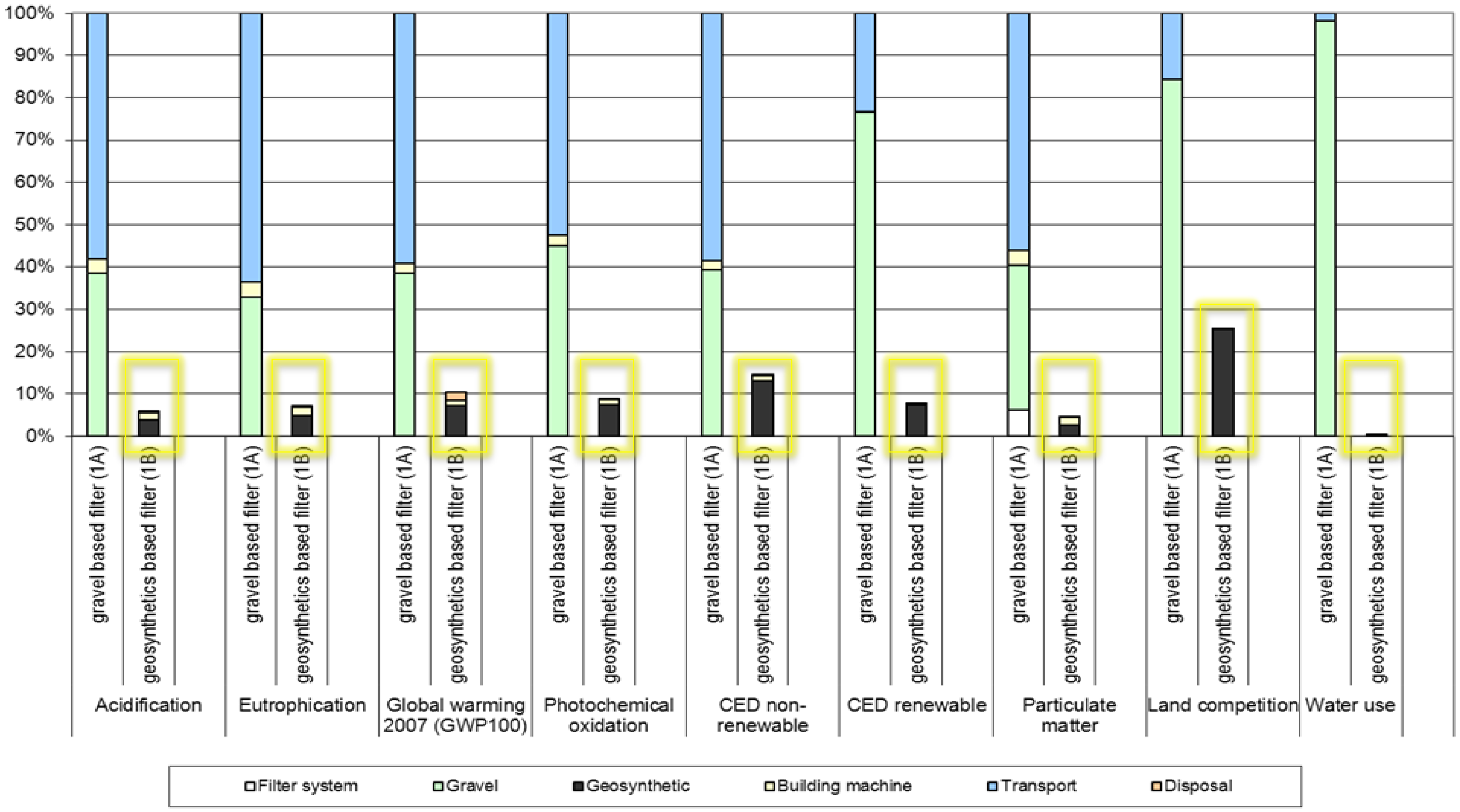
EAGM LCA Case 1





EAGM LCA Case 1

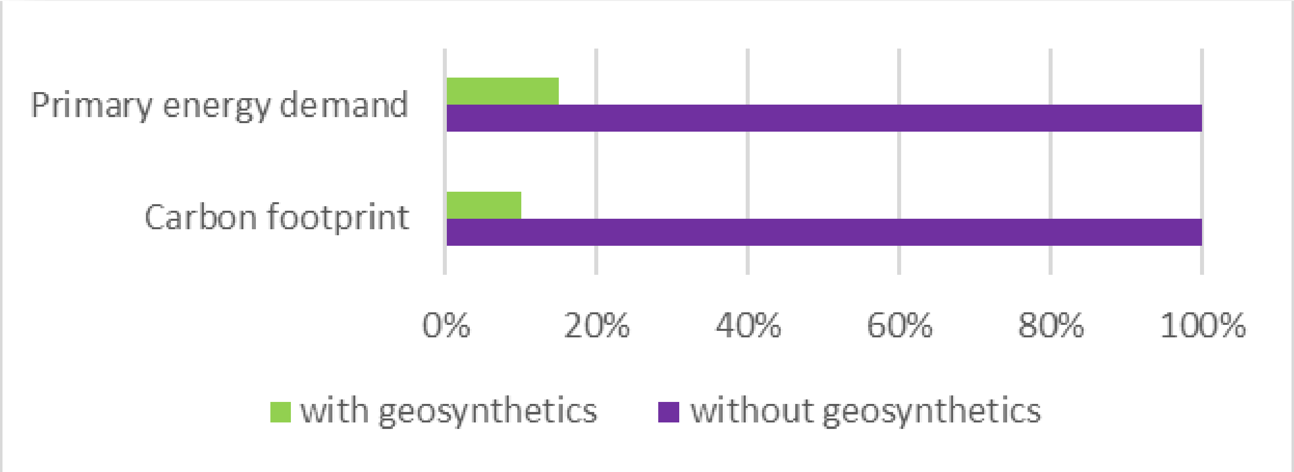
The Nine impact category indicators



EAGM LCA Case 1

The use of geosynthetics leads to:

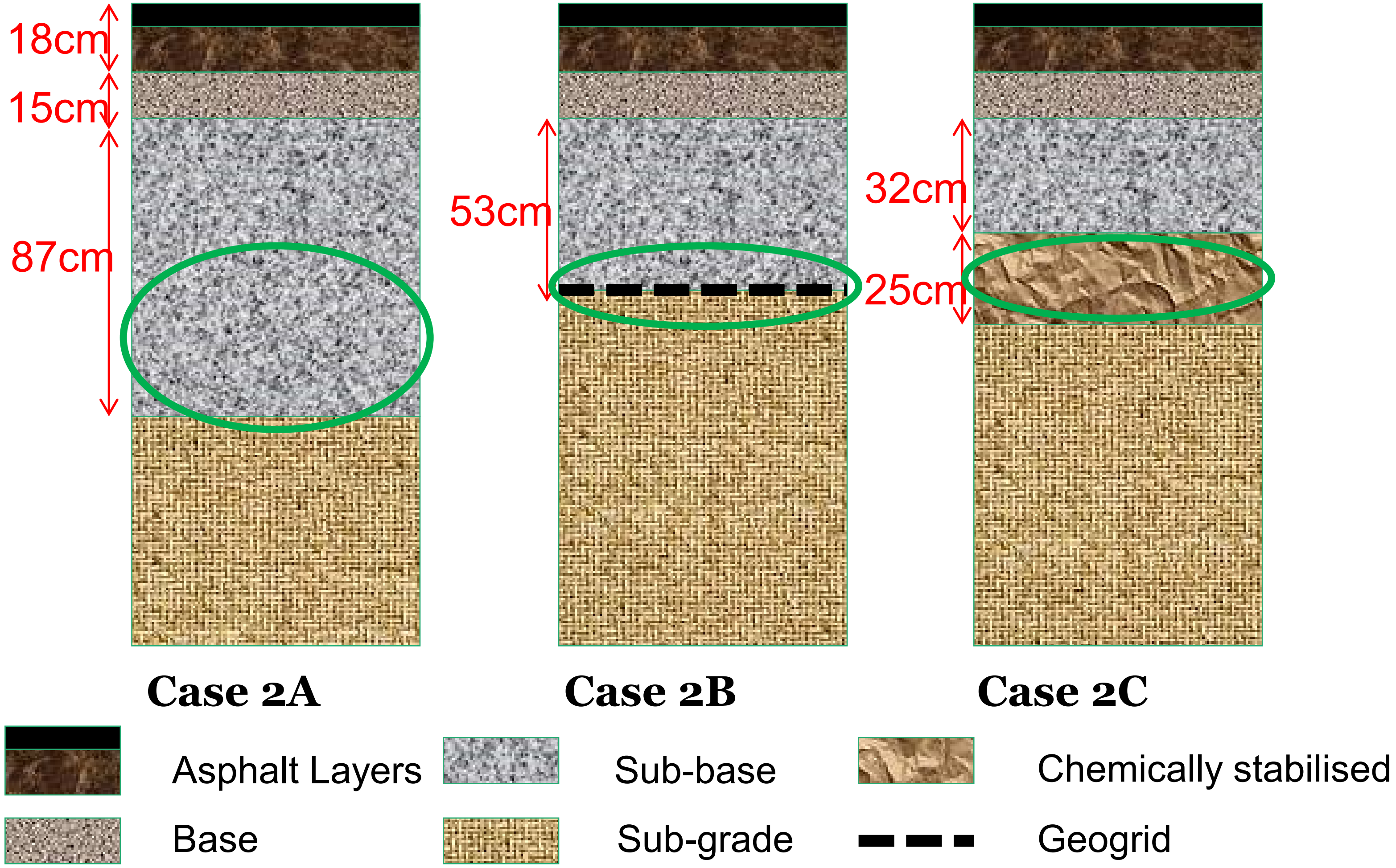
- **75% (min.) lower environmental impact for all indicators**
- **~ 85% lower non-renewable cumulative energy demand**
- **~ 90% lower cumulative greenhouse gas emissions**



EAGM LCA Case 2

Road Foundation Construction

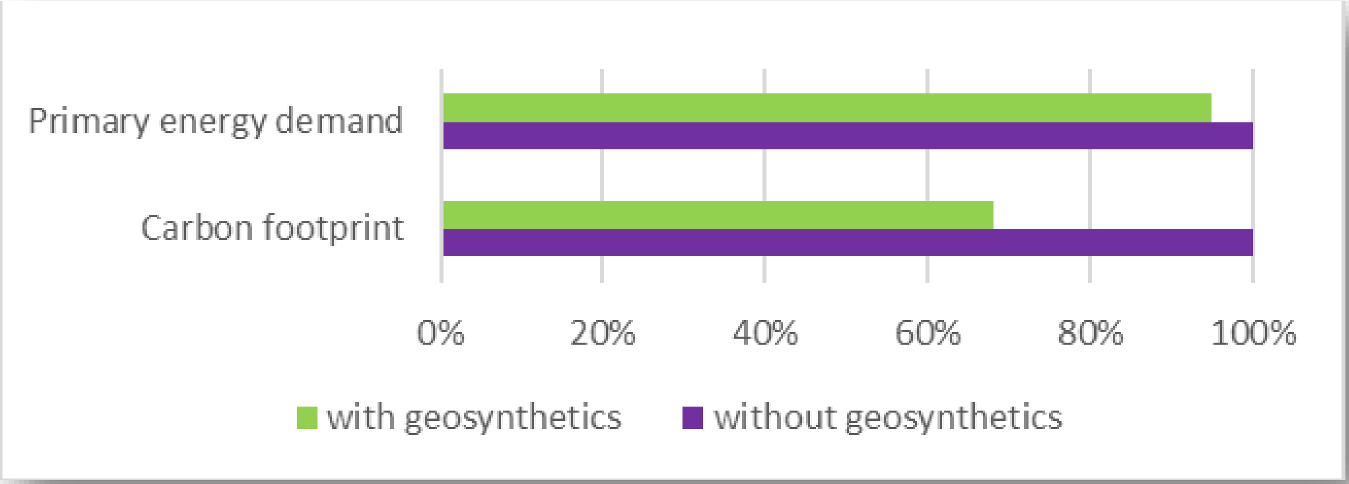
EAGM LCA Case 2



EAGM LCA Case 2

The use of geosynthetics leads to:

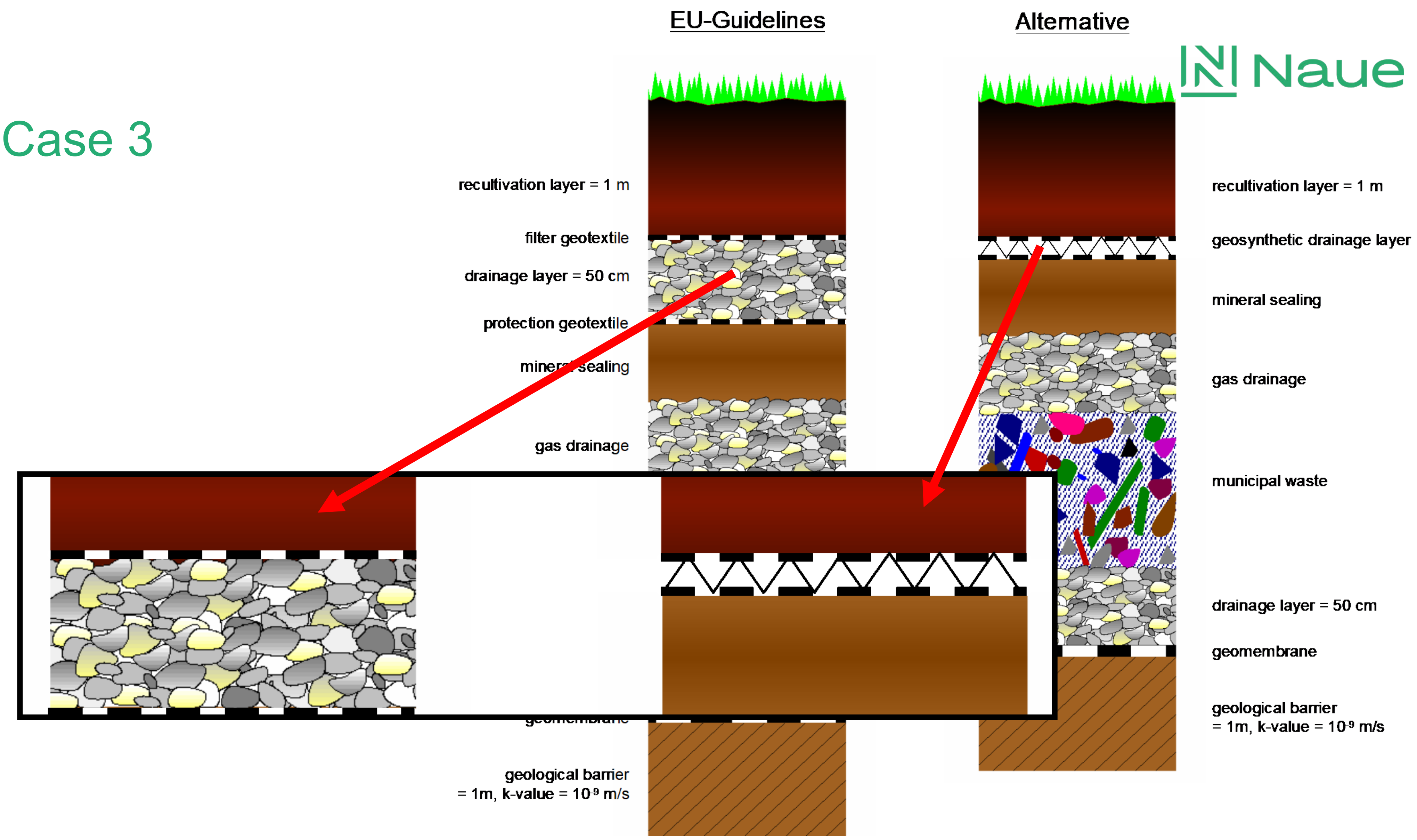
- **lower environmental impacts concerning all indicators investigated compared to a conventional road**
- **lower climate change impacts compared to lime or cement stabilization**
- **~ 11% (or 800 tons) saving in CO_2 per 10km of road ≈ 3,200,000 km in a car (80 trips around the world)**
- **vs. lime/cement stabilization save 30% CO_2 ≈ 12,000,000 km**



EAGM LCA Case 3

Drainage in a Landfill Capping System

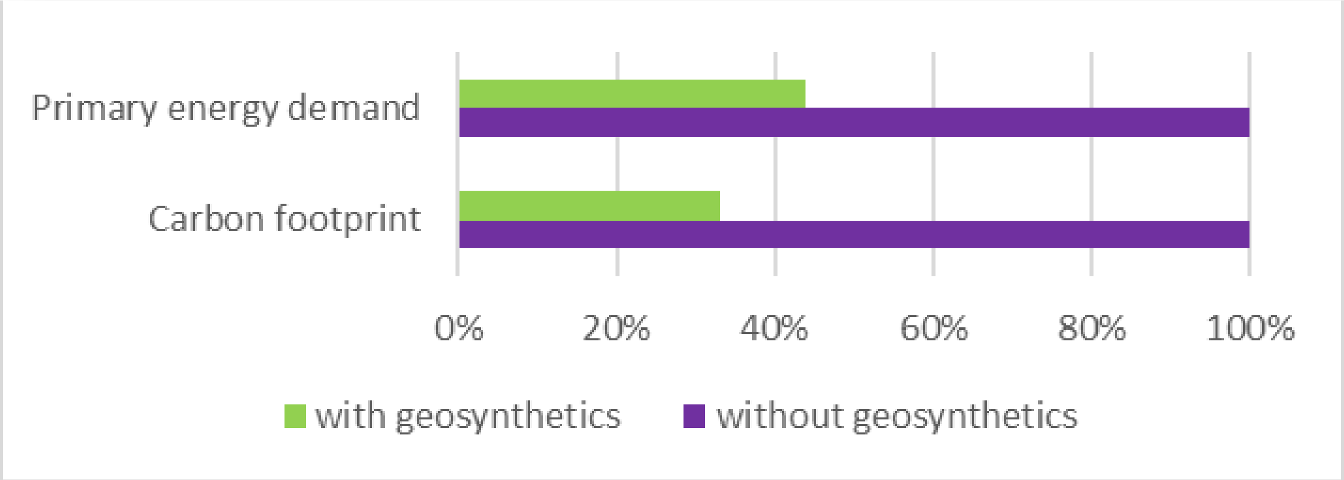
EAGM LCA Case 3



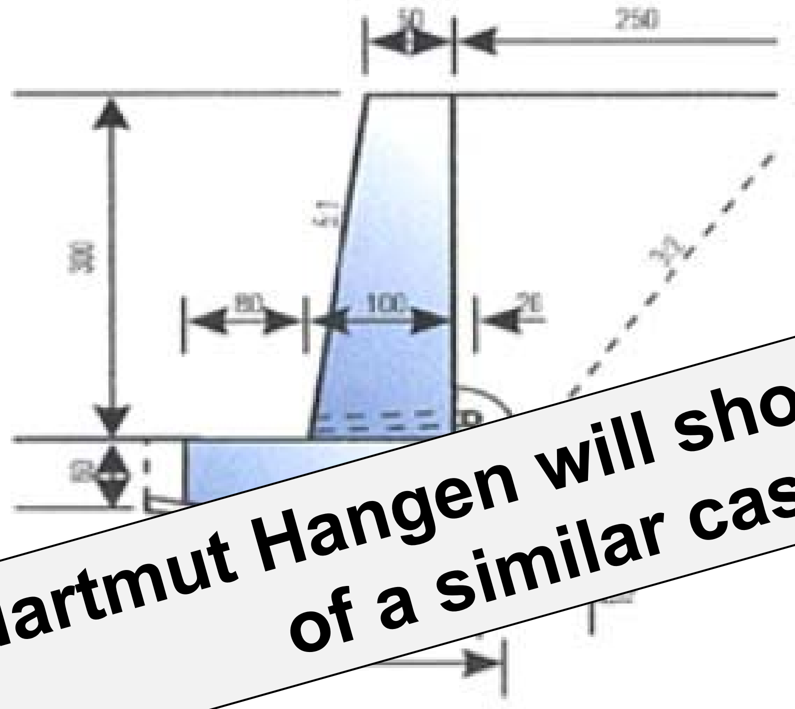
EAGM LCA Case 3

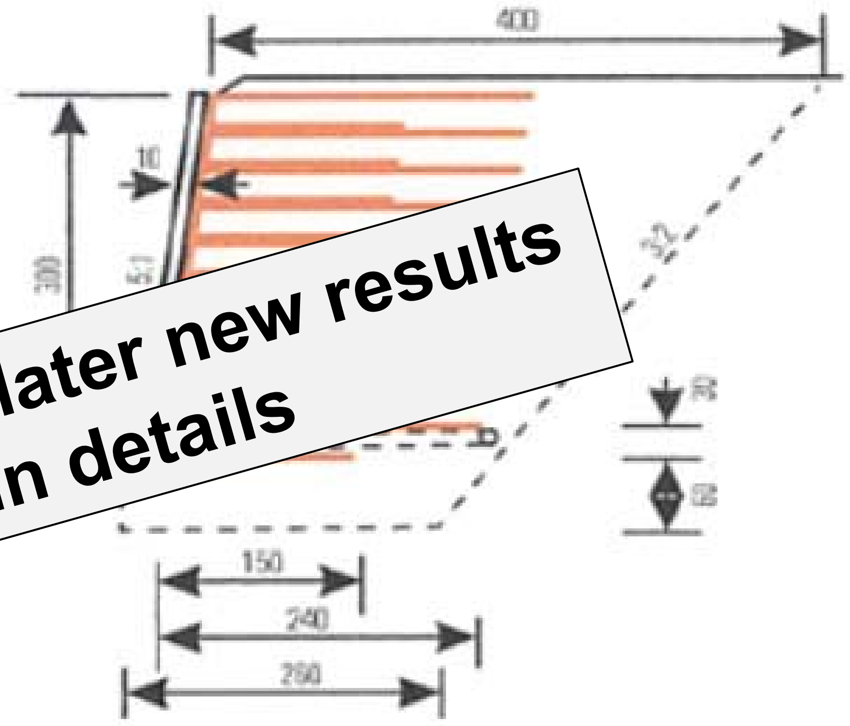
The use of geosynthetics leads to:

- **lower environmental impacts in all impact categories considered , except land competition which is about the same in both cases**
- **220 tons CO_2-eq saving on a landfill with an area of 30,000m²**



EAGM LCA Case 4





Hartmut Hangen will show later new results of a similar case in details

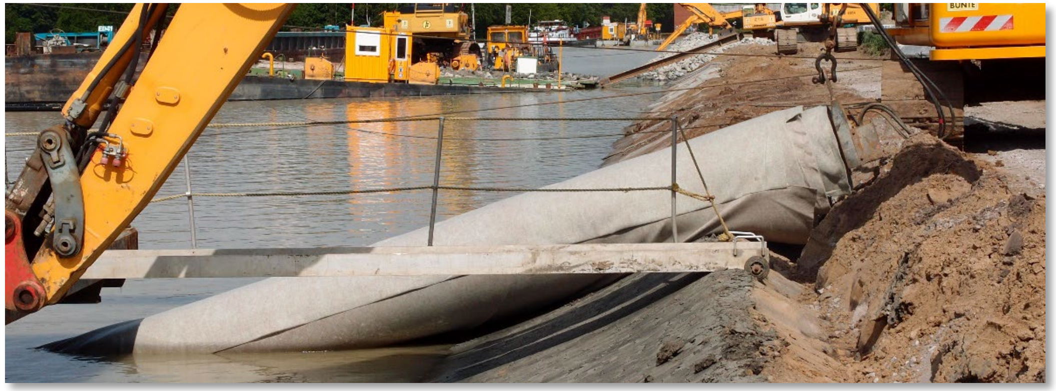
Retaining concrete wall reinforced with steel (strength class B300)

Soil wall reinforced with geosynthetics (LTDS 14 kN/m)

EAGM LCA Case 5,

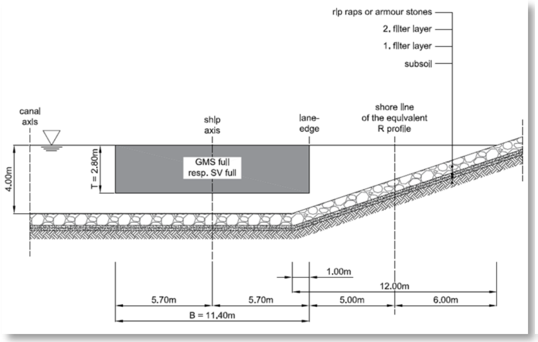
geosynthetics versus conventional construction materials in a river construction

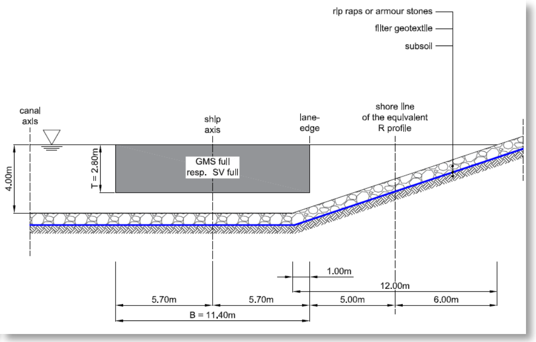
source: Solmax



source: Naue

source: Edilfloor





EAGM LCA Case 5,

Scenarios, average European and maximum European Requirements

	Unit	**Base**
Characteristic		**light** **short**
Geosynthetic weight (transportation to site = 795 km)	g/m^2	**350**
Distance supply of mineral materials	km	**20**

EAGM LCA Case 5,

Scenarios, average European and maximum European Requirements

	Unit	**Base**	Scenario 1
Characteristic		**light** **short**	light long
Geosynthetic weight (transportation to site = 795 km)	g/m^2	**350**	350
Distance supply of mineral materials	km	**20**	50

EAGM LCA Case 5,

Scenarios, average European and maximum European Requirements

	Unit	**Base**	Scenario 1	Scenario 2
Characteristic		**light** **short**	light long	heavy short
Geosynthetic weight (transportation to site = 795 km)	g/m^2	**350**	350	750
Distance supply of mineral materials	km	**20**	50	20

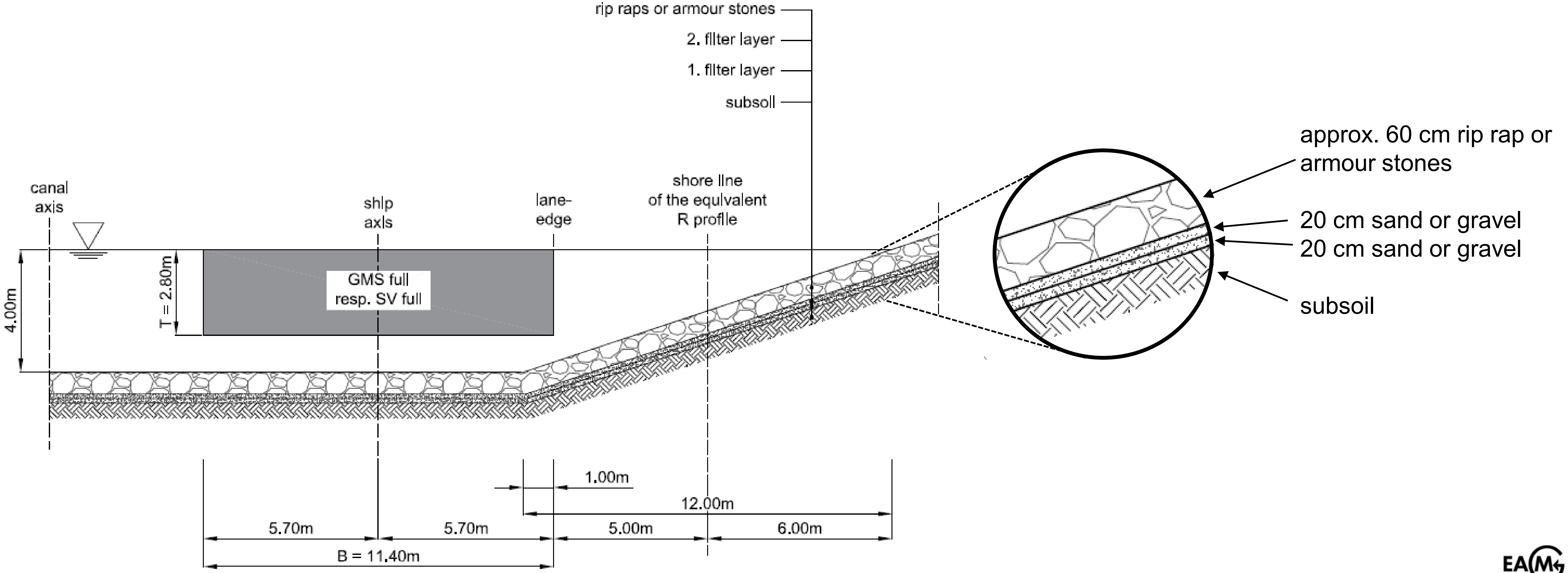
EAGM LCA Case 5,

Scenarios, average European and maximum European Requirements

	Unit	**Base**	Scenario 1	Scenario 2	Scenario 3
Characteristic		**light short**	light long	heavy short	heavy long
Geosynthetic weight (transportation to site = 795 km)	g/m^2	**350**	350	750	750
Distance supply of mineral materials	km	**20**	50	20	50

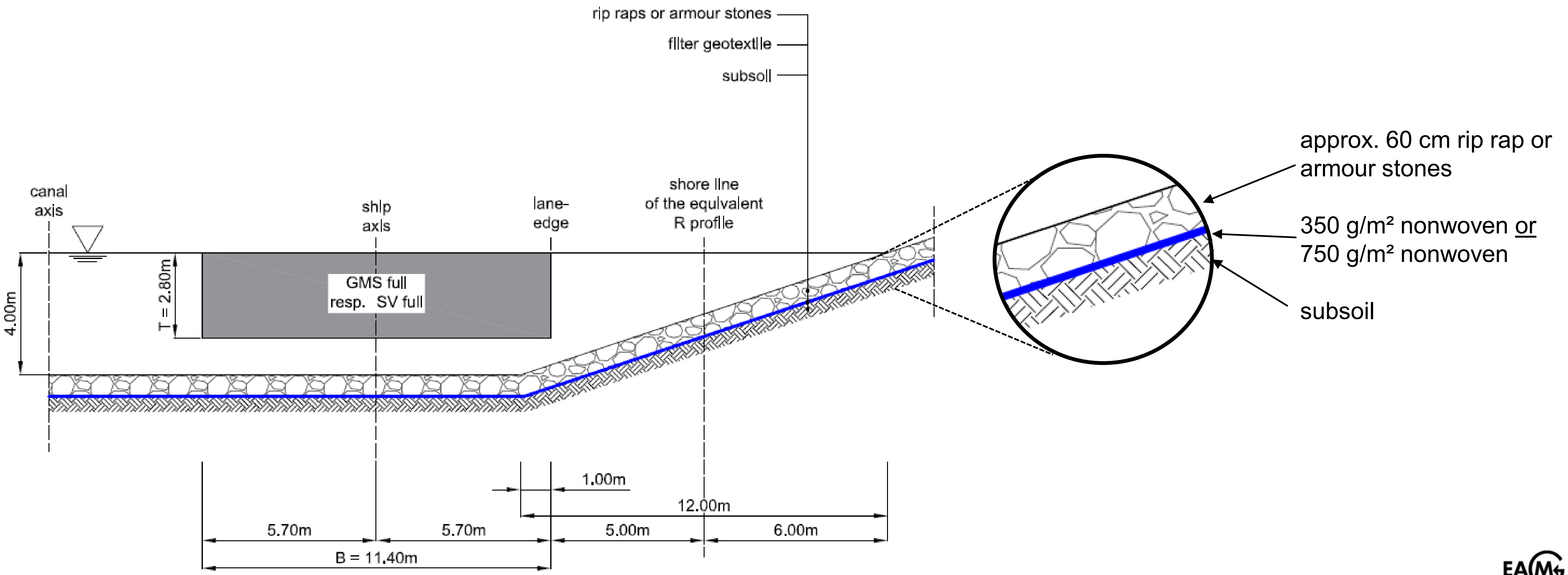
EAGM LCA Case 5,

Construction with Gravel / Sand



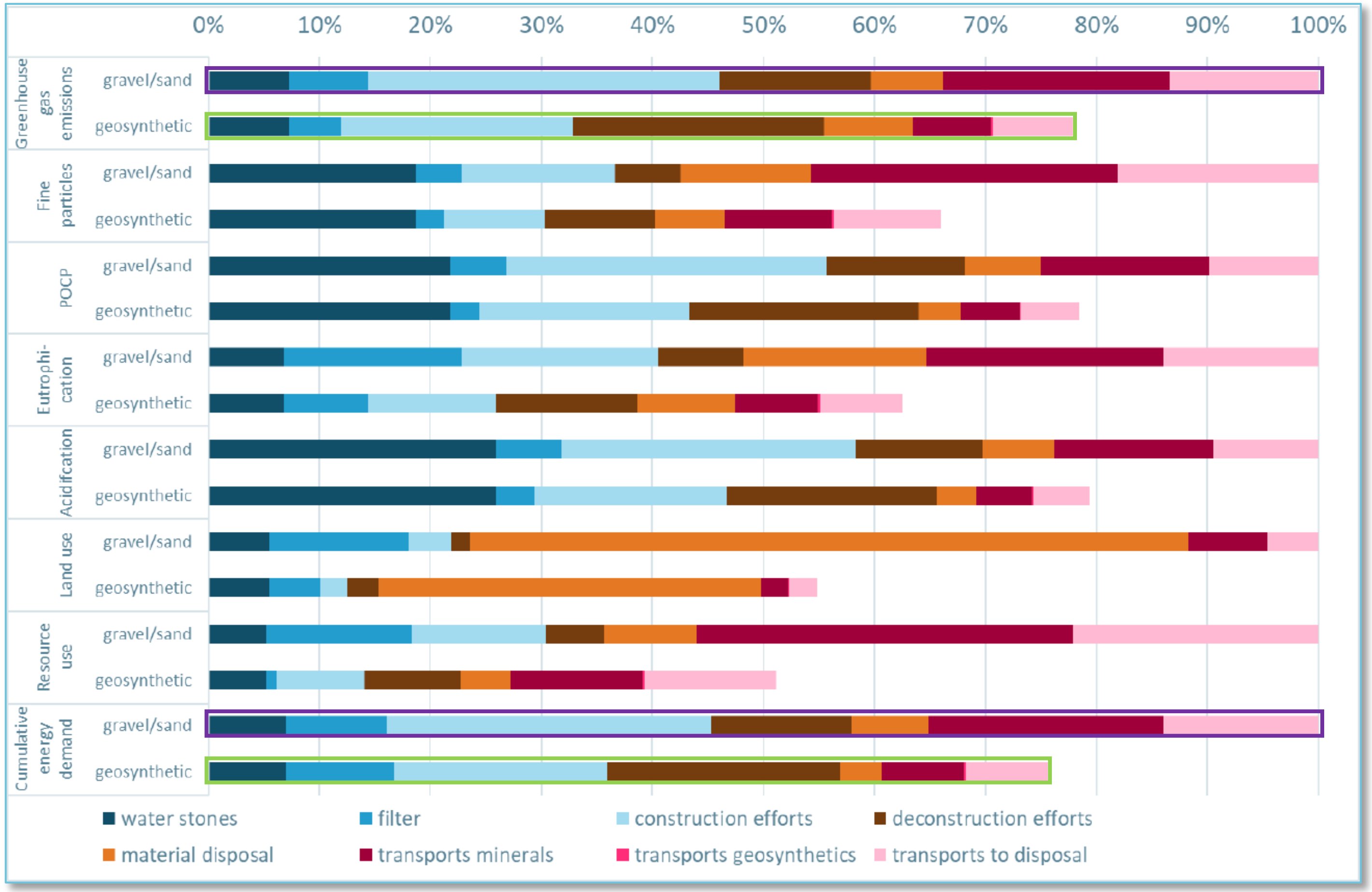
EAGM LCA Case 5,

Construction with Geosynthetic



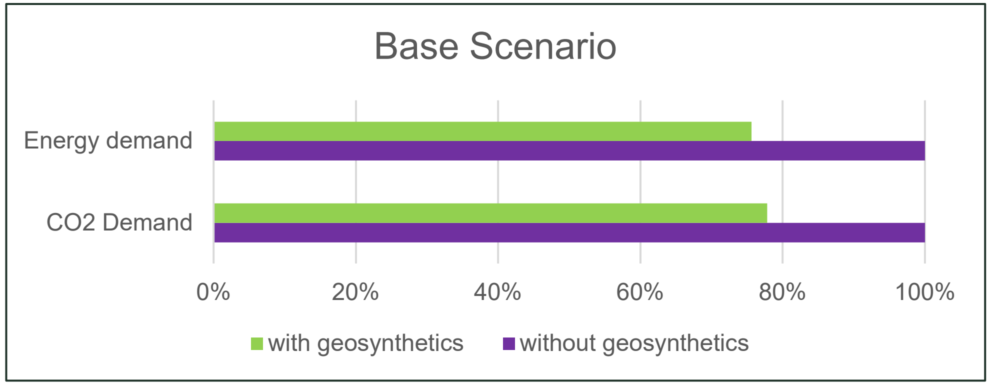
EAGM LCA Case 5,

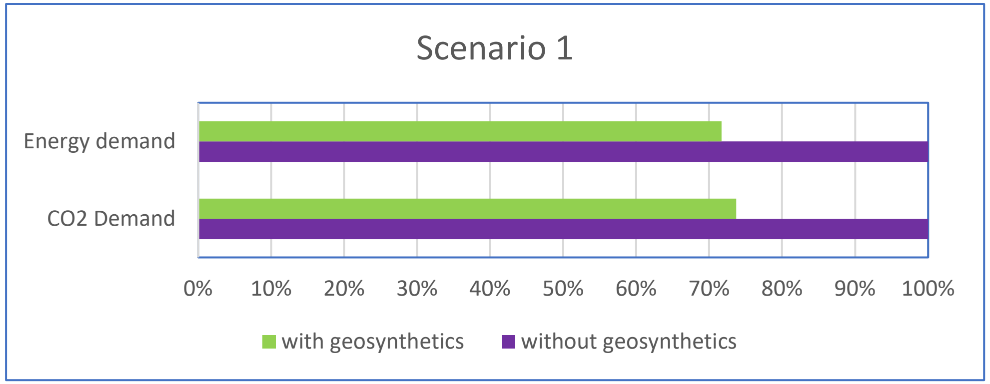
Results Base Scenario; light / short

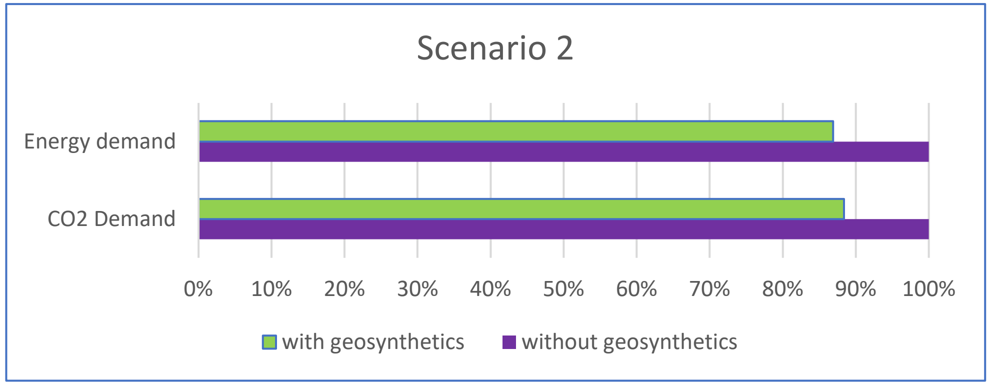


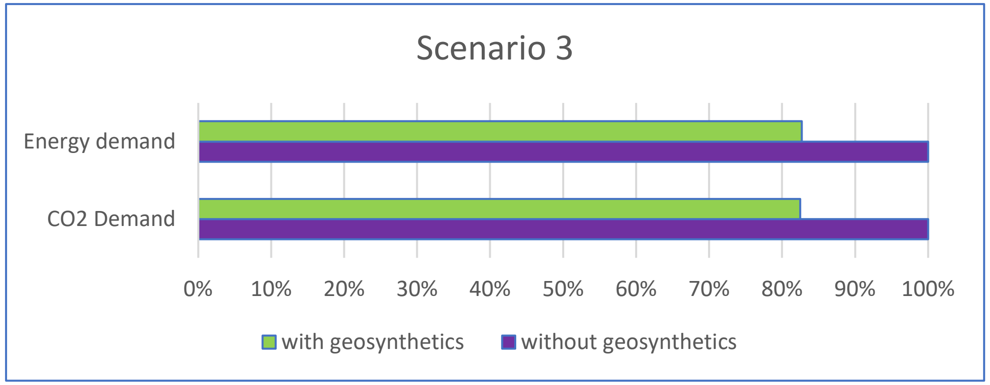
EAGM LCA Case 5,

Results of the 4 Scenarios









THE EAGM STUDIES SHOWS

- **Geosynthetics can significantly contribute to civil engineering constructions with lower climate change impacts in all cases.**

- **The use of geosynthetics may also lead to lower environmental impacts such as acidification, eutrophication, and to lower cumulative energy demands.**

- **The complete Life Cycle of a construction must be assessed and compared. Merely using the environmental cost of manufacturing a construction material one might attain incorrect comparison results.**

- **Detailed results for all four cases can be found in the proceedings of the latest IGS conferences, the whole studies are available on: http://www.eagm.eu/**

The International Geosynthetics Society

creative geosynthetic engineering

Technical Committee on Hydraulics (TC-H) Workshop

Prague, 13 November 2019

Carbon Footprint Reduction generated by the use of geocomposite drains on the A14 Huntingdon to Cambridge Bypass

David Shercliff

Chief Engineer

ABG Geosynthetics Ltd

david@abgltd.com

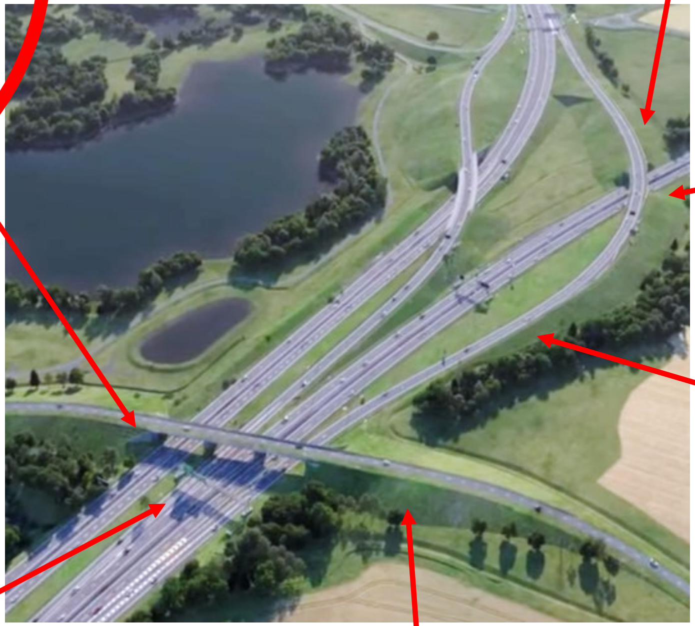
abg creative geosynthetic engineering

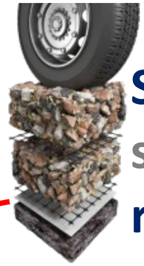
Naue

Highways Geosynthetics using filters

Structural Drainage—replace stone or concrete

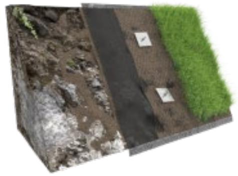
Starter and Consolidation Layers—replace stone blankets





Stabilisation—stone layer reduction

Geocomposite - back of wall drain



Green Erosion Protection and stabilisation—replace stone

Highway Drainage—replace french stone drains

Counterfort Drainage—replace stone herringbones

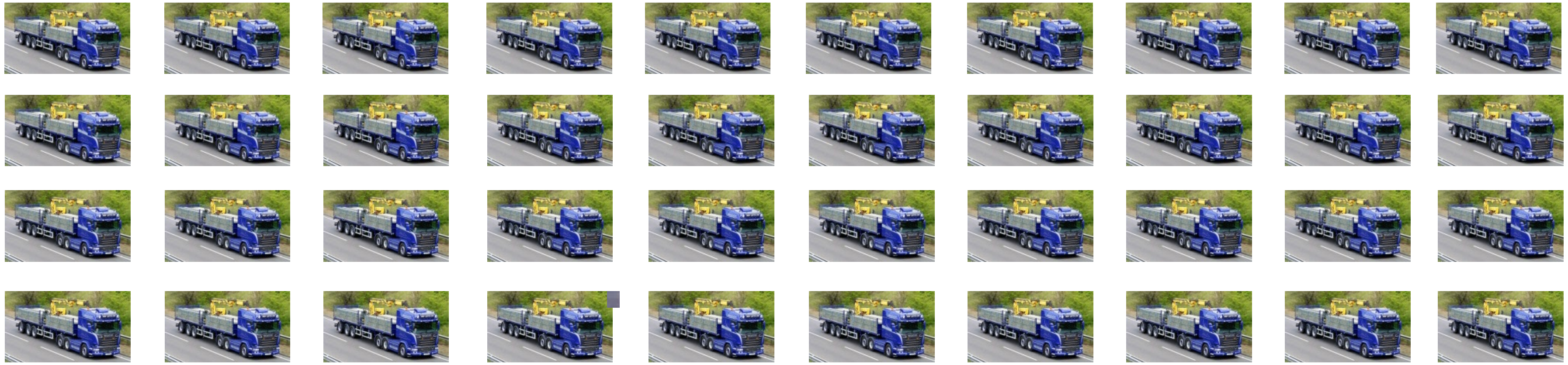
Shercliff, 2019

Transportation to site

60 of these.....

= 1 of these

Blocks



Drainage Geocomposite

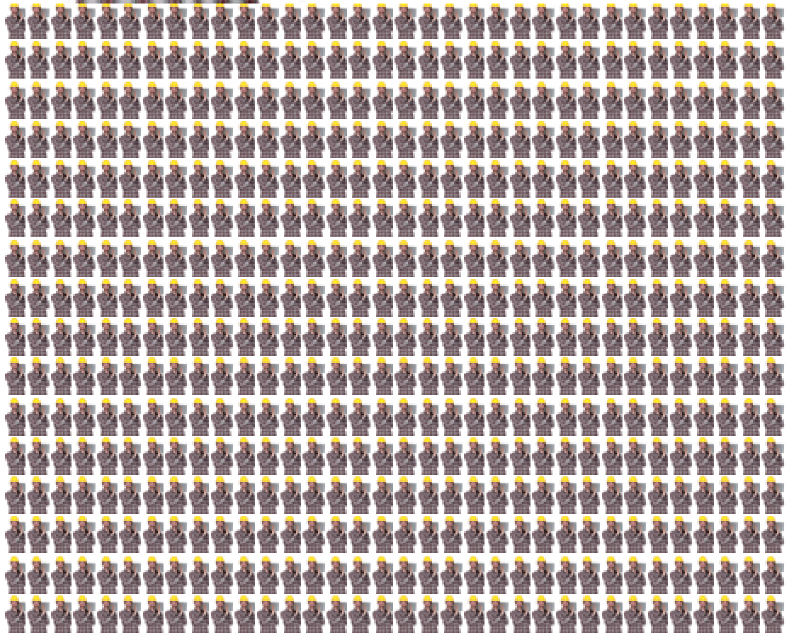
Infill stone

Shercliff, 2019

Installation speed and safe handling

550 of these....

0.44 x 0.23
= $0.1m^2$



= 1 of these

25m x 2.2m
= $55m^2$

Shercliff, 2019

Naue

Output – comparison for one roll of geocomposite - per 55m2

Output			
Construction Stage	**Geocomposite Drain**	**Hollow concrete blocks and gravel**	**No-fines concrete**
Part A - Removal of waste material	-	-	-
Part B - ECO_2e of imported materials	148 kg	1,220 kg	2,475 kg
Part C - CO_2e from transporting imported materials to site	2 kg	49 kg	524 kg
Part D - CO_2e emissions during Construction	-	520 kg	1,311 kg
Total CO_2e	**150 kg**	**1,789 kg**	**4,310 kg**

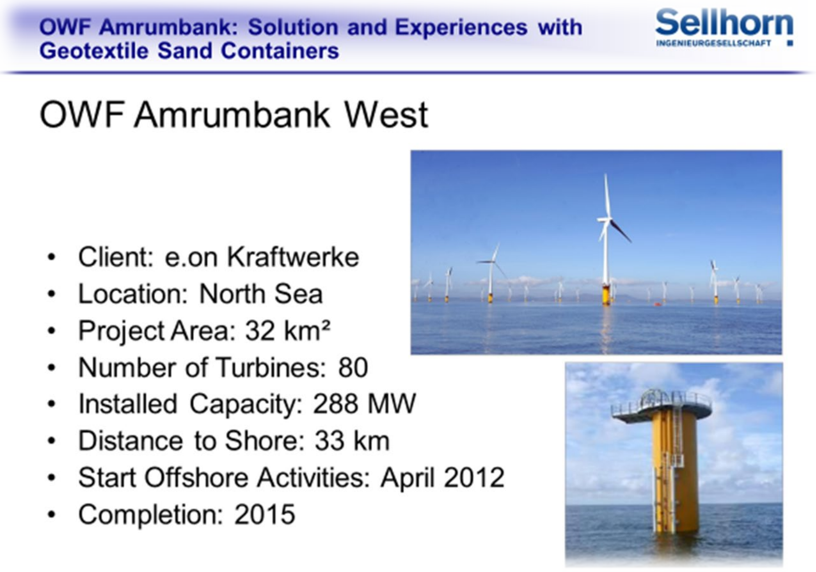
91% CO2e reduction Geocomposite vs. hollow concrete blocks

Shercliff, 2019

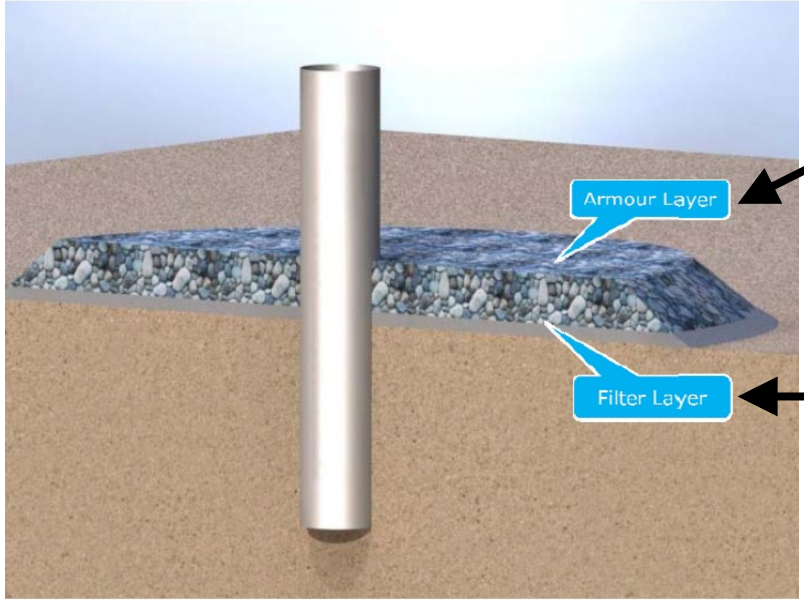
Scour protection for offshore wind park

2 solutions

- **GSC**
  - **Amrumbank West, GER**
- **Conventional (rock)**
  - **Amrumbank West, GER**
  - **Rampion, UK**
  - **Riffgat, GER**



Common scour protection on mineral basis

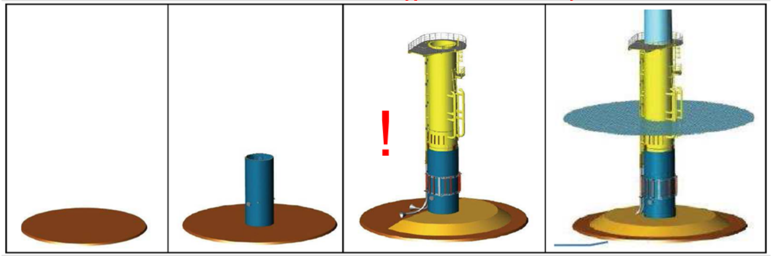


Two essential elements:

Armour layer: confining stress and protection against erosion of granular filter layer

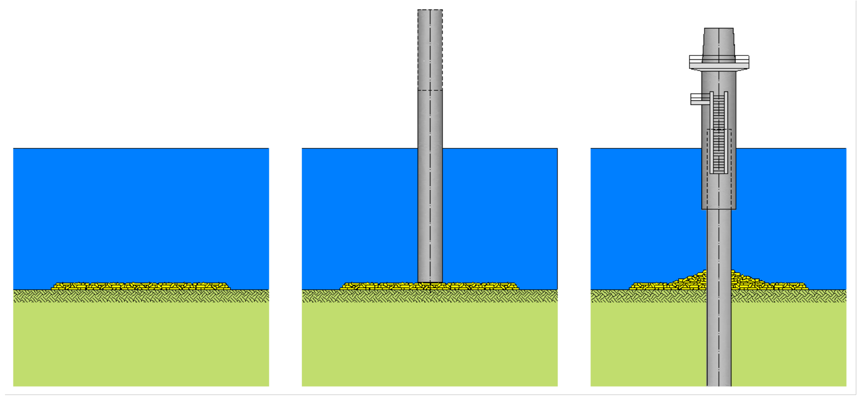
Filter layer: smaller grained material for bottom stabilisation (avoiding sediment movement)

Risk of erosion during installation phase!



Construction phase	Final stage

Scour protection using Geotextile Sand Container (GSC)

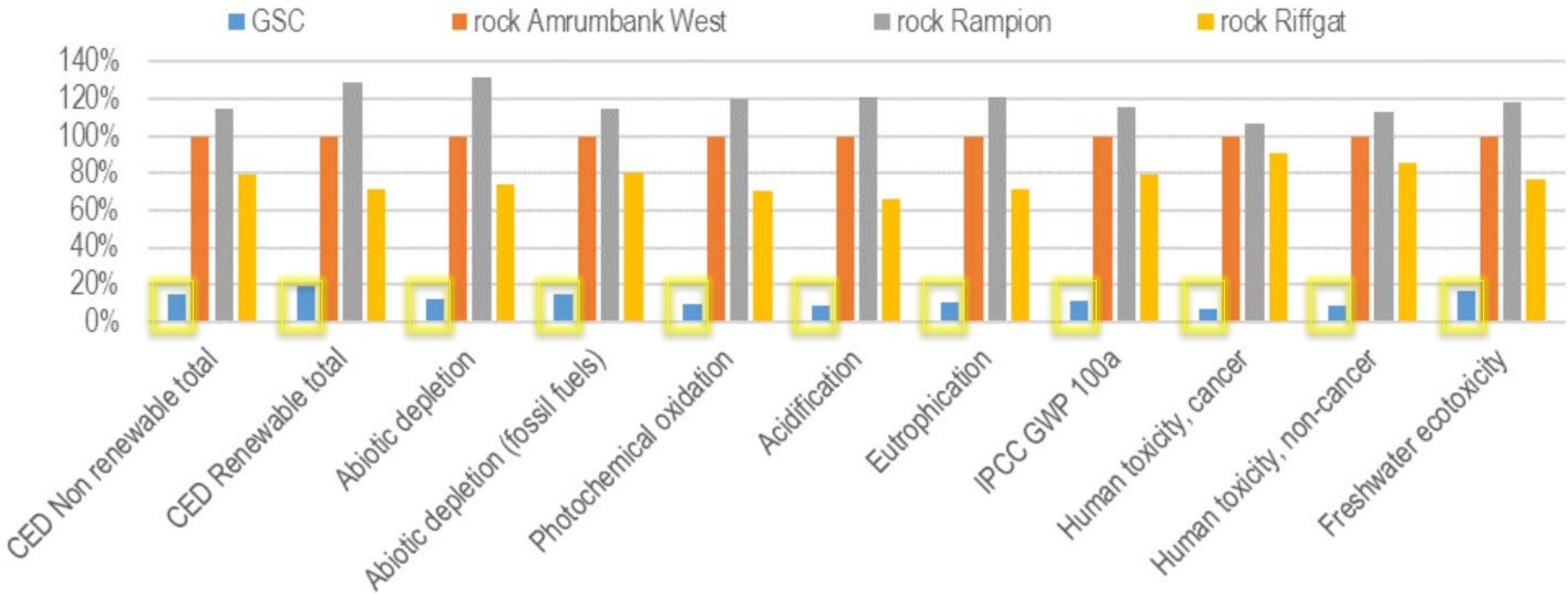


Step 1:
2 layers GSC as effective scour protection

Step 2:
Mono-Pile driving

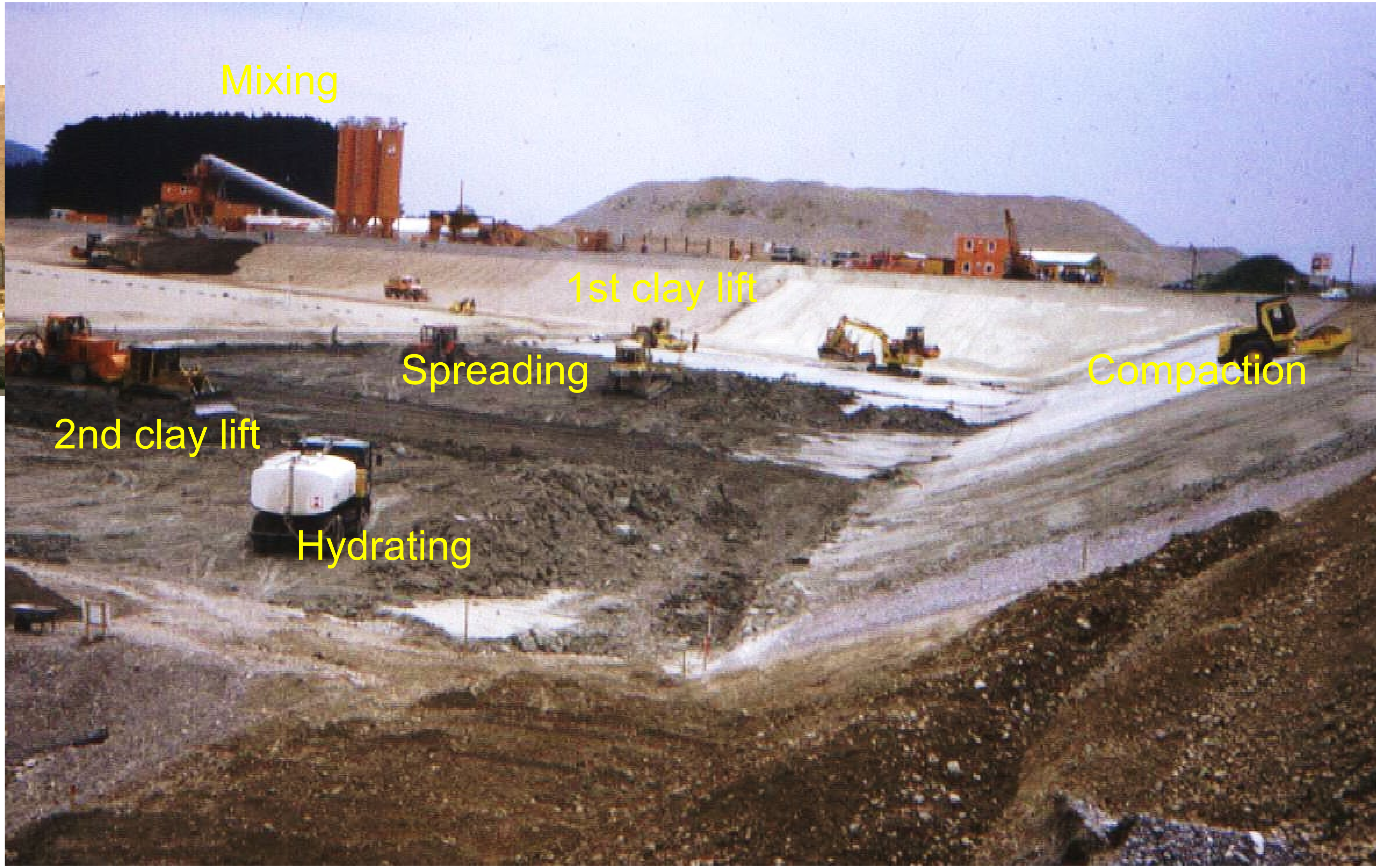
Step 3:
Adding singular GSC elements as "collar"

LCA scour protection



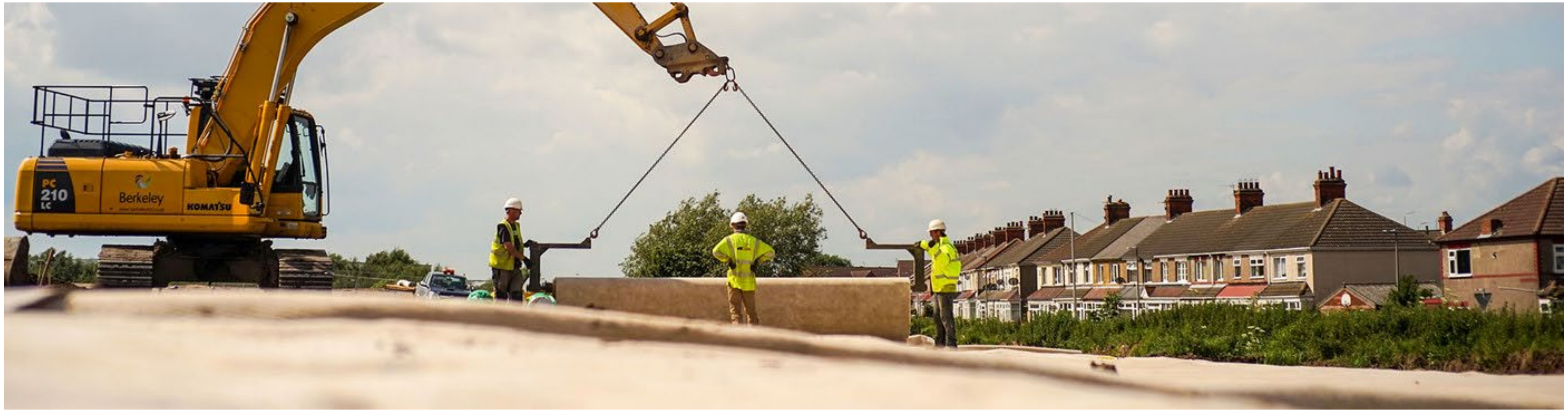
LCA CCL vs. GCL

CCL (Compacted Clay Liner)

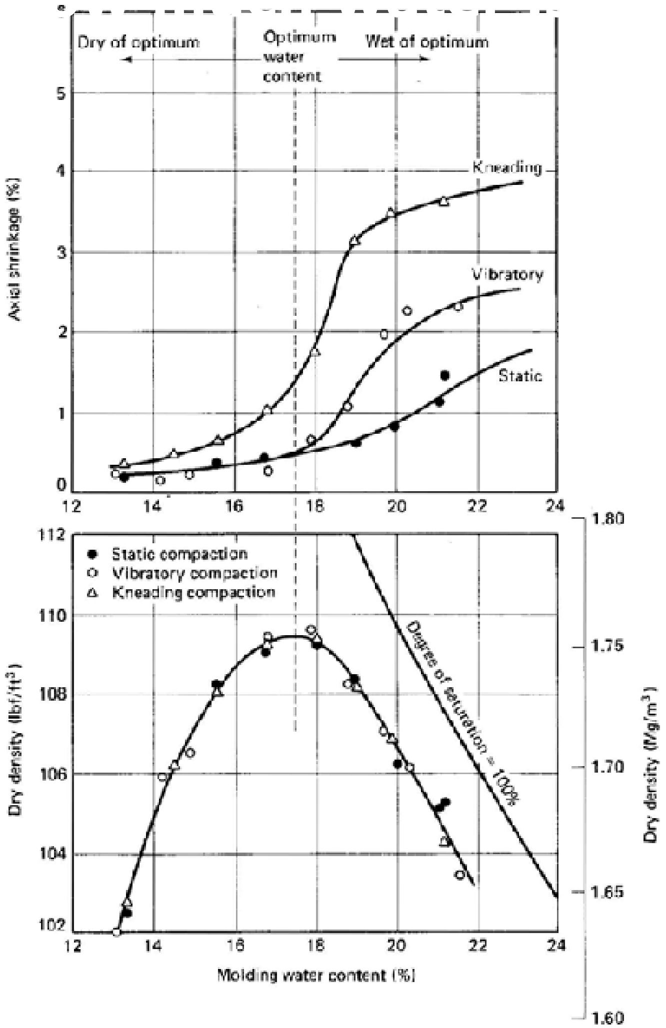


LCA CCL vs. GCL

GCL (Geosynthetic Clay Liner)



LCA CCL vs. GCL



Delivered vs. Required moisture content

Area: 40,000m² - Clay thickness: 0.5m
Need to add approx. 2,340m³ of water

LCA CCL vs. GCL

Reduces transport costs and reduces the CO_2 emissions

Example:

- **4500m² sealing with GCL**

Equals:

- **1 truck**

LCA CCL vs. GCL

Reduces transport costs and reduces the CO2 emissions

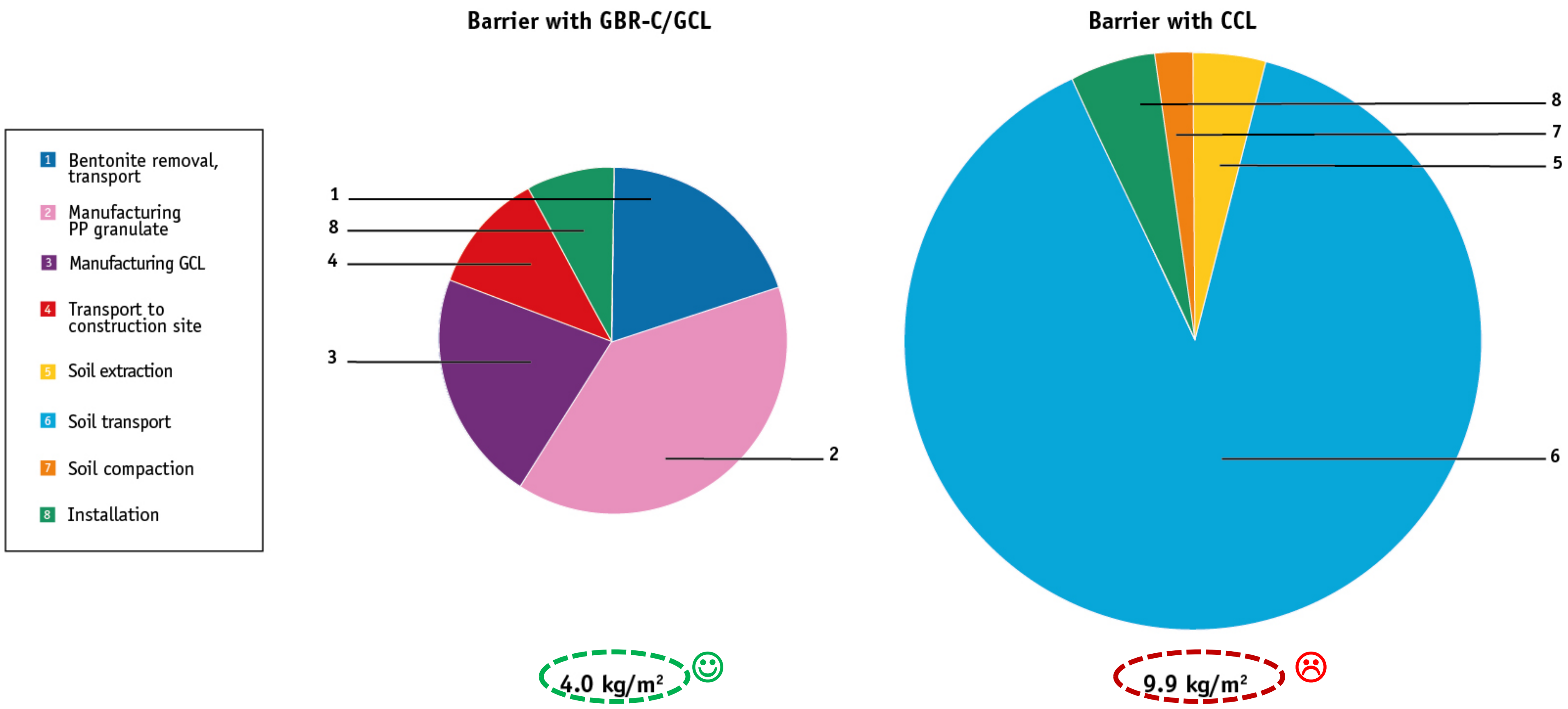
Example:

- **4500m² sealing with compacted clay 500mm thick**

Equals:

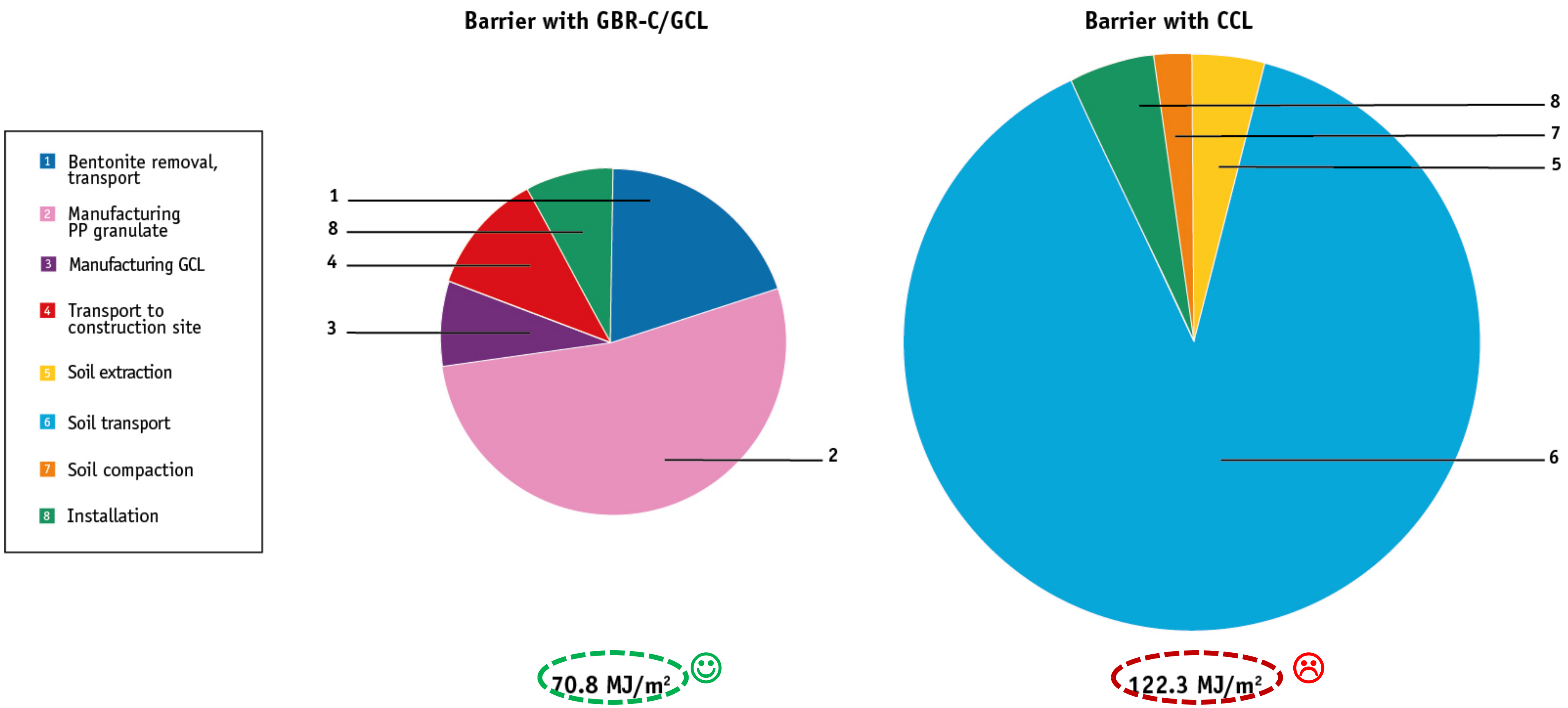
- **187 trucks (each 24 tons)**

LCA CCL vs. GCL



The installation of a GCL results in 59% less CO_2 emissions than a CCL!

LCA CCL vs. GCL



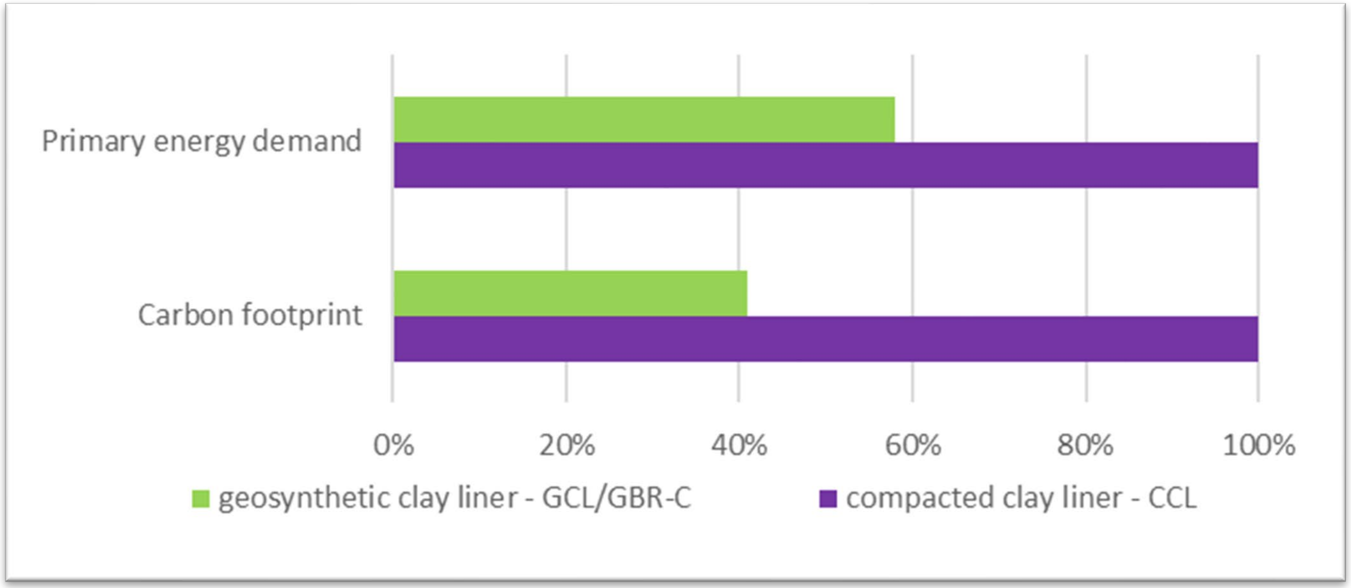
The installation of a GCL results in 42% less energy demand than a CCL!

LCA CCL vs. GCL

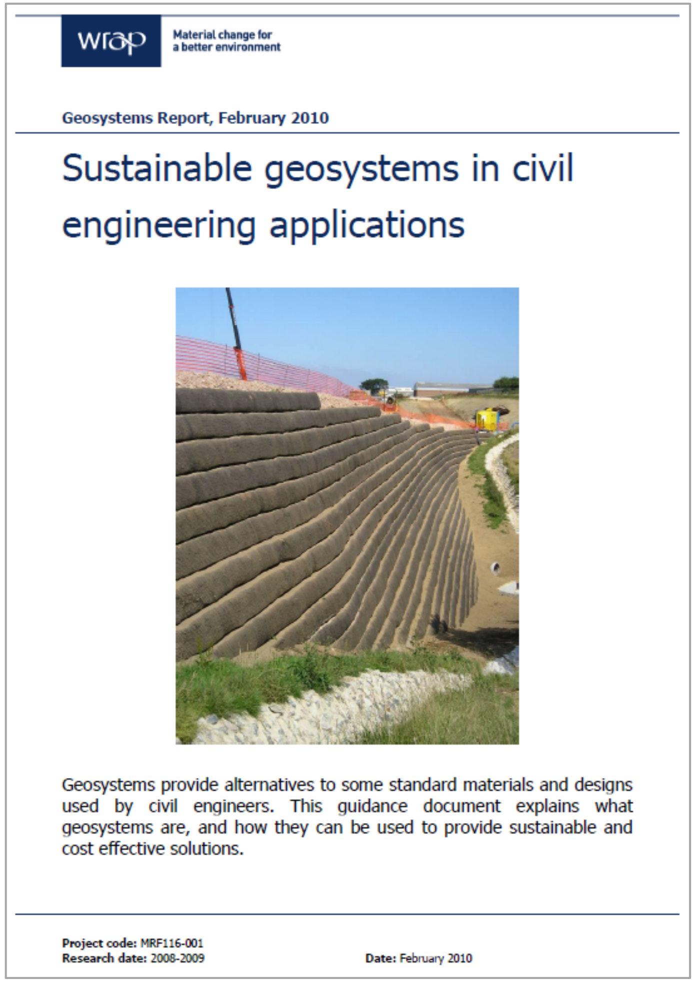
Naue

Conclusion

- **with a GCL/GBR-C in comparison to CCL a major amount of natural resources like water and clay will be secured / saved**
- **more waste can be disposed with a GCL/GBR-C with same cubature of a landfill compared with a landfill build with CCL**
- **a huge amount of CO_2 and energy demand will be saved with a GCL/GBR-C**



Some more examples, WRAP, UK, 2010

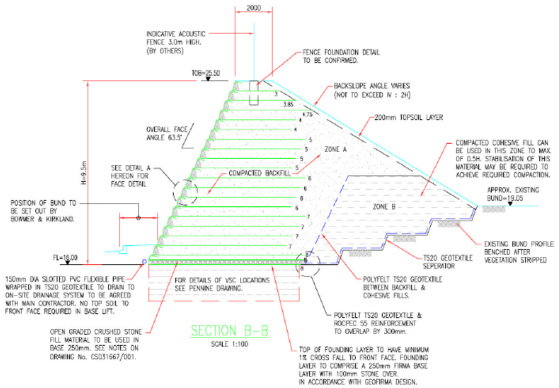

wrap Material change for a better environment

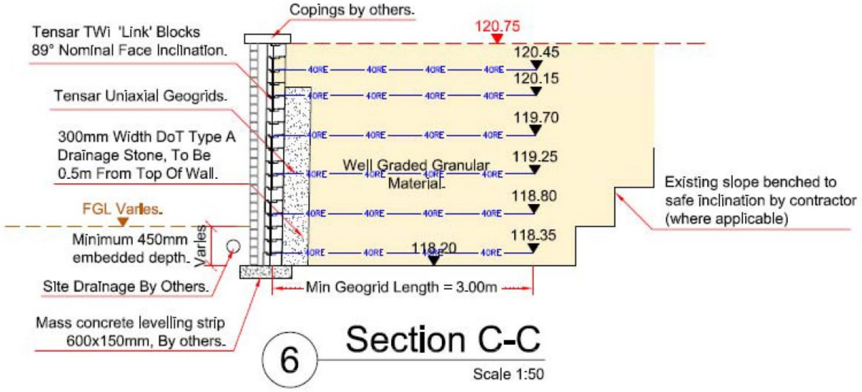
Geosystems Report, February 2010

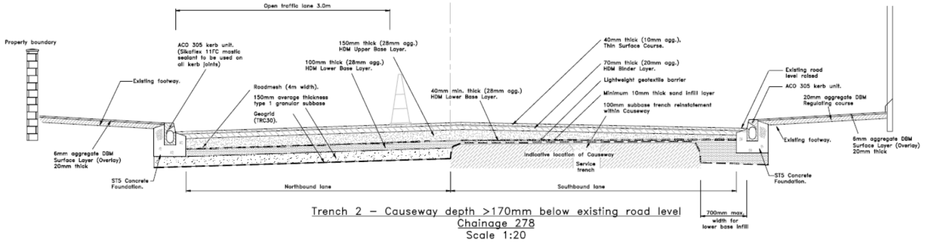
Sustainable geosystems in civil engineering applications

Geosystems provide alternatives to some standard materials and designs used by civil engineers. This guidance document explains what geosystems are, and how they can be used to provide sustainable and cost effective solutions.

Project code: MRF116-001
Research date: 2008-2009
Date: February 2010

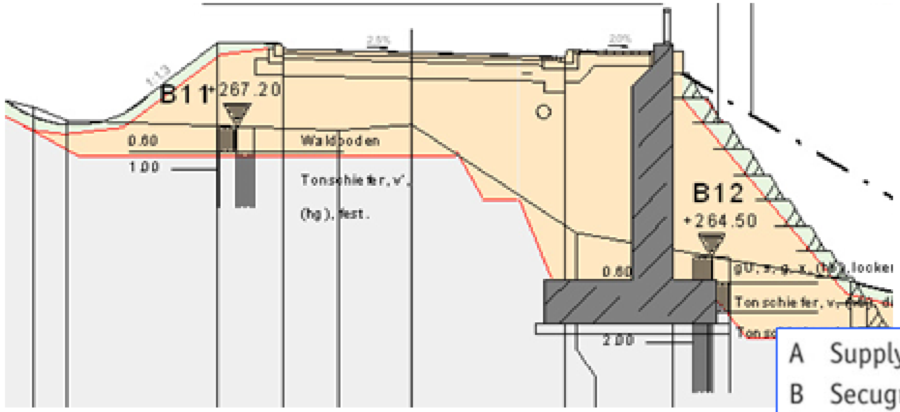






Some more examples, LCA Idstein

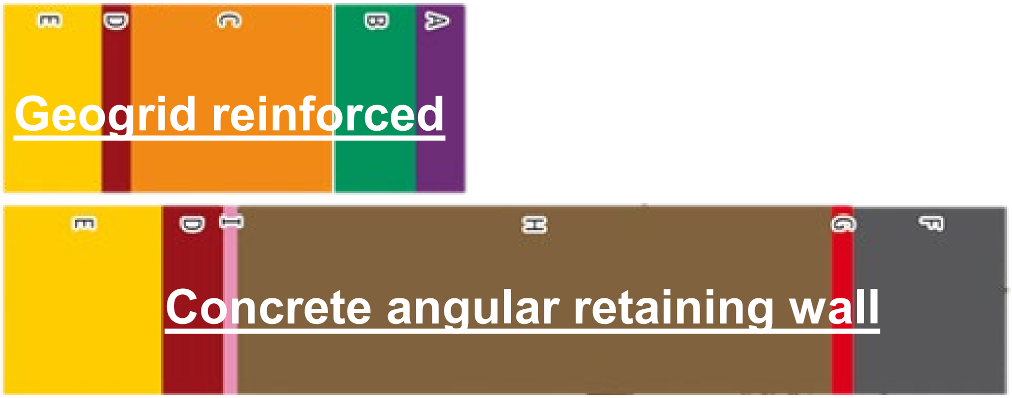
- **similar case to case 4 of EAGM, but different transportation distances**
- **tender with concrete, built with reinforcing geosynthetic**
- **also with cost comparison**



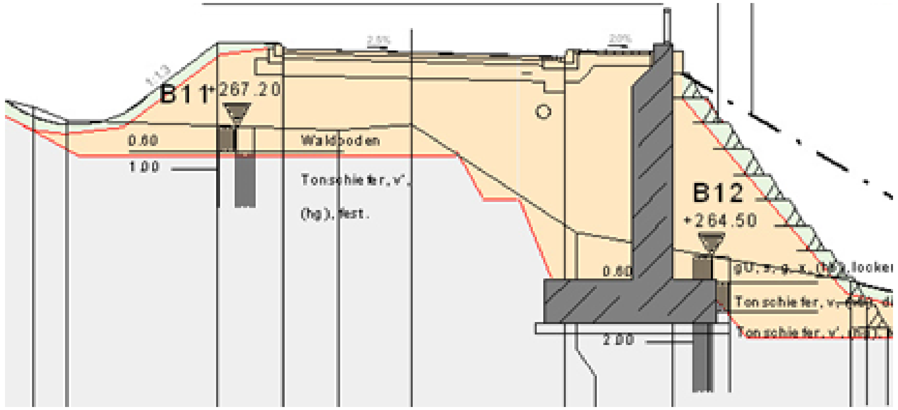
A Supply and placement of cover soil
B Secugrid® geogrid
C Steel facing
D Construction site equipment
E Supply of fill material, placed and compacted in layers
F Foundation
G Insulation and drainage
H Concrete cast in-situ
I Joint filling

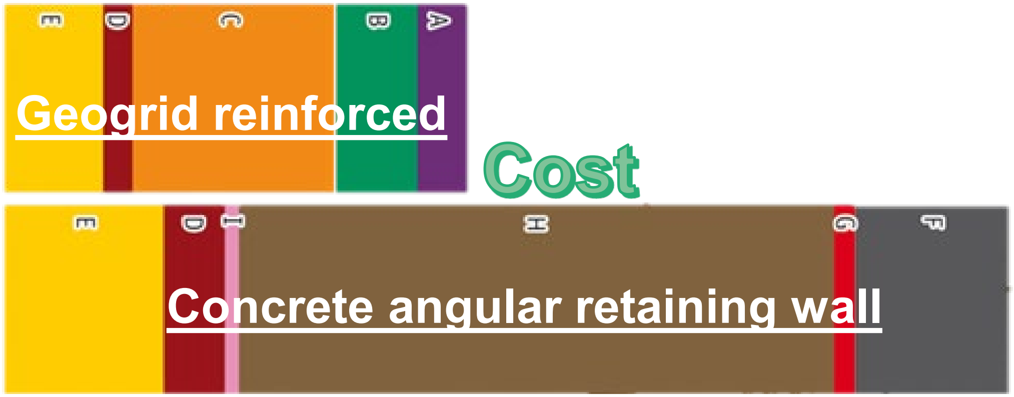
Cost comparison of a Geogrid- reinforced wall versus a concrete angular retaining wall (Idstein/Germany):

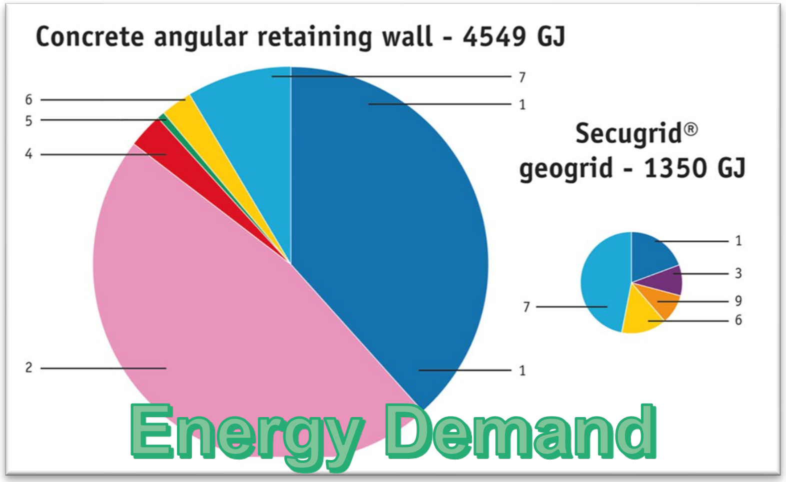
266,724€ (more than 50%) savings in comparison to approx. 500,000€ total costs with concrete

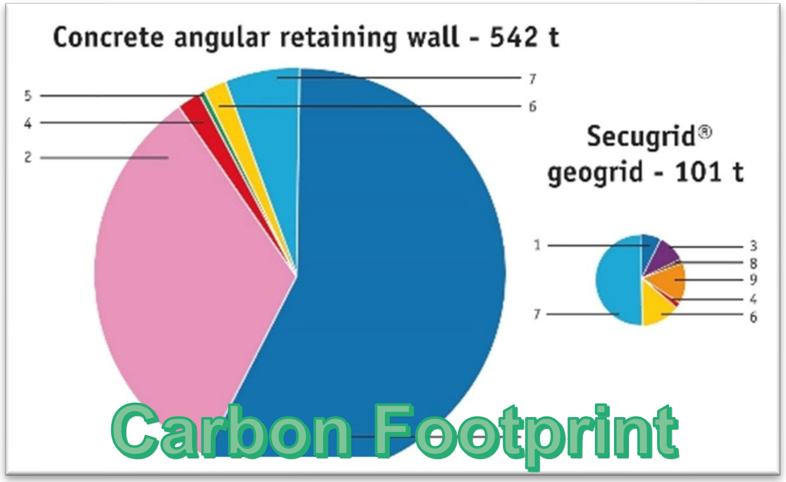


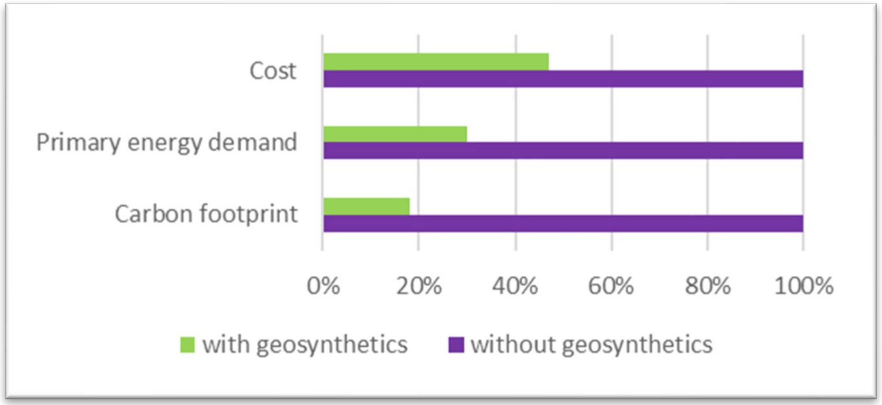
Some more examples, LCA Idstein





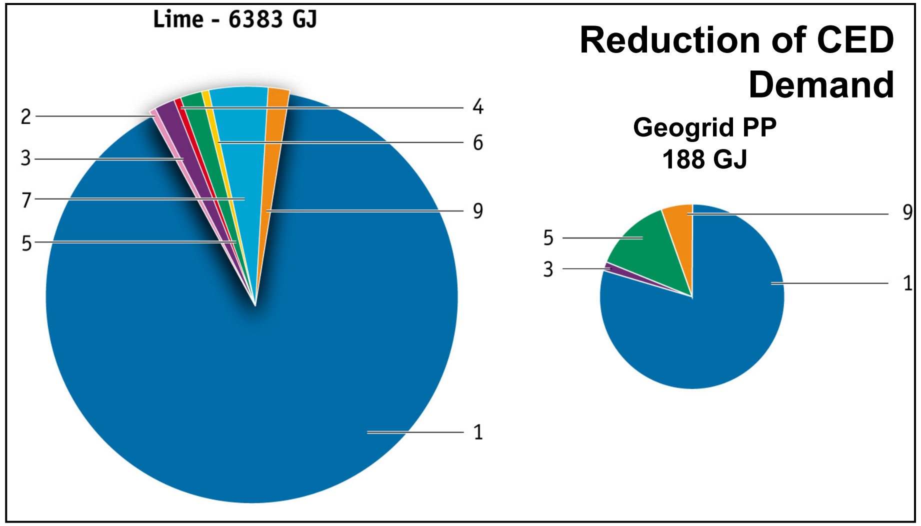


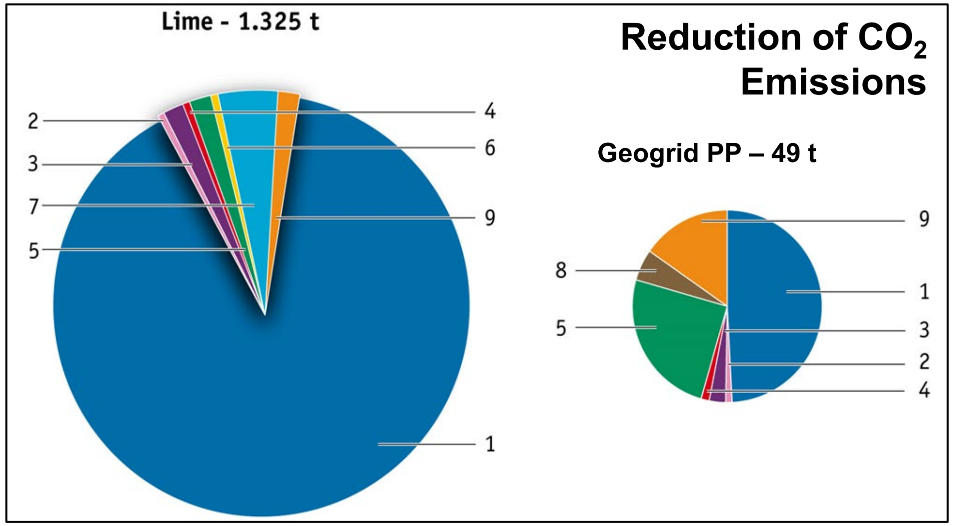




CO_2 Emission and / cumulated Energy Demand (CED) with an example from IVG, stabilised road

1 Production
2 Setting
3 Shipment to the job-site
4 Removal
5 Soil placement and compaction
6 Binder distribution (Distribution machine)
7 Milling binder (Rotorator)
8 Laying geogrids
9 Soil compaction






eco
LINE
HUESKER
Ideen. Ingenieure. Innovationen.
100%
RECYCLED
PET
HUESKER 2021

Reinforcement from recycled PET

Why?

„In 2017, the European Commission confirmed it would focus on plastic production and use and work towards the goal of ensuring that all plastic is recyclable by 2030“

HUESKER 2021

CO_2 comparison - recycled yarn vs. virgin yarn

Each kilogram of PET recycling yarn saves approx. 4.3 kg CO_2 emissions compared to virgin yarn. This corresponds to a car journey of 33 km.

* Car with emissions of 130 g equiv. CO_2/km | Life Cycle Assessment Analysis von RDC Environment

HUESKER 2021

CO_2 comparison - recycled yarn vs. virgin yarn

Extrapolated to the production of geotextiles the size of a football pitch (7,140 m^2), about 5,500 kg of CO_2 are saved, which corresponds to a distance of approx. 42,400 km by car.

* Car with emissions of 130 g equiv. CO_2/km | Life Cycle Assessment Analysis von RDC Environment | Calculated with HaTelit C 40/17 and approx. 180 g/m² PET yarn

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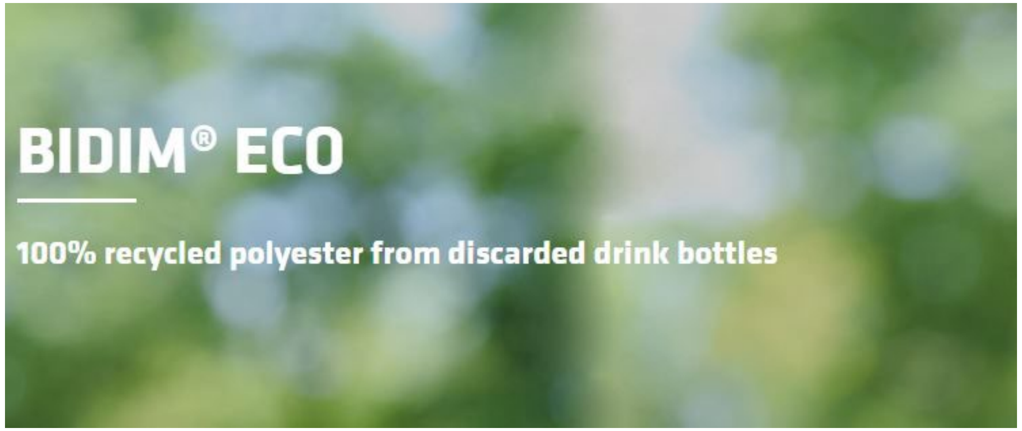
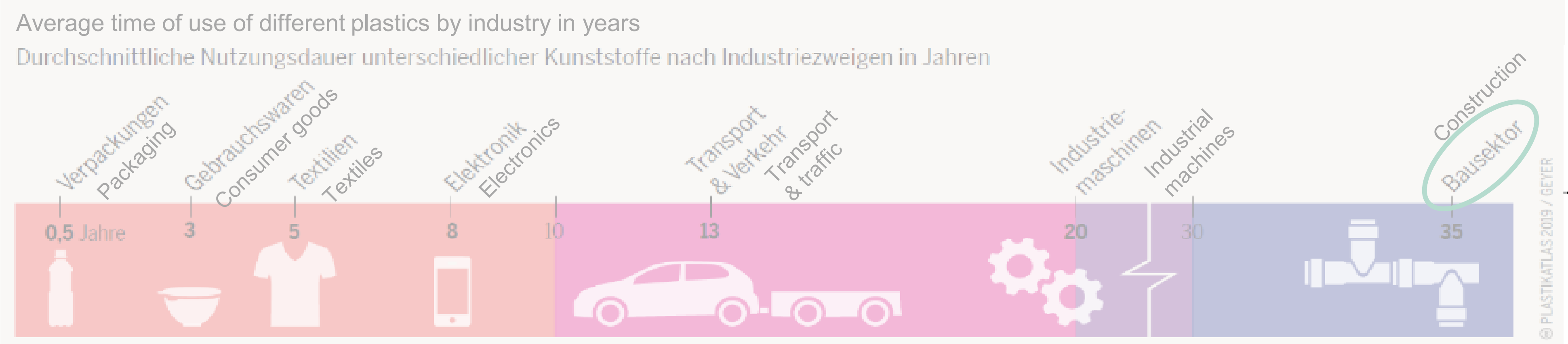
Some more examples Nonwoven from recycled PET

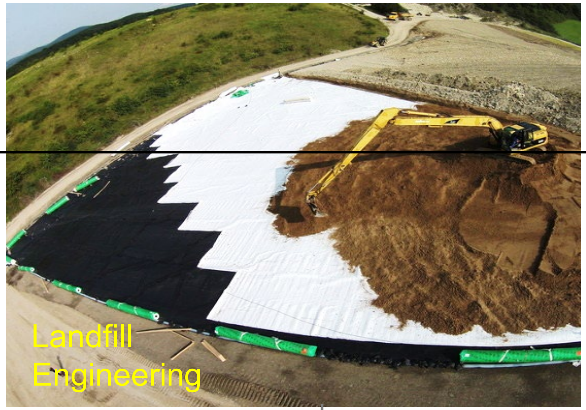


Geofabrics 2021

service life in construction industry



service life in geotechnical constructions

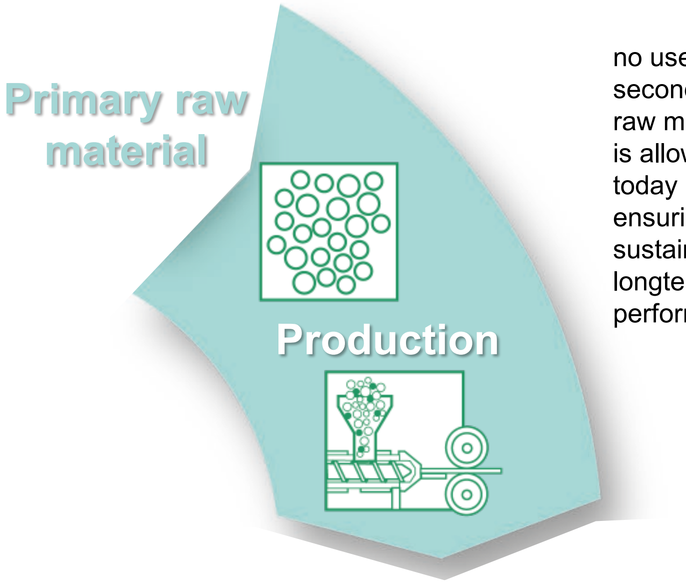


100

Some more examples

Circular Economy

- **today**

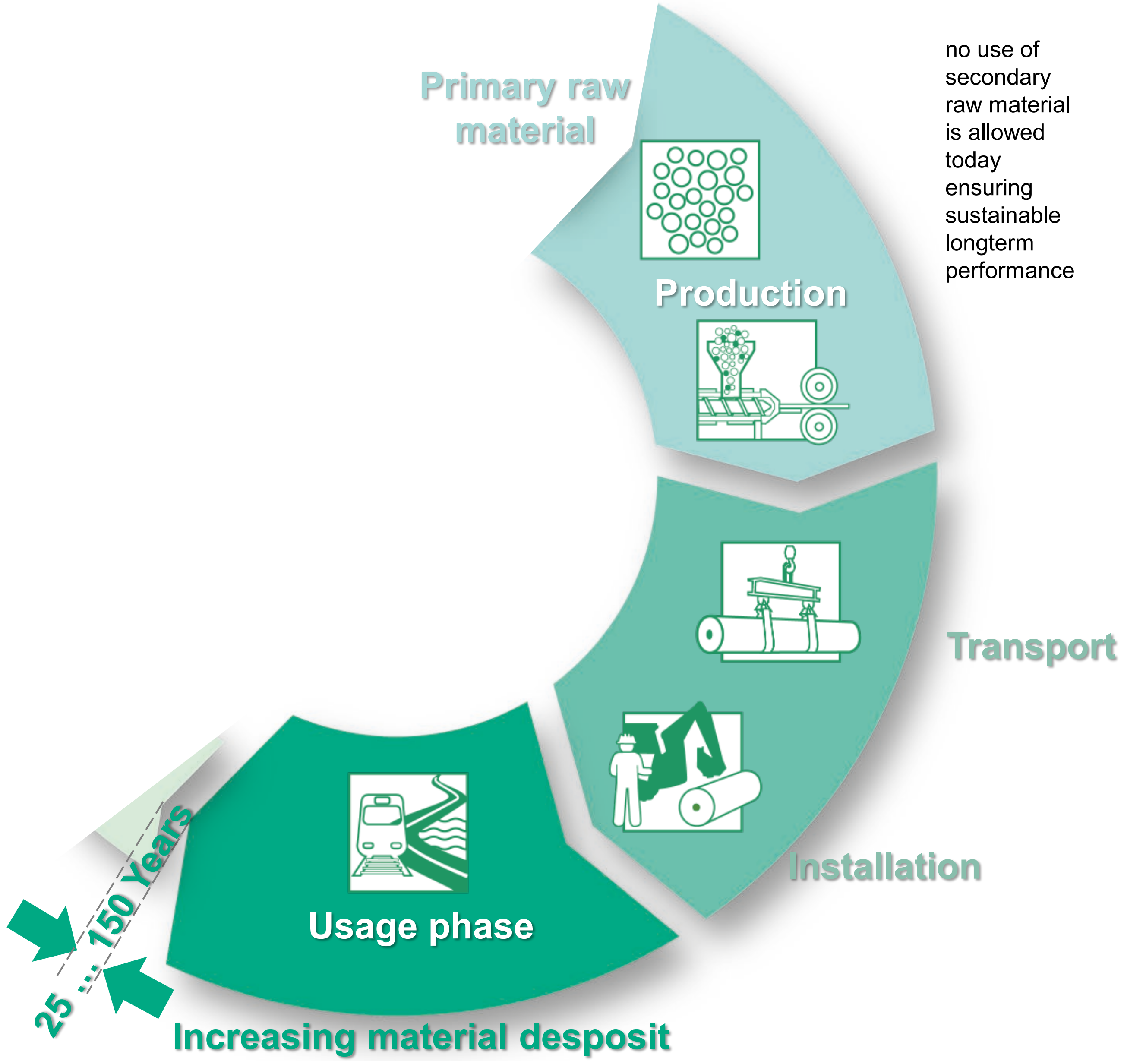


no use of secondary raw material is allowed today ensuring sustainable longterm performance

Some more examples

Circular Economy

- **today**

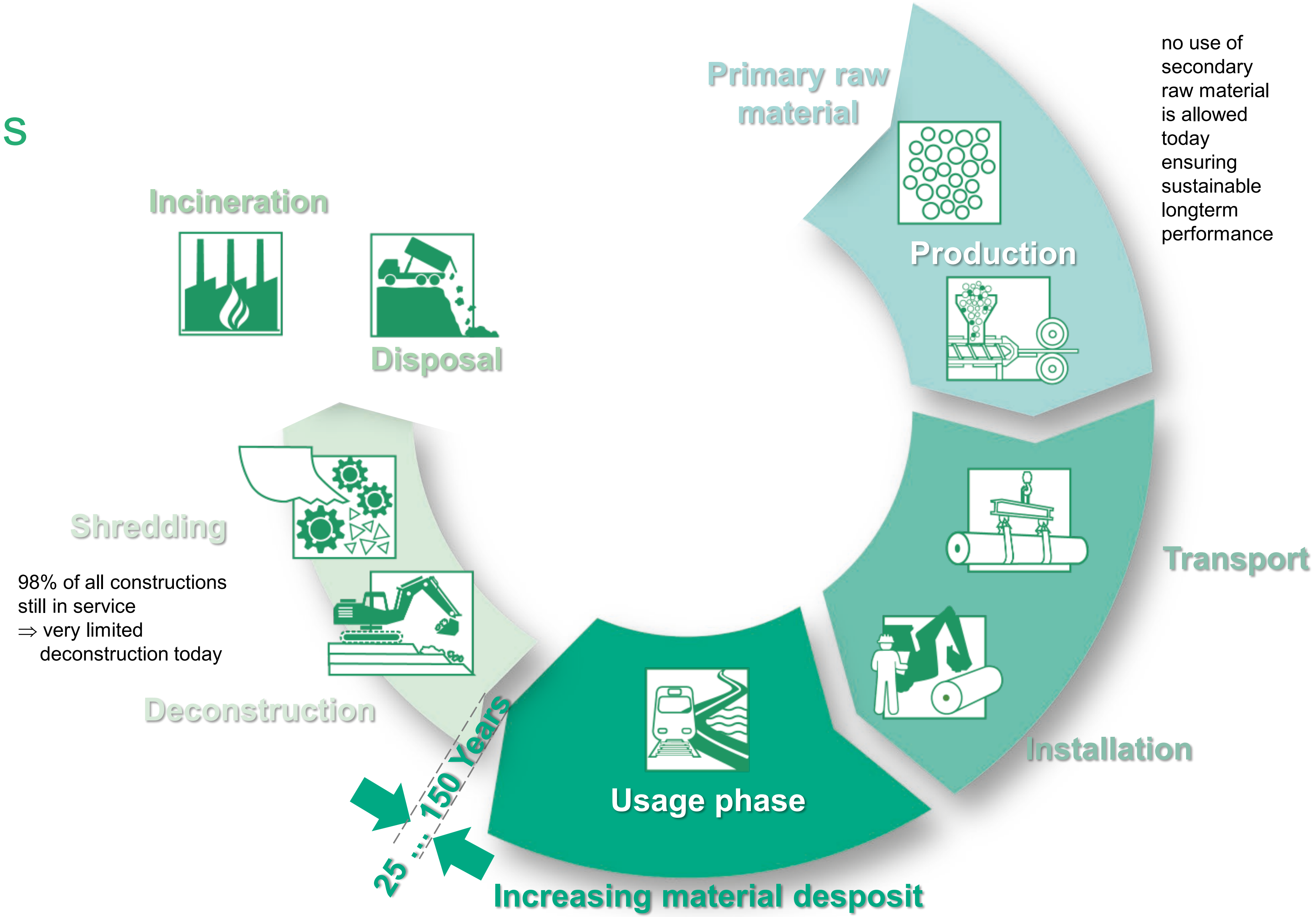


no use of secondary raw material is allowed today ensuring sustainable longterm performance

Some more examples

Circular Economy

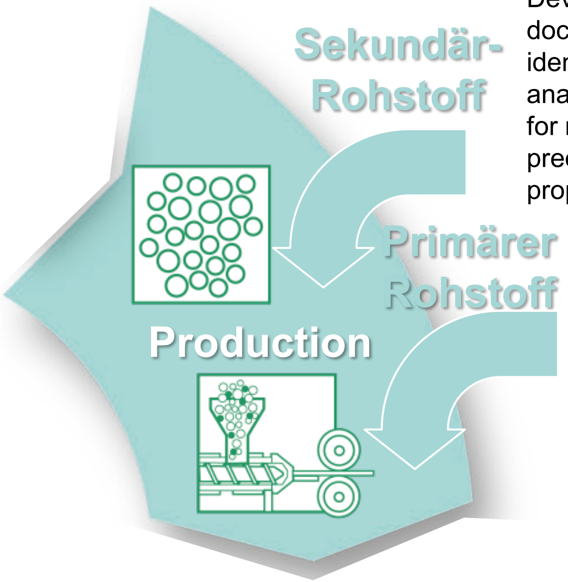
- **today**



Some more examples

Circular Economy

- **tomorrow**



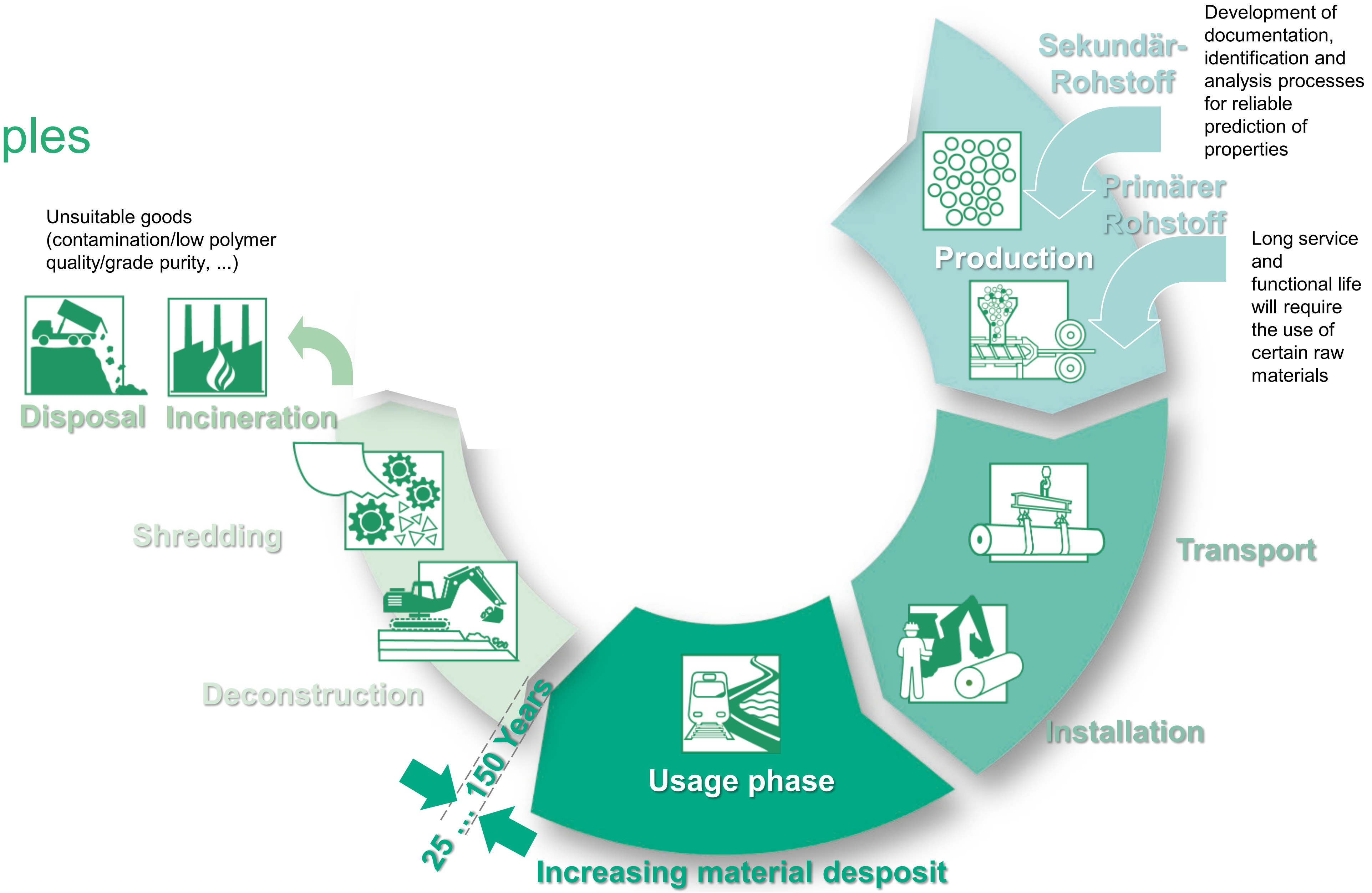
Development of documentation, identification and analysis processes for reliable prediction of properties

Long service and functional life will require the use of certain raw materials

Some more examples

Circular Economy

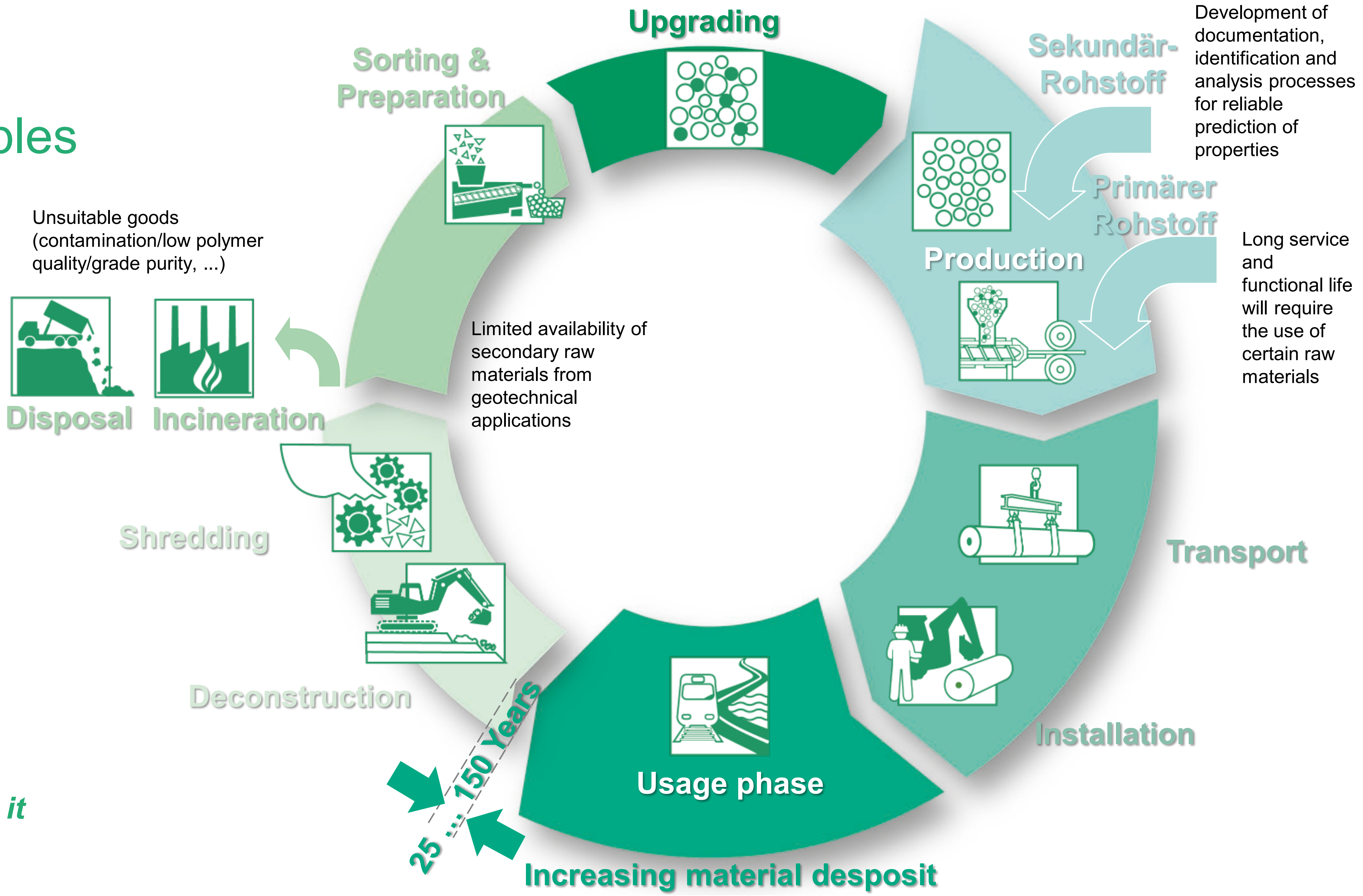
- **tomorrow**



Some more examples

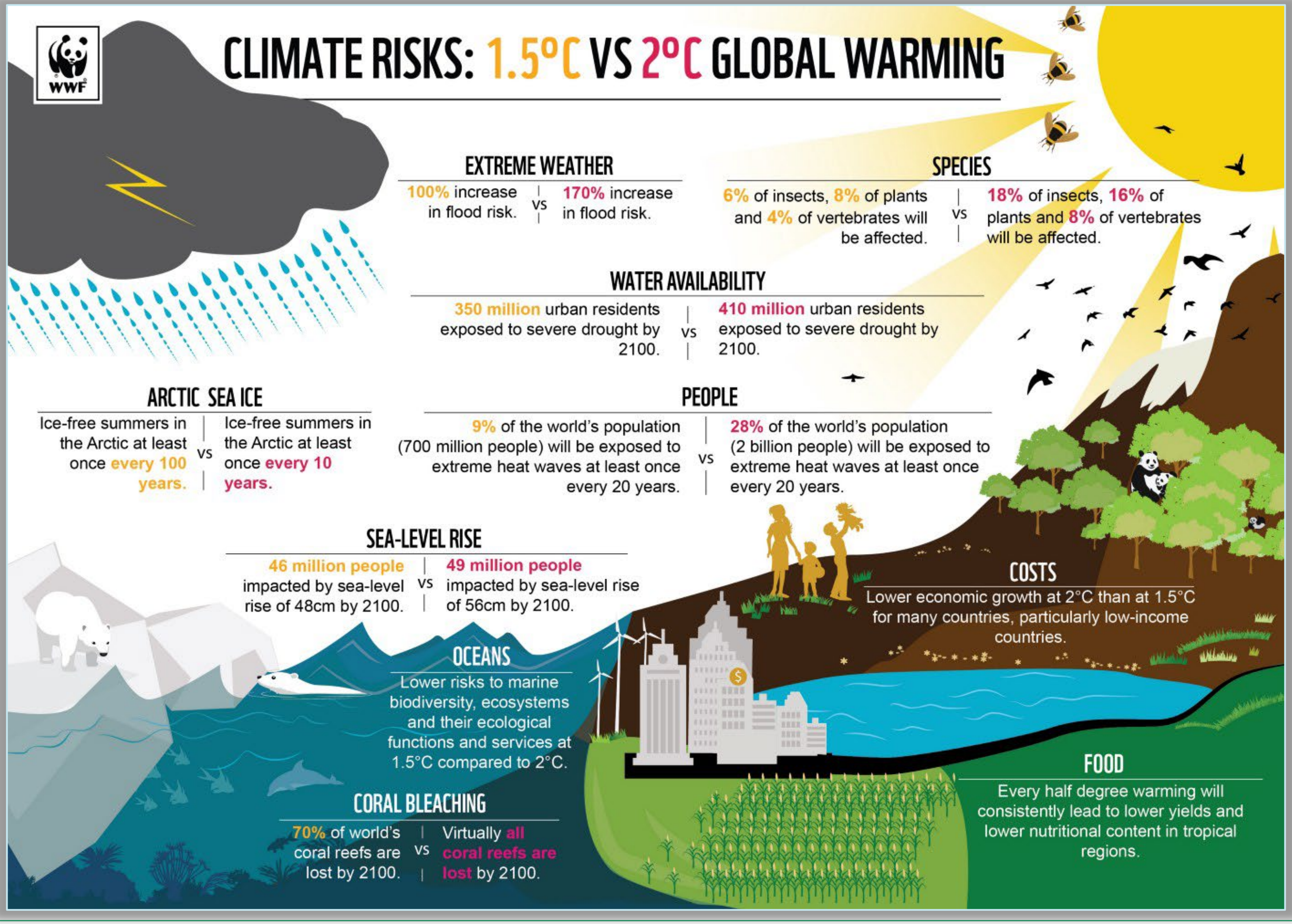
Circular Economy

- **tomorrow**

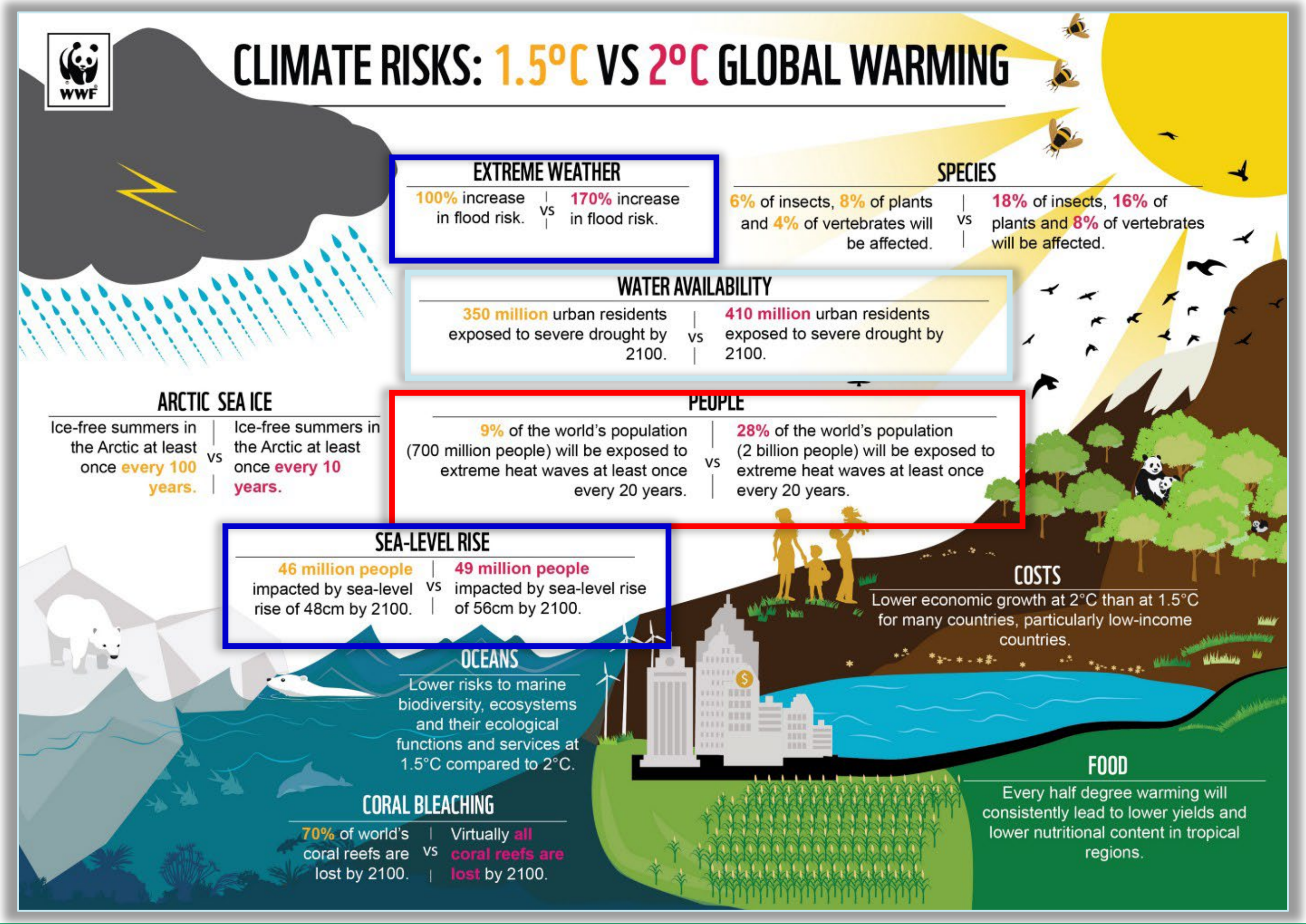


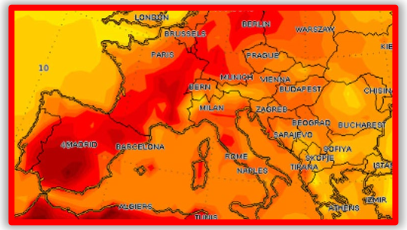
The Industry is working on it

LCA (of a construction) – WHY?



LCA (of a construction) – WHY?
to reduce CO_2 emissions and their impact





Conclusion 1/2

Examples are shown how constructions using geosynthetics are able to support the European Climate Law and some of the United Nations' Sustainable Development Goals:

- **save CO_2 and other emissions**
- **reduce the energy demand (CED)**
- **save natural resources**
- **save fresh water**
- **reduce construction costs**
- **reduce the impacts for residents near constructions**
- **…**

Conclusion 2/2

Geosynthetics combine benefits from economic, ecological and social perspective

Geosynthetics clearly contribute to achieving the goals of the United Nation Sustainable Development Goals (UNSDGs), the European Green Deal, the EU Circular Economy Action Plan, and the Strategy for a Sustainable Built Environment

The main future task is the reduction of CO_2 Emissions – see wwf Climate Risks – and with using Geosynthetics we can significantly reduce the CO_2 Emissions in/from constructions

Thank You.

Building on sustainable ground.