ASiRE^2

Assessment method and Selection instrument to Reduce Energy poverty and Environmental impact

Els Van de moortel

KU Leuven

ASiRE²

- Aim of the project
- Method and applications of LCA
- Further outlook

ASiRE²

- **Aim of the project**
- Method and applications of LCA
- Further outlook

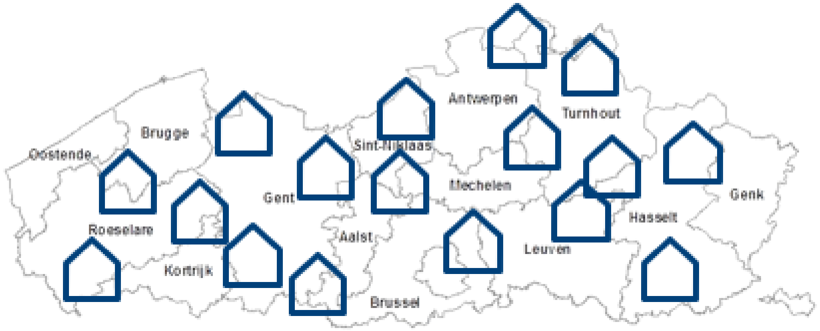
ASiRE² Aim of the project

Reduce

environmental impact

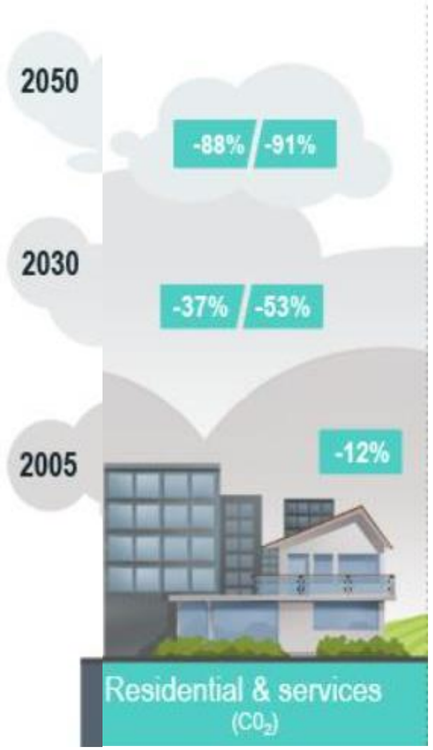
and

energy poverty

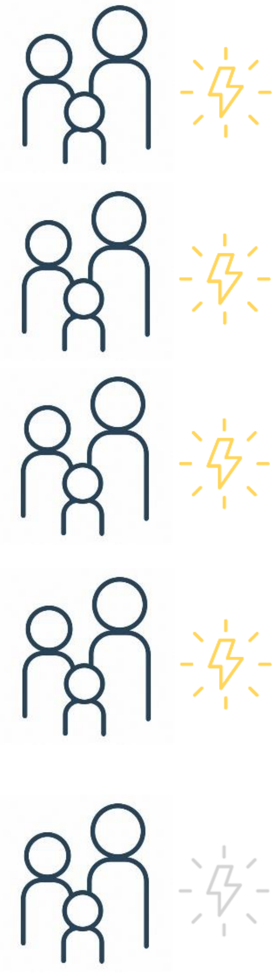


Residential building stock

Feasible and affordable



Source: European Parliament Low-carbon strategy for 2050

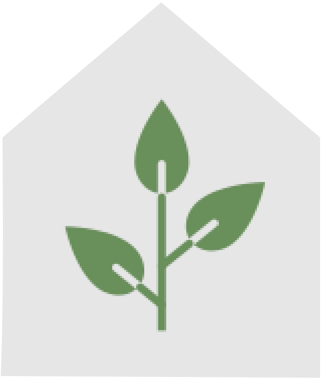


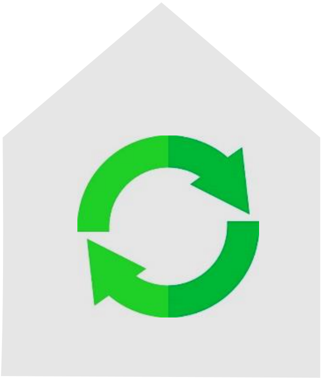
Source: Energiearmoede Vlaanderen

ASiRE^2 Aim of the project

→ Integrate recent economic developments:

biobased, circular, collective and cooperative economy





→ Test case social housing stock

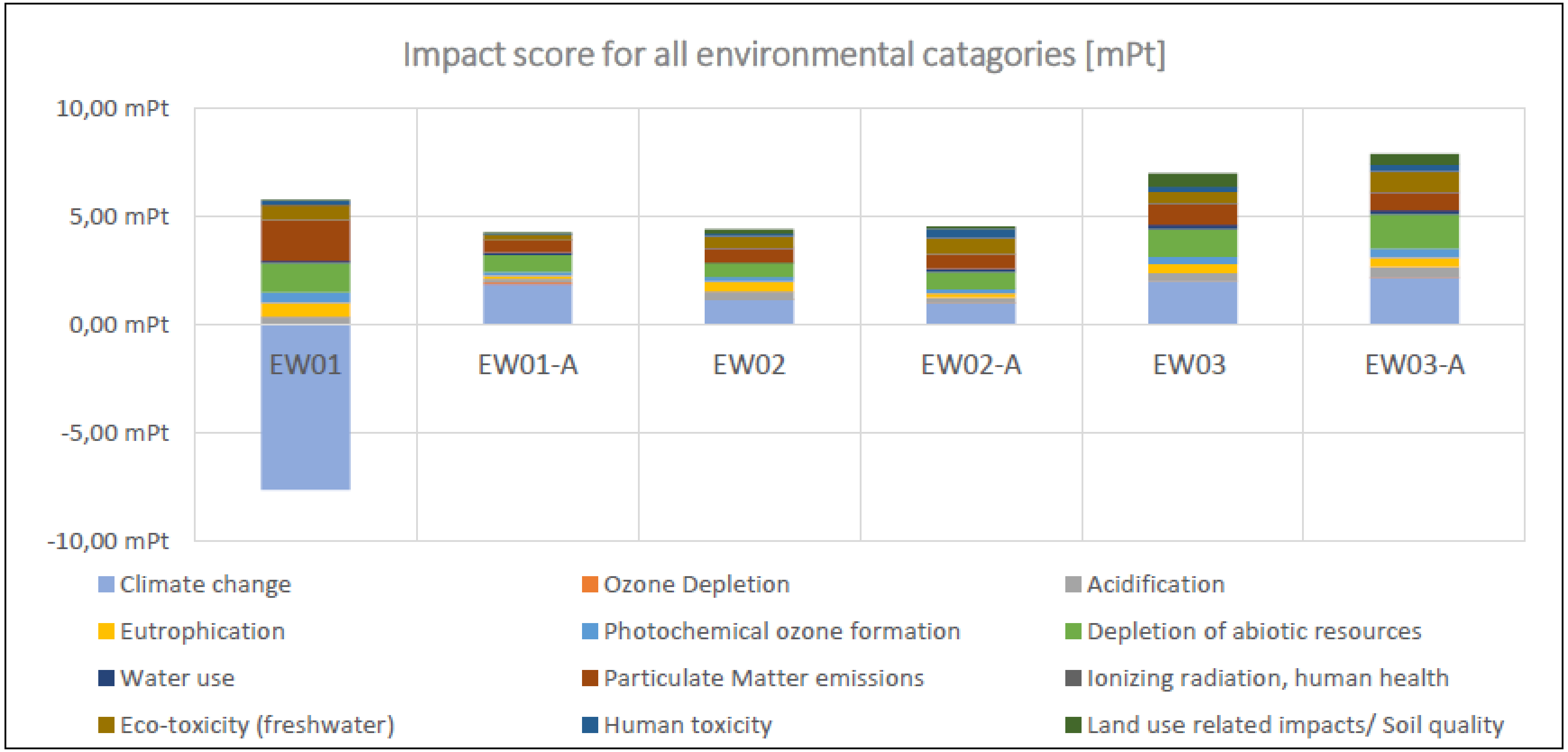
ASiRE²

- Aim of the project
- **Method and applications of LCA**
- Further outlook

ASiRE² Method and applications of LCA

Environmental LCA to assess

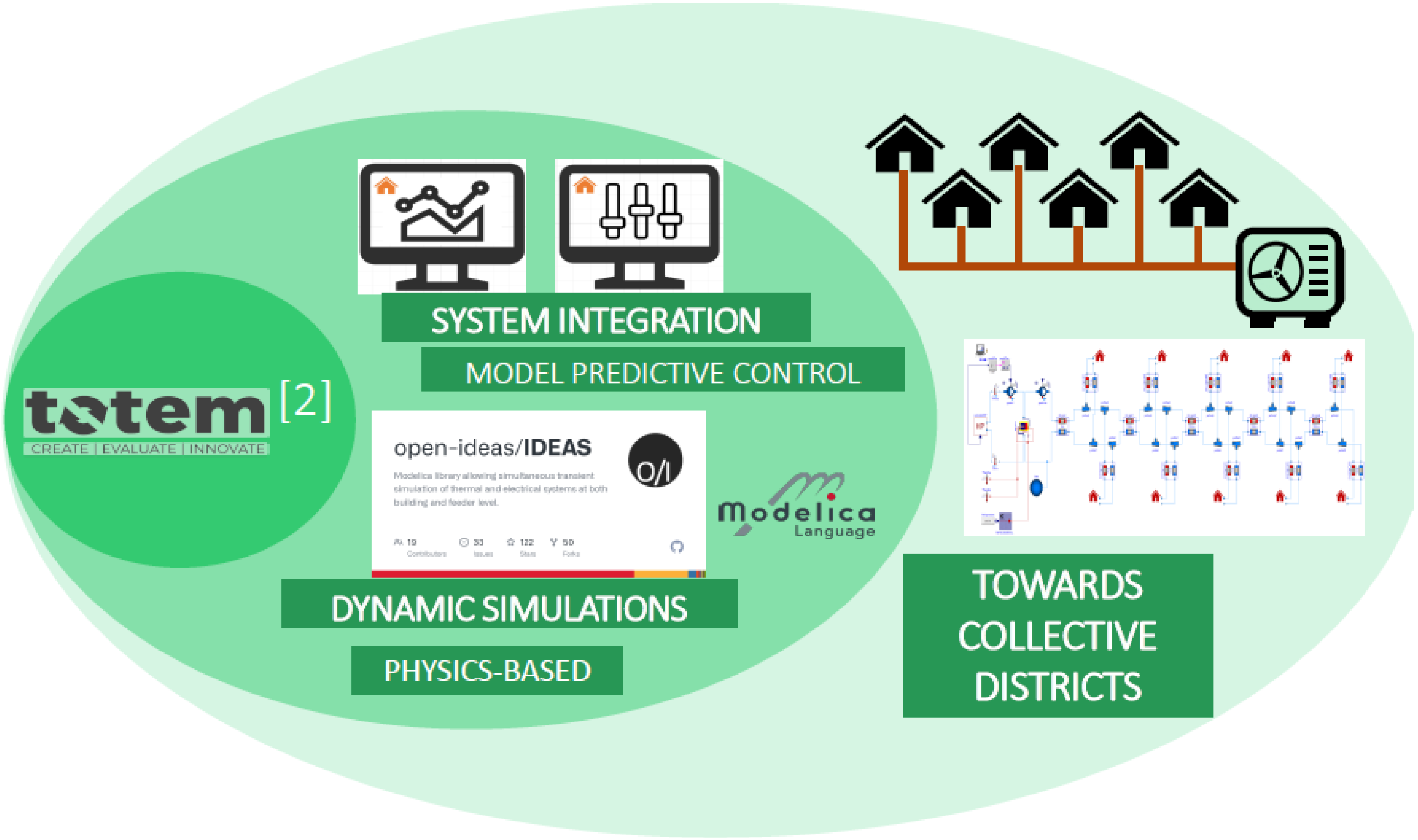
environmental impact of biobased materials



S. Brahma et al.; 2024; The risk of shifting environmental burdens in biobased construction - Life cycle assessment of a residential renovated building case study in Belgium

Method and applications of LCA

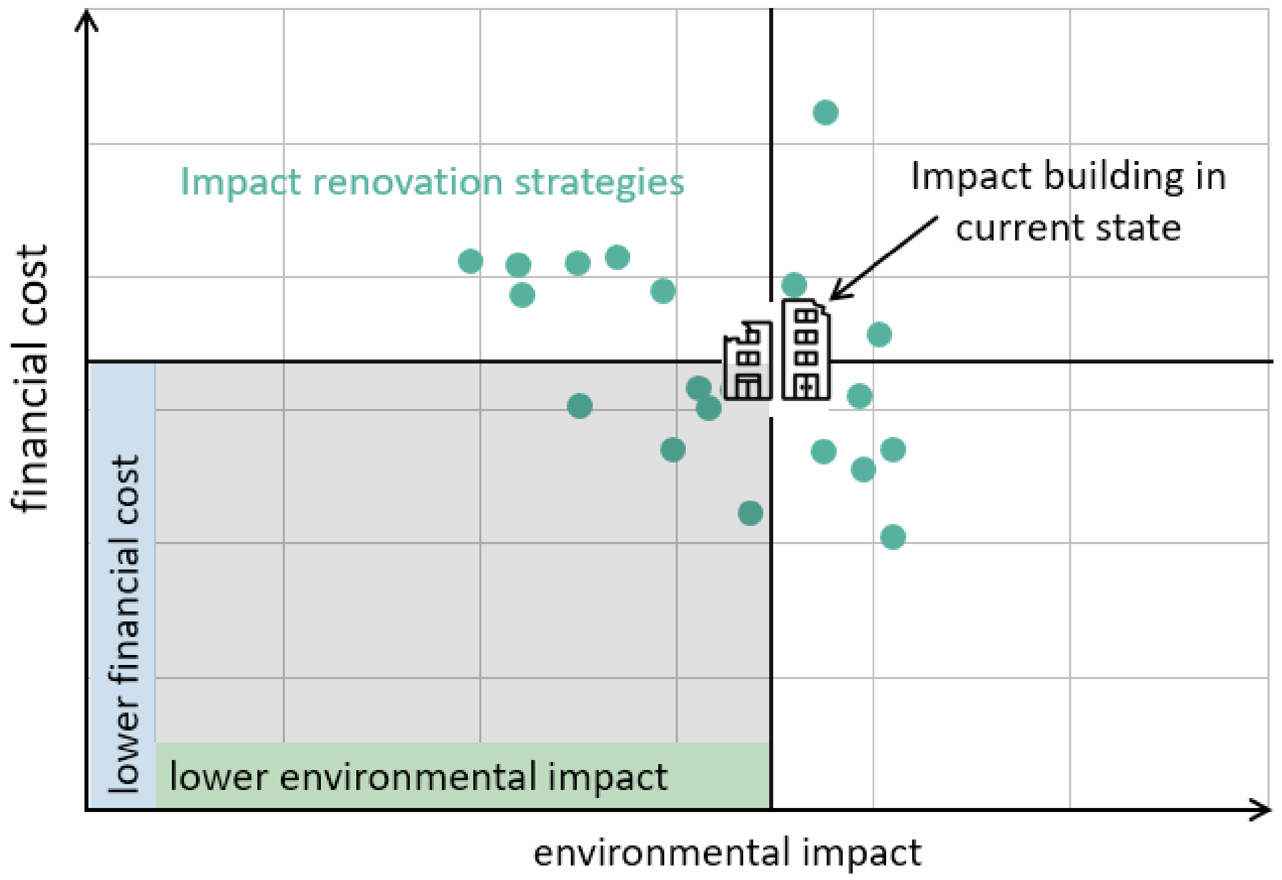
Environmental LCA to assess environmental impact of collective heating system



N. Adam et al.; 2023; LCA of Collective Districts Expansion Of A Tool To Guide Sustainable Renovations

ASiRE² Method and applications of LCA

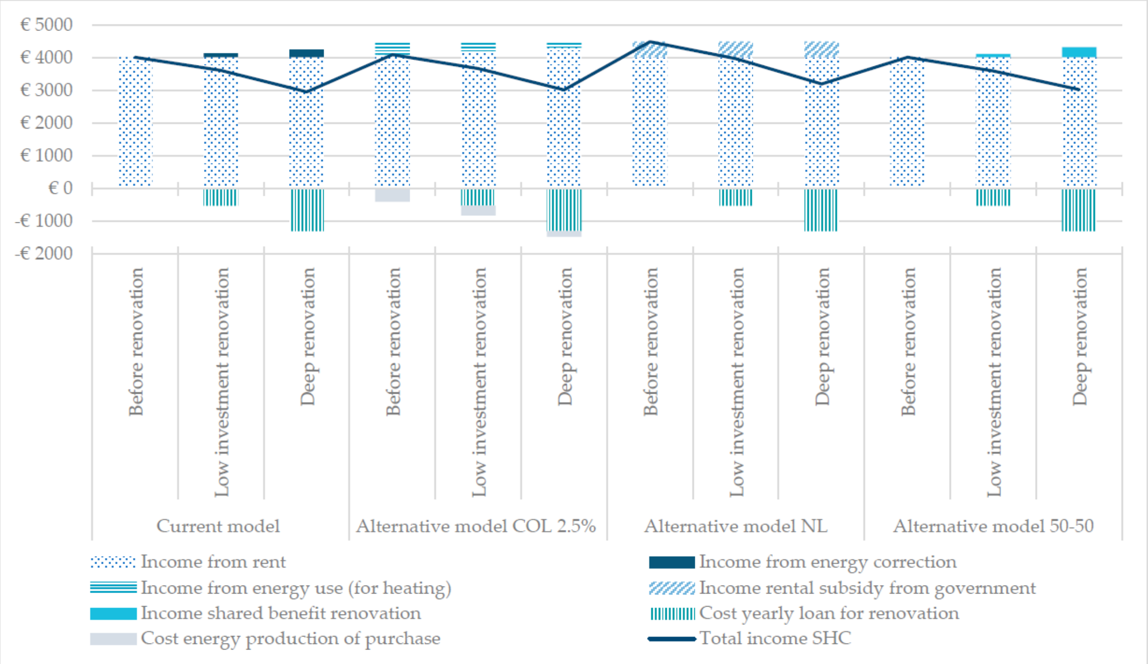
LCA and LCC to assess efficiency and feasibility of renovation scenarios

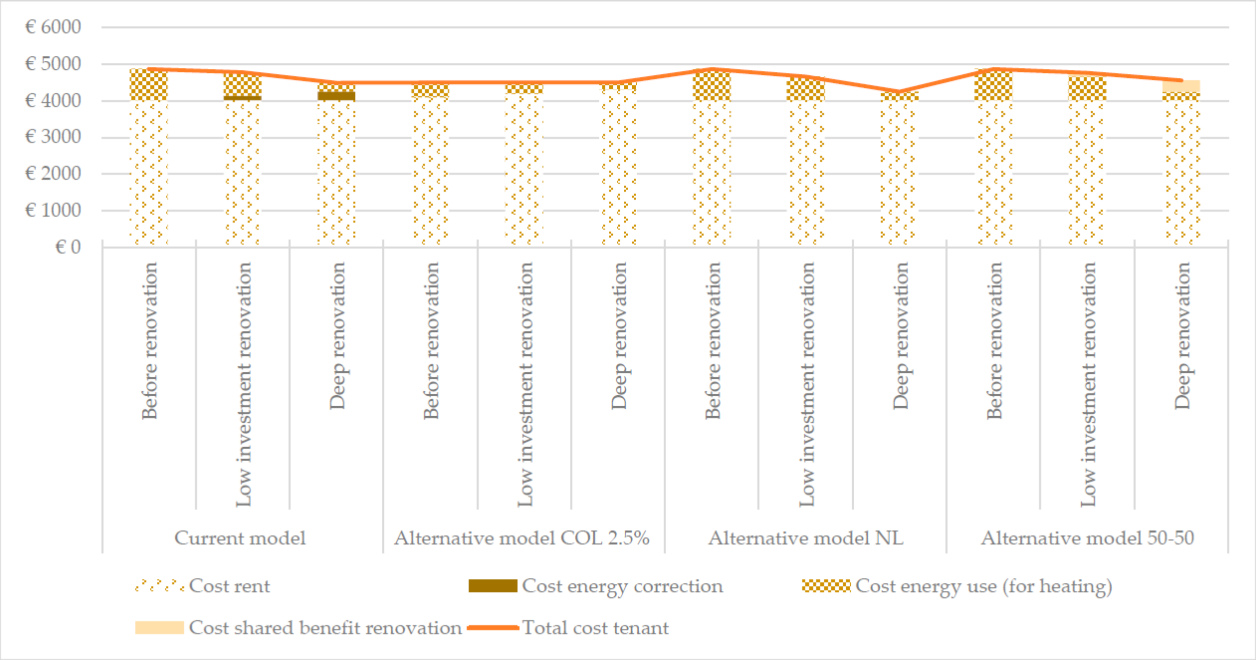


E. Van de moortel; 2022; Development of a tool to guide sustainable renovation of social housing in Flanders

Method and applications of LCA

LCC to assess affordability of renovation for housing company and for tenants





E. Van de moortel E. and K. Allacker; 2024; To what extend could alternative economic models increase investment in the renovation of and reduce energy poverty in social housing in Flanders

ASiRE²

- Aim of the project
- Method and applications of LCA
- **Further outlook**

ASiRE²   Further outlook

Internal funding KU Leuven → further develop research for application in practice

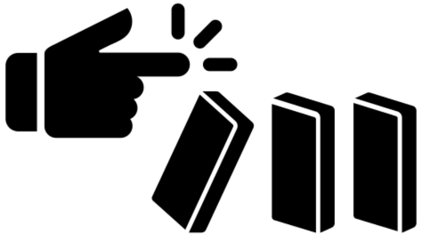
Design and Engineering of Construction and Architecture, Leuven (Arenberg)

Design and Engineering of Construction and Architecture, Sint-Lucas Brussels and Ghent Campuses

Applied Mechanics and Energy conversion (TME), Leuven (Arenberg)

Looking for opportunities to collaborate

- EU projects
  - Green RenoV8
  - INDICATE
  - …
- Policy support
- Collaboration with industry
- ….



KU Leuven funding C3/22/029

Thank you for your attention

els.vandemoortel@kuleuven.be

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FACULTEIT INGENIEURSWETENSCHAPPEN

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REGEN

REGENeration of neighbourhoods towards a low-carbon, inclusive and affordable built environment

The impacts of regeneration interventions

Calin Boje 24/09/2024

calin.boje@list.lu

Development of a catalogue of interventions for neighborhoods regeneration

- A catalogue of interventions that focus on increasing the well-being and economic prosperity of citizens in a low carbon, sustainable built environment

- Each intervention will be evaluated from multiple perspectives: qualified in terms of technical, operational, maintenance needs, performance, environmental impacts, and implementation costs
-alignment with AFUR indicators

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

Regen interventions sample

	#	Interventions	Type	Impact categories
Reduce GHGE	I1	Prefer multifamily houses to single (detached) houses - Spatial implications: Neighbourhoods layouts.	P&R, I, B	GHG, RE
	I2	Fuel switching for heating purposes (from oil, gas, to biomass, heat pumps, district heating) - Spatial implications: space needed for heat pumps in surroundings.	P&R, I, E	GHG, PM, W
	I3	District heating network optimisation (renewable heat generation, distribution, connection of buildings) - Spatial implications: Land take for generation units	I, E, S	GHG, PM, L
	I4	Conceive modular buildings according to Circular Economy principles - Spatial implications: New building typologies.	P&R, I	GHG, PM, RE
	I5	Deconstruct existing buildings by increasing reuse and high-value recycling, and reducing backfilling and waste - Spatial implications: storage on-site, sharing/re-use physical platforms occupy significant space.	I, T	GHG, RE, M
	I6	Developing urban mining of materials and components for augmenting local re-use and recycling - Spatial implications: see I5 (platforms).	I, T	GHG, RE
	I7	Reduce heat islands - Spatial implications: unseal built areas.	P&R, I, NBS	GHG, PM, L
Renature and deploy NBS	I8	Increase greens areas and deploy Nature-Based Solutions - Spatial implications: Less dense urban parcels, unseal built areas, use buildings and infrastructures (roofs, walls)	P&R, I, NBS	GHG, PM, CU, ES, LS
	I9	Unseal built parcels and/or monitor net-zero land uptake - Spatial implications: need for storage areas to re-use/recycle materials issued from unsealing.	P&R, I	GHG, CU
Reduce energy use in buildings	I10	Renovate low energy-efficient buildings. Spatial implications: increasing the renovation rate encompasses the need for more storage spaces of materials in cities. It affects the building envelope (dimensions/aesthetics) as well.	P&R, I, E	GHG, RE
	I11	Educate citizens on their energy use (deploying smart metering)	B	GHG, LS
	I12	Deploy energy communities - Spatial implications: Renewable generation occupy the city space and landscape, space needed inside buildings for new machineries	P&R, T, I, E	GHG, RE,
	I13	Upgrade smart readiness in buildings portfolios - Spatial implications: NA	P&R, T	GHG, PM, W
	I14	Install green roofs to regulate indoor air temperature and save energy, purify air, increase biodiversity, provide rainwater buffer - Spatial implications: plants archetypes to be regulated in planning laws.	P&R, I, E	GHG, PM, ES, LS

REGEN

Task 2.5 AFUR methodology

Identify ways to quantify and compare impacts

Based on LCSA
- Environmental
- Social
- Costs

Applied on interventions

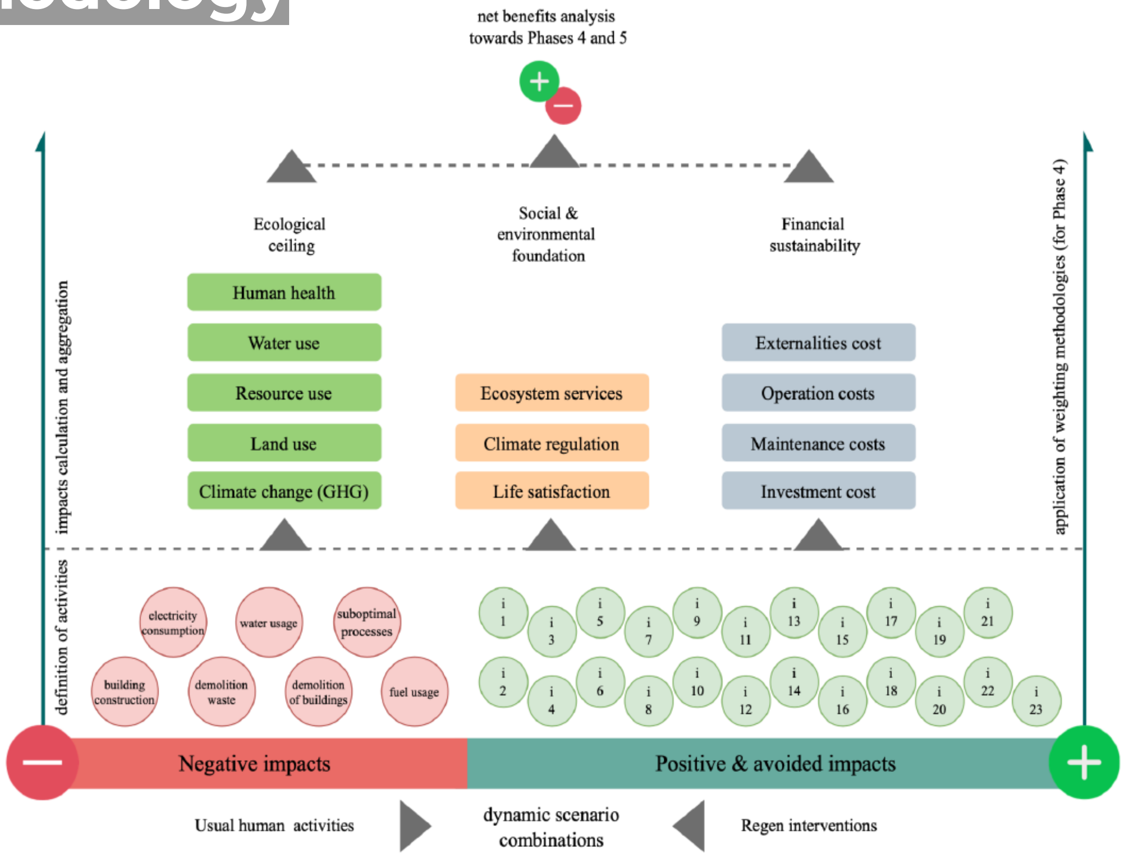
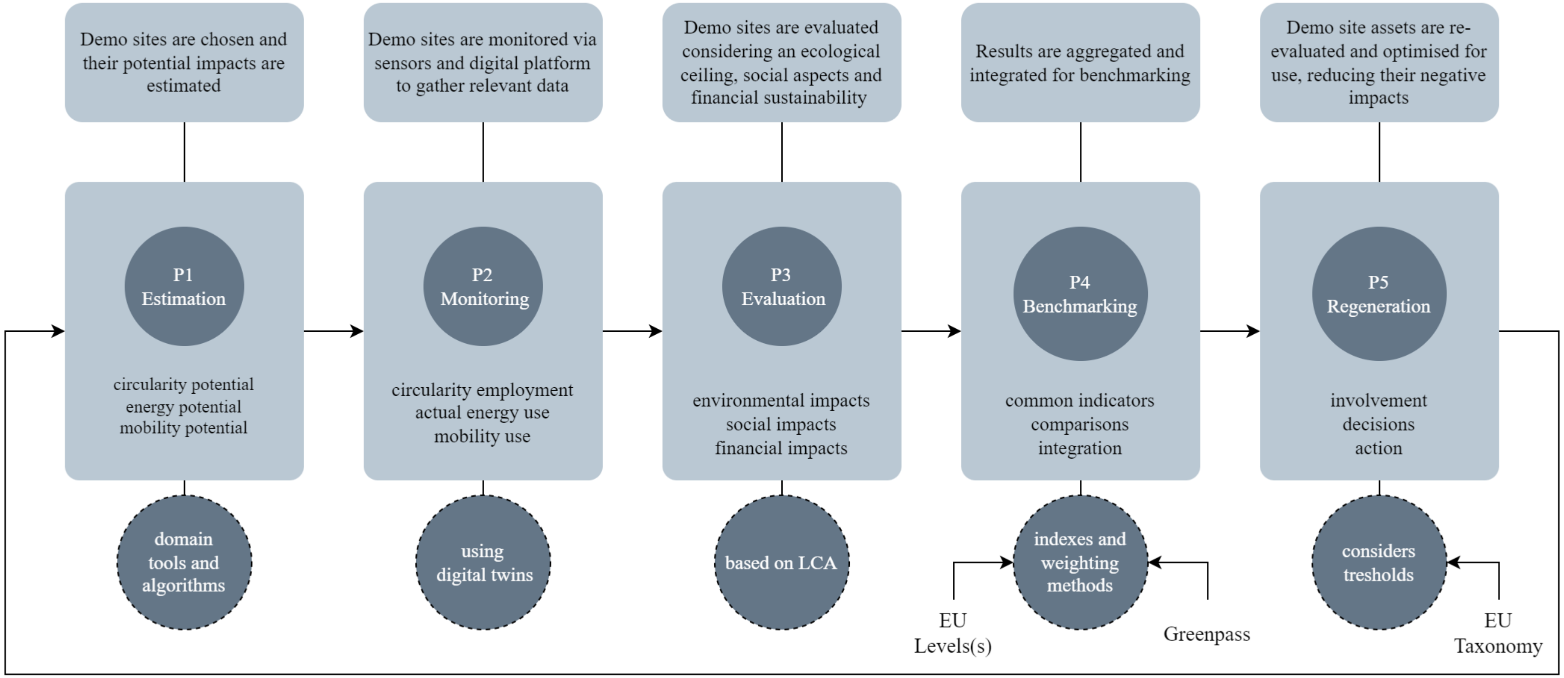


Figure 19 : Evaluation of REGEN Intervention Impacts

Task 2.5: Development and validation of the REGEN Assessment Framework for Urban Regeneration (AFUR): (M1-M18) LIST

- This task will develop and validate a framework for the assessment of the impacts of the urban regeneration interventions. AFUR defines the assessment process to be deployed at demo sites in several phases

REGEN's digitally supported framework for sustainable cities



ELSEVIER

Journal of Building Engineering
Volume 76, 1 October 2023, 107232

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

A framework using BIM and digital twins in facilitating LCSA for buildings

Calin Boje, Álvaro José Hahn Menacho, Antonino Marvuglia, Enrico Benetto, Sylvain Kubicki, Thomas Schaubroeck, Tomás Navarrete Gutiérrez

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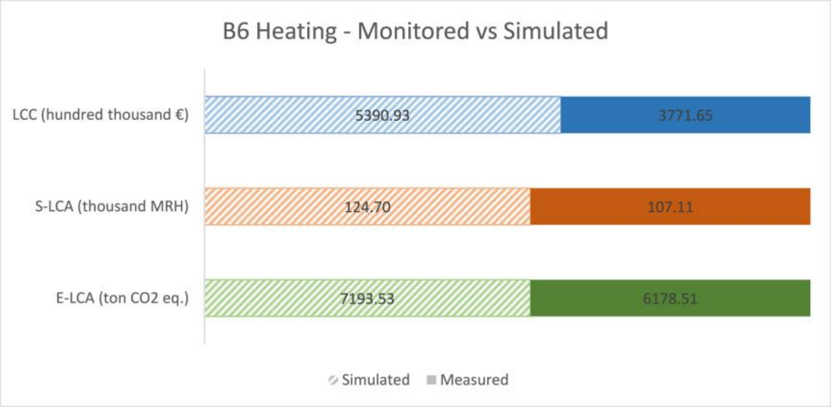
Highlights

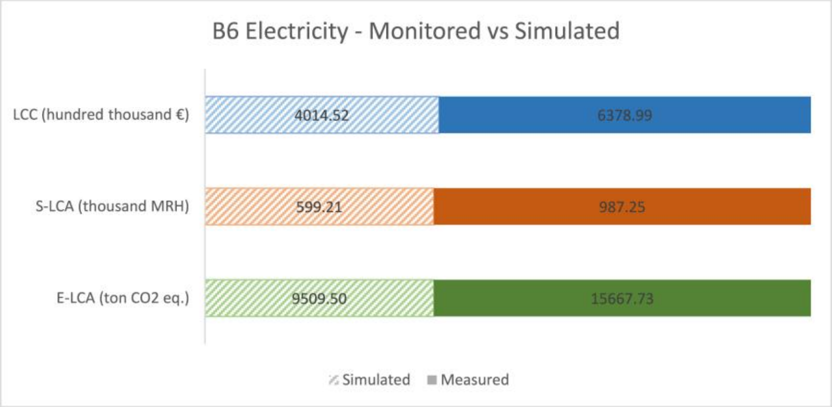
- A review on the integration of life cycle assessment and building information modelling.
- A novel framework to include digital twins and building information modelling.
- The framework targets environmental, social and economic sustainability assessment.
- A case study on a real building is presented and discussed.
- Recommendations on digital tools to help support sustainability are highlighted.

- An example on a real building
- Including simplfied LCA, LCC and S-LCA

- We considered the building materials, energy and water usage (A1-3, B6, B7 of the EN 15978

Results of B5-B7

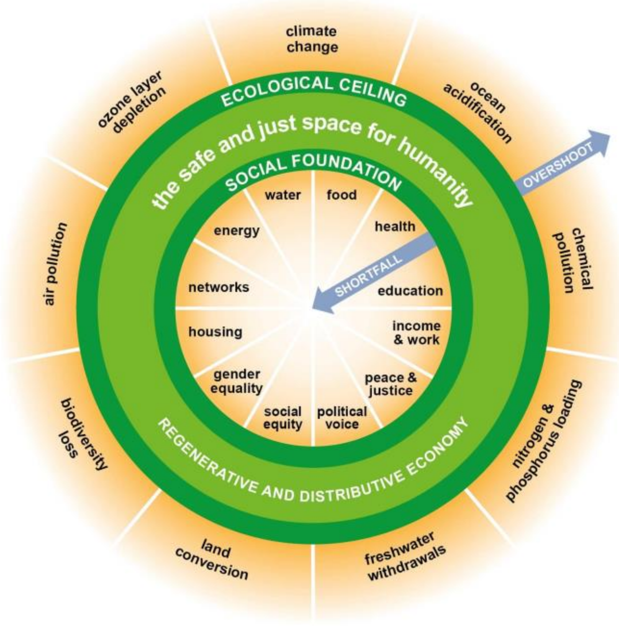




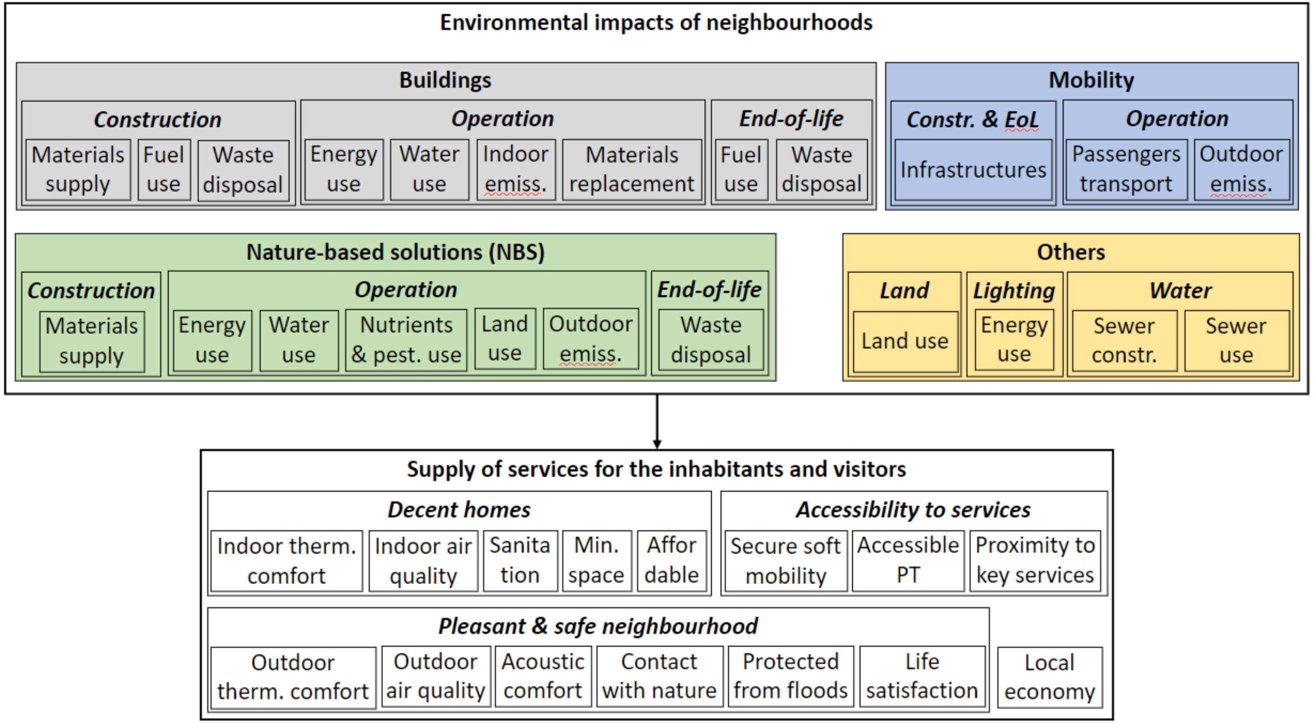
- Problem for Regen
  - Local scale should be considered (impacts on actual city occupants)
  - While costs and environmental impacts can be quantified, social impacts remain problematic

Alignment with Doughnut Economics

- We looked at different frameworks:
  - DGNB (buildings + districts)
  - LEED/BREEAM
  - WELL
  - GREEN PASS
  - Etc
- A mapping of indicators and doughnut economics already exists
- We tried to identify indicators related to social impacts
- An LCA-based methodology is not clear however



Overarching consideration impacts vs social gains



Thank you

Get in touch for more information!

REGEN

REGENeration of neighbourhoods towards a low-carbon, inclusive and affordable built environment

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Esch-sur-Alzette, Luxembourg

SUSTAINABLE PLACES 2024

23-25 September 2024

Luxembourg

LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY LIST

R2M SOLUTION

Life cycle sustainability assessment
WORKSHOP

Life cycle sustainability assessment
Environmental and social applications of LCA in the built environment

REGEN

CIRCUSTAIN
IMPACT ASSESSMENT OF CIRCULAR ECONOMY INITIATIVES IN CONSTRUCTION

IMMEC
EFFICIENCY AND ENVIRONMENTAL IMPACTS OF BUILDING MATERIAL CYCLES

ASIRE²
Assessment method and Selection Instrument to Reduce Energy poverty and Environmental impact

MIRACLE
Photonic Concrete

www.sustainableplaces.eu

Agenda:

11:00 – Workshop Opening (Moderator: Calin Boje, LIST)

11:05 – **IMMEC Project** – Integrated Modelling Of Material Efficiency And Environmental Impacts Of Building Materials Cycles (Thomas Gibon, LIST)

11:15 – **CIRCUSTAIN Project** – Impact assessment of circular economy initiatives, with a focus on PVC in the construction sector (Nirvana Marting, LIST)

11:25 – **MIRACLE Project** – A transformative approach to engineer low-tech concrete and cement-based materials into high-performance functional photonic metamaterials (Nick Adams, KUL)

11:35 – **REGEN Project** – REGENeration of neighbourhoods towards a low-carbon, inclusive and affordable built environment (Calin Boje, LIST)

11:45 – **ASIRE Project** – LCA to reduce the energy poverty and the environmental impact of the residential building stock (Els Van de moortel, KUL)

11:55 – **Brainstorming** – Managing trade-offs with LCA, Integration of environmental and social LCA

12:25 – Closing remarks

THE ENVIRONMENTAL COSTS OF CLEAN CYCLES

INSIGHTS FROM PROJECT "IMMEC"

Thomas Gibon[1], Sarah Schmidt[2], Tomás Navarrete Gutiérrez[1], and David Laner[2]

[1]SUSTAIN Unit, **Luxembourg Institute of Science & Technology**
5 avenue des Hauts-Fourneaux, 4362 Esch-sur-Alzette Luxembourg

[2]Research Center for Resource Management and Solid Waste Engineering, Faculty of Civil and Environmental Engineering, **University of Kassel**, Mönchebergstraße 7, 34125 Kassel, Germany

September 24th, 2024

Credit: figures and slides by Sarah Schmidt

PROJECT “IMMEC”

INTEGRATED MODELLING OF MATERIAL EFFICIENCY AND ENVIRONMENTAL IMPACTS OF BUILDING MATERIALS CYCLES

Principal investigators: **Thomas Gibon (LIST, LU) and David Laner (University of Kassel, DE)**
Funding program and project period: **Funded by FNR and DFG as a joint project**
Funding period: **from 05/2022 – 08/2025**

DFG Deutsche Forschungsgemeinschaft

Fonds National de la Recherche Luxembourg

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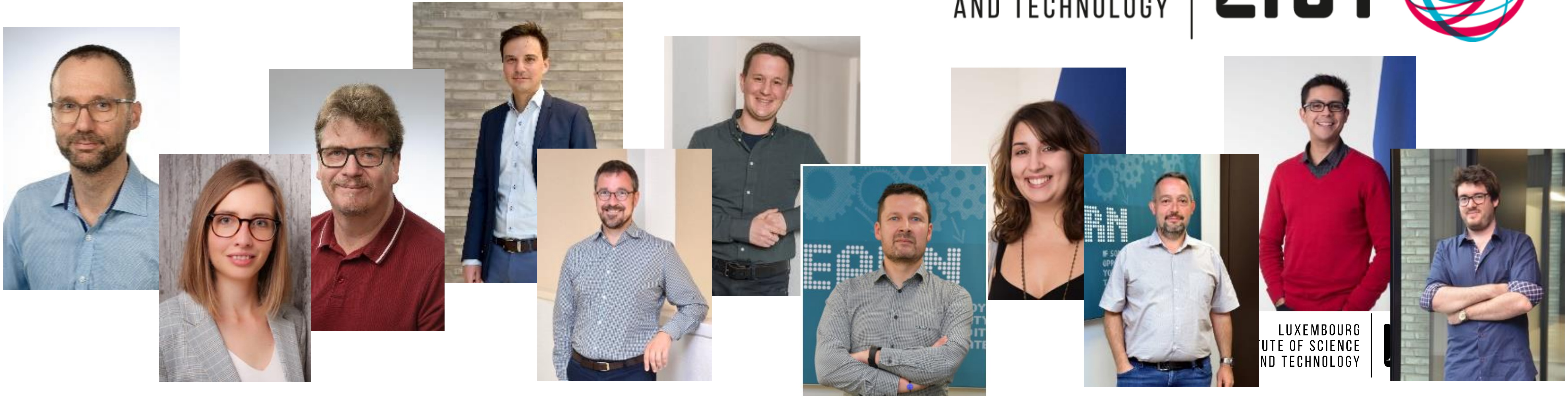

CHALLENGES

Future **climate change impacts** of the **plastics** industry can be reduced by enhanced **recycling**.

Bachmann et al. (2023) Towards circular plastics within planetary boundaries. Nat Sustain. doi:10.1038/s41893-022-01054-9

The presence of **legacy contaminants** is a significant **barrier** for more effective recycling markets.

OECD (2018) *Improving Markets for Recycled Plastics: Trends, Prospects and Policy Responses.*

Products in the **building and infrastructure** sector are used over **long periods of time**.

Geyer et al. (2017) Production, use, and fate of all plastics ever made. Sci Adv 3(7). doi:10.1126/sciadv.1700782

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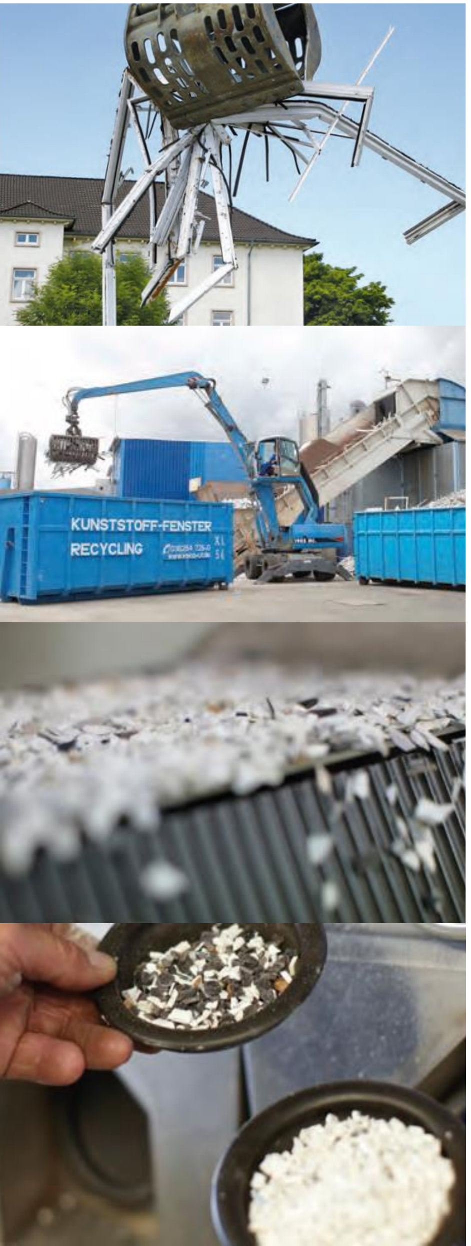
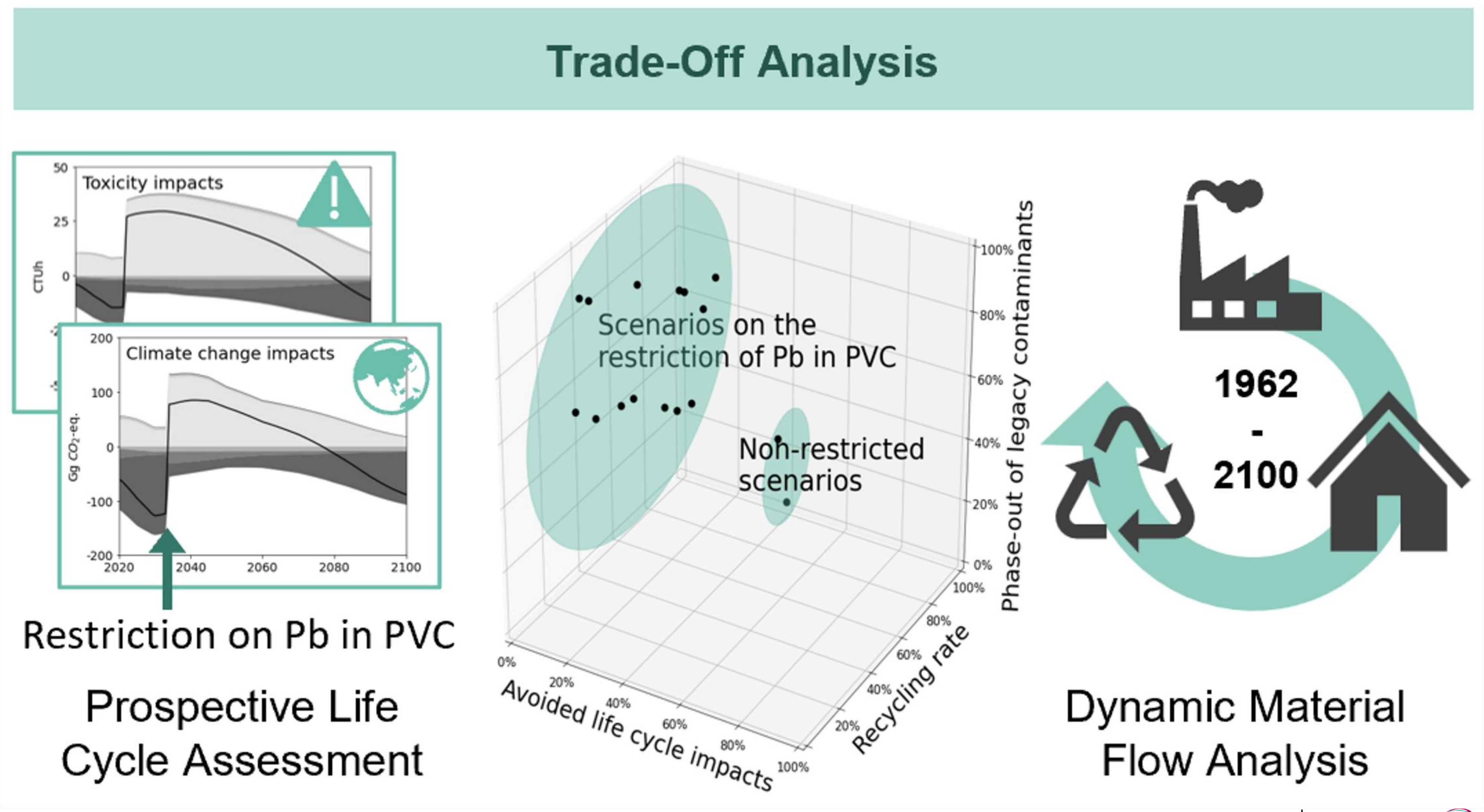
THE ENVIRONMENTAL COSTS OF CLEAN CYCLES: CASE STUDY





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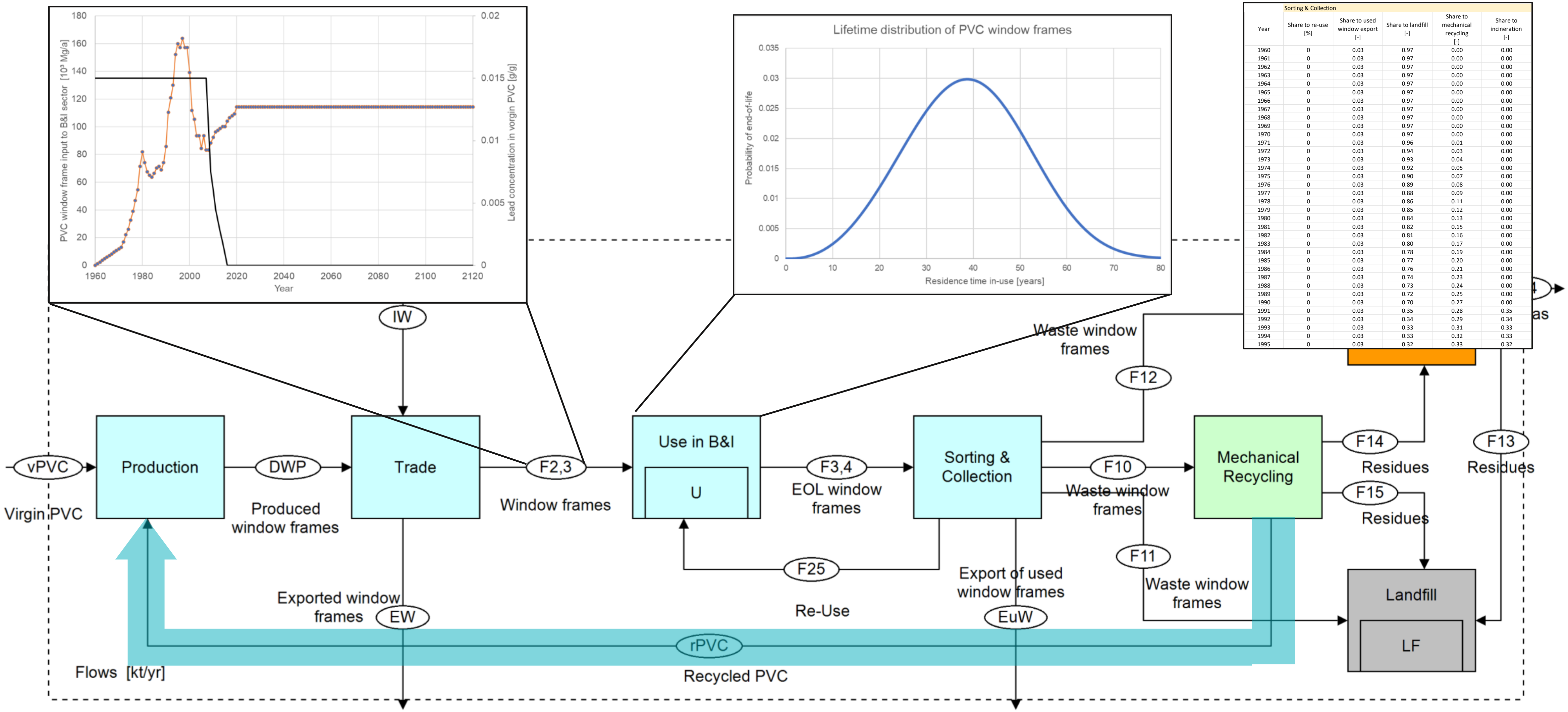
INPUT-DRIVEN DYNAMIC MATERIAL FLOW AND STOCK MODEL



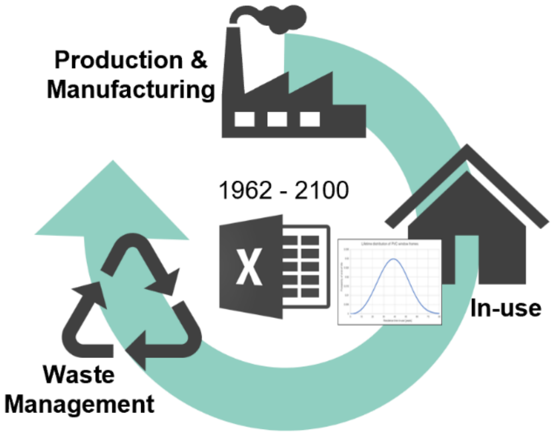
Year	Sorting & Collection Share to re-use [%]	Share to used window export [-]	Share to landfill [-]	Share to mechanical recycling [-]	Share to incineration [-]
1960	0	0.03	0.97	0.00	0.00
1961	0	0.03	0.97	0.00	0.00
1962	0	0.03	0.97	0.00	0.00
1963	0	0.03	0.97	0.00	0.00
1964	0	0.03	0.97	0.00	0.00
1965	0	0.03	0.97	0.00	0.00
1966	0	0.03	0.97	0.00	0.00
1967	0	0.03	0.97	0.00	0.00
1968	0	0.03	0.97	0.00	0.00
1969	0	0.03	0.97	0.00	0.00
1970	0	0.03	0.97	0.00	0.00
1971	0	0.03	0.96	0.01	0.00
1972	0	0.03	0.94	0.03	0.00
1973	0	0.03	0.93	0.04	0.00
1974	0	0.03	0.92	0.05	0.00
1975	0	0.03	0.90	0.07	0.00
1976	0	0.03	0.89	0.08	0.00
1977	0	0.03	0.88	0.09	0.00
1978	0	0.03	0.86	0.11	0.00
1979	0	0.03	0.85	0.12	0.00
1980	0	0.03	0.84	0.13	0.00
1981	0	0.03	0.82	0.15	0.00
1982	0	0.03	0.81	0.16	0.00
1983	0	0.03	0.80	0.17	0.00
1984	0	0.03	0.78	0.19	0.00
1985	0	0.03	0.77	0.20	0.00
1986	0	0.03	0.76	0.21	0.00
1987	0	0.03	0.74	0.23	0.00
1988	0	0.03	0.73	0.24	0.00
1989	0	0.03	0.72	0.25	0.00
1990	0	0.03	0.70	0.27	0.00
1991	0	0.03	0.35	0.28	0.35
1992	0	0.03	0.34	0.29	0.34
1993	0	0.03	0.33	0.31	0.33
1994	0	0.03	0.33	0.32	0.33
1995	0	0.03	0.32	0.33	0.32

PVC window frames, Germany, 1960-2120

SCENARIO MODELLING

Comprehensive analysis of material and substance flows and associated environmental impacts

Dynamic Material Flow Analysis
to quantify PVC and lead flows and stocks in window profiles



Life Cycle Assessment
to assess the environmental impacts associated with the management of EOL PVC window profiles

Brightway · ecoinvent · premise

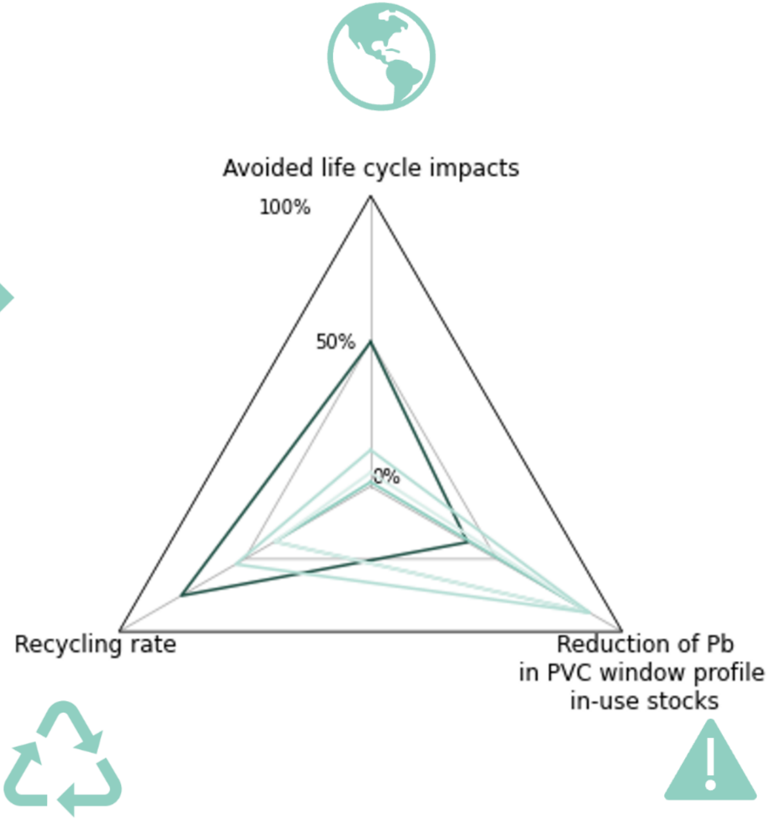
Modular calculation approach

Dynamic Inventories X Background system specific unit impacts = Prospective Impacts

Scenario Analysis
to consider alternative pathways for future development

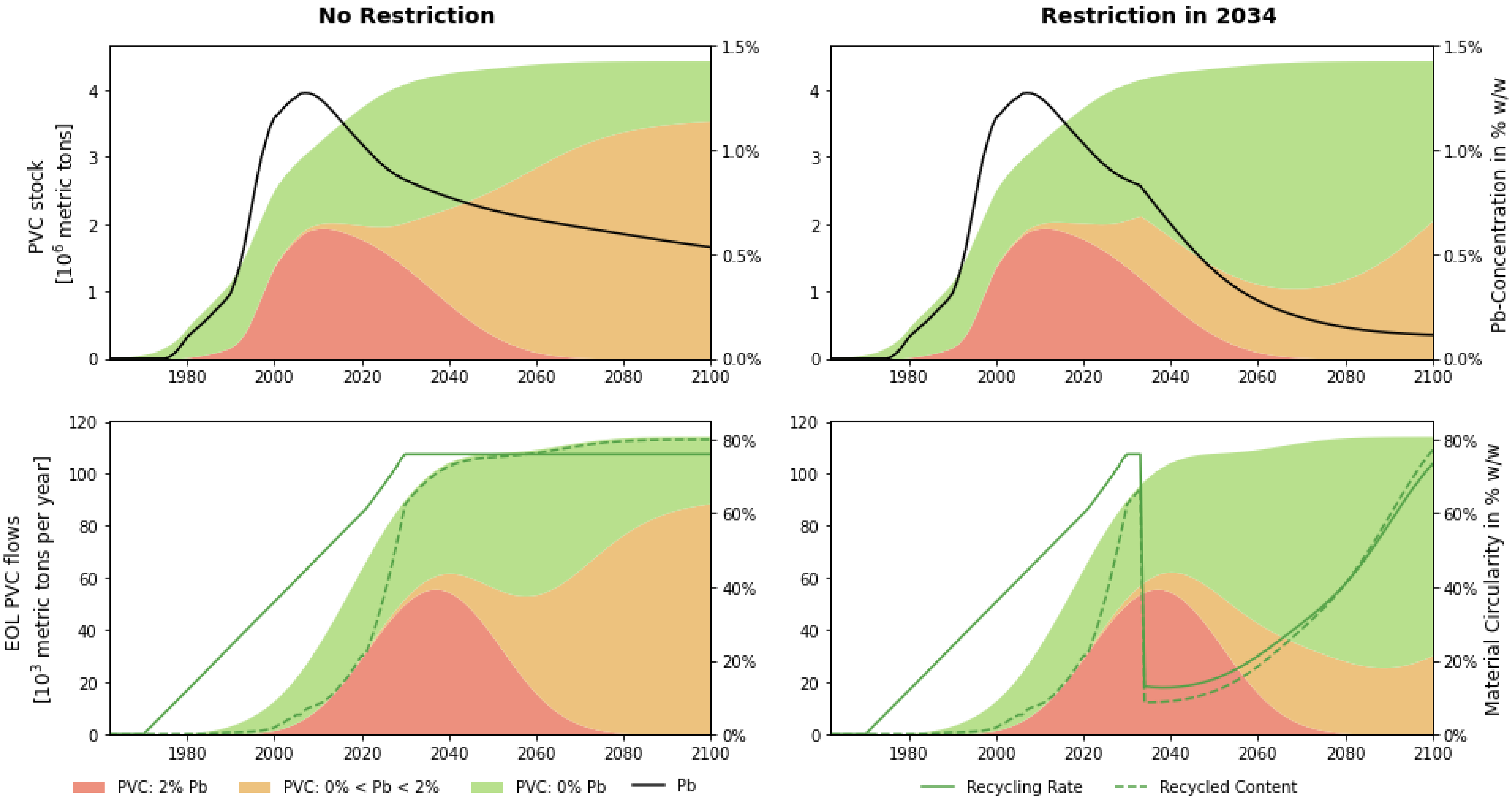
Restriction Scenarios	Technology Scenarios	Pb-detection Scenarios	Market Scenarios	Background System Scenarios
No restriction Restriction 2034	MSWI MSWI with CCS MSWI with HCl recovery	No Pb-detection Pb-detection	Saturation Growth Decrease	Static SSP2-BASE SSP2-RCP2.6

Evaluation of trade-offs between material circularity, phase-out of problematic substances, and climate change impacts



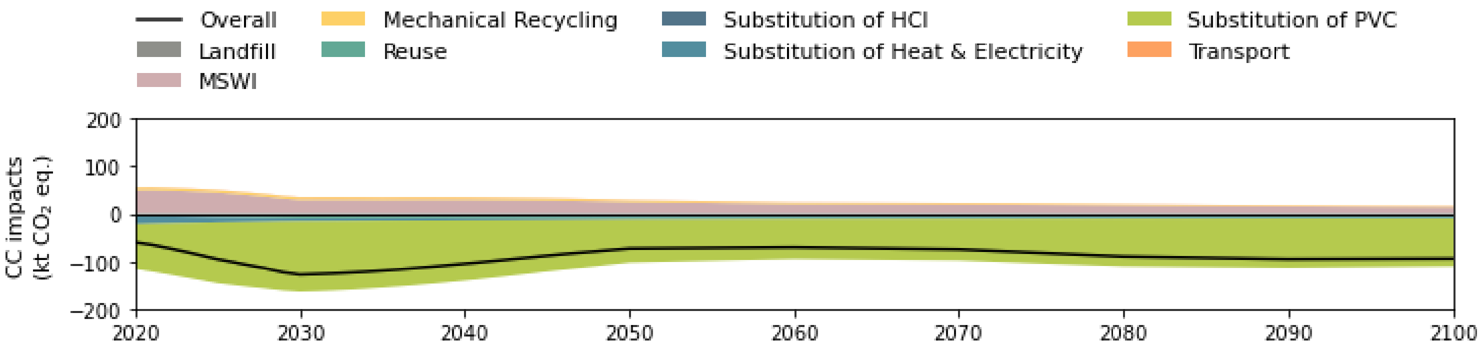
STOCKS AND FLOWS OF PVC WINDOW FRAMES

Market scenario: saturation



ENVIRONMENTAL IMPACTS

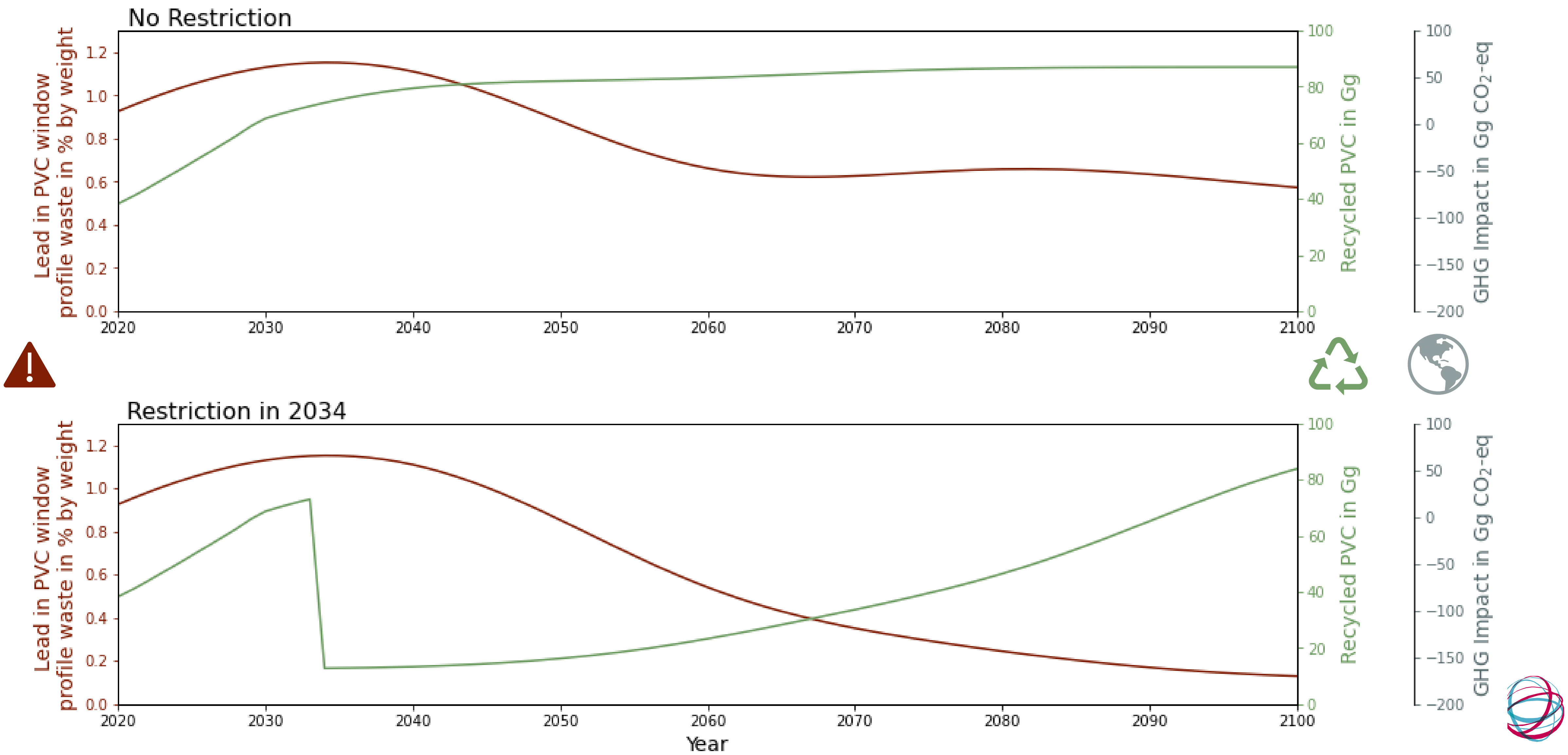
Climate change



No Restriction

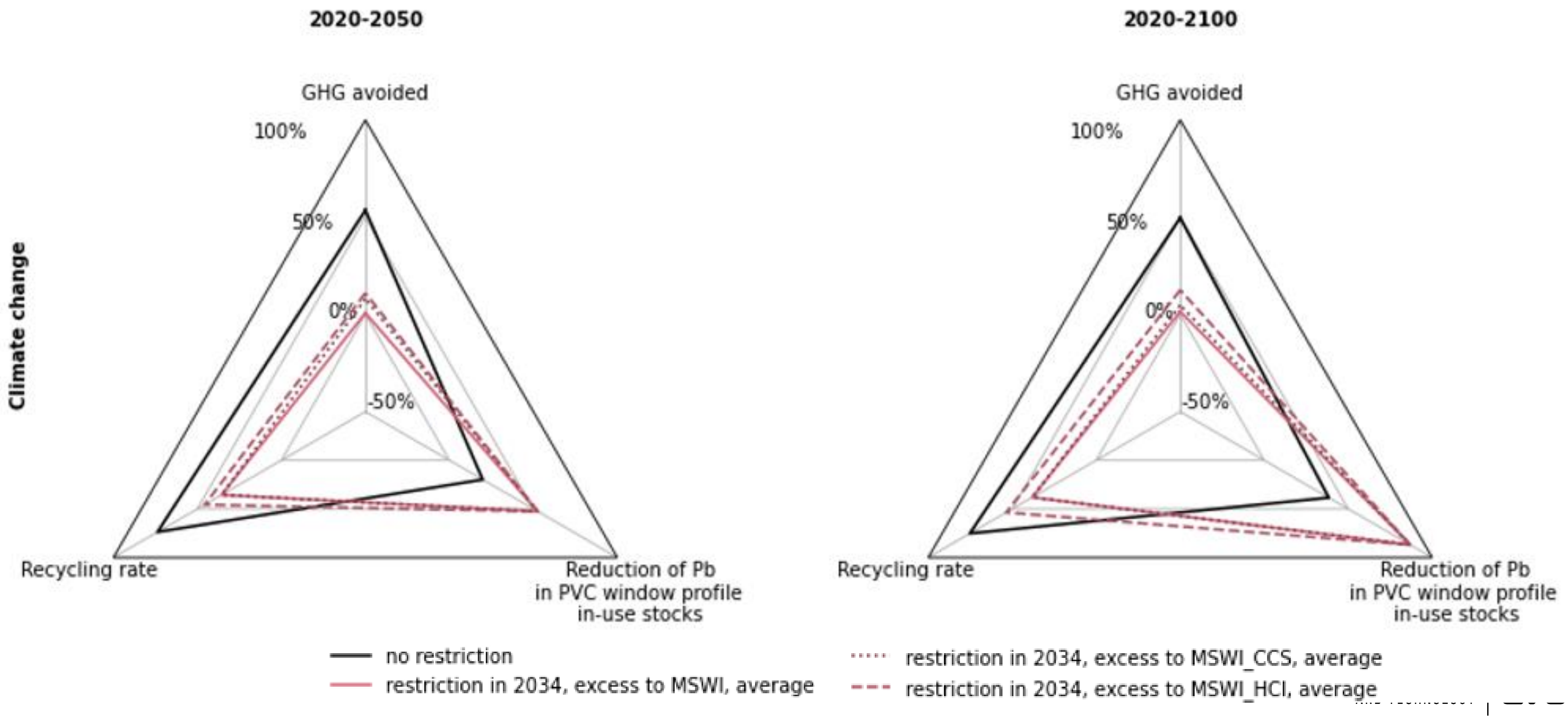
EFFECTS OF A PB RESTRICTION IN RECYCLED PRODUCTS

Threshold: 0.1% by weight 2034 (EU2023/923)



TRADE-OFF ANALYSIS
Circularity, contaminant phase-out, and climate change impacts

Background system scenario: RCP 2.6, Market scenario: saturation



KEY MESSAGES

EOL PVC window flows are expected to increase by factor 1.7 between 2020 and 2050.

Pb will be present in EOL PVC window frames in concentrations above 0.5% for at least three more decades.

Restriction on Pb in new PVC window frames will limit future mechanical recycling.

Environmental impacts for different EOL PVC management scenarios with Pb restriction and without Pb restriction were assessed in view of changing background system conditions.

Assessment showed that alternative treatment pathways can mitigate the effect of excess PVC in mechanical recycling.

THANK YOU!

thomas.gibon@list.lu

THE ENVIRONMENTAL COSTS OF CLEAN CYCLES: CASE STUDY

Challenges & solution

Data access

Ideally we would extend the model to more European countries, accounting for trade

Data is not available in a similar format (or even incomplete)

Policy modelling

We test Pb restriction as a one-off intervention

How should we test various policy interventions (on more substances, with finer thresholds, …), and which ones should we model in priority?

Future technologies

End-of-life treatment options are currently restricted to existing technologies

What approach should be adopted to model upcoming solutions (e.g. chemical recycling)?

Policy relevance

What results and interpretation could be further exploited for policymaking?

What needs could be foreseen, and how to adapt the model accordingly to maximize policy-relevance?

The integration and application of LCA in the H2020 Project MIRACLE

Event: Sustainable Places 2024, Luxemburg

Date: 24/09/2024

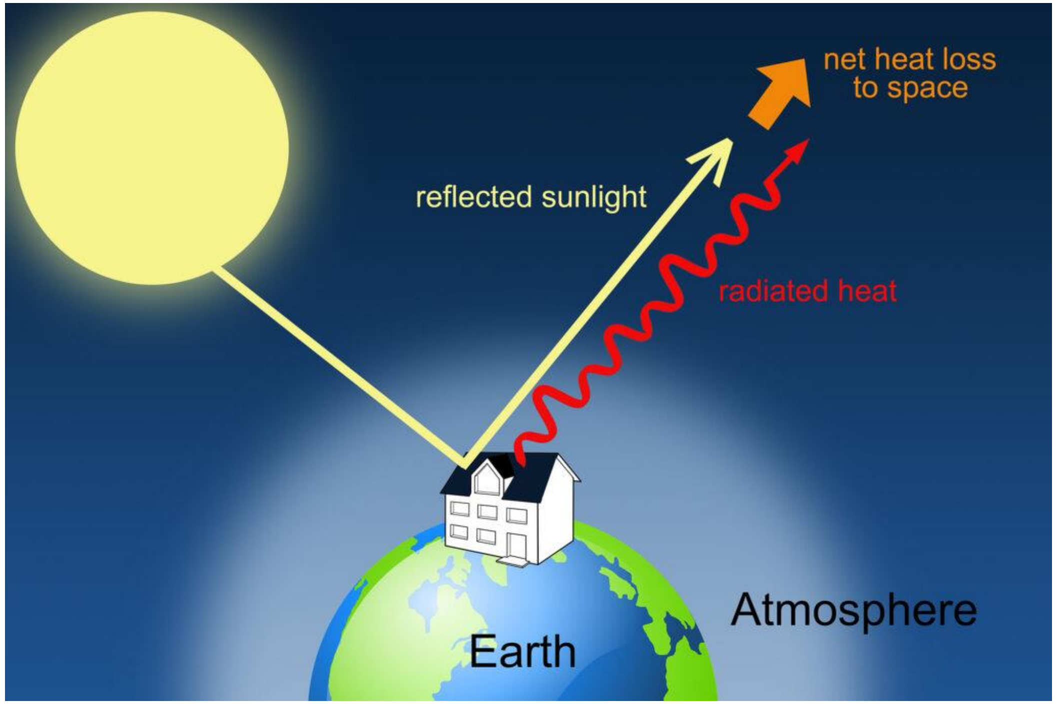
Author/Partner: KU Leuven

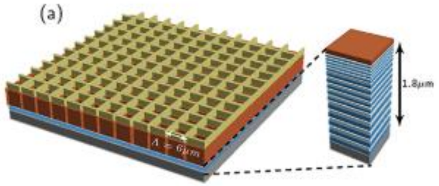
MIRACLE
GA 964450

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 964450.

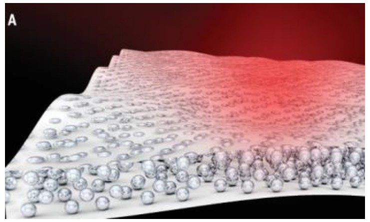
KU LEUVEN

Radiative cooling materials

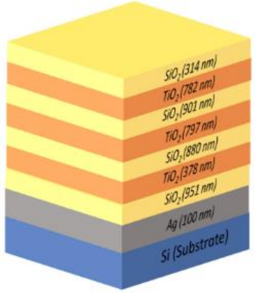




Rephaeli E, Raman A, Fan S (2013) Ultrabroadband photonic structures to achieve high-performance daytime radiative cooling. Nano Lett 13:1457–1461. https://doi.org/10.1021/nl4004283



Zhai Y, Ma Y, David SN, et al (2017) Scalable-manufactured randomized glass-polymer hybrid metamaterial for daytime radiative cooling. Science (1979) 355:1062–1066. https://doi.org/10.1126/science.aai7899



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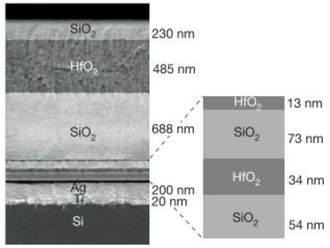
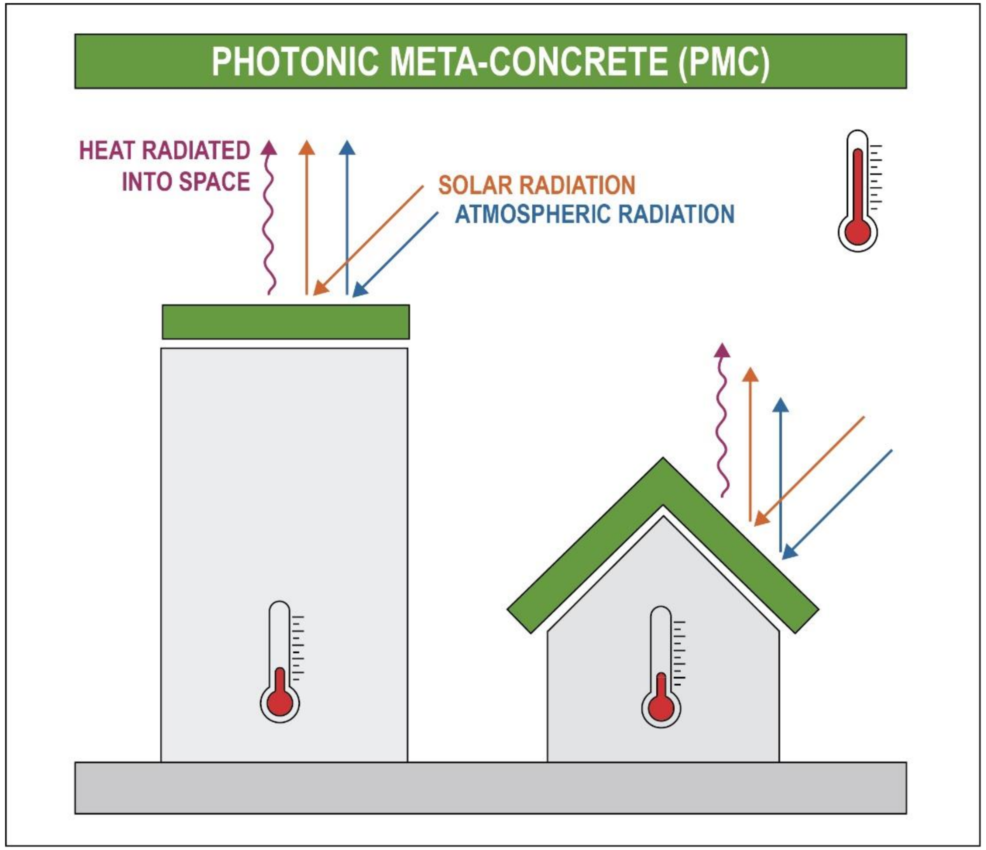
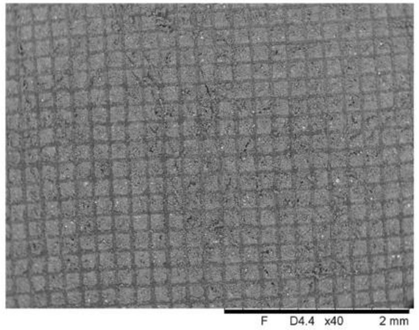


Raman AP, Anoma MA, Zhu L, et al (2014) Passive radiative cooling below ambient air temperature under direct sunlight. Nature 515:540–544. https://doi.org/10.1038/nature13883

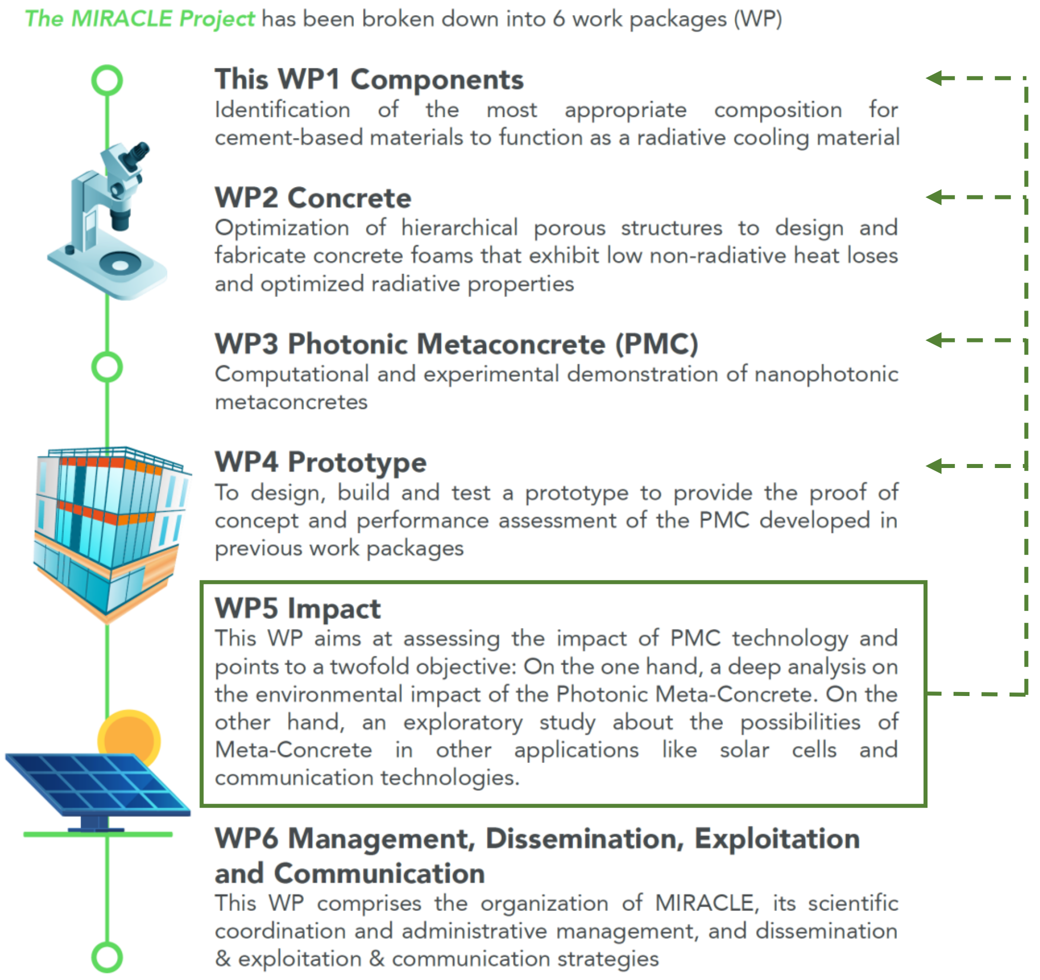
MIRACLE project

photonic Metaconcrete with Infrared RAdiative Cooling capacity for Large Energy savings





MIRACLE project



Cradle-to-gate environmental impact assessment of:

- The components and the mixtures of MIRACLE
- Extisting radiative cooling materials

Life cycle assessment of prototype and final mixtures, taking into account:

- Production process
- Construction
- Use phase
  - Positive (and negative) impact energy use of buidlings **(Building simulation)**
  - Possitive (and negative) impact on the urban heat island and climate change **(climate modelling)**
- End of life

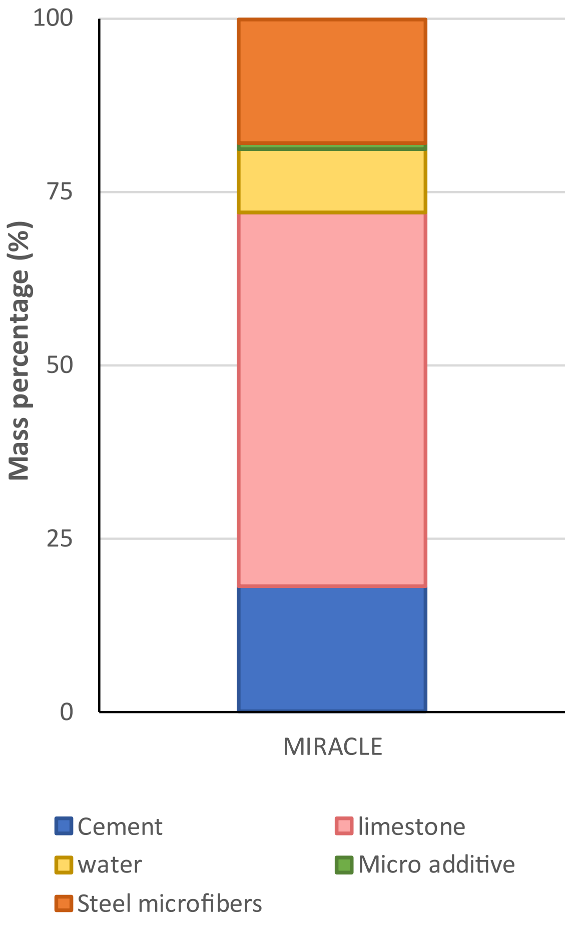
WP5 Impact

- Research topics
  - **Environmental impact MIRACLE and state-of-the-art radiative cooling materials**
  - Effect of cooling potential on buildings (reduction energy use for cooling)
    - In starting phase
  - Urban heat-island mitigation
  - Climate change mitigation (radiative forcing)

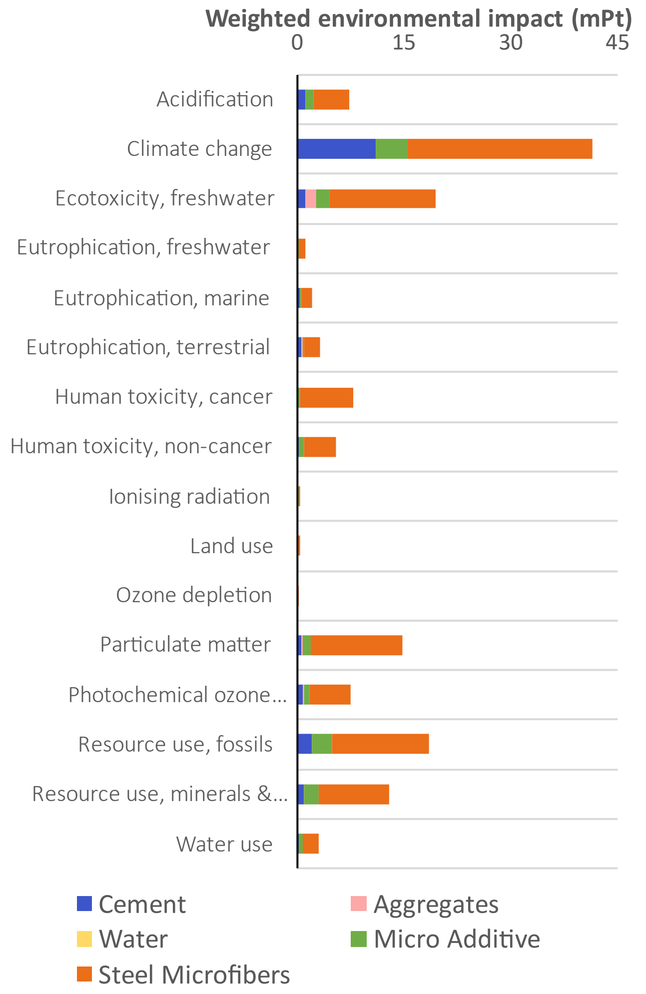
MIRACLE project (cradle-to-gate)

- First composition

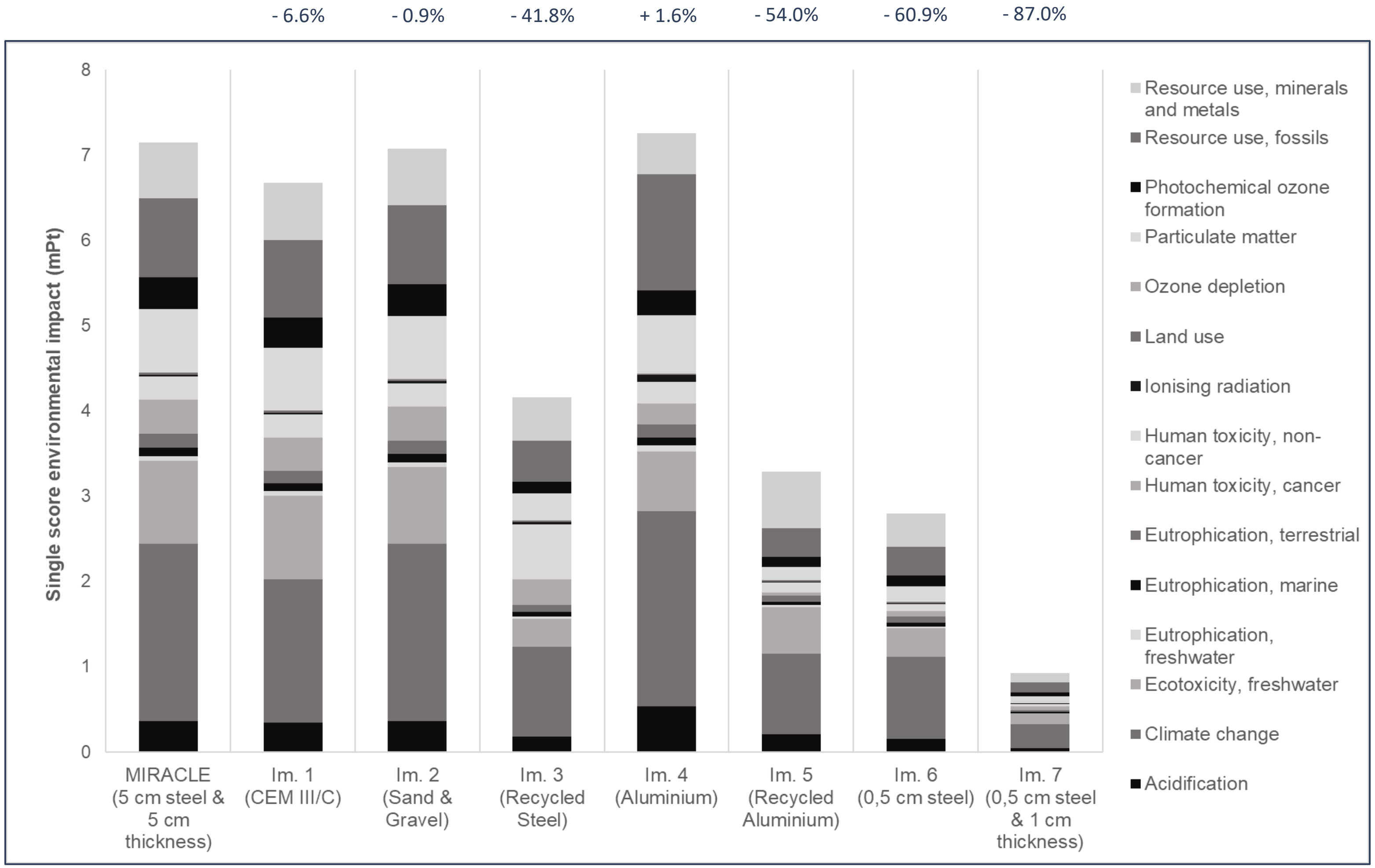
Components	Mass in 1 m³ (kg)
Portland cement	484,86
Limestone aggregates	1454,57
Water	242,43
Micro-additions	24,24
Steel microfibers	484,86
Total	2690,96



(1 m³)



MIRACLE project (cradle-to-gate)



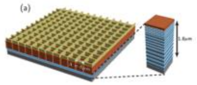
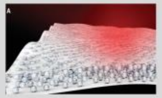
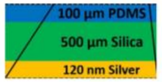
MIRACLE Photonic Concrete

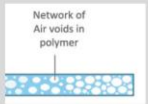
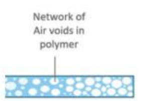
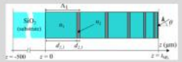
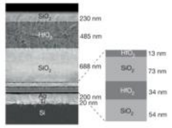
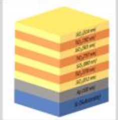
MIRACLE project (cradle-to-gate)

- Framework to assess and benchmark existing radiative cooling materials based on (cradle-to-gate) environmental impact and cooling performance

Framework

1. **Selecting the RC materials**
2. Environmental impact assessment
3. Cooling performance
4. Pareto front optimalization

Name	composition				Source
	# layers	Material	Thickness of each layer	Illustration	
D1	4	TiO_2	20-300 nm		Kecebas MA, Menguc MP, Kosar A, Sendur K (2017) Passive radiative cooling design with broadband optical thin-film filters. J Quant Spectrosc Radiat Transf 198:1339–1351. https://doi.org/10.1016/j.jqsrt.2017.03.046
	3	SiO_2	20-300 nm		
	1	Ag	50 nm		
	1	Si-wafer	/		
D2	31	TiO_2	20-220 nm		Kecebas MA, Menguc MP, Kosar A, Sendur K (2017) Passive radiative cooling design with broadband optical thin-film filters. J Quant Spectrosc Radiat Transf 198:1339–1351. https://doi.org/10.1016/j.jqsrt.2017.03.046
	31	SiO_2	50-401 nm		
	1	Ag	100 nm		
	1	Si-wafer	/		
D3	1	Quartz	2500 nm		Rephaeli E, Raman A, Fan S (2013) Ultrabroadband photonic structures to achieve high-performance daytime radiative cooling. Nano Lett 13:1457–1461. https://doi.org/10.1021/nl4004283
	1	SiC	8000 nm		
	15	TiO_2	25-75 nm		
	15	MgF_2	35-105 nm		
	1	Ag	50 nm		
D4	1	TPX with 6% SiO_2 spheres	2500 nm		Zhai Y, Ma Y, David SN, et al (2017) Scalable-manufactured randomized glass-polymer hybrid metamaterial for daytime radiative cooling. Science (1979) 355:1062–1066. https://doi.org/10.1126/science.aai7899
	1	Ag	200 nm		
D5	1	PDMS	100 µm		Kou J long, Jurado Z, Chen Z, et al (2017) Daytime Radiative Cooling Using Near-Black Infrared Emitters. ACS Photonics 4:626–630. https://doi.org/10.1021/acsphotonics.6b00991
	1	Si-wafer	500 µm		
	1	silver	120 nm		

Name	composition				source
	# layers	Material	Thickness of each layer	Illustration	
D6	1	PET	300 µm		Mandal J, Fu Y, Overvig AC, et al (2018) Hierarchically porous polymer coatings for highly efficient passive daytime radiative cooling. Science (1979) 362:315–319. https://doi.org/10.1126/science.aat9513
	1	Steel	100 µm		
D7	1	Polyvinyl fluoride	500 µm		Mandal J, Fu Y, Overvig AC, et al (2018) Hierarchically porous polymer coatings for highly efficient passive daytime radiative cooling. Science (1979) 362:315–319. https://doi.org/10.1126/science.aat9513
	1	Al	200 µm		
D8	11	SiO_2	113-462 nm		Osuna Ruiz D, Lezaun C, Torres-García AE, Beruete M (2023) Metal-free design of a multilayered metamaterial with chirped Bragg grating for enhanced radiative cooling. Opt Express 31:22698. https://doi.org/10.1364/oe.492404
	11	Si	20-97 nm		
	1	Si-wafer	500 µm		
D9	4	SiO_2	54-230 nm		Raman AP, Anoma MA, Zhu L, et al (2014) Passive radiative cooling below ambient air temperature under direct sunlight. Nature 515:540–544. https://doi.org/10.1038/nature13883
	3	TiO_2	34-485 nm		
	1	Ti	20 nm		
	1	Ag	200 nm		
	5	Si-wafer	750 µm		
D10	4	SiO_2	314-951 nm		Kecebas MA, Menguc MP, Kosar A, Sendur K (2020) Spectrally selective filter design for passive radiative cooling. Journal of the Optical Society of America B 37:1173. https://doi.org/10.1364/josab.384181
	3	TiO_2	378-782 nm		
	1	Ag	100 nm		
	1	Si-wafer	/		

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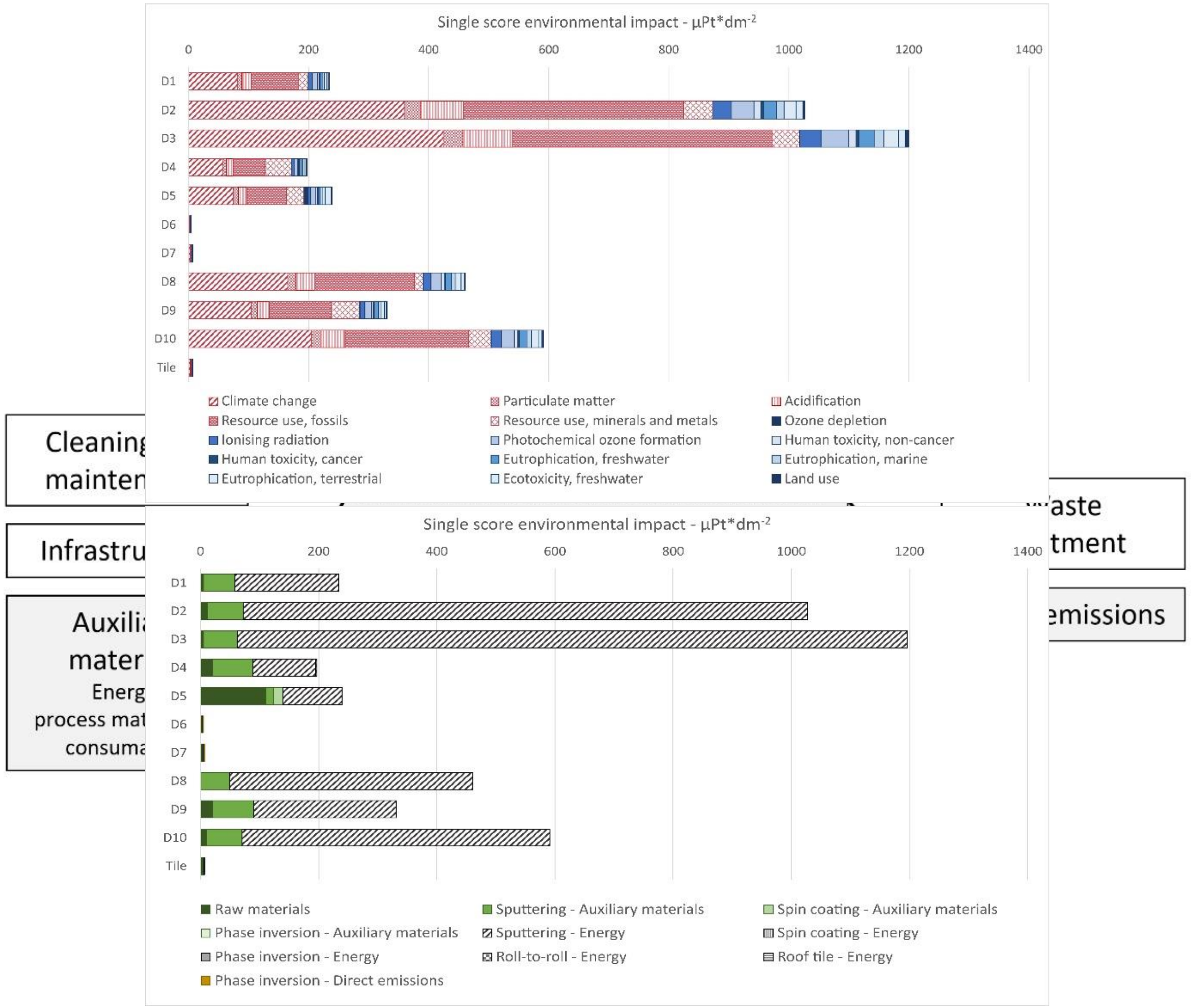
MIRACLE project (cradle-to-gate)

- Framework to assess and benchmark existing radiative cooling materials based on (cradle-to-gate) environmental impact and cooling performance

Framework

1. Selecting the RC materials
2. **Environmental impact assessment**
3. Cooling performance
4. Pareto front optimalization



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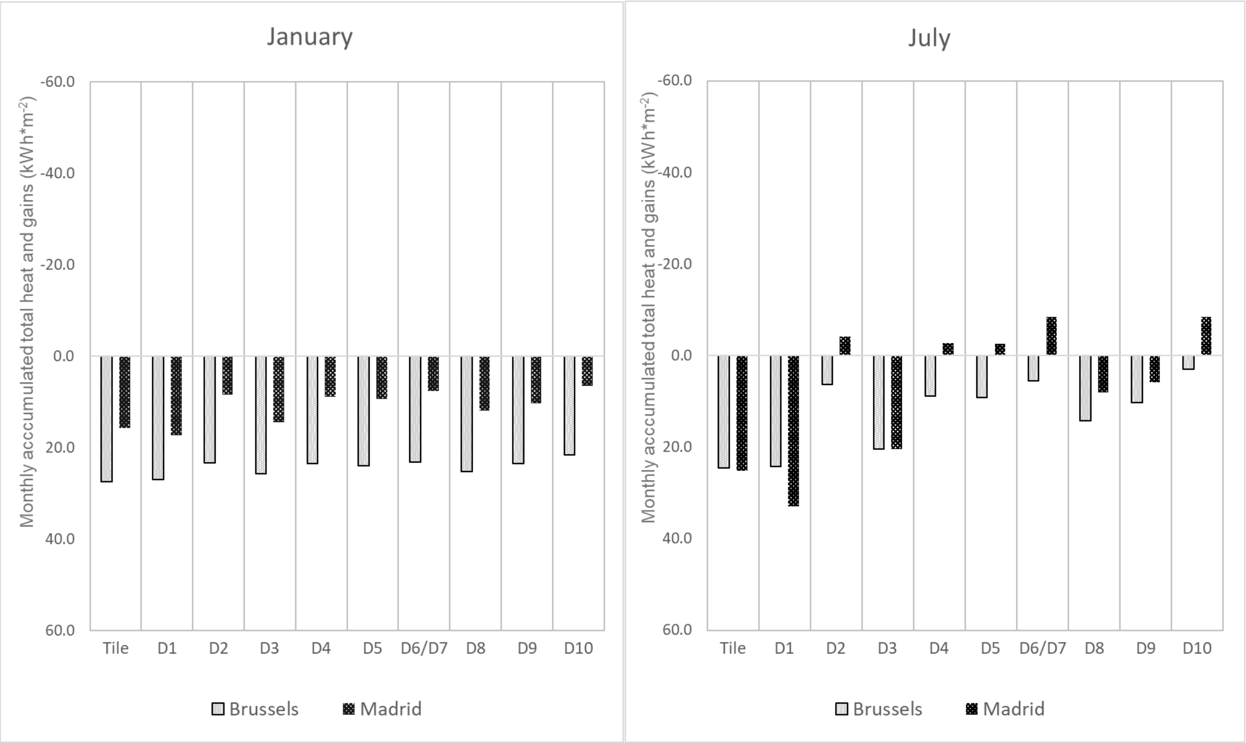

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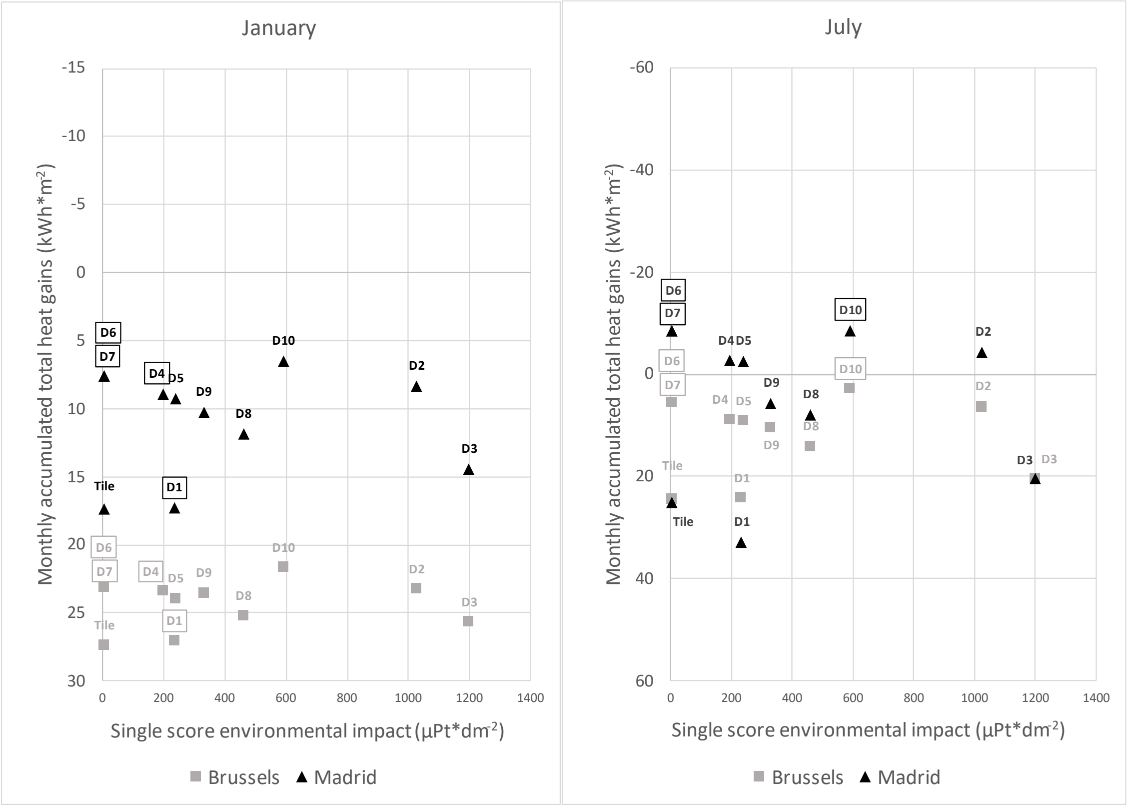
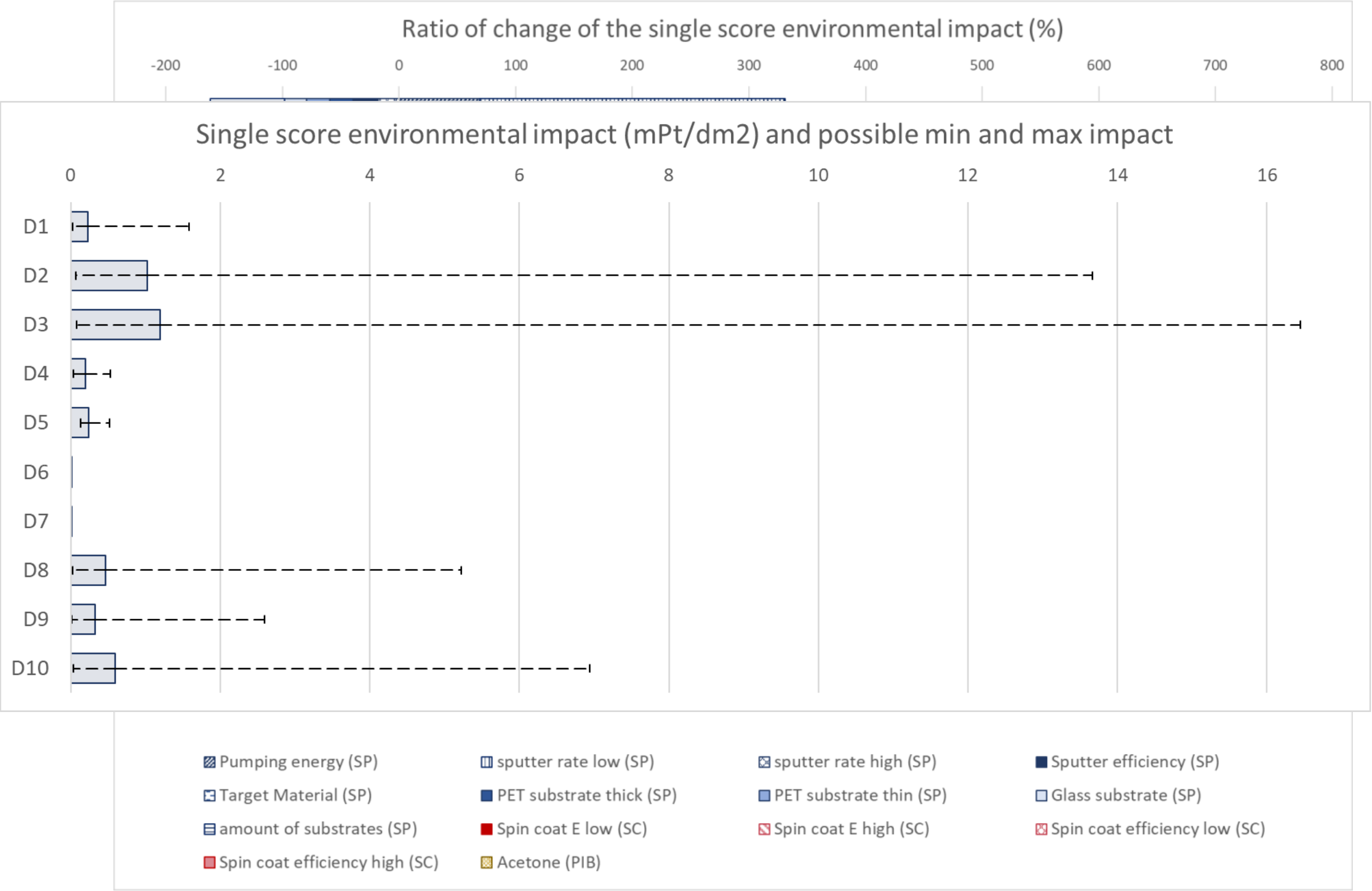


MIRACLE project (cradle-to-gate)

- Uncertainty data collection and assumptions
- Uncertainty from data collection bigger than uncertainty Ecoinvent data and LCA methodology
- Data collection = biggest challenge



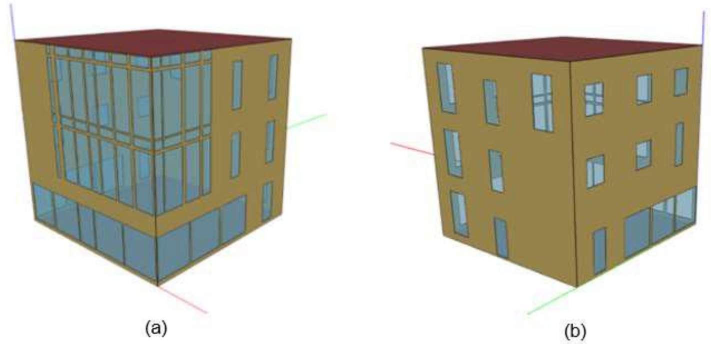
WP5 Impact

- Research topics
  - Environmental impact MIRACLE and state-of-the-art radiative cooling materials
  - **Effect of cooling potential on buildings (reduction energy use for cooling)**
    - In starting phase
  - Urban heat-island mitigation
  - Climate change mitigation (radiative forcing)

MIRACLE project (EnergyPlus)

MIRACLE Photonic Concrete

- EnergyPlus building energy simulation software
- Geometry of KUBIK test building
- Building components 20cm thick concrete
- We assess the outdoor and indoor temperature and energy use [kWh/m2]
- PMC = changing albedo and emissivity of the concrete structure
- Thermal insulation; U = 0.24W/m2



	Without PMC
Without thermal insulation	Simulation 1

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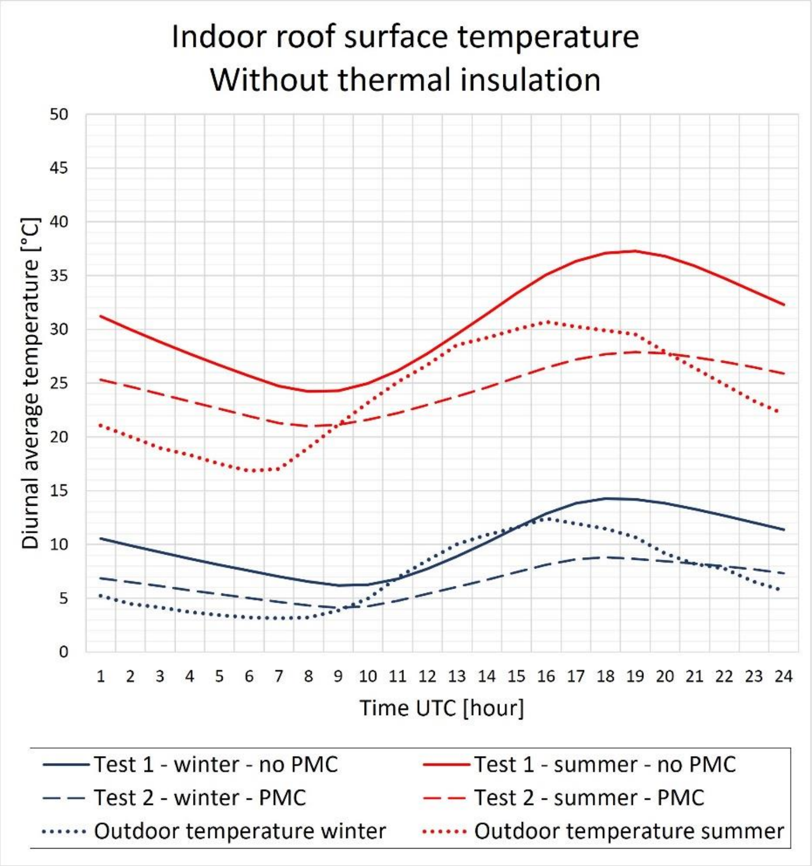
MIRACLE project (EnergyPlus)



WP5 Impact

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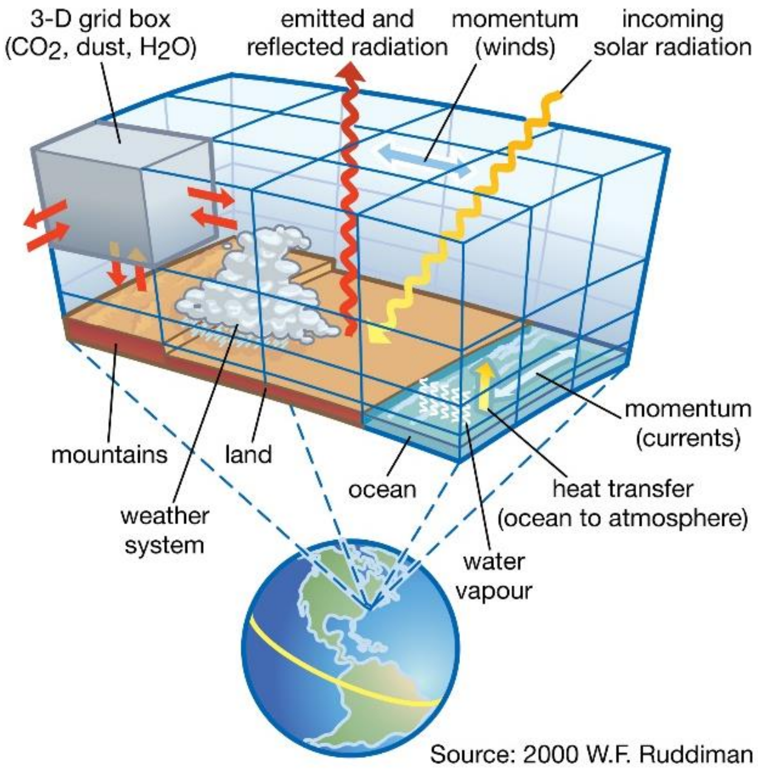
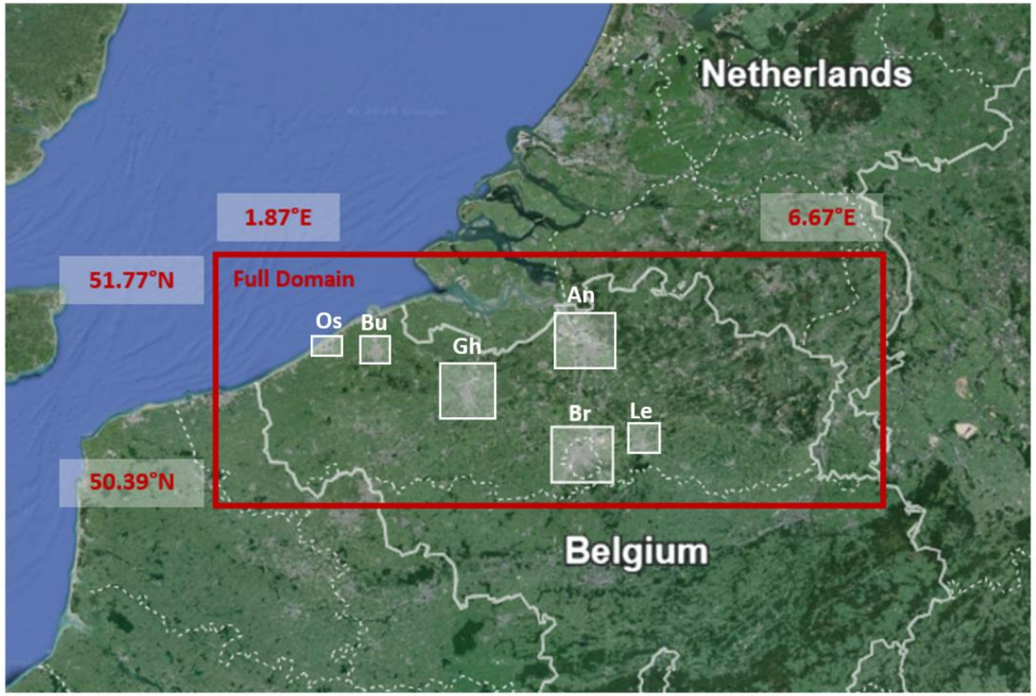
  - Climate change mitigation (radiative forcing)

MIRACLE project (Climate modelling)





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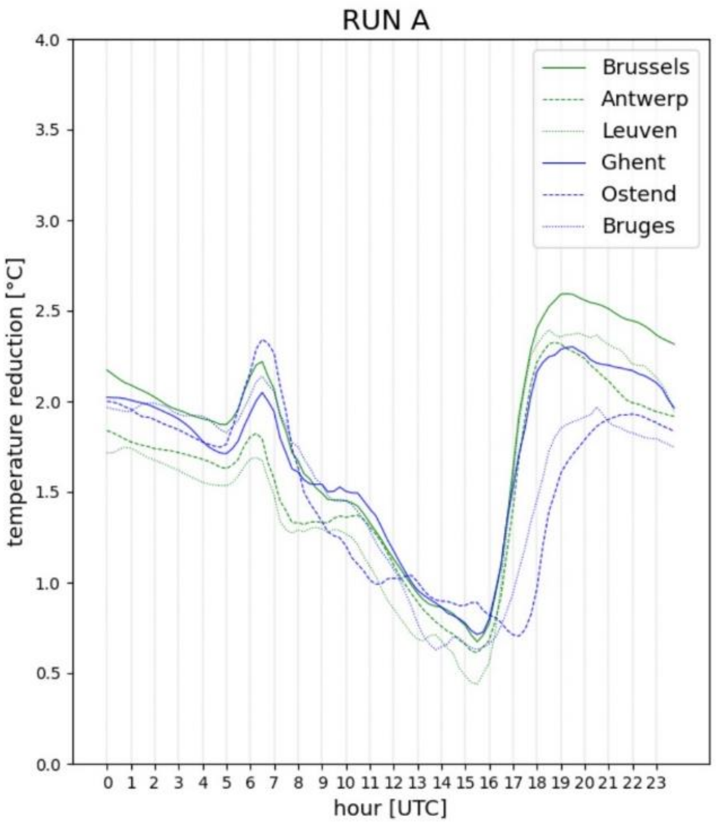
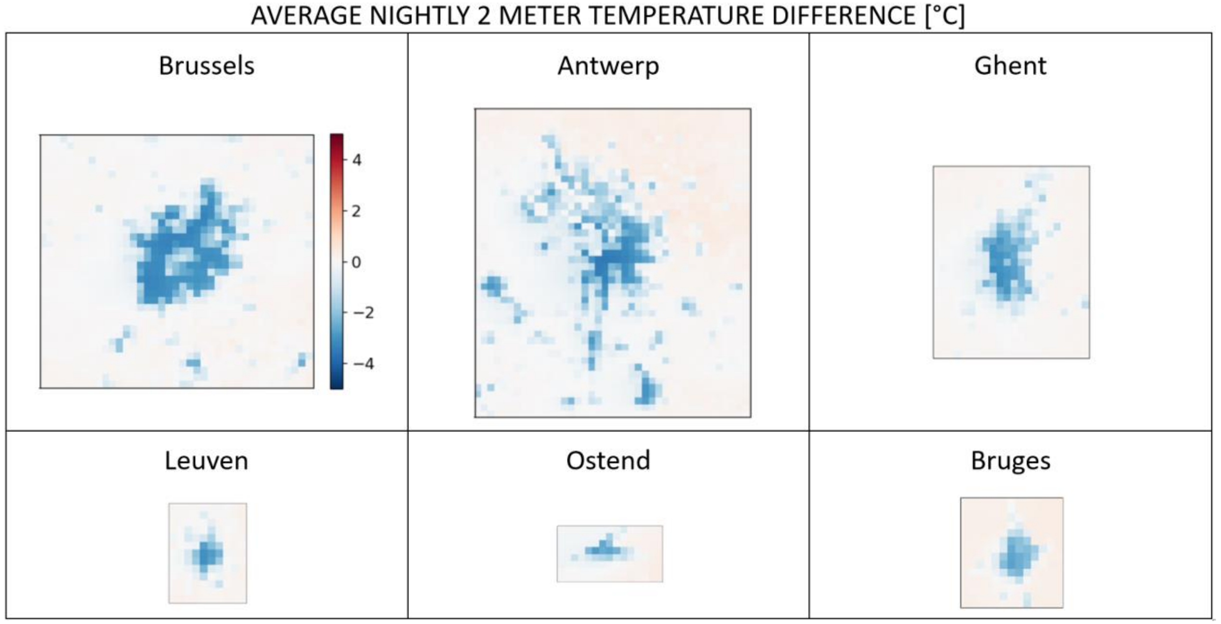
MIRACLE project (Climate modelling)





WP5 Impact

- Research topics
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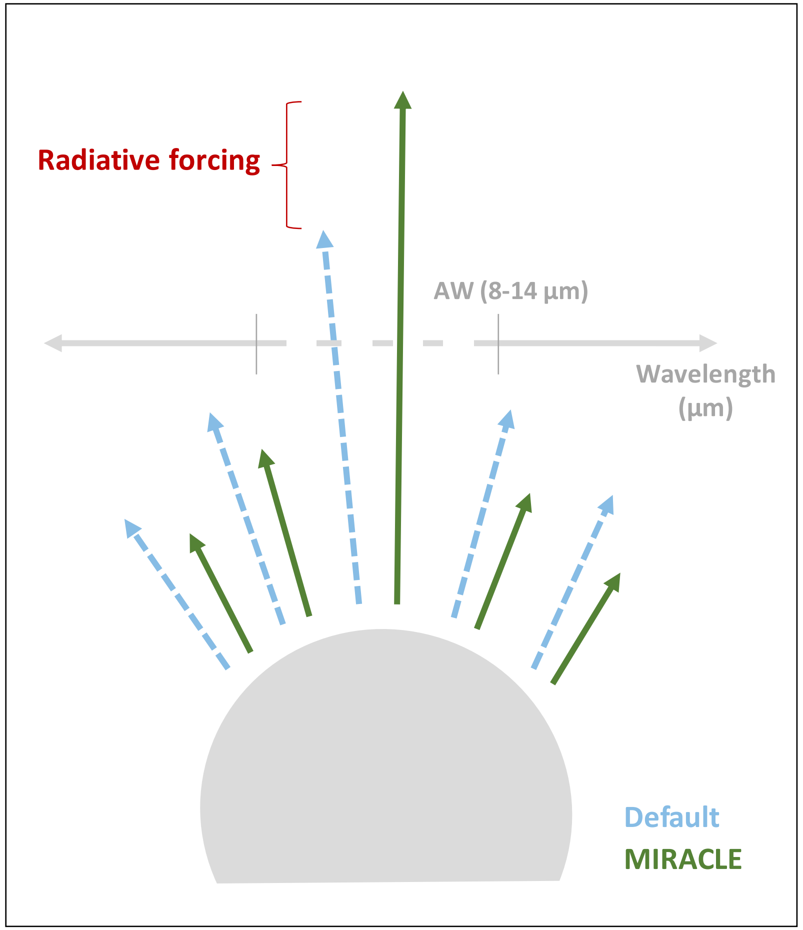
  - **Climate change mitigation (radiative forcing)**

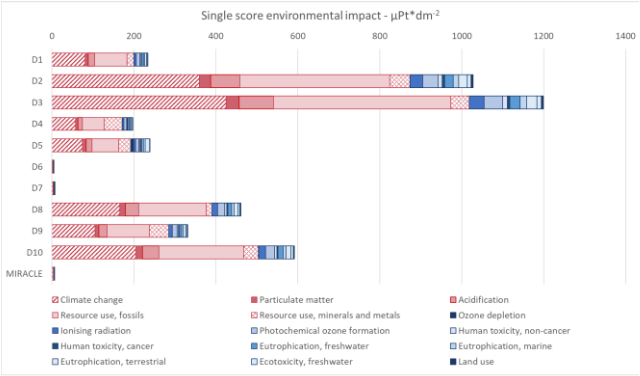
MIRACLE project (Climate modelling)



	Albedo difference	Emissivity difference		
		Mean surface temperature	Minimum surface temperature	Maximum surface temperature
Radiative forcing (W/m²)	65.61	4.476	4.332	4.609
Reduced emissions 5 day heatwave (kg CO_2 eq)	2.04E+07	1.39E+06	1.35E+06	1.43E+06

MIRACLE goal

- Combining all 4 topics
  - Expressing **environmental impact** in Kg CO_2 eq.
  - Expressing **urban heat island mitigation** in Kg CO_2 eq.
  - Expressing **climate change mitigation** in Kg CO_2 eq.
  - Expressing **cooling potential on buildings** in Kg CO_2 eq.



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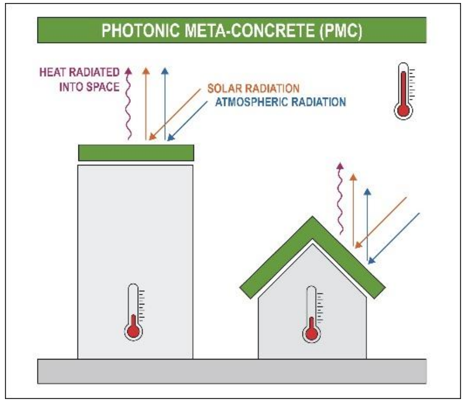

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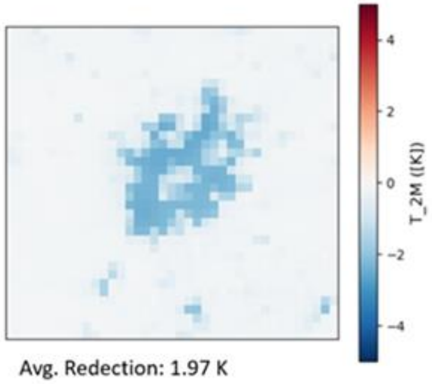

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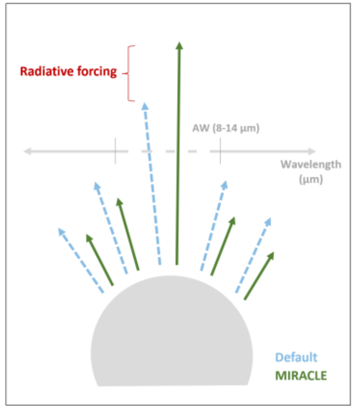
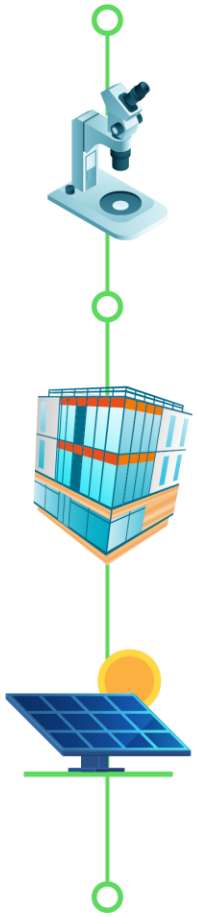


MIRACLE project

MIRACLE Photonic Concrete

The MIRACLE Project has been broken down into 6 work packages (WP)



This WP1 Components
Identification of the most appropriate composition for cement-based materials to function as a radiative cooling material

WP2 Concrete
Optimization of hierarchical porous structures to design and fabricate concrete foams that exhibit low non-radiative heat loses and optimized radiative properties

WP3 Photonic Metaconcrete (PMC)
Computational and experimental demonstration of nanophotonic metaconcretes

WP4 Prototype
To design, build and test a prototype to provide the proof of concept and performance assessment of the PMC developed in previous work packages

WP5 Impact
This WP aims at assessing the impact of PMC technology and points to a twofold objective: On the one hand, a deep analysis on the environmental impact of the Photonic Meta-Concrete. On the other hand, an exploratory study about the possibilities of Meta-Concrete in other applications like solar cells and communication technologies.

WP6 Management, Dissemination, Exploitation and Communication
This WP comprises the organization of MIRACLE, its scientific coordination and administrative management, and dissemination & exploitation & communication strategies

Cradle-to-gate environmental impact assessment of:

- The components and the mixtures of MIRACLE
- Extisting radiative cooling materials

Life cycle assessment of prototype and final mixtures, taking into account:

- Production process
- Construction
- Use phase
  - Positive (and negative) impact energy use of buidlings **(EnergyPlus)**
  - Possitive (and negative) impact on the urban heat island and climate change **(climate modelling)**
- End of life

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Thank you for your attention

Event: Sustainable Places 2024, Luxemburg

Date: 24/09/2024

Author/Partner: KU Leuven

MIRACLE
GA 964450

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 964450.