A "SUSTAINABLE-BY-DESIGN" APPROACH IN RESEARCH AND TECHNOLOGY ORGANIZATIONS

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LCM 2021 conference

September 7th, 2021

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CONTEXT

LIST is a research and technology organization developing innovative technologies in the fields of information/communication, environment and advanced materials

LIST implemented a sustainability strategy, with two complementary sides:

Operational impacts

- Carbon footprint (Scopes 1, 2 and 3 excl. downstream impacts of products/services)
- Implement/monitor reduction actions

Sustainability and Sustainable Development

- Knowledge transfer/decision support tools for partners
- **Sustainable by Design technologies**
- Contribution to UN SDGS, Green Deal Objectives

RESEARCH, INNOVATION & TECHNOLOGIES

How to operationalize this concept?

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OBJECTIVES

Develop a proof-of-concept for the operationalization of Sustainable-by-design:

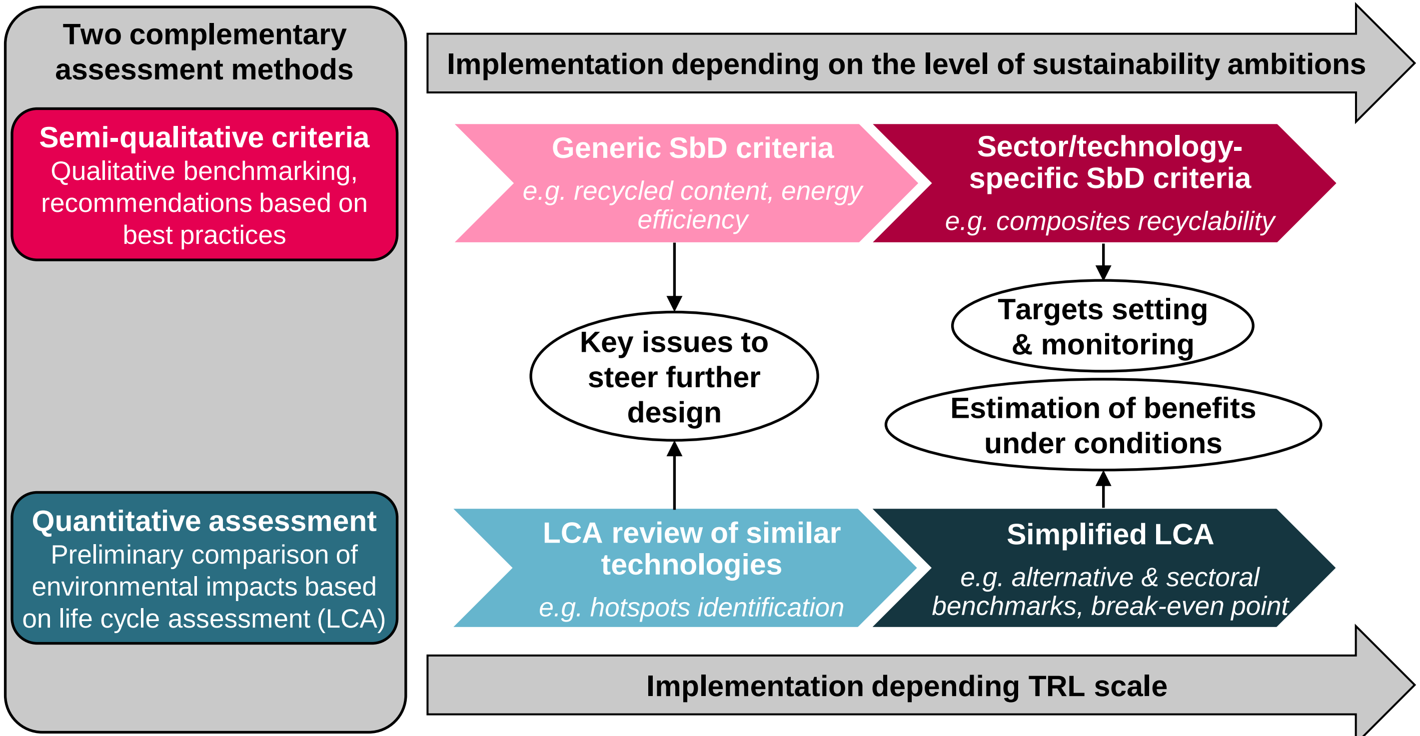
- **Definition of relevant criteria**
- **Development of an evaluation tool**
- **Test the approach for a case study on composite development**

APPROACH DEVELOPMENT

Specifications:

- Environmental, social and economic pillars should be considered, but a focus is made on environmental sustainability as priority
- Qualitative and quantitative criteria to cover different TRLs and design aspects
- Specific criteria at technology/sectoral level required to better support researchers
- Flexible tool depending on the ambitions, from key issues analysis to targets setting and monitoring
- The contribution to absolute sustainability targets could bring additional insights, especially due to the potential long time period before full implementation

OVERALL STRUCTURE OF THE PROOF OF CONCEPT



FRAMING QUESTIONS

Sustainable-by-Design framing

- What is the type of funding and associated expectations?
- What is the scope of research (e.g. new material, process development)?
- What are the sustainability ambitions (e.g. ensure minimum viability due to potential environmental taxes, regulations or resource shortage, or "eco-innovation" as central goal)?
- What is the starting and targeted TRL scale?
- What is the awareness/experience of the project team?

Level of ambitions/ levers of actions (first three questions)

Level of feasibility/ complexity (last two questions)

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SEMI-QUALITATIVE CRITERIA

- Generic environmental, social and economic criteria evaluation along the lifecycle
- Indicate if the developed technology contributes to the improvement, deterioration or neither of both of the listed indicators

Examples of criteria	Technology life cycle			Justification
	Production / assembly	Use/ operation	End-of-life	
Lower use of critical raw materials				
Lower exposure to hazardous chemicals				
Saving water / water security				
Improved material efficiency				
Improved energy efficiency				
Improved durability, reparability, reusability				
Providing an essential service/use/function				
Positive impacts on workers				
Exceed legal standards				
Reducing costs related to occupational injuries				
Contribution to digital transition				
Contribution to European resilient value chain				

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SEMI-QUALITATIVE CRITERIA

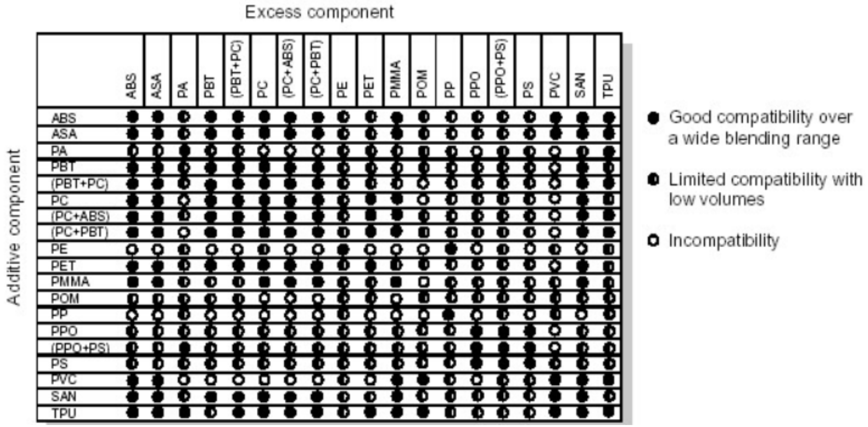
Development of specific criteria to better support researchers

For composites materials, it includes:

- Materials recyclability: classification based on current technology/market conditions

	Highly recyclable	Moderately recyclable	Poorly or not recyclable
Matrix	PP PET HDPE LDPE PS ABS	PVC PA6 PMMA PLA PC PEEK	Thermosets (e.g. melamine, epoxy, PU) Elastomers (e.g. polybutadiene rubber, EPDM) POM
Fillers	Thermoplastic filler (if grade identical to the thermoplastic used for the matrix – see list above)	Carbon fibres Glass fibres Thermoplastic filler (if grade identical to the thermoplastic used for the matrix)	Natural fibres (e.g. flax, hemp)

- Design for disassembly: materials compatibility

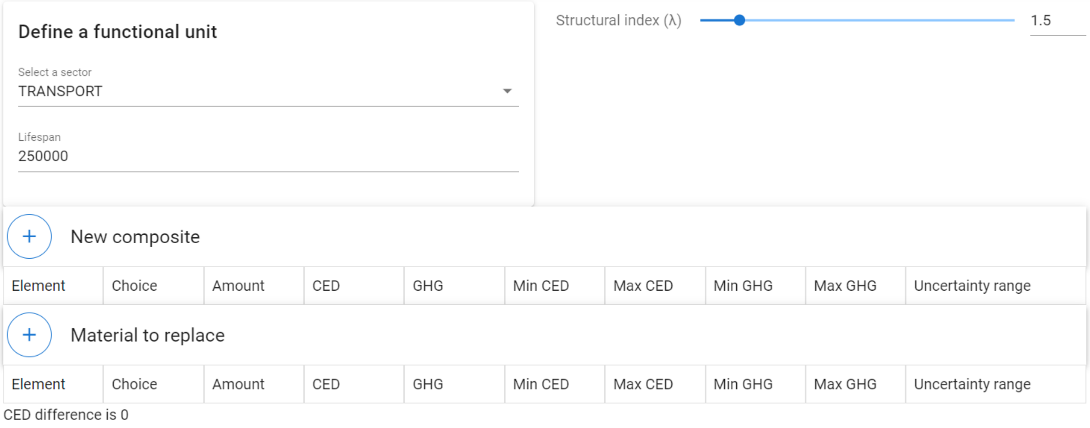


Source: Bayer

SIMPLIFIED LCA TOOL FOR COMPOSITES DEVELOPMENT

Lightweighting of passenger cars with carbon-fibre reinforced polymers (CFRPs)

- ➢ Web-based tool with user parameters (e.g. composite materials weight, density, stiffness)
- ➢ Pre-calculated impacts (CED and carbon footprint) for raw materials, processing and disposal
- ➢ Calculation of replaced mass ratio (Tapper et al. 2020) $R_{mass} = (\rho_C / \rho_S) \times (E_S/E_C)^{1/\lambda}$
- ➢ Calculation of energy savings during use phase (Tapper et al. 2020) $\Delta E_{use} = E_{WTW} \times \rho_f \times F_{CP}$



Tapper et al., 2020. An evaluation of life cycle assessment and its application to the closed-loop recycling of carbon fibre reinforced polymers. https://doi.org/10.1016/j.compositesb.2019.107665

SIMPLIFIED LCA TOOL FOR COMPOSITES DEVELOPMENT

Lightweighting of passenger cars with carbon-fibre reinforced polymers (CFRPs)

Outputs to support technology design and understand its benefits:

- Choice of materials/processes thanks to unitary impacts + replacement matrix

Comparison of substitution rates with structual index=1.5

● lighter

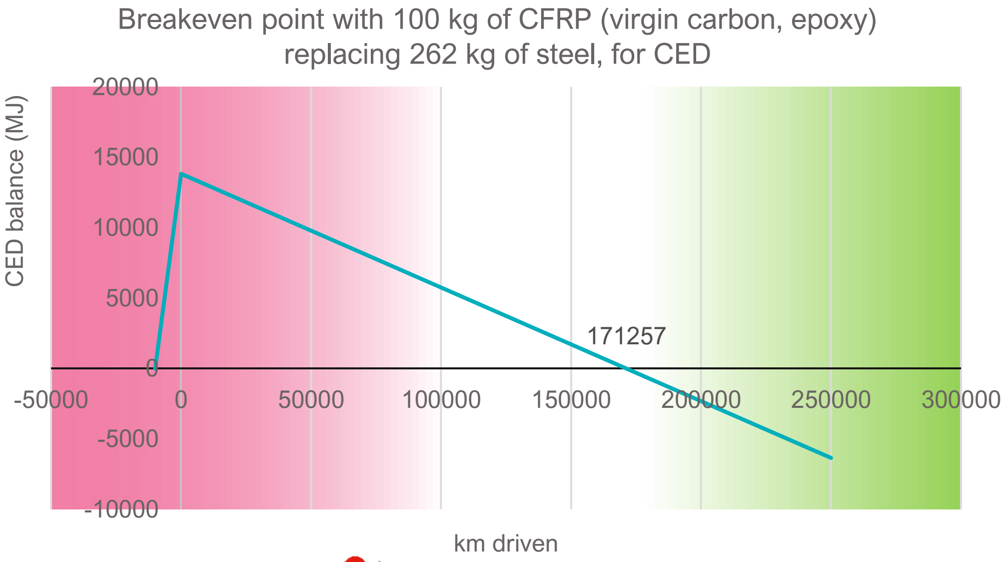
	Glass-filled epoxy (35%)	Glass-filled polyester (35%)	Glass-filled nylon (35%)	S-glass epoxy (45%)	Carbon epoxy (61%)	Kevlar epoxy (53%)	Cast Iron, grade 20	Steel, AISI 1045	Aluminum 2045-T4	Aluminum 6061-T6	Alumina	MgO	Nylon 6/6	Polyethylene (HDPE)	Polypropylene	Epoxy	Phenolic
Phenolic	34.2	49.1	41.5	23.9	9.06	13.1	51.1	34.9	23.8	24.7	11.8	16	89.2	192	132	83.5	100
Epoxy	41	58.8	49.6	28.6	10.8	15.6	61.2	41.7	28.5	29.6	14.1	19.1	107	229	158	100	120
Polypropylene	26	37.3	31.5	18.2	6.88	9.91	38.8	26.5	18.1	18.8	8.95	12.1	67.7	145	100	63.4	75.9
Polyethylene (HDPE)	17.9	25.7	21.6	12.5	4.73	6.82	26.7	18.2	12.4	12.9	6.16	8.33	46.6	100	68.8	43.6	52.2
Nylon 6/6	38.4	55.1	46.5	26.8	10.2	14.6	57.3	39.1	26.7	27.7	13.2	17.9	100	215	148	93.7	112
MgO	215	308	260	150	56.8	81.8	321	218	149	155	73.9	100	559	1200	826	524	627
Alumina	290	417	352	203	76.8	111	434	296	202	210	100	135	757	1620	1120	709	848
Aluminum 6061-T6	138	199	168	96.7	36.6	52.8	207	141	96.3	100	47.7	64.5	361	774	533	338	404
Aluminum 2045-T4	144	206	174	100	38	54.8	215	146	100	104	49.5	67	374	804	553	351	420
Steel, AISI 1045	98.2	141	119	68.6	26	37.5	147	100	68.3	70.9	33.8	45.8	256	549	378	240	287
Cast Iron, grade 20	67	96.1	81.1	46.8	17.7	25.5	100	68.2	46.6	48.4	23.1	31.2	174	375	258	163	196
Kevlar epoxy (53%)	262	376	318	183	69.4	100	392	267	182	189	90.3	122	683	1470	1010	640	766
Carbon epoxy (61%)	378	543	458	264	100	144	565	385	263	273	130	176	985	2110	1450	922	1100
S-glass epoxy (45%)	143	206	173	100	37.9	54.6	214	146	99.6	103	49.3	66.7	373	801	551	349	418
Glass-filled nylon (35%)	82.6	119	100	57.7	21.8	31.5	123	84.1	57.4	59.6	28.4	38.5	215	462	318	202	241
Glass-filled polyester (35%)	69.7	100	84.4	48.7	18.4	26.6	104	70.9	48.5	50.3	24	32.5	181	390	268	170	203
Glass-filled epoxy (35%)	100	144	121	69.8	26.5	38.1	149	102	69.6	72.2	34.4	46.6	260	559	385	244	292

SIMPLIFIED LCA TOOL FOR COMPOSITES DEVELOPMENT

Lightweighting of passenger cars with carbon-fibre reinforced polymers (CFRPs)

Outputs to support technology design and understand its benefits:

- ➢ **Choice of materials/processes thanks to unitary impacts + replacement matrix**
- ➢ **Realistic benefit along the lifecycle compared to existing materials?**
  - ✓ Distance break-even point (extra production impacts offset by use phase savings)
  - ✓ Production impacts break-even point in case of missing data (completely new material)



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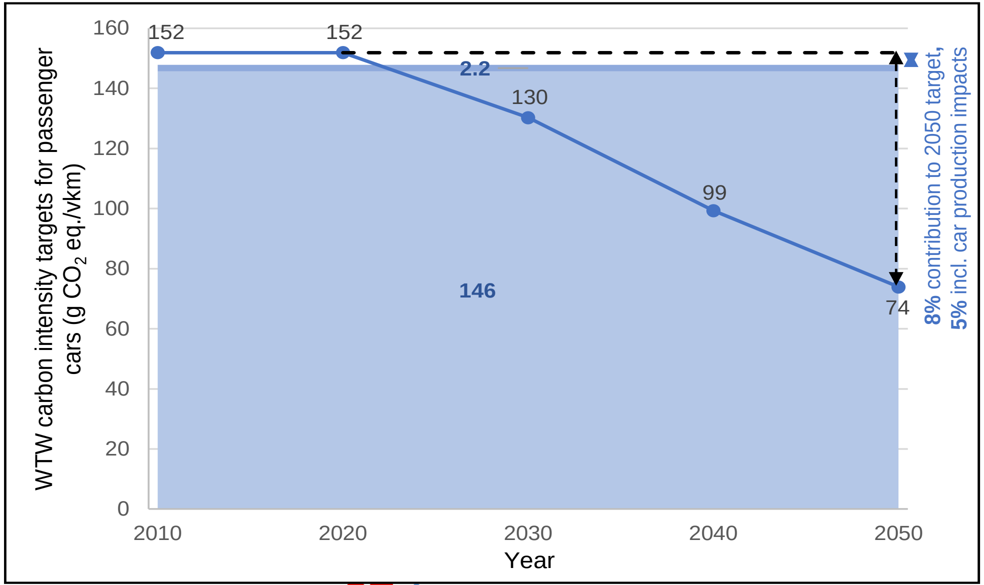
- **Realistic benefit along the lifecycle compared to existing materials?**
  - ✓ Distance break-even point (extra production impacts offset by use phase savings)
  - ✓ Production impacts break-even point in case of missing data (completely new material)
- **Contribution to the sectoral decarbonization target for 2050?**
  - ✓ Share to the reduction target from below 2°C pathways for passenger cars (SBTi)



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CONCLUSIONS AND FURTHER DEVELOPMENT

- **Researchers should investigate systematically the sustainability of the solutions they develop**
- **A proof-of-concept was developed to allow a multi-level evaluation and thus facilitate its use regardless the level of development, ambition or competence**
- **The approach can support researchers to identify the key design choices that should be further improved and understand the potential benefits of the developed technologies**
- **The comparison with sustainability targets could support the prioritization of technologies that need to be implemented to reach "absolute sustainability" levels**
- **Further development pathways of the tool:**

✓ Integration of all evaluation steps into a single web-platform with a monitoring along TRL scale
✓ Increase the number of user parameters (e.g. specific energy use for a processing step, choice of market application)
✓ Include quantitative evaluation of social and economic impacts (LCC, S-LCA)
✓ Interpretation and visualization of results (MCDA, trade-offs warning, colour scale for data quality, etc.)

thank you

contact information

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