

A structured approach to guide technological developments towards sustainability

■ Context and concept

- **Motivations**
 - Sustainability is attracting increasing interest, but various concepts and terms with different definitions are used when referred to the technology domain

- **Approach**
 - Visual framework that helps to position and drive research projects and technology developments towards sustainable innovation
 - Contribution to the coherence of concepts related to sustainability

Initial version of the framework published in:

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Sustainable technology and Technology for sustainability: The paths towards Eco-innovation

Electronics Goes Green 2024



■ The framework

Level 1
Life Cycle Sustainability Assessment
of an existing technology

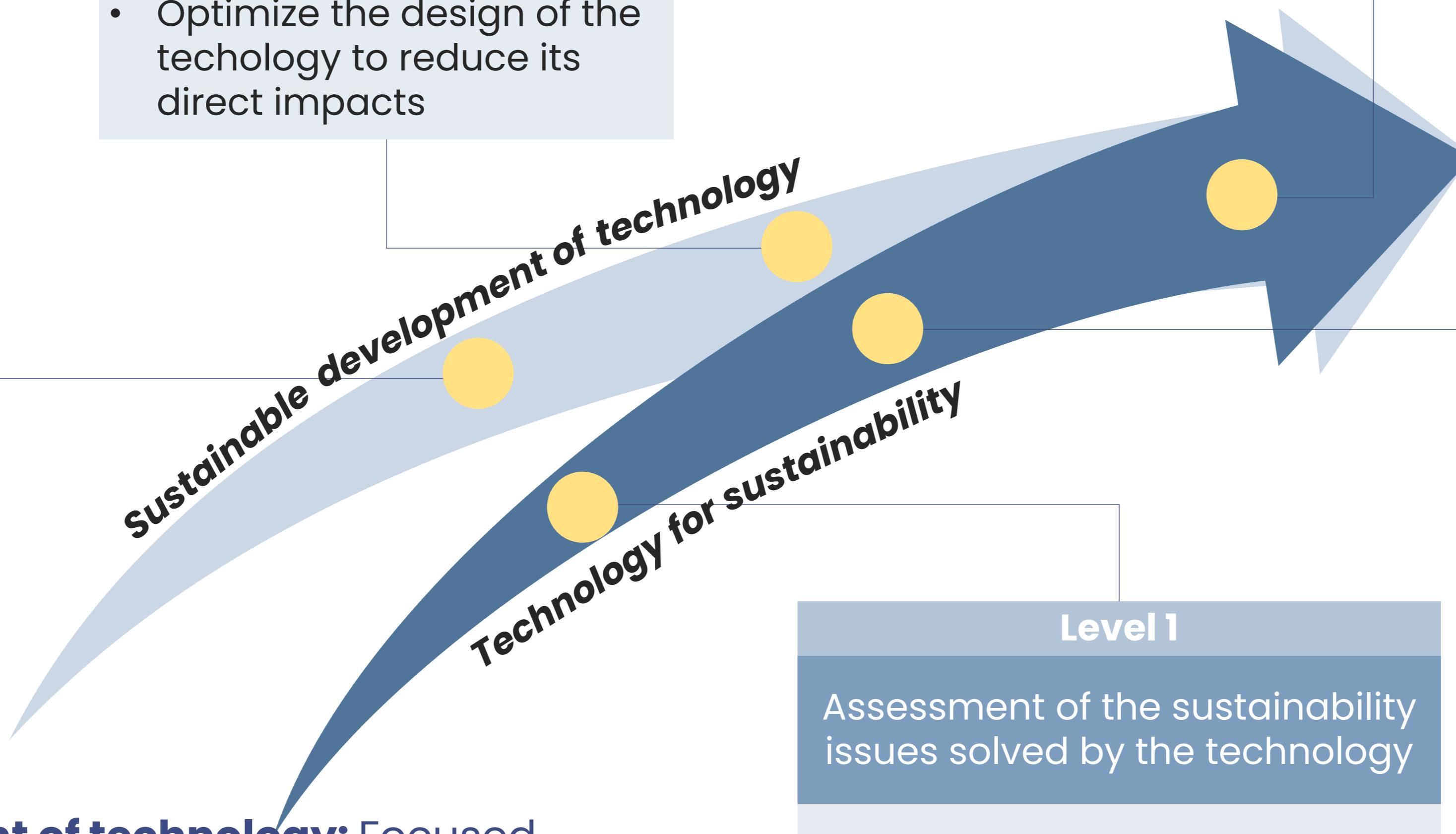
- Focus on the technology itself
- Measure the direct impacts

Level 2
Eco-socio design
taking into account social and economic considerations

- Optimize the design of the technology to reduce its direct impacts

Level 3
Sustainable innovation
Benefits of eco-socio designed technology's deployment exceed its costs by using results of both paths

- Only achievable if the technology has validated all the previous steps and has net-positive impacts



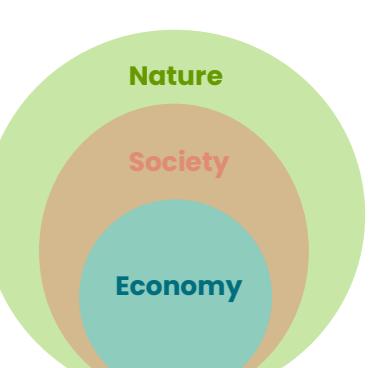
Sustainable development of technology: Focused on reducing the direct impacts generated by the technology itself on its own value chain

Technology for sustainability: Technology designed or implemented to tackle sustainability issues

Level 2
Assessment of the indirect impacts of the solution

- Take into account the higher order impacts, such as rebound effects

- Adoption of the strong sustainability model
- For each level, at least the environmental pillar must be addressed



■ Case study: AI for heat pump control

The AI4HP project

Introduction of an innovative incremental AI algorithm in the command system of a heat pump to forecast hot water needs depending on dynamic factors

Coordinator: Lilli Frison (Fraunhofer ISE)
Incremental AI: Marina Reyboz (CEA-LIST)
Laboratory tests: Hugues Bosche (EDF R&D)



Level	Sustainable development of technology	Technology for sustainability	Sustainable innovation
Level 1	LCA of the AI algorithm (highly parametric because the algorithm is not fully specified at the current development status)	Use of the parametric LCA developed in Level 1 for design space exploration: <ul style="list-style-type: none"> • Should the algorithm run on the cloud or embedded in HP? • Design of a lightweight AI 	Using results of both paths, demonstrate that environmental benefits of eco-designed technology's deployment exceed its costs
Level 2	1. Compare the AI algorithm with baselines in terms of forecast accuracy and potential energy savings. 2. Verify those projections with laboratory tests, then real-world tests	Exemple of identified higher order effects: <ul style="list-style-type: none"> • Rebound effect: if AI-controlled HP saves energy, it saves money, which could boost HP deployment 	

■ TRL integration

- Framework-based sustainability analysis extended to integrate Technology Readiness Level
- Adoption of four groups of TRL based on the application environment

TRL 1-2: Research (Documentary environment)

TRL 3-4: Development (Laboratory environment)

TRL 5-6: Demonstration (Representative environment)

TRL 7-9: Deployment (Customer operational and final environment)

Example

TRL 1-2	Sustainable development of technology	Technology for sustainability
	Exploratory LCA with data from published articles and databases	<ul style="list-style-type: none"> • Evaluation of the emissions within the application domain • Consequence tree analysis

