ETSAP Fall Workshop
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Modelling Circular Economy in TIMES

Making a linear model more circular

S. Simoes[a], P. Fortes[b]

[a] LNEG Laboratório Nacional de Energia e Geologia I.P.

[b] CENSE NOVA NOVA School of Science & Technology

EU CALL CLOSED IN SEPTEMBER 2021

HORIZON-CL5-2021-D1-01-02: Modelling the role of the circular economy for climate change mitigation

Expected Outcome:

Project results are expected to contribute to all of the following expected outcomes:

- **Improve existing** European and/or global **climate mitigation models** by **better representation of basic industrial value chains** (including reliable data) and **potential mitigation technologies** including the impact of circular economy
- Improve the **quantification of the impacts and potentials** of the circular economy for climate change mitigation
- Support the **integration of the circular economy into climate action**, policies and their evidence base, including externalities
- Support the **integration of the GHG emission reduction / mitigation in the circular economy criteria**

EU CALL CLOSED IN SEP 2021

HORIZON-CL5-2021-D1-01-02: Modelling the role of the circular economy for climate change mitigation

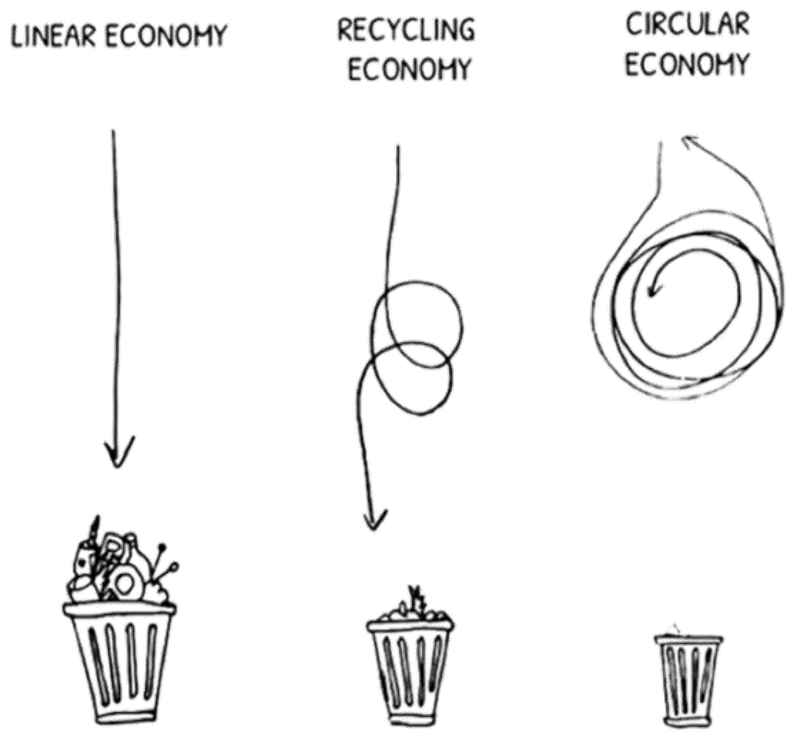
"look beyond the specific measures needed to deliver a circular economy and **propose a framework** for revealing, demonstrating and quantifying the circular economy's potential contribution to climate goals, as well as **improving the coverage of basic industry value and supply chains in models** (or suites of models) used to analyse mitigation pathways"

(…) also **improve the understanding of the connections between climate action and other environmental areas** and issues **as well as social and health issues** (…)

CIRCULAR ECONOMY

"Looking beyond the *current take, make and dispose* industrial model, the **circular economy** (…) aims to redefine products and services to design waste out, while minimising negative impacts".

(Ellen MacArthur Foundation)



Circular Economy examples:

> Production of products with less raw materials
> Substitution of fossil materials by renewable biomaterial (e.g., plastics vs bioplastic)
> Increase of products lifetime
> Sharing services such as mobility

TIMES VS CIRCULAR ECONOMY (CE)

TIMES models currently represent **linear patterns of economic activity**.

- GHG emissions are **modelled per economic sector and no downstream value chains** are considered
- **upstream value-chains are poorly represented**, **indirect GHG emissions** are mostly not included
- **extending products lifetime**, **sharing models**, and **feedback loops** - generally not considered
- increased resource use for climate mitigation is not addressed

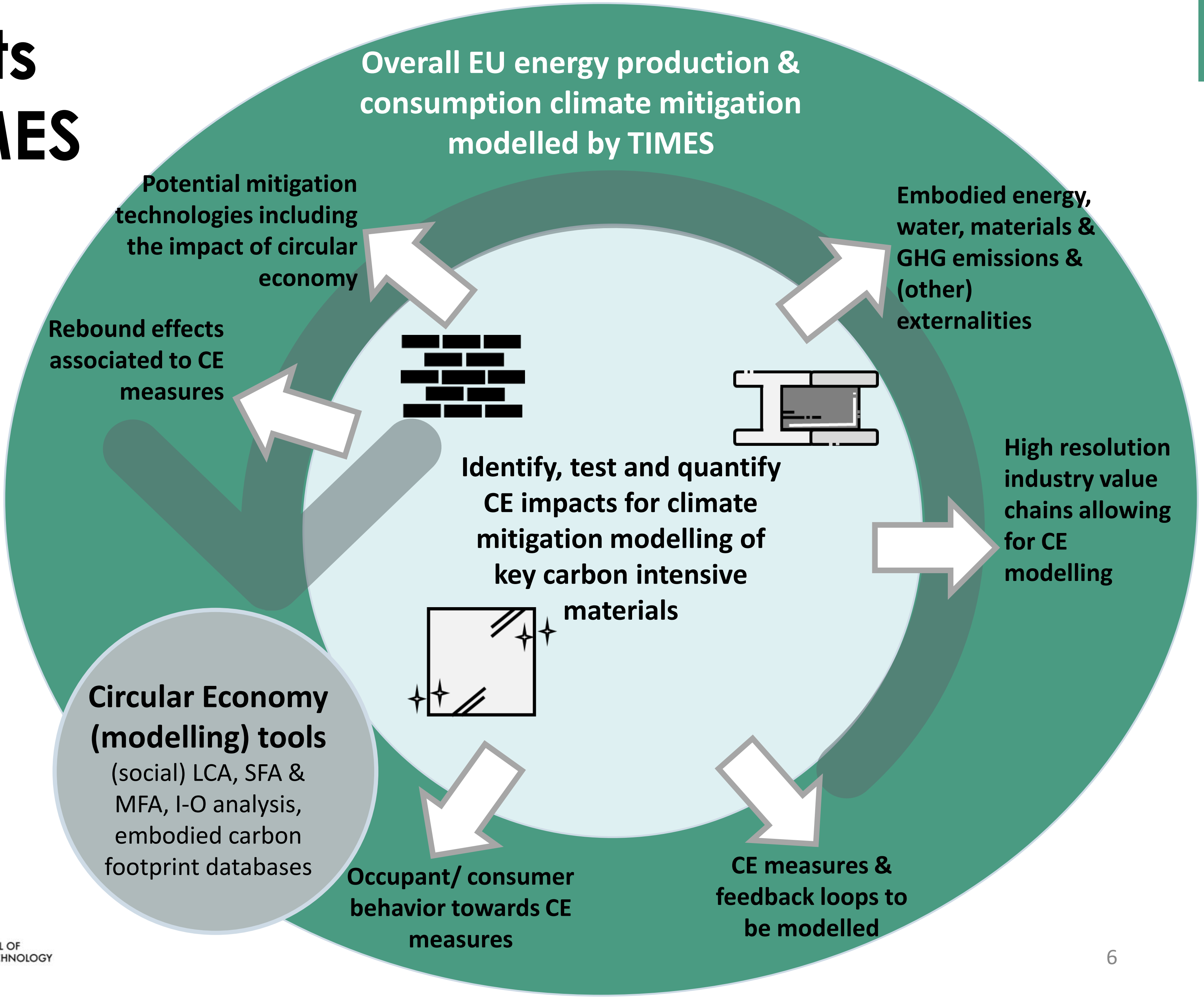
TIMES models cannot account for materials' circularity

there is increased attention to the need to transform linear models into circular models

Bridge the gap between **TIMES** modelling and **CE analytical tools** used for cradle-to-cradle assessments (e.g., LCA-Life Cycle Assessment, MFA-Material Flow Analysis, or value-chain analysis)

TIMES models need a **high level of technical detail** to adequately represent CE measures and to integrate feedback loops characteristic of CE practices

Some elements for making TIMES less linear



SOME OUTPUTS

Policy recommendations
GHG emissions gains
Impacts on GHG abatement and on energy costs
Hotspots for CE measures that impact GHG mitigation

APPROACHES TO INTEGRATE CIRCULAR ECONOMY IN TIMES

1. Consider changes in demand for energy services due to modifications in consumption patterns (e.g. due to sharing spaces)
2. Change allocation of emission across economic sectors (e.g. emissions are allocated to cement users not cement producers)
3. Include impacts of CE as externalities (e.g. land-use) as “costs”
4. **Disaggregate sectors as construction and waste management**
5. **Model sectors in more detail with mass balances (currently mostly done for steel, cement, glass and paper)**
6. **Include explicitly feedback loops (& value-chain) between material producers and consumers**

Can be applied to these sectors:

- **Buildings (energy use in commercial & residential buildings)**
- **Construction (renovating, demolishing and building new)**
- **Electricity generation (including offshore power)**
- **Refining & hydrogen production**
- **Cement production**
- **Glass production**
- **Steel production**
- **Other industry**
- **Mobility (passenger & freight)**
- **…**

MAKING TIMES MORE CIRCULAR

CE Strategies	Description	How they can be approached in TIMES
Smarter product use and manufacture		
R0 Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product	TIMES does not focus on "final end-use" use products for households except for cars and appliances. Can be considered intermediary products are considered (e.g. clinker) and replacement possibilities with radically different products
R1 Rethink	Make product use more intensive (e.g. by sharing product)	Modeling of shared buildings occupancy, shared mobility, or sharing of offshore RES foundations with other uses
R2 Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials	This is already done in TIMES
Extend lifespan of product and its parts		
R3 Reuse	Reuse by another consumer of discarded but still functional product	Can be considered with diferente demand scenarios?
R4 Repair	Repair and maintenance of defective product so it can be used with its original function	Model the material, energy & water flows associated with buildings repair & renovation? Other repair activities are rather tricky….
R5 Refurbish	Restore an old product and bring it up to date	
R6 Remanufacture	Use parts of discarded product in a new product with the same function	Redesign value chains to include all possible feedback loops and include these in TIMES industry sectors
R7 Repurpose	Use discarded product or its parts in a new product with a different function	
Useful application of materials		
R8 Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality	Value chains redesign to include recycling feedback loops and model these in mass balances in TIMES
R9 Recover	Incineration of material with energy recovery	TIMES model already considers waste incineration for electricity and heat production

EXAMPLE OF MODELLING OF CE IN TIMES_PT

	Circular Economy Rationale	*Modelling Assumptions*
Construction & Buildings	- Efficient management of construction materials - Use of new materials (e.g., wood) - Increasing valuation of Constr.&Demolition waste	↓ **Cement demand** ↓ **Clinker incorporation** in cement production
	- Multifunctional and shared buildings - Shared equipment's - Net Zero Buildings	↓ Area, ↑insulation, ↓ **heating and cooling needs** ↓ Lower equipment ownership: Energy services needs transfer to services ↑ Decentralized Solar PV potential
Mobility	- Implementation of sharing systems - Autonomous shared vehicles - Higher digital market and inverse logistics;	↑ Increase in the **occupancy rate** and **load factor** of vehicles ↑ Higher **distance travelled per vehicle** ↑ Demand for **goods mobility** Last mile transport - Transfer of goods transported in heavy road vehicles to light vehicles
	Vehicle technology/design - evolution of materials (e.g., less weight, 3D printing)	↑ **vehicle efficiency** and **life-time**

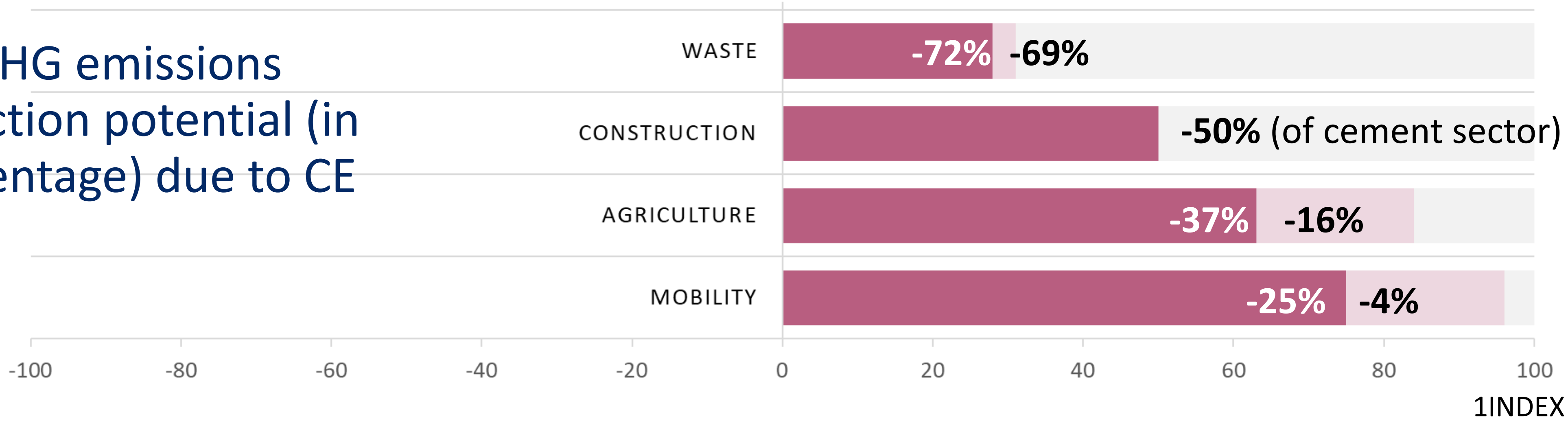
EXAMPLE OF MODELLING OF CE IN TIMES_PT

RNC2050
Carbon Neutrality Roadmap

Industry & Waste

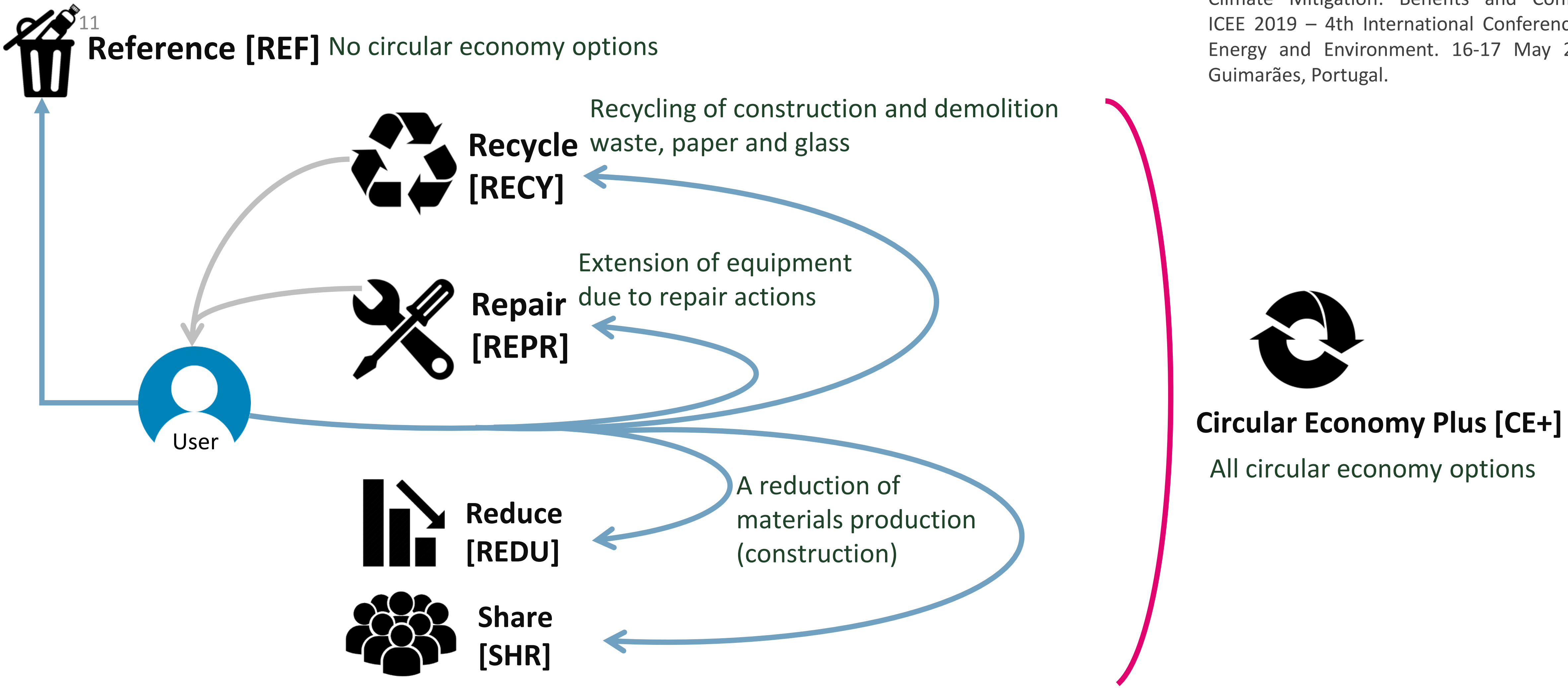
Circular Economy Rationale	*Modelling Assumptions*
- Optimised packaging for further collection (e.g., dark glass) - Substitution of plastic package per paper/glass	↑ **Secondary materials incorporation** in industrial processes (e.g., paper, glass, steel) ↑ Paper and glass demand
- Increase separated multi-material collection, including bio-waste	↓ **Waste production per capita** / ↓ Waste in landfills ↑ Use of biogas (higher potential)

GHG emissions reduction potential (in percentage) due to CE



EXAMPLE OF MODELLING OF CE IN TIMES_PT

Fortes, P., et al. (2019). Circular Economy and Climate Mitigation: Benefits and Conflicts. ICEE 2019 – 4th International Conference on Energy and Environment. 16-17 May 2019, Guimarães, Portugal.



EXAMPLE OF MODELLING OF CE IN TIMES_PT

	REF	REDU	SHR	REPR	RECY	CE+
Energy service **demand**	Based on socio-economic development	-45% of cement and ceramic production	-50% for households washing and drying machines (transferred to services)	=REF	=REF	=REDU
Tecnhologies life-time and O&M costs	Standard according to the existing literature	=REF	Buildings appliances • Lifetime: -10% • Use: +10% annual • O&M: +5% Freight transport • Load Factor: +35% Shared vehicles*	Buildings appliances and private vehicles: • Lifetime and O&M costs: +20%	=REF	=SHR and REPR
Recycling **material incorporation**	• Clinker/Cement ratio: 75% • Glass: 50% • Paper: 18%	=REF	=REF	=REF	• Clinker/Cement ratio: 65% • Glass: 75% • Paper: 70%	= RECY

*Occupation rate: 3.5 persons/vehicle (1.5 p./vech. REF), Travel distance: 100 000 km vehicle/year (20 000 km/vech. REF); Lifetime to 4-years (15 years REF).

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CONCLUSIONS FROM CE MODELLING IN TIMES

> In general CE contributes to a reduction of energy consumption and have **positive effects in GHG emissions reduction** in the evaluated cases;

> Benefits are **not straightforward**:

- **Recover and recycling processes may lead to a lower availability and higher prices of some sub-products** - its scarcity may conduct to further substitutions that may not be optimal from a climate mitigation perspective.
- **Extension of technologies life-time conduct to a reduction of energy efficiency**.

> **Limitations**:

- Highly **uncertain** assumptions;
- TIMES is mostly focused on the **energy system**, representing in a roughly way other material/services flows that may have a crucial role in CE.

FINAL REMARKS

- There is an urgent call for speeding up mitigation efforts and to minimise its environmental (and social impacts) – thus **circular economy strategies should be considered** in climate mitigation efforts.
- There are **several possible approaches** to integrate circular economy in TIMES models, with varying degrees of complexity.
- It is unclear yet to what extent such approaches are **compatible and worthwhile** – will they add unnecessary complexity to already rather large models? What is the perfect trade-off between model comprehensiveness and usefulness?
- To make TIMES more circular it will always be necessary to **work in cooperation** with experts in value chain management, industrial processes and other

Thank you!

LNEG
Laboratório Nacional de Energia e Geologia I.P.

CENSE

NOVA
NOVA SCHOOL OF SCIENCE & TECHNOLOGY

sofia.simoes@lneg.pt
p.fs@fct.unl.pt