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Analysing the impact of retrofitting and new construction through probabilistic life cycle assessment.

A method applied to the environmental-economic payoff value of an intervention case in the Albanian building sector

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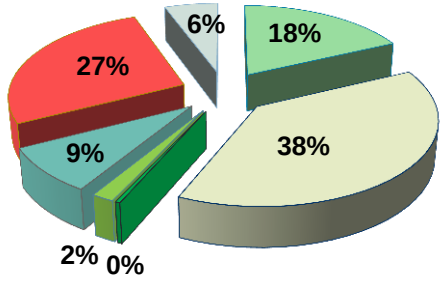
Overview of the existing building stock in EU

- EU - replacement rate of old buildings by new build = 1% / year (1)
- Renovation rate= 1-2% * year (1)
- More than 90% of existing stock in EU was built before 1990 (1) → **Major role** in employing **Energy Efficiency** goals
- Importance of joint pursuit in global scale for achieving CO2 emissions reduction until 2050 → Engagement of **non EU countries** in the **EE** and **environmental protection strategies**

(1) European Parliament *Boosting Building Renovation: What Potential and Value for Europe?* 2016 Study for the ITRE Committee

- Candidate country into EU
- Contracting Party of **Energy Community Treaty** (2006)



National total- 2 067 ktoe (2)

- Industry
- Transport
- Aviation
- Other modes of transport
- Service
- Residential
- Others

SLED

(Support for Low Emission Development in South Eastern Europe)

- Building sector

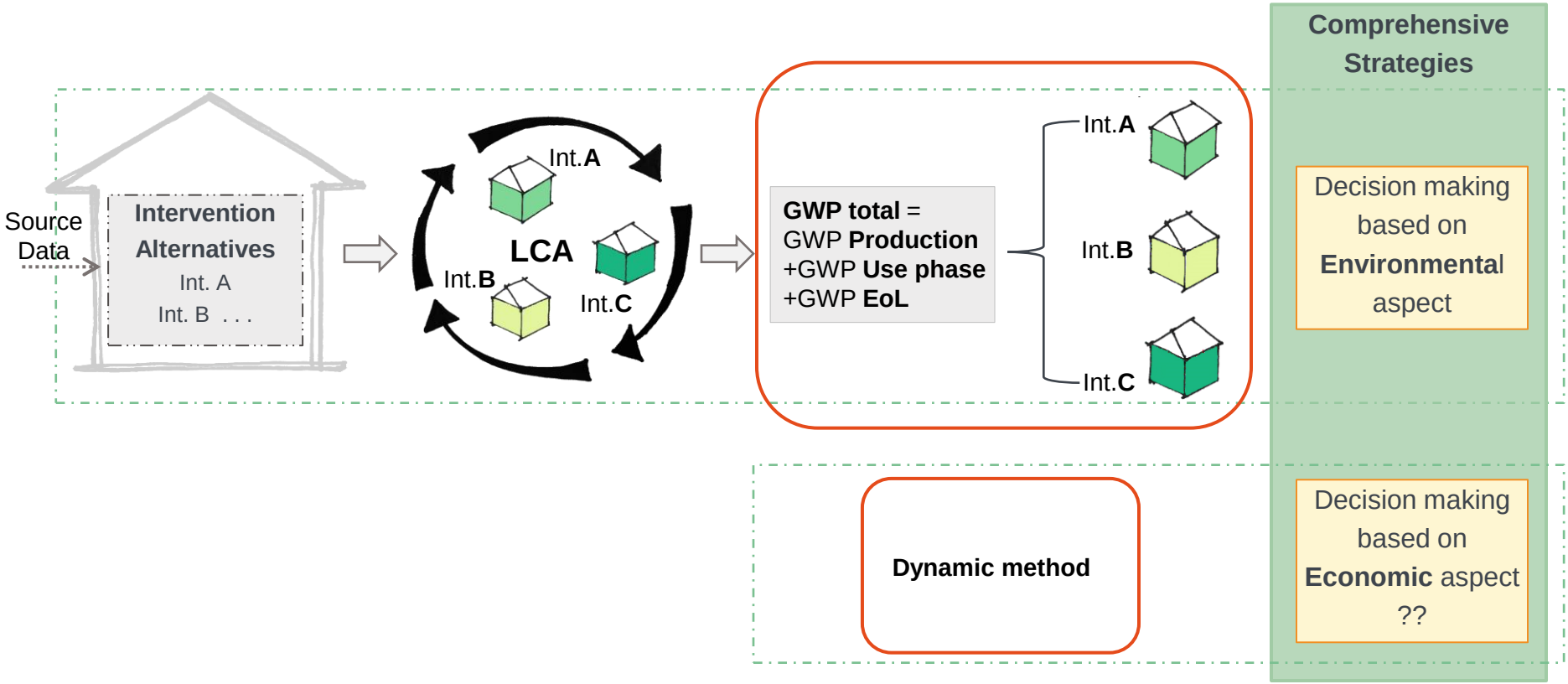
Intervention packages
Energy consumption
CO2 emissions reduction

→ Investment strategies for economic growth

? → **Environmental Consideration** *of intervention alternatives*

(2) *Energy Balance Sheets (EUROSTAT) 2016-data, 2018 edition*

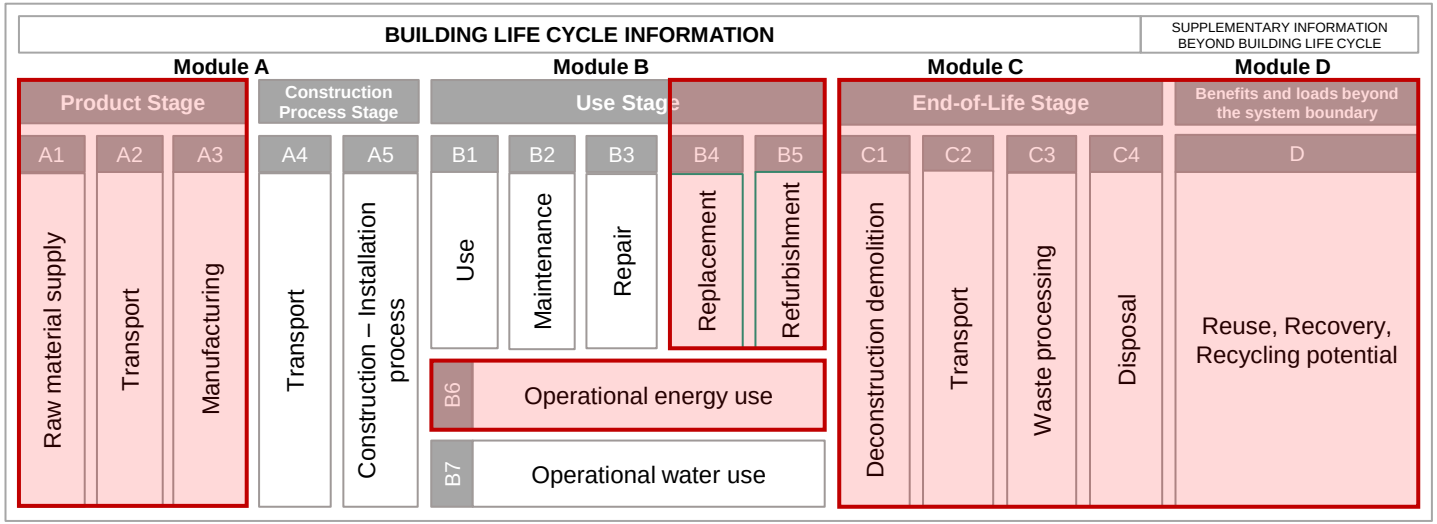
Life Cycle Assessment application



Static LCA

- System boundaries
  Cradle – Grave
- Building lifespan
  50 years
- Functional Unit
  Net surface area

DIN EN 15804



- Environmental Impact
  GWP
  (kg. CO2 eq.)

	Indicator	Unit	Model
Climate change – total*	Global Warming Potential total (GWP-total)	kg CO2 eq.	Baseline model of 100 years of the IPCC based on IPCC 2013

- Intervention Alternatives

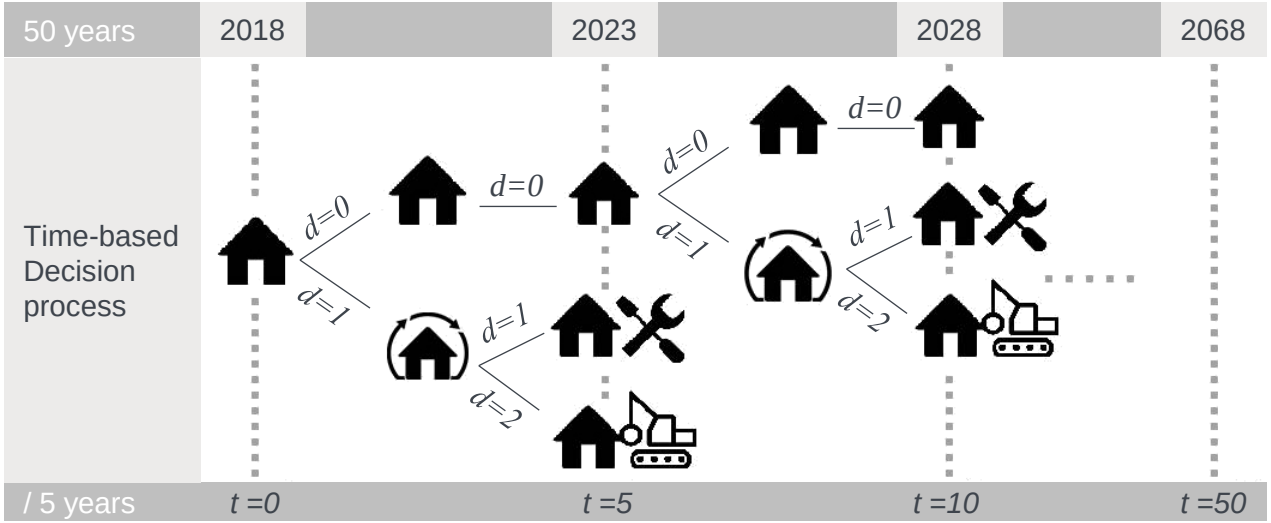
Existing (no intervention) USE PHASE & END OF LIFE

Intrv. A - **Refurbishment** (intervention in existing structure to extend its nominal service life) – PRODUCTION & END OF LIFE

Intrv. B - **Rebuild** (demolition of existing & build a new) - END OF LIFE FOR EXISTING & PRODUCTION + USE FOR NEW

Probabilistic LCA with application of Monte Carlo simulation

- Decision making
  5 year intervals
- Observation period
  50 years



- 1st Decision: Intervention? **0 / 1**
- 2nd Decision: Refurbishment/ Rebuild? **A / B**
- Total GWP for interventions during 50 years **∑ GWP**

$$R_V = \begin{cases} \geq P(I) & \text{No intervention Dec=0} \\ < P(I) & \text{Intervention Dec=1} \end{cases}$$

$$C_{t+p\ (Intr.A)} = \begin{cases} \geq 75\% * C(Reb) \rightarrow & \text{Intrv. B Dec = Intrv.B} \\ < 75\% * C(Reb) \rightarrow & \text{Intrv. B Dec=Intrv.A} \end{cases}$$

⇦ **€ Costs** consideration

$$GWP_{tot} = \sum_{y=1}^{50} GWP_{prod,\,y} + GWP_{use,\,y} + GWP_{EoL}$$

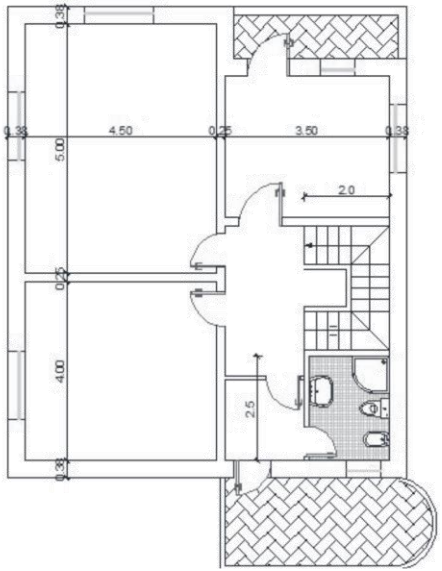
Building B1 (Albanian residential building typology: Simaku, Thimjo and Plaku 2014b)

- Type: **detached house**
- Building period: **1961-1980**
- **Construction elements:**

Exterior wall	Solid red brick
Roof/ceiling	Red roof tiles
Floor slab	Concrete floor
Windows	Single glazed, wooden frame
Exterior door	Wooden door
Energy supply system	National electricity network Multi-split AC, Pellet-boiler

Building	Cilmate Region
B1	Tirana

Treated floor area	135,12	m²
Heated volume	472,92	m³
Number of Floors	2	



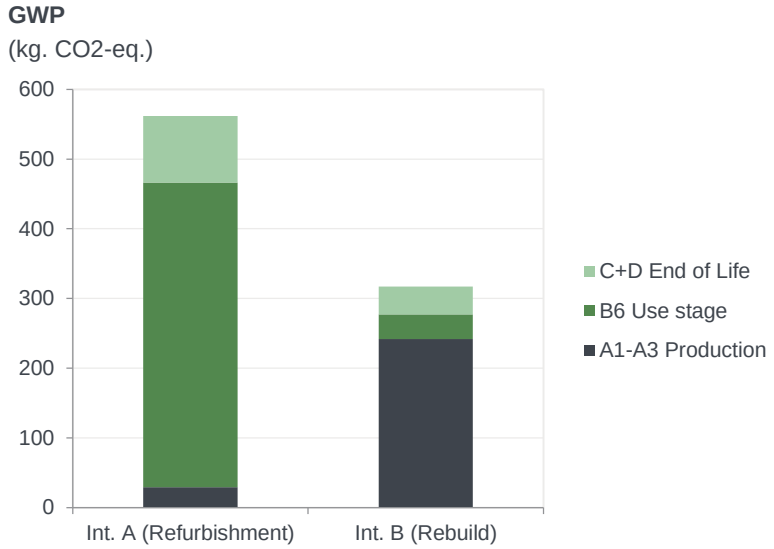
Intervention alternatives (3)

Construction	Refurbishment measures	Rebuild characteristics*
Exterior wall	Red brick, Polystyrene EPS 10cm *U-Value=0.29 W/m²K*	Limestone, EPS , Plaster *U-Value=0.24 W/m²K*
Roof/Ceiling	Roof with red tiles, Polystyrene EPS 12cm *U-Value=0.27 W/m²K*	Plasterboard, Therm. insulation EPS, Wood constr., MDF-plates, Roof tiles, *U-Value=0.176 W/m²K*
Floor slab	Concrete floor, Polyst. EPS 5cm, *U-Value=0.54 W/m²K*	Cement, Insulation EPS, PVC-P, reinforced concrete, mineral-wool, gips, *U-Value=0.14 W/m²K*
Window	Triple thermal insulation glass, 90% Plastic frame *U-Value =0.65 W/m²·K*	=
Exterior door	Plastic door *U-Value =0.75 W/m²·K*	=
Energy supply system	Electricity (Hydropower) Pellet boiler 25% energy Low temperature gas system 10% energy Multisplit-clima unit 65% energy	Energy supply based on electricity based systems Electricity from Hydropower 100%
Energy demand	9.410,5 kWh/y. electricity demand 27.785,9 kWh/y. heat energy demand	16.079,3 kWh/year

* Based on EnEV 2014 requirements

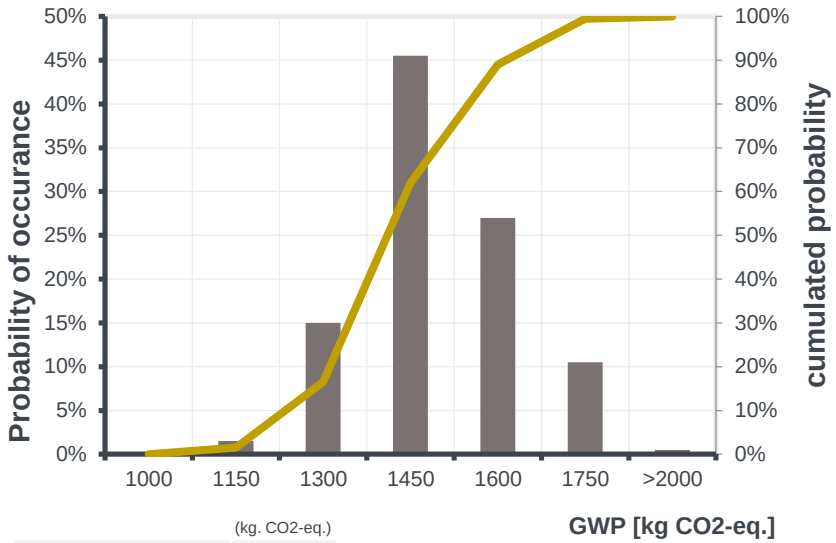
(3) Novikova Szalay Simaku Thimjo Salamon Plaku and Csoknyai *The typology of the residential building stock in Albania and the modelling of its low-carbon transformation* 2015

Static LCA



Decision making based on **Environmental** aspect ⇄ Decision making based on **Economic** aspect

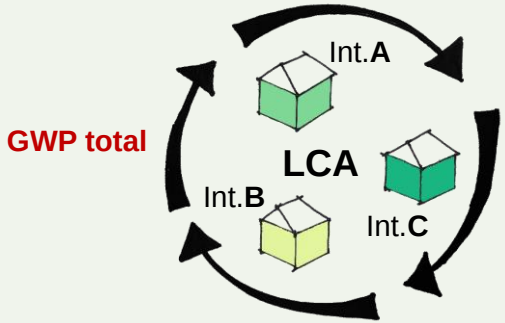
Probabilistic LCA



	(kg. CO2-eq.)
MAX	4281,49
MIN	1052,57
Average	1372,95
Standard deviation	242,38
MEAN VALUE	1530

Nr of refurbishments (for 200 runs)	572
Nr of rebuilds (for 200 runs)	56
Total nr of interventions (200 runs)	628

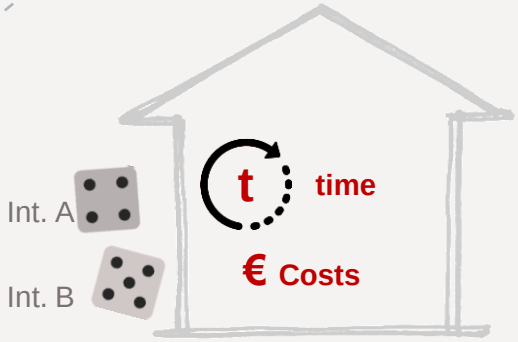
The more complex and rich the assessment method – the more relevant the results



Decision making based on **Environmental** aspect

- Global intervention for structural enhancement
- Other local Intervention options
- Impact indicators (ODP, AP, EP, Pene, . . .)

Comprehensive Strategies



Decision making based on **Economic** aspect

- Rest value of building after intervention
- Value of new building
- Life span of building after intervention
- Risk factors
- User preference

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Thank you!
Questions?

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