

Estimating the National Scale Economy of Reusable Building Components Through Simulation

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Second Hand PRO Market

Rakennusosien laajamittainen uudelleenkäyttö:
Selvitys edellytyksistä, arvoketjusta ja prosessista

Tuemme kiertotaloutta ja vähähiilistä rakentamista kehittämällä uudenlaista arvoketjua, jossa vanhat rakennusosat otetaan tehokkaasti uudelleen käyttöön.

Käynnissä
1.5.2024–30.10.2025

Budjetti
90 000 €



My friends call me “RAKSA”

- Objective is to research for a commercially viable and large-scale value chain for the reuse of building components, promoting low-carbon construction.
- The city of Forssa serves as a test area, with the model potentially setting an example nationally and internationally.
- Mapping the requirements for storage, certification, logistics, and trade, and developing a circular economy-based system.
- In partnership with Häme University of Applied Sciences (HAMK) and city of Forssa.
- Target groups are construction sector stakeholders, including municipalities, developers, designers, experts, construction companies, and logistics firms.
- [Second Hand PRO Market – HAMK](https://www.hamk.fi/projektit/second-hand-pro-market/)
<https://www.hamk.fi/projektit/second-hand-pro-market/>

Aim of the talk

Analyse the potential market of selected building components and materials and study different logistic and storage solutions for efficient supply chain



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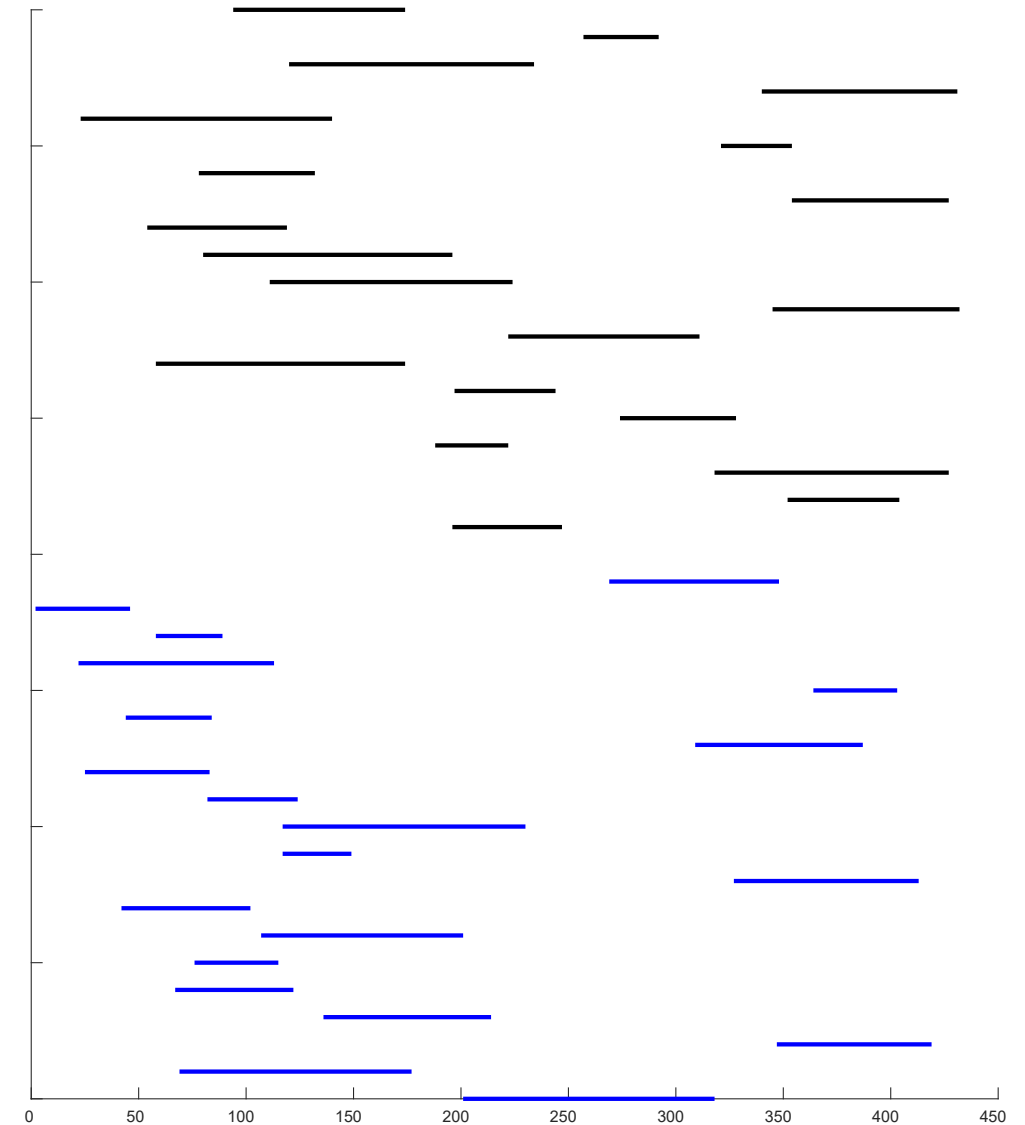


Terminology

- Deconstruction site
 - Source of material
 - Functions: announces material to be available between set period for a fixed price.
- Construction site
 - Sink: user of the material
 - Functions: announces material need at a set period.
- Satellite storage
 - Mobile container that would store (may or may not process the material to higher value, currently modeled as only a storage)
- Second hand pro shop (2ndHPS)
 - “Forssa site”: secondhand marketplace, “hardware store”, that may or may not process the material to higher value such as, for example, harmonization and cleaning of wood, i.e., cutting the planks to same length and removing paint

Market match

- Study of the material movement based on supply and demand.
 - Material is available at a deconstruction site for a given period of time (black line). If not bought, transported to Forssa site.
 - Construction site has a set storage capacity in time (blue line). Direct purchase between sites is possible, when storage capacities overlap.
- Only full truckloads are considered.
- Extended storage capability in disassembly site simulates is a possibility of satellite storage.



Simulation aim is to evaluate the market in different scenarios to find viability estimates

For a chosen

- set of disassembled sites' locations, material availability, type and storage times
- set of construction sites' locations, needs and storage times
- Forssa second hand shop location and initial stock

with parameters

- disassembly cost
- upcycling cost
- installation cost (different for disassembled and upcycled)
- transportation cost (1 euro per km)

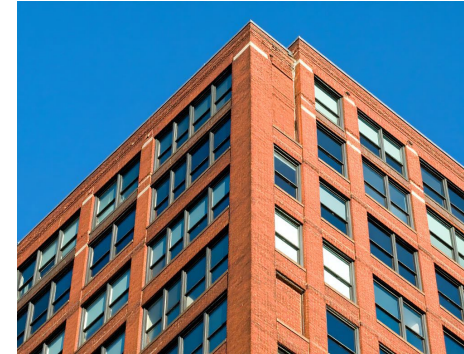
evaluate the spenditure and carbon footprint of the construction companies.

Material price



- From deconstruction to construction

$$\bullet \frac{\text{deconstruction}}{\text{unit}} + \frac{\text{installation}_1}{\text{unit}} + \frac{\text{transport cost } (\frac{\text{€}}{\text{km}})}{n \frac{\text{units}}{\text{km}}}$$



- Maintained and sold through Second Hand Pro Shop

$$\bullet \frac{\text{deconstruction}}{\text{unit}} + \frac{\text{processing}}{\text{unit}} + \frac{\text{installation}_2}{\text{unit}} + \frac{\text{transport cost } (\frac{\text{€}}{\text{km}})}{n \frac{\text{units}}{\text{km}}}$$

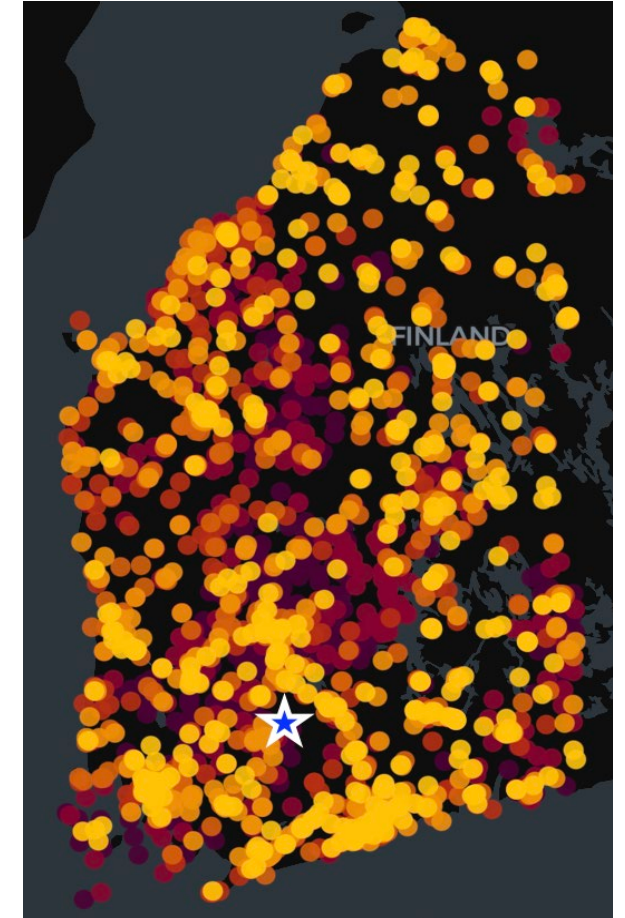
- Typically $\text{installation}_2 < \text{installation}_1$
 - We could say $\text{installation}_2 = 0$

Model

- Disassembly and construction sites appear randomly depending on the model parameters with time window of material availability.
- If a source site has material at the end of the time window, material is transported to Second hand pro shop.
- Construction site starts making purchases as soon as it appears and keeps purchasing for as long as there is need. Buys from Second hand pro shop if it is profitable with the knowledge of coming disassembly sites.
- All material is counted in full truckloads.
- AnyLogic implementation available at <https://cloud.anylogic.com/model/ae382db1-7c58-443d-9d9f-53f105e7013e>

Population of possible sites

- Area around the most populated cities in Finland was selected for locations modelling.
- Simulation can read the locations from an excel file for custom area research.
- Second hand pro shop site into model is in the city of Forssa (blue star).
- Location of sites appearing is randomly selected from the population.
 - Site population density is correlated with real population density.



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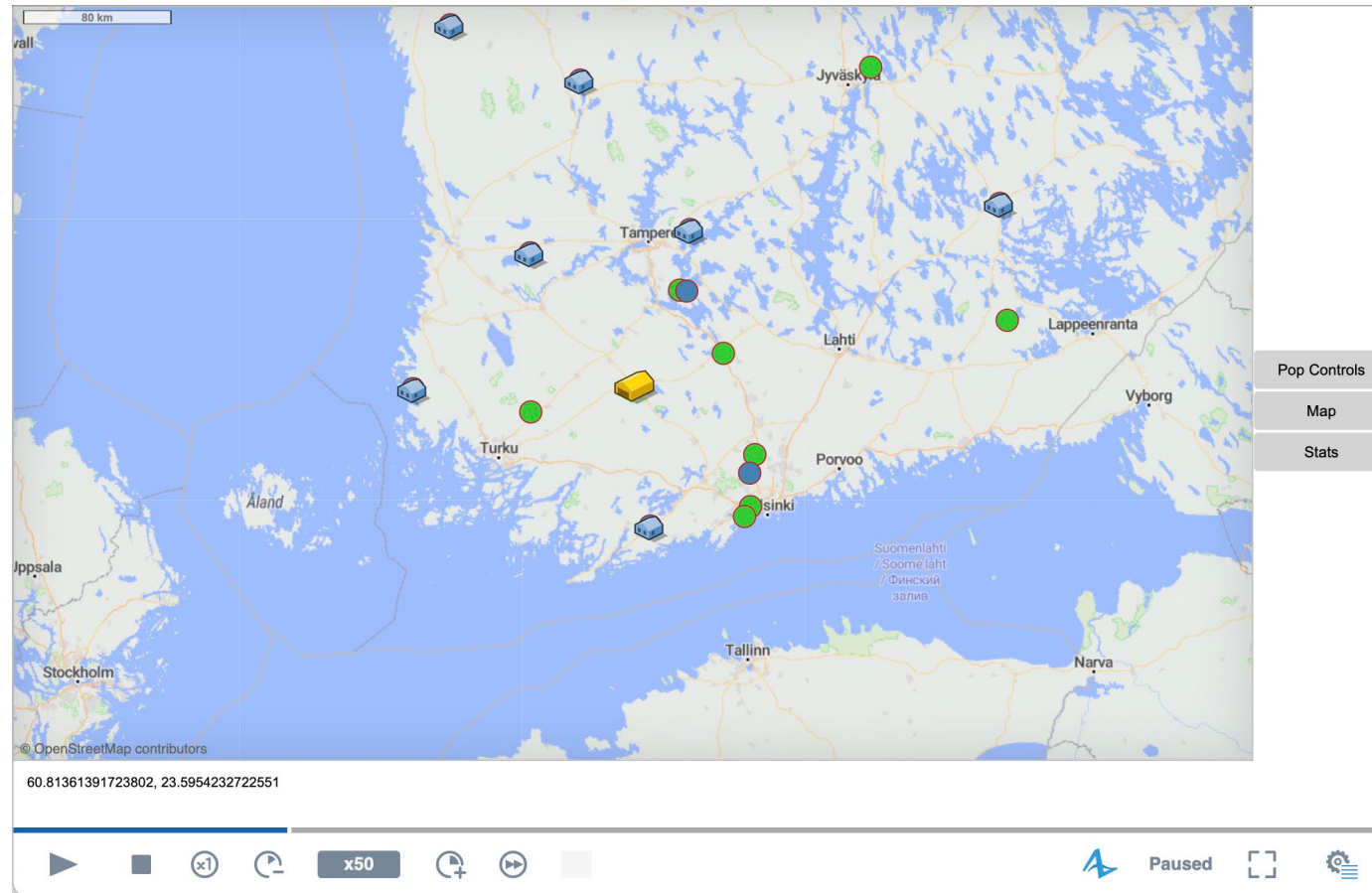
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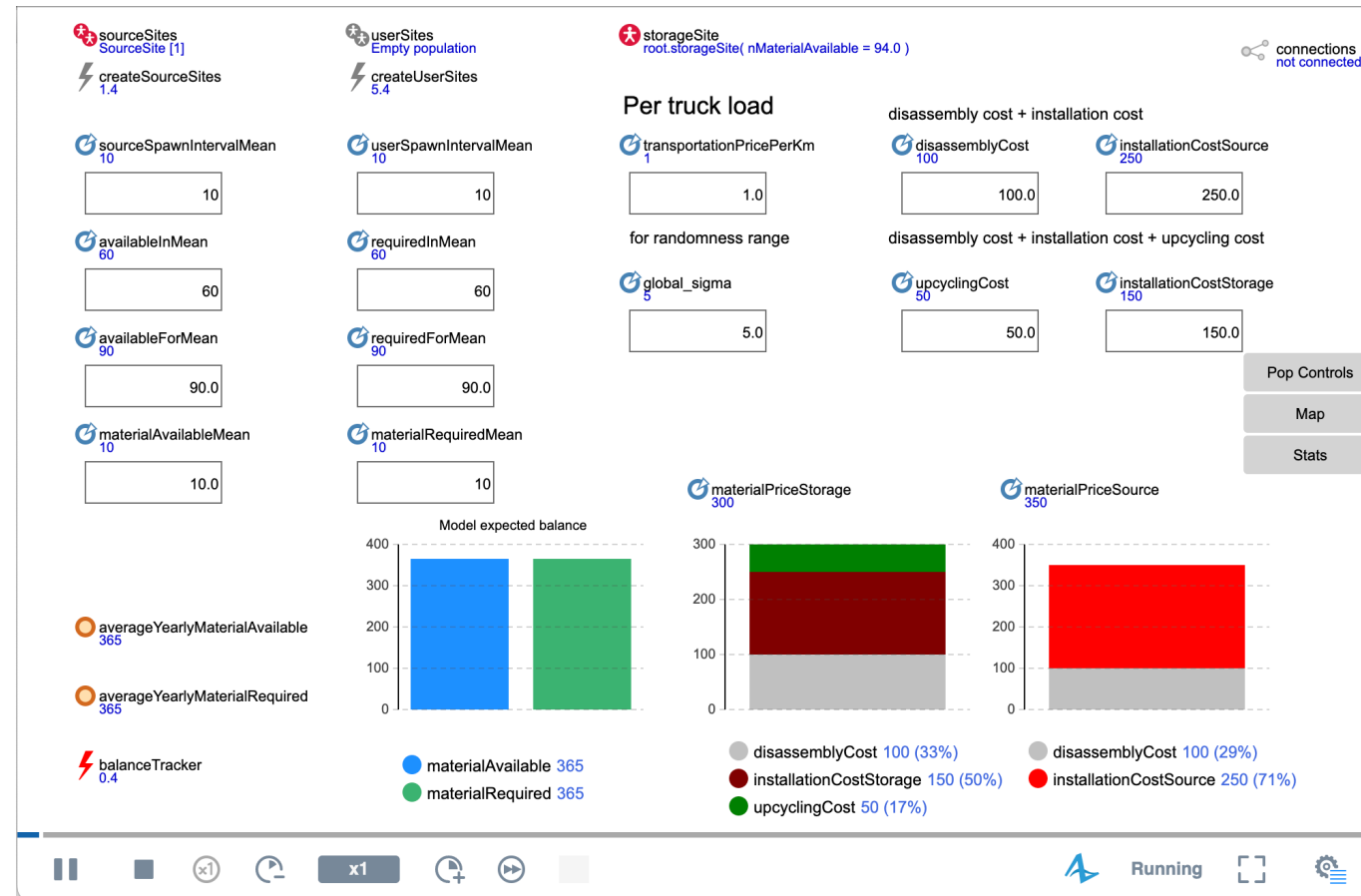
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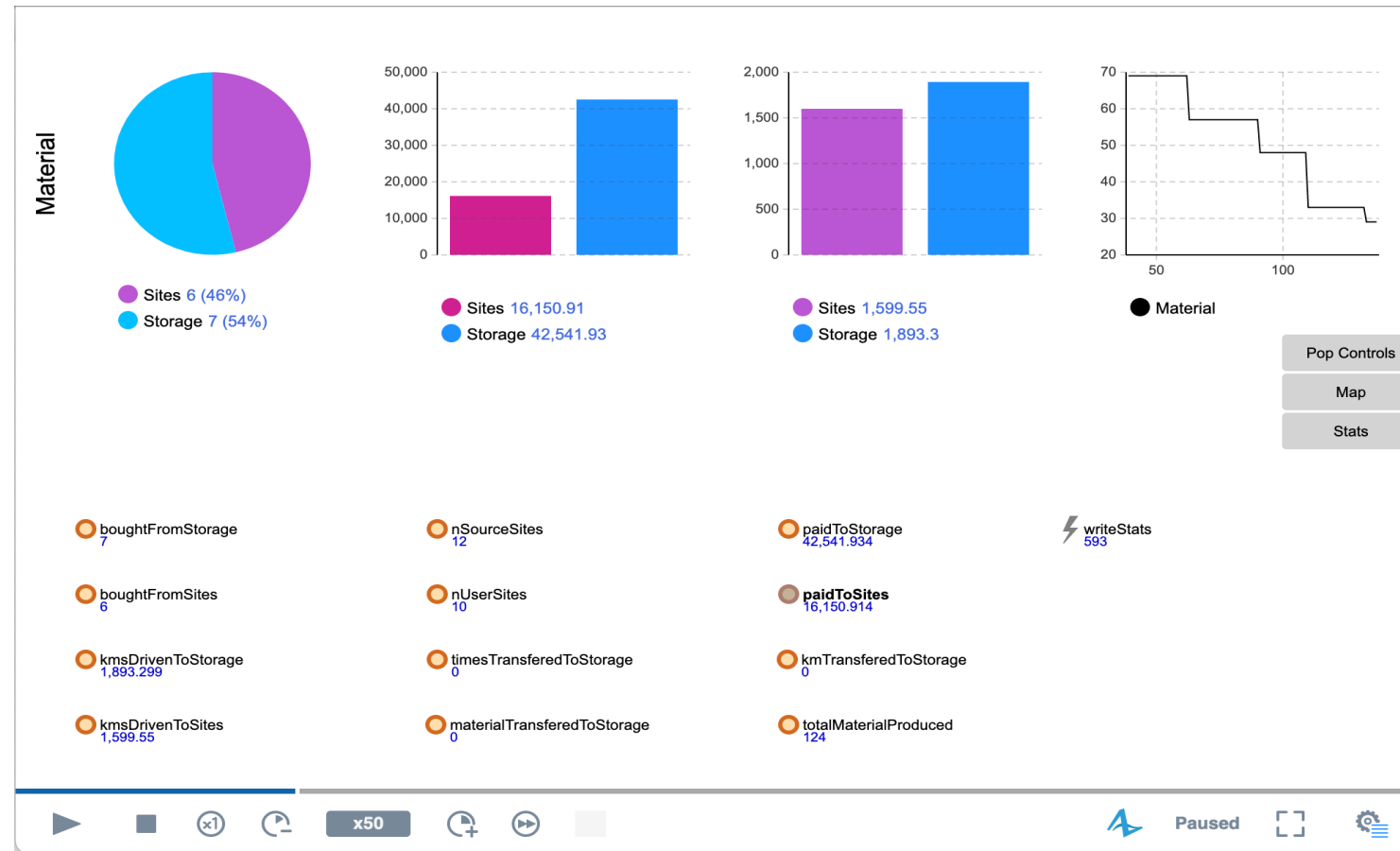
Model interface



Model interface



Model interface



Example of a case study: “windows”

- Disassembly cost estimate
 - Two persons 1.5 hours per window to sever, wrap for transport and load to truck, 50 €/h → 150 €/window
 - 20 windows per one truck load → **3000 € disassembly cost**
- Installation cost directly from disassembly site
 - Two persons at least 2.25 hours per window → 20 windows installation cost from 4500 € to 9000 € varied with 1500 € step.
- Upcycling costs
 - One hour to three hours per window → varied from 1000 € to 3000 € with 1000 € step
- Installation cost from Second hand pro shop
 - One hour to three hours per windows → varied from 1000 € to 3000 € with 1000 € step

Effect of varying storage length and amount of material

- Storage length from 60 to 360 days with 30-day step
 - Simulates satellite storing
- Normal amount of material 360 truckloads
- Low amount of material 50 truckloads
 - Should increase the likelihood of long transportations

Case study: “windows” / results

Installation from source 4500 e, available for mean 90

2nd HPS total	bought from storage	bought from sites	material transfered to storage	km total	eCO2 (t) (827 g/km)	paid total (M€)
2000	62	4	524	36073	30	3,23
3000	62	4	524	36073	30	3,80
3000	62	4	524	36073	30	3,80
4000	53	15	472	29462	24	4,36
4000	53	15	472	29462	24	4,36
4000	53	15	472	29462	24	4,3
5000	8	95	132	37031	31	4,64
5000	8	95	132	37031	31	4,64
6000	3	104	107	42480	35	4,68

Installation from source 4500 e, available for mean 180

2nd HPS total	bought from storage	bought from sites	material transfered to storage	km total	eCO2 (t) (827 g/km)	paid total (M€)
2000	47	44	273	30999	26	3,66
3000	47	44	273	30999	26	4,04
4000	42	41	289	25064	21	4,39
3000	47	44	273	30999	26	4,04
4000	42	41	289	25064	21	4,39
5000	5	100	82	32660	27	4,62
4000	42	41	289	25064	21	4,39
5000	5	100	82	32660	27	4,62
6000	3	102	72	33729	28	4,65



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Case study: “windows” / results

Installation from source 4500 e, available for mean 180

2nd PS total	bought from storage	bought from sites	material transfered to storage	km total	eCO2 (t) (827 g/km)	paid total (M€)
2000	47	44	273	30999	26	3,66
3000	47	44	273	30999	26	4,04
4000	42	41	289	25064	21	4,39
3000	47	44	273	30999	26	4,04
4000	42	41	289	25064	21	4,39
5000	5	100	82	32660	27	4,62
4000	42	41	289	25064	21	4,39
5000	5	100	82	32660	27	4,62
6000	3	102	72	33729	28	4,65

Installation from source 9000 e, available for mean 90

2nd PS total	bought from storage	bought from sites	material transfered to storage	km total	eCO2 (t) (827 g/km)	paid total (M€)
2000	62	4	524	36073	30	3,35
3000	62	4	524	36073	30	3,92
4000	62	4	524	36073	30	4,48
3000	62	4	524	36073	30	3,92
4000	62	4	524	36073	30	4,48
5000	62	4	524	36073	30	5,05
4000	62	4	524	36073	30	4,48
5000	62	4	524	36073	30	5,05
6000	62	4	524	36073	30	5,62



fixed upcycling 2000 e, available for mean 90							eCO2 (t) (827 g/km)
installation cost source	installation cost storage	paid total (M€)	bought from storage	bought from sites	km total		
4500	1000	3,80	62	4	36073		30
6000	1000	3,84	62	4	36073		30
7500	1000	3,88	62	4	36073		30
9000	1000	3,92	62	4	36073		30
4500	2000	4,36	53	15	29462		24
6000	2000	4,41	62	4	36073		30
7500	2000	4,44	62	4	36073		30
9000	2000	4,48	62	4	36073		30
6000	3000	4,97	62	4	36073		30
7500	3000	5,01	62	4	36073		30
9000	3000	5,05	62	4	36073		30
4500	3000	4,64	8	95	37031		31

fixed upcycling 2000 e, available for mean 180							eCO2 (t) (827 g/km)
installation cost source	installation cost storage	paid total (M€)	bought from storage	bought from sites	km total		
4500	1000	4,04	47	44	30999		26
6000	1000	4,37	47	44	30999		26
7500	1000	4,69	47	44	30999		26
9000	1000	5,02	47	44	30999		26
4500	2000	4,39	42	41	25064		21
6000	2000	4,74	47	44	30999		26
7500	2000	5,07	47	44	30999		26
9000	2000	5,40	47	44	30999		26
4500	3000	4,62	5	100	32660		27
6000	3000	5,11	47	44	30999		26
7500	3000	5,44	47	44	30999		26
9000	3000	5,77	47	44	30999		26



Example of a case study: “bricks”

- Disassembly cost estimate
 - One person collects 100 pieces in one hour of manual work (from wall to truck). Truck fits 10 000 bricks (22 tons) → **5000 € disassembly cost**
- Installation cost directly from disassembly site
 - Additional cost of 1.5 to 3 times the cost of new bricks.
 - 50 €/h → 7500 to 15 000 €
- Upcycling costs
 - 0.10, 0.30 or 0.50 €/brick → 1000 € to 10 000€ with 1000 € step.
- Installation cost from 2ndPS
 - Compare to price of installing a new brick → 0 €.

installation cost source	upcycling cost	available for mean	total (M€)	bought from storage	bought from sites	material transferred to storage	km total	eCO2 (t) (827 g/km)
5000	2000	90	4,43	62	4	524	36073	30
7500	2000	90	4,50	62	4	524	36073	30
10000	2000	90	4,56	62	4	524	36073	30
5000	5000	90	6,05	28	59	246	26715	22
7500	5000	90	6,19	62	4	524	36073	30
10000	5000	90	6,26	62	4	524	36073	30
5000	8000	90	6,20	3	104	107	42480	35
7500	8000	90	7,60	8	95	132	37031	31
10000	8000	90	7,96	62	4	524	36073	30
5000	2000	180	4,96	47	44	273	30999	26
7500	2000	180	5,50	47	44	273	30999	26
10000	2000	180	6,05	47	44	273	30999	26
5000	5000	180	6,03	25	66	173	22207	18
7500	5000	180	6,62	47	44	273	30999	26
10000	5000	180	7,17	47	44	273	30999	26
5000	8000	180	6,16	3	102	72	33729	28
7500	8000	180	7,58	5	100	82	32660	27
10000	8000	180	8,29	47	44	273	30999	26
5000	2000	360	5,48	25	77	90	24978	21
7500	2000	360	6,49	25	77	90	24978	21
10000	2000	360	7,49	25	77	90	24978	21
5000	5000	360	6,02	20	77	71	19388	16
7500	5000	360	7,06	25	77	90	24978	21
10000	5000	360	8,06	25	77	90	24978	21
5000	8000	360	6,15	3	104	21	30525	25
7500	8000	360	7,57	4	103	28	30013	25
10000	8000	360	8,63	25	77	90	24978	21



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installation cost source	upcycling cost	available for mean	total (M€)	bought from storage	bought from sites	material transferred to storage	km total	eCO2 (t) (827 g/km)
5000	2000	90	0,84	56	0	90	32443	27
7500	2000	90	0,84	56	0	90	32443	27
10000	2000	90	0,84	56	0	90	32443	27
5000	5000	90	1,16	20	53	25	21793	18
7500	5000	90	1,18	56	0	90	32443	27
10000	5000	90	1,18	56	0	90	32443	27
5000	8000	90	1,20	4	78	6	30318	25
7500	8000	90	1,46	6	75	7	27474	23
10000	8000	90	1,52	56	0	90	32443	27
5000	2000	180	0,84	56	0	75	30785	25
7500	2000	180	0,84	56	0	75	30785	25
10000	2000	180	0,84	56	0	75	30785	25
5000	5000	180	1,16	16	62	8	19516	16
7500	5000	180	1,18	56	0	75	30785	25
10000	5000	180	1,18	56	0	75	30785	25
5000	8000	180	1,20	4	79	0	29036	24
7500	8000	180	1,46	4	78	0	26557	22
10000	8000	180	1,52	56	0	75	30785	25
5000	2000	360	0,84	56	0	44	28765	24
7500	2000	360	0,84	56	0	44	28765	24
10000	2000	360	0,84	56	0	44	28765	24
5000	5000	360	1,16	12	69	0	19180	16
7500	5000	360	1,18	56	0	44	28765	24
10000	5000	360	1,18	56	0	44	28765	24
5000	8000	360	1,20	4	79	0	28955	24
7500	8000	360	1,46	4	78	0	26476	22
10000	8000	360	1,52	56	0	44	28765	24



Thank you!

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