

Article: supplementary materials

Inflows and Outflows from Material Stocks of Buildings and Networks and their Space-Differentiated Drivers: The Case Study of the Paris Region - Supplementary materials

Table S1. Scope of materials

Main material group	Material	Buildings	Transport networks	Energy and water networks
Non-metallic minerals	Concrete	x	x	x
	Concrete block			
	Aggregates for asphalt concrete, ballast and paving		x	
	Stone	x	x	x
	Masonry		x	
	Solid clay brick	x		
	Hollow clay brick	x		
	Clay tile	x		
	Tiling	x		
	Glass	x		
	Plaster (including plaster and plaster-based adhesive mortar)	x		
	Mortar and mineral plaster (including polymer-supported plaster)	x		
	Mineral wool	x		
Asbestos cement			x	
Metals	Steel	x		x
	Cast iron			x
	Aluminum	x		x
	Zinc	x		
Timber	Timber	x	x	
	Chipboard	x		
Plastics	Polyvinyl chloride (PVC)	x		x
	Polystyrene	x		
	Polyurethane	x		x
	High density polyethylene (HDPE)		x	
Other petroleum-based materials	Mastic asphalt	x		
	Asphalt		x	

Source: authors

Table S2. Criteria to estimate demolished and constructed surfaces

	Description	Total aboveground surface in 2009*	Total aboveground surface in 2014	Minimum year of construction (<i>jannatmin</i>) recorded in 2014	Difference between total aboveground surfaces in 2014 and 2009**
Demolition	Total demolition without further reconstruction	>0	0	Not null	Criteria not used
	Total demolition followed by reconstruction	>0	>0	>2008***	>50 m ² and >10% of total aboveground surface in 2009
	Partial demolition	>0	>0	≤2008	>50 m ² and >10% of total aboveground surface in 2009
Construction	Construction on a vacant plot in 2009	0	>0	≥2008	Criteria not used
	Partial construction	>0	>0	≤2008	>50 m ² and >10% of total aboveground surface in 2009

Source: authors

* calculated as in [37] with *spevtot*, *dniv*, *ccopl* and *cconlc* fields.

** for each plot, databases are joined with *idpar* and *idparm* fields.

** 2008 is chosen instead of 2009 to take into account delays in the updating of *fichiers fonciers* data.

Table S3. Coefficients used to convert aboveground *surfaces réelles* from *fichiers fonciers* in aboveground gross floor area, absolute values*

	Before 1914	1914-1947	1948-1974	1975-2000	Since 2001	Unknown year	
						Minimum	Maximum
Collective housing	1.4	1.3	1.4	1.4	1.4	1.3	1.4
Individual housing	1.2	1.3	1.2	1.2	1.4	1.2	1.4
Shopping malls and buildings dedicated to transport and storage	1.1					1.1	1.1
Other commercial and administrative buildings	1.4	1.4	1.4	1.4	1.5	1.4	1.5
Industrial buildings	1.1		1.1			1.1	1.1

Source: authors' calculation from BD Topo 2013 and *fichiers fonciers* 2014

*As is the stock analysis [43], information on the construction period and the activity are used to assign a type. To simplify data processing (comparison on each plot between two versions of *fichiers fonciers*), only one building type is assigned for each plot. Load-bearing structures within a construction period are not distinguished.

Table S4. Coefficients used to convert aboveground *surfaces réelles* from *fichiers fonciers* in underground gross floor area, absolute values

	Urban area	Before 1914	1914-1947	1948-1974	1975-2000	Since 2001	Unknown year	
							Minimum	Maximum
Collective housing	Paris	0.13	0.11	0.26	0.30	0.31	0.11	0.31
	PC	0.13	0.13	0.20	0.20	0.22	0.13	0.22
	GC	0.09	0.09	0.11	0.13	0.13	0.09	0.13
Individual housing	Paris	0.14	0.08	0.19	0.11	0.11	0.08	0.19
	PC	0.11	0.12	0.12	0.12	0.09	0.09	0.12
	GC	0.13	0.12	0.13	0.13	0.11	0.11	0.13
Shopping malls and buildings dedicated to transport and storage	Paris	0.04					0.04	0.04
	PC	0.04					0.04	0.04
	GC	0.04					0.04	0.04
Other commercial and administrative buildings	Paris	0.13	0.12	0.28	0.25	0.27	0.12	0.28
	PC	0.15	0.16	0.26	0.21	0.20	0.15	0.26
	GC	0.10	0.09	0.16	0.14	0.15	0.09	0.16
Industrial buildings	Paris	0.02		0.02			0.02	0.02
	PC	0.02		0.02			0.02	0.02
	GC	0.03		0.02			0.03	0.03

Source: authors' calculation from *fichiers fonciers* and underground gross floor surfaces estimated in [43]

Tableau S5. Refurbishment rates by building type, %

Type	Refurbishment rate	
	Minimum	Maximum
Collective housing before 1914	0.7	2.6
Collective housing 1914-1947	0.7	2.6
Collective housing 1948-1974	0.7	2.6
Collective housing 1975-2000	0.7	2.6
Collective housing since 2001	0.7	2.6
Collective housing with unknown construction year	0.7	2.6
Individual housing before 1914	1.5	3
Individual housing 1914-1947	1.5	3
Individual housing 1948-1974	1.5	3
Individual housing 1975-2000	1.5	3
Individual housing since 2001	1.5	3
Individual housing with unknown construction year	1.5	3
Shopping malls and buildings dedicated to transport and storage	1.5	3.3
Other commercial and administrative buildings before 1914	1.5	3.3
Other commercial and administrative buildings 1914-1947	1.5	3.3
Other commercial and administrative buildings 1948-1974	1.5	3.3
Other commercial and administrative buildings 1975-2000	1.5	3.3
Other commercial and administrative buildings since 2001	1.5	3.3
Other commercial and administrative buildings with unknown construction year	1.5	3.3
Industrial building before 1948	1.5	3.3
Industrial building since 1948	1.5	3.3

Type	Refurbishment rate	
	Minimum	Maximum
Industrial building with unknown construction year	1.5	3.3
Non-residential building with unknown activity built before 1914	1.5	3.3
Non-residential building with unknown activity 1914-1947	1.5	3.3
Non-residential building with unknown activity 1948-1974	1.5	3.3
Non-residential building with unknown activity 1975-2000	1.5	3.3
Non-residential building with unknown activity since 2001	1.5	3.3
Non-residential building with unknown activity and unknown construction year	1.5	3.3

Source: adapted from [45]

Table S6. Extension, renewal and demolition rates for the road network, 2013, %

	Motorways			Regional and main roads			Local roads		
	Extension rate	Renewal rate	Demolition rate	Extension rate	Renewal rate	Demolition rate	Extension rate	Renewal rate	Demolition rate
Paris	0	6.6	0	0	3.3	0	0	3.3	0
Hauts-de-Seine	0	6.6	0	0	3.3	0	0.5	3.3	0
Seine-Saint-Denis	0	6.6	0	0	3.3	0	0.4	3.3	0
Val-de-Marne	0	6.6	0	0	3.3	0	0.1	3.3	0
Seine-et-Marne	0	6.6	0	0	3.3	0	0.6	3.3	0
Yvelines	0	6.6	0	0	3.3	0	0.7	3.3	0
Essonne	0	6.6	0	0	3.3	0	0.4	3.3	0
Val-d'Oise	0	6.6	0	0	3.3	0	0.3	3.3	0

Source: extension and demolition from [46], renewal from A. Ventura et M. Dauvergne (personal communication) and [48]

Table S7. Extension, renewal and demolition rates for railway, energy and water networks, 2015

Network	Extension rate		Renewal rate		Demolition rate
	%	Source	%	Source	
Railway network	Network developed in 2013 by railway type and <i>département</i> according to BD Topo		Region: 2.5	[49,50,51]	0 (idem construction)

Electricity networks	Paris: 0 PC: 0.1 GC: 0.3	[52]	Region: 0.5	[53]	0 (idem construction)
Gas networks	Paris: 0.0 PC: 0.2 GC: 0.3	[54,55]	Region: 0.3	[55]	0 (idem construction)
Heating and cooling networks	Paris: 1 PC: 3 GC: 3	EIDER database (2002-2009), [56]	Region: 0.3	idem Gas networks	0 (idem construction)
Drinking water networks	Paris: 0 PC: 0.05 GC: 0.2	<i>Eau et assainissement dans les collectivités locales en 2008</i> (EIDER database)	Paris & PC: 0.5 Seine-et-Marne: 0.2 Yvelines: 0.7 Essonne: 0.3 Val-d'Oise: 0.4	[57]	0 (idem construction)
Non-potable water network	Paris et PC: 0	[58]	Paris & PC: 0.1	[58]	0 (idem construction)
Sewerage networks	Paris: 0 PC: 0.05 GC: 0.2	<i>Eau et assainissement dans les collectivités locales en 2008</i> (EIDER database)	Paris & PC: 0.5 Seine-et-Marne: 0.2 Yvelines: 0.7 Essonne: 0.3 Val-d'Oise: 0.4	idem Drinking water networks	0 (idem construction)

Source: see in table

Table S8. Inflows and outflows to and from stocks per capita and by process, the Paris region, Paris, Petite Couronne, Grande Couronne, 2013, t/capita

		Paris region		Paris		Petite Couronne		Grande Couronne	
		Low range	High range	Low range	High range	Low range	High range	Low range	High range
Inflows	Building construction	1.2	1.4	0.4	0.4	1.3	1.5	1.6	1.7
	Road network development	0.1	0.1	0	0	0.05	0.05	0.24	0.2
	Railway network development	0.01	0.01	0	0	0.02	0.02	0.01	0.01
	Energy and water network development	0.01	0.01	0.0001	0.0001	0.001	0.001	0.01	0.01
	Building refurbishment	0.1	0.2	0.03	0.2	0.1	0.2	0.1	0.3
	Road network renewal	0.3	0.3	0.05	0.0	0.2	0.2	0.5	0.5
	Railway network renewal	0.03	0.03	0.02	0.02	0.02	0.02	0.04	0.04


	Energy and water network renewal	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.04
	Total inflows	1.8	2.1	0.5	0.7	1.6	1.9	2.6	2.9
Outflows	Building refurbishment	0.1	0.2	0.03	0.2	0.1	0.2	0.1	0.3
	Road network renewal	0.3	0.3	0.05	0.05	0.2	0.2	0.5	0.5
	Railway network renewal	0.02	0.02	0.01	0.01	0.01	0.01	0.03	0.03
	Energy and water network renewal	0.02	0.02	0.01	0.01	0.01	0.01	0.04	0.04
	Building demolition	0.6	1.0	0.3	0.8	0.7	1.1	0.7	1.0
	Total outflows	1.0	1.5	0.4	1.0	1.0	1.4	1.3	1.8

Source: authors

Figure S9. Inflows and outflows by material, Paris region, 2013, %

		Share in inflows		Share in outflows		
		Low range	High range	Low range	High range	
Non-metallic minerals	Concrete (ready-mixed and concrete block)	64	61	37	33	
	Aggregates (in asphalt concrete and ballast)	21	19	36	32	
	Stone and masonry	0.02	0.02	13	12	
	Clay brick, tile and other ceramic materials	5	7	5	10	
	Other non-metallic minerals	Mineral wool	0.2	0.3	0.3	0.6
		Mortar and mineral plaster (including polymer-supported plaster)	3	3	0.1	0.1
		Plaster	3	5	2	5
		Glass	0.2	0.3	0.2	0.4
Metals	Steel and cast iron	2	2	2	2	
	Aluminum and zinc	0.02	0.02	0.1	0.1	
Timber	Timber and chipboard	0.5	0.7	1	2	
Plastics and other petroleum-based materials	PVC, polystyrene, polyurethane, HDPE	0.5	0.4	0.2	0.2	
	Other petroleum-based materials	2	2	3	3	
Total		100	100	100	100	

Source: authors

Table S10. Comparison between constructed buildings surfaces according to bottom-up results (2007 to 2014) and according to Sit@del2 database (2007 to 2011), urban areas within Paris region, % 

Main urban area	Types	Difference (%)
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Paris	Housing	5
	Collective housing only	6
	Individual housing only	-13
	Non-residential buildings	-26
	All buildings types	-14
Petite Couronne	Housing	18
	Collective housing only	0
	Individual housing only	107
	Non-residential buildings	-12
	All buildings types	4
Grande Couronne	Housing	26
	Collective housing only	-6
	Individual housing only	61
	Non-residential buildings	-4
	All buildings types	11
Paris region	Housing	22
	Collective housing only	-3
	Individual housing only	70
	Non-residential buildings	-8
	All buildings types	7

Source: authors and Sit@del2

Note: for bottom-up results, construction which takes place between 2009/01/01 and 2014/01/01 according to *fichiers fonciers* is observed, when in Sit@del2 started construction projects after data correction by the ministry of housing and between 2007/01/01 and 2011/12/31 are recorded (so called *logements commencés en date réelle*). An average two years delay between construction projects launch and achievement is taken into account for a relevant comparison.

Table S11. Comparison between estimated flows in this study and regional statistics on the consumption of aggregates, t/capita

	This study		Statistics	
	Low range	High range		Source
In cement concrete (ready-mixed and concrete products)	0.7	0.7	0.8	[63] (assuming a 67% share of aggregates in concrete)
	0.7	0.7	1.3	[62]
In asphalt concrete	0.3	0.3	0.2	[66]
Road and railway network development and renewal	0.3	0.3	0.3	[62]
Civil engineering works	0	0	1.0	[62]

Source: authors, [62,63,66]

Table S12. Comparison between estimated flows in this study and regional waste statistics, t/capita

	This study		Regional waste statistics [66]	
	Low range	High range	Low range	High range
Building refurbishment	0.06	0.21	0.23	0.34
Building demolition	0.62	0.99	0.59	0.81
Cement concrete waste (all processes)	0.32	0.32	0.29	0.29
Asphalt concrete waste (road network renewal)	0.29	0.30	0.04	0.25

Source: authors and [66]

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