

International trends and nuances in the construction of multi-story timber buildings

Vittorio Salvadori

5 floor



Spöttlgasse
Vienna, Austria
2004

9 floor



Stadthaus
Londra, UK
2009

14 floor



TREET
Bergen, Norway
2014

18 floor



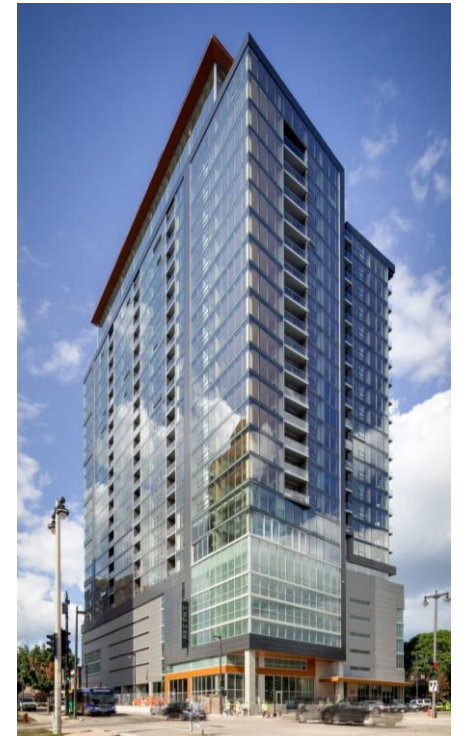
UBC Brock Commons
Vancouver, Canada
2017

24 floor



HoHo Wien
Vienna, Austria
2019

25 floor



Ascent
Milwaukee, USA
2022

Why building with Timber

New Materials: Engineered Wood Products



Source: Pollmeier

Glulam (1906)
O. Hetzer (Germany)



Source: Pollmeier

LVL (1950)
S. Preston (USA)



Source: Sohm Holzbautechnik

DLT (1978)
J. Natterer (Germany)

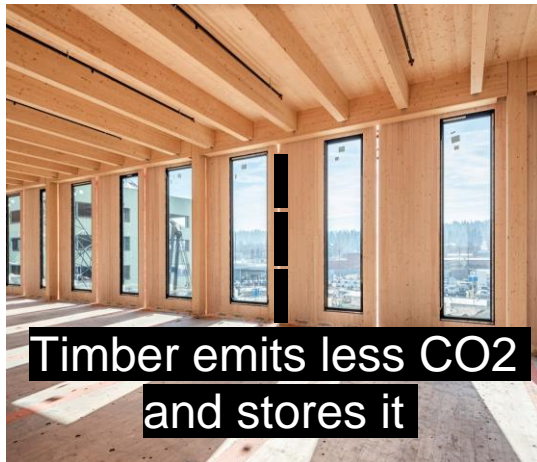


Source: Maria Laguarda-Mallo

CLT (1995)
K. Moser (Germany) &
G. Schickhofer (Austria)

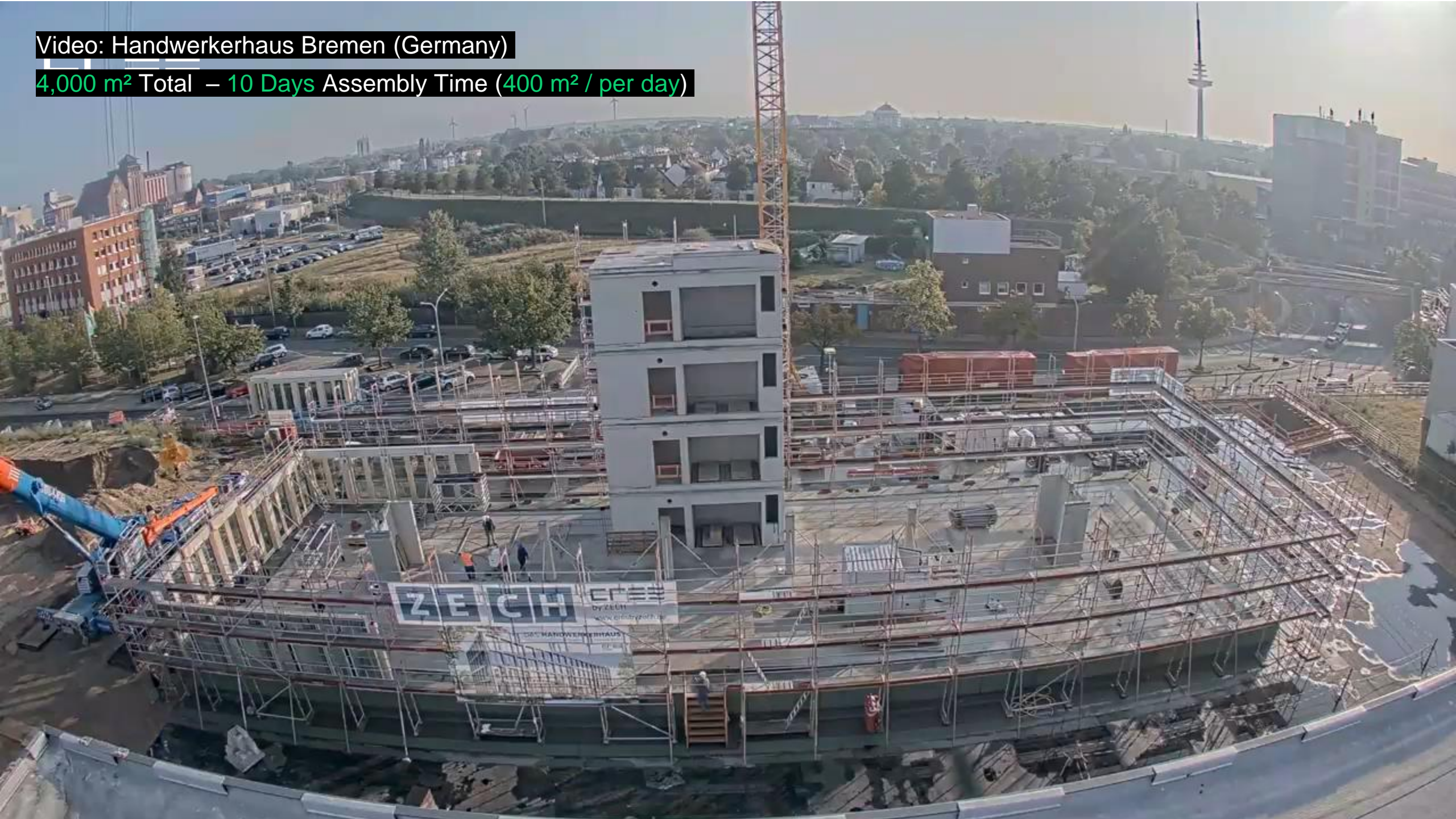
Why building Multi-storey with Timber





Video: Handwerkerhaus Bremen (Germany)

4,000 m² Total – 10 Days Assembly Time (400 m² / per day)



Research Methodology to create
the largest comparative survey
~~ever~~ done

Research Questions

- 1) **Where** were they built?
- 2) **When** were they built?
- 3) **How** were they built?

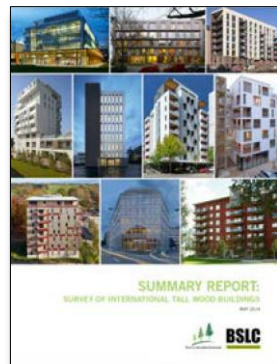
- 4) **Why** were they built?
- 5) **By whom** were they built?



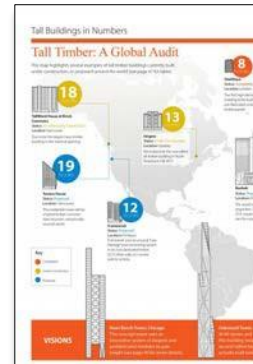
Previous Comparative Studies



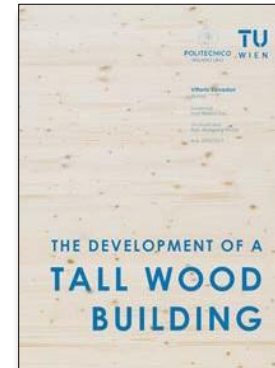
Perkins+Will,
2014



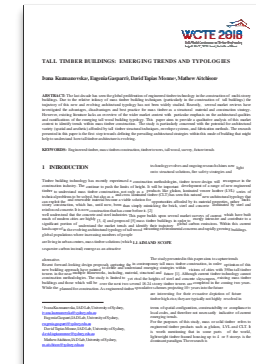
Solid Timber
Construction
Report, 2015



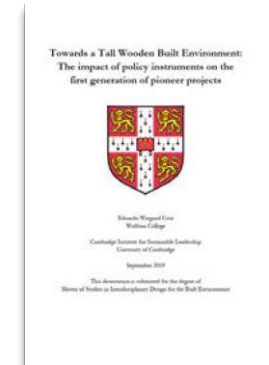
CTBUH Audit,
2017



Salvadori,
2017



Kuzmanovska
et al., 2018



Wiegand,
2019

N. Case-studies	10	18	49	40	46	49
Status	Built	Built	Built, Idea	Built, Idea	Built, Idea	Built, Idea
Lowest Limit	5 Floors	None	7 Floors	22 meters	25 meters	7 floors

Methodology


- 1) Literature Analysis/Data Source
 - # Existing Comparative Studies
 - # Academic Papers
 - # "Gray" Literature
 - # Internet and Site Web Databases
- 2) Reserach Criteria
 - # Criterion 1: Definition Multi-story Wood-Hybrid Buildings.
 - # Criterion 2: Height (> 4 Floors)
 - # Criterion 3: Completion Year (2004-2019)
- 3) Definition of Quantitative and Qualitative Data to be searched

Spöttlgasse

Year Completion	2004
Country	Austria
City	Vienna
Number of Storeys	5
Number Timber Storeys	4

DESIGN DATA

Number of Buildings	1
Total surface built (m ²)	5300
Total surface built (€)	57049

Structural category  Panelised timber-concrete (podium-core)

Podium Ground Floor
Core Concrete
Floor slabs CLT

Program Residential - Social Housing

External Cladding Plaster


Indoor elements exposed All the elements

Building volume Regular

CONTEXTUAL DATA

Type of Commission	Direct
Influence	Public
Motivations	Sustainability
Architect	Hubert Riess, AT
Engineer	JR Consult, AT
Timber Engineer	Woschitz Group, AT
General Contractor	Kulmer Holzleimbau, AT
Timber Contractor	Kulmer Holzleimbau, AT
Timber Supplier:	
Structural Elements	KLH, AT
Floor Elements	KLH, AT
Client	Sozialbau AG, AT

SOURCE OF IMAGES
Sozialbau AG, Woschitz Group, KLH



General *Analysis* of the Case-studies



Where

— North America

24 Case-study

— Europe

161 Case-study

— Other Countries




12 Case-study





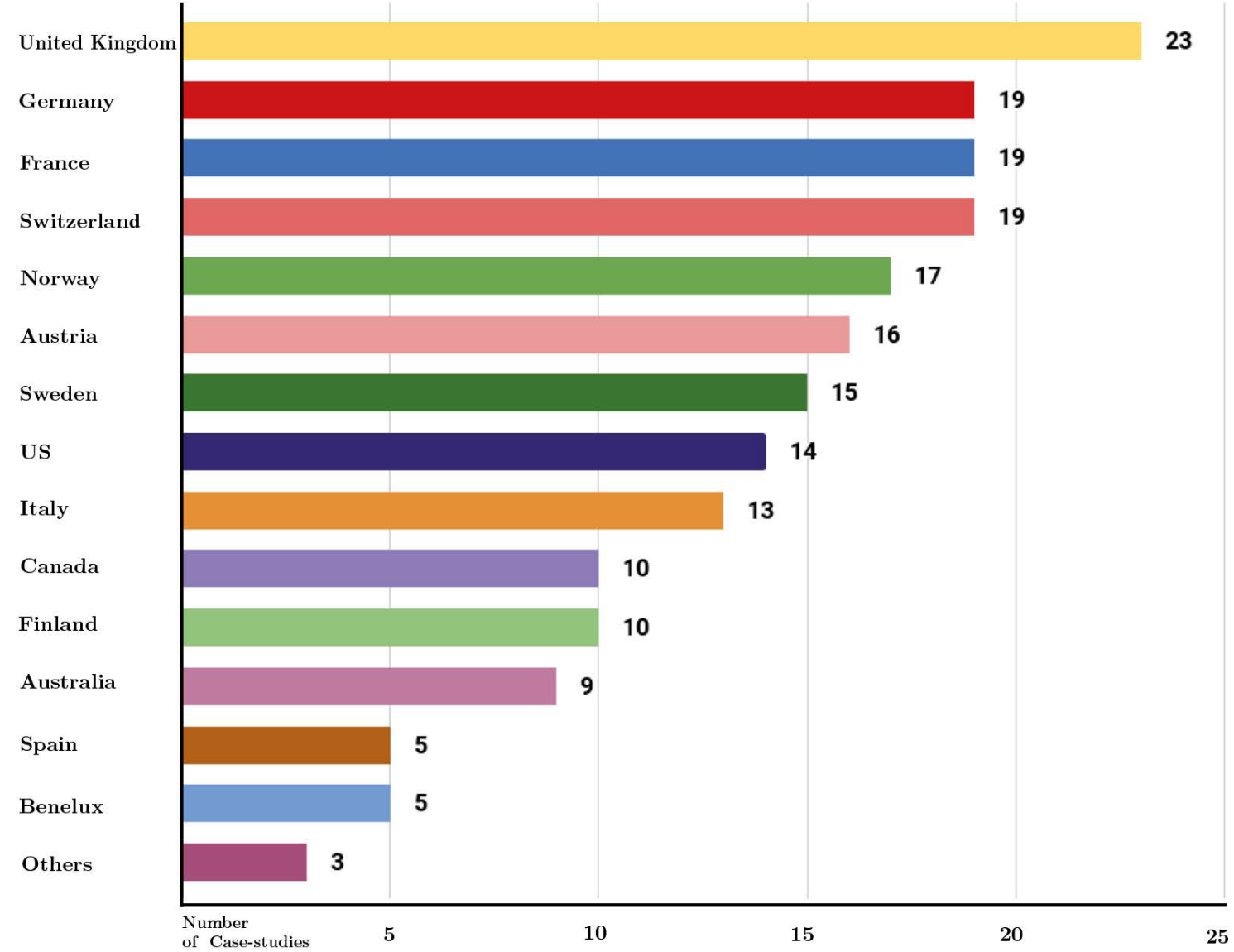
Spain



-  Number of storeys
-  Panelised all-timber
-  Panelised timber-concrete



Number of Projects

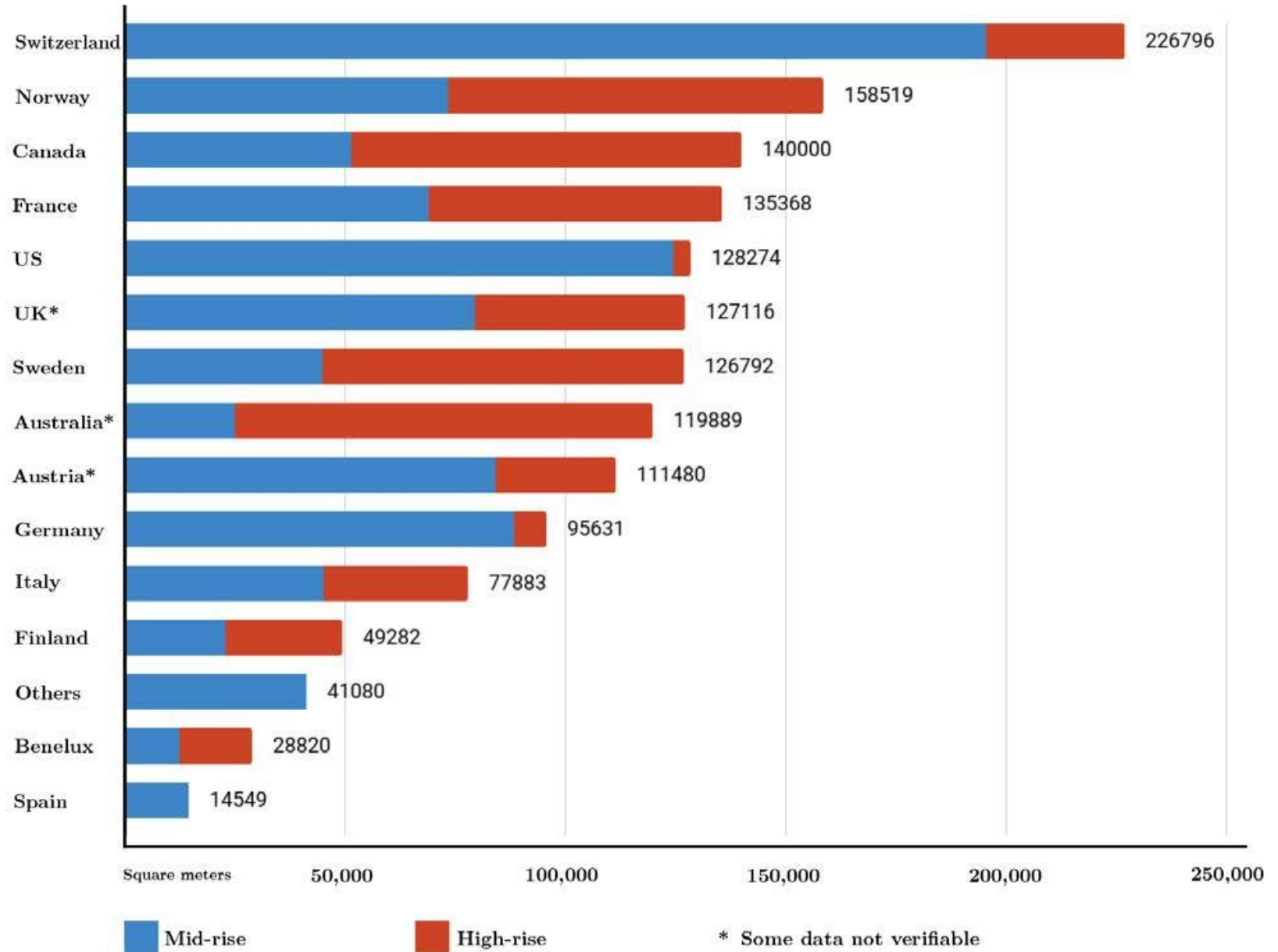


Dimensions



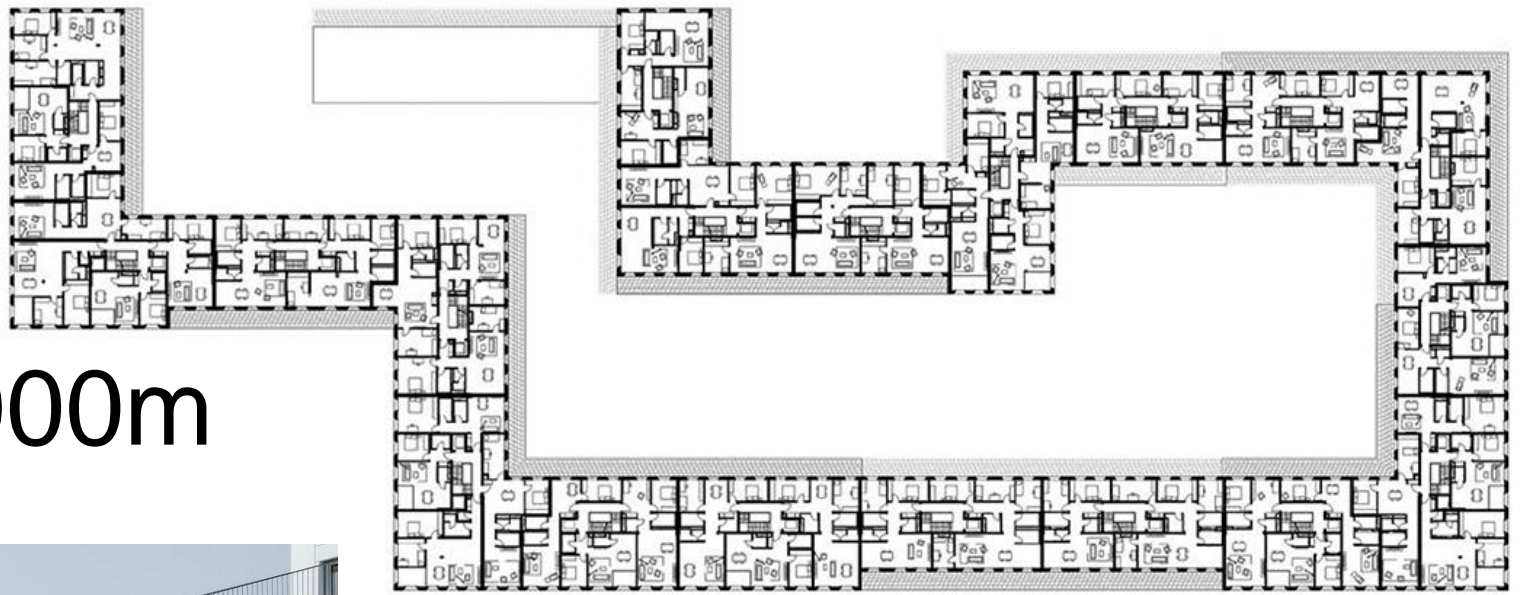
15 Buenavista
409 m²

Source: b76 Architectura





Sue&til (CH): 53,000m



Source: Implenia AG





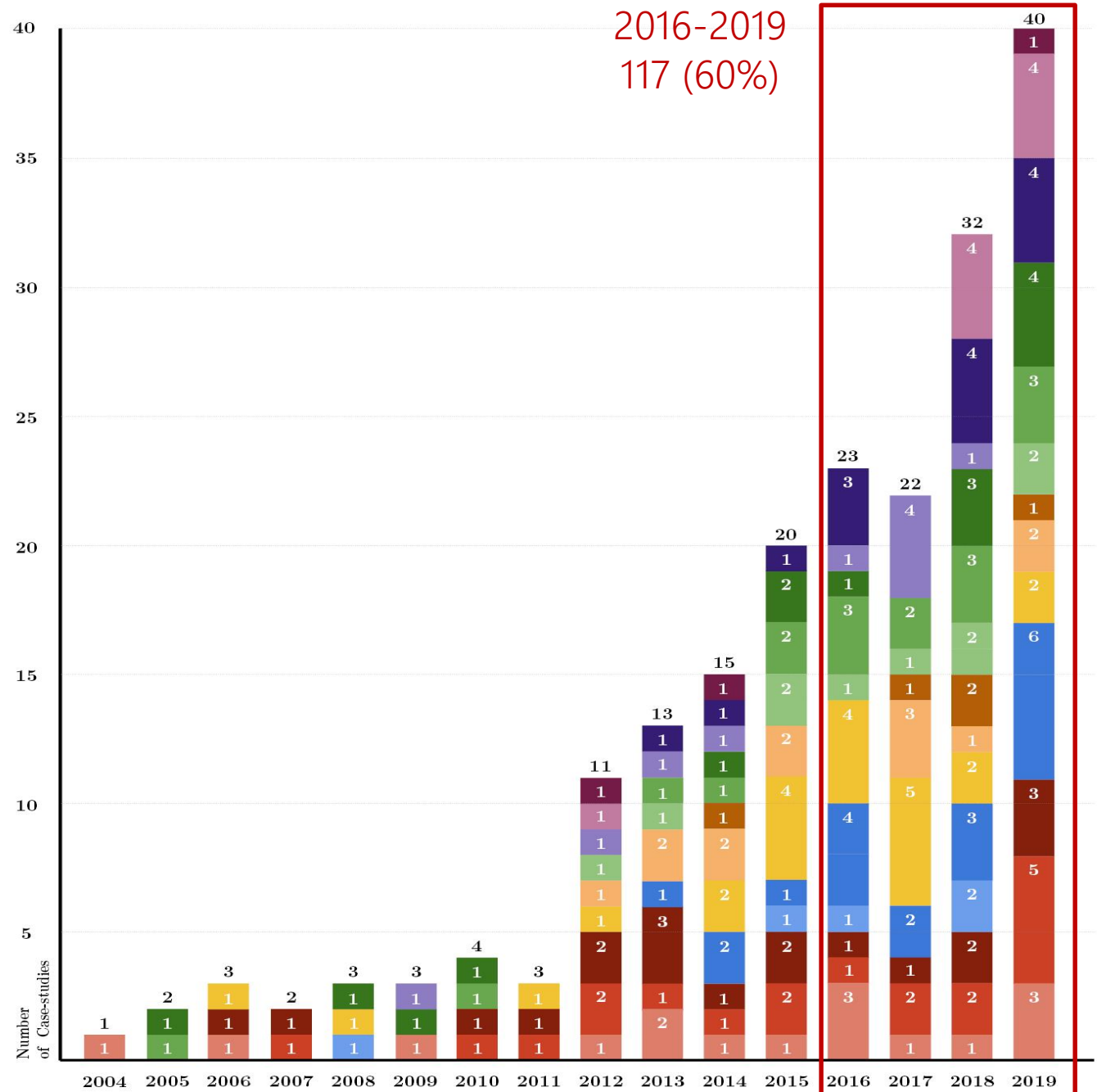
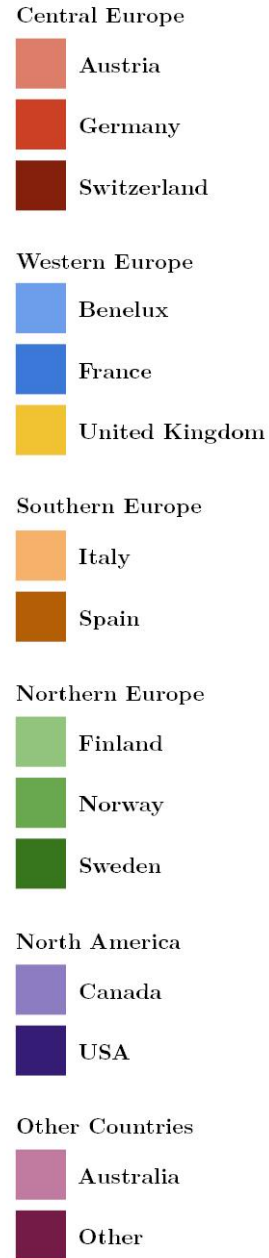
Siemens Campus

Erlangen, Deutschland

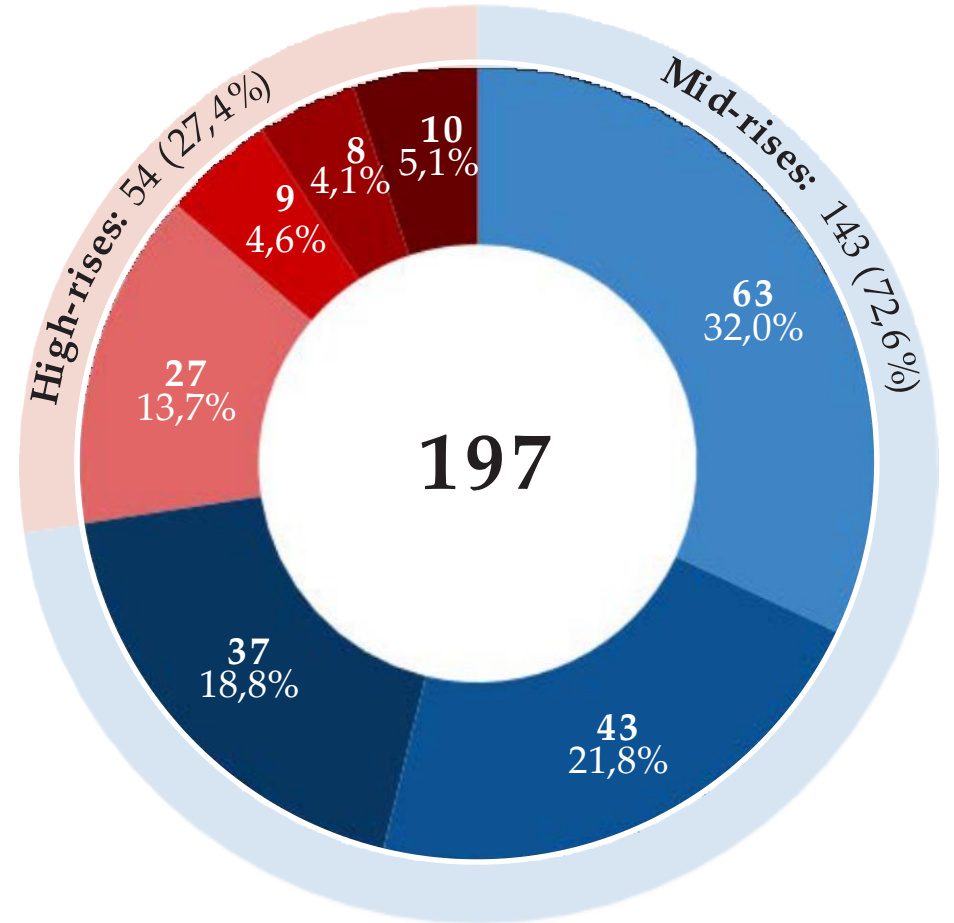
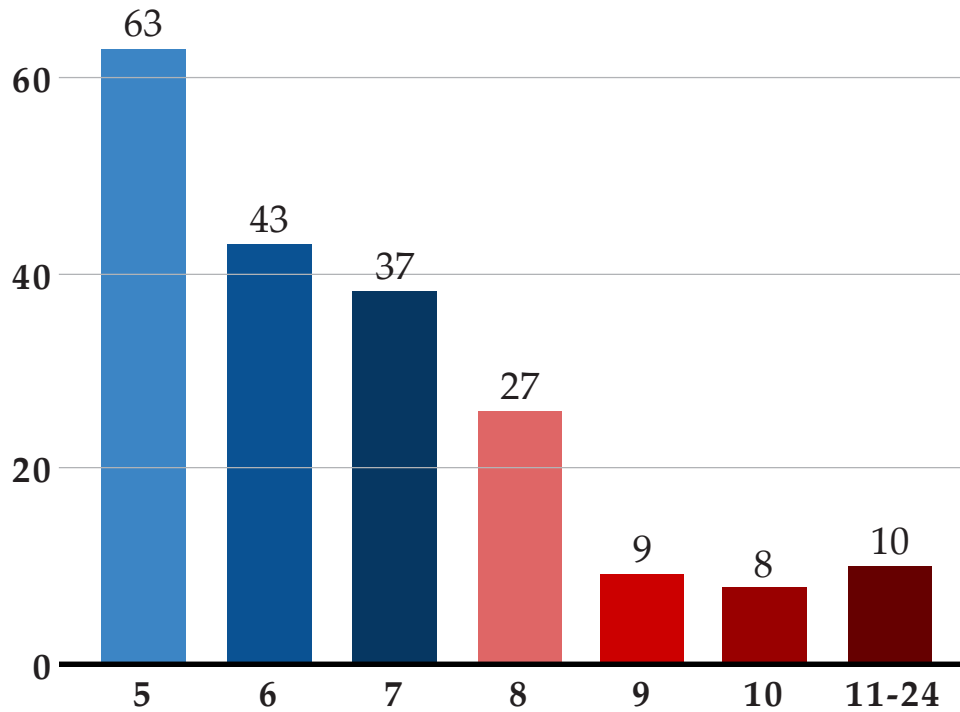




Number Buildings 5
Height 5 Floors
Total Surface 75.500 m²



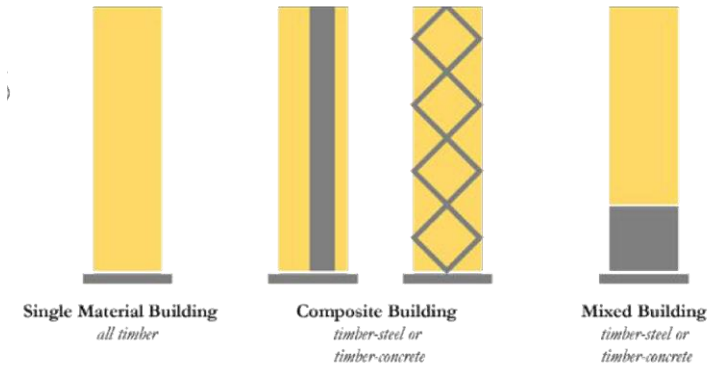
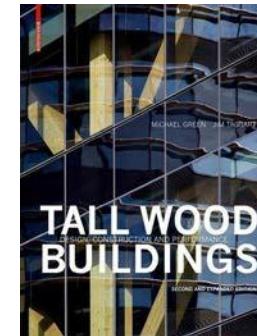
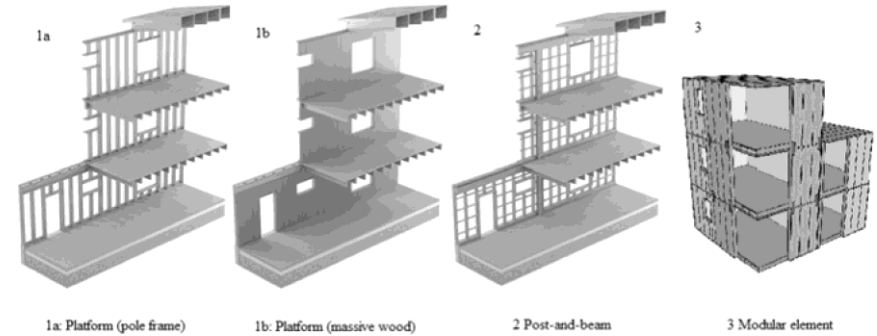
Mid- or High-rise?



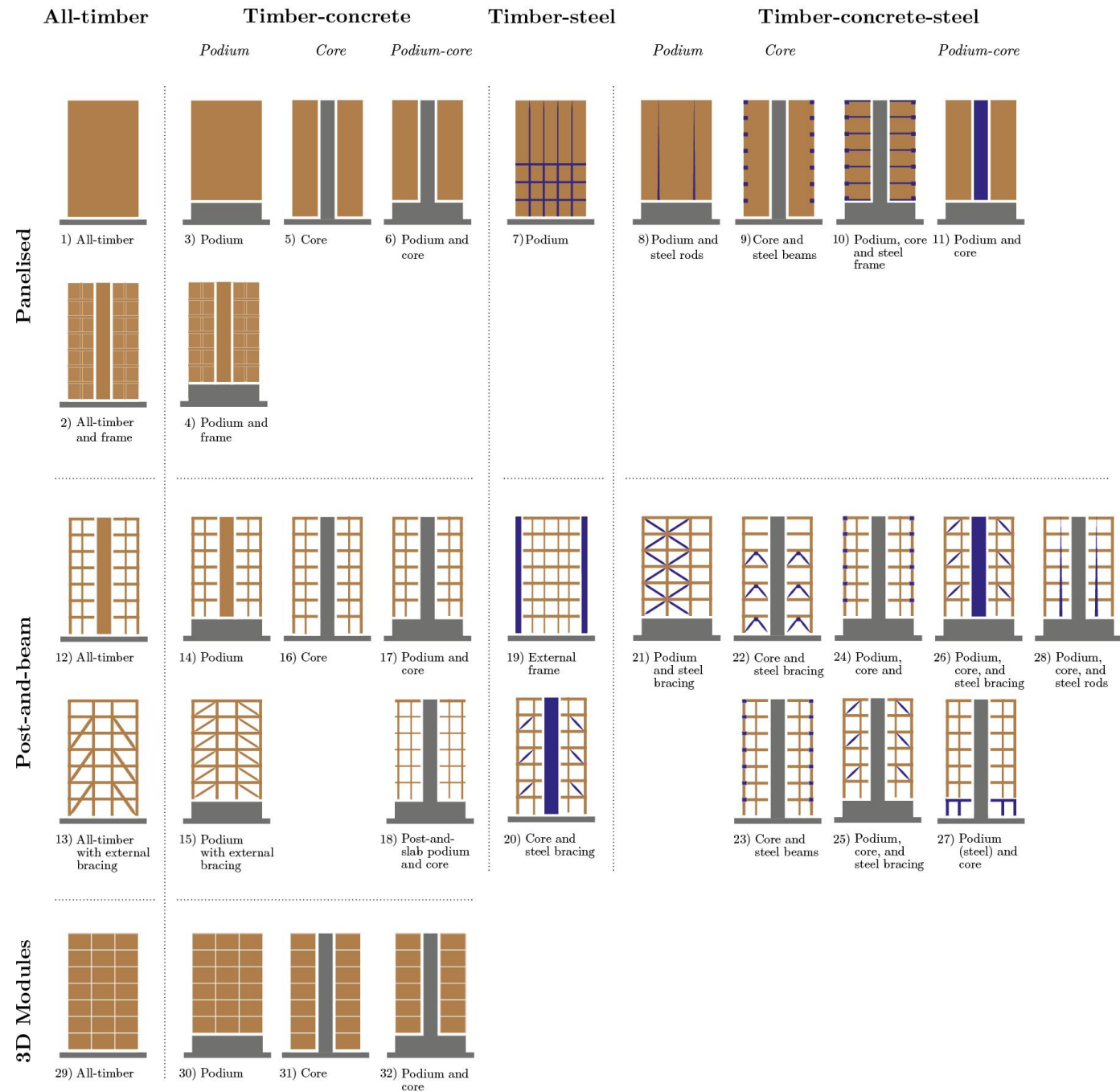
Structural Analysis of the Case- studies

Structural Categorization

- 1) Platform, Post-and-beam, Modular 3D
- Hurmekoski et al., 2017
- 2) Panel Systems, Frame Systems, Hybrid Systems
- Green and Taggart, 2018
- 3) Single Material, Composite, Mixed
- Foster et al, 2017, Wiegand, 2019



Structural Categorization





Structural Categorization



1) All-timber

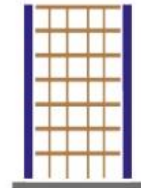


6) Podium
and core

Structural Categorization



15) Podium with external bracing

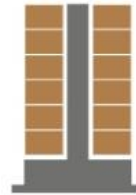


19) External frame

Structural Categorization



26) Podium,
core,
and steel
bracing

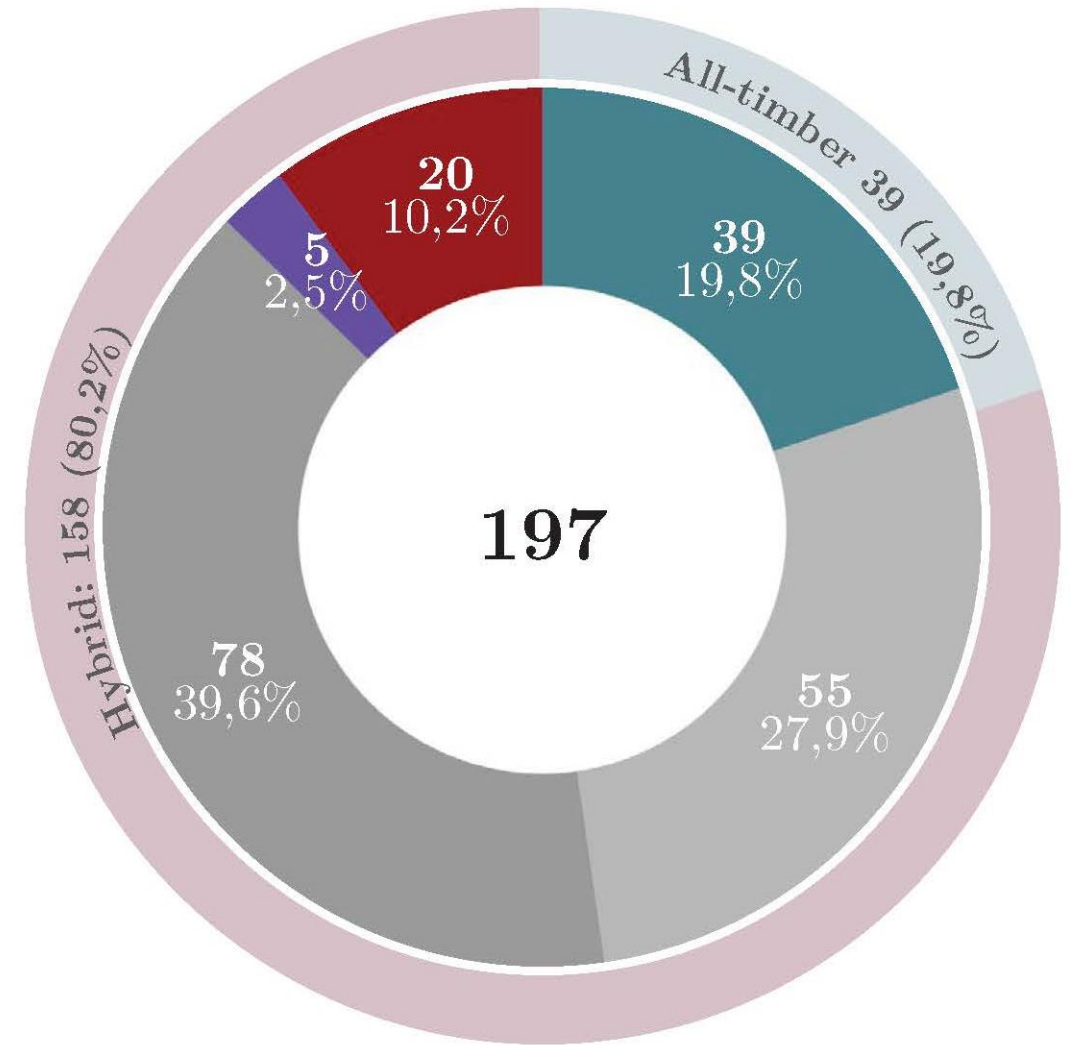


32) Podium
and core

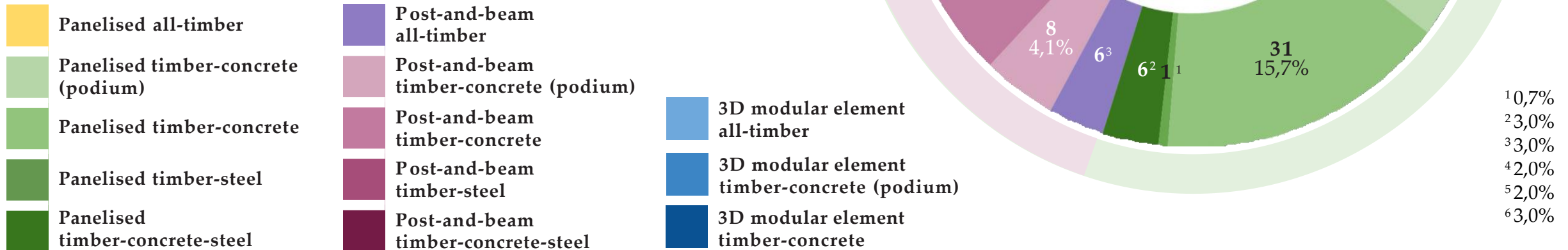


Structural Analysis

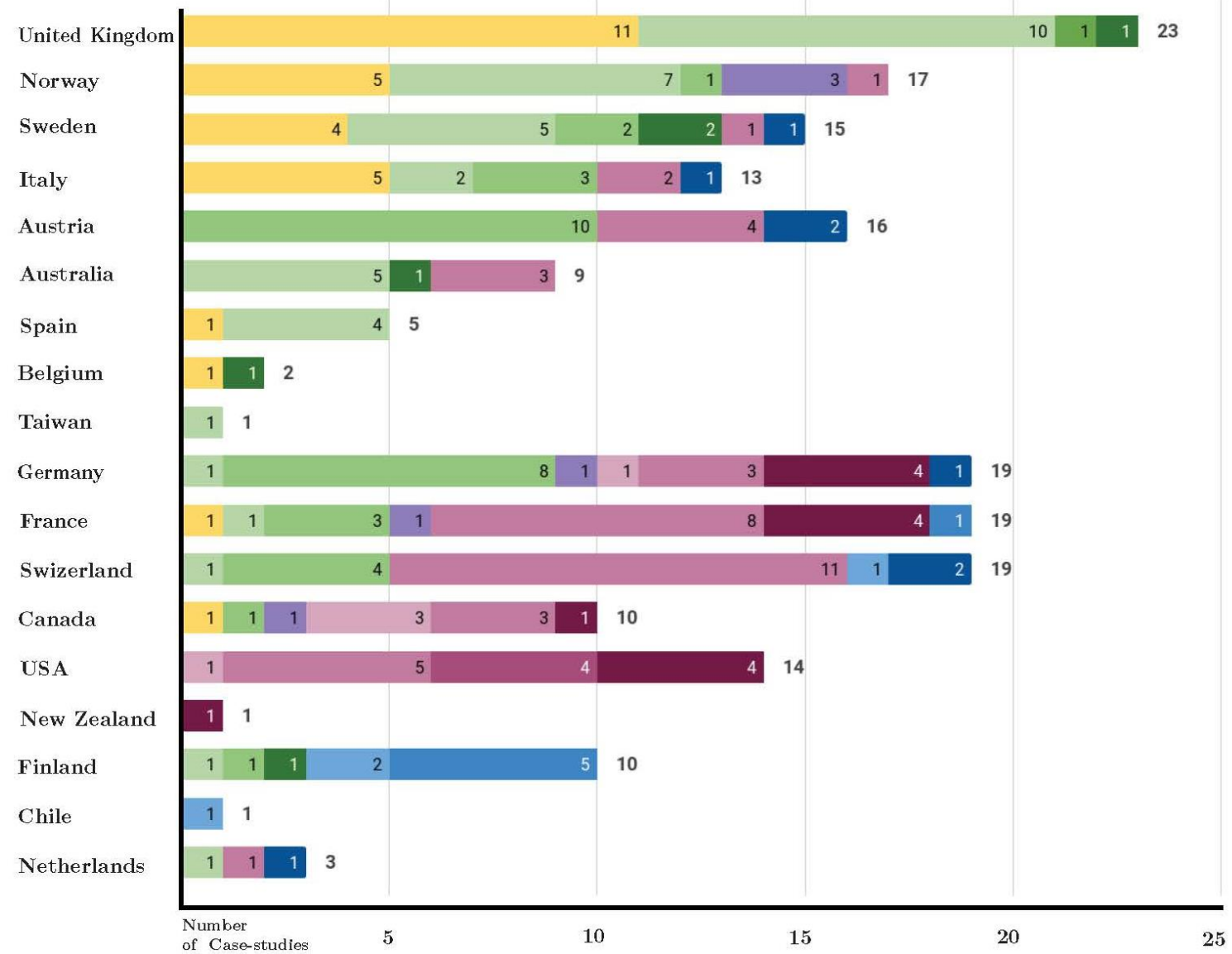
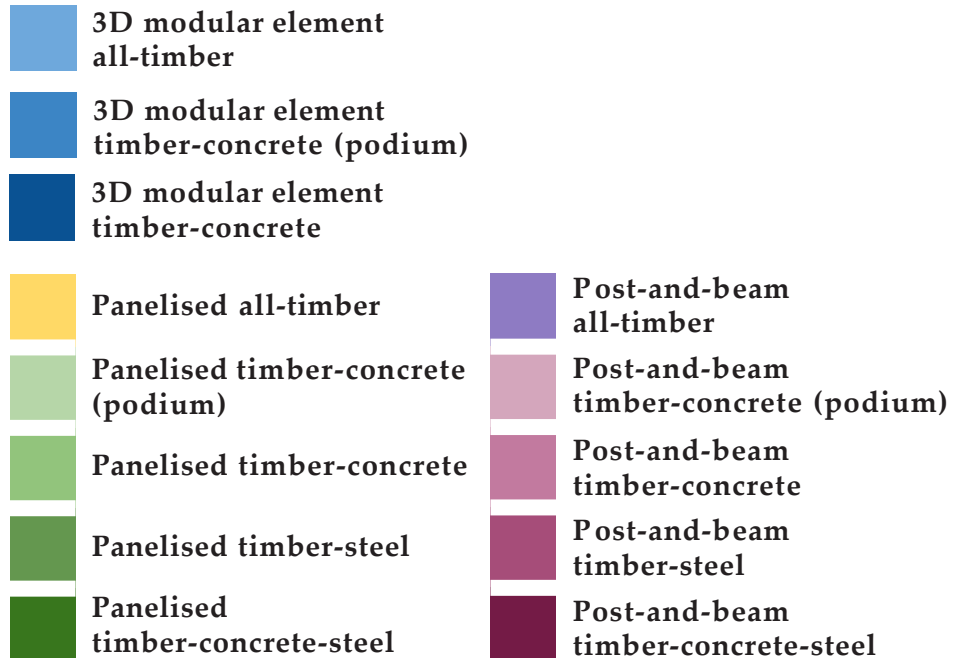
- All-timber
- Timber-concrete (podium)
- Timber-concrete
- Timber-steel
- Timber-concrete-steel






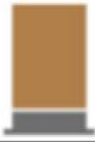






Structural Analysis



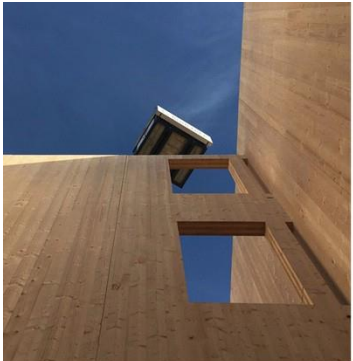
Structural Analysis



Spain

Project (name)	(image)	Storeys (number)	Timber Storeys (number)	Structural system (logo)	(category)	Core (material)	Floor Slabs (material)	Total Built Surface (m ²)	Program (type)	Facade cladding (material)	Structural timber exposure (category)
Contralaminada		5	5		Panelised all-timber	CLT	CLT	940	Residential - Social Housing	Plaster	Ceiling
Hondarribia Visesa VPO		5	4		Panelised timber-concrete (podium)	CLT	CLT	9000	Residential - Social Housing	Other	Ceiling
ARV8		6	5		Panelised timber-concrete (podium)	CLT	CLT	1200	Residential	Metal	Ceiling
La Borda		7	6		Panelised timber-concrete (podium)	CLT	CLT	3000	Residential - Co-housing	Wood	Ceiling
15 Buenavista		5	4		Panelised timber-concrete (podium)	CLT	CLT	409	Residential	Wood	Walls

Core



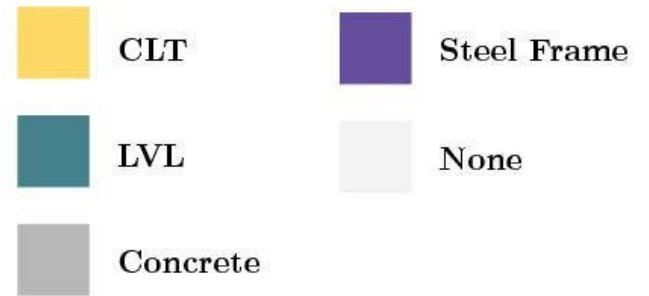
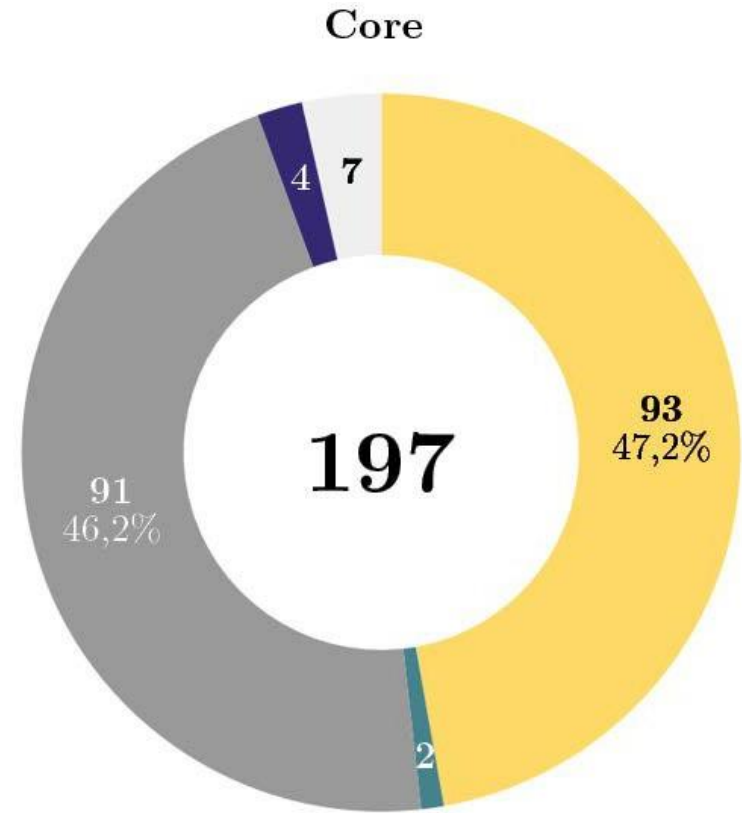
 CLT



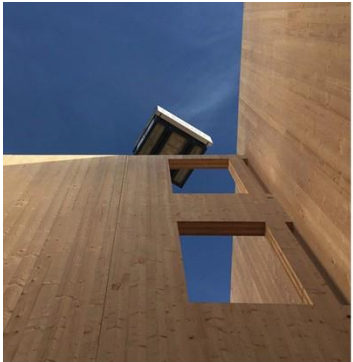
 Concrete



 Steel



Core



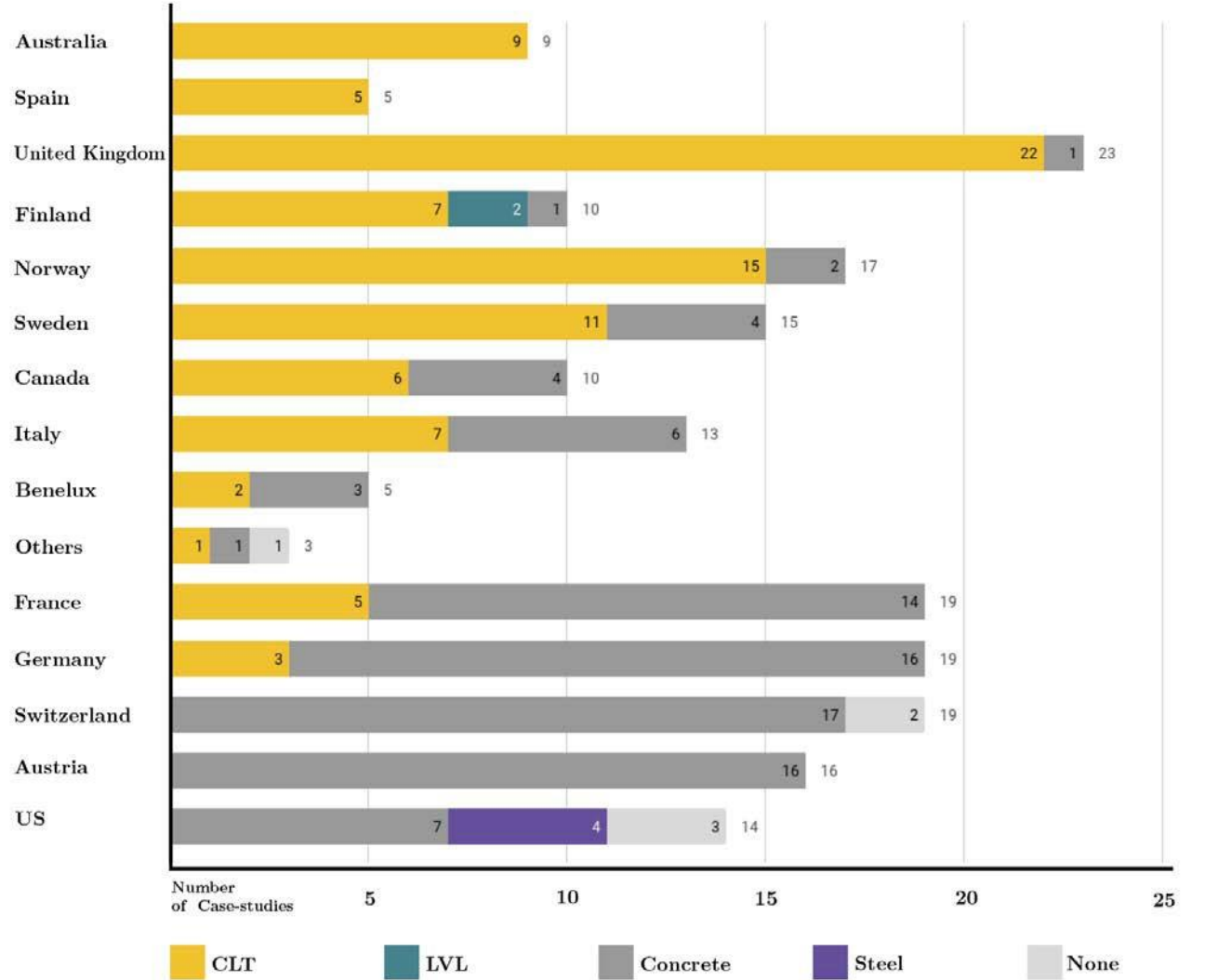
 CLT



 Concrete



 Steel



Floor slabs



CLT



CLT-Concrete



LVL



CLT-Glulam



DLT



NLT

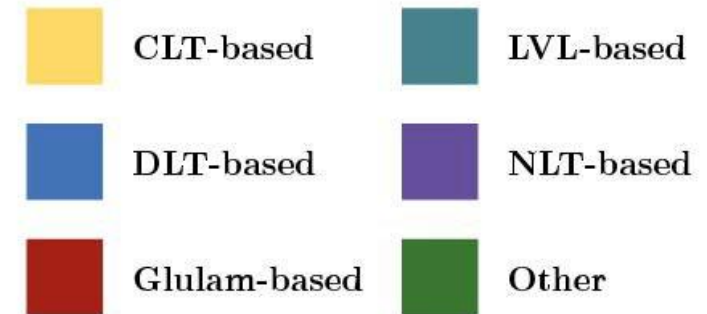
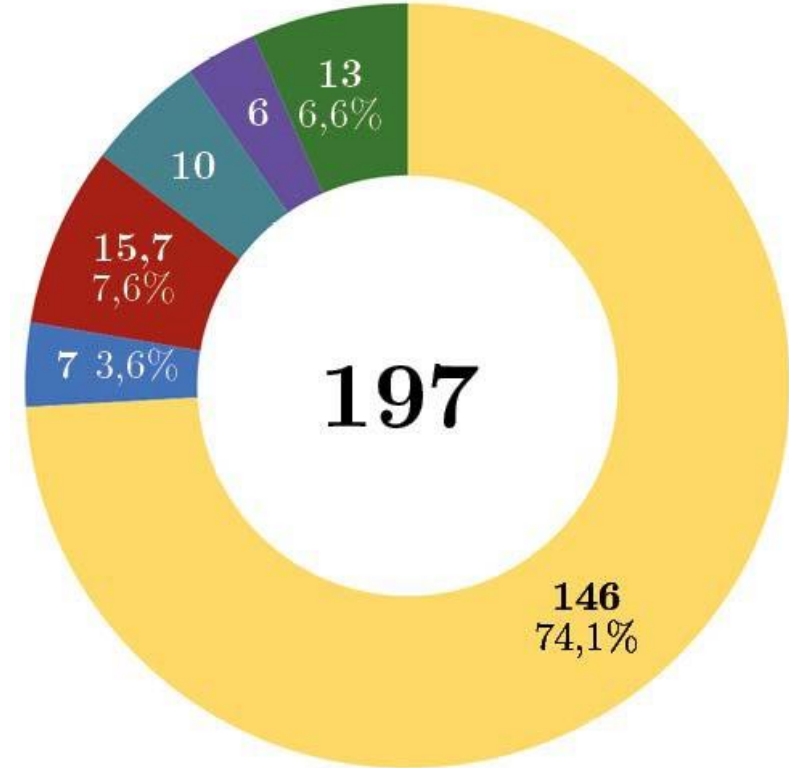


Glulam



Glulam-concrete

Floor Slabs



Floor slabs



CLT



CLT-Concrete



LVL



CLT-Glulam



DLT



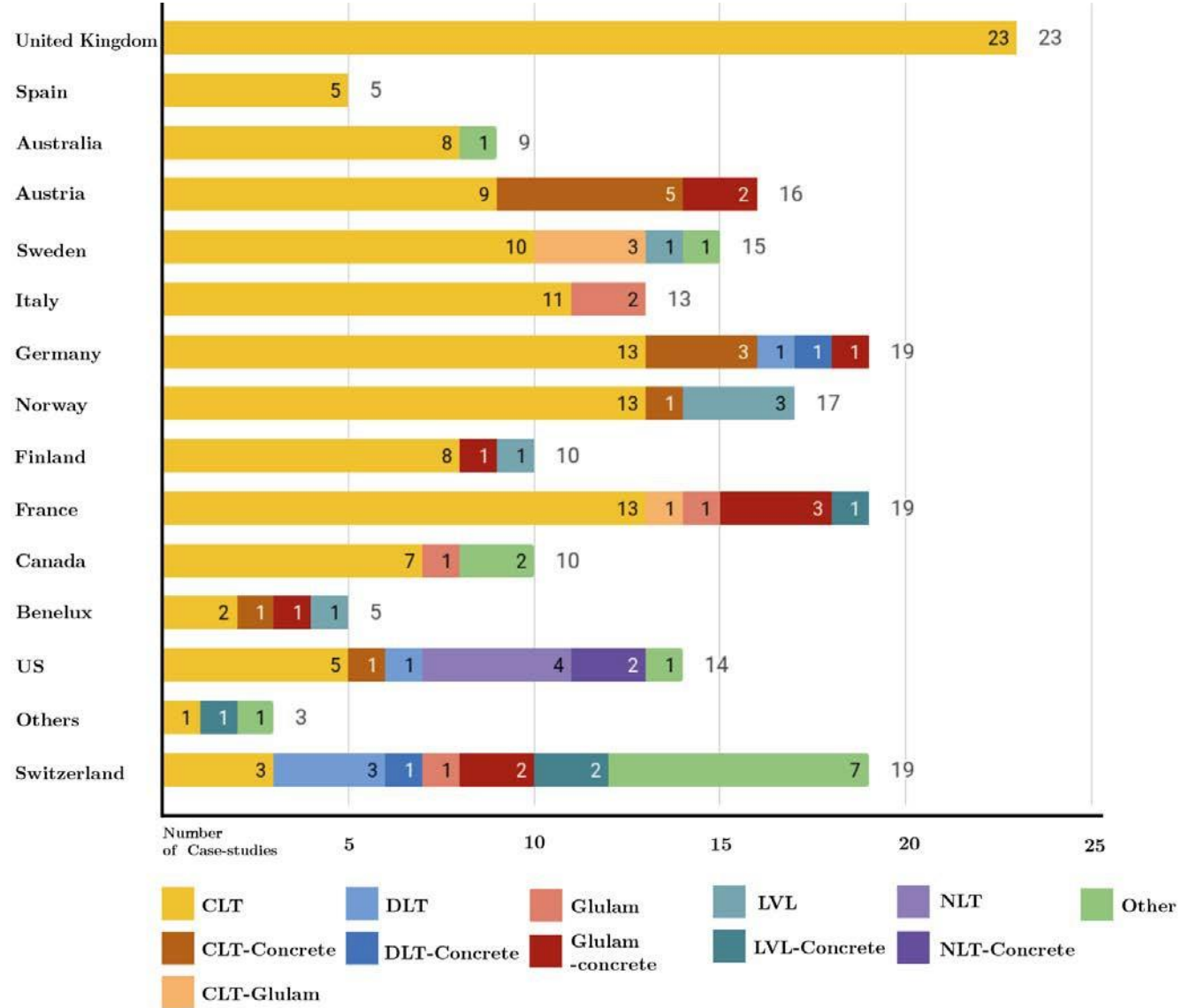
NLT



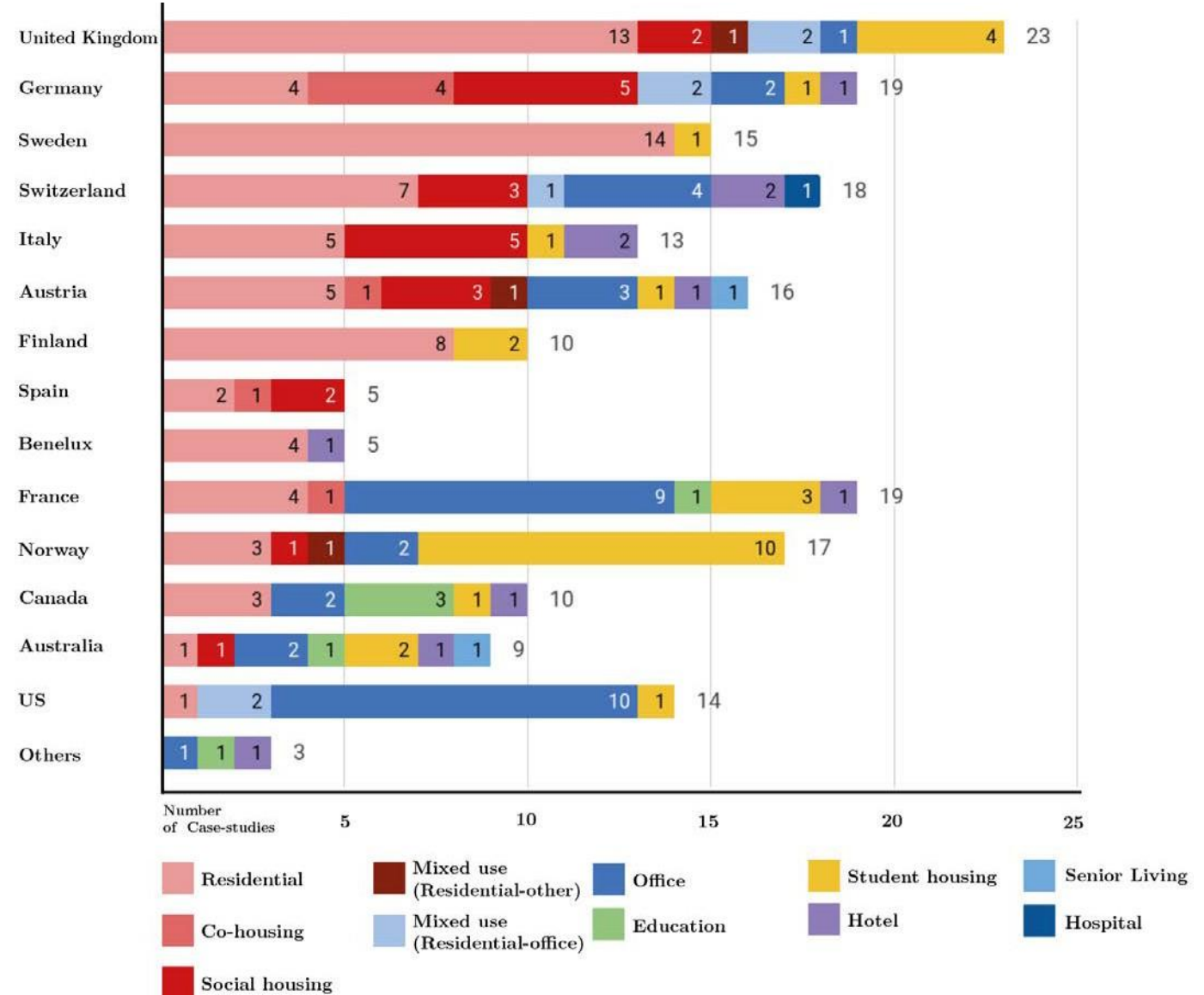
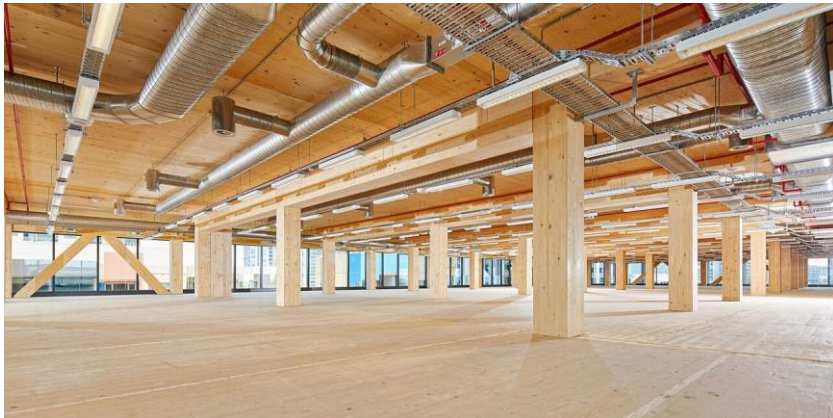
Glulam



Glulam-concrete



Typology



Timber Exposure



All elements



Ceiling



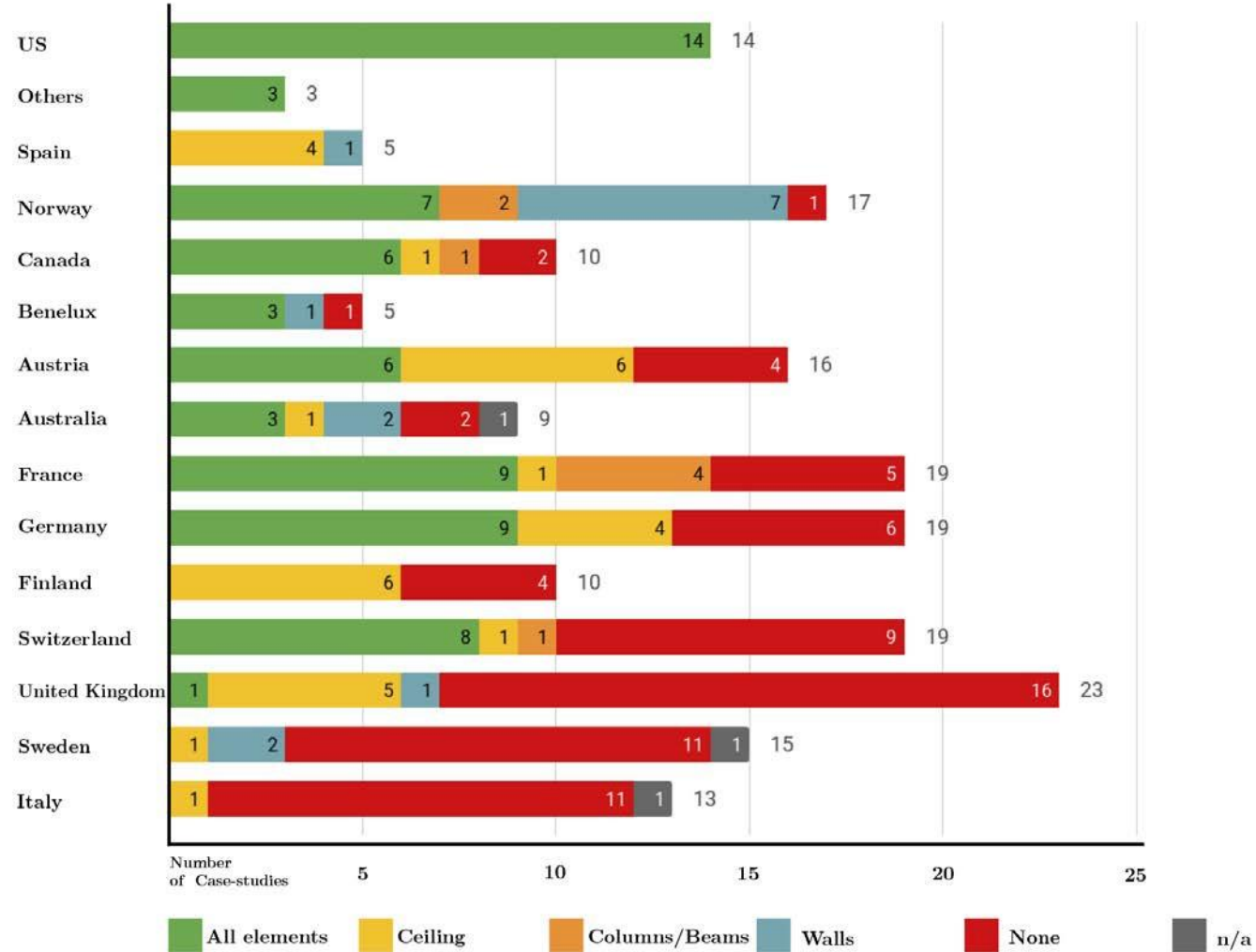
None



Columns/Beams

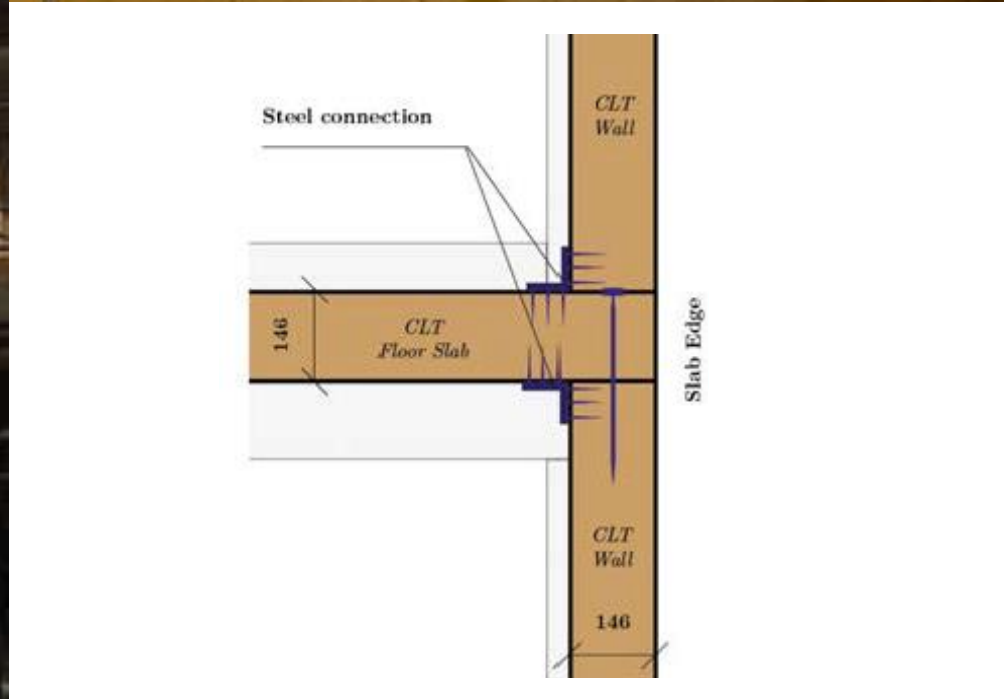


Walls



Project Clusters





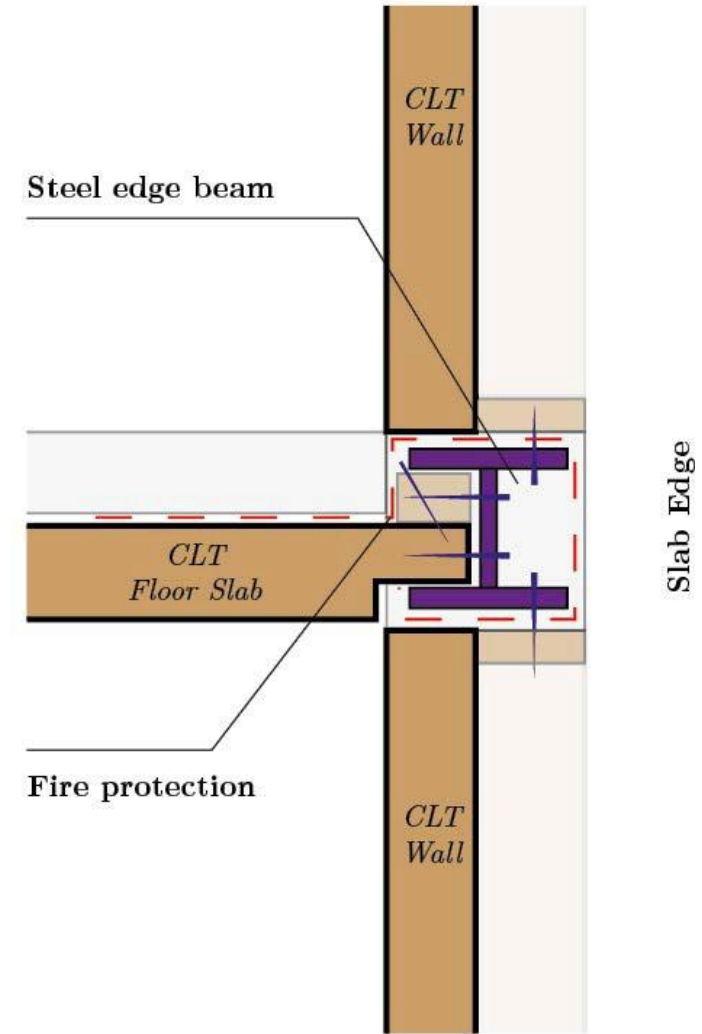




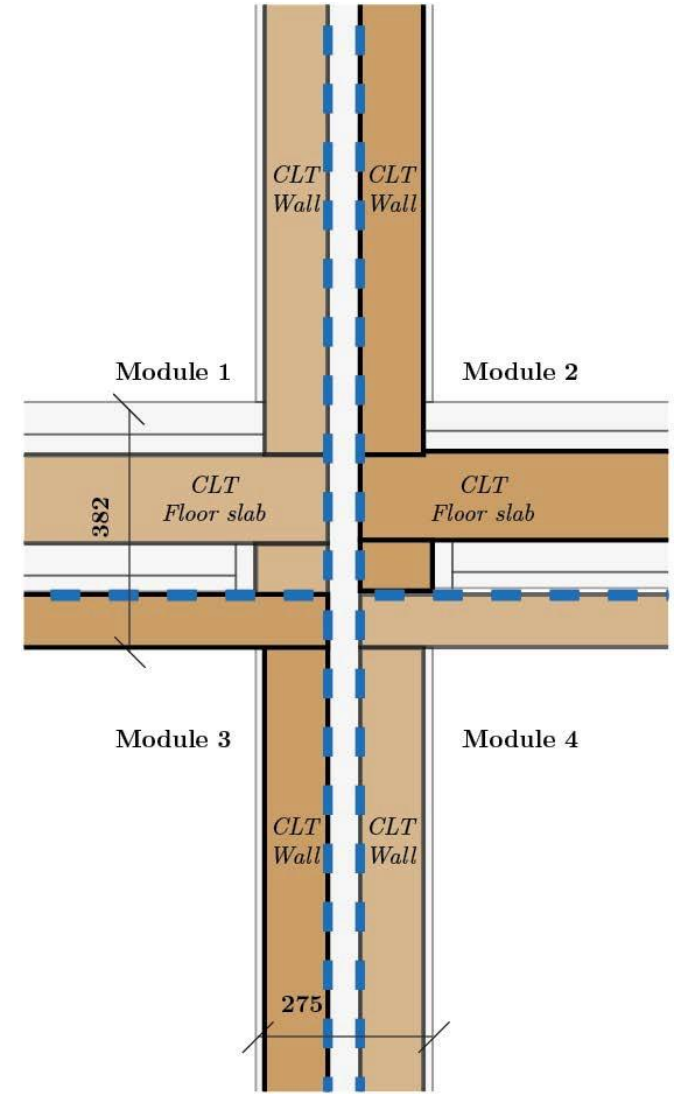




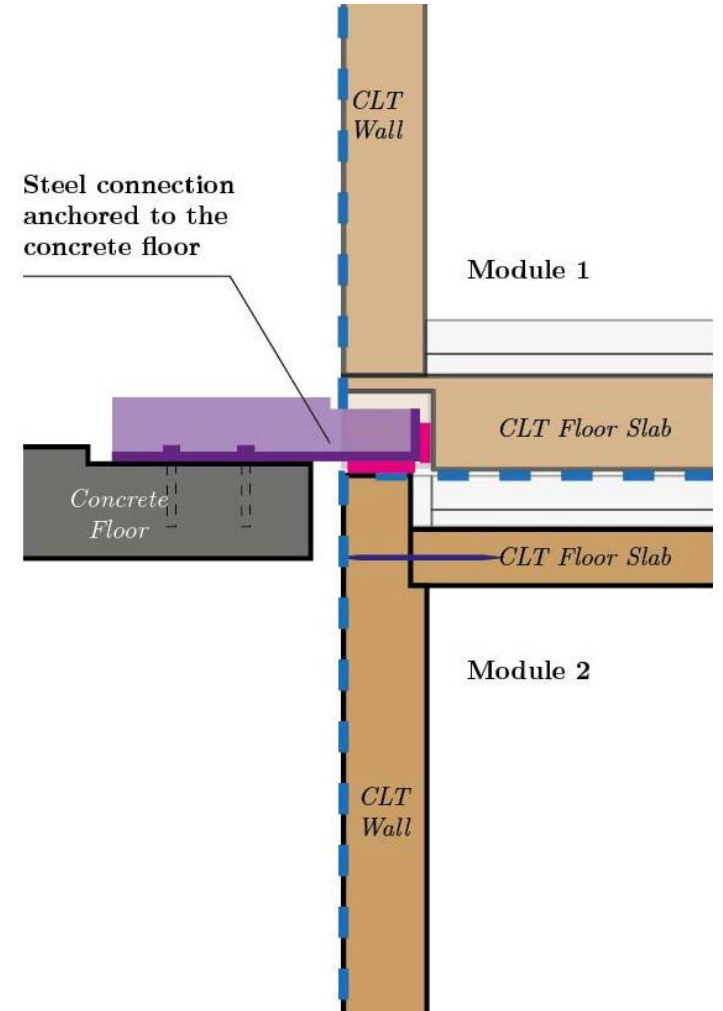




Skaio
Germany

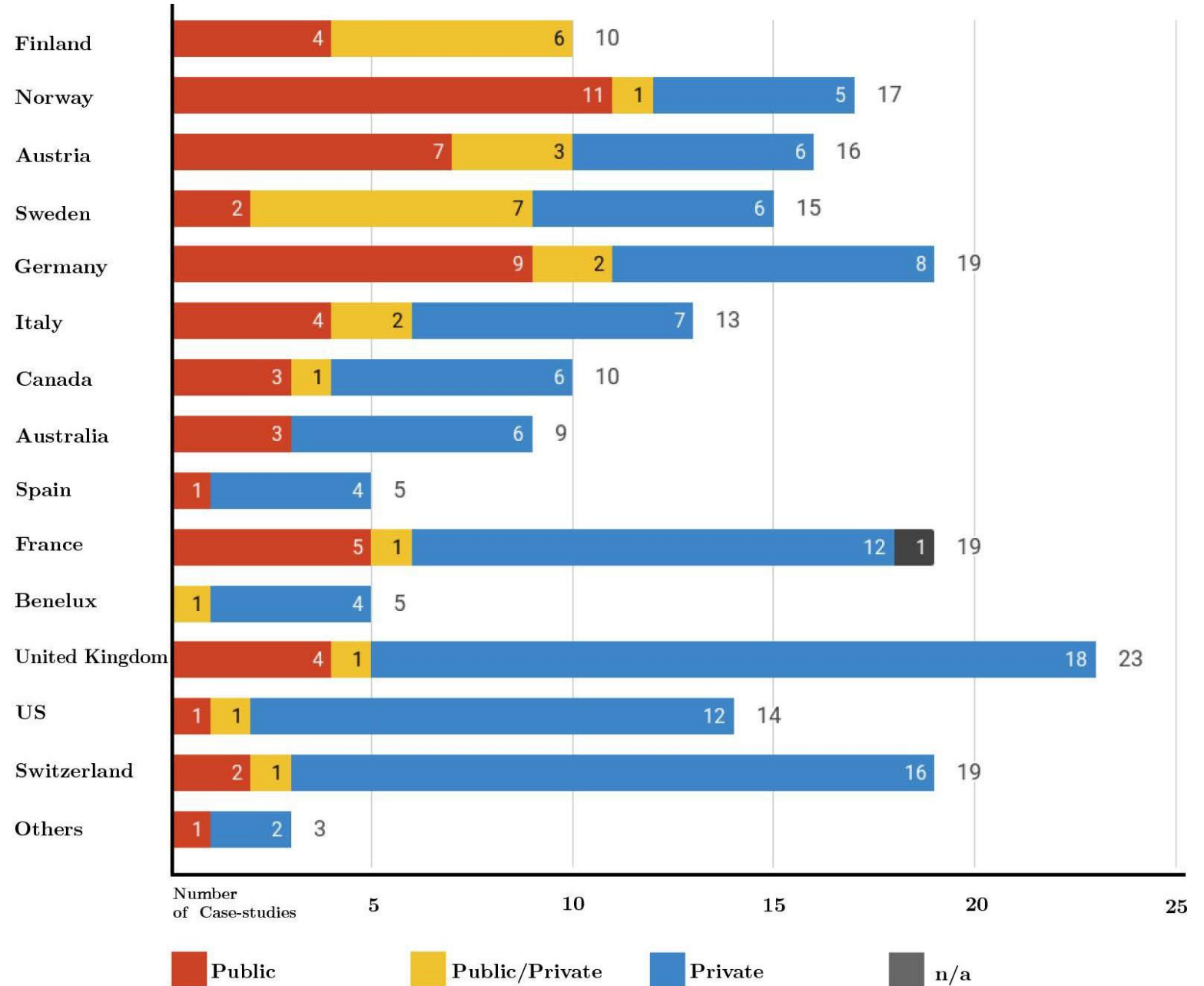
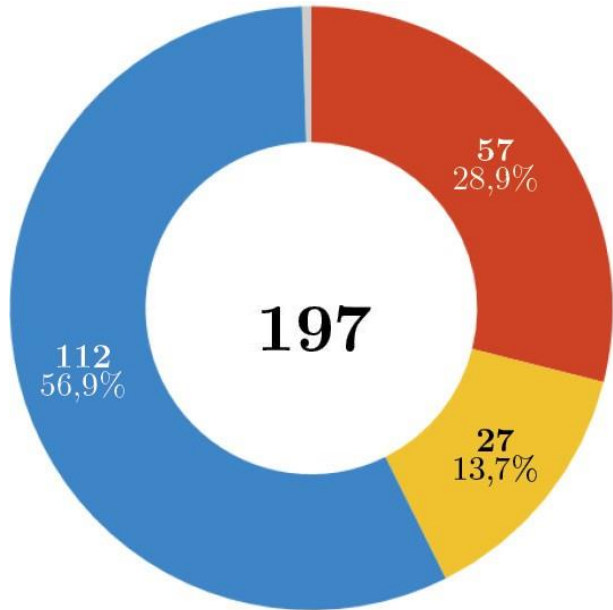


Puukuokka
Finland

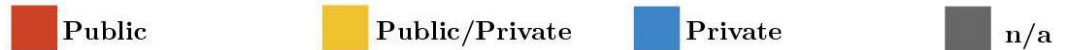


Drivers' Analysis

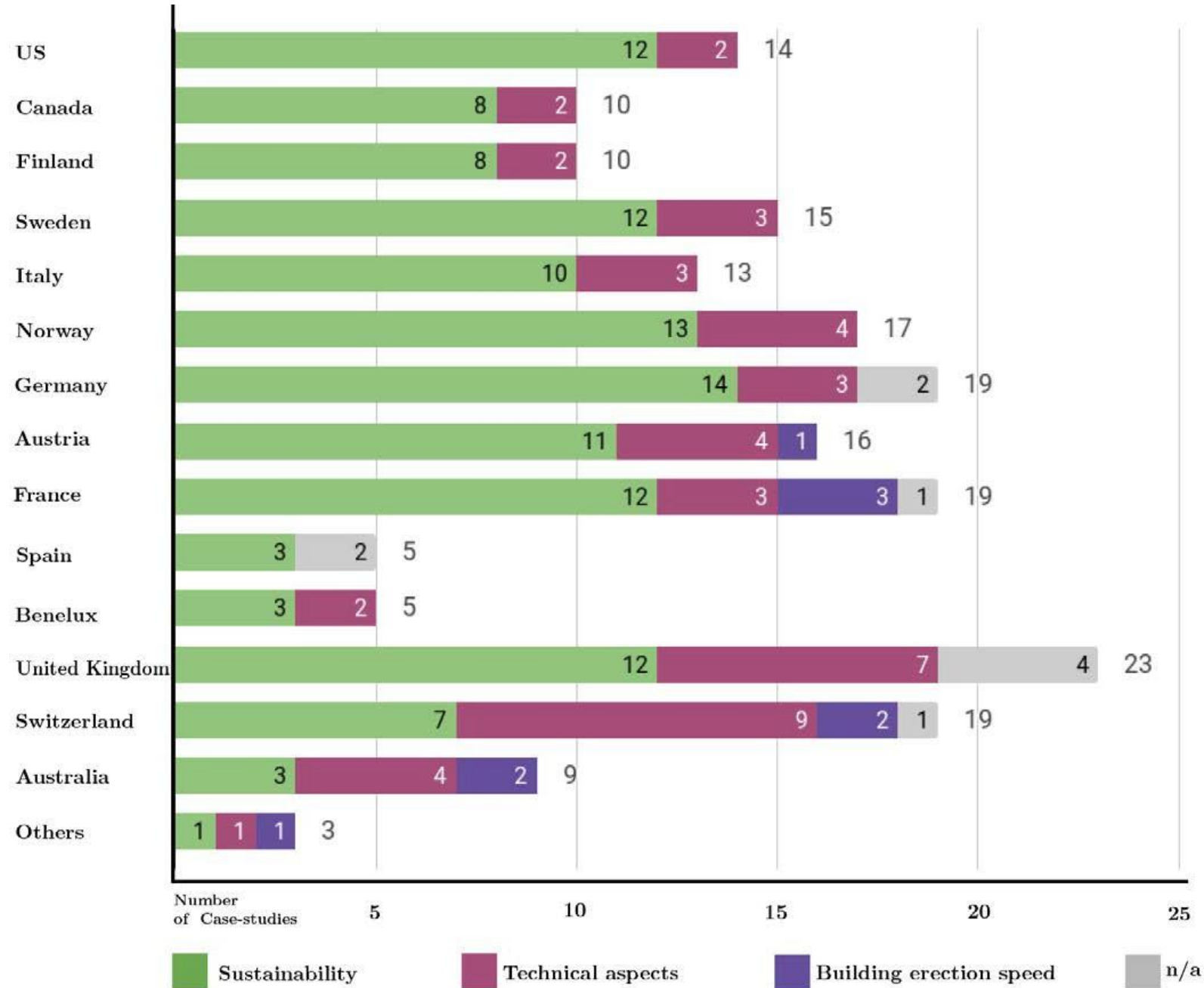
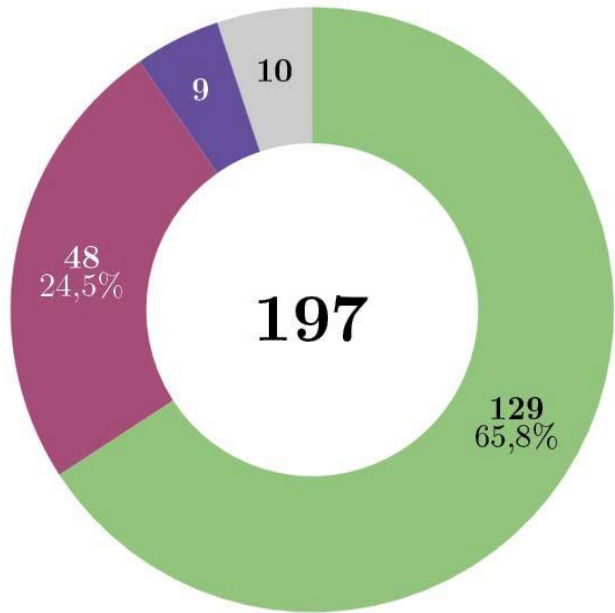
Commission



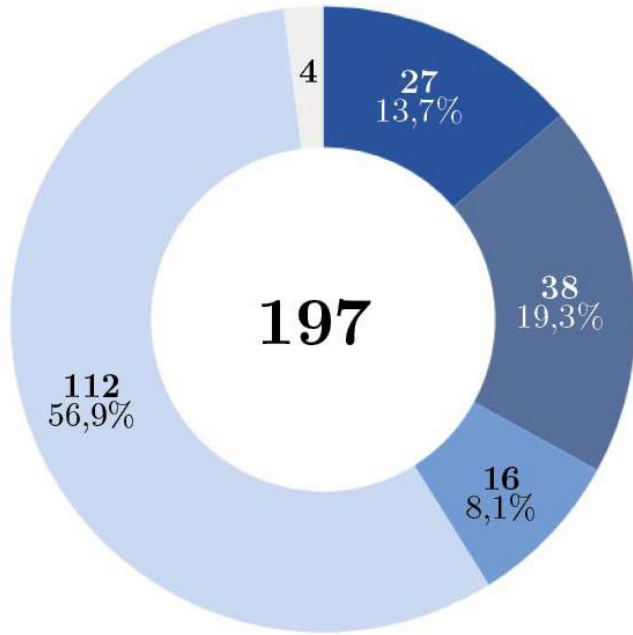
Number of Case-studies



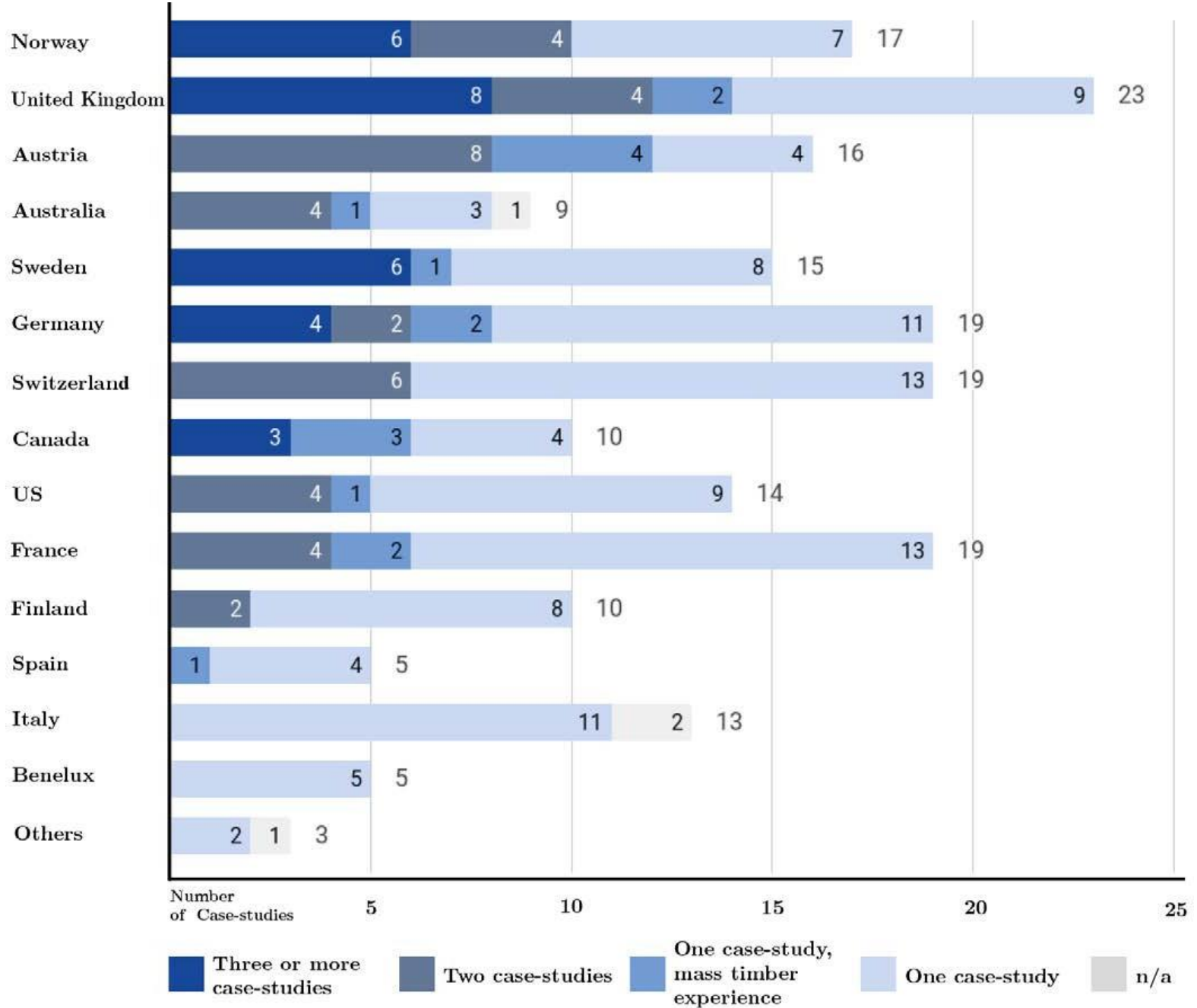
Motivation



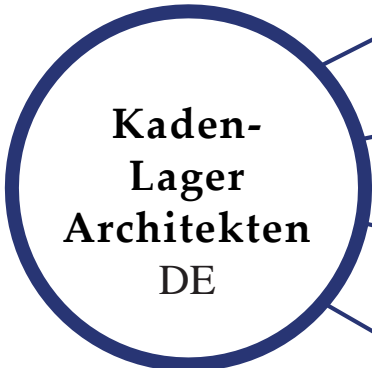
Architects



Three or more case-studies
Two case-studies
One case-study, mass timber experience
One case-study
n/a



Number of Case-studies
Three or more case-studies
Two case-studies
One case-study, mass timber experience
One case-study
n/a



E3



C13



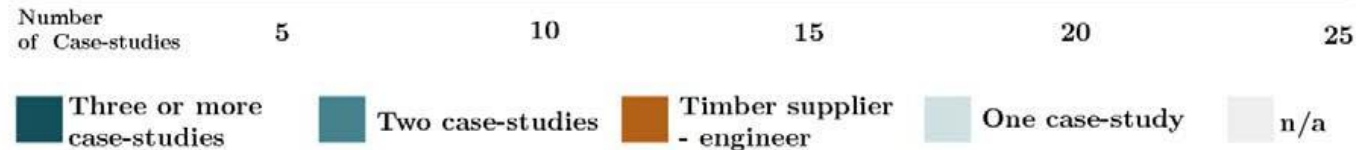
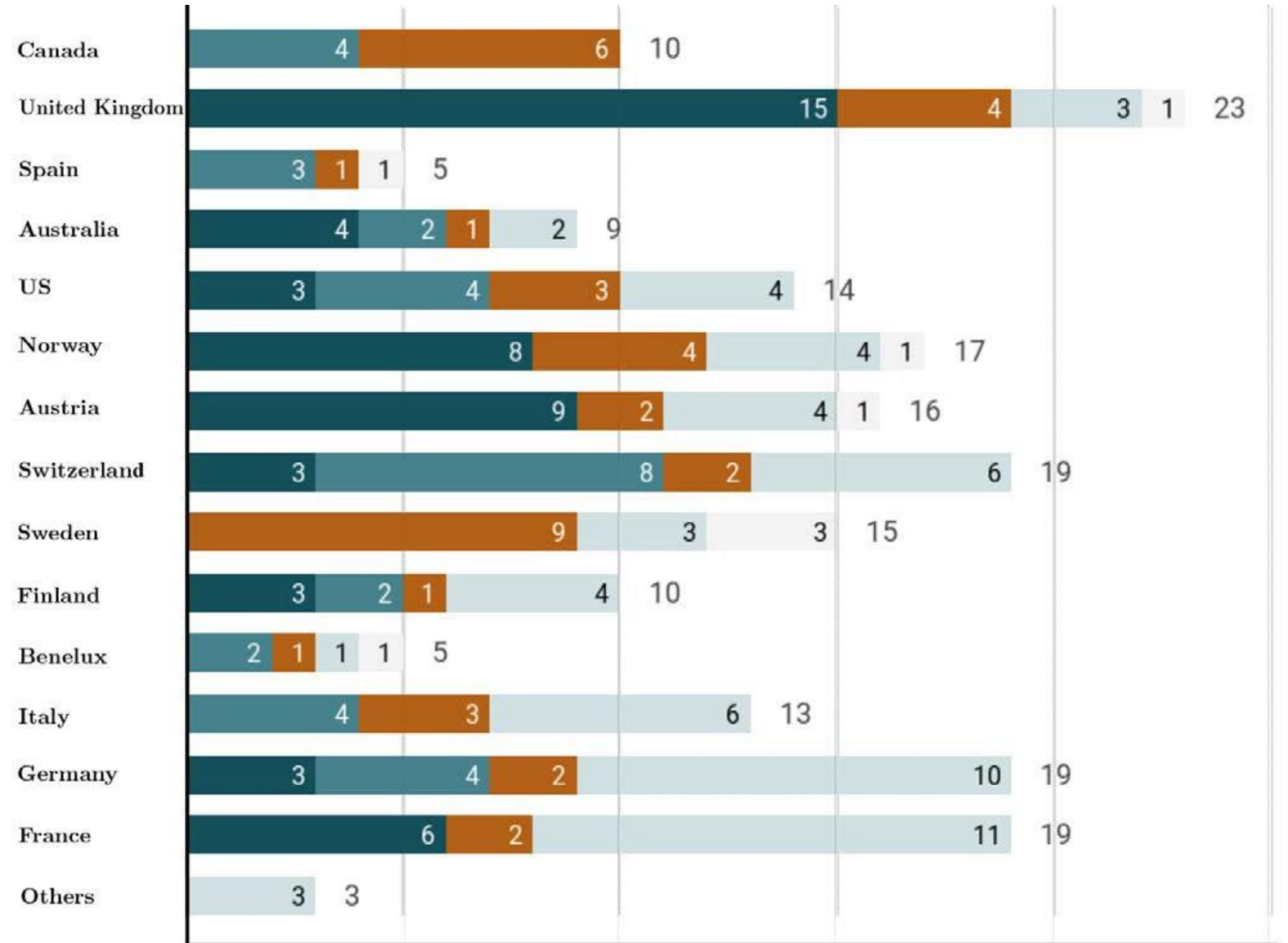
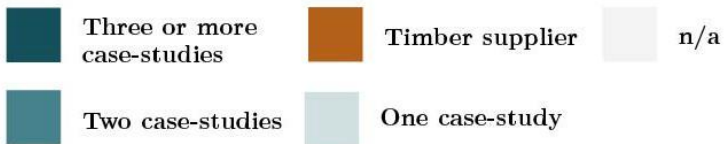
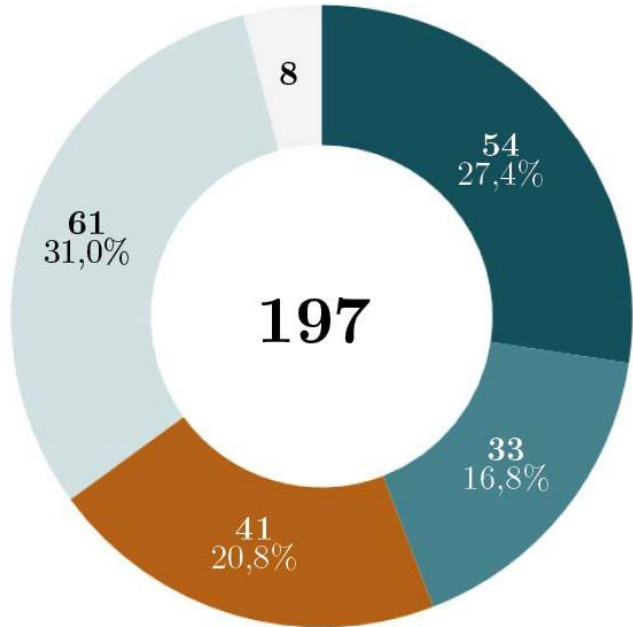
Famju



Skaio



Engineer (Timber)





Stadthaus



Dalston Lane



Whitmore Road



55 Pitfield



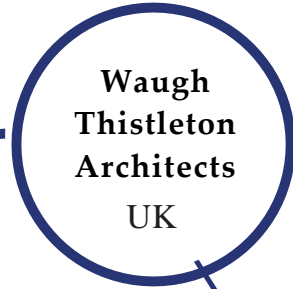
Curtain Palace



Green House



106 Lewis Road



Woodberry Down



Fairmule House



Highpoint Terrace



Birdport House



Hands Building



Cobalt Place



Press House



Trafalgar Place



Boiler House

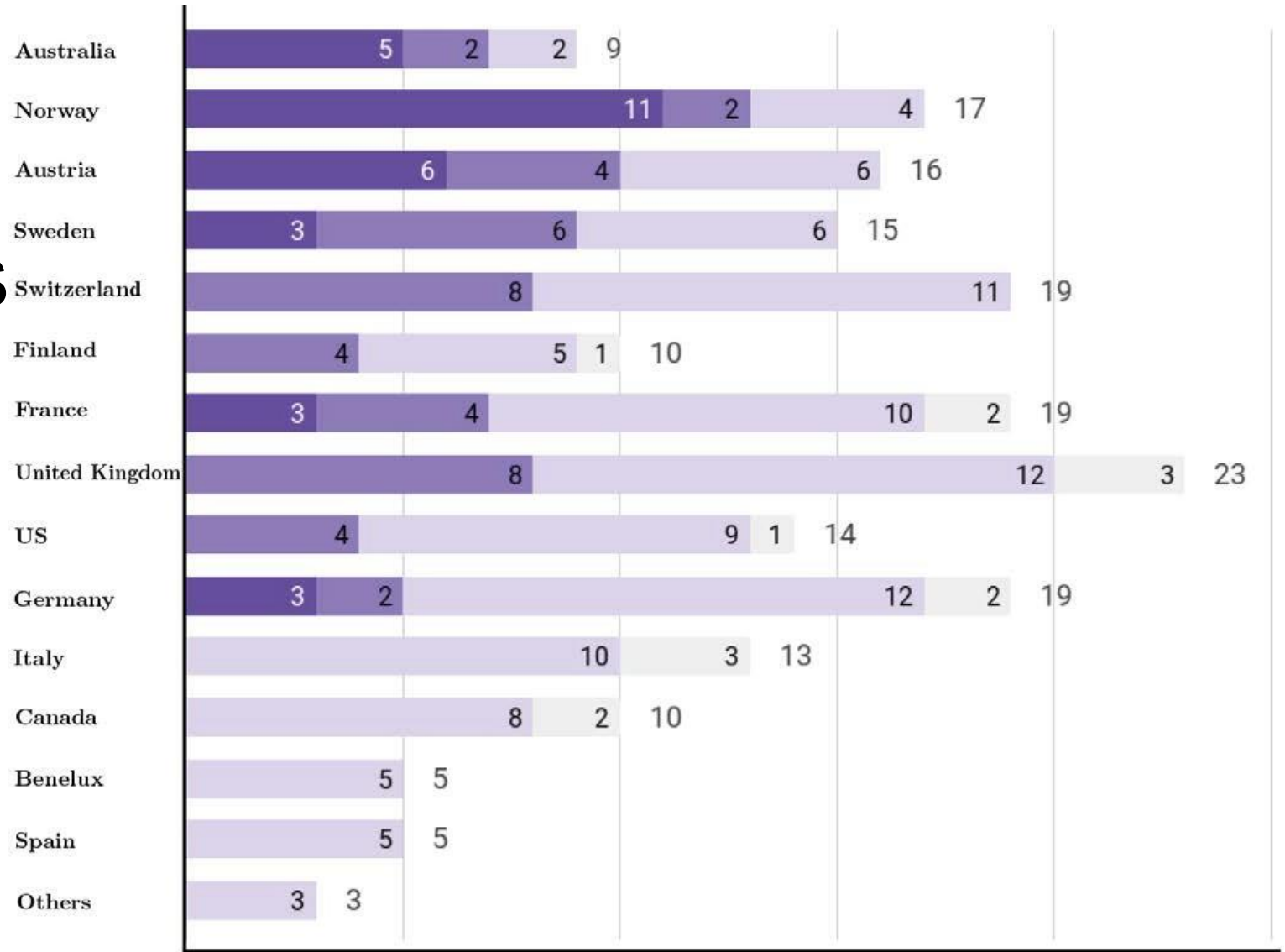
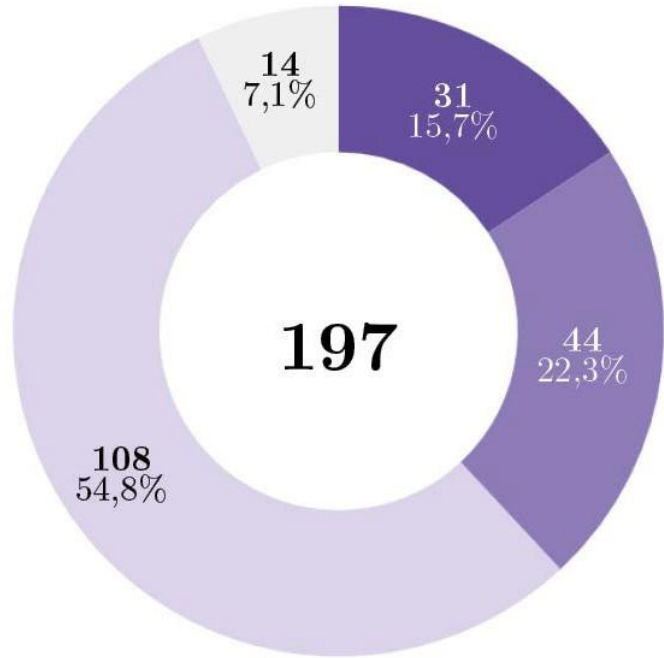


Bacton Low Rise

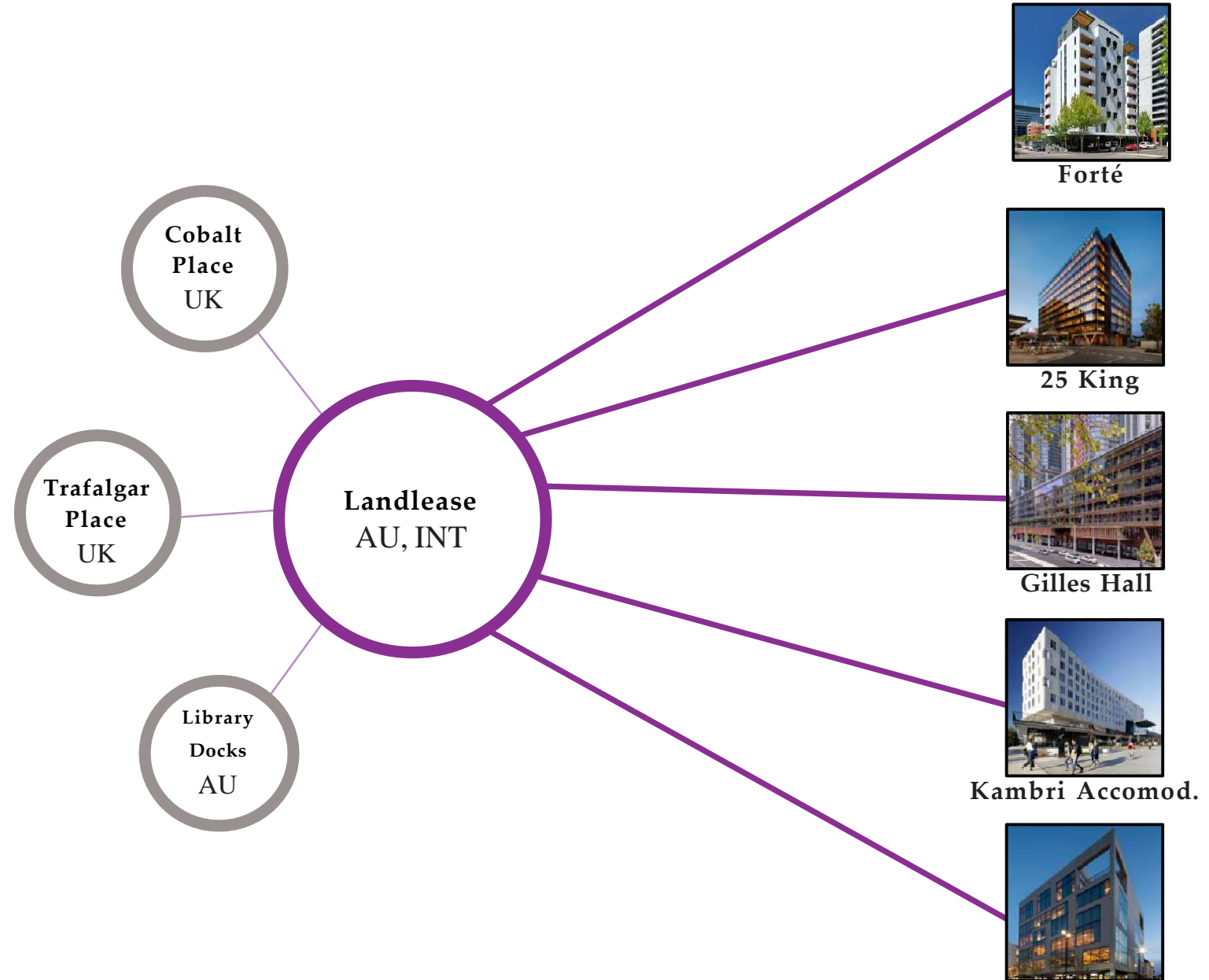


Ellerslie Road

General Contractors



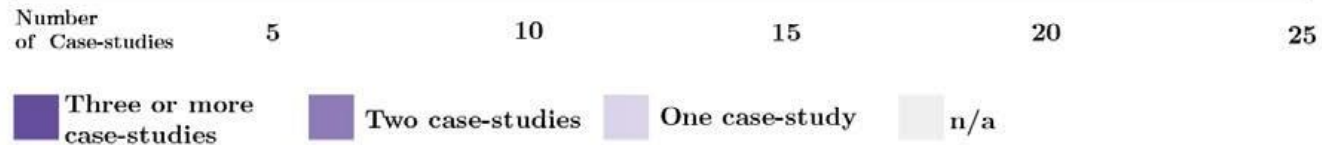
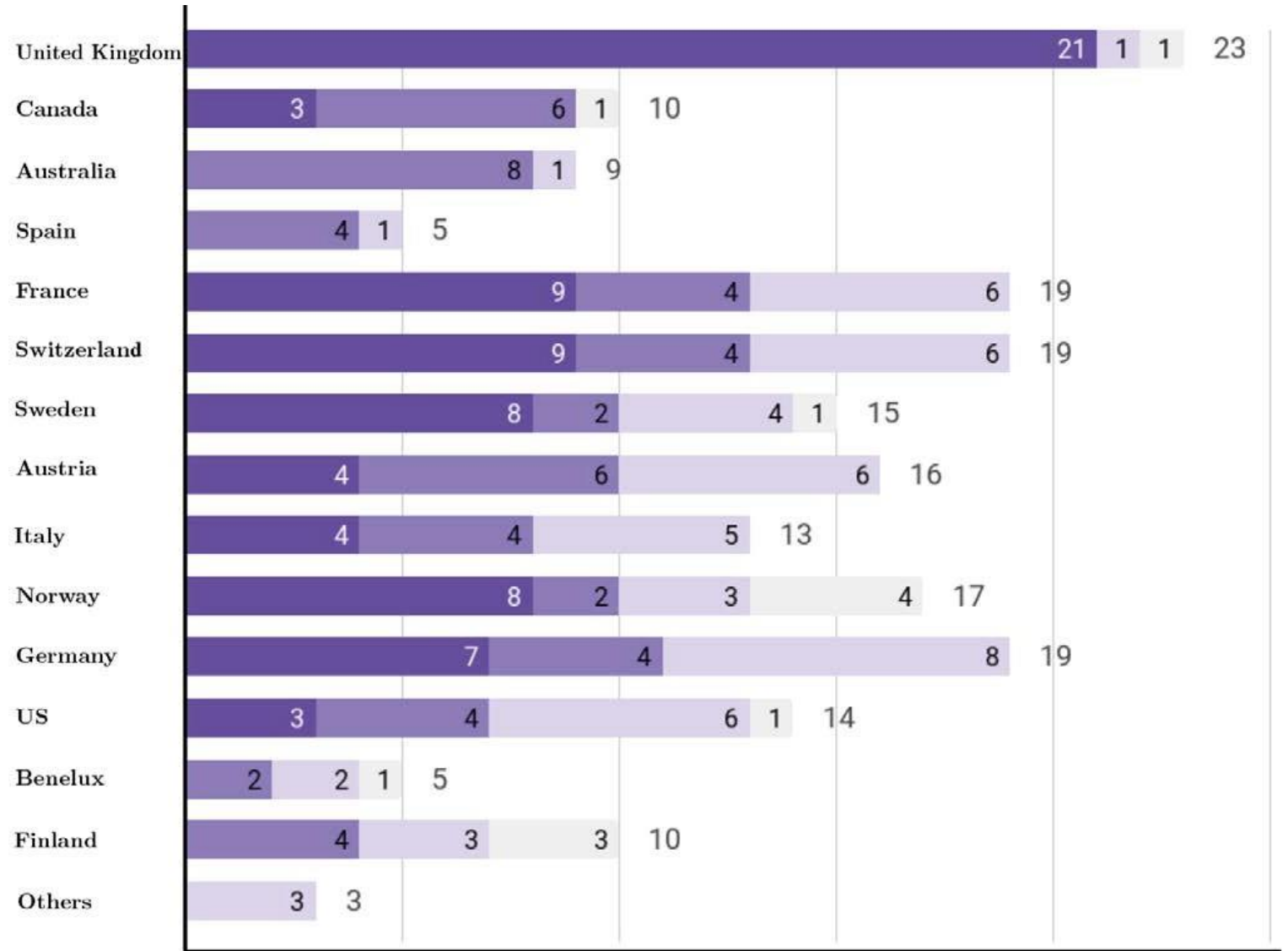
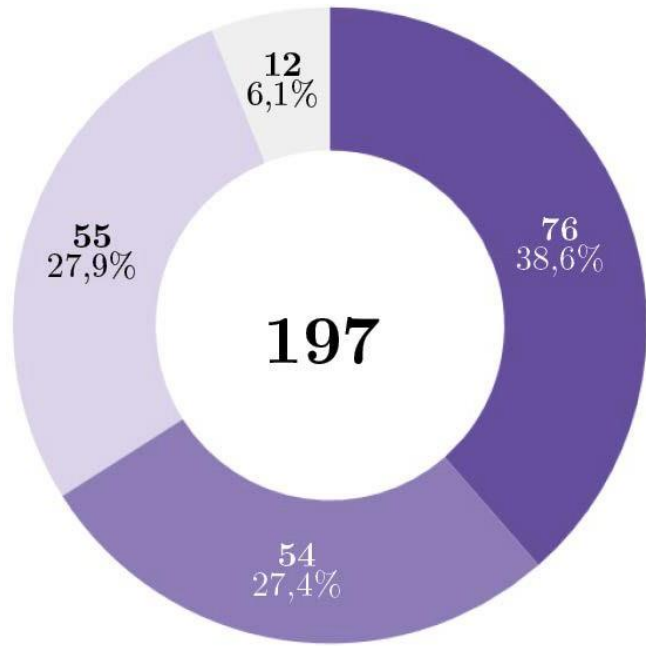
Australia



Norway



Timber Contractors



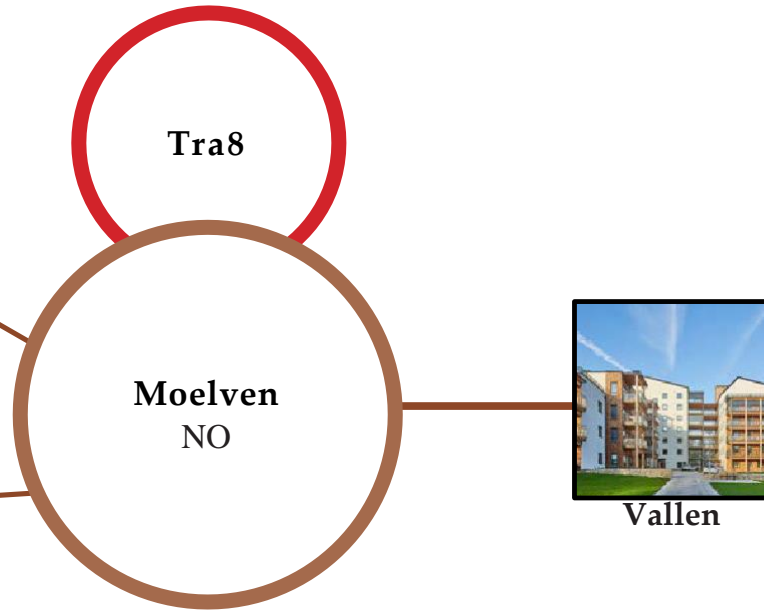
—
Norway



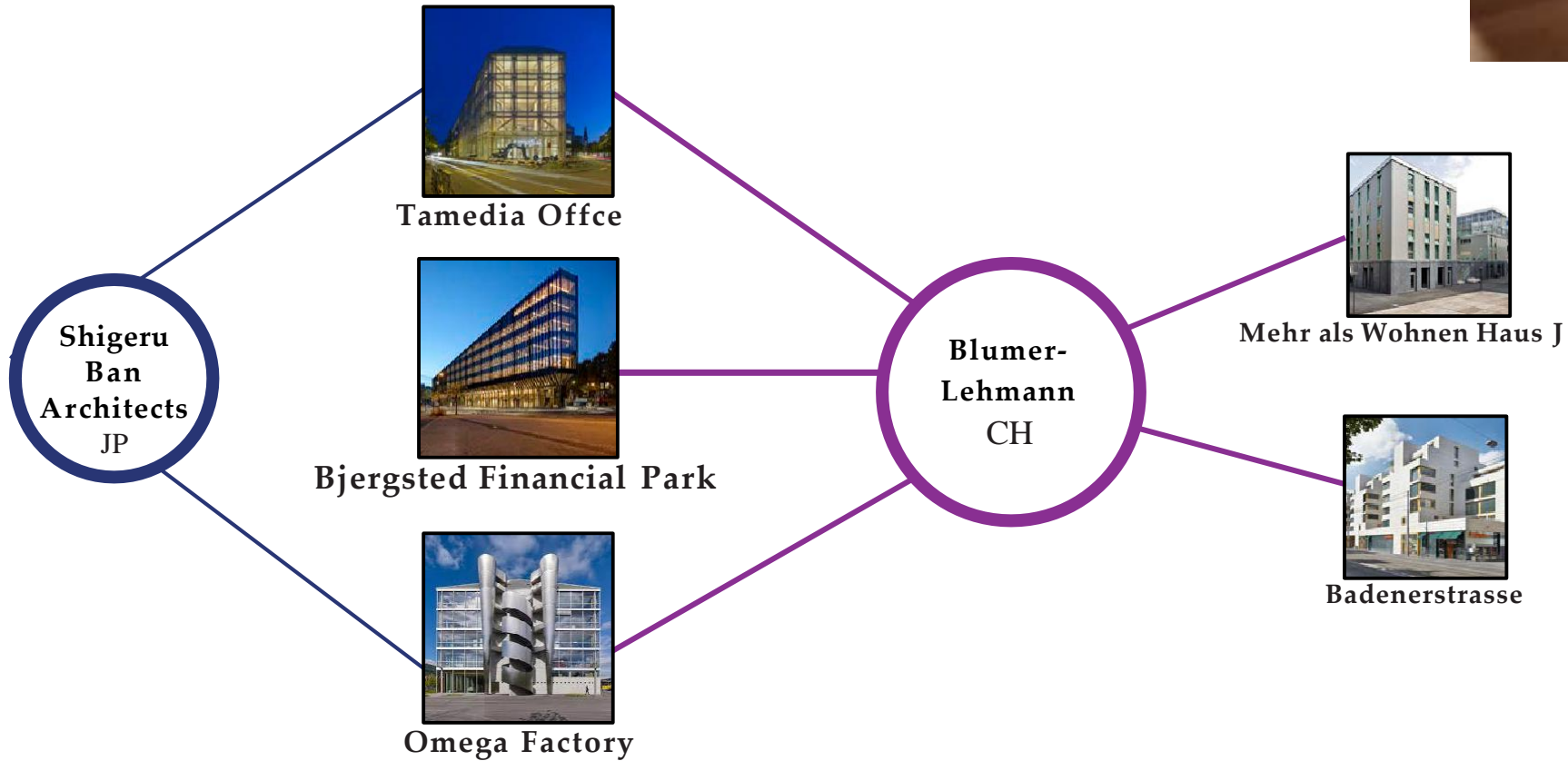
Treet

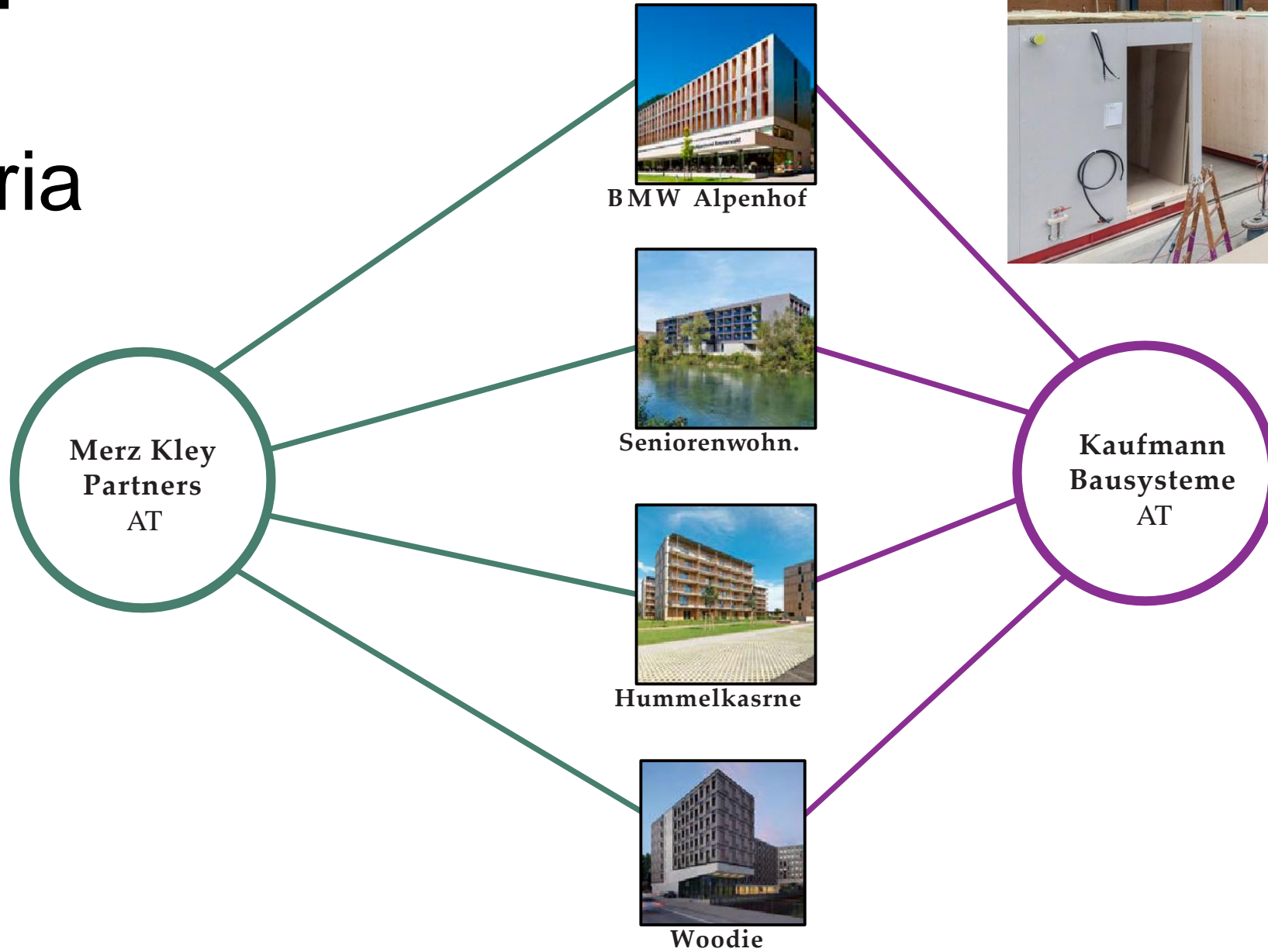


Mjøstårnet



Switzerland

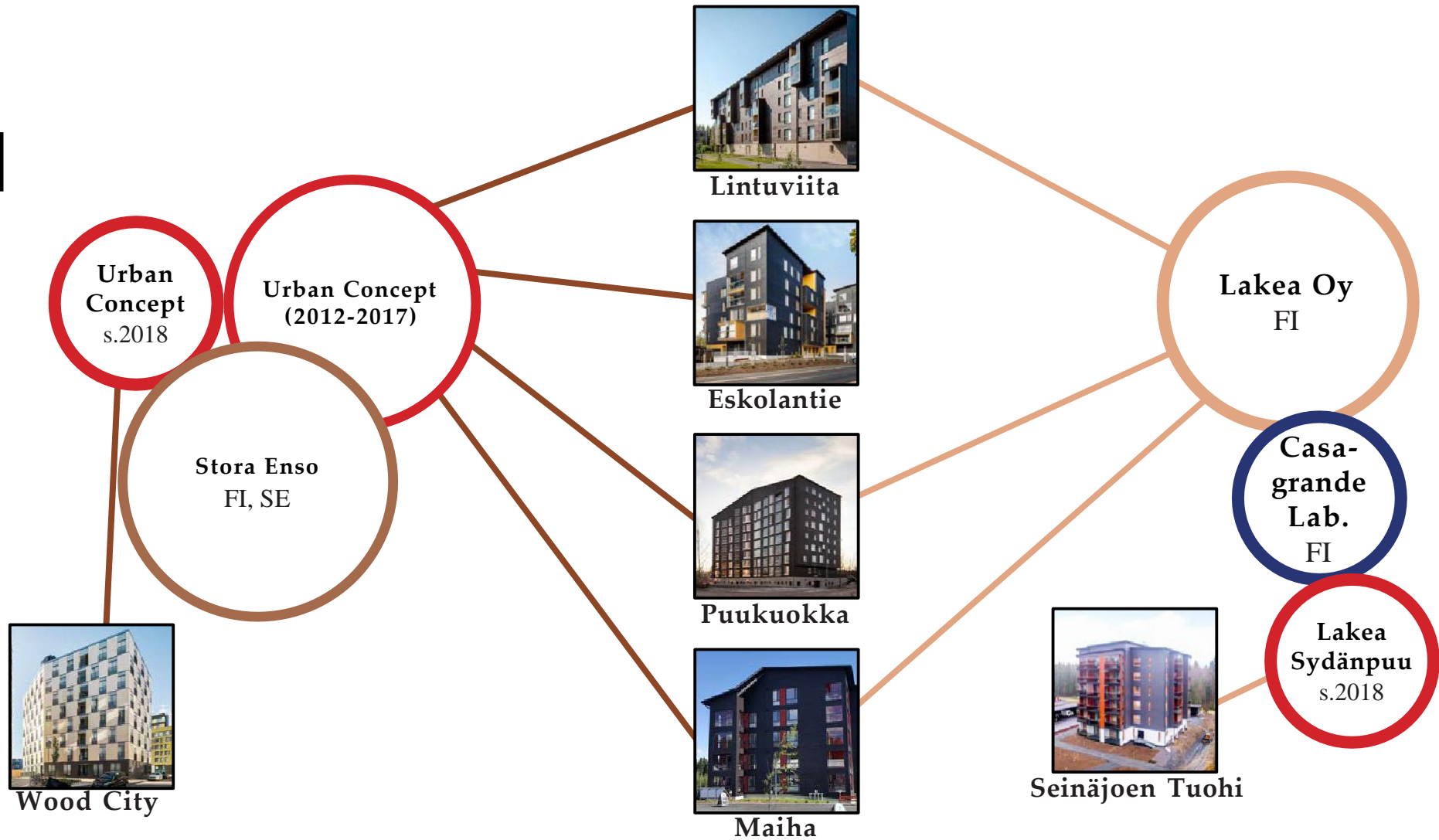




Source: Kaufmann Bausysteme

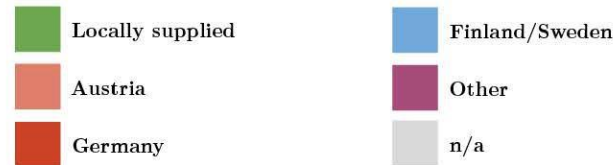
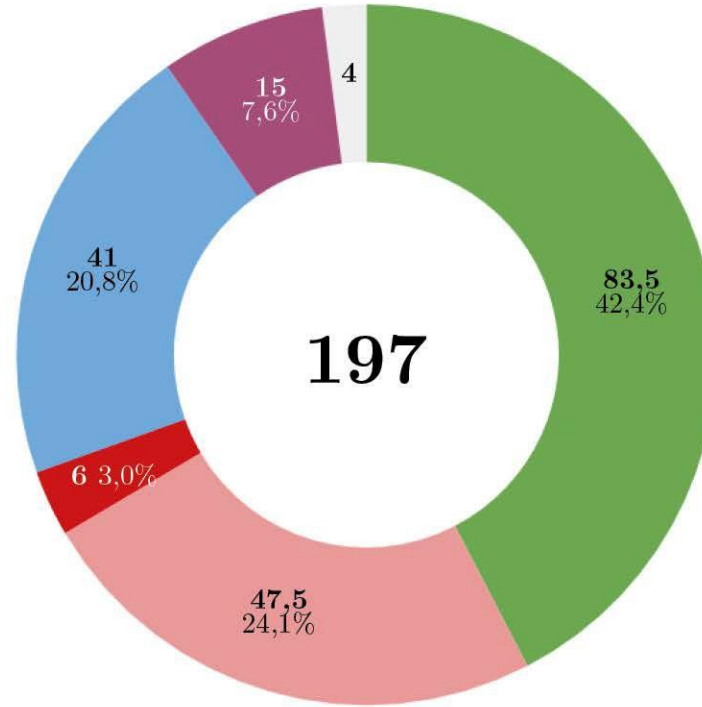


Finland

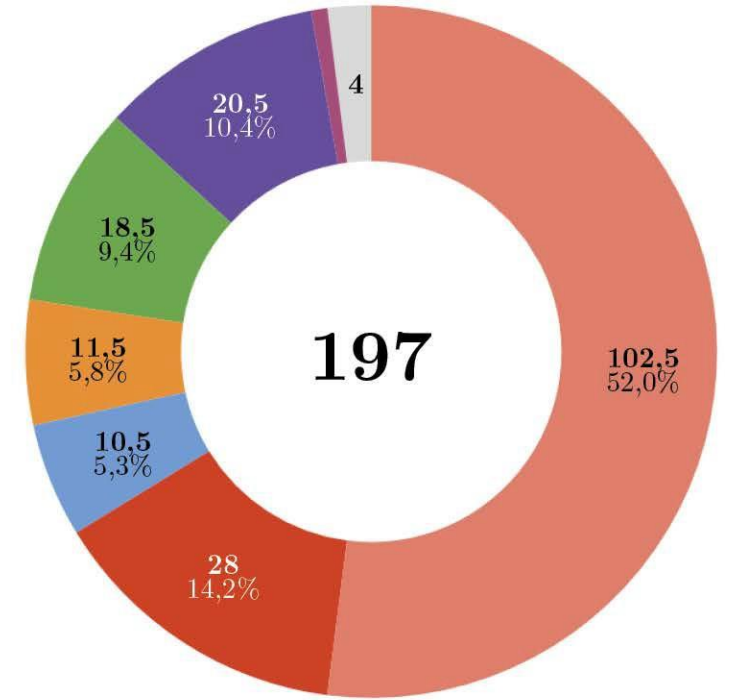


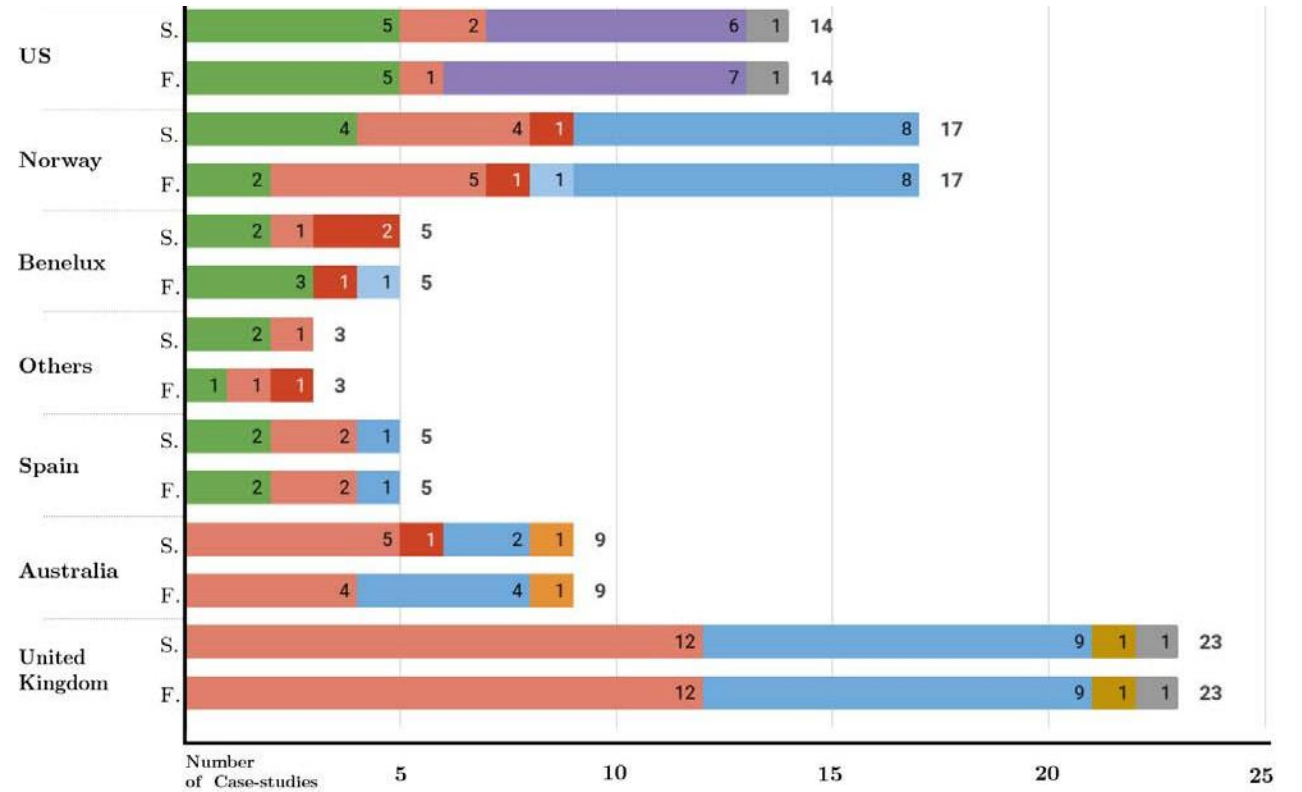
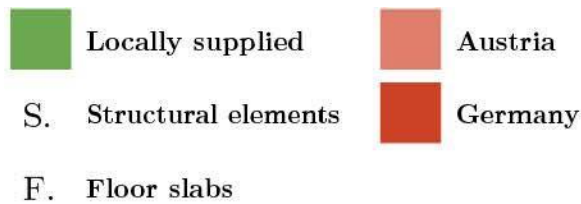
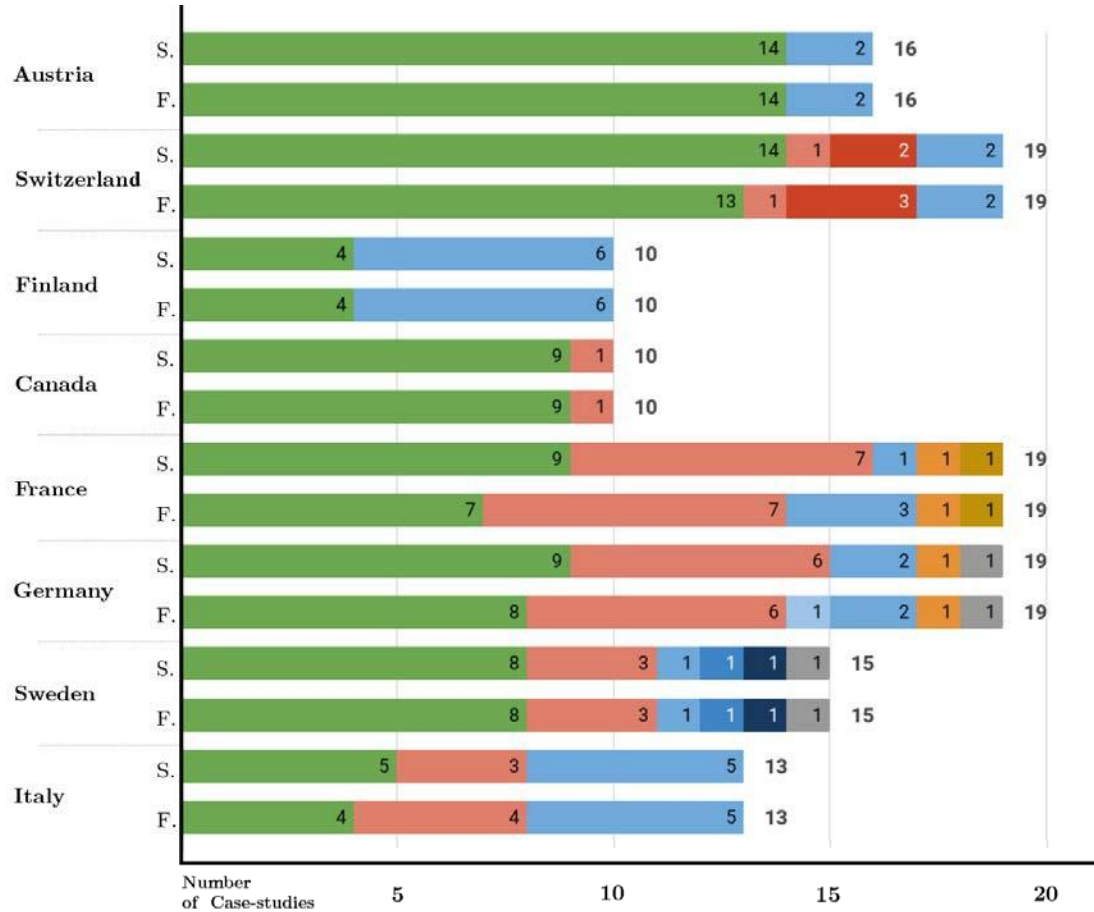
Who supplied the timber?

Local vs foreign timber suppliers



Country or macro-region in which EWPs were produced





Conclusions



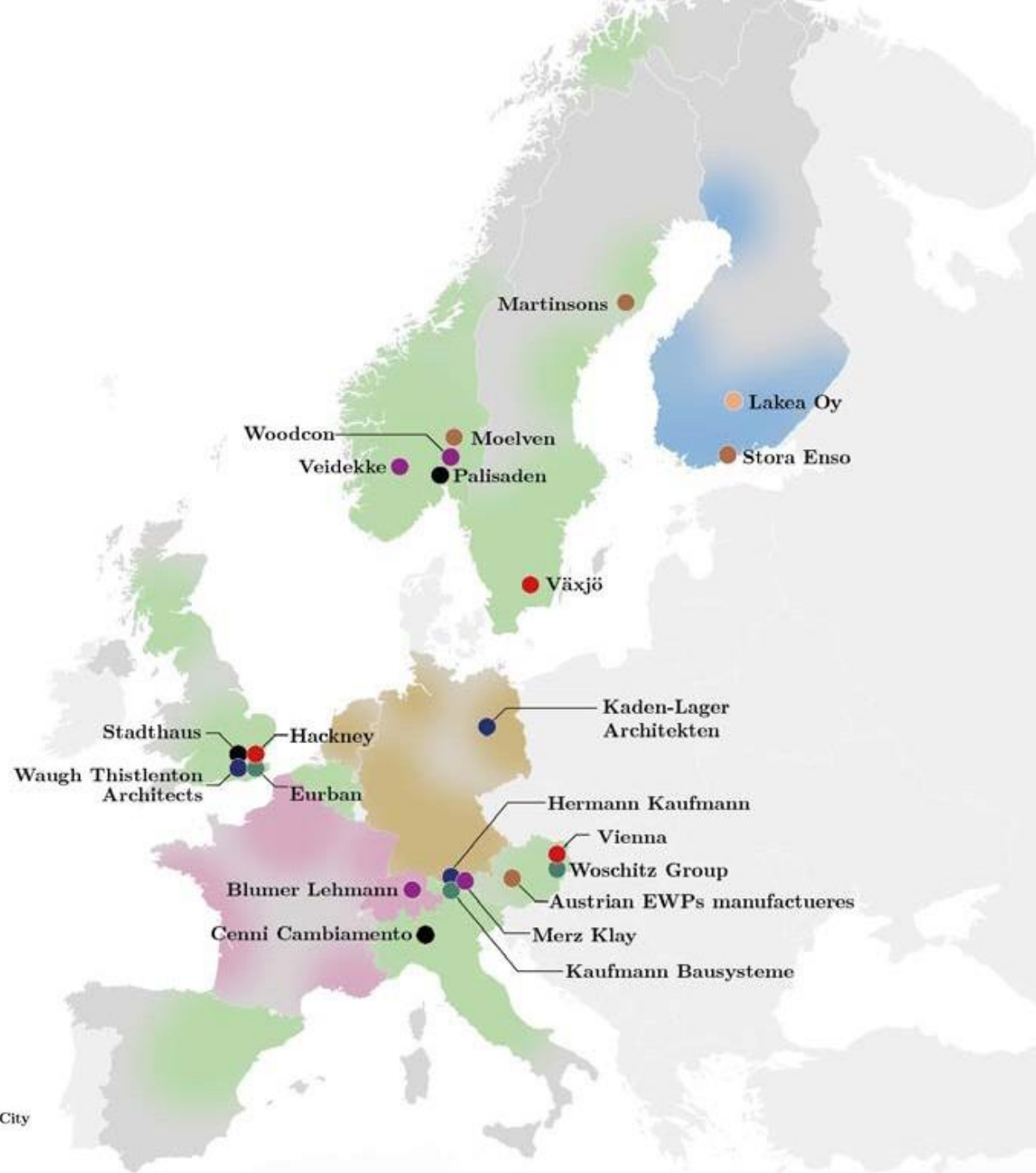
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Europe

Prevalent structural system

- Panelised
- Post-and-beam
- Both panelised and post-and-beam
- 3D modular elements

Main players

- Architect
- Contractor
- Timber manufacturer
- City
- Engineer
- Case-study
- Client



North America



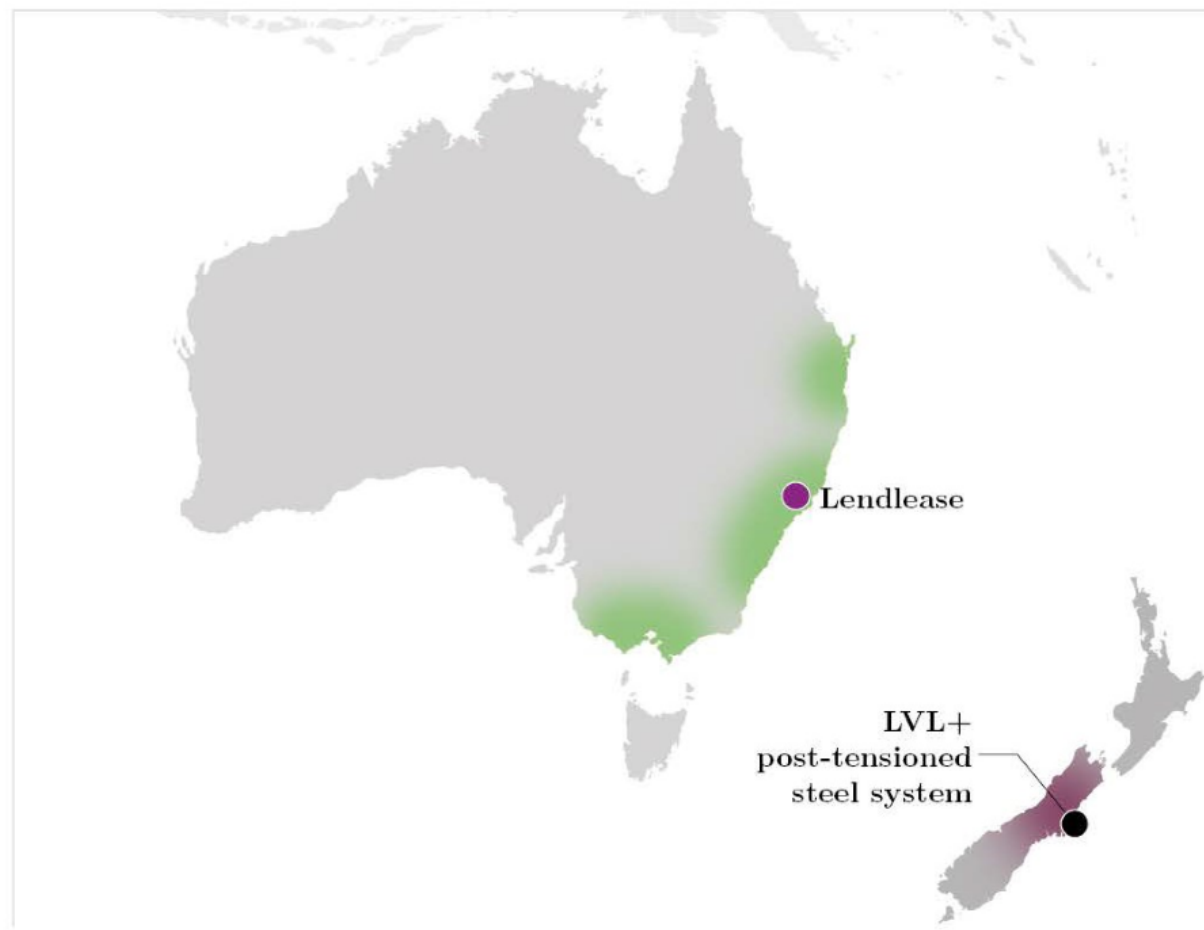
Prevalent structural system

- Panelised
- Post-and-beam
- Both panelised and post-and-beam
- 3D modular elements

Main players

- Architect
- Contractor
- Engineer
- Case-study
- Timber manufacturer
- Client
- City

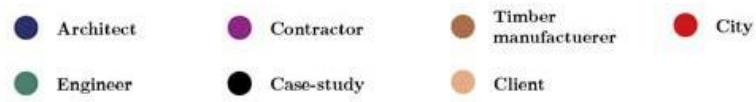
Other Countries



Prevalent structural system

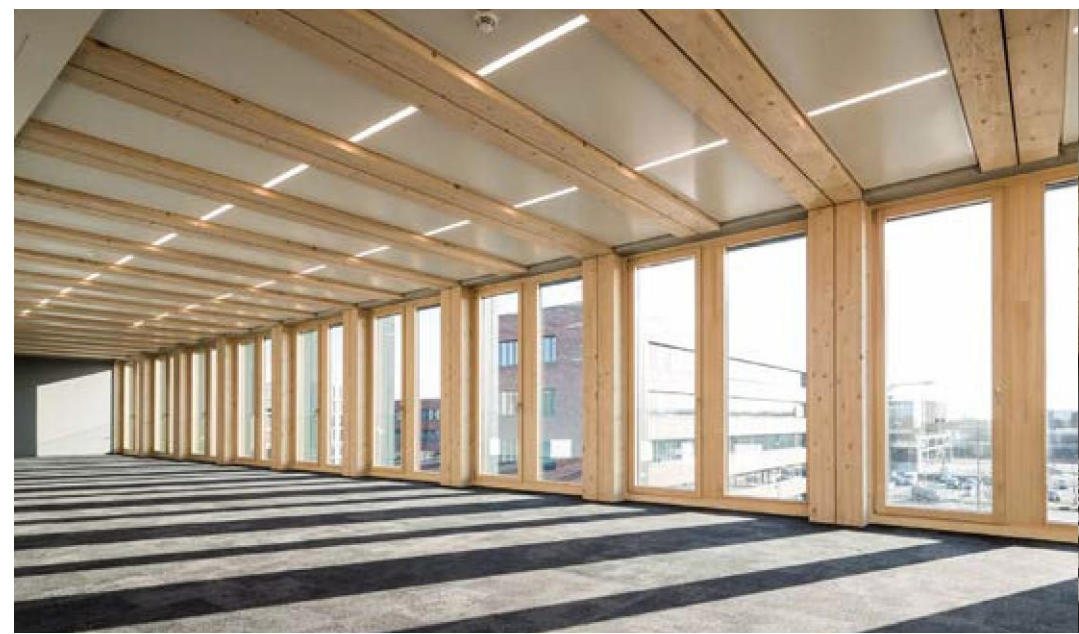


Main players



Conclusions

- 1) **National Differences** in the **Design** of Multi-story Timber Buildings and existence of design **Clusters**
- 2) Trends: hybrid **timber-concrete** structures and **CLT**
- 3) **Role** of **designers, contractors and suppliers** is important
- 4) **Timber** as construction material: **Global** and **Local**
- 5) **Future**: Prefabrication and Made to Measure Assembly



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Gracias.

