



Session 4

Building LCA and green building certificates

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Content

- Life cycle assessment (LCA)
- Green building certificates
- LEED as a green building certificate

Definition of LCA:

Life Cycle Assessment (LCA) is a systematic method for evaluating the environmental impacts of products, processes, or services throughout their entire life cycle.

Stages of LCA:

Raw Material Extraction: Harvesting or mining the raw materials.

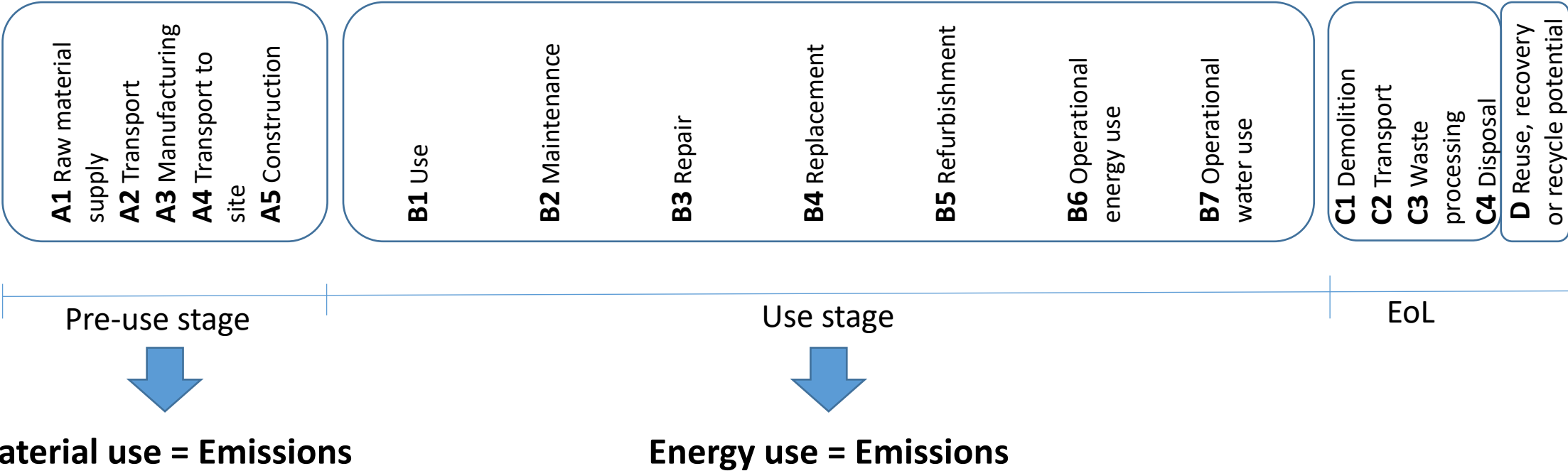
Production: Manufacturing the product.

Distribution: Transporting the product to the consumer.

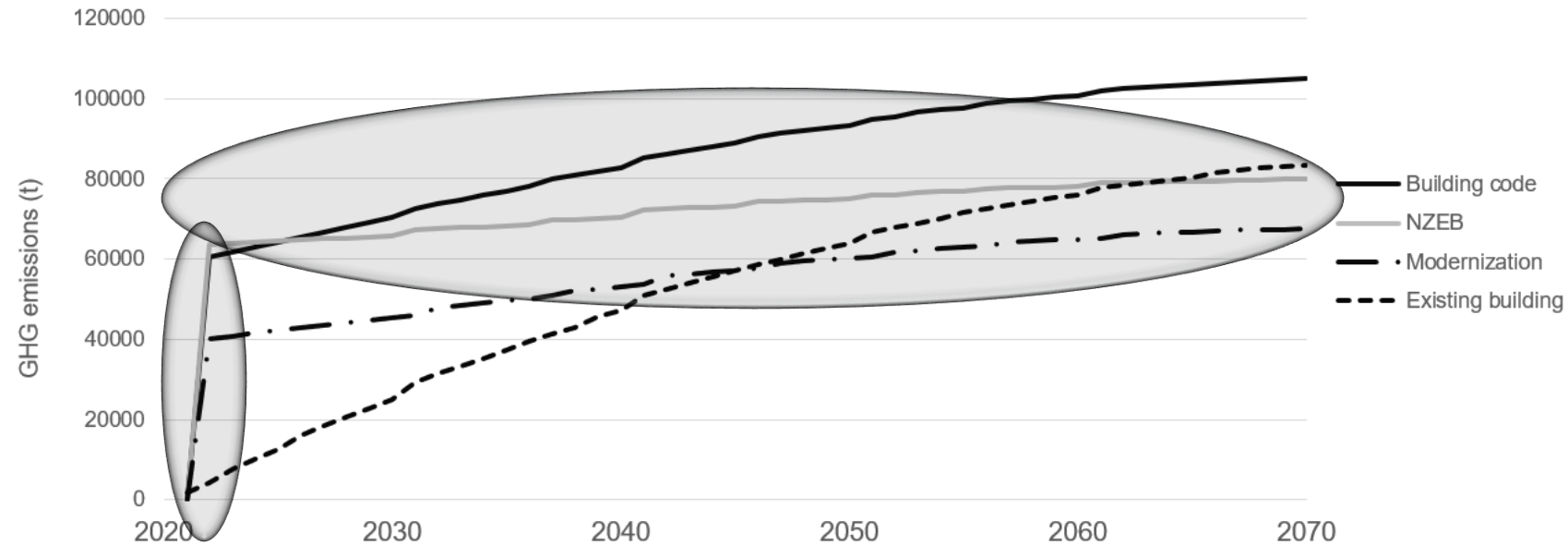
Usage: Using the product during its operational life.

End-of-Life: Disposing or recycling the product.

Buildings' life cycle consist of three main stages



What can we
do for less
emissions?



- Maybe we can focus on use stage which results in thicker insulation, improved thermal performance of windows, and more efficient heat recovery systems.
- **Or any smart idea (D1)?**

The life cycle of a building includes several key phases: **design, construction, operation, and end-of-life.**

During the **design phase**, architects and engineers focus on sustainability and efficiency. The **construction phase** involves significant energy use and emissions due to material extraction, processing, and building activities. The **operational phase**, the longest, entails energy and water use, along with maintenance. Finally, at the **end-of-life**, buildings are demolished or deconstructed, with materials recycled or disposed of. Effective management aims to minimize environmental impacts at each stage through sustainable practices and efficiency improvements.

How to minimize energy and material use in buildings?

Green buildings

- Yudelson (2010) describes a green building as “A high-performance property that considers and reduces its impact on the environment and human health.”
- Kibert (2016) defines green buildings as “Healthy facilities designed and built in a resource-efficient manner, using ecologically based principles.”

The need for clear and uniform definition



Green building certificates

(during the last 25 years)

Imagine that you want to design a point-based green building certificate. What is the criteria you give points? (D2)

Life cycle stages	Product			Construction		Use stage							End-of-life				Benefits and loads beyond the system boundary		
	Modules	A1	A2	A3	A4	A5	Related to the building fabric					Related to the building operation		C1	C2	C3		C4	D
							B1	B2	B3	B4	B5	B6	B7						
	Raw material supply	Transport	Manufacturing	Transport	Construction	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Demolition	Transport	Waste processing	Disposal		Reuse / Recovery / Recycling potential	

Pre-use stage

Use stage

End of life (EoL)

Different certification systems

- **BREEAM**
British Building Research Establishment Environmental Assessment Method

- **LEED**
Leadership in the Energy and Environmental Design

Categories	LEED v2.2	LEED v3 (2009)	LEED v4
Location and Transportation (LT)	-	-	16 (14.6%)
Sustainable Sites (SS)	14 (20.3%)	26 (23.6%)	10 (9.1%)
Energy and Atmosphere (EA)	17 (24.6%)	35 (31.8%)	33 (30)
Water Efficiency (WE)	5 (7.3%)	10 (9.1%)	11 (10%)
Indoor Environment Quality (IEQ)	15 (21.7%)	15 (13.6%)	16 (14.5%)
Material and Resources (MR)	13 (18.8%)	14 (12.7%)	13 (11.8%)
Innovation (ID)	5 (7.3%)	6 (5.5%)	6 (5.5%)
Regional Priority (RP)	-	4 (3.7%)	4 (3.6%)
Integrative Process (IP)	-	-	1 (0.9%)
Total	69	110	110

- **G-SEED (Korea)**
Green Standard for Energy & Environmental Design
- **CASBEE (Japan)**
Comprehensive Assessment System for Built Environment Efficiency
- **Green Star (Australia)**



Categories, credits, prerequisites, and available points in LEED v4

LEED for Building Design and Construction
LEED for Interior Design and Construction
LEED for Building Operations and Maintenance
LEED for Neighborhood Development

Categories	Prerequisites	Credits	Available points	Share %
Integrative Process (IP)	-	1	1	0.9
Location and Transportation (LT)	-	7	16	14.6
Sustainable Sites (SS)	1	6	10	9.1
Water Efficiency (WE)	3	4	11	10
Energy and Atmosphere (EA)	4	7	33	30
Materials and Resources (MR)	2	5	13	11.8
Indoor Environmental Quality (IQ)	2	9	16	14.5
Innovation (IN)	-	2	6	5.5
Regional Priority (RP)	-	4	4	3.6
Total	12	45	110	100


The LEED certification is based on points and includes four levels, namely Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points).



Projects in the world

- LEED has grown to become the world's most widely used green building rating system, with nearly **80,000 projects** participating in LEED across **162 countries**, including more than 32,500 certified commercial projects

A?

		 Location & Transportation									
Overview of Credits	Credit	Title	NC	CS	Schools	Retail	Data Centers	Warehouses & Distribution Centers	Hospitality	Healthcare	
	LT Credit	LEED for Neighborhood Development Location	8-16	8-20	8-15	8-16	8-16	8-16	8-16	8-16	5-9
	LT Credit	Credit Sensitive Land Protection	1	2	1	1	1	1	1	1	1
	LT Credit	High-Priority Site	1-2	2-3	1-2	1-2	1-2	1-2	1-2	1-2	1-2
	LT Credit	Surrounding Density and Diverse Uses	1-5	1-6	1-5	1-5	1-5	1-5	1-5	1-5	1
	LT Credit	Access to Quality Transit	1-5	1-6	1-4	1-5	1-5	1-5	1-5	1-5	1-2
	LT Credit	Bicycle Facilities	1	1	1	1	1	1	1	1	1
	LT Credit	Reduced Parking Footprint	1	1	1	1	1	1	1	1	1
	LT Credit	Green Vehicles	1	1	1	1	1	1	1	1	1



Source: USGBC

9	0	6	Location and Transportation		15
0	0	0	Credit	LEED for Neighborhood Development Location	15
1	0	0	Credit	Sensitive Land Protection	1
0	0	2	Credit	High Priority Site	2
4	0	1	Credit	Surrounding Density and Diverse Uses	5
4	0	0	Credit	Access to Quality Transit	4
0	0	1	Credit	Bicycle Facilities	1
0	0	1	Credit	Reduced Parking Footprint	1
0	0	1	Credit	Green Vehicles	1

Requirement

Intent

To avoid the development of environmentally sensitive lands and reduce the environmental impact from the location of a building on a site.

Option 1.

Locate the development footprint on land that has been previously developed.

OR

Option 2.

Locate the development footprint on land that has been previously developed or that does not meet the following criteria for sensitive land: Prime farmland, floodplains, habitat, water bodies, or wetlands.

From session 2



Sustainable human settlements

- One of today's hot questions is

"How should we arrange our societies and the built environment to minimize the environmental loads?"

- Currently planning / urban development mostly follows the idea of higher density being the policy guideline to follow
- However, so far the result has been just an illusion of low-carbon cities





Energy & Atmosphere

Overview of Credits

Credit	Title	NC	CS	Schools	Retail	Data Centers	Warehouses & Distribution Centers	Hospitality	Healthcare
Prerequisite	Fundamental Commissioning and Verification	Req	Req	Req	Req	Req	Req	Req	Req
Prerequisite	Minimum Energy Performance	Req	Req	Req	Req	Req	Req	Req	Req
Prerequisite	Building-Level Energy Metering	Req	Req	Req	Req	Req	Req	Req	Req
Prerequisite	Fundamental Refrigerant Management	Req	Req	Req	Req	Req	Req	Req	Req
EA Credit	Enhanced Commissioning	2-6	2-6	2-6	2-6	2-6	2-6	2-6	2-6
EA Credit	Optimize Energy Performance	1-18	1-18	1-16	1-18	1-18	1-18	1-18	1-20
EA Credit	Advanced Energy Metering	1	1	1	1	1	1	1	1
EA Credit	Demand Response	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
EA Credit	Renewable Energy Production	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
EA Credit	Enhanced Refrigerant Management	1	1	1	1	1	1	1	1
EA Credit	Green Power and Carbon Offsets	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2

7	0	24	Energy and Atmosphere		31
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
4	0	2	Credit	Enhanced Commissioning	6
0	0	16	Credit	Optimize Energy Performance	16
0	0	1	Credit	Advanced Energy Metering	1
0	0	2	Credit	Demand Response	2
0	0	3	Credit	Renewable Energy Production	3
1	0	0	Credit	Enhanced Refrigerant Management	1
2	0	0	Credit	Green Power and Carbon Offsets	2

Intent

To increase participation in demand response technologies and programs that make energy generation and distribution systems more efficient, increase grid reliability, and reduce greenhouse gas emissions.

Requirement

Design building and equipment for participation in demand response programs through load shedding or shifting. On-site electricity generation does not meet the intent of this credit.



Materials & Resources

Credit	Title	NC	CS	Schools	Retail	Data Centers	Warehouses & Distribution Centers	Hospitality	Healthcare
Prereq	Storage and Collection of Recyclables	Req	Req	Req	Req	Req	Req	Req	Req
Prereq	Construction and Demolition Waste Management Planning	Req	Req	Req	Req	Req	Req	Req	Req
Prereq	PBT Source Reduction—Mercury	NA	NA	NA	NA	NA	NA	NA	Req
Credit	Building Life-Cycle Impact Reduction	2-5	2-6	2-5	2-5	2-5	2-5	2-5	2-5
Building Product Disclosure and Optimization									
Credit	Environmental Product Declarations	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Credit	Sourcing of Raw Materials	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Credit	Material Ingredients	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Credit	PBT Source Reduction—Mercury	NA	NA	NA	NA	NA	NA	NA	1
Credit	PBT Source Reduction—Lead, Cadmium, and Copper	NA	NA	NA	NA	NA	NA	NA	2
Credit	Furniture and Medical Furnishings	NA	NA	NA	NA	NA	NA	NA	1-2
Credit	Design for Flexibility	NA	NA	NA	NA	NA	NA	NA	1
Credit	Construction & Demolition Waste Management	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2

Source: USGBC



0	9	4	Materials and Resources		13
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management F	Required
0	3	2	Credit	Building Life-Cycle Impact Reduction	5
0	2	0	Credit	Building Product Disclosure and Optimization - Environmental Product	2
0	2	0	Credit	Building Product Disclosure and Optimization - So	2
0	2	0	Credit	Building Product Disclosure and Optimization - Ma	2
0	0	2	Credit	Construction and Demolition Waste Management	2

Intent

To encourage adaptive reuse and optimize the environmental performance of products and materials.

Requirement

Demonstrate reduced environmental effects during initial project decision-making by reusing existing building resources or demonstrating a reduction in materials use through life-cycle assessment. Achieve one of the following options.

Emissions reduction in at least three of these:

- global warming potential (greenhouse gases), in CO₂e;
- depletion of the stratospheric ozone layer, in kg CFC-11;
- acidification of land and water sources, in moles H⁺ or kg SO₂;
- eutrophication, in kg nitrogen or kg phosphate;
- formation of tropospheric ozone, in kg NO_x or kg ethene;
- depletion of nonrenewable energy resources, in MJ.

From the
previous
session

Examples of more sustainable materials, available now

- Mycelium
- Hempcrete
- Biocrete
- Biocement
- CLT and other timber and bamboo products

Mycelium



CLT



Hempcrete



Biocrete





Indoor Environmental Quality

Credit	Title	NC	CS	Schools	Retail	Data Centers	Warehouses & Distribution Centers	Hospitality	Healthcare
Prereq	Minimum Indoor Air Quality Performance	Req	Req	Req	Req	Req	Req	Req	Req
Prereq	Environmental Tobacco Smoke (ETS) Control	Req	Req	Req	Req	Req	Req	Req	Req
Prereq	Minimum Acoustical Performance	Req	Req	Req	Req	Req	Req	Req	Req
Credit	Enhanced Indoor Air Quality	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Credit	Low-Emitting Materials	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
Credit	Construction Indoor Air Quality Management Plan	1	1	1	1	1	1	1	1
Credit	Indoor Air Quality Assessment	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Credit	Thermal Comfort	1	1	1	1	1	1	1	1
Credit	Interior Lighting	1-2	1-2	1-2	2	1-2	1-2	1-2	1
Credit	Daylight	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-2
Credit	Quality Views	1	1	1	1	1	1	1	1-2
Credit	Acoustic Performance	1	1	1	1	1	1	1	1-2

Source: USGBD

5	3	8	Indoor Environmental Quality		16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
Y			Prereq	Minimum Acoustic Performance	Required
0	0	2	Credit	Enhanced Indoor Air Quality Strategies	2
0	3	0	Credit	Low -Emitting Materials	3
0	0	1	Credit	Construction Indoor Air Quality Management Plan	1
0	0	2	Credit	Indoor Air Quality Assessment	2
1	0	0	Credit	Thermal Comfort	1
1	0	1	Credit	Interior Lighting	2
1	0	2	Credit	Daylight Modelling	3
1	0	0	Credit	Quality Views	1
1	0	0	Credit	Acoustic Performance	1

Intent

To connect building occupants with the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space.

Requirement

Option 1. Simulation: Spatial Daylight Autonomy and Annual Sunlight Exposure

Option 2. Simulation: Illuminance Calculations

Option 3. Measurement

INNOVATION (IN)

IN CREDIT: INNOVATION

To encourage projects to achieve exceptional or innovative performance

IN CREDIT: LEED ACCREDITED PROFESSIONAL

To encourage the team integration required by a LEED project and to streamline the application and certification process.

REGIONAL PRIORITY (RP)

RP CREDIT: REGIONAL PRIORITY

To provide an incentive for the achievement of credits that address geographically specific environmental, social equity, and public health priorities.



0	2	1	Innovation		6
0	2	0	Credit	Innovation	5
0	0	1	Credit	LEED Accredited Professional	1
3	0	1	Regional Priority		4
1	0	0	Credit	Regional Priority: Specific Credit	1
1	0	0	Credit	Regional Priority: Specific Credit	1
1	0	0	Credit	Regional Priority: Specific Credit	1
0	0	1	Credit	Regional Priority: Specific Credit	1
32	14	64	TOTALS		Possible Points: 110
Certified: 40 to 49 points, Silver: 50 to 59 points, Gold: 60 to 79 points, Platinum: 80 to 110					



Picture: students from the previous course

KOy Keilaniemen
Torni (Keilaniementie
1, Espoo, Finland)

OVERALL LEED SCORECARD

Integrative process credits	0/1
Location & transport	19/20
Sustainable sites	1/11
Water efficiency	9/11
Energy & atmosphere	23/33
Material & resources	5/14
Indoor environmental quality	4/10
Regional property credits	3/4
Innovation	2/6
Total	67/110

As Oy Espoon Leppävaaran Atleetti (“Juli Leppävaaran Atleetti”) is the first residential building in Finland to receive LEED Gold certificate¹. The building was originally constructed in 1987 to serve as an office building and was converted into residential use with 94 dwelling units in 2021.

Location and transportation (LT)

- Bicycle facilities (1/1 p)
- Surrounding density and diverse uses (5/5 p)

Sustainable sites (SS)

- Light pollution reduction (1/1 p)
- Open space (1/1p)

Energy and Atmosphere (EA)

- Optimize energy performance (12/18)

Water efficiency (WE)

- Water metering (1/1)

Indoor environment quality (IEQ)

- Daylight (3/3)
- Quality views (1/1)

Material and resources (MR)

- Construction and demolition waste management (2/2)
- Building life-cycle impact reduction (2/5)



Picture: students from the previous course



How much extra
you pay for a green
building? *(Q2 and Q3)*

Schedule

16.5.	Building LCA and green building certificates	T2	Ali Amiri
23.5.	Circular construction	Online	Katarzyna Jagodzinska
30.5.	Carbon storing potential of the built environment	T2	Ali Amiri



Any question?





Thank you