A background image of a curling rink with several curling stones on the ice. The stones are in various colors: red, yellow, and orange. The ice has blue and orange markings. A hand is visible holding a stone on the right side.

Lecture 13

Sustainability targets and course wrap-up

CIVIL-239: Engineering a sustainable built environment

Andrew Sonta

Outline

- Mechanisms for enacting sustainability
 - Targets, policies, labels, etc.
- Exam details
- Course review

Master in Urban Systems



- Started fall 2025
- Hosted in environmental engineering section
- Academic title: MSc EPFL in Urban Systems, EPF qualified engineer
- Admissions: consecutive for GC and SIE, specialized for SAR and others

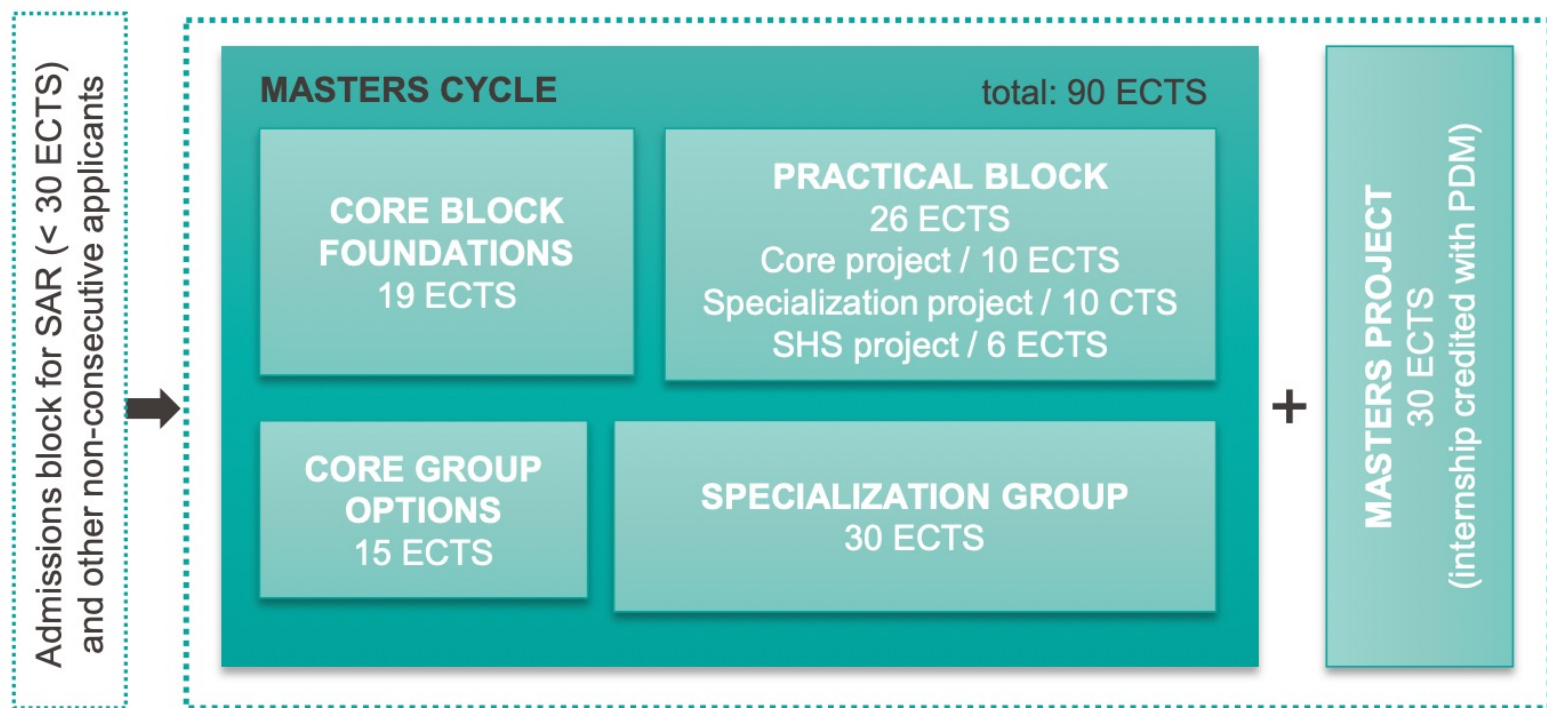
Master in Urban Systems

CORE TOPICS : Territorial design and analysis / Systems engineering in urban and territorial contexts / Policy and governance for sustainable agendas / Computational thinking for transition

SPECIALIZATIONS

1. **Mobility and transportation in a changing climate**
2. **Sustainable transitions in urban systems**
3. **Health and well-being in urban environment**

STRUCTURE



Sustainability targets, pathways, policies, standards, labels, and guidelines

- Target: **where we want to get to**
- Pathway: a **trajectory** for getting there
- Policy: a **regulation** that restricts actions to achieve a certain target or pathway
- Standard: defines formalized **performance criteria**
- Label: **certification** that indicates that a given **standard** was met
- Guideline: **recommendation** or **best practices**

Sustainability target – Paris Agreement

- Treaty adopted in 2015 under UN Framework Convention on Climate Change (UNFCCC)
- Signing countries agreed to limit global warming to “**well below 2°C**” above pre-industrial levels, while pursuing efforts to keep warming to 1.5°C
- Signing countries submit their plans – called Nationally Determined Contributions
- Legally binding in its framework but **relies on voluntary national commitments**



Source: Wikimedia Commons

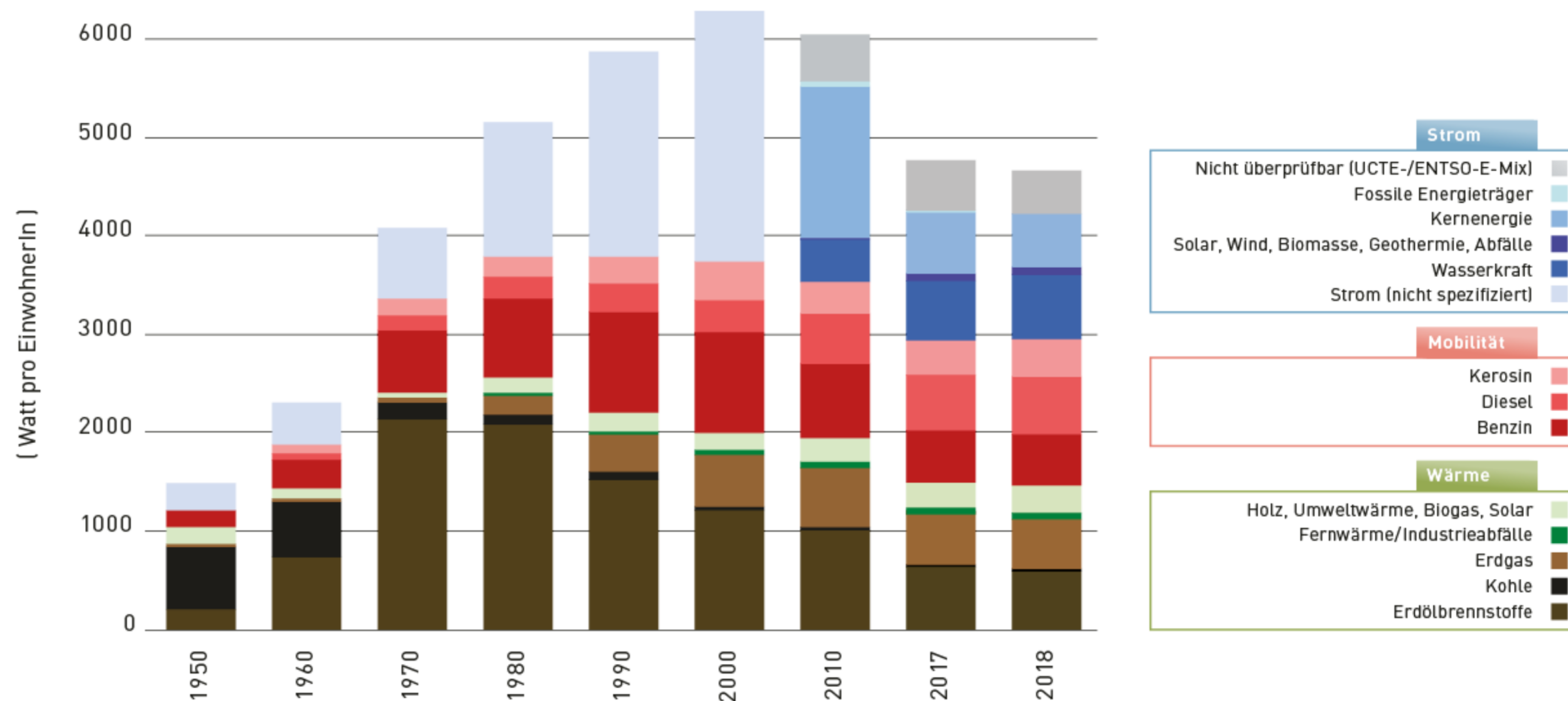
Sustainability target – 2000 watt society

- Goal is to reduce energy consumption to the equivalent of 2000 watts of continuous power consumption per person
 - Energy: 2kWh/h-person
- First introduced by ETHZ researchers
- Concept has been embraced by cities (Zurich, Basel, Lausanne) and the Swiss Federal Office of Energy
- Focuses on energy demand specifically
- In line with meeting the goals of the Paris Agreement

Sustainability target – 2000 watt society

2000-Watt-Bilanzierung für die Schweiz

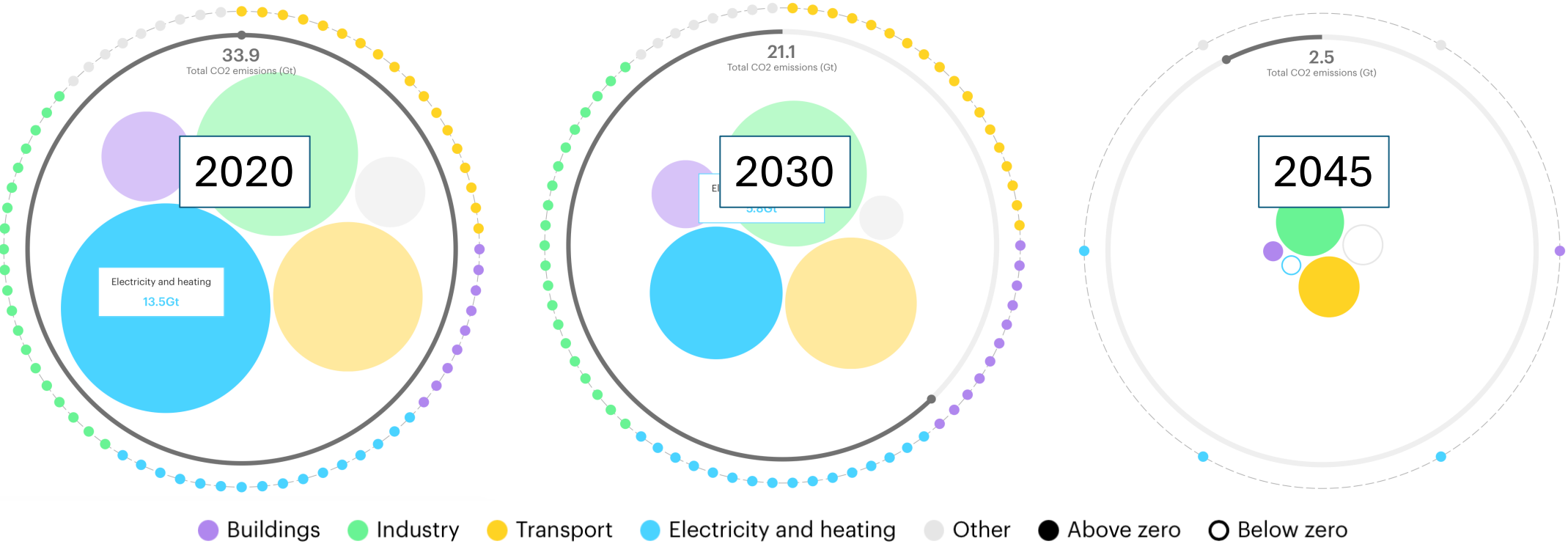
Dauerleistung nach Energieträger (Stufe Primärenergie, Basis Endenergie)



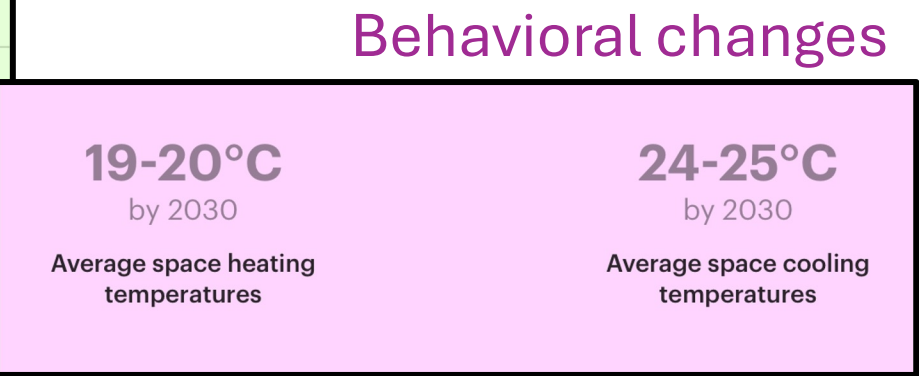
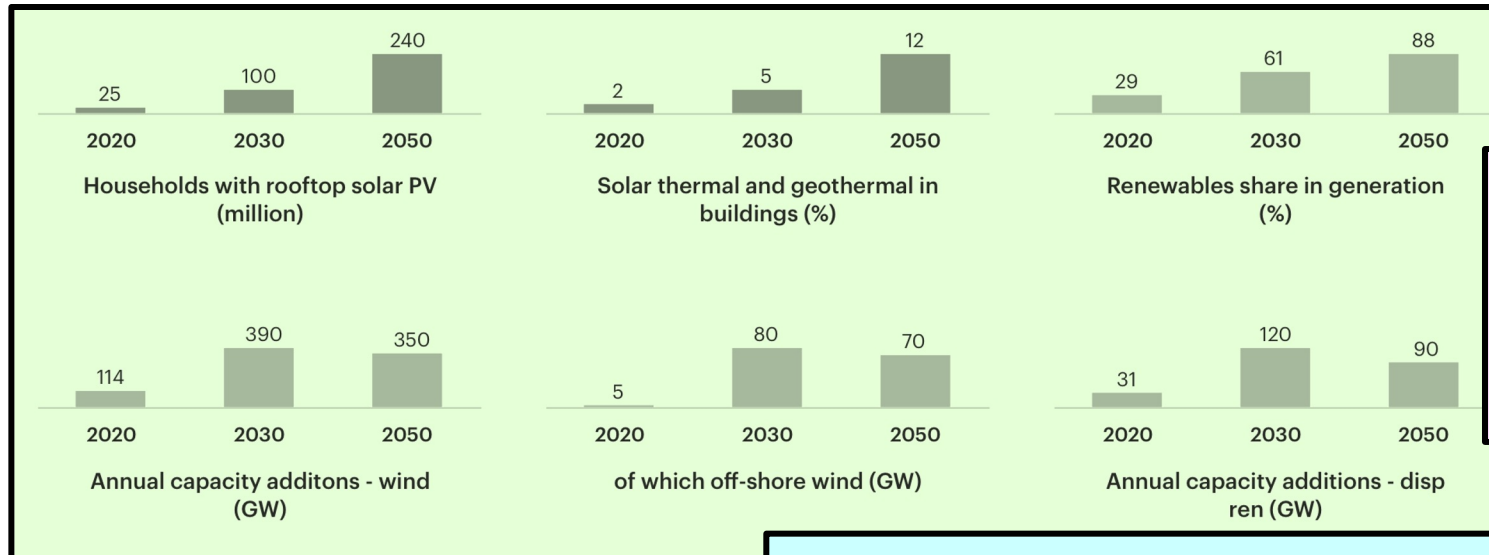
Grafik: Fachstelle 2000-Watt-Gesellschaft, Stand: August 2019. Datengrundlage: Gesamtenergiestatistik CH 2018; KBOB-Empfehlungen; Bilanzierungskonzept 2014; Gesamterhebung Stromkennzeichnung 2017 (2005 – 2017); www.stromkennzeichnung.ch (2014 – 2017)

Sustainability pathway – IEA Net Zero by 2050

- IEA Net Zero by 2050 roadmap provides a pathway to limiting warming to 1.5°C (focusing on the energy sector)
 - This means reaching net-zero emissions by 2050
 - Outlines trajectories between now and 2050

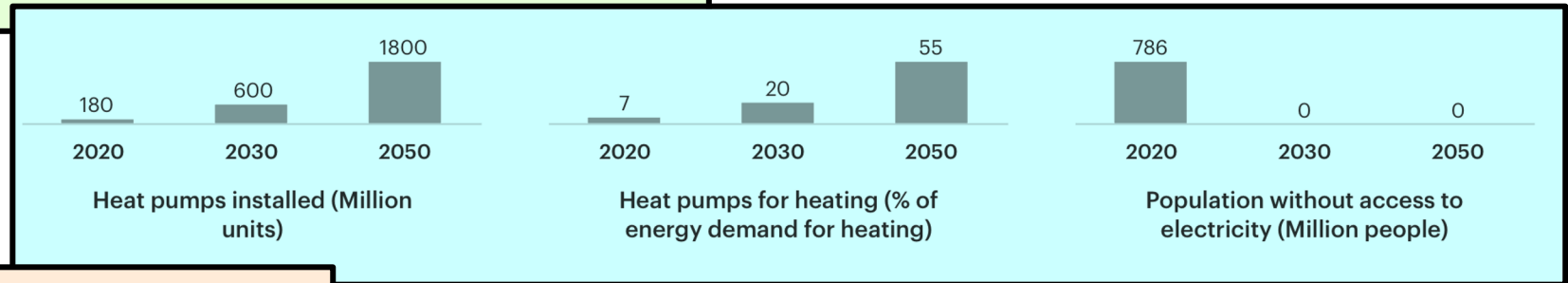


Sustainability pathway – IEA Net Zero by 2050

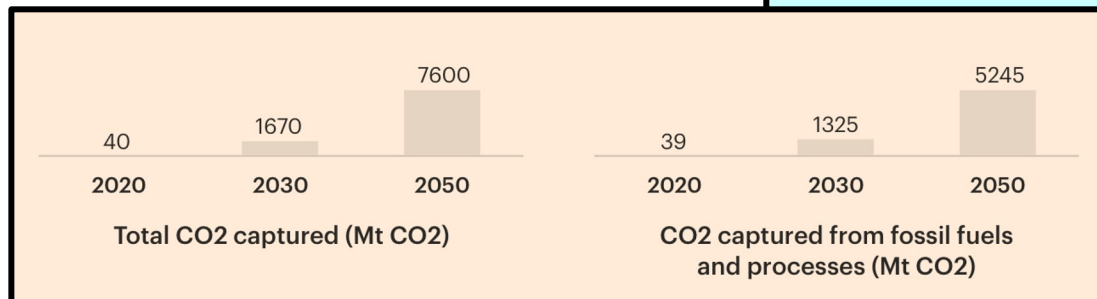


Renewables

Carbon capture



Electrification

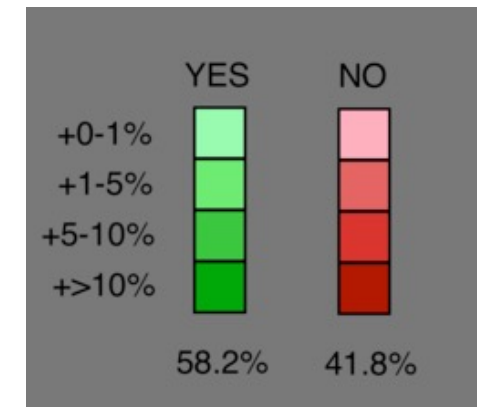
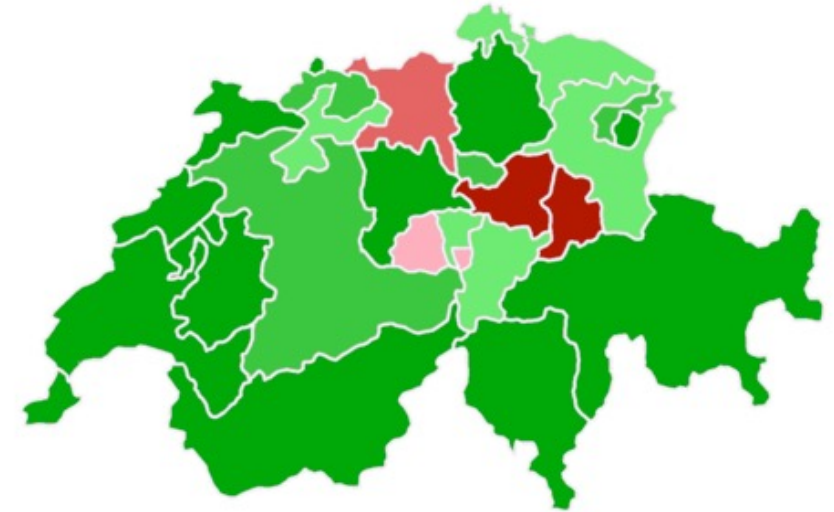


Sustainability policies

- Legal instruments
- Policies include specific and legally binding requirements implemented by governments
- In civil engineering, these are engineering **codes**
 - Legal minimum required for buildings and infrastructure
- There are many, and they can range in scope
 - National example: Swiss Energy Strategy 2050
 - State-level example: California Air Resources Board
 - City example: New York City Local Law 97

Sustainability policy – Swiss Energy Strategy 2050

- History
 - 2013: Federal Council submitted bill to Parliament concerning total revision of existing Federal Energy Act
 - 2016: Parliament adopted the revised act
 - 2017: Swiss voters approved the act in a referendum
 - 2018: Entered into force
- Network of policies which requires amendments of other policies and legal instruments
- Built on a package of measures



Sustainability policy – Swiss Energy Strategy 2050

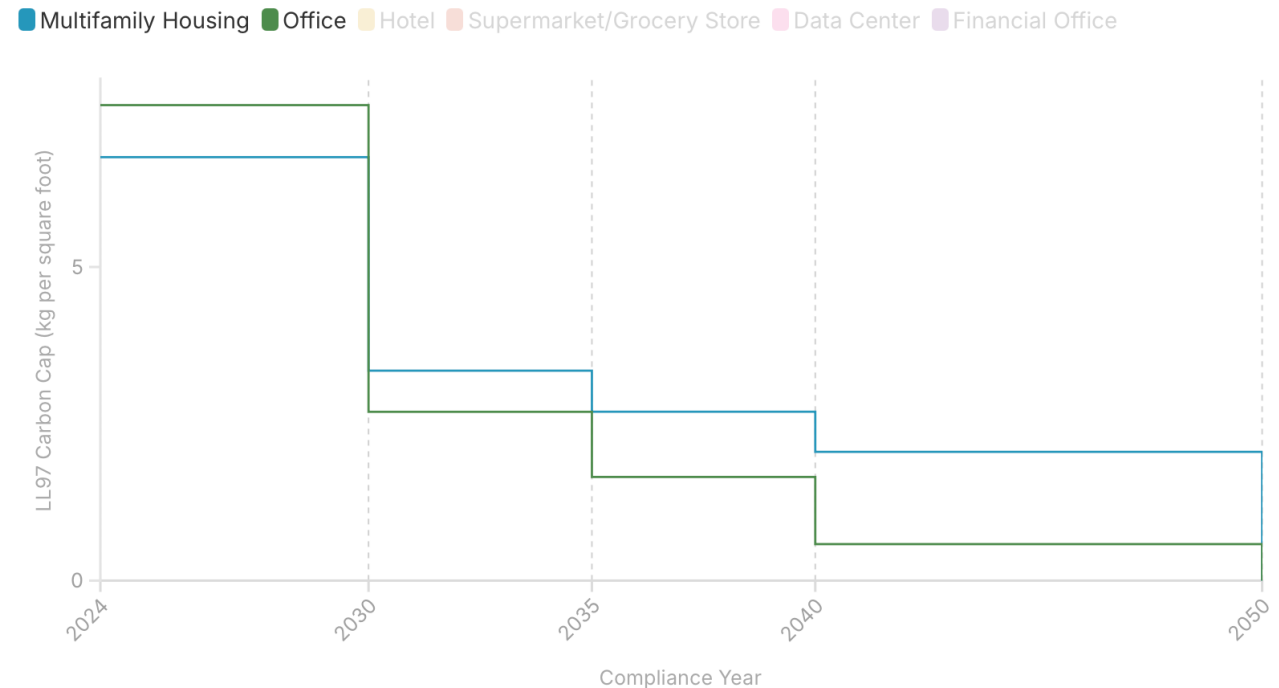
- Energy efficiency measures
 - Tax incentives for building renovation
 - Emissions specifications for motor vehicles (reduction to 95 kgCO₂/km)
- Renewable development measures
 - Subsidies for solar, wind, geothermal, and biomass electricity production
 - Subsidies that contribute toward investments costs for renewables
 - Subsidies to large hydropower plant operators (to cover the impact of lower electricity prices)
- Ban on new nuclear power (following Fukushima disaster in 2011)
- Changes to legal procedures for electric grid development and projects
 - Goal is to make it easier to adapt the grid to changing conditions

Sustainability policy – California Air Resources Board

- California is the only state in the US authorized to set its own vehicle emissions standards
- Other states are allowed to follow the California standards if they choose but may not set their own – 17 states currently follow California standards
- 2022: the California Air Resources Board (CARB) adopted a new standard that will transition the state to 100% electric vehicle sales by 2035
- This will have major direct impacts within California and the 17 other states
- How else will this impact vehicle sales in the US?

Sustainability policy – New York City

- Policies can also be quite local
- New York City has implemented Local Law 97, which requires:
 - 40% reduction in building emissions by 2030 (compared to 2005)
 - 80% reduction in building emissions by 2050 (compared to 2005)
- Applies to buildings over 25,000 square feet (~2300 square meters)
- Fines are applied if the caps are exceeded



Related policies – building codes

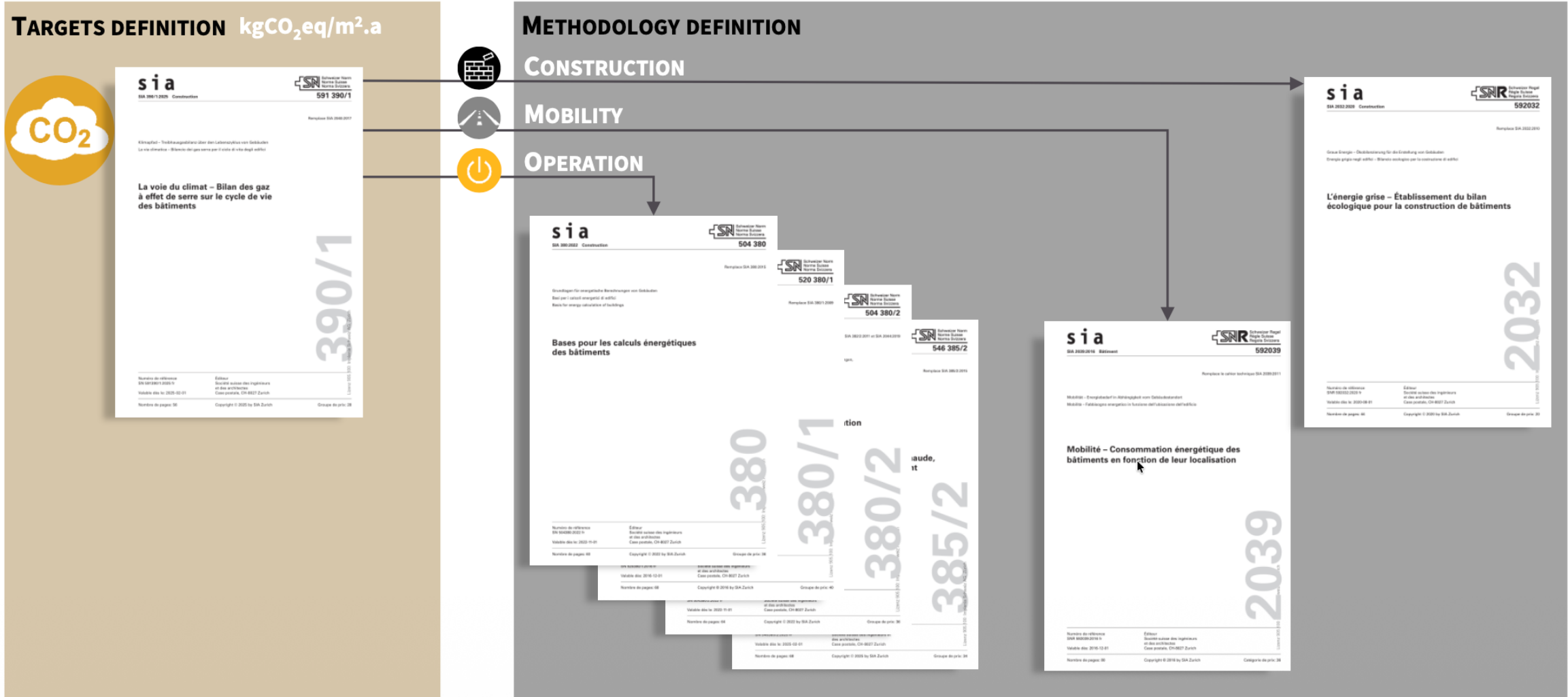
- Building codes are the legal requirements for buildings and construction
- In Switzerland, building codes are implemented at the cantonal level
- The scope of building codes includes:
 - Land use and zoning – what types of buildings can be built in different areas (e.g., residential, commercial, mixed-use)
 - Structural safety
 - Energy efficiency
 - Health and safety
 - Accessibility
- Codes may reference **standards** (next slide)



Sustainability standards – SIA

- The Swiss Society of Engineers and Architects (SIA) produces standards for building and construction
- **Standards are not legally binding on their own**, but are often referenced by local building codes
- Standards may go beyond the legal minimum
- Examples:
 - SIA 380/1 – energy efficiency in buildings
 - SIA 260 – structural design

Sustainability standards – SIA



Sustainability standards – other examples

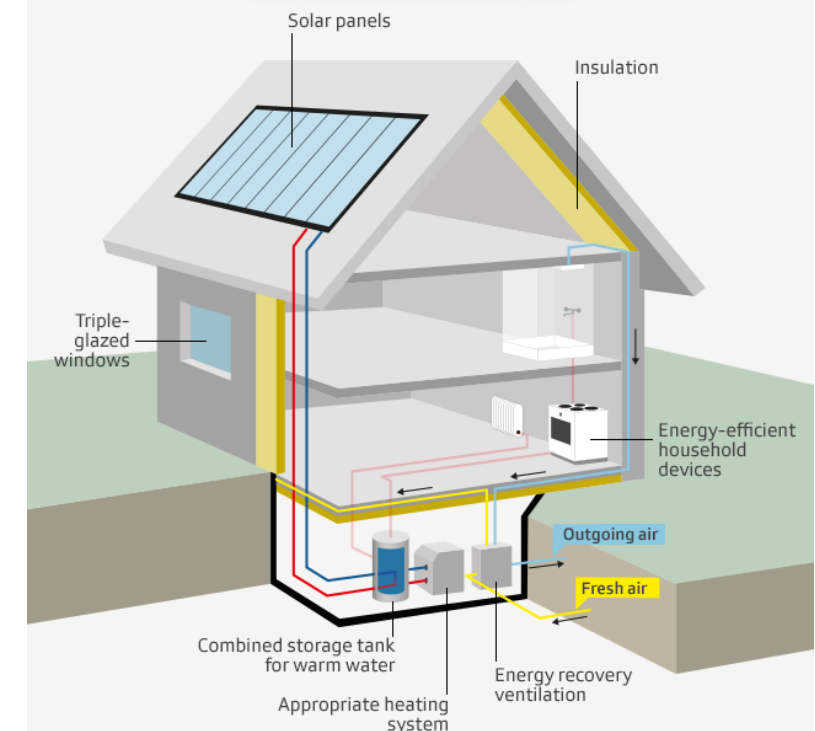
- Many organizations create standards
- Outside Switzerland, the most well-known standards for energy in buildings come from:
 - **ASHRAE**: American Society of Heating, Refrigerating, and Air-Conditioning Engineers
 - **REHVA**: Federation of European Heating, Ventilation, and Air Conditioning Associations
- The International Organization for Standardization (ISO) has over 25,000 standards
 - ISO 14040: Life-cycle assessment
 - ISO 14064-1: Specification for quantification and reporting of greenhouse gas emissions and removals
 - ... and many, many more

Sustainability labels – Minergie

- Some standards also offer **labels**
- Minergie is an example of a label that can be acquired by meeting certain standards set by the Minergie governing body
- Minergie labels:
 - Minergie: base sustainability certification
 - Minergie-P: advanced thermal properties
 - Minergie-A: energy producing buildings
 - Minergie-Quartier: neighborhood scale
 - Minergie-ECO: ecology and health

MINERGIE®

Overview of Minergie home



Sustainability labels – others

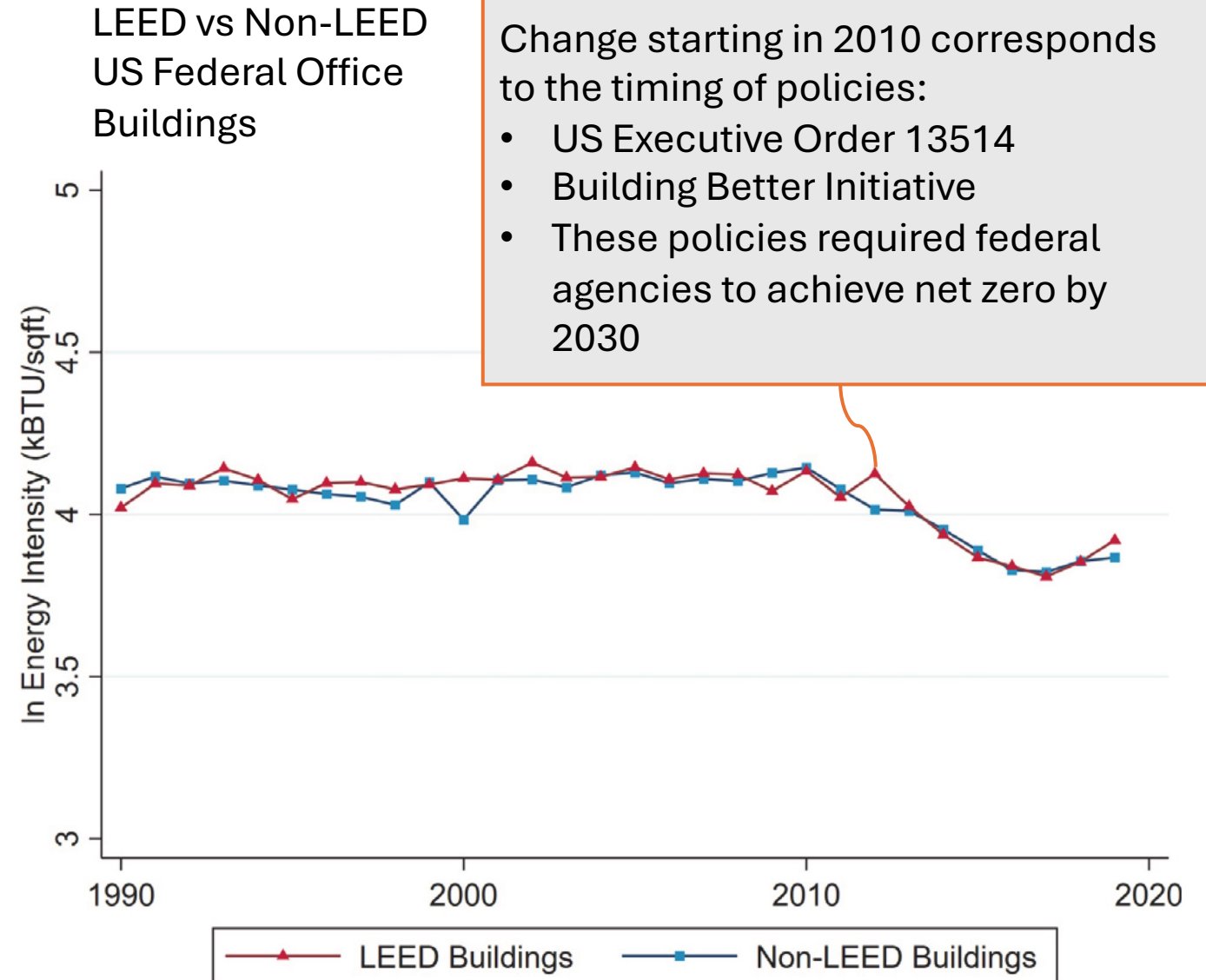
- **LEED** (Leadership in Energy and Environmental Design) is the most widely used green building standard and label
 - Administered by the U.S. Green Building Council
- **WELL** is a healthy building sustainability label and standard, focusing on the quality of the indoor environment (e.g. air quality)
- **Envision** is a label and standard focused on sustainability of infrastructure beyond individual buildings



ENVISION™

Do labels work?

- Findings are mixed, but some scientific studies have found no evidence that LEED buildings use less energy
- One of the problems with labels is that they can be **prescriptive** rather than **operational**



Sustainability guidelines

- Guidelines provide less formal requirements and offer best practices toward reaching a certain goal
- Example: European Commission's Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan (SUMP)
 - Audience: cities and local governments
 - Purpose: to provide best practices for developing and implementing plans for sustainable mobility



European Platform
on Sustainable Urban
Mobility Plans

GUIDELINES FOR
**DEVELOPING AND IMPLEMENTING A
SUSTAINABLE URBAN MOBILITY PLAN**

SECOND EDITION

Exam details

- Covers the whole semester
 - More focus on the material after the midterm exam
- Wednesday, 28 January 9:15-12:15
- Location: BCH 2201 (other side of campus)
- Same format as midterm exam
 - Some multiple choice, some open ended
 - Closed notes
 - Bring a simple calculator

Lecture 01: introduction and the climate crisis

- Drivers of the climate crisis
- CO₂ and other greenhouse gas emissions
- Trends in energy, CO₂ emissions, and global temperatures
- Economic growth and CO₂ emissions
- Climate change impacts
- Definitions of sustainability
- Motivations for addressing sustainability in civil engineering

Lecture 02: Sustainability indicators

- Foundational measures: GDP
- Sufficiency
- Human Development Index
 - Construction of index
- Health: HDI approach, DALYs
- Education
- Inequality: Gini coefficient
- Biodiversity
- **Ecological footprint**

Lecture 03: Energy demand and buildings

- Energy units, unit conversions
- Building electricity consumption
- Cement and steel production
- Heating and cooling fundamentals
- Heat transfer
- Heat pumps and COP
- Active vs. passive heating and cooling

Lecture 04: Energy supply

- Energy supply definitions
- Levelized cost of electricity and discounting
- Wind energy
- Solar energy
- Hydropower
- Matching electricity supply and demand

Lecture 05: Transportation

- Transportation energy sources
- Vehicle fuel efficiency and electric vehicles
- The transportation system
- Systems thinking
- Causal loop diagrams

Lecture 06: Sustainability mobility

- Feedback loops
- Active mobility
- Walkability metrics
- Link between active mobility and social systems

Lecture 07: Embodied carbon

- Embodied vs operational energy
- Building demolition
- Circular system
- Structural design basics
- Global warming potential of structural elements
- Materials
- Structural systems
- Lifespan and reuse

Lecture 08: Life-cycle assessment

- LCA framework
- Goal and scope
 - Function and functional unit
 - System boundaries
- Inventory analysis
- Impact assessment
- Interpretation
 - Sensitivity analysis

Lecture 09: Natural capital

- Ecosystem services
- Natural capital definition
- Natural capital assessment and accounting
- Gross Ecosystem Product
- InVEST software tool

Lecture 10: Natural systems in civil eng.

- Definition of natural systems
- Resilience
- Multicriteria decision making
- Carbon sequestration
- Sensitivity analysis
- Nature-based solutions

Lecture 11: Safety and reliability

- Risk
 - Hazards
- Design philosophy – resistance and action effects
 - Probabilistic approach
 - Reliability index
- Structural verification
 - Limit states
 - Design values
 - Characteristic values
 - Load combinations
- Actions and loads

Lecture 12: Industry lecture

- Opportunity for sustainability impact over project life cycle
- Value for CO2 reduction strategies
- Stakeholder engagement

Lecture 13: Targets

- Targets
- Pathways
- Policies
- Standards
- Labels
- Guidelines