Lecture13
Sustainability targets, course wrap-up, debate

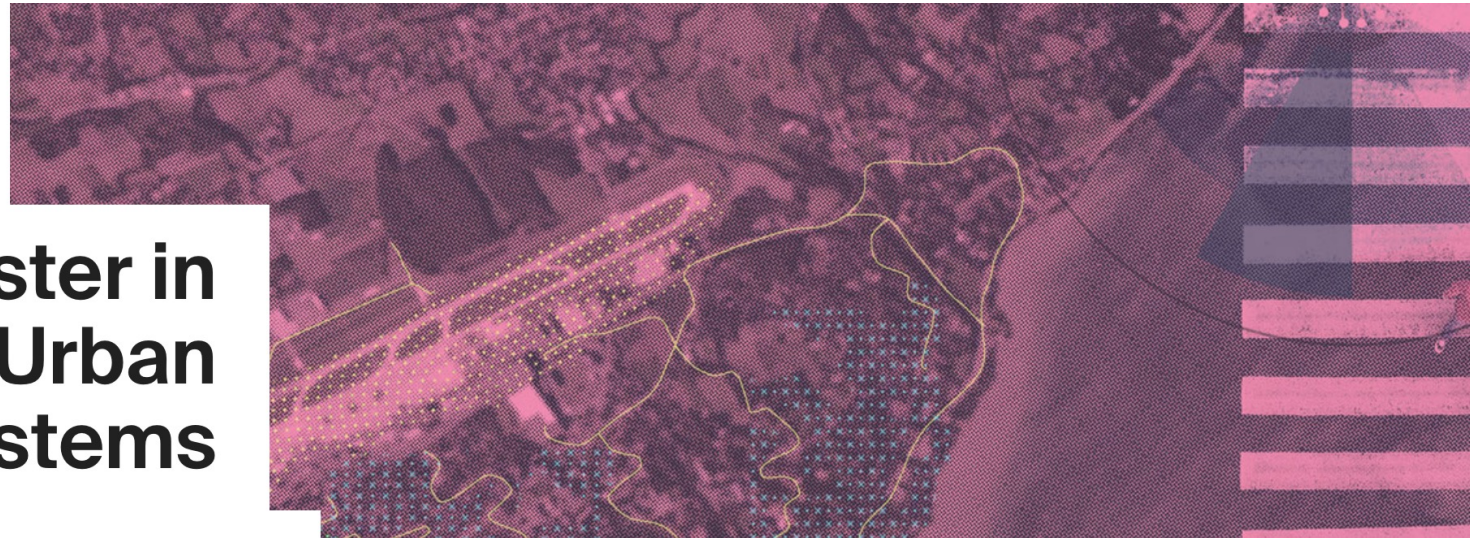
CIVIL-239: Engineering a sustainable built environment

Andrew Sonta

Outline

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

Master in Urban Systems



- Starting 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

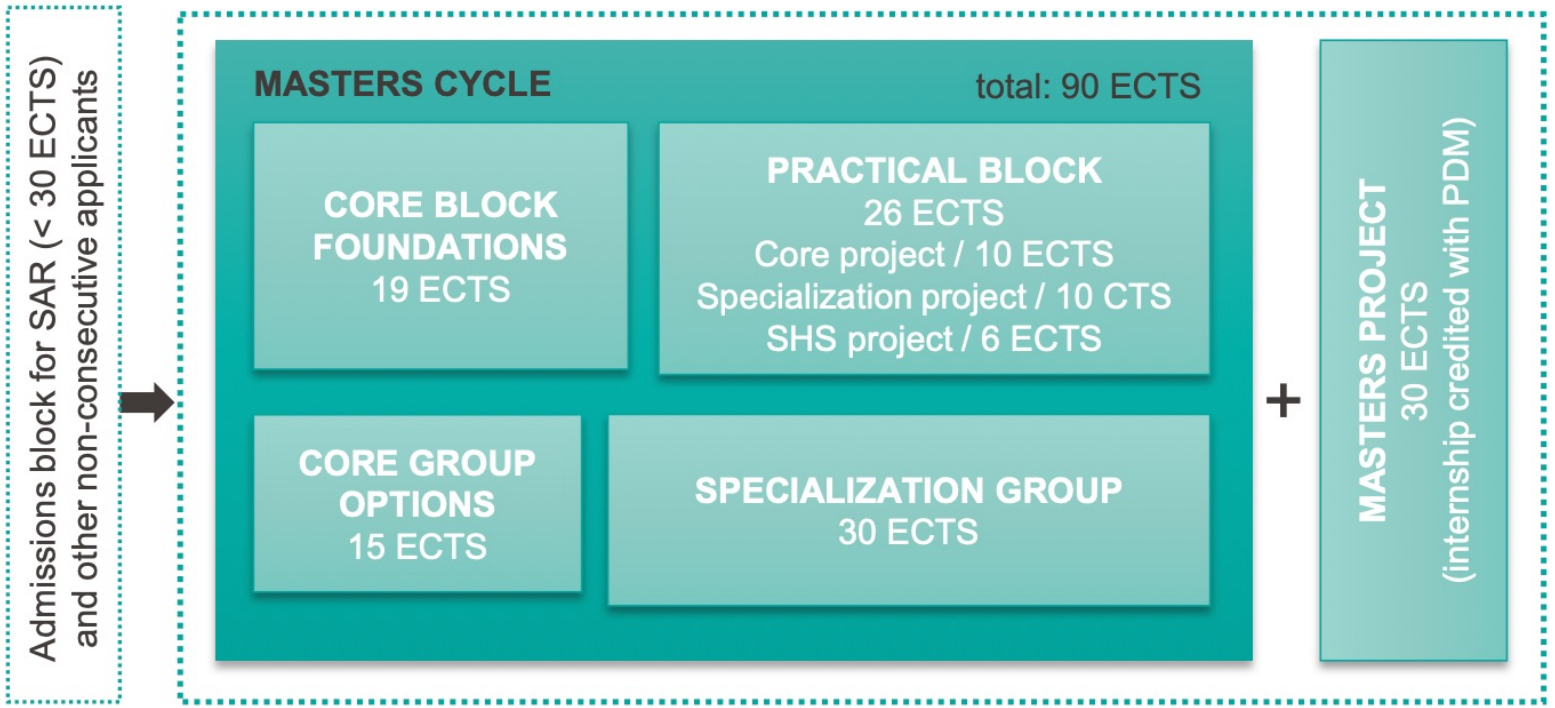
Master in Urban Systems

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

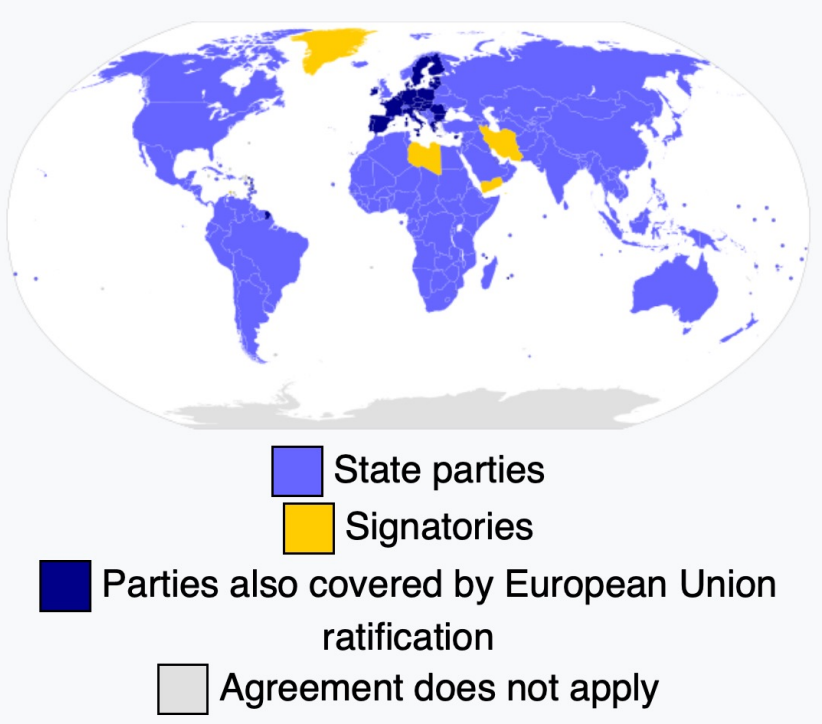


Sustainability targets, pathways, policies, standards, labels, and guidelines

- 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 (UNFCC)
- Signing countries agreed to limit global warming to **“well below 2ºC”** above pre-industrial levels, while pursuing efforts to keep warming to 1.5ºC
- Signing countries submit their plans – called Nationally Determined Contributions
- Legally binding in its framework but **relies on voluntary national commitments**



Source: Wikimedia Commons

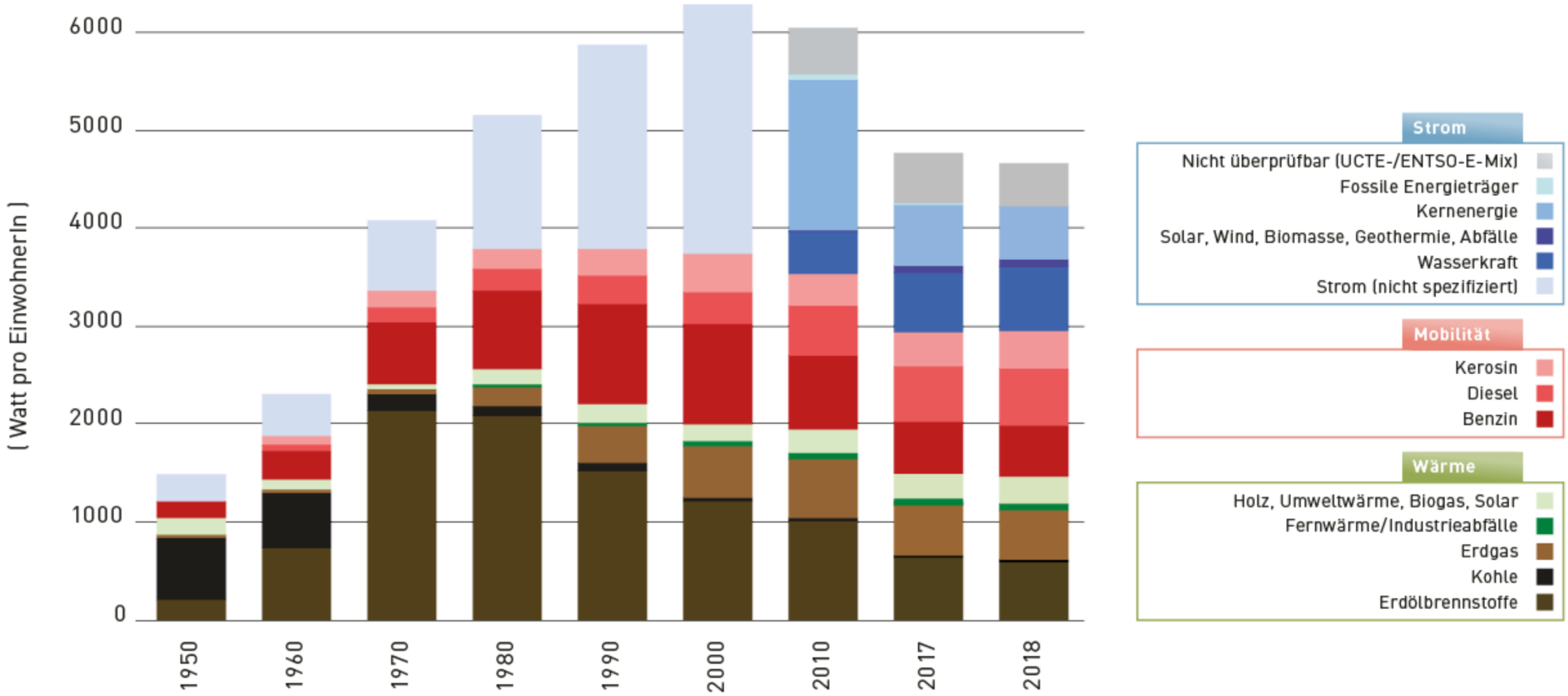
Sustainability target – 2000 watt society

- Goal is to reduce energy consumption to the equivalent of 2000 watts of continuous power consumption
  - Energy: 2kWh/h
- 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

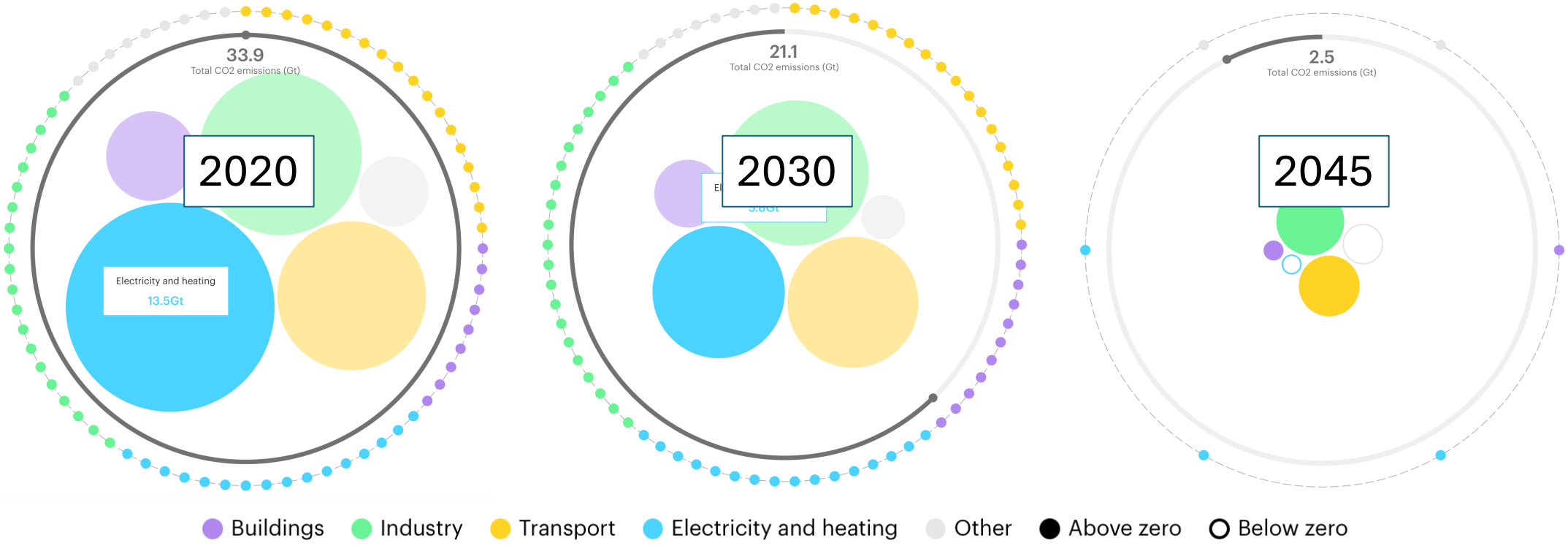
Dauerleistung nach Energieträger (Stufe Primärenergie, Basis Endenergie)



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)

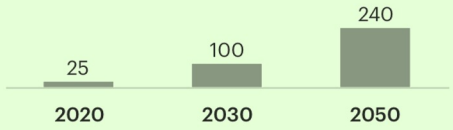
Sustainability pathway – IEA Net Zero by 2050

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

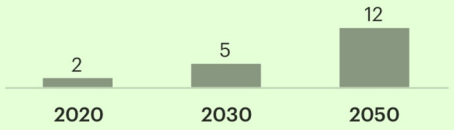


Sustainability pathway – IEA Net Zero by 2050

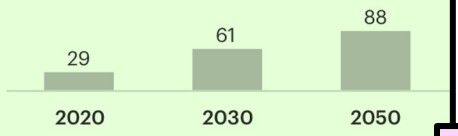
Renewables



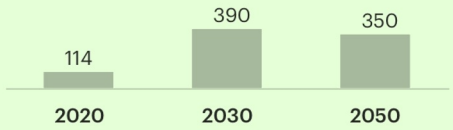
Households with rooftop solar PV (million)



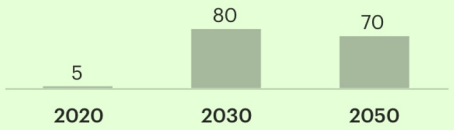
Solar thermal and geothermal in buildings (%)



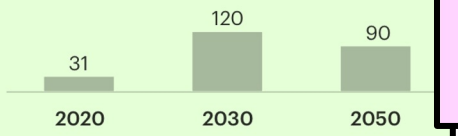
Renewables share in generation (%)



Annual capacity additons - wind (GW)



of which off-shore wind (GW)



Annual capacity additions - disp ren (GW)

Behavioral changes

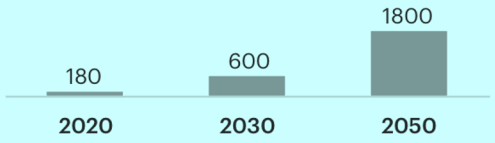
19-20°C
by 2030

Average space heating temperatures

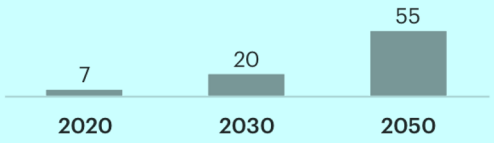
24-25°C
by 2030

Average space cooling temperatures

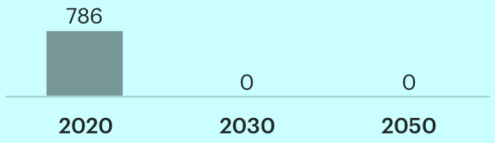
Electrification



Heat pumps installed (Million units)

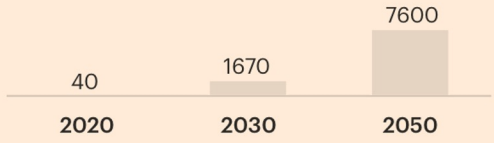


Heat pumps for heating (% of energy demand for heating)

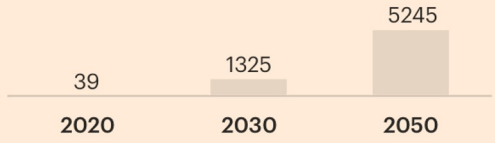


Population without access to electricity (Million people)

Carbon capture



Total CO2 captured (Mt CO2)



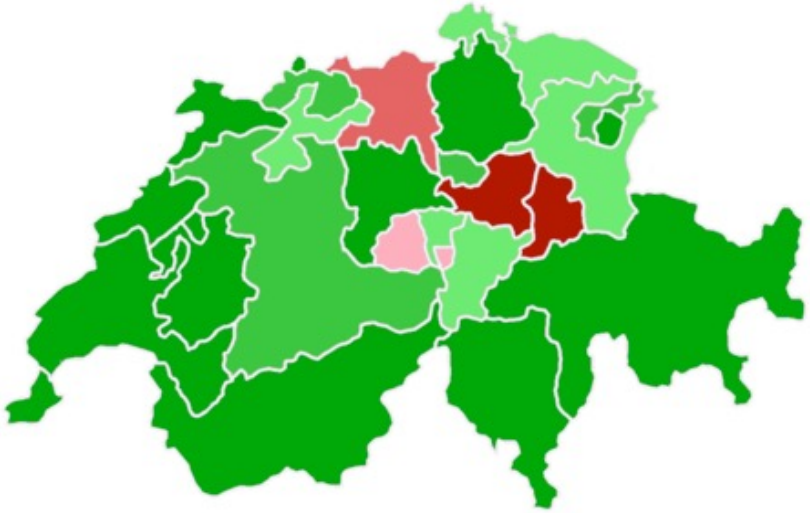
CO2 captured from fossil fuels and processes (Mt CO2)

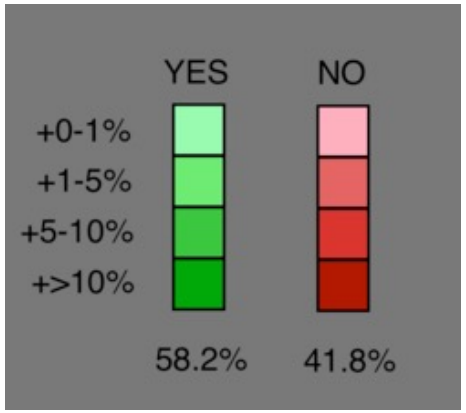
Sustainability policies

- 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

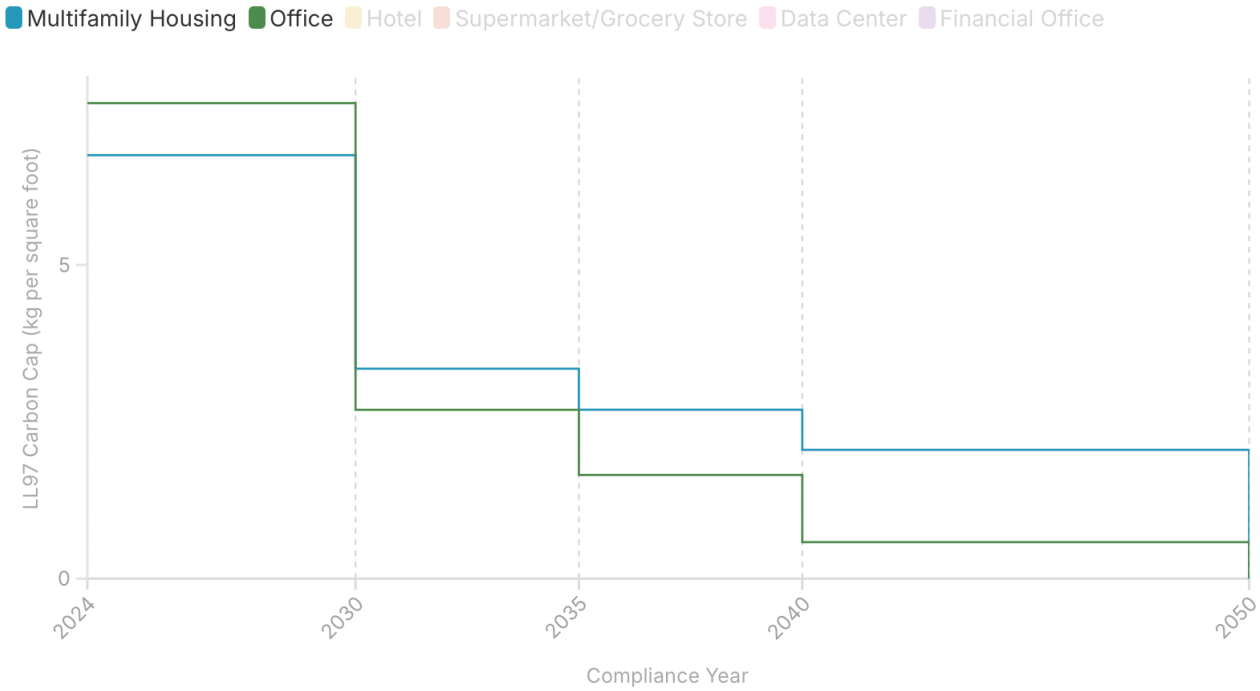
- Energy efficiency measures
  - Tax incentives for building renovation
  - Emissions specifications for motor vehicles (reduction to 95 kgCO2/km)
- Renewable development measures
  - Subsidies for solar, wind, geothermal, and biomass electricity production
  - Subsidies that contribute toward investments 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



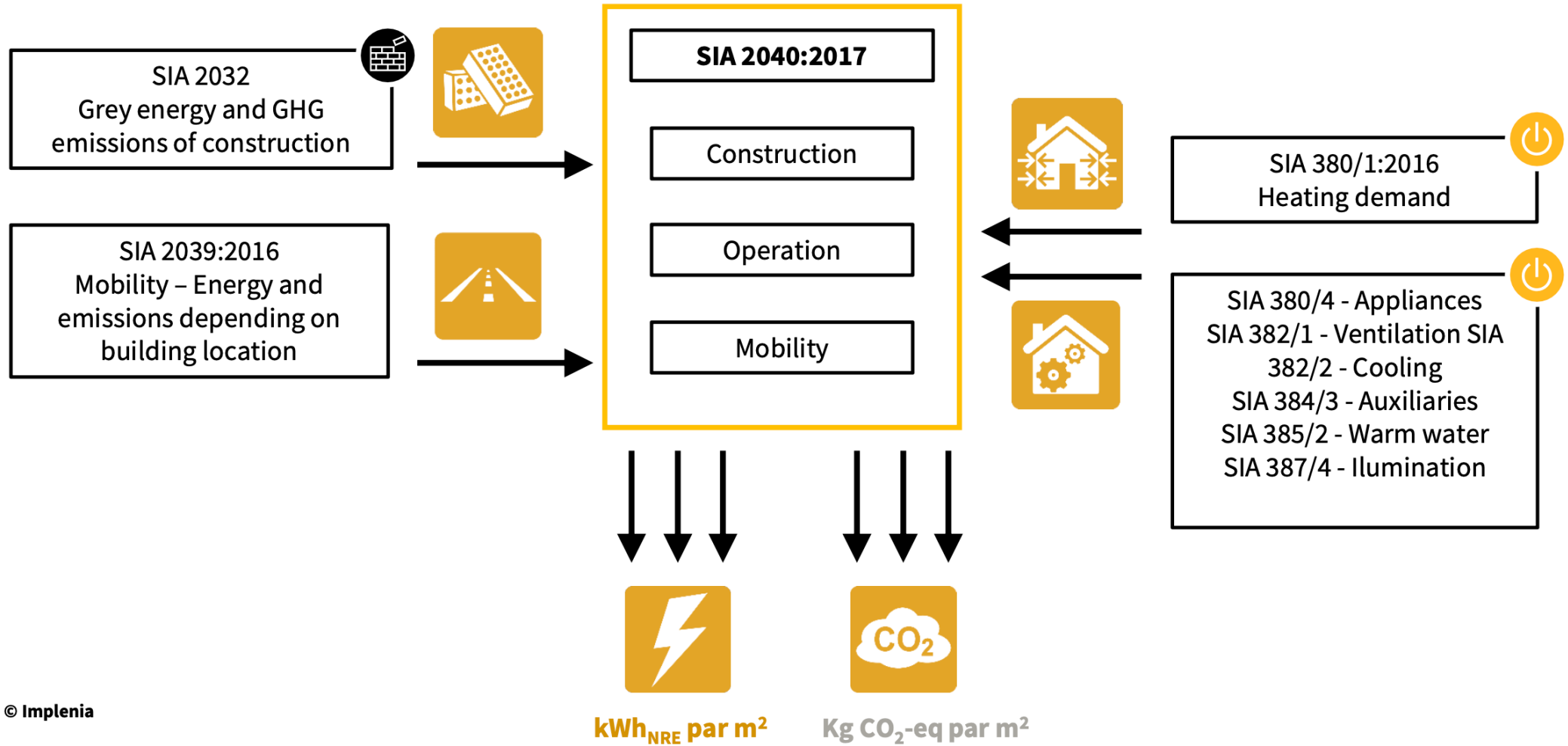
Related policies – building codes

- 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 are 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



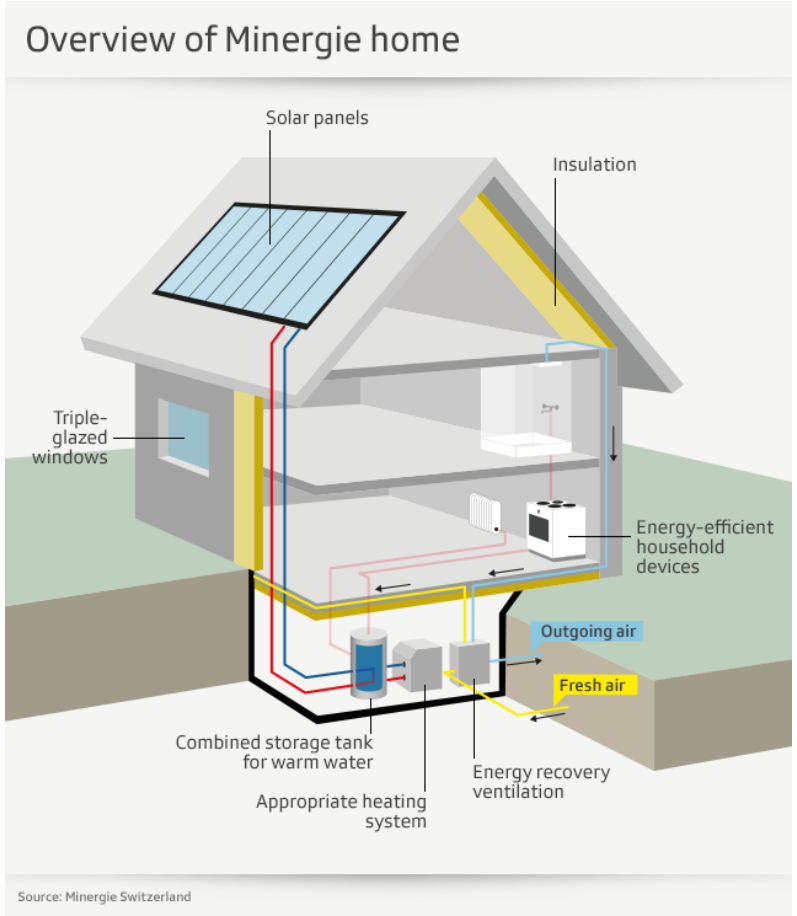
Sustainability standards – other examples

- 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®

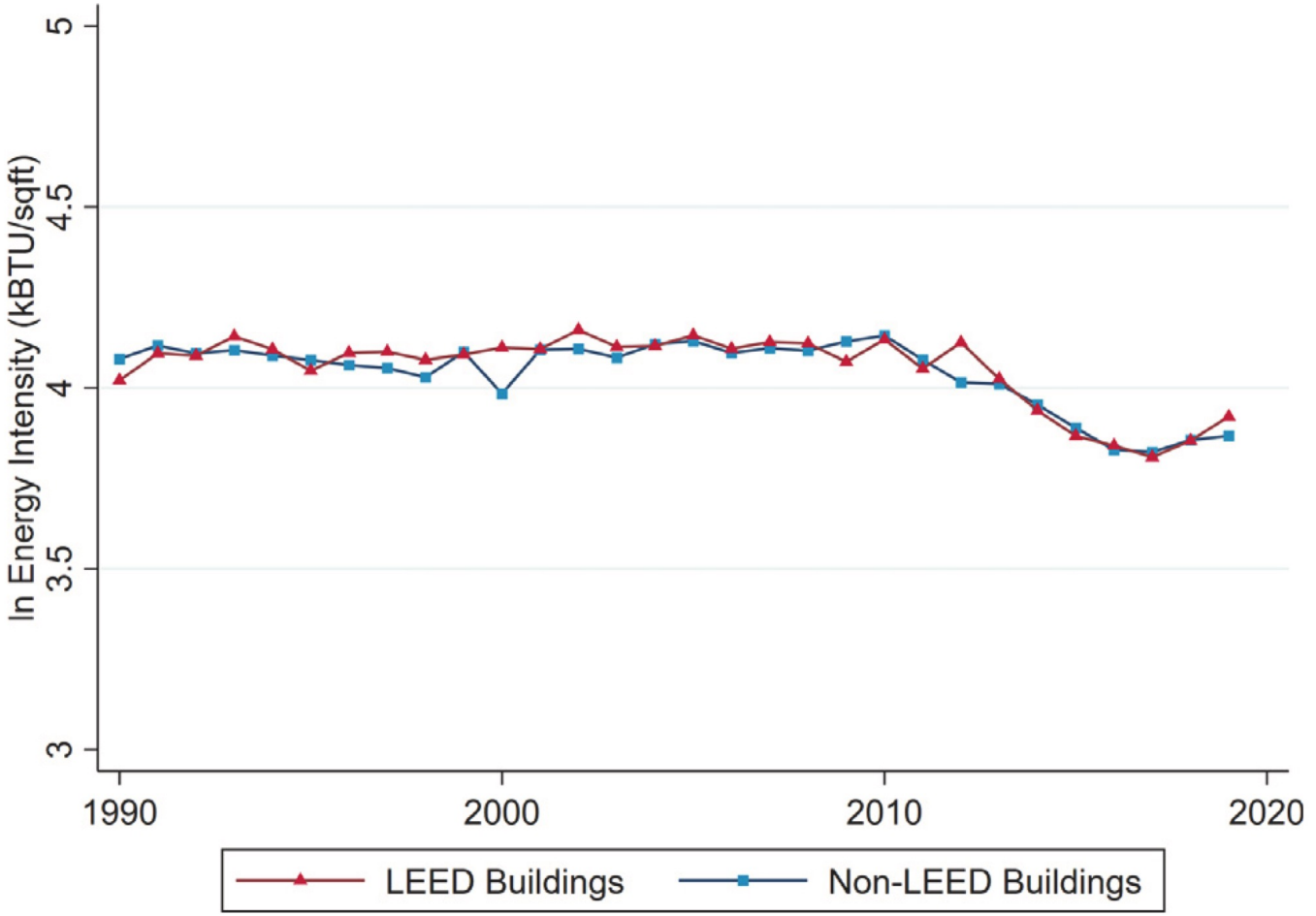


Sustainability labels – others

- **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

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



Clay et al. 2023

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

Exam details

- Covers the whole semester
  - More focus on the material after the midterm exam
- Monday, 27 January 9:15-12:00
- Location: CE 1 4
- Same format as midterm exam
  - Some multiple choice, some open ended
  - Closed notes
  - Bring a simple calculator
- Designed for 2 hours (but you can take until 12:00)

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

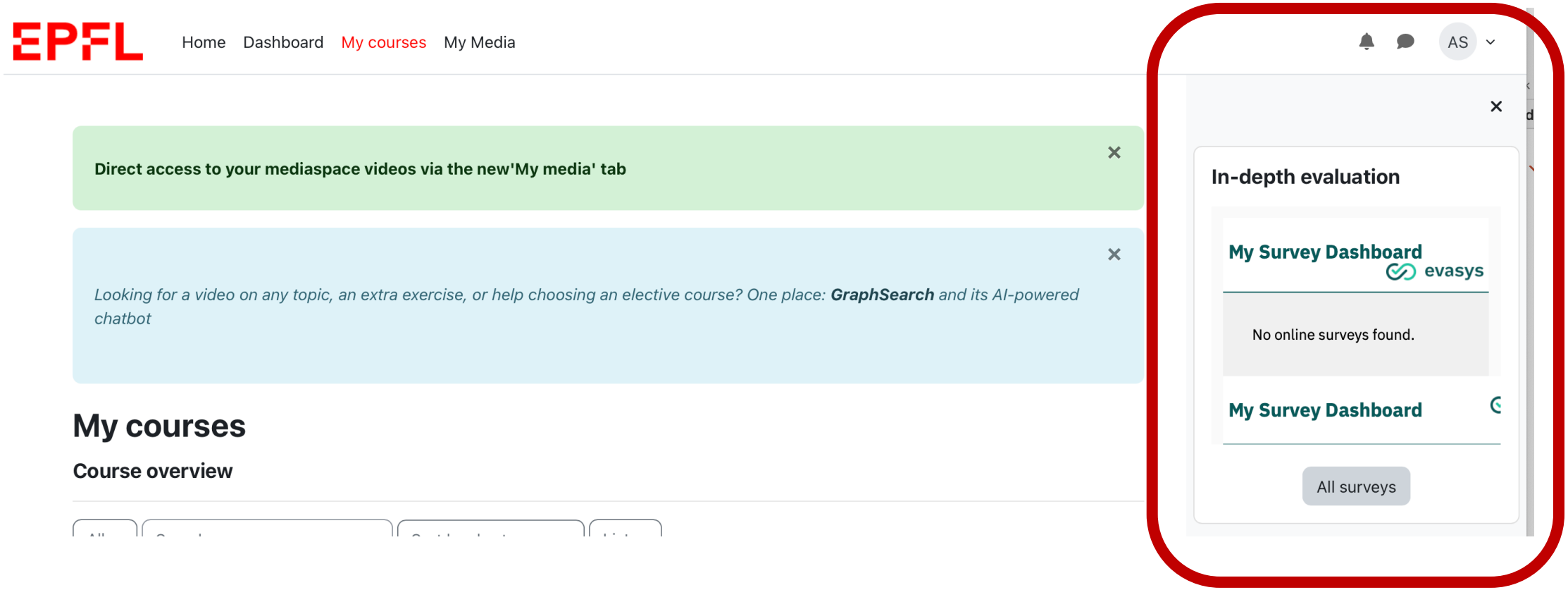
- Impact over time
- Value for CO2 reduction strategies
- Stakeholder engagement

Lecture 13: Targets

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

Course feedback

Please log into Moodle and complete the course feedback!



Class debate

- The Lausanne city council has announced that 10 million CHF have been made available for projects related to “sustainability” (they leave this vague on purpose)
- We will split the class into 5 groups
- Each group represents a different advocacy group:
    1. Investment in **research** for new high-tech solutions for reducing carbon emissions (e.g., AI, smart materials, ???)
    2. Investment in solutions to **adapt** to the changing climate and improve resilience
    3. Investment in sustainable and active **mobility** projects
    4. Investment in projects that replace hydropower with **solar power**
    5. Investment in requiring construction projects to **reuse materials** when possible and otherwise use low carbon materials
    6. Investment in climate change **education** programs
    7. Investment in **restoration and renaturation** projects (nature-based solutions)

Class debate

1. Investment in **research** for new high-tech solutions for reducing carbon emissions (e.g., AI, smart materials, ???)
2. Investment in solutions to **adapt** to the changing climate and improve resilience
3. Investment in sustainable and active **mobility** projects
4. Investment in projects that replace hydropower with **solar power**
5. Investment in requiring construction projects to **reuse materials** when possible and otherwise use low carbon materials
6. Investment in climate change **education** programs
7. Investment in **restoration and renaturation** projects (nature-based solutions)

Class Debate Process

- Set groups and spokesperson
- Group 1 votes and picks a topic, then group 2, etc.
- 15 mins to prepare a 2-min speech on why this is the best solution (and better than the others)
- Class votes (can’t vote for your own group)
- 2 top groups face off (5-min debate)
- Rest of class votes for a winner