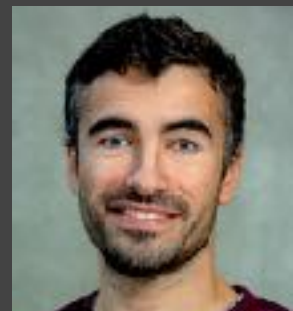


1. Intro Class

Sustainable Software Engineering
CS4295



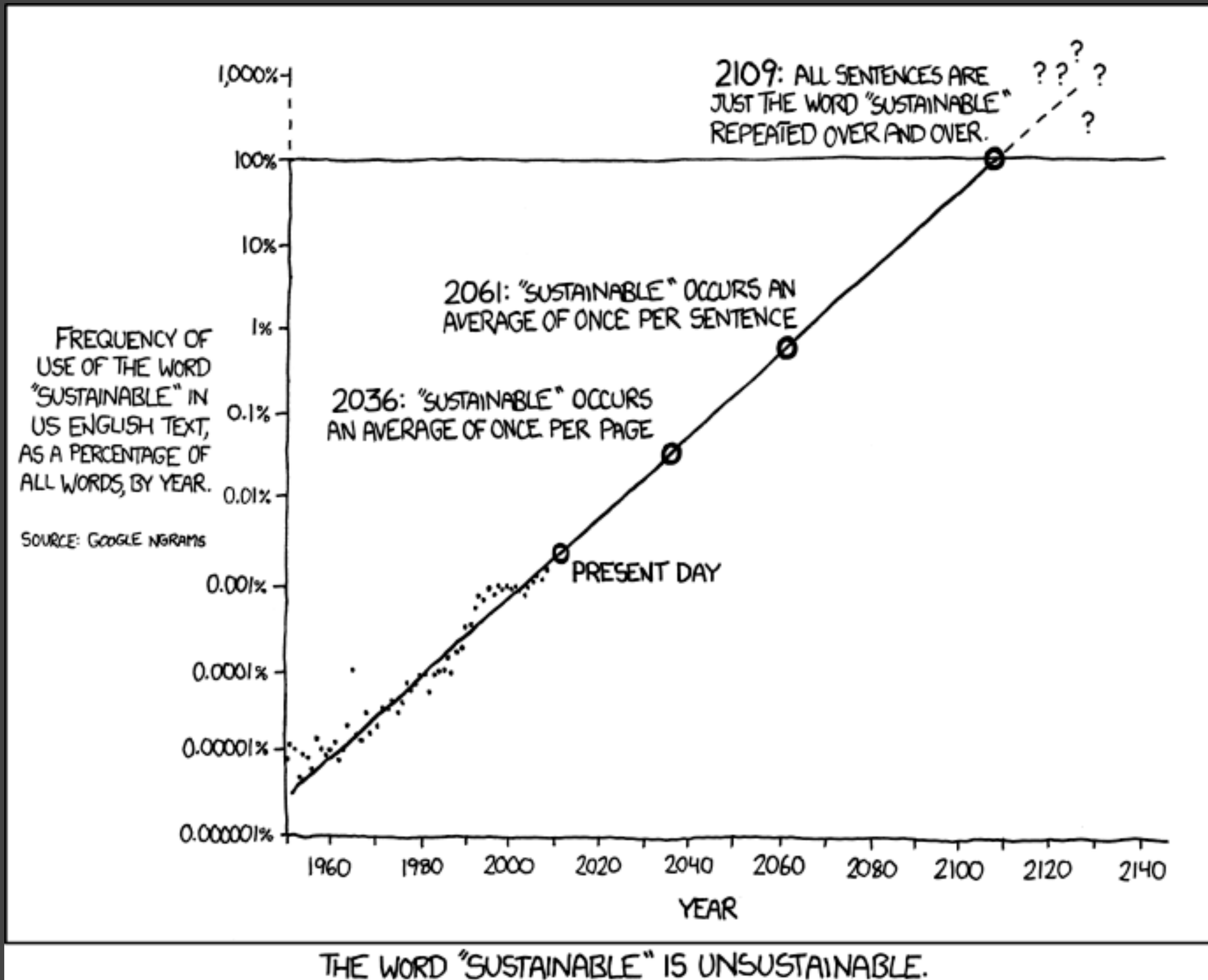
Luís Cruz
L.Cruz@tudelft.nl

**Sustain
ableSE**



1. Intro to Sustainable SE
2. Intro to the course

Sustainability



THE WORD "SUSTAINABLE" IS UNSUSTAINABLE.

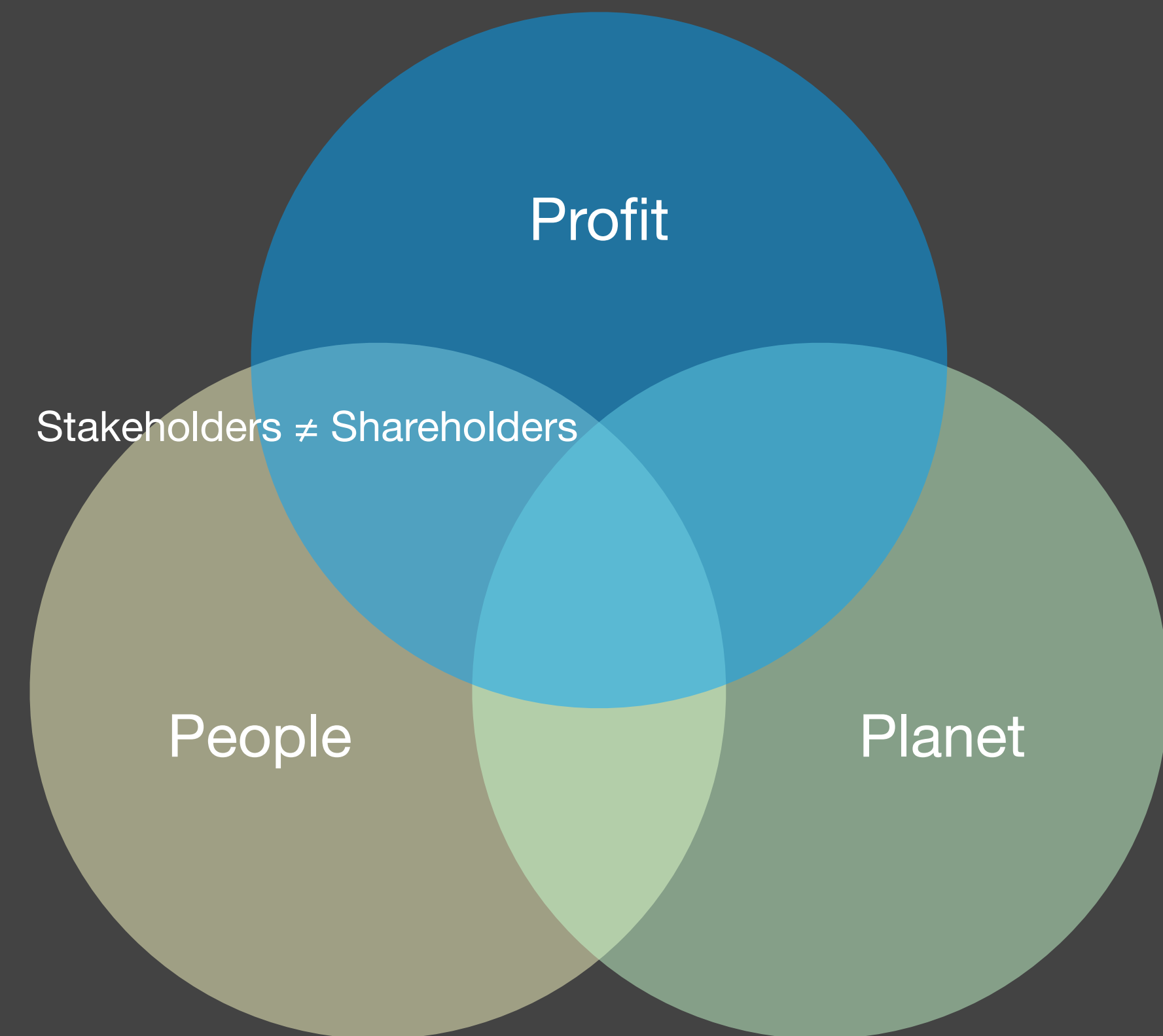
Buzz words

- Eco-friendly
- Climate change, action, adaption
- Energy efficiency
- Environmental-responsible
- Carbon-neutral; Climate-neutral; Net zero
- Carbon-offsetting
- Carbon-free
- Clean technology
- E-waste

Triple Bottom Line (TBL or 3BL)

?

- 3 P's: **p**rofit, **p**eople, **p**lanet
- Concept from **Economics**
- Address the world's most pressing challenges to drive **business success**
- Defining sustainability **goals** and create a **strategy** is not trivial
- Framework used to understand business's **sustainability efforts**.





What is **Sustainable
Software Engineering**?



<https://www.menti.com/uns9d89kzn>

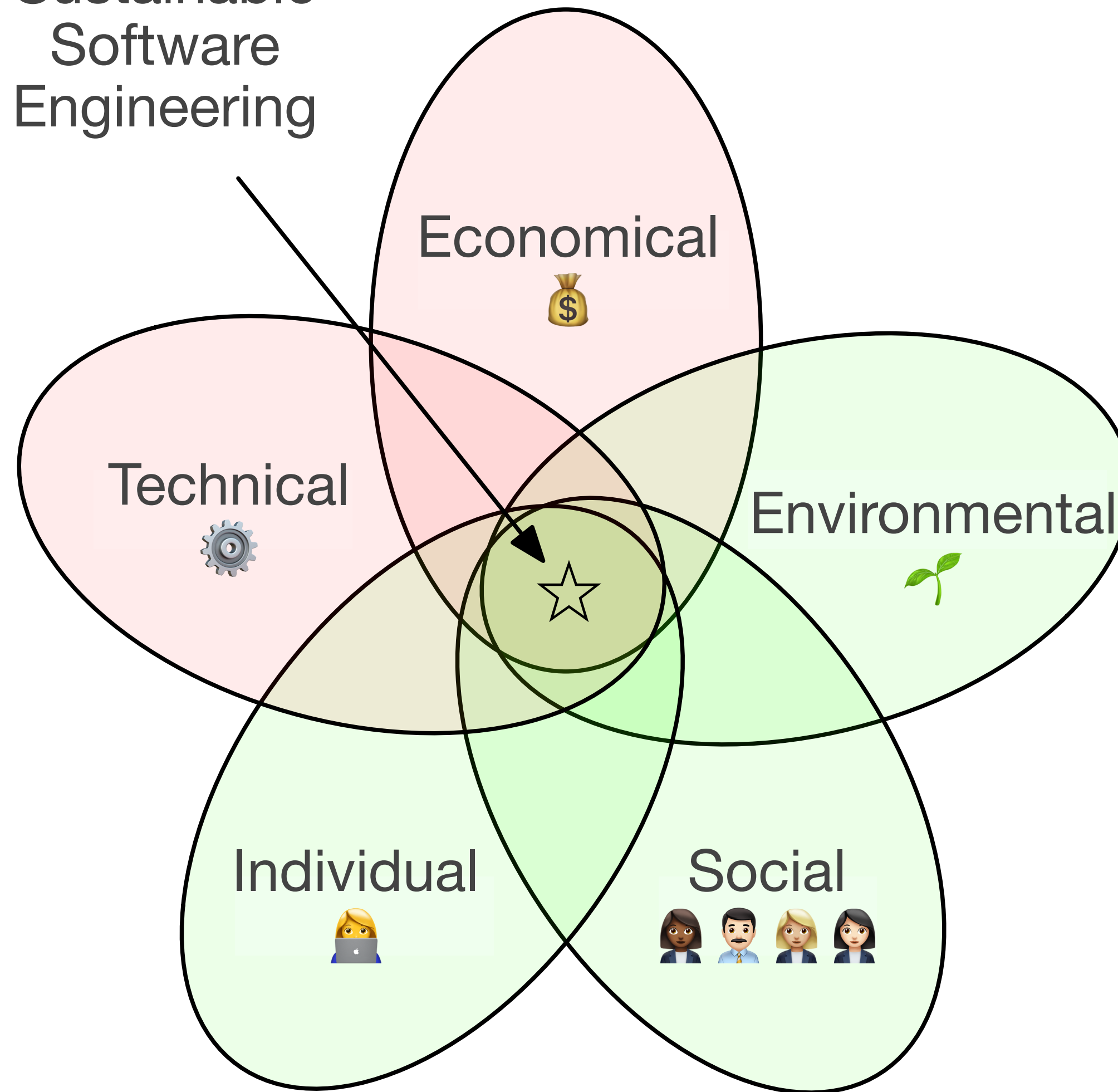


Sustainable Software Engineering is...

...the discipline that studies the process of creating software systems that are able to create value in the long term without hindering its surrounding environment.

?

Sustainable Software Engineering



Economical

- Focused on **assets**, **capital** and **added value** (wealth creation, prosperity, profitability, capital investment, income, etc.)
 - Nr of customers
 - Man-day-rate estimate
 - Next round of funding
 - Meet requirements in the contract



Technical

- Longevity of information, systems, and infrastructure and their adequate evolution with changing surrounding conditions.
- Examples:
 - **Technical Debt**
 - Does it scale?
 - Software testing
 - **Truck-factor**
 - Data integrity
 - Innovation
 - ...

```
    this._config.interval =  
  }  
  
  var transitionDuration =  
    $(activeElement).one(Util.  
      $(nextElement).removeCl  
      $(activeElement).remove  
      _this4._isSliding = fal  
      setTimeout(function ()  
        return $(_this4._elem  
      }, 0);  
    }).emulateTransitionEnd(t  
  } else {  
    $(activeElement).removeCl  
    $(nextElement).addClass(C
```


Individual

- Well-being of the individuals in an organisation. Includes how well individuals interact with each other within the org.
- Examples:
 - mental and physical **well-being**
 - **education**
 - **self-respect**
 - **skills**
 - **mobility**
 - ...



Social

- concerned with **societal communities** (groups of people, organisations) and the factors that erode **trust in society**.
- Examples:
 - **Social equity**
 - **Justice**
 - **Employment**
 - **Democracy**
 - ...
- Also includes compliance with policies and regulations





What is **Sustainable Software Engineering**?



<https://www.menti.com/uns9d89kzn>

Sustainability

- Almost identical to **Green Software**.
- the branch of Software Engineering that studies the *development of software that has **minimal impact in our planet** throughout its **whole lifecycle**.*
- Looking at software at different levels:
 - Developing
 - Using
 - Serving
 - ...
- Also includes **e-waste**.



Bordallo II



What is the **sustainability dimension** you are most interested in?



<https://www.menti.com/uns9d89kzn>

Green Procurement

- Customers decide on providers that **share their values**
- This is currently the **main trigger** for all the buzz around Sustainability and Green Software.
- Examples of green procurement:
 - Developers that only work for companies that are eco-friendly
 - Companies that only use green providers
 - Customers that only buy green services
- Green procurement makes environmental sustainability essential for economical sustainability.

Sustainability via compliance

- EU wants to be **carbon neutral** by 2030
- This also affects the **ICT sector**. Estimated to impact **14% of the global carbon footprint** by 2040.
- Some initiatives are already being negotiated.
 - Extending the smartphone lifetime to **7 years**.
 - **Right-to-repair** movement. <https://repair.eu>
 - Making clean energy more accessible (less taxes).



EUROPE,

LET'S

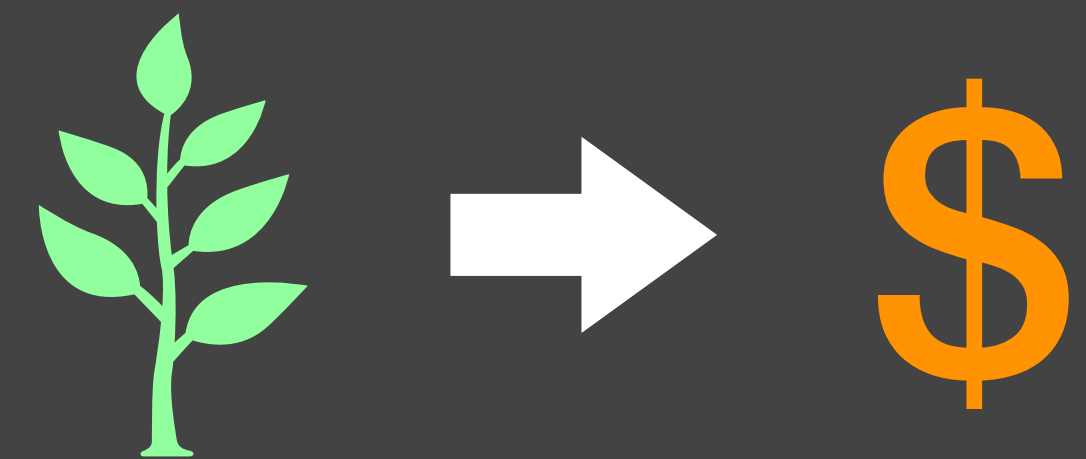
REUSE

REFURBISH

REPAIR

Economical sustainability tops the environment

- In general, a software project will not survive if it's not economical sustainable
- Yet, a project can survive even if it is not environmental sustainable
- **The mindset is changing!**
 - Software consumers have started to worry about the **climate impact of their behaviour as users.**
 - Being environmentally sustainable is now an important competitive factor
- Marketing teams are already using all eco-friendly labels. Technical teams are not there yet, though.
 - **It's easier said than done!**



Green Washing

- Deceptively use marketing techniques to claim being eco-friendly.
- Opting for **green-coloured designs**.
 - Red/orange is usually **perceived as tasty**.
 - Green is **perceived as eco-friendly**.
- The VW case.



The VW scandal

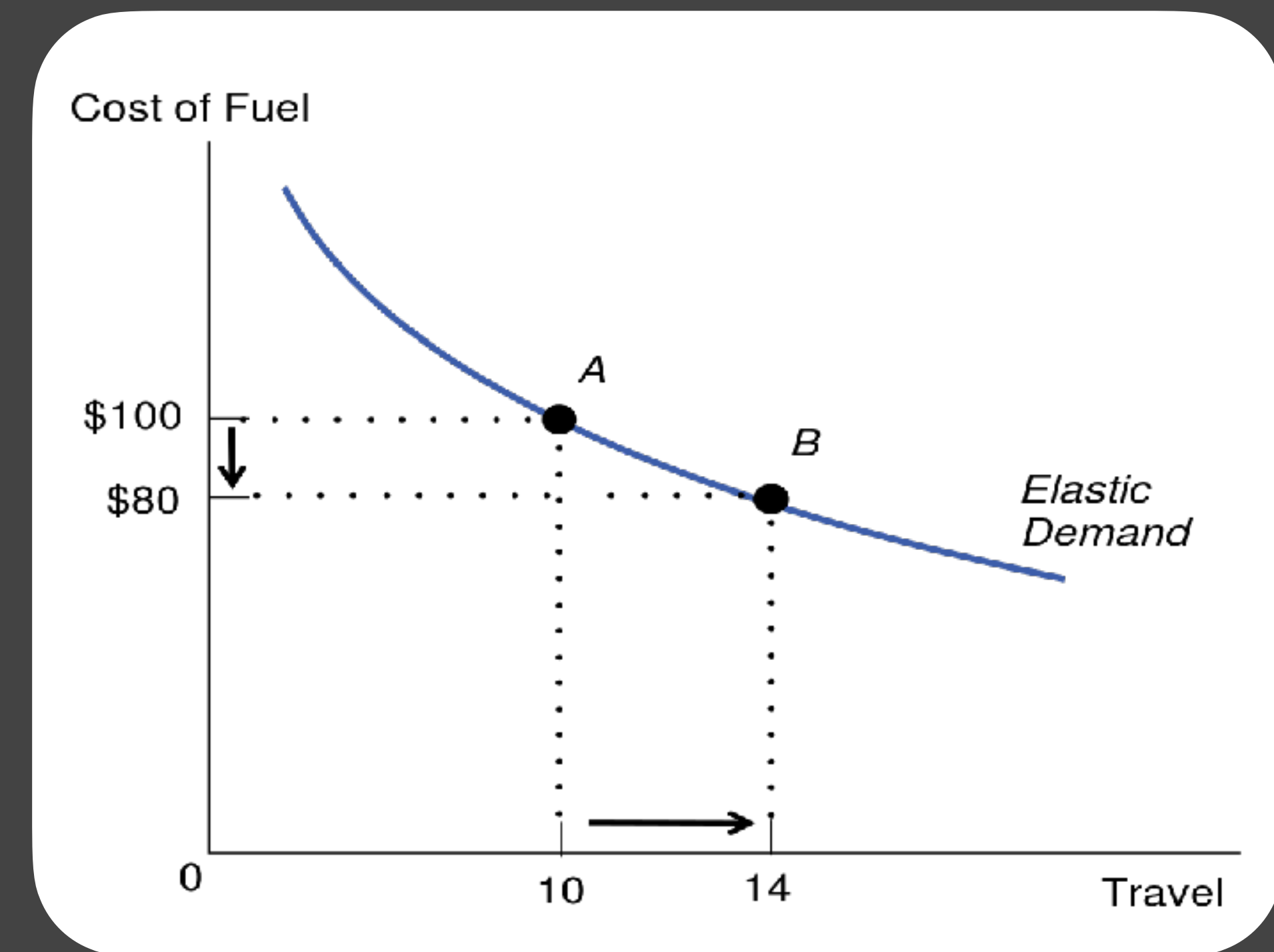
Greenwashing

- Used software to **cheat on vehicle emissions tests**.
- The vehicle's software **could detect** whether they were being **tested**, **changing the performance** accordingly to improve results.
- Affected **11M cars** worldwide, 8M in Europe.



The Rebound Effect

- It happens when you make a technology more energy-efficient but it does not necessarily lead to less usage of energy.
- Imagine that you reduce the energy consumption of training a neural network by 50%.
 - Hence, data scientists saw an opportunity to improve the model by increasing the complexity of the neural network and the size of the input data.
 - Although you have a more energy-efficient network, you might not be saving energy.
- (Other fields have their own paradoxes: **Jevons Paradox** – economics; **Downs–Thomson paradox** – mobility)



Is sustainability an **ethical issue**?

- Climate change is more likely to affect **the poorest** countries.
 - Less financial resources to adapt; Climate-impact does not necessarily harm the emitting country.
- Poorest countries have contributed less to the climate change.
- But **morality** is **different** from **moralising** and is often poorly served by it.
- We need to figure out how to **do more using less** resources.

Political ideology?

- Some environment activists address sustainability as a tool to fight capitalism.
 - “Capitalist corporations need to pay for the damage” ...
- Indeed we need to control/promote/enforce sustainability practices.
- But we want **everyone together** and we need to acknowledge everyone’s contribution to society.
- Other concerns need to be addressed separately in their own thread.

Off-topic

John Cleese vs Extremism



<https://youtu.be/HLNhPMQnWu4>

Positive vs Negative speech

- **Positive speech** has been used for decades but it **did not work**.
- It had been hibernating until **Greta Thunberg** showed up with a catastrophic (yet great) speech.
 - **Very effective** in delivering the message.
 - People could not be neutral about it and had to **react** to her speeches (either positive or negative).
- So indeed there's a **sweet spot** between using a positive and a negative tone.
 - **My personal opinion**: we need negative speech to engage people in the discussion; we need positive speeches for the discussion (i.e., public, political, scientific discussion)



Carbon-free giants

- **Google, Microsoft, Meta/Facebook** want to be **carbon free by 2030**
 - **Carbon free** is different from **carbon neutral**
 - Green IT experts are needed to meet these goals

Green Software

- **Sustainability** and energy **efficiency**.
- Building **energy-efficient software** is important also from a **technical sustainability** POV.
- Smartphones, smart wearables, IoT devices, etc. run on **limited power resources**.
 - Developing software to these devices require energy-efficiency testing and improvement.
- It also leads to environmental sustainability (e.g., less battery cycles)
- Important for **UX** (e.g., no need to walk around with power banks)



Why?

Why?

- Throughout your career you might:
 - Design/maintain/contract data centers
 - Set up **operations/devops**
 - Develop **AI for IoT** devices
 - Be the next **CEO/CTO** of a software company



Why?



- Sustainability can be your **main role**:
 - Green Software Developer
 - Sustainability Consultant
 - Green Advocate
 - Founder of a **Green Tech startup** (B2B?)

How?

How?

- Improve **Green Literacy**. The more people understand it the better it gets.
- Learn how to **measure** software energy efficiency.
- **Carbon-aware design**
- Efficient software **integration processes** (ci/cd?)
- Add energy metrics to **operations**. E.g., scale servers down to zero.
- Do **research** in this topic.
- ...

Content of the course



- **Social** and **Individual** Sustainability (Weeks 1–2)
- Software **Energy Efficiency** (Weeks 2–4)
 - Code patterns, power measurements, datacenters, etc.
- **Green AI** (Week 5)
- **Empirical Methods** (Week 5)
- Projects 1 and 2

Format of classes

- Hybrid (Tue, Thu)
- In-person [or fully offline 🙅]
- Lectures (like today)
- Guest lectures (online/hybrid/in-person – depends on the guest)
- Labs (bring laptop)
- Steering meetings (after week 5, new schedule)

Format of classes - Lectures

- I'm not going to vomit slides
- There's no exam in this course. It's more important that we learn how to discuss this topic and come up with new ideas than learning all the theory.
Critical thinking over checkboxes.
- Mix of content and discussion
- Ultimately, the lectures aim to give you food for thought and the necessary knowledge to excel in Project 2. (We will talk about it later)

Guest Lectures



Daniel Feitosa
University of Groningen
Netherlands 🇳🇱



Rui Pereira
University of Minho / OutSystems
Portugal 🇵🇹



Stefanos Georgiou
Queen's University
Canada 🇨🇦

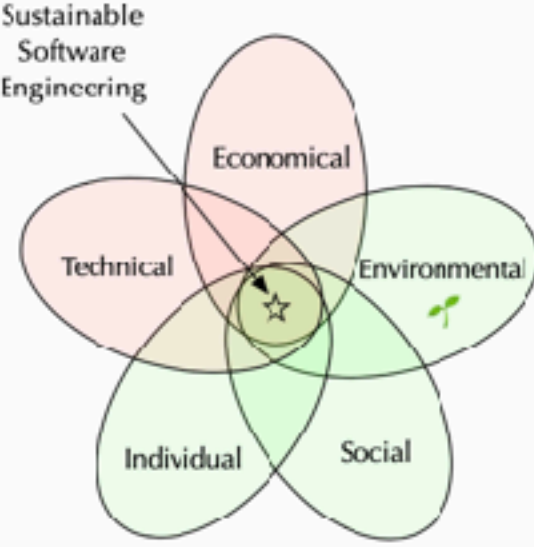
SustainableSE Sustainable Software Engineering 🌱

Sustainable Software Engineering 🌱

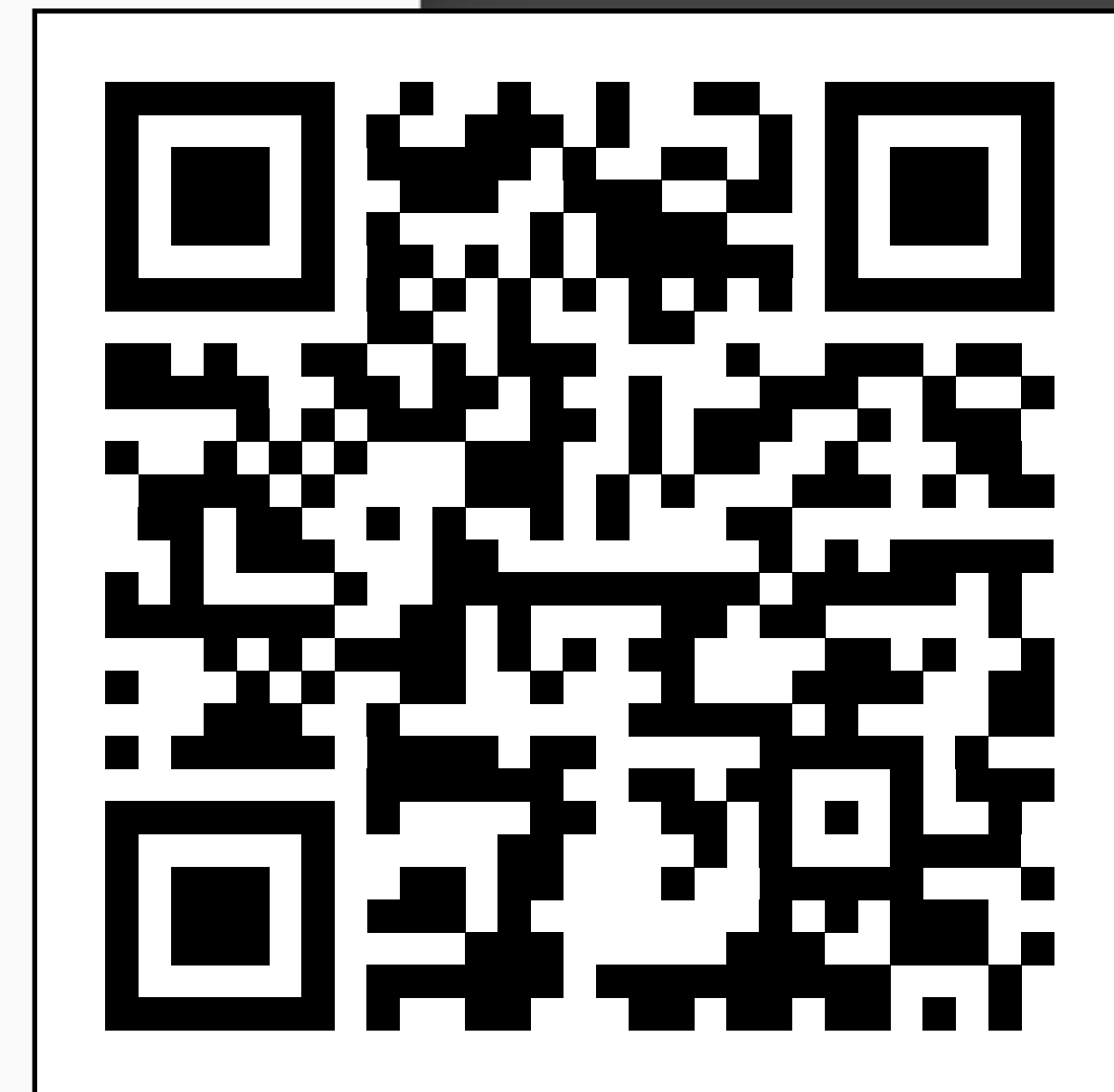
CS4415 | Edition of 2021/22

[Delft University of Technology](#) [MSc in Computer Science – Software Technology]

Sustainable Software Engineering is an overarching discipline that addresses the long-term consequences of designing, building, and releasing a software project. By definition, sustainability covers five main perspectives: **environmental, social, individual, economic, technical**. This course focuses on the first three.



Software Engineering (SE) has long addressed sustainability by **narrowing it down to economic and technical sustainability**. However, our society is facing major sustainability challenges that can no longer be overlooked by software engineers and computer scientists. It was estimated that, **by 2040, the ICT sector will contribute to 14% of the global carbon footprint**. Hence, environmental, social, and individual ought to be part of the equation when it comes to design, build, and release software systems. The problem is far from simple, but **we need expert computer scientists** to bring sustainability into the core values of the next generation of tech-leading organisations.



https://luiscruz.github.io/course_sustainableSE/

TU Delft

< Back

Channels

SustainableSE

Find channel

FAVORITES

CHANNELS

Off-Topic

Town Square

DIRECT MESSAGES

Invite Members

Town Square

Website

Beginning of Town Square

Welcome to Town Square!

Post messages here that you want everyone to see. Everyone automatically becomes a permanent member of the team.

Add members to this channel

Set a Header

Today

System 5:13 PM
@Sander van den Oever joined the team.
You were added to the team by @Sander van den Oever.
@Sander van den Oever left the team.

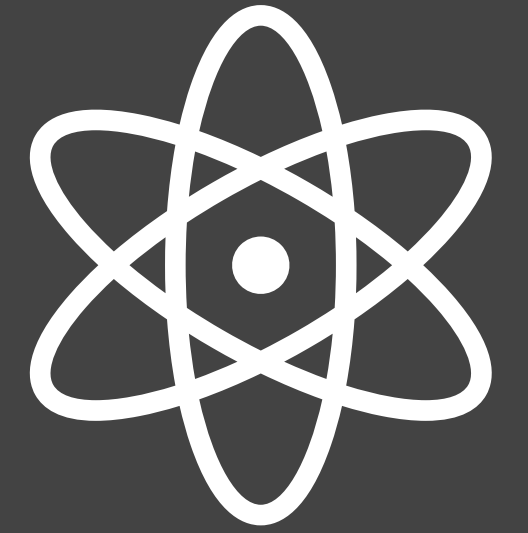
System 6:13 PM
@Luís Cruz updated the channel header to: [Website](https://luiscruz.github.io/course_sustainableSE)

Write to Town Square

Help

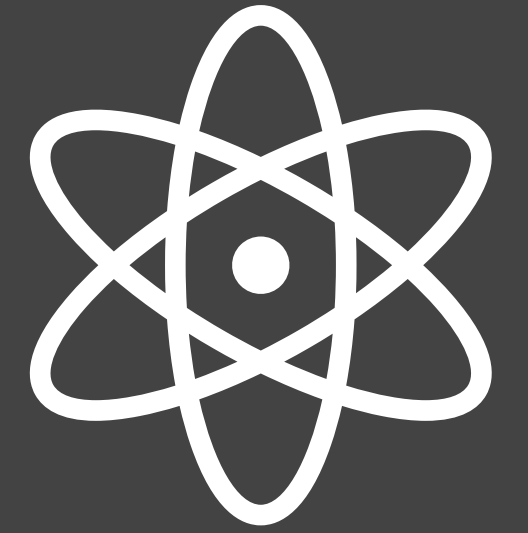
Sign-up link: https://mattermost.tudelft.nl/signup_user_complete/?id=amhohw9r9tbiue879nhz7wxr9w

Project 1



- **Goal:** Measure the energy consumption of a software application.
- **Approach:** energy measurement tools; use case testing.
- **Deliverable:** blog-style report (approx. 2500 words)
- **Deadline:** Week 3, 24 Feb 2022
- **Group size:** TBD

Project 2



- **Goal:** Create a solution/tool/technique that helps building green software. (You can come up with **your own idea** or choose one from a **list of suggestions**).
- **Approach:** open-source software development; literature review.
- **Deliverable:** library/tool/app; paper; presentation.
- **Deadline:** Week 9, 4–7 April 2022
- **Group size:** TBD

Steering Meetings



- Can be **online** or **in-person**!
- Weekly meeting 15–20 minutes
- Mostly for progress updates and feedback
- Weeks 5–9
- To be scheduled in week 5.

Community

How to get involved?

Green TU

- <https://www.tudelft.nl/sustainability/get-involved/greenttu>
- Student organisation at the TU Delft devoted to stimulating sustainability in **education**, **research**, **university operations** and **community engagement**.



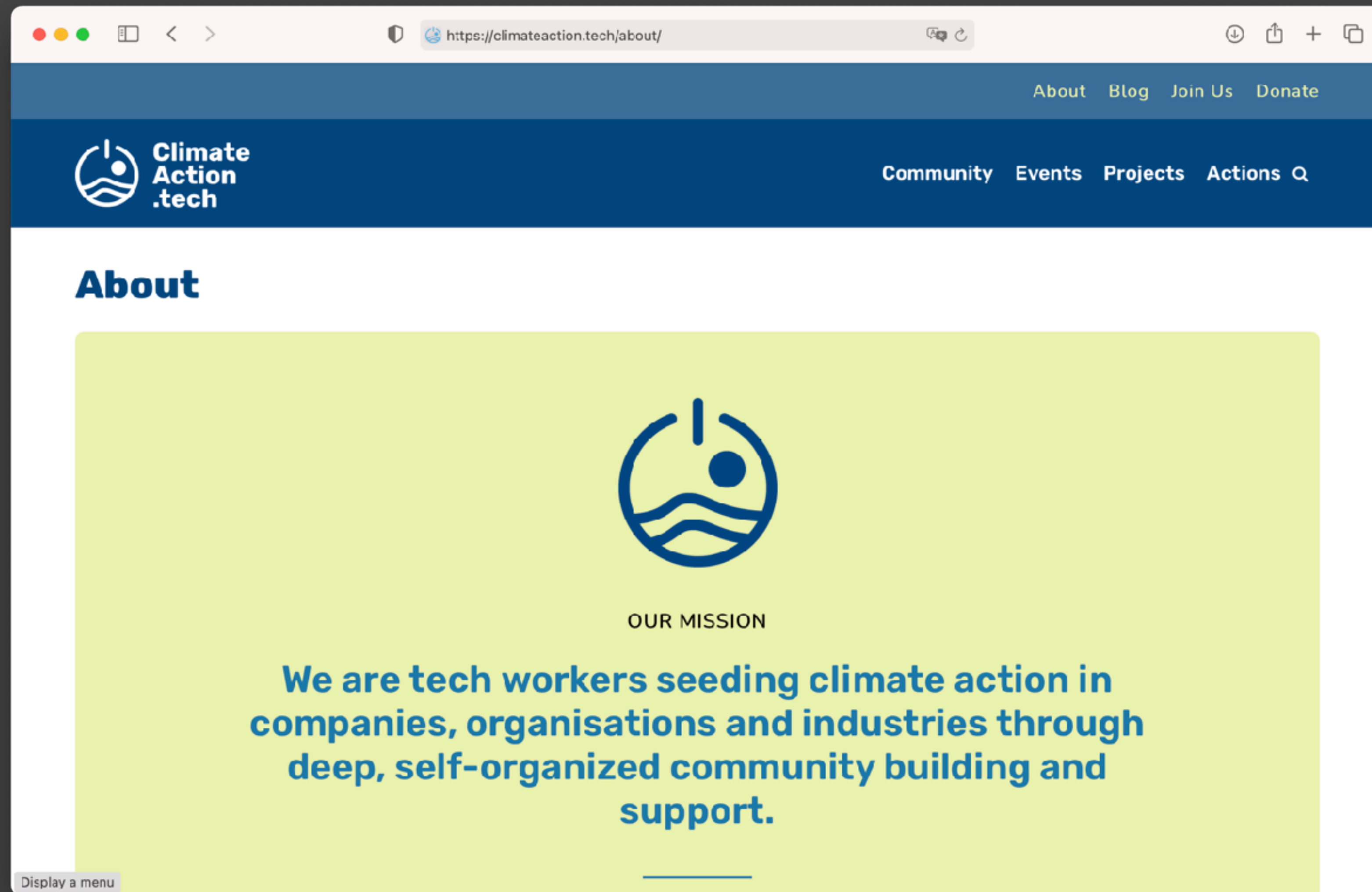
ClimateAction.tech

- Great **community** for outreach
- Based on Slack
- Regular meetings, talks, social events
- You can join as a volunteer and simply to connect to other techies
- Also good to for **job hunting on green tech.**




**Climate
Action
.tech**

ClimateAction.tech



Branch magazine

- Stay **up-to-date** on sustainable tech
- **Creativity** booster
- **Carbon-aware** UI
- <https://branch.climateaction.tech> 



Sustainability in your thesis project

- Most research/software projects have a sustainability angle
 - Topic on **dev/team productivity** – **discuss** individual sustainability
 - Topic on **software quality** – **discuss** impact on energy consumption
 - Topic on **AI** - **report** carbon emissions (no shame!).
 - Topic on **Green Software** – also a good idea ;)



This is the first edition



- Typically new courses
- Early feedback is welcome! **Email** or **DM!**
- Planning on handing a short & anonymous survey on week 6.