

Sustainability

IF2180 Sosio-informatika dan Profesionalisme

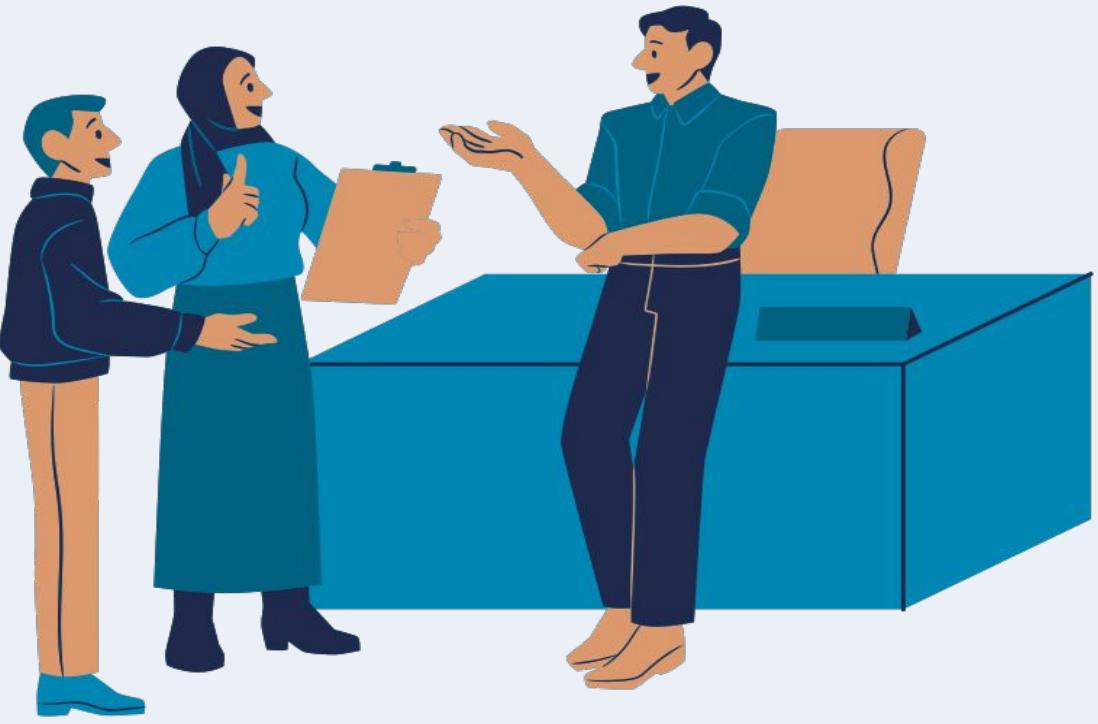
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Program Studi Teknik Informatika
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Today Talk

- **Sustainabilitas dalam Pembangunan**
- **Mengapa Memperhatikan Sustainabilitas?**
- **Praktisi Sustainabilitas**
- **Elemen Sustainabilitas**
- **Solusi Sustainabilitas**



Tujuan Perkuliahan

- Memahami apa yang dimaksud sustainabilitas dalam dunia IT/ICT dan green software
- Memahami pentingnya membangun perangkat lunak atau sistem IT yang “hijau”



1. Sustainabilitas

Sustainability

Meeting the needs of the present
without compromising the ability of
future generations to meet their own
needs

(United Nations)



Sustainabilitas dalam Pembangunan

Pembangunan yang memenuhi kebutuhan manusia tanpa membahayakan generasi yang akan datang.



Mengapa Memperhatikan Sustainabilitas?

Perkembangan teknologi memiliki dua sisi:

- Positif
 - Memudahkan, meningkatkan kualitas hidup manusia
- Negatif
 - Dampak pada lingkungan, masyarakat dan juga pribadi



We're an integral part of the solution.



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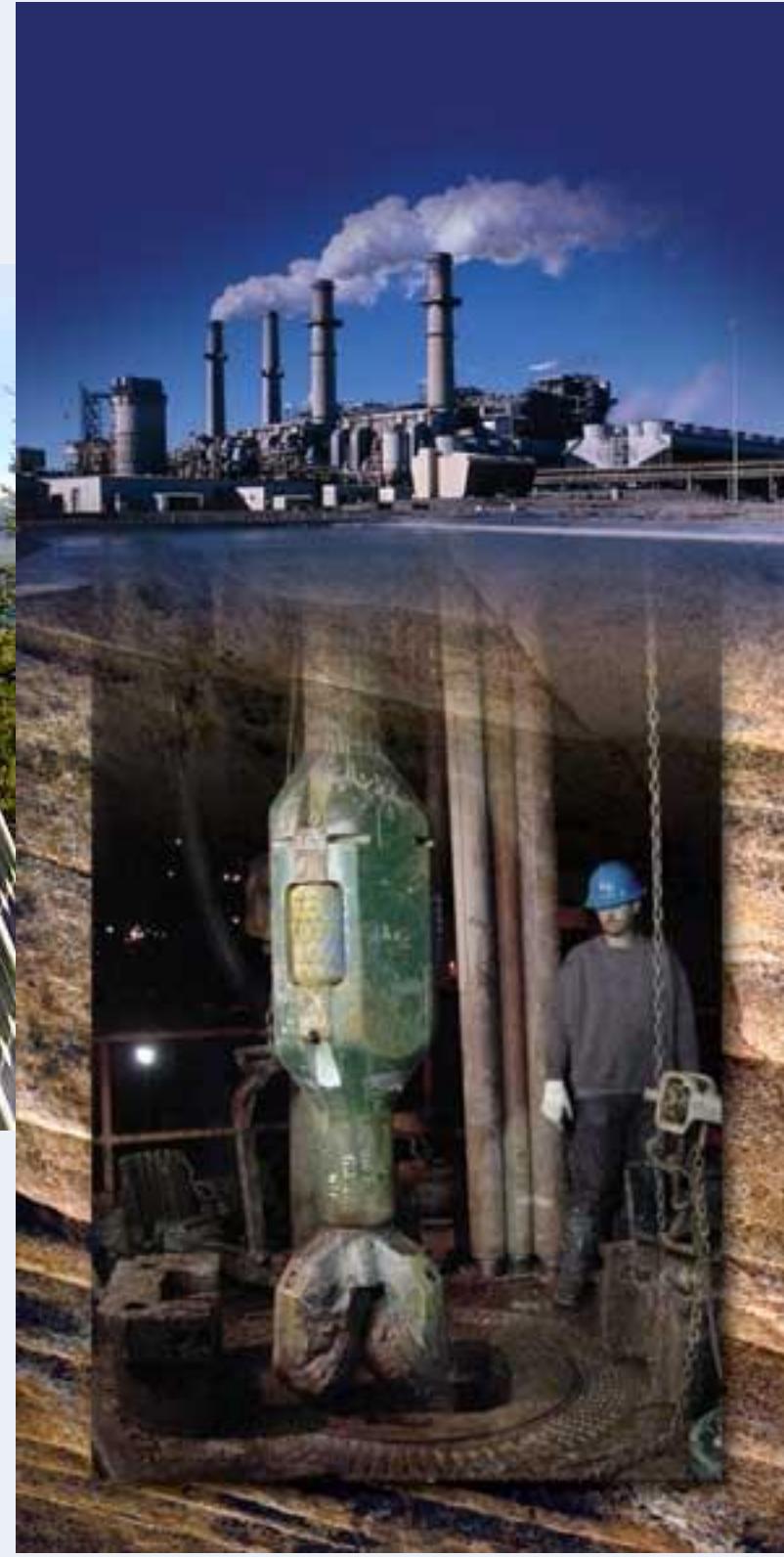


We're an integral part of the solution.



The new headquarters of Dubaitech in Dubai is set to be one of the world's largest green buildings. The LEED certified 22-story headquarters and laboratory buildings will be home to the center of excellence for biotechnology education and research, with two connected buildings oriented to maximize day-lighting and views while minimizing solar gain. It will also integrate a 500,000 sq ft animal reserve for indigenous conservation and wildlife protection. The design comes from design firm [CUH2A](#), and is scheduled for completion in 2009.

We're an integral part of the solution.



But engineers are also part of the problem



But engineers are also part of the problem



Praktisi Sustainabilitas

Selalu memperhatikan dampak dari setiap keputusan yang diambil terhadap lingkungan sosial dan budaya

- pemilihan kebijakan organisasi
- tindakan ekonomi
- konsumsi energi
- dll



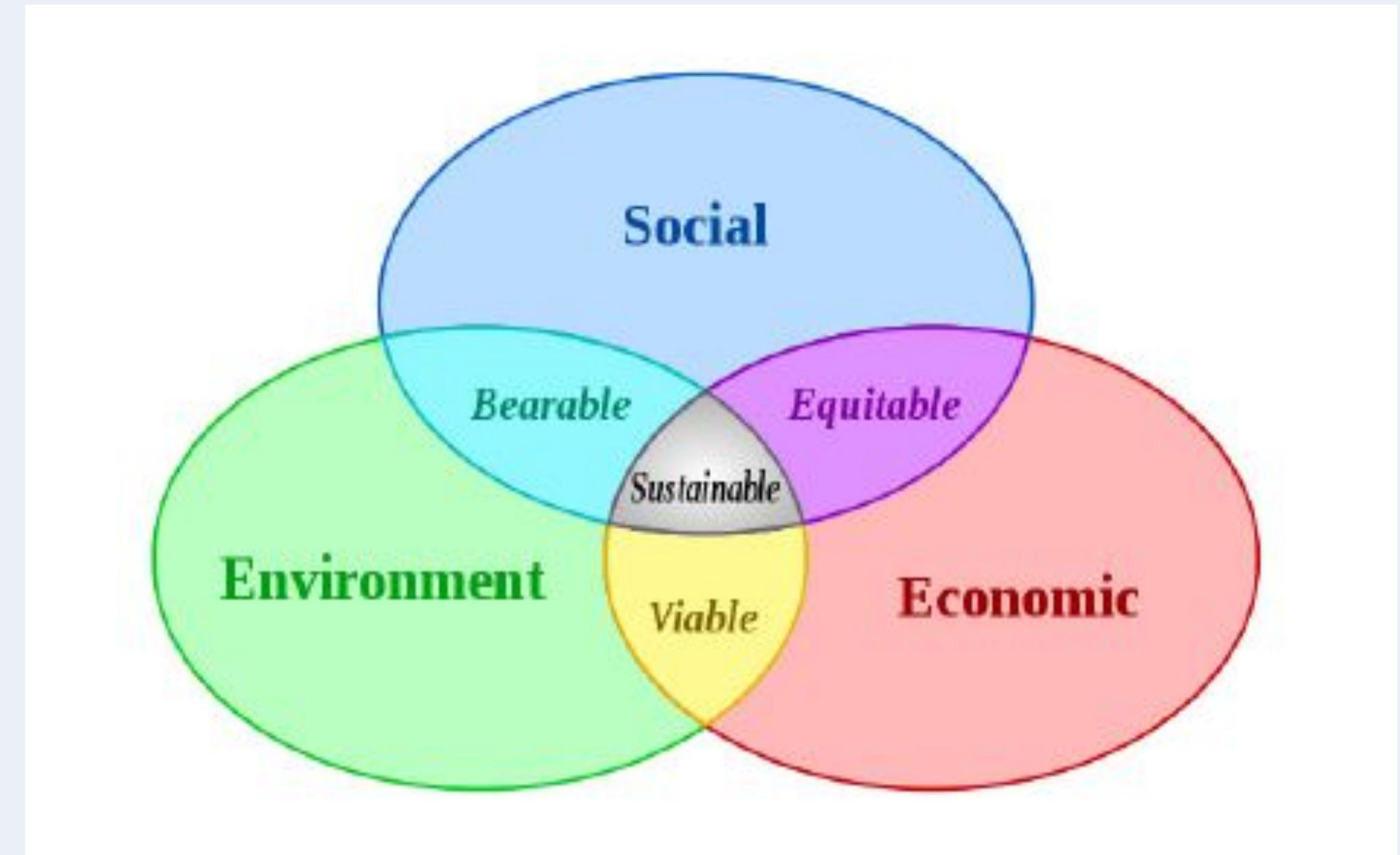
Elemen Sustainabilitas



World Commission on Environment and Development, 1987

Triple P concept (People, Planet, Profit)

- **People:** Fair practices for all people and does not exploit interest of separate parties based on money, status or growth.
- **Planet:** Management of renewable and non renewable resources while reducing waste.
- **Profit:** Financial benefit enjoyed by the majority of society.



Economic Sustainability	Return on Investment	- Direct financial benefits - Net Present Value
	Business Agility	- Flexibility / Optionality in the project - Increased business flexibility
Environmental Sustainability	Transport	- Local procurement - Digital communication - Traveling - Transport
	Energy	- Energy used - Emission / CO2 from energy used
	Waste	- Recycling - Disposal
	Materials and resources	- Reusability - Incorporated energy - Waste
Social Sustainability	Labor Practices and Decent Work	- Employment - Labor / Management relations - Health and Safety - Training and Education - Organizational learning - Diversity and Equal opportunity
	Human Rights	- Non-discrimination - Freedom of association - Child labor - Forced and compulsory labor
	Society and Customers	- Community support - Public policy / Compliance - Customer health and safety - Products and services labeling - Market communication and Advertising - Customer privacy
	Ethical behavior	- Investment and Procurement practices - Bribery and corruption - Anti-competition behavior

Solusi Sustainabilitas

- Penggunaan material yang dapat didaur ulang
 - Pola hidup: 3 R (Reuse, Reduce, Recycle)
- Penggunaan energi yang aman dan reliable
- Konservasi dan penggunaan energi yang dapat diperbarui.
- Pola hidup sehat
- Komunikasi dan koordinasi yang efektif
- Pengembangan intelektual dan spiritual.
- Memperhatikan dampak global dari setiap aksi yang dilakukan



Traditional Engineering Design Criteria:

- Function
- Cost
- Safety

Sustainable Engineering Design Criteria:

- Traditional engineering criteria plus:
 - Impact on people (society)
 - Impact on the planet (environment)
- ...

2. Sustainabilitas di Dunia IT/ICT



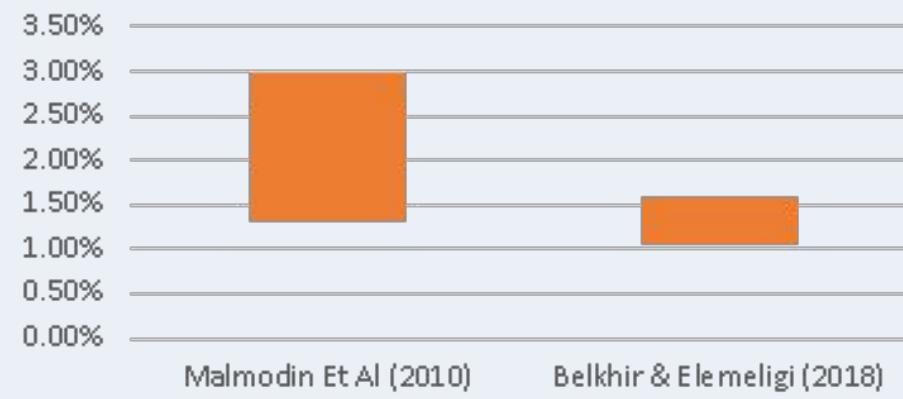
Permasalahan

- Sektor ICT menyumbang:
 - sekitar 2% emisi global karbondioksida dan meningkat terus
 - sekitar 8% penggunaan listrik Uni Eropa
- Konsumsi listrik sektor ICT meningkat hampir 60% dari tahun 2007 ke tahun 2020

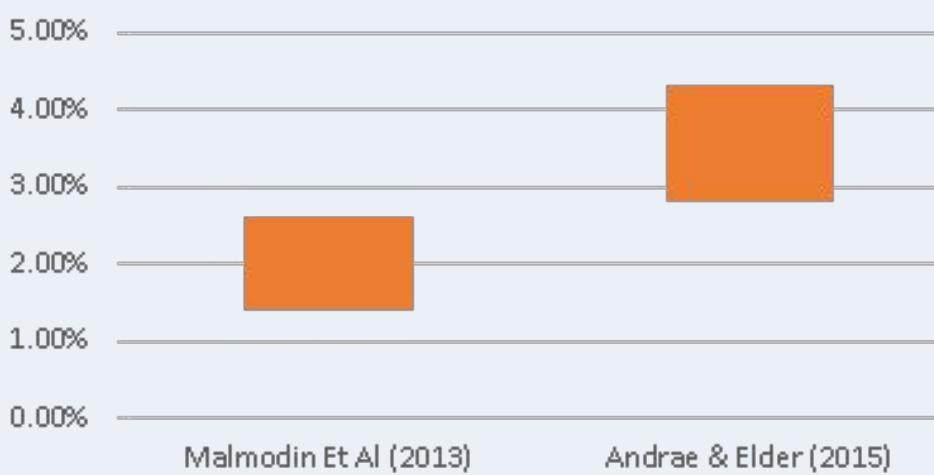


Global GHG emissions in ICT sector

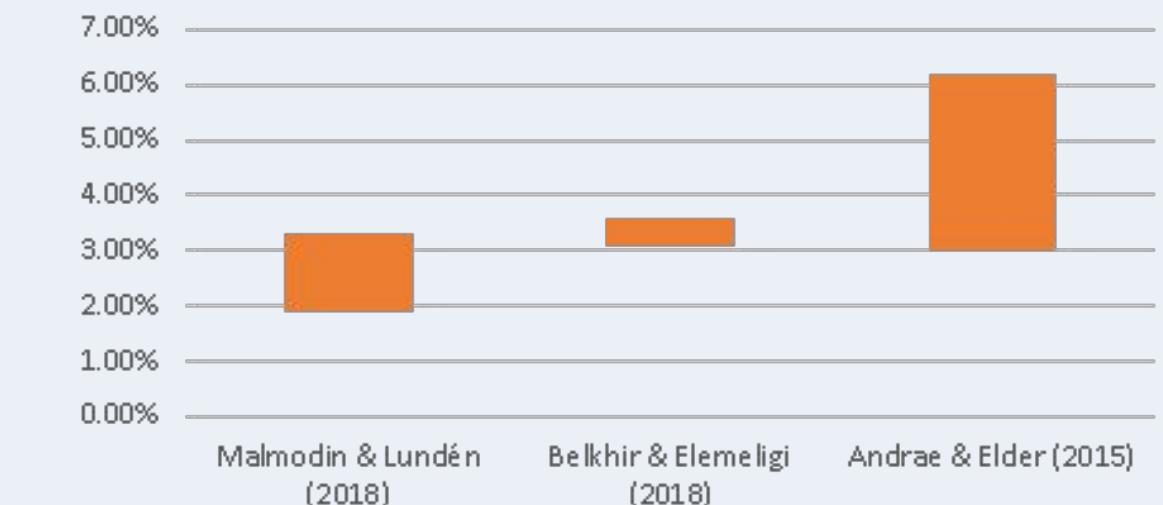
2007 ICT's share off global GHG emissions



2015 ICT's share off global GHG emissions



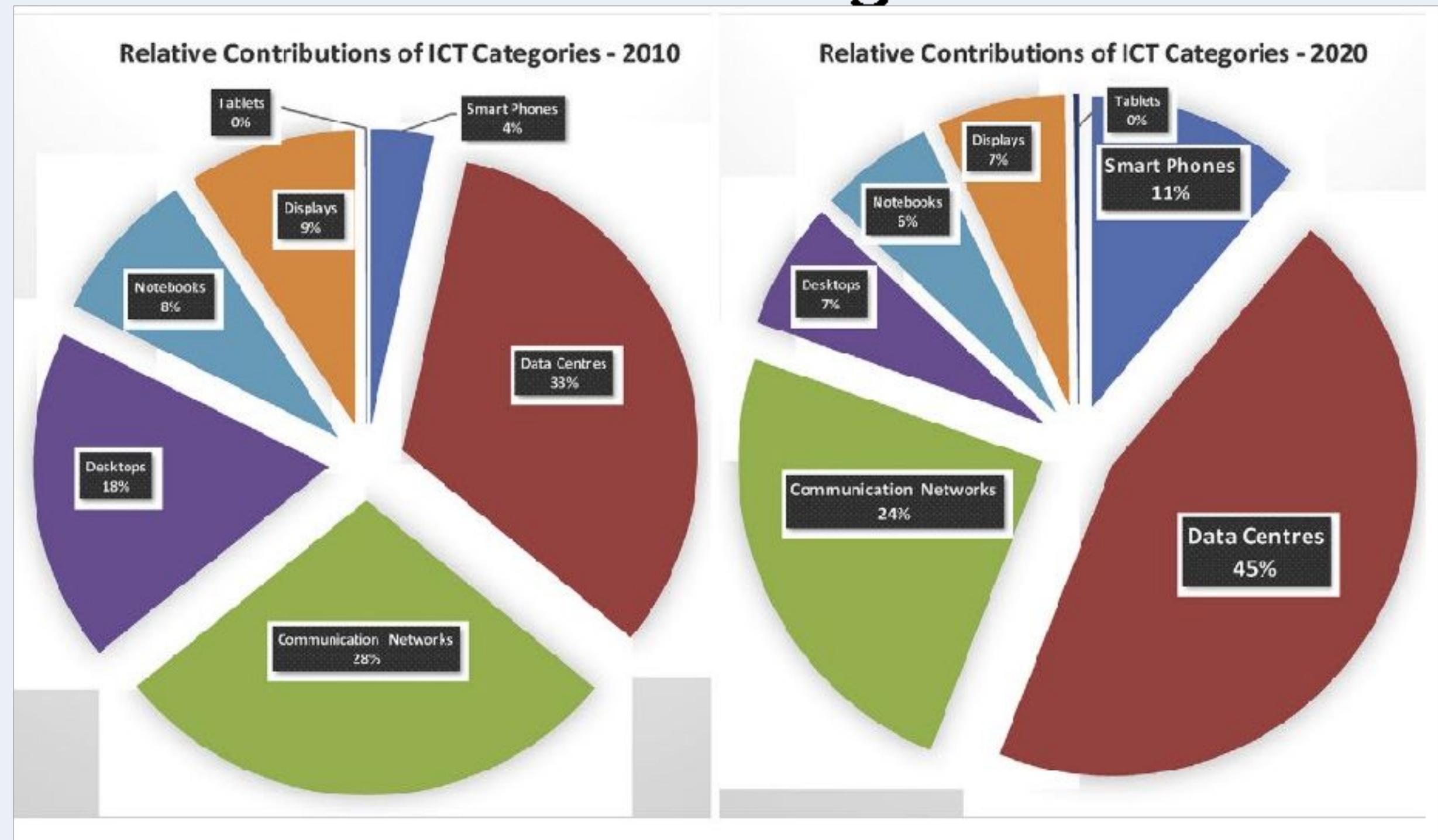
2020 ICT's share off global GHG emissions



ICT's share off global GHG emissions



Relative contribution of ICT categories



Source: Belkhir and Elmeliqi
(2018)

Motivasi

- Konsumsi energi oleh data centre di dunia naik dari 58 TW di thn 2000 ke 205 TW di 2018 (1-2 % konsumsi listrik dunia)
 - Energi dunia: batu bara 41%; gas alam 22%; nuklir 11 %; air 16%,...
- Konsumsi oleh pemanfaatan internet bertambah dari 8 % (2014) menjadi 10 % (2019) dari penggunaan listrik dunia (Swedish KTH)

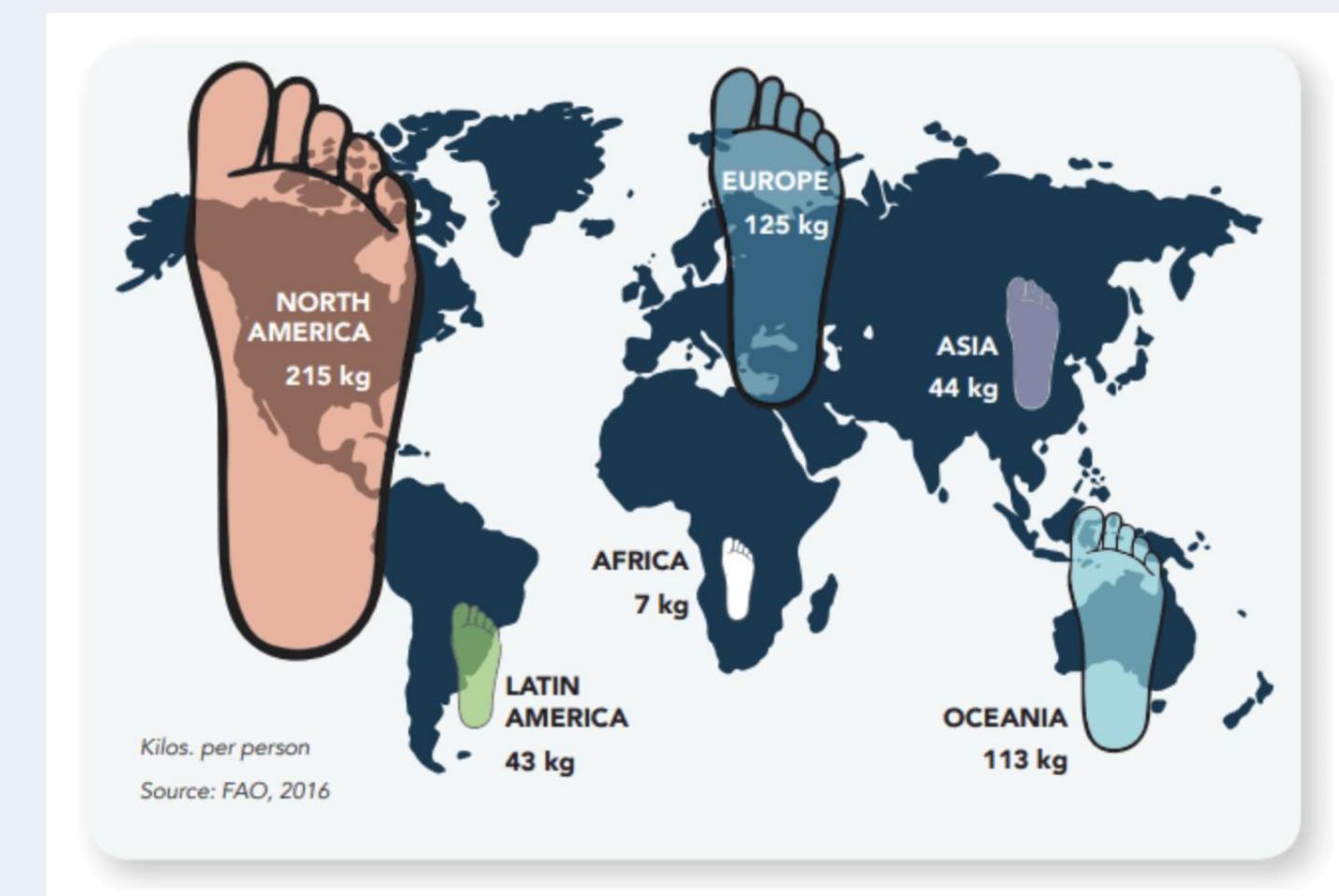
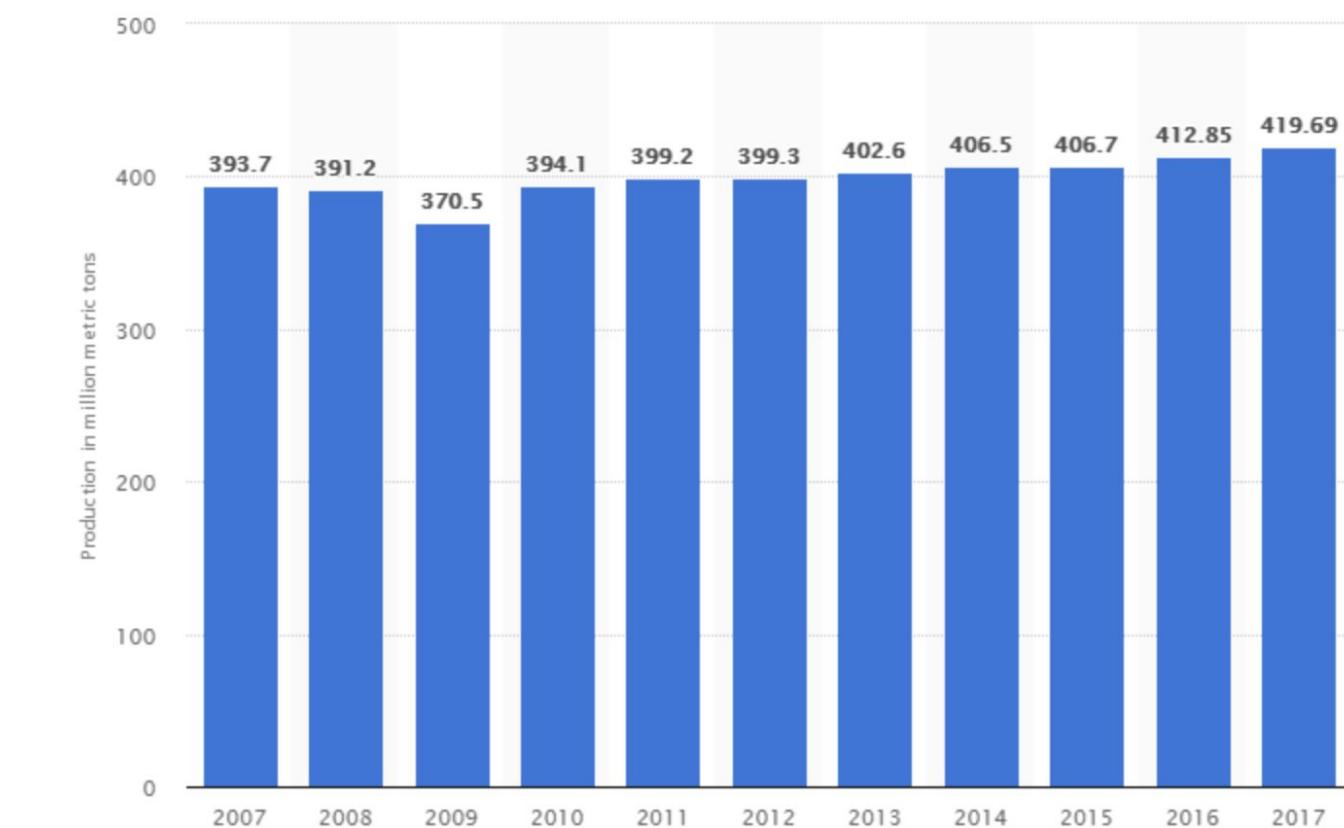


Motivasi

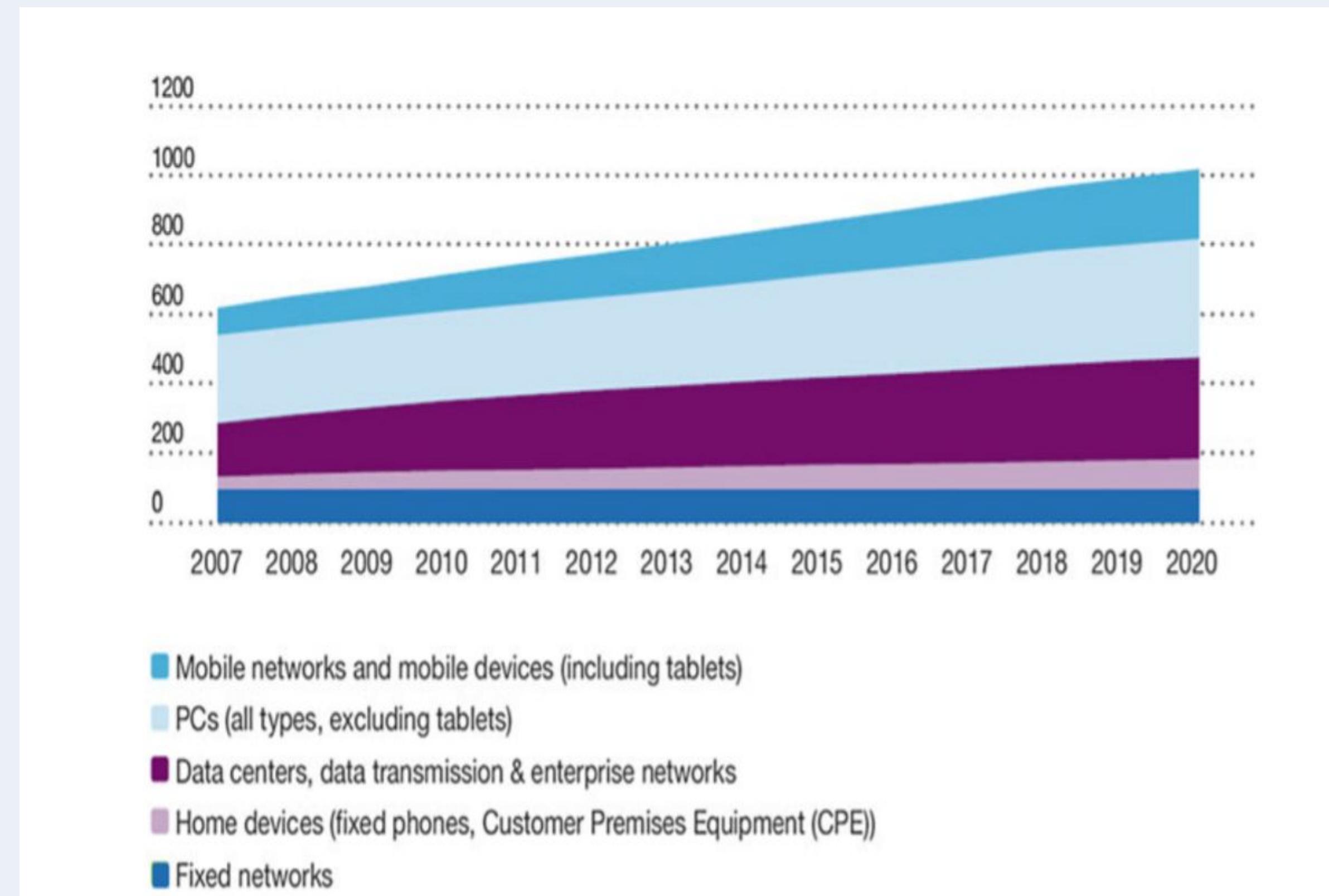
Paperless Society is a myth

- Satu pohon untuk +/- 8000 lembar kertas
- 24 pohon untuk satu 1 ton kertas
- Setahun 10 miliar pohon => 200 ribu km² hutan
- Amazon 5,5 juta km² hutan

Global Paper and Cardboard Production Volumes 2007 - 2017 (in million metric tons)



Emisi Karbondioksida Sektor ICT



Emisi Karbondioksida Pembangunan Model AI

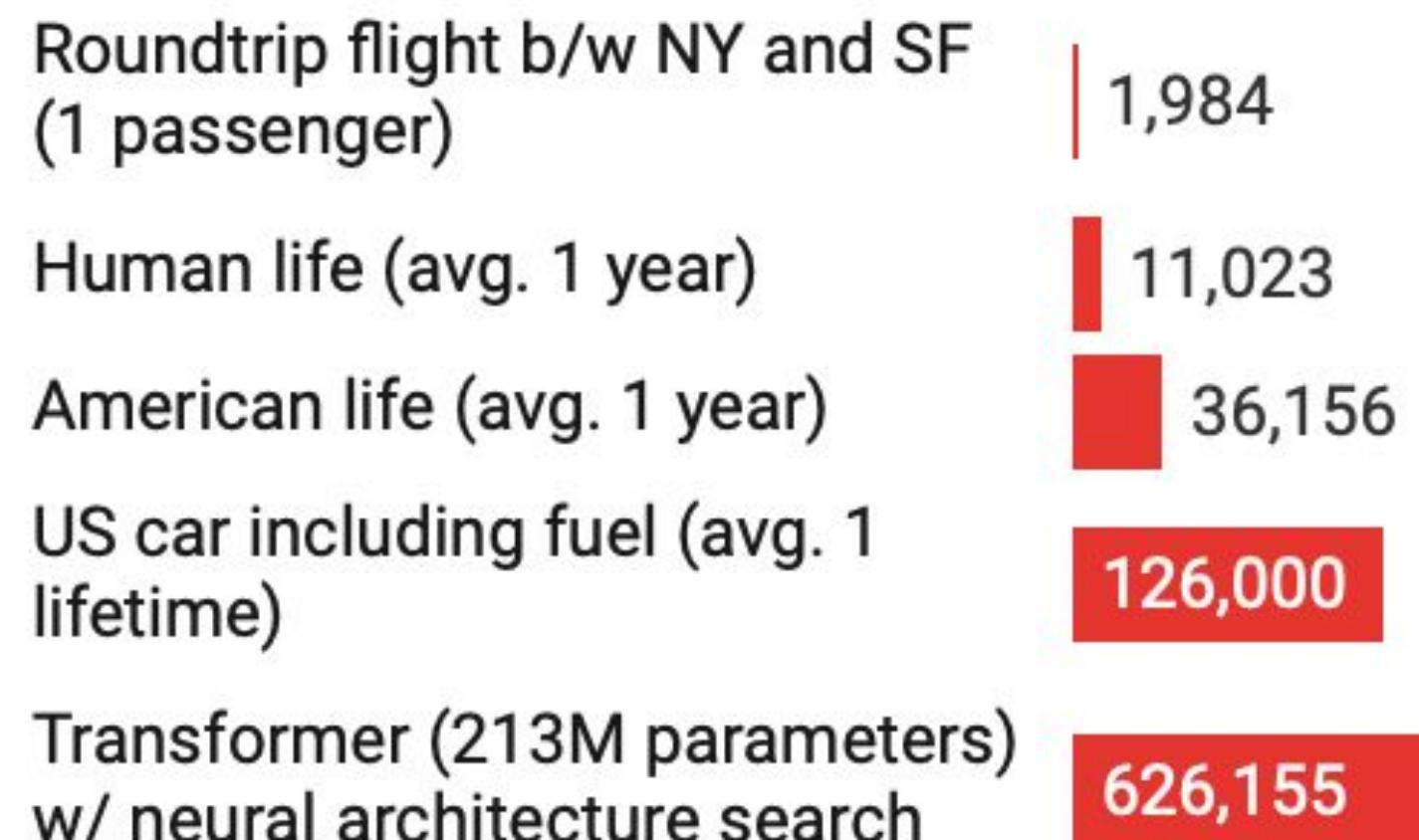


Date of original paper	▲ Energy consumption (kWh)	Carbon footprint (lbs of CO2e)	Cloud compute cost (USD)	
Transformer (65M parameters)	Jun, 2017	27	26	\$41-\$140
Transformer (213M parameters)	Jun, 2017	201	192	\$289-\$981
ELMo	Feb, 2018	275	262	\$433-\$1,472
BERT (110M parameters)	Oct, 2018	1,507	1,438	\$3,751-\$12,571
Transformer (213M parameters) w/ neural architecture search	Jan, 2019	656,347	626,155	\$942,973-\$3,201,722
GPT-2	Feb, 2019	-	- \$12,902-\$43,008	

Emisi Karbondioksida Pembangunan Model AI

Common carbon footprint benchmarks

in lbs of CO₂ equivalent



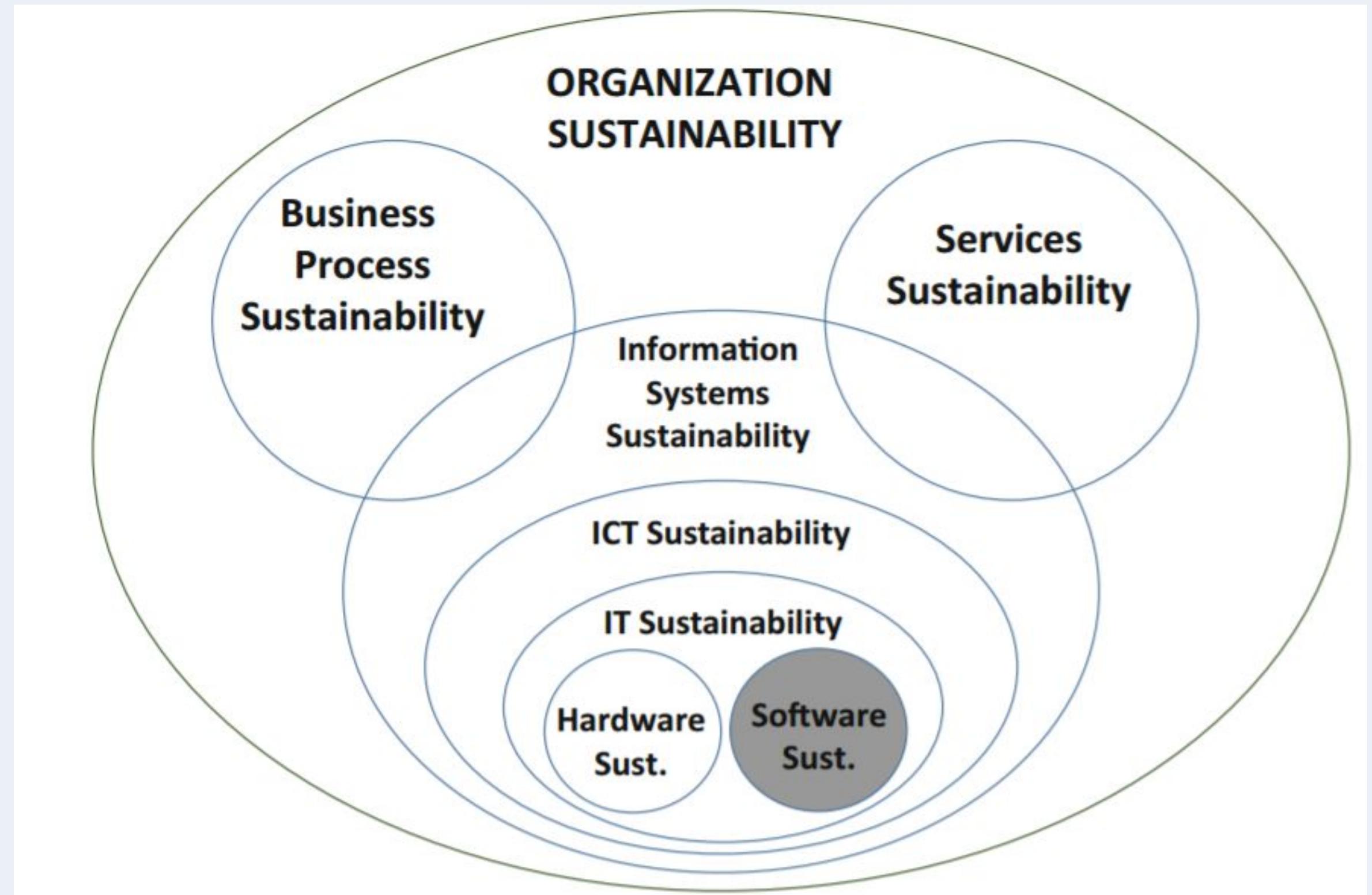
Trend Sustainabilitas di Sektor IT

- Sustainability menjadi semakin penting
 - Sebuah bisnis yang gagal dalam pembangunan berkelanjutan (sustainabilitas) banyak menerima kritik publik dan kehilangan legitimasi pasar
- Menurut survei IBM global (2008):
 - 47% organisasi di bidang ICT mulai menerapkan konsep “strategic sustainability” yaitu mempertimbangkan:
 - Keberlanjutan
 - Menjadikan pembangunan s/w berkelanjutan sebagai sumber baru inovasi
 - Pemotongan biaya
 - Keberlanjutan sebagai keunggulan kompetitif.

Terminologi dan Lingkup

Sustainability in IT (Green or Greening ICT/IT/Software):

The initiatives that foster respect for the environment by means of ICT, IT, software, etc.



IS Sustainability

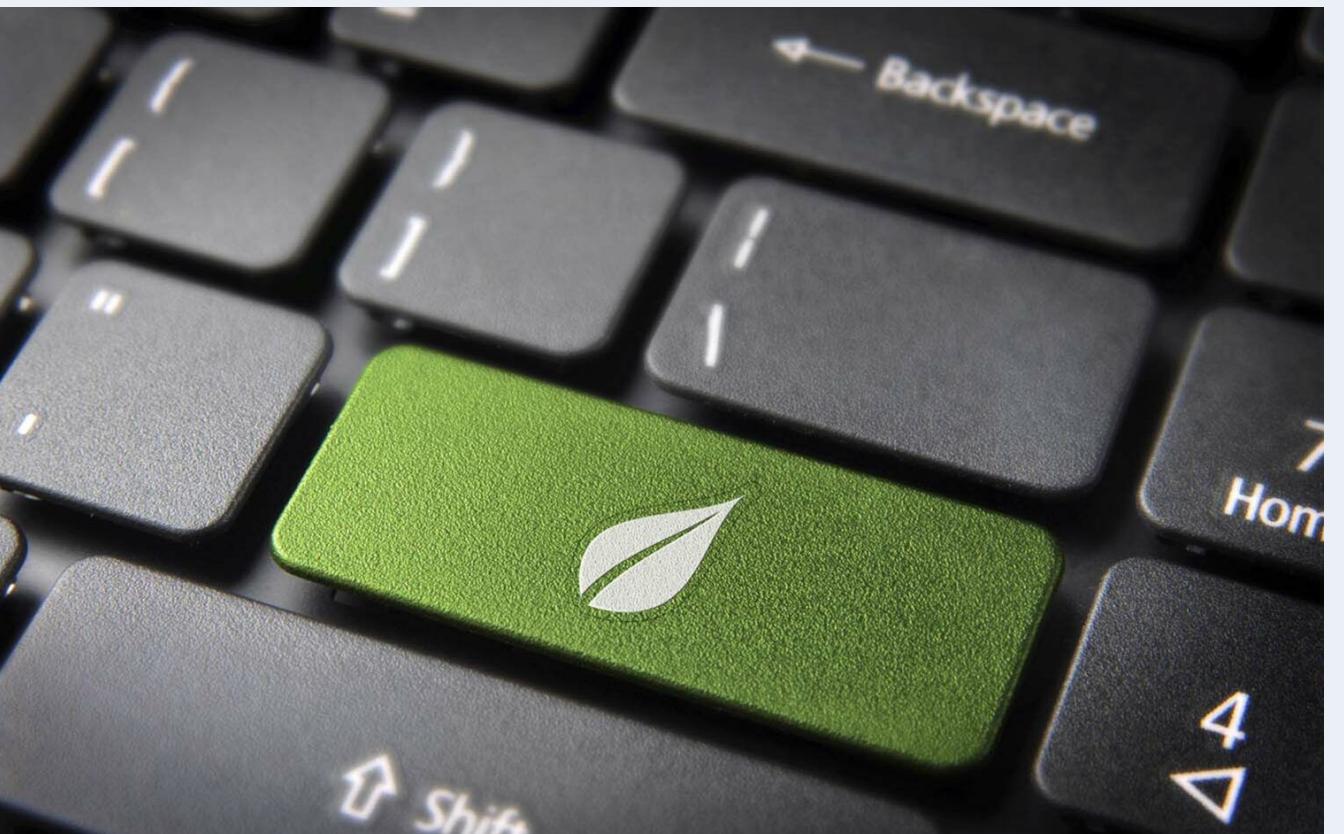
Must take into account aspects such as:

- efficiency systems
- forecasting
- reporting and awareness
- energy-efficient home computing
- behaviour modification



ICT/IT Sustainability

- Aligning all ICT processes and practices with the core principles of sustainability, which are to *reduce, reuse and recycle*
- Finding innovative ways to use ICT in business processes to deliver sustainability benefits across the enterprise and beyond



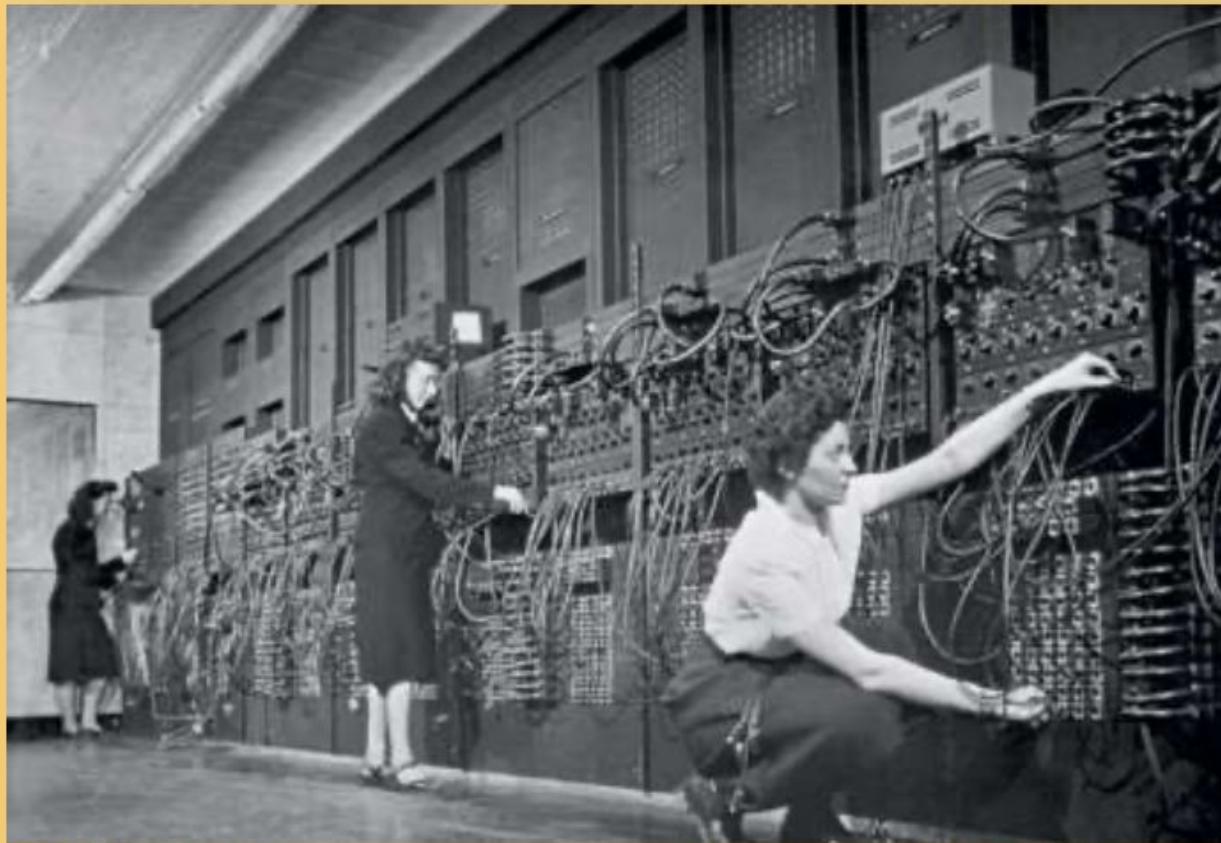
Smart and Sustainable



9.7 billion connected things being used by 2020
Software as glue, and transformational power

Source: 盧柏宇, Wikimedia Commons
An artist's illustration of a smart city

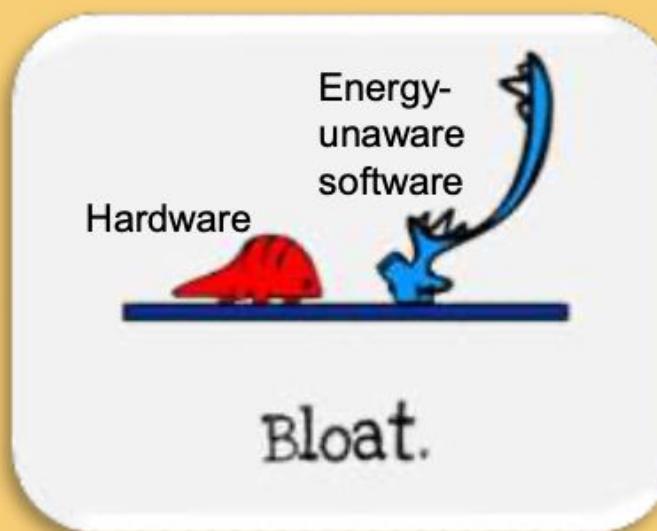
The software industry and *unsustainability*



ENIAC Programmers Project (1946)
Photo: Corbis



Steve Jobs unveils the iPhone (2007)
Photo: Wikimedia Commons



Hardware optimizations are negated by
software inefficiencies [cf. Wirth's Law]



Potential 87% energy savings with cloud
migration of legacy software [Berkeley Labs]



“Software is eating the world”. Marc Andreessen, 2011

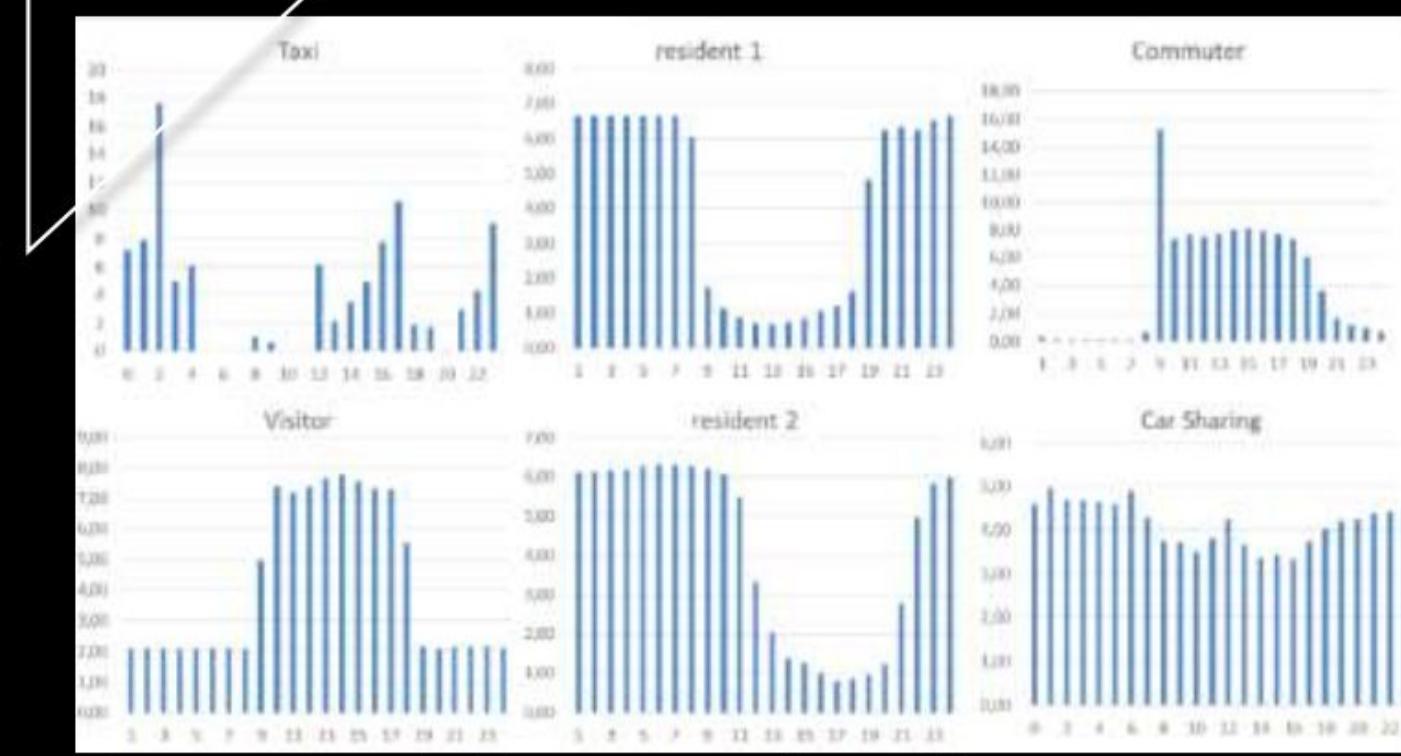
Quality of Service



User-centric



Software technical challenges



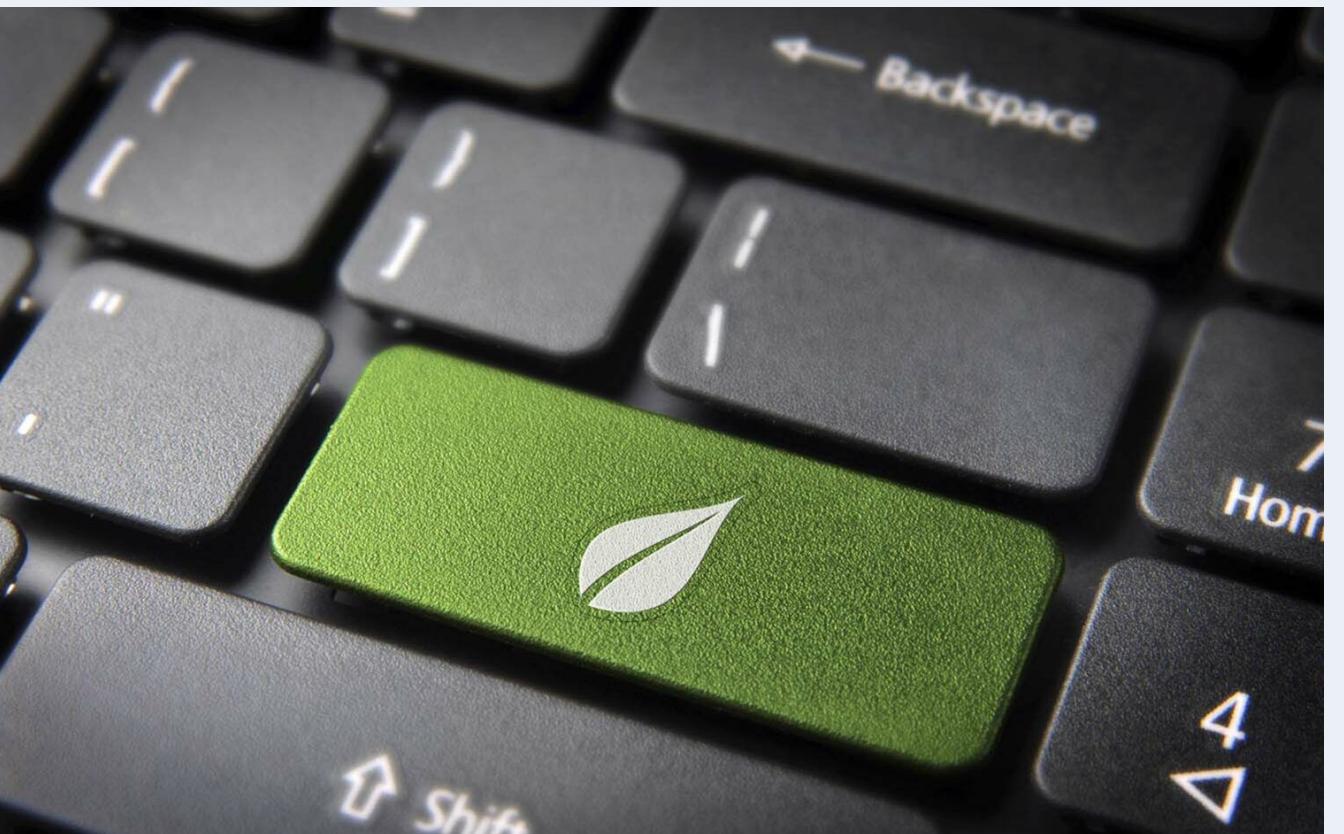
Source: Nanda Piersma et al., 2015

Lasting

Elastic

Software Sustainability

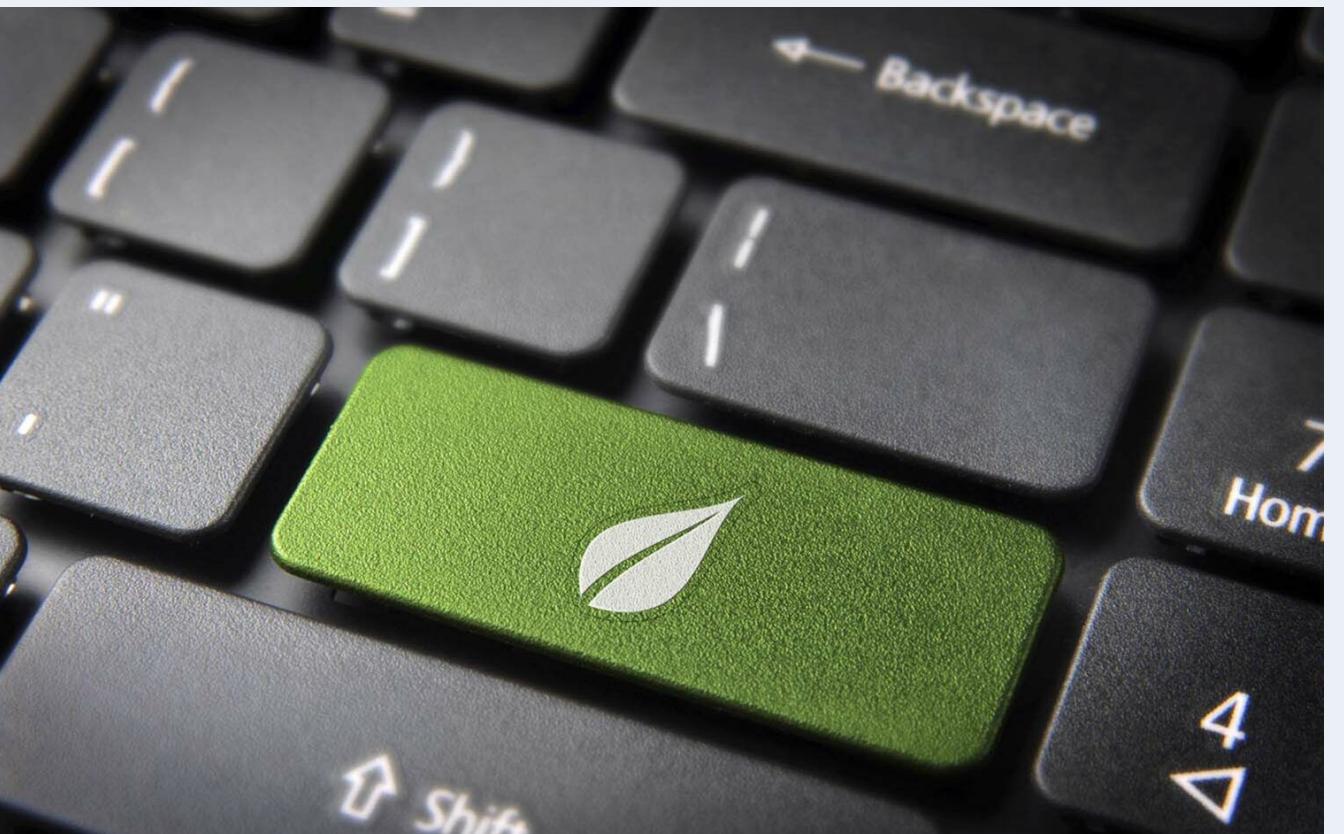
- Development and production processes cyclically evaluate and minimize their direct and indirect consumption of natural resources and energy.
- Direct and indirect consumption of natural resources, which arise out of deployment and utilization, are monitored, continuously measured, evaluated and optimized.



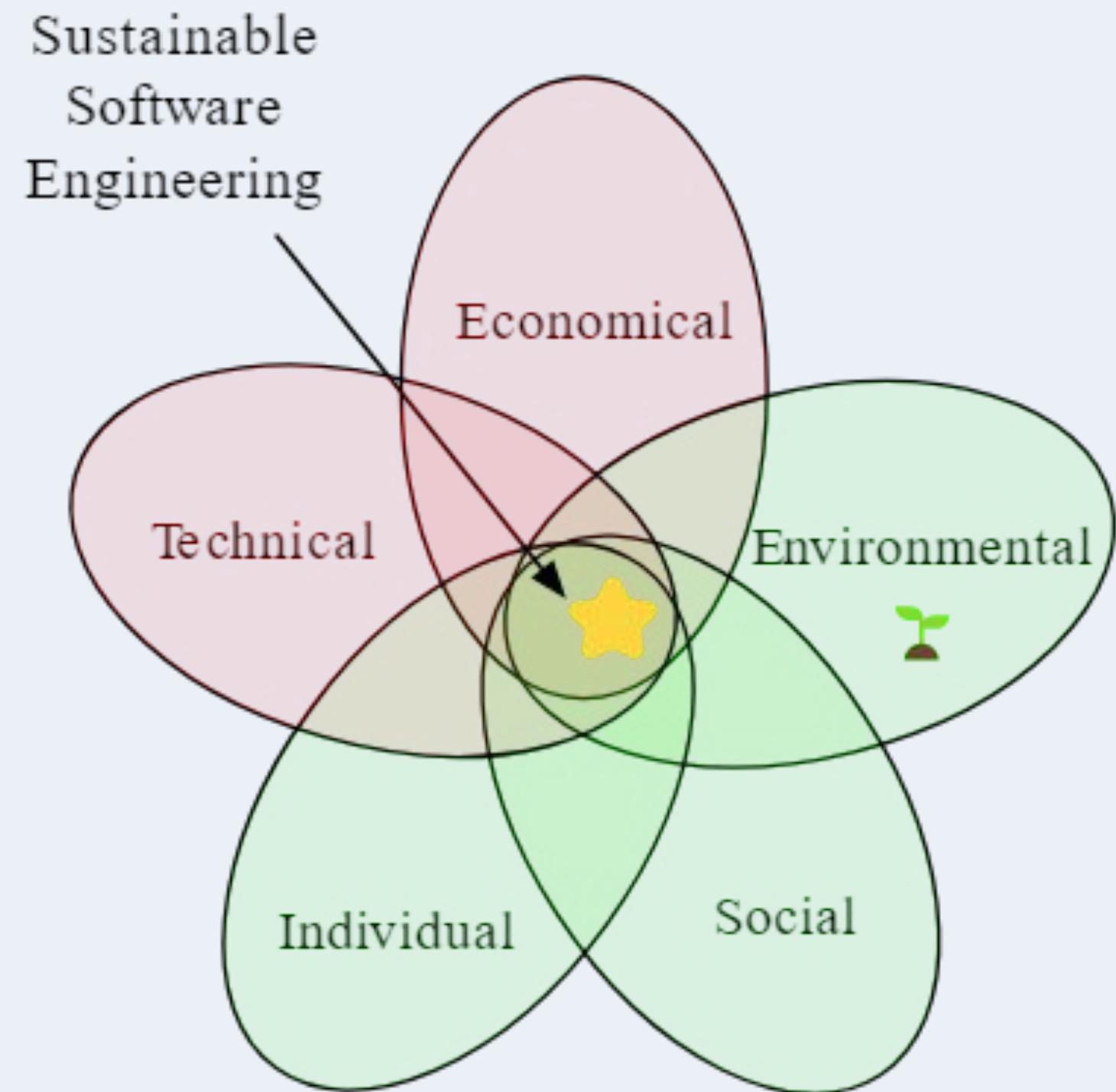
Software Engineering Sustainability

Sustainable software engineering aims to create:

- reliable
- long-lasting software that meets the needs of users
- while reducing environmental impacts



5 Dimensions of sustainability in SE



1. Individual sustainability

- Maintenance of the private good of individual human capital:
 - Health
 - education
 - skills
 - knowledge
 - leadership
 - and access to services constitute human capital
- ‘How can software be created and maintained in a way that enables developers to be satisfied with their job over a long period of time?’



2. Social Sustainability

- Maintaining social capital (investments and services) and preserving the solidarity of societal communities.
- ‘What effects do software systems have on society (e.g. communication, interaction, government)?’



3. Economic Sustainability

- This aims to maintain assets.
- Assets include not only capital but also added value.
- ‘How can software systems be created so that the stakeholders’ long-term investments are as safe as possible from economic risks?’



4. Environmental Sustainability

- This seeks to improve human welfare by protecting natural resources such as water, land, air, minerals and ecosystem services;
- Environment includes:
 - the sources of raw materials used for human needs
 - sink capacities recycling human wastes
- ‘How does software affect the environment during, inter alia, development and maintenance?’



5. Technical Sustainability

- Technical sustainability has the central objective of:
 - long-time usage of systems
 - their adequate evolution with changing surrounding conditions and respective requirements
- How can software be created so that it can easily adapt to future change?



Figure 1. Framework for sustainability software-quality requirements.

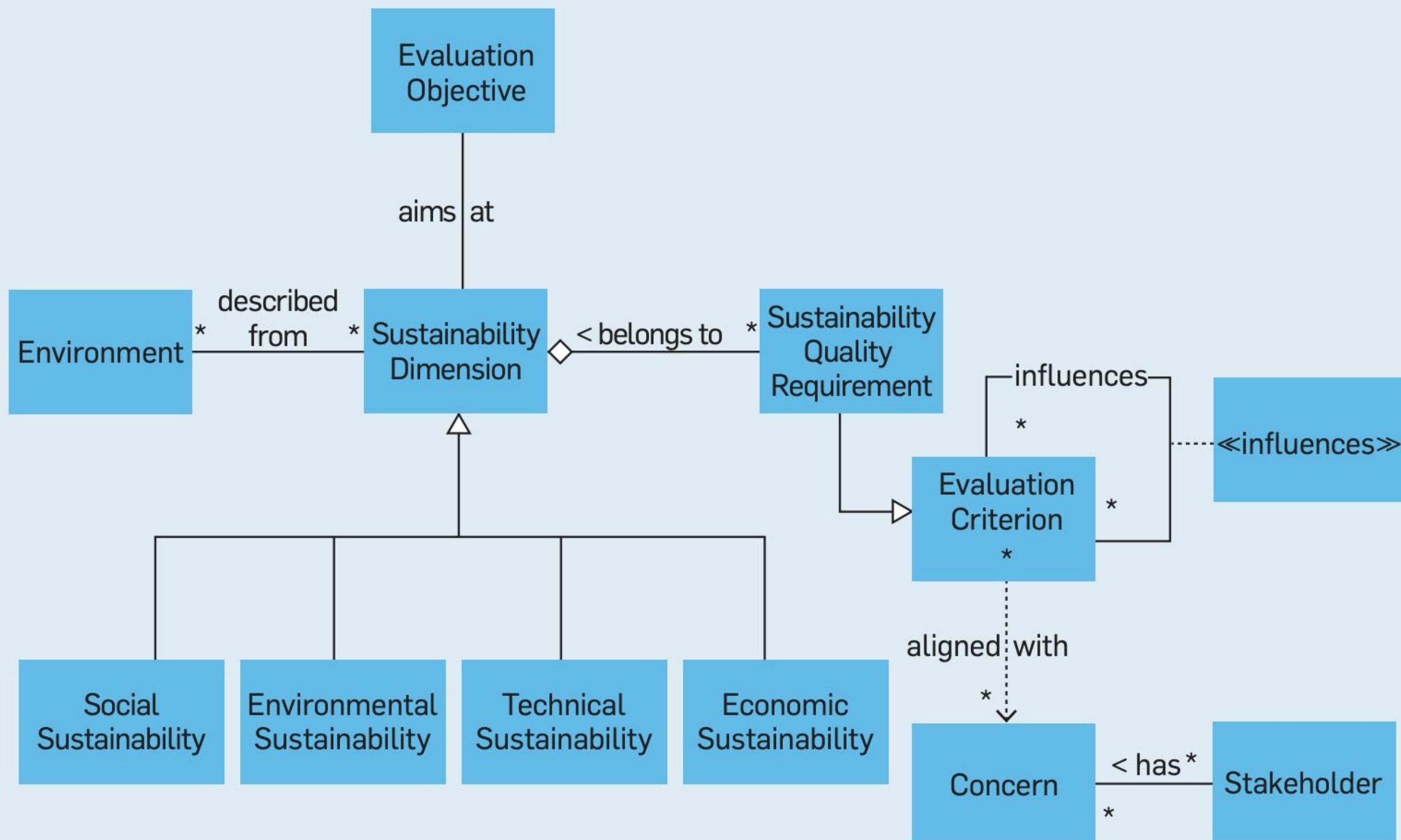


Figure 2. Sustainability quality requirements: Paper-mill control system.

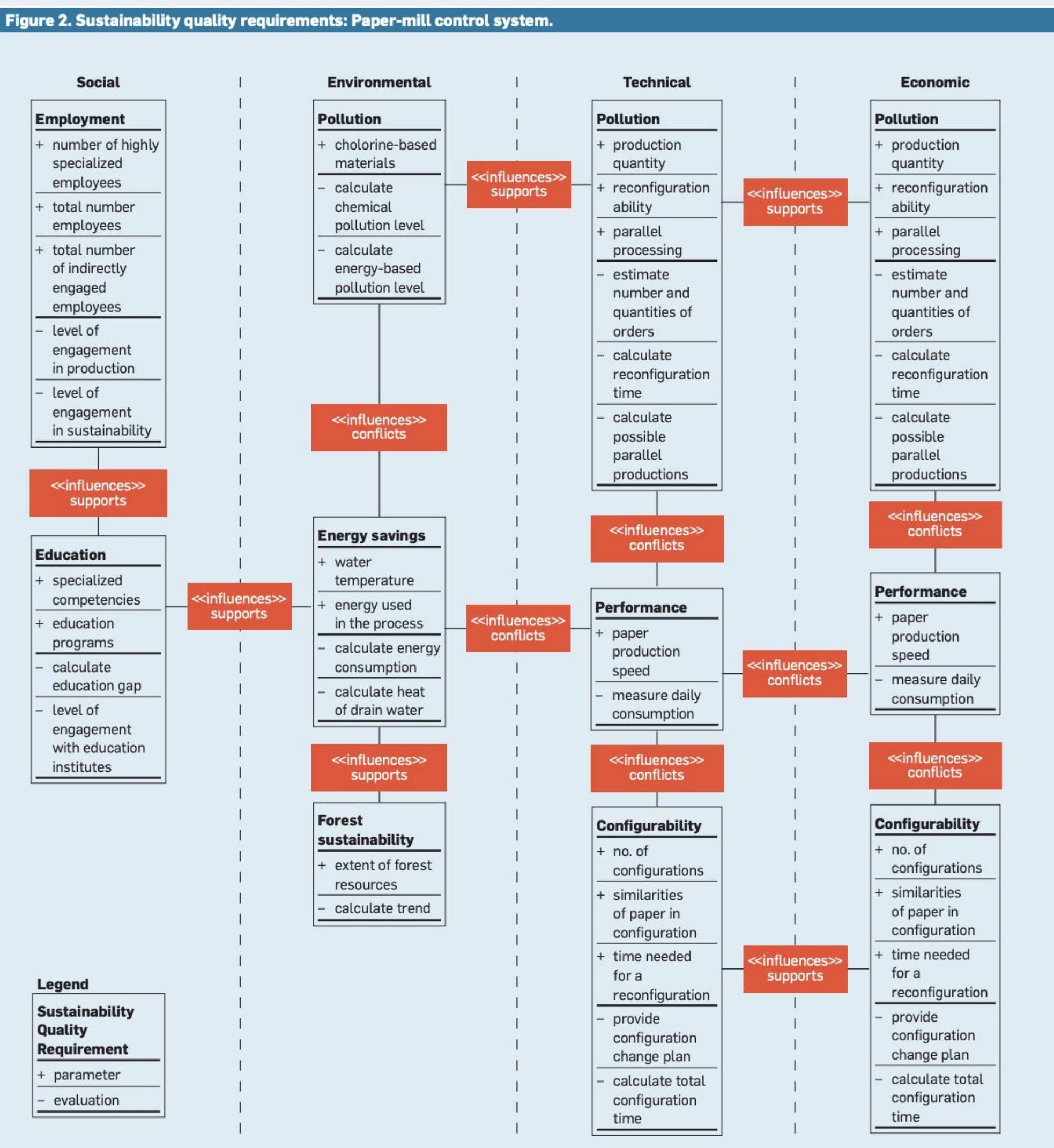
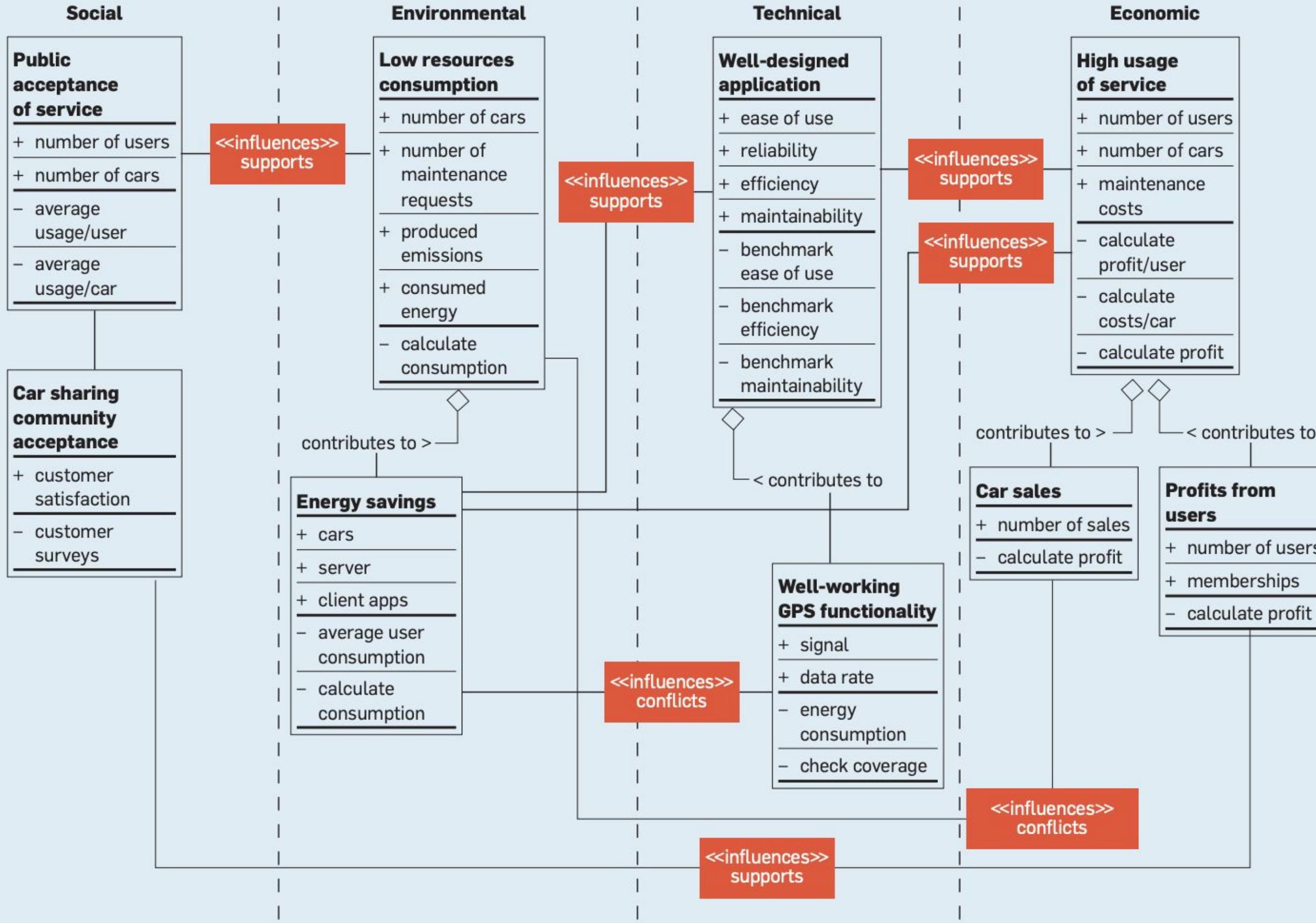


Figure 3. Sustainability quality requirements: car-sharing platform.





Software architecture provides a bird's eye view to address the effects on the four dimensions of sustainability.

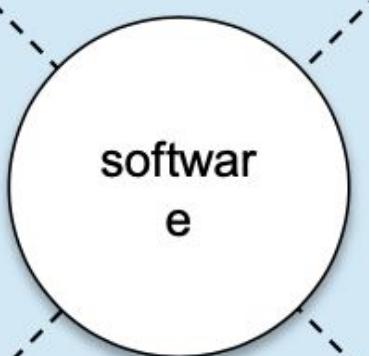


Photo: adapted from Anonymous

TECHNICAL

ENVIRONMENTAL

ECONOMIC



software

IMMEDIATE IMPACT

ENABLING IMPACT

SYSTEMIC IMPACT

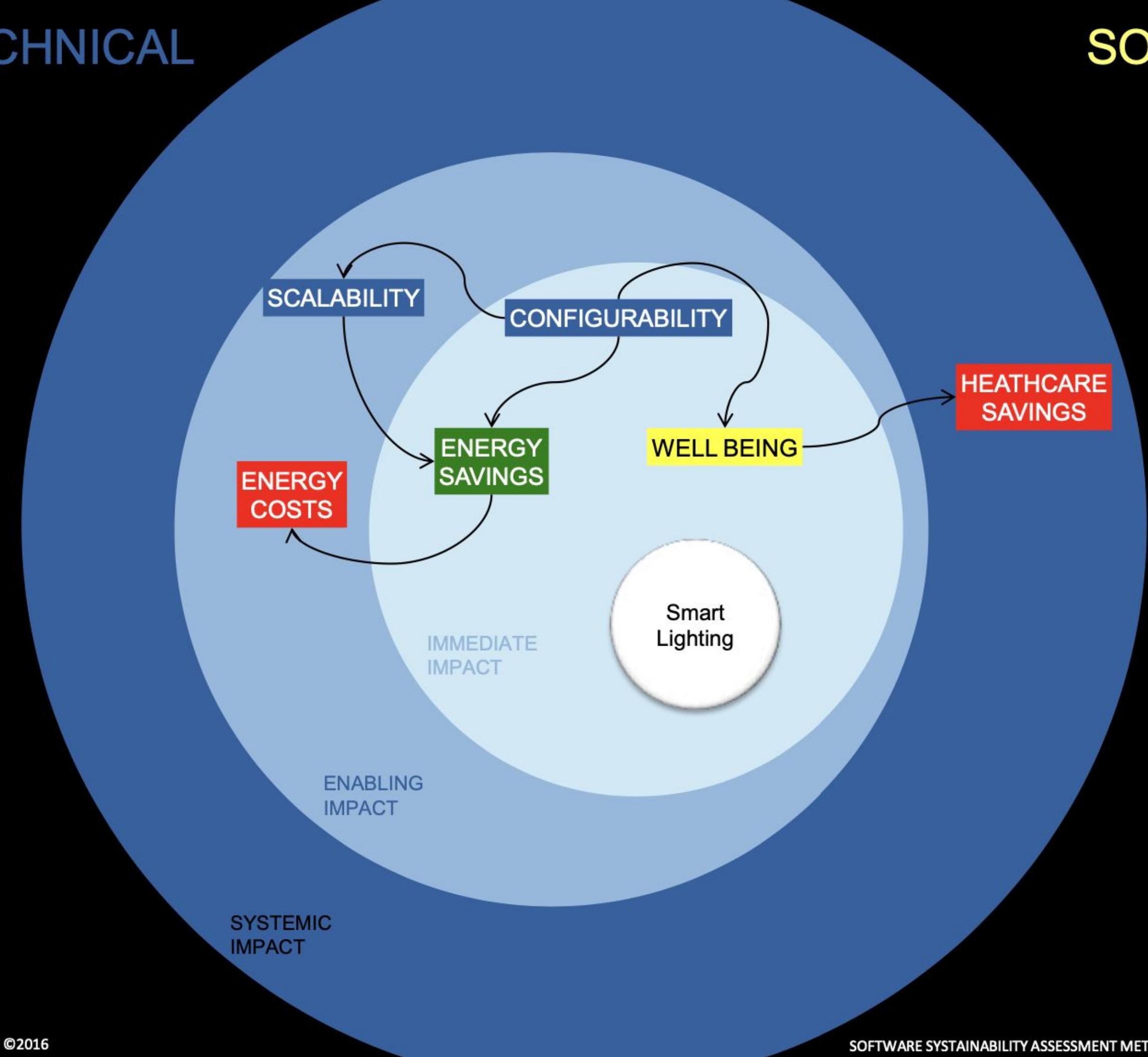
SOCIAL

TECHNICAL

SOCIAL

ENVIRONMENTAL

ECONOMIC

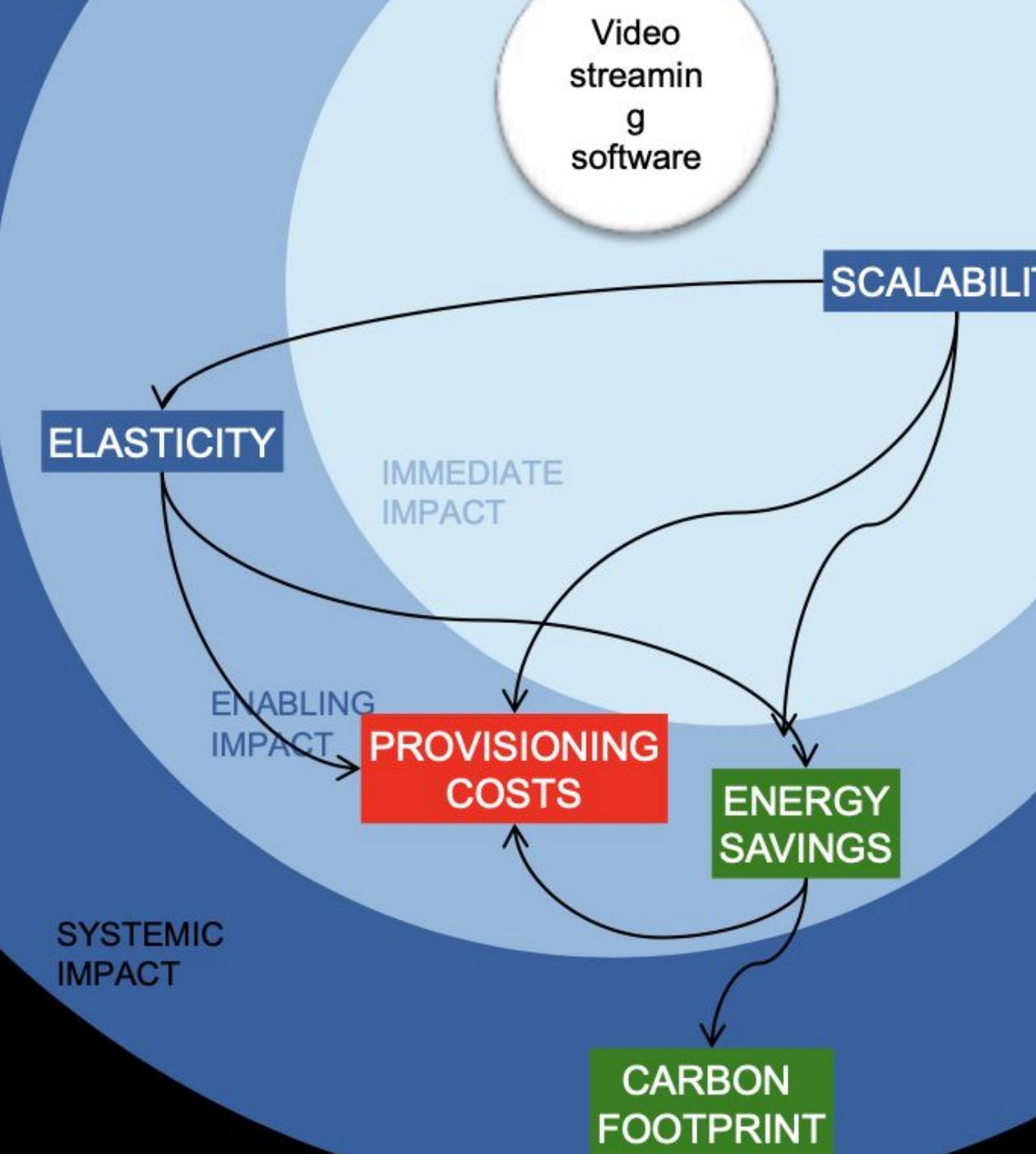


ENVIRONMENTAL

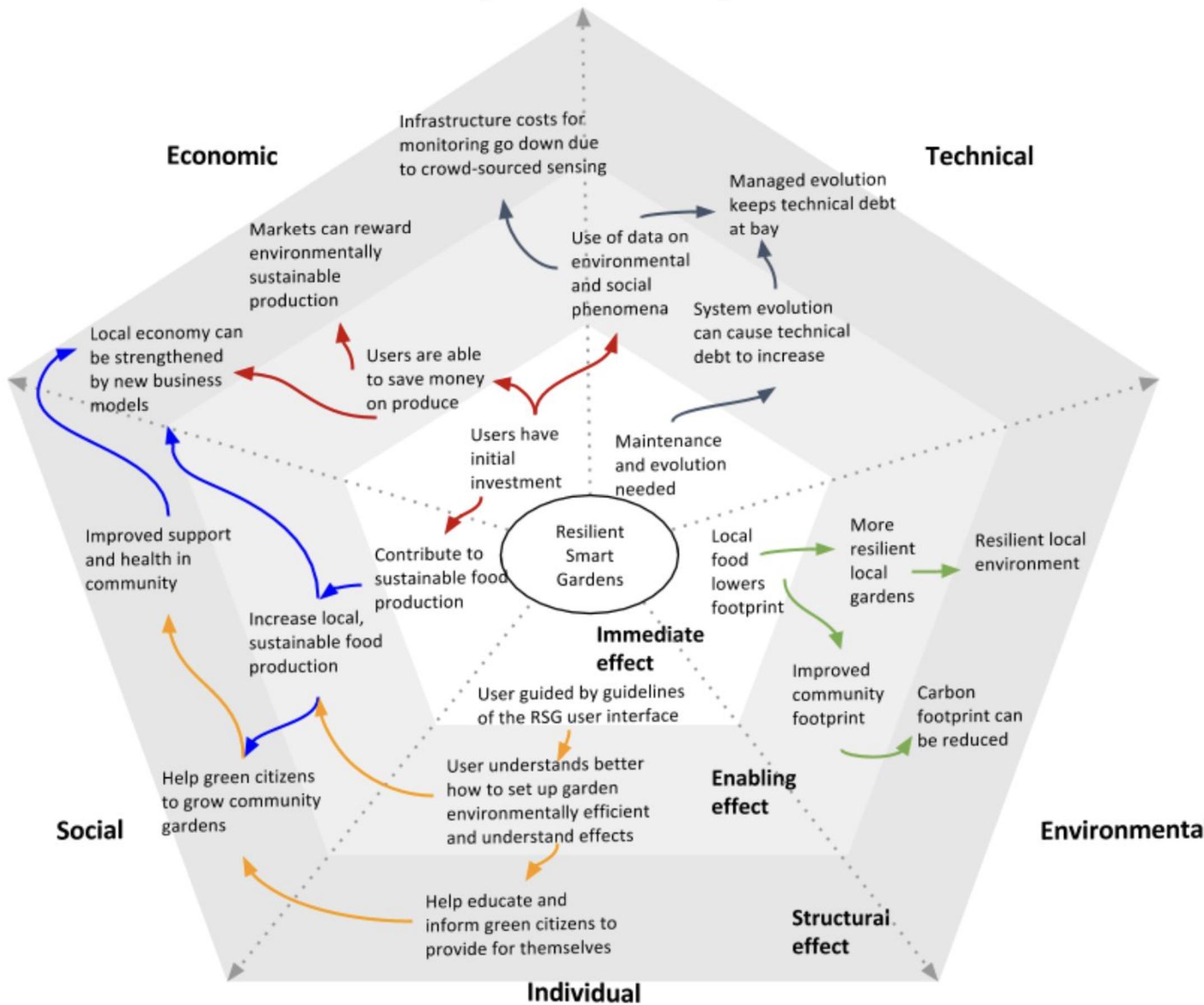
TECHNICAL

SOCIAL

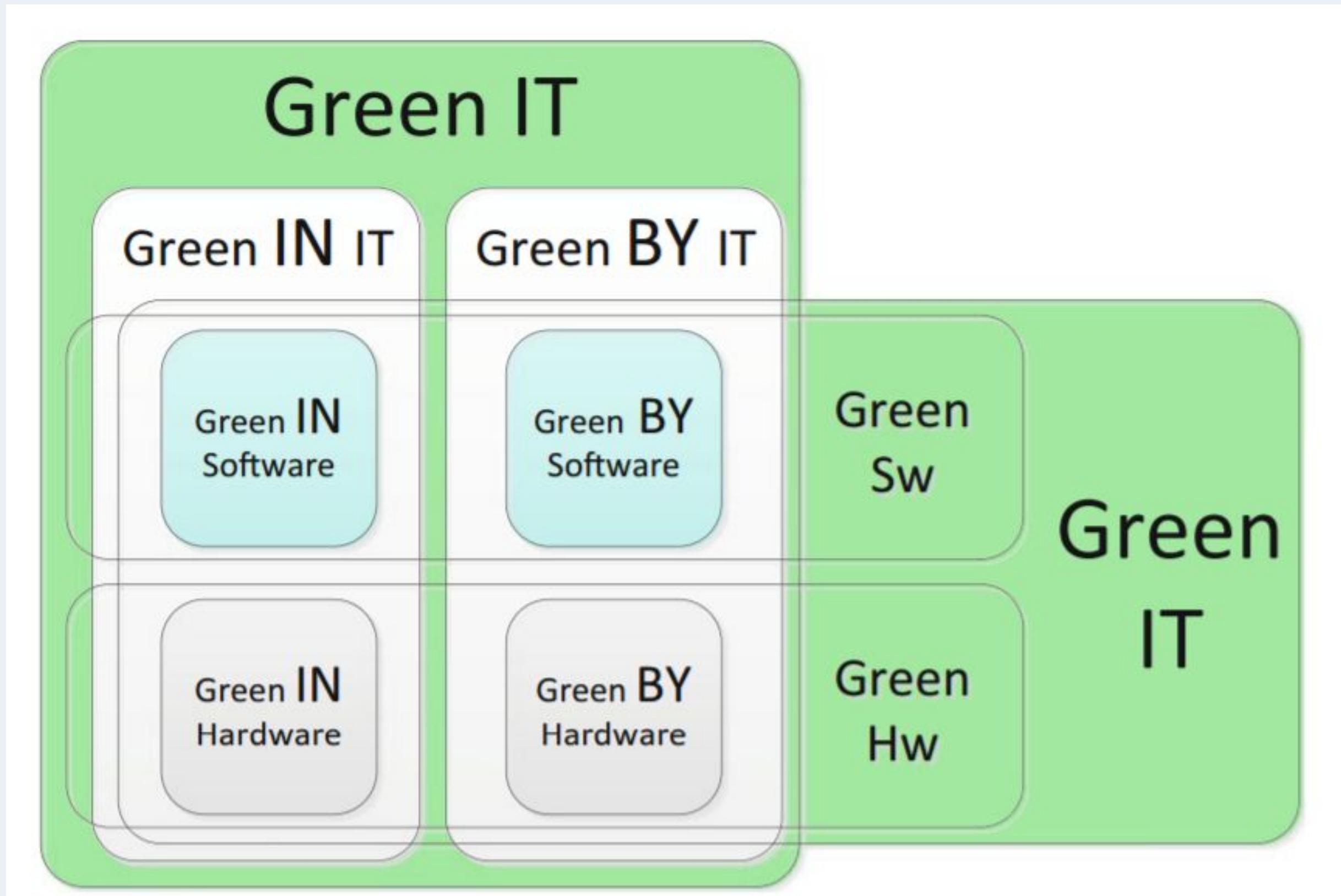
ECONOMIC



Sustainability analysis instance

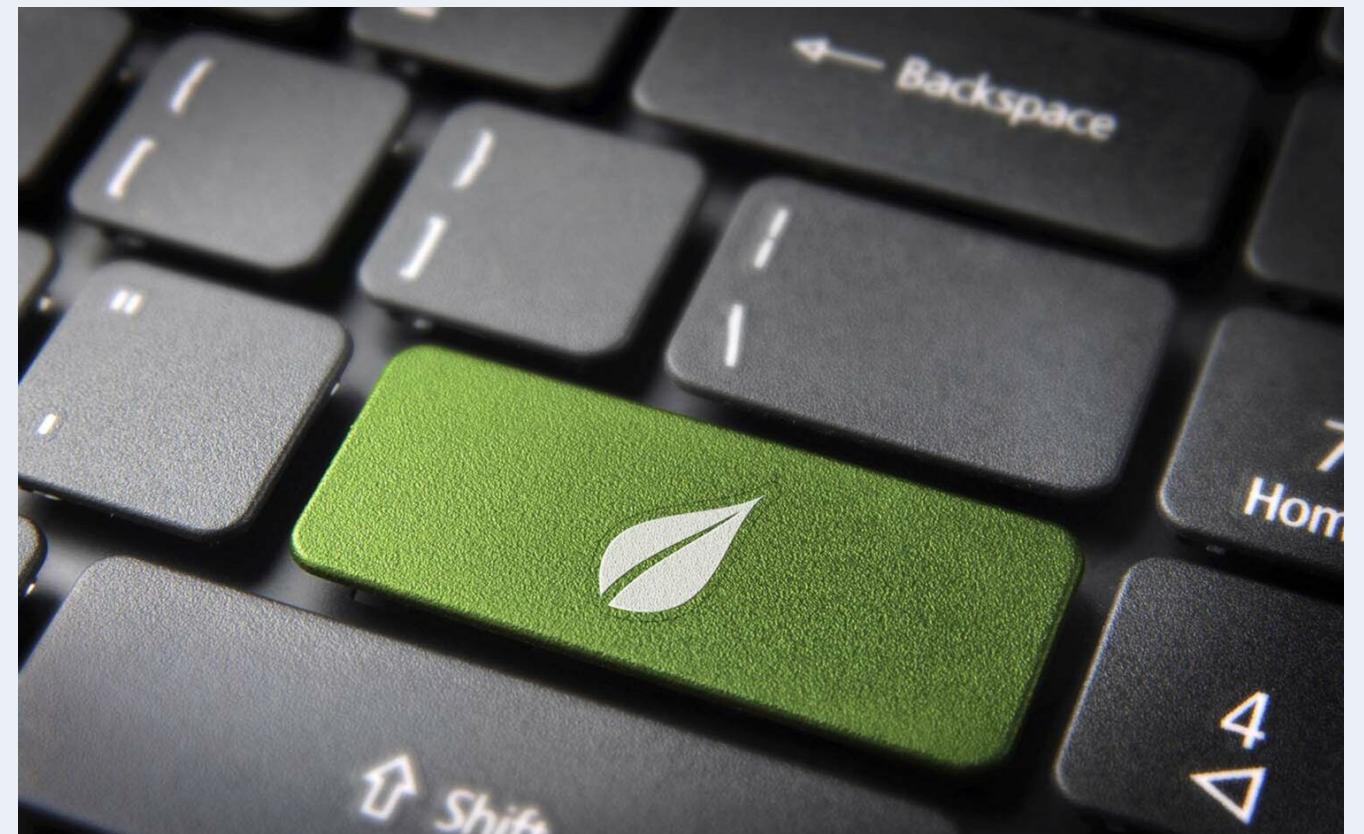


From Sustainability to Greenability



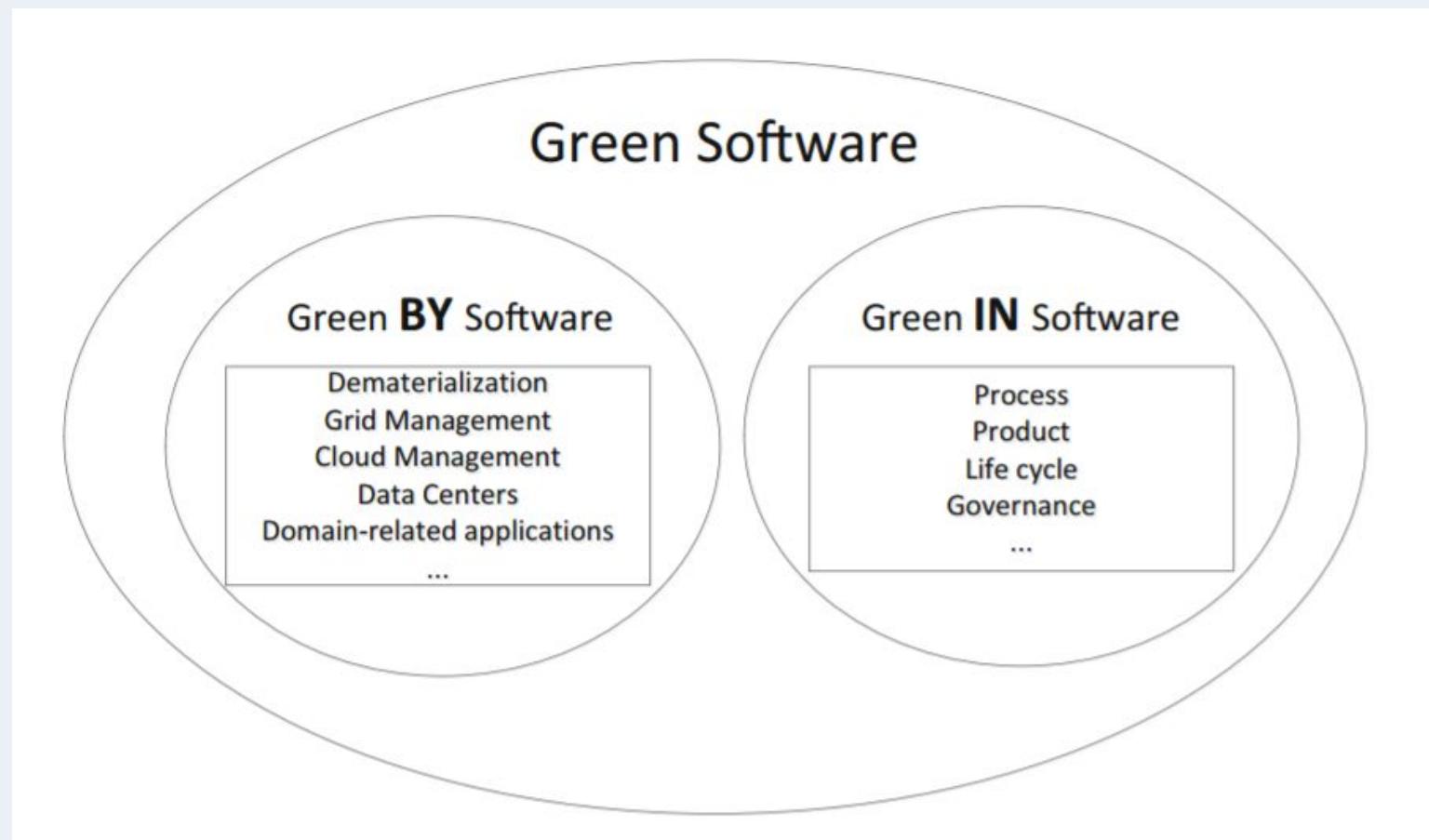
Green Software

- An application that produces as little waste as possible during its development and operation.
- Must fulfil three high-level requirements:
 - The required software engineering processes of software development, maintenance and disposal must save resources and reduce waste.
 - Software execution must save resources and reduce waste.
 - Software must support sustainable development.

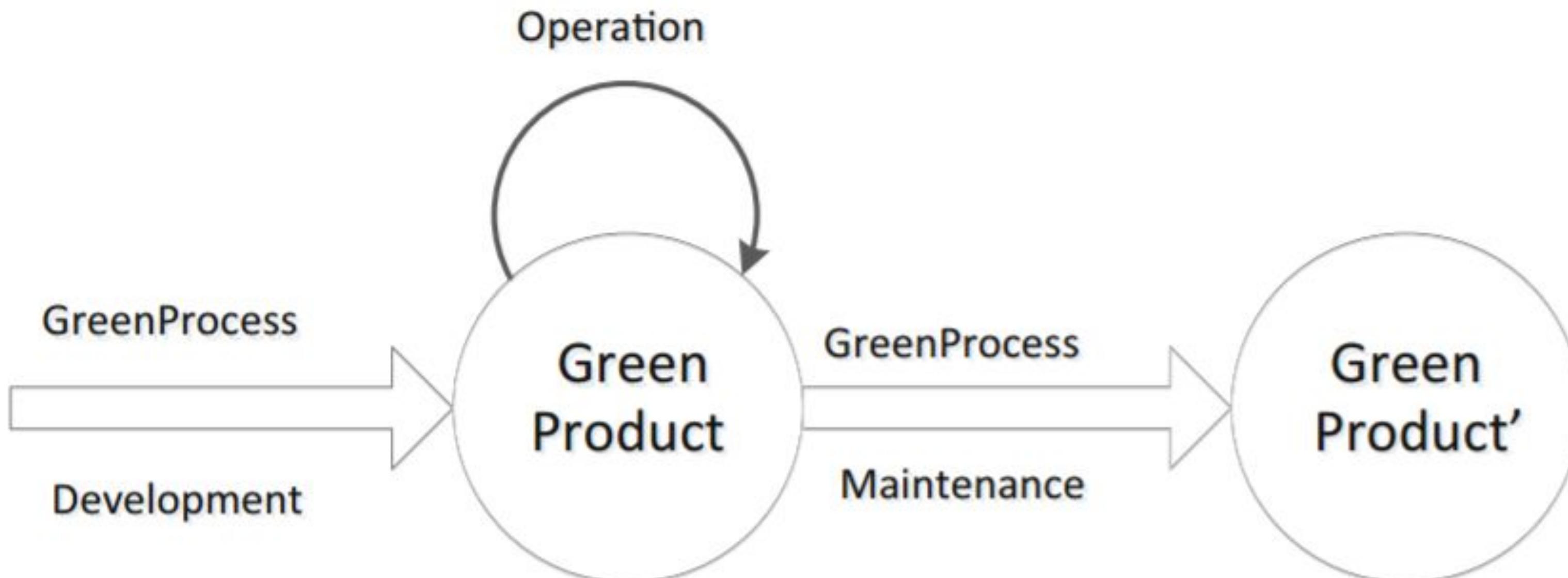


Green Software Categories

- Software that is greener (consumes less energy to run)
- Embedded software that assists other things in going green (smart operations)
- Sustainability-reporting software (or carbon management software)
- Software for understanding climate change, assessing its implications and forming suitable policy responses



Green in Software Engineering



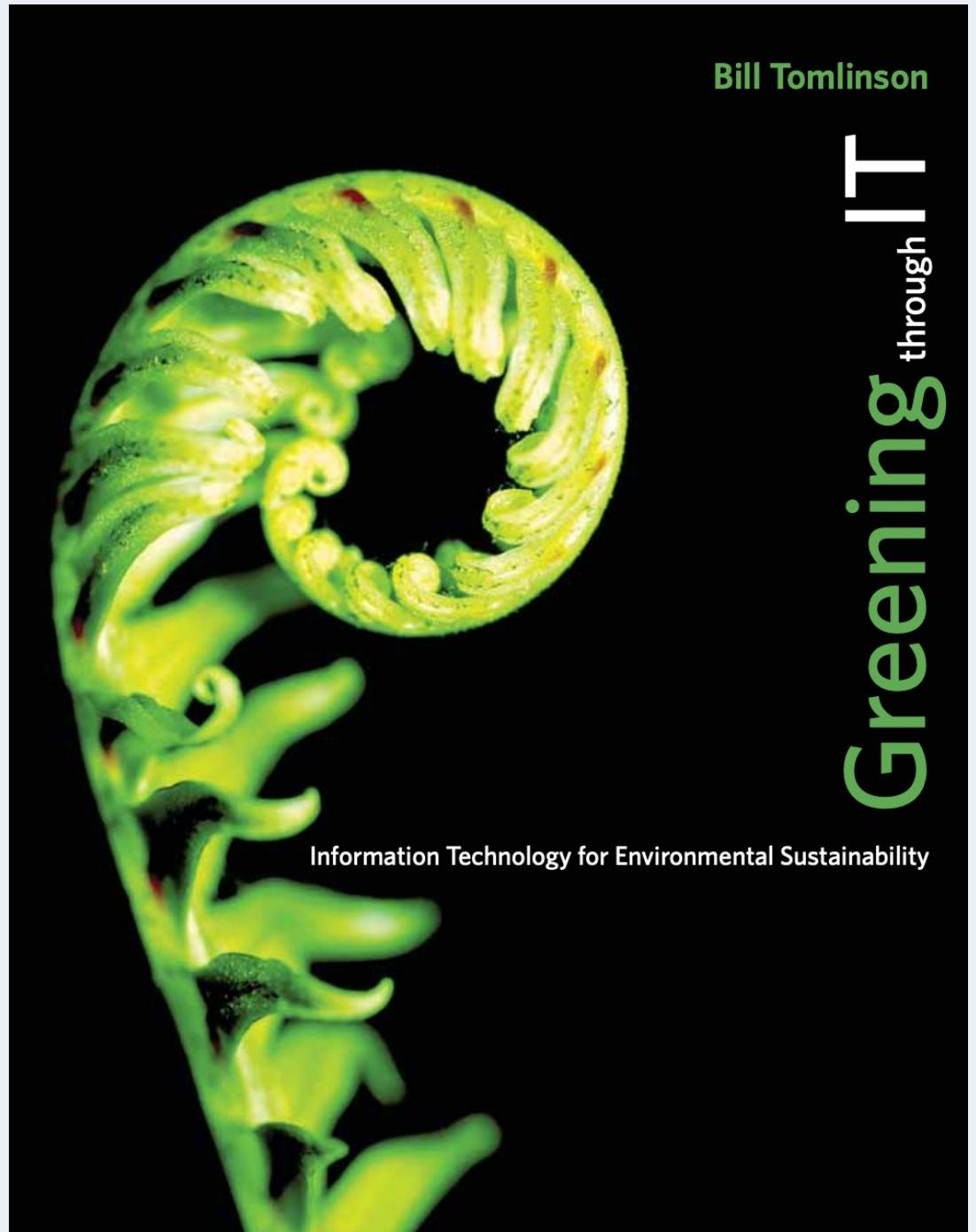
Green in Software Engineering

Tools for measuring carbon impacts

Commercial or Free	Name of the tool	Objective	More about the tool
Free	Ecoindex	Measure the carbon footprint of websites	www.ecoindex.fr
Free	Self-assessment tool	To obtain the approx. climate change and primary energy footprint of an ICT-based organization	www.ictfootprint.eu
Commercial	CO2 neutral website	Calculate CO2 emissions from website and reduce a similar amount of CO2 through climate projects	www.co2neutralwebsite.com
Commercial	CAST Green IT index	Measure software's environmental effect based on how efficiently it carry out intended actions, and how robust it is	www.castsoftware.com
Commercial	Greenspector	Performance measuring tool for mobile apps	www.greenspector.com
Commercial	Ecochain	Activity-based footprinting at the product, company, and value chain level	www.ecochain.com

Referensi

- Lago, Framing sustainability as a property of software quality, CACM, 2015
- Coral Calero and Mario Piattini (2015): Introduction to Green in Software Engineering, Chapter 1



"Please feel free to reach out if you have any questions!"

