AI FOR REMANUFACTURING

SESSION 3: AI CHALLENGES AND OPPORTUNITIES FOR GREEN MANUFACTURING

AIM-NET NETWORKING EVENT – 24/05/23
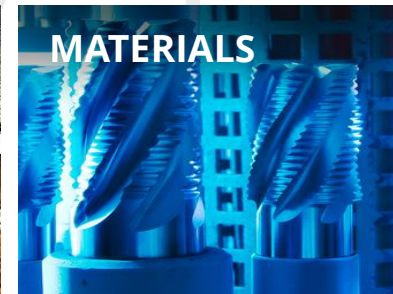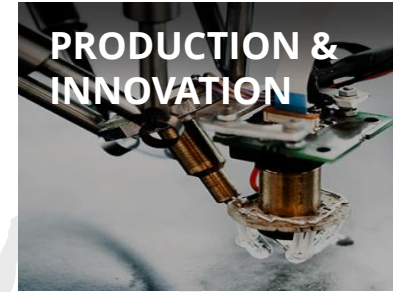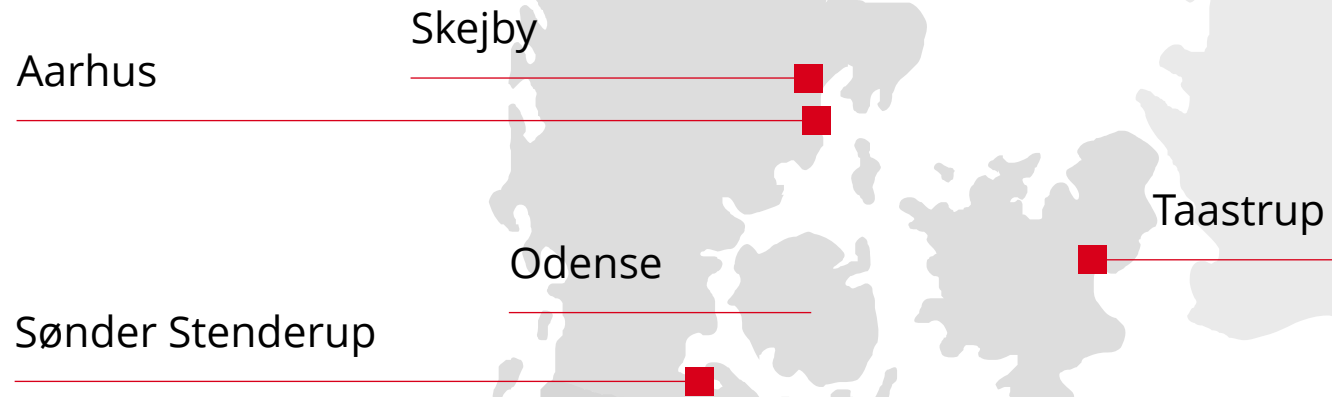
Francois Picard
Software engineer – Vision & AI
Danish Technological Institute
fpi@teknologisk.dk

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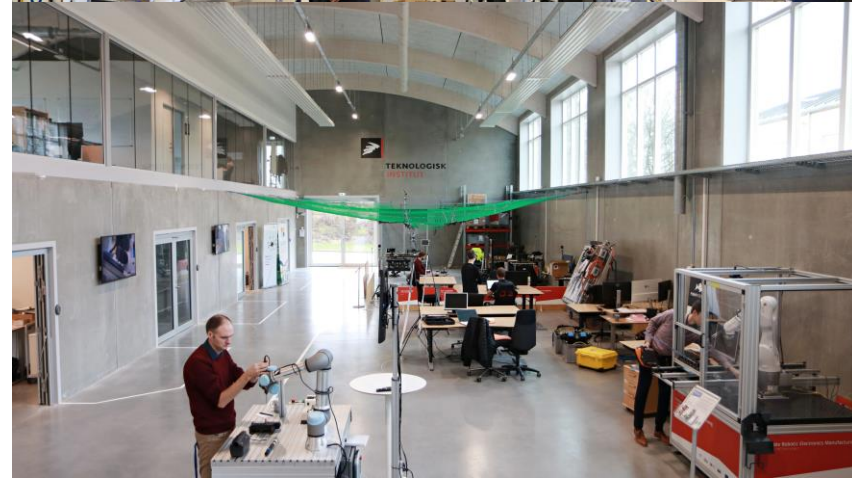TECHNOLOGICAL
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DTI is a RTO SINCE 1906

Supporting Danish industry, mainly small enterprises, by providing technical assistance in the form of teaching, advice, testing and technological research

Skejby

Aarhus

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Odense

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AGROTECH

PRODUCTION & INNOVATION

BUILDING & CONSTRUCTION

MATERIALS

ENERGY & CLIMATE

LIFE SCIENCE

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DOMAIN EXPERIENCE

AGRICULTURE

CONSTRUCTION

EDUCATION

FOOD PRODUCTION

HEALTH CARE

INSPECTION & MAINTENANCE

MANUFACTURING

WASTE SORTING

... AND MORE

AREAS OF EXPERTISE

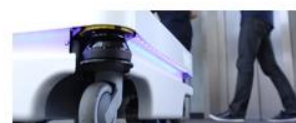INDUSTRIAL AUTOMATION

ARTIFICIAL INTELLIGENCE

COLLABORATIVE ROBOTS

INDUSTRY 4.0

DRONE TECHNOLOGY

MOBILE ROBOTS

PRODUCTIVITY & QUALITY

ROBOT SAFETY

VISION & SENSORS

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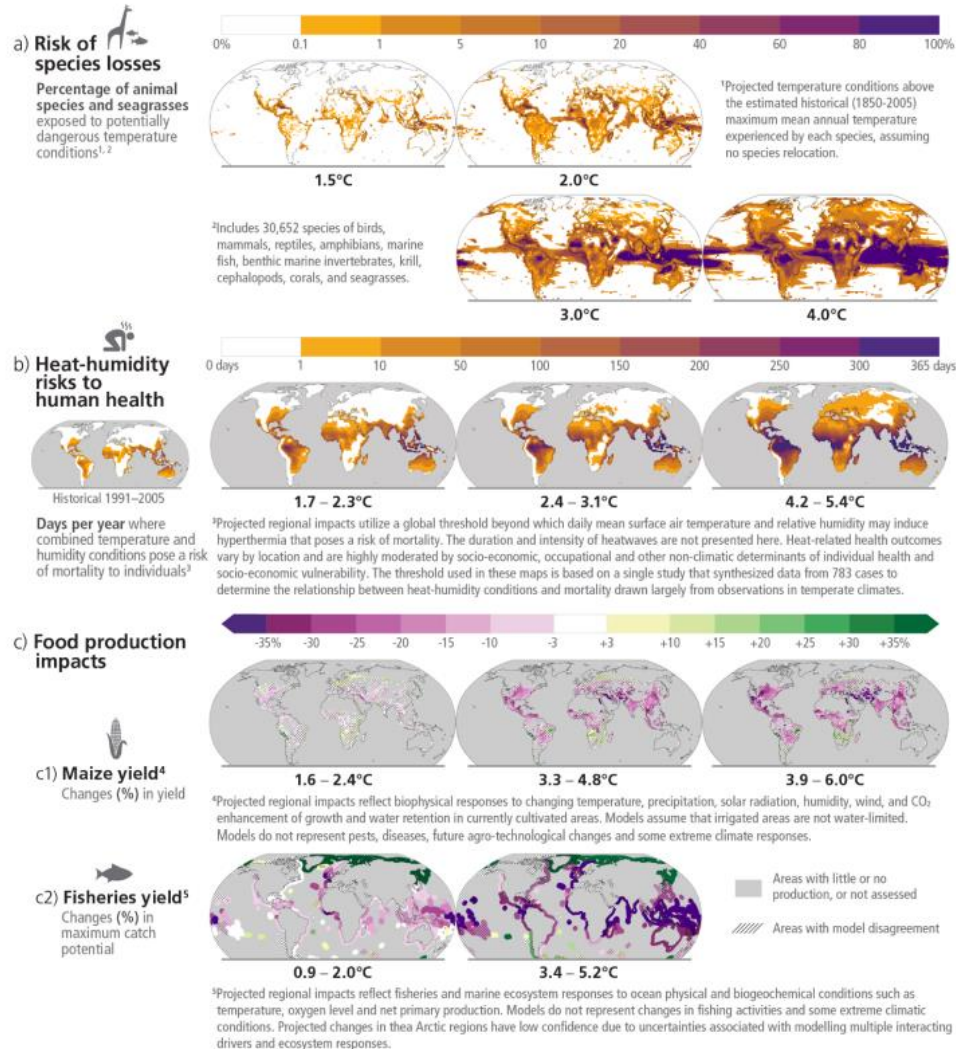
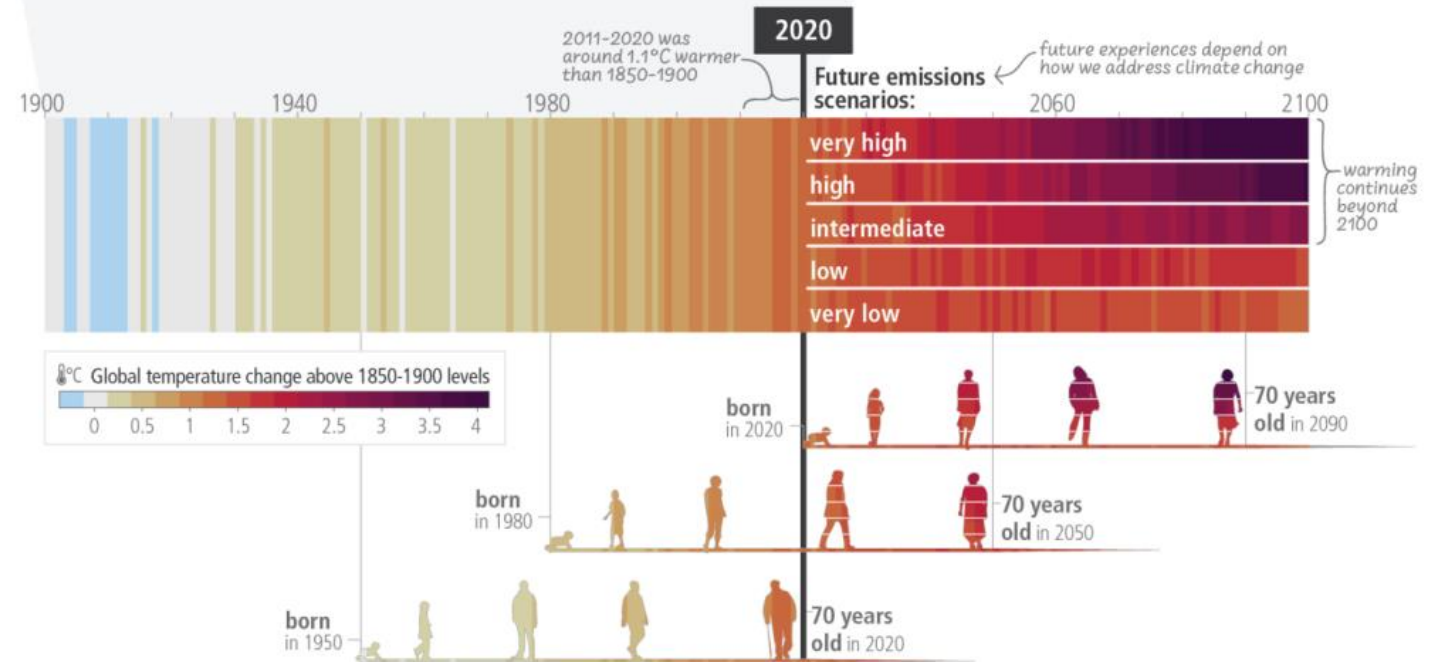# AS WE ARE TALKING ABOUT GREEN STUFF...

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JUST FYI...

Future climate change is projected to increase the severity of impacts across natural and human systems and will increase regional differences

Examples of impacts without additional adaptation

a) Risk of species losses

Percentage of animal species and seagrasses exposed to potentially dangerous temperature conditions[1,2]

[1]Projected temperature conditions above the estimated historical (1850-2005) maximum mean annual temperature experienced by each species, assuming no species relocation.

[2]Includes 30,652 species of birds, mammals, reptiles, amphibians, marine fish, benthic marine invertebrates, krill, cephalopods, corals, and seagrasses.

b) Heat-humidity risks to human health

Historical 1991-2005

Days per year where combined temperature and humidity conditions pose a risk of mortality to individuals[3]

[3]Projected regional impacts utilize a global threshold beyond which daily mean surface air temperature and relative humidity may induce hyperthermia that poses a risk of mortality. The duration and intensity of heatwaves are not presented here. Heat-related health outcomes vary by location and are highly moderated by socio-economic, occupational and other non-climatic determinants of individual health and socio-economic vulnerability. The threshold used in these maps is based on a single study that synthesized data from 783 cases to determine the relationship between heat-humidity conditions and mortality drawn largely from observations in temperate climates.

c) Food production impacts

c1) Maize yield[4]
Changes (%) in yield

[4]Projected regional impacts reflect biophysical responses to changing temperature, precipitation, solar radiation, humidity, wind, and CO_2 enhancement of growth and water retention in currently cultivated areas. Models assume that irrigated areas are not water-limited. Models do not represent pests, diseases, future agro-technological changes and some extreme climate responses.

c2) Fisheries yield[5]
Changes (%) in maximum catch potential

[5]Projected regional impacts reflect fisheries and marine ecosystem responses to ocean physical and biogeochemical conditions such as temperature, oxygen level and net primary production. Models do not represent changes in fishing activities and some extreme climatic conditions. Projected changes in thea Arctic regions have low confidence due to uncertainties associated with modelling multiple interacting drivers and ecosystem responses.

c) The extent to which current and future generations will experience a hotter and different world depends on choices now and in the near-term

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IMPACTS OF THE DIGITALIZATION & AI

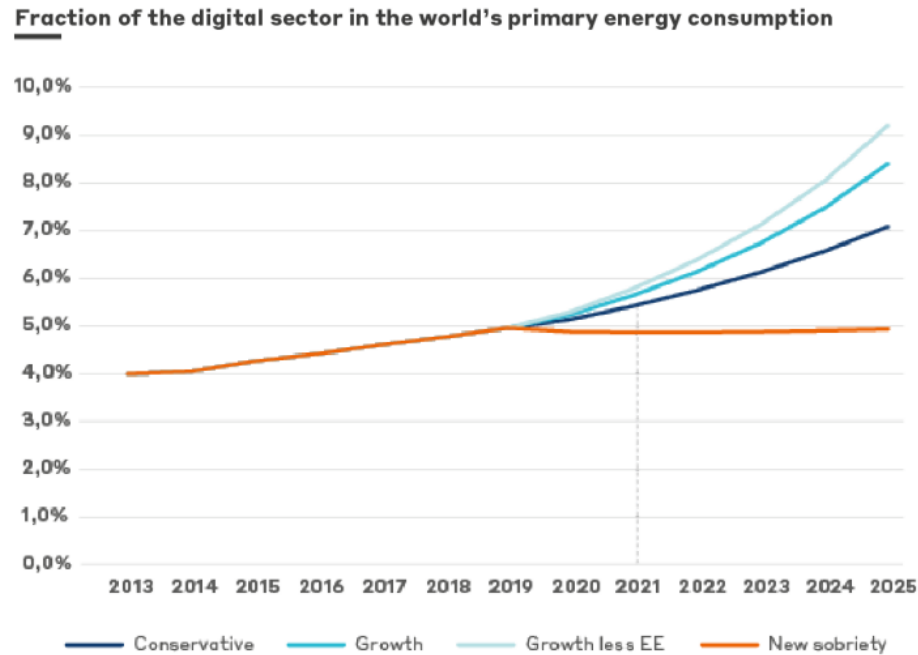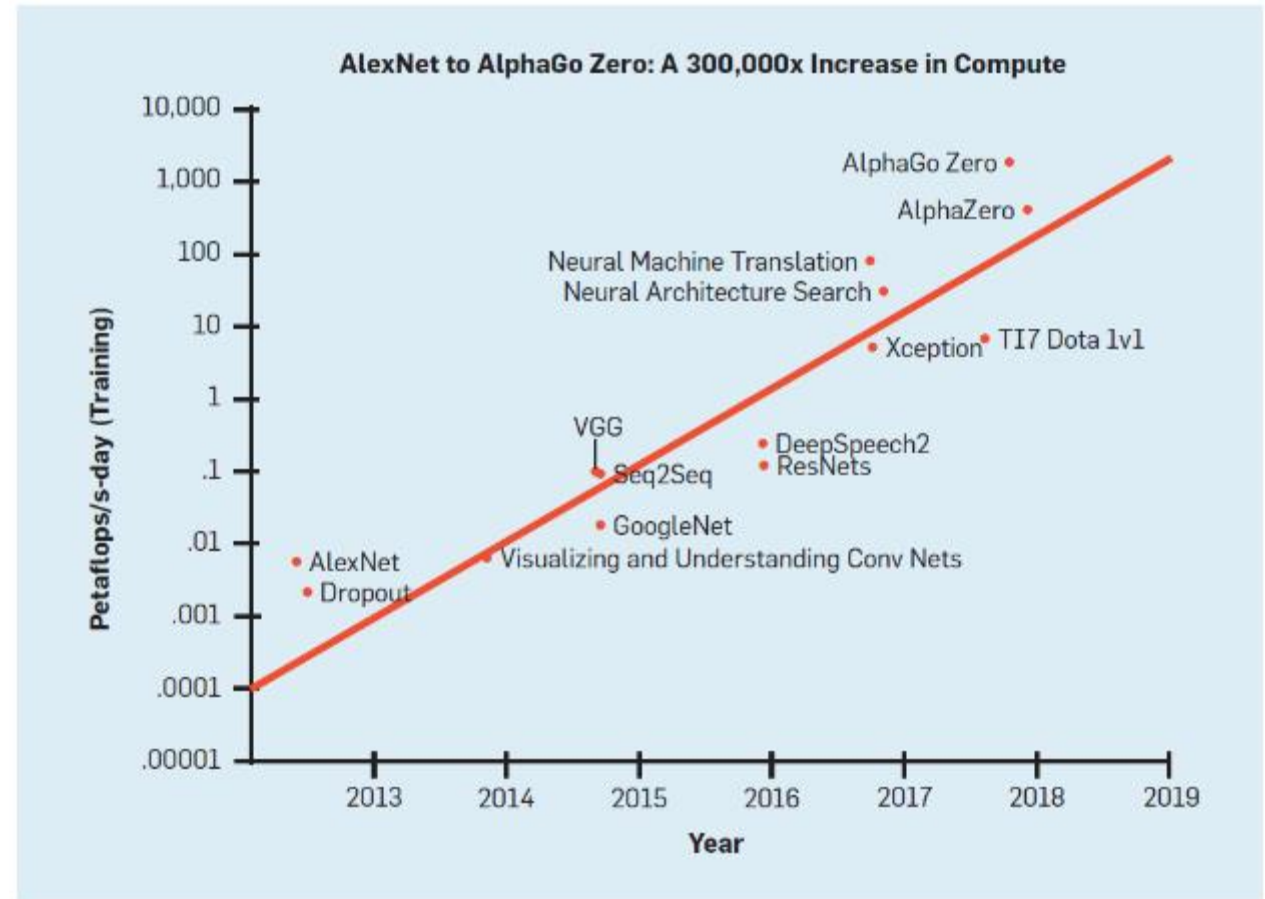Fraction of the digital sector in the world's primary energy consumption

Figure 1: Evolution 2013-2025 of the share of digital technologies in global primary energy consumption (The Shift Project - Forecast Model 2021)
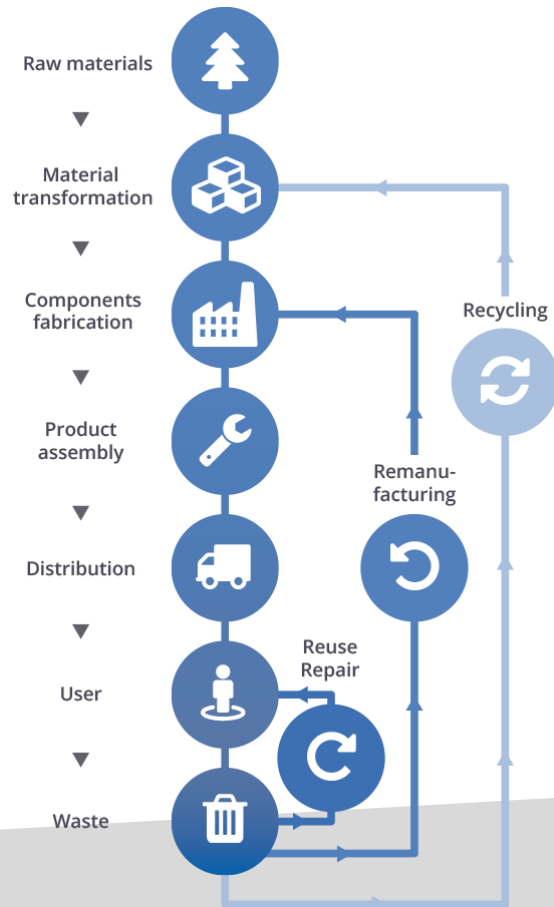

AlexNet to AlphaGo Zero: A 300,000x Increase in Compute

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REMANUFACTURING

DEFINITION

- **Remanufacturing** is an industrial process that restores cores (e.g., used, discarded, or broken products) to **like-new condition** (Lund, 1984)

- Remanufacturing is a concept within **circular economy**

WHY REMANUFACTURING IS GOOD BUSINESS

- **We have a problem of resources and of waste**

The 90 natural elements that make up everything
How much is there? Is that enough? Is it sustainable?

Read Support Notes and play the video game http://bit.ly/euchems-pt

Edition 3 (2023)
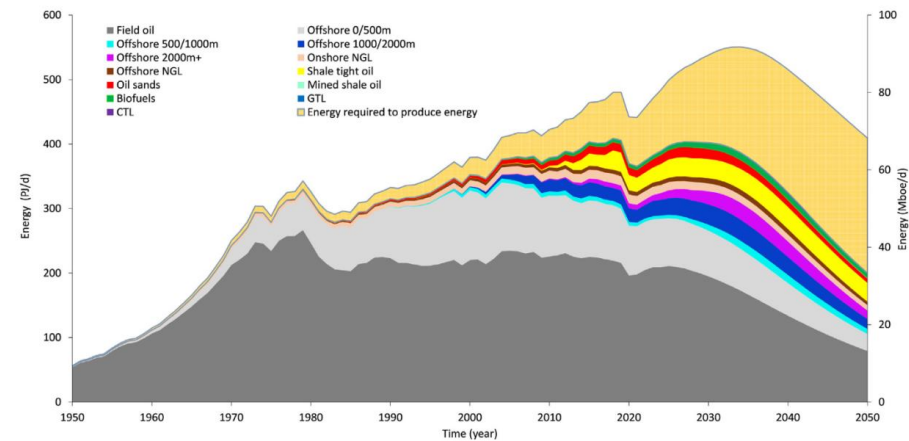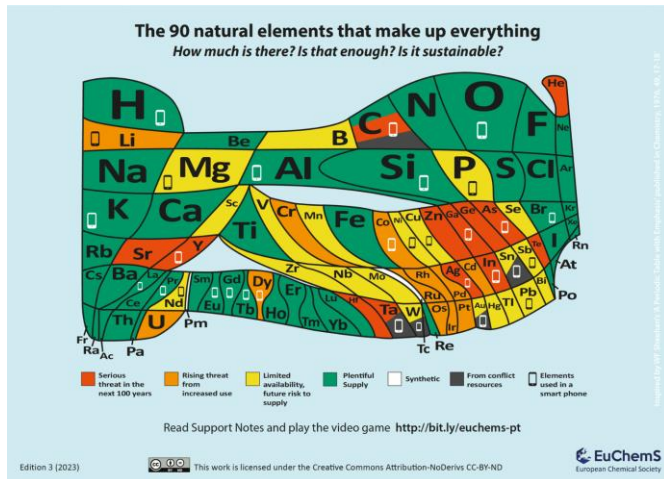
Fig. 1. Average oil liquids net-energy production from 1950 to 2050, compared to the gross energy.

- Remanufacturing is **one possible solution**

WHY REMANUFACTURING IS GOOD BUSINESS

- And it can indeed become **a good business**!

- The estimated market for remanufacturing is **90 billion euros in 2030**

- For instance, a smartphone has a material value of approximately **1-3 euros** when it is **reused/recycled** (after its end-of-life)
  If you **repair** it instead and sell it again, it has a value of anywhere between **130-1.300 euros**

- **Only 1.9 percent** of the total value of production in the EU in 2015 came from remanufacturing
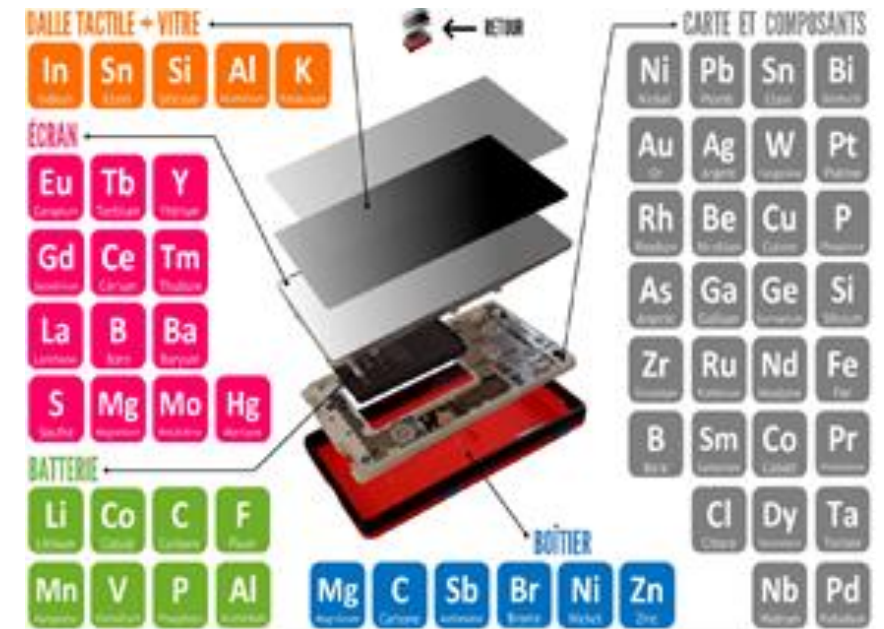
GREAT POTENTIAL FOR REMANUFACTURING

- **Electronics and household appliances**
  - Stove, dishwasher, oven (*Elretur*, *Ragn-Sells*)
  - Computers, smartphones, headphones (*Refurb*, *Tier1Asset*, *B&O*)
- **Battery and components dedicated to transport**
  - Car battery (*Lithium balance*)
  - Gear box
  - Brake Caliper (*Budweg*, since 2008)
- **Furniture**
  - Desk chair, desk, table, shelves (*3R Kontor*)
- **Machine industry**
  - Robots (*Universal Robots*)
  - Companies manufacturing industrial electronics, motors and production machinery (*Danfoss*, *Grundfos*, *Nilfisk*)
  - Wind turbine manufacturers and wind turbine components (*KK Wind Solutions*, *Linkun*, *Vestas*)

Digital equipment in a 4-person household in an OECD country

2012	2017	2022
2 smartphones	4 smartphones	4 smartphones
2 laptops / computers	2 laptops / computers	2 laptops / computers
1 tablet	2 tablets	2 tablets
1 DSL/Cable/Fibre/Wifi Modem	2 DSL/Cable/Fibre/Wifi Modem	3 DSL/Cable/Fibre/Wifi Modem
1 Printer / scanner	1 Printer / scanner	1 Printer / scanner
1 Game console	1 Game console	1 Game console
	1 connected television	3 connected television
	2 network attached storage	1 network attached storage
	2 eReaders	2 eReaders
	1 smart metre	1 smart metre
	2 connected stereo systems	3 connected stereo systems
	1 energy consumption display	1 energy consumption display
	1 internet connected car	2 internet connected car
	1 pair of connected sport shoes	3 connectes sport devices
	1 pay as you drive device	2 pay as you drive devices
		1 digital camera
		7 smart light bubles
		5 internet connected power socker
		1 weight scale
		1 eHealth device
		1 intelligent thermostat
		4 home automation sensors

Figure 9: Digital equipment in a 4-person household in an OECD country (Source: (GSMA, 2015))

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IT IS NOT "THE" SOLUTION

- Scaling up is rare and requires **large investments**
  It is still less expensive to produce new "stuff" than to repair, reuse and recycle

- **Difficult challenges:** higher variability of inputs, hard to quality-check, very different working "conditions"

- If one wants to collect and resell (something), **the network and the supply chain need to be ready**

- Implementing remanufacturing requires **collaboration**, **change** and **new business models**

- Remanufacturing is **<u>not</u>** the best way to become more environmentally sustainable
  The solution is largely to produce & consume far less

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Manufacturers are increasingly turning to AI solutions (ML, DL) to **analyze data**, **cope with high variability**, and **support decision-making**

- Detection & recognition of objects
- Defect detection
- Predictive maintenance
- Energy management
- Operation checking (screw driving process for instance)
- Path management for autonomous robots
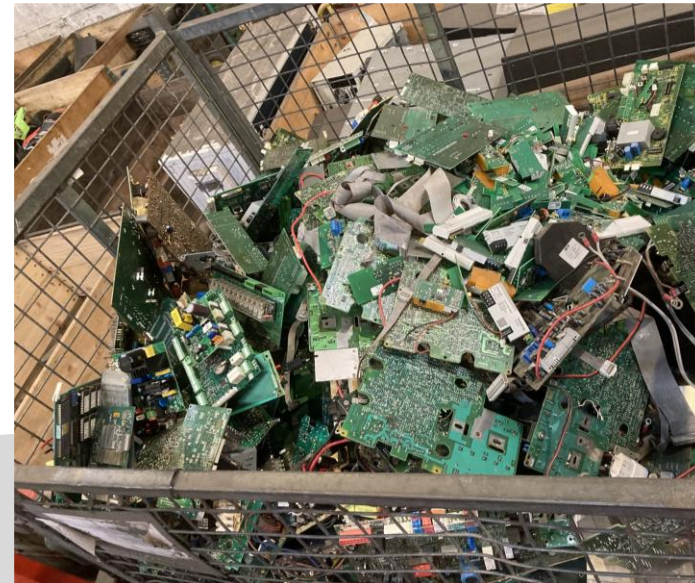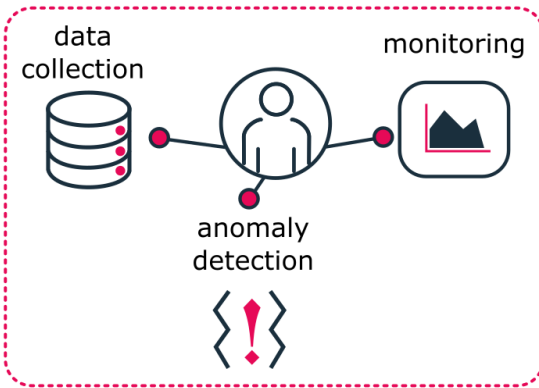- Eventually self learning robots
- Operator decision-making support

USE CASE – TIER1ASSET

Initial grading 1

Cleaning 2

Disassembly 3

Component grading 4

Component replacement & upgrades 5

Reassembly & functional testing 6

Final laptop stress testing 7

Visual inspection & quality 8

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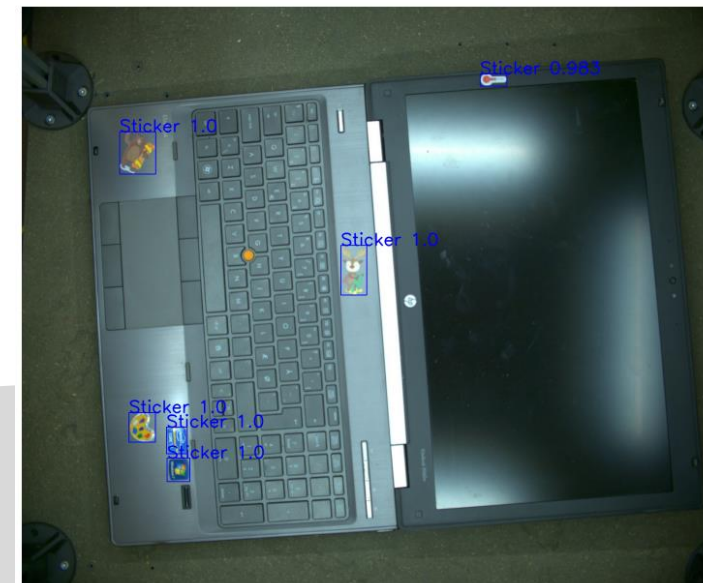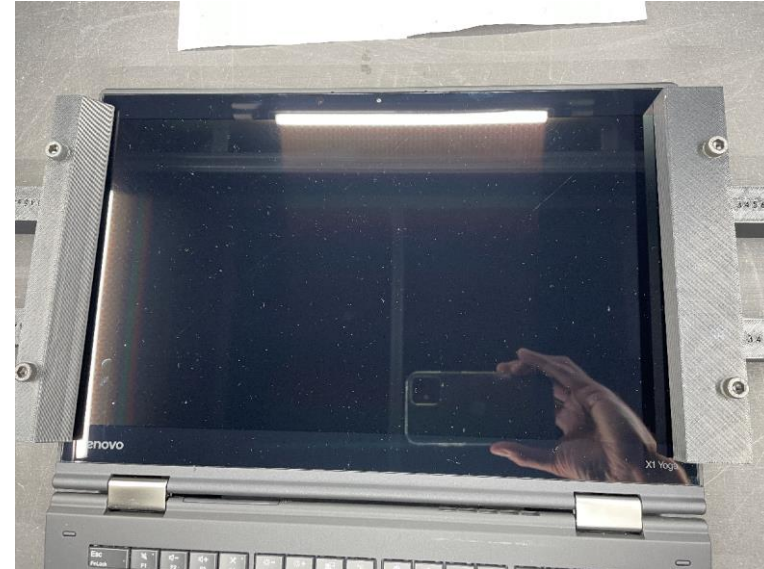
USE CASE – RAGN-SELLS

USE CASE – SHOP4CF
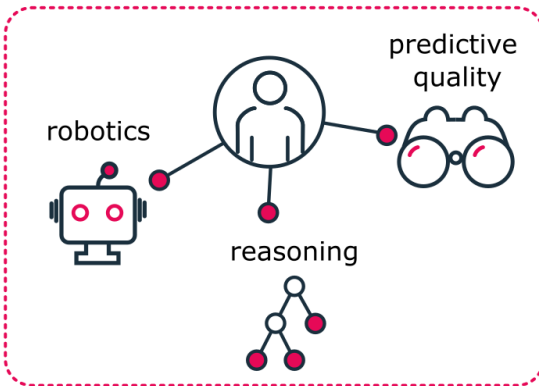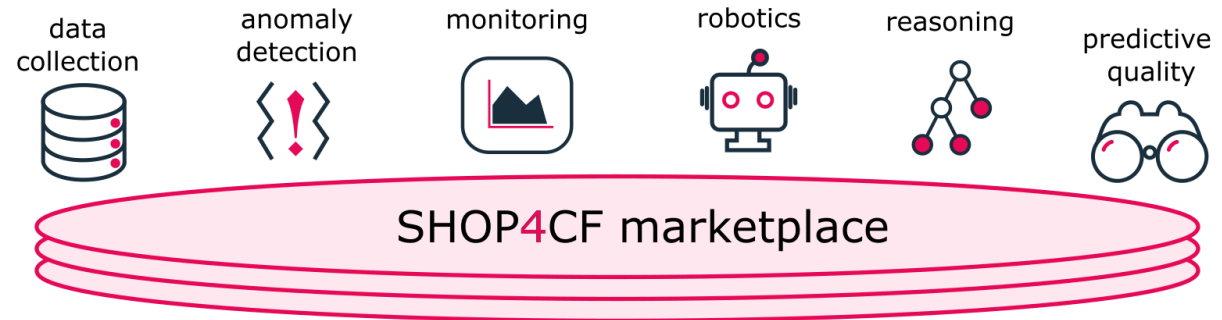
AI FOR REMANUFACTURING
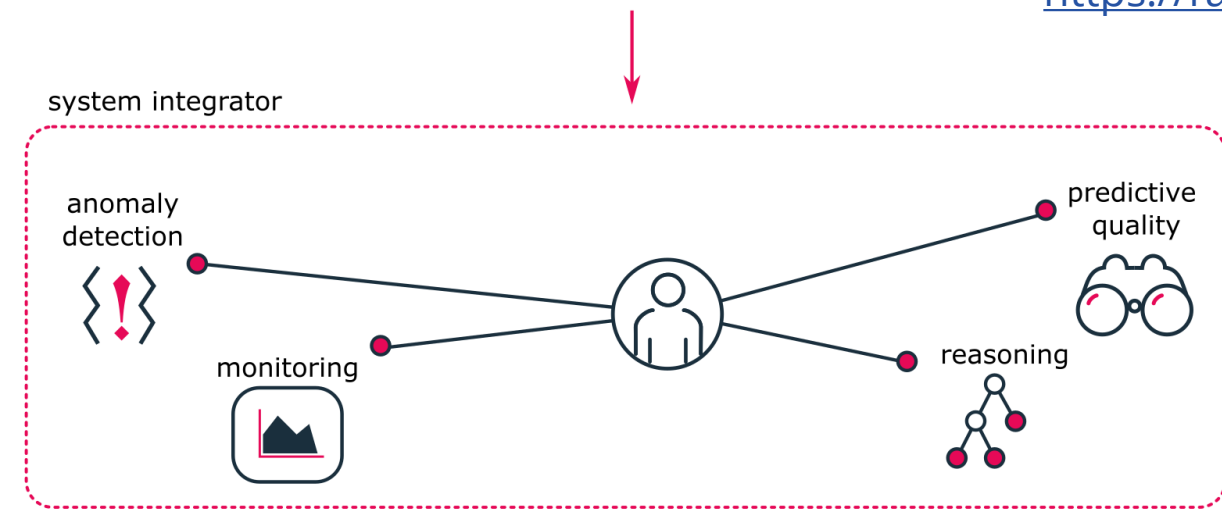
- Yes, implementing remanufacturing processes **is a bit greener**...

- ... and **can be even greener** if we implement AI algorithms the "right" way

- **Greener AI** means:

  - Think carefully the data you need and then, install the sensors to acquire the data

  - Switch from model-centric to data-centric approach

  - Make it simple, do not overfit

  - Choose your hardware wisely

  - If you use cloud-based implementation, choose where you train your models and store your data

  - Keep track of your CO2-equivalent emissions (with LCAs and many other online and open-source tools)

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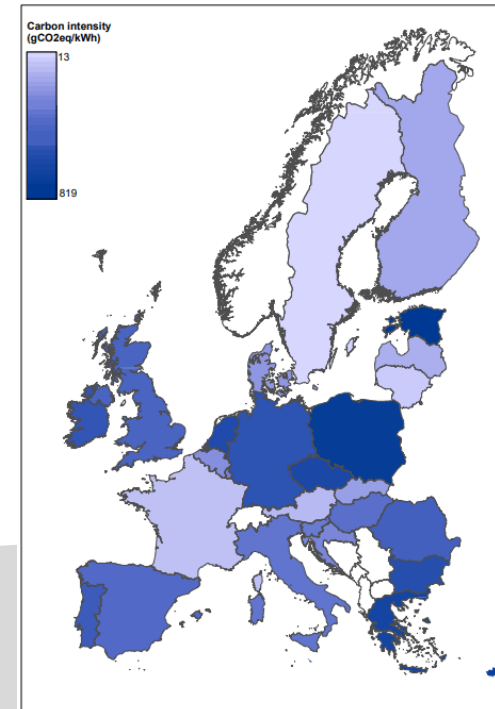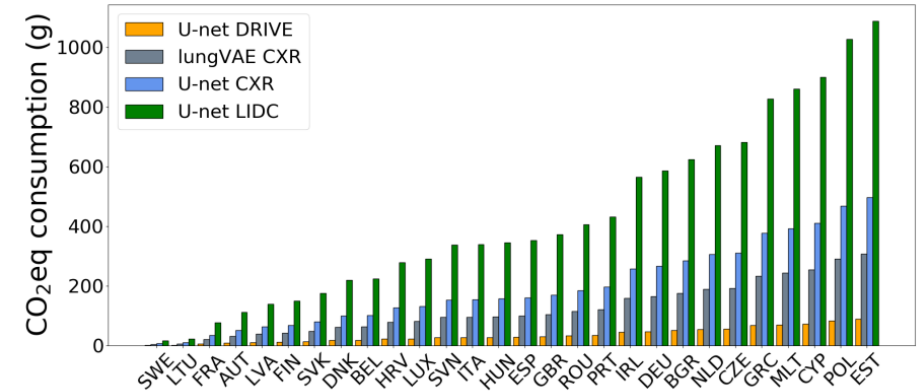
THANK YOU & LET'S KEEP IN TOUCH!

- **CL4-2024-TT-01-05:** Technologies/solutions to support circularity for manufacturing – 07/02/24
- **CL4-2024-RESILIENCE-01-41:** 'Innovate to transform' support for SME's sustainability transition – 07/02/24
- **CL6-CircBio-02-3-two-stage:** Increasing the circularity in electronics value chains – 22/02/24
- **CL6-CircBio-02-1-two-stage:** Circular solutions for textile value chains through innovative sorting, recycling, and design for recycling – 22/02/24

Francois Picard
Software engineer – Vision & AI
Danish Technological Institute
fpi@teknologisk.dk

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