Eco-Strategies for Next Generation Electronics

Rodrigo Martins

NOVA SCHOOL OF SCIENCE AND TECHNOLOGY | FCT NOVA

CEMOP | UNINOVA

IRSP 2023 Plenary Talk

World in 1980

Office

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World in 2020

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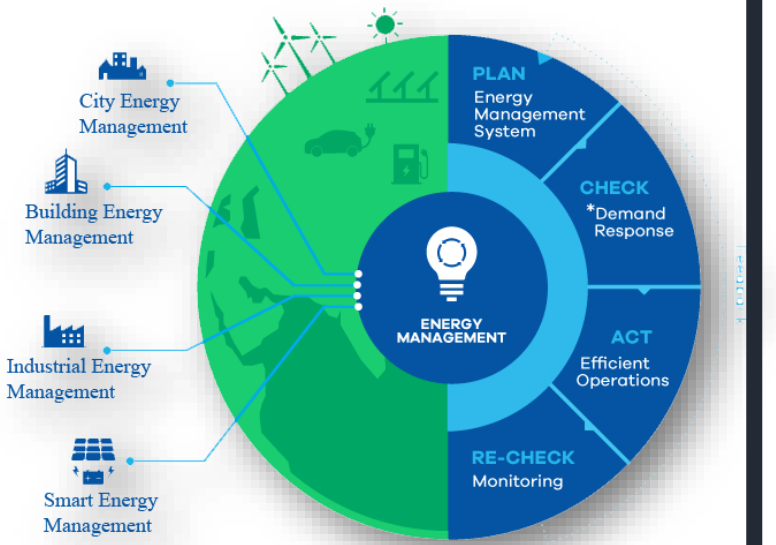
Restaurant

School

21st Century: The Key Challenges

Natural Resources

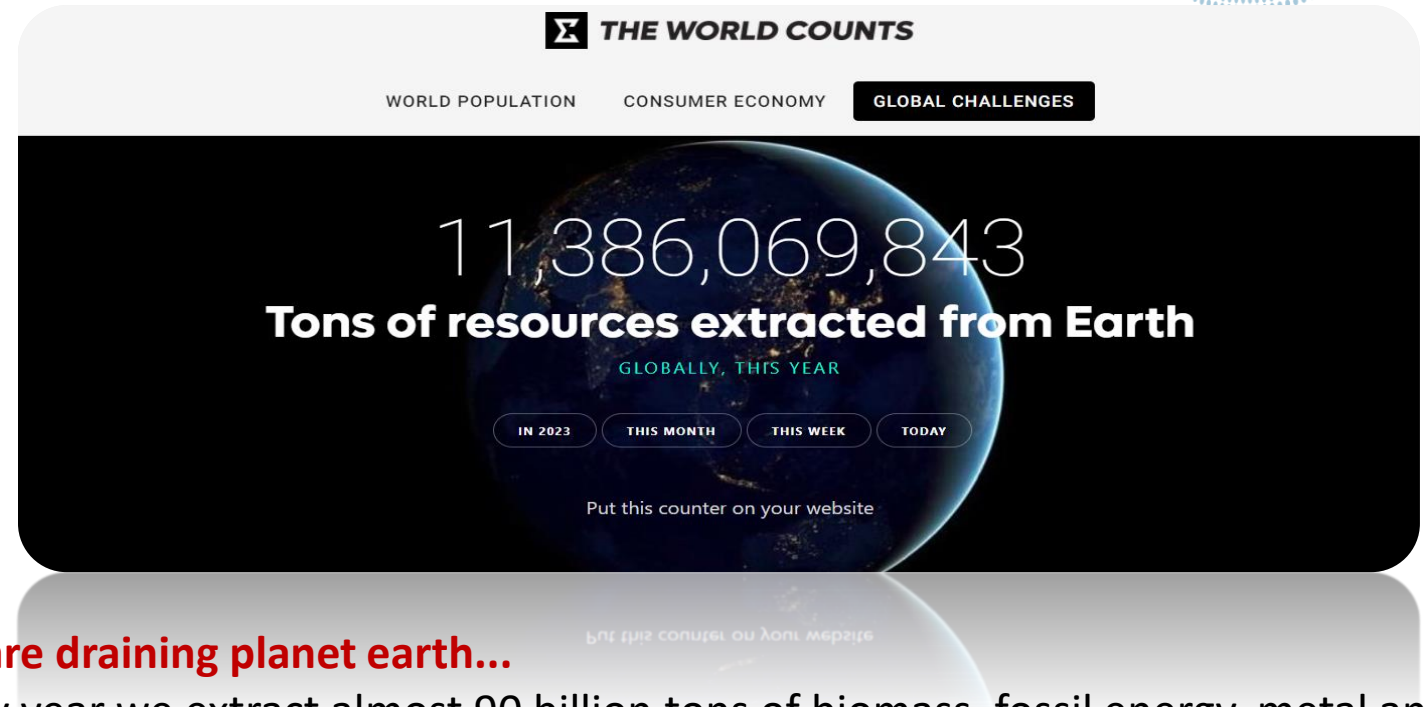
Energy Consumption



e-Waste Management

21st Century: The Key Challenges

Natural Resources



We are draining planet earth...

Every year we extract almost 90 billion tons of biomass, fossil energy, metal and minerals from the earth - more than 11 tons for every single person on the planet. And for people in the western world this number is much higher.

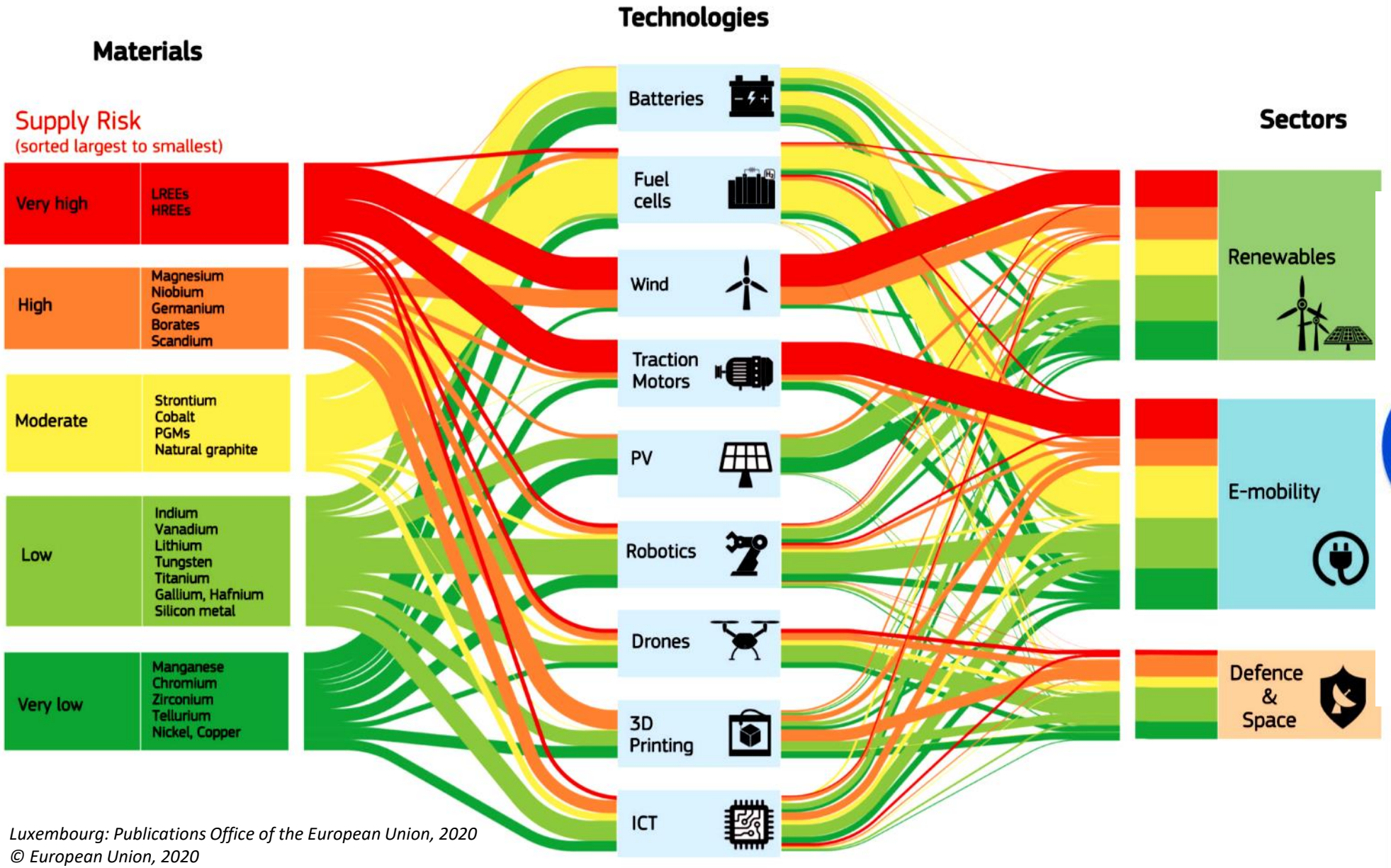
...at an increasing rate

In the 47 years between 1970 and 2015, human consumption of Earth's natural resources more than tripled. Our use of natural resources is expected to continue its growth and more than double from 2015 to 2050.

Natural Resources: Behind the Challenges

- ✓ **Overpopulation……** With 7 billion people on the planet, the demand on Earth's resources continue to increase.
- ✓ **Overconsumption…..** This is the excessive and unnecessary use of resources.
- ✓ **Minimum waste recovery….**Leading to loss of biodiversity and destruction of Eco-system.
- ✓ **Use of critical raw materials and fossil-based resources**…..Limiting the future resources.
- ✓ **Technological and Industrial Development**….Leading high demanding of resources.
- ✓ **Erosion**…Gradual destruction by physical or chemical action.
- ✓ **Pollution and Contamination of resources**…..Bad handling of waste management.

Flows of raw materials and their current supply risks



Luxembourg: Publications Office of the European Union, 2020

Circular economy: A new strategy in eco-design

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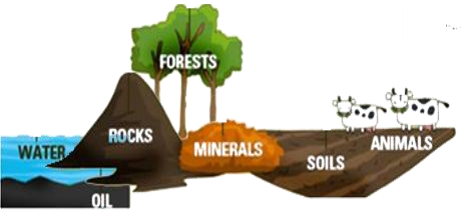
Traditional business is linear



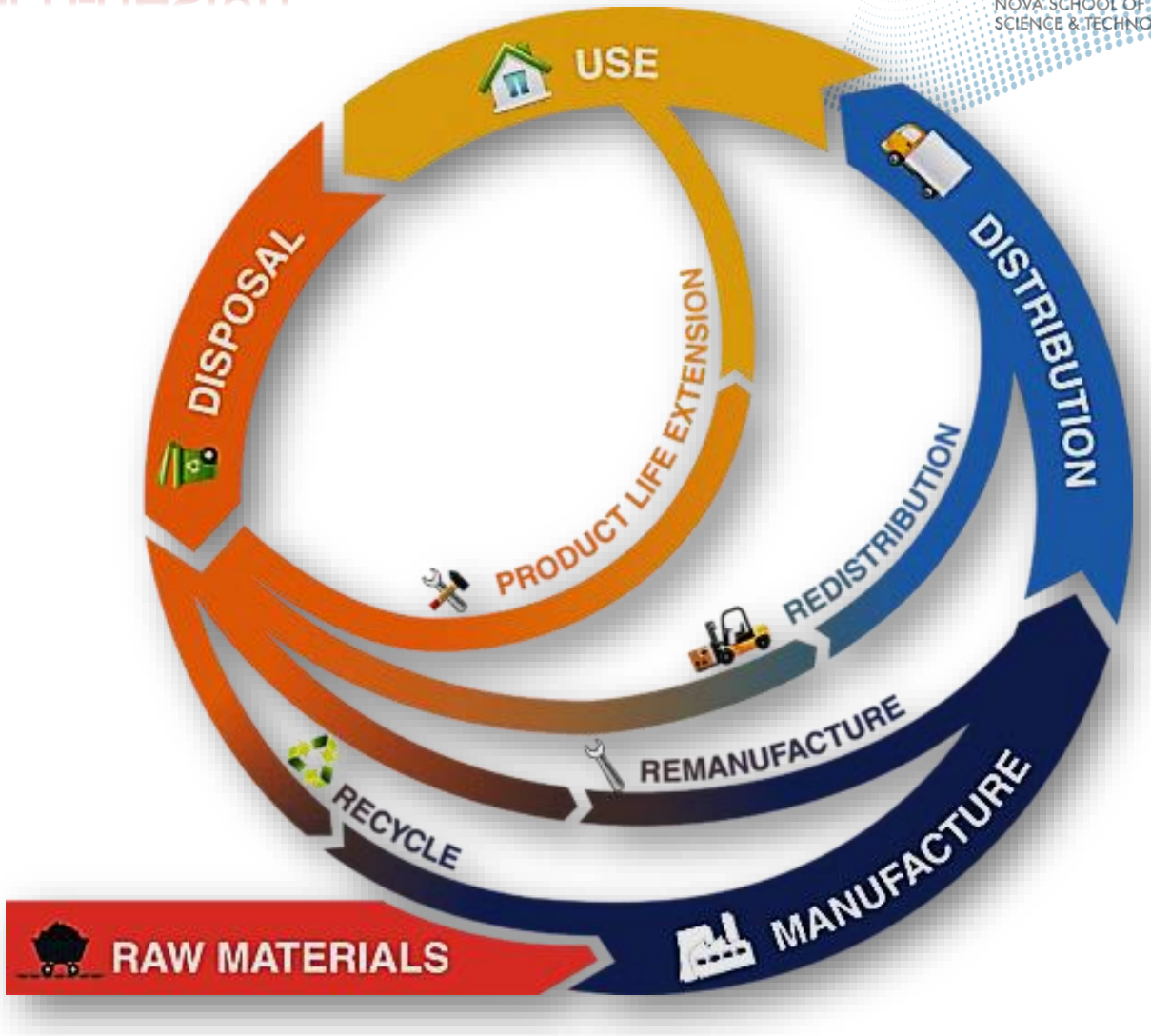
Adopt
Raw materials or resources

Business
Manufacturing & distribution

Consumption

Dispose

Using **RESOURCES** and
Returning **GARBAGE**

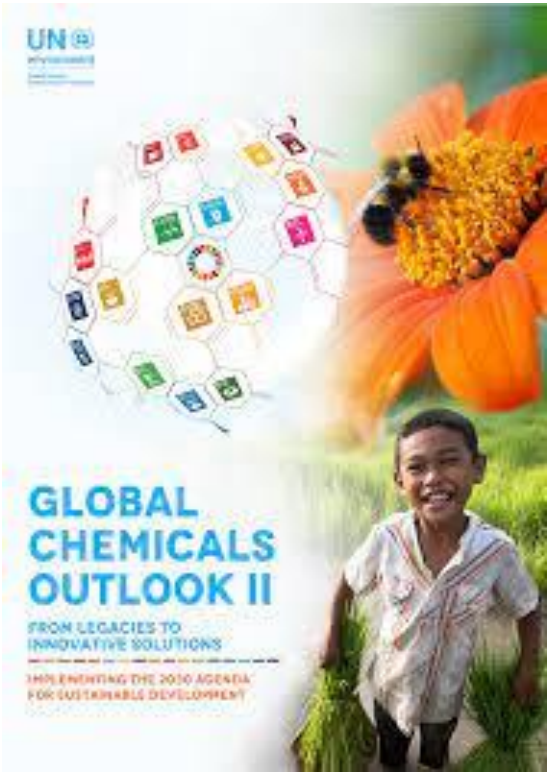


CIRCULAR ECONOMY …A different concept

Smaller the circle, Smaller the impact and Bigger the benefit

The UN Global Chemicals Outlook predicts> Chemical industry will double from US$5 trillion by 2030

- ✓ Using more non-toxic, bio-compatable and bio-degradable materials.
- ✓ Using low-cost and simple materials processing systems.
- ✓ Using more multi-functional.
- ✓ Using more and more flexible and nano- technology that will minimize the product size....so minimize the raw materials.
- ✓ Need substitution: Design new materials behaving like ORGANS! We need STEM Materials!
- ✓ Packaging Strategy : Design new bio-degradable materials for packaging. Less packaging Less Garbage.



The specific vision of the research work should be to build effective cooperation between science and society, to materialize new smart technology for science and to pair scientific nobility with social awareness and responsibility.

Materials Research: Frontier for an intelligent world

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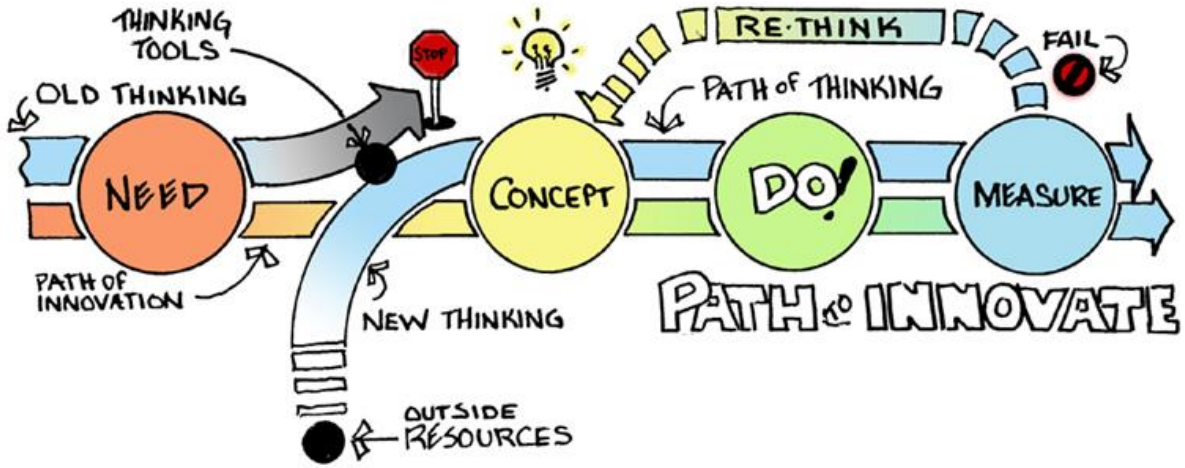
MATERIALS

With Multifunctionality

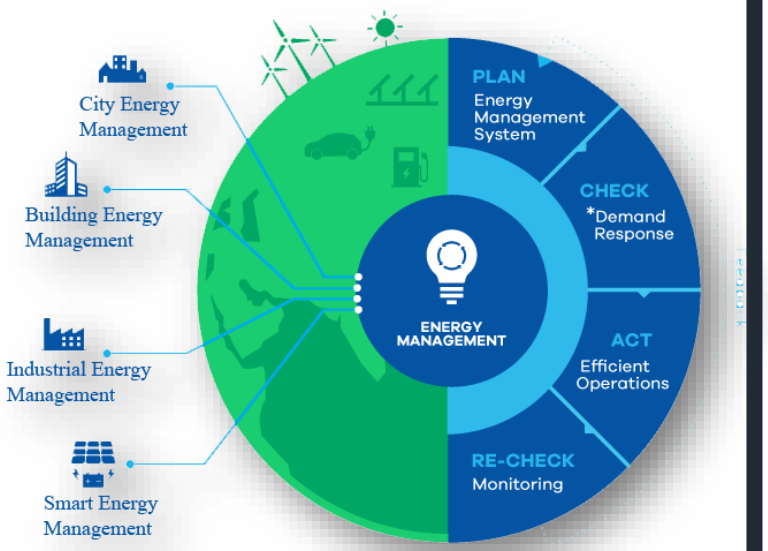
- Physics
- Chemistry
- Engineering
- Biology
- Genetics
- Mathematics
- Nanotechnology

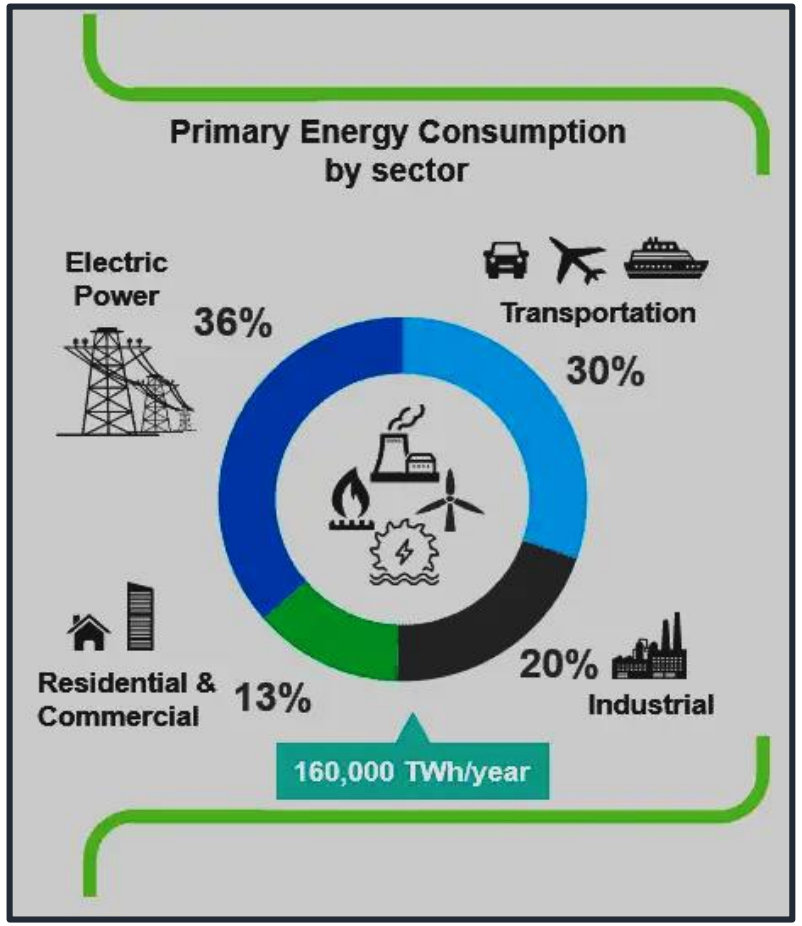
- Health
- Energy
- Robotics
- Fashion
- Transportation
- Smart Technology

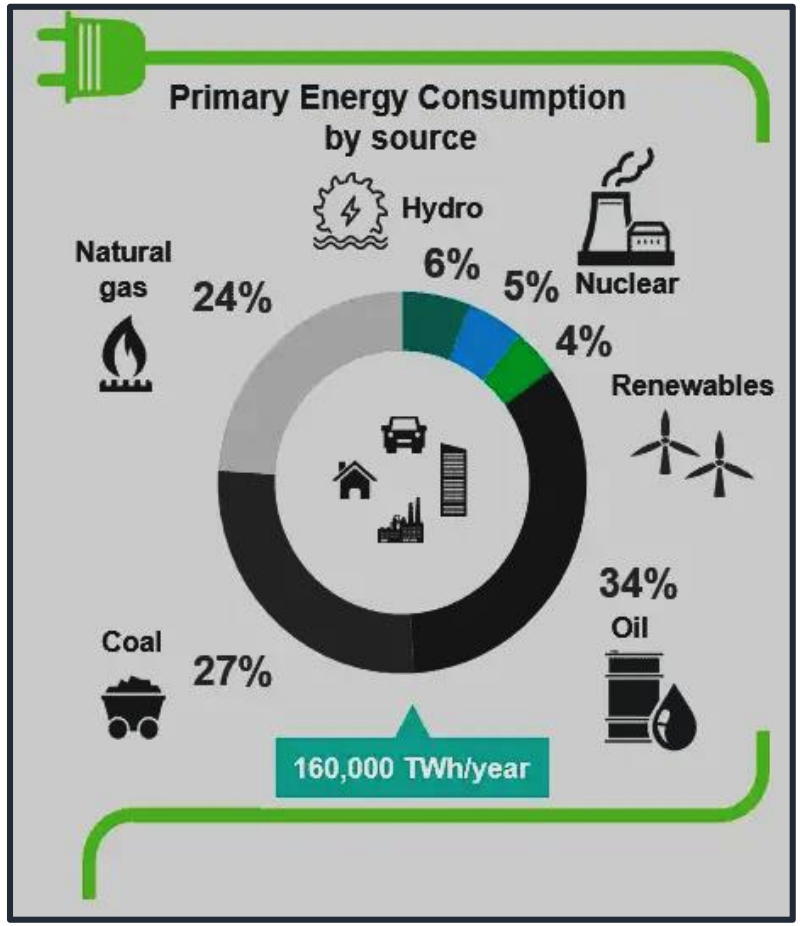


21st Century: The Key Challenges

Energy Consumption







Energy Consumption: Behind the Challenge

Energy

Electricity sector is the largest source of greenhouse gas emissions

Energy Consumption: Behind the Challenge

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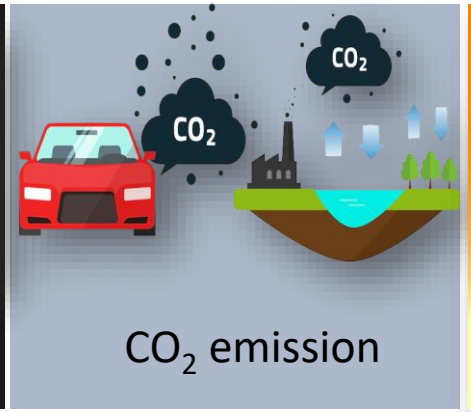
The Problem

Finite supply of fossil fuels



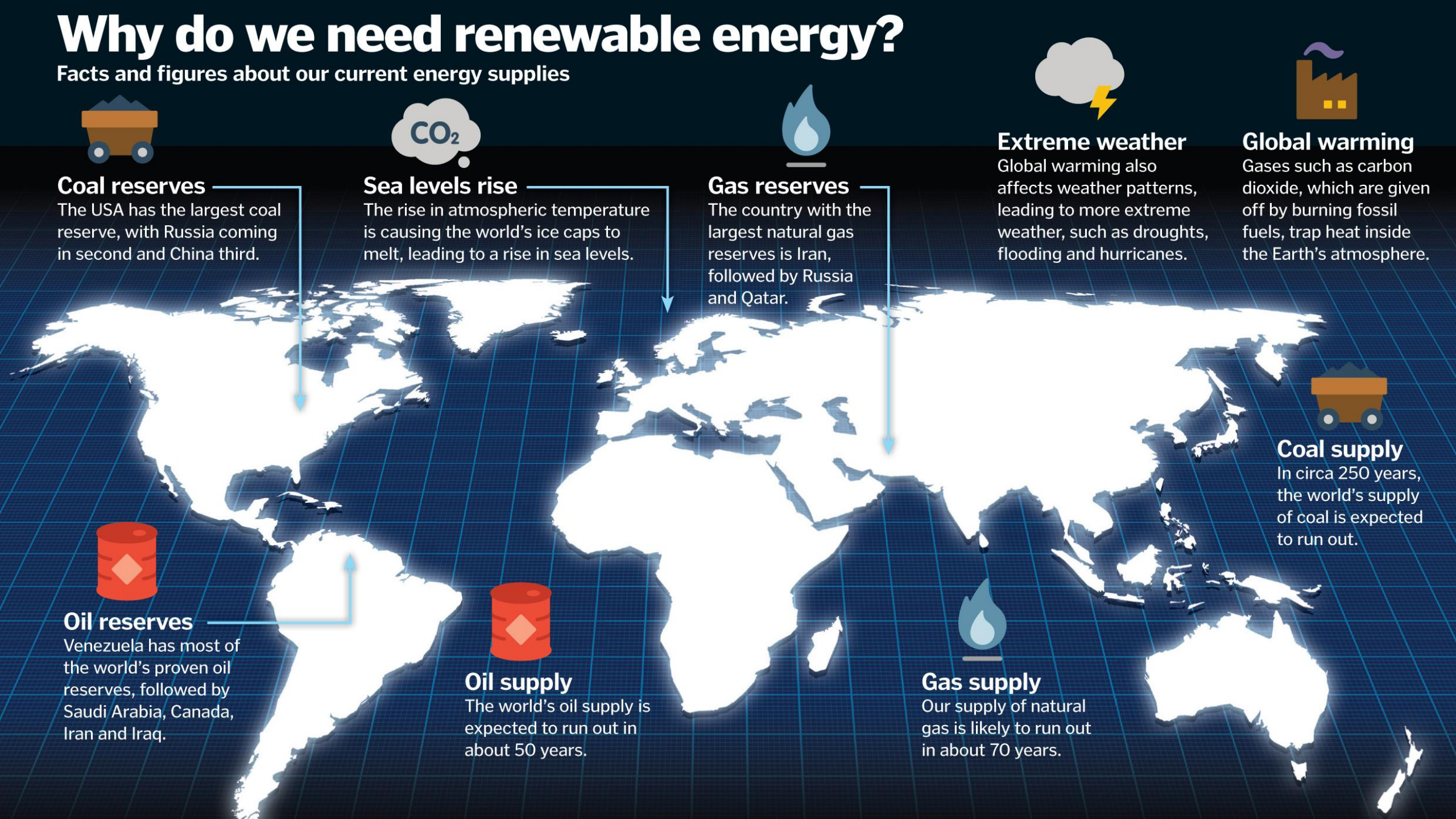
CO_2 emission

Energy

Electricity sector is the largest source of greenhouse gas emissions

Why do we need renewable energy?

Facts and figures about our current energy supplies



Coal reserves

The USA has the largest coal reserve, with Russia coming in second and China third.

Sea levels rise

The rise in atmospheric temperature is causing the world's ice caps to melt, leading to a rise in sea levels.

Gas reserves

The country with the largest natural gas reserves is Iran, followed by Russia and Qatar.

Extreme weather

Global warming also affects weather patterns, leading to more extreme weather, such as droughts, flooding and hurricanes.

Global warming

Gases such as carbon dioxide, which are given off by burning fossil fuels, trap heat inside the Earth's atmosphere.

Coal supply

In circa 250 years, the world's supply of coal is expected to run out.

Oil reserves

Venezuela has most of the world's proven oil reserves, followed by Saudi Arabia, Canada, Iran and Iraq.

Oil supply

The world's oil supply is expected to run out in about 50 years.

Gas supply

Our supply of natural gas is likely to run out in about 70 years.

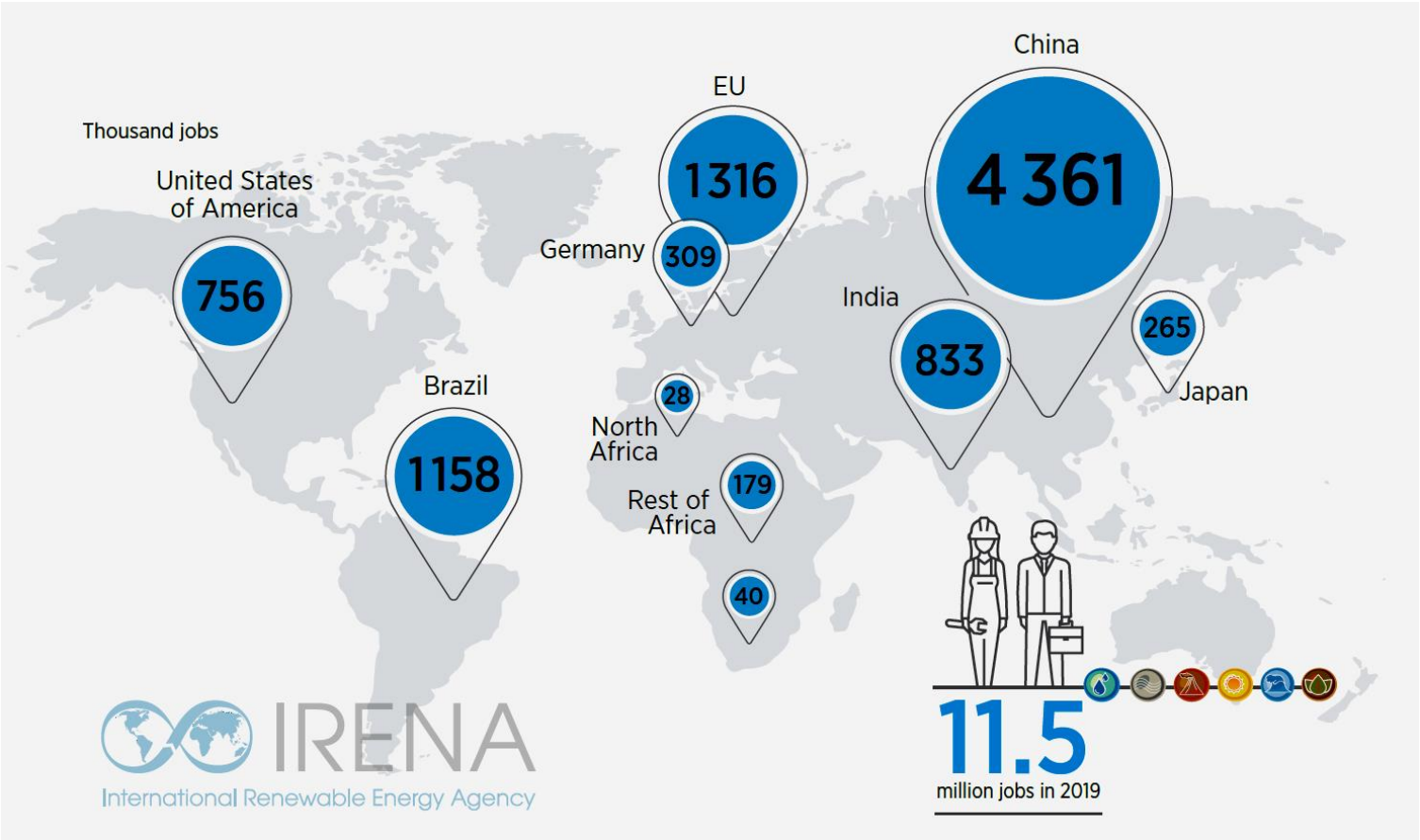
Energy

Green and Renewable Energy: Progress and Jobs

- ✓ Burning natural gas for electricity releases between 0.6 and 2 pounds of CO_2 equivalent per kilowatt-hour (CO_2 E/kWh).
- ✓ Coal emits between 1.4 and 3.6 pounds.
- ✓ Wind is responsible for only 0.02 to 0.04 pounds.
- ✓ Solar Energy sector emits: 0.07 to 0.2 pounds.
- ✓ Geothermal Energy sector emits : 0.1 to 0.2 pound.
- ✓ Hydroelectric Energy sector emits 0.1 to 0.5 pound.

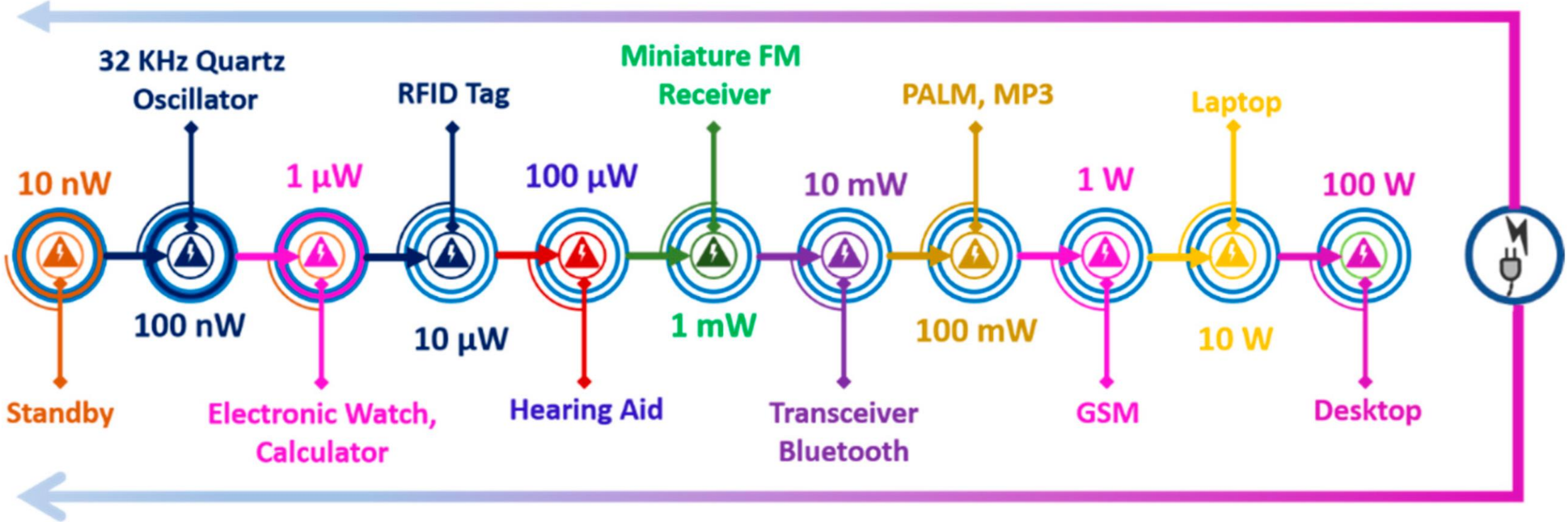
Energy

Green and Renewable Energy: Progress and Jobs



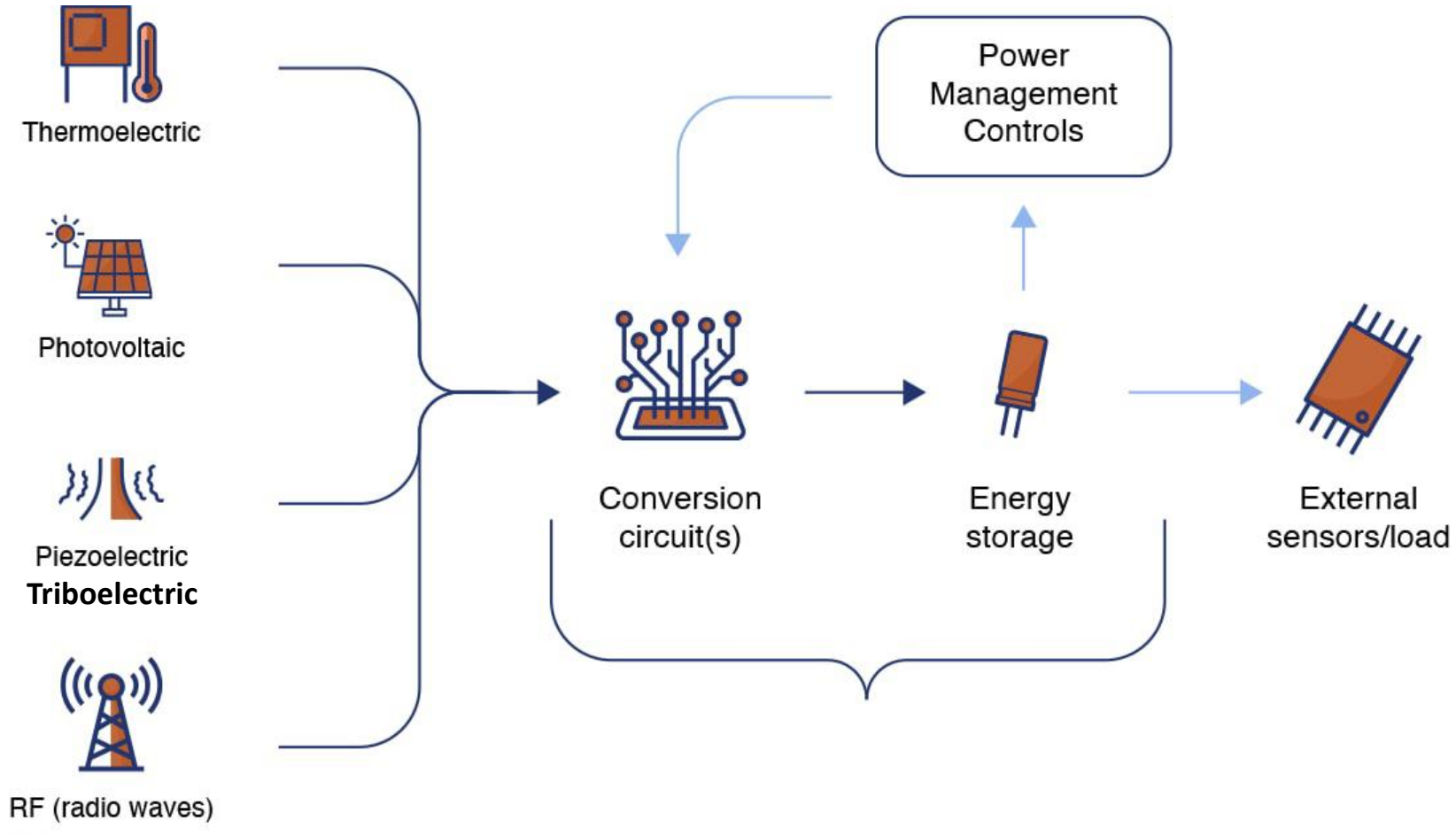
Leading countries – China, Brazil, the United States, India and members of the European Union

Power Requirement of IoT Enabled Smart Electronics



Types of Smart Energy Device: Self-powered Wearables

Self-powered technology means that the device can maintain its own operation by collecting energy in the working environment without an external energy supply. The effective collection of various forms of energy in the working environment is the basis of self-powered technology.



- Wearable Electronics
- Health Monitoring
- Sports and Lifestyles
- Smart Packaging
- Security system
- Automobile

21st Century: The Key Challenges

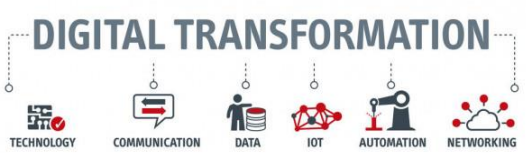
e-Waste Management

Consumption of Electrical & Electronic Equipment (EEE) and Electronic Waste (e-Waste)

Higher levels of Disposable income

Urbanization

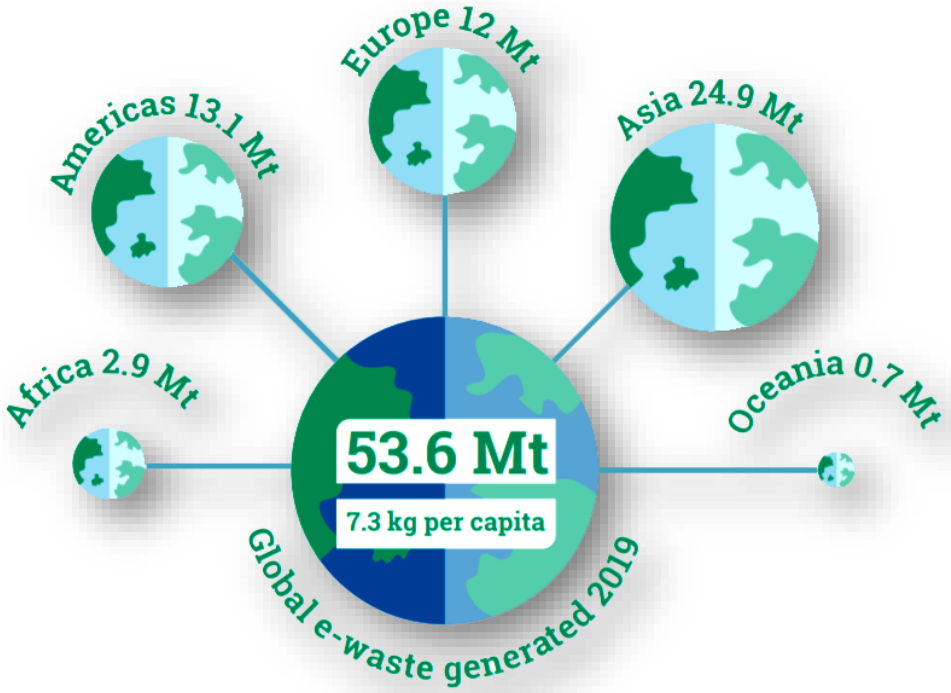
Industrialization



Digitalization

Annual growth of 2.5 Mt

Growth of 9.2 Mt Since 2014



Higher consumption rates of EEE

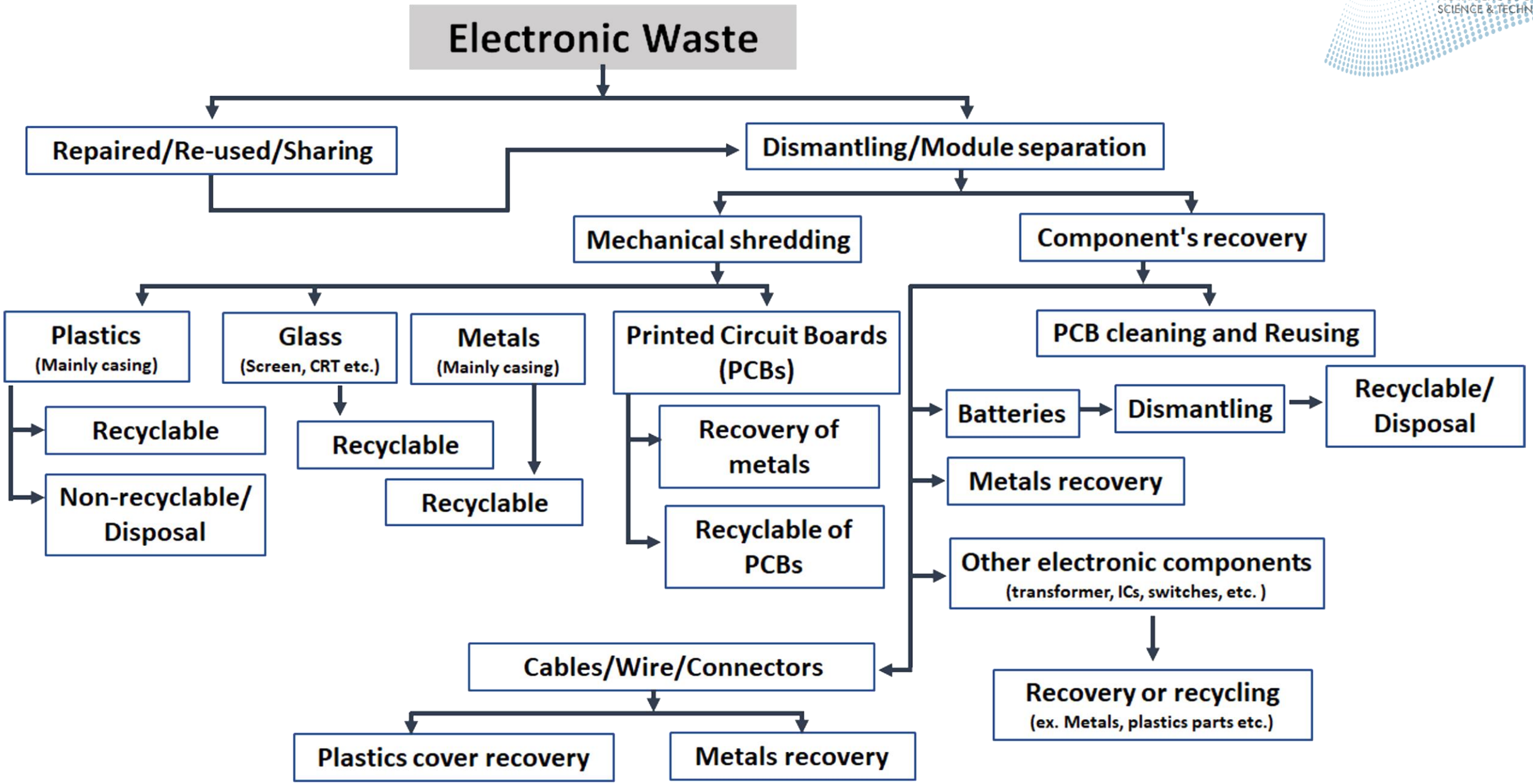
Short life cycles

Less repair options

Ref. The Global E-waste Monitor 2020: Quantities, flows and the circular economy potential.

e-Waste Impact on the Health of Children and Workers

Waste Management: Electronics



Paper Electronics

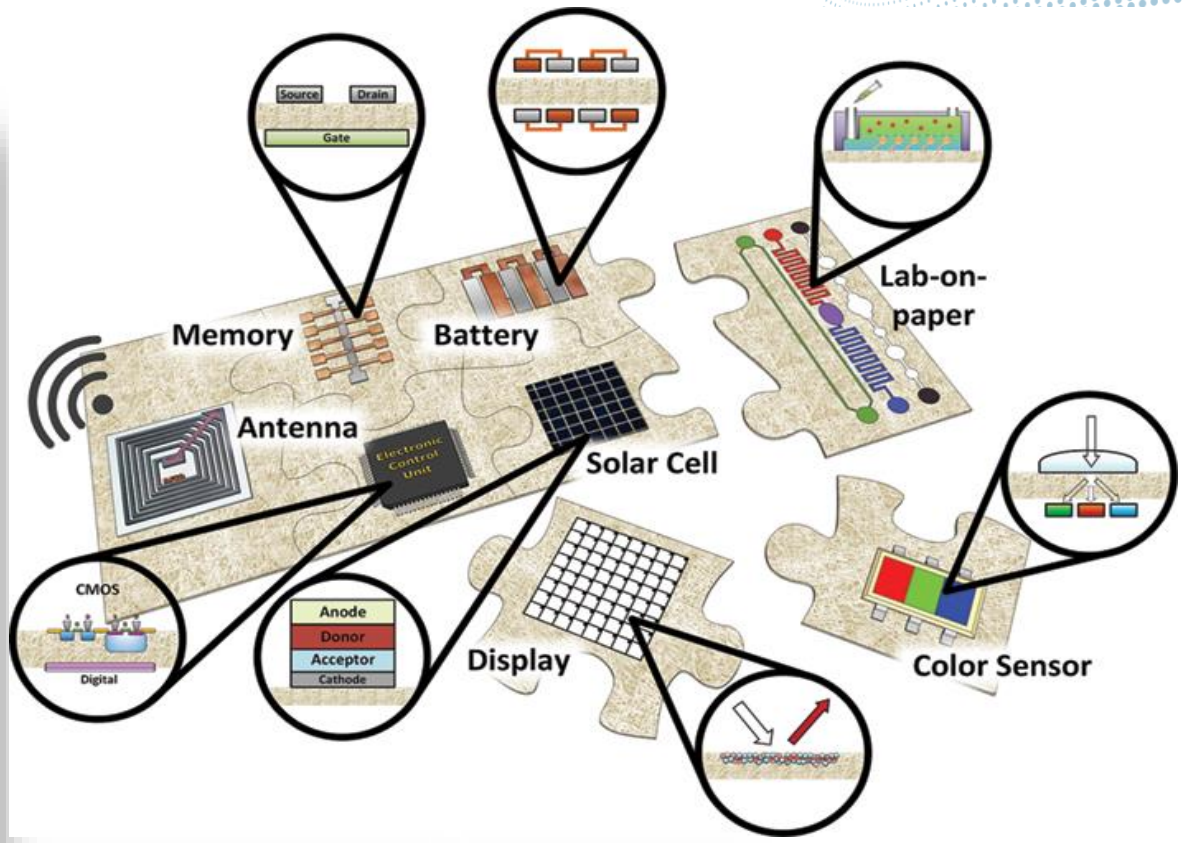
Paper electronics: Towards the step to zero e-waste

There was 53.6 million tonnes (MT) e-waste in 2019, which is a nearly 21% increase in just five years.

Asia generated the greatest volume (around 24.9 MT) followed by the Americas (13.1 MT) and Europe (12 MT). Africa and Oceania generated 2.9 MT and 0.7 MT respectively.

And who takes this e-waste? Most of the developing countries like India, Pakistan, China, Brazil, Africa...*

*Global E-waste Monitor 2020




nature electronics

Editorial | Published: 13 August 2018

A lesson on paper

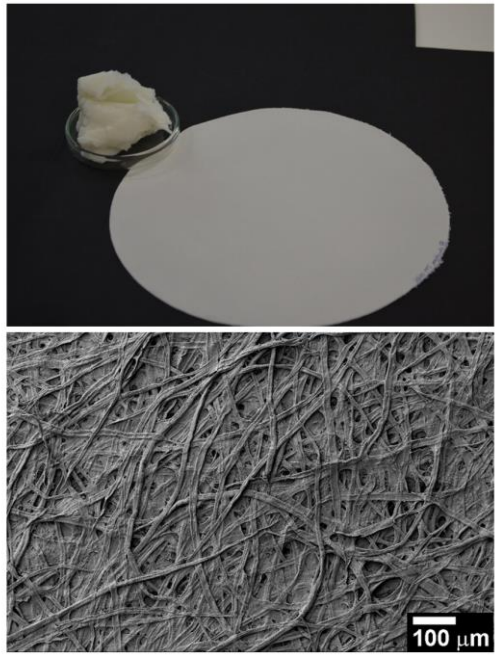
Nature Electronics 1, 429 (2018) | Download Citation

Cellulose: A Contribution for the Zero e-Waste Challenge.
Hall of Fame Review
Adv. Mater. Technol. **2021**, 2000994

Paper or Cellulose can be a high impact alternative choice

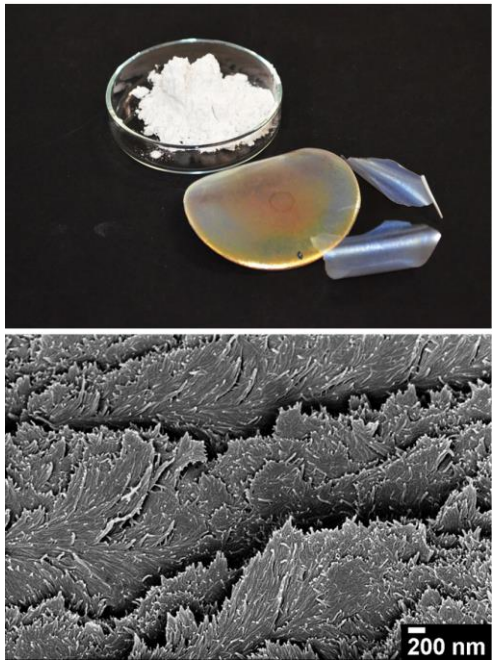
Cellulose: New generation materials

Paper pulp



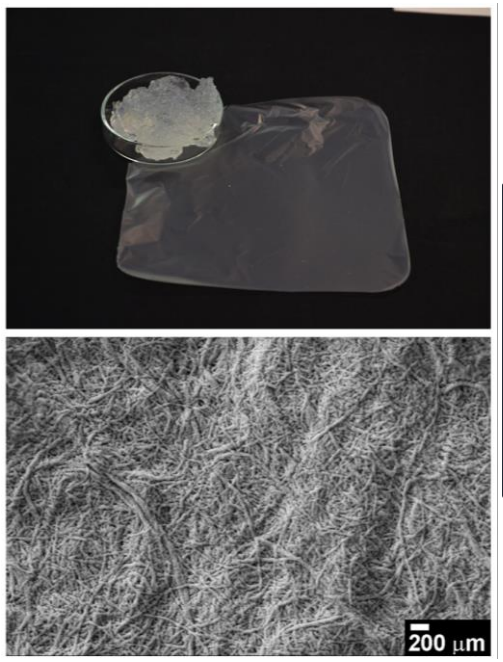
Composed of multiple interconnected elementary fibrils, with **approximate length of 0.5–10 mm and width of 10–100 nm.**
Example: Office paper, Tracing paper, Glassine, Parchment paper, Wax papers, etc.,

Cellulose nano-crystalline



Appear as highly crystalline regions of CFs. Fiber **lengths ranging between 50 and 500 nm and widths between 3 and 5 nm**.

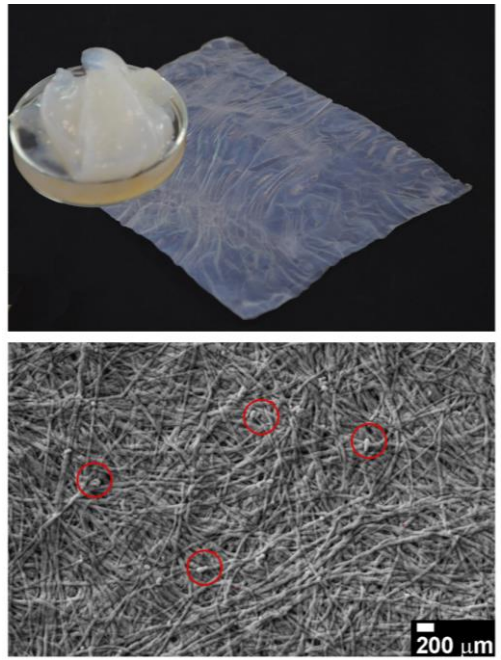
Nano-cellulose



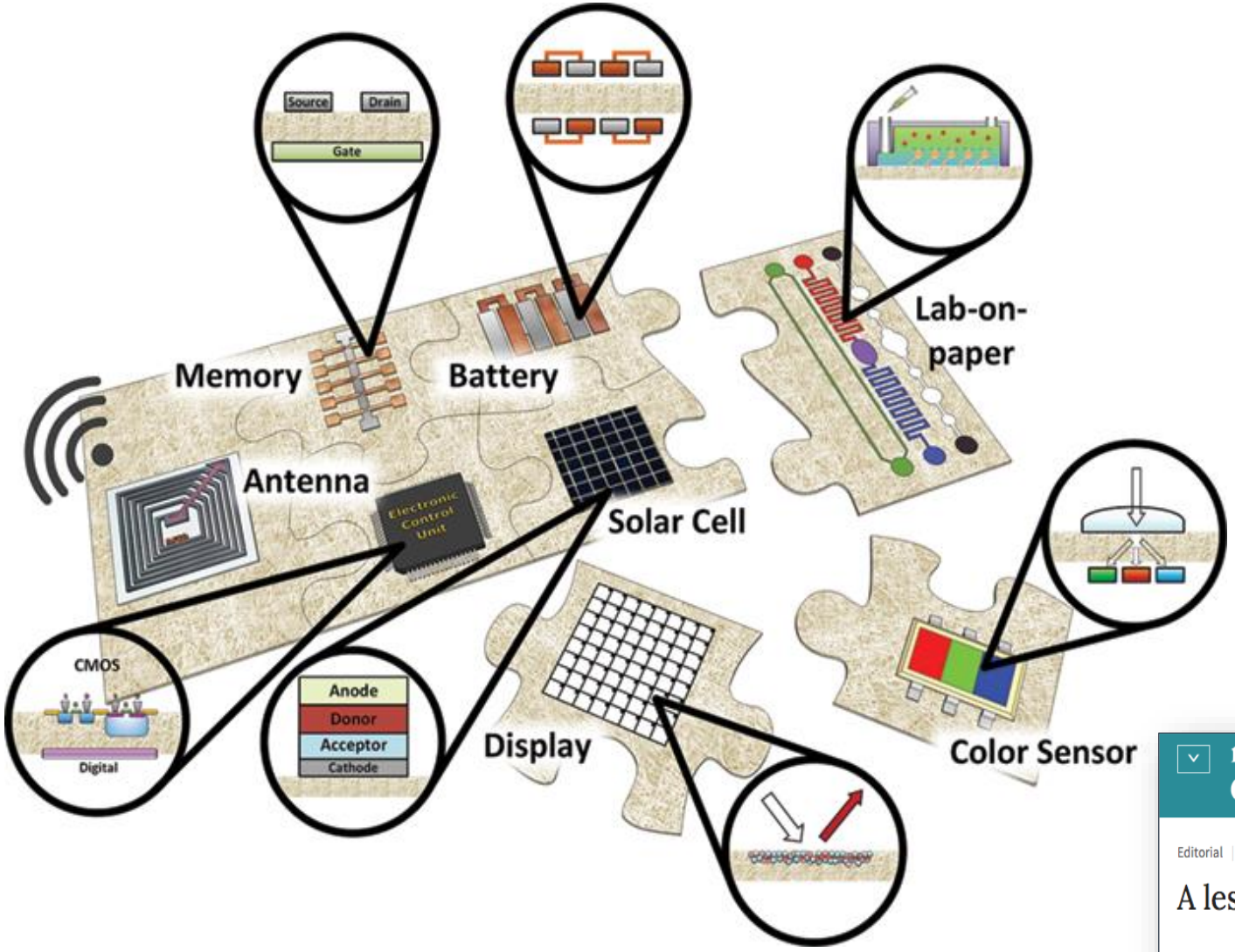
Containing both crystalline and amorphous structures. The elemental fibers **length of 500–2000 nm and width of 4–20 nm**.

Natural cellulose is processed in the presence of microbes or bacteria. The diameter of the **BC fibers typically ranges between 20 and 100 nm.**

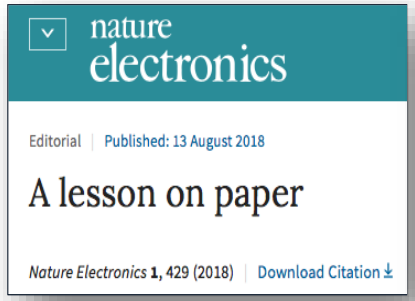
Bacterial cellulose



Paper electronics: Towards the step to zero e-waste



- ✓ Paper or cellulose is most abundant, eco-friendly, low-cost, light weight, flexible materials.
- ✓ Annual paper production volume exceeds 300 Mt, and it turns to 400 Mt.
- ✓ Among all, 70% are recycled.
- ✓ At present, paper recycling in Europe is 71.5%.



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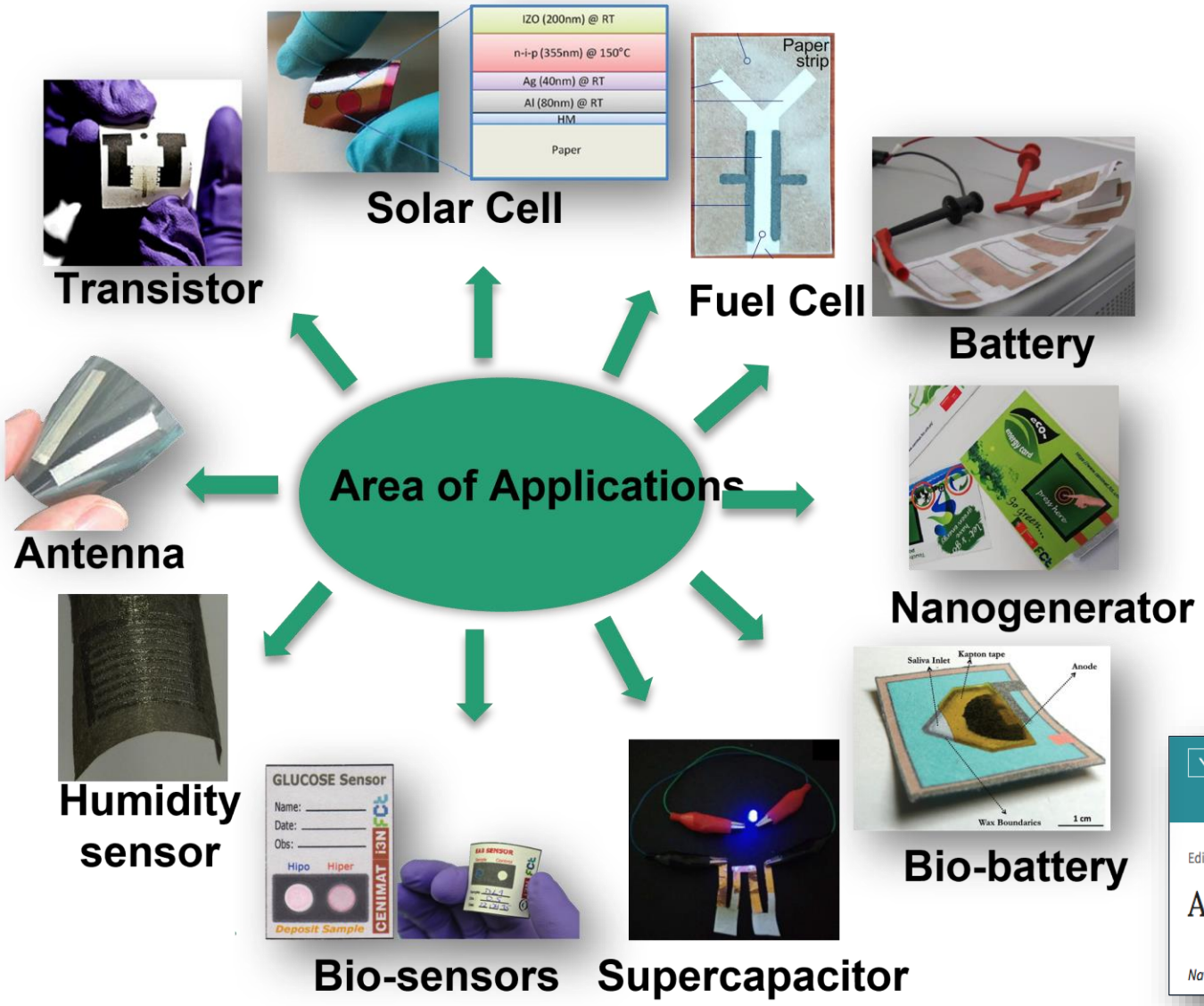

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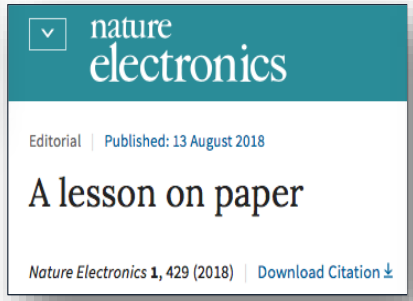

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What is the "Eco-Strategies" ?

Technology side》

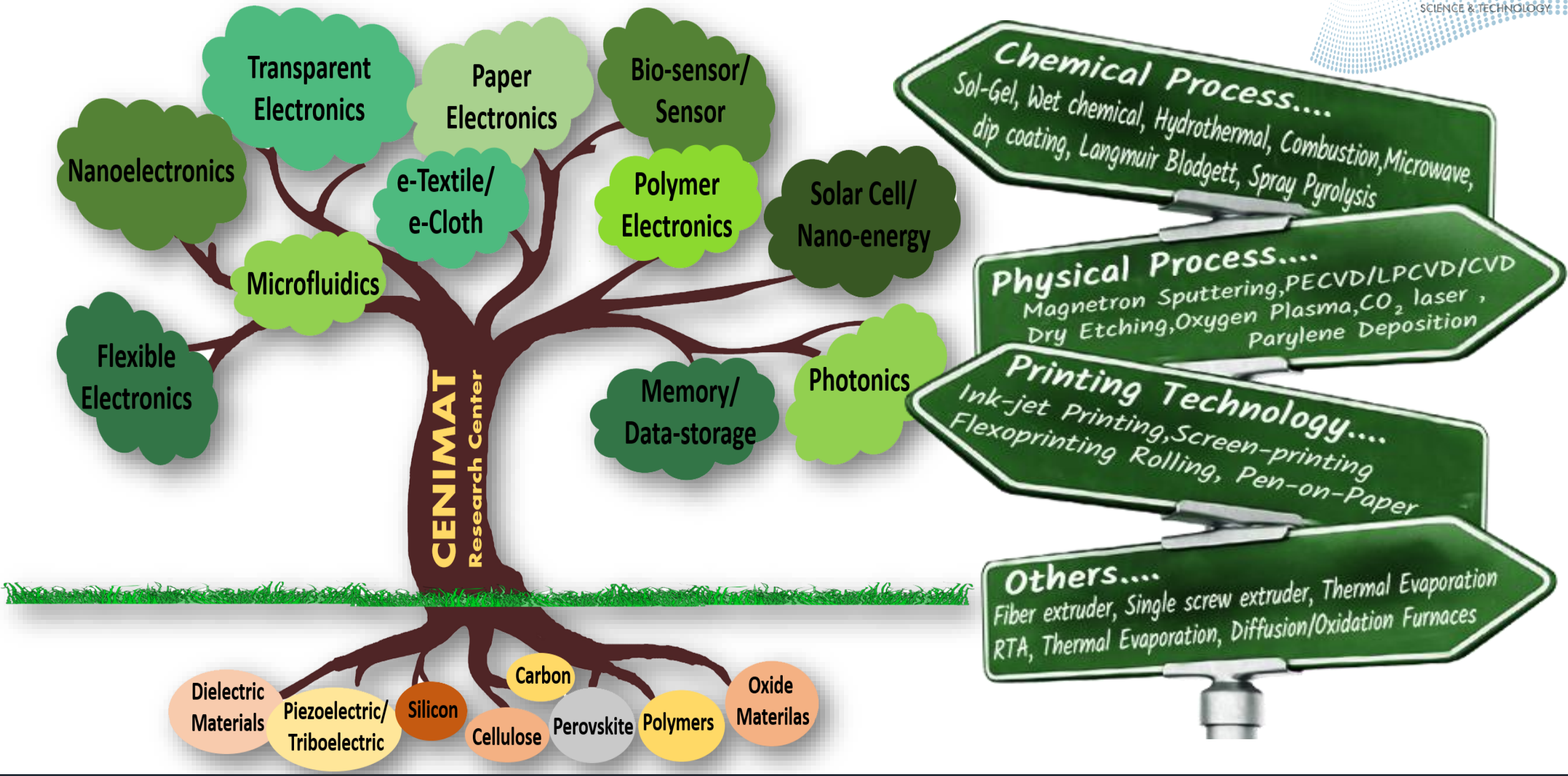
- Decrease Fossil Fuel Dependence /CO_2 Emission
  - Apply Non-carbon Input for Energy
  - Apply Non-fossil Carbon Input for chemicals
- Decrease Critical Element (Rare-metal, Rare-earth, etc.)
  - Consumption and develop Manufacturing Technologies with Ubiquitous Resources
- New Manufacturing Process with minimum power consumption
  - Out of High-temperature /High- pressure / Large-scale cost-effective process
- Cyclic Eco-friendly Production Complex
  - Recycling, Repairing and Reprocessing of used product/materials
  - Proper waste management after end-of product life
- On-demand/Reconfigurable/No-warm-up Production
- Green Technology
  - Low power consumption device manufacturing
  - Minimum circuitry design with highly efficient device output

Eco-Strategy: Five Golden Rules

Siberia, one of the coldest places on Earth, is on fire. The Amazon, one of the wettest places on Earth, is on fire. **Fires are burning across the planet**, we need to act fast.

There is NO Plan(et) B

CENIMAT/CEMOP: At a glance



Thank you!

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SYNERGY

M-ERA.NET
BRIGHT

EMERGE
Emerging Printed Electronics Research Infrastructure

Symbiotic

roll-out

INCM
IMPRENSA NACIONAL CASA DA MOEDA

HORIZON 2020

BET-EU
MATERIALS SYNERGY INTEGRATION FOR A BETTER EUROPE

PORTUGAL 2020

CMA
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erc
European Research Council
Established by the European Commission
Supporting top researchers from anywhere in the world

MERCK

i-FLEXIS
Integrated flexible photonic sensor system

ALMASCIENCE
beyond paper

PRR
Plano de Recuperação e Resiliência

ALMADA
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