Content Unit

Nano and the Circular Economy

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Nano and the Circular Economy

First introduction
Recently, climate change has been a hot topic. To help fight climate change and achieve a better tomorrow, science and society have joined hands. And nano is part of the conversation! As key-enabling technology, nano can help reach the goals of the European Green Deal as well as transition into the circular economy. Let's discover how nanotechnological innovations are already ensuring a better future for all of us!

Practical relevance – This is what you will need the knowledge and skills for
In this unit, you will learn what is the circular economy, the European Green Deal and how nano can contribute to them. Also, you will learn how nano can help us achieve a cleaner and more sustainable environment as well as save energy and fuel.

Overview of learning objectives and competences
In *Understanding the circular economy*, you will learn about the circular economy, the European Green Deal and how nano contributes to them.

In *Nano for a Better Environment*, you will learn how nano helps us reduce environmental waste, develop more sustainable infrastructures, and achieve a cleaner environment.

In *Nano, Energy and Fuel Savings*, you will learn how nano can help produce renewable energy, save fuel and its potential in developing multifunctional materials that will contribute to building and maintaining lighter, safer, smarter, and more efficient vehicles, aircraft, spacecraft, and ships.

Learning objectives	**Fine objectives**
LG_Nano and the Circular Economy_Understanding the Circular Economy	FO_Nano and the Circular Economy 01_01: What is the circular economy? FO Nano and the Circular Economy_ 01_02: Nano and the circular economy_ What is the European Green Deal? 01_03: Nano and the circular economy_Nano in the circular economy and the European Green Deal
LG_ Nano and the Circular Economy_Nano for a Better Environment	FO_ Nano and the Circular Economy 02_01: Nano reducing environmental waste

	FO_ Nano and the Circular Economy 02_02: More sustainable infrastructures FO_ Nano and the Circular Economy _02_03 Nano for a Cleaner Environment
LG_ Nano and the Circular Economy_Nano, energy and fuel savings	FO_ Nano and the Circular Economy 03_01: Nano and renewable energy FO_ Nano and the Circular Economy 03_02 Nanotechnology and fuel savings FO_ Nano and the Circular Economy_03_03 Nanotechnology's potential

1.Understanding the circular economy

To understand the role that nanotechnology can play in the circular economy; it is important to first understand what a circular economy means. The circular economy is « a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended. »

This approach seeks to **reduce waste** to a minimum. Thus, when a product reaches the end of its life, its materials can be productively used again thereby **creating further value**.

The circular economy is thus different from linear economy, which is based on a "take-make-consume-throw away pattern". This model relies on large quantities of cheap, easily accessible materials and energy. One consequence of this model is planned obsolescence. This is when a product has been designed to have a limited lifespan to encourage consumers to buy it again.

Definition
Circular economy The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the **life cycle of products is extended.**

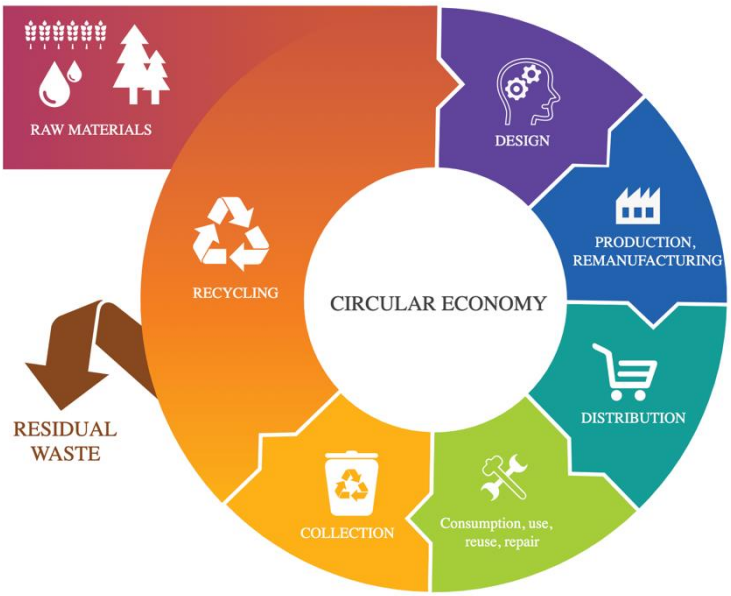
You might wonder why it is important to change to a circular economy. Well, the supply of raw materials is finite. Meanwhile, the global population keeps growing and so does the demand. As well, the extraction and use of raw materials has an impact on the environment which increases energy consumptions and CO_2emissions (European Parliament, 2021).

Measures such as waste prevention, ecodesign and re-use could save EU companies money while also reducing total annual greenhouse gas emissions. The current production of materials we use daily account for 45% of the CO_2 emissions (European Parliament, 2021).

Moving towards a more circular economy could help fight climate change, improve the security of the supply of raw materials, increase competitiveness, stimulate innovation, boost the economy and creating jobs (700,000 jobs in the EU alone by 2030) (European Parliament, 2021).

As a consumer, you will benefit from more durable and innovative products that will increase the quality of life and save you money in the long term.

Figure 1 : The circular economy



A circular economy is part of the ambitions of the European Green Deal. The **European Green Deal** is a set of policy initiatives by the European Commission with the overarching aim of making the European Union (EU) climate neutral in 2050. The climate change and environmental degradation are an existential threat to Europe and the world. To overcome these challenges, the European Green Deal will transform the EU into a modern, resource-efficient and competitive economy, ensuring:

- no net emissions of greenhouse gases by 2050
- economic growth decoupled from resource use
- no person and no place left behind

The European Commission adopted a set of proposals to make the EU's climate, energy, transport and taxation **policies fit for reducing net greenhouse gas emissions by at least 55% by 2030**, compared to 1990 levels (European Commission, 2019).

Important
European Green Deal The **European Green Deal** is a set of policy initiatives by the European Commission with the overarching aim of making the European Union (EU) climate neutral in 2050

Now, you might wonder how does nanotechnology play a role in the circular economy? They are many ways in which nanotechnology can help us reach the European Green Deal goals and help us transition to a circular economy.

Nanotechnology has many implications. As you have learned in our previous texts, at the very small nano-scale, the properties of materials can be different from those on a larger scale. Thus, nanomaterials can help reduce the use of critical raw materials as well as bulk materials, but it can also help us save energy and fuel. Critical raw materials (CRMs) are **raw materials of high importance to the EU economy and of high risk associated with their supply** (European Parliament, 2021.)

Apart from European Green Deal and the European Commission's new Action Plan for a Circular Economy, the EU also launched the new European Industrial Strategy and the Chemicals Strategy for Sustainability. They are all different plans to achieve a sustainable, fair, and inclusive European Union's economy. These plans require that any new material or product should be not only functional, but also safe and sustainable. Nanotechnology is one of the technologies that could enable this green growth (Shan *et al*. 2009).

Definition
Critical raw materials (CRMs) Critical raw materials (CRMs) are **raw materials of high importance to the EU economy and of high risk associated with their supply.**

Figure 2: The benefits of the European Green Deal

In the following sections, you will learn more about how nanotechnology can contribute to the circular economy and the European Green Deal by reducing the number of raw materials used – including CRMs – as well as how it can help reduce the amount of energy and fuel required in the production process as well as in transportation. Finally, you will learn how it can the renewable energy sector more efficient.

Important
Nano in the circular economy and European Green Deal Nanotechnology is one of the technologies that could help us achieve a sustainable, fair, and inclusive European Union's economy.

2. A cleaner and more sustainable environment

Now that you have learned that nanotechnology can help us achieve the goals of the European Green Deal and transition to a circular economy, it is important to understand how nanotechnology can facilitate reaching these goals.

Nanomaterials can help us reduce the environmental burden and industrial and agricultural wastes, as well as control pollution. First, environmental burden reduction involves green process and engineering, emissions control, desulfurization/denitrification of nonrenewable energy sources, and improvement of agriculture and food systems. Second, reduction/treatment of industrial and agricultural wastes involves converting wastes into products, groundwater remediation, adsorption, delaying photocatalysis, and nanomembranes. Regarding water pollution control, nanomaterials alter physical properties on a nanoscale due to their high specific surface area to volume ratio. They are used as catalysts, adsorbents, membranes, and additives to increase activity and capability due to their high specific surface areas and nano-sized effects. In brief, **nanomaterials are more effective at treating environmental wastes because they reduce the amount of material needed** (Shan *et al.* 2009). As we learned before, reducing the amount of material needed is very important since the supply of raw materials is finite.

Nanomaterials can help us reduce the environmental burden, industrial and agricultural wastes, and control pollution

Remember

Nano reducing environmental waste

Nanomaterials are more effective at treating environmental wastes because they reduce the amount of material needed. As we learned before, reducing the amount of material needed is very important since the supply of raw materials is finite.

Nano-engineering of aluminum, steel, asphalt, concrete and other cementitious materials, and their recycled forms offers great promise in terms of improving the performance, resiliency, and longevity of highway and transportation infrastructure components while reducing their life cycle cost. New systems may incorporate innovative capabilities into traditional infrastructure materials, such as self-repairing structures or the ability to generate or transmit energy (NNI, 2018). **This directly contributes to achieving a circular economy by expanding the lifetime of products**.

Nanoscale sensors and devices may provide cost-effective continuous monitoring of the structural integrity and performance of bridges, tunnels, rails, parking structures, and pavements over time. Nanoscale sensors, communications devices, and other innovations enabled by nanoelectronics can also support an enhanced transportation infrastructure that can communicate with vehicle-based systems to help drivers maintain lane position, avoid collisions, adjust travel routes to avoid congestion, and improve drivers' interfaces to onboard electronics (NNI, 2018).

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In addition, there are also many ways that nanotechnology can help detect and clean up environmental contaminants. For instance, nanotechnology can help with low-cost detection and treatment of impurities in water. Engineers have developed a thin film membrane with nanopores for energy-efficient desalination. This molybdenum disulphide (MoS_2) membrane filtered **two to five times more water than current conventional filter**s (NNI, 2021).

Researchers have also developed a nanofabric "paper towel" woven from tiny wires of potassium manganese oxide that **can absorb 20 times its weight in oil for cleanup applications**. Researchers have also placed magnetic water-repellent nanoparticles in oil spills and used magnets to mechanically remove the oil from the water (NNI, 2021).

Moreover, many airplanes' cabins filtres and other types of air filters are nanotechnology-based filters that allow "mechanical filtration," in which the fiber material creates nanoscale pores that trap particles larger than the size of the pores. The filters also may contain charcoal layers that remove odors (NNI, 2021).

As well, nanotechnology-enabled sensors and solutions are now able to detect and identify chemical or biological agents in the air and soil with much higher sensitivity than ever before. One example is a sensor developed by NASA as a smartphone extension that firefighters can use to monitor air quality around fires (NNI, 2021).

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Thus, nanotechnology can help us achieve a cleaner and more sustainable environment in a more efficient way, from treating environmental waste to filtering water and air. Nanomaterials are more effective at treating environmental wastes because they reduce the amount of material needed As well, nano-engineering of materials can make our cities infrastructures more sustainable by increasing the lifecycle of infrastructures such as pavement or bridges.

Remember
Nanotechnology and clean water Engineers have developed a thin film membrane with nanopores for energy-efficient desalination. This molybdenum disulphide (MoS_2) membrane filtered two to five times more water than current conventional filters.

3.Nano, energy and fuel saving

Nanotechnology can contribute to alternative energy approaches to help meet the world's increasing energy demands while helping combat climate change. Researchers are looking into various ways to develop clean, affordable, and renewable energy sources, along with means to reduce energy consumption and environmental pollution. For instance, nanotechnology is improving the efficiency of fuel production from raw petroleum materials through better catalysis. It is also enabling reduced fuel consumption in vehicles and power plants through higher-efficiency combustion and decreased friction. As well, nanotechnology is also used in oil and gas extraction using nanotechnology-enabled gas lift valves in offshore operations and the use of nanoparticles to detect microscopic oil pipeline fractures. (NNI, 2021). Another good example is how nano-thermal coatings on wind turbines enhance the efficiency of wind farms by 25%. Indeed, the nano-thermal coating prevents ice build-up on the wind turbines. (CISION PR Newswire, 2019). As well, epoxy containing carbon nanotubes are being used to make windmill blades that are longer, stronger, and lighter-weight than other blades to increase the amount of electricity that windmills can generate (NNI, 2021).

Another renewable energy sector that nanotechnology can help in solar energy. Indeed, one of the biggest disadvantages of solar energy is the high cost associated with manufacturing solar cells. Furthermore, modern solar cells can lose as much as 10% of acquired power as a result of direct optical loses, since the surface of these cells will reflect anywhere between 2% - 10% of incoming sunlight. Nanotechnology offers the ability to solve this problem. Since nanostructures typically are only a few hundred nanometers in size, they create an interface between the air and the nanostructure, particularly those comprised of silicon, become graded rather than planar. This change in the solar cells' design allows for light to be precisely guided and absorbed into the cell, rather than reflected away (Cuffari, 2018). Moreover, nanotechnology can be incorporated into solar panels to convert sunlight to electricity more efficiently, promising inexpensive solar power in the future. Nanostructured solar cells could be cheaper to manufacture and easier to install, since they can use print-like manufacturing processes and can be made in flexible rolls rather than discrete panels. Newer research suggests that future solar converters might even be "paintable" (NNI, 2018).

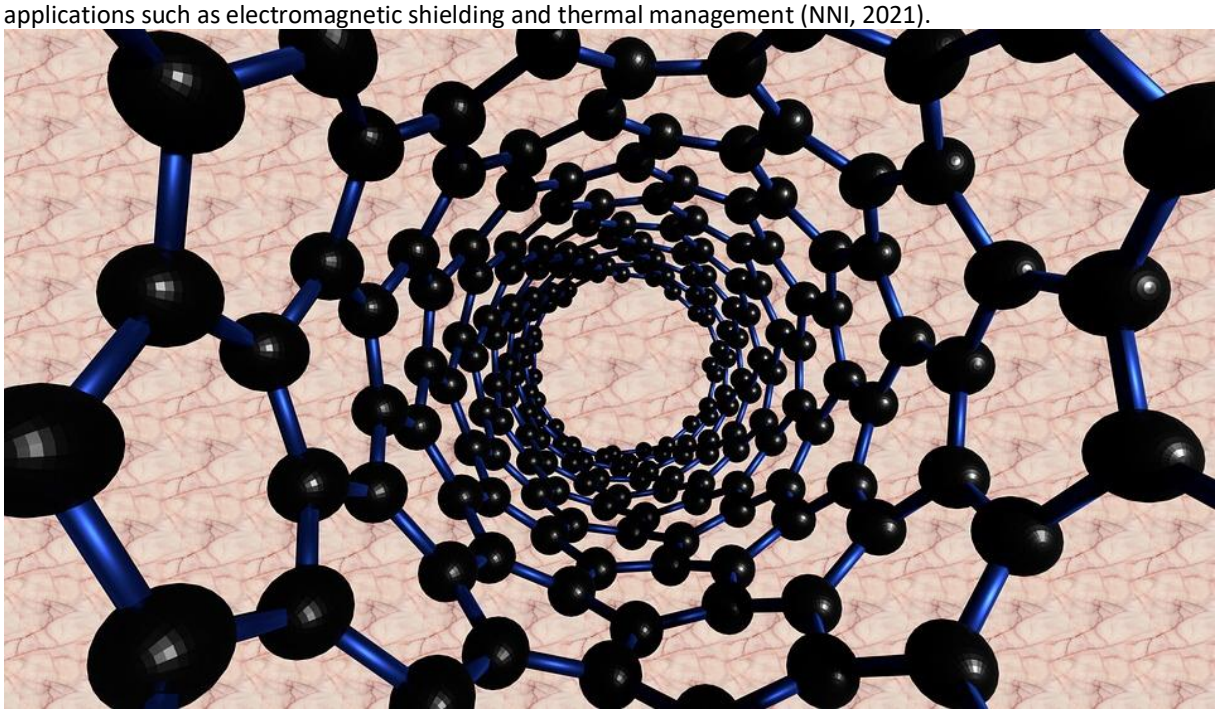
Furthermore, wires containing carbon nanotubes are being developed that will have much lower resistance than the high-tension wires currently used in the electric grid, thus reducing transmission power loss. Similarly, various nanoscience-based options are being pursued to convert waste heat in computers, automobiles, homes, power plants, etc., to usable electrical power (NNI, 2018).

Energy efficiency and energy saving products are increasing in number and types of application. In addition to those noted above, nanotechnology is enabling more efficient lighting systems; lighter and stronger vehicle chassis materials for the transportation sector; lower energy consumption in advanced electronics; and light-responsive smart coatings for glass.

Thus, nanotechnology can help us create more efficient products which minimize the loss of energy and maximize outputs.

Remember
Nanotechnology in renewable energy Nanotechnology can help us create more efficient products which minimize the loss of energy and maximize outputs.

Early we mentioned how nano can help us save fuel. Indeed, nanotechnology can lightweight cars, trucks, airplanes, boats, and space craft which could lead to significant fuel savings. As we learned before, the incredible properties that nanomaterials have able us to have materials that are as resistant as the bulk material, but to weigh less. Nanoscale additives in polymer composite materials are also being used in baseball bats, tennis rackets, bicycles, motorcycle helmets, automobile parts, luggage, and power tool housings, making them lightweight, stiff, durable, and resilient. Carbon nanotube sheets are now being produced for use in next-generation air vehicles. For example, the combination of light weight and conductivity makes them ideal for applications such as electromagnetic shielding and thermal management (NNI, 2021).



Carbon nanotube

Moreover, nanotechnology is improving the efficiency of fuel production from raw petroleum materials through better catalysis. It is also enabling reduced fuel consumption in vehicles and power plants through higher-efficiency combustion and decreased friction (NNI, 2021).

Remember
Nano and fuel saving Nanotechnology is improving the efficiency of fuel production from raw petroleum materials through better catalysis. It is also enabling reduced fuel consumption in vehicles and power plants through higher-efficiency combustion, decreased friction and lightweighting.

In brief, nanotechnology offers the promise of developing multifunctional materials that will contribute to building and maintaining lighter, safer, smarter, and more efficient vehicles, aircraft, spacecraft, and ships. In addition, nanotechnology offers various means to improve the transportation infrastructure.

As discussed above, nano-engineered materials in automotive products include polymer nanocomposites structural parts such as:

- high-power rechargeable battery systems
- thermoelectric materials for temperature control
- lower rolling-resistance tires
- high-efficiency/low-cost sensors and electronics
- thin-film smart solar panels
- fuel additives and improved catalytic converters for cleaner exhaust and extended range.

To summarize, nano can make renewable energy more efficient and save fuel by improving the efficiency of fuel production from raw petroleum materials through better catalysis and enabling reduced fuel consumption in vehicles and power plants through higher-efficiency combustion, decreased friction and lightweighting.

Remember
Nanotechnology's potential Nanotechnology offers the promise of developing multifunctional materials that will contribute to building and maintaining lighter, safer, smarter and more efficient vehicles, aircraft, spacecraft, and ships.

1.Save knowledge

Summary

You reached the end of the content unit 'Nano and the circular economy'. As there was a lot to learn, please check out this quick summary of the most important things you learned about this topic:

Nanotechnology has many implications. As you have learned in our previous texts, at the very small nano-scale, the properties of materials can be different from those on a larger scale. Thus, nanomaterials can help reduce the use of critical raw materials as well as bulk materials, but it can also help us save energy and fuel. (European Parliament, 2021.)

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