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VERAM

Vision and roadmap for European raw materials

Vision for Raw Materials in Europe and for Europe Part I

D4.1 – Report on economic outlook and raw material needs for 2050

WP4 – Creating a vision 2030 and 2050 for raw materials

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Disclaimer

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The EU economic outlook as available/predictable today forecasts an increase in raw material needs for whichever scenario of a future society we choose!
Despite higher resource efficiency in production and use and higher circularity of value chains, efforts in the predictable future will be offset by

- **growth and partially aging of world population**
- **aspired improved standard of living**
- **higher environmental and climate protection requirements**

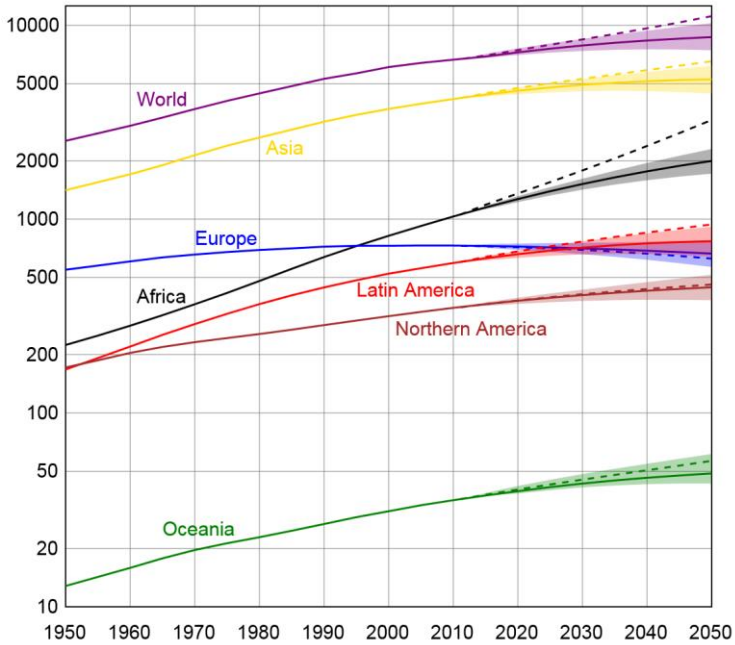
I. The General Economic Vision till 2030 and 2050

1. Introduction - Addressing key global and European challenges till 2050

The global population is forecast to reach 9 billion by 2030, including 3 billion new middle-class consumers. This places unprecedented pressure on natural resources to meet future consumer demand. Balancing resource supply and demand in the 21st century: Projections for energy technology, urbanisation and economic growth will dramatically increase the demand for all raw materials. In addition, in Europe and other parts of the world aging populations creates additional challenges. The ESPAS Report[i] on Global Trends to 2030 sets out five global trends.

2. Population growth and change

Demographic changes, in particular population growth in developing countries and an ageing population in developed countries, coupled with increasing standards of living and urbanisation trends will foster a greater demand for products and applications linked to human well-being, health, hygiene and sustainability. As a consequence, the worldwide demand for raw materials is expected to increase while global resources and land become less available.



World population growth predictions
Source: United Nations, 2016

To meet the challenges caused by an increased, continuous demand for sustainably sourced raw materials, reduced access to natural resources and climate change, a shift towards a more resource-efficient, circular economy and sustainable development is becoming more crucial than ever.

Food: The projections show that feeding a world population of 9.1 billion people in 2050 would require raising overall food production by some 70 per cent between 2005/07 and 2050 (High Level Expert Forum - How to Feed the World in 2050, Italy 2009).

Water: Nearly 1 billion people still do not have access to improved sources of drinking water and there are more people without access to tap water in cities today than there were at the end of the 1990s. (UN World Water Development Report, 2014)

Energy: The global energy system has to be transformed in order to limit the global temperature rise to below 2°C in the present century. The world needs to increase the share of renewable energy in TFEC from 19% in 2017 to two-thirds by 2050. In parallel, the global economy needs to reduce energy intensity by 2.8% per year on average to 2050, compared with the 1.8% annual fall achieved in recent years. This would bring global energy consumption in 2050 to slightly below current levels despite significant population and economic growth over the period. (IRENA 2018[1]).

[1] IRENA (2018), Global Energy Transformation: A roadmap to 2050, International Renewable Energy Agency, Abu Dhabi.

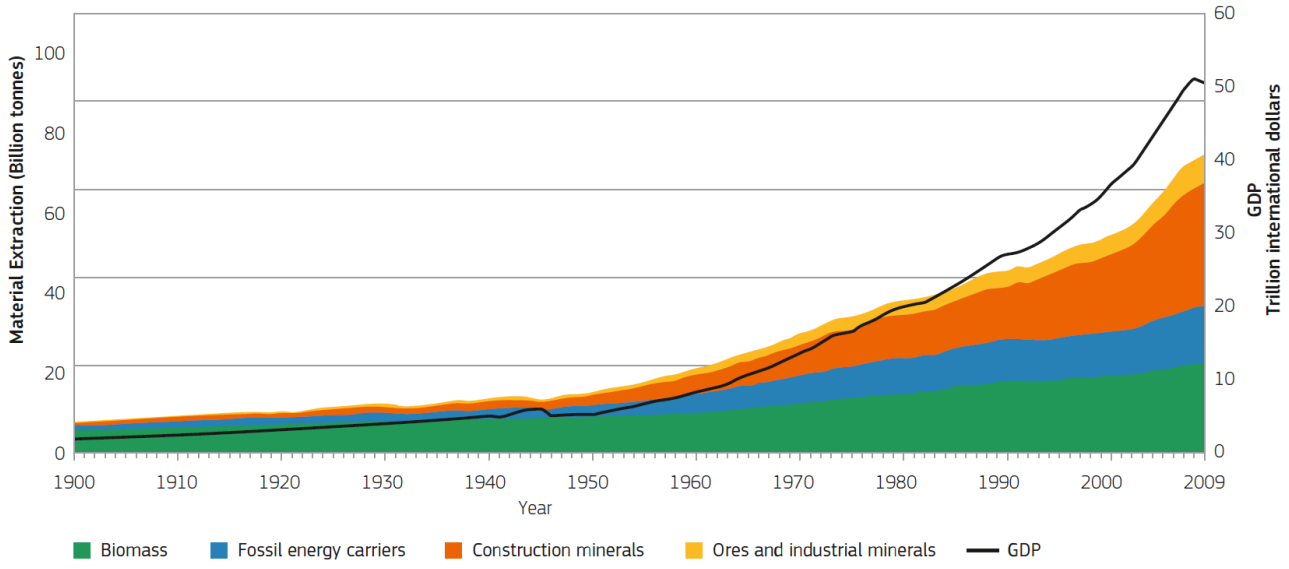
Land is limited: Rural areas producing raw materials provide a livelihood for hundreds of millions of people worldwide. Deforestation in developing countries can cause desertification, soil erosion, loss of clean water supply and loss of biodiversity.
At the same time the multi-functionality of forests and other rural areas, provides spiritual recreation and more.
The social and environmental benefits for consumers are easily taken for granted, but in an increasingly urbanised world, forest services are becoming ever more valuable both for society and forest owners. Providing them in the face of changing and potentially conflicting demands, and significant regional differences across Europe, requires continuous research into new management strategies, ecosystem businesses and innovative service concepts.

Availability of labour force: Widespread ageing will probably have major repercussions on the labour force, personal savings and global productivity. Social protection systems in the advanced countries, particularly in Europe, will come under pressure, especially in the health sector, and will struggle to manage the consequences of old-age dependency. Perhaps even more than the ageing of its population, it is the threat of a long-term decline in its active population that gives cause to fear for Europe's economic prosperity and standing in the world. The shrinking of its labour force will put a downturn pressure on economies and could induce long-term stagnation, unless there are significant gains in productivity, coupled with focused approaches to education and training.

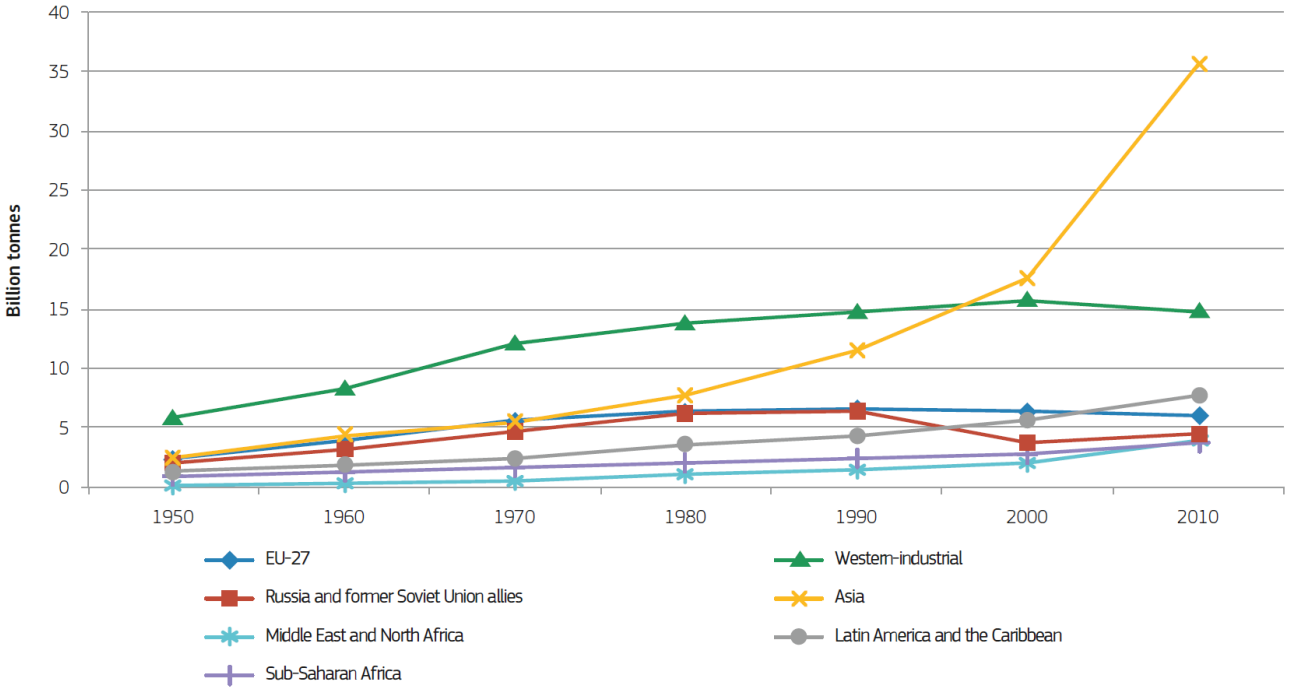
Productivity: Almost all current analyses and forecasts foresee a fall in productivity over the coming decades and therefore a long period without substantial economic growth.

For raw materials that means that the next 20 to 30 years will still see an increase in material demands because of:

- the sheer numbers of human beings and their growing demands,
- the large volumes of material have gone and will continue to go into infrastructure and housing which has an average lifetime of 30 to 100 years,
- new technologies are not necessarily material poorer,
- new technologies are going to support the aging population and hence this will result in more machinery/robots and hence use of materials,
- the access to some materials for recycling will only be facilitated with the next generation of products.



Global material extraction by resource type and GDP (1900-2009).
Source: EU Raw Material Scoreboard, page 12 (adapted from UNEP, 2011; and EEA, 2015)



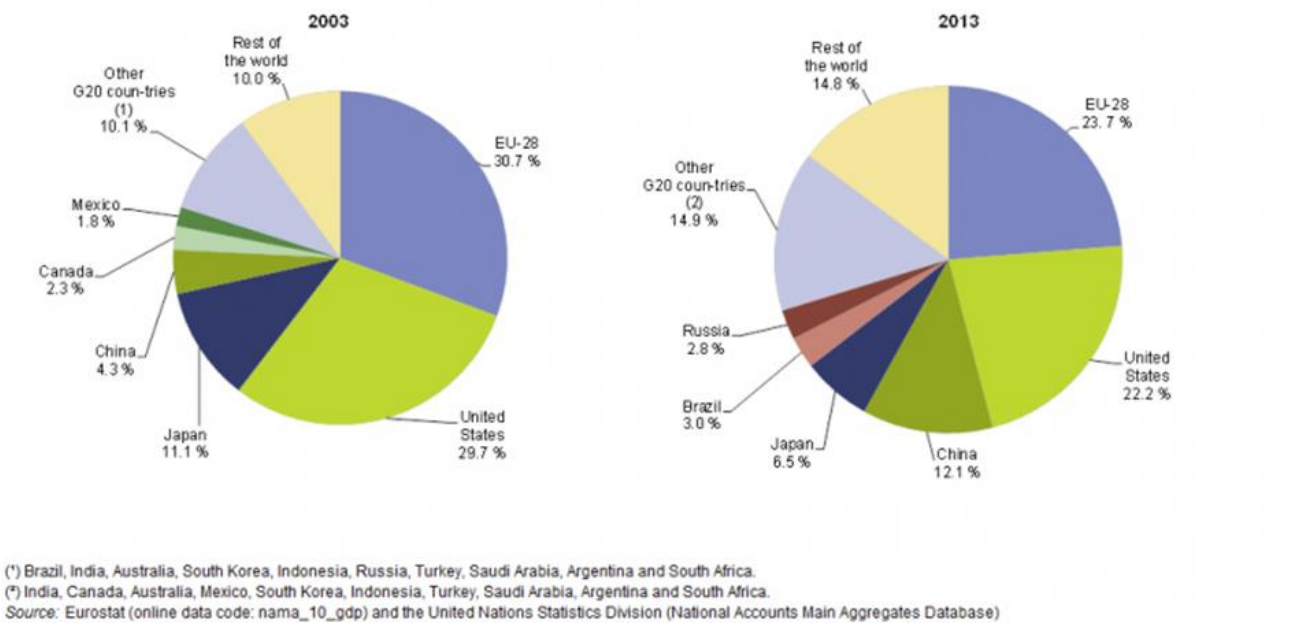
Domestic material consumption per region (1950-2010)
Source: EU Raw Material Scoreboard, p. 13 (Schaffartzik et al, 2014).

Raw materials are essential for sustainable development and the production of low-carbon technologies necessary to meet its climate and energy objectives. The demand for certain raw materials is expected to increase the by a factor of 20 by 2030.

3. The economic weight is shifting

The OECD economic experts[ii] forecast "*that once the legacy of the global financial crisis has been overcome, global GDP could grow at around 3% per year over the next 50 years. Growth will be enabled by continued fiscal and structural reforms and sustained by the rising share of relatively fast-growing emerging countries in global output.*
Growth of the non-OECD will continue to outpace the OECD, but the difference will narrow over coming decades. From over 7% per year over the last decade, non-OECD growth will decline to around 5% in the 2020s and to about half that by the 2050s, whereas trend growth for the OECD will be around on average 1¾ to 2¼% per year.
The next 50 years will see major changes in the relative size of world economies. Fast growth in China and India will make their combined GDP measured at 2005 Purchasing Power Parities (PPPs), soon surpass that of the G7 economies and exceed that of the entire current OECD membership by 2060."

Notwithstanding fast growth in low-income and emerging countries, large cross-country differences in living standards will persist in 2060. Income per capita in the poorest economies will more than quadruple by 2060, and China and India will experience more than a seven-fold increase, but living standards in these countries and some other emerging countries will still only be one-quarter to 60% of the level in the leading countries in 2060. Domestic raw materials production in Europe creates EUR 280 billion of added value and more than four million jobs. But if the EU is not going to look after its own resource base, this will change.



Share of world GDP, 2003 and 2013 (%) EU world15
Source: Eurostat

But what has already been seen over the last decade will continue. A new global 'middle class' in the emerging countries will expand rapidly, mainly in cities, and particularly in Asia. The shift in the world economy towards Asia will continue; trade in goods may slow down, with service and investment flows increasing; emerging nations will be forces for global economic and political change; an 'economic G3' — United States, China and the European Union — will dominate, with China expected to rise to first place.

Source: OECD, *Note: Emerging refers to non-OECD countries*

Predictions state that the United States, Europe and China will account for almost 55% of the world's GDP in 2030. The main change is related to their position relative to one another: China's gross domestic product is expected to overtake both the European Union and the United States. The European Union would drop to second place and the United States to third. Without any major political accidents, China should remain by far the largest advanced emerging economy, more than 2.5 times the size of the Indian economy.

After 2030, however, India's growth rate could outstrip China's because of its dynamic population growth, although that will not be enough to outstrip total Chinese GDP in the foreseeable future. At the same time, new economic powers — notably Mexico and Indonesia — are likely to emerge and join the current middle-ranking group, which will still include Brazil, Japan and possibly Russia.

For raw materials that means that in the coming years the manufacturing centre of the world for consumer goods and IT goods will remain in Asia and the European economy will remain dependent in many raw materials on China in particular, unless alternative sourcing can be established and further developed. The sustainability of the imported raw materials will gradually improve; however, the juxtaposition of the EU's restrictive environment and energy policies on the one hand and its aging population have less purchasing power in the future favouring cheap products and the Chinese economic policy on the other hand will continue to be a hindrance to the competitivity of non-Chinese raw materials production and manufacturing.

Europe is confronted with several challenges along the entire raw materials value chain that is composed of exploration and management, extraction and harvesting, processing and refining, manufacturing, use and recycling as well as substitution. Yet, innovation in raw materials value chains remains untapped despite the sector's great potential.

A more coordinated approach towards raw materials management will help reduce external supply dependency and lead to an efficient use of existing resources. Meanwhile, trends such as the emerging "sharing economy" and changing raw material demands as new technologies develop, will reshape the world we live in and influence our need for raw materials. The opportunities enabled by emerging technologies, digitalisation, artificial intelligence (AI) and additive manufacturing applications will bring about unforeseeable breakthroughs in technologies and the organisation of human work.

Securing reliable and undistorted access to raw materials and developing domestic value chains are crucial to boosting growth, jobs and competitiveness in Europe. Currently, the EU is dependent on imports of many raw materials that are crucial for a strong European industrial base.

4. A revolution in technologies and their applications

The first industrial revolution (from 1760 to 1840) was launched by the development of the steam engine, the mechanisation of textile manufacture and the use of coke instead of charcoal, followed by the mass production of steel and lastly the development of the railways. The second industrial revolution (from 1870 to 1914) was triggered by the mass production of steel, electrification, telecommunications, and lastly the development of the motor car and the production line.

Although there has been an undeniable social impact, the development of information and communication technologies has not yet given rise to an industrial revolution on the scale of the 18th and 19th centuries. Core digital technologies are evolving and converging rapidly, fuelled by broad territorial connectivity and real-time, real-world data. We may be on the brink of a real third industrial revolution. United States' digital exports are already close to EUR 500 billion. This makes them the third-largest category of exports, with Europe as the main client.

A technological revolution based on new industrial production, bio-scientific, communication and digital processes will transform societies; the speed of technological change is accelerating; autonomous decision-making processes will rapidly rise; Europe and the United States will remain world leaders in science and knowledge-creation, though worries persist about applied research.
In 2030 the following can be expected:

- The 'Internet of things': big data and data-mining, cloud computing and super-calculators, brain-machine interfaces and sensors. Multiplication of big data will affect and transform the whole of society. Collecting, purchasing and controlling these data will be regarded as an essential resource for the economies and societies of the future. In 2020, more than 50 billion items, ranging from cars to coffee machines, will be connected to the Internet. The mass of data generated could represent an incalculable resource for those who can access and interpret them.
- Cloud computing revolutionises IT platforms while reducing operating costs, with very significant growth potential (with a turnover reaching EUR 174 billion in 2020, against EUR 30 billion in 2011). The economic impact of its use could be around EUR 1.2 to EUR 4.5 trillion in 2025.
- Intelligent mobility: in 2030, 75 % of the world's population will have mobile connectivity and 60 % should have broadband access. Energy, transport and information systems will be closely linked by sensors of all kinds.
- Modelling and enhanced (virtual) reality will be everyday design tools across a broad spectrum, including infrastructure, cars and aircraft, and climate forecasting for example.

- Ubiquitous sensors will govern communications devices (including future smartphones), clothes, houses, vehicles and drones. It will be possible to merge information with satellite data and to use it for predictive modelling of events, like pollution or traffic.
- Additive transformation (3D printers) will play a significant part in industrial production systems, with impacts on the costs and localisation of production.
- A combination of robots, nano-technology and artificial intelligence will replace humans engaged in repetitive and advanced production or even in household services. By around 2025, autonomous and even self-teaching algorithms will enable vehicles, mini-drones and anthropomorphic robots to operate autonomously.
- A combination of nano-, bio- and information-technology will revolutionise healthcare.
- The generation of smart materials that react in an engineered way to stimuli such as electrical current, temperature fluctuations, or chemical compounds would be useful in a broad range of domains, such as wood preservation, healthcare, packaging and the media.
- Advanced metals and minerals with innovative self-healing properties will reduce maintenance needs significantly.

In 2030, it can be assumed new regional innovation and production centres will be established in North America, Europe and Asia. Their power of development will depend on the openness of markets, university and technological infrastructures, trade and information circuits and the financial capacity available for business development. Such locations will strongly affect the productivity, growth and wealth of the economies of the countries where they are sited.

For raw materials that means the sector needs to embrace these developments for its own development, but also as an opportunity to provide new materials and services.

Additive transformation (3D printers) will play a significant part in industrial production systems, with impacts on costs and localisation of production, but also on specialisation and customisation and the potential for designs and materials uses which can facilitate the reuse, recovery and recycling of raw materials and contribute to resource efficiency in a much more systematic way.

5. Global nature of the European Union geo-political interests

The geopolitical and commercial requirements for competitiveness will be closely associated with the access to resources, the control of operating technologies, patent protection for products, the ability of Europe to create and develop such an innovation and production cluster and leverage its strengths, and to promote sustainability worldwide. Now a fact of global life, the interdependence of economies and trade partners is not matched by strengthening global governance.

The European Union's awareness of its global interests has increased in the recent past and is reflected by the increasing importance of foreign policy in European Union Treaties since Maastricht: in particular the foundation of the European External Action Service (EEAS). Member States are more aware than before that common positions and a common voice can make a difference on the world stage.

With the Lisbon Treaty, the European Union established for itself a clearer roadmap of objectives on the international scene, based on democratic values, promotion of peace and defence of European Union interests.

By 2030, the European Union's strategic interests should probably be expressed more clearly, since fragmentation and global insecurity may well force the Union to take on more responsibilities for its security and possibly its defence and hence the access to specific raw materials.

For raw materials that means that a more strategic approach needs to be developed.

On the one hand the EU needs to continue to invest in the exploration of its own resources, access to them and their sustainable and competitive processing, but also the development of new materials for new arising markets with attention to their life-cycle from cradle to grave.

But it also needs to address issues such as land-use planning and the NIMBY phenomenon resulting for past legacies and bad experiences. In particular it needs to strategically address the rehabilitation of its coal mines and the social restructuring of these regions if it does not want to create additional re-enforcement of the NIMBY effect for decades to come.

It should seek strategic alliances with those countries that have interests in developing their own resources and not only attempt trade in resources, but develop joint industrial activities beneficial for both sides.

Whilst the dominance of China in the area of non-biotic resources is likely to continue for the coming decades, the EU should try to either develop its own resource base but protect it against the "unfair, unsustainable competition", or seek better cooperation to improve standards.

6. The EU needs to regain its economic vigour and resilience till 2030 and 2050

By 2050, the EU must secure a resilient and sustainable raw material supply base for the entire life-cycle in the EU to ensure competitiveness and growth of Europe by contributing to the:

- increase of well-being and standard of living,
- Improvement of quality and quantity of employment,
- Improvement of the health of its population,
- Improvement of the environment,
- Increase its innovative capacity and,
- Underpinning the UN's Sustainable Development Goals within and outside of Europe and contribute to the alleviation of poverty worldwide.

6.1. The need for a comprehensive industrial policy

In its resolution, the European Parliament stated that the European industry is a global leader in many industrial sectors, accounting for over half of Europe's exports and around 65 % of research and development investments, and providing more than 50 million jobs (both directly and indirectly), meaning 20 % of jobs in Europe[iii]. Up until today the contribution of the European manufacturing industry to the EU's GDP has decreased from 19% to less than 15.5% during the last 20 years and its contribution to jobs and investment in research and development has declined during that period.

EU policy needs to enable and strengthen European industry to preserve its competitiveness and capacity to invest in Europe, to keep expertise and know-how in the EU and to address all social and environmental challenges.

The European Council Conclusions on a future EU industrial policy strategy in its meeting on 22 and 23 June 2017 stressed:

"(1) the essential role of industry as a major driver for growth, employment and innovation in Europe and its contribution to the Union's prosperity, as well as the critical importance of industry for dealing with major transformations in the EU economy, including sustainability, servitisation and digitisation with specific emphasis on enterprises of all sizes operating in the manufacturing industry and related services sectors;
(2) that industry and related services in the EU are operating in a highly dynamic global environment, involving technological, societal and sustainability challenges; and that it is essential to enhance the attractiveness of Europe's industrial ecosystems for stimulating investment;
(3) the importance of fostering a competitive, forward looking and innovative industrial base in Europe; and acknowledged that a holistic industrial policy approach based on integrated value chains, inter-clustering linkages and activities is crucial, with a particular focus on SMEs, start-ups, scale-ups and mid-caps; this approach should include, when necessary, sectorial initiatives for sectors facing economic change and high growth potential sectors;[iv]
(…)
In particular with regard to industrial policy it:

1. Underlines the essential role of industry as a driver for sustainable growth, employment and innovation in Europe;

2. Emphasises the importance of strengthening and modernising the industrial base in Europe, while recalling the EU's target of ensuring that 20 % of Union GDP is based on industry by 2020;

3. highlights the fact that this Union strategy must be based inter alia on digitalisation, on an energy- and resource-efficient economy and on a life-cycle and circular economy approach;
(…)
5. Stresses that the competitiveness clusters, business networks and digital innovation hubs are a very useful solution for bringing together relevant stakeholders; calls for the EU to support public investment in innovation, as it is strategic in this domain; asks the Commission to support these clusters and their cooperation at European level, ensuring the involvement of SMEs, research centres and universities at regional and local level; calls on the Commission to develop smart specialisation platforms encouraging inter-sectoral and interdisciplinary links; stresses the need to strengthen interregional cooperation in order to develop transnational opportunities and transversal innovation alliances;

6. Highlights the importance of the Energy Union, the Digital Single Market, the Digital Agenda and Europe's connectivity through adequate, future-proof and efficient infrastructure;

7. Stresses the importance for the EU of supporting the qualitative rise of European products through reindustrialisation processes, notably through research and digitalisation, in order to improve competitiveness in Europe;"

6.2 Jobs, growth and competitiveness

Europe needs jobs, growth and competitiveness. The return of economic growth to all 28 Member States is a positive development that needs to be consolidated. The European Council discussed how to best use the potential of the Single Market and of trade and industry to that effect, while ensuring that these developments benefit all parts of society. The European Council therefore emphasises that further efforts are needed from the EU and its Member States to achieve the level of ambition as reflected in the June 2016 conclusions for the Single Market, including on services, the Digital Single Market, the Capital Markets Union and the Energy Union, including interconnections.

Building on the Council conclusions of May 2017, which call for a future industrial policy strategy, the European Council underlines the essential role of industry as a major driver for growth, employment and innovation in Europe. In line with its own earlier conclusions, it calls for concrete action to ensure a strong and competitive industrial base of the Single Market.

It underlines that a new industrial policy strategy must align different policy areas with industrial policy - most importantly trade, environment, research, health, investment, competition, energy and climate – to form one coherent approach.

6.3 Digital Europe

Looking ahead at the work programme for the second half of the year, and in particular the Digital Summit in Tallinn on 29 September 2017, the European Council highlighted the overarching importance of an ambitious digital vision for Europe, its society and economy. A holistic approach to digital is necessary to face up to the challenges of and use the opportunities flowing from the 4th industrial revolution. This requires the implementation of the Digital Single Market strategy in all its elements. At the same time, a broader look at markets, infrastructure, connectivity, societal and cultural aspects, including the digital divide, norms and standards, content and data, investment, cyber-security, e-government and research & development is required. A support strategy for the digitalisation of industry is essential for the competitiveness of the European economy.

The integration of telecommunications, computers and the necessary software and audio-visual systems that enable users to access, store, transmit, and process information underpins innovation and competitiveness across a range of private and public markets and sectors, including the forest-based sector. The development of open platforms and technologies such as the systematic use of radio frequency identification (RFID), embedded components and systems, process control as well as robotics, micro- and nano-electronics. Working together in new applications, these technologies minimise waste in the production process, prevent illegal logging, facilitate product recovery for recycling, or make it almost impossible to counterfeit important documents. ICT has reduced production costs both in forestry and the forest-based industries. Mobile ICT solutions will continue to revolutionise the monitoring and management of forest resources. Light Detection And Ranging technology (LIDAR), an optical remote sensing technology, and other augmented reality and global tracking systems will play a crucial role in the whole value chain, from forest management and harvesting operations to transportation and logistics, manufacturing and processing, product development and resource management. One challenge will be to come up with ideas for further applications of ICT and for new customer-oriented services using ICT as a platform. In addition, ICT will assist in developing intelligent communication systems allowing complex participation in public decision-making processes concerning the forest-based sector.

6.4. Sustainable connectivity

Increasing connectivity is and will remain one of the main engines of globalisation as it keeps slashing the cost of distance. Hence a growing international integration of production systems and a constant Ricardo-Schumpeterian pressure for efficiencies.

This is fine as long as these efficiency gains are, or perceived to be, fairly distributed. But, as we have seen in recent times, opening may turn to protectionist or isolationist discourse if gains are not equitably distributed. This is also fine as long as economic development remains compatible with ecological sustainability, which is not the case anymore.

Conclusion: whereas less connectivity would be absurd, more connectivity does not work for sustainable prosperity under any conditions and these conditions need more attention than in the past. They have to do with social and cultural security, different structures of relative prices (capital / labour, environmental externalities), new forms of accountability and democratic choices, approximating global ethics, etc. A new version of what I called the 'Geneva consensus' as opposed to the old Washington consensus.

The exponential growth in digitisation and internet connectivity is creating significant new opportunities for business and society. What makes the changes so significant is the combination and leverage of multiple technologies: algorithms, sensors, data, cloud, artificial intelligence, machine learning and virtual reality working together that is new. These digital technologies can also combine with other technologies such as 3D printing, robotics, advanced materials, and energy storage, to have a multiplier effect on the way we live and work. The result is that digitisation is transforming what we do - from smart factories, to smart homes, to smart health - from the means of production to our personal well-being.

Much of the focus on the digital economy has been on the growth of digital industries relative to the rest of the economy, technology investment, internet usage, digital jobs and digital skills. Governments have been busy creating the enabling conditions for the digital economy from new computing curriculum, digital skills strategies, to new e-Government services. These initiatives are important in that they enhance efficiency, reduce costs and encourage innovation.

Multiple solutions will require platforms to work together to recognise the traveller and allow for new ways of integrating transport. The societal benefits through time saved and reduced emissions could be significant in many cities. Add to transport solutions the possibility of more efficient use of available logistics capacity, which would offer better rates, more convenience and real time tracking of goods. Logistics has low utilisation rates, particularly in trucking fleets, due to empty backhauls faced by most truckers. The EU trucking industry is very fragmented; well over 90% of the players operate a fleet of less than 20 trucks. The creation of a logistics platform to match demand with empty backhaul capacity opens the door to improved utilisation; which in turn offers the potential for less empty trucks, lower emissions and lower delivery costs.

Digital opportunities come in many forms. A Europe that has always believed in a balanced socio-economic model needs to look at digital in the same way. The digital economy is growing faster than the rest of the economy; but this growth undervalues the additional societal benefits that can be achieved through time savings, reduced emissions, and better utilisation of assets. To achieve these societal benefits will require forward looking policy makers and collaboration across sectors.

One thing we know is that digital is blurring industry boundaries and enabling new cross industry partnerships to be formed; realising societal benefits through digital begins will the identification of opportunities in sectors such as transport and energy and then requires strong cross sector collaboration to agree on the policies, incentives, standards and pilots to unlock societal value for all our citizens.

6.5 Mobility and transport infrastructure

Transportation is humanity's greatest lever for economic growth. More than any other technology, transport is the catalyst for big leaps in culture and ideas. And transport has itself been the engine for growth on a global scale. The Great Acceleration of the Rail Age enabled the transport of produce and people in volume, which in turn enabled urbanisation and the development of the mass market. Powered by coal, constructed of iron and steel, and financed on new capital markets, the railways themselves became a primary driver of the Industrial Revolution.

The great question facing global leaders is whether our current transportation options can meet the inexorable and conflicting demands of growth and environmental stewardship. At current 2.7% annual rates of growth, mobility demand in the developed world will double in 25 years and rise sixteen-fold in a century. Existing modes have served us well, but offer only incremental improvements when a step change in performance and energy efficiency is required.

Cars are evolving into sophisticated, connected data platforms which allow for new features from assisted vehicles to semi-autonomous and ultimately fully driverless vehicles and robo-taxis. The societal benefit is that assisted driving features will improve overall vehicle and road safety as well as reducing fuel consumption. In the UK, the Insurance Institute for Highway Safety has estimated there is a 7% reduction in crashes for vehicles with a basic forward-collision warning system and a 14% reduction for those with automatic braking. Assisted driving has the potential for value creation, through value addition for the industry, value impact for customers, and value impact for society and the environment. Assisted driving can deliver a number of societal benefits: less people killed or injured on the roads; reduced CO2 emissions, and savings for customers who opt for usage based insurance premiums through the adoption of ADAS 'advanced driver assistance systems' in cars.

The full benefits of digitisation will not be realised without a sharper societal lens; digital benefits require multiple players to come together; for cars, it will involve the car manufacturers, driver groups, highways agencies, insurance sector with Government playing a catalysing role.

Connected cars are only the start of a wide range of potential societal benefits; there are opportunities for new mobility solutions that connect road, rail, ferry, public and private transport with walking and cycling.

Reshaping mobility is a key element to achieving a Europe of innovation and lasting competitiveness, and also of wellbeing. In future, 'mobility' will be a combination of physical movement and virtual presence. Major social changes may result.

Technological convergence will transform the transport sector in the near future. Combined progress in, inter alia, robotics, automatic systems, electric or hydrogen engines, sensors and satellite navigation systems will allow us to move in an autonomous vehicle while working or surfing online, or interacting with smart homes. Together with the use of mini-drones to transport objects, this evolution will revolutionise travel between and within urban centres.

A green transport sector requires new lightweight packaging, perhaps with inbuilt tracking systems, and innovative lightweight vehicle components developed from biomaterials such as fibres or bio-polymers. Integrated research and innovation approaches are required, jointly with other key actors in the transport sector. Cooperation will lead to co-investments in new European transport innovations that reduce environmental impact and benefit the European and rural economy.

Apart from safer roads (casualty numbers keep decreasing and lower atmospheric pollution, such autonomous transportation would generate considerable efficiency gains: congestion is estimated to cost 1.5 % of GDP in the European Union. The resulting economies of scale will be significant, taking account of the convergence of holographic virtual reality and 5G, which will revolutionise telepresence and therefore telework, including from autonomous vehicles.

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The EU trucking industry is very fragmented; well over 90% of the players operate a fleet of less than 20 trucks. The creation of a logistics platform to match demand with empty backhaul capacity opens the door to improved utilisation, which in turn offers the potential for less empty trucks, lower emissions and lower delivery costs.

6.6. The Paris Agreement on climate change

The European Council strongly reaffirmed the commitment of the EU and its Member States to swiftly and fully implement the Paris Agreement, to contribute to the fulfilment of the climate finance goals, and to continue to lead in the fight against climate change. The Agreement remains a cornerstone of global efforts to effectively tackle climate change, and cannot be renegotiated. The Agreement is a key element for the modernisation of the European industry and economy. It is also key to implementing the 2030 Agenda for Sustainable Development; the recent adoption of the new European Consensus on Development, while pursuing a broader agenda, will also contribute to this objective. The EU and its Member States will enhance cooperation with international partners under the Paris Agreement, in particular with the most vulnerable countries, thereby demonstrating solidarity with future generations and responsibility for the whole planet. The European Council calls on the Council and the Commission to examine all means to achieve these goals. The EU will continue to work closely with all non-State actors, building on the successful example provided by the Global Climate Action Agenda.

Planted forests represent today around 7% of the world's forest area and contribute 36% of the annual requirements in round wood. As global demand for biomass grows, interest will grow in species that are tailor-made for specific purposes such as fibre production, reassembly of larger solid wood items, energy production, or for being rich in particular chemical substances. Different management schemes will be developed respectively. Novel bio-refinery concepts are able to provide completely new materials as substitutes for petroleum-based chemicals, polymers and fuels. Increased use of wood will require the forest-based sector both to make more wood available to the market and increase the growth rate of forests. The visionary target is to increase the sustainable harvest of the valuable forest biomass by 30% by 2030. A secure, adapted and sustainable supply of forest-based raw material is a prerequisite for the further development of the bio-economy. More precious biomass can also be supplied sustainably by integration along value chains from forest to end-product, shortening lead times, increasing capital turnover, improving profitability of forest ownership and reducing environmental impacts. Economic harvesting and fractionation methods will help industry select the right wood for the right use and thus improve efficiency of wood handling and processing.

6.7. A changing global energy landscape

Even in a best-case scenario, the effects of the present rising energy consumption will be lasting and even become a major problem in the more distant future. The increase in global consumption will be linked mainly to population growth and rising incomes. By 2030, 93 % of the rise in consumption will come from non-OECD countries. Energy savings and the development of renewables will not be enough to limit the growth of CO2 emissions by 2030-40. The use of traditional nuclear power will remain controversial but it cannot, in any case, measure up to the magnitude of the problem. Progress in energy efficiency, CO2 storage and demand management will probably not suffice either.

The global energy landscape will be determined more by a shift in supply flows than by reserves which are plentiful, including those from non-conventional sources such as shale gas.[2]

New mining technologies will continue to transform the global politics of energy. Since the first oil crisis in 1973, the geo-politics of energy have reflected the balance of power between the producer countries, mainly OPEC and Russia, and the importing countries, notably the United States and Europe. This will change dramatically as the United States becomes largely energy-independent. Asia's share of global energy imports will further increase significantly. China, in particular, will play an increasing role as importer, but also as a diplomatic actor in the oil producing region. OPEC might well decline in importance as its share of world production is shrinking. In many producer countries too, activity is shifting away from the large multinationals to domestic companies, sometimes with a return to a policy of 'resource nationalism'. This may impact on the search for and development of less accessible reserves, for which these companies lack the technical capability or investment resources.

According to the latest data, world energy consumption will be about 30 % higher in 2030 than in 2010 (80). The proportion accounted for by fossil fuels is projected to remain roughly constant. In Europe, fossil fuels will still make up a large proportion, even if consumption stagnates, and imports will rise from 56 % in 2010 to almost 70 % in 2030. Natural gas will play a bigger role, replacing coal in electricity production, and possibly oil for some forms of transport.

The natural gas market is expected to grow substantially — by around 50 % by 2035. Globalisation in this field will continue, at least for liquefied natural gas, and its share will increase even more strongly if the United States decides to export some of its shale-gas production. Even more than the

[2] IRENA (2018), Global Energy Transformation: A roadmap to 2050, International Renewable Energy Agency, Abu Dhabi

shale-gas boom, the outstanding feature in the coming decades will be the exploitation of gas resources in non-OECD countries, including in the Middle East, Africa and Russia. Europe's imports will likely continue to increase.

The coal market is currently experiencing strong growth which is likely to continue until 2030. This is at odds with current targets for limiting climate change, unless there is rapid development and deployment of techniques for carbon capture and utilisation/ geological storage of CO2.

Nuclear and renewables are expected to account for 24 % of production and 40 % of the growth in energy demand by 2035.

Europe's energy strategy calls for a significant increase in the use of renewable resources for the production of power, heat and transport fuels. By 2020, 20% of all energy used in the EU should be of renewable origin. By 2050, the EU aims to cut greenhouse gas emissions from energy production to 80-95% below 1990 levels. These are bold objectives.

Biomass-derived energy (bioenergy) represents a large part of renewable energy in the EU (approximately 60%). Decentralised concepts and operational systems of CHPs as well as biochemical, liquid or gasified fuel technologies contribute both through material and energy efficiency to sustainable development and the overall well-being of societies in urban and rural settlements.

The EU's SET-Plan (Strategic Energy Technologies) will help to accelerate the development and commercialisation of new energy technologies. There are more than 1 000 existing sites and more than 500 recovery boilers in forest-based industries, with further capacity to efficiently convert more biomass from agriculture and municipal waste streams to energy.

Finally, there could be a dramatic positive technological shift by 2030. Unexpected progress has recently been made in useable plasma confinement under the ITER international fusion project, which is due to come into service in 2025 for ten years' testing, up to 2035. Such a technological breakthrough could rapidly change the global energy landscape, and in the longer run slow down and even halt global warming attributable to 'traditional' energy consumption.

6.8. European energy market

The European economy's dependence on energy and natural resources contribute to the vulnerability of industry and threaten its competitiveness. By 2030, the European Union may likely still need to import 65-70 % of its energy needs, and will remain a net importer of raw materials for

its industry. The European Union will thus remain very vulnerable to disruptions in supply and price volatility, within a tight global situation — the availability of resources will be under worldwide pressure from an increased population and higher living standards. Water will become a precious commodity, particularly in Southern Europe, while continuing to be used predominantly in farming and the energy sector.

Among energy resources, the share of fossil fuels is expected to remain stable. With a dependency rate of around 83 %, natural gas should become more important within the energy mix, partly replacing oil for some means of transport. Nuclear power may return to the forefront, both globally and in certain European Union Member States, as a result of political decisions, with investment mechanisms involving state aid. This could follow the present UK model for the electricity market, where prices for operators are negotiated with the state and guaranteed for up to 35 years ahead. The share of renewable energies will likely surpass the European Union target of 20 % in 2020, but growth may slacken: high costs due to sub-optimal and dispersed support mechanisms and the sporadic nature of solar and wind energy production are to blame.

A truly European energy market pre-supposes a true physical market at European level, which is far from achieved at present. The electricity and gas markets are still highly fragmented; less than 10 % of electricity production currently crosses borders.

Market conditions can only converge and balance out in the medium and long term if the physical infrastructure allows genuine interconnection and trade. Better infrastructure for larger volumes of trade is the best means of bucking the current underlying trend towards de facto renationalisation of energy policies. It is also the best response to the problem of security of recent events in Ukraine have highlighted. More and better integrated pipelines are needed, including north-south connections and pipelines that allow two-way flows; as well as more storage infrastructure and more terminals for liquefied natural gas (LNG). In short, the European Union needs a competitive, integrated and fluid internal energy market to ensure the optimum circulation of gas and electricity.

6.9. Raw materials required for new technologies

The portfolio of emerging technologies analysed by a study by ITS and Fraunhofer identified a list of required sectors and technologies which is far from complete and would deserve an expansion to even more emerging technologies. [v]

Automotive engineering,	1. Light-gauge steel
	2. Electric traction motors for vehicles
	3. Fuel cells electric vehicles
Aerospace industry	4. Super capacitators
	5.Scandium alloys for constructing lightweight airframes
Information and communication technology, optical technologies, micro-technologies	6. Lead-free solders
	7. RFID
	8. Indium-Tin-Oxid
	9. Infrared detectors
	10.White LED
	11. Fiber optic cable
	12. Microelectronic
	13. High performance micro
Energy, electrical and drive engineering	15. Thermoelectric generato
	16. Dye-sensitized solar cells
	17. Thin layer photovolatics
	18. Solarthermal power stations
	19. Stationary fuel cells -SOFC
	20. CCS – Carbon Capture Storage
	21. High performance lithium-ion batteries
	22. Redox flow batteries for electricity storage
	23. Vacuum insulation
Chemical, process, production and environmental technology, mechanical engineering	24. Synthetic fuels
	25. Seawater desalination
	26. Solid state lasers for industry
	27. Nano-silver
Medical engineering	28. Orthopaedic implants
	29. Medical tomography Materials technology
Materials technology	30. Super-alloys
	31. High-temperature superconductors
	32. High performance permanent magnets

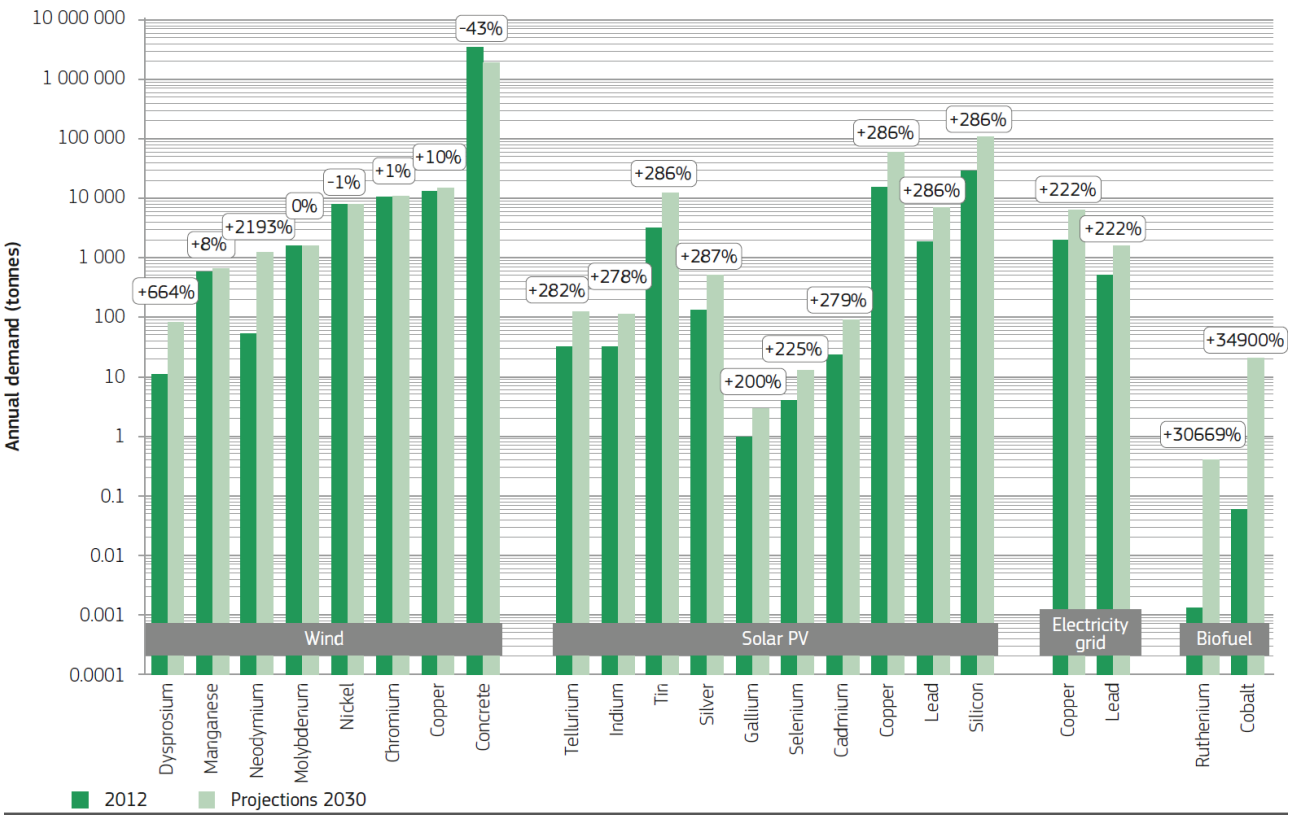
Based on these technologies the global demand has been estimated and clearly indicates the increases in demand expected.

Global demand of the Emerging technologies analysed for raw materials in 2006 and 2030 related to today's world production of the specific raw materials[vi]

Raw material	2006	2030	Emerging technologies (selected)
Gallium	0.28	6.09	Thin layer photovoltaics
Neodymium	0.55	3.82	Permanent magnets, laser technology
Indium	0.40	3.29	Displays, thin layer photovoltaics
Germanium	0.31	3.29	Fibre optic cable, IR optical technologies
Scandium	low	2.28	SOFC, aluminium alloying element
Platinum	low	1.56	Fuel cells, catalysts
Tantalum	0.39	1.01	Micro capacitors, medical technology
Silver	0.26	0.78	RFID, lead-free soft solder
Tin	0.62	0.77	Lead-free soft solder, transparent electrodes
Cobalt	0.19	0.40	Lithium-ion batteries, synthetic fuels
Palladium	0.10	0.34	Catalysts, seawater desalination
Titanium	0.08	0.29	Seawater desalination, implants
Copper	0.09	0.24	Efficient electric motors, RFID
Selenium	low	0.11	Thin layer photovoltaics, alloying element
Niobium	0.01	0.03	Micro capacitors, ferroalloys
Ruthenium	0	0.03	Dye-sensitized solar cells, Ti-alloy
Yttrium	low	0.01	Super conduction, laser technology
Antimony	low	low	ATO, micro capacitors
Chromium	low	low	Seawater desalination, marine technologies

If one matches these materials with the EU's study on critical raw materials it becomes very quickly obvious that already for some of these applications the supply situation already today is quite difficult and can easily be disrupted.

Raw materials are indispensable for the development and large-scale deployment of low-carbon energy technologies:



Current (2012) and projected (2030) annual demand of raw materials used for selected low-carbon energy technologies.
Source: European Raw Materials Scoreboard, 2016

7. Contribution of the European raw materials sector by 2030

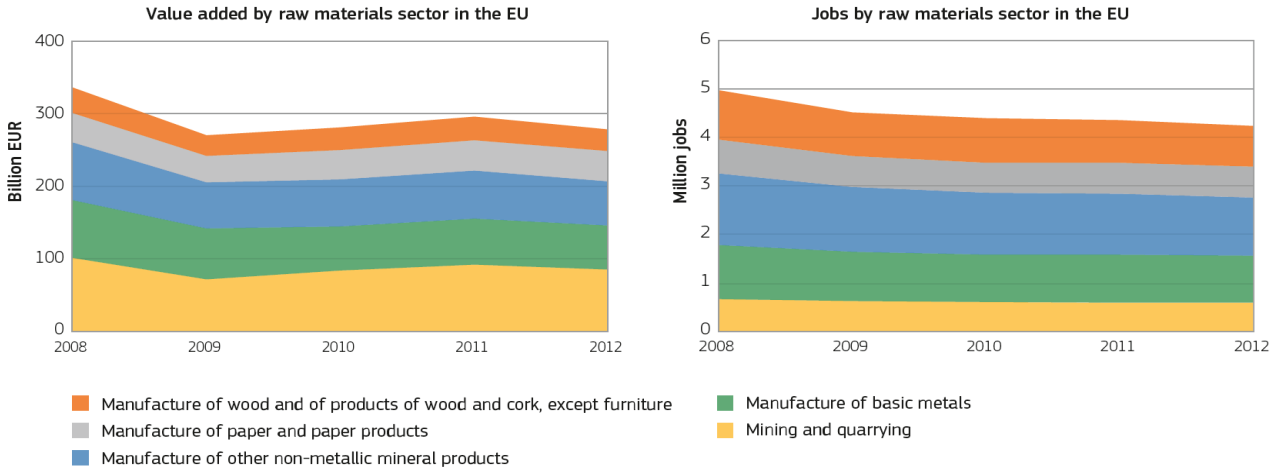
The forecast is that by 2030 there will still be the following main factors determining the raw materials supply for Europe:

- Large-scale exploitation of natural resources will remain concentrated in a small number of dominant countries and regions;
- Food and water supply will be about managing scarcity — a problem made worse by climate change;
- By 2030, 93 % of the rise in energy consumption will be in non-OECD countries.

Today 19 resources (including crops, timber, fish and meat, metals, fossil fuels and fertilisers) the three largest producers on average account for 56 % of global production. The eight dominant players are China, the United States, Australia, the European Union, Brazil, Russia, India and Indonesia. Faced with growing demand for raw materials, worldwide mining capacity should double by 2030.

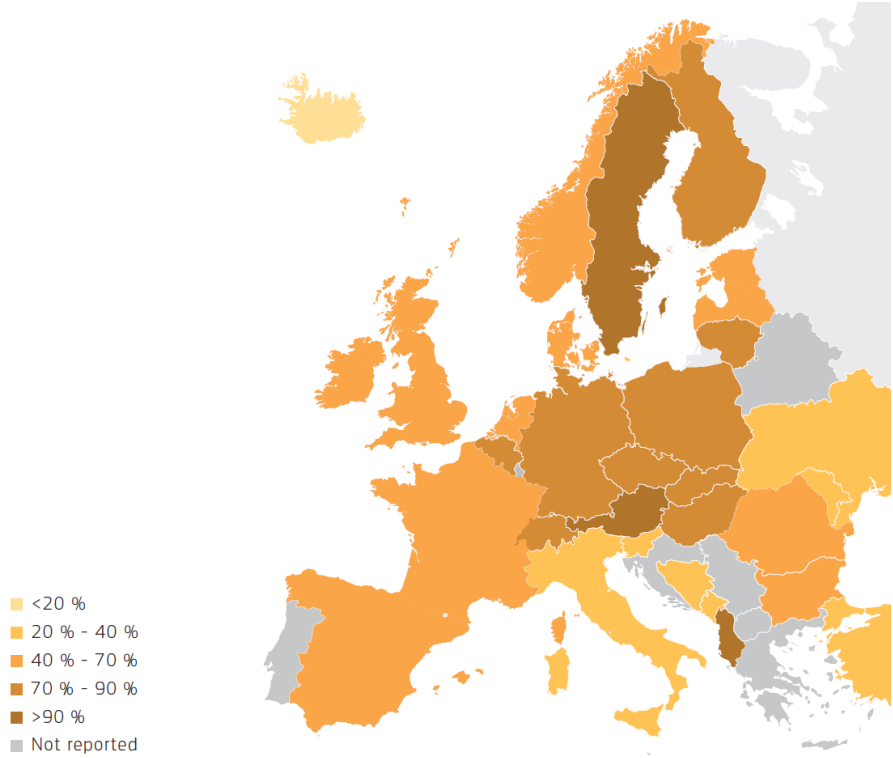
In 2030, managing arising scarcities will be the principal challenge for food and water supply. Demand for food is expected to be 50 % higher than in 2008. This rise is mainly due to the improving living standards of the fast-growing middle class in the major emerging economies. The availability of agricultural land will pose another major challenge, as will some agricultural inputs, in particular those based on potassium.

However, for raw materials we are in general not dealing with scarcity, but with unavailability or too high costs.



Value added at factor cost (left) and number of jobs (right) for a selection of raw materials economic sectors in the EU (2008-2012)
Source: EU Raw Materials Scoreboard 2016.

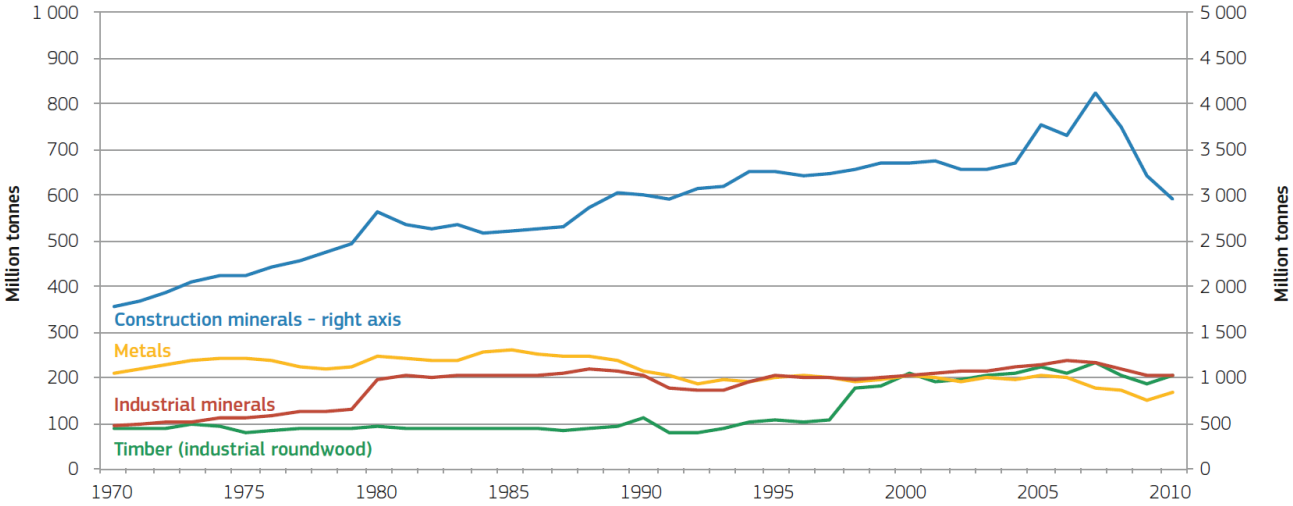
Managed with care and knowledge the forests of Europe offer renewable raw materials, as well as being a source of great biodiversity and recreational value for citizens. In fact, if all the forests in the world were managed as sustainably as those in Europe today, they would for a period be able to absorb most of the CO2 emissions caused by humankind.



Geographical distribution of felling rates (% of net forest increment, 2010)

Source EU Raw Materials Scoreboard 2016

Domestic extraction of construction minerals and harvesting of wood has increased since the 1970s, allowing the EU to remain more or less self-sufficient



Domestic extraction of raw materials (EU-28, 1970-2010;

Source: EU Raw Materials Scoreboard, p. 37. Source: UNEP (2016), Material Flows and Resource Productivity (forthcoming) Paris.

For 2030 it can be envisaged that the EU raw material sector can and will continue to:

1. **contribute to the EU GDP and its economic growth through**

- EU technological leadership in for all aspects of resource management (exploration, extraction, processing, re-processing, reuse, recycling, recovery, design, …),
- Upgrade and maintenance of infrastructure (health, transport, energy, …),
- Contribute to Industry 4.0,
- Sharing equitably the benefits of information technology.

2. **contribute to the resilience of the EU industrial landscape and society through**

- Complete modern database and economic assessment of EU primary and secondary resources,
- Potential self-sufficiency in raw materials for alternative energies,
- Enabling electric mobility across Europe and satisfying the necessary material demand,
- Better product design taking into account sustainability of material use and reuse,
- Better process ecology and symbiosis across industrial sectors reducing wastes,
- Providing better performing materials.

3. **address legacies and improve public acceptance through**

- In depth investigation of existing and future new legacy sites due to EU's climate change policies and closure of coal and lignite mines,
- EU resource diversification and increased resource efficiency by improved and new , in particular in situ processing technologies,
- Increased material valorisation of by-products and waste-to-product,
- Electric and remote-controlled vehicles for all activities on rough terrain,
- Small scale, mobile container packed quarry and mine –to-go,
- No waste water emissions from new mines and quarries.

8. Contribution of the raw materials sector by 2050

Despite the eventual slowdown in the world's population growth by 2050, global competition for access to natural resources will continue to intensify, as will the associated risks, in terms of market volatility, geo-political tensions and instability due to the catching up of the developing countries in terms of their standard of living and consumption.

The circular economy can contribute to the reindustrialisation of Europe and on lowering energy consumption and dependence on raw materials coming from third countries, whereas investment in renewable energy and energy efficiency is an important driver for the promotion of industrial renewal capable of creating virtuous circles. However, these efforts are likely be outpaced by new developments and the demand in developing countries. The desirable sustainability of prolonged

lifespans of products, the increasing complexity and automation of products and services to be provided to an aging population will also contribute to an increased material consumption and a binding of resources into longer-lasting infrastructures.

For large bulk materials recovery and recycling rates are quite high.

For other materials, recycling's contribution to meeting materials demand is relatively low, because life-span of products is high or materials are difficult to collect or in complex structures which pose difficulties to recycling and recovery. High-quality recycling is sometimes commercially or technically not feasible.

End-of-life recycling input rates (EOL-RIR) for a selection of raw materials
Source: EU Raw Materials Scoreboard:

Arctic and marine zones — new opportunities

Whatever the scenario, it is certain that the Arctic region as well as the marine regions will become gradually more accessible. This will provide opportunities but will also pose economic, geopolitical, environmental and human challenges. Europe and Russia will occupy a strategic position controlling access to the northern passage, which will be open for more than 50 days in the summer (Northern East route).

Both the Arctic and the marine region contain substantial natural resources — between 15 % and 30 % of undiscovered gas reserves — and mineral resources (zinc, nickel, manganese, graphite).

The opening-up of semi-permanent shipping routes will bring considerable gains, in terms of the links between Europe, North America and Asia, especially as they will become navigable for longer stretches of time during the year. This could influence world trade routes, although the forecasts for traffic are still highly uncertain: the Arctic routes could account for between 2 % and 15 % of

total cargo traffic by 2030. By then, at least 500 ships a year, totalling 1.4 million TEU (twenty-foot equivalent units), could be taking the northern route.

By 2050 it can be envisaged that the EU resource sector can and will:

1. **contribute to the EU's GDP and economic growth by**:

- providing EU market leadership by technology exports worldwide increasing sustainability (exploration, extraction, processing, re-processing, harvesting, reuse, recovery, design, …).

2. **contribute to the resilience of the EU industrial landscape and society through**

- survey of the EU landmass and marine environment with modern exploration technology,
- full automation of deep and surface mines and quarries in Europe,
- optimised valorisation of available resources, i.e. new technologies in place, increased reuse, recovery and recycling rates, material efficiency used in higher performance products,
- reducing the gap between resource supply and consumption through optimised use and reduction of resource consumption, recovery of materials and backflow into the economy,
- developing environmental footprint assessments of the full life-cycle of materials and products.

3. **addressing legacies and public acceptance through**

- remediation of EU's existing legacy sites identified till 2020 and returning land to future use.

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[i] ESPAS report: Global Trends to 2030: Can the EU meet the challenges ahead?, 2015
[ii] Åsa Johansson ; Yvan Guillemette; Fabrice Murtin ; David Turner ; Giuseppe Nicoletti ; Christine de la Maisonneuve ; Philip Bagnoli ; Guillaume Bousquet ; Francesca Spinelli : Looking to 2060: Long-term global growth prospects. Paris 2012.
[iii] JOINT MOTION FOR A RESOLUTION pursuant to Rules 128(5) and 123(4) of the Rules of Procedure replacing the motions by the following groups: PPE (B8-0440/2017), S&D (B8-0445/2017), Verts/ALE (B8-0446/2017), ALDE (B8-0447/2017), ECR (B8-0449/2017) on building an ambitious EU industrial strategy as a strategic priority for growth, employment and innovation in Europe (2017/2732(RSP))
[iv] European Council meeting (22 and 23 June 2017) – Conclusions Brussels, 23 June 2017 (OR. en) EUCO 8/17 CO EUR 8 CONCL 3
[v] IZT and Fraunhofer : Final report abridged. Raw materials for emerging technologies. Karlsruhe/Berlin 2009, page 6
[vi] IZT and Fraunhofer : Final report abridged. Raw materials for emerging technologies. Karlsruhe/Berlin 2009, page 10