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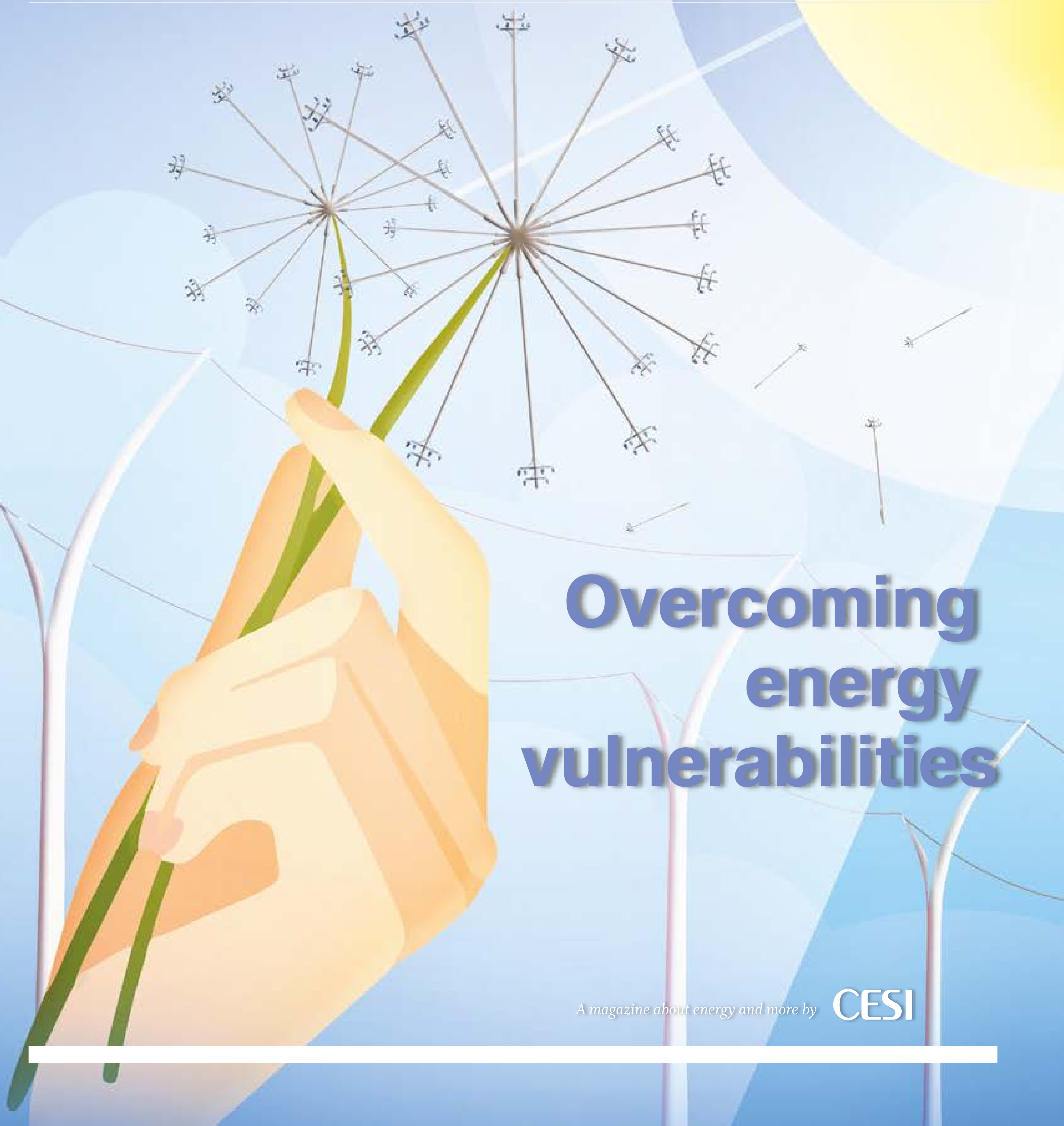

Overcoming energy vulnerabilities

A magazine about energy and more by CESI

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Editorial

The Changing Roadmap of the Ecological Transition

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It has been extremely complicated to analyze and make forecasts concerning energy scenarios and global supplies in recent weeks. In addition to the economic consequences of the pandemic, there now is a war in Ukraine that has significant international political repercussions. It is very difficult to make forecasts with a war underway, let alone imagine what effects it will have on global economies and the energy sector. In any case, it is obvious that Europe will have to grow increasingly independent from Russian gas, whilst not jeopardizing its decarbonization objectives and the roadmap for the energy transition.

The International Energy Agency has recently elaborated a ten-point plan for the European Commission that aims to reduce Russian gas imports by no less than 30% in one year. In 2021, the European Union imported 155 billion cubic meters of natural gas from Russia, accounting for around 45% of EU gas imports and close to 40% of its total gas consumption. The application of the IEA plan would lead to a saving of ca. €50 billion over the next twelve months.

In developing this issue of Energy Journal dedicated to the main vulnerabilities that affect the energy transition and their possible solutions, we ascertained how the transition towards a carbon-free economy is a complex process – even just to document – that has a significant impact on the technology and supply systems that produce the necessary components.

Our "Top Story" (Pg. 18) addresses the strategic importance of rare earth elements and minerals and the shifting equilibria that are being brought about by the race to garner the industrial metals needed for the ecological transition. This is confirmed by European Union estimates presented in a document entitled *Critical Raw Materials Resilience: Charting a Path towards greater Security and Sustainability*: "In terms of electric vehicles and storage batteries, the EU will require 18 times more lithium and 5 times more cobalt by 2030." In fact, by 2050, the demand for rare earths used in permanent magnets could increase tenfold. In order to interrupt this trend, which will also have to consider competition from emerging economies, the EU has devised a series of efficient measures and solutions, including recycling and technological substitution.

In turn, this reveals the risks and vulnerabilities of supply chains that are currently under pressure due to the geopolitical and post-pandemic scenario that no one would have dared to hypothesize just a few months ago. The increase in the cost of energy, logistics, raw materials, and products is addressed by the "Industries and Countries" article (Pg. 26) that will also present possible solutions and strategies to mitigate risks to the energy supply chain. Even before the Ukrainian invasion by Russia, while the previously expanding renewables market was losing nearly US$2 billion/month due to delayed investments, the cost of gas was on the rise. Indeed, by the first week of March, it had hit a record cost of €200/MWh. Similarly, the cost of a barrel of Brent Oil, the European reference standard, shot above US$119 for the first time since 2013.

Cognizant that over the short- to medium-term we will still need fossil fuels – especially gas – this calls for the adoption of a series of measures, whilst keeping in mind that renewables and nuclear are the only sources of energy which can truly provide security of supply to final consumers by reducing the dependence from other countries. Above all, gas imports must be diversified as much as possible either through existing infrastructure or newly built regasification terminals. Secondly, looking at the EU, it is important to optimize the benefits that a greater integration amongst EU member states can provide, in particular in terms of bargaining power vs commodities suppliers.

In any case, the entire global scenario is shifting its center of gravity. The increase in the demand for energy and the drive towards renewables will dislocate the energy axis away from the United States, Russia and the Middle East – the undisputed protagonists of the oil era – towards China, Central Asia and Africa, especially on account of their resources in terms of rare earth elements. In view of the risks deriving from external events and internal factors – including the critical issue of cybersecurity – the "Scenario" article addresses system vulnerabilities together with identified economic strategies and technological solutions. In order to achieve the green transition objective, Europe needs to decrease its dependence on energy, technology and raw materials from China. Consequently, it must develop internal, integrated, and associated supply systems, in addition to fostering recycling, the development of sustainable technology and extraction/production of raw materials from inner sources.

Speaking of energy security solutions, in the "Future & Technology" section we address CESI's projects and activities aimed at reducing the vulnerability of energy systems and guaranteeing their secure operation. In view of the increasingly important role of batteries in the energy system of the future, it is critical to test their reliability in terms of performance, security, and lifespan. This is what our colleagues at KEMA Labs (CESI's Testing, Inspection and Certification Division) do in their facilities around the world. Designed to reproduce the actual operating environment of battery cells, in order to measure their key parameters, and model their behavior to forecast ageing and performance failures, the new Services & Smart Technologies Unit provides a series of tests that satisfy the new requisites of electric vehicles.

Finally, the Opinions section presents some key remarks from Sara Moarif, IEA's Head of Environment and Climate Change Unit, who underlines that climate emergency, recently neglected by the media, continues to represent a central risks in the evolution of mankind in the coming decades.

Enjoy the reading.

Guido Bortoni ***Matteo Codazzi***

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"A nation that can't control its energy sources, can't control its future."

***Barak Obama**, President of the United States of America (2009 – 2017)*

News

Latest from CESI

Lithuania

Design and Construction of Synchronous Condenser substations in Lithuania

In the last few years, the Lithuanian government have set up a program to synchronize its local power system with Continental Europe power systems (Continental Europe Synchronous Area, CESA) and to ensure, at the same time, an increase in system inertia for strengthening the grid. This last aspect has an increasing importance throughout Europe, considering the significant growth of power generation from renewable sources in Lithuania. In this respect, CESI – who already worked with the local TSO in the previous phase of the project (preparation of technical specifications) – was asked to render technical assistance to the client during all phases of design, manufacturing, factory acceptance, installation and commissioning of three new synchronous condenser (SC) systems. CESI's scope of works covers all main electromechanical equipment that will be installed, namely rotating machines, flywheels, power transformers, HV equipment for grid connection, together with electrical auxiliaries and control and protection systems.

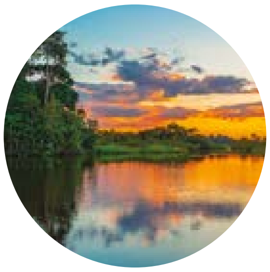
> **“To synchronize its local power system with Continental Europe power systems.”**

KEMA Labs

Product safety testing for energy meters

The international standardization committee IEC TC13 drew up standard IEC 62052-31 in 2015, which set requirements regarding the product safety of energy meters. Even though this standard has been available for some time, it took several years before it was integrated into the sector. In this respect, KEMA Labs (the CESI Testing, Inspection and Certification Division) has carried the very first project for an international manufacturer to test the product safety of an energy meter. To this end, KEMA Labs has set up various test facilities, including a laboratory where tests with high currents of up to 10,000 amps can be carried out to test internal switches. All necessary tests and assessments are performed by trained personnel at KEMA Labs. In addition, KEMA Labs has been recently ISO 17025 accredited by the national Dutch accreditation council for all testing activities required to prove compliance with the IEC 62055-31 and IEC 62054-21 standards in the Netherlands.

> **“A laboratory where tests with high currents of up to 10,000 amps.”**



Suriname

CESI offers Technical Assistance on Suriname distribution system networks

The Republic of Suriname consists of seven isolated areas: EPAR (the main one, with the capital Paramaribo), Moengo, Albina, Coronie, Wageningen, ENick and Apoera. Due to this peculiar characteristic of the country, CESI Group has been chosen by N.V. Energie Bedrijven Suriname (NV EBS) to provide technical consultancy and improve EBS' distribution network performance indexes, from the planning and operational point of view. The project will indeed cover the EPAR area and the isolated areas outside EPAR: these six smaller areas have an overall load that does not exceed 20 MW, but they have a distribution network that needs to be modernized nonetheless. In this respect, CESI involvement consists of a study that will ensure consistency with the results of the previously studied Master Plan (developed by CESI as well), in terms of transformation capacity, number and location of primary substations, etc. The project has been subdivided into four tasks, including the distribution system assessments and recommendations. Furthermore, CESI will analyze the use of advanced technologies (such as remote control, automation, SCADA, DMS, etc.) and ongoing pilot activities, to provide recommendations regarding smart grids. Moreover, the Group will assess economic and financial aspects connected to the distribution network performance. Finally, CESI will provide an analysis of the regulatory framework and recommendations about possible improvements.

> **“A study that will ensure consistency with the results of the previously studied Master Plan.”**

Technologies

The 30-year anniversary of the first XLPE cable prequalification test

In 1992, BEWAG, the then-electrical utility of Berlin, had launched an initiative to investigate the feasibility of setting tip an urban bulk power connection using 400-kV XLPE cables. The project, first of its kind in history, aimed to replace the traditional oil filled cables around the city of Berlin with XLPE cables, due to lower installation cost, lower dielectric losses and thermal resistance, and because this type of cable was considered maintenance-free once put into operation. The tender was awarded to CESI, which obtained the project thanks to its already established expertise and, above all, thanks to its independence. What CESI embarked on had been a very challenging task: at the time of the tender and the subsequent tests (from 1992 to 1995), there was no experience regarding the life and the reliability of XLPE cables when used so extensively. Furthermore, there were no international standards over the years those tests were carried out by CESI. However, CESI was able to overcome such challenges, as these tests paved the way to modern cable market as well as to the definition of the IEC 62067 standard.

> **“CESI was able to overcome such challenges.”**

Scenario

The Geopolitics of Energy: New Solutions and Measures for Energy Security

The war in Ukraine has driven the implementation of new policy measures for the energy sector in many countries. The agenda focuses on how to guarantee energy security through a series of initiatives that will accelerate the transition and drive the technological modernization of power networks.

February 24 is a date that will go down in history. The Russian invasion of Ukraine has shocked the world, both politically and economically. Public opinion is dazed. This action has immediate and serious implications; not only in terms of humanitarian concerns and the respect of international law, but also for international energy security. Russia is one of the major producers and exporters of natural gas and oil and plays a strategic role on global energy markets. In terms of energy supplies, the importance of this vast transcontinental state, which lies for a quarter in Europe and three in Asia, is clearly outlined in the IEA analysis entitled "The Energy Mix: The Global Energy Sector Impacts of Russia's Attack on Ukraine". The data published at the beginning of March by the International Energy Agency reveals the reasons behind the European Union's reliance on Russia for energy, both oil

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and gas. In 2021, the European Union imported 155 billion cubic meters of natural gas from the Russian Federation, ca. 45% of the total amount of EU gas imports and nearly 40% of its total consumption. In fact, the total supply of Russian gas increased from 25% in 2009 to 32% in 2021. Moreover, the IEA also emphasizes another recent trend. Due to the reduction of Russian gas supplies to the EU market, EU member states were not able to stock enough gas by the beginning of the winter season. More specifically, Russian gas supplies decreased by 25% on an annual basis in the third trimester 2021, and this further decreased by 37% during the first seven weeks of 2022. Germany received its last supplies of gas via the YAMAL pipeline (which crosses Belarus) on December 20, 2021. The flow of gas through Ukraine towards Slovakia dipped by an average of over 80 million cubic meters/day to a mere 36 million cubic meters/day during the first seven weeks of 2022. Overall, the flow of Russian gas through Ukraine averaged 55 million cubic meters/day during this period, well below its potential capacity to deliver 109 million cubic meters/day.

The consequences were immediately felt on energy markets. The reduced flow delivered from the Russian pipelines, in conjunction with low levels of fuel storage, contributed to a rise in the cost of gas in Europe, which increased by 50% on a daily basis on February 24, 2022, reaching US$44/MMBtu following Russia's invasion of Ukraine. In a chain reaction, the spot price of Asian LNG (Liquified Natural Gas) increased by 30%, reaching US$37/MMBtu.

The oil market endured similar effects. The Russian invasion took place in a scenario already characterized by rigid global oil markets, a marked volatility in prices, commercial reserves at their lowest level since 2014, and the limited ability of producers to provide further supplies in the short term. And Russia plays a significant role in the oil sector, too. It is the third global producer of oil and its largest exporter with ca. 5 million barrels/day, accounting for 12% of global oil commerce. Moreover, Russia's 2.85 million barrels per day of oil products represent ca. 15% of the global trade in refined products. To date, oil exports have interested Europe (60%) and China (20%).

The global energy sector, and especially the European one, had already weathered the Covid-19 pandemic. Now, it is developing a series of immediate measures to face this new emergency caused by the Russian Ukrainian Conflict. Countries are rapidly implementing new political and economic solutions in the attempt to guarantee the reliability and diversification of supplies. A meeting in Brussels, between the President of the European Commission, **Ursula von der Leyen**, and Italian Prime Minister **Mario Draghi** produced a joint press note emphasizing the need to "diversify supplies, to move away from Russia, and to seek more reliable suppliers."

On March 8, the European Commission presented the REPowerEU Initiative that contains a series of joint initiatives amongst member states to promote more affordable, secure, and sustainable energy. The initiative is based on three pillars: strong investments in renewables, acceleration of the Green Deal, and improvement of energy efficiency. The plan also calls for a marked decrease in Russian gas imports by the end of the year. Specific attention also addresses "the cost of energy impacting on consumers and activities. It is necessary to ensure that the EU market remains efficient," explains President von der Leyen. Here, she describes the horizon of European action: "There is a large quota of gas and oil in the European energy mix. We must increase our quota of renewables. While this will radically alter our market, it must remain efficient."

Thus, notwithstanding this difficult moment, the EU is maintaining its focus on decarbonization, a commitment renewed in the "Fit for 55" Plan that calls for a 55% reduction in greenhouse gas emissions by 2030 (compared to the levels measured in 1990) and the achievement of carbon neutrality by 2050. Over these weeks of conflict, new international measures have revealed the EU's united front against the new issues determined by the war. After the successful tests and technical procedures to break off from the Russian network, the Ukrainian and Moldovan power networks were synchronized with the ENTSO-e continental area. In parallel, in mid-May, new sanctions with immediate effect were enacted against Russia, including measures targeting the energy sector: the prohibition to export machinery, technology, and services related to the energy industry. Furthermore, Russia will no longer be considered a "most favored nation" in the World Trade Organization (WTO). Russia's response was immediate. The Reuters Press Agency informed the world that the supply of Russian gas flowing westward to Europe through the Yamal-Europe pipeline had been interrupted. Meanwhile, the flow of Russian gas to Europe via other pipelines, including North Stream 1, which crosses the Baltic Sea, remains stable.

New issues are arising on the oil front. The International Energy Agency fears that the global oil supply may undergo a shock because

of the sanctions imposed on Russia, including the cessation of Russian oil imports to the United States and Great Britain. The IEA has warned that the "prospective of vast scale turmoil in Russian oil production could lead to a global oil supply shock."

To counter this emergency, the 31 countries on the Governing Board of the International Energy Agency have decided to release 60 million barrels of oil from their emergency reserves. In fact, IEA members stock a reserve of 1.5 billion oil barrels. The initial release of 60 million barrels, or 4% of their reserves, is equivalent to 2 million barrels per day for 30 days. This coordinated release is the fourth in IEA history, following the actions undertaken in 2011, 2005, and 1991. IEA Executive Director **Fatih Birol** commented: "I am grateful that IEA member states have provided an initial 60 million barrels of oil to provide stability to oil markets and I'm also happy that our member states are committed to doing their best to support Ukraine in terms of fuel supplies."

To help the European Union to rapidly manage this new emergency, the IEA has also formulated an accurate ten-point plan that aims to reduce dependence on Russian supplies by over one third, by continuing to promote the European Green Deal. According to the Agency, the European Union could reduce natural gas imports by over 50 billion cubic meters through a combination of measures supporting energy security. In greater detail, the medium- to long-term plan call for: not signing any new supply contracts with Russia to drive a greater diversification of the supply; substituting Russian supplies with gas from other countries (including Norway and Azerbaijan), which could be increased to 10 billion cubic meters next year, and import up to 20 billion cubic meters of LNG, increasing total gas supplies to ca. 30 billion cubic meters within a year; introduce minimum

gas storage quotas to improve the resilience of the system by next winter; accelerate the implementation of new wind and solar projects to reduce gas requirements by 6 billion cubic meters in 2022; drive the production of power from bioenergy and nuclear in order to reduce the consumption of gas by 13 billion cubic meters per year; rapidly adopt fiscal measures that will protect consumers from the increasing cost of electricity, although the cost of gas remains high; accelerate the substitution of gas heaters with heat pumps to decrease the consumption of gas by a further 2 billion cubic meters within a year; improve the energetic efficiency of buildings and industry, which would lead to a further 2 billion cubic meter reduction in gas consumption in a year; encourage consumers to turn their thermostats down by 1 °C to save about 10 billion cubic meters of gas in one year; intensify the commitment to diversify and decarbonize sources to secure the flexibility of the power system and loosen the strong ties between the supply of gas and the provision of electricity in Europe.

Analyzing the various solutions proposed by the IEA, two elements stand out. In the first place, the numbers mentioned consider the urgency of restocking European storage plants in 2022, following the scant supply of gas delivered by Russia that has led to these unusually low levels. Secondly, solutions must focus on **accelerating investments in clean and efficient technology**. The IEA also believes that it is fundamental to strengthen international cooperation with other countries that could supply gas and LNG. These include Algeria, Azerbaijan, and Norway, which have already increased their supplies to the European Union, compared to last year, and especially the United States. In fact, the diminished flow of Russian gas to the European Union and the United Kingdom have been partially compensated

by a greater supply of LNG, which increased by 63% on a yearly basis at the beginning of 2022, reaching a record 13 billion cubic meters in January, which is a threefold increase over the previous year. The United States have supplied more than half of the LNG imported into the EU and the UK, or 37% of total LNG supplies. This highlights the significance of strong transatlantic bonds for European energy security.

The IEA plan reveals that the agenda of all policy makers centers on issues concerning energy security, a crucial issue for every country. However, the concept of energy security now has new nuances and has extended its horizon to be even greener. To analyze this evolution, we should begin with its definition: energy security refers to the ability to provide power wherever it is required and in sufficient quantities to satisfy the various final uses (industrial production, residential and commercial needs, mobility) over the short, medium, and long term. Assessing the security and access to energy supplies has begun to play an increasingly important role, especially over the past decade and particularly in countries such as the European Union that have to rely heavily on the importation of natural gas, oil, and coal. Over the medium term, these resources remain crucial to satisfying the needs of individual states, notwithstanding the constantly growing importance of renewables. Indeed, the novel element in this crisis sparked by the Russian-Ukrainian conflict is that no country has questioned its commitment to decarbonization; rather, each has confirmed its pledge to overcome the emergency by banking on the energy produced by renewables.

Indeed, this matches the forecast presented by the IEA which expects a record increase in solar, photovoltaic, and wind capacity in the European Union thanks to a total energy production from renewable sources equivalent to over 100 TWh, a 15% increase over 2021. However, the IEA believes that a concentrated political effort can manage driving a further 20TWh of renewable capacity over the next year. How? By expediting authorization processes and completing industrial scale photovoltaic and wind projects.

How does the concept of energy security influence and condition the development of renewables and their technical characteristics? In another article in this issue – our Top Stories at pg. 18 – we have analyzed how the energy transition and the expansion of renewables are determining a marked increase in the demand for rare earths and critical materials, elements that are indispensable for the development of any type of electronic device, and fundamental to wind turbines, photovoltaic panels, EV batteries, and fiber optics. The supply of rare earths and critical materials also conditions new geopolitical energy scenarios and determines a series of sector vulnerabilities that countries, including the European Union, are addressing via a series of measures and solutions to avoid reliance on China, one of the greatest global producers of these elements.

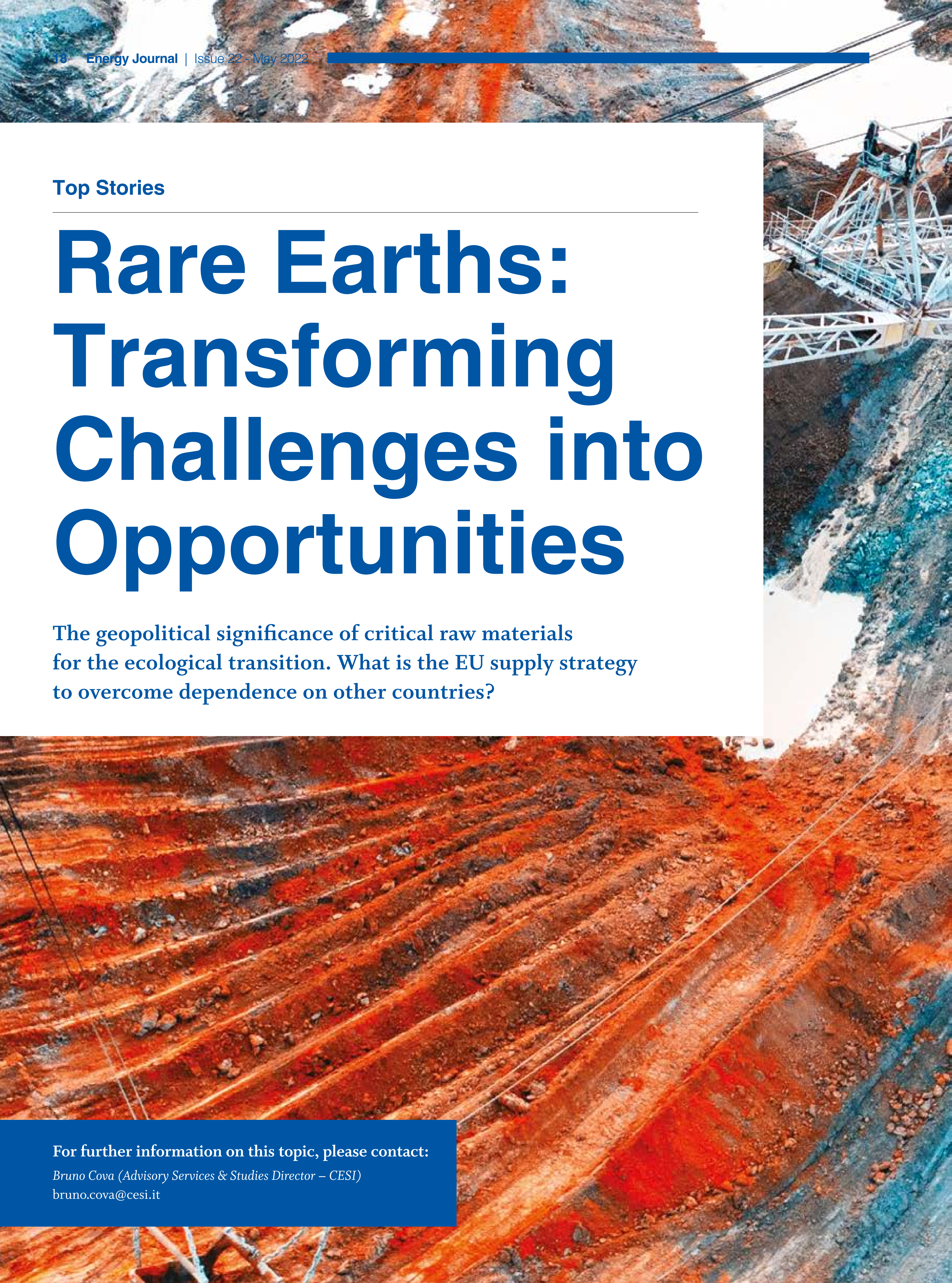
Let's now look at the close relation that exists between the production of renewables, greater system electrification, and the issue of global electric security. **Networks will have to be strengthened** and it will be crucial for member states to identify solutions to mitigate the characteristic intermittency of renewables. Moreover, electrification and digitalization will also lead to an increased risk of cybernetic attacks. The solutions that are immediately necessary to guarantee the security of electrification concern networks reinforcement: solutions to address the intermittency of power generation from non-programmable renewables, or solutions that are largely based on interconnection and greater storage potential. This implies a true revolution for the **modernization of electric networks to support all the implemented innovative system solutions**: from HDVC (the so-called broadband of power that allows the transportation of greater quantities of electric energy over greater distances) to smart metering (considered the main enabler of smart networks), from automation and control systems (that gather data and use algorithms to process information through peripheric sensors – and allow the transmission of real-time commands and actuators – represent the backbone of smart grids) to decentralized solutions based on hedge computing that are easier to integrate with

renewables and more resilient to external phenomena. **Only such a modernized network will be able to avoid any type of vulnerability** because it will be capable of guaranteeing continuous service without power interruptions and to react in a controlled manner to adverse phenomena. "Volatile" and non-programmable power such as that generated by wind and photovoltaic plants calls for a greater attention to networks. The growing use of massive renewable energy sources to produce power (i.e., wind farms and solar parks in North Africa and the Middle East) requires the development of thousands of kilometers of interconnection and transport systems and the management of a network with thousands of hubs. This requires the development of extremely high voltage connections over long distances, as in China, where there are already 6-7 GW lines carrying extremely high-voltage direct current (HVDC).

Therefore, all solutions that are propaedeutic to global-level energy efficiency are fundamental. With an outlook to increasing decarbonization and the growing technological complexity of networks, the **strategic development of interconnection systems will play a key role for each country**, becoming a true issue of national security. The development of an electric network can only be achieved through technological implementation, which according to the IEA "Net Zero by 2050" Report will only be possible thanks to a threefold increase in global network investments, forecast to reach US$820 billion by 2030 and US$1 trillion by 2040.

The development of renewables and the modernization of the electric network are the solutions that will guarantee the greatest self-sufficiency. They will allow us to reduce energy imports, limiting our exposure to supply cuts and reliance on producing countries, as well as decreasing the impact of the volatility of fuel prices. So, while the localization of energy production may lead to conflictual issues and security risks, in this new energy scenario it is important to establish **new ties of positive and sustainable interdependence with neighboring countries**, founded on renewables. Renewables can be produced more efficiently in some regions due to weather conditions: sun, wind, or even just the availability of free land.

What are the effects of a more local energy scenario in Italy? Close collaboration with countries in Northern Africa and in the Balkans on renewable energy production can create jobs in emigration areas, open new commercial opportunities for Italian companies, and reinforce the political stability amongst neighboring countries. The latter aspect has become crucial to implement the energy transition. We must avoid the social, political, and economic collapse of the countries whose development models are still founded on the production and trade of fossil fuels, such as the Middle East and North Africa. Italy's geographic position, as a bridge to these two regions, could make our peninsula particularly exposed to any negative future repercussion. And current history is teaching us not to undervalue any vulnerability in the energy sector.



Top Stories

Rare Earths: Transforming Challenges into Opportunities

The geopolitical significance of critical raw materials for the ecological transition. What is the EU supply strategy to overcome dependence on other countries?

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The foremost global powers focus their attention on these two key words: rare earths. There are seventeen elements in Mendeleev's Periodic Table that provide fuel to the energy transition and are necessary to develop new technology for decarbonization, such as wind and photovoltaic generation, and e-mobility. The adjective "rare" suggests a series of critical issues. Indeed, although these elements are present around our planet, rare earths are scant in mineral deposits. They are mixed in with rock and their extraction process is very complex. Above all, their rarity is due to the fact there are no other elements in nature with such properties. And, to date, they are considered fundamental to achieve a carbon-free status. Let's see why.

We begin this analysis of the challenges presented by rare earths by taking a better look at them. REEs (Rare Earth Elements) include scandium, yttrium, and 15 Lanthanides: lanthanum, cerium, praseodymium, neodymium, promethium, samarium europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium. These elements are further subdivided, based on their atomic weight, into LREEs (Light Rare Earth Elements), MREEs (Medium Rare Earth Elements), and HREEs (Heavy Rare Earth Elements). Other raw materials that are similarly important for the development of green technology include ferrous metals and several non-metals such as lithium, cobalt, and nickel. Together, these are known as **critical raw materials**. They are considered economically significant, their supply is unreliable, and they are essential to the operation and integrity of a wide range of industrial ecosystems.

The strategic importance of these elements is confirmed in the European Union's forecasts presented in the *Critical Raw Materials Resilience: Charting a Path towards Greater Security and Sustainability* document: "In terms of electric vehicles and storage batteries, the EU will require 18 times more lithium and 5 times more cobalt by 2030, and nearly 60 times more lithium and 15 times more cobalt by 2050, as compared to the current supply. The demand for rare earths used in permanent magnets could increase tenfold by 2050." This data portrays the extent to which the energy transition and the high-tech industry currently drive an economic system based on critical materials. Moreover, these raw materials are also required in a wide range of other sectors: from defense to robotics, from medicine to steel, and other industrial sectors. Thus, there also is a keen intra-sector competitionto procure these materials.

This growing demand for critical materials poses complex challenges addressing not only their availability, but also their supply system. We now turn to the reasons, consequences, and strategies that have been, or will be, implemented to guarantee the development of green technology.

A Fundamental Presence

Critical raw materials are necessary for the production and operation of no less than 200 products. They are fundamental to the resistance, lightness, and magnetic, luminescent, and conductive properties of alloys. They are used not only in smartphone touchscreens, computers, TVs, and hard disks, but also in green technology components: from permanent magnets that are indispensable for wind turbines and photoelectric panel electric sensors to catalytic converters, EV batteries, fiber optics, and lasers. Thus, the need for these critical raw materials is fundamental, constant, and absolute. And their indispensable nature raises various issues, beginning with availability.

Let's examine the e-mobility sector. There currently are over one billion vehicles on our roads and forecasts suggest a strong increase in the presence of electric vehicles, especially given that nearly all countries will soon ban internal combustion engines and promote BEVs (Battery Electric Vehicles). In China, for example, the objective is to reach 15% EVs by 2025 and 40% by 2030. In Europe, diesel and petrol cars will be banned in Germany (from 2030) and in France and the United Kingdom (from 2040), although the European Commission is pushing for 2035. Translating these plans into numbers, we can calculate the number of EVs that will be in circulation in 2030. According to Bloomberg, there will be 100 million EVs, while Barclays estimates 200 million.

In order to achieve such widespread e-mobility, the first challenge will be to satisfy the growing demand for lithium, nickel, and cobalt, fundamental elements for EV battery technology (based on lithium and nickel hydride ions, containing both lithium and cobalt). The U.S. Geological Survey estimates that 7 million tons of cobalt, the equivalent of 57 years of production, can be obtained from deposits with our present technology (as the material is nearly completely obtained through the extraction of copper in the Republic of Congo). However, the boom of electric vehicles equipped with lithium

and NiMH ion batteries is destined to exhaust cobalt reserves far sooner, and this is without even considering various medical sectors and other industrial sectors that require cobalt to produce superalloys and steel.

The situation is far less complex for lithium as supplies are abundant, albeit concentrated in a few countries. Currently, 58% of global lithium supplies are produced in Australia, 20% in Chile, 11% in China, and 6% in Argentina. Other rare earths (dysprosium, lanthanum, neodymium, and terbium) are used to produce alloys and maintain the magnetization of electric motors. These elements are concentrated in China (70%), Australia (12%), and the United States (8%).

Above all, however, the issue of REE extraction concerns two elements, neodymium and praseodymium, that are the most expensive and most sought by industry. In fact, these two elements are used not only to produce magnets for EVs, but also in wind turbines, which require forty times more for every Megawatt (MW) of installed capacity than EVs. This means that if a wind turbine has a capacity of ca. 3 MW, the quantity of neodymium and praseodymium necessary for the turbine is 120 times greater than that necessary for an EV motor. In 2020, amongst all uses of rare earths, permanent magnets accounted for 35% of REE sales

and 91% of their overall value. According to market projections, the demand for magnets will increase by 500%. And if today we require 130,000 tons, by 2030 the demand will reach 270,000 tons, accounting for 40% of all REE demand.

Moving on to supplies, many raw minerals are extracted and processed by one or two countries. In this case, the monopoly is Chinese. China detains nearly one third of global REEs (44 million cubic tons) and is the foremost producer, accounting for nearly 60% of the global market according to the US Geological Survey. The United States places second with just over 15% of global production, while Europe is heavily dependent on other countries for REEs, importing 75-100% of its requirements. In order to interrupt this trend, which must also take competition from emerging economies into account, the EU has devised a series of efficient measures and solutions. These include recycling and substitution with other technology (which will be addressed in the "Future & Technologies" Section), as well as other important innovations and initiatives that will help solve the EU's reliance on other countries, as well as the environmental impact caused by REE mining, our next topic.

Environmental Impact

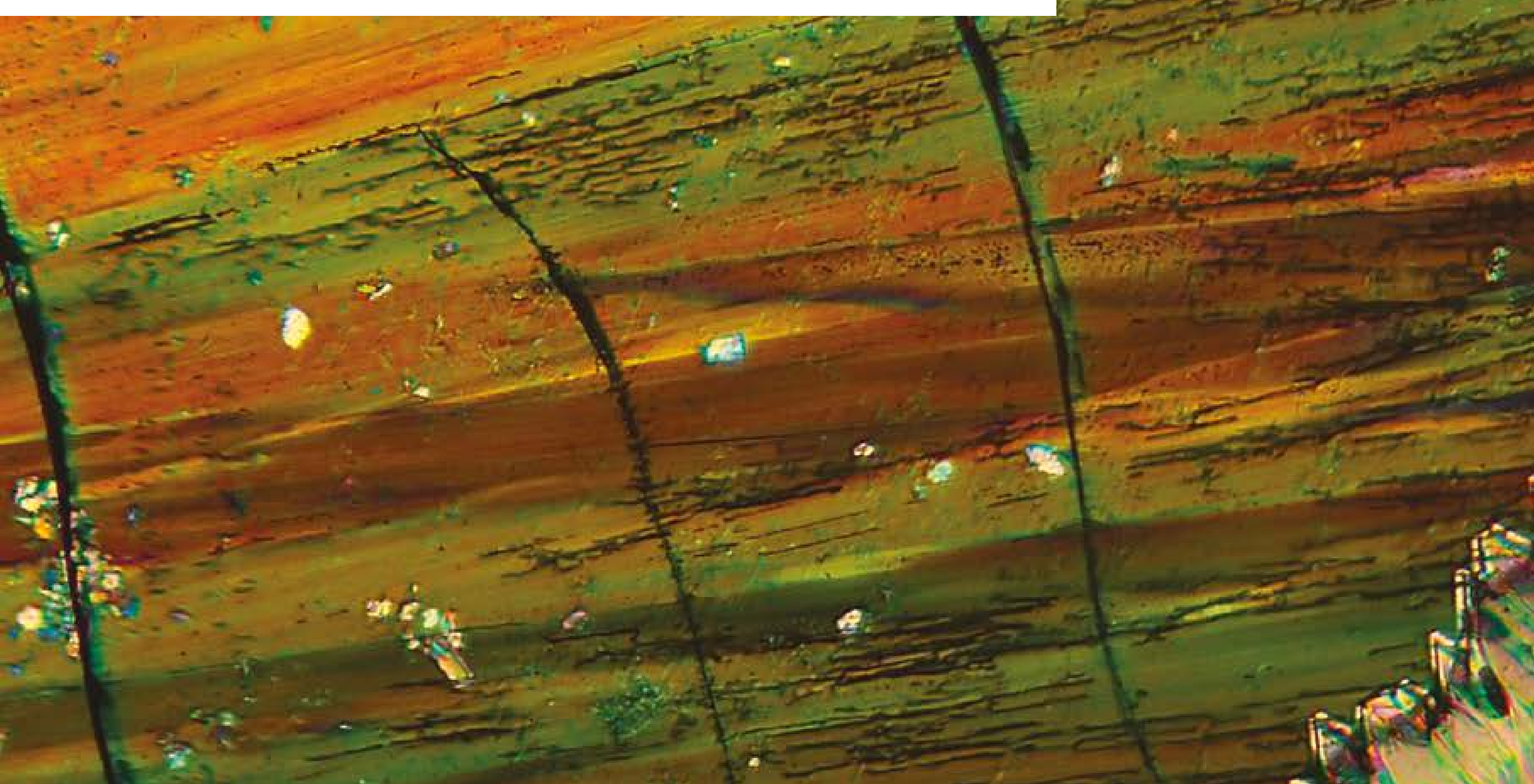
A full overview of REEs and critical elements also requires us to address the environmental impact caused by their extraction and processing. Although these elements are critical to a sustainable economy, their production entails a complex sequence of toxic chemical treatments. Most raw minerals containing REEs also include thorium, a radioactive element

“Efficient decarbonization will necessarily require a decreased dependence on critical raw materials from other countries.”

that is concentrated in waste. Moreover, all rare earths have a low yield per volume of raw material. Thus, the production of one kilogram of rare earth oxide also produces 1-2 tons of waste materials. This, in turn, leads to enormous treatment costs. In 2016, the China Water Risk Initiative tried to estimate the cost, calculating that the recovery of the mining area in Ganzhou would require US$6 billion, an enormous amount, also considering that the Province of Jangxi, in which the Ganzhou District lies, only accounts for 8.6% of Chinese REE production.

On the greenhouse gas emissions front, we will look at the production of lithium, one of the least complex elements to process. The mining of rock, from which the mineral is extracted with the use of fossil fuels, requires a great quantity of water and causes the release of 15 tons of CO_2 per every ton of lithium. If the global demand for lithium reaches 450 KTON by 2030, this will lead to the emission of 4.5 million tons of CO_2 into the atmosphere, not to mention other critical materials with an even greater impact in terms of greenhouse gasses.

In Europe, research and new technology are introducing significant new solutions, such as green lithium, which is obtained with geothermal vapor and is limited to inexistant environmental impact. Further good news is that water tables in the Upper Rhine Valley in Germany are particularly rich in lithium, with a concentration of ca. 150 mg. per liter of water. This means that the Bruchsal Geothermal Plant in Germany could produce enough green lithium for 20,000 EV batteries. Moreover, further financing could lead to a tenfold increase in the production of green lithium in the Rhine basin. Lithium-rich sedimentary basins have also been identified in many other areas of Europe, and one of the most promising is the Po Valley in Italy. This green lithium potential in Europe could solve part of the supply problem for raw materials required by the carbon-free ecological transition. And Europe is eager to pursue this route.



Critical Raw Materials 2020

The European Commission will carefully monitor nickel given the increase in demand of raw materials for batteries.

Hafnium
Antimony
Barite
Bauxite Fluorite
Beryllium
Bismuth
Borate
Coke Coal
Cobalt
Phosphorite
Phosphorous
Gallium
Germanium
Natural rubber
Natural graphite
Indium
Lithium
Magnesium
Platinum group metals
Niobium
Scandium
Metallic Silicon
Strontium
Tantalum
Light Rare Earths
Heavy Rare Earths
Titanium
Tungsten
Vanadium

The proactive European stance also includes the mobilization of public and private investments on a large scale through the European Battery Alliance, a program that aims to satisfy 80% of the European lithium demand via internal sources by 2025. Further trust in European supplies have also been bolstered by a recent EuroGeoSurveys study that indicates the presence of many critical raw materials on the Old Continent too. The EU has a precise strategy: financing some of the European areas that are still dependent on coal mining to begin extracting critical raw materials.

An equilibrium in the supply of critical raw materials will be achieved by bolstering the EU's trade policy tools, even via free exchange agreements and strategic partnerships with resource-rich countries like Canada and Australia, as well as Africa and Latina America, but also with neighboring Norway, Ukraine, and the Western Balkans. Serbia, for example, has rich borate deposits, while Albania has significant reserves of platinum.

So, efficient decarbonization will necessarily require a decreased dependence on critical raw materials from other countries. The European Union will have to step up this coordination, both politically and industrially.

Conclusions and Key Messages

The revolution for a carbon-free economy is a highly complex process. It is not only related to the shift from fossil to renewable fuels such as electricity and hydrogen but will also have a significant impact on the production of various high-tech components. A clear understanding of the entire supply chain of all the involved materials is fundamental to address and resolve our current vulnerabilities. Moreover, the process of decarbonization in OECD countries requires that negative environmental impact or greenhouse gas emissions not be transferred to the countries supplying such critical materials.

Thus, the development of plans for the reduction of Green House Gases (GHG) must consider GHG emission indicators along the entire supply chain, for all the components involved, including their treatment. Adequate labeling of all materials contained in the components employed in the green economy will provide a greater understanding of their carbon footprint and the risks inherent in the system, allowing us to adopt all the necessary mitigation measures. These indicators will be supplemented by "classic" indicators on the economic indices of various projects, technical performance of energy systems, and the conformity of development plans to the UN's Sustainable Development Goals.

Thus, the availability of materials is already critical in our drive for decarbonization. Europe must address this issue so to not further complicate the vulnerable supply of fossil fuels (gas and oil). Solutions are available and include recycling of critical materials, their substitution with alternative technology (i.e., permanent magnet rotors replaced by rotors with excitation circuits creating magnetic fields), adoption of new environmentally friendly technology for the extraction and processing of materials (such as geothermal lithium), and the creation of a domestic supply system for the extraction of materials.

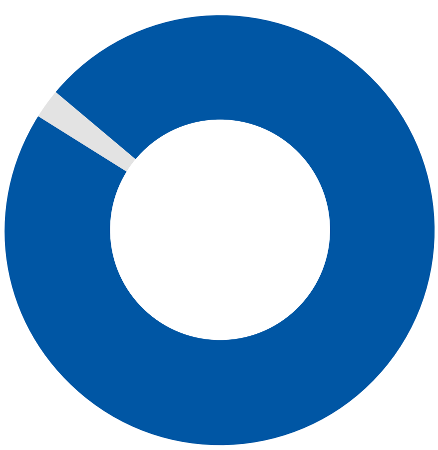
EU – Supply of Critical Raw Materials

China

98%

Rare Earth Elements (REEs)

Turkey



98%

Borates

South Africa

71%

Platinum and majority of Iridium, Rhodium, and Ruthenium

The EU supply of hafnium and strontium is satisfied by European companies.

Industries & Countries

Supply Chains: Global Risks and Solutions

The ongoing pandemic crisis has caused severe global supply chain issues, increasing the cost of energy, logistics, raw materials, and products. Europe is seeking to overcome its dependence on foreign energy through a program based on green measures and innovation. Italy has authorized the development of six wind farms in Basilicata and Puglia.

The health crisis caused by Covid-19 has undermined global markets and their equilibria in terms of both production and distribution, laying bare the main weaknesses in the supply chains of global players: their dependence on a single country for key components and raw materials. The effects of this strategy are creating a bottleneck in global supply chains and increasing prices across sectors, from health to pharmaceuticals and electronics to construction, as well as to the energy sector which lies at the very center of current events.

According to energy sector analysts, on the one hand, the rapidly expanding market for renewables is losing up to US$2 billion/month due to delayed investments, while, on the other hand, prices are increasing because of the specific dynamics affecting the gas market. This situation is defined as a "perfect storm" of issues on the Los Angeles Times by Nick Vyas, Executive Director of the Kendrick Global Supply Chain Institute at the USC Marshall School of Business: "We might be able to buffer against one type or two types of risk, but it's the fact that all these challenges are happening at the same time." Nicole DeHoratius, Professor of Operations Management at the University of Chicago's Booth School of Business agrees: "the cost of labor, transport and logistics are

increasing, our capacity is reduced because of issues along the entire supply chain, and there is a limited quantity of resources along the line, including the number of containers and productive potential." The consequences include increased prices caused by the hike in transport costs, which are justified by the lack of supply and a strong demand for shipments. In fact, the cost of moving a container from China to the western coast of the United States has increased fourfold compared to just one year ago, and tenfold compared to before the pandemic.

The Consequences of Not Diversifying

The core issue is the lack of supply chain diversification that has generated a nearly total dependence on certain countries. Dubbed "the world's factory," China is an integral part of the global supply chain, and all other countries depend on its production of final goods and components.

China's central role as a global manufacturing hub first emerged in the 90s. It rapidly became a global production leader thanks to its vast territory, large work force, and continuous technological progress, all elements that allow it to guarantee low-cost production. Although over the last ten years competition from neighboring countries with similar labor resources drove some companies to move from China to Vietnam, India,

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and Thailand, the phenomenon only affected sectors requiring intensive, low-skilled labor. Indeed, there is a vast technological gap between China and its competitors. China remains the undisputed global leader for all technology related to green energy and aims to lead the climate battle, too. It is the first global producer of EVs, but also produces 70% of all the lithium batteries required by BEVs. The same holds true in terms of renewables. China produces 70% of all solar panels and nearly 50% of wind turbines.

However, the crucial match will be played over rare earths and critical materials, another area of Chinese supremacy. The EU Report on *Critical Raw Materials Resilience: Charting a Path towards Greater Security and Sustainability* emphasizes how Light and Heavy Rare Earth Elements – necessary for wind turbines, motors, and fuel cells – pose the greatest supply issues. As China satisfies 98-99% of the global demand for REEs, what is the outlook?

According to **Wood Mackenzie**, renewable supply chain issues will tend to multiply over 2022. Analysts believe that the growth of China (+8% in 2021) has driven further internal demand for energy, and this has significantly increased national investments in wind and solar energy. So, what happens if the country that currently produces 50% of wind turbines and nearly 70% of solar panels, decides to boost internal installations? It is likely that the global market, which is already facing a range of bottlenecks, will undergo a further shortage.

A further issue for supply chains is represented by Beijing's "Zero Covid Objective," which translates into more careful frontier inspections and even more rigid quarantine measures. **Frederic Neumann**, who conducts economic analyses on the Asian market for HSBC, believes that the program implemented to contain the Omicron variant may further strain supplies. "Consumption in western countries currently depends on Chinese production. However, the 'Zero Covid Objective' policy is causing production interruptions and contractions due to the mass tests conducted on entire cities and the extended lockdowns that are implemented even in the case of minor outbreaks. Samsung (South Korea) and Micron (United States), two of the most important microchip producers worldwide have been experiencing problems in their Xi'an factories, following the lockdown imposed on the city."

Breaking Free

Taking advantage of this situation, various countries, including Japan, India, and the United States, have begun providing incentives for their companies to transfer production from Chinese to domestic plants. However, this is easier said than done, not only on account

of the large investments that these companies have already made to develop complex supply chains in China, but also because of the very advantages provided by Asian giant. Indeed, in addition to skilled labor, China also guarantees sophisticated production plants and a system that is more resilient and reactive in case of shock. Thus, while Vietnam, India, and Thailand may compete with low-cost labor, they do not possess Chinese technological know-how. Japan and the United States, on the other hand, are technologically advanced, but have far higher production costs than China. And this means they are not attractive to other countries.

What can Europe do in such a complex context to achieve the objectives it has laid out for the green transition? First, it must decrease its dependence on China for energy, technology, and raw materials. In the European Union, this means developing internal, integrated, and associated supply systems to produce the solutions necessary for the energy transition. Moreover, a further strategy may be emancipation from the "just in time" production model.

Also known as "lean manufacturing," the "just in time" production model, which has spread globally, calls for production based exclusively on orders with the acquisition of no more than the strictly necessary supply of components. Although this reduces the cost of components and storage, thereby increasing profits, it also leaves no leeway for error, as any individual delay in the supply system will place an entire process at risk. Moreover, both the pandemic and (increasingly frequent) extreme climactic phenomena have demonstrated

that what is often earned in terms of greater efficiency and speed of the supply chain, may be lost in terms of resilience. Supply chain interruptions cost billions of dollars. They block production and reduce turnover. Many experts believe that when we finally leave the current crisis behind us, European companies will have to re-evaluate the Lean Model, and return to managing stock to increase their resilience, even if this may in the short term mean less profit.

Russian Gas and the Ukrainian Conflict

Another hot topic in terms of energy supplies concerns gas, which reveals yet another example of dependence, this time from Russia. In terms pipeline supplies, Europe imports 41.1% of its natural gas requirements from Russia and only 16.2% from Norway. The infrastructure that transports gas in Europe is composed of a dense network of pipelines whose installation in one country rather than another provokes both political and economic repercussions as has been clearly revealed by the extension of the Ukrainian conflict. On March 15, monitoring supply data along the Polish-German border, the Reuters International Press Agency announced that Russia had blocked the Yamal-Europe pipeline the directs Russian gas westwards to Europe. Yamal is one of three pipelines that Gazprom employs to provide natural Russian gas to Europe. The Yamal pipeline alone delivers ca. 10% of the total gas supplies from Russia. On February 22, the authorization process was halted for North Stream 2, the pipeline that was projected to directly deliver a further 55 billion cubic meters (bcm) of gas/year to Germany via the Baltic route. German Chancellor Olaf Scholz officially declared: "in light of Russia's most recent actions, the authorization process for the North Stream 2 pipeline cannot be certified."

In order to fully understand how the gas supply chain affects the dynamics of relations between Russia and Ukraine, it is important to remember that European supply issues have a prior problematic history. It all started in 2005 when Russia demanded the payment of the debt accumulated by Ukrainian company Ucraina Naftogaz. Tension between the two states led to a three-day interruption of the supply of gas to Ukraine. Subsequently, a new supply contract was undersigned to resolve the issue, but, in 2007, Gazprom threatened to block supplies again if the debt was not paid in whole. In 2008, the two countries reached an agreement for the debt to be paid in instalments, but by 2009 a new interruption in gas supplies blocked Ukrainian industry and led to a decrease in supplies to 18 European countries. What were the consequences?

On the one hand, Russia decided to build new pipelines that would circumvent Ukraine. These include the South Stream Pipeline that would connect Russia directly to Bulgaria via the Black Sea, North Stream 1, and the above-mentioned North Stream 2 that would increase supplies to Germany. The latter pipeline, which was completed last September, which was awaiting operative authorization, was blocked due to the war in Ukraine. Earlier, following the 2104 Ukrainian crisis, the European Union had blocked South Stream Pipeline, deviating it through Turkey, thereby increasing the EU's vulnerability. The United States, which exports liquified natural gas (LNG) to Europe, has always been amongst the countries contrary to the activation of the North Stream 2 pipeline. LNG supplies are

more expensive, but also more flexible, and represent an alternative supply source for the European Union, although current imports of LNG are limited.

A further consequence of the 2009 crisis has been the European Union's decision to diversify its sources and reduce the quota of long-term contracts with Gazprom, which the EU views as a tool used to abuse a dominant position. Indeed, such contracts hinder access to the European markets by potential competitors. And Gazprom is now taking advantage of the change in pricing strategy demanded by the European Commission. Notwithstanding the fact that it still holds a large portfolio of long-term contracts, the Russian company has increased both spot and short-term contracts, using them as a powerful negotiating tool during periods of high demand and price increase. The European Union is paying the cost of having incentivized flexible contracts to promote market competition during periods of surplus supplies, but it did not consider potential contractions, such as the current one, during which suppliers can toy with supply volumes and costs. Moreover, the European member states are also facing strong competition from Asian countries for supplies that were, until recently, guaranteed by long-term contracts.

In fact, Asian industrialized economies are also gas hungry. While Japan became the main importer after the 2011 Fukushima Accident (as an alternative to nuclear energy), China's rapid industrial recovery during the pandemic caused a sharp peak in its demand for gas - both produced internally and imported. According to the Oxford Institute for Energy Studies, in the first

semester of 2021 alone, the Chinese demand for gas reached 192 bcm, a 32 bcm increase over 2020. The forecast demand for 2022 is 400 bcm, nearly 10% of the global demand.

Diversifying the Future

What is Europe doing to address this further need? Diversifying supply sources seems to be the most efficient solution, and, in this respect, the EU has taken a leading global role with innovative measures and ambitious initiatives for the development of renewables and decarbonization. A good example is the Green Deal, which, amongst other measures, includes the **"Fit for 55"** package that calls for a 55% reduction of climate altering emissions by 2030. In order to achieve this objective, the EU has implemented a plan to bolster renewables thanks to which, within 10 years, green energy should provide 40% of the energy needs of member states (as opposed to the current 20%). In the meantime, the Italian government has given the go-ahead for the development of six wind farms in Basilicata and Puglia for a total power capacity of 350 MW. "Thanks to this powerful program of renewables, energy community, and liberalization, we are accelerating faster than any other country," declared Italian Minister for the Ecological Transition, Roberto Cingolani.

The European Commission is on the same wavelength: "In the medium and long-term, renewables are the solution to the energy crisis. And all European countries must urgently expedite their authorization processes." Indeed, in June, the Commission will publish a specific recommendation on permitting procedures. In addition, Europe must also accelerate the development of renewables by working with a series of institutions that must be both involved and included in the process. This had led to the development of a "Sustainable Finance Taxonomy," a classification system listing environmentally sustainable economic activities. The EU goal to become climate-neutral by 2050 requires not only public funds (such as those provided by Next Generation EU), but also private ones. Thus, Brussels has decided to orient private capital towards promoting sustainable economic development. The taxonomy will provide "a practical guide for politicians, enterprises and investors," explains the European Commission, "on how to invest in economic activities that contribute to promoting an economy that will not have a negative environmental impact." In this context, the EU has identified six types of activities: mitigating climate change; adapting to climate change; sustainable use and protection of seas and marine resources; transition towards a circular economy; prevention and monitoring of pollution; safeguarding and restoration of

biodiversity and ecosystems. Moreover, on February 2, the European Commission approved a Complimentary Climate Delegated Act that includes specific activities in the nuclear energy and low-emission gas sectors in the EU taxonomy.

In terms of gas supplies, the key word is "diversification" to optimize imports from various pipelines, from those connecting Europe to North African pipelines (Green Stream and TransMed) to those reaching Spain (Medgaz and Maghreb). Moreover, four further priority corridors have been identified: NSI West Gas (North-South in Western Europe), NSI East Gas (new pipelines through the Baltic, Adriatic, Aegean, Oriental Mediterranean, and Black Seas), BEMIP Gas (Baltic Sea area) and the Southern Gas Corridor (SGC). Italy is exploiting a significant infrastructure: the Trans Adriatic Pipeline (TAP) which connects Azerbaijan to Puglia in southern Italy. The capacity of the TAP pipeline, which was completed in 2020 and has been active since last October, may soon be doubled to 20 bcm to provide an alternative to Russian gas. In the long-term, yet another project, the EastMed pipeline, will connect the European network to offshore gas that has recently been discovered in Cyprus, Egypt, and Israel. Work on the pipeline – including Poseidon, the pipeline that will connect EastMed to Italy from Greece – should be completed by 2027.

Future & Technology

Focusing on Security and Reliability

Facing the challenges to reduce the vulnerability of energy systems, CESI uses strategies and projects to guarantee secure technology and solve supply issues.

Converting the production of energy, especially electricity, from fossil to renewable fuels requires the adoption of new technology. Until recently, it has been possible to keep costs competitive even by using low-performance generation plants. Soon, however, the only lever for competitiveness will be the access to technology that allows the same km/hour of wind, the same photon of solar light, or the same cubic meter of hydrogen to produce a greater quantity of energy. Controlling the key technology for the energy transition, and managing risk and vulnerabilities, will be fundamental for country-systems or economic areas to obtain an advantage over other competitors.

Before the winds of war between Russia and Ukraine arose, European electric energy systems had already been exposed to the fragility of the green transition with cyberattacks, blackouts caused by climactic factors, lack of raw materials such as lithium for EVs, and dwindling supplies of gas. “The fragilities of the energy system can develop into crises if all risk factors concur together,” analysts warn.

In view of the war in Ukraine, it is increasingly evident that Europe must become independent from Russian gas supplies. In this sense, the system through which energy reaches millions of European families remains fragile, also because of the slow rollout of the energy transition. Renewables are becoming more economically competitive. However, to drive their spread and use, authorization processes need to be streamlined further and technology must be adopted to compensate for the non-programmable nature of renewables and better adapt them into existing power networks.

The incessant rhythm of technological progress and the fact that advanced innovation prospers outside of the old continent has recently driven the European Commission to propose new regulations to avoid that some member states remain excluded from the elaboration of protocols that are key to technology, such as electrochemical batteries and artificial intelligence. A further objective is to guarantee an accessible cost for energy, avoiding negative repercussions both at the social level and on the European economy

as well as to ensure adequate access to capital for investments in new electric plants, digitalization, and energy efficiency.

Mitigating the Risk of Cyberattacks

Vulnerability travels along fiber optics. While increasingly pervasive digitalization is key to developing resilient systems, it also represents one of the main weaknesses of energy systems in terms of IT security risk. For years, electric utilities and critical infrastructure have been the object of cyberattacks, most of which aim to steal information rather than cause network blackouts. By stealing information from electric companies, hackers can map critical infrastructure and reconstruct how companies operate, exposing them to ever greater risks. Every time that IT threats are not identified and blocked, "pirate" organizations gain precious data on components, networks, monitoring systems and employee information.

In the United States, the Industrial Control System Cyber Emergency Response Team (ICS-CERT) has emphasized how the energy sector is the most frequent target of cyberattacks (33%) followed by the manufacturing industry (26%). In Europe, the EU Energy Expert Cyber Security Platform (EECSP), which provides recommendations to the European Commission on how to safeguard information in the energy sector, has identified the main global cybersecurity challenges. These include the mitigation of risk for existing infrastructure (including electric networks and nuclear plants), the integrity of energy system components, the externalization of infrastructure and services, and a greater interdependence amongst market operators. And many of these challenges are not unique to the electric sector, but also the include the oil & gas sector, with wide-ranging and intersectoral cases.

While the management of risk related to IT security includes all company levels, in the case of critical infrastructure,

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the involvement extends to all stakeholders. CESI, together with its American subsidiary EnerNex – a company specializing in innovative technology consulting for the electric sector, including smart grids, Internet of Things, and cybersecurity – is working to develop concrete solutions to IT threats for sector utilities. Consulting activities range from security requirements for smart meters to the identification of vulnerable points, risks, and network threats. The “cyber risk assessment” is a complete security audit involving all engineering processes, software, and IT management procedures that identifies and evaluates risk levels, also in view of threats and relative consequences, and provides real-time support during attacks, as well as support a return to normal operative conditions.

Flexibility and Resilience of Electric Networks

Today, more than ever before, electric networks depend on the operation of smart electronic devices that measure, protect, and control energy. During the pandemic, thanks to the close collaboration between European TSOs, the system remained functional and avoided blackouts. Nonetheless, the market grew more fragmented not because of network congestion, but due to its lack of flexibility. Besides interconnectivity (addressed in Issue N. 21 of Energy Journal), flexibility is the other key component of modern electric systems. It can be used to counter the volatility of renewables and extreme conditions, from climactic ones to unexpected pandemics. As illustrated in an IRENA Report on the innovation landscape, flexible solutions that allow the greatest integration of green energy are based on a combination of innovative technology, business models and new regulations.

Helping energy system operators manage the growing demand for electricity and guarantee the resilience of electric networks is the role of the so-called TIC Industry (Testing, Inspection, and Certification), an invaluable technological engineering sector that certifies every detail and that every component works exactly as expected on installation. The objective is to avoid blackouts and other inconveniences that have an enormous negative impact on enterprises and people. One of the main activities required to avoid system failures is the timely replacement of older devices. This requires the scheduling of maintenance that must be coordinated and planned well ahead of time. Interruptions that are often averted at the last second are caused by significant loads on the network and energy demand. The only way to address

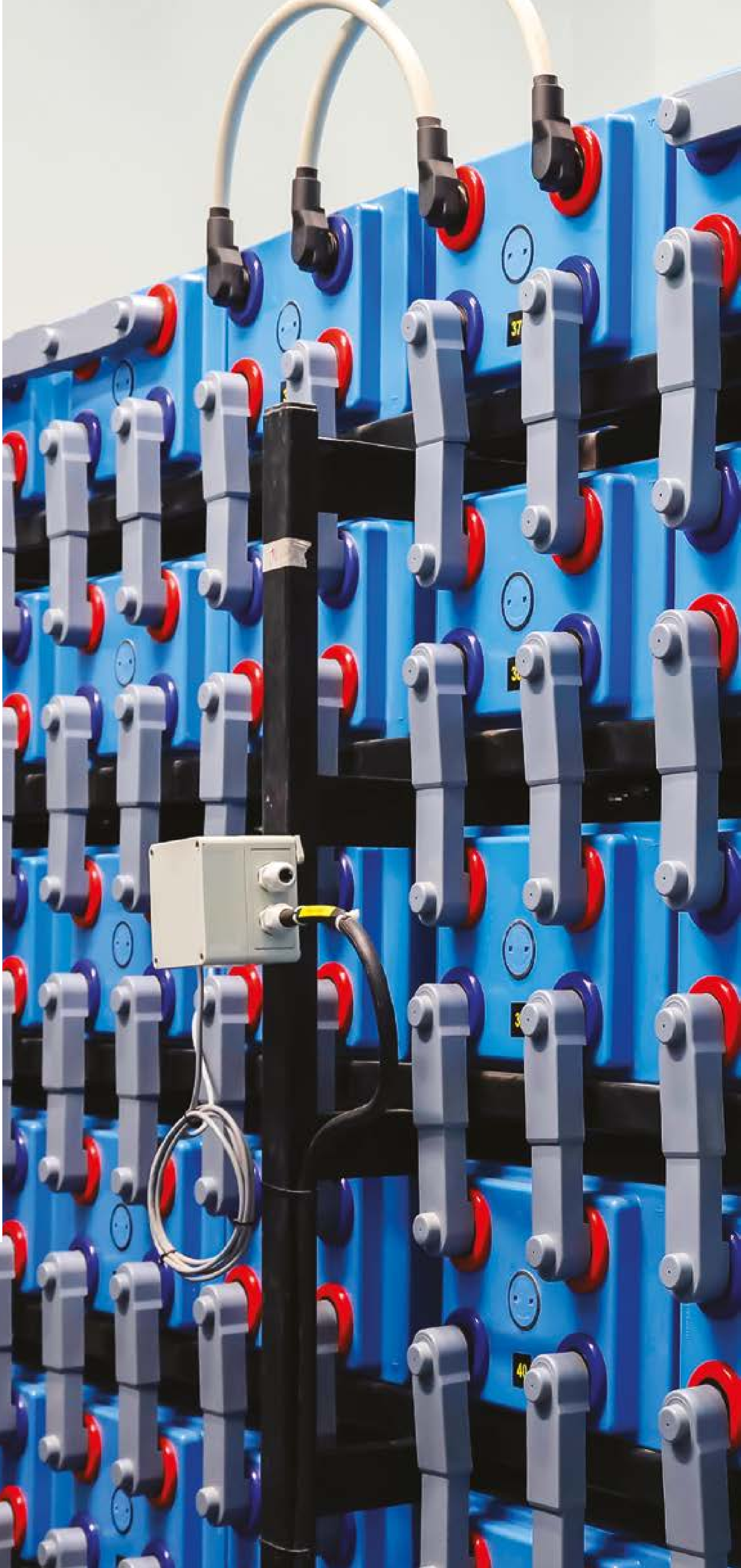
these issues is by performing an extensive number of tests to accumulate operative experience and make the network more reliable and "fit" for urgent maintenance.

Thanks to its division dedicated to Testing, Inspection, and Certification (KEMA Labs), CESI is a global leader in these areas for the electric sector. Seven KEMA Labs (from Holland to Italy, and Germany to the United States) allow CESI to conduct tests for the development of key electromechanical components such as cables, switches, control panels, transformers, and isolators, used with low to extremely high voltages. The tests evaluate the correct operation of the products from an electrical, mechanical, and climactic/environmental point of view, both during the initial research, development, and prototyping phases and subsequently in advanced production phases. The tests guarantee the security and resilience of the entire electric network. KEMA Labs test over 200,000 components per year for over 4000 clients around the world. In Arnhem, Holland, the CESI infrastructure includes the biggest high-voltage laboratory in the world with short circuit powers up to 10,000 MVA. Also in Holland, CESI has a specific lab for simulating the behavior of electric networks during the intense exploitation of renewables. The Flex Power Grid Lab in Arnhem allows CESI to simulate and test the integration into electric networks, not only of renewables, but also of batteries, charging stations, and electric vehicles. Furthermore, experts conduct on-site exams with diagnostic tools to verify the correct operation of generators, high-voltage lines, electronic meters, and substations. Five thousand kilometers of cables are tested every year.

In an increasingly digital world, the Internet of Things (IoT) is expanding and changing the way in which plants and substations are managed. With the aim of reducing vulnerabilities, new technology is being introduced to develop T&D digital substations and components. Indeed, non-conventional transformers with sampled digital outputs are substituting conventional analogical transformers for measuring, protection, and control activities. This type of innovation requires new and updated tests for electric network components that will guarantee their correct operation and greater network resistance and resilience. KEMA Labs are also equipped to test smart electronic devices in terms of functional operation, communication requisites, data integrity, IT security parameters, electromagnetic compatibility, product safety, and environmental influence. Thanks to these tests, crucial electric network components are increasingly able to resist high voltage, manage interruptions, and avoid both failures and interruptions.

Batteries as Storage Technology

As explained, the evolution towards a carbon-free economy requires the adoption of new technology across all sectors. Electricity cannot be stored as such but must first be converted into other forms of energy that can be stocked and then reconverted. Electric power can be transmitted rapidly and can reach distant areas in a matter of milliseconds; however, electric plants require a perfect equilibrium and synchronization between generation and consumption. These two issues have led to a vast debate on the energy storage



technology that should be used for electricity and the resilience of the future "electric era."

Looking at an increasingly sustainable scenario, many investments are focusing on the electrification of short-range mobility. In fact, batteries provide an adequate "mileage" for typical journeys and, according to some data, are more efficient than vehicles with hydrogen-driven fuel cells. Indeed, as batteries in electric vehicles are far larger than effectively necessary for such typical daily journeys (and the cars are parked for most of the time anyway), bidirectional charging allows us to fully exploit the potential of EV batteries, activating a flow of electric energy both to and from electric vehicles. When EVs are parked, they do not require their electric charge and the batteries can operate as small, decentralized energy storage devices. And this technology is readily available and capable of driving the energy transition. In addition to the distributed storage potential of EV batteries, there also are "utility scale" batteries. According to the data of the International Energy Agency, in 2020, battery storage capacity increased by 5 GW, while a 12 GW increase was forecast for 2021. In order to align with the zero-emissions scenario scheduled for 2050, by 2030, a storage capacity of nearly 600 GW will be available in electrochemical batteries.

Whilst awaiting the development of further forms of energy storage, both electrochemical and hydrogen-based, current car battery technology is mainly based on lithium ions (Li-ion) and nickel-metal hydride (NiMH) that contains lithium and cobalt. Clearly, this will lead to a marked increase in their consumption. While lithium resources are relatively abundant, although concentrated in a few countries (such as Australia, Chile, and Bolivia), the availability of cobalt is far more limited. According to the US Geological Survey, the global cobalt reserves that can be exploited with current technology amount to ca. seven million tons, or 57 years of production at pre-pandemic levels. However, the boom of EVs with lithium ions and NiMH batteries will exhaust these reserves far sooner. Moreover, we must also take into consideration the consumption of cobalt by other industrial sectors. Indeed, it is required to produce superalloys, steel, and medicine, too. And this means that only about 50% of the current cobalt production will be reserved for rechargeable batteries.

What is the status of technological innovation against the vulnerabilities of the green mobility system? Given the increasingly significant role of batteries, it will be necessary, to ensure network resilience, to test

the reliability of these devices in terms of performance, security, and life expectancy. And this is exactly what happens in KEMA Labs, the CESI Testing, Inspection, and Certification Division, around the world. CESI technicians conduct cutting-edge tests to verify the reliability of EVs and charging systems, and their interaction with existing electric networks.

Designed to reproduce the environmental and operational conditions of battery cells, identify their vital parameters, and develop a model for ageing and life expectancy, the new Services & Smart Technologies Unit, based on the collaboration between CESI offices in Milan and Arnhem (Holland), provides a series of tests that satisfy new requisites for EV battery systems. Equipped with climactic chambers, thermocyclers, and data acquisition systems (tools that simulate and reproduce the behavior of battery cells in the real world), the KEMA Labs Battery Laboratory analyzes how batteries can provide power to electric networks and satisfy the growing demand for energy.

These tests are fundamental not only to allow utilities to improve network performance under all operating conditions, but also to accrue greater experience on various fronts such as green hydrogen, for example, which will play an important role in sustainable mobility, especially for heavy transport and trains. Indeed cross-sector coupling aims to use green hydrogen in hard-to-abate sectors such as the chemical, steel, and cement industries, as well as oil refineries, all sectors, together with heavy transports, which are not suited to electrification.

The Climate Change Challenge

In this scenario of energy system vulnerability, we cannot overlook the risks that are caused by external events due to climate change. Are our power systems safe against such extreme events? If we are to observe what recently happened to our most advanced energy systems, especially in Western Europe and North Africa, the answer is not very encouraging. During the cold front that struck Europe in January 2017, the system managed to continue working and avoid blackouts only thanks to a close coordination amongst TSOs and the supply of cross-frontier energy transfers. Indeed, for many days, the interconnected European power system was managed with very low security margins.

In 2018, an extraordinary heat wave and drought caused a series of forest fires in California, leading to the death of over one hundred people and damaging thousands of houses and structures. One of the fires, called Camp Fire after the location where it started, was particularly catastrophic. It was the most lethal and destructive fire in the history of the state, and probably the severest global natural disaster in 2018 in terms of economic damage. The investigation ascertained that the fire was due to lack of maintenance on electric transmission infrastructure. Following this episode, power companies around the world understood the true importance of carefully selecting electric transmission and distribution equipment and carrying out efficient, periodic maintenance on all installed infrastructure.

With a view to avoiding such devastating events – and to meet the parameters established by California's Department of Forests and Fire Protection (Cal Fire) for electric lines (minimum distances between transmission towers/utility poles, additional restrictions based on potential fire risk) – US Group Hubbell Incorporated (international producer of products and components for energy systems, with a global revenue of US$4.2 billion in 2020) contacted KEMA Labs Chalfont to conduct tests on its equipment installed along transmission lines in California. The aim of the test was to demonstrate that the surge protection devices equipped with specific selectors could control possible short circuits, sparks, and overheating to avoid setting fire to inflammable vegetation in installation areas. The positive test results allowed the Hubbell Group to present Cal Fire with a report indicating that all previous issues had been resolved – a case history that demonstrates the importance of testing electric network components to guarantee that networks will be increasingly resilient, especially at times like these, when extreme meteorological events due to climate change are on the rise, both in frequency and intensity, year after year.

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Future & Technology

Technological Recycling and Sustainability

Four types of measures can be taken to reduce risks to the raw materials supply system: recycling, substitution, new sustainable technology, and internal production.

It is hardly a mystery that both the United States and the European Union are critically dependent on other countries for the raw materials necessary for the digital and energy transition. And, although both have begun addressing the challenge and taking actions to reduce this, they are still vulnerable in many ways. So, solutions and countermeasures must be taken to improve this situation.

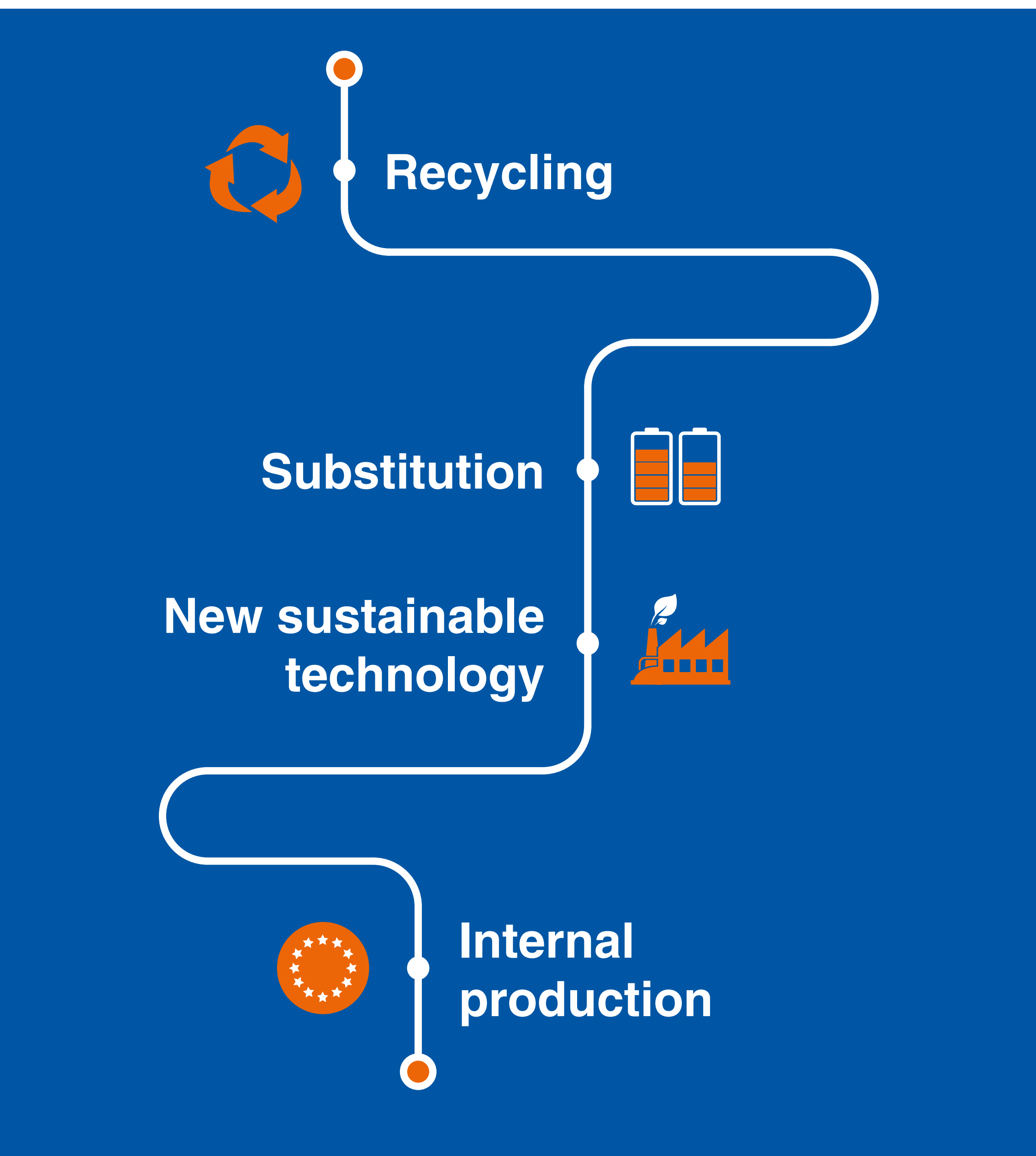
In the first place, closer cooperation between Europe and the United States in mapping supply chains, and delineating similar approaches to reduce risk and create more resilient supply systems, is one of the main issues that emerged from the **EU-US Trade and Technology Council**. This collaboration platform, which was held at the end of September 2021 in Pittsburgh, Pennsylvania, addressed multiple objectives: strengthening technological leadership, stimulating innovation, protecting critical infrastructure, promoting workers' rights, **improving supply chains**, helping low-income earners, fighting the climactic crisis, and protecting the environment.

In May 2021, the European Commission published an updated industrial strategy document on dependence and strategic capacity that identified thirty critical raw materials for which the EU is strongly dependent on imports from other countries. The following month, the White House published a similar report on the development of supply systems with an entire section dedicated to 35 critical minerals. Both reports mapped supply chains, conducted risk evaluations on the supply situation, and described similar approaches to reduce the risk of economic constriction, especially to develop a greater resilience of supply chains, increasing national production and research and development.

The European Strategy

Evolution towards a carbon-free economy is a complex process. It is bound, on the one hand, by the shift from fossil fuels to renewable fuels and, on the other, by the technology and supply systems necessary to produce components for green technology. The development of scenarios envisaging a reduction of emissions focuses on **new indicators that address the entire supply chain of components, including their treatment**. This is necessary to ensure that the decarbonization process in OECD countries will not have a negative environmental impact and lead to greenhouse gas emissions in the countries providing the critical materials. Therefore, the European strategy seeks to solve critical issues in the global supply chain not only by addressing the growing short-term energy requirements, but also by seeking to establish **energetic sustainability for the global supply chain**. Indeed, this is the only means of guaranteeing future security to the entire sector.

The measures taken to mitigate raw material supply chain risk and the vulnerability of the carbon-free economy may be **grouped into four categories**: recycling of critical materials, their substitution with other technologies, and the adoption of new sustainable technology for the extraction and processing of materials. The fourth point concerns internal production, the creation of a domestic supply chain to extract these elements in the European Union.



In terms of **recycling**, in Europe, 50% of industrial materials such as iron, zinc, and platinum are reprocessed, driving the circular economy. However, hardly any of the materials necessary for the green economy are recycled. An initial solution to this issue could be to provide greater information on the materials contained in waste (as in the food industry), **indicating the content of raw materials on product labels**. A good example of this are old tungsten lightbulbs; 42% of the EU demand for tungsten is satisfied by recycling.

Tracking requires **efficient new technology**. However, the technology that is currently used to retreat products and extract materials for reuse still requires a high input of energy and is therefore inefficient and not cost-effective. An example? Recycling the lithium contained in batteries costs more than purchasing new lithium.

The European Commission has promoted a wide range of research programs to promote the identification of practical solutions for material recycling. The EU has addressed critical issues concerning material availability through Program **Horizon 2020** to promote research and innovation on new treatment and extraction technology, as well as substitution and recycling processes. Parallelly, industrial initiatives have been promoted for battery recycling: **Umicore** in Belgium and **Northvolt** in Sweden (similar to the Tesla Gigafactory in the United States).

Denis Goffaux, Executive Vice President of Umicore points out that, "*By recovering key critical elements for the Li-ion battery supply chain, such as lithium, cobalt, nickel, and copper, in the most efficient and environmentally friendly way, Umicore is leading the way towards a battery circular economy, providing solutions to the growing demand for sustainably sourced materials while lowering their CO_2 impact.*" However, until more advanced recycling technology is available, an interesting solution is re-use; when a battery reaches the end of its functionality for mobility, it can still be used efficiently in the energy sector to level the production of non-programmable wind and solar energy.

Emma Nehrenheim is Chief Environmental Officer at Northvolt and heads the Revolt Project for the assembly of Lithium batteries for heavy vehicles using recycled materials. She states, *"Revolt is based on the recycling of nickel, cobalt, and manganese found in batteries though a low-energy water-based hydrometallurgical treatment that separates the reusable metals from other waste materials. Our commitment has demonstrated that there clearly is a circular economy process to produce vehicle batteries. And that there is sustainable model for producing them that is alternative to the conventional one. The recycling process can recover up to 95% of the metals in a battery to a level of purity on par with fresh virgin material."*

A further solution to efficiently mitigate risk, when the principles of the circular economy cannot be applied, is **substitution**. Some REEs (neodymium, samarium, dysprosium) are used in electric motors and wind turbine rotors for their properties of permanent magnetism. However, there are alternative solutions to the use of these critical materials. In the e-mobility sector, for example, BMW has launched the iX model with a brushed electric motor that works without permanent magnets. Other automotive producers (Mercedes) are working on the adoption of batteries with a low percentage of cobalt and a greater amount of nickel. In the long term, the objective is to substitute this critical material. Similarly, the use of asynchronous induction generators with caged rotors in wind power generators (i.e., Vestas) is another alternative to the use of permanent magnets. The current volatility of raw material prices is driving the industry to adopt technological solutions based on more widely available materials.

Sustainable Technology

In relation to the raw materials necessary for a greener economy, the third point of the EU strategy is to develop **new sustainable technology** to reduce its carbon footprint and, more in general, the environmental impact of mining and subsequent treatment processes. Extracting and processing rare earths require a complex sequence of chemical treatments that often have a negative impact on both land and water. Moreover, most raw minerals rich in REEs (such as monazite) also contain thorium, a radioactive element that is concentrated in waste products. And there also are other byproducts that require treatment. Due to their low yield per volume of raw material, the production of one kilogram of rare

earth oxide generates 1-2 tons of waste materials. Naturally, this has local consequences and enormous treatment costs.

Adopting new sustainable technology will also be fundamental to reduce the environmental impact of GHGs. Mining for lithium, one of the least complex materials to extract and process, and the fossil fuels required by the extraction process leave true scars on the landscape; in addition to consuming a great quantity of water, it causes the release of 15 tons of CO_2 per every ton of lithium produced. In the best cases, in which lithium is collected from salty lakes in South America, the carbon footprint is reduced to 5 tons of CO_2. However, considering the expected increase in BEVs, the global demand for lithium could reach ca. 450 KTON by 2030 and cause the release of 4.5 million tons of CO_2 emissions into the atmosphere.

One solution to better manage the extraction of lithium is so-called **green lithium**, which is obtained by using geothermal vapor and has a low to inexistant environmental impact. Given that underground water tables in the sedimentary basins of the Upper Rhine Valley in Germany are particularly rich in lithium (with a concentration of 150 mg/liter of water), the Bruchsal Geothermal Plant in Germany could produce **sufficient lithium for 20,000 EV batteries**. Moreover, a wider exploitation of the Rhine Valley could produce a tenfold quantity of lithium. And there also are other lithium-rich sedimentary basins in Europe, such as the Po Valley in Italy.

Promoting Internal Production

The Old Continent is rich in raw materials. So, internal supplies, such as green lithium, represent a further measure that can be implemented to mitigate the vulnerability of a carbon-free economy. Yet a further resource is represented by the **European Battery Alliance**, which, since 2017, has aimed to make Europe independent in battery production by 2025.

One key issue of the internal production of raw materials concerns the social acceptance of mining activities and the **understanding of the importance of industrial minerals** for both daily life and the economy (with an advanced level of security and environmental sustainability). A wide range of mineral solids are extracted throughout Europe as raw materials or additives for industrial productions. The internal supply of these minerals requires **clear and comprehensible legislative measures** to support the competitiveness of enterprises and ensure a sustainable use of land. Some areas, for example, which still depend on coal mining could shift production to critical raw materials, supported by funding measures with a positive socioeconomic impact.

Opinions

A just transition to clean energy needs to be accelerated

In this issue of Energy Journal, which is focused on the unstable markets veering towards an interconnected future, we have asked for the opinion of Sara Moarif, head of the Environment and Climate Change Unit at the IEA. «The current crisis has also highlighted the importance of energy security and diversifi- cation in Europe. Existing environmental and climate policies will improve energy security and there is no reason to discontinue them».

Sara Moarif

Sara Moarif has been head of the Environment and Climate Change Unit at the IEA since late 2019. In this role she oversees a range of internal and external work on energy and environment policy issues, from carbon pricing systems in the power sector to the climate resilience of energy systems, along with IEA participation in the OECD-IEA Climate Change Expert Group and parts of the IEA's international climate-related engagement.

1 *In your opinion, could the Ukrainian crisis slow down the energy transition towards decarbonization?*

At this point in time, it is difficult to gauge the overall impact of the current crisis on the energy transition; this will likely vary by country and region, and the near- and medium-term effects could be very different. While some near term actions may go against energy transition objectives, the present crisis also highlights the need to accelerate the equitable transition to clean energy.

High fuel prices can spur investment and innovation away from fossil-fuel use. This happened following the oil-price shocks of the 1970s (the first of which led to the creation of the IEA in 1974), and sparked a surge of investment in nuclear power along with a much greater push towards energy efficiency. However, there is a distinction between oil and natural gas. High oil prices can reduce driving, make public transit use more attractive, and render alternatives such as electric vehicles more cost effective. High natural gas prices can make electrification more attractive (e.g. use of heat pumps), but in practice has led to fuel switching from gas to coal for electricity generation (as happened in Czechia).

High fuel prices impose costs on consumers in an inequitable way, and require the development of alternatives to fossil-fuel use, e.g. modern, reliable public transit networks or better insulated homes. When imposed, reduced fuel use can have a negative impact on low-income households risking of a backlash against policies that support the energy transitions. The impact of the crisis on energy prices and food prices will have a disproportionate impact on less well-off and more vulnerable households. In some countries, governments will be able to manage these impacts. In others, such as those in sub-Saharan Africa, they may be much more difficult to recover from.

2 *In the current crisis scenario, several countries (e.g. Germany, Italy) have decided to increase the energy production from fossil fuels, even from coal. In your opinion, in this time is an update of environmental policies necessary or can we continue along the path already undertaken?*

The possibility of restarting decommissioned coal plants is being discussed in Italy, while Germany is moving hard-coal power plants scheduled for retirement into a security reserve, and France is allowing coal-fired plants burn more coal. We see these are short-term measures, an immediate response to a sudden and unexpected crisis.

Today's environmental policies aimed at mitigating greenhouse gas emissions and climate impacts have been developed over many years and have a clear long-term focus. While the current crisis might lead to short-term changes, there is no reason that it should impact these overarching policies.

The current crisis has also highlighted the importance of energy security and diversification in Europe. Existing environmental and climate policies will improve energy security and there is no reason to discontinue them. They can of course be strengthened, but with longer-term objectives in mind, not in response to an immediate shock.

The discussion around reopening coal plants is a sign that energy sources have not been significantly diversified; as the IEA Executive Director Fatih Birol has stated, the clean energy transition will help increase energy security, not decrease it. As such, making decisions that will significantly slow down the clean energy transition is against the interests of governments in Europe and elsewhere.

Renewable electricity prices continue to be lower and more stable than those of fossil fuels; investment in domestic clean energy production and greater energy efficiency both contribute to reducing the EU's energy import bill and dependence on non-EU fuel suppliers. The current crisis is not a sign that more renewable energy is not helpful; indeed, the crisis would be much worse if there were fewer renewables in Europe. IEA's 10-Point Plan to Reduce the EU's Reliance on Russian Natural Gas and 10-Point Plan to Cut Oil Use both contain practical measures that will accelerate energy efficiency and renewable deployment, also lowering GHG emissions.

Reductions of pump prices or freezing of taxes are unlikely to have a lasting impact on decarbonisation, given they are currently planned as temporary respite measures. Energy prices are already very high, and a small, temporary reduction in these prices is unlikely to have major impacts on the pace of policies intended to reduce oil use.

This is of course, not the same as having artificially low fuel prices in the long run, which could lead to less efficient, more fuel-intensive transport systems. As such, given that the need to decarbonise energy systems will not change with this crisis, any measures that will lead to changes that will have a negative impact in a five-year time period and beyond are unwise from a public policy perspective.

3 *In some countries there is a debate on the suspension of the Emissions Trading Scheme to support some sectors in crisis due to the increase in energy costs. In your opinion is it a useful and viable choice?*

The short answer is no. Calls for a temporary suspension of the EU emissions trading system (ETS) do not stem from the current energy crisis but started in late 2021 when EU ETS price soared. The main arguments in favour of temporary suspension are that carbon prices contribute to the overall energy price increases and high EU ETS prices may result from speculative market manipulation.

On the first point, however, suspending the EU ETS would not have a significant impact in stabilising and reducing energy prices, as only a small share of the rises in energy costs to date can be attributed to the higher carbon price.

Prices in the EU ETS have been steadily increasing since 2017, reflecting long-term climate fundamentals. What the energy market is currently facing is a supply shock. Energy prices historically are much more volatile than CO_2 prices, and the increase in gas prices last year was much more significant than that of CO_2 prices. The European Commission has found that the effect of the gas price increase on the electricity price is nine times larger than that of the carbon price increase.

Increasing income support for low-income households, fostering energy efficiency measures, and new incentives for clean energy investment, would be more effective measures in the short term than suspending the ETS.

4 *In the current crisis scenario, what are the areas in which it is important to keep investing for increasing the energy sector climate resilience?*

Uncertainty on how the Ukraine crisis will impact today's investment decisions doesn't mean we can't and shouldn't keep investing in climate resilience, which remains important over the coming decades. More than ever, the crisis illustrates the need for climate-resilient energy infrastructure to strengthen energy security.

Our energy infrastructure is facing an increase in physical risks from the changing climate. The IEA estimates that around a quarter of the world's electricity networks face a high risk from destructive cyclone winds, while over 10% of dispatchable power generation plant and coastal oil refineries face the threat of severe coastal flooding. A third of freshwater-cooled thermal power plants are located in areas that face high water stress. These risks are set to increase over time, highlighting the urgent need to enhance the resilience of energy systems to climate change irrespective of the present crisis.

A lack of resilience in electricity systems can obstruct energy transitions, especially in regions where electricity infrastructure is vulnerable to long-term changes in climate and more frequent extreme weather events. The current crisis illustrates what can happen when energy supply is disrupted: greater energy-sector climate resilience will help limit these disruptions and speed up recovery.

The benefits of building resilient energy systems are much greater than the costs in most energy scenarios given the increasing impact of climate change. The United Nations estimate that for every United States dollar invested in climate-resilient infrastructure, six United States dollars are saved. Moreover, operational measures adopted as early actions can cost less than physical hardening at a later stage.

Operational measures can include better assessments, planning, regulations, and incentives for changing how energy providers invest in and deliver services. Physical system hardening can avoid critical damage for generation, transmission and distribution assets. The relocation of generation assets from flood-prone areas to higher ground can reduce damage from flooding. A transmission system with upgraded towers and a distribution network with underground lines will also be more resilient to strong winds and high storm surges.

The benefits of investing in climate resilience are likely to become tangible only after a few years or even decades, while the capital cost of implementation is incurred immediately. But if there is one thing this crisis has taught us, it is to be prepared and not to act when the problem arises as the consequences will already be felt.

News & Events

Upcoming Energy Events

All-Energy 2022

May 11-12, 2022

Glasgow, United Kingdom

www.all-energy.co.uk

This two-day event provides a meeting point where renewables and low-carbon-emission energy communities have the opportunity to analyze the entire supply chain of renewables. This is the most important event in the United Kingdom for networking and establishing connections with RECs, creating virtuous energy production, consumption and sharing systems.

Intersolar Europe

May 11-13, 2022

Munich, Germany

www.intersolar.de/home

Solar energy is expanding rapidly in Europe. Analysts forecast that this source will represent the largest capacity of electric energy production ever installed in Europe by 2025. This prominent international fair for the solar industry provides visitors with the opportunity to understand sector dynamics and the developments that will drive solar to expand as an energy supply source. The event will focus on the most recent technological developments in thermal solar technology, solar plants, network infrastructure and solutions for the integration of renewables.

Powergen International - Destination 2050

May 23-25, 2022

Dallas, USA

www.powergen.com

This event is dedicated to the leading suppliers of technology and solutions for the green energy transition: digitalization, decarbonization and energy efficiency. The international conference will focus on technology to optimize the performance of plants, hydrogen, the future of electricity, energy storage innovation, and energy leadership by 2050. The event addresses the energy industry, its current challenges and how to face emerging trends.

World Wind Energy Conference 2022

May 28-30, 2022

Rimini, Italy

https://wwec2022.org/topics/

WWEC2022 will focus on "Collaborating for a Renewable Future." The event aims to promote the many opportunities arising for collaboration on wind energy projects in terms of geography, technology, and social issues. Wind and renewable energy experts from around the world will meet to discuss the advancement and management of wind energy technology, the integration of renewables and storage system, RES, and communities.

Energy Executive Summit 2022

June 15, 2022

Milan, Italy

www.utilityday.it/

The summit will plot a strategic roadmap for the digital, cultural, and technological transformation of Italian utilities towards a sustainable and carbon-free energy system. The event provides an opportunity for discussing the drivers of the energy transition for the transformation of the energy industry by addressing energy and climate, innovation and security, development and sustainability, and energy mixes and business models for green energy.

Expo Energía Perú 2022

June 20-21, 2022

San Isidro, Peru

expoenergiaperu.com

The tenth edition of the conference addresses "The Challenge of Energy: The Transition towards a New Energy Model" to analyze and compare the many different aspects related to the energy transition, technological innovation, and renewables. Participants include authorities from the energy sector, researchers and professionals working in the Latin American Energy sector.

Shaping a Better Energy Future

CESI is a world-leading technical consulting and engineering company in the field of technology and innovation for the electric power sector. In particular, through its Division KEMA Labs, CESI is the world leader for the independent Testing, Inspections and Certification activities in the electricity industry. With a legacy of more than 60 years of experience, CESI operates in 40 countries around the world and supports its global clients in meeting the energy transition challenges. CESI also provides civil and environmental engineering services.

The company's key global clients include major utilities, Transmission System Operators (TSOs), Distribution System Operators (DSOs), power generation companies (GenCos), system integrators, financial investors and global electromechanical and electronic manufacturers, as well as governments and regulatory authorities. In addition, CESI works in close cooperation with international financial institutions such as, among others, the World Bank Group, the European Bank for Reconstruction and Development, the European Investment Bank, the Inter-American Development Bank, the Asian Development Bank.

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