The 2023 Euro-CASE Annual Conference
"Energy challenges in Europe. The role of Engineering in securing supplies and technologies"

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Engineers play a key role in society through the design and importantly the implementation of positive solutions supporting society and the environment.

Engineering and Technology are key players in tackling energy challenges in Europe. Our Annual Conference addressed current challenges such as power systems for security and reliability of clean energy, security of minerals supply, while maintaining European strategic sovereignty.

The energy transition in Europe brings significant changes for the energy sectors and industry, as well as widespread economic consequences. The most dramatic changes are expected for the oil and gas sectors in which engineering and technology will play a crucial role for delivering sustainable transformation.

The 2023 Euro-CASE Annual Conference explored both the development of engineering solutions and the enablers, barriers and practicalities of technology deployment. Discussions highlighted how engineers can play a valuable role in guiding decision makers on how to make the best use of technological progress in order to solve complex transitional problems with many interdependencies.

Throughout this conference, we showcased how engineers can provide valuable insights into the implementation of effective and sustainable solutions for the Energy challenges in Europe. Europe is in clear stage of transformation in which energy transition and digitalization is changing slowly but surely our society.

The Conference addressed three main issues related to these changes, electricity mix in which electrification and renewable are playing a greater role, the minerals and metals needed for the huge investments in renewables and electrification and the inevitable transformation of the oil and gas industries. Three broad and key issues in which engineering is necessary and should provide sustainable solutions.

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Opening session

Dr Colino Martínez, the President of the Royal Spanish Academy, welcomed everyone and opened the conference by highlighting the importance of addressing energy challenges in Europe, especially European energetical sovereignty, power systems for security and reliability of clean energy, and security of minerals supply.

Dr Colino Martínez stressed the often-overlooked role of engineers in the society by naming sectors such as energy, healthcare, water supply, household, infrastructure and others where engineers are responsible for their development, implementation, maintenance and eventual dismantling.

The Chair of Euro-CASE, Tuula Teeri, reiterated that the conference aims to address issues related to European competitiveness from the engineering perspective as engineers are those who “get things done”.

Keynote speeches

Thierry Breton, European Commissioner for Internal Market

In this speech, Thierry Breton addressed an audience of academics in applied science and technologies and introduces the theme of the year's conference, emphasizing the critical importance of energy in Europe's strategic autonomy. The speaker acknowledges the potential weaponization of energy dependencies and the need to transition away from fossil fuels toward clean technologies to achieve Europe's goal of becoming a climate-neutral continent by 2050.

Mr Breton highlights the necessity to double Europe's electricity generation capacity and produce clean hydrogen to accelerate the clean energy transition and reduce reliance on Russian energy sources. He stresses the importance of an ambitious European industrial policy to boost the production and deployment of decarbonized energy sources, including renewables and nuclear energy.

The speech emphasizes the belief in Europe's technological capabilities to shape a more sustainable future and the need to turn this technological advantage into commercial leadership. The role of engineers as solution finders and technology makers is highlighted in achieving these ambitions.

Furthermore, the speech underlines the importance of securing energy supplies and technologies, making energy systems resilient to cyberattacks, and investing in transformative projects such as clean, deep, and digital technologies. Thierry Breton warned of the dangers of shipping new dependencies from fossil fuels to minerals, advising that Europe needs to emphasise strong industrial policy and full consideration of the value chain for the manufacturing of components and equipment. The speaker also expresses the necessity of preparing the engineers needed to drive these changes and calls on the conference attendees to contribute to these efforts. In conclusion, Thierry Breton acknowledges the significant work ahead and the expectation that the conference will play a vital role in advancing these goals.

Loreto Ordóñez, CEO of Engie Spain

The CEO of Engie Spain, Loreto Ordóñez talked about the need of collaboration between different sectors of engineering and economy to achieve decarbonization solutions for the future whilst retaining gas part of the energy mix. Loreto Ordóñez joined Thierry Breton in the message about significance of European cooperation, especially the EU market reform and its terms of energy regulation. The CEO concluded that with a note about Spanish carbon neutrality goal set for 2045 and mentioned that social acceptance is often forgotten in discussions about energy. Thus, successful implementation of green energy shall be performed at the same pace in all sectors of economy.

Introductory address from the European Commission

Hélène Chraye, Deputy Director for RTD C “Clean Planet” and Head of Unit of C1 “Clean Energy Transition”

In this speech, Hélène Chraye, discusses several key challenges and strategies related to the energy transition and sustainable development. She mentions that significant work has been done by the commission in response to the war in Ukraine, resulting in the production of new ideas and regulations that have exceeded expectations.

The Deputy Director highlights the first challenge related to energy and fossil fuels, emphasizing that energy production is responsible for over two-thirds of greenhouse gas emissions. Hélène Chraye stress the need for a rapid and comprehensive shift to renewable energy sources, which comes with its own set of challenges, including intermittency, decentralization, and the importance of digitalization and cybersecurity.

The second challenge addressed is the scarcity of planetary resources, including minerals and water, for supporting a global transition to clean energy. She acknowledges that

addressing this issue requires both short-term measures like improving extraction and long-term research and innovation to find sustainable solutions.
The third challenge is ensuring that technological innovations are accessible to all citizens and do not create societal divisions. The speaker emphasizes the importance of designing technologies that meet the needs of people from all demographics, including the elderly and less privileged, to avoid social tensions and evictions.
Hélène Chraye discusses the concept of "circularity by design," where engineers and researchers consider recyclability and resource efficiency throughout the development process. She also stresses the need for testing innovations in the EU to accelerate their market uptake.
The speech mentions the Set Plan, a tool for achieving the Green deal policies and delivery n issues of strategic importance. The Set Plan considers hydrogen as a storage of renewable energy and fuel for certain sectors.
In conclusion, the Hélène Chraye highlights the multifaceted nature of the energy transition challenge and the importance of coordinating efforts across various domains. She emphasizes the need for engineers and scientists to anticipate future challenges, avoid technological dependencies, and ensure that Europe leads the way in sustainable development through research and innovation.

First session: Electricity mix and power systems for reliable supplies

Introduction, set of the scene and key issues

Ignacio Perez Arriaga, Fellow RAI, Research Affiliate MIT Energy Initiative and Center for Energy and Environmental Policy Research (CEEPR)

Ignacio Perez Arriaga addressed a session focused on the electricity mix and power systems' reliability. The objective of the session is to explore how engineering can contribute to the clean energy transition, decision-making regarding the future energy mix in Europe, and control of demand and supply in the power sector.

The speaker begins by providing an overview of the current energy mix in Europe, emphasizing the dominance of fossil fuels (coal, natural gas, oil) and nuclear energy, along with the slow growth of renewables such as solar and wind. He highlights the trends over the years, including the decline of coal and the steady presence of nuclear energy.

The importance of electricity in the energy landscape is emphasized, as it accounts for approximately 24% of total energy consumption. Ignacio Perez Arriaga also notes that electricity's role in the final utilization of energy is expected to grow significantly as economies electrify various sectors.

The presentation briefly touches upon the sources of electricity production in European countries, with an emphasis on renewable sources like wind and hydro, as well as nuclear energy, coal, and natural gas.

Next, the Ignacio Perez Arriaga discusses the European Union's commitments and programs (such as Green Deal and REPowerEU) aimed at reducing greenhouse gas emissions and achieving climate neutrality by 2050. He stresses the importance of cleaning the energy sector, given that it contributes more than 75% of greenhouse emissions.

Opportunities and challenges for the power sector are highlighted. Opportunities include the potential for substantial growth in electricity demand, digitalization, and a shift to carbon-free resources, with an emphasis on renewables. The speaker also mentions the importance of protecting vulnerable customers and minimizing uncertainty for investors. Ignacio Perez Arriaga addressed the energy needs of neighbouring regions, particularly in Africa that are estimated to grow significantly in the future.

In summary, the Ignacio Perez Arriaga sets the stage for the session by providing context on the current energy landscape in Europe, the EU's climate goals, and the opportunities and challenges that lie ahead for the power sector.

First Panel Session

Daniel Iracane, Fellow of the National Academy of Technologies of France
Systems analysis of the capacity of decarbonized electricity mixes to support the decarbonization of the economy

Daniel Iracane set out to illustrate the efficiency of the mix by the utilization factor.
The speaker introduces the concept of the utilization factor, which measures how effectively electricity generation capacity is utilized. He explains that while the availability factor of generators depends on technology and operators, the utilization factor is a system parameter influenced by the overall dynamics of the energy system.
Daniel Iracane breaks down the energy system into three subsystems: dispatchable generators (e.g., nuclear and hydro), intermittent sources (e.g., wind and solar), and a compensation system (which ensures supply matches demand). The speaker discusses the potential for hydrogen production when excess intermittent energy is available.
Daniel Iracane points out that although hydrogen has high utilization coefficient, the utilization factor of the combined renewable and dispatchable system is around 70 %, increasing the load factor of the electricity generation but displacing the lower load factor onto the electrolyser. Thus, the speaker calls for an increase of the production of hydrogen since otherwise up to 30 % of the capacity of the system might happen to be unused. Daniel Iracane concludes that based on his simulations, Europe is facing a trade-off. This is because increased hydrogen production leads to increased load factor of electricity generators; however, load factor of electrolytes is thereby decreased. The speaker demonstrates that the performance of the energy mix depends on the amount of hydrogen produced and how it's balanced with other factors.
In summary, Daniel Iracane provides insights into the challenges and complexities of managing the evolving electricity mix, emphasizing the role of engineers and the need for comprehensive simulations and market design to ensure a sustainable and efficient energy transition.

Filip Johnsson, Professor in Energy Systems, Department of Space, Earth and Environment, Chalmers University of Technology, Göteborg

To balance supply and demand in future electricity systems

In the presentation Filip Johnsson, started by mentioning his Swedish background where an unhealthy debate is being led between supporters of clean energy and nuclear energy although in Filip Johnsson's judgement the country needs a combination of both.

The speaker mentions his involvement in writing the SAPEA report, which focuses on the energy transition in Europe. He highlights key findings from the report, with a particular emphasis on the importance of strong system integration for expanding electrification.

Filip Johnsson discussed the concept of system integration, stressing its importance in smartly integrating various sectors like industry, transport, and buildings. He emphasizes that these sectors need to collaborate more effectively due to changes in electricity generation systems.

Filip Johnsson underscores the value of having diverse technologies, especially on the demand side, to facilitate the integration of non-dispatchable electricity generation, such as wind and solar power. The speaker explains that without utilizing flexibility options, the value of renewable energy sources diminishes.

The speaker presents various flexibility measures, including electric fuels, smart EV charging, gas turbines, small modular reactors, batteries, and hydrogen production. He cited examples from Sweden, such as hydrogen-based steelmaking. Filip Johnsson also emphasizes the importance of increasing import and export capacity between member states to enhance the integration of non-dispatchable electricity generation.

Filip Johnsson introduces the concept of "net load," which represents the remaining electricity demand after subtracting contributions from non-dispatchable sources like wind and solar. Using an example from a techno-economic model, he demonstrates how a combination of flexibility measures, including hydropower, batteries, hydrogen production, and electrified heat production, can reduce net load to zero, ensuring a stable electricity supply. However, Filip Johnsson underscores that the presented model is system dependent.

Dirk Uwe Sauer, RWTH Aachen, E.ON Energy Research Centers
Electricity storage and flexibilities for supporting renewable power generation

In his speech, Dirk Uwe Sauer highlights Germany's policy targets, aiming for 80% renewable energy in the electricity sector by 2030 and an increase in power generation to 680-750 terawatt-hours. He acknowledges that these targets are insufficient in the long run to meet global climate goals as outlined in the Paris Climate Agreement.
Although the scope of Dirk Uwe Sauer's presentation is short term flexibility, he calls for means of ensuring long term flexibility as well. He illustrates this on an example from Germany where the renewable electricity generation was during 2 weeks by far too small to cover the demands, which he calls "Dunkelflaute"
Dirk Uwe Sauer shows a prognosis of the global battery storage market which is predicted to grow mainly due to demand for batteries in electric vehicles. He highlights the rapid growth of the electric vehicle market, both globally and in Germany. Electric vehicles offer substantial battery capacity, which can be harnessed for grid flexibility without significantly affecting the vehicle's lifespan. The speaker recognized the prominence of lithium iron phosphate batteries in the market, emphasizing that cost-effective solutions tend to dominate. Dirk Uwe Sauer lastly discusses sector coupling, focusing on the interconnection of different energy sectors, such as using surplus electricity for heating systems instead of converting it into hydrogen.
In summary, the speech underscores the importance of market flexibility, the role of electric vehicles and other technologies in providing grid flexibility, and the need for clear energy market structures to support these initiatives in the transition to a more sustainable energy system.

1st Panel Session: Moderated discussion between speakers and the audience.

Ignacio Perez Arriaga took the privilege to start the discussion with a question about Daniel Iracane's analysis. Daniel Iracane suggested that the energy sector shall avoid power to gas and back to power system to compensate for intermittency. Ignacio Perez Arriaga pointed out that there is also an idea of an inter-seasonal energy storage with green hydrogen production and asked what Ignacio Perez Arriaga's view on this solution is. Ignacio Perez Arriaga summarized that there is an energy cost and economic cost to every solution. The energy cost of the inter-seasonal system is around 30% energy loss in transition to hydrogen and back to power. The economic cost is that the utilization factor of the system will be very low and hence the capital cost will be difficult to amortize.
Ignacio Perez Arriaga then turned to Filip Johnsson for his stand on sector coupling as an option that could be used to cope with the energy demand variability. Filip Johnsson agreed and mentioned that combinations of flexibility methods linking supply and demand differ based on the origin of electricity. For example, the best coupling method for wind power is hydrogen storage, whereas batteries are a good fit for solar power.
Filip Johnsson then reacted to the Daniel Iracane's concerns about converting power to gas and back to power. He said that this solution could be particularly valuable during a "Dunkelflute" when the demand for electricity is high.

Ignacio Perez Arriaga also recalled the Fit for 55 agreement and asked for Filip Johnsson's opinion on the EU regulation. Filip Johnsson highlighted the importance of a common European policy and reminded the audience that free allowances will be phased out by 2033, thus some industries such as steel, cement, petrochemical will likely need to pay up to 150 EUR per a ton of CO_2. Therefore, technologies such as carbon storage will become profitable. Filip Johnsson warned that once these policies will come into place, some countries in the EU will experience negative effects on their economies and negotiation will need to take place.
Andre Ramirez from the TU Delft touched upon the goal to reach negative emissions by 2050 which is more ambitious and challenging than carbon neutrality. Filip Johnsson predicted that there will be an overshoot in emissions before the Paris agreement is reached and thus carbon capture technologies will be necessary in Europe. However, he explained the need for European solution for financing carbon negative initiatives since such solutions benefit the whole Europe and it would be thus unfair for national governments to fund 100% of these facilities.
Jakub Zemek from the online audience asked a provocative question about Dirk Uwe Sauer's stand on the ban of nuclear energy in Germany. Dirk Uwe Sauer stated that Germany followed the plan to shut down its nuclear powerplants with slight extensions in their operation due to the invasion of Ukraine. In the question of opening new nuclear powerplants Dirk Uwe Sauer said that calculations suggest the cost of electricity would be too high.
Lastly, Ignacio Perez Arriaga asked Daniel Iracane if the production of hydrogen from the surplus electricity will cover the demand for hydrogen in Europe both for electricity production and for the industry. Daniel Iracane answered that hydrogen production from surplus electricity certainly will not meet the European hydrogen needs and thus electricity production needs to increase and/or the hydrogen needs to be imported.

Second Panel Session

Tomás José Domínguez Autrán, Director of Operation, Red Eléctrica de España
Renewables integration in the electricity system, the case of Spain

Ignacio Perez Arriaga introduced Tomás José Domínguez Autrán, who commenced his speech by presenting the Spanish energy mix that is renewable from 63 %. The speaker then provided data indicating the rapid growth of renewable energy in Spain, with a year-over-year increase in renewable energy penetration. This demonstrated Spain's commitment to expanding its renewable energy capacity. Mr Autrán discusses the need to balance the intermittent nature of renewable energy sources. He stresses the importance of observability (real-time monitoring) and controllability (ability to send set points) for renewable facilities. These measures help ensure the stability and reliability of the electrical system. In Spain, this is achieved through the CECRE center that accurately forecasts renewable energy production which is crucial. Mr Autrán explains that real-time studies in Spain contribute to observations made by the CECRE center that are then used for forecasts. These forecasts are in turn

deployed to cover and balance the demand by creating real time set points. This system works in circular manner.
The speaker emphasizes the need to prevent voltage dips that could affect renewable energy generation. A rapid response tool is used to trip renewable power plants during grid contingencies, preventing overloads and increasing the integration of renewable energy.
Mr Autrán anticipates that the integration of renewables will continue to be a challenge in the future. He emphasizes the need for more intensive efforts and better regulations to accommodate real-time operations effectively. He introduces the SRAP system that allows for solving post-contingency overloads by means of corrective automatic power reductions.
In summary, the speaker's speech focuses on Spain's renewable energy sources, the challenges and strategies for integrating these sources into the electrical system, and the tools and measures implemented to ensure stability and minimize curtailment.

Francisco Suárez Ortiz, (ES), Vice-Chair of the European Nuclear Society Young Generation Network (ENS-YNG), Tecnatom*

The role of nuclear in the electricity mix for the energy transition

Francisco Suárez Ortiz mentions that nuclear power contributed to 25% of electricity production in the EU in 2021, and globally, nuclear power accounts for 10% of electricity production.
The speaker highlights the importance of achieving net-zero emissions by 2050 and emphasizes the attributes of nuclear technology, including high capacity factors, grid stability, low carbon emissions, and cost competitiveness. Francisco Suárez Ortiz states that currently large nuclear reactors are in operation whereas small modular reactors (SMRs), and microreactors will enter service in the future.
Francisco Suárez Ortiz named several opportunities for nuclear power, for example, contributing to high electrification, addressing non-grid emissions, and enhancing energy security.
Challenges include the rapid deployment of nuclear capacity, cost competitiveness, public acceptance, and licensing for advanced reactors. However, public perception of nuclear power is on the rise, with growing support in Europe, the US, and Poland.
Francisco Suárez Ortiz concludes that nuclear power can be compatible with renewable energy deployment and suggests considering the extended long-term operation of existing nuclear power plants.
In summary, nuclear technology has the potential to contribute to a sustainable and low-carbon future, but challenges like public acceptance and cost competitiveness need to be addressed. The speech provides an overview of the current state of nuclear power, its potential role in the future energy mix, and the challenges and opportunities associated with its continued development and deployment.

2nd Panel Session: Moderated discussion between speakers and the audience.

Ignacio Perez Arriaga closed the first session by raising a question towards Tomás José Domínguez Autrán about controlling supply and demand for energy without thermal generation. Mr Autrán stated that the majority of energy in Spain is provided by a combined cycle and that they have designed a specific balancing product to meet the demand. He hopes that Spain will be allowed to continue with that product under the EU regulation.
Ignacio Perez Arriaga then addressed Francisco Suárez Ortiz about whether the nuclear sector is an attractive sector to pursue a career for the younger generation. Mr. Ortiz encouraged young people who are already interested in engineering to get involved in nuclear engineering as it is an interdisciplinary sector and therefore engineers with various backgrounds can participate.
Mark Jolly representing the UK's Royal Academy of Engineering asked Mr. Ortiz whether he has done any scenario modelling with regard to how many small modular reactors could be used to meet the need for electrification in the industry.
Mr. Ortiz agreed that there is a significant potential for small modular nuclear reactors, especially in the metal industry.
Since the small nuclear reactors would be potentially based next to explosive hazard areas, additional regulatory work is necessary in order to assess all safety risks.
The last question came from Daniel Iracane who was asking about Francisco Suárez Ortiz's view on the current EU approach to nuclear power plants as non-renewable energy sources. Francisco Suárez Ortiz acknowledged that nuclear power could be exploited to produce hydrogen that can be sold on the EU green market.

Second session: Energy transition and Digitalization: the challenge of minerals for a strategic sovereignty

Introduction, set of the scene and key issues

Eloy Álvarez Pelegry, Fellow of the RAI and Professor Ad honorem at Superior Technical School of Mining and Energy in Madrid

Eloy Álvarez Pelegry begins by referring to a recent study by the International Energy Agency, indicating that the critical minerals market has doubled in the last five years, which aligns with previous projections. He also mentions the projected increase in demand for materials due to digitalization and hence the importance of avoiding new dependencies on critical minerals.

Eloy Álvarez Pelegry proposes measures to combat new dependencies, for example by reducing European reliance on fossil fuels and illustrates which parts of the world supply minerals to Europe for the energy transition. speaker distinguishes between critical and strategic minerals and refers to the list of critical materials defined by the European Commission which has expanded from 13 in 2011 to more than 30 in recent years. He stressed the importance of domestic production of minerals in Europe as the best way to avoid dependency and contribute to European sovereignty.

Furthermore, Eloy Álvarez Pelegry suggests that developing and implementing supply chains within European territories is a key strategy to avoid new dependencies. He emphasizes that the entire value chain, from mining exploration to equipment production, must be considered. The speaker underlines the vital role of engineering and technology in enabling the energy transition and points out that engineering and digitalization play a role throughout the value chain, from mining to equipment production.

Eloy Álvarez Pelegry mentions Spain's long tradition in mining and metallurgy in the light of European sovereignty and highlights the possibilities in the mining of various metals. He references a book published by the Royal Academy of Engineering and Mining Schools, which discusses Spain's potential in the field. The speaker concludes by presenting several discussion points for further exploration and encourages discussion on reliance on imports versus self-sufficiency. Eloy Álvarez Pelegry stressed the importance of domestic production of minerals in Europe as the best way to avoid dependencies and contribute to European sovereignty in his speech.

First Panel Session

Stephane Bourg, BRGM, Director of the French Observatory of Mineral Resources (OFREMI)
Strategic minerals for energy transition, France strategy in the European context

Stephane Bourg emphasizes the integral relationship between the energy transition and raw materials, as both energy technologies and the production of raw materials require each other. He informs that France has developed a comprehensive strategy to position itself in the global context and address these challenges. Global context is important here since the political framework includes EU initiatives such as the Critical Raw Materials Act and the European Green Deal and national strategies and regulations in France.
Stephane Bourg discusses the technical framework to promote French raw material strategies that involved the creation of an interministerial delegation to coordinate efforts across different government ministries, the establishment of a French Observatory for mineral resources, the formation of an investment fund to promote raw material production, and the development of an internal French investment plan managed by France 2030 and the Public Investment Bank (BPI).
The French Observatory stands in the middle of this framework and focuses on analysing global value chains, quantifying supply, and assessing the impacts of technological developments on supply and demand.
Stephane Bourg provides examples of strategic actions in the mobility sector, such as positioning value chain components for electric vehicle production in northern France. Another example relates to the permanent magnets industry, where efforts are being made to refine rare earth elements and establish methylation industries, currently lacking in the EU.
The speaker introduces the French research and development framework covering different areas of research focused on producing raw materials with minimal environmental impact, improving recycling processes, battery technology, and developing more efficient materials. Hydrogen plans also play a part in the innovation strategy.
The speech provides an overview of France's comprehensive strategy for addressing the challenges related to raw materials in the context of the energy transition. The emphasis is on both political and technical frameworks, strategic examples, and the importance of collaboration and innovation.

Susanne Norgren (SE), Group Expert Materials Design, Department of Mechanical Engineering, Division of Production and Materials Engineering, Lund University (online)
The role of engineering in new technologies for mining exploration and operations

Susanne Norgren addresses the significant challenges related to raw material consumption in Europe, particularly focusing on the demand for materials in the mining equipment sector and their crucial role in the context of the energy transition. At first, Susanne Norgren highlighted that Europe consumes 20% of the world's raw materials but only produces 2%.
Next, Susanne Norgren showed the global flow of raw materials, from upstream (extraction and mining) to refining and middle stream, and ultimately to consumption. From there it was apparent that a substantial portion of raw materials comes from Asia.
In the mining phase, the industry relies on raw materials such as tungsten and cobalt for equipment and processes and despite efforts to increase recycling, the demand for new raw materials is still high due to the energy transition. The speaker identified tungsten and cobalt are identified as two crucial elements for mining equipment.
Susanne Norgren supported her argument by providing data on the demand for tungsten, which showed a dip during the pandemic but has now returned to pre-pandemic levels. Tungsten's primary use is in tungsten carbide products, which are essential for rock drilling and metal cutting.
Next, the speaker focused on cobalt, a vital material for batteries, that is expected to see a 25-fold increase in demand by 2030. An increase in the demand for cobalt has led to ethical concerns, particularly related to its mining in conflict areas. The speech mentions recycling efforts and presents an example of recycling rock drill buttons. Although recycling offers sustainability benefits, more research is needed to make recycling energy and carbon-efficient while maintaining product performance.
The speaker calls for a discussion within the European Union to address the environmental impact and dependency on raw materials.
The speech highlights the significant role of Europe in consuming raw materials and the challenges in the mining equipment sector, particularly regarding tungsten and cobalt. It also underlines the ethical concerns associated with raw material sourcing and the importance of recycling to reduce environmental impact and material dependence.

Egbert Lox (BE), Former Senior Vice President Government Affairs Umicore and Honorary Professor at Karlsruhe Institute of Technology

The role and possibilities of circularity for metals

In his presentation Egbert Lox addresses the importance of recycling metals, particularly in the context of lithium-ion batteries, while emphasizing that despite substantial developments, lithium-ion battery technology is still relatively young, having received a Nobel Prize in 2019. The presentation references the European Union Battery 2030+ research initiative, involving renowned European institutions and researchers, which indicates a continuous focus on battery innovation and development.

The speaker mentions the remarkable growth in global battery demand, which has multiplied by a factor of 14 between 2018 and the present. The rapid expansion of this technology, particularly within the European Union and other regions, raises concerns about managing such unprecedented growth.

In the automotive industry, lithium-ion batteries, specifically traction batteries, make up approximately 50% of the weight and value of electric vehicles.

Egbert Lox outlines the multiple factors driving the need for battery recycling, such as legislative drivers and sustainability. Recycling helps meet recycled content targets for new battery production and contributes to the environmental and economic goals of the industry. Notably, recycling can reduce the carbon dioxide footprint of battery materials by up to 96%.

However, to ensure effective recycling, Egbert Lox reminds that engineering skills and competencies are essential. The speaker calls for a production of high-quality battery-grade materials to enable their integration into high-volume markets effectively. The speech further touches on data collection and sensor technologies which are expected to play a vital role in determining the recyclability of modules and cells.

Egbert Lox emphasizes the availability of information materials and resources, including reports, publications, and initiatives, that can help stakeholders learn and make informed decisions about battery recycling.

The overall message is that recycling is fundamental in the context of lithium-ion batteries and the growing importance of sustainable energy solutions. It is a powerful tool to meet environmental and economic goals while addressing the rapid growth in demand for batteries. Egbert Lox highlights the role of engineering competencies and collaborative initiatives in realizing effective and sustainable recycling practices.

1st Panel Session: Moderated discussion between speakers and the audience.

The questions posed to the speakers during the discussion delved into crucial aspects of France's strategy for managing materials, circular economy practices, and Europe's contributions to mineral demand. Stephane discussed the role of recycling, highlighting the challenge that recycling will only meeting a fraction of the future material needs. He emphasized that closing the loop for lithium-ion batteries will not ensure material availability to meet all needs, but that it will still have a role to play in the energy transition.

Susan addressed Europe's role in contributing to mineral demand, acknowledging the issues related to open mines, land conflicts, and the complexities of recycling processes, especially for non-steel metals. She noted that Europe has developed recycling processes for many metals, but certain metals have technical challenges that pose a barrier to metals recycling.

Egbert responded to a question about the supply of materials for batteries in electrified mobility, discussing report that emphasized the need for a different approach to mobility (e.g., shared fleets), instead of a one-for-one replacement of petrol vehicles with electric vehicles. Egbert and Stephane both discussed the importance of downsizing vehicles and the need to rethink mobility and car ownership as an effective part of the energy transition.

Following on from this, the final question emphasized the scale of lithium production needed for a significant shift to electric vehicles and the importance of changing car ownership models. It was suggested that recycling should not be the primary focus; instead, a shift towards making products last longer, repair, maintenance, and repurposing were underscored as more effective sustainability measures. Stephane pointed out the trade-offs between product longevity and recycling efficiency, as extended product life can lead to material degradation. Overall, the questions and responses emphasized the complex and interconnected challenges of transitioning to sustainable materials and mobility systems.

Second Panel Session

Robert Dominko (SI), National Institute of Chemistry and associate professor at University of Ljubljana

Alternative materials for future batteries

Robert started his talk by speaking about the progress that has been made in battery materials, with a drastic increase in the lifetime of lithium-ion batteries and the importance of this increase in applications such as electric vehicles. He presented an overview of the Battery 2030+ programme, which aims to increase battery quality reliability, lifetime and safety whilst lowering the cost and reducing the environmental footprint.

Robert then went on to talk about the supply risk on raw materials associated with lithium-ion batteries, which may be a barrier to the rollout of low-carbon technologies dependent on batteries such as EVs. He summarised that without mining the demand for battery input materials will not be met, so whilst recycling processes are important, developing resilient supply chains for lithium-ion batteries will be essential. He then went on to discuss the battery technologies which may replace lithium-ion and do not have the same supply chain risks as lithium-ion batteries, such as solid state and sodium-ion. Presenting a map of the ongoing and planned lithium-ion battery production sites, he concluded by offering his opinion that these are substantial announcements, but whether Europe has enough raw materials to supply these factories remains to be seen.

Migle Laukyte (LT), Member of the European Group on Ethics in Science and New Technologies (EGE)

Ethical and environmental responsibility of engineers in energy transition and digitalisation

Migle's presentation started her talk by underscoring the crucial role of European engineers in addressing challenges and opportunities arising from emerging technologies and scientific advancements on areas that are particularly relevant to the future of Europe. She discussed the need for a new mindset in engineering, highlighting that the history of human interaction with natural resources through engineering has being based on the word "use". Migle emphasized for the need of a paradigm shift away from traditional resource dynamics characterised by "take, make, dispose", towards a more sustainable approach of "produce, reuse and recycle", with avoidance of wastage wherever possible.
In both the short and long term, she called on engineers to play a pivotal role in facilitating this shift. In the short term, she proposed a proactive approach towards legal compliance with the highest possible environmental standards, supported by research and innovation. In the long term, she challenged engineers to think about what it is we are producing, why and for what specific ends, providing not only technical expertise but working to shape a more sustainable future. Working from the bottom up, engineers can have substantial impacts on industry, investors and regulators. She ended by stated that the ethical and environmental responsibility of engineers is not a choice, but a duty, and should not just be limited to those working in industries that are seen as more closely linked to the environment and the energy transition.

Mark Jolly (UK), Professor and Director of Manufacturing Academic & Business Support, Cranfield University

The role of engineering and new technologies in metallurgy operations

Mark started his talk by stating that he was going to go back to basics, avoiding talking about "sexy" materials like those that go into batteries but focusing instead on the five materials that

are the major source of industrial carbon emissions: steel, cement, paper, aluminium, and plastics, making up 16% of global emissions.
He discussed the strong relationship between energy and carbon intensity in producing these materials, with the production of metals such as aluminium, steel and copper having the highest energy and carbon intensities. Speaking about the recyclability of metals, Mark challenged the depiction of aluminium as infinitely recyclable, discussing the energy consumption required for recycling and the risk of “downcycling” when other alloys are present in aluminium products (e.g., soft drinks cans).
Focusing on aluminium and steel production, he presented the technologies available for decarbonising their production. For aluminium, this includes the decarbonisation of electricity used in production (with currently over 70% used for aluminium production being fossil fuel based) and the introduction of inert electrodes into the production process. For steelmaking, he discussed the use of electric arc furnaces, using the hydrogen direct reduced iron production pathway, and implementing carbon capture and storage into the conventional steel production route. As he closed his speech, he reflected on the urgent need to decarbonise key materials production in industry rapidly.

2nd Panel Session: Moderated discussion between speakers and the audience.

The first question touched upon the financial support going towards new technologies (e.g. iron reduction with hydrogen), highlighting that there is significantly less money going towards this compared to other projects like battery manufacturing “Gigafactories” and asking what can be done about this. Robert agreed, highlighting the challenges that he had found in advocating for the Government of Slovenia to accelerate TRLS from 1-3 to 4-7; this is an approach that was prioritised in China and is a key action that European governments should adopt.
The second question asked if electric vehicles could be used as an energy storage technology, with Robert replying that the lithium-ion cells are good enough technically to be used in this way. However, Robert highlighted the point from an earlier presentation about the movement away from individual car ownership, which could pose barriers to the large-scale usage of electric vehicles for energy storage.
The next question asked about the relative environmental benefits of recycling versus mining for additional materials, highlighting the impact of carbon intensity of electricity and asking about how can engineering play a role in addressing these complexities. Migle responded by discussing the need for an effective answer to this question, with the responsibility of engineers to present the facts and explain complex technical problems to the rest of society.

Third session: The role of Engineering in the transformation of the oil and gas sectors

Introduction, set of the scene and key issues

Luis Cabra Dueñas, Deputy CEO of Repsol

He introduced the final session which explored the *role of engineering in the transformation of the oil and gas sectors*. He set the scene of the to the energy transition, discussing the challenges ahead associated with reducing greenhouse gas emissions but remaining positive given the scale of ambition announced by companies and governments on climate change.
Touching upon the debate over the role(s) and responsibilities of the oil and gas industry, he expressed some disappointment in the depiction of the industry not doing enough to respond to the climate crisis, highlighting that it is the collective responsibility of the whole of society to effectively respond to the climate crisis given the size of the problem facing us. In his words "the challenge is huge […] but if we apply technology and we apply engineering, we can decarbonise the energy mix faster".

Luis went on to present the key solutions available for the oil and gas industry to decarbonise their operations; renewable electricity, low-carbon molecules, and carbon capture & storage (CCS). He highlighted that the industry is well-equipped to integrate these solutions into its operations, presenting a schematic for how refineries and petrochemical sites could be converted into low-carbon modes of operation. Without further ado, he introduced the speakers of the first panel; Nicolas Aimard (Senior Vice-President of TotalEnergies OneTech), Andrea Ramirez Ramirez (Faculty of Technology, Policy and Management at the Technical University of Delft) and Joachim Meister (Global Senior Vice President, Worley).

First Panel Session

Nicolas Aimard (FR), SVP of TotalEnergies OneTech
System engineering development for biofuel and synthetic fuel

During his talk, Nicolas highlighted TotalEnergies' shift away from conventional oil and gas operations towards emerging energy sources to meet demand by 2050, both low-carbon electricity (e.g., renewables) and molecules (e.g. green hydrogen and e-fuels). Whilst Nicolas discussed how these technologies will become an important part of TotalEnergie's operations, he highlighted that TotalEnergies anticipates 25% of its energy production and sales to still be oil, LNG and natural gas by 2050. This reliance will need to be compensated for through carbon capture and storage to address the associated emissions.
The speaker than moved on to discuss the market demands for decarbonisation solutions for transport, stressing the importance of a diverse range of solutions beyond just electrification and including e-fuels and biofuels. Nicolas noted that producing these molecules at the large industrial scales required will be challenging, with the production and logistics of e-fuels production in particular requiring substantial changes to existing assets. He presented the pathways available for producing sustainable aviation fuel, a technology which will be required by the aviation industry to decarbonise given some of the challenges to direct electrification in the sector.
In his closing remarks, Nicolas noted that industry needs to move at a more rapid pace to respond to the demands of the energy transition than in previous oil and gas development phases, so there is a heavy reliance on modelling and research to inform the decisions being taken by TotalEnergies and the rest of the oil and gas industry.

Andrea Ramírez Ramírez (NL), Faculty of Technology, Policy and Management, Technical University of Delft

How engineering is adapting and transforming for improving efficiency in refineries for decreasing CO2 emissions.

Following on from the reflections on the approach that TotalEnergies is taking to respond to the demands of the market for decarbonised energy solutions, Andrea introduced the key strategies for the petrochemical industry to decarbonise its operations and the role that engineering can play. Firstly, reducing the amount of resources consumed, through increases in efficiently, reuse, recycling, and touching upon degrowth. Secondly, she stressed the need for the decarbonisation of energy sources, and finally the replacement of fossil fuels with alternative feedstocks such as waste, biomass, and alternative sources of CO2.

The production of ethylene was presented as an example by Andrea, with 69 alternative routes to its conventional production at varying levels of technology readiness, with difficulty for the industry in making long-term decisions due to uncertainty over which will likely be the decarbonised production process(es) of the future. Andrea also discussed the symbiotic nature of the petrochemical industry and how this induces difficulties to the energy transition, with just the port of Rotterdam having 5 refineries with up to 45 other chemicals plants and 5 biorefineries (all of which are highly integrated).

Andrea then delved into the complex challenges of identified which processes are using the most energy-intensive and generate the most carbon emissions, presenting an approach to modelling the system interactions and level of interconnections between different processes lines and pathways which should be used to inform decisions made over how to decarbonise and improve resource efficiency. Andrea also pointed out that changing feedstocks or processes could have cascading impacts not only on the product and its price but on the overall mass-energy balances within all stages of the production processes.

Concluding the discussion, Andrea highlighted the importance of multidisciplinary and multiscale approaches in energy to facilitate decarbonisation, with early integration of theory, simulations and experiments critical to decrease costs, reduce risks and uncertainty and provide a comprehensive evaluation of deployment trajectories and their impacts.

Joachim Meister (UK), Global Senior Vice President, Power & New Energy, Worley
The role of hydrogen in Oil and Gas industry in the energy transition

Following on from the overview of the strategies needed to decarbonise and change the processes within the oil and gas industry, Joachim's discussion was focused on the role of hydrogen in the energy transition. He highlighted that hydrogen has long played a role in the oil and gas industry, having been used in various processes for many years. He emphasised the potential for hydrogen (when produced from renewable electrolysis or through other low-carbon processes) to play a more fundamental role as a feedstock for decarbonised fuels in the future energy system. To achieve this, he highlighted that generation needs to be done at scale, referring to the "Power-to-X" collective approach which uses clean hydrogen and other molecules such as CO2 and N2 to produce a host of carbon neutral fuels such as green ammonia or e-methanol.
Joachim then went on to discuss the opportunity for oil and gas, highlighting that oil and gas industry only makes up a small proportion (7-9%) of announced Power-To-X projects up to 2030 and that announced projects are not matching the required demand according to BNEF's modelled Net Zero scenario. He described the "clash of two engineering worlds" taking place over Power-To-X, with the oil & gas and renewables sectors both being involved in the new and emerging industry of green hydrogen production. He highlighted that there is a substantial opportunity for the oil & gas sector to create carbon-neutral fuels to decarbonise hard-to-abate sector by leveraging their expertise in hydrogen and its use to scale up green hydrogen production.
His discussion also shed light on the challenges associated with Power-To-X, including those associated with market dynamics, offtaker risk, social & environmental permitting, stakeholder management, technical obstacles, and bankability. Joachim highlighted the role of engineering in addressing all these challenges, with a vital role in developing, scaling and delivering the right solutions that address barriers within the industry.

1st Panel Session: Moderated discussion between speakers and the audience.

The question-and-answer session after the first panel was brief, but touched upon interesting areas, including the use of ammonia as a hydrogen carrier, the future cost of fossil fuels and the regions in which large-scale Power to X projects are happening. Joachim noted that ammonia is definitely one of the potential options for transporting hydrogen, but comes with its own challenges, particularly around its inherent toxicity and transport close to population centres, which engineering can address but needs to be solved, whilst Nicolas stated that products like green ammonia will compete and may be used in some applications, but there will not be any one single solution for everything. Following on from this question, there was a discussion over the use of blue hydrogen and ammonia as a bridge to renewable-powered production in the short to medium term, which Andrea noted could help bridge the gap and address the "chicken and egg" problem of hydrogen demand and supply.

Second Panel

Following a short break, Luis introduced the speakers of the second panel discussion: Francesca Zarri (ENI's Chief Technology Officer), Marie Bysveen (Chief Market Developer at SINTEF Energy for CCUS and Smart Sustainable Cities), and Vicente Cortés Galeano (President of INERCO). Without further ado, he handed over to Francesca for her presentation.

Francesca Zarri (IT), ENI's CTO

Engineering and technologies opportunities: keys for transition in oil and gas sectors

Francesca highlighted that the oil and gas industry possesses a strong capability to adapt to the needs of the energy transition, with strengths in scale projects very fast. She spoke about the knowledge and learning from innovative projects in the industry, such as deepwater drilling. However, Francesca also pointed out that there is a tendency of the industry to repeat what has been done over the last 50-70 years, with some resistance to change and the need for more innovative approaches.

Francesca then went on to speak about the portfolio of solutions that the sector is developing in order to support progress towards a decarbonisation future, such as carbon capture and storage. ENI was cited as one of the early adopters in bringing engineering, research & development, and digitalisation teams together to develop innovative technologies for the energy transition. Francesca highlighted that a lot of the topics and technologies mentioned together have already been deployed or examined within ENI to reach concrete results, for example biorefineries converted in the last few years having transitions to new, cleaner

processes. In her closing notes, she touched upon the cultural changes that have been taking place within ENI to derive and support the broad shift towards decarbonisation.

Marie Bysveen (NO), Chief Market Developer at SINTEF Energy for CCUS and Smart Sustainable Cities
Carbon capture storage

Following on from Francesca's discussion of the new technologies being developed and researched within ENI, Marie presented a talk on the role of CCUS in the oil and gas industry. She highlighted its importance as a building block for the climate neutrality and ultimate transformation of the oil and gas sector, arguing that it will be crucial for the energy transition, as recognised by both the International Energy Agency and the European Union.
Marie advocated for Europe's prioritisation of CCUS to achieve its 2030 and 2050 climate targets, whilst also unlocking the potential for large volumes of low-carbon hydrogen in the near-term. Unlike other decarbonisation technologies, Marie highlighted that CCUS is not sensitive to the critical global situation relating to rare earth minerals, though there are challenges due to the inherently complexity and uniqueness of CCUS systems. The successful delivery of a CCUS system is reliant upon a range of skills and expertise (both technical and non-technical).
Marie identified CCUS as a key solution for hard-to-abate industries and oil & gas businesses, such as cement, steel, pulp & paper, and refineries, with permanent storage of CO2 underground addressing emissions that cannot be removed through other decarbonisation approach. Her discussion also touched upon ongoing debates around the EU Net-Zero industry and CCUS's potential inclusion within technologies that will be supported, with current uncertainty over Europe wide CO2 storage and transport infrastructure and the CO2 injection capacity target(s) that will be agreed upon. IN conclusion to her speech, Marie touched upon the impact of the Greenshift Summit on September 21st 2023, which gathered representatives from business, governments, civil society and research communities to identify next steps for CCUS and blue hydrogen in countries across the EU.

Vicente Cortés Galeano (ES), President INERCO

Carbon capture and use

Following on from Marie's discussion on the role of CCUS in the oil and gas industry, Vicente started his talk by discussion the upcoming commercial products that INERCO will be offering that are facilitated by carbon capture, such as e-methanol and e-methane. The challenges associated with CCUS were a focal point for Vicente's discussion, with six key challenges outlined. These were 1) the sourcing of CO2 for these new products, 2) issues associated with modularity and downsizing, including sizes of conversion units and electrolysers and how these will affect costs, 3) issues raised by intermittent electricity supply versus continuous plant operation, which will require hydrogen storage and flexible processes, 4) carbon footprint standards over what can be referred to as "low-carbon", 5) challenges associated with the design philosophy of "Do No Significant Harm" and 6) technical barriers in advancing the technology readiness levels of emerging technologies and processes.

Vicente's talk touched upon the need for these substantial engineering challenges to be effectively addressed, noting the complexity of the current landscape in the EU energy transition business, with many conversion processes having low technology readiness levels and regulations for emerging technologies still very much in development. The importance of front-end loading of projects and processes that will use carbon (either sourced from fossil CO2, from the air or from biogenic sources) was highlighted, with an essential role of engineering in the early stages of project development.

2nd Panel Session: Moderated discussion between speakers and the audience.

The first question from Luis touched upon the proposals for the oil and gas sector to be required to store carbon emissions associated with the products that they produce, following on from Marie's discussion of the reaction of the oil and gas industry to these proposals. He believes that the oil and gas sector would be willing to put their knowledge and capabilities towards CCS, but the real question is whether a stick or carrot approach should be followed to ensure that the sector is involved in the deployment of these technologies. Francesca was the first to respond to this point, detailing that the oil and gas industry will need to be the first to deploy these technologies, but that it is the role of the local and national government to make this possible. Vicente touched upon the regulations that are being introduced, explaining that they lean towards the "stick" side of the approach. Marie expressed worries over the polarization over CCS and how this could be a barrier for the development of a CCS value chain in Europe.

From the audience, the first question asked talked about the opinions expressed by Fatih Birol and Antonio Guterres over the prospects for reaching net zero. He asked what can we, as engineers rather than companies tell citizens and politicians when they are seeing the impacts of climate change first hand. Luis's thoughts were that we should provide a positive but realistic response, detailing the solutions that engineers are working on but conveying being honest about the costs and impacts of the energy transition. Marie referred to a discussion over lunch, quoting that the politicians need to understand one thing; these are the goals you need to

achieve, and the tools that engineers can provide to achieve those goals, expressing a need to make it clearer so that they can solve and address complex problems. Vicente fully agreed with Luis's thoughts over engineering being able to achieve the required targets, expressing that engineers are fully capable of achieving what is needed for the energy transition. He expressed uncertainty over whether engineers will be able to reverse climate change that has already occurred.

Eloy Alvarez fielded the next question, which was over how the cost of new technologies could push their deployment of technologies, and how the US's policy approach to decarbonization compares with the EU's approach. Francesca spoke about the importance of innovation and working with universities to reduce costs and increase the feasibility of low TRL technologies, with tools such as digitalization and computer modelling key to research and innovation. For the costs to come down, Vicente spoke about the need to move along the learning curve. On the IRA, Vicente spoke about the relative costs and subsidy for carbon capture, whilst Marie touched upon the relative difficulties over applying for the same subsidies in the EU.

The final question asked about nuclear fusion and ENI's involvement in this area. Francesca spoke about the collaboration between ENI and MIT, mentioning that nuclear fusion will be an option for future decarbonization, with the potential prospect of the first commercial fusion station in the 2030s.

Closing Session

Antonio Colino Martínez, President of the RAI.

In his closing speech, the president highlighted the pivotal role of engineering in addressing the complex challenges of the ongoing energy transition. He emphasized that while technology and engineering have been instrumental in shaping the world, the integration of culture, science, and research is essential for successful progress. He referred to the profound impact of historical industrial revolutions and acknowledged the ongoing fourth industrial revolution. The president also extended his best wishes to Miklos for the upcoming 2024 annual conference, concluding on a positive note.

Tuula Teeri, Chair of Euro-CASE

In her closing address, Tuula expressed gratitude to the hosts and organizers of the conference and reflected on the significance of engineers in addressing the challenges posed by energy security and the ongoing energy transition. She stressed that the decisions made now have far-reaching economic, societal, and political consequences, particularly in the context of climate change mitigation. While acknowledging the complexities and conflicts of interest that come with these solutions, Tuula emphasized the need for industry and society to embrace change. The overall tone was one of hope and commitment, with a call to action for engineers to contribute to a globally competitive and sustainable Europe. She underscored the importance of conveying certainty and making effective, translatable communication a priority. The address concluded with an introduction to Miklos, the host of the Euro-CASE 2024 annual conference, indicating a commitment to further collaboration and action.

Miklos Bendzsel, President of the Hungarian Academy of Engineering, hosting the 2024 Annual Conference

In his address, Miklos began by congratulating the Royal Academy of Engineering (Spain) for a successful conference, emphasising the belief of all in attendance in the role of engineering to shape and improve society by providing innovative solutions. He then presented a video exploring the innovations and technologies created by Hungarian engineers, and ended by summarising the three key themes that would be explored next year in Budapest: 1. Current environmental challenges, 2. The monitoring and control of urban transport systems, and 3. The role of technology in addressing health issues and ageing populations. He ended by wishing everyone all the best and looking forward to seeing everyone in Budapest.

Euro-CASE 2023 Annual Conference Minutes
Prepared by Luke Hatton & Jakub Zemek
Eloy Alvarez Pelegry, Fellow of RAI and Chair of the Programme Committee
Patrick Maestro, Secretary General of Euro-CASE
Nadia Pipunic, Euro-CASE

PROGRAMME

Opening session
Antonio Colino Martinez, President of the Royal Academy of Engineering of Spain.
Tuula Teeri, President of Euro-CASE

Keynote speeches
Thierry Breton (FR), European Commissioner for Internal Market
Loreto Ordóñez (ES), Chief Executive Officer, Engie Spain

Introductory address from the European Commission
Helene Chraye (FR), Deputy Director for RTD C "Clean Planet" and Head of Unit of C1 Clean energy transition

First session: Electricity mix and power systems for reliable supplies
Ignacio Perez Arriaga, Fellow RAI
Daniel Iracane (FR), NATF
Filip Johnsson (SE), Department of Energy and Environment, Energy Technology, Chalmers University of Technology, Göteborg
Dirk Uwe Sauer (DE), RWTH Aachen, E.ON Energy Research Centers
Tomás José Domínguez Autran (ES), Director of Operation, Red Eléctrica de España
Francisco Suarez Ortiz (ES), Vice-Chair of the European Nuclear Society Young Generation Network (ENS-YNG), Tecnatom*

Second session: Energy transition and Digitalization: the challenge of minerals for a strategic sovereignty
Eloy Alvarez Pelegry, Fellow of the RAI and Professor Ad honoren at Superior Technical School of Mining and Energy in Madrid
Stephane Bourg (FR), BRGM, Director of the French Observatory of Mineral Resources (OFREMI)
Susanne Norgren (SE), Group Expert Materials Design, Department of Mechanical Engineering, Division of Production and Materials Engineering, Lund University
Egbert Lox (BE), Former Senior Vice President Government Affairs Umicore and Honorary Professor at Karlsruhe Institute of Technology
Robert Dominko (SI), National Institute of Chemistry and associate professor at University of Ljubljana
Migle Laukyte (LT), Member of the European Group on Ethics in Science and New Technologies (EGE)
Mark Jolly (UK), Professor and Director of Manufacturing Academic & Business Support, Cranfield University

Third session: The role of Engineering in the transformation of the oil and gas sectors
Luis Cabra Dueñas, EMD Energy Transition, Technology, Institutional Affairs, & Deputy CEO, Repsol
Nicolas Aimard (FR), SVP of TotalEnergies OneTech
Andrea Ramirez Ramirez (NL), Faculty of Technology, Policy and Management, Technical University of Delft
Joachim Meister (UK), Senior Vice President Global Power & New Energy, Worley
Francesca Zarri (IT) ENI's CTO
Marie Bysveen (NO), Chief Market Developer at SINTEF Energy for CCUS and Smart Sustainable Cities
Vicente Cortés Galeano (ES), President INERCO

Closing of the Conference
Antonio Colino Martinez, President of the Royal Academy of Engineering of Spain.
Tuula Teeri, President of Euro-CASE
Miklos Bendzsel, President of the Hungarian Academy of Engineering, hosting the 2024 Annual Conference