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Energy: new technologies, new horizons.

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Editorial

The Impact of New Technology on the Energy Transition

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Technology is shaping the very route of our transition towards a carbon-free world. The title chosen for this issue "New Technologies, New Horizons" presents a scenario in which investments in research and development are accelerating, and disruptive technology is becoming the "norm".

In this issue of Energy Journal, you will find articles and interviews about artificial intelligence, sensors and the Internet of Things applied to electrical grids. In addition to digital tools, we will also take a look at new storage systems and green chemistry, energy efficiency and electric mobility, innovative strategies related to the use of hydrogen and solar energy. Moreover, our focus will address cybersecurity, a fundamental pillar of the "new normal" that awaits us. We also have a number of interesting interviews with leaders of innovation who explain to EJ the impact of technology on the energy transition. Ms. Mechthild Wörsdörfer (Deputy Director-General of the Directorate-General for Energy at European Commission and she is still Director of Sustainability, Technology and Outlooks at IEA) addresses the worrisome discrepancy between the magnitude of investments needed in clean energy and the capital that is effectively available to support them. Covid-19 has aggravated the situation in many developing economies – both in terms of mobilizing internal investments and in terms of attracting international capital – and Ms. Wörsdörfer invites us to concentrate on how to bridge this financing gap by connecting available capital to clean energy research projects.

Prof. Daniel Merson Kammen (Energy and Resources Group at the University of California, Berkeley) identifies Austria, China, New Zealand, South Korea and the United States as the most active global countries for investments in innovative technology with a focus on renewables, speaking of fiscal measures to drive technological innovation in the energy sector. Charles Kolstad (Professor of Energetic and Environmental Economy at Stanford University) explains that "disincentives for carbon emissions (such as a carbon emission fee) would be an important action for any country."

An analysis conducted by CESI key experts about the impact of the first lockdown on the European power system reveals the need to implement additional flexibility measures to guarantee secure conditions when the market utilizes a high proportion of non-programmable renewables. As we explain in the "Future and Technology" Section, this entails further progress in terms of deployment of new technologies and digital solutions. Smart grids must further enhance their capability and allow them to respond to sudden external change caused not only by extreme weather, but also by new, previously unknown factors. The same article also focuses on IRENA's (International Renewable Energy Agency) framework used to describe innovation and centred on four pillars: enabling technology, business models, market design and system operations. Taking a look at sustainable energy goals for 2030, we review the benefits offered by "mini grids". We explore the case of rural African communities that are working on developing technological models to purify drinking water, create cold chains, and drive agricultural processing activities and mobility. Indeed, even the United States government has allocated funding to improve technology for the creation of fuels from carbon capture, thanks to a system that captures CO_2 in the atmosphere.

Furthermore, in the United States, a group of engineers at the State University of Pennsylvania has redesigned an electrolyzer, in order to decrease the cost of producting green hydrogen from sea. After publishing their studies in the Energy & Environmental Science Journal, Penn State researchers explain how the production of green hydrogen from sea may become one of the main objectives of building offshore renewable plants. Indeed, offshore wind energy has become one of the main sources for the generation of renewable electric energy in Europe. EU Project Horizon 2020 aims to reduce the costs of offshore wind turbine maintenance by using predictive algorithms based on machine learning, IoT and cloud computing.

Finally, we take a look at what the energy transition will mean for "green jobs" growth. This trend is forecasted by IRENA in its "Renewable Energy and Jobs – Annual Review 2020" study. The future green job profile that emerges is one of "hyper-specialized" professional figures that are currently extremely difficult to find on the labor market. Energy Journal addresses this issue on page 40 in the "The Future of Work in the Energy Sector."

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"Today's technology was unthinkable fifty years ago. But technology alone is not enough.
What is needed is a broader vision."

Rita Levi-Montalcini*, Italian Nobel laureate, honored for her work in neurobiology and awarded the 1986 Nobel Prize in Physiology or Medicine*

News

Latest from CESI

Open Meter tests

CESI and E-Distribuzione collaborate on User Device – Open Meter integration tests

E-Distribuzione has started a collaboration with certification laboratories, that have proven experience in the world of electronic equipment tests, with regard to data transmission via powerline, for the execution of integration tests of User Devices (UD) with intelligent electricity meters "Open Meter" supplied by E-Distribuzione. Due to its expertise and state-of-the-art certification laboratories, KEMA Labs (CESI's Testing, Inspection and Certification Division) is one of the key partners of E-Distribuzione in this initiative. In this respect, in our Smart Metering Laboratories, in a space of less than 400 m2, we have created a test bench system with more than 2,000 electrical loads running simultaneously to test how meters interact with real power loads. The tests that we will carry out within this initiative have the purpose of verifying the compatibility, from the point of view of communication, between the DUs and the Open Meters by means of the communication protocol used on the Chain 2 channel. E-Distribuzione has defined and verified the procedure for the integration tests that will be carried out by our laboratories in complete autonomy, for the companies that intend to have their UD checked. The verification of compatibility and, in general, the passing of the integration tests by the UDs are preparatory to the activation of the Chain 2 Full 2.0 service.

> **"During the tests we will analyze how the meters interact with real power loads."**

Asian Countries

The new CESI Group subsidiary in China

Recently, the CESI Group subsidiary in China "KEMA (Shanghai) Technology Consulting Company Limited" has been established in Shanghai and is starting to be officially operational. The KEMA Labs Chinese sales team is focusing on sales & marketing for the Great China region, in order to promote CESI Group's testing business for Chinese manufactures and also to support them for testing their component at worldwide KEMA labs (High Power Lab, High Voltage Lab and SS&T). At the same time, the Chinese inspection team is providing inspection services in Great China and Asian countries in order to witness the type tests and FAT at manufacturer's laboratories or at the Chinese National Laboratories. The setting up of this new branch will enhance competence for both Consulting and Testing, Inspection and Certification business of the CESI Group in China, while also showing the confidence and expectation for Chinese market in the future. Last year, the ownership of KEMA Laboratories was transferred to CESI. By combining the extensive expertise and capabilities of its laboratories with those of KEMA, CESI has become the world leader for independent testing of advanced technological components for the energy industry.

> **"The new branch strengthens the skills of the CESI Group in China."**

World Bank Group

Smart Grid Infrastructure in Developing Economies: CESI works side by side with the World Bank Headquarter

Due to the need of implementing smart grids worldwide, especially when it comes to developing countries, World Bank Group (WBG) has issued in the past months an international open tender which was eventually awarded to CESI and EnerNex. This flagship mandate has the goal to analyze the state of Smart Grid infrastructure in a collection of developing countries, to identify barriers and lessons learned from key projects already performed in different contexts and environments and to develop detailed guidance and recommendation on how World Bank Group may assist clients in the deployment of Smart Grid infrastructure for both power transmission and distribution. Such award confirms the international leadership of the CESI Group in the Grid Modernization space, based on the unique combination of experiences gained in highly advanced economies, such as US and Western Europe, and those collected in developing countries with the long list of assignments backed by the International Financial Institutions.

> **"The project aims to improve power infrastructures in developing countries."**

Microgrids in the US

CESI and EnerNex boast microgrids distribution in the US

Production from renewable resources is experiencing constant growth (select USA estimates claim it will reach 50% of all electric energy production by 2030) and investments in smart technologies remain among the highest in the world (14.4 billion USD in 2017, according to Bloomberg New Energy Finance). It is the birth of what is known as the Advanced Energy Economy, a term that encapsulates the entire ecosystem of merchandise, services and technologies that support the transmission, distribution, storage and consumption of energy in the American market, worth roughly 200 billion dollars. In this respect, EnerNex (a CESI Company) has developed use cases, requirements and RFPs for multiple microgrids with various primary and backup generation options. These solutions help to ensure power delivery to critical facilities, including fire stations, police stations, city halls, emergency shelters and nursing homes. EnerNex determined the best options and developed business cases, performed cost benefit analyses for generation options including combined heat and power (CHP), natural gas and propane fuels. It, also, calculated the total electric load and wrote the generator specifications for a number of communities microgrids. Additional design considerations included the need to support cold load pickup, to operate in hurricanes, floods and other severe weather situations and the need to integrate into existing communications and electric distribution systems.

> **"EnerNex and CESI work side by side to support the development of smart meters in North America."**

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Scenario

Smart Technology for Secure Networks and Green Mobility

Science allows us to look to a better future with a strong acceleration of new technology for the energy industry. Here is how innovation and artificial intelligence are driving smart mobility and the electric networks of the future.

During the Covid-19 emergency, technology allowed us to keep a window open into the world. From the management of public health services to e-commerce, from distance learning for students to smart working for their parents, from guaranteeing the operation of organizations to the enjoyment of content across a variety of media platforms, all of this was possible. This has allowed our professional and private lives to continue, notwithstanding the lockdown and social distancing.

The coming months will continue to be fraught with uncertainty; enterprises will continue to face change thanks to partnerships that guarantee a profound understanding of core processes, as well as the continuous updating of skills related to technological innovation. Together with the issue of vaccines, science allows us to look to a better future with a strong acceleration of **new technology for the energy industry**. In this issue, we will address artificial intelligence, sensors and IoT for electric networks, along with new green chemistry and storage systems, energy efficiency and electric mobility, and innovative strategies for hydrogen and solar-based energy. Other articles will address 5G networks and cybersecurity.

During the presentation of the recent report on "Power Systems in Transition," the International Energy Agency reiterated how digitalization will provide many advantages to the transition of the energy system and the success of clean energy. However, in parallel, it will also be exposed to IT threats with a concrete risk of data loss, service interruption, and blackouts. "Governments around the world," explains the agency directed by **Fatih Birol**, "can improve their IT resilience through a series of political and normative measures. Implementation strategies must be adapted to the national contexts and take into account the global nature of the risk."

The time is ripe for **disruptive technology**. Indeed, innovation is transforming our daily lives with green driverless vehicles, machine-to-machine interaction, smart cities and new robotics, and advanced solutions for energy management. In Italy, thanks to its innovation communities, the **Enel Group** is actively committed to exploring this automation revolution. The paradigm of autonomous technology was the main issue of debate at the last "**MeetUp Autonomous World**," an on-line event organized by Enel with enterprise and university experts from around the world (from IBM to Amazon, Boston Dynamics to Hitachi, from the University of California - Berkeley to the Pontifical Gregorian University). During the MeetUp, **Salvatore Bernabei, CEO of Enel Green Power**, presented projects that entail

the use of drones and sensors, technology that guarantees a greater plant security and resilience. In terms of energy, robots will be increasingly employed to monitor electric substations, transport freight, manage waste, and sanitize plants. Thanks to the use of cloud services for simulations, engineers will be able to train robots quickly and economically.

At the end of 2020, **Capgemini** published the 22nd edition of its annual study on global energy markets. Analyzing consolidated trends, the report, the **World Energy Markets Observatory** (WEMO), addresses the marked impact that Covid-19 had on the energy sector in 2020, an impact that will change our standards and kick off a "**new normal**." In terms of network stability, a characteristic that requires programmed production, storage capability, and consumption flexibility, the WEMO identifies various methods for improving the infrastructural balance. Together with a high quota of renewable sources, this requires better energy production forecasts, zero-emission carbon capture and storage options, and the short-term development of batteries and other hydrogen-based technology. Addressing the strategies to improve the management of a well-distributed energy mix, the WEMO authors underline the importance

of leveraging **digitalization, smart grids, artificial intelligence, and automation** to obtain greater precision in the forecast and management of the demand for energy.

Data Management through Artificial Intelligence

In Italy, in 2021, the company that manages the national electric grid (**Terna**) and the National Agency for New Technology, Energy and Sustainable Economic Development (**ENEA**) are collaborating on research addressing energy security to test new technology dedicated to secure and resilient electric networks. The solutions, based on **sensors, data management, artificial intelligence, and Internet of Things** (IoT) will contribute to the development of management models for high-voltage networks. In fact, the collaborative work focuses on the development of support systems for decisional processes during extreme events, both through graphical representation of the phenomena and through forecast models of possible physical damage to infrastructure.

Over 2020-24, Terna has allocated ca. 900 million euro in investments for the development of technological innovation related to the electric grid and system. In terms of networks, Terna is working on satellites, drones, robots, and advanced sensor systems, as well as on predictive maintenance through the development of algorithms and advanced simulation and forecasting tools. Research will also be conducted on nanotechnology and new materials with advanced properties to increase network component resilience and reliability and ensure greater environmental sustainability. In terms of system innovation, Terna is studying storage systems (pumped, electrochemical, and compressed-air) and a better breakdown between utility-scale and distributed solutions. Work on smart grids addresses technology that contributes to increasing system flexibility, such as synchronous compensators, reactors, and FACTS. And in terms of open innovation, since 2019, Terna has inaugurated three innovation hubs, each dedicated to a specific technological area. The Turin hub focuses on IoT (Internet of Things) and advanced monitoring of energy transmission plants. The Naples hub is dedicated to the digital transformation of enterprise processes and innovative tools for the Human Resources and Organization Sector. The Milan hub is conducting studies on advanced analytics and system operator innovation.

The **Bielefeld University of Applied Sciences** (Northern Rhineland, Germany) is working on smart infrastructure and on how to forecast fluctuations in demand vvand supply to predict issues. One of the greatest challenges to the diffusion of wind and photovoltaic as energy sources is their unpredictability; demand and supply are not always synchronous. In order to compensate for this phenomenon, a group of researchers is integrating **artificial intelligence tools into energy distribution systems** to improve energy management and avoid local overloads. The **KI-Grid** Project entails the development of smart vehicle recharging stations that calculate the demand

> **“One of the greatest challenges to the diffusion of wind and photovoltaic as energy sources is their unpredictability.”**

of the connected vehicles and compare it with the available energy supply. During peak sun hours, the smart two-hour recharge will be incentivized, while at dusk, electricity is supplied at a slower rate and vehicles will take eight hours to charge.

On the other side of the world, **New Zealand start-up Emrod** is working with Powerco, the country’s second largest energy distributor, to implement its **wireless electric transmission** system. In order to transmit energy wirelessly, without networks and cables, the company has designed a plant that converts electric energy into the ISM frequencies (Industrial, Scientific, and Medical) reserved for non-commercial radiocommunication applications. This type of technology requires a transmission antenna, relay stations to extend the signal and a special receiving antenna that reconverts the frequency into electricity. Emrod’s wireless network is still a prototype. However, as the start-up’s founders point out, thanks to its high degree of efficiency and nearly lossless quality, the system is suitable for commercial scaling in the future. Indeed, the same technology can be used to transmit 100 times more power over much greater distances.

In terms of sustainable development, Africa is the only continent where the number of people without energy will probably continue to grow until 2030. One of the partnerships active on this front is the “**Field Studies for Mini Grid Optimization**” (FS4MGO) with an intense collaboration between researchers at Sapienza University of Rome, MIT-Boston, the State University of New York and the universities of Perugia and Pisa, as well as the universities of Makerere (Uganda) and Strathmore (Kenya) in Africa. The technological evolution of mini grids presents a number of opportunities. In addition to the reduction of the cost of photovoltaic panels and lithium-based storage systems, the focus is on integrated solutions, concentrating not solely on electricity but on the real needs of final users. Besides energy, residents in rural African communities **require technology to purify drinking water, for refrigeration, to process agricultural activities and facilitate mobility**.

In collaboration with FS4MGO, **Equatorial Power**, a company based in Uganda, is developing more holistic, integrated models. Its “mini grids 2.0” have a double configuration. On the one hand, they supply renewable generated energy and storage systems and, on the other, a three-pronged demand service (smart meters for households and small companies; agro-industrial hubs with services for purifying drinking water, producing ice and food-processing; and electric mobility with charging stations for scooters and electric boats). The technological integration of bidirectional generation-consumption hubs allows the use of technology (**demand response and artificial intelligence**) to optimize the load curve and correlate supply and demand.

A Mobile Charging Station Robot

This system was designed to provide a solution to the lack of a fully developed system of recharging stations, one of the main entry barriers for individuals looking to purchase an electric vehicle. We are back in Europe, where **smart mobility technology** is progressing by leaps and bounds. At the end of 2020, **Volkswagen Group Components** presented a project for an electric vehicle charging device based on mobile systems, that can be activated via app or V2X communication, to charge electric vehicles fully and autonomously. Although the number of charging stations continues to increase across the globe, their integration in specific structures (such as **underground parking lots** or large shopping malls) is expensive and complex. The first mobile recharging robot prototypes are capable of completing the entire operation from opening the charging socket flap to connecting the plug. Moreover, the system is capable of recharging various vehicles simultaneously thanks to a mobile storage unit. Once the vehicle charging is completed, the robot retrieves the mobile energy storage units and drives them back to the base to be recharged.

In another venture in smart mobility innovation, **Australian start-up Applied Electric Vehicles**, in collaboration with **Teijin, a Japanese chemical and pharmaceutical company**, has developed a new photovoltaic vehicle for the mobility of the future, a small **robotic vehicle for passengers that is 100% electric and has a solar roof**. By using a Panlite polycarbonate resin and proprietary technology to develop a roof that is exceptionally impact-resistant, the Japanese company has contributed to the development of the prototype whose photovoltaic cells achieved a power of 330W during the tests (a value equivalent to that of conventional glass solar panels). The EV tests suggest that the photovoltaic roof could provide as much as 30% of the energy demand of the vehicle under ideal conditions and ca. 15-20% in real conditions. This means the vehicle can extend its autonomy by 30-55 kilometers.

This brief technological survey ends in the **United States** where the Argonne National Laboratory and SLAC have received US$4.5 million in federal funding to improve **technology for converting atmospheric carbon into combustible fuels**. The objective is to create an artificial process of photosynthesis, a system capable of capturing atmospheric CO_2 by imitating the ability of plants to capture carbon and synthesize useful products. Furthermore, the aim is also to improve **CCU technology for the production of methanol and acrylic acid** and expand available energy sources. In particular, research will focus on the study of specific supramolecular structures known as MOFs (metal-organic frameworks) that can absorb and collect solar light.

Top Stories

The New Normal of Smart Energy

Thanks to new solutions provided by the Internet of Things, the energy industry is innovating production, distribution, and consumption, both in terms of efficiency and sustainability, with a special interest in energy storage and clean hydrogen.

Increasing numbers of governments, enterprises, health systems, and even the education sector are exploiting the Internet of Things (IoT) and artificial intelligence (AI) to independently address the effects of the pandemic that continues to spread globally. Naturally, this is also of interest to the energy sector in which innovative IoT solutions are driving the efficient and sustainable management of **smart energy** that includes smart grids, smart metering, smart building, and smart homes with automated illumination, air conditioning, and security systems. The longer-term goal is to develop smart cities, intelligent cities in which energeticand environmental monitoring improves the quality of life of its residents.

According to a research study presented in 2020 by the **Milan Polytechnic Internet of Things Observatory**, smart metering and smart asset management in utilities are the top segment of the Italian IoT market with a value of 1.7 billion euro (+19% over 2018) or 27% of the total market turnover, which in 2019 amounted to 6.2 billion euro (+24% over 2018). Smart building represents a value of 670 million euro (+12%) and is mainly related to video surveillance systems and the management of energy consumption by buildings.

The research study reveals that the smart home market has increased by 40% (530 million euro in 2019) and indicates that **smart energy management cannot be achieved without IoT devices**. In fact, thanks to the connectivity provided by embedded systems and cloud computing, sensor-equipped devices monitor interactions with the external world, and exchange this data with other devices and final users. Electric networks, meters, and buildings become "smart" thanks to the development of interconnected systems that generate and analyze data in real time (IoT analytics) to optimize the flux of produced, transmitted, distributed, and consumed energy.

Energy Storage and Green Hydrogen

The marked increase in energy production from renewable sources and the growing demand for energy, especially electric energy, makes storage systems the most likely candidates for the stable and reliable supply of energy. According to the forecasts made by the United States Energy Information Administration (EIA) in the International Energy Outlook 2019, renewable resources will multiply fivefold over the next 30 years, especially in the production of electric energy. The new European Commission aims to make the continental economy carbon-free by 2050. In fact, the **EU has recently reviewed its decarbonization objective** and is set to reduce the 1990 greenhouse gas emission levels by 55% by 2030.

The growth of renewable resources in conjunction with the impossibility of programming a continuous supply of photovoltaic and wind energy is driving **technological innovation to focus on solutions that guarantee energy storage and system flexibility**. Energy storage systems, that can optimize technical-economic efficiency, reduce bottlenecks caused by excessive production of wind and sun energy at peak times, and compensate the lack of generation at other times, are based not only on mechanical principles, such as hydroelectric pumping, compressed air, or flywheel systems, but also on electrochemical, chemical, and electromagnetic processes.

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The most widespread and fundamental storage technology for renewable resources remain **electrochemical batteries that play an increasingly important role**. Besides not producing dangerous or noisy emissions, they operate rapidly and flexibly, deliver high currents working at different voltages, and provide modularity through a wide range of standard sizes globally. In 2017, Tesla developed the largest battery in the world (129 MWh capacity, 100 MW power) at the Hornsdale Power Reserve (Southern Australia) and kicked off a race for global energy storage with increasingly ambitious large-scale international projects. In February 2021, New South Wales CEP Energy presented the project for the Kurri Kurri storage plant which will supply a power of 1.2 GW.

Power reserves that accumulate this much energy must constantly be monitored. It is fundamental to constantly control temperature, current and voltage surges, and cell integrity, providing all data in real time to allow an optimal management of the systems.

At the beginning of this year, **StoreDot** presented a new technology for sustainable mobility that reduces lithium battery charging time. The Israeli company substituted the graphite in electrodes with stratified silicon nanoparticles that are incorporated into an organic conductive matrix. This innovative process, which will allow batteries to be produced at the same cost as traditional lithium batteries, is based on a holistic development achieved following an in-depth study conducted with sensors, artificial intelligence and automatic learning tools. The result is that lithium batteries will be able to be charged in just 5 minutes, which is substantially the amount of time it takes to fill a car tank with petrol or diesel.

Australian start-up LAVO has launched the first hydrogen-based energy storage system for houses and companies. Besides an inverter connected to a renewable resource system, the storage system also needs to be hooked up to the water supply. The renewable LAVO System uses water and electricity to separate hydrogen and oxygen molecules. It then stores the hydrogen in a metal hydride "sponge" at a pressure of 30 bar. As energy is required, a fuel cell reattaches hydrogen molecules to oxygen to produce electricity (max power 5 kW, total energy 40kWh). Although this is a small domestic system, the technology is advanced and requires the constant monitoring of all operational parameters through sophisticated sensors and optimization algorithms.

On the hydrogen front, the European Commission has officially presented the "A Hydrogen Strategy for a Climate-neutral Europe" Plan that aims both to extend the use of this fuel to replace fossil fuels and to decarbonize its production. According to Executive Vice President Frans Timmermans, "developing and implementing the clean hydrogen (produced via electrolization with the use renewable energy) chain of value, Europe will become a global pioneer and maintain its leadership in clean technology." In fact, hydrogen can fuel sectors that are difficult to electrify such as energy-intensive industries, as well as air freight and shipping. Moreover, it will be capable of providing storage, even over the long period, to balance the seasonal flux of non-programmable renewables on the grid.

A group of engineers from **Pennsylvania State University** have redesigned electrolyzer architecture to make the production of clean hydrogen from sea water simpler and cheaper. The team of experts replaced the ion exchange membrane in electrolyzers with thin, semi-permeable membranes originally developed to purify water through inverse osmosis. After publishing their studies on Energy & Environmental Science, the team explained that the production of clean hydrogen from the sea is currently one of the main objectives pursued by investors in offshore renewable energy.

Waste, Efficiency and Wind Farms

According to the **European Environment Agency**, digital technology is gradually also gaining a foothold in the waste management sector. Robotics, Internet of Things, cloud computing, artificial intelligence, and data analysis can be used to improve logistics, recycling rates, and optimize differentiation. The European Waste2GridS Project, conducted by ENEA, the Lausanne Polytechnic, the Technical University of Denmark and the Solidpower Industrial Group, has been developed to produce electric energy from waste and to use surplus wind and photovoltaic energy to produce fuel. A system of solid oxide cells allows the process to be reversed; the mechanism of electrolysis is used to produce gaseous fuel and fuel cells to generate electricity.

As part of its strategy to address the environmental challenge, IBM is collaborating with The Alliance to End Plastic Waste to design a **new data platform (PRISM)** that will be hosted on the IBM cloud to trace plastic waste and contribute to its global collection. The Plastics Recovery Insight and Steering Model will serve as a single coherent database providing information on action undertaken by NGOs, members of value chains, communities, regulatory authorities, and other organizations to improve decision-making and waste management programs.

On the subject of efficiency, "recycling" waste heat is one of the most precious solutions for saving energy. Over the years, technology has progressed significantly and now allows us to reutilize the same thermal energy in various different processes or convert it into electricity. In order to create conversion devices capable of operating even at minimal temperature differences, a **team of German and Japanese scientists** (respectively from the Karlsruhe Institute of Microstructure Technology and the University of Tōhoku) has worked on thermomagnetism to develop a system that will increase the electric power of thermomagnetic generators. "Based on the research results," the team pointed out, "thermomagnetic generators are now competitive with thermoelectric ones. This has brought us a step closer to the objective of converting waste heat into electric energy even at minute differences in temperature."

Electric components in buildings can also operate intelligently thanks to the IoT. In fact, researchers at the University of Singapore have developed a solution for real time monitoring of every electric outlet in a building thanks to chips that communicate via Wi-Fi with a central server. Every time a plug is inserted into a smart outlet, a reader identifies the connected device, and the central server identifies the device specifications from its database. The invention does far more than allows devices to be turned on and off remotely. It also allows authorized network operators to monitor and quantify the amount of electricity consumed by a given device, configure the system to provide energy only as necessary, and prevent fires or other accidents were a device to absorb more current than it should.

The production of offshore wind energy has become one of the main ways of generating renewable electric energy in Europe. As of 2019, Europe's offshore capacity was 22.1 GW. **How can IoT help offshore wind farms?** The Internet of Things can markedly improve both energy production and the predictive maintenance of offshore plants. The EU Horizon 2020 Project aims to reduce the cost of offshore wind turbine maintenance by using predictive algorithms based on machine learning, IoT, and cloud computing. The development of a platform to analyze and manage collected data and the installation of an IoT device on each turbine will allow real time monitoring of the wind farms through wireless data collection. This type of IoT platform can be used, for example, to transmit data on instant tension to develop a model of the wind turbines' power curve. Moreover, the sensors installed on the turbines react to meteorological conditions in real time and measure specific environmental parameters such as wind speed and direction, which are essential for reliability studies. Moreover, by mapping plant layouts, constantly identifying which turbines are downwind from others, and varying the inclination angles of turbine blades and the yaw and pitch of the nacelles, the devices collect further data on interaction amongst the turbines. These parameters are invaluable to select the most suitable locations to install all the elements of a wind farm. Furthermore, the Internet of Things allows monitoring of the correct operation of the sensors and actuators themselves, providing information on the duration of IoT node batteries.

According to research conducted for the **Vodafone IoT Spotlight May 2020 Report**, 84% of companies believe that IoT ensured company continuity throughout the pandemic and 95% identified a positive return on their investment. Even before the Covid emergency, the Internet of Things was well underway, and one out of every three companies was already using this new technology. Moreover, the launch of 5G now allows a greater number of devices to be connected on-line simultaneously. Covid-19 has turned out to be a brutal stress test for many companies. Industrial sectors experienced more interruptions in just a few months during 2020 than in the previous decade, but, indeed, embracing digital transformation through the Internet of Things can help build a better future.

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Future & Technology

The Future of Energy is already here

Investing in technological innovation and digitalization is a constant commitment at CESI to guarantee the services and competences necessary to manage any new development in the energy sector.

The energy sector, which has long been a locus for the convergence of important investments in digitalization and technological innovation, has proven its responsiveness during the current pandemic crisis. Indeed, over the last year, the sector has demonstrated its resilience with a marked acceleration towards the energy transition. The sector was ready to counter the consequences generated by the initial lockdown that led to a drastic drop in demand. This caused a significant drop in carbon dioxide emissions, but as underlined by the International Energy Agency (IEA), the greatest challenge faced by the electricity sector in these conditions consisted in operating the system with a marked penetration of non-programable renewable resources. In a recent study, CESI pointed out that what took place in the electric system during the first lockdown in Europe (imposed by the first wave of COVID-19) – in terms of the penetration of Renewable Energy in relation to the load – coincided with the annual forecast expected for 2026; 44% as opposed to the 30% recorded for 2019. This analysis indicates the need to implement measures to ensure the flexibility necessary to guarantee safe conditions of operation when the market employs high rates of non-programable renewable resources. This requires greater system flexibility through pumping, batteries, non-conventional storage, and demand response, but also via the development of infrastructural projects for interconnection and market models that allow for a cross-frontier exchange of resources. At CESI, this means pursuing progress in terms of technological innovation and digitalization, day in and day out. The objective is to innovate smart networks and allow them to counter sudden external changes caused not only by climactic events, but also by rapid and unfathomable new factors.

The trends that are underway in the energy sector are explained by the International Renewable Energy Agency (IRENA) that has grouped innovations guaranteeing a greater resilience of electricity networks and reducing emissions into four categories. The first is “enabling technology” that plays a key role in the integration of renewables (i.e., batteries, electric vehicle recharging, blockchain, IoT, and big data). Then, there are “innovative business models” that allow the development of new services to implement system flexibility (such as energy-as-a-service or peer-to-peer trading). The third category is "market design" that devises new market structures to create business opportunities in a decarbonized system (specifically, time-of-use tariffs and the introduction of new services within markets). The fourth category in the IRENA matrix is "system operation" that aims to implement innovative operational conditions for the electric system through advanced weather forecasts and new DSO-TSO cooperation configurations.

Digitalization is a cross-enabler for these four dimensions of innovation and digital pervasiveness, at all levels, is imminent. In terms of IoT (Internet of Things), the forecast is for 75 billion globally connected devices by 2025.

The IEA adds a further important element to this analysis; investments in electric networks are increasingly focused on digital tools. According to an IEA study, expenses related to digital infrastructure have increased substantially in recent years, reaching 19% of total investments in the power sector in 2019, an annual increase of ca. 8%. The investments fielded by CESI to remain at the center of digital transformation and at the forefront of digitalization processes allowed a continuous supply of innovative services even during the lockdown.

In terms of electric components, CESI has always guaranteed maximum support to producers and utility companies to enable resilient networks through high-quality testing of T&D equipment based both on global standards and client specifications. The KEMA Labs Division employed augmented reality to allow clients equipped with special visors to remotely interact with lab technicians and conduct the activities necessary to test products in real time. Thanks to the new Remote Lab Experience, the CESI Testing, Inspection and Certification Division guarantees the uninterrupted local assemblage of products and testing by qualified experts, remotely directed by clients. Test results are shared in real time, also thanks to the presence in the labs of experts who provide support in case of unexpected situations. In addition, CESI also conducts remote testing in video streaming in its labs in Italy, Germany, Holland, the Czech Republic, and the United States. In this case, a series of continuous streams from different angles ensures efficient interaction with clients and the full respect of all the specific procedures necessary to guarantee objectivity and quality in certification and inspection services.

In terms of distribution networks, smart meters are key. Monitoring and recording

"The KEMA Labs Division employed augmented reality to allow clients equipped with special visors to remotely interact with lab technicians and conduct the activities necessary to test products in real time."

the energy exchanged amongst system operators and final users, smart meters are a critical digital technology for the managers of distribution systems. In order to verify how these devices interact with real power loads (guaranteeing maximum efficiency, functionality, and security), the KEMA Labs Division has set up Smart Metering Laboratories to test the reliability of communication via power lines amongst 700 single-phase and 300 polyphase smart meters in distribution networks and households. A 400 m2 area is used to conduct a series of tests with over 2000 simultaneously operating electric loads, including household appliances, lights, various types of electronic devices, and industrial equipment. This is equivalent to the load of a city with 1400 residents. Recently, E-Distribuzione has begun collaborating with renowned certification labs on the testing of electronic components, with a particular reference to data transmission via power lines, to execute integration tests for user devices with E-Distribuzione's smart "Open Meters." Thanks to our experience and unique structures, the CESI Testing, Inspection and Certification Division – KEMA Labs – was selected by E-Distribuzione as a main partner for this initiative. The tests aim to verify the communication compatibility between user devices (UDs) and E-Distribuzione's Open Meters via a communication protocol employed on the Chain 2 Channel. E-Distribuzione will supply the information necessary to set up the integration tests that will be conducted independently in our labs for any company interested in testing their user devices. The compatibility tests and, more in general, the integration certification test for UDs is propaedeutic to the activation of the Chain 2 Full 2.0 service. The growing penetration of renewable resources in the production mix of the electrical system and the progressive dismissal of traditional thermoelectric plants make the management of electrical transmission systems increasingly critical. In addition, most renewable generation resources are connected to medium and low-tension distribution networks, so-called distributed generation, which represents a further issue both in terms of safe management and the economic optimization of transport networks, as these resources cannot be controlled and are often not even monitored.

At present, transmission network operators are able to acquire real time signals and measurements from generation plants that are directly connected in high-tension. However, we cannot observe what occurs in distribution networks and measurement data from primary cabins is misleading as it represents the algebraic sum of the distributed generation and the underlying electric load. Thus, a sudden variation in measurement – since we cannot know if it is caused by a loss in generation or an increase in load – could lead to the implementation of completely erroneous countermeasures.

CESI has assisted the national transmission network operator in the development of an estimation algorithm, which, based on a limited set of measurements that can be managed by network central systems, provides a relatively accurate indirect measurement in real time of production and load by exploiting the fact that production

from renewable distributed generation is typically a function of meteorological variables such as sun radiation or wind velocity and direction.

Integrating available real-time signals and measurements with information derived from time series and variable estimates through big data analysis techniques and advanced analytics yields accurate real-time estimations, both of the values of distributed generation differentiated by primary resource (wind or photovoltaic) and the load for each primary cabin in the network.

In terms of sustainable energy transition, electric mobility is essential. This sector is undergoing extremely rapid technological development. CESI is at the forefront in this sector, too. It operates last generation testing tools, structures, and labs. In fact, the KEMA Labs test the reliability of electric vehicles (EVs), charging systems, and their interaction with existing networks. The tests guarantee high standards for a wide range of products and services that are being developed in this emerging market. Moreover, the new KEMA Services & Smart Technologies Unit – created through in collaboration by our Milan (DGL) and Arnhem (FPGL) labs – provides a series of tests that satisfy the new requisites for Electric Vehicle Supply Equipment (EVSE). The Arnhem labs conduct energy supply and communications protocol tests (CHADEMO and CCS) for direct current stations. Furthermore, the KEMA Labs system provides a completely controllable network equivalent that operates at a wide range of frequencies, harmonics, tensions, and power levels. The Milan labs conduct a wide range of certification tests including electric security, IEC 61851-1 standard product conformity and EMC, as well as climactic environmental and mechanical tests. In the meantime, the Berlin KEMA Services & Smart Technologies LV Lab is concentrating on innovative tests for electric vehicle components.

With one foot already in the future, CESI is also studying the advantages that 5G bring to the energy sector and analyzing the types of change that will affect the management and security of electric networks. Thanks to the fifth generation of mobile networks, energy distribution will become even quicker and more efficient. Companies will be able to collect data at rates up to 20 gigabit a second and similarly respond more rapidly and efficiently, given the exponential decrease in latency (ca. 1 millisecond). Energy suppliers

will receive a greater quantity of detailed data far more rapidly and manage it in enormous databases, where it will inform smart sensors controlling energy distribution, if necessary. Thanks to the data archived by control centers, sensors will also signal how much energy utilities require, guaranteeing a punctual and satisfactory supply. This means that the energy system will become even more flexible and custom-tailored to the needs of individual users. It's a revolution in the making in which CESI, together with its American company, EnerNex, will increasingly support utilities at a global level to implement the modernization of the electric sector.

It is also true, however, that ubiquitous digitalization will make electric systems vulnerable to cyberattacks, unless all opportune IT defense mechanisms are implemented. In the United States, according to the Industrial Control Systems Cyber Emergency Response Team (ICS-CERT), there have been over 240 cyberattacks, a third of which targeted the energy sector. Nearly 40% of these attacks are classified as "advanced persistent threats" as utilities did not react timely to the attacks. In this context, CESI and EnerNex specialists have been active for years now, supporting electric utilities to develop anti-hacker barriers, leveraging not only in-house software tools combined with IT sector experience, but also a detailed knowledge of the operation of electric systems.

We must act rapidly as the technological future of energy is already here.

Opinions

Investing in Sustainable Energy Technology to overcome the Crisis

In this issue of Energy Journal dedicated to the topic of technological innovation in the "new normal" for companies in the energy sector, and to better understand the impact of technologies on the energy transition, we have asked for the opinions of three key players in the sector. From the role of technology in boasting sustainability to the economic impact of clean energy tech and research, our interviews with Ms. Mechthild Wörsdörfer (Director of Sustainability, Technology and Outlooks at IEA), Professor Charles Kolstad (Co-faculty Director of the Bits & Watts Initiative; Senior Fellow at The Stanford Institute for Economic Policy Research, at The Precourt Institute for Energy and at The Woods Institute For The Environment - Stanford University) and Professor Daniel Merson Kammen (Director of Renewable and Appropriate Energy Laboratory; Professor in the Energy and Resources Group Energy and Resources Group; Professor of Public Policy Goldman School of Public Policy; Distinguished Chair in Energy at the University of California, Berkeley).

Mechthild Wörsdörfer

Mechthild Wörsdörfer (@MWorsdorfer) has been recently appointed Deputy Director-General of the Directorate-General for Energy (ENER) at European Commission (the date of effect of this appointment will be determined later). At present, she still holds the position of Director of Sustainability, Technology and Outlooks (STO) at IEA. Ms Wörsdörfer plans and co-ordinates the IEA's work on energy sustainability, encompassing clean energy technologies and climate change policy. Previously, Wörsdörfer held several senior management positions in the European Commission, where she coordinated the work on the 2030 Energy and Climate Framework, the Clean Energy Package and the 2050 Energy Roadmap. She had been involved with the IEA for a number of years as IEA Governing Board Representative for the EU, and served in the Cabinet of Commissioners, in charge of industry, competitiveness, trade and digital economy.

Are companies that invest in renewables more likely than others to emerge from the crisis and why?

In addition to generating higher total equity returns over the past decade, compared with fossil fuels and the wider equity markets, the financial performance of renewable power has remained more resilient during periods of crisis, owing to the contracted nature of their revenues, enabled by policy support, and falling costs. In the latest joint report by IEA and Imperial College Business School, listed renewable-power companies outperformed listed fossil-fuel companies and public equity markets on average in all markets over the past 10 years. At a global level, the total return of renewable power portfolio was 423%, compared to 59% for fossil fuel portfolio. In the past ten years, financial performance of renewable companies was more resilient compared to fossil-fuel companies and that of the wider market during three periods of economic crisis - the European sovereign debt crisis in 2010-12, global economic shocks in 2016 and covid-19 crisis in 2020 - implying a diversification benefit from investing in renewables.

During the Covid-19 market shock in February-April 2020, renewable companies held up better than fossil fuel companies, exhibiting a lower drawback (-19% vs -31% for total return) and lower volatility (41% vs 70% for annualized volatility) on average at a global level. Over this period, renewable companies also generated higher returns on average (-19% vs -21%) than the relevant market index and displayed lower volatility (41% vs 64% for annualized volatility).

Which countries in the world invest and will invest more in innovative technologies, with focus on renewables, for the energy transition?

The Covid-19 crisis triggered a drop in sorely needed energy-sector investment, with the exception of some renewable energy technologies. Given the trillions needed for investment around the globe to deliver the clean energy transition, countries should be starting today to ensure that clean energy is at the heart of their recovery packages – the largest and most visible being those of the US and the EU.

But not all countries are in a position to make expansive commitments to expand public support for clean energy, and I'd like to focus in these remarks on the issue of clean energy investment in emerging and developing economies. This is where the growth in energy demand is going to come from, as these countries urbanize and industrialize. In our view, today there's a dangerous mismatch between the scale of clean energy investment needed in developing economies and the capital that is actually available to support them. In aggregate, there is more than enough capital to make transitions a success, but no guarantee that it will get to where it is needed. Covid-19 has complicated the situation in many developing economies, both to mobilize domestic investment and to attract international capital.

We need to focus on bridging this gap, and find ways to connect the available capital seeking clean energy projects, including the growing wave of sustainable finance in North America and Europe, with opportunities in developing countries in Asia, Africa, Latin America. What does that mean in practice? This is what the IEA is working on in a major new piece of analysis to be released in June, in collaboration with the World Bank and the World Economic Forum. We are seeing what has worked, drawing on lessons from around the world, to mobilize and align private finance in support of clean energy investments.

Of course, there are messages there for developing economies, their policy and legal frameworks and so on. But we believe that more needs to be done on the international front as well: the $100 billion a year target of the COP is a start, but bigger structural change in global financing is needed. If we don't accelerate in this area, this will be a major fault line in the global effort to address climate change and achieve sustainable development goals.

To what extent are the decarbonization goals really achievable in light of the structure of the current world energy markets?

Pathways to meet global objectives for limiting global warming below 2 degrees, and aiming for 1.5 degrees are still achievable, something we describe in our Sustainable Development Scenario and in our net-zero by 2050 Scenario, which is coming out on May 18th.

Reaching these goals will require swift, concerted action to achieve, however, with governments playing a critical role in redirecting markets toward the investments needed for these pathways. The current economic situation the world finds itself after the pandemic makes some of these changes harder, particularly in the developing world where strained economies further limit the ability for governments to use financial policies to direct markets.

Nonetheless, the economic-recovery spending that governments are mobilising in the wake of the crisis provide a once-in-a-generation opportunity to boost public and private spending in line with energy and climate goals.

Our Sustainable Recovery Plan, published in June 2020 in co-operation with the International Monetary Fund, estimates that an additional 1 trillion USD a year between 2021 & 2023 would be required globally to put the world on a trajectory to achieving these goals, with around 30% of that total coming from public expenditure.

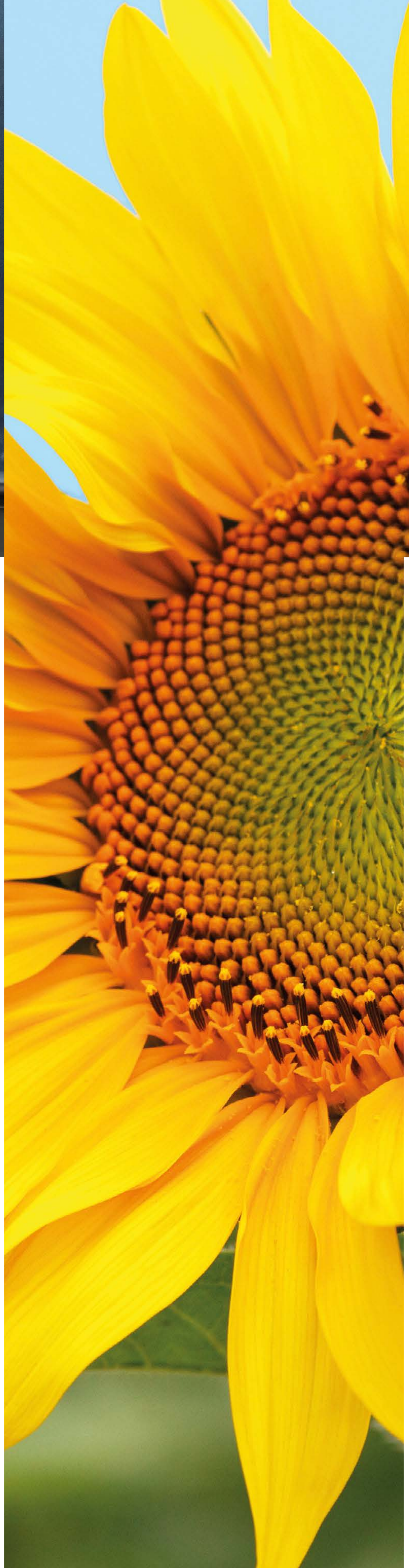
To date, only a small share of government spending on economic relief has been for clean energy. Governments have mobilized around 14 trillion USD in economic relief packages, with clean energy related measures well-below the 7% of recovery spending needed to meet the targeted spending in the Sustainable Recovery Plan. While a large sum, this share is modest, even compared to the 2008-09 crisis, where 16% of stimulus was spent on clean energy technology and environmental management measures.

Again, about recovery, what kind of fiscal and / or financial measures and policies could come to help energy technological innovation?

Half of the emission reductions needed to reach net-zero emissions must come from technologies that do not exist commercially today. While markets are vital for mobilizing capital and catalyzing innovation, they will not deliver net-zero emissions on their own. Governments have an outsized role to play in supporting transitions towards net-zero emissions, especially in mobilizing early investments toward needed innovations. Governments have a handful of levers at their disposal to foster faster innovation on emerging clean technologies. These include:

- Strengthen markets for technologies at an early stage of adoption
- Develop and upgrade infrastructure that enables technology deployment
- Boost support for research, development and demonstration
- Expand international technology collaboration

While direct funding will be a major financial measure for governments to support early-stage RD&D, other policy or fiscal measures can accelerate commercialization, including policies that drive up demand for new innovative products, such as portfolio standards, blending rates, and procurement requirements; and financial measures can eliminate risks in terms of early-stage investment, such as preferential loans, tax incentives, and providing procurement backstops.



Daniel Merson Kammen

Daniel Merson Kammen is Professor of Energy at the University of California, Berkeley, with parallel appointments in the Energy and Resources Group (where he serves as Chair), the Goldman School of Public Policy, and the department of Nuclear Engineering. He was appointed the first Environment and Climate Partnership for the Americas (ECPA) Fellow by Secretary of State Hilary R. Clinton in April 2010, and was appointed Science Envoy for the State Department in 2016. Kammen is the founding director of the Renewable and Appropriate Energy Laboratory (RAEL), and Chair of the UC Berkeley Roundtable on Climate and Environmental Justice. Kammen has served as a contributing or coordinating lead author on the Intergovernmental Panel on Climate Change since 1999. The IPCC shared the 2007 Nobel Peace Prize.

Are companies that invest in renewables more likely than others to emerge from the crisis and why?

Yes, the financial market for clean energy is improving day-by-day, and so these companies are well positioned post-COVID, even if the amount of recovery stimulus investment in this sector has - so far - been disappointing worldwide.

In your opinion, which countries in the world invest and will invest more in innovative technologies, with focus on renewables, for the energy transition?

The most active countries so far have been Austria, China, New Zealand, South Korea and now the United States with the plans for a $3 trillion green stimulus/recovery and infrastructure package.

To what extent are the decarbonization goals really achievable in light of the structure of the current world energy markets?

Decarbonization is completely achievable. The 100% clean energy plan for the US (100% clean electricity by 2035) can be done, and if the largest economy can do so, most anywhere can. There are now many roadmaps and plans for a fully clean energy sector.

Again about recovery, what kind of fiscal and / or financial measures and policies could come to help energy technological innovation?

There are many critical steps that engaged governments can launch. These include:

- Utilizing a social cost of carbon in all government decision-making
- 100% clean energy federal procurement, including only purchasing EV and H2 vehicles
- Investing in weatherization and energy efficiency for low-income families (energy and climate justice).

Charles D. Kolstad

Prof. Charles D. Kolstad is an energy and environmental economist with a research focus on the economics of climate change. He is also involved in research on energy markets, fossil fuels being largely responsible for greenhouse gases in the atmosphere. Kolstad has been a Lead Author and a Convening Lead Author for the Intergovernmental Panel on Climate Change, co-recipient of the 2007 Nobel Peace Prize, is a founding Co-Editor of the University of Chicago Press journal Review of Environmental Economics & Policy and has served on many advisory boards. He is a former president of the Association of Environmental and Resource Economists (AERE). At Stanford, Prof. Kolstad is the faculty co-director of the Bits & Watts Initiative. In addition to his affiliation with the Department of Economics, Prof. Kolstad holds senior fellow appointments in the Precourt Institute for Energy, the Stanford Institute for Economic Policy Research (SIEPR) and the Woods Institute for the Environment.

Companies that invest in digital and sustainability are - according to a research by Accenture - 2.5 times more likely than others to emerge from the crisis. In the "new normal", what kind of investments will be a priority for energy companies?

Being ahead of the curve on investments is often considered a sign of a progressive company. Often stock valuations are higher for such companies, with investors viewing progressive actions in the energy arena as signals of a well-run company, with good relations with customers and employees, which may or may not be true! With regard to electricity generators, developing innovating ways of integrating consumer decision-making with that of suppliers can be a positive step no matter what the future brings. Moving consumers to electrify energy demand and figuring out how to move consumer demand around in time and intensity will be a win-win.

To what extent are the decarbonization goals really achievable in light of the current structure of the current world energy markets?

Decarbonization of the electric grid, or should I say dramatic reduction in the carbon content of grid electricity, is certainly attainable in many countries. India is in a less advantageous position because of a lack of natural gas and a great deal of coal. The series of virtual decarbonization workshops, sponsored by Stanford University's Bits and Watts initiative has explored many of the dimensions of decarbonizing the grid. Decarbonizing fossil fuel use will be tougher. Coal is relatively easy to eliminate in most places; reducing oil use requires transportation to be electrified; and natural gas is needed, even in electric power, as a backup.

In your opinion, which countries in the world invest and will invest more in technologies for the energy transition?

The US, the EU and China. China, in part, because of its high savings rate. Ironically, China will help bring down the cost of storage and renewables as well as electricity powered end-use demand (heat pumps, electric vehicles). China itself has said it intends to decarbonize electricity but their demand for electricity is so strong that may be difficult. But it will help others.

Again about recovery, what kind of fiscal and / or financial measures and policies could come to help energy technological innovation?

Certainly disincentives for carbon emissions (such as a carbon emission fee) would be an important action for any country. Beyond that, measures to address the country specific obstacles to decarbonization should be addressed. (for political reasons, the US has a difficult time eliminating coal). Finally, rewards for intellectual property development can pay off strongly. These different measures will vary from one country to another. The world is a big place.

Industries & Countries

Proactive Cybersecurity in the New Normal

The crisis caused by the pandemic has modified the needs of the energy sector. An analysis of the issue of security identifies new risks and reveals how a strategic response should be organized, even at the European level.

Recent research on cybersecurity, referring both to national and global scenarios, indicates that we are facing a complex period. The data on IT threats presented in ***A Constant State of Flux – Trend Micro 2020 Annual Cybersecurity Report*** reveals that 119,000 menaces a minute were detected in 2020, a 20% increase over the previous year. The study also reveals that the increase in smart work during the pandemic was one of the reasons for this spike. Moreover, in 2020, Italy placed fifth globally in terms of macro malware attacks (first in Europe), seventh in terms of malware attacks, and eleventh for ransomware attacks.

Thus, in addition to the 2020 pandemic emergency, Italian companies were also called to address a growing cybersecurity emergency. According to the **Cybersecurity Odyssey: The Key to Evolution** Report, published by the Cybersecurity & Data Protection Observatory at the Milan Polytechnic School of Management, 40% of large companies faced a greater number of cyberthreats than during the previous year. In addition, the economic impact of the pandemic forced Italian companies to address these security challenges with reduced budgets. In general, the crisis related to the Covid-19 pandemic has slowed down the expansion of the cybersecurity market, but not stopped it. Indeed, 19% of large enterprises has reduced its investments in cybersecurity (against 2% in 2019), while only 40% increased investments (against 51% in 2019). However, research reveals that for more than one out of every two enterprises

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(54%), the **emergency has represented an opportunity to invest in technology**. In 2020, cybersecurity expenses reached a value of 1.37 billion euro, a 4% growth over the previous year (in 2019, the market increased by 11% over 2018): 52% in security solutions and 48% in services. Cybersecurity investments focus primarily on endpoint cloud security, smart working, and big data. Also, they focus on operational technology security (which has experienced an acceleration in investments) and artificial intelligence, which is employed in cybersecurity by 47% of companies.

Thus, the Covid emergency has driven not only digitalization but also cybersecurity in large enterprises across a wide range of sectors. **And both of these trends have been underway for various years in the energy sector** (and more specifically in the electricity sector) as they are central to the energy transition process. In this context, we refer to Industry 4.0 not just to describe the industrial automation trend that integrates new technology to increase plant productivity and improve quality, but also to drive the analysis of the consequences of crucial aspects applied to the energy sector, such as marked digitalization, the exchange of enormous amounts of data, and the growing number of sensors and connected objects.

The Risk to Electricity infrastructure

Electricity infrastructure is critical as any interruption of power will impact the supply of many other crucial services, from transports to health services. Critical electricity infrastructure includes classic large-scale thermal and hydroelectric generation plants, renewable generation plants (wind, photovoltaic, etc.), and energy transmission and distribution centers with thousands of primary cabins and hundreds of thousands of secondary cabins.

In addition to the large quantity of critical electricity infrastructure, there is also a further element of risk, the decentralization of electricity production. This phenomenon is brought about by the increasing use of small-scale and polygeneration renewables. According to the forecasts indicated in November by the International Energy Agency (IEA) in a report entitled **Renewables 2020**, renewables will continue to increase worldwide, in contrast with the sharp decline caused by the Covid-19 pandemic in many other energy sectors, including oil, gas, and coal. Analysts estimate that the net installed capacity for the production of renewable energy will increase by nearly 4%, reaching a record level of ca. 200 Gigawatts (GW). This constant growth will also determine an increasing number of prosumers, capable of producing energy on a small-scale, and feeding it into the grid, thereby making the energy flow bidirectional.

Inevitably, the increase in the number of stakeholders involved in this process advances in parallel with an increase in the use of interconnected, intelligent devices with advanced functions (i.e., smartphones and electric vehicles). Indeed, this is the reason that the entire energy sector has become the fulcrum of digitalization and decentralization processes, from suppliers to aggregators and from distribution to sales and relations with clients.

In summary, the issue of critical electricity infrastructure is further compounded by decentralization and polygeneration, which driven by the development of renewables, determines not only an increase in the number of stakeholders in the energy sector, but that of interconnected smart devices too.

This means that the electricity sector is facing an increasingly complex context in terms of cybersecurity. However, there is a further peculiarity that characterizes the equilibria and dynamics of this sector and that cannot be underestimated in terms of system vulnerability. This is the extremely close interconnection amongst the organizations operating in this sector, which rely on one another for business-critical services and components. This interconnection has been further cemented by the introduction of digital technology, which has increased the cybersecurity risks that companies need to face and manage jointly, as an attack on one organization also exposes all the others to the same threat.

Moreover, we must emphasize that digitalization has also determined a significant change in the security issues faced by electricity networks, especially in terms of the shift from the security of physical systems to cyber physical systems security. Whereas the electricity system (and its security) once rested on the net separation between IT (Information Technology) and OT (Operation Technology), the exponential increase in data generated by embedded systems developed by Machine to Machine (M2M) and Internet of Things (IoT) devices now represents the core of the system. In fact, IoT units installed by utilities have increased by 23% globally.

Thus, it is fundamental to develop a cybersecurity strategy that integrates IT and OT, notwithstanding the fact that these two environments are functionally diverse and have different security requisites. In IT, the priority is confidentiality, while in OT it is availability. So, a multidisciplinary approach is required to design a security governance based on a series of strategies that truly extend risk analysis (i.e., in Italy, this cannot be limited to the framework of the NIST - National Institute of Standard Technologies, but must also include other security contexts, such as NERC-CIP, ISA, IEC).

Moreover, it is also necessary to apply security by design principles to guarantee the adoption of cybersecurity rules from the initial deployment of OT/IT/IoT systems and infrastructure, and to constantly update them throughout their entire lifecycle. Moreover, the interconnection amongst electricity organizations means that the entire sector must adopt a systematic approach and evaluate security issues from a complete supply system point of view to eliminate any possible trickle-down effects. Similarly, best practices need to be shared to provide the greatest possible awareness of risk and real-time updating of solutions.

European Cybersecurity Strategy

A full EU-level cybersecurity strategy is thus essential to develop a resilient, digital continent. The measures taken to date have not been sufficient. Following Italian and European regulations for automation and control systems, ISA 99/IEC 62443 standards address three aspects to define a correct IT security strategy: employed technology, processes, and personnel operating the systems.

Another fundamental element is the Network and Information Security (NIS) Directive ratified by the European Council in 2016, and implemented in Italy in 2018, that aims to improve the cybersecurity capability of individual member states through the adoption of specific security measures in critical sectors. The NIS Directive applies to OESs (operators of essential services, including critical infrastructure) and digital service providers.

The need for a new EU cybersecurity strategy seems to have been decisively addressed in the **new action plan presented on March 22 by the European Council**. The document addresses various issues and identifies a series of sector-related actions:

1. Develop a network of Security Operation Centers (SOCs) throughout the EU to monitor and pre-empt signals of network attack.
2. Define a joint cyberspace unit to provide univocal direction to the management of cybersecurity crises in the EU.
3. Apply the measures indicated by the EU 5G Toolbox and pursue commitment to guarantee security of 5G Networks and the development of future generations of networks.
4. Field a joint effort to accelerate the adoption of Internet security standards that are fundamental to drive the competitiveness of the European industry.
5. Promote the development of advanced cryptography as a tool to guarantee digital security.
6. Increase the efficiency of the EU Cyber Diplomacy Toolbox, especially to prevent and contrast cyberattacks with systemic effects that may pose a menace to supply chains, critical infrastructure and essential services, institutions, and democratic processes, threatening economic security.
7. Create an IT Intelligence Work Group to strengthen the specific capabilities of the European Intelligence and Situation Centre (INTCEN) in this sector.
8. Increase cooperation with international organizations and partner countries to promote a shared understanding of IT threats.
9. Draft an EU agenda for the development of external IT know-how to increase cyber-resilience and know-how worldwide.

The new European strategy calls for a renewed cultural approach to the issue of cybersecurity, moving beyond the mere use of the technology and expertise necessary to secure networks, plants, and industrial systems. It is clear that cybersecurity requires a proactive attitude that is not limited to reacting to attacks, but constantly works to prevent them through a system of actions delineating a new operational system.

A good example of this is **Israel Electric**, an Israeli corporation in the electricity sector that not only sells electricity, but also promotes cybersecurity services. Israel Electric launched SOPHIC, an IT security platform that can be used to manage hacker attacks to critical infrastructure such as electric plants and networks. The company decided to provide cybersecurity platforms following the many cyberattacks it underwent itself. This, in turn, led to the development of an IT threat diagnosis tool and defense technology that has been shared externally, a good example of how such incidents can be turned into precious experience to counter cyberattacks.

Technological Innovation and Cybersecurity

Thus, the new normal is increasingly hyperconnected and calls for advanced cyber-defense programs. Both at the individual and company level, a cybersecurity attack may lead to identity theft, extortion, and the loss of important information. The situation is even more serious when attacks address critical infrastructure such as electric plants, hospitals, and financial institutions. The new frontiers of technological innovation must be applied to cybersecurity systems to guarantee the full protection of companies and infrastructure and ensure the correct operation of all the services essential to individuals and society.

A fundamental innovation in **cloud security** has been the development of **Internet Security Gateways** providing a wide range of ad hoc cloud computing security solutions. This technology allows access from one IT environment to another through a series of operations; indeed, Internet Security Gateways are implemented as "checkpoints" between endpoints, networks, and the cloud.

In addition to "traditional" solutions (prevention of classic web-based attacks such as phishing for credentials through mock websites), Internet Security Gateways provide advanced security solutions addressing **threat intelligence, cloud encryption, and secure cloud storage services.** Threat intelligence service providers gather information on security incidents through global networks and are able to discern whether an attack is actually a signal of a subsequent, more serious, second-wave attack. In terms of cloud encryption and secure cloud storage, Internet Security Gateways are capable of evaluating if and how data in transition from an endpoint to the cloud are protected by efficient cryptography systems.

Artificial intelligence algorithms are another technological innovation employed to improve cybersecurity management. These algorithms are capable of analyzing enormous volumes of data and provide a quicker answer to counter cyberattacks. Indeed, the challenge to develop a new generation cybersecurity system based on artificial intelligence and big data is already underway. AI algorithms identify anomalies that pose a potential threat by analyzing and comparing a vast quantity of heterogeneous data. Indeed, data may contain information on who or what is connecting to the systems that require protection, access to the data, connections towards external sites, changes made to the system, and alerts generated by the security systems. AI algorithms identify all events that represent a deviation from what is considered "standard behavior" within an organization and act consequently. In this context, the analysis and comparison capacity of AI systems (such as neural networks) is particularly significant as these systems can be continuously updated to correctly identify new threats.

Fundamentally, this is also the **role of AI in informing decision-making processes** through expert systems (composed of an informational database and an inferential engine) that are used to identify solutions to issues based on available information. This allows event analysis to be conducted more rapidly and in a standard manner, establishing whether an issue should be considered a security incident, and whether to deploy the uniform response procedures. Yet another application of AI in IT security lies on the cusp between military and civilian matters. This is an area that employs so-called smart agents, software components that possess characteristics of intelligent behavior such as proactivity, understanding of Agent Communication Language (ACL), and reactivity (capability of making decisions and acting autonomously). In terms of cybersecurity, smart agents are based on software systems that are either independent or integrated into traditional platforms (firewalls, anti-intrusion systems, routers, etc.) and that have a wide range of abilities: monitoring activities underway on IT systems, analysis, identification of cyberattacks, and countermeasures. These distributed systems protect networks by intercommunicating and analyzing the information collected individually before implementing a defense strategy, with hardly any direct supervision by human specialists. However, we should not underestimate the fact that increasingly efficient artificial intelligence techniques are also developed by hackers who wish to attack and override cybersecurity defense systems. This leads to a sort of competition, a true escalation between attack and defense actions fielded by AI systems. Indeed, **Adversarial Machine Learning** is a very active field of research in which AI systems are developed to produce results that can trick another AI system. After all, as Physicist Stephen Hawking famously stated: "Intelligence is the ability to adapt to change."

New Skills

The Future of Work in the Energy Sector

The transition in the energy sector, the changes imposed by the pandemic crisis, the diffusion of smart grids, and the digitalization of networks are redefining the skills and profiles required for new professions and green jobs.

The great changes affecting the energy market are significantly transforming the sector. Innovative challenges and new business models continue to arise in response to the accelerated energy transition, the pandemic crisis, and the rigid objectives of the European decarbonization schedule. The resulting scenario is one of rapid evolution in a sector pervaded by digitalization, which in turn, requires clear solutions in terms of energy security, operative efficiency, and cybersecurity.

The megatrends we face include the energy transition, technological disruption, sustainability, smart cities, and the transformation of business models. Each one calls for a new strategy and new professional figures, capable of managing the 4.0 revolution by redefining the interaction amongst machines, humans, and data. Indeed, it's the very abundance of data available in the energy sector that drives companies to conduct the detailed analyses that are fundamental to improving and automatizing management, operational, and decision-making processes.

The greater our capacity to accurately gather, analyze, and exploit data, the vaster its impact and efficiency will be of new technology. This trove of information includes both real-time data, collected in the field via increasingly sophisticated sensors and specialized operators, and static data archived in databases. Indeed, this is driving the great influx of artificial intelligence, Internet of Things, and big data management experts into the energy sector, together with teams of data scientists and application developers.

The push towards a green economy and the relentless development of renewable sources require the application of technological innovation in all sectors – industry, tertiary, residential, and transports – to promote the growth of new industrial and service areas, as well as the rise of new professions. Clearly, this will have marked effects on the entire production system.

This phenomenon is described in the recent **McKinsey & Company** Report (December 2020) entitled "Net-Zero Europe."

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According to their analysts, the Green Deal will create ca. 11 million new jobs, whilst also eliminating 6 million, for a total net increment of 5 million jobs. Furthermore, many new job opportunities will arise in renewable energy (1.54 million), agriculture (1.13), and construction (1.1).

The achievement of the "zero emissions" objective may require the professional retraining of 18 million workers, especially for positions that do not currently exist (3.4 million by 2050). For example, engineers that are currently working in the gas and oil industries will probably move to the carbon capture and storage (CCS) industry.

Thus, green jobs seem to be the answer to the new needs of the energy transition, a trend that was forecasted in the "**Renewable Energy and Jobs – Annual Review 2020**" published by the International Renewable Energies Agency (IRENA). The study indicates that 11.5 million new jobs have already been created in the energy sector at the global level. What are the emerging professions in the energy sector? Let's take a closer look.

The Italian panorama is presented in a report entitled "Evolutionary Trajectories and Competences for Energy Enterprises"[1] published by the LUISS Business School. The study indicates that eleven of the major companies operating in the energy sector in Italy (including ENEL and Terna) are planning to hire an increasing number of data scientists, analysts, architects and managers, open innovation experts and innovation managers, IoT and digital marketing managers, UX designers, scrum masters and product marketing experts, as well as engineers with digital know-how, predicative maintenance engineers for networks and plants, ICT and Telecom experts, connectivity (in view of the issue of data transmission and infrastructure) and fiber optic experts, specialized hydraulic and electricity operators, international construction site management experts, economists with a background in energy, middle managers, hydraulic and chemical engineers, and geologists.

There also is a marked demand not only for digital technology technicians, but also for big data analysts due to the strong increase in the sensor-based monitoring systems for networks, infrastructure, and plants that guarantee the predictive maintenance of networks and apparatus. **Network planners** are called to organize network development following a detailed analysis of the needs of the companies investing on their infrastructure. The same is true for network designers who must know how to use digital systems to analyze and mine system data (digital counters, remotely controlled plants, video cameras, environmental monitoring systems, sensor

1. Original title: *Traiettorie evolutive e competenze per le imprese Energy*

systems), integrating their activity with that of data analysts and scientists. Yet another significant profile is the **improved-efficiency renewable resource electric network installer** who must have a complete and fully up-to-date understanding of technical and technological innovation, besides a profound knowledge of sector regulations and the application of safety standards.

Another job of the future is that of **smart grid expert**. This digital and resilient infrastructure is fundamental for the decarbonization and electrification of the energy system through the integration of distributed generation from renewable sources and the active participation of consumers on the energy market. In order to address the need for highly qualified professionals, capable of facing complex development issues and promoting technological innovation in electric energy systems, the ENEL Group has organized a second-level professional university master course on Smart Grid, a post-master's degree specialization in collaboration with the Milan Polytechnic. The objective is clear. In order to implement the energy transition, immediate investments are necessary to train new professional profiles that are not available on the market. This is the only way to make our future immediately part of our present.

Professions 4.0

A new survey by Adecco has identified the most sought-after profiles by the companies working to address the new trends that have emerged over the past year in relation to new technology and sustainability in the sector. These are highly specialized professions that are often difficult to find on the market.

Sustainability Manager

This is a strategic role for a figure that often has direct relations with company management and stakeholders. The objective is to drive change and innovation through a strategic, sustainability-oriented process.

Energy Management Expert (EME)

This is an interdisciplinary professional role that acts in the context of a liberalized energy market, interpreting the changes that have taken place in the sector over the past years in order to intercept and balance the interests of consumers, suppliers, utility companies, and energy service companies. A fundamental characteristic of this professional figure is the ability to manage energy rationally, improving energetic efficiency to reduce consumption, and limit the impact of emissions on the environment.

Data Scientist

According to the United States Bureau of Labor Statistics (BLS), this is an increasingly important role that will experience an 11% increase in demand by 2024. Through the organization and analysis of large quantities of (structured and unstructured) data – collected through big data, analytics, cloud technology, automation, and machine learning – data scientists allow companies to achieve precise objectives.

Cloud Architect

This is one of the most requested profiles by companies such as Microsoft, Amazon, IBM, Salesforce, and SAP that

firmly believe in the importance of having professionals capable of **designing and developing scalable and resilient cloud environments** that are easily adaptable to sudden change and **changing business needs**. Cloud architects have a **profound knowledge of cloud computing system architecture and IT solutions**, including a detailed **understanding of back-end** and low-level resources, from networks to storage and hypervisors.

Growth Hacker

Growth hackers employ their understanding of computer engineering, marketing, and communications to design and develop strategies for company growth. Competences include coding, data analysis, finance, networking, marketing, and design. In Silicon Valley, this profile is considered to be one of the highest paid jobs of the future.

Plant Manager

As a high responsibility profile that allows companies to maximize productivity, plant managers monitor the operation of plants and guarantee their efficiency, supervising daily operations, assigning roles and functions to workers, and collecting and analyzing production data **to identify possible areas for improvement**.

Energy Manager

This profile requires a good knowledge of the energy market, capability for economic evaluation, and an understanding of contracts and company organization to drive the best use of energy by identifying actions, procedures, and operations to promote a rational use of energy.

UX Designer

UX designers analyze and interpret the behavior of digital consumers (websites, apps, software) to guarantee the best consumer experience. The role is based on integrating a project-based approach and problem-solving capability with an understanding of digital marketing, design, semiotics, and cognitive ergonomics.

News & Events

Upcoming Energy Events

ARPA-E Energy Innovation Summit

May 24-27, 2021

On-line event

https://www.arpae-summit.com/

Organized annually, the summit provides a showcase on future technology developed to address American energy challenges in an innovative manner. Currently in its 11th edition, the event takes place over four days of general debate sessions and technological showcases.

EU Green Week 2021

May 31– June 4, 2021

On-line and in-presence events around Europa

www.eugreenweek.eu

Organized annually by the European Commission's Directorate General for the Environment, EU Green Week 2021 is dedicated to the objective of "zero pollution." It represents a precious opportunity to discuss and debate European environmental policy and the European Green Deal initiatives. Moreover, analyses will also be conducted on initiatives related to climate, chemical substances, energy, industry and mobility.

Hydrogen Americas Summit

June 8-10, 2021

On-line event

www.hydrogen-americas-summit.com

The summit is dedicated to analyzing the potential of hydrogen in North, Central and South America. The event focuses on various aspects of the American energy transition and the shift towards a hydrogen-based economy. The objective is to develop a common strategy identifying hydrogen as the solution for American energy security and climactic change.

Executive Days / Executive Summit

June 15, 2021

Milan – Live streaming

https://www.utilityday.it/

This event includes two initiatives: an executive summit in June and a main conference on November 24, 2021. The two appointments provide energy sector managers with the opportunity to share experience, gain information on the latest trends, shape business evolution and orient their companies' transformation. The debate will focus on distributed renewable generation, new digital technology and various consumer aspects that are creating a new and more complex, competitive and stimulating world of energy.

Vienna Energy Forum 2021

July 6 -7, 2021

Hofburg Imperial Palace, Vienna - Austria

https://www.viennaenergyforum.org/

The Vienna Energy Forum (VEF) is a biennial global, multi-stakeholder forum that brings together political leaders, international organization and professionals from the private sector to promote solutions for sustainable development through practical solutions.

Intersolar Europe 2021

July 21-23, 2021

Messe München, Munich - Germany

https://www.intersolar.de/

This is one of the major European events dedicated to solar energy with a focus on thermal solar technology, photovoltaic systems, network infrastructure and solutions for the integration of renewables. The initiative, which involves producers, service providers, distributers and solar industry partners, promotes the medium- to long-term substitution of the current mechanisms for the production of electricity.

Besides, market trends and innovations, the 2021 edition will also address photovoltaic production.

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.

CESI is a fully independent joint-stock company headquartered in Milan and with facilities in Arnhem, Berlin, Prague, Mannheim, Dubai, Rio de Janeiro, Santiago de Chile, Knoxville (USA) and Chalfont (USA).

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