

GTIPA Perspectives: Clean/Renewable Energy and Sustainability Innovations



GLOBAL TRADE & INNOVATION
POLICY ALLIANCE

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INTRODUCTION

The Global Trade and Innovation Policy Alliance (GTIPA) represents a global network of over 50 independent, like-minded think tanks from over 30 countries throughout the world who believe trade, globalization, and innovation—conducted on market-led, rules-based terms—can maximize welfare for the world’s citizens. The Alliance exists to collectively amplify members’ voices and enhance their impact on trade, globalization, and innovation policy issues while introducing new scholarship into the world on these subjects.

Among their shared principles, GTIPA members are committed to approaching globalization and trade through an innovation-based perspective. This perspective recognizes the immense potential of innovation in improving existing processes, products, services, and business models, and its role in expanding economies and promoting sustainable development. Applied to clean technologies (“cleantech”), innovation holds the promise of not only achieving economic and developmental goals, but also making progress toward international climate goals. Thus, cleantech innovations are of the utmost importance for international economies and for the planet.

The GTIPA recognizes the role of clean energy and sustainability innovations in producing solutions to some of the most challenging effects of climate change. This report provides GTIPA members’ perspectives on some of the most exciting, innovative clean energy technologies in their countries. The included briefs demonstrate how governments and private entities are fostering transformative innovations in both what is typically thought of as part of the clean energy sector—hydro, wind, solar, and nuclear power—and in seemingly unrelated industries like microbreweries and the production of everyday household products.

This volume compiles vignettes from sixteen countries and one region: Australia, Austria, Bangladesh, Brazil, Chile, Colombia, Ecuador, Germany, Indonesia, Italy, North Macedonia, Panama, the Philippines, Poland, Taiwan, and the United States, including the San Francisco Bay Area.

The Need for Clean Energy Investment

Clean energy and sustainability innovations are desperately needed in order to reach the international climate goals of achieving net zero carbon emissions by 2050 and keeping further warming below 2°C by the end of the century.¹ To meet the former, the Intergovernmental Panel on Climate Change (IPCC) estimates that nations will need to reduce carbon emissions by 43 percent through 2030.²

In the absence of significant behavioral changes to reduce emissions, clean energy technologies may provide some, but not total, relief. However, underinvestment in clean energy innovation poses a considerable challenge to developing the requisite technologies. To reach net-zero, experts estimate that an additional \$90 billion in public research and development (R&D) and deployment funding is needed globally through 2030.

Greater investment in R&D is not enough, however, to meet the full challenge of climate change. The International Energy Association (IEA) estimates a total need of \$4.4 trillion (in 2019 dollars) in investment in infrastructure and implementation of cleantech innovations.³ Successful clean energy deployment will require new pipelines for transporting clean energy like hydrogen, as well

as facilities for storing clean energy reserves. Further, the IEA has argued for the reprioritization of government-led R&D investment toward emissions reduction and decarbonization. Critically, this need for clean energy innovation and implementation must be met by 2030.

Preview of GTIPA Contributions

As the contributions in this report demonstrate, clean energy innovations take many forms. From solar and nuclear to wind and hydro, energy innovations are growing outward, combining energy sectors, embracing digital technologies like artificial intelligence (AI), the Internet of Things (IoT) and blockchain, and continually building upon one another to create marginal efficiencies and improvements to aspects of everyday life.

New innovations in solar energy are improving overall efficiency and cost-effectiveness. One innovation uses perovskite—a naturally occurring mineral that can be cheaply and easily synthesized—to tailor solar panels to absorb different colors of the solar spectrum to provide more efficient, cheaper power. Advancements in photovoltaic (PV) modules are enabling higher voltage solar power in North Macedonia, and everyday applications of solar are being tested in Colombia, including for brewing beer. Other innovations have made solar power more reliable, such as NeWorld's device that isolates solar-powered homes from residential microgrids during power outages. Another theme was empowering citizens and students as activists to support development of clean and renewable energy solutions. For instance, Indonesia-based GERILYA is empowering student activists to engage in a Solar Power Initiative Movement, with the goal of accelerating clean energy and encouraging start-up development and investment in new renewable energies.

Meanwhile, innovative cleantech in nuclear energy is improving the safety and sustainability of nuclear power. In Italy, Newcleo's fourth-generation development of small modular nuclear reactors enhances the nuclear fission process by maintaining the speed of moving neutrons (instead of slowing them) and by cooling the reactors with lead to produce safer, more reliable power that generates less radioactive waste than do traditional reactors.

Other innovations in renewable energies, like wind and hydrogen, are de-carbonizing the planet. In Chile, a wind farm project uses a wind conversion process to filter CO₂ out of the air and synthetically recombine this CO₂ with hydrogen to create a carbon-neutral fuel.

Emerging advancements in the Philippines are also combining clean energy technologies to produce the Sessy e-boat, a prototype that uses a solar-assisted plug-in to power e-boats alongside lead acid and lithium batteries.

This combination of multiple clean energy technologies demonstrates the innovative uses that are emerging alongside innovations themselves. Throughout the vignettes, this theme, as well as the following themes of clean energy storage, geographic advantages, digital technology use, and waste management are echoed in the examples of clean technology startups and applications.

Clean Energy Storage Solutions

One of the biggest challenges that has long plagued the clean energy sector is the ability to store renewable energy for later use, when daylight or wind is not available or ample enough to meet energy needs. Innovative solutions to this intermittency problem are being developed, in many cases by using natural geographic features to enable storage. In Indonesia, solar power generated

during sunny days allows clean energy use throughout the rainy season, thanks to pumped hydro energy storage (PHES) that uses solar power to pump water uphill to a higher reservoir. Similarly, coastal cliffs in Chile enable energy storage through hydraulic pumping plants that send seawater up to concavities in the cliffs for later energy use. Further, Chilean solar power concentration (SPC) technology enables energy generation day and night, thanks to innovations in thermal energy storage. Meanwhile, in Italy, Green Energy Storage (GES) is developing flow batteries to store energy for domestic grid systems. The technology developed by GES holds potential for wider application in transportation and EV charging facilities.

Geography-Driven Clean Energy Innovations

Like the reservoirs in Chile and Indonesia, unique geographic features are at the center of new cleantech. In coastal nations, solar and wind companies are leveraging the nearly endless ocean space to build floating solar panels and wind farms. This is particularly true in Indonesia, where coastal territory is often more expansive than land resources. Tidal In-Stream Energy Conversion (TISEC) technology strategically uses naturally occurring tides to power turbines and generate electricity. The San Bernardino Ocean Energy Project is among the first to use ocean energy generation technology in the Philippines, and by taking advantage of strong tidal locations, this TISEC can provide electricity to more rural areas that are not on the electric grid. Off-shore floating wind farms are also emerging as technology that is no longer bound by land or near-shore ocean floors. In the United States, government and private ventures are taking advantage of new innovations that expand the area where wind turbines can operate, including U.S. federal waters and off the coast of California and Maine.

Cleantech Using AI, IoT, and Blockchain Technologies

Recent innovations in clean energy technology have also featured applications of advanced digital technologies such as AI, IoT, and blockchain. By combining cleantech with digital tech, innovators can build new efficiencies that have a large environmental impact. In Colombia, Solenium combines AI and IoT applications for a smart metering system in the production of craft beer, while startup Unergy uses blockchain and AI to connect buyers and sellers of clean energy.

Managing and Reducing Waste

Innovative solutions to waste management, transformation, and reduction are another promise of cleantech. Some biomass technologies serve the dual purpose of reducing waste and pollution while also producing beneficial by-products. For example, Takachar's portable biomass converter transforms waste into products such as biofuels, fertilizers, and chemicals, while at the same time preventing carbon emissions from harmful waste burning. Biomass cleantech can also generate renewable energy, like La Fabril's project in Ecuador that generates steam energy through the processing of palm fruit and palm kernel shells. Meanwhile companies like Geocycle have turned recycling waste management into a business through its innovative "co-processing" technology that manages waste in the cement industry.

The briefs that follow demonstrate the power of innovations in providing cheaper, safer, more reliable, and more efficient clean energy.

AUSTRALIA

IPAG Asia Pacific, Australia

Syed Munir Khasru

I. Powerledger

Powerledger develops software solutions for the tracking, tracing, and trading of renewable energy. It believes in the democratization of power for a sustainable future. Recently, Powerledger has developed a series of world-leading blockchain energy applications, such as its peer-to-peer (P2P) energy trading application. Powerledger's technology brings resilience and flexibility to electricity grids. The company's technology is helping clients like TDED in Thailand, CUB in Australia, and ekWateur in France bring new ideas and forms of energy to powering their clients and workplaces.⁴

II. Amber Electric

Amber Electric was founded with the goal of using new technologies to benefit customers and build a more-sustainable world. Amber Electric is making it easier and more affordable to buy renewables for Australian households. The company's wholesale model rewards everyday energy customers for using greener energy and empowers solar and battery owners to get the most value out of their exports. Essentially, Amber gives customers access to wholesale electricity prices, which are cheaper when the sun's shining and the wind's blowing.⁵

III. HB11 Energy

HB11 Energy will realize electricity generation with the fusion of hydrogen and boron-11 (HB11) using lasers.⁶ It will create an unlimited source of clean, safe, and reliable energy using fuels that are abundant in nature and a reaction process that does not produce radioactive waste. HB11 produces a non-thermal, non-radioactive reaction that produces clean, safe, and unlimited electricity. HB11's concept offers a simple alternative that does not require heating fuels to extreme temperatures; it therefore doesn't encounter anywhere near the level of technical and engineering challenges faced by other fusion approaches. As HB11 explains, "our concept converts nuclear power directly into electricity, we won't need the steam turbines and generators required for coal or conventional nuclear power plants, so our plants can be much smaller and there is no risk of reactor meltdown."⁷

AUSTRIA

Austrian Economics Center

Scott B. Nelson

Austria is home to several cutting-edge initiatives designed to combat climate change. The flipside of environmental sustainability is energy efficiency and, as such, many of these innovations are in the energy sector.

The excellent report, "Energy Innovations Made in Austria: The Green Deal for a Climate-Neutral Future" gives an overview of this topic.⁸ In 2019, total public expenditure on clean energy research, development, and demonstration projects in Austria reached €149.1 million. There were three key priorities: energy efficiency (€74.9 million); renewable energy sources (€23.5 million); and transmission, distribution, and storage technologies (including smart grids, €20.5 million). Some of the projects that came out of this funding include the following:

Six-dimensional (6D) BIM (Building Information Modelling) Terminal. BIM takes into account the environmental and sustainability dimensions of a building over the course of its whole lifecycle, including at the planning stage. This project resulted in the development of a tool where BIM models can be input and 6D BIM elements can be created out of 3D elements. These data are more extensive than just geometrical and representational elements and are therefore important in considering cost, deadlines, and sustainability.

There is also work being done at the urban level: Campagne-Reichenau (eastern part of Innsbruck) is designed to be a “Smart City” urban district with approximately 1,100 apartments, commercial centres, sports facilities, and a community center. It is not just about optimizing the energy potential of the buildings themselves, but also designing the district in such a way that is sustainable (e.g., when it comes to transport and mobility, utilities, and waste management). The long-term objective is to make it a “zero-emission urban region,” key aspects of which are: reducing greenhouse gas emissions, adapting to climate change, social sustainability, energy efficiency, ecological quality, and renewable energy sources. Buildings are to be heated by water/water-heat pump systems (low-temperature heating systems for the construction area with warmth through floor heating). Roofs are to be outfitted with photovoltaic systems, which will supply electricity needs for ventilation and heat pumps. Hydropower also will supply energy needs.

Along similar lines, Energy²POG is a hybrid energy project for the Steirereck am Pogusch restaurant and hotel business, relying on optimizing different renewable energy systems and using solar, regional biomass, and passive components, along with local food production (self-sustainable agriculture) and greenhouses.⁹ Various components have also been installed in order to ensure energy storage and regulation of its generation and consumption: a heating buffer tank, drinking water reservoir, service water cisterns for using rainwater, thermal activation of concrete and foundation components, stationary battery storage system (planned), load and energy management for power consumption systems, mobile battery storage from electric vehicles (planned), smart regulation concept, heat recovery from commercial refrigeration systems, and waste heat recovery from wooden stoves.

The Austrian company Wienerberger is developing TOREtech, a technology enabling more energy-efficient brick production through an innovative jet pump pure gas burner designed for tunnel furnaces. It also produces highly insulating bricks, further aiding sustainability.

The AIT Austrian Institute of Technology is collaborating with partners in the SANBA project to provide energy to a 40-hectare site owned by the Ministry of Defence sourced from industrial low-temperature waste heat produced by processes at the nearby NÖM dairy farm.

OxySteel, a project led by Montanuniversität Leoben, aims to increase energy efficiency and reduce CO₂ emissions in electro-steel plants. Recycled scrap is melted down in electric arc furnaces and then turned into steel products. Melting down recycled scrap results in fewer emissions and requires less energy compared to converting iron ore to iron in blast furnaces. Moreover, the project aims to integrate oxyfuel combustion and CO₂-separation, thereby also incorporating carbon capture and utilization in the production process. On this note it is worth mentioning that there are various initiatives that seek to make use of the circular economy in order to achieve greater energy efficiency and environmental sustainability.

Still other ways of optimizing energy efficiency and environmental sustainability include integrated energy management. This is what is being developed and tested in Salzburg in the CE4T flagship project spearheaded by NEFI (New Energy for Industry—a network comprising research institutes, technology providers, and companies). Given that winter tourism in Austria is an energy-intensive sector, CE4T seeks to integrate many of the affiliated processes, such as snowmaking, ski lifts, slope grooming, restaurant services, and mobility.

The Hydrogen Initiative Energy Model Region Austria Power & Gas (WIVA P&G) aims to convert the Austrian economy into a predominantly CO₂-neutral structure, producing and using renewable hydrogen in energy, manufacturing, and mobility sectors. Results are to be applied in the Fronius Solhub, which is an innovative system solution involved in the production, usage, and storage of green hydrogen. The storage capability also enables additional photovoltaic power accumulated in the summer to be carried over into winter or made available on low-sunshine days.

UPHY I&II (a part of WIVA P&G) seeks to upscale green hydrogen for industry and mobility, (e.g., fueling public buses in Vienna). An electrolysis plant of up to 10 MW is being planned.

AVL leads the KeyTech4EV initiative aimed at an efficient and cost-effective CO₂-free powertrain concept for e-vehicles by combining hydrogen fuel cells and battery technology. Such a hybrid is expected to reduce powertrain costs, with energy efficiency equivalent to fuel consumption of 2.5L/100 km for a mid-sized vehicle, eliminating CO₂ emissions, in addition to cutting down on recharging time and being practical over longer ranges (i.e., more than 500 km).

Ammonia to Power (A2P) is a concept that would treat ammonium contained in waste product streams, such as industrial wastewater and municipal sewage. Ammonium in wastewater has a negative effect on the environment. A2P would therefore separate the ammonia with a solid oxide fuel cell, and then recover the ammonia's energy by using it in an ammonia fuel cell. Waste heat can also be recycled and used as energy in the distillation process.

In addition to biomass technologies, district heating, and solar, geothermal is another promising source of energy production in Austria in order to reach the national goal of climate neutrality by 2040.¹⁰ Studies have indicated that the Vienna basin holds between 40 and 60 percent of Austria's thermal energy (450-700 MW). Wien Energie intends to install 140 MW of geothermal energy by 2030, supplying 135,000 households and saving up to 260,000 tons of CO₂ per year. Spatial energy planning (SEP) is also integral to researching Austria's geothermal potential. ENERGIEatlas is a GIS-based online application that synthesizes map information with energy requirements, supply infrastructure, and potential for renewable energy supplies thereby allowing for an innovative and comprehensive basis for planning.

Photovoltaics (PV) are also intended to make an important contribution to Austria's plans to become climate neutral by 2040 and to generate 100 percent of its energy (on balance) from renewables by 2030.¹¹ 11 TWh (terawatt hours) will come from PV, 10 TWh from wind, 5 TWh from hydro, and 1 TWh from biomass. One promising technology in this area is CIGS thin-film solar cell technology, which are low cost, lightweight, and highly bendable, thus opening up fruitful opportunities for implementation (e.g., in automobiles and airplanes). Sunplugged—Solare Energiesysteme is the company behind these developments. In light of the fact that some three-quarters of the human population will be living in towns and cities by the end of the century, innovations to combat the “urban heat island” effect are also in the works. The PowerShade project

looks into these, such as building-integrated photovoltaics (BIPV), which integrate PV into windows and facades, thereby maximizing the PV potential in ways that conventional PV have been unable to achieve. Similarly, the Tyrolian company HELLA is looking into integrating bendable, lightweight PV thin-film modules into shading systems. Finally, the PV Re2 project aims to optimize the recycling of PV modules, such as by researching designs that lend themselves better to recycling in terms of assembly and disassembly, as well as in terms of cutting down on toxic materials and substances.

Finally, in all areas, digitalization can help improve efficiency and environmental sustainability.¹² Hydropower is one area of particular relevance in Austria, given that around 60 percent of Austria's electricity is sourced from hydroelectric power plants. The DIGI-Hydro project, led by the Institute for Energy Systems and Thermodynamics at the Technical University of Vienna, aims to create a digitalization strategy for hydroelectric power plants, formulating data-driven predictions of the lifespan of water turbines. This consists of using sensors to monitor the plants, new methods of storing and analyzing data, and developing models that allow for automatic assessment of the hydropower plants.

Needless to say, Austria's innovations lay not just in the technological field, but also in integrating R&D with incentives. Climate Austria, for instance, supports innovative climate protection projects in Austria (many are accommodations in the countryside that run off of renewable energy and avoid producing excess CO₂).¹³ Austria is also looking in the coming years to promote the reallocation of public spaces, making town centers and public spaces more attractive; implementing measures to adapt to climate change (e.g., green spaces and car-free zones); internalizing external costs according to the "polluter-pays" principle; promoting new registrations of zero-emission commercial cars, using more battery electric buses and hydrogen fuel cell buses; campaigning for fair taxation of jet fuel; adopting district cooling, whereby waste heat rather than electricity is responsible for the cooling (the district cooling center in Spittelau, for example, saved 62 percent of primary energy and 70 percent in greenhouse gas emissions compared to conventional cooling centers); and converting gravel roofs into green roofs in Vienna, amongst many other measures.¹⁴

BANGLADESH

Institute for Policy, Advocacy, and Governance (IPAG)

Rubayat E. Shams Anik

I. SOLshare

Bangladesh-based renewable energy startup SOLshare's platform creates solar microgrids allowing household solar panel owners to buy and sell electricity according to their needs, while also providing their neighbors with access to electricity, often for the first time. SOLshare has been awarded a \$120,000 cash prize along with a \$364,000 fund for investment by EIT InnoEnergy, the world's largest sustainable energy engine, to support expansion of SOLshare's pioneering peer-to-peer solar trading platform.

The Current Energy Matrix

Brazil is a country with great potential to produce clean energy due to its geographic location, hydrographic basins, abundant biodiversity, and sufficient solar irradiation. Data released by the energy regulatory agency shows that Brazil is a clean energy country, with 46 percent of its energy needs sourced from renewable energy, compared to 14 percent globally.

In Brazil, hydraulic energy (61 percent) is the predominant renewable energy source, followed by wind energy (9 percent), biomass (8 percent), nuclear (1 percent), and solar (1 percent), according to 2019 data. The country is the second-largest producer in the biofuels sector globally. Brazil has benefited the most from solar energy in terms of increased production, and the country now ranks 13th in the world for solar energy.

In recognition of the importance of clean energy in the country, Brazil was unanimously chosen to host, in 2024, the 15th Clean Energy Ministerial (CEM) and the 9th Ministerial Meeting of the Mission Innovation (MI). In the same year, Brazil will hold the Presidency of the G20, a group of leading economies in the world, and will link the two events to the Energy Ministerial Meeting of the group. As multilateral platforms that bring together developing and developed countries, CEM and MI aim to accelerate the transition to clean energy around the world.

I. The Case of Ethanol

Sugarcane derivatives are one of the main sources of renewable energy in Brazil, representing 19 percent of the total energy generated in the country. From sugarcane, it is possible to produce ethanol, bioelectricity, and biogas.

Starting in the 1920s, Brazilians began extracting sugarcane ethanol to produce fuel, but it was not until 11 years later that they began mixing this ethanol with gasoline. In 1973, the OPEC oil crisis created additional energy needs for Brazilians, and in 1975, the Brazilian government responded with an ethanol incentive program, “Pro-álcool.” The government intended for the program to promote Brazilian energy independence and to develop an industry for cars that run only on alcohol. The so-called Flex vehicles, which run on alcohol and gasoline, generate demand in the domestic biofuel market.

Currently, Brazil is the largest producer of sugarcane ethanol in the world and the second largest ethanol producer in the world, second only to the United States (which produces the fuel from corn). All gasoline sold in the country contains 25 percent of biofuel in its formulation. Widely considered a better fuel for the environment, this mixture also reduces greenhouse gasses by motor vehicles.

II. Solar and Wind Technologies

Brazil, due to its climate and surface area, has enormous wind and solar potential, but does not sufficiently exploit its capacity in these areas. In part, this shortfall is due to economic reasons.

Investing in energy matrices from renewable sources has a high upfront cost and is typically considered a risky investment. Two challenges impeding the development of renewable energies in Brazil are, therefore, the need for large initial investments with high associated costs (higher than those of traditional energy sources), in addition to the intermittence of new sources (wind and solar, mainly), which make it unattractive.

Brazil currently has the capacity to produce 22,000 megawatts (MW) of wind energy, and the Northeast region alone is responsible for 20,000 MW, that is, more than 90 percent of the national production. There are 828 wind farms in operation in the country, of which 725 are in the Northeast. Photovoltaic energy, also known as solar energy, also has great potential for growth and investment in the country, since the sun is a constant in the climate. While the irradiation in Brazil is extremely advantageous, solar energy still represents only 2 percent of the country's total energy sources.

In the first four months of 2022, Brazil increased the production of clean energy and reduced the production plants that are highly polluting. The survey by the Electric Energy Commercialization Chamber shows that the generation of clean energy grew by 6 percent in the first four months of this year, compared to the same period in 2021. In the National Interconnected System, the share of hydraulic energy, which comes from hydroelectric plants, went from 73 percent last year to 77 percent this year. Wind power reached 10 percent from 9 percent, and solar, doubled: from 1 to 2 percent. In the same period, thermal energy had a reduction from 17 to 11 percent. However, there are other challenges in the country, such as the impact of climate change on water cycles and the intermittency of wind and solar generation.

Lowering costs represents a key measure for competitively building wind and solar plants, but there are still battles to be won and strategies to be taken. New technologies and innovation have made wind turbines much more powerful, and the global maturity of solar energy has made it possible to reduce the cost of photovoltaic panels.

III. Is Green Hydrogen the Future?

Another potential for innovation is the use of hydrogen as an effective alternative to the decarbonization of the global economy. Green hydrogen, obtained from renewable sources, is an option that does not emit greenhouse gasses in its production, yet has a high calorific value (amount of internal energy) and an ability to accelerate climate neutrality by 2050.

Green hydrogen is one of the most discussed topics in Brazil and in the world when it comes to energy transition. The Northeast region, mainly the states of Ceará and Rio Grande do Norte, have attracted significant investments from European countries, which are betting on this fuel as an alternative to fossil fuels.

According to a study by McKinsey & Company, Brazil has the potential to become a leader in the production of green hydrogen and attract \$200 billion in investments over the next 20 years. The intention of these countries is to import the green hydrogen produced by Brazil and guarantee a cleaner energy matrix.

I. Cerro Dominador

Cerro Dominador, in the middle of the Atacama Desert, is an innovative project that is destined to become one of the main postcards of renewable energy innovation in Chile. It represents the first solar power concentration plant in Latin America, consisting of a 110 MW solar thermal plant and a 100 MW photovoltaic plant. Cerro Dominador has already begun supplying its power purchase agreement (PPA) contracts with the distributors, as awarded in the electricity tender in 2014, producing energy 24/7. Solar thermal energy solves the problem of the intermittency of other non-conventional renewable energies, allowing consistent energy production. The solar thermal plant avoids the emission of 643,000 tons of CO₂ per year and has the capacity to supply 382,000 homes. The solar complex is owned by EIG Energy Global Partners Innovation and will be fundamental to achieve the goal of carbon neutrality by 2050. It uses 10,600 mirrors (heliostats), each of 140m² of surface, on a plot of more than 700 hectares, which reflect sunlight, concentrating heat in a receiver located at the top of the main tower, 250 meters away. What is interesting and revolutionary about this plant is that it can generate energy both day and night, thanks to thermal energy storage, and it can achieve the same efficiency as plants producing energy from coal or gas.

II. Espejo de Tarapacá (Valhalla Chilean Enterprise)

Although the project has not started operations yet, the initiative is very remarkable. The project already obtained the approval of its Environmental Impact Study (EIA), for its Espejo de Tarapacá (EdT) project, which will have an installed capacity of 300 MW. This will allow a clean and constant energy supply to the Chilean electric system. With an estimated investment of \$400 million, EdT is considering installing a hydraulic pumping plant, which during the day will bring seawater to the top of a coastal cliff using solar energy, accumulating it in natural concavities located 600 meters high. During the night, when there is no solar energy available, it will generate electricity by dropping that water through the tunnels themselves. In this way, it will offer clean and constant energy (24 hours a day, 7 days a week), overcoming the intermittency. The great particularity of this project is that it combines the best conditions in the world for the production of solar energy and for large-scale energy storage. The latter is due to the exceptional and unique geographical characteristics of the Atacama Desert: high-altitude coastal cliffs very close to the sea, with natural concavities in its upper part that allow storing seawater without the need to build dams, which reduces construction costs and allows the energy produced to be competitive with other sources of generation. EdT is the first Chilean project that combines highly proven technologies worldwide (e.g., a pumping hydroelectric power plant and solar plants), which can be replicated and integrated with other renewable sources. This will make it possible to transform Chilean electricity generation parks through the use of local, clean, and infinitely abundant resources. Also, being an emissions-free project, it will be a great contributor to the commitments Chile assumes as a country in the reduction of CO₂ emissions.

Another remarkable aspect of this initiative was the work process developed with the communities near the project, from the beginning and before starting any field study. This process was characterized by active participation where input was provided by many communities in the

development of the project, which led project managers to incorporate modifications to the design, considering not only technical and economic variables, but also social.

III. Green Hydrogen (Magallanes Region)

Highly Innovative Fuels (HIF) and its partners Enel Green Power, Siemens Energy, Porsche, and Chilean state-owned ENAP have recently presented the Environmental Impact Study (EIA) of the Faro del Sur wind farm project to the Environmental Assessment Service (SEA) of the Magallanes Region and the Chilean Antarctic, to build a green hydrogen production plant using wind energy as a starting point for a process of conversion and synthesis of carbon-neutral elements. The bet will put Magallanes at the center of a major process of decarbonization of the energy matrix not only of the country, but globally, attracting likewise first-level talent and human capital and new investments and opportunities. A pilot project came into operation at the end of 2021, which will be followed, in 2023, by the commencement of the construction of the first commercial plant and then additional decarbonization units, and by 2030, the completion of the project's goal to remove 14 million tons of CO₂ annually from the atmosphere. To achieve this goal, the Magellan complex will have to produce up to 7.8 million tons of methanol per year or its equivalent of gasoline, that is, 3.25 million tons of this green fuel, which will be enough to provide 100 percent of the gasoline required in Chile.

The project, which includes the installation of 65 state-of-the-art wind turbines, will have a capacity of 325 MW. It also entails an underground transmission line of 33 kV and 12.1 kilometers in length, which will allow it to feed with renewable energy the future eFuel plant at Cabo Negro. The force of the wind as a primary element of the project will allow it to produce fuel with the air while decarbonizing it. With this, hydrogen will be obtained by separating, through electrolysis, oxygen from the hydrogen present in water. After a filtering process, the project aims to capture the CO₂ present in the atmosphere, purifying the air. Then, it will combine the hydrogen obtained from electrolysis with the CO₂ captured from the atmosphere through a synthesis process. The result will be a CO₂-neutral fuel. When used, the amount of CO₂ emitted will be recaptured to produce more e-fuel. It is estimated that, upon obtaining the Environmental Qualification Resolution (RCA), the construction of the wind farm will take about 24 months.

COLOMBIA

TicTac

Nathalia B. Gamboa

I. Electric Mass Transportation System in Bogota

Mobility is a critical element in any city, and Bogota is no exception. Being the eighth-most congested city in the world (and the first in Latin America) and losing 94 hours in such congestion, the city requires relief for both the local environment and citizens.¹⁵ For this reason, and within the framework of the UK Sustainable Infrastructure Program led by the Inter-American Development Bank and the UK Government, Colombia (and three other countries in the region) has received economic support since 2018 to strengthen development and close gaps in Colombia's sustainable, low-carbon, and climate-resilient infrastructure.¹⁶ Investments in Colombia have amounted to \$1.7 billion. One of the main items has been clean energy and the electrification of public transportation, hand in hand with Transmilenio, Bogotá's mass transit system.

In total, the city has a fleet of 655 electric buses, which also have free WiFi, panic buttons, and cameras that provide greater security to citizens. According to Bogotá's mayor's office, the number of buses to be completed in the year "is equivalent to planting one million trees that absorb 3,200 tons of CO₂."¹⁷ With these investments plus local taxes, 830 additional vehicles are expected to arrive during the remainder of 2022 to improve mobility in one of the most congested cities in the world.

II. Solar Energy to Produce Craft Beer

Solenium is a Colombian company dedicated to improving profitability and sustainability, lowering energy consumption with the application of AI, IoT, smart metering systems, solar panels, and other technologies.¹⁸ In six years of work, its sustainability projects have avoided the generation of over 2,000 tons of CO₂, saved more than 15,500 trees, and generated nearly 3,050 megawatt hours (MWh) of energy.¹⁹

Likewise, Unergy, a startup located in Medellín, connects entities interested in buying clean energy at the best cost with people interested in participating in solar energy projects and achieving profitability.²⁰ With the use of AI and blockchain, the more than 4,000 people who finance these projects can be sure of their transactions with real-time monitoring.²¹

Solenium and Unergy joined forces in 2021 with "La Pola del Pub," an artisanal microbrewery in the center of the country, to produce beer conscientiously.²² In their brewery, the partners installed 253 solar panels, which, together with the AI-enabled smart energy measurement service, have helped to avoid the emission of 837,000 kilograms (kg) of CO₂, saving approximately 239 trees in the process of making beer.

III. Ideas for Change: Energy in Motion

This is a program of the Ministry of Science, Technology, and Innovation (formerly Colciencias), which seeks to support ideas for innovative solutions to help improve the quality of life for vulnerable communities in Colombia. Participation is based on contributing knowledge and experience during annual calls that rotate throughout regional areas of the country and focus on specific, varying topics.²³

A recently featured topic highlighted the indigenous community of Kanalitojo, located in Puerto Carreño, Vichada, a municipality bordering Venezuela that is commonly affected by violence, forced displacement, very high temperatures (27°C average that can even exceed 40°C), and the constant risk of flooding of the surrounding rivers. All of these factors make it difficult for this community to settle, and the remoteness and, in some places, poor access, mean that developed technological alternatives are not long-lasting.²⁴ The challenge lies in creating solutions that overcome these geographical conditions to enable lasting technological alternatives and to allow adoption of sustainable solutions that are adaptable to their nomadic practices.

For this reason, the research group Centro de Innovación y Desarrollo Tecnológico del Sector Eléctrico (CIDET) worked with the community of Kanalitojo in the design and implementation of a photovoltaic system that provides electricity, refrigerators to store food, connection points for computers, and lighting for the school; this is complemented with 33 kits containing two portable lamps and a solar panel to provide lighting for homes and charging points for mobile phones. All

of this is monitored from a device that allows the community to manage equipment and batteries, allowing them to move around the region without limitations.²⁵

ECUADOR

Fundación Internacional Bases

Leonard Quinde Allieri

I. Geocycle's Co-Processing

Geocycle, a company within the international group Holcim, is a leading provider of industrial, agricultural, and municipal waste management services worldwide. What differentiates it from other initiatives is that the company uses a proven “co-processing” technology, using existing facilities in the cement industry to solve waste problems sustainably. Geocycle’s innovative methods allow it to recover energy and recycle materials from waste, contributing to a circular and regenerative economy that closes resource cycles. Geocycle manages more than 10 million tons of waste per year globally, thus tangibly contributing to bringing society closer to a future without waste.

Geocycle differs from other sustainability projects because it operates under a strategy of business performance, value creation, sustainable development, and the environment component, as well as the Certification for Hazard Identification and Risk Assessment in operations that manage alternative fuels, Acert. That is, it’s not only sustainable but also profitable.

II. Sociedad Agrícola e Industrial San Carlos S.A.’s Energy Recycling

Since 2001, Sociedad Agrícola e Industrial San Carlos S.A. has communicated its environmental sustainability successes with stakeholders. Consequently, the community knows that sugar is more than sugar when San Carlos makes it; it’s also sports, care for the environment, education, and health. In 2019, and as a direct result of its renewable energy sources initiative, such as cane grinding waste, San Carlos avoided 107,542 tons of CO₂ emissions, a further reduction of 18.2 percent compared to the previous year.

For the calculation of emissions reduction, the total energy generated with biomass in the reporting year was considered. This energy was multiplied by the last CO₂ emission factor of the National Interconnected System of Ecuador, established by the National Environmental Authority corresponding to the year 2013, which was 0.5076 ton CO₂e / Mwh. According to the greenhouse gas measurement methodology, these reductions correspond to indirect emissions from power generation. From 2015 to 2019, an accumulated amount of 526,167.1 tons of CO₂e were avoided, representing an increase of 25.7 percentage compared to the previous report.

The combustion sources for the generation of electrical energy were cane bagasse resulting from the grinding process and bunker used in the start-up operations of boiler #8. Bagasse is a recycled residue used as a renewable energy source, allowing energy to be generated cleanly for domestic consumption and export to the interconnected national system.

Of the total materials used as an energy source for energy cogeneration, only 0.029 percent came from a non-renewable source and 99.97 percent from a renewable source (residue from grinding cane), managing to recycle and reduce the generation of solid waste.

III. La Fabril's Steam Generation with Biomass

In March 2019, La Fabril inaugurated a new boiler that uses renewable energy as part of its project, "Steam Generation System with Biomass."²⁶ In Ecuador, residual biomass is a renewable energy source with a high potential for use. This initiative, which responds to the company's interest in environmental care, consists of replacing diesel as fuel for industrial steam generation with a by-product of the extraction of red palm oil, known as palm kernel shell, or PKS. The use of biomass provides significant advantages in environmental matters; it contributes to the better and greater use of co-waste, and, given that biomass energy does not contribute to global warming, the application of biomass produces a reduction in emissions of polluting gases into the environment.

In economic terms, this technology reduces the number of processing boilers and generates savings in the cost of purchasing fossil fuels such as diesel or bunker.

Currently, La Fabril processes around 530,000 tons of palm fruit, equivalent to more than 130,000 tons of biomass, of which 30,000 tons correspond to palm kernel shell, which will be used as the primary fuel source for this boiler.

GERMANY

German Economic Institute

Thilo Schaefer

I. Envelio's Intelligent Grid Platform

The efficient use of electricity produced from renewable sources is one of the main challenges of the energy system transition toward carbon neutrality. A functioning system that addresses the issues of decentralized producers and volatile demand requires absolute transparency. Today, grid operators often manage data in isolated systems manually. This is not only time-consuming, but also error prone.

Envelio is a clean-tech software company in Cologne that has received numerous awards. In May 2017, it was established as a spin-off of Aachen Technical University (RWTH). Its "Intelligent Grid Platform" offers a solution to this challenge. It provides a software platform that combines grid data and allows operators digital and automatic grid planning and grid operation management processes.

The Grid Hub lays at the core of the Intelligent Grid Platform. Here, all grid-relevant data is bundled in one place and linked to form a complete grid model. Grid topology, resource data, and supply tasks are all included in this model.

II. Lorenz GmbH & Co. KG's Smart Water Meters

Lorenz GmbH & Co. KG specializes in flow measurement and supplies residential, domestic, and bulk water meters, as well as the corresponding communication technology and services. Lorenz's meters enable the operation and monitoring of public supply networks, and are used to control industrial plants.

As an interface between public supply networks and private residential and commercial buildings, water meters serve to accurately record consumption and ensure fair billing. The networking of metering points, efficient data collection and transmission, and systematic analysis offers

opportunities for supply quality, including substantial savings through the detection of shrinkage, location of leaks, and avoidance of service trips. The urgency of this is heightened in the face of increasing treatment demands (e.g., pharmaceutical and fertilizer residues, groundwater drawdowns, etc.). Measurement technology is further crucial to collect the data necessary for “Water Supply 4.0” and to transmit it quickly and securely.

For all meters, full recyclability has been ensured over at least two product life cycles. The development of a new high-precision electronic counter has reduced the number of parts to a minimum. A unique, modular platform concept for software and electronics enables individualized counters and compatibility with different radio communication systems.

After use and calibration-related replacement, Lorenz takes back the smart meters to refurbish them and return them to the production cycle. The take-back from utilities, municipalities, or metering services takes place against repayment or within the framework of rental and service models. All the prerequisites for a 100-percent closed loop system have been created; realistically (considering return rates, customer cooperation, damage, etc.) 80 percent efficiency can be expected. This represents a major and highly scalable breakthrough for the circular economy, both economically and ecologically.

The resulting price competitiveness of a high-quality measuring device with high accuracy and stability, compared to low-cost disposable products, is important for the successful digitalization of water supply.

At the German Innovation Awards for Climate and Environment (IKU) 2020, Lorenz GmbH & Co. KG received an award in the category “Environmentally Friendly Products and Services.”

III. IN4climate.NRW: A Unique Initiative of Policymakers, Entrepreneurs, and Scientists

As a unique, nationwide platform where industry, science, and politics work together, IN4climate.NRW provides a space to develop innovative strategies for a climate-neutral industry.

Industry is responsible for 22.4 percent of CO₂ emissions in North Rhine Westphalia (NRW) (as of 2019). For a competitive and climate-neutral industrial location, fundamentally new production processes and procedures, as well as improved infrastructures and framework conditions, are indispensable. In order to shape this process of change together with companies, scientific research institutions, and the state government, the Ministry of Economic Affairs, Innovation, Digitalization, and Energy of North Rhine-Westphalia has launched the IN4climate.NRW initiative. As a working platform, IN4climate.NRW provides significant impetus for the necessary transformation processes in industry—and not only in NRW, but also across the federal government and states and in international cooperation projects.

IN4climate.NRW is designed as a knowledge, dialogue, and working platform. Around 40 companies and associations from the steel and metals, chemicals, cement, glass, paper, and building materials sectors as well as six research institutions are participating in the initiative.

Together with working groups, an innovation team develops ideas and measures for a climate-neutral industry. Currently, the focus of the working groups of the same name is on hydrogen, industrial process heat, carbon economy, circular economy, and political framework conditions. The organizational threads come together at the IN4climate.NRW office. The process is also

accompanied by a Strategy Board at both the board and ministerial levels. The SCI4climate.NRW Competence Centre accompanies the process scientifically and investigates the development and design options for a climate-neutral primary industry.

As a think tank, IN4climate.NRW plots a concrete path toward a climate-neutral industry. The initiative's central field of work is developing new technologies and innovative approaches for a sustainable, competitive economy.

Such a substantial change in industry requires considerable investments on the part of companies. They need investment security and reliable accompaniment and support in order to be able to survive as pioneers on the global market. For this reason, IN4climate.NRW is working with experts from industry, science, and government to develop concrete measures for climate-neutral production processes and value chains, as well as for the necessary infrastructures and the political and social framework conditions.

INDONESIA

Paramadina Public Policy Institute

Ahmad Khoirul Umam

Fossil fuels not only cause climate damage and lead to high energy bills, but also contribute to the loss of industrial competitiveness. Carbonizing energy systems also puts countries across the globe in a highly vulnerable situation given the impact of unstable geopolitics and regional security on the supply chain. Therefore, renewable energy could become a key solution for the global energy system. As one of the world's largest greenhouse gas emitters, Indonesia has pledged to achieve carbon neutrality by 2060. Furthermore, as current holder of the G20 Presidency, Indonesia also promotes the tagline of "Recover Together, Recover Stronger," emphasizing three core priorities, namely: 1) securing energy accessibility; 2) scaling up smart and clean energy technologies; and 3) advancing clean energy financing. This commitment is fundamentally aligned with the goals of the Paris Agreement, UNFCCC-COP 21 (2015), UNFCCC-COP 26 (2021), and the 2021 Rome G20 Summit, all of which promote decarbonization and acceleration of green energy growth. Moreover, in his state speech at the Annual Assembly ahead of Indonesia's Independence Day on August 16, 2022, Indonesia's President Joko Widodo explicitly reaffirmed his commitment by ensuring national stakeholders that the clean energy from solar heat, geothermal, wind, ocean waves, and bio energy will gradually attract industrialization that produces low-emission products.

The positive trend will become a big opportunity as Indonesia has the potential for a large, scattered, and diverse renewable energy portfolio to support national energy security and to achieve the target of mixed capacities of renewable energies. Hydro potential is spread throughout Indonesia, especially in North Kalimantan, Aceh, West Sumatra, North Sumatra, and Papua. Meanwhile, potential solar energy spans areas of higher solar radiation such as East Nusa Tenggara, West Kalimantan, and Riau, while wind potential (>6 m/s (metre per second)) is mainly found in East Nusa Tenggara, South Kalimantan, West Java, South Sulawesi, Aceh, and Papua. On the other hand, the potential for marine energy can be found in Maluku, NTT, NTB, and Bali, while geothermal potential is spread throughout the ring of fire area, covering Sumatra, Java, Bali, Nusa Tenggara, Sulawesi, and Maluku (ESDM, 2021).

Based on the energy transition outlook data (IRENA, 2021), Indonesia will be able to reach net zero ahead of its target of 2050, through a significant scale-up of renewables covering two-thirds

of its energy demand. Indonesia's political will to accelerate the state's efforts to reach sustainable, affordable, and reliable access to renewable energy was reconfirmed during a meeting on May 9, 2022 between the U.S. Special Presidential Envoy for Climate John Kerry and Coordinating Maritime Affairs and Investment Minister Luhut Pandjaitan. The confirmation is expected to mobilize significant public and private finance for investment in Indonesia's energy transition. There are several examples of the decarbonizing energy projects currently promoted in Indonesia:

I. Electric Vehicle Conversion Program

Indonesia is passionately pursuing an effective transition from imported oil to homegrown green power by using electricity for transportation, domestic activities, and industrial activities. In anticipation of the global shift to electric vehicles (EVs), Indonesia is preparing for expectations that EVs will represent more than 50 percent of new vehicle sales globally by 2035. However, in Indonesia, the EV sector is still developing. Around 15,000 EVs, mostly all bikes, were sold in 2019, representing less than 0.2 percent of annual vehicle sales. According to Gupta and Hansmaan (2021), the demand for passenger electric cars will reach 250,000 units per year by 2030, equal to 16 percent of all new passenger car sales, while the demand for electric two-wheelers could reach 1.9 million units per year in that time frame, or 30 percent of new two-wheeler sales. As such, the Indonesian government, in an effort to position Indonesia as a pivotal player in global EV supply chains, began leveraging the country's reserves of nickel, bauxite, copper, and other valuable materials for the manufacture of electric batteries. However, it must be recognized that the number of EVs is still very limited in Indonesia. Therefore, as part of an effort to accelerate development of the EV market, the newly issued Presidential Instruction No.7/ 2022 mandated the use of battery electric vehicles for government officials across the country. Moreover, the use of EVs will also be exhibited by President Jokowi at the G20 Summit in Bali on November 15–16, 2022.

As part of a larger government initiative to foster the development of downstream stages of extractive industries and accelerate EV manufacturing in the country, Indonesia inaugurated a hydrometallurgical nickel laterite production facility in Morowali Industrial Park, Central Sulawesi. The project aims to produce nickel manganese cobalt oxide (NMC) to make nickel-based battery cells and to produce 50,000 tonnes of pure nickel annually. The project is promoted by joint venture PT QMB New Energy Materials, consisting of Jakarta-based PT Indonesia Morowali Industrial Park, Tokyo-based Hanwa Co. Limited, and Chinese companies Tsingshan, GEM Co. Limited, and Contemporary Amperex Technology Co. Limited's subsidiary Brunp, with total investment reaching around \$700 million.

However, some critical stakeholders are not sure about the Indonesian government's moves, considering that national EV production is still very limited and tends to depend on foreign manufacturers. Many stakeholders suspect that the narrative of the importance of EVs will only be used as a "political gimmick" during the G20 Summit. Indonesia's political-economic process in the near-future will show the truth. To make EV production sustainable, Indonesia's government must develop three enablers, namely: 1) increased long-term nickel production for batteries; 2) local manufacturing; and 3) supportive infrastructure. The adoption of electric vehicles in Indonesia is still early. But, if government stakeholders, state-owned enterprises, and the private sector can effectively collaborate to build the local EV ecosystem, there exists great potential to significantly increase both Indonesia's economy and the quality of its environment.

II. GERILYA as a Solar Power Initiative Movement

GERILYA is a Solar Power Initiative Movement run by the Directorate General of EBKTE (2022). It aims to prepare university students as clean energy activists who will work to accelerate clean energy (i.e., rooftop solar power) and support the goal of 23 percent of mixed New-Renewable Energy (NRE) by 2025. At the same time, the university students are also directed to create a start-up development for NRE to encourage innovation and investment in NRE development. The role of startups in NRE development is to initiate renewable energy projects, stimulate the investment climate to positively impact the economy, off-set job losses from the decline in extractive industries, generate labor-intensive jobs, and create innovations in the field of renewable energy that are directly beneficial to the community.

Furthermore, these activists will be innagurated as “Energy Patriots,” a young generation of social, active, intelligent, passionate, motivated, and well-trained students. The Energy Partiotics will aim to encourage the development of NRE in the 4T areas (Disadvantaged, Frontier, Outermost, and Transmigration areas) to improve community welfare in Indonesia. The roles of the Energy Patriots are: 1) Identifying and mapping the potential of NREs, especially in the 4T area in the context of providing sustainable, NRE-based energy; 2) Assistance in the development of power plant-NRE through socialization, supervision, facilitation of the formation of management institutions, and handover of assets; 3) Monitoring and evaluation on de-dieselization by assisting in supervising the de-dieselization program of 5200 PLTD; and 4) Identification of power plant-NRE problems, including damage, repairs, and facilitation of the establishment of a management agency.

III. Solar and Hydro Energy Storage in Java, Bali, and Sumatera

Solar and hydro energies provide great potential for Indonesia to meet its energy needs. Through the installation of billions of solar panels, Indonesia could harvest 640,000 terrawatt-hours (TWh) per year from solar energy, which is equivalent to 2,300 times the level of this type of electricity production in 2020. Indonesia has more than enough sunlight, while its electricity consumption was 1 megawatt-hour (MWh) per capita in 2019. The projected electricity demand will reach 2,600 TWh, or 7.7 MWh per capita by 2050. At that time, Indonesia needs a total capacity of 1,500 gigawatt (GW) of solar photovoltaic power plants to convert sunshine to electricity using photovoltaic modules. Meanwhile, Indonesia possesses large areas to install PVs, which consumes around 8,000 square kilometres, or about 0.4 percent of the country’s land area. Moreover, solar panels can also be installed on water, such as placed on floats on lakes and sheltered seas, as it has very wide water territory as the world’s largest archipelago.

When the rainy season comes, Indonesia also has a nature-based solution of using its enormous potential for off-river pumped hydro energy storage (PHES). According to Firnando and Blakers (2022), “PHES is a technique to store energy by using excess power produced from solar panels during sunny days to pump water uphill to a higher reservoir. When power generation is low during cloudy weather or at night, electricity can then be dispatched on demand from PHES by releasing the stored water downhill to the lower reservoir through the turbine.” The best sites for these reservoirs are most likely in Java, Bali, and Sumatra.

Despite the incredible energy potential, investment in the renewable energy sector is still limited. Both the solar-dominated electricity system and hydro energy contributed less than 2 percent to the country’s total electricity production in 2021. In response to investment concerns, President

Joko Widodo recently issued Presidential Regulation (Perpres) No. 112/2022 on renewable energy regulation, but with an unattractive pricing scheme: There is no feed-in tariff and the ceiling price set for electricity purchased by state-owned electricity company PLN is lower than expected. The ceiling price allows some room for solar power plant developers to gain small profit margins. However, it is difficult for developers to meet the local content requirements (TKDN), which must be around 40 percent, for solar photovoltaic modules. Indeed, as is commonly the case, countries' local content requirements such as these often backfire. It makes the solar power projects economically difficult and unfeasible. Therefore, this big agenda must bring together policymakers, companies, and investors to work together to make investment in renewable projects more feasible and accessible.

ITALY

Competere & I-Com

Pietro Paganini & Stefano da Empoli

I. Green Energy Storage

The innovative Italian small to medium-sized enterprise (SME) Green Energy Storage (GES) was founded in 2015 by Salvatore Pinto, President of Axpo Italy, an energy company based in Trento. It is committed to developing flow batteries with a revolutionary 100-percent green technology. The new generation of GES batteries, based on a hydrogen/liquid hybrid technology, is envisaged to considerably outperform current storage systems. GES plans to develop a flow battery for stationary applications with a higher density than the best-performing batteries in the industry today, with a service life of 15 to 20 years and a more competitive storage cost compared to lithium batteries. While in today's lithium batteries, energy and power are combined in a single device, GES batteries are intended to exploit the decoupling of the power and energy components provided by the architecture of redox flow batteries (RFBs) to create accumulators of different sizes and use contexts, something that is not achievable with the classic lithium-ion battery pack. Compared to traditional RFB accumulators, the batteries produced by GES have a higher energy density (its new technology can reach a density of 100 Wh/litre (watt hour per litre)) and are based on a hybrid system made up of hydrogen and a patented liquid electrolyte—the battery self-produces the required hydrogen for a closed charge/discharge circuit. Moreover, the GES goal is to produce non-toxic, safe accumulators made of readily available, corrosion-free materials that can operate at room temperature to avoid overheating, thus ensuring a high level of security.

The GES battery development project consists of the initial development of the key components of the new battery (e.g., electrolytes, membranes, electrodes, catalysts, and digitization of the product), followed by a *"First Industrial Development"* during which a first production plant will be constructed, and an initial market entry of the product will take place, prior to industrial-scale commercialization. The GES project will also benefit from the expected decrease in hydrogen costs, resulting from the increasing global investment in the sector. Moreover, compared to traditional flow batteries, the presence of a single electrolyte is a considerable advantage, halving production costs and the amount of raw material required. This should allow GES to sell the product on the market at a highly competitive price, exploiting large economies of scale involving the entire supply chain, from the purchasing of raw materials up to the recycling stage. In addition, the battery is designed to facilitate end-of-life management and material reuse, respecting the principles of the circular economy.

The new GES battery technology will be applied in domestic storage (becoming an integral part of buildings, thanks to its lifespan of several decades) and in all large renewable generation plants, be they grid-connected or available to local microgrids. They will serve as the interface between the grid and all large public high-power charging facilities designed for electric vehicles. They could also find an application in transport, for example, in ships, buses, and trucks. The new technology being promoted by GES could represent a significant enabler for a fully decarbonized electricity system, impacting on a storage market with an estimated global value reaching \$400 billion/year in the future, accelerating the ecological transition, and contributing to Italy's economic and industrial relaunch. GES has recently received €53 million in funding from the European Union (EU) and the Italian government for a project focusing on R&D for stationary batteries, in the framework of the second IPCEI (Important Projects of Common European Interest) dealing with the *European Battery Innovation* initiative.

II. Newcleo

Newcleo, launched in September 2021, aims to be a disruptor in the field of nuclear energy. The company's goal is to develop innovative fourth-generation nuclear power plants capable of producing energy safely and sustainably. The project's financiers include LIFTT, a venture capital firm formed by the public-private partnership between the Polytechnic University of Turin and Compagnia di San Paolo (one of the oldest and largest Italian foundations, set up in 1563 and endowed with assets of about €7 billion), the Club degli Investitori (an Italian business angel network), and Exor Seeds. The start-up is comprised of a group of Italian scientists and engineers based in London who will conduct most of its R&D in Italy.

In collaboration with leading Italian research institutes, including the Polytechnic University of Milan and the Polytechnic University of Turin, the Newcleo team is working on designing two fourth-generation small modular reactors (SMRs). These are small-sized, lead-cooled reactors, which will have a capacity of 30 million watts of electricity (Mwe) and 200 MWe. The first is designed to be able to meet the electricity demand of small remote communities and islands, or used to power large ships, while the second is intended to be a cost-effective solution for supplying national power grids. The first electrical prototypes will be developed in cooperation with ENEA, the Italian National Agency for Energy Efficiency, where new infrastructures for analysis and experimentation will be implemented, with planned investments worth more than €50 million. The working group made up of ENEA and Newcleo personnel will jointly develop the nuclear technology needed to build more reliable and safer reactors.

Currently operating nuclear reactors produce energy through the fission of heavy atoms (typically uranium or plutonium), which are bombarded by neutrons and split into lighter atoms. During the fission process, both energy (in the form of heat) and additional neutrons, which move at very high speeds, are released. The released neutrons are slowed down by a neutraliser and, in turn, contribute to the fission of other nuclei, triggering a chain reaction while the released heat is collected by the reactor using the cooling liquid the core is immersed in. Instead, the innovative reactors developed by Newcleo will be lead-cooled fast nuclear reactors and will, therefore, have two important differences compared to conventional reactors. First, the neutrons released during fission will not be slowed down by a neutralising mechanism, but remain fast and, second, the

cooling agent will consist of liquid lead and not of water or sodium. These features will help make the reactors safer and more reliable and will enable them to produce a smaller and less dangerous volume of radioactive waste compared to that produced by conventional nuclear reactors. Furthermore, this new technology will also allow the radioactive waste to be used as fuel, thus reducing the environmental impact and financial cost of waste disposal. In fact, as part of its medium-term strategy, Newcleo is committed to setting up a plant to produce mixed oxide fuel (MOX), a fuel based on plutonium and depleted uranium, and also intends to explore the use of thorium as a natural fuel. This is just one step toward an even more ambitious goal, namely, that of designing and commercialising an Accelerator Driven System (ADS), an innovative technology proposed by Carlo Rubbia, Nobel Prize Winner in Physics in 1984, and based on the combination of a subcritical nuclear reactor with a proton accelerator. This technology will enable nuclear energy to be produced in a totally safe and sustainable manner, considerably reducing the volume of waste produced. After a first-round worth more than €100 million, the nuclear start-up Newcleo raised a further €300 million in June 2022.

III. Glass To Power

One of the most interesting and innovative technologies that has recently been developed in Italy is the “Glass To Power” spin-off of the Bicocca University of Milan, which was set up in 2016. Glass To Power involves the creation of photovoltaic insulating plexiglass windows made of nanoparticles that convert sunlight into electricity. In particular, the developed system uses nanoparticles as chromophores that enable the complete decoupling of light absorption and emission processes.

The “luminescent solar concentrators” produced by Glass To Power are transparent sheets made of plastic materials that emit photons with a longer wavelength when absorbing sunlight. The photons are guided by total internal reflection toward the edges of the device where the conversion into electricity takes place with the help of photovoltaic cells. Thanks to their very low visual impact, the slabs produced by the company can be easily integrated into any type of building and are practically invisible. Moreover, the nanocomposites from which the products are made do not interfere with light and do not alter the chromatic perception of vision, while the level of transparency can be adjusted during production to achieve the right trade-off between indoor lighting and energy production. In addition to energy production, the panels provide excellent thermal and acoustic insulation, thus reducing energy consumption for heating and cooling. Finally, the company’s manufactured sheets are made of durable materials that are completely recyclable at the end of their life cycle. In November 2016, the photovoltaic slabs made by Glass To Power became the first Italian project to be awarded the Special Recognition Award for the Green Technology category in the 54-year history of the R&D 100 Awards.

Over the years, the start-up has financed itself through two crowdfunding campaigns with a total value of around €2.4 million. The growth process led it to be listed on Euronext Paris last February, with a placement price of €48 per share, reaching a capitalisation of more than €25 million. Where operating volume is concerned, the company achieved a turnover of approximately €400,000 in 2021 and forecasts for the current year a growth of €3 million.

I. PiKCELL Group

PiKCELL Group was founded in 2018 in Skopje, Republic of Macedonia and is a high technology company that focuses on the development and production of monocrystalline and polycrystalline photovoltaic solar modules and photovoltaic thermal modules. PiKCELL was the first company of this type to open in Macedonia and in the region that covers an area of 4,000m² with an annual production capacity of 250MW of monocrystalline and polycrystalline solar modules.

The photovoltaic solar modules, as part of the solar energy product, consist of many PV cells connected in parallel to increase the current and series to produce a higher voltage. The industry standard of 36 mobile modules is combined with tempered glass (or some other transparent material) on the front surface, and with a protective and waterproof material on the back surface. The edges are sealed for protection against atmospheric influences, and often there is an aluminium frame that keeps everything together in the mounting unit. In the back of the module there is a junction box or wire leads that provide electrical connections. Besides solar modules, the company's products also include polycrystalline PV and monocrystalline PV modules—basic materials for the silicon chips found in every electronic device.

II. Mikrosam Prilep

The future of hydrogen is now, and Mikrosam from Prilep Macedonia can help deliver it. The company is a well-known manufacturer of filament winding machinery for compressed natural gas (CNG) and hydrogen tanks and has developed a new generation of high-capacity carbon fiber tanks for hydrogen. The complete production process is optimized with Mikrosam using fast-fiber splicing and spool replacement, automatic resin mixing and refiling, patented fiber cut and restart systems, robot or gantry manipulators, continuous curing ovens, auxiliary stations, and single automation control and quality control software.

The increasing demand for renewable and alternative energy sources including storage and transportation requirements is driving the demand for the hydrogen economy. According to Stratview Research, the demand for automotive pressure vessels for hydrogen is expected to grow at a compound annual growth rate (CAGR) of 16.6 percent over the next five years to reach a value of \$6.6 billion in 2026. Together with Holland-based H2Storage, Mikrosam used towpreg supplier material to increase production productivity and improve part performance and consistency for their 300L+ tanks.

III. Zoka Energy Solutions

ZOKA Energy Solution DOOEL, founded in Negotino in 2020, provides environmentally friendly solutions to landfill waste problems, transforming waste into renewable energy and recycled raw materials for industry. The center for processing municipal, commercial, industrial, and agricultural waste (waste to energy) uses proven technology for the process of gasification and thermal treatment of gases, which produces energy in the form of heat or electricity. Zoka Energy Solution's process of generating electricity eliminates about 90 percent of all waste, and the minimal release of carbon in the process leads to significantly reduced air pollution.

I. HomeBiogas System

Panama City's waste management strategy consists of an open-air dump that holds population refuse. Panama's waste generation exceeds 12,000 tons per year, but only 10,950 tons received final disposal, which means that 14 percent of waste is still on our streets and environment.²⁷ Previous efforts to optimize this process have focused on increasing the fleet of waste collection trucks. Now, however, innovators and government leaders are seeking sustainable solutions for waste management, as the contract governing Panama City's open-air dump ends in 2023.

Open-air dumps increase greenhouse gas (GHG) emissions worldwide. For the nearly 40,000 people who live within a 5-kilometer radius of Panama City's open-air dump, air quality and wellness are compromised. Waste generation led innovators and researchers to explore ways to improve management and collection, keeping targets of sustainability and shared responsibility among stakeholders.

Organic waste represents 50 percent of Latin America's waste.²⁸ Our homes are organic waste generators. Recognizing this fact as an opportunity, the Israeli company HomeBiogas developed a solution that uses organic waste to produce renewable energy. The HomeBiogas digester system transforms organic waste into natural gas (ideally for stove supply) through the facilitation of bacterial growth. Besides allowing users to cook delicious dishes with renewable energy and promote sustainable waste management from home, the HomeBiogas 2.0 system produces a liquid fertilizer perfect for vegetable gardens, flowers, and trees. Its closed system prevents odors and GHG emissions while it works.²⁹

The HomeBiogas digesters have saved 526,554 trees, mitigated 58,506t (tons) of CO₂ emissions, and provided 6,405,750 hours cooked on clean energy.³⁰ At the same time, the company seeks to expand its impact with HomeBiogas 7.0, a model with new features and capabilities that enable animal manure usage, becoming an excellent alternative for businesses, entrepreneurs, and families involved in the livestock and poultry industries.³¹ Panama's users reported that HomeBiogas systems could produce six liters of fertilizer per day and save more than B/.250.00 in propane gas annually, a product subsidized by the government.

Renewable energy production with organic waste provides a holistic approach to addressing Panamanian leaders' 2023 waste management decisions and raises social awareness by setting innovative and sustainable practices in different sectors of society. In this way, HomeBiogas systems have the potential to emerge as an ally for Panama's local governments.

II. Panama Steps Toward E-Mobility

The approval of the E-Mobility Law was a major advancement for Panama's transport energy transition. The public policy development created an ecosystem of stakeholders involved in business, education, non-governmental organizations (NGOs), government, science, and industry. Its alignment signaled a strategic outlook to address COP27 challenges, especially for those who seek Paris Agreement compliance.

Ensuring clean and renewable energy is one of the main challenges for E-Mobility success. For this reason, identifying a country's energy sources and regulations provides valuable data to escalate solutions through innovation. Panama's energy sources consist of 44.7 percent hydroelectric, 37.1 percent thermoelectric, and 18.2 percent non-conventional renewable sources.³² Despite the recent wind and solar power investments, innovators face technical barriers that reduce renewable energy integration in electric vehicle charging stations. Hence, regulations and policies have become essential tools to break these barriers by promoting new business models.

InterEnergy Group is an innovator that has played an active role in the E-Mobility Law co-creation and put it into practice by funding EVERGO, a platform for electric vehicle charging stations that increased E-Mobility acceptance in Panama. Upon deploying over 75 charging stations around the country, InterEnergy Group, launched the SER (Supply of Renewable Energy) initiative, which provides 100 percent renewable energy to clients with consumption above 100 kWh per site.³³

Besides owning an extensive network of charging stations, InterEnergy Group leads Ikakos Solar Park (Tecnisol), featuring 138,960 solar panels with 40MW of generation capacity, and Laudato Sí (UEP Penonomé II S.A.), the biggest wind farm in Central America and the Caribbean with 215MW of generation capacity. Both projects support the SER initiative injecting clean and renewable energy into Panama's electricity matrix.

What could not be reached through infrastructure and technology was achieved through innovative policies and regulations. That is the case of Power Purchase Agreements, a financial tool for SER clients' access to renewable energy.

This joint effort between generators, distributors, regulators, clients, policymakers, and innovators allowed EVERGO to deploy 14 charging stations powered by 100 percent renewable and clean energy in SER client locations. Thus, InterEnergy Group has made incredible steps to advance E-Mobility in Panama, building strategic alliances to guarantee sustainability and innovation in the transport energy transition.

III. AES Innovation Lab

“Smart City” is a revolutionary and cosmopolitan concept that has emerged over the last few years. Think tanks, governments, consulting firms, and international cooperation agencies have been working on different definitions of a smart city. However, they agree that the main characteristic of smart cities is the information-enabled decision making through interactions between devices and software.

A smart city improves multiple aspects of our lives daily, from increasing a city's safety to decreasing citizens' energy bills. By 2025, they are projected to reduce commuting times by 15 to 20 percent through smart-mobility applications. Smart city solutions are flexible enough to be applied in governance, health, education, environment, economy, and research. Nonetheless, human intervention is a relevant factor in solution development. In this way, living labs such as AES Innovation Lab stand out as an open ecosystem where innovators co-create solutions to improve energy services and users' experiences.

AES Innovation has three primary stakeholders, each with its own needs. A “Client” provides feedback from company services, a “Champion” is an AES associate with innovative ideas to escalate, and an “Ambassador” is a leader that identifies potential Champions and fosters an

innovation culture. Thus, the company has been able to develop products that add value to its operations and generate data for businesses, families, and even cities. One example is the EnerEx platform, a solution that adopts AI to capture data from Panama's energy market, as a step toward the energy transition.

AES Innovation Lab has earned more than 34 million balboas (\$34 million) in profits through its Performance Monitoring & Analytics Center (PMAC). This software optimizes energy generation equipment by analyzing parts, sending alerts, and displaying a digital prototype in real time. On the other hand, by providing personalized service, smart data allows clients to take control of their energy consumption through a user-friendly platform interface.

Extending the action range from products quoted, the AES Verse, a digital adaptation of AES Innovation Lab, explores updates in dynamics where Associates and Clients interact in the metaverse with virtual reality (VR) glasses, avatars, and 3D shapes. At the same time, it enhanced the collaboration between participants from different countries, which decreased mobility expenses.

Undoubtedly, these innovations settled a new route for decision-making in Panama's energy sector. The AES Innovation Lab invites cities, businesses, and innovators to co-create solutions that guarantee clean energy and re-defined what we know as a smart city.

PHILIPPINES

Philippine Institute for Development Studies (PIDS)

Adoracion Navarr

I. Conversion of Gasoline-fueled Farm Equipment to LPG-fueled Farm Equipment

Using liquefied petroleum gas (LPG) as fuel for farm equipment is cleaner than using gasoline and diesel. A comparison of full fuel-cycle greenhouse gas emissions shows that LPG use emits 14.7 percent less greenhouse gases than diesel and 34 percent less than gasoline.³⁴ Although the use of LPG in the agriculture industry is not new and has been practiced in other countries, such is not the case in the Philippines because most farm equipment in the country is currently configured as gasoline-fueled equipment. A project for the conversion of gasoline-fueled farm equipment to LPG-fueled ones is thus currently being implemented through a Memorandum of Agreement between the Energy Utilization and Management Bureau of the Department of Energy (DOE, a national-level agency) and the Isabela State University (ISU, a public university in northern Philippines).

In addition to yielding environmental benefits, the project caters to the needs of farmers for agricultural machinery and cushions them against high gasoline and diesel prices. Because converting to the use of LPG as a substitute fuel for farm equipment will lessen the dependence of farmers on more expensive fuel, the project also supports the poverty alleviation objective of the government.

The project lead is the ISU's College of Agriculture, which excels in R&D regarding mechanization of agricultural operations and innovations in farm equipment for the efficient and expanded harvesting and processing of agricultural products. At present, the project is giving the following services to farmers: 1) demonstrating the procedure for the conversion of gasoline-fueled farm equipment to LPG-fueled ones and the use of LPG as an alternative fuel source; and 2) supporting

the operation of LPG-fueled farm equipment with all necessary materials and tools. The project is also developing an LPG conversion manual, prototyping basic farm equipment using LPG instead of gasoline or diesel, and developing local technical expertise in the conversion of farm equipment. At this point, further studies are being conducted on the performance of the converted equipment with a view to introducing the conversion to a wider set of users.

II. The Sessy E-Boat Project

The Safe, Efficient, and Sustainable Solar-assisted Plug-in Electric Boat, or Sessy E-Boat, project is a R&D project being jointly pursued by the DOE and the Department of Science and Technology (DOST), which is also a national-level government agency. The Sessy E-Boat Project involves the design and fabrication of two e-boat units, benchmarking of the e-boats with other technologies, and performance tests when used for inter-island transportation and tourism purposes. Both e-boats use solar panels, but one uses lead acid batteries and the other uses lithium-ion batteries. The e-boats also use a locally developed automatic identification system as a safety feature. The prototype developers are also exploring the development of controllers for autonomous electric boats.

The project promotes the use of alternative and innovative energy technologies to address local needs, ensure energy security, and reduce pollution. The government envisions the e-boats as viable replacements for gasoline-powered boats currently used in inter-island transportation for tourists. If successful, the project would eventually help reduce air and noise pollution and cut expensive gasoline consumption.

The implementing units, the DOE's Energy Utilization and Management Bureau and the DOST's Philippine Council for Industry, Energy, and Emerging Technology Research and Development, are currently testing the prototypes and conducting further R&D. Forthcoming R&D activities will involve local government units along the coastline of Laguna de Bay, the largest lake in the Philippines.

III. San Bernardino Ocean Energy Project: Capul

While using water flow as an energy source has long been adopted, it is oftentimes through manmade dams that divert flow to move turbines. In nature, gravity-pulled water flows in seas and oceans create strong waves that can also be utilized to produce energy. Processes that exploit these forces for electricity generation are called Tidal In-Stream Energy Conversion (TISEC) technologies. In TISEC, turbines are strategically placed in areas where strong tidal currents occur, and these currents push the rotor blades of these turbines, which can generate electricity. The amount of energy produced by TISEC technologies depends on the frequency and magnitude of the targeted currents, which occur in different bodies of water almost indefinitely.

The San Bernardino Ocean Power-Capul Project is the first to utilize TISEC technology in the Philippines. Pursued by the San Bernardino Ocean Power Corporation, the project will house a tidal power generation plant across the San Bernardino strait and aims to produce 3 megawatts of electricity for nearby communities in Capul Island, an island municipality in Northern Samar province.

Among the ocean energy projects awarded with renewable energy service contracts by the DOE, the San Bernardino Ocean Power-Capul Project is the most advanced, as it is the only project

currently in the development stage in 2022. The others are in pre-development stages. As envisioned, the San Bernardino Ocean Energy Project will not only help diversify the Philippines' energy mix by introducing ocean energy generation, but it will also support the country's universal electrification objective by providing electricity in off-grid areas.

POLAND

THINKTANK Center for Dialogue and Analysis

Adrianna Śniadowska

I. GreenEvo: Green Technology Accelerator

The Green Technology Accelerator is an original project of the Polish Ministry of Climate (previously named the Ministry of the Environment), created to promote green technologies. It was launched as a result of 14th UN Climate Change Conference, which took place in Poland in 2008.

GreenEvo promotes the sustainable development of companies, green technologies, and, in consequence, the economy itself.³⁵ Its main purpose is to help Polish SMEs enter into international contacts, provide them with necessary tools to enable their dynamic development, and strengthen the position of advanced green technologies in the process of building a circular economy. Proponents of proven, implemented, and highly efficient technologies join its Laureates. GreenEvo Laureates are credible business partners, willing to share their knowledge, experience, and technologies with developing countries that face local environmental challenges. The program consistently builds the environmental awareness of domestic technology buyers and educates potential foreign partners to reduce environmental impacts through technology use.

The sectors that qualify for the project include water-sewer management, waste management, renewable energy sources, energy-saving technologies, air quality, protection of biodiversity, passive construction, low-emissions transport, and protection of the climate (including measures reducing greenhouse gas emissions).

II. Reverse Vending Machine: Smart RVM

R3 is a Polish company that builds the Smart RVM system, which supports the process of recovering beverage packaging, motivating its return, and building pro-ecological awareness across society.³⁶ It produces return machines for aluminum cans and polyethylene terephthalate (PET) packaging; in other words, it's a smart reverse vending machine (RVM), also known as a recyclomat.

RVM is a high-end machine for collecting, compacting, and segregating the disposable drink containers. It collects three kinds of products (PET bottles, aluminum cans, and caps) into three designated containers. Recyclomat has an internal EAN codes database (EAN refers to a standard describing a barcode symbology and numbering system) of PET and aluminum containers, and it allows easy identification and registration of containers. Central module managing reverse vending machines controls the state of recyclomats and how full they are. There is a loyalty program in place to motivate consumers to use drop-off machines in exchange for certain benefits. For every returned package, users earn points they collect as paper receipts or in electronic form (in a mobile app). The points can be integrated into existing loyalty programs. These programs cause more returns and make consumers act in accordance with the ideals of the circular economy.

III. Nexbio

Nexbio is a lab conducting scientific analyses of microorganisms and plant pathogens based upon molecular methods and DNA identification. Team members consist both of people who have a solid academic background in genetics and molecular methods, and of persons who focus on implementation of genetic methods into everyday life.

NEXBIO offers innovative biotech solutions that support better plant protection. It runs ground-breaking analyses that help farmers with early detection of potential plant diseases (long before they are visible) and personalized plant protection, which increases the efficiency of the crop.

NEXBIO's own DNA analyses allow one to assess plant diseases very early, one to five months before visible signs appear. It is possible because NEXBIO's technology enables it to identify even a single cell of a microorganism that may affect plantation, long before a disease hits.

NEXBIO's solution may be described as personalized crop diagnosis which helps to make a proper choice of plant-protecting chemicals. Therefore, protection is cheaper and more effective at the same time: farmers may use only those measures that are aimed at existing threats and estimate the right quantities. As a result, efficiency is higher while the amount of pesticides used is usually lower, which means crops are produced more ecologically. The significant scientific background of the lab can be used to increase the output of the European agricultural sector, guaranteeing ever-more sustainability and productivity of the crop yields.

SAN FRANCISCO BAY AREA, UNITED STATES

Bay Area Council Economic Institute

Sean Randolph

As home to the United States' largest concentration of innovative and fast-growing cleantech startups, the San Francisco/Silicon Valley Bay Area region generates many emerging companies and technologies with the potential to transform the energy sector and positively influence climate change. While many are still small, some have achieved significant scale. Their growth has been enabled by policies in the state of California that prioritize greenhouse gas reduction, encourage energy and water efficiency, and facilitate the transition from fossil fuels to alternative energy sources through investment in research as well as by aggressive regulatory standards. Cleantech startups are also supported by the venture capital community, universities such as Stanford and Berkeley that encourage and incubate cleantech startups, and cities that provide early-stage test markets. Several examples suggest the potential of this activity.

I. Epic Cleantec

San Francisco-headquartered Epic Cleantec—co-founded by two Israelis and Aaron Tartakovsky—deploys onsite water reuse systems for residential, commercial, and industrial buildings, producing treated water for reuse in non-potable applications such as toilet flushing, irrigation, cooling towers, and laundry. Its technology enables property owners and real estate developers to reuse up to 95 percent of the water used in their structures onsite, reducing utility costs while at the same time improving resilience and sustainability. Its approach includes a resource recovery component that converts wastewater organics into fertilizer and recovers wastewater heat that can be repurposed for the building's internal hot water supply.

The company was developed based on initial work supported by the Bill and Melinda Gates Foundation's "Reinvent the Toilet Challenge," which seeks to provide novel water and wastewater solutions for the roughly 3.5 billion people in the world who lack access to clean water and basic sanitation. That led to the realization that decentralized wastewater solutions that are independent of centralized systems and large wastewater treatment plants have critical applications in developed economies as well. The technology is particularly applicable to new, large residential and commercial buildings and is finding a key market in the real estate development sector.

In 2015, San Francisco mandated onsite water reuse systems in all new construction of buildings of more than 250,000 square feet, and Los Angeles similarly requires that cooling towers in all new buildings over 25 stories use at least 50 percent recycled water. By 2023, California plans to develop a uniform water recycling framework to help cities across the state develop similar programs. Buildings in San Francisco where Epic Cleantec systems are currently operating include the 45-story NEMA tower south of Market Street and the newly constructed Fifteen Fifty apartment tower on South Van Ness Avenue. More high-profile projects are in development throughout California and across the United States, including Park Habitat, a 20-story green office tower planned for downtown San Jose.

II. Coreshell Technologies

Coreshell Technologies, based in Berkeley, has developed a nanotechnology coating for rechargeable batteries, potentially accelerating the transition to electric vehicles and decarbonization in the transport and energy sectors.

To achieve the U.S. Department of Energy's Energy Storage Grand Challenge goal of the \$80/kWh cost for a 300-mile range electric vehicle battery deemed necessary for the mass adoption of electric vehicles, a shift is needed in both the cost and capacity of lithium-ion batteries that in addition to electronic applications are key to the development of clean energy applications such as electric vehicles and grid storage. Limited cost-effectiveness, finite energy density, and limited service lifetime, however, are roadblocks.

Silicon-based anode materials contain over 10 times the capacity of standard graphite materials and would advance this goal, but during normal battery use silicon expands and contracts dramatically, leading to pulverization of the material due to internal stresses, loss of conductivity, and consumption of lithium, causing batteries with even small amounts of silicon to fail rapidly. The introduction of a protective coating at the electrode/electrolyte interface can provide the extra mechanical and chemical stability needed to improve performance, but current technology for applying these coatings uses costly and low-throughput techniques.

Coreshell's innovation is a breakthrough nanofilm electrode coating that is inexpensive to apply and industrially scalable, protecting batteries from degrading during charge and discharge while increasing their performance and safety and at the same time lowering production costs. The company estimates that its technology produces a 30 percent increase in useable battery capacity and increases heat tolerance by 200 percent.

A graduate of the Alchemist Accelerator and the Berkeley Skydeck program, Coreshell counts the National Science Foundation among its investors, has begun a collaboration with BASF, and recently closed its Series A round.

III. Bloom Energy

Founded in 2001 with technology spun off from NASA, Bloom Energy produces solid oxide fuel cells that generate commercial-scale energy on-site. Its technology was originally developed to convert Martian atmospheric gasses to oxygen for life support and propulsion. That led to an electrochemical fuel cell for NASA, developed by the company's founder, capable of producing air and fuel from electricity generated by solar panels.

More than \$1 billion in venture capital was raised before the company went public in 2018. By 2020, Bloom had installed approximately 6,000 megawatts of container-sized fuel cells, selling on-site power from its units to large buildings, manufacturing facilities, and data centers. Less expensive than buying power from the grid, the company's fuel cells also generate less CO₂ than grid-sourced power. With 1,700 employees, Bloom expects to be profitable in 2022 based on 16 percent revenue growth.

IV. CalTestBed: ALD Technical Solutions, Takachar, NeWorld Energy, and Twelve

CalTestBed is a program designed to accelerate California's transition to clean energy by providing the state's entrepreneurs with access to the University of California's (UC) world-class testing facilities at 10 campuses and the Lawrence Berkeley National Laboratory. The program enables them to rigorously test their products, generating scientific data to support later engagement with investors who can help commercialize their innovations. Working with CalTestBed, New Energy Nexus, an international non-profit, conducts statewide solicitations through which cleantech entrepreneurs compete for awards of up to \$300,000 for testing services at one of 60 UC testing sites. Since the program launched in 2020, 40 companies have participated. Funding comes from the California Energy Commission's Electric Program Investment Charge (EPIC) program, which invests in scientific research to accelerate the transformation of the state's electricity sector around climate and energy goals. ALD Technical Solutions, Takachar, NeWorld Energy, and Twelve are examples of innovative cleantech companies advancing with the state of California's support.

ALD Technical Solutions has developed a method for upgrading existing transmission lines, with the potential to double power carrying capacity. If applied to the country's 200,000 miles of high-voltage lines and 5.5 million miles of local distribution lines, it could dramatically increase the availability of renewable energy. The company's technique of wrapping power lines with special composite wires also strengthens transmission systems, adding protection from climate change-induced wildfires and high winds while reducing maintenance costs.

Takachar has developed compact, portable equipment that can convert biomass waste (agricultural waste, culled trees, and trimmed vegetation) onsite into useful products such as biofuels, fertilizers, and commercial chemicals—an alternative to the \$120 billion in crop and forestry residues that are currently burned in the open. Its impact may be to dramatically cut carbon emissions and air pollution while producing beneficial by-products. The system is particularly well suited for small-scale landowners and for difficult terrain where the transportation of biomass is difficult. Takachar participated in Lawrence Berkeley National Laboratory's Cyclotron Road accelerator, which is sponsored by the U.S. Department of Energy.

NeWorld Energy produces an "Energy Quarterback," a compact device that nests under an existing utility smart meter with the capacity to turn home solar systems into residential microgrids during power outages. Typically, when a power grid goes down, home solar systems do as well, so that

even homes with solar don't have power. NeWorld's device automatically isolates solar homes from grids during outages, allowing them to continue drawing power from their panels and storage systems.

Twelve, a company founded by Stanford engineers, has developed a device that transforms CO₂ into valuable precursor chemicals and feedstocks that can be used in a range of applications from jet fuel to sunglasses and car parts. These products are currently made from petroleum coming from the ground, but Twelve's technology enables their production from carbon emissions, helping to moderate global warming. Its devices can be attached to any carbon-emitting industrial source, employing a catalytic process that uses renewable energy and water as the sole inputs.

TAIWAN

Chung-Hua Institution for Economic Research

Kristy Hsu

I. Taiwan Cement Corporation (TCC)

From traditional manufacturer to leader in green transformation

Established in 1954, Taiwan Cement Corporation (TCC) has successfully diversified from a traditional cement producer to an innovation-driven leader through green transformation in response to the company's climate commitments and reaching net-zero by 2050.

TCC's core business adopts three primary carbon-reduction strategies, including the use of low-carbon cement, green energy, and recycling programs. TCC aligns with the Science Based Targets initiative (SBTi) and works with the Global Cement and Concrete Association (GCCA) to deliver carbon-neutral concrete by 2050.³⁷ In August 2022, TCC announced its membership in the Climate Group's EP100 initiative, making it the first large-size manufacturing company in Taiwan and the fourth cement company in the world to pass the verification to become a member of EP100.

TCC moves toward the 2050 net-zero goal through multiple integration, accomplished by improving the process technology, optimizing waste-to-heat power generation, reducing the purchased power, and improving energy efficiency; by promoting a cross-industry circular economy, developing biomass energy and biomass fuels, and reusing waste resources as alternative fuels to reduce waste, carbon, and coal; by investing in carbon capture and microalgae carbon fixation technology R&D development and commercialization models; and by mobilizing renewable energy and smart energy storage to develop new and green energy.

TCC has been actively developing renewable energy businesses, such as wind power, solar, geothermal, and ocean thermal energy conversion (OTEC), while expanding the energy storage, smart grid (microgrid), and high-end battery manufacturing businesses that aim to help reduce carbon and generate healthy profits.

In April 2021, TCC's subsidiaries, TCC Green Energy and E-One Moli Energy (E-Moli), jointly completed and activated Taiwan's first automatic frequency control system (AFC) with energy storage system (ESS) installation capacity of 5MW, benchmarking Taiwan's first large-size energy storage project. Connected to the grid, AFC helps Taiwan Power, the state-owned power provider in Taiwan, expand its ESS power auxiliary services to continue providing stable energy supply.

II. ProLogium Technology

Inspire global battery innovation on solid-state battery technology

Solid-state battery (SSB) systems have been heralded as the most promising next-generation battery technology for electric vehicles. ProLogium Technology, founded in 2006, is an energy innovation company focused on SSB research, development, and manufacturing, providing next-generation battery solutions for electric vehicles in consumer markets and industrial applications. With its automated pilot production line, ProLogium has provided nearly 8,000 SSB sample cells to global car manufacturers for testing and module development.

ProLogium is currently the world's only SSB manufacturer that has reached mass production and continues to inspire global battery innovation toward a fully electric, sustainable future. With its superior oxide technology and SSB technology platform, as well as its innovative SSB packaging model, ProLogium has developed safer, more-innovative technologies that solve the interface challenges of SSB to enable fast battery charging, long battery life, and low-temperature performance. ProLogium refuses to support using conflict minerals and expects each of its suppliers to comply with the Responsible Business Alliance standards, such as only sourcing materials from socially responsible suppliers.

ProLogium also works with established automakers such as Mercedes-Benz to develop next-generation EV battery cells, and Gogoro, a Taiwan-based company for electric motorcycles, to jointly develop the world's first solid-state battery for two-wheel battery swapping.

III. “Green Power for Public Welfare” Initiatives

Demand for green power is increasing in most Taiwanese industrial sectors in order to meet companies' climate commitments and the government's related requirements. In response, a group of NGOs have been working together to provide and turn green power/ green electricity into financial assistance to support other, usually smaller, non-profit organizations (NPOs), while promoting awareness of climate change issues.

In collaboration with Taiwanese companies, a group of NGOs started the “Green Power for Public Welfare” Initiatives to provide green power in the market, while assisting NPOs for public welfare. One successful model involves participating companies—typically larger manufacturing or service sector companies—forming mutually beneficial partnerships with NGOs to install solar panels. This scheme works as follows: NGOs provide solar panels that have been donated to them, and companies provide the surface area, such as an office building or a factory, for NGOs to install the solar panels. In return, the private companies have lower energy costs, and donate sales of green power to smaller NPOs. This win-win design allows participating companies to achieve de-carbonization goals and NPOs to receive long-term operating funding.

UNITED STATES

Information Technology and Innovation Foundation

Grace Sly

I. Enhanced Geothermal Systems: Ormat Technologies

An enhanced geothermal system (EGS) produces carbon-free power by harnessing the earth's heat from deep beneath the ground. An EGS accesses the heat by injecting water at a high pressure from wells on the surface. The water creates fractures in deep rock formations, and the rocks, in

turn, heat up the water. The water is then pumped back up, carrying enough heat to produce steam for power generation. EGS promises to harness the inexhaustible heat of the earth's crust to help power the world.³⁸

While the United States has more geothermal capacity than any other country, the U.S. EGS industry is in its infancy. The American Recovery and Reinvestment Act (2009) included \$350 million for EGS R&D and led to a spike in installed capacity. The Energy Act of 2020 allots \$105 million for EGS demonstrations and \$300 million for the Department of Energy's (DOE) Frontier Observatory for Research in Geothermal Energy in fiscal years 2021 through 2025. The bipartisan Infrastructure Investment and Jobs Act authorizes an additional \$84 million for EGS R&D and deployment (RD&D) in FY22-FY25.

The U.S. Department of Energy has aided the EGS industry by funding a series of demonstration projects, such as Ormat Technologies' Desert Peak 2 geothermal power plant in Nevada. Ormat's air-cooled power plants are located in the Hot Spring Mountains and are known for re-injecting geothermal fluid rather than consuming water when converting energy into electricity.³⁹ Their site was chosen for a collaborative project jointly led by the DOE, Ormat, and GeothermEx due to the existing operational infrastructure, accessible resource database, reasonably well-known geological conditions, and availability of wells.⁴⁰

The DOE contributed \$5.4 million of \$8 million in total funding for a four-year initiative—notably, the first ESG project to be connected to an electricity grid—in order to demonstrate the impact that advanced technologies can have on sub-commercial wells through generating increased power and revenue.⁴¹ By utilizing innovative subsurface technology, R&D teams stimulated an existing sub-commercial injection, thereby increasing the injection rate up to 1,600 gallons per minute without consuming or discharging water at the surface-level and using exiting geothermal brine returned to the original aquifer. Upon completion, the DOE, Ormat Technologies, and GeothermEx reported that an additional 1.7 MW had been produced and the plant and increased power output by 38 percent.⁴²

II. Perovskite Solar Photovoltaic Cells: Hunt Perovskite Technologies

Perovskite is a naturally occurring mineral that can be synthesized from abundant and cheap chemicals, and which has emerged as a promising material for making better solar PV cells.⁴³ Perovskite solar cells can be fine-tuned to absorb different colors of the solar spectrum, converting sunlight to energy with high efficiency.⁴⁴ Manufacturers of this technology place a perovskite layer over a layer of perovskite, silicon, or other PV materials. When paired with silicon—which has an inflexible bandgap—solar cells could reach over 30 percent efficiency. Perovskite solar cells could be a game-changer, offering the tantalizing possibility of more efficient, cheaper solar power.

While perovskite solar cells have yet to reach commercialization in the United States, the DOE has invested \$60 million to advance perovskite solar technologies focused on improving conversion efficiency and stability, addressing challenges with manufacturing perovskite modules, and validating the technology to ensure long-term performance. The Energy Act of 2020 authorizes \$300 million annually for fiscal years 2021 through 2025 to boost solar cell innovation and directs the DOE to explore a range of advanced solar energy technologies.

Several U.S. companies are making significant strides toward producing perovskite solar cells, such as Hunt Perovskite Technologies (HPT) of Dallas, Texas. Launched in 2013, HPT specializes in stable metal halide perovskites with single-junction solar panels for the utility market and has formulated its own efficient perovskite solar cell and ink-based manufacturing process.⁴⁵ The company, which has been heralded as undertaking “some of the most innovative work in the field,” believes perovskites should be as simple and easy to deploy as possible.⁴⁶ Notably, its solar cells have an increased efficiency of 18 percent.

In April 2021, the DOE awarded HPT \$2.5 million as part of the department's Solar Energy Technologies Perovskite Funding Program. In the project, titled “Slot-Die Fabrication of Lead-Safe, Robust, and Stable Metal Halide Perovskite Modules,” HPT was tasked with demonstrating perovskite PV's manufacturability, scaling, durability, and chemical safety by creating efficient and lead-safe solar PV modules using the company's slot-die coating manufacturing process.⁴⁷ HPT will also serve as a co-principal investigator and partner for two additional DOE initiatives: 1) a \$1.5 million award Stanford Linear Accelerator Center (SLAC) National Accelerator Laboratory meant to advance characterization tools that study perovskite and; 2) a \$1.25 million award to the University of North Carolina focused on developing efficient and stable formamidinium-cesium perovskite solar PV products.⁴⁸ In June 2021, HPT merged with Massachusetts-based silicon wafer company 1366 Technologies to form a new enterprise called CubicPV. CubicPV aims to develop and manufacture affordable and durable solar technology.⁴⁹

III. Floating Wind Farms: Aqua Ventus I

While traditional wind turbines are rooted to the ground, a floating wind farm is comprised of an array of sea-based wind turbines on floating platforms.⁵⁰ Each floating platform is tethered to the seabed with mooring lines and anchors that prevent it from drifting off. There are three major types of floating platforms used in demonstration projects: spar-buoys, semi-submersible platforms, and tension-leg platforms. Floating wind turbines can be installed in deep waters where much of the world's wind energy lies.

The Department of Interior's Bureau of Ocean and Energy Management (BOEM) is responsible for managing and permitting offshore wind farms in U.S. federal waters on the outer continental shelf and has recently announced commitments to expand development across the country. The DOE has budgeted an increase in funding for floating wind innovation projects and has established a National Offshore Wind Research and Development consortium to work with states and private companies, while the Advanced Research Projects Agency-Energy (ARPA-E) supports a robust portfolio of floating wind projects as well.

A growing number of states are looking to install floating wind farms. Maine's Ocean Energy Task Force has proposed installing 5 GW of offshore wind capacity by 2030 and emphasized the state's need for floating wind technology. The DOE's Offshore Wind Advanced Demonstration Program is funding the University of Maine's New England Aqua Ventus I, the nation's first floating wind demonstration project, which will begin operating in 2023. Aqua Ventus I will be approximately 12 MW in size and installed in 150 feet of water off the Monhegan Island in the Gulf of Maine.⁵¹ In utilizing concrete semi-submersible platforms, the project can use wind energy to overcome the barriers facing fixed-platform systems in deeper waters. With a focus on creating economic

opportunities, the prototype is expected to create 350 jobs during construction and produce more than \$150 million in total economic output.⁵²

Aqua Ventus uses a platform technology called VoltturnUS. VoltturnUS is a “segmental” concrete semisubmersible based on modular bridge designs. It is the first offshore turbine to deliver power to the U.S. grid system.⁵³ The technology is suited for deep-water deployment and designed to be highly transferable (able to be installed by localities around the country). In addition to Aqua Ventus, the University of Maine has received several grants from the DOE to initiate a series of projects, such as a \$1.4 million award to design and ultra-lightweight concrete floating wind power concept.⁵⁴

CONCLUSION

While the challenges of climate change will require greater international coordination and action beyond innovation, clean energy and sustainability innovations can improve environmental outcomes and make progress toward global climate goals. Together, the GTIPA members’ perspectives presented in this report reveal the great potential of innovation, especially in cleantech. Moreover, the ideas offer an exciting path forward for international governments, private companies, and startups to address climate change.

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