ASIA SOCIETY POLICY INSTITUTE

SUMMARY REPORT

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NET-ZERO GHG EMISSIONS IN KOREA:

EU and United States study tour of Korea's Young Leaders in Climate and Energy Policy

EXECUTIVE SUMMARY

Korea is committed to playing a key role in international climate action through its 2050 net-zero greenhouse gas (GHG) emissions target and a 40 percent reduction in GHG emissions by 2030 compared with 2018. This will require a huge transformation toward a carbon-neutral energy mix, decarbonized industrial sector, electric vehicles, and zero emissions buildings, supported by effective climate financing.

The Asia Society Policy Institute, with the generous support of the Korea Foundation, organized a study tour to the EU and the United States in which eight Korean young leaders in climate and energy policy participated in meetings and networking events. The project was aimed at equipping participants with knowledge, networks, and inspiration to help develop and implement the required policies, plans, and technologies to put Korea on the pathway to achieve the net-zero 2050 GHG emissions target including ambitious 2030 GHG emissions reduction targets.

The key learning points from the study tour that can support Korea in achieving its 2050 net-zero GHG emissions target and ambitious 2030 GHG emissions reduction target can be summarized as follows:

Power Sector

Korea's **power sector** needs to rapidly reduce the share of coal-fired power generation and increase the share of renewables, while ensuring reliability of electricity supplies despite the intermittency of renewables. In the EU, this is the sector where emissions decreased a great deal under the EU Emissions Trading System (ETS) and where the biggest change will be seen by 2030. This rebalancing is also regarded as relatively easy to implement in the United States and was California's first climate action priority, where coal-fired generation was phased out through the Renewables Portfolio Standard (RPS). Furthermore, the requirement for greater electrification to achieve net-zero GHG emissions makes decarbonizing the power sector critical to enable other sectors to decarbonize as well.

For renewables, the EU has developed a comprehensive and practical policy framework to achieve its ambitious 2030 target of 45 percent. Substantial progress in deploying wind and solar power in the EU and United States provides many implementation lessons regarding overcoming permitting barriers and managing intermittency. The comprehensive funding programs for new clean energy technologies in both jurisdictions including green hydrogen will also be important takeaways. Overall, learning points to consider for Korea's power sector include the following:

- **Develop the Korean emissions trading system (K-ETS) cap** to be consistent with declining carbon budgets **to achieve the revised national GHG emissions reduction target of 40 percent by 2030.** This will ensure the K-ETS plays a key role in Korea's net-zero pathway and will increase the carbon price, leading to much more low-carbon action. The EU experience shows that a clear methodology, transparent modeling, evidence-based impact assessment, and stakeholder consultation enabled the agreement of an ambitious ETS cap.

- **Introduce full auctioning for the power sector in the K-ETS**, in combination with implementation of the "Environmental Merit Order" which will include carbon costs in the ranking for dispatching power

Cover Photo: Offshore wind turbines in Jeju Island (Shutterstock)


Solar panels in Dangjin-si (Shutterstock)

stations, and removal of limits on cost pass-through to retail electricity prices. This will strengthen the K-ETS carbon price signal, encourage a change in power station dispatch decisions away from coal, and facilitate reductions in electricity consumption.

- **Establish an effective fund to support investment in key technologies to achieve carbon neutrality**, sourced by K-ETS auction revenue and supported by the above actions. The design and implementation of the fund should benefit from experiences in the EU and the United States, such as the EU's Innovation Fund, EU Member States' funds sourced by EU ETS auction revenue, the U.S. Department of Energy (DoE) Loans Program, and others and should include mechanisms to improve the viability of projects, such as carbon contracts for difference (CCfD). Such a fund can be targeted toward strategic decarbonization priorities in K-ETS sectors, alleviating higher energy costs to vulnerable households and industrial sectors (caused by the above actions), and addressing other social purposes as appropriate.

- **Increase targets under Korea's Renewables Portfolio Standard** to achieve ambitious levels of renewable energy in total power generation in line with Korea's net-zero pathway. Support this with measures to address key barriers in implementing renewables projects including permitting, learning from the recent EU policies under the REPowerEU plan, and developing best practice guidance on how to get projects permitted.

- In conjunction with the above, **ensure an effective approach for managing intermittency of renewable generation.** On the supply side, wind and solar are complementary and should be developed together; electricity networks will need to be redesigned, and energy storage solutions will need detailed consideration including for green hydrogen. Meanwhile, the demand side will require load shifting to move electricity consumption from one time period to another. Germany is an example of good practice in managing these issues while having a relatively high share of renewables (more than 40 percent). The analysis of intermittency challenges and solutions can be achieved with models such as Enertile.

- **Consider special financial mechanisms to facilitate the smooth phaseout of coal** including greater attention to affected stakeholders and reduced political resistance, for example, with coal securitization bonds supported globally by the Coal Asset Transition Accelerator (CATA).

- **Ensure the acceleration of green hydrogen uptake in Korea,** as a key clean energy source for hard-to-abate industry sectors and backup to handling intermittency of renewable power, taking into account best practice in funding programs, research, and implementation in the EU and the United States. Green hydrogen in Korea should leverage available energy resources including nuclear and, in the future, offshore wind.

Industry Sector

Korea's energy-intensive **industry sector** will need to invest in large-scale and expensive decarbonization technologies such as hydrogen-based steelmaking, electrically heated petrochemical steam cracker furnaces, carbon capture utilization and storage in the cement sector, and many others to achieve net-zero. Furthermore, substantial amounts of renewable energy will be required.

The EU is taking significant steps toward achieving net-zero in the industrial sector. Key drivers include the EU's long-term net-zero targets, the increasing carbon price under the

EU ETS, and the availability of funds to support investment including those sourced from the EU ETS, in addition to corporate sustainability incentives. Examples of best practices were also found in major technology companies, driven by ambitious corporate net-zero and 100 percent renewable targets. Overall, learning points to consider for Korea's industrial sector include the following:

- **Develop the K-ETS cap in line with the revised GHG emissions reduction target of 40 percent by 2030, introduce full auctioning for the power sector, and establish an effective fund sourced by the auction revenue to support investment in key technologies to achieve carbon neutrality**, as mentioned above for the power sector.
- **Implement further revisions to the K-ETS to support industry sector decarbonization** including (1) further reducing surplus allocation (by making GHG emissions benchmark levels more ambitious such as those in California and the EU, in addition to the previously mentioned action to tighten the cap); (2) improving market predictability and transparency (by introducing rule-based controls learning from California's Allowance Price Containment Reserve and associated price tiers and ceiling); and (3) improving liquidity (by including more third-party financial organizations).
- **Ensure that as the K-ETS cap tightens and levels of free allocation reduce, the most GHG emissions-efficient industrial companies are protected from the risk of carbon leakage** by a regular review of the free allocation policy and potential alternatives such as a carbon border adjustment mechanism.

Transport Sector

For the **transport sector**, which is so far proving difficult to abate even in the EU, the path forward is a package of policies aimed at both existing and new vehicles, which combines incentives as well as regulations. In addition to promoting electric vehicles (EVs), they should also discourage use of fossil fuel vehicles. Overall, learning points to consider for Korea's transport sector include the following:

EV charging station in Gyeonggi-do (Shutterstock)

- **Introduce mandatory requirements for all new vehicles to be zero-emission,** with separate dates for light duty vehicles (LDVs; cars and vans) and heavy duty vehicles (HDVs; trucks and buses), taking into account experiences in the EU, California, and elsewhere. An ambitious timescale would provide a further incentive for Korea's car manufacturers to accelerate their development of EVs and gain corresponding commercial benefits.
- **Ensure Korea's GHG and fuel economy standards are consistent with achieving the 40 percent GHG emissions reduction target by 2030,** and encourage the shift toward EVs, including assessing targets against EU's forthcoming Euro 7 standard as well as standards in the United States.
- **Consider additional measures to specifically address emissions from existing road vehicles and maritime vessels,** for example, developing Korea's Renewables Fuel Standard into a Low Carbon Fuel Standard (LCFS) similar to that in California; include transport fuel suppliers (and the associated emissions) in the K-ETS; and reduce the emissions thresholds for inclusion in the K-ETS for the transport sector enabling large maritime vessels to be included.

Building Sector

The **building sector** is also proving difficult to decarbonize in the EU and the United States, with the main challenge being existing buildings. However, Korea's relatively high turnover of buildings should make it an easier sector to address. The EU's proposed revision to the Energy Performance of Buildings Directive to achieve a decarbonized building stock by 2050 should be a valuable reference, including requirements for nearly zero-emissions buildings, energy performance standards, renovation requirements, and modernization requirements including energy system integration. Overall, learning points to consider for Korea's buildings sector include the following:

- **Ensure policies are in place requiring that all newly constructed buildings will be nearly net-zero emissions.**
- **Implement sufficiently ambitious energy performance standards for existing buildings** combined with long-term renovation strategies, taking into account details of the proposed revision to the EU's Energy Performance of Buildings Directive.
- **Ensure sufficiently ambitious standards for energy performance of appliances are in place** reflecting best practice in the EU and California.

Overall, the study tour not only provided concrete best practices that can be adapted to Korea's local circumstances but also highlighted the challenges that Korea will need to address to meet its ambitious climate goals.

PROJECT DETAILS

The EU and the United States are gaining valuable experience in developing policies, plans, and technologies to achieve net-zero GHG emissions.

A study tour by Korea's young leaders in climate and energy policy met leading experts in the EU and the United States in May 2022 to learn about this experience and shared this with a wider group of stakeholders to help Korea develop its own effective policies and plans to achieve these targets.

The study tour took place over eight days in May 2022 in Brussels, Washington, D.C., and California (San Francisco, Sacramento, and Silicon Valley); the tour participants met with leading EU and U.S. climate and energy policy,

Solar panels installed on existing buildings in Cheongju (Shutterstock)

technology, sectoral, and other experts, including staff from the following organizations:

- **POLICYMAKERS:** European Commission DG Climate Action (EU ETS Policy Coordination and International Carbon Markets), U.S. Department of State (Office of Global Change), U.S. EPA (International Environmental Program), U.S. Climate Alliance, California Air Resources Board and California Energy Commission;
- **SECTORAL ORGANIZATIONS AND CORPORATIONS:** European Chemical Industry Council (Cefic), European Cement Association (Cembureau), European Association for Electromobility (AVERE), U.S. Green Building Council, Google, Amazon, and Apple.
- **TECHNOLOGY AND CLIMATE FINANCE:** Wind Europe, Hydrogen Europe, Gas Infrastructure Europe, Fluxys, LEILAC Group, U.S. Department of Energy (Hydrogen and Fuel Cell Technologies Office and Loan Programs Office), Business Council on Sustainable Energy, American Clean Power Association, Solar Energy Industries Association, Center for Energy Efficiency and Renewable Technologies (CEERT), and TeraWatt Infrastructure.
- **ADVISORS ON POLICY, SECTORAL STRATEGIES AND TECHNOLOGIES:** European University Institute (School of Transnational Governance), Fraunhofer ISI, Center for Climate and Energy Solutions, Natural

Resources Defense Council, Resources for the Future, Center for American Progress, World Resources Institute, Rocky Mountain Institute, and USG Schwarzenegger Institute.

The learning was shared to a broader group of Korean stakeholders in an online workshop in July 2022.

Participants represented leading stakeholders in Korea's climate and energy policy including the Greenhouse Gas Inventory and Research Center of Korea (GIR), Korea Energy Economics Institute (KEEI), Green Climate Fund (GCF), Climate Change Center (CCC), Green Environment Youth Korea (GEYK), BigWave, KIA Corporation, Korea Investment and Security, Ecoeye, and Korea University.

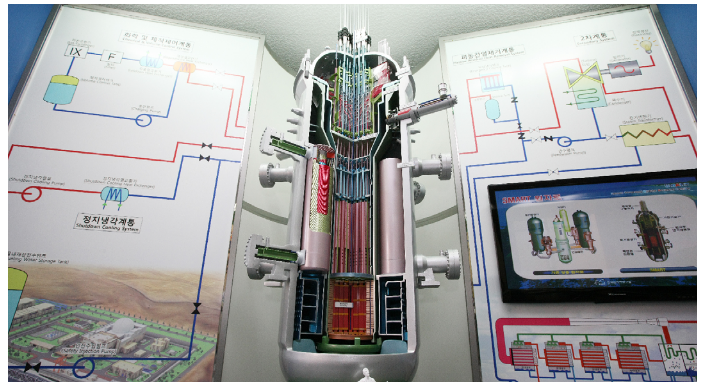
This document presents a summary of the learning points from the study tour.

CLIMATE POLICY BACKGROUND

Korea

Korea's commitment to achieve net-zero GHG emissions by 2050 was legally established in 2021 in the Framework Act on Carbon Neutrality and Green Growth for Climate Change (the Carbon Neutrality Act), with its Enforcement Decree effective beginning in 2022. The Carbon Neutrality Act stipulates that South Korea's Nationally Determined Contribution (NDC) is a reduction in GHG emissions of 40 percent from 2018 levels by 2030, a significant improvement compared with a previous reduction target of 26.3 percent.

A major initiative to support achievement of the 2050 net-zero goal and the 2030 NDC is Korea's Green New Deal, with planned government funding of approximately 60 trillion won (~$50 billion). This is to support the transition to a low-carbon economy including green transition of infrastructure (e.g., zero-energy public buildings), low-carbon and decentralized energy supply (smart grid, promotion of renewable energy use, and expanded supply of electric and hydrogen vehicles), innovation in green industry (establishing low-carbon and green industrial complexes and support for green innovation through R&D and financial sectors), and a carbon reduction program for industries.



Small modular nuclear reactor (Korea Atomic Energy Research Institute)

Under Korea's new administration beginning in 2022 and led by President Yoon Seok-youl, five policy directions for carbon neutrality have been announced:

1) Build a reasonable carbon-neutral energy mix on the basis of harmonizing the proportion of renewable energy and nuclear power generation.

2) Promote the optimization of the research and development system for the cross-century development of green technologies and create new growth drivers that are carbon neutral including the integration of small modular nuclear reactors.

3) Promote green finance through measures such as expanding participation in the third-party market in the K-ETS, connecting Environmental, Social and Governance (ESG) operations, and improving the tax system.

4) Strengthen the "climate and energy alliance" and the global cooperation system with the United States and other major countries.

5) Restructure the governance architecture for carbon neutrality and green growth.

EU

The EU is demonstrating strong leadership for climate action including through President Ursula von der Leyen's focus on implementing the European Green Deal,[1] with a legally binding target of net-zero GHG emissions by 2050 and a challenging GHG emissions reduction target for 2030 of 55 percent compared with 1990 levels (previously 40 percent) under the "Fit for 55" package.[2] Reductions so far amount to only 25 percent, so significant further reductions will be needed. Despite the impacts of the war in Ukraine on energy supplies, the EU plans to stick to this target. In fact, to promote energy security the EU further increased its 2030 renewables target to 45 percent (previously 40 percent) as a part of the REPowerEU plan. [3,i] The EU's entire climate policy will need to be reconstructed to meet the more ambitious targets under the Fit for 55 package.

Climate policy development in the EU is especially impressive given the difficulty in getting agreement across 27 Member States, with large differences in economic performance, emissions profiles, and energy systems.

The EU benefits from a significant amount of financing to help deliver its climate targets. The EU's overall budget commits to spending at least 30 percent on climate action, a target that rises to 37 percent when it comes to the €800 billion recovery fund from the Covid-19 crisis. Furthermore, no spending from the EU budget can go against the objective of the Green Deal. The challenge for climate action in the EU is not money but good governance and good projects.

U.S.

Under the Biden administration, the United States also has a 2050 net-zero GHG emissions target and an ambitious 2030 GHG emissions reduction target of 50 - 52 percent compared with 2005 levels. The United States takes a whole-of-government approach to addressing climate change with new rule making covering power sector emissions, methane emissions regulations, vehicle emissions standards, energy efficiency standards, and climate-related financial risk disclosure. Furthermore, federal procurement will aim to attain carbon neutral electricity and zero-emissions vehicles by 2035.

Many states are playing a key role in climate and energy policies and will continue to lead on electricity portfolio standards (clean/renewable energy standards), low-carbon fuel standards, and carbon pricing (Emissions Trading Systems). The U.S. Climate Alliance plays a key role in covering 24 states, more than half of the U.S. economy, and more than 40 percent of U.S. emissions. Alliance States commit to reduce GHG emissions by at least 26 - 28 percent by 2025 and 50 - 52 percent by 2030 and achieve net-zero as soon as practicable, no later than 2050.

Reaching the 2030 target will require the federal government to take a whole-of-government approach; states continuing with ambitious actions; and businesses making net-zero commitments, investing in new products and services, and purchasing clean energy. However, a key precondition to make sure the United States is on track to meet its 2030 targets is for the Build Back Better [ii] or similar legislation to be passed, which will be a driver of the speed at which the United States can invest in reducing GHG emissions from the power sector.

California

Within the United States, California is good source of best practice in climate policymaking partly as a result of its ability to develop more stringent emissions standards than federal standards due to the state's poor air quality. Other states can copy California's lead, which makes the California Air Resources Board an important agency.

California's 2022 Scoping Plan [4] will be a major milestone, laying out how the state can get to carbon neutrality by 2045 and reduce GHG emissions by 40 percent below 1990 levels by 2030. Like the EU, California adopts a systematic, transparent, and consultative impact assessment approach to policymaking. In developing the plan, four alternative scenarios for carbon neutrality were considered,[iii] as well as a

i The REPowerEU Plan would bring total EU renewable energy generation capacity to 1,236 GW by 2030, in comparison with 1,067 GW by 2030 envisaged under Fit for 55. As part of this plan, the EU Solar Energy Strategy will boost the rollout of photovoltaic energy, aiming to bring online more than 320 GW of solar photovoltaic capacity by 2025, more than twice today's level, and almost 600 GW by 2030.

ii The Build Back Better framework would provide $555 billion for clean energy and climate investments including $320 billion for clean energy tax credits; $105 billion for resilience investments; $110 billion for investments and incentives for clean energy technology, manufacturing, and supply chains; and $20 billion for procurement in new clean energy technologies.

iii (1) Carbon neutrality by 2035, nearly complete phaseout of all combustion, limited reliance on carbon capture and sequestration and engineered carbon removal, restricted applications for biomass derived fuels; (2) carbon neutrality by 2035 and aggressive deployment of a full suite of technology and energy options, including engineered carbon removal; (3) (Proposed Scenario) carbon neutrality by 2045, deploy a broad portfolio of existing and emerging fossil fuel alternatives and clean technologies, and align with statutes and Executive Orders; and (4) carbon neutrality by 2045, deployment of a broad portfolio of existing and emerging fossil fuel alternatives, slower deployment and adoption rates than the Proposed Scenario, and a higher reliance on CO_2 removal.

number of key metrics assessed for each. [iv]

Stakeholders have demonstrated much resistance to California's policies including the Low Carbon Fuels Standard and the Cap-and-Trade Program by initiating lawsuits; however, experiencing climate change on a personal level, such as wildfires and droughts, made people realize they had to do something. Furthermore, the Cap-and-Trade Program gained support because it was the least expensive policy option with a high probability of achieving the GHG emissions reduction targets. The first priority for California's climate policy was phasing out coal through the Renewables Portfolio Standard (RPS), which sets continually escalating renewable energy procurement requirements. A key lesson from California is the need to build very broad support through coalitions, including businesses.

EMISSIONS TRADING SYSTEMS

Under the Fit for 55 package, the EU ETS is subject to a number of proposed revisions. The most significant relates to **cap setting**, with a proposed 61 percent reduction (currently 43 percent) in the EU ETS cap by 2030 from a 2005 baseline. Interestingly, this was not a major issue in negotiations due to its clear methodology,[v] transparent modeling,[vi] evidence-based impact assessment, and stakeholder consultation. The expected scarcity of allowances created by such a tight cap has already seen EU ETS carbon prices increase to between €60 and €100/t CO_2e. In the California Cap-and-Trade Program,[5] the cap already extends to 2050 in the regulations; it may be revised following the 2022 Scoping Plan, which would be an 18-month process including development of concepts and proposals, workshops, consultation, impact assessments, hearings, and so on.

Free allocation to protect against carbon leakage is provided in line with ambitious GHG emissions intensity **benchmarks** in the EU ETS equivalent to the average of the top decile performance,[vii] although it will gradually be replaced by auctioning under the proposed **Carbon Border Adjustment Mechanism (CBAM)**[viii] for sectors covered by the CBAM. The proposed CBAM will put a carbon price on imports to the EU of a targeted selection of goods beginning in 2026 with the aim of ensuring that ambitious climate action in the EU does not lead to carbon leakage. The initial industrial CBAM sectors are iron and steel, cement, fertilizers, and aluminum, which represent around 50 percent of the total current free allocation. The scope is expected to expand in the future with some strong support to also include chemicals in the initial phase. In California, benchmarks are equivalent to 10 percent below average performance.[ix] In comparison, K-ETS benchmarks, based on average performance, are less ambitious than those in the EU and California.

Under the EU ETS, protection against carbon leakage also applies to the impact of higher electricity prices on the electro-intensive industry through a compensation mechanism.

A key feature of the EU ETS is the high level of **auctioning**, representing approximately 57 percent of allowances. There is no free allocation to the power sector and decreasing levels of free allocation for industrial sectors due to the ambitious and tightening benchmarks, with auctioning being the alternative allocation method. The EU ETS has gained much support from the significant value of **auction revenue** generated—nearly €120 billion from 2013 to 2021,[x] which is mainly used to support climate action projects including financing the transition to net-zero. This funding goes to a diverse range of beneficiaries, many of which are outside the ETS sectors. The EU proposes that the entirety of revenues from auctioning

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[iv] Key metrics include annual build rates of solar and battery storage, vehicle early retirements, residential early retirements, hydrogen demand and electrolysis need, petroleum-refining capacity remaining, total carbon capture and storage (CCS) needs and residual emissions.

[v] Based on equal cost-effectiveness for ETS and non-ETS sectors.

[vi] Member States discuss the model and provide input.

[vii] Under the proposed revisions, the maximum annual reduction rate of the benchmarks will be increased to 2.5 percent (currently 1.6 percent) to shift more free allocation to sectors that are harder to decarbonize. The scope of benchmarks will also broaden to remove barriers for the deployment of new technologies such as green hydrogen or hydrogen-based steel.

[viii] Free allocation will be reduced by 10 percentage points each year for CBAM sectors, starting at 90 percent in 2026 and reaching zero in 2035.

[ix] If no plant achieves that level, it is set at the best-in-class level.

[x] Including €16 billion in 2019, €22 billion in 2020, and €38 billion in 2021.

should be used for climate and energy (including societal programs) purposes. California has a similar auction revenue recycling system — California Climate Investments. So far, more than $18 billon has been generated for low-carbon action projects across various sectors and to support disadvantaged communities.

The EU ETS is also the source of funding for the EU's **Innovation Fund**,[6] which will provide tens of billions of euros from 2020 to 2030 (from revenues from auctioning 650 million EU ETS allowances) for the commercial demonstration of innovative low-carbon technologies in energy-intensive industries,[xi] aiming to bring to the market industrial solutions to decarbonize Europe and support its transition to climate neutrality. The Innovation Fund is implemented through calls for large- and small-scale projects. Carbon contracts for difference (CCfD)[xii] will be supported under the Innovation Fund — a tool to provide support for the early deployment of innovative technologies and to complement the existing funding mechanisms in the Innovation Fund. In addition to EU-wide funding schemes, there are various additional schemes at the national level.[xiii]

Both the EU and Californian systems have rule-based **market stability measures** to manage the carbon price. The EU's Market Stability Reserve (MSR) is dealing with historical allocation surpluses and is subject to further revision. California's Allowance Price Containment Reserve system manages low prices with an auction reserve price and high prices with three price control levels; when reached, these levels cause allowances to be released from the reserve, including tier one (halfway between auction reserve price and price ceiling), tier two (three-quarters of the way), and the price ceiling[xiv] ($72/t in 2022). All price levels escalate at five percent plus inflation each year. This system allows covered entities to hedge against dramatic increases in the price of allowances and helps ensure that program administrators do not need to decide that market conditions require an intervention. In comparison to programs in California and the EU, the K-ETS does not yet have this type of rule-based system.

Liquidity in the carbon market is achieved by third-party participants (particularly financial organizations) in the EU and California[xv] with higher levels than those currently in Korea. Controls on these organizations include registration requirements, purchase and holding limits, and pivotal supplier tests,[xvi] with market monitoring teams undertaking surveillance.

The **scope** of the EU system is proposed to expand to include the **maritime sector**, following implementation of monitoring, reporting, and verification in recent years. Furthermore, to address the difficulty in reducing emissions, the EU's **building and road transport sectors** (where emissions have actually been increasing), the EU is proposing a separate upstream ETS applying to energy suppliers. There will be full auctioning due to no carbon leakage risk as costs can be passed through to prices, and 25 percent of revenues will go to a Social Climate Fund to address the social impacts of this policy on vulnerable groups. The California Cap-and-Trade Program also applies to transport fuel suppliers.

ENERGY AND POWER SECTOR

The power sector in the EU will be a very small contributor to GHG emissions by 2030. Emissions have come down a great deal under the EU ETS with this sector seeing the biggest

xi Including products substituting carbon-intensive ones, carbon capture and utilization (CCU), carbon capture and storage (CCS), innovative renewable energy generation, and energy storage.

xii Under a carbon contract for difference, if the actual carbon price is lower than the contracted price, the government compensates for the difference; if the price is higher, the company pays the difference to the government.

xiii In Germany, for example, support for energy transition and climate change mitigation is also provided by SpinD (agency for breakthrough investments), the Environmental Innovation Program, and the Program for Industrial Decarbonization. As these generally focus on support for capital costs, a new funding scheme is being developed, CCfD for Industry Support, targeting steel, cement, lime, and ammonia sectors, which would provide support for operating costs.

xiv If all allowances in the reserve tiers and price ceiling are exhausted, the government purchases an equal or greater amount of reductions that meet offset criteria, using revenue from the auction to protect the environmental integrity of the system. Factors considered when setting the price ceiling include the need to avoid adverse impacts on residential households, businesses, and the state's economy; the full social cost associated with emitting GHGs; the cost of GHG emissions reductions to achieve the emissions targets; the potential for environmental and economic leakage; previous performance; etc.

xv California has a market with 700 to 800 participants of which 10 to 20 percent are financial organizations (banks, security companies, etc.).

xvi Could any entity hold enough allowances to force a price change?

change up to 2030. In the United States, the power sector is also seen as having the most potential for abatement by 2030.

The average share of renewables in the EU and the United States is currently around 20 percent, compared with only approximately six percent in Korea. A massive buildup of renewable energy is taking place in the EU, with a big driver being demand from EU industry.

The priority for the United States will be phasing out coal as soon as possible, ideally by 2030, and minimizing the extent to which it is replaced by natural gas (unless fitted with carbon capture), combined with significant expansion in wind, solar, and batteries. Within the United States, California currently has nearly 50 percent renewables, with a target of 60 percent by 2030 and 100 percent by 2045.

With the expansion of renewables, the economics of coal get increasingly negative due to low running hours, thus further promoting renewables.

Policies

Key energy policies in the EU include the **Energy Efficiency Directive**,[7] which sets rules and obligations for achieving the EU's 2030 energy efficiency targets including the "energy efficiency first" principle, and the **Renewable Energy Directive**,[8] which is the legal framework for the developing renewable energy, removing barriers, stimulating investments, and driving cost reductions in renewable energy technologies.

In the EU, the main problem limiting uptake of renewable energy is not cost (the financial sector favors it), technology, or supply chain. It is **permitting**—which is too cumbersome, complex, and paper based. A web of legislation that protects biodiversity slows projects down. Under the REPowerEU plan, a Commission Recommendation[9] will tackle slow and complex permitting for major renewable projects, and an amendment to the Renewable Energy Directive[10] will recognize renewable energy as an overriding public interest. Member States will put in place dedicated "go-to" areas for renewables with shortened and simplified permitting processes in locations with lower environmental risks. In the United States, permitting is also a challenge, particularly understanding where you can build, which delays projects. A key requirement is ensuring consistent and predictable permitting rules.

Getting a renewables project "over the line" is usually a question of the effectiveness of the project developer. In the EU, industry-wide principles have been developed to support successful wind projects, focusing on how to engage with communities,[xvii] with compensation being part of this conversation. Some stakeholders, for example, the fishing community, have fears about what they do not know.

A cost-effective way of deploying wind is through c**ontracts for difference (CfD)**.[xviii] CfDs ensure that generators receive a fixed, pre-agreed-upon price for the electricity they produce, known as the "strike price."[xix]

The U.S. clean energy policy for the past 30 years has focused on tax credits, in line with political viability, which have provided powerful incentives for wind and solar and helped the industry get started. However, they are regarded as less effective than renewable energy mandates.

Key recent legislation includes the **Bipartisan Infrastructure Law**, which will promote the new technologies needed for the next five to 20 years. More than $65 billion has been allocated for investment in clean energy transmission and the electric grid: to upgrade power infrastructure to facilitate the expansion of renewable energy; to promote smart grid technologies that deliver flexibility and resilience; and to invest in demonstration projects and research hubs for next generation technologies like advanced nuclear reactors, carbon capture, and clean hydrogen.

A significant source of financial support for clean energy investment in the United States is the **U.S. Loan Programs Office (LPO)**, under the Department of Energy (DoE). This provides debt financing in the form of loans for large clean energy and decarbonization projects to support GHG mitigation goals including energy storage, advanced

xvii Including engaging early, communicating often, being flexible, and being good at telling the story.

xviii With CfD, the cost could be €50/MWh; without it, the price could be more than €90/MWh.

xix When the market price is below the strike price, they will receive a top-up payment from the government to the level of the strike price. Conversely, if the market price is above the strike price, the generator must pay back the difference.

nuclear, biofuels, transmission infrastructure, offshore wind, solar, and so on. It focuses on new and innovative technologies that other banks do not finance due to some risks to deployment and serves as a bridge to bankability for breakthrough projects and technologies. The LPO has more than $40 billion in loans and loan guarantees available; over the past decade, it has closed deals worth more than $30 billion. The LPO works to make projects successful, adopting commercial lending standards, with a relatively low loss rate and getting DoE to assist companies regarding technology deployment. Strong growth opportunities exist for partnership with Korean companies in the battery, nuclear, and vehicle sectors.

Hydrogen production facility with storage tank (Shutterstock)

Green hydrogen, produced from renewable energy, will play a key role in the transition to net-zero but is expensive and should be applied in carefully selected sectors and applications. Some key elements of the EU's support for green hydrogen include the following:

- The EU's Hydrogen Strategy,[11] adopted in 2020, puts forward a vision for the creation of a European hydrogen ecosystem from research and innovation to scale up production and infrastructure to an international dimension, to help decarbonize the EU economy in a cost-effective way. Twenty action points[12] followed.
- The "Hydrogen Accelerator" aims to scale up the deployment of green hydrogen, with plans to produce 10 million tonnes and import 10 million tonnes into the EU by 2030, when 50 percent of hydrogen should be green.
- Several research and innovation projects on hydrogen are under the Horizon Europe funding program including the Clean Hydrogen Partnership,[13] with €1 billion to spend in seven years on approximately 300 innovative projects, with a big focus on "hydrogen valleys" that create integrated hydrogen ecosystems.
- The initiative "Important Projects of Common European Interest — Hydrogen" (IPCEI) is supporting a cleaner hydrogen value chain from renewable and low-carbon hydrogen production; to hydrogen storage, transmission, and distribution; and hydrogen application notably in industrial sectors.
- To facilitate the integration of hydrogen in the EU's existing gas network, the EU developed the Hydrogen and Decarbonized Gas Market Package.[14]
- Under the REPowerEU plan, the EU will roll out carbon contracts for difference to support the uptake of green hydrogen by industry and specific financing under the Innovation Fund, using EU ETS revenues to further support the switch away from Russian fossil fuel dependencies.

The United States is also placing a significant emphasis on support for green hydrogen and its associated infrastructure. In particular, H2@Scale[15] is a U.S. Department of Energy initiative that brings together stakeholders to advance affordable hydrogen production, transport, storage, and utilization to enable decarbonization and revenue opportunities across multiple sectors. Under the Bipartisan Infrastructure Law, $9.5 billion is available to support green hydrogen projects, including hydrogen hubs and valleys.

An important policy to support the clean energy transition relates to **coal phaseout**. There is the potential for huge political resistance if excessive costs fall on energy consumers and communities, with those least able to pay likely to be hit the hardest. Intelligent policy intervention is needed to avoid this, for example, by refinancing coal assets with a rate-payer-backed securitization bond to significantly reduce the near-term burden including providing transitional assistance to communities. This approach is increasingly being applied in the United States, and the principles are generalizable to most countries internationally. To support implementation of this type of coal securitization mechanism, the Coal Asset Transition Accelerator (CATA)[xx] has been launched, a first-of-its-kind platform that will use finance to accelerate the coal transition globally.

Technologies

In Europe, **wind energy** is set to become the dominant source of electricity shortly after 2025. It currently provides approximately 15 percent of electricity (12 percent onshore, 3 percent offshore), with capacity projected to grow from 28 GW to 150 GW by 2050 when it is estimated to provide 50 percent of the EU's electricity (two-thirds onshore, one-third offshore). WindEurope claims the sector provides 300,000 jobs today, with a projection of 450,000 by 2030. It estimates one turbine provides €10 million to the EU economy. Key trends in the EU wind sector include scaling up offshore (increasing the size of turbines and wind farms), industrializing floating offshore wind (one-third of offshore by 2050 is projected to be floating), encouraging society to embrace wind by reducing impacts on communities and biodiversity and repowering onshore wind.

Solar is the least expensive way to produce electricity in the EU. Most panels are currently from China, although the next generation of solar panels in the EU will be domestically produced.

Both wind (more in winter and evenings) and solar (more in summer and in the middle of day) are needed, as they are complementary and provide a daily and annual balance.

High levels of renewables require rethinking **electricity market organization** and the grid to provide sufficient balancing to address the **intermittency** of wind and solar. The EU has a network development plan[16] with a vision to 2050 of what the system will look like. Germany is a leader in achieving this balancing with a high share of renewables (currently 41 percent with a target of 65 percent by 2030). Flexibility enablers are needed that include load shifting to move electricity consumption from one time period to another in line with availability, supported by pricing electricity differently at different times, battery storage, and use of hydrogen to provide back-up energy. The Enertile model[17] is a leading European software package for the analysis of such challenges.

Views on the role of nuclear energy vary among EU Member State. Many do not rule out new nuclear plants, some (e.g., Belgium) plan to extend the life of old nuclear plants, while others (e.g., Germany) are not going for nuclear power at all. Advanced nuclear power use is receiving a lot of funding support in the United States, including funding for the first new nuclear reactor in 30 years.

Green hydrogen will play an important role in decarbonizing hard-to-abate industry sectors (e.g., steel, cement, glass, and ceramics) and heavy duty vehicles (HDVs) and providing backup energy for the electricity grid, addressing intermittency of wind and solar. Details of the first large-scale power to gas installation in Belgium ("HyOff Wind") were presented whereby hydrogen is produced by alkaline hydrolysis using offshore wind electricity and transported by tube trailers and injected into the gas grid for use by transport operators.

The costs of producing green hydrogen in Europe by 2030 are estimated to be around €3/kg compared with approximately €1.5/kg for gray hydrogen (derived from natural gas and produced from fossil fuels). However, the relative economics are changing in favor of green hydrogen due to higher natural gas prices. In the United States, the goal is to bring down the cost of producing green hydrogen to $1/kg, excluding costs for storage and distribution. The main cost is the clean electricity cost.

Green hydrogen should leverage available resources including nuclear, wind, solar, and hydropower. In Korea, this could include nuclear and new offshore wind.

Existing gas distribution infrastructure can be used for hydrogen. Two main options for pipelines include repurposing for 100 percent hydrogen[xxi] and retrofitting where a relatively small quantity of hydrogen (up to the range of five percent to 20 percent) is blended with natural gas, a very cost-effective transitional solution.

[xx] CATA aims to ensure the successful navigation of the rapid, equitable, and managed transition away from coal through analyses, expertise, and a suite of tools and resources.

[xxi] Repurposing has 80 percent lower costs compared to building new pipelines.

INDUSTRY SECTOR

Industry sector GHG emissions reductions in the EU will mainly take place after 2030. Progress is relatively slow with the focus currently on installing equipment.

Policies

Policy ambition and certainty are key to getting industry to act. In the EU, the main policy addressing industrial sector GHG emissions is the **EU ETS**, as described earlier. The visibility of the EU ETS cap to 2030 in combination with the EU's 2050 net-zero GHG emissions target have created a clear drive for industry to develop and start to implement net-zero strategies. This is closely combined with the financial support available to help industry invest in decarbonization technology through the use of EU ETS **auction revenue** and the **Innovation Fund**, also described previously, as well as other sources of funding at a national level.

Climate change and energy policies for industry sectors fit within a wide and complex landscape of policies that, in the example of the EU chemical industry, include product policy, waste plastics minimization, digital transformation, and sustainability policies. To navigate these multiple challenges and support successful implementation of the European Green Deal goals, EU industry sectors are developing transition pathways.

The United States, in the absence of a national ETS, envisions that a key driver for decarbonization of the industrial sector will be clean procurement standards, for example, requiring purchase of zero-carbon steel. Leading U.S. states in terms of industrial GHG emissions reduction policy include Colorado, New Mexico, Louisiana, and Michigan.

Technologies and strategies

The study tour examined net-zero technologies and strategies for the steel, chemicals, cement, and technology sectors.

For the **steel industry**, a key decarbonization route is through replacement of blast furnaces with hydrogen-based direct reduction (DRI) using electric arc furnaces (EAFs) as well as increased scrap usage. DRI plants can start with natural gas and switch over to hydrogen as it becomes available. Around 30 percent of EU primary steel production is expected to be decarbonized using green hydrogen by 2030. Another route is an optimized blast furnace with carbon capture and storage (CCS), for example, as at Tata in the Netherlands. The following insights were shared about plans in the German steel industry:

- **SALZGITTER AG** aims to achieve almost carbon-free steel production (95 percent reduction in CO_2) by 2035, based on a three-stage concept established in 2015. First, by 2025, it plans to commission the first DRI plant and decommission the first blast furnace,[xxii] reducing CO_2 by 30 percent; second, by 2030, this will be repeated for the second DRI plant and blast furnace, reducing CO_2 by 50 percent; and, finally, by 2035, further reduction of emissions through more hydrogen use is planned to achieve a 95 percent reduction in CO_2.
- **THYSSENKRUPP** aims to reduce CO_2 emissions by 30 percent by 2030 and achieve climate neutrality by 2050. In 2019, the company started injecting hydrogen into a blast furnace and plans to produce 400,000 tonnes of low-CO_2 steel by 2025. By 2030, the company is aiming for 3 million tonnes with construction of a DRI plant by 2025. The plant is designed with an integrated smelting unit, and the existing product portfolio is retained because existing steelworks and processes can continue to be used.

Thyssenkrupp steel plant in Duisburg, Germany (Shutterstock)

xxii Salzgitter already has the world's largest high-temperature electrolysis and two (Polymer electrolyte membrane) PEM electrolysis plants in operation as well as a 30 MW wind farm.

- **ARCELORMITTAL** aims to reduce CO_2 emissions in Europe by 30 percent by 2030 and to achieve climate neutrality by 2050. Operation of a DRI pilot plant has started in Hamburg. In Bremen, the company plans to build a DRI plant including an EAF by 2026 and phase out basic oxygen furnaces (BOFs) and build an additional DRI by 2030. Eisenhüttenstadt plans to build a DRI pilot plant by 2026 using fine ore and phase out the BOF and set up two EAFs by 2027. Hydrogen will be produced by electrolysis through a regional North German association and made available to both steelworks.
- **THE DEKARBIND PROJECT**[18] provides road mapping for decarbonized steel and cement in Germany, networking between stakeholders, and a process for collecting opinions and creating policy.


Steam cracker at BASF chemical plant in Ludwigshafen, Germany (BASF via Flickr)

The **chemicals industry** is regarded as particularly difficult to decarbonize due to its large energy footprint and multiple products. The petrochemicals sector needs a technology breakthrough to reach carbon neutrality that includes cracker furnace redesign, use of biomass, recycling of waste material to produce chemical products, carbon capture and sequestration, electrification of crackers using renewables, hydrogen furnaces, and CO_2 and hydrogen chemistry to make chemicals.

The European Chemical Industry Council, Cefic, publishes materials on how the industry is contributing to the European Green Deal by improving carbon circularity and minimizing GHG emissions by revolutionizing materials, production processes, and services across all sectors through “ChemistryCan,” including case studies of innovative solutions to support the transition to carbon neutrality.[19]

BASF, the leading chemical company in Europe, has a 25 percent CO2 emissions reduction target by 2030 compared with 2018 and net-zero by 2050. BASF is expected to obtain 100 percent of its 2021 global power demand from renewable sources by 2030, with the company publishing an annual CO_2 emissions forecast as part of its outlook with an uncertainty of plus or minus 0.5 million tonnes. Switching to renewable energy will be the main driver of emissions reduction until 2025 including investing in its own renewable power assets and purchasing green power from third parties.[xxiii] A major project is an electrically heated steam cracker furnace at BASF’s Ludwigshafen site in Germany, replacing the current gas heating, with completion expected by 2023 subject to a positive public funding decision.[xxiv] BASF’s Antwerp site is planning to import green power from offshore wind parks in combination with the deployment of new, low-emissions technologies and a planned large-scale CCS project, with the goal of becoming the first petrochemical site to approach net-zero in 2030. For CO_2-free production of hydrogen, BASF is developing new processes such as methane pyrolysis.

The EU **cement industries**’ plan to reach net-zero by 2050 is outlined in the 2050 Carbon Neutrality Roadmap[20] by the European Cement Association, Cembureau. The sector aims to achieve carbon neutrality along the full value chain (clinker, cement, concrete, construction, and (re)carbonization), known as the 5C approach, requiring innovation in processes, business methods, and products. Key strategies include (1) use of alternative fuels instead of fossil fuels;[xxv] (2) reduction of the clinker share in cement by substituting blast furnace slag, fly ash, calcined clay, and so on;[xxvi] and (3) carbon capture, utilization, and storage (CCUS). The latter will be a key technology for the cement sector with demonstration projects this decade and commercialization and rollout afterward. A map of current decarbonization projects in the European

xxiii For example in 2021, BASF purchased a stake in what will be the world’s largest offshore wind farm with a total capacity of 1.5 GW.

xxiv Other new approaches at this site include generating steam using electricity and upgrading waste heat so it can be used as steam.

xxv This can increase to 100 percent with no technical issues.

xxvi However, due to safety issues there is a limit on the reduction in clinker share, e.g., from 76 to 72 percent.

cement sector is available on the Cembureau website.[21]

Details of a cement sector CCUS pilot project were presented — the LEILAC (low emissions intensity lime and cement) project. The pilot project has proven the technology works, with a demonstration project aiming to prove it works with a range of energy systems (natural gas, hydrogen, electricity, solid fuels, etc.). This technology captures CO_2 emissions from the chemical reactions in the manufacture of clinker, the key raw material for cement, using special alloy materials selected for specific plant conditions, particularly levels of contaminants. The technology does not require additional energy or chemicals and can be retrofitted to an existing cement plant. The cost of CO_2 capture is €20 to €25/t. Captured CO_2 can be used in the chemical or food industries and building products or can be stored offshore or onshore, after compression and transportation. Transport and storage are the major costs and inhibitors of rapid development.

For the **technology sector**, meetings were held with Google, Apple, and Amazon to investigate their net-zero GHG emissions strategies.

Google consumes a significant amount of energy (more than 12 TWh globally) given that every search, video upload, and so on requires energy, with consumption growing 20 percent per year. The company achieved carbon neutrality by 2007 and 100 percent renewable energy (wind and solar) by 2017, with a target of 24/7 carbon-free energy by 2030. This requires matching operational electricity use of Google operations in all places with nearby (or on the same regional grid) carbon-free energy sources every hour of every day. Google has 23 data centers that it plans to make the most energy efficient in the world. Google's overall strategies relate to purchasing (buying more and different types of clean energy), technology (supporting acceleration of technology innovations to reduce carbon footprint, using adaptive controls for data centers, shifting tasks between hours and data centers depending on renewables' availability, using recycled aluminum, and so on), and policy (advocating policies to decarbonize electricity grids).

Apple achieved 100 percent renewable energy for corporate offices in 2018 and carbon neutrality in 2020 for scope one and two emissions[xxvii] and 100 percent renewable energy at all offices and data centers. Scope three emissions,[xxviii] mainly from product manufacturing, are more difficult to control. Apple helps its manufacturers transition to renewable energy and increase their use of recycled materials. All of the supply chain uses 100 percent renewable energy for the portion of production that is supplied to Apple. Apple's overall strategy for GHG reduction includes low-carbon design, energy efficiency, and renewable energy. This is aimed at reducing emissions by 75 percent, with the remaining 25 percent of reductions achieved by investing in carbon removal projects (forestry sequestration, etc.). Apple is part of the First Movers Coalition, which aims at harnessing the purchasing power of companies to decarbonize seven "hard to abate" industrial sectors that currently account for 30 percent of global emissions: aluminum, aviation, chemicals, concrete, shipping, steel, and trucking.

Amazon was the world's largest buyer of renewable energy in 2020, and the company is growing by approximately 25 percent per year. Of the company's CO_2 uses, including transport, energy,[xxix] and supply chain, the latter is the biggest challenge. Amazon works with vendors to lower their carbon footprint through its Climate Pledge Fund, launched in 2020 to support the development of sustainable and decarbonizing technologies and services. With an initial $2 billion of funding, Amazon invests in companies whose products and solutions will facilitate the transition to a low-carbon economy, focusing on energy generation, storage, and utilization; food and agriculture; manufacturing;[xxx] renewable energy technologies; and transportation.[xxxi] To reduce its transport emissions, Amazon is a major global purchaser of electric vehicles (EVs), planning to have hundreds of thousands by

xxvii Scope one covers direct emissions from owned or controlled sources. Scope two covers indirect emissions from the generation of purchased electricity, steam, heating, and cooling consumed by the reporting company.

xxviii Scope three emissions are the result of activities from assets not owned or controlled by the reporting organization but that the organization indirectly impacts in its value chain. Scope three emissions include all sources not within an organization's scope one and two boundaries.

xxix Note that Amazon does not pursue 24/7 carbon-free energy, as does Google, as it is not possible to get it in some places, e.g., Japan, and can undermine the ability to get a cost-effective deal. Amazon prefers to achieve an equivalent target by doing more in some places balancing doing less in others.

xxx E.g., lowering embodied carbon in cement.

xxxi E.g., working on low-carbon aviation fuels.

2030. It is quite feasible for its fleet to find EV solutions for the short distances at the end of the delivery chain, as they are more mature, whereas it is harder to find solutions for the longer distances in the middle of the delivery chain. All low-carbon investments need to be justified financially in the same way as any investments, with net present value (NPV) analysis.

Amazon is part of a U.S. renewable buyers' alliance that provides a unified voice to promote renewable energy, involved in "green corridors" developing electric port facilities, working with governments on fuel standards, partnering with United Nations Framework Convention on Climate Change (UNFCCC) to build a technology innovation hub to help developing countries identify low-carbon technologies and strategies, and working with governments on nature-based solutions where they pay for demonstrated performance.

ROAD TRANSPORT SECTOR

Road transport is the "problem" sector in the EU, where GHG emissions have actually increased by seven percent between 2014 and 2019. Because of this, the EU is planning to include transport fuel suppliers in a new ETS, as described above.[xxxii] In both the EU and the United States, a mix of policies is considered necessary to address road transport emissions, from both new and existing vehicles. Transport sector GHG emissions reductions in the EU will mainly take place after 2030. Progress is relatively slow with the focus currently on installing equipment for EVs. A key source of information on European e-mobility policies and trends is "The End of the Ice Age." The United States is lagging behind the EU in EVs but is developing quickly. Key drivers for EVs include subsidies, falling prices, increasing attractiveness of e-mobility, and improving charging infrastructure. Key bottlenecks relate to the supply chain.

For light duty vehicles (LDVs; cars and vans), EVs will be the most efficient zero-emissions option. For heavy duty vehicles (HDVs; trucks and buses), EVs can be feasible up to approximately 300 km, with hydrogen vehicles having an advantage for longer distances, as batteries would be too heavy. Smart grids and smart (time-of-use) charging systems can address concerns regarding the potentially high peak demand for charging. A key area to work on in the future will be decreasing price, increasing range, and improving charging speed of batteries.

The European Commission's work to achieve a green transport system is detailed in its "Sustainable and Smart Mobility Strategy" together with an Action Plan,[23] with the goal of achieving a 90 percent reduction in GHG emissions by 2050. The goals by 2030 include at least 30 million zero-emissions cars to be in operation on European roads, 100 European cities to be climate neutral, high-speed rail traffic to double across Europe, scheduled collective travel for journeys under 500 km should be carbon neutral, automated mobility will be deployed at a large scale, and zero-emissions marine vessels will be market ready. By 2035, zero-emissions large aircraft will be market ready. By 2050, nearly all cars, vans, buses, as well as new HDVs will be zero-emissions; rail freight traffic will double; and a fully operational, multimodal Trans-European Transport Network (TEN-T) for sustainable and smart transport with high-speed connectivity will be in place.

The EU proposes that all new cars and vans (LDVs) will be zero-emissions beginning in 2035. This legislation is a key part of the Fit for 55 package[24] and mandates that carmakers reduce their fleet-wide emissions averages by 100 percent beginning in 2035, with interim steps in 2025 and 2030. Corresponding dates for HDVs (trucks, buses, etc.) will be determined later. California has the same requirement for cars and vans, and a 2045 deadline for medium and heavy duty vehicles.

Furthermore, under the REPowerEU plan, to enhance energy savings and efficiencies in the EU transport sector and accelerate the transition toward zero-emissions vehicles, a Greening of Freight Package will be developed, aiming to significantly increase energy efficiency in the sector and increase the share of zero-emissions vehicles in public and corporate car fleets above a certain size.

A significant policy in the EU to promote EVs is the **Euro emissions standard**, with the latest (Euro 7) standard under development and expected to be implemented in 2025. This policy, which is part of the European Green Deal, will develop stricter emissions standards for all gasoline and diesel cars, vans, lorries, and buses, including CO_2 and air pollutants.

[xxxii] It is noted that the K-ETS already covers transport sector emissions from entities that have emissions above the K-ETS inclusion thresholds.

The U.S. has similar types of vehicle emissions standards, as well as the corporate average fuel economy (CAFE) standard, with the latest standards applying to 2024 to 2026 and requiring continually increasing levels of fuel efficiency. EVs are part of how companies can comply with the emissions and fuel economy standards.

An important policy in California to addresses CO_2 emissions from existing as well as new vehicles is the **Low Carbon Fuel Standard (LCFS)**. This is designed to encourage the use of cleaner low-carbon transportation fuels and production of those fuels and, therefore, reduce GHG emissions. Carbon intensity (CI) scores for each fuel are compared to a declining benchmark for each year. Low-carbon fuels below the benchmark generate credits, while fuels above the CI benchmark generate deficits. Providers of transportation fuels must demonstrate that the mix of fuels they supply for use meets the LCFS benchmarks for each annual compliance period. A deficit generator meets its compliance obligation by ensuring that the number of credits it earns or otherwise acquires from another party is equal to or greater than the deficits it has incurred. The LCFS includes electricity so that EV charging stations can generate credits that can be sold to gasoline distributors. The value of the credit can then be passed through to the EV driver, providing a further incentive for the use of EVs. This policy is expanding across the U.S. West Coast as part of the Pacific Coast Collaborative, a regional agreement among California, Oregon, Washington, and British Columbia, to strategically align policies to reduce GHG and promote clean energy.

Substantial funding supports EV infrastructure, for example, $7.5 billion from the U.S. Bipartisan Infrastructure Bill to fund a national network of EV charging stations. Policy frameworks for these investments are critical including the EU's Alternative Fuels Infrastructure Regulation,[25] specifying key details such as required distances between charging stations for cars and trucks. In the EU, one of the most complex elements of the legislative package to support EVs has been the 2020 Battery Regulation, with requirements on recovering raw materials from old batteries to use for new ones.

BUILDINGS SECTOR

Like road transport, the EU buildings sector is also proving difficult to decarbonize, with emissions increasing in recent years, hence the drive for additional policies including the new ETS as described above. The main challenge in both the EU and the United States in reaching net-zero in this sector is existing buildings, given the age of the building stock. This is an area where Korea should have an advantage given its relatively high turnover of buildings.

To boost energy performance of buildings and achieve an efficient and decarbonized building stock by 2050 and a 60 percent reduction in GHG emissions by 2030 compared with 2015, the EU has proposed a revision of the Energy Performance of Buildings Directive.[26] Key measures include minimum energy performance standards for new buildings and existing buildings undergoing major renovation and for the replacement or retrofitting of key building elements; beginning in 2021, a requirement for all new buildings to be nearly zero-energy constructions;[27, xxxiii] enhanced long-term renovation strategies[28] aiming at decarbonizing the national building stocks by 2050, with indicative milestones for 2030, 2040, and 2050; increased reliability, quality, and digitalization of Energy Performance Certificates;[29] modernization of buildings and their systems; and better energy system integration (for heating, cooling, ventilation, charging of EVs, renewable energy). The European Commission has established a set of standards and accompanying technical reports to support the directive called the energy performance of buildings standards (EPB standards).[30] This policy will be integrated with other initiatives of the European Green Deal package, in particular with the proposed new ETS for fuels used in buildings, the Energy Efficiency Directive, the Renewable Energy Directive, as well as the Alternative Fuels Infrastructure Regulation.

California is also a good reference for ambitious energy-efficiency building standards, although policies for decarbonizing existing buildings are still being developed. In the United States in general, however, energy performance building codes and standards are voluntary.

[xxxiii] A nearly zero-emissions building (NZEB) has a very high energy performance, while the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including those produced on-site or nearby.

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