Building Resilient Energy Systems: Technical Considerations and Actions for Achieving Greater Energy Security, Affordability and Net-zero in the ECE Region

Note by the Bureaux of the Groups of Experts on: Cleaner Electricity Systems, Coal Mine Methane and Just Transition, Energy Efficiency, Gas, Renewable Energy, and Resource Management

I. Statement of purpose

Taking into account the contemporary challenges in the United Nations Economic Commission for Europe (ECE) region,

Taking into account the sovereign right of states to determine their national energy policies, conditions for exploiting their national resource endowments as well as choice between different energy sources, and the general structure of its energy supply, and acknowledging a variety of individual countries' incentives for energy system transformations determining their pace and ways of implementation at national levels,

Recognizing that the efforts that are being currently undertaken on the global scale are insufficient to meet the objectives of the 2030 Agenda for Sustainable Development in general and of the 1.5-2-degree target as per Paris Agreement in particular, and

Bearing in mind that the Committee on Sustainable Energy greatly benefits from the expertise of its six subsidiary bodies to facilitate the transition to a more sustainable energy future and resilient energy system.

1. The Bureaux of the subsidiary bodies of the Committee on Sustainable Energy, the Groups of Experts on Cleaner Electricity Systems, on Coal Mine Methane and Just Transition, on Energy Efficiency, on Gas, on Renewable Energy, and Expert Group on Resource Management:

   a) Present the Committee with this jointly developed background document, which aims to provide member States with a list of technical considerations and possible actions on achieving greater energy resiliency, affordability, and environmental sustainability of energy systems in the ECE region, and

   b) Invite the Committee to discuss and determine which, if any, recommendations the Committee may wish to explore in-depth with the view of enabling attainment of greater energy resilience in the ECE region.

II. Context

2. ECE region faces a number of crises that pose a significant challenge to the existing energy system, exposing its vulnerabilities:

   a) *The COVID-19 pandemic* that started in 2019 is still having region-wide implications. The pandemic was one of the most severe economic and energy shocks that the region has experienced over the last few decades. While the pandemic led to temporary reductions in fossil fuel consumption and emissions, these will not be enough to put the region on the trajectory to 1.5 degrees Celsius global warming target. In addition, the emphasis on economic recovery at the expense of energy transition progress poses an additional risk to the attainment of the Paris Agreement targets; [1]

[1] UNFCCC, March 2015, Paris Agreement, https://unfccc.int/sites/default/files/english_paris_agreement.pdf

b) *The ongoing geopolitical crisis* is, among other, shifting energy trade and its currents, thus disrupting normal energy system operations. In a number of net energy importing countries, disruptions in energy trade and supplies are expected to threaten economic recovery and growth aspirations and to create further pressure on end-users, in particular by elevating the energy prices on resource in short supply in short- to medium-term;

c) *The possible impacts of the supply chain disruptions* on the transition to a more sustainable energy system in the ECE region are to be seen. Many factors are influencing the deployment of renewable energy and other clean energy technologies, such as: i) exponential increase in demand for critical raw materials and disruption of supply chains leading to increased cost of the raw components for manufacturing of solar panels, wind turbines, electrolyzers, and batteries; ii) higher than pre-pandemic global costs of shipping and logistics adversely impacting consumer prices; and iii) clean technology market players; and iv) limited technology standardization and (v) trade restrictions;

d) *The climate change crisis* is recognized as a significant threat to international peace and security and is a "threat multiplier". According to one of the latest United Nations Intergovernmental Panel on Climate Change (IPCC) reports, every additional degree of global warming is likely to increase the intensity and frequency of extreme climate events, such as drought and flooding, and will severely impact biodiversity and life on this planet.[2]

3. The challenges above expose the fragility and vulnerability of the current energy system in the ECE region which is affected by:

a) **Disrupted energy availability** due to limited access to resources, combined with climate-change driven severe weather events, geopolitical factors, that are affecting the region's energy security and disruptions in demand that create uncertainties for long term energy investments;

b) **Inadequate energy accessibility** that is resulting in region-wide energy price increases that are inhibiting economic growth and increase energy poverty across the region; and

c) **Questionable energy sustainability** as some countries are considering, or already increasing power generation by unabated coal-fired power plants to maintain national energy security. This will increase CO_2 emissions in the short term and potentially delay the attainment of net zero.

4. It is essential to focus efforts, resources and expertise on addressing the range of crises in an integrated way. The current challenges that the region is facing provide a unique opportunity for member States to rethink the existing energy system and infrastructure to ensure access to affordable, reliable, sustainable, and modern energy for all while reducing greenhouse gas emissions and the carbon footprint of the energy consumption of the region.

III. Defining a resilient energy system

5. A resilient energy system ensures that energy makes an optimal contribution to a country's social, economic, and environmental development.

[2] IPCC, February 2022, Climate Change 2022: Impacts, Adaptation and Vulnerability, https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/#:~:text=The%20IPCC%20has%20finalized%20the,55th%20Session%20of%20the%20IPCC.

6. For the purposes of this document, the definitions from the ECE project on Pathways to Sustainable Energy are used.[3] In that project, *Sustainable Energy* is defined based on three pillars: i) energy security, ii) quality of life and iii) environmental sustainability. Each of the pillars contributes to attaining sustainable energy. Still, none of them alone fully describes *Sustainable Energy,* a golden thread that underpins the delivery of the 2030 Agenda for Sustainable Development. Premised on this, the definition of a *Resilient Energy System* is based on those pillars:

a) **Energy security - Securing the energy needed for economic development**. There are significant social, economic, environmental and technological factors which come into play in this area. Some countries might define energy security as energy independence, whereas others see energy security in a regional context, focusing on interconnectivity and trade;

b) **Quality of life - Providing affordable energy available to all at all times.** A resilient energy system improves the living conditions of citizens by providing access to safe, sustainable, reliable, modern and affordable energy for all. This objective includes physical access to electricity networks and stand-alone grids, and the quality and affordability of access to the broader concept of energy services. Costs and ensured uninterrupted availability for energy services, including electricity, heating, cooling, and transport, are important considerations when assessing the resiliency of a system;

c) **Environmental sustainability - Limiting the impact of the energy system on climate, ecosystems and health**. Energy emissions contribute 75% of total anthropogenic greenhouse gas emissions[4 5], so the energy sector needs to reduce its carbon footprint to support climate change mitigation efforts. Energy and associated resource consumption should be used more efficiently by all sectors and end-users, and consider circularity aspects that reduce energy demand and accelerate energy transition. Beyond climate change concerns, this pillar also includes other nexus topics such as water scarcity in the energy sector, transport emissions, and air pollution caused by energy generation and consumption.

8. Finding a balance between the three pillars is a complex social, political, economic, and technological challenge. A dialogue under the ECE Committee on Sustainable Energy would constitute a significant step for the member States as it allows them to identify the possible trade-offs and synergies between delivering on (i) energy security, (ii) quality of life and (iii) environmental sustainability. While there are no easy answers, there is an urgent need to find a balance between those competing yet interrelated interests.

IV. Towards more resilient energy systems: Summary of key recommendations for policymakers

9. To build more resilient energy systems, the Bureaux of the Groups of Experts consider it appropriate to put forward the following policy recommendations:

a) **Implement energy efficiency solutions immediately** - Energy efficiency solutions should be implemented to the greatest possible extent throughout supply, transformation, and consumption. Measures and solutions that will help enhance systemic efficiencies across industry, buildings and transport sectors, as well as energy generation, transmission, distribution, and consumption should be deployed vigorously to multiply the effect of scaled-up renewable generation

[3] UNECE, January 2020, Pathways to Sustainable Energy - Accelerating Energy Transition in the UNECE Region https://unece.org/fileadmin/DAM/energy/se/pdfs/CSE/Publications/Final_Report_PathwaysToSE.pdf

[4] IEA, 2021, Greenhouse Gas Emissions from Energy: Overview, https://www.iea.org/reports/greenhouse-gas-emissions-from-energy-overview

[5] Our World Data, Hannah Ritchie, Max Roser and Pablo Rosado (2020), "CO_2 and Greenhouse Gas Emissions", https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

and associated energy infrastructure; in this context, turn attention to digital solutions aimed to improve energy efficiency, which are characterized by their short deployment time thus bringing almost immediate and tangible positive effects.

b) **Digitalize the energy systems** – Capitalize on opportunities arising from availability of digital solutions and improved digital literacy, throughout the transition process and across all layers and stakeholders of the energy systems to reduce the end-use energy demand as well as the need for redundancy to maintain energy system resiliency;

c) **Decreasing carbon footprint of the energy sector** – Replacing more carbon-intense fuels with their less carbon-intense alternatives, where technically and economically feasible, and in line with national development aspirations and endowment of natural resources, technological base, pursued socio-economic model, cultural heritage, as well as institutional, legal and regulatory structure;

d) **Diversify the energy supply** - Energy supply sources of both the ECE Region and the individual member States should be diversified to enhance energy security and avert future supply and price shocks; interconnectors and pipelines between regions, countries and continents, as well as deep-water terminals for LNG, ammonia or hydrogen are an important mean to diversify the physical transport of energy and play a significant role in making energy system more robust, and in harnessing systemic efficiencies.

e) **Consider the risk climate change is imposing on energy resilience –** Water scarcity, flooding or extreme weather, including rising sea levels impose a threat to the resilience of energy generation and transmission across the UNECE region[6]; ensure that contingency plans take the impact of draughts and flooding on the energy system in consideration to boost its resilience.

f) **Build a workforce to deliver on energy transition** – Address the skills and labour shortage to create the next generation of qualified experts that can advise on, deploy and maintain clean energy and energy efficiency technologies; in this regard, consider capacity building for developing skillsets in the area of digitalization of energy, to leverage opportunities and manage perceived risks and challenges.

g) **Implement a shared principles-based, integrated, sustainable resource management framework** - Tools such as the United Nations Framework Classification for Resources (UNFC) and the United Nations Resource Management System (UNRMS)[7] UNFC and UNRMS should be applied to minerals, petroleum, renewable energy, injection projects including carbon and hydrogen storage, nuclear fuel resources, anthropogenic resources (residues and wastes), groundwater, and the raw materials needed along the respective supply chains to better manage resources;

h) **Integrate circular carbon economy considerations into decision-making** – Transformation of the energy system towards a cleaner one implies increased recyclability of materials and resources, and both repairability and recyclability-by-design of goods. In that context, ensure most efficient extraction, processing and use of fossil fuels, which cannot be replaced in the current state of technological development, takes place efficiently and with the application of technologies that reduce or eliminate their carbon footprint;

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[6] According to WMO, 87 % of global electricity generated from thermal, nuclear and hydroelectric systems directly depended on water availability. World Meteorological Organization (2022) Press release "Climate change puts energy security at risk" https://public.wmo.int/en/media/press-release/climate-change-puts-energy-security-risk

[7] United Nations (2021) Policy Brief "Transforming Extractive Industries for Sustainable Development" https://unece.org/info/Sustainable-Energy/UNFC-and-Sustainable-Resource-Management/pub/356790

i) **Adopt the principles of just transition** – The energy transition process must be just and inclusive, aiming at finding the right balance between the member States' (i) goals and targets of the 2030 Agenda for Sustainable Development, (ii) national energy security concerns, (iii) quality of life and other social ambitions, as well as (iv) their environmental and economic objectives.

j) **Recognize that there is not a one-size-fits-all approach** – Taking into account the countries' endowment of natural resources, technological base, pursued socio-economic model, cultural heritage, as well as institutional, legal and regulatory structure, recognize unique national circumstances and development aspirations;

k) **Acknowledge that all low- and zero-carbon technologies play a role** - To progress with energy system transformation while recognizing that each member State is free to choose its own energy development pathway, ECE countries are encouraged to increase cooperation and develop non-discriminatory regulatory frameworks and financing mechanisms for region-wide investments in sustainable energy;

l) **Address behavioural barriers** – Although the technologies and capabilities are in place to achieve more resilient energy systems, this process remains sporadic and slow. One of the crucial factors at the end-use level, and arguably the missing link, is human psychology. To apply skills and use the full potential of technology, psychological aspects need to be taken into account, as well as individual psychological roadblocks that hinder the successful implementation. Also harnessing organizational and behavioural optimization potentials should be recognized and overcome to ultimately contribute to improved energy behaviour.[8]

V. Detailed energy demand-related considerations and recommendations

10. Expanding on section *IV. Towards more resilient energy systems: Summary of key recommendations for policymakers* above, the Experts identified several cross-cutting technical considerations relevant across the whole energy demand side:

a) **Energy efficiency** is one of the most critical determinants of a secure and resilient energy system, and it needs integrated thinking and governance. Energy efficiency can reduce consumption, contribute to load profile management, and reduce infrastructure investment while also bringing social and environmental benefits. Solutions that improve energy efficiencies on both the demand and the supply side need to be explored and extensively deployed. Vast opportunities remain untouched, although their challenges often are less technical and more of a systematic or adoption nature. This would require effective awareness-raising campaigns to enhance the perception of all stakeholders on the vast range of easy to implement measures at low or no cost that deliver short-term results. This will further increase demand for efficient solutions that unfold their impact in the short-, medium- and long term.[9] [10] [11] Such campaigns and materials

[8] UNECE, "Addressing Behavioural Barriers towards Energy Benefits Enabled by Digitalization" (ECE/ENERGY/GE.6/2022/6), October 2022.

[9] IEA, "Saving Electricity in a Hurry 2011". Available at https://www.iea.org/reports/saving-electricity-in-a-hurry-2011

[10] IEA, "Insights Series 2018 - Saving Oil in a Hurry". Available at: https://iea.blob.core.windows.net/assets/194d57e4-9126-425f-a1b3-7a25e097b677/Insights_Series_2018_Saving_Oil_in_a_Hurry.pdf

[11] Van Genuchten, "How To Reduce The Impact Of Increasing Energy Prices". Available at: https://medium.com/the-environment/how-to-reduce-the-impact-of-increasing-energy-prices-79ef853f4c5

should be designed with customized narratives aligned with the values of different stakeholders to empower and trigger their intrinsic action.

b) **Capacity building -** Making use of the potential of energy efficiency further requires extensive capacity for manufacturing of the relevant equipment, for providing advice, training and for implementation for high-scale time-bound deployment;

c) **System-wide digitalization** has the potential to bridge many gaps at the system level while catalyzing new opportunities through a more profound change in how the devices, systems, and actors communicate. Digital technologies can unlock massive potential with demand-side flexibility, which could be a key instrument for balancing the grid and reduce carbon footprint in a cost-effective manner. Machine learning and artificial intelligence can optimize energy use, identify inefficiencies and anomalies, and enable automatic switching between different energy sources depending on price and availability.[12] Digital tools further allow to shape real-time resource-use optimisation pathways, as well as individual decarbonisation roadmaps and determine the economically ideal composition of respective measures;[13] [14]

d) **Fuel switching options**, if combined with the local generation of clean energy and use of on-site resources lost otherwise, such as waste heat, could decrease the load on the energy systems, reduce exposition to price and supply shocks, and increase self-sufficiency and resilience against costly and harmful outages.

11. The experts recommend the following actions and initiatives to improve energy efficiency and decarbonization across the **buildings** sector:

a) Improve energy efficiency in the buildings sector, including by broader deployment of digital technologies in materials, products, structures, and in engineering systems, decarbonization of the building supply chain industries, ensuring use of advanced materials and construction techniques, also on the back of **enhanced retrofitting and insulation** of the existing buildings and ensuring new buildings are sustainable and energy-efficient;[15,16]

b) Scale-up net-zero buildings sector energy consumption programmes by developing **distributed renewable energy generation** on roofs and enhancing prosumers' role. In this context, consider applications of artificial intelligence that may help predict individual needs, and hence, enable a predictive operation and increase overall energy security along with ensuring integration of renewable energy sources. Also, distributed and other non-traditional energy resources mark challenging the integration of variable renewable energy

[12] UNECE, “Digitalization: enabling the new phase of energy efficiency” (GEEE-7/2020/INF.3), Available at: https://unece.org/documents/2020/12/informal-documents/digitalization-enabling-new-phase-energy-efficiency

[13] UNECE, “A pathway to reducing the greenhouse gas footprint in manufacturing: determinants for an economic assessment of industrial decarbonization measures”, ECE/ENERGY/GE.6/2021/3. Available at: https://unece.org/sed/documents/2021/07/working-documents/pathway-reducing-greenhouse-gas-footprint-manufacturing

[14] UNECE, “Digitalization: Accelerating the Electricity System Transformation”, ECE/ENERGY/GE.5/2022/4, ECE/ENERGY/GE.6/2022/4. Available at: https://unece.org/sed/documents/2021/06/working-documents/improving-efficiency-buildings-through-digitalization

[15] UNECE, “Framework Guidelines for Energy Efficiency Standards in Buildings” (ECE/ENERGY/GE.6/2020/4), available at: https://unece.org/documents/2020/12/updated-framework-guidelines-energy-efficiency-standards-buildings

[16] UNECE, “Improving Efficiency of Buildings through Digitalization – Policy Recommendations from the Task Force on Digitalization in Energy” (ECE/ENERGY/GE.6/2021/5). Available at: https://unece.org/sed/documents/2021/06/working-documents/improving-efficiency-buildings-through-digitalization

sources, as the fuel mix and operational characteristics of the system will change, necessitating changes to how the system is planned and operated, requiring enhanced coordination across the transmission and distribution interface with the help of digital solutions;

c) Modernize **Heating, Ventilation, and Air Conditioning** (**HVAC)** systems and ensure their efficient operation. Deploying heat pumps and heat recovery systems could attain significant emissions reduction and increase energy savings across the domestic, commercial and industrial domains. Incentives should be provided to modernize traditional HVAC systems to digitally enabled higher efficiency units. As such, consider deployment of active fully automated control of electricity and heat coupled with switch from self-consumption to grid supply;

d) Apply digital approaches were possible across the buildings sector, such as smart **appliances and smart metres**, coupled with **data analytics** and feedback loop while ensuring data protection;

e) Maximize the **district heating (and cooling)** and heat network opportunities from low-carbon sources, such as renewable energy, waste heat (e.g. waste heat from data centres, industrial estates, refineries and others can be utilized to heat homes or businesses, with numerous examples already (being) employed in Europe), nuclear power (for countries that support this technology), and low-carbon and renewable hydrogen, and from fossil fuels with emissions reductions technologies;

f) Introduce the **"Energy and Resource as a Service**" model that moves away from the current commodity and product-based models towards the subscription-based models that are outcome-focused. Under this model, an energy provider commits to deliver to the recipient an agreed upon outcome (service), e.g., a certain temperature or brightness at a given venue, for which the recipient is to be charged, rather than delivering energy that it is to be priced per a specific unit (e.g., kWh). As a result, contrary to the current approach, the provider will have an interest in efficiency improvements rather than benefiting from the energy inefficiency of the recipient, because the improvements will translate directly into energy savings and thus the provider's greater profits. The service approach is crucial in progressing toward a circular economy, significantly increasing resource efficiency, reducing carbon and other environmental footprints and eliminating wastes.

12. The experts recommend the following actions and initiatives to improve energy efficiency and decarbonization in the industry sector:

a) Assessing the status quo, in context of energy and resource consumption as well as emission footprints, notably by **keeping track of energy use across all different forms of energy**, ideally by automatic energy data metering;[17]

b) Apply, where possible, across industries sector, digital approaches, such as smart **meters**, anomaly and leakage detection, and advanced load management and energy flexibility techniques on the back of energy and resource consumption data.

c) Foster the awareness and adoption of **market-ready innovations with high energy saving potentials for industry**[18] as well as the range of non-technical measures that help save energy in the short run and identify saving potentials that would otherwise remain unnoticed; note that full adoption of the these market-ready innovations has the technical potential to reduce industrial energy

[17] UNECE, “Framing the ambition of carbon neutrality”, GEEE-7/2020/INF.2

[18] BMWK, “Marktverfügbare Innovationen mit hoher Relevanz für die Energieeffizienz in der Industrie“. Available at: https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/marktverfuegbare-innovationen-mit-hoher-relevanz-fuer-energieeffizienz-in-der-industrie.pdf

demand by approximately a third, the waste heat utilising high-temperature heat pump alone by a quarter. [ibid.]

d) More than sixty percent of industrial energy demand is driven by carbon-intense sources mostly used for heating or cooling, which cannot be substituted with clean sources in the short run. Increasing the availability of skilled personnel in this field is necessary to implement measures and technologies to increase **heating- and cooling efficiency**, process decarbonisation and electrification and in particular **waste heat utilisation**;

e) **Decarbonize hard-to-abate sectors through innovative low-and zero-carbon solutions.** Some industries, such as cement production, primary steel-making, or some chemical processes, cannot be easily electrified. Innovative technologies, such as carbon capture, use and storage (CCUS) or low-carbon and renewable hydrogen, need to be deployed to decarbonize these hard-to-abate sectors.

f) Improve recyclability and repairability of products to achieve **full circularity**, ideally 'designed for net-zero', allowing for reduced emissions and easing difficulties of acquiring sufficient raw materials and interim products.

g) Apply the principles and requirements of the United Nations Resource Management System **(UNRMS)**, which stresses resources as a service, value-addition, circularity, and innovation.[19]

h) Ensure mechanisms are in place that are successful in reaching **micro, small and medium-sized companies' (MSMEs)** attention making them fully aware of their potential to increase energy resilience and reduce their energy-related costs and empowering them to take action, for instance via local/regional advisory programmes, guided b2b collaboration networks, multi-language online training and material repositories.[20] [21] [22]

13. The experts recommend the following actions and initiatives to improve energy efficiency and decarbonization across the transport sector:

a) **Foster deep decarbonisation** of the transport sector through enabling policies, reducing oil demand and lowering emissions, including compatible charging, fuelling, metering and billing infrastructure.

b) Increase the **efficiency of the transport system by applying digital means** to avoid congestions, improve traffic and parking management systems, increase capacity of low carbon transportation systems and further ease multi-modal transport and ticketing.

c) Undertake measures to raise **awareness of energy saving potentials in the transport sector**, such as tyre pressure, avoidable loads, idling engines, and fuel economic driving.

d) Continue with **developing alternative low-carbon solutions**, such as low-carbon and renewable hydrogen, battery-storage, synthetic fuels, and carbon dioxide removal from the air, for means of transportation that cannot be easily electrified, such as long-haul road transport, aviation and maritime, as well as railroads that are not (yet) electrified.

e) Emphasise the role of **location efficiency in urban planning and spatial development to** minimize transportation needs.

[19] UNECE, 2022, Draft United Nations Resource Management System: Principles and Requirements https://unece.org/sites/default/files/2022-04/ECE_ENERGY_GE.3_2022_6.pdf

[20] INNOVEAS „Trainings for Small and Medium sized Enterprises", available at: https://innoveas.eu/

[21] SME Climate Hub, Available at https://smeclimatehub.org/

[22] GIP Green Industry Platform, Available at: https://www.greenindustryplatform.org/

VI. Detailed energy supply and storage-related considerations and recommendations

14. Expanding on section *IV. Towards more resilient energy systems: Summary of key recommendations for policymakers* above, the experts recommend the following actions and initiatives to scale renewable energy deployment across the ECE region:

a) **Accelerate the deployment of renewable energy** technologies (such as solar and wind). The policymakers should take advantage of the economic and environmental benefits of renewable energy technologies, including effective re-powering schemes and robust end-of-live scenarios to re-use scarce materials;

b) **Adopt UNFC and UNRMS as socially and environmentally focused standards** to comprehensively assess the renewable energy resource potential and integrate its development with other sectors. This should promote a nexus approach between water, food and energy security while managing the natural resource base in the region. The unique capability of UNFC and UNRMS to include social and environmental factors should be harnessed to support sustainable energy transitions;

c) **Encourage implementing distributed renewable energy generation** projects to minimize power transmission and distribution, and reduce transformation and grid losses. Micro-wind, hydro, geothermal and solar schemes could be an option in places where the environment is unsuitable for larger-scale installations. The development of flexible power and heat generation allows for a balance of variable generation profiles;

d) **Deploy decentralized smaller scale solar photovoltaic and solar thermal installations** on public, commercial, and private roofs to significantly accelerate the transformation of the energy system. If combined with various types of smart storage, it could create a buffer storage capacity removing an additional part of the burden from the transmission infrastructure and ease the pressure on scarce resources. This would also make the consumers more robust against outages and the price and supply shocks;

e) **Explore to what extent coal, in addition to gas, can be an effective short-term supplement** to intermittent solar and wind resources to deliver continuous electricity supplies in times of an uncertain gas supply.

f) **In the medium to long-term, demand-side flexibility and virtual storage provided by large energy consumers, as well as a variety of storage types (electric, mechanic, thermal, chemical), should be employe**d to decrease the need for fossil-based electricity or thermal generation in this role unless it can be made net-zero compatible by other means (i.e. carbon capture and storage, either directly or via direct air carbon dioxide removal);

g) **Develop an effective dispatch of variable generation** to match the load following the capability of the rest of the fleet. This could be a viable alternative to integrating renewable-based energy with highly flexible balancing resources. While taking steps to improve the flexibility of the balance of the system to minimize renewable curtailments;

h) **Scale renewable energy deployment through an integrated energy system approach**. Such approach connects electricity, heating and cooling systems. For example, wind- or solar-based electricity surplus would heat thermal storage tanks for district heating and supply heat to end-customers, along with waste heat from industry;

i) **Scale hydropower project development** which brings benefits associated with storage and operating flexibility for intermittent renewable energy integration. Some ECE countries (e.g. Tajikistan, Russian Federation) are abundant in untapped hydropower resources, and hydropower projects should be scaled to unlock the full potential in these countries while respecting high environmental and social standards. But before that, the existing hydropower infrastructure should be evaluated in terms of its capacity for expansion and opportunities for developing new reservoir-based generation plants across the ECE Region should be assessed. It should be noted that reliable operation is dependent on sufficient water supply which at present causes an issue to many hydro schemes across the ECE region due to extreme weather events, thus respective measures on ensuring operational resilience-by-design should be taken.

j) **Develop pumped hydro storage** as a potential vehicle for providing large scale electricity storage capacity to balance renewables. Depleted oil fields and abandoned mines may potentially be suitable and less intrusive locations worth exploring for pump hydro, other energy storage schemes, and district energy installations;

k) **Expand the transmission systems** to integrate increasing renewable energy and electrolyzers capacity into the grid network. Also, implement mechanisms to ensure that surplus renewable energy that the grid cannot absorb is stored and not wasted. Further extend interconnections between regional, national, and pan-regional grids to allow surplus energy to be feed through to areas with increased demand and to enhance the overall grid resilience.

15. The experts recommend the following actions and initiatives to scale biofuels and waste deployment across the ECE region, while considering the potential environmental impacts associated, including water depletion and pollution, soil degradation, nutrient depletion and the loss of wild and agricultural biodiversity and concurrence to food security:

a) **Deploy biofuels** such as corn ethanol or biogas to decarbonize the transport sector. However, land use economics, potential environment impacts, and trade-offs with food security, especially if fertilizer production is also to be affected by natural gas costs will need to be considered in that context;

b) **Develop** projects for combined heat, cold and power generation that use biomass and waste with carbon capture, use and storage (CCUS) to enable energy security and diversify supply and facilitate the circularity of the economies in municipalities and regions;

c) **Unlock the full potential of biomass and organic waste** in the energy system through the deployment of biofuels. Biomass and organic waste are well-positioned as feedstock for biogas and upgraded biomethane production, allow harnessing arising waste heat and increase resilience of energy supply as they are predominantly locally sourced. Both can be injected into the gas grid and utilized for multiple uses that range from combined heat & power (CHP) to heavy-duty transportation.

16. Until the full potential of low-carbon and renewable gases is unlocked and capitalized on, natural gas is likely to remain an important fuel enabling and driving energy transition. Experts recommend the following actions and initiatives to deploy natural gas and manage carbon and methane emissions across the ECE region:

a) **If renewable energy cannot satisfy the demand, increase oil and gas production from domestic sources**, which also includes increasing production at the depleting oil and gas reservoirs in the North Sea in the Western European context. Once fully exhausted, those reservoirs, where compatible, could be used for energy or carbon storage. This activity could be combined with CO_2 storage, either via Enhanced Oil Recovery (EOR) to increase the recovery of the oil in place or in depleted oil and fields once economic recovery is complete;

b) **Rethink European oil and gas production options**, including reinitiating the debate on fracking exploration sites where geologically unharmful (i.e., outwit seismic active areas), for the countries that support this technology, to enhance the security of supply;

c) **Explore the possibility and necessity of expanding the Liquified Natural Gas (LNG) import and export capacity** across the region. Developing LNG capacity and increasing the LNG fleet are required to meet the expected demand for LNG in countries having no or insufficient access to pipelines and gas storage. It will also need the expansion of interconnections to overcome supply chain bottlenecks and unlock the total capacity and versatility of the existing gas infrastructure, at the same time enhancing resilience and ability to react on regional shortages. Furthermore, the developed infrastructure could also be used for ammonia or hydrogen trade in the future, and CO_2 exports from regions without local geological storage;

d) **Explore possibilities for developing synthetic gas** and exploiting coal mine methane, abandoned mine methane, and coal-bed methane for power generation. Coal to synthetic gas is a proven but expensive technology that requires the deployment of emission reduction technologies to achieve net-zero emissions (as does natural gas, but to a different extent);

e) **Deploy CCUS technologies** to limit the carbon footprint of fossil fuel infrastructure and produce low-carbon gases, such as hydrogen from natural gas, biomass, or coal, with CCUS. Captured CO_2 might be shipped and stored into depleting oil and gas reservoirs through enhanced oil (and possibly gas) recovery processes, used as industrial gases or be converted into stone[23];

f) **Reduce fugitive emissions from natural gas** production and transmission to the lowest possible levels, following the best practice already demonstrated in leading countries in the ECE region. Doing this will increase the amounts of gas available to use as well as reduce methane emissions, with their high global warming potential.

18. Coal remains a widely used source of power generation across the ECE region. Uncontrolled emissions from fossil-based generation are incompatible with the set environmental goals. While coal, natural gas, and other fossil fuel use may be identified as a short-term solution to deliver energy security, its long-term role in the energy mix is questionable unless combined with carbon and methane emissions mitigation technologies along the whole value chain. Experts recommend the following technical actions to deploy clean coal projects and manage methane emissions in active and abandoned coal mines across the ECE region:

a) **Accelerate deployment of CCUS and high-efficiency low emission (HELE)** retrofit technologies on the existing coal-based generation infrastructure, especially in the countries across the ECE region where there are no other viable and quickly deployable other low- and zero-carbon alternatives;

b) **Ensure the effective management of fugitive methane emissions from coal mines**, including after mine closures. The capital and operating costs of projects to reduce methane emissions at coal mines are less than the costs of CCUS projects on a per tonne of CO_2e basis;

c) **Put in place regulatory and financial frameworks facilitating the development of coal mine methane (CMM), coal bed methane (CBM), abandoned mine methane (AMM), and CCUS projects.** Unblocking investments in the sector and providing funds for the deployment of the above-mentioned solutions would help to reduce the carbon footprint across the whole coal supply chain.

19. For countries that support nuclear, nuclear power generation can be a low-carbon source of energy and heat. In countries that decide to deploy nuclear power, it can play an important role in decarbonizing the energy system. Experts recommend, for those countries

[23] https://www.carbfix.com/

that support nuclear, the following technical actions to scale nuclear power deployment across the ECE region:

a) **Extend the operational lifetime of existing nuclear power reactors** that are structurally safe to improve regional energy security. The ECE countries that deploy nuclear power might want to reconsider the existing plans for the closure of their nuclear power stations to delay that process until the capacity of other zero- and low-carbon technologies is sufficient to fully cover the energy demand;

b) **Accelerate the development and deployment of advanced nuclear technologies for new nuclear reactors,** including small modular reactors (SMRs), to produce high-temperature heat and hydrogen. New nuclear power stations should be considered as long as they are safe and feasible (compliant). SMRs are safer, cheaper, and more efficient than conventional reactors. They could be deployed at scale to satisfy the energy needs in places where renewable energy sources alone cannot meet the demand.

20. Hydrogen that is already used as a chemical feedstock could also be used as an energy carrier and storage medium. Experts recommend the following technical actions to scale hydrogen projects and unlock their potential to decarbonize hard-to-abate sectors, such as long-haul transport, production of steel and chemicals, etc.

a) **Scale-up all low-carbon and renewable hydrogen production pathways** (fossil fuels with CCUS, pyrolysis of methane captured at coal mines, biomass with CCUS, or electrolysis from renewable energy or nuclear power, in countries that support it) to ramp up a regional hydrogen ecosystem;

b) **Develop a clear regulatory framework** and support mechanisms to scale up low-carbon and renewable hydrogen projects near to mid-term;

c) **Build on the existing natural gas infrastructure**. This would provide numerous operational and economic advantages, as most of it could be repurposed cost-effectively for transporting hydrogen instead of natural gas. Such adaptation would cost only a small fraction of the expenses that would otherwise be necessary for building a new hydrogen pipeline network.

d) **Prepare the demand side** to assess where and how a switch from natural gas or other forms of energy is feasible, encourage that gas fired combined heat and power installations are hydrogen ready and have upgrade kits for existing installations; further develop platforms where end-users, notably industry, can test and explore how their operations could be switched to hydrogen.

VII. Detailed regional technology innovation-related considerations and recommendations

21. Resilient energy systems in the ECE region will require continuous investments into research and development of all low- and zero-carbon technologies and sector-wide digitalization until the next generation of zero-carbon technologies is developed and ready to be commercialized. The countries should work together to exchange knowledge and experience to accelerate the development of all low- and zero-carbon technologies. Expanding on section *IV. Towards more resilient energy systems: Summary of key recommendations for policymakers* above, the experts recommend the following priorities related to regional technology innovation:

a) **Advance storage technology** (e.g., batteries) with extended lifetime capacity and rapid discharge rates for renewable integration;

b) Promote the availability of **social and environmental reference data** on primary and secondary (recycled) critical raw materials in the region based on

UNFC and UNRMS, which is required for effective planning and decision making;

c) **Advance efficiencies** across all supply-side technologies and support further development of all innovative solutions, such as CCUS, next generation of nuclear power (SMRs) (in those countries that support it) and low-carbon and renewable hydrogen;

d) **Develop digital controls and load management systems** focusing on security and strong controls around remote access and routable connectivity;

e) **Improve cyber security** of the supply chain of critical components, such as protective relays, transformers, and the operating technology software. Comply with supply risk management standards[24] that require the development of at least one documented supply chain cyber security risk management plan;

f) **Digitalize the electricity grid** based on opportunities associated with a broader energy system digitalization. Development of digital technologies, controls and digitally-enabled load management systems should continue with a focus on system-level security and consumers' privacy aspects.[25] This is likely to result in technical benefits, such as flexibility to integrate various decentralized resources, decentralization of operations, reduction of grid investments, a better understanding of the actual state of the network, greater flexibility in operations, automation, optimization, etc;

g) **Encourage 'open energy data'**, which is a crucial enabler to research, development, and demonstration of new technologies, business models and policy solutions to support flexibility and efficiency services;[26]

h) **Carbon capture and storage** in all its forms, be it direct capture of CO_2 at source, from the air, or as part of hydrogen production, is an emerging but widely applicable group of technologies. Research collaboration should be encouraged. Countries leading in practical deployment should make their legal, regulatory and technical experience as fully available to others as possible.

VIII. Cross-cutting technical considerations and recommendations

22. Attaining resilient energy systems for the ECE region that are energy secure, affordable and environmentally friendly would require the deployment of low- and zero-carbon technologies. For the region to succeed in this endeavour, the experts find that it will be necessary to: i) raise awareness and develop campaigns to inform all the stakeholders why the current energy system is fragile and what is necessary to develop a resilient energy system and how this can be achieved; ii) develop a clear regulatory framework and energy system design to allow all technologies to be deployed and integrated into such an energy system effectively, and iii) develop financing mechanisms and unlock both private and public funding.

23. Expanding on section *IV. Towards more resilient energy systems: Summary of key recommendations for policymakers* above, the experts identified the following **technical considerations and actions related to <u>awareness-raising</u>:**

a) **Establish the language which resonates with all the stakeholders**, taking into account the current crises and the resulting repercussions felt by stakeholders;

[24] CIP-013-1 – Cyber Security - Supply Chain Risk Management, NERC

[25] UNECE, "Digitalizing electricity systems" (ECE/ENERGY/GE.6/2022/4−ECE/ENERGY/GE.5/2022/4), Available at: https://unece.org/sed/documents/2022/07/session-documents/digitalization-accelerating-electricity-system

[26] UNECE, "Policy discussion - Challenges of big data and analytics-driven demand-side management" (GEEE-9/2022/INF.3), Available at: https://unece.org/sed/documents/2022/07/informal-documents/policy-discussion-challenges-big-data-and-analytics-driven

b) **Inform stakeholders** of the wide range of measures they can undertake at no or low cost **to tackle** so far **unnoticed and unnecessary inefficient energy consumption**. This will allow to realize short-term effects and develop their ability to use this knowledge to identify further opportunities to reduce and optimize energy demand.

c) **Ensure** that the stakeholders perceive the suggested measures as beneficial and that all the **stakeholders are familiar with all benefits and risks** associated with other low- and zero-carbon technologies and solutions;

d) **Create an environment that enables stakeholders to lose fear, remove mental roadblocks, gain confidence** to successfully implement the proposed solutions, and take individual action towards achieving the set goals;

e) Identify and apply the approaches that have proven **to boost stakeholders' competence and awareness levels** and thus led to widespread and decentralized uptake of the suggested solutions.

24. Experts identified the following **technical considerations and actions related to <u>regulatory frameworks & system design</u>:**

a) **Develop and implement clear, technically non-discriminatory regulatory frameworks f**or all zero- and low-carbon technologies required to deliver resilient energy systems in the region;

b) Promote a **nexus approach to managing the natural resource base** in the region with firm linkages to food, water and energy security, along with preservation of nature;[27]

c) Put **consistent policies and market frameworks, as well as plannability** across the region necessary to provide favourable investment signals and attract private finance for high capital cost projects;

d) **Review of the interconnection infrastructure across the region** is needed. Network design is technically highly complex and, therefore, the introduction of any changes to the existing structure should be carefully studied and well understood;

e) **Separate interconnections to isolate system disturbances** and prevent them from cascading;

f) **Ensure (cyber-) security by design, and circularity-by-design** are considered in all aspects and on all levels of the energy system transformation;

g) **Consider energy system integration** (ESI). The energy system's coordinated planning and operating (across multiple energy carriers, infrastructures, and consumption sectors) could promote efficiencies and enhance resource diversity and sharing;

h) **Study practical ways to ensure affordability** of energy in the ECE region by examining current regulations and tariffs, and identifying ways to enhance the cost effectiveness of energy production and delivery to end user.

25. The experts identified the following **technical considerations and actions related to <u>financing</u>:**

a) **Establish cooperation with the global financial community** on developing an investment framework that facilitates the development and deployment of all low- and zero-carbon technologies (including those focused on CCUS, capture and use or conversion of methane released during fossil fuel extraction, low-

[27] UNECE (2021) Natural Resource Nexuses in the ECE region https://unece.org/info/Sustainable-Energy/UNFC-and-Sustainable-Resource-Management/pub/355180

carbon and renewable hydrogen production, nuclear power (for those countries that support it), and renewable energy);

b) **Support development projects** with an appropriate risk-sharing structure and facilitate access to low-cost financing to accelerate the deployment of new innovative technologies;

c) **Develop climate and sustainable finance classifications** based on scientific and technology-neutral methodologies and support the transition to a low-carbon economy;

d) **Encourage the international financing institutions to recognize and provide access to the necessary financing** for CCUS, CMM, CBM and AMM projects, low-carbon and renewable hydrogen production pathways, and new generation nuclear projects in countries that support nuclear power;

e) **Inventory and evaluate current approaches to carbon pricing and energy subsidies in the ECE region** and beyond to identify improvements and best practices that could be applied in the ECE region, ensuring pricing incorporates externalities and that the market sends the appropriate signals to consumers and investors;

f) **Encourage the decision-makers and the end-users to make the investment decision**. In many instances, energy and decarbonization-related aspects of the project exceed the core area of work and experience of (financial) decision-makers, thus leading them to an over proportional perception of risk that effectively prevents investments even though the financial means are available.

IX. Next steps for Committee consideration

26. If ECE and its member States succeed in mobilizing widespread, bottom-up stakeholder action, the Bureaux of the Groups of Experts concluded that both the pace of decarbonization and the regional resilience will significantly increase. The Bureaux of the Groups of Experts recommended a continuation of ongoing activities related to the previous recommendations and identified several next steps that the Committee on Sustainable Energy might consider for strengthening the mobilization of efforts in the region. Specifically, the Bureaux suggested the Committee launch the **ECE Forum on Resilient Energy Systems** to coordinate efforts related to energy resilience across the ECE region and form strategic partnerships. The Forum would involve, but not be limited to, the following new or expanded activities:

a) **Host a series of dialogues on Resilient Energy Systems** to facilitate an exchange among member States, technical experts, industry and others on relevant topics identified by the Bureau, including the current challenges to resiliency, energy security, technical options, financing resilient energy systems and clean energy projects, lessons learned and best practices. These dialogues are intended to increase the capacity of ECE member States to attain more secure, affordable, and environmentally-friendly energy systems.

b) **Increase and target awareness raising activities to more explicitly consider resiliency** and to focus on the potential of low- and zero-carbon technologies and usage-related measures to deliver resilient energy systems that are more secure, affordable and environmentally friendly for the ECE region, including a focus on full life-cycle assessment, the cost-benefits analysis of all the technologies and of non-technical measures, and the potential impacts of technology and policy on economics, air quality, methane, climate change, health, energy security and resiliency.

c) Help significantly improve energy efficiency in the ECE region, among other by means of digital technologies, by hosting a technical and policy dialogue addressing matters related to implementation of energy efficiency measures in industry, transport, buildings, and other energy end-uses and the associated implications and requirements on the regulatory framework.

d) **Support an expanded Pathways to Sustainable Energy initiative** to facilitate the selection and implementation of effective policies across the ECE region, including targeted, country-specific deep dives on technology choices, business models and policy solutions that can build energy system resiliency and achieve short- and long-term energy, economic and environmental goals; This initiative could focus on Central Asia initially and then follow with other subregions as the interest arises.

e) **Expand efforts to reduce methane emissions,** increasing short-term energy supply with recovered methane and providing targeted support to member States in the ECE region to design and implement policies that increase energy supply in the short term by eliminating methane leaks, increase resiliency and support long-term methane mitigation goals, including of the Global Methane Pledge; **Co-host a Global Methane Forum** as part of the next Sustainable Energy Week to foster dialogue between member States and with other countries on best practices and promote the integration of resiliency considerations and goals into methane mitigation planning. This would expand the Committee's reach and fostering the replication of methane mitigation activities that build resilient energy systems and achieve greater energy security, affordability and environmental sustainability of energy systems in the ECE region

f) **Explore and increase understanding of climate financing** in the ECE region to identify policies and mechanisms that can leverage financing for climate change projects in the ECE region and enable the region to implement climate policies that increase energy system resiliency.

g) **Support a dialogue across a diverse set of relevant stakeholders in member States to substantially increase the uptake of renewable energy**. Renewable energy development, together with all the technologies, will be essential to deliver resilient energy systems while preserving the climate and the environment, and contributing to the attainment of the Sustainable Development goals.

h) **Increase engagement with other organizations, conferences, ministerials and initiatives working on similar or complementary objectives to integrate resiliency considerations**, including but not limited to the UN Framework Convention on Climate Change (UNFCCC) Conference of the Parties, the Clean Energy Ministerial, UN Development Programme, the World Economic Council, the Global Methane Initiative, the Global Methane Pledge, the UN Environment Programme, the UN Industrial Development Organization, the International Energy Agency to expand the reach of the Committee and leverage others' investments, providing greater support to the design and deployment of resilient energy systems that provide access to affordable, reliable, sustainable, and modern energy for all and that help reduce greenhouse gas emissions and the carbon footprint of the energy system in the region and support the transition to net zero greenhouse gas emissions.