United Nations ECE/ENERGY/GE.6/2024/4

# Economic and Social Council

Distr.: General
8 July 2024

Original: English

## Economic Commission for Europe

Committee on Sustainable Energy

**Group of Experts on Energy Efficiency**

**Eleventh session**
Geneva, 16–17 September 2024
Item 5 of the provisional agenda
**Supporting energy efficiency improvement and decarbonization in industry**

# Increasing energy resilience, saving costs, and curbing emissions with systemic efficiency approaches

## Note by the secretariat

*Summary*

The Task Force on Industrial Energy Efficiency of the Group of Experts on Energy Efficiency pursues an overarching objective to set in motion a process of effectively engaging policymakers and industry in a productive discussion and action to accelerate industry-led energy efficiency implementation based on a business case approach and the subsequent development of transformative polices to support and drive these actions.

In serving as a platform for expert dialogue that creates conducive environment for achieving a long-term ambition to enhance engagement between policymakers and industry, the Task Force Industrial Energy Efficiency, in cooperation with other Task Forces of the Group of Experts on Energy Efficiency, identified and articulated multiple interdependencies between the economic sectors that are deemed to be crucial for significant improvement of energy efficiency and contribution to climate change mitigation efforts. These resulted in the emergence of the notion of *systemic efficiency*.

This document leverages findings from the proceedings of the Group of Experts on Energy Efficiency to introduce the umbrella term of systemic efficiency as a holistic delivery mechanism that implies optimization of energy use across entire systems, considering the interconnectedness and synergism of various components and sectors rather than addressing them in isolation. It provides actionable insights on harnessing systemic efficiency to factor into energy resilience, lower energy costs, and reduced carbon footprint of the energy sector, and highlights the need for further collaborative research in this direction by the subsidiary bodies of the Committee on Sustainable Energy.

# I. Introduction

1. Systemic efficiency considers the interactions between different energy users and sources to maximize the benefits of energy savings, resilience, and emission reductions through clean electrification, efficient infrastructure, and digital technologies that integrate the sectors.

2. Systemic efficiency optimizes energy consumption within interconnected networks, such as electricity grids, transportation systems, industrial processes, and buildings. Yet, many current policies tend to approach individual sectors or established cross-sectoral ecosystems. While their integrated nature cannot be underestimated, integrated solutions are argued to provide for an impact which is greater than a sum of that of individual sectors, notably:

(a) Energy resilience: Enhancing energy resilience means creating energy systems that can withstand and quickly recover from disruptions, whether due to natural disasters, technical failures, or other external or internal factors. Systemic efficiency ensures that energy systems are more robust and adaptable by optimizing energy flows and incorporating redundancy and flexibility;

(b) Cost savings: Optimizing energy use at the system level can lead to substantial cost savings for consumers, businesses, and governments. By reducing waste and improving the efficiency of energy consumption, systemic approaches lower operational costs and extend the lifespan of energy infrastructure, reducing the need for costly upgrades and maintenance;

(c) Emission reductions: Systemic efficiency contributes significantly to emission reductions and thus combating climate change, by rationalizing energy use, decreasing the overall energy demand, and, among other, facilitating the integration of renewable energy sources.

# II. Prerequisites and applications of systemic efficiency

3. Systemic energy efficiency necessitates clarity about the aspired goal (e.g., net-zero, energy resilience, minimum dependency, future-proofness, a combination of these, etc.), input factors (e.g., natural resource endowment, infrastructure, dependencies and relationships, etc.), and knowledge of the current state.

4. Collaboration among diverse stakeholders is of the essence and shall go beyond technological solutions, also taking innovative business models, education and training, and behavioural aspects into consideration. Increasing energy resilience, saving costs, and reducing emissions are thus inextricably linked to the existing resources and to how effectively the interaction of the individual factors of a system (technical, economic, organizational, and human) are optimized.

5. In other words, a more integrated system catering for a larger optimization and circularity potentials, shall be the result of an adequately financed collaboration throughout the entire value chain, including in the form of public-private partnership, among such sectors as the built environment, mobility, providers of equipment and technology, energy utilities, and other actors. In many instances, this represents a significant change in current business models and value chains, including changing the material flows in raw materials supply chains, deployment of innovative technologies that help improve resource efficiency, measures to enhance energy efficiency, as well as stimulation for development of markets and building effective demand for low-carbon solutions.

6. In industrial sector, electrification of processes is an important step towards reducing carbon footprint of the use of fossil fuels in manufacturing, which in turn represents a set of challenges such as changing production processes. Electricity represents about a third of the industrial energy demand, and only a portion of it is argued to be renewables-based. In most

economies, neither the additional capacity to electrify the remaining two-thirds nor to serve it with non-electric renewables (e.g., biofuels) exist at present.[1]

7. In some cases, electrification might be more efficient (to, i.e., reach a certain temperature) considering conversion losses, while in others, a fuel switch to hydrogen might be. It is deemed particularly essential to guide and enable manufacturers with a high proportion of energy carriers apart from electricity in identifying what transformation path can work for them, giving what they already have on-site, what they need, and what is available in the surrounds, also in consideration of the future-proofness of both process and products manufactured – for instance with application platforms that allow testing various scenarios and whether hydrogen or electrification is the wiser choice.

8. For example, process heating and cooling, often fuelled by fossil fuels, account for almost three quarters of industrial energy consumption in some geographies, while the potentials of waste energy often remain unrecognized or neglected. Identification of such sources, however, needs to be differentiated from energy efficiency improvements.[2]

9. The success of energy efficiency programmes largely hinges on promotion and facilitation. While targeted support for enterprises is a crucial element for ensuring widespread ability of taking up systemic efficiency opportunities across businesses, building awareness and creating trust are of particular importance. This specifically applies to stakeholders who, catering for acute business-related issues, tend to not concern with energy efficiency and decarbonization. There, a frequent challenge is to overcome barriers of often prohibitive initial investments. Conversely, efficiency gains from addressing energy waste can happen at virtually no costs and deliver substantial reductions in energy costs.

10. As for storage and demand-side flexibility, earlier research underscores that there is a large variety of types of energy storage for different types of needs. It also underlines the relevance of interconnectors and sufficient capacities for both electricity and other forms of energy, in conjunction with utilizing end users' and backup energy providers' ability to adjust.[3] At both system and user level, the ability to adapt energy demand to an unstable supply and/or to use suitable storage types for one's own forms of energy and usage patterns, ensures a stable energy system and increases security of supply, proportional self-sufficiency in combination with local generation, and thus energy resilience of a stand-alone system. On an energy system level, interventions are clearly more complex and come at a much higher cost.

11. The general principle of systemic efficiency also applies to other areas such as built environment and infrastructure, where it shall be assumed that transportation is only required when a required product or service is not available in the immediate surroundings and the digital infrastructure cannot meet the need.

12. An illustrative example of a practical challenge on the path towards electrification, achieving net-zero, and systemic efficiency, for example, might be decarbonization of railway infrastructure. A costly, time-consuming, and requiring the route to be shut during the overhaul, it might prove non-reasonable financially it to electrify branch routes. However, technologies such as stationary superchargers for battery-electric trains located at interchange stations can help to bridge the gaps between the non-electrified branch lines and the electrified main lines, provided these can be largely served by locally generated renewables.

13. The key to the systemic efficiency are therefore interconnectors, local renewables-based generation, demand-side flexibility, and storage at the right locations, along with bottom-up information on the operations. Collection and interpretation of this data is largely reliant on digital technologies that enable the twin transition.

14. Digital approaches, including monitoring the consumption of all types of energy (electricity, heating, cooling, compressed air, oil, gas, coal, etc.), are the basis for detecting anomalies, identifying potential, optimizing use, and developing mix of measures to achieve systemic efficiency, while also having the potential to change end-user consumption patterns.

[1] See: ECE/ENERGY/GE.6/2023/5
[2] See: ECE/ENERGY/GE.6/2023/2, para 27
[3] See: ECE/ENERGY/GE.6/2023/6

For example, virtual power plants and digital twins represent a revolutionary shift in how electricity is generated, managed, distributed, and used. Unlike traditional power plants, which rely on a single large facility, virtual power plants aggregate multiple decentralized energy resources, such as household solar panels and battery storage systems, which are coordinated through advanced software to function as a unified power plant. The result is a flexible, reliable, and scalable energy solution that can respond dynamically to demand fluctuations and integrate seamlessly with renewable energy sources.

15. These solutions emerge as key enablers for optimizing energy systems, enhancing efficiency, and increasing resilience to offer transformative potential in reshaping the energy landscape including unlocking new revenue streams. The two technologies are state-of-the-art and powerful on their own, but their true potential for a cleaner, smarter, and more efficient energy ecosystem, lies in their integration as they are not just independent technological advancements: jointly, they enable simulation and planning tools for optimizing energy infrastructure, complex scenario planning and risk assessment, supply chain optimization, resource management, efficiency, and real-time data monitoring to track the performance and the social, economic, and environmental impacts of energy projects.

# III. Conclusions and recommendations

16. By viewing energy systems as interconnected wholes, systemic efficiency maximizes the benefits of energy optimization and supports the broader goals of sustainable energy. It will be a cornerstone in achieving sustainable and equitable energy systems moving towards a more resilient and low-carbon future where no one is left behind. Similarly to region-wide considerations, this applies for country, subregional, and company-specific considerations.[4]

17. Collaborative approaches to spatial planning and policymaking, combined with the application of innovative technologies and design supported by effective financing and favourable conditions in place, as well as the combination of efficiency, clean end-use electrification, active energy management, and integrated design can significantly reduce energy consumption and emissions in the economic sectors. Digital solutions need to become embedded into this chain to drive a connected, data-rich future that will enable more human-centred design. This involves:

(a) Early planning and strategic vision: sustainability and low-carbon opportunities shall be identified and harnessed as early as possible to realize the benefits of assets' integrated design;

(b) Going beyond independent projects: creating an ecosystem that delivers more than a sum of individual, isolated projects to harness multiple benefits;

(c) Accelerating twin transition in the energy sector: enabling data collection and analysis and the exchange of information between energy system actors to reduce waste, including notably energy waste, and enhance energy and resource efficiency.

18. Better awareness of system interactions is required, along with developing complex solutions that transcend individual disciplines. While technologies can be instrumental, their impact is contingent on affordability and accessibility. Even then, the 'unfamiliar' is often associated with a higher perceived risk, which is why changes, even when technical solutions are known, are difficult if the 'buy-in' of decision-makers is not gained.

19. The procurement of necessary resources, as well as skilled labour, prompts consideration of what constellation of technical, economic, social measures are required as foundation of reaching the aspired goal and of sustainable operations. This additional perspective underscores the urgency for systemic efficiency as a linchpin in global efforts toward a resilient and sustainable future.

[4] See: CSE-31/2022/INF.2 rev 1