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THE FUTURE-PROOF ARTIFICIAL INTELLIGENCE (AI) AND THE RESILIENT DIGITAL AND ENERGY INFRASTRUCTURE NEXUS

About 8000 data centers are worldwide (33% - the USA, 16% - the EU, 10% -China). Between 2017 and 2021 (EPRI, 2024), electricity used by Meta, Amazon, Microsoft, and Google for data center cloud computing doubled. In the USA, data centers will consume up to 9.1% of electricity annually by 2030 versus about 4% in 2024. The total ICT energy consumption in the world can rise from 2-3% up to 16% for the next decades. The growth of data centers and the adoption of artificial intelligence (AI) rely on the availability of electric power. Opportunities for investors in power infrastructure and adjacent sectors are quickly arisen. Electricity operating expenditures comprise about 20 percent of the total cost base for data center business models, which have proved highly profitable for large companies. The US government (gov) currently classifies AI as a national security issue (House, 2024). It also addresses additional sensitive security issues, including countering adversary use of AI. The EU targeted 75% of European enterprises to leverage cloud computing, big data, and AI to drive innovation and efficiency by 2030 (The European Commission, 2023). In 2024, the UA gov and the Ministry of Digital Transformation issued the concept (КОНЦЕПЦІЯ Державної цільової науково-технічної програми з використання технологій штучного інтелекту в пріоритетних галузях економіки на період до 2026 року, 2024), the road map (Ministry of Digital Transformation in Ukraine, 2023), and the white paper (Ministry of Digital Transformation in Ukraine, 2024) about the AI future. The special focus is on the state AI program for 2024-26, including legislation. The World Bank survey has shown that the ICT-energy nodes represent one of the key risks during the war.

Technical and engineering aspects embody a gap in the UA gov documents. The war in Ukraine increased the attention on ensuring energy security, affordability, and achieving the Paris climate goals (Energy Institute, 2024). Intriguingly, the BP Institute put energy security and affordability before or in line with attaining Paris climate goals. Ukraine reflects general trends with the war specific: the frequent outages in conflict zones and beyond. Because energy management for ICT systems has been a relatively underexplored topic in cases of wars and disruptions, it prioritizes the topic of ICT infrastructure resiliency in the energy system nexus.

Future-proofed AI and stable generation should balance immediate resilient digital and energy infrastructure nexus needs with future-proof AI needs and long-term sustainability development goals (SDG). Or (McKinsey, 2024) how can data centers and the energy sector sate AI’s power hunger? The answer lies in assessing data center energy efficiency and how they use electricity (HAI Stanford, 2024). There are three data centers’ hardware facilities depending on the age, configuration, type, and function: 1. IT equipment (servers, storage, network infrastructure), typically composing 40%–50% of data center energy consumption; 2. Cooling systems (HVAC), typically composing 30%–40% of data center energy consumption; 3. Auxiliary components (uninterruptible power supplies, security systems, and lighting), typically composing 10%–30% of data center energy consumption.

Intermediate nexus. Due to the war, diesel generators, energy storage systems, fuel cells, and microgrids are the leading technologies for powering ICT. The three stages of resilience are (i) preparedness, (ii) response and relief, and (iii) recovery and reconstruction within the context of energy resilience and anti-crisis tools. For managing electricity demand, there are mainly three strategies to support data centers (Ana Cabrera-Tobar et al., 2023):

1. Energy efficiency and increased flexibility refer to cooling, water, and types of powering. 2. Close coordination, sometimes convergence, between data center developers and electric companies regarding power needs, decentralized grids, timing, operational and financial flexibility, and constraints. 3. Simulating sustainable and resilient tools to plan the investments for grids considering the interactions and interdependencies between ICT and power suppliers and communities. The author could add substation protection, implement the NFPA (National Fire Protection Association) standards, physical-cyber resiliency, mitigate the supply chain disruption. Cross-disciplinary elements (Mykhailo Prazian, 2024): environmental, social, and governance (ESG) regulations, financials, legals, and skills-set can be considered for the nexus better off.

Future-proof powering AI implies using the ‘Power mix’**:** Nuclear track, renewable, oil, and gas. The professional community has witnessed big names such as Amazon, Google, Facebook, Microsoft, and others trying to establish direct lines with power companies, triggering a new era for nuclear energy, for example, with Three Mile Island (Microsoft). The Asia tech companies even considered coal a sustainable resource for AI powering. The top oil players, Exxcon-like, redirect their activism to forge new partnerships with tech giants. The big companies take this time as a big claim for the “AI cake or wedding.” (Elliott, 2024). Soluna computing (Soluna, 2024) proposed building an integrated energy ecosystem by establishing renewable energy as a foundation supplemented by nuclear power. It maximizes efficiency through co-location strategies and cooperation between tech companies, energy providers, and policymakers within a framework without compromising safety or environmental protection.

Conclusions. Focusing on the immediate nexus and interdependency between digital and energy infrastructure is necessary, but more is needed. At the strategic level, government, business, and society should foresee the place and growth of AI and digital infrastructure in the economic landscape. Ukraine's acute deficit of electricity and power makes the object’s nodes uneasy, but engineering and technological simulations of sustainable and resilient AI should be started without delay. The demand for power will emerge in the world (OECD, 2023). Stakeholders need to mitigate the risks of being behind the technological progress driven by AI.

All types of energy mix should be considered for sustainable power production: nuclear, oil and gas, renewable, and others. Future-proofed AI physical-cyber resiliency should be reached with appropriate policies, organizational, and business models, including convergence between ICT and energy units, supply chain reconsidering, and coping with technical, financial, and labor resource deficits.

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