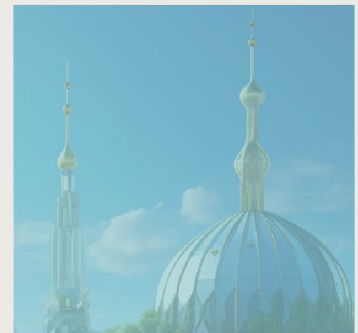
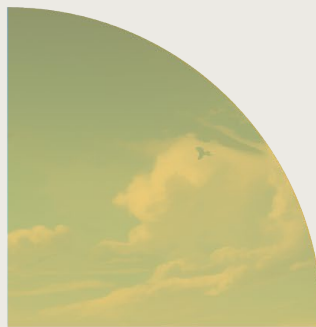


Industrial Applications



Roadmap for a climate-neutral,
sustainable Ukrainian energy sector
and its role in an integrated EU
energy market

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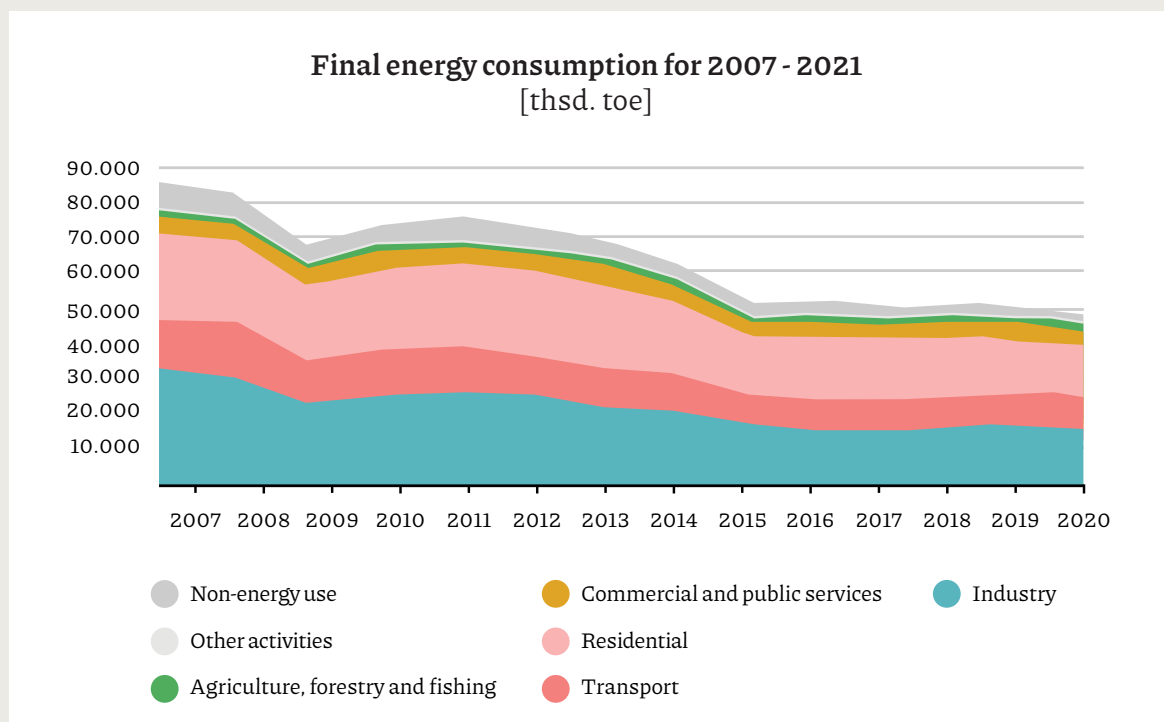
The industrial sector is the largest energy consumer in Ukraine. Products include ferrous metals, a wide range of heavy machinery, and many different chemicals, foods, and other products. The ultimate effects of the ongoing war, not least in the industrial heartland of the Donetsk Basin, are difficult to predict, and it is not clear to what extent and under which circumstances the manufacturing sector can be rebuilt or established

again in a shape that is efficient and competitive in the global markets. As in other sectors, however, the destruction caused by the war offers a chance to start fresh by applying innovative methods and procedures and boosting productivity and prosperity while reducing environmental and climate effects. This section looks at manufacturing and hydrogen applications separately.

Manufacturing

As shown below, the energy consumption of the industrial sector in Ukraine has been steadily decreasing over the years due to deindustrialization and economic decline. According to the State Statistic Service of Ukraine, the industrial sector consumed almost 16 million tons of oil equivalent

(mtoe) in 2020, of which iron and steel production accounted for over 8 mtoe. The most common energy sources are coal, peat, and natural gas, while biofuels, waste, and direct electricity (which is partly renewable) account for only a small part of the energy consumed.



Development of final energy consumption by sector in Ukraine (excluding occupied areas) in million tons of oil equivalent from 2007 to 2021
Source: State Statistics Service of Ukraine.

Manufacturing plays a pivotal role in the Ukrainian economy, contributing significantly to both productivity and revenue generation. The production of cast iron, rolled steel, and steel pipes takes place primarily in the Donetsk Basin, the country's industrial heartland (which has been occupied by Russia for almost a decade). There is also a great deal of heavy industries manufacturing vehicles, generators, turbines, and other equipment and machinery. The country's strong agricultural sector is supported by numerous processing plants.

Manufacturing applications are characterized by wide variation in the type and quantity of energy required. Industrial processes can require low-grade heat, high-grade heat, cooling, kinetic energy for motors and similar processes, energy for chemical processes, or electricity for applications such as computers or lighting. Leveraging innovation in energy to achieve a more vibrant, dynamic, and competitive industrial sector is therefore associated with a range of challenges.

The sector comprises a number of state-owned enterprises, many of which are inoperative (being in territories occupied during the Russian aggression) or inefficient and unprofitable. The Ukrainian government plans to privatize or wind down

Recommendations

Ukraine's progress towards a vibrant and dynamic industrial sector based on innovative technologies and methods hinges on wise choices during its reconstruction. From an energy perspective, the country needs to establish **renewable-energy sources as the backbone of the energy supply** and ensure a **streamlined legal environment** that facilitates a dynamic and resourceful industrial renaissance, not least by implementing a **robust greenhouse-gas emissions certification scheme** to guide and accelerate the path towards achieving net-zero emissions in a way that is **cost-effective** and **technology-oriented** and conforms with **market principles**. It would also help **allocate scarce resources** transparently and proficiently, **strengthen energy-efficiency measures**, and **safeguard against waste**.

In the near term, Ukraine must prioritize the rebuilding and reconstruction of destroyed energy infrastructure using the best available technologies that minimize greenhouse-gas emissions.

most of these. Realistically, reconstruction will depend largely on decisions and transitions undertaken by private-sector operators in an uncertain timeframe. The Ukrainian government and its partners will therefore foster the decarbonization of manufacturing through regulation and supportive measures rather than direct operational decisions.

One example of a constructive initiative is the Coalition for the Green Recovery of the iron and steel sector, a program by the Government of Ukraine that Breakthrough Energy is helping set up and operate. The coalition aims to develop a pipeline of investment projects, address financial and policy issues, and facilitate coordination among stakeholders and with other recovery initiatives in the country. This will help Ukraine make the most of its existing assets in terms of infrastructure, expertise, and raw materials, and establish dynamic green steel industries by leveraging smart investment choices.

Ukraine can become a global leader in green iron and steel, and build a revitalized industrial sector that provides plenty of quality employment while supporting Europe's industrial and climate goals.

The Ukrainian authorities should, wherever possible, also include **climate and sustainability considerations** in their privatization plans (the exact definitions depending on the given industry sectors). Special care should be given to **iron and steel production**, which are particularly important to Ukraine's economy but have high energy consumption.

Combined heat and power (CHP) plants should be explicitly included in medium and long-term strategies and considered in the relevant cost-benefit analyses as an efficient measure to balance the grid system or during capacity shortages. The government should see to it that **no lock-in effects** occur with CHP plants that initially operate with fossil energy carriers – CHP plants should be planned to eventually use **hydrogen or similar** energy carriers. Regulations should be implemented to support the use of sustainable bioenergy originating in residual materials and waste, improving economic circularity. Eventually, CHP

plants can be retrofitted for use with more renewable-energy carriers.

Given its EU candidacy, Ukraine must join **the EU's emissions trading scheme (ETS)** or develop **its own carbon-pricing system**. Both options have economic implications that need careful evaluation. Joining the ETS is a shortcut to high standards but requires adjusting to demanding EU policies. Establishing a national scheme would offer more flexibility but less access to European markets. Strengthening the efficiency of the sector is vital for both options. Considering circumstances post-war, it may be prudent to introduce a **gradual and phased approach** to avoid overburdening the industrial sector.

Transition bonds can be used as a debt instrument for projects that enhance energy efficiency,

Hydrogen

Hydrogen and its derivatives will be essential in the future energy mix required to achieve a prosperous, technologically advanced future and energy independence for Ukraine. Europe's energy transition, for instance, foresees large-scale production and use of hydrogen – and given European climate goals, this may eventually largely have to be renewable or climate-neutral hydrogen, that is, hydrogen produced through electrolysis powered by renewable solar, wind or hydro energy. Pink (made through nuclear-powered electrolysis) and blue (made with fossil-powered electrolysis with carbon capture) hydrogen are, however, also admissible under EU rules, and likely to remain so indefinitely.

- governmental subsidies and incentives, e. g. grants or tax incentives to promote hydrogen projects, especially those focusing on green hydrogen production from renewable sources;
- public-private partnerships, which help mitigate risks and provide access to government resources;
- green bonds, which are especially favorable for investors looking to support sustainable-energy projects; and
- hydrogen-investment funds specifically focusing on hydrogen-related projects to provide financing and expertise in the hydrogen sector.

No large-scale hydrogen production projects will come on stream within the first few years after the war in Ukraine ends. However – as with the energy

reduce emissions, or support renewable-energy adoption in their operations. Leveraging **government grants and incentives** can help reduce the financial burden of deploying inventive new methods and technologies, as well as energy-transition initiatives.

A legal basis should be established for an **energy exchange**, giving energy-market participants access to transparent liquidity, standardized contracts, and centralized clearing, There should also be a legal framework that makes it easier for industrial enterprises to run **small-scale renewable-power plants** to meet their own demand. A circular-economy law should also be adopted to promote sustainable **resource management and supply chains**, not least when it comes to batteries. This would help promote **greater investment, transparency, and sustainability in critical industries**.

The production of hydrogen requires great amounts of energy. Ukraine has plenty of renewable-energy resources compared to its European peers. The country may also have spare nuclear-power capacity which can be used to keep electrolyzers running when general demand for electricity is low.

The choice of financial instruments for hydrogen projects depends on the specific technology, scale, and market conditions. The following instruments show promise in the financing of hydrogen projects in a Ukrainian context:

transition in general – it is important that no path dependencies be created during this time that might prevent the later deployment of innovative

solutions and technologies. To give just an example from the steel industry, the lifetime of a blast furnace – that is, the period until its refractory lin-

ing needs to be completely renewed – is around 15-20 years. Other plant components can have even longer lifetimes.

Recommendations

It is important for Ukraine to design projects and establish partnerships between domestic hydrogen producers and buyers as well as between domestic hydrogen producers and international buyers – a global market for hydrogen does not yet exist, but is emerging. This applies to **political agreements as well as concrete partnerships** and projects at company level. Declarations of intent should gradually be backed up with concrete project approaches so as to **build a project pipeline** during the period right after the end of the war.

In addition, renewable-energy generation must be expanded, as this is the main bottleneck of hydrogen production. The first pilot projects involving the production and deployment of hydrogen should be carried out soon after the end of the war to build up expertise. Above all, Ukraine's long-standing expertise in European **gas transport should be harnessed** for possible export ambitions. It is crucial that the country be continuously guided by **European requirements**, ensuring that products are **qualified for export** to the EU. Specific measures for the near term include:

- adapting regulations and incentives to foster innovation and investments into **hydrogen infrastructure**;
- preparing **licensing authorities for new technologies, allowing them to implement appropriate processes and train employees in a timely manner**;
- connecting with European transmission-system operators and fostering knowledge transfer; and
- carrying out cost-benefit analyses and plans for **making gas infrastructure hydrogen ready**.

In the medium and longer term, the first **blast furnaces** should be converted to **direct reduction** with hydrogen, creating know-how that can be transferred to other plants. Partnerships between hydrogen producers and the steel industry should be intensified and binding contracts concluded.

In **road transport**, too, the use of hydrogen or its derivatives should be ramped up where there is no alternative. And the **ammonia industry** – for which hydrogen is a major feedstock – should be gradually decarbonized, making it ready for export to the rest of Europe.