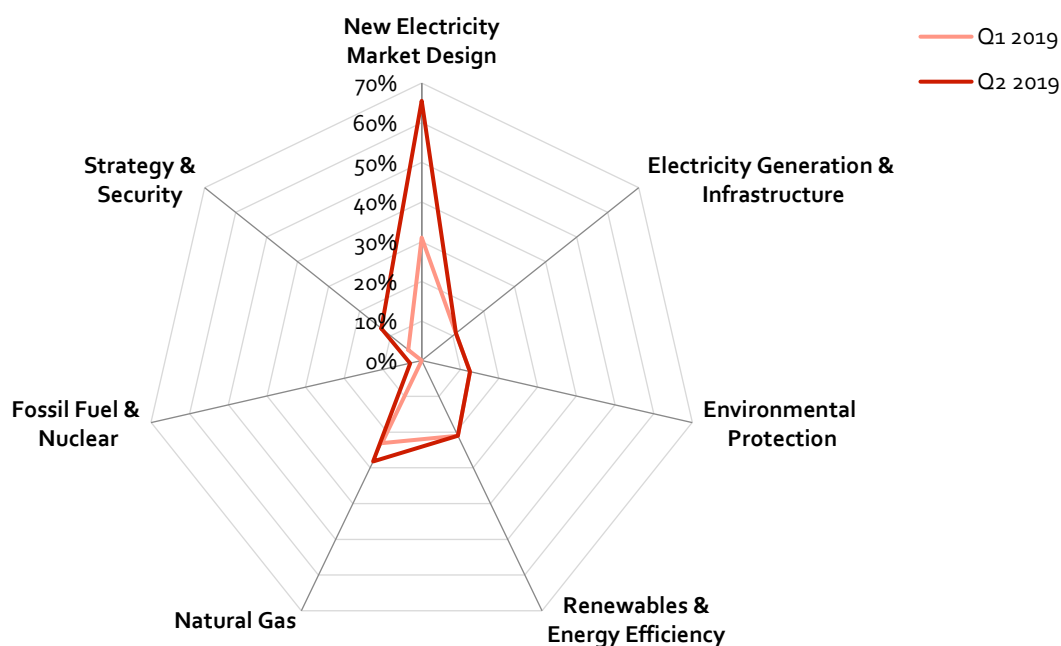


Quarterly Monitoring Report on the Implementation of Ukraine's Energy Action Plan

August 2019



Executive Summary

The most important development relevant to the implementation of the Energy Strategy in the last month was the election of a new President and a new Parliament. Correspondingly, we exceptionally dedicate two pages of this report on providing our view what we see as priorities for the **new administration**. Our five priorities are (1) Make gas and electricity markets competitive; (2) Increase the share of renewables, (3) Facilitating structural change in the coal sector and coal regions, (4) Raise investments in the energy infrastructure, (5) Further increase energy efficiency in the residential sector.

The other big event was the opening of the new electricity wholesale market. This is an eventful process which we follow in more detail in our **Monitor of Electricity Market Opening (MEMO)** series. LCU's general assessment is that the transparency of activities on the regulated segments is a good start, but that the current rules establish a complex series of segments with administratively fixed prices. As long as structural issues such as cross-subsidisation and market power are not resolved – the market will not function to the long-term benefit of Ukrainian consumers.

Finally, we argue that a quick and cheap way to enable the integration of higher shares of renewables and ensure system stability is to allow the transmission system operator to temporarily reduce the output of wind and solar plants (so called **curtailment**).

In this Quarterly Monitoring Report we exceptionally analyse the developments of the past four month (April-July).

Assessment by Sector

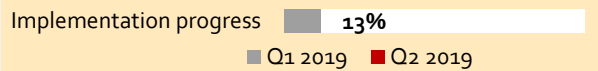
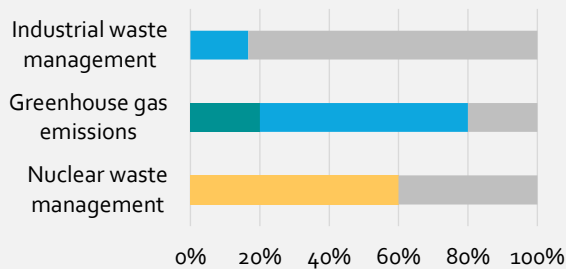
About the Assessment

IN this quarterly monitoring report, we assess Ukraine's progress on implementing the Action Plan measures for the Energy Strategy of Ukraine until 2035 (ESU). We grouped 206 actions into **seven sectors** and rated their status of implementation: completed, in political process (e.g., being discussed or provisionally adopted), overdue, or scheduled for a later date. Completed actions are classified as serving or not serving the purpose, i.e., whether or not they contribute to achieving the goals laid out in the Energy Strategy of Ukraine until 2035. The report and additional material will be made available online at www.LowCarbonUkraine.com.

Legend

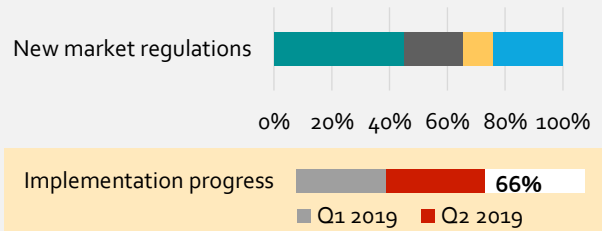
- Completed and serving the purpose of the ESU
- Completed but not serving the ESU's purpose
- In the political process
- Overdue
- Scheduled for later

Environmental Protection



Ukraine's government approved two concepts for state programs on **nuclear waste**, in particular the concept for a government program on **used nuclear fuel** for the period until 2024 (on June 5) and the concept for the environmental government program on the **decommissioning of uranium facilities** in 2019-2023 (on April 24). The CoM considered the possibility of postponing the implementation of the **National Emission Reductions Plan** for large combustion plants for 2018-2033 from two to four years due to the reduction of electricity produced by thermal power plants in the last years. The draft laws 9253 "On principles of GHG emissions monitoring, reporting and verification" and 9082 "On Ozone Depleting Substances and Fluorinated Greenhouse Gases" are waiting for the second reading in the Verkhovna Rada. The work on updating Ukraine's **NDCs** is ongoing, with a methodology approved by the EBRD.

New Electricity Market Design

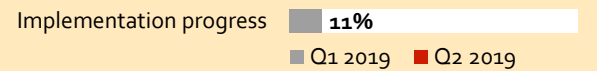
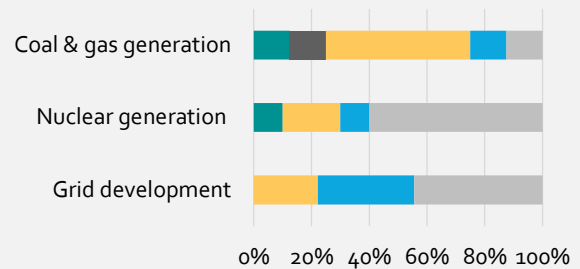


The **new electricity market model** (with the exception of ancillary services) was launched on July 1, with lots of regulations prepared on short notice. Initial **technical issues** with the electronic trading platform were fixed. The **public service obligations mechanism** adopted by the Cabinet of Ministers (CoM) rules that 90% of Energoatom's and 20% of Ukrhydroenergo's electricity must be sold on regulated auctions, thus restricting competition and leading to higher non-household electricity prices. The regulator has set **bidding caps** on the day-ahead and intraday market to avoid a surge in prices. During the first month, prices aligned to these caps, and industrial consumers claim a significant increase in electricity cost.

Ukrenergo was registered as a state-owned **Private Joint-Stock Company** which is a necessary step to be certified as an independent transmission system operator (TSO).

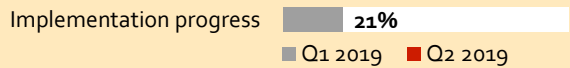
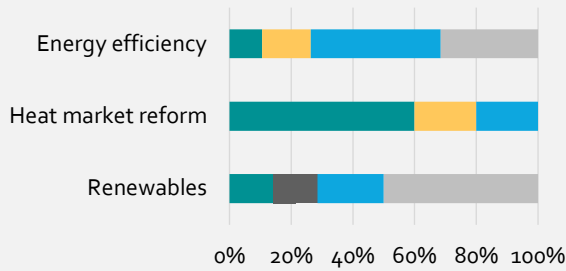
For details see LCU's Monitor of Electricity Market Opening.

Electricity Generation & Infrastructure



Ukrenergo launched the construction of a new **fiber-optic communication line**, repair works for power lines in the Zakhidna power system as well as the modernisation and/or installation of transformers at the "Rivne", "Poltava", and "Kremenchuk" substations. The CoM decided to seek a EUR 149 mln **loan from EBRD** for transmission network modernisation. The **Ten-year network development plan for 2020-2029** was publicly discussed but is not yet adopted. Ukrenergo initiated a discussion on the construction of the DC back-to-back converter station between Ukraine's main power system and the **Burshtynska TPP Island** (which is connected to the EU system). Some TPP and combined heat and power units took part in preparatory measures for Ukraine's **ENTSO-E integration**. Zaporizka, Yuznnonukrainska and Rivnenska nuclear power plants passed the **nuclear security international monitoring inspections**.

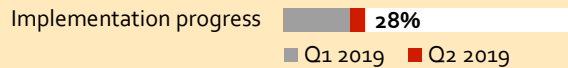
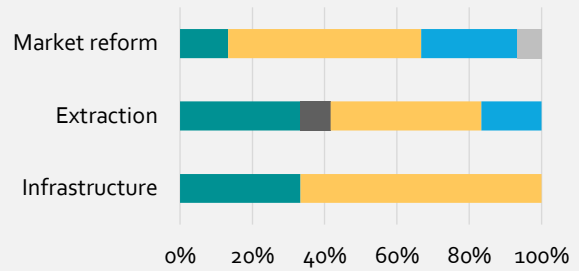
Renewables & Energy Efficiency



The law 2712-VIII introducing **auctions for renewables (RES)** was signed by the President on May, 18. The Ministry of Energy and Coal Industry created working groups to start the development of the **National Energy and Climate Plan** until 2030.

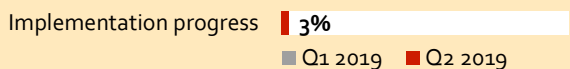
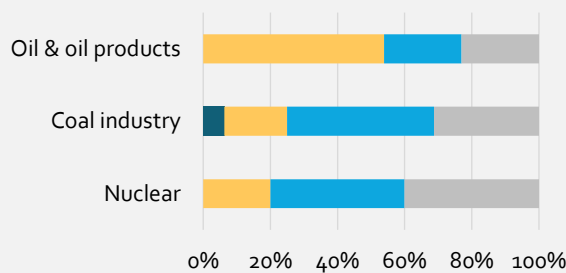
The CoM adopted a resolution on the **monetisation of benefits** in housing and utilities which will take effect from October 1. Regional and municipal authorities gradually adopted acts on implementing regional/municipal energy management systems as well as updated regional energy efficiency (energy saving) programs.

Natural Gas



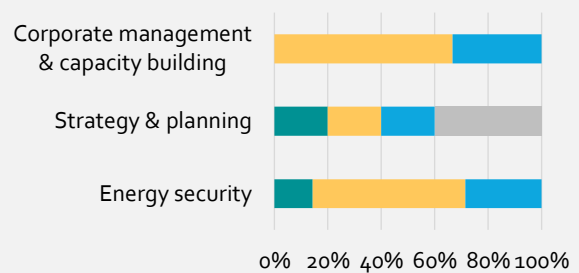
The CoM has updated its **unbundling plan**, reinforcing its commitment to ownership unbundling (with MGU to become the new TSO). The regulator adopted amendments to network codes and regulations, including those on **short-haul services**, and also published a draft **entry/exit transmission tariffs methodology**. The Ministry of Energy published draft amendments to the Gas Market Law on exchange trade, but liquidity is still limited to the market's commercial segment, as households are supplied under PSO. **E-auctions and PSA competitions** were successfully held. Also, **mining allotments** for the oil & gas industry were finally lifted. The launch of an **e-service platform for subsoil users** was officially announced but the development of a New Subsoil Code was postponed to end-2019.

Fossil Fuels & Nuclear



The Ministry of Energy presented draft concepts on **oil and gas refining, crude oil supply and transit** as well as on the **oil transmission system**. An inception report was prepared on the construction of **new refining facilities**. There is significant delay in approving the draft law on creating **minimum stocks** of crude oil and petroleum products. The restructuring of **SOEs** in the coal sector continues and the process of big privatisation (incl. Krasnolymanska mine) was unblocked. Yet, no tangible solutions were adopted for settling the **growing debts** to the electricity supplier of last resort. The Ministry of Energy published the draft **Program for Nuclear Industry Development by 2024**. The CoM conditionally approved the merger of SkhidGZK with Energoatom.

Security, Strategy & Governance



Corporate governance reform is moving slow, with the Ukrhydroenergo supervisory board now elected. The system for short-term energy balance forecasting is not yet developed. The Ministry of Energy approved the **Energy Strategy** action plan (stage one) with **monthly reporting** and a final report in 2020. It has also started a public discussion of the draft law **"On Basics of Energy Security"**. The UAEITI report was rescheduled to autumn 2019. The Anti-Monopoly Committee (AMCU) continues to build the **State Aid** portal, while the draft CoM resolution on state aid eligibility in the coal sector is pending approval. As to **cyber security**, the draft law "On Critical Infrastructure and its Protection" was registered.

Key Developments in Ukraine's Energy Sector

Constitutional Court decision on NEURC-law provisions

AFTER reviewing the complaint submitted by 46 MPs back in December 2016, the Constitutional Court (CC) ruled on June 13 that some provisions of NEURC law regulating the regulator's independence – as required by the EU directives – and its formation do not comply with constitution. These provisions shall become invalid from December 31, 2019.

According to the CC ruling, NEURC is an executive authority. Hence, its activities should have been subordinated to the CoM. Fundamental principles laid down in the Third Energy Package are therefore put at risk: legal distinction and functional independence (no direct instructions from any government or other public entity), financial independence (budget not requiring approval by another public body, and autonomy in the implementation, with adequate human and financial resources), and effective binding nature of decisions (no approval or registration by another public body). In addition, in the case of transferring NEURC to the executive, a conflict of interest might emerge as some of its licensees are subordinated to the Cabinet of Ministers or certain ministries.

Given the important role NEURC plays in the transition to new market models, including market monitoring and certification of TSOs, the regulator's independence has to be maintained. We would recommend to revise NEURC's scope of responsibilities (e.g. to enforce "REMIT light"), relations with other regulators and authorities (to ensure decision-making independence), structure and set-up, ensure full financial independence and effective binding nature of decisions. For this purpose, amendments to the law on NEURC focusing on the selection processes and basic guarantees of independence might not be sufficient.

A comprehensive regulatory reform could require amendments to the Constitution – for the creation of a separate chapter on independent bodies, and thus a consistent framework to secure regulatory independence in compliance with the EU acquis. As necessary amendments might not be completed before February 2020 (second session of the new Rada), the implementation deadline set by the CC appears difficult to meet.

Issues on the gas market - unbundling and PSO

The government has updated the resolution on unbundling, reinforcing its decision on ownership unbundling and setting new deadlines. According to the updated plan, by August 1, 2019, Naftogaz shall submit a draft act on assigning MGU with the management rights for the assets accounted on the balance sheet of Ukrtransgaz (pipelines, compressor stations, storage facilities, etc.) to the CoM. The Ministry of Economic Development, the Ministry of Energy and the State Property Fund are responsible for transferring this property to the MGU balance sheet. Thereafter, the government plans to temporarily transfer MGU corporate governance rights to Naftogaz, while providing for the unconditional return of these rights to the Ministry of Energy from January 1, 2020.

However, despite submitting an updated unbundling action plan to the CoM, Naftogaz continues to publicly support the

ISO model. From July 1, it has transferred the technical functions of the gas transmission system from Ukrtransgaz to its branch Gas TSO LLC. This company will operate as a separate legal entity under Ukrtransgaz by December 31, 2019, and – according to Naftogaz – shall be subject to preliminary certification by NEURC and the Energy Community Secretariat. On January 1, 2020, Gas TSO LLC will be transferred from Naftogaz to "the organisation authorised by the CoM". This leads to the conclusion that the CoM-Naftogaz conflict on TSO unbundling has not been settled yet.

On June 5, the CoM also approved changes to the mechanism for setting regulated gas prices for households and district heating companies under PSO. Naftogaz shall use a new algorithm for determining the wholesale price, using the minimum value among the four "benchmarks": 1) average customs value of imported gas in the previous month, 2) weighted average price of month-ahead exchange trade, 3) average price for industry (under advance payment) in the previous month, 4) price under the PSO formula, i.e. Naftogaz average price for July-September 2018 with discount.

Despite setting some kind of market-based price benchmarks, the PSO regime still restricts competition due to provisions designating specific retailers (suppliers affiliated to distribution system operator) and setting revenue caps. In addition, winter gas prices under PSO would be below market level anyway (reflecting market level only in off-heating season).

Launch of the NECP development process

As a member of the Energy Community, Ukraine has committed to develop an integrated National Energy and Climate Plan (NECP) that will cover the five Energy Union dimensions for the period 2021 to 2030 with a perspective up to 2050. To start the NECP working process, the project Low Carbon Ukraine organized in coordination with the responsible Ministry of Energy and Coal Industry a kick-off meeting on May 22 in Kiev with high-ranking officials from the Ministry of Energy, the Ministry of Ecology and Natural Resources and the State Agency of Energy Efficiency (SAEE).

Janez Kopač, Director of the Energy Community Secretariat, outlined the goals, timeline and recommended development methodology for the NECP. He pointed out that the NECP shall enhance the development of more strategic energy and climate policy, in this sense serving as a master strategic and planning document. Thereby, it is meant to ensure consistency with relevant long-term policy objectives at EU, UNFCCC and Energy Community level and thus opens the possibility to add more ambitious targets and actions. Based on a reference scenario (for state-of-play policy) and future policy scenarios, the NECP will allow for the first time to project joint outcomes of existing and planned strategies and measurements. Low Carbon Ukraine has offered to the Ukrainian side its support for modelling and the development of the required future scenarios. The drafting process has to be accompanied by stakeholder consultations.

In July, the Ministry of Energy set up eight dedicated working groups of experts. The initial meeting is to be held in August.

Energy and Climate Policy Priorities for the New Administration

UKRAINE has elected a new president, a new parliament and will soon have a new government. This provides an opportunity for new momentum in energy and climate policy. As there is no shortage of issues that need to be taken care of, we have drawn up a list where we see the priorities for energy and climate policies in the next legislature. What we have in mind is not an unrealistic revolution that questions all past strategic decisions, but a number of effective actions that are realistic to be achieved by determined administration until 2024.

Make gas and electricity markets competitive

Why: Well-functioning markets for electricity and gas will improve investment, operation and consumption decisions of all market actors reducing costs and thus lead to lower prices for companies and the population. Furthermore, they are a prerequisite for closer cooperation with the EU. Ensuring the integration of Ukraine's power system into the ENTSO-E system will foster competition (leading to lower prices) and improve energy security.

2024 target: Full implementation of target market schemes and market-based pricing for all consumers. Overall, the new administration should assume leadership in the market reform process (which is currently driven by interested companies) in order to ensure solutions that are good for Ukraine as a whole.

How: In the gas market, the new administration should enforce full ownership unbundling of the gas transportation system from other gas sector activities to ensure that new firms are able to access the network infrastructure. This entails a conditional certification of the new TSO by January 1, 2020.

In the electricity market, the new administration should enforce a true separation of distribution from other electricity sector activities (unbundling). Furthermore, the administration needs to devise credible mechanisms to curb market power of generators (including strict market power monitoring, effective penalties for market power abuses, sale of Centrenergy to a non-incumbent player, examine enforced divestment of incumbents, opening of cross-border trade, ...). This will lead to true competition and allow to gradually remove price caps. In addition, the compensation mechanisms (PSO, feed-in tariffs) should be monetised. Finally, ENTSO-E integration should become a strategic – and well-resourced – target of Ukraine.

Increase share of RES

Why: Increasing renewable energy is not an end in itself. Instead, renewable energy sources offer a cost-effective way of replacing old, delapidated electricity production which has to be decommissioned over the next years. By doing so, RES can help Ukraine to become less reliant on energy imports – including from Russia – and thus increase its energy security. Finally, RES may increase competition in the energy sector – assuming not only existing players invest in RES capacity.

2024 target: The objective of the government is to provide good framework conditions for investments in RES to take place. Formulating medium-term targets (such as a 25% share in TPES and over 25% in gross electricity generation by 2035) are useful to guide action and measures if RES uptake is on track.

How: One of the important tasks is to make sure that Ukraine's power system can cope with increasing RES. Here, a first step should be the roll-out of the auction support scheme under the new legislation enacted in 2019 in a way that stimulates competition. Auctions and other measures should optimise RES deployment in terms of technology, size and location in order to increase the RES absorption capacity power system. Increasing the capacity to absorb RES will also require other improvements such as well-targeted network reinforcements as well as balancing and storage capacities, fair network access rules, high-accuracy load and weather forecasting etc. The update of the National Renewable Action Plan due in 2019 provides a good opportunity to develop a consistent plan for the interacting measure.

Facilitating structural change in the coal sector and coal regions

Why: Despite high subsidies, Ukrainian coal production is losing competitiveness and production has been declining for years. Amidst an increasing importance of other energy sources including renewable energy and possible carbon pricing, this trend is likely to continue and even accelerate. Although the overall economic importance of coal is moderate, coal extraction still accounts for a significant share of employment in some regions. Thus, there is a need to smoothen and facilitate the inevitable transition in order to avoid economic hardship for the affected communities and ensure that alternative employment options are created.

2024 target: The inevitable structural change resulting from declining importance of the coal industry requires a high-level policy response. Such a response has to assist affected regions with suitable policies in order to replace coal production with economic activity in other sectors and reduce the economic costs of the transition.

How: The basis for the transformation of the coal sector should be a strategy and an accompanying action plan; all developed together with all relevant stakeholders. On the one hand, the strategy needs to set a time-line for a gradual reduction of coal subsidies and establish a transparent coal market. It also has to specify how to restructure state-owned coal enterprises and, importantly, formulate criteria in order to identify which mines have to be closed and when. This needs to be flanked by measures which help those regions and people most affected by declining coal production in order for as many jobs as possible to move to more future oriented industries. Pilot projects could be used in order to test and replicate measures.

Raise investments in energy infrastructure

Why: For decades, affordable prices were secured at the cost of underinvesting in critical infrastructure. As a result, gas and electricity grids, production and generation facilities, storages, heating networks and other crucial infrastructure are often decayed. This comes at the cost of frequent shutdowns, power or supply failures and high transmission losses especially in the heat sector. Old electricity grids are not able to cope with increased renewables which have a large role to play when replacing old generation infrastructure.

2024 target: Provide the right framework conditions for both private and public operators in the energy sector to have incentives and means to invest.

How: A first step should be introducing cost-reflective tariffs for TSOs and DSOs in gas and electricity, as well as municipal heating systems along with strengthening regulatory oversight over their implementation. Those new tariff models have to promote efficiency and capital investments, rather than just ensuring higher revenues, so the regulatory regime has to include specific performance indicators for operators. Further, the administration should pursue a full and effective implementation of the National Emissions Reduction Plan so generators are forced to carry out the needed investments in order to comply with target levels of SO₂, NO_x and PM emission.

Further increase energy efficiency in the residential sector

Why: About half of the Ukrainian population lives in 240.000 multi-storage residential buildings from Soviet times. Up to 80% of those houses urgently need energetic refurbishment to reduce the tremendous energy losses (Ukraine's heating consumption is twice as high as in climatically comparable EU countries). After subsidies have been cut over the last years, energy costs predictably skyrocketed, partly being compensated for vulnerable consumers.

2024 target: Enable all affected parties – from housing associations to companies that offer modernization services – to successfully implement refurbishment projects to measurably reduce energy consumption. Ensure the successful energetic modernization of first typical large neighbourhoods, that serve as a model for Ukraine-wide energetic refurbishments.

How: First steps include reaching full commercial metering of gas and heat supply to households. Energy Efficiency Fund products for housing associations and individual households have to be further developed and offered at large scale, while funding schemes should be closely connected to comprehensive modernization concepts, integrating the neighbourhoods and district heating systems. All municipalities and communities have to establish energy management and monitoring systems. Progress in this field also means elimination of all subsidies and benefits, with vulnerable consumers to be protected by means of monetized social support. To successfully implement energetic refurbishment projects, Ukraine needs a massive qualification campaign for technical experts, that includes quality assuring project management.

Selected works of LCU on the priorities

Make gas and electricity markets competitive

- [Monitor of Electricity Market Opening](#)
- [Policy Paper: Ukraine on the way to a functioning electricity market – what is in place, what is missing?](#)

Increase share of RES

- [Low Carbon Ukraine has given detailed economic recommendations on the design of the auctioning scheme](#)

Facilitating structural change in the coal sector and coal regions

- [Policy Brief: Promoting structural change in Ukrainian coal regions](#)

Further increase energy efficiency in the residential sector

- [Policy Brief: A Scenario-based 2035 Forecast of Electricity Demand in Ukraine](#)

The Benefits of RES Curtailment in Ukraine

WITH an increasing integration of renewable energy sources (RES), system operators across the world are faced with the challenges to balance the weather-dependent and thus fluctuating generation from wind and solar plants with dispatchable plants or energy storage. At the same time, the share of dispatchable plants in the system, such as coal plants, is declining due to higher RES shares.

This balancing challenge can be addressed by adding flexible generation or storage, increasing transmission capacity as well as improving demand-response abilities.

Another administrative flexibility measure is to temporarily limit the output of RES plants when the safe operation of the system is threatened or when local transmission lines cannot absorb additional electricity. This is called "curtailment".

Curtailment as a flexibility option in the short and long run

In the short term, curtailment "buys time" until new flexible generation, storage and transmission capacities are deployed. With flexible capacity still lacking in Ukraine today, curtailment could ease the pressure to substitute low-emission baseload generation such as nuclear for reserve-providing thermal capacity as a means of integrating higher RES shares – and would therefore mitigate the so-called "green-coal paradox" to some extent. Once the necessary infrastructural, operational and institutional changes to increase system flexibility have been made, curtailment ratios will likely settle down.

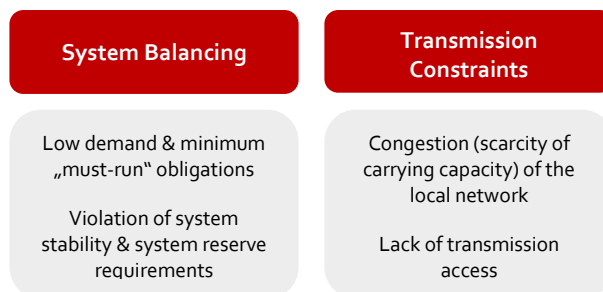
But even in highly flexible electricity systems, curtailment may still be the most cost-efficient option in some cases: Instead of absorbing the last kWh of a short-lived peak in wind generation with expensive storage or transmission investment, curtailing local and/or short-term generation peaks may be cheaper.

As of now, the day-ahead dispatch process of Ukraine's TSO Ukrenergo does not foresee the curtailment of renewable electricity generation. Based on weather forecasts, the expected RES generation during the next day is taken as given. When determining the necessary operating reserves to be held in order to balance spontaneous imbalances in electricity supply and demand and to cover contingency events such as the loss of a large generator, the day-ahead forecast error of RES as well as their inherent variability are taken into account. The more renewable energy is in the system, the larger the fluctuations and thus the larger the necessary reserves. In Ukraine, those reserves are provided by thermal power plants (TPPs) and big hydro plants. If 100% of potential RES electricity are used in Ukraine's electricity system, the limited amount of available operating and contingency reserves sets a natural limit to the further deployment of renewables.

If, however, Ukrenergo could order RES producers to decrease or stop their production in times where reserve requirements leave no room for further infeed of RES electricity or when the grid is locally congested, a significantly higher RES share would be feasible already today without having to invest into additional flexibility options. In the long-run, a more flexible electricity system with increased fast-responding capacities

and energy storage would then help to reduce curtailment to its optimal low level.

The two main reasons for curtailing RES electricity



Source: own visualisation

Mitigating the green-coal paradox through curtailment

A concern associated with an increasing share of renewables in Ukraine is that due to the electricity system's inflexibility, more renewables with priority dispatch could perversely increase both system-wide emissions and costs – the so-called "green-coal paradox". We argue that temporary curtailment poses a feasible option to deal with rising shares of fluctuating renewables in the short run.

With rising RES penetration, an increasing amount of operating reserves (upwards and downwards) needs to be held in the system to be able to balance fluctuations in RES generation (and load). If there is less wind and sunlight than forecasted, reserve units are ordered to increase their power generation to avoid a frequency drop. The opposite holds if RES electricity generation exceeds its forecast – downwards reserves are activated, i.e. plants that are "online" are decreasing their output. Everything else equal, more renewable capacity means larger absolute forecast errors and thus larger reserve requirements.

In the Ukrainian electricity system, this could lead to a higher share of coal and a lower share of nuclear generation: In order to provide the necessary operating reserves, a large number of old coal-fired units with minimum stable loads of more than 70% have to work in the middle of their operating range to provide sufficient leeway up- and downwards. These "must-run" obligations imply that coal plants partly take over the base-load generation originally provided by nuclear plants, eventually leading to an increase in system-wide emissions and operating costs.

However, curtailment can help to alleviate this problem in a scenario where RES deployment is faster than the installation of more flexible gas turbines or batteries – hence bridging the time gap until investments into flexibility options are completed. But also in the long run, allowing curtailment can reduce the costly demand for storage to a more efficient level.

The Benefits of RES Curtailment in Ukraine

Curtailment experiences across the world

A comparison of RES penetration and curtailment figures shows that high shares of RES are almost always associated with a certain degree of curtailment.

While some countries, including Germany, still prefer to implement curtailment through DSOs and TSOs, other countries such as Denmark have made the dispatch-down of RES a part of the regular balancing market. While such a market-based approach might be economically most efficient as the compensation for dispatching down RES is determined through the interaction of supply and demand for electricity rather than a lump sum compensation, curtailment ratios close to 0% should not be interpreted as if RES plants would always work at full output. Instead, they voluntarily decide not to produce if prices for electricity turn negative. The following table shows curtailment and wind/solar penetration (RES electricity generation/Total demand) for selected countries.

Curtailment & penetration for selected countries in 2017

Country	Total production, TWh	Penetration		Curtailment	
		Wind	PV	Wind	PV
China	6313	5%	2%	12%	6%
Germany	654	18%	7%	5%	1%
Ireland	31	26%	n.a.	4%	n.a.

Sources: China National Renewable Energy Centre (CNREC); Bundesnetzagentur, (BMWi), Statistisches Bundesamt, Eirgrid, Soni, seaI

The high levels of curtailment in China can be explained by the rapid expansion of renewable capacity, a suboptimal geographic distribution of load centers and renewable energy generation as well as insufficient transmission capacity between load and generation centers. Especially in China's north, where most RES capacity is located, electricity demand is low and a lack of transmission capacity prevents a significant share of renewable electricity to be transported to load centers. Must-run obligations for coal plants, a lack of flexible generation capacity and the need to keep CHPs generation for district heating in winter are further aggravating factors.

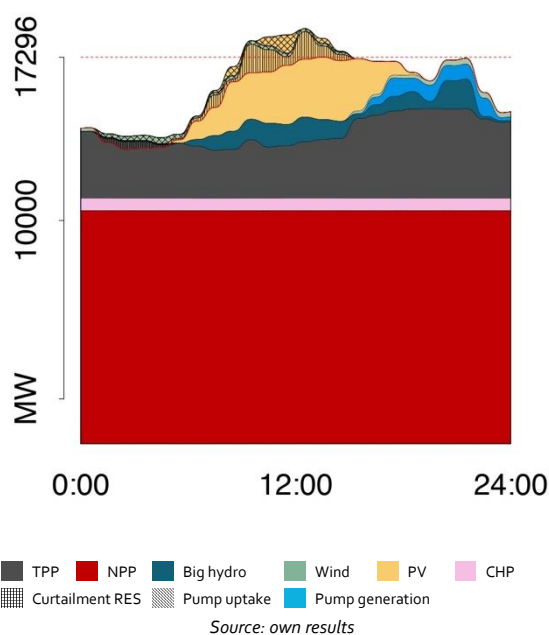
Ireland shows that even with a high penetration of renewables, modest levels of curtailment are achievable in a flexible system. In 2017, where wind plants covered 26% of electricity demand, only 4% of total available wind energy was curtailed. Dispatch-down due to system balancing typically occurs in times of low electricity consumption from 11pm to 6am when minimum generation levels are imposed on conventional plants, whereas dispatch-down due to local network congestion is more likely throughout the day.

Curtailment vs. hardware solutions

The current discussion in Ukraine on how to deal with growing RES shares is focused on the appropriate hardware solutions – i.e. gas turbines and battery storage. We argue that Ukraine's electricity system must indeed become most flexible on the generation side. However, modernising plants and increasing storage capacity is only one of many flexibility options. Curtailment, should be considered too. The economic trade-off between curtailment and hardware solutions can moreover be determined by electricity system models that minimise the cost of system operation. In a forthcoming policy paper, Low

Carbon Ukraine will employ its Optimal Dispatch Model of the Ukrainian electricity system to quantify curtailment under different scenarios. The graph below shows the cost-optimal dispatch for a working day in summer, based on the 2018 load trajectory.

Power flow of a working day in summer with 7.5 GW RES and curtailment



The figure indicates, that curtailment is an important component to a cost-optimal dispatch of Ukraine's electricity system. Hence more work on how it can be properly introduced and remunerated is needed.

This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag.

All results of the project are available online at www.LowCarbonUkraine.com.

We are grateful for feedback on this monitoring report, in particular comments how to make it even more useful for supporting the implementation of the energy strategy and contributing to a low-carbon development for Ukraine. Please get in touch via info@LowCarbonUkraine.com.

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