SELECTED HIGH-IMPACT MEASURES

Synchronising Ukraine's and Europe's electricity grids

by Dr. Georg Zachmann and Lukas Feldhaus

Low Carbon Ukraine

Implemented by Berlin Economics

Supported by: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

based on a decision of the German Bundestag

Motivation and project background

This policy proposal is part of a series which was elaborated in the framework of the project Low Carbon Ukraine (LCU) supporting more ambitious paths for selected energy and climate policy areas.

The idea to develop the present ten "Policy Proposals" arose in the course of LCU's support for the Ministry of Energy of Ukraine in setting up a National Energy and Climate Plan for Ukraine. While Ukraine's climate targets are partially very ambitious, we often observed a lack of underlying analysis and concrete policy measures to achieve those targets. For the most crucial topics, we provide a comprehensive analysis and propose concrete policy measures based on international experience.

Each Policy Proposal was written in a multi-stage process: a first draft of LCU experts or invited professionals was discussed over summer and early autumn 2020 with Ukrainian experts and stakeholders. Results of those discussions were taken into account when updating the Policy Proposals. It is important to note, that the presented results reflect the view of the authors and not necessarily the position of the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety).

We hope that the present analysis and proposals will contribute to a fruitful and constructive discussion and help Ukraine to develop ambitious, yet realistic energy and climate policies.

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Low Carbon Ukraine is a project with the mission to continuously support the Ukrainian government with demand-driven analysis and policy proposals to promote the transition towards a low-carbon economy. It is part of the International Climate Initiative (IKI) and is funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) on the basis of a decision adopted by the German Bundestag. The project is implemented by BE Berlin Economics GmbH.

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Executive Summary

For Ukraine the cost of synchronisation with the Continental Europe power system will be significant. But the benefits in terms of energy security, market integration, energy efficiency, decarbonisation and competitiveness - i.e. the five dimensions of the Energy Union - would be even larger.

Ukraine and its TSO Ukrenergo intend to synchronise the Ukrainian with the Continental European electricity grid for political, economic, and technical reasons. Their aim is to finalise this integration already by 2023. This time plan is very ambitious as several key difficulties needs to be overcome before synchronisation:

1. A lack of balancing and frequency control capabilities. In a 2016 feasibility study, Ukrenergo's systems were not able to dampen its network's frequency in a hypothetical connection scenario with Europe. If modern systems are not installed and working, synchronisation will not be possible.
2. The need for cross-border transmission lines to Continental Europe. We estimate the cost for necessary lines to Ukraine's Western neighbours at more than EUR684 million.
3. Electricity market reforms. While not a strictly necessary criterion for synchronisation, technical synchronisation with Europe will be simpler if also the market structures are aligned.
4. To be allowed to export significant electricity volumes on the EU market, Ukraine will need some form of carbon pricing in its electricity sector.
5. Decoupling from the former Soviet electricity system (IPS) will have negative technical, economic and political implications for Belarus and Russia. To avoid a backlash, these effects need to be considered and managed.

Despite the difficulties, there are strong arguments for Ukraine to put political momentum behind the synchronisation initiative:

1. In the case of synchronisation, Eastern Europe's power sector emissions would fall by 18%, or by 14 Mt/year. However, only if Ukraine like the EU puts a price on carbon.
2. New balancing and frequency control technology would save Ukrenergo billions of EUR, estimates the World Bank.
3. Ukraine would no longer rely on the Russian Federation for balancing and frequency control.
4. Curtailment in Eastern Europe, including Ukraine, would fall by 3.6% in the case of synchronisation. These 3.6% represent a value of more than EUR850 million.
5. Lower prices for consumers due to integration benefit consumers more than they hurt producers, while more cross-border electricity flows mean more rents for TSOs.

While benefits outweigh the costs by far, considerable political will is necessary to achieve integration. It concerns many different layers of government, such as the ministries of energy, finance and foreign affairs, the transmission system operator Ukrenergo, private electricity generators, as well as international agencies such as the Energy Community, and ENTSO-E. Synchronisation can only happen if the entire Ukrainian government is committed to synchronisation, and vehemently pushes for it in its internal and international political dealings.

Challenges	Benefits
Lack of balancing and frequency control capabilities Need for new cross-border transmission lines to Continental Europe Electricity market reforms. Political relations with Russia might deteriorate, as Russia faces costs of decommissioning and loses influence	In the case of synchronisation, Eastern Europe's emissions would fall by 18%, or by 14.2 Mt/year New balancing and frequency control technology would save Ukrenergo billions of USD Curtailment in Eastern Europe, including Ukraine, would fall by 3.6% Ukraine would no longer rely on Russia for balancing and frequency control. Lower prices for consumers

Status Quo

Switching the Ukrainian grid from the Russian IPS to the European grid requires major efforts

Integrating the entire Ukrainian electricity system into the Continental European synchronous grid will be a major step. Currently, Ukraine is split in terms of its electricity system. A relatively small western area bordering Slovakia, Hungary, Romania and Poland is already synchronised with the Continental Europe power system [1]. This area is called the Burstyn Energy Island (BEI). In 2017, the BEI had 650MW of single-circuit transmission capacities to neighbouring ENTSO-E States. However, the largest part of Ukraine, including the temporarily occupied areas, is synchronised with the integrated power system (IPS) of the former Soviet republics, which also includes Belarus, Moldova, Russia, and the Baltic States. Synchronisation of Ukraine's main system with the Continental Europe power system in the next decade would inevitably imply de-synchronisation from the IPS (UCTE and TEN-E, 2008). In the long run it might be feasible to synchronise the Russian IPS and the European grid, but this option would require deep political shifts that are currently not conceivable. Given the context, costs and benefits of synchronisation need to not only be assessed on an economic and technical, but also on a political level.

Political will in Ukraine supports synchronisation with the European grid

Synchronisation has been discussed for a long time. In fact, Ukraine and Moldova already applied for it with ENTSO-E´s predecessor in 2006. But with the changes in geopolitical orientation after both the Euromaidan and Russian aggression, integration into the European grid has gained relevance. Meanwhile, the Ukrainian grid has also become more suitable for integration, due to the gradual implementation of the EU's Acquis Communitaire in Ukraine's energy sector (Energy Community Secretariat, 2020b), and Ukraine's electricity market reform of 2019[2].

2017: Ukrenergo signs Connection Agreement with ENTSO-E → needs to fulfil legal, regulatory, market and technical requirements

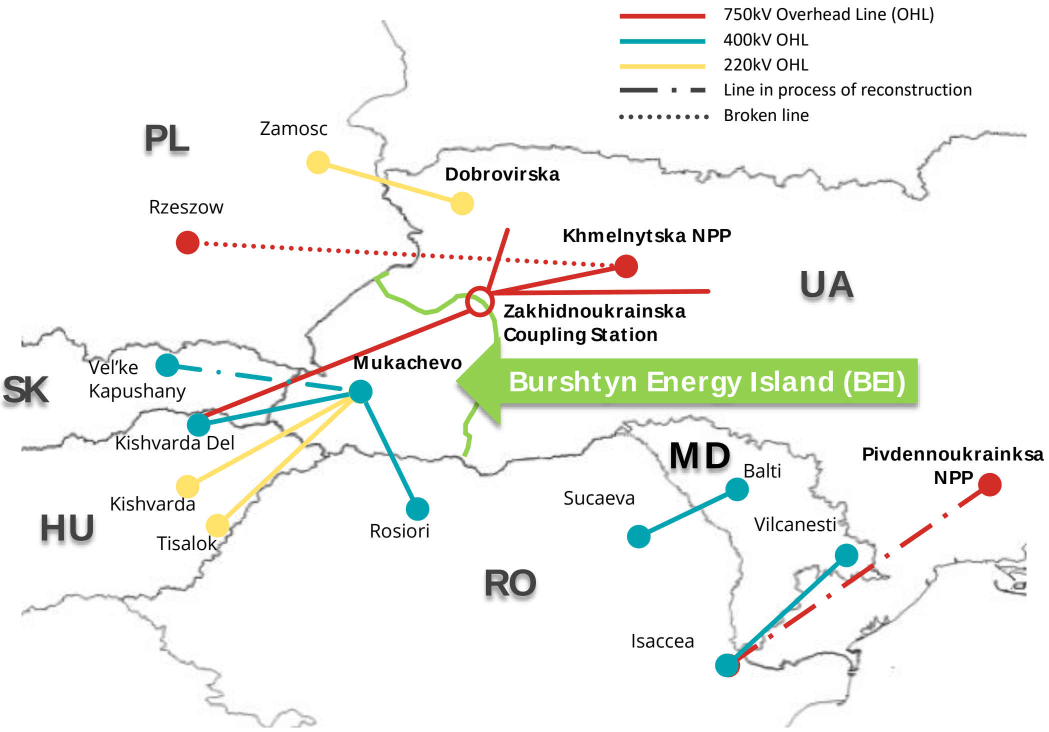
Thus, in 2017 the Ukrainian Transmission System Operator (TSO) Ukrenergo signed a Connection Agreement with the Moldovan TSO Moldelectrica and ENTSO-E, called "Agreement on the Conditions for Future Interconnection of Power System of Ukraine with Power System of Continental Europe with Ukraine's Ukrenergo and Moldova's Moldelectrica" (Energy Community Secretariat 2020). The agreement

[1] Burshtyn Thermal Power Plant (2,400 MW), belonging to DTEK Zakhidenergo (4,700 MW in total)

[2] E.g. as part of Ukrenergo's corporatization, its ownership was transferred from the Ministry of Energy and Environmental Protection (MoEEP) to the Ministry of Finance. In 2019, it became a private company. However, the MoF still holds all its shares.

contains, inter alia, a catalogue of legal, regulatory, market and technical requirements to enable accession to the synchronous European grid within a set timeframe of 6 years.

Figure 1: Transmission lines between Ukraine, Moldova and neighbouring European states (European Commission 2018, Ukrenergo 2019b)



Background info

How does synchronisation with the continental European grid work?

Ukraine and Moldova are not the first countries to seek synchronisation with the Continental European grid. Turkey did so in 2015, and the Baltic States Estonia, Latvia and Lithuania are currently also in the process of integration. All applicants go through a predefined series of integration steps:

Phase A

First, the applying TSOs (in this case Ukrenergo) seek the support from other European TSOs to apply at ENTSO-E for synchronisation with the Continental European grid. Most relevant is the support of neighbour states' TSOs. After the application, ENTSO-E prepares a feasibility study. In the case of Ukraine, such a feasibility study has been available since 2016. For more details, please see the next chapter.

With the feasibility study comes a "Connection Agreement", outlining the necessary steps the applicant needs to take in order to be able, and allowed, to synchronise its grid with Continental Europe´s. It is signed between the requesting party, ENTSO-E, and the majority of European TSOs.

Phase B

This is the phase Ukraine currently finds itself in. It consists of implementing and monitoring the technical and organizational measures in the applicants' systems, as stated in the Connection Agreement.

Phase C

Before the final synchronisation, the applicants' systems need to run an extensive set of tests, both in isolated and inter-connection modes, to see whether they are fit for integration. Key indicators are balancing capabilities, market functioning, sufficient power reserves and regulatory independency.

Synchronisation

The final step begins with an extensive interconnection trial operation, after which – if successful – the applicants sign a long-term agreement (LTA) with ENTSO-E. Upon signature of the LTA, the synchronous operation is permanent.

The LTA's main goal is to ensure that the TSOs maintain their compliance with the operational rules of the synchronous area (i.e. ENTSO-E's Operation Handbook) and with the grid connection codes, market guidelines and system operation code of the Third Energy Package (Network Codes, EU regulation (EC) 714/2009).

Challenges for synchronisation

De-synchronisation from the IPS and synchronisation with the Continental European power system requires thorough preparation. Especially, since in 2016 ENTSO-E's feasibility study indicated a number of shortcomings. It found problems relating to (1) the Ukrainian electricity sector's operational capabilities such as balancing, communication and ancillary services, (2) the way the sector is regulated and organized, as well as to (3) its cross-border transmission network (Bolborici, Zachia and Lazaroiu, 2016).

Main issues: Secure operations, efficient market regulation, and cross-border transmission

The original Connection Agreement, signed in 2017, planned complete synchronisation between Ukraine and the Continental Europe power system to be implemented already in 2023. In a recent study however, the World Bank found this objective to be optimistic (World Bank, 2020).

Full synchroni-sation by 2023 is extremely ambi-tious

While synchronisation faces challenges, the benefits of integration prevail. To understand the effects, we undertook a cost-benefit analysis of Ukrainian synchronisation with the European power grid, modeling the effects of interconnection on key indicators such as curtailing volumes, trans-border electricity flows, producer and consumer surplus, as well as greenhouse gas emissions. For this purpose, we assumed that the BEI will be connected to the Ukrainian IPS, either under a complete synchronisation of Ukraine with the Continental European power system, or just via a Back-to-back (B2B) connection between the BEI and the rest of Ukraine. Such a solution is already gaining support to bridge the time until complete synchronisation (World Bank, 2020). For existing connections, please see Table 1 and Figure 1.

A B2B connection with the BEI is already in discussion. We therefore disregard the possibility of the BEI not being connected to the IPS in the near future.

Table 1: Number of existing cross-border transmission lines to Ukraine's neighbours, by voltage class

Ukraine to…	750 kV	400 kV	330 kV	220 kV	110 kV	45 kV
Poland	1 (IPS, in need of refurbishment)	-	-	1 (IPS)	-	-
Slovakia	-	1 (BEI, getting re-established)	-	-	-	1 (IPS)
Hungary	1 (BEI)	1 (BEI)	-	2 (BEI)	-	-
Romania	1 (IPS, getting re-established)	1 (BEI) 1 (MLD)	-	-	-	-
Moldova	-	-	7 (IPS)	-	11 (IPS)	-

BEI = connecting the Burstyn Energy Island to other States
IPS = connecting the Ukrainian IPS to other States
MLD = connecting Moldova to other States

Source: (European Commission 2018, Ukrenergo 2019b)

The process of integration is coupled with numerous difficulties and large needs for investment. Yet, Ukrenergo, the main responsible for bringing Ukraine's electricity grid up to European speed is determined to synchronise. It expects great benefits from being part of a network promising a *"single legislation base, unified tech standards, market pricing, free interstate trade, and distributed contribution to the system´s stability"* (Ukrenergo, 2018). Overall, Ukrenergo estimates benefits of EUR1.2/1.3 billion per year, compared with costs of EUR352 million (Ukrenergo, 2020a). This might however be a too low estimate, as we analyse in chapter IV.

Ukrenergo is optimistic, sees benefits in market structure, in supply security & stability, and in cost-saving

Due to the large benefits of integration and the high political stakes at play, synchronisation would profit strongly from political support in the highest ranks of the Ukrainian government. An important first step was the adoption of Ukrenergo's "Synchronisation Plan" by the Ukrainian Cabinet of Ministers, which outlines the key steps to take until synchronisation. This plan, however, is not public (Ukrenergo, 2019a)

I. Improving operations: Balancing, ancillary services, and communications[3]

To ensure that a country´s system can contribute to the security of the European system, it needs to (1) prove its ability to independently balance its own electricity system, as well as (2) ensure being able to absorb potential fluctuations entering from other parts of the integrated system. If the joining system would return such fluctuations or even amplify them, this could cause systemwide problems.

Most crucial for synchronisation: To overcome Ukrenergo's frequency damping problems

As a 2016 feasibility study by ENTSO-E explains, low Ukrainian frequency control capabilities could potentially lead to rolling blackouts across Europe, if not addressed before an integration (Bolborici, Zachia and Lazaroiu, 2016). Due to a lack of power stabilisation capabilities at Ukrainian thermal power plants, a sudden loss of 1GW generation in Spain could lead to escalating frequencies all across the European grid (see Figure 2). However, the exact severity of shortcomings and investment needs is difficult to establish, as none of the highly technical studies is public.

Overcome frequency problems with damping technology, and sufficient reserves

In general, investments in both hardware and software could help overcome the network challenges. For instance, more reserves would improve both (1) and (2). Currently, Ukraine´s reserves are not sufficient. However, as Ukrenergo has certified several hydro power plants for the provision of balancing reserves, USAID and Tetra Tech estimate that enough reserves will soon be available (Tetra Tech, 2020).

To Do: install balancing and demand-forecasting technology

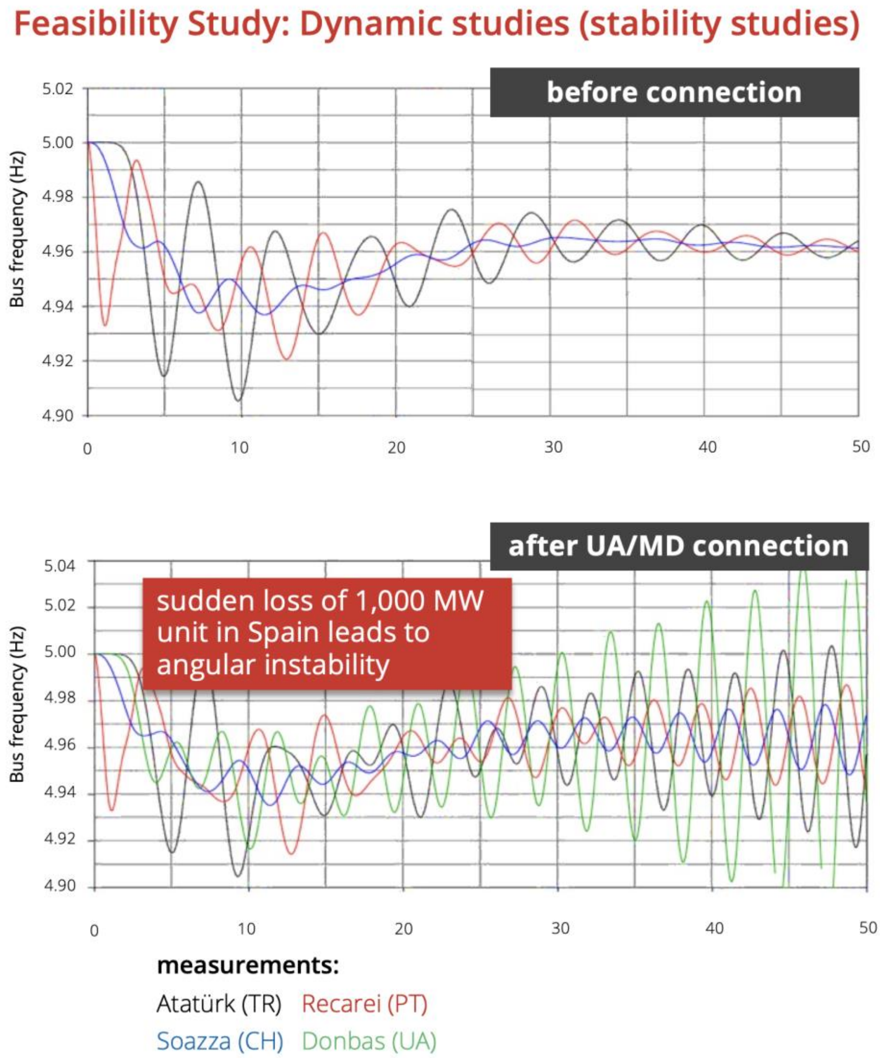
A better demand-forecasting system would similarly benefit Ukraine on both fronts. Additionally, such a system would save Ukraine USUSD11.5 billion of future investment needs (World Bank, 2020). Ukrenergo could apply the DAKAR software, which is already being used in the BEI (Kovalchuk, 2019).

To Do: Data collection and sharing: e.g. on network security, voltage, congestion, and reactive power management

Another important issue is the collection and sharing of data on electricity demand and supply forecasts, as well as of actual generation and consumption. Exchanging data with neighbouring countries would strengthen Ukraine's ability to absorb the EU network's fluctuations (2). Besides the establishment of data centres, the 2016 feasibility study also recommends Ukraine to establish a reliable communication network between the TSO and generators, to control the dispatch of electricity in a timely manner (Bolborici, Zachia and Lazaroiu, 2016).

[3] For a more extensive version of this chapter, please refer to chapter 0 in the Appendix.

Figure 2: Balancing Problems (Transelectrica, 2019)



A successful implementation of up-to-date damping technology is not unlikely. Ukrenergo is already participating in an EU awareness system for data-sharing (ENTSO-E, 2020b), and is adopting EU regulation on congestion management methodologies (Nitsovych, Serebrennikov and Mykhailenko, 2020). This assessment is underscored by an ongoing feasibility study of Ukraine's frequency control capabilities, using new balancing and frequency data from 2019, by USAID and UHE (World Bank, 2020).

Success not likely, due to ongoing efforts in Ukraine and international support

II. Basic regulations mandating TSO operation[4]

The role of ENTSO-E: connecting European TSOs, creating and implementing network codes

ENTSO-E's Network Codes are mandatory for EU Member States: (1) market codes, (2) operation codes, and (3) grid connection codes (so far, only (3) mandatory for Ukraine)

ENTSO-E, the "European Network for Transmission System Operators for Electricity", was established in 2009 by the EU's Third Legislative Package for the Internal Energy Market (Regulation (EC) 713/2009). It is an association of 42 TSOs from 35 countries across Europe, extending beyond the EU. ENTSO-E drafted eight Network Codes, which are legally binding for all EU member States, as well as for members of the Energy Community, of which Ukraine is a contracting party (Energy Community Permanent High Level Group, 2012; Energy Community Secretariat, 2018). However, the EnC has so far only adopted the three grid connection codes (please compare Table 2).

Table 2: EU Electricity Network Codes and Guidelines

Market Codes	System Operation Codes	Grid Connection Codes
Capacity Allocation and Congestion Management Guideline (CACM GL)	Electricity Transmission System Operation Guideline (SO GL)	Network Code on Requirements for Grid Connection of Generators (RfG NC)
Forward Capacity Allocation Guidelines (FCA GL)	Emergency and Restoration (ER NC)	Demand Connection Network Code (DC NC)
Electricity Balancing Guideline (EB GL)		Requirements for Grid Connection of High Voltage Direct Current systems and direct current-connected Power Park Modules Network Code (HVDC NC)

Most crucial for synchronisation: compliance with operational rules

TSOs can reject Ukraine's bid for synchronisation in case of balancing and frequency issues – as in 2016 feasibility study.

As ENTSO-E´s member TSOs have the final say over whether Ukraine is allowed to synchronise with the European grid, they may reject Ukraine´s bid for integration despite political will in the EU to pursue it. They will definitely not allow synchronisation if Ukraine does not comply with operational rules. Further, the TSOs will carefully assess any deviations from other Network Codes (please compare chapter I).

Looking beyond operational security, Ukraine has further room for improvement. The Energy Community regularly criticises Ukraine for not fulfilling its market regulations and for political circles to rule into the electricity markets. Recently, it refused to certify the independence of Ukraine´s regulator NEURC (Kopač, 2020). Any step closer to the Energy Community would be a step closer to European regulations, and thus one step closer to synchronization.

Compare also LCU´s policy paper on electricity markets by Alex Mykhailenko

For further analysis of Ukraine's electricity markets, and thus its implementation of the Network Codes not relating to operational security, please have a look at Policy Proposal "Reforming Ukraine's electricity market" (Supponen, 2021).

[4] For a more extensive version of this chapter, please refer to Annex.

III. Transmission lines

The European Union and ENTSO-E demand from their parties to have cross-border transmission capacities with neighbouring ENTSO-E States equaling 10% (2020) or 15% (2030) of their total installed generation capacity (ENTSO-E, 2016; European Council, 2020). Ukraine went one step further and in its *Energy Strategy 2035* plans to achieve 15% interconnection by 2025 already (Szabó, Mezősi and Kácsor, 2020). (For an overview over all currently existing connections between Ukraine and ENTSO-E, please compare Table 1 and Figure 1).

The EU demands from its parties to have interconnect-tions of 10% by 2020 and 15% by 2030

Since in April 2020, Ukraine's total installed generation capacity reached 53.6 GW (Nitsovych, Serebrennikov and Mykhailenko, 2020), 10% interconnection would entail transmission lines to Hungary, Moldova, Poland, Romania and/or Slovakia of around 5.4 GW, while 15% would require 8 GW of transmission capacity. Ukraine is still far from achieving these levels. Currently, it has a 0.7 GW connection to Moldova, while the Burstyn Energy Island possesses additional 0.7 GW of single-circuit capacity, and there is one small interconnection between the Ukrainian IPS and Poland (0.2 GW). Larger lines connect the Ukrainian market with Russia and Belarus, but are in low use due to political turmoil (NEURC, 2018). Total electricity flows in and out of the country hardly ever exceed 1.5 GW. This level was reached last in March 2020 (Ukrenergo, 2020b).

Ukraine needs ca. 4 GW of additional transmission capacity to fulfill the 10% goal

While Ukrenergo still emphasises the need to synchronise with the Continental European grid by 2023, it is realising that time is running short. It thus proposes to build a Back-to-back connection via an AC-DC-AC converter station with the Burstyn Energy Island by 2023, to quickly enable the benefits of integration. Currently, Ukrenergo intends to build a 600MW connection. It aspires to build the interconnection in just two and a half years, at costs of USUSD150 million. It expects gains of USUSD150 million already in the first year of operation (Kosatka Media, 2019). A World Bank study from 2019 finds the project to entail great benefits for Ukrainian load-balancing capabilities and power quality, and therefore proposes to fund it via the International Bank for Reconstruction and Development. However, the World Bank expects a cost of USUSD224 million (World Bank, 2020) (please also compare chapter IV on the costs of synchronisation).

To quickly benefit from interconnect-tion without sync, a B2B station between BEI and Ukraine could be helpful and quickly recover costs

A further project is the rehabilitation of a 750 kV line connecting Ukraine with Poland, the so-called "Rzeszow – Khmelnytska" line with a capacity of 1.3 GW (*Poland's international power connections*, 2012). It was decommissioned in 1995, when Poland synchronised with the Continental European grid and thus was not synchronised with the Ukrainian network any longer. Energoatom would like to refurbish the line, in order to export electricity from the Ukrainian Khmelnitsky Nuclear Power Plant to Poland. The line would thus run in synchronisation with the Polish, and therefore the European grid. This project, called "Energy Bridge", was also assessed as beneficial for damping and demand balancing by 2016´s feasibility study. However, in a letter to the then-acting Ukrainian Minister of Energy and Environmental Protection Vitalii Shubin in April 2020, the Polish government saw "no compelling value in this undertaking", especially not for Polish electricity consumers (Naimski, 2020). Ukrenergo is equally opposed to the new connection, since it doesn't see any value of only exporting electricity from one power plant (Ukrainian Energy, 2019).

The "Energy Bridge" from Ukraine to Poland – rejected by the Polish government

Ukrenergo is pushing two other projects of transmission, both of which are considered 'Projects of Mutual Interest' (PMI) (European Commission, 2018), in line with the 'Trans-European Networks for Energy Regulation' (European Parliament and European Council, 2013), aiming to foster the construction of cross-border transmission capacity in Europe. First, it endeavours to rehabilitate a 400kV line between Mukacheve in Ukraine and Kapusany in Slovakia and second, to revive and modernize a 750 kV line between the Pivdennoukrainska Nuclear Power Plant in Ukraine and Isaccea in Romania. Being accepted as a PMI by the Energy Community does not necessarily bring financial benefits but fosters cooperation by the States crossed by the transmission line. Judging by the capacity of similar lines, these two projects might add around 1.5-2 GW of cross-border transmission capacity to the Ukrainian grid.

Projects of Mutual Interest: The EU supports new Ukrainian cross-border trans-mission lines

4.3 GW of lines between Ukraine and Russia, and Belarus would need to be dismantled

It must further be taken into account that in the case of synchronisation with the Continental Europe power system the 17 transmission lines to Belarus and Russia, representing 4.3 GW of connection capacity might need to be decommissioned or combined with Back-to-back converters, a potentially time-consuming and expensive process (Energy Community Secretariat, 2019). The costs in this case would not only be borne by Ukraine, but also by Belarus and Russia.

Ukrainian regulators have understood the need to improve and extend transmission capacities. In this regard, NEURC approved Ukrenergo's Transmission System Development Plan for 2020-2029 in March 2020, aiming to enhance cross-border connections. The total cost projection sums up to EUR2.3 billion, of which around EUR300 million are supposed to go to cross-border projects, and which is supposed to be funded mainly by international financial institutions like the EBRD, the EIB, the KfW, etc. (Ukrenergo, 2019b; Nitsovych, Serebrennikov and Mykhailenko, 2020).

Additional regulatory changes necessary to make use of interconnections and participate in EU markets

However, this transmission capacity will be of most value to Ukraine if the country manages to take part in international markets. To achieve this, Ukraine would need to implement the regulations mentioned in chapter II. Using international markets as emergency suppliers in moments of high demand will, for example, only be possible if the SAFA standards[5] for cross-border capacity allocation are respected and implemented (Kovalchuk, 2019). Ukraine gained first experiences with such capacity allocation procedures in 2017, when cheap electricity imports from Belarus and Russia were made possible, however only under one-year contracts (Szabó, Mezősi and Kácsor, 2020).

IV. Costs

Ukrenergo's cost assumptions are lower than in international comparison. Nonetheless, synchronisation would benefit Ukraine financially.

Beyond the precise effects for consumers and producers, Ukrenergo estimates that the monetisable benefits alone from synchronisation are worth more than EUR1 billion annually, while it estimates costs at around EUR352 million (Ukrenergo, 2017). In total, Ukrenergo sees costs for grid development at around EUR130 million, additional generation, as well as new balancing and damping technology similarly at EUR130 million, communication infrastructure for quick dispatch orders at EUR92 million, and additional feasibility studies to be in the range of another EUR5 million.

So far, it hopes to receive funds of EUR138 million from international financial institutions, and to pay EUR222 million itself (Kovalchuk, 2019). These numbers might be estimated too low, though. The World Bank, in a recent project assessment for the International Bank for Reconstruction and Development (IBRD) estimates alone the B2B interconnection between Ukraine and the BEI to cost at least USUSD224 million (ca. EUR191 million) (World Bank, 2020).

Transmission lines alone would likely cost more than EUR1 billion.
For one B2B station, Ukrenergo could build around 200km of 600 MW AC overhead lines.

Overall, Ukrenergo's estimates seem to be quite optimistic. Necessary transmission projects alone would cost Ukraine and its TSO more than EUR600 million. These costs arise when simply adding up the cost for two B2B stations (one already planned in the BEI and one additional station Ukraine might need to increase its transmission capacities, at EUR191 million each), Ukrenergo's own estimate for the cost of transmission lines to Romania and Slovakia of EUR226 million and EUR17 million respectively (REKK, 2016; Ukrenergo, 2019b), and the costs of re-establishing the 750kV line to Poland (which we use as a proxy for the costs of a similar line which Ukraine would need to build/rehabilitate) of EUR4 million according to Ukrenergo. The latter are however a stark underestimate according to the Energy Community's experts (REKK, 2018). They instead foresee costs of around EUR240 million for the line to Poland. Summed up, one arrives at costs for

[5] Refers to the ´Synchronous Area Framework Agreement´, to which Ukraine submitted in the Connection Agreement of 2017. SAFA is mandated by ENTSO-E's Network Code on System Operation, article 118. It is a contract between all its member TSOs and regulates cross-border load-frequency control and reserves (European Commission, 2017).

transmission infrastructure alone of EUR629 million, even when disregarding the Energy Community´s higher estimate for the Polish connection.

According to Ukrenergo, not all of these projects are necessary for the possibility of synchronisation. Yet they are, if Ukraine would like to follow through on its own commitments of 15% interconnection by 2025, or EU regulations demanding 15% interconnection by 2030 (please compare previous chapter III).

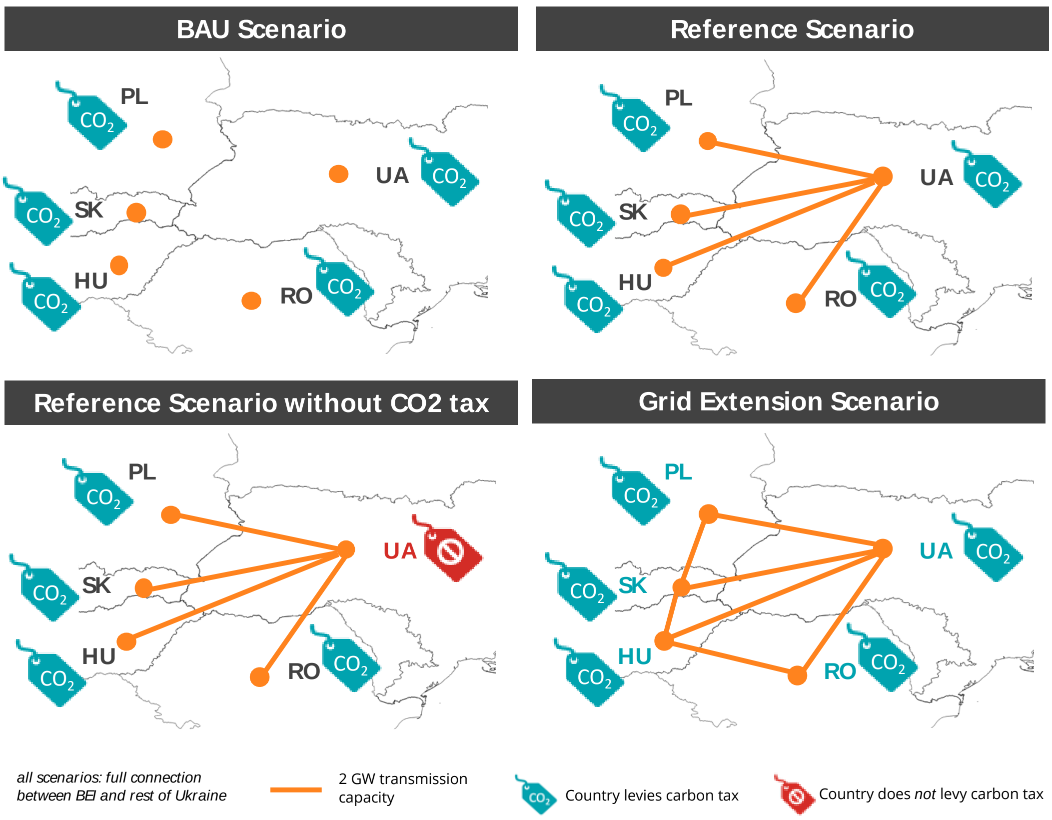
B2B stations furthermore are expensive. For the envisaged EUR191 million, Ukrenergo could build around 180 km of a 400 kV, AC, double-circuit overhead line (REKK, 2016).

Assessment: Effects of Network Synchronisation

This paper assesses 4 different scenarios comparing the effect of different levels of interconnection between Ukraine and its neighbours

In order to compare the integration of the Ukrainian electricity grid with Continental Europe, we modelled four scenarios of possible future developments of cross-border transmission capacities. In all scenarios, the BEI and the rest of Ukraine are well-connected and can be counted as one network node. In the business as usual (BAU) scenario, Ukraine´s grid is separated from its European neighbours. We then modelled one reference scenario, with 2GW of transmission capacities between Ukraine and each of its neighbouring countries ("Reference scenario"). In an additional scenario, we hold everything equal to the Reference scenario, but assess the effects of what happens if Ukraine does not introduce a price on carbon. Fourth and lastly, we modelled a "Grid Extension scenario" with 2GW of transmission capacities between all countries. More details can be found in the Annex and in Figure 3. According to already existing cross-border transmission capacities between Ukraine´s neighbouring States, the 2GW are a reasonable assumption (ENTSO-E, 2020c). For the development of fuel prices, GDP and demographics, we chose assumptions also taken in Ukraine´s draft NDC scenario 2.

Figure 3: Transmission Capacities of the four scenarios



We will present the resulting effects of a synchronisation along the five pillars of the European Energy Community, to which Ukraine is a party: (I) Energy security, solidarity and trust, (II) a Fully integrated internal energy market, (III) Energy efficiency, (IV) Climate action – decarbonising the economy, and (V) Research, innovation and competitiveness.

I. Energy security, solidarity, and trust

Synchronisation with the Continental Europe power system would lower Ukrainian dependence on Russian balancing services

Security of electricity includes both political, and technical elements. Currently, Ukraine's electricity system is synchronised with the Russian and Belarussian grid. In this context, Ukraine relies on Russian balancing and frequency damping capabilities, as well as on Russian coal for Ukrainian thermal power plants (World Bank, 2020). In light of current geopolitical tensions, Ukraine is in a weak spot should the Russian Federation choose to make use of this dependency. Energy independence thus is part of Ukraine´s sustainable development strategy "Ukraine – 2020", as well as of Ukrenergo's reform strategy 2017-2026 (Ukrenergo, 2018). Additionally, Ukrenergo perceives integration with the European Union's grid to offer the advantage of a single legislation base, grid balancing support and access to additional energy emergency reserves. However, de-coupling from the Russian PIS will in the short-term worsen balancing services in Ukraine, and the risk remains that Russia will politically retaliate against this further integration of Ukraine into the European realm[6]. Even beyond political concerns, Russia also has reason to protest against the de-synchronisation due to the unsolicited costs for the Russian system. Russia would have to either decommission the lines on its side, reconnect them internally to close the lines´ electric circuits, or build B2B stations.

After synchronisation lower need for primary reserves in Ukraine, due to higher security of supply

On the technical side, Ukrenergo estimates that integration with the European grid, and the ensuing modernisation, will enhance reliability and security of its electric supply, lowering the need for primary reserves by approximately 140-160 MW compared to business as usual (Ukrenergo, 2018). It further expects improved grid resilience and options for mutual assistance with Europe due to non-simultaneous peak hours for electricity demand.

II. A fully integrated internal energy market

Cross-border trade in electricity would grow from USUSD250 million to USUSD1.5 billion a year

While integrating Ukraine's transmission lines would be beneficial for the European grid, as Ukrainian transmission lines would improve the connection between northern and southern Europe, Ukrenergo expects cross-border trade in electricity to increase almost fourfold from currently 4-5 billion kWh/year (representing approximately EUR213 million) to 18 billion kWh/year (EUR1.28 billion) (Ukrenergo, 2017). LCU's 'Grid Extension' scenario even projects cross-border flows of more than 30 billion kWh/year (compare Figure 6).

III. Energy efficiency

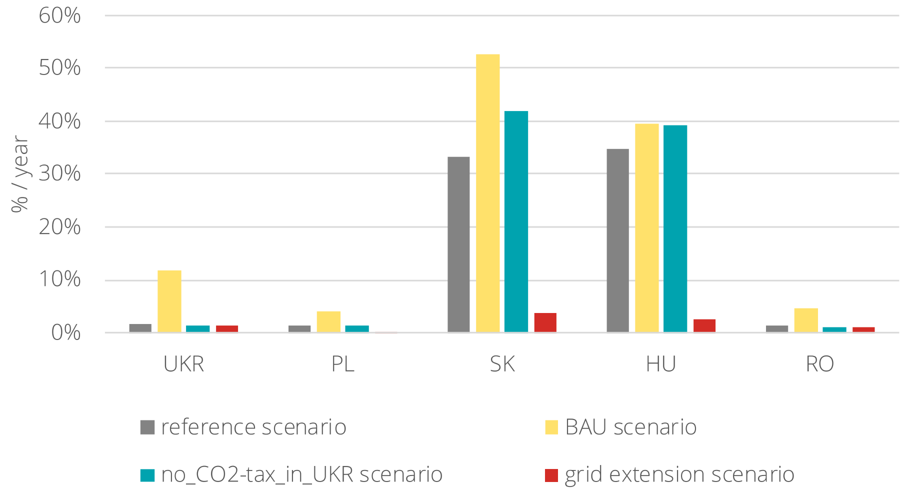
Ukraine and its neighbours would face far lower curtailment rates in the case of synchronisation

Adopting the Energy Community's market standards would also mean the end of subsidized electricity prices for consumers, thus improving investment incentives for the right times and the right locations, as prices would rise in times of real scarcity. As Ukrenergo expects trade to increase by four times, rapid and frequent cross-border flows would also allow to use generation capacities more efficiently, especially since Ukrainian and European peak demand hours do not coincide (Ukrenergo, 2018). As our model shows in Figure 4, necessary curtailment of electricity sources due to grid congestion or imbalances would therefore

[6] Not being connected to the Russian IPS might reduce costs for Russia to launch cyberattacks on Ukraine's electricity system. Meanwhile, higher standards and grid modernization stemming from the synchronisation can offset this risk for Ukraine.

shrink in an integrated scenario, compared with business as usual. In our grid extension scenario, this would benefit all States, but especially so Slovakia and Hungary, who suffer high curtailment needs. In absolute terms, Ukraine would benefit even more, since 10% curtailment in Ukraine correspond to more TWh (3.6 TWh, worth ca. EUR230 million) than 52% in Slovakia (1.7 TWh) or in Hungary (2.5 TWh), since Ukraine´s total electricity consumption is so much larger.

Figure 4: Electricity curtailment rarely required under grid extension scenario

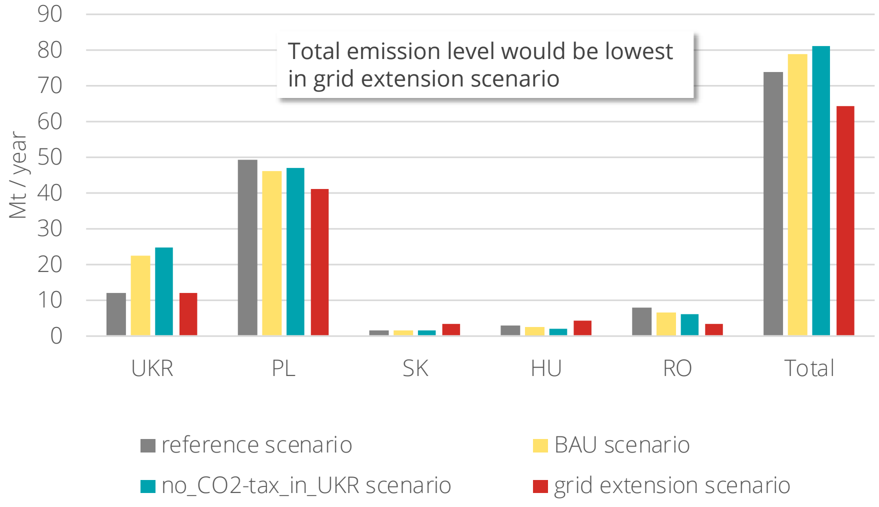


IV. Climate action – decarbonising the economy

Synchronisation would lower emissions substantially, but only if Ukraine also implements a carbon tax

As curtailment reaches its lowest levels, so would Ukrainian greenhouse gas emissions. However, only if Ukraine couples its integration into the European electricity markets with a price on carbon. In the politically hardly realistic case that Ukraine would be allowed to trade electricity with EU countries without being forced to implement a substantial price on carbon, electricity production from neighbouring countries would be replaced by Ukraine's old coal power plants, which is reflected in our scenario without a carbon tax. This would result in even higher emissions than in the case of a continuation of business-as-usual policies. Nonetheless, if Ukraine does introduce a carbon tax of around EUR35 per tonne of CO_2 equivalents, both Ukraine and its neighbouring countries would be more likely to fulfil their international commitments in the fight against climate change. Integration into the Continental Europe power grid would also be beneficial for all countries' emission balances, as the higher flexibility stemming from cross-border balancing transfers lowers the need for base-load coal and gas plants. Compared to the reference scenario, overall emissions from thermal power plants would be down by 12.9% relative to the reference scenario in the case of the grid extension scenario. On the other hand, if the grid is extended, but Ukraine does not introduce a carbon tax, emissions will rise by 9.4%. Please find absolute results in Figure 5.

Figure 5: Emission in Mt/y (from TPPs)



V. Research, innovation and, competitiveness

Ukrenergo projects that integration with Continental Europe would increase liquidity and competition in Ukraine's wholesale market (Ukrenergo, 2018). In our most ambitious scenario 'Grid Extension', imports would make up 15.4% of total electricity consumption in Ukraine by 2030 (please compare Figure 6).

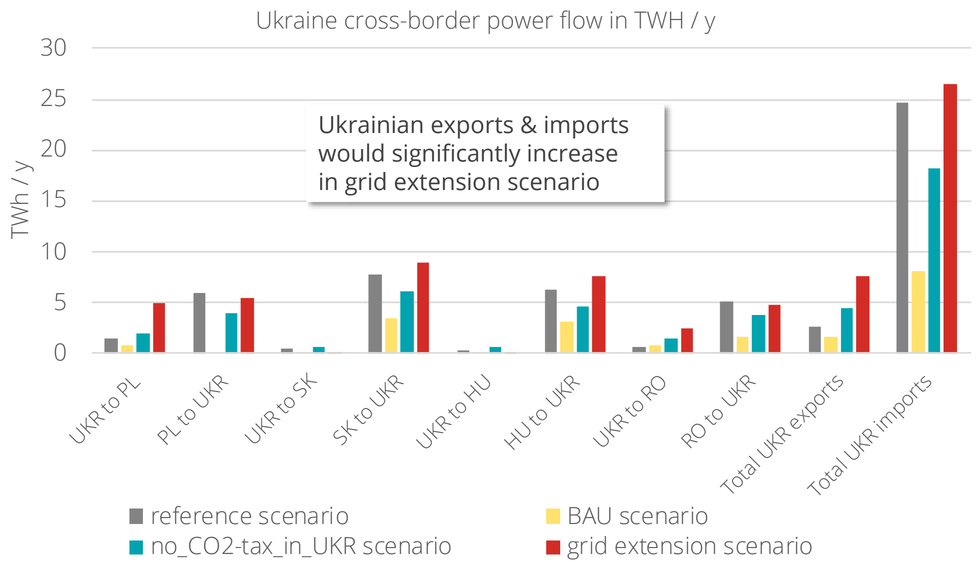
Synchronisation would benefit mainly Ukrainian consumers, and Ukrenergo but not Ukrainian producers. The latter would lose profits to foreign competitors, explaining incumbents' opposition to synchronisation.

In our "reference" scenario opening up cross-border transmission would thus **increase consumer surplus by EUR0.9 billion, and the transmission system operator's congestion rent by EUR0.3 billion,** compared to a "business as usual" development with no connections. However, producer surplus would shrink, as competition from neighbouring countries would eat away profits. In their analysis of cross-border transmission lines between Ukraine and its neighbours, the Energy Community's experts expect even higher benefits for transmission operators and consumers when assessing the lines' benefits (REKK, 2020).

Cancelling the CO_2 tax would have an even larger effect on producer surplus. It would lower producer surplus by more than USUSD3.9 billion in comparison to the connected reference scenario with a price for carbon, as generators lose their windfall profits. However, overall Ukrainian welfare does not decrease, as gains in consumer surplus and congestion rents would more than offset the producer's losses. Consumers would benefit from lower prices, but due to the international competition also from better service quality and higher energy security, as generators compete for customers. In effect, Ukraine would become a net importer of electricity (please compare Figure 6).

Besides fostering competition, Ukrenergo also forecasts higher investment attractiveness for the Ukrainian electricity sector, due to less curtailment and a both well-known and stable regulatory environment. According to the TSO, the additional investments would benefit especially renewable energy sources, leading to a diversification of the national energy mix (Ukrenergo, 2018).

Figure 6: Ukrainian exports and imports under different scenarios



Conclusion: Benefits of synchronisation surmount

Ukraine would benefit from an integration into the Continental European grid. While for a successful synchronisation, it still faces challenges such as the need to install frequency-damping technology, implement data-gathering and dispatch control mechanisms, and establish new transmission lines to neighbouring countries, the costs are more than offset by the potential gains.

These gains would materialise first and foremost for consumers, benefitting from cheaper electricity and better services, due to international competition, but also by the environment, which would see significantly lower total emission levels in Eastern Europe. Also, the transmission system operators would gain from higher congestion rents, and generators would face less curtailment. Additionally, Ukraine would be connected to the EU's internal energy market, benefitting the EU via better north-South connections, and Ukraine via clearer regulations and access to new and secure emergency electricity supply.

As benefits thus outweigh the costs by far, considerable political will is necessary to advance the project of integration. It concerns many different layers of government, such as the ministries of energy and finance, the transmission system operator Ukrenergo, private electricity generators, as well as international agencies such as the Energy Community, and ENTSO-E. Synchronisation can only happen if the entire government is committed to overcoming the challenges this report has presented and vehemently pushes for synchronisation in its internal and international political dealings.

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Annex

I. Model assumptions

Table 3: Different scenarios and their respective assumptions

	BAU scenario	Reference scenario	Reference Scenario without CO_2 tax	Grid Extension scenario
JRC-data for Electricity demand in 2030 used	✓	✓	✓	✓
Burshtyn Electricity Island connected with the Ukrainian grid	✓	✓	✓	✓
2 GW transmission capacity between Ukraine and each of its neighbours		✓	✓	✓
Ukraine puts a price on carbon	✓	✓		✓
2 GW transmission capacity between all countries				✓

Transmission capacities

The model calculates optimal dispatch levels in 2030, comparing four scenarios: first, a business as usual scenario (BAU) with hardly any interconnection between Ukraine and its neighboring countries Hungary, Poland, Romania, and Slovakia. Second, we analyze optimal dispatch level in a reference scenario with 2GW transmission capacity between Ukraine and each of its neighbors. Third, we modeled the same scenario again, but without Ukraine levying a price on carbon, as it does in all other scenarios. We assumed this price to be EUR35 per ton of CO_2 equivalent emission, as it would be under the projected EU ETS price by 2030. Fourth and lastly, we modeled a "Grid Extension" scenario with 2 GW interconnections between all named countries (again with Ukraine putting a EUR35 price tag on emissions).

We found 2 GW interconnections to be plausible, as Ukraine has the goal to establish 15% transmission capacity relative to its installed generation capacity already by 2025 (15% interconnection are also the goal for all EU member States by 2030). In Ukraine's case, 15% correspond to overall levels of 8.04 GW transmission capacity. For a more in-depth analysis of International transmission lines, please refer to chapter 3.3.

Meanwhile, the Burshtyn Energy Island is assumed to be entirely connected with the Ukrainian main grid under both scenarios, also in line with Ukrainian plans and existing interconnectors. Moldova, another neighbor of Ukraine is however excluded from the model, as data from the country was scarce and not reliable.

Installed capacities, incl. reserve capacities

We acquired data on projected generation capacities for 2030 for Hungary, Poland, Romania, and Slovakia from the JRC Open Power Plants Database (Kanellopoulos K. *et al.*, 2019). This data base uses ENTSO-E data and cross-checks it with several other publicly available data bases. For Ukraine, we assumed the capacities projected by Scenario 2 of the NDC process ("Nationally Determined Contributions" under the Paris Agreement framework), which are currently still under discussion in the Ukrainian Ministry of Energy. The NDC scenario 2 projects a moderate but ambitious increase in RES from around 6GW (2020) to 15 GW (2030), as well as a feasible coal phase-out from 17 GW to 10 GW during the same time period. Total assumed generation capacities can be seen in Table 4.

We further assumed all countries to have sufficient reserve capacities in order to balance out their own electricity grids.

Table 4: Assumed generation capacity in 2030

Capacity in GW	Ukraine	Hungary	Poland	Romania	Slovakia
Total Generation	51	11	55	24	10
Thereof RES	15	4	22	11	3
Thereof Thermal	15	3	29	5	3

Demand structure and fuel prices/generation costs, incl. carbon taxes

We furthermore assumed relative fuel prices to stay constant, meaning that the relation between coal, uranium and gas prices would stay as they were in 2018/2019.

Meanwhile, we took demand projections for the year 2030 for Hungary, Poland, Romania, and Slovakia from the JRC Open Power Plants Database (Kanellopoulos K. *et al.*, 2019), just as the generation capacity projections.

The price on carbon levied on tonnes of greenhouse gas emissions in scenarios 3 and 4 we assumed to be at EUR35/tonne of CO_2 equivalent, in line with the EU´s Emission Permit System´s projections for 2030.

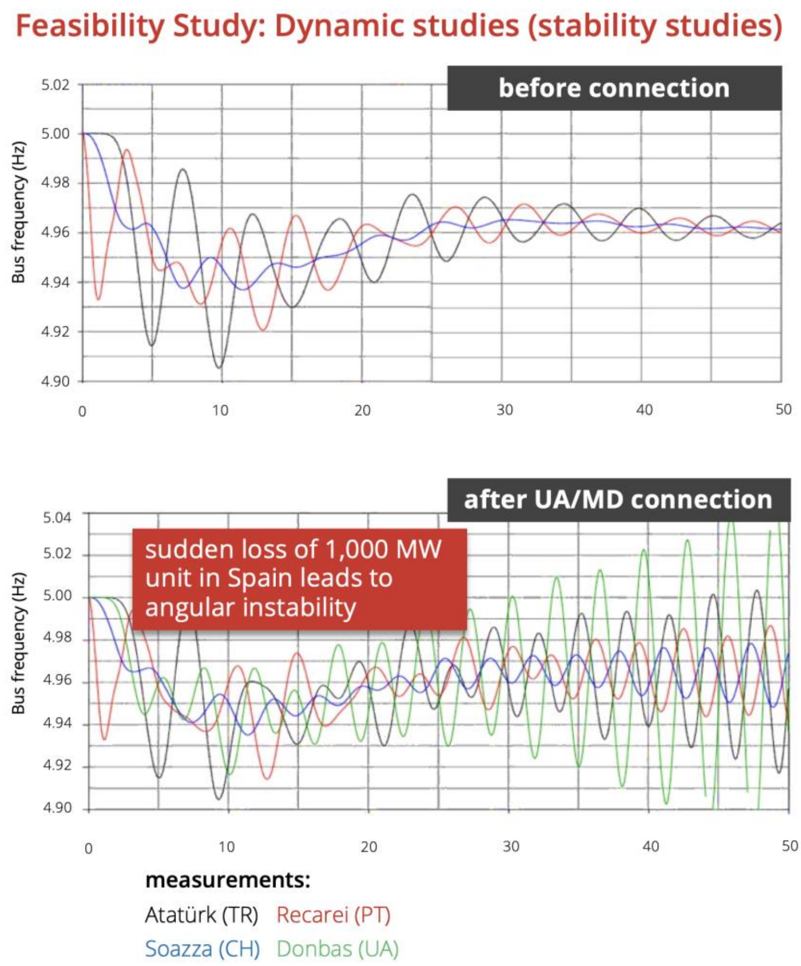
II. "Improving operations: Balancing, ancillary services, and communications", in detail

Most crucial for synchronisation: To overcome Ukrenergo's frequency damping problems

Arguably most crucial for the viability of Ukraine's bid to join the European power system, are the frequency balancing problems found by 2016's feasibility study. As the study explains, they could potentially lead to rolling blackouts across Europe, if not addressed before an integration (Bolborici, Zachia and Lazaroiu, 2016).

Especially Ukrainian electricity flowing into the EU posed a severe problem for the system's frequency in the simulations. Damping of the newly detected inter-area oscillation modes was very poor for winter peak and for summer off-peak scenarios. In the feasibility study´s model, oscillations strongly escalated after a sudden 1GW loss in Spain. The effects, including black-outs, and damaged machinery and power plants, would be felt across Portugal, Switzerland, Turkey, and Ukraine (Bolborici, 2019). For a graphic depiction of the escalating frequencies, please see Figure 7.

Figure 7: Balancing Problems (Transelectrica, 2019)



Overcome frequency problems with damping technology, and sufficient reserves

To ensure that a country´s system can contribute to the security of the European system, it needs to prove the availability of sufficient reserves, as well as of modern damping equipment at its power plants, and a well-administered dispatch steering and control system.

We assess the current level of Ukraine's balancing and ancillary reserves from the situation of its balancing and ancillary services markets. The immediate situation shows room for improvement, but recent developments promise beneficial changes in the near future. So far, only the balancing market has been implemented, as Ukrenergo's frequent price changes for ancillary services delayed the ancillary services market (Tetra Tech, 2020). Meanwhile, the balancing market has been off to an only partially successful start, since low supply often only provided 55% of the needed capacity for short-term load-increase or -decrease, granting the few suppliers large market power. (Szabó, Mezősi and Kácsor, 2020).

Balancing Market does not yet offer enough reserves for down- and upwards regulation

However, Ukrenergo has by now certified ten hydro power plants to offer their services on a future ancillary services market (Tetra Tech, 2020). USAID and Tetra Tech estimate that reserves will soon outpace demand for ancillary services. According to Ukrenergo, they even already do (Tetra Tech, 2020):

Ancillary services market not yet running, but certification of reserve capacities is ongoing and promising

- Frequency Containment Reserves (Primary): +-115 MW certified vs +-119 MW demand,
- Automatic Frequency Restoration Reserves (Secondary): +-724.5 MW vs. +-372 MW
- Manual Frequency Restoration Reserves (Secondary): 3,483 MW vs. 628 MW
- Restoration Reserves (Tertiary): 3,900MW vs. 1,000 MW

Additionally, the World Bank intends to finance up to five battery storage projects, in each case connected to renewable energy projects, that could contribute to a more liquid ancillary services market.

However, for balancing and ancillary services to become available, and thus help control frequency and load levels, TSOs first need to install and use balancing technology and a precision demand-forecasting system. According to the World Bank, in the case of Ukraine these systems would save the country USUSD13 billion and USUSD11.5 billion respectively, in terms of future investment needs for new power sources and other infrastructure (World Bank, 2020).

To Do: install balancing and demand-forecasting technology

Another important issue is the collection and sharing of data on electricity demand and supply forecasts, as well as of actual generation and consumption. Since March 2020, an EU energy support project for Eastern European States, EU4Energy, is helping Ukrenergo to implement systems to monitor and share congestion management data, and disaggregated generation data, translated into English (Bolborici, Zachia and Lazaroiu, 2016; Mykhailenko, Vereshchynska and Mukha, 2020). ENTSO-E also generally recommends all TSOs to share real-time calculations of network security, including data for voltage and reactive power management.

To Do: Data collection and sharing: e.g. on network security, voltage, congestion, and reactive power management

In order to profit from the damping equipment, as well as from the ancillary and balancing markets, TSOs also need a strong communication infrastructure. Only then can a TSO order (or prevent) the dispatch of electricity in a timely manner. 2016's feasibility study recommends Ukrenergo to install special protection systems, such as duplicate communication links (Bolborici, Zachia and Lazaroiu, 2016).

To Do: install communication infrastructure

Further, Ukrenergo deems it necessary to implement automatic 24-hour demand forecasting (Kovalchuk, 2019). For this, Ukrenergo could use the DAKAR software, which is already being used in the Burstyn island. 2017's Connection Agreement additionally requires Ukrenergo to conduct its operational planning on a yearly, monthly, weekly and daily basis in XML format, in order to be able to share it with neighbouring TSOs. Transelectrica, Romania's TSO, also found in 2019 that Ukrenergo yet has to implement the usage of real-time "n-1" calculations in its control rooms (Bolborici, 2019).

To Do: use demand forecasting software, conduct operational planning on a yearly, monthly, weekly and daily basis in XML format

A successful implementation of up-to-date balancing technology is not unlikely. Ukrenergo is already participating in an EU awareness system for data-sharing (ENTSO-E, 2020b), and is adopting EU regulation on congestion management methodologies (Nitsovych, Serebrennikov and Mykhailenko, 2020). The World Bank also estimates that Ukrainian power plants have enough capacities to provide for a functioning and liquid balancing market (World Bank, 2020). This assessment is underscored by an ongoing feasibility study

Success not unlikely, due to ongoing efforts in Ukraine and international support of Ukraine's frequency control capabilities, using new balancing and frequency data from 2019, by USAID and UHE (European Parliament and European Council, 2009). Such feasibility studies will have to indicate which substations need to be strengthened to accommodate changing flow patterns from synchronisation.

III. "Basic regulations mandating TSO operation", in detail

The role of ENTSO-E: connecting European TSOs, creating and implementing network codes

ENTSO-E, the "European Network for Transmission System Operators for electricity", was established in 2009 by the EU's Third Legislative Package for the Internal Energy Market (Energy Community Permanent High Level Group, 2012; Energy Community Secretariat, 2018). It is an association of 42 TSOs from 35 countries across Europe, extending beyond the EU. Ukrenergo is not a member of ENTSO-E, which would be a separate step from synchronisation with the European grid. The EU's third energy package, aimed at further liberalization and integration of the bloc's energy markets, gave ENTSO-E the mandate to create and implement so-called Network Codes. ENTSO-E drafted eight such codes, which after a process stretching over several years became EU regulations in 2017. They are therefore legally binding for all EU member States, as well as for some additional States who subjected themselves to following the codes deliberately, such as the members of the Energy Community, of which Ukraine is a contracting party (Energy Community Permanent High Level Group, 2012; Energy Community Secretariat, 2018). The Energy Community is an EU organization with the goal to unify the European energy market. However, while the Energy Community has set itself the goal to adopt all network codes, it has so far only adopted the three grid connection codes (compare Table 5) (Energy Community Secretariat, 2020a).

ENTSO-E's Network Codes are mandatory for EU Member States: (1) market codes, (2) operation codes, and (3) grid connection codes (so far, only (3) mandatory for Ukraine)

The codes are usually presented in three groups: (1) market codes organizing the integration of power markets across ENTSO-E member States, (2) system operation codes organizing the seamless operation of integrated power systems, and (3) grid connection rules organizing how and which generators can be interconnected with one-another, with consumers, and across borders (please compare Table 5). Both 'codes' and 'guidelines' are legally binding for EU States.

Table 5: EU Electricity Network Codes and Guidelines

Market Codes	System Operation Codes	Grid Connection Codes
Capacity Allocation and Congestion Management Guideline (CACM GL)	Electricity Transmission System Operation Guideline (SO GL)	Network Code on Requirements for Grid Connection of Generators (RfG NC)
Forward Capacity Allocation Guidelines (FCA GL)	Emergency and Restoration (ER NC)	Demand Connection Network Code (DC NC)
Electricity Balancing Guideline (EB GL)		Requirements for Grid Connection of High Voltage Direct Current systems and direct current-connected Power Park Modules Network Code (HVDC NC)

While Ukraine is bound by its obligations to the Energy Community to implement the codes, the key question remains as to which level of compliance with the Network Codes Ukraine needs to achieve in order to be able to synchronise its grid with the Continental Europe power system. The threshold for integration is difficult to make out, as the currently already synchronised parties within the network have not implemented all codes themselves (ENTSO-E, 2020a). And despite the political will from Brussels supporting Ukrainian integration into the Continental Europe power system, the ENTSO-E's member TSOs might reject synchronisation if the Ukrainian grid fails balancing and frequency control tests, such as in 2016's feasibility study. Arguably, the most important codes Ukraine needs to implement are thus the operational codes (please compare chapter I).

TSOs can reject Ukraine's bid for synchronisation in case of balancing and frequency issues – as in 2016 feasibility study. Most crucial for synchronisation: compliance with operational rules

Looking beyond operation codes to assess Ukraine´s readiness for integration with Europe, a comparison can be drawn between Ukraine's potential future, and Turkey's 2015 synchronisation with the Continental Europe power system. In 2015, the Energy Community (EC) hailed Turkey to be "legally synchronised" with the Energy Community (Energy Community Secretariat, 2015). The EC especially praised Turkey's balancing markets and its power exchange. The EC perceived Turkish markets as about to fulfill the Third Energy Package, which had been adopted by the EU five years before, and fully compliant with the Second Energy Package from twelve years earlier.

When Turkey synchronised its grid with continental Europe in 2015, its regulations were better aligned with the Energy Community's than Ukraine's are today.

Ukraine is in a similar position now as Turkey was in 2015. However, in Ukraine's case, the Third Energy Package was adopted eleven years ago, and the Network Codes four years ago. Judging by the Energy Community's assessment of the current state of Ukrainian regulations and laws, Ukraine still has room for improvement in terms of implementation of the Network Codes and Guidelines. For any party, a step closer to the Energy Community's regulations would be a step closer to synchronization with the European grid. In general, Ukraine could further unbundle its electricity generators, as well as increase the political independence of Ukrenergo and the regulator NEURC (Kopač, 2020).

Market codes also not implemented in Ukraine: missing liberalization

In its latest analysis of Ukrenergo, the Energy Community for example refused to certify the **independence of the TSO Ukrenergo** (European Parliament, 2009; Energy Community Secreteriat, 2020). Its experts stated that *"Ukrenergo does not own the electricity transmission assets as required by Article 9(1) of the Electricity Directive 2009/72/EC, and does not enjoy and exercise rights over them equivalent to an owner."* (European Parliament, 2009; Energy Community Secreteriat, 2020).

Ukrenergo's missing certification by the Energy Community: Lacking independence

For further analysis of Ukraine's electricity market, and thus its implementation of the Network Codes not relating to operational security, please have a look at Policy Proposal "Reforming Ukraine's electricity market" (Supponen, 2021)

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We are grateful for your feedback on this Policy Proposal. Please get in touch via info@LowCarbonUkraine.com.

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