The Green Pivot

Cyprus and the regional market

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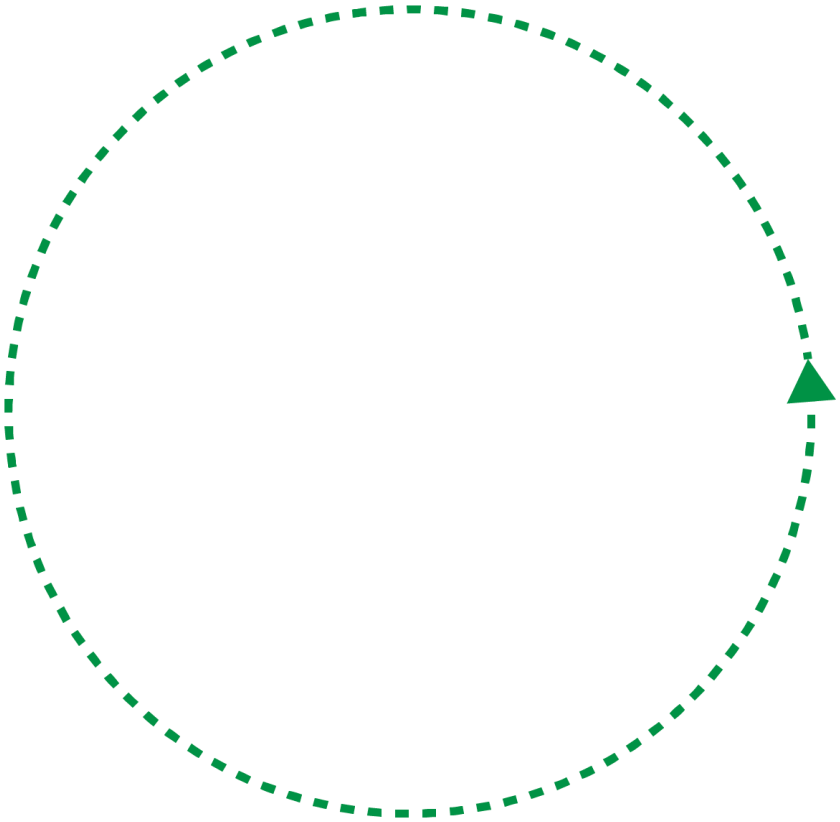

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Alma Economics combines unparalleled analytical expertise with the ability to communicate complex ideas clearly.

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Under the auspices of the Mediterranean Growth Initiative

The Mediterranean Growth Initiative (MGI) aims to refocus the lens on the Mediterranean through data and analysis. It is aimed at investors, policymakers, and analysts, as well anyone who wants to gain an in-depth understanding of the region and its potential.

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Executive summary

Moving to a green interconnected market-based energy model for Cyprus

- Without swift and drastic action in the energy sector, humanity faces a future of dire climatic consequences and instability.
- Cyprus is heavily relying on fossil fuels; only 15% of Cyprus's electricity was generated by renewables in 2021. Regarding its grid interconnectivity, Cyprus is not currently interconnected with other countries, although there are plans for the EuroAsia Interconnector to become operational in 2026. A competitive electricity model is also expected to be introduced in Cyprus by the end of 2022.
- Norway, which is interconnected with other countries, heavily relying on renewables and using a market-based and flexible energy model, holds important lessons for Cyprus.
- Moving toward a green interconnected market-based model requires current plans to be realised and further arrangements to be made. Some key elements of such a model are the following: physical interconnectivity, energy storage installations, electric power grid upgrade, full liberalisation of the electricity market, cross-border trading, and transparency.
- Such a model will generate benefits for Cyprus, including lower CO_2 emissions, energy supply security, and lower electricity costs.
- The average electricity consumer could save €200 per year off energy bills.

Cyprus is an island with high electricity prices, heavily relying on fossil fuels. There is great potential to introduce grid interconnectivity and invest in renewable energy sources to help Cyprus achieve decarbonisation, security of energy supply, and decreased electricity costs.

Alma Economics, in partnership with the Peace Research Institute Oslo (PRIO) and under the auspices of the Mediterranean Growth Initiative (MGI), explored the current state of the Cypriot energy market to provide evidence that can support the country's transition to a green interconnected market-based energy model. The research team conducted a thorough evidence review to fully understand the current and future state of play in Cyprus and identify best practice from the Nordic power market, considered one of the world's most successful. Interviews with sector experts from Cyprus and Norway helped fill gaps in the team's understanding and draw attention to important aspects of the Cypriot and Nordic power markets.

Key features of the Cypriot energy market

Cyprus's electricity is mainly generated by conventional sources, with only 15% from renewable energy sources in 2021.[1] Cyprus cannot continue to rely on fossil fuels to this extent as EU regulations regarding emissions of greenhouse gases and air pollutants are becoming stricter. The country's current plans are to cover 30% of its electricity consumption with renewables by 2030, mainly through solar power.

[1] TSOC, 2021. "Ποσοστά Διείσδυσης Ηλεκτροπαραγωγής από ΑΠΕ". Available at: https://tsoc.org.cy/electrical-system/energy-generation-records/res-penetration/

Natural gas reserves were recently discovered in Cyprus's exclusive economic zone (EEZ). The most probable scenario is that this natural gas will first be transported to countries with natural gas liquefaction technology and infrastructure, such as Egypt, before being exported to the international market. Projects such as the EastMed Pipeline, currently in design, are intended to connect Cypriot natural gas fields to Europe, introducing Cyprus's interconnectivity.

Cyprus is not currently connected to any neighbouring power systems. The EuroAsia Interconnector, currently being designed and due to become operational in 2026, will introduce grid interconnectivity in the region, supporting grid flexibility and increasing renewables in the energy mix. This EuroAsia Interconnector between Cyprus, Israel, and Greece will end Cyprus's energy isolation.

Regarding the liberalisation of the Cypriot electricity market, the transitory regulation of the electricity market in Cyprus will remain in effect until the new competitive electricity market model is implemented. Current plans suggest that the new model, the so-called Net Pool, will be in place by the end of 2022.[2]

Norway and the Nord Pool model

The Net Pool model is very similar to the Nord Pool model currently in place in the Nordic region. This Nordic power market is currently connected to power markets in the rest of Europe through physical interconnectors. The Nordic market is also connected to Europe through financial market integration. Over half of the energy in the Nordic market is produced by hydropower, Norway's main energy source, which makes the Nordic market have a higher share of RES in its energy mix than the rest of the EU.

The key differences between the Norwegian and Cypriot power systems are as follows:

(i) **Use of renewable energy sources:** Norway relies to a large extent on hydropower, while Cyprus's primary renewable energy source is solar power. Hydropower produces a significant amount of electricity without heavily relying on weather conditions, while solar panels depend on the amount of sunshine received which leads to fluctuations in the power supply. Additionally, Norway's hydropower production can be flexible due to its energy storage capacity, which is currently lacking in Cyprus.

(ii) **Grid interconnectivity:** Norway currently has direct electricity interconnections with other European countries, while Cyprus is only expected to connect with other countries when the EuroAsia Interconnector becomes operational in 2026.

(iii) **Cross-border trading:** Norway shares a common electricity market with other Nordic countries, having a common Nordic power exchange. The Nordic market is also interconnected with the rest of Europe. Cyprus does not currently have any plans for cross-border trading at any stage of the competitive market it plans to introduce.

The way ahead for Cyprus

Although Cyprus is already on a path to achieving decarbonisation, interconnectivity, and competition in the power market, it is important that it develops a national, long-term strategy covering the following elements:

(i) successful completion of current plans to achieve **physical interconnectivity**.

(ii) increase in the availability of **energy storage installations**.

[2] Philenews, 2022. "Ν. Πηλείδου: Επανεξέταση του μοντέλου ηλεκτρισμού". Available at: https://www.philenews.com/oikonomia/kypros/article/1522400/n-pileidoy-epanexetasi-toy-monteloy-ilektrismoy

(iii) **upgrading the Cypriot electric power grid** to a smart grid.

(iv) completion of the **full liberalisation of the Cypriot electricity market**. Further arrangements could include the decentralisation of the shares in the electricity market, so there is no dominant player, as well as the transparent, fast and easy provision of licenses for renewable electricity generation and supply.

(v) arrangements for **cross-border electricity trading**.

(vi) **transparency (e.g., equal access to information** for all parties involved in the power market, using the **common European algorithm** to calculate market prices).

Cyprus faces significant challenges in moving towards a green interconnected market-based model. First, it is a small country with a small energy market, which limits the number of potential electricity suppliers and hence the level of competition. Second, due to its geographical position, grid interconnectivity is more technically difficult and costly. Finally, geopolitical tensions in the Eastern Mediterranean region make it more difficult to achieve the level of interconnection between Cyprus and its neighbours than is enjoyed by Nordic countries.

Despite the challenges, the potential gains in terms of the cost of electricity, reduction of CO_2 emissions, and security of energy supply are large.

Socio-economic benefits

As a result of moving toward a green interconnected market-based model, energy production generated by renewables (e.g., solar and wind power) would increase, resulting in less reliance on fossil fuels and lower CO_2 emissions. Increased interconnectivity in the greater region would also result in increased security of energy supply for Cyprus and all other interconnected countries. Reliable connections between countries will help alleviate electricity deficits.

As a result of grid interconnectivity, there can be large economies of scale in both power generation and transmission. In particular, interconnectivity can allow the introduction of big-size units in the power systems, thus, increasing efficiency in production and leading to increased competition and reduced electricity bills. Additionally, economies of scale in transmission can also be significant, as higher voltage cables cost less per MW of power transferred than lower-voltage lines.

Increased interconnectivity in the greater region of Cyprus could reduce the cost of electricity substantially. Under a set of reasonable assumptions, we estimate that each electricity consumer could save €200 per year through lower energy bills.

Introduction

Due to the current energy price crisis and its consequences, such as potential backsliding to dirty fossil fuels,[3] investment in renewable energy sources (RES) and increased interconnectivity seem to be a one-way road to achieving decarbonisation, energy security, and reduced electricity costs. Cyprus also needs to follow this pathway as it is currently an island with no interconnection with other countries, heavily reliant on fossil fuels, and its electricity is the seventh most expensive in the EU.[4]

Alma Economics, commissioned by PRIO and under the auspices of the Mediterranean Growth Initiative (MGI), reviewed the existing state of play in Cyprus and set an indicative pathway for the future of the Cypriot energy market and interconnectivity in the region. Our research team explored available evidence to understand the energy market in Cyprus, Cyprus's plans relating to increasing the use of RES, as well as expected interconnectivity in the region. The Nordic model was also examined, aimed at identifying key differences between the Norwegian and Cypriot power markets as well as any lessons learnt from the Norwegian power market that could be applied in Cyprus. Based on the above, our team summarised current plans and further arrangements required for Cyprus to move toward a green interconnected market-based energy model. We also discussed the challenges and benefits that will arise from such a transition. Apart from a thorough evidence review, our team also conducted interviews with sector experts from Cyprus and Norway to better understand the current and future state of play in both countries. Our interviews focused on understanding: (i) the energy mix in Cyprus, including the share of renewables in the energy mix and expected imports of liquid natural gas, (ii) natural gas reserves in Cyprus, (iii) interconnectivity in the region, (iv) liberalisation of the Cypriot electricity market, and (v) the Nordic model.

This report includes the following chapters: (i) The energy market in Cyprus, which discusses Cyprus's energy sources, its natural gas reserves, RES in the energy mix, grid interconnection, and plans for full liberalisation of the power market; (ii) The Nordic model, which explores Norway's energy supply system, the key characteristics of the Nordic model, as well as the differences between the Norwegian and Cypriot power markets; (iii) Moving to a green interconnected market-based model, which discusses the plans and further arrangements for such a transition, the resulting benefits, as well as potential challenges.

[3] Financial Times, 2022. "EU warns against fossil fuel 'backsliding' as coal replaces Russian gas". Available at: https://www.ft.com/content/a8b179e2-b565-42b6-bb41-90aea44536e1

[4] Financial Mirror, 2022. "Cyprus electricity is seventh most expensive in EU". Available at: https://www.financialmirror.com/2022/08/30/cyprus-electricity-is-the-seventh-most-expensive-in-eu/

The energy market in Cyprus

The current energy market in Cyprus

According to the Electricity Authority of Cyprus (EAC),[5] which is responsible for the country's generation, transmission, distribution, and electricity supply, Cyprus's energy market relies heavily on imported fuels, such as heavy fuel oil and gas oil.[6] Although generating and supplying electricity are competitive activities, EAC as a producer and supplier currently holds a dominant position in the energy market. Transmission and distribution activities are monopolistic; the transmission system belongs to the EAC, but Cyprus Transmission System Operator (TSOC), the Management Unit of the Transmission System, is an independent legal entity. The distribution system also belongs to the EAC, and the Distribution System Operator (DSO), which is designated by the EAC, is responsible for the operation, maintenance, and development of the distribution system.[7]

Energy power is currently generated at three thermal power stations[8] which have a total capacity of 1,478MW,[9] although the use of renewables is currently increasing. According to TSOC, there are six onshore windfarms[10] across the country with a total capacity of around 157.5MW, solar panels of 262.7MW, and 12.4MW of biomass.[11] There is also additional solar energy capacity from net metering systems. In 2021, 85.1% of total electricity was generated by conventional sources, 9.2% by solar systems, 4.9% by onshore wind farms, and 0.8% by biomass.[12]

Introducing natural gas to the Cypriot energy market

As the regulations regarding emissions of greenhouse gases and air pollutants become stricter, Cyprus cannot continue to heavily rely on fossil fuels. Although the share of renewable energy sources is expected to continue increasing in the Cypriot energy mix, unexpected variations in renewable energy outputs also require using other energy sources, fossil fuels or natural gas, to compensate for shortfalls in energy production (Alma Economics, 2021). However, using fossil fuels to generate energy leads to CO_2 emissions which would not allow Cyprus to meet the EU goal of zero carbon emissions by 2050. Additionally, the use of fossil fuels is also affecting the cost of electricity paid by consumers. The prices of oil used by EAC for power generation are expected to increase even more due to the embargo imposed on Russian oil and oil product imports.[13]

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[5] Electricity Authority of Cyprus. Available at: https://www.eac.com.cy/EN/Pages/default.aspx

[6] Electricity Authority of Cyprus. "Energy Generation". Available at: https://www.eac.com.cy/EN/EAC/Sustainability/Pages/ElectricityProduction.aspx

[7] Cyprus Energy Regulatory Authority (CERA). "Electricity – Transmission and Distribution System". Available at: https://www.cera.org.cy/en-gb/ilektrismos/details/transmission-system

[8] Electricity Authority of Cyprus. "Power station capacity". Available at: https://www.eac.com.cy/EN/RegulatedActivities/Generation/powerstationcapacity/Pages/default.aspx

[9] International Trade Administration. "Cyprus – Country Commercial Guide". Available at: https://www.trade.gov/country-commercial-guides/cyprus-renewable-energy-sources-res

[10] Alpha Cyprus, 2022. "Αιολική ενέργεια: Πως θα πετύχουμε μείωση στην τιμή του ηλεκτρικού (ΒΙΝΤΕΟ)". Available at: https://www.alphanews.live/cyprus/aioliki-energeia-pos-tha-petyhoyme-meiosi-stin-timi-toy-ilektrikoy-binteo

[11] TSOC, 2022. "Ημερήσια Παραγωγή Ηλεκτρικού Συστήματος – Πέμπτη, 25 Αυγούστου 2022". Available at: https://tsoc.org.cy/electrical-system/total-daily-system-generation-on-the-transmission-system/

[12] TSOC, 2021. "Ποσοστά Διείσδυσης Ηλεκτροπαραγωγής από ΑΠΕ". Available at: https://tsoc.org.cy/electrical-system/energy-generation-records/res-penetration/

[13] CyprusMail. "How to tackle expensive electricity in Cyprus". Available at: https://cyprus-mail.com/2022/06/19/how-to-tackle-expensive-electricity-in-cyprus/

Another solution for the country to meet its carbon targets would be to add natural gas to its energy mix, as greenhouse gas emissions generated by natural gas are much lower than oil-generated emissions. The lifecycle greenhouse gas emissions of electricity generated by natural gas and oil are 450gCO_2/kWh and 840gCO_2/kWh, respectively (Kaldellis and Apostolou, 2017).

Cyprus has plans to add imported Liquified Natural Gas (LNG) to its energy mix in 2023. In 2020, Cyprus started building its first LNG import terminal at the port of Vasilikos, which has been delayed due to several challenges that prevent the project's progress.[14] According to current plans, this project will be completed in summer 2023, allowing Cyprus to add natural gas to its energy mix.[15] However, LNG prices have been increasing significantly and will probably remain high through 2025 and beyond.[16] Such a transition would likely increase the electricity price by at least 25%.

Natural gas reserves in Cyprus

Offshore natural gas reserves estimated to be around 200 tcf[17] have recently been discovered in Cyprus's exclusive economic zone (EEZ) (Tsangas et al., 2018). Currently, there is an ongoing gas project in the eastern Mediterranean Sea 160km south of Limassol, namely the Aphrodite gas field project which is scheduled to start operating in 2026/2027.[18] The most likely scenario is that the natural gas from Aphrodite will be transported through an undersea pipeline to an Egyptian LNG plant where it will be liquified and exported to the international market.[19] This project, measured to be around 4.5 tcf, could generate more than €9bn of direct economic benefits.[20]

Other natural gas fields in Cyprus are Calypso (3.5 tcf), Glaucus (6.5 tcf), and the latest discovery, Cronos-1.[21] In August 2022, natural gas reserves were discovered at the Cronos-1 well off Cyprus, with some preliminary estimates indicating that it contains around 2.5 tcf of natural gas.[22] Although there needs to be further exploratory drilling to conclude where the field can be exploited, the first results indicate that the natural gas is of good/excellent quality. Following this discovery, the Minister of Energy, Commerce and Industry (MECI) of Cyprus noted that Cyprus has prospects to support the EU's efforts to wean off of Russian natural gas.[23] In particular, the Minister submitted a letter to the European Commissioner discussing the prospects for using Cyprus's natural gas reserves and potential opportunities for this natural gas to be exported to the EU.[24]

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[14] CyprusMail, 2022. "LNG project: Problems from the outset". Available at: https://cyprus-mail.com/2022/02/07/lng-project-problems-from-the-outset/

[15] Financial Mirror, 2022. "LNG terminal will be ready summer 2023". Available at: https://www.financialmirror.com/2022/02/08/lng-terminal-will-be-ready-summer-2023/

[16] CyprusMail. "How to tackle expensive electricity in Cyprus". Available at: https://cyprus-mail.com/2022/06/19/how-to-tackle-expensive-electricity-in-cyprus/

[17] Tcf (trillion cubic feet) is the volume measurement of natural gas commonly used in the US. A tcf is equivalent to approximately one quadrillion of a British thermal unit.

[18] Kathimerini Cyprus. "Cyprus to export natural gas by 2026, energy minister says". Available at: https://www.ekathimerini.com/economy/1183547/cyprus-to-export-natural-gas-by-2026-energy-minister-says/

[19] Alpha Cyprus, 2022. "Βίντεο: Η Νατάσα Πηλείδου για την ανακάλυψη φυσικού αερίου στο τεμάχιο 6". Available at: https://www.alphanews.live/politics/binteo-i-natasa-pileidoy-gia-tin-anakalypsi-fysikoy-aerioy-sto-temahio-6

[20] NS Energy. "Aphrodite Gas Field". Available at: https://www.nsenergybusiness.com/projects/aphrodite-gas-field/

[21] ERT News, 2022. "Κοίτασμα φυσικού αερίου στην Κύπρο: Ελπίδες στην Ευρώπη – Πότε θα ξεκινήσει η εκμετάλλευσή του". Available at: https://www.ertnews.gr/eidiseis/diethni/koitasma-fysikoy-aerioy-stin-kypro-elpides-stin-eyropi-pote-tha-xekinisei-i-ekmetalleysi-toy-video/

[22] Reuters, 2022. "TotalEnergies, Eni announce major Cyprus gas find". Available at: https://www.reuters.com/business/energy/totalenergies-eni-announce-major-cyprus-gas-find-2022-08-22/

[23] ERT News, 2022. "Κοίτασμα φυσικού αερίου στην Κύπρο: Ελπίδες στην Ευρώπη – Πότε θα ξεκινήσει η εκμετάλλευσή του". Available at: https://www.ertnews.gr/eidiseis/diethni/koitasma-fysikoy-aerioy-stin-kypro-elpides-stin-eyropi-pote-tha-xekinisei-i-ekmetalleysi-toy-video/

[24] Kathimerini Cyprus. "Cyprus to export natural gas by 2026, energy minister says". Available at: https://www.ekathimerini.com/economy/1183547/cyprus-to-export-natural-gas-by-2026-energy-minister-says/

Natural gas and interconnectivity

According to stakeholders, another project relating to developing natural gas infrastructure and related equipment for the transmission of natural gas is the EastMed Pipeline. The EastMed Pipeline, currently in design, is intended to be an onshore and offshore natural gas pipeline connecting Cyprus to mainland Greece via Crete.[25] The pipeline is envisaged to connect natural gas fields in the Eastern Mediterranean – Leviathan in Israel and Aphrodite in Cyprus – to Europe (Tziarras, 2019). According to Tziarras (2019), there have been concerns about the development of this project mainly due to technical difficulties as well as adverse financial and geographical circumstances. However, a recent feasibility study suggested that the project, currently in the final engineering phase, is technically mature and is expected to operate commercially in 2027.[26] If materialised, the EastMed pipeline could provide Cyprus with the opportunity to connect with the European gas system, further supporting gas trade in the region.[27]

Renewable energy sources (RES) in Cyprus

Cyprus adopted the Law on the Promotion of Renewable Energy and Energy Efficiency in the early 2010s,[28] establishing a fund that finances costs related to renewable electricity generation.[29] In 2010, Cyprus produced 97MW of renewable energy, which almost tripled by 2018 (IRENA, 2019). Between 2005 and 2019, Cyprus increased its renewable energy share of gross energy consumption by around 10% (European Commission, 2020). In order to meet the EU carbon reduction targets, Cyprus will need to increase energy generated by exploiting RES. According to the European Commission (2020), Cyprus should aim to increase the share of RES in the gross final consumption of energy to 23% by 2030. Regarding Cyprus's electricity sector, the country aims to cover 30% of its electricity consumption from RES by 2030, mainly through solar power. According to sector experts, Cyprus expects an additional increase in RES capacity of 360MW by 2023, mainly through increases in solar power. To achieve these targets, there is a need for the development of energy storage technologies and an increase in grid interconnectivity in the region.[30]

At the EU level, the Renewable Energy Directive (RED),[31] which set renewable energy and carbon-related targets at national and European levels in 2009, was revised by the Parliament in 2018, suggesting an increase in the share of renewable energy consumed from the 27% initial target to 32% by 2030.[32] In 2021, the European Commission adopted the "fit for 55" package as part of the European Green Deal, which increases the 32% target to a minimum 40% share of RES in final energy

[25] NS Energy. "Eastern Mediterranean Pipeline Project". Available at: https://www.nsenergybusiness.com/projects/eastern-mediterranean-pipeline-project/

[26] DNV, 2022. "DNV further confirms feasibility and maturity of the EastMed pipeline". Available at: https://www.dnv.com/news/dnv-further-confirms-feasibility-and-maturity-of-the-eastmed-pipeline-226712

[27] NS Energy. "Eastern Mediterranean Pipeline Project". Available at: https://www.nsenergybusiness.com/projects/eastern-mediterranean-pipeline-project/

[28] IEA. "Cyprus". Available at: https://www.iea.org/countries/Cyprus

[29] IEA, 2017. "Law on the Promotion of Renewable Energy and Energy Efficiency". Available at: https://www.iea.org/policies/2282-law-on-the-promotion-of-renewable-energy-and-energy-efficiency

[30] International Trade Administration. "Cyprus – Country Commercial Guide". Available at: https://www.trade.gov/country-commercial-guides/cyprus-renewable-energy-sources-res

[31] European Commission. "Renewable energy directive". Available at: https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

[32] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN

consumption by 2030.[33] Due to the current energy price crisis, MEPs voted in July 2022 to change this target and raise the share of renewables in the EU's final energy consumption to 45% by 2030.[34]

Although increasing renewable energy production in Cyprus can help decrease electricity prices (as RES energy generation is less costly than energy generated by conventional sources),[35] private producers of renewable electricity charge EAC high prices (compared to the cost), which further leads consumers to be charged a high price. Evidence from June 2022 suggests that renewable electricity was sold to EAC at $0.18-0.19 per kWh, while the production cost was only $0.04-0.06 per kWh. Although Cyprus Energy Regulatory Authority (CERA) plans to decrease the renewable electricity prices to $0.11 per kWh for some solar power producers,[36] the renewable electricity prices were set at around $0.02 per kWh at that time in other European countries, such as Spain and Portugal.[37]

Cyprus has yet to fully exploit its solar potential to meet its carbon targets and resolve energy-related challenges. Cyprus has an abundance of unused land that could be used to install solar panels. Likewise, solar panels can also be installed on more residential rooftops across Cyprus.[38] In August 2022, the Cypriot Cabinet approved the financial extension of the country's subsidy scheme for net metering[39] and energy-efficiency measures.[40] According to the 2022 National Report to the European Commission for the year 2021 by CERA, MECI announced a series of measures earlier in 2021, including the introduction of virtual net-metering in the scheme. This would allow consumers unable to install photovoltaic systems on their buildings' roofs to install them on rooftops of other buildings or on the ground. The produced electricity would be offset against the consumption of that specific household. However, increasing RES in the energy mix requires improving Cyprus's grid system and, eventually, transitioning to a smart power grid, including smart metering[41] and smart devices.[42]

Currently, for reasons of grid safety and reliability, the grid operator may partially or fully reduce renewable electricity output at any time.[43] According to sector experts, the RES energy curtailment is estimated to around 1%, but it is expected to increase soon. To avoid curtailing energy, there is a need for storage technologies and grid interconnection.[44]

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[33] European Parliament, 2021. "Revision of the Renewable Energy Directive: Fit for 55 package". Available at: https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2021)698781

[34] European Parliament, 2022. "MEPs back boost for renewables use and energy savings". Available at: https://www.europarl.europa.eu/news/en/press-room/20220711IPR35006/meps-back-boost-for-renewables-use-and-energy-savings

[35] Hélène Pelosse. "The True Costs of Conventional Energy". United Nations, UN Chronicle. Available at: https://www.un.org/en/chronicle/article/true-costs-conventional-energy

[36] According to sector experts, the price decrease concerns specific solar power producers who have made an agreement with the Ministry of Energy, Commerce and Industry (MECI), and not the whole market.

[37] CyprusMail, 2022. "How to tackle expensive electricity in Cyprus". Available at: https://cyprus-mail.com/2022/06/19/how-to-tackle-expensive-electricity-in-cyprus/

[38] Fhilenews, 2022. "Ηλεκτρική ενέργεια – Ανανεώσιμες Πηγές – ΑΗΚ". Available at: https://www.phileneWs.com/oikonomia/kypros/article/1511931

[39] Net metering is an electricity billing tool that credits solar energy system owners for the electricity they add to the grid. Solar Energy Industries Association (SEIA). "Net Metering". Available at: https://www.seia.org/initiatives/net-metering

[40] pv-magazine, 2022. "Cyprus expands funding for solar net metering". Available at: https://www.pv-magazine.com/2022/08/26/cyprus-expands-funding-for-solar-net-metering/

[41] Smart metering system is an electronic system capable of measuring electricity consumption or electricity fed into the grid. European Commission. "Smart grids and meters". Available at: https://energy.ec.europa.eu/topics/markets-and-consumers/smart-grids-and-meters_en

[42] Cyprus's Integrated National Energy and Climate Plan, 2020. Available at: https://energy.ec.europa.eu/system/files/2020-01/cy_final_necp_main_en_0.pdf

[43] Legal sources of renewable energy. "Cyprus – Use of the grid – Curtailment". Available at: http://www.res-legal.eu/search-by-country/cyprus/single/s/res-e/t/gridaccess/aid/use-of-the-grid-6/lastp/115/

[44] Cyprus's Integrated National Energy and Climate Plan, 2020. Available at: https://energy.ec.europa.eu/system/files/2020-01/cy_final_necp_main_en_0.pdf

Grid interconnection in the region

Cyprus is not currently connected to any neighbouring power systems. However, current plans focus on increasing grid interconnectivity in the region, supporting grid flexibility, and increasing RES in the energy mix. The EuroAsia Interconnector will be a 2,000MW electricity interconnector between Hadera (Israel) – Kofinou (Cyprus) – Crete (Greece).[45] This European Project of Common Interest (PCI) will connect the three countries through a 1,208 km subsea HVDC cable. According to the current plans, the project will commence in December 2025.[46]

The EuroAsia Interconnector will end Cyprus's energy isolation, which also aligns with EU objectives. It will ensure energy supply security for Cyprus, the other two involved countries, as well as the overall EU energy system. According to European Commission President, Ursula von der Leyen, this project will support the EU in reducing energy dependency on Russia and accelerate the decarbonisation of the EU's energy mix.[47] In particular, according to sector experts, interconnectivity in the region will support increased RES integration in the region's energy mix without requiring significant investments in grid reinforcement. By promoting the increased exploitation of RES, the EuroAsia Interconnector simultaneously supports the reduction of CO_2 emissions.

Additionally, this project is expected to bring socio-economic benefits of €10 billion to the partner countries.[48] The efficient power generation by natural gas and RES will reduce electricity costs. Thus cheaper energy will be transferred between the interconnected countries (Directorate-General for Energy (European Commission), 2019). Additionally, the electricity cost will be lower due to avoiding replacing old power plants.[49]

Apart from this PCI, there are also plans concerning the grid interconnection of Cyprus, Greece, and Egypt (2022 National Report to the European Commission for the year 2021 by CERA). This project will connect Egypt with Cypriot and Greek power grids through an HDVD cable with a transmission capacity of 2,000MW.

Liberalisation of the Cypriot electricity market

In 2014, CERA decided to fully liberalise the electricity market, however, it has not yet been implemented.[50] Since 2014, all electrical energy consumers can choose their supplier, but until the first quarter of 2021, the only supplier in Cyprus was 'EAC Supply' (2022 National Report to the European Commission for the year 2021 by CERA). The transitory regulation of the electricity market in Cyprus is currently in effect, during which two other private suppliers have entered the market. Those private suppliers buy RES energy from RES producers – 29 producers in the transitory market – which is supplied to specific consumers under bilateral contracts. This transitory period started in 2017 and will continue until the new competitive electricity market model is implemented. Current plans suggest that the new model, the so-called Net Pool, will be in place by the end of 2022.[51]

[45] EuroAsia interconnector. EuroAsia at a glance. Available at: https://euroasia-interconnector.com/at-glance/

[46] EuroAsia Interconnector. EuroAsia project schedule. Available at: https://euroasia-interconnector.com/at-glance/project-timeline/

[47] Offshore Energy. "Von der Leyen: EuroAsia Interconnector to help free EU from energy dependence". Available at: https://www.offshore-energy.biz/von-der-leyen-euroasia-interconnector-to-help-free-eu-from-energy-dependence/

[48] EuroAsia interconnector. EuroAsia at a glance. Available at: https://euroasia-interconnector.com/at-glance/

[49] EuroAsia Interconnector. EuroAsia project schedule. Available at: https://euroasia-interconnector.com/at-glance/project-timeline/

[50] Cyprus – Country report, 2014. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/2014_countryreports_cyprus.pdf

[51] Philenews, 2022. "Ν. Πηλείδου: Επανεξέταση του μοντέλου ηλεκτρισμού". Available at: https://www.philenews.com/oikonomia/kypros/article/1522400/n-pileidoy-epanexetasi-toy-monteloy-ilektrismoy

CERA decided to adopt the Net Pool model in 2015 as it was considered to be the most appropriate trading arrangement approach for the Cypriot electricity market and which also aligned with the EU target model. Lately, the EU has put under review the target model for the electricity market mainly due to the very high natural gas prices.[52]

The key characteristics of the Net Pool model currently being discussed to be implemented in Cyprus are the Day-Ahead Market (DAM), the Integrated Scheduling Process (ISP), and the real-time Balancing Mechanism (BM) (CERA, 2015). The DAM is a centrally-managed, wholesale electricity market where half-hourly blocks of electricity are negotiated for the following day. The DAM is a market where producers submit unit-based bids while suppliers submit bids based on their individual forecasts. The DAM opens one day before the delivery day and runs from 10:30 EET to 13:00 EET. A Market Operator (MO), which manages the DAM, runs a process of matching bid curves to optimise the dispatch of residual volumes. The MO is also responsible for publishing the market results and informing the participants as well as the Transmission System Operator 45 minutes after the DAM has closed. It also runs the purchase and sale transactions in the DAM; it has a contract with market participants, and the contracts are determined at the DAM clearing price.

In 2021, major changes took place following the introduction of the legal framework for opening up the electricity market in Cyprus. For example, the TSOC has become a fully independent and autonomous legal entity under public law, which is required by the role it is called to play as the objective and neutral operator of the electricity market.[53]

An Integrated Scheduling Process (ISP) will be operated by the TSOC on the day ahead of the delivery day to schedule generating units and dispatchable load as well as procure most types of operating reserves. A real-time Balancing Mechanism will also be used to optimise real-time dispatch actions and balance electricity supply and demand (CERA, 2017).

After the competitive market starts operating, market participants are expected to participate in intraday trading, aiming to minimise their exposure to imbalances. In particular, market participants will be able to trade energy units on an intraday platform, which is set to be organised in the future to support market operations. Finally, there are no current plans or arrangements relating to cross-border trading at any stage of the market (forward, day ahead, intraday or real-time) according to stakeholders.

[52] Philenews, 2022. "Ν. Πηλείδου: Επανεξέταση του μοντέλου ηλεκτρισμού". Available at: https://www.philenews.com/oikonomia/kypros/article/1522400/n-pileidoy-epanexetasi-toy-monteloy-ilektrismoy

[53] Philenews, 2021. "Ψηφίστηκε από τη Βουλή το άνοιγμα της αγοράς ηλεκτρισμού στην Κύπρο". Available at: https://www.philenews.com/oikonomia/kypros/article/1298390

The Nordic model

Norway's energy supply system

Norway's energy supply system is mainly based on hydro and wind power; around 88% of energy production capacity is covered by 1,960 hydropower plants and 10% by 53 wind farms.[54] In 2020, only 2% of Norway's total production capacity was covered by the 30 thermal power plants operating in the country.

Norway also has more than 1000 storage reservoirs with a total storage capacity equivalent to 70% of its annual electricity consumption. Due to its high energy storage capacity, Norway's production capacity can be flexible, corresponding to energy demand at a low cost. In contrast, adjusting thermal power plants' production would be both time-consuming and costly. Using storage reservoirs, Norway can produce electricity even during periods with adverse weather conditions (such as in times with little precipitation). To fully exploit this potential, it is necessary for Norway to have a well-developed power grid.

The electricity grid in Norway consists of the transmission, regional, and distribution grids.[55] The transmission grid is operated by Statnett, Norway's Transmission System Operator, while the regional and distribution grids are operated by 130 different distribution system operators (DSO).[56] The transmission grid connects producers with consumers through a nationwide system. Additionally, the interconnectors with other countries are also connected to the transmission grid. The regional grid connects the transmission grid to the distribution grid, and the distribution grid consists of local electricity grids and supplies smaller end users. Large electricity producers and consumers (such as power-intensive manufacturers) are connected to the transmission or regional grid, while smaller producers and consumers (such as households) are connected to the distribution system.

In Norway, there are more than 200 electricity production companies, of which around 90 are solely producers. The ten largest companies are responsible for producing 70% of the total hydropower production capacity. Additionally, more than 120 companies conduct grid-related activities, although not all of them are connected to customers.

The Nordic model

In the 1990s, Denmark, Finland, Norway, and Sweden opened up their electricity markets for competition in generation and retailing (Amundsen and Bergman, 2006). Since 2000, the four countries have shared a common electricity market; the Nordic countries have been linked by physical interconnectors and financial market integration.[57] Following the liberalisation of energy legislation in

[54] Norwegian Ministry of Petroleum and Energy. "Energy facts-Norway – Norway's energy supply system – Electricity production". Available at: https://energifaktanorge.no/en/norsk-energiforsyning/kraftmarkedet/

[55] Norwegian Ministry of Petroleum and Energy. "Energy facts-Norway – Norway's energy supply system – The electricity grid". Available at: https://energifaktanorge.no/en/norsk-energiforsyning/kraftnett/

[56] NVE FAKTA NR. 08/2018. "The Norwegian power system. Grid connection and licensing". Available at: https://publikasjoner.nve.no/faktaark/2018/faktaark2018_03.pdf

[57] Nordic Energy Research, 2019. "New 2030 Vision and Roadmap for the Nordic Electricity Market". Available at: https://www.nordicenergy.org/article/press-release-new-2030-vision-and-roadmap-for-the-nordic-electricity-market/

the Nordic countries and the increased interconnectivity among them, the Nord Pool Spot power exchange system was established, allowing power to be traded across the Nordic countries.[58]

This Nordic power market is currently connected to power markets in the rest of Europe through physical interconnectors with the Netherlands, the Baltic States, Germany, Poland, and Russia. Recently, two other interconnectors between Norway and Europe have been operational; the Nord Link cable to Germany and the North Sea Link to the UK.[59]

The Nordic market is also connected to Europe through financial market integration. Nord Pool is currently operating markets in the Nordic and Baltic Regions, Germany, Poland, France, the Netherlands, Belgium, Austria, Luxemburg, and the UK. Nord Pool is a Nominated Electricity Market Operator (NEMO) in 15 European countries and services power markets in Bulgaria, Croatia, and Georgia.[60]

The main power generation sources of the Nordic electricity market are hydro, nuclear, and wind power. Over half of the energy is produced by hydropower, which gives the Nordic market a higher share of RES in its energy mix than the rest of the EU. The energy produced is used by intensive industries or for household heating.[61]

A market-based power system

The power supply system is based on the principles that electricity production and trading should be market-based while electricity transmission and distribution are monopolistic operations.[62] Power trading is organised based on the principle that power flows from low-price areas to high-price areas. For example, if Norway has increased demand for power but low production due to adverse weather conditions (e.g., little rain), power prices in Norway would rise. However, importing power from other countries in the same power system would be cheaper.[63]

The power market consists of the wholesale and the end-user markets. In the wholesale market, power is traded between power producers, power suppliers, brokers, energy companies, and large industrial consumers. In the end-user market, individual consumers buy electricity under contracts with power suppliers.

The wholesale market

The day-ahead market

The wholesale market consists of: (i) the day-ahead market, (ii) the continuous intraday market, and (iii) the balancing markets. In the day-ahead market, large volumes of electric energy are traded one day prior to delivery day. Participants in the day-ahead market submit their purchase or sale offers

[58] Norwegian Ministry of Petroleum and Energy, 2016. "The power market and prices". Available at: https://www.regjeringen.no/en/topics/energy/the-electricity-grid/the-power-market-and-prices/id2076000/

[59] Norwegian Ministry of Petroleum and Energy. "Energy facts-Norway – Norway's energy supply system – The power market". Available at: https://energifaktanorge.no/en/norsk-energiforsyning/kraftmarkedet/

[60] Nord Pool, 2022. "Postponement of the Core Flow-Based Market Coupling project Go Live". Available at: https://www.nordpoolgroup.com/en/message-center-container/newsroom/exchange-message-list/2022/q2/postponement-of-the-core-flow-based-market--coupling-project-go-live/

[61] Nordic Energy Regulators (NordREG), 2019. "An overview of the Nordic Electricity Market". Available at: https://www.nordicenergyregulators.org/about-nordreg/an-overview-of-the-nordic-electricity-market/

[62] Norwegian Ministry of Petroleum and Energy. "Energy facts-Norway – Norway's energy supply system – The power market". Available at: https://energifaktanorge.no/en/norsk-energiforsyning/kraftmarkedet/

[63] Norwegian Ministry of Petroleum and Energy, 2016. "The power market and prices". Available at: https://www.regjeringen.no/en/topics/energy/the-electricity-grid/the-power-market-and-prices/id2076000/

between 08:00-12:00 every day. The Transmission System Operators announce the trading capacities for the bidding areas. The auction closes daily at 12:00 and the per-hour prices are calculated based both on the selling and purchasing bids as well as the network constraints provided by TSOs.

The submitted orders in the Nordic day-ahead market are matched with orders in the pan-European marketing coupling process (the Single Day-Ahead Coupling (SDAC)) through a common European algorithm. This process, called Price Coupling of Regions (PCR), is currently operated by 8 Power Exchanges, including Nord Pool, aiming to develop a single price coupling solution to calculate electricity prices across Europe. Apart from the simultaneous calculation of prices, market coupling ensures the effective use of energy resources as well as electricity flows between different areas through implicit auctioning.[64] Lately, the EU has been putting more emphasis on the integration and coupling of energy markets. Currently, 24 countries are interlinked by European market coupling, covering around 90% of European electricity consumption.

The intraday market

Although the day-ahead market aims to balance energy supply and demand, some unexpected events (e.g., weather forecasts) might distort this balance. The intraday market works primarily as a correction market, adjusting trading in case actual production or consumption differs from the initial forecasts in the day-ahead market.[65] The intraday market operates following the clearance of the day-ahead market and closes one hour before the delivery hour. The intraday market of Nord Pool operates in the Nordic and Baltic regions as well as Germany and the UK.

The balancing market

The day-ahead and intraday markets aim to create a balance between power production and consumption before the operation starts. The balancing market preserves the balance during the time of operation by trading reserves used by TSOs. The TSOs (Svenska kraftnät, Statnett, Fingrid, and Energinet) are responsible for operating the balancing market. Statnett, the Norwegian TSO, is responsible for ensuring enough reserves to preserve balance in the Norwegian part of the power market.

Statnett's responsibilities can be summarised as follows: (i) coordination of the power supply system operation, (ii) calculating capacity, (iii) handling congestion, and (iv) supporting power trade with other countries. Statnett is also responsible for preserving balance in the system by adjusting either th production or consumption of electricity and providing market-based solutions for developing and utilising the power supply system efficiently.

Market-based price formation

System price

The system price is the spot price calculated by Nord Pool every day. The system price is a clearing reference price for the Nordic region based on the assumption that there is no congestion in the Nordic transmission grid. Producers make proposals suggesting how much they can produce at a specific price, while end-users submit bids stating how much they will consume at different prices.

[64] Norwegian Ministry of Petroleum and Energy. "Energy facts-Norway – Norway's energy supply system – The power market". Available at: https://energifaktanorge.no/en/norsk-energiforsyning/kraftmarkedet/

[65] NordREG, 2019. "An overview of the Nordic Electricity Market". Available at: https://www.nordicenergyregulators.org/about-nordreg/an-overview-of-the-nordic-electricity-market/

The price in the day-ahead market is equal to the level at which supply and demand reach an equilibrium. This price is equal to the marginal cost of producing power, thus ensuring that the cheapest resources are used and that electricity demand is covered at the lowest possible cost to society.[66]

Area prices

The Nordic areas are divided into bidding areas to deal with potential congestion in the electricity grid.[67] The Nord Pool sets different prices for these bidding areas, the so-called area prices, which take into account the different power situations among the different bidding zones. For example, area prices are higher in bidding zones with a power deficit, while power usually goes from low-price areas to high-price areas to help meet demand. The area prices will be the same in all bidding zones and equal to the system price in case of no grid bottlenecks (if the flow of power between bidding zones is within the capacity limits set by the TSOs).

The end-user market

In Norway, consumers purchasing power for their own consumption, also known as end users, can freely choose their power supplier. Large end users, such as industrial companies, either buy power directly in the wholesale market or through bilateral agreements with producers. Small end users buy power from electricity suppliers.

Consumers can access the website strømpris.no, established by the Norwegian Consumer Council and the Norwegian Water Resources and Energy Directorate, which sets out the contracts provided by energy suppliers. End users can choose the contract that meets their needs best. The electricity bill they receive is composed of the power price (electricity), grid tariff (due to using the power grid), electricity tax, value added tax, as well as other fees for the Energy Fund (Enova) and electricity certificates.[68]

Differences between the Norwegian and Cypriot power systems

This section discusses the key differences between the Norwegian and Cypriot power systems using the best available evidence and sector experts' insights. The Norwegian energy supply system is renewable, flexible, market-based, integrated, and secure.[69] On the other hand, Cyprus is moving toward a competitive energy market, with plans for increased RES in the energy mix and interconnectivity with other countries in the near future.

Use of renewable energy sources

First, Norway heavily depends on hydropower, with 1,690 hydropower plants covering almost 90% of the Norwegian production capacity. Cyprus's primary renewable energy source is solar power, with current solar panel energy capacity at 262.7MW. The key difference between these two renewable energy sources is that hydropower produces a significant amount of electricity without heavily relying

[66] Norwegian Ministry of Petroleum and Energy. "Energy facts-Norway – Norway's energy supply system – The power market". Available at: https://energifaktanorge.no/en/norsk-energiforsyning/kraftmarkedet/

[67] Nord Pool. "Price calculation". Available at: https://www.nordpoolgroup.com/en/trading/Day-ahead-trading/Price-calculation/

[68] Norwegian Ministry of Petroleum and Energy, 2016. "The power market and prices". Available at: https://www.regjeringen.no/en/topics/energy/the-electricity-grid/the-power-market-and-prices/id2076000/

[69] Norwegian Ministry of Petroleum and Energy. "Energy facts-Norway – Norway's energy supply system". Available at: https://energifaktanorge.no/en/norsk-energiforsyning/kraftmarkedet/

on weather conditions. On the other hand, energy production from solar panels depends on climate conditions (i.e., sunshine), meaning that unsuitable atmospheric conditions could lead to unpredictable shortfalls in the power supply.

Additionally, Norway's hydropower production can be flexible due to its storage capacity. The country's more than 1000 storage reservoirs can cover 70% of Norway's annual electricity consumption. On the other hand, Cyprus has only just announced measures in 2021 to enhance the deployment of energy storage technologies. However, no solid plans and timelines have been currently announced by MECI (2022 National Report to the European Commission for the year 2021 by CERA).

Despite the different nature of the renewable energy sources in the two countries, the key conclusion is that Cyprus must use its main renewable energy source to move to a green interconnected model. For Cyprus to increase the share of solar power and, more generally, RES in its energy mix, the country will likely need to invest in energy storage, such as battery technologies, thermal storage, or green hydrogen, to deal with potential energy shortfalls.[70]

Grid interconnectivity

The characteristics of hydropower production, the well-functioning grid operations, and the physical interconnection with other countries' power systems are the key attributes that make the Norwegian power system flexible and resistant to potential fluctuations in production.

Norway currently has direct electricity interconnections with other European countries. Interconnectivity allows the grid to accommodate increasing levels of variable RES, supporting interconnected countries' sustainable development and decarbonisation of their energy mix.[71] Apart from contributing to reducing CO_2 emissions, interconnectivity results in increased security of energy supply, allowing access to reliable and ample supplies of all forms of energy.

On the other hand, Cyprus is not yet interconnected with any other country. Current plans focus on introducing grid interconnectivity in the region through the EuroAsia Interconnector. This project will end Cyprus's isolation and will be a stepping stone toward increasing the country's power system flexibility and RES in the country's energy mix.

Cross-border trading

Norway shares a common electricity market with other Nordic countries, having a common Nordic power exchange. The Nordic market is also interconnected with the rest of Europe. This interconnected electricity market has been developed based on the belief that the increased competition will result in greater efficiency and, thus, benefit consumers (Amundsen and Bergman, 2006). According to the International Energy Agency (IEA) (2022), Norway's industry and household electricity prices have consistently been the lowest in the past years compared to the rest of the IEA countries.[72]

For multiple reasons, the Nordic power market is considered one of the world's most successful power markets. According to Amundsen and Bergman (2006), the Nordic power market's success factors are summarised in the following points: (i) simple and sound market design, which is heavily based on

[70] Press release, European Parliament, 2020, "Boost energy storage in the EU to help spur decarbonisation". Available at: https://www.europarl.europa.eu/news/en/press-room/20200706IPR82726/boost-energy-storage-in-the-eu-to-help-spur-decarbonisation

[71] Interreg North Sea Region. "North Sea Region interconnection". Available at: https://northsearegion.eu/northsee/e-energy/north-sea-region-interconnection/

[72] The list of all IEA countries is available at: https://www.iea.org/about/membership

hydropower, (ii) multiple countries sharing a common market with diluted market power, (iii) strong political support, and (iv) commitment to public service by power companies. According to Mr Bredesen,[73] the former CEO of Nord Pool Consulting, transparency, that is, equal access to information for all involved parties, is one of the cornerstones of a competitive electricity market. Readily accessible data, such as on prices, production, and consumption information, has contributed to a transparent Nordic power market. Sector experts also highlighted that using the common European algorithm to calculate market prices also sets the basis for a transparent market without corruption and manipulation. On the contrary, Cyprus does not have any plans to introduce cross-border trading at any stage of the competitive market.

[73] Hans-Arild Bredesen, 2015. "Nord Pool Market Model". Available at: http://www.asean-aemi.org/wp-content/uploads/2015/11/AEMI-Connectivity-Singapore_Hans-ArildBredesen.pdf

Moving to a green interconnected market-based model

Current plans and further arrangements

Cyprus is already on a path toward achieving decarbonisation, interconnectivity, and a competitive power market. However, further arrangements are required to facilitate the transition to a green interconnected market-based model. A national, long-term strategy covering the following plans and arrangements can support Cyprus's green pivot.

First, **physical interconnectivity** projects should be realised following current plans. For example, the EuroAsia Interconnector project has already been postponed due to technical and institutional challenges. The current plans suggest that the project will be operational in 2026, while the initial delivery date was December 2023.[74] Additionally, there are plans for a project concerning the interconnectivity between Cyprus, Greece, and Egypt. Such interconnectivity projects, once realised, will support Cyprus's clean energy transition and help end its isolation.

Second, there are no solid plans for **electricity storage** in Cyprus. Cyprus's Integrated National Energy and Climate Plan (2020)[75] suggests that some of Cyprus's key policy planning priorities should be the development of a regulatory framework for integrating energy storage systems into the electricity market as well as the provision of financial incentives for developing electricity storage installations. In 2021, some measures were announced by MECI aiming to enhance the deployment of such technologies, however, no solid plans and timelines have been currently announced (2022 National Report to the European Commission for the year 2021 by CERA). Cyprus should proceed with planning its way forward to accelerate the availability and deployment of energy storage solutions.

Cyprus needs to **upgrade its electric power grid** to increase RES in its energy mix. In particular, upgrading the electricity distribution and transition network to a smart grid will further support Cyprus's efforts to increase RES production, move away from fossil fuels, and, eventually, decrease electricity costs.[76]

The **full liberalisation of the Cypriot electricity market** will be completed by the end of 2022. Although further arrangements are expected to take place by the end of this year, some important steps have already been taken, such as TSOC becoming an independent and autonomous legal entity as required for its role as Market Operator. According to the Association of Participants in the Competitive Electricity Market,[77] full liberalisation of the Cypriot electricity market requires regulatory decisions with asymmetric measures. Such measures would decentralise the shares in the electricity market. As of now, EAC remains the dominant player in both production and supply of electricity.

[74] Newmoney, July 2022. "EuroAsia Interconnector: Στη Nexans το συμβόλαιο για τη διασύνδεση Κύπρου – Κρήτης". Available at: https://www.newmoney.gr/roh/palmos-oikonomias/energeia/euroasia-interconnector-sti-nexans-to-simvoleo-gia-ti-diasindesi-kiprou-kritis/

[75] Cyprus's Integrated National Energy and Climate Plan, 2020. Available at: https://energy.ec.europa.eu/system/files/2020-01/cy_final_necp_main_en_0.pdf

[76] CyprusMail, 2020. "Cyprus must upgrade grid for wind and solar". Available at: https://cyprus-mail.com/2020/10/29/cyprus-must-upgrade-grid-for-wind-and-solar/

[77] Simerini, 2022. "Αναγκαία η μετάβαση στην υγιή Ανταγωνιστική Αγορά Ηλεκτρισμού". Available at: https://simerini.sigmalive.com/article/2022/6/17/anagkaia-e-metabase-sten-ugie-antagonistike-agora-elektrismou/

Sector experts also suggested that more arrangements should be made to support the transition to a green interconnected market-based energy model, such as accelerating some processes. For example, according to sector experts, there are plans to accelerate the provision of licenses for renewable electricity generation and supply and make it online-based. This transparent, easy, and fast process will help increase RES in the energy mix.

Currently, Cyprus does not have any plans for **cross-border electricity trading**. However, evidence suggests that participating in a common electricity market can ensure energy supply security, facilitate decarbonisation, and, thus, lower electricity prices.[78] For example, Norway, which is heavily based on hydropower energy production and participates in the Nordic power market, had the lowest electricity price among other EU countries in July 2022; Norway's electricity price was €0.1283 per kWh.[79] Following the potential interconnection of Cyprus with the European grid,[80] Cyprus could start exploring the potential of cross-border electricity trading and proceed with necessary arrangements.

Another lesson that could be learned from the Nordic model is the importance of **transparency**, mainly though providing **equal access to information** to all parties involved in the power market and using the **common European algorithm** to calculate market prices. These elements set the basis for a transparent market deterring corruption and manipulation.

Main challenges

Cyprus is a **small country** with a **small energy market**. This means that the Cypriot energy market might not allow for many electricity suppliers to operate in the market as in the Nordic countries. Still, a sufficient number of independent suppliers will be able to operate in the Cypriot electricity market, thus allowing the Cypriot electricity market to move away from a monopoly of electricity provision.

Islands, such as Cyprus, tend to have limited or no grid interconnection, mainly due to **geographical challenges**. Connecting the power grid of Cyprus to the neighbouring mainland requires building a subsea cable of more than 1,000km in deep waters, which can be more challenging and costly than building onshore grid interconnections. The construction of subsea cables is constrained by geographical construction conditions, ocean engineering conditions, and the availability of construction equipment. A wide range of technology, a large investment scale, and complex construction techniques are prerequisites for achieving offshore grid interconnection (Wang et al., 2017).

Furthermore, Cyprus must balance **geopolitical tensions** while transitioning to a green, interconnected market-based model. Geopolitical tensions in the Eastern Mediterranean region make it more difficult to achieve the level of interconnection between Cyprus and its neighbours than is enjoyed by Nordic countries. According to Sülün (2022), political decisions about the interconnection of the whole island must be taken, otherwise grid interconnection projects, like the EuroAsia Interconnector, may generate new political frictions in Cyprus. Despite the challenges, the potential gains in terms of the cost of electricity, reduction of CO_2 emissions, and security of energy supply are large.

[78] World Bank Blogs, 2014. "Power Pools: How Cross-Border Trade in Electricity Can Help Meet Development Goals". Available at: https://blogs.worldbank.org/trade/power-pools-how-cross-border-trade-electricity-can-help-meet-development-goals

[79] Financial Mirror, August 2022. "Cyprus electricity is seventh most expensive in EU". Available at: https://www.financialmirror.com/2022/08/30/cyprus-electricity-is-the-seventh-most-expensive-in-eu/

[80] SMARD. "Cross-border electricity trade". Available at: https://www.smard.de/page/en/wiki-article/5884/6012

Benefits from moving to a green interconnected market-based model

As a result of moving toward a green interconnected market-based model, energy production generated by renewables (e.g., solar and wind power) would increase, resulting in less reliance on fossil fuels and fewer CO_2 emissions. Increased interconnectivity in the greater region would also result in increased security of energy supply for Cyprus and all other interconnected countries. Reliable connections between countries will help alleviate electricity deficits. The EU has set interconnection targets for all EU countries, suggesting that they achieve at least 15% interconnectivity by 2030. This means that each EU country should install cables that will allow 15% of its produced electricity to be transferred to other countries.[81]

As a result of grid interconnectivity, there can be large economies of scale in both power generation and transmission. In particular, interconnectivity can allow the introduction of big-size units in the power systems, thus, capturing economies of scale ((American Wind Energy Association (AWEA), 2019)). Additionally, economies of scale in transmission can also be significant as higher voltage cables cost less per MW of power transferred than lower-voltage lines (UN Department of Economic and Social Affairs-Division for Sustainable Development, 2006). According to a study by the UK Department of Energy & Climate Change (2013),[82] interconnection can allow for the most efficient generation of electricity, leading to increased competition and reduced electricity bills.

Another study by Jacobson (2021) explored the impact on energy costs of grid interconnection between counties in Western Europe, assuming that the electricity transferred would be produced by RES (wind, water, sunlight). According to the study's findings, electricity interconnection across Western European countries could reduce energy costs by around 13% relative to isolated power systems in each country.

Assuming that Cyprus's grid interconnectivity with neighbouring countries will reduce energy costs by around 13% and this reduction in energy costs will be directly reflected in electricity prices, then the average electricity consumer would see a reduction in their electricity bills following the country's interconnection to other electricity grids. For example, assuming that the annual electricity consumption in Cyprus is 4.6 billion kWh[83] and that the current electricity price in Cyprus is around €0.30 per kWh, Cyprus's interconnectivity with neighbouring countries would generate around €180 million annual savings for all electricity consumers. Thus, we estimate that each electricity consumer could save €200 per year as a result of lower energy bills.

[81] European Commission. "Electricity interconnection targets". Available at: https://energy.ec.europa.eu/topics/infrastructure/electricity-interconnection-targets_en

[82] The Department of Energy & Climate Change became part of the Department for Business, Energy & Industrial Strategy in July 2016.

[83] Electricity Authority of Cyprus. "STATISTICAL FIGURES. Electricity Sales". Available at: https://www.eac.com.cy/EN/eac/financialinformation/Pages/StatisticalFigures.aspx

We use estimates on Total Sales (GWh) as a proxy for total electricity consumption in Cyprus. We also use estimates from 2019, that is 4,615.4GWh, to capture pre-lockdown trends.

Conclusion

Alma Economics, in partnership with PRIO and under the auspices of the Mediterranean Growth Initiative (MGI), explored the current and future situation in the energy market in Cyprus, providing evidence that will support the country's transition to a green interconnected market-based energy model.

The way ahead for Cyprus

Cyprus is an island with no current grid interconnection with other countries, has the highest electricity prices in the EU, and heavily relies on fossil fuels. Although Cyprus is already on a path to achieving decarbonisation, interconnectivity, and competition in the power market, it is important that it develops a national, long-term strategy covering the following elements:

(i) successful completion of current plans to achieve **physical interconnectivity.**

(ii) increase in the availability of **energy storage installations.**

(iii) **upgrading the Cypriot electric power grid** to a smart grid.

(iv) completion of the **full liberalisation of the Cypriot electricity market**. Further arrangements could include the decentralisation of shares in the electricity market so that there is no dominant player, as well as the transparent, fast and easy provision of licenses for renewable electricity generation and supply.

(v) arrangements for **cross-border electricity trading**.

(vi) **transparency (e.g., equal access to information** for all parties involved in the power market, using the **common European algorithm** to calculate market prices).

Challenges may arise during Cyprus's shift toward a green interconnected market-based model. First, Cyprus is a small country with a small energy market. This means that the Cypriot energy market might not allow for many electricity suppliers to operate in the market, limiting the level of competition. Second, due to Cyprus's geographical position, grid interconnectivity is more technically difficult and costly. Finally, geopolitical tensions in the Eastern Mediterranean region make it more difficult to achieve the level of interconnection between Cyprus and its neighbours that is enjoyed by Nordic countries.

Despite these challenges, moving toward a green interconnected market-based model will generate large benefits for Cyprus, including lower CO_2 emissions, energy supply security, and lower electricity costs. Under a set of reasonable assumptions, we estimate that each electricity consumer could save €200 per year as a result of lower energy bills.

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