# The role of nuclear power in the new EU electricity market design

**Wojciech Wrochna, LL.M.**
Vice President of the Management Board
ORLEN Synthos Green Energy sp. z o. o.
Warsaw, Poland
w.wrochna@kochanski.pl

**Bartosz Brzyski**
Associate, Energy, Infrastructure & Environment Practice Group
Kochański & Partners
Warsaw, Poland
b.brzyski@kochanski.pl

## ABSTRACT

The European Union is setting itself increasingly ambitious targets for both moving away from fossil fuels and decarbonising the economy, with new investments in renewable energy sources and innovative low-carbon technologies being promoted. In this context, there has been heated public debate over the last few years as to whether nuclear power should also be a means of achieving the above targets. The latest position of the EU legislator makes it clear that nuclear energy is essential for the European economy. However, this raises a number of questions about how to align the characteristics of nuclear units (including their technical aspects) with the main assumptions of the EU electricity market reform. In this paper, the authors explain the main principles governing the EU electricity market and highlight what difficulties they bring in the context of nuclear power. Moreover, they identify the main challenges for nuclear facilities in Europe in relation to new ways of contracting energy, new financial support schemes and the need to ensure flexibility in electricity supply and demand.

**Keywords:** EU electricity market design; European Union; nuclear new build; state aid;

## Introduction

Opening up and unifying the individual energy markets of each EU Member State has been a great achievement of the European Union. However, ensuring consistent policy mechanisms and balancing different concerns (such as ensuring the security of energy supply, affordable prices, etc.) is not a simple task. The authors of this article will thus focus on the issue of the contemporary electricity market design in the European Union and its impact on the development of new nuclear power plants, as the analysis of the regulation in place leads to justified concerns that the current market structure may not meet the needs of nuclear new build, thus potentially acting as a disincentive for new projects.

## The relationship between nuclear energy and the European Union

From its inception, nuclear power was at the very heart of the European Union. After all, the very foundations of the EU we know today are based on two treaties from 1957 - the Treaty establishing the European Economic Community[1] (EEC) and the Treaty establishing the European Atomic Energy Community[2] (Euratom). Although at the time of their signature the latter received less attention - being considered by some as "irrelevant"[3] - the Euratom Treaty created an organisation which continues to exist to this day. Moreover, its original tasks remain materially unchanged despite the passage of over 50 years - to contribute to the raising of the standard of living in the Member States and to the development of relations with the other countries by creating the conditions necessary for the speedy establishment and growth of nuclear industries[4].

The above introduction is intended to show that, despite the passage of time, changes in the geopolitical situation and developments in technology, nuclear power continues to be an important industry in the European market. In fact, recent years show that the demand for nuclear new build is rapidly increasing worldwide. In 2023 a political declaration was made of tripling global nuclear energy capacity by 2050[5]. From a European perspective, the motivation behind this aspiration is primarily fuelled by increasing pressure to reduce greenhouse gas

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[1] Treaty establishing the European Economic Community (EEC Treaty), Rome, 25 March 1957.
[2] Treaty establishing the European Atomic Energy Community (EURATOM Treaty), Rome, 25 March 1957.
[3] D. Dinan, Europe Recast: A History of European Union, Lynne Riener Publishers, Inc., 2014, p. 80.
[4] EURATOM Treaty, Article 1.
[5] 28th Conference of the Parties to the U.N. Framework Convention on Climate Change - Declaration to Triple Nuclear Energy, 2 December 2023, <https://www.energy.gov/articles/cop28-countries-launch-declaration-triple-nuclear-energy-capacity-2050-recognizing-key> [access: 17 October 2024]

emissions and combat climate change. It is also crucial in ensuring energy security, stabilising affordable energy supplies and making "the Old Continent" less dependent on fossil fuels.

Although nuclear technologies appear to be the ideal means of achieving these goals, a number of significant hurdles must be cleared before their wider implementation in the EU market and wider commitment to selling nuclear generated electricity.

## Harmonization of the electricity market in the European Union

The economy of the modern EU is generally based on the concept of the European single market. In principle, this is a market area that covers the territory of all 27 EU member states, as well as – with some exceptions – the territory of three additional European Economic Area (EEA) countries (Norway, Iceland and Liechtenstein[6]) and Switzerland[7].The European single market is based on four fundamental freedoms:

- the free transfer of goods,
- the free transfer of services,
- the free transfer of people, and
- the free transfer of capital.

In simplified terms, the main purpose of the above freedoms is to allow the free flow of their respective subjects between the participants of the European single market. With reference to energy, electricity trading is generally covered by the free transfer of goods[8], which means that it is falls within the scope of the customs union established in the EU, which involves the prohibition between Member States of customs duties on imports and exports and of all charges having equivalent effect, along with the adoption of a common customs tariff in their relations with third countries[9].

The removal of the above-mentioned barriers to trade was, however, only one of the elements necessary to promote cross-border energy trade in the European Union. From a historical perspective, the energy sector was primarily administered by state-owned

[6] Agreement on the European Economic Area, Porto, 2 May 1992, OJ L 1, 3.1.1994.
[7] Relationship between the EU and Switzerland is based on the number of bilateral agreements, details available here: Switzerland's European Policy, <https://www.eda.admin.ch/europa/en/home/bilateraler-weg/ueberblick.html> [access: 17 October 2024].
[8] CJEU Judgment of 27 April 1994, C-393/92, *Municipality of Almelo and others v NV Energiebedrijf Ijsselmij*, ECLI:EU:C:1994:171; it is also indirectly confirmed in CJEU Judgment of 15 July 1964, C-6/64, *Flaminio Costa v E.N.E.L.*, ECLI:EU:C:1964:66.
[9] Consolidated version of the Treaty on the Functioning of the European Union (TFEU), OJ C 326, 26.10.2012, Article 28(1).

companies, which meant that the energy markets of each EU Member State were relatively isolated from each other, both legally and technologically[10]. Therefore, acting in the spirit of "an ever closer union among the peoples of Europe"[11], the attempt to integrate the individual national markets and create a single energy market was a natural next step in the development of the EU single market.

One of the first moves in this direction was initiated in 1996 by the adoption of Directive 96/92/EC concerning common rules for the internal market in electricity[12] (the so called "First Energy Package"). In its text, it has been explicitly underlined that establishment of the internal market in electricity is particularly important in order to increase efficiency in the production, transmission and distribution of this product, while reinforcing security of supply and the competitiveness of the European economy and respecting environmental protection[13]. Moreover, it was stated that an internal market in electricity needed to be established gradually, in order to enable the industry to adjust in a flexible and ordered manner to its new environment and to take account of the different ways in which electricity systems are organized[14], whilst keeping in mind that this market must favour the interconnection and interoperability of systems[15]. In other words, the First Energy Package set the bar high in its aims to open up and unify the European electricity markets.

The process of creating a single electricity market has not stopped since then and has been subject to constant evolution. Over the following years four additional "Energy Packages" were adopted, which gradually led to harmonised rules for electricity markets across Europe. A common supranational body (the European Union Agency for the Cooperation of Energy Regulators, ACER) was established in order to fill the regulatory gap at Community level and to contribute towards the effective functioning of the internal market in electricity[16].

In fact, the issue of creating a single European-wide energy market was so important, that it was ultimately explicitly included in the Treaty on the Functioning of the European Union (TFEU - one of the two key legislative acts governing the European Union). In line with the

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[10] A. Ispolinov, T. Dvenadtsatova, The creation of a common eu energy market: a quiet revolution with far-reaching consequences, The creation of a common EU energy market: a quiet revolution with far-reaching consequences, Baltic Region, No. 2(16), 2013, s. 80-81.
[11] Consolidated version of the Treaty on European Union (TEU), OJ C 202/1, 7.6.2016, Article 1(1), paragraph 2.
[12] Directive 96/92/EC of the European Parliament and of the Council of 19 December 1996 concerning common rules for the internal market in electricity.
[13] Directive 96/92/EC, Preamble, Para 4.
[14] Directive 96/92/EC, Preamble, Para 5
[15] Directive 96/92/EC, Preamble, Para 6
[16] Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators (Text with EEA relevance), Preamble, Para 5.

changes introduced by the Lisbon Treaty, a new article has been added, which states that in the context of the establishment and functioning of the internal market and with regard for the need to preserve and improve the environment, Union policy on energy shall aim, in a spirit of solidarity between Member States, to:

a) ensure the functioning of the energy market;
b) ensure security of energy supply in the Union; and
c) promote energy efficiency and energy saving and the development of new and renewable forms of energy; and
d) promote the interconnection of energy networks[17].

Analysis of all of these legislative developments leads to the conclusion, that cooperation and unification of energy trade rules within the European Union will deepen. The level of harmonisation is currently high enough that, in principle, most of the key rules for the sale of electricity are based in European Union law, with which the national legal frameworks of each Member State should be consistent. This means that despite some of the legal differences that exist in each country with regard to the development of nuclear power plants, the operation of new nuclear units must be somehow framed within the rules governing the electricity market across the entire Europe (which also includes rules on competition).

**Merit order and marginal pricing**

In order to assess where nuclear power stands in the EU electricity sector, it is necessary to mention some basic principles that govern this market. Some of these rules are described in EU Regulation 2019/943 on the internal market for electricity (EMR)[18]. In this context, it is especially worth recalling that:

a) prices shall be formed on the basis of demand and supply[19],
b) market rules shall encourage free price formation and shall avoid actions which prevent price formation on the basis of demand and supply[20],
c) market rules shall facilitate the development of more flexible generation, sustainable low carbon generation, and more flexible demand[21],

[17] Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community, signed at Lisbon, 13 December 2007, Article 176A(1) (currently constituting Article 194 of the TFEU).
[18] Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast) (EMR) (Text with EEA relevance.).
[19] EMR, Article 3(a).
[20] EMR, Article 3(b).
[21] EMR, Article 3(c).

d) market rules shall enable the decarbonisation of the electricity system and thus the economy, including by enabling the integration of electricity from renewable energy sources and by providing incentives for energy efficiency[22];
e) day-ahead and intraday markets shall be organised in such a way as to be non-discriminatory[23];
f) similarly balancing markets, including prequalification processes, shall be organised in a non-discriminatory way[24], respecting the need to accommodate the increasing share of variable generation, increased demand responsiveness and the advent of new technologies[25].

Overall, the above assumptions can be summarised as indicating that the EU electricity market should be non-discriminatory, conducted on a competitive basis, with prices being formulated in a market-driven manner. The application of these rules implies that the market is virtually based on the merit order principle and marginal production cost comparison.

In simplified terms, according to the merit order mechanism, generator supply bids are listed according to their marginal production costs (i.e. costs required to produce an additional unit of electricity), where the cheapest bids are considered first and the most expensive bids last[26]. The productions costs are mostly calculated as the result of 3 factors:

a) costs of fuel used for energy generation – associated with the fuel commodity price,
b) carbon cost – which in the EU is related to purchasing emission allowances under EU Emissions Trading System (ETS),
c) variable operational and management costs – which reflects costs of the plants day-to-day operations, including labour and maintenance[27].

With reference to the above, the marginal productions costs of electricity produced from fossil fuels (e.g. coal or natural gas) are typically the highest, while the costs of renewable energy sources (e.g. solar, wind, hydro power) are the lowest. In terms of nuclear power, the marginal cost is primarily based on the price of uranium, which has been relatively low and

[22] EMR, Article 3(f).
[23] EMR, Article 7(2)(a).
[24] EMR, Article 6(1)(a).
[25] EMR, Article 6(1)(d).
[26] A. Gasparella,, D. Koolen, and A. Zucker, The Merit Order and Price-Setting Dynamics in European Electricity Markets, European Commission, Petten, 2023, JRC134300, pp. 2-3.
[27] Ibidem.

very stable for some years[28]. Nevertheless, this factor will always make nuclear power slightly more expensive than renewable energy, which does not require purchasing fuels for its operation[29].

After the list of bids of increasing marginal prices has been created, this is cross-referenced with actual market demand at a given time. The market-clearing price is established by the price of the last accepted bid covering the demand (the so called "pay-as-cleared" mechanism) (see Figure 1 below)[30].

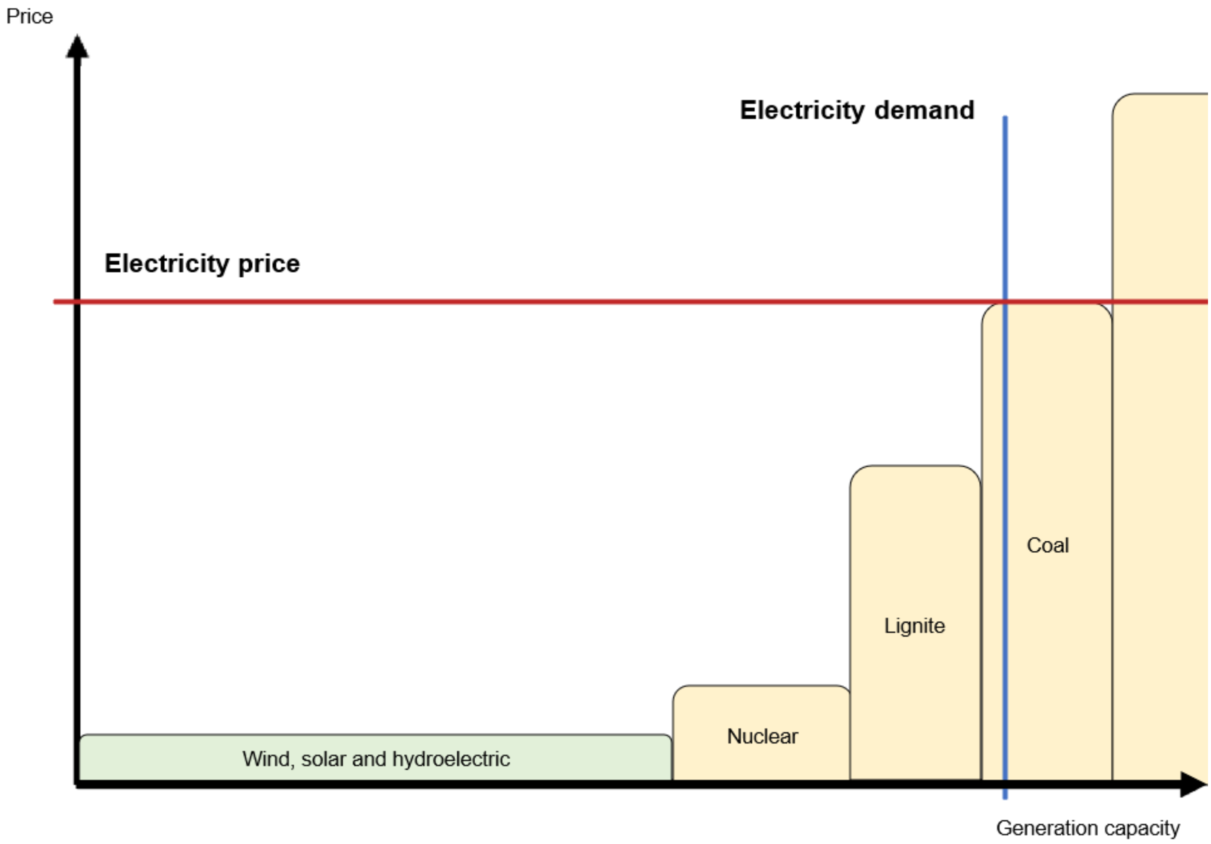


**Figure 1 – Visualisation of the merit order supply stack**

*Source: Elaboration based on Figure 2 – Simplified merit order supply demand stack, Gasparella, A., Koolen, D. and Zucker, A., The Merit Order and Price-Setting Dynamics in European Electricity Markets, European Commission, Petten, 2023, p. 3.*

[28] Uranium Prices chart, Trading Economics, https://tradingeconomics.com/commodity/uranium [access: 24 September 2024].
[29] A. Gasparella,, D. Koolen, and A. Zucker, op. cit., p. 3.
[30] Ibidem.

**Place of nuclear in the electricity market design**

In simple terms, the success of deployment of nuclear power plants in Europe is largely based on the ability to efficiently sell electricity at a price that allows the operator to recover its investment costs and generate profit. In this context it could be stated, that this goal may be achieved if the high capacity factor (CF) is reached by the nuclear power plant.

The capacity factor, can be defined as "The actual energy output of an electricity-generating device divided by the energy output that would be produced if it operated at its rated power output (Reference Unit Power) for the entire year. Generally expressed as percentage."[31]. A high capacity factor is crucial to the success of a nuclear power plant because it significantly improves its economics[32]. In light of this definition, any event that causes a reduction in the energy production capacity (e.g. refuelling, emergency shutdown etc.) will result in a reduction of capacity factor. Ensuring a high CF helps ensure steady energy sales (and thus steady revenues) and allows optimal management of resources, reducing variable costs and offering the best electricity price[33]. Since the energy produced by nuclear fission is, in principle, produced in a constant manner (and requires interruptions only due to the need for refuelling), the fundamental need to achieve high CF is the prerequisite to allow nuclear energy to be sold on the market, and to allow it to be sold at a sufficient price.

However, mechanisms in place in the EU electricity market may potentially impact the possibility to secure a high capacity factor for nuclear power facilities. This is related to the principles governing electricity dispatching and redispatching according to the EMR. For the purpose of this paper, power "dispatching" can be defined as a decision-making process associated with scheduling the power generation in a way that will ensure inter alia the security of the power grid, low prices and demand coverage[34]. The EMR itself does not define "dispatch" however, based on the definition of "priority dispatch" it can be inferred that "normal" dispatching refers to scheduling energy generation on the basis of the economic order of bids and (depending on the dispatching model) from network constraints, giving priority to the

[31] Glossary of Terms in PRIS Reports, Power Reactor Information System (PRIS), IAEA, <https://pris.iaea.org/PRIS/Glossary.aspx> [access: 25 September 2024].
[32] B. Mignacca, G. Locatelli, Economics and finance of Small Modular Reactors: A systematic review and research agenda, Renewable and Sustainable Energy Reviews, Volume 118, 2020, p. 8.
[33] Cf. A. Veenstra, X. Li, M. Mulder, Economic Value of Nuclear Power in Future Energy Systems Required subsidy in various scenarios regarding future renewable generation and electricity demand, CEER - Policy Papers, no. 12, April 2022, pp. 40-41.
[34] Z. Yang, P. Yong, M. Xiang, Revisit power system dispatch: Concepts, models, and solutions, iEnergy, Vol. 2, No. 1, 2023, p. 43.

dispatch of particular generation technologies[35]. On the other hand, the term "redispatching" has been defined in the EMR and means "a measure, including curtailment, that is activated by one or more transmission system operators or distribution system operators by altering the generation, load pattern, or both, in order to change physical flows in the electricity system and relieve a physical congestion or otherwise ensure system security"[36].

The dispatching of power-generating facilities in the EU electricity market shall be non-discriminatory, transparent and (subject to few exceptions) market based[37]. This means that it could be very difficult to justify the priority dispatch of electricity from a nuclear power plant to the power grid unless it is based on purely economic criteria.

The same applies to the "redispatching" mechanism which shall be non-discriminatory. open to all generation technologies and be generally market-based[38]. However, despite the above, the legislation also grants a more preferential status for certain generation sources. For example, power-generating facilities using renewable energy sources shall only be subject to downward redispatching if no other alternative exists or if other solutions would result in significantly disproportionate costs or severe risks to network security[39]. The exception is also provided for the electricity generated in a high-efficiency cogeneration process[40]. Unfortunately there is no such exception provided for nuclear power. This means that if there is a need to use redispatching in order to ensure the security of the electricity system (e.g. against a blackout), the curtailed power generation will likely affect nuclear units first, while renewables and high-efficiency cogeneration sources will be affected later. It should also be noted that the increasing deployment of renewable energy sources is likely to increase the frequency of redispatching. Most common threats to the electricity system (in particular the injection of too much energy in relation to the capacity of the electricity grid) are currently the result of the variable operation of renewable sources, which generate excessive amounts of energy at certain times of the day and cause shortfalls at others.

Since ensuring priority dispatching or providing protection against unplanned redispatching seems difficult in the current legal framework, nuclear power plants may be legally compelled to operate in the load-following mode (flexible operation). This means

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[35] EMR, Article 2(20).
[36] EMR, Article 2(26).
[37] EMR, Article 12(1).
[38] EMR, Article 13(1) and 13(2).
[39] EMR, Article 13(6)(a).
[40] EMR, Article 13(6)(b).

"varying the output of a generating unit in a planned way, or in response to an instruction or control signal from the grid control centre, reducing the output when the load (electrical demand) on the system is reduced (e.g. during the night, at weekends and on public holidays) and increasing the output to maximum when the electrical demand is high"[41]. As a rule, load-following implies lower capacity factors for nuclear plants[42]. This is in contrast to the baseload operation model, which means "operation of a power station or generating unit at steady full load as far as possible, and not load following or providing automatic frequency control"[43]. In other words, in baseload operation mode, reduction in power output is induced by the plant operator's needs, rather than the grid system operator's needs[44].

The choice of a load-following or a baseload model has also direct implications on the technical and operational aspects of the plant. Most notably it can be stated that:

a) baseload operation may lead to more efficient utilization of nuclear fuel as the thermal output during a fuel cycle is more predictable, and core design is optimized;
b) design and licensing of plants are simpler for operation at constant load, as degradation in design and safety margins as plants age vary more predictably and can be better anticipated during design;
c) non-baseload operation may require increased monitoring and maintenance, and may complicate the reliability and ageing assessments of some systems, structures and components[45].

The literature points out that in general, capital intensive technologies (such as e.g. nuclear power plants) prove viable if their load factors are higher than 90% in order to recover their high capital cost[46]. Naturally this suggests that nuclear power plants should primarily operate in a baseload mode. This is also achievable in a load-following system, but depends very much on the characteristics of the specific electricity system and availability of other energy sources that could provide required flexibility instead of nuclear. In fact, as indicated in research, in simulations prepared for 2050, only two European regions (Central-Western

[41] IAEA, Non-baseload Operation in Nuclear Power Plants: Load Following and Frequency Control Modes of Flexible Operation, Glossary, IAEA Nuclear Energy Series, No. NP-T-3.23, Vienna 2018, p. 166.
[42] R. Loisel, V. Alexeeva, A. Zucker, D. Shropshire, Load-following with nuclear power: Market effects and welfare implications. Progress in Nuclear Energy, No. 109, 2018, p. 1.
[43] IAEA, Non-baseload Operation in Nuclear Power Plants: Load Following and Frequency Control Modes of Flexible Operation, Glossary, IAEA Nuclear Energy Series, No. NP-T-3.23, Vienna 2018, p. 165.
[44] Ibidem, p. 4.
[45] Ibidem, p. 6.
[46] R. Loisel, V. Alexeeva, A. Zucker, D. Shropshire, op. cit., p.12.

Europe and Northern Europe) noted NPP operator gains from load-following operation in comparison to baseload operation. In the remaining three regions (Central-Eastern, South-Western and Western Europe) NPP operators would record loses from operating flexibly[47]. This raises a justified concern whether new nuclear power plants would be capable of generating enough profit to recover its investment costs, if their capacity factor is regularly lowered due to the non-market-based redispatching.

Last but not least, in parallel to the legislation in place that seems to promote the load-following mode, the very design of the EU electricity market carries risk for nuclear power in the long term. The European Union is currently focused on achieving its very ambitious goals related to climate neutrality. In fact, it has set itself a binding climate target of a domestic reduction of net greenhouse gas emissions by at least 55 % compared to 1990 levels by 2030[48]. Further efforts to reduce emissions in the energy sector can therefore be expected. The current target is that EU Member States shall collectively ensure that the share of energy from renewable sources in the Union's gross final consumption of energy in 2030 is at least 42.5 %[49].

As mentioned above, an EU electricity market generally operates on the basis of a merit order mechanism. If there would be an increase in the capacity of renewable energy sources, it is hypothetically possible that at some periods of time (e.g. on sunny or windy days) the bids related to renewable energy may cover full market demand. This could push nuclear energy further within the merit order mechanism, setting the market-clearing price below the marginal costs of nuclear power (thus potentially not allowing for the effective recovery of investment costs). The visualisation of this scenario is presented in Figure 2 below.

[47] Ibidem, pp. 15-19.
[48] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'), Article 4(1)
[49] 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, Article 3(1).

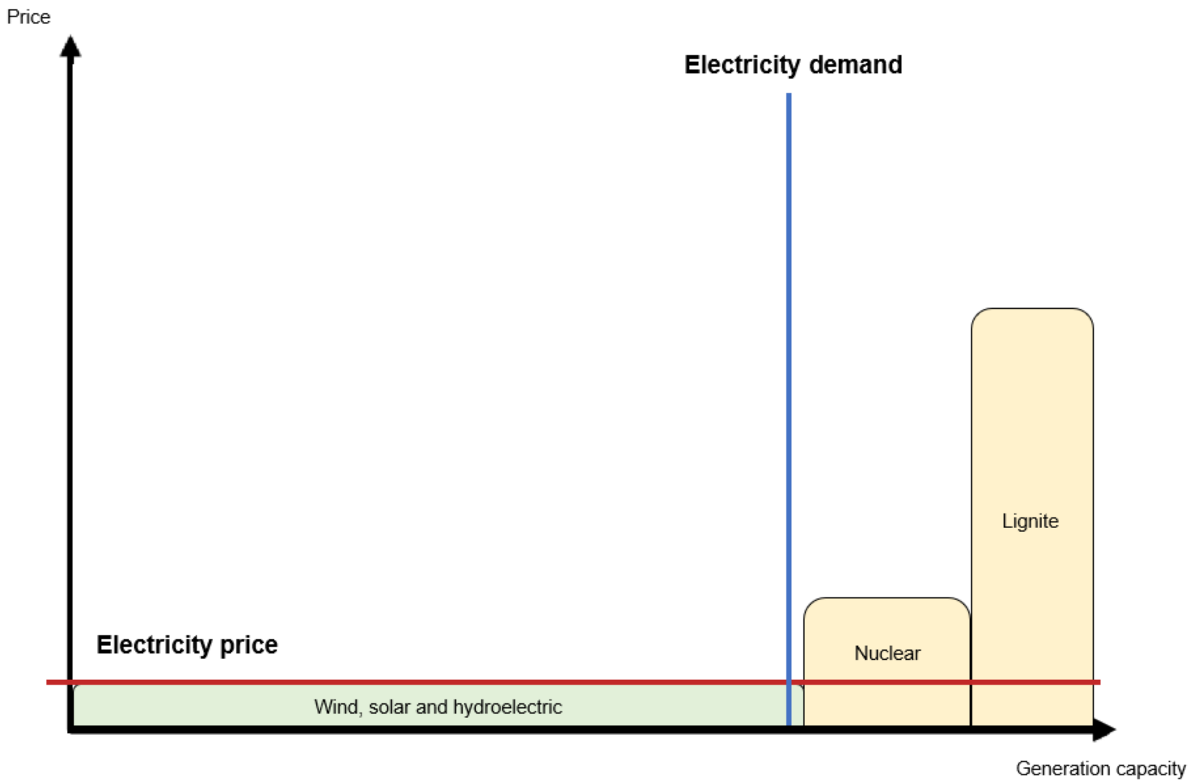


**Figure 2 – Potential consequences of increasing renewables in the merit order mechanism**

*Source: Own elaboration.*

### State aid and support schemes

Since nuclear energy is naturally less competitive than renewables according to the merit order mechanism, and there is a risk that it can be subject to increasingly frequent redispatching, the question arises of how energy can be sold on the EU electricity market to keep new nuclear power plants profitable and to recover funds invested in their construction. The answer may lie in the implementation of an appropriate public support scheme that could allow nuclear power plants to achieve their primary business objectives, i.e. generating stable revenues.

In addition to the business side of developing a suitable model for state co-financing of energy sales, it is also necessary to pay attention to legal aspects related to this issue in the EU. According to the TFEU, save as otherwise provided in the Treaties, any aid granted by a Member State or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods shall, in so far as it affects trade between Member States, be incompatible with the internal market[50]. This means that any EU Member State interested in developing nuclear power in its territory is

[50] TFEU, Article 107(1).

prohibited from freely subsidizing the execution or operation of the nuclear project, if such actions may pose competition concerns.

In practice, introduction of a public financial support scheme in the EU requires prior notification to the European Commission. The Commission then proceeds to verify the notification, and decides whether the notified measure can be considered a state aid, and if yes – whether it is permissible according to EU competition rules[51]. What is also important, is that the Commission is entitled to attach to a positive decision conditions subject to which aid may be considered compatible with the internal market[52].

Assessing whether a particular support scheme will constitute permissible or impermissible state aid is always a complex and delicate task. However, the current electricity market design provides for certain hints on which forms of public support are likely to be considered acceptable. In 2024 a major EU electricity market reform took place. The amendments introduced took the form of a regulation[53] and a directive[54]. The main reason to implement new legal measures was to overcome the challenges associated with very high energy prices and volatility in electricity markets which have been observed since 2021[55].

One of the major changes is the introduction of a new set of regulations established to promote the uptake of power purchase agreements (PPAs)[56] – long term contracts ensuring the sale of energy at a specific price. Moreover, it is assumed that investments in new power-generating facilities based on solar, wind, geothermal, hydropower (however without reservoirs) and nuclear energy will be based on support in the form of two-way contracts for difference (CfDs) or equivalent schemes with the same effects.[57]. According to the European Commission a "two-way contract for difference is a contract signed between an electricity generator and a public entity, typically the State, which sets a strike price, usually by a competitive tender. The generator sells the electricity in the market but then settles with the public entity the difference between the market price and the strike price. It thus allows the generator to receive a stable revenue for the electricity it produces, while at the same time it

[51] Council Regulation (EU) 2015/1589 of 13 July 2015 laying down detailed rules for the application of Article 108 of the Treaty on the Functioning of the European Union, OJ L 248, 24.9.2015.
[52] Regulation 2015/1589, Article 9(4).
[53] Directive (EU) 2024/1711 of the European Parliament and of the Council of 13 June 2024 amending Directives (EU) 2018/2001 and (EU) 2019/944 as regards improving the Union's electricity market design.
[54] Regulation (EU) 2024/1747 of the European Parliament and of the Council of 13 June 2024 amending Regulations (EU) 2019/942 and (EU) 2019/943 as regards improving the Union's electricity market design.
[55] Regulation 2024/1747, Preamble, Para 1.
[56] Regulation 2019/943, Article 19a.
[57] Regulation 2019/943, Article 19d.

provides a revenue limitation for generators when market prices are high. In a two-way CfD, if the market price is below the strike price, the generator receives the difference; if the market price is above the strike price, the generator pays back the difference."[58]. The principle of the two-way CfD mechanism is presented in the figure below.

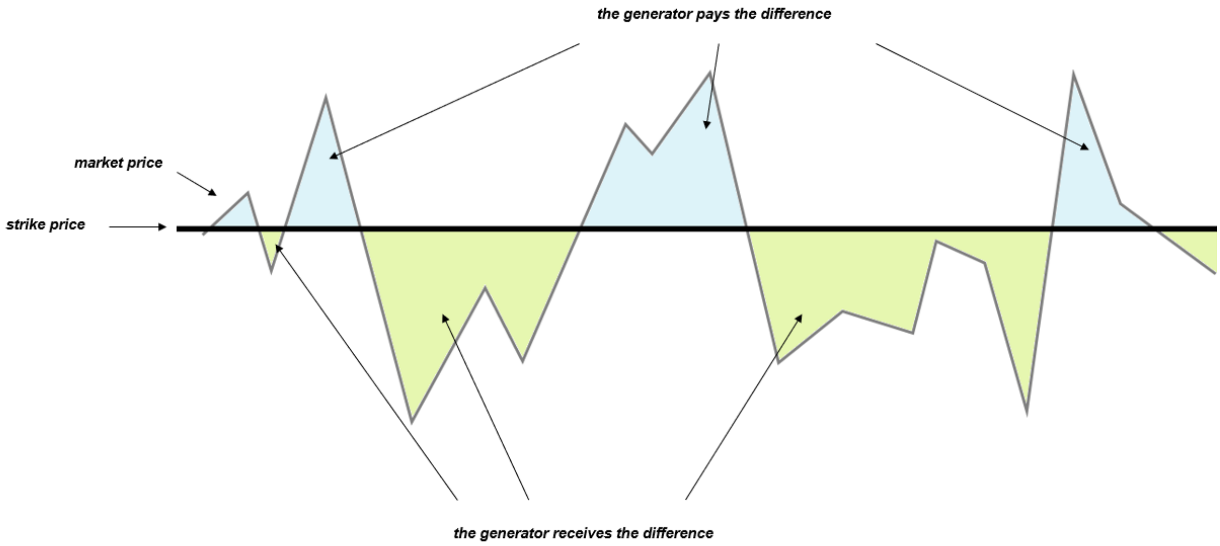


**Figure 3 – Visualisation of the principles of the two-way CfD contract**

*Source: Own elaboration based on visualisations made by the European Council and the Council of the European Union, https://www.consilium.europa.eu/en/policies/electricity-market-reform/#0 [access: 17 October 2024].*

At a glance, the two-way CfD seems to be a fair solution that protects both the operator of the energy-generation plant and end-users from excessive risks related to price fluctuations. However, in relation to nuclear power, the above model seems not to be fully adapted to the needs of nuclear power plant projects. First and foremost, unlike renewables, nuclear power projects require high initial construction costs, and the construction process itself spans many years. Based on the CfD model, construction costs incurred can be recovered only after the facility is commissioned and has started actual energy sales. This means that prior to that point, it is the nuclear power plant investor who bears most of the financial risk, a fact which can act as a disincentive for new investments. The same comments can be made with regard to the PPA model, where it is possible to secure the stable amount of revenues, but only after the plant begins operations. Moreover, CfDs typically suffer from a general lack of flexibility and are difficult to adapt to the changing market conditions[59].

[58] European Commission, Questions and Answers on the revision of the EU's internal electricity market design, <https://ec.europa.eu/commission/presscorner/detail/en/qanda_23_1593> [access: 17 October 2024].
[59] A. Ason, J. D. Poz, Contracts for Difference: the Instrument of Choice for the Energy Transition, April 2024, OIES Paper: ET34, p. 7.

In summary, the legally promoted financial support schemes may not be sufficient to back up nuclear energy needs in the EU electricity market. At the same time, proposing "an equivalent scheme with the same effects"[60] as the two-way CfD may present an evidentiary challenge, that will involve heated discussions on design of the scheme as part of the state aid notification procedures in front of the European Commission. This raises concerns as to whether it would be possible to introduce any reasonable alternative, such as for example the Regulated Asset Base (RAB) model[61].

## Conclusions and final thoughts

Legislators in the European Union currently face the extremely difficult task of balancing many different considerations relating to the electricity market. They have to ensure the security of supply[62], fair competition, affordable energy prices for end users and all while achieving climate targets. In this regard, nuclear power is considered a very stable, zero-emission source of energy, also providing some of the lowest energy prices. Renewable energy sources theoretically could provide even lower energy prices (if based on marginal production costs), however suffer from extreme volatility in production, thus not achieving security of supply.

The current EU electricity market design is evidently focused on relying on market-based mechanisms related to marginal production costs of energy. As such, this promotes the generation of energy from renewable sources, while not addressing the unique needs of nuclear projects throughout their entire development cycle (which is significantly different than for renewables). Without the inclusion of additional protection mechanisms, e.g. from excessive redispatching, nuclear power may prove to be uncompetitive or even uneconomic on the European electricity market.

It should be recalled once again that ambitious climate targets are forcing a gradual shift away from the use of fossil fuels in the European energy sector. This means that it is more important than ever to focus on assuring the security of supply. In this field, renewables will be unable to match nuclear power for many more years to come. At the same time, public energy consumption needs are growing now, right before our eyes. If the EU wishes to keep reducing

[60] Regulation 2019/943, Article 19d.
[61] Nuclear Regulated Asset Base (RAB) model, Ofgem, <https://www.ofgem.gov.uk/energy-policy-and-regulation/policy-and-regulatory-programmes/nuclear-regulated-asset-base-rab-model> [access: 17 October 2024].
[62] TFEU, Article 122.

greenhouse gas emissions while ensuring energy security, a greater focus on promoting nuclear power generation would seem to be an obvious solution. If nuclear new build is to take place in Europe, investment incentives must be provided, starting with guaranteeing the sale of energy at appropriate prices and providing support in the early stages of project development. Moreover, the current electricity market design, due to its generally unified approach to all Member States, does not take into account differences in the characteristics of various electricity systems, subliminally emphasising the need to ensure the load-following characteristics of nuclear power plants. From a business perspective this may not be the best mode of operation for countries, which require baseload demand coverage. Ultimately it can lead to both revenue disruption on the part of the nuclear power plant operator and price increases on the part of the general public. All of the above highlight the need to further adapt the principles governing the EU electricity market and explore new options of state aid support schemes for nuclear.

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