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ANALYSIS OCTOBER 2019[1]

ACCELERATING THE COAL-TO-CLEAN TRANSITION IN PORTUGAL AND SPAIN

INSIGHTS FROM THE DECLINE OF COAL GENERATION IN 2019

ARTUR PATULEIA AND CHRIS LITTLECOTT

During summer 2019, Portugal and Spain experienced an unprecedented period of low electricity production from coal-fired power plants. Portugal's electricity system ran coal-free for 19 days, while Spain's coal-fired electricity generation met less than 1% of the country's consumption over 10 consecutive days.

UN Secretary General Antonio Guterres has called on governments to curtail coal power generation in response to the climate crisis. The substantial and sustained reduction in coal use in his own country Portugal is further evidence that this is a realistic request also achievable by others.

In Spain, the reduced profitability for coal power generation led utility company Endesa to announce in September that it will retire two additional power plants in 2020, which had previously been intended for life extensions. In total 83% of the existing coal capacity in Spain is now set to be retired in 2020.

While coal is heading towards the exit, Portugal and Spain enter decisive weeks in their national politics. This paper offers analysis on the recent period of low coal use and presents policy recommendations that can help complete the coal-to-clean transition.

We find that the two Iberian electricity systems are now confronted with an extended period of very low use of coal for electricity generation. This experience demonstrates that a coal-free electricity system in Portugal and Spain

[1] This analysis was first published on 24 September 2019. It has been updated to incorporate details of additional plant closures announced in Spain, which further highlight the dynamics identified in this paper.

is now closer than ever, with 2023 and 2025 timeframes a realistic prospect for explicit government policy commitments to phase out coal generation.

The energy transition is an important topic of the political debate in Portugal and Spain, with both countries entering important political moments. Coalition negotiations are now underway to form a Government in Portugal following the election on 6 October. Similarly, Spain heads to elections again on November 10. The successful low use of coal throughout 2019 in both electricity systems should encourage political leaders in both countries to grasp the energy transition as part of an agenda for economic renewal and progress.

We identify here four recommendations to successfully deliver this agenda in the new political cycle:

1. **Introduce an aligned CO_2 floor price for the electricity sector in Portugal and Spain.** The unpredictable evolution of CO_2 prices in the ETS markets leads to an uncertain timeline for the closure of coal power plants and negatively impacts the planning of new investments in electricity grid flexibility services, reducing the economic and innovation benefits of the clean economy transition. Portugal has sought to address this through the introduction of a CO_2 tax in addition to the ETS price, however this creates a price difference for the emission of CO_2 inside the Iberian energy market, potentially affecting the emissions reduction pathway in Spain. Both Spain and Portugal supported the implementation of a minimum CO_2 price in the Lisbon Declaration[1] of July 2018. We recommend a coordinated approach between Spain and Portugal, and preferably also with France, on the implementation of an aligned CO_2 minimum price at regional level, ideally also addressing imports of coal-fired electricity from Morocco.

2. **Prioritize innovation and investments to address a coal-free electricity system.** The phase-out of coal power plants can be an opportunity to attract clean energy investment and develop innovation-based grid flexibility services. This opportunity can be addressed by prioritizing investment in renewables and grids needed for a coal-free electricity system, following the recommendations of security of supply and grid resilience assessments.[2] Policy makers can also grasp the coal-to-clean transition as an opportunity to incentivize the development of innovation-based flexibility services, like Demand Side Response (DSR) or vehicle-to-grid, developing high-value added sectors and setting a new step into the digitisation of grids operation. The UK National Grid has been very successful in combining the UK coal phase-out policy with this new generation of grid flexibility services.[3]

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3. **Active engagement with local communities and businesses on a social transition plan.** An active engagement with unions and local businesses will be required to safeguard the interests of the workers affected by the retirement of coal power plants. The coal-to-clean economy transition represents new job opportunities for workers, who can be reskilled to new positions. Also, relocation opportunities in the same company or early retirements schemes can be part of the solution, all assisted by clarity on timeframes.

4. **Set up regular high-level talks between the Governments of Portugal and Spain to coordinate the energy transition at regional level.** Portugal and Spain are facing a similar set of developments, such as the prospects of an accelerated coal phase out and high interest in renewable energy capacity development. These similar challenges, driven by economic factors, require a coordinated approach between Portugal and Spain that can be focused on the following agenda topics:

   > Capacity development of coal and renewables in both electricity systems

   > Policy mechanisms to be implemented (e.g. aligned minimum CO_2 price for the two countries and electricity sector taxation policy)[4]

   > Cooperation on security of supply and Iberian energy market development

   > Development of interconnections with France

   > Solution to the challenge of coal-fired electricity imports from Morocco.

This cooperation would be in line with the recommendations of the European Commission regarding the draft National Energy and Climate Plans submitted by Portugal and Spain.[5] A similar regional coordination was recently initiated by Germany and The Netherlands at very high level of Government – an approach that has the advantage of providing greater predictability to investors.[6]

Overall, we believe that policy makers in both Spain and Portugal can have confidence in pursuing an accelerated coal phase out across both countries. The experience of 2019 has shown that the two Iberian electricity markets have operated with historically low levels of generation from coal yet delivered secure supplies of electricity, at lower prices for consumers, during a period low generation from hydropower. This experience can provide an impulse for further investment in clean energy and deeper cooperation between policy makers from both countries.

Introduction to the electricity systems of Portugal and Spain

The electricity systems of Portugal and Spain have a relatively high interdependency and share an electricity wholesale market for the Iberian Peninsula, the MIBEL, since 2007. The high interconnection level has resulted in low residual wholesale price differences between the two countries.[7] Both countries have also historically been largely dependent on coal-fired power plants for 'baseload' production, also providing increased generation in dry years in place of reduced levels of hydroelectricity generation.

Portugal

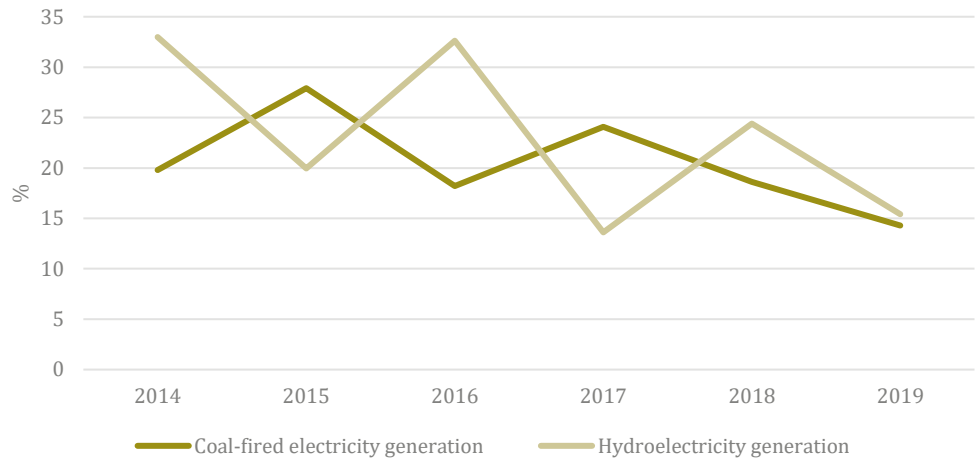
Portugal has two coal-fired power plants, Sines (1180 MW[8]) and Pego (576 MW[9]), which represent 8.8% of the installed capacity.[10] Sines power plant is located close to the deep-sea port of the same name, while Pego is located inland in central Portugal. Imported coal is used in both plants, principally sourced from Colombia (79% of imports in 2017).[11] In the case of Pego, daily trains transport coal from Sines port to the power plant.

Sines operates as a participant in the wholesale market, while Pego has a Power Purchase Agreement (PPA) with a regulated buyer (REN Trading) until the end of 2021[12] - the same timeframe as the end date of its current license to operate. Sines has an indefinite operating license.

Coal-fired electricity generation usually represents between 20% and 28% of electricity generation in Portugal,[13] depending on the rainfall regime. Despite the dry summer in 2019, the share of coal-fired electricity generation reached a low of 14.3% for the period January-August, as shown in Figure 1 below.

As a member of the Powering Past Coal Alliance,[14] Portugal has committed to phase-out its coal units by 2030 at the latest but has not committed to a specific date in national policy. However, the Minister for Environment and Energy Transition has recently announced that the Pego power plant would be retired by 2022, in line with the timeframe of its PPA contract and operating license.[15] The Government started to introduce supportive policies in 2018 through requiring the gradual removal of a tax benefit on the use of coal for electricity production.[16] By 2022, coal-fired electricity generation will no longer be exempt from this tax, further reducing the profitability of coal-fired generation.

Figure 1: Share of coal-fired and hydro electricity generation in Portugal (Jan-Aug).



Source: Redes Energéticas Nacionais (REN)

Spain

Spain has 15 operational coal-fired power plants, totalling 10.03 GW.[17] These correspond to 9.6% of the country's total installed capacity,[18] providing 14-20% of generation over the period 2013-2018. A minority of this coal-fired electricity generation still uses domestic coal, with the majority now imported, as presented in Figure 2. Imported coal is mainly sourced from Russia (46% share) and Colombia (26% share). [19]

Spain has a history of domestic coal mining, which over many decades was supported directly with public subsidies. EU State Aid requirements have required the closure of uncompetitive coal mines by the end of 2018. [20] The impending closure of these mines saw the incoming PSOE government introduce the ambitious 2019-2027 social transition programme *Transición Justa de la Minería del Carbón y el Desarrollo Sostenible de las Comarcas Mineras para el periodo 2019-2017*, which included early retirement and reskilling schemes for nearly 1700 coal mine workers, and a 250 M€ sustainable development programme for the regions affected.[21] [22] [23]

Spain is the last remaining country in Western Europe that has not set a date for the phase out of coal power generation and is not yet a member of the Powering Past Coal Alliance.[24] However, ten of the current operational coal power plants are expected to fully retire by 2020, mainly as a result of the costs associated with investments needed to comply with pollution control requirements of the EU Industrial Emissions Directive (IED). In addition, a further two coal-fired power plants will retire half of their generating units by 2020 (Aboño and

Alcudia). **This means that 83% of the Spanish coal power plant capacity is likely to retire by 2020**.

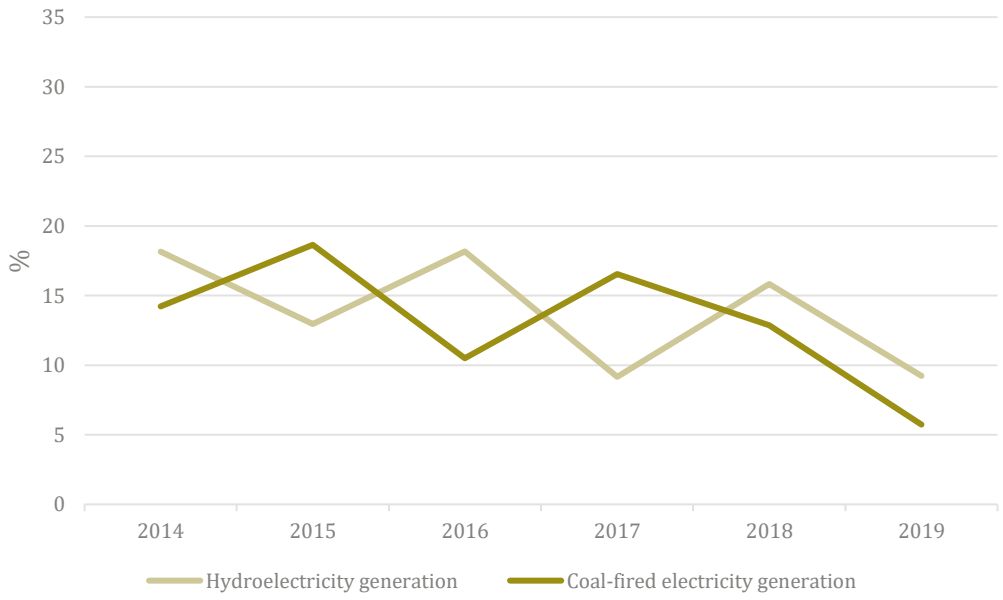
Figure 2: Share of domestic and imported coal in Spain's electricity generation (Jan-Dec)

Share of coal fired electricity generation	2013 14.5%	2014 16.3%	2015 19.7%	2016 14.3%	2017 17.2%
% electricity production using domestic coal	2.9%	4.0%	3.1%	2.0%	2.3%
% electricity production using imported coal	11.6%	12.3%	16.7%	12.4%	14.9%

Source: IRMC[25]

Between 2014-2018, the share of coal in Spain's electricity system ranged between 10% and 19% for the months January-August (see Figure 3 below). As is the case in Portugal, the availability of hydroelectricity has historically been negatively correlated with coal power production. It is thus remarkable that during 2019, a year with low hydropower production, the share of coal-fired generation has fallen to a minimum of 5.7% for this period.

Figure 3: Share of coal-fired and hydroelectricity generation in Spain (Jan-Aug)



Source: Red Eléctrica de España (REE)

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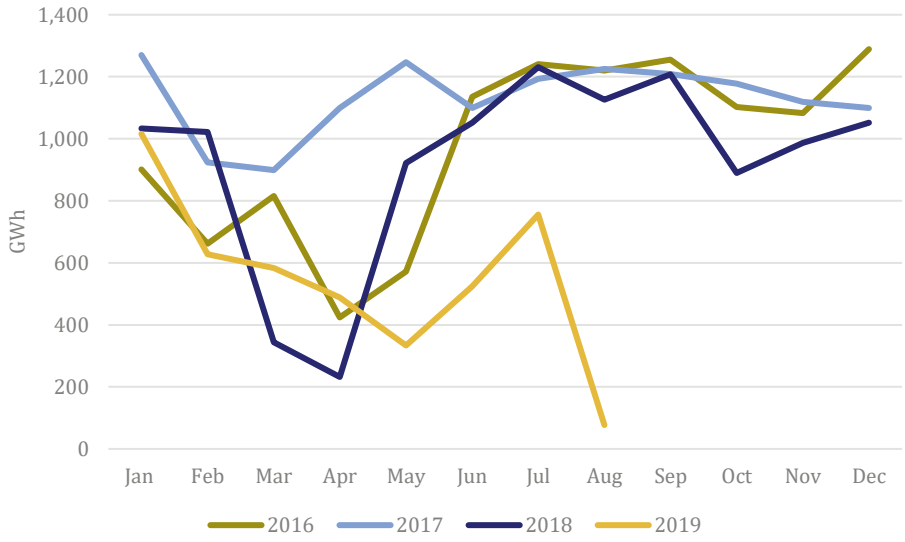
Coal-fired electricity production is significantly down in 2019

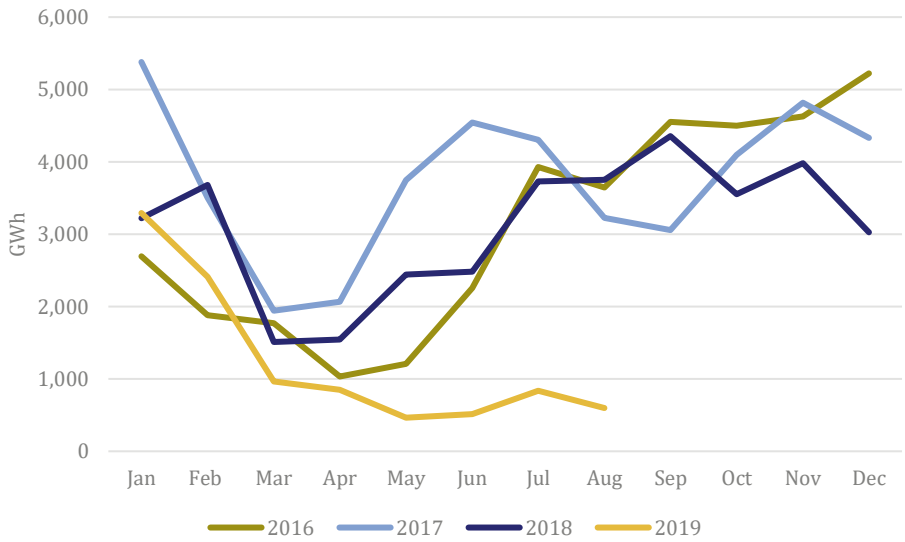
Both Portugal and Spain have experienced rapid decreases in coal-fired electricity production throughout 2019. The evolution of coal-fired electricity generation for the years 2016-2019 is presented in Figures 4 and 5 respectively.

Figure 4: Monthly coal generation in Portugal for the years 2016-2019



Source: Redes Energéticas Nacionais (REN)

Figure 5: Monthly coal generation in Spain for the years 2016-2019



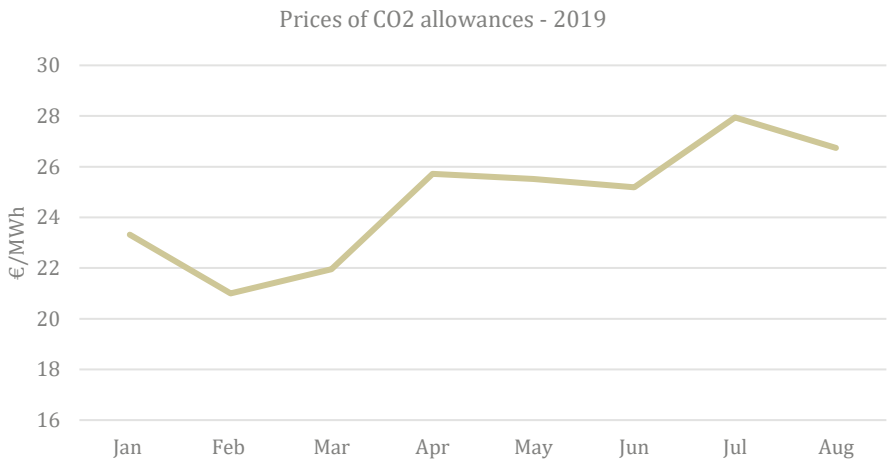
Sources: REE

Compared to the 2013-18 average use for the January-August period, Portugal has seen a 43% drop in generation, with Spain experiencing a 61% fall.

The short-term drivers for the collapse in coal generation in Portugal and Spain have been higher CO_2 prices, national taxation measures and increased competitiveness of wholesale gas prices versus coal, in the context of lower electricity prices and increased generation from renewables.

> **CO_2 pricing**
Average CO2 prices increased 46% between August 2018 and August 2019. As coal has a higher (+141%) emission factor than gas, an increase in CO_2 price has a higher impact on coal plants, reducing the competitiveness of coal-fired power plants. The evolution of CO_2 price over 2019 is presented in Figure 6.

Figure 6: Prices of CO_2 allowances in 2019



Source: Sandbag

> **National taxation**

> In 2019 Portugal reduced a tax exemption on the use of coal for electricity production from 90% to 75% of the rate. It also added a carbon tax to the ETS price, which has higher impact on coal-fired coal power plants.[26]

> In October 2018 Spain exempted natural gas plants from a hydrocarbon tax payment while requiring that it was still paid by coal-fired power plants.[27]

> **Commodities**

Both gas and coal wholesale prices have decreased between January 2019 and August 2019. However, the reduction of gas was higher (-51%)[28] than the reduction of coal (-35%).[29] This provides additional competitiveness to gas-fired power plants, which are also typically more efficient.

In addition, further investment in renewable capacity is expected to result in additional pressure on coal. An important driver for investment in renewables is the lower cost of these technologies.

In August 2019 Portugal auctioned 1.4 GW of solar energy with an average price of around 20 €/MWh[30] and a low price of 14.73 €/MWh. In Spain, 1.1 GW of solar capacity has already been added this year, resulting in a total capacity of approximately 5 GW of solar. In total, solar and wind have approximately 31 GW capacity installed across both countries. Furthermore, a total of 60.1 GW of preliminary permits[31] have been issued by the Spanish grid operator REE for new renewables (peninsular system), which include 42.4 GW of solar and 17.7 GW of wind.[32] The installation of this lower cost renewable capacity will further impact coal-fired electricity generation, pushing it out of the market and increasing its operating costs.

Despite the year-on-year reduction of coal-fired electricity generation for the period January - August, it is notable that the Iberian grid also saw an aggregate reduction of 564 GWh of electricity imports from other electrical systems. The year-on-year imports into the Iberian grid from France have seen an even greater reduction (-934.8 GWh, -10%). Conversely, imports from Morocco, which consist mainly of electricity generated from a new coal power plant, have increased by 370 GWh (equivalent to an 126% year-on-year increase).[33]

These trends suggest that the positive impact of reduced coal generation within the Iberian system could be undermined by increased coal-fired electricity imports from Morocco. Spain and Portugal recognized earlier this year the need to find a solution for this situation, but were not successful in their request to the European Commission to introduce a carbon border tax at EU-level.[34] In the absence of a CO_2 price on coal generation in Morocco this creates unfair competition and undermines the investment case for clean technology in Portugal and Spain, such as grid flexibility solutions. Moreover, imports of electricity from coal from Morocco may reduce public support for the energy transition when viewed against a backdrop of power plant closures at home. We return to this challenge below.

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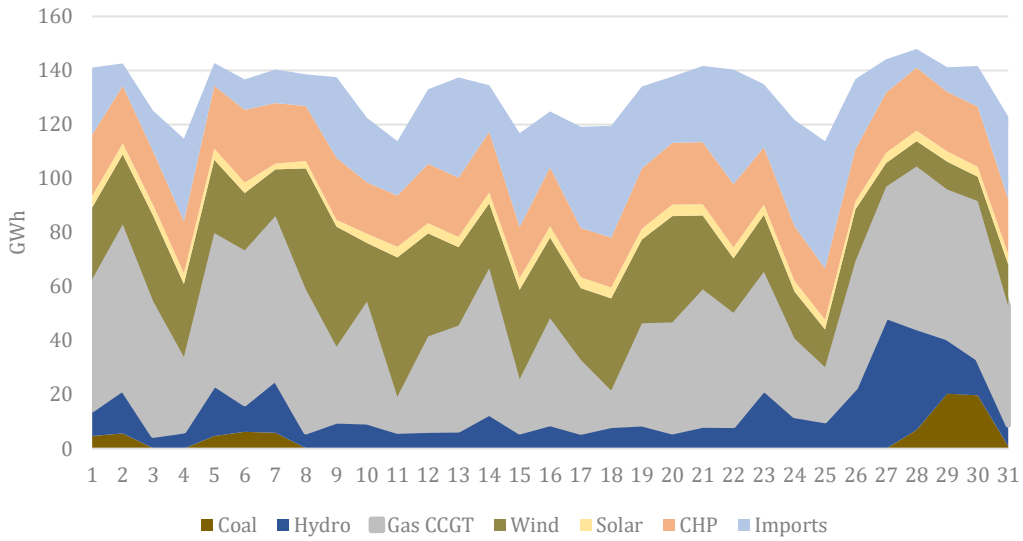
Portugal: 19 days coal-free electricity production

In the period of 8 – 26 August, Portugal experienced a total of 19 consecutive days of coal-free electricity production, as shown in Figure 6. In addition, the largest coal power plant in Portugal, located in Sines, did not operate for 33 days, between July 26 and August 27.

Figure 7: 19 days without coal: electricity generation by technology in the Portuguese electricity system, August 2019



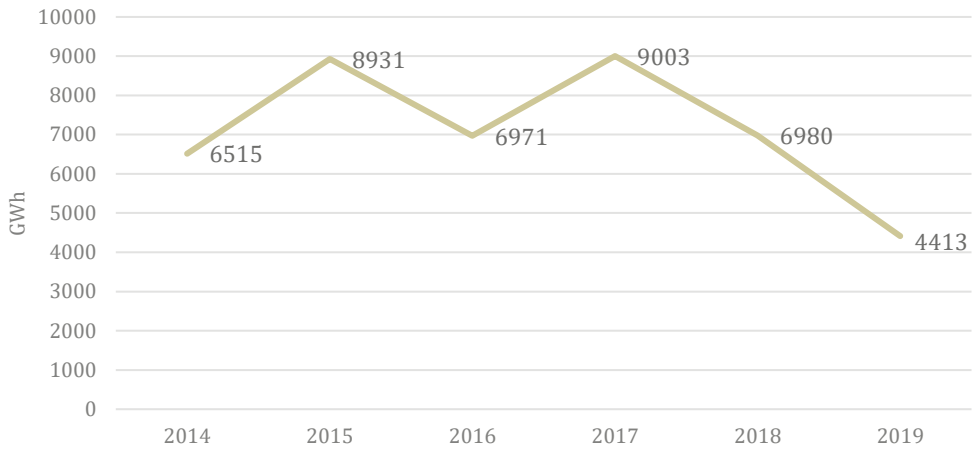
Source: http://www.omie.es/

Portugal has not experienced such a long coal-free period since the introduction of the Iberian wholesale market (MIBEL) in 2007. Since 2007, coal-free periods[35] have been primarily the result of rainy periods, which provide large electricity production volume for hydro plants and allow coal power plants to go idle. The combination of the dry year Portugal is experiencing, plus the additional dry conditions of the summer period, should typically result in a high utilization of coal-fired power plants to compensate for the low hydro volume production. It is thus remarkable that such a coal-free period happened during summer 2019 in a year with low rainfall.

The 33-day shutdown of Sines power plant is also noteworthy, as it is the largest in the south of the country and the shutdown took place during the peak of the summer holiday, the period with the highest demand in this region. This shows that the Portuguese electricity grid can operate with high reliability and resilience during a prolonged shutdown of Sines.

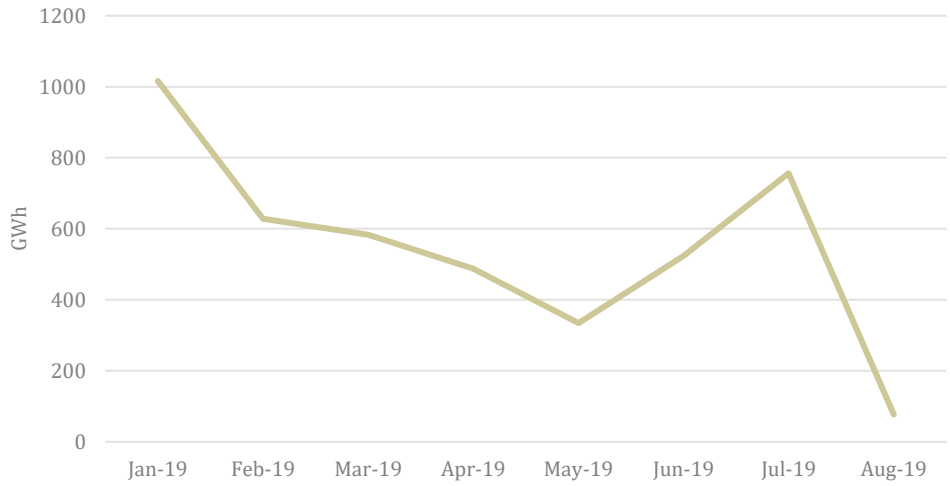
The reduction in the utilization of coal power plants in summer 2019 is in line with a broader trend, as depicted in Figures 8 and 9. In fact, coal-fired electricity generation has experienced a 37% reduction year-on-year for the January-August period in 2018, and a 43% reduction compared to the January-August average of the 5 previous years.

Figure 8: Coal-fired electricity generation in Portugal (Jan-Aug)



Source: REN

Figure 9: Monthly coal-fired electricity generation in Portugal - 2019



Source: REN

This gap was filled by an increase of production from gas power plants (+9.3%, year-on-year) and imports from Spain (+240.6%), together with a reduction of demand (-2%, year-on-year). The higher imports from Spain consist of higher production of gas power plants in Spain, which generally have lower marginal

costs than the Portuguese gas power plants. These plants have increased their electricity production by 114%, year-on-year.[36]

This low utilization of coal power plants constitutes a positive outlook for the future operation of a coal-free network in Portugal. In fact, the national security of supply assessment had already concluded that electricity demand can be met without coal-fired electricity generation.[37] Moreover, the technical investments needed to safely operate such a coal-free network have been identified by the grid operator, REN, in the 2016 and 2018 grid development plans.[38] In this plan, the grid operator indicated that, even without completing these investments, the grid could already be safely operated without Pego and without 2 of the 4 generating units of Sines.

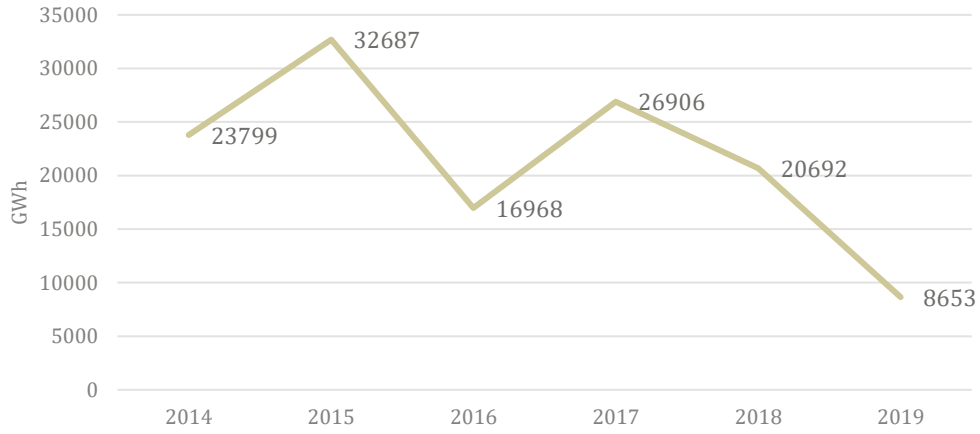
Spain: significantly reduced electricity production from coal-fired power plants

In the period January - August 2019, coal-fired electricity production in Spain was 64% down compared with the average of the same period over the past 5 years, as shown in Figure 9. In addition, 10 consecutive days saw daily electricity production from coal power plants below 7 GWh levels for the first time in the summer months, which is less than 1% of the country's electricity consumption.

The lower use of coal-fired electricity generation (-12038 GWh, -42% year-on-year) in the period January-August 2019 has been more than compensated with a higher generation by gas-fired units (+17872 GWh, +114%) and to a lesser extent by increased wind and solar production (+1179 GWh, +3% year-on-year). Moreover, the reduction in demand also contributed to the reduction of coal-fired electricity generation (-2906 GWh, -1.71% year-on-year), showing that energy efficiency remains an important tool for the energy transition.

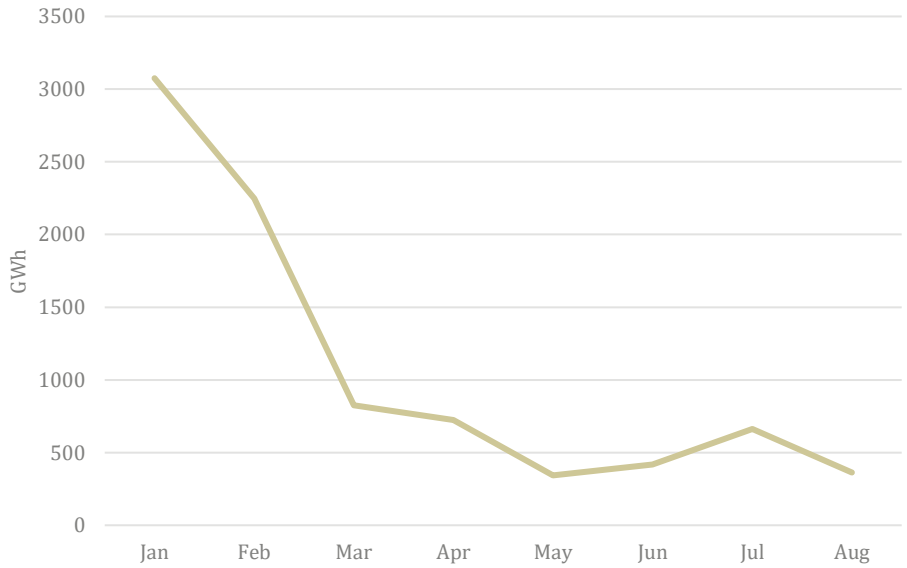
The electricity system of Spain has therefore shown it can withstand an extended period of low coal-fired electricity production. A previous supply of assessment performed by REE[39] has already shown that the security of supply can be guaranteed without the operation of the coal power plants that will be retired in June 2020.

Figure 10: Coal-fired electricity generation in Spain 2014-2019 (Jan-Aug periods)



Source: REE

Figure 11: Monthly coal-fired electricity generation in Spain - 2019



Source: REE

No official security of supply or grid resilience study of a completely coal-free electricity system has been published to date. However, the reduced utilization of coal-fired power plants in 2019 provides a foretaste of the further decline in coal generation and a positive outlook on the system's capability to cope with the impending wave of coal power plant retirements. Moreover, the addition of the large volume of renewable energy capacity, currently under development, will not only add lower cost electricity to the Spanish electricity system, but also support an accelerated pathway to coal-free operation.

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Conclusions and Recommendations

The extended low use of coal during 2019 is a significant new trend for the electricity systems of Portugal and Spain. From these recent developments we underline the following takeaways:

> **Coal-fired plants are becoming increasingly less profitable in Portugal and Spain,** resulting in extended periods of shutdown this summer. This resulted from the combination of higher production costs for coal power plants (mainly due to CO_2 pricing), being challenged by lower wholesale prices (as result of lower gas prices and higher electricity production from renewable sources). This reduced profitability may result in an accelerated phase-out of power plants by operators, as has been experienced in the UK.[40]

> **Renewables are a lower cost alternative to expensive coal-fired electricity generation**. Coal-fired electricity is now the most expensive source of energy in Portugal and Spain, having become uncompetitive compared to gas-fired electricity generation and new renewables. The recent solar auction in Portugal resulted in new minimum prices of 14.7 €/MWh.[41] The average price of this auction (20.33 €/MWh) is more than half of the operating costs of a coal power plant in the Iberian Peninsula. A transition from coal-to-clean is thus an excellent opportunity to reduce consumer electricity prices.

> **The development of new renewable projects will be an additional driver for coal phase-out in the Iberian Peninsula.** In Spain the grid operator has issued 60.1 GW of preliminary permits for new renewable projects.[42] The development of these projects will lead to a 220% increase of the current wind and solar capacity.[43] In addition, Portugal expects to add 2.1 GW of solar capacity by 2022, approximately 24% of the country's peak demand. This market interest, mainly driven by the lower cost of renewables, will reduce the number of operating hours of coal power plants, exacerbating the declining profitability of the coal-fired units. We expect that these developments, combined with increasing CO_2 prices, will lead ultimately to the permanent shutdown of coal units.

> **Electricity systems can maintain high security of supply standards even when generation from coal reduces rapidly.** The lower utilization of coal-fired coal power plants has not compromised the security of supply in Portugal nor in Spain. This provides a positive outlook for a safe operation of a coal-free electricity system and should give confidence to decision-makers to encourage the retirement of coal power plants while maintaining security of supply.

> **Reducing the role of coal in the electricity system is effective in reducing national CO_2 emissions.** Coal-fired power plants represent 18% of Portugal's national emissions (2015)[44] and 15% of Spain's national emissions (2015).[45]

The reduction of coal-fired electricity generation is thus instrumental for the reduction of CO_2 emissions.

> **National electricity sector taxation and CO_2 pricing policies can affect cross-border emission pathways.** A lack of cooperation on electricity sector taxation and CO_2 pricing policies in the context of a highly integrated Iberian energy market may ultimately lead to the export of emissions between the two countries due to cross-border electricity flows. This could complicate the pursuit of national emission reduction targets and delay national coal-fired capacity phase-out plans.

> **A coal-to-clean transition plan increases predictability for workers and investors.** The lower use of coal-fired power plant units has mainly been a result of market factors, such as CO_2 pricing and commodities price variation. This can lead to uncertainty regarding the remaining lifetimes of power plants, impacting negatively on the development of social transition pathways for impacted workers. In addition, energy system planning would be better placed to reap the economic and innovation benefits of the clean economy transition if it can anticipate investment needs for the coal-to-clean transition. This can be address through a clearer policy framework combined with guidance on the expected investment in new renewables and a timeline for the retirement of coal units.

We expect that the combination of increased renewable energy capacity and increasing CO_2 prices will lead to further reduction in coal production and ultimately to the phase-out of these units. In light of the recent experience of the UK we believe that these factors provide the conditions for a coal phase out to be completed in Portugal by 2023 and in Spain by 2025, which could therefore become explicit target dates in government policy.

The poor economics of coal and the low cost of new renewables provide an opportunity to deliver a political agenda centred on economic renewal and energy sector investment. The start of new Government cycles in Portugal and Spain can be an important opportunity to deliver this agenda.

We identify here four recommendations to successfully deliver this agenda in the new political cycle:

1. **Introduce an aligned CO_2 floor price for the electricity sector in Portugal and Spain.** The unpredictable evolution of CO_2 prices in the ETS markets leads to an uncertain timeline for the closure of coal power plants and negatively impacts the planning of new investments in electricity grid flexibility services, reducing the economic and innovation benefits of the clean economy

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- Policy mechanisms to be implemented (e.g. aligned minimum CO_2 price for the two countries and electricity sector taxation policy)[49]
- Cooperation on security of supply and Iberian energy market development
- Development of interconnections with France
- Solution to the challenge of coal-fired electricity imports from Morocco.

This cooperation would be in line with the recommendations of the European Commission regarding the draft National Energy and Climate Plans submitted by Portugal and Spain.[50] A similar regional coordination was recently initiated by Germany and The Netherlands at very high level of Government – an approach that has the advantage of providing greater predictability to investors. [51]

Overall, we believe that policy makers in both Spain and Portugal can have confidence in pursuing an accelerated coal phase out across both countries. The experience of 2019 has shown that the two Iberian electricity markets have operated with historically low levels of generation from coal yet delivered secure supplies of electricity, at lower prices for consumers, during a period of low generation from hydropower. This experience can provide an impulse for further investment in clean energy and deeper cooperation between policy makers from both countries.

More broadly, UN Secretary General Guterres has called on governments to curtail coal power generation in response to the climate crisis. The substantial and sustained reduction in coal use in his own country Portugal is further evidence that this is a realistic request also achievable by others.

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About the Authors

Artur Patuleia, Senior Associate

Between 2016 and 2017 Artur Patuleia served as Energy Policy Advisor to the Government of Portugal, leading working groups on energy markets and infrastructure. He also worked on policy subjects related to the transition to a low carbon electricity system. Previously he held technical positions at TenneT, the Dutch-German Transmission System Operator, and at TNO, the Netherlands Organization for Applied Scientific Research. He has an MSc in Electromechanical Engineering from the University of Beira Interior (Portugal) and recently obtained his MBA at the Rotterdam School of Management (The Netherlands), which included an exchange period at UC Berkeley (USA).

Chris Littlecott, Associate Director

Chris Littlecott leads E3G's activities on the transition from coal to clean energy, with a focus on supporting the growing international diplomatic effort to accelerate the phase out of coal power generation. Chris has been closely involved in UK coal policy since 2008. He has worked as a policy analyst, civil society advocate, and advisor to government throughout this period, helping to shape the UK's progress from facing a wave of new coal power plant proposals through to its world-leading commitment to an end to coal power generation. Chris currently leads E3G's strategic advice to decision makers on the global coal transition challenge as well as analytical projects such as E3G's annual scorecard of progress on coal by G7 countries.

About E3G

E3G is an independent climate change think tank accelerating the transition to a climate safe world. E3G builds cross-sectoral coalitions to achieve carefully defined outcomes, chosen for their capacity to leverage change. E3G works closely with like-minded partners in government, politics, business, civil society, science, the media, public interest foundations and elsewhere. In 2018 E3G was ranked the fifth most globally influential environmental think tank for the third year running.

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ENDNOTES

[1] Source: **https://ec.europa.eu/info/sites/info/files/lisbon_declaration_energyinterconnections_final.pdf**

[2] In Portugal, these recommendations have already been included in the national security of supply assessment (*Relatório de Monitorização da Segurança de Abastecimento do Sistema Elétrico Nacional, by Direação-Geral de Energia e Geologia)* and in the grid development plant by the Transmission System Operator (*Plano de Desenvolvimento e Investimento da Rede de Transporte de Eletricidade)*. In Spain, the coal-free operation can be addressed in the 2021-2026 grid development planning *(Planificación de la red de transporte de energia eléctrica para el period 2021-2026).*

[3] **https://www.nationalgrideso.com/balancing-services/demand-side-response-dsr**

[4] The end of the tax exemption on coal use for electricity production in Portugal ("ISP measure") or the introduction of a tax for the electricity sector in Spain ("Impuesto sobre el Valor de la Producción de Energía Eléctrica") are examples of measures with cross-border impacts.

[5] Source: **https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union/national-energy-climate-plans**

[6] Source: **https://www.bundesregierung.de/breg-en/news/klimakabinett-1663420**

[7] Price spreads between Portugal and Spain evolved from 10 €/MWh in 2007 to 0,23€/MWh in 2018. Source: Annual Reports on the Electricity and Natural Gas Markets by ERSE, Portugal's Electricity and Gas markets sector regulator. Available at **http://www.erse.pt/eng/international/euromarkets/Paginas/NationalREports.aspx**

[8] Source: Redes Energéticas Nacionais, **http://www.centrodeinformacao.ren.pt/PT/InformacaoTecnica/Paginas/CentraisTermoelectricas.aspx**

[9] Source: Redes Energéticas Nacionais, **http://www.centrodeinformacao.ren.pt/PT/InformacaoTecnica/Paginas/CentraisTermoelectricas.aspx**

[10] Source: Redes Energéticas Nacionais, *Caraterização da Rede Nacional de Transporte* (2018). Autonomous Regions of Madeira and Açores were not included.

[11] Source: Direção-Geral de Geologia e Energia (**http://www.dgeg.gov.pt/**)

[12] Source: **https://www.publico.pt/2019/05/24/economia/noticia/governo-quer-encerrar-central-termoeletrica-pego-2022-1874000**

[13] Autonomic Regions of Madeira and Açores were not included.

[14] Source: **https://poweringpastcoal.org/**

[15] Source**: https://tvi24.iol.pt/politica/jose-pedro-matos-fernandes/governo-quer-encerrar-central-termoeletrica-do-pego**

[16] In 2018, the exemption was 90%; In 2019 it is 75%; In 2020 it will be 50%; In 2021 it will be 25%.

[17] Source: Red Eléctrica de España, "Statistical Series of the Spanish Electricity System (2018)"

[18] Source: REE, "The Spanish Electricity System, Preliminary Report", 2018.

[19] Source: Secretaria de Estado de Comercio Exterior, *Estadísticas del comercion exterior español*.

[20] Council decision 2010/787/EU

[21] In 2019, Spain is building on this experience by co-leading efforts on Social Transition for the UN Climate Action Summit.

[22] Source: **https://www.miteco.gob.es/es/prensa/ultimas-noticias/el-gobierno-y-el-sector-de-la-minería-del-carbón-firman-un-acuerdo-para-la-transición-justa-y-el-desarrollo-sostenible-de-las-comarcas-mineras/tcm:30-483648**

[23] Source: **https://www.irmc.es/reestructuracion_mineria/PlanSocial-ides-idweb.asp**

[24] See Europe Beyond Coal **https://beyond-coal.eu/data/**

[25] Source: **https://www.irmc.es/Noticias/common/Acuerdo-Marco-para-una-transicion-justa-de-la-mineria-del-carbon-2019.pdf**

[26] Source: **http://app.parlamento.pt/OE2019/HTML/OrcamentoEstado2019.html**

[27] Source: **https://www.boe.es/boe/dias/2018/10/06/pdfs/BOE-A-2018-13593.pdf**

[28] Source: **http://www.mibgas.es/mercados-de-gas/**

[29] Source **http://www.theice.com/**

[30] Source: **https://www.euractiv.com/section/energy/news/portugals-solar-energy-auction-breaks-world-record/**

[31] A preliminary permit does not necessarily translate into installed capacity in the future

[32] Source: REE

[33] Source: REE

[34] Source: **https://elpais.com/economia/2019/05/24/actualidad/1558725430_875077.html**

[35] In 2010 the Portuguese electricity system operated for 14 days without coal (March 24 – April 7), while in 2011 coal-free periods were registered between 15 and 25 of January (11 days) and between 18 and 27 of April (10 days). In 2018 a total of 12 consecutive coal-free days were registered (March 29 – April 9). Source: **http://www.omie.es/**

[36] Source: REN

[37] Source: Direção-Geral de Energia e Geologia, *Relatório de Monitorização da Segurança de Abastecimento do Sistema Elétrico Nacional 2019-2040 (RMSA-E 2018)*.

[38] Plano de Desenvolvimento e Investimento da Rede Nacional de Transporte 2016-2015 and 2018-2027.

[39] Source: **https://www.farodevigo.es/economia/2019/03/22/red-electrica-descarta-riesgo-suministro/2073012.html**

[40] See e.g**. https://www.e3g.org/library/summary-insights-from-the-uk-coal-phase-out-experience**

[41] Source: **https://www.euractiv.com/section/energy/news/portugals-solar-energy-auction-breaks-world-record/**

[42] A preliminary permit does not necessarily translate into installed capacity in the future

[43] Source: **https://www.ree.es/es/actividades/acceso-conexion-y-puesta-en-servicio/estado-de-las-solicitudes**

[44] E3G calculations based on REN, Agência Portuguesa do Ambiente and Direção-Geral de Energia e Geologia data. Total emissions do not consider land use, land-use change, and forestry.

[45] E3G calculations based on REE and Ministerio para la Transición Ecológica data. Total emissions do not consider land use, land-use change, and forestry.

[46] **https://ec.europa.eu/info/sites/info/files/lisbon_declaration_energyinterconnections_final.pdf**

[47] In Portugal, these recommendations have already been included in the national security of supply assessment (*Relatório de Monitorização da Segurança de Abastecimento do Sistema Elétrico Nacional, by Direação-Geral de Energia e Geologia)* and in the grid development plant by the Transmission System Operator (*Plano de Desenvolvimento e Investimento da Rede de Transporte de Eletricidade)*. In Spain, the coal-free operation can be addressed in the 2021-2026 grid development planning *(Planificación de la red de transporte de energia eléctrica para el period 2021-2026).*

[48] Source: **https://www.nationalgrideso.com/balancing-services/demand-side-response-dsr**

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[50] Source: **https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union/national-energy-climate-plans**

[51] Source: **https://www.bundesregierung.de/breg-en/news/klimakabinett-1663420**