Data analysis of frequency fluctuations in the Balearic grid before and after coal closure

Pere Colet

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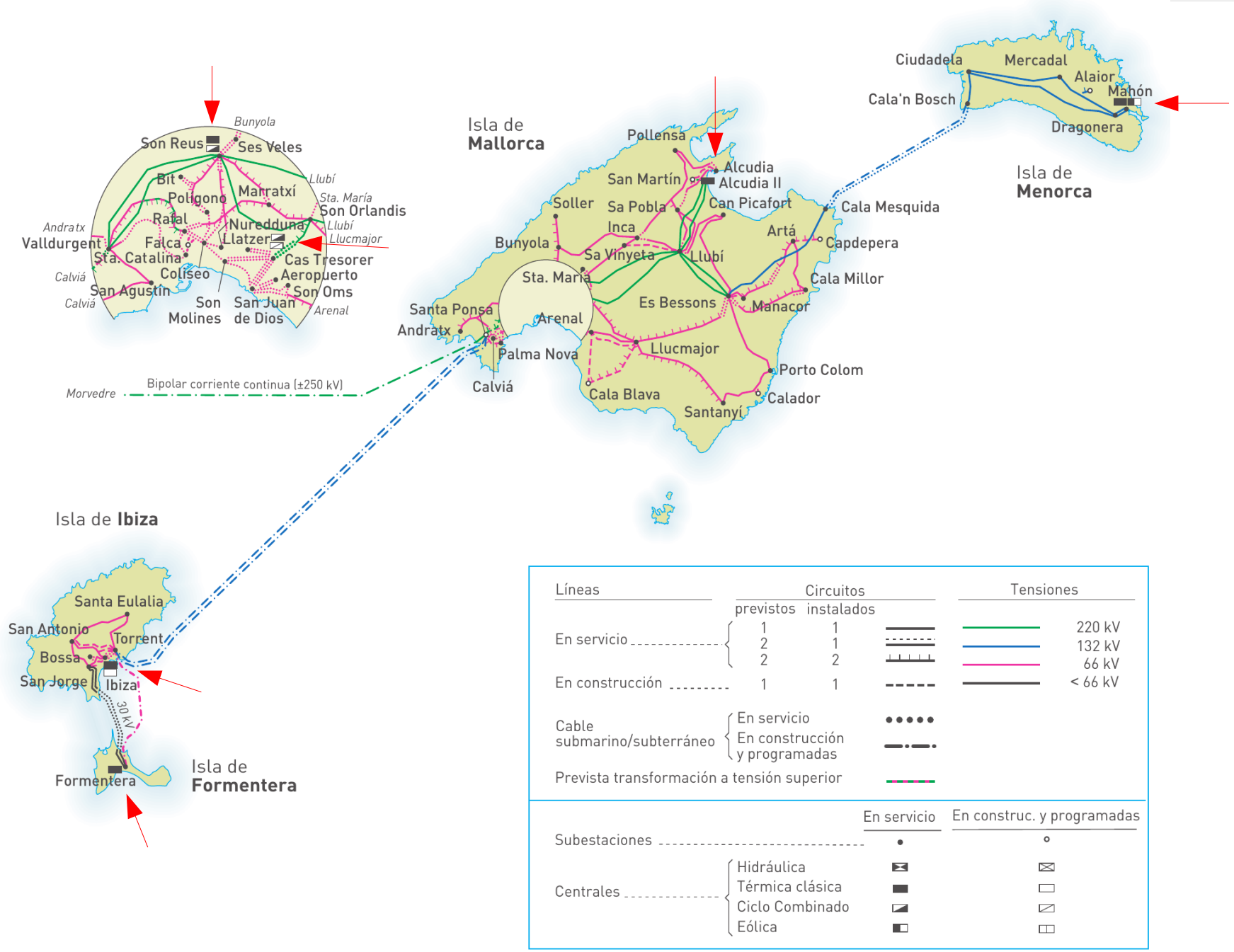
Energy 2021
Special track MoDyPoG

Outline

- Balearic grid and closure of coal
- Frequency fluctuations nowadays
- Frequency fluctuations when coal generation was in operation
- Discussion
- Concluding remarks

Balearic power grid



https://www.ree.es/sites/default/files/01_ACTIVIDADES/Documentos/folleto_romulo_es.pdf

Balearic grid power plants

Power plant	**Generation type**	**Installed capacity** (MW)
Mahón (Menorca)	gas turbine + ancillary	171.7 32.7
	diesel engine (ancillary)	40.8
Es Murterar (Mallorca)	coal	241.2
	gas turbine	65.4
Son Reus (Mallorca)	CCGT	394
	gas turbine	134.8
Cas Tresorer (Mallorca)	CCGT	429
Ibiza	gas turbine + ancillary	119 68
	diesel engine + ancillary	69.6 29
Formentera	gas turbine (ancillary)	11.5

Es Murterar closure

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Iniciar sesión Regístrate
NOTICIAS SUCESOS DEPORTES OPINIÓN XALOC PARTICIPA OCIO VIPS GUÍA ÚTIL MONOGRÁFICOS

Noticias / Local

La central térmica de Es Murterar apaga sus dos grupos más antiguos

Vista de la central térmica de Murterar. | **Efe**

Margalida Ramis | Palma | 30/12/2019

Ha llegado el día que quedará marcado en el calendario como el primer paso hacia la **descarbonización de Baleares**. Este lunes han dejado de funcionar los dos grupos más **contaminantes** de la **central térmica de Es Murterar**, en Alcúdia, que generan electricidad a través de la quema de carbón. Así se contempla en la Ley de Cambio Climático de las Islas aprobada la pasada legislatura y así se rubricó a principios de febrero en el Consolat de Mar en un encuentro en Govern, Gobierno y Endesa, propietaria de la central.

Baleares vive un gran hito en **materia energética**. Se trata del primer paso hacia la descarbonización de las Islas y el avance hacia la transición de energías limpias.

El objetivo final es que las Islas lleguen a 2050 libres de combustibles fósiles. Sin

In 2019, the electric utility company Endesa, Balearic and Spanish Governments reached an agreement to close down 2 out of the 4 coal generating units of Es Murterar the most polluting power station in Mallorca.

Besides operation time of the two remaining units is limited to 1500 hours/ year until 2021. After that, 500 hours/year per year until the complete close down of the power plant, which will coincide with the activation of a new connection to mainland.

Majorca Daily Bulletin

Palma 23°

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Partial closure of Alcudia power station formally authorised

2019-03-29 Palma By Majorca Daily Bulletin reporter

Endesa will come up with a plan for dismantling the first two units to be closed.
29-03-2019 Efe

Energy minister Marc Pons yesterday formally signed the authorisation of the closure of two production units at the Es Murterar power station in Alcudia. The units are therefore now scheduled to close down at the start of January 2020.

For the government, the partial closure is of the "most polluting" facility in the Balearics and is integral to its energy transition strategy; the plant is responsible for 27% of CO2 emissions in the Balearics.

Endesa is to present a plan by October for dismantling the two units; this work is expected to be completed within a four-year period. The Balearic Environment Commission will meanwhile start work next month on scheduling a reduction in the plant's operating hours. Until August 2021 there will be a maximum of 1,500 hours (annually); from August 2021, this is due to go down to 500 hours.

The closure of the other two units will follow once Red Electrica has completed the second electricity cable connection from the mainland. This is contained in the grid company's plan for 2020 to 2025. Complete closure of Es Murterar could therefore be by 2025, although 2027 has been mentioned as an alternative.

An agreement between Endesa and the national and regional governments should secure jobs for workers at the plant. There has as yet, however, not been any indication where these jobs might be.

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Partial demolition of Es Murterar to start this year

2020-04-17 Alcudia By Majorca Daily Bulletin reporter

There were protests at the Balearic government's decision to close Es Murterar.
13-11-2018

The Balearic Environment Commission has given the green light to the demolition of the two production units at the **Es Murterar power station in Alcudia** that were closed down at the end of last year.

The demolition work, for which Endesa will be responsible, will **cost 7.5 million euros and take three years to complete**. It is scheduled to start at the end of this year and will involve the removal of boilers, silos and so on plus work to the land; these two units occupy a space of some 22,000 square metres.

Magdalena Frau, head of communications and external relations at Endesa, says that the company has always planned that workers at the power station and with supplier companies should get **employment in the demolition and in the creation of photovoltaic plants**. No workers who are directly employed by Endesa have lost their jobs. Some have relocated to other power stations, and ultimately eighty workers will remain. The two other production units need maintaining and will be operational in very reduced fashion over the next few years; the total closure of Es Murterar will probably be in 2026.

Training is to be given to those workers who will carry out the demolition. Mostly all of them, be they directly employed or with contractors, live in Alcudia. The mayor, Barbara Rebassa, has expressed her particular satisfaction that Endesa will be ensuring that there is employment for workers with supplier companies.

Comment

Mallorca Zeitung

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SERVICE MZ-Schlagzeilen per Telegram aufs Handy - so einfach geht's

Mallorca Zeitung » Lokales

Mallorcas Dreckschleuder geht am 30. Dezember in Teilen vom Netz

Der Konzern Endesa schaltet zwei der vier Produktionslinien ab und kommt damit einer Forderung der balearischen Linksregierung nach

Frank Feldmeier | F. Guijarro | 18.12.2019 | 09:42

Es Murterar. **Foto: Terrassa**

Das Heizkraftwerk Es Murterar auf Mallorca geht noch vor Jahresende in Teilen vom Netz. Knapp vier Jahrzehnte nach ihrer Inbetriebnahme sollen die **Produktionslinien I und II** am 30. Dezember abgeschaltet werden. Um 10 Uhr werde der Schalter umgelegt, berichtet die MZ-Schwesterzeitung "Diario de Mallorca".

Mit dem Schritt kommt der **Energiekonzern Endesa** einer zentralen Forderung der balearischen Linksregierung nach - die Einigung über die Abschaltung war Anfang des Jahres zustande gekommen. Vertreter des Landesministeriums für **Energiewende** wollen sich am Mittag ein Bild von der Lage in dem Kraftwerk bei Alcúdia im Nordosten von Mallorca machen, in dem vor allem Kohle aus Südafrika verfeuert wird.

Mallorca Zeitung

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Mallorca Zeitung » Lokales

Kohlekraftwerk auf Mallorca nur noch mit halber Kraft

Die älteren Produktionslinien von Es Murterar sind am Montagmorgen (30.12.) abgeschaltet worden

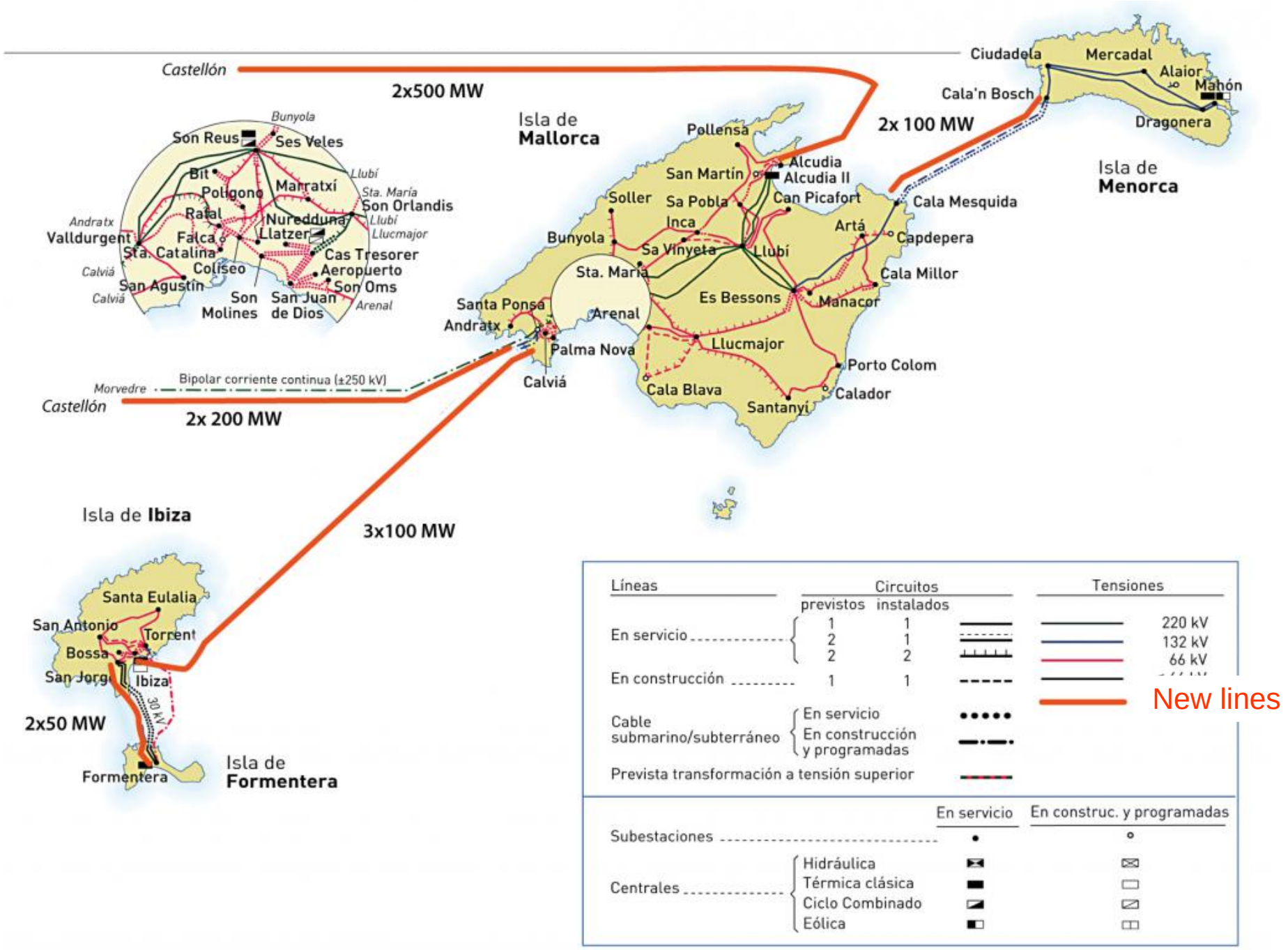
30.12.2019 | 10:49

Es Murterar. **Foto: Terrassa**

Das Heizkraftwerk Es Murterar auf Mallorca ist zur Hälfte abgeschaltet worden. Die Produktionslinien I und II sind am Montagmorgen (30.12.) außer Betrieb gegangen, wie es in einer Pressemitteilung der balearischen Landesregierung heißt.

Mit dem Schritt kommt der Energiekonzern Endesa einer zentralen Forderung der balearischen Linksregierung nach - die Einigung über die Abschaltung war Anfang des Jahres zustande gekommen. Mit der Abschaltung der älteren von insgesamt vier Produktionslinien senke man nicht nur deutlich die Kohlendioxid-Emissionen, sondern es verbessere sich auch die Luftqualität, betonte Energieminister Juan Pedro Yllanes (Podemos). Die Energieversorgung von Mallorca sei nicht in Gefahr.

Future Balearic power grid



Data sources

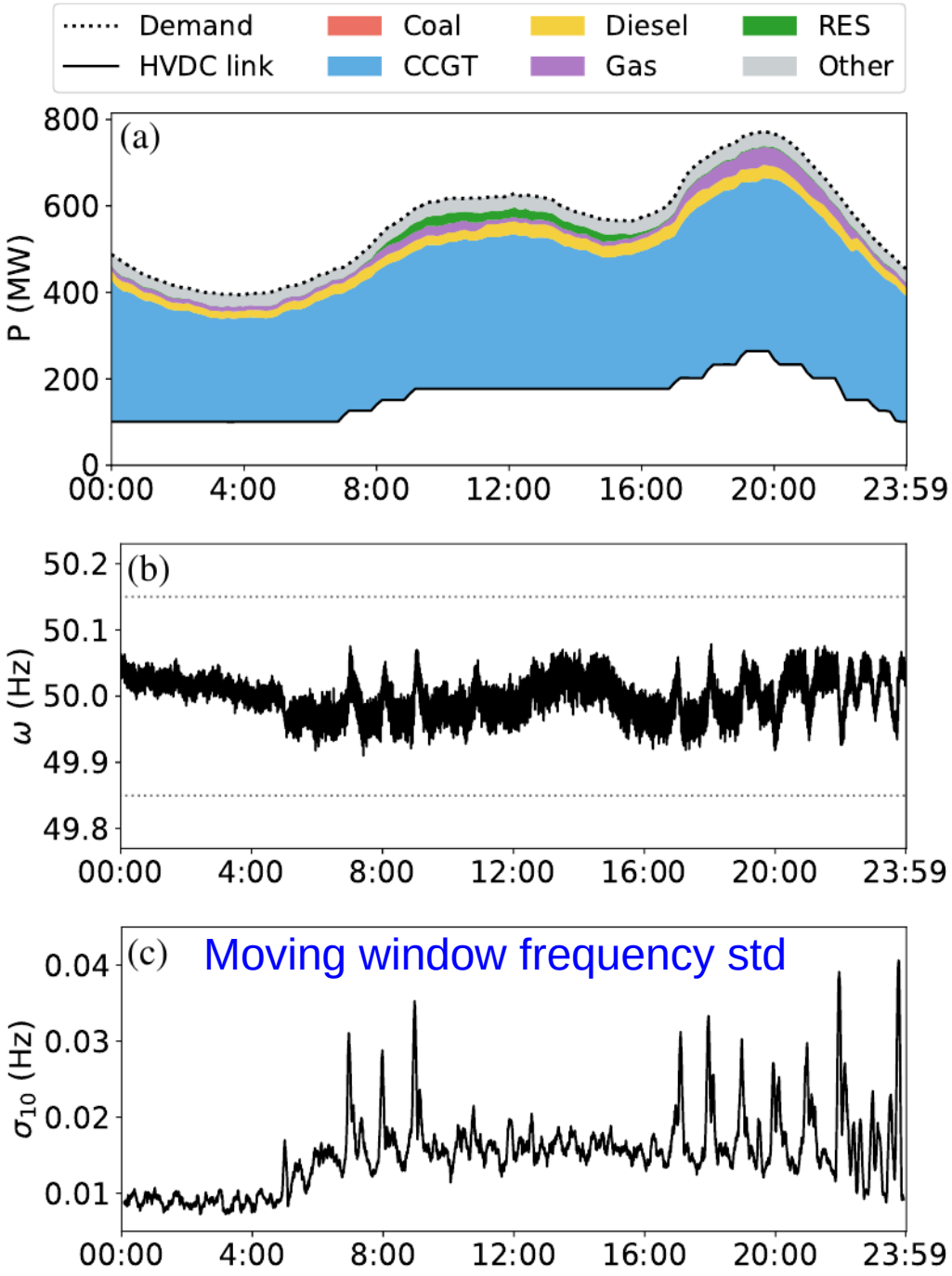
Frequency data measured every second is obtained from the open database.
R. Jumar, H. Maass, B. Schäfer, L.R. Gorjão, and V. Hagenmeyer, “Power grid frequency data base”. https://osf.io/by5hu/.
L.R. Gorjão et al., Nat. Commun., **11**, 1–11, 2020.

The database includes measurements from October 2019 until December 2020, except the months of August and October 2020.

Data taken at a single location in the island of Mallorca, assumed to be representative.

Demand and generation available on Red Eléctrica de España web:
https://demanda.ree.es/visiona/home
This includes overall demand and generated power averaged over 10 minutes and power through the HVDC line. Generation is disaggregated by power plant technology.

Frequency fluctuations on a typical day without coal generation



January 26, 2020

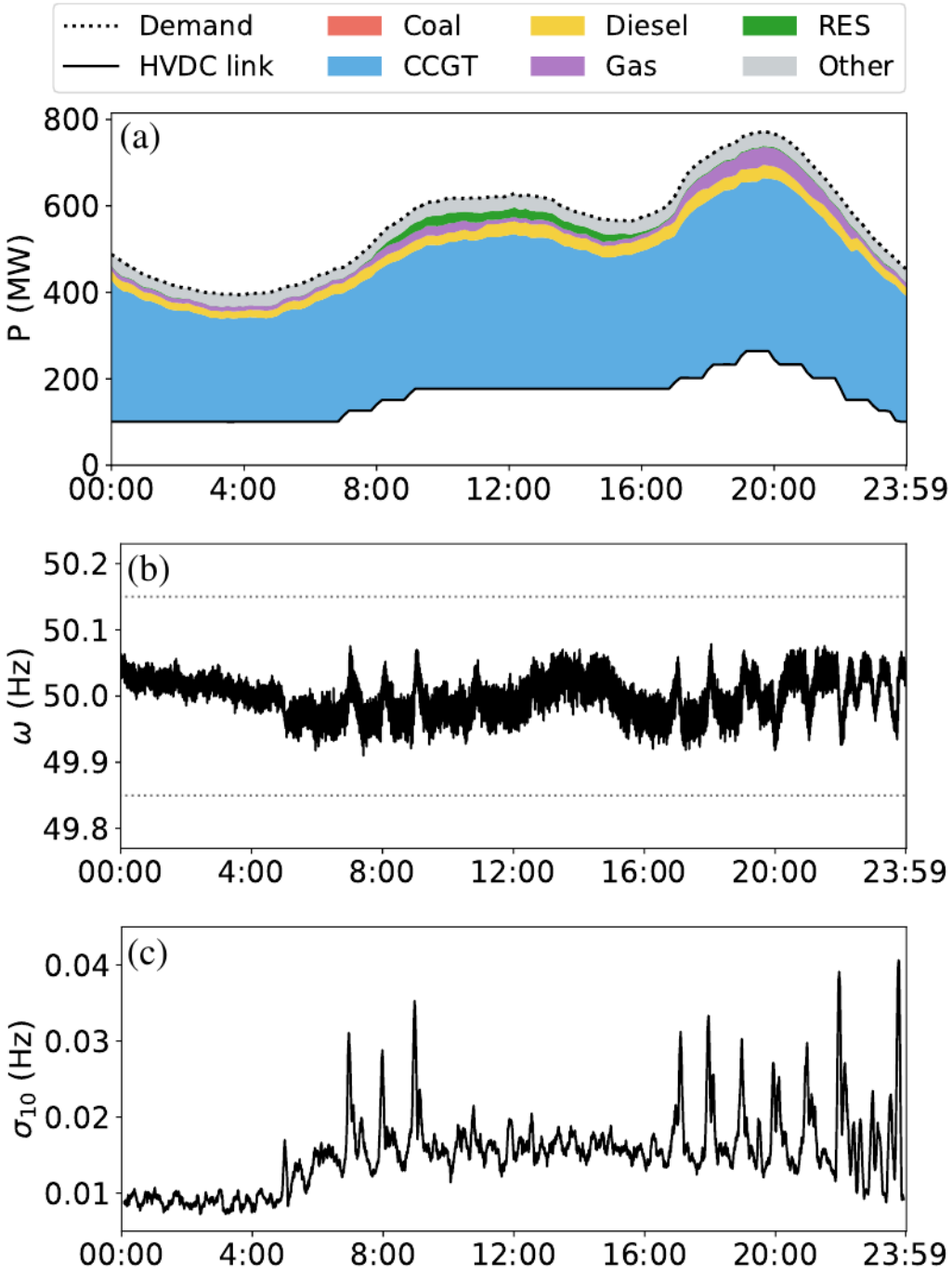
Frequency follows demand pattern. Generation runs behind demand (as expected from power plant controls adapting generation to demand)

- When demand decreases (0h-4h) frequency is above 50Hz. .
- When demand increases frequency is below 50Hz.

There are also fast fluctuations due to stochastic changes in demand. Its amplitude is smaller at night (valley hours) and larger during the peak hours.

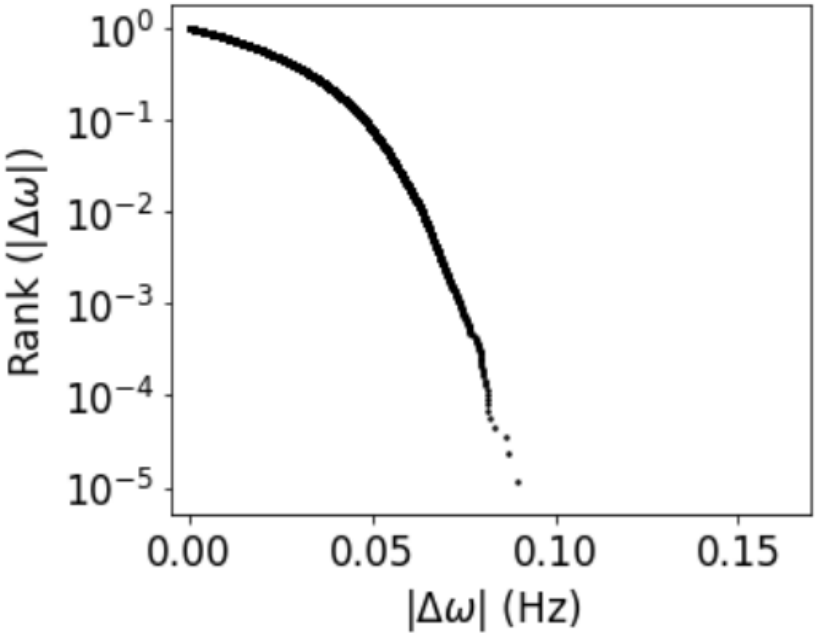
There are also large deterministic frequency variations triggered by step-like changes in HVDC cable power.

Frequency fluctuations on a typical day without coal generation



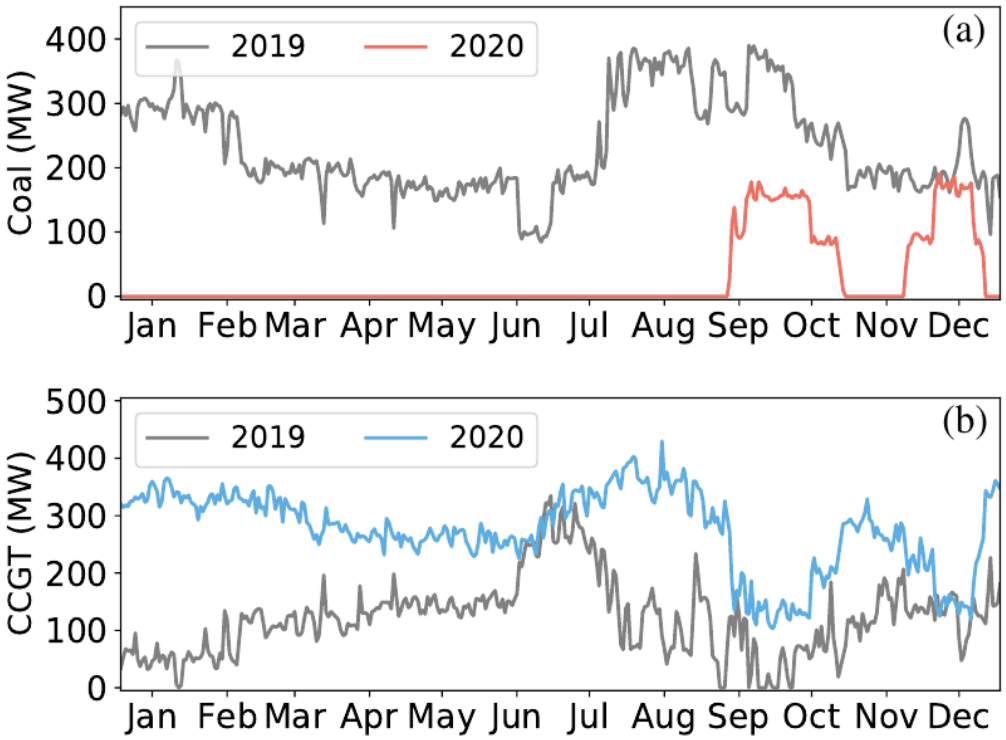
January 26, 2020

Consider the rank distribution of the frequency deviations with respect to 50Hz. $R(|\Delta\omega|)$. Measures the probability to have a fluctuation of size larger than $|\Delta\omega|$.



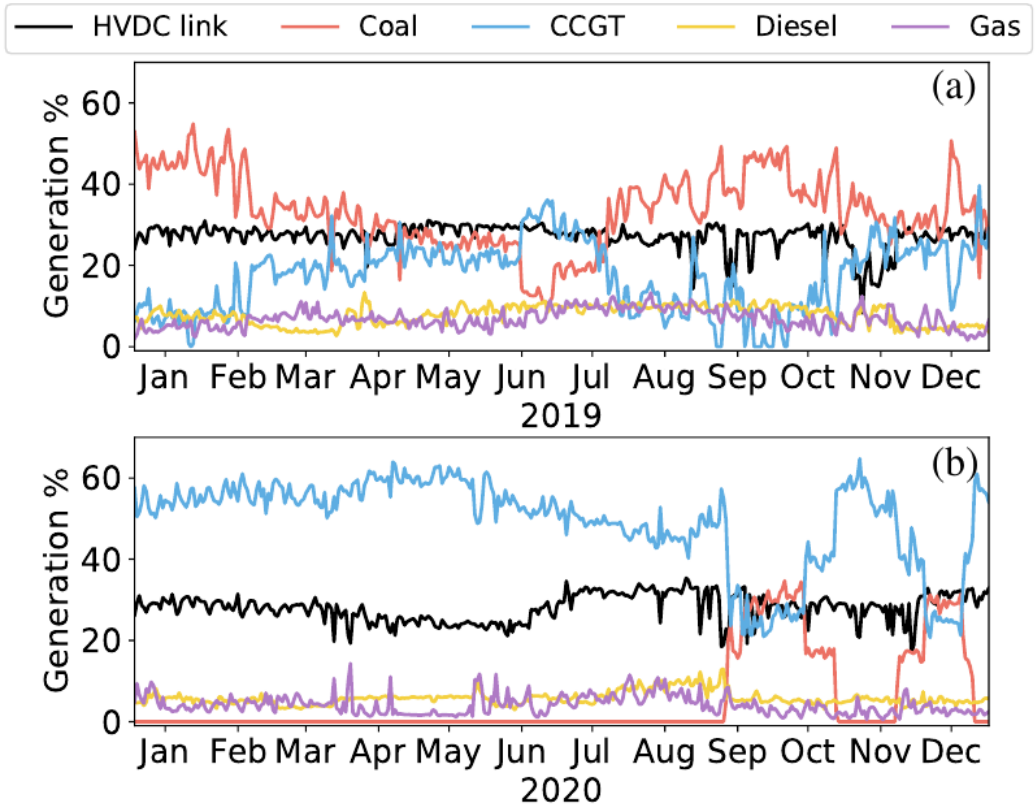
Frequency variations stay way below the statutory limit 0.15Hz.

Coal generation

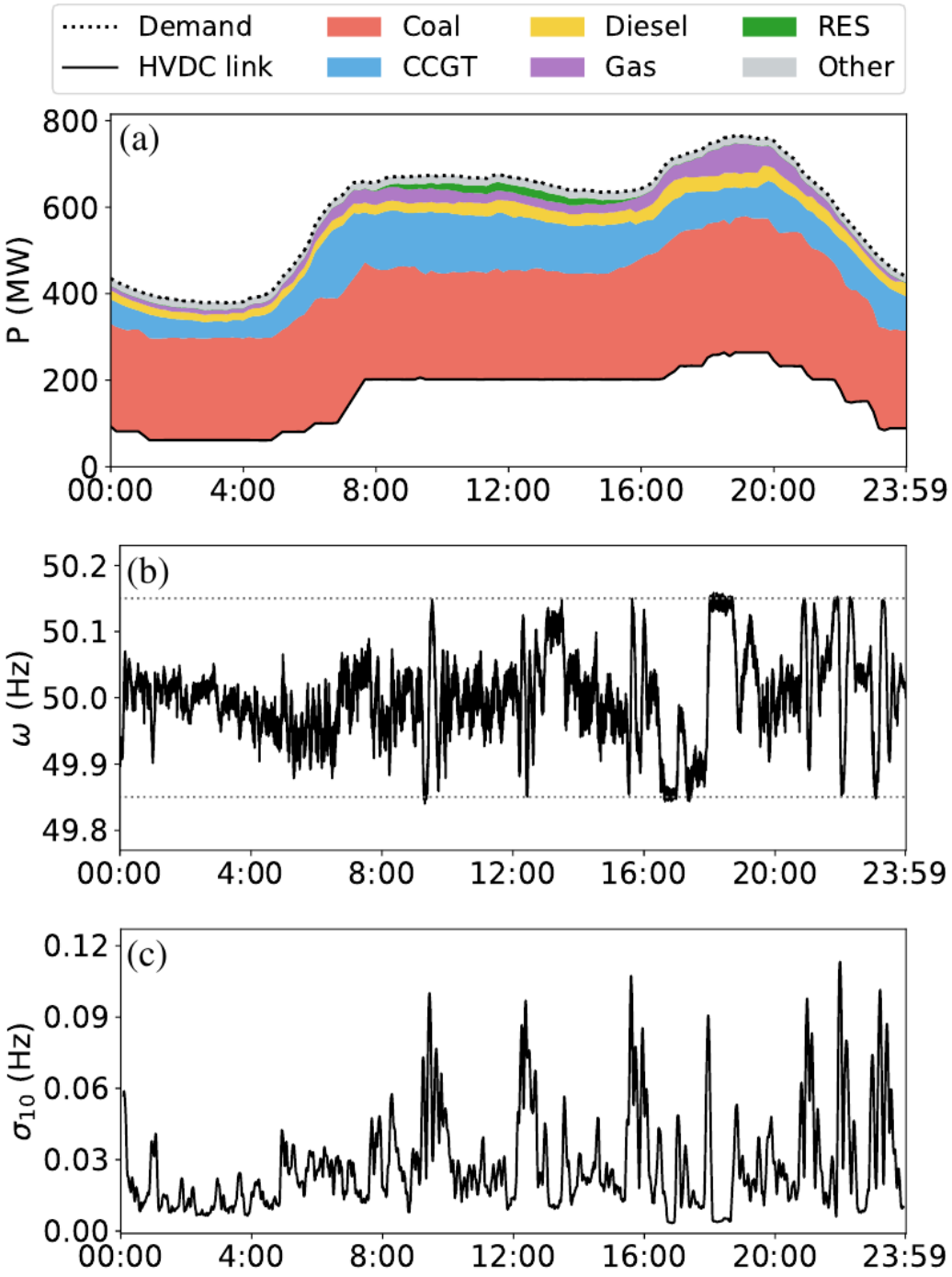


Up to December 2019 coal was the main source of power generation in the Balearic Islands

In 2020 coal generation has been replaced by natural gas (combine cycle), except for a few months of the year.



Frequency fluctuations on a typical day with coal generation



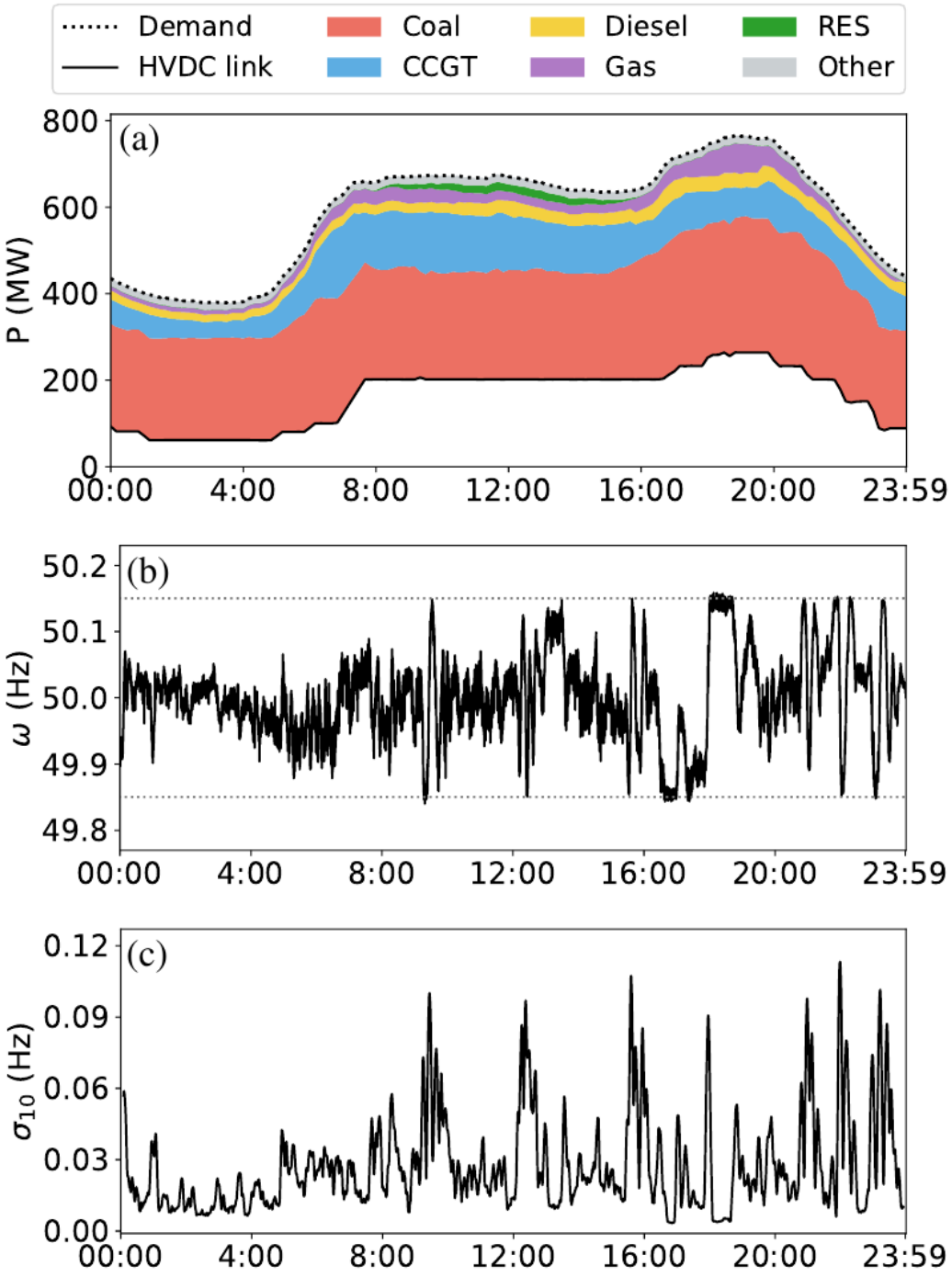
December 18, 2019

Frequency deviations are much larger, reaching on several occasions statutory limits.

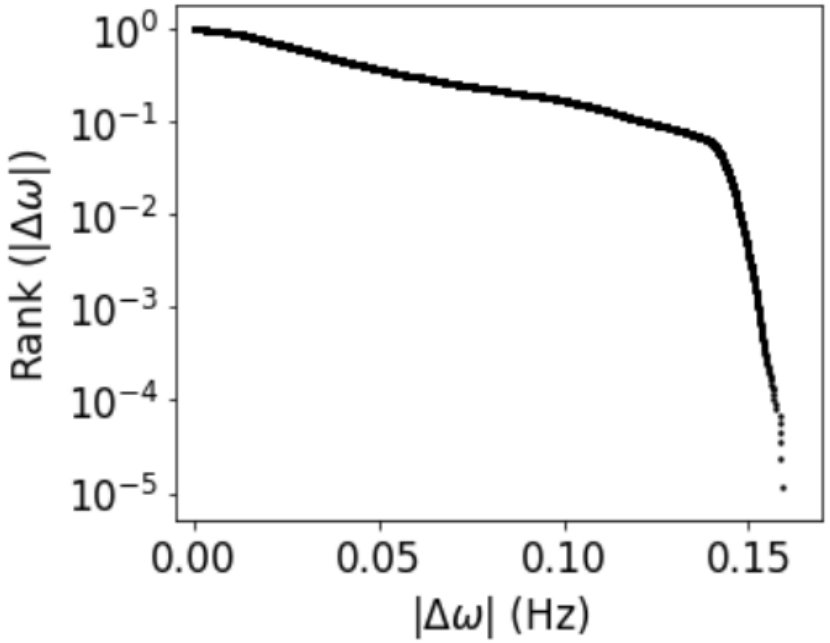
Despite the large inertia provided by coal plants, the overall control capability is significantly smaller.

However, there are no fluctuations beyond the limits.

Threshold-like frequency control



December 18, 2019



The rank distribution of frequency deviations clearly shows a change of behavior at 0.15Hz. Large frequency deviations are strongly damped.

Typical power plant control mechanisms proportional to frequency deviations lead to a smooth rank distribution.

There must be an additional control which is activated when statutory limits are reached.

Threshold-like frequency control without coal generation

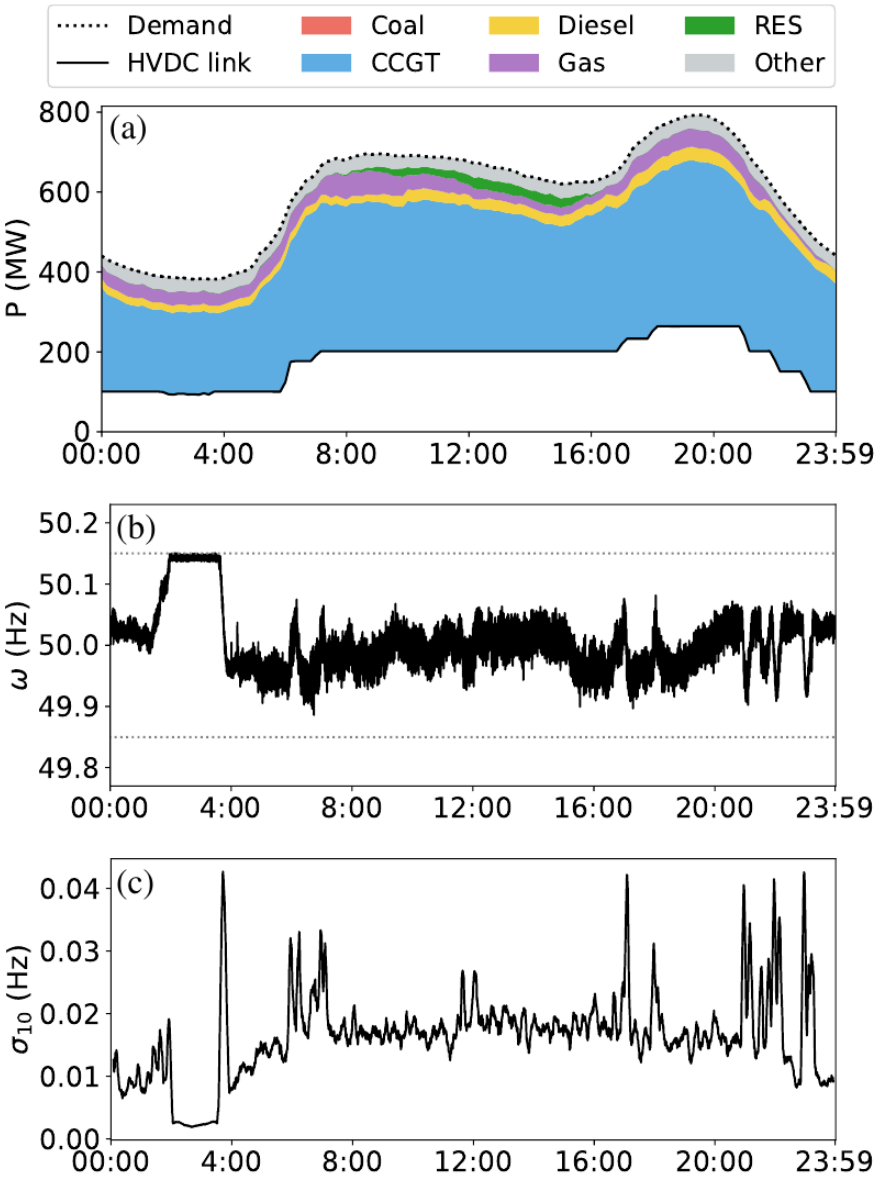
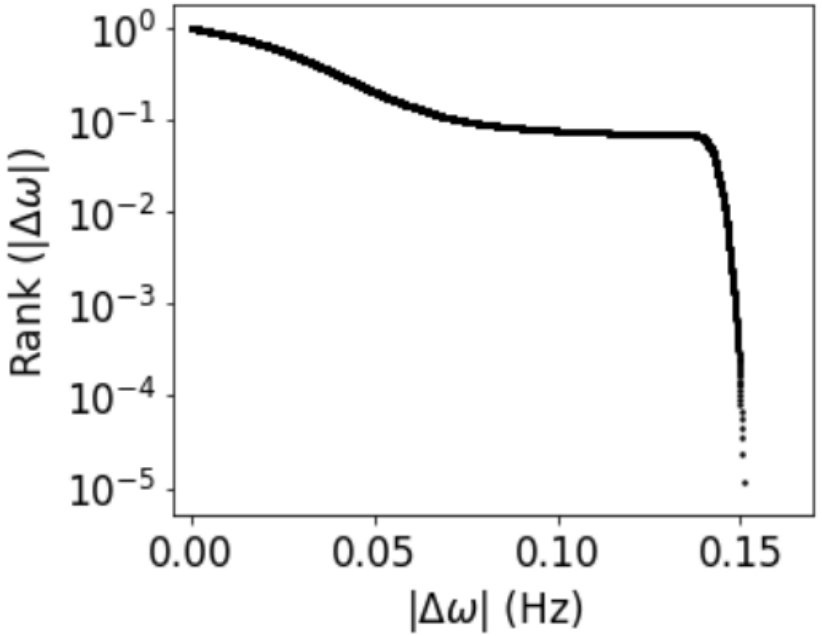
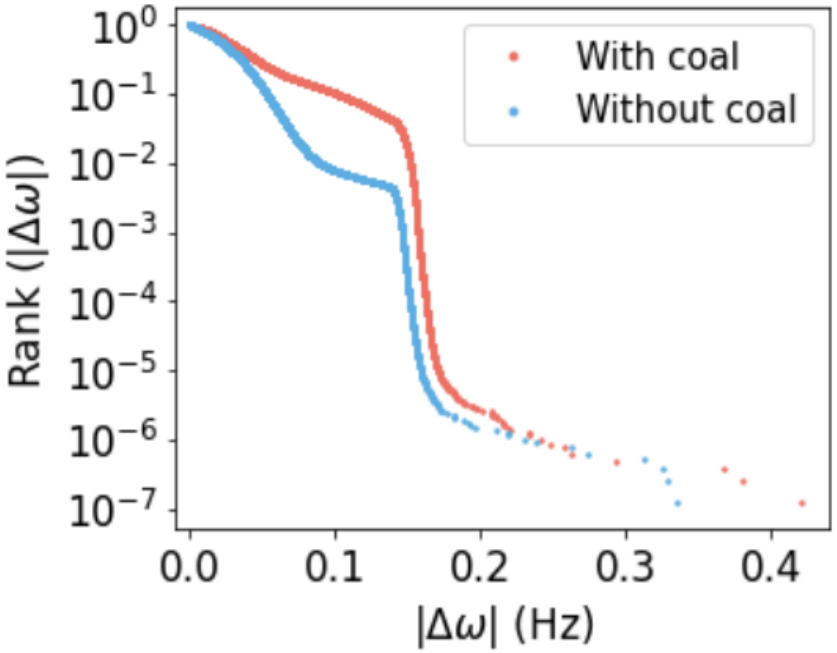


Figure 7. Time evolution of the demand and generation (a) and frequency fluctuations (b) on January 30, 2020. On panel (a), generation is disaggregated by power plant technology, including the HVDC connection to mainland. On panel (b), the dotted lines indicate the statutory operational limits, i.e., (50.00 ± 0.15) Hz. Panel (c) shows the frequency volatility σ_{10}.

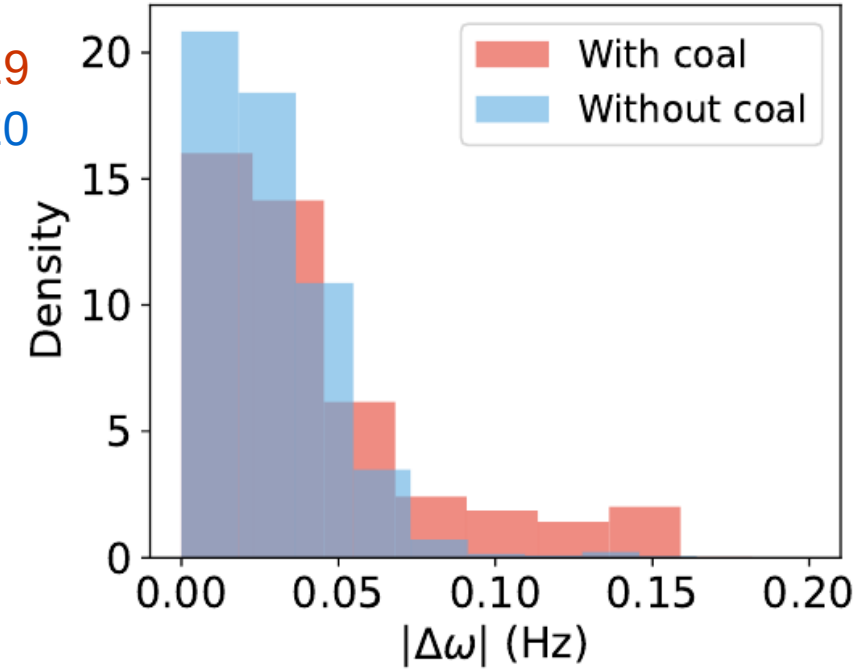
January 30, 2020

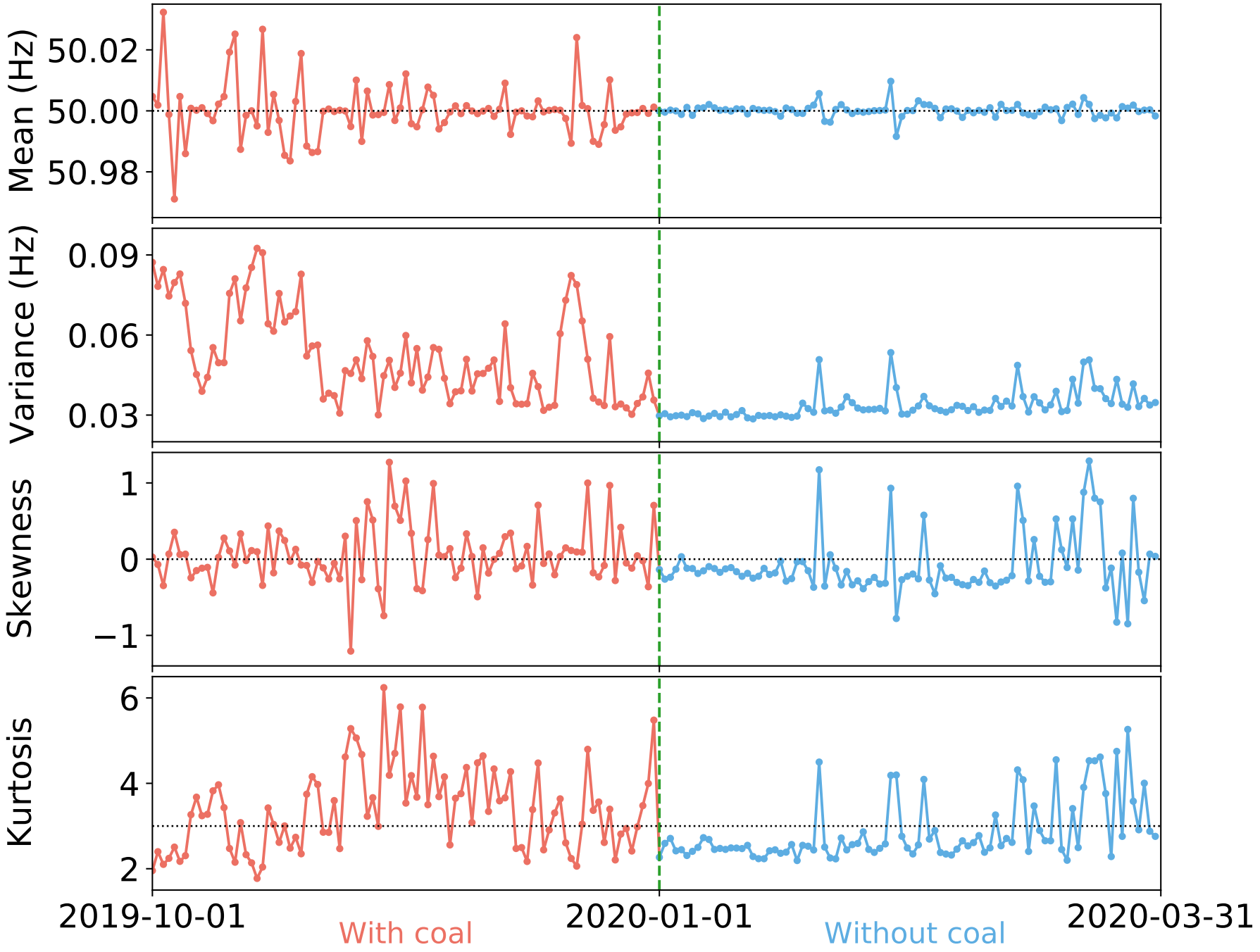




Oct-Dec 2019
Jan-Mar 2020

Oct-Dec 2019
Jan-Mar 2020




Mean (Hz)
50.02
50.00
50.98
Variance (Hz)
0.09
0.06
0.03
Skewness
1
0
−1
Kurtosis
6
4
2
2019-10-01
2020-01-01
2020-03-31
With coal
Without coal

Concluding remarks

- Coal generation closure in the Balearic Islands, despite decreasing the inertia capability has not lead to an increase of the frequency fluctuations rather than a clear reduction of them.
- This is because it has been replaced by combined cycle gas turbines which, despite having smaller inertia, are more flexible and have a larger control capability.
- There is evidence of threshold-like frequency control being used when the frequency deviations reach the statutory limits strongly damping fluctuations beyond these limits.
- The threshold-like frequency control was frequently triggered when coal was in operation while it is seldom triggered nowadays.
- As a contribution to the discussion on the power grid reliability upon the introduction of variable renewable sources, this results shows that inertia reduction is not as relevant for grid stability as having a fast flexible control.