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O Presidente da República

Lisbon  
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# “Portugal and the Energy Transition: - Some Vital Strategic Questions”

Clemente Pedro Nunes



Engineering Solutions for a Sustainable World

Ordem dos Engenheiros

# “Portugal and the Energy Transition: Some Vital Strategic Questions”

*UNESCO WFEO World Engineering Day*

Conference “Energy Transition and Sustainability”


Ordem dos Engenheiros

Lisboa, 4 / March / 2024

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# 1. Portugal, the Energy Transition, and Economic Competitiveness

- **Engineers** have as their **mission** to use **Science and Technology** to promote **Projects** that **enhance** the **economic** and **social** development;
- As such, it is of the **utmost importance** that the **engineers** take good **note** of the **latest scientific** and **technological realities** that affect the current **Energy Transition**;

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- In **Portugal**, one of the main **challenges** to the **economic viability** of this **transition**, is related to its **Electric System**, that is currently **based** in **intermitent power sources**.
  - It is also very important to stress that **Portugal** is a **member** of the **European Union**, and as such **our Electric System** has to be **articulated** with those of the **other european countries**, and with the **decisions** of the **European Commission**.  
In **special** with **Spain**, and also with **France**.

## 2. An Historic Introduction to the Portuguese Electric System


- The national expansion of the **Electrical System Network** only occurred after **WW II**, based on the **National Hydroelectric Plan** of Professor Ferreira Dias.


After 1960 this System was strengthened with fuel oil based **Power Stations** to guarantee the **stability** of the electric supply.

- After the two **oil shocks** of 1973/74 and 1980/81, Portugal prepared the **Energy Plan of 1983** that led to two major decisions:
  - refuse the introduction of **nuclear power**;
  - to **base** the **firm power** supply in **coal** and **natural gas** based power stations, **both** of which to be **imported** .

### 3. *The Revolution of the Intermittent Power Sources: The FIT – Feed In Tariffs*

- This **Electricity System** was **subverted**, from **2005 onwards**, by the introduction of massive of **intermittent sources**, **wind and solar**;
- This “**revolution of a new intermittent base**” was introduced **without** the **necessary preliminary studies** to evaluate the **cost / benefits** of the several available **alternatives**, in order to **optimize** the overall **economic competitiveness** of the **Electric System**.

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- **Most “final energy products”**, like diesel, natural gas or biomass, **can be transported and stored** in a relatively **easy way**, and can be **used afterwards whenever** the client **request** them;
  - But **electricity**, which is basically an “electronic flow”, **can not be directly stored**;
  - Which means that **electricity** “has always to be **used** in the moment **when** it is **produced**”;

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- To **guarantee** the **profitability** of the **investment** of **intermittent** power **sources**, it was **granted** to them by the portuguese government the **contractual regime** of the **FIT – Feed In Tariffs**;
  - The **FIT grants**, to those that benefit from them, **two decisive advantages**:
    - **Whenever produced**, they are **paid** at a **fixed price**, **regardless** of the **consumption** that prevails in **each moment**;
    - **Besides**, these **intermittent powers** are **entitled** to “**expel**” any **competition** from the **market**, **even** in the case that the **alternative** is **much cheaper** for the consumer .



#### 4. How an Unbalanced Electric System was Created

- **Till 2011** were granted **FIT** to more than **6,000 MW** of **intermittent power sources: 5,400** from **wind** and **600 MW** from **solar**;
- As the **consumption** in the “**empty**” hours in only **3,900 MW** in **Portugal**, the **backup** power sources have to **adjust** to the **intermittency** of **wind** and **solar**, with all the **surcharges** that this imply;
- Already in **2008** this situation was the **origin** of the **Tariff Debt of the Electrical Sector**, that **remained ever since**, despite the fact that the Portuguese government promised in 2011, to the Troika, that it would be fully paid till 2020;

- And **more ominous** is the fact that **ERSE**, the **Portuguese Energy Regulator**, announced last December that this **Debt** is going to **rise** again to **2,000 million euros** in **2024**, and its **payment** is the **responsibility** of the **consumers**.
- As these **FIT** were **granted** for **15 years**, counted from the respective start-up, it means that **till 2028** the **System** “will be held **hostage**” of two very serious **consequences** for the **consumers**:
  - The **backup power sources** will **have to** continue to **adjust** to the **intermittent** nature of **wind** and **solar**;
  - Any **new electric production**, including new and more efficient wind and solar power sources, **shall be** “**expelled** from the market ” whenever the “**old FIT decide**”.



## 5. Intermittent Power, Indirect Storage of Electricity and the Need of Guaranteed Power Backup

- In order for the **electricity production to be adjusted to the consumers requirements**, there are **two alternatives**:
  - To **produce electricity when the consumers need it**, or,
  - To **instal a complex technological process that is able to “indirectly store electricity”**


- In **Portugal**, the **three alternatives** that exist, or have already been proposed, for the “**indirect storage of intermittent electricity**”, are the following:
  - To **pump water upriver** in **hydroelectric dams**, that will be turbined afterwards when it is required by the consumers ;
  - **Reversible electrochemical reactors**, commonly known as “**batteries**”;
  - To **produce**, with the eventual surplus of electricity, an “**intermediate chemical compound**”, that will be **later reconverted** back into **electricity** when it will be necessary .
- “**Electrolytic Hydrogen**” is the **intermediate compound** that was recently **proposed** by the **Portuguese Government** for this purpose.

## 6. Electrical Intermittency and Electrolytic Hydrogen

Hydrogen, produced from the **electrolysis of water**, is “a **tool** to promote the **indirect storage of intermittent electricity**”.

### 6.1 - Electrolytic Hydrogen: Risks and opportunities

- **Electrolytic hydrogen** is very **inefficient** in terms of energy and, besides **requires high purity water**;
- It is **very difficult** that **hydrogen** reaches a **high energy density** in **volume**, since the respective **condensation temperature** is **extremely low**, - **253 °C**, and its **liquification** by compression needs very **high pressures**, of around **700 atmospheres**;

- 
- As such, very important preliminary **technological developments** are still **needed** in order for **electrolytic hydrogen** to be able to **compete** in the **marketplace**;
  - Unfortunately, **RCM n° 63/2020**, of 14 August, that establishes **seven targets** to be achieved by **electrolytic hydrogen till 2030**, is **not based** in any type of **economic analysis** .

## 7. The Evolution of Energy Sources in Portugal

### 7.1 – Electricity Imports

- In Portugal, the value of liquid electricity imports have climbed in the last few years, having reached in 2022 an absolute high record.

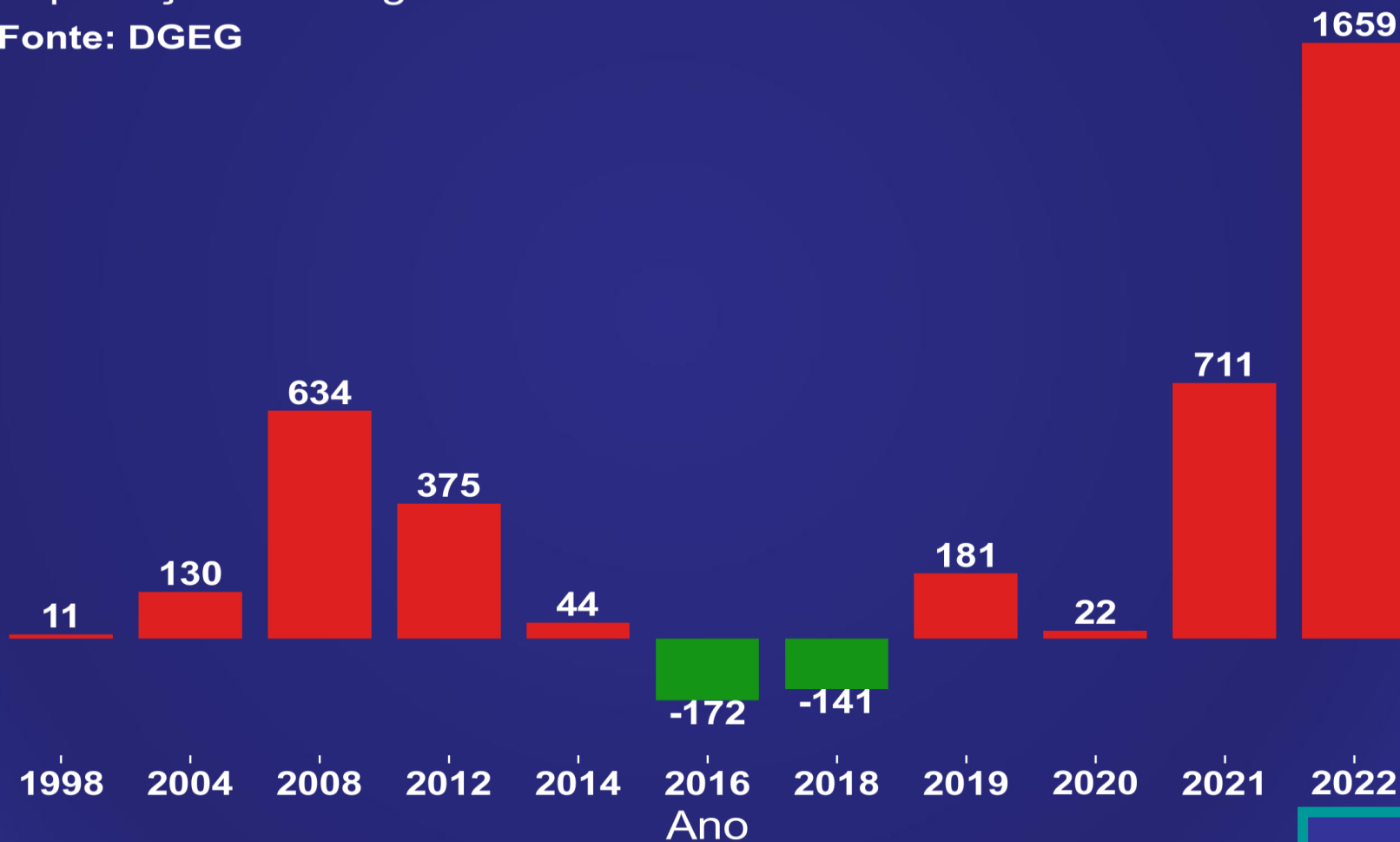
As it can be seen in Table 1 below (Source DGEG) :

**Evolution of the value of the Liquid Imports of Electricity in Portugal from 1998 to 2022 (in millions of Euros)**

	1998	2004	2008	2012	2014	2016	2018	2019	2020	2021	2022
Eletricidade	11	130	634	375	44	-172	-141	181	22	711	1659

## Importações Portuguesas de eletricidade em M€

Fonte: DGEG




**16**



- The liquid **imports** of electricity have **risen from 181 million euros in 2019 to 1.659 million euros in 2022**, which means that its **value** has been **multiplied by 9 !**
- This important **bleeding of financial resources** is **regrettable**, since **Portugal disposes of 20,000 MW of installed power capacity**, for a **consumption of only 10,000 MW** at “**maximum consumption**” hours and **only 3,900 MW** at “**empty**” hours .

What is the **reason** for this **apparent nonsense** ?

With the **closing down** of the **coal based power plants** in **2021**, **Portugal** can **only** use **natural gas** as a **reliable power source** and when possible, of hydric storage, in order to **avoid blackouts** .



In order to **avoid** the **surcharges** of the **stop and go** regime, that the **backup** power stations are forced **due** to the **FIT** granted to the **intermittent power sources**, it is **preferable** in many occasions, in terms of pricing, to **use imports** of electricity **from Spain**.

**Spain** that continues to **have** several “**reliable power sources**” based in **coal, natural gas** and **nuclear**, for instance.

## 7.2 - Evolution of the Imports of All Energy Sources

**Table 2 Evolution of the Value of the Liquid Energy Imports in from 1998 to 2022  
(in millions of Euros)**

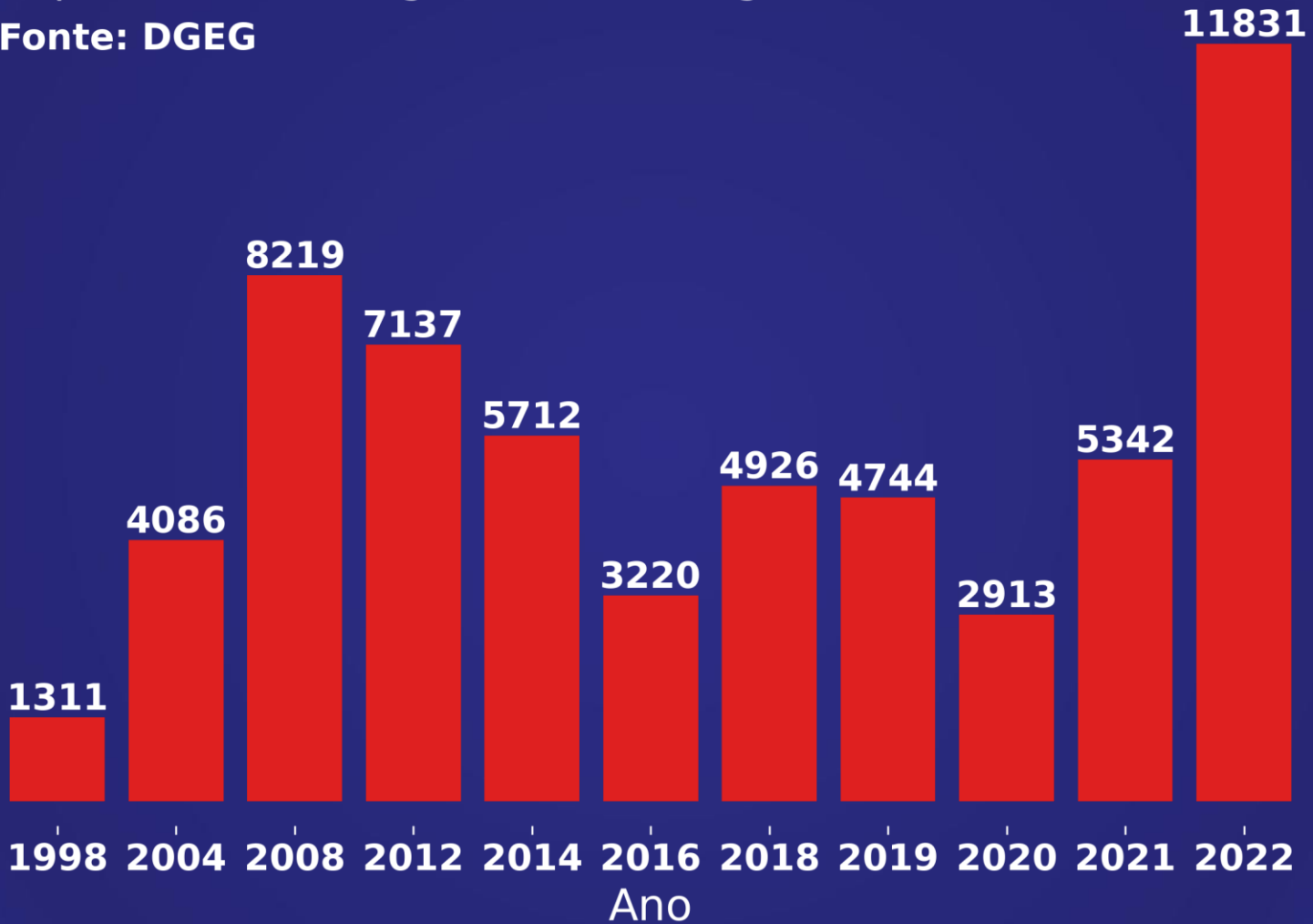
	<b>1998</b>	<b>2004</b>	<b>2008</b>	<b>2012</b>	<b>2014</b>	<b>2016</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>
Carvão	164	261	455	342	231	248	356	143	-1	4	6
Petróleo e Derivados	1.224	3.233	(1) 5.881	(1) 5.059	(1) 4.035	(1) 2.289	(1) 3.440	(1) 3.368	(1) 2.031	(1) 3.043	(1) 6.410
Gás Natural	65	462	1.249	1.432	1.493	921	1.371	1.207	993	1.625	3.814
Eletricidade	11	130	634	375	44	-172	-141	181	22	711	1.659
Biomassas e Biocombustíveis	-	-	-	-71	-91	-66	-100	-155	-132	-41	-58
<b>TOTAL</b>	<b>1.464</b>	<b>4.086</b>	<b>(1) 8.219</b>	<b>(1) 7.137</b>	<b>(1) 5.712</b>	<b>(1) 3.220</b>	<b>(1) 4.926</b>	<b>(1) 4.744</b>	<b>(1) 2.914</b>	<b>(1) 5.342</b>	<b>(1) 11.831</b>

(1) Não estão incluídas nestas estatísticas oficiais as significativas quantidades de combustíveis líquidos adquiridos em Espanha diretamente pelos consumidores (Fonte DGEG)

**+121,5%**

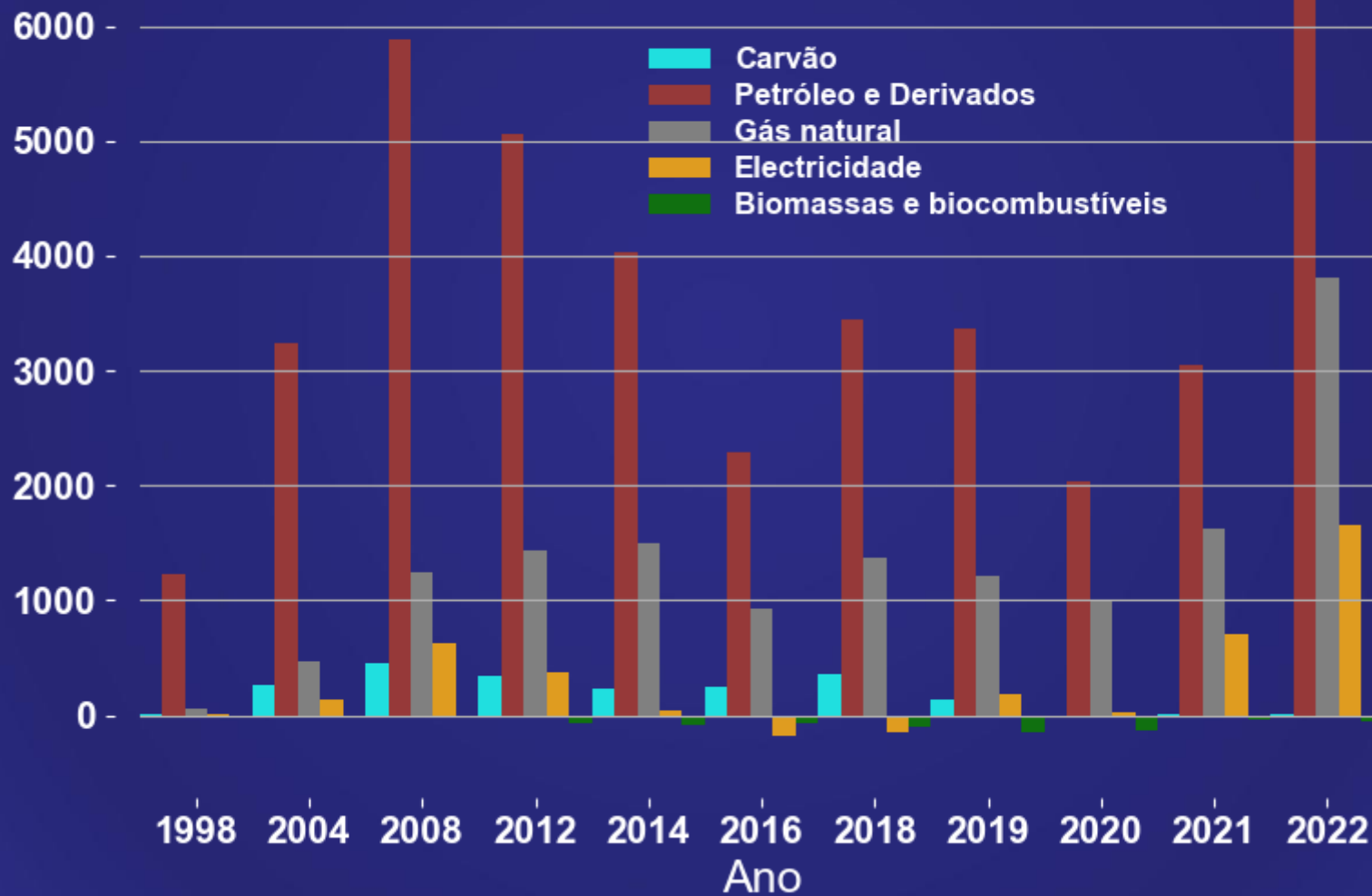
## Importações Portuguesas de energia em M€


Fonte: DGEG




## Importação das fontes Portuguesas de energia em M€


Fonte: DGEG



- 
- The evolution of the **Overall Energy Imports** of Portugal, presented in **Table 2**, is a **decisive element** form de analysis of the **competitiveness of our economy**, and of the equilibrium of our external accounts..
  - **Besides** the evolution of the Liquid Imports of Electricity that was already presented before, the **evolution** of the **other items** of the **Overall Energy Imports between 1999 and 2022** also **very troublesome**.
  - In fact, the **Overall Energy imports of Portugal** reached **11.831 million euros** in **2022**.

That is, almost **6%** of our **GDP!**

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- This also represents:
    - a **huge increase** of **121,5%**, in relation to the **5.321 million euros** of **2021**.
    - an **increase** of **7.077 million Euros** in relation to **2019**, that was the last “normal year” before the pandemic.
    - a **new absolute record**, and **3.612 million euros** above the **previous record** registered in **2008**.
  - It should be stressed the **Overall Energy Bill** of **2008** was one of the **factors** that led to the **near – bankruptcy** of **2011**.

- 
- If we analyse **Table 2**, we can see that the value **increase** of the **oil** and **natural gas imports** were also very relevant, besides electricity as already pointed out before.
  - As such, and in **financial terms**, **coal** is a very **attractive alternative** to the imports of electricity and natural gas.
  - It is then **understandable** the **decision** of **Spain** to **restart** the **coal** based power plants in **October 2021**, **contrary** to what **happened** in **Portugal** that **decided** to drastically **increase** the **dependence** on **natural gas**.



## 8. Proposals for the Optimization of the Electric System till 2045

### 8.1 – To be Carried out in Portugal

To **optimize** the **Electric System**, and to “integrate” the intermittent power capacities already installed, I put forward **five proposals** in order to promote **economic competitiveness**:


- a) **Keep** in operation the **natural gas** based **power stations** till **2045** as part of the **backup** system, as Germany has already decided;
- b) **Increase** urgently the **electrical interconnections** between **France** and the **Iberian Peninsula** till **8,500 MW**, that is the more efficient way to “**soften the intermittency**” and to **reduce** the **CO2 emissions** within the European Electricity Market, as referred in 8.2 below;
- c) **Increase** in **400 MW** till **2030** the **biomass** based **electricity capacity**, thus **strengthening** the **backup** based in **renewable** and **reliable** power;

- d) To **promote R+D** Projects on the main **alternatives** for the “**indirect storage of electricity**” in order to obtain reliable data concerning the best solution to be adopted for this purpose;
- e) The sequence of the **three dams** that already exist in the **river Zêzere – Cabril, Bouçã e Castelo de Bode** – offers an **excellent opportunity** to install new **reverse pumping systems** in the first two dams, thus **strengthening** the “**national capacity to store intermittent electricity**” in Portugal, allowing for the maximized production of hydroelectricity **without reducing** the strategic **storage** for the supply of **drinking water** to the greater **Lisbon** region.

As the **concession** of the **Cabril dam** is up for **renewal**, it is very **urgent** to include this aspect in the ongoing negotiations.


## 8.2 – Electrical Interconnections within the European Union: Stable and Intermittent Power Capacities

- **Portugal** is a full member of the **European Union** and the **optimization** of its **Electric System** depends on the overall **grid network** in the **European Union**, and specially on the **future strengthening** of the **interconnections** between **France** and the **Iberian Peninsula**;
- Besides, and due to the **strong electric interconnections** that already exist **between Portugal** and **Spain**, the **optimization** of our **Electric System** has first of all take **good note** of what **happens** with the **evolution** of the electric production capacities that exist in **Spain**;

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- As **Portugal** has **chosen** two types of **intermittent power sources** as its baseload, **wind** and **solar**, the **dependence** of its **Electric System** towards **Spain** has strongly **increased after** it was decided to **close down in 2021** the **coal based power plants** that existed till then in Pêgo / Abrantes and Sines;
  - **Spain maintained several types** of **stable electric sources**, that includes nuclear, coal and natural gas, which has **indirectly contributed** for a greater **security** of the **electrical supply** in **Portugal**.

This “**Spanish protection**” has however triggered a **drastic increase** of the overall liquid **imports of electricity from Spain**;

- In order to promote economic competitiveness within the European Union, the **intermittent capacities, wind and solar, need an important increase of the electric Interconnections;**
- This is the **only way to sell** in the market, at **competitive prices**, the eventual **excesses of intermittent short term electric productions.**  
It allows also to have **better access** later on to **stable electric productions** when the intermittent sources disappear, and it is **necessary to avoid “blackouts”;**
- The **construction under way of a new Electric Interconnection, in the Gulf of Biscay**, that will increase these overall **interconnections between France and Spain to 5,500 MW**, is **very positive.**

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- It is however necessary to take in consideration that this new connection is forecasted to be concluded only in 2028;
  - As such, and as the **Electricity Production and Distribution Networks** in the **European Union** is vital for the **Portuguese and European economic prosperity**, this **Conference on “Energy Transition and Sustainability”**, that was organized today within the framework of the UNESCO WFEO World Engineering Day 2024, is so important.



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**Many Thanks for your Best Attention  
I will be at your Disposal for any Questions  
that you may Want to Put Forward**

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