Reply to ECHA consultation on PFAS – impact of a potential PFAS restriction

Executive Summary

In this paper, EUTurbines elaborates further on the reasons that lead the turbine and steam power plant industry to ask for a derogation on the PFAS restriction. The reduced proportion of PFAS used in the whole Energy sector compared to others, as well as the minimal PFAS present in power plant components, added to the meticulous control of said components while in operation and in their end-of-life phase make it reasonable for our sector to ask for a derogation until alternatives are feasible. Currently there are no reliable alternative materials to PFAS in the power plant field, as the paper exposes, yet numerous tests have taken place and the industry keeps on investing in R&I to find alternatives, with no sign of findings in the short or middle term. Moreover, the reliance of the European electricity market on our products highlights the need for a derogation, given that a halt in operations would seriously disrupt generation all over Europe.

1. Introduction and scope

EUTurbines is the business association representative of manufacturers of turbine-based gas and steam power plants in the EU. This paper acts as a general statement complementing the information submitted as a response to the ECHA consultation by EUTurbines. For compliance reasons, the document does not contain confidential information, given that it has been redacted by a team of professionals from different companies. However, its purpose is to serve as an explanation to our proposal of a derogation of the restriction on our sector.

2. General approach to our sector: The role of Gas and Steam turbines

The Gas and Steam Turbine Industry is one of the main pillars of the European Electricity system, given the continent's reliance on power plants both for reliable and flexible power generation and heating, in case of cogeneration plants. As Europe continues its transition toward more sustainable energy sources, the roles of these turbines will evolve to guarantee a more balanced and environmentally friendly energy landscape. Around 90% of the world's Electricity was produced in the 2000's with steam and gas turbines (1), and as of today, more than 1.200 gas power plants in Europe still provide with electricity and heating using this technology.

The versatility and inherent straightforwardness of turbine technology, allows to use heat from any sources for generating electricity. While in the past the heat came mainly from burning coal and oil, more and more other sources like gas, hydrogen but also geothermal or solar heat and even industrial waste heat are used. Consequently, even within a future decarbonised electricity market, turbines will retain a pivotal function by offering grid stability and reliability for the future decarbonised system. Turbines provide the necessary dispatchable and flexible electric generation in the evolving decarbonised electricity market dominated by

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weather-dependent wind and solar energy in Europe's energy landscape. The vital attribute of being net-zero power plants positions them as key players in meeting future energy demands.

In addition, the integral function of turbines within the district heating system, presents a challenge for finding equally efficient alternatives. The substantial investments and effort required for replacing such a system further enhance the relevance of turbines in this context.

Consequently, the application of a ban on PFAS needs a very careful and comprehensive approach, because it could potentially become a serious stump in the road to the EU's climate neutrality by disrupting not only the electricity market, but the whole planned green energy infrastructure.

3. The technology and the role of PFAS

What does a turbine do? Why is it relevant?

The turbines are, together with the generators, the most important components of power plants. An elementary explanation is that the role of the turbine is to transform the thermal energy created by a heat source into mechanical energy (rotation) that is transferred to the generator, which transforms it to electrical energy. A gas turbine generates the heat by burning a gas, while steam turbines use external heat sources for this.

In a Combined Cycle Gas Turbine (CCGT) power plant, the gas turbine is used identically, but additionally, the waste heat of the gas turbine is used to operate an additional steam turbine, turning the waste heat into additional electricity and thus increasing the efficiency of the process.

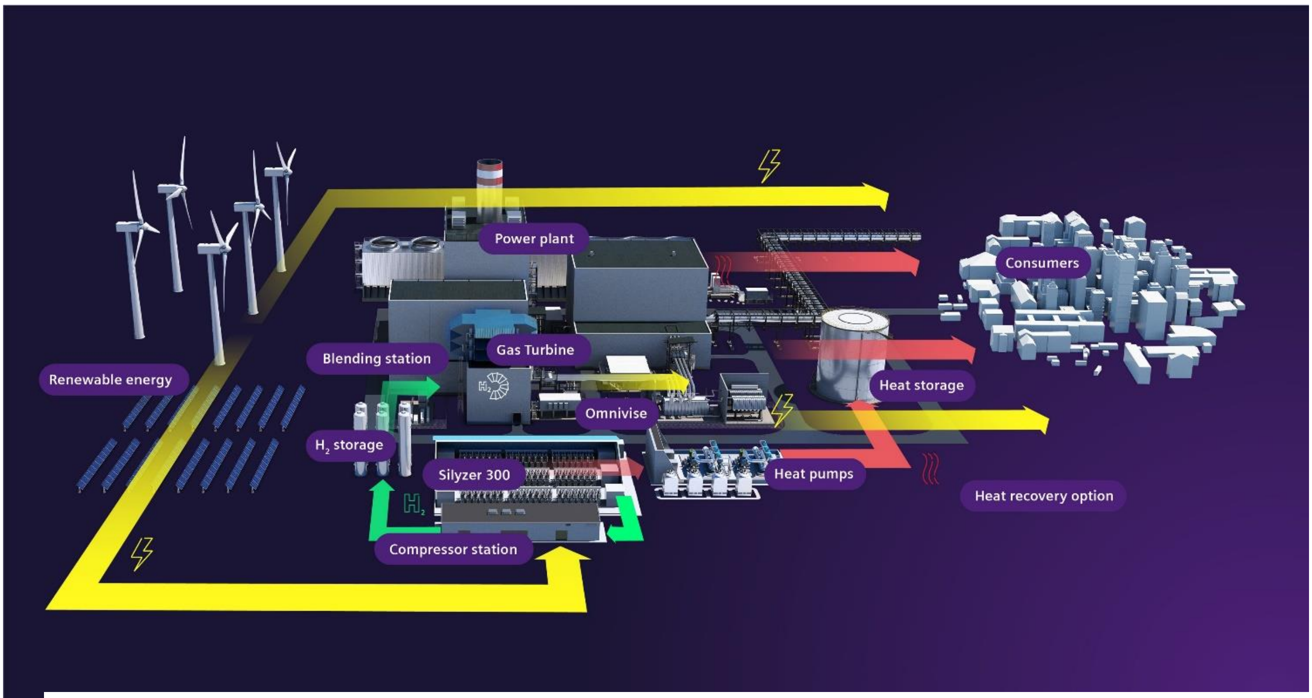

Figure 1 - Combined Heat & Power hydrogen gas turbine power plant schema (15)

A CCGT power plant is the most complete example to illustrate the importance of PFAS in the sector, given that it comprises a gas and a steam turbine plus several other components like a generator or heat recovery systems. The elements of a CCGT power plant are described in the section below.

4. Components of a CCGT Power Plant

Gas Turbines

Gas turbines compress air via an intake, then mixes it with fuel in a combustion chamber to thermal energy, which is transformed into mechanical energy, making the turbine rotate.
It has three main parts:

- **Compressor:** where the incoming air is compressed and pressurised, then fed into the combustion chamber.
- **Combustion chamber:** where the fuel is injected and ignited, generating a high temperature-pressure gas stream that expands.
- **Turbine blades:** where the expanding gas is converted into mechanical energy by making them spin, which, connected to a generator via a shaft produces electricity.

They're able to operate with a range of gases, including renewable gases such as hydrogen and biomethane, and can be deployed quickly providing a very flexible source of power, making them well-suited for meeting fluctuations in electricity demand and providing backup power during peak periods. This combined-cycle configuration increases overall plant efficiency and reduces fuel consumption, contributing to a more sustainable energy production process. Such turbines can efficiently respond to sudden changes in demand or supply, helping to maintain grid frequency and voltage within acceptable limits.

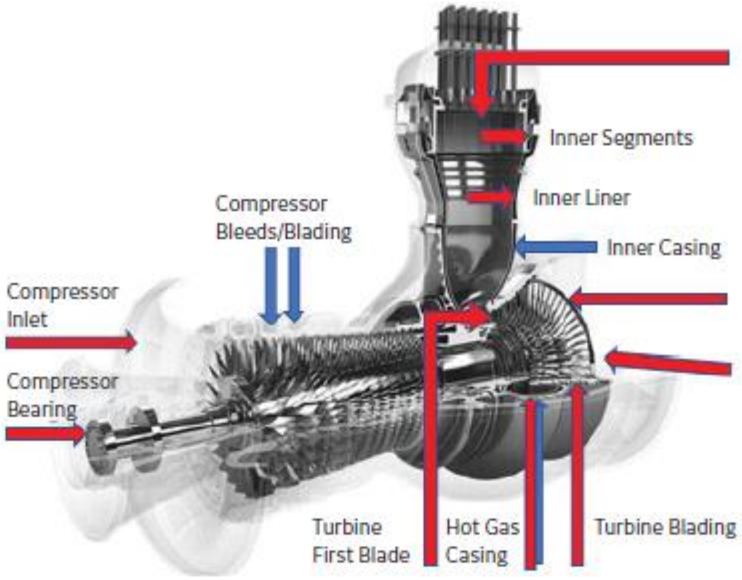

Figure 2 - gas turbine with silo combuster (16 p. 52)

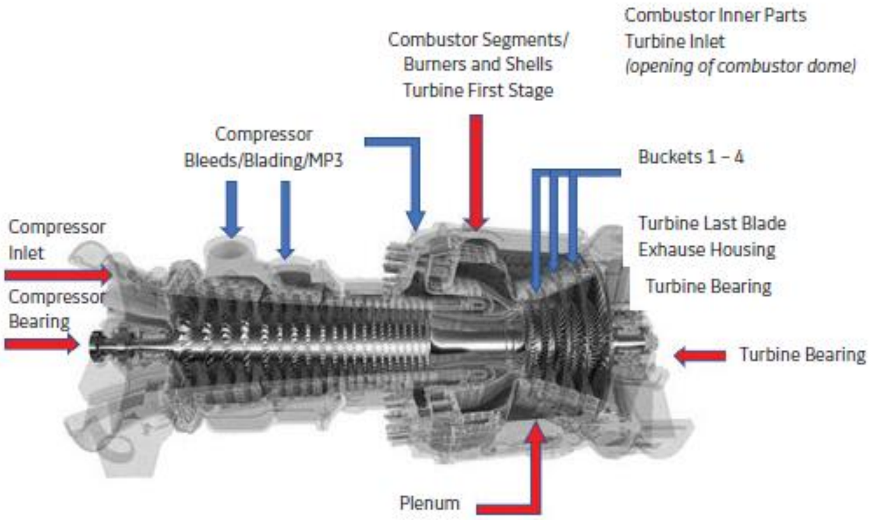

Figure 3 - gas turbine with annular combuster (16 p. 52)

Steam turbines

As for steam turbines, they convert thermal energy from high temperature and pressure steam (independently from the heat source) into mechanical energy, which drives generators to produce electricity. When integrated into combined-cycle power plants, the waste heat generated by the gas turbine's exhaust is used to produce steam, which drives a steam turbine for additional electricity generation.

They consist of the following 3 main components:

- **Rotor:** where the energy from the steam is extracted by an impeller with mounted blades and transferred to the shaft.
- **Turbine blades:** which may be stationary blades with increasing size connected to the rotor shaft, or moving blades connected to the casing. The blades are turned by the steam passing through them, driving the generator to produce electricity.
- **Casing:** whose function is to dissipate the steam and ensure proper sealing.

These turbines can be used in cogeneration or Combined Heat and Power (CHP) systems, where waste heat from industrial processes or power generation is used for other applications, such as district heating or industrial processes. This improves energy efficiency by maximising the use of generated heat. Notably, steam turbines are also used in various industrial processes, such as the production of chemicals, refining, and pulp and paper manufacturing, where steam is often a byproduct of these processes.

Over the last century, these facts have helped establish power plants, and the turbines inside, as main power resources given the relative facility to improve their efficiency reusing the waste heat from gas turbines in steam turbines, generating power or heat with both at the same time.

Steam turbines can also be used in some concentrated solar power (CSP) plants, where sunlight is focused to heat a fluid to produce steam, which then drives a turbine.

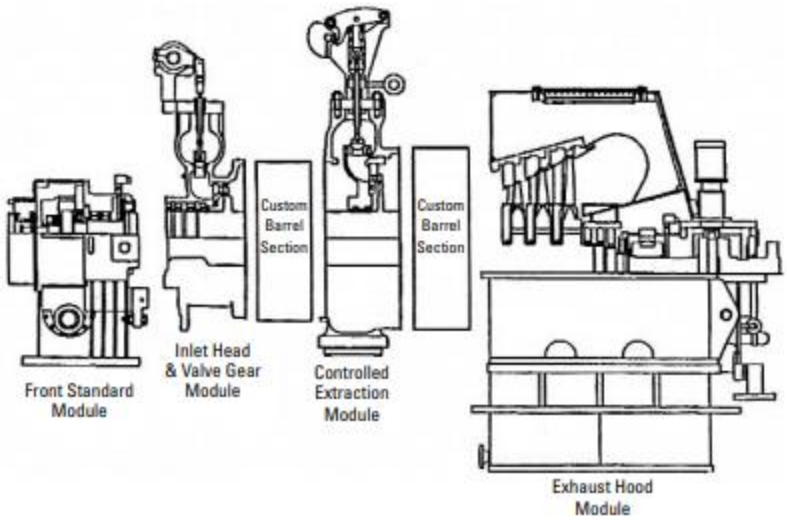

Figure 4 - Industrial Steam Turbine building block structure, designed from standard modules with customised steampath (14 p. 5)

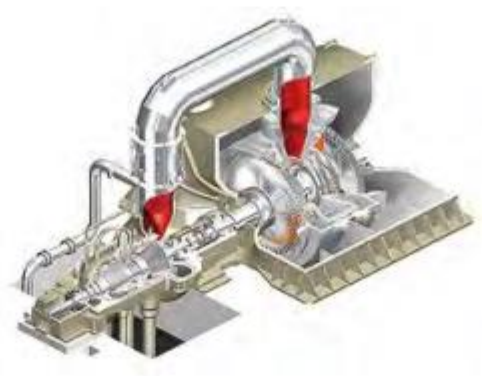

Figure 5 - Two Casing (steam) Turbine for CCGT Plant Applications (19)

Compressors & mechanical drive applications

Compressors, also included in the category of turbines and manufactured by our members, have similar parts and components as generation turbines and in many cases are integrated into them. Turbine-technology based compressors are used mainly in industrial applications, compressing gases or liquids. They are also an essential part of gas and oil pipelines ensuring the compression and transport of the gas. In addition, turbines are used in industry to provide a mechanical drive.

The current LNG import system which is sustaining the gas market in Europe is one of the main applications for compressors nowadays. But they are also essential for carbon capture and storage, and the whole hydrogen infrastructure, which is key in reaching the Green Deal objectives by decarbonising for example steel manufacturing.

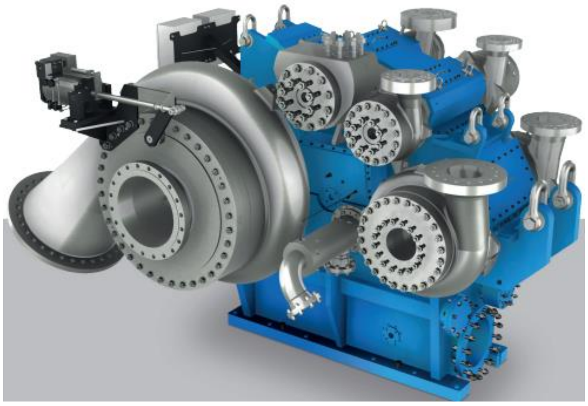

Figure 7 - integrally geared compressor used for a range of applications including power generation (18)

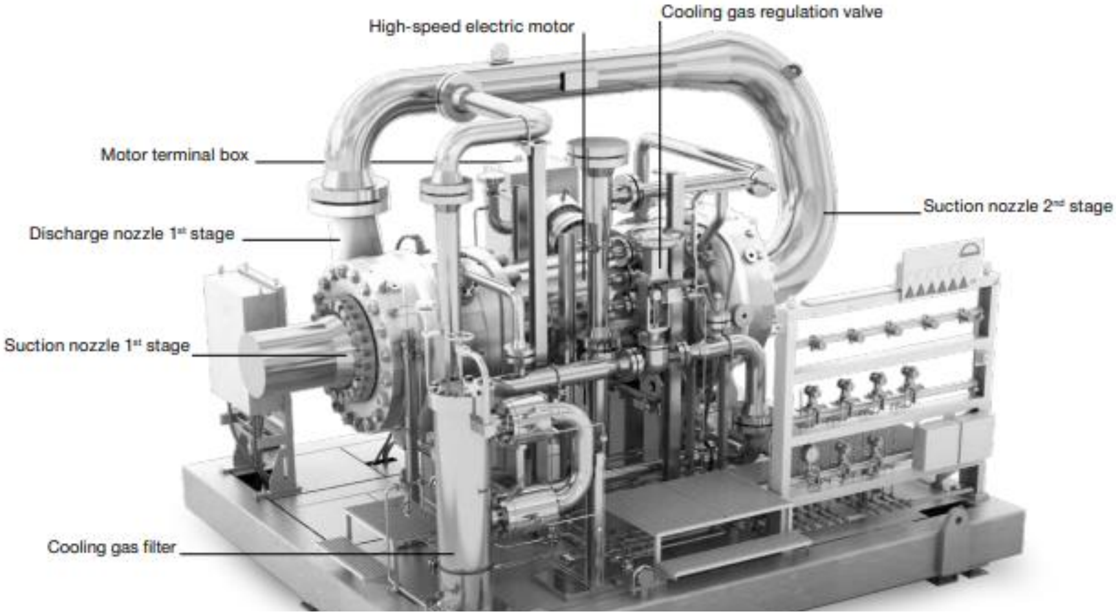

Figure 6 - typical arrangement of a hermetically-sealed, compact motor-compressor system used in gas transport grids. (17)

Turbine technology has proven its value and relevancy to the European energy system in the past and will still play a decisive role in the future electricity market. A restriction on the use of PFAS would completely disrupt the activity of currently operating turbine power plants and stop the production of turbines and compressors all over Europe, risking the security of electricity supply to Europe and endangering the climate targets set for 2030 and 2050.

5. Methodology used:

This paper was developed with the input provided by EUTurbines' members, to the extent of they were able to share it. Due to the short time frame available to respond to the consultation and the magnitude of the task at hand -namely finding all components in our members' products that contain PFAS- the information displayed here is limited and can be updated in the future.

As well, for compliance reasons, there is confidential information that EUTurbines' members weren't allowed to share, and which can be found in their individual responses to the Consultation.

6. PFAS containing components in turbine power plants

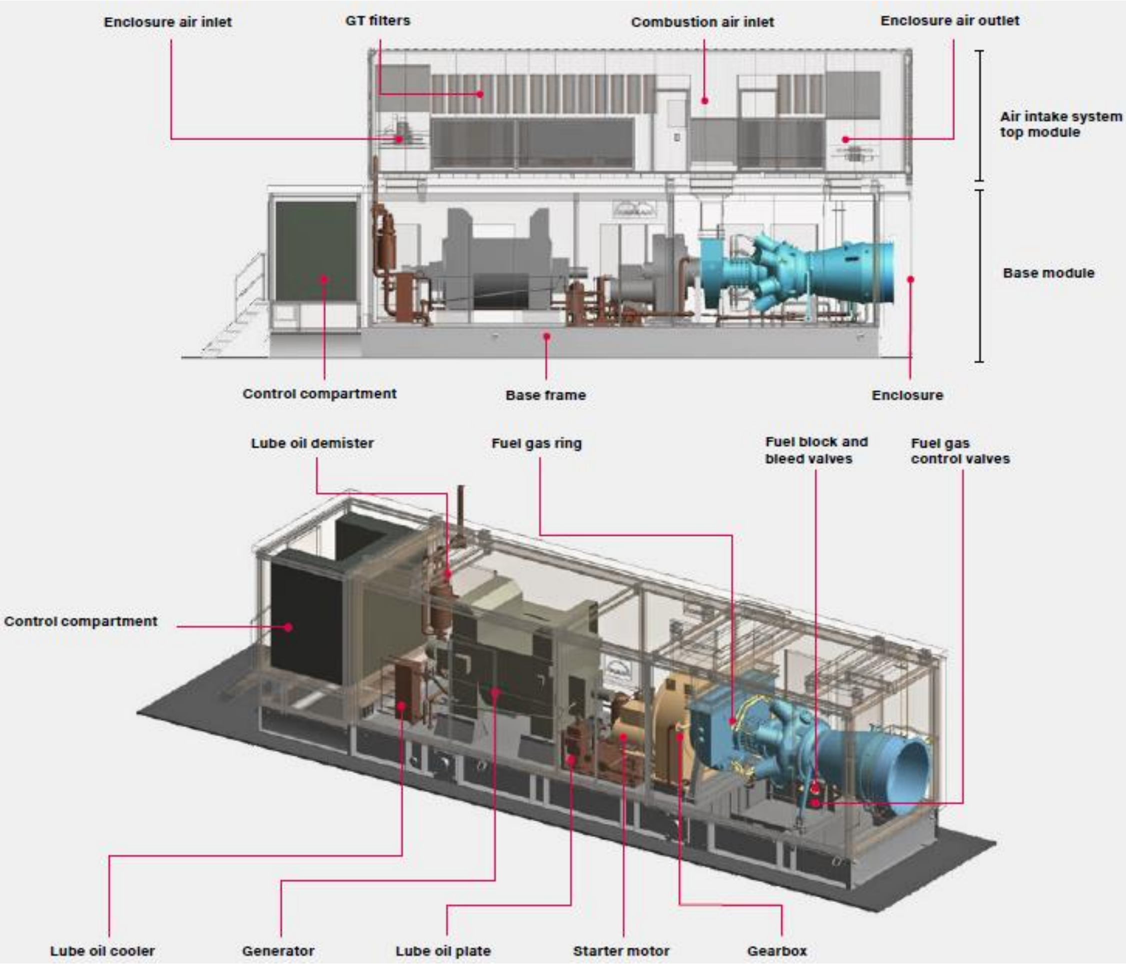

Figure 8 - package and main components for the function of a gas turbine in power plant applications (2 p. 6)

Table 1 - non exhaustive list of PFAS used in gas and steam turbines, compressors and mechanical drives, and auxiliary options

Component	Use	PFAS
Lube oil system: • Main lube oil pump • Auxiliary lube oil pump • Emergency lube oil pump • Lube oil filter	One of the most important auxiliary systems. Delivers lubrication oil to the bearings, gearbox, and driven equipment (2 p. 13). Before the gas turbine can be started, the oil is heated to minimum starting	• Fluoroelastomer (FKM) • Perfluoroelastomers (FFKM) • Polytetrafluoroethylene (PTFE) • Tetrafluoroethylene propylene (FEPM)

• Pressure and temperature control valves • Lube oil cooler • Oil mist separator	temperature, and cooled within operating window during operation. Oil is then pumped from the lube oil tank and funnelled to the bearing of the components – hot oil runs through the return lines from the bearings back into the tank	
Fuel System	The design can vary depending on Original Equipment Manufacturer (OEM) and turbine type. For a gas turbine, fuel is provided to the fuel control valves via a shut-off and vent valve combination. Two separate fuel control valves control the fuel flow to the pilot gas line (needed for start-up and for flame stabilisation) and main gas line (2 p. 11), and provokes the required combustion	• FKM • FFKM
Generator: • Bearings • Bearing housing insulation • Stator insulation • Shaft seals • Diode & thyristors • Rotor and components • Exciter rotors • Flywheels • Elastomers for sealing function • Electrical insulation	Converts rotating energy into electricity	• PTFE • Fluorinated ethylene propylene (FEP) • Perfluoroalkoxyl polymer (PFA) • FKM • FFKM • Fluorosilicones (FVQM) • FEPM • Ethylene tetrafluoroethylene (ETFE)
Electrical starting system, consists of: • Starter motor • Shaft-driven main lube oil pump	Needed to start the operation of the power plant. • The gearbox provides the	• PTFE • FKM • FFKM

• Load gear • Gear box	necessary torque to start the gas turbine up to self-sustaining speed, and reduce the rotor speed to that required by the generator of driven equipment. • The shafts connect the gas turbine with the gearbox, and the gearbox with the driven equipment or generator (2 p. 12).	
Airfoils	Their size and disposition allow for the compression of air in the intake. Must be heavily coated to withstand temperatures	• PTFE
Air filtration system	Gas turbines ingest huge amounts of air and are operated in industrial environments that can contain corrosive containments which require filtration to prevent being carried through the gas turbine. Without filtration, these contaminants can cause chemical reactions between the particles (eg sulfides and salt) and the metallic surfaces of the airfoils, and can also cause surface abrasion. Fouling can also occur, when contaminants adhere to surfaces, altering their structure and shape (2 p. 17)	• PTFE
Exhaust gas diffuser	Space for expansion of the compressed gases after combustion	

Silencers	Filter out noises from compressor inlet and exhaust outlet	
Cables	Needed for the connection of all components, and particularly to transport of the generated electricity to the grid	• PTFE • PFA • FEP • Polyvinylidenefluoride (PVDF)
Couplings	Ensure stable torque transmission	
Shaft seals	Prevents damage to bearings caused by shaft currents	• PTFE • FEP • PFA • FKM • FFKM • FVMQ • FEPM
Insulation components	Prevents damage to insulated components from corrosive substances and electrical charge damage	• ETFE • PTFE
Inlet sections and casings	Require high degree of thermal flexibility for long casing life under cyclical conditions	• PTFE
Valve gear	Used with the inlet sections as a function of inlet flow; internal induction valves; internal grid valve for district heating.	• PTFE • Polychlorotrifluoroethylene (PCTFE) • ETFE
Bearings	Provide optimal rotor stability and ensure reliability due to tolerance of misalignment. These are insulated to prevent shaft currents created by rotating currents.	• PTFE
Axial exhausts	These incorporate an in-line condenser which reduces exhaust losses from previously used down exhaust with	

	underslung condenser arrangements.	
Turning gear	Electrical motors that drive reduction gear through torsionally resilient coupling	
Control cabinet	Room for controlling the proper functioning of the power plant. Needs to be sealed for safety reasons	• PTFE
Fluid systems	Hydraulically separate lubrication and lubricating oil dehydration systems, hydraulic fluid supply	• FKM • FFKM
Washers	A type of disc-shaped fastener with a hole in the centre, used to distribute the load of a threaded fastener, such as a bolt	• FKM • FFKM • PTFE • PCTFE
Gaskets	Used for sealing the gaps between surfaces in a turbine. These gaskets are made of very specific polymers in the case of Turbines (3) in order to ensure the sealing is complete and will resist the extreme conditions in which the turbine works	• FKM • FFKM • PTFE
Washing System • Washing nozzles • Feedwater line • Water drainage	The compressor needs to be washed regularly because of the large amounts of air taken in, to prevent the formation of deposits from pollution. The materials used in this system need to be able to withstand degradation by detergents, as well as anti-freeze when temperatures are below 8°C.	• FKM • FFKM • PTFE

Gas detection system	Gas sensors are connected to an alarm and trigger turbine shutdown	• FKM • FFKM • PTFE

FFKM is one of the main PFAS present in turbines, and is used across all components for sealing purposes, given its high chemical resistance to volatile substances, as well as the thermal resistance to extreme temperatures.

PVDF and PTFE is also used as their properties are similar to FFKM, yet with different thresholds of temperature, which makes them ideal for auxiliary items such as cables or pipes attached to the turbines that need all these resistances in a lower degree.

All these components cannot possibly be manufactured without a share of PFAS given the extreme conditions of operation that require materials with high sealing properties, as well as chemical resistance. The use of alternative materials has been tested in the past when designing our products but were deemed unusable given that their short lifespan would force power plants to substitute them at a pace that would render the plants inoperable.

The PFAS are used in Turbines due to their extreme resistance to wear caused by friction (**tribological properties**), and for their **tolerance to extreme temperatures**, as well as their **sealing properties**. In the case of power plant components complementary to turbines, such as pipes or cables, they are used as well for chemical resistance and flame resistance. As displayed in Figure 5, power plants and turbines are composed by a linear succession of different components, which makes the operating process relatively simpler, but requires many isolation pieces and materials throughout the whole procedure. Given the extreme conditions in which a power plant must operate, the isolation materials must be resistant to high temperatures and pressures, as well as friction and contact with chemicals such as the lubricants utilised. These extreme operational conditions also the reason why the turbines and the PFAS containing components are enclosed and isolated from staff and environment, with entry into the turbine enclosure forbidden.

It is difficult to estimate the total amount of PFAS present in our components. However, we can calculate that the proportion is inferior to 0,1% of the weight of the turbines, which is an insignificant amount when compared with the PFAS used in other industries.

What is the process of the inclusion of PFAS in our components?

The majority of the PFAS found in our turbines and derivate products are already present in the components bought from specialized suppliers. This means that, although PFAS are a part of our products, our members don’t directly handle the chemical substances when it comes to manufacture.

The assembly process of Turbines take place as well in a protected, isolated environment, by trained professionals, impeding any possibility of emission of PFAS to the environment or any contact with humans.

End-of-life phase of PFAS in our industry

The end-of-life phase of the components is to some extent out of reach of our members, given that they are responsible for the manufacture of the power plants, but once sold they become the owner's property, who becomes responsible for the equipment's decommissioning. The handling of PFAS containing components originating from turbine power plants is therefore normally performed by the owner/operator according to the specific regulatory framework applied in each particular region.

However, to some extent our members take voluntarily responsibility for this period. They also offer a circular economy approach to this final phase by taking back the old components -in case the owner wants to dispose of them- and refurbish them or handle the recycling, or thermal recovery. Components can be broken down and sorted into individual parts, such as steel, copper, aluminium and rubber; which can be recycled or disposed of for energy recovery.

Should operators select disposable for energy recovery, which is often utilised in the case of municipalities for district heating, the temperatures used in these processes are sufficient to incinerate PTFEs without degrading them to further PFAS-by-products with potential to harm the environment or population (4 pp. 898-906). The study concludes therefore that regular municipal incineration should be an acceptable form of disposal for these PFAS.

Alternatives to PFAS in Turbine Power Plants

PFAS are used when other polymers cannot meet the required performances in terms of safety and durability, due to usage conditions. In some of the applications where fluoropolymers are used, other polymers can be used as soon as the boundary conditions allows (temperature, pressure, chemical environment), but a much shorter replacement time is needed for other materials. As they are used in critical conditions, where other materials have proven to fail, there is no real chance for replacement that could be currently considered.

In the gas and steam turbine industry, alternatives like silica-based coating, PEEK or UHMW-PE have been tested, but their properties do not fulfil the technical requirements and their cost is much higher, to a point that could render power plants unprofitable. Unlike the wind turbine industry, our turbines operate in potentially explosive environments and require different, more volatile resistant properties.

For gaskets and washers, already mentioned as essential for sealing, various materials with similar properties have been, such as ceramics and alternative polymers. However, the lack of versatility, and their inferior properties (lower temperature resistance, inability to withstand corrosive substances, higher friction) has rendered them incompatible. They have shown in the best cases high resistance to either temperature or friction but are incapable of completely fulfilling the role of PFAS due to lower sealing capacities or much lower resistance.

In this regard, tested plastic solutions with no PFAS showed brittleness when it came to operating under high temperatures and sealing of chemical lubricants, a key requirement for turbine operation. In the case of ceramic materials, the resistance to temperature is adequate, but they showed an incapacity to resist wear appropriately, causing the need to be replaced in very short intervals, which completely disrupts the operation of power plants rendering them inefficient, and expensive to operate and to the environment, with high waste loads. The same problem is raised in the case of PFAS-containing valves, for which a non-PFAS alternative has not yet been possible to implement. Yet the R&D process of PFAS-free valves, specifically, according to our members, is estimated to be possible to develop within a range of the next 2 decades.

Possibility of operation in case of a restriction

The exclusion of the use of PFAS in turbines from the proposed derogations would result in major problems in the EU energy system:

- A total restriction would effectively end the manufacturing and use of gas and steam turbines in the EU for energy generation, as well as halting maintenance and spare parts for turbine applications already operating at EiF.

- Every operating power plant utilising gas or steam turbines would effectively cease operation, as there are no drop-in alternatives available for currently used PFAS containing components. This would cause the early retirement of these power plants and their equipment prior to their typical 25 year lifespan, and immediate waste of otherwise operable equipment.

- Complete redesigns of the turbines and their components would be required to integrate non-PFAS alternatives. This complete redesign would require time for design, and safety and reliability testing. New materials or redesigns would also require new standards, which would result in current operators unable to continue to run their applications due to insufficient licensing.

- Forcing non-PFAS alternatives would been a safety risk to the employees, operators, and surrounding areas of turbine power plants; with the risk of leaks and explosions almost certain.

- It is also important to take into account the impact that this restriction would have in the EU's climate targets, as compressors, a key element in the decarbonised economy, fall under the components of turbines and no PFAS-free alternative has been identified.

- A partial restriction without a specified timeline would also considerably disrupt the security and flexibility of the European electricity system. We have to consider that turbines are complex, large - up to 20 tonnes - machines that operate at extremely high speeds and very high temperatures (over 1000°C), operating in environments with highly explosive/flammable fuels such as methane or hydrogen. A restriction issued too early in the process of developing alternative, PFAS-free components could lead to power plants stopping operations until the safety of the new components is completely proven and can be implemented wide-spread. This would, again, cause tension in the European electricity market to a new degree that could be unbearable for the EU due to the need for powerplants to provide stability and flexibility to the grid as a complement to traditional renewables and would severely compromise the activity of our members and the stability of thousands of jobs, as well as impacting EU citizens as the security of their electricity supply is compromised.

- A derogation of the restriction for turbines must as well include the components used for maintenance, if we want to avoid stranded, inoperable assets, and ensure the stability of the electricity grid. This is why we propose a total derogation of the restriction for turbine-based power plants in the energy sector.

The switch from PFAs-containing materials - which account for – as previously mentioned - around 0,01% of the total weight of the turbines - to PFAS free components is for now impossible in the transition timeline as described in the Restriction proposal, as alternative components are not in a stage mature enough for a switch in the next years.

Socio economic impact assessment

Should a derogation not be provided for gas and steam turbines within the energy sector, EUTurbines members expect a loss of 100% revenue in the EU, ending operations immediately and causing the loss of thousands of jobs.

Furthermore, if the PFAS ban is not derogated for the energy sector, gas and steam turbine applications that are operating at EiF would need to cease operations due to lack of PFAS-free alternatives and standards allowing these substitutions. This immediate and synchronous exit of turbine-based power plants from the electricity market would endanger the security of energy supply throughout the EU, causing power outages not only to residential homes and buildings but also to important infrastructure and industries across Europe, potentially accounting for thousands of millions worth of losses.

A derogation for power plants, together with a restriction for manufacturers of components would equally disrupt the electricity market, given that it would prevent the maintenance of already functioning power plants, as spare parts contain PFAS as well. This would affect all the power plants in Europe, including the most recently installed ones, shortening their service lifespan of around 25 years.

Proposed derogation by EUTurbines

Taking into account all of aforementioned arguments, plus the confidential information submitted by EUTurbines' members as individual responses to this consultation; all of which demonstrates further the need for turbine power plants in the EU, and the need for PFAS in said power plants, **EUTurbines asks for a full derogation of the restriction within the energy sector for gas and steam turbine power plants, compressors and mechanical drives, and auxiliary options. EUTurbines asks for a full derogation on PFAS used in spare parts used for maintenance and refurbishment of gas and steam turbine applications already in operation at EiF. EUTurbines also asks for a full derogation on gas and steam turbines and their compressors and mechanical drives used in applications outside of power plants[1], but within the energy and industrial sectors.**

[1] Non-Power Plant Applications include: gas transport; gas storage; industrial gases (helium, nitrogen, hydrogen); liquified natural gas carbon capture, utilisation and storage (CCUS); heat pumps; hydrocarbon processes; high-temperature compression; oil & gas; refineries; chemicals & petrochemicals; fertiliser industry; iron & steel, mining.

Our sector, which accounts for a minimal proportion of the total emissions of PFAS in Europe, is aware of the risks associated with the use of PFAS for the environment and human health. This is why the adequate guidelines and safety codes have been developed and are revised regularly to handle as best as possible the handling of PFAS materials at the phases of assembly, operation, and end-of-life. However, the operating conditions needed for power plants, including turbines and compressors, require materials that reliably withstand the operating conditions previously described, for which alternatives to PFAS are not feasible, at least in the next decade.

The derogation is proposed for the whole energy sector because as stated our members do not directly manufacture the chemical substances or parts that contain the PFAS - this being performed in many cases by the Petroleum and Mining Industry. As downstream users, we support the derogation of the restriction for their industry as well.

We acknowledge the risks posed by some PFAS to human health and environment, however highlight the low concern associated with Fluoropolymers, which are the main PFAS-containing materials used in our members' equipment. This low-risk associated with FPs is one of the reasons we are calling for a derogation, yet still we propose to establish a clear, common framework for manufacturing, use, and particularly the recycling stage of FPs in the derogated cases, in order to implement a circular economy approach which would improve the availability and efficiency of these materials in our industry. We also encourage to continue the research into PFAS-free substitute materials, trusting that if for now there isn't a possibility to stop using FPs in the next decade, with enough advances in R&I, it will become a possibility in the longer term, something towards which our members will work for.

7. Information on Hazard and Risks

The PFAS found in Turbine power plants are, as previously stated, already present in the components that are acquired from specialised suppliers. The use of PFAs is therefore never handled by our members, but by the suppliers in their manufacturing plants, reducing in good measure the potential risks to health and environment of the substances during the phase in which they are handled by our members.

The assembly of these components takes place in a carefully secured site, complying with all the security requirements and where the components are handled only by specialised, highly trained staff in order to avoid further risks. Once the turbines are assembled and delivered to the buyer, they arrive to the power plants, which are equally or better secured with public access completely restricted. Here, due to the already mentioned extreme pressure and temperature in which these components will operate, they are completely isolated with the appropriate components and materials, inaccessible even during "non-operation", given that power plants turbines are kept rotating at 3rpm when not in use for technical reasons, and therefore kept completely isolated even in non-operating periods.

The only moment where access is granted, is again, only to highly-trained, specialised staff, during maintenance and scheduled replacement of components, guaranteeing the safety of operations and minimizing exposure to PFAS.

As explained before, the end-of-life phase is responsibility of the customer – although our members can advise on how to dismantle equipment and handle the disposal of individual parts (e.g. recycling, thermal recovery), as well as provide the service of specialized personnel to handle this decommissioning – the final end-of-life process is the decision of the operator and restricted by local legislation and regulations.

Identity of the substance(s)

The Annex XV Restriction Report has identified PFAS "*as substances that contain at least one fully fluorinated methyl (CF3-) or methylene (-CF2-) carbon atom, without any H/Cl/Br/I attached to it.*" (4 p. 14). The report justifies the broad grouping due to the substances very high persistence (or degradation PFAS arrowheads) as a common characteristic; however, this approach fails to identify and assess the different and distinct properties of the substances including their subsequent profile of fluoropolymers or high and low concern.

Although we understand that PFAS are a large group of diverse substances which can make distinction in their assessment challenging (4 p. 316), by failing to do so, safe, reliable, low concern fluoropolymers, are facing the same fate as more hazardous substances such as non-polymers and side-chain fluorinated polymers, resulting in disproportionate regulations.

It is important to consider the different properties within the PFAS "grouping" because they present stark, important differences in their hazard profiles, and a generalized ban will see safe, reliable substances removed from the market despite no alternatives – or worse yet, alternatives which haven't been fully studied to ensure they are "safer".

The timeline for consultation and the methods used to gather information have proven somewhat limited and may not have fully considered the needs of all stakeholders. The process of collecting knowledge and feedback has led to certain sub-sectors being inadvertently omitted from the dossier. Additionally, the way sectors are categorized may not comprehensively encompass all industries and sectors affected by a potential PFAS restriction. As a result, the burden of improving and enriching the dossier appears to fall on the shoulders of stakeholders, without further support of the submitter.

As such, despite extensive research and action undertaken by EUTurbines and its member stakeholders, we present what we can only assume is a non-exhaustive list of fluoropolymers used in our sector.

It is important to understand that the stakeholders in the Turbine Power Plant sector do not manufacture PFAS substances or individual PFAS containing parts themselves – rather, their products are an assembly of parts manufactured upstream, generally by suppliers and manufacturers categorized by the Restriction Report as the "Mining and Petroleum" Industry.

As a downstream users, our stakeholders use a wide variety of different fluoropolymers, which the Restriction Report states that *"the number of individual products/components…totals in the thousands. It has not been possible to conduct an analysis of potential alternatives for all individual uses or components produced from fluoropolymers in this assessment*" (5 p. 498) and that the manufacturers and suppliers in this sector advised that "*the fluoropolymer-containing components and products supplied…are made to a specific order for downstream users and operations, so the specific functionality required will be unique to individual products. Given the many hundreds or thousands of individual products likely to be* *provided…assessment of technical feasibility for potential alternatives very challenging*" (5 p. 502).

Considering the inability of the Dossier submitters to assess the many products used in our sector as downstream users of the Petroleum and Mining sector, we submit that we have been presented with an insurmountable challenge to identify every PFAS substance and every PFAS containing part used in the Power Plant sector within the current timeline.

Physical and chemical properties

Fluoropolymers are high molecular weight (MW>100000Da) plastics with unique properties attributable to the strong C-F bonds, the strongest bond between C and another atom, making them highly stable. Carbon atoms alone form the fluoropolymer backbone, each surrounded by an envelope of F Atoms (6 p. 318).

They have high thermal, chemical, photochemical, oxidative, hydrolytic and biological stability; have low flammability, neutral electrical charge, and resistance to degradation; have negligible residual monomers and low molecular weight oligomer content; have limited low molecular weight leachables; and have no reactive functional groups of concern (6 p. 318). They are also practically or totally insoluble in water (6 p. 322) (7 p. 402).

The Turbine Power Plant sector utilises fluoropolymers where their high-performance functionality consistently is required, and manufacturers have already indicated to the Dossier submitters that for our sector applications, the main alternative to one PFAS would be another (e.g. PFA is the alternative to PTFE). Our sector requires a very high and very specific level of performance from the materials in the components and products used, to ensure efficiency, reliability, and safety of operations. Furthermore, durability, high temperature resistance (>540°C), chemical resistance, and high mechanical strength in harsh environments are essential requirements for technical function (5 p. 502).

Environmental contact

As stated in the Annex XV Restriction report, the environmental emissions depend on the rate of environmental release of PFAS, with the emission rate dependent on the physical state of the PFAS as well as the application (open or closed) (4 pp. 38-39).

As we previously explained, the manufacturers or Power Plants and their components do not directly manufacture PFAS substances or mixtures, or handle PFAS substances. This is performed by the upstream suppliers and manufacturers. Therefore, we would anticipate that any emissions during our manufacturing phase is negligible, as the PFAS substances are already applied, or the PFAS based products have already been produced.

Power Plants are restricted premises and many of the components operate within additional closed environments. For example, the generators connected to the turbines to convert rotating power into electricity require specific sealing elastomers to prevent shaft currents (8).

However, all the parts of the generator are assembled into a completely closed component, meaning there is no opportunity for emissions from the PFAS containing products, or contact with humans[2] or the environment once assembled and during the use-phase.

Due to the large molecular weight, insolubility and long chains of the substances used in our sector, they are not highly mobile, in contrast to the short chain PFAS (9 p. 8). We understand the concern with PFAS contamination in the environment, however time and time again the studies we have found do not identify the substances used in our sector in their results of environmental contamination tests – again, the main contaminants are short chain, soluble, small molecule PFAS (9).

Disposal of our products is the responsibility of the end-user. Our sectors' products are built to operate reliably for extended periods of time and therefore waste emissions typically occur only at the end-of-life stage of a component.

In any case according to Machinery Directive 2006/42/CE the manufacturer includes in the instruction manual the correct disposal methods for any substance of concern.

Human health hazard assessment

Power Plants are a closed environment, accessible only to approved personnel. Furthermore, the equipment within the Turbine Power Plants typically operate in closed conditions, whereby entry to the Power Plant premises does not automatically allow physical access to the equipment/products.

The manufacture (assembly) of the Power Plant components occurs at our members manufacturing sites, which are also closed to the general public and usually with highly restricted access.

As we explained in the Environmental contact section, there is negligible PFAS emissions from Power Plants during the use-phase, with the most likely emission scenario being at end-of-life/waste phase. Therefore, the hazard risk to human health is low to negligible due to the closed and inaccessible conditions of the in-use phase, and the highly restricted, highly regulated manufacturing phase.

The EU assessment report (BIO by Deloitte 2015) states that the "*most potential health concern polymers have a number average molecular weight, Mn,<1000 Da and oligomer content >1%.*" (10) (6 p. 323). However, the 500 Dalton rule proposes that with a MW increasing over 500 Dalton, absorption of the molecules through normal human skin rapidly declines. Furthermore, chemicals which cause contact dermatitis are under 712 Dalton (11 p. 166). The PFAS substances used in our sector have MWs well exceeding any of these guidelines, which, together with their water insolubility, results in negligible risk to human health via skin contact or consumption of drinking water.

[2] Exception: trained and certified maintenance & operation personnel

Here, we have reviewed and focus here on the potential toxicity of contact with PTFE, the fluoropolymer we believe is the most commonly used by our sector.

Specifically, a Literature Review (12) into the Biological Safety of PTFE ingestion shows that there is no apparent mechanism of toxicity for orally administered PTFE, with no toxicologically significant effects observed following oral administration. This lack of toxicity was attributed to a negligible gastrointestinal absorption due to PTFE's extremely high molecular weight (even for fine powder), that it is chemically inert under physiological conditions, and that it is not metabolized (12 p. 972).

PTFE is also considered with reasonable certainty, to not cause developmental toxicity given its extreme inertness and its routine use in humans *in vitro* fertilisation techniques (12 p. 972) and considered safe in regards to immune toxicity, evident by its tolerability in surgical applications. Regarding carcinogenicity, despite extensive studies (both animal and long-term human), no meaningful data can be attributed to the carcinogenicity of PTFE and so far can be reasonably considered as non-carcinogenic, based on its chemical properties and extensive use, and low immune response (12 p. 973).

This Review also addressed bioaccumulation, and found that due to the large particle size, lack of absorption through the intestinal tracts, and insolubility, almost the entire administered content was eliminated through faecal excretion and would not bioaccumulate (12 pp. 973-974).

Conclusion

Gas and Steam Turbines used for power generation, as well as compressors and motors, are essential components of the electricity and gas transportation systems. Despite this, their use sector was overlooked by the Annex XV Restriction Report. We therefore request that they be included as a sub-sector of the Energy Sector.

As downstream users of the PFAS containing parts identified by suppliers and manufacturers in the Mining & Petroleum sector, which has a 13.5 year derogation on fluoropolymers proposed – we implore the Dossier Submitters to extend this derogation to our gas and steam turbine power plants, their compressors, auxiliary options and spare parts, as well as their use in non-power plant (industrial, eg gas transportation) applications.

A lack of appropriate derogations would pose a risk to the security of the current and future electricity supply within the European Union, as well as trigger economic losses not only to stakeholders in the gas and steam turbine sector, but also to industries and consumers across all Europe.

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