European Engine Power Plants Association EUGINE

Amended on 10 October 2023[1]

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

Executive Summary

Engine Power Plants are an essential component of the electricity system. We therefore regret that Engine Power Plants were missing as a sub-sector from the Annex XV Report, thus overlooking its pivotal role within the energy sector. EUGINE therefore compels to include a derogation for Engine Power Plants as a sub-sector within the Energy Sector in the proposed restriction on the manufacture, placing on the market and use of per- and polyfluoroalkyl substances (PFAS).

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 kindly request the European Chemical Agency (ECHA) to extend this derogation to Engine Power Plants within the Energy Sector and its components and auxiliary options, including but not limited to: Insulating gas in Engine Power Plant electrical equipment, battery energy storage systems, and spare parts used for repair, replacement, or refurbishment.

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 Engine Power Plant sector, but also to industries and consumers across all Europe.

1. Introduction and scope

EUGINE is the European Engine Power Plants Association. For a decade, EUGINE has been the voice of leading European manufacturers of engine power plants and their key components. Comprising of 8 members, our collective knowledge and dedication drive our mission to foster positive change in the energy sector. This valuable expertise positions EUGINE as an important resource, catering to businesses, policymakers, and the public stakeholders throughout Europe.

PFAS play a crucial role in the manufacturing of engine power plants components and for the efficient use of the plant itself. According to the following analysis, the use of the Fluoropolymers (most common PTFE, FKM, FFKM, PFA, ETFE and FEPM) in engine power plants is indispensable. Enforcing a total ban on PFAS in the engine power plant sector is anticipated to have an adverse impact on society, affecting aspects such as energy availability and overall quality of life, as outlined in this brief assessment by EUGINE.

[1] This version supersedes all other publications of this paper.

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This report provides a snapshot of the data shared by EUGINE members, capturing their current status in addressing PFAS concerns. It is crucial to acknowledge that some members are still in the process of developing their strategies and responses, leading to certain questions remaining unanswered at this stage. As ongoing research and requirements unfold, it is expected that perspectives may evolve, thus necessitating periodic updates to reflect the latest developments.

2. Engine power plant's role in empowering our society

Engine power generation is an important element of the energy landscape, delivering both (renewable) electricity and heat to sustain daily activities, while ensuring security of electricity supply. Currently, engine power plants, mostly operating with renewable and non-renewable gases, together with turbine-based gas power plants, provide a quarter of the EU's electricity supply and considerable amounts of heat for district heating and industrial processes. As the share of renewable electricity grows over the next decades, engine power plants operating with hydrogen and other climate-neutral gases will remain important to ensure the reliability and security of the electricity supply.

We therefore regret that Engine Power Plants were missing as a sub-sector from the Annex XV Report, and its pivotal role within the energy sector overlooked. **EUGINE therefore compels to include a derogation for Engine Power Plants as a sub-sector within the Energy Sector in the proposed restriction on the manufacture, placing on the market and use of per- and polyfluoroalkyl substances (PFAS)**.

While engine power plants have historically played a central role in electricity generation, their role is poised to expand further in the coming years. They will provide essential flexibility to complement intermittent renewable sources, owing to their proven capacity to swiftly respond to fluctuations in electricity demand and supply, thereby contributing to the stability of the grid.

Based on a recent study (1), by 2050 engine power plants will bridge residual energy demand that cannot be supplied by other sources to cover an energy supply gap of roughly 100TWh during periods of high residual loads.

Engine power plants exhibit distinct characteristics that make them invaluable assets in the energy sector:

- **Steady, Reliable and Flexible Power Generation**: engine power plants serve various purposes such as grid stability management, handling peak, intermediate, and base load operations. This is possible due to their ability to quickly and easily start up, shutdown, and adjust their output according to the electrical grid's demand, ensuring a stable power supply to homes, businesses, and industries, even in challenging environments such as sub-zero temperatures, hot climates, and high altitudes.

- **Enhancing Energy Efficiency**: Engine power plants also have a crucial role in Combined Heat and Power (CHP) applications. In CHP systems, these plants produce electricity and capture the heat generated to use for heating purposes in buildings, district heating networks and industries. This approach boosts energy efficiency, reduces waste, and cuts emissions by utilizing both electrical and thermal energy outputs from a single source.

- **Backup Power**: Engine power plants can serve as peaker generators during peak demand periods or in island mode in case of grid failures. They can quickly provide electricity to prevent blackouts or ensure uninterrupted power supply to critical infrastructure such as hospitals and data centres.

- **Flexibility in Fuel Sources**: Due to their fuel flexibility, engine power plants already use biogases, carbon neutral methane and are also capable of operating on 100% green hydrogen, making them a key component for the Green Deal targets.

- **Hybrid power**: Hybrid power plants combine energy storage and a flexible engine power plant, which can be integrated with renewable assets.

In summary, engine power plants are essential within the energy sector, facilitating dependable and adaptable power generation that ensures a steady energy supply for communities, industries, commercial buildings such as hospitals and various other applications. However, a universal PFAS ban might lead to the oversight of this crucial function.

PFAS are recognized for their exceptional stability, their ability to withstand high temperatures, chemical resistance, oil repellence, lubrification, insulation and their hydrophobic properties. As a result, they are incorporated on a regular basis into critical components of engine power plants. The outcome of such a comprehensive ban would be a deterioration in the quality of essential energy services for consumers, as well as a severe impact on human lives and the environment if these critical components would no longer meet their operation and emission requirements.

3. The technology and the role of PFAS

An efficiently operating engine power plant necessitates secure parts, meticulous system trials, regulated standards, and thorough high-temperature monitoring. EUGINE members are engaged in the design and manufacture of dependable, superior-quality, and high-performance products. These encompass a range of items, notably engines and synchronous generators but may additionally also offer batteries energy storage systems and other auxiliaries, as illustrated in Figure 1, 2 & 3 – a mere glimpse into EUGINE members' comprehensive production portfolio.

Notably intricate, these offerings comprise a substantial component count, typically ranging up to several hundred parts. Each individual constituent assumes a distinctive role, collectively ensuring the power plant's optimal functionality, safety, and efficiency. Moreover, these components are meticulously tailored to their respective applications, encompassing variables such as operational fuel type and environmental conditions (including temperature, humidity, and mechanical stresses), all in the pursuit of meeting specific operational requirements.

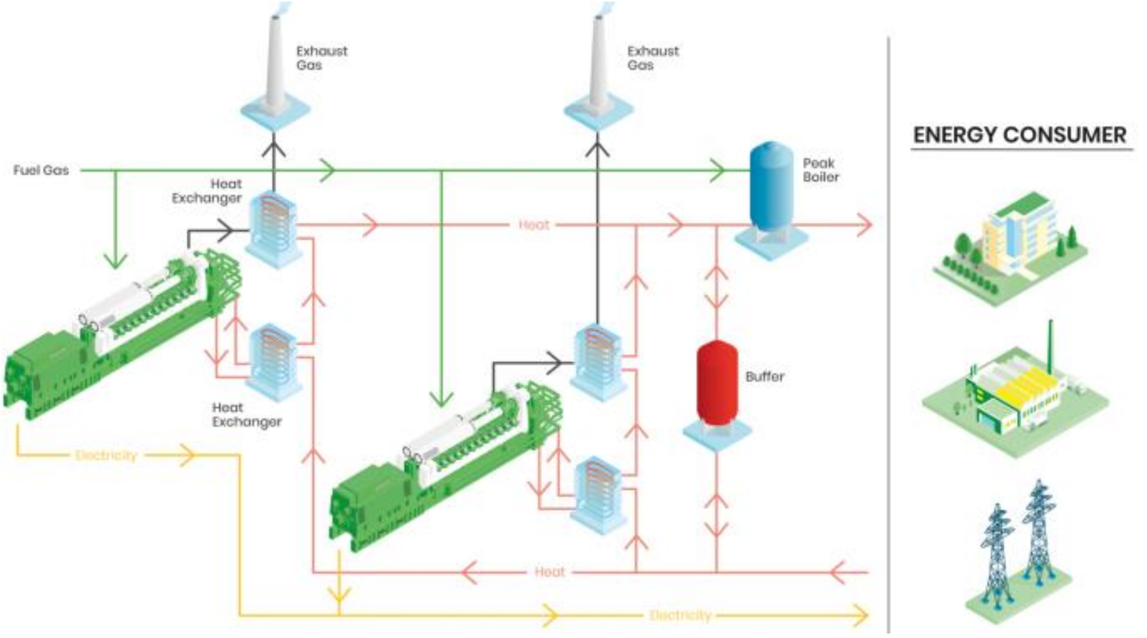

Figure 1 - schema of a Cogeneration/CHP Engine Power Plant [16]

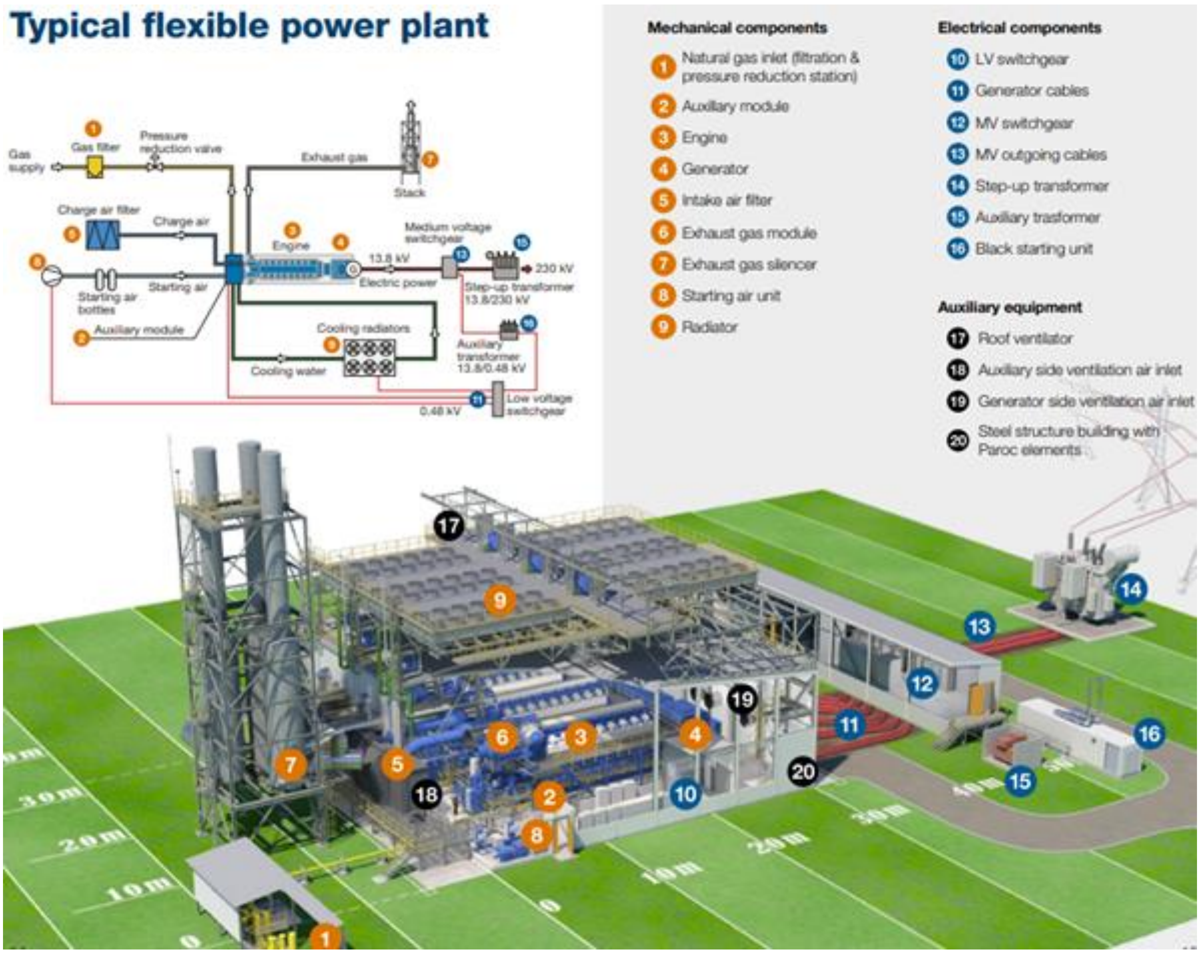

Figure 2 - schema of Combined Heat & Power system [18 p. 56]

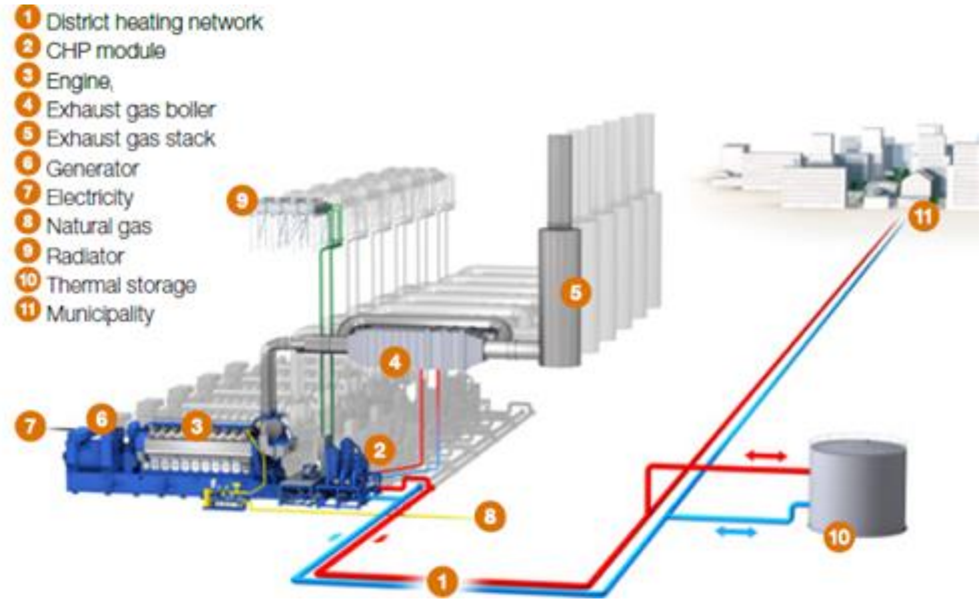

Figure 3 - typical flexible power plant and their components (22 p. 15)

Engines

Engines transform thermal energy into mechanical energy. Specifically in power plants, internal combustion engines (ICEs) driven by hydrogen or natural and renewable gases, employ the expansion of hot gases to push a piston within a cylinder, converting the linear movement of the piston into the rotating movement of a crankshaft to generate power.

This process requires the engine to maintain high temperatures for a long period of time, in order to have the maximum thermal efficiency while producing energy. Here, substances such as Polytetrafluoroethylene (PTFE) are used in high temperatures components such as rotary shaft seals, valves, electrodes, tubing, cables, and gaskets, given its low friction properties making it ideal in the prevention of leaks and preventing the entry of contaminants into the system. Fluorine rubber (FKM), Perfluorelastomers (FFKM), and Tetrafluoroethylene propylene (FEPM), are used in sealings due to their resistance to high temperatures, toxic, and flammable chemicals. Additionally, Ethylene tetrafluoro-ethylene (ETFE) is employed in engine cables and sensors given their high chemical and temperature resistance, as well as their ability to slow down thermal aging.

Large engines cannot be manufactured competitively for the global market without components containing Polymer PFAS, as there are currently no known alternatives that provide adequate performance.

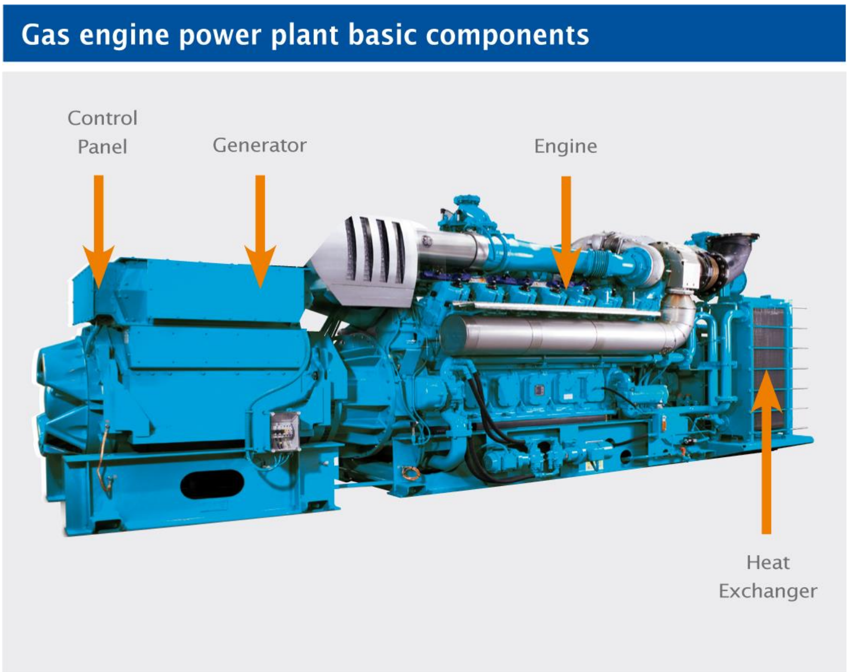

Figure 4 - Gas engine power plant basic components

Figure 5 - totally enclosed combustion engine [22 p. 9]

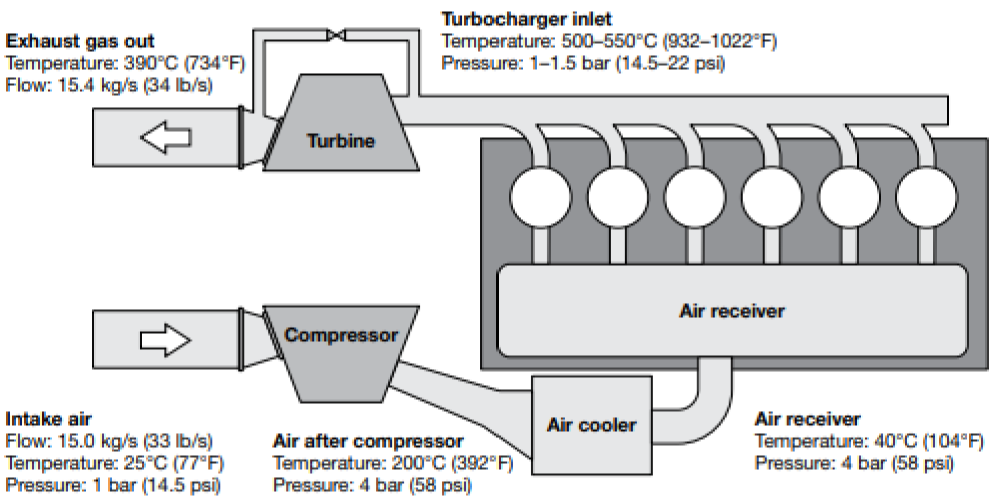

Figure 6 - typical temperatures, pressures and mass flows from a 10 MW combustion engine (5 p. 4)

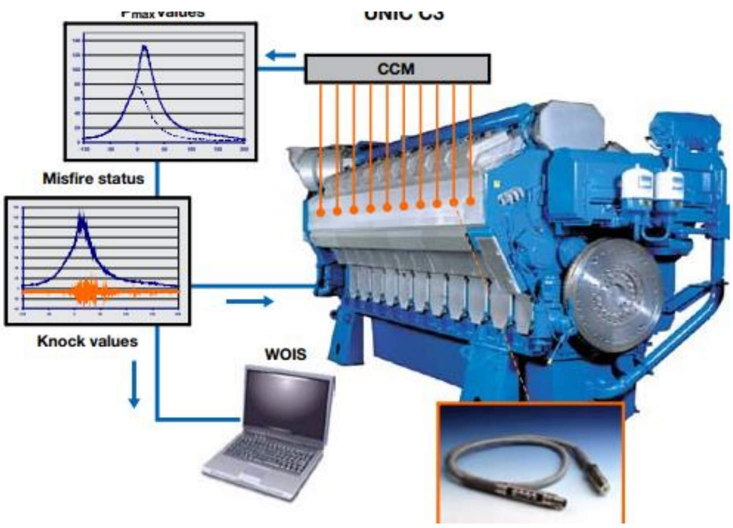

Figure 7 - modern combustion engine equipped with computerised control systems [5 p. 6]

Synchronous Generators[2]

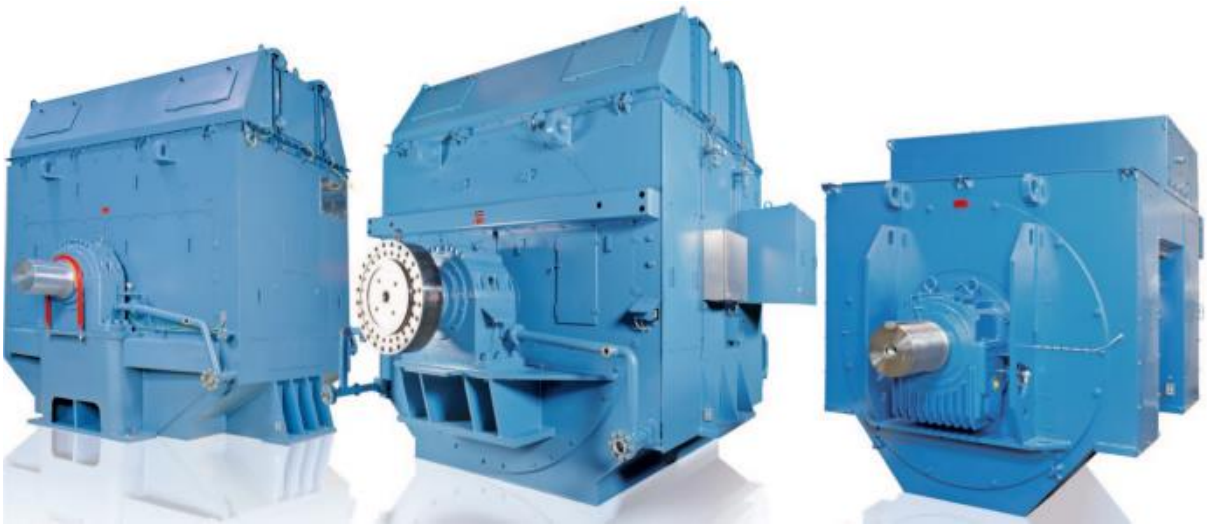

Figure 8 - totally enclosed synchronous generators for diesel and gas engines (21 p. 3)

Every engine has a generator connected to it, which converts mechanical energy into electricity. Various types of PFAS are used, for functions such as sealing, accessories cable & wire insulation, and lubrication, and are selected based on their ability to withstand electrical discharge and high temperatures, low friction, as well as their inertness when in contact with corrosive substances such as organic fuels and lubricants.

As shown in Figure 9, a generator is an assembly of many different parts, which must:

- Withstand the environmental conditions of the application, including temperature, pressure, speed, abrasion, and prevent shaft currents;
- Safely operate within potentially explosive atmosphere. Flammable gases are not in contact with generators in normal circumstances, but may be present occasionally (2 p. 7), especially if other components within the power plant were to fail;
- Prevent bearing damage from circulating currents (3) and to other equipment within the power plant;

[2] Please note that a previous version of this paper incorrectly identified PFAS containing substances in the typical insulation system in high voltage stator windings. This incorrect information has been subsequently removed.

In-use phase waste is reduced through highly reliable, robust components requiring minimal replacement.

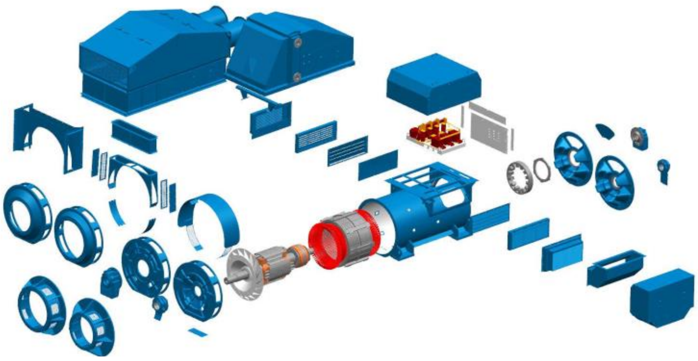

Figure 9 - exploded view of pre-engineered configurations for customisation of a compact high-voltage generator (2 p. 28)

Battery energy storage systems (BESS)

In the evolution of engine power plants and their applications, manufacturers have added complementary components such as BESS. In some cases, batteries are used to, for example, provide additional power to the grid if needed, hence increasing its flexibility.

Most stationary BESS are based on lithium-ion technology and are built based on the same battery cells as used in many other applications. Multiple cells are put together in modules, and multiple modules into racks. Multiple racks are typically containerised in a BESS.

Batteries cells are comprised of two electrodes, a separator and an electrolyte, as schematized in Figure 10. Each electrode consists of an active material mass which is coated onto a current collector.

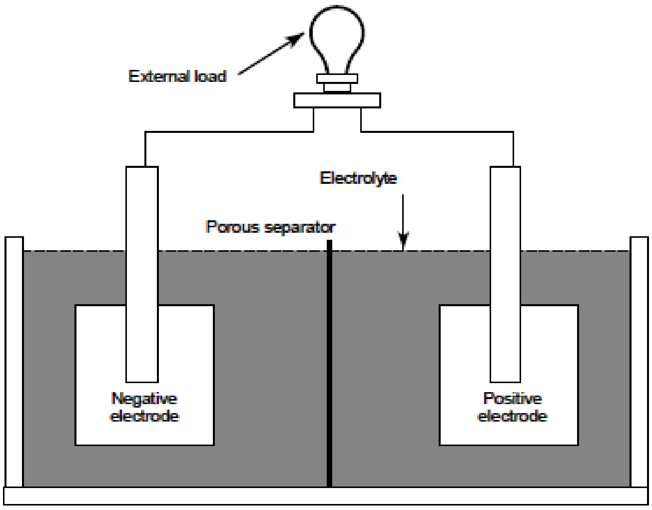

Figure 10 - Components of a battery

Chemical resistance and the ability to withstand a wide range of working temperatures are vital attributes for batteries, making PFAS indispensable in critical components across high-performance and lithium-ion battery technologies. Two distinct materials, Polytetrafluoroethylene (PTFE) and Polyvinylidene difluoride (PVDF), in both homopolymer and copolymer forms, serve as binding agents in the active material within electrode masses across a diverse array of battery technologies.

While the PVDF binder constitutes only a modest fraction of the composite electrode's mass (typically ranging from 2% to 5%), its role is pivotal in ensuring the electrode's flexibility, particularly in cylindrical designs. The positive electrode binder must withstand the mechanical stresses arising from the expansion and contraction of active materials during charge and discharge cycles. Furthermore, PVDF demonstrates exceptional thermal stability, both during the common curing and drying processes in electrode fabrication and in the battery's operation across various temperature ranges. To support prolonged and uninterrupted battery function, PVDF is utilised for chemical and electrochemical stability, preventing any degradation over extensive usage and numerous cycles of the binder, as well as preventing short-circuits and thermal runaway.

4. The use of PFAS in engine power plant components and complementary components

EUGINE members have identified different PFAS substances, with Polytetrafluoroethylene (PTFE) and Fluorine rubber FKM being the most common PFAS used, in more than several hundred components (key uses outlined in the below table). The assessment to identify where PFAS are used within EUGINE members equipment is still ongoing, with certain challenges in identifying all PFAS used as outlined after the table.

It is important to understand that Engine Power Plant manufacturers do not directly handle PFAS substance during the assembling process of components. Instead, they are handled by either component suppliers or chemical supplier companies. **As EUGINE members do not engage in chemical manufacturing, they depend on suppliers for information, often safeguarded under intellectual property rights of the respective chemical supplier. Consequently, the specific substance identification may not be shared with customers, as companies prioritize the protection of their investments.**

Table 1 - non-exhaustive list of PFAS and their use in Engine Power Plants

<table>
<tr><th>Uses</th><th>PFAS substances</th><th>Properties</th></tr>
<tr><td>HV cables for HV power plant connections</td><td>Polytetrafluoroethylene (PTFE)
Perfluoroalkoxyl polymer (PFA)</td><td rowspan="2">High temperature resistance
Might mechanical strength
Chemical resistance
Corrosion resistance
Inertness</td></tr>
<tr><td>Sealings in the engine systems and auxiliaries</td><td>Fluoroelastomer (FKM)
Perfluoroelastomers (FFKM)</td></tr>
</table>

	• **(Polyvinylidenefluoride/ hexafluoropropene)** • **Tetrafluoroethylene propylene (FEPM)**	• Non-adhesive/low friction resistance • Low permeation • Flexibility/ductility • Light weight • Non-flammable
Sealings in the engine systems and auxiliaries	• **Tetrafluoroethylene propylene (FEPM)**	
• Pipes • Hose liners • Cables • Wiring insulation • rotary shaft seals • gaskets • valves • electrodes • bearing bushes • gaskets • insulating tubes • strips & tapes in the engine systems and auxiliaries	• **Polytetrafluoroethylene (PTFE)** • **Fluoroelastomer (FKM)**	
• Cable & wiring insulation	• **Fluorinated ethylene propylene (FEP)** • **Ethylene tetrafluoro-ethylene (ETFE)** • **Perfluoroalkoxy polymer (PFA)** • **Polyvinyldiene fluoride (PVDF)**	
Battery energy storage systems: Binder in active material mass, electrical systems, etc. Contain aggressive electrolytes – seals, separator films/coatings	• **Polyvinylidene fluoride (PVDF)** • **Polytetrafluoroethylene (PTFE)** • **Perfluoroalkoxy alkanes (PFA)**	
Gas insulated HV switch gear	• **Fluoronitrile and Fluoroketone**	
O-Rings	• **Perfluoroelastomer (FFKM)** • **Fluoroelastomer (FKM)**	

Synchronous Generators & Components[3], e.g.: • Bearings • Bearing housing insulation • Shaft seals • Diode & thyristors • Elastomers for sealing function • Accessories cable & wire insulation • Sensors	• **PTFE** • **FEP** • **PFA** • **FKM** • **FFKM** • **Fluorosilicones (FVQM)** • **FEPM** • **Ethylene tetrafluoroethylene (ETFE)**	
Exhaust treatment system seals and tubes Fuel supply systems: • Cryogenic applications • Heat exchangers • Control, electrical and automation systems • Cylinders,valves, seals, hoses, solenoid valves, actuators	• **PTFE** • **PCTFE** • **PFA** • **PVDF** • **ETFE** • **Polycholorotrifluoroethylene (PCTFE)** • **FKM** • **FFKM** • **FVQM**	High temperature and chemical resistance High temperature and chemical resistance, long lifetime, leakage prevention, withstands pressure, abrasion / wear resistance, tribological issue, low permeation

As stated earlier, the above table includes materials identified by EUGINE members to date. However, it is essential to note that ongoing efforts continue to identify additional substances. The process of gathering PFAS information, while already initiated by several EUGINE member companies, **in some cases spans from 2 years or more to complete**, which we further elaborate on in the section "Identity of Substance(s)".

In the following section, we have compiled a non-exhaustive list of components that commonly contain PFAS in engine power plants. Additionally, we have underscored the potential implications associated with adopting a PFAS- free approach in these components.

Gaskets & O-rings

The gaskets are used for sealing the gaps between surfaces in an engine. These gaskets are made of very specific polymers to ensure the sealing is complete and will resist the extreme conditions in which the engine works.

[3] Please note that a previous version of this paper incorrectly identified PFAS containing substances in stator insulation. This incorrect information has been subsequently removed.

O-rings made of special fluoroelastomers are also used almost exclusively in fuel lines and injection and ignition systems.

Alternatives: In the past, manufacturers trialled PFAS free O-rings in their designs, made of Bisphenol carbon rubber – however these could not withstand the aggressive substances in the cooling system, requiring the implementation of fluorinated materials. Currently available proposed alternatives such as EPDM non-fluorinated polymers, or acrylate and silicone rubbers are unable to withstand the running temperatures (above 150°C), contact with a wide range of aggressive substances (4 pp. 6-7), as well as, and their high permeability (4 p. 12) making them non-conducive to sealing. PEEK's durability is poor and oxidates easily.

Consequences: very short running times of engines – i.e., minutes, compared to current capabilities of decades. It is highly probable that engines will encounter difficulties starting up due to component failures. Exploring alternative substances is not a viable solution due to the risk of leakages. Previous attempts to use PFAS-free components proved unsuccessful, as they were unable to withstand the high temperatures, resulting in oil leaks.

Electrical cables for engine and generator sensors

Modern engines are controlled using sophisticated computerised combustion control systems, which continuously monitors engine parameters such as load, speed, cylinder exhaust gas temperature and cylinder pressure (5 p. 6).

In the engine sensors, electrical cables made of PFAS are used on exhaust gas temperature sensors with PTFE coatings, due to their high temperature resistance, and on seals for pressure sensors.

In the generator sensors, electrical cables covered with PTFE sleeves are used on winding and bearing temperature measurement, due to high temperature resistance, dielectric and sealing properties.

More generally, fluoropolymer substances can be found in electrical and electronic equipment, e.g., in components, printed circuit boards and cables, and/or in the manufacturing processes.

Alternatives: PEX is unsuitable due to inability to withstand the high operating temperatures and potential contact with aggressive chemicals. PEEK cannot be readily coloured for identification.

Consequences: Premature breakdown of cables, complete failure of electrical and electronic equipment.

Sealing rings, shaft seals

In the engines, fluoropolymers are used for sealing rings near the combustion chamber. The high temperature of the combustion chamber parts requires sealing material with high temperature resistance.

Sealing rings for cooling water, which is used to cool the combustion chamber parts, are particularly critical. If similar products with lower resistance to higher temperatures are used, this will lead to increased and accelerated material wear.

Shaft sealing rings play a crucial role in securely sealing the crankshaft within combustion engines. These rings must effectively seal off the crankshaft space, where a combination of fuel and oil circulates. Given the exceptionally high rotational speeds of crankshafts, friction generates substantial heat, often exceeding 160°C. To meet these demanding conditions, the ideal sealing material is FKM.

Sealings are also critical to large rotating machines (i.e., generators). PFAS are used in almost all applications within the mechanical sealing industry due to their broad chemical, temperature and physical performance characteristics which are needed to meet compatibility, operational and safety requirements, and include PTFE, FEP, PFA, FKM, FFKM, FVMQ and FEPM.

Alternatives: Hydrocarbon elastomers are not resistant against mineral oil used as lubricant, or fuel in genset diesel engines (6 p. 400). Alternative elastomer materials like NBR or HNBR, commonly found in the market, lack the requisite temperature and chemical resistance. Over a brief operational period, these alternatives tend to become brittle, posing a risk of machinery damage and potential media leakage.

Similar lack of alternatives as identified for Gaskets & O-Rings.

Consequences: The use of insufficiently resistant sealing materials can lead to cooling water leaks with the risk of damage to surrounding equipment, the environment and people. Reductions in reliability and seal life, increased maintenance costs, and alternative environment conditions would need to be adopted.

Insulation

ETFE insulation and PTFE as tape insulation are used in many cables and wires in Engine Power Plants. These cables must meet very high requirements to function in volatile environments, while maintaining their flexibility and dielectric properties.

Bearings in electrical machines are used to support and locate the rotor, keep the air gap small and consistent, and transfer loads from shaft to the motor frame. They need to enable high and low speed operations, absorb vibration, and minimise friction. They are insulated with PTFE sheets to avoid damage from circulating currents. PTFE is used due to its high insulating properties, low friction allowing alignment of the bearings, is malleable and compressible to create tight interfaces, effectively rejects dirt and impurities which can cause short circuits, and good aging resistance.

PTFE is also used in diode and thyristors due to its heat resistance and insulation properties.

Alternatives: Alternatives are missing either low friction, low stiffness, or high temperature resistance.

Consequences: increased electrical stress and premature degradation and failure of equipment, leaking of corrosive substances. Environmental impact due to higher in-use scrap rate.

5. Alternatives to PFAS in engine power plants

The components of engine power plants operate in potentially explosive atmospheres, where flammable gases and other substances mix with air, risking explosions. Therefore, the reliability and safety of the materials used is paramount.

The use of alternative, PFAS-free components is, at least for now, highly unlikely, as there are no identified alternatives in a development stage advanced enough to be deployed at the required scale in the upcoming years.

The use of alternative materials with lower levels of functional performance would lead to a greater potential for leakage, which in turn has implications, both on the exposure of workers to chemicals, and increasing the likelihood leakage of various substances into the environment. There could also be a higher risk of exposure of staff to hazardous substances due to more frequent maintenance and shutdowns (6 p. 504).

For existing applications, a change in their design by replacement of parts with different materials (either through immediate change due to a PFAS ban, or through alternative replacement parts due to lack of derogation for PFAS containing spare parts) would require new standards, and new tests for those standards. This is not possible for products already in-use and would result in consumers no longer being permitted to operate their applications.

This would result in a direct contradiction to the “repair-as-produced-principle” constituted in EU product legislation such as Directive 2009/125/EC.

The restriction would constitute a major risk to the existing electricity system at European level, as there is no engine power plant currently in operation that is in a position to make an immediate, rapid switch to non PFAS alternatives, due to the lack of replacement components immediately needed, or for the maintenance and service of existing plants. These engine powerplants would face immediate shutdown upon Entry into Force (EiF) due to no possible "drop-in" replacements, and all in-use equipment would need to be retired immediately, despite no alternatives to replace them. This premature retirement of equipment would have environmental impacts in the form of immediate waste (6 p. 265) and will cause a large energy gap that other technologies cannot cover. Thousands of biogas plants would be stopped.

Furthermore, any future maintenance of existing engine power plants, or replacement of engine power plants nearing their end-of-life, would no longer be possible due to the lack of alternatives, posing safety risks to in-operation power plants, security of electricity supply.

6. Socio economic impact assessment for engine power plants

The limitations of using PFAS have raised significant concerns within our association regarding our ability to continue manufacturing and maintaining engine power plants in Europe. The continent has long been a global leader in this technology sector, and these restrictions jeopardize our position in the global market and our capacity to serve European customers. Equally concerning is the potential impact on the upkeep of existing engine power plants, as the restricted availability of essential replacement parts poses a challenge to maintaining a reliable electricity and heat supply across Europe.

On the other hand, Combined Heat and Power (CHP) engine power plants are essential for providing backup electricity to critical places like hospitals, data centres, airports and nuclear power plants. These facilities need a constant supply of electricity to keep things running smoothly and safely. CHP power plants are designed to be highly efficient and flexible. When there is a power outage or an emergency, they can quickly start up and provide a dependable source of backup power. In times of grid outages or emergencies, CHP systems can seamlessly transition into operation, supplying a reliable source of backup power. In addition, this capability not only enhances the resilience of these essential facilities but also contributes to energy efficiency by utilising waste heat for heating or cooling purposes. In simpler terms, CHP engine power plants are a safety net for hospitals, data centres, and airports, making sure they can keep operating even in unstable times.

Should a PFAS ban be implemented, essential facilities such as hospitals, data centres, airports, nuclear power plants~~,~~ and more generally infrastructure in the EU, might encounter heightened difficulties, as engine power plants could struggle to maintain the same level of supply efficiency or exit the electricity market completely.

7. Proposed derogation by EUGINE

Considering the presented facts, we strongly emphasise the request for exempting an unrestricted scope of PFAS usage in engine power generation for commercial and industrial applications across the categories mentioned above for the maximum possible period. This measure is essential to maintain our pursuit of climate protection and decarbonization objectives. Below we additionally request specific arguments for a derogation divided by components of engine power plants. Such exemptions should apply universally, encompassing both new construction projects and the supply of spare parts for existing applications. Additionally, the exemptions outlined in the current restriction proposal, particularly those pertaining to the energy sector, should be augmented and broadened to ensure the continued operation of essential facilities such as Engine Power Plants.

Hence, we demand a derogation for the complete scope of engine power plants and auxiliary options within the energy sector technologies.

PFAS substances do not pose a relevant risk to workers, plant operators or the environment in this specific context, but, on the contrary, guarantee the safety of workers within manufacturing facilities, the safety of the manufactured industrial products and production processes as well as the safety of the general public as many engine power plants supply power to critical places (e.g. hospitals, airports). In summary, some PFAS groups ensure the reliable operation of Engine Power Plants and must be exempted from the ban.

Regarding spare parts used energy sector technologies we request to have them exempted for their whole life-time should they have been placed on the market before the PFAS restriction enters into force and/or a specific derogation expires. EUGINE sees that the "repair as produced" principle shall be respected in PFAS restriction. For our members, it will be extremely difficult to perform redesign, on-site testing, certification, as it would require unreasonably long downtimes for the installation and consequently disruption in energy generation and supply. This is unacceptable for technologies supporting critical infrastructure (e.g. hospitals, airports, nuclear power plants).

The manufacture of Engine Power Plants for the Energy sector involves the assembly of parts manufactured and supplied by the Petroleum and Mining Industry. Therefore, as emphasised by their stakeholders, we as the downstream users, will be heavily impacted by the inability to use fluoropolymers due to the high-performance functionality we require (6 p. 498). Hence, the maximum possible derogation of 13.5-year being proposed for their industry by the Dossier Submitters of "Derogation for Fluoropolymers" should also be submitted for Engine Power Plants and their Components within the Energy Sector, which are downstream users of the products and components manufactured by the Petroleum and Mining Industry.

Even though we ask for a derogation of 13.5 years, based on the above presented data and the ongoing research on alternatives, this may not be sufficient for engine power plant applications that are already in operation at EiF. As the lifespan of an engine power plant is

20+ years, power plants that have only recently commenced operation would still face shutdown at the end of the derogation period, due to the reasons outlined in section 5.

Complete product range derogation:

Derogation for all types of PFAS in Engine Power Plants and its components and auxiliary options, including but not limited to: Insulating gas in Engine Power Plant electrical equipment, Battery energy storage systems, and spare parts used for repair, replacement, or refurbishment.

Duration: 13.5 years

Alternatives: Sufficiently strong evidence that technically and economically feasible alternatives will not be generally available, and that the substitution potential will be low. Unknown substitution potential, depending on R&D progress, but continued R&D increases the chance that alternatives for the relevant applications will be identified.

Cost impact: There will be mainly four categories of potential cost impacts on our industry. Each category highlights the various cost implications associated with product alterations and the difficulty of identifying alternatives:

- Maintenance Cost: The alteration of product components to be compatible with any single change is incalculable. Product alteration would necessitate costs related to quality and safety assurance. It would also require a complete redesign of components such as a complete overhaul of an Engine. This could lead to increased maintenance costs and operational downtimes.
- Operational License Cost: There could be increased costs associated with obtaining new operational licenses.
- Repairing Cost: Altering the product components might result in increased repair costs due to the need for extensive redesign and modifications. Loss of functionality in this sector could lead to substantial economic implications, including shorter operational lifetimes of components as well as the increase of the frequency and expenses of repairs.
- PFAS Free approach cost: Transitioning to a PFAS-free approach could incur a very high cost, particularly in redesigning engines. Identifying technically and economically feasible alternatives may help in avoiding some costs associated with product functionality loss. Costs related to product reformulation and quality assurance would still exist but might be spread out over a longer period.

Use-specific derogation:

Derogation for all types of PFAS in Engine Power Plants and spare parts used for repair, replacement, or refurbishment.

Duration: maximum duration allowed (minimum 13.5 years)

Alternatives: due to the long operating lifespan of engine power plants (20+years), engine power plant applications that are already operating at EiF may not be sufficiently covered by a 13.5 year derogation and would face early retirement due to the reasons outlined in section 5.

Cost impact: increased costs to both the manufacturers and the end consumers, due to early retirement of equipment due to no drop-in PFAS free solutions for parts that need replacement, due to complete redesign of equipment required to be compatible with alternative materials. To allow the applications to keep running, manufacturers would be forced to completely redesign applications which may include components that are obsolete but necessary for operation, which otherwise could easily maintain operation with the use of original spare parts containing PFAS. Consumers would be forced to replace their equipment early, despite the use of spare parts or refurbishment allowing continued operation and would violate the "repair-as-produced" directive.

8. Information on Hazard and Risk

The majority of the PFAS found in our engine power plants and derivative products are already present in the components acquired from specialised suppliers. This means that, although PFAS are an essential part of our products, there is no direct utilisation of the chemical substance itself by our members. Instead, the production and assembly of equipment takes place within a controlled factory environment with all the necessary health and safety protocols, where the power plant components are meticulously crafted and assembled to meet precise specifications.

Once completed, the equipment is transported to a highly secure power plant site, where access is restricted to trained and specialised personnel only. The installation takes place within a secure building, surrounded by protective walls. Due to the high material stress level from rotation and high temperatures in the process, the components within (but not limited to) engines, generators, are completely enclosed (see also Figure 5 and **Error! Reference source not found.**). This stringent security protocol ensures that PFAS-containing components are handled and maintained under strict control.

Regular maintenance is a critical aspect of this application, overseen by experts who periodically replace components as needed. Their expertise guarantees the safe and efficient operation of the equipment while minimizing the risk associated with PFAS.

Finally, at the end of its operational life, the equipment undergoes dismantling by trained personnel, ensuring that PFAS-containing components are properly managed and disposed of according to regulations and environmental standards. However, as this is a customer responsibility, as manufacturers we have limited information on the end-of-life phase.

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.*" (8 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 (8 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 by EUGINE and its member stakeholders, we can at present only assume is a non-exhaustive list of fluoropolymers used in our sector (Table 1).

It is important to understand that the stakeholders in the Engine 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 downstream users, our stakeholders use a wide variety of different fluoropolymers, which the Restriction Report states *"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*" (6 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*" (6 p. 502).

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 (9 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 (9 p. 318). They are also practically or totally insoluble in water (9 p. 322) (10 p. 402).

The Engine 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 (>270°C), chemical resistance, and high mechanical strength in harsh environments are essential requirements for technical function (6 p. 502).

Environmental fate properties

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) (8 pp. 38-39).

As we previously explained, the manufacturers or engine 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.

Engine Power Plants are restricted premises and many of the components operate within additional closed environments. For example, the generators connected to the engines to convert rotating power into electricity require specific sealing elastomers to prevent shaft currents. However, all the parts of the generator (Figure 9) are assembled into a completely closed component (Figure 8) meaning there is no opportunity for emissions from the PFAS containing products, or contact with humans[4] or the environment once assembled and during the use-phase. As can also be seen in Figure 5, all the components of the combustion engine are also fully enclosed.

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 (11 p. 8). We understand the concern with PFAS contamination in the environment, however time and time again the data 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 (11).

Disposal of our products is the responsibility of the end-user. Our manufacturers can provide instructions to the end-user on how to disassemble components and how to manage their disposal (e.g. recycling, energy recovery) as well as relevant European Waste Catalogue (EWC) codes; however ultimate disposal will be performed by the end-user and will be subject to their local regulations. 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.

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

If the components of our products were to be incinerated, it has been shown that they can be completely destroyed at incineration levels available in municipal incineration (such as used in heat to power generation) and is an acceptable form of waste treatment. For example, it has been shown that no PFAS-by-products are created during the incineration of PTFE (12 p. 905).

Human health hazard assessment

Engine power plants are a closed environment, accessible only to approved personnel. Furthermore, the equipment within the engine power plants typically operates in closed conditions, whereby entry to the premises does not automatically allow physical access to the equipment and components.

The manufacture (assembly) of the engine 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 fate properties, there is negligible PFAS emissions from engine power plant 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%.*" (13) (9 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 (14 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.

Specifically, 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. A Literature Review (15) 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 (15 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 (15 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 (15 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 (15 pp. 973-974).

Conclusion

Engine Power Plants are an essential component of the electricity system. Despite this, our Use sector was overlooked by the Annex XV Restriction Report. We therefore request the sector to 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 Engine Power Plants within the Energy Sector and its components and auxiliary options, including but not limited to: Insulating gas in Engine Power Plant electrical equipment, battery energy storage systems, and spare parts used for repair, replacement, or refurbishment.

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 Engine Power Plant sector, but also to industries and consumers across all Europe.

References

1. **Frontier Economics.** *The Need for Clean Flexibility in Europe's Electricity System.* s.l. : EUGINE, EUTurbines, Frontier Economics, 2023. Study.
2. **ABB.** *Synchronous HV compact generators for engines.* 2021. Catalog. 9AKK106113 REV J EN 06-2021.
3. —. Bearings. *Technical note - HIgh voltage generators for diesel and gas engines.* 2011.
4. **ShinEtsu.** Characteristic properties of Silicone Rubber Compounds. 2005.
5. **Haga, Niklas.** *Combustion engine power plants.* s.l. : Wärtsilä, 2011. White Paper.
6. **ECHA - European Chemicals Agency.** *Annex E to the Annex XV Restriction Report.* s.l. : ECHA, 2023.
7. **ABB.** *Controlling partial discharge in high voltage motors and generators - White Paper.* 2017.
8. **ECHA - European Chemicals Agency.** *Annex XV Restriction Report.* 2023. 2.
9. *A Critical Review of the Application of Polymer of Low Concern.* **Barbara J Henry, Joseph P Carlin, Jon A Hammerschmidt, Robert C Buck, L William Buxton, Oscar Hernandez.** Maryland, USA; Delaware, USA; Oerebro, Sweden; Virginia, USA; Washington, USA; : Integrated Environmental Assessment and Management, 2018, Integrated Environmental Assessment and Management, Vol. 14, pp. 316-334. 3.
10. **Blanchet, Thierry A.** Fluoroplastics. [book auth.] Olagoke Olabisis and Kolapo Adewale. *Handbook of Thermoplastics, 2nd Edition.* Boca Raton : CRC Press, 2016.
11. *PFAS: forever chemicals—persistent, bioaccumulative and mobile. Reviewing the status and the need for their phase out and remediation of contaminated sites.* **Brunn, Hubertus, et al.** s.l. : Environmental Sciences Europe, 2023, Vol. 35.
12. *Waste incineration of Polytetrafluoroethylene (PTFE) to evaluate potential formation of per- and Poly-Fluorinated Alkyl Substances (PFAS) in flue gas.* **Aleksandrov, Krasimir, et al.** 0045-6535, Karlsruhe : Chemosphere, 2019, Vol. 226, pp. 898-906.
13. **BIO by Deloitte.** *Technical Assistance related to the review of REACH with regard to the registration requirements on polymers. FInal report prepared for the European Commission (DG ENV), in collaboration with PIEP.* 2015.
14. *The 500 Dalton rule for the skin penetration of chemical compounds and drugs.* **Bos, Jan D. and Meinardi, Marcus M. H. M.** 9, Amsterdam : Experimental Dermatology, 2000.
15. *Polytetrafluoroethylene Ingestion as a Way to Increase Food Volume and Hence Satiety Without Increasing Calorie Content.* **Naftalovich, Rotem, Naftalovich, Daniel and Greenway, Frank L.** 4, s.l. : Journale of Diabetes Science and Technology, 2016, Vol. 10.
16. **Innio Jenbacher.** Cogeneration/CHP. *Jenbacher.* [Online] [Cited: 09 07 2023.] https://www.jenbacher.com/en/energy-solutions/applications/cogeneration-combined-heat-power.
17. **MAN Energy Solutions.** Electro-thermal energy storage (ETES). *MAN Heat Pump.*
18. **Wärtsilä.** Wärtsilä CHP System. *Energy Solutions.*
19. **Haga, Niklas, Kortela, Veikko and Ahnger, Anders.** Smart Power Generation. *District Heating solutions.* s.l. : Wärtsilä, 2012.
20. **ABB.** District Heating Pumps. *ABB Industry Solutions.* [Online] https://industrysolutions.drivesmotors.abb.com/presentation/show/waste-to-energy.
21. —. Synchronous generators for diesel and gas engines. *Proven generators - reliable power.* 2012.
22. **Wärtsilä.** *Gas and multi-fuel power plants.* 2017.

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