



Innovation Stress Test Case Study: Bio-based innovative polymers under the Single-Use Plastics Directive

Introduction

Innovative bio-based polymers such as Polyhydroxyalkanoates (PHAs), a family of bio-based, biodegradable polymers are often mentioned as a sustainable alternative to conventional plastics. They are produced by micro-organisms (usually via fermentation) and can biodegrade in various environments, including marine settings. They have been promoted as an innovative solution for single-use products, aligning with circular economy goals. As an example, the European Union has invested substantial research funding into PHA development – over €108 million in EU grants by 2021 according to industry estimates – with the vision that PHAs could replace traditional plastics in applications like packaging, disposable food service ware, and other single-use items¹.

However, when the EU adopted its Single-Use Plastics Directive (Directive (EU) 2019/904) in 2019, PHAs and other similar polymers fell victim to a regulatory definition that did not exempt them from the scope of “plastic”. The Directive defines “plastic” broadly to include all polymer-based materials, **explicitly excluding only “natural polymers that have not been chemically modified.”** In its interpretative guidance, the European Commission clarified that **bio-based and biodegradable plastics (including PHAs and other nature-identical biopolymers) are considered plastics under this Directive**, because their polymerisation process is industrial (fermentation) rather than a naturally occurring polymerisation in nature. In practical terms, this meant that single-use items made of PHA are subject to the same restrictions and bans as items made of conventional plastics like polypropylene or polystyrene.

This outcome was paradoxical. On one hand, the EU was funding projects to develop and scale PHA-based materials as eco-friendly substitutes for single-use plastic products, in line with its Circular Economy strategy². On the other hand, the new law addressing plastic pollution effectively **left no regulatory space for PHA products** in single-use applications, at least until further review. Companies that had invested in PHA innovations suddenly found that, legally, their products were treated no differently than the very fossil-based plastics the EU wanted to phase out, and could even be banned from the market if falling under the Directive’s product scope (e.g. PHA single-use cutlery or straws).

This section examines how the **innovation stress test’s ten questions** can illuminate the issues that arose with PHAs under the Single-Use Plastics (SUP) Directive. We first detail **how PHAs and others were classified and regulated** by the Directive, and the **consequences for innovation and investment** – highlighting the disconnect between EU policy objectives and

¹ <https://www.plasticsnews.com/news/pha-organisation-gopha-calls-ec-guidelines-inconsistent/>

² <https://cordis.europa.eu/project/id/773872>

outcomes in this case. We then assess which Innovation Stress Test criteria would have flagged these issues and how applying the stress test during the policy-making process might have mitigated the harm to an otherwise promising green innovation.

PHA and DEB and the SUP Directive: Definition and Consequences

Under the SUP Directive's definitions, **PHAs and other biopolymers did not qualify as "natural polymers" exempt from the plastic ban**, despite their biological origins. The Directive excludes "*natural polymers that have not been chemically modified*" from the definition of plastic. In its May 2021 official guidelines on the SUP rules, the Commission took the position that **polymers produced via industrial fermentation are *not* natural**, because the polymerisation "*has not taken place in nature*". Specifically, the guidance stated that³:

"Polymers resulting from biosynthesis through man-made cultivation and fermentation processes in industrial settings, e.g. polyhydroxyalkanoates (PHA), are not considered natural polymers... If a polymer is obtained from an industrial process and the same type of polymer happens to exist in nature, the manufactured polymer does not qualify as a natural polymer."

This interpretation meant that **PHA,-based single-use items fell squarely within the SUP Directive's scope**. From 3 July 2021 (when the Directive's market restrictions kicked in), any single-use product made wholly or partly of PHA would be subject to the same rules as fossil-plastics. For example:

- Disposable PHA cutlery, plates, straws, or stirrers – which some companies were gearing up to produce as compostable, bio-based alternatives – are banned from being placed on the EU market (since the Directive bans those product categories made of plastic).
- PHA film or coating on a paper food container means that container is treated as a plastic single-use product, so Member States must take consumption-reduction measures or other actions on those items.
- PHA items like biodegradable plastic bags (if not thick enough to be reusable) or packaging are not directly banned by SUP, but they would count toward targets and could face restrictions under related legislation (Packaging Directive revisions, etc.), since they are not exempt as "non-plastic".

From an innovation standpoint, this classification had several **significant consequences**:

- **Regulatory setback for a sustainable material:** PHA, despite being bio-based and biodegradable, were legally equated with conventional plastics like PE or PP. This runs somewhat counter to the directive's secondary aim of "*promoting the transition to a circular economy with innovative and sustainable...materials*". PHA innovators argue that

³ https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=oj:JOC_2021_216_R_0001

their material meets the spirit of the law – providing the functionality of plastic with far less environmental harm if littered. Yet, because no distinction was made, the law effectively **removed PHA items from the market (or dis-incentivised their development)** in the short term. The Commission’s rationale was rooted in precaution: it noted the absence of “*widely agreed technical standards*” to prove a plastic is marine-biodegradable in a safe and quick manner⁴. Until such standards exist, regulators were unwilling to exempt materials like PHA for fear of loopholes or unverified claims. While this caution has merit – preventing a scenario where things labeled “biodegradable” still pollute – the converse effect is that **even genuinely biodegradable innovations are held back** if they cannot yet conclusively satisfy criteria that regulators require (criteria which are still under development for marine biodegradability).

- **Disconnect with EU-funded innovation projects:** The EU, through Horizon 2020 (its research funding programme), actively financed numerous projects to develop PHA and other bioplastics for single-use applications. For instance:
 - The **YPACK project** (2017–2021, ~€6 million EU contribution) scaled up innovative food packaging solutions based on PHBV (a type of PHA), using food industry by-products like whey and almond shells. YPACK aimed to create **compostable food trays and flow wrap films** from PHA that are biodegradable and recyclable, thereby reducing plastic waste and food waste simultaneously. It explicitly worked on regulatory and policy aspects to ensure alignment with EU legislation.
 - The **NENU2PHAR⁵ project** (2020–2024, €5 million EU funding) set out to establish a European value chain for PHA for high-volume consumer products. Its objective was to produce 8 different PHA-based plastic products and demonstrate their performance and end-of-life (compostability, recyclability) as superior alternatives to fossil plastics.
 - Several other consortia (e.g. **PRESERVE**, **UPLIFT** and others under the Bio-Based Industries Joint Undertaking) further advanced PHA for packaging, often citing single-use packaging and films as key targets for replacement.

These projects were launched in alignment with EU policy priorities like the **Bioeconomy Strategy** and **Circular Economy Action Plan**, which encourage replacing fossil materials with bio-based, biodegradable ones where appropriate. Horizon 2020 calls even stressed innovative biodegradable packaging as a desired outcome (as in YPACK’s call “Innovative solutions for sustainable food packaging”). Yet, as the SUP Directive came into force, **companies emerging from these projects faced a legal barrier:** their

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https://ec.europa.eu/commission/presscorner/api/files/document/print/en/qanda_21_2709/QANDA_21_2709_EN.pdf

⁵ <https://cordis.europa.eu/project/id/887474>



PHA packaging would be considered “plastic” under a law whose very purpose was to reduce single-use plastics.

It is a striking policy inconsistency that did not go unnoticed. The Global Organization for PHA (GO!PHA), an industry group, pointed out that the EU had “*already poured over €108 million into research grants to valorise waste organic carbon to produce PHA*”, signaling strong public support for PHA innovation. Yet the regulatory stance “*stops the development and growth*” of this class of materials in the EU. Researchers and start-ups who had participated in EU projects suddenly found an uncertain home market for their innovations. This not only risks **wasting the public investment** but could also dampen private investment – why invest in scaling a technology that EU law has effectively sidelined, at least in the near term?

- **Chilling effect on investment and commercialization in Europe:** In the aftermath of the Commission’s guidelines confirming PHA’s non-exempt status, there have been concrete impacts on industry confidence. GO!PHA reported that at least “*one manufacturer has put on hold plans to build a substantial volume PHA factory in Europe, which will now be built elsewhere*”⁶. In other words, a facility that could have created jobs and manufacturing capacity in the EU for this innovative material is moving abroad, directly because the regulatory environment is seen as unfavorable. This is a prime example of **deterring investment**: capital and talent flow to jurisdictions with more accommodating or clear rules. While Europe stalls on PHA uptake pending further review (the Directive mandates a review of biodegradability criteria by 2027), other regions – potentially the USA or Asia – are moving forward, meaning European companies might commercialise their PHA innovations outside Europe first. Over time, this could erode the EU’s competitive edge in biopolymers, a field it has been actively nurturing through R&D. GO!PHA criticised the EU’s stance as uniquely strict: “*The EU is alone in adopting this stance... elsewhere, the technology will continue to develop*”, implying that no other major jurisdiction has outright hindered PHA in this way.
- **Lost environmental opportunity and slower innovation feedback loop:** From an environmental perspective, some argue that **excluding PHAs from the market may itself have downsides**. If PHAs truly biodegrade harmlessly in the environment (a claim their proponents make, citing that PHA is biologically akin to natural materials like cellulose or proteins), then allowing them in place of conventional plastics could reduce pollution. GO!PHA’s position paper⁷ contends that “*PHA’s exclusion [from the Directive’s ban] would have allowed consumers to enjoy the same benefits of plastics without the environmental pollution caused by fossil plastics*”, which was the Directive’s very inspiration. By not distinguishing PHA, the Directive potentially forgoes a chance to immediately cut plastic pollution via substitution in certain applications. Moreover, part of

⁶ <https://www.plasticsnews.com/news/pha-organisation-gopha-calls-ec-guidelines-inconsistent/>

⁷ <https://www.gopha.org/gophapublications/positionpaper2>



innovation is iterative learning: if PHAs were deployed more widely, it would spur further research in improving their properties and end-of-life behavior. Instead, with a de facto ban in single-use domains, that **real-world learning and improvement cycle is slowed**. The Commission's plan is to wait for standards and revisit in a few years. In the interim, Europe sticks largely to paper, coated paper, or other alternatives for disposable items, some of which (like plastic-lined paper cups) aren't easily recyclable and may have higher CO₂ footprints or other drawbacks. There is an environmental trade-off here: the precaution of blocking PHA until proven versus the potential gains of enabling a material that early evidence (though not officially standardised) suggests is low-impact.

- **Outcry and reputational impact among innovators:** The PHA case became something of a cause célèbre in discussions about EU innovation-friendliness. Stakeholders in the bio-based materials sector saw it as a **symbol of regulatory inflexibility**. European Bioplastics, an association, diplomatically noted that the Directive “*missed an opportunity*” to incentivise truly biodegradable solutions, while strongly supporting the overall goal of reducing pollution. GO!PHA was more blunt, calling the Commission's interpretation “*inconsistent with science*”, as PHA's polymerisation involves natural organisms (microbes) even if in an industrial setting. They pointed out that certain materials like cellulose film or viscose (produced via substantial industrial processing) were exempted as “natural polymers” in the guidelines, whereas PHA – produced by bacteria – was not exempt. This perceived inconsistency fueled arguments that the policy was *unfairly disadvantaging a green innovation*. For EU policymakers, such criticism from the innovation community can be damaging: it sends a message that even eco-innovators find the regulatory environment frustrating and unpredictable. If European research grants produce technologies that European law then restricts, it raises questions about policy coordination between the innovation agenda and environmental regulation.

In summary, the treatment of PHA under the SUP Directive resulted in a **regulatory barrier to an innovation that was otherwise aligned with EU sustainability objectives**. The consequences included halted investments, potential relocation of industrial activity, and dissatisfaction among innovators who felt their solutions were not recognised by policy. To be balanced, the Commission's stance was motivated by legitimate caution – ensuring that claims of biodegradability are vetted and that one environmental problem is not swapped for another (e.g., accumulation of “compostable” plastics in the ocean without proper breakdown). The Commission is assessing various parts, and by 2027 the Directive must be reviewed with regard to scientific progress on biodegradable plastics, and a horizontal **EU policy framework on bio-based and biodegradable plastics**⁸ was issued in late 2022 to guide future action. That framework acknowledges the promise of materials like PHA but still emphasizes careful evaluation and suitable applications (for example, it suggests biodegradable plastics should be

⁸ <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0682&qid=1763027333862>



targeted to specific uses like agriculture or compostable packaging where collection is assured, rather than litter-prone single-use items, unless proven).

However, for the period 2019–2027, the reality is that **EU regulations did not differentiate PHA from conventional plastics in single-use contexts**. This case reveals a gap where innovation policy and environmental policy did not fully sync up. The **Innovation Stress Test**, had it been applied, might have caught that gap early in the legislative process.

Would the Innovation Stress Test Have Mitigated the PHA Issue?

Applying the **ten Innovation Stress Test questions** to the PHA situation highlights several areas where the SUP Directive’s formulation could have been improved to avoid hampering this innovation:

- **Criterion 1: “Protects public interests and enables innovation?”** – The SUP Directive undoubtedly protects the public interest (environmental protection) by targeting plastic pollution. But did it also *enable innovation* to achieve its goals? In the case of PHA, arguably not. A **strict reading of Criterion 1 would have flagged a potential imbalance**: the law took a hard line on banning plastics but did not accommodate a novel material that might achieve the same environmental aims. The stress test would ask if the initiative recognises the need for innovation to reach its objectives. The Directive’s objectives and recitals include the goal of promoting “innovative and sustainable materials” as part of the solution, yet its operative provisions did not provide a pathway for such materials (other than a distant promise of a review). An innovation stress test might have prompted regulators to consider an **adaptive regulatory design** – for example, including a clause that allows certain materials to be exempted by a change to guidelines or through a delegated act if and when they are proven to meet biodegradability criteria. Such a built-in flexibility would protect the environment *and* incentivise innovators to develop truly marine-biodegradable plastics that could earn exemption. In essence, the test would highlight that *enabling innovation* (in this case PHA and similar bio-based and biodegradable polymers) could itself further public interests, rather than viewing innovation and precaution as oppositional. The Commission might then have more proactively supported standardisation research for PHA biodegradation to speed up an exemption, rather than essentially saying “not now, maybe in 2027.” In short, on Criterion 1 the SUP Directive’s handling of PHA was **borderline**: it protected the environment but arguably sidelined an innovation that serves that same end. A stress test would push for solutions where innovation and precaution reinforce each other (e.g. controlled roll-out of PHA with monitoring, instead of a flat ban) which would have helped to develop materials to substitute plastics and the particular environmental problems related to it.
- **Criterion 2: “Avoids deterring investment in innovation (joined-up policymaking)?”** – Here the SUP Directive rather clearly falls short, as evidenced by the halted PHA



factory investment in Europe. Joined-up policymaking means aligning various arms of policy so they don't undermine each other. The PHA case reveals a **disconnect between EU innovation funding and regulation**: research policy encouraged companies to invest in PHA development, but environmental regulation then closed the market for that innovation. An Innovation Stress Test would have *immediately flagged this policy clash*. Under Criterion 2, the question essentially is: *are our policies sending coherent signals to investors?* In 2019, one could see that Horizon 2020 was actively supporting bio-plastics as part of the Circular Economy, while the draft directive (finalised in 2019) was moving to restrict all plastics equally. A stress test would demand that the Commission reconcile these signals. Practically, this could have led to the directive including explicit **mention of PHAs and other biopolymers that are no plastics** acknowledging their development. For example, the directive or its recitals might have stated: "Innovative bio-based and biodegradable biopolymers, e.g. PHA, polysaccharides) are under development and should be exempted from the scope or alternatively, the Commission will assess without delay once scientific criteria are established whether certain materials can be excluded from the scope of restrictions if proven sustainable. While the current law defers this to a 2027 review, an earlier or conditional review (say in 2023 or upon adoption of an EU standard) could have been written in. This would have reassured investors that new innovative, sustainable plastics substitutes are exempt or that the EU is *open to adjusting* as soon as innovation delivers results, rather than giving a fixed long timeline. In essence, the stress test would push policymakers to **coordinate with DG RTD (research)** and programs like Horizon to avoid undercutting their outcomes. The criterion explicitly calls for not creating barriers to new innovation investment – yet in PHA's case, a barrier was erected. Thus, on Criterion 2 the law would likely have "failed," prompting either a redesign or at least a strong justification. No such justification was given at adoption, beyond the evidence concerns; the stress test would force the Commission to explain how it will prevent loss of investment. The harm that did occur – a plant built outside the EU or not built at all – shows the cost of not heeding this criterion.

- **Criterion 3: "Provide clarity and certainty for innovators?"** – In one sense, the Commission did provide clarity: through its guidelines and Q&A, it made explicit that PHAs and similar industrially made polymers – even if identical to those found in nature are in scope. Innovators, though unhappy, at least know where they stand legally (there is no ambiguity that could lead to wasted effort developing a product mistakenly thought compliant). So on pure *legal clarity*, the process eventually scored a **Yes** – after some months of uncertainty in 2019–2020 when industry was unsure how "natural polymer" would be interpreted. The guidance resolved that in 2021. However, from the perspective of "certainty for investors," the bigger issue is **policy consistency** (tied to Criterion 2). The stress test's clarity question is about whether innovators can understand and predict the regulatory environment. The surprise for PHA developers was that a polymer produced by bacteria through fermentation would be deemed not natural – a definition

nuance not obvious without legal expertise. GO!PHA argued PHA should qualify as natural because it's made by the *same microorganisms* that produce it in nature, but the Commission applied a definition from the REACH guidance for polymers. It is worth noting that this guidance from 2012 was developed for very different reasons and not fit to be used in SUPD. An innovation stress test could have encouraged the Commission to communicate with the bio-plastics community earlier and more transparently about this interpretation. In fact, workshops with ECHA and stakeholders did occur (April 2020 workshop is referenced in GO!PHA's paper), but evidently **the outcome was not favourable to innovators**. A stress test mindset might have led the Commission to issue *draft guidance for comment*, giving industry a chance to formally react (GO!PHA would have objected, as they did informally). While ultimately the Commission might still have decided the same, the process would have felt more inclusive. Crucially, clarity is also about future expectations: innovators now know PHAs are banned in SUP items, but do they know what the criteria will be in 2027 for a change? Right now, that's still vague (since standards are in development). The stress test would push regulators to outline a **clear roadmap**: e.g. "by 2023, develop a standard for marine biodegradability; by 2024, allow materials meeting it." That kind of certainty (even if conditional) helps companies plan R&D. In summary, the SUP Directive partially met Criterion 3 (clear definitions eventually) but fell short on giving innovators a **clear pathway forward**. The stress test would identify that gap and likely recommend setting clearer criteria or interim milestones to guide innovators' efforts.

- **Criterion 4: "Aligns with Better Regulation processes?"** – The formal Impact Assessment for the SUP Directive did follow Better Regulation guidelines, but it arguably did not fully account for the **innovation angle** regarding bio-based plastics. The Impact Assessment noted that biodegradable plastics do *not* solve the litter problem unless they biodegrade in natural conditions, and mentioned the lack of standards as an issue. However, this was a relatively brief consideration; the focus was on known alternatives like paper, not on fostering new plastic alternatives. The innovation stress test (which is meant to reinforce Better Regulation) would ensure that even in the IA stage, **innovation impacts were thoroughly examined**. For example, the IA could have included a dedicated analysis of how the directive would affect the bio-based plastics industry and ongoing EU innovation projects – essentially, an "Innovation Principle" evaluation. This might have surfaced the Horizon 2020 projects in progress and asked whether the directive could incorporate a mechanism to support, rather than negate, their results. Since the Commission did follow standard procedures and consulted stakeholders, one can say it ticked Criterion 4 in general. But the **Regulatory Scrutiny Board** and others apparently did not flag the PHA issue strongly. A stress test would elevate that specific concern. In practice, fulfilling Criterion 4 in spirit would mean the Commission should have included in its proposal how it took into account the input from bio-plastics innovators (who did participate in consultations) and the analysis of R&D impacts. There is scant evidence in public documents that this was deeply addressed. Therefore, an

innovation stress test might have led the RSB or the inter-service consultation to request “*evaluate impact on bio-based innovation*”, potentially leading to adjustments in the proposal or at least acknowledgement of the trade-off being made.

- **Criterion 5: “Involves innovators in policy design?”** – The process did involve them to an extent: bio-based industry stakeholders (including PHA producers) provided feedback during the public consultation and bilateral meetings. GO!PHA’s extensive positions show they were actively trying to shape the outcome. However, despite this involvement, their key request – to classify PHA as a natural polymer and exempt it – was not accepted possibly because strong efforts by producers of cellulose based materials at an early stage, including the impact assessment which considered them as a sustainable alternative to plastics. The innovation stress test would ask if the consultation *ensured policies do not unintentionally undermine investor confidence*. In this case, innovators forewarned the Commission that treating PHA as a banned plastic would undermine confidence (which it did). Yet the Commission proceeded, presumably judging the environmental risks of exempting PHA to be too high or evidence insufficient. If an innovation stress test had been in place, it might have created more pressure to find a compromise with innovators, or at least to demonstrate that their concerns were considered and mitigated. For instance, the Commission could have offered a formal statement: “We commit to revisiting PHA and similar new materials as soon as test methods are validated, and will support the development of those methods in the meantime,” accompanied by perhaps funding a fast-track CEN standard or pilot programs for disposal. Such gestures, possibly born out of stress test thinking, would show innovators that their input had tangible effect, thereby maintaining some confidence. Without it, innovators felt essentially ignored on the final decision, even if meetings were held – a scenario the stress test explicitly tries to avoid. So, on Criterion 5, the SUP Directive process was **inclusive but not responsive and innovators benefiting from Horizon 2020 funding should have been better considered**. The stress test would score that as a problem, pushing for a better integration of innovators’ feedback (or requiring justification why it was overruled, with a plan to address it later).
- **Criterion 6: “Ensures transparency and manages conflicts of interest?”** – There was no notable conflict of interest issue in the PHA debate; it’s more a disagreement on scientific/regulatory approach. The process was transparent (consultations, published guidance, etc.), so Criterion 6 is largely satisfied. One might say the Commission relied heavily on advice from ECHA (European Chemicals Agency) which took a conservative view – not a conflict per se, but a particular institutional perspective. Innovators might feel that the process gave more weight to voices of caution (some NGOs were opposed to exempting biodegradables, fearing greenwashing). But these differences are ideological. There probably were also some private sector biases as economic actors fitting the natural polymer definition saw no reason to change it. So an innovation stress test would probably mark this criterion as **OK** in this context, as no one was secretly benefiting from

hampering PHA – it was a policy choice made in the open though at a very late stage when the guidance was completed.

- **Criterion 7: “Bases decisions on sound evidence?”** – This is an interesting one. The Commission’s justification for including PHA and other similar biopolymers was based on using the natural polymers definition and the lack of evidence meeting a required standard of proof (marine biodegradability). On the definition, the Commission had received evidence from scientists⁹ and others that it wrongly classified some biopolymers as plastics. They also did have evidence *of the problem* (that alleged biodegradable plastics can persist or that standards are not ready) which is why they acted cautiously. But one could argue the Commission did *not* incorporate all available scientific evidence on PHA’s biodegradability. By 2018, some studies suggested that certain PHAs can biodegrade in marine conditions relatively quickly, certainly faster than traditional plastics. GO!PHA and European Bioplastics provided such data in their advocacy materials. The Commission’s stance was that until an official standard and consensus exists, these data aren’t sufficient to carve exceptions. The Innovation Stress Test might have challenged whether the Commission was truly considering the “*best available up-to-date evidence*” – especially as the Horizon projects themselves were generating evidence on PHA end-of-life. If the stress test were applied, the Commission might have been pushed to commission a focused scientific review on PHA (and other bio-based polymers) during the directive’s drafting. For example, a panel of independent experts could have assessed the claims of PHA biodegradability and provided a risk analysis: What is the harm if we exempt PHA and it biodegrades 90% in 6 months vs 99% in 2 years? Is that tolerable or not? That kind of nuanced evidence-based discussion does not appear in the public rationale. Instead, a blanket “no standard, so no exemption” approach was taken. A stress test would encourage a more granular look. Perhaps it would conclude the evidence is promising but not conclusive – in which case, the test could recommend including a sunset clause or pilot exemption: e.g., allow PHA for a trial period in certain uses while monitoring real-world biodegradation, which is an evidence-generating approach. By not doing so, the EU chose certainty over experimentation. That’s defensible, but it is a conservative and over-precautionary stance on evidence usage (favouring proven harm avoidance over potential innovation gains). The stress test leans toward giving innovation a chance if evidence is incomplete but hopeful, provided risk mitigation is possible. In PHA’s case, one mitigation could have been limiting PHA use to items that are likely to be industrially composted or collected, to ensure they don’t just get littered – thereby controlling risk while evidence improves. In conclusion, while the Commission’s decision was evidence-aware (lack of standard = evidence gap), the Innovation Stress Test might class this as **not fully leveraging evidence to support innovation**. It would likely prompt a more dynamic evidence strategy (as described), rather than a static ban pending future proof.

⁹ <https://renewable-carbon.eu/publications/product/open-letter-to-dg-environment-which-polymers-are-natural-polymers-in-the-sense-of-the-single-use-plastic-ban-%E2%88%92-full-version/>

- **Criterion 8: “Does not worsen skill shortages?”** – At first glance, a plastics directive seems unrelated to skills. But GO!PHA’s argument brings in a relevant angle: the PHA industry could create numerous *high-skilled jobs in biotechnology and materials science* in Europe. Stifling it means those potential jobs (and the expertise with them) might go elsewhere. If a major PHA (or similar bio-based polymers) plant is built overseas instead of in the EU, European engineers and scientists might relocate or at least the new graduates have fewer opportunities here. So yes, hindering the PHA sector could indirectly impact the development of specialised skills and human capital in the EU’s bioeconomy sector. The innovation stress test would likely catch this under Criterion 8: it asks if the policy negatively affects the availability of skills for innovation. One could argue the SUP Directive’s general benefits (reducing pollution) do not inherently cause skill loss – in fact it spurs other innovation sectors like plastic alternatives (paper or multi-use systems). But for the specific niche of bio-plastics, it was a setback. The stress test analysis might note that an entire community of EU researchers working on PHA (funded by EU money) faced diminishing prospects of translating their knowledge into EU jobs and companies, which in the long term could see talent drift away. Mitigating that would require keeping the PHA field active in Europe. The Commission could have, for instance, coupled the directive with an announcement of increased R&D support to crack the biodegradability standard, thereby retaining scientific talent on the problem and signalling that these skills will be valued when standards are met. That would soften the “brain drain” risk. Without it, Criterion 8 raises a caution that the directive might inadvertently discourage a burgeoning skill area (industrial biotech for materials). While this criterion is less obvious than the direct investment impact, it’s part of the holistic view: innovation needs people, and if policies discourage a field and hence investments, the best people may pivot to other fields or regions.
- **Criterion 9: “Avoids creating gender imbalances?”** – The PHA issue is not directly connected to gender. The stress test would likely mark this as not applicable or no impact. (One could only tangentially note that many startups in green tech are led by diverse teams, but that’s speculative. There’s no clear gender dimension here.)
- **Criterion 10: “No conflict with innovation incentives (tax, R&D support)?”** – This is where the PHA case is perhaps most clear-cut. The SUP Directive’s effect on PHA directly conflicts with EU R&D incentives provided via Horizon 2020. The stress test explicitly asks whether a proposal conflicts with existing or future incentives for innovation. Horizon 2020 (and now Horizon Europe) grants are a form of incentive – they encourage research and pilot projects in targeted domains (in this case, sustainable plastics). By rendering the commercial deployment of those project results more difficult, the regulation has diluted the impact of the incentive. It’s almost analogous to offering a tax credit for developing a new technology, then banning the technology’s use: clearly a contradictory signal. Additionally, there are conflicts with broader EU ambitions to defossilize the materials sector, to meet climate change and bioeconomy goals. Some Member States have also or had incentives like lower taxes or mandated

quotas for bio-based materials (for example, Italy promotes compostable bags). The directive didn't pre-empt those directly, but it might neutralise them in single-use contexts (Italy, for instance, had to ban even compostable plastic plates despite earlier encouraging them). So at both EU and national levels, there were policy tools pushing bio-material innovation that the SUP rules effectively overrode. An innovation stress test would shine a spotlight on this and require the Commission to address it. Two plausible mitigations could have emerged: (1) **Transitional arrangements** – e.g., giving PHA and similar materials a longer transition or conditional exemption to reconcile with the trailing edge of Horizon 2020 projects, so that at least pilot deployments could conclude and data be gathered. (2) **Bridging policies** – e.g., a funded program to help PHA innovators pivot to durable or multiple-use applications (where SUP doesn't ban them) so that the innovation doesn't go entirely to waste. If a direct exemption was off the table, something like an "innovation sandbox" could have been devised: allow limited market introduction of PHA products under controlled conditions to evaluate performance. This is the kind of creative solution an innovation-centric review might propose to avoid nullifying the effect of innovation incentives. In the actual event, no such measures accompanied the SUP Directive; it was a blunt market intervention. Thus, on Criterion 10, the PHA case is a **clear failure** – a regulatory action conflicting with substantial public investment in innovation. The stress test would not accept that without at least demanding a justification and offset plan.

Bringing these points together, it is evident that an Innovation Stress Test applied in 2018 during the drafting of the SUP Directive would have **identified the PHA issue as a significant concern** on multiple fronts: policy coherence, investment deterrence, and conflict with EU innovation programmes. The likely outcome of that identification would be to force policymakers to **explicitly grapple with the trade-off**: Is the (perceived) environmental risk of exempting PHAs so high that we are willing to accept damage to an innovation sector we have championed? If yes, how can we minimize that damage? If no, how can we accommodate PHAs safely? It is also important to consider the possibility to issue along side the impact assessment an innovation stress test report which would help the co-legislators to better understand impacts on innovation particularly if there is already an emerging innovation sector.

One can imagine a more nuanced SUP Directive as a result:

- It might have included a narrowly defined **conditional exemption**: e.g., "Member States may exempt single-use products made of PHA from the ban, provided that those products meet compostability standards and are collected for organic recycling, until an EU standard for marine biodegradability is established." This would have allowed some market for PHA (in controlled conditions like composting systems) and kept investment in Europe, while mitigating marine litter concerns (since only composted uses would be allowed). It's a compromise path that was not taken.



- Or the Directive could have mandated the Commission to **assess specific materials within a short timeframe**. Instead of waiting until 2027 broadly, it could say: “by 2022, Commission shall assess whether any bio-based polymer can be safely excluded and propose amendments accordingly.” This would light a fire under the development of standards and data for PHAs, aligning regulatory timing with innovation progress. As it stands, 2027 is far, and in policy terms, that often means “we’ll see then”; an earlier deadline would show seriousness. An innovation stress test would favour earlier re-evaluation, because long lags can kill nascent industries.

Furthermore, the stress test would encourage communication to the innovation community to **soften the blow**: perhaps a Commission statement recognizing PHA’s potential, coupled with new funding (as mentioned) for research to meet the criteria. In reality, the Commission’s 2022 Plastics Policy Framework does acknowledge future roles for biodegradable plastics but also warns against viewing them as a panacea. It’s a mixed message that still leaves innovators of PHA and similar materials in limbo for certain applications.

In conclusion, had the Innovation Stress Test been applied, the **issue of PHAs under the Single-Use Plastics Directive would have been anticipated and addressed more strategically**. The test’s holistic view would have flagged the contradiction between EU innovation efforts and the regulatory outcome, pushing for a more innovation-friendly solution *without sacrificing the environmental goals*. This could have meant a more flexible directive or at least parallel measures to support and redirect the PHA innovation so that Europe didn’t lose out. The case of PHA showcases exactly why an innovation stress test is valuable: it exposes when a well-intentioned regulation might inadvertently undermine a technology that contributes to the same aims, and it urges policymakers to find a smarter route.

As things stand, the **harm to innovation and investment** from the SUP Directive’s handling of PHA is real – but not necessarily irreversible. If the EU accelerates the development of standards and perhaps allows limited use of genuinely biodegradable plastics sooner than 2027, it may regain momentum. The PHA and similar industries negatively effected by the SUPD, continues to advocate and innovate (as evidenced by ongoing Horizon projects and private sector developments in packaging, medical uses, etc.). The hope is that this dialogue between innovators and regulators leads to a science-based adjustment of policy, where materials like PHA are assessed on their merits and deployed in ways that truly reduce pollution. That outcome – aligning innovation with regulation – is precisely what the innovation stress test framework is designed to facilitate.