# THE OPTIONS FOR CREATING A MORE SUSTAINABLE INHALER

**With growing pressure to tackle climate change, Phil Seeney, a Drug Delivery Specialist at PA Consulting, looks at the arguments in favour of creating more sustainable inhalers, and examines potential strategies to accomplish it.**

Despite the current coronavirus pandemic, climate change remains a serious global problem, and addressing it is an urgent priority. There is general agreement that everyone has a role to play in reducing the carbon footprint (CF) and global warming potential (GWP) of the products we use every day.

Recently, the hydrofluoroalkanes (HFAs) used in pressurised metered dose inhalers (pMDIs) have come under attack.[1,2,3] There is much debate as to the overall impact and GWP of pMDIs but for the UK NHS (and others), they form a significant percentage of the organisation's CF and GWP. GSK calculated that 32% of its carbon footprint was from patient use of its pMDI inhalers, with its dry-powder inhalers (DPIs) having a carbon footprint approximately one twenty-fifth of a propellant-based inhaler.[4]

Thus, alternative approaches to pMDIs have to be found, even though their contribution to global emissions is less than 0.05% of all greenhouse gas emissions.[5] Encouraging patients and their medical practitioners to switch from pMDIs to DPIs to reduce their CF may be acceptable and appropriate for some patients. The UK National Institute for Health and Care Excellence (NICE) even provides guidance on the inhaler selection decision process and considers CF.[6] However, DPIs are not suitable for all patients – e.g. hospitalised chronic obstructive pulmonary disease (COPD) patients, those with inadequate inspiratory flow, etc.

Furthermore, there are practitioner concerns that patients' health could be at risk if, in changing to a DPI, patients who may have taken years to stabilise risk losing the established control of their asthma and experience exacerbations, resulting in hospitalisation or death. In the interim, companies are actively investigating replacing the current HFAs with HFA 152a which has a claimed CF approximately the same as a DPI[7] – but it will take time and effort to prove equivalence.

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Many of the pMDI products in use are well-proven, long-standing drugs that provide effective treatment for millions of patients globally.[8] However, despite this, we can expect increased regulatory and market pressure on pharmaceutical companies, suppliers and bulk users (hospitals, etc) to reduce their use. It would therefore be prudent for developers of inhalers to address these needs now, given the time it takes to achieve regulatory approval for new products, even using existing drugs.

So, what are the options for pharma and device developers/suppliers given the likelihood that future legislation imposes limits on GWP/CF for inhalers? (Assuming the target is to reduce the GWP and CF of respiratory devices, without compromising patients' health).

It is unlikely that there will be a single, universal solution to the problem and the answer is going to be delivered by a multi-pronged approach to inhaler design and drug delivery, together with a progressive adoption of more sustainable options. However, we are potentially at a cusp where the holistic cost of an inhaler – including its environmental cost – must be considered from a fresh viewpoint at the start of any project.

The approach to sustainable design, and particularly redesign, is to adopt the principles of the five Rs:

- **Replace** – replace unsustainable materials with ones from sustainable sources or with much lower GWP/CF.

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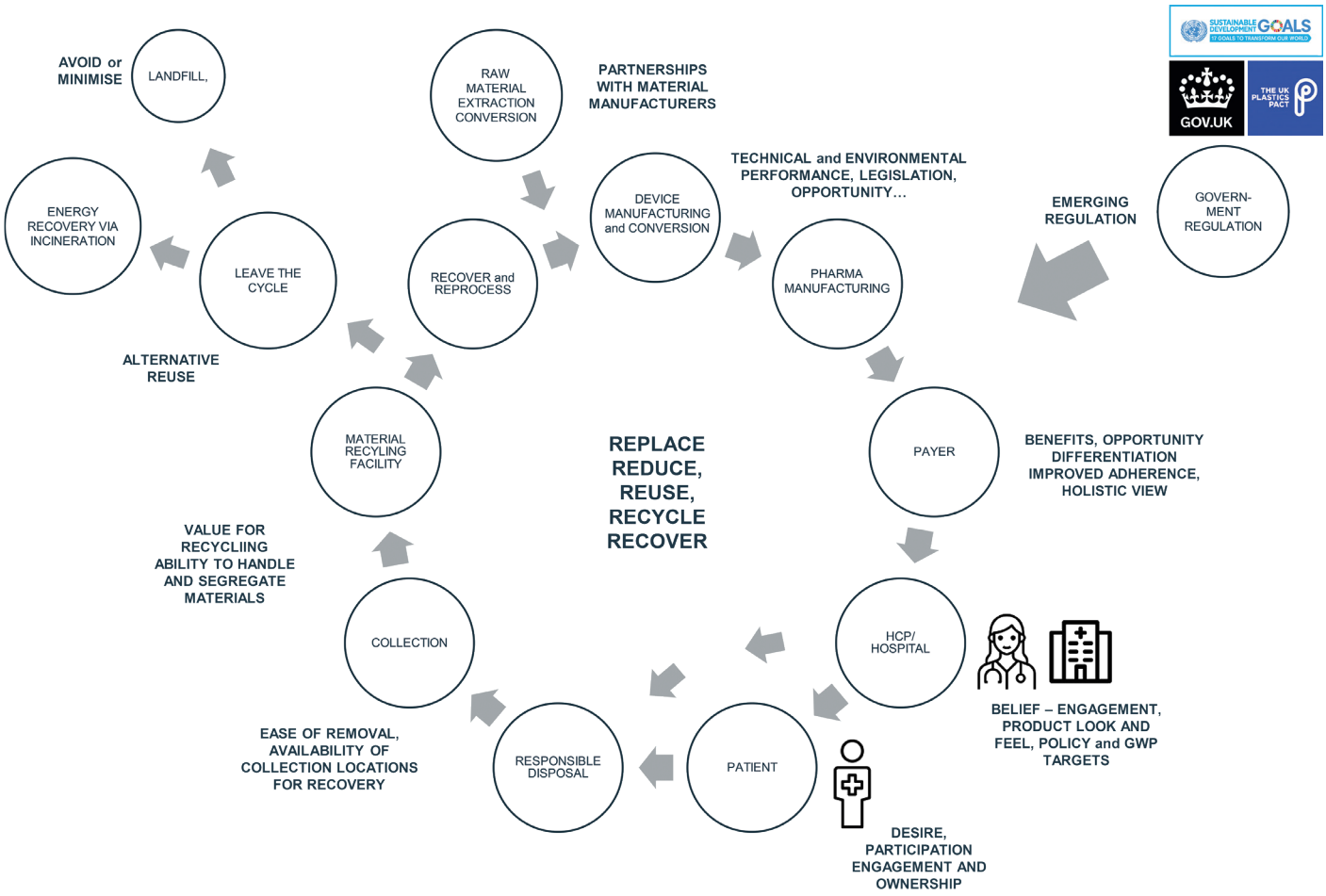


Figure 1: The holistic vision – a virtuous cycle of sustainable design.

- **Reduce** – reduce unsustainable high GWP/CF materials which cannot be replaced with better alternatives.
- **Reuse** – create reusable/refillable systems that have a longer market life and, as a consequence, a reduced environmental impact/dose (the "planetary cost" of ownership is reduced). This also has the potential to reduce the financial cost/dose for some products.
- **Recycle** – design the product to enable the separation and recovery of recyclable materials for reuse in the same product supply chain (where possible) or in other supply chains with sufficient demand.
- **Recover** – as a final measure, recover the energy from the materials by incinerating in an energy recovery plant, avoiding disposal via incineration/landfill.

It is important to note that these are not individual solutions – a preferred solution may be a combination of multiple approaches comprising all elements (Figure 1). Even if we can create an inhaler that uses sustainable materials and/or reduces the content of less sustainable materials, it will still be preferable to design an inhaler format that is reusable and reduces whatever environmental impact the device has through multiple use cycles and ultimately disposal.

It is not the intention of this article to describe how to perform a full lifecycle analysis (LCA) of the inhaler journey, cradle to grave. There are tools and databases available now that can support design teams in assessing the GWP and CF of materials and processes, and these should be used to evaluate alternative concepts and model environmental impacts. However, we already know that the use of current HFAs is a main contributor to the GWP of pMDIs and that, once this is resolved, the pressure will then be placed on multiple material, disposable systems (e.g DPIs) that will then lose the currently perceived advantage over pMDIs.

The following sections examine potential options using the "replace to recover" approach identified above.

## REPLACE AND REDUCE

Although replacing HFAs in pMDIs with other variants is a valid, short-term approach with potentially little change to other components, a more radical longer-term approach should investigate all the potential ways a drug solution could be delivered to the lung. A first investigation therefore could consider the alternative technologies that can produce an aerosol suitable for inhalation, to avoid the use of HFAs or reformulating as a dry powder.

Figure 2 shows some of the principal technologies that might yield suitable new products (including a DPI). We then need to devise selection criteria to initially perform a coarse assessment of these technologies against targets of performance, cost per dose, environmental impact, development risk, etc. For example, a refillable, reusable, mechanically pressurised device, using a novel aerosolisation element, may tick all the boxes and also deliver the benefits of reusability.

However, if we home in on a solution too early, there is a danger that the development may not deliver the concept's full potential. It is important that, in the next step, the concept is evaluated against a broader range of requirements. To do this, we have to map out the lifecycle of the product and understand the process it goes

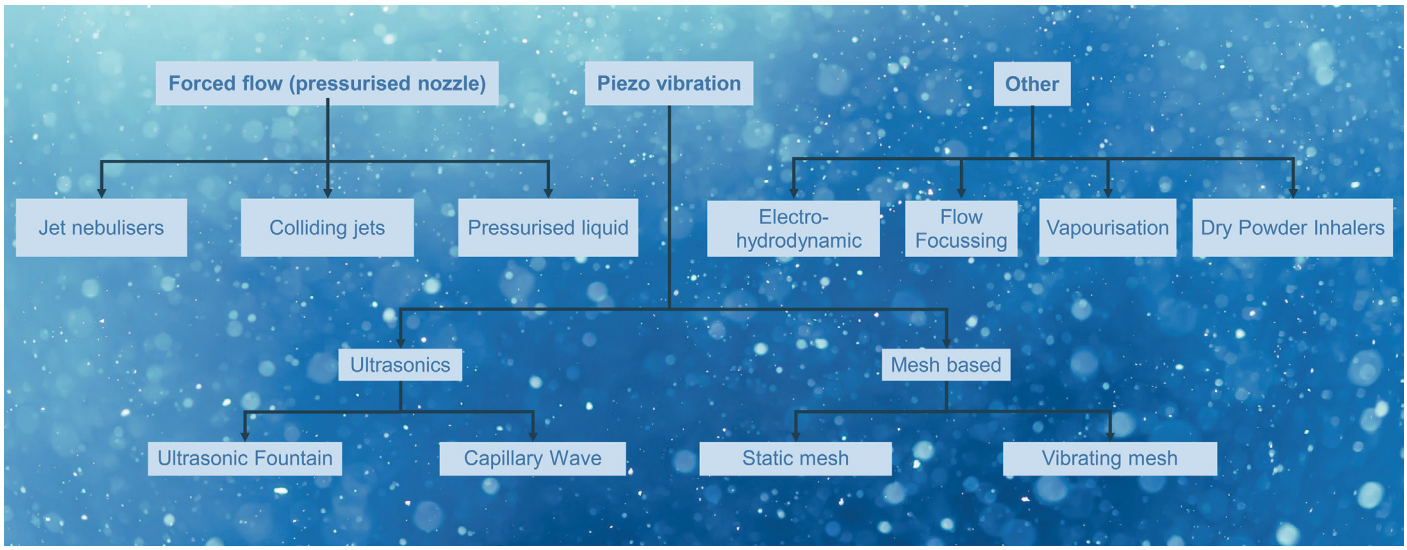


Figure 2: A selection of aerosalisation technologies.

through at each stage of its life, including raw material sourcing, conversion, recycling and recovery/disposal. This is where, for a drug delivery device, the challenge becomes more demanding.

Even if the strategic plan is to gradually phase out pMDIs and develop DPIs that are even more sustainable than current products (anticipating pMDI manufacturers will develop more sustainable products and current DPIs will not retain the sustainability high ground without further development), the broad outline approach above still applies – it is product and solution agnostic.

For example, we consider here the challenge of developing a DPI that is aiming at an idealised solution but the approach could equally apply to an autoinjector or other drug delivery system that uses a range of engineering polymers and metals and, due to this complexity, is difficult to recycle and is typically disposed of after one month's use.

We all know we can sort household waste and segregate different materials to different recycling and recovery streams. However, it is not so straightforward for a drug delivery device where we have to consider:

- Is the product (or part of it) clinical waste – e.g. sharps or potentially biologically contaminated?
- Is there any drug remaining in the product? Can the drug contact components be separated, cleaned and recovered with a net environmental benefit?
- How can we (by design) use existing recovery infrastructures rather than having to create dedicated plant and infrastructure – e.g. as is needed for the recovery of unused HFAs from pMDIs?
- Can we create inhalers where significant parts of the device can be reused – i.e. in a refillable concept, extending the life of the main "engine" such that even if more exotic, robust engineering polymers are needed, the GWP/CF is reduced by 90% through extending product life from one month to one year or longer?
- The collection and handling of inhaler waste products (e.g. from hospitals, pharmacies, central locations, etc).

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However, for inhalers in general use, 58% of patients own up to disposing of their inhalers in household waste,[9] much of which ends up in landfill, so we must also help patients change their habits.

In the short term, we may need to accept that some critical components in a DPI still have to be made from special engineering polymers and that it will take time for the emerging plant-based and more sustainable polymers – such as polylactic acid (PLA) as a replacement for acrylonitrile butadiene styrene (ABS) – to evolve sufficiently to meet demanding requirements and standards of life-critical drug delivery systems.

It is important to recognise that sustainability is not the primary aim of the development – it is one of the requirements. Keeping patient and performance needs at the forefront, the redesign provides an opportunity to improve the usability and patient experience (clinical outcome) and reduce environmental impact. This can be achieved by rethinking how we transition from current inhalers to solutions which provide inhalers that are better for the patient and better for the planet.

## REUSE

Making DPIs reusable has the potential to reduce the GWP/CF by 90% or more if we make them a little more robust, such that the primary engine can reliably provide a 12-month duty cycle with monthly replacement drug cartridges. However, there are other considerations and decisions of usability that surface for refillable versus disposable devices:

- How do we address the need to provide a dose counter?
- Can the dose counter be automatically reset when a new refill is inserted or does the dose counter have to stay with the drug cartridge (increasing the disposable element)?

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- How do we prevent a part-used drug cartridge being removed and then reinserted and resetting the counter incorrectly?

The development team has to rise to these challenges and create truly innovative solutions for the next generation of reusable, refillable DPIs.

## RECYCLE AND RECOVER

Even if we have a concept that can use more sustainable materials, minimises the use of fossil fuel derived polymers and is reusable, how do we recycle and ultimately recover the disposable and reusable elements? Can the disposable elements be recycled or recovered, given they are contaminated with drug and also potentially a biohazard? Can trying to clean and recover these elements provide a net environmental benefit or are we now in the tail of diminishing returns? Of course, the reusable element of our new DPI (almost by definition) will comprise potentially valuable materials and should be designed to optimise recycling.

The development team should try to minimise the number of materials used, especially if they are fossil-fuel based, and – where differences in performance are needed – try to select materials that can use the same recycling pathway. For example, if sustainable PLAs have been used, these might be chemically recovered in dedicated recycling plants rather than being lumped in with other general polymer recycling streams. Whatever the options, it is clear a redesign of the DPI requires a modular concept where the individual modules are designed to be reusable, recyclable and/or in some other way recoverable – the intention being to avoid any element ending up as landfill.

Some 235 million people worldwide[8] who suffer from asthma use currently effective and life-changing inhaled medications. They will need to be transitioned to more sustainable alternatives once it is demonstrated these are as effective and usable, in a similar or even better way, than current products. Providing new inhalers (DPIs or liquid systems) that gain patient confidence can take us down a virtuous cycle where all parties benefit from this opportunity to overhaul inhaler design, use and recovery.

But what will it cost? Improved, reusable inhalers need not be significantly more expensive if we factor in improved adherence, improved outcomes and reduced patient hospitalisation costs, delivered by better next-generation products. We need to move to a more holistic "cost" model, both in monetary and environmental terms. The cost to the planet and patients in defending the current position and maintaining the status quo is no longer acceptable – change is on the horizon; and it's happening now.

## ABOUT THE COMPANY

PA Consulting is a global innovation and transformation consultancy with more than 3,200 specialists working in a number of key industries. It has over 40 years' experience in the design, development, characterisation and evaluation of drug delivery devices. PA has dedicated inhaled and parenteral drug delivery teams, covering both conventional and smart connected devices using low-cost printed electronics and electronic-free acoustic connectivity. Services include complete device development, device identification, selection and customisation, device strategy, product characterisation, development of custom test equipment, human factors studies, design verification programmes and transfer to manufacturing.

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## ABOUT THE AUTHOR

**Phil Seeney** is a Drug Delivery Specialist and a member of the applied science team at PA Consulting in Cambridge, UK. He is a mechanical engineer and industrial designer with more than 45 years' product development experience covering the healthcare, consumer durable and fast-moving goods sectors. For the past 30 years, he has specialised in drug delivery and medical devices, particularly inhaled drug delivery, its associated technologies and manufacturing. Mr Seeney supports companies in the development of novel inhalation devices and in the identification and acquisition of new/emerging technologies.