Multi-Industry Market Potential for Solid Carbon

Graforce's methane plasmalysis not only produces clean hydrogen but also yields high-purity solid carbon — a versatile material that can replace carbon-intensive substances across major industries. Unlike conventional carbon black, this carbon has the potential to scale with hydrogen demand by tapping into broader, Carbon-intensive industries.

In fact, our solid carbon is designed as a **drop-in, low-emission alternative** to calcined petroleum coke and other carbons used in heavy industries. Key application areas include:

- **Carbon Black & Calcined Petcoke Replacement:** Our carbon can directly substitute **carbon black and petcoke** in uses like pigments, coatings, and metallurgical reduction. For example, calcined petcoke is widely used in **titanium dioxide (TiO_2) pigment production** and metal smelting. Graforce carbon can fulfill these roles with *80–90% lower CO_2 emissions* compared to petcoke from oil refineries. The addressable market here is enormous – calcined petcoke alone is projected to exceed **$43 billion by 2030**, indicating a multi-million-ton demand. By tapping into this, our carbon output can scale in tandem with hydrogen production.
- **Graphite & Electrode Materials:** Another major use is as a **graphitic carbon substitute** in applications like electrodes for steelmaking. We have tested adding Graforce carbon to **graphite electrode manufacturing** (which traditionally relies on needle coke). In trials, replacing a portion of needle coke with just 2–5% of our carbon *improved the baked electrode density* (via better particle packing) without compromising final graphitization. This suggests our carbon can integrate into the **~1 million+ ton/year graphite electrode market** (market 4.2 billion US-Dollar) as a partial substitute, supporting steel recycling and EAF steel production with a lower-footprint carbon source.
- **Fertilizers & Soil Enhancement:** We are also exploring the agricultural sector. Our solid carbon can be used as a **soil improvement agent or fertilizer additive**, much like biochar. Its porous structure helps retain water and nutrients in soil, boosting fertility. Importantly, this "carbon fertilizer" locks CO_2 into the ground for centuries (analogous to *Terra Preta* soil). We are developing a new fertilizer product that utilizes our carbon – reducing the CO_2 emissions of fertilizer production and improving soil quality simultaneously. Given the scale of agriculture, this could become a **gigaton-scale carbon sink** and market. (Notably, our recent pilot facility's carbon byproduct is already planned to be used to *enhance agricultural soils*.)
- **Building Materials (Concrete, Asphalt & Cement):** The construction industry presents one of the **largest potential markets** for our carbon. Graforce carbon can be used as a functional additive in cement, concrete, bricks, and asphalt. In fact, replacing a portion of Portland cement with our carbon is a very promising route – cement is highly CO_2-intensive (~0.9 kg CO_2 per kg cement), and any reduction has huge climate benefits. **Pilot tests have shown up to 20% of cement clinker can be replaced by our carbon** without loss of strength or durability. This is groundbreaking: it means concrete producers could use less cement by adding our CO_2-neutral carbon, cutting emissions and **permanently sequestering carbon in buildings**. Moreover, carbon-enriched concrete becomes *electrically conductive*. We have developed conductive concrete bricks containing ~15% of our carbon, which cure faster and can be electrically heated. This enables novel heated infrastructure – imagine **bridge decks, floors, or parking surfaces that can heat themselves** to de-ice or warm facilities, using carbon as the heating element. Such innovations not only create new functionality but also could consume large volumes of carbon in each project. Given that the construction sector

uses billions of tons of material annually, even a modest adoption of carbon-additive concrete or asphalt would equate to a **multi-megaton demand** – easily keeping pace with hydrogen output growth.

In short, **our solid carbon targets several high-volume markets** (steel/metallurgy, construction, chemicals, agriculture) rather than relying on just traditional carbon black uses. This diversified approach ensures that as hydrogen production scales to thousands of tons, the co-produced carbon can be **readily absorbed by existing industries** at scale, all while displacing more polluting materials.

Strong Offtaker Interest & Use Cases in Progress

Crucially, these opportunities aren't just theoretical – we are already seeing strong interest from industrial customers (offtakers) who want to use Graforce's carbon, validating the market on a practical level. Some examples:

- **Pigments & Coatings Industry:** One large industrial customer in the pigment sector (paint/coatings) requires roughly **300,000 tonnes of calcined carbon per year** for its TiO_2 pigment production. They are evaluating Graforce's carbon as a direct replacement for their current petcoke-based material. This client is so keen on securing a cleaner carbon source that they have even expressed interest in co-financing a Graforce plasmalyzer dedicated to their supply. Our carbon's performance has been proven suitable for TiO_2 processes – e.g. in abrasion tests, it maintained particle integrity with only ~3% fines (comparable to standard petcoke), indicating it can handle the chlorination reactors without issues. This gives pigment manufacturers confidence that Graforce carbon can *plug into their existing process* at large scale.
- **Foundries & Metallurgy Partnerships:** We are collaborating with metal foundries and steel producers to use our carbon as a **replacement for foundry coke** Gießereien nutzen unseren 99,9 % reinen Kohlenstoff direkt für ihre stahl im gefüge. er wird direkt in die schnelze gegeben. Eine Studie zeigt, dass Kohlenstoffverkäufe (~450 €/t) die Wasserstoffkosten um ~1,44 €/kg senken. This kind of arrangement turns carbon from a disposal challenge into a *profit center*. We're already in discussions to supply foundry partners with Graforce carbon for their cupola furnaces and induction furnace operations. They value the consistency and low impurities of our product.
- **Conductive Building Materials with Cement Companies:** We have initiated partnerships with a major cement manufacturer and precast concrete companies to integrate our carbon into **"green concrete" and asphalt products**. Together, we are testing formulations where a portion of cement or bitumen is replaced by Graforce carbon to create lower-CO_2, *conductive* building materials. Early prototypes of concrete blocks with ~10–15% carbon content have been made, and they demonstrate comparable strength plus the ability to conduct electricity (for applications like heated floors and pavements). We're also exploring carbon-infused asphalt for roads that could be heated to prevent ice. These partners are interested in scaling up production of such materials, which could translate into hundreds of thousands of tons of annual carbon usage if adopted in infrastructure projects. Not only do these applications sequester carbon for decades in structures, but they also add value (faster curing, thermal functionality) that customers are willing to pay for.
- **Graphite Electrode Manufacturers:** As mentioned, we've run **pilot trials with a graphite electrode producer** to assess our carbon in their manufacturing process. The trials involved substituting a small percentage of the needle coke feedstock with Graforce carbon. The result: electrodes with Graforce carbon had a higher green

(ungraphitized) density – ~1.74 g/cc vs ~1.68 g/cc baseline – after baking, thanks to improved particle packing. After the final graphitization step, densities equalized around 1.76 g/ccg (i.e. our carbon caused no adverse effects in the end). This is a significant validation: it means our carbon can **blend into electrode production** without compromising quality. Electrode manufacturers see this as an opportunity to diversify their raw material supply and reduce reliance on petroleum needle coke, especially as our carbon has a much lower CO_2 footprint. We anticipate scaling these trials up and potentially supplying carbon for commercial electrode production in the near future.

- **New Carbon-Enriched Fertilizer Product:** We are working on a proprietary fertilizer/soil additive that incorporates Graforce carbon. By binding nutrients to our porous carbon, we create a fertilizer that not only provides essential minerals to crops but also **stores carbon in the soil**. This product aims to significantly cut CO_2 emissions associated with fertilizer production (since our process emits no CO_2 and even uses waste streams), and once applied, the carbon remains sequestered in farmland. Initial field tests are planned to evaluate improvements in soil moisture retention and crop yield. The farming industry and even governments (through regenerative agriculture programs) have shown interest in such a solution, since it could help meet climate targets in agriculture. This could open up a completely new and **very large market** for solid carbon, with demand in the megaton range if adopted widely (considering the volume of fertilizers used globally).

Each of these examples demonstrates that **real-world customers are actively seeking Graforce's carbon** for large-scale uses. This interest gives us confidence that for every kilogram of hydrogen we produce, the 3 kg of solid carbon co-product can find a high-value home – whether in a **chemical plant, a foundry, a bridge, or a farmer's field**. Far from being a niche waste, our carbon is on track to become a major **industrial commodity** in its own right.

High-Quality Carbon with Unique Properties

One reason our carbon can penetrate these diverse markets is its **exceptional quality and properties**, which often **exceed those of conventional carbon blacks or cokes**. Some key characteristics of Graforce's solid carbon (as produced from methane plasmalysis) are:

- **Ultra-High Purity:** The carbon is ~99.9% pure carbon by XRF analysis. Inorganic impurities (like metals) are in the low ppm range (e.g. iron ~0.007%), and ash content is practically negligible (0.02–0.3%). This purity is **unmatched by typical petroleum coke or even many specialty carbon blacks**, and it means our material performs consistently and won't introduce contaminants in sensitive processes (e.g. battery cells, electrodes, or fertilizers).
- **High Fixed Carbon, Low Volatiles:** Graforce carbon has >96–97% fixed carbon content and very little volatile matter (around 2%). Essentially all you get is carbon, with minimal smoke, moisture (~0.5–1%) or off-gassing. This makes it ideal for high-temperature applications (it won't emit tar or gases) and ensures stability as a long-term additive in materials.
- **Lightweight, High-Structure Powder:** Our carbon is produced as an extremely fine, "fluffy" powder with a bulk (tap) density around **0.26 g/mL** – much lighter than standard carbon blacks (for example, a common N990 carbon black is ~0.77 g/mL). This means it has a **high structure and porosity**, which correlates with a larger surface area (~32–38 m²/g by BET analysis). In practical terms, the material is easy to disperse and can provide more surface contact in applications like catalysis, filtration, or as a

reactive additive. Despite being light, it still has a calorific value (~8000 cal/g) on par with conventional carbon blacks, reflecting its carbon richness.

- **Mixed Nanostructure (Amorphous/Fibrous):** Unlike the uniform spheroidal particles of typical furnace carbon black, Graforce carbon features a **unique morphology**: under electron microscopes we see **amorphous carbon clusters, interwoven with 2D graphene-like nanosheets and nano-fibrous structures**. This combination is highly unusual from a single process and gives our carbon a versatile profile. The nanosheets can enhance electrochemical performance in batteries or supercapacitors, the porous clusters are great for filtering and adsorption, and the fibrous portions add electrical conductivity and mechanical reinforcement (useful in composites or rubber). Essentially, our carbon can play multiple roles at once (conductive filler, structural additive, etc.), adding value in products from **battery electrodes to polymer composites**.
- **Electrical Conductivity:** Thanks to the graphitic nano-domains in it, Graforce carbon is **electrically conductive** – measured at about 4–6 S/m under compression. While it's not as conductive as fully graphitized carbon, it is sufficient to impart antistatic or conductive properties when mixed into plastics, rubbers, concretes, and paints. Moreover, the conductivity improves with pressure (particles making better contact), which is ideal for compacted uses like electrodes or pressed composite materials. This property underpins our **conductive concrete** and also suggests uses in making ESD-safe (electrostatic dissipative) materials and sensor-integrated rubbers.
- **Thermal Stability:** Our carbon remains stable at high temperatures. Thermogravimetric analysis shows **no significant weight loss up to ~800°C in inert atmosphere**. Even in air, it only starts oxidizing around 650°C, which is on par with many graphitic carbons. This means it can be used in high-temp processes (steelmaking, refractories) without decomposing. It can also serve as a **carbon-neutral fuel** in applications like cement kilns if ever needed, since its combustion releases only previously-captured biogenic CO_2 (when sourced from biomethane).
- **Excellent Dispersibility & Mixability:** Graforce carbon has an Oil Absorption Number (OAN) of ~72–74 mL/100g, roughly double that of a reference N990 carbon black (~33 mL). A higher OAN indicates a more structured, aggregate-rich carbon that can absorb more liquid. In practical terms, this means our carbon **mixes extremely well with oils, polymers, and binders**, ensuring uniform distribution in rubber compounds, plastics, inks, or concrete admixtures. Users have found that it blends readily without clumping, and its high structure can even reinforce materials (similar to how carbon black strengthens tires). This high dispersibility is a key quality marker for many technical applications.
- **Proven Industrial Compatibility:** We have thoroughly tested our carbon's performance against industrial standards. For instance, in the TiO_2 pigment production context, carbon must be robust enough to avoid excess fines that could disrupt reactors. Our carbon passed this test: after simulating the handling and chlorination conditions, the **particle size distribution remained largely above 500 µm, with only ~3–4% fine fraction** – well within industry norms and even better than some benchmark carbons that had up to 7% fines. Also, the ultrafine (<50 µm) portion was minimal, indicating stability. These results confirm that Graforce carbon can be used in **demanding processes (like chlorination or high-temperature reactors) without breaking down**, a testament to its mechanical strength. Moreover, our carbon is produced in a plasma process and **needs no additional milling or post-treatment** – it comes out ready to use, saving energy and cost in the supply chain.
- **Lower Carbon Footprint:** Perhaps most importantly, every ton of our carbon avoids a substantial amount of CO_2 compared to conventional carbon materials. If produced from

natural gas (or biomethane) with renewable power, our analyses show **on the order of 5.5 tons of CO_2 are avoided per ton of Graforce carbon** when replacing petcoke-based carbon black. This accounts for the emissions that would have resulted from producing an equivalent amount of carbon black or coke (which involve burning fossil feedstocks). In addition, when our carbon is used in long-lived products (buildings, roads, etc.), it effectively **locks that carbon away** from the atmosphere for decades or more. Thus, our carbon is not just *low-carbon*, it is often *carbon-negative*: it helps remove and store CO_2 from the cycle. This gives it an edge in a world where end-users are increasingly seeking sustainable materials. Companies can reduce their Scope 3 emissions by switching to our product, and even potentially earn **carbon credits** (for example, builders can claim carbon storage in concrete, farmers in soil, etc.). Sustainability is a core selling point of Graforce carbon alongside its technical merits.

To summarize these qualities: Graforce's solid carbon is a **high-performance, versatile material** that meets stringent requirements of various industries (purity, conductivity, strength) while delivering a *much greener footprint*. This combination of **performance + sustainability** makes it very attractive and helps drive the strong market interest we're seeing.

Technical Validation and Scalability

You also asked whether these applications are merely theoretical or truly scalable and economically viable. We're happy to report that **extensive validation work has been done**, and results show that our carbon applications are not only technically **feasible at scale** but also **cost-effective**, with a high substitution potential in large markets:

- **Pilot and Lab Validation:** Many of the use cases described have moved beyond concept. We have: (a) **Pilot concrete mixes** where 20% of cement was replaced by our carbon – they have been tested for compressive strength and durability, showing *no loss in performance*, effectively using carbon as a cement filler in structural concrete. (b) **Prototype batches of conductive concrete bricks** with ~15% carbon, which demonstrated both good strength and reliable electrical heating capability (these were showcased side-by-side with standard bricks for comparison). (c) **Laboratory trials in TiO_2 production** and **graphite electrode making**, done in collaboration with industry partners, to ensure compatibility of our carbon with those processes (results discussed above showed positive outcomes, meeting process specs). (d) **Soil incubation tests** (ongoing) to measure improvements in water retention and nutrient uptake when our carbon is added – early data is promising, mirroring known benefits of biochar. In short, we aren't just assuming our carbon *can* work in these fields; we have actively tested it with experts in each field, and the technology has passed key benchmarks.
- **Economic & Scale Feasibility:** From an economic standpoint, using and scaling our carbon is very promising. Because our hydrogen production inherently co-produces carbon, the marginal cost of generating the carbon is low – we essentially harness the value of what would otherwise be a byproduct. When that carbon is sold into industrial markets, it **improves the overall economics of hydrogen production** significantly. As noted, one case study at a steel plant showed that revenue from carbon sales could reduce hydrogen costs by ~€1.4 per kg, turning a potential disposal cost into a revenue stream. Additionally, the industries we're targeting are **huge (multi-billion dollar markets)** with urgent decarbonization needs, meaning there is both *room and incentive* to adopt our product. For example, the global concrete and cement market is on the order of 4 billion tons per year – even capturing a small percentage of that as carbon additive translates to megatons of carbon demand. The carbon black market is ~14

million tons/year and growing, and calcined petcoke usage in aluminum, TiO_2, and fuels is likewise in the tens of millions of tons. These volumes indicate that if we produce, say, 1 million tons of hydrogen via plasmalysis (which yields ~3 million tons of carbon), it is **realistically feasible** to absorb that carbon across a combination of concrete, steel, chemical, and agricultural uses worldwide. In fact, those sectors are **hungry for sustainable carbon** replacements: cement companies want additives to lower their clinker factor, steelmakers need to cut coal usage, and farmers seek soil enhancers – all aligning with what our carbon offers.

- **Scalability of Production:** On the production side, Graforce's plasmalyzer units are modular and can be scaled in number to increase H_2 and carbon output. Because each module's carbon can be collected, handled, and stored (via standard pneumatic conveyors and silos), scaling to higher output is mainly a matter of adding more modules and downstream handling capacity. We have designed the carbon handling system to be robust and continuous, so larger plants (e.g. dozens of modules producing hundreds of tons of carbon per day) can be realized without bottlenecks. We are also collaborating with EPC firms like Worley to ensure that scale-up to industrial levels (hundreds of MW plasmalysis) is engineered properly for both hydrogen and carbon outputs. **Importantly, the modular nature means carbon production can ramp up in step with demand** – we can start with smaller plants and grow, avoiding a situation of oversupply. Given the active interest from off-takers, we anticipate that any new H_2-plasmalysis plant we deploy will have pre-agreed **carbon supply offtake contracts** in place, which de-risks the business case and proves the scalability on the market side as well.
- **High Substitution Potential:** Each of the targeted applications has a high potential to substitute existing materials **on a one-to-one (or better) basis**. For example, every ton of our carbon used in concrete displaces a ton of cement (saving ~0.9 ton CO_2), plus sequesters 1 ton of carbon permanently – a double climate win. In steel, each ton used can replace a ton of coal or petcoke in furnaces, directly cutting emissions. In batteries or electrodes, our carbon can replace a portion of graphite or carbon black, which helps alleviate supply constraints of those materials. And in fertilizers, each ton of carbon additive can mean a ton less of conventional fertilizer needed (since it improves efficiency of nutrient use) and long-term carbon storage in soil. These substitution ratios are favorable and often come with **added benefits** (e.g. improved product performance or new functionalities as discussed). This means the market isn't forced to take our carbon out of altruism; they take it because it *adds value* while also substituting a more carbon-intensive product. That's the recipe for sustained, large-scale adoption.

In summary, we have a high degree of confidence – backed by data, pilot results, and partner feedback – that Graforce's solid carbon can scale up **hand-in-hand with hydrogen**. By tapping into multiple massive markets and delivering a product that is both **technically superior and environmentally beneficial**, we turn the co-produced carbon into a significant **asset** rather than a liability. The scenarios you worry about (carbon markets being too small) transform when you consider new and expanded applications: the addressable market grows by orders of magnitude, more than enough to accompany the world's hydrogen ambitions. In fact, our vision is that **every ton of carbon we produce enables further decarbonization in another industry** – whether it's greener concrete, cleaner steel, or regenerative agriculture.

Outlook and Next Steps

We remain extremely optimistic about the role of solid carbon in enabling a hydrogen economy. Far from limiting hydrogen's growth, it can be a **catalyst for cross-sector decarbonization**, creating synergies between energy, industry, and agriculture. Graforce is actively engaging with industry leaders in all the mentioned sectors to **scale these solutions**. The interest and pilot projects so far have only strengthened our belief that the demand for our carbon will keep pace with (and in some cases even drive) the deployment of methane plasmalysis for hydrogen.