Pyrolysis to Biochar in NYC - Final Report

Prepared for: Town+Gown: NYC / DSNY

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1. Abstract

This report evaluates pyrolysis technologies suitable for converting DSNY's woody organics and compost overs into biochar and analyzes potential local markets for that biochar in New York City. The client, DSNY, is exploring the feasibility of piloting a non-permanent or mobile pyrolysis unit at the Staten Island Compost Facility at Fresh Kills.

The analysis synthesizes available commercial technologies from vendors including PYREG, BioForceTech, Aries Clean Technologies, and mobile carbonizer systems. These technologies were evaluated for throughput, feedstock compatibility, emissions controls, energy requirements, PFAS destruction potential, capital and operating costs, and suitability for DSNY's operational and regulatory environment.

The report also maps likely biochar demand across NYC Parks, DEP green infrastructure programs, landscape contractors, environmental remediation firms, and urban agriculture groups. Market conditions suggest that several hundred to approximately one thousand tons of biochar per year could realistically be absorbed in the NYC region, especially if DSNY coordinates with partner agencies on early applications.

Overall, containerized continuous pyrolysis units in the one to three tons per day range appear best suited for DSNY's pilot goals. Systems built for biosolids may become important in future phases if DSNY expands into sludge treatment or PFAS mitigation. This report concludes with a recommended procurement strategy and a conceptual pilot framework for Fresh Kills.

2. Introduction

New York City aims to create a more sustainable, circular economy for its organic waste. While DSNY's composting programs successfully convert much of the city's yard waste and food scraps into finished compost, certain organic byproducts remain difficult to manage. One of these is the coarse woody material known as compost overs, which accumulates when finished compost is screened. Overs can exceed available markets and storage capacity.

Pyrolysis offers a promising complementary solution. Through heating biomass in a low-oxygen environment, pyrolysis produces biochar, syngas, and condensates. Biochar is a stable, carbon-rich material that can improve soil structure, water retention, and nutrient dynamics. In city applications, biochar can enhance stormwater management, support green infrastructure, improve tree planting soils, and potentially immobilize contaminants.

DSNY is considering whether a pyrolysis system could help reduce waste volumes, create a beneficial soil product, and open new pathways for carbon sequestration. The Staten Island Compost Facility at Fresh Kills is a logical site for such a pilot due to its large footprint, existing organics flows, and opportunities for operational learning.

This report mirrors the structure and clarity of a prior Town+Gown capstone study, adapting that approach to the specific questions of pyrolysis viability and biochar market potential in New York City.

3. Problem Statement

The central question guiding this project is whether DSNY can deploy a practical, emissions-compliant pyrolysis system that turns woody organic materials into marketable biochar and whether sufficient market demand exists to justify a long-term investment.

Key challenges include:

1. Technology diversity
   Pyrolysis equipment varies widely in scale, feedstock tolerance, automation, emissions control sophistication, and mobility. DSNY needs a structured way to compare these options.

2. Operational and permitting constraints
   Any system at Fresh Kills must meet strict environmental regulations, integrate smoothly with on-site equipment, and be feasible for DSNY operators to maintain.

3. Unclear biochar markets
   Biochar is emerging, not standardized. While promising for green infrastructure and soil restoration, demand volumes and price points must be clarified.

4. PFAS concerns
   While the current focus is woody material, PFAS-containing biosolids may become a future feedstock, so technology choices should consider long-term flexibility.

This report provides the structured analysis needed to address these challenges.

4. Literature Review

Biochar and carbon sequestration

Biochar is recognized for its stability in soils, retaining a significant portion of its carbon for centuries. Its production from urban woody waste offers a carbon-negative opportunity when paired with beneficial soil use.

Soil and water benefits

Research consistently shows improved water retention, reduced bulk density, enhanced nutrient retention, and potential reductions in soil greenhouse gas emissions when biochar is incorporated into soil blends.

Municipal pyrolysis examples

Cities in Europe, Australia, and the United States have installed pyrolysis systems to manage green waste or biosolids. These systems demonstrate that continuous pyrolysis can operate reliably at municipal scale, offering both emissions compliance and stable biochar output.

PFAS destruction

High-temperature pyrolysis has shown promising results in degrading PFAS in sludge and contaminated feedstocks. This is relevant for DSNY's long-term strategic planning, even if the pilot does not initially process biosolids.

Lessons from prior Town+Gown studies

A previous capstone project on construction and demolition waste demonstrated the value of transparent evaluation frameworks, structured analysis, and clear communication for supporting policy and procurement decisions. This report follows that model.

5. Project Context and Data

Project goals

DSNY seeks to pilot a pyrolysis system capable of processing woody debris and compost overs. The equipment should ideally be non-permanent, modular, or mobile, enabling relocation to other DSNY sites after the Fresh Kills pilot.

Data inputs

This report relies on publicly available vendor specifications, academic research on pyrolysis and biochar applications, municipal case studies, and contextual knowledge about NYC's composting operations and soil-based programs. No proprietary DSNY operations data were required.

Feedstock assumptions

For sizing and comparison, we assume compost overs and woody materials at 25 to 50 percent moisture, ground to manageable particle sizes. Feedstock volumes at Fresh Kills appear sufficient to support a one to three tons per day pyrolysis unit.

6. Technology Landscape and Vendor Information

Technology categories

1. **Open flame-cap and simple batch kilns**
   Low cost but not practical for an urban environment due to limited emissions control.

2. **Enclosed batch retort kilns**
   Cleaner than open kilns but still labor-intensive and relatively low in throughput.

3. **Continuous containerized pyrolysis units**
   Highly suitable for municipal operations, offering emissions control, enclosure, and scalability.

4. **Integrated drying and pyrolysis systems for biosolids**
   Designed for wastewater utilities; relevant to future PFAS and sludge management scenarios.

5. **Mobile trailer-mounted systems**
   Designed for forestry and field operations. Potentially useful for storm debris but less suited for routine processing at a composting site.

Representative vendors

Vendor	Proximity/Role	Primary Market Focus	Key Differentiator & Spec Data	Ideal for DSNY
PYREG	European company with multiple systems in North America; common reference for municipal biochar projects.	Biochar from biomass and biosolids; carbon removal and nutrient recovery.	Continuous, containerizable slow-pyrolysis plants; mid-scale capacity (roughly 1–3+ t/day) with integrated gas cleaning.	Strong reference + potential vendor for a containerized pilot and future sludge/PFAS phases.
ARTi	US-based (Iowa); active in North American biochar projects.	Containerized biochar reactors for woody biomass, crop residues, and other organics..	Modular 20-/40-ft container systems; multiple reactors per container; pilot to multi-ton/day configurations.	Very good match for a containerized DSNY pilot at Staten Island using woody debris and overs.
BioForceTech	US company (California) with municipal installations.	Biosolids drying + pyrolysis to produce engineered biochar.	Integrated BioDryer + Sigma continuous pyrolysis line; high volume reduction and PFAS-focused marketing.	Best as a future option for NYC wastewater/biosolids, not for initial compost-overs pilot.
Aries Clean Technologies	*US firm with large biosolids facilities (e.g., in NJ).*	Large-scale gasification/pyrolysis of biosolids for energy and char/ash..	Fluidized-bed reactors sized for hundreds of tons/day; waste-to-energy plus mineral product.	Useful long-term reference for centralized sludge treatment, not a small compost-site pilot.
Air Burners – CharBoss	*US manufacturer; mobile units used for forest and land-management projects.*	Mobile treatment of wood and vegetative waste with biochar co-product..	Trailer-mounted air-curtain burner with biochar recovery; self-contained and towable.	Good for storm-debris piles and demos; could complement but not replace a containerized pilot.

7. Methodology

Technology screening

Systems were screened for scale, enclosure, emissions control, feedstock compatibility, and mobility potential.

Technology scoring

Technologies were evaluated on throughput, energy efficiency, operational complexity, biochar quality, PFAS treatment ability, footprint, capital and operating costs, and vendor track record.

Market analysis

The market analysis identifies potential buyers, matches biochar characteristics to application needs, estimates reasonable demand volumes, and considers price ranges based on similar markets.

8. Meetings

Big Reuse Compost Program

The meeting with Big Reuse established a foundational understanding of DSNY's organic feedstock characteristics and their implications for biochar production. It highlighted the high moisture content of food scraps and compostable materials, emphasizing the need for drying and stabilization as essential pre-processing steps. Discussions clarified that biochar should be viewed not as a profit-oriented commodity but as a long-term environmental asset that enhances soil structure, stormwater performance, and circular-economy value. The collaboration with Big Reuse centers on public education, demonstration projects, and community engagement, laying the groundwork for integrating biochar applications into NYC's sustainability initiatives.

Pyrolysis System Engineering (DP / GB + MOT Team)

This technical session provided an in-depth overview of the engineering requirements and operational principles for pyrolysis systems. The team reviewed the importance of maintaining an oxygen-free, temperature-stable environment to ensure safe operation and high-quality biochar production. Emission control systems—such as particulate filters and scrubbers—were identified as critical for environmental compliance. Two system models were compared, highlighting trade-offs between capacity, stability, and cost. The discussion also emphasized operator training and data tracking through the Mission Control framework, forming the technical foundation for DSNY's future pilot-scale implementation.

Cincinnati Parks / PRD Biochar Program

The meeting with Cincinnati Parks and PRD offered a practical, real-world perspective on operating municipal-scale pyrolysis systems. Participants discussed the challenges of feedstock variability, moisture control, and diverse site conditions, along with the need for tailored reactor selection and operator training. Air-quality compliance processes were reviewed, including coordination with the EPA and Ohio EPA, where low permit fees contrast with high documentation needs due to the lack of formal biochar codes. The conversation underscored the growing but still nascent biochar market and set a vision for a 10-year regional sustainability plan linking soil health, stormwater management, and urban forestry.

Final Integrated Insight

Collectively, the three meetings provided a comprehensive framework linking feedstock management, technological feasibility, and long-term implementation. Big Reuse defined the upstream realities of organic material handling and community engagement; the DP/GB session established the engineering and operational blueprint; and the Cincinnati Parks discussion illustrated deployment, compliance, and market integration. Together, they form a coherent system pathway—from feedstock preparation to pyrolysis processing, emissions control, and market adoption—supporting DSNY's long-term goal of developing a scalable, low-emission, and community-aligned biochar program for New York City.

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9. Biochar Market Analysis

9.1 About Biochar

Biochar is a carbon rich material produced when organic biomass is heated under controlled conditions with limited oxygen. In this project, biochar is examined not as a standalone product, but as the outcome of a broader system that connects waste management, environmental stewardship, and urban infrastructure. The feedstocks relevant to New York City include woody debris, yard waste, and compost overs generated through routine DSNY operations. When subjected to pyrolysis at stable temperatures, typically near five hundred degrees Celsius, these materials undergo transformation rather than combustion, yielding a solid form of carbon that is both chemically stable and environmentally durable.

What distinguishes biochar from other organic soil amendments is its permanence. Unlike compost, which continues to decompose, biochar remains intact for centuries, storing carbon while improving soil structure, water retention, and nutrient availability. Conversations with DSNY partners and compost operators reinforced that biochar's value lies less in short term commercial returns and more in its capacity to support long term city objectives. These include climate mitigation, stormwater management, and soil resilience. As a result, biochar is best understood not as a commodity competing in traditional markets, but as a strategic material embedded within a circular urban system.

9.2 Important Factors for Biochar Market Analysis

Evaluating the biochar market requires attention to a set of interrelated factors that extend beyond simple supply and demand. The first is feedstock quality and consistency. Urban organic waste streams vary widely in moisture content and composition, and this variability directly affects system performance and output quality. Effective pre-processing and moisture management therefore play a central role in determining whether biochar production can be reliable at scale.

A second factor is product specification. Biochar is not a uniform material, and its characteristics such as particle size, porosity, pH, and trace metal content shape its suitability for different uses. Stakeholder interviews highlighted that higher quality biochar enables broader applications but also increases production costs. This creates a tradeoff between maximizing performance and maintaining operational feasibility. Successful market adoption depends on aligning production specifications with realistic end uses rather than pursuing theoretical optimal quality.

Regulatory context is a third critical consideration. While biochar itself is lightly regulated, the technologies that produce it are subject to air quality and emissions standards, particularly in dense urban environments. Experiences shared by municipal programs in other cities suggest that early engagement with regulators and transparent emissions data can significantly reduce implementation risk. Finally, market maturity must be acknowledged. Biochar adoption is still driven primarily by institutional users who value environmental outcomes, which means education, demonstration projects, and internal alignment are as important as pricing in shaping demand.

9.3 Biochar Market in US

Across the United States, the biochar market is growing steadily but unevenly. Demand has emerged most strongly in applications where environmental performance matters more than immediate financial return. These include agriculture, landscaping, environmental remediation, stormwater management, and urban forestry. In these settings, biochar is valued for its ability to improve system performance over time, whether by enhancing soil health, reducing runoff, or sequestering carbon.

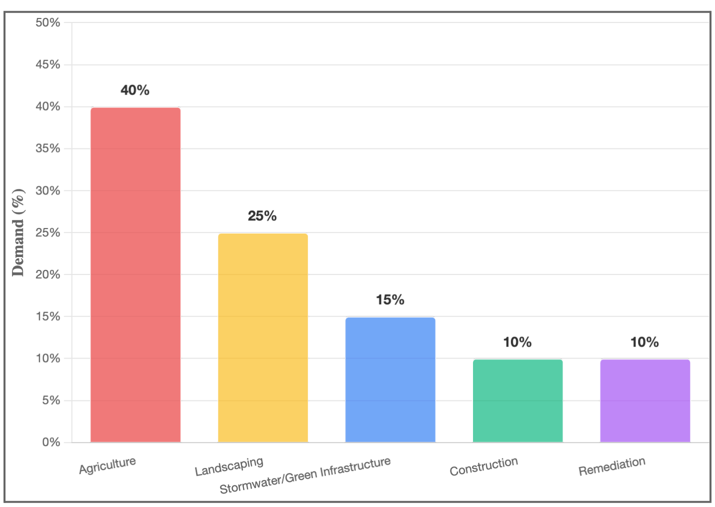


Figure 1: Biochar uses in U.S.

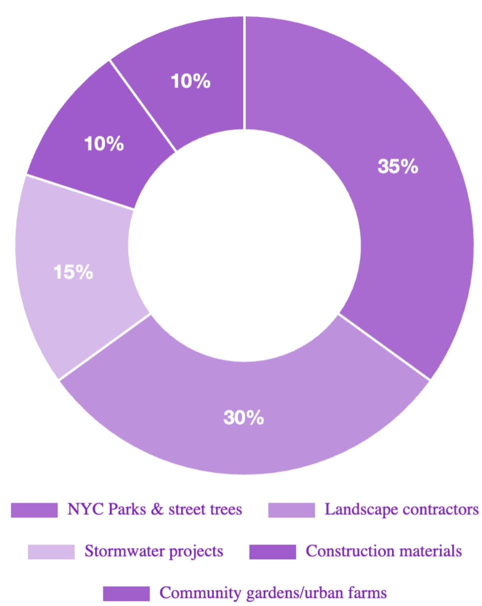
Municipal case studies illustrate how public sector demand can anchor early stage markets. Cities that integrate biochar into existing programs such as tree planting or soil restoration create stable internal demand while gaining operational experience. Pricing across the United States reflects this developmental stage. Lower value applications cluster around conservative price points, while higher value uses remain limited to niche contexts with specific performance requirements. The national picture suggests that biochar succeeds when it is embedded in broader sustainability strategies rather than positioned as an independent revenue generating product.

9.4 Biochar Market for New York City

In New York City, the biochar market is best understood as a municipal and institutional ecosystem, rather than a traditional commercial marketplace. Potential end uses identified through this project include street-tree planting mixes, municipal landscaping, stormwater and green infrastructure systems, compost blending, and selective construction material applications. These use cases closely match NYC's environmental priorities and existing agency operations.

Key local buyers and partners include NYC Parks, DSNY (for internal reuse), DEP/MOCEJ-affiliated initiatives, large landscaping contractors, and community organizations such as Big Reuse. Stakeholder interviews emphasized that blended products, such as compost mixed with biochar, are more likely to achieve adoption than raw biochar alone, due to ease of use and clearer performance benefits.

However, several barriers remain specific to NYC. These include stringent emissions and permitting requirements, uncertainty around long-term procurement pathways, limited large-volume buyers, and sensitivity to production costs relative to perceived benefits. As highlighted in the final presentation, the most realistic pathway forward is a pilot-based approach, where DSNY produces biochar at a modest scale, validates quality and use cases, and gradually expands deployment across agencies and sites.



Overall, the NYC biochar market is less about external sales and more about capturing environmental, operational, and climate value internally. With the right equipment, partnerships, and phased strategy, biochar has strong potential to become a durable component of New York City's circular waste management system.

9.5 Potential Buyers

1. Batch and Retort Systems:

While these systems are capable of producing biochar, their labor intensity and permitting challenges make them impractical for DSNY's operational scale. As a result, biochar generated through these systems would primarily support localized and community focused use cases rather than citywide deployment.

Potential users in New York City include community gardens and urban agriculture programs supported by organizations such as GreenThumb, nonprofit composting and reuse organizations like Big Reuse, and academic institutions conducting pilot research or soil studies. These groups value experimentation, education, and soil improvement over consistent high volume supply and would benefit from small batch production tied to outreach or demonstration initiatives.

2. Continuous Containerized Systems:

Biochar produced from containerized systems could be directly utilized by NYC Parks for street tree planting, soil blending, and urban forestry applications. DSNY itself could use the material internally to enhance compost products and improve soil performance across city managed sites. Additional institutional users include DEP and MOCEJ affiliated green infrastructure projects focused on stormwater management. Large landscaping contractors that work on municipal projects, including those serving Parks and DOT installations, also represent viable downstream users if material specifications are met.

3. Biosolids Oriented Systems

Biochar produced from biosolids oriented systems would likely be directed toward highly regulated applications. Potential users include environmental remediation firms operating within New York City, agencies involved in brownfield redevelopment, and research partners evaluating contaminant immobilization.

4. Mobile Units

In New York City, potential users of biochar from mobile systems include NYC Parks operations responding to storm damage, short term soil restoration projects, and pilot demonstrations coordinated with community partners. These use cases emphasize rapid deployment and proximity rather than long term supply consistency. While mobile systems are not ideal as a core production strategy, they can support targeted applications and early proof of concept efforts.

Vendor	Proximity/Role	Primary Market Focus	Key Differentiator & Spec Data	Ideal for DSNY Biochar
NY Carbon	*Local Producer (Hudson Valley, NY)*	Compost, Landscaping, Stormwater, Building Materials, Carbon Sequestration.	Certification: NOFA-NY approved for USDA Organic use. Feedstock: Clean wood-cuts. Role: Local buyer/collaborator with established regional distribution channels.	High-Volume Bulk Sales & Collaboration
Standard Biocarbon	*Regional Producer (Maine/New England)*	Engineered Soils, Landscaping, Turf, Environmental Remediation, Carbon Sequestration.	Organic Carbon: >90% (Highest fixed carbon). Ash Content: <2% (Extremely low). Purity: Tested for PFAS, PAHs, Dioxins. Role: Major professional/industrial bulk buyer.	High-Value, High-Purity Bulk Sales
CharGrow	*National Supplier*	Soil Mixes, Erosion Control, Landscaping, Turf, Vegetable Gardens, Composting.	Certification: Exceeds IBI Standards and NOP Standards. Particle Size: 3mm minus. Process: Slow Pyrolysis (~850°F) for stability. Role: Bulk ingredient buyer for their blended soil products.	Ingredient Buyer for Blended Products
Bio365	*Regional Supplier (NY Presence)*	Horticulture, Turf, Tree Applications. Primary focus on finished soil media.	Product: Uses bioCORE™ (high-temp, low-ash biochar) as an ingredient (1-7% by volume) in OMRI-Listed, prepared soil mixes. Role: Direct, dedicated ingredient buyer.	Raw Biochar Ingredient Sales
American BioCarbon	*National Supplier*	Soil Amendment, Water Filtration, Hydroponics, Carbon Sequestration.	Key Spec: Biochar suitable for water filtration (high surface area/porosity) and carbon sequestration (high stability/fixed carbon). Role: Diversified end-user for both environmental and agricultural markets.	Remediation & Carbon Sequestration Sales

10. Air pollution emission analysis

Air permitting is a critical regulatory component for the deployment of pyrolysis systems within municipal solid-waste and compost operations.
It ensures that process emissions remain within federal and state environmental limits, while providing a framework for operational transparency and safety.
For the Department of Sanitation of New York (DSNY), securing air permits represents both a compliance requirement and a demonstration of environmental stewardship, particularly as the city explores scalable, low-emission pathways for biochar production.

Category	Description	Risk Level	Key Considerations
Compliance Path Clear	The technology has already received positive feedback from the U.S. EPA and meets established air-quality and emission standards.	Low	Streamlined permitting process; minimal documentation required; suitable for near-term deployment.
Technology New	Represents emerging or modified pyrolysis systems that require additional validation, testing, and documentation to verify compliance.	Moderate	Pilot-scale data and emission-testing reports must be provided; moderate review time before approval.
Oxygen Intrusion Risk	Occurs when oxygen unintentionally enters the reactor, triggering partial combustion and short-term emission spikes.	High	Requires precise temperature control, airtight system design, and continuous operational monitoring.

Emission Characteristics and Control Measures

Pyrolysis operates under oxygen-limited conditions, which prevents open combustion and reduces uncontrolled smoke or flame formation.
The primary emission constituents include fine particulates, acidic gases such as HCl, SO_2, and HF, and trace amounts of volatile organic compounds.
To mitigate these pollutants, systems integrate particulate filters and wet scrubbers, which capture dust and neutralize acidic gases before discharge.
Maintaining consistent reactor conditions—temperature, residence time, and oxygen exclusion—is essential for ensuring stable operation and reproducible emission performance.
When compared with conventional waste-management methods such as composting or open burning, pyrolysis can reduce total pollutant output by more than half, while simultaneously generating a stable, carbon-rich biochar product that contributes to carbon sequestration.

Regulatory Framework and Agency Coordination

Air permitting for pyrolysis requires coordination among multiple regulatory bodies, including the U.S. Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (DEC), and local air-quality management authorities.
Although the annual permit fee—approximately $200 per unit—is minimal, the administrative process demands rigorous documentation of emission controls and environmental safeguards.
Because biochar currently lacks a specific regulatory code, DSNY and its partners are expected to play an active role in educating regulators and helping define appropriate classifications under existing combustion or carbonization standards.
Key compliance areas include not only air emissions, but also stormwater management, feedstock storage, and handling of residual ash or condensates.

Operational and Technical Implications

To maintain compliance, pyrolysis systems must be equipped with:

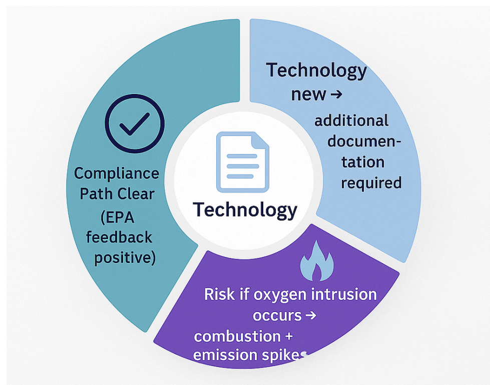
- Airtight enclosures and seals to eliminate oxygen intrusion;
- Automated temperature-control systems for process stability;
- Real-time emission monitoring for rapid response to performance deviations;
- Portable filtration and scrubbing units for mobile or containerized systems.

Operator training is equally vital. Personnel should understand the correlation between feedstock moisture, reactor temperature, and emission behavior to maintain safe, repeatable performance.
Comprehensive data collection and transparent reporting will strengthen DSNY's regulatory position and support continuous improvement across sites.

Summary and Implications for DSNY

The success of DSNY's air-permitting strategy depends on selecting technologies with verified emission control, documented operational safety, and regulatory alignment.

- Low-risk systems—those with proven compliance—can advance quickly to pilot or demonstration phases.
- Moderate-risk systems offer innovation potential but require extensive documentation and agency engagement.
- High-risk scenarios emphasize the need for airtight operation and active monitoring to prevent combustion events.



Overall, a well-designed air-permitting framework not only enables legal compliance but also reinforces DSNY's commitment to sustainable waste-to-value innovation and climate-positive outcomes.

11. Results

11.1 Technology Assessment

Batch and retort systems

Useful for community projects and demonstrations, but too small, labor-intensive, and difficult to permit for DSNY's operational scale.

Continuous containerized systems

Provide the best balance of throughput, emissions performance, modularity, and ease of relocation. Strong fit for Fresh Kills and future DSNY applications.

Biosolids-oriented systems

Highly advanced and essential for long-term PFAS management. They may be considered in later phases but exceed the needs of a woody-feedstock-focused pilot.

Mobile units

Valuable for storm response or temporary field operations, though not ideal for routine processing at Fresh Kills due to more limited emissions control.

Technology Type	Emissions Control	Throughput	Mobility	Suitability for DSNY Pilot
Open kilns	Low	Low	High	Low
Retort kilns	Medium	Low	Medium	Low to Medium
Containerized continuous	High	Medium	Medium	High
Biosolids-oriented systems	High	High	Low	Medium (future phases)

Mobile trailer systems	Medium	Medium	High	Medium

Summary table: Continuous containerized units emerge as the most practical option for DSNY's near-term goals.

11.2 NYC and Regional Biochar Market Analysis

Potential demand segments

1. NYC Parks
   Biochar can be incorporated into tree pits, sports field renovations, natural area restoration, and general landscape soils.

2. DEP green infrastructure
   Engineered soils for bioswales, rain gardens, and stormwater systems can benefit from the water-holding and structural properties of biochar.

3. Landscape and construction contractors
   Private developers with sustainability goals are increasingly open to low-carbon soil amendments.

4. Urban agriculture and community gardens
   Smaller but enthusiastic user base for soil conditioning and compost blends.

5. Environmental remediation
   Biochar can be used in amendments for contaminant immobilization and brownfield stabilization.

Expected market absorption

A pilot scale of 300 to 1,000 tons of biochar per year appears realistic for NYC's current and emerging applications, especially if DSNY coordinates with Parks and DEP to develop standardized soil mixes incorporating biochar.

Pricing

Bulk biochar typically ranges from a few hundred dollars per ton to over one thousand dollars per ton for specialty products. The NYC market would likely fall in the mid-range, depending on product quality and blending.

11.3 Fresh Kills Pilot Concept

Site integration

The pilot would integrate grinding, optional drying, continuous feeding into a containerized pyrolysis unit, and covered storage of cooled biochar. A concrete pad, electrical service, and safe loader access would be required.

Staffing

One or two dedicated operators supported by existing compost facility staff could manage the system. Vendor support would be important during commissioning.

Monitoring

Key data to collect include fuel and power use, feedstock moisture, biochar yield, emissions performance, and results from soil application trials with agency partners.

12. Discussion

The analysis shows that DSNY is well positioned to pilot a pyrolysis system at Fresh Kills using existing organics streams. The technology exists, is commercially proven, and aligns with NYC's sustainability goals. Local market conditions appear strong enough to support the distribution of biochar, particularly through partnerships with NYC Parks and DEP.

While there are uncertainties around permitting, long-term economics, and market adoption rates, these risks can be managed with a well-designed pilot that emphasizes monitoring, collaboration, and flexibility.

Pyrolysis should not replace composting but rather complement it, creating an outlet for tough-to-use woody fractions and contributing to the city's broader climate and soil health initiatives.

13. Conclusion

Pyrolysis represents a viable, strategically aligned opportunity for DSNY to add value to woody organics and compost overs. Continuous, containerized pyrolysis units offer a balance of operational robustness, emissions compliance, and flexibility that suits a Fresh Kills pilot.

There is credible local demand for biochar, particularly from agencies involved in soil-based infrastructure and urban greening. With thoughtful planning, DSNY could establish biochar as a locally produced, environmentally beneficial material and integrate it into multiple city programs.

This report supports moving forward with a pilot installation, continued vendor engagement, and early coordination with biochar end-users across city agencies.

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14. Recommendations for DSNY

1. Develop a formal RFI or RFP that clearly states pilot goals, feedstock characteristics, mobility needs, and emissions expectations.
2. Prioritize containerized continuous pyrolysis units for the pilot phase, focusing on systems in the one to three tons per day range.
3. Coordinate early with NYC Parks and DEP to develop pilot soil mixes and trial plots incorporating biochar.
4. Create a structured monitoring program to track operational performance, emissions, biochar quality, and user feedback.
5. Plan for the future possibility of PFAS-containing feedstocks, ensuring chosen technologies can evolve as regulations demand.
6. Invest in outreach and education to build familiarity with biochar among city agencies, contractors, and community users.

15. Future Scope

This project establishes a strong foundation for continued collaboration and deeper technical and market exploration. New York University has previously completed capstone work with Future Labs, including projects supported by Michael Frank at Data Future Labs, demonstrating an existing relationship and institutional familiarity with this ecosystem. Building on that history, there is clear potential to extend this work beyond the current semester.

One potential direction is to continue the project with a more focused scope, aligned with specific operational or policy questions identified during this phase. These could include deeper evaluation of pilot scale deployment strategies, refined emissions and permitting analysis, or expanded assessment of downstream biochar applications within city agencies. The possibility of continuing the work along targeted directions was discussed, particularly where early findings suggest strong alignment with DSNY and Town & Gown priorities.

There is also an opportunity for co-sponsorship, should Future Labs wish to engage more formally. A co-sponsored structure could allow the project to integrate applied research, startup ecosystem perspectives, and municipal implementation considerations. This would enable future student teams to build on the current analysis while advancing toward pilot design, procurement guidance, or policy frameworks.

Overall, the project is well positioned to evolve from an exploratory assessment into a more implementation oriented effort. Continued collaboration among DSNY, Town and Gown, NYU faculty, and external partners such as Future Labs would allow subsequent phases to translate analytical insights into practical, scalable outcomes for New York City.

15. References

- Vendor documents and technical specifications from leading pyrolysis equipment manufacturers.
- Peer-reviewed studies on biochar's soil, environmental, and carbon sequestration benefits.
- Municipal case studies from U.S. and international biochar programs.
- Industry reports on PFAS destruction using thermal treatment technologies.
- NYC agency materials related to green infrastructure, landscaping, and organics management.

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16. Appendices

Appendix A: Technology Evaluation Rubric

A detailed scoring sheet comparing vendors and system types.

This rubric was developed to systematically evaluate pyrolysis and biochar production technologies relevant to DSNY's operational needs and long term sustainability goals. It enables consistent comparison across system types and vendors by applying a common set of evaluation dimensions aligned with scale, environmental performance, operational feasibility, and strategic fit for New York City.

Evaluation Dimensions

1. **Throughput and Scalability**
   This dimension evaluates the system's ability to process woody biomass at volumes compatible with DSNY operations. Consideration is given to current processing capacity, modular expandability, and the feasibility of scaling from

a pilot system to a larger deployment over time.

2. **Environmental Performance and Permitting**
 This dimension assesses emissions control technologies, air quality impacts, and the likelihood of successful permitting within New York City. Systems with advanced gas handling, enclosed processing, and demonstrated regulatory compliance score higher.

3. **Operational Complexity and Staffing Requirements**
 This dimension examines labor intensity, level of automation, maintenance demands, and required operator expertise. Technologies that integrate smoothly into existing DSNY workflows and require minimal specialized staffing are scored more favorably.

4. **Mobility and Siting Flexibility**
 This dimension evaluates whether the system can be containerized, relocated, or adapted to multiple sites. Systems that offer flexibility for deployment at Fresh Kills and potential future DSNY locations receive higher scores.

5. **Feedstock Compatibility and Reliability**
 This dimension considers the system's ability to consistently process DSNY generated woody biomass, including variability in size, moisture content, and contamination risk. Systems tolerant of feedstock variation score higher.

6. **Biochar Quality and Market Suitability**
 This dimension evaluates the stability, purity, ash content, and carbon content of the biochar produced. Higher scores are given to systems capable of producing biochar suitable for NYC markets such as soil amendment, landscaping, remediation, and carbon sequestration.

7. **Safety and Community Impact**
 This dimension assesses operational safety, noise, odor, and overall community compatibility. Systems designed for enclosed operation with minimal off site impacts score more favorably in dense urban environments.

8. **Cost Considerations and Long Term Viability**
 This dimension examines capital costs, operating costs, maintenance expenses, and long term economic sustainability. Technologies that balance upfront investment with durable performance and future revenue potential receive higher scores.

Appendix B: Biochar Quality Testing Plan

Methods for analyzing carbon content, pH, ash, contaminants, and physical properties.

This testing plan outlines the analytical methods used to evaluate biochar quality produced through pyrolysis systems under consideration for DSNY. The purpose of this plan is to ensure that biochar meets regulatory requirements, aligns with market expectations, and supports intended end uses such as soil amendment, environmental remediation, and carbon sequestration within New York City.

Testing Objectives

1. Verify carbon stability and suitability for long term sequestration

2. Confirm chemical properties required for agricultural and environmental applications

3. Identify potential contaminants that could limit marketability or regulatory approval

4. Assess physical characteristics that affect handling, blending, and application

Analytical Methods and Parameters

1. **Total Carbon Content**
   Total carbon content will be measured using elemental analysis through dry combustion. This method determines the percentage of carbon by mass and provides insight into the stability and sequestration potential of the biochar. Higher fixed carbon values indicate greater long term carbon storage capacity.

2. **Fixed Carbon and Volatile Matter**
   Proximate analysis will be conducted to quantify fixed carbon, volatile matter, and moisture content. This analysis helps distinguish between stable carbon fractions and more reactive components that may influence performance or emissions during handling.

3. **pH and Electrical Conductivity**
   Biochar pH will be measured using a standardized water slurry method. Electrical conductivity will also be evaluated to assess salt content. These parameters are critical for determining suitability for soil applications and avoiding negative impacts on plant growth.

Appendix C: Market Engagement Plan

Proposed outreach and stakeholder engagement with key NYC agencies and private contractors.

This market engagement plan outlines a structured approach for engaging public agencies, private organizations, and potential end users to support the adoption and utilization of biochar produced through DSNY aligned pyrolysis systems. The goal of this plan is to validate demand, identify priority use cases, and build relationships that enable practical deployment within New York City.

Key Public Sector Stakeholders

1. **New York City Department of Parks and Recreation**
   Outreach will target applications in street tree planting, park soil improvement, erosion control, and long term soil health management.

2. **New York City Department of Environmental Protection**
   Engagement will explore stormwater management, green infrastructure, filtration media, and water quality improvement applications.

Private Sector and Nonprofit Stakeholders

1. **Compost and Soil Product Manufacturers**
   Organizations such as Bio365 and CharGrow will be engaged to assess demand for biochar as an ingredient in blended soil products and compost amendments.

2. **Environmental and Remediation Firms**
   Companies focused on soil remediation, filtration, and green infrastructure will be contacted to evaluate higher specification biochar use cases.

3. **Nonprofit and Community Organizations**
   Groups such as Big Reuse will be engaged to support education, training, and community based applications of biochar.

4. **Carbon and Climate Focused Organizations**
   Engagement with organizations involved in carbon accounting and sequestration will help evaluate long term climate value and potential credit pathways.