Rheaply

Leveraging AxM Technology to Empower Material Reuse and Embodied Carbon Reporting in the Built Environment

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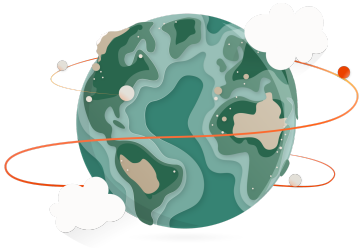
Topic 4: Sustainable Materials Management | SubTopic 4D: Low Impact Construction Materials and Technologies that Reduce Embodied Carbon of Buildings

Wayfinding

Technical & Commercial Volume

"Climate change is the existential threat to humanity."
– President Joe Biden



The world population has extensively harvested Earth's limited resources as though such resources would never run out. This Malthusian consumption -- long unchecked, has unearthed dire consequences as global atmospheric carbon dioxide (CO2) concentrations have radically increased and revealed a steady drip of resultant environmental problems. In a quest for remedies to this "carbon problem," world governments, private organizations and individual citizens are continually exploring ways to conserve our materials consumption demands from the remaining capacity left on Earth. Business as usual cannot continue.

However, therein lies a paradoxical challenge. The very carbon usage we are trying to squeeze and demand less of, is simultaneously a critical linchpin to many aspects of our global future, including economic development, infrastructure redevelopment and energy production. To fulfill our human needs while still remaining competitive in the world economy, the U.S. must focus on sustainable use of materials.[1]

As the single largest consumer of materials and energy use worldwide, the construction sector remains a prime target for materials reuse reform. (Krausmann et al., 2009; De la Rue du Can & Price, 2008). Construction and ongoing operation of the built environment extracts a significant amount of resources -- and on an ongoing basis. According to the U.S. Green Building Council (USGBC), buildings account for approximately 40% of total energy use, 40% of raw materials use, 30% of waste output, 13.6% of total potable water consumption, 73% of total electricity consumption, and 38% of greenhouse gas (GHG) emissions (USGBC, 2015). Research, regulatory compliance and even voluntary efforts to lower the built environment's GHG demand have consistently and aggressively focused on managing, measuring and reporting the energy efficiency lifecycle from design through post-occupancy performance.

However, energy efficiency is responsible for only *one* portion of a building's GHG emissions; its operational carbon impact. Embodied carbon -- the remaining carbon impact -- derives from the combined GHG emissions caused by extraction, manufacture, transportation, construction, maintenance, replacement, deconstruction, disposal, and end of life activities for the collective materials and systems that comprise a building. Annually, embodied carbon is responsible for 11% of global GHG emissions and 28% of global building sector emissions.

Sustainable Materials Management demands a lifecycle approach to promoting environmentally responsible harvesting, management and usage of a quite complex and often-commingled supply chain of resources. In the built environment, this calls for a shift in "cradle to gate" design thinking to "cradle to cradle" design thinking.

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Rheaply's Asset Exchange Manager (AxM)™ is a web-based asset management system that employs the best-in-class features on a modern-day online marketplace to increase asset visibility, utilization, and redeployment. On Rheaply's AxM, construction stakeholders can request and exchange reclaimed building materials. This paper proposes to go beyond typical usage of surplus materials and invest in additional features that will enable AxM to empower decarbonization efforts by reporting on embodied carbon savings related to each transaction of reclaimed materials.

Technical Approach

What questions must be answered to determine the technical feasibility of the proposed concept?

Phase I will address the following specific research and development questions:

Feasibility of Consistent Reporting

- Is there a **market fit** for Rheaply's AxM within the built environment's management of materials? Can a commercial, cloud-hosted software platform (AxM) provide missing infrastructure and data to:
    - promote "end to end" material lifecycle visibility and supply chain traceability of deconstructed and reclaimed materials
    - facilitate identification, collection, transaction and use of deconstructed / reclaimed building materials
    - provide reportable embodied carbon metrics to stakeholders
    - leverage centralized technology to facilitate the network reach and scale necessary to disrupt Construction and Demolition (C&D) "business as usual"
- Are there **reliable strategies** to consistently estimate and report on the embodied carbon reduction from usage of a reclaimed material transacted on AxM (versus an accepted green building baseline for material alternatives)
- **What raw data about a reclaimed material must be collected**, and at what points in order to derive the estimated embodied carbon reduction from usage of that reclaimed material (e.g. including estimation of any resultant carbon impact from recirculating construction materials -- such as transporting deconstructed material to new job site for reclamation).
- **What existing data sources and technologies can be leveraged** and / or potentially integrated with AxM to facilitate:
    - collection, capture and sharing of data on reclaimed building materials
    - forecast of deconstruction materials anticipated to be eligible for reclamation
    - timely identification, design specification, transaction and use of formerly deconstructed / newly reclaimed materials
- Construction & Demolition and Materials Management are complex industries that overlap with many others.
    - There will be many key stakeholders. What role do each of these **stakeholders** need to play within the R/R&D efforts to ensure success for prototype development in Phase II or Phase III opportunities?

What are the key objectives you plan to accomplish during Phase I to answer those questions?

The primary goal of Phase I is to determine, insofar as possible, the scientific, technical, and commercial feasibility of the concept. The secondary goal is to report on these findings and propose recommendations on paths forward for either a) a Phase II prototype or b) strategies that may usher forward and pave the road to success for similar disruptive technologies in the future.

Key Objectives Include:

Conducting Research Synthesis
Translated findings from embodied carbon and building materials literature review. The synthesis will set the foundation and the pace for the project and uncover the questions we want to explore in our assessment of the feasibility.

Onboarding Stakeholders to AxM
To test the viability of facilitating exchange of deconstructed materials and empowering reuse, we will onboard a cadre of relevant stakeholders to our AxM Platform. During onboarding, we will provide product education, training, and ongoing troubleshooting support. We will also collaborate with stakeholders to:

- identify and configure AxM roles and permissions such as Materials Marketplace *Administrator* versus *End User*
- allow users to configure settings that best facilitate the exchange of reclaimed building materials.

Conducting Process Mapping
Engage stakeholders in an iterative, perspective-based process mapping exercise to document the "cradle to cradle" material reuse journey(s) of materials from extraction through reclamation via AxM (and beyond). For example, the exercise will include identifying:

- sequencing and temporal needs to facilitate notification, specification and reuse
- communication among stakeholders to coordinate reuse
- regulatory compliance anchors (permitting, site safety, material removal safety etc.)
- estimated costs and savings measures (tipping fees)
- material storage, collection and transport
- material quality control measures

Conducting Usability Testing
Throughout User Testing, we will ask Admins and End User stakeholders to do the following:

- ask relevant stakeholders to upload data related to deconstruction and material reclamation, including:
    - deconstruction site
    - reclamation site (request)
    - material reclamation requests
    - shop drawings
    - manufacturer information
    - Environmental Product Declarations (EPDs)
    - observed condition of reclaimed material
    - image of reclaimed material
    - weight
    - quantity

    - value
    - transaction cost / fee
    - pick up site
    - MasterFormat data

etc. via industry-accepted standardized formats (e.g. MasterFormat). Captured during data input / upload in AxM, this information will be immediately visible to stakeholders, enabling a more holistic view of material. With added visibility into volume, location and material provenance, Phase I efforts will explore the viability of varied stakeholders across the construction industry leveraging AxM to communicate about, take action on, and report about reusable building materials.

Conducting Admin & End User Experience Interviews

To test the commercial viability of leveraging AxM to facilitating exchange of deconstructed materials and empowering reuse, our approach will include collecting user feedback on:

- usability testing results, user interface (UI) and user experience (UX) for the diverse group of stakeholders of varying technical proficiencies
- platform's ability to mirror / map known and / or anticipated stakeholder workflows and processes (e.g. permitting, specifications, etc.)
- perceived adaptability of existing features, configurations, and accessibility to support

Conducting Admin & End User Motivation Interviews

Conversations with our Admins and End Users to obtain insights and input into:

- core drivers and barriers (both real and perceived) around their embodied carbon targets and broader green building goals
- baseline requirements for confidence in reported embodied carbon metrics related to reclaimed materials (e.g. baseline requirements for return on investment; social reporting; compliance accountability; regulatory adoption; etc.)

Technology Ecosystem Analysis

An exploration and analysis of existing tools, technologies and potential integration pathways that may empower AxM reuse features such as:

- leveraging existing digital technologies to extract key building and material information
- generating technical requirements for future technologies to include such information
- leveraging artificial intelligence (AI)-enabled simulation technologies to:
    - forecast cost efficient deconstruction and demolition sequencing in order to preserve potential reclaimed materials
    - generate iterative models estimating the available material supply embedded within a region's existing infrastructure (including the ability to forecast this in the future)
- leveraging existing digital technologies to facilitate Architect and Owner preference for reclaimed material specification in the design phase:
    - e.g. leveraging virtual reality (VR) and augmented reality (AR) to convey the design effects of using reclaimed materials for new construction, renovations, and / or

furniture, fixtures and equipment (FFE).
    - simulate cost efficiency impacts of leveraging the reclaimed material versus new or recycled baseline materials
- automated collection and sharing of demolition site characteristics, building history, materials data
- supply chain traceability of material life cycle pre and post reclamation
- Integration with embodied carbon data sources

Ongoing Reporting on Findings
Ongoing and iterative monthly reporting on:

- the estimated embodied carbon reduction by reclaimed materials transacted on the platform, including methodology used for estimation
- traceability mapping and data analysis of reclaimed materials transacted on the platform
- progress to date and stakeholder feedback.

Describe the key performance characteristics, including costs, necessary to meet customer needs.

The green building movement is no longer new. Spurred to action by a myriad of motivators -- including environmental stewardship, green building initiatives and carbon curbing regulations, adoption of green demolition practices by the construction industry continues to grow. This includes the following:

Demolition - The efficient tearing down of a structure or its parts to clear the site as quickly as possible, resulting in debris suitable for some bulk, mixed commodity recycling, and disposal.

Deconstruction - the systematic and "selective dismantling or removal of materials from buildings before, or instead of, demolition." Building parts are intentionally removed in reverse order of construction in order to maintain their maximum value and extend their existing reuse potential (California EPA, 2001). These salvaged materials can then become **reclaimed materials** or previously-used building materials that are repurposed as construction materials without reprocessing.

Another commonly-referenced option, materials recycling, includes processes in which the material quality is degraded, and the recovered product is then either directly reused as a lower quality material or processed to create a different product (Thomark, 2001). Out of the aforementioned methods, **deconstruction for building material reuse retains the most carbon neutral benefits** by allowing the material to retain its original form. Although reclaimed materials may be adapted and cut to size, cleaned up and refinished, they fundamentally are being given new homes in other buildings -- and reused in their authentic form. This reclamation also means those materials forego the additional embodied carbon impacts from reprocessing those materials to make them into material composed of recycled content.

Although building material reuse conserves natural resources, diverts waste from landfills and minimizes air pollution, the construction industry struggles to consistently implement it over other measures. Since our primary circular economy goal is to significantly increase the amount of reclaimed material usage, our key performance characteristics must take into account why such reuse is not presently "business as usual."

- **Key Performance Indicator #1: Transaction of Materials**
- **Key Performance Indicator #2: Consistent Data Collection & Reporting**
- **Key Performance Indicator #3: Demonstrations of Scalability**

Cited Deterrents to Material Reuse		
INSTITUTIONAL & HABITUAL	**ECONOMIC**	**TECHNICAL & PERFORMANCE**
- Institutional culture and established practice promotes preferred material palette - Time constraints prevent consideration of alternatives and favour familiar designs - Lack of established advocacy groups for alternatives - Lack of effective marketing from material producers - Lack of user–producer relationships - Habitual specification and historic practice of individual practitioners - High level of design inconvenience	- High cost of new products - Market externalizes cost of embedded emissions - Uncertainty premium placed on novel products - High transaction costs of additional professional training and research - Money sunk in existing materials (e.g. training, establishing supply chain relations, etc.) - Lower design:fee ratio due to increased detailing - Insufficient comparative info on costs - Unwillingness to accept associated financial risk - Access to finance for small and medium-sized firms (SMBs) - Project financing incompatible with time constraints - Anticipated increase in lead times - Lack of supply chain coordination - Small industries producing alternatives cannot compete against established industries' economies of scale	- Lack of established standards, design guides and tools, and standardized details - Lack of material performance data - Lack of full-scale demonstration projects - Policy and regulatory limitations and restrictions - Lack of confidence in contractor ability and availability of skilled labour prevents inclusion in design - Shortage of specialist skills prevents installation - Insufficiently developed supply chains - Local availability of materials and technologies - Difficulty obtaining insurance for novel and reused materials
Source: Adapted from Giesekam et al. (2014)		

The chart above is a select representation of consistent reasons that Architecture, Engineering, and Construction professionals (collectively "AEC professionals") fail to leverage reclaimed materials on a consistent basis. Construction industry supply chains are lengthy, complex, and involve diverse stakeholders -- many of which often have contraindicated motivations and priorities on a per project basis. Regardless of whether the above are *real* or *perceived* barriers to using reclaimed materials consistently, our hypothesis is that any disruptive strategy must address the core underpinnings of these issues.

Key Performance Indicator #1: Transaction of Materials

Transaction or exchange of materials of the platform serves as an indicator that technology solves a few key issues:

Missing infrastructure:

Leveraging AxM as a centralized platform to locate, inventory, and redistribute items simplifies a process that is currently deemed overwhelming, as many different stakeholders own disparate parts of the material life cycle. Even where there are local and grassroots material marketplaces, AEC professionals may not be aware of them, and have to navigate disparate, singular

marketplaces in order to leverage them. Transactions will indicate the ability of AxM to serve as a central hub for multiple types of materials, and that it is navigable by a diverse group of professionals.

Temporal Relevance

A truly circular built environment embeds the principles of a circular economy across all its functions, establishing a system that is regenerative, accessible and abundant by design. -- Google Real Estate and Workplace Services (REWS)

Ongoing transactions in AxM around built environment materials would demonstrate intervention along critical points in the project lifecycle that inform whether deconstructed materials find new homes:

Design Phase:

Engagement early and often in the design process is a critical linchpin to making sure deconstructed or surplus materials *actually find* new homes. If reclaimed materials are presented after design specifications have already occurred, this late engagement becomes a hefty barrier. **A recent USGBC-funded study found over 40% of architecture firms across the country have not used salvaged materials because they did not know where to source them and over 75% would be more inclined to use salvaged materials if there were more resources around material availability** (USGBC-12). To empower a circular materials economy, architects need to specify material building end of life "next use" plans in Computer Aided Design (CAD) or Building Information Model (BIM) shop drawings .

Construction Phase:

For sustainable projects in particular, material choice is considered earlier in the design process, for a longer period of time, and with many specialists (Arup & WBCSD, 2012). Even if an AEC wanted to leverage the material, this would require design reworks, engagement with subcontractors and general contractors, installers, suppliers, or even change orders at cost. Transactions will demonstrate sufficient visibility and temporal relevancy for materials to be identified, suggested, recovered, specified and *actually implemented* for reuse.

Pre-"Demolition":

The EPA reports that demolition represents more than 90 percent of total C&D debris generation, while "full-scale" (as opposed to select) deconstruction accounts for only a small fraction of total building removal projects in the United States. Even within that fraction, most occur for residential projects.

The economic feasibility of deconstruction varies greatly based on regional, site and project conditions. The range of estimates is broad from $2 per square foot (Denhart, 2010; Thomark, 2001). to $16 per square foot (Dantata et al.). Although deconstruction typically requires less mechanical labor, which is especially helpful within densely-packed urban environments, deconstruction requires specialized manual labor to carefully dismantle individual building components and preserve the integrity of reusable materials (National Association of Homebuilders (NAHB, 2000). The cost of labor plus the time-intensive nature of deconstruction are often cited as reasons it does not often occur.

However, commercial and residential clients alike increasingly specify or prefer environmentally-conscious building materials and practices. Preserving regional vernacular and facilitating place-making, deconstruction is often selected based on requests or intent to preserve historically and personally significant parts of buildings (Denhart, 2009). This is significant, because recovering and implementing materials such as reclaimed steel and reclaimed masonry are more expensive than their modern similar counterparts (AISC 2020). Several green building certification programs give incentives for artfully incorporating local reclaimed materials "of their place" into building design. Studies (Giesekam et al 2016) show that deconstruction is most likely to occur when:

- clients have specified it as the preferred method
- site materials have been previously identified and specified for reclamation -- either by building owner, AEC professionals, or local officials
- regulations prioritize (oftentimes select) deconstruction via incentives or deterrents

Key Performance Indicator #2: Consistent Data Collection & Reporting

Missing Data

An important ingredient of the material selection and specification process includes collecting available data about building materials. This information is readily available and frequently updated for not only newly manufactured construction materials, but more prevalently for materials with partially recycled content. Data about reclaimed materials -- which vary in age and composition -- is less readily available, and attempting to collect such data typically falls on the party seeking to reuse that item or could be contested by General Contractors at Risk (CMAR). Other materials such as wood, may be less likely to pass the inspection and verification processes -- ultimately impacting *how* and *whether* that reclaimed material is reused.

Thus an ability to consistently collect data about reclaimed materials will demonstrate that doing so is in fact feasible, but also shed light on which metrics are most often and easily collected as well as the best time to collect that information (e.g. prior to deconstruction) throughout the material life cycle. The ability to report on data about the reclaimed materials that pass through the platform solves the missing data challenge.

Embodied Carbon Reporting

A united combination of regulatory compliance measures, green building certification programs and voluntary commercial disclosures have increased the proliferation of built environment and materials carbon data reporting. Although this reporting has increased, the vast majority of reporting has focused on operational carbon reduction / energy monitoring. Materials environmental product declarations -- primarily targeted at new construction carbon offsets, report energy efficient measures in raw material extraction and / or percentage of recycled content in new materials. For example, the International Living Future Institutes (ILFI) Petals Program mandates that new projects demonstrate a 10% reduction in the embodied carbon of the primary materials of the foundation, structure, and enclosure compared to an equivalent baseline.

There is currently no easy way to quantify the carbon impact of incorporating reclaimed products into building design. Because voluntary and mandatory embodied carbon reporting

remains an incentive in the built environment across all stakeholders, better data is needed around the estimated impact of embodied carbon savings from leveraging reclaimed materials reuse. In reference to materials reuse, AEC professionals report that it is still “really really hard” to access good-quality data on embodied carbon. The level of detail and consistency of this data must increase for it to be considered quantifiable, reliable and reportable. Because AxM centralizes data about reclaimed materials, it offers an opportunity to compare the usage of those materials against:

- estimated embodied carbon of a comparable equivalent recycled content material
- estimated embodied carbon of an alternative new material

Key Performance Indicators include: identifying strategies to generate these metrics for 65% of the materials transacted within the platform; empowering AEC professionals to show comparative carbon cost of material choices; and obtaining positive feedback from Green Building Organizations and Government Regulatory Agencies who rely upon metrics for carbon accountability and commercial incentives.

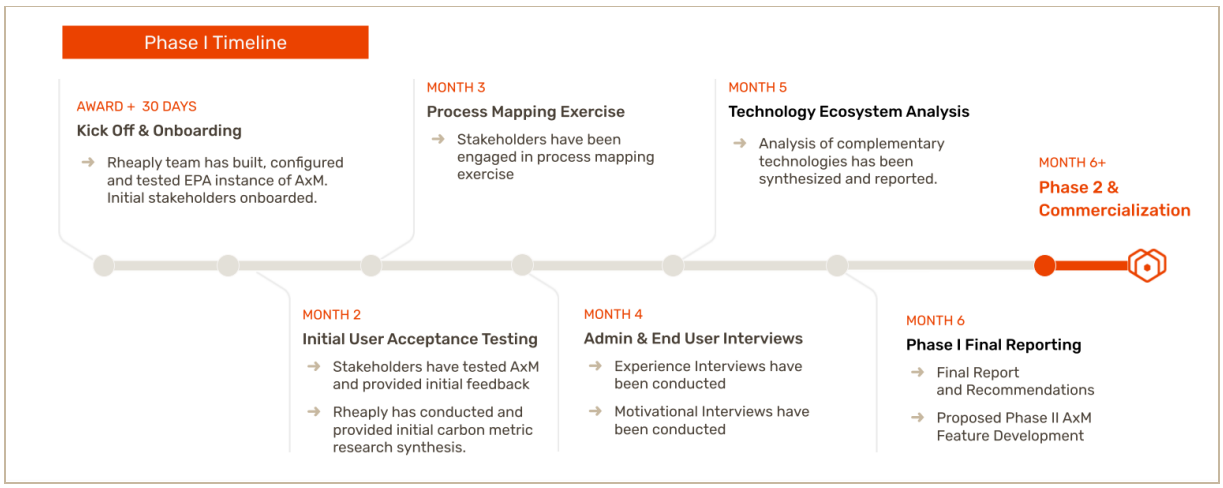
Key Performance Indicator #3: Demonstrations of Scalability

Even when other challenges are overcome, scalability is the underpinning of many referenced barriers to reusing building materials. Over half the embodied carbon in construction is associated with the consumption of materials -- which are required in sufficient, consistent, and timely volume (Giesekam et al., 2016).

Whether materials from building deconstruction are reused, recycled, or disposed of depends on myriad factors, including the material and its condition -- but most notably, the existence and demand of local markets.

Describe the technical milestones you plan to meet to achieve each objective and provide a visual timeline of these objectives and milestones during the project.

The objectives documented in the Key Performance Objectives section above will be carried out along the following timeline captured in the graphic below:



Phase I Deliverables

Number	Title	Form	Expected Delivery
#1	Project Plan	PDF	Award + 30 Days
#2	Initial User Acceptance Results	Demo	Award + 60 Days
#3	Circular Materials Process Map	PDF	Award + 90 Days
#4	Admin & End User Interview Feedback	PDF	Award + 120 Days
#5	Technology Ecosystem Analysis Report	PDF	Award + 150 Days
#6	Final Report & Phase II Recommendations	PDF	Award + 180 Days

Describe the key technical challenges for bringing the technology to market and how you will overcome them.

Available commercially today, Rheaply AxM has already made several key technical milestones and demonstrated the ability to gain traction:

- Rheaply already has a MHSA (Master Host Services Agreement) with Google from our prior and current work with Alphabet and Google Hardware
- Rheaply is a member of the Google for Startups Network
- Rheaply has already completed Google's Cyber Security Audit Questionnaire and AxM has been granted single sign-on SSO access, which allows users to leverage their Google domain email address for easy authentication and platform log in. This also demonstrates that Rheaply's AxM platform technology has been vetted and found complicit with Google's cybersecurity requirements

Technical challenges Rheaply continues to work on include the following:

Technology Compliance

FedRAMP

The Federal Risk and Authorization Management Program (FedRAMP) is a government-wide program that standardizes security assessment and authorization for cloud-hosted products and services used by U.S. federal agencies. The program ensures federal data is consistently protected at a high level in the cloud, while also streamlining availability of cloud solutions. Many State and Local Governments as well as Higher Education entities have also adopted FedRAMP compliance. Collectively, these public sector stakeholders are key players to building sustainable supply, demand, and supporting policies within the circular economy. Because Rheaply's AxM platform is a cloud-based, commercial Amazon Web Services (AWS)-hosted solution, we are continually looking for FedRAMP sponsors while getting "FedRAMP-ready."

CMMC

The Cybersecurity Maturity Model Certification (CMMC) mandates that any vendor within the Department of Defense supply chain implement requirements designed to ensure the protection of Controlled Unclassified Information (CUI) on Non-Government Networks. Rheaply believes the AxM platform has many dual use supply chain management applications -- as demonstrated by our existing contracts with Defense Logistics Agency (DLA) and Air Force customers. We are dedicated to diligently obtaining CMMC compliance at the appropriate maturity level in order to further commercialize our technologies and support DoD mission priorities.

Company / Team (Technical)

Describe the expertise and experience of the team / key participants,

CeCe Smith, Assoc AIA, LEED AP, CGP | Senior Solutions Engineer

BA, Political Science and Government, BArch, Architecture

As Principal Investigator, CeCe Smith will leverage her passion at the intersection of technology, the circular economies and the built environment to drive the team's research objectives and application. Passionate about the built environment's capacity to transform communities, CeCe began her career interning for City of Detroit Mayor Dave Bing in an incubator program transforming abandoned warehouses into sustainable prefab manufacturing studios. She returned to her hometown in San Antonio, Texas to work for Lake|Flato, which has received more sustainable design excellence awards by the American Institute of Architects (AIA) The Committee on the Environment (AIA COTE 2016) than any firm in American history. CeCe worked on the Pearl Brewery Redevelopment which transformed a derelict, 26-acre brownfield site into a vibrant mixed-use village by artfully salvaging and repurposing 300,000 / 450,000 square feet of existing inventory and historic building stock, diverting 83% of site materials from landfill (AIA COTE n,d,). CeCe also conducted sensor-based building performance reporting, parametric modeling and co-performed rigorous Living Building Challenge Certification (LBC) for the Josey Pavilion, which became the 1st Certified Living Building in the State of Texas; and 11th in the World (ILFI 2016; AIA COTE n.d.). CeCe sits on the U.S. Green Building Council (USGBC) Exam Board, creating ethical test questions for Professional Accreditation (LEED AP). Prior to joining Rheaply, CeCe spent 3 years at a startup facilitating adoption and commercialization of sensor-based technologies by DoD and Intelligence Community Customers. In her Solutions Engineer role at Rheaply, CeCe collaborates closely with the Product and Engineering Teams to ensure customer feedback is channeled into new features that solve customer problems and drive the circular economy.

Eric Lewandowski | Director, Public Sector

MA in International Economics and China Studies, Johns Hopkins University, School of Advanced International Studies; BS in Accounting, Elon University

Eric Lewandowski manages USG accounts at Rheaply and has five years of program management and government sales experience at the intersection of emerging technology and federal, state and local government. He has 3.5 years experience at Orbital Insight delivering data analytics to the US Air Force, intelligence community, World Bank, and World Resource Institute. Additionally,

Eric has 3 years of teaching experience, and regularly translates this experience into helping Rheaply customers learn product features most relevant to their business and workflow processes.

Sabira Lakhani, | Director of Product

MS in Engineering and Management, Massachusetts Institute of Technology; BS in Economics, New York University

Sabira is a Product Manager at Rheaply and has experience in designing products and systems for circular economies. She has been a consultant with IBM, an associate at an impact investing venture fund, City Light Capital, an operational director at Saahas Zero Waste, and an Environmental Designer at Apple. Sabira leverages her skills in design, business, and product management to understand customer and user needs and partners with development teams to deliver on time. Sabira leads a growing Product Management team at Rheaply responsible for prioritizing and building features for the AxM product line. She will lead end user engagement and discovery for the Phase I effort.

Daniel Kietzer | Director, Ecosystem Growth

BA in Anthropology, University of Texas at Austin

Daniel leads Ecosystem Growth at Rheaply, providing strategic, organizational and technical support to scale and create new reuse market opportunities between Rheaply clients and partners in select priority regions. He has 10+ years of experience designing and leading impact-focused circular economy and sustainability programs with forward-thinking companies and organizations across the globe. While reuse and recycling market development is Daniel's specialty, past projects have also targeted social entrepreneurship, sustainability in the built environment, water, carbon, and a variety of other sustainability-related themes.

Impact / Relevance to Topic

Describe the environmental benefits and costs associated with the lifecycle (inputs, manufacture, use, and reuse/recycle/treatment/disposal) of your technology.

To maximize environmental benefit, our technology advocates for **prioritizing deconstruction over demolition and reuse of salvaged building materials in new buildings over creation of new building materials** from recycled C&D content. Our solution is a cloud-hosted technology that will **meet stakeholders where they are** and incentivize local exchanges of building materials. The environmental benefits of deconstruction are bountiful: it displaces virgin material production, sequesters carbon in wood products, and reduces C&D in landfills (Guy and McLendon, 2000). **The greatest environmental benefit results from the higher material reuse rates that leverage our existing building stock**, which significantly reduces the impacts of new construction (Thomark, 2001).

Environmental Benefits Associated with Material Reuse & Reclamation

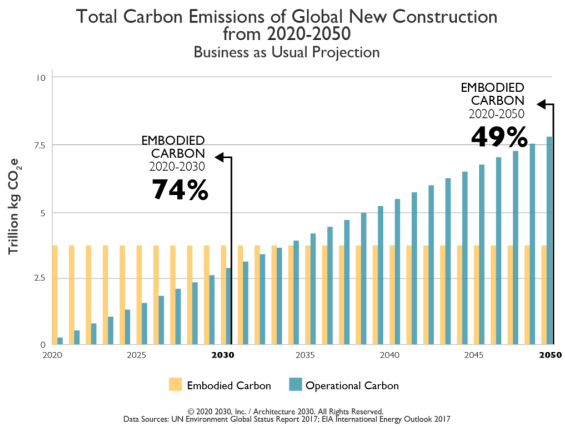
In addition to the unprecedented growth in the global building sector, nearly two-thirds of the building area that exists today will still exist in 2050. Therefore, any transition to

low-carbon / carbon neutral built environment must address both new construction and existing buildings. - Architecture2030

As we prepare to pour more resources into updating our national infrastructure, we have the opportunity to lessen the environmental impact of inevitable new construction by seeing our cities as abundant material stores for the future. A circular economy of reclaimed material reuse lessens the demand on extracting raw material and conserves the energy and other inputs required to return recycled products back to a useable form.

Higher Focus on Embodied Carbon

Prioritizing operational carbon impact of new buildings at the expense of neglecting embodied carbon impact of existing buildings has significant consequences that threaten to derail our ability to meet the Paris Climate Accord objectives. Embodied carbon is projected to be responsible for *almost half* of total new construction emissions between now and 2050 (Arch2030). Unlike operational carbon emissions, which can be -- and also *have* -- reduced over time as both new construction and renovations benefit from innovations in energy efficiency and renewable energy sources, embodied carbon emissions are locked in place once a building is stood up.

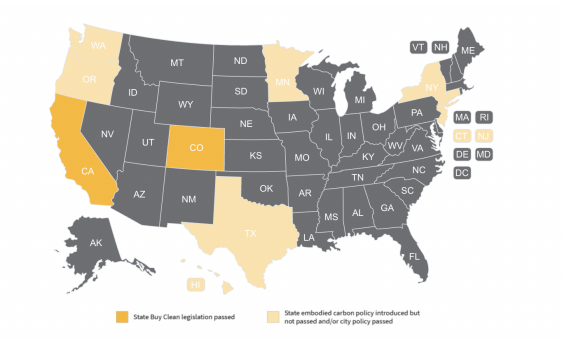


Therein embodied carbon becomes the great equalizer as we run out of operational opportunities to significantly diminish the overall carbon impact of the built environment. Facilitating carbon impact savings reporting and generating a robust market of reclaimed material use will disrupt the perception and habitual practice of buildings being structures of "waste in waiting." Current asset management valuation simulations neglect to assign and adequately quantify the significant end of life value inherent in building materials that can be reused. Because Master Plans and Capital Plans inform construction and demolition investments, intervening early and often along the materials supply chain -- especially in the design specification and planning phases -- will help AEC professionals design, simulate and plan in advance for material "next use" while conveying the value of those materials to Owners.

Timely Resilience in the Face of the COVID-19 Pandemic

The COVID-19 global pandemic disrupted multiple supply chains and created surges on the price of goods. The construction industry bore a significant brunt of these impacts in addition to costly project scheduling delays. Construction Indices report the 2020 monthly and yearly price increases for materials such as lumber, copper, and steel were the highest recorded in the past 35 years (AGC 2021). Uncertainties and delays around material availability and delivery have required that the construction industry quickly adapt in order to facilitate sustainable recovery of the construction sector, amid declines in new construction demand from key industries such as commercial retail. This offers an unprecedented opportunity to shift the traditional habits and thinking of industry stakeholders. Reuse of materials from our existing building stock is an

opportunity to creatively compensate for material uncertainties that exist within the traditional supply chain.



Empowering Embodied Carbon Policy with Technology

Policies addressing embodied carbon -- especially decarbonization of the built environment -- are spreading rapidly across the United States, many of them being championed at the regional and local levels. This is notable since most green building regulation to date has primarily focused on managing operational GHG emissions associated with energy-intensive activities like space heating, cooling and lighting (EPA 2017; ILFI n,d.). Timely regulation is attributed as a key driver for adoption and most effective accountability mechanism for built environment decarbonization reform and results (Osmani & O'Reilly, 2009). As they seek to manage the embodied carbon associated with the initial production of structures, construction stakeholders will benefit from the critical technology and development of AxM's embodied carbon savings metric. [CAPTION: U.S. Map representing implementation of embodied carbon policy, (Arch2030 n.d.)]

Environmental Benefits Associated with Prioritizing Deconstruction

The COVID-19 pandemic emphasized the life and death consequences of long-festering societal racial and economic inequalities. Unfortunately, the construction industry has historically been either an active driver or the vehicle for widening these disparities. Decarbonization efforts must *not only* thoughtfully consider *but also* actively engage these communities in climate solutions. This will ensure the cumulative benefits of energy conservation and carbon neutrality programs both *flow to* and are *championed by* low-income communities and communities of color.

Because a circular reuse supply chain demands supply, it paves the way for deconstruction to become a critical link and preferred method for taking buildings apart. Because deconstruction demands a higher degree of labor to quickly and carefully recover items, it creates specialized training and job opportunities. Additionally, local residents are more able and likely to engage in material reuse efforts when deconstruction practices are used -- such as Post-Katrina efforts in New Orleans, where residents participated in hands-on recovery of historic artifacts later incorporated in new construction (Denhart, 2009; Denhart 2010). Materials reuse is an equitable development approach that reduces disparities while fostering healthy and vibrant communities. It is also considered an effective, placed-based action for creating strong and livable communities (EPA 2017).

AxM and built environment market exchange programs fosters digital *inclusion* by creating job opportunities for low-income communities and communities of color. The AxM platform is available on mobile devices

Combined, deconstruction, material reuse and our proposed AxM technologies create the following paths towards economic recovery and resilience in low income communities:

MATERIALS REUSE	DECONSTRUCTION	AXM
- Benefits communities by lowering disposal costs, reducing tax liabilities for material donors and providing access to low-cost or free building materials. - Reduction of air and petroleum emissions from material transit - Diverts construction waste from landfills, which are located near low income communities - Facilitates equitable development supply for adaptive reuse, retrofitting and brownfield rehabilitation - Conversion of abandoned / vacant commercial and industrial properties into community assets - Conversion of abandoned / vacant commercial and industrial properties into community assets - Creates specialization training and jobs for reclaimed material installation - Reinforces energy poverty mitigation plans	- Requires less encroachment on urban space than mechanized demolition - Minimizes site disturbance - Green jobs creation - Reduction of harmful air emissions and improvement of air quality - Reduction of ecosystem and biodiversity disruption - Cost efficiencies from material recovery - Facilitates compliance with C&D waste diversion regulations - Facilitates preservation of historic artifacts - Facilitates adaptive reuse by preserving structural core - Facilitates community engagement and place-making - Facilities design excellence by allowing materials to be recovered for future use - Demonstrates supply chain coordination - Increased planning for deconstruction early on in Master and Capital Planning - Demands less carbon emissions than recycling or generating new materials from recycled C&D content	- Foster digital inclusion via mobile access to supply chains - Discovery of sites where deconstruction assistance is needed - Discovery and fulfillment of material reclamation requests - Access to surplus materials for home and building repairs and maintenance - Connection, relationship-building and mentoring with local business owners - Visibility to business owners seeking to conduct Diversity & Inclusion procurement - Education, training and job opportunities on material supply chains - Education, training and job opportunities on AEC industry - Active and vital champions of the circular economy - Specialist skills training for material installation - Grows previously, insufficiently developed supply chains - Access to local availability of materials and technologies

How well does the proposed technology address the solicitation topic (and EPA priorities)?

Sustainable Materials Management

Rheaply's AxM is technology-empowered sustainable materials management. Today, customers use AxM to uncover hidden surplus assets within their organization and facilitate exchange of those assets to save procurement costs and extend the total life cycle of those assets by finding them new homes. This same underlying technology can successfully help AEC professionals manage surplus building materials and reclaimed building materials from deconstruction.

4D: Low Impact Construction Materials and Technologies that Reduce Embodied Carbon of Buildings

Our proposed research actively addresses key reasons that deconstruction and material reuse reportedly occur less frequently -- including data gaps and inability to estimate and report the embodied carbon reductions from using a reclaimed material. **Reclaimed building materials from our existing infrastructure are the lowest impact construction materials available**. Leveraging Rheaply AxM, our commercial and scalable cloud-hosted technology, to facilitate

exchange of low impact construction materials -- and enable embodied carbon savings estimation reflects the spirit of the topic.

EPA Priorities

Combined, our proposed research and commercial AxM technology supports the following EPA priorities:

EPA's Environmental Justice 2020 Action Agenda to protect communities disproportionately affected by pollution through environmental justice work. AxM directly facilitates the following action agenda objectives:

- enforcement and compliance program planning and implementation
- identification of programs and cases to pursue
- development of solutions to benefit overburdened communities.

- **Green Job Creation:** Development of new markets for recovered and reclaimed C&D materials generates demand for a workforce that understands the industry from product development to product certification, distribution, and reuse.

- **Waste minimization**: diversion of materials from landfills and incinerators, increasing C&D reuse and reclamation of existing building material stores.

Innovation/Intellectual Property (IP)

Describe the technology's current stage of development—bench/pilot/field—and what must be done to reach the next stage.

Rheaply's commercial off-the-shelf (COTS) AxM product is a cloud-hosted software combining asset management functionality with an online marketplace to promote the sharing of underutilized assets within large organizations. AxM makes it easy and efficient for organizations in technology, government, retail, healthcare, and higher education to track and utilize the assets they already have before making a purchasing decision. The platform also enables companies to share and sell physical assets within and between organizations.

In large organizations, from universities and local governments to Fortune 500 technology and biopharma companies, ownership and management of physical assets typically occurs within a smaller sub-organization or physical location. When physical assets are unused within that sub-organization, for example, a specific department, lab, or building, the unused asset is put in storage, and sits idly while still capable of fulfilling a need. Elsewhere within the organization, there may be demand for the same type of asset. Without visibility into the surplus, an expensive, time-consuming procurement process is initiated. The result is duplicative purchasing of assets, higher storage and disposition costs, delays as the asset is procured, and environmental harm from the manufacturing, transportation, and eventual landfilling of this inventory.

Rheaply's AxM platform is already in use by dozens of commercial entities across the biopharma, technology, real estate, energy, and higher education markets. Since inception, Rheaply has $230K in commercial sales and $955K in government sales. Commercial customers include:

- **Google:** Recaptured $119K of asset value through the platform, diverted 0.5 tons of waste from landfill, and reduced overhead costs at a single pilot warehouse location in CA.
- **AbbVie:** Recaptured 4x value from surplus assets relative to pilot program cost; diverted 393.5kg of waste. Next phase of expansion involves expanding from 4 sites to 22 sites.
- **Massachusetts Institute of Technology (MIT):** Partnered with MIT's Office of Sustainability to divert 0.8 tons of waste from landfills, onboard 897 users, and save $86K in procurement costs.
- **City of Chicago:** Partnership to launch the Chicago PPE Market, connecting 2,600 small businesses and nonprofits with a network of local manufacturers and suppliers of protective supplies at cost-controlled rates to support safe reopening of businesses in the wake of the Covid-19 pandemic.

To reach the next stage of commercialization, Rheaply needs to partner with key stakeholders like the EPA on feature research and development that can be additive to critical asset management problems today:

- further collaboration with build environment stakeholders
- quantifying embodied carbon savings from material reuse
- demonstrating asset and supply chain traceability
- integrations with complementary tools that can facilitate material reclamation practices.

Describe the demonstrations you will carry out to help move the technology to the next stage—including scale, facilities, partners, other resource needs and availability, etc.

Demonstration

To test the viability of facilitating exchange of deconstructed materials and empowering reuse, we will demonstrate the ability for AEC stakeholders to engage in transactions on the AxM platform. This includes the following:

- demonstration of AxM to meet multiple environment and configuration demands of varied stakeholders (e.g. Architect, Construction Manager, Regulatory Compliance Manager, etc.)
- mapping AxM Admin and End User roles and permissions to AEC stakeholder positions (e.g. Materials Marketplace *Administrator* versus *End User)*
- demonstration of usability and transactions of materials
- demonstration of embodied carbon reporting metrics, and mock up design wireframes

Describe the current and planned intellectual property associated with this project and how you plan to protect it.

Since the proposed research will be a licensed customization of the AxM application owned by Rheaply, the Participating Government Customer (EPA), will not have co-ownership of the platform itself, but will have Administrative configuration authority. However, select relevant research, findings, and processes will be designed to be shareable to a public audience to advance the field of urban sustainability.

Rheaply will retain unlimited intellectual property rights of all Feature Research and Development and resulting Technical Data and Computer Software. As a key tenet of our commercialization strategy, this measure will ensure that Rheaply is able to retain the rights to matriculate the researched data and derivative features into our existing commercial AxM platform and commercialize them.

Feature Research and Development (Feature R&D) is defined as research and data (regardless of form) first produced by Rheaply in performance of discovery and development services under the contract with the Participating Government Customer, which data are not generally known (e.g. unknown unknowns), and which data without obligation as to its confidentiality have not been made available to others by Rheaply or are not already available to the public.

Technical Data: is defined as recorded information (regardless of the form or method of the recording) of a scientific or technical nature (including computer software documentation and reports).

Computer Software is defined as any of the following (1) Computer Programs that comprise a series of instructions, rules, routines, or statements, regardless of the media in which recorded or hosting environment, that allow or cause a computer to perform a specific operation or series of operations; and (2) Recorded information comprising source code listings, design details, algorithms, processes, flow charts, formulas, and related material that would enable the computer program to be produced, created, or compiled.

Market Opportunity

Describe the target market for the innovation—including nature, size, business and economic dynamics, etc.

Market Size:

The State of the Practice of Construction and Demolition Material Recycling is estimated to be between $204 billion and $248 billion (EPA 2017).

As regulatory compliance and building owner corporate sustainability goals continue to rise, so too does the demand for green building products and tools that help Construction Managers and Building Operators meet these goals. Expenditure in the green building market increased from 1% in 2005 to approximately 10% in 2012, with indications that the market will continue to grow (McGraw-Hill Construction, 2012).

State, County & Local Government

Responsible for over 70 percent of global energy consumption and CO2 emissions -- which come primarily from buildings -- cities offer an opportunity to focus on reclaiming existing materials from our densely-backed urban environments (Arch2030). Because C&D is regulated by State Environmental and Health Departments, and jurisdictional differences impact C&D disposal mandates and allowances, State and Local Government entities are target candidates for AxM Administrators. Even when state mandates do not include broad-reaching waste diversion and material reuse mandates, some municipalities and counties often opt to create their own bans. For example, 47% of California counties comprising 88% of California's total population have implemented C&D diversion initiatives [EPA 2017)].

Federal Government

With a domestic building inventory of approximately 300,000 owned and leased buildings requiring $21 billion of annual operation and maintenance expenditures, the Federal Government is the largest real property owner in the United States (Executive Office of the President of the U.S). AxM Technologies can facilitate the federal government's goal and mandate to divert at least 50% of non-hazardous construction and demolition materials and debris while reducing their embodied carbon impact.

Private Corporations / Companies

Public policy and green building initiatives have led to increased corporate policies around C&D management practices. This includes policy to design and construct buildings that meet varying levels of U.S. Green Building Leadership in Energy and Environmental Design (LEED) certification program requirements, which attribute multiple credit opportunities for material reuse and deconstruction practices.

- Johnson and Johnson requires that all new construction and major renovations (totaling $5 million and all standalone buildings of lesser value) meet the requirements of "LEED Certified or Equivalent." (Johnson & Johnson 2021)
- Avon requires all new facilities and renovations be designed and built in accordance with the LEED Green Building Rating System and has achieved certification for all five of their new facilities. (Avon 2021)
- Google sets goals and benchmarks for building performance based on LEED and Living Building Challenge (LBC) rating systems. The innovator has LEED-certified over 4 million square feet of building program (EPA 2017, Google 2021)

Participation in these certification programs improves corporate social recognition for upholding environmental stewardship and generates trust with consumers, who are likely to become brand-loyal customers.

Describe how you validated the market opportunity—e.g., the number of interviews with customers and others, published studies (cite), industry journal articles, consultants, etc.
We have validated the market opportunity through the following ways:

- Research Synthesis as referenced by the sources outlined in this proposal
- Multiple Stakeholder Interviews with AEC professionals, Government Regulators and Commercial Corporations
- Review of other Tools and Programs: such as the Zero Cities Project; Zero Tool; CarbonPositive Initiative; 2030 Palette, and others referenced throughout this paper.

Describe the drivers for and barriers to selling to your target market, including regulatory.
Demand for Carbon Accounting & Education

Tools like the Greenhouse Gas Protocol have responded to carbon accounting demand by providing standards, guidance, tools and training for business and government to measure and manage climate-warming emissions. Building on a 20-year partnership between World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), GHG

Protocol works with governments, industry associations, NGOs, businesses and other organizations.

Financial Drivers - Green Building Programs

Green building programs are trending due in part to government incentives and tax breaks at both local and national levels for builders, developers, and homeowners. Examples of financial incentives for the green building include tax credits, fee reductions, and expedited permitting. The State of New York was the first in the nation to sign a green building tax credit into law in 2000. Over a 9-year period, it provided $25 million in income tax credit for owners and tenants of buildings that meet certain criteria related to building size, construction materials, energy and water use, and select other issues (Kneeland, 2006).

Financial Drivers - Tax Incentives

The following is a list of the most common, though not an exhaustive list of, incentives offered for green building practices, which include decarbonization mandates: Tax Incentives; Bonus Density; Expedited Permitting; Net Metering; Grants (including fee subsidization); Loans; Permit/Zone Fee Reduction; Rebates and Discounts on Environmental Products (e.g., Energy Star); Corporate Tax (tax levied on the profits made by companies or associations); Gross Receipts Tax (tax levied on the total gross revenues of a company – charged to the seller of goods); Income Tax (tax levied on the financial income of persons, corporations, or other legal entities); Property Tax/Ad Valorem Tax (tax levied on the value of property); Sales Tax (tax levied on goods and services – charged at the point of purchase) and Local Tax (tax levied from cities and counties).

Regulatory Drivers include:

- Government Waste Reuse Requirements mandating that all government agency construction actively divert a portion of waste from the landfills
- Disposal Ban outlawing disposal of certain waste materials in a landfill
- Disposal Taxes that artificially inflate the cost of disposal to make recycling or reuse a more economical option for construction managers
- Educational efforts performed by the government to increase reuse awareness specifically for green C&D practices
- Green Building Regulations that encourage building certification with programs such as LEED, WELL, LBC, or others.
- Salvage Requirements that require Demolition Contractors to post advance notice of impending demolition to empower timely recovery and salvage of reusable materials. This extends to other components of national infrastructure, including the department of transportation, highways, railways, etc.

Describe your potential end users/customers.

The AEC Community

The AEC community is the primary vehicle for designing and executing eco-conscious material reuse enhancement to the built environment. Stakeholder Roles include: Architects, Sustainable Design Consultants; Information Technology Design Consultants; Urban Planners & Designers; General Contractors and Construction Managers.

Commercial Business Owners & Operators

As clients of the AEC industry, Commercial Business Owners directly impact the design and construction decisions for their buildings. Additionally, these Owners assume risk and economic liability for the carbon (both embodied and operational) footprint of their buildings. Roles include Operations & Maintenance Professionals, Project Managers, and Capital Planning Managers.

Government Regulators

Regulators that engage with the build environment include Environmental Protection Agency Stakeholders, Construction Permitters, Environmental Health Departments, and Waste Management Departments.

Describe the competition and how your technology will compare. How do you expect the competitive landscape to change by the time your product enters the market?
Rheaply's Asset Exchange Manager is the only technology on market that increases visibility and use of an organization's assets while providing management and tracking solutions. To date, Rheaply's AxM has:

- Recaptured over $1.6 million in asset value
- Established a network of 5000+ users Diverted over 5 tonnes in waste from landfill
- Obtained a MHSA (Master Host Services Agreement) with Google from our prior and current work with Alphabet and Google Hardware
- Rheaply is a member of the Google for Startups Network; has already completed a Cyber Security Audit Questionnaire which granted AxM SSO access, demonstrating that our technology has been thoroughly vetted to meet Google's cybersecurity requirements

Commercialization Approach

Describe your commercialization approach for taking the technology from its current stage of development to commercialization.

Garry Cooper, Jr., PhD, CEO and co-founder of Rheaply, is a neuroscientist who co-invented the only disease-modifying therapeutic measure for Parkinson's disease (in late-stage clinical review). Dr. Cooper founded Rheaply based on his efforts to reduce double-buying of surplus and available resources at Northwestern University as well as to increase the speed of experimental throughput by reducing supplier wait times.

Rheaply's plan to maximize revenue in the determined serviceable addressable market over the next five years includes the following activities:

Identify Global 500 companies that have surplus or supply chain problems through referrals, trade shows, use-case publications, white papers, scientific publications, and digital marketing. Rheaply has three dedicated Business Development Representatives that meet with corporate and public sector prospects weekly. As of May 2021, the Revenue and Marketing team headcount exceeds 10 full-time members.

Execute low cost and low risk Proof-of-Concept projects with potential customers, demonstrating how Rheaply's technology solves their problems and adds value. Adopt a 'land and expand' approach, inspired by the three phases of the SBIR process, to conduct exploratory feasibility studies, prototype, and transition to widespread operational use. Rheaply is currently testing this approach with two of the largest tech companies in the world, as well as a top retailer.

Conduct Technical Assistance Programs: Education is a key component of all incentive options. Demand for sustainable design is increasing rapidly, but even in the development community there are still questions over exactly what kind of green design techniques are most effective and in demand. Enthusiastic political advocates of sustainable design will continue to raise awareness but this must be matched by technical expertise and supporting technology infrastructure, like Rheaply's AxM. Similarly, we will partner with government entities to provide quality service and support to the development and design community by training planners, building inspectors, and other local officials, as these are cumulatively the main points of contact between jurisdiction and private building interests.

Define recurring, value-based pricing for the continued use of Rheaply's technology as an integral component of the Customer's supply chain, investment recovery, or sustainability practices.

Provide estimates of the revenue potential, detailing your underlying assumptions.

Asset visibility, management, and tracking is a $11+ Billion dollar US market slated to triple in the next 10 years. Rheaply's Key account verticals include: Healthcare and biopharma, energy, higher education, the federal-civilian government (including expansion within the National Institutes of Health), and the buildout of a State/Local/Education-focused contingent of Rheaply's Public Sector team. Rheaply's revenue was $50K in 2019, the first year of formal AxM product release. In 2020, revenue eclipsed $950K, and 2021 sales projections exceed $2M with 2022 revenue targets set upwards of $5M.

What resources will you need to implement your commercialization approach and how will you secure them?

Cooperation with Green Building Programs

Green building certification programs have helped underscore the environmental impacts associated with the disposal of building materials. A notable example is the U.S. Green Building Council's LEED certification program. Sound material and resource utilization through the reuse and recycling of C&D and the use of recycled-content building materials help achieve the green building certification. Therefore, LEED and other programs are believed to have fostered the growth of C&D material recovery and the development of markets for recovered C&D (EPA 2017).

Strategic Partnerships / Relationships:

It takes a village to disrupt the built environment and materials supply chain. Rheaply will leverage our Ecosystems Team to expand partnerships with movers and shakers in the built environment such as the U.S. EPA, Architecture2030, Carbon Leadership Forum, International Living Futures Institute, and others.

Reuse Storytelling & Marketing Campaigns

By facilitating reuse storytelling, we can demonstrate the impact that reclaimed materials make in their local communities while inspiring more organizations to donate surplus materials, divert waste from landfills, and encourage increased deconstruction practices within their community.

Letter of Support - Microsoft

Microsoft Corporation
12120 Sunset Hills Rd
Reston, VA 20190

Tel 703 673 7600
Suite 100
http://www.microsoft.com/

Microsoft

July 28, 2021

U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460

Re: Letter of Support for the U.S. Environmental Protection Agency Small Business Innovation Research Phase I Solicitation Number 68HERC21R0144, topic 4D: Low Impact Construction Materials and Technologies that Reduce Embodied Carbon of Buildings

To Whom It May Concern:

Microsoft Corporation ("Microsoft") is pleased to provide this letter of support related to Rheaply's application for the U.S. Environmental Protection Agency's (EPA) Small Business Innovation Research (SBIR) funding opportunity. Microsoft is a global technology leader enabling digital transformation to empower every person and every organization on the planet to achieve more, through our cloud solutions, devices, and other offerings. Microsoft has been carbon neutral across the world since 2012 and is committed to being carbon negative by 2030. Our sustainability mission is to accelerate progress toward a more sustainable future by reducing our environmental footprint, accelerating research, and helping our customers build sustainable solutions.

Through our Climate Innovation Fund, Microsoft is investing in innovative technologies to address global emissions. We have identified Rheaply as offering a promising solution and have made an investment in the company. Microsoft's investment will support Rheaply's approach to enabling and measuring reuse of materials as an encouraging pathway to reducing the waste and carbon footprint of many industries, at scale. Solutions like those offered by Rheaply will be instrumental to enabling a more sustainable and circular economy.

Microsoft supports Rheaply's application for the EPA SBIR Phase I (Solicitation Number: 68HERC21R0144), topic 4D: Low Impact Construction Materials and Technologies that Reduce Embodied Carbon of Buildings.

Respectfully submitted,

Heidi Kobylski

Heidi Kobylski
GM, Microsoft Federal-CIV

Attachment 1: Phase I Quality Assurance Statement (QAS)

Offerors must state whether or not their proposal involves data collection or processing, environmental measurements, modeling, or the development of environmental technology (whether hardware-based or via new techniques). The QAS describes the processes that will be used to assure that results of the research satisfy the intended project objectives. The EPA is particularly interested in the quality controls for data generation and acquisition, and how data validation and usability will be verified.

(1) Quality Assurance & Quality Control (QA | QC)

Our Team leverages a Design Thinking-based product management framework. Product Manager, Sabira Lakshmi is a Director-level professional at the Company who regularly conducts product development, discovery and research efforts with diverse stakeholders who have varied needs. Sabira will partner with CeCe Smith, Principal Investigator, who is a Senior-level Solutions Engineer at the firm. CeCe has experience conducting collaborative design charrettes and research efforts within the construction industry

An often invisible part of the construction industry, data significantly impacts every stakeholder and part of the construction lifecycle. AEC professionals, Building Owner / Operators, Permitters and Compliance Bodies all leverage and proliferate data throughout the design, planning, bidding, execution, resource management and portfolio management lifecycle. Maintaining a thoughtful information framework for capturing, storing, and preserving data -- as well as any relevant metric methodology, will be an important component of Data Governance for AxM's built environment features.

- Conduct Admin and End User / Stakeholder interviews
- Consistently collect, capture and disseminate feedback from Stakeholder
- Engage Stakeholders

Data Privacy & Governance

AxM virtually convenes multiple diverse stakeholders and facilitates exchange of information about available assets and building materials. This includes both internally within an organization as well as externally between multiple organizations. As part of facilitating these transactions, stakeholders provide profile information such as their name, position / role, and geographic or general office site location. To facilitate commercialization of AxM, Rheaply will maintain compliance with Data Privacy and Data Sharing regulations to ensure protection of data about individuals, organizations and their assets while facilitating the circular economy.

(2) Disclosure of Project Objectives

Project objectives, further detailed and contextualized in the Key Performance Objectives section of our Technical Volume, include

- leverage our existing city infrastructure and building stock as the primary material stores for new construction
- serve as scalable infrastructure to facilitate exchange and tracking of reclaimed building materials
- prioritize deconstruction of full materials over traditional demolition practices that expend carbon emissions even when recycled C&D content is recrafted into new materials
- assess the feasibility of deriving and reporting the estimated embodied carbon savings from using reclaimed building materials (vs a baseline such as new materials or ones made of partially-recycled content)
- disrupt the built environment material supply chain by activating a circular economy of reuse!
- Leveraging Rheaply's Asset Exchange Manager (AxM) Platform to empower decarbonization efforts by reporting on embodied carbon savings related to each transaction of reclaimed materials.
- Evaluating the feasibility of reporting upon data and metrics as relates to reused materials exchanged on the platform and estimated carbon savings. This could include:
    - Tonnes of waste diverted from landfill by reclaiming the material
    - Embodied carbon savings: the amount of carbon emissions saved as a result of reusing the AxM reclaimed material versus a new building material (according to established baselines)
    - Track the energy consumption and expenditures associated with the asset's reclamation journey (e.g. distance traveled from from demolition site to new site home)

(3) Primary Data Sources

Our goal is to obtain a minimum sample size of at least 100 building materials. Building materials within a set will be counted as 1 building material within the study (e.g. quantity of 500 tiles

picked up from site will count as 1 building material) although the quantity within a set will also be reported as a key indicator of scale. We will seek to obtain project site and material diversity.

We will collaborate with a cadre of Construction Industry Stakeholders representing varied roles along the building lifecycle as further outlined in our proposal.

(4) Existing / Secondary Data

- Throughout User Onboarding and Testing, we will ask a diverse set of Construction Industry Stakeholders with Admins and End User Permissions on AxM to upload data related to deconstruction and material reclamation, including:
    - deconstruction site
    - reclamation site (request)
    - material reclamation requests
    - shop drawings
    - manufacturer information
    - Environmental Product Declarations (EPDs)
    - observed condition of reclaimed material
    - image of reclaimed material
    - weight
    - quantity
    - value
    - transaction cost / fee
    - pick up site
    - MasterFormat data
    - Building Information Model (BIM)

Within our research objectives, we will report on the viability of consistently identifying, capturing and sharing the aforementioned fields above for surplus and reusable building materials originating from deconstruction sites and used as reclaimed in new projects. This reporting may include data on:

- the viability of obtaining the data
- sources (people or materials) most likely to have the respective data
- how data sources were validated
- % of fields most left empty
- stakeholder-reported reasons as to why fields were / are left empty
- prioritization of data fields across stakeholder groups

Our Client Success Team will regularly conduct data quality checks to verify the veracity and completeness of the data. We will also leverage platform role permissioning for quality control to ensure only authorized Admins may input data.

(5) Method Development

As further contextualized in our Technical Volume, we will regularly conduct research spikes, user interviews and user acceptance testing to develop, conduct testing on, collect feedback on and evaluate our methodology for deriving estimated carbon savings from built environment materials. The criteria of these procedures are further detailed and contextualized within the Key Objectives portion of our proposal.

(6) Development & Refinement of Models

This Phase I research proposal contemplates the feasibility of developing a methodology to report on deriving estimated embodied carbon reduction savings from built environment materials. Should we find that this methodology is both feasible and reliable, we may seek to develop a back-end algorithmic model that assists customers by automatically calculating the estimated carbon savings and incorporate it into our AxM platform during a proposed Phase II and / or future commercialization efforts.

(7) Development or Operation of Environmental Technology

Rheaply's AxM currently offers the following functionality, which will be leveraged for this research program:

- Asset Tracking: Quick, simple input of assets/equipment and clean accounting of assets and their status.
- Asset Agnostic System: - Ability to input and track any asset or equipment type. Asset categories are customizable.
- Rentals - Scheduling functionality
- Requests - Submit / track requests for items you are interested in and receive notifications.
- Photos - Upload photos from any device (desktop, mobile) for an intuitive, visual view of material inventory.
- Marketplace - AxM enables easy exchange of surplus materials within an organization (internal) or among multiple organizations (external).
- Connect with other organizations - Connect with others who are a part of the Rheaply AxM or a regional / local network.
- Partner with Nonprofits - Invite nonprofits to benefit from surplus materials.
- Surplus Discoverability - Easily search for the exact thing you need or browse by category, location, price, and more.

- Curated Suggestions - AxM lets you know when materials you're interested in are available.
- Real-time In-app reporting - Operationalize and visualize environmentally-focused metrics via internal and external transactions, waste diversion, and value recaptured.
- Messaging - Message users conveniently within the app.
- Offers & Activity Management - Users are empowered to manage and exchange surplus within or across teams, departments, or cost centers. Admins can keep track of current and past activity.
- Roles and Administration - Tiered User Roles allow users the appropriate level of system access, data quality and control.
- Gamification - Users earn points for engagement and waste diversion. Org leaderboard creates incentives for reuse.
- Profile & Contacts - highlight user skills and engagement to encourage collaboration.
- Technical Specs Single Sign On (SSO) - AxM integrates with any existing SSO protocol.
- Easily access all of the powerful desktop features on any device via our Progressive Web App (PWA) technology.

(8) Data Management

Within AxM, we store all of our data in a relational PostgreSQL database. The listings, rentals, requests, and user profile data is also indexed into elastic search so that users can perform free text searches. Rheaply maintains a risk management program according to NIST SP 800-37, Risk Management Framework for Information Systems and Organizations: A System Life Cycle Approach for Security and Privacy (Revision 2).

As described and contextualized further in the Commercialization section of our Technical Volume, Rheaply anticipates and is actively preparing for the compliance steps (e.g. FedRAMP, CMMC, etc.) necessary to scale our technologies.

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