ECORARE BUSINESS PLAN

ENVIRONMENTAL INNOVATION CHALLENGE

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INTRODUCTION

PROBLEM

Since the late 1990s, China has dominated 85 - 95 percent [1] of the world's supply of rare earth elements (REEs). These vital minerals, including lanthanum, neodymium, and cerium, are used everywhere from national defense technology to high-end consumer electronics such as the iPhone. Last year, the United States imported $160 million worth of REEs, supplying 90% of our economic needs [2]. In an era of increasing geopolitical conflict, import reliance may lead to disaster for our economy if the supply is cut off. We urgently need to develop domestic supplies of REEs to preserve our economic resilience.

China's vertically integrated REE supply chain and economies of scale are difficult to compete with, and redeveloping exploration, mining, extraction, and separation capabilities is expensive. Current methods of mining and separating rare earth elements (REEs) are not only expensive and labor intensive, but also take a devastating toll on the environment. Therefore, the Department of Energy has dedicated $30 million of funding for developing alternative domestic sources. We have found a viable solution that leverages an overlooked resource to preserve the United States' REE supply.

SOLUTION

We are looking to leverage Sandia National Laboratories' (SNL) patent-pending "Green Extraction of Rare Earth Elements from Coal Waste" technology to add an additional domestic supply of rare-earth elements (REEs) from coal ash. 113 million tons of coal ash is generated annually in the United States (including 38 million tons of fly ash) [3], with unused fly ash containing a high concentration of REEs amounting to 8910 tons. This alone satisfies 94% of the United States' annual consumption. SNL's process works by using cheap and readily available water, supercritical carbon dioxide (SCO2), and food-grade citric acid to chemically separate target elements from coal ash, as well as remove heavy metals.

We will demonstrate an economic model for commercializing SNL's efficient process to automate rare-earth extraction and provide coal-fired power plant operators with a distributed one-stop solution. They will benefit by having an additional revenue stream, as well as mitigating transitional and regulatory risks such as the expense of EPA-mandated heavy-metal removal from coal waste. Should this business succeed, American manufacturers (clean tech, electronics, automotive, etc.) will gain a tariff-free, local, diversified, and green supply of REEs. Furthermore, it establishes a viable domestic source of REEs to reduce import reliance and enhance national security.

Figure 1

MARKET & OPPORTUNITY

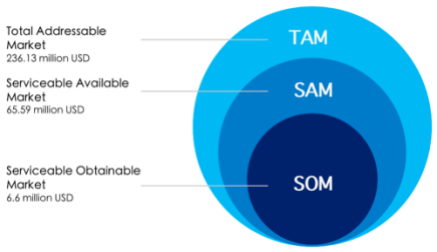

Figure 2

MARKET SIZE

In 2023, the TAM for the global recycled REE market had an estimated size of $236.13 million, with a CAGR of 11.4% [4]. The SAM is the US recycled rare earth element market, with an estimated size of $65.59 million. Since there is only limited competition within the US recycled REE market according to the USGS, we assume to take up to 10% of the total market, which leads to an estimated SOM size of $6.6 million.

COMPETITION

We identify our competition to come from three main groups of competitors, Chinese mining companies, US mining companies, and our direct competitors in rare earth recycling (e.g. Quantum Ventura, Anactisis, Skyhaven Systems, LLC, Wyonics).

With our technology, we are able to out-compete them by providing both a sustainable and available source of REEs at a reasonable cost. As demonstrated by our diagram, we will be able to provide a solution that is cost-competitive (affordability), while beating our mining and recycling competitors in supply chain resilience and local availability. We are also more eco-friendly than our recycling competitors due to the lack of dangerous solvents in our chemical process, as well as doing better than our mining competitors due to the destructive nature of mining.

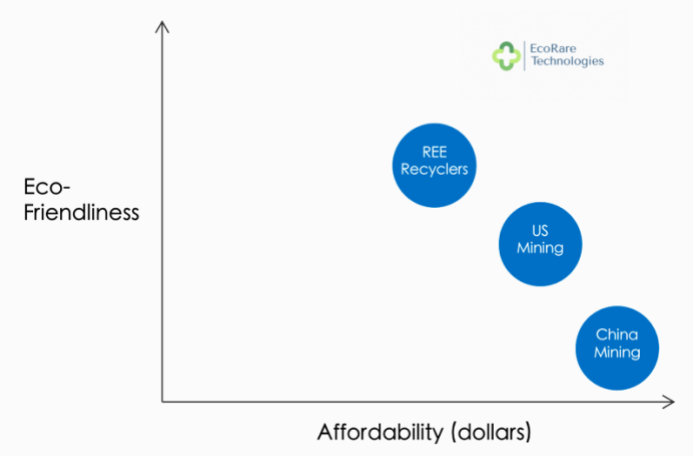

Figure 3

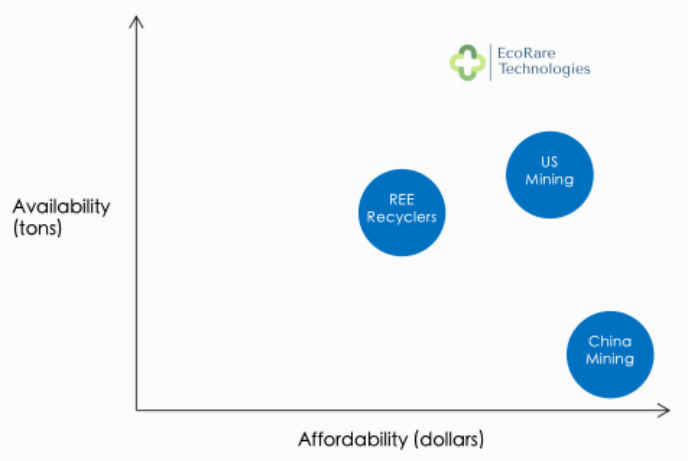

Figure 4

ECORARE

ROLLOUT PLAN

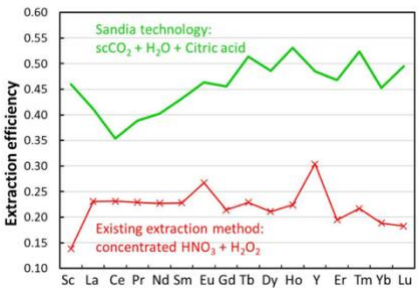

Figure 5

We are looking to commercialize a process designed and implemented by SNL. SNL has a working laboratory prototype demonstrated to extract REEs from coal ash at a 42% efficiency. However, they have not developed a fully integrated industrial-scale solution that can be deployed on-premises at coal-fired power plants. As demonstrated in the project timeline, we expect to put in another two years of R&D to achieve Technology Readiness Level: 7, where we will have an integrated pilot system demonstrated. In the year 2025, we expect to pilot our system in an operational environment at partnered coal-fired power plants.

BUSINESS VIABILITY

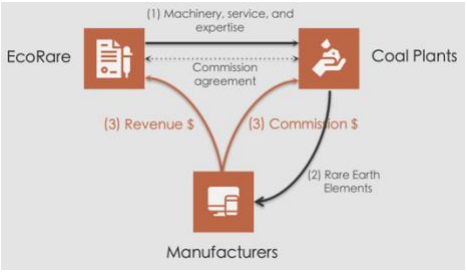

Figure 6

Meanwhile, we will focus on demonstrating our business viability. As mentioned previously, we are providing a distributed one-stop solution for coal-fired power plants to recover valuable critical REEs (neodymium, europium, terbium, dysprosium, yttrium) while removing heavy metals for an additional revenue stream and regulatory compliance. Our business is made viable and competitive through the following factors:

- **Distributed:** The machinery is installed on-site for the direct processing of coal ash with the benefit of reduced transportation risk & cost, as well as increased local supply.
- **One stop:** With our engineering expertise and buyer network, we provide customers with a hassle-free experience that turns coal waste into a revenue stream.
- **Eco-friendly:** Generating no additional hazardous waste, we help customers reduce environmental, occupational health and safety, and regulatory burdens.
- **Commission-based model:** we provide all machinery, service, and distribution to help coal plants gain an additional revenue stream, which is then shared with us at a predetermined rate.

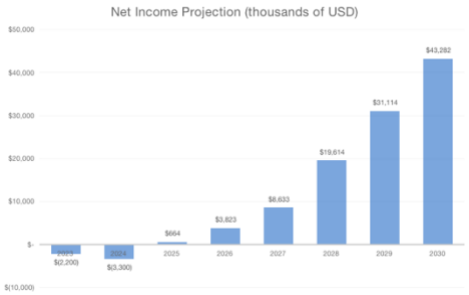

Figure 7

FINANCIALS

Our financial forecast comes with our estimated project timeline (refer to financial forecast in appendix). Starting from now, we estimate 2 years of R&D to scale up and test our solution. After that, we estimate one year of piloting with coal-fired power plants. From then, we expect full operation with a CAGR of 100%.

CLIMATE IMPACT

Our eco-friendly extraction process has significant positive climate impacts as compared to other options on the REE market. As we grow, we expect our carbon footprint to grow as well but will implement a mitigation strategy and incorporated solutions into our business to reduce carbon emissions. Our carbon footprint is projected in Figure 8.

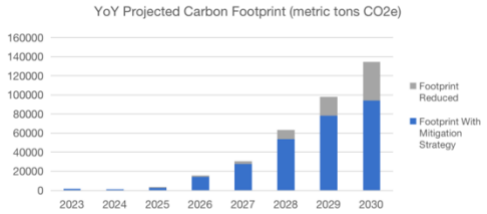

Figure 8

To mitigate some of these climate impacts, we intend to reduce our office and business travel footprints. We also intend to incorporate recycled metals such as aluminum into the manufacturing of our machinery. As it stands, the production of 1 ton of recycled aluminum emitted 0.6 tons of CO_2, compared to 17 tons emitted by mining the same amount [5].

In 2025, our first year in the market, we have projected our carbon emissions in Figure 9 and Figure 10. Most of our emissions during full operations are expected to come from Scope 3, predominantly from the procurement, logistics, and use of our extraction machinery by third parties, as well as purchased goods and services that aid those processes. Our Scope 1 and 2 emissions are centered around manufacturing activities.

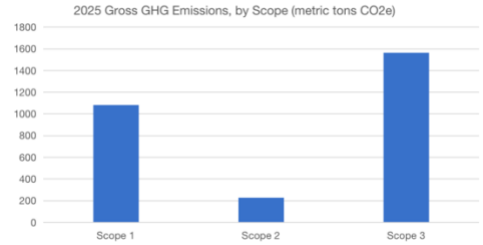

Figure 9

EcoRare outperforms other market sources of REEs in reducing carbon dioxide emissions. Currently, most of the United States' supply of REEs comes from China. Shipping most of the 9600 tons of REEs that the US consumed from China in 2018 emitted 1,121,318 tons of CO_2. Trucking the same amount domestically would only emit 388,320 tons, a reduction of 65% [6].

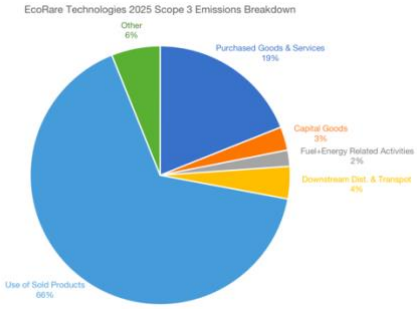

Figure 10

Other examples of our sustainability advantages include the benefits of avoiding mining REE ores. Mining activities both domestically and internationally contribute 8% of global CO_2 emissions, which are eliminated by an extractive process. Lastly, the revenue generated for coal-fired plant operators provides a financial cushion that allows them to transition their facilities to renewable energy sources, accelerating the rollout of the net-zero grid.

TOXIC WASTE REDUCTION

Alongside reducing carbon emissions, our technology has positive impacts on reducing toxic waste in the environment. Currently, coal ash is disposed of in toxic waste dumps, which leach into the surrounding environment. This poses a major hazard to workers handling the waste and presents an expensive regulatory risk for the coal-plant operators that are forced to manage it. Fly ash alone contains 3072 ppm of heavy metals [7]. Our solution scrubs these toxic elements from coal ash. Also, recycling reduces mining waste and destruction. Mining a single ton of REE ore produces a whopping 2000 tons of toxic waste that must be disposed of [8]. By using an extractive process from coal ash, this toxic mining waste is eliminated entirely.

OVERALL IMPACT

EcoRare's entry into the market will have positive effects on national security and the economy, as well as improving environmental, health, and safety outcomes. By creating a domestic supply of REEs, manufacturers and the government will be able to continue producing vital goods such as semiconductors, automobiles, and air defense systems. This domestic supply will have additional economic benefits, including controlling the costs of REEs for manufacturers in crucial sectors, de-risking legacy power plant operators from regulatory costs associated with fossil fuel use, and providing them with a financial cushion that facilitates the transition to a net-zero grid. By cleaning heavy metals out of toxic coal ash and putting unused fly ash to use, EcoRare's technology will improve occupational health and safety for the workers who process it. By eliminating these heavy metals and the environmentally hazardous chemicals and solvents that coal ash absorbs during coal consumption, environmental hazards and risks to nearby communities are reduced for the waste disposal process.

TEAM

FOUNDERS

Peilun Sun is a M.S. Business Analytics student at the University of Washington. With a M.S. Environmental Engineering background and extensive experience in the venture capital and recycling industry (project developer for medical equipment recycling), he is excited to bring his industry and technical knowledge to the EcoRare team. By leveraging his skills in business analytics, engineering, and management and domain knowledge in recycling, he will drive EcoRare's business development and expansion with our industry partners.

Daniel Rashevsky is studying for his B.S. Computer Science at the University of Washington. As a member of the Lavin Entrepreneurship Program, he has extensive experience in market research, product development, and the startup lifecycle. In 2021, he launched RigMonkey, a PC gaming startup that raised $5300 and signed up 200 users for its concierge gaming PC design service. He looks forward to applying his technical, system design, and entrepreneurial skills to driving EcoRare's commercialization journey.

ADVISORS

Srini Vasan is the CEO of Quantum Ventura, a technology innovation company with a single mission of delivering customer-centric advanced solutions to US Federal & State Governments and Private Sector customers. He is a software entrepreneur with a specialization in databases, ERP, Big Data, General Management, Social Media Analytics and Digital Marketing. Currently Quantum Ventura is building a 7kg/day prototype plant utilizing Department of Energy E-RECOV technology to extract precious metals and rare-earths from e-waste.

APPENDIX

FINANCIAL PROJECTION

Financial Forecast

	Development & Testing		Pilot Operation	Explicit Forecast				
In thousands of USD	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Number of Machines Implmented			1	5	10	20	30	40
Production Capactiy (kg / day)	-	-	7.00	35.00	70.00	140.00	210.00	280.00
Average Raw Rare Earth Price (per kg)	$ 1.00	$ 1.06	$ 1.11	$ 1.16	$ 1.19	$ 1.23	$ 1.26	$ 1.30
Adjusted for inflation	7.1%	6.0%	5.0%	4.0%	3.0%	3.0%	3.0%	3.0%
Revenue	**$ -**	**$ -**	**$ 2,805**	**$ 14,585**	**$ 30,045**	**$ 61,892**	**$ 95,623**	**$ 131,322**
Market Share								
Less: Comission to Coal Plants			(841)	(4,375)	(9,013)	(18,568)	(28,687)	(39,397)
Coal Plant Comission Rate			30%	30%	30%	30%	30%	30%
Gross Revenue	**$ -**	**$ -**	**$ 1,963**	**$ 10,209**	**$ 21,031**	**$ 43,324**	**$ 66,936**	**$ 91,925**
Operating Expense:								
Machinary Manufactuering Cost			10	50	100	200	300	400
Service and maintenance Cost			2	11	24	36	53	85
Service and Maintenance as percentage of Machinary Costs			20%	18%	15%	10%	8%	8%
R&D	1,900	2,850	294	1,225	1,682	1,733	2,677	3,677
R&D as Percentage of Revenue			15.0%	12.0%	8.0%	4.0%	4.0%	4.0%
SG&A	300	450	550	2,552	4,837	8,665	12,048	15,627
SG&A as Percentage of Revenue			28%	25%	23%	20%	18%	17%
Total Operating Expense	(2,200)	(3,300)	(856)	(3,838)	(6,644)	(10,634)	(15,079)	(19,789)
EBIT	$ (2,200)	$ (3,300)	$ 1,107	$ 6,371	$ 14,388	$ 32,690	$ 51,857	$ 72,136
Interest, Tax, Cost of Debt (40% of EBIT)			(443)	(2,548)	(5,755)	(13,076)	(20,743)	(28,855)
Net Income	$ (2,200)	$ (3,300)	$ 664	$ 3,823	$ 8,633	$ 19,614	$ 31,114	$ 43,282
Accumulated Cash Flow	$ (2,200)	$ (5,500)	$ (4,836)	$ (1,013)	$ 7,619	$ 27,234	$ 58,348	$ 101,630

CARBON FOOTPRINT PROJECTION

Carbon Footprint Projection

	Development & Testing		Pilot Operation	Explicit Forecast				
	2023	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Revenue (thousands of USD)	$ -	$ -	$ 2,805	$ 14,585	$ 30,045	$ 61,892	$ 95,623	$ 131,322
Multiplier (metric tons CO2e/$ Revenue)			0.001463	0.001463	0.001463	0.001463	0.001463	0.001463
CalculatedFoot print (metric tons CO2e)	825.66	1238.49	2871.87	14935.77	30768.35	63383.01	97927.37	134486.28
CalculatedFoot print with mitigation (metric tons CO2e)	825.66	1238.49	2785.71	14039.62	27691.52	53875.56	78341.89	94140.39
Adjusted for mitigation	0.00%	0.00%	3.00%	6.00%	10.00%	15.00%	20.00%	30.00%

Carbon Footprint Breakdown by Scope

	Scope 1	Scope 2	Scope 3					
In metric tons CO2e			**Purchased Goods & Services**	**Capital Goods**	**Fuel+Energy Related Activities**	**Downstream Dist. & Transpot**	**Use of Sold Products**	**Other**
2023	541.35	113.44	147.90	22.97	0.00	0.00	0.00	0.00
2024	812.02	170.16	221.85	34.46	0.00	0.00	0.00	0.00
2025	1082.69	226.88	295.80	45.95	31.59	63.18	1031.00	94.77
2026	5630.78	1179.93	1538.38	238.97	164.29	328.59	5361.94	492.88
2027	11599.67	2430.70	3169.14	492.29	338.45	676.90	11045.84	1015.36
2028	23895.40	5007.26	6528.45	1014.13	697.21	1394.43	22754.50	2091.64
2029	36918.62	7736.26	10086.52	1566.84	1077.20	2154.40	35155.93	3231.60
2030	50701.33	10624.42	13852.09	2151.78	1479.35	2958.70	48280.57	4438.05

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Figure 5. https://phys.org/news/2021-10-environmentally-hazardous-coal-diminished-citric.html