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ZHIDA: BLOCKCHAIN POTENTIAL IN HOUSEHOLD WASTE RECYCLING

Yu Gong, Shenghao Xie, Steve Brown, Changjun Li, and Jiang Duan wrote this case solely to provide material for class discussion. The authors do not intend to illustrate either effective or ineffective handling of a managerial situation. The authors may have disguised certain names and other identifying information to protect confidentiality.

In 2020, a waste crisis was looming across the world. Only 13 per cent of global waste was being recycled.[1] Despite the emergence of legal measures and circular economy practices[2] being implemented in recent years, the recycling industry seemed to be in a state of chaos, especially in developing countries. Widespread issues included solid waste accumulation around cities, illegal waste dumping, and marine ecological destruction caused by discarded plastic.

Zhida Environmental Technology Co. Ltd. (ZD) was a waste management company dedicated to urban household waste in China. Xinlong Zhu, the chief executive officer of ZD, was debating a decision to transform the service. Since ZD's founding in 2014, the Internet-centric solutions the company had established were hailed by peers as best practice standards in the recycling industry. However, ZD had gradually lost its initial competitiveness in changing markets. Stagnant participation by residents, low recycling rates, competing forces, new industry entrants, and tightening financial budgets had placed ZD into a sluggish period. Zhu realized it was time to explore forward-looking solutions.

Zhu's attention veered toward the emerging blockchain technology (BCT). He noticed that some international organizations had piloted BCT into circular economy practices, which had generated favourable results when combined with key BCT functions. Zhu realized that some of those applications could work at ZD as well. However, he was concerned about the unpredictable risks of being a first mover in the market. Currently, there were no BCT practices being used in the Chinese recycling industry that Zhu was aware of. The question of whether or not to adopt BCT for a potentially more competitive position placed him and his company at a crossroads. What benefits could BCT provide to ZD? How could it help the company improve the service it provided? How could ZD balance the trade-offs between potential benefits and unknown risks?

[1] Silpa Kaza, Lisa C. Yao, Perinaz Bhada-Tata, and Frank Van Woerden, *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050* (Washington, DC: The World Bank, 2018).

[2] The circular economy was a model of production and consumption that involved sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible. In this way, the life cycle of products was extended. "Circular Economy: Definition, Importance and Benefits," European Parliament, March 3, 2021, https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits.

COMPANY BACKGROUND

ZD was founded in Nanjing, in China's Jiangsu province, in 2014. The company functioned as a commercial waste collector and hauler, as well as promoting and guiding residents to sort waste. It collected and transported waste to business partners for further processing or recycling (see Exhibit 1). ZD was a pioneer in the recycling industry, with its own smart digital Internet-based system assisting in the waste management process. Novel initiatives pushed ZD to form a public and private partnership with the Community Committee, the lowest level of government in China, to sort waste and work with residents. The Community Committee also provided subsidies to support ZD's daily waste management services. After more than ten years of exploration, ZD was gradually transformed into a technology-driven waste management company with more than 200 employees. Through its intensive publicity and exploration, ZD expanded from Nanjing to eight cities in China (see Exhibit 2).

The most innovative service ZD provided was known as its credit reward mechanism. ZD encouraged residents to sort household waste and then compensated them with reward credits the residents could either use to shop in the ZD supermarket or exchange for community services. The company's smart online platform provided scientific and convenient support for waste sorting, while also accumulating recycling data. Its innovative waste management model also attracted various co-operative opportunities. For example, ZD worked closely with multinational corporations including The Coca-Cola Company and Tetra Pak to explore their packaging recycling. ZD also looked for innovative solutions by conducting joint recycling research with Nanjing University in China and Kobe University in Japan, among others.

CURRENT OPERATIONS OF ZD

Zhu's idea of embracing BCT was serious. With over ten years of experience and observation, Zhu was quite familiar with the recycling industry. He knew that the Chinese recycling industry was beginning to undergo dramatic changes as a result of a new law banning waste imports that China enacted in 2017.[3] He was confident that ZD had a solid foundation for further exploration, especially with its online platform. ZD's smart waste management system was widespread, covering four major components: waste reward credits, fixed time and place for waste collection, Internet-based waste sorting, and separate waste collection and transportation.[4]

Waste Reward Credits

Residents who sorted waste properly could earn reward credits that could be exchanged for various products. ZD awarded credits by type of waste. For example, sorting of renewable resources and hazardous waste earned blue credits, whereas sorting kitchen waste earned green credits. The measure was intended to promote participation from residents. This practice differed from the traditional cash for recycling waste collection that was prevalent in China, which was opposite to the practice in some developed countries where residents paid to have their waste collected.[5] ZD's initiative also served to bridge communities by promoting social values. Common recycling activities among communities helped bring residents closer, according to ZD's operations manager, Shuo Chen:

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[3] Tom Hancock, "China Recyclers Grind to Halt amid Crackdown on Imported Waste," *Financial Times*, January 15, 2018, https://www.ft.com/content/63cf220c-f8ee-11e7-9b32-d7d59aace167.

[4] "Nanjing Zhida: Exploring the Market of 'Waste Classification + Renewable Resources'" [in Chinese], Ministry of Commerce People's Republic of China, March 8, 2018, http://ltfzs.mofcom.gov.cn/article/ztzzn/201803/20180302718405.shtml.

[5] Bo Fan, Wenting Yang, and Xingchen Shen, "A Comparison Study of 'Motivation-Intention-Behavior' Model on Household Solid Waste Sorting in China and Singapore," *Journal of Cleaner Production* 211, no. 20 (2019): 442–454, https://doi.org/10.1016/j.jclepro.2018.11.168.

> We set up credits mainly for improving waste collection. Without source classification, the waste accumulation would be inevitable, and it would cause troubles to the rest [of the] recycling chain. If we continue to use cash to purchase waste, residents may think of us more like a commercial organization, which increases a sense of distance from communities. Also, we provided community activities for the elderly group, serving as a channel to interact with residents.

Fixed Time and Place for Waste Collection

ZD adopted scheduled waste collection with a fixed time and place, based on Western countries' practices, to help residents sort household waste effectively. ZD's role in promoting favourable waste sorting behaviour by citizens was to provide supervision, education, and publicity. The two fixed times were 6:30 a.m.–11:00 a.m. and 5:00 p.m.–9:00 p.m. The fixed place referred to a specific collection area where residents could drop off their waste. The initiative was referred to as a *breaking-bag* process, where residents were required to "break" open their packed waste bags and place waste into sorting bins according to the type of waste.

Internet-Based Waste Sorting

In 2015, ZD introduced its digital online system called Hui, which included both hardware and software components (see Exhibit 3). The hardware consisted of a digital scanner for residents to scan their ZD Hui waste sorting card. The software enabled waste sorting credits to be digitally deposited into customer accounts after they successfully sorted their waste. To engage more users, ZD connected the digital online system with social media accounts such as WeChat, which had widespread use across China. The Hui program recorded the customer's waste sorting behaviour, promoted waste sorting dynamics, and allowed booking of recycling services by appointment. ZD also established a data service that it called its Waste Sorting Big Data Centre. This service stored participation rates, recycling rates, waste types, waste amounts, and source information (see Exhibit 4).

Separate Waste Collection and Transportation

ZD enhanced its waste sorting service with a smart green station in the front end of the service and detailed transportation solutions in the back end. The smart green station, which replaced traditional waste bins, was equipped with automated sensors that were specially designed for waste weighting and collection. ZD also set up specific disposal processes for each stage, including sorting, collection, storage, and transportation to processing plants for further disposal and recycling (see Exhibit 5).

ZD became known as the best practice standard for innovative recycling solutions in China. For extensive coverage across the country, ZD set up a mass local base for its smart waste management system. After piloting the system on Yaohua Street, a major artery in Jiangsu province's capital city of Nanjing, the system became known as the Yaohua model. The system's success included over 80 per cent of residents in the community sorting more than 60 per cent of waste, with an accuracy rate of 90 per cent. In 2020, ZD catered to more than 300,000 households in twenty-three Nanjing communities.

DEVELOPMENT CHALLENGES

Although the success of the ZD business model was widely acknowledged, the company still faced various obstacles, including problems with its internal recycling operation. ZD's innovative concept of using a reward

credits system was a key factor in the company's expansion. However, residents' enthusiasm was soon stalled by the cumbersome waste sorting and credits exchange process. Some residents joined the program only because it was mandatory, and they found the products offered in the credits exchange lacked interest or usefulness (e.g., daily necessities). Current ZD participants consisted mainly of older and senior adults, with a very low participation rate among young people, as Zhu recalled: "Young people showed much less enthusiasm. Coming home from work, they were so tired that they did not even consider recycling. Even if they did recycle, they may not have cared about credits because they did not find them attractive enough."

The service scope of the ZD data capture platform was limited. It could only record recycling data from the collection stage, but no data was available after the waste was transported to processing centres, so ZD was not aware of the activities that took place in the recycling plants. Therefore, full transparency across the entire recycling chain was not available to ZD. In addition, the company faced various external challenges that were even more complex. The proliferation of Internet technology, combined with the concept of a circular economy and smart cities, led to widespread emergence of recycling companies and proposals for innovative solutions, such as establishing renewable resources recycling platforms and e-commerce for electronic product recycling. Chen explained how the situation was unfolding:

> In the early days of ZD's establishment, we were one of the few waste management companies in Nanjing. We can even say that we were the benchmark in the industry. Now, the number of recycling companies has increased dozens of times in the last five years. They will certainly not follow the traditional door-to-door collection method, but embrace the popular Internet model, like us. Obviously, we need innovation and transformation to be more competitive.

Additionally, public and private partnerships meant that local government support was critical. Losing competitiveness would weaken co-operation with local departments, which would mean less financial and policy support. Another sales revenue stream for ZD was reselling collected waste to specialty recycling companies. But this market suffered greatly from uncertainty factors such as the fluctuating prices of materials. ZD also considered local communities as its main waste collection channel, with household waste accounting for the majority of its product. However, this material was normally mixed with much less valuable recyclable items such as glass bottles and kitchen waste, as Chen explained:

> The price of recyclable waste fluctuated dramatically. We experienced dramatic changes in scrap metal prices, as well as ongoing fluctuations in paper and plastic prices. Financial abundance is a huge problem for us, and it will be our long-term challenge. We expect more subsidies from the government, but I have to say it is still difficult for us to obtain loans from the government or banks. We are also running at a high operating cost, compared to other recyclers that only deal with valuable recyclable waste. Therefore, we are facing an important stage of service transformation.

These emerging challenges inspired Zhu's determination to pursue his company's transformation. Following a trend of widespread Internet usage and a circular economy, ZD expected a new waste management paradigm to emerge. In recent years, some start-ups had adopted novel recycling solutions, and ZD responded by enhancing its Internet-based competitiveness. Improvement services required more efficient auxiliary tools and engaging a larger group of users. Therefore, ZD was motivated to design more creative and forward-looking waste management models, such as incorporating BCT, as well as continuously expanding implementation in other cities.

INCORPORATING BCT INTO RECYCLING

ZD's idea for a disruptive market solution was to use BCT to help the company overcome the current challenges. BCT was an emerging technology that had originated from the evolution of bitcoin. BCT was

expected to disrupt existing business models. Using a distributed ledger design, BCT could store information within a decentralized mechanism without central or third-party control.[6] It could guarantee authenticity and reliability of information. It also had high openness or transparency characteristics that allowed users to view all relevant and linked information. BCT ran on agreed-upon specifications and agreements called *smart contracts* that could automatically verify and enforce contract terms. These elements of BCT provided huge potential for traditional operations such as cost reduction, transparency information, efficient traceability, flexible executive services, and sustainability.[7]

In addition to initial financial systems application, BCT promised great impact in terms of supply chain management transformation. It was widely accepted that BCT was suitable for multi-party collaboration. Recycling chains required the collaborative participation of citizens, supervision by government departments, waste transportation and disposal by waste companies, and co-operation by various other parties. It was not feasible to complete the recycling process independently using a unilateral initiative. Therefore, it appeared that BCT and recycling both shared a prerequisite for combinations of collaboration.

The most distinctive function of BCT in recycling was known as *digital token services*, which rewarded recycling activities. Users were encouraged to participate in recycling and would obtain digital token credits as a reward.[8] This approach disrupted the original idea of making participation for recycling mandatory because the behaviour of residents would be positively motivated. BCT also allowed traceability and transparency in the flow of waste, as it had already proven successful in the food industry.[9]

The peer-to-peer BCT network design could enhance waste data integrity and digital identity, which was especially useful to trace the increasing rate of electronic waste by using a tamper-proof mechanism. As a result, waste could be diverted from flowing into landfills, whether it was legitimately or illegally dumped. Some studies showed that BCT could be combined with other emerging technologies, such as artificial intelligence and the Internet of Things, to offer service optimization.[10] For example, waste sorting and transportation routes could potentially be optimized. BCT had already been piloted in some municipalities by various pioneer companies that were attempting to improve the management of solid waste.[11]

DECISION-MAKING TRADE-OFFS FOR ZD

Before deciding on adopting BCT, ZD had to thoroughly consider all outcomes and potential results. For ZD, this new initiative was not radical. The company already had a digital foundation for BCT implementation, thanks to its Internet-based architecture. The basic logic for adopting BCT was that ZD could solve current service bottlenecks and enhance its recycling service performance. Ideally, these

[6] Gabriella M. Hastig and ManMohan S. Sodhi, "Blockchain for Supply Chain Traceability: Business Requirements and Critical Success Factors," *Production and Operations Management* 29, no. 4 (2020): 935–954, https://doi.org/10.1111/poms.13147.
[7] Nir Kshetri, "1 Blockchain's Roles in Meeting Key Supply Chain Management Objectives," *International Journal of Information Management* 39 (2018): 80–89, https://doi.org/10.1016/j.ijinfomgt.2017.12.005.
[8] Sara Saberi, Mahtab Kouhizadeh, Joseph Sarkis, and Lejia Shen, "Blockchain Technology and Its Relationships to Sustainable Supply Chain Management," *International Journal of Production Research* 57, no. 7 (2019): 2117–2135, https://doi.org/10.1080/00207543.2018.1533261.
[9] Behzad Esmaeilian, Joe Sarkis, Kemper Lewis, and Sara Behdad, "Blockchain for the Future of Sustainable Supply Chain Management in Industry 4.0," *Resources, Conservation and Recycling* 163 (2020): 105064–105079, https://doi.org/10.1016/j.resconrec.2020.105064.
[10] Aditya Chidepatil, Prabhleen Bindra, Devyani Kulkarni, Mustafa Qazi, Meghana Kshirsagar, and Krishnaswamy Sankaran, "From Trash to Cash: How Blockchain and Multi-Sensor-Driven Artificial Intelligence Can Transform Circular Economy of Plastic Waste?," *Administrative Science* 10, no. 2 (2020): 23–40, https://doi.org/10.3390/admsci10020023.
[11] A.S.L. França, J. Amato Neto, R.F. Gonçalves, and C.M.V.B. Almeidab, "Proposing the Use of Blockchain to Improve the Solid Waste Management in Small Municipalities," *Journal of Cleaner Production* 244 (2020): 118529–118537, https://doi.org/10.1016/j.jclepro.2019.118529.

positive benefits would eventually scale up ZD's business and help the company gain support from local government departments. ZD was open to new innovative solutions, and this new venture could potentially increase the effectiveness of the company's current operations. ZD could once again become a first mover in the market by embracing BCT, much like the company's position when it was first to introduce Internet-based services in the waste management industry. Undoubtedly, however, threats of uncertainties and risk were likely to be encountered.

BCT Potential for ZD

The diversity of functions in BCT provided attractive options for ZD. Past practices had proven that simply relying on top-down policy enforcement could not fundamentally change residents' awareness about the importance of waste management. Introducing reward credits into the waste management process proved to be an important catalyst to engage users. However, service bottlenecks soon materialized, including in setting up a comprehensive credit system, creating an effective distribution of reward credits, finding other applicable functions, determining who should control the system, and increasing transparency.

BCT's digital token service could enhance the company's reward credits program. BCT could combine the program with a cryptocurrency to reward residents with digital tokens for their recycling activities. The digital token function could be extended to include urban public services; online shopping; and even bank financial products, such as loans.[12] It could also serve as a channel to consolidate informal sector recyclers, such as street waste collectors, who managed to collect over 80 per cent of the municipal waste in Nanjing.[13] These informal groups could gain business opportunities and earn reliable waste collection profits by jointly conducting waste collection and sorting services. ZD, as the initiator and coordinator, could offer a positive incentive mechanism to integrate other stakeholders into its program and drive multi-party collaboration.

BCT could help ZD further improve transparency in its services. The guarantee of a transparent recycling chain would be derived from the inherent immutability feature of BCT. Currently, the scope of ZD's service included collection and transportation, but the back end of the process was not under ZD's control. By leveraging the BCT traceability function, ZD could fully reveal the entire flow of waste management. At the collection stage, ZD could determine which types of materials accounted for the highest amounts of waste and which types caused the most pollution. At the back end, ZD could trace the activities of downstream recycling companies, especially those with specific quality requirements for recycled materials. A decentralized design could also form a co-governance mechanism to restrain improper behaviour of recycling chain members. This was possible because the entire recycling chain would be transparent, as Zhu explained:

> We especially look forward to the transparency of blockchain. For those companies that have strict standards for recyclability, we can show the source and composition. Also, transparency can indirectly monitor downstream companies. In particular, we do not know about waste flows after downstream reprocessing. Our efforts for waste sorting are useless if they have no proper treatments, such as for incineration and landfills.

ZD's position as the best practice standard in the industry was due to a high number of users and large amounts of waste collection. However, these figures came from ZD's own data platform, so they could be contested. The BCT system could provide ZD with credibility under public scrutiny. By adopting BCT, the company's performance and recycling chains data could be trusted without the need for a third party's verification.

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[12] David Katz, "Plastic Bank: Launching Social Plastic® Revolution," *Field Actions Science Reports* 19 (2019): 96–99, https://journals.openedition.org/factsreports/5478.

[13] Fu Chen, Zhanbin Luo, Yongjun Yang, and Jing Ma, "Enhancing Municipal Solid Waste Recycling through Reorganizing Waste Pickers: A Case Study in Nanjing, China," *Waste Management & Research* 36, no. 9 (2018): 767–778, https://doi.org/10.1177/0734242X18766216.

External factors in the industry and across the country provided Zhu with more convincing indicators. In 2019, the Chinese government set a strategic plan to become a global leader in BCT. It was the first time in history that Chinese leaders issued a clear strategy about a specific technology. BCT was the core technology in various national plans.[14] Zhu was aware that embracing BCT could reshape some of the company's current public and private partnerships, but it would also provide a great opportunity to take a first mover position in the market by using BCT in the recycling industry. With the Chinese recycling industry still in an infancy stage, recycling operations awareness was low and its efficiency was still limited. Adopting BCT could provide ZD with non-substitutable resources to secure a considerable market share.

From a global perspective, successful BCT circular economy practices around the world provided Zhu with the confidence he needed to launch the BCT project. The Canadian company Plastic Bank, in particular, had been using a BCT program with cryptocurrency rewards in developing countries including Haiti, Brazil, Indonesia, and the Philippines. The program had not only achieved efficient waste collection, but it had also delivered social benefits for informal groups.[15] Zhu believed that these triple-bottom-line benefits were naturally embedded in the Chinese recycling context. In particular, the BCT solution could provide stable living wages and raise the profile of informal waste groups.[16]

However, Zhu was also well aware of the risks of this disruptive technology application. Despite the numerous benefits that BCT could provide, there were various potential difficulties to consider.

Challenges of Adopting BCT

The first obvious challenge was who to pay for the BCT technology. Zhu realized that a major investment could be a huge burden on the company. Current existing BCT applications were mainly run by multinational companies with strong financial resources, such as the Danish integrated shipping company A.P. Møller – Mærsk A/S (commonly known as Maersk) and the US multinational retailer Walmart Inc. Therefore, Zhu had financial concerns for his company:

> We must recognize that starting this project can be expensive; in particular, it is still under development. For ZD, the primary task is solving financial problems, because our other businesses are still running. We cannot rely on a brand new technology just for an attempt, and abandon our existing systems. We hope our value chain members can share the investment cost. Or, it would be even better if a government department could pay for us.

Zhu also had to consider that his company would face technical problems due to a lack of expertise. ZD would have to make some choices among the different BCT features, including whether to opt for a *permissioned* or *permissionless* BCT format. For example, should all stakeholders in the recycling chain have access to the BCT network, or should only trusted and verified peers be able to join? Other considerations included whether ZD should act as a coordinator to install the BCT network and if the technology should be developed in-house or by external contracted experts. Also, what functions should the digital token service design adopt? The many technical considerations prompted Zhu to seek professional technology expert advice, which in itself involved a high investment cost.

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[14] Qiang Wang, Min Su, and Rongrong Li, "Is China the World's Blockchain Leader? Evidence, Evolution and Outlook of China's Blockchain Research," *Journal of Cleaner Production*, 264 (2020): 121742–121762, https://doi.org/10.1016/j.jclepro.2020.121742.

[15] Michael Peshkam, "Transforming Plastic Pollution Using Blockchain: Toward a World Without Single Use Plastic Packaging Waste," *Blockchain Research Institute*, August 13, 2019, https://www.Blockchainresearchinstitute.org/project/transforming-plastic-pollution-using-Blockchain.

[16] Siddharth Hande, "The Informal Waste Sector: A Solution to the Recycling Problem in Developing Countries," *Field Actions Science Reports*: *The Journal of Field Actions* 19 (2019): 28–35, https://journals.openedition.org/factsreports/5143.

The transparency issue was a two-sided dilemma. Transparency would increase trust, but it would also lead to privacy issues. Residents could be reluctant to disclose what products they consumed. Downstream recycling partners would be unwilling to fully display their recycling processes due to intellectual property issues. Even ZD itself was concerned about being overly transparent, as Chen explained:

> We do not want to disclose all waste information, such as how much aluminum or copper I send to the recycling station, which processing company I sold to, and at what price. The aim for transparency is always for service improvement. I believe that residents and recycling companies have similar considerations, especially for those recycling companies that have special degradation methods for certain packaging materials.

Zhu was also wondering if other recycling chain members would join ZD's BCT initiative. For local waste management departments, a decentralized management mechanism could weaken their supervisory power. More importantly, the level of worker awareness and formal education in the recycling industry was relatively low, as Zhu pointed out:

> I would say BCT is very new to the recycling industry. The initial trend was integrating Internet concepts, but it is still immature, even though it has been proposed for several years. For recyclers, it is difficult for them to understand such a complex technology. Even big recycling companies are not familiar with BCT. The underlying techniques need to be solved by experts, and residents only care about convenience. Our task is to show the unique advantages of BCT and call for more people to participate.

MOVING FORWARD

Combined with current environmental concepts such as the circular economy and carbon neutrality, BCT solutions for recycling was an attractive business opportunity with great potential. ZD had transformed itself from a traditional waste management start-up to a technology-driven company that conducted continuous exploration. Potential BCT functions seemed to be feasible for ZD. This innovative solution could even reshape the chaotic traditional recycling industry, which had been losing prominence in society for some time. Zhu and his team hoped to seize this opportunity and become the industry leader once again. However, issues such as cost, technical expertise, level of experience, function hurdles, and design concerns could be barriers for the company. Zhu was hesitating to move forward too quickly to embrace BCT as a key component of ZD's business model.

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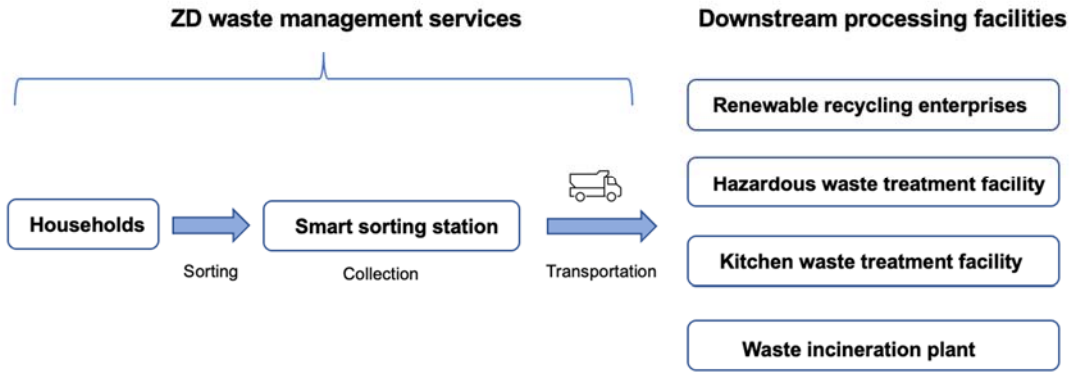
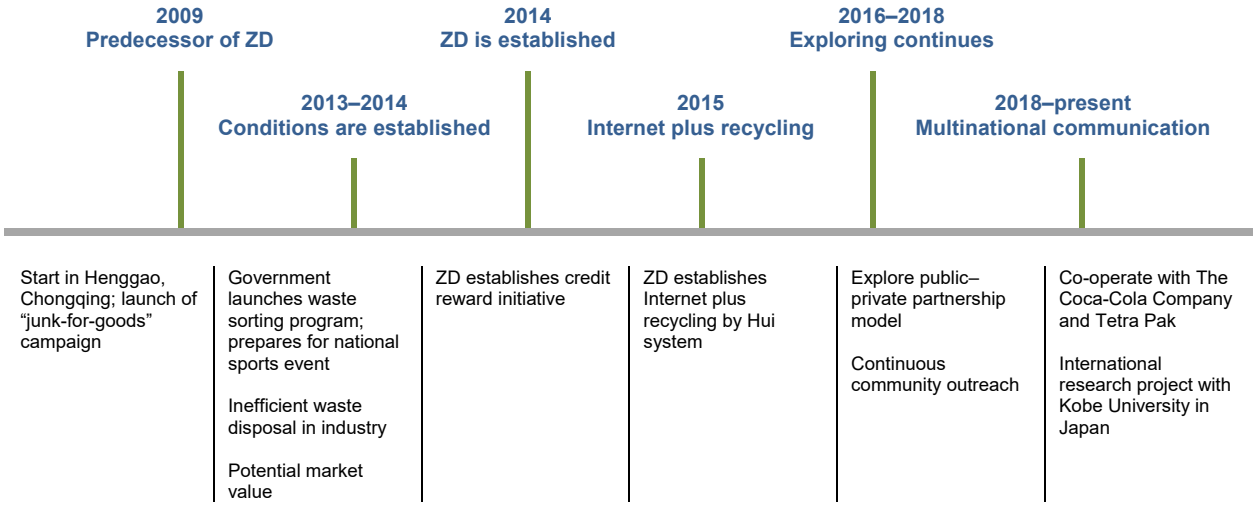
EXHIBIT 1: RECYCLING CHAIN OF ZHIDA ENVIRONMENTAL TECHNOLOGY (ZD)



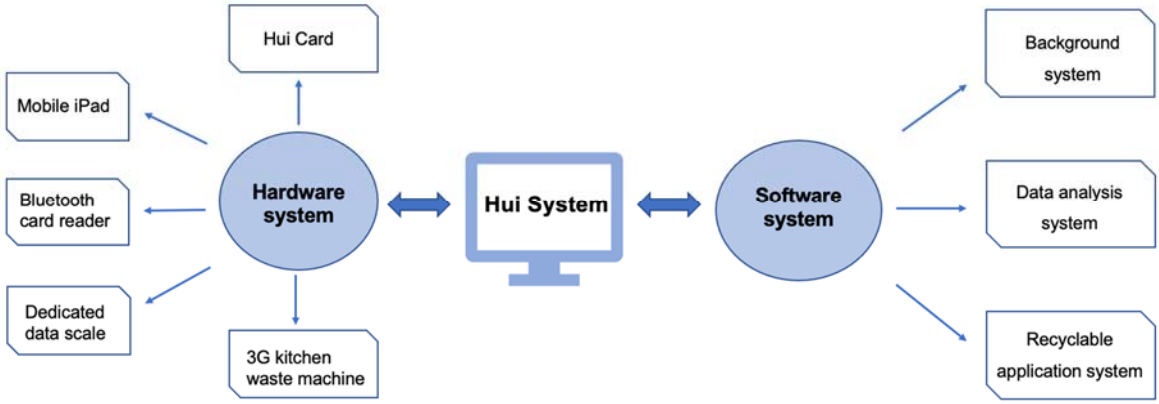
Source: Created by the case authors based on company files.

EXHIBIT 2: DEVELOPMENT TIMELINE OF ZHIDA ENVIRONMENTAL TECHNOLOGY (ZD)



Source: Created by the case authors based on company files.

EXHIBIT 3: HUI DIGITAL RECYCLING SYSTEM



Source: Created by the case authors based on company files.

EXHIBIT 4: ZHIDA ENVIRONMENTAL TECHNOLOGY DIGITAL RECYCLING PLATFORM

Source: Company files.

EXHIBIT 5: FOUR DIFFERENT WASTE DISPOSAL PROCESSES

Source: Created by the case authors based on company files.

SOMAIYA VIDYAVIHAR UNIVERSITY

Semester: Jan – Mar 24 **Maximum Marks: 50 Examination: ETE Exam Date: 26/03/2024 Duration: 3 Hrs**		
Programme code: 01 **Programme: MBA(DS-Major)**	**Class:** SY	**Semester/Trimester: VI**
College: K. J. Somaiya Institute of Management	**Name of the department/Section/Center:** Data Science & Technology	
Course Code: 217P01C601	**Name of the Course: Blockchain Technologies**	
Instructions: 1. Q.1 is compulsory 2. Do not mix-up sub questions 3. Answer **any two** from Q.2 to Q. 4		

Question No.		**Max. Marks**
Q 1	Using the case **'ZHIDA:Blockchain potential in household waste recycling'** answer the following questions: a. What is ZD's current recycling chain (or business model)? b. What are the current operation challenges for ZD? c. Based on its characteristics, what functions can BCT add to the recycling chain? d. How can BCT improve ZD's recycling operation performance? e. Considering all advantages and potential risks, should ZD embrace BCT and adopt it into its business model?	6M X 5 = 30 M
Q 2	What are cryptographic hash functions, asymmetric cryptography and digital signatures? How are they utilized to help make blockchain technology verifiable and immutable?	10 M
Q 3	What is permissioned or private distributed ledger technology? How does it differ from permissionless or open blockchain applications? Explain with an example.	10 M
Q 4	a. What is Ethereum framework? How it is different from bitcoin? b. What do you mean by blocks in blockchain technology? What are Merkle trees? How important are Merkle trees in blockchain?	5 M 5 M