Evaluation of economic feasibility of construction and demolition waste recycling plants in Vietnam

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Given the remarkable growth of the construction industry, construction and demolition waste (CDW) has become a major issue that Vietnam must now confront more seriously. A survey by Hoang et al. (2019) on the current state of CDW generation and management in Vietnam estimated that Vietnam generated approximately 0.57 tons of CDW per capita in 2014, which well exceeded other Southeast Asian countries, including Malaysia (0.31 tons/person) and Singapore (0.23 tons/person), as well as more advanced economies, namely Japan (0.47 tons/person in 2011) and Spain (0.16 tons/person). In the total waste generated at 15 construction and demolition sites investigated in Hanoi, merely 10% was reused and recycled whist the rest was subject to disposal, 22% and 6.9% of which were reportedly discarded at unverifiable and unofficial locations respectively, such as ponds and company sites (Hoang et al., 2019). This situation raises a need for aggressive methods to encourage CDW recycling in Vietnam. Accordingly, a thorough and quantitative evaluation of potential of this management option is of great importance. In response, this study analyses economic feasibility of CDW recycling in Vietnam through providing cost estimation and investment analysis of four CDW recycling plant models.

Cost estimation was conducted based on two main recycling technology options, which are stationary and mobile plants (Ulubeyli et al., 2017). Given that concrete and brick account for more than 50% of total CDW generated in Vietnam (Hoang et al., 2019) and recycled concrete and brick are widely employed as construction materials (Symonds Group, 1999), these two CDW components are considered input materials of the analysed CDW recycling models. Expected outputs are recycled construction materials for concrete production, road subbase construction and backfilling. Technical specifications of the plants, including design capacity, machinery, land allocation, etc. were obtained through literature review and interviews with construction experts and relevant government agencies in Vietnam, as well as CDW recycling companies in Japan. Data on capital costs were collected through quotations provided by heavy machinery providers and interviews with CDW recycling enterprises. Both brand-new and used equipment was taken into consideration. Regarding operational cost such as land renting, energy, and labour, consumption amounts were identified based on regulations of the Vietnamese government on consumption norms of machine shifts, labour grades and rates, etc., and consultation with Japanese CDW recycling plants. Unit prices were in accordance with the rates listed by government agencies in Vietnam (e.g. Hanoi PC, 2013; MOF, 2010; MOIT, 2019). To be simple, transportation cost is not incorporated in these plant models. Given that illegal dumping and uncontrolled backfilling are prevalent in Vietnam (Hoang et al., 2019), it is assumed that gate fees of CDW recycling plants are equal to zero to encourage CDW recycling, and therefore, their revenue are from sales of CDW recycled products only. The discount rate is set at 5%.

Table 1 indicates specifications of the modelled CDW recycling plants. Designated capacity of CDW recycling plants varies with plant types and regions. For fixed plants, capacity can range from 100 ton/hour to 350 ton/hour, or 1,000 ton/day to 3,500 ton/day with 10 hour operating per day (Ulubeyli et al., 2017). CDW recycling plants with capacity from 1,500 ton/day to 3,500 ton/day are considered large scale and often experienced in the US and Europe, where advanced technologies and machinery for CDW recycling are available (Ulubeyli et al., 2017). These plants, therefore, require significant upfront investments. Consequently, they might not be suitable for developing countries, in which Zhao et al. (2010) suggested CDW recycling plants of 100 ton/hour capacity. For mobile CDW plants that deploy basic machinery and technique for in-situ recycling, capacity is recommended to not exceed 1,000 ton/day (Ulubeyli et al., 2017). Consequently, this study addresses fixed CDW recycling plants of 1,000 ton/day and mobile ones of 360 ton/day of capacity.

Table 1: Assumed specifications of modelled CDW recycling plants

		Stationary recycling plant	Mobile recycling plant
Overall	Capacity	1,000 tons/day	360 tons/day
	Working days	300 days/year	220 days/year
	Working hours	10 hours/day	6 hours/day
	Operation duration	10 years (new equipment), 5 years (used equipment)	6 years (new), 3 years (used)
Capital cost	Equipment	1 hopper, 1 vibrating feeder, 1 jaw crusher, 1 impact crusher, 1 vibrating screen, 5 conveyors, 1 weighbridge, 2 wheel loaders	1 mobile crusher, 1 excavator loader, 1 water truck
	Land allocation	40,000 m^2	0 m^2

		Stationary recycling plant	Mobile recycling plant
Operational cost	Labour	1 manager, 3 machine operators, 4 administration staff	3 machine operators
	Land renting	0.5% of land price per year	No land renting fee
	Energy	Water: \$0.5/m^3 Electricity: \$0.06/kWh Diesel: \$0.7/litre	Water: \$0.5/m^3 Electricity: \$0.06/kWh Diesel: \$0.7/litre
	Disposal	\$0.8/ton	\$0.8/ton
	Maintenance	5% of capital cost (new), 10% (used)	5% of capital cost (new), 10% (used)

Figure 1 reports preliminary results on Internal Rate of Return (IRR) of the four recycling models, stationary and mobile plants with brand new and used equipment in accordance with different options of recycled material price, which is set as equal, 10% and 20% lower, or 10% and 20% higher than the price of virgin materials. IRR is the discount rate at which Net Present Value equals 0, indicating profitability of investments. The general rule of thumb for IRR is that the higher IRR is, the more economically promising the investment is. IRR value of the mobile plants, with both new and old machines, are either negative or lower than the discount rate of 5% in case the selling price of recycled CDW products are lower than natural materials. Their IRR value is significantly positive (52%) only if their outputs are sold for 20% more expensive than natural materials, that however makes them less attractive to consumers. This result implies a need for price incentives or strict regulations on green procurement for construction of the Vietnamese government to support mobile CDW recycling facilities. Meanwhile, IRR of fixed CDW recycling models is positive at all price options considered. It is remarkably high (156%) in case the plant uses second-hand machinery and its products' price is 20% higher than virgin materials. This indicates the economic potential of CDW recycling industry in Vietnam. However, it is worth emphasizing that transportation cost was not included in this preliminary analysis, making profitability of these models higher than they can actually be. Since fixed CDW recycling plants create much higher levels of noise and dust than the mobile ones, they are often located far from city centers. Therefore, once transportation cost is incorporated, the selling price can exceed natural materials' price by even more than 20%. This factor needs to be taken into full consideration before investments are made.

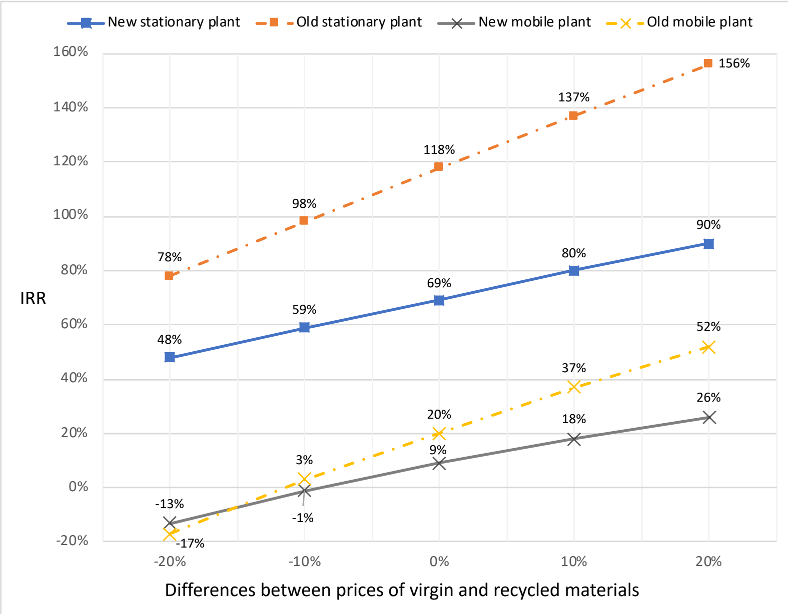

Figure 1: IRR of modelled CDW recycling plants

To conclude, the preliminary analysis reveals a low level of profitability of mobile CDW recycling plants, which is possibly explained by its lack of cost advantages of economies of scale, from which the stationary plants benefit. Nevertheless, since IRR can be inadequate to compare projects with different scales and duration, further analysis using other economic indicators are necessary to provide precise evaluation of these CDW recycling models.

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