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Concept model for the second life cycle of vehicles in Palestine

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Abstract

Old road vehicles in Palestine like most of other countries are inefficient in terms of fuel consumption, unequipped with proper modern passenger safety means and produce high levels of exhaust toxic emissions. One important aspect that needs attention is when these vehicles fail to meet licensing regulations and become a real problem, especially in Occupied Palestine that has a special circumstances and limited resources, hence there is no specific national policy to recycle them. This case is also applicable on badly damaged vehicles by accidents. This paper will present a concept for the second life cycle of vehicle by reusing, remanufacturing, recycling its parts. The model will investigate the vehicle parts by creating data-base system of possible recycling parts. Good condition parts will be available for the second hand use; other parts will be sold as scrap metals. The economic, environmental and social impact of the proposed model will be discussed at the end of the paper.

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Keywords: Vehicle recycling; vehicle reused; vehicle remanufacturing; Vehicle second life cycle

1. Introduction

The world has entered an era of unprecedented resource challenges and opportunities that force industries to make fundamental shifts in the way they operate. Global market development, focusing on economic growth, results in growing levels of resource consumption and negative environmental impacts such as waste generation, depletion

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of natural resource, and ecosystem disruption. This growing level of resource consumption threatens global capacity to endure. Sustainability aims to enhance the economic, environmental, and social standards simultaneously. Value creation on the other hand aims to enhance the industrial profit and growth[1]. The principles and objectives of sustainable development: economic prosperity, social equity, and environmental protection and global responsibilities [2]. Sustainability is analyzed from three perspectives: environmental, social, and economical [3].

The term green design and manufacturing is now in common usage in all industrial activities, with a major emphasis on design for the environment (DFE). This approach considers all possible adverse environmental impacts of materials, processes, operations, and products, so that they can all be taken into account at the earliest stages of design and production. End-of-life (EOL) strategies have been incorporated in the manufacturing processes to reduce the negative environmental impact, and at the same time to meet the customer expectations.

Remanufacturing is an active area of research due to its cost saving capabilities and emission-reduction benefits. After being disassembled, cleaned and inspected, the core components go through a series of reconditioning operations before being reassembled into the final remanufactured product, and tested to ensure quality [4]. Remanufacturing is a process of bringing used products to a ‘‘like-new’’ functional state with warranty to match [5]. Its significance is that it can be both profitable and less harmful to the environment in comparison to conventional manufacturing. It is suggested that 85% of the weight of a remanufactured product may be obtained from used components, and that such products have comparable quality to equivalent new products but require 50% to 80% less energy to produce. Its economic benefits include providing 20% to 80% production cost savings in comparison to conventional manufacturing [6]. Three requirements for remanufacturing are collection of used products, efficient remanufacturing processes, and demand for remanufactured products [7].

The transport sector, despite being crucial for economic development, has been lagging behind in terms of sustainability performance. The transition to a more sustainable transport sector is thus of great significance in order for tackling the challenges of air pollution and resource shortage [8]. Technology improvements such as more efficient internal combustion engines (ICE) could contribute to certain environmental targets in the short term, but in the long run, only a zero-emission transport system should prevail [9]. Many countries concerned about the vehicles waste are implement standards related to end-of-life vehicle (ELV) recycling and to regulate businesses that recycle ELVs [10]. According to the automotive recycling association (2016) each year approximately 95 percent of vehicles retired from use are processed for recycling. The recycling of these vehicles saves an estimated 85 million barrels of oil that would have been used in the manufacturing of new or replacement parts [11]. Additional energy and resource conservation is realized by recycling rebuild-able "core" parts to the automotive parts rebuilding industry.

Palestine, just like other countries faces the problem of old vehicles, and needs to get rid of them for many reasons, such that old vehicles are: wasteful in fuel consumption, unequipped with modern safety means, produces high amounts of lethal gas emissions, and are expensive to maintain. Rough roads especially between the cities and in rural areas and shorter travel distances and frequent stops but more stress on vehicles and their parts for example shock absorbers, tires and so on. Hence car parts need to be replaced more often and in shorter periods comparing to vehicles driven in EU and USA. For all mentioned and unmentioned reasons, the officials began to apply more restricted arrangement on authorizing these old vehicles, in order to check their competence to be driven on the roads. According to section (3) of the Palestinians Transportation and Connectors Law, vehicles that exceed twenty years old, must acquire a specialized license twice a year. The crucial part is that, when these vehicles fail to meet authorizing regulations, they turn into a real issue as there are no particular arrangements to reuse them; also there are no real governmental plans, and regulations governing the end of life vehicles, private sector engagement is driven by economic values and profitability with less concern about the environment and social impact of vehicle generated waste.

2. Integrated model for second life of vehicles’ parts

Some of used cars can be renovated and reused as a whole car for a second life cycle. But most of them are dismantled into separate parts where each part can be recycled, reused or remanufactured to be implemented again in a new application. Figure 2 shows an IDEF block model that depicts the path in which each part or category of parts goes through.

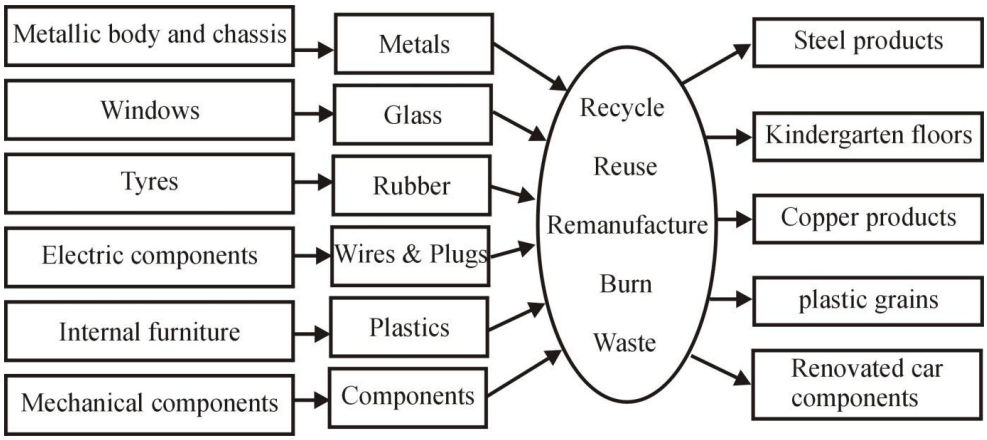

Fig. 2. IDEF flow model for second life of road vehicles.

The different parts of the road vehicles can be classified into six categories as shown in Figure 2. The model uses the components and their materials as an input and the application in which these materials are used as an output passing through a specific process for each category:

1- **Mechanical components**: can be either reused or recycled. If these car parts are in good conditions, they can be cleaned, renovated and reused for a second life cycle with a lower price. If not, the metal of these parts can be molten and remanufactured for a new implementation.
2- **Windows**: are manufactured by a polymer coated glass. This glass can also be reused for a second life cycle. Melting glass will burn the polymer accompanying this glass which forms a source of air pollution.
3- **Tires**: are made of rubber material which is very harmful for environment if wasted. One of the main solutions for this part is done by crushing these tires into small grains. The crushed material is then mixed with a polyurethane binder and used to coat the floors of the playgrounds and kindergartens. Burning old tires results in air pollution and a toxic, flammable oily runoff. They can be turned into rubberized asphalt for highways.
4- **Electric components**: include wires and plugs. Plugs are mostly renovated and reused for a second life cycle. While, wires are burned to get rid of the plastic coating the wire to use the copper material as a raw material for new products. This burning is environmentally harmful.
5- **Internal furniture**: is made of clothes, tissues, plastic and other materials. This is mostly is a waste to be disposed of.
6- **Metallic body and chassis**: doors and sides of the car body are cleaned and reused for a second life cycle if they are in good conditions. The chassis and rest of body are pressed in scrap press to be molten and remanufactured in a new metallic implementation.

3. Model implementation

3.1. Vehicles data

Table 1 gives the number of vehicles in Palestinian Territories for last 7 years. The number of private cars, commercial and others are also given. Private are mostly passenger cars and four wheel drive vehicles, while commercial are mostly large trucks, Lorries buses and all are driven by diesel engines.

Table 1. Licensed vehicles in Palestine for years 2008 to 2014 [12]

	2008	2009	2010	2011*	2012	2013	2014
Private	65200	91109	116595	134505	145395	173335	121675
Commercial	19830	20274	34304	35178	34287	39310	36637
Others	11706	12238	31567	37247	37325	21591	4200
Totals	96,736	123,621	182,466	206930	217007	234236	162512

*Gaza vehicles assumed 33% of total licensed in Palestine.

Figure 3 shows the year make for the licensed cars in the years 2013 and 2014, based on the MOT records. With 41% of vehicles are 10 years old and more (year 2003 and before for 2013 vehicles, year 2004 and older for 2014 vehicles). New and up to three years old vehicles form 16.8% of the total licensed cars.

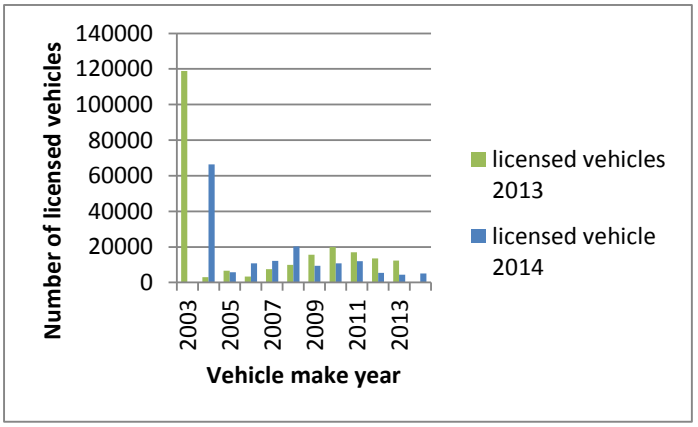

Fig. 3. Licensed vehicles in 2013 and 2014 by make year [13, 14].

According to MOT large commercial vehicles have life time of 20 years; private vehicles which have not been licensed for the last 10 years are not functioning anymore and expected to be scraped. Vehicle data is not complete for all years; hence analysis will be made mainly based on years 2013 and 2014 since most data is available for these two recent years, see table 2.

Table 2. Vehicles data for years 2013 and 2014[13, 14]

	2013	2014
Total licensed number	234236	162512
Unlicensed for more than 10 years	45615	46530
sold by police as scrap in auctions	12736	14986
Total estimated scraped vehicles	58351	61516

Total number of cars to be considered for end of life vehicles ELV is estimated as scraped cars by police in auctions, plus the unlicensed ones for the last 10 years. This figure for year 2013 is 58351 vehicles and for 2014 are 61516 vehicles [13, 14].

3.2. Amount of car waste and parts generated

For vehicle second life main steps include preliminary assessment and removal of oils, fluids including AC refrigerants. The assessment is done by highly experienced technicians. Second step is the dismantling of parts in good condition in the scrap yard by trained technicians; such parts may include mechanical and engine parts, battery, body parts such as doors, windows, bumpers, tires, hoses, and electronics components, and more. Third step is crushing of remaining car frame and parts and shredding to small pieces, the resulting material contains, plastics, glass, metals or classified into ferrous, nonferrous metals and shredded residue. Metals are recycled while the residue can be used for incineration and combustion to produce energy.

Table 3. Vehicle parts and material generated on the average from scraped vehicles per year, based on 2014 data..

	Vehicle parts/ material	Amounts/ numbers	Reuse/remanufacture/recycle
Dismantled parts, number of parts or systems	Tires	61516*4 = 246064	Shredded and use for construction
	Tires rims	61516*4 = 246064	Refurbished and sold for reuse
	Batteries	61516*1= 61516	Refurbished and sold for reuse
	Engine	61516 units	Refurbished and sold for reuse
	Catalyst converter	61516	Extract its components
	Steering mechanisms	61516	Refurbished and sold for reuse
	Suspension system	61516*4= 246064	Refurbished and sold for reuse
	Water pump	61516	Refurbished and sold for reuse
	Starter & alternator	61516	Refurbished and sold for reuse
Recycled materials, kg	Metal	49981750kg	Assuming 65% metal. Send to recycling facility
	Plastics	19223750kg	Assuming 25% plastics, used for combustion.
	Other	7689500kg	Assuming 10% disposed in landfill

Note: Average passenger car 1250kg.

Dismantled vehicle parts such as engines, transmissions, doors and bumpers are sold for reuse in other vehicles. Other parts that can also be remanufactured include starters, alternators and water pumps. Batteries, catalytic converters, tires and some plastics are removed and their materials are recycled into new products. Fluids such as engine oil, coolant, and gasoline are carefully managed to prevent releases by storing them in double-walled tanks and/or secondary containment prior to being reused or recycled.

3.3. Business model

The model is built on already available structures and systems in the vehicle supply chain. The model consists of the collection of vehicles to be scraped from various sources. Many scrap and vehicle dismantling workshops are in place in different regions in Palestine. Major collection locations are suggested in south, north, and middle of WB similar locations for Gaza Strip. Collection locations to document all incoming vehicles and a data base to be developed including type, year, and general condition of vehicle. Figure 4 shows the suggested model for second life vehicle.

Based on preliminary assessment possible parts to be disassembled are listed for each vehicle. Such parts are dissembled then cleaned parts will be labeled coded and stored for distribution to vehicle parts- agents, the data base will be available on line for search.

Remaining car skeleton will be compacted and moved to a shredding facility. Shredding facilities are not available in Palestine; it is suggested to build one shredding facility in West Bank. The shredding facility will be provided with separation systems of shredded materials to be separated and sold as such ferrous, nonferrous, and shredded residue SR. Shredded residue if not incinerated then it is sent to landfills for disposal.

Businesses should adopt environmental best practices by removing and managing the following types of materials prior to crushing: fuels, lubricating oils including transmission fluids, brake and steering fluids, coolant fluids, refrigerants, windshield washer fluid, lead acid batteries or other batteries, oil filters, lead battery cable connectors, tire weights and any other lead containing parts.

New businesses will be created or enlarging the existing ones in process of this vehicle second life. Cars towing and collection service, and cars dismantling centers and workshops will be developed further. Training and capacity building of existing technicians and experience would be needed. Storing, classification and coding of parts and

creating of storage and data base will be developed. Compacting the vehicle skeleton after parts dismantling, then crushing and shredding facilities also to be established. More investigation of the resulting shredded material to be carried out in cooperation with vehicle manufacturers and other interested institutions. The loop will be closed by selling and reusing the dismantled and refurbished parts. Existing auto part agents and distribution centers would be involved as well as establishing more IT managed parts distribution system.

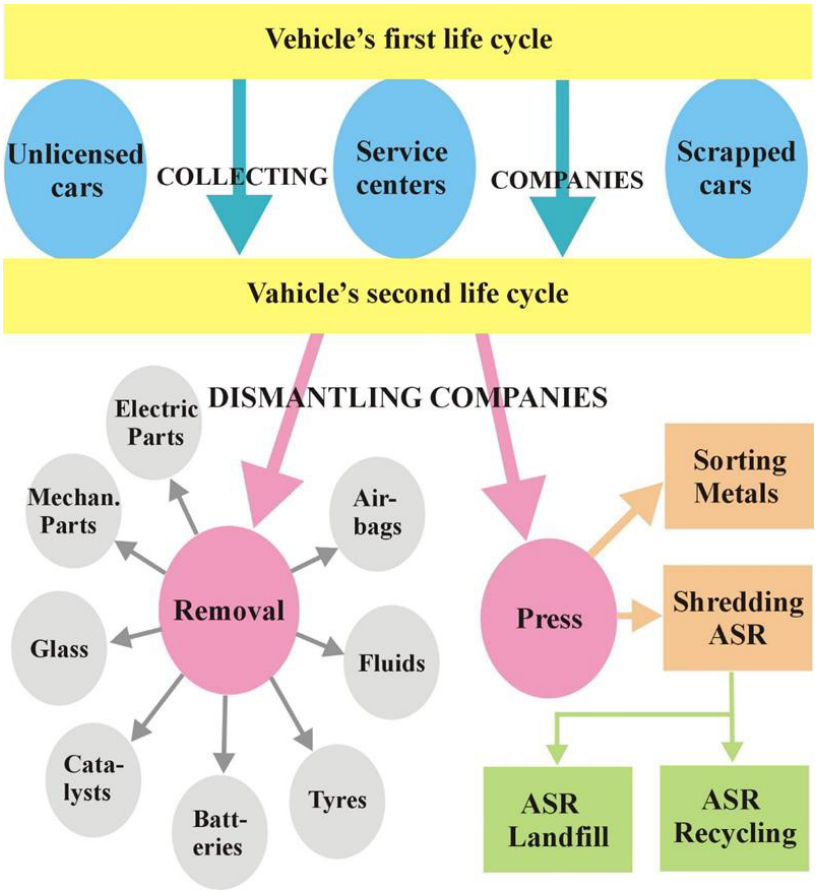

Fig. 4. Proposed model for vehicle second life.

4. Economical, environmental, and social impact

4.1. Economic Impact

Recent reports of the National Bureau of Statistics show that the total number of vehicles in Palestine is significantly growing, and is expected to continue to grow at rapid rates; a good portion is imported as used cars from Israel and other countries to be affordable by mostly middle and low income people. This means that considerable percentage of these vehicles will reach their end of life due to many reasons, which impacts economically due to disposing of such vehicles while they still contain significant value in their useful parts as replacements in maintenance services and in the materials of the vehicle construction. Recycling of used vehicle parts and materials could reduce the one-way flow of financial resources to import new ones. It also reduces the volume of wasted materials that going to be burned or deposited, which can cause air, soil, and water pollution over time, this of course reduces the end-of-life vehicles pollution costs. Recyclability of end-of- life vehicles could reach

up to 85% of vehicle mass according to European directive for 2015, which means that there is a considerable economic value in such vehicles, and accordingly there is a strong incentive for reuse and recycle such materials and develop relevant businesses. It is estimate that the value of recycled vehicle parts as 61 million US$ per year. This will be a saving and reduction of the imported vehicle parts. Detailed analyses are essential in order to determine how to benefit from the materials such as steel alloys, light metals, and composites that are used to build the vehicle.

4.2. Environmental Impact

Palestinian urban environment is the mostly affected by the end-of-life vehicles. This due to the fact that National Authority cannot enforce regulations and rules related to these vehicles due to restrictions imposed by Israeli occupations forces. It is very easy to observe and detect the impact on the local environment in terms of air quality, soil quality, and water quality due to depositing of these vehicles in open or agricultural fields. Disposing one car produces about 100 million cubic meters of polluted air, [15]. Sometimes the situation becomes much worse due to lubricants and air-conditioning gases leakage in addition to depositing for dismantling or burning vehicle bodies to obtain metals. Such practices in many cases take places nearby residential areas where the risk of cancer and heart disease are highly eminent in addition to pollution effects. Among the most alarming cases are the spilling of lead-acid batteries contents, which can be recycled to recover the lead content, given the fact that releasing lead into the environment creates serious problems if vehicles recyclers and dismantlers fail to remove and properly handle lead batteries. This problem could become worse if the end-of-life vehicles are hybrid electric ones, given their batteries usually consisting of nickel-hydride or lithium-ion, which are highly toxic materials. This of course gives a huge motivation for studies like the present one to provide ideas for proper solutions that could help to reduce the environmental impact of the end-of-life vehicles on Palestinian urban areas. The CO_2 avoided emission by not burning vehicle plastic but recycling it is estimated as 27330 ton CO_2, meanwhile for vehicle tires is estimated as 4266 ton CO_2 annually [16, 17].

4.3. Social Impact

Depositing end-of-life vehicles in open fields and nearby urban areas has sever negative health effects, especially for vulnerable people who could have respiratory and lung problems. This could result in forcing people to move from nearby such areas or even to abandon their agriculture lands for such activities. In addition, the cost of health care could increase significantly, which lowers life standards. Therefore, it is important to stimulate discussions regarding the toxicity and materials management concerns facing the local society. Also, there should be national strategy to deal with issue, given the fact that there is a huge potential in developing relevant business, which results in creating a wide range of new jobs, it is estimated that around 600 new jobs will be created when implementing the suggested second life vehicle model. This of course leads to wide cycle of investments and an added value to the national economy, which helps to develop many social aspects and reduce the negative impact.

Conclusion

The Situation of the second life cycle of vehicles in Palestine was presented in this paper. Statistics show that there is no specific national policy to recycle them. An integrated flow model for SLC was depicted to show inputs, output and the different processes related to vehicle recycling. Recyclability is a strong incentive for reuse and recycle such materials and develop relevant businesses. National strategy should be implemented to deal with the huge potential in developing relevant business, which results in creating new jobs. This of course leads to wide cycle of investments and an added value to the national economy, which helps to develop many social aspects and reduce the negative impact. Palestinian National Authority cannot enforce regulations and rules related to these vehicles due to restrictions imposed by Israeli occupations forces. Air, soil and water quality is affected due to depositing of these vehicles in open or agricultural fields. This of course gives a huge motivation for studies like the present one to provide ideas for proper solutions that could help to reduce the environmental impact of the end-of-life vehicles on Palestinian urban areas.

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