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VEHICLES FLEET RENEWAL THROUGH A SCRAPPING SCHEME IN LEBANON

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VEHICLES FLEET RENEWAL THROUGH A SCRAPPING SCHEME IN LEBANON

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Foreword

Ministry of Environment

Through the publications of Lebanon's Initial and Second National Communications to the United Nations Framework Convention on Climate Change, and the Technology Needs Assessment for Climate Change, the Ministry of Environment drew the large climate change picture in the country. The picture shed the light on a number of climate change matters: Lebanon's contribution to global greenhouse gas emissions, the sectoral share of national emissions, the socio-economic and environmental risks that the country faces as a result of climate change, and the potential actions that could and should be undertaken to fight climate change both in terms of mitigation and adaptation.

Through these series of focused studies on various sectors (energy, forestry, waste, agriculture, industry, finance and transport), the Ministry of Environment is digging deeper into the analysis to identify strengths, weaknesses, threats and opportunities to climate friendly socio-economic development within each sector.

The technical findings presented in this report (Vehicles Fleet Renewal through a Scrapping Scheme in Lebanon) will support policy makers in making informed decisions. The findings will also help academics in orienting their research towards bridging research gaps. Finally, they will increase public awareness on climate change and its relation to each sector. In addition, the present technical work complements the strategic work of the National Climate Change Coordination Unit. This unit has been bringing together representatives from public, private and non-governmental institutions to merge efforts and promote comprehensive planning approach to optimize climate action.

We are committed to be a part of the global fight against climate change. And one of the important tools to do so is improving our national knowledge on the matter and building our development and environmental policies on solid ground.

Mohamad Al Mashnouk

Minister of Environment

Foreword

United Nations Development Programme

Climate change is one of the greatest challenges of our time; it requires immediate attention as it is already having discernible and worsening effects on communities everywhere, including Lebanon. The poorest and most vulnerable populations of the world are most likely to face the harshest impact and suffer disproportionately from the negative effects of climate change.

The right mix of policies, skills, and incentives can influence behaviour and encourage investments in climate development-friendly activities. There are many things we can do now, with existing technologies and approaches, to address it.

To facilitate this, UNDP enhances the capacity of countries to formulate, finance and implement national and sub-national plans that align climate management efforts with development goals and that promote synergies between the two.

In Lebanon, projects on Climate Change were initiated in partnership with the Ministry of Environment from the early 2000s. UNDP has been a key partner in assisting Lebanon to assess its greenhouse gas emissions and duly reporting to the UN Framework Convention on Climate Change. With the generous support of numerous donors, projects have also analysed the impact of climate change on Lebanon's environment and economy in order to prioritise interventions and integrate climate action into the national agenda. UNDP has also implemented interventions on the ground not only to mitigate the effects of climate change but also to protect local communities from its impact.

This series of publications records the progress of several climate-related activities led by the Ministry of Environment which UNDP Lebanon has managed and supported during the past few years. These reports provide Lebanon with a technically sound solid basis for designing climate-related actions, and support the integration of climate change considerations into relevant social, economic and environmental policies.

Ross Mountain

UNDP Resident Representative

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Acronyms

ASR	Automobile Shredder Residues
CARS	Car Allowance Rebate System
CDM	Clean Development Mechanism
CNG	Compressed Natural Gas
ELV	End-of-Life Vehicle
EU27	27 European Union countries
GBA	Greater Beirut Area
GHG	Greenhouse Gas
GoE	Government of Egypt
MCA	Multi Criteria Analysis
MoF	Ministry of Finance
MoIM	Ministry of Interior and Municipalities
MSW	Municipal Solid Waste
TNA	Technology Needs Assessment
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

This study reviews the feasibility and the available options for vehicle scrapping schemes, the current practices for recycling End-of-Life Vehicles (ELVs), and proposes future recommendations for the adoption of a renewal of car fleet strategy. The work is based on the recommendations of the Technology Needs Assessment (TNA) Report for Climate Change (2012) as one of the main mitigation strategies proposed by the report is to renew the existing passenger cars' fleet in Lebanon.

A vehicle-scrapping scheme is a potential opportunity for Lebanon to be effective in parallel to public transport systems, and reduce traffic congestions and air pollution from the transport sector. Additionally, the scrapping and recycling of ELVs control the highly toxic and hazardous components of the ELV, as well as a number of environmental and socio-economic benefits.

ELVs are already being scrapped in Lebanon by small and large-scale metal scrapping facilities. However, the existing facilities are unregulated and the current initiatives are limited to metal scrapping; tires, glass and plastics end up in the municipal waste stream, and the spare parts are sold through a black market at elevated rates. Therefore, a vehicle-scrapping scheme is highly needed to renew the existing fleet and introduce cleaner vehicles. This study, through a Multi Criteria Analysis (MCA), evaluates three scenarios with the existing case of Lebanon, which differ according to the level of implementation of the vehicle recycling schemes. The scenarios are: (1) do nothing, (2) establishment of new facilities, and (3) usage of the existing limited initiatives.

Results show that scenario 3 can be considered as a potential vehicle scrapping scheme with its relevant modifications according to the local financial, institutional and technical capacities. Also, scenario 3 generates various safety and health benefits, initiates sustainability and brings in higher revenues. Especially that scenario 3 invests in the existing initiatives, links various stakeholders through a comprehensive scheme, and establishes vehicle recycling with less cost on the developer, machinery and new technologies. Further studies are needed to thoroughly analyze the cost-effectiveness of such a scheme to support decision makers and policy makers.

الملخص التنفيذي

إن إحدى أهم استراتيجيات التخفيف التي اقترحها تقرير تقييم الاحتياجات التكنولوجية لتغير المناخ (٢٠١٢) هي تجديد أسطول سيارات الركاب الموجود في لبنان. وتستعرض هذه الدراسة الجدوى والخيارات المتاحة لمخططات تخريد السيارات كما الممارسات الحالية لإعادة تدوير السيارات المحتضرة (ELVs) وتقترح توصيات مستقبلية لاعتماد استراتيجية تجديد أسطول السيارات.

إن مخطط تخريد السيارات هو فرصة محتملة للبنان لأن يكون فعالًا إزاء أنظمة المواصلات العامة والحد من الازدحام المروري وتلوث الهواء الناجم عن قطاع النقل. إضافة إلى ذلك، تؤدي عملية تخريد السيارات المحتضرة وإعادة تدويرها إلى السيطرة على المكوّنات السامة فيها، فضلًا عن وجود عدد من الفوائد البيئية والاقتصادية والاجتماعية.

لقد سبق وتم تخريد السيارات المحتضرة في لبنان من قبل منشآت صغيرة أو كبيرة لتخريد المعادن. إلا أن المنشآت الموجودة غير منظّمة وتقتصر أنشطتها الحالية على تخريد المعادن؛ فينتهي الأمر بالإطارات والزجاج والبلاستيك في مجرى النفايات البلدية، فيما يتم بيع قطع الغيار عبر السوق السوداء وبأسعار مرتفعة. لذلك، ثمة حاجة ملحّة لوضع مخطط لتخريد السيارات وبذلك تجديد الأسطول الموجود وإدخال مركبات أنظف إلى السوق. وتقيّم هذه الدراسة، ومن خلال تحليل متعدّد المعايير، ثلاثة سيناريوهات للوضع القائم في لبنان. وتختلف هذه السيناريوهات بحسب مستوى تنفيذ مخططات إعادة تدوير المركبات. والسيناريوهات هي التالية: (١) عدم القيام بشيء، و(٢) إنشاء منشآت جديدة، و(٣) استخدام المبادرات المحدودة الموجودة.

وتشير النتائج إلى أنه يمكن اعتبار السيناريو رقم ٣ على أنه مخطط تخريد مُحتمل للسيارات المحتضرة مع تعديلات معينة ووفقًا للقدرات المالية والمؤسسية والتقنية المحلية. إضافة إلى ذلك، يولّد السيناريو رقم ٣ عددًا من فوائد السلامة والصحة كما يبادر بالاستدامة ويعود بإيرادات أعلى. أيضًا فإن السيناريو رقم ٣ يستثمر في المبادرات الموجودة ويربط مختلف أصحاب المصلحة بعضهم ببعض من خلال مخطط شامل ويضع عملية إعادة تدوير المركبات في كلفة أقلّ على المطوّر والماكينات والتقنيات الجديدة. وثمة حاجة إلى المزيد من الدراسات لتحقيق تحليل دقيق لفعالية الكلفة لمثل هذا المخطط وذلك لدعم صنّاع القرارات وواضعي السياسات.

1. Introduction

End-of-life vehicles refers to "vehicles that their owner wants or is obliged to dispose it. The time that the vehicle is considered an ELV cannot be clearly defined and often each nation has different policy on this issue" (EU Parliament, 2000)

The rise of the automotive production industry and increased sales have raised the number of End-of-Life Vehicles (ELVs). The global number of ELVs by 2020 is expected to exceed 100 million. Reduce, reuse and recycle principles have been gradually employed in processing vehicles and their parts, to endorse sustainable development (Tian and Chen, 2013). The basic vehicle dismantling and processing includes removal of the battery, draining of the fluids, dismantling the different parts and finally either recycling or disposal of the remaining parts. This process is similar on an international scale. However, efficiency of the recycling and the following steps for processing of various parts are contingent upon the effectiveness of the dismantling process. The dismantling process can be classified into two types, the 'European/American mode' (Mayyas et al., 2012) and the 'Asian mode' (Che, Yu, and Kevin, 2011), the former including large-scale mechanized dismantling (common in Europe and the United States) and the latter including 'mechanical + manual' dismantling due to the low cost of labor.

In Lebanon, the transport sector suffers from poor traffic infrastructure, traffic congestions, and an old vehicle fleet. The old fleet is fuel inefficient and contributes to air pollution and Greenhouse Gas (GHG) emissions. Different solutions are needed to tackle the various problems of the transport sector, and in this report the focus is on the renewal of the passenger car fleet.

2. Purpose of the study

According to the "Technology Needs Assessment" (TNA) (2012), there are three different mitigation strategies to reduce emissions from the transport sector. The strategies adopted include: 1) revitalizing public transport systems, 2) renewing existing passenger car fleet, 3) optimizing road networks. For the renewal of the car fleet, the only option available is the establishment of a vehicle-scrapping scheme, which substitutes the old cars by efficient and newer vehicles. Ultimately, this will contribute in reducing the carbon dioxide (CO_2) emissions from the transport sector, reducing the consumption of fuel in addition to assuring passenger safety and reducing the cost of maintenance. This study reviews the feasibility and the available options for vehicle scrapping schemes, the current practices for recycling End-of-Life Vehicles (ELVs) and proposes recommendations for the adoption of the renewal of the car fleet strategy.

3. Background

Several countries (e.g. USA, South Korea, Japan, Germany, and the Netherlands) recently introduced temporary policies to scrap older cars, not only to reduce the negative impacts of the economic crisis but also to improve environmental conditions. There were comparable policies in the 1990s in several European countries, including France, Spain, Italy, Hungary, Norway, Denmark, and Greece, as well as several US states and Canada. These policies adopted environmental benefits (mainly concerning air quality) as the dominant motivation for the schemes. Other reasons to establish vehicle scrapping policies were to boost car sales (e.g. Britain and France in the 1990s) or to improve safety (e.g. Italy, Ireland, Argentina) (Van Wee, De Jong, and Nijland, 2011).

In the 27 European Union countries (EU27), processing of ELVs has been shaped by Directive (2000/53/EC), which includes regulatory, economic and technological aspects. The regulatory aspects with its amendments assign 85% by weight recycling and reuse rate of an ELV by 2015, and restrictions related to landfill waste deposition (JRC European Commission and Institute for Prospective Technological Studies, 2009).

In the Middle East region, Iran launched a USD 1 billion scrapping scheme to support reviving the demand for heavy vehicles in Iran during the global economic crisis. The government was aiming to replace 12,813 vehicles with new ones by the end of 2009-2010 (Business Monitor International, 2011). Egypt established the ‘Vehicle Scrapping and Recycling Program’ under the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) (Table 1), where the owners surrendered their old vehicles for a financial incentive that was used to purchase a new fuel-efficient vehicle (CDM, 2011).

3.1. The Egyptian experience

Table 1: Summary of the Egyptian vehicle scrapping and recycling program

Title of the scheme	"Egypt vehicle scrapping and recycling program" and later submitted as a small-scale Clean Development Mechanism Programme of Activities.
Aim	Substituting around 43,000 taxis >20 years old, with the purpose of accelerating the rate of fleet replacement, which would improve air quality and reduce the number of traffic accidents (safety), sustaining and increasing jobs, and reducing up to 0.6 million tonnes of CO_2 over a period of 10 years.
Enforcement law	Traffic law #121 (2008), which stipulates that owners of 'mass transport vehicles' (taxis, microbuses and buses) older than 20 years are not eligible for license renewal. The law provides a 3-year grace period for the owner to renew his vehicle.
Cost	**Total:** USD 270.5 million **African Development Bank loan:** USD 150 million **Middle income countries grant:** USD 905.35 thousand **Government of Egypt (GoE):** USD 119.145 million (USD 100 million from Nasser Social Bank)
Timeframe	**Effectiveness:** May, 2011 **Completion:** December, 2015 **Last disbursement:** December, 2016
Stakeholders (signed a protocol with the Ministry of Finance (MoF), which identifies responsibilities and participation agreement) (Figure 6 - Annex III)	**Ministries:** : Ministry of Finance (MoF) (coordinating and managing entity), Ministry of Interior and Municipalities (MoIM) **Banks:** National Bank of Egypt, Banque Misr, Bank of Alexandria, and NSB **Auto dealerships:** Daewoo Egypt Aboul Fotouh (Speranza), Ghabbour Auto (Hyundai), Al Mansour Auto (Chevrolet), Al Amal (Lada and BYD), Wagih Abaza (Peugeot) **Insurance company:** Misr Insurance **Different advertising entities**
Incentive	USD 906 compensation for the taxi owner to be used as a down-payment for the soft loan received (repayment period is 5-7 years).

Source | CDM, 2011, African Development Bank, 2010

4. Overview of the transport sector in Lebanon

The Lebanese fleet constitutes 1.28 million vehicles, from which 1.07 million (83.5%) are private vehicles, according to the latest cleansed data (MoIM, 2012). The road transport sector is responsible for over 60% of the total oil consumption (99.2% is gasoline). The transport sector is one of the largest contributors to air quality deterioration, accounting for 59% of nitrogen oxide (NO_x) emissions, 24% of CO_2 emissions, 3% of sulfur dioxide (SO_2) emissions, and 79% of non-methane volatile organic compounds (NMVOCs) emissions (MoE, 2010). Public transport systems in Lebanon are characterized by being inefficient, unreliable and cost-ineffective. The number of vehicles registered constitutes 4,735 buses and 28,168 taxis (MoIM, 2012).

The statistical surveys reflect low driving range in Greater Beirut Area (GBA) with a high rate of congestion and high a rate of short-time stops. The speed acceleration frequency distribution shows that the acceleration rates are significant at very low speed. This reflects the fact that the internal combustion of engines is inefficient, resulting in a high rate of fuel consumption and pollutant emissions in conventional gasoline powered vehicles. Ultimately, passengers suffer from high budget requirements for transport and high pollution rates particularly in urban areas. All the previous factors make the road transport an important sector for reducing national emissions and total fuel consumption (MoE, URC and GEF, 2012).

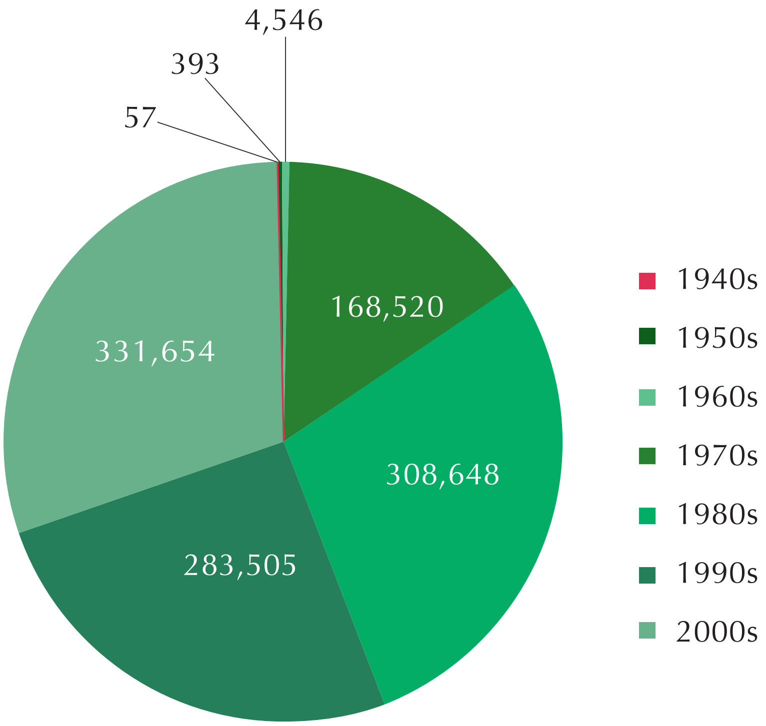

Figure 1: Private vehicle and taxi age distribution according to production date

Source | MoIM, 2012

5. Scrapping schemes

5.1. Definition

Vehicle scrapping schemes usually target old vehicles, which are less fuel-efficient and have high carbon emissions in comparison with to newer vehicles. These schemes provide financial incentives for drivers of older vehicles to remove their vehicles off the road before the vehicle's lifespan is completed. Generally there are two types of scrappage schemes as indicated below.

5.1.1. Cash-for-scrappage

A certain amount of payment offered to the consumers for their vehicle, irrespective of how the consumer replaces the scrapped vehicle.

5.1.2. Cash-for-replacement

A certain amount of payment offered to the consumer with the condition that the consumer would replace the vehicle with a specific type of vehicle (usually, but not necessarily, a newer and more efficient vehicle) (Brand, Anable, and Tran, 2013).

5.2. Components of the scrapping process

5.2.1. Delivery of the End-of-life vehicles (collection)

This step follows the finalization of the vehicle paperwork and the registration procedures. The owner takes the vehicle directly to the scrapping facility or to independent collection points, from where the vehicles are later transported to the scrapping facility.

5.2.2. Dismantling/disassembling of the vehicle

The following step constitutes the bulk of the scheme, which can be time-consuming and costly. It may also require labor, management and monitoring. The dismantling process starts by the drainage of the fluids from the vehicle followed by the removal of all recyclable or reusable spare parts (i.e. tires, glass and mechanical parts).

5.2.3. Crushing and shredding

After dismantling, the remaining (body and chassis) is either directly fed to the shredder or crushed (flattened) before sending to the shredder. There can be a transportation phase between crushing and shredding in case the shredding is not done on site or the material is sold abroad.

5.2.4. Recycling and disposal

The final step of the scrapping process is the retrieval of recyclable material and the disposal of the remaining waste generated from the shredder. The largest portion of the vehicle that is recycled is the metallic part. The remaining small unrecyclable portion is usually landfilled.

Table 2 states all the components of the ELVs, their composition and their respective processing practices and applicability in Lebanon.

Reusing components of vehicles prevents wasting land (i.e., junkyards) and serves as an economic incentive. 70-75% of ELVs is composed of ferrous and non-ferrous metals (Taub et al., 2007). When raw materials such as metals are recycled, a great amount of energy is saved (British Metals Recycling Association, 2010):

- Recycling steel has an energy saving potential of 62-74%, reduction in air pollution of 86%, water use saving of 40% and water pollution of 76%;
- Recycling aluminum has an energy saving potential of 95%;
- Recycling copper has an energy saving potential of 85%;
- Recycling lead has an energy saving potential of 60%;
- Recycling zinc has an energy saving potential of 60%.

Table 2: ELV components: description, composition, recycling practices and outcome materials

Component	Description	Composition	Current practices	Feasible practices in Lebanon	Output material
1. Fluids	Oil and water based fluids in the vehicle	**Oil based (6.01 kg):** engine oil (2.86 kg), transmission oil (2.06 kg), suspension oil (0.58 kg), brake fluid (0.37 kg), oil filter oil (0.14 kg) **Water based (5.03 kg):** coolant (3.43 kg), screen-wash (1.6 kg)	**Practice 1**: Separate storage of 5-6 fractions, which are sent to different reprocessing or regeneration facilities. **Practice 2:** Separate storage of 2 fractions: waste oils + brake fluid + coolant + screen wash. The former used for energy recovery and the latter sent for regeneration. **Practice 3**: Separate storage of 1 fraction: waste oils + brake fluids are stored and sent for recycling or energy recovery: A. Vacuum distillation + clay treatment, B. Vacuum distillation + chemical treatment, C. Hydrogen pre-treatment + vacuum distillation Incineration in cement kiln, D. Incineration in asphalt plant coolant + screen wash are left in the body of vehicle. **Practice 4:** No specific rule regarding the number of fractions to be stored separately, all fractions can be remained in the vehicle.	Practices 2, 3 and 4	Regenerator coolant Fuel [1]

Component	Description	Composition	Current practices	Feasible practices in Lebanon	Output material
2. Batteries (13.5 kg)	Lead-acid batteries	**Lead containing components** (60-64% weight (wt)) **Sulfuric acid electrolyte** (23-28% wt) **Polypropylene** (5-8%) **Others** (3%) [1] [2] [3]	**General:** Manual or mechanical breaking/dismantling of the battery, draining the acid to be used in desulfurization or be neutralized with calcium/sodium hydroxides, plastic recovery[4]. **Practice 1:** The battery is left in the car body which is sent to the shredder. **Practice 2:** The battery is manually dismantled to remove and sell the lead-bearing components; the electrolyte spills in the soil and the remaining waste is dumped in the environment. **Practice 3:** The whole battery is removed and sold to dedicated treatment facilities. **Practice 4:** The battery is removed and sold, without the electrolyte, to dedicated treatment facilities; the electrolyte is drained (probably with a view to avoiding risk of fire from batteries and then facilitating their handling) and spilt in the environment (to avoid any storage constraint) [1].	Practices 3 and 4	**Sulfuric acid** (if not neutralized) **Polypropylene** (pellets) **Sodium sulfate or calcium sulfate** (gypsum) (in case of neutralization), the former can be used in production of detergents, glass and wallboard [4]. **Pure lead** **Lead (Pb) - Copper (Cu) Alloys** **Hard lead** [5]

Component	Description	Composition	Current practices	Feasible practices in Lebanon	Output material
3. Airbags	Inflating bags in different parts of the car board	Airbag 50 – 150 g of sodium azide (NaN_3) This material is harmless following airbag deployment, but can damage shredding equipment if inadvertently left in vehicles that are being recycled [6].	**General:** Reusing or disposing of the working airbags, and disposing the detonated airbags [1]. **Practice 1:** Dismantlers remove working air bags and sell them for re-use (secondary airbags). **Practice 2:** Airbags are removed by dismantlers and deployed in a separate chamber. **Practice 3:** Airbags are blown up by dismantlers inside the ELV placed in a controlled environment. **Practice 4:** Airbags are left within the body of the car and for the working ones, explode in the shredding equipment.	Practices 1 and 4	**Secondary airbags** (if not detonated) **Waste**
4. Catalytic converters (900 g)		Ceramic material 900 g Platinum 1.2 g Palladium 0.176 g Rhodium 0.274 g [1]	**General:** The removal of precious metals, which is a highly complicated process. **Practice 1:** Since the processing is complicated, the catalysts usually end at specialized industrial facilities. **Practice 2:** The catalytic converters are removed and landfilled.	Practice 1 abroad	**Precious metals** (platinum, palladium, and rhodium) **Waste**

Component	Description	Composition	Current practices	Feasible practices in Lebanon	Output material
5. Tires	Four to five tires (spare for trucks) per vehicle	Tires are made of rubber (60–65% wt), carbon black (25–35% wt) and the rest consists of accelerators and fillers. Vehicle tires (both passenger and truck) are mainly a blend of natural and synthetic rubber (butyl rubber and styrene–butadiene copolymer) [8].	**Practice 1:** Reuse instead of new tires. **Practice 2:** Disposing in landfills and monofills [7]. **Practice 3:** Energy applications including power plants, tire manufacturing facilities, cement kilns, and pulp and paper production among others [1]. **Practice 4:** Civil engineering practices; landfill construction, concrete and asphalt manufacturing, rubber engineering as a filler for virgin and de-vulcanized rubber blends and for the production of shoe heels and soles, tubes, conveyor belts, automobile floor mats, flaps, etc. **Practice 5:** Material recovery, mechanical grinding, cryogenic grinding, reclaiming and pyrolysis [8].	Practices 1 and 2	**Reusable tires** **Shredded tires with a high calorific value** (35–40 MJ/kg) [8] **Waste**

Component	Description	Composition	Current practices	Feasible practices in Lebanon	Output material
6. Car glazing/ glass (2.9% wt of ELV)	Windshield and back windows (15.2 kg) Side windows (6 kg) [1]	Side windows have a simple structure. The windshield and back windows glass is mixed with polyvinyl butyral (PVB) interlayer in laminated glass of windshield, enamel/ ceramic inks, silver printing and electrical connectors. There are also encapsulation materials and fixing clips in all types of windows [9] .	**Practice 1:** Disposal in landfill with the rest of the unused parts of the vehicle. **Practice 2:** Car glazing treatment is done at a flat glass treatment center. This processing includes shredding, sieving, magnetic picking for ferrous metal separation, cyclone for PVB removal, eddy current for nonferrous metal removal, and optical separation [9].	Practices 1 and 2	From the treatment process: **glass cullet** (windshield 93%, side windows 99% and back windows 99%), PVB foil (windshield 6%), and minimal waste (aluminum, non-ferrous parts, glass loss 0.5-5%) [9] **Waste**
7. Mercury switches	Mercury light switches are often found on the car's hood and/or trunk [10].	The mercury switch is the small, bullet-shaped metal or glass capsule that forms the base of the light socket.	**Practice 1:** Remains in the body of the vehicle. **Practice 2:** Removal by cutting the power supply wire attached to the base of the light fixture and removing any fasteners in order to separate the entire fixture from the vehicle.	Practices 1 and 2	**Recyclable mercury**

Component	Description	Composition	Current practices	Feasible practices in Lebanon	Output material
8. Automobile Shredder Residues (ASR) (15-30% wt. of ELV) [11] [12] [13]	The mass remaining after de-pollution, dismantling, shredding of the hulk, and removal of metals from the shredded fraction.	Metals: ferrous, aluminun, non-ferrous, wire Rubber Plastics Foam (PUR) Wood + cardboard Dirt + non-combustibles Textile Glass Others [12]	**Practice 1:** Landfilling the shredded ASR. **Practice 2:** Metal recovery from the ferromagnetic fraction and disposal of the residue. **Practice 3:** After practice 2, co-combustion with Municipal Solid Waste (MSW) for energy recovery, feedstock, incineration, cement kilns, etc. **Practice 4:** After practice 2, separation of plastic matter, and the residue used for energy recovery. **Practice 5:** After practice 2, the output is subjected to a gasification process to produce syngas, which is eventually converted to methanol [13].	Practices 1 and 2	**Metal recovery** **Plastic recovery** **Energy recovery** **Waste**

Component	Description	Composition	Current practices	Feasible practices in Lebanon	Output material
9. Metal components	Body-in-white, some parts of the chassis and the powertrain systems [14]	Ferrous metals (65-71% wt of ELV) Non-ferrous metals (7-10% wt of ELV)	**Practice 1:** The vehicle parts remains stay in a junkyard. **Practice 2:** Processing the remaining parts of the vehicle, which includes the main procedures of shredding, magnetic separation, sink-float separation and eddy current separation [15].	Practices 1 and 2	**Various ferrous and non-ferrous metals**

Source | [1] ICF International, 2006, [2] Rydh, 1999, [3] McManus, 2012, [4] Stevenson, 2009, [5] Sloop et al., 2009, [6] Mayyas et al., 2012, [7] Van Beukering and Janssen, 2001, [8] Martinez et al., 2013, [9] Farel et al., 2013, [10] EPA, 2003, [11] Roy and Chaala, 2001, [12] Vermeulen et al., 2011, [13] Ciacci et al., 2010, [14] Lutsey , 2010, [15] Jirang and Hans, 2010

5.3. Experience from across the world

Economic growth, green economy, environmental conservation, employment, and improvement of living standards are different aims of vehicle scrappage schemes (Quaker Council for European Affairs, 2010). Table 3 summarizes the major examples of the latest vehicle scrapping schemes around the world with their respective incentives and outcomes.

It is worth mentioning that there might be various industrial actors involved in End-of-Life Vehicle management such as dismantlers, shredders, recyclers, municipal waste managers and material producers (Bellmann and Khare, 2000). Involving them during policy making and initiation of the vehicle scrapping scheme is an important step that affects the success of the schemes.

Table 3: Summary of scrapping schemes, their characteristics and observations

Scheme/date of effectiveness	Country	Scheme characteristics	Observations
Car Allowance Rebate System (CARS) 2009	USA	Federal incentive (maximum USD 4,500) for trading less fuel efficient cars (<25 years) for safer, cleaner and fuel efficient cars (not obligatory).	- Cost the government USD 3 billion, which was unanticipated but the scheme resulted in large demand. - The scheme boosted car sales. - 677,000 vehicles scrapped in one year [1].
Umweltprämie 2009	Germany	EUR 2,500 incentive for each vehicle, which had to be of age >9 years and the car had to be registered with the applicant for at least one year. The new vehicle should have fulfilled emission standard Euro-4 and not registered with another party for more than 14 months. The aim was to reduce the age of car fleet and be an economic stimulus.	- Cost the government EUR 5 billion. - Benefit for the German car producers. - 1,308,000 vehicles scrapped in one year. - German authorities discovered an illegal scheme through which scrapped vehicles have been exported to Eastern Europe and Africa. This was due to the fact that the program required the scrapped vehicles to be dumped in junkyards [2].
Prime à la casse 2009	France	EUR 1,000 incentive for vehicles >10 years. The new cars should have met the emission requirement of 160 g CO_2 / km.	- Cost the government EUR 550-600 million. - 470,000 vehicles scrapped in one year [1].
Cash for clunkers 2011	Greece	Drivers that have cars >12 years old are given the incentive of up to EUR 2,800 when buying the new vehicle that has an engine capacity under 2,000 cc.	- 82,057 old cars were removed from circulation, but were replaced with only 33,931 new cars during the year [3].

Scheme/date of effectiveness	Country	Scheme characteristics	Observations
Vehicle scrappage scheme 2009	UK	GBP 2,000 discount from the new car (no emission restriction) when >10 years vehicle scrapped, with the condition it should be registered with the last owner more than 12 months, weight less than 3.5 tonnes.	- Cost the government GBP 400 million (GBP 300 million originally and then additional GBP 100 million). - 400,000 vehicles had been replaced. - In addition to car sales boost, the new cars had on average 25% less CO_2 emissions [4].
Vehicle scrappage scheme 2008	Cyprus	Scrapping vehicles >10 years old only, or scrap and purchase a new car with maximum fuel economy 7 liters/100 km or 5 liters/100 km. The incentive includes EUR 675 - 1,700 per ELV.	- Cost EUR 11.3 million. - Scrapped 15,500 vehicles.
Vehicle scrappage scheme 2009	Austria	Scrapping End-of-Life Vehicles >13 years, with an incentive of EUR 1,500 for buying a new vehicle, which had to be according to Euro-4 standards.	- The funding scheme was exhausted quickly, with funding only for 30,000 vehicles instead of 49,000 [5].
Auto old-to-new replacement 2009-2012	China	Gradually increasing incentive from USD 450-900 in 2009 to USD 1,700-2,800 in 2012 for small- and medium-sized old vehicles and yellow-sticker vehicles (buses/trucks) that do not meet the Euro-1. The new vehicles should have the emission restrictions of Euro-3 and meet other local limitations [6], [7], [8].	- The subsidies provided by the government were relatively low compared to the vehicle value once sold in the black market. - The black market does not pay the 17% sales tax and the safe waste disposal fees. This led to illegal dismantling and harmful environmental consequences. - In 2010, 4.8 million ELVs were scrapped. - In 2011, 3.77 million ELVs were deregistered, 40.6% legally dismantled, 30% were illegally dismantled and 29.4% flowed into the underground market. - The reason for the decrease in the number is due to the higher price of the black market and the absence of implementation of policies.

Scheme/date of effectiveness	Country	Scheme characteristics	Observations
Taxi fleet renewal 2009	Egypt	Replacing taxis that are >20 years old. The incentive of USD 900 and soft loans for buying a new locally-produced efficient cars (12.87 liter/100 km for motor gasoline vehicles, 12.23 m^3/100 km for Compressed Natural Gas (CNG) vehicles, and 14.14 liter/100 km for diesel vehicles) from 5 selected types.	- 17,500 cars had been replaced by 2009. - By 2012, 49,973 cars had been replaced [9], [10].
Act of resource recycling of electrical and electronic equipment and vehicles 2008	Korea	ELVs are collected with a payment of USD 117 per car to the owner. The vehicles are processed in various facilities (dismantling, shredding, recycling and reusing parts) [11].	- 670,000 vehicles were dismantled per year during the period of 2008 to 2010 in South Korea. Remaining End-of-Life Vehicles are exported as second-hand cars and collected in junkyards [12].
ELV scrapping scheme 2009	Netherlands	An incentive of EUR 750-1,750 for buying a new vehicle and scrapping gasoline vehicle >13 years old, and incentive of EUR 1,000-1,750 for buying a new vehicle and scrapping diesel vehicle >9 years old.	- 80,000 End-of-Life Vehicles aimed to be recycled by the time the capital is exhausted. - Annually 230,000 ELVs are received and recycled in Netherlands [5].
ELV scrapping scheme 2009	Slovakia	An incentive of EUR 1,500 for scrapping a car >10 years old and buying a new car with maximum cost of EUR 25,000 [5].	
Vive plan or plan 200E Since 2009	Spain	Vive plan: 0% loan up to EUR 10,000 to buy new or <5 years old car. Scrapping ELVs >10 years and older. Plan2000E: Scrap ELVs >10 years or with >250,000 km driven, and buy a new car with a EUR 2,000 purchase incentive. Emission limits range between 140 g CO_2/km to max 160 g CO_2/km [5].	

Source | [1] International Transport Forum, 2011, [2] B'ockers, Heimeshoff, and Muller, 2012, [3] Business Monitor International Ltd., 2012, [4] Harari, 2009, [5] IHS Global Insight, 2010, [6] Wang and Chen, 2013, [7] Li, Yu, & Gao, 2014, [8] Zhao and Chen, 2011, [9] Quaker Council for European Affairs, 2010, [10] CDM, 2011, [11] Harraz and Galal, 2011, [12] Park et al., 2014

6. Benefits of scrapping and recycling End-of-Life Vehicles

6.1. Highly toxic and hazardous components

- Motor oil and transmission fluids can cause injury or death when ingested, inhaled or touched. The improper disposal of oil or changed oil can pollute the soil and contaminate both surface and groundwater.

- Fuel, power steering and wiper fluids are toxic, flammable and can contaminate the soil and water, in addition to causing a fire hazard.

- Antifreeze and brake fluids are also toxic and the latter is corrosive. Beside water and soil contamination, they might cause hazard to animals due to their sweet taste, which attracts the animals when exposed to it.

- Automotive paint can be a source of contamination if the automobile is improperly disposed.

- Battery acid is a highly hazardous solution that can lead to soil or water contamination if not properly managed.

- Refrigerants (i.e. freon) if not managed properly in the air conditioning condensers can have ozone-depleting effect.

- Undeployed airbags contain potentially hazardous substances like sodium azide, which is considered acutely toxic, with a lethal dose for an adult human of about 0.7 g, and therefore require proper disposal and recycling.

6.2. Environmental and socio-economic benefits

- There are no other alternatives to scrapping vehicles apart from retrofitting vehicles, which is an unachievable scenario in a country like Lebanon due to the lack of vehicle monitoring, the absence of significant data and the very old age of the existing fleet. In addition, retrofitting for a large number of vehicles is a very costly and complex process.

- There are various environmental benefits that are embodied in scrapping programs. Renewal of the fleet reduces air pollution when fuel-efficient and vehicles with catalytic converters are introduced. Recycling ELVs prevents a great portion of vehicles ending up in the municipal waste stream and eventually in landfills, such as tires, glass, foam, plastics, etc.

- Initiating scrapping programs can be a useful method for the removal of all disposed vehicles in parking spots, road sides and junkyards, or total-loss vehicles from accidents.

- Renewing the car fleet through scrapping schemes can be a start to regulate the market of spare parts and prevent the existence of illegal black markets. Both selling spare parts and new cars can be a great source of revenue to the car retailers and ultimately to the government, since various stakeholders (advertising agencies, recycling companies, car retailers, and mechanics) are involved and can revitalize the market.

- Scrapping schemes can create various job opportunities and enhance the livelihood of citizens. In Egypt, taxi-owners were expected to increase by 40%, while at least 21,250 were sustained and different direct and indirect jobs were created in the form of drivers, staff of vehicle factories, car maintenance and car scrapping companies.

- There will be a market for old cars, where all the owners of old cars that do not know how to dispose their cars will possibly be able to make revenue and safely dispose ELVs.

- A vehicle-scrapping scheme is a potential opportunity for Lebanon to be effective in parallel to public transport systems, and reduce traffic congestions and air pollution from the transport sector.

7. Existing scrapping initiatives in Lebanon

End-of-Life Vehicles are already being scrapped in Lebanon by small and large-scale metal scrapping facilities. The usual practice is that the vehicle is either directly received at the scrapping facility (metal recycling) or passes through a dismantling facility where reusable parts are removed for resale while the body and chassis (unusable parts) are sent to the scrapping facility. However, there is no governmental regulation over the practice and there have been no incentives or scrapping schemes in the previous years to encourage old vehicle owners to scrap their vehicles.

Through surveying the main scrapping facilities in Lebanon, the following general processing steps were observed:

1- The owner of the vehicle receives an 'ELV license' (ورقة إنقاض) from the Car Registration Office which acknowledges that the car has been put out of service and consequently allows the processing by the scrapping facility. The main flow of vehicles is from private owners who deliver cars they want to dispose of due to end of life or accidents. There are also infrequent scrappage cases of insurance companies delivering damaged cars, with fewer cases by the car registration office.

2- The owner delivers the car to the scrapping yard, where the vehicle is weighed and an average of LBP 400,000 (USD 264.5) is paid to the owner. It is considered that each vehicle's weight is equivalent to an average of 1 tonne of iron, from which 125 kg are deducted to account for the weight of the non-recyclable material such as the interior, glass, tires and fluids if present. The payment is done after the owner signs the 'authorization form' (ورقة تعاهد), authorizing the scrapping facility to process and sell the ELV.

3- The vehicle is dismantled semi-mechanically (i.e., manual disassembly using a crane and a welding machine). Each vehicle is handled by 2 to 3 workers and the dismantling process includes:

   a. The removal of batteries, which are sold to a local company in the Bekaa area.
   b. The drainage of fluids (coolant, engine oil, fuel) which are stored in containers. The oil-based fluids are sold (by volume) to a local company for recycling.
   c. The dismantling process continues with the removal of tires, glass, and the interior.
   d. The mechanical parts (motor, transmission and any reusable parts) are stored to be sold later on. Tires, glass, plastics and the remaining ASR after the removal of wires and metallic parts are disposed as domestic waste.
   e. After the removal of wires and metallic parts, the tires, glass, plastics and the remaining ASR are disposed of as municipal waste.

4- The resalable parts are sold to mechanics or shipped abroad in containers in bulks as scrap metal (aluminum and iron). The rest of the car (chassis and body) is sold as ferrous metal scrap by weight, which is eventually shipped abroad. The facility does not use shredding due to its high cost and it is unnecessary since the car is sold by weight. The copper wirings are granulated and sold as granules by weight.

In the visited scrapping facility, the production date of the scrapped vehicles ranges from 1970s to early 1990s. The facility has the capacity of 50 cars/day, however, the number of processed vehicles does not exceed 5 to 6 cars/week.

7. 1. The vehicle dismantling components: the Lebanese case study

Table 4: Recycling for components of scrapped cars

Component	Quantity/ELV	Recycling
Aluminum	20-40 kg	Sold to foreign countries (i.e. India, Korea) for an average USD 1,500 - 1,600/tonne.
Copper wires	2 kg	Granulated and sold.
Ferrous metal	800 kg	Sold to foreign countries (i.e. Turkey) for an average USD 300/tonne.
Batteries	1	Sold with packaging and components to local companies average USD 8/battery.
Fluids	2-3 kg oil-based	Sold locally and transported abroad for USD 67-90/200 liter barrels.
ASR	125 kg	Dumped with the municipal waste stream.
Tires	4-5	Dumped with the municipal waste stream.
Glass (glazing)	-	Dumped with the municipal waste stream.
Catalytic converter	1	Sold locally for USD 15-40/unit according to size and composition.
Spare parts (motor, alternator, compressor, radiator and condenser etc.)	1	Sold to the local market of mechanics, otherwise sold as metal scrap.

7.2. The Lebanese fleet

Tables 5 and 6 below present a categorization of the Lebanese vehicle fleet, as per the traffic, truck and vehicle management authority at the MoIM. The numbers are from the year 2012 and are categorized either by the vehicle production date (vehicle manufacturing year) or by the vehicle circulation date (year when the vehicle was registered in Lebanon).

As illustrated, the Lebanese fleet is mainly composed of private vehicles (83.5% of total fleet) mainly manufactured in the 1980s, 1990s and 2000s.

Table 5: Lebanese vehicle fleet (according to production date)

			Type of vehicle							Total
			Motorcycle	Private bus	Private freight	Private vehicle	Public bus	Public freight	Taxi	
Vehicle Production Date	1940s	Count	2	0	10	57	0	1	0	70
		% within vehicle production date	2.9%	0.0%	14.3%	81.4%	0.0%	1.4%	0.0%	100.0%
		% within type of vehicle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		% of total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	1950s	Count	2	4	46	393	1	2	0	448
		% within vehicle production date	0.4%	0.9%	10.3%	87.7%	0.2%	0.4%	0.0%	100.0%
		% within type of vehicle	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		% of total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	1960s	Count	16	92	348	4,411	42	158	135	5,202
		% within vehicle production date	0.3%	1.8%	6.7%	84.8%	0.8%	3.0%	2.6%	100.0%
		% within type of vehicle	0.0%	1.5%	0.3%	0.4%	0.9%	1.7%	0.5%	0.4%
		% of total	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.4%
	1970s	Count	97	438	9,137	159,745	169	2,074	8,775	180,435
		% within vehicle Production date	0.1%	0.2%	5.1%	88.5%	0.1%	1.1%	4.9%	100.0%
		% within type of vehicle	0.2%	7.0%	8.4%	14.9%	3.6%	22.0%	31.2%	14.1%
		% of total	0.0%	0.0%	0.7%	12.5%	0.0%	0.2%	0.7%	14.1%
	1980s	Count	13,301	1,034	28,284	302,539	123	2,284	6,109	353,674
		% within vehicle production date	3.8%	0.3%	8.0%	85.5%	0.0%	0.6%	1.7%	100.0%
		% within type of vehicle	24.3%	16.5%	26.1%	28.3%	2.6%	24.3%	21.7%	27.6%
		% of total	1.0%	0.1%	2.2%	23.6%	0.0%	0.2%	0.5%	27.6%
	1990s	Count	34,461	3,130	48,487	275,773	2,600	2,146	7,732	374,329
		% within vehicle production date	9.2%	0.8%	13.0%	73.7%	0.7%	0.6%	2.1%	100.0%
		% within type of vehicle	62.9%	49.9%	44.7%	25.8%	54.9%	22.8%	27.4%	29.2%
		% of total	2.7%	0.2%	3.8%	21.5%	0.2%	0.2%	0.6%	29.2%
	>2000	Count	6,875	1,578	22,263	326,237	1,800	2,743	5,417	366,913
		% within vehicle production date	1.9%	0.4%	6.1%	88.9%	0.5%	0.7%	1.5%	100.0%
		% within type of vehicle	12.6%	25.1%	20.5%	30.5%	38.0%	29.2%	19.2%	28.6%
		% of total	0.5%	0.1%	1.7%	25.5%	0.1%	0.2%	0.4%	28.6%
	Total	Count	54,754	6,276	108,575	1,069,155	4,735	9,408	28,168	1,281,071
		% within vehicle production date	4.3%	0.5%	8.5%	83.5%	0.4%	0.7%	2.2%	100.0%
		% within type of vehicle	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of total	4.3%	0.5%	8.5%	83.5%	0.4%	0.7%	2.2%	100.0%

Numbers reflect rounding

Source | MoIM, 2012

Table 6: Lebanese vehicle fleet (according to circulation date)

Vehicle Production Date			Type of Vehicle: Motorcycle	Private bus	Private freight	Private vehicle	Public bus	Public freight	Taxi	Total
Vehicle Production Date	1940s	Count	0	0	4	35	0	1	0	40
		% within vehicle circulation date	0.0%	0.0%	10.0%	87.5%	0.0%	2.5%	0.0%	100.0%
		% within type of vehicle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		% of total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	1950s	Count	0	3	38	230	1	0	0	272
		% within vehicle circulation date	0.0%	1.1%	14.0%	84.6%	0.4%	0.0%	0.0%	100.0%
		% within type of vehicle	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		% of total	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	1960s	Count	3	72	224	2,413	31	81	31	2,855
		% within vehicle circulation date	0.1%	2.5%	7.8%	84.5%	1.1%	2.8%	1.1%	100.0%
		% within type of vehicle	0.0%	1.1%	0.2%	0.2%	0.7%	0.9%	0.1%	0.2%
		% of total	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.2%
	1970s	Count	9	162	2,373	20,490	70	651	359	24,114
		% within vehicle circulation date	0.0%	0.7%	9.8%	85.0%	0.3%	2.7%	1.5%	100.0%
		% within type of vehicle	0.0%	2.6%	2.2%	1.9%	1.5%	6.9%	1.3%	1.9%
		% of total	0.0%	0.0%	0.2%	1.6%	0.0%	0.1%	0.0%	1.9%
	1980s	Count	105	274	8,593	156,679	32	1,363	5,427	172,473
		% within vehicle circulation date	0.1%	0.2%	5.0%	90.8%	0.0%	0.8%	3.1%	100.0%
		% within type of vehicle	0.2%	4.4%	7.9%	14.7%	0.7%	14.5%	19.3%	13.5%
		% of total	0.0%	0.0%	0.7%	12.2%	0.0%	0.1%	0.4%	13.5%
	1990s	Count	1,759	1,790	29,637	429,513	1,401	3,318	12,450	479,868
		% within vehicle circulation date	0.4%	0.4%	6.2%	89.5%	0.3%	0.7%	2.6%	100.0%
		% within type of vehicle	3.2%	28.5%	27.3%	40.2%	29.6%	35.3%	44.2%	37.5%
		% of total	0.1%	0.1%	2.3%	33.5%	0.1%	0.3%	1.0%	37.5%
	>2000	Count	52,876	3,975	67,705	459,789	3,200	3,994	9,901	601,440
		% within vehicle circulation date	8.8%	0.7%	11.3%	76.4%	0.5%	0.7%	1.6%	100.0%
		% within type of vehicle	96.6%	63.3%	62.4%	43.0%	67.6%	42.5%	35.1%	46.9%
		% of total	4.1%	0.3%	5.3%	35.9%	0.2%	0.3%	0.8%	46.9%
	Total	Count	54,752	6,276	108,574	1,069,149	4735	9408	28,168	1,281,062
		% within vehicle circulation date	4.3%	0.5%	8.5%	83.5%	0.4%	0.7%	2.2%	100.0%
		% within type of vehicle	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of total	4.3%	0.5%	8.5%	83.5%	0.4%	0.7%	2.2%	100.0%

Numbers reflect rounding

Source | MoIM, 2012

a. **% within vehicle production/circulation date =** the total of the type in a certain period over the total of that period, e.g. $\frac{\text{90s private vehicles}}{\text{90s total}} = \frac{275{,}773}{374{,}329} = 73.7\%$

b. **% within type of vehicle =** the total of the type in a certain period over the total of the type, e.g. $\frac{\text{90s private vehicle (production)}}{\text{total private vehicles}} = \frac{275{,}773}{1{,}069{,}155} = 25.8\%$

c. **% of total =** the total of the category out of the total vehicles, e.g. $\frac{\text{90s private vehicle (production)}}{\text{total private vehicles}} = \frac{275{,}773}{1{,}281{,}071} = 21.5\%$

d. The reported data is a cleansed output according to circulation and production dates, i.e. the exclusion of data entry errors (% error = $\frac{1{,}382{,}521 - 1{,}281{,}071}{1{,}382{,}521} \times 100 = 7.3\%$)

8. Proposed scenarios for vehicle scrapping schemes in Lebanon

There are various sites in Lebanon where old cars are received, partially dismantled and the remaining metals sold by weight. The dismantled parts are sold back into the market through mechanics and car maintenance services. However, the existing facilities are unregulated and the current initiatives are limited to metal scrapping; tires, glass and plastics end up in the municipal waste stream, and the spare parts are sold through a black market for elevated rates. Figure 2 presents the increase in the Lebanese private vehicle fleet between 2000 and 2030 and the corresponding End-of-Life Vehicles through each period. The increase rate of the fleet is taken as an average of annual 2% increase (Mansour, 2014), and the fact that an import of vehicles with the production date older than 8 years is prohibited according to customs regulations. Figure 2 presents the accumulated ELVs throughout the years, taking into consideration that the numbers might slightly vary, since some of the vehicles can be scrapped and sold as scrap metals. However, this is an uncommon practice and old vehicles usually remain in the fleet for a long period of time, which is one of the main causes of air pollution. Therefore, a vehicle-scrapping scheme is highly needed to renew the existing fleet and introduce cleaner vehicles. There are three scenarios evaluated with the existing case of Lebanon, which differ according to the level of implementation of the vehicle recycling schemes.

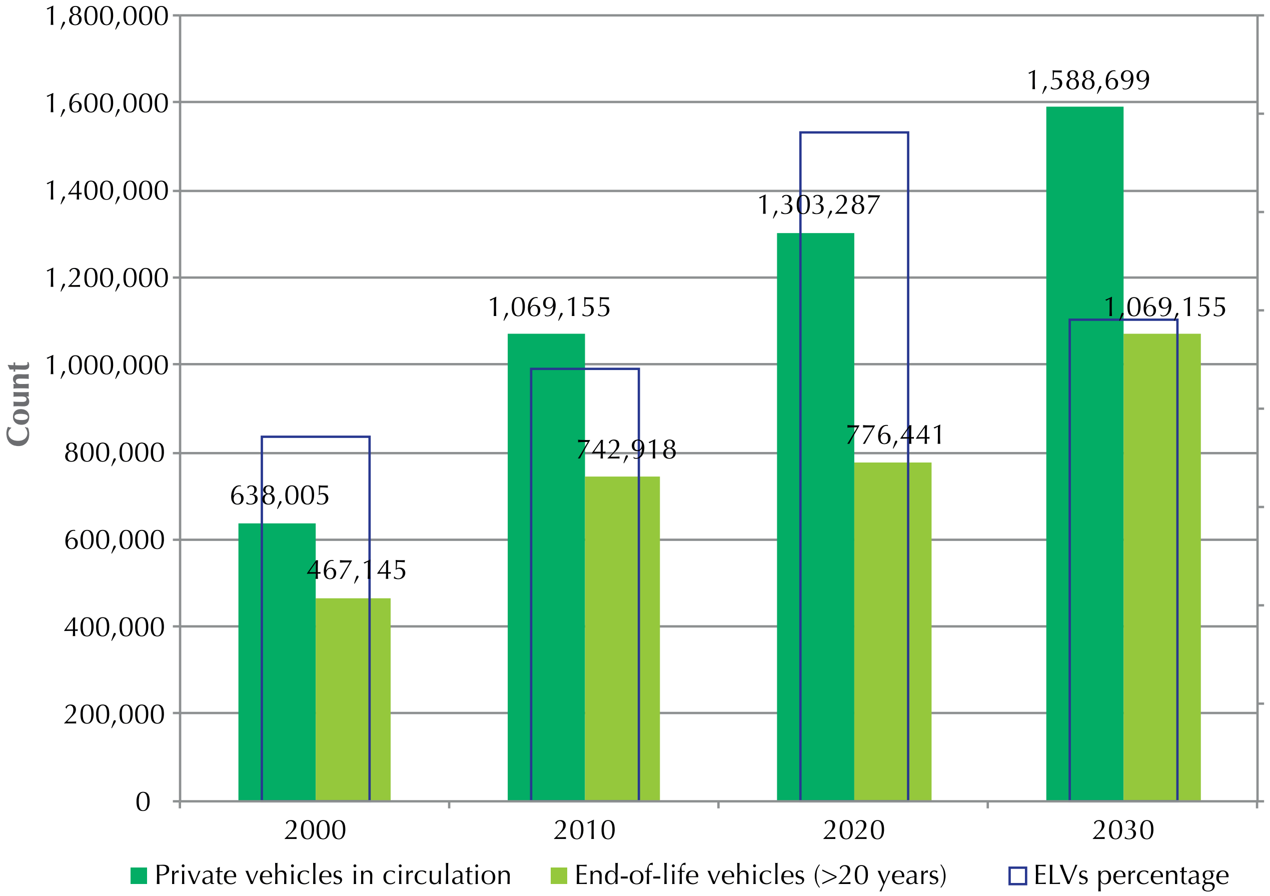

Figure 2: Private vehicles projection and End-of-Life Vehicles (>20 years) percentage

8.1. Scenario 1: do nothing

This scenario considers that a vehicle-scrapping scheme will not be established, and the ELVs will continue to be disposed of through the basic and unregulated metal scrapping facilities, where the delivery of vehicles is voluntary. There will be a great proportion of fuel inefficient vehicles in the Lebanese fleet, with an expected 68% of the total private vehicles fleet older than 20 years in 2020.

8.2. Scenario 2: establishment of new scrapping facilities

- **Delivery:** Vehicle-scrapping scheme will be organized with proper instruments and incentives to encourage the delivery of the vehicle under a legal framework. In parallel, the facilities responsible for scrapping will be accredited after meeting the assigned environmental and technical conditions set according to national regulations.

- **Legalization:** The scheme would follow a legal framework, which would control:
  - The involvement of all relevant and essential stakeholders required for the establishment of an optimum scheme;
  - The transfer of the vehicle from the owner to the processing facility;
  - The financial re-imbursement to the owner of the vehicle;
  - The environmental standards and regulations respected by the processing facility (dismantling, shredding, recycling and dumping) and the replaced new cars instead of the vehicle;
  - The recordkeeping and the monitoring of all activities and procedures throughout the different steps of the scheme to avoid illegal activities and the creation of proper inventory for all recycled cars and their spare parts;
  - The authorization of the processing facilities to sell and transport spare parts and recyclables according to market price and legal procedures, to protect the retailer's and consumer's rights.

- **Incentive:** There will be an incentive for the drivers or the owners of the vehicles, which can either be a direct payment for the owner to support him in buying a new car or a subsidized loan that facilitates the purchase of a new car.

- **Dismantling:** The processing of the vehicle will be done by the newly established facilities, with semi-automated process. The workers would dismantle all the parts that can be resold as spare parts and store them. Moreover, for very old cars, mercury switches will be removed to be treated as hazardous waste.

- **Drainage:** This step will include the removal of the battery and storage to be processed at a separate facility. In addition, there will be the drainage of fluids, such as the fuel, the brake oil, the engine oil, the condenser and air conditioning fluids and their respective storage in separate containers to be transported and recycled.

- **Shredding (optional):** The rest of the vehicle – after removal of the reusable parts in good condition – will be hydraulically flatted to be shredded or directly shredded to retain the different components of ferrous, non-ferrous and ASR for recycling and disposing.

- **Transportation (retail):** The final step of the scheme will be the selling of spare parts, the hulk of vehicle (in case of no shredding) or the shredder ferrous and non-ferrous metals. The rest (residues in small quantities) are transported to be disposed in a sanitary landfill.

8.3. Scenario 3: usage of the existing limited initiatives

The following scenario is similar to scenario 2 in terms of delivery, legalization and incentives. However, this scenario differs in the processing steps of the collected vehicles. The previous includes the assumption that all the unavailable recycling methods for the different components of vehicles will be compensated with one of the practices mentioned in Table 2 according to its effectiveness, feasibility and cost-benefit analysis.

- **Improvement:** In this scenario, the enhancement of the existing facilities in terms of process flow is essential. Currently, the metal scrapping facilities do minimal dismantling for the vehicle and have limited input on a weekly basis. To meet the capacity of the new scheme, different steps of the process have to be modified and new processes need to be added, i.e., the delivery area, the dismantling area with the adequate number of workers and the drainage equipment used for removal and storage of fluids.

- **Drainage/ depollution:** The following step is done by the removal of the battery, which can be sold and/or completely recycled on/off site, and the removal of the airbags for possible reuse or recycling. In addition, there will be the drainage of fluids, such as the fuel, the brake oil, the engine oil, the condenser and air conditioning fluids and their respective storage in separate containers to be transported and recycled.

- **Dismantling:** The disassembling of the vehicle will be by the existing metal scrapping facilities, which already receive cars as an input material. After depollution, dismantling processes remove the interior - as part of the ASR - and the systems of powertrain (engine, transmission, exhaust system, fuel tank), chassis (suspension, tires, wheels, steering, brakes), miscellaneous (electrical, lighting, thermal, windows, glazing) (Lutsey, 2010) and each component can be resold, transported, reused or processed respectively. Moreover, for very old cars, mercury switches will be removed to be treated as hazardous waste.

- **Shredding (optional):** The rest of the vehicle – after removal of the reusable parts in good condition – will be hydraulically flatted to be shredded or directly shredded to retain the different components of ferrous, non-ferrous and ASR for recycling and disposing.

- **Transportation (retail):** The final step of the scheme will be the selling of spare parts, the hulk of vehicle (in case of no shredding) or the shredder ferrous and non-ferrous metals. The rest (residues in small quantities) are transported to be disposed in a sanitary landfill.

9. Recommendations

In order to compare and evaluate the proposed scenarios, a multi-criteria analysis was performed, taking into consideration major financial, environmental and socio-economic criteria, as presented in Table 7.

Table 7: Criteria definition

Costs and demands	
Cost on the developer	The cost of initiating the scrapping scheme, which consists of the capital allocated for the financial incentive (offered to the driver) and the cost of reforming existing logistics, scrapping facilities and registration paperwork.
Cost on the scrappage facilities	The cost for modifying existing practices and adding new activities or equipment (dismantling additional parts, additional workers, dismantling equipment, etc.).
Cost of new technologies	The cost of having new equipment, machinery and technologies (shredders, vehicle crushing machinery, magnetic separators, etc.).
Demand for new technologies	The project requires new and advanced technologies, and non-existing machinery and equipment.
Demands for existing logistics reforms	The project requires national policy changes, vehicle registration paperwork reforms, change in collection of End-of-Life Vehicles.
Environmental benefits	
GHG emission reduction	The project significantly reduces GHG emissions and air pollutants during operation and during the conversion of the old fleet to a newer and efficient one.
Air quality enhancement	The project significantly reduces GHG emissions and air pollutants during operation and during the conversion of the old fleet to a newer and efficient one.
Hazardous waste reduction	The project reduces the generation of hazardous waste and the improper disposal of hazardous waste generating from vehicles (batteries, acid, oil based fluids, etc.).
Socio-economic benefits	
Traffic safety improvement	The project impacts and improves the safety of the drivers that have old cars.
Livelihood improvement	The project improves the livelihood of vehicle drivers, taxi drivers and create job opportunities in various fields of work.
National plans	
Sustainability	The project assures future sustainability, renewal of the vehicle fleet on the basis of different phases, and the collaboration with different stakeholders.
Relevant to national strategies and policies	The project is aligned with national plans for reducing GHG emissions and air pollution from the transport sector, and initiating public transport.

As shown in Table 8 and using a scoring range of -5 to 5, scenario 3 can be considered as a potential End-of-Life Vehicle scrapping scheme with its relevant modifications according to the local financial, institutional and technical capacities. Scenario 3 requires various logistical modifications similar to scenario 2 in terms of car registration paperwork, including stakeholders in the scheme, and substituting the old fleet with newer more effective vehicles in the shortest period of time. However, scenario 3 generates various safety and health benefits, initiates sustainability and brings in higher revenues. Especially that scenario 3 invests in the existing initiatives, links various stakeholders through a comprehensive scheme, and establishes vehicle recycling with less cost on the developer, machinery and new technologies.

Table 8: Multi Criteria Analysis (MCA) for the proposed scenarios

Criteria	Scenario 1	Scenario 2	Scenario 3
Costs and demands			
Cost on the developer	0	-5	-5
Cost on the scrappage facilities	0	-4	-3
Cost of new technologies	0	-5	-2
Demand for new technologies	0	-5	-2
Demands for existing logistics reforms	0	-3	-3
Environmental benefits			
Reduction of GHG emissions, air quality enhancement	-5	5	5
Reduction of hazardous waste	-5	5	5
Socio-economic benefits			
Traffic safety improvement	-5	5	5
Livelihood improvement	-5	5	5
National plans			
Sustainability	-5	3	5
Relevant to national strategies and policies	0	2	2
Total	**-25**	**3**	**12**

The scoring numeric values are from 0 to 5, and determined by the following:

5: high significance/ high positive impact
3: significant/ moderate positive impact
1: less significant/ less positive impact
0: not significant/ no impact
-1: less insignificant/ less negative impact
-3: insignificant/ moderate negative impact
-5: high insignificance/ high negative impact

9.1. ELV eligibility criteria

Eligibility criteria are one of the most important characteristics of any scrapping scheme. There are certain approaches for defining eligibility criteria acquired by different countries such as: age of production, age of circulation, type of vehicles, kilometers driven, or CO_2 emissions. The former three can be possible options in the case of Lebanon due to the availability of comparable and traceable data. For example, according to the 2012 car fleet data, private vehicles produced in the 1970s, 1980s and 1990s constitute 12.5%, 23.6% and 21.5% of the entire fleet, respectively (MoIM, 2012). These are relevantly more polluting and less fuel efficient than newer cars, and can consequently be considered as a substantial target for a national ELV scrapping initiative.

Another example related to the kilometers driven can be targeting the old taxis, which are continuously circulating – with high kilometers driven - and are highly polluting. Taxi drivers can be an accessible target population, since the vehicle is their source of income and they would be willing to renew their taxi car within a reasonable scrapping mechanism. This would be more appealing when fuel consumption, maintenance, mobility cost, comfort and passenger safety between the old and new taxis are compared.

The sustainability of the scrapping scheme and the input of vehicles is noteworthy, since Lebanon is a small country and has a small fleet compared to other countries. In general, the national Customs Office and the Car Registration Office, where the whole car fleet is managed and controlled, can direct the optimum eligibility criteria and update them through different stages of the scheme.

In addition to the previous eligibility criteria for the ELVs, there are other cases, which can be considered as an input to the scrapping scheme such as the total lost cars from accidents and the abandoned cars. The former can be received directly by the owners or the insurance companies, and the latter can be managed by a similar flowchart for 'street abandoned cars' in Taiwan in 1997 (Ching-Hwa, 1997) (Annex II).

9.2. Incentive schemes

There is a wide range of financial incentives in developing and developed countries to encourage ELV recycling, which is received by the owner USD 117–4,500/ ELV. In addition to compensation, there are various cases of soft loans or even 0% loans given to the drivers to encourage replacing the old vehicle and buying a newer and efficient vehicle. The financial incentive is a crucial pillar for the success of any scrapping program. The incentive has an essential impact on the input of cars by owners, in case of a voluntary scrapping scheme, which is the usual trend. Incentives can be joined with enforcing mechanisms, for example, in Egypt amending the Traffic Act supported the initiation of the ELV scrapping program. The Act prohibited the renewal of licenses of 20-year-old taxi vehicles and provided the owners a grace period of 3 years to adapt and eventually replace their old cars (Harraz & Galal, 2011).

9.2.1. Cost of a scheme

The main cost of a scrapping scheme depends on the value of the cash given as an incentive to the owner of the vehicle, and the schemes often continue till the exhaustion of the allocated budget. To optimize the provided incentive, a cost-benefit analysis is necessary to minimize the cost of initiating the program. This can be achieved by increasing the input of revenues from recycling processes, and benefiting from existing facilities, yards and recycling companies rather than creating new establishments. Involvement of the banks in managing loans and reimbursements is central to properly allocate financial resources and validate bookkeeping.

Third parties between the government and the scrapping facility can help in reducing the cost of initiating the scrapping scheme or increasing the incentive, such as advertisement companies (Figure 3), or car retailers that can provide newer vehicles for subsidized prices. In the UK, 41 car manufacturers were involved in the scrapping scheme and they were responsible for providing the GBP 1,000 (USD 1,680) out of the GBP 2,000 incentive per vehicle (Harari, 2009). The involved manufacturers consider this as an economic incentive since it increases the production and demand of cars. In the Egyptian scheme, five car dealers were involved in providing fuel-efficient taxis under the protocol signed with the MoF (CDM, 2011).

Figure 3: Advertisements on a taxi in Beirut

9.3. Scrapping facilities

Vehicles are most often received at the scrapping facility, where the depolluting, dismantling, crushing and shredding activities take place. There are cases in which the crushing and the shredding – for metal recycling – take place in a different facility after transporting the remaining parts of the vehicle. There are certain characteristics and requirements for the scrapping facility that should be considered in parallel to policy instruments:

1- **Size and accessibility of the facility** must be within a reasonable capacity to be suitable for dismantling activities, and often a larger size is required in case the storage (closed area) of the spare parts is on-site. The size of the facility can be determined beforehand according to the amount of ELVs that should be scrapped during each scrapping scheme period (annually) and depending on future projections. Easy accessibility to the site is encouraged, since in common cases the owner delivers the vehicle to the scrapping facility.

2- **Employees** are defined according to the dismantling process 'mechanical + manual', and availability of technicians is important for proper dismantling and storage of reusable parts.

3- **National and international environmental protection standards** shall be considered to preserve the workers' safety and prevent environmental contamination. This is essential in the case of Lebanon if existing metal scrapping facilities will be involved in the scheme. Accreditation of facilities can be achieved by following environmental standards.

4- **Record-keeping** is required to generate data for future studies and to avoid illegal dismantling activities or improper inventory of vehicle parts.

5- **Joint certification** between the scrapping facility and the government (i.e. Car Registration Office) should be achieved to assure the closed loop of recycling of the ELVs under the scheme, and prevent the owners from illegally scrapping their vehicle after receiving the 'ELV license'.

9.4. Scrapping process, dismantling and recycling

In various countries, the scrapping and dismantling process of vehicles are defined through regulatory frameworks. For example, European countries have been shaping their national standards according to the EU27 Directive (2000/53/EC), which defines the percentage by weight of the vehicles that should be recycled, and the available or encouraged practices and procedures for recycling each component.

The flow of the ELV recycling process can be defined by the government through policy instruments, which constitute the three categories of collection, dismantling and shredding. Figure 4 presents the basic flowchart from deregistration till disposal of residual waste. These instruments can define if the owner – after finalizing the paperwork – takes the vehicle directly to the scrapping facility or at independent collection points. After the collection and according to the available capacity and resources, the tasks of the dismantling facility should be defined. In Lebanon, there is a market for spare parts resale and there are companies responsible for receiving the automobile oil, batteries and metal scrap generated from the vehicle. However, there are no responsible companies or facilities that receive tires, glazing (glass), plastic or the interior, which constitute parts of the Automobile Shredder Residues. Establishing local processing techniques or transporting currently unmanaged components are the only two options for a future scrapping scheme, with the former being a more feasible option. Recycling the remaining components requires comparably more complex technologies and a higher cost, and these methods are available abroad in European countries.

The final step of the recycling process is usually retrieving the metallic (ferrous and non-ferrous) mass of the vehicle after shredding. Both cases of transporting (selling locally or abroad) and shredding, or separating and transporting are available in Lebanon. In this case, what should be defined are the characteristics of the shredding process, the magnetic separation of the ferrous metals, the separation of non-ferrous metals and the sorting out the shredder waste, in addition to their relevant collection and storage.

Throughout the recycling process and specifically during the draining of fluids and dismantling of parts, there are various types of hazardous waste that are generated. Mercury switches (from old vehicles), coolant, refrigerant and oil filters, should be collected in special containers and transported or treated with the certain regulations of hazardous wastes.

10. Conclusion

The creation of a vehicle scrapping scheme is a key solution for the transport sector in Lebanon. The transport sector suffers from an old car fleet, which in addition to traffic congestion contributes to air pollution. A managed scrapping scheme can substitute the old vehicles by new and efficient ones, while at the same time preserving livelihood, generating revenues and creating job opportunities.

The success of such schemes has been recorded in many countries, and by reviewing the situation of Lebanon, there are great potentials to be invested in. This report presented the possible options and the future considerations in the case of creating a vehicle-recycling scheme. However, there is a need for thorough analysis of the cost-effectiveness of such a scheme to support decision-makers and policy makers. Moreover, it is of great importance to expand this recycling scheme beyond the private vehicles and taxis, which constitute the largest portion of the Lebanese fleet. For example, recycling End-of-Life freights and motorcycles can be an option for a future study.

The profound importance of the vehicle scrapping scheme stands in the fact that there are no alternatives for it. Retrofitting the fleet, which can be presented as an alternative is an impossible task to achieve, especially in a developing country such as Lebanon. This leaves us with the only option of scrapping, which assures legal, profiting, and a systematic and environmentally-friendly mechanism for removing the old fleet from the streets and substituting with it with a less polluting new fleet.

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Annex I

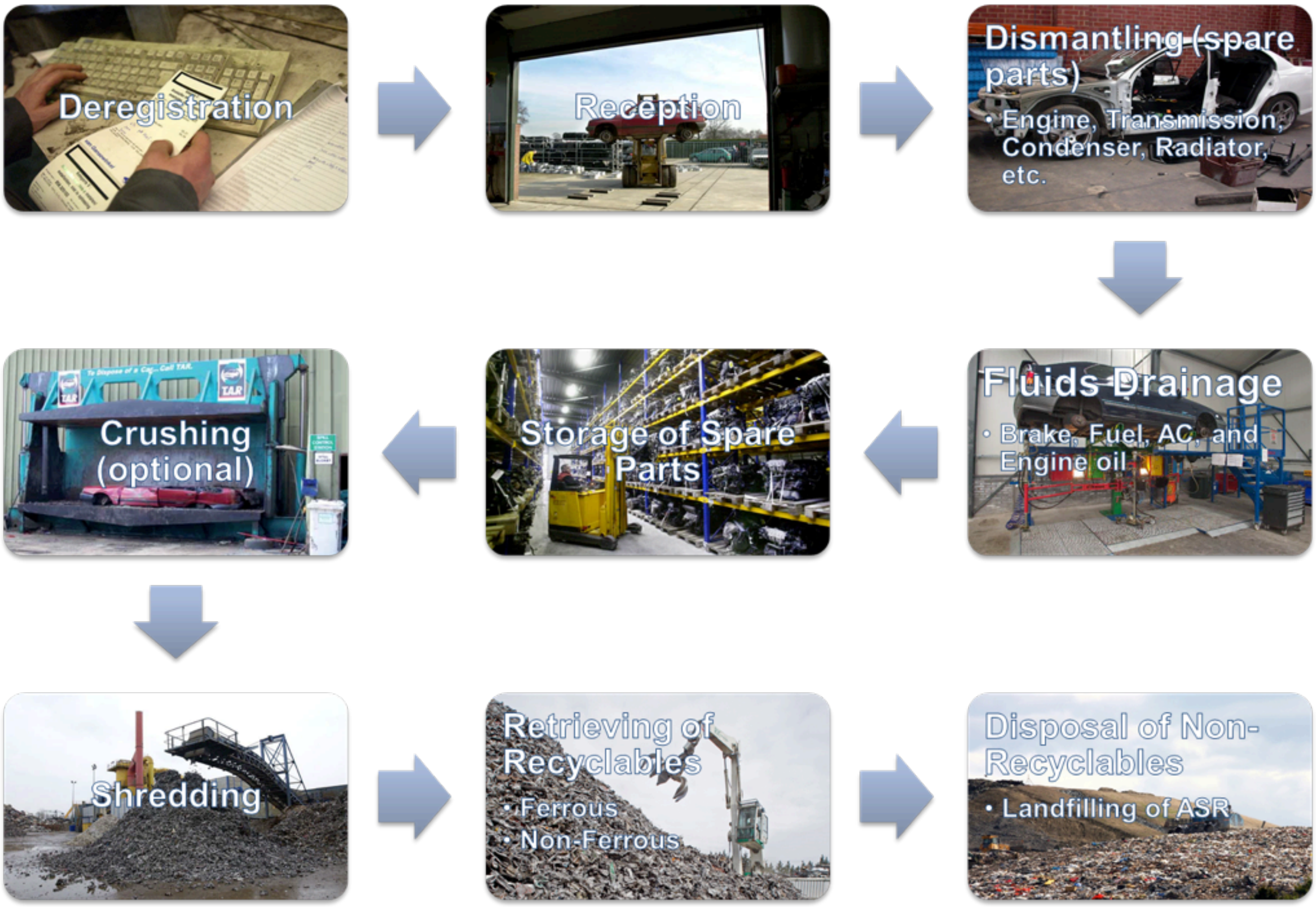

Figure 4: End-of-Life Vehicle recycling process

Annex II

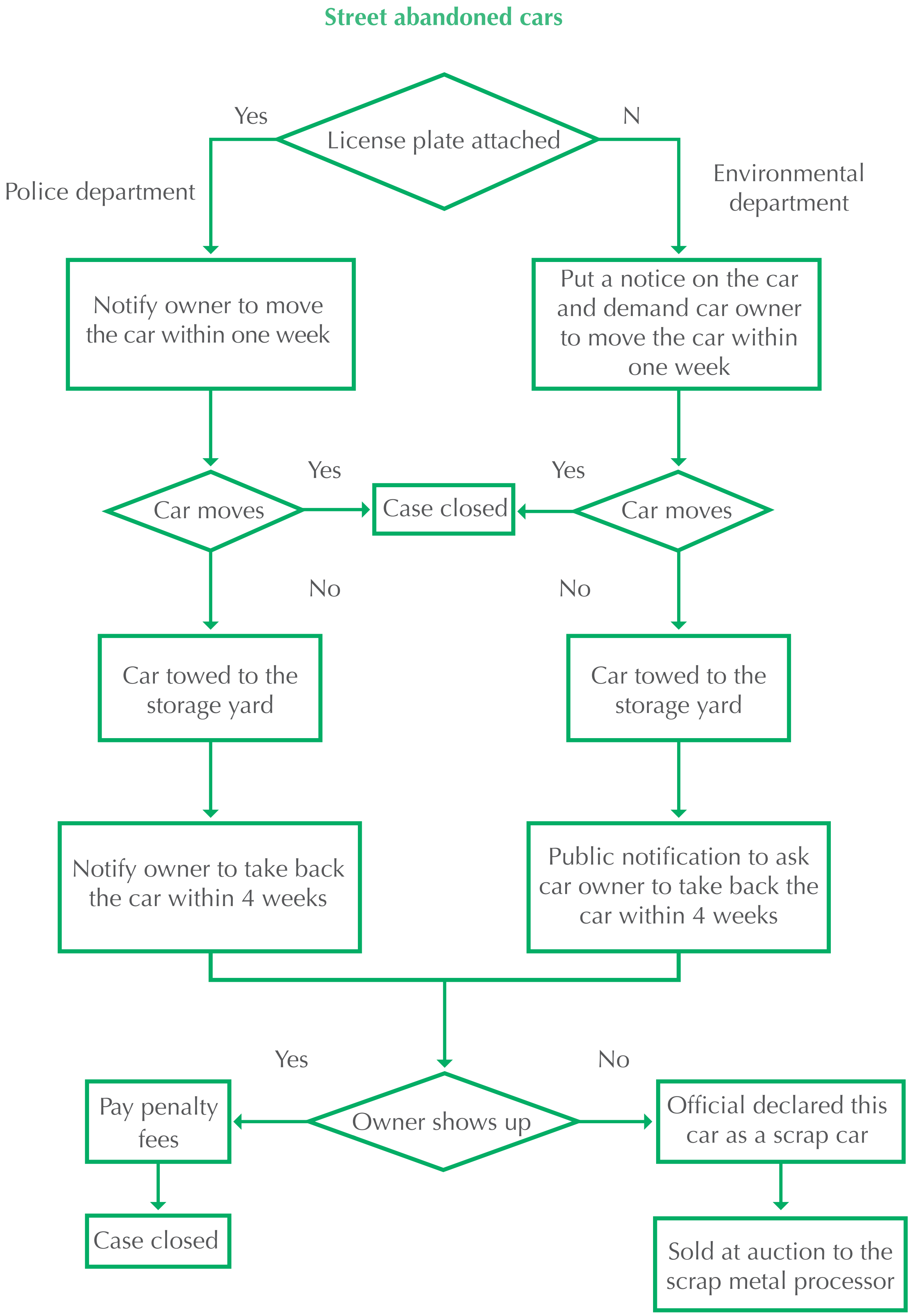

Figure 5: 'Street abandoned cars' retrieval flowchart, Taiwan 1997

Annex III

Ministry of Finance
(Project entity)

- Oversees PoA management and on-site scrapping site management;
- Provides vehicle owners with payment for surrendered eligible vehicles;
- Pays vehicle sales taxes on behalf of the owner;
- Exempts customs on imported components of the vehicle;
- Guarantees the loan against default in select cases;
- Places program advertising and awareness in local and national media;
- Manages comments and complaints from vehicle owners and drivers (via hotline and periodic survey);
- Maintains registered project database;
- Upon PoA registration, shall oversee CDM project monitoring activities, as presented in this PoA-DD.

Ministry of Interior

- Provides land for scrapping site;
- Manages initial vehicle inspection and scrapping of surrendered vehicles;
- Manages licensing of new vehicles;
- Provides security and monitoring services for scrapping site; and
- Locates vehicles in case of loan default;
- Provides data necessary for calculating the compliance rate every year.

Participant auto dealers

- Provide discounted vehicles to eligible vehicle owners who have surrendered their old vehicles;
- Prepare vehicles for mass transport use (e.g., install meters and paint exteriors);
- Provide up to 3-year warranty on vehicles;
- Provide routine maintenance;
- Guarantee loans against default, where the dealer repossesses the vehicle and pays the outstanding loan to the bank;
- Provide branch office representetives at processing and scrapping site; and
- Shall cooperate with Ministry of Finance on arranging annual monitoring surveys after PoA.

Participant advertising entities (optional)

- Provides loan supplements to vehicle owners in exchange for use of internal and external advertising space;
- Shall cooperate with Ministry of Finance or arranging annual monitoring surveys after PoA registration (but shall not be responsible for conducting surveys).

Participant insurance firm

- Provides insurance for all replacement vehicles;
- Provides branch office representatives at scrapping site.

Participant banks

- Provide low-interest loans to eligible vehicle owners who have surrendered their old vehicles;
- Provides branch office representatives at scrapping site.

Recycling firm

- Manages vehicle recycling facility.

Ministry of Environment

- Monitors scrapping and recycling facility.

Vehicle owners

Submit old vehicles and purchase new ones.

Figure 6: Schematic diagram for the operation and management plan of the Egyptian program