

End-of-Life Tires



**A framework for effective
management systems**



Managing End-of-Life Tires

The member companies of the Tire Industry Project understand the importance of working together on sustainability topics, which impact our businesses, our societies and our environment. In this spirit of collaboration, we have focused on understanding end-of-life tire (ELT) management practices around the world.

We support all efforts to effectively manage the annual generation of ELTs. We understand that both the impact and the value of our products do not end when the tire's use for its intended purpose, on a vehicle, is over. Even when a tire can no longer be used on a vehicle, it still has value as an energy source or as a secondary raw material. Therefore ELTs are a valuable resource as part of a closed loop, sustainable world.

We commit to sharing our experiences and our understanding with our trade associations, within our industry, and with local and national governments. We hope to support the advancement of ELT management globally, in deference to local cultures. We invite all stakeholders to join our dialogue.
(June 2010)

TIP members



The Tire Industry Project is a voluntary industry initiative bringing together eleven leading tire companies to collaborate on sustainability issues related to the environment, societies and industry. The Project operates under the umbrella of the World Business Council for Sustainable Development (WBCSD), and is chaired by Bridgestone (Japan), Goodyear (USA) and Michelin (France).

The Tire Industry Project members would like to thank the European Tyre and Rubber Manufacturers' Association (ETRMA), the Japanese Automobile Tyre Manufacturers Association (JATMA), and the Rubber Manufacturers' Association (RMA) in the USA for direct input into the development of this manual, and other tire associations around the world for their provision of data and support in this process.

End-of-Life Tires: A Framework for Effective Management Systems

Prepared by the WBCSD Tire Industry Project

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1. Introduction and Document Scope

The question of what should happen to a tire after it has reached the end of its useful life on a vehicle is increasingly being asked by our customers, government representatives, regulators and the environmental community. In response, in July 2008, some World Business Council for Sustainable Development's (WBCSD) Tire Industry Project (TIP) members formed a working group to investigate the state of end-of-life tire (ELT) management in different parts of the world, and to better understand different stakeholders' roles in the management process.

This manual aims to provide the industry with valuable information based on some of its experience in ELT management from around the world. It is hoped that it will support local management who are considering or responding to the establishment of an ELT management system in their country, or in places where existing systems are being modified. It should be viewed as a working document, to be further developed as more lessons are learned from ELT management. Anyone implementing an ELT management system must do so clearly understanding the local market, legislative framework, culture, etc. This document is not intended to provide specific country detail. The TIP welcomes additional input to the document from others working on this issue (*please e-mail: tires@wbcsd.org*).

2. Definitions

ELT (end-of-life tire)	a tire that can no longer be used for its original purpose; all tires including passenger car, truck, airplane, agricultural, 2-wheel & off-road tires result in ELTs; however, most ELTs result from car and truck tires
ELT-derived products	reclaimed rubber, shredded tires, ground and powdered rubber, char, oil, steel cord, textiles, etc.
UT (used tire)	retreadable tires + second hand tires + exportable tires + ELTs
annual generation of UTs	annual sales of replacement tires (including those to be used for retread, reuse or export) plus input of UTs from ELVs
annual generation of ELTs	annual sales of replacement tires (excluding those to be used for retread, reuse or export) plus input of ELTs from ELVs
ELT management	process beginning at point when a Used Tire is designated as an ELT up to its supply to an ELT recycling or recovery company
ELT operators	entities needing a permit to operate within the ELT management system that collect, sort, transport or process used tires or ELTs
monofill	landfill used for one single material or product
processing company	oversees activities to produce an ELT-derived product (e.g., secondary raw material like shredded or ground rubber, or alternative energy source e.g., for cement kilns)
recovery company	companies using ELTs for energy generation (e.g., in cement kilns)
recovery routes	reuse, retread, export, energy recovery (tire derived fuel), material recycling (e.g., civil engineering projects, ground rubber applications)
recycling company	companies using the secondary raw material derived from ELT processing for their product sold on the market (turf, steel plants, thermoplastics, etc.)
R&D projects	projects to develop ELT-derived products for new, more valuable applications as secondary raw materials; stakeholders: recycling and recovery companies, processing companies, tire industry, laboratories, universities, administrative bodies
tire provider	individual or organization that manufactures, imports or acquires tires that are placed on the market for sale in a given country

3. Background on ELT Management

An estimated one billion tires worldwide (about 17 million tonnes) reach the end of their useful lives every year. This number has been growing steadily and this trend is expected to continue in the future. Various regional efforts by governmental authorities, the tire industry, and individual manufacturers are underway to manage ELTs and good progress is being made, although in many areas there is still much to be done.

When an ELT is taken off a vehicle, several markets exist to manage them, the most common including:

- **Energy generation:** tire-derived fuel
- **Material recycling:**
 - a. e.g., civil engineering uses in which tires are shredded, cut or used whole
 - b. e.g., ground rubber for rubber-modified asphalt, recreational surfaces including playground, synthetic field turf and athletic track applications, flooring, molded new rubber products.

ELTs that do not enter an end-use market typically follow one of two paths:

- Legally landfilled, in jurisdictions that allow landfilling of ELTs
- Dumped illegally into a stockpile or by the roadside

Uncontrolled landfilling is not desirable because of health (e.g., potential malaria threat due to mosquito nesting) and environmental (e.g., fire risk) impacts. Furthermore, landfilling leads to the loss of a resource that could be used beneficially elsewhere. The challenge and opportunity for all stakeholders in a given region where landfilling is still an option, including tire manufacturers, is to create an ELT system where ELTs are considered as a resource entering useful end-use markets.

In order to create this kind of system, a legal framework must address the collection, transport and storage of ELTs. The situation regarding historical ELT stockpiles must also be fully assessed, and addressed with local/national governments. Equally important to the success of an ELT system is the development of environmentally sound, economically viable, and self-sustaining end-use markets.

Various ELT management systems exist in different countries around the world. They have developed according to local cultural, political and industrial contexts. In many cases, ELT management is continually evolving, and existing systems have been adapted over time as learning about ELT management has increased. This document aims to bring together that learning.

Objectives for the industry to engage in ELT management

- To ensure the industry fulfills its social and environmental responsibilities
- To ensure ELTs are recognized as a potentially valuable secondary resource, in a global context of increasing resource scarcity and raw material costs
- To proactively manage threats to the industry of non-action (cost and image threats)
- To promote the goal of 100% recovery rate, to treat ELTs generated annually and to treat existing stockpiles

Specific goals:

- To decrease the cost of the ELT chain by developing new markets
- To ensure ELT management is in line with legislative and environmental obligations in the countries in which this industry operates
- To develop new recovery routes by supporting R&D programs
- To participate in the process of creating or improving legislation regarding ELTs, in order to secure sustainable and economic treatment of ELTs

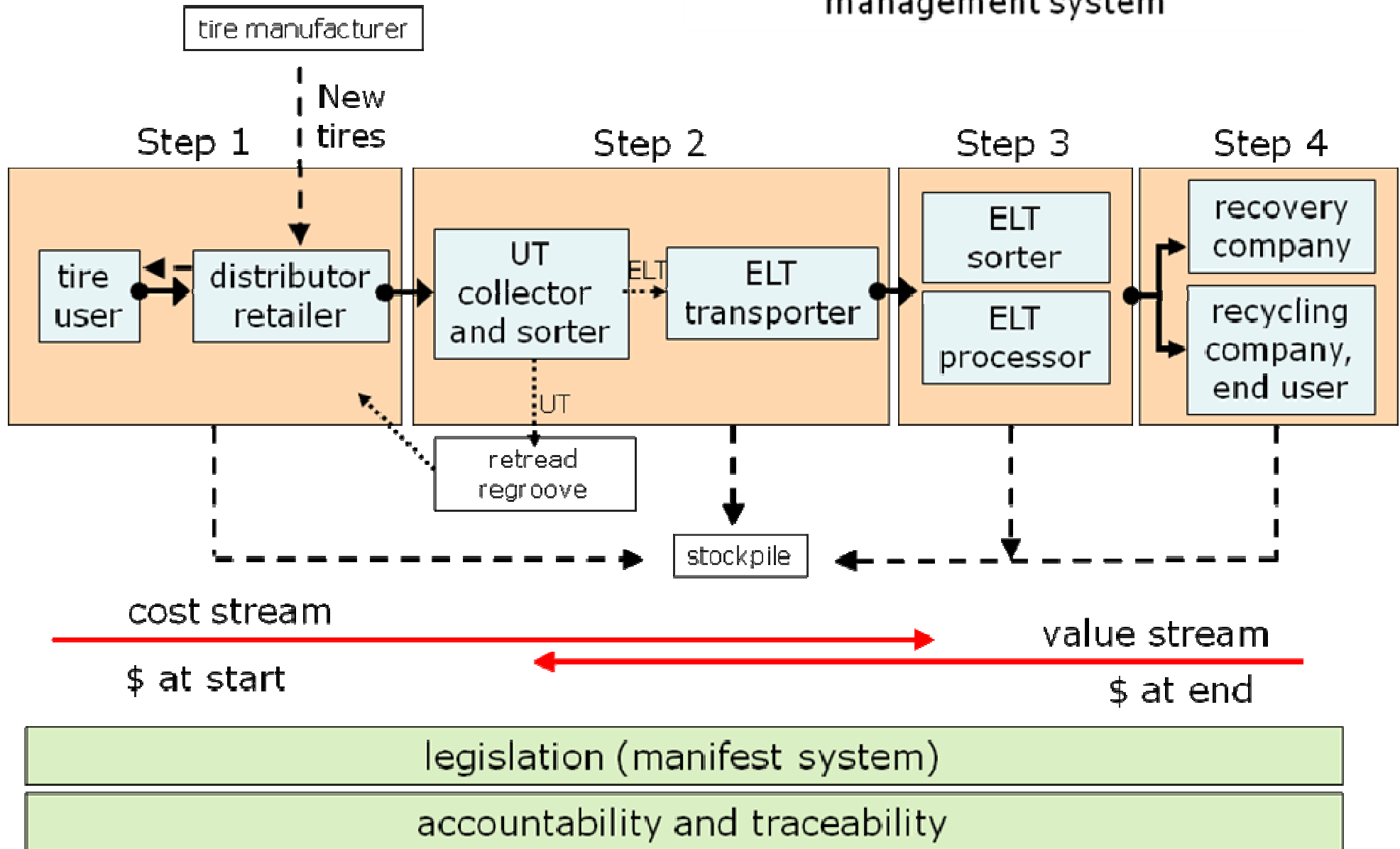
CHALLENGE: Quantifying the value of ELTs as a secondary resource (alternative fuel)

Life cycle analysis (LCA) (e.g., State of California, cement industry studies) can show the calorific value of ELTs, and their value as an alternative fuel to other industries. Results/benefits should be clearly and fully communicated to all stakeholders at the start of an ELT management system. The promotion of ELTs as tire-derived fuel (TDF), relative to greenhouse gas legislation, can lead to emissions credits. ELTs are an energy source that can replace other fossil fuels and help conserve natural resources. A portion of ELTs comes from renewable sources (natural rubber) and may result in reduced greenhouse gases compared to fossil fuels.

CHALLENGE: Seeing ELTs recognized as a valuable resource

Policy-makers can instigate official definitions for ELTs, which impact their recovery routes and the opportunities to create beneficial end-use markets. For example, in 2008 the European Commission addressed the need to develop criteria to consider ELT-derived products as a resource and no longer as a waste. This discussion is expected to last several years.

End-of-Life Tire flow in effective management system

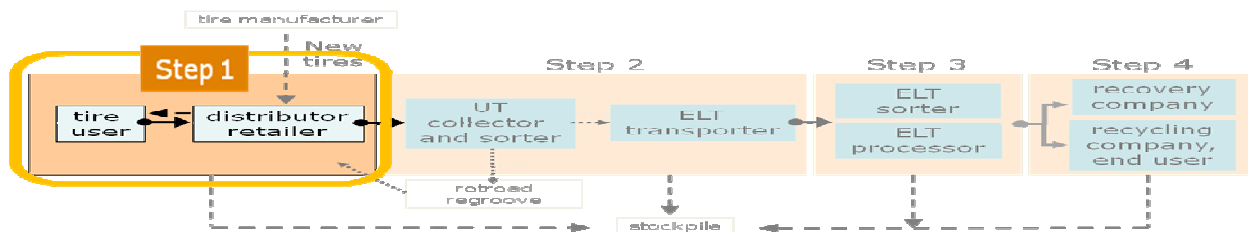


To note: this flow diagram depicts one potential version of an ELT management system. Multiple options exist which vary in detail from the diagram above

4. Functional Requirements for Effective ELT Management

Regardless of the type of system in place, ELT management systems must accomplish the following functions on a sustainable basis, shown here at the different stages of ELT management.

STEP 1: Manage used-tire disposal



The process

Tire user disposes of UTs at authorized collection point, which may be a tire dealer or a designated collection point.

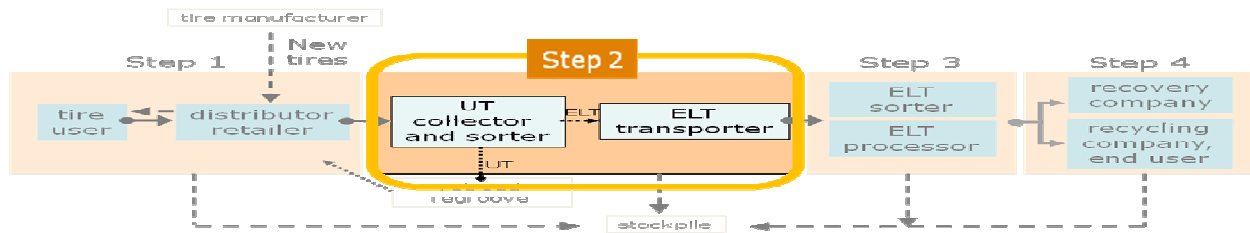
At the start of the system, payment is required at this stage to fund the process. In both cases, the UT owner is charged a disposal fee, which appears as a line item on their new tire invoice. Generally the buyer pays the fee when purchasing the new tire. Fees/receipts to the collection point are based on market value or cost of ELT processing. The collection point is responsible for appropriate handling.

The UT, when it can no longer be used for its intended purpose, is designated as an ELT, and transferred/sold/bought by an authorized agent for beneficial use (i.e., not for landfill or dumping).

Legislation should ensure that:

- ELTs can only be disposed of through authorized/certified tire disposal routes or with authorized/certified collectors or dealers.
- It is illegal to landfill or monofill UTs in any form (including ELTs).
- Any storage of UTs and ELTs at collection point is regulated.

STEP 2: Collect and sort UTs, and transport ELTs to ELT sorter/processor

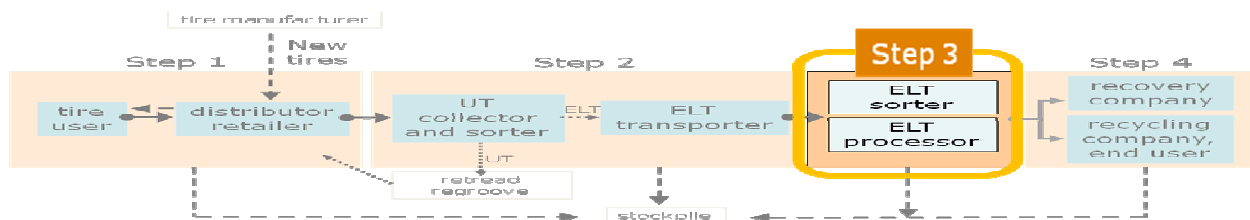


The process

UTs are transported from the collection point and sorted into UTs or ELTs (according to standards to ensure the safe handling of the product). The companies are paid by the dealer/collection point (if free market model is in operation) to transport ELTs to the ELT sorter, processor or third party.¹ A regulated storage/sorting facility is needed. UTs are transported for retread or regroove.

Legislation should govern the operation of transporters, sorters and storage facilities, and require them to be authorized / certified. Landfilling or monofilling UTs in any form (including ELTs) should also be made illegal.

STEP 3: Sort and process ELTs



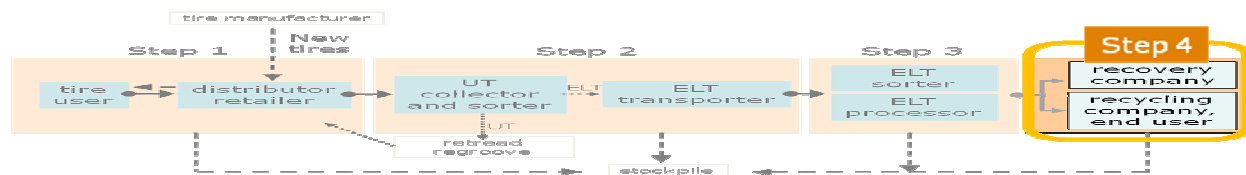
The process

ELTs are sorted for processing. Processing companies shred and/or grind tires, i.e., they process ELTs for alternative energy for use by recovery companies, or they process ELTs as a secondary raw material for use by recycling companies. Processing companies are either paid by or charged by (increasingly) the collector or third party, depending on local market conditions and legislation. The companies overseeing this stage are generally small or belong to an industrial group.

Legislation should ensure that landfilling and monofilling are regarded as the least favored options. Authorization for processing companies to operate should be based on strict regulations related to storage, fire safety, financial soundness and sustainability, etc.

¹ "Third party" could be an ELT management company mandated to oversee ELT management by the manufacturers (if producer responsibility model is in operation) or the administration (if tax model is in operation).

STEP 4: Recover or recycle ELTs



Energy generation companies: cement kiln or other energy use. This use is based on calorific properties and must respect local environmental regulations. They generally belong to an industrial group.

Recycling companies: material use, for example, asphalt, turf, steel plants, thermoplastics, or other products derived from processed ELTs (e.g., ground or powdered rubber) used as secondary raw materials. These are generally small companies that can belong to industrial groups.

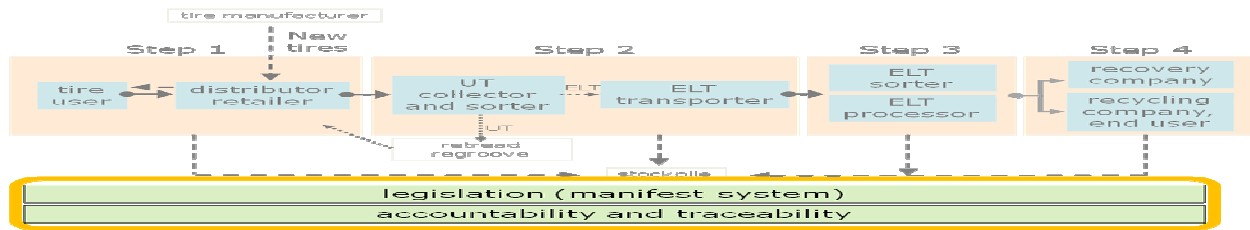
The process

ELTs (whole or shredded) are either paid for or charged for (increasingly) by the recovery or recycling companies or third party², depending on local market conditions and legislation.

Legislation should recognize ELT-derived products as alternative energy sources or secondary raw materials with respect to certain criteria identified by that country's/region's regulation. The introduction of standards for ELT-derived products is key for their recognition as alternative energy sources or secondary raw materials and for their payment as such. Legislation must address the need to avoid landfilling and monofilling.

² "Third party" could be an ELT management company mandated to oversee ELT management by the manufacturers (if producer responsibility model is in operation) or the administration (if tax model is in operation).

Research and development (R&D) and accountability



Research and development (R&D)

It is beneficial if processing, recovery and recycling companies participate in R&D projects to develop new applications for ELT-derived products, in association with the tire industry, laboratories, universities, administration.

Accountability throughout the whole system

In principle, throughout all steps, each actor must operate in a way that ensures a reliable and transparent supply chain, with appropriate traceability systems in place. At **every** stage of the process, from the time the ELTs is collected to its final end market, a **manifest system** must be in place to document the tire's disposal route (including tire characterization (type of tire, etc.), date collected and left by tonnes or units, details of end recipient, etc.). ELTs are effectively managed on the basis of weight, which should be stipulated by law. When the traceability system is based on item weight, and when this is thoroughly implemented at every step of ELT management, the deviation of ELTs from the authorized management system into illegal landfilling or dumping is prevented. This is basically a paper trail to ensure that all regulations are followed and the tire is treated appropriately at every stage of ELT management. This data should be shared in a transparent way with the third party³. Details of different manifest systems are outlined in the appendix.

At the stages of ELT transportation, sorting and end market use, periodical verification is necessary to ensure adequate safety and environmental standards are met in the following areas:

- Record keeping
- Financial standing (i.e., solvency)
- Financial security (insurance and bonding)
- Audit scores

³ "Third party" could be an ELT management company mandated to oversee ELT management by the manufacturers (if producer responsibility model is in operation) or the administration (if tax model is in operation).

5. Legislative Requirements for Effective ELT Management

Legislation of ELTs will develop to respond to perceived needs. The tire industry must participate in the design of public policies regarding ELTs, and share its knowledge on ELT management experiences from around the world. Stakeholders must be properly informed of all issues surrounding ELT management, and prepared to guide each other to effective and sustainable management systems, whatever the political and cultural context.

Different regions of the world have adopted different types of ELT management systems to suit the local context and to incorporate cultural and political norms. However, all legislation that relates to successful ELT management systems has the same key components:

Legislative topic	Desired content of legislation
	To promote an ELT management program, legislation must clarify the responsibilities and obligations of all stakeholders
ELT status	State that ELTs are non-hazardous waste
Responsibilities	The responsibilities of each stakeholder must be clear and agreed by all throughout the design and implementation of an ELT management system
Disposal of ELTs	Ban illegal dumping/fly-tipping or uncontrolled landfilling
Cost transparency	Separate line item on new tire invoice showing tire disposal fee
Transport of ELTs	All transporters must obtain a permit or license (permit includes background check against criminal activities, posting performance bond used to clean up any unlawfully dumped ELTs)
Storage	Comply with specific environmental and safety guidelines (e.g., length of time of storage, volume and configuration of storage)
ELT-derived product status	State that ELT-derived products are secondary raw materials or alternative energy (criteria to be defined)
ELT-derived product use	Promote use of ELT-derived products in public contracts
Reporting e.g., manifest system	A reliable reporting system has to be set up to secure a sound flow from the dealer to the recovery or recycling company. Every time the ELT changes hands, requirements for reporting (transparent system, volume/weight, regular reporting, auditing procedure) must be met
Enforcement	Set the right enforcement procedures to make sure the legislation is respected

Around the world, varied ELT management systems have developed according to local cultural, political and industrial contexts. In the appendix you will find:

- References for further, detailed resources
- A description of the responsibilities under 3 specific models: “Producer Responsibility”, “Free Market” and “Tax” models
- Case studies highlighting ELT management from around the world

CHALLENGE: Regulatory changes

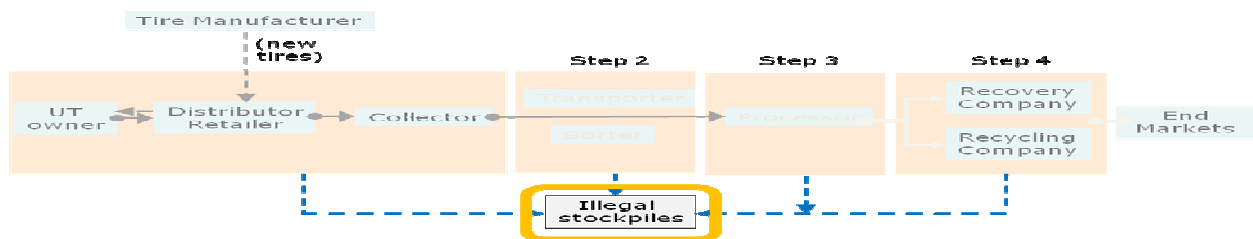
Building good relationships with policy-makers will help provide an insight into potential policy changes, but the policy framework around ELTs should still be continually monitored (stockpiles, ELT management, co-processing, recycling, landfilling). Where possible, industry should aim to engage with policy-makers on new developments.

Where ELT management systems have been set up in the past with a capped budget or under one legislative system, changes could result in sudden stopping of ELT management. This should be anticipated where possible, and new systems put in place when older ones finish.

6. Stockpile abatement

CHALLENGE: Treatment of existing, legacy stockpiles

Legacy stockpiles should be treated in parallel to annual generation of ELTs, within an ELT management system, and markets should be created for stockpiles. Stakeholder communication is key to gain trust and credibility on this.



STEP ONE: Stop the creation of new stockpiles

See section 5 on legislative requirements. The first step is to set up an ELT system to treat the annual generation of ELTs and to stop the increase of stockpiles. It may take several years to create the conditions to arrive at this point for companies/countries starting from zero. It is necessary that this goal is addressed gradually.

STEP TWO: Reduce and eliminate existing stockpiles (“historical” or “legacy” piles)

Abatement of stockpiled ELTs can be achieved in one of three ways:

- The **landowner** takes responsibility for abatement of the stockpile at their own expense
- The **government entity** takes direct responsibility for abatement and may or may not seek reimbursement from the stockpile owner. This is usually done when a government has established a funding source for this effort (this may be a tax) e.g., USA
- Abatement responsibility is **shared** between different organizations e.g., France, Japan, Portugal

The decision regarding who is responsible depends on the local context, but, nearly always, the government makes the first move. Stockpile abatement should be government-sponsored (e.g., if funded through taxes), or, if not, coordinated as a joint effort. No matter which ELT management system is developed, the process of stockpile assessment and abatement will remain virtually identical.

7. Developing End-Use Markets for ELTs

Existing markets

The development of long-term, viable end-use markets for ELTs is a key factor for success for all ELT management programs. Many ELT markets already exist, and can be categorized as either energy recovery or material recycling. *Managing End-of-Life Tires: Full Report* (WBCSD, 2008) gives more detail about some of these markets.

Developing new markets

Several critical factors should be assessed when developing end-use markets, including:

- Is there existing demand for ELT-derived products?
- What is the supply chain of ELTs?
- Are regulations in place that will allow for ELT processing/market infrastructure to be developed?
- **Is the market viable in the long-term?** The critical factor in ensuring that ELT markets are successful in the long-term is to develop markets that are viable both 1) economically and 2) environmentally. In general, regardless of the overall ELT management system, the process of developing markets for ELTs will remain virtually the same.

1. Economics

ELT markets that can continue to exist in a competitive free market without subsidies are considered viable in the long-term. The tire-derived materials receive a fair market value on the marketplace, allowing market forces to set the true cost for both the collection and processing services, and the tire-derived material sold. This typically creates the most economically efficient system for effective, long-term ELT management.

The ELT industry is a demand-driven industry. Although collection and processing are key factors, experience has clearly shown that even if ELTs are collected and processed efficiently, these activities do not create or ensure a demand for tire-derived materials produced. In the same way, an effective supply chain is required to provide a reliable source of ELTs into the system.

2. The environment

In any effective ELT management system, environmental concerns must be well understood and managed. Many guidelines exist (see appendix page 1), for example on the use of tire-derived fuel in the cement industry, or on using ground rubber as playground cover or synthetic sports surfacing infill. New markets must follow such good practice guidelines and ensure they comply with any relevant legislation.

Research and development

Research and development (R&D) is necessary to explore new and viable technologies that could improve existing, or develop new, end-use markets. R&D must be multi-stakeholder and involve the end-use industries, ELT processors, and the tire industry, and should be funded by joint financial schemes between industry, laboratories and governments, etc. Government support is key in activating material recycling through promotion of its business value and supporting R&D investment.

Supply chain based on multiple recovery routes

Effective management systems need stable ELT processing infrastructure to supply ELTs to the end markets. Such processing is costly, on account of, for example, land and equipment purchase, permitting procedures, fire prevention, personnel training, wages before the processing facility is operational, taxes and insurance. Once the ELT processing facility is operational, two types of costs will be incurred: fixed costs (independent of size i.e. whether the processing facility takes in and processes one or one million ELTs) and operational costs (a function of the number of ELTs taken in and processed).

Experience shows that the greater the number of ELTs taken in, the more cost efficient the processing system becomes. Establishing a large-scale end-use market satisfies several necessary conditions: it allows for a continual intake of ELTs, it provides revenue to the ELT processing company, and provides a base market upon which all other end-use markets can be developed. Examples of large-scale, base markets are tire-derived fuel (TDF), tire-derived aggregates (TDA) and energy feedstock for electric arc furnaces. The price paid for these materials and the return on investment for the tire industry is still relatively low; however, having these base markets allows for:

- The necessary economies of scale to establish and maintain the processing capacity for higher value-added material
- Provision of a revenue stream while higher-value added markets (i.e., ground rubber of any size) are developed as market demand for these materials generally takes longer to develop
- Reduced costs through processing economies of scale for manufacturing ground rubber
- Diversity to protect the processing company from shifts in market dynamics.

The greater the number of recovery routes established, the better the true value of all end markets can be recognized.

8. Financing ELT Management

A competitive market dictates an efficient and reliable service. If the market value of ELTs increases over time (in the context of increased resource scarcity and costs of raw materials as well as stricter environmental requirements), the cost of ELT treatment should be progressively offset by the increasing revenue of the recovery.

In a country where no ELT program exists, the activity around treatment of used tires is often a gray area with some practices being unprofessional and environmentally-unfriendly. In these situations, profit may be made, but the system is most likely to be unsustainable.

The tire industry has to be an active supporter of ELT management to contribute to the goal of 100% recovery of annual ELT generation. The current context of increasing environmental awareness, plus scarcity and increasing costs of energy and raw materials, offers new opportunities to ensure ELTs are viewed as a resource not a waste. Nevertheless, to ensure the ELT management system is sustainable, various recovery routes are needed to ensure that recovery of annual ELT generation has a sound economic base, independent of the market situation for raw materials and energy.

The system in place needs to be self-financing, based on professional operators able to secure a reliable supply chain of ELTs, and, the more transparent the system, the better. An environmental fee should be paid when buying a new tire, and should be visible to the buyer as separate line item on their invoice, and the end consumer is encouraged to leave his/her UT at the dealers' shop. This fee is dependent on collection, transportation and treatment costs, and the value of the end-use market. An anti-trust waiver may be required to establish a uniform rate.

Even after a country or region abates all its (known) ELT stockpiles and has markets for its annually generated scrap tires, the ELT management entity (e.g., a government, ELT management authority or industry-sponsored entity) should maintain a modest tire fund within the tire fee and use the fund for enforcement of regulations, occasional amnesty day or small-scale abatement project and maybe some modest market development activity.

The value of the ELT should increase along the value chain, and consequently the chain from the dealer to the processing or recovery company should shift from a cost center to break-even situation. The increase of value moves upstream in relation to market conditions. At the beginning of any system the fees are higher, but may drop over time as the system is optimized – i.e., the flow of money reverses over time.

Cost information related to different ELT markets around the world, based on data collected in 2009 by the TIP co-Chair companies, may be made available to TIP member companies on request (tires@wbcscd.org).

9. Implementing ELT Management Systems

This section provides checklists for initiating a new ELT management system. It does not indicate the stakeholders responsible for each as these depend on the context, but it aims to provide a list of all aspects that need to be considered by any stakeholder aiming to set up the right framework for effective ELT management.

a) ANALYSIS OF CURRENT SITUATION

Key performance indicators (KPIs)

- Volume: annual ELT generation
- Rate of beneficial use: percentage
- Recovery rates: percentages by known end-use markets
- Estimating existing stockpile sizes and size change over time

Legislation

- Existing legislation, new laws under development, potential new laws
- Understanding gaps in legislation
- Stockpile prevention and abatement
- Understanding the administrative authorities and stakeholders involved
- Ensuring development of certification/permitting systems for collection, storage, transportation and processing

National culture and social practice

- Understanding local sense of responsibility around environmental issues, or recycling/recovery of other materials
- Recovery rates by type of industry, benchmarks and good practices of other material recovery
- Existence of markets for ELT-derived products
- Consumer acceptance of end markets for ELT-derived products, consumer acceptance of payment of environment fee for ELT

Tire industry activities

- Existence of joint industry activity in any tire industry-related topic
- Maturity of local tire industry on the ELT topic
- Existence of government relations
- Current involvement of local top management (for effective implementation)
- Evaluation of strategic risk and loss of opportunities for the industry if no action taken

ELT management stakeholders to engage

- Tire and vehicle manufacturers
- Tire and vehicle importers
- Trade association(s)
- Governments
- Society/consumers
- Companies that create the market for ELT-derived products/other industries

Existing ELT treatment capacity

- Type of companies involved by nature of activity: size, professionalism, financial sustainability
- Evaluation of ELT treatment capacity vs. annual ELT generation
- Existing practice of recovery of other products and related infrastructure/organization in place (e.g., collection, transport and storage networks, recovery/recycling companies)
- Understanding the gray areas around existing ELT disposal

b) BENCHMARKING

After diagnosing the current situation, benchmarks can be made with existing ELT management systems, for example:

- Through ETRMA (Brussels): operations in Europe (e.g., Producer Responsibility model in Spain and France)
- Through JATMA (Tokyo): operations in Japan or other regions in Asia
- Through RMA (Washington): operations in specific states in the USA

Potential timings to implement ELT management system

Step 1 (in first 3 months): Initiation

Initiate steering committee (SC) of local tire industry top management
Identify working group (WG) with full-time project leader
SC launches work program to understand current status of ELT management (6 months+)

Step 2 (~1 year): Analysis

Analysis of work program and strategic decision by SC to promote implementation of ELT management system
Start benchmarking visits and experience-sharing with other regions

Step 3 (~6 months): Decision and strategy

Conclude benchmarking and propose characteristics of appropriate ELT management system
Propose Key Performance Indicators (KPIs), budgets, implementation planning, stakeholder engagement, industry organization
Development of implementation strategy including start of legislation development

Step 4: Implementation

Experience has shown that starting an ELT management system from zero could take **up to 3 years** from beginning of analysis to start of effective operation

Comprehensive references and resources on ELT management exist: the appendix to this document provide some guidance and case studies.

