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State-Led Approaches to Electronic Waste Management in the U.S.: A Study of Stakeholder Involvement in Take-Back Legislation Efficiency

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STATE-LED APPROACHES TO ELECTRONIC WASTE MANAGEMENT IN THE US: A STUDY OF STAKEHOLDER INVOLVEMENT IN TAKE-BACK LEGISLATION EFFICIENCY

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Abstract

Information technology has proliferated over the past two decades, and waste from electronics represents the fastest growing waste stream in the world. The production and disposal of electronics, from cradle to grave, pose critical threats to human health and the environment. The management of electronic, or e-waste, streams poses a particular set of challenges for solid waste management, hazardous waste management, and economic development in the United States. As e-waste accumulates, state governments, municipalities and private landfills are refusing to accept the responsibility for its disposal. To address this problem, the federal and state governments must find a safe and economically feasible way to process e-waste. This thesis analyzes the lessons learned from both the European Union's e-waste programs and from a set of US e-waste cases. These range from state-led e-waste programs to manufacturer-led and voluntary e-waste programs. Based on this comparative case method, a set of key barriers emerge in the US cases that undermine e-waste management policies: the perception that US manufacturers will recycle electronic products properly, the power of the electronics industry to block policies, the lack of public consumer education about the environmental consequences of e-waste disposal, and the fact that recycling e-waste is more expensive than extracting raw materials. These factors reflect political and socio-economic realities within the US, including the power of the electronics industry, the perceived capacity of municipal solid waste systems, and the salience and the perception of consumers that US federal laws appropriately manage e-waste disposal. Part of the issue is that e-waste falls into regulatory gaps across major waste management federal laws. This thesis argues that state-led e-waste management policies are not adequate because of the lack of cooperation from all e-waste stakeholders from the federal government, state government, electronics industry, third party processors, and consumers.

Executive Summary

Electronic waste (e-waste) supply chain management in the United States (US) needs further improvement to impact amassing e-waste, to combat illegal export and illegal disposal practices, and to relieve the administrative and legal burden it causes. In the US, 25 states and Washington D.C. apply extended producer responsibility (EPR) programs to manage e-waste. In an EPR program, producers are held responsible for funding the collection, recycling, and managing e-waste. EPR policies are based on the idea that because producers have control over preventing waste, they should fund proper and responsible disposal of existing e-waste, create products built for disassembly, and minimize the use of toxic materials. However, the question remains whether these programs are effectively diverting e-waste from export and landfills, whether they are relieving the burden on consumers and municipalities, and whether they are cost effective in the US.

Global awareness about e-waste began when non-profits, like Greenpeace, exposed the dumping of millions of pounds of e-waste in developing countries such as Africa, China, and India. E-waste is hazardous and toxic when humans are subjected to water, air and soil contaminated by it. In response, the United Nations developed the Basel Convention treaty, which bans all exports of e-waste to developing countries. Every nation has ratified the treaty except for the US.[1] The European Union (EU) was one of the first to fall in line with the Basel Convention by creating the Waste Electrical and Electronic Equipment (WEEE) Directive.

This research uses analytics from the EU to ascertain incentives and barriers to primary constituents such as consumers, producers, retailers, and governments that relate the

[1] Although the US has not formally ratified the treaty, state practice in states that have passed laws on e-waste management is to incorporate guidelines from the code set in the Basel Convention.

US. While in the US, state-led EPR programs vary greatly from state to state and across regions, the EU has well researched e-waste EPR and supply chain practices, and since many producers are multinational producers, the incentives and barriers provide relevant comparisons.

This thesis then assesses the e-waste supply chain in the US to understand why domestic EPR programs have limits. It identifies incentives and barriers for key stakeholders throughout the supply chain: producers, consumers, processors, retailers, and state/local governments. Incentives for the producers and retailers include 1) to include other stakeholders such as the consumers, governments, and processors as responsible parties to reduce the burden, 2) to make programs inexpensive and easy to understand for producers in states that have programs, 3) to follow the trend of 'green' products marketing to reach more consumers and increase revenue, and 4) to allow manufacturers to work together under a collective producer responsibility model (CPR) where producers hold each other accountable. Barriers include 1) targets that are too stringent to meet, 2) programs that are complex and expensive, and 3) producers as the primary or only responsible party. Research on manufacture-led vs state-led programs indicates that both program structures have the potential to successfully manage e-waste. More important factors are 1) ensuring that the stakeholders are cooperating and 2) assessing state-level environments to identify individual needs.

The thesis then focuses on two US states, Maine and Washington, to identify similar trends (or differences) in stakeholder participation. These two cases offer insight into the efficacy of state-run e-waste programs and some lessons learned from on-the-ground experience. Maine and Washington are considered best practice states and have similar laws

and programs to manage e-waste based on EPR principles. The case studies show that successful practices from both states include, 1) obtaining support from the electronics industry, 2) having state histories of environmental activism, 3) encouraging strong lobbying efforts from non-profits and other organizations, and 4) maintaining and updating a website for consumers to access disposal options for e-waste. Differences occurred in how the states accomplish these goals. Maine gained support from the electronics industry by ensuring profit and a revenue increase whereas Washington developed a council for manufacturers to take control of their own funding and programs.

Public perception in the US is that this end-of-life technology, e-waste, is adequately handled by current solid waste management policies. The reality is that e-waste is burdensome for most states to handle because the existing facilities are not large enough to handle such a volume. Governments, businesses, citizens, must understand the risks, costs, and advantages associated with implementing e-waste regulations.

The thesis concludes that each state in the US has a unique set of needs for an e-waste program to efficiently collect and process e-waste with minimal burden to each stakeholder (i.e. producer, consumer, municipality, or government). Federal legislation is an ideal path to manage e-waste because it relieves administrative burden for multinational companies, reduces confusion for consumers and states, and tightens enforcement for transboundary shipments of waste from one state to another. It must be stressed that a federal law is only effective and ideal when the main governing entity, the Environmental Protection Agency (EPA), has the interest of safeguarding the environment in mind. If, for instance, the EPA is likely to relax environmental regulations, then states are better off abiding by individual state laws. To this end, this thesis further offers a set of policy recommendations that encourage

states to strengthen their own programs by 1) developing a framework policy that involves a network of surrounding states, 2) increasing monitoring and data collection efforts to better quantify the progress of the EPR programs, and 3) to encourage incorporation of the support of the electronics industry by means that reflect the needs of the industry and the state.

Chapter 1: Introduction

Expanded production and sale of electronic technology need carefully planned policies for its maintenance and disposal. Since the 1980's, technology's use has shifted from being a simple convenience to a necessity. E-mailing from a cell phone or answering a phone call from nearly anywhere has become routine. Innovations in electronic technology have produced innumerable benefits: revolutionizing international communication, improving productivity, and creating a demand for raw materials (Veit & Bernardes, 2015). This technology has generated the world's fastest growing waste stream. Huge spikes in consumer demand for electronics yield eventual huge spikes in electronic waste. Globally, the United Nations documented e-waste growing at a rate almost three times faster than any other municipal solid waste stream[2] (Schwarzer, Bonno, Peduzzi, Guiliani, & Kluser, 2005). Now with the huge spike in e-waste or waste electric and electronic equipment (WEEE) comes the need to control that waste management and its high costs to the environment and humanity.

The problem with this rapid accumulation is that electronics are not so easy to dispose of as they are to buy. Most often, consumers discard e-waste in the garbage thinking there is no other feasible, free option for disposal. Industry leaders, such as Dell or Best Buy, often resist introducing free take-back programs because recycling e-waste is expensive and complex. Cheaper disposal routes are usually landfilling, exporting, or incinerating e-waste (Sepulveda, et al., 2010). Improper disposal from these cheaper options results in serious environmental and human health concerns (EPA, 2017). For example, landfilled e-waste leaches heavy metals and hazardous chemicals including lead, PCBs, hexavalent chromium,

[2] The UNU reported global annual e-waste generation at 41.8 million tons, enough to fill the Rose Bowl 76 times (Baldé, Wang, Kuehr, & Huisman, 2015). It is reportedly difficult to quantify WEEE due to information gaps, however the UNU provides the most thorough methodology to date with the available statistical data (Baldé, et al., 2015).

and cadmium into the soil and waterways[3] (United Nations University, 2007). Incinerating e-waste releases particulate matter and ozone depleting substances into the atmosphere. Chronic exposure to toxic waste such as e-waste can lead to mental impairment, cancer, kidney and liver failure, not to mention degrading soil, air, and waterways[4].

The primary focus of this thesis examines the current state government e-waste management practices in the US based on extended producer responsibility (EPR). Two areas of interest are analyzing first how various stakeholders, i.e. producers, consumers, government, respond to e-waste policies. The second area of interest is following how the formulation and implementation styles of those existing programs balances stakeholder needs. To address these issues this thesis looks at the progress of EPR programs in the US and asks what are the key barriers to a more effective implementation of EPR in the United States?

The US is a major generator of e-waste, generating about 7.1 million tons in 2014, almost double the 3.14 million tons generated just three years before (Baldé, et al., 2015; PSI, 2016). Managing e-waste in the US poses a set of challenges with regulatory gaps being the primary concern. While a few major environmental laws do exist in the US to address responsible disposal for waste products, there is no federal law that regulates e-waste specifically. Lack of federal action leaves the responsibility of e-waste disposal to private corporate initiatives or to the states. Thus, e-waste regulation falls between two major federal laws: the 1965 Solid Waste Disposal Act (SWDA) and the 1976 Resource Conservation and Recovery Act (RCRA). The SWDA regulates everyday refuse and RCRA regulates

[3] Appendix holds a more detailed account of the hazardous components within e-waste.
[4] Refer to Appendix A for an outline of the most common and prevalent WEEE components with the potential risks.

hazardous waste. An expired personal computer, for example, can be thrown away while meeting the guidelines of SWDA, but the inner components are made up of heavy metals and plastic that become hazardous in large quantities. E-waste is not explicitly covered either law meaning that decades of e-waste has entered landfills or incinerators in relatively small quantities. Thus, leading to millions of pounds of improperly disposed hazardous material over a period from the 1980's until the early 2000's in the US.

Lack of a unified federal regulatory system governing the states has created a second challenge: a fragmented system of state laws that emerged in the 2000's to manage e-waste disposal. Each state has applied a different set of guidelines. For instance, some states allow landfill disposal of e-waste, some do not. Some states have responsible e-waste disposal initiatives called e-Cycle programs that require stakeholders throughout the supply chain to recycle and some states do not address the e-waste issue at all. State-led e-Cycle programs attempt to tackle the e-waste crisis, but offer instead a fragmented array of state-led policies and the manufacturer-led programs. External stakeholders, like the Electronics TakeBack Campaign (now called the Electronics TakeBack Coalition (ETBC)), Basel Action Network the Product Stewardship Institute, the Silicon Valley Toxics Coalition (SVTC), and many others validated the need for state-led legislation for WEEE (Gui, Atasu, Ozlem, & Toktay, 2013).

Currently, one cutting edge policy option is extended producer responsibility (EPR) that was created to reduce the waste stream and to avoid the leakage problem. Most US state laws are EPR based policies. EPR is a policy principle[5] that requires manufacturers to be

[5] EPR is a policy principle meaning that it is a guideline to apply to existing policies or a guideline to form policies upon, however it is not a stand-alone policy. For example, take-

financially responsible for the entire life-cycle of the product including the take-back and final disposal of obsolete products. (Lindhqvist, 2000). Only 25 states in the US have adopted an EPR scheme to address e-waste issues. A patchwork structure of either voluntary initiatives led by private groups and/or a small number of states with public initiatives makes-up of US e-waste mitigation strategies rather than one overarching program. In recent years (2011-2014), federal initiatives have focused on national stewardship programs like the National Strategy for Electronics Stewardship (NSES) rather than passing a law (EPA, 2017). The NSES is a task force that provides recommendations for all stakeholders in the e-waste supply chain. This thesis examines the progress of EPR programs in the US and asks what are the key barriers to a more effective implementation of EPR in the United States? To answer this question, this thesis compares two of the most established states: Maine and Washington. Maine and Washington both have a state-led regulatory framework.

Chapter 2 provides a background on international e-waste emergence, its dissemination into the US, and mitigation strategies. Chapter 3 includes a review of the literature regarding stakeholder participation and e-waste management cases. In addition, chapter 3 provides literature of stakeholder behavior of key actors throughout the life cycle of e-waste along with an outline of their incentives for participation. Chapter 4 assesses the pros and cons of manufacturer-led and state-led approaches by following the life cycle of e-waste in two state-led programs, Maine and Washington, alongside a shorter comparison of voluntary programs in 5 other states. The 5 states represent the range in e-waste management systems. By following the product from sale to disposal, certain cases will identify loop-holes within e-waste governance in both mandated and voluntary programs. A typology of

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back legislation is a common policy used to implement the EPR scheme, but the two are not used interchangeably. One is a policy, the other is a scheme (Lindhqvist, 2000).

adjacent states will be used to discern key factors of what produce a successful program. Identifying gaps in the life cycle of e-waste will enable policy analysts working on e-waste control to address factors that hinder the effectiveness of existing EPR schemes in the US. Policy makers may modify legislation to accommodate all stakeholders and therefore provide a more cohesive, stable system. Chapter 5 makes policy recommendations for US EPR programs and e-waste recycling initiatives.

Outcomes of this research concur that there is not enough statistical data to determine trends from either a national or state perspective, even in states with strong regulations. The efficiency of EPR programs for e-waste is contingent upon individual state needs. Observations show that state-led systems achieve higher targets, but with the available data, it seems the programs are plateauing with reported recycled e-waste. State-led systems with the strongest programs are successful if 1) they have a history of environmental activism at the state level, 2) they have strong state level lobbying efforts by non-profits and the public, 3) they overcome the opposition by electronics industry effectively, and 4) the state in question has supportive cross-boundary relationships from near-by states. The primary recommendation supports using federal legislation, as seen in the EU since most states with existing e-waste laws defer to the guidelines of EU policies like the WEEE Directive. One salient law that would solve the transboundary issues between states and reduce complexity for business. In the absence of one unified set of regulations, recommendations to improve existing programs include: 1) establishing a stronger and more consistent data collection at the state level. Data will generate urgency and provide a foundation for understanding the extent of the e-waste crisis; 2) developing an effective lobbying campaign. Lobbyists influence the industry leaders by focusing on their green reputations and encourage business

buy-ins, rather than influencing legislation, 3) creating policies that correspond with those of neighboring states, and 4) changing the metric of monitoring that measures e-waste recycling from ‘weight’ to ‘number of products’. The amount of recycled e-waste is typically measured by weight, and as electronics become lighter, the poundage will not reflect the amounts recycled.

Chapter 2: E-waste and the US: What is it and how did it develop?

This chapter defines e-waste and explains why e-waste is hazardous. Then, the following section discusses the history of e-waste policy in the European Union to follow the evolution of e-waste policy leading up to the US. The chapter follows the history of e-waste by introducing e-waste management strategies and the chapter finishes by laying out the background of e-waste of key regulatory frameworks in the US. The key regulatory frames are two US federal laws: SWDA and RCRA. Alongside the two federal laws are a patchwork of 25 states that have EPR policies, private corporate initiatives, non-profit stewardship programs, and a national stewardship program led by the EPA. The background of the US explains the complexities for e-waste management for stakeholders within the e-waste supply chain.

2.1 E-waste: the basics

The focus of this thesis is the US, but the e-waste issue is global and as such has similarities that all nations understand. The following section provides the background of e-waste.

2.11 What is e-waste?

There is no standard definition to date for e-waste or waste electric and electronic equipment (WEEE), but for this thesis, e-waste refers to the disposal of electronic components of any appliance that uses electricity[6] (OECD, 2001). E-waste is a broad term for electric and electronic equipment (EEE) that has reached its life cycle limit. Every state compiles an

[6] There is no universal definition of e-waste because every nation has a different idea about what constitutes as e-waste. At the national or sub-national level, there are varying degrees that e-waste is regulated. Some nations cover all parts of a computer– monitor, keyboard, mouse – whereas another country only covers the monitor.

individual list of what it constitutes as e-waste. Appendix C has a table of the products recycled by each state.

2.12 How much e-waste is there?

WEEE is one of the fastest growing waste streams across the world. The amounts of e-waste continually grow because e-waste is generated more rapidly than it can be processed. As of 2014, the UN reported global e-waste generation at 41.8 million tons[7], a number expected to climb to 50 million tons by 2018 (Baldé, et al., 2015). The US EPA reported 2.4 million tons of e-waste in 2009 and expected that number to rise radically (EPA, 2017).

2.13 Where does it come from?

Nonprofit groups, like BAN or Greenpeace, have traced sources of e-waste from the European Union, the United States, and Japan to multiple countries in Asia and Africa (BAN, 2002). Manufacture and use of electronic products primarily in developed countries, but most e-waste predominately ends up in the Global South. Analyzing the transboundary flows of e-waste is beyond the scope of this thesis, but research indicates that much of the U.S. and the EU e-waste streams end up in an (often cheaper) international illegal waste industry (Zhang, Schnoor, & Zeng, 2012).

2.14 Why is e-waste hazardous?

E-waste comprises thousands of plastics, metals, and rubber materials. Appendix A provides a list of the common materials found in e-waste that are often carcinogenic and persistent in

[7] These estimations vary depending on the country, time frames, or region and because of a discrepancy among how they define-waste.

the environment (BAN, 2002). There is concern about certain types of plastic, (polyvinyl chloride) PVC, for example. PVC is a hormone disruptor in humans and also releases dioxin into the environment when burned (Schwarzer, Bono, Giuliana, & Kluser, 2005). Heavy metals, like lead, cadmium, and mercury, are carcinogenic and known to accumulate in living organisms (Sepulveda, et al., 2010). Although these materials are not always toxic in small quantities, they become a threat with prolonged their exposure to living organisms or as waste accumulates at a dump site, landfill or incinerator. Heavy metals can enter the soil-food-crop pathway, increasing exposure to animals and humans (McAllister, 2013).

Exposure to these substances poses a threat to the public and the environment, especially when e-waste is not properly disposed of. Contact with these toxins is particularly problematic for less developed countries as they are disproportionately burdened with e-waste (BAN, 2002). Due to a lack of funding, inadequate infrastructure, and poor working conditions, the people and the environment typically have tons of e-waste with only the ability to manage it by shredding and then burning or melting, or landfill disposal (Lindhqvist, et al., 2007).

2.15 What does responsible disposal imply?

Ideally, e-waste and all its components would be recycled and re-used in a close-loop system. As e-waste was not built for break down, realistic, responsible disposal of e-waste in any context requires: 1) a safe environment for processors, 2) containment of hazardous waste effluent from e-waste, 3) recycling as much as possible, 4) only incinerating or landfilling non-toxic and non-hazardous parts, and 5) not carelessly dumping e-waste without processing.

One scheme is to break down the product and separate out independent components (Schwarzer, et al., 2005). Items that need to be processed further would be done in a ventilated place where the workers were wearing appropriate coverage, i.e. gloves and mask. For example, a personal computer would first be dismantled and separated into plastics, cathode ray tubes (CRT)[8], circuit boards, etc. The CRTs would be sent to a third-party recycling facility, as would the circuit boards, to either be recycled into new products or precious metals, like gold, are extracted for later resale. Atlee and Kirchain (2006) break down the flow of e-waste through a responsible disposal system. In an ideal situation, e-waste is collected, disassembled, sorted, and then processed for materials. Materials of value include copper, lead, and metal. Expenses include CRTs, landfill material, and hazardous material.

2.16 Why is e-waste a concern for policy makers?

E-waste poses numerous challenges for policy makers. First, it has become a social justice issue as it poses a threat to public health and the environment, often in the Global South, far from consumers of the products. Second, e-waste is also seen as a security issue as many products hold valuable personal information about individuals. A third indirect challenge is that difficulties in categorizing and recycling e-waste in the US leads to very complex and costly recycling programs reducing the opportunities for profit. Therefore, the cheaper routes of illegal export, illegal dumping, incineration, or landfilling along with the consequent environmental and health risks, persist.

[8] Cathode ray tubes were used predominantly in electronics before flat screens were invented. CRTs are typically of most concern when it comes to outdated e-waste because they are composed of leaded glass. This leaded glass is both difficult and expensive to recycle, and contains a neurotoxin – lead.

The informal recycling sector that has emerged in developing countries is a serious competitor with responsible e-waste management initiatives. The informal recycling sector for e-waste handles about 50-80 percent of global e-waste. Although people in the Global South often resort to shredding, burning, and melting e-waste in unsafe environments, it is a cheaper resort (McAllister, 2013).

2.17 Summary

The prior section provides the fundamentals of the global e-waste issues before delving into the US history of e-waste and its complexities. In short, e-waste is a rising crisis that needs managing, but e-waste is difficult to manage because e-waste is 1) difficult to categorize, 2) expensive to disassemble, 3) difficult to quantify because there are decades of unmonitored dumpsites across the world, and the public assumes that e-waste is harmless or that it is managed properly. Despite the complexities, the public sector is pursuing proper waste management. The short section 2.2 now presents the e-waste policy issue in US.

2.2 Existing solid waste management in the US

The purpose of this section is to situate the e-waste policy dilemma in the US. Beginning with how e-waste emerged onto the national agenda, the following section will continue to explain how e-waste policies translated from an international level down to the US.

2.21 E-waste issue emergence in the US

The platform for the e-waste policy issues to emerge onto the scene was driven by 1) rising public awareness for protecting the environment in the 1970's and 1980's, 2) the

enforcement of the Basel Convention in the 1990's, 3) international exposure of illegal dumping of e-waste by the US in the 2000s, and 4) lobbying efforts by NGOs and the public that pushed for responsible e-waste management in the 2000s.

Beginning in the 1970s to the 1980s, the US shifted focus from disposal to recycling and re-use when the Love Canal case in 1978 proved 'out-of-sight and out-of-mind' practices were insufficient (Oklahoma DEQ, 2016). Love Canal is a famous case where toxic chemicals seeped out of a dumpsite into the land of nearby communities[9]. Despite action at the domestic level to regulate hazardous waste, the US has been resistant to ratify the Basel Convention and to regulate the global movement of hazardous wastes.

There is a significant presence of the electronics industry based in the United States: Apple, Hewlett Packard, Lenovo, Walmart, and Best Buy that all have significant leverage over e-waste governance. The concern for e-waste grew throughout the 1990s and into the early 2000s from the presence of environmental lobbyists, concerned citizens, and the one of the strongest NGOs, the Basel Action Network (BAN), (BAN, 2002). BAN is a non-profit based is Washington State that is a watchdog over the trade and recycling of e-waste and they seek to adopt the Basel Convention initiative to the US.

The US responded to public complaints with stringent environmental regulations and the creation of such governing agencies as the Environmental Protection Agency (EPA), to oversee environmental concerns. Most of these regulations for hazardous waste were costly and required treatment or proper recycling (Closed Loop Fund, 2016). Often the cheaper option of dumping toxic materials in developing countries like Africa and Eastern Europe where there were few regulations or safeguards was taken (UNEP, 2016). Recognition of this

[9] Soon after, Congress passed Superfund to remediate old contamination sites (Oklahoma DEQ, 2016).

injustice provoked an international response that resulted in the 1989 Basel Convention in Switzerland. The Basel Convention will be discussed in more detail later in section 3.4, but it was after this event that e-waste management took hold in the US in the early 2000s. An environmental activist, John Puckett, founded a non-profit called BAN in Seattle that materialized a face for the e-waste crisis in the US.

2.22 What does responsible disposal look like in the US?

The existing responsible disposal system in the U.S. is typically a cradle-to-grave system that begins with a generator and ends with a recycler, an incinerator, or the landfill (EPA, 2013). Essential objectives for the system include providing safe working conditions, containing hazardous substances and transporting them to a treatment facility, and recycling or landfilling non-hazardous components. RCRA and SWDA outline how specific materials are handled (EPA, 2014).

Electronics are collected at monthly collection opportunities, by the curbside or at a collection site, refurbished or disassembled for parts. Some states, but not all, have created responsible programs to manage e-waste (EPA, 2011). Most states with existing programs are either in a fledgling status and need more robust implementation. Federal agencies like the EPA and state environmental agencies encourage donating electronics second-hand or recycling them (EPA, 2015).

2.23 US Governance structure of the waste stream

Two main laws SWDA and RCRA (discussed in more detail later) designate the EPA as the governing agency over solid and hazardous wastes. The EPA typically assigns responsibility

over to the individual states for implementation of solid waste management practices. At this point, each state takes the initiative to either enact a law, implement a program, enforce concentration guidelines of hazardous effluents, etc. Since it e-waste is not outlined anywhere nationally, states are not legally required to adopt e-waste management practices.

2.24 History of federal laws in the US

Televisions, video game consoles, and personal computers were used widely since at least the late 30s, 60s, and 70s, respectively (Doms, 2004). However, it was not until the late 1980's to the early 1990's, sales of electronics dramatically increased (Doms, 2004). Technology was advancing rapidly to accommodate the surge of the internet during the same time the environmental movement was taking root in the US and in the early stages of identifying hazardous waste.

The US was historically a strong leader in environmental regulation. The US was the first nation to implement and enforce laws on environmental concerns with waste in response to rapid industrialization and urbanization in the 1970s. (Oklahoma DEQ, 2016). The Solid Waste Disposal Act (SWDA) in 1965 was the first federal law to manage national waste. The SWDA seeks to reduce waste responsibly and safely for humans and the environment.

The federal government formed the Environmental Protection Agency (EPA) alongside the Resource Conservation and Recovery Act (RCRA) in 1970 for hazardous waste (EPA, 2014). RCRA amends the SWDA by requiring additional government involvement and includes guidelines for hazardous waste. These are the two main laws that cover waste management that contribute to a regulatory gap for e-waste. The SWDA and RCRA designate the governing agency over e-waste as the EPA.

Since the 1970s, the US at the federal level has moved on managing and reducing the waste stream. There is a suite of federal laws in place shown in table 1 that were put in place to address the rising concern over environmental toxins. Other federal laws relating to environmental protection or the management of waste:

Table 1. Federal Laws Related to Electronic Waste Management

Year	Law
1965	**Solid Waste Disposal Act**
1976*	**Resource Conservation and Recovery Act**
1976	Toxic Substances Control Act
1978	Comprehensive Environmental Response, Compensation, and Liability Act
1984	Hazardous and Solid Wastes Amendments Act
1986	Superfund Amendments and Reauthorization Act
1990*	Pollution Prevention Act
1996*	Land Disposal Program Flexibility Act
1996	Mercury Containing & Rechargeable Battery Management Act
2002	Small Business Liability & Brownfields Revitalization Act
2011*	**Responsible Electronics Recycling Act**

**Highlights important laws pertaining to the separate components of electronic waste once they become hazardous.*

It is important to recognize that only one law addresses electronics specifically, and this law bans the exportation of end-of-life electronic products internationally called the Responsible Electronics Recycling Act of 2011. For the US, this law is in lieu of ratifying the Basel Convention Ban Amendment that banned all transboundary exports of e-waste (BAN, 2002).

2.25 Why are the existing federal laws insufficient for e-waste management?

E-waste has not been completely captured by these federal laws. The fate of e-waste is left to either solid waste management which does not provide strict oversight or to hazardous waste management that follow a strict cradle to grave management system. There have been no updates to federal law, although the science and technology has changed significantly. In

2005, the EPA submitted a design for a national system, but never materialized (EPA, 2005). The only action taken by the federal government, via the EPA, was the National Strategy for Electronics Stewardship (NSES) (EPA, 2017). The NSES is a council made up of 16 federal agencies that provides recommendations for electronics industry, retailers, consumers, and state governments.

Other laws shown in table 1 address materials within the EEE, but since electronics are typically disposed of in full through household or small business waste, these laws do not apply until the landfill reaches toxic concentration levels.

Household waste is permitted in landfills under RCRA, as well as waste from small businesses because small amounts of hazardous waste in the landfill or incinerated waste was thought of as low risk to public health (EPA, 2013). That is until household e-waste began to corrode and leak over time after its internal components were broken open and exposed to the environment This became a problem when “safe levels” of waste were exceeded after piling up over a long period.

To underline the point: at the start, e-waste fails to meet the RCRA definition of hazardous waste (Musson et al., 2006). The test thus allows potentially hazardous products to be exposed to the expected leaching conditions in a landfill. The EPA then tests the leachate to determine if it contains any toxic substances above the defined threshold (Musson et al., 2006). The issue with the initial definition is that it tests e-waste as a whole product rather than its parts, which may not adequately reflect the individual toxicity of each component (GAO, 2010). If these levels do not exceed a certain limit, as monitored by the EPA, then disposal is permitted.

Furthermore, hazardous waste disposal from households and small businesses is exempt from regulation under RCRA. For example, RCRA allows the EPA to monitor and evaluate hazardous waste that exhibits toxic characteristics (among others) (GAO, 2008). Further, RCRA only regulates CRTs, which are inside most electronic products like older computer monitors and televisions. The components of e-waste are inarguably toxic, yet most electronic products inevitably pass the leachate test by the EPA. Household e-waste is legally considered non-hazardous, thus making its management a state issue rather than a federal.

2.26 E-waste as a universal waste

For some states, e-waste is listed as a universal waste[10], which means that the waste is nationally recognized as hazardous and follows a streamlined set of regulations. (EPA, 2013). The EPA sets the general guidelines of universal waste to control collection and recycling of waste, divert waste from landfills, and to reduce the burden on retail stores. It is then up to the states whether they adopt e-waste as under the 'universal waste' category. Table 2 shows states that have included electronics under the category of universal waste.

Table 2. States to adopt electronics as universal waste.

Universal Waste Material	**Adopting States**
Cathode Ray Tubes (CRTSs)	Maine, New Hampshire, Rhode Island
Electronics	Arkansas, California, Colorado, Connecticut, Louisiana, Michigan, Nebraska, New Jersey

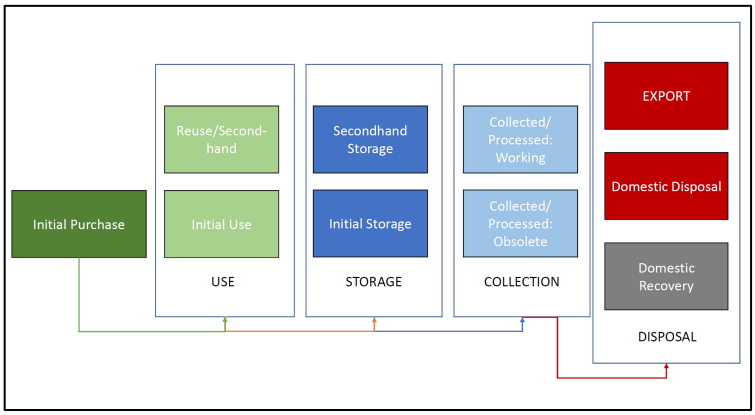
Source: EPA, 2016.

[10] Universal waste is a category of hazardous waste that multiple industries generate (EPA, 2013). Under universal waste regulations, waste can be stored for up to one year upon disposal.

2.27 Life cycle flow of e-waste in the US: where does it go?

The flow of electronics in the US shown in Figure 1 is adopted from Duan, Miller, Gregory, & Kirchain (2013) that modeled the domestic life-cycle of end-of-life electronics.

Figure 1. Flow of Electronic Products in the US.



Source: Duan, Miller, Gregory, & Kirchain, 2013.

The cycle starts with purchasing of the product, rather than product design, and continues towards storage and recycling. For example, a person named Claudia may purchase a laptop from the Microsoft® store. Claudia will use the laptop for a period until it either does not work or until something new comes out. She finds a new laptop that works faster, so she just stores the old laptop in the attic. When it finally stopped working, she took it to local collection event in town to recycle it. Depending on the state, the laptop is either landfilled, dismantled for parts, or exported as a secondhand good. Secondhand goods can only legally be exported if they are tested and functional. From 2006-2009 about 75%-78% of e-waste ended up in landfills (EPA, 2017).

This process, however, does not adequately reflect the total volume of e-waste because a significant portion of e-waste is still thought to be held in storage in some capacity – houses, small businesses, basements. Illegal export of electronic waste is a persisting issue,

for example, Beveridge and Diamond reported a recycling company exporting over a million dollars' worth of e-waste over four years (Beveridge and Diamond, 2013). Figure 1 is a general guideline for the flow of electronics in the US. The cycle of electronics will vary within each state given the fragmented nature of policies in the US.

2.28 Conclusion

The recent section serves to outline the existing legislation that is available for state governments to address e-waste management. EPA is the governing agency that enforces the two primary laws, SWDA and RCRA, but the EPA authorizes states to implement by choice their own programs and laws for e-waste. The following section explains the new tools that states began adopting to secure funding for the recycling and disposal of e-waste called extended producer responsibility.

2.3 New tools to manage e-waste

A variety of tools exist for managing e-waste[11]. Section 2.2 provides an overview of the predominant policy principle used for addressing e-waste in the US: extended producer responsibility (EPR).

2.31 What is EPR?

Extended producer responsibility (EPR)[12] was coined in 1990 and is a policy mechanism that requires manufacturers to fund recycling and/or proper disposal of end-of-life products (Nash

[11] Advanced recovery fees (ARFs) are the competing policy tool used in the US, but will not be addressed in the scope of this thesis.

& Bosso, 2013). The official definition given by the environmental strategies expert, Thomas Lindhqvist of Sweden[13], is as follows:

> A policy principle to promote total life cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product. A policy principle is the basis for selecting the mix of policy instruments that are to be used in the particular case. Extended Producer Responsibility (EPR) is implemented through the administrative, economic, and informative policy instruments (Lindhqvist, 2000, p. 154).

EPR was designed to promote cleaner waste management schemes and cleaner production (Lindhqvist, 2000). It was introduced during the movement in the 1990s towards environmental awareness and public concern for waste management in Europe and China (BAN, 2002). EPR principles shift responsibility away, theoretically, from consumers, municipalities, and designated authorities to the producer of products. In short, EPR reflects "pollution prevention", "life cycle thinking", and "polluter pays" principles (p. 9).

2.32 Types of EPR instruments

EPR shows up in various ways and each program may utilize more than one instrument at a time. Table 1 highlights the available policy tools used to implement EPR.

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[12] EPR was proposed at the Swedish Ministry of the Environment identifying producers as financially responsible for the environmental consequence of their products (Lindhqvist, 2000). Lindhqvist intended EPR as an ideal used within a policy package, but EPR itself is not a policy instrument like a take-back mandate or economic incentive (Lindhqvist, Manomaivibool, & Tojo, 2007).

[13] There is also another claimant as the founder of EPR, Hans Töpfer, a German Minister of the Environment around 1990. However, further research revealed inconclusive information as to whether he played an official role (Lifset, 1993).

Table 3. Types of EPR instruments.

Type of EPR approach	Tools
Product take-back programs	- Voluntary or negotiated take-back programs - Mandatory take-back programs
Economic	- Deposit-refund scheme - Advance recycling fees - Fees on disposal - Material taxes/subsidies
Regulatory	- Minimum product standards - Prohibitions of specific hazardous materials or products - Disposal bans - Mandated recycling
Voluntary industry practices	- Voluntary codes of practice - Public/private partnerships - Leasing and servicing - Product labeling

Source: OECD, 2001; adopted from Khetriwal, 2009.

2.33 Can manufacturers work together or independently?

Depending on the mandate, manufacturers may work together (collective producer responsibility) or independently (independent producer responsibility) to meet the mandated targets (Atasu, Van Wassenhove, & Sarvary, 2009).

Collective producer responsibility (CPR) indicates that manufacturers cooperate on managing e-waste throughout the life cycle. For example, Washington State has a CPR program wherein all multi-national electronics manufacturers, i.e. Sony®, Apple®, Microsoft®, etc., oversee funding, collecting, processing, and disposing of e-waste because it is required under a mandatory take-back program (DOE, 2007). The benefit of such a program is that if one company falls short in meeting the funding requirement or set target, the other companies will fill in the gap.

Individual collection requires each manufacturer to manage their own product. For instance, Apple ® has a voluntary take-back program after developing its latest robot, Liam ("Coalition wants more", 2005). Liam was built to disassemble the latest iPhones; thus, Apple is voluntarily taking back its products and only its products.

2.34 Conclusion

Section 2.2 provides a brief background into EPR schemes and how those tools may be used in a program. The purpose of the EPR background information is helpful to understand the development of policies, particularly in the US and to give context to the case studies covered in the chapter 4. The next section will discuss issue emergence in the US and how EPR was introduced as a solution.

2.4 EPR and the United States

Section 2.3 was a brief overview of what EPR is and the different capacities EPR can be applied. Section 2.4 presents the structure of EPR in the US and explains the general drivers to the fragmented EPR system.

2.41 The US at a glance: what does e-waste management look like today?

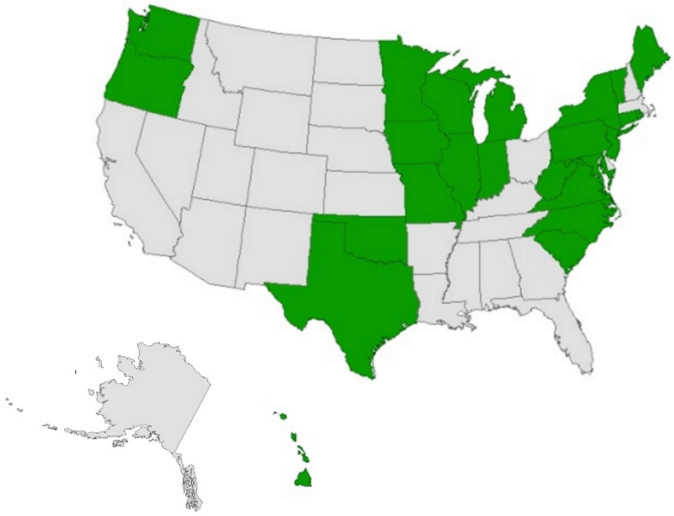
For the U.S., e-waste refers to products like desktop computers, televisions, laptops, and peripherals in some cases. See Appendix C for a breakdown of products by state. This definition of the waste stream does not include other hazardous components[14]. The laws

[14] The management of electronics varies per region. For the US, products such as batteries, cathode ray tubes (CRTs), nor other consumer goods that contribute to e-waste like cell

governing e-waste vary by state, by the number of products covered, and how they cover them.

The United States has a fragmented EPR system for e-waste that emerged in the early 2000s. These fragmented systems consist of a variety of either of state-led programs or voluntary initiatives led by manufacturers. Almost 25 states have enacted legislation mandating statewide e-waste recycling and take-back as shown in Figure 2. All green states[15], whether they have public or voluntary programs, require some form of Producer Responsibility for end-of-life products (Electronics Takeback Coalition, 2013).

Figure 2. States with existing EPR take back legislation.



There are several factors that contribute to the patchwork state policies rather than an overarching federal regulation of e-waste in the US. These include 1) the power of the

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phones have their own laws and therefore individual management separate from that of electronics. These products are beyond the scope of this thesis.

[15] California and Utah have laws in place to manage e-waste, however Utah only requires manufacturers to educate post-consumer disposal options and California implemented consumer fees at the point of sale to cover disposal. These states are not covered in the scope of this thesis.

electronics industry and 2) competing ideas over who bears responsibility, either the consumer, industry or state for e-waste management (Nash & Bosso, 2013). In addition, 3) in some places, the general public and the public sector perceive that there is already sufficient governance in place to manage the waste stream. The combination of these ideas obscured the identification as e-waste as problem across states (Lepawsky, 2012). The following section will describe the historical events leading up to the perception of e-waste as a public-sector problem in the US. United States EPR policies have morphed from producer responsibility into producer stewardship (Short, 2004).

2.42 When did EPR enter waste management practices?

EPR was introduced into waste management practices in the US during the early 1990s for various hazardous wastes like batteries or paint (Nash & Bosso, 2013). It was not until the early 2000s, however, that EPR was used for electronics when states started to examine a range of policy options, including the EPR policy legacy. EPR policies targeting WEEE were first implemented in the US in 2004 in Maine. EPR policies take many forms depending on the implementing state. Variance between states include specific performance levels, fees if performance levels are not met, and some framework policies incorporate responsibilities for retailers and consumers (Nash & Bosso, 2013).

2.43 Other stakeholder initiatives involving EPR: voluntary initiatives

As these state level policies are expensive for manufacturers, the manufacturers began to press for their own voluntary programs and national coalitions because they would be cheaper (Consumer Technology Association, 2015). National coalitions take the form of non-

profit agencies that developed in lieu of federal action. These initiatives have successfully recycled 281,000 Mt of electronics in 2013 (Consumer Electronics Association, 2013). Typically, nationwide coalitions like the Consumer Electronics Associations (CEA), organize an industry-led effort to manage e-waste at multiple points in the life cycle (Consumer Electronics Association, 2013).

External stakeholders, like the Electronics TakeBack Coalition (ETBC), Basel Action Network the Product Stewardship Institute, and many others validated the need for state-led legislation for WEEE (Gui, et al., 2013). In 2005, the ETBC unified the perspective of multiple environmental groups to push for Apple to offer free recycling for all Apple products and not just iPods ("Coalition wants more", 2005). This group specifically pushed for e-waste legislation in four states, including Washington. This environmental support directed at state and major metropolitan areas has sponsored numerous policies and resolutions, such as the Washington e-Cycle program or the Connecticut Recycling Law, to reduce economics, health, and environmental impacts (PSI, 2016).

2.45 Why is the US a patchwork of voluntary and mandated initiatives?

Notably, The US Environmental Protection Agency (EPA) is the federal agency with oversight over solid waste management, including WEEE. The EPA is the supervising agency while states are responsible for implementation. The EPA delegates responsibility of solid waste management issues over to the states (EPA, 2013). In response to this rising pressure[16], from 2001 – 2004, the EPA attempted to organize a council called the National

[16] E-waste management became an agenda item for the EPA after states, trade associations (like Electronic Industries Alliance), and environmental advocate groups (like BAN) pushed for fair and sustainable recycling efforts (Greenbiz, 2004).

Electronics Product Stewardship Initiative (NEPSI)[17] based on the EPR principle (Nash & Bosso, 2013). NEPSI sought to reach a national agreement on ways to finance e-waste recycling and disposal by combining efforts of electronics producers, retailers, and governments (GAO, 2005). NEPSI was an intended formalized council to tackle e-waste on a broad scale.

The industry representatives were multi-national companies that included Dell, Epson, Hewlett Packard, Panasonic, and Sharp (GreenBiz, 2004). These companies are large corporations and would show the greatest hope at tackling e-waste disposal on a large scale. The initiative collapsed in large part because of a lack of support from television producers. Televisions make up for more than half of documented e-waste and without the support of television producers, the rest of the industry feared funding e-waste management would be too expensive (Nash & Bosso, 2013). Again, burdening states and municipalities with the responsibility to govern e-waste disposal (GAO, 2005).

2.46 Conclusion

The previous section provides the current structure of EPR in the US and explains that while other national initiatives were attempted by the EPA, they failed. The patchwork of EPR states is a result of competing interests and a failure of governing agencies to collaborate with the electronics industry.

[17] Again in 2011, the National Strategy for Electronics Stewardship was introduced to improve management of used electronics and to stimulate the electronics recycling economy. The focus of this initiative is to encourage product design improvements and to implement new projects (Herat & Agamuthu, 2012).

2.5 History of e-waste policy: tracing development to the US

The following section follows the issue emergence of e-waste onto the international agenda and the Basel Convention. Many US states incorporate the regulations and requirement of the Basel Convention into state law, so it is important to follow the trend from an international forum with the United Nations to a sub-national policy mechanism in the US states.

2.51 E-waste: issue emergence onto the international agenda

The e-waste movement gained momentum in 2002 when a non-profit, Greenpeace, found computer dump sites in China and Africa, and released the data in a toxics waste report (BAN, 2002). Following the release of the report, Greenpeace presented their findings of illegal dumping of hazardous e-waste at the Basel Convention in Switzerland (J. Puckett, personal communication). The Basel Convention is an international United Nations treaty where a network of organizations manages the treatment and movement of hazardous waste (Basel Convention & UNEP, 2011). As this treaty is extensive – covering now 186 nation-states and the European Union – the topic of e-waste making it onto the agenda was monumental.

The Basel Convention[18] entered into force in 1992 and has had more than two decades to solidify hazardous waste management regulations. The long-standing framework for waste management under the Basel Convention allowed for an easy adoption of e-waste

[18] The full title for the Basel Convention is otherwise known as, "The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal" (Basel Convention & UNEP, 2011).

under the hazardous waste definition. At the 6th Basel Convention meeting[19] in 2002, e-waste was formally identified by the global community as the most prevalent toxic waste stream (Herat & Agamuthu, 2012).

2.52 Why is the Basel Convention significant for the US?

The Basel Convention affects the ability of the US to export and import of hazardous and other wastes with other countries. The transboundary movements of hazardous wastes are tightly regulated where trade of such material is limited to parties within the convention (the 186 parties). The US is the only developed country that has not yet ratified the convention, which means that the US cannot legally trade or export hazardous refuse – e-waste in this case – to other countries[20].

As export for more than a few decades was a significant route of disposal for the US, they were then burdened with millions of pounds of e-waste to manage. As will be discussed later in this chapter, management of e-waste is problematic because the federal laws do not recognize the problematic components of e-waste. The Basel Convention could be an initial driver to e-waste management becoming a priority on the US agenda.

2.53 EPR translation into the EU

The EU has the most progressive e-waste management systems to date. As such, the EU became the paradigm model for other countries, like the US, to follow.

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[19] The 6th meeting of the Basel Convention is commonly known as the Basel Convention's 6th Conference of Parties (COP6). The COP gathers almost every two years and makes decisions by consensus (Basel Convention & UNEP, 2016).

[20] Shipments to countries that are not party to the treaty are illegal unless special arrangements are legally made. The treaty also requires each nation to produce legislation to enforce the sound treatment of hazardous waste (UNEP, 2016).

In contrast to advanced recycling systems like those in Europe, US consumers are encouraged to donate functional products to organizations like World Computer Exchange, recycle with an "e-Steward" certified facility, or locating a collection opportunity with a manufacturer or retailer. Manufacturing companies offer voluntary take-back programs and offer money back and some retailers, like Staples or Best Buy, take back products for free (ETBC, 2013). Ultimately, it is best practice to avoid the landfill or illegal dumping.

Individual collection requires each manufacturer to manage their own product. For example, within the EU, Lenovo® is responsible for collecting, recycling, and processing all Lenovo® products under and individual producer responsibility (IPR) system.
For instance, multi-national computer manufacturers, i.e. Sony®, Apple®, Microsoft®, are responsible under the EU system for all the collection, recycling, and disposal of computers together.

2.54 Conclusion

This chapter gives the general background for the climate of e-waste management on the global platform and how the issue translated into the US. The following chapter will provide a literature review on the importance of all stakeholders through the life cycle of e-waste and how considering consumers, processors, and government could contribute to the efficiency and effectiveness of e-waste recycling programs.

Chapter 3: Review of the Literature: Barriers to US EPR programs

This literature review focuses on the condition of EPR programs in the US. Since the early 2000's, the number of state programs has increased from zero to 23. The e-waste issue is ever evolving and as more time passes, more states are beginning to follow the trend of other state EPR programs. The argument in the literature is whether EPR programs in the United States are successful. The following section tries to understand the current progress of state programs, but there are limited analyses on state-level programs. To fill in the gap, this literature reviews extends to EU programs that are well documented to relate existing barriers and drivers.

The barriers that inhibit effectively implementing EPR policies in the EU may apply to those of the US. Then, the literature review concludes with a review of the supply chain to reveal barriers and incentives to key stakeholders in the US by borrowing from a stream of operations literature that primarily focuses on the processes of actors within a management system. A supply chain for e-waste follows an electronic product from cradle to grave – production to disposal. There may be gaps throughout the supply chain that contribute to the slow or otherwise unsuccessful transfusion of EPR take back policies in the US.

This analysis also borrows from the framework of Gregory & Kirchain (2008) who designed a framework to characterize the function of all the elements in the electronics recycling system. The framework dissects stakeholder responsibility for the cash flow, activities, and modes of processing. The analysis of this thesis contributes to the framework by adding the behavior of stakeholders in the US and using this analysis to provide policy recommendations.

3.1 Current literature on the US state EPR programs

Nash & Bosso (2013) did the most extensive and conclusive research on e-waste EPR programs in the US. Their study compartmentalizes hazardous waste products – batteries, paint, mercury thermostats, and e-waste – and follows the trend to the present. Their research also compiles statistical data of amount of recycled e-waste per state program and it also includes a background history in the US following EPR programs from the early 1990s on paint and batteries to e-waste in the 2000s. The conclusion of their research 1) advocate for the future success of EPR programs for e-waste, 2) suggests that EPR programs have a limit because states, coalitions, local governments, etc. have not yet collaborated for one framework approach, and 3) recommends federal legislation.

A large majority of information on EPR policies comes from coalitions like the Electronic Takeback Coalition (ETBC), non-profits like Product Stewardship Institute (PSI), National Center for Electronics Recycling (NCER), Basel Action Network (BAN), and Northeast Recycling Council (NERC), and prominent recyclers like Electronic Recyclers International (ERI), environmental advocates like League of Conservation Voters (LCV), Silicon Valley Toxics Coalition (SVTC), and cooperative forums like the Electronics Recycling Coordination Clearinghouse (ERCC) that provides a space for agencies to share information (ETBC, 2013; PSI, 2016; LCV, 2006; SVTC, 2004, ERCC, 2016). All the organizations and agencies provide current information of legislation status per state and have an accessible website. Maps of the US with information relevant to e-waste are available: landfill bans, existing legislation, etc.

The purpose of itemizing all the entities communicates that there is a substantial for e-waste advocacy, but also that all these separate entities add an additional complexity to the

US patchwork system. They all strive to compile e-waste information, follow e-waste legislation, and to recycle e-waste safely, but there are not unified and can be confusing to consumers, policy makers, and producers.

3.2 Relating to the EU experience: Lessons learned

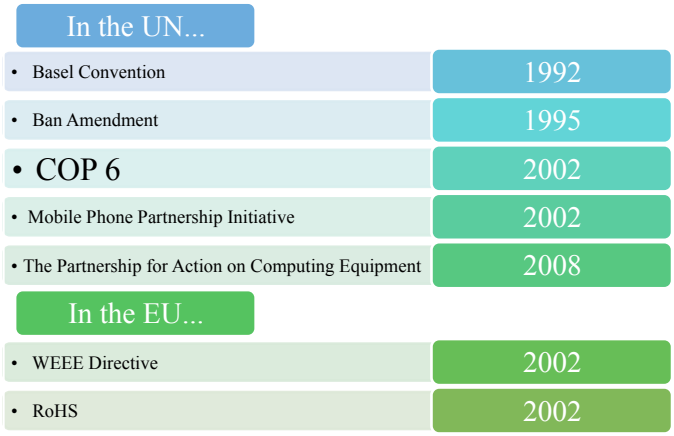
This section examines a set of factors that contribute to the acceptance of EPR in the EU. Looking at these set of factors will set the foundation of analyzing the EPR programs in the US. The EU can offer lessons learned for the US. First, the EU had external drivers such as lack of land that encouraged waste management. Second, the environmental movement and history leading up to the emergence of e-waste secured swift action from social acceptance and political cohesion. Third, the EU passed two blanket laws governing e-waste and hazardous waste. Fourth, they established organizations called producer responsibility organizations (PROs) that are specifically responsible for monitoring producer involvement and funding for take-back programs. Lastly, the EU follows the Basel Convention initiative that acts as one blanket law for all countries.

Developed countries like the EU – Germany, Norway, and Sweden – have incorporated take-back legislation and seen robust increases in products recycled per capita at about 8.8 pounds and rising (Nash & Bosso, 2013). These EPR policies show promise in increasing recycling rates, collection sites, generating revenue, and diverting e-waste from landfills (OECD, 2001). The countries in the EU that were the most aggressive were prompted in a large part by a lack of land for disposal and strong social sector commitment (European Environment Agency, 2010).

The keys to their success may also be attributed to the cohesive nature of countries in the larger political environment leading up to the implementation of the policies. The 1970s marked a transitionary period for the EU as they gained more member states in the face of an energy crisis and economic depression (European Union, 2016). In the absence of war, the EU began allocating money towards revitalizing impoverished areas and towards job security. It was during this period that the polluter pay principles were adopted into EU laws. As the EU gained more countries and became more unified through the 1980s, this set the stage for a unified front to address the environmental concerns of the people. As trade and commerce opened between member states, the economy encouraged the infiltration of technology, namely cell phones and the internet to allow for easy communication into the 1990's (European Union, 2016).

As mentioned previously, the influx of e-waste emerged in 2002 onto the international agenda at the Basel Convention. In the wake of this meeting, the EU established two governing instruments, the Directive of Waste Electrical and Electronic Equipment (WEEE Directive) and the Restriction of Hazardous Substances (RoHS). The WEEE Directive was rooted in EPR and it instituted a foundation that unified all EU members to responsibly recycle and treat all products by setting recycling targets and holding mass-based collection without delegating cost to the consumer (European Parliament and Council, 2003). The second, RoHS, is an added measure to regulate or prohibit the use of toxic substances inside electronics (Valli, 2002). The EU is a paradigm for the implementation of EPR policies for e-waste, through take-back legislation.

Figure 3. Timeline of important dates for the emergence of e-waste.



Source: European Union, 2016; United Nations, 2016; Herat & Agamuthu, 2012.

The benefit of having established a relationship across member states within the EU at the time when these two pieces of legislation passed was that transboundary movements of waste could be tightly regulated under one uniform umbrella. In addition, the cooperation makes the Directive guidelines salient for manufacturers in the electronics industry, thus promoting industry compliance. Manufacturers in the electronics industry are a major stakeholder who have substantial influence when it comes to policy formation. This factor is particularly important with the US case later, as the US has experienced a significant push back from the electronics manufacturers. A contributing factor to a lack of participation from the manufacturers is because the US has a segmented patchwork of states.

Producer responsibility organizations (PROs) are the final factor that contributed to the successful implementation of take-back programs in the EU. PROs are non-profit, third party organizations owned by the electronics industry that are municipal level or national (Quoden, 2016). Typically, the electronics manufacturers are responsible for managing and financing the product throughout the life cycle under an EPR scheme. A PRO reduces the

administrative burden on manufacturers by ensuring that the manufacturers follow the Directive by monitoring the life cycle of a product, in this case, e-waste. Examples of the duties of a PRO include, but are not limited to: coordinating with local agencies, meeting targets set by legislation, managing education and outreach with electronics companies to improve design and minimize waste, compiling data from these companies, and finally reporting this data to the national agencies (Quoden, 2016). The presence of PROs in the market effectively reduced recycling costs by encouraging competition (Lee & Shao, 2009).

3.3 Following the chain of waste production

Although there is minimal literature for identifying barriers and incentives for consumers, producers, and governments in a patchwork system, the following section will borrow from operations management literature to help understand the state of EPR programs in the US. Simply, analysts have borrowed from the concept of a supply chain from industry to follow the thread from production to sale and applied it to the waste stream of electronics.

The supply chain is a linear (or, if materials are recycled, a cyclical) process that links key stakeholders in the industry. Key stakeholders in the electronics industry are: federal/state governments, retailers, producers, consumers, and processors. In the US, the chain begins with the extraction of raw materials, then the manufacturing of the product followed by the sale at a retailer. The consumer buys the product and then upon disposal the product goes through a processor (sorting facility or waste management facility), a recycler, or the landfill. Notably, a supply model is normally transboundary, which is why the ultimate concern for stakeholders is leakage of e-waste to the Global South.

Yano & Sakai (2016) say that waste prevention is the primary driver for stakeholders to work collaboratively because it is cost effectively and benefits all those in the supply chain. In the case with e-waste and the US, the waste prevention mechanism is EPR and take back legislation (Kunz, Atasu, Mayers, & Wassenhove, 2014; Atasu, Özdemir, & Wassenhove, 2013; Zoeteman, Krikke, & Venselaar, 2010). The following sections will analyze potential barriers and incentives for each stakeholder in the US to comply with a waste prevention initiatives like EPR.

3.31 Producers

Operations literature, as referenced earlier, anticipates how producers *should* respond to take-back policies (Atasu & Van Wassenhove, 2011). The main purpose of operations management literature is understanding how take-back initiatives influence the behavior of the producer while following stakeholder analysis of this thesis. Incentives for producers discussed below are 1) to include other stakeholders such as the consumers, governments, and processors as responsible parties to reduce the burden, 2) to make programs inexpensive and easy to understand for producers in states that have programs, 3) to follow the trend of 'green' products marketing to reach more consumers and increase revenue, and 4) to allow manufacturers to work together under a collective producer responsibility model (CPR) where producers hold each other accountable. Barriers include 1) targets that are too stringent to meet, 2) programs that are complex and expensive, and 3) producers as the primary or only responsible party.

Incentives

In the early developmental stages of EPR schemes, the producer was clearly demarcated as the manufacturer in theory and in practice. Further discussion by Clement and others in the literature suggest that this still does not adequately identify one party to take final responsibility because every actor has a role of responsibility (1998). Hypothetically speaking, a producer could take responsibility for the product design and ensure minimal use of toxic materials and make the product easy to disassemble. Processors would be responsible for dismantling and recycling products separately and efficiently. Consumers would take on responsibility of buying eco-friendly products, taking them to the proper recycling facility, or not burning or landfilling the products.

Not surprisingly, producers prefer policies including a range of stakeholders to reduce the logistical and financial burden. In a 2015 survey by Lindhqvist, Tojo, and Tasaki, respondents[21] agreed that "manufacturers of a product" and "importers of a product" were identified as the responsible in an EPR scheme (p. 27). Notably, within the open-ended answers, some of the respondents included that "everyone involved in the manufacture, use, and sale of a product has some responsibility" in mitigating the environmental impacts. While others simply identified that it is important to highlight that the context of EPR may vary from "…product to product and country to country depending on the structure of the market…" (p. 29). Although there are varying opinions on identifying one responsible party, the fact remains that either one simple definition of a producer or more salient guidelines about specific producer responsibilities will ease the burden on administrative duties and

[21] Respondents of the study consisted of a wide range of stakeholders from producers, to NGOs, to research institutes and all had varying knowledge of EPR practices (Lindhqvist, Tojo, and Tasaki, 2015). The respondents for the study were chosen at random.

enforcement (Nash & Boss, 2013). A potential incentive for producer participation would be to involve multiple stakeholders to lessen the burden on producers (Clement, 1998).

Since it is not the case in the US for all stakeholders to take responsibility, producers pushed back on the taking full financial responsibility for their products because the cost of responsibility from cradle to grave is disproportionately expensive, where producers incur much of the cost (Atasu, Ozdemir, & Wassenhove, 2013). The main drivers to increase producer participation is a program that is inexpensive and cost-efficient, and with clear implementation requirements (Kunz, et al., 2014).

A third incentive for producers is to follow the corporate social responsibility movement. This is an important factor in influencing producers to modify their operations processes and business models to accommodate more environmentally friendly standards (Apple, 2016). For instance, Apple® is known for 100% of their facilities running on renewable energy. Also, Apple® created a robot named Liam that is designed specifically to disassemble late model iPhones (Apple, 2016). If improving product design, managing e-waste properly, and recycling would generate more revenue for the producers, the producers are less likely to resist EPR laws. A paradigm business model is Apple that 1) developed a robot called Liam to disassemble iPhones generation 6 and newer, 2) offers a voluntary take back initiative for all their products and offer a cash back incentive, 3) incorporated an eco-friendly product design that uses more recycled materials and less raw materials. Most manufacturers do not operate in such a way independently, but usually implement a voluntary take-back program for e-waste to avoid expensive regulations and infrastructure.

Barriers

Recycling targets are a potential barrier for producers because the targets are too high, making them expensive and difficult to meet (Nash & Bosso, 2013; Linnel, 2006). Alev, Agrawal, & Atasu (2016) suggest that increased recycling targets may push manufacturers to recycle WEEE earlier than necessary just to meet the guidelines.

Another stream of literature paints the picture of the dynamics between national scale manufacturers in the economic market. Toyasaki, Boyaci, & Verter (2011) conduct a study arguing that competition reduces product prices for the consumer, yet increases revenue for the manufacturer via take-back legislation because manufacturers will compete by lowering their prices. Lower prices encourage consumers to buy products, therefore generating more revenue. The outcome helps us understand the interactions between manufacturers and allows us to recognize incentives to manufacturer behavior.

Their work suggests further that monopolies within the market encourage "free riders"[22] that discourage manufacturers from participating. In a different study, Alev, Agrawal, and Atasu (2016) conclude that manufacturers may only participate in recycling second-hand goods to meet state requirements rather than considering a reduce and reuse scheme. Atasu & Subramanian (2011) research shows that producers are more likely to participate in recycling systems if they are permitted to work together under a collective

[22] Free riders are smaller manufacturers that piggy-back on more capable manufacturers to meet recycling targets (Toyasaki, Boyaci, & Verter, 2011). In a hypothetical example, if all computer manufacturers in Wyoming are required to meet a 3,000 lbs recycling target, all computer manufacturers are required to fulfill that in a monopolistic scheme. If Apple and Sony were the only two computer manufacturers, one would they both would contribute 1,500 lbs. However, a monopolistic scheme would allow Sony to contribute only 100 lbs because they are smaller and Apple contribute the rest because they have a more efficient operational capacity. In this case, Sony would be the hypothetical free rider.

system (CPR systems) because it is cheaper even though statistically the cost sharing has proven unfair.

3.32 Consumers

Consumers play a crucial role in the e-waste chain. Consumers are crucial to the recycling of e-waste process because they are at the metaphorical end of the supply chain – the consumer could either choose recycling to close the loop or choose an end of life disposal of e-waste to continue the cradle to grave system. Consumers participate in the waste stream by either dumping their e-waste illegally, storing it, throwing in the garbage, or recycling (Lindhqvist, Manomaivibool, Tojo, 2007). In addition to convenience, information and low or non-existent fees. Saphores, Nixon, Ogunseitan, & Shapiro (2006) researched consumers in California and found that educating the youth would encourage recycling.

For a consumer to recycle responsibly, however, or to take their electronics out of the attic and to a recycle bin, the collection of e-waste must be convenient, cheap (if not free), and the consumer must be educated on how to recycle the product. Often there are recycling events held in local townships yet if consumers are unaware, they will not go. A study done by Nicolescu & Jula (2016) notes that consumers are more likely to recycle WEEE if: 1) there are a larger number of collection units, 2) if the consumers are compensated, and 3) if recycling is visible, attractive, and obvious (Slade, 2012). Bouvier & Wagner (2011) study the collection habits of televisions and computers in Maine. The study, shows that collection centers with longer hours and that are open more often will encourage consumers to recycle due to the increased convenience. Bouvier & Wagner (2011) and GAO (2005) They suggest as well that a fee for recycling e-waste dissuades consumers from recycling.

3.33 Retailers

Retailers in the US, like Best Buy or Radioshack, hold a unique place in the e waste chain literature because they are treated as both a producer and a retailer. This means they are responsible for providing collection points for e-waste and educating consumers regarding what constitutes proper recycling practices. They do so not only for the equipment they produce but also for the goods of other manufacturers like Dell or Apple. The combination of a retail and manufacturer role, however, creates complexity for these companies who are playing a double role as producer and retailer in the e-waste chain.

Best Buy runs the largest e-waste program in the US and recently began charging consumers $25 per TV or monitor returned because the cost of collection and recycling was a net negative (Waste 360, 2016). The consumer fee could prove as an incentive for other retailers to begin recycling. Also, the recent rise in gold (a component of e-waste) commodity prices may encourage recycling as it becomes more profitable (Engel, Stuchtey, & Vanthournout, 2016). As commodities become more valuable, e-waste becomes more valuable rather than seen as costly, incentivizing retailers to collect more e-waste, and to modify the production chain to keep disassembly in mind for product design.

Alev, Agrawal, & Atasu (2016) further discussed the effect of EPR policies on the secondary markets and durable goods. Secondary markets are retail corporations, like Amazon, that sell previously used products. Their research found that with durable goods, in this case electronics, the second-hand or re-use market is important to the retailing industry, like Amazon or eBay, that allow the opportunity for consumers to make money back on their products that are still usable. For example, in 2001, eBay sold about one billion dollars of ICT products alone and 60% of those products were not new (Williams, et al., 2008). With

more stringent regulations, manufacturers may buy or recycle these goods just to meet collection targets. The potential interference with the secondary market may prove to be a barrier for retailers to support in EPR policies.

Further analysis of the take-back legislation on aftermarket activity of goods is prevalent in the operations literature (Krikke, Bloehmhof-Ruwaard, & Wassenhove, 2003; Walther & Spengler 2005; Hammond & Buellens, 2007). These analyses are research of deep economic and statistical theory and provide a detailed account of network design and reverse logistics. Although beyond the scope of this study, their research contributes to the intricacies of EPR practice and how it would impact actors in the aftermarket, like retailers.

3.34 E-waste Processors

Processors are companies responsible for disassembling and sorting e-waste products. For example, processors are typically incentivized by larger volumes of waste as an opportunity for new business (Gui, et al., 2013). Given that the management scheme varies by state, some barriers for processors may include competing with manufacturing or other recycling facilities for higher volumes of waste. There is a delicate balance between large volumes of waste and volumes of waste that are too large, where the cost for the processor surpasses the benefit (Pennsylvania DEP, 2015). Another barrier may be the cost of breaking down hazardous components, like CRTs, or the cost of buying more efficient/larger infrastructure to handle more volume (Gui, et al., 2103). In Pennsylvania, processors began to shut down and to simply refuse e-waste because they got overwhelmed with the sheer volume.

Processors can range from large scale that handle volumes from multiple states or smaller private businesses that only handle materials from nearby municipalities. An emerging processing sector is the individual. Consumers are realizing that e-waste has

valuable materials inside that can be sold for profit, i.e. gold or copper or other metal commodities (personal communication).

3.35 Government/State

The final key stakeholder is states. Many scholars argue that when there is a lack of federal action at the national level, states move to fill the gap. In terms of a lack of federal regulation for e-waste this is true (Nash & Bosso, 2013; Elisha, 2010; PSI, 2014; ETBC, 2012). Yet states face challenges and barriers in crafting e-waste policies and laws in part due to the regulatory thicket caused by the SWDA and RCRA. As neither of these two federal laws work to regulate e-waste and contributes to opacity rather than transparency in e-waste disposal. For example, international export of e-waste is prohibited, however transboundary movement across states is permitted (BAN, 2016). Landfill disposal in some states is permitted, and in other states it is not (ERCC, 2016). The fragmented nature of the state policies and the gaps in the federal laws create jurisdictional barriers in the relationships of state programs. This gap makes it difficult to track, regulate, and monitor e-waste (Nash & Bosso, 2013; BAN, 2016).

The incentives for the states to use EPR policies are to push the burden of cost onto the producers rather than onto the state economy (Nash & Bosso, 2013). With e-waste, state governments were motivated to respond with EPR laws as the state and municipal economies began suffering the burden of financial payments for management (Washington DOE, 2016). These financial concerns from the bottom encouraged states to adopt e-waste programs.

There is a tradition in US politics called cooperative federalism where states serve as policy or innovation labs. In terms of climate policy, federal inaction prior to the Obama

administration created a period of active sub-national movement on climate policies by states and localities. (Rabe, 2008a; Rabe, 2013; Rabe 2008b). In terms of e-waste, state governments in the US are responsible for monitoring and evaluating implementation and state level programs. For instance, they ensure that municipalities are offering convenient collection sites or holding collection events for the consumers.

3.4 Understanding state strategies in lieu of federal support

This thesis borrows from a deep and older tradition of federalism. This thesis climate change as an interesting parallel that is environmental. trends are seen in other political environmental arenas with waste or climate change. The states in the US began to respond to the e-waste issue voluntarily, which parallels trends in climate change.

The US is a federal structure that gives states a lot of leeway. States deliver 90% of environmental permits and manage most areas of environmental policy, including waste management (Rabe, 2008b). When comparing state control with federal control over environmental policy, states are found to be creative and strategic policy innovators in reaction to environmental problems, where federal involvement can result in failure (Rabe, 2008a; Rabe, 2008b). As happened with the case in of Washington State and Oregon in the 2000s, e-waste policies advanced quickly with a bill being passed and implemented in close to 2 years. Again, as seen with climate change policy evolution, states started to become actors in the international climate change realm and began to work with Canadian provinces and the EU (Rabe, 2007). Maine and Washington are two states that reflect what the EU has done with e-waste (Rabe, 2007). State achievements are supported by extensive public advocates for local concerns, the growth of advocacy groups and state agencies that generate

novel ideas, networks of environmental professionals across states encourage policy diffusion, and all states can pass their own legislation (Rabe, 2008a).

When climate change initiatives were ignored by the federal government, states stepped in with pilot programs to test new ideas that were then transformed later into state legislation. These state level policy initiatives were effective and successful because states had the opportunity to tailor the legislation to the unique needs of the state (Selin & VanDeveer, 2009). Rabe (2007) reports that it is likely for states to seek partnership together when the federal government fails to respond. Just as with the more recent case with low-level radioactive waste, states like Washington State, Nevada, and South Carolina refused to become permanent disposal sites and pressured the government for federal legislation (Rabe, 2013). In response, states were instead encouraged to form state coalitions and cooperate (Rabe, 2013). Very similar outcomes are to be expected with e-waste policy innovation.

3.5 Manufacturer-led versus state-led

There are two types of regulatory cultures of EPR in the US: manufacturer-led programs and state-led programs (ERCC, 2016; PSI, 2016; ETBC, 2013). The EPA encouraged these structures in the 2000s at the federal level, but now they are implemented at the state level or voluntarily by manufacturers (EPA, 2017). In either manufacturer or state-operated systems, the manufacturer can operate and fund the e-waste management system or the state can (Atasu, Ozdemir, Van Wassenhove, 2032). Atasu, Ozdemir, Van Wassenhove (2013) show that both structures effect policy implementation choices and further that ‘operational details matter’ (p. 19). Simply, both models are theoretically functional and would successfully protect the environment and process e-waste. They argue that ‘operational details matter’

meaning that the fluidity and cohesiveness between all stakeholders throughout the life cycle is crucial to the success of the program and the not just the producers. Notably, operating costs incentivized all stakeholders – including producers – to participate in the program (Atasu, Ozdemir, Van Wassenhove, 2013).

Funding streams determine divide programs into public and private. In the public model, the state governments or local governments control the finances to ensure proper and responsible disposal of e-waste. In the private model, the manufacturers manage the financial flows. An additional responsibility of the lead stakeholder is guideline requirements, such as recycling targets or collection sites.

There is little literature on the debate between which program is more efficient or more successful with state programs, likely due to policies being in a fledging state and more data is needed for an adequate study. Atasu, et al. (2009) argue that state-led models are more effective at establishing higher recycling targets and placing more collection sites because the state governments are more responsible at holding manufacturers accountable. Manufacturer-led models, they argue, typically lack the incentive to set high standards because they are more costly. In the same vein of thought, state-led models are thought to have stringent regulations accompanied by strict enforcement. On the other hand, it is argued that manufacturers will improve the design for e-waste over time to minimize costs of management since they are solely responsible for financing (Gui, et al., 2013).

3.6 Conclusion

The literature review has laid the foundation for analyzing the behavior of key stakeholders in the e-waste industry through the supply chain in the following cases of Maine and

Washington. As mentioned previously, factors for e-waste recycling systems vary greatly from state to state and across regions.

The conclusion of the research of Nash & Bosso (2013) 1) advocated for the future success of EPR programs for e-waste, 2) suggested that EPR programs have a limit because states, coalitions, local governments, etc. have not yet collaborated for one framework approach, and 3) recommended federal legislation.

The assessment of the supply chain in the US was done to understand why the EPR programs have limits by identifying incentives and barriers for key stakeholders throughout the supply chain: producers, consumers, processors, retailers, and state/local governments. Incentives for the producers and retailers include 1) to include other stakeholders such as the consumers, governments, and processors as responsible parties to reduce the burden, 2) to make programs inexpensive and easy to understand for producers in states that have programs, 3) to follow the trend of 'green' products marketing to reach more consumers and increase revenue, and 4) to allow manufacturers to work together under a collective producer responsibility model (CPR) where producers hold each other accountable. Barriers include 1) targets that are too stringent to meet, 2) programs that are complex and expensive, and 3) producers as the primary or only responsible party.

Incentives for consumers are accessible collection sites that have long hours of operation, collection sites are attractive and communicate proper education about acceptable items. Any additional costs or inconvenience will drive consumers away from proper recycling.

An analysis of the EU also offered lessons learned, such as: 1) the EU had external drivers such as lack of land that encouraged waste management. 2) the environmental

movement and history leading up to the emergence of e-waste secured swift action from social acceptance and political cohesion. 3) the EU passed two blanket laws governing e-waste and hazardous waste. 4) they established organizations called producer responsibility organizations (PROs) that are specifically responsible for monitoring producer involvement and funding for take-back programs. Lastly, the EU follows the Basel Convention initiative that acts as one blanket law for all countries.

Section 3.3 offered insight into the trends of e-waste policy by borrowing from an existing literature of federalism in attempt to parallel climate policy with e-waste policy trends. Just as with climate, it is expected for states to take initiative when the federal government refuses to act or cuts funding, as is the case with most environmental situations in the US. Expected outcomes for e-waste policy development is for states to form multi-state alliances and for states to begin to operate as independent nations and work internationally with other countries, such as the EU.

Lastly, the literature on manufacture-led vs state-led programs indicates that both program structures have the potential to successful manage e-waste. More important factors are 1) ensuring that the stakeholders are cooperating and 2) assessing state-level environments to identify individual needs. The following chapter will dissect two states, Maine and Washington, to identify similar trends (or differences) in stakeholder participation. These two separate cases should offer insight into the efficacy of state-run programs and offer some lessons learned.

Chapter 4: E-waste Supply Chains in Washington and Maine: Case Studies

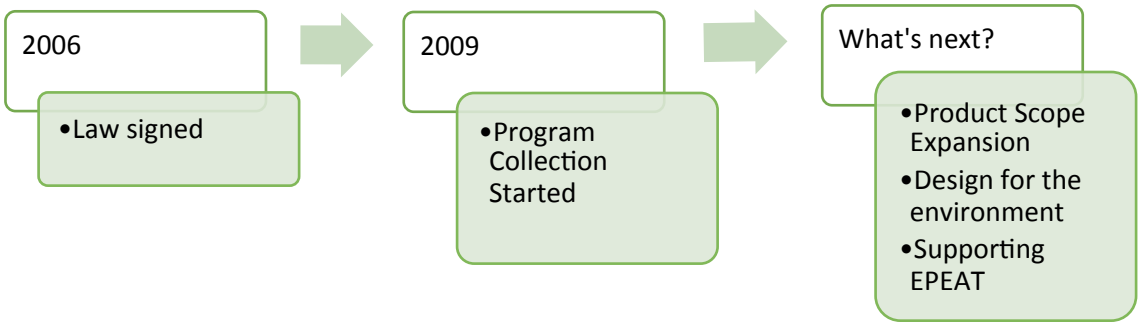
The following chapter examines two states considered 'best practice' states for e-waste: Washington and Maine. Each case is set up to follow the supply chain of e-waste to identify potential gaps within the chain that contribute to inefficiencies in the state e-waste EPR programs. EPR programs, as explained in the background and literature review, may be most efficient under certain circumstances such as having support from the electronics industry, effective lobbying campaigns, and setting strict recycling targets under state-operated programs. The following cases illuminate *how* Maine and Washington accomplished obtaining support from the electronics industry, for example, by analyzing their incentives for cooperating. The chapter will identify key stakeholders for each state and then examine the effect of state-operated efforts on those key stakeholders of Maine and Washington, along with a set of mini cases, to assess the successes and failures of take-back legislation in collecting and recycling e-waste.

4.1 Washington State

4.11 Basic summary of e-waste in Washington State

The Washington State e-Cycle program gained a good track record for its recycling rate, the amount of e-waste it recycled over a short period of time, and the turn-over of passing an e-waste law. The Electronic Product Recycling Act was passed in just one year and in just a few short years recycled over 300 million pounds of e-waste (Washington DOE, 2010). The following figure shows the development of the bill at a glance.

Figure 4. Significant dates in the formation of Washington's present law.



Source: Electronics TakeBack Coalition, 2016; SB 6428

4.12 The Electronic Product Recycling Act and the e-Cycle program details

Washington was an early mover, passing e-waste legislation in 2006, the Electronic Product Recycling Act (EPCRA). The Act required manufacturers to meet recycling targets, provide outreach and education to consumers, and fund recycling and disposal of electronics. Enacting it by 2007 began to form a council of manufacturers and set up collection sites. This was furthered by the addition of the e-cycle program by 2009 (Washington DOE, 2010). Under this law, Washington has reached some of the highest collection rates, almost 6 pounds per capita, in the US and continues to evolve by expanding its product scope (Nash & Bosso, 2013). The high collection rates are partially attributed to the strong participation of the electronics industry in the port cities of Washington State, establishing collection sites even in rural areas, government support, and a persuasive presence of NGOs, like the Basel Action Network (BAN).

The EPRCA launches a new management system for covered electronic products (CEPs) and to encourage a more recyclable product design that used less toxic materials for CEPs (SB 6428). The EPCRA initiated the e-Cycle Washington electronic product recycling program as the new management system that requires the take back and recycling of e-waste

products, education, and collection sites and garbage pick-up. The EPRCRA designates manufacturers as responsible for funding the program, however all stakeholders must participate for the program to properly function.

The EPCRA requires free collection, transportation, and recycling services for specified covered electronic products[23] (CEPs) as outlined in Table 1. Manufacturers must submit a plan to collect, transport, and recycle CEPs to the state Department of Energy. Although the state sets the standard the EPRCA has built in flexibility for manufactures to comply. The manufacturers may choose to submit either a voluntary plan, one that is created by the council of manufacturers and approved by the government (DOE). The plan allows manufacturers to either work collectively to fund, collect, and handle e-waste to meet targets or individually. Otherwise, manufacturers must adhere to the standard plan of the legislation, but both plans must be approved by the DOE.

The standard plan – by the state – defines where and how much e-waste is recycled and by whom. In short, the standard plan in Washington is based on a return-share scheme where the manufacturer is responsible for a certain weight percentage recovered of CEPs based on brand. For any CEPs that are not branded, all manufacturers split the cost of recovery. For example, the total pounds collected for the 2015 was 604, 949 lbs. The target must be met by all manufacturers that participate in the plan. Sony Electronics took back the most products identified by brand, therefore they were accountable for a larger share of the costs (Washington DOE, 2016). If Sony were to introduce a voluntary plan, they would be

[23] Washington State Senate defines a "covered electronic product" (CEP) as a "…cathode ray tube or flat panel computer monitor…a desktop computer, laptop or portable computer; or a cathode tube or flat panel television having a viewable area greater than four inches…" (Department of Ecology, 2010).

responsible for their market share, so if Sony sold 15% of the product in the market, then Sony is responsible for an equivalent percentage of the payment.

Table 4. Recipients, CEPs, and collection methods under the e-Cycle Washington program

Program Recipients	Households, Charities, Small Businesses, School Districts and Schools, Small governments[24], Special purpose districts[25], and Charities
Covered Products	Televisions, Computers, Computer Monitors, Portable Laptops (including tablet computers), E-readers, and Portable DVD Players
Available Collection Methods	Curbside Recycling Collection Bins Mail-back systems Collection events
Source: SB 6428; Department of Ecology, 2016	

The regulatory framework explained above gives the general overview of how the program works under the law in Washington. Among all the stakeholders, the following section highlights key players like manufacturers, the state governments, retailers, and consumers and their responsibilities.

Stakeholder Responsibilities

Under Washington's law, the DOE is the state level governing agency that has jurisdiction over the e-Cycle program. To sell products within Washington, all stakeholders must register with the DOE. However, in partnership with the DOE, the law created an "Authority" that is

[24] Small governments are defined under SB 6428 as any government agency within Washington "…with a population less than 50,000 or a county…with a population less than 125,000."

[25] Special purpose districts are separate from a city, town, or county government and they provide services like "…electricity, fire protection, flood control, health, housing, irrigation, parks and recreation, library, water-sewer service and more recently stadiums, convention centers, and entertainment facilities that are not otherwise available from city or county governments." (SB 6428).

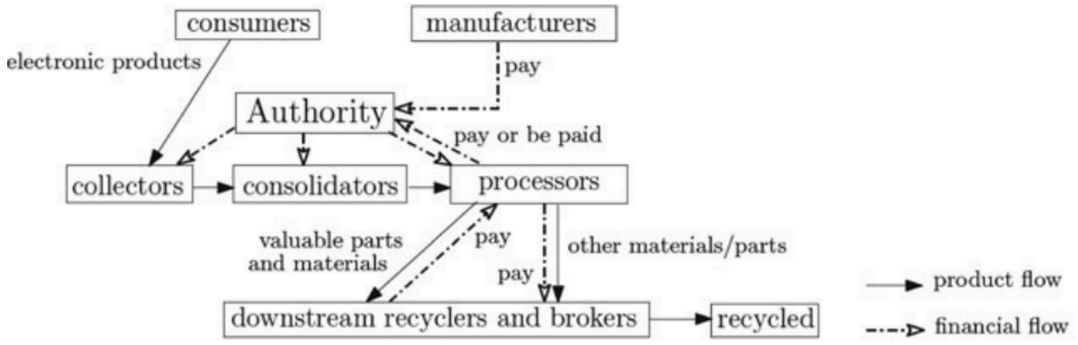
composed of manufacturing representatives called the Washington Materials Management and Financing Authority (WMMFA). The WMMFA is the public body made up of eleven participating manufacturers that administers the program finances (RCW 70.95N.280). Among the board members are representatives from Dell, Lenovo, HP, Apple, VIZIO, LG, and Samsung (WMMFA, 2016). Both the WMMFA and the DOE implement the standard plan. As discussed, below in addition the flexibility mechanism the WMMFA was an important incentive for private sector support for the e-waste waste law of Washington.

The WMMFA is also responsible for collecting funds from participating manufacturers to finance the system. The board of directors and is comprised of 11 participating manufacturers with five positions reserved for the top ten leading brand owners (70.95N.290). These five positions are held for leading brand owners because the WEEE recycling system is based on market shares and return shares. Market shares represent the percentage of recycling each manufacturer is responsible for funding.

The state participates in the enforcement of the standard plan by overseeing the WMMFA council and they also aid in promoting CEP recycling; however, the state government designates manufacturers as the governing entity over the flow of finances and products (Gui, et al., 2013). This gives manufacturers flexibility within an otherwise stringent program.

The flow of finances is shown in Figure 1 of all finances go the “Authority”, otherwise known as the WWMFA, and is recycled through all entities that handle CEPs. it is important to recognize that the WWMFA gives the manufacturers freedom to create their own program and coordinate with other manufacturers in an otherwise stringent law.

Figure 5. Flows of finances and products of WEEE through the electronic recycling system



Source: Gui, et al., 2013

Products flow typically from the manufacturers, to retailers, to consumers and then are managed through other entities to properly collect, strip apart, re-manufacturer, and recycle. Destination sites could include landfills and incinerators from improper disposal by the consumes into household waste. There are two other entities, retailers and refurbishers, that are two alternative destinations for WEEE.

The potential key to the success of the program is that Washington's program incorporates responsibilities for multiple stakeholders into the details of the program: including collectors, transporters, and processors. Each of these actors in the waste supply chain are required to register with the DOE. The key stakeholders and their responsibilities are laid out in Table 3.

Table 5. Key players throughout the lifecycle CEPs.

Stakeholders	**Responsibilities**
Consumers	Return CEPs to a collection location Be responsible
Retailers	Sell products from registered manufacturers only Educate consumers upon purchase of CEPs

Manufacturers	Pay a fee to a DOE to cover administration costs Pay collectors and processors for services Provide collection sites for every county within the state Renew/update plan every five years Participate in a standard plan or independent plan Finance program implementation Oversee financing operations Encourage CEP recycling with educational campaigns
State Government (DOE)	Registering manufacturers Approving independent plans Delineate performance standards for collectors, transporters, and processors Quantifying return shares for manufacturers Monitoring the WMMFA Consumer education
WMMFA	Manage the standard plan Collect funds from participating manufacturers to cover operational and logistical costs

Source: SB 6428; Gui, et al., 2013

Stakeholder Interaction

To look at the supply chain of e-waste within Washington state, this section provides a layout of stakeholders under Washington's law. The DOE is the state department that has jurisdiction over the e-Cycle program. Much of their power is relieved by the manufacturers as the law created a quasi-public council called the "Authority".

Retailers are not included in the figure, but are an integral piece to the flow of finances and products. Retailers are often both a manufacturer and a retailer, where the company sells products from multiple manufacturers, but also sells its own brand. Retailers can also set up collection sites if needed.

Refurbishers are companies or non-profits that recycle and reuse disposed goods that are still functional. With the rapid development of technology, many of the products discarded in the trash are still relatively useful. These companies also recover damaged equipment for re-use.

4.13 How does the e-Cycle program work?

Washington's e-waste recycling is meant to be transparent and easy to follow. One strategy to engage consumers is the state's website for all stakeholders to determine the respective responsibilities and how to fulfill their requirements. In theory, consumers, manufacturers, retailers, and processors can access the site and determine where and how to recycle their products or what each of their responsibility are under the law[26].

A preliminary analysis from 2012 of the e-cycling program sponsored by the King County Solid Waste Division and the Western Product Stewardship Collaborative (WPSC) revealed that the e-cycling program generated about 140 net new jobs in the first 10 months of operation and the report showed efficiency and collection success (2012). The progress of the program is based on pounds of electronics recycled and amount of collection bins dispersed in counties throughout the state since the program start date in 2009.

Given the data of recycled electronics, it is unclear whether recycling of electronics has increased because of the e-Cycle program or if recycling rates rose simply because availability of EEE rose. In 2009, more than 22,000 tons of electronic were recycled and by 2013 it increased to just over 51,000 tons (Washington DOE, 2016). However, total solid waste disposal decreased after e-Cycle program began, which could potentially show that e-waste was diverted from the landfill.

It is important to show that the e-waste recycling business could generate jobs and revenue for elected officials to maintain voter support and for the state to prove to the industry that there is an opportunity for profit. It essential for environmental interests and the

[26] Ultimately, any voluntary or mandatory plan must provide collection services in every county and city with a population greater than 10,000 (70.95N.280, 2006). No independent plans have been approved through the DOE (Gui, et al., 2013).

state to develop the argument that e-waste recycling is viable and has the potential for profit in the US because competing alternatives for e-waste recycling are raw material extraction, disposal, or export. There are over 400 manufacturers involved in the program, to date (Gui, et al., 2013). Table 6 shows the available recycling rates per capita of Washington's e-Cycle program.

Table 6. Per Capita rates of e-Waste before and after the e-Cycle program.

Per Capita	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Electronic Waste Recycled	5.24	6.66	7.60	9.20	11.22	14.94
Electronic Waste Disposed	15.42	14.11	13.80	13.20	13.16	13.29
Electronic Waste Generated	20.66	20.77	21.40	22.40	24.37	28.24
Total MSW Disposed (tons)	4,978,496	4,613,329	4,548,275	4,377,843	4,396,880	4,485,333

Source: Department of Ecology, 2016.

4.14 Challenges and benefits to implementing the program in Washington

The State of Washington, hereafter referred to as Washington, is in the Pacific Northwest of the US and is bordered by Canada, Idaho, and Oregon. Washington is a large state that is 66,455 mi^2 and is mostly rural with its most dense populations in coastal metropolitan areas like Snohomish and King County. (U.S. Census Bureau, 2015; Access Washington, 2010). The eastern portion of the state has a mountainous terrain for most of its geography and significant of land with low population density open for agriculture and farming. The geography of Washington poses a challenge for e-waste recycling initiatives to reach outlying counties. The e-Cycle program is based on reaching a target number of collection

sites rather than reaching a weight target for e-waste, but dissemination to rural areas is still difficult and transportation expense is still a barrier.

Over the past few years, the state economy has grown more robust with an increasing demand for consumer products and electronics. (U.S. Census Bureau, 2015). Per the Bureau of Economic Analysis (BEA), Washington's GDP was $386.335 billion USD ranking Washington 14th in terms of US state economies. The strongest industries in Washington are total trade, transportation, health, education, and manufacturing. Retail trade alone grew by 0.62% in Washington and contributed to its steady economic growth (2015). The point here is that the economy of Washington still grew even after implementing the e-Cycle program, which is typically viewed as a very expensive process.

Another contribution to the success of the Washington e-Cycle program lies in the diversity of state interests. Historically, Washington has had a strong environmental constituency from environmental advocacy groups and from government officials while supporting an economy that is heavily based on fossil fuels, health, education, trade and durable/non-durable goods manufacturing (Washington Environmental Council, 2016). Even though these interests are often competing (fossil fuels vs. environmental advocacy), the diversity in Washington may lend itself to more flexibility and so makes the state more able to adapt to economic shifts.

One of the last factors to the program success is the strong presence of the electronics industry. Rather than being a barrier, the state swiftly moved to incorporate manufacturers onto a council and doing such contributed to the e-waste bill passing. The state's information and communication technologies (ICT) sector is composed of roughly 8,610 firms and generates about 238,900 jobs and contributes a combined $18 billion to the state economy

(Department of Commerce, 2016). In 2006, the Washington state legislature called for research and pushed forward an electronic waste recycling program to ebb landfill disposal of e-waste. After research on WEEE in Washington, the Washington Department of Ecology recommended a manufacturer-funded processing system based on the electronic industry's large stake in product market share (SB 6428). Large corporations like Apple, Hewlett Packard, Lenovo, Microsoft, and Samsung have manufacturing facilities in Washington (HP, 2015). Microsoft has headquarters in Washington (Microsoft, 2016). The strength of the ICT sector and the demand for electronic products put Washington in the unique position regarding how its advanced technology sector engages in handling e-waste. What is interesting in this case is that in a state with powerful producers and high tech companies, the state government passed a state law to manage e-waste sustainably.

4.15 Issue emergence in Washington

The electronic recycling bill took effect on July 1, 2006, per the Revised Code of Washington (RCW) section 70.95N.902. The then Washington Governor Christine Gregoire signed the law in 2009 where she only vetoed Section 26 that specified stringent regulations on international exports of e-waste and ship waste (SB 6426, 2009). The Bill (you need to say briefly what is does or why it is comprehensive)

To understand the emergence of the bill, there are four main drivers leading to the roll out: a long history of environmental interest groups (i.e. government officials, universities, and NGOs), the emergence of hazardous waste issues, negligence from the federal government, and illegal dumping and export of WEEE in developing countries.

History of Environmental Interest Groups

Washington has strong political will to support environmental issues and the safety of public health at both the state and local levels. The Senate and the House has sided with environmental concerns for more than fifteen years (League of Conservation Voters, 2009). In addition, King County and the City of Seattle are famous for climate and environmental focus with strong collaboration from Universities. The University of Washington has a long history since the 1970's in support of recycling (2016). In the early 2000s UW conducted a pilot program Smart Cans to divert more than 30% of waste from landfills and by 2007 the University introduced an e. Media recycling program that providing recycling bins for electronic waste across campus to reach overall recycling rates of 70% (2016). Just last year in 2015, UW received over $50,000 from the Green Seed Fund Project to pilot new strategies on e-waste management (University of Washington, 2015).

A few environmental advocacy groups dedicated to e-waste issues in Seattle emerged in the early 2000s. Included in the list are other environmental groups, charities, and national coalitions that are dedicated to e-waste have evolved in conjunction with Washington's initiatives. A set of NGOs and coalitions focusing on e-waste were important into pushing legislation through the state assembly.

Emergence of Hazardous Waste Issues

Two years preceding the emergence of the e-waste issue in 2004, the Seattle Precautionary Principle Working Group released a white paper introducing a precautionary principle framework for mad cow disease, asbestos, and benzene for the City of Seattle and King County. Environmental health advocates, the EPA, representatives from the health sector, and investment shareholders all participated in the working group and provided multiple

perspectives on the benefits of pollution prevention over risk assessment. This set the stage for later EPR policies as EPR policy is fundamentally a precautionary principle. These issues catalyzed a movement among researchers, policy makers, and the public toward a new framework to manage potentially hazardous substances. The precautionary principle is not explicitly written in the law, but the law acts to prevent waste rather than react to a hazard.

Behind the scenes, and in part leading up to Washington banning all flame retardants, was the EPA acting to deregulate toxics reporting in 2005, as with most efforts under the Bush administration, environmental interests fell to the wayside (Dinnage, 2006). States, like Washington, strongly opposed the new rule to reduce monitoring of toxics. States feared they would "…lose federal funding for several state and regulatory agency toxic reporting programs…" as Meghan Purvis from the US Public Interest Research Group (PIRG) stated (as cited in Dinnage, 2006, p. 11). The state government even sought funding for e-waste programs through producer responsibility programs ("Manufacturing & Technology News", 2006). The issue with the hazardous risk from e-waste was only compounded when state-led government programs could not find funding to support programs, so manufacturer funded programs were a feasible option when other solid waste management fees were at threshold ("Manufacturing & Technology News", 2006).

As a response to the EPA rule controversy, Washington passed a bill. The reason behind the bill was in part a response to mitigate pollution from PBDE's and in part to maintain a prevent change in toxics reporting at the state level even if the EPA reduced reporting. In 2007, Washington was the first state in the US to pass a ban on all flame retardants (Washington Toxics Coalition, 2007). This is an example of the environmentally

progressive nature of Washington and an example of a driving factor for the e-waste legislation, as PBDEs are found within the plastics of electronics.

Relaxed Federal Regulation and State Involvement

The story with PBDEs is linked to another driver of the e-waste bill: lax federal standards. In 2005, the EPA Administrator Stephen Johnson endorsed a rule that decreased the frequency of reporting to once a year to once every two years for PBDEs (Dinnage, 2006). For many states this infringed upon the viability of their toxic right-to-know laws because reporting once every two years is an extended period to be uninformed.

In a response to lax regulatory leadership shown by the federal government, Washington (and other states) responded with state-led environmental initiatives that banned the use of PBDEs in 2006. This effort was modeled on the EU Directive model for Restriction of the Use of Certain Hazardous Substances (RoHS) that bans specific hazardous substances in EEE (Hsiao, Reinhard, & Linden, 2007).

As discussed in chapter 2 about the emergence of the e-waste issue, state management of e-waste also grew in lieu of federal involvement. In the case with PBDE, the federal government sought to relax monitoring under the then Bush administration. In the case with e-waste, the federal government resists acknowledging the urgency of the issue. Although different, both cases have minimal participation from the federal government drove states to handle e-waste fitting with the needs of that state setting. Since Washington state already had the laid ground work for PBDE chemicals, when the bill for e-waste was introduced, (SB 6428 & HB 2662) the bill passed quickly is just one year. There were 35 sponsors from each branches of the government (2006).

Surprisingly, resistance from the electronics industry was not strong enough to impede the e-waste law. In a report of the Technology Administration, manufacturers opposed state-led, producer responsibility initiatives because they interfere with their ability to "compete and innovate" because high compliance costs and inefficient models (Technology Administration, 2006, p. 3). However, due to the involvement of other economic majorities like the health sector and NGOs, the bill passed (Technology Administration, 2006; BAN, 2016).

Illegal Waste Export and Developing Countries

Illegal export still exists of CEPs to developing countries. Developing countries have a strong, cheap market for WEEE from developed countries that outcompetes with that of recyclers from the United States (Basel Action Network, 2008). In 2009, the EPA reported illegal exports from Washington to Hong Kong. Despite the federal 2011 Responsible Electronics Recycling Act, illegal exports still occur in Washington. Washington State has major port cities, such as Seattle, where many shipments of e-waste are likely to exit. The ban on exporting e-waste means that tons of e-waste remains on US soil. To curb illegal export, careless dumping or improper disposal of e-waste, Washington passed e-waste law, but it may not be efficient enough.

A news release in 2013 stated that in U.S. exports of used CEPs was valued at nearly $1.5 billion dollars in 2011, as reported by the US International Trade Commission (USITC). Executive Recycling, Inc. was fined $4.5 million in 2013 for illegal export of e-waste (Beveridge & Diamond). This presents Washington with a dilemma given that illegal waste often leaves their domestic ports.

When it comes to the e-waste bill, it cannot place a ban or regulate exports of e-waste without federal assistance. The Governor stated in a veto message that the State of Washington cannot ban export of e-waste to other countries because it lacks the authority to do so (Gregoire, C., 2006). This authority would come from the Department of Commerce of further federal legislation.

4.16 Conclusion

The Washington model shows promise for the future of WEEE, demonstrating a gradual increase in recycling rates over time, substantial stakeholder involvement, and a program with the capacity to expand its product scope. The benefit of the state-led model for Washington is that it required manufacturers to participate and coordinate with other stakeholders that would otherwise not contribute to the system or 'free rider' problem. The "free rider" problem is where other (usually smaller) manufacturers fail to contribute to recycling take back efforts by letting the other manufacturers handle the burden. For example, in a collective system where say HP, Lenovo, and Microsoft were collectively responsible for meeting a recycling target of 10 computers a day, HP and Microsoft may meet that target and Lenovo would not contribute anything, thus the free-riding.

The Council of State Governments (CSG) is the only national organization that collaborates between all branches of the state government to facilitate public policy (CSG, 2016). CSG looked to Washington as a paradigmatic model over because it is comprehensive and targeted hazardous substances through e-waste management (Hsiao, et al., 2007). Around the time of the Washington bill, 20 other states attempted to push a bill through,

however, Washington was the only one bill enacted seemingly because it was the only bill with a financial plan for recycling programs ("E-waste regulations advance", 2006).

Washington has overcome barriers like transportation in rural areas and large quantities of e-waste, that other states have viewed as too costly or inconvenient. Washington could overcome these barriers because many stakeholders participated in building the infrastructure and there is a strong presence of supporters from the electronics industry to cover the financial costs for transportation, collection, and processing. Further, Washington has a strong infrastructure base to recycle large quantities of e-waste.

Although there is significant collaboration and support for the e-Cycle program, Washington still experiences some push-back from retailers. Often a retailer is considered both a manufacturer and a retailer because they make their own products, as well as, sell products of other name brands. These interest groups push for voluntary programs in the face of stringent regulations because they are less costly and more convenient. These retailers include Best Buy, Radioshack, and Staples and retailers are the only entity that recycles peripheral computer equipment not covered under the program for free. Best Buy is fighting these initiatives not only because it is too costly and inconvenient, but also since Best Buy often will bear the financial burden of more than the market share.

Key lessons from WA state are that outreach and education is important to disseminate information even to rural areas. Outreach seems effective with a transparent website that communicates the amounts of recycled e-waste, as well as, outlined responsibilities for manufacturers, consumers, and other stakeholders. A second lesson learned from WA state is that collection sites from rural areas or consistent collection events pulls in consumers to participate in recycling of e-waste. Third, WA is already an

environmentally minded state with the public, academic universities, and businesses in favor of taking care of the environment. Lastly, the state encouraged the cooperation of the electronics industry, which is fundamental for the program to function. For WA, developing a council for manufacturers to manage their own funding and programs worked best. Despite the progress of the WA state e-Cycle program, major port cities of Washington still struggle with illegal e-waste export and improper disposal because 'third party' recyclers or processors simply do not have the infrastructure or money to afford disassembly of the large quantities of e-waste.

4.2 Oregon & Canada

The bilateral support around Washington is another factor that contributes to the successful implementation and enforcement of its e-Cycle program. Oregon and Canada have similar interests to Washington. Oregon implemented an e-Cycle program in 2009, the same year as Washington, but it is entirely manufacturer operated (ERCC,2016). Oregon and Washington have together developed mutual coalitions to manage the transport of e-waste across borders. Further, the laws and ideal cover similar product scope for the same entities that provides consistency and clarity for consumers, manufacturers, and processors. The fact that Oregon and Washington have passed similar laws around the same time reinforces enforcement operations. This way, Washington and Oregon do not have to struggle with the logistical stumbling blocks of interstate commerce or struggle with liability. For instance, when two bordering states have differing laws over who is responsible for the financial burden of disposal, waste usually gets dumped illegally because there is a loophole that no party wants to fill (Lepawsky, 2012).

The case with Oregon is similar in Canada. Canada, bordering Washington to the North, has also furthered development on e-waste legislation since 2003 and recycles seven types of covered electronic products (Lepawsky, 2012). In theory, the combination of the three entities – Oregon, Washington, and Canada – should yield simpler logistics to monitor and track the transboundary flows of e-waste. Lepawsky (2012) reports on the contrary, that the patchwork of state-level systems leads to jurisdictional confusion. While on the surface the three regions would seem to cooperate to ease the regulatory burden, the result is just the opposite. The small variations in the definition of what constitutes "garbage" or "junk", for instance, has caused garbage to be dumped just because no one took responsibility. The patchwork system of EPR programs has led to a downfall of states regulating transboundary waste flows (Lepawsky, 2012).

4.3 Maine

4.31 Background on Maine

Maine is a relatively small state with much of the state being rural leaving the most densely populated cities to the east coast. Until the election of Governor LePage in 2012, Maine was a leader in environmental issues, but also it is heavily dependent on manufacturing, mining, agriculture, and public services (Netstate, 2016) Maine was the first state to adopt an EPR law in 2004 to manage e-waste in the US within household waste streams. Electric and electronic equipment (EEE) ranks second in the manufacturing sector for Maine economy (Netstate, 2016). The e-waste law, hereafter referred to as Maine's Electronic Waste Recycling Law, proposed to reduce the economic burden on municipalities by shifting

responsibility towards the producers, in contrast to Washington State (38 M.R.S.A. §1610). Maine's framework is unique in that the cost of transportation, collection, and recycling is shared across manufacturers, consumer, and municipalities to handle e-waste. The 'framework' idea is meant to extend a similar framework to nearby states (Nash & Bosso, 2013). Two years later in 2006, the State implemented the new e-waste program called the Extended Producer Responsibility Program for E-waste Recycling.

In the wake of this program, Maine experienced a relatively rapid decrease in e-waste disposal in landfills and an increase in recycling rates through the program (Wagner, 2009). More than 14 million pounds of covered electronic products[27] (CEPs) were recycled in the first three years of operation and rose to more than 66 million by 2015 (Maine DEP, 2016).

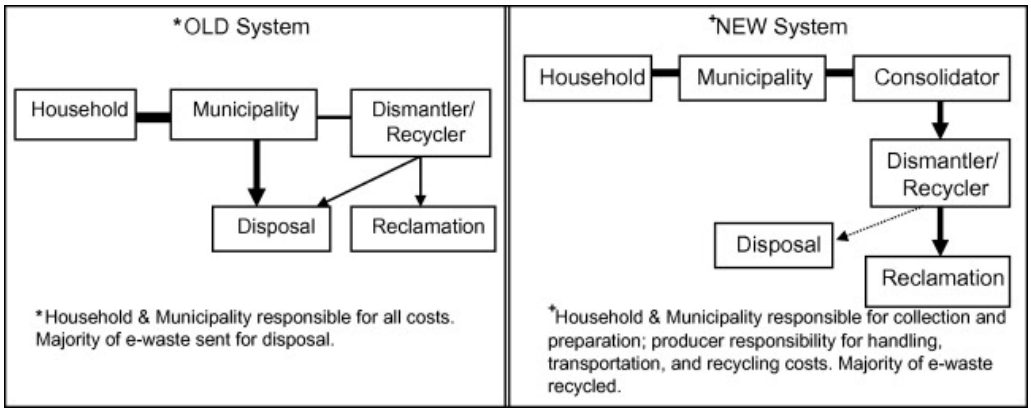
Maine, therefore, became the paradigmatic model for other states interested in the collective responsibility mechanism that spread the cost among all stakeholders rather than solely among producers. In addition, Maine is the most established state in terms of EPR policy for CEPs in the US and has 10 years of experience and data.

4.32 How has the program worked?

The new system changed the framework to an in-management system of waste where end-of-life products are recycled for initial use rather than planning for landfill disposal. Figure 3 shows the management of e-waste under the new program.

[27] Covered electronic products (CEPs) are defined by Maine Law as "…computer central processing units, a desktop printer, a video game console, a cathode ray tube, a cathode ray tube device, a flat panel display, or similar video display device with a screen that is greater than 4 inches measured diagonally…" (38 M.R.S.A. §1610).

Figure 6. The new program system under the Maine e-waste law.



Source: Wagner, 2009

Maine's recycling and collection rates remain some of the strongest relative to other states in the US, but rates relative to Maine alone have plateaued at just over 8 million pounds since 2013 (Maine DEP, 2016). The recycling program expanded the product scope over the past few years, but still the recycling rates remain stagnant at about 8 million pounds, which hints that Maine has potentially reached a peak recycling capacity (Maine DEP, 2016),

4.33 History of Maine's e-waste Law and issue emergence

Maine led many other states passing an e-waste law in 2004 and progressed the law grew significantly over time. After just three years, the program collected 14 million pounds of e-waste and expanded its scope from four products to twelve.

Maine has a history of having a strong environmental stewardship, as they are known to draw in tourists for whale watching, eating fresh lobster, and enjoying the pristine scenery of the coast. In the early 2000s, Maine's economy was stagnant, the manufacturing sector was shrinking, and unemployment rates were rising (Bell & Burke, 2005).

Around the same time in the early 2000s, the e-waste bill was introduced in 2006 in response to the previously passed landfill disposal ban of cathode ray tubes (CRTs). The ban was passed by the state government. Maine's Department of Environmental Protection needed an alternative disposal system for CRTs that did not disproportionately impact consumers and burden municipalities ("Bangor Daily News", 2004). Legislators introduced a producer responsibility bill soon after for all CEPs. There was little to no manufacturer resistance to this bill as manufacturers initially saw the bill to make money since Maine government began importing waste from other states. Additionally, environmental lobbyists and the public also viewed the new bill as an opportunity to protect the environment and stimulate the economy. ("Bangor Daily News", 2004).

The economic decline in Maine is mostly attributed to a decrease in durable-goods manufacturing with the real estate, construction and government industries performing substantially (Murphy, 2015). To address this economic stagnation, then Governor Baldacci (2003-2011) and leading corporations in Maine like Apple, Hewlett-Packard, IBM, Dell, and Intel, argued that importing solid waste would generate revenue and jobs (Bell & Burke, 2005). The idea to import waste from other states happened discreetly with minimal knowledge given to the public (Bell & Burke, 2005).

One answer to generating new jobs was buy offering up land for refuse from other states. Bringing in landfill material from other states would bring revenue and jobs that would stimulate the economy (Bell & Burke, 2005). The producer responsibility law could represent a second answer to relieve the financial burdens of the government, generate jobs for consumers, while pleasing environmental lobbyists. The producer responsibility law

would require the manufacturers to pay for their own products rather than burdening the local and state governments (Lindhqvist, 2000).

However, household disposal of e-waste nationwide was permitted (and in some states, is still permitted), allowing e-waste to accumulate (RCRA). The consequence of importing waste from other states was receiving all the e-waste, as most states do not have a landfill ban on that waste. While waste was intended to generate revenue from tipping fees per ton[28], the State now was responsible for expense of the tons of e-waste that could not be landfilled (Bell & Burke, 2005).

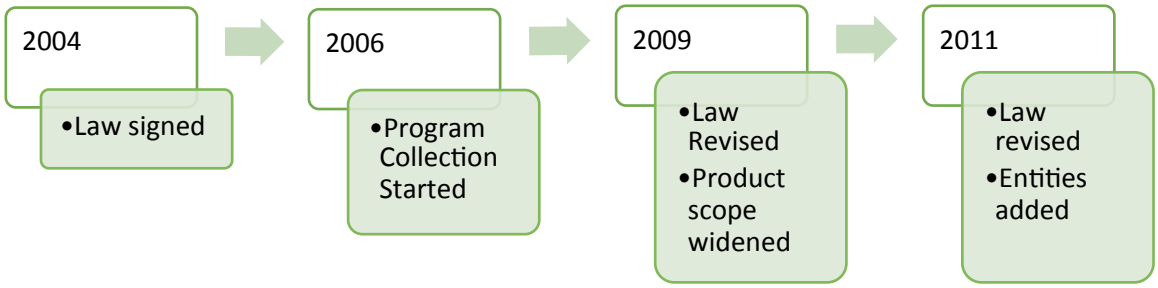
In further benefit, some manufacturers, for example, Hewlett Packard and Dell supported the bill because it included responsibility for all stakeholders for product management ("Bangor Daily News", 2004). Manufacturers generally tend to gravitate towards individual collection and recycling responsibility because this reduces costs and prevalence free-riders, as mentioned previously in chapter three.

4.34 The details of Maine law and program

Governor John Baldacci signed the law on April 22, 2004. The initial bill, called "the Act to Protect Public Health and the Environment by Providing for a system of Shared Responsibility for the Safe Collection and Recycling of Electronic Waste", was introduced by the House on March 2, 2004, and sponsored by the Democratic Representative Ted Koffman with very little opposition from other members (Maine State Legislature, 2004).

[28] Tipping fees are a fee tacked onto waste to cover processing and disposal. These fees are usually paid by the consumer or the municipality upon drop off at the landfill.

Figure 7. Significant dates in the formation of Maine's present law.



Source: Electronics TakeBack Coalition, 2016; 38 M.R.S.A. §1610

This law initially only covered televisions, monitors, and laptops coming from households (ETBC, 2016). The collection program started two years later in 2006. After successfully collecting and recycling more than 14 million pounds of CEPs in three years, the State decided to cover more products under the program in 2009 (Maine DEP, 2016).

Despite adding more products under the program, the collection rate went from 7, 912, 292 pounds to 5, 368, 467 pounds in 2010 (Maine DEP, 2016). This may have led to the State broadening the scope of entities in 2011 from households to four other entities like small businesses and non-profits, as listed in Table 2.

There has been a decrease is products recovered and recycled over time and this could be due to less refuse or there could be leakage within the life cycle of e-waste recovery. The following section outlines covered products along with the key stakeholder in Maine to follow the products through the life cycle.

Products Covered and Stakeholder Responsibilities

The stewardship program under Maine's law moves away from a linear disposal system towards a cyclical recycling management system (as shown in figure 6). The program covers

a wide range of products from various entities as shown in Table 2. The Maine Department of Environmental Protection, hereafter referred to as the Department, is the enforcing entity.

Table 7. CEPs and entities covered under the program.

Products Covered	Televisions, portable DVD players, game consoles, computer monitors, laptops, tablet e-readers, desktop printers, digital picture frames
Entities Covered	Household, elementary schools, secondary schools, small businesses of 100 employees or less, non-profits
Landfill Bans	CRTs and mercury containing products

Source: 38 M.R.S.A. §1610

There are three main stakeholders: manufacturers, consumers, and municipalities. Their responsibilities are outlined in Table 3. Manufacturers must register their brands that are sold within, report all past and present brands sold in the state, and label all outgoing products.

Table 8. Primary stakeholders in Maine and their responsibilities.

Stakeholder	**Responsibility**
Manufacturer	Funds recycling of all products
Municipality	Funds transportation for collection Establishes collection sites in every municipality
Consumer	Takes CEPS to nearest collection sites Pays occasional collection fee

Source: 38 M.R.S.A. §1610

These stakeholders ensure provide funding for Maine's e-waste program. Other stakeholders are also crucial to the success of the e-waste program: retailers, state government, consolidators, and recycling and dismantling facilities. Their role in implementing the e-waste program are shown in Table 4.

Table 9. Secondary stakeholders in Maine and their responsibilities.

Stakeholder	**Responsibility**
Retailers	Can only sell from registered and complying manufacturers
State Government	Enforces manufacturer participation Monitors manufacturer and stakeholder compliance Manages registration fees and covers costs for manufacturers that fail to pay Allocates the manufacturer's annual share of orphan waste
Consolidators	Must identify the manufacturer of each CEP Monitor monthly log of incoming CEPs
Recycling/Dismantling Facilities	Environmentally sound disassembly and recycling of CEPs

Source: 38 M.R.S.A. §1610

There were other options the State of Maine could have sought for offsetting the cost of collection and recycling of e-waste, such as advanced recovery fees or property taxes. Given that consumers already paid a state tax of 5%, pay initial fees for products like tires, and paid tipping fees for solid waste management, the State feared any additional fees for e-waste would burden consumers. Additionally, ARF could have driven electronics consumers towards cheaper options in the neighboring state or online (Wagner, 2009).

4.4 Comparison

In comparison with Washington, although Maine's program precedes Washington's by two years, it has collected and recycled substantially less CEPs (Washington reached 300 million pounds as of 2016). This phenomenon could be explained by the difference in populations of both states – Washington is almost 5 times larger than Maine – which correlates directly to

the difference in recycling rates being almost 5 times higher in Washington than Maine (US Census Bureau, 2014

The implementation process in Washington is robust, relatively speaking, in comparison to other US e-waste policies (Nash & Bosso, 2013). In comparison to Maine, Washington is equally if not more efficient in e-waste recycling. In 2003, only 20% of e-waste was recycled, but as a 2013 that percentage rose to 53%. Maine has a state led program that is similar to Washington in that it requires all stakeholders to participate, however Maine also allows more flexibility in including voluntary programs into its legislation, where Washington does not.

Conclusions of both states offer lessons learned for other existing or upcoming states to work together in formatting a policy with a framework that neighboring states mutually enforce, collaborate with the electronics industry to maintain funding and reduce resistance, and focus lobbying efforts on industry practices rather than just recycling more e-waste to influence a more ‘green’ design rather than new law.

Ch. 5 Conclusions and Policy Recommendations

Conclusions

The world thrives on technology. This technology, once obsolete, presents risks to the environment and to human health. These risks need to be swiftly minimized and controlled through education and regulation. The public perception in the US is that this end-of-life technology, e-waste, is adequately handled by the present solid waste management policies in place. The reality is that e-waste is burdensome for most states to handle because the existing facilities are not large enough to handle such a volume. Governments, businesses, citizens, must understand the risks, costs, and advantages associated with implementing e-waste regulations.

Some controls, such as EPR, show potential. Since the early 2000's, over 23 states and D.C. have implemented EPR take-back legislation and other states are beginning to follow the trend. These programs are costly, where the financial burden falls onto the manufacturer for funding collection, disposal, outreach and education (Reinan, 2006; Sachs, 2015).

The barriers to the patchwork of state initiatives are that they can become blurred and a logistic inconvenience as most e-waste manufacturers are multi-national. Each state requires an individual set of regulations that the manufacturers must follow. Secondly, transboundary flows of e-waste are difficult to monitor and evaluate (Zotos, Karagiannidis, Zampetoglou, Malamakis, & Tchobanaglous, 2009). Each state collects a different number of products under programs that began at a different time. For data collection, this means that there are significant gaps in data, which make it difficult to determine trends. As most

programs are still young, not enough time has passed to yield one time-period of study (i.e. 15-20 years). Third, each state categorizes e-waste differently. For some states, e-waste constitutes everything, including the keyboard or peripheral cords. Other states only consider the monitor. This also makes comparing states difficult.

Other conclusions are that public-led systems achieve higher targets, but programs are plateauing in the amounts of e-waste collected and recycled. They achieve higher targets because there is a fine associated with meeting the target. It is unclear why the programs are plateauing. In the initial years of Maine and Washington, for example, the programs recycled millions of pounds of electronics, but as the program continues, that rate has slowed. This may because e-waste is getting lighter, there may be leakage of e-waste elsewhere, or in that state e-waste is diminishing.

Benefits from private-led systems (manufacturer-led systems) are that they are good at engaging stakeholders, like producers and retailers (Young, 2007). Manufacturer-led systems give the manufacturers the freedom to establish their own targets, boundaries, programs, and money flows. Some recent evidence shows that many, like Best Buy, are retreating from the take-back programs in the face of high costs (Best Buy, 2016). On the contrary, Apple is an on-going example of how private system can work, especially in a closed-loop take-back system. They have improved their product design by minimizing hazardous components and planning a method for disassembly. Apple also encourages consumers to return obsolete products for the chance of a refund. Private actors typically engage in voluntary systems to 1) avoid public regulation because of high costs and stringent standards, 2) increase positive marketing and to follow the green movement in drawing consumer buy-in for a ‘greener’ product, 3) increase foot traffic in stores, for example, Best

Buy or Radio Shack provides containers for consumers to drop off electronics, and likely consumers will go inside to buy more.

Starting a program is easier if they 1) are green states and have a history of environmental activism; 2) have effective state level lobbying by non-profits and the public; 3) overcome opposition from the electronics industry by providing an incentive for profit, as seen in the Maine case or allow the electronics industry to determine their own contribution and recycling levels, as seen in Washington State; 4) have supportive cross-boundary relationships by neighboring states or nations, such as Washington, Oregon, and Canada (Serrona, Yu, Aguinaldo, & Florece, 2014).

Policy Recommendations

This thesis suggests a framework for a unified supply chain scheme, where all actors are responsible for a part, as designated by prescribed legislation. Also, this thesis suggests a federal law. E-waste EPR programs would be most sustainable, while maintaining high collection rates and continually diverting e-waste from incinerators, the landfill, or illegal export. A long-term goal for e-waste management should be one uniform standard or federal policy. The CEO of the Consumer Electronics Association (CEA) states that moving towards a national solution would best replace, "…the complicated patchwork of rules that varies from state to state…" (CEA, 2014). Although that more than half of the states in the US have enacted a state law, most states include a federal preemption section that specifies that the law is void if an equivalent federal law is establish. The Governor of Washington, for example, outlined this before she signed the bill (70.95N.340). Federal legislation would be

optimal because it solves the transboundary leakage issue, reduces complexity for consumers, policy makers, and business.

The report from the Technology Administration (2006) indicates that one law, albeit nationwide, already presents a set of challenges, let alone a variety of laws from multiple states (Technology Administration, 2006). The report concluded that a nationwide system via state legislation may best fit the needs of the US. An article from Manufacturing & Technology News explains that the patchwork national system that is currently gaining momentum could negatively impact the technology sectors ability to innovate and compete because much of their funding would be lost through endless compliance regulations (2006). This may not be true given this news article is almost over a decade old and the technology sector has seemingly been uninhibited although the prevalence of EPR policies have grown. This may shed light on one reason that EPR instruments have reached a limit in terms of recycling rates and ultimate efficiency. After a few years, programs have seemed to plateau in recovery rates and this could be attributed to a patchwork style of legislation where there are too many rules to abide by. Most state EPR laws include a federal preemption section that specifies that the law is void if an equivalent federal law is established (70.95N.340). This shows that states made adequate preparations for the eventual federal law. Neither state-led initiatives nor the industry-led initiatives have resulted in federal policy even though that is seemingly the goal for all stakeholders (CEA, 2016).

In the absence of federal policy, policy recommendations for states with existing EPR laws or for states seeking EPR laws there are a few recommendations. First, establish efficient and cohesive data gathering at the state level. Gathering adequate data of existing e-waste, collected e-waste, types, weight, and quantity will help researchers frame the issue.

The generated information can be used to create a sense of urgency within the state and helping the public understand the extent of the problem.

Second, develop an effective lobbying campaign, especially if the state does not have a past of environmental conscientiousness. Adapting the lobbying campaign to the needs and interests of the state will encourage business buy-in and generate public awareness.

Third, create a policy that fits or reflects the policies of neighboring states. In lieu of federal legislation, or blanket law as seen in the EU, similar policies will help with transboundary enforcement and monitoring of e-waste. Lobbying efforts could also communicate that e-waste has the potential to make money. Scholars researched that e-waste has the potential to generate revenue, raise employment, and minimize use of raw and rare materials, like indium. The Institute for Scrap Recycling Industries (ISRI) reported 19,000 new jobs in end-of-life management with the electronics industry bringing in $1.5 billion in the US (2006). This thesis argues that EPR shows promise in the US given that enacted laws cater to all actors throughout the lifecycle, i.e. producers, consumers, processors, retailers and the state government.

Fourth, build an automatic tightening or adjustment into existing legislation for e-waste. E-waste domain is evolving rapidly and policies should be created to reflect that evolution. For instance, as e-waste becomes lighter, weight will no longer serve as a clear metric for “pounds of waste recycled”. A suggestion could be to require manufacturers to recycle a percentage of what they sold in that fiscal year, and as every year passes, that percentage increases.

Fifth, refocus lobbying and non-profit efforts on the reputations of companies instead of trying to pass a public-led mandatory law. Redirecting energy of advocates from a law to

manufacturer reputations could result in holding manufacturers accountable for an insufficient, albeit cheap, route of disposal. Manufacturers will not jeopardize profit for bad publicity.

Lastly, encourage closed loop product take-back initiatives. Shifting the cradle-to-grave system to a reduce, reuse, recycle system will aid in diverting waste from landfills by not creating waste in the first place. Additionally, third party logistics are unclear and vague. Many third-party recyclers or landfills allow illegal wastes into the landfill simply due to negligence. A part of the closed-loop process is monitoring all stakeholders through sufficiently.

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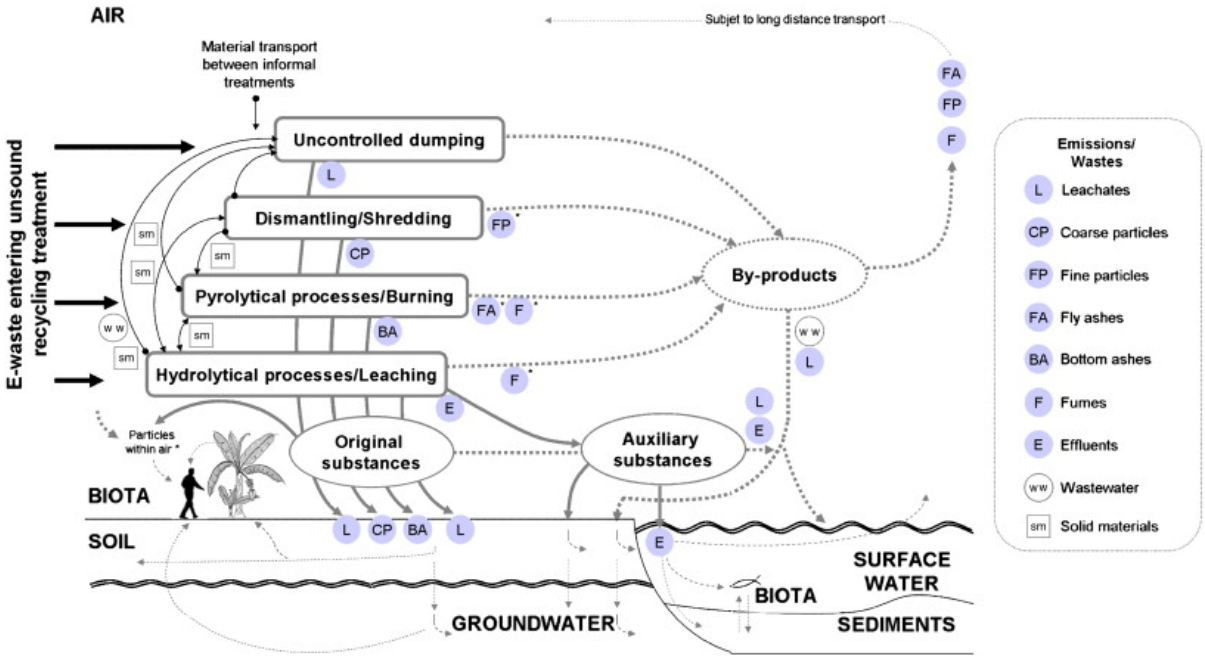
Appendix A: Components of e-waste and their health implications

WEEE is comprised of rubber, plastic, and many precious metals. What some may not know are the potential health and environmental risks that come with mishandling and improper disposal of such substances. Table 1 lists some materials used in desktop computers. The components are adopted from a list compiled by the Silicon Valley Toxics Coalition (SVTC, 2004). Highlighted in the table are the most abundant materials that generate the utmost concern to the environment and human health.



Source: Sepulveda, et al., 2010

Table 1. Itemized substances found within e-waste products.

Elements within e-waste	Health Risks	Environmental Risk
Brominated Flame Retardants (PBB & PBDE)	Endocrine disruptors, inhibitors to development growth, digestive and lymphatic cancer	Concentrated levels can transcend the food chain. Point sources are waste dumps and landfill leachate
Lead	Central and peripheral nervous system damage, kidney damage, endocrine disruptor, inhibits brain development in youth,	Environmentally accumulates, damages plants and animals, can contaminate drinking water supplies
Cadmium	Kidney dysfunction, possible skeletal damage, and carcinogenetic	Environmentally persistent, uptake by crops, like potatoes and carrots, and can become airborne if burned

Mercury (methyl mercury, once exposed)	Chronic brain damage	Accumulates in living organisms and transcends through the food chain
Hexavalent Chromium	Allergic reactions, asthmatic bronchitis, DNA mutagen, carcinogenic	Seeps into landfill leachate, and if burned, become airborne
Polyvinyl Chloride (PVC) (type of plastic used in older models of computers)	Accumulates in human body fat, carcinogenic, and is a hormone disruptor	When burned, dioxin is released. It is environmentally persistent with the potential to settle on crops and in waterways.

Source: SVTC, 2004.

The implications for management and exposure to these metals is obvious for developing countries that burn and otherwise improperly dispose of WEEE. What is less obvious is that the risk of significant exposure is very much so a possibility in the US. The US maintains inconsistent data about the flow of WEEE: some reaches the landfill as household waste, some is incinerated, and some is still sent for illegal export. This is partially due to the difficulty in categorizing and recycling the individual components of EEE.

Cathode ray tubes (CRTs) are used for older video displays for the years between 1997 and 2004 (SVTC, 2004). These components are considered hazardous waste under both federal and state law because they contain high levels of lead and other heavy metals (about 4-8 lbs per television), as will be discussed later in the complications with e-waste management (SVTC, 2004).

Initiatives are led nationwide to improve on the quality and design of EEE to include less heavy metals and hazardous substances, which means easier re-use and recyclability for future EoL products. However, the issue is with the existing and growing Everest of e-waste as households and small businesses clear out their basements of unused equipment and know of no other option to dispose of their products except for the landfill. Furthermore, as enforcement on international and transboundary movements of e-waste becomes more stringent, e-waste will persist in the environment until it is properly managed.

Appendix B: Categories of EPR Models

Dual Model

The Dual Model holds the industry or the producer solely responsible for costs and proper disposal of the products throughout the lifecycle (Lindhqvist, 2015, p. 5). This model exists in Austria, Germany, and Sweden. Germans hold a seminal example of the Dual Model with the "German Green Dot" scheme implemented back in 1991 to manage waste packaging (Fleckinger & Glachant, 2009, p. 2). This is one of several dual systems to mandate manufactures and distributors to take back empty packaging from consumers free of charge. The green dot on packages to communicate to consumers that it could be recycled (Baughan & Evale, 2004, p. 7). The manufacturer here is then responsible for recycling the returned waste.
As a result, many companies began using less packaging. This scheme has since extended towards e-waste, according to the German-British Chamber of Industry and Commerce (n.d., p. 2). This schematic is very successful for companies that have an identifiable logo, especially when it comes to electronics (Lindquist, 2000, p. 63; Fleckinger & Glachant, 2009, p. 5). In the United States the take-back legislation is intended to incentivize manufacturers to design for product recovery (DfR) (Atasu & Subramanian, 2011). This means using less hazardous materials in construction, reusing old components, and by recycling all materials for EoL products. In cases where the distributor is traceable, Producer Responsibility Organizations (PRO) are key stakeholders, as coined in the EU (Deloitte, 2014). PROs set up industry-wide schemes to reinforce EPR approaches (OECD, 2001). The manufacturers can choose to form a coalition with other like-organizations to gather similar products, which can reduce costs for the individual manufacturer and can encourage large-scale infrastructure for recycling (Fleckinger & Glachant, 2009, p. 3). Although PROs are either voluntary or legislative movements, only voluntary coalitions exist in the US.

Industry-municipality model

In countries where the communities are not satisfied with the manufacturer output, the industry-municipality model was born. This model outlines an arrangement between the producer and the local municipalities for cooperative e-waste management and collection (Lindhqvist, 2015, p. 5). This model alleviates pressure from the manufactures and provides a framework to manage solid waste in parcels. The municipalities manage sorting and collection, while the manufacturer provide funding. In theory, this should provide a more efficient and convenient service for the people. An unspoken nuance, but no less important, is that the model would not be successful without the support of the government (Lindhqvist, 2015, p. 5).

Countries like Belgium, Spain, France, and the Czech Republic applied the industry-municipality model to solid waste management to address the issues with the dual model. For instance, the model in Belgium reflects the industry-municipality model with one uniform program for collection with local or municipal level adaptations (Adams, 2015, p. 3). Very

like the German Dot Program, the Belgians first focused on take-back initiatives for packaging products. The difference being more commitment for the local authorities. Private waste collectors gather all industrial and commercial waste, door to door collection for household waste, and incentivizing consumer independence with composting (Adams, 2015, p. 16). The EPR scheme is coupled with a policy instrument like recycling targets or landfilling bans passed a certain tonnage (Adams, 2015, p. 10). This model has proven successful in countries that have a reliable reinforcement from the law and strict government sanctions. Many examples of this in the US are at the state level in Wisconsin or Minnesota that have implemented strict recycling targets for producers to collect e-waste (Nash & Bosso, 2013). This resulted in about a 4-lb. per capita recycling rate in just one year in Minnesota (Nash & Bosso, 2013). This model is regionally appropriate given economic stability and a 'level playing field' (Adams, 2015, p. 28). In short, success of the model is contingent upon natural fair competition.

Trade credits model

The tradable credits model is adopted mainly in the United Kingdom where the producers buy 'packaging recovery notes' or evidence that the waste product was upcycled (Lindhqvist, 2015, 12). This schematic allows producers within the same industry to trade recyclable commodities, so that an industry-wide target is met. This allows perhaps smaller firms within an industry to perform less efficiently than another firm with more advanced infrastructure. It does not matter who meets the goal, but it matters that the goal is met (Walls, 2006, p. 3). This is a model like carbon standards, yet applied to solid waste management. Walls (2006) states that the feasibility of this model is more cost-effective, but an industry-wide recycling target might not drive producers to improve the 'design for the environment' (DfE) like reducing material usage, downsizing a product, or make a product less hazardous if the standards can still be met without a large change (p. 20). The trade credits model is yet to be seen in the US.

Other variations between models

The three models outline the most prominent global distinctions between EPR models (Lindhqvist, 2015, 12). Within the models themselves, there can be subtle inconsistencies with the allocation of power, i.e. the ratio of responsibility between municipalities, producers, and consumers. Another variation could be who regulates the PRO for an industry or competition between several PROs may change the economic role (Lindhqvist, 2015, 11). Competition between systems could increase efficiency and productivity or result it monopolies. In some cases, this has proved to show a lack of control of the government over the industry, thus leading to economic instability.

Theoretically, the flexibility of the EPR schematic is ideal because it is flexible and adaptable to changing economic structures and political instruments. The debate is whether EPR is functional on the ground for e-waste even after 20 years of development in OECD countries.

Appendix C: Recycled E-waste Organized by State

#	State	Program Type	Collection Start Date	Recycling Program	For Electronics?	Landfill Ban for Electronics	Effective Year Ban?	Enforcing Department?	Sources
1	CA	Advance Recycling Fee	2005	California Electronic Waste Recycling Program	Yes, given to the state to pay recyclers	Yes, for CRT, TV, monitors, computers, printers, VCRs, CP, telephones, radios, and microwaves, 2006	2006	- California Department of Resources Recycling and Recovery (CalRecycle) - Department of Toxic Substances Control	- SB50 - SB20 - Electronic Waste Recovery and Recycling
2	CT	Producer Responsibility Program – take back	2010	State operated program	Yes, Connecticut's Electronics Recycling Law	Yes, computers, laptops, computer monitors, TVs, printers, and components	2009	- CT DEEP	Connecticut's Electronics Recycling Law
3	Hawaii	PRP	2010	Manufacturer operated Hawaii electronic device and television recycling law	Yes, Computers, Laptops, Computer Monitors, Computer Printers, Televisions	None	---	Hawaii Department of Health	Hawaii Electronic Waste and Television Recycling and Recovery Law
4	Illinois	Producer Responsibility Program	2010	Manufacturer Operated Program	yes, computers, laptops, computer monitors, printers, televisions, electronic keyboardsm fax machines, VCRs, portable digital musics players, DVD players, video game consoles, small scale servers, scanners, electronic mice, digital converter boxes, cable receivers, satellite receivers, DVRs	Yes, computers, laptops, computer monitors, televisions, and printers	2012	Illinois Environmental Protection Agency	Public Act 097-0287

#	State	Program Type	Collection Start Date	Recycling Program	For Electronics?	Landfill Ban for Electronics	Effective Year Ban?	Enforcing Department?	Sources
5	Indiana	Producer Responsibility Program – take back	2010	Manufacturer Operated Program, Indiana E-waste Program	Yes, computers monitors, laptops, televisions	Yes, computers, laptops, computer monitors, televisions, printers and others	2011	Indiana Department of Environmental Management	
6	Maine*	Producer Responsibility Program – take back	2006	State operated program – Maine E-waste Manufacturer Responsibility Program	Yes, laptops, computer monitors, printers, televisions, digital photo frames, DVD players	Yes, CRT containing devices	2006	Maine Department of Environmental Protection	
7	Maryland	PRP – take back	2006	Man. Operated, Maryland Recycling Program	Yes, computers, comp monitors, laptops, TVs	None		Maryland Department of the Environment	Maryland Statewide Electronics Program
8	Michigan	Producer Responsibility Program – take back	2010	Man. Operated, Michigan Electronic Waste Takeback Program	Yes, computers, comp monitors, laptops, printers, televisions	None	-	Michigan Department of Natural Resources and Environment	Michigan Electronics Law
9	Minnesota	Producer Responsibility Program – take back	2007	Manufacturer Operated, Minnesota Electronics Recycling Program	Yes, comp monitors, laptops, TV, comp, peripherals (printers, keyboards, mice), fax machines, DVD players, VCRs	Yes on CRT computer monitors and TV	2006	Minnesota Pollution Control Agency	Minnesota Electronics Recycling Act

#	State	Program Type	Year	Recycling Program	For Electronics?	Landfill Ban for Electronics	Effective Year Ban?	Enforcing Department?	Sources
10	Missouri	PRP	2010	Manufacturer operated, e-cycle Missouri program	Yes, computers, laptops, computer monitors	None	-	Missouri Department of Natural Resources	-Missouri Manufacturer Responsibility and consumer Convenience Equipment Collection and Recovery Act -Electronic Scrap Management Rule
11	New Jersey	PRP – trade credits	2011	Manufacturer operated Program, E-cycle New Jersey Program	Yes, computer, comp monitors, laptops, televisions	Yes, comps, laptops, comp monitors, TVs	2011	New Jersey Department of Environmental Protection	Link to Legislation:New Jersey Electronic Waste Management Act E-Waste Management Rules (proposed)
12	New York	Producer Responsibility Program – take back (both individual and collective)	2011	Manufacturer operated - New York E-waste Program	comp, Laptops, comp Peripherals (comp Monitors, Keyboards, Mice, Fax Machines, Printers, Scanners), Small Electronic Equipment (Portable Digital Music Players, VCRs, DVD Players, DVRs, Digital Conv.Boxes, Cable/Satellite Receivers, Video Game Consoles), Small Scale Servers, TVs	Yes, manufacturer, retailers, and owner/operators – 2011; individual/household – 2012; all entities - 2015	2011, 2012, 2015	New York Electrnoic Equipment Recycling and Reuse Act	New York Electronic Equipment Recycling and Reuse Act

#	State	Program Type	Year	Recycling Program	For Electronics?	Landfill Ban for Electronics	Effective Year Ban?	Enforcing Department?	Sources
13	North Carolina	PRP – take back & trade credits	2010	Manufacturer Operated – North Caroline Electronics Management Program	Yes, Computers, Laptops, Computer Monitors, (Keyboards, Mice), Printer Devices, Televisions	Yes, computers, laptops, comp monitors, televisions, keyboards, mice	2011	North Caroline Department of Environment and Natural Resources	Discarded Computer Equipment and Television Management Law
14	Oklahoma	PRP – take back	2009	Manufacturer operated	Yes, computers, laptops, computer monitors	None		Oklahoma Department of Environmental Quality	Oklahoma Computer Equipment Recovery Act Oklahoma E-Waste Recycling Rule
15	Oregon	PRP	2009	Manufacturer operated, Oregon e-cycles	Yes, Computers, Laptops, Computer Monitors, and Televisions. (Beginning in 2015, Keyboards, Mice, and Printers)	Yes, computers, laptops, comp monitors and TVs	2010	Oregon Department of Environmental Quality	Oregon Electronics Recycling Law Oregon Laws 2015 (PDF)
16	Pennsylvania	PRP -	2012	Manufacturer operated, PA electronics recycling management program	Yes, Computers, Laptops, Computer Monitors, (Printers, Keyboards, Mice), Televisions	Yes, certain electronics	2013	Pennsylvania Department of Environmental Protection	Pennsylvania Covered Device Recycling Act
17	Rhode Island	PRP – take back legislation and trade credits	2009	Yes, state operated, rhode island electronic waste program	Yes, computers, laptops, computer monitors, and televisions	Yes, comp, laptops, comp monitors, and TVs	2009	Rhode Island Department of Environmental Management	Rhode Island Electronic Waste Prevention, Reuse and Recycling Act
18	South Carolina	PRP – take back & trade credits	2011	Manufacturer operated - e-cycle south carolina	Yes, comps, laptops, comp monitors, printers, TVs	Yes, comp, laptops, comp monitors, TVs, printers, keyboards, mice	2011	South Carolina Department of Health and Environmental Control	South Caronlina Covered Device Recycling Act
19	Texas	PRP – take back legislation	2008	Manufacturer operated – Texas computer equipment recycling program and Texas television equipment recycling program	Yes, Computers, Laptops, Computer Monitors, Computer Peripherals (Keyboards, Mice), Televisions	None		Texas computer equipment recycling law	Texas Computer Equipment Recycling Law

#	State	Program Type	Year	Recycling Program	For Electronics?	Landfill Ban for Electronics	Effective Year Ban?	Enforcing Department?	Sources
20	Utah	PRP – plan only		Manufacturer operated	Yes, Computers, Laptops, Computer Monitors, Computer Peripherals (Printers, Keyboards, Mice), Televisions, Television Peripherals	None		Utah Department of Environmental Quality	Utah Disposal of Electronic Waste Law
21	Vermont	PRP	2011	State operated, Vermont e-cycles program	Yes, Computers, Laptops, Computer Monitors, Printers, Televisions, Computer Peripherals	Yes, computers, laptops, computer monitors, printers, computer peripherals, televisions, personal electronics (PDA, personal music player), electronic game consoles, fax machines, cell phones, telephones, answering machines, VCRs, DVD players, digital converter boxes, stereo equipment, and power supply cord (as used to charge electronic devices)	2011	Vermont Department of Environmental Conservation	Vermont Collection and Recycling of Electronic Devices Law Vermont Procedure for the Environmentally Sound Management of Electronic Devices for Collectors, Transporters, and Recyclers
22	Virginia	PRP	2009	Manufacturer program, Program Website:Virginia Computer Recover and Recycling Program	Yes, computers, laptops, comp monitors	None		Virginia Department of Environmental Quality	Virginia Computer Recovery and Recycling Act
23	Washington	PRP – state operated – producer pays– trade credits	2009	State operated – e-cycle Washington	Yes, computers, laptops, comp monitors, TVs	None		Washington Department of Ecology	--Washington Electronic Product Recycling Law --Washington Electronic Products Recycling Program Rules

#	State	Program Type	Year	Recycling Program	For Electronics?	Landfill Ban for Electronics	Effective Year Ban?	Enforcing Department?	Sources
24	West Virginia	PRP	2009	Manufacturers operated – west Virginia electronics recycling programs	Yes, computers, laptops, comp monitors, televisions	Yes, computers, laptops, comp monitors, TVs	2011	West Virginia Department of Environmental Protection	West Virginia Covered Electronic Device Law
25	Wisconsin	PRP	2010	Manufacturer operated - E-Cycle Wisconsin Program	Yes, Computers, Laptops, Computer Monitors, Printers, Televisions	Yes, televisions, computers, laptops, computer monitors, computer peripherals, printers, fax machines, DVD players, VCRs and cell phones that became effective	2010	Wisconsin Department of Natural Resources	Wisconsin Electronic Waste Recycling Act

Source: ETBC, 2016; ERCC, 2016; PSI, 2016

Key	
	Advance Recycling Fee
	Education Only
	State-Operated Program
	Manufacturer-Operated Program