AN INDUSTRY BLOWING SMOKE

10 Reasons Why Gasification, Pyrolysis & Plasma Incineration are Not "Green Solutions"

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Global Alliance for Incinerator Alternatives
Global Anti-Incinerator Alliance

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EXECUTIVE SUMMARY

Studies that have comprehensively reviewed gasification, pyrolysis and plasma incinerators have found that they provide little to no benefit when compared to mass burn incinerators, while being an even riskier investment. For example, the Fichtner Consulting Engineers report *The Viability of Advanced Thermal Treatment in the UK* commissioned by the United Kingdom Environmental Services Training in 2004 states that, "Many of the perceived benefits of gasification and pyrolysis over combustion technology proved to be unfounded. These perceptions have arisen mainly from inconsistent comparisons in the absence of quality information."[1] The core impacts of all types of incinerators remain the same: they are toxic to public health, harmful to the economy, environment and climate, and undermine recycling and waste reduction programs.

The term "staged incineration" referenced by Fichtner Consulting Engineers (2004)[2] is used in this report to refer to gasification, pyrolysis and plasma incineration technologies. All of these technologies utilize a multi-step process that results in incineration. The following is a summary of the ten reasons addressed in this report why gasification, pyrolysis and plasma incineration are not "green solutions" as claimed by industry representatives:

REASON #1: When compared to conventional mass burn incinerators, staged incinerators emit comparable levels of toxic emissions.

The European Commission's *Integrated Pollution Prevention and Control Reference Document on the Best Available Technologies for Waste Incineration* found that "...emission levels for releases to air from the combustion stage of such [gasification and pyrolysis] installations are the same as those established for incineration installations."[3]

Overall, identified emissions from staged incinerators include particulate matter, volatile organic compounds (VOCs), heavy metals, dioxins, sulfur dioxide, carbon monoxide, mercury, carbon dioxide and furans.[45] Even small amounts of some of these toxins can be harmful to human health and the environment. Mercury, for example, is a powerful and widespread neurotoxin that impairs motor, sensory and cognitive functions.[6] Dioxin is the most potent carcinogen known to humankind—to which there is no known safe level of exposure.[7] Health impacts of dioxin include cancer,[8] disrupted sexual development, birth defects, immune system damage, behavioral disorders and altered sex ratios.[9] Incineration of municipal solid waste is a leading human-made source of dioxins in the United States.[10] Particularly at high risk of exposure to dioxin and other contaminants are workers at incinerators[11] and people living near incinerators,[12 13 14] but the toxic impacts of incineration are far-reaching: persistent organic pollutants (POPs) such as dioxins and furans travel thousands of miles and accumulate in animals and humans. Contaminants are also distributed when food produced near incinerators is shipped to other communities.[15]

In all incineration technologies, air pollution control devices are mainly devices that capture and concentrate the toxic pollutants; they don't eliminate them. By capturing and concentrating the pollutants, pollutants are transferred to other environmental media such as fly ash, char, slag, and waste water.

REASON #2: Emissions limits for incinerators (including mass burn, gasification, pyrolysis and plasma incineration) don't ensure safety. Also, emissions from incinerators are not measured sufficiently and thus overall emissions levels reported can be misleading. In addition, emission limits are not always adequately enforced.

First, emissions standards tend not to be based on what is scientifically safe for public health, but on what is determined to be technologically feasible for a given source of pollution. As the U.S. EPA itself has written, "Since EPA could not clearly define a safe level of exposure to these cancer-causing pollutants, it became almost impossible to issue regulations."[16] Instead, U.S. EPA standards were created solely to require "emitters to use the best control technologies already demonstrated by industry sources."[17] As a result, these standards allow for the release of unsafe levels of harmful pollutants such as dioxins, mercury and lead. Additionally, these inadequate standards only regulate a handful of the thousands of known pollutants, and do not take into account the exposure to multiple chemicals at the same time. These are called "synergistic" impacts and have countless harmful effects on health and the environment. Second, emissions from incinerators are not measured sufficiently. The most dangerous known pollutants, such as dioxin and mercury, are rarely monitored on a continuous or accurate basis in gaseous, solid and liquid emissions from incinerators. Thus overall emissions levels reported can be misleading. Third, emission limits that do exist are not always adequately enforced. Existing incinerators are sometimes allowed to continue to operate despite emission limit violations.

REASON #3: Gasification, pyrolysis and plasma incinerators have a dismal track-record plagued by malfunctions, explosions and shut-downs.

Many operational problems at staged incinerators have proven costly and dangerous for the communities where such facilities have been constructed. For example, Thermoselect's Karlsruhe, Germany incinerator—one of the largest municipal solid waste gasification incinerators in the world—was forced to close down permanently in 2004 due to years of operational problems and loses totaling over $400 million Euros.[18] Operational problems included an explosion, cracks in the reactor siding due to temperatures and corrosion, a leaking waste water basin, a leaking sediment basin that held cyanide-contaminated wastewater, and forced closure after uncontrolled releases of toxic gases were discovered.[19] Likewise, in 1998, a "state-of-the-art" pyrolysis incinerator in Furth, Germany that was processing municipal solid waste suffered a major failure, resulting in the release of pyrolysis gas into the air. An entire neighborhood had to be evacuated, and some residents in the surrounding community were brought to the hospital for observation.[20]

In many countries, including Canada, France, India, the United States and United Kingdom, municipalities have rejected proposals for gasification, pyrolysis and plasma incineration technologies because the emissions, economic, and energy benefits claimed by industry representatives have proven to be unfounded. As the *Palm Beach Post* newspaper reported about the Geoplasma plasma arc proposal in St. Lucie County, Florida, U.S., "'The numbers,' Commissioner Coward said, 'were pretty impressive.' He asked for proof. The company couldn't provide it. The county hired a consultant, who said there is no proof."[21]

REASON #4: Staged incineration is not compatible with recycling; gasification, pyrolysis and plasma incinerators compete for the same financing and materials as recycling programs. Incineration also undermines efforts to minimize the production of toxic and unrecyclable materials.

In order to survive financially, staged incineration technologies need a constant supply of both waste and public money in the form of long term "put or pay" contracts. Put or pay incinerator contracts require municipalities to pay a predetermined monthly fee to the incinerator for decades to come, regardless of whether it makes economic or ecological sense to do so in the future. As a result, these contracts destroy the financial incentives for a city to reduce and separate its waste at the source, and reuse, recycle and compost.

Staged incinerators destroy otherwise recyclable and compostable materials. U.S. EPA data shows that approximately 90% of materials disposed in U.S. incinerators and landfills are recyclable and compostable materials.[22] Similarly, even with a citywide recycling rate at over 70%, the San Francisco Department of Environment 2006 *Waste Characterization Study* found that two-thirds of the remaining materials that are being disposed of are readily recyclable and compostable materials.[23] As the San Francisco City and County Environment Director said in a 2009 press release, "'If we captured everything going to landfill that could have been recycled or composted, we'd have a 90 percent recycling rate.'"[24]

The high costs and long-term waste contracts of gasification, pyrolysis and plasma incinerators also undermine efforts to minimize the *production* of toxic and unrecyclable materials. The small percentage of materials left over after maximum recycling, reuse and composting—called "residuals"— are often toxic, complex and have low energy value. Staged incineration is not an appropriate strategy to deal with this portion of the waste stream. Doing so creates harmful emissions, can facilitate operational issues, provides little to no energy value, and undermines efforts to minimize waste. A more practical approach is to cost-effectively and safely contain the small unrecyclable percentage of the waste, study it, and implement extended producer responsibility and other regulations and incentives so that these products and materials are phased out of production and replaced with sustainable practices.

REASON #5: Staged incinerators are often even more expensive and financially risky than mass burn incinerators.

The public bears the financial burden of all types of incineration. Costs to local governments are high, and communities end up paying with tax money and public health costs. Alternatively, recycling and composting make more sense economically than either incineration or landfilling.

Gasification, pyrolysis and plasma incineration are often even more expensive and financially risky than already costly conventional mass burn incinerators. The United Kingdom Fitchtner Consulting Engineers report *The Viability of Advanced Thermal Treatment* found that, "…there is no reason to believe that these technologies [gasification and pyrolysis] are any less expensive than combustion and it is likely, from information available, that the more complex processes are significantly more expensive."[25]

One example of higher costs are the proposed tipping fee estimates provided by gasification, pyrolysis and plasma incinerator companies to Los Angeles County, California, US in 2005. The estimated tipping fees are two to four times greater than the average U.S. incinerator tipping fee.[26]

Gasification, pyrolysis and plasma incinerators also present financial risk due to an operational history plagued by malfunctions, an inability to produce electricity reliability, regular shut-downs and explosions. As the European Commission 2006 report concludes, "At the time of writing, the additional technological risk associated with the adoption of gasification and pyrolysis for many wastes, remains significantly greater than that for better proven, incineration type thermal treatments."[27]

REASON #6: Incinerators inefficiently capture a small amount of energy by destroying diminishing resources. Gasification, pyrolysis and plasma incinerators are even less efficient at generating electricity than mass burn incinerators.

Incinerator power plants inefficiently generate electricity through the combustion of waste and/or waste gases. In terms of overall energy benefit, it is always preferable to recycle materials rather than incinerate them. Recycling saves three to five times the amount of energy that incinerator power plants generate.[28] As the 2008 Tellus Institute report *Assessment of Materials Management Options for the Massachusetts Solid Waste Master Plan Review* commissioned by the Massachusetts Department of Environmental Protection explains:

> Recycling saves energy, reduces raw material extraction, and has beneficial climate impacts by reducing CO2 and other greenhouse gas emissions. Per ton of waste, the energy saved by recycling exceeds that created by landfill gases or the energy harnessed from thermal conversion technologies.[29]

Promoters of gasification, pyrolysis and plasma arc incinerators claim that these technologies have higher energy efficiency rates than mass burn incinerators, but these claims are unfounded. In fact, the United Kingdom Fichtner Consulting Engineers report *The Viability of Advanced Thermal Treatment* found that, "The conversion efficiencies for the gasification and pyrolysis technologies reviewed were generally lower than that achievable by a modern [mass burn] combustion process."[30] Other researchers and journalists have found that some staged incineration plants have not been successful in producing more electricity than they consume in the process.

The issue of energy inefficiency lies with the fundamental nature of staged incineration technologies. First, gasification, pyrolysis and plasma incinerators often require pretreatment processes to prepare the wastes such as shredding and drying; these processes can consume significant quantities energy. Second, unlike mass burn incinerators which rely on oxygen to keep the fire burning, the starved-oxygen environments used in these technologies requires additional input of energy to maintain the process. This energy input is generated by the combustion of fossil fuels such as natural gas and oil, and by the use of heat and electricity generated by the incineration process.

REASON #7: Incinerating discarded materials depletes resources and in many cases permanently damages the natural environment.

The large volume of waste disposed in landfills and incinerators around the world is not sustainable. In the past three decades alone, one-third of the planet's natural resource base has been consumed.[31] Incinerators contribute to the environmental crisis by cornering large amounts of public money for the purpose of long-term disposal of diminishing natural resources. Resolving the environmental crisis requires that municipalities invest in preventing waste and reusing, recycling and composting materials currently disposed in incinerators and landfills.

It is vital that biodegradable (biomass) materials immediately cease to be put into landfills, where these materials decompose in conditions that generate potent greenhouse gas emissions. Likewise, incinerating biodegradable and other materials contributes greenhouse gas emissions and environmental degradation. For the health of the climate and the soil, it makes far more sense to prevent waste and compost, anaerobically digest or recycle biodegradable materials than to incinerate or landfill them.

An emerging technology called anaerobic digestion shows promising signs for safely and sustainably processing source separated biodegradable discards—while simultaneously generating energy. As the 2008 Tellus Institute report *Assessment* *of Materials Management Options for the Massachusetts Solid Waste Master Plan Review* commissioned by the Massachusetts Department of Environmental Protection concludes:

> The prospects for anaerobic digestion facilities appear to be more favorable [than gasification and pyrolysis] given the extensive experience with such facilities in the U.S. for the processing of sewage sludge and farm waste and the fact that no significant human health or environmental impacts have been cited in the literature. Moreover, since anaerobic digestion is more similar to composting than high-temperate combustion, its risks are expected to be akin to composting, which is considered low-risk.[32]

REASON #8: Staged incineration technologies contribute to climate change, and investment in these technologies undermines truly climate-friendly solutions.

In terms of greenhouse gas emissions released per ton of waste processed, recycling is a much preferable strategy to staged incineration. As the findings of the Tellus Institute report reveal:

> On a per ton basis, recycling saves more than seven times eCO_2[33] than landfilling, and almost 18 times eCO_2 reductions from gasification/pyrolysis facilities.[34]

Mass burn incinerators emit more CO_2 per unit of electricity generated than coal-fired power plants.[35] Incinerators also emit indirect greenhouse gases such as carbon monoxide (CO), nitrogen oxide (NOx), non-methane volatile organic compounds (NMVOCs), and sulfur dioxide (SO2).[36] [37] Gasification, pyrolysis and plasma incinerators are even less efficient generators of electricity than mass burn incinerators, and require inputs of additional fossil fuel-derived fuels and/or electricity to operate, and energy for the pre-processing of materials. As a result these incinerators may have an even larger climate footprint than conventional mass burn incinerators.

U.S. incinerators are among the top 15 major sources of direct greenhouse gases to the atmosphere that are listed in the US EPA's most recent inventory of US greenhouse gas emissions.[38] Far greater than the impact of greenhouse gas emissions released from incinerators is the lifecycle climate impact of incinerating rather than preventing waste and reusing, recycling or composting materials. For every item that is incinerated or landfilled, a new one must be created from raw virgin resources rather than reused materials.

For biodegradable materials, source separation of materials followed by composting and/or anaerobic digestion allows insignificant fugitive methane releases to the environment, and, overall, yields far fewer greenhouse gas (GHG) emissions than landfills and incinerators.[39]

Incinerator companies often do not count CO_2 emissions released from biomass combustion and claim that these emissions are "climate neutral". They claim that this is consistent with the protocol established by the Intergovernmental Panel on Climate Change (IPCC). This is not accurate. The IPCC clearly states that biomass burning for energy can *not* be automatically considered carbon neutral even if the biomass is harvested sustainably.[40] The IPCC also clearly states that incinerating biomass is *not* "CO_2 neutral" or "carbon neutral". Ignoring emissions from incinerating biomass fails to account for lifecycle releases in CO_2 caused when materials are incinerated rather than conserved, reused, recycled or composted.

REASON #9: All types of incinerators require a large amount of capital investment, but they create relatively few jobs when compared to recycling and composting programs.

Recycling industries provide employment benefits that far outpace that of waste incinerators and landfills. The U.S. EPA has said that, "for every 100 recycling jobs created, …just 10 jobs were lost in the solid waste industry, and three jobs were lost in the timber harvesting industry.[41] There is no specific job data for staged incinerator technologies available, but it is likely that job prospects for these facilities would be similar to mass burn incinerators. Because incinerators compete with recycling programs for the same funding and materials, constructing a gasification, pyrolysis or plasma incinerator can undermine job creation opportunities.

The U.S. Environmental Protection Agency's *U.S. Recycling Economic Information Study* found that recycling industries already provide more than 1.1 million jobs in the U.S., which is comparable in size to that of the U.S. auto manufacturing and machinery manufacturing industries.[42] Recycling industries generate an annual payroll of nearly $37 billion and gross over $236 billion in annual revenue.[43] With a meager 34% national recycling rate in the U.S., there is great potential for what can still be achieved for workers and the economy through greater materials reuse. The quality of recycling jobs is not guaranteed. In some locations where worker rights are not protected, recycling jobs can be unsafe and low paying. However, employment conditions can be significantly improved when workers are unionized.

Regions that have made commitments to increase recycling rather than disposal are realizing tangible benefits to their local economies. For instance, because the state of California, U.S., requires the recycling and reuse of 50 percent of all municipal solid waste, recycling accounts for 85,000 jobs and generates $4 billion in salaries and wages.[44] Similarly, according to a 2007 Detroit City Council report, a 50 percent recycling rate in Detroit would likely result in the creation of more than 1,000 new jobs in that city alone.[45] Greater public investment in reuse rather than disposal of valuable discarded materials could spark a green economy in countries around the world, restoring much-needed quality unionized jobs to communities.

REASON #10: Wasting valuable natural resources in incinerators and landfills is avoidable and unnecessary.

The vast majority of discarded resources can be reused, recycled or composted.[46] Residual materials that are too toxic or complex to recycle can and should be required to be made so that they are recyclable, built to last, and non-toxic. To do so requires a commitment to work for what is known as "Zero Waste".

Zero Waste means establishing a goal and a plan to invest in the infrastructure, workforce, and local strategies needed to eliminate our dependence on incinerators and landfills. Cities around the world, including Buenos Aires (Argentina), Canberra (Australia), Oakland (U.S.), Nova Scotia (Canada), Seattle (U.S.) and others, have already made great progress towards achieving Zero Waste. These cities are building recycling and composting parks, implementing innovative collection systems, requiring products to be made in ways that are safe for people in the planet, and creating locally-based green-collar jobs. A variety of policies, such as Extended Producer Responsibility, Clean Production, packaging taxes, and material- specific bans (such as plastic bags, styrofoam, PCBs, etc.) have proven effective at reducing and eliminating problematic materials in different locales.

Supporting Zero Waste requires ending subsidies for waste projects such as staged incineration that contaminate environments and the people who live in them, and instead investing in innovative waste reduction, reuse and recycling programs. Besides saving resources and money, and generating more jobs for local communities, Zero Waste produces far less pollution than waste disposal techniques, including global warming pollution.

Introduction

A NEW GENERATION of waste incinerators called gasification, pyrolysis and plasma (or plasma arc) are being proposed in communities around the world. Companies promoting these technologies claim that they can safely, cost-effectively and sustainably turn many different types of municipal, medical, industrial and other waste materials into electricity and fuels. Many companies go so far as to claim that their technology is "green," "pollution-free," produces "renewable energy" and is not, in fact, incineration at all.

However, these technologies are classified as incinerators by the U.S. Environmental Protection Agency[47] and the European Union.[48] The term "staged incineration" referenced by Fichtner Consulting Engineers (2004)[49] is used in this report to refer to gasification, pyrolysis and plasma incineration. All of these technologies utilize a multi-step process that combines high heat followed by combustion. Staged incinerators processing municipal solid waste (MSW) release dioxins, heavy metals, carbon dioxide, and other harmful pollutants into the air, soil and water.[50,51] Many municipalities around the world have rejected proposals for these technologies because the benefits purported by industry representatives have not been supported by facts. Other municipalities have invested in these technologies only to find that they have been plagued by high costs, operational failures, harmful emissions and an inability to reliably produce electricity.

Studies that have comprehensively reviewed staged incinerators have found that they provide little to no benefit when compared to mass burn incinerators, while being an even riskier investment. For example, the Fichtner Consulting Engineers report *The Viability of Advanced Thermal Treatment in the UK* commissioned by the United Kingdom Environmental Services Training in 2004 states that, "Many of the perceived benefits of gasification and pyrolysis over combustion technology proved to be unfounded. These perceptions have arisen mainly from inconsistent comparisons in the absence of quality information."[52]

Similarly, the Tellus Institute report *Assessment of Materials Management Options for the Massachusetts Solid Waste Master Plan Review* commissioned by the Massachusetts Department of Environmental Protection in 2008 concludes that, "gasification and pyrolysis facilities are unlikely to play a major role in MSW management in Massachusetts [U.S.] by 2020" due to the following issues:

> the lack of experience in the U.S. with large-scale alternative technology facilities successfully processing mixed MSW and generating energy; the long lead times to plan, site, construct, and permit such facilities; the significant capital costs required and the loss of solid waste management flexibility that is associated with the long-term contractual arrangements that such capital-intensive facilities require; and the relatively small benefit with respect to greenhouse gas emissions compared to diversion or landfilling.[53]

In fact, this study by the Tellus Institute found that, "On a per ton basis, recycling saves more than seven times eCO2 than landfilling, and almost 18 times eCO2 reductions from gasification/pyrolysis facilities."[54]

The core impacts of all types of incinerators are the same: they are toxic to public health, harmful to the economy, environment and climate, and damaging to recycling and waste reduction programs. This document exposes the reality behind the myths promoted by the gasification, pyrolysis and plasma incinerator industry and provides ten reasons why staged incineration is not the "green" solution often claimed by industry representatives.

What are gasification, pyrolysis and plasma incinerators?

There are many different kinds of incinerator technologies and many different combinations of material feedstocks that are processed by incinerators. (A list of technologies and feedstocks are presented in appendix A). This report focuses on staged incineration technologies including gasification, pyrolysis and plasma, which are utilized to incinerate a variety of material feedstocks such as municipal solid waste, medical waste, industrial waste and biomass. Like mass burn incinerators, gasification, pyrolysis and plasma incinerators turn discarded materials into solid byproducts (such as ash, slag and char), liquid discharges, and gaseous emissions and heat which can be used to generate electricity.

The core impacts of all types of incinerators remain the same: they are toxic to public health, harmful to the economy, environment and climate, and damaging to recycling and waste reduction programs.

There are notable process differences between conventional mass burn incinerators and staged incinerators. In basic terms, while mass burn incinerators combust waste in one single chamber in an oxygenated environment, gasification, pyrolysis and plasma incinerators heat waste materials in one chamber with limited oxygen present, and then combust the released waste gases (and char and other solid byproducts in the case of some staged incinerators) in a separate chamber.

Gasification, pyrolysis and plasma incinerators typically utilize either a steam or a gas turbine to generate electricity. Steam powered technologies generate electricity by combusting waste gases to create heat; using the heat to create steam; and then using the steam to power a turbine. Gas powered technologies generate electricity by combusting waste gases in a gas-fired engine, which then directly powers a turbine. In addition to these processes, some companies claim that they can use waste gases and oils to create liquid fuels to be combusted in vehicles or industrial facilities off-site.

The major variations between gasification, pyrolysis and plasma incineration technologies have to do with the different temperature levels used in the processes and the amount of air or oxygen present. Precise definitions of these technologies are not clearly established and there is a lack of consistency across the industry in the use of each term. The three processes can be roughly defined as follows:

Gasification: The rapid thermal decomposition of material by partial oxidation through the addition of limited amounts of air or oxygen. Moderate temperatures are typically above 750° C.

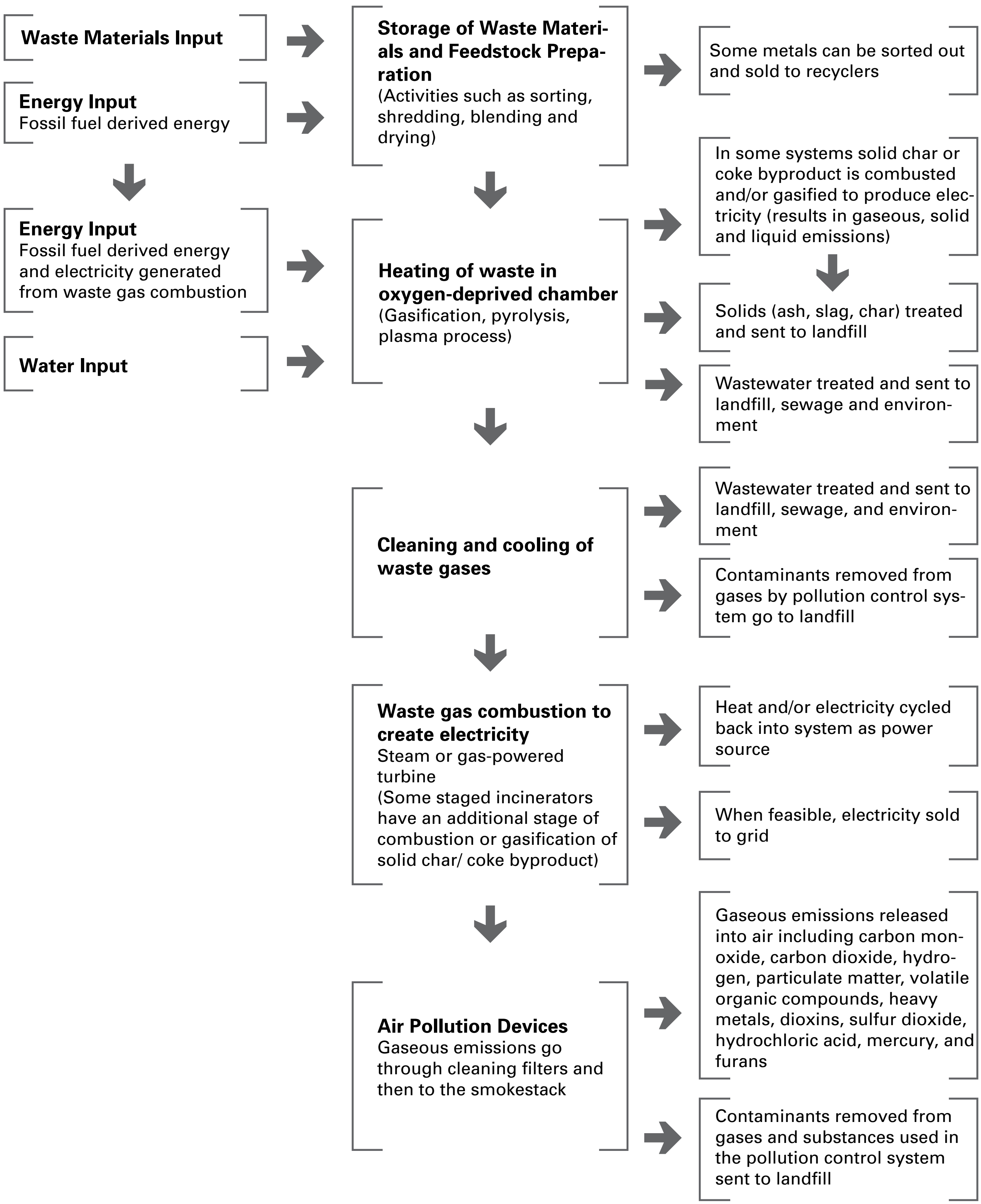
Pyrolysis: The rapid thermal decomposition of material without the addition of air or oxygen (although there is inevitably oxygen present in the waste materials themselves). The temperature range is approximately 250–700 °C.

Plasma: The rapid thermal decomposition of material by partial oxidation through the addition of limited amounts of air or oxygen. This technology uses electrical energy and high heat with temperatures ranging approximately from 1000–4500 °C. Plasma is usually described as being part of a gasification system.

In general, pyrolysis uses less air or oxygen in the process and lower temperatures than gasification. As a result, (in addition to syngas produced) other byproducts in addition to gases can vary; char and pyrolysis oil are produced through pyrolysis, rather than bottom ash produced through gasification. In addition, high temperature gasification and plasma gasification or plasma arc gasification can produce a vitrified slag residue.

There are several major stages which generally occur in the processes of gasification, pyrolysis and plasma incinerator technologies, which are summarized in the table below. Note that the processes for different technologie can vary.

CHART #1: Staged Incineration Processes



10 Reasons Why GASIFICATION, PYROLYSIS & PLASMA Incineration are Not the "Green Solutions" Often Claimed by Industry Representatives

REASON #1: Gasification, pyrolysis and plasma incinerators (like mass burn incinerators) contaminate people and the environment with toxic and cancer-causing gaseous, liquid and solid releases.

INDUSTRY MYTH: Gasification, pyrolysis and plasma incinerators are safe and pollution-free.

Gasification, pyrolysis and plasma incineration companies often claim that their technologies do not have toxic consequences for communities and the environment. However, studies show that, when compared to conventional mass burn incinerators, staged incinerators emit comparable levels of toxic emissions. For example, the European Commission's *Integrated Pollution Prevention and Control Reference Document on the Best Available Technologies for Waste Incineration* found that "...emission levels for releases to air from the combustion stage of such [gasification and pyrolysis] installations are the same as those established for incineration installations."[55] Similarly a 2008 Tellus Institute report commissioned by the Massachusetts Department of Environmental Protection found that, "Pyrolysis produces low levels of air emissions containing particulate matter, volatile organic compounds, heavy metals, dioxins, sulfur dioxide, hydrochloric acid, mercury, and furans. (The types of emissions produced are similar to those from conventional incinerators.)"[56] Moreover, environmental regulatory agencies anticipate the same categories of releases from these types of incinerators.

Studies show that dioxins are created in plasma,[57] pyrolysis[58,59] and gasification[60] incinerators. The 2009 study *Comparison between emissions from the pyrolysis and combustion of different wastes* that appeared in the Journal of Applied and Analytical Pyrolysis, found that pyrolysis incineration can lead to an increase in total toxicity including dioxin and furan formation. The study says, "The formation of PCDD/Fs [dioxin and furans] is important in both combustion and pyrolysis processes. In pyrolysis, there can be a significant increase of congeners and/or an increase of the total toxicity due to the redistribution of the chlorine atoms to the most toxic congeners."[61]

Similarly, a 1997 study published in the journal Chemosphere that examined a commercial scale German municipal waste gasification system operating under pyrolysis conditions, found that dioxins and furans were indeed formed in the process, with particularly high levels in liquid residues.[62] And a 2001 study published in Chemosphere examined the formation of dioxins and furans under pyrolysis conditions and concluded that even at oxygen concentrations lower than 2 percent, considerable amounts of highly toxic polychlorinated dioxins and furans were formed.[63]

In the *Whitepaper on the Use of Plasma Arc Technology to Treat Municipal Solid Waste*, the Florida Department of Environmental Protection (in the U.S.) states its concerns about the pollutants that can be formed by plasma incineration. It says:

> There is considerable uncertainty about the quality of the 'syngas' to be produced by this technology when processing MSW. While the high temperatures can destroy organics, some undesirable compounds, like dioxins and furans, can reform at temperature ranges between 450 and 850 degrees F if chlorine is present.[64]

Likewise, data from the California South Coast Air Quality Management District found that the pilot pyrolysis plant in Romoland, CA emitted significantly greater concentrations of dioxins, NOx, volatile organic compounds and particulate matter (PM10) than the two aging mass burn incinerators in the Los Angeles area.[65]

Some companies claim that they will process waste to create a gas or fuel that can be combusted off-site to power vehicles or other industries. Currently, the author knows of no commercial facility in the world that is successfully producing a liquid fuel from municipal solid waste gasification, pyrolysis or plasma processing. However, if a fuel were to be produced from such a facility the health risks could be even greater than facilities where combus-

TABLE 1: Mass burn vs. pyrolysis: Los Angeles South Coast Air Quality Management District lbs/ton municipal solid waste feed[66]

Pollutants	IES Romoland Pyrolysis Incineration	Mass Burn Incineration Average (regional)
CO	0.22	0.45
NOx	1.60	1.78
SOx	0.01	0.04
VOC	0.35	0.04
PM10	0.05	0.0046
Dioxins/Furans	3.68x10-8	1.85x10-8

tion occurs on site. This is because combustion of gases and/or fuels containing toxins such as dioxin and heavy metals could occur in off-site industries and vehicles that may be even less stringently monitored and regulated than incinerators.

Thomas Cahill, an air pollution expert and retired UC Davis physics professor cautioned in a 2008 Sacramento Bee newspaper article about a proposed plasma arc incinerator for Sacramento, CA, that the environmental concerns extend beyond what comes out of the plant stack to the safety of the gas produced for sale. Cahill says in the article, "When that gas is sold to be burned, say at a power plant, it could emit ultrafine particles of nickel, lead and other toxic metals that can lodge deep in the lungs, enter the bloodstream and raise the risk of a heart attack…If you were near a power plant that burned this, you would be in serious trouble."[67]

Overall, identified emissions from staged incinerators include particulate matter, volatile organic compounds (VOCs), heavy metals, dioxins, sulfur dioxide, carbon monoxide, mercury, carbon dioxide and furans.[68,69] Even small amounts of some of these toxins can be harmful to human health and the environment. Mercury, for example, is a powerful and widespread neurotoxin that impairs motor, sensory and cognitive functions[70], and dioxin is the most potent carcinogen known to humankind—to which there is no known safe level of exposure.[71] Health impacts of dioxin include cancer,[72] disrupted sexual development, birth defects, immune system damage, behavioral disorders and altered sex ratios.[73] Incineration of municipal solid waste is a leading source of dioxins in the United States.[74]

Because emissions released from staged incinerators are comparable to those released from mass burn incinerators, comparable long-term health impacts are likely. Studies show the presence of elevated levels of dioxin in the blood of people living near mass burn municipal solid waste incinerators, when compared to the general population.[75,76,77] Particularly at high risk of exposure are workers at incinerators. As the Commission on Life Sciences of the National Research Council report *Incinerators and Public Health* (2000) states:

> Studies of workers at municipal solid-waste incinerators show that workers are at much higher risk for adverse health effects than individual residents in the surrounding area. In the past, incinerator workers have been exposed to high concentrations of dioxins and toxic metals, particularly lead, cadmium, and mercury.[78]

But high levels of dioxins are also found in food and dairy products produced near incinerators, demonstrating that the toxic impacts of incineration are as far-reaching as the shipment of that food to other communities. This is of particular concern because the U.S. Environmental Protection Agency has found that eating foods such as beef, poultry, fish, milk and dairy products is the primary source of dioxin exposure.[79] These known pollutants are also not the only cause for concern; there are also many unidentified and unregulated compounds in incinerator emissions.

It is also important to consider that in all incineration technologies, air pollution control devices are mainly devices that capture and concentrate the toxic pollutants; they don't eliminate them. By capturing and concentrating the pollutants, pollutants are transferred to other environmental media such as fly ash, char, slag, and waste water. As Dr. Jorge Emmanuel explains in the film *Pyrolysis and Gasification as Health Care Waste Management Technologies,* "In one pyrolysis system I examined in the late 1990s for example, I found that some of the air emissions were actually coming out with the waste water through the sewer system, so stack tests were not at all representative of all the air emissions coming out of that particular pyrolysis system."[80]

Some gasification, pyrolysis and plasma companies claim that all byproducts are inert and can be safely used for commercial purposes such as roadbed construction. However, there is considerable uncertainty about the safety of using solid and liquid residues for commercial purposes due to their high concentration of toxins; rather, it is likely that these residues must be landfilled. The Florida Department of Environmental Protection addresses the issue of contaminants in slag produced by plasma incineration in its *Whitepaper on the Use of Plasma Arc*

Technology to Treat Municipal Solid Waste:

> There is considerable uncertainty about the quality of the 'slag' to be produced by this technology when processing MSW. There is very little leaching data on this material for MSW. One leaching TCLP (Toxicity Characteristic Leaching Procedure) test by PyroGenesis suggests arsenic and cadmium may leach above the groundwater standards. This may adversely impact the beneficial use of this material.[81]

A 1998 review of pyrolysis systems by the Center for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET), a UK research group, raises concerns about residues from pyrolysis and gasification processes:

> The various gasification and pyrolysis technologies have the potential for solid and liquid residues from several process stages. Many developers claim these materials are not residues requiring disposal but are products which can be used. However in many cases such claims remain to be substantiated and any comparison of various waste treatment options should consider releases to air, water and land.[82]

CADDET also paid particular attention to liquid residues:

> The sources of liquid residues from [mass burn combustion] plant are boiler blow-down and wet scrubbing systems, when used for flue gas cleaning. Whilst these sources remain for gasification and pyrolysis systems using steam cycles or wet scrubbers, these technologies can also produce liquid residues as a result of the reduction of organic matter. Such residues have the potential to be highly toxic and so require treatment. Any releases of liquid residues into the environment should therefore be carefully considered.[83]

In the case of pyrolysis incinerators, toxic pollutants such as heavy metals and dioxin are actually consolidated in the solid char byproduct. Fichtner (2004) explains,

> It is true that low temperature pyrolysis plants will tend to volatilise less of certain pollutants into the flue gas resulting in lower emissions. This benefit should be weighed against more pollutants in the pyrolysis residues that have to be landfilled and significantly lower energy efficiency due to the unconverted carbon in the residue.[84]

In addition, studies about particles called "ultra-fines" or "nanoparticles" reveal increased cause for concern about incinerator emissions of dioxin and other toxins.[85] Ultra-fines are particles from any element or byproduct (including PCBs, dioxins and furans) that are smaller in size than what is currently regulated or monitored by the U.S. Environmental Protection Agency. Ultra-fine particles can be lethal to humans in many ways including as a cause of cancer, heart attacks, strokes, asthma, and pulmonary disease, among others.[86] Because of their small size, ultra-fines are difficult to capture with air pollution control devices, and they travel long distances, penetrate deep into the lungs, and can carry neurotoxic metals into the brain.[87]

Some companies claim that they will avoid harmful emissions by only incinerating "clean-burning" materials like wood waste or biomass. However, wood waste often contains hard-to-detect contaminants such as pesticides, preservatives, lead paint, copper, creosote and chlorine. Incineration of these materials can result in emissions including dioxins, furans and lead. Furthermore, economic pressures can encourage incinerator operators to mix waste materials like tires and plastics into what is promoted as "clean" and organic feedstocks, causing increased levels of air pollution. This is especially true when cleaner fuel sources become short in supply or are less financially profitable to the plant. For example, in a 2008 Sacramento Bee newspaper article the assistant city manager of Sacramento, California, U.S., Marty Hanneman, is quoted speaking about the economic pressure to process toxic materials in a plasma arc facility proposed for Sacramento. He says of the company U.S. Science & Technology that, 'They are going to have to look at electronic waste, tires and medical wastes so that they can charge a higher fee to put it into the system.'"[88]

Of particular concern in the United States is a loophole in federal regulations that allows for so-called "biomass boilers" to incinerate up to 35 tons per day of municipal solid waste without being designated an incinerator and regulated under stricter incinerator emissions limits.[89]

Safety related to explosions and systems failures is another area of concern. Explosions can be caused by the leakage of combustible gases from treatment chambers. Corrosion, tar contamination of generators, and fuel blockages are examples of other engineering issues of concern. In 1998, for example, a "state-of-the-art" pyrolysis incinerator in Furth, Germany that was processing municipal solid waste suffered a major failure, resulting in the release of pyrolysis gas into the air. An entire neighborhood had to be evacuated, and some residents in the surrounding community were brought to the hospital for observation.[90]

In another example of operational dangers, prior to being shut down in 2004, the Thermoselect gasification incinerator in Karlsruhe, Germany, experienced operational problems including an explosion, cracks in the reactor siding due to temperatures and corrosion, a leaking waste water basin, a leaking sediment basin that held cyanide-contaminated wastewater, and forced closure after uncontrolled releases of toxic gases were discovered.[91] Likewise, the U.S. federal court case Peat, Inc. v. Vanguard Research Inc., cited in the U.S. state of Indiana that "While undergoing Phase I testing in January of 1999, the plasma energy system designed by PEAT experienced an explosion which blew an 80-pound door off the incinerator." The following month Peat's plasma operation was cancelled.[92]

REASON #2: Emissions limits for incinerators (including mass burn, gasification, pyrolysis and plasma incineration) don't ensure safety. Emissions from incinerators are also not measured sufficiently and thus overall emissions levels reported can be misleading. In addition, emission limits are not always adequately enforced.

INDUSTRY MYTH: Gasification, pyrolysis and plasma incinerators are regulated to standards that ensure that they are safe.

Gasification, pyrolysis and plasma companies often claim that their technologies are regulated to standards that ensure that they are safe. However, this is not true:

Emission limits don't ensure safety. Emissions standards tend not to be based on what is scientifically safe for public health, but on what is determined to be technologically feasible for a given source of pollution. As the U.S. EPA itself has written, "Since EPA could not clearly define a safe level of exposure to these cancer-causing pollutants, it became almost impossible to issue regulations."[93] Instead, U.S. EPA standards were created solely to require "emitters to use the best control technologies already demonstrated by industry sources."[94] As a result, these standards allow for the release of unsafe levels of harmful pollutants such as dioxins, mercury and lead. Additionally, these faulty standards also only regulate a handful of the thousands of known pollutants, and do not take into account the exposure to multiple chemicals at the same time. These are called "synergistic" impacts and have countless harmful effects on health and the environment.

Emissions measurements are insufficient and often misleading. The most dangerous known pollutants, such as dioxin and mercury, are rarely monitored on a continuous basis in gaseous, solid and liquid emissions from incinerators which is the only way to accurately estimate environmental exposure to these emissions. Toxic emissions vary widely based on changes in waste stream feedstock, stack temperature, and other shifting operating conditions, thus occasional monitoring is not adequate for assessing overall emissions levels. If an incinerator is in a country that monitors emissions, it is common for incinerators to only be subject to one or two dioxin stack tests per year, each consisting of a six-hour sample, rather than continuous monitoring, which would be more appropriate. As the Commission on Life Sciences of the National Research Council report Incinerators and Public Health (2000) states:

> Typically, emissions data have been collected from incineration facilities during only a small fraction of the total number of incinerator operating hours and generally do not include data during startup, shutdown, and upset conditions.[95]

These tests are rarely, if ever, conducted during the peak periods for dioxins creation and release (during start-up and shut-down periods, and periods of upset conditions).[96,97] Furthermore, the U.S. EPA does not effectively regulate toxins in ash and the liquids discharged from incinerators, nor does the U.S. EPA even monitor ultrafine particles that contain pollutants such as heavy metals, PCBs, dioxins and furans. Thus overall emissions levels reported can be misleading.

Emissions limits are not always adequately enforced. Existing incinerators are sometimes allowed to continue to operate despite emission limit violations. For example, between 1990 and 2000, the Bay Area Air Quality Management District allowed the Integrated Environmental Systems (IES) medical waste incinerator in Oakland, California, U.S. to keep operating despite more than 250 citations for air quality violations.[98] By IES's own admission, the plant's emissions-control system, designed to capture gases such as dioxin, failed 34 times between 1996 and 2001.[99] Similarly, at the federal level in the U.S., a 2007 a federal judge ruled that the U.S. EPA had been unlawfully reclassifying certain incinerators under less stringent "boiler" emission limits,[100] allowing these incinerators to avoid the more stringent incinerator emission limits on mercury, lead, arsenic, dioxins, and other highly toxic pollutants.

REASON #3: Gasification, pyrolysis and plasma incinerators have a dismal track-record plagued by malfunctions, explosions and shut-downs.

INDUSTRY MYTH: Gasification, pyrolysis and plasma incinerators are operationally proven.

In many countries, including Canada, France, India, the United States and United Kingdom, municipalities have rejected proposals for gasification, pyrolysis and plasma incineration technologies because the emissions, economic, and energy benefits claimed by industry representatives have proven to be unfounded. As the Fichtner Consulting Engineers report *The Viability of Advanced Thermal Treatment in the UK* states: "Many of the perceived benefits of gasification and pyrolysis over combustion technology proved to be unfounded. These perceptions have arisen mainly from inconsistent comparisons in the absence of quality information."[101]

For example, *The City of Los Angeles Bureau of Sanitation Report* (June 2009) recommends that Interstate Waste Technologies' proposal for a gasification facility and Plasco Energy Group's proposal for a plasma gasification facility—the only staged incineration technologies evaluated in the report—are "not viable" for the city of Los Angeles, U.S.[102] and do not warrant further evaluation.[103] In particular, the report states that Plasco Energy Group's plasma gasification facilities have:

> …not been able to continuously operate on MSW [municipal solid waste] and have encountered shutdowns to address engineering design issues… During a site visit, the facility was non-operational, and could not be started after several attempts by the operators.[104]

There have been many operational problems with staged incinerators that have been constructed. Thermoselect's Karlsruhe, Germany incinerator—one of the largest municipal solid waste gasification incinerators in the world—was forced to close down permanently in 2004 due to years of operational problems and loses totaling over $400 million Euros. [105]

The plasma-arc incinerator in Utashinai, Japan also has suffered from operational problems, and one of the two lines has been regularly down for maintenance.[106] This didn't stop the company Geoplasma from making claims to county commissioners in St. Lucie, Florida, U.S. that the plasma arc technology is commercially safe and proven. As the *Palm Beach Post* newspaper explained about this Geoplasma proposal, "'The numbers,' Commissioner Coward said, 'were pretty impressive.' He asked for proof. The company couldn't provide it. The county hired a consultant, who said there is no proof."[107]

Similarly, the plasma arc gasification incinerator in Richland, Washington, U.S., owned and operated by the Allied Technology Group (ATG), was closed in 2001 before ever operating at full capacity due to operational and financial problems.[108] ATG filed for bankruptcy and terminated most of its 120 Richland workers.[109] During its brief tenure the incinerator routinely shut down because of problems with emissions equipment leading to a large buildup of untreated waste.[110] As Greenaction for Health and Environmental Justice discovered, the plasma arc medical waste incinerator in Honolulu, Hawaii, U.S. operated by Asian Pacific Environmental Technology had to be shut down for a period of approximately eight months between August 2004 and April 2005 because of "refractory damage"[111] and "electrode"[112] issues to the plasma arc equipment. And the gasification company Brightstar Environmental was dissolved by its parent company after its only incinerator closed. The facility, located in Australia, was plagued by operational failure and emissions problems, although it was referred to as model of achievement by other companies around the world for years.[113,114,115] By the time the facility closed in April of 2004 it had lost at least $134 million U.S.[116]

Likewise, the Ze-Gen pilot gasification incinerator in New Bedford, Massachusetts, U.S. suffered from operational failures requiring it to be shut down for months after its first day of operation. According to the Massachusetts Department of Environmental Protection, this facility was offline from July 2007 until March 2008[117] and had been unsuccessful in processing wood chips and construction and demolition materials.[118] After months of not operating, Ze-Gen shifted to wood pellets as the feedstock for the facility, similar to what people use in their home stoves.[119] In January 2009 a Ze-Gen company representative confirmed that the facility had once again gone off-line.[120] (See Reason #1 for other examples of malfunctions, explosions and shutdowns.)

System failures can have a dramatic impact on the safety and operating costs of these incinerators, and increase the financial burden to host communities.

REASON #4: Staged incineration is not compatible with recycling; gasification, pyrolysis and plasma incinerators compete for the same financing and materials as recycling programs. Incineration also undermines efforts to minimize the production of toxic and unrecyclable materials.

INDUSTRY MYTH: Gasification, pyrolysis and plasma incinerators are compatible with recycling.

Gasification, pyrolysis and plasma incineration companies claim that their technologies and recycling are compatible. However, staged incinerators and recycling programs are not compatible; they compete for the same materials and financing. Staged incineration is also not an appropriate strategy to deal with the relatively small unrecyclable portion of the waste stream. Doing so creates harmful emissions, can facilitate operational issues, provides little to no energy value, and undermines efforts to minimize waste.

First, staged incinerators and recyclers compete for the same funding in the form of subsidies and municipal contracts. Gasification, pyrolysis and plasma incinerators have infrastructure and operational costs that meet or exceed that of mass burn incinerators.[121] In order to survive financially, staged incineration technologies need a constant supply of both waste and public money in the form of long term "put or pay" contracts. Put or pay incinerator contracts require municipalities to pay a predetermined monthly fee to the incinerator for decades to come, regardless of whether it makes economic or ecological sense to do so in the future. As a result, these contracts destroy the financial incentives for a city to reduce and separate its waste at the source, and reuse, recycle and compost. In a world of limited financial resources, by cornering large sums of public money and subsidies, incinerator contracts create an unequal and unfavorable economic market for recycling industries to compete. This can impede the growth of otherwise viable recycling programs for decades to come (see Reality #5 for example). As the Tellus Institute report states in the case of the state of Massachusetts, U.S.:

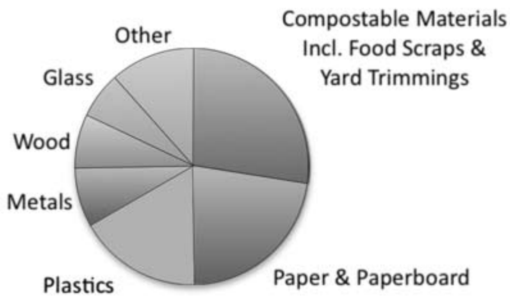
> Similar to the situation for WTE (waste to energy) incinerators, the capital requirements for building alternative technology facilities [gasification and pyrolysis] and their likely need for long-term contracts to ensure an adequate feedstock waste stream may limit the future flexibility of the state's [Massachusetts, U.S.] overall materials management efforts. That is, locking in the use of waste for energy production may forestall potential additional recycling or composting in the future, something the MA Solid Waste Master Plan has heretofore explicitly avoided.[122]

As the San Francisco City and County Environment Director said in a 2009 press release, "If we captured everything going to landfill that could have been recycled or composted, we'd have a 90 percent recycling rate."

Second, staged incinerators and recyclers compete for the same materials. The vast majority of materials that are trashed in incinerators and landfills are recyclable and compostable materials. As detailed in the pie graph below, recyclable and compostable materials including paper and paperboard, food scraps and yard waste, plastics, metals, glass and wood account for nearly 90% of what is currently disposed in U.S. incinerators and landfills.[123] Similarly, even with a citywide recycling rate at over 70%, the San Francisco Department of Environment 2006 *Waste Characterization Study* found that two-thirds of the remaining materials that are being disposed of are readily recyclable and compostable materials.[124] As the San Francisco City and County Environment Director said in a 2009 press release, "If we captured everything going to landfill that could have been recycled or composted, we'd have a 90 percent recycling rate."[125]

Real world economics demand that incinerators produce and sell electricity as a source of revenue. As a result, incinerator operators seek materials that are efficient to incinerate for the purpose of producing electricity. Many of the most cost-effective materials to recycle, like paper, cardboard and certain plastics, are also materials that incinerate most efficiently for generating electricity. For each ton of paper, cardboard or plastic that we incinerate, one ton less is available to recycle or compost. Incinerators require a constant supply of waste

Materials Disposed in U.S. Incinerators and Landfills (Source: US EPA)



in order to generate electricity. Shutting down an incinerator even momentarily can be costly, and some of the most dangerous emissions such as dioxins and furans are often generated in higher concentrations by incinerators during the shut-down and start-up periods. Thus, in order to operate efficiently and economically, incinerators constantly consume otherwise recyclable materials.

Third, staged incineration is not compatible with transition strategies that minimize waste disposal. As discussed above, the vast majority of materials currently disposed in landfills and incinerators are recyclable and compostable materials. Unfortunately, a small fraction of our waste stream (often called "residual materials") is too toxic or complex to cost-effectively recycle. Examples of these materials include certain electronic and appliance wastes, batteries, pesticides, compressed wood, and complex packaging such as Tetrapaks. These materials pose a real challenge for any community working to minimize disposal. However, incineration is not a sensible strategy for dealing with these materials for three main reasons:

First, these materials have low Btu energy value or are too complex to effectively process in staged incinerators. Processing residual materials in staged incinerators can facilitate operational problems and provide little to no energy value. As the 2008 Tellus Institute report *Assessment of Materials Management Options for the Massachusetts Solid Waste Master Plan Review* commissioned by the Massachusetts Department of Environmental Protection explains:

> In considering alternative processing technologies – gasification, pyrolysis, and anaerobic digestion – it is important to note that a significant fraction of the undiverted waste stream (well over one million tons [in Massachusetts, USA], comprising fines and residuals, other C&D and non-MSW, and glass) is largely inert material and not appropriate for processing in these facilities.[126]

Second, treating products containing toxic materials at high temperatures can create even more harmful toxins like dioxin. Many communities that host trash incinerators become a magnet for harmful waste in the region, often while subsidizing the cost of neighboring communities' waste disposal. In Detroit, USA, for example, residents of the city pay over $170 per ton of materials disposed at the Detroit incinerator while neighboring communities pay only $10.45 per ton of materials that they send to the incinerator. [127]

Third, the high costs and long-term waste contracts of gasification, pyrolysis and plasma incineration run counter to efforts to minimize the *production* of toxic and unrecyclable materials. By requiring long-term disposal of discarded materials, incinerator contracts provide an incentive to continually generate waste materials and products that are designed for disposal, rather than designed to minimize waste. A more practical approach is to cost-effectively and safely contain the small unrecyclable percentage of the waste, study it, and implement regulations and incentives so that these products and materials are phased out of production and replaced with sustainable practices. There are many successful examples of what are called "Extended Producer Responsibility" (EPR) programs and policies, which work to minimize the production of toxic, wasteful and difficult to recycle materials.[128] Staged incineration necessitates long-term extraction and destruction of valuable natural resources, and the emission of toxins into the air, soil and water. A far more sustainable alternative is to invest in innovative technologies, policies and practices that ensure that products are designed to be safe, recyclable and reusable.

REASON #5: Staged incinerators can be even more expensive and financially risky than mass burn incinerators.

INDUSTRY MYTH: Gasification, pyrolysis and plasma incinerators are a wise investment.

The public bears the financial burden of all types of incineration. Costs to local governments are high, and communities end up paying with tax money and public health costs. Alternatively, recycling and composting make more sense economically than either incineration or landfilling.

Proponents of gasification, pyrolysis and plasma incineration often make promises of economic benefit for host communities. However, these incinerators can be even more expensive and financially risky than already costly conventional mass burn incinerators. The United Kingdom Fitchtner Consulting Engineers report *The Viability of Advanced Thermal Treatment* found that, "…there is no reason to believe that these technologies [gasification and pyrolysis] are any less expensive than combustion and it is likely, from information available, that the more complex processes are significantly more expensive."[129]

One example of higher costs are the proposed tipping fee estimates provided by gasification, pyrolysis and plasma incinerator companies to Los Angeles County, California, US in 2005, shown in Table 1. The estimated tipping fees are two to four times greater than the average U.S. incinerator tipping fee.

Similarly, the U.S. Department of Defense estimates that capital costs for plasma and pyrolysis for treating chemical weapons waste are equal to or greater than the cost of state-of-the-art mass burn incinerators and that the operational and maintenance costs could be 15 to 20 percent higher than that of a mass burn incinerator.[132]

Gasification, pyrolysis and plasma incinerators also present financial risk due to an operational history plagued by malfunctions, an inability to produce electricity reliability, regular shut-downs, and even explosions. As the European Commission 2006 report concludes, "At the time of writing, the additional technological risk associated with the adoption of gasification and pyrolysis for many wastes, remains significantly greater than that for better proven, incineration type thermal treatments."[133]

In addition to the examples of operational problems described elsewhere in this report, the plasma arc incinerator in Utashanai, Japan provides another illustration of financial risk. As the only commercial plasma arc incinerator processing municipal solid waste anywhere in the world, this facility has been economically unsuccessful. In 2007 *Nature Magazine* found that "despite its promise [plasma arc] has not yet turned trash to gold" and that this plasma arc incinerator, "has struggled to make ends meet since opening in 2002." [134]

Overall, the long-term financial burden of staged incineration technologies is uncertain at best. The Florida Department of Environmental Protection explains in its *Whitepaper on the Use of Plasma Arc Technology to Treat Municipal Solid Waste* that, "The economics for this technology are not well known. Clearly if the available power for export cannot be sold at a reasonable rate then the viability of a project may be hindered."[135]

The Economics of Incineration:

All types of incinerators are generally funded in three ways: (1) public financing and subsidies (such as tax credits); (2) payments that the municipality makes to the incinerator per ton of garbage, or otherwise by contractual agreement, called tipping fees; (3) sales of energy generated from incinerating waste.

Subsidies are important for the financial viability of incinerators because mixed garbage is a very inefficient energy source, and incineration is by far the most expensive waste management op-

Table 1: Estimated tipping fees and capital costs presented by companies to Los Angeles County (US) in 2005[130] compared to the average incinerator tip fee in the US in 2004[131]

Company	Tons per day	Tipping fee $/ton
Ebara	70	$289
Interstate Waste Technologies (Thermoselect)	300	$186
Geoplasma	100	$172
Average U.S. Incinerator tipping fee	n/a	$61.64

tion.[136] Incinerators cost tens to hundreds of millions of dollars to build and maintain. Expensive monthly contracts and the need for a constant flow of trash binds communities in a cycle of disposal and debt that can last for decades.[137]

For example, the town of Sanford, Maine, U.S., received a bill in 2009 for $109,000 from the waste to energy incineration parent company Casella Waste because it had "underproduced" trash for a local incinerator to which it was contractually obligated to send 10,500 tons of waste each year. As an editorial in the Biddeford / Saco Journal Tribune explains:

> According to a report by Staff Writer Tammy Wells, Sanford has been 'underproducing' trash for consumption by the Maine Energy Recovery Company in Biddeford. The town is contractually held to 10,500 tons, a mark it hasn't hit in years. So, instead of a 'at-a-boy' from Casella, Sanford received a bill for $109,000. According to Maine Energy General Manager, Sanford isn't alone. Numerous communities within the Maine Energy system did not meet their quotas, and received letters saying as much.[138]

Incinerators undermine often less expensive reuse, recycling and composting options, and cheaper disposal options such as landfilling, by cornering public funding through "put-or-pay" contracts. These long-term (often 20-30 year) contracts guarantee that the incinerator will receive public dollars for years to come regardless of whether or not waste is sent to the incinerator. This provides a perverse incentive for municipalities to continue to send materials to be incinerated, even when it is more affordable and sensible to recycle them. To provide a metaphor, it is as if host communities for incinerators have signed a long-term non-negotiable 20-year lease for a fleet of expensive gas-guzzling Hummer Sport Utility Vehicles. As petroleum prices rise and climate change becomes a reality, these communities do not have the ability to switch to the new generation of more affordable and fuel efficient electric hybrid vehicles; they have already bought into an impractical and environmentally unsustainable long-term investment.

Incinerators often prove to be more of a financial burden for the host community than at first glance. Incinerator contracts sometimes place the future financial risk of their product on the public, rather than investors, through "liability clauses" that require cities to pay for unforeseen operating costs down the road. Operating an incinerator also incurs many other costs including the expense of disposing ash, slag and wastewater, and preprocessing waste (such as drying and shredding) before it is put into the incinerator.

For example, the municipal solid waste incinerator in Detroit, Michigan, U.S., has been an economic disaster for the city. By the end of the contract in 2009, Detroit taxpayers will have paid over $1 billion to build and operate the incinerator over a 20 year period. Detroit currently pays a fee of $156 per ton of garbage burned at the incinerator, to cover the incinerator's operating expenses and debts — an amount more than five times as much as other cities in the region pay to send their waste to the incinerator. The Ann Arbor Ecology Center estimates that Detroit could have saved over $55 million in just one year (2003) if it had never built the incinerator. This misuse of taxpayer money to subsidize an incinerator has impacted other under-funded Detroit services like public schools, housing, health facilities and transportation.[139] These economic impacts are not unusual for communities that host incinerators.

The capital costs per ton for incinerators have increased over time, even while controlling for inflation and depreciation.[140] One reason for this is the cost associated with changing air emissions regulations for incinerators. For example, the spike in costs for incinerators in the U.S. from 1993-1995 was possibly due to implementation of air pollution control regulations made in 1991.[141]

Future regulatory uncertainty is particularly important when considering the costs of building a new incinerator. Two lawsuits won in 2007 against the U.S. EPA will require that incinerator emission limits be strengthened within coming years.[142,143] This may result in increased costs down the road for incinerator operators, and there is uncertainty about what these costs will be as the new regulations are not yet established. In addition, the air pollution control devices and other measures that incinerators will be required to implement will not be known until the new regulations are in place. There is also the further risk that a new incinerator will not be able to meet air emission regulations in the future, regardless of investments made now or later in pollution control devices. This can prove economically devastating for a community that has already invested large sums of capital, or that is tied to a long-term incinerator contract.

In addition, incineration has also been linked to decreasing property values. In the study, "The Effect of an Incinerator Siting on Housing Appreciation Rates" published in the *Journal of Urban Economics*, authors Kiel and McClaine find that the presence of an incinerator begins to have an effect on property values even before it begins operation, and that it continues to drive down prices for years. According to this study, "appreciation rates are affected as early as the construction stage of the incinerator, and the adjustment continues several years after the facility has begun operation." Over the seven-year period of the incinerator operation studied, the average effect observed led to **property values more than 20% lower** than they otherwise would have been.[144]

REASON #6: Incinerators inefficiently capture a small amount of energy by destroying diminishing resources. Gasification, pyrolysis and plasma incinerators are even less efficient at generating electricity than mass burn incinerators.

INDUSTRY MYTH: Gasification, pyrolysis and plasma incinerators reliably produce "renewable energy."

While incinerator advocates describe their installations as "resource recovery," "waste-to-energy" (WTE) facilities, or "conversion technologies," incinerators are more aptly labeled "waste of energy" (WOE) facilities. In terms of overall energy benefit, it is always preferable to recycle materials rather than incinerate them. As the 2008 Tellus Institute report *Assessment of Materials Management Options for the Massachusetts Solid Waste Master Plan Review* commissioned by the Massachusetts Department of Environmental Protection explains:

> Recycling saves energy, reduces raw material extraction, and has beneficial climate impacts by reducing CO2 and other greenhouse gas emissions. Per ton of waste, the energy saved by recycling exceeds that created by landfill gases or the energy harnessed from thermal conversion technologies.[145]

In fact, recycling saves three to five times the amount of energy that incinerator power plants generate.[146] When a ton of office paper is incinerated, for example, it generates about 8,200 megajoules; when this same ton is recycled, it saves about 35,200 megajoules. Thus recycling office paper saves four times more energy than the amount generated by burning it.[147]

In terms of overall energy benefit, it is always preferable to recycle materials rather than incinerate them.

Why does recycling save so much more energy than incinerators generate? The reason is that when a product is incinerated rather than recycled, new raw virgin resources must be extracted from the earth, processed, manufactured and transported to replace the product that has been destroyed. At each step, energy is wasted.

First, when a product is incinerated rather than recycled, energy is wasted extracting virgin resources such as minerals and timber from the earth. Second, energy is wasted during the processing and manufacturing of virgin resources. Because recycled materials require far less processing than virgin materials, the amount of energy needed to create products from virgin materials far exceeds the energy needed to produce products from recycled materials. Third, since virgin material sources often lie far from sites of manufacture and end-use, they require more transportation, another waste of energy.

The Intergovernmental Panel on Climate Change recognizes that production from virgin materials uses significantly more energy and releases significantly more greenhouse gases than production from recycled materials:

> Waste management policies can reduce industrial sector GHG emissions by reducing energy use through the re-use of products (e.g., of refillable bottles) and the use of recycled materials in industrial production processes. Recycled materials significantly reduce the specific energy consumption of the production of paper, glass, steel, aluminum and magnesium.[148]

Given that most materials can be recycled many times—thereby avoiding the extraction of new resources many times over—the energy saving benefits of recycling increase exponentially.

To illustrate the vast quantities of energy that are lost through disposal, consider plastic bottle disposal in the U.S. Each day in the U.S. 60 million water bottles are wasted in incinerators and landfills.[149] The annual lifecycle fossil fuel footprint of bottled water consumption and disposal in the U.S. is equivalent to 50 million barrels of oil—enough to run 3 million cars for one year.[150] Much of this energy can be conserved by recycling rather than incinerating or landfilling the plastic bottles. Of course, the most energy efficient option is to minimize the amount of one-time-use plastic bottles that are used in the first place.

The environmental and energy benefits of recycling are significant. In the U.S., for example, about one-third of all household materials discarded are recycled. Even this relatively low recycling rate conserves the equivalent of approximately 11.9

billion gallons of gasoline, and reduces greenhouse gas emissions equivalent to taking one-fifth (40 million) of all U.S. cars off the roads every year.[151]

Staged Incineration: A Waste of Energy

Incinerator power plants inefficiently generate electricity through the combustion of waste and/or waste gases. Promoters of incinerators that use gasification, pyrolysis and plasma arc claim that these technologies have higher energy efficiency rates than mass burn incinerators, but these claims are unfounded. In fact, the United Kingdom Fichtner Consulting Engineers report *The Viability of Advanced Thermal Treatment* found that, "The conversion efficiencies for the gasification and pyrolysis technologies reviewed were generally lower than that achievable by a modern [mass burn combustion process]."[152]

Others researchers have found even less promising energy efficiency results for gasification and pyrolysis plants. The 2008 study *Gasification of refuse derived fuel in a fixed bed reactor for syngas production* found that, "There is yet to be a process designed for steam gasification of RDF [Refuse Derived Fuel] that is energy efficient. In most gasification/pyrolysis plants, the energy required to keep the plant running is only slightly less than the amount of energy being produced."[153]

Although pyrolysis companies often promote their technologies as being energy efficient, achieving even a moderate energy efficiency rate requires combusting or gasifying the solid char byproduct that is created during the pyrolysis process. Unfortunately, doing so releases toxins stored in the char such as heavy metals and dioxins into gaseous form. This is summarized in Fichtner (2004):

> The emission benefits of low temperature processing are largely negated if the char subsequently undergoes high temperature processing such as gasification or combustion. The solid residues from some pyrolysis processes could contain up to 40% carbon representing a significant proportion of the energy from the input waste. Recovery of the energy from the char is therefore important for energy efficiency.[154]

The issue of energy inefficiency lies with the fundamental nature of staged incineration technologies. First, gasification, pyrolysis and plasma incinerators often require pretreatment processes to prepare the wastes such as shredding and drying; these processes can consume significant quantities energy. Second, unlike mass burn incinerators which rely on oxygen to keep the fire burning, the starved-oxygen environments used in these technologies requires additional input of energy to maintain the process. This energy input is generated by the combustion of fossil fuels such as natural gas and oil, and by the use of heat and electricity generated by the incineration process.

Table 2: Fichtner Consulting Engineers' reported energy efficiency of gasification/pyrolysis incineration technologies compared to mass burn incineration steam cycle technologies.

Technology	Efficiency
Mass Burn Steam Cycle	19-27%
Gasification/Pyrolysis Gas Engine	13-24%
Gasification/Pyrolysis Steam Cycle	9-20%

Operating staged incineration facilities have experienced problems reliably generating electricity for sale. For example, the Thermoselect gasification incinerator in Karlsruhe, Germany consumed 17 million cubic meters of natural gas to heat the waste without returning any electricity or heat to the grid in 2002, two years before the facility closed.[155]

In plasma-based incinerators, the plasma torch or arc may achieve temperatures ranging from 3,000 to 20,000 degrees Fahrenheit. Plasma incinerators generate a high-energy electrical discharge or arc, which requires considerable energy to operate. The Sacramento, California, U.S. Municipal Utility District's assistant general manager for energy supply was quoted in a Sacramento Bee newspaper article questioning whether or not a plasma incinerator can generate more energy than it takes in, "Do you use more electricity in the process than you gain from the gas stream that you use to burn and generate electricity?"[156] According to the Danny May, the chief financial officer of the plasma arc company Alter NRG, the plasma arc incinerator in Utashanai, Japan has been able to sell only a "nominal" amount of electricity.[157] However, no independent data is available from any commercial plasma facility to validate the claim that any electricity has been produced for sale. It is yet to be proven that a full-scale commercial plasma incinerator can generate more electricity than that which is put into the process to treat the waste.

Incinerator companies often talk about the benefit of "renewable" energy generation from the incineration of materials. This means that these companies see waste as "renewable". Incineration destroys valuable materials, depriving future generations of raw materials and natural resources. The materials in waste are indeed a resource, and need not be wasted in incinerators and dumps; instead, they can be returned to the economy, industry, and soil.

REASON #7: Incinerating discarded materials depletes resources and in many cases permanently damages the natural environment.

INDUSTRY MYTH: Gasification, pyrolysis and plasma incinerators are environmentally sustainable.

Incinerators contribute to the environmental crisis by cornering large amounts of public money for the purpose of long-term disposal of diminishing natural resources. Resolving the environmental crisis requires that we invest in preventing waste and reusing, recycling and composting materials currently disposed in incinerators and landfills.

Gasification, pyrolysis and plasma incinerator companies often claim that incinerating waste is a "sustainable" energy source. However, the large volume of waste disposed in landfills and incinerators around the world is not sustainable. In the past three decades alone, one-third of the planet's natural resource base has been consumed.[158] The United Nation's 2005 "Millennium Assessment Report" concluded that approximately 60% of the earth's ecosystem services examined (including fresh water, capture fisheries, air and water purification, and the regulation of regional and local climate, natural hazards, and pests) are being substantially degraded or used unsustainably at an accelerating rate.[159] The report found that "the harmful effects of the degradation of ecosystem services...are being borne disproportionately by the poor, are contributing to growing inequities and disparities across groups of people, and are sometimes the principal factor causing poverty and social conflict."[160] In addition, the report details the trend of global deforestation stating that, "The global area of forest systems has been reduced by one half over the past three centuries. Forests have effectively disappeared in 25 countries, and another 29 have lost more than 90% of their forest cover."[161]

Casting an eye at the world's largest consumer, the U.S. represents only 5 percent of the world population, but consumes 30 percent of the world's resources[162] and creates 30 percent of the world's waste.[163] On average, each U.S. resident sends three pounds of garbage to incinerators and landfills for disposal daily.[164] The vast majority of this garbage is reusable materials such as paper, aluminum, and plastic.

Municipal waste materials represent only the tip of a very big iceberg. For every full can of garbage that is put on the curb for disposal, about 71 cans full of waste are produced during manufacturing, mining, oil and gas exploration, agriculture, coal combustion, and other activities related to the manufacture and transport of products.[165]

Only one percent of the total amount of materials that flow through our economy is still in use six months after its sale in North America.[166] That means 99 percent of what we dig, drill, chop down, process, ship, deliver, and buy is wasted within six months.[167] As resources around the world such as oil become increasingly scarce, the growing waste problem is driving costly resource wars. This is a system in crisis.[168]

Organics: To Incinerate or to Compost?

Instead of acknowledging this crisis and its contribution to it, the incinerator industry misleadingly characterizes incineration as a "solution" for the disposal of organic (such as food waste, yard waste, wood, paper, agricultural waste, crops, and other biomass) and other materials. Gasification, pyrolysis and plasma incineration companies are currently attempting to site new incinerators and to gain subsidies to incinerate organic materials in order to generate electricity and fuels. Incinerating organic materials, however, is unsustainable for the climate and the soil. While it is vital that we immediately stop putting organic materials into landfills, where these materials decompose in conditions that generate potent greenhouse gas emissions, incineration is by no means a solution to this problem.

Biomass incineration is a carbon-intensive form of energy generation. Global forest and soil systems are being rapidly degraded causing a large net transfer of carbon from the earth to the atmosphere—accounting for as much as 30% of global greenhouse gas emissions. Even healthy forest and soil ecosystems can take decades to reabsorb carbon dioxide (CO_2) released into the atmosphere when biomass is extracted for energy purposes. Unfortunately there is limited time to address climate change; scientists indicate that severe climatic tipping points must be avoided within the next 10-15 years. Building the capacity of forests, ecosystems, and soils to store biotic carbon—rather than further degrading these resources—is critical for addressing climate change globally.

A much more sound investment is to compost organic materials and return this valuable resource to the soil as fertilizer and humus. Around the world, soil is in a state of crisis; approximately

40% of the world's agricultural land is seriously degraded.[169] As a 2007 article in the Guardian newspaper explains, "Among the worst affected regions are Central America, where 75% of land is infertile, Africa, where a fifth of soil is degraded, and Asia, where 11% is unsuitable for farming."[170] Similarly, on over half of the best cropland in the U.S., the soil erosion rate is more than 27 times the natural rate.[171] In addition, topsoil is eroding ten to twenty times faster than it can be formed by natural processes.[172] As Alice Friedemann explains in the article *Peak Soil*, we as humans need healthy soil to grow our food and sustain the life upon which the entire planet depends.[173] Without it, societies suffer grave consequences, particularly in a time of concern about food supplies and soil fertility.

In the past three decades alone, one-third of the planet's natural resource base has been consumed.

When composted and returned to cultivation, organic matter provides multiple benefits. It locks carbon in soil; improves the structure and workability of soils (reducing the need for fossil fuels for plowing and tilling); improves water retention (irrigation is a heavy consumer of energy); displaces energy-intensive synthetic fertilizers; and results in more rapid plant growth (which takes CO_2 out of the atmosphere). No industrial process can reproduce the complex composition of soil, which needs to be replenished with organic matter; yet incinerators and landfills interrupt this cycle, leading to long-term soil degradation.

The loss of nutrient-rich topsoil means that farmers apply increasing amounts of fossil-fuel intensive chemical fertilizers to the soil in order to grow food. This requires increasing amounts of fossil fuels to be used in agriculture. In fact, energy related to the manufacture and application of fertilizers represents 28 percent of the energy used in U.S. agriculture. [174] Alternatively, maintaining and replenishing topsoil by re-introducing organic discards as compost avoids or greatly reduces chemical and energy use.[175]

The sheer volume of organic waste makes the potential benefits of composting significant. For example, in the U.S. organic waste represents approximately one-third (not including paper and paperboard) of the waste in trash cans, and composting this would mean that nutrients could be recycled back into the soil rather than be wasted. In places outside the U.S., the percentage of waste that is compostable can be even higher. For example, in the city of Chihuahua, Mexico, 48% of waste (not including paper) is organic.[176] In addition to reducing fossil fuel inputs to the soil related to the application of chemical fertilizers, composting organic waste to create fertilizer and humus also stores carbon in the soil. When the same materials are incinerated, the carbon is immediately released into the atmosphere.[177] Composting rather than incinerating organic materials thus means that less carbon will exist in the Earth's atmosphere as a greenhouse gas. (Please see Reason #8 for more information about the climate impact of incinerating biomass materials).

An emerging technology called anaerobic digestion shows promising signs for safely and sustainably processing source separated organic discards—while simultaneously generating energy. As the 2008 Tellus Institute report Assessment of Materials Management Options for the Massachusetts Solid Waste Master Plan Review commissioned by the Massachusetts Department of Environmental Protection concludes:

The prospects for anaerobic digestion facilities appear to be more favorable [than gasification and pyrolysis] given the extensive experience with such facilities in the U.S. for the processing of sewage sludge and farm waste and the fact that no significant human health or environmental impacts have been cited in the literature. Moreover, since anaerobic digestion is more similar to composting than high-temperate combustion, its risks are expected to be akin to composting, which is considered low-risk.[178]

In short, for the health of the climate and the soil, it makes far more sense to compost, anaerobically digest or recycle organic materials than to incinerate or landfill them.

REASON #8: Staged incineration technologies are contributors to climate change, and investment in these technologies undermines truly climate-friendly solutions.

INDUSTRY MYTH: Gasification, pyrolysis and plasma incinerators are good for the climate.

In terms of greenhouse gas emissions released per ton of waste processed, recycling is a much preferable strategy to staged incineration. As the findings of the Tellus Institute report reveal:

> On a per ton basis, recycling saves more than seven times eCO_2 than landfilling, and almost 18 times eCO_2 reductions from gasification/pyrolysis facilities.[179]

The Tellus Institute study finds that gasification and pyrolysis incinerators have a slightly smaller climate footprint than mass burn incinerators. However, due to a limited commercial track record, there is very little independently verified greenhouse gas emission data for staged incineration facilities. Data that exist are often limited to claims presented by companies themselves or modeled emissions. As a result, it is possible that the greenhouse gas impact of gasification and pyrolysis facilities is even greater per ton of waste processed than the already relatively high levels found in the Tellus Institute study. As the Tellus Institute study explains, "…there remains significant uncertainty as to whether commercial scale gasification/ pyrolysis facilities processing MSW and generating energy can perform as well as the vendor claims or modeled emissions."[180]

"Increased composting of municipal waste can reduce waste management costs and emissions, while creating employment and other public health benefits."

As discussed in Reason #7, gasification, pyrolysis and plasma incinerators are even less efficient generators of electricity than mass burn incinerators, and often require inputs of additional fossil fuels and/or electricity to operate, and for the preprocessing of materials. As a result these incinerators may have an even larger climate footprint than conventional mass burn incinerators .

The Intergovernmental Panel on Climate Change (IPCC), the European Union, the U.S EPA and others clearly indicate that source separation and recycling are the preferred waste management options in terms of greenhouse gas emissions. For example, the European Union's comprehensive analysis on the topic states: "Overall, the study finds that source-segregation of various waste components from MSW [municipal solid waste], followed by recycling or composting or anaerobic digestion of putrescibles offers the lowest net flux of greenhouse gases under assumed baseline conditions."[181] Likewise, the IPCC states:

> Waste minimization, recycling and re-use represent an important and increasing potential for indirect reduction of GHG emissions through the conservation of raw materials, improved energy and resource efficiency and fossil fuel avoidance.[182]

Similarly a 2008 report from the California Air Resources Board in the U.S. titled *Recommendations of the Economic and Technology Advancement Advisory Committee (ETAAC) Final Report on Technologies and Policies to Consider for Reducing Greenhouse Gas Emissions in California* found that:

> Recycling offers the opportunity to cost-effectively decrease GHG emissions from the mining, manufacturing, forestry, transportation, and electricity sectors while simultaneously diminishing methane emissions from landfills. Recycling is widely accepted. It has a proven economic track record of spurring more economic growth than any other option for the management of waste and other recyclable materials. Increasing the flow through California's existing recycling or materials recovery infrastructures will generate significant climate response and economic benefits.[183]

For biodegradable materials (which accounts for the largest single fraction of the municipal waste stream) source separation of materials followed by composting and anaerobic digestion allows insignificant fugitive methane releases to the environment, and, overall, yields far fewer greenhouse gas (GHG) emissions than landfills and incinerators.[184] As the International Panel on Climate Change (IPCC) has stated, "Increased composting of municipal waste can reduce waste management costs and emissions, while creating employment and other public health benefits."[185]

Incineration and Climate Change

Incineration is not a climate-friendly waste management strategy; neither is it a source of "green" energy. Incinerators directly emit more CO_2 per unit of electricity generated than coal-fired power plants.[186] Incinerators also emit indirect greenhouse gases such as carbon monoxide (CO), nitrogen oxide (NOx), non-methane volatile organic compounds (NMVOCs), and sulfur dioxide (SO_2).[187,188] U.S. incinerators are among the top 15 major sources of direct greenhouse gases to the atmosphere that are listed in the U.S. EPA's most recent inventory of U.S. greenhouse gas emissions.[189]

Far greater than the impact of greenhouse gas emissions released from incinerators is the lifecycle climate impact of incinerating rather than preventing waste and reusing, recycling or composting materials. Incineration plays a pivotal role in the unsustainable materials cycle that is warming the planet. For every item that is incinerated or landfilled, a new one must be created from raw resources rather than reused materials. This requires a constant flow of resources to be pulled out of the Earth, processed in factories, shipped around the world, and burned or buried in communities. The impact of this wasteful cycle reaches far beyond local disposal projects, causing greenhouse gas emissions thousands of miles away.

Incinerators directly emit more CO2 per unit of electricity generated than coal-fired power plants.

One example is the case of paper and wood products. Felling trees and processing virgin lumber is more energy-intensive than using recycled stock; but it also contributes to deforestation and reduces the capacity of forests and forest soils to act as carbon sinks. Paper is one of the most readily available materials to recycle or compost, yet it accounts for more than one-quarter of all materials disposed in the U.S. Paper is consumed in the U.S. at an annual per capita rate that is seven times that of the world average, and only half of all discarded paper is recycled; the remaining half is incinerated or landfilled.[190] Recycling instead of burning materials such as paper keeps more forests and other ecosystems intact, stores and sequesters large amounts of carbon, and significantly reduces greenhouse gas emissions. Still, incinerator companies promote the combustion of paper and other materials as a sustainable practice.

It should come as no surprise that increased waste prevention, recycling and composting are among the most effective climate protection strategies available. Implementing a comprehensive national waste reduction, reuse, recycling and composting program in the U.S. would cut greenhouse gas (GHG) emissions by the equivalent of taking half the nation's cars off the road[191], or shutting down one-fifth of the nation's coal-fired power plants.[192] In addition, recycling is one of the most affordable climate protection strategies; avoiding one ton of CO_2 emissions through recycling costs 30% less than doing so through energy efficiency, and 90% less than wind power.[193] Yet, two-thirds of municipal waste materials are still burned or buried in the U.S.,[194] despite the fact that the technical capacity exists to cost-effectively recycle, reuse or compost the vast majority of it.

In addition to the millions of tons of diminishing resources that are incinerated annually, incinerators are also receiving taxpayer money needed to support real renewable energy, waste reduction and climate solution projects. With limited resources to fix the colossal climate problem, no taxpayer money should be wasted on incinerators.

CO_2 Emissions from Biomass are <u>not</u> Climate Neutral

As mentioned above, incinerators emit up to twice the CO_2 per kilowatt-hour of electricity as coal-fired power plants. The incinerator industry disputes this figure by ignoring the portion of CO_2 emissions attributable to burning biomass (known as biogenic carbon). They defend this accounting practice with the claim that CO_2 released from the incineration of biomass is part of a sustainable carbon cycle where the CO_2 is being equally reabsorbed by living biomass to replace that combusted in the incinerator. Incinerator companies also claim that their accounting methodology of ignoring CO_2 emissions released from biomass combustion is consistent with the protocol established by the Intergovernmental Panel on Climate Change (IPCC). Both of these claims are false as detailed below.

First, incinerating biomass materials, rather than conserving, reusing, recycling or composting them, causes a net transfer of carbon from greenhouse gas emissions from the soil and forests to the atmosphere. The emissions from incinerating biomass are *not* climate neutral. As discussed in Reason #7, global forest and soil systems are being rapidly degraded causing a net transfer of carbon from the earth to the atmosphere—accounting for as much as 30% of global greenhouse gas emissions.[195] Even healthy or sustainably managed forest and soil ecosystems can take decades to reabsorb CO_2 released into the atmosphere when biomass is extracted and then used for energy purposes. Preventing and/or delaying the release of CO_2 from biomass into the atmosphere is particularly important given that many scientists indicate that severe climatic tipping points must be avoided within the next 10-15 years. In contrast to incineration, conservation, waste prevention, reuse, recycling and composting can prevent or delay the release of CO_2 in biomass-based materials, resulting in significant benefits for the climate. Building the capacity of forests, ecosystems, and soils to store biotic carbon—rather than further degrading these resources—is critical for addressing climate change globally. As a result, it is essential that CO_2 emissions released from incinerating biomass materials not be ignored.

Second, the Intergovernmental Panel on Climate Change (IPCC) makes clear that even if biomass is harvested sustainably, biomass burning for energy can *not* be automatically considered carbon neutral because of greenhouse gas emissions associated with the processing, transportation and other related lifecycle activities.[196] As the IPCC National Greenhouse Gas Inventories Programme states in the frequently asked questions section of their website:

As the IPCC makes clear, incinerating biomass is not "CO2 neutral" or "carbon neutral".

Biomass burning for energy can not be automatically considered carbon neutral even if the biomass is harvested sustainably, there still may be significant emissions from processing and transportation etc. of the biomass. While CO_2 emissions from biomass burnt for energy are reported as zero in the Energy Sector, the net CO_2 emissions are covered in the AFOLU [Agriculture, Forestry and Other Land Use] Sector.[197]

The IPCC protocols are designed for a holistic assessment of GHG emissions. As the IPCC makes clear, incinerating biomass is *not* "CO_2 neutral" or "carbon neutral."[198] Ignoring emissions from incinerating biomass fails to account for lifecycle releases in CO_2 caused when materials are incinerated rather than conserved, reused, recycled or composted.

REASON #9: All types of incinerators require a large amount of capital investment, but they create relatively few jobs when compared to recycling and composting programs.

INDUSTRY MYTH: Gasification, pyrolysis and plasma incinerators create good jobs.

As Table 2 shows, recycling industries provide employment benefits that far outpace that of waste incinerators and landfills.[199] The U.S. EPA has said that, "for every 100 recycling jobs created, …just 10 jobs were lost in the solid waste industry, and three jobs were lost in the timber harvesting industry.[200,201] There is no specific job data for staged incinerator technologies available, but it seems likely that job prospects for these facilities would be similar to mass burn incinerators. Because incinerators compete with recyclers for the same funding and materials, constructing a gasification, pyrolysis or plasma incinerator can undermine job creation opportunities.

There are significant financial and operational risks associated with incineration. As a result, jobs that are created by the operation of incinerators are not always secure. For example, when the incinerator in Harrisburg, Pennsylvania, U.S. was privatized, more than 45 unionized city jobs were eliminated in 2006 alone. Similarly, most of the 120 jobs provided by the plasma gasification incinerator in Richland, Virginia, U.S. were terminated when the incinerator owner, Allied Technology Group, was forced to shut down the incinerator and declare bankruptcy.[202] Further, those workers had to engage in a fight for adequate severance pay.[203]

Many communities seeking to develop their local economies are now looking to recycling programs to create green and sustainable jobs. The success of recycling efforts depends on an integrated system of industries that can re-use, recycle, and compost resources discarded in every community in America. Recycling industries include activities such as curbside collection of materials, deconstruction of buildings and products, processing of recycled materials, composting, repair and reuse businesses, and manufacturing of new products using recycled content.

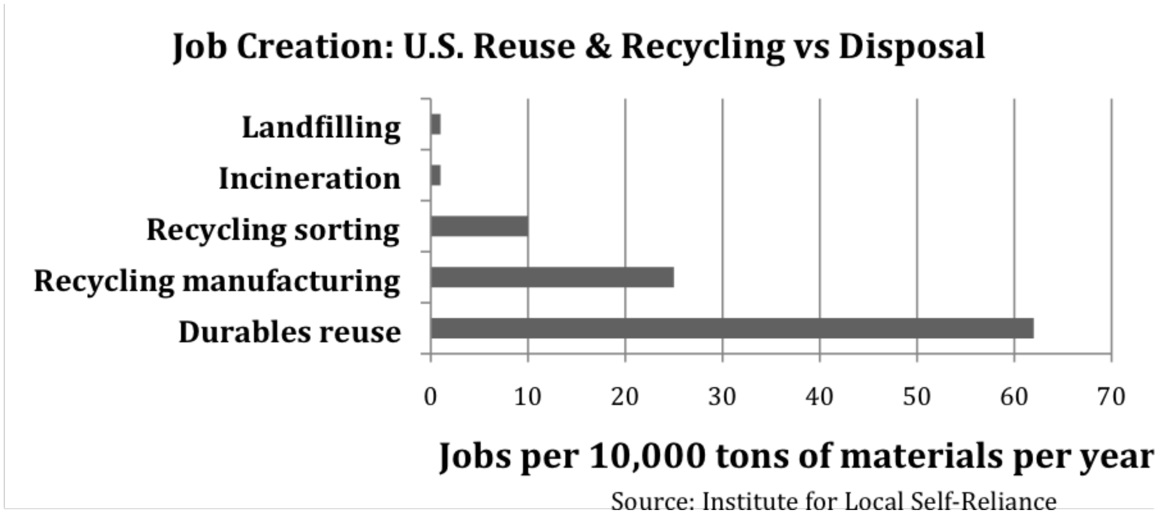
The U.S. Environmental Protection Agency's U.S. Recycling Economic Information Study found that recycling industries already provide more than 1.1 million jobs in the U.S., which is comparable in size to that of the U.S. auto manufacturing and machinery manufacturing industries.

The quality of recycling jobs is not guaranteed. In some locations where worker rights are not protected, recycling jobs can be unsafe and low paying. However, employment conditions can be significantly improved when workers are unionized. For example, the 2009 Good Jobs First study *High Road or Low Road? Job Quality in the New Green Economy* found that non-unionized workers in a recycling facility in Los Angeles make a starting hourly wage of $8.25 as compared to unionized workers in a recycling facility in San Francisco who earn a starting hourly wage of $20.00.[204]

The U.S. Environmental Protection Agency's *U.S. Recycling Economic Information Study* found that recycling industries already provide more than 1.1 million jobs in the U.S., which is comparable in size to that of the U.S. auto manufacturing and machinery manufacturing industries.[205] Recycling industries generate an annual payroll of nearly $37 billion and gross over $236 billion in annual revenue.[206] With a meager 34% national recycling rate in the U.S., much more can be achieved for workers and the economy through greater materials reuse.

One of the greatest opportunities for job creation and economic development in this field lie in recycling-based manufacturing, in which new products are created using recycled or reused materials. One example of this is in the realm of electronics; research from the Institute for Local Self-Reliance has found that the business of repairing computers creates nearly 300 jobs for every one paid position at an incinerator or landfill.[207] Composting also provides significantly more job opportunities than incinerating or landfilling food scraps and yard waste[208], and product re-use creates the most jobs in waste-related industries.

CASE STUDY: WASTE JOBS IN THE UNITED STATES



Regions that have made commitments to increase recycling rather than disposal are realizing tangible benefits to their local economies. For instance, because the state of California requires the recycling and reuse of 50 percent of all municipal solid waste, recycling accounts for 85,000 jobs and generates $4 billion in salaries and wages.[209] Similarly, according to a 2007 Detroit City Council report, a 50 percent recycling rate in Detroit would likely result in the creation of more than 1,000 new jobs in that city alone.[210] Likewise outside the U.S. increasing recycling rates provides opportunities for job growth. In 1999 the organization Waste Watch in the United Kingdom found that increasing the national United Kingdom recycling rate from 9% to 30% could create 45,000 jobs.[211]

Greater public investment in reuse rather than disposal of valuable discarded materials could spark a green economy in countries around the world, restoring much-needed quality unionized industry jobs to communities.

REASON #10: Wasting valuable natural resources in incinerators and landfills is avoidable and unnecessary.

INDUSTRY MYTH: Wasting materials is inevitable.

Incinerator companies often say that there are only two viable options for dealing with the majority of discarded materials: incineration and landfilling. However, U.S. EPA data shows that approximately 90% of materials disposed in U.S. incinerators and landfills are recyclable and compostable materials.[212] Similarly, even with a citywide recycling rate at over 70%, the San Francisco Department of Environment 2006 *Waste Characterization Study* found that two-thirds of the remaining materials that are being disposed are readily recyclable and compostable materials.[213] As the San Francisco City and County Environment Director said in a 2009 press release, "If we captured everything going to landfill that could have been recycled or composted, we'd have a 90 percent recycling rate."[214] All products also can and should be required to be made so that they are recyclable, built to last, and non-toxic. To do so requires a commitment to work for what is known as "Zero Waste".

Zero Waste[215] means establishing a goal and a plan to invest in the infrastructure, workforce, and local strategies necessary to eliminate our dependence on incinerators and landfills. Supporting Zero Waste requires ending subsidies for waste projects that contaminate environments and the people who live in them, and instead investing public money in innovative waste reduction, reuse and recycling programs. In practice, communities who are working for Zero Waste are investing in laws, technologies and programs that ensure that all products are made and handled in ways that are healthy for people and the planet. These communities have recognized that on a planet with a finite amount of resources, the only responsible course of action is to live in such a way that protects the environment and public health for generations to come.

Cities around the world, including Buenos Aires (Argentina), Canberra (Australia), Oakland (U.S.), Nova Scotia (Canada), Seattle (U.S.) and others, have already made great progress towards achieving Zero Waste. These cities are building recycling and composting parks, implementing innovative collection systems, requiring products to be made in ways that are safe for people in the planet, and creating locally-based green-collar jobs. A variety of policies, such as Extended Producer Responsibility, Clean Production, packaging taxes, and material- specific bans (such as plastic bags, styrofoam, PCBs, etc.) have proven effective at reducing and eliminating problematic materials in different locales. As the residual portion shrinks, the system approaches its goal of zero waste to disposal. Rather than pouring money into harmful waste disposal projects like gasification, pyrolysis or plasma incinerators, these cities have devised specific and achievable plans to invest in sound economic development and jobs that will benefit their residents.

Besides saving resources and money, and generating more jobs for local communities, Zero Waste produces far less pollution than waste disposal techniques, including global warming pollution. It eliminates methane emissions from landfills by diverting organics; it eliminates greenhouse gas emissions from incinerators by closing them; it reduces greenhouse gas emissions from industry by replacing virgin materials with recycled materials; and it reduces greenhouse gas emissions from transport by generally keeping such materials close to the end-user. A successful Zero Waste system also provides workers with the right to unionize, a living wage and safe working conditions.

ZERO WASTE MEANS:

- **Striving to reduce waste disposal in landfills and incinerators to zero**
- **Investing in reuse, recycling and composting jobs and infrastructure**
- **Requiring that products are made to be non-toxic and recyclable**
- **Ensuring that manufacturers of products assume the full social and environmental costs of what they produce**
- **Ensuring that industries reuse materials and respect worker and community rights**
- **Preventing waste and reducing unnecessary consumption**

Leading the way, San Francisco is on track to achieve Zero Waste by the year 2020. Already, San Francisco is reducing waste by 72 percent through waste prevention, reuse, recycling, and composting, and its unionized workers receive comparably high wages and benefits.[216]

Achieving Zero Waste is a process, and it may take years. As a practical matter, most communities will continue landfilling a small residual portion of their waste stream while various elements of the Zero Waste program are phased in. While this may be necessary in the short-term, the success of any Zero Waste system should be measured by its ability to prevent waste, eliminate use of both landfills and incinerators and return materials safely and cost-effectively back into the earth and economy. Because residual materials contain significant contaminants, including plastics and household hazardous wastes, it is essential that regulations be strengthened to limit liquid, solid and gaseous emissions of pollutants (including methane). While stronger regulations of waste disposal are essential, subsidies for landfill and incinerator "waste to energy" plants undermine more sensible waste prevention, reuse, recycling and composting solutions.

Try as they might, incinerators companies will never be able to make the legacy of the "throwaway economy" disappear—a legacy steeped in unsustainable consumption, transportation, energy use, and resource extraction. Shutting down the incinerators that pollute communities and achieving critical greenhouse gas emission reductions depend on sustainable alternatives gaining increased support from decision-makers at the local, regional and federal level.

The future health of communities around the world depends on the choices that municipalities make today. Investment in innovative waste reduction and recycling programs, rather than incineration, can be a vehicle for truly "green" environmental and economic renewal.

Appendix A: Incinerator feedstocks, technologies and emissions

What stuff goes in? (feedstocks

- Municipal Solid Waste (MSW)
- Refuse Derived Fuel (RDF)
- Contaminated woodwaste
- Clean woodwaste
- Construction and Demolition waste (C&D)
- Water
- Biomass
- Tires
- Sewage sludge
- Medical waste
- Hazardous waste
- Agricultural waste
- Poultry and animal waste
- Chemical weapons waste
- Coal and waste coal
- Pesticides
- Radioactive waste
- Petroleum coke
- Blended Fuels

→

What incinerator technologies are used?

- Mass burn
- Gasification
- Pyrolysis
- Plasma arc
- Thermal -Depolymerization
- Catalytic cracking
- Cement kiln
- Fischer-Tropsch, Gas-to-liquids (gasification/liquefaction)
- Cellulosic ethanol (waste-to-ethanol)
- Fluidized bed
- Molten metal/molten salt
- Coal burning with blended fuels

What comes out? (releases, emissions) → **Where does it go?**

→ Gaseous Releases

Carbon monoxide, carbon dioxide, hydrogen, particulate matter, volatile organic compounds, heavy metals, dioxins, sulfur dioxide, hydrochloric acid, mercury, furans & more

→ Air we breath, Atmosphere, Soil, Food and dairy, Electricity, Ethanol, Hydrogen, Methanol, Heat for buildings

→ Liquid Releases

Wastewater from cleaning equipment

Oils

Heavy metals

→ Landfills, Soil, Drinking water, Sewage

→ Solid Releases

Bottom Ash

Fly Ash

Slag

Obsidian

Heavy metals, organic compounds like PAHs, PCBs, dioxins and others

→ Landfills, Soil, Drinking water, Fish and food, Cement, Roadbed, Construction

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