MUNICIPAL WASTE INCINERATION:
A POOR SOLUTION FOR THE TWENTY FIRST CENTURY

A presentation by

Dr. Paul Connett
Professor of Chemistry
St. Lawrence University
Canton, NY 13617.

at the

4th Annual International Management Conference
Waste-To-Energy
Nov. 24 & 25, 1998
Amsterdam

About the Author
Dr. Paul Connett is a full and tenured professor of chemistry at St. Lawrence University in Canton, NY, where he has taught for 15 years. He obtained his undergraduate degree in natural sciences from Cambridge University and his Ph.D. in chemistry from Dartmouth College in the US. For the past 14 years he has researched waste management issues with a special emphasis on the dangers posed by incineration and the safer and more sustainable non-burn alternatives. He has attended numerous international symposia on dioxin, and with his colleague Tom Webster has presented six papers at these symposia which have been subsequently published in Chemosphere. He has given over 1500 public presentations on these issues in 48 states in the US and 40 other countries. With his wife Ellen he edits the newsletter Waste Not, which is in its twelfth year of publication. With Roger Bailey, Professor of Fine Arts at St. Lawrence University, he has produced over 40 videotapes on waste management, dioxin and other environmental issues.

EXECUTIVE SUMMARY
Far from it being the universally proven technology claimed by its promoters, the incineration of municipal trash with energy recovery has been an experiment which after 20 years has left the citizens of industrialized countries with a legacy of unacceptably high levels of dioxins and related compounds in their food, their tissues, their babies and in wild life.

The author argues that as the industry has struggled to make incineration safe, they have, like the nuclear power industry before them, priced themselves out of the market. Moreover, as they have sought air pollution control devices to capture the extremely toxic by-products of combustion, the resulting residues have become more problematic and costly to handle, dispose and contain.

There are still remaining concerns about the safety of incinerators, especially as they are built in developing economies, which do not have the resources to build, operate or monitor them properly. However, even if these concerns are overcome, as we move into the twenty first century, the role of trash incineration, with or without energy recovery, will become less and less

viable, both economically and environmentally. Our future task will be dominated by a need to find sustainable ways of living on the planet. Those who have been preoccupied with making incineration safe have lavished their engineering ingenuity on the wrong question. Society's task is not to perfect the destruction of our waste, but to find ways to avoid making it.

The argument that burning waste can be used to recover energy makes for good sales promotion, but the reality is that if saving energy is the goal, then more energy can be saved by society as a whole by reusing and recycling objects and materials than can be recovered by burning them. Municipal waste is a low tech problem. It is made by mixing. It is unmade by separation. Both problem and solution are at our fingertips, not on the drawing boards of Swiss or Swedish engineers. In the longer term, after the citizen has played his or her part by supporting source separation, reuse, recycling, composting and toxic removal, industry has to pay more attention to the way objects and materials are made and used. How an object is going to be reused or recycled has to be built into the initial design decisions. To recognize that it is overconsumption that is giving us both global warming and a waste disposal crisis, is to recognize that trash is the most concrete connection each individual has to the global crisis. More effort has to be put into resisting the largely post-war American philosophy that "the more one consumes the happier one becomes"', before it makes the planet uninhabitable. A way has to be found to tame the voracious appetites of the multinational corporations which plunder the world for short term profit. This cannot be done until we as individuals find a way to resist the skillful advertising that traps us within a whole web of false needs. The antidote to overconsumption is community building. The fierce local arguments that ensue over the siting of both landfills and incinerators can be used to force these issues onto the political agenda.

Incineration might make sense if we had another planet to go to, but without that sci-fi escape, it must be resisted in favor of more down-to-earth solutions that we can live with, both within our local communities and on the planet as a whole. Both incineration and raw waste landfilling attempt to bury the evidence of an unacceptable throwaway lifestyle. Every incinerator built delays this fundamental discussion by at least 20 years.

Introduction: As I deliver these comments I am very conscious of the fact that many of the people sitting in this audience earn their living from the operation of incinerators. They will probably find many of my views antithetical to their own. I applaud the organizers of this conference for having the courage to allow me to speak. Too often, decision makers do not discover the downside to incineration until the wrath of the public is unleashed. To paraphrase the words of Shakespeare's character Mark Anthony, I come here not to praise the idea of the incineration of municipal waste with energy recovery, but to bury it. However, whether you agree with my position or not, I hope you agree with Joseph Joubert, who said, " 'Tis better to debate a question without settling it, than to settle a question without debating it" (1).

In my view, incineration of municipal waste looks back to the nineteenth century, not forward to the twenty first. Indeed, the first waste-to-energy plant was operating in Hamburg, Germany in 1895. I will argue that even if the finest engineers were able to make incineration safe - i.e. captured all of the toxic emissions and found a safe method of handling and storing the ash - from an ethical point of view, they would not have made the incineration of trash acceptable. It simply doesn't make ethical sense to spend so much time, money and effort destroying materials we should be sharing with the future. Thus, those who have set themselves the Herculean task of perfecting the art and science of incineration, have poured a massive amount of attention into the wrong end of the problem and produced a sophisticated set of answers to the wrong question. As we prepare to enter the twenty first century, society's task is not find a new place or a new machine in which to put the trash, but to find ways of not making waste in the first place.

When one first hears about trash incineration it seems like a good idea. I certainly thought so. It promised to rid our Northern NY county of 32 leaking landfills and to produce energy as well. It seemed like a win-win situation. For a municipal official beleaguered with the responsibility for a mountain of trash coming at him or her on a daily basis it appears to offer a quick fix solution, with little or no modification of the existing infrastructure for picking up trash. For a politician with citizens yelling at him or her because they don't want to live near a proposed landfill, or the expansion of an old one, the modern waste-to-energy incinerator looks like a perfect political escape plan.

It is only when one spends time looking below the surface appeal of these facilities that one realizes the huge backward step they represent, environmentally, socially, economically and from the point of view of moving towards a sustainable society. I will discuss the arguments against building more trash incinerators under seven headings. They are: 1. Toxic emissions. 2. Ash disposal. 3. Economic costs. 4. The waste of energy involved. 5. Public opposition. 6. A few words on the alternatives. 7. Sustainability.

1.TOXIC EMISSIONS

Introduction. Let me acknowledge out the outset that the incineration industry has made huge strides in reducing the emissions of toxic substances since the 70's, 80's, and even the early '90s. However, this improvement has not been uniform. For example, it is only recently that France has been forced to take the dioxin problem seriously. The industry's task has been very complicated, their solutions inevitably incomplete and most importantly, not likely to be reproduced in countries where their regulatory apparatus is less competent, or their budget is inadequate to pay for the massive costs involved.

Most chemists blink when they see more than three chemicals in a test tube. The task set by a modern incinerator is to burn all the substances society produces in one huge machine, as well as tapping the energy liberated to generate heat and/or electricity efficiently. In this extremely complicated process, a number of things occur.

1.1 Hydrogen chloride is formed. Most of the chlorine in the waste stream is converted into hydrogen chloride, a strong acid gas which at high temperatures will attack most metals it meets. Most of the hydrogen chloride can be removed with alkaline scrubbing devices before the flue gases leave the stack, but not necessarily before this acid gas has damaged some of the materials from which the incinerator is built. Furnace linings, ductwork and boiler tubes need frequent and costly attention.

1.2 Nitric oxide is generated. At the high temperatures of combustion the nitrogen and oxygen in the air combine to form nitric oxide (NO). Because this gas is neutral, it cannot be removed by scrubbers using alkaline chemicals, such as lime. Systems involving the injection of ammonia or urea can convert some of the nitric oxide back into nitrogen, but these high-energy reagents are expensive (they are normally used as fertilizers) and the removal of the nitric oxide is only about 60% effective. Any nitric oxide that is not removed is later converted by sunlight into nitrogen dioxide (NO2) which contributes to photochemical smog and acid rain.

1.3 Toxic metals are released. At the temperatures of combustion many of the toxic metals such as lead, cadmium, arsenic, mercury and chromium are liberated from otherwise fairly stable matrices like plastics. Furthermore, they are liberated in the form of tiny particles or gases, which, if they escape from the stack, vastly increase the potential surface area of contact between themselves and the environment. They also penetrate deep into human lungs, where they are rapidly exchanged with the bloodstream. The traditional method of removing metals from emissions is via particulate control devices such as electrostatic precipitators or baghouses (fabric filters). The former, while being very robust, are less efficient at removing the tiniest particles of concern. The latter are more efficient but suffer from breakage and blockage and need careful maintenance.

1.3.1 Mercury, a highly problematic pollutant, is difficult to control. A particularly problematic metal has been mercury. At the temperature of combustion it is a gas and evades the simple particulate control discussed above. As a result trash incineration has been a major source of mercury going into the environment (2). Many modern incinerators now employ activated carbon to absorb the mercury. However, this is another expensive item, and the public needs a way of knowing that the activated carbon is being used continuously, because no trash incinerator, that I am aware of, monitors toxic metal emissions on a continuous basis. Mercury removal poses several further questions. What is the fate of the mercury captured on the activated carbon, or the fly ash residues? Is the spent charcoal sent for reactivation, if so where does the mercury go? Is the spent charcoal burned in the incinerator, in which case where does the mercury go, as it can't stay in the incinerator for ever? How does the presence of activated carbon effect the leaching and other characteristics of ash disposed of in landfills? In hot climates will the mercury evaporate from the ash?

1.4 Dioxins, Furans and other by-products of combustion are formed. Shortly after the infamous accident in Seveso, Italy, (1976) which made the chemical 2,3,7,8-Tetra Chlorinated Dibenzo-para-Dioxin (2,3,7,8-TCDD or the singular "dioxin"), into a household word, Kees Olie and co-workers in the Netherlands identified this same substance in the emissions from trash incinerators (3). They, and subsequent workers, also found many other members of the dioxin family (there are 75 poly chlorinated dibenzo para dioxins, or PCDDs) and members of the furan family (there are 135 poly chlorinated dibenzo furans, or PCDFs) in these emissions. The major response to this discovery from consultants representing the incinerator industry was to claim that as long as the incinerator furnace was operated at a high temperature all the dioxins and furans would be destroyed(4), however these claims were subsequently found to be based on fraudulent manipulation of the data (5).

1.4.1 Post combustion formation of dioxin. In 1985, the reason why high temperatures alone could not solve the dioxin problem was revealed at the International Symposium on Dioxin held in Bayreuth, Germany. Two groups showed that dioxins could be reformed after the flue gases left the combustion chamber (6,7). It is now well established that if the flue gases from an incinerator are passed through air pollution control devices operating at temperatures in the range 200-400 degrees Celsius, more than a hundred fold increase in dioxin and furan formation can take place (8). A strategy that would essentially minimize post combustion formation of dioxin would require the quenching of the flue gases immediately after they emerge from the combustion chamber. However, this strategy conflicts with the aim of generating electricity, because this requires the flue gases to go through boilers to generate steam to drive turbines, thus delaying the moment when flue gas quenching occurs.

1.4.2 The fly ash dioxin problem. Without the immediate quenching system, the fly ash collected in the scrubbing devices will be contaminated with dioxins and furans. While some commentators have argued that modern incinerators are net destroyers of dioxins and furans (9) this argument does not hold if more appropriate dioxin levels in the incoming waste are assumed and if the dioxins in the fly ash and the bottom ash are included (10). A hundred times more dioxin may leave the facility on the fly ash, than from the air emissions. However, until recently, regulatory agencies, particularly the US EPA, have turned a blind eye to the dioxins and furans left on the fly ash, even though in some cases the combined ash (a combination of bottom ash and fly ash) is being used as daily cover in some US landfills. In stark contrast, in Japan, as a result of growing concern about the dioxin problem there, the government announced in 1997 that they were limiting the total dioxin emissions (i.e. air emissions plus fly ash plus bottom ash) to 5 micrograms of dioxin International Toxic Equivalents (I-TEQ) per metric ton of trash burned. According to presentations made at Dioxin '97 in Indianapolis, this will almost certainly require the fly ash from Japanese incinerators to be vitrified, which will still further escalate the costs of incineration (11,12).

1.4.3 No continuous monitoring of dioxins possible. Even when the most stringent precautions are taken to minimize dioxin air emissions it is still very difficult to convince the public that the emissions are low because there is no equipment available in the world capable of monitoring dioxins and furans on a continuous basis. Instead, we have to rely on measurements made on a spot-check basis, with advance notice given to the operator that they are going to be monitored on a particular day. It is very rare for this to occur more than once a year. Indeed, until recently, very few incinerators in the US had been measured more than once in their whole operating lifetime (13). Thus, even with the best designed incinerators, the public is still hostage to how well they are operated, maintained and monitored over their lifetime of 20 years or more. The potential problems are well illustrated by the Indianapolis incinerator. This modern facility went on line in late 1988. Through tenacious sleuthing by a local environmental group, it emerged that this facility violated its permit limits over 6000 times, including by-passing its air pollution control devices 18 times, in the first two years of operation. In addition, the incinerator had 27 boiler tube failures within one year (14). No one knows what the dioxin emissions were like when these events took place. In short, in most countries neither the regulatory authorities nor the industry has been able to put the monitoring of dioxin from these facilities onto a truly scientific foundation. The matter threatens to get worse as these incinerators get built in Southern and former Eastern European countries, where current regulatory control abilities are already low and where they have no facilities to monitor dioxin even on a spot-check basis.

1.4.4 Rising concern about current dioxin levels. Dioxin emissions have to be put against the backdrop of an increasing public concern about background dioxin levels in the environment, in our food and in our tissues (15). Of particular concern, is the fact that the highest doses of these potent endocrine disrupting chemicals are reaching us from our food and being delivered to the unborn fetus. While industry spokespersons frequently argue that dioxin emissions are extremely low (especially when compared to conventional pollutants), the counter argument is to note that dioxins interfere with several hormonal systems, in which the hormones function in human tissues at part per trillion levels. A critical finding occurred in 1992, when Dutch scientists discovered that even at background exposures dioxin was capable of interfering with the thyroid metabolism of babies at one week of age (16).

1.4.5 Dioxin emissions easily captured in food chains. Any dioxin released from an incinerator, be it in large quantities from badly operated facilities, or smaller quantities from better run ones, is readily captured by grazing animals and fish. In 1986, Tom Webster and I calculated that one liter of milk would deliver as much dioxins as a human would get breathing the air next to the cow for eight months (17). More recent calculations indicate that in one day a grazing cow puts as much dioxin into its body (from dioxin which has deposited on the grass), as a human being would get if he or she breathed the air next to the cow for fourteen years (18). This is not just an academic affair. In 1989, 16 dairy farmers downwind of a huge incinerator in Rotterdam, were told not to sell their milk, because it contained three times higher dioxin levels than anywhere else in the Netherlands (19). This situation continued until 1995 by which time the incinerator had been retrofitted. Nor was this concern put to rest in 1995. In January of this year (1998) three incinerators were shut down in the Lisle area of France, because local milk produced downwind of these facilities had been contaminated with dioxin to levels three times higher than the permitted sale level (5 parts per trillion TEQ in the milk fat) (20).

1.4.6 Ireland provides an indicator of how large the legacy of dioxin pollution from incinerators has been. A little publicized report from Ireland indicates just how extensive the contamination of the European milk supply from dioxin has been. Dr. Christopher Rappe analyzed 32 cows' milk samples from different parts of Ireland (21). The reported levels ranged from 0.12 to 0.51 ppt. (parts per trillion) of dioxin I-TEQs in the milk fat, with an average of 0.23 ppt. . These levels are much lower than the levels reported in Switzerland, Germany, Holland, France and the UK. In my view it is significant that Ireland has no trash incinerators.

1.4.7 Advances in one country do not always translate to success in others. Again and again, optimistic reports about how well one particular country, or one particular incinerator, has done with limiting dioxin emissions, has been used to promote the building of incinerators in other countries, where the operators are neither as conscientious nor the regulators as competent. For example, long after Swedish consultants and scientists had told the world that Sweden had solved the dioxin emission problem (about 1986), incinerators were built and operated in the US which had extremely high dioxin emissions. For example a 2000 ton per day trash incinerator built in Norfolk, Virginia in 1988, was found in 1994, to be putting out more dioxin (approximately 2000 grams of toxic equivalents per year) than the combined emissions from all of the traffic, incinerators, industry and all other sources in Sweden, Germany and the Netherlands added together (22).

1.5 The attention being paid to end-of-the-pipe dioxin control on incinerators will not solve the dioxin contamination of the environment. Whether one accepts the need for trash incineration or not, one has to applaud the efforts and success of those who have reduced dioxin emissions from these facilities. However, this effort cannot solve the dioxin problem generated by municipal waste. As long as chlorinated plastics like poly vinyl chloride (PVC) and poly vinylidine dichloride (PVDC) are present in the waste stream, dioxins and furans are going to be generated in every back yard burner, landfill fire, roadside burning and accidental fires in homes, businesses and industry. The reduction of dioxin emissions in northern incinerators, should not make us complacent about the potential dioxin contamination from the building of inferior quality incinerators in southern countries and the continued contamination from the casual and accidental burning of trash in both north and south. In my view, the dioxin problem can only be solved by phasing out the use of chlorinated plastics and the industrial use of chlorine.

1.6 Modifications to counteract one pollutant can lead to increases in others. The incineration industry has had to develop on the fly. New scientific and environmental findings trigger new pollution control devices and expensive retrofits. Incinerators are built and financed with the expectation that they will operate at least 20 years. However, incinerators operating today look very different from those built 20 years ago. We can anticipate that those operating 20 years from now, will look very different from today's. The trouble with making changes on the fly, is that a solution to one pollutant problem, may make other pollutant problems worse. For example, the demand for higher furnace temperatures and better combustion to combat the dioxin problem, led to higher nitric oxide formation, the greater liberation of toxic metals, and reduced mercury control (less soot available for mercury absorption). Both the desire to capture energy via water boilers and the use of electrostatic precipitators for particulate control, increased the post combustion formation of dioxin. The use of lime and baghouse scrubbing combinations, has led to a more toxic fly ash product. The public has had to live through this ongoing experiment for many years, and continues to do so. For example, in 1993, the citizens of Columbus, Ohio, who were aroused by anecdotal reports of an increase in rare neurological symptoms and other illnesses, including cancer, in the vicinity of a 2000 ton per day incinerator, discovered that measurements made at the facility in 1992, but not reported to the public, indicated that nearly 1000 grams of dioxin TEQs were being emitted from the facility annually (23). This was more than the total dioxin generated in the whole of Germany at that time. The citizens received two further shocks. First, scientists from the US EPA reported at Dioxin '93, that the total quantity of dioxin emitted from all the US trash incinerators combined (about 130 at that time) was between 60 and 200 grams of dioxin TEQs (24), which was less than the single Columbus incinerator by itself. Second, the Ohio Health department reported that a 1000 grams of dioxin (about one half of a Seveso accident) falling annually on their heads and surrounding areas posed no health problems (25).

1.6.1 In the UK, officials have had to admit that their trash incinerators operating in the '70s, '80s and even into the early '90s, could not meet new European dioxin standards without major retrofits, and that these "old" incinerators had been responsible for putting most of the dioxin into the UK environment, including cows' milk. We have already noted that both the range and the average dioxin level in cows' milk in the UK (i.e. background levels) is much higher than the truer "background" levels in Ireland. Instead of issuing a massive apology for permitting this pollution of the food supply, the UK is currently proposing to build more incinerators as part of their "alternative" energy program.

2. ASH DISPOSAL

Introduction. There are two kinds of ash generated by an incinerator: the bottom ash which falls through the grate system in the furnace (about 90% of the ash), and the fly ash, which is the very fine material which is collected in the boilers, the heat exchangers and the air pollution control devices. As far as toxic metals are concerned, it is a chemical truism to state that the better the air pollution control the more toxic the fly ash becomes.

2.1 Fly ash hazard often obscured. In some jurisdictions like Ontario, Canada and Germany, the fly ash is assumed to be a highly toxic material and is automatically sent to hazardous waste containment facilities. In Japan, current regulations will probably force the vitrification of the fly ash. However, in other jurisdictions the toxicity of the fly ash (particularly) is obscured by three things: a) the mixing of the fly ash with the bottom ash before testing and disposal, b) not testing for the absolute levels of toxics like metals and dioxins in the ash, but rather only looking at what dissolves out of the ash during a leachate test and c) the interference of the lime present in the ash with some of these leaching tests (26). All three of these machinations particularly pertain in the US. Because of this situation, in my view, neither workers nor members of the public have been fully warned of the dangers of being directly exposed to this ash. Further, in some jurisdictions the ash is being handled and disposed of in a cavalier fashion, which while it may save the operators money, is highly unsatisfactory from an environmental point of view. For example, in the Netherlands, as of 1994, 35% of the fly ash was going into asphalt (27). In the US combined ash has gone directly to municipal landfills and mixed with trash containing organic material. In many instances it is used for landfill cover. Elsewhere, the fly ash has been used to make concrete, with no warning on the product label that it contains toxic metals or dioxins.

2.2 Ash represents a Catch-22 for the incineration industry. If handled properly, ash makes incineration prohibitively expensive, for all but the wealthiest communities. If handled improperly, it poses both short and long term health and environmental dangers.

3. ECONOMIC COSTS

3.1. Incinerators are formidably expensive. At the time the small incinerator proposal (200 tons per day) was defeated in our county in Northern NY (St. Lawrence County), in 1990, the capital costs had risen to $34 million. The investment firm Moodys had estimated that the tipping fee (the cost to consumers of delivering one ton of trash to the facility) would be a staggering $180 per ton. Such tipping fees have essentially eliminated facilities in the US much smaller than 750 tons per day. In 1983, a 1500 ton per day facility built in North Andover, with only a three field electrostatic precipitator for air pollution control, cost about $190 million. The current tipping fee is $95 per ton, but could rise as high as $200 per ton in order to pay for new air pollution control. A 1000 ton per day facility which went on line in 1994 in Syracuse, NY, and fitted with state-of- the-art air pollution control, cost $178 million. A 2000 ton per day facility, which went on line near Amsterdam in the Netherlands in 1995, cost a massive $600 million with half the investment going into air pollution control (28). Tipping fees reported from some German incinerators are staggering.

3.2. Very few jobs are created for this massive economic investment. Most of the money spent on these incinerators is going into complicated equipment. Apart from the number of jobs created in the building of the plant, very few permanent jobs are forthcoming. A large incinerator may employ about 100 workers. On the other hand, if the community puts its efforts into source separation, reuse and repair, recycling and composting, a very large number of jobs are created, both in the actual handling of the waste and in the secondary industries which utilize the recovered material.

3.3 Most of the money invested in the incinerator leaves the community. The huge engineering firms that build incinerators are seldom located in the host community and thus most of the money invested leaves the community (and the country if the company is foreign based). On the other hand, money invested in the low tech alternatives stays in the community creating local jobs and stimulating other forms of community development.

3.4 Loss of capital is acute in developing economies. Developing economies, can ill afford to lose capital and local job opportunities. In 1997, authorities in the Philippines were considering three large trash incinerators for the Manila area (and as many as 7 others outside Manila). The Danish company Volund is offering to build a 1300 ton per day facility at the old, and infamous, Smoky Mountain dump, to burn excavated plastics from the old landfill there. The American company, Ogden Martin is being considered to build a 2000 ton per day facility at the Carmona landfill, just outside Manila, and the Swiss Swedish conglomerate Asea Brown and Boveri (ABB) is part of a proposal to build a 4500 ton per day facility (which would be the largest in the world) at the San Mateo landfill. It is extremely frustrating to witness the potential squandering of huge amounts of taxpayers' money on these capital intensive facilities, while the largely voluntary and local efforts to develop recycling and composting programs in the Barangays (small political jurisdictions within the city) wither for lack of financial and governmental support. These truths are often concealed from taxpayers, because the incinerator projects are frequently promoted as being "privately financed". This coupled with the PR hype of "waste-to-energy" tricks many into believing that the public will not be paying for these facilities, when in fact, apart from a relatively minor return from energy sales (discussed below) the bulk of the repayment on the investment (plus profits) has to come from the tipping fee which comes out of the public exchequer.

3.5 Taxpayers usually find out true costs when it is too late. In order to pay back the massive investment involved in building an incinerator, the builder usually has to secure contracts which commit communities to deliver their trash to the facility for an extended period of time. The latter have to sign a so-called "put-or-pay" agreement. These commit the communities to deliver a prescribed amount of trash to the incinerator each month or year, at a fixed rate, and should they fail to do so they have to pay the scheduled amount anyway.

3.5.1 Flow control outlawed in the US. In the US, the Supreme Court threw a monkey wrench into this system when it ruled that these kind of "flow control" measures as applied to waste haulers were unconstitutional, claiming that they interfered with "inter-state commerce". In short, waste haulers are now allowed to take the waste where they choose. This means that in many states, trash haulers are taking the waste to distant landfills where the tipping fee is much cheaper. For example, in 1998, the spot market price for getting rid of trash in Massachusetts is about $45 a ton, which means that facilities like the North Andover incinerator, charging $95 a ton tipping fee, are in serious financial trouble. In New Jersey, political leaders are in a turmoil trying to work out how to finance the remaining $1.6 billion debt on the five incinerators that have been built there (at one point NJ wanted to build 22 incinerators!) (29). Again, each incinerator is not receiving the amount of waste (and hence income) anticipated. The current debate is over who should pay off these debts: the county operating the incinerator, the counties using the incinerator or the state as a whole.

4. INCINERATION IS A WASTE OF ENERGY

4.1. Modern incinerators do produce salable energy. The modern trash incinerator can be used to generate hot water, steam and/or electricity. Trash in industrialized countries contains enough paper and plastic for it to burn without the need of any (or much) auxiliary fuel. As few communities recover energy from the waste dumped into landfills, this energy recovery represents a net energy gain to the local community. Long term contracts for the sale of steam to local companies, or state facilities, like prisons, can sometimes be secured or the sale of electricity to power utilities can be negotiated. In some cases state or national governments require the utilities to purchase the energy from incinerators. In the UK, the government even offers subsidies to trash incineration under its Non-Fossil Fuel Obligation (NFFO) incentive scheme to promote alternatives to fossil fuels for power generation.

4.2 Reality versus Public relations. While, the claim that the modern trash incinerator is a "waste-to-energy" facility makes for good public relations, the reality is that they produce very little energy and energy production certainly doesn't justify the huge costs involved in building them. For example, the 1500 ton per day facility built in North Andover (Massachusetts) at a cost of $190 million, receives trash from about half a million people, but only provides enough electricity to power 28,000 homes. All of Japan's 193 waste-to-energy incinerators combined produce less energy than one nuclear power station (30) and if the United States burned all its municipal waste it would contribute less than 1% of the country's energy needs (31).

4.2.1 Consider these simple points: 1) A trash incinerator is the only kind of power station which gets paid to accept the fuel it burns. 2) The costs of generating electricity increases significantly as the fuel gets dirtier and trash is the dirtiest fuel burned in any "power station". Enormous amounts of money have to go into air pollution control and ash disposal, if these are done properly. 3) A trash incinerator has to run for several years before there is a net production of energy. Large quantities of energy have to go into building, operating, maintaining and dismantling it after its life is over. 4) The economics of paying for the building and running of an incinerator revolve around the tipping fee paid by communities to use the facility. The income from electricity sales is a minor contributor. For example a facility I visited in Poggibonzi, Italy, in 1998, was receiving 10 times more money from tipping fees than they were obtaining from the sale of electricity.

4.3 Recycling saves more energy than incineration yields. The most telling argument against the waste-to-energy promotion comes from two studies performed in the US (32,33) which show that if the currently marketable recyclable material, which is typically burned in a modern trash incinerator, was recycled instead, some 3-5 times as much energy would be saved compared to that produced from it being burned. The reason for this big difference is that incineration can only recover the some of the calorific value contained in the trash. It cannot recover any of the energy invested in the extraction, processing, fabrication and chemical synthesis involved in the manufacture of the objects and materials in the waste stream. Reuse and recycling can.

4.4 A larger vision is needed. From a national or global perspective, an incinerator is a "waste-of-energy" facility not a "waste-to-energy" facility. Unfortunately, this is often lost on the local decision maker, who sees a net local production of energy compared to land filling. A larger vision is needed to see the loss of energy that incineration represents. Simply put, every time a local community burns something the larger community has to replace it with all the huge energy costs of primary processing and fabrication. It is only reuse, recycling and composting that allows us to partially reduce the energy (and pollution) costs of primary processing and fabrication.

5. PUBLIC OPPOSITION

5.1. In the US incineration is the most unpopular technology since nuclear power. Since 1985, in the US, over 300 trash incinerators, have been defeated or put on hold. In 1985, California had plans for 35 incinerators, only 3 were built, the rest were canceled. In 1985, New Jersey had plans for 22 trash incinerators, only 5 have been built. A sixth planned for Mercer County, was finally defeated after many years of struggle, in November 1996. Since 1994, more incinerators have been closed down than those that have gone on line.

5.2 US development at a standstill. As of this writing (October 1998) there is not one active proposal to build a trash incinerator of any significant size (i.e. above 40 tons per day) in the US. The last proposal considered was one by Foster Wheeler in the town of Pennsville, NJ. Not only did the County Commissioners reject this proposal, but Foster Wheeler has announced since this defeat and a humiliating debacle with the fluidized bed incinerator which it built in Robbins, Illinois (34), that it is getting out of the Waste- to-energy incineration business in the US (35). Several other large engineering firms have pulled out of the incinerator business in the US, including Combustion Engineering, Blount, Dravo, Westinghouse, General Electric and Ebasco. This leaves only three major players: Ogden Martin, Wheelabrator and American Refuel. Two of these are owned by major waste companies (WMI and BFI) which can cover their loss on the incinerator front with developments in other areas of their waste business.

5.3 Opposition in other countries. It isn't just the US where incineration has proved so unpopular. There has been strong opposition to new incinerator proposals in Australia, Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, New Zealand, Poland, Spain, the UK and many other countries, both in the North and in the South. There is not enough time to go into much detail here, but three countries provide particularly interesting examples.

5.3.1 Germany. Germany is considered by many to build, operate and regulate their incinerators better than any other country, and yet the opposition to the building of new incinerators there since the late '80s has been intense. For example, a citizens' coalition called "Das Bessere Mullkoncept"(the Better Garbage Concept) in 1990, was able to get a referendum on the ballot in Bavaria which would have virtually eliminated trash incineration as a waste option. At that time the Bavarian government was planning 17 new incinerators. The coalition was able to get over one million people to go to their town halls, in a 12 day period, to sign a lengthy petition in support of getting this referendum on the ballot (36). Even though the referendum was narrowly defeated, this was an amazing achievement and an indication of the massive unpopularity of incineration in this state.

5.3.2 France. Many of us in the environmental movement, had given up on France as far as challenging incineration was concerned. Any country that can go half way around the globe and explode atomic bombs in someone else's backyard is hardly amenable to environmental or ethical arguments. However, in the last few years a grass roots movement against incineration has emerged in France which is second to none. The National Coalition Against the Importation, Exportation and Incineration of Waste, has over 100 communities as members, has already stopped several incinerators, and has generated more press coverage on dioxin and the contamination of the food chain than any other country in the world.

5.3.3 Bangladesh. When citizens in Khulna (a port in the Bay of Bengal) heard about a proposal by an American company to build a power station in their town, they were excited. When however, the Bangladesh Environmental Law Association investigated the matter, they found that the actual proposal was a huge trash incineration plant which would burn trash shipped in from New York City. They were far from impressed and organized, successfully, to stop the project. So, even in countries, which are economically depressed, citizens are capable of seeing through the "waste-to-energy" promotion hype, if there is some individual or group prepared to do some homework.

5.4 The dangers of ignoring public opinion. Too often decision makers make the decision to build an incinerator before they have consulted with the public in a meaningful way. They usually rely on large consulting companies to review their options. Because such companies draw much of their expertise from an engineering background, they have a natural tendency towards the high-tech solution and give little credence to solutions in which organization and education must play a dominant role. PR firms are used to devise strategies which attempt to negate the public's "irritating" opposition. However, treating the public in this way usually proves disastrous. What is billed as a "quick-fix" solution isn't quick, if the public organizes to oppose it.

5.5 Look at more than one option. Even if decision makers believe that incineration will be a part of their waste solution, they would be advised to put serious attention and equal funding (with a careful choice of consultants) into an alternative plan that doesn't include incineration. This way they can avoid the trap of coming to the public with a proposal which essentially says, "accept our incinerator or opt for chaos".

5.6 Even a true believer should not lead with incineration. Politically it does not make sense to lead with the most problematic, most expensive and most contentious alternative to landfilling. It makes more sense to lead with those alternatives which are least contentious, namely reuse, recycling and composting. Only when these have been maximized, should incinerators or other destructive technologies be considered.

5.7 The non-burn alternatives are more popular. In sharp contrast to incineration, recycling and composting are far more popular with the general public. In the US, more people recycle than vote! Despite pessimistic predictions by waste experts in the mid- '80s, the American people have emphatically embraced recycling. Currently, there are nearly 9000 curbside recycling programs, and over 3000 yard waste composting programs in operation in the US (37). Seattle, a city of one million people is close to a 50% diversion from landfill. The state of NJ, as a whole, has achieved a 45% diversion rate, with some individual communities exceeding 60%. Communities in the Quinte region of Ontario, Canada have achieved over 70% diversion from landfill. Small communities near Milan, Italy have also achieved diversion rates of over 70%, and two communities near Padua are at 80% and above.

6. A FEW WORDS ABOUT ALTERNATIVES

This presentation is already far too long for me to spend much time discussing the details of non-burn alternatives. There are, however, a few points that can be made which throw more light on the incineration debate.

6.1 Landfills. It is clear that no solution to waste will get rid of landfills, at least for the foreseeable future. The question then becomes what kind of landfill can your community live with. A raw waste landfill? A landfill that receives the ash, bulky waste and other material by-passed from the incinerator? A residue landfill after an intensive source separation, reduction, reuse, recycling, toxic removal and composting program? Put like that, most people would probably opt for third option, assuming that they had confidence in the quality of the program. But we can make such a landfill even better, if we insist that it be preceded by a screening facility to ensure that only non-toxic and non-biodegradable material is buried. Unfortunately, such a "front end" approach seems to be out of step with most regulatory authorities which endorse a "back end" approach. Their approach consists of lining systems, leachate collection, leachate treatment, daily cover, final cover and capping as the way of protecting the environment from dumping things into a hole in the ground. Because of the economy of scale, this approach of "controlling what comes out" tends to drive the building of regional mega- landfills. These excite intense opposition from host communities, and usually have to be pushed through undemocratically. The alternative approach of "controlling what goes in", means that we can return to small, more politically acceptable, community controlled landfills.

6.2 The importance of composting. While most people often describe the alternative to landfilling and incineration as "recycling", in my view, the most important component of the alternative strategy, after the critical first step of source separation (discussed below), is "composting". This is because the material which causes most of the problems in landfills is organic (biodegradable) waste. This otherwise relatively benign material, once it gets into a landfill creates methane, which contributes to global warming, odors, and an acid leachate, which in turn, can move toxics into the surface or ground water. Composting, at a far lower environmental and economic cost than incineration, can keep this organic material out of landfills.

6.3 Integrated waste management. Undoubtedly, one of the responses to this presentation from incinerator advocates will be, "We agree with you about the necessity to maximize reduction, reuse and recycling (they often forget to include composting on this list), but you are still going to have some stuff left over, doesn't it make sense to burn this material and recover its energy content rather than to dump it in a landfill?" This argument goes by the name "integrated waste management". It sounds good, but it seldom yields what it promises. Once a community embarks on building an incinerator, it soaks up all the available cash, little is left over for a really aggressive recycling and composting program. Moreover, once the incinerator is built it will need all the waste it can get (which in the US often includes non-municipal waste) in order to pay off the massive loans needed to build it.. In essence, once built you have to maximize the use of an incinerator. It is inflexible: other new options will be resisted. On the other hand, if one backs up the reuse, recycling and composting program with an expensive landfill (or the temporary export of waste to a distant landfill) one can minimize its use without penalty. Ideally, decision makers should strive to design a program where increased waste reduction, reuse, recycling and composting, visibly saves the community money from avoided landfill tipping fees. In this way one will have "integrated" the environmental solution with the economic solution.

6.4 Five principles. Left to highly paid consulting firms, municipal waste can become an extremely complicated business. Certainly, incineration done properly is a very complicated process. However, if we look at the "waste" in our homes it is a relatively simple material. In essence, its most of the material we paid good money for yesterday and we don't want today. Waste is made by mixing all this material together. It can be unmade with source separation. This is the vital first step in solving the waste crisis. With source separation we can get reusable objects, materials that can be recycled back to industry, materials that can be composted (preferably in our backyards), some household toxics and an educated household. With manufacturers, and especially the packaging industry, producing ever more complicated mixtures of materials, some objects once separated, still pose problems. However, rather than allowing these poorly designed materials drive the building of expensive incinerators, these "left over" materials should drive research into better industrial design. In my view, the five principles, or imperatives, we need to apply in order to solve the waste crisis in an environmentally sound and economically cost effective manner, are: 1. Keep the solution simple. 2. Keep the solution local. 3. Integrate the solution with the local economy. 4. Integrate the solution with local community development. 5. Make sure the solution is sustainable.

7. SUSTAINABILITY

7.1 Cheap fossil fuels conceal our non-sustainability. I argue that the fragile biosphere of our planet is threatened because the industrialized nations have imposed, at an ever increasing pace, a linear system of handling materials, onto a biological system which handles materials in a circular fashion. Our linear approach is not sustainable on a finite planet. However, its non-sustainability has been hidden from us for over 200 years by an apparent "abundant" supply of fossil fuel. The end result is the conversion of material resources to waste, at an ever increasing rate. Even world famous economists have rationalized a system which lives off capital rather than income. The use of incineration fails to challenge this linear system.

7.2 Incineration is a wasted opportunity. Every time we burn something in an incinerator, or dump it in a landfill, we have to replace it. This means going back to all the high energy inputs, resource depletion and pollution of primary processing. It is precisely the enormous growth in primary processing that is giving us global warming. In other words, it is overconsumption that is giving us both the local trash crises and the global crisis. It is only by reusing, recycling and reducing consumption that we can do anything about either. The trash bag or can is the most concrete connection each individual has with the global crisis.

7.3 Forces behind overconsumption. At the national level the fires of overconsumption are further stoked by economies which measure their success in the global economy by their annual growth of their GNP and not the welfare of their citizens or the quality of the environment which they plunder. By and large, the individual has been seduced with an elaborate web of false needs woven by a very sophisticated advertising industry, harbored by an equally alluring and distracting host medium called television.

7.4 Fighting the dominant paradigm. As long as the prevailing western (largely post- war American) philosophy - the more we consume the happier we will become - threatens to rule the world, as a species we are doomed. Our salvation rests on those who can show that they have become happier while consuming far less. As Gandhi so elegantly put it, "the world has enough for every one's need but not enough for every one's greed."

7.5 Community building. We need to find the strength to put human relations and community building at the center of our lives, instead of the TV set. Educating our citizens to reduce, reuse, recycle and compost is not a total solution but it is a fine beginning. On the other hand, every trash incinerator built delays this discussion and squanders the opportunity to move our communities and our species in the right direction to fight overconsumption and the global warming it spawns.

8. CONCLUSION

In the above presentation I have presented the arguments which support my conclusion that incineration is not an appropriate waste management solution in the twenty first century. Fortunately, the public's fears about the pollutants released and those captured in the residues, as well as incineration's enormous economic costs, when made visible, have dramatically slowed down the building of these facilities in both northern and southern countries alike. If one avoids the beguiling but inaccurate label "waste-to-energy" one can see that these facilities do not belong in a future in which sustainability will become the key issue for survival. In my view, when you build an incinerator in your community you are advertising to the world that you were not clever enough, either politically or technically, to recover your discarded resources in a manner which is responsible to your local community or future generations.

REFERENCES

1. Joubert, J. cited in "Poisoned Harvest" by Robbins, C., p.7, Gollancz (pub.), London, 1991.
2. Connett, E. and Connett, P. (1996). "Mercury in Massachusetts: an evaluation of sources, emissions, impacts and controls", Waste Not # 363, Summer 1996. Waste Not, 82 Judson Street, Canton, NY 13617.
3. Olie, K.., Vermeulen, P.L. and Hutzinger, O. (1977). "Chlorodibenzo-p-dioxins and chlorodibenzofurans are trace components of fly ash and flue gases of some municipal incinerators in the Netherlands", Chemosphere, 6, 455.
4. Hasselriis, F. (1984) "Relationship between combustion conditions and emission of trace pollutants", paper presented at the NY State Air Pollution Association, May 2, 1984.
5. Commoner, B., McNamara,M., Shapiro, K. and Webster, T. (1984) "The origins of chlorinated dioxins and dibenzofurans emitted by incinerators that burn unseparated municipal solid

waste and an assessment of methods for controlling them", Center for the Biology of Natural Systems,. Queens College, Flushing , NY, Dec.1, 1984.
6. Ozvacic, V. (1986)." A review of stack sampling methodology for PCDDs and PCDFs", Chemosphere, 15, 1173.
7. Vogg, H. and Stieglitz, L.., (1986) "Thermal behavior of PCDD/PCDF in fly ash from municipal incinerators",Chemosphere, 15, 1373.
8. US EPA (1989) "Municipal waste combustors-background information for proposed standards: post combustion technology performance". EPA-450/3-89-27c, August 1989.
9. International Ash Working Group (1997). "Municipal Solid Waste Incinerator Residues", Studies in Environmental Science 67, Elsevier (pub.), Amsterdam.
10. ENDS Report (1997). "Incinerators remain net dioxin sources, says ETSU", Oct. 1997.11. Abe, S., Kanabayashi, F., Kimura, T. and Kokado, M. (1997). "Decomposition of dioxins and related compounds in MSW ash melting". Organohalogen Compounds, 31, 348.
12. Sakai, S. Hiraoka, M., Ishida, M., Shiji, R., Nie, P. and Nakamura, N. (1997). "A study of total PCDDs/Fs release to environment from MSWI". Organohalogen Compounds, 31, 376.
13. Webster,T and Connett, P. (1996), "Dioxin emission inventories: the importance of large sources", Organohalogen Compounds, 28, 95.
14. Connett, E. and Connett, P. (1992). " Ogden Martin is cited by the EPA with over 6,000 permit violations at its 2,300 tpd municipal waste incinerator in Indianapolis, Indiana", Waste Not, # 209, September 1992.
15. USEPA (1994), "Estimating exposure to dioxin-like compounds", Volume II: Properties, Sources, Occurence and Background Exposure. EPA/600/6-88/005Cb, External Review Draft, June 1994 (released to the public, Sept 13, 1994).
16. Pluim, H. J., Koppe, J.G., Olie, K., von der Slikke, J.W., Kok, J.H., Vulsma, T., van Tijn, D. and de Vijlder, J.J.M. (1992). "Effects of dioxins on thyroid function in newborn babies", The Lancet, 339, 1303, May 23 1992.
17. Connett, P. and Webster,T. (1987) "An estimation of the relative human exposure to 2,3,7,8-TCDD emissions via inhalation and ingestion of cow's milk", Chemosphere, 16, 2079.
18. McLachlan, M.S. (1995) "Accumulation of PCDD/F in an agricultural food chain", Organohalogen Compounds, 26, 105.
19. Connett, E. and Connett, P. (1989). "The Netherlands: milk and meat products contaminated by dioxin from solid waste incienrator", Waste Not # 61, June 29, 1989.
20. ENDS Daily (1998). "Dioxin alert shuts French Waste Incinerators", Jan. 29, 1998.
21. EPA (Ireland) (1996). "Dioxins in the Irish environment. An assessment based upon levels in cow's milk", Colman Concannon, Regional Inspectorate, Pottery Road, Dun Laoghaire, Ireland, April 1986.
22. USEPA (1995). "Compilation of MWC dioxin data", Office of Air Quality Planning and Standards, July 27, 1995.
23. Connett, E. and Connett, P.(1994). "Columbus, Ohio to Oklahoma" , Waste Not # 270, part 10 of a 14-part series: "A review of Waste-to-Energy trash incinerators in the USA", Waste Not #s 251-274, December, 1993 - January, 1994 and "The Columbus, Ohio 'waste-to-dioxin' trash incinerator", Waste Not #275, April 1994.
24. Schaum, J., Cleverly, D., Lorber, M., Phillips, L. and Schweer, G. (1993). "Sources of dioxin-like compounds and background exposure levels." Thirteenth International

Symposium on Chlorinated Dioxins and Related Compounds, Vienna, Austria, September 1993.
25. Ohio EPA (1994). "Ohio EPA study finds no substantial threat posed by dioxin emissions", News release, Feb. 24, 1994 and "Risk assessment of potential health effects of dioxins and dibenzofurans emitted from Columbus Solid Waste Authority's Reduction Facility", February, 1994.
26. Connett, E. and Connett, P. (1995). "The Great Incinerator Ash Scam", Waste Not #s 316-319, March 1995.
27. Bremmer, H.J., Troost, L.M., Kuipers, G., de Koning, J. and Sein, A.A. (1994). "Emissions of dioxins in the Netherlands", National Institute of Public Health and Environmental Protection (RIVM), Bilthoven, The Netherlands, Report 770501018. February, 1994.
28. Olie, K., (1995) personal communication.
29. Greczyn, M. (1998). "Waste battle in N.J. grows", Waste News, 3:49, 1, April 20, 1998.
30. Warmer Bulletin (1998). "Japan plans to boost EfW", Warmer Bulletin ,59,12, March, 1998.
31. Spiro, T.G. and Stigliani, W.M. (1996). "Chemistry of the Environment", Table 1.2, p.9, Prentice Hall (pub.), Upper Saddle River, N.J.
32. Morris, J. and Canzoneri, D. (1993). "Recycling versus incineration: an energy conservation analysis", SRMG Inc., 5025 California Ave, SW, Seattle, Wa 98136.
33. Franklin Associates, Ltd. (1994) "The role of recycling in integrated solid waste management to the year 2000", prepared for Keep America Beautiful, Stamford Ct, September, 1994.
34. Knapp, K.(1998). "Illinois incinerator going up in smoke", Waste News, 4:14, 4, and "Robbins' mess", editorial, Waste News, 4:14, 8, August 17, 1998.
35. Geiselman, B. (1998). "Foster Wheeler cuts WTE focus", Waste News, 4:16, 1, August 31, 1998.
36. Connett, E. and Connett, P. (1990). "Over one million people in Bavaria vote to put an anti-incinerator referendum on the ballot", Waste Not # 122, October 25,1990.
37. Goldstein,N. and Glenn, J. (1998)."The State of garbage in America", Parts I and II, Biocycle, April, May 1998.