THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release October 5, 2009

EXECUTIVE ORDER

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FEDERAL LEADERSHIP IN ENVIRONMENTAL, ENERGY, AND ECONOMIC PERFORMANCE

By the authority vested in me as President by the Constitution and the laws of the United States of America, and to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas emissions a priority for Federal agencies, it is hereby ordered as follows:

Section 1. Policy. In order to create a clean energy economy that will increase our Nation's prosperity, promote energy security, protect the interests of taxpayers, and safeguard the health of our environment, the Federal Government must lead by example. It is therefore the policy of the United States that Federal agencies shall increase energy efficiency; measure, report, and reduce their greenhouse gas emissions from direct and indirect activities; conserve and protect water resources through efficiency, reuse, and stormwater management; eliminate waste, recycle, and prevent pollution; leverage agency acquisitions to foster markets for sustainable technologies and environmentally preferable materials, products, and services; design, construct, maintain, and operate high performance sustainable buildings in sustainable locations; strengthen the vitality and livability of the communities in which Federal facilities are located; and inform Federal employees about and involve them in the achievement of these goals.

It is further the policy of the United States that to achieve these goals and support their respective missions, agencies shall prioritize actions based on a full accounting of both economic and social benefits and costs and shall drive continuous improvement by annually evaluating performance, extending or expanding projects that have net benefits, and reassessing or discontinuing under-performing projects.

Finally, it is also the policy of the United States that agencies' efforts and outcomes in implementing this order shall be transparent and that agencies shall therefore disclose results associated with the actions taken pursuant to this order on publicly available Federal websites.

Sec. 2. Goals for Agencies. In implementing the policy set forth in section 1 of this order, and preparing and implementing the Strategic Sustainability Performance Plan called for in section 8 of this order, the head of each agency shall:

(a) within 90 days of the date of this order, establish and report to the Chair of the Council on Environmental Quality (CEQ Chair) and the Director of the Office of Management and Budget (OMB Director) a percentage reduction target for agency-wide

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reductions of scope 1 and 2 greenhouse gas emissions in absolute terms by fiscal year 2020, relative to a fiscal year 2008 baseline of the agency's scope 1 and 2 greenhouse gas emissions. Where appropriate, the target shall exclude direct emissions from excluded vehicles and equipment and from electric power produced and sold commercially to other parties in the course of regular business. This target shall be subject to review and approval by the CEQ Chair in consultation with the OMB Director under section 5 of this order. In establishing the target, the agency head shall consider reductions associated with:

(i) reducing energy intensity in agency buildings;

(ii) increasing agency use of renewable energy and implementing renewable energy generation projects on agency property; and

(iii) reducing the use of fossil fuels by:

(A) using low greenhouse gas emitting vehicles including alternative fuel vehicles;

(B) optimizing the number of vehicles in the agency fleet; and

(C) reducing, if the agency operates a fleet of at least 20 motor vehicles, the agency fleet's total consumption of petroleum products by a minimum of 2 percent annually through the end of fiscal year 2020, relative to a baseline of fiscal year 2005;

(b) within 240 days of the date of this order and concurrent with submission of the Strategic Sustainability Performance Plan as described in section 8 of this order, establish and report to the CEQ Chair and the OMB Director a percentage reduction target for reducing agency-wide scope 3 greenhouse gas emissions in absolute terms by fiscal year 2020, relative to a fiscal year 2008 baseline of agency scope 3 emissions. This target shall be subject to review and approval by the CEQ Chair in consultation with the OMB Director under section 5 of this order. In establishing the target, the agency head shall consider reductions associated with:

(i) pursuing opportunities with vendors and contractors to address and incorporate incentives to reduce greenhouse gas emissions (such as changes to manufacturing, utility or delivery services, modes of transportation used, or other changes in supply chain activities);

(ii) implementing strategies and accommodations for transit, travel, training, and conferencing that actively support lower-carbon commuting and travel by agency staff;

(iii) greenhouse gas emission reductions associated with pursuing other relevant goals in this section; and

(iv) developing and implementing innovative policies and practices to address scope 3 greenhouse gas emissions unique to agency operations;

(c) establish and report to the CEQ Chair and OMB Director a comprehensive inventory of absolute greenhouse gas emissions, including scope 1, scope 2, and specified scope 3 emissions (i) within 15 months of the date of this order for fiscal year 2010, and (ii) thereafter, annually at the end of January, for the preceding fiscal year.

(d) improve water use efficiency and management by:

(i) reducing potable water consumption intensity by 2 percent annually through fiscal year 2020, or 26 percent by the end of fiscal year 2020, relative to a baseline of the agency's water consumption in fiscal year 2007, by implementing water management strategies including water-efficient and low-flow fixtures and efficient cooling towers;

(ii) reducing agency industrial, landscaping, and agricultural water consumption by 2 percent annually or 20 percent by the end of fiscal year 2020 relative to a baseline of the agency's industrial, landscaping, and agricultural water consumption in fiscal year 2010;

(iii) consistent with State law, identifying, promoting, and implementing water reuse strategies that reduce potable water consumption; and

(iv) implementing and achieving the objectives identified in the stormwater management guidance referenced in section 14 of this order;

(e) promote pollution prevention and eliminate waste by:

(i) minimizing the generation of waste and pollutants through source reduction;

(ii) diverting at least 50 percent of non-hazardous solid waste, excluding construction and demolition debris, by the end of fiscal year 2015;

(iii) diverting at least 50 percent of construction and demolition materials and debris by the end of fiscal year 2015;

(iv) reducing printing paper use and acquiring uncoated printing and writing paper containing at least 30 percent postconsumer fiber;

(v) reducing and minimizing the quantity of toxic and hazardous chemicals and materials acquired, used, or disposed of;

(vi) increasing diversion of compostable and organic material from the waste stream;

(vii) implementing integrated pest management and other appropriate landscape management practices;

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(viii) increasing agency use of acceptable alternative chemicals and processes in keeping with the agency's procurement policies;

(ix) decreasing agency use of chemicals where such decrease will assist the agency in achieving greenhouse gas emission reduction targets under section 2(a) and (b) of this order; and

(x) reporting in accordance with the requirements of sections 301 through 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. 11001 *et seq.*);

(f) advance regional and local integrated planning by:

(i) participating in regional transportation planning and recognizing existing community transportation infrastructure;

(ii) aligning Federal policies to increase the effectiveness of local planning for energy choices such as locally generated renewable energy;

(iii) ensuring that planning for new Federal facilities or new leases includes consideration of sites that are pedestrian friendly, near existing employment centers, and accessible to public transit, and emphasizes existing central cities and, in rural communities, existing or planned town centers;

(iv) identifying and analyzing impacts from energy usage and alternative energy sources in all Environmental Impact Statements and Environmental Assessments for proposals for new or expanded Federal facilities under the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 *et seq.*); and

(v) coordinating with regional programs for Federal, State, tribal, and local ecosystem, watershed, and environmental management;

(g) implement high performance sustainable Federal building design, construction, operation and management, maintenance, and deconstruction including by:

(i) beginning in 2020 and thereafter, ensuring that all new Federal buildings that enter the planning process are designed to achieve zero-net-energy by 2030;

(ii) ensuring that all new construction, major renovation, or repair and alteration of Federal buildings complies with the *Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings* (Guiding Principles);

(iii) ensuring that at least 15 percent of the agency's existing buildings (above 5,000 gross square feet) and building leases (above 5,000

gross square feet) meet the Guiding Principles by fiscal year 2015 and that the agency makes annual progress toward 100-percent conformance with the Guiding Principles for its building inventory;

(iv) pursuing cost-effective, innovative strategies, such as highly reflective and vegetated roofs, to minimize consumption of energy, water, and materials;

(v) managing existing building systems to reduce the consumption of energy, water, and materials, and identifying alternatives to renovation that reduce existing assets' deferred maintenance costs;

(vi) when adding assets to the agency's real property inventory, identifying opportunities to consolidate and dispose of existing assets, optimize the performance of the agency's real-property portfolio, and reduce associated environmental impacts; and

(vii) ensuring that rehabilitation of federally owned historic buildings utilizes best practices and technologies in retrofitting to promote long-term viability of the buildings;

(h) advance sustainable acquisition to ensure that 95 percent of new contract actions including task and delivery orders, for products and services with the exception of acquisition of weapon systems, are energy-efficient (Energy Star or Federal Energy Management Program (FEMP) designated), water-efficient, biobased, environmentally preferable (e.g., Electronic Product Environmental Assessment Tool (EPEAT) certified), non-ozone depleting, contain recycled content, or are non-toxic or less-toxic alternatives, where such products and services meet agency performance requirements;

(i) promote electronics stewardship, in particular by:

(i) ensuring procurement preference for EPEAT-registered electronic products;

(ii) establishing and implementing policies to enable power management, duplex printing, and other energy-efficient or environmentally preferable features on all eligible agency electronic products;

(iii) employing environmentally sound practices with respect to the agency's disposition of all agency excess or surplus electronic products;

(iv) ensuring the procurement of Energy Star and FEMP designated electronic equipment;

(v) implementing best management practices for energy-efficient management of servers and Federal data centers; and

(j) sustain environmental management, including by:

(i) continuing implementation of formal environmental management systems at all appropriate organizational levels; and

(ii) ensuring these formal systems are appropriately implemented and maintained to achieve the performance necessary to meet the goals of this order.

Sec. 3. Steering Committee on Federal Sustainability. The OMB Director and the CEQ Chair shall:

(a) establish an interagency Steering Committee (Steering Committee) on Federal Sustainability composed of the Federal Environmental Executive, designated under section 6 of Executive Order 13423 of January 24, 2007, and Agency Senior Sustainability Officers, designated under section 7 of this order, and that shall:

(i) serve in the dual capacity of the Steering Committee on Strengthening Federal Environmental, Energy, and Transportation Management designated by the CEQ Chair pursuant to section 4 of Executive Order 13423;

(ii) advise the OMB Director and the CEQ Chair on implementation of this order;

(iii) facilitate the implementation of each agency's Strategic Sustainability Performance Plan; and

(iv) share information and promote progress towards the goals of this order;

(b) enlist the support of other organizations within the Federal Government to assist the Steering Committee in addressing the goals of this order;

(c) establish and disband, as appropriate, interagency subcommittees of the Steering Committee, to assist the Steering Committee in carrying out its responsibilities;

(d) determine appropriate Federal actions to achieve the policy of section 1 and the goals of section 2 of this order;

(e) ensure that Federal agencies are held accountable for conformance with the requirements of this order; and

(f) in coordination with the Department of Energy's Federal Energy Management Program and the Office of the Federal Environmental Executive designated under section 6 of Executive Order 13423, provide guidance and assistance to facilitate the development of agency targets for greenhouse gas emission reductions required under subsections 2(a) and (b) of this order.

Sec. 4. Additional Duties of the Director of the Office of Management and Budget. In addition to the duties of the OMB Director specified elsewhere in this order, the OMB Director shall:

(a) review and approve each agency's multi-year Strategic Sustainability Performance Plan under section 8 of this order and each update of the Plan. The Director shall, where feasible, review each agency's Plan concurrently with OMB's review and evaluation of the agency's budget request;

(b) prepare scorecards providing periodic evaluation of Federal agency performance in implementing this order and publish scorecard results on a publicly available website; and

(c) approve and issue instructions to the heads of agencies concerning budget and appropriations matters relating to implementation of this order.

Sec. 5. Additional Duties of the Chair of the Council on Environmental Quality. In addition to the duties of the CEQ Chair specified elsewhere in this order, the CEQ Chair shall:

(a) issue guidance for greenhouse gas accounting and reporting required under section 2 of this order;

(b) issue instructions to implement this order, in addition to instructions within the authority of the OMB Director to issue under subsection 4(c) of this order;

(c) review and approve each agency's targets, in consultation with the OMB Director, for agency-wide reductions of greenhouse gas emissions under section 2 of this order;

(d) prepare, in coordination with the OMB Director, streamlined reporting metrics to determine each agency's progress under section 2 of this order;

(e) review and evaluate each agency's multi-year Strategic Sustainability Performance Plan under section 8 of this order and each update of the Plan;

(f) assess agency progress toward achieving the goals and policies of this order, and provide its assessment of the agency's progress to the OMB Director;

(g) within 120 days of the date of this order, provide the President with an aggregate Federal Government-wide target for reducing scope 1 and 2 greenhouse gas emissions in absolute terms by fiscal year 2020 relative to a fiscal year 2008 baseline;

(h) within 270 days of the date of this order, provide the President with an aggregate Federal Government-wide target for reducing scope 3 greenhouse gas emissions in absolute terms by fiscal year 2020 relative to a fiscal year 2008 baseline;

(i) establish and disband, as appropriate, interagency working groups to provide recommendations to the CEQ for areas of Federal agency operational and managerial improvement associated with the goals of this order; and

(j) administer the Presidential leadership awards program, established under subsection 4(c) of Executive Order 13423, to recognize exceptional and outstanding agency performance with respect to achieving the goals of this order and to recognize extraordinary innovation, technologies, and practices employed to achieve the goals of this order.

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Sec. 6. Duties of the Federal Environmental Executive. The Federal Environmental Executive designated by the President to head the Office of the Federal Environmental Executive, pursuant to section 6 of Executive Order 13423, shall:

(a) identify strategies and tools to assist Federal implementation efforts under this order, including through the sharing of best practices from successful Federal sustainability efforts; and

(b) monitor and advise the CEQ Chair and the OMB Director on the agencies' implementation of this order and their progress in achieving the order's policies and goals.

Sec. 7. Agency Senior Sustainability Officers. (a) Within 30 days of the date of this order, the head of each agency shall designate from among the agency's senior management officials a Senior Sustainability Officer who shall be accountable for agency conformance with the requirements of this order; and shall report such designation to the OMB Director and the CEQ Chair.

(b) The Senior Sustainability Officer for each agency shall perform the functions of the senior agency official designated by the head of each agency pursuant to section 3(d)(i) of Executive Order 13423 and shall be responsible for:

(i) preparing the targets for agency-wide reductions and the inventory of greenhouse gas emissions required under subsections 2(a), (b), and (c) of this order;

(ii) within 240 days of the date of this order, and annually thereafter, preparing and submitting to the CEQ Chair and the OMB Director, for their review and approval, a multi-year Strategic Sustainability Performance Plan (Sustainability Plan or Plan) as described in section 8 of this order;

(iii) preparing and implementing the approved Plan in coordination with appropriate offices and organizations within the agency including the General Counsel, Chief Information Officer, Chief Acquisition Officer, Chief Financial Officer, and Senior Real Property Officers, and in coordination with other agency plans, policies, and activities;

(iv) monitoring the agency's performance and progress in implementing the Plan, and reporting the performance and progress to the CEQ Chair and the OMB Director, on such schedule and in such format as the Chair and the Director may require; and

(v) reporting annually to the head of the agency on the adequacy and effectiveness of the agency's Plan in implementing this order.

Sec. 8. Agency Strategic Sustainability Performance Plan. Each agency shall develop, implement, and annually update an integrated Strategic Sustainability Performance Plan that will prioritize agency actions based on lifecycle return

on investment. Each agency Plan and update shall be subject to approval by the OMB Director under section 4 of this order. With respect to the period beginning in fiscal year 2011 and continuing through the end of fiscal year 2021, each agency Plan shall:

(a) include a policy statement committing the agency to compliance with environmental and energy statutes, regulations, and Executive Orders;

(b) achieve the sustainability goals and targets, including greenhouse gas reduction targets, established under section 2 of this order;

(c) be integrated into the agency's strategic planning and budget process, including the agency's strategic plan under section 3 of the Government Performance and Results Act of 1993, as amended (5 U.S.C. 306);

(d) identify agency activities, policies, plans, procedures, and practices that are relevant to the agency's implementation of this order, and where necessary, provide for development and implementation of new or revised policies, plans, procedures, and practices;

(e) identify specific agency goals, a schedule, milestones, and approaches for achieving results, and quantifiable metrics for agency implementation of this order;

(f) take into consideration environmental measures as well as economic and social benefits and costs in evaluating projects and activities based on lifecycle return on investment;

(g) outline planned actions to provide information about agency progress and performance with respect to achieving the goals of this order on a publicly available Federal website;

(h) incorporate actions for achieving progress metrics identified by the OMB Director and the CEQ Chair;

(i) evaluate agency climate-change risks and vulnerabilities to manage the effects of climate change on the agency's operations and mission in both the short and long term; and

(j) identify in annual updates opportunities for improvement and evaluation of past performance in order to extend or expand projects that have net lifecycle benefits, and reassess or discontinue under-performing projects.

Sec. 9. Recommendations for Greenhouse Gas Accounting and Reporting. The Department of Energy, through its Federal Energy Management Program, and in coordination with the Environmental Protection Agency, the Department of Defense, the General Services Administration, the Department of the Interior, the Department of Commerce, and other agencies as appropriate, shall:

(a) within 180 days of the date of this order develop and provide to the CEQ Chair recommended Federal greenhouse gas reporting and accounting procedures for agencies to use in carrying out their obligations under subsections 2(a), (b), and (c) of this order, including procedures that will ensure that agencies:

(i) accurately and consistently quantify and account for greenhouse gas emissions from all scope 1, 2, and 3 sources, using accepted greenhouse gas accounting and reporting principles, and identify appropriate opportunities to revise the fiscal year 2008 baseline to address significant changes in factors affecting agency emissions such as reorganization and improvements in accuracy of data collection and estimation procedures or other major changes that would otherwise render the initial baseline information unsuitable;

(ii) consider past Federal agency efforts to reduce greenhouse gas emissions; and

(iii) consider and account for sequestration and emissions of greenhouse gases resulting from Federal land management practices;

(b) within 1 year of the date of this order, to ensure consistent and accurate reporting under this section, provide electronic accounting and reporting capability for the Federal greenhouse gas reporting procedures developed under subsection (a) of this section, and to the extent practicable, ensure compatibility between this capability and existing Federal agency reporting systems; and

(c) every 3 years from the date of the CEQ Chair's issuance of the initial version of the reporting guidance, and as otherwise necessary, develop and provide recommendations to the CEQ Chair for revised Federal greenhouse gas reporting procedures for agencies to use in implementing subsections 2(a), (b), and (c) of this order.

Sec. 10. Recommendations for Sustainable Locations for Federal Facilities. Within 180 days of the date of this order, the Department of Transportation, in accordance with its Sustainable Partnership Agreement with the Department of Housing and Urban Development and the Environmental Protection Agency, and in coordination with the General Services Administration, the Department of Homeland Security, the Department of Defense, and other agencies as appropriate, shall:

(a) review existing policies and practices associated with site selection for Federal facilities; and

(b) provide recommendations to the CEQ Chair regarding sustainable location strategies for consideration in Sustainability Plans. The recommendations shall be consistent with principles of sustainable development including prioritizing central business district and rural town center locations, prioritizing sites well served by transit, including site design elements that ensure safe and convenient pedestrian access, consideration of transit access and proximity to housing affordable to a wide range of Federal employees, adaptive reuse or renovation of buildings, avoidance of development of sensitive land resources, and evaluation of parking management strategies.

Sec. 11. Recommendations for Federal Local Transportation Logistics. Within 180 days of the date of this order, the General Services Administration, in coordination with the Department of Transportation, the Department of the Treasury, the Department of Energy, the Office of Personnel Management,

and other agencies as appropriate, shall review current policies and practices associated with use of public transportation by Federal personnel, Federal shuttle bus and vehicle transportation routes supported by multiple Federal agencies, and use of alternative fuel vehicles in Federal shuttle bus fleets, and shall provide recommendations to the CEQ Chair on how these policies and practices could be revised to support the implementation of this order and the achievement of its policies and goals.

Sec. 12. Guidance for Federal Fleet Management. Within 180 days of the date of this order, the Department of Energy, in coordination with the General Services Administration, shall issue guidance on Federal fleet management that addresses the acquisition of alternative fuel vehicles and use of alternative fuels; the use of biodiesel blends in diesel vehicles; the acquisition of electric vehicles for appropriate functions; improvement of fleet fuel economy; the optimizing of fleets to the agency mission; petroleum reduction strategies, such as the acquisition of low greenhouse gas emitting vehicles and the reduction of vehicle miles traveled; and the installation of renewable fuel pumps at Federal fleet fueling centers.

Sec. 13. Recommendations for Vendor and Contractor Emissions. Within 180 days of the date of this order, the General Services Administration, in coordination with the Department of Defense, the Environmental Protection Agency, and other agencies as appropriate, shall review and provide recommendations to the CEQ Chair and the Administrator of OMB's Office of Federal Procurement Policy regarding the feasibility of working with the Federal vendor and contractor community to provide information that will assist Federal agencies in tracking and reducing scope 3 greenhouse gas emissions related to the supply of products and services to the Government. These recommendations should consider the potential impacts on the procurement process, and the Federal vendor and contractor community including small businesses and other socioeconomic procurement programs. Recommendations should also explore the feasibility of:

(a) requiring vendors and contractors to register with a voluntary registry or organization for reporting greenhouse gas emissions;

(b) requiring contractors, as part of a new or revised registration under the Central Contractor Registration or other tracking system, to develop and make available its greenhouse gas inventory and description of efforts to mitigate greenhouse gas emissions;

(c) using Federal Government purchasing preferences or other incentives for products manufactured using processes that minimize greenhouse gas emissions; and

(d) other options for encouraging sustainable practices and reducing greenhouse gas emissions.

Sec. 14. Stormwater Guidance for Federal Facilities. Within 60 days of the date of this order, the Environmental Protection Agency, in coordination with other Federal agencies as appropriate, shall issue guidance on the implementation of section 438 of the Energy Independence and Security Act of 2007 (42 U.S.C. 17094).

Sec. 15. Regional Coordination. Within 180 days of the date of this order, the Federal Environmental Executive shall develop and implement a regional implementation plan to support the goals of this order taking into account energy and environmental priorities of particular regions of the United States.

Sec. 16. Agency Roles in Support of Federal Adaptation Strategy. In addition to other roles and responsibilities of agencies with respect to environmental leadership as specified in this order, the agencies shall participate actively in the interagency Climate Change Adaptation Task Force, which is already engaged in developing the domestic and international dimensions of a U.S. strategy for adaptation to climate change, and shall develop approaches through which the policies and practices of the agencies can be made compatible with and reinforce that strategy. Within 1 year of the date of this order the CEQ Chair shall provide to the President, following consultation with the agencies and the Climate Change Adaptation Task Force, as appropriate, a progress report on agency actions in support of the national adaptation strategy and recommendations for any further such measures as the CEQ Chair may deem necessary.

Sec. 17. Limitations. (a) This order shall apply to an agency with respect to the activities, personnel, resources, and facilities of the agency that are located within the United States. The head of an agency may provide that this order shall apply in whole or in part with respect to the activities, personnel, resources, and facilities of the agency that are not located within the United States, if the head of the agency determines that such application is in the interest of the United States.

(b) The head of an agency shall manage activities, personnel, resources, and facilities of the agency that are not located within the United States, and with respect to which the head of the agency has not made a determination under subsection (a) of this section, in a manner consistent with the policy set forth in section 1 of this order to the extent the head of the agency determines practicable.

Sec. 18. Exemption Authority.

(a) The Director of National Intelligence may exempt an intelligence activity of the United States, and related personnel, resources, and facilities, from the provisions of this order, other than this subsection and section 20, to the extent the Director determines necessary to protect intelligence sources and methods from unauthorized disclosure.

(b) The head of an agency may exempt law enforcement activities of that agency, and related personnel, resources, and facilities, from the provisions of this order, other than this subsection and section 20, to the extent the head of an agency determines necessary to protect undercover operations from unauthorized disclosure.

(c) (i) The head of an agency may exempt law enforcement, protective, emergency response, or military tactical vehicle fleets of that agency from the provisions of this order, other than this subsection and section 20.

(ii) Heads of agencies shall manage fleets to which paragraph (i) of this subsection refers in a manner consistent with the policy set forth in section 1 of this order to the extent they determine practicable.

(d) The head of an agency may exempt particular agency activities and facilities from the provisions of this order, other than this subsection and section 20, where it is in the interest of national security. If the head of an agency issues an exemption under this section, the agency must notify the CEQ Chair in writing within 30 days of issuance of the exemption under this subsection. To the maximum extent practicable, and without compromising national security, each agency shall strive to comply with the purposes, goals, and implementation steps in this order.

(e) The head of an agency may submit to the President, through the CEQ Chair, a request for an exemption of an agency activity, and related personnel, resources, and facilities, from this order.

Sec. 19. Definitions. As used in this order:

(a) "absolute greenhouse gas emissions" means total greenhouse gas emissions without normalization for activity levels and includes any allowable consideration of sequestration;

(b) "agency" means an executive agency as defined in section 105 of title 5, United States Code, excluding the Government Accountability Office;

(c) "alternative fuel vehicle" means vehicles defined by section 301 of the Energy Policy Act of 1992, as amended (42 U.S.C. 13211), and otherwise includes electric fueled vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles, dedicated alternative fuel vehicles, dual fueled alternative fuel vehicles, qualified fuel cell motor vehicles, advanced lean burn technology motor vehicles, self-propelled vehicles such as bicycles and any other alternative fuel vehicles that are defined by statute;

(d) "construction and demolition materials and debris" means materials and debris generated during construction, renovation, demolition, or dismantling of all structures and buildings and associated infrastructure;

(e) "divert" and "diverting" means redirecting materials that might otherwise be placed in the waste stream to recycling or recovery, excluding diversion to waste-to-energy facilities;

(f) "energy intensity" means energy consumption per square foot of building space, including industrial or laboratory facilities;

(g) "environmental" means environmental aspects of internal agency operations and activities, including those aspects related to energy and transportation functions;

(h) "excluded vehicles and equipment" means any vehicle, vessel, aircraft, or non-road equipment owned or operated by an agency of the Federal Government that is used in:

(i) combat support, combat service support, tactical or relief operations, or training for such operations;

(ii) Federal law enforcement (including protective service and investigation);

(iii) emergency response (including fire and rescue); or

(iv) spaceflight vehicles (including associated ground-support equipment);

(i) "greenhouse gases" means carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride;

(j) "renewable energy" means energy produced by solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project;

(k) "scope 1, 2, and 3" mean;

(i) scope 1: direct greenhouse gas emissions from sources that are owned or controlled by the Federal agency;

(ii) scope 2: direct greenhouse gas emissions resulting from the generation of electricity, heat, or steam purchased by a Federal agency; and

(iii) scope 3: greenhouse gas emissions from sources not owned or directly controlled by a Federal agency but related to agency activities such as vendor supply chains, delivery services, and employee travel and commuting;

(l) "sustainability" and "sustainable" mean to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations;

(m) "United States" means the fifty States, the District of Columbia, the Commonwealth of Puerto Rico, Guam, American Samoa, the United States Virgin Islands, and the Northern Mariana Islands, and associated territorial waters and airspace;

(n) "water consumption intensity" means water consumption per square foot of building space; and

(o) "zero-net-energy building" means a building that is designed, constructed, and operated to require a greatly reduced quantity of energy to operate, meet the balance of energy needs from sources of energy that do not produce greenhouse gases, and therefore result in no net emissions of greenhouse gases and be economically viable.

Sec. 20. General Provisions.

(a) This order shall be implemented in a manner consistent with applicable law and subject to the availability of appropriations.

(b) Nothing in this order shall be construed to impair or otherwise affect the functions of the OMB Director relating to budgetary, administrative, or legislative proposals.

(c) This order is intended only to improve the internal management of the Federal Government and is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

BARACK OBAMA

THE WHITE HOUSE,
October 5, 2009.

# # #

United States Environmental Protection Agency

Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response

September 2009

Legal Note

This document contains information designed to be useful and helpful to governments, the public, and the regulated community. This document does not impose legally binding requirements, nor does it confer legal rights, impose legal obligations, or implement any statutory or regulatory provisions. This document does not restrict, expand or otherwise change EPA's authority to address greenhouse gas emissions under existing statutes. This document does not change or substitute for any statutory or regulatory provisions. This document presents technical information based on EPA's current understanding of the link between global climate change and materials and land use management programs. Finally, this is a living document and may be revised periodically without public notice.

The EPA welcomes public comments on this document at any time and will consider those comments in any future revisions of this document.

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Appendix A

Technical Support for Opportunities to Reduce Greenhouse Gas Emissions through Materials and Land Management Practices A-1

Executive Summary

The Intergovernmental Panel on Climate Change has determined that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level."[1] The U.S. Environmental Protection Agency (EPA) has proposed that climate change is primarily the result of greenhouse gas (GHG) emissions, its effects will worsen over time in the absence of regulatory action, and the overall rate and magnitude of human-induced climate change will likely increase, such that risks to public health and welfare will likewise grow over time so that future generations will be especially vulnerable; their vulnerability will include potentially catastrophic harms.[2]

To respond to the risk associated with climate change, this document describes the link between climate change and the materials and land management programs carried out by EPA's Office of Solid Waste and Emergency Response (OSWER), and its federal, regional, state, tribal, community, and other public and private partners. The purpose of this document is two-fold. First, in order to increase understanding of the link between materials and land management and GHG emissions, this document presents an estimate of the portion of U.S. GHG emissions associated with materials and land management practices. Second, it presents a set of materials and land management scenarios—referred to as total technical potential scenarios—as a first step to identifying areas of opportunity for EPA and its partners to reduce GHG emissions through materials and land management.

Introduction

OSWER and its partners implement environmental programs that are broadly categorized into three areas: materials management through resource conservation and recovery; land management through prevention of contaminant releases and cleanup and reuse of contaminated sites; and emergency response and preparedness. These three program areas all have direct impacts on communities across the United States. *Materials management* refers to how we manage material resources as they flow through the economy, from extraction or harvest of materials and food (e.g., mining, forestry, and agriculture), production and transport of goods, provision of services, reuse of materials, and, if necessary, disposal. EPA promotes materials management approaches that serve human needs by using and reusing resources productively and sustainably throughout their life cycles, minimizing both the amount of materials involved and the associated environmental impacts. *Land management* refers to how we manage and use land to provide open space and habitat, food, natural resources, and places for people to live, work, and recreate. EPA promotes integrated land management strategies that use land as productively and sustainably as possible by preventing and minimizing the occurrence of contamination and cleaning up, reusing, and restoring contaminated land for beneficial reuse. EPA's *emergency response and preparedness* programs will have a key role in adapting to the environmental changes spurred by climate change.

How we manage our materials and land—two of OSWER's three core program areas—has a significant impact on U.S. GHG emissions and sinks. Strategies for reducing emissions through materials and land management also have substantial environmental and economic co-benefits for communities.

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1 Intergovernmental Panel on Climate Change. *Fourth Assessment Report (AR4).* p. 30. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

2 Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act. Proposed Rule. 74 Fed. Reg. 18886-18910. April 24, 2009.

Additionally, unlike many GHG mitigation options, materials and land management are heavily influenced by states and communities. Working with its partners, EPA can leverage its materials and land management programs to achieve measurable GHG reductions while yielding multiple environmental, human health, and economic benefits for communities and the nation. This document promotes the recognition that materials and land management programs, while complementing other EPA program goals, can also produce significant climate change mitigation benefits.

Understanding U.S. GHG Emissions

The United States annually reports its GHG emissions in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* ("the Inventory").[3] This report quantifies the country's primary anthropogenic sources and sinks of GHG emissions based on comprehensive and detailed methodologies consistent with international guidance that enables parties to the United Nations Framework Convention on Climate Change (UNFCCC) to compare the relative contribution of different emission sources and GHGs to climate change. The information in the Inventory is often summarized by apportioning emissions to economic sectors. This sector-based view of data in the Inventory is important for framing a range of GHG emissions mitigation strategies, including end-of-pipe strategies for reducing emissions and technology substitutions within a sector.

To better understand and describe the connections between materials and land management and climate change, this report presents a systems-based view of U.S. GHG emissions, where each system represents and comprises all the parts of the economy working to fulfill a particular need. For example, the provision of food system includes all emissions from the electric power, transportation, industrial, and agricultural sectors associated with growing, processing, transporting, and disposing of food. The systems view is helpful for framing opportunities to reduce GHG emissions through prevention-oriented mitigation strategies that act across an entire system. The systems are selected to illustrate the GHG emissions associated with materials and land management, as shown in Figure ES-1. Appendix A provides the methodology used for this analysis, including key assumptions and references for source data.

Combined, materials management is associated with an estimated 42% of total U.S. GHG emissions and land management is associated with an estimated 16% of total U.S. GHG emissions. Based on a preliminary estimate provided in this report, GHG emissions from greenfield development are equivalent to approximately an additional 4% of total U.S. emissions.[4] The land-based carbon sink reported in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* has been included in this figure to help convey the effect land management has on U.S. emissions and sinks. The land-based carbon sink is equivalent to 13% of 2006 U.S. GHG emissions.[5]

Figure ES-1 shows the relative magnitude of the emissions associated with materials and land management. By allocating the emissions reported in the *Inventory of U.S. Greenhouse Gas Emissions*

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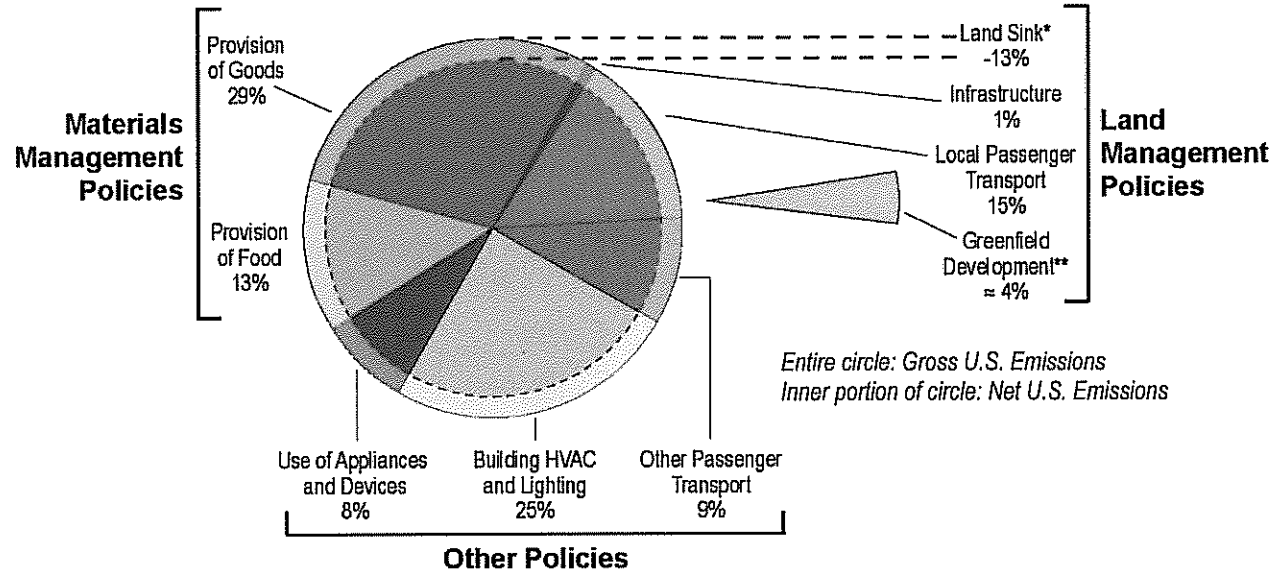
[3] U.S. EPA. 2008. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006.* Available at: http://www.epa.gov/climatechange/emissions/usgginv_archive.html. This report relies on the Inventory data published in 2008; a more recent version, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007*, was published in 2009 and can be found at http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

[4] Emissions from greenfield development are not calculated in the U.S. Inventory, but this estimate may overlap with existing land sink value.

[5] U.S. EPA. 2008. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006.* p. ES-14. Available at: http://www.epa.gov/climatechange/emissions/usgginv_archive.html

and Sinks by system, the impact of decisions related to materials and land management on the country's total GHG emissions and sinks is evident.

Figure ES-1
Systems-Based View of U.S. GHG Emissions (2006)



This figure presents the U.S. GHG emissions data reported in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, allocated to systems, and by materials and land management, as described in Appendix A. Emissions from U.S. territories are not included in this figure.

* The Land Sink, represented by the outer ring, offset the equivalent of 13% of total U.S. anthropogenic emissions in 2006. It is graphically represented here as a semi-transparent ring that erases a portion of emissions from all other slices shown in the pie chart. The entire pie chart represents total U.S. emissions in 2006; once the offset provided by the Land Sink is applied, the inner portion of the pie chart represents net U.S. emissions.

** Greenfield development represents emissions from land clearing (equivalent to roughly 4% of U.S. emissions in 2006); this calculation is not included in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, and is therefore depicted outside of the pie chart. It may include some overlap with the existing land sink value.

Potential GHG Reductions through Materials and Land Management

Significant GHG emission reductions have been achieved to date in the United States by EPA, states, local governments, and stakeholders through numerous materials and land management-related activities.[6] Selected examples include:

- In 2006, U.S. municipal solid waste (MSW) recycling resulted in the avoidance of nearly 183 million metric tons of carbon dioxide equivalent ($MMTCO_2E$) in GHG emissions.[7]
- In 2006, waste-to-energy recovery systems combusted MSW and resulted in the avoidance of 17 $MMTCO_2E$ in GHG emissions.[8]
- In 2005, EPA's WasteWise partners reported source reduction and recycling activities that resulted in the avoidance of 27 $MMTCO_2E$ in GHG emissions.[9]

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[6] The following tools were used to calculate the selected examples of GHG emissions reductions, in addition to the data sources referenced for each example below: U.S. EPA. March 2009. *Greenhouse Gas Equivalencies Calculator*; U.S. EPA. September 2008. *WAste Reduction Model (WARM)*; and Fogt, Robert. 2008. *Online Conversion Tool for Energy*.

[7] U.S. EPA, Office of Solid Waste and Emergency Response. November 2007. *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2006*, p. 1-8.

[8] Ibid.

[9] U.S. EPA. October 2006. *WasteWise 2006 Annual Report*. p. 1. Available at: http://www.epa.gov/waste/partnerships/wastewise/pubs/report06.pdf

To help illustrate the potential for GHG reduction and avoidance opportunities from materials and land management practices, this analysis includes several "total technical potential" scenarios. Box ES-1 summarizes these scenarios and Appendix A describes the analytical methodology, assumptions, and data sources used to calculate the potential impacts for these hypothetical changes in materials and land management practices.

The term *total technical potential* refers to the estimated GHG emission reduction that could occur if the scenarios presented are achieved, setting aside economic, institutional, or technological limitations. Such scenarios, which are a common first step in climate policy analysis, allow for the examination of the GHG reduction potential of various mitigation strategies contained in those scenarios. These total technical potential scenarios are useful for scoping the order-of-magnitude impact of an activity and identifying areas of promise for more detailed analysis and potential activity. They also illustrate how changes in behavior can lead directly to significant reductions of GHG emissions on a national scale.

The total technical potential scenarios presented here represent early analysis based on existing and available data. As more analysis is completed, total technical potential scenarios can be generated for a greater number of materials and land management approaches.

Box ES-1: Summary of Total Technical Potential Scenarios

Source Reduction		Estimated GHG Emission Benefit*
Reduce packaging use by:	50%	40—105 $MMTCO_2E/yr$
	25%	20—50 $MMTCO_2E/yr$
Reduce use of non-packaging paper products by:[10]	50%	20—70 $MMTCO_2E/yr$
	25%	10—35 $MMTCO_2E/yr$
Extend the life of personal computers by:	50%	25 $MMTCO_2E/yr$
	25%	15 $MMTCO_2E/yr$
Reuse/Recycling		
Increase recycling of construction and demolition debris to:	100%	150 $MMTCO_2E/yr$
	50%	75 $MMTCO_2E/yr$
	25%	40 $MMTCO_2E/yr$
Increase national municipal solid waste (MSW) recycling and composting rate from 2006 rate (32.5%) to:	100%	300 $MMTCO_2E/yr$
	50%	70—80 $MMTCO_2E/yr$
Increase composting of food scraps from 2006 rate (2%) to:	100%	20 $MMTCO_2E/yr$
	50%	10 $MMTCO_2E/yr$
	25%	5 $MMTCO_2E/yr$
Energy Recovery / Disposal		
Combust percentage of currently landfilled MSW:	100%	70—120 $MMTCO_2E/yr$
	50%	35—60 $MMTCO_2E/yr$
	25%	20—30 $MMTCO_2E/yr$
Combust MSW remaining if national recycling rate is increased to 50%:		65—110 $MMTCO_2E/yr$
Capture percentage of currently emitted methane at U.S. landfills for electricity generation:	100%	150 $MMTCO_2E/yr$
	50%	70 $MMTCO_2E/yr$
	25%	35 $MMTCO_2E/yr$

[10] Non-packaging paper products include magazines and third class mail, newspaper, office paper, phonebooks, and textbooks.

Box ES-1: Summary of Total Technical Potential Scenarios		
Land Revitalization		**Estimated GHG Emission Benefit***
Shift 60% of expected new development to compact development patterns:[11]		79 $MMTCO_2E/yr$
Reuse percentage of qualifying EPA-tracked contaminated land for utility-scale solar:[12]	100%	2,200 $MMTCO_2E/yr$
	50%	1,100 $MMTCO_2E/yr$
	25%	540 $MMTCO_2E/yr$
Reuse percentage of qualifying EPA-tracked contaminated land for community and utility-scale wind:[13]	100%	40 $MMTCO_2E/yr$
	50%	20 $MMTCO_2E/yr$
	25%	10 $MMTCO_2E/yr$
Reduce electricity use for the most energy-intensive treatment technologies at National Priorities List sites by:	100%	0.4 $MMTCO_2E/yr$
	50%	0.2 $MMTCO_2E/yr$
	25%	0.1 $MMTCO_2E/yr$
Reforest percentage of qualifying former mine lands for carbon sequestration:	100%	4 $MMTCO_2E/yr$
	50%	2 $MMTCO_2E/yr$
	25%	1 $MMTCO_2E/yr$

* Most of the total technical potential scenarios presented in this table have been rounded to one significant figure. See following Appendix A for more detail on these estimates.

Looking Forward

There is a strong link between U.S. GHG emissions and the management of materials and land. EPA, along with its partners, can help address the challenges of global climate change through materials and land management programs. As we develop programs and policies with our partners, more detailed studies that account for both the limitations and opportunities of economic, technical, and policy aspects of the scenarios introduced in this paper will be needed.

[11] Expected annual benefit through 2030.

[12] The 100% scenario represents 141 times the projected increase in solar power between 2008 and 2030. See Appendix for more detail.

[13] The 100% scenario represents 75% of projected increase in wind power between 2008 and 2030. See Appendix for more detail.

The Impact on Health of Emissions to Air from Municipal Waste Incinerators

September 2009

Summary

The Health Protection Agency has reviewed research undertaken to examine the suggested links between emissions from municipal waste incinerators and effects on health. While it is not possible to rule out adverse health effects from modern, well regulated municipal waste incinerators with complete certainty, any potential damage to the health of those living close-by is likely to be very small, if detectable. This view is based on detailed assessments of the effects of air pollutants on health and on the fact that modern and well managed municipal waste incinerators make only a very small contribution to local concentrations of air pollutants. The Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment has reviewed recent data and has concluded that there is no need to change its previous advice, namely that any potential risk of cancer due to residency near to municipal waste incinerators is exceedingly low and probably not measurable by the most modern techniques. Since any possible health effects are likely to be very small, if detectable, studies of public health around modern, well managed municipal waste incinerators are not recommended.

The Agency's role is to provide expert advice on public health matters to Government, stakeholders and the public. The regulation of municipal waste incinerators is the responsibility of the Environment Agency.

Introduction

1. The use of incineration for waste disposal in the UK is increasing. Applications for permits to build and operate incinerators give rise to local concerns about possible effects on health of emissions. Responsibility for the environmental permitting of municipal waste incinerators lies with the Environment Agency. The Health Protection Agency (HPA) has a statutory responsibility to advise Government and Local Authorities on possible health impacts of air pollutants.

2. The operators of modern waste incinerators are required to monitor emissions to ensure that they comply, as a minimum, with the limits in the EU Waste Incineration Directive (2000/76/EC), which sets strict emission limits for pollutants. This Directive has been implemented in England and Wales by the Environmental Permitting (EP) (England and Wales) Regulations 2007 (note

that from April 2008 these replaced the Pollution Prevention and Control (PPC) (England and Wales) Regulations 2000).

3. Under the EP Regulations, the operator is required to apply for an environmental permit. Consideration of this application will include such issues as health effects and organisations such as the local Primary Care Trust (PCT); the HPA and Food Standards Agency (FSA) are usually consulted. The permit itself will set out strict operating requirements which must be complied with, this will include monitoring. Should a breach of the permit occur, action may be taken by the regulator.

4. Applications to build and operate incinerators invariably include an assessment of likely emissions to air. Modern incinerators emit only small amounts of chemicals to air (see para 16) in comparison with older incinerators and, although no absolute assurance of a zero effect on public health can be provided, the additional burden on the health of the local population is likely to be very small. Studies published in the scientific literature showing health effects in populations living around incinerators have, in general, been conducted around older incinerators with less stringent emission standards and cannot be directly extrapolated with any reliability to modern incinerators (see paras 6 and 26)

5. The incineration process can result in three potential sources of exposure, (1) emissions to the atmosphere, (2) via solid ash residues, and (3) via cooling water. Provided that solid ash residues and cooling water are handled and disposed of appropriately, atmospheric emissions remain the only significant route of exposure to people. This paper is thus concerned only with the health effects of emissions to air.

6. The comparative impacts on health of different methods of waste disposal have been considered in detail in a report prepared for the Department of Environment, Food and Rural Affairs (Defra 2004). This work was undertaken by a group of consultants led by the independent consultants Enviros and included experts in the air pollution field. The report was reviewed by The Royal Society and its comments were incorporated by the authors of the report. This report is the most extensive available in the field and concludes that well managed, modern incinerators are likely to have only a very small effect on health. Since the evidence base has not changed significantly since 2004 it would be an inefficient use of resources to repeat the work undertaken by Enviros (see above) for Defra when applications to build and operate individual incinerators are being considered. The HPA's view is that the study undertaken for Defra by Enviros can be relied on although, like all scientific findings, it may be subject to revision if new data were to emerge.

7. Concerns about possible effects on health of emissions to air tend to focus on a few well known pollutants: particles, polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzo-*p*-furans (commonly referred to as "dioxins") and other carcinogens such as the polycyclic aromatic hydrocarbons (PAH). Much is known about the effects on health of these

compounds. Detailed reports prepared by expert advisory committees are available: these include reports by the Department of Health's Committee on the Medical Effects of Air Pollutants (COMEAP) on particulate matter (COMEAP, 1995, 1998, 2001a, 2009); by Defra's Expert Panel on Air Quality Standards (EPAQS) on benzene, 1,3-butadiene (reports 1 and 2), particles (reports 1 and 2), PAH compounds, and metals and metalloids[1] (Department of the Environment, 1994a,b, 1995; Department of the Environment Transport and the Regions, 1999, 2001; Department for the Environment, Food and Rural Affairs, 2002, 2009) and the Committee on the Toxicity of Chemicals in Food, Consumer Products and the Environment's statement on dioxins and dioxin-like polychlorinated biphenyls (Committee on Toxicity, 2001).

Particles

8. Questions are often asked about the possible effects on health of particles emitted by incinerators. The Committee on the Medical Effects of Air Pollutants (COMEAP) has published a series of statements and reports on the effects of air pollutants on health in the UK. It is accepted that exposure to current levels of common air pollutants damages health. The Air Quality Strategy for England, Scotland, Wales and Northern Ireland seeks to reduce concentrations of air pollutants. Where concentrations of air pollutants are raised, Air Quality Management Areas are defined and plans to reduce concentrations are developed by Local Authorities. Details of the Air Quality Strategy can be found on the Defra website:
http://www.defra.gov.uk/environment/airquality/strategy/index.htm

9. Both long-term exposure and short-term increases in exposure to particles can damage health. This is widely accepted (World Health Organization, 2006). Long term exposure affects the risk of mortality, especially from cardiovascular disease and from lung cancer (COMEAP, 2009, COMEAP, 2006; Health Effects Institute, 2000). Short-term increases in concentrations cause cardio-respiratory effects including an increase in deaths from heart attacks and from respiratory disease, increased hospital admissions for treatment of these disorders and increases in related symptoms. No thresholds of effect can be identified for either the effects of long-term exposure or for the effects of short-term increases in concentrations. Thus, any increase in particle concentrations should be assumed to be associated with some effect on health. The critical step in assessment of effects on health is not simply making the correct assertion that some effect is possible but in estimating the size of that effect. This is discussed below.

10. Evidence of the effects of particles on health comes, in the main, from epidemiological studies. For the effects of long-term exposure attention has been focused on $PM_{2.5}$; for the effects of short-term increases in concentrations both $PM_{2.5}$ and PM_{10} have been extensively used as metrics of the ambient aerosol. PM_{10} is defined as the mass of particles of less than

[1] Arsenic, chromium, nickel and beryllium

(about) 10 microns in diameter per cubic metre of air. $PM_{2.5}$ is an analogous measure: in this case, the mass of particles of less than about 2.5 microns in diameter per cubic metre of air. The exact definitions are given in the recent Defra report on ambient particles (Defra, 2005). The exact mechanisms of effect of particles on health are incompletely understood but several plausible hypotheses are being pursued; the generation of free radicals in the respiratory system and more widely in the body, the induction of an inflammatory response in the lung, effects on clotting factors in the blood, effects on the rate of development of atherosclerotic plaques in coronary arteries and effects on the regulation of the heart beat are all being studied intensively. It is possible that metals found in association with particles play an important role. It is also possible that the ultrafine component of the ambient aerosol plays an important role. These, and other, possibilities are not yet proven.

11. The lack of a complete understanding of the mechanisms of effects of particles does not prevent prediction of the effects on health of increased concentrations of particles monitored as PM_{10} and/or $PM_{2.5}$. Meta-analytical techniques have been applied to the results of primary studies and summary coefficients linking PM_{10} and $PM_{2.5}$ with effects on health have been derived (COMEAP, 1998, 2009; World Health Organization, 2006). If these coefficients are applied to the small increases in concentrations of particles produced, locally, by incinerators, the estimated effects on health are likely to be small. This is because the coefficients themselves are small, the increase in concentration due to operation of the incinerator is likely to be small, and so is the size of the potentially exposed local population.

12. It is sometimes claimed that the "wrong particles" are considered when estimating the possible effects on health of emissions from incinerators. It should be understood that impact calculations of the effects on health of emissions from incinerators are done by using the coefficients derived from epidemiological studies. Because we do not know with certainty the active components of the ambient aerosol, coefficients linking effects on health with changes in mass concentrations (PM_{10} and/or $PM_{2.5}$) are used in the impact calculations. At present we have no clear epidemiological evidence to distinguish between the toxicity of samples of particles collected for PM_{10} or $PM_{2.5}$ measurements in different areas. National policy (Defra, 2007a,b) and the EC Directive on Ambient Air Quality and Cleaner Air for Europe (European Parliament and Council of the European Union, 2008) are based on the assumption that particles collected for PM_{10} and $PM_{2.5}$ measurements do not differ in their effects on health from place to place. In this context it is worth noting that PM_{10} and $PM_{2.5}$ samples from around the world can vary substantially in their chemical composition and size distribution but nonetheless exhibit similar concentration-response coefficients in time-series epidemiological studies. It is accepted that this view could change and that monitoring of chemical characteristics of the ambient aerosol (for example, its metallic components), the number of particles per unit of volume of air, the total surface area of particles per unit volume of air, or the capacity of particles to generate free radicals could prove more valuable than measurements of mass concentrations (PM_{10} and $PM_{2.5}$). But none of this is yet well

established and international and national regulations are currently framed in terms of mass concentrations. It seems reasonable that these regulations and the approaches upon which they are based should be applied to considerations of the effects on health of particles emitted by incinerators. It may be asked why studies of the specific impacts on health of the small increases in local concentrations of particles produced by incinerators are not done routinely. The main reason for this is that the concentration increment produced by incinerators is likely to be too small to allow an impact on health to be identified in the local population.

13. It is sometimes claimed that PM_{10} measurements ignore particles most likely to be deposited in the lung, or, more specifically, in the gas exchange zone of the lungs. This is incorrect and stems from a misunderstanding of the term PM_{10}. Tapered element oscillating microbalance (TEOM) monitors are equipped with a sampling head that selects essentially all particles of less than 10 µm aerodynamic diameter. PM_{10} measurement is designed to collect effectively all those particles small enough to pass the upper airways (nose, mouth, pharynx, larynx) and thus of a size that allows a chance of deposition in the lung. $PM_{2.5}$ is intended to represent that fraction of the aerosol with a high probability of deposition in the gas exchange zone of the lung in vulnerable individuals. It will be obvious that PM_{10} includes $PM_{2.5}$ and that $PM_{2.5}$ cannot exceed PM_{10} in any given sample of air.

14. It is sometimes, further, claimed that PM_{10} or $PM_{2.5}$ do not include nanoparticles present in the air. This is also incorrect. Nanoparticles are efficiently collected by PM_{10} and $PM_{2.5}$ samplers but make only a small contribution to the results expressed as PM_{10} or $PM_{2.5}$. If particles of less than 100 nm diameter alone were collected from a known volume of air and weighed, the resulting concentration could be expressed as $PM_{0.1}$ (100 nm = 0.1 microns). In a sample of air collected in a UK urban area on a typical day we might expect results similar to those given below:

PM_{10}	20 µg/m^3
$PM_{2.5}$	13 µg/m^3
$PM_{0.1}$	1-2 µg/m^3

PM_{10} includes and exceeds $PM_{2.5}$ which in turn includes and exceeds $PM_{0.1}$.

15. It is quite correct to say that nanoparticles make a large contribution to the number of particles per unit volume of air. Particles of less than about 500 nm in diameter dominate the number concentration of ambient particles. It might be correctly suggested that if a specified source, for example an incinerator, produced mainly nanoparticles, changes in local mass concentrations (PM_{10} and to a lesser extent $PM_{2.5}$) would not reflect the increase in numbers of particles in the air. We do not, however, know how to interpret measurement of number concentrations of particles in health terms. Work in this area is developing. It may be that, although the evidence is as yet weak in comparison with that relating to mass concentrations, particle numbers will link with some effects on health better than mass concentrations. No generally accepted coefficients that allow the use of number

concentrations in impact calculations have yet been defined. As stated above, regulations are currently framed in terms of mass concentrations and it is unreasonable to expect local health professionals to interpret number concentrations in quantitative health terms when national experts have not yet judged that the evidence is sufficient to do so. COMEAP will be looking at whether quantification of the effects of particle number concentrations is possible as part of its work on the quantification of the health effects of air pollution. No Air Quality Standards are defined in terms of number concentrations of particles.

16. The contribution made by waste incineration to national emissions of particles is low. Data provided by Defra (National Emissions Inventory www.naei.org.uk) show that 2006 national emissions of PM_{10} from waste incineration are 0.03% of the total compared with 27% and 25% for traffic and industry respectively[2]. This low proportion is also found at a local level – the Environment Agency have informed HPA of one incinerator modelling study that found a modelled ground level increment in PM_{10} of 0.0005 $\mu g/m^3$ as an annual average (Environment Agency, 2009). The increment in $PM_{2.5}$ could not exceed this, and would be likely to be lower. In addition, Defra is expanding its general $PM_{2.5}$ monitoring and will scrutinise this to see if any individual sources make a noticeable addition to measured concentrations.

17. Questions are often asked about the effects of air pollutants, including those emitted by waste incineration, on children's health. The World Health Organization (WHO) in its 2005 report on Air Pollution and Children's Health and Development, concluded that there was an association between air pollution and infant mortality that appeared to be mainly due to particulate air pollution. COMEAP, in a 2008 statement on Air Pollution and Children's Health, endorsed WHO's general conclusions although the COMEAP statement does not comment on which pollutant is likely to be responsible. Annexes to the statement indicate that, of the studies published since the WHO report, some find effects of particulate air pollution and some do not. Metrics of particulate air pollution used in these studies included PM_{10} and total suspended particulates, as well as $PM_{2.5}$. The size of the effects reported in these studies relates to large changes in $PM_{2.5}$, larger than would be expected to be caused by the operation of an incinerator. Given the small effects of incinerators on local concentrations of particles, it is highly unlikely that there will be a detectable effect of any particular incinerator on local infant mortality.

18. When carrying out studies which investigate health effects around point sources of pollution such as incinerators, or when mapping health effects around such sources, it is important to control for other factors which can influence the health outcomes under investigation before drawing any conclusions. So when investigating the effect of a source of $PM_{2.5}$ emissions on infant mortality rates, it would be important to control for other sources of $PM_{2.5}$ emissions, and for factors which are known to influence infant mortality

[2] National Atmospheric Emissions Inventory PM_{10} http://www.naei.org.uk/emissions/emissions_2006/summary_tables.php?action=unece&page_name=PM1006.html'

rates, for example, socio-economic factors or ethnicity. Maps showing death rates or levels of morbidity are useful in raising hypotheses, but they do not supply evidence of cause and effect.

Carcinogens

19. Chemicals which cause cancer are described as carcinogens. For risk assessment purposes, carcinogens are divided into two groups depending on their mechanism of action:

(a) Genotoxic carcinogens: these induce cancer by a mechanism that involves the compound itself, or a metabolite, reacting directly with the genetic material of cells (DNA), producing a mutation. This process is called mutagenicity. It is theoretically possible that one "hit" on DNA may produce a mutation that can eventually develop into a tumour. The assumption is thus made for genotoxic carcinogens that they do not have a threshold and that any exposure is associated with an increase in risk, albeit this may be very small. Most of the known human chemical carcinogens are in this group, e.g. aflatoxins, benzene, 1,3-butadiene, 2-naphthylamine, polycyclic aromatic hydrocarbon (PAH) compounds.

(b) Non-genotoxic carcinogens: these induce cancer by mechanisms that are not based on mutagenicity. These chemicals give negative results in the well recognised tests for mutagenicity. Unlike the genotoxic carcinogens, which are characterised by a common mechanism, there are a number of different mechanisms involved. Examples include sustained cell proliferation in a sensitive tissue (resulting in expression of a spontaneous mutation) due to cytotoxic effects, hormonal stimulation or immunosuppression. These effects have a threshold based on the precursor toxicological effect such as cytotoxicity, i.e. there is a level of exposure below which they do not have an effect. Examples of such compounds are oestrogens and 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD or "dioxin").

20. In the air pollution field, genotoxic carcinogens are the major focus of interest. In the following discussion, the term "carcinogens" is used to represent genotoxic carcinogens.

21. The carcinogenic effects of PAH compounds can be identified by means of studies in experimental animals only at very much higher concentrations than occur in ambient air. These high exposures are necessary because practical limitations regarding the number of animals used in these tests mean that they cannot reliably detect increases in tumour incidence below a few percent. However, for public health purposes, the principal concern is about effects that occur at a much lower incidence in the human population, but are undetectable in animal studies. The calculation of cancer risk at low environmental exposures from mathematical modelling of

the results from the high dose animal data presents great difficulty. The expert advisory committee, the Committee on the Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC) has consistently expressed concern at the use of such modelling to extrapolate to levels of exposure that are orders of magnitude lower than the observed range. This was most recently stated in the 2004 guidelines. (The reasons are based on the fact that the various models available do not take into account the biological complexity of the carcinogenesis process, the extrapolations are based on a few data points over a very narrow and high dose range, and very wide variations in risk estimates are produced depending on the models used. Their use gives an impression of precision that cannot be justified). The COC does not recommend their use for routine risk assessment.

22. In some cases, carcinogenic effects have been demonstrated in epidemiological studies in humans. Such studies have almost always involved occupational exposure where workplace levels in the past may have been much higher than those in ambient air. It is difficult to demonstrate the effects of exposure to ambient concentrations of carcinogens (the concentrations are so low that vast numbers of people would need to be studied to produce clear results) but such effects are assumed to be possible, on the grounds that there is no threshold for the effects of many of these compounds. If good quality epidemiological studies are available it is possible to derive models of the relationship between exposure and effect that allow prediction, with some confidence, of likely cancer incidence at ambient concentrations. It should be noted, however, that the actual accuracy of such predictions cannot be assessed and such extrapolations still involve some considerable uncertainty and should be used with caution.

23. The Expert Panel on Air Quality Standards (EPAQS) has recommended air quality standards for benzene, 1,3-butadiene and PAH compounds using a different approach from that used by the World Health Organization (WHO), which is based on quantitative risk assessment. This is because of the concerns of the COC regarding the use of mathematical models to estimate cancer risk. Indeed, the COC endorsed the approach used by EPAQS. This involved the application of Uncertainty Factors to the results of studies of the effects on man of exposure to high concentrations of the carcinogens specified above. Standards derived in this way do not offer a complete guarantee of safety (this is impossible with non-threshold compounds) but do define concentrations at which the risks to health are likely to be very small and unlikely to be detectable. If it is found that incinerators emit the carcinogens considered by EPAQS, it is reasonable to compare the augmented local concentration (i.e. the local background concentration plus the increment contributed by the incinerator) with the EPAQS standard. If this is not exceeded it may be reasonably assumed that the additional risk imposed by the emissions is minimal. If, on the other hand, the emissions cause the local concentrations to exceed the EPAQS standard(s), the appropriate regulator would need to decide whether the additional risk posed by the incinerator was a cause for concern and what further reductions may be necessary.

Dioxins

24. It is recognised that there are particular concerns about emissions of dioxins from incinerators. The HPA and DH are advised on the health effects of such compounds by the independent expert advisory committee, the Committee on the Toxicity of Chemicals in Food, Consumer Products and the Environment (COT). The COT has recommended a tolerable daily intake (TDI) for dioxins, which is the amount which can be ingested daily over a lifetime without appreciable health risk. This TDI is based on a detailed consideration of the extensive toxicity data on the most well studied dioxin, TCDD, but may be used to assess the toxicity of mixtures of dioxins and dioxin-like PCBs by use of Toxic Equivalency Factors, which allow concentrations of the less toxic compounds to be expressed as an overall equivalent concentration of TCDD. These toxicity-weighted concentrations are then summed to give a single concentration expressed as a Toxic Equivalent (TEQ). The system of Toxic Equivalency Factors (TEFs) used in the UK and a number of other countries is that set by the World Health Organization (WHO)[3], and the resulting overall concentrations are referred to as WHO-TEQs (van den Berg, 2006). Thus, the COT has recommended a tolerable daily intake for dioxins of 2 picograms WHO-TEQ/kg body weight/day based on the most sensitive effect of TCDD in laboratory animals, namely, adverse effects on the developing fetus resulting from exposure *in utero*. As this was the most sensitive effect it will protect against the risks of other adverse effects including carcinogenicity. The advice of the other sister committees, COC and the Committee on Mutagenicity of Chemicals in Food, Consumer Products and the Environment (COM), informed the conclusion, namely that dioxins do not directly damage genetic material and that evidence on biological mechanisms suggested that a threshold based risk assessment was appropriate. The full statement is available (COT, 2001).

25. The majority (more than 90%) of non-occupational human exposure to dioxins occurs via the diet, with animal-based foodstuffs like meat, fish, eggs, and dairy products being particularly important. Limited exposure may also occur via inhalation of air or ingestion of soil depending on circumstances. Regarding emissions from municipal waste incinerators, the current limit for dioxins and furans is 0.1 nanogram per cubic metre of emitted gases. A nanogram is one thousand millionth of a gram. Inhalation is a minor route of exposure and, given that Defra has calculated that incineration of municipal solid waste accounts for less than 1% of UK emissions of dioxins[4], the contribution of incinerator emissions to direct respiratory exposure of dioxins is a negligible component of the average human intake. However, dioxins may make a larger contribution to human exposure via the food chain, particularly fatty foods. Dioxins from emissions could also be deposited on soil and crops and accumulate in the food chain via animals that graze on the pastures,

[3] Note: The Waste Incineration Directive (2000/76/EC) sets Air Emission Limit Values for dioxins using a slightly different system of TEQs i.e. international- or I-TEQs, which vary slightly from WHO-TEQs.

[4] Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes. Extended Summary. Enviros, University of Birmingham and Defra. May 2004.

though dioxins are not generally taken up by plants. Thus the impact of emissions on locally produced foods such as milk and eggs is considered in deciding whether to grant a permit. These calculations show that, even for people consuming a significant proportion of locally produced foodstuffs, the contribution of incinerator emissions to their intake of dioxins is small and well below the tolerable daily intake (TDI) for dioxins recommended by the relevant expert advisory committee, Committee on Toxicity of Chemicals in Food, Consumer (see http://cot.food.gov.uk/cotstatements/cotstatementsyrs/cotstatements2001/dioxinsstate).

Epidemiological studies: municipal waste incinerators and cancer

26. The COC has issued two statements on the cancer epidemiology of municipal waste incinerators. The initial statement followed a review of a large study by the Small Area Health Statistics Unit which examined cancer incidence between the mid 1970s and the mid 1980s in 14 million people living within 7.5 km of 72 municipal solid waste incinerators in Great Britain[5] (Elliott *et al*, 1996; COC, 2000). Prior to this there had been very few studies of cancer mortality around municipal waste incinerators and none in the UK. The incinerators studied by Elliott *et al* (1996) were the older generation operating prior to introduction of strict emission controls and were more polluting than modern incinerators. After considering this study, the COC concluded that: "*any potential risk of cancer due to residency (for periods in excess of 10 years) near to municipal solid waste incinerators was exceedingly low, and probably not measurable by the most modern techniques*" (COC, 2000).

27. In 2008, the Committee reviewed seven new studies on cancer incidence near municipal solid waste incinerators which had been published since 2000 (Comba et al, 2003; Floret et al, 2003; Knox E, 2000; Viel et al, 2000; 2008a and 2008b; Zambon et al, 2007). All had studied the older generation of incinerator and three studies were of an incinerator for which emissions of dioxins were reported to have exceeded even the older emission standard. There were problems interpreting most of these studies due to factors such as failure to control for socio-economic confounding or inclusion of emission sources other than municipal waste incinerators. The COC concluded that *"Although the studies indicate some evidence of a positive association between two of the less common cancers i.e. non-Hodgkin's lymphoma and soft tissue sarcoma and residence near to incinerators in the past, the results cannot be extrapolated to current incinerators, which emit lower amounts of pollutants. ...Moreover, they are inconsistent with the results of the larger study...carried out by the Small Area Health Statistics Unit."* It concluded that there was no need to change its previous advice but that the situation should be kept under review (COC, 2009).

[5] These included all known municipal incinerators which opened before 1976. Incinerators starting from 1976 were excluded, to ensure an appropriate lag period for development of any cancer associated with the emissions.

Conclusions

28. Modern, well managed incinerators make only a small contribution to local concentrations of air pollutants. It is possible that such small additions could have an impact on health but such effects, if they exist, are likely to be very small and not detectable. The Agency, not least through its role in advising Primary Care Trusts and Local Health Boards, will continue to work with regulators to ensure that incinerators do not contribute significantly to ill-health.

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Glossary

Aflatoxins
Naturally occurring toxins produced by the fungus *Aspergillus sp.*

Aerodynamic diameter
The actual diameter of a spherical particle of unit density with the same terminal velocity as the particle under consideration. The term aerodynamic diameter allows particles of differing densities and shapes to be compared in terms of their likelihood of depositing in the lung.

Air Quality Standard (AQS)
The concentration of a pollutant (expressed, generally, as mass per unit volume) and qualified by an averaging time, regarded as acceptable by an Expert Group or other standard setting body. Air Quality Standards do not provide an absolute guarantee of safety for health.

Ambient aerosol
An aerosol is a suspension of fine particles or liquid droplets in a gas. Ambient refers to the surroundings. In the air pollution context, this refers to the suspension of fine particles in the general outdoor air.

Atherosclerotic plaques
The discrete lesions of the arterial wall in atherosclerosis i.e., disease of the blood vessels involving the accumulation of fatty material in the inner layer of the arterial wall resulting in narrowing of the artery. These fatty deposits are known as plaques.

1,3-butadiene
An industrial chemical used in the production of synthetic rubber. It is also produced by the combustion of petrol and diesel. It is efficiently removed by catalytic convertors.

Carcinogens
Agents that cause cancer. Chemical carcinogens are chemicals that may produce cancer.

Cell proliferation
An increase in the number of cells as a result of cell growth and cell division.

Clotting factors
Substances (proteins) in blood that act in a complex series of reactions to stop bleeding by forming a clot.

Coefficients
A constant multiplication factor. For example, a health effect might increase by 0.5% for every unit increase in the concentration of a pollutant. This can be derived as the slope from a graph relating health effects and pollutant concentrations.

Coronary arteries
The network of blood vessels that supply heart muscle with oxygen-rich blood.

Cytotoxic
Toxic to cells.

Dioxins
This refers to a large group of chemicals with similar chemical structure (chlorinated dibenzo-p-dioxins and chlorinated dibenzo-p-furans). They vary greatly in toxicity, some being very toxic, others showing a similar pattern of toxicity but of lower potency. They are not produced commercially but are formed in small amounts in most forms of combustion (fires etc.). The most studied compound in this series is the highly toxic TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin).

Dioxin-like PCBs
Polychlorinated Biphenyls (PCBs) are another group of substances, some of which have similar biological activity to dioxins. These are referred to as Dioxin-like PCBs. There are many other PCBs that do not have dioxin-like properties.

Epidemiological studies
Studies of the distribution and the aetiology (causes) of disease in humans.

Free radicals
Highly reactive chemical structures (due to the presence of a chemical species that has lost an electron and thus contains an unpaired electron in the outer shell of the molecule). They are unstable and can react in biological systems with nearby substances such as lipids, proteins or DNA producing damage.

Furans
Chemicals related to furan. Furan contains carbon, hydrogen and oxygen with the carbon atoms and an oxygen atom forming a 5 sided ring.

Gas exchange zone
The part of the lung in which oxygen diffuses from the air to the blood and carbon dioxide diffuses from the blood to the air. The alveoli, alveolar ducts and respiratory bronchioles make up the gas exchange zone.

Immunosuppression
Suppression of the immune system.

Incidence
New occurrence of a disease over a specified time period.

In-utero
In the uterus (womb).

Larynx
Dilated region of the airway above the upper end of the trachea or windpipe. The vocal cords lie within the larynx.

Mass concentration of particles
The mass of particles per unit volume of air. Usually expressed as $\mu g/m^3$ (micrograms per cubic metre).

Metabolite
Chemicals that enter the body can be changed by processes in the body into different chemicals. These are described as metabolites of the original chemical.

Metalloid
An element that is not clearly a metal or non-metal but has some intermediate properties in terms of malleability, ductility, conductivity and lustre. The following elements are generally considered to be metalloids: boron; silicon; germanium; arsenic; antimony; tellurium; polonium.

Meta-analysis
In the context of epidemiology, a statistical analysis of the results from independent studies which aims to produce a single estimate of an effect.

Metric
A measure for something. PM_{10} is a measure (or metric) of the concentration of particles in the air.

Microgram (µg)
One microgram is 1×10^{-6}g. There are 1,000,000 (1 million) micrograms in a gram.

Micron (µm)
This is a unit of length that equals one thousandth of a millimetre.

Mortality
Deaths.

Mortality rate
The number of deaths in a population.

Morbidity
Ill health.

Mutation
A permanent change in the amount or structure of the genetic material (DNA) in a cell or organism which can result in a change in its characteristics. A mutation in the germ cells of sexually reproducing organisms may be transmitted to the offspring, whereas a mutation that occurs in somatic cells may be only transferred to descendent daughter cells.

Nanogram (ng)
One nanogram is 1×10^{-9} gram. There are 1,000,000,000 ng in one gram.

Nanoparticles
These are usually considered to be particles of less than 100 nanometres diameter. One nanometre is a millionth of a mm. To put into some context this is about a ten thousandth of the width of a human hair.

2-naphthylamine
A chemical used in the past in the manufacture of dyes. It is made up from 2 benzene rings with a nitrogen and hydrogen side chain.

Non-Hodgkin lymphoma
A type of malignant cancer of the lymphatic system or lymphoid tissue. Most lymphoma are of this type (as opposed to being Hodgkin lymphoma).

Number concentration of particles
The number of particles found in a specified volume of air, usually 1 cubic metre.

Pharynx
The throat and back of the nose.

Point sources
Sources of pollution from a fixed point in space e.g. an industrial site. The term is used in contrast to mobile sources of pollution e.g. cars.

Polycyclic aromatic hydrocarbons (PAHs)
These are a group of structurally related organic compounds that contain 2 or more fused rings. They are formed as a result of combustion/pyrolysis.

PM_{10}, $PM_{2.5}$
The concentration (expressed in $\mu g/m^3$) of particles generally less than 10µm and 2.5µm respectively[6]. The terms PM_{10} and $PM_{2.5}$ are sometimes used to describe particles of diameter of less than 10 and 2.5 µm respectively but this is not strictly correct: the terms refer to the concentrations of particles and not to the particles themselves.

Picogram (pg)
A picogram is $1x\ 10^{-12}$ gram. There are 1,000,000,000,000 pg in one gram.

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[6] Strictly, particles that pass a sampler entry with 50% efficiency at 10 micrometres or 2.5 micrometres respectively.

Spontaneous mutation
A mutation that occurs as a result of natural processes in cells, as opposed to those that arise because of interaction with an outside agent or mutagen.

Soft tissue sarcomas
These are a rare type of cancer that develop from cells in the soft, supporting tissues of the body such as muscle, fat and blood vessels. They may occur in limbs, chest, abdomen or pelvis and less commonly in head and neck.

TCDD
The most studied dioxin, and the one that is used as a reference compound when considering the toxicity of mixtures of dioxins, is often referred to simply as TCDD. This is an abbreviation of its full chemical name, 2,3,7,8-tetrachlorodibenzo-p-dioxin. It is considered the most toxic dioxin.

TEOM
Tapered Element Oscillating Micro-balance. An instrument used to measure the mass concentration of particles in the air. Particles are collected on a vibrating rod: the mass deposited affects the frequency of vibration of the rod and this, being recorded, allows the mass of particles in the air to be calculated.

Tolerable Daily Intake (TDI)
An estimate of the amount of contaminant, expressed on a body weight basis (e.g., mg/kg body weight) that can be ingested daily over a lifetime without appreciable health risk.

Total suspended particulates
A measure of particles derived by collecting particles of approximately 100 µm or less in a sampler. This includes particles that are too large to enter the lung. The measurement method has generally been superseded by measurement of PM_{10}.

Toxic Equivalency Factor (TEF)
A measure of the relative toxicological potency of a chemical compared to a well characterised reference compound. TEFs can be used to sum the toxicological potency of a mixture of chemicals which are all members of the same chemical class, having common structural, toxicological and biochemical properties e.g. dioxins. In the case of dioxins the reference compound is TCDD.

Toxic Equivalent (TEQ)
This is a method of comparing the total relative toxicological potency within a mixture using TEFs (see above). It is calculated as the sum of the products of the concentration of each chemical multiplied by the TEF.

Ultrafine component
The component of particles less than about 100 nm in diameter.

Uncertainty factors
Value used in extrapolation from experimental animals to man (assuming that man may be more sensitive) or from selected individuals to the general population; for example, a value applied to the No Observed Adverse Effect Level (NOAEL) to derive a TDI. The value depends on the size and type of population to be protected and the quality of the toxicological information available.

Los Angeles County

Conversion Technology Demonstration Project

OVERVIEW: Conversion Technology Environmental Fact Sheet

Conversion technologies provide an opportunity to reduce our dependence on landfill disposal while reducing air emissions, including greenhouse gases. These are state-of-the-art processes capable of creating useful products, green fuels, and clean, renewable energy from solid waste. More than 130 commercial facilities operate in Europe and Asia as a safe and clean alternative to traditional waste management practices.

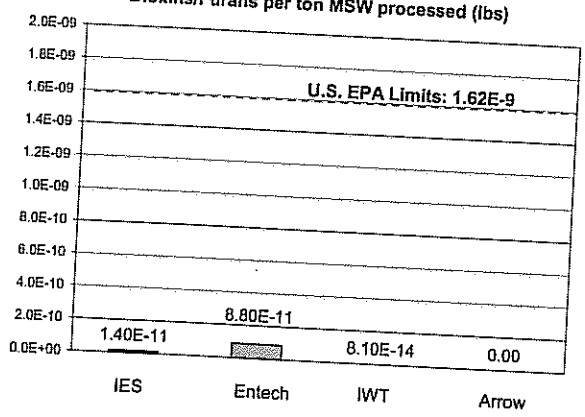
Following a decade of research, the County Los Angeles Department of Public Works has compiled this environmental fact sheet to summarize publicly available data, demonstrating that conversion technologies are a **superior option to traditional solid waste management practices** such as landfilling and waste-to-energy and **more than capable of meeting the most stringent air quality standards.**

Key Findings

Conversion technologies are capable of fully complying with the most stringent air emissions standards

Conversion technologies have been shown in actual operation to reduce dioxin and furan emissions in amounts **dramatically below the already low EPA limits** (see graph 1)

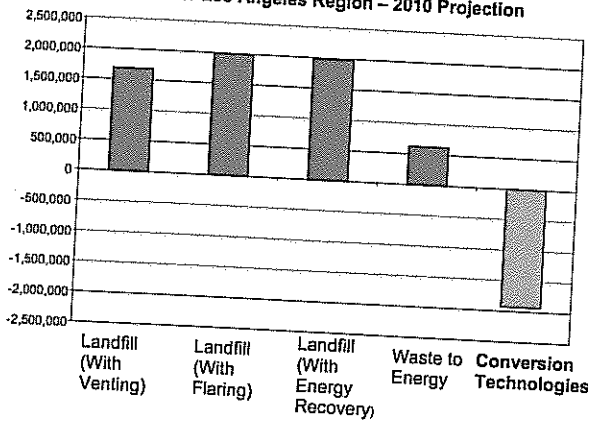
Graph 1



Conversion technologies actually make our air CLEANER

On a net-basis, conversion technologies can actually help **make our air cleaner** (see graph 2) by offsetting higher emissions from other sources, including greenhouse gas (GHG) emissions

Graph 2



Conversion technologies can help us address climate change

Conversion technologies have the potential to **reduce GHG emissions each year by millions of tons of CO_2 equivalent** in California alone

Attached is an environmental fact sheet summarizing public data that substantiates these findings. For more information, please visit: ***www.SoCalConversion.org***

Los Angeles County

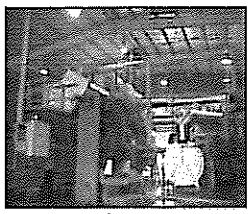
Conversion Technology Demonstration Project

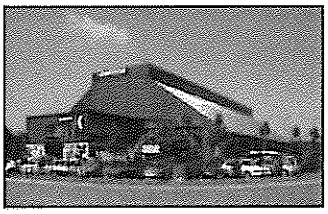
Conversion Technologies: A Clean Solid Waste Alternative

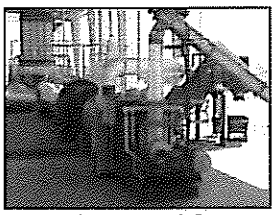
The Los Angeles County Department of Public Works (County) is taking an active role in developing environmentally-sound alternatives to landfilling and waste-to-energy that would convert post-recycled residual solid waste into useful products, green fuels, and clean, renewable energy. These technologies may include biological, thermal, chemical, and mechanical processes; however they do not include waste-to-energy (combustion) as the trash is not actually burned. Public agencies and universities alike have studied air emissions from conversion technologies and concluded that they are capable of operating within regulatory limits. More than 130 commercial facilities, processing a wide variety of wastestreams, operate in Europe and Asia[1] as a safe and clean alternative to traditional waste management practices such as landfilling or waste-to-energy.

Sample Conversion Technologies From Around the World


Germany


Malaysia


Japan


Southern California

Independent, Peer-Reviewed Studies

Extensive studies have recently been completed by trusted California authorities. For example, a 2006 peer-reviewed study conducted by the University of California, Riverside, on behalf of the California Integrated Waste Management Board, analyzed third-party emissions data from three thermal technology facilities:

- ***International Environmental Solutions*** - Operates a pyrolysis facility in Romoland, California that utilizes solid waste
- ***BRI Energy*** - Operates a gasification facility in Fayetteville, Arkansas that was tested with solid waste from California
- ***Integrated Environmental Technologies*** - Operates a gasification process in Richland, Washington and other parts of the world that utilizes medical waste among other feedstocks

Additionally, Los Angeles County has been evaluating conversion technologies for more than a decade. After review of over 100 technology companies from around the world, the County is considering four technology companies to develop one or more demonstration facilities in Southern California. All four companies

participating in the process have demonstrated the ability to divert at least 87 percent of waste away from disposal, and in some cases 100 percent of the waste. The technology companies being considered by the County are the following:

- ***Arrow Ecology and Engineering (Arrow)*** - Operates anaerobic digestion facilities in Israel and Australia that process solid waste
- ***Entech*** – Operates a gasification facilities in Poland, England and Malaysia that process various forms of waste including solid waste, medical waste, and mixed plastics
- ***International Environmental Solutions (IES)*** - Operates a pyrolysis facility in Romoland, California that utilizes solid waste
- ***Interstate Waste Technologies (IWT)*** - Operates gasification/ pyrolysis facilities in Japan that process various forms of solid waste

The 2006 UC Riverside study, the County's conversion technology reports, and other key reports can be found online at www.SoCalConversion.org.

Conversion Technologies Meet Environmental Regulations

Since local regulations for conversion processes have not yet been established, UC Riverside researchers compared emissions data to similar known limits, including U.S. EPA limits for starved air solid waste combustors and German thermal conversion regulatory limits. **All three conversion facilities studied were, or will likely be, below these regulatory limits (see below).**

Air Emissions Comparison of Regulations and Three Thermal Technologies[2]

REGULATORY LIMITS	Particulate Matter	Nitrogen Oxides	Cadmium	Lead	Mercury
US EPA Limits	18.0	220	0.01500	0.15000	0.01500
German Limits	14.0	281	0.04200	0.70000	0.04200
ACTUAL FACILITY EMISSIONS[3]					
International Environmental Solutions	3.9	275[4]	0.000150	0.00028	0.00056
BRI Energy	2.0	10	0.005000	0.02000	0.00010
Integrated Environmental Technologies	<3.3	162	0.000027	0.01100	0.00067

(All limits normalized to mg/N-m^3 at 7% O_2)

Los Angeles County also analyzed dioxin/furan data from the four conversion processes currently under consideration in our process. Our research and review of emissions test results reveals that these conversion technologies should have no issues complying with U.S. EPA regulations. In fact, these conversion technologies have been shown in actual operation to produce dioxins and furans in amounts **dramatically lower than the already low U.S. EPA limits**, far less than many commonplace and natural activities such as a wood burning fireplace, and well within safe guidelines (see below).

Air Emissions Comparison of Dioxin/Furan Regulation[5]

REGULATORY LIMITS	Dioxin/Furan
US EPA Limits (for new sources)	0.000000001617131 (1.62×10^{-9})
ACTUAL FACILITY EMISSIONS[6]	
International Environment Solutions	0.000000000014174 (1.42×10^{-11})
Entech Environmental	0.000000000087715 (8.77×10^{-11})
Interstate Waste Technologies	0.000000000000081 (8.10×10^{-14})
Arrow Ecology and Engineering	This biological process does not produce dioxins or furans

(All limits normalized to lbs dioxins/furans per ton municipal solid waste)[7]

It's important to note that any conversion technology facility constructed in the South Coast Air Quality Management District (SCAQMD) will be subject to even more stringent permitting conditions than the limits above. SCAQMD is the air pollution control agency for Orange County and the urban portions of Los Angeles, Riverside, and San Bernardino counties. Because this region does not meet the Clean Air Act standard for healthy air, it is identified as a "non-attainment" area, requiring a "New Source Review"[8] for all new and modified sources in the area. Any facility or process that still produces emissions after the best available controls are implemented (above a very low threshold level) are required to offset those emissions in excess of the emissions generated, typically at a ratio of 1.2 to 1. After an extensive vetting process, the County is confident that the four technology companies under consideration by the County (i.e. Arrow, Entech, IES, and IWT) will operate within all regulatory guidelines.

Conversion Technologies Are By Far The Most Energy-Efficient Waste Management Practices, And Can Reduce Net Air Emissions

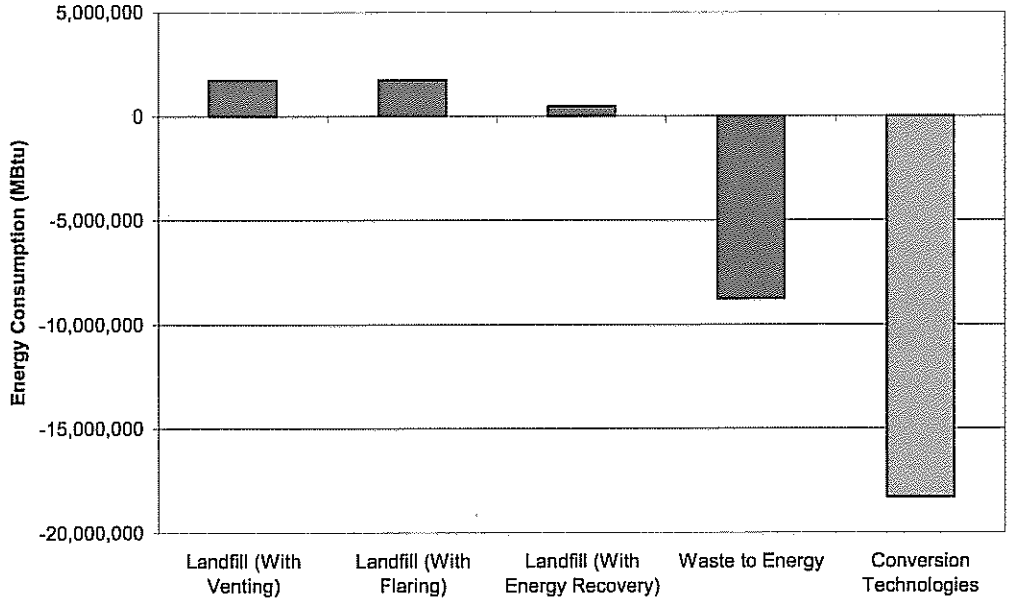
In the 2007 Staff Report to the Board entitled *New and Emerging Conversion Technologies*[9], the California Integrated Waste Management Board (CIWMB) developed several hypothetical waste management scenarios for a projected amount of waste generated in the year 2010. As noted in the CIWMB report, energy is an important factor when conducting a lifecycle analysis of a waste management scenario because air and water emissions are often a result of energy production. The report found that "as compared to the alternative management scenarios, the conversion technology scenario ranges from two times lower in net energy consumption when compared to the waste-to-energy scenario, to 11 times lower than the landfill without energy recovery scenarios[10]".

The CIWMB report attributes these conversion technology savings are to:

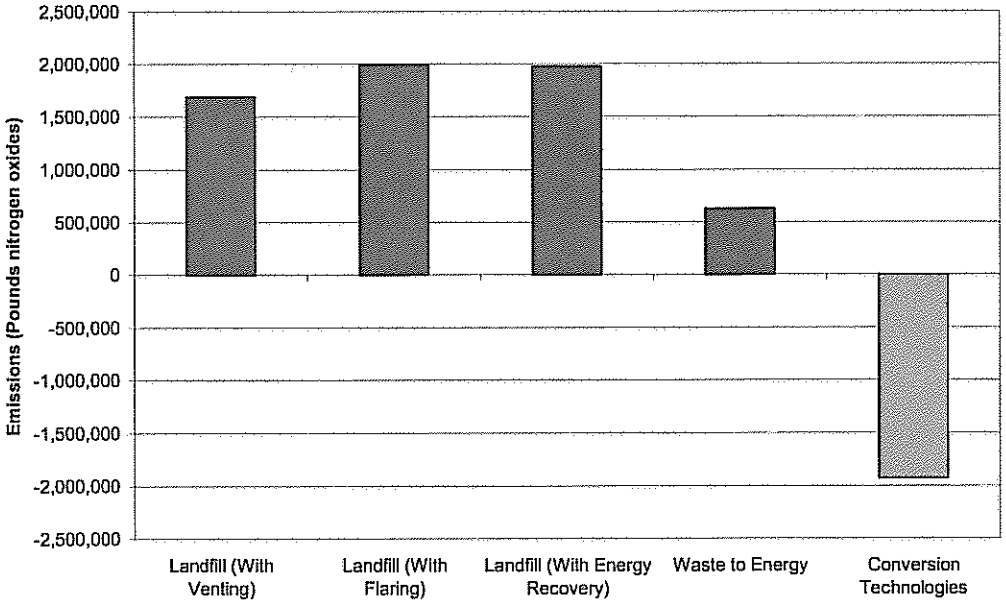
1) electricity production which offsets electricity produced by the utility sector;
2) biofuels production which offsets fuel production from fossil fuel sources; and
3) recyclable and reusable materials that are recovered, which offset the production of these products from virgin resources.

The CIWMB developed the following graphs, which compare emissions from landfills, waste-to-energy, and conversion technologies. The research indicates the **conversion technologies have the lowest net criteria air pollutant levels and GHG emissions**, and can actually help **make our air cleaner** by offsetting higher emissions from other sources:

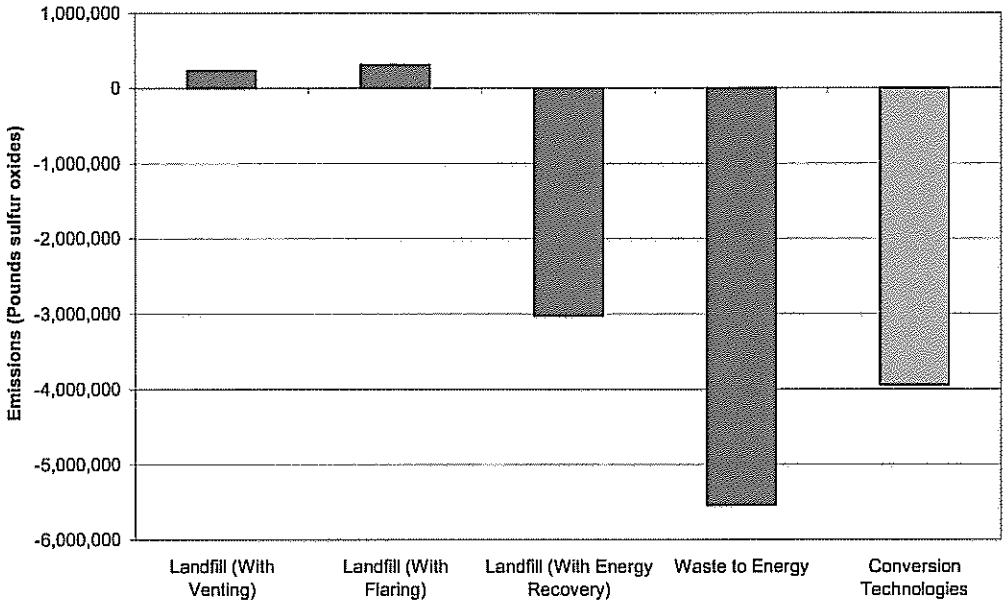
Annual Net Energy Consumption - Greater Los Angeles Region
2010



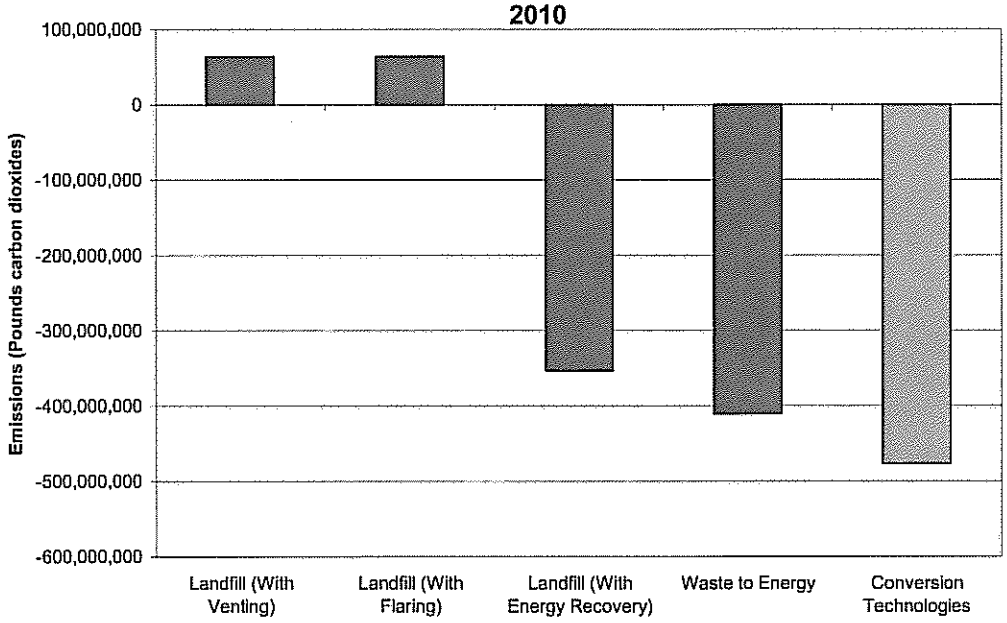
Annual Nitrogen Oxides Emissions - Greater Los Angeles Region
2010



Annual Sulfur Oxides Emissions - Greater Los Angeles Region 2010



Annual Carbon Dioxide (from Fossil Fuels) Emissions - Greater Los Angeles Region 2010



Conversion Technologies Are An Integral Climate Change Solution

In February 2008, the California Air Resources Board's Economic and Technology Advancement Advisory Committee (ETAAC) released a report noting that *by conservative estimates,* conversion technologies have the potential to **reduce** annual GHG emissions by approximately **five million metric tons of CO_2 equivalent in California**.[11]

In fact, the potential GHG reduction of conversion technologies may be significantly greater, since conversion technologies have a simultaneous triple benefit to the environment: 1) reduction of transportation emissions resulting from long distance shipping of waste; 2) prevention of methane and other emissions from waste that would otherwise be landfilled; and 3) displacement of the use of fossil fuels from the energy (fuel and electricity) produced by conversion technologies. The ETAAC report only estimated reductions from this third benefit.

Conversion Technologies vs. Current Energy Production Practices

According to the U.S. Department of Energy and the California Energy Commission, approximately half of the electricity used in the United States and about one-sixth of California's electricity is generated by coal combustion[12]. Coal has the highest carbon intensity among fossil fuels, resulting in coal-fired plants having the highest output rate of carbon dioxide per kilowatt hour[13]. Emissions from coal combustion for electricity constitute 32 percent of total U.S. carbon dioxide emissions[14]. For comparison purposes, the following table illustrates the difference in emissions between a typical coal plant and a theoretical IES pyrolytic facility operating in Southern California. In all categories, the IES facility emits fewer pollutants including 67 percent less CO_2 than the coal plant.

Air Emissions Comparison of Equivalent-Sized Coal and Conversion Technology Facilities

POLLUTANT	10 MW COAL PLANT[15]	10 MW IES CONVERSION TECHNOLOGY FACILITY[16]
Sulfur Dioxide	400,000	230
Nitrogen Oxide	408,000	76,755
Carbon Dioxide	148,000,000	49,033,364
Small Particles	20,000	1,701
Hydrocarbons	8,800	1,555
Carbon Monoxide	28,800	0.00
Arsenic	4.50	0.03
Lead	2.28	0.01
Cadmium	0.08	0.01
Mercury	3.69	0.09

(All pollutants measured in pounds/year)

Conclusion

Managing our waste through the best available conversion technologies rather than relying on current disposal options can lead to a net reduction in air emissions. These technologies have been used successfully in other parts of the world. Any new facilities developed would be required to comply with the most stringent air emissions controls and standards in the U.S., and are capable of doing so. Conversion technologies have the potential to provide real benefits to our ability to address the energy, solid waste and climate change crises. For more information and to download copies of key reports, please visit: **www.SoCalConversion.org**

A Project of Los Angeles County Department of Public Works

"Communities where residents live and work in a safe, clean and sustainable environment"

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[1] California Integrated Waste Management Board, *Staff Report to the Board: New and Emerging Conversion Technologies*, 2007 pg 10

[2] Adapted from University of CA, Riverside "Evaluation of Environmental Impacts of Thermochemical Conversion Technologies Using Municipal Solid Waste Feedstocks: Final Summary Report", 2006

[3] Significant figures are provided for ease of comparison; however, the actual measurements may not be accurate to this level of detail.

[4] IES utilized selective non-catalytic reduction (SNCR) for controlling nitrogen oxide emissions. Typically SNCR control efficiency ranges from 10 - 40%. This control technology was utilized in source testing due to engineering and manufacturing time schedules. Additionally SNCR lowered the nitrogen oxide emissions below SCAQMD permit limit for 24/7 operation. Although the use of SNCR brought these emissions during source testing into compliance, future IES facilities are being designed to use selective catalytic reduction (SCR) for nitrogen oxide control. This technology is proven to reduce nitrogen oxide emissions from 65 - 90%. It is anticipated that the use of SCR will bring the nitrogen oxide emissions well within the EPA limit.

[5] Adapted from *Los Angeles County Conversion Technology Evaluation Report - Phase II Assessment*, prepared for Los Angeles County Department of Public Works by Alternative Resources, Inc, 2007

[6] Significant figures are provided for ease of comparison; however, the actual measurements may not be accurate to this level of detail.

[7] Dioxin and furan emissions listed herein are evaluated on a basis known as ITEQ (International Toxic Equivalents), which accounts for the relative toxicity of the individual compounds. In the United States, dioxin and furan emissions are often reported on a total mass basis, which does not account for the toxicity of the individual compounds. U.S. EPA published an equivalency between total mass and toxic equivalents, specifically for traditional waste-to-energy technology, in 60 FR 65396. The total mass statistics available in the United States were converted to ITEQ. For comparison, traditional waste-to-energy facilities in California, on average, generate 0.000000000540838 (5.41x 10-10) Lbs Dioxins/Furans per ton MSW processed, also well below the U.S. EPA limit for new sources.

[8] South Coast Air Quality Management District: "New Source Review" http://www.aqmd.gov/prdas/NSR/index.html

[9] California Integrated Waste Management Board, *Staff Report to the Board: New and Emerging Conversion Technologies*, 2007, pp 60-64

[10] Ibid, pg 60

[11] Economic and Technology Advancement Advisory Committee, *"Technologies and Policies to Consider for Reducing Greenhouse Gas Emissions in California"*, 2008

[12] Energy Information Administration (EIA) http://www.eia.doe.gov/fuelelectric.html

[13] US Dept. of Energy, *Carbon Dioxide Emissions from the Generation of Electric Power in the United States*, 2000

[14] Energy Information Administration (EIA) Annual energy outlook And EIA 2007 Emission of greenhouse gases in the U.S., 2008

[15] Union of Concerned Scientists, *"How Coal Works"* (values prorated from a 500 MW coal plant), http://www.ucsusa.org, 2008

[16] International Environmental Solutions (IES), 2006 Air Kinetics Report, values prorated from testing of 13.36 tpd MSW

Emissions from Municipal Waste Combustion Units

Pollutant	1990 Emissions (tons/year)	2005 Emissions (tons/year)	Percent Reduction
CDD/CDF, TEQ basis*	4,400**	15.0**	99+%
Mercury	57	2.3	96%
Cadmium	9.6	0.4	96%
Lead	170	5.5	97%
Particulate Matter	18,600	780	96%
HCl	57,400	3,200	94%
SO2	38,300	4,600	88%
NOx	64,900	49,500	24%

*Dioxin/furan emissions in units of toxic equivalent quality (TEQ), using 1989 NATO toxicity factors
**in grams/year

Source: EPA's August 10, 2007 Memo on Large & Small MWC Facilities

HDR

Why burning garbage is the best option

Trash is a resource and burying it is wasteful. Incinerators also produce fewer pollutants than landfills do

BY LOIS E. JACKSON, SPECIAL TO THE SUN SEPTEMBER 29, 2009

Intuitively, burning our garbage seems outdated. Some people believe it's the wrong thing to do.

That's not what leading public health, environment and waste management experts have told Metro Vancouver.

They've provided the region with independent advice that suggests a modern waste-to-energy facility which generates heat and electricity from garbage incineration is the best way to dispose of the trash we can't recycle.

Metro Vancouver residents generate 1.5 tonnes of waste per person each year. That's too much. On the bright side, Metro recycles 55 per cent of that waste -- far better than the 22 per cent Canada-wide average.

Participants at community forums this spring told the region to do better - and our board of directors agrees. We have set an aggressive zero-waste target for waste reduction, aiming to recycle 70 per cent by 2015.

But even if we meet that target, we'll still be left with more than one million tonnes of waste for disposal.

Landfills are the old standby. We've been burying trash -- in someone else's neighbourhood -- for a long time. In addition to using the City of Vancouver's landfill in Delta and our own waste-to-energy facility in Burnaby, the region has, for the past 20 years, been trucking half a million tonnes of trash annually to a Cache Creek landfill.

Last year, because the Belkorp-owned landfill was getting full, we called the best waste management experts in the world to look at alternatives.

One is called Mechanical Biological Treatment, a labour-intensive process that involves a further level of sorting and then a biological treatment that neutralizes waste, reducing further the risks of toxic run-off or air pollution. But the treated trash still ends up in a landfill or is burned for fuel.

Waste-to-energy is a third option.

WTE plants used to be known as "incinerators" -- a word that summons outdated images of everything from backyard burn barrels to giant smoke stacks.

That is not an option we're considering. The modern WTE plants now favoured by Europe's greenest capitals are the safest option for health and environmental risk factors. There are more than 400 waste-to-energy facilities in Europe, in the heart of cities like Paris and Vienna, and in mountain-confined airsheds in Switzerland, Italy and Norway.

We all want to protect air quality in Metro Vancouver and the Fraser Valley.

Unlike landfills, air emissions from waste-to-energy facilities can be continuously monitored and regulated. Even modern landfills emit far more dioxins and other potentially-harmful air pollutants than a new waste-to-energy facility. Our studies show that Metro Vancouver's current waste management system produces only about one per cent of the total air emissions in the Fraser Valley airshed. Our air emissions would remain the same or become even smaller with waste-to-energy.

Waste-to-energy is also the best option for reducing the gases that cause global warming. Dollar for dollar, investments in waste-to-energy will achieve twice the reduction of carbon dioxide compared to mechanical biological treatment.

Metro Vancouver's existing Burnaby waste-to-energy facility -- now more than two decades old -- hasn't led to any human health problems or harmed the environment. But it has helped to reduce garbage disposal costs: the Burnaby facility generated about $11 million in energy revenues last year, while landfills cost $30 million.

Garbage is a resource we waste when we bury it in the ground.

One tonne of trash has the energy equivalent of one barrel of oil. Heat from one moderate-sized waste-to-energy facility in this region could be used to heat 46,000 homes with hot water pipes and generate enough electricity for 33,000 homes.

What are the financial implications for taxpayers?

Waste-to-energy comes with a significant up-front capital expense, but it is the least expensive in the long run. A life-cycle analysis shows that, over 35 years, we will spend $1.7 billion on one medium-sized waste-to-energy facility, $3 billion on landfills, or $7.6 billion on mechanical-biological treatment.

That's some of the information in the studies that are now public. No formal decision has been made, but the studies suggest the region should consider building one more waste-to-energy facility. The region will host public consultation meetings in the coming months, to listen to your concerns. And Metro Vancouver's board of directors will take community opinion and priorities into account.

Please help us come to a conclusion that will safeguard our health, honour our environment and fulfill our responsibilities -- to our neighbours and to those who will inherit all that we leave behind.

Join the conversation on Metro Vancouver's website: www.metrovancouver.org

Lois E. Jackson is the chairwoman of the Metro Vancouver board of directors and mayor of Delta.

JOHN P. DEVILLARS

The Boston Globe

It's not waste; it's energy

By John P. DeVillars | December 2, 2009

WITH ONE executive action, the Commonwealth can make substantial progress on two environmental challenges: reducing greenhouse gas emissions and disposing of our garbage more sustainably. These important objectives can be met by lifting the state's ban on building waste-to-energy facilities.

Twenty years ago, Massachusetts issued the nation's first solid waste master plan. At the time, the Commonwealth recycled less than 5 percent of its garbage and sent the remainder to either hundreds of unlined town dumps, eight in-state waste-to-energy facilities, or out of state. The state's master plan sought to overhaul that approach by strongly emphasizing recycling and halting the construction of any landfills or waste-to-energy plants.

The Commonwealth's efforts to implement that plan have paid substantial environmental dividends. We now recycle more than one-third of our waste and recover through energy, composting, and reuse another 25 percent. Scores of unregulated landfills have been closed. And those waste-to-energy facilities have added millions of dollars worth of advanced air pollution control technologies to meet the new public health and environmental standards that the US Environmental Protection Agency and the state have established.

Yet the job of responsible waste management is far from done. Our recycling rate has leveled; last year it actually went down. As more landfills reach capacity, we are fast running out of in-state disposal capacity - in the next five years we are slated to more than double the costly and unsustainable practice of exporting our waste to other states.

New waste-to-energy facilities can help meet these challenges. They can add in-state capacity so that we can end the practice of burying our waste in someone else's backyard. They can help advance recycling by diverting recyclable wastes from their facilities to recycling centers. And because every ton of trash that we turn into energy is the equivalent of using one less barrel of oil or one-quarter ton less coal, generating energy from waste can contribute to addressing the global challenge of climate change.

For those who are concerned that adding waste-to-energy capacity will hurt our efforts to recycle, the data suggest otherwise. Massachusetts communities served by waste-to-energy plants have embraced the concept of reduce, reuse, recycle and recover. They consistently recycle at a higher rate than communities not served by such facilities.

The rest of the industrialized world is moving in precisely this direction. The European Union is on course to reduce use of landfills by 65 percent and replace those with waste-to-energy facilities and greater recycling. China plans to kick the coal habit in part through waste-to-energy. Their goal is 30 percent of their waste stream dedicated to energy production. Germany is already at 30 percent; Denmark is currently even higher - 55 percent of its waste stream goes to creating clean energy. The US government, 25 states, and the District of Columbia consider waste-to-energy as a renewable resource. Here and abroad policy makers recognize that this approach to waste management is not only an environmentally sustainable use of our garbage but also an important step in the fight to combat global climate change.

The moratorium on new waste-to-energy facilities made sense 20 years ago, but the world has changed. So, too, should our policies. It's time to lift the moratorium.

John P. DeVillars was environmental secretary of Massachusetts from 1988 to 1991 and New England administrator of the US Environmental Protection Agency from 1994 to 2000. He is a partner in BlueWave Strategies, a firm that advises the Energy Recovery Council, which has waste-to-energy members. ■