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Appropriate Approaches of Environmental Control Technology for Reduction of Risk

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Introduction

Definition of risk can be various. In environmental science, risk is often defined as the potential that the hazard can cause unwanted and adverse health effects. Hazard, potential for harm, is the source of a risk. In air pollution, the hazard can be air pollutants, activity of people who cause the release of the chemicals, and activity influencing exposure to these chemicals.

Scientists utilise various risk assessment techniques to determine or estimate risk of a specific hazard. Often risk is indirectly measured or estimated from supporting information. The risk assessment methodology requires assumptions and models. The process is often complex and difficult to quantify. The results of the analysis will be the measure of the risk. The risk is often described as probability of individual's incurring a specific health effect.

Risk depends on hazards and concentration. Therefore, we can reduce risk by controlling the hazards and concentration. Hazards can be various forms: physical, chemical and biological contaminants. In this presentation, I will confine to chemical contaminants. Each chemical has different toxicity. Minimising use and generation of toxic chemicals leads to less risk.

Concentration of air pollutant is calculated from amount of toxic chemicals in environment divided by volume of involving environment. We now understand that concentration could be controlled by the two factors. In order to control amount of toxic chemicals in environment, I will discuss three approaches: 3Rs (reuse, reduce and recycle), pollution prevention and end-of-pipe control. Volume of environment is inversely proportional to concentration. Increase of involving environmental volume can reduce concentration. There will be more approaches, but I will discuss two approaches in this paper: environmental impact assessment and ecologically sustainable development.

We now understand that risk can be affected by toxic chemicals, amount of emission and spatial distribution of emission sources. I will discuss scientific and technological approaches to reduce the factors. However, this paper is not comprehensive review for all available approaches.

Toxics

Toxics are chemicals that cause adverse health effects. Exposure to toxics can cause various health effects: cancer, respiratory, cardiovascular, reproductive and neurological problems but not limited to them. US EPA regulates a few air pollutants, called criteria air pollutants that are common throughout residential and industrial areas. These pollutants can injure health, harm the environment and cause property damage.

The current US criteria pollutants are: Carbon Monoxide (CO), Lead (Pb), Nitrogen Dioxide (NO_2), Ozone (O_3), Particulate matter with aerodynamic diameter less than or equal to 10 micrometers (PM10), and Sulfur Dioxide (SO_2). US EPA recently determined ambient standard for particulate matter with aerodynamic diameter less than or equal to 2.5 micrometers (PM2.5). US National Ambient Air Quality Standards for criteria air pollutants are shown in Table 1. There are two types of air quality standards. Primary standards set to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings

Table 1. US National Ambient Air Quality Standards

Pollutant	Standard value	Standard type
Carbon Monoxide (CO)		
8-hour Average	9 ppm 10 mg/m^3	Primary
1-hour Average	35 ppm 40 mg/m^3	Primary
Nitrogen Dioxide (NO_2)		
Annual Arithmetic Mean	0.053 ppm 100 μg/m^3	Primary & Secondary
Ozone (O_3)		
1-hour Average*	0.12 ppm 235 μg/m^3	Primary & Secondary
8-hour Average	0.08 ppm 157 μg/m^3	Primary & Secondary
Lead (Pb)		
Quarterly Average	1.5 μg/m^3	Primary & Secondary
Particulate $<$ 10 μm (PM10)		
Annual Arithmetic Mean	50 μg/m^3	Primary & Secondary
24-hour Average	150 μg/m^3	Primary & Secondary
Particulate $<$ 2.5 μm (PM2.5)		
Annual Arithmetic Mean	15 μg/m^3	Primary & Secondary
24-hour Average	65 μg/m^3	Primary & Secondary
Sulfur Dioxide (SO_2)		
Annual Arithmetic Mean	0.03 ppm 80 μg/m^3	Primary
24-hour Average	0.14 ppm 365 μg/m^3	Primary
3-hour Average	0.50 ppm 1300 μg/m^3	Secondary

* The ozone 1-hour standard applies only to areas that were designated non-attainment when the ozone 8-hour standard was adopted in July 1997. This provision allows a smooth, legal, and practical transition to 8-hour standard.

In addition, 1990 Clean Air Act Amendments (Section 112) listed a number of hazardous air pollutants. Table 2 shows the list of hazardous air pollutants.

Table 2. List of Potential hazardous air pollutants in urban areas that pose a threat to human health.

Chemical Name
Acetaldehyde
Acetamide
Acetonitrile
Acetophenone
2-Acetylaminofluorene
Acrolein
Acrylamide
Acrylic acid
Acrylonitrile
Allyl chloride
4-Aminobiphenyl
Aniline
o-Anisidine
Asbestos
Benzene (including benzene from gasoline)
Benzidine
Benzotrichloride
Benzyl chloride
Biphenyl
Bis(2-ethylhexyl)phthalate (DEHP)
Bis(chloromethyl)ether
Bromoform
1,3-Butadiene
Calcium cyanamide
Caprolactam
Captan
Carbaryl
Carbon disulfide
Carbon tetrachloride
Carbonyl sulfide
Catechol
Chloramben
Chlordane
Chlorine
Chloroacetic acid
2-Chloroacetophenone
Chlorobenzene
Chlorobenzilate
Chloroform
Chloromethyl methyl ether
Chloroprene
Cresols/Cresylic acid (isomers and mixture)
o-Cresol
m-Cresol
p-Cresol
Cumene
2,4-D, salts and esters
DDE
Diazomethane
Dibenzofurans
1,2-Dibromo-3-chloropropane
Dibutylphthalate
1,4-Dichlorobenzene(p)
3,3-Dichlorobenzidene
Dichloroethyl ether (Bis(2-chloroethyl)ether)
1,3-Dichloropropene
Dichlorvos
Diethanolamine
N,N-Diethyl aniline (N,N-Dimethylaniline)
Diethyl sulfate
3,3-Dimethoxybenzidine
Dimethyl aminoazobenzene
3,3¬-Dimethyl benzidine
Dimethyl carbamoyl chloride
Dimethyl formamide
1,1-Dimethyl hydrazine
Dimethyl phthalate
Dimethyl sulfate
4,6-Dinitro-o-cresol, and salts
2,4-Dinitrophenol
2,4-Dinitrotoluene
1,4-Dioxane (1,4-Diethyleneoxide)
1,2-Diphenylhydrazine
Epichlorohydrin (l-Chloro-2,3-epoxypropane)
1,2-Epoxybutane
Ethyl acrylate
Ethyl benzene
Ethyl carbamate (Urethane)
Ethyl chloride (Chloroethane)
Ethylene dibromide (Dibromoethane)
Ethylene dichloride (1,2-Dichloroethane)
Ethylene glycol
Ethylene imine (Aziridine)
Ethylene oxide
Ethylene thiourea
Ethylidene dichloride (1,1-Dichloroethane)
Formaldehyde
Heptachlor
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Hexamethylene-1,6-diisocyanate
Hexamethylphosphoramide
Hexane
Hydrazine
Hydrochloric acid
Hydrogen fluoride (Hydrofluoric acid)
Hydrogen sulfide
Hydroquinone
Isophorone
Lindane (all isomers)
Maleic anhydride
Methanol
Methoxychlor
Methyl bromide (Bromomethane)
Methyl chloride (Chloromethane)
Methyl chloroform (1,1,1-Trichloroethane)
Methyl ethyl ketone (2-Butanone)
Methyl hydrazine
Methyl iodide (Iodomethane)
Methyl isobutyl ketone (Hexone)
Methyl isocyanate
Methyl methacrylate
Methyl tert butyl ether
4,4-Methylene bis(2-chloroaniline)
Methylene chloride (Dichloromethane)
Methylene diphenyl diisocyanate (MDI)
4,4¬-Methylenedianiline
Naphthalene
Nitrobenzene
4-Nitrobiphenyl
4-Nitrophenol
2-Nitropropane
N-Nitroso-N-methylurea

N-Nitrosodimethylamine
N-Nitrosomorpholine
Parathion
Pentachloronitrobenzene (Quintobenzene)
Pentachlorophenol
Phenol
p-Phenylenediamine
Phosgene
Phosphine
Phosphorus
Phthalic anhydride
Polychlorinated biphenyls (Aroclors)
1,3-Propane sultone
beta-Propiolactone
Propionaldehyde
Propoxur (Baygon)
Propylene dichloride (1,2-Dichloropropane)
Propylene oxide
1,2-Propylenimine (2-Methyl aziridine)
Quinoline
Quinone
Styrene
Styrene oxide
2,3,7,8-Tetrachlorodibenzo-p-dioxin
1,1,2,2-Tetrachloroethane
Tetrachloroethylene (Perchloroethylene)
Titanium tetrachloride
Toluene
2,4-Toluene diamine
2,4-Toluene diisocyanate
o-Toluidine
Toxaphene (chlorinated camphene)
1,2,4-Trichlorobenzene
1,1,2-Trichloroethane
Trichloroethylene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
Triethylamine
Trifluralin
2,2,4-Trimethylpentane
Vinyl acetate
Vinyl bromide
Vinyl chloride
Vinylidene chloride (1,1-Dichloroethylene)
Xylenes (isomers and mixture)
o-Xylenes
m-Xylenes
p-Xylenes
Antimony Compounds
Arsenic Compounds (inorganic including arsine)
Beryllium Compounds
Cadmium Compounds
Chromium Compounds
Cobalt Compounds
Coke Oven Emissions
Cyanide Compounds1
Glycol ethers2
Lead Compounds
Manganese Compounds
Mercury Compounds
Fine mineral fibers3
Nickel Compounds
Polycylic Organic Matter4
Radionuclides (including radon)5
Selenium Compounds

NOTE: For all listings above which contain the word "compounds" and for glycol ethers, the following applies: Unless otherwise specified, these listings are defined as including any unique chemical substance that contains the named chemical (i.e., antimony, arsenic, etc.) as part of that chemical's infrastructure.

Air pollutants can be generated by natural and anthropogenic sources. Even though environmental problems are mainly caused by anthropogenic sources, natural sources also can cause significant impacts on environment. Volcano is one of the natural sources with great global impact. Recently, Indonesia is suffered by bush fire that affects the South East Asian region significantly. Even though the bush fire was initiated by logging industry, it was spreading to larger area due to inappropriate practices and unusual dry weather conditions.

US EPA classify anthropogenic sources by emission strength as follows:

Major Source -- Any source (ie, a contiguous area under common control) of toxic air pollution that emit or has the potential to emit 10 tons annum of any listed hazardous air pollutant, or a combination of listed hazardous air pollutants of 25 tons or more.

Lesser Quantity Major Source -- Certain other sources that are considered major sources even though they emit less than the 10/25 ton limit figure. Lesser quantities can be set for pollutants which are highly toxic to human health or the environment. If EPA sets a lesser quantity limit for a particular industrial group, all sources within that group that emit more than the established limit, will be classified as major sources.

Area Source -- These smaller sources emit less than 10 tons annum of a single air toxic, or less than 25 tons per year of a combination of air toxics. Most area source emissions are small, but the collective volume can be hazardous in densely developed areas where large numbers of such facilities are packed tightly into urban and industrial areas.

In other classification scheme, emission sources can be divided into point source and mobile source.

Emission Reduction Technology

(1) 3Rs (Reduce, Reuse, and Recycle)

These three terms are to minimise use of natural resource, eventually pollution emission. They should be applied in combination rather than individually.

Reduction is all about the things that we don't have to buy. For example, we can reduce to purchase disposable items or over-packaged goods. Considering what people purchase, large portion of the purchase is actually headed right into the garbage can. Practicing the art of reduction is really the most difficult of all the 3Rs because, for many, it requires a major change in lifestyle and buying habits.

Many things or materials could be used again. Things could be used for different purposes after initial use. Paper box could be reused for children toy and plastic tubs could be reused as storage containers. Newspapers could be used to wrap gifts. Used appliances, clothes or furnishings should be donated to charitable organisations and reuse centres. Or people could sell unwanted things by a garage sale or flea market. Our unwanted things could be valuable for other people.

Recycling is the practice that collects certain materials and recycles as resources of manufacturing. This practice often requires a third party (for example, waste collection and recycling organisation), unlike reduce and reuse. Aluminium is a good example for recycle. Because aluminium is expensive and valuable material, corporations have started recycle before government initiates the recycling program. Unfortunately, there are many materials that can be recycled but economically not viable. Throughout the world, many governments provide economic incentives to operate recycling program.

Items that can be recycled include:
newspapers and newsprint fliers
magazines and catalogues
glass bottles and jars
plastic bottles and jugs
metal cans used for food and drinks
aluminium containers (no foil wrap)
household paper (junk mail, envelopes, writing and computer paper)
paper egg cartons and paper roll tubes
paper gift wrap and cards
board boxes (tissue, shoe, detergent, cereal boxes, etc.)
telephone books

pizza boxes and other corrugated cardboard
books (hard and soft cover)

The amount of municipal solid waste (household and commercial waste) that the average person generates varies widely by country. According to the World Resources Institute, some typical waste generation rates are:

United States	4.4 lb/person/day
Canada	3.9 lb/person/day
Spain	1.7 lb/person/day
Finland	1.5 lb/person/day
Korea	2.9 lb/person/day (1994)

The environmental impact of this consumption varies with how much recycling and composting is done in each country. The primary impacts of 3R are natural resource use, energy use, and the air pollution emissions associated with energy use.

Internet address of US EPA's Reusable News:
http://www.epa.gov/docs/OSWRCRA/non-hw/recycle/reuse/

Internet address of Creighton University's 3R Program:
http://alouette.creighton.edu/curecycle/

(2) Pollution Prevention

Definition of pollution prevention (P2) can be reduction of pollution at the source, as well as protection of natural resources through conservation or increased efficiency in the use of energy, water, or other materials. The US Pollution Prevention Act explained the term as "source reduction".

Application of pollution prevention eliminates or minimises pollution at the source -- so pollution isn't created in the first place and never enters into our environment. Most traditional environmental protection has involved controlling, treating or cleaning up pollution after we create. However, it is clear that traditional "end-of-pipe" control approaches not only can be expensive and less than fully effective, but also sometimes transfer pollution from one medium to another (this requires additional clean-up process). Therefore, pollution prevention is very effective to improve environmental quality by preventing pollution from occurring.

Pollution prevention can achieve minimum health and environmental risks because it:
1. eliminates the hazards associated with any release of pollutants to the environment
2. avoids transfer of pollutants from one medium (air, water or land) to another,
3. minimises use of natural resources for future generations, by reducing wastes and conserving resources

Preventing pollution also provides economic benefits, because non-creation of pollutants avoids the need for expensive investments in waste management or clean-up process. Pollution prevention has the great potential for both protecting the environment and strengthening economic growth through more efficient manufacturing and raw material use.

Success of pollution prevention can depend on a number of factors, including regulations, collaborative efforts that offer recognition and technical assistance, public participation, the availability of clean technologies, and the practices and policies of large public agencies.

Four actions may be needed to achieve this potential. First, government must coordinate different regulations affecting the same industry. New regulation for pollution prevention should be avoided. This approach will lead to reduce transaction costs, minimise cross-media transfers of waste, and provide a clearer sense of long-term environmental protection goals for the regulated community.

Second, permission, inspection, and enforcement programs must be utilised to encourage pollution prevention as a means of compliance. In order to achieve national environmental protection and fair competition between industry, minimum regulation should be implemented.

Third, improvement of environmental quality through pollution prevention needs cooperative efforts with university, industry, government and people. It can raise awareness of prevention opportunities and attract leading scientists and engineers to engage in demonstration, development, and research focused on new prevention technologies.

Finally, better data collection should be implemented. When regulations encourage investments in cleaner and more efficient manufacturing processes, industry can achieve cost saving as well as better environmental quality. To determine cost-effective program, data collection is needed. These approaches can utilise, such as toxics emission inventory and life-cycle analysis.

Internet address of US EPA Office of Pollution Prevention and Toxics' (OPPT): http://www.epa.gov/opptintr/p2home/

Internet address of Canadian Centre for Pollution Prevention (C2P2): http://c2p2.sarnia.com/

Emission inventory

Emission inventory is combination of sources of pollution in a given geographical area and an estimate of the pollutants emitted to the atmosphere from those sources over time. Identification of emission sources may be possible, although it is not easy to identify all individual sources. But, monitoring all emissions in a given area is not possible or feasible. Therefore, we often use emission factors to estimate emissions for many of the sources included in an inventory.

Emission inventory can be used to prevent non-compliance of air quality standard, develop sustainable development plan, operate permit programs, and trade pollution credit in open market trading.

a. Emission inventory provides amount of pollutants emitted, location of emission sources, and temporal emission profile. This information, along with meteorological data, can be used to estimate ambient air quality.

b. In order to sustain environmental quality and develop the area, emission inventory can provide current emission power in a given area. We can develop sustainable development plan to maintain acceptable air quality.
c. We can use emission factors conjunction with other data to determine whether a specific source emits or will emit pollutants at levels requiring a permit or other regulatory controls.
d. Pollution credit has been traded in certain area. Emission factors can play a significant role in open market trading system. For instance, emission factors can be used extensively to help determine the emission trading baseline and compute credits available for trading.

Internet address of National Pollutant Inventory (Australia):
http://www.erin.gov.au/net/npi.html

Internet address of the Emission Factor and Inventory Group of US EPA:
http://www.epa.gov/ttnchie1/welcome.html

(3) End-of-pipe control

This is traditional approach to control environmental problems. As we discussed, the best approach is not to produce air pollution in the first place. Our current technologies use fossil fuels as energy source. The most production is based on transfer of one form of energy to another. Since efficiency of the energy transfer is generally low, energy is wasted and by-products are generated. Alternatively, we can utilise renewable energy sources: for example, solar energy, wind energy, tidal forces, hydroelectric energy and so on. Because of low energy density of the renewable energy sources and technical difficulties (for example, energy loss during transfer and energy storage), less than 10% of world energy consumption is based on the renewable energy sources.

There are various control technologies to control air pollutants. Sometimes, natural processes can clean pollution. However, this process often takes long time and the efficiency is often so low that it is difficult to control the massive emission by current mass production technologies. The technologies to control pollutant emission are achieved by chemical, physical, biological means and combination. Interestingly, all anthropogenic control technologies require energy. The energy production for control technology can be another pollution sources. Biological control technologies may require minimum energy. However, the most current control technologies are based on chemical and physical techniques.

The common pollution control technologies are gravitational settling, inertial collectors, wet collectors, fabric collectors, electrostatic precipitators, absorption control, adsorption control, and catalytic control.

In this discussion, I would like to emphasise on overall end-of-pipe control strategy. End-of-pipe control strategy should consider individual emission source strength and number of emission sources. Technically, it may be possible to remove all pollutants from emission. Economically, this practice is not acceptable. Therefore, emission of air pollutant is not avoidable in our technology using non-renewable energy sources.

Question will be how much emission is acceptable to reduce health risk. To answer this question, we have to consider both spatial and temporal frequency of emission.

Internet address of Nonpoint Source Pollution Control Program of US EPA: http://www.epa.gov/OWOW/NPS/

Internet address of The Center for Emissions Control: http://www.cec-dc.org/

Internet address of POSCO Environment: http://www.posco.co.kr/about/environment/

Increase of Spatial Distribution

(1) Environmental Impact Assessment (EIA)

Environmental impact assessment studies, forecasts, and evaluates the impact of each development project on the environment. This practice can be used to prevent environmental pollution by the project likely to seriously affect the environment. The purpose of the EIA is to provide environmental input for a proposed action of identifying future configurations for selected facilities.

Environmental impact assessment is a tool used for decision making regarding projects, developments and program such as incinerators, airport runways, and power plant. EIA is intended to identify the environmental, social and economic impacts of a proposed project prior to decision making. EIA will identify the most environmentally suitable option before initiation or at an early stage, the best practicable environmental option and alternative processes.

The project managers can use EIA to address these problems in order to avoid or minimise environmental impacts in conjunction with their project planning. EIA is carried out in order to produce a report that must include a description of the project: location, design, scale, size etc, description of significant effects, mitigating measures and a non-technical summary. All interested parties including general public should review the report.

There are two steps in EIA. The two steps are

1. Preliminary Assessment: Carried out in the early stages of planning
2. Detailed Assessment: Carried out during project planning until the project plan is completed and are reported formally.

Scoping is used to identify the key issues of concern at an early stage of the planning process. Scoping should be carried out at an early stage to aid site selection and identify any possible alternatives. The scoping process should involve all interested parties such as the proponent and planning or environmental agencies and members of the general public. The results of scoping will determine the scope, depth and terms of reference to be addressed within the report.

Screening is a comprehensive and clear method of decision making. It is practical, quick and easy to use. This should include both alternative sites and alternative techniques. This search must be genuine, well documented and carried out before a decision has been made. It is usually that alternative sites are available as well as practical. However, it is not always the case. Some projects are site specific such as mining. The extraction from a mine can only occur where the mineral is sited. In this case other measures such as scale, mitigating measures and traffic management should be addressed. This reviews the action taken to prevent, avoid or minimise the actual or potential adverse environmental effects of a project. The measure could include the abandoning or modifying of a proposal, substitution of techniques using BATNEEC (Best Available Technology Not Entailing Excessive Costs). This would include the various pollution abatement techniques that would be required to reduce emissions to the legal limits.

EIA should be used to make a decision. If the uncertainties of the project are not acceptable, *if consequences of the project can be significant to environment and if* there are no mitigating measures, the development plan should be rejected. If there are uncertainties that might be reduced by further studies, the applications should be deferred until further studies are carried out.

(2) Ecologically Sustainable Development

Ecologically Sustainable Development (ESD) represents one of the greatest challenges facing governments, industry, business and community in the coming years. While there is no universally accepted definition of ESD, in 1990 the Australian Commonwealth Government suggested the following definition for ESD:

'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased'.

ESD aims to meet the current development needs, while conserving our ecosystems for the benefit of future generations. To do this, we need to develop ways of using environmental resources appropriately and, where possible, improving their range, variety and quality.

By following an ecologically sustainable development, we should be able to reduce the likelihood of serious environmental impacts arising from our economic activity. ESD can decrease the number of divisive and damaging confrontations which have characterised some of development projects. More practically, ESD will mean changes to patterns of resource use, including improvements in the quality of air, land and water, and in the development of new, environmentally friendly products and processes.

The goal of ESD is to improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. To achieve the goal, objectives are to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations to provide for equity within and between generations to protect biological diversity and maintain essential ecological processes and life-support systems. Decision making processes of ESD should effectively integrate both long and short-terms economic, environmental, social and equity considerations where there are threats of serious or irreversible environmental damage. One of short comings, lack of full scientific certainty, should not be used as a reason for postponing measures to prevent environmental degradation the global dimension of environmental impacts of actions. Policies based on ESD should be recognised and considered the need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection.

Success of ESD will require changes in the patterns of decision-making and actions by all groups and individuals. Significant increases in the overall level of awareness of development and environmental problems and their solutions will also be required. There are concerns, however, that any ESD-related actions and decisions do not result in an unequal burden of adjustment on particular regions, sectors or groups in society. Therefore, the appropriateness of some policies and progress on implementation will vary between regions. It is critical to develop regional or national policy.

Embracing ESD will ultimately rest on the ability of all participating parties to contribute individually, through modifying everyday behaviour, and through the opportunities open to us to influence community practices. These will vary from how we respond to environmentally friendly products on our supermarket shelves, to changes in water, energy and waste disposal pricing, to our support for changes to product packaging and improved recycling facilities. All participating party each have the capacity to influence public demand for products and services which are less harmful to the environment while also supporting our economy and providing employment.

Internet address of Environment Australia - Ecologically Sustainable Development: http://www.erin.gov.au/portfolio/esd/integ.html

Internet address of International Institute for Energy Conservation (IIEC): http://www.iiec.org/

Internet address of United Nations Environmental Program-Working group of Sustainable Product: http://unep.frw.uva.nl/

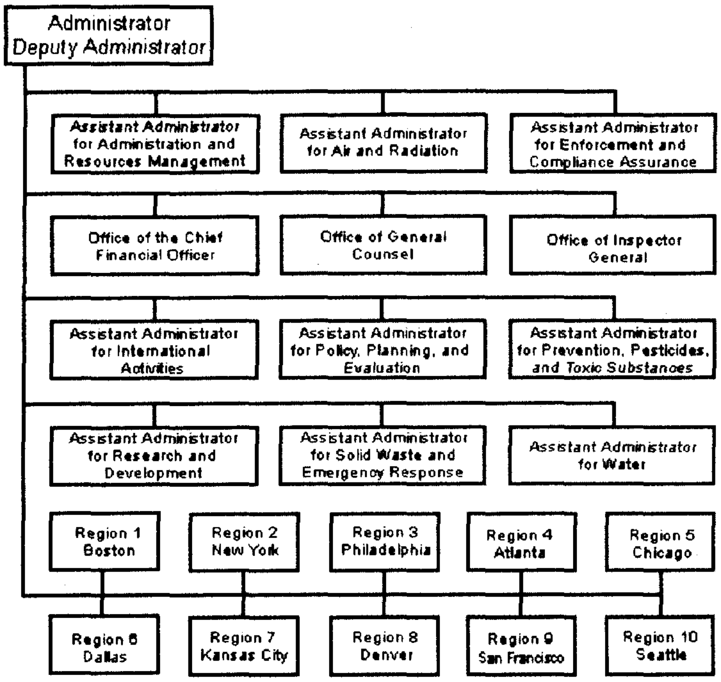
Governmental Systems for Environment: Australia and America

The mission of the U.S. Environmental Protection Agency is to protect human health and to safeguard the natural environment — air, water, and land — upon which life depends.

US EPA's purpose is to ensure that:

"All Americans are protected from significant risks to human health and the environment where they live, learn and work. National efforts to reduce environmental risk are based on the best available scientific information. Federal laws protecting human health and the environment are enforced fairly and effectively. Environmental protection is an integral consideration in U.S. policies concerning natural resources, human health, economic growth, energy, transportation, agriculture, industry, and international trade, and these factors are similarly considered in establishing environmental policy. All parts of society—communities, individuals, business, state and local governments, tribal governments—have access to accurate information sufficient to effectively participate in managing human health and environmental risks. Environmental protection contributes to making our communities and ecosystems diverse, sustainable and economically productive. The United States plays a leadership role in working with other nations to protect the global environment.

Structure of US EPA is shown in Figure 1.



Australian Federal government has Department of Environment. Department of Environment includes four divisions: Environment Australia, Australian Antarctic Division, Bureau of Meteorology, and Corporate Management Division. In addition, there are four statutory bodies: Australian Heritage Commission [AHC], Great Barrier Reef Marine Park Authority [GBRMPA], and Australian National Parks and Wildlife Service [ANPWS]. Australian governmental department for environment regulates not only anthropogenic environment but also natural environment.

Environment Australia

- Australian & World Heritage Group
- Biodiversity Group
- Environment Priorities and Coordination Group
- Environment Protection Group
- Portfolio Marine Group
- Supervising Scientist Group

Australia consists of six states and two territories. Each state government has its own system. As one of the examples, I will briefly review Queensland Department of Environment.

The Department's organisational structure matches its program structure of Environment, Conservation and Business Support Services programs. The Environment, Conservation, and Corporate Services Programs account for 16 percent 73 percent and 11percent of the Department's budget and 19 percent, 64 percent and 17 percent of its workforce respectively.

High profile services include:
Great Barrier Reef Marine Park management, Wet Tropics World Heritage Area management, Beach Protection Authority, Air and water quality monitoring, David Fleay Wildlife Park, Fraser Island World Heritage Area management, Impact assessment and planning, State-of-Environment reporting

Five Department Regions have been created to support efficient and equitable localised delivery of program services: Far Northern (Cairns), Northern (Townsville), Central Coast (Rockhampton), Southwestern (Toowoomba), Southeastern (Brisbane).

Similar to federal government, state government regulates not only anthropogenic environment but also natural environment.

Goals of the department are

- a clean and safe environment
- maintenance of biological diversity
- sustainable use of wildlife resources
- sustainable economic and community development
- maintenance of cultural heritage

In order to achieve the goals, the department indicates the following strategies

- promote adoption of ecologically sustainable management policies through a whole-of-government approach
- improve research, monitoring and state-of-environment reporting capabilities
- promote cleaner production, waste avoidance and improved environmental management
- promote integrated environmental planning, impact assessment and development approvals
- improve community awareness, appreciation and understanding of the environment
- promote community-based conservation and community involvement in environmental planning
- implement a world-class system of protected areas including national parks, marine parks, nature-based recreation areas and cultural heritage places
- implement a mix of economic and regulatory schemes to foster better environmental practices
- support nature-based and cultural heritage tourism
- improve our client focus, service delivery standards and the accountability, wellbeing and productivity of our workforce
- value our support services and embrace continuous improvement of our business practices

Department of Environment has the Department's Corporate Plan that includes details of how the Department is tackling its tasks. This plan covers a three-year period and is revised each year to better reflect changing government policy and community aspirations. Department activities are directed to five major outcomes. These provide the basis for preparing business plans. Progress towards achieving the outcomes can be judged by the state of supporting outcomes and performance indicators.

Outcomes

- A clean and safe environment to support the economic and social wellbeing of Queensland
- Maintenance of biodiversity to support the economic and social wellbeing of Queensland
- Sustainable use of wildlife resources to support the economic and social well-being of Queensland
- Sustainable economic and community development
- Maintenance of cultural heritage to support the economic and social well-being of Queensland

Internet address of US EPA: http://www.epa.gov/

Internet address of Environment Australia: http://www.erin.gov.au/

Internet address of Queensland Department of Environment: http://www.env.qld.gov.au/