Two categories of risk to human health:

Carcinogenic: chemicals that cause cancer   
non carcinogenic: any other human related disease that’s caused by chemicals

NRC: National Research Council defined a four step risk assessment.  
**HAZARD assessment DOSE-RESPONSE assessment EXPOSURE assessment   
RISK CHARACTERIZATION**

CDI: Chronic Daily Intake. Average daily dose of a chemical over the lifetime of an individual, normalized in his/her body weight  
CDI= {average daily dose (mg/day)} **/** {body weight (kg)}

PF: **Potency Factor** is the incremental cancer risk for a chronic daily intake (CDI) of 1 mg/kg-day

Since carcinogen dose-response is linear PF is the slope of the line.

Incremental life time risk= CDI \* PF

Level of acceptable risk:

A lifetime risk of 10^-6 is an acceptable risk which is one chance in a million. One in a thousand or greater is considered as serious risk. Another way is to compare the risk to the background cancer rate.

Cancer rate= # of cancer/ # people   
annual community risk = # of additional lifetime cancer/ # of years per lifetime

Non carcinogenic risk assessment:

NOAEL is no observable adverse effect level

RfD= NOAEL/ [UF \* MF] MF is usually equal to 1.0  
**reference dose Hazard quotient**

**reference dose:**  the reference dose is a key parameter used in risk assessment to characterize the safe dose of a non-carcinogenic chemical

ADD= [concentration\* consumption] / body weight

HQ= Average daily dose (ADD)/reference dose (RfD)

Acceptable risk for a non-carcinogen = HQ=< 1.0

Options for risk management:

1. **The source of the risk can be reduced or eliminated**, such as by removing contaminated soil, closing a facility, or installing environmental control technology to reduce emissions.
2. **The exposure pathway can be modified or avoided**, such by installing an engineered barrier that prevents contaminant migration through the soil, or a tall chimney that disperses pollutant beyond the local community.
3. **Human exposure to the contaminants can be reduced or eliminate**d, such as by relocating the affected population or prohibiting access to a contaminated area.
4. In the least desirable option, **effects can be treated or compensated for after they occur**, such by medical treatment or monetary payments from parties responsible for the contamination.

An influence diagram is a way of visualizing the important connections among different elements of a problem.

Calculating decision tree: expected value= probability of each branch\*the value of each branch

EV= SUM (PV)

Chapter 15

Modeling the future:

1. Drivers of environmental change: **population, standard of living (economic growth), technology.**
2. Modeling of environmental processes: change in the rate of change

Annual Growth Rate Model:

P=Po(1+r)t

P=Poert or dp/dt= rP

tm= tmid, p = ½ pmax

tm=(1/r)ln[(Pmax/Po) – 1]

Demographic models are thus limited in their ability to forecast long-term changes in population. On the other hand, they can be very useful for analyzing scenarios of future population trends under different conditions.

Economic Growth models:

1-Activity coefficients 2-Economic Growth and Energy Use 3- input-output models 4-macroeconomic models.

Input-output model quantifies the value of goods and services that each sector requires from other sectors(the inputs) in order to make its own product(the outputs)

Macroeconomic model concerns the structure and performance of national economics and the effect of government policies on aggregate economic activity. **it explains economic activity in terms of the behavior of three classes of economic actors: firms, household and the government.**

GNP: Gross national Product:

G= PK0.3L0.7

Where G is real GNP in billions of dollars. K is the annual value of all capital goods used for production, L is the size of the labor force(millions of workers) and P is the annual productivity factor for the economy.

Technological change:

**Types of technology change:**

1. improvement to current technology design
2. substitution for an alternative technology
3. new classes of technology
4. change in technology utilization

**Scenarios of alternative technologies   
Rates of technology adoption  
Rates of technology innovation**

Chapter 7

The most important overall principle behind the life cycle assessment is to provide a framework so that decisions made today will, to the extent possible, be viewed many years from now as the “right” decisions from the standpoint of environmental

Steps in life cycle assessment:

**Inventory analysis: lists and quantifies the inputs and outputs of the processes at each stage in the life cycle.**

**Impact analysis: is to identify the impact of any input or output on the environment**

**Improvement analysis: identifies what can be done to reduce environmental impacts by changes in product or process design. This is the key step for engineering design decisions.**

Inventory analysis can identify which processes have the greatest environmental burdens; Impact analysis can identify where in the life cycle the most adverse effects can occur; in either case the result can guide research on where to look for improvements that can significantly reduce environmental damage.

Major components of an inventory analysis:

Flow diagram that includes the major categories of interest and defines the scope of the study.

1. Raw material acquisition
2. Manufacturing
3. Use of product by consumer/reuse/maintenance
4. Recycling/ waste management

The input is usually raw materials and energy, where output is wastes and emissions of toxics.

\*output is not the product\*

Categories of impacts:

1. Depletion of natural resources
2. Effects on human health
3. Effects on ecosystem
4. Impairment of human welfare

TRI: Toxic release Inventory

The steps to rank impacts:

1. The physical extent of the impacted area is important such as the population of affected region.
2. The danger posed by the environmental change is of the considerable concern.
3. The extent of exposure is an additional criterion.
4. The penalty for making wrong decision

Chapter 5

Net Plant Efficiency:

Reducing environmental impacts:

1. Technological measures to control or remove a pollutant before it is released to the environment. (“end of pipe”)
2. Increase the efficiency of electric power generation. (“green design”)
3. Selecting and utilizing cleaner energy sources and alternative technologies with lower environmental impacts.

ESP: electrostatic precipitator

The simple principle of ESP is that the electric field is imposed between two plates and a wire suspended in the gas flow path. Once the flue gas flows between the plates, ash particles in the gas are bombarded with negative ions, taking on a negative electric charge. Electrostatic attraction then pulls the charged particles toward the positively charged plates, where they are collected. At intervals the electric field is momentarily relaxed letting the collected particles to fall into a collection hopper.

FGD: flue gas desulfurization

FGDs are required in all new coal fired plants constructed in USA.

Gypsum is hydrated calcium sulfate: CaSO4˖2H2O

Two general method of reducing Nitrogen Oxide NOx are:

Combustion modification and SCR selective catalyst reduction.

SNCRs do not use catalyst and therefore are not as efficient as SCRs.

Improving energy efficiency:

Increased operation temperature:

note that the temperature is in kelvin

Cogeneration:

Reuse of the heated water for other purposes rather than releasing it to nearby residence or industries.

Advanced cycles:

1. Integrated gasification combined cycle(IGCC)
2. Integrated Gas Turbine Fuel Cell

Alternative sources of energy for electric plants:

Nuclear energy: Nuclear power plants are steam electric generators that use uranium rather than fossil fuels to produce a steam that drives a turbine generator.

Biomass and refuse energy: biomass has less energy content than coal (about half 10 to 15 MJ per Kg) biomass does not have net CO2 release.

Geothermal Energy: Energy that derived from molten core of the earth.

Hydroelectric energy: the turbine is driven by water (the water wheel).

Wind Energy: ½ mairv2 = ½ (ρV)v2 = ½ (ρAvΔt)v2

Power= ½ πr2ρv3

Electro chemical generators

Photovoltaic generators