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联合国工业发展组织绿色丝绸之路项目  
绿色工业园区建设指导原则

UNIDO Green Silk Road Project  
Guidelines for Green Industrial Park



联合国工业发展组织  
中国南南工业合作中心

地址：北京市东城区安定门东大街28号雍和大厦C座11层  
邮编：100007  
电话：010-84000516  
传真：010-64097898



联合国工业发展组织  
中国南南工业合作中心

UNIDO Centre for South-South Industrial  
Cooperation, China

# 绿色工业园区导则

## Guideline for Green Industrial Park

本指导原则是联合国工发组织支持的“绿色丝绸之路项目”的成果之一，意在结合相关国际经验，为中国的绿色工业园区建设提供相关的政策和技术方面的指导。

*The guideline is one of the outputs of UNIDO Green Silk Road Project, whose objective is to provide guidance on policies and technologies needed for development of Green Industrial Parks in China and other countries along the New Silk Road region according to international experiences.*

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## 1. 绿色工业园区概述（Introduction to Green Industrial Park）

2012年联合国可持续发展大会于6月20日至22日在巴西里约热内卢召开，大会主要聚焦两个主题：可持续发展和消除贫困背景下的绿色经济与可持续发展的体制框架。绿色经济作为“RIO+20”峰会的主要议题之一，是指一种旨在提高人类福祉、使最广大人群充分享有经济发展成果，同时又能显著减少人类活动对环境不良影响的经济模式。其本质是以生态、经济协调发展为核心的可持续发展经济，是以维护人类生存环境、合理保护资源、能源以及有利于人体健康为特征的经济发展模式，是一种平衡式经济。在这种经济模式下，环保技术、清洁生产工艺等众多有益于环境的技术被转化为生产力，实现经济的可持续增长，并最终消除贫困。因此，发展绿色经济已经成为世界发展的一个重要趋势。国际社会普遍认识到，发展绿色经济不仅可以节能减排，而且能够更有效地利用资源、扩大市场需求、创造新的就业，是保护环境与发展经济的重要结合点。绿色发展还需要“绿化”工业、城市、建筑、交通等方面。正是这些大规模的物质层面的建设，构成不可再生自然资源特别是能源消耗的大户。物质层面的绿色建设和改造为绿色发展提供了巨大的机会和空间。

绿色工业园区作为绿色经济发展的重要载体，是实现区域绿色经济发展的关键所在。绿色工业园区是指以可持续发展理念、清洁生产要求、循环经济理念和工业生态学原理为指导，通过物质流或能量流传递等方式寻求物质闭路循环、能量多级利用和废物最小化的途径，从而形成资源共享和副产品互换的产业共生组合，最大限度的提高资源能源利用效率，从工业生产源头上将污染物的产生降至最低的一种新型工业园区。

绿色工业园区最早也是最著名的雏形是丹麦的卡伦堡工业园区。

卡伦堡是一个仅有 2 万居民的工业小城市，位于北海海滨，距首都哥本哈根以西 100 公里左右。上世纪 60 年代初，这里的火力发电厂和炼油厂已经开始了产业生态方面的探索，当时园区内的阿斯内斯电厂，改变了其传统的运行规律，把一部分热量送到附近的斯塔托伊尔炼油厂，形成“热电联产”。随着年代的推移，卡隆堡的主要企业开始相互间交换“废料”：电厂向炼油厂和药厂等供应水蒸气，多余热量还供应一个养鱼场，而鱼塘的污泥回收作为肥料；炼油厂过量的高硫瓦斯被加氢脱硫回收了硫磺，成为一家硫酸厂的原料，并把清洁的瓦斯卖给电厂，节省了煤炭；电厂利用石灰将本来要造成污染的烟道气中的硫脱除，产生硫酸钙直接卖给墙板厂代替石膏；电厂的飞灰等废物被利用，用于筑路和制造水泥。应该说，卡伦堡工业园区在实际上已经形成了一种“工业共生体系”，在这一体系中体现了其环境和经济优势，即减少资源消耗，减少造成温室效应的气体排放和污染，使废料得到了重新利用。虽然卡伦堡产业生态系统的形成是一个自发的过程，而不是遵循某一人为的预先设计，但它的成功给我们展示了产业生态应用的前景。

由此可见，绿色工业园区展现了工业建设的美好前景，使工业建设的环保工作跃上了“经济环境双赢”的新台阶，实现了新跨越。

制定本指导原则是联合国工发组织支持的“绿色丝绸之路项目”的一项重要成果。在此之前，部分编写组成员在该项目的支持下考察了日本和韩国的工业园区、主管政府部门和科研机构，参照了中国的相关政策和技术指标，并借鉴了其它发达国家在建设绿色（生态）工业园区方面的成功经验。本指导原则的制定意在结合相关国际经验，为中国的绿色工业园区建设提供相关的政策和技术方面的指导。在经过相关的试用后，可以将其做进一步的完善。希望本指导原则能够成

为引领中国今后建设绿色工业园区的重要参照，为中国及丝绸之路沿线国家实现包容及可持续工业发展服务。

## 2. 组织架构（Institutional Framework）

绿色工业园区的建设是一项跨部门、跨行业、跨企业的综合性系统工程。园区应该成立建设领导小组，明确各部门在园区的责任，将指标和工程项目分解到责任单位，园区与责任单位签定目标责任状，定期进行检查和通报。

表2-1 组织机构及职能分工

序号	部门	职责
1	领导小组	<ul style="list-style-type: none"> <li>➤ 负责组织编制绿色工业园区建设规划、制订相关的优惠政策（土地、财政、金融和排污费返回等优惠政策）；</li> <li>➤ 统筹人、财、物资源，解决园区建设过程中所遇到的各种重大问题；</li> <li>➤ 提供环境管理体系建立、实施与保持所必需的组织及资源，包括人力、物力和财力资源；</li> <li>➤ 批准、发布园区环境方针；</li> <li>➤ 主持环境管理体系的管理评审，审核《环境管理手册》，审定《环境管理程序文件》；</li> <li>➤ 审定重要环境因素，目标、指标和方案，并及时将管理方案的实施情况报告最高管理者；</li> <li>➤ 负责组织实施绿色工业园区建设规划的总体实施。</li> </ul>
2	办公室	<ul style="list-style-type: none"> <li>➤ 负责园区建设综合调度；</li> <li>➤ 负责土地征地政策的制定、征地的组织和实施；</li> <li>➤ 与宣传部门共同负责园区环境方针的对外宣传工作；</li> <li>➤ 负责园区紧急事故的协调工作；</li> <li>➤ 负责内部消防安全责任制的检查与考核，编制内部火灾应急预案，组织消防应急演练，处理内部火灾紧急事故。</li> <li>➤ 负责区内的征地管理工作。</li> </ul>



3	环保部门	<ul style="list-style-type: none"> <li>➤ 负责环境影响评价制度在区内执行；</li> <li>➤ 负责园区大气、水环境和声环境质量监控；</li> <li>➤ 负责园区企业“三废”排放监督管理工作；</li> <li>➤ 负责园区新进项目的环境准入审批；</li> <li>➤ 负责绿色饭店、绿色宾馆建设；</li> <li>➤ 负责生态工业、清洁生产、循环经济的宣传及管理工作；</li> <li>➤ 负责工业安全卫生管理工作及安全事故的处置工作；</li> <li>➤ 负责开展园区内的节能工作、节能宣传及管理工作；</li> <li>➤ 负责园区主要污染物的防控和减排工作。</li> </ul>
4	规划房产部门	<ul style="list-style-type: none"> <li>➤ 负责园区重大项目建设规划、评价及管理；</li> <li>➤ 负责环境保护基础设施建设的规划工作；</li> <li>➤ 负责建设项目规划的审核、上报；</li> <li>➤ 编制、实施市政基础设施建设规划和年度计划；</li> <li>➤ 负责园林绿化规划、城市景观设施建设管理和旅游管理；</li> <li>➤ 负责道路桥梁等市政交通设施建设及公共交通等事务；</li> <li>➤ 负责绿色社区、绿色医院、生态文化、绿色学校等规划。</li> </ul>
5	投资促进部门	<ul style="list-style-type: none"> <li>➤ 负责制订年度绿色招商引资计划和招商引资活动安排；</li> <li>➤ 负责各类入区投资项目的审核、评估和批准；</li> <li>➤ 负责制订投资促进、产业促进的政策、措施并组织落实；</li> <li>➤ 根据产业政策和产业规划，策划和引进外资重大制造业项目、高新技术产业项目和行业领先企业。</li> </ul>
6	经贸发展部门	<ul style="list-style-type: none"> <li>➤ 统计、分析绿色工业园区内经济运行状况；</li> <li>➤ 贯彻执行相关安全生产的法律法规，负责园区的安全生产综合监督管理工作，全面履行安全监督、监察职能；</li> <li>➤ 负责园区信息产业发展管理工作；</li> <li>➤ 负责协调和指导园区信息化产业发展；</li> <li>➤ 负责园区安全生产事故的统计，监察和处理工作；</li> <li>➤ 负责对相关部门应急准备和响应进行检查、评价、考核；</li> <li>➤ 负责研究提出园区国民经济和社会发展战略、规划；</li> <li>➤ 负责园区对内经贸工作、商业管理、利用外资和科技工作。</li> </ul>

7	建设部门	<ul style="list-style-type: none"> <li>➤ 负责园区绿色化建设过程中环境形象和环境卫生的管理；</li> <li>➤ 负责电力、电信、供热、供气等公用事业合理建设工作；</li> <li>➤ 负责园区公用设施的养护管理。</li> </ul>
8	财政部门	<ul style="list-style-type: none"> <li>➤ 负责园区绿色化建设资金的筹集和保障；</li> <li>➤ 负责安排落实环保资金；</li> <li>➤ 负责政府绿色采购计划的制定及资金落实；</li> <li>➤ 负责环保资金使用情况的监督检查工作。</li> </ul>
9	科技部门	<ul style="list-style-type: none"> <li>➤ 负责组织、谋划、申报、管理各类科技项目；</li> <li>➤ 负责高新技术产业化项目的谋划、申报和管理；</li> <li>➤ 负责科技型中小企业技术创新基金的申报、审核、协调与管理；</li> <li>➤ 负责科技成果的登记、产品鉴定评优及拔尖人才的推荐选拔；</li> <li>➤ 负责专利、技术市场及科技信息的管理工作；</li> <li>➤ 负责科技成果的推广和应用工作</li> </ul>
10	国土部门	<ul style="list-style-type: none"> <li>➤ 负责土地管理，完成土地资源的利用和保护工作。</li> </ul>
11	社区事务管理部门	<ul style="list-style-type: none"> <li>➤ 协调企业绿色化改造工作。</li> </ul>
12	统计部门	<ul style="list-style-type: none"> <li>➤ 统计园区绿色化建设各种指标；</li> <li>➤ 负责核查绿色化建设各种指标完成情况。</li> </ul>
13	新闻宣传中心	<ul style="list-style-type: none"> <li>➤ 负责园区的宣传，加深企业对绿色工业园区建设的认识。</li> </ul>

在建设绿色工业园区过程中，除了建立相应的组织机构外，还必须建立切实可行、灵活机动的运行机制。要充分发挥政府、企业、社会组织和公众等各主体的作用，明确各主体的责任和义务，调动社会各界的积极性，逐步建立和完善“政府主导、市场推进、法律规范、政策扶持、科技支撑、公众参与”的运行机制。园区内企业和公众职责见表 2-2。

**表2-2 绿色工业园区企业和公众职责**

序号	机制成员	职责
1	企业	<ul style="list-style-type: none"> <li>➤ 负责定期向环保部门上报企业的环境信息，包括污染物产生、削减以及排放状况，废物贮存处置可能存在的突发事故风险；并严格执行公示公告制度；</li> <li>➤ 配合环境保护相关部门实施企业的清洁生产审核，开展企业清洁生产潜力分析，并积极开展清洁生产；</li> <li>➤ 积极实施绿色工业园区建设规划要求，根据规划采取生态链的完善措施（如补链和断链等措施），积极开展产品的生态化设计，提高产品的附加值；</li> <li>➤ 定期开展企业环境效益绩效评估，并及时公示公告。</li> </ul>
2	公众	<ul style="list-style-type: none"> <li>➤ 通过公示公告制度有权监督园区企业的环境污染行为，并及时向有关部门举报；</li> <li>➤ 有权参与园区绿色化建设相关内容的公开听证会；</li> <li>➤ 积极开展环境保护的宣传和落实，从我做起，如营建绿色社区，倡导绿色消费，推行绿色文化等；</li> <li>➤ 积极参与园区内企业开展的环境影响评价工作，参与并监督园区内新、改、扩建企业或项目的环境影响评价的意见征求工作。</li> </ul>

### 3. 规划编制 (Plan)

规划先行是绿色工业园区建设的基础，特别是在新园区的绿色化建设中，规划编制的首先应该明确未来主导行业或者主要入住企业类型，从而可预见环境问题的类型，例如，企业是否为用水大户、耗能大户或高污染。

对于企业选址过程中主要考虑以下几点经济因素：(1) 面积。由于园区经多年分阶段开发，选址面积应有足够的空间满足园区未来发展。(2) 基础设施。能够为园区未来发展方向提供必要的土地条件(良好的排水条件、建筑地基良好)、充足的水供给、发达的交通运输网络、完善的电力供应和电信设施、污水处理厂和固废处理设置建设的可行性等。

选定的区域应能适用区域的环境管理规划和条例，能将环境影响降到最低，并对未来环境影响做好评估。除了经济因素和环境因素外，还应对园区建设对社会的影响做充分的评估。如周边基础设施(如住房、交通、医院、学校等)能否承受园区建设带来的压力，能否满足未来对住房和服务的需求；工业园区与住宅区域是否存在安全距离以避免受环境污染影响等。

因此，环境规划署建议在绿色生态工业园区规划设计中遵循以下六个原则：(1) 明确区域环境承载力；(2) 尽量保持自然区域及植被；(3) 保留自然排水系统；(4) 提高开发密度(资源共享企业聚类，严格控制高污染产业入园)；(5) 提高能源效率(研究替代能源如风能、太阳能、地热等的可行性)；(6) 实现工业共生。

#### 绿色工业园区建设规划大纲

##### 1、园区概述

- (1) 基本信息
- (2) 经济发展情况
- (3) 环境质量情况

## 2、建设意义和有利条件

- (1) 优势和有利条件
- (2) 问题和制约因素
- (3) 绿色工业园区建设的意义

## 3、总体设计

- (1) 规划基本原则
- (2) 规划范围
- (3) 总体思路（包括定位、建设总体框架等）
- (4) 总体目标和具体指标

## 4、行业绿色化发展规划（分行业分别阐述）

- (1) 现状分析
- (2) 发展目标和具体指标
- (3) 绿色化建设规划

## 5、主要污染物控制方案

- (1) 水污染及循环利用方案
- (2) 大气污染控制方案
- (3) 固废循环利用方案
- (4) 能源利用方案

## 6、重大项目及其投资与效益分析

- (1) 项目入园条件
- (2) 重点支撑项目（包括工业项目、基础设施、服务设施等）
- (3) 效益分析（经济效益、环境效益、社会效益）

## 7、保障体系

- (1) 组织机构和管理保障体系
- (2) 政策保障
- (3) 经济激励制度
- (4) 技术保障
- (5) 其他保障

#### 4. 环境管理体系（Environmental Management System）

环境管理体系是绿色工业园区内部全面管理体系中的一个组成部分，它包括为制定、实施、实现、评审和保持环境方针所需的组织机构、规划活动、机构职责、惯例、程序、过程和资源，还包括对环境方针、目标和指标等管理的内容。因此，环境管理体系是一个组织有计划，而且协调运作的管理活动，它通过有明确职责、义务的组织结构来贯彻落实，目的在于防止对环境的不利影响，目前比较成熟的环境管理体系是 ISO14000 环境管理体系。

对于绿色工业园区而言，环境管理体系旨在提升园区发展过程的绿色化水平，并持续不断地改善提升，不断达到更好更优的高度，因此，绿色工业园区的环境管理体系应至少包括以下几个方面。

- **环境服务体系：**包括供水、集中供热、废物回收、副产品交换、废物集中处理设施、危险废物收集转运系统、固体废物处理处置、环境培训与教育、环境咨询（政策法规、新技术、新工艺等）、环境审计、环境应急等体系。
- **环境监测体系：**包括环境质量监测、污染物排放监测、固体废物监管、化学品存储输送泄露监测、危险废物存储转运监测、应急监测、地下水监测和土壤监测等。
- **政策法规体系：**包括国际环境保护法规（维也纳公约、蒙特利尔议定书、巴塞尔公约等）、环境管理制度（环境影响评价制度、排污收费制度、污染物排放总量控制等）、环境标准（环境质量标准、污染物排放标准、水环境标准、大气环境标准、土壤环境标准、噪声环境标准等）等法律法规。
- **保障制度体系：**包括经济政策、技术保障、人才培养与引进、绿色环境管理（绿色社区、绿色学校、绿色医院、绿色交通等）、

绿色物流、低碳政策等。

- **信息平台体系**：是绿色工业园区实现信息化管理的载体，其包含园区环境综合管理平台、清洁生产平台、节能节水管理平台、信息公开平台、固体废物交换平台等平台建设。

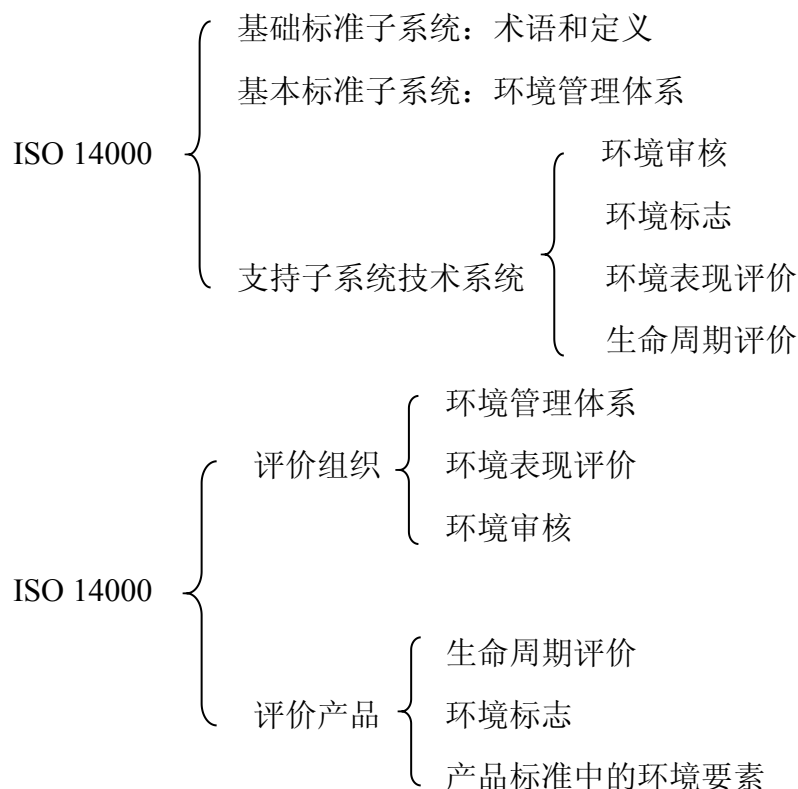
### ISO14000 环境管理系列标准

ISO14000 环境管理系列标准是国际标准化组织 ISO/TC207 负责起草的一份国际标准,是一个系列的环境管理标准，包括环境管理体系、环境审核、环境标志、生命周期分析等国际环境管理领域内许多焦点问题，旨在指导各类组织取得较好的环境行为。

表 1 ISO14000 系列标准的标准号分配表

分会	名称（标准子系统）	标准号
SC1	环境管理体系（EMS）	14001—14009
SC2	环境审核（EA）	14010—14019
SC3	环境标志（EL）	14020—14029
SC4	环境表现评价（EPE）	14030—14039
SC5	生命周期评估（LCA）	14040—14049
SC6	术语和定义（T&D）	14050—14059
WG1	产品标准中的环境指标（EAPS）	14060
	备用	14060—14100

ISO 14000 系列标准是个庞大的标准系统。标准系统中各个子系统的标准属性和功能是不一样的，不同的子系统的结合可以表现出不同的系统功能。



ISO/TC207 对制定 ISO14000 系列标准规定了七条关键的原则:

- ISO14000 系列标准应具有真实性和非欺骗性;
- 产品和服务的环境影响的评价方法和信息应意义准确, 并且是可检验的;
- 评价、实验方法不能采用非标准方法, 而必须采用 ISO 标准、地区标准、国家标准或其他技术上能保证再现性的标准试验方法;
- 应具有公正性和透明度, 但不应损害机密的商业信息;
- 非歧视性;
- 能进行特殊的有效的信息传递和教育培训;
- 应不产生贸易壁垒, 保证国内、国外的一致性。



ISO14000 的运行模式如下图所示。

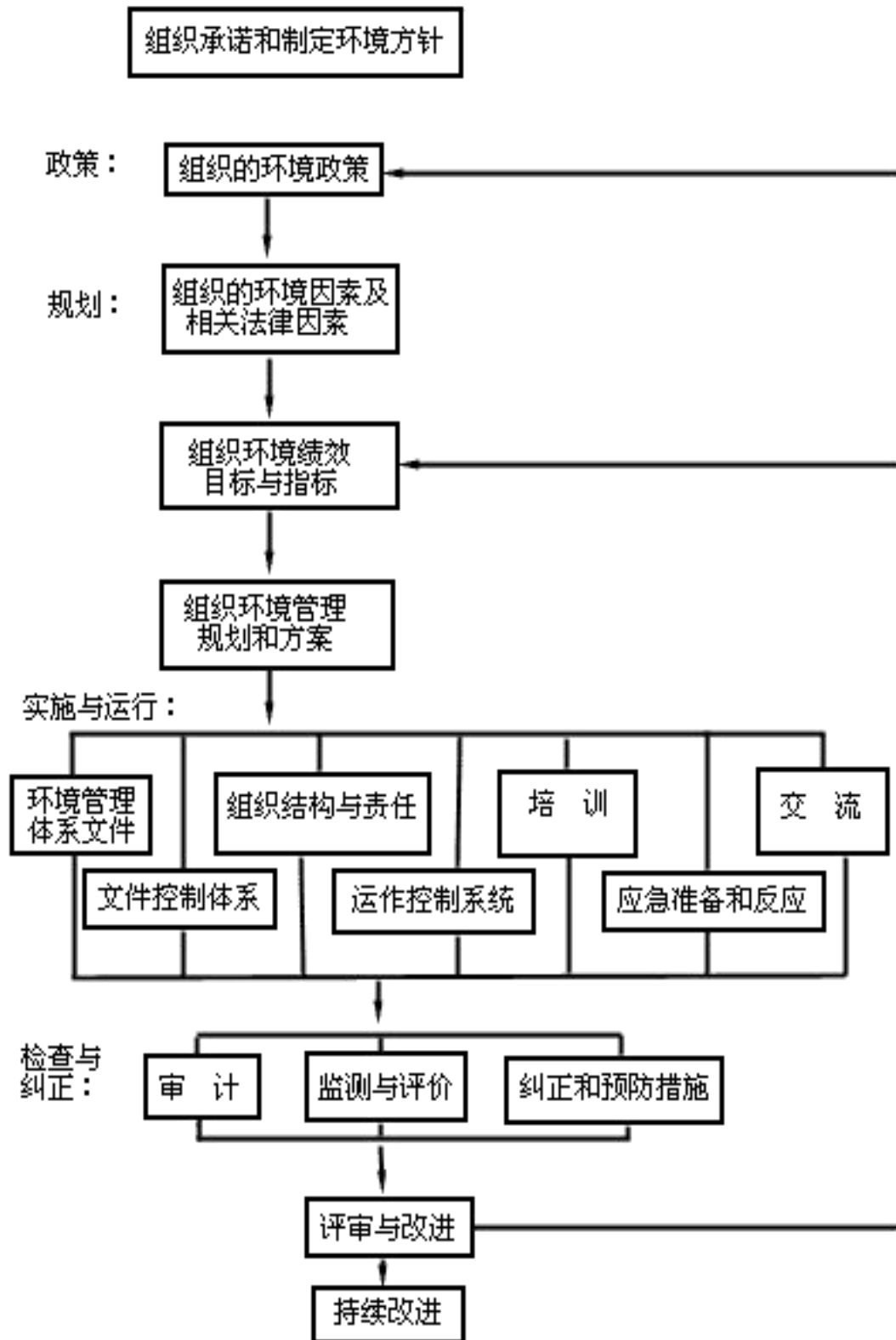


图 1 环境管理体系运行模式图

## 5. 清洁生产（Cleaner Production）

清洁生产在不同的发展阶段或者不同的国家有不同的叫法，例如“废物减量化”、“无废工艺”、“污染预防”等，但其基本内涵是一致的，即对产品和产品的生产过程采用预防污染的策略来减少污染物的产生。

清洁生产是人们思想和观念的一种转变，是环境保护战略由被动反应向主动行动的一种转变。联合国环境规划署在总结了各国开展的污染预防活动，并加以分析提高后，提出了清洁生产的定义，并得到国际社会的普遍认可和接受，其定义为：

“清洁生产是一种新的创造性的思想，该思想将整体预防的环境战略持续应用于生产过程、产品和服务中，以增加生态效率和减少人类及环境的风险。

——对生产过程，要求节约原材料和能源，淘汰有毒原材料，减降所有废弃物的数量和毒性。

——对产品，要求减少从原材料提炼到产品最终处置的全生命周期的不利影响。

——对服务，要求将环境因素纳入设计和所提供的服务中。”

清洁生产要求转变态度、进行切实负责的环境管理以及科学而全面地评估技术方案。清洁生产的内容包括清洁的产品、清洁的生产过程和清洁的服务三个方面，它包含了生产者、消费者和全社会对于生产、服务和消费的希望。（1）它是从资源节约和环境保护两个方面对工业产品生产从设计开始，到产品使用后直至最终处置，给与了全过程的考虑和要求；（2）它不仅对生产，而且对服务也要求考虑对环境的要求；（3）它对工业废弃物实行费用有效的源削减，一改传统的不顾费用有效或单一末端控制方法；（4）它可提高企业的生产效率和经

济效益，与末端处理相比，成为受到企业欢迎的新事物；（5）它着眼于全球环境的全面保护，为全人类共建一个洁净的地球带来了希望。

从园区的角度出发，推行清洁生产可以从以下几方面的工作入手：（1）制定相关政策鼓励企业实施清洁生产；（2）完善现有的环境法律和政策以克服障碍；（3）进行产业和行业结构调整；（4）安排各种活动提高公众的清洁生产意识；（5）支持工业示范项目；（6）为工业部门提供技术支持；（7）把清洁生产纳入各级学校教育之中。

从企业的层次来说，实施清洁生产可以从以下几个方面的工作入手：（1）进行企业清洁生产审核；（2）开发长期的企业清洁生产战略计划；（3）对职工进行清洁生产的教育和培训；（4）进行产品全生命周期分析；（5）进行产品生态设计；（6）研发清洁生产替代技术。

### 清洁生产审核

推行企业清洁生产审核是推行企业清洁生产的关键和核心。整个审核过程可分解为具有可操作性的 7 个步骤。

**阶段 1（筹划和组织）：**主要是进行宣传、发动和准备工作。

**阶段 2（预评估）：**主要是选择审核重点和设置清洁生产目标。

**阶段 3（评估）：**主要是建立审核重点的物料平衡，并进行废弃物产生原因分析。

**阶段 4（方案产生和筛选）：**主要是针对废弃物产生原因，产生相应的方案并进行筛选，编制企业清洁生产中期审核报告。

**阶段 5（可行性分析）：**主要是对阶段 4 筛选出的中/高费清洁生产方案进行可行性分析，从而确定出可实施的清洁生产方案。

**阶段 6（方案实施）：**实施方案并分析、跟踪验证方案的实施效果。

**阶段 7（持续清洁生产）：**制定计划、措施在企业中持续推行清洁生产，最后编制企业清洁生产审核报告。

## 6. 生态效率 (Eco-efficiency)

生态效率的概念是 1992 年“世界可持续发展工商理事会”(World Business Council for Sustainable Development, WBCSD) 首次提出, 其定义为必须在提供具有价格竞争力的产品和服务, 满足人们的生活需求和提高人们的生活质量的同时, 在产品的整个生命周期内逐步将其对天然资源的消耗和对环境的影响减少到地球的承载能力以内。世界经济合作与发展组织 (organization for economic cooperation and development, OECD) 认为生态效率是指“生态资源满足人类需要的效率”, 它可看作是一种产出/投入的比值, 其中“产出”是指一个企业、行业或整个经济体提供的产品与服务的价值, “投入”指由企业、行业或经济体造成的环境压力。

因此, 生态效率和清洁生产密切相关, 两者也有很多共同点, 他们都是帮助实现资源能源消耗最小化、减少环境影响和降低环境风险。联合国环境规划署和 WBCSD 曾比较过着两个概念之间的相似性, 并指出: “Eco-efficiency starts from issues of economic efficiency which have positive environmental benefits, while Cleaner Production starts from issues of environmental efficiency which have positive economic benefits”

生态效率可以通过以下几个方面提升:

- 降低材料和能源的使用强度,
- 减少使用有毒有害材料,
- 增强材料的可回收性,
- 使用可再生资源,
- 延长材料的使用寿命
- 增加产品的服务强度。

### 生态效率指标 (EEI)

在绿色工业园区的生态效率规划中，管理部门可以像推进清洁生产一样，通过推广生态效率高的工艺和对材料、能源的低消耗所产生的经济价值来推进，而这些都是需要一个指标来表征，即生态效率指标，其通用公式如下：

$$\text{生态效率} = \frac{\text{经济数据}}{\text{环境影响}}$$

在上式中的环境影响可以用能源消耗、原料消耗、水耗、污染物排放量来表征，通过追踪企业或园区的生态效率指标变化，即可反应出企业或园区在环境绩效上的变化，一般来说，生态效率指标越高，则表征对环境的影响越小或同等环境代价所获取的经济收益越高。

## 7. 节能 (Energy Conservation)

绿色工业园区的管理部门应该清楚的认识到经济成本才是最容易驱动企业进行节能的因素。因此，如果园区采用集中供热，不仅能摊薄企业的成本，而且还能减少 CO<sub>2</sub>、SO<sub>2</sub> 和氮氧化物等大气污染物的排放。

除了集中供热外，绿色工业园区可以实现节能的其他途径还有：

### (1) 热电联产

通常的火力发电，其效率约为 30~35%，这意味着每产出 1 兆焦的电能，就有 2 兆焦的热量白白浪费掉，将这部分热量加热水变成蒸汽，用来满足园区企业和住宅区的用热需求，这种同时生产电、热能的工艺过程，称为热电联产。热电联产较之分别生产电、热能方式更节约燃料，对外供热的蒸汽源是抽汽式汽轮机的调整抽汽或背式汽轮机的排汽，压力通常分为 0.78~1.28MPa 或 0.12~0.25MPa，前者可用于工业生产，后者可供民用采暖。热电联产的蒸汽没有冷源损失，所

以能将热效率提高到 85%，比大型凝汽式机组（40%）还要高得多，在提升能源效率的同时，减少了能源消耗。

## （2）能源梯级利用

指将能源按其品位（可转换为机械功的大小）逐级加以利用的过程，如高、中温蒸汽先用于需热温度较高的工艺，使用过的低温蒸汽再用于低温工艺。能源梯级利用可以提高整个系统的能源利用效率，是节能的重要措施。

## （3）合同能源管理

节能服务公司与用能单位以契约形式约定节能项目的节能目标，节能服务公司为实现节能目标向用能单位提供必要的服务，用能单位以节能效益支付节能服务公司的投入及其合理利润的节能服务机制。其实质就是以减少的能源费用来支付节能项目全部成本的节能业务方式。这种节能投资方式允许客户用未来的节能收益为工厂和设备升级，以降低运行成本；或者节能服务公司以承诺节能项目的节能效益、或承包整体能源费用的方式为客户提供节能服务。

合同能源管理是 70 年代在西方发达国家开始发展起来一种基于市场运作的全新的节能新机制，中国的合同能源管理国家标准是 GB/T24915-2010《合同能源管理技术规范》，同时从 2010 年起加大了对合同能源管理商业模式的扶持力度，并从政策上、资金上给予大力支持，促进节能服务产业的健康快速发展。

## （4）能源审计

指用能单位自己或委托从事能源审计的机构，根据国家有关节能法规和标准，对能源使用的物理过程和财务过程进行检测、核查、分析和评价的活动，是一种加强企业能源科学管理和节约能源的有效手段和方法，具有很强的监督与管理作用。

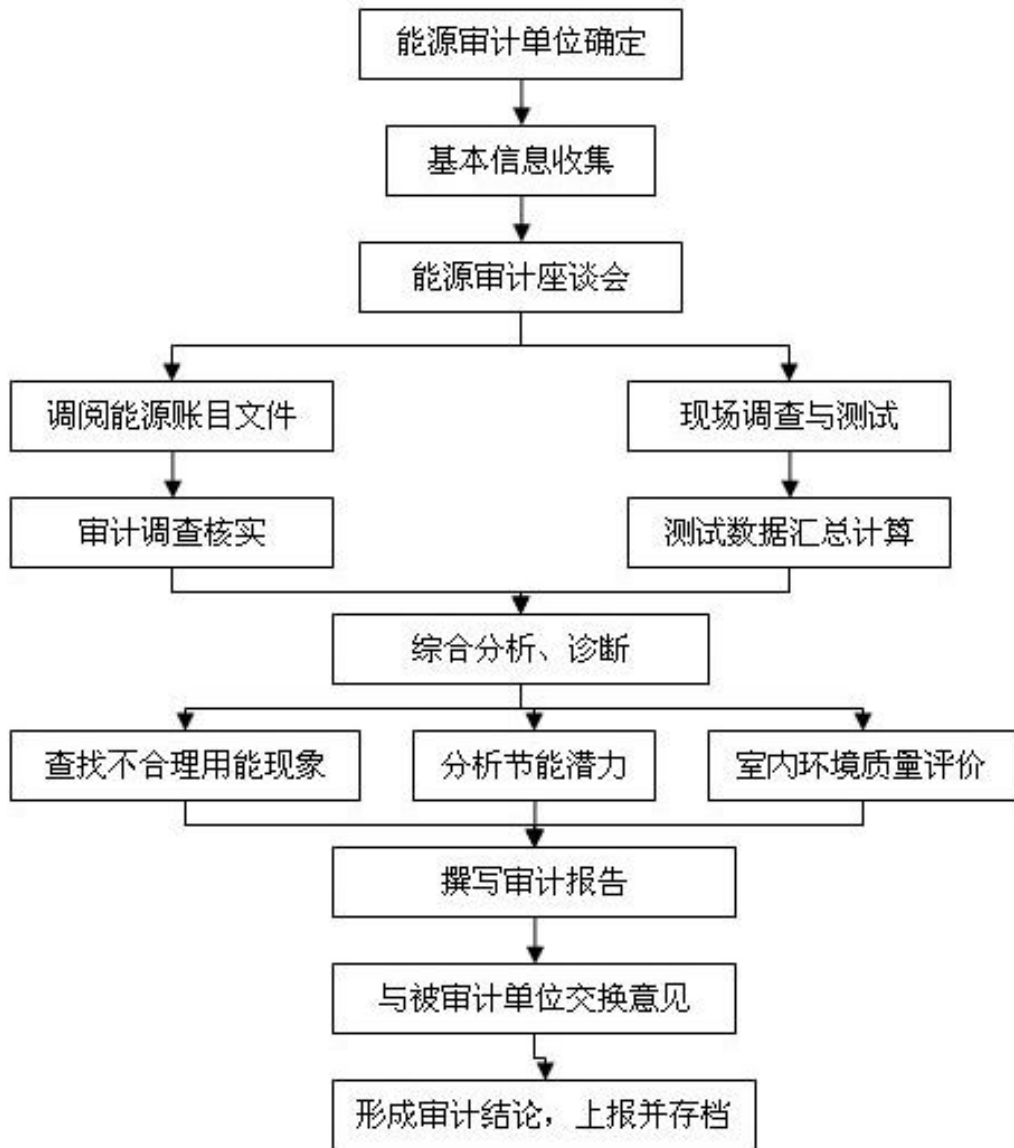


图 7-1 能源审计流程

### (5) 清洁能源

对能源清洁、高效、系统化应用的技术体系。如水力发电、风力发电、太阳能、生物能（沼气）、海潮能等，这些能源的含义有三点：第一清洁能源不是对能源的简单分类，而是指能源利用的技术体系；第二清洁能源不但强调清洁性同时也强调经济性；第三清洁能源的清洁性指的是符合一定的排放标准。

## (6) 其他技能技术:

- **节能建筑:** 节能建筑是指遵循气候设计和节能的基本方法, 对建筑规划分区、群体和单体、建筑朝向、间距、太阳辐射、风向以及外部空间环境进行研究后, 设计出的低能耗建筑, 其主要指标有: 建筑规划和平面布局要有利于自然通风, 绿化率不低于 35%; 建筑间距应保证每户至少有一个居住空间能获得 2 小时满窗日照等。
- **绿色照明:** 绿色照明是美国国家环保局于上个世纪 90 年代初提出的概念, 是指通过科学的照明设计, 采用效率高、寿命长、安全和性能稳定的照明电器产品, 改善提高人们工作、学习、生活的条件和质量, 从而创造一个高效节能、环保、安全、舒适的照明。完整的绿色照明内涵包含高效节能、环保、安全、舒适 4 个方面, 高效节能意味着以消耗较少的电能获得足够的照明, 从而减少因发电造成的大气污染物排放, 以达到环保的目的; 安全、舒适指的是光照清晰、柔和及不产生紫外线、眩光等有害光照, 不产生光污染。

### 能源消耗指标 ESI

一般用能源消耗强度来表征能源利用的效率, 可通过下式表征:

$$\text{能源消耗强度} = \frac{\text{能源消耗总量}}{\text{经济数据}}$$

式中经济数据常采用国民生产总值、工业总产值或工业增加值等经济指标, 能源消耗总量用标准煤来核算, 各类能源对标准煤的折算系数可参考《GB/T 2589-2008 综合能耗计算通则》。



## 8. 节水 (Water Conservation)

绿色工业园区的生产生活需要大量的水，这种大量消耗水的行为对环境影响显著。例如，地下水的过度采取会导致水位下降；从冷却塔出来的温水如果排入河道势必影响水生生态系统。因此，绿色工业园区对水资源环境管理中应充分考虑：

- **源头减量**：通过推行企业清洁生产，降低水耗强度；通过调整工业结构，淘汰或限制耗水量大的行业；通过推行生活节水用具，提高公众节水意识，降低生活用水量。
- **梯级利用**：设计多源供水方案，提出饮用水、工业用水、冷却水、景观用水、绿化用水和生活杂用水等集成与共享的水资源梯级利用模式与方法。
- **再生回用**：构建废水循环再生利用方案，要防止二次污染；同时优化园区企业间管网设计，减少再生水回用的管网重复投资。

需要注意的是，如果废水回用成本高于新鲜水成本，那将不会对企业使用再生水产生任何驱动，这个时候需要园区管理者提供相应的政策和经济补偿来驱动。

### 节水指标 WSI

节水指标可以用水耗强度来表征：

$$\text{水耗强度} = \frac{\text{水耗总量}}{\text{经济数据}}$$

式中经济数据常采用国民生产总值、工业总产值或工业增加值等经济指标，水耗总量可选用新鲜水消耗总量、总用水量等指标。

节水的另一个指标是水重复利用率，即

$$\text{水重复利用率}(\%) = \frac{\text{重复用水量}}{\text{用水总量}} \times 100\%$$

## 9. 污染预防和控制 (Integrating Pollution Prevention and Control)

一个工业园区是没有办法避免污染，尽管可以通过清洁生产、节能节水、废物管理来减少废物的产生和实现废物循环利用，但最终还是会有一些废物排放出来，因此，园区如何处理这部分废物就成为了一个重要的问题。目前，许多工业园区都配套建设了污染处理处置设施，如污水处理厂、垃圾焚烧厂、填埋场等，有些园区甚至还建设了在线监测体系来实时监测污染物的排放。

对于污染控制而言，由于目前工业园区污染物质的复杂性，经常会在污染控制过程中发生污染物的跨介质转移，如含有重金属的废水经过生化处理沉淀至污泥中后，污泥经焚烧处理重金属又转移至飞灰中，这就意味着污染控制必须是一个整体系统，需要考虑跨介质的污染控制，这在无形中增加的现阶段污染控制的难度。然而对于污染预防而言，仅仅通过改变生产活动，从源头减少污染物和废物最小化等途径，即可实现污染物的减排。同时，从经济成本来看，污染控制的成本随时间增加而呈极速增长，而污染预防（清洁生产）虽在前期投入较高后，后期将趋于平稳增长。因此，园区如何整合污染预防和污染控制就显得尤为重要，不仅直接影响着末端治理设施的需求，还影响着企业环境治理的成本。

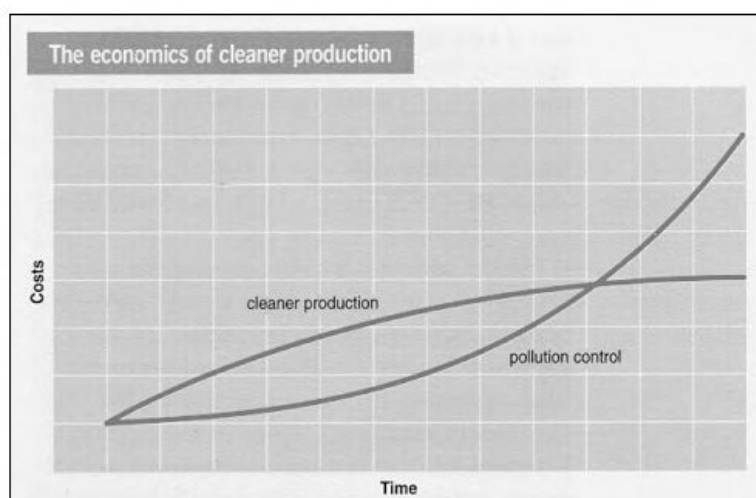


图 9-1 污染控制和污染预防（清洁生产）的投资比较

特别是在园区建设初期，有计划的整合污染预防和污染控制将有助于缓解园区建设末端治理设施面临的资金匮乏问题。例如在园区建设初期对入园企业建设小型模块化污水处理装置，并实现污水的循环回用，其投资成本远低于建设末端处理设施；而在园区建设后期，由于入园企业的增多，再考虑建设污水处理设施。

目前，所有园区都日益重视末端处理设施（污染控制）的建设，资金问题是一个较大的制约因素，因此，对于资金有限的园区，有计划的整合污染预防和污染控制则具有重要的现实意义。

#### 主要污染物指标

根据园区所处的区域，主要污染控制指标应包括但不局限于以下方面：

- (1) 国家及区域控制污染物指标：COD、氨氮、SO<sub>2</sub>、NO<sub>x</sub>、重金属等；
- (2) 国际履约所涉及的污染物指标：Hg、POPs 及各项国际公约中要求的污染物；
- (3) 对公众健康影响较大的污染物指标：PM<sub>2.5</sub>、VOCs 等。

对上述污染物指标在绿色工业园区建设过程中的控制要严于该区域或国家层次的指标要求。

### 10. 环境友好型产品（Environmentally Conscious Products）

环境友好型产品是指在材料采购、生产、流通、使用、报废、回收再利用等生命周期内对环境有益、友好的产品，也称为环境无害化产品或低公害产品。这类产品与传统产品的本质区别在于不仅能满足消费者的需求，而且符合环境保护的要求。

绿色工业园区通过倡导生态设计、绿色采购和绿色认证等工作，可以有效促进环境友好型产品的推进工作。

**生态设计：**也称绿色设计、生命周期设计或环境设计，指将环境因素纳入设计之中，辅助确定设计的方向，从而在源头设计上实现可持续的方向。生态设计要求在产品开发的所有阶段均考虑环境因素，

从产品的整个生命周期减少对环境的影响，最终引导产生一个更具有可持续性的生产和消费系统。生态设计活动主要包含两方面的涵义，一是从保护环境角度考虑，减少资源消耗、实现可持续发展战略；二是从商业角度考虑，降低成本、减少潜在的责任风险，以提高竞争能力。

**绿色采购：**指政府通过庞大的采购力量，优先购买对环境负面影响较小的环境标志产品，促进企业环境行为的改善，从而对社会的绿色消费起到推动和示范作用。绿色采购之所以能起到促进社会绿色消费作用，主要是通过以下几个方面实现的：首先，绿色采购可以积极影响供应商，供应商为了赢得政府这个大客户，肯定会采取积极措施提高企业的管理水平和技术创新水平，尽可能地节约资源能源和减少污染物排放，提高产品质量和降低对环境和人体的负面影响；其次，政府绿色采购还因其量大面广，可以培养扶植一大批绿色产品和绿色产业，有效地促进绿色产业和清洁技术的发展，进而形成国民经济的可持续生产体系；此外，绿色采购也可以促使人们改变不合理的消费行为和习惯，倡导合理的消费模式和适度的消费规模，减少因不合理消费对环境造成的压力，进而有效地促进绿色消费市场的形成。

**绿色认证：**指政府职能部门或经政府认可的社会中介机构按照相关的绿色标准对企业或其产品的环境保护特性所作的公证和评估。目前主要的绿色认证标示有能源之星（美国）、欧洲之花（欧盟）、RoHS 认证（欧盟）、中国环境标志、CQC 质量环保标志、中标节能节水标志、Ecoleaf（日本）、Carbon Labeling（韩国）等。

## **11. 废物管理（Waste Management）**

绿色工业园区废物管理是一个对工业园区废物进行全过程管理的复杂系统，基于工业生态学和循环经济的理论指导，通过构建工业共生网络，形成由管理目标、管理内容、评价体系和实施环境组成的

废物管理模式。

绿色工业园区废物管理就是在工业园区内把不同的行业、不同的企业、不同的生产过程通过资源共享、副产品交换和废物共生的组合连接起来，以实现产业闭路循环。因此，在这个关系网络中，副产品和废物一旦产生，可以通过园区环境服务体系中的信息平台发布，然后由提供资源化技术支持的单位进行副产品和废物资源化，变成原料后再通过信息平台被需要的行业或企业购买，进入下一个生产过程。

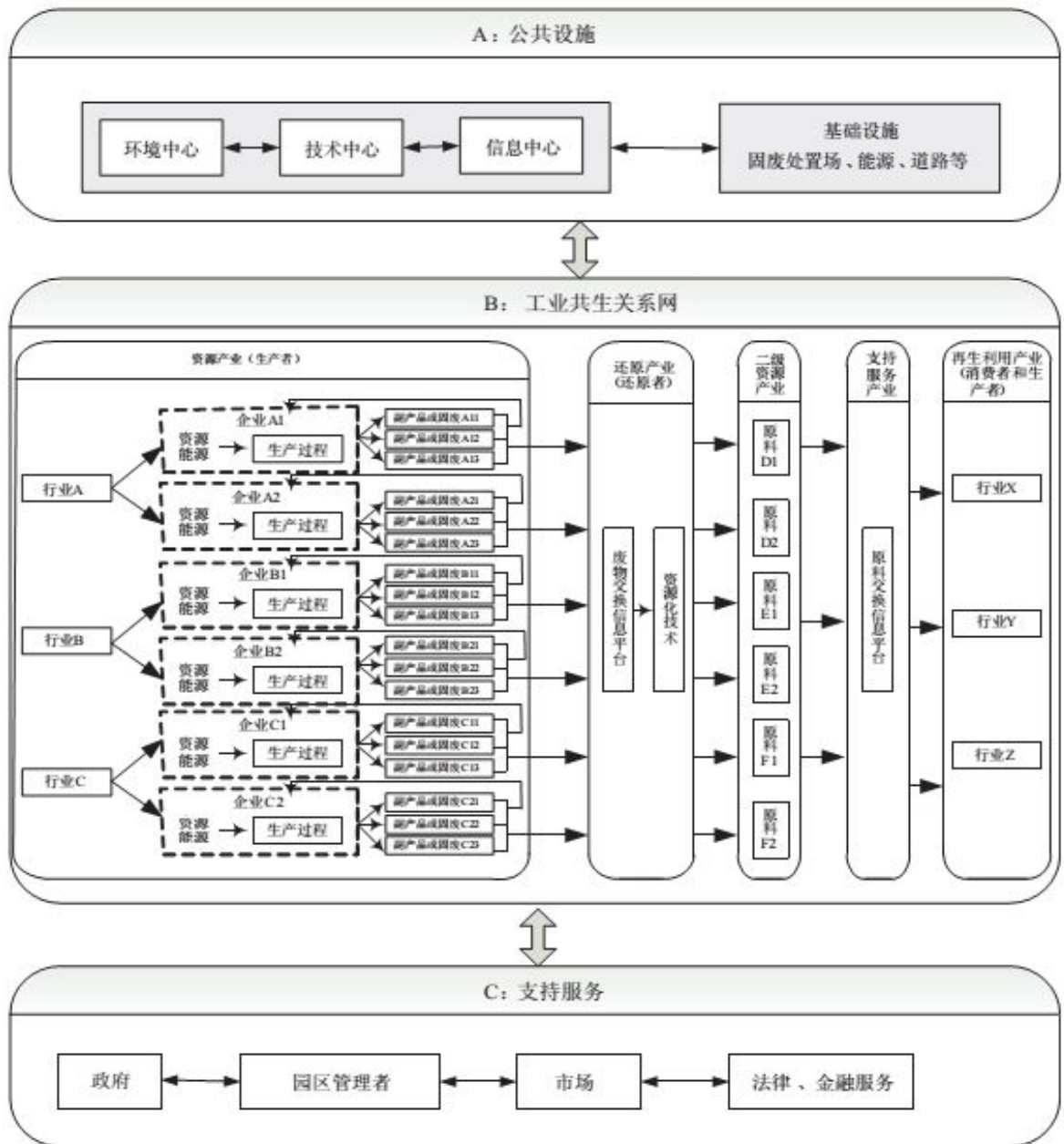


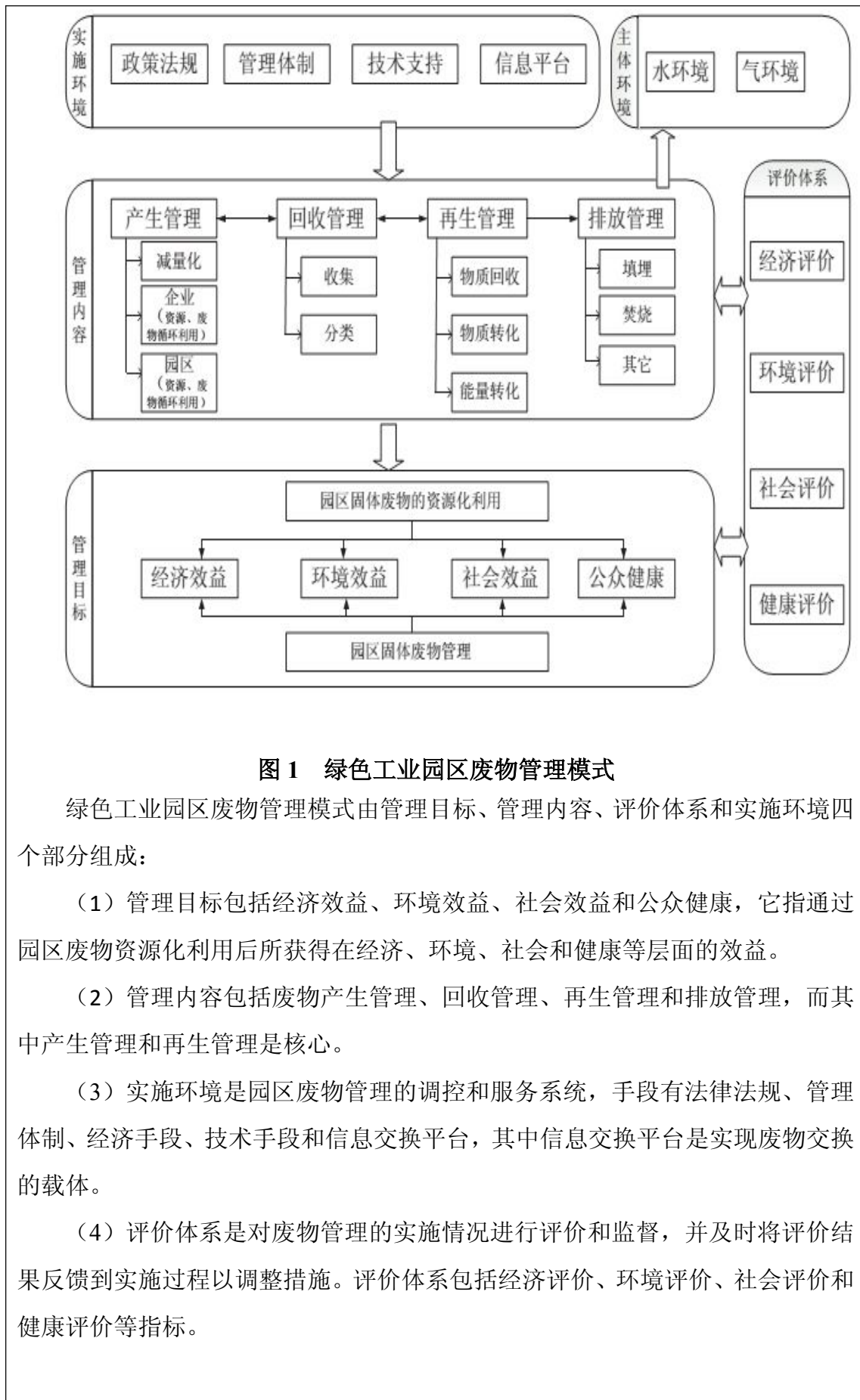
图 11-1 绿色工业园区废物管理要素分析

在这个系统中，影响工业共生系统稳定运行的要素主要有三类：一类是公共设施，即支持园区内企业发展的一些公共设施，包括信息中心、技术中心、环境中心，道路交通、固废处置场、能源中心（电、热、气）等；第二类是工业共生关系网，是指园区内的企业，按照生产者、消费者和还原者的关系分别处于这个共生网络中的不同位置上，并按照生物链的运作规律进行着资源、能量和废物的流动；第三类是支持服务，包括政府、园区管理者、市场和法律、金融等，这些因素将从政策、资金和市场的角度来影响和规范园区内的企业。

### 绿色工业园区废物管理模式的设计

绿色工业园区产生废物的工业生产过程较多且较复杂，产生废物的种类也比较多，涉及到废物产生、回收、再生和处理处置等管理过程也较复杂，因此，绿色工业园区废物管理模式的设计不仅要充分考虑到技术、经济、环境、社会以及公众健康等许多因素，还要考虑到不同的利益群体如废物的产生、回收、再生及处理处置企业，技术、产品和公共服务以及基础设施，接纳废物排放的环境主体等。

因此，对工业园区废物进行管理要将废物生产、回收、再生、排放作为一个完整的系统，对整个废物流进行管理，同时对所有可以运用的废物管理方法进行组合选择，综合考虑整体的环境效益、经济效益、社会效益，包括公众健康等因素，找出对经济、环境、社会及公众健康最有益的废物管理模式。



**图 1 绿色工业园区废物管理模式**

绿色工业园区废物管理模式由管理目标、管理内容、评价体系和实施环境四个部分组成：

(1) 管理目标包括经济效益、环境效益、社会效益和公众健康，它指通过园区废物资源化利用后所获得在经济、环境、社会和健康等层面的效益。

(2) 管理内容包括废物产生管理、回收管理、再生管理和排放管理，而其中产生管理和再生管理是核心。

(3) 实施环境是园区废物管理的调控和服务系统，手段有法律法规、管理体制、经济手段、技术手段和信息交换平台，其中信息交换平台是实现废物交换的载体。

(4) 评价体系是对废物管理的实施情况进行评价和监督，并及时将评价结果反馈到实施过程以调整措施。评价体系包括经济评价、环境评价、社会评价和健康评价等指标。

## 12. 危险化学品管理（Chemicals Management）

危险化学品是指具有毒害、腐蚀、爆炸、燃烧、助燃等性质，对人体、设施、环境具有危害的剧毒化学品和其他化学品。绿色工业园区应根据所在国家的危险化学品目录，对园内企业所使用的危险化学品进行生产、储存、使用、经营和运输的安全管理。

### 绿色工业园区危险化学品管理制度设计

绿色工业园区危险化学品管理制度应包括但不限于以下几个方面建立：

（1）**清单目录**：园区应由安全生产监督管理部门会同公安、环保、卫生、质监、工商、交通等相关部门，根据化学品危险特性建立危险化学品清单目录，并进行公布，清单目录需要定期更新，以适应园区面对不同时期环境保护的需求。

（2）**责任分工**：应对危险化学品的生产、储存、使用、经营、运输过程的安全进行明确的责任和职能分工：

- **安全生产监督管理部门**负责危险化学品安全监督管理综合工作，组织确定、公布、调整危险化学品目录，对新建、改建、扩建生产、储存危险化学品的建设项目进行安全条件审查，核发危险化学品安全生产许可证、危险化学品安全使用许可证和危险化学品经营许可证，并负责危险化学品登记工作。
- **公安机关**负责危险化学品的公共安全管理，核发剧毒化学品购买许可证、剧毒化学品道路运输通行证，并负责危险化学品运输车辆的道路交通安全管理。
- **质量监督检验检疫部门**负责核发危险化学品及其包装物、容器生产企业的工业产品生产许可证，并依法对其产品质量实施监督，负责对进出口危险化学品及其包装实施检验。
- **环境保护部门**负责废弃危险化学品处置的监督管理，组织危险化学品的环境危害性鉴定和环境风险程度评估，确定实施重点环境管理的危险化学品，负责危险化学品环境管理登记和新化学物质环境管理登记；依照职责分工调查相关危险化学品环境污染事故和生态破坏事件，负责危险化学品事故现场的应急环境监测。



- **交通运输部门**负责危险化学品道路运输、水路运输的许可以及运输工具的安全管理，对危险化学品水路运输安全实施监督，负责危险化学品道路运输企业、水路运输企业驾驶人员、船员、装卸管理人员、押运人员、申报人员、集装箱装箱现场检查员的资格认定。铁路主管部门负责危险化学品铁路运输的安全管理，负责危险化学品铁路运输承运人、托运人的资质审批及其运输工具的安全管理。民用航空主管部门负责危险化学品航空运输以及航空运输企业及其运输工具的安全管理。
- **卫生管理部门**负责危险化学品毒性鉴定的管理，负责组织、协调危险化学品事故受伤人员的医疗卫生救援工作。
- **工商行政管理部门**依据有关部门的许可证件，核发危险化学品生产、储存、经营、运输企业营业执照，查处危险化学品经营企业违法采购危险化学品的行为。
- **邮政管理部门**负责依法查处寄递危险化学品的行为。

(3) **日常监管**：对危险化学品的登记、储存、生产、使用、经营、运输过程的管理制度，应建立分级分类的管理制度。

(4) **事故处理**：制定园区层面的危险化学品事故应急预案，包括应急程序、应急救援器材设备管理、通报机制等方面的相关规定。

### 13. 健康和安​​全（Health and Safety）

在一个绿色工业园区的建设中必须包括健康和安​​全，这有因为在一个工业园区内有大量的不同类型的企业，工业原料中暴露于外界的有毒有害物质会发生复杂混合，可能会导致健康和安​​全风险的提升，这些风险并不能在“正常的”生产生活中得以体现，而是不断提升并发展成事故。

特别是当绿色工业园区建设过程中将资源高效利用、废物最小化等生态工业领域的工作作为重点后，往往会忽视这些工作所带来的健

康和安​​全问题，如增加废旧材料循环回用可能会提升工人回用这些材料时所面对的健康和安​​全风险。因此，健康和安​​全在绿色工业园区建设中显得尤为重​​要。

在绿色工业园区，所有企业都必须对工人的健康和安​​全负责，识别所有工艺过程的风险，规范对员工健康有潜在危害的操作行为，以减少健康风险。这就要求工人不仅要了解他们使用的材料安全性能及所用容器的安全性能；还要求工人必须接受培训，了解安​​全的生产方式；最后还要求企业所有的生产设备能确保安​​全的运行环境。

尽管企业工人的健康和安​​全，主要受其自身的生产活动影响，但也会受到周边企业的影响。因此，虽然个别公司的生产活动可能不是特别危险，但他们集聚在工业园区的时候，集聚带来的健康安全​​风险可能会增大。正是基于在这一点，生态工业园区的管理者将变得尤为重​​要，因为管理者不仅了解和掌握所有企业的生产活动，还可以对企业间的产品交换进行风险评估，这些系统分析和评估将协助管理者建立园区的应急响应预案，从而降低工业园区整体的健康安全​​风险。

此外，工业园区还应通过以下几个方面对工人的健康安全​​领域提供帮助：

- **组织培训：**要求所有企业都必须对员工进行培训，包括工作场所的安​​全意识、安​​全操作规程、应急程序、急救措施、事故报告机制、事故防护措施等。
- **信息中心：**建立化学品信息中心，包括对园区所有企业使用的化学品的来源、安​​全防护和应急处置信息，这种监管应纳入园区的日常安​​全管理体系中。
- **救助中心：**建立一个安​​全救助中心，可以对小型事故进行处理处置，并提供相关领域的安​​全健康经验问题的咨询工作。

## 14. 应急响应 (Emergency Response and Apell)

应急响应机制是由职能管理部门推出的针对各种突发公共事件而设立的各种应急方案，通过该方案使损失减到最小。绿色工业园区为了及时、有效、安全地预防和处理各类突发环境事件，提高应对突发环境事件的能力，保障区域生态环境，保护公众人身安全，维护社会稳定，促进区域社会、经济、自然的全面、协调、可持续发展，应针对园区内的废气、废水、固体废弃物（包括危险废物）、危险化学品（包括有毒化学品）、电磁辐射、放射性污染源等方面的环境突发事件建立的应急响应机制，并编制相应的应急预案，应急预案应包括应急机构设置、分级预警、应急相应程序等方面内容。

绿色工业园区对突发环境事件的应急处置实行属地为主、分级响应原则，其主要工作任务如下：

- 受理环境突发事件报告，调查了解事故原因、污染源性质以及事故发展过程，立即做出反应。
- 及时向园区管理部门、省市环保部门报告辖区内发生的环境污染和生态破坏事故。
- 参加有关应急救援工作。
- 负责处理发生在园区内的突发环境事件所造成的环境污染，指挥所属应急分队进行应急处置。
- 指导公众进行防护，协助有关部门妥善开展消毒去污处理工作。

按照突发环境事件应急处置工作原则，应急响应机构设立应包括突发环境事件应急指挥部、应急指挥部办公室、部门应急分队（部门紧急救援队伍）、企业应急分队（区内高环境风险企业）、专家咨询组，组织机构见图 13-1。

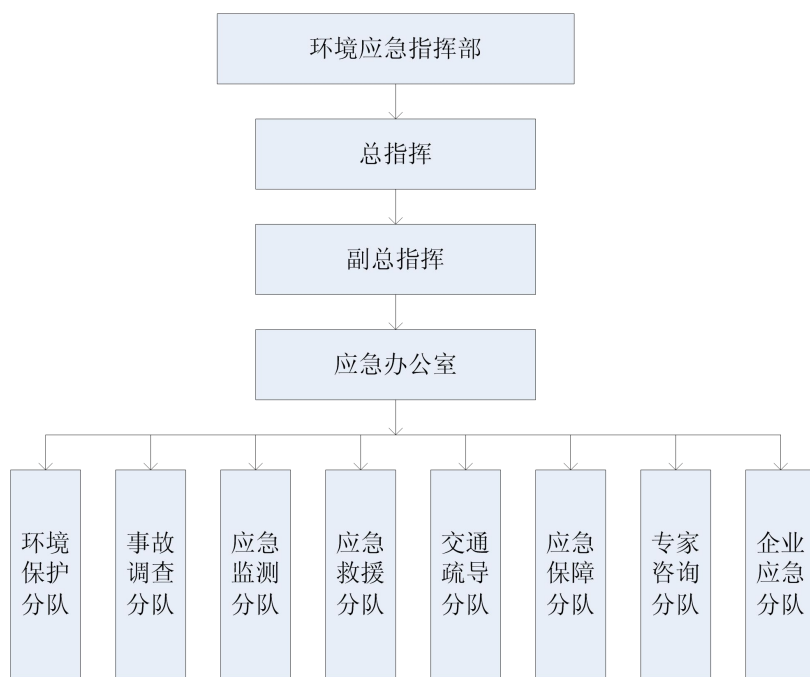


图 14-1 园区突发环境事件应急组织机构图

应急响应程序包括事故报警、接警处置、应急响应、信息报送与处理等几个方面。

#### (1) 事故报警

事故发生单位在事故发生后立即向园区报警。

#### (2) 接警处置

接警后立即向园区环境应急办公室报告，环境应急办公室立即通知相关预案责任部门负责人和有关专家赶赴现场，对事故情况和等级进行初步判断，并将初步判断的情况迅速报告环境应急指挥部，应急指挥部根据事故情况派遣相关应急分队赶赴现场进行事故先期处置。

#### (3) 应急响应

- 分级响应：根据突发环境事件的严重性和紧急程度，根据事故分级启动响应预案。
- 应急响应程度：下达预备通知，派出应急分队；分析判断，明确任务，组织保障；下达应急通知。

- 应急处置措施：以生命救援为首要目标实施救援行动；随时掌握事故进展情况并向社会发出避险警告；实施动态监测确定污染物的性质、浓度及可能影响范围及时向有关部门报告监测结构；转移、撤离可能受到危害的人员；调集应急物资等。
- 应急终止：应急结束应注意次生事件的发生，妥善做好设施查验、隐患排查、人员安抚等后续工作。

#### (4) 信息报送与处理

- 后期处置：包括善后处置、事故评估和责任调查、恢复重建、责任追究等。
- 监督管理：包括宣传培训、演习演练、奖惩等。

## **1. INTRODUCTION TO GREEN INDUSTRIAL PARK**

The United Nations conference on sustainable development held on June 20 to 22, 2012, in Rio DE Janeiro, Brazil, mainly focused on two themes: the green economy under the background of sustainable development and poverty eradication and the systematic framework of sustainable development. The green economy, one of major issues in ‘Rio+20’ summit, refers to an economic mode that aims at improving human well-being, keeping the broadest masses to fully enjoy the fruits of economic development, as well as significantly reducing the harmful impact of human activities on the environment. Its essence is the sustainable economic development with the coordination of ecology and economy as the core, the economic development mode characterized by the maintenance of human living environment, the reasonable conservation of resources and energy, and the benefits to human health, as well as a balanced economy. In this mode, the environmental technology, the clean process and many other environmental friendly technologies are turned into productivity, to realize the sustainable growth of economy, and eventually eliminate poverty. Therefore, advancing green economy has become an important development trend around the world. It is generally recognized by the international community that not only can the green economy conserve energy and reduce emissions, but it can also more efficiently use resources, enlarge market demand, and create new jobs, as a key combination of environmental protection and economic development. It also needs to ‘green’ industry, city, building, transportation, etc. Since it is this massive

material construction that constitutes major non-renewable resources consumers, especially for energy consumption, the green construction and transformation at the material level provide a great opportunity and a huge space for the green development.

Green industrial park, as an important carrier of green growth, is the key to realize the regional green economic development in the future. It refers to a new type of industrial park, which is guided by the concept of sustainable development, the requirements of cleaner production, the idea of circular economy and the principle of industrial ecology, through the material or energy flow seeking ways for closed materials circulation, multistage energy use and waste minimization, thus forming an industrial symbiosis of resources sharing and by-products exchange, with the maximum improvement of the efficiency of resources and energy utilization, and the minimum pollutants generated from the industrial production source.

The earliest and the most famous prototype of green industrial park is Kalundborg Industrial Park in Danish. Kalundborg is a small industrial city with only 20 thousand residents in the North Sea coast, about 100 kilometers west from capital Copenhagen. The first exploration on industrial ecology was made by the thermal power plant and the oil refinery in the early 1960s, when Asnaes power plant in the park, with a break in its traditional running routine, provided part of its heat to Startoil refinery, forming ‘cogeneration’. As time passes, main enterprises in Kalundborg began to exchange ‘waste’ with each other: power plants supplied steam to oil refineries and pharmaceutical factories, with extra

heat to a fish farm, the sludge of which was recycled as fertilizer; excessive high-sulfur gas generated from oil refineries, through the process of hydrodesulphurization, became sulphur, raw materials of a sulphuric plant, while the clean gas was sold to power plants to save the coal; by lime, the power plant desulfurized the flue gas that would cause pollution, in which the calcium sulfate produced was directly sold to wallboard plants to replace gypsum; wastes such as fly ash of power plants was used for road construction and cement manufacture. It should be said that practically Kalundborg Industrial Park has formed a kind of ‘industrial symbiosis system’, in which the environmental and economic advantages are given a full play, that is, the decrease of resources consumption, the reduction of gas emissions that can cause the greenhouse effect and pollution, and the reuse of wastes. Despite of the fact that Kalundborg industrial ecosystem was formed spontaneously, rather than to follow some upfront design, its success describes the prospects of the application of industrial ecology.

It can be seen that the green industrial park shows the promising prospects of industrial construction, to promote the environmental protection in the construction to a new level of win-win result in both economy and environment, and achieve a new leap forward.

This guideline is the main output of UNIDO Green Silk Road Project. Part of writers has previously investigated the industrial park, competent government departments and research institutions of Japan and Korea. The guideline referenced relevant policies and technical specifications of China, and learned from successful experience in the construction of



green (ecological) industrial park in other developed countries. The objective is to provide guidance of policies and technologies for green industrial park in China according to international experiences which can be further improved after trial application. We hope this guideline to become the important reference to the construction of the green industrial park in the future China, and to service for achieving inclusive and sustainable industrial development in China and other countries along the Silk Road.

## 2. INSTITUTIONAL FRAMEWORK

The construction of green industrial park is a comprehensive systematic engineering across sectors, industries, and enterprises. The industrial park should set up a leading group for the construction, clarify responsibilities of various departments in the industrial park, decompose indexes and projects into responsible units, sign objective responsibility with these units, and inspect and report timely.

**Table 2-1 Institutional framework and functional division**

No.	Department	Responsibilities
1	Leading group	<ul style="list-style-type: none"> <li data-bbox="564 1406 1359 1608">➤ Responsible for organizing the plan formulation of the green industrial park construction, making relevant preferential policies (land, finance, and pollution charge refunds) ;</li> <li data-bbox="564 1630 1359 1771">➤ Coordinate people, capital and goods, solve various major problems encountered in the course of the park construction;</li> <li data-bbox="564 1794 1359 1991">➤ Provide necessary organizations and resources for the establishment, implementation and maintenance of the environmental management system, including human, material and</li> </ul>

		<p>financial resources;</p> <ul style="list-style-type: none"> <li>➤ Approve and release environmental guidelines on parks;</li> <li>➤ Direct the management and review on the environmental management system, audit the environmental management manual, approve the environmental management program files;</li> <li>➤ Examine important environmental factors, targets, indicators and plans, and report the implementation of management plan ton to top management;</li> <li>➤ Responsible for organizing the overall implementation of construction plan on green industrial park.</li> </ul>
<b>2</b>	<b>Office</b>	<ul style="list-style-type: none"> <li>➤ Responsible for the comprehensive control of park construction;</li> <li>➤ Responsible for the formulation of land acquisition policy, the organization and implementation of land acquisition;</li> <li>➤ In charge of external publicity on environmental guidelines of the park, jointly with the propaganda department;</li> <li>➤ Responsible for the coordination in an emergency;</li> <li>➤ Responsible for the internal inspection and examination on the safe fire control responsibility system, the compilation of internal fire emergency plan, the organization of fire drill, and dealing with internal fire emergency;</li> <li>➤ Responsible for the management of land acquisition in the area.</li> </ul>

3	<b>Environmental Protection Department</b>	<ul style="list-style-type: none"> <li>➤ Responsible for the implementation of environmental impact assessment in the area;</li> <li>➤ Responsible for monitoring the air, water and acoustic environment quality of the park;</li> <li>➤ Responsible for the supervision and administration of ‘three wastes’ from enterprises in the park;</li> <li>➤ Responsible for the approval of environmental access for new projects;</li> <li>➤ Responsible for the construction of green restaurant and hotel;</li> <li>➤ Responsible for the publicity and management of ecological industry, cleaner production and circular economy;</li> <li>➤ Responsible for the management of industrial safety and health, and the disposal of safety accident;</li> <li>➤ Responsible for conducting energy conservation, publicity and management in the park;</li> <li>➤ Responsible for the prevention and control of major pollutants and the reduction of emissions.</li> </ul>
4	<b>Housing Planning Department</b>	<ul style="list-style-type: none"> <li>➤ Responsible for the planning, evaluation and management of major projects in the park;</li> <li>➤ Responsible for the planning of the construction of environmental protection infrastructure;</li> <li>➤ Responsible for the approval and report of the planning on the project construction;</li> <li>➤ The establishment and implementation of construction plans and annual plans for municipal infrastructure;</li> </ul>

		<ul style="list-style-type: none"> <li>➤ Responsible for the landscaping planning, and the management of urban landscape facilities and tourism;</li> <li>➤ Responsible for the construction of roads, bridges and other municipal traffic facilities, and the public transportation, etc.</li> <li>➤ Responsible for planning the green community, green hospital, ecological culture and green school.</li> </ul>
<b>5</b>	<b>Investment Promotion Department</b>	<ul style="list-style-type: none"> <li>➤ Responsible for the formulation of annual green investment promotion plan, and the arrangement of investment promotion activities;</li> <li>➤ Responsible for the audit, assessment and approval of all investment projects entering the park;</li> <li>➤ Responsible for making policies and measures on investment and industry promotion, and organizing the implementation;</li> <li>➤ According to industrial policies and plans, plan and introduce foreign major manufacturing, high-tech industrial projects and industry-leading enterprises.</li> </ul>
<b>6</b>	<b>Economy &amp; Trade Development Department</b>	<ul style="list-style-type: none"> <li>➤ Statistically analyze the economic operation of the green industrial park;</li> <li>➤ Carry out relevant laws and regulations for safety production, responsible for the comprehensive supervision and administration of safety production in the park, fully implement the function of safety supervision and supervisory;</li> <li>➤ Responsible for the management of information industry development in the park;</li> </ul>

		<ul style="list-style-type: none"> <li>➤ Responsible for coordinating and guiding the information industry development in the park;</li> <li>➤ In charge of the statistics, monitoring and disposal for safety production accidents;</li> <li>➤ Responsible for inspecting, evaluating and examining the emergency preparedness and response by relevant departments;</li> <li>➤ Responsible for the research and proposal of the strategy and planning for the park's economic and social development;</li> <li>➤ Responsible for the internal economic and trade work, business management, utilization of foreign capital and technology work.</li> </ul>
7	<b>Construction Department</b>	<ul style="list-style-type: none"> <li>➤ Responsible for the management of environmental image and health during the park's greening construction;</li> <li>➤ Responsible for the construction of electric power, telecom, heat and gas supply, and other public utilities;</li> <li>➤ Responsible for the maintenance and management of public facilities.</li> </ul>
8	<b>Financial Department</b>	<ul style="list-style-type: none"> <li>➤ Responsible for the fund raising and security of the greening construction;</li> <li>➤ Responsible for arranging the capital implementation for environmental protection;</li> <li>➤ Responsible for the formulation of government green procurement plan and the capital implementation;</li> <li>➤ Responsible for supervising and examining the use of environmental protection funds.</li> </ul>
9	<b>Technology</b>	<ul style="list-style-type: none"> <li>➤ Responsible for the organization, planning,</li> </ul>

	<b>Department</b>	<p>application and management for all kinds of science and technology projects;</p> <ul style="list-style-type: none"> <li>➤ Responsible for the planning, application and management for high-tech industrialization projects;</li> <li>➤ Responsible for the application, examination, coordination and management for technology innovation funds of the science- and technology-oriented mid- and small-scale enterprises;</li> <li>➤ Responsible for the registration of scientific and technological achievements, the product identification and assessment, and the talents selection and recommendation;</li> <li>➤ Responsible for the management of patent, technology market and information;</li> <li>➤ Responsible for the promotion and application of scientific and technological achievements.</li> </ul>
<b>10</b>	<b>Land Department</b>	<ul style="list-style-type: none"> <li>➤ In charge of the land management, complete the work of using and conserving land resources.</li> </ul>
<b>11</b>	<b>Community Affairs Management Department</b>	<ul style="list-style-type: none"> <li>➤ Coordinating the greening reformation on enterprises.</li> </ul>
<b>12</b>	<b>Statistical Department</b>	<ul style="list-style-type: none"> <li>➤ Run statistics on various indicators concerning the park's greening construction;</li> <li>➤ Responsible for verifying the completion of various indicators of the greening construction.</li> </ul>
<b>13</b>	<b>News Publicity Center</b>	<ul style="list-style-type: none"> <li>➤ In charge of the propaganda, deepen enterprises' understanding on the green industrial park construction.</li> </ul>

In the process of the green industrial park construction, in addition to corresponding organizations established, the practical and flexible operation mechanism must also be set up. To give full play to the main body's role of the government, enterprises, social organizations and public, define clear responsibilities and obligations of each body, arouse social initiative, gradually establish and improve the operating mechanism 'led by government, promoted by market, regulated by laws, encouraged by policies, supported by science and technology, and participated by public'. The enterprises and public responsibilities in the industrial park are shown in table 2-2.

**Table 2-2 The enterprises and public responsibilities for green industrial park**

No.	Member	Responsibilities
1	Enterprise	<ul style="list-style-type: none"> <li data-bbox="528 1088 1358 1592">➤ Responsible for the regular report to the environmental protection department on enterprise's environmental protection information, including the pollutants generation, reduction and emission, and the possible accident risk of waste storage and disposal; strictly implement the publicity and announcement system;</li> <li data-bbox="528 1626 1358 1928">➤ Implement the cleaner production audit in cooperation with relevant environmental protection departments, perform the cleaner production potential analysis, and actively carry out cleaner production;</li> </ul>

		<ul style="list-style-type: none"> <li>➤ Actively implement the construction plan on green industrial park, according to the plan take measures to perfect the ecological chain (e.g. fill up or cut off the chain), positively carry out the ecological design on products, improve the added value of products;</li> <li>➤ Regularly carry out environmental performance evaluation and timely implement the publicity and announcement.</li> </ul>
<b>2</b>	<b>Public</b>	<ul style="list-style-type: none"> <li>➤ According to the publicity and announcement system, have the right to supervise enterprises' environmental pollution behaviors, and report to relevant authorities in time;</li> <li>➤ Have the right to attend public hearings concerning the construction of green industrial park;</li> <li>➤ Actively conduct the publicity and implementation of environmental protection, start from me, such as building green community, advocating green consumption, promote green culture, etc.;</li> <li>➤ Actively participate in the environmental impact assessment implemented in enterprises, involve and supervise the work of soliciting opinions over environmental impact assessment on new, converted and expanded enterprises or projects.</li> </ul>



### **3. PLAN**

‘Planning First’ is the foundation of green industrial park construction, especially in the new green industrial park construction. The first step in the planning process for a new industrial park is to define the potential clients, or tenant companies. The decision as to the type of park that is to be developed will determine the type of environmental issues that may be anticipated. For example, whether tenant companies will be large users of water or energy, or large producers of waste materials.

Some economic factors that will be considered in the choice of the site for the park are: (1) The size of the site relative to the expected future demand for space. (2) Infrastructures include suitable land conditions (gently sloping ground for drainage, good ground conditions for building foundations), adequate water supplies, good access to cities, ports and airports, reliable electricity supply and telecommunication facilities, and the possibility to install wastewater treatment facilities and solid waste disposal.

With good planning and site environmental management, environmental impacts can be minimized. And the most useful tool at this stage is an Environmental Impact Assessment (EIA). Besides the economic and environmental factors, it is also important to evaluate the potential socio impacts of an industrial park in a particular area. The influx of workers into a region to find employment may put local infrastructure – such as housing, transport, hospitals or schools – under great pressure. It is very important to assess whether an increased future demand for housing and services can be met. Unless there are strict zoning laws to prevent the establishment of unplanned residential areas too close to the industrial park, resulting from insufficient housing infrastructure, there will be the possibility of surrounding communities being put at risk in the case of an accident.

UNEP suggests the following six principles as contributing to an

ecologically-sensitive design of the green industrial park: (1) Define the carrying capacity of the site. (2) Maintain natural areas and indigenous vegetation as much as possible. (3) Retain natural drainage systems. (4) Increase the density of development (enterprise cluster, strict control of high pollution industries entrance). (5) Improve energy efficiency (research on alternative energy such as wind, solar, geothermal, etc.). (6) Achieve industrial symbiosis.

## **OUTLINE FOR GREEN INDUSTRIAL PARK**

### **1. Overview**

- (1) Basic Information
- (2) Economy Development
- (3) Environmental Quality

### **2. Meanings and Advantages**

- (1) Advantages
- (2) Problems and Restricts
- (3) Meanings of Construction

### **3. Overall Design**

- (1) Principles
- (2) Location
- (3) Overall Idea (Orientation, Structure)
- (4) Overall Goals and Indexes

### **4. Industrial Green Development Plans (Ever Industry Needs its Own Plan)**

- (1) Current Status Analysis
- (2) Goals and Indexes
- (3) Green Development Programmes

### **5. Pollutions Control**

- (1) Water Pollutions Control
- (2) Air Pollutions Control
- (3) Solid Waste Control

(4) Energy Utilization

## **6. Major Projects and Benefit Analysis**

(1) Access Conditions

(2) Major Projects (Industrial Projects, Infrastructures, Service Facilities)

(3) Benefit Analysis( Economic Benefits, Environmental Benefits, Social Benefits)

## **7. Security System**

(1) Organization and Management

(2) Policy

(3) Economic Reward

(4) Technology

(5) Others

## **4. ENVIRONMENTAL MANAGEMENT SYSTEM**

Environmental management system, a component part of the comprehensive management system in the green industrial park, involves not only the necessary organizations, planning activities, responsibilities, conventions, procedures, processes and resources for the formulation, implementation, realization, review and maintenance of environmental guidelines, but also contents concerning the management, such as environmental guidelines, objectives and indicators, etc. Therefore, environmental management system is an organized, planned and coordinated management activity, which is implemented through an organization structure with clear responsibilities and obligations, to prevent harmful impacts on the environment. Currently, ISO14000 environmental management system is one of systems that are relatively mature.

For green industrial park, since environmental management system is designed to continuously promote greening level during the park

development, to a better and higher level, the environmental management system for green industrial park, at least, should include the following aspects.

- **Environmental service system:** including water supply, centralized heating, waste recycling, by-product exchange, facilities for central disposal of waste, hazardous waste collection and transportation system, solid waste treatment and disposal, environmental training and education, environmental consulting (policies and regulations, new technology, new process, etc.), environmental auditing, environmental emergency response system, etc.
- **Environmental monitoring system:** including environmental quality monitoring, pollutant emissions monitoring, solid waste supervision, chemical storage and transport leakage monitoring, hazardous waste storage and transport monitoring, emergency monitoring, underground water monitoring and soil monitoring, etc.
- **Policies and regulations system:** including international environmental protection laws and regulations (the Vienna convention, the Montreal protocol, the Basel convention, etc.), environmental management system (environmental impact assessment, pollution charges, total pollution load control, etc.), environmental standards (environmental quality standards, pollutant discharge standards, water environmental standards, air environmental standards, soil environmental standards, noise environmental standards, etc.), and so on.
- **Security system:** including economic policies, technical support, personnel training and introduction, green environmental management (green communities, green schools, green hospitals, green transportation, etc.), green logistics, low carbon policies,

etc.

- **Information platform system:** the carrier of information management for the green industrial park, including integrated environmental management platform, cleaner production platform, water and energy saving management platform, information platform open to the public, solid waste exchange platform, etc.

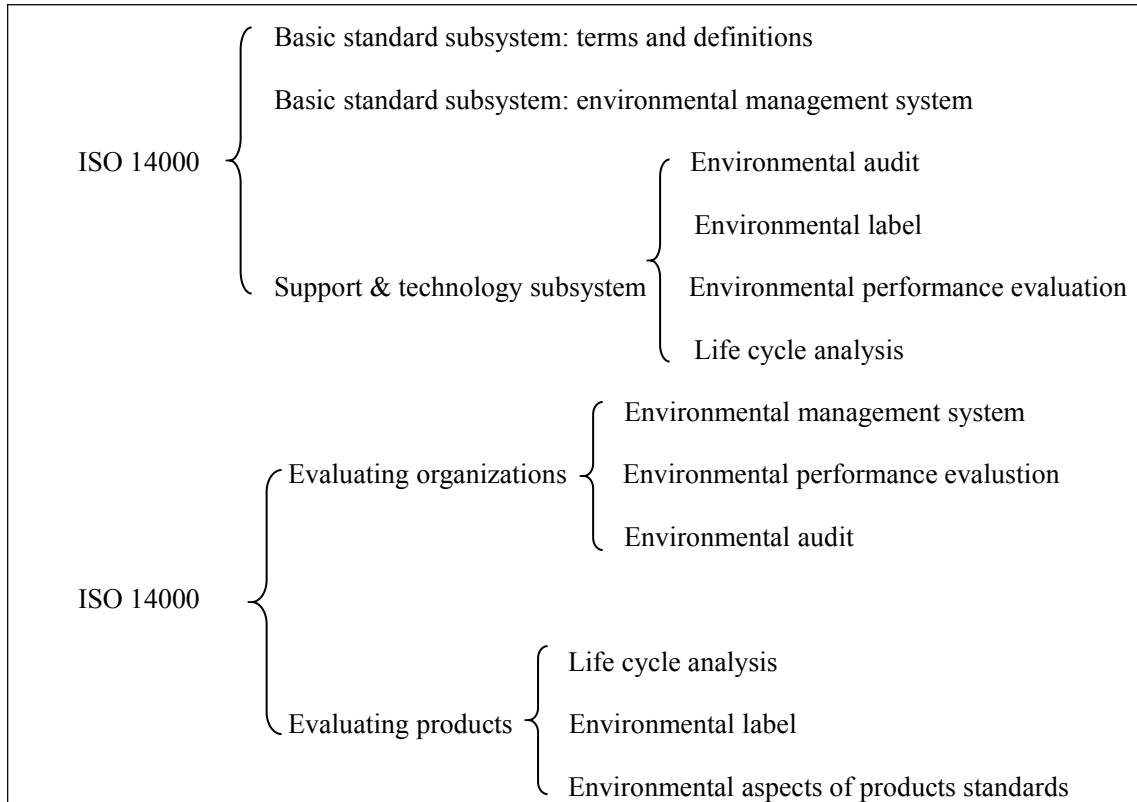
**ISO14000 environmental management series standards**

The ISO14000 environmental management series standards, as the international standards drafted by the international organization for standardization ISO/TC207, are a series of environmental management standards, including the environmental management system, environmental auditing, environmental labelling, life cycle analysis and many other heated issues in the field of international environmental management, designed to guide organizations to be more environmental friendly.

**Table 1 The standard number distribution in ISO14000 series standards**

Chapter	Name (Standard subsystem)	Standard No.
SC1	Environmental Management System (EMS)	14001—14009
SC2	Environmental Audit (EA)	14010—14019
SC3	Environmental Label (EL)	14020—14029
SC4	Environmental Performance Evaluation (EPE)	14030—14039
SC5	Life Cycle Analysis (LCA)	14040—14049
SC6	Terms and Definitions (T&D)	14050—14059
WG1	Environmental Aspects of Products Standards (EAPS)	14060
Reserve		14060—14100

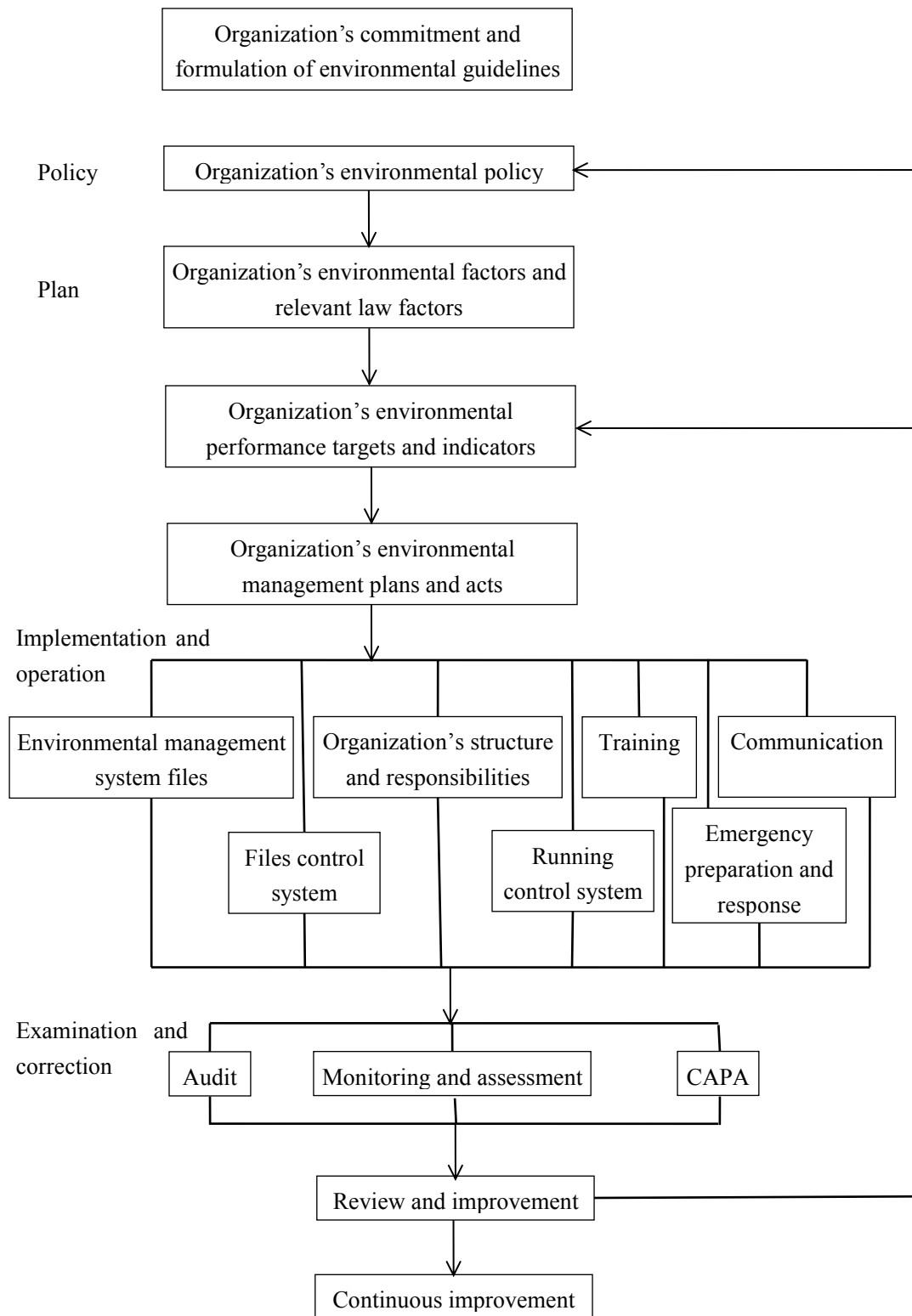
The ISO 14000 series standards is a huge standard system, in which the standard attribute and function of each subsystem are different, and the system function varies depending on the combination of different subsystems.



There are seven key principles stipulated by ISO/TC207 for the development of ISO14000 series standards:

- The ISO14000 series standards should be authentic and non-deceptive;
- The method and information of environmental impact assessment on products and services should be accurate and verifiable;
- Instead of adopting non-standard methods, the evaluating and experimental methods should adopt ISO standards, regional standards, national standards or other standard test methods that can guarantee the reproducibility technically;
- Fairness and transparency, without harming the confidential business information;
- Non-discrimination;
- Be capable for the specific and effective information transfer and education training;
- No trade barriers, to ensure the consistency both inside and outside the country.

The running mode of ISO14000 is shown in the figure below.



**Table 1 The running mode of environmental management system**

## 5. CLEANER PRODUCTION

Cleaner production has different names in different stages of development or different countries, such as ‘waste minimization’, ‘non-waste technology’, ‘pollution prevention’. But the basic meanings are consistent. It is pollution prevention strategies are adopted for products and the production processes to reduce pollutants.

Cleaner production is a new idea which means change of ideas and transformation of strategy of environmental protection from passivity to initiative. UNEP summarized the national pollution prevention activities, and then proposed the definition of cleaner production after analysis. The definition is universally accepted by the international community, which is defined as:

‘Cleaner production is a new and creative idea by which environmental strategy of overall prevention is adopted for production processes, products and services. It can increase eco-efficiency and reduce human and environmental risks.’

——It is required in the production processes to save raw materials and energy and eliminate toxic raw materials. Besides, the volume and toxicity of waste should be decreased.

——It is required in the whole life cycle of products to reduce adverse effects from raw material extraction to final disposal.

——It is required in the services that the environmental factors to be considered in the design and services.

Attitude changes, responsible environmental management, and scientific and comprehensive assessment of technology solutions are required in cleaner production. Three aspects in cleaner production are



cleaning products, cleaning processes and cleaning service, which include wishes from producers, consumers and society for production, service, and consumption. (1) Two aspects of resources savings and environmental protection on industrial production are considered in the full process from design to disposal; (2) Environmental requirements are considered for both production and service; (3) Costs on industrial waste are effectively reduced instead of traditional method in which regardless of costs effectiveness or single end control; (4) Compared to end-of-pipe treatment it can improve the production efficiency and economic benefit, and accordingly becomes popular things; (5) The cleaner production focus on comprehensive protection of the global environment, bringing hope to building a cleaner earth for humankind.

From the perspective of the industrial park, it can start from the following several aspects to implement cleaner production: (1) Develop policies to encourage enterprises implement cleaner production; (2) Perfect existing environmental laws and policies to overcome obstacles; (3) Adjust the structure of industries; (4) Arrange various activities to improve public consciousness of cleaner production; (5) Support industrial demonstration projects; (6) Provide technology support for industrial department; (7) Put cleaner production into education.

From the perspective of enterprises, it can start from the following several aspects to implement cleaner production: (1) Implement cleaner production audit in enterprises; (2) Develop long-term strategical plans of enterprises cleaner production; (3) Train workers for cleaner production; (4) life cycle analysis of products; (5) Eco-design for products; (6) Develop alternative technology of cleaner production.

## **CLEANER PRODUCTION AUDIT**

Cleaner production audit is the key to implement cleaner production.

There are seven workable steps in the whole audit process.

Stage 1 (Plan and Organization): publicity, mobilization and preparation.

Stage 2 (Pre-evaluation): choose the audit emphasis and set cleaner production goals.

Stage 3 (Evaluation): establish material balances of audit emphasis and analyze the source of waste.

Stage 4 (Programmes and Selecting): Make up and select programmes aimed at the causes of waste, and prepare interim audit report of enterprises cleaner production.

Stage 5 (Feasibility Analysis): Analyze the feasibility of the programmes middle/high cost, and determine the cleaner production programmes which can be implemented.

Stage 6 (Implementation): Implement the programmes and track the effects.

Stage 7 (Sustain Cleaner Production): Make up plans to sustain cleaner production in enterprises and write audit report

## 6. ECO-EFFICIENCY

According to the World Business Council for Sustainable Development (WBCSD) firstly definition in 1972, eco-efficiency was achieved through the delivery of ‘competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing environmental impacts of goods and resource intensity throughout the entire life-cycle to a level at least in line with the Earth's estimated carrying capacity’. The Organization for Economic Cooperation and Development (OECD) pointed that eco-efficiency was efficiency of ecological resources to meet human needs. It was defined as the ratio of output and input. The output refers to the value of production and service from enterprise, industry or economic unit, while the input refers to the environment pressure from enterprise, industry or economic unit.

Therefore, Eco-efficiency and cleaner production are closely related, the two approaches have a lot in common, which are helping to achieve resource and energy consumption minimization, reduce environmental impact and decrease environmental risks. UNEP and WBCSD have considered the similarities between the two approaches. They comment that – ‘Eco-efficiency starts from issues of economic efficiency which have positive environmental benefits, while Cleaner Production starts from issues of environmental efficiency which have positive economic benefits.’

Eco-efficiency can be improved by the following aspects:

- reducing the material and energy intensities of goods and services,
- reducing the dispersion of toxic materials,
- enhancing the recyclability of materials,
- maximizing the sustainable use of renewable resources,

### **Eco-efficiency Indicator (EEI)**

In the Eco-efficiency plan of green industrial park, Eco-efficiency can be promoted like cleaner production, by promoting green technology and economic benefit from low energy and material consumption. Eco-efficiency needs an indicator to characterize, and a typical way of representing eco-efficiency is via the equation given below:

$$EEI = \frac{\text{Production or Service Value}}{\text{Environmental Impacts}}$$

where the environmental impact can be measured in terms of the consumption of energy, raw materials or water, or the quantity of emissions. By tracking the evolution of the eco-efficiency over time, one then obtains an indicator of how the environmental performance of the company or industrial park is really evolving. Usually the larger the EEI, the less environmental impact and best economic benefit.

## **7. ENERGY CONSERVATION**

The management department of the green industrial parks should clearly recognize that economic cost is the most likely factor of driving companies' energy conservation. Therefore, if the parks take central heating, it will not only dilute the cost of business, but also reduce the emissions of CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub> and other atmospheric pollutants.

In addition to central heating, there are other ways to achieve energy efficiency for green industrial parks:

### **(1) Cogeneration of heat and power**

To usual thermal power, its efficiency is about 30 to 35%, which means that every 1 MJ of energy output, there are 2 MJ of heat wasted. We put hot energy from this part to turn heat water into steam, it will meet the enterprises and residential areas of the park in heat demand. The above process which produces both electricity and heat is called cogeneration. Compared to produce electricity and heat respectively, the cogeneration is

a more fuel-efficient manner. Its external heat source is regulated extraction steam of extraction turbine or exhaust of back-pressure turbine, with usually 0.78~1.28MPa or 0.12~0.25MPa, the former can be used in industrial production, while the latter is available for civil heating. Steam of cogeneration has no cold source loss, so its thermal efficiency can be increased to 85%, which is much higher than large condensing turbines (40%). It can improve energy efficiency and reduce energy consumption.

### **(2) Cascade utilization of energy**

It refers to the process of utilizing the energy according to their grade (can be converted into the amount of mechanical work) step by step, such as high, medium temperature steam prior to the process with high heat demand, and low-temperature steam to low-temperature process. Energy cascade utilization which can improve energy efficiency of the whole system is an important measure for energy conservation.

### **(3) Energy management contracting (EMC)**

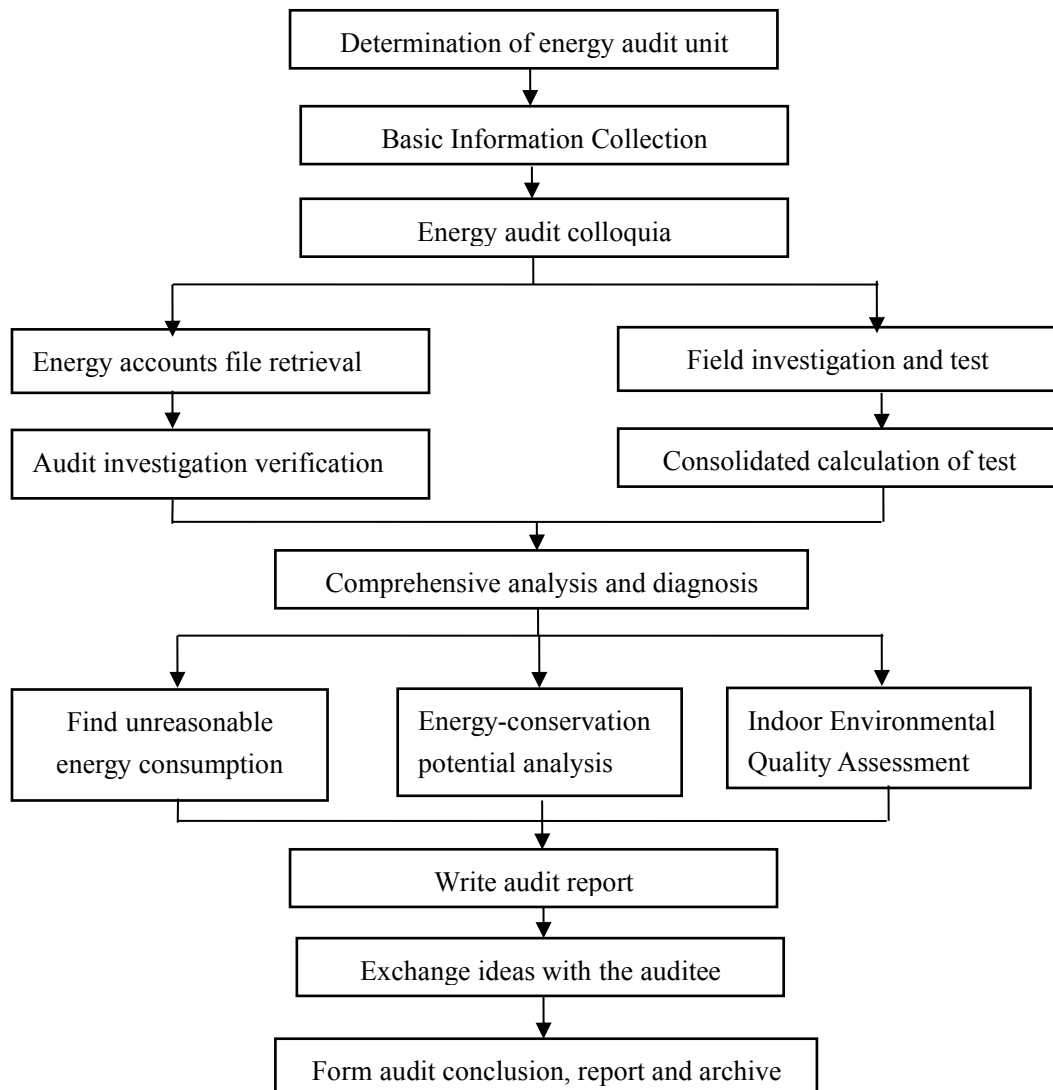
It is an energy service mechanism that energy service companies (ESCOs) and energy consumption units agreed on the energy efficient goals of energy saving projects in the form of contracts, to achieve energy efficient goals, ESCOs offer necessary services to energy consumption units, and energy consumption units pay for ESCOs' investment and reasonable profit by energy efficiency. Its essence is an energy-saving business way to pay for the full cost of energy-saving projects business with reduced energy costs. This investment way allows customers to use future energy efficiency revenue for the plant and equipment upgrade to reduce operating costs, or ESCOs provide energy services by committing to energy-efficiency of energy-saving projects, or contracting the overall energy costs.

Energy management contracting is a new energy-efficient mechanism on the basis of the market which began to develop in the western developed countries in the 1970s. In China, the national standard for energy management contracting is GB/T24915-2010 'technical

specifications of energy management contracting’. Since 2010, China government strengthened the supporting for energy management contracting business model, and provided policy support and funds to promote the rapid and healthy development of energy service industry.

#### (4) Energy audit

It refers to energy consumption units or the commissioned agencies examine, test, verify, analyze and evaluate the physical and financial process of energy use based on regulations and standards of energy conservation. It is an effective method to scientific energy management and energy conservation in enterprises, and has a strong role in supervision and management.



**Figure 7-1 Procedure of Energy Audit**

## **(5) Clean energy**

Clean energy means a technical system of energy's clean, efficient and systematic application, such as hydropower, wind power, solar energy, bio-energy (biogas), tidal energy, etc. These energies have three meaning points: first, clean energy is not a simple classification of energy, but an energy utilization technology system; second, clean energy emphasizes both clean and economy; third, the cleanliness of clean energy refers to meet certain emission standard.

## **(6) Other technologies**

- **Energy-Efficient Buildings:** energy-efficient buildings is low-energy buildings designed following the basic approach to climate and energy-saving design after studying the architectural planning division, groups and monomers, building orientation, spacing, solar radiation, wind direction and the outer space environment. Its main indicators are: architectural planning and plane layout conducive to natural ventilation, greening rate of not less than 35%, at least one living space to get two hours of full window sunshine in building spacing and so on.
- **Green Lighting:** Green Lighting is the concept proposed by the United States Environmental Protection Agency in the early 1990s, which can improve the conditions and qualities of people's work, study and life and create an energy-efficient , environmentally friendly , safe and comfortable lighting. Complete meaning of green lighting contains following four aspects: energy efficient, environmentally friendly, safe and comfortable. Energy efficient means to obtain adequate lighting with less power consumed. Environmental friendly means to reduce the emissions of air

pollutants caused by electricity generation. Safe and comfortable illumination means clear, soft, and no ultraviolet light, glare and other harmful light, no light pollution.

### **Energy Consumption Indicators (ECI)**

Generally use energy consumption intensity to characterize energy utilization efficiency which can be characterized by the following equation:

$$\text{energy consumption intensity} = \frac{\text{the total energy consumption}}{\text{economic data}}$$

where the economic data often use economic indicators such as gross national product (GDP), total industrial output value or industrial added value. The total energy consumption accounting is conducted by coal equivalent. Coal equivalent of various energies can get from 'GB/T 2589-2008 General principles for calculation of the comprehensive energy consumption'.

## **8. WATER CONSERVATION**

Industrial park can be very large consumers of water, when infrastructure activities and enterprises' activities are considered together. As a result, the environmental impact of this large water consumption can be quite important. For example, excessive use of ground water can lead to the lowering of water tables while the release of warm water from cooling towers into watercourses can affect aquatic ecosystems. Therefore, in environmental management of water resources in green industrial park should take adequate consideration:

- **Source Reduction:** reduce water consumption by cleaner production; decrease the water intensity, eliminate or restrict heavy



water-consuming enterprises by industrial structure adjustment, reduce domestic water consumption by implementing water-saving apparatus and improving water-saving consciousness.

- **Cascade Utilization:** design multi-source water supply scheme, propose cascade utilization patterns and methods of integrated and shared water such as drinking water, industrial water, cooling water, landscape water, greening water and domestic miscellaneous water and so on.
- **Recycle & Reuse:** construct wastewater recycled program to prevent secondary pollution, optimize the design of campus-enterprise network and reduce the repetitive investment of recycled water pipeline network.

It should be noted that, if cost of wastewater reuse higher than fresh water, it will not drive enterprises to use recycled water. And then the industrial park managers need to provide the appropriate policy and financial compensation.

#### Water Conservation Indicator (WCI)

Water saving indicator can be characterized by water consumption intensity:

$$\text{water consumption intensity} = \frac{\text{the total water consumption}}{\text{economic data}}$$

Where the economic data often use economic indicators such as gross national product (GNP), total industrial output value or industrial added value. The total water consumption can adopt fresh water consumption or the total water use.

Another indicator is the ratio of water reuse, ie:

$$\text{ratio of water reuse}(\%) = \frac{\text{reuse water consumption}}{\text{the total water consumption}} \times 100\%$$

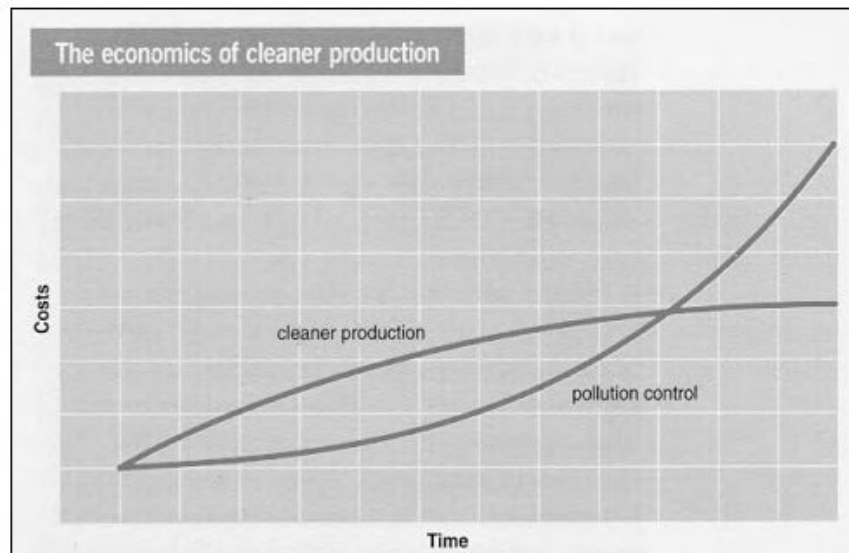
## **9. INTEGRATING POLLUTION PREVENTION AND CONTROL**

There is no way to avoid pollution entirely in the industrial park. Although cleaner production, energy conservation, water conservation and waste management help companies in an industrial park to generate less waste and recycle waste materials as raw materials, some unusable materials will always be left over. This brings us to the important question of how to deal responsibly with this waste. At present, many industrial parks offer a range of environmental services such as wastewater treatment facility, incineration and landfill. Even Some park establishes the on-line monitoring system for real-time monitoring of pollutant emissions.

Because of the complexity of the pollution in the industrial park, a cross-media approach must be used that considers the best overall option for pollution control. For example, heavy metal wastewater after biochemical treatment, the heavy metal is precipitated to the sludge, and after sludge incineration the heavy metals is transferred to the fly ash. This means that the pollution control must be a whole system, and a cross-media approach must be considered. It is virtually increased the difficulty of pollution control at present stage.

Of course, the only way to reduce emissions to all media is to ‘prevent pollution’, as we have already seen, by changing the activities occurring within the industrial park such as minimizing waste and reducing emissions at the source. On the other hand, in Figure 9-1 we saw how the cost of pollution control always increases with time, unlike the cost of pollution prevention (cleaner production) that tends to stabilize after a certain period of time. Therefore, in an industrial park it is important to

integrate pollution prevention and pollution control, which not only directly affects the demand of waste treatment facilities, also affects the cost of environmental management.



**Figure 9-1 The economics between pollution control and pollution prevention (cleaner production)**

By integrating pollution prevention and control during the planning phase, the management can avoid finding itself in a difficult financial situation due to a drop in the demand for end-of-pipe treatment. For example, at an early stage it would be less investment to build small modular installations for wastewater treatment and reuse with pollution prevention approaches, and at later period it would be considered to build treatment facility for the increasing amount of enterprise in industrial park.

Nowadays, the management in many industrial parks is increasingly taking responsibility for providing environmental services, including pollution control activities. However, the funds is a major problem. Thus it is more judicious to adopt an integrated pollution prevention and control approach so as to avoid future problems for the financial viability of the industrial park.

### **Main Pollution Indicator**

According to the zone the industrial park located in, the main pollution control indicators should include, but not limited to the following aspects

(1) National and regional control pollutants: COD, Ammonia Nitrogen, SO<sub>2</sub>, NO<sub>x</sub>, heavy metal and so on;

(2) pollutants of Multilateral Environmental Agreements: Hg、 POPs;

(3) pollutants of larger impact on public health: PM<sub>2.5</sub>、 VOCs and so on.

The pollution control level of above pollutant in the construction and operation of green industrial park should be stricter than region or national level.

## **10. ENVIRONMENTALLY CONSCIOUS PRODUCT**

Environmentally conscious product means environmentally preferable and environment-friendly in the materials procurement, production, circulation, use, scrap, recycle stage of life cycle. Environmentally conscious product also named environmentally harmless product or low-pollution product. Environmentally conscious product which is difference from traditional products can meet both consumer demand and environmental requirements.

Green industrial park can effectively promote environmentally conscious product by advocating eco-design, green procurement and green certification, etc.

**Eco-design:** also known as green design, life cycle design or environmental design. It brings environmental factors into the design to achieve sustainable from the source design. Eco-design requires to consider environmental factors at all stages of products, to reduce the environmental impacts from the whole life cycle, and to develop a more sustainable production and consumption systems. Eco-design mainly

includes two meanings, one is achieving sustainable development strategy from environmental prevention and reducing consumption, and the other is get economic benefit from lowering costs, reducing potential liability risks and enhancing competitiveness

**Green Procurement:** the government gives priority to purchasing environmental label products, promotes the improvement of enterprises' environment behavior and plays a demonstration and promotion role for green consumption of the society. Green procurement pushes green consumption of the society through the following aspects: First, green procurement brings a positive impact on supplier. The suppliers take proactive measures to improve business management level and technological innovation level so that it can reduce resources, energy consumption, pollutant emission and the negative impact to human health. Second, green procurement can support a large number of green products and industries, and promotes the development of green industries and clean technologies, then form a sustainable production system of national economy. Besides, green procurement can also motivate people to change their irrational consumption behaviors and habits, advocates rational consumption pattern and moderate consumption scale, reduces environmental pressure caused by irrational consumption, and then promotes the formation of green consumer market.

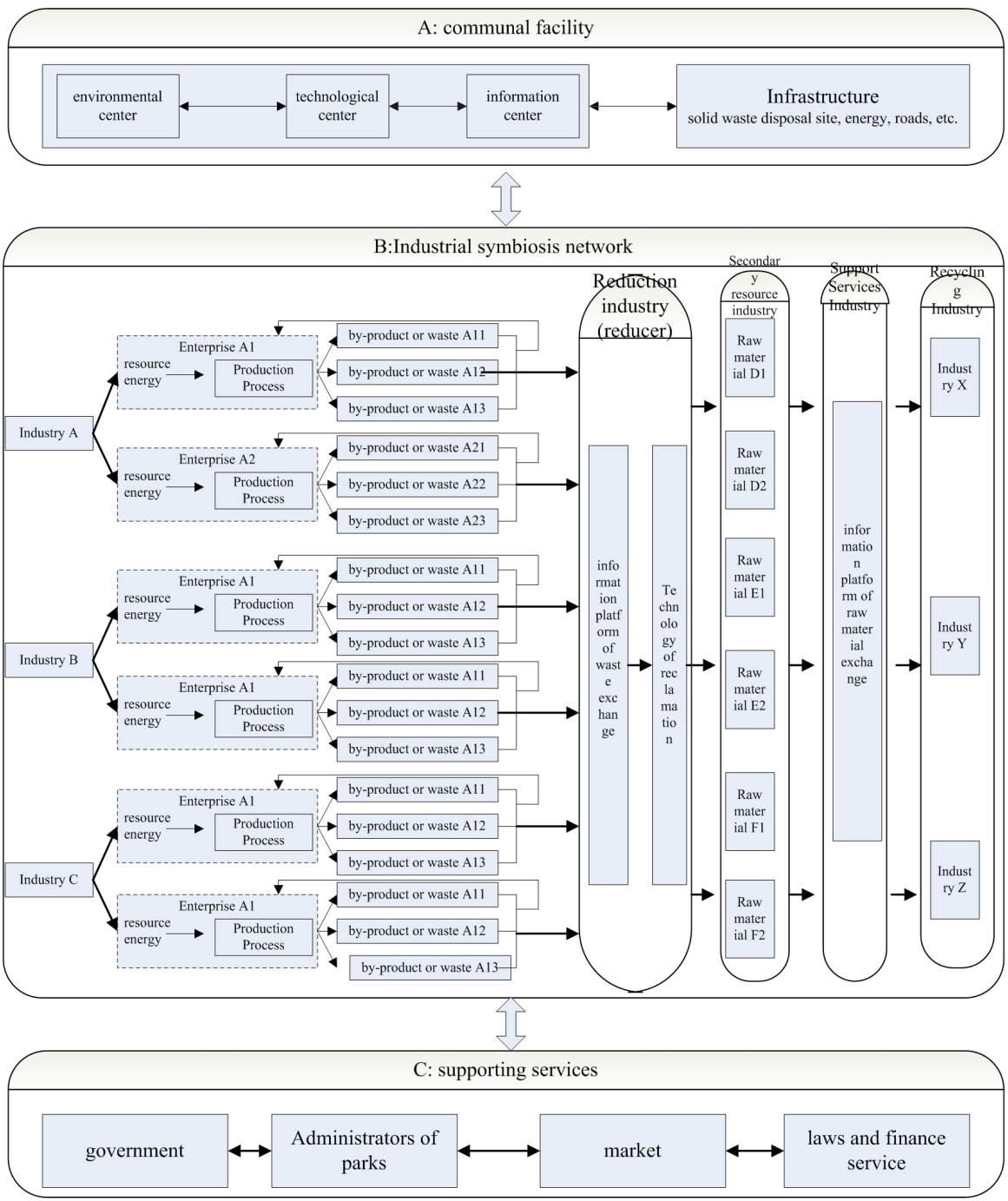
**Green Certification:** it refers to the notarization and evaluation of environmental feature for enterprises or their products by government departments or government-approved social intermediary agencies. At present, mainly green certification labels are Energy Star (United States), European flower (EU), RoHS (EU), China Environmental Labeling, CQC quality green flag, China energy and water conservation certification, Ecoleaf (Japan), Carbon Labeling (Korea), etc.

## **11. WASTE MANAGEMENT**

The waste management of green industry parks is a complicated system for the whole process management of waste in industrial parks. The industrial symbiosis networks are structured, based on the theories of industrial ecology and circular economy, to generate a waste management mode which is comprised of management objectives, management contents, evaluation system and implementation environment.

The waste management of green industry parks is to combine different production processes, industries and enterprises together through resource sharing, by-product exchange and waste symbiosis, aiming at the realization of closed loop of industries. So, in case by-products and waste are produced, the news will be released by information platform in environmental service system of parks, then reclamation of by-products and waste will be realized by department who can provide technological supports and the raw materials coming from reclamation will be purchased by industries and enterprises in demand by information platform again and enter into the next production process.

There are mainly three elements which can have an effect on the stable operation of industrial symbiosis system. The first one is communal facilities, namely some communal facilities supporting the development of enterprises within industrial parks, such as information center, technological center, environmental center, roads & traffic, solid waste disposal site and energy center (electricity, heat and natural gas), etc. The second one is relational networks of industrial symbiosis, which means the enterprises within industrial parks dwell on different locations of the symbiosis networks according to the relations of producer, consumer and reducer and the flow of resources, energy and waste will be in operation under the disciplines of biologic chain. The last one is supporting service, which contains the factors that will affect and regulate enterprises within parks in terms of policy, capital and market, such as government, administrators, market, laws and finance, etc.



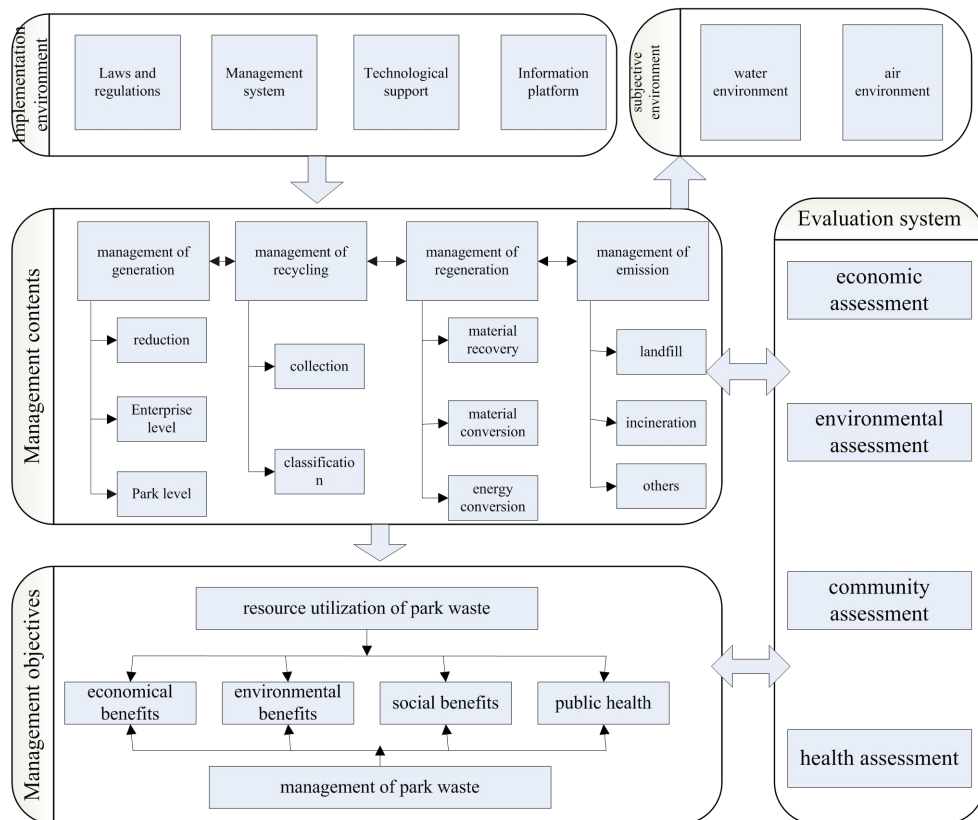
**Figure 11-1 Factor analysis of waste management in green industry parks**

**Design of Waste Management Model for Green Industrial Park**

The industrial processes of production which generate waste are abundant and complicated and the varieties of generated waste are numerous. In addition, the management processes involving generation, recycling, reuse and disposing are also complex. Therefore, when it

comes to design of waste management model for green industrial park, not only are the factors, such as technology, economy, environment, society and public health considered, but also are other stakeholders are involved, such as enterprises for generation, recycling, regeneration and disposing of waste, public service and facilities, and the environmental bodies who are responsible for absorption of discharged waste.

Hence, for the waste management in industrial parks, the generation, recycling, regeneration and disposing of waste should be considered as an integrated system, based on which the entire waste stream is managed, and portfolio selection over methods of waste management that can be applied is operated. Then, environmental benefits, economic benefits, social benefits, including public health and other factors are overall considered, and the most beneficial waste management model for economy, environment, society and public health is identified.



**Figure 1 The management model for green industrial park**



The management model for green industrial park contains four parts, involving management objects, management contents, evaluation system and implementation environment.

(1) **Management objectives** include economic benefits, environmental benefits, social benefits and public health, which are corresponding effects benefited from waste reutilization in industrial parks.

(2) **Management contents** include the management of waste generation, recycling, reuse and emission, among which generation and reuse management is the core

(3) **Implementation environment** is regulation and service system for waste management which includes laws and regulations, management system, economic instruments, techniques and information exchange platform, among which information exchange platform is the realization carrier for waste exchange.

(4) **Evaluation system** takes waste evaluation and oversight for implementation of waste management, and timely sends the feedback of the evaluation to the implementation process to adjust the measures. Evaluation system includes a series of indicators, such as economic assessment, environmental assessment, community assessment and health assessment.

## 12. CHEMICALS MANAGEMENT

Dangerous chemicals refer to what have toxic, corrosive, explosive, combustion, combustion-supporting properties, with the highly toxic chemicals and other hazardous chemicals on the human body, facilities, and environment. It should be based on the hazardous chemicals catalog in their countries so that get safe management of dangerous chemicals used on the enterprises to carry out production, storage, use, operation and transport in the green industrial park.

## **Dangerous Chemicals of Green Industrial Park Management System Design**

Dangerous chemicals of green industrial park management system shall include but not limited to the following several aspects to establish:

(1) **Listing Directory:** The green industrial park should establish and publish dangerous chemicals lists according to its properties by the supervision and administration of production safety department jointly with the public security, environmental protection, health, quality supervision, industry and commerce, transportation and other related departments. The listing directory needs to be updated regularly, to adapt the requirements of environmental protection in different times.

(2) **Division of Responsibility:** in order to ensure the safety of dangerous chemicals production, storage, use, management, transportation process, that should be a clear division of responsibilities and functions:

- **Work safety supervision and management departments** in charge of comprehensive work safety supervision and management of dangerous chemicals, and organizations to identify, publish, adjust the list of hazardous chemicals, new construction, renovation, expansion of production and storage of hazardous chemicals to review security conditions for construction projects, issuance of safety production license of hazardous chemicals, hazard chemicals safety use license and permit for operation of dangerous chemicals, and is responsible for registration of dangerous chemicals.
- **Public security organs** are in charge of public safety management of dangerous chemicals, buy permits issued by

highly toxic chemicals, highly toxic chemicals road transport permits and is responsible for road traffic safety management of dangerous chemical transportation vehicle.

- **Quality supervision, inspection and quarantine departments** are responsible for the issuance and packaging of hazardous chemicals, container production enterprises industrial product manufacturing license and supervise according to the quality of its products, is responsible for the import and export of hazardous chemicals and their packaging to carry out the inspection.
- **Environmental protection authorities** responsible for the supervision and control of waste disposal of hazardous chemicals, dangerous chemicals, environmental hazard identification and risk assessment, determine implementation focused on environmental management of hazardous chemicals, is responsible for the environmental management of hazardous chemicals registration and the registration of new chemical substances and environmental management according to survey of shared responsibilities related to hazardous chemicals pollution and ecological damage, responsible for hazardous chemical accident emergency environmental monitoring.
- **The transport sector** is responsible for the licensing of dangerous chemicals road transport, sea transport as well as transport safety management and safety supervision of water transport of hazardous chemicals, dangerous chemicals road transport enterprises, transport enterprises responsible for drivers, crew members, management personnel, escorts, reporting, handling container loading scene examiner accreditation. Railway

authorities are responsible for railway transportation safety management of dangerous chemicals, hazardous chemicals responsible for qualification examination and approval of railway transportation carriers, shippers and transportation security administration. Civil Aviation Authority is responsible for air transport and air transport enterprises of dangerous chemicals and its transportation security administration.

- **Health authorities** responsible for managing hazardous chemicals toxicity evaluation, is responsible for organizing and coordinating medical rescue work in hazardous chemical accident injuries.
- **Industrial and commercial administrative departments** in accordance with the relevant sectoral permits, issuance of transportation of dangerous chemicals production, storage, management, business license, investigate and deal with illegal purchasing of enterprises for hazardous chemicals hazardous chemicals Act.
- **Postal administration department** is responsible for investigating the mailing of hazardous chemicals.

(3) **General Regulatory:** The classification management system of registration, storage, production, use, operation, transportation should be established.

(4) **Accident Treatment:** The accident emergency plan at the park level should be developed, which including emergency procedures, emergency and first-aid equipment management, and notification mechanism.

### **13. HEALTH AND SAFETY**

The green industrial park must include health and safety. It is worthwhile remembering that in an industrial park containing a large number of different companies, important health and safety risks may result from exposure to a complex mixture of hazardous materials. The risk may be associated with ‘normal’ operating conditions within the companies or arise from industrial accidents.

By focusing too strongly on the ‘environmental aspect’ in an industrial ecology approach such as high efficient utilization of resource and minimizing waste we may miss opportunities to improve the health and safety issues associated with production processes. The use of strategies such as recycle and reuse may put workers at higher risk as a result of increased handling of waste materials. Therefore, health or safety in the green industrial park is particularly important.

In the green industrial park, responsibility for the safety and health of workers within the individual companies rests with the companies themselves. The companies must make sure that materials that are dangerous to the health of their workers are carefully controlled so as to minimize health risks. This requires workers to be informed about the properties of the materials and containers they are using. It also requires training of the workers to be carried out so that they know how to work with the materials in a safe way. And finally they must have the necessary equipment so that they can work in a safe manner.

However, although in an industrial park the safety and health of workers is affected primarily by the activities of their own company, at a secondary level it is also influenced by the activities of neighboring companies. Thus while the activities of individual companies may not

appear to be particularly hazardous, their clustering together on an industrial park can result in a combined risk that is appreciably greater. It is at this point that the role of the industrial park manager becomes important in the safety and health sphere, because the industrial park manager not only has an overview of the activities of the estate, but also evaluates the synergies between different companies' activities. Such this analysis and assessment will also help the manager to establish the emergency response plan for the industrial park. As a result of such an analysis, the risk of safety and health in the industrial park would be minimized.

In addition, the industrial park also offers other services in the health and safety area. These services might include:

- **Training** for workers of all companies on the industrial park in: awareness of hazards in the workplace, health and safety routines and procedures, emergency procedures, first-aid, reporting of incidents, accident prevention and safe conduct and so on.
- **An Information Centre** for chemical, including a library of source, prevention and emergency sheets for chemical. This should be included in the daily safety management system of the industrial park.
- Provision of some form of **Health Care Service**, either a small medical centre that can intervene in the case of minor accidents on the industrial park and provide consultancy service on safety and health.

## **14. EMERGENCY RESPONSE**

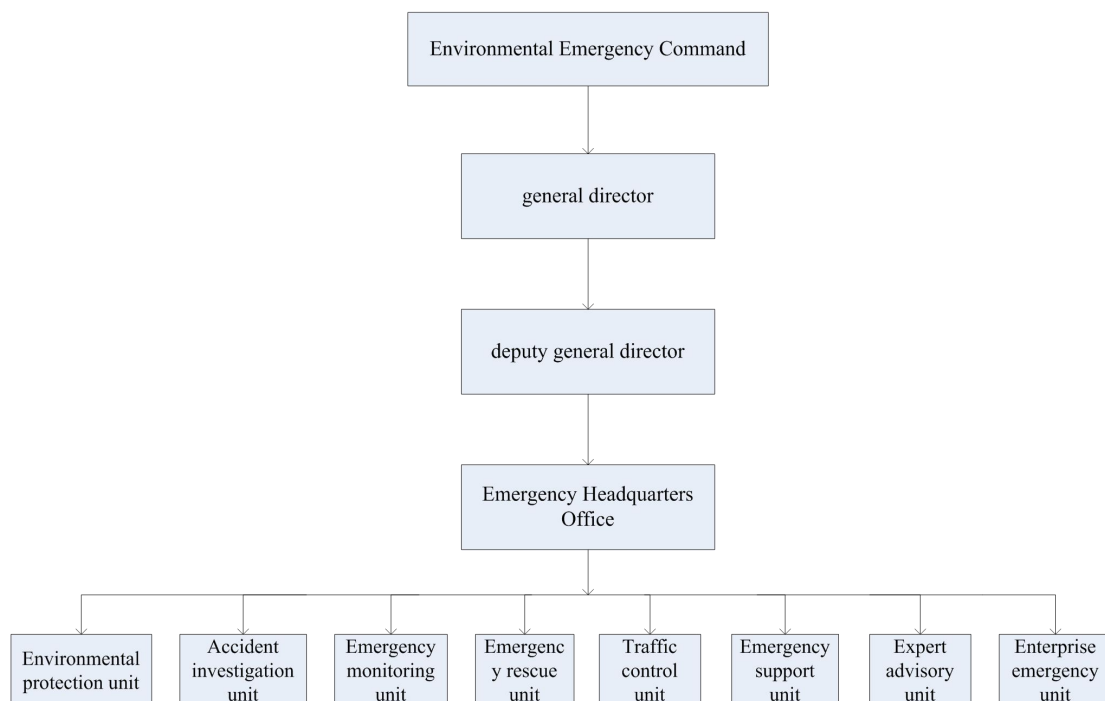
Emergency response mechanism is emergency plan, introduced by functional management departments, aiming at a variety of public contingency events, so that minimized loss can be guaranteed. In order to timely, effectively and safely prevent and treat various types of environmental emergencies, to improve the ability to respond to environmental emergencies, to protect regional ecological environment and the personal safety of the public, to maintain social stability and to promote comprehensive, coordinated and sustainable development among regional society, economy and nature, green industrial park should establish a series of emergency response mechanisms and prepare appropriate emergency plans focusing on waste gas, waste water, solid waste (including hazardous waste), hazardous chemicals (including toxic chemicals), electromagnetic radiation, radioactive sources and other aspects of environmental emergencies. Contingency plans should include establishment of emergency response agencies, grading response, emergency procedures and other aspects.

Green industrial park clings to the principle of territorial-based and grading response to implement emergency response and its main tasks are as follows:

- Accept environmental emergencies report, investigate causes of the accident, properties of pollution sources and processes of incidents development, then to respond immediately.
- Promptly report incidents of environmental pollution and ecological damage happened in the area to the management department of industrial park and environmental protection department of city and province.

- Participate in relevant emergency rescue work.
- Be responsible for handling environmental pollution caused by environmental emergencies occurring in the industrial park, command an emergency unit for emergency disposal.
- Guide the public to prevent and protect, assist the relevant departments to properly carry out disinfection and decontamination processing.

In accordance with the principles of emergent environmental incidents disposal work, emergency response framework should include environmental emergency command, emergency headquarters office, department emergency unit (departmental emergency rescue teams), enterprise emergency unit (companies of high environmental risks within area) and expert advisory group. The institutional framework is shown in Figure 14-1.



**Figure 14-1 Emergency response institutional framework in green industrial park**



Emergency response procedures include accident alarming, alarm handling, emergency response, information submission and procession and other aspects.

### **(1) Accident Alarming**

Accident unit should immediately call after the accident happens.

### **(2) Alarm Handling**

The police should report immediately to the environment emergency office after receiving alarm and the office shall immediately notify the relevant responsible department personnel and experts to the scene of the accident. Then, preliminary judges, which should be quickly reported to environmental emergency headquarter, are given about the grade and initial situation of accidents. Then headquarter dispatch related emergency unit to the scene and to conduct an early treatment for accident according to the situation.

### **(3) Emergency Response**

- Grading response: Depending on the severity and urgency of environmental emergencies, start response plan according to the incident grading.
- Emergency response level: issue a preliminary notice and dispatch emergency unit; analyze, judge, determine the tasks and organize security; issue an emergency notice.
- Emergency measures: implement relief operations with life-saving as primary objective; keep abreast of the progress of the accident and issue hedge warning to the community; implement dynamic monitoring to determine the nature, concentration and possible affected scope of the pollutant and report monitoring result to the authorities promptly; transfer , evacuees the potential endangered

people; mobilize emergency supplies.

- Emergency termination: secondary incidents should be noted at the end of emergency and carry out proper inspection for facilities, hidden investigation, officers appease and other follow-up work.

#### **(4) Information Submission and Procession**

- Post-disposal: include the aftermath treatment, the accident assessment, responsibility investigation, reconstruction, accountability and so on.

Supervision and administration: include publicity and training, exercises and drills, rewards and punishment, etc.