Chapter 8. Promoting New Technologies and Solutions

Given that Asia is the world's fastest-growing environmental market, there will be significant and growing opportunities for Asian-based small and medium-sized enterprises to meet local demand. Governments can promote enterprise development through an industrial policy that supports the growth of a national environmental industry.

The global market for environmental goods and services is huge and growing fast. The UN Conference on Trade and Development estimated that this market was worth about $607 billion per year in 2005. Given worldwide trends toward greater attention to resource efficiency and environmental management, the market is projected to grow to over $800 billion over the next decade.

The Asia and Pacific market is estimated to account for roughly $40 billion (or just 6.5%) of the current global market. However, the market is expected to grow at an annual rate of between 10% and 12%—the fastest in the world.[232] The overall annual turnover in environmental goods and services in the developing countries of Asia could triple to more than $100 billion by 2015.[233]

This could underestimate the size of the regional market, because environmental requirements will likely be tighter and growth in the environmental goods and services industry will likely accelerate. Furthermore, many types of environmental infrastructure investment are not included in these figures. Annual demand for infrastructure investments in East Asia alone already amount to approximately $200 billion.[234] Whatever the size of the market, expanding opportunities are increasingly attracting mainstream venture capital funds, financing technologies ranging from solar cells and lithium-ion batteries to software that boosts manufacturing efficiency.

This chapter discusses the role of governments in promoting enterprise development and developing new technologies, and looks at some major areas of environmental technology and services that investors should consider as solutions to resource efficiency and economic development.

Government's Role in Enterprise Promotion and Technology Development

A big part of government's role in promoting resource efficiency is to support the development and/or transfer of promising technologies. Governments set policies for manufacturing and service firms and for the operation of its own facilities and services. They are themselves major investors in environmental technology and research and development (R&D), and play a role in regulating and guiding private investors, such as banks and investment funds. They also have the power to reduce subsidies that discourage development and use of various technologies. The private sector is more likely to invest in new technologies, such as renewable energy systems, if public policy provides a favorable government regulatory framework that permits full cost recovery. The costs and risks must be shared by society or the lowest-cost alternatives will continue to dominate the market, especially given the greater uncertainties associated with the introduction of new technologies.

All these functions give government special leverage in promoting resource-efficient investments.

232 Environmental Business International Inc. and ADB staff estimates.

233 Ibid.

234 ADB, Japan Bank for International Cooperation, and World Bank. 2005. *Connecting East Asia: A New Framework for Infrastructure*. Manila.

Some strategies that governments can pursue include

- identifying opportunities for international joint ventures, technical transfer, and transfer of business models;
- creating business incubators to provide space, assistance in financing, and administrative support for startups—these are often funded through public-private partnerships;
- developing government procurement policies that support new enterprise development in environmental technology;
- coordinating research by government, university, and private research institutes to advance the technologies required;
- offering incentives and promotional programs for private investment institutions, encouraging them to make loans for new enterprise development and expansion of existing firms; and
- creating revolving loan funds (as public-private partnerships) to support the same types of loans, particularly for SMEs.

Here, we focus on three important roles of governments in promoting technology development: research and development, technology transfer, and technology evaluation.

Research and Development

For national governments, the importance of promoting R&D is central to supporting investment in the environment and energy industries for resource efficiency. Most new technologies originate in the more developed countries, although some adaptations of these technologies or indigenous technologies are also produced in developing countries. R&D may be carried out by educational and research institutions, by industry institutes, and by the companies themselves. Government can encourage R&D by providing grants through nonprofit institutions and by offering tax credits or similar incentives to firms for R&D expenditure, so long as results will be publicly available. Developing green industrial parks can also help centralize research and extension services by providing a home for new and expanding businesses, along with business associations, incubator services, and a research base to improve the success of investment in various sectors.

R&D of EE technology is not as common in most Asian countries as in Europe and North America due to lack of funding. Efforts in Asia center more on technology transfer or technology procurement instead of local R&D. In cases where local R&D does exist, the focus is usually on small-scale projects and equipment. However, investments in EE R&D can provide huge energy and cost savings for countries. Locally developed and produced EE technology may be cheaper to produce and sell in the long run than importing similar technology.[235] An example is given in Box 8.1.

Box 8.1: Innovative Irrigation in India's Deccan Plateau

One area where research has played a key role in the region is improving the productivity of water in agriculture. For instance, on India's Deccan Plateau, researchers relied on local expertise to help the tribal people of the Akole Taluka region improve their crop yields and replenish groundwater supplies by implementing simple strategies. Gullies were plugged and water was diverted, which slowed runoff, reduced erosion, and allowed water to pool and seep into the soil. Later, rooftop harvesting and storage tanks were built, filled first by rains each year and later, in the dry season, by bullock-cart deliveries. With higher food production and rising incomes, villagers are embracing the new strategies.

Source: Conway, Kevin. Local Solutions to the Global Water Crisis. Available: http://www.idrc.ca/en/ev-25649-201-1-DO_TOPIC.html

Technology Transfer

Another strategy is to promote technology transfer by supporting partnership development with companies in more developed countries. Companies based in the EU, Japan, and US are rapidly entering the growing Asian market for environmental goods and services, competing with local firms. However, they often benefit from joint ventures with these same firms and are themselves employers of the local workforce. In many cases, a foreign company with an advanced

235 UNEP. 2006. *Improving Energy Efficiency in Industry in Asia: A Policy Review.* Bangkok, Thailand.

technology may be relatively small and needs to partner with local entrepreneurs and technologists to market their innovations. Even larger firms usually find market entry in Asia and the Pacific easier with such a partner.

For instance, a US company builds, owns, and operates sludge treatment facilities, financing installations with outside money. The company supplying the sludge pays a tipping fee and has the choice of being a co-investor to receive revenues or energy from the facility. Many energy service companies favor a similar participation in the benefits of their intervention, and also open markets for new technology companies (energy service companies, page 82).

In addition, Asian entrepreneurs can benefit from collaboration within and among the different clusters of this industry. Often different types of renewable energy complement one another when integrated in a whole building design or an energy generation facility. For instance, fuel cells may become a highly efficient way to store power from intermittent sources like solar and wind. Policy makers can benefit from discussions with environmental trade associations on the types of incentives and market support that firms need.

Evaluating Environmental Technologies and Services

There is a great deal of innovation in environmental technology, both products and services. Competent, systems-based evaluation of environmental technology innovations is essential for understanding how they can most effectively be deployed, and possibly for opening up cost-effective use earlier in the development cycle. Public works managers, for instance, could use support in assessing the claims of competing salespersons offering solid waste management systems. At a higher level, they might benefit from examining broad strategies for cutting wastes to create a context for choosing among technologies.

Another important role for technology evaluation is assessing technologies for commercial application. A technology that appears effective at a bench test or as a prototype may fail when applied commercially. The failure may be strictly technical or come from errors in estimating the real costs of construction or operation. A commercially proven technology is typically preferable to one that is at an earlier stage. However, many municipalities and companies see high value in installing renewable energy systems or technologies for reducing GHGs even when such systems are not yet cost competitive. They want to build capacity in this area so they will be ready for more complete application later.

In addition, it is important to consider the support and maintenance needs of technologies. Often environmental technology investments fail because the system requires a level of support that is not available in the region where they are applied.

Some useful criteria for evaluation [236] are:

- Has the technology or service demonstrated success at a commercial scale?
- If it involves the use of a by-product, does it offer the highest and best use of that resource?
- What are the financial, environmental, and social impacts of using this technology (crop biomass energy, for instance, may use more energy—and cause more environmental impacts—than the energy it generates)?
- Does the technology require high levels of energy and water to function?
- What level of support and maintenance does the technology require? Can investors be sure that this support will be available at the sites where the technology will be used?
- Is there a financially feasible business model for the company or agency offering the solution and the one that will operate the technology?
- Do the technology's benefits justify initial public subsidy of the business? Perhaps it cuts public costs of disposal of solid waste or sludge or creates major employment opportunities.
- Does the innovation meet a narrow or broad need of sponsoring agencies, companies, or other end users?
- What are the opportunities for applying the technology as part of a more complete system?
- How does this technology or service compare with competing products in terms of these criteria?

[236] Lowe, Ernest. 2006. *Eco-Industrial Park Training Manual*. Prepared for Korean National Cleaner Production Center, Seoul.

Given all these possible criteria, it is important for technology evaluation teams to work with clear criteria to evaluate competing offerings. They must always watch for high-leverage solutions that offer benefits in several areas, such as a bioenergy system that processes both farm and village biomass (crop residues, manure, sewage, etc.), reduces contamination of water and land, and yields organic fertilizer along with biogas. An independent technology evaluation and strategic planning firm could fill a valuable role in this market. Parallel opportunities could be developed in supporting industrial plant managers and R&D teams.

Business Opportunities in Resource Efficiency

This section discusses some of the huge and emerging business opportunities that have arisen as part of the drive to use resources more efficiently. Investment by companies and government agencies to increase their resource efficiency opens domestic markets for new and expanding environmental enterprises. There are also growing export markets in this sector.

The business opportunities covered in this chapter are

- resource recovery firms, including collection, processing, reuse, remanufacturing;
- renewable energy and EE firms, including solar, wind, biomass gas and fuel, and geothermal;
- biomass production and processing (bioenergy and bioproducts);
- wastewater reuse for agricultural and urban uses;
- sustainable farming support companies; and
- green chemistry and nanotechnology companies and institutes.

Resource Recovery and Recycling

As discussed throughout this paper, by-products that were once regarded as wastes or low value by-products are increasingly looked at as valuable resources. As a result, initiatives to recover and treat used materials for reuse or recycling are increasing worldwide, and material markets arising from recovery are developing and expanding internationally. Similarly, "waste" water is increasing in value in the many water-scarce regions of Asia and there are markets for treated secondary water.

Integrated resource recovery systems manage by-products from industrial, residential, commercial, and government sources for optimal recovery of value. This creates major enterprise and employment development opportunities in collection, processing, reuse, remanufacturing, and bioenergy.

Source: Kojima Mickikazu, JETRO.

In most developing countries, biomass constitutes the largest portion of municipal waste streams and may be used as feedstock for the production of bioenergy or various products, such as nonchemical fertilizer (see discussion on biomass production and processing on page 130). However, other materials can be recovered and treated to be reused or recycled, including metals, plastics, paper, and waste electrical and electronic equipment (Table 8.1).

Waste recovery and recycling already form a profitable industry in the developed world. The Bureau of International Recycling estimates that the recycling industry employs about 1.5 million people and represents revenues of $160 billion worldwide.[237] A world waste survey estimated that the market revenue in Japan was $67 billion in 2000 and $47.3 billion in the US in 2003.[238] In highly industrialized

237 Lacoste, Elisabeth, and Philippe Chalmin. 2006. *From Waste to Resource: An Abstract of "2006 World Waste Survey*." Cyclope. Commissioned by Veolia Environmental Services. Paris, France.

238 Ibid.

Table 8.1: Typical "Wastes" and their Recycling Potential

Waste	Recycling Potential
Biomass	Several types of compost can be produced using biological processes and depending on the basic organic waste. In addition to regulatory incentives, the future of compost depends on its environmental and agronomic qualities and on the dynamism of its market.
Paper and cardboard	The exchange of recovered paper is increasing, notably in Asia and in particular in the People's Republic of China, whose imports are constantly increasing (17 million metric tons [Mt] in 2005). The recovery rate and the deposit level in Asian countries do not meet their demands. New investments are increasing the need for recovered and less expensive fibers.
Plastics	Increasingly stringent regulations and growing demand for recovered plastics, particularly in Asia, favor the development and internationalization of this market. However, due to many limiting factors (e.g., cost of collection systems, volatile prices), the recovered plastics market represents a low proportion of the 169 Mt of plastics produced globally in 2003.
Ferrous metals	Scrap metals are essential in the production of steel and have become true commodities. In 2004, world production of scrap metal rose to 450 Mt and consumption reached 405.5 Mt. Ferrous metals can be recovered from municipal waste (e.g., end-of-life vehicles, large electrical appliances, tin cans), construction waste, shipbreaking, and offcuts recovered from steel production.
Nonferrous metals	Most nonferrous metals reached record prices in 2005, which boosted supply and demand of secondary metal. The demand for aluminum, nickel, and copper is rapidly increasing in emerging countries.
Batteries	Prices reached by copper, lead, nickel, and cadmium over the last few years were high enough to cover the costs of collecting and recycling 15 billion batteries and accumulators thrown out each year around the world; 3.2 Mt of secondary lead is recovered worldwide.
E-waste	It is estimated that 10 million computers contain 135,000 metric tons of recoverable materials. Waste electrical and electronic equipment contains a significant quantity of recyclable materials, such as base metals (steel, aluminum, copper, lead, and zinc), silicon, glass, plastic, and precious metals (gold, palladium, platinum, and silver).
Asphalt and concrete	This material can be crushed and reused for a variety of purposes, such as base aggregate for street maintenance activities, backfill in sewer trenches, and road shoulder maintenance.
Ash and Slag	Brick makers and concrete mixing sites use fly ash as a low-cost ingredient that also can add strength to the product. Bottom ash is used in road construction and other construction requiring aggregates. Slag from blast furnaces can be used as an alternative material for cement production, and can reduce greenhouse gas emission from substituted limestone.
Sludge	Depending on the biological content, municipal sewage sludge and food processing sludge is a source for biogas energy using anaerobic digesters. Multi-stage digester processes can greatly reduce the bulk of toxic sludge, decreasing hazardous disposal costs and environmental pollution.

Source: Lacoste, Elisabeth, and Philippe Chalmin. 2006. *From Waste to Resource: An Abstract of "2006 World Waste Survey."* Paris: Cyclope. Commissioned by Veolia Environmental Services.

economies, major material industries and consumer goods makers are competing to expand their business in material recovery using their advantages of existing market networks, technologies, and know-how. This trend is supported by raising consciousness on EPR, as well as instruments such as product take-back and deposit funds.

In Japan, local governments are implementing policies geared toward the establishment of recycling-based systems with the support of the Ministry of Economics, Trade and Industry (METI). Kitakyushu City, the first city designated as a METI "eco-town enterprise," is implementing programs that will transform the Kitakyushu into a "full-scale recycling city" (Box 8.2).

Meanwhile, in developing Asia, a major formal industry is growing from its roots in the informal economy. In time, the recovery and recycling industry in developing Asia may surpass that of Japan and the US. ADB analysts estimate that the recycling market in Asia could reach $320 billion per year (assuming that recycling rates will double to 20% of the waste generated) and that future waste generation reaches European levels of about 1 ton per person per annum, at a conservative value of $80 per ton.

Box 8.2: Kitakyushu—An Asian EcoTown

The Kitakyushu Eco-Town Project is composed of the Comprehensive Environmental Industrial Complex, the Hibiki Recycling Area, and the Practical Research Area. The Comprehensive Environmental Industrial Complex enables companies to handle and distribute recyclables generated from a broad area. It features thermal and materials recycling. The Hibiki Recycling Area supports small and medium-sized enterprises that are venturing into the environmental industry by preparing business sites for long-term lease. The Practical Research Area acts as a center for environmental industries in the city by bringing together organizations that engage in research and development on cutting-edge environmental technologies in this area.

The city also implements a wide range of eco-efficiency measures toward making the city sustainable, including renewable energy development, treated sewage utilization, a biotope network, regional consumption of agricultural produce, biomass composting, greening of roof-tops and walls, a green village project, and a recycling port project. A new recycling program requires residents to separate recyclables at the source, using plastic bags of different colors for different types of waste. The program also includes recycling various items, such as old fluorescent lamps and milk and juice cartons.

Behind all of these movements is a full-scale effort to build collaborative activities with city stakeholders and interactive communications with citizens. There is a 10,000-strong citizens' forum for sustainable society, a children's eco-club, a regional currency project for eco-city development, an eco-partner project, community involvement for local cleaning activities, promotion of a community-based recycling system, and a green consumer project.

Source: Institute for Global Environmental Strategies. 2005. *Good Practices Inventory: Kitakyushu Eco-Town Project.* Available: http://www.iges.or.jp/APEIS/RISPO/inventory/db/pdf/0147.pdf

However, most countries in the region still have insufficient technologies in resource recovery and recycling (Table 8.2). As mentioned in Chapter 4, the 3R Knowledge Hub recently undertook research aimed at presenting the prevailing technology, management, and policy gaps preventing 3R implementation in 13 selected Asian countries. The study concluded that only Japan fulfilled almost all the technology aspects in the three areas studied—urban municipal solid waste, health care waste, and electronic waste (Box 8.3).

Fortunately, practices in developed countries like Japan, Republic of Korea, and Singapore can be considered as benchmarks. As discussed in the previous chapter, developing countries can fill technology gaps by leapfrogging to technologies that are found to be predominantly successful in developed countries, although this depends on their application, generation rates, and waste composition.

Much of the growth in this sector will likely occur in the PRC, where new legislation is supporting rapid growth of the industry, now valued at $5.4 billion per year. PRC authorities recently promoted the creation of the first national recycling business—China National Resources—to handle the potentially lucrative business of recycling electronics. By 2007, the company will invest up to $100 million to set up five large recycling industrial zones to serve the PRC's major manufacturing centers.[239] These zones will take waste materials from throughout their regions and will house recycling plants for every major commodity, including steel and aluminum, and will handle toxic chemicals like mercury and lead. Electronics manufacturers can subcontract them to make sure all of their used products are properly collected and recycled in accordance with the new laws. The company will also set up consulting companies to help electronics manufacturers comply with the new laws.

Over time, resource recovery and recycling will grow into a mature industry in developing Asia, featuring core resource-recovery businesses, manufacturing firms, and wholesale and retail businesses, as follows:[240]

Core resource-recovery businesses. These involve drop-off, buyback, and distributed collection strategies for discards, and may be operated by an integrated resource recovery program, by a resource recovery business association, or by collection companies. These companies include

[239] Wang, Peter. 2005, May. *Precious Waste: China National Resources Wants to Grow the Recycling Business into a Trillion-dollar Industry in the Country*. AsiaInc. Available: http://www.asia-inc.com/May05/Fea_precious_may.htm

[240] Lowe, Ernest A., and Andreas Koenig. 2006. *Eco-Industrial Park Training Manual.* Prepared for Korean National Cleaner Production Center, Seoul.

Table 8.2: Technology Status for Resource Recovery and Recycling of Three Types of Waste for Selected Asian Countries

Waste Category	Technology	Country									
		Bangladesh	Bhutan	Cambodia	PRC	India	Indonesia	Malaysia	Philippines	Thailand	Viet Nam
Urban Municipal Waste	Thermal Recovery		◊	◊			◊	l			◊
	Fuel Recovery		◊	◊			◊	l			◊
	Material Recovery		◊	n	n	®	n		n		n
	Sorting	n	®	n	n	®	n	◊	◊	◊	n
	Pulverizing		◊	n	®	®	◊	◊	◊	◊	n
	Composting	n	◊	◊			n	◊	◊	n	
	Incineration	®	◊	◊	l		®	l	®		®
	Collection	®	®	®		n	®		n		n
E-Waste	Material Recovery	®			n	®	◊	®	®	®	®
	Sorting	®	◊		®	®	®	®	®	®	®
	Pulverizing	®	◊		®	n	◊	◊	◊	®	◊
	Collection	®	®			®	◊	®	n		®
Health Care Waste	Thermal Recovery	®	◊	◊	n	n	◊	l		®	◊
	Fuel Recovery	®	◊	◊	®	n	◊	l		®	◊
	Material Recovery	®	◊	◊	n	n		◊		◊	◊
	Sorting	®	◊	®	®	n	◊	◊		◊	◊
	Pulverizing	®	◊	®	®	n	◊	◊		◊	◊
	Incineration	®	◊	®	N.I.	n	◊	N.I.			N.I.
	Collection	®	®	®		n	◊	®	®		

l = formal and strong; = formal and weak; n = informal and strong; ® = informal and weak; ◊ = technology gap; N.I. = no information, PRC = People's Republic of China.

Formal and informal denote the presence or absence of regulations, laws, and rules to govern an activity. An activity is said to be formal if it has specific laws and rules that mandate, enforce, encourage, and allow the activity within a specified regulatory framework. An informal activity is one that does not have any law, rule, or guiding policy; still, the activity might be happening by itself.

Strong and weak represent the level and scale of a particular activity. A strong activity typically uses state-of-the art technologies. A weak activity is one carried out at the micro and meso scale, often for livelihood purposes. Weak activities generally use primitive technologies and often operate haphazardly.

Technology gap denotes where no law or rule exists and the practice is totally absent.

Source: 3R Knowledge Hub Secretariat. 2007. Gap Analysis in Selected Asian Countries. Bangkok: Asian Institute of Technology.

- recycling firms that process paper, plastic, chemicals, glass, tires, biomaterials, textiles, and metals into usable feedstocks;
- niche collection companies that serve particular types of businesses by gathering and delivering unused materials to other firms, e.g., office discards, food and paper discarded by restaurants, solvents, and other chemicals;
- composting and soil mixing firms that target soils, ceramics, plant debris, putrescible items, and scrap wood (all organic and mineral materials with no higher-value use);

Box 8.3: Findings of the Survey on Gap Analysis in Selected Asian Countries

Municipal solid waste. 3R-oriented technologies, such as thermal recovery (direct combustion of waste to recover heat) and fuel recovery (production of refuse-derived fuel and packaging-derived fuel from waste), are effectively practiced in India, Japan, Republic of Korea, Malaysia, and Singapore. Such technologies as incineration are formally strong in the People's Republic of China (PRC), Republic of Korea, Malaysia, Philippines, and Thailand. Successful countries have good technologies and adequate management and policy instruments. In countries like Cambodia and Viet Nam, technologies for materials recovery, sorting, and pulverizing are informal but strongly practiced. Remarkable technology gaps were found in Bhutan, followed by Cambodia due to lack of national policies; barriers to international flow of information, technology, and services; and insufficient international cooperation.

E-waste. Japan was found to have formal and strong technologies like material recovery, sorting, and pulverization. Next are the Republic of Korea and Thailand, with successful practices in material recovery and sorting. Among the other countries, Cambodia has informal but strong practices, while Bangladesh and the PRC have largely informal and weak systems. This can be attributed to the insufficient management and policy frameworks.

Health care waste. Among the 3R-based technologies for health care waste, incineration is predominant in such countries as PRC, Japan, Republic of Korea, Malaysia, Philippines, Singapore, and Thailand. Waste-to-energy technologies for recovering heat energy, fuel, and materials were found to be practiced strongly in the Republic of Korea, Malaysia, and Singapore. In India, although various technologies are practiced, they are often informal, but strongly deployed. This is due to the inadequate policies and management systems. In countries like the Philippines, appropriate policies and essential instruments are in place but there is lack of cooperation and a dearth of good practices. Bhutan and Viet Nam are among the countries showing insufficient management systems and policies.

3R = reduce, reuse, recycle.

Source: 3R Knowledge Hub Secretariat. 2007. *Gap Analysis in Selected Asian Countries*. Bangkok: Asian Institute of Technology.

- construction and demolition businesses that collect and process debris from deconstruction or dismantling, used building materials (e.g., scrap lumber, doors, windows, plumbing fixtures, and ceramics), concrete and asphalt recycling, and processors of roofing materials, bricks, and mixed demolition debris;
- biomass energy firms that use selected organic materials to produce methane, ethanol, or methanol sludge from sewage treatment, pharmaceutical, food processing, and chemical plants are large-scale sources);
- biomaterials firms that process biomass to produce a variety of feedstocks, including some higher-value specialty chemicals;
- dismantlers that reduce such goods as older electronics and household equipment that cannot be repaired or reused, to usable components and, with good management, safe discards; and
- by-product specialists, who negotiate with industries to use discards not taken by other companies in a by-product exchange.

Manufacturing firms are a major component of the materials recovery sector. Examples include

- firms that use the feedstock created by the processors to manufacture recycled products;
- plants that remanufacture capital and consumer goods (electronics, construction, transportation, and medical equipment are major niches for remanufacturing);
- producers of equipment for resource recovery, renewable energy, and EE;
- repair shops for household and office equipment; and
- firms that draw on outputs of any of the above, such as: greenhouses and intensive agriculture with specialty food processing (energy, water, and carbon dioxide); fish farms (energy and water); microenterprises making products or crafts from recycled materials or offering repair services; environmental consulting and service companies; and investment recovery firms.

Wholesale and retail businesses involved in recovery include companies dealing with

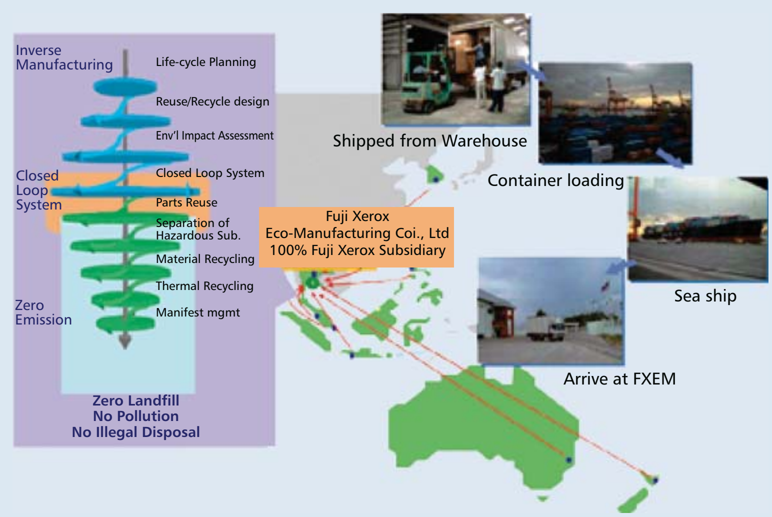
- reused household and office equipment, clothing, furniture, etc.;
- used and remanufactured industrial equipment and materials;
- finished goods from firms with high use of recycled materials; and
- brokering of recycled commodities.

The increasing international trade in secondary materials will continue to be a major driver for expanding resource recovery and recycling operations in developing Asia, despite the potential that such trade may lead to increased pollution and health risks (page 165). Several major multinational corporations have initiated efforts to establish global recycling systems that involve the collection of used products from various countries and disassembling them at a single plant, followed by the reuse or recycling of components. For instance, AER Worldwide, a global electronics recycling resource and components distributor, recently opened an electronics de-manufacture and sorting center in Penang, Malaysia. The center will provide original equipment manufacturers and contract manufacturers located in Asia with close-to-source material sorting and deconstruction services.

Another good example is Fuji Xerox Co., Ltd, which developed a take-back system, drawing on their lease-based business model that has proven effective in both developed and developing countries. In late 2004, the company opened a recycling factory in Chonburi province, Thailand, the first case in Asia of a company crossing borders to set up a regional recycling center (Figure 8.1). The factory recycles end-of-life copy machines that are collected from the company's nine operation sites in Asia and the Pacific.

Initially, senior Thai government officials objected to the plan, questioning the necessity of bringing waste from other countries into Thailand. The Government of Thailand imposed two conditions: (i) no import of wastes or used products for final disposal in Thailand, and (ii) reexport of hazardous elements to countries with appropriate treatment facilities. In response, Fuji Xerox has proven itself to be a leading recycling company. It has achieved a 99.6% waste recycling ratio (in terms of weight) based on its system of separating the collected materials into 64 different categories that include iron, aluminum, lenses, glass, and copper.

Figure 8.1: Transnational Recycling Mechanism by Fuji Xerox



Source: Watanabe, Tomio. 2006. Fuji Xerox International Resource Recycling System in Asia-Pacific Region. Presentation at Asia 3R Conference. 30 October–1 November. Tokyo.

Alternative Energy Business Development

As discussed earlier in this report, the accelerating rate of climate change, along with increasing fuel prices, is driving increased interest in EE measures, as well as increased commercialization of renewable energy technologies. The pace is expected to grow even more with the help of CDM, which will allow EE and renewable energy projects executed in developing countries to generate revenues through certified emissions reduction.

The primary categories for alternative energy business development include the following:[241]

Energy service companies (ESCOs). As described earlier in this report, these companies conduct energy audits, design more efficient energy systems for new and existing buildings or processes, and play a key role in design of systems for cogeneration

[241] Lowe, Ernest A., and Andreas Koenig. 2006 *Eco-Industrial Park Training Manual*. Prepared for Korean National Cleaner Production Center, Scoul.

and cascading of energy from one quality of use to another. Such ESCOs often offer to design, build, and finance performance-guaranteed system improvements. Many also offer training in energy conservation behavior for both industry and commerce. Energy services could be part of a comprehensive resource service company (RSCO) that also works to optimize water and materials efficiency.

Manufacturers of EE equipment. EE equipment is increasingly being designed and produced in the region, including products for more efficient lighting, heating, ventilation, and air conditioning systems; appliances; insulation; windows; industrial and office equipment; and energy-use sensors. National policies and instruments with clear EE targets can play a key role in promoting this trend, as can ecolabeling schemes and RoHS legislation.

Manufacturers of equipment for renewable energy. Such products include wind energy generators and support equipment; solar cells; fuel cells for energy generation and transportation; solar water heaters; biomass energy systems, including landfill gas recovery, digesters, and combustion; sterling engines; and ocean energy from waves and thermal gradients.

Specialty engineering services. These offer resource assessment, feasibility studies, cost analysis, planning, design, project coordination, and installation/startup contracting services, as well as ESCO models of design, build, and finance performance-guaranteed renewable systems and system improvements. An example is engineering and construction of ground, heat-pump geothermal systems to cool buildings in the summer and warm them in the winter.

System integration. Integration could emerge in the next decade as a significant business opportunity. The feasibility of using renewable energy could be enhanced by integrating two or more of the technologies needed to best meet a specific site's needs. A company serving as energy systems integrator for industrial facilities or for commercial, office, and residential buildings could serve a variety of functions in engineering/design, installation, and maintenance. Such a company could assess the customer's energy requirements and budgets, determine EE strategies that can reduce the demand, select the optimum combination of renewable sources, and coordinate installation of the system. It could also negotiate financing and sales of excess energy to utilities. Depending on the tax structure and incentives provided, such a company could conceivably operate as a distributed utility, owning the equipment and selling the energy services.

Fossil fuel plants require large, long-term investment, with scale usually based on projections of present levels of EE. Wise investors would use scenario planning to view alternatives, including much higher efficiency of use, more rapid commercialization of renewable systems, and diversified energy portfolio investment.

One of these alternatives is distributed renewable energy systems that, with incentives for EE and conservation, can reduce or avoid large investments in fossil power plants and transmission grids. In regions without major power plants and distribution grids already built, a distributed, integrated system of renewable energy sources can be cost-competitive with fossil fuel-based systems and the costly power grid they require. For instance, new urban development in some regions of western PRC involves constructing basic infrastructure and offers the opportunity to use decentralized approaches.

Policy makers need to do a whole-system cost-benefit analysis, counting the benefit of using biomass rather than disposing of it, the high line loss of energy in electricity grids, and the cost of pollution from coal or oil fired plants. The benefits of such a distributed energy system would be enhanced by energy conservation policies as well as policies and building codes supporting high-performance design of new buildings and facilities.

Biomass Production and Processing[242]

In most Asian countries, the majority of the municipal waste stream is biomass, most of which is discarded in landfills or dumped in the countryside. Industries,

242 This section is based on materials from Indigo Development (www.indigodev.com) and policy options from an Eco-City planning process for the Dalian Development Zone in the PRC, conducted by RPP International and Indigo Development. Ivan Weber, President of Weber Sustainability Consulting made major contributions.

public utilities, and households waste valuable natural resources at a significant cost to the economy. Discarded organic resources (wastes) come from many different sources and occur in many forms and with many attributes. Potential supplies of biomass include both virgin materials from dedicated crops and a high variety of residues from harvesting, waste streams from processing, wholesale and retail consumers, and collection systems. Only a few types of discarded biomass are now recovered, e.g., landscaping discards to compost and food scraps for animal feed. Farmers may plow a portion of crop residues into soil or use them for compost, but many still burn them, adding to local air pollution and GHGs.

Most current recovery of biomass discards operates at a relatively low economic value. A potentially profitable goal for Asian economies is to establish a system for highest-value conversion of biomass to both energy and materials. Achieving this goal could enable business development, delivering services and technologies throughout Asia. However, many large and small schemes in the region have not worked or are not operating at full capacity. The resource-recovery industry, including biomass processors, is underdeveloped and fragmented in many Asian cities and regions.

There are a number of reasons for this, including high operating and maintenance costs compared to open landfills and incomplete separation of materials, such as plastics and glass, which results in poor quality compost for agricultural application. Environmentally preferred energy, products, and materials from biomass also face a market-entry challenge because they compete with traditional producers, while fluctuations in supplies cause unstable prices for recovered materials. New businesses in emerging fields tend to have a high failure rate.

In pursuing opportunities in production and processing of biomass, it is important to understand some of the potential problems that may result. Planners must consider that too-heavy focus on the commercial viability of technologies for biomass recovery may delay emergence of more productive and value-adding options. For example, some organic chemistry products and hydrogen for fuel cells could become commercially feasible sooner in integrated biomass processing systems. In addition, when the biomass processing industry is developed, it risks damaging environmental impacts to air, water, and land, as discussed in Chapter 3.

The following discussion of business opportunities in this sector covers opportunities to convert biomass to energy (bioenergy) and biomass to products (bioproducts), as well as the integration of production and processing of biomass resources.

Bioenergy

Conversion of biomass to energy involves various techniques and sources, such as crops for biofuels or waste sources from garbage, sewage sludge, landscape trimmings, and farm and food-processing residues. Bioenergy schemes have been developed as one way to address rising energy costs, energy independence, and GHG control. PRC, India, and other Asian countries are advancing with large and small projects. However, conflict with food production and impacts on sustainable land use and ecosystems need to be carefully assessed in planning this option.

There are many commercially proven technologies for creating biogas and biofuel from either virgin or discarded biomass. A number of emerging technologies should also be considered for testing and development. Two levels of economic development can be pursued: (i) attracting companies that manufacture equipment, and (ii) developing the energy companies that use local biomass for generation. Some of the leading development opportunities in the region include

- ethanol fermentation plants using crop and food residues, or specific bioenergy crops using corn, cassava, coconut oil, etc. as an input (Box 8.4);
- facilities producing methane and fertilizer from animal manure or sewage sludge with anaerobic or aerobic digesters—generators can use the methane to produce electricity, as direct input to some types of fuel cells, or cracked to yield hydrogen for other cells;
- companies operating distributed methane producing systems, with equipment placed on large farms and dairies or next to sewage plants;
- fuel cell technologies to produce energy—hydrogen can be produced directly from some processes or from methane;
- firms manufacturing biomass processing

Source: AFP.

equipment, including fermentation equipment for ethanol, digesters to produce methane, generators to burn methane, and bulk materials transport and handling equipment; and

- farms growing dedicated crops for biofuel and biogas.

In addition, significant opportunities exist in Asia to retrofit existing and closed landfills to capture and treat methane emissions, a major GHG. Landfill gas (LFG) is a reliable and renewable fuel option that represents a largely untapped environmental and energy opportunity at thousands of landfills around the world. LFG systems collect and control gas emissions through a system of wells and prevent subsurface migration of gas off site. The most common market options for LFG are on-site power generation for on-site needs (leachate handling, lighting, etc.), power export to the grid, and short-distance transmission of low-to-medium heating value gas to adjacent industrial users.[243] In the future, the development of these landfills into bioreactors should further improve technical, environmental, and economic performances related to the production of biogas from waste. Projects to capture methane and carbon dioxide from landfills can be used to obtain emission reduction certificates under the CDM.

Government policies on energy and solid waste management can promote or hinder the beneficial use of LFG. Currently, most governments in the region have not enacted legislation requiring methane capture from existing or closed landfills. Project developers can be subject to different and sometimes conflicting laws at the local, regional, and national levels. Another important issue is the structure of energy prices. As countries begin to implement laws, regulations, and policies to improve solid waste management practices, promote alternative energy, and address GHG emissions, the economic viability of LFG energy projects will improve and investors can be

Box 8.4: Using Coconut Oil as Fuel in the Pacific Islands

Struggling with rising oil prices, Pacific island nations are increasingly looking to coconut oil, long a basic foodstuff, as an economically and ecologically sound petroleum alternative. Today, residents of the Cook Islands, Marshall Islands, Samoa, and Vanuatu use coconut oil as fuel for diesel engines, although on a relatively small scale. Trials have shown that a blend with diesel works best.

Coconut oil is seen as an inexpensive and efficient renewable energy source, particularly in Vanuatu, which has a population of 217,000 people and spends about 20% of its annual budget on imported petroleum. Increased reliance on coconut oil could help such island nations reduce their dependence on imported gasoline. It is cheaper, costing about $0.80 per liter compared with $1.17 for diesel. It also does not pollute.

And if it catches on as a fuel source, it could rescue Pacific island economies that have been hard hit by plummeting prices for coconut oil, one of their chief exports. However, the economics of using coconut oil for fuel are marginal, although the copra industry is already subsidized in many island countries, making diesel substitution more viable.

Ironically, the growth in the use of biofuels worldwide has helped push the price of crop oils higher and coconut oil now fetches nearly $1,000 a ton. There is a strong demand for vegetable oils in the United States and Europe. The Pacific island countries could get into a situation where they cannot afford to use the oil themselves and would profit more by sending their oil to other countries. One of the drawbacks of coconut oil, and one that will limit its export potential, is that it can be used as fuel only at a minimum ambient temperature of 17° celsius.

Sources: *Terra Daily*. 2005. Pacific Islands Look to Coconut Oil as Energy Saviour. 18 January. Available: http://www.terradaily.com/2005/050118033932.d0dgfeuw.html; Brooks, David. 2007. Pacific Islands look to coconut power to fuel future growth. Philippines Inquirer.net. 24 September. http://services.inquirer.net/print/print.php?article_id=90397

243 Nexant. 2004, November. *Study of the Market Potential for Recovered Methane in Developing Countries.* Prepared for USAID Global Climate Change Team. Available: www.usaid.gov/our_work/environment/climate/docs/nexant_mpm.pdf

more secure in the technical and policy framework that supports LFG energy projects.[244]

One important issue for project development is that open dumps and unmanaged landfills are the predominant disposal options in many developing countries. These sites can be less than optimal candidates for LFG energy development because they contain only small amounts of methane (resulting from aerobic degradation and rapid waste decomposition). However, many developing countries are currently transitioning to landfills from more uncontrolled systems. Sanitary landfills are a more environmentally sound disposal option for these countries, but they also will produce more methane.[245]

Another option for converting biomass to energy is waste-to-energy (WTE) conversion. At an incineration plant, combustion with recovery of energy involves treating waste to produce energy (heat, steam, or electricity) to supply other facilities or houses. The energy produced by waste incineration represents a significant proportion of energy needs in countries that have relatively high ratios of incinerated municipal waste per capita. In Japan, where the incineration market is currently estimated at $4 billion, 236 plants produce the equivalent in energy of a nuclear power station. Japanese companies are now beginning to build WTE plants in the PRC and Southeast Asia, where local governments are struggling to cope with overflowing landfills and huge volumes of waste. As part of its 10th Five Year Plan, the PRC will spend 50 billion yuan (CNY) ($6.5 billion) to construct municipal garbage treatment plants, half of which will be spent on incineration plants.[246] Japan is also building refuse-derived fuel (RDF) facilities (Box 8.5)

Many factors limit WTE operations using waste or refuse-derived fuel. Cost is one such factor. Combustion of municipal solid waste is a capital-intensive process, with net costs highly sensitive to the scale of operation and the revenues received for the energy recovered. In addition, in the developed world almost half the investment cost is in emission control systems. Another factor is the calorific power of waste, which is especially relevant in developing countries. For combustion technologies to succeed, they require about 2,000–3,000 calories per kilogram (cal/kg). Otherwise, auxiliary fuel has to be added. Indian garbage has an average calorific value of only about 800 cal/kg.[247]

Also, all the negative impacts of incineration need to be considered for WTE facilities. Conventional incineration facilities emit toxic compounds, such as dioxins and furans, heavy metals, and other pollutants. However, advanced facilities are now designed to optimize the volume of usable material outputs, as well as energy, making WTE a relatively safer option for countries that can afford high-end incineration technologies. Developers of WTE need to work closely with environmental and solid waste agencies and NGOs to ensure that the technologies are evaluated according to the strictest air, water, and solid emissions standards.

Finally, incineration even with the capture and use of the energy, is not necessarily the highest value use of the waste. Other options, such as composting and processing for chemicals recovery, may offer higher value, both financially and in terms of the efficient use of resources.

Bioproducts

Although bioenergy is receiving the majority of attention for utilization of both crop and residual biomass, biomaterials (or bioproducts) also present very positive opportunities for business development using this resource. As discussed on page 15, the world has witnessed a dramatically increased use of nonrenewable materials. Due to cost and/or more desirable properties, synthetic fibers have replaced natural fibers, synthetic oil has replaced natural oil, and plastic has replaced wood. However, rising concerns about future supplies of petroleum, along with high oil prices are stimulating interest and investment in renewable plant and crop-based sources.

A 1999 industrial chemicals and materials future scenario developed by the US Department of Energy

244 *Methane to Markets*. Available: http://www.methanetomarkets.org/landfills/landfills-bkgrd.htm

245 Ibid.

246 McIlvaine Company. 2004, Jan. *Scrubber/Absorber Update*. Available: http://www.mcilvainecompany.com/ sampleupdates/ScrubberAdsorberUpdateSample.htm

247 Toxic Link. 2005, *30 Apr. Campaign Against RDF and for Sustainable Waste Management in Delhi: Petition by environment, health, labour, civil society groups. Available:* http://www.toxicslink.org/alert-viewp.php?alertnum=6

Box 8.5: Refuse-Derived Fuel Facilities in Japan

Refuse-derived fuel (RDF) typically consists of pelletized or fluff waste that remains after the removal of noncombustible materials, such as materials and glass. The remaining material is then sold as RDF and used in dedicated RDF boilers or co-incinerated with coal or oil in a multifuel boiler.

There are more than 50 RDF-related facilities in Japan. One of these is located in Tado, Mie Prefecture. The Mie RDF power station has an output of 12,050 kilowatts, burning 200 tons of RDF a day at the maximum. The output is enough to meet the electricity demand of some 20,000 households. By using RDF produced in 26 municipalities in the prefecture, the power station can save energy equivalent to some 100,000 drums of petroleum a year, which means that Mie Prefecture will be able to reduce the emission of carbon dioxide equivalent to 0.6% of its target of carbon dioxide emission reductions.

In August, 2003, an explosion occurred at the Tado power plant due to inappropriate storage of RDF. This was one of a number of sequential troubles reported at RDF facilities, which resulted in strengthening technical and safety guidelines for RDF facilities.

Sources: *Kippo News.* 2002. Power stations using RDF comes on line in Mie. Vol. 9, No. 406. 11 December. Available: http://www.kippo.or.jp/KansaiWindowhtml/News/2002-e/20021211_NEWS.HTML; Institute for Global Environmental Strategies. 2003. Top News on the Environment in Asia. Available: http://www.iges.or.jp/en/pub/asia_2003.html

suggests what may lie ahead. The authors envisioned that 10% of industrial chemicals and materials would come from renewable resources by 2020, with as much as 45–50% from renewable sources by 2050. In the course of this coming biorevolution, there will be a relatively rapid shift to reliance on plant and crop-based resources for a significant portion of energy and chemical products.[248]

While it is unlikely that renewable materials will provide all of the basic building blocks of the future economy, the potential for bioproducts is vast and is far greater than is currently being realized. Using a number of current and developing technologies, an array of biobased materials—from forest thinnings and crop residues to animal and human wastes—can be transformed into a wide variety of products, including power, liquid fuels, plastics, chemicals, and chemical feedstocks (Figure 8.2).

Biomaterial opportunities range from relatively low-value composting of biomass to production of specialty materials for construction and green chemicals, such as:

- specialty paper mini-mills using fiber by-products such as rice or wheat straw;
- building products plants using fiber by-products, such as fiberboard, particle board, and laminated beams;
- biorefineries producing organic chemical feedstocks and products, such as feedstocks for chemical and other product formulation (e.g., polymers, nonpolymers produced from lignocellulose, or its components of cellulose, lignin, and hemicellulose); and final products, such as ketones, alcohols, glucose, furfural, and organic acids;
- bioplastic plants utilizing feedstock from the biorefinery;
- solid and liquid fertilizers from methane generators and biofuel processing plants;
- composting facilities; and
- animal feed production plants.

The bioproducts movement will have many advantages, but will also come with significant challenges. One of the many advantages is that the movement can be carbon neutral. The growth of replacement crops can sequester atmospheric carbon in a quantity equivalent to that released when the harvested crops are burned, representing a substantial advantage over the combustion of fossil fuels. At the same time, significant bioenergy production can only be obtained by bringing vast areas of land into production and using significant amounts of water, which may conflict with food security.[249]

248 US Department of Energy. 1999. *The Technology Roadmap for Plant/Crop-Based Renewable Resources 2020*. Office of Industrial Technologies, Energy Efficiency and Renewable Energy. Available: http://www.agrotechcommunications.com/pdf/technology_roadmap.pdf#search='Chemical%20and%20Material%20Demand%2010%%20from%20Renewable%20Resources%20by%202020'

249 Bowyer, J., J. Howe, P. Guillery, and K. Fernholz. 2005. *Bio-energy—Momentum is Building for Large Scale Development*. Minneapolis: Dovetail Partners. 20 May. Available: http://www.dovetailinc.org/documents/DovetailPulpPaper0705new.pdf

Figure 8.2: An Integrated Bio-Economy Has Many Facets

Integrated Biomass Production and Processing Systems

A successful biomass production and processing system needs to adapt to changes in supply and demand, including seasonal fluctuations. Seeing suppliers as a system and understanding the logistics of materials acquisition from these different sources help to support this adaptation. The outputs should include both energy and materials products, matched to market demand in the area. Planning for bioenergy and biomaterials should recognize the synergy and potential resource flows between the two types of facilities. With a systems approach, it is easier to define solutions that seek the highest-and-best reuse. It also supports incorporation of evolving technologies as they approach commercial feasibility.

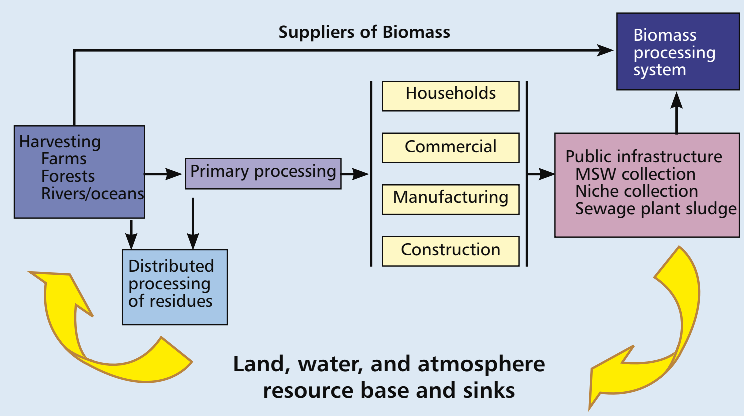
This complexity means that the potentials and problems of utilizing them demand a systems approach, not a piecemeal one (Figure 8.3). Economically feasible and environmentally sound recovery of these abundant resources depends on combining the best mix of low- and high-technology solutions in a system that optimizes use of the organic discards available. Some guidelines for optimizing production of biomass are provided in Box 8.6.

The business success of organic materials resource recovery may depend on the integration of networks of companies more than the establishment of large enterprises. The complex would incorporate plants performing different functions, including coordination and support, energy generation, and materials production. The diversity of sources, inputs, and products may be handled most effectively by this sort of value added network approach. The appropriate balance of companies in the complex would be determined by the supply and demand in the region—supplies available from virgin plant sources and discards of biomass from all sources as well as demand from markets for energy and materials.

An integrated biomass processing system would be analogous to a petrochemical refinery, with different units producing energy and material products through a sequence of refining steps (Figure 8.4). The primary difference is the high diversity of feedstocks and suppliers and the nature of the specific production processes. Some units in the system could be distributed to be close to supplies, such as digesters to produce methane from farm animal manure. Others would benefit from co-location, and possibly from integration with a standard petrochemical complex.

Such networks frequently function with a hub member that serves in a coordinating and resource-

Figure 8.3: System for Biomass Production and Processing



MSW = municipal solid waste.

Source: Lowe, Ernest. 2003. Report to the Dalian Development Zone on the Eco-Planning Process Phase 1. RPP International and Dalian University of Technology.

Box 8.6: Guidelines for Optimizing Production from Biomass

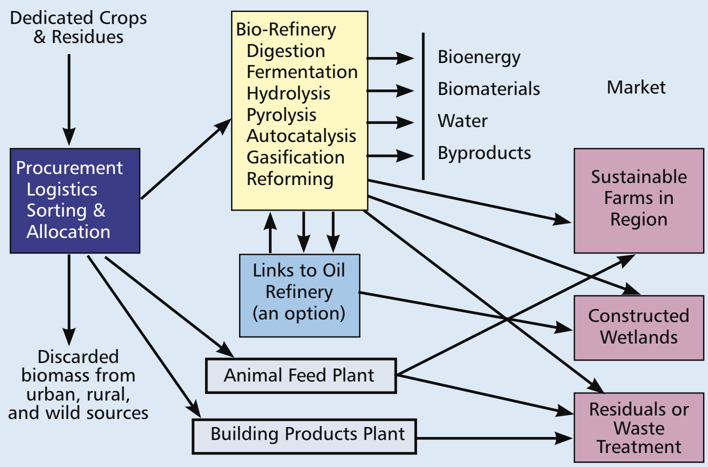
- In the allocation of discarded biomass resources, seek the highest-and-best reuse for each class of materials.
- Consider the business interests of traditional processors, such as composting lots and food waste collectors serving animal farms. These firms have a role in the whole system.
- Classify discarded organic materials as far upstream as possible to maximize resource value and allow strategic separation or blending, as technological choices dictate. Shipping costs, embodied energy, processing requirements, and impacts must all be considered in classification in the "high-to-low" or "upstream-downstream" continuum of relationships specific to a system for processing such materials.
- Many technologies that can recycle discarded biomass may also utilize crops grown for the purpose (e.g., soy, rapeseed, and others for biodiesel; sugarcane, corn, and cassava for ethanol; and production of organic chemicals). Design of resource recovery systems needs to balance the management of supplies from both discard and virgin resource streams. The redundancy of sources helps the system deal with short-term interruptions affecting any one supplier.
- Scale of operation is critical. Some technologies may not be feasible if resource streams are restricted to those available within a site, neighborhood, or industrial community. If, however, transportation costs, infrastructure, and administration allow absorbing materials from a broader region, some projects may attract a volume of supplies that is economically feasible (e.g., cooking oil from urban and institutional restaurants, wood and agricultural fiber wastes from forest or food processing operations).
- Distance is critical. Most supplies to a biomaterials processing system are bulky and of low value. Some technologies can and should be distributed systems, rather than centralized ones, particularly those with inputs from farms.
- Energy and water inputs are necessary to operate biomass recycling processes. Use of renewable energy inputs lessens the environmental burden of these forms of recycling. Where possible middle or gray water inputs should be used.
- In designing systems to utilize organic discards, consider the problems, needs and constraints that may be outside the usual scope of "waste management." These include water treatment, energy production, agricultural nutrient needs, soil amendment needs, landscaping, air quality, and neighborhood quality of life.
- Solving environmental problems of biomass recycling must be factored into economic feasibility analyses (e.g., prevention of sewage outfalls into coastal waters may avoid contamination loading, but may not be intrinsically feasible without accounting for the public-sector value of that diversion and treatment).
- Some counter-intuitive decisions may be valid, such as placing more organic waste of selected types into landfills that are well-designed to produce and capture biogas for fuel cells.

Source: Lowe, Ernest. 2003. Report to the Dalian Development Zone on the Eco-Planning Process Phase 1. RPP International and Dalian University of Technology.

allocating role, based on competitive bidding or a quota system. This logistic function is essential to the success of the whole system of businesses. The central coordinating organization would be responsible for optimizing flows to serve the whole system and balancing the needs of each member company. It could function in a brokering role or strictly as an enabling entity. The system needs to balance the need for long-term contracts between suppliers and customers with the ability to adjust flows based on seasonal variations in both supply and demand. As hub to a network of companies, this entity could also market products, as the firms choose. The coordinator could be a for-profit business or it might be an organization formed by the network to serve the common interests of its members.

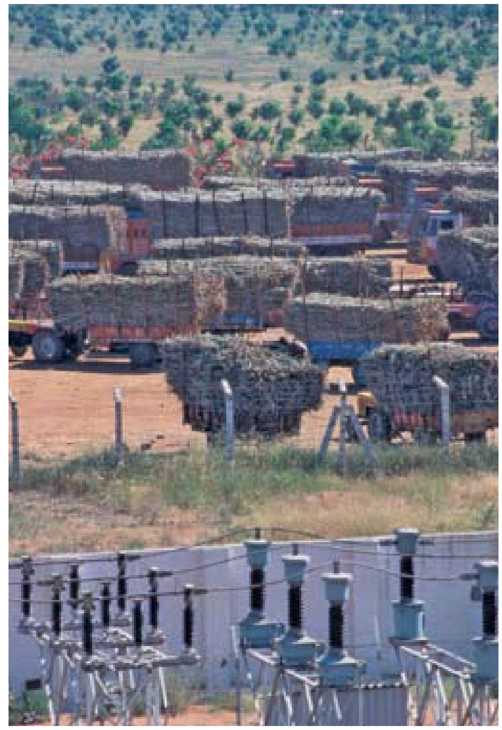
Clearly this model is more complex than planting huge monocultures of fuel crops and building single-function processing plants. It requires regional leadership, expert guidance, entrepreneurs committed to sustainable business, investors who are willing to learn how the complexity actually safeguards their capital, and widespread citizen participation.

Figure 8.4: Elements of Regional Biomass Processing for Optimal Utilization



with input from Anita Burke, the Catalyst Institute

Source: Lowe, Ernest A. 2007. Integrated Regional Action Planning of Biomass Utilization. Presentation to California Association of Resource Conservation and Development Councils Fall Conference, 25 April. Indigo Development.



Wastewater Reuse for Agricultural and Urban Uses

Countries that wish to pursue decentralized and integrated wastewater reuse as described in Chapter 7 will benefit from promoting system-level solutions. Knowledge and skill in the design of decentralized water treatment is an important asset, as is experience in getting the highest performance out of central sewage treatment plants.

Water management includes companies with products and services for

- a spectrum of filtration systems with costs and engineering appropriate for different flows;
- distributed sewage treatment systems that yield water suitable for secondary uses in the community;
- constructed wetlands for pretreatment of river water and/or for tertiary sewage treatment, through ecosystem processes on dedicated lands other than natural wetlands;
- living-machine water treatment systems that use ecological processes in closed environments;
- industrial, commercial, and home equipment that reduces water demand;
- engineering of secondary water distribution systems (gray or middle water);
- water purification technologies, including toxic cleanup and home purification; and
- coastal energy systems for water treatment (salt gradient solar ponds, tidal and wave energy, etc.).

Opportunities also exist for RSCOs that can provide packages of integrated solutions to a combination of industrial, government, and commercial clients. These can include design of water systems for new buildings, audits and rehabilitation plans, systems of water efficient hardware, conservation management practices, and system engineering. Components of this system include onsite, distributed treatment of water and sewage; minimization of water use; recycling of water used; and application of related renewable energy technologies. Unique synergies will develop when a variety of the best available practices and technologies and innovative business models are developed as a whole system. Thus, collaboration with energy service companies can generate synergies offering further cost savings.

Some countries are already getting much of their agricultural water from recycled and treated

Box 8.7: Ecosanitation in Nepal

The Environment and Public Health Organization (ENPHO) in Nepal is trying to revolutionize the way municipal governments approach their water pollution problems, in part by introducing ecosanitation (ecosan). For years, ENPHO has watched local governments struggle with the financial and technical capacities to manage the more modern and sophisticated sanitation and wastewater treatment systems that donor money has bought them. As an alternative, ENPHO works with communities and local governments to adopt low-technology sanitation solutions. The logic is to keep systems simple, affordable, and manageable.

Supported by the Asian Development Bank's Pilot and Demonstration Activities (PDA) program for water, ENPHO was able to install more than 150 ecosan units in low-caste households in the Kathmandu valley by the end of 2005. Ecosan is a dry toilet system that collects and recycles urine and feces separately as organic fertilizer and conserves the use of water. The basic principle of ecosan is to close the loop between sanitation and agriculture to help prevent diseases, protect the environment, conserve waste, and recover and recycle nutrients. Ecosan recognizes that human excreta is a resource, not a waste; that water is a precious resource that should not be used to transport excreta; and that excreta should be managed as close as possible to its source. After installation of these toilets, people in the communities are quite impressed with the technique and are demanding more.

Source: Alipalo, Melissa Howell. 2006. Simple, Low-technology Solutions to Sanitation Problems Offer Communities Affordable and Manageable Means to Improve Their Quality of Life and Environment. *ADB Review*. April-May. Available: http://www.adb.org/Documents/Periodicals/ADB_Review/2006/vol38-1/viable-alternatives.asp

wastewater. However, it is not cheap to restore water to a standard suitable for agriculture, especially if the water goes to irrigate food crops. The success of projects is greatly influenced by local circumstance and experience, but health and environmental precautions are always critical.

Many promising schemes involve recycling gray water from showers, kitchens, and laundry facilities into water fit for irrigating small market gardens. A research project initiated by IWMI in the Musi River area in Hyderabad, India, studied the importance of wastewater for the livelihoods of various groups of people. The study found that a wide range of income-generating and income-saving activities are sustained by wastewater irrigation. For example, using recycled water, para grass has overtaken paddy cultivation and can be harvested for more than 20 years without replanting. Wastewater is also used for fisheries and toddy.[250]

Small household and village gray water systems, as well as ecosanitation schemes (Box 8.7), can generate enough income to cover building and maintenance costs. The revenue gained from selling additional produce is often enough to encourage local participation. Where these systems replace septic tanks, households save further on the cost of pumping them out. As an added benefit, such projects frequently favor women because women play leadership roles in financing, operating, and managing both water treatment systems and market gardens.[251]

Sustainable Farming and Support Enterprises

The transition to sustainable agriculture appears to be inevitable due to the high consumption of fossil fuels in conventional farming, as discussed in the previous chapter. The transition to sustainable farming opens unique business development opportunities. The support system for sustainable farming requires new understanding and skills not usually available to the earlier providers of petrochemical materials and services.

Enterprises to serve sustainable farming include

- manufacturers of equipment and products that support sustainable farming:
    - farm monitoring and information systems for efficient water and nutrient management;
    - water and nutrient delivery systems;
    - light-weight, low-impact, energy-efficient cultivation, harvesting, and hauling equipment;

250 International Water Management Institute (IWMI). *Smallholder Water Management Solutions*. Battaramulla, Sri Lanka. Available: http://www.iwmi.cgiar.org/smallholdersolutions/index.asp?nc=8851&id=685&msid=132

251 Conway, Kevin. *Local Solutions to the Global Water Crisis*. Ottawa: International Development Research Centre. Available: http://www.idrc.ca/en/ev-25649-201-1-DO_TOPIC.html

  - o organisms and services for pest management; and
  - o blends of custom soil amendments for high productivity and soil renewal.
- nursery for growing plants for farms, reforestation, and wetlands restoration;
- a farm marketing cooperative as the hub for distribution to local, national, and international markets;
- value-added food processing enterprises that improve returns to the local economy;
- laboratory to analyze soil, air, and water and suggest improvement strategies; and
- farm-scale energy systems to produce bioenergy from biomass residues.

Government support for the emergence of a sustainable farming business cluster is important to assist the farming industry to make the transition to sustainability and become more competitive.[252] Areas where policy and capacity development are needed are in:

- funding and providing research and training through government and university institutes and experimental stations;
- organizing training and agricultural extension services to support farmers in their adoption of sustainable practices;
- using government procurement to open markets for organic products;
- supporting development of sustainable farm exports through trade policy;
- coordinating the activities of agriculture, commerce, and environmental agencies; and
- managing publicly owned forests, parks, and farms according to agroecological principles.

High-End Technologies: Green Chemistry and Nanotechnology

Green chemistry, or sustainable chemistry, refers to the use of environmentally friendly chemicals and processes that reduce pollution and support environmental performance and resource efficiency of all manufacturers and users of chemicals. It emphasizes developing economically viable products and processes that require fewer reagents, less solvent, and less energy than conventional processes, while being safer, generating less waste, and having a lower environmental impact.

This field of innovation provides a basis for coordinating the work of government and corporate R&D centers, for process and product improvement in companies, and for stimulating development of new enterprises, especially in downstream specialty chemical companies.

Green chemistry R&D searches for new solutions in several basic areas, including

- changes in chemical process design:
  - o alternative pathways for synthesis that reduce pollution and energy consumed;
  - o alternative catalysts and reagents for chemical production processes;
  - o software tools for multivalue, complex process design; and
  - o analytic tools for monitoring and controlling processes.
- changes in manufacturing processes that use chemicals:
  - o process intensification, getting more output per unit of chemical input; and
  - o alternative catalysts, reagents, enzymes, and feedstock for specialty chemical companies and industry in general.
- new products that replace polluting chemicals:
  - o benign petrochemical products;
  - o liquefied and supercritical carbon dioxide;
  - o biomaterials such as bioplastics; and
  - o biofuels such as ethanol and methanol for direct use or as feedstock to provide hydrogen for fuel cells.

Companies in the green chemistry cluster support changes in cracking and synthesis processes and new product development for major petrochemical facilities. They also create their own new products from petrochemical feedstocks and renewable materials for the broader market.

The field of nanotechnology is another emerging high technology area, which may contribute substantially to environmental protection. Nanotechnology is the manipulation of materials

[252] Funes, Fernando. 2002. *Sustainable Agriculture and Resistance: Transforming Food Production in Cuba*. Oakland, CA: Food First Books.

at very small scale,[253] where materials take on novel or unusual physical and chemical properties not experienced before. Nanotechnology will increasingly make it possible to allow molecule-by-molecule assembly of entirely new products, new components, new coatings, and surface treatments that are stronger, lighter, and more durable than products and materials currently available.

Governments, companies, and venture capitalists invested $6 billion into nanotechnology research in 2003 alone, producing daily breakthroughs. At least 300 products are already on the market, such as cosmetics, sunscreen, baby lotion, computer chips, paint, and other finishes. The National Science Foundation expects nanotechnology to grow into a $1 trillion market worldwide by 2015,[254] while Techcast studies forecast that nanotechnology will be used in 30% of all products by 2018, plus or minus 6 years.[255] Applications in the medical, environmental, and computer fields are especially promising.

Through application of nanotechnology, it may also be possible to reuse fibers indefinitely, which could revolutionize materials recycling. For instance, there are currently limits to how many times any specific type of paper can be recycled. Wood and other fibers from which paper is made are degraded each time they are recycled. In most cases the practical limit to reuse is 4–9 times depending on the type of paper being made. This translates to a loss of 12–50% of fiber delivered to a recycling mill each time that recycling occurs. The obvious implication is that a continual flow of virgin fiber is needed to replace fiber that is lost in the recycling process. Advances in nanotechnology suggest that it may be possible to repair recovered fibers through the addition of nanoparticles to damaged surfaces of wood fibers, which could someday enable unlimited reuse of paper.[256]

It may also become possible to use plant-derived materials in the manufacture of high-technology materials and products now made entirely from nonrenewable raw materials. In the longer term, increased understanding of plant biology and physiology, coupled with continued advances in nanotechnology, may lead to development of a vast array of products that self-assemble using little or no energy in the process.[257] If this occurs, it will have huge implications not only for the bottom line, but for society at large.

Given the likely impact of nanotechnology and the benefits in resource efficiency that may accrue from such technologies, countries in the region should support investments in nanotechnology research, especially research that focuses on increasing the use of biomaterials in nanotechnology applications. The PRC is already investing heavily and will soon surpass Japan's R&D budget.

However, application of nanotechnology should be carefully monitored and controlled. As a very new field with dramatically different technology and materials, the possible environmental and human health risks from nanotechnology are little understood at present. Application of the precautionary principle described in Chapter 3 is particularly important for nanotechnology innovations.

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253 The scale is between 1 and 100 nanometers. A human hair is roughly 100,000 nanometers wide.

254 *BusinessWeek.* 2002. Nanotechnology. 25 March.

255 ADB. 2005. *Asian Environmental Outlook: Making Profits, Protecting Our Planet*. Manila.

256 Eadula, S., Z. Lu, G. Grozdits, M. Gibson, and Y. Lvov. 2006. Paper Properties that Can Benefit from LbL Nano-Assemblies. Forest Products Society 60th International Convention. Newport Beach, California. 28 June.

257 Bowyer, J., J. Howe, K. Fernholz, and M. Wenban-Smith. 2006. *Nanotechnology and Forest Products Industry: Exciting New Products.* Minneapolis: Dovetail Partners. 26 September. Available: http://www.dovetailinc.org/documents/DovetailNanoTec0906.pdf.