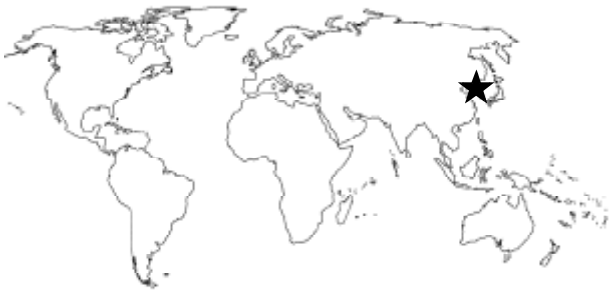
Case Study 59 Anaerobic Digestion of Food Waste



Objective: Recovery of energy from food waste and solve landfill resource problem
Location: Anyang City, Kyunggido, Republic of Korea
Website: http://www.caddet-ee.org/infostore/details.php?id=3234

Description:
One of the major goals of the Korea Institute of Energy Research (KIER) is to develop and apply new technologies for the recovery of energy from various wastes including municipal solid wastes (MSW). The project dealing with the production of biogas and compost from large quantities of Korean food wastes is a co-operative effort between KIER, the Korea Ministry of Trade, Industry, Energy, and Halla Engineering and Heavy Industries, Ltd.

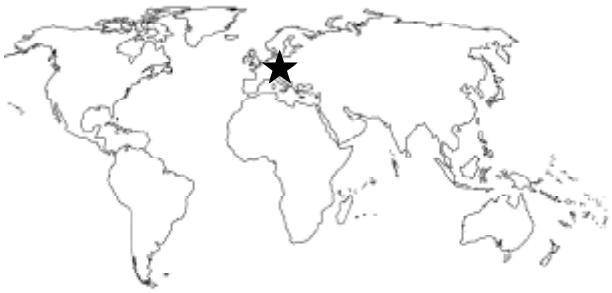
The project was first initiated to resolve the problem of food waste management in Korea. Problems of Korean food waste are caused first of all by its ever increasing volume and by its high moisture and salt content. Highly urbanised and populated towns in Korea do not have enough space for landfill and the high moisture and salt content of food waste hinders effective recycling for compost production or incineration for energy recovery.

The anaerobic process plant of this project, located at the Anyang City incinerator site, produces biogas and humus from the treatment of 5 tonnes/day MSW containing approximately 3 tonnes of food waste.
The major achievements of this project are;
1) development of a two-phase anaerobic process optimised for Korean food waste treatment and biogas (energy) recovery;
2) development of a sorting pre-treatment process suitable for Korean MSW collection systems;
3) demonstration of the feasibility of Korean food waste treatment as one component of an integrated waste management system including landfill and incineration.

In case of the 15 tonnes/day food waste treatment capacity, the operational cost of the plant was estimated to be $25/tonne of food waste. Treatment and the construction costs were estimated to be $435/tonne of MSW in Korea. However, no more landfill sites are available for the disposal of food waste in Korea because of environmental impacts such as leachate and bad odour etc.

The process was verified to be suitable for energy recovery from pre-sorted food waste in Korea. A plant sorting 15 tonnes/day of pre-sorted food waste using this process is under construction in Euiwang City for initial start-up in March 1997.

Case Study 60 Anaerobic Digestion of Industrial Waste Water



Objective: Production of electricity and heat from industrial waste water

Location: Wezep, The Netherlands

Website: http://www.caddet-re.org/infostore/details.php?id=3198

Description:

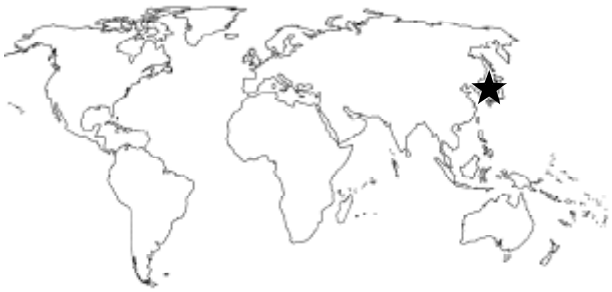
The Vita Company of Wezep in The Netherlands, produces vacuum-packed peeled potatoes. The process generates about 700 m^3/day of waste water, which has to be cleaned prior to being discharged into the sewer.

The water treatment unit incorporates an anaerobic digestion stage, which produces biogas which was previously burned off. In this project, a new biogas-fired three-pass fire-tube steam boiler has been installed next to an existing natural gas fired boiler. The steam generated by this new boiler is fed to the existing steam grid. 325, 000 m^3 of natural gas is saved every year and it is expected that the project will have recouped costs within 2.7 years.

Another project in the Netherlands has demonstrated substantial savings in operations costs by using biogas produced by a fermentation process. In this process, the sewage water is treated in three stages. In stage one waste water is led into a settling tank where particles are allowed to settle and the sediment, called primary sludge, is removed.

In the second stage, micro organisms digest organic components in an aerobic process, converting them to carbon dioxide, water and solids. The process takes place in an aeration basin through which outside air is blown. In the third stage, solid organic compounds are collected in a second settling tank. Collected sediment is mixed with the primary sludge and the mixture is heated in a heat exchanger to a temperature of 32.5°C and allowed to ferment in a fermentation tank. Gaseous fermentation products (containing methane) are collected and used in the gas engines driving the aeration blowers. Natural gas can be added to the fuel in case of a shortage; and surplus bio-gas is blown off.

Case Study 61 Fuel Cell Combined Heat and Power using Biogas from Brewery Effluent



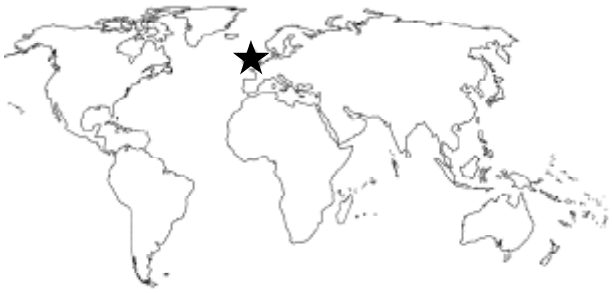
Objective: Production of electricity and heat from industrial waste water
Location: Chiba, Japan
Website: http://www.caddet-re.org/newsletter/display.php?id=1757

Description:
The Chiba brewery in Japan has recently changed their waste treatment practice from an aerobic activated sludge process to an anaerobic pre-treatment process that simultaneously reduces the power required to treat the waste and also produces biogas. The company, Sapporo Breweries, decided to install a fuel cell combined heat and power system that can use 80% of the energy content of the biogas, rather than burning the biogas in steam boilers.

High concentration organic effluent from the brewery is pre-treated in an acid fermentation tank, neutralised and fed into an anaerobic digestor which produces methane. Impurities such as sulfides can be harmful to the operation of fuel cells and these are removed from the biogas in a gas pre-treatment system. This pre-treatment process also absorbs carbon dioxide from the biogas improving the quality of the gas.

The system generates 1728 MWh/year of electrical energy and 1768MWh/year of thermal energy for use in the plant. The amount of power purchased from the grid for each bottle of beer has been reduced to one third and the energy savings are worth about 30 million Y a year.

Case Study 62 Use of Land Fill Gas in Brick Kilns



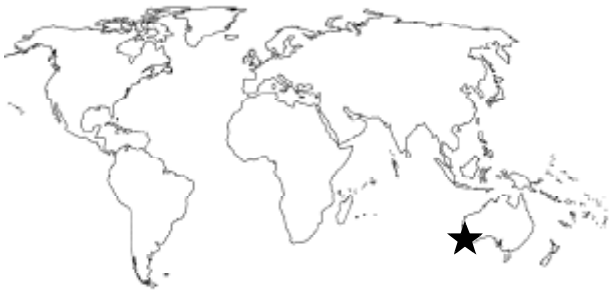
Objective: Production of heat for brick making from land fill gas
Location: Barnsley, United Kingdom
Website: http://www.caddet-re.org/html/technical.htm
http://www.caddet-re.org/brochures/display.php?id=1883
Description:
The kilns at the brickworks are fired using land fill gas from a landfill site situated adjacent to the clay quarries. There is an ongoing process of clay extraction and filling with refuse, and land fill gas is extracted by wells as the gas quality becomes useable.

The land fill gas is used in the medium temperature parts of the brickworks kiln at 870-960°C, and natural gas is used for higher temperature processing (up to 1050°C). All of the burners can be switched from one type of gas to the other with no interruption to the flame.

Land fill gas has been used by the brickworks for more than 12 years and the system has performed reliably, with little need for changing the gas supply to any particular burner. Gas pre-treatment consists of a simple moisture removal and filtration step. The kilns operate 24 hours a day, and land fill gas meets 20-30% of the gas requirements. Very little servicing has been required, and there have been no problems with contaminants or condensation.

By the end of 1995, use of land fill gas had saved the plant £1,330,000, from an initial investment of about £330,000. The payback period was longer than expected, as the land fill gas flow was smaller than expected, however the return on investment was achieved in 3 years.

Case Study 63 Anaerobic Digestion of Municipal Waste Water



Objective: Production of electricity and heat from municipal waste water

Location: Perth, Australia

Website: http://www.watercorporation.com.au/environment/content-wastewater-woodman.asp

Description:

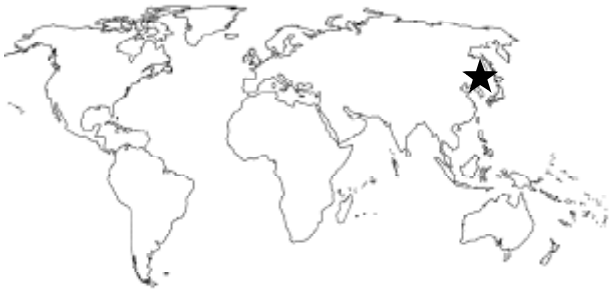
The production of biogas by anaerobic digestion at the Woodman Point waste water treatment plant in Western Australia enables provision of the plant's power requirements for most of the day. Ninety-nine per cent of the waste water arriving at Woodman Point is from household kitchens, bathrooms, laundries and toilets. First the waste water is screened to remove any large objects (paper, rags etc) before passing through settling tanks to remove grit (sand etc). Next, the waste water spends several hours in large sedimentation tanks to remove settleable solids, or "sludge". The sludge is digested in one of two 38-metre tall anaerobic digesters.

Biogas produced by the digester is used on-site to provide electricity, and excess power is sold to the local electricity retailer, Western Power Corporation. A sludge is left after the digestion is complete and the gas is extracted. This bio-solid is dried then sold as a soil conditioner and fertilizer to the agricultural and landscaping industries. A significant future option for this plant is in providing an industrial water supply which is of great importance in the arid West Australian climate. Fittingly, the next by-product of Woodman Point could be water, for industry. Investment of $100 million in a project based on a commercial partnership will amplify the Woodman Point plant to give wastewater 'secondary treatment'. This further refinement produces discharge water suitable for re-use in industry. Plant amplification is the cornerstone of the WaterLink Project, which will promote water efficiencies, provide a choice of water qualities for industry, and increase the proportion of groundwater and scheme water supplies available for the general community.Amplification will prepare Woodman Point for population growth in southern Perth, lifting throughput from today's 100 million litres daily, to 160 million litres.

At the Subiaco Wastewater Treatment Plant, the world's first *Oil From Sludge* (OFS) Plant has been developed. The OFS process is a patented thermochemical process called Enersludge in which the organic content of sludge is converted to an oil with properties similar to diesel oil. Raw sludge and excess activated sludge are pumped first to the sludge blending tank where they are mixed prior to dewatering. After drying, sludge is then heated in a reactor vessel in the absence of oxygen. During this process, almost half of the sludge is vaporised. In the second stage of the reactor, the vaporised sludge contacts with the sludge char, converting the organic molecules to principal components of crude oil, called *aliphatic hydrocarbons*.

This process will produce about 150 to 300 litres of oil per tonne of sludge processed, along with char, non-condensable gas and reaction water. These latter three are burned in a hot gas generator, which produces most, if not all, of the energy required for sludge drying and reactor heating.

Case Study 64 Incineration of MSW to Produce Combined Heat and Power



Objective: Production of local heating and electricity while mitigating landfill problem
Location: Seoul, Korea
Website: http://www.caddet.org/infostore/details.php?id=2989

Description:

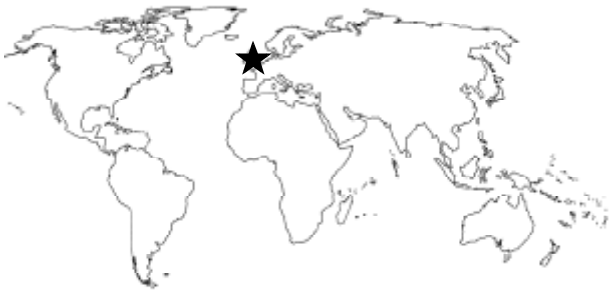
There are several plants in Seoul that provide heat for industrial complexes and domestic units. In the Mok-Dong area, there is a large quantity of waste available from the local apartment blocks, which is being used to produce district heating and sell power to the electricity retailer. In addition to saving energy, the project reduces the volume of waste to land fill by 87%.

Waste is delivered by truck to a weighing station, and then deposited into a storage unit. A crane delivers the waste into the boiler for incineration. The plant has capacity for 150 tonnes/day of waste, while the boiler can incinerate 15 tonnes/hour. The average heating value of the waste is around 1,900 kcal/kg (7,950 kJ/kg).

The pollution control system includes an odour reduction system which involves high temperature dissolution (850-950°C) of refuse drainage. An electrostatic precipitator reduces dust emissions with 99% efficiency. Harmful emissions from the stack are reduced with a wet scrubber flue gas treatment system. Considerable effort has been made to minimise its environmental effect on those living nearby.

The project saves energy equivalent to 6.56 million Nm^3 of liquid natural gas every year, at a saving of 1.3 billion Korean Won per year. The investment in the plant was 5.1 billion Won.

Case Study 65 Energy From Poultry Litter



Objective: Production of electricity from poultry litter
Location: Suffolk, U.K.
Website: http://www.fibrowatt.com/UK-Eye/index.html

Description:
This is the world's first commercial electricity generating plant using poultry litter as the fuel. The 12.7MW plant which started operation in 1992, generates sufficient electricity for 29,000 homes. The plant consumes over 150,000 tonnes of poultry litter per year.

The plant was the first project over 10MW to come on stream under the UK Government's Non-Fossil Fuel Obligation, which provides support for renewable electricity generation, as well as the first Small Generator to join the British Electricity Pool.

After transportation to the plant and storage, the fuel is conveyed into the boiler via a mechanical distribution system. Air from the storage hall is drawn into the furnace by fans and is used as the combustion air within the boiler. Here temperatures reach in excess of 850°C (1500°F), destroying any odour and bacteria.

The plant incorporates a single, conventional boiler design with a feed system and grate specifically designed to combust poultry litter and other biomass fuels. The boiler is equipped with a combustion chamber, a superheater, a generating bank and an economizer.

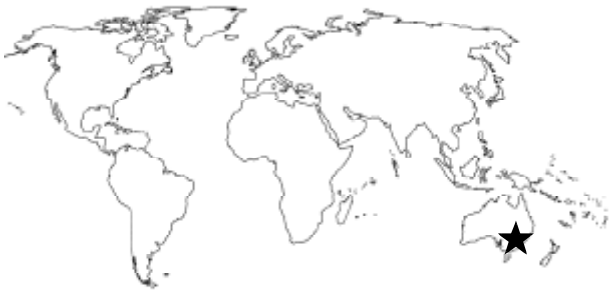
Boiler combustion air obtained from the fuel storage building is preheated for use as primary and secondary air. The preheated primary air is fed under the grate, and preheated secondary air is injected at strategic locations above the grate. The boiler combustion chamber or furnace is made up of water-wall tubes.

The plant was built under a turn-key contract by Aalborg Boilers A/S, the Danish turn-key contractor and boiler maker. The turbine was provided by NEI-Allen (W.H. Allen of Bedford). Foster Wheeler Energy Ltd acted as Owners' Engineer on the project throughout construction and commissioning. Third party finance was provided via a European Union grant and a £20 million Project Financed Senior Debt facility arranged by Bank of Tokyo-Mitsubishi.

The plant was architect-designed to be environmentally attractive. It consist of a low-key steel structure with a curved roof, partially sunk into the ground and surrounded by landscaped embankments to reduce its visual impact. The height of the building does not exceed typical heights of parish churches in the neighbourhood.

Eye is in the centre of one of the UK's largest poultry growing areas. The plant consumes over 150,000 tonnes of poultry litter per year, enough to fill 25 football pitches to a depth of 6 feet.

Case Study 66 Solid Waste to Energy Recycling Facility



Objective: Production of electricity, heat and recycled products from municipal solid waste
Location: Wollongong, Australia
Website: http://wollongong.nsw.gov.au/news/media/20010207_openswerf.html

Description:
Located at Woollongong City Council's Whytes Gully landfill site, this new Solid Waste-to-Energy Recycling Facility (SWERF) project includes:

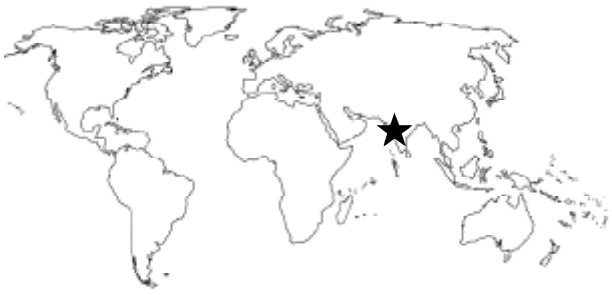
- a pre-treatment process to separate recyclable products from the waste stream leaving the balance as a biomass feedstock or MGW (Municipal Green Waste)
- conversion of the MGW using a gasification process, and
- electricity generation using a high efficiency gas engine and generator.

Following the development of a synfuels gasifier in 1996, the SWERF concept using the gasifier evolved in 1997 and took 3 years to develop, evaluate and commercialise. The first project at Wollongong was opened in May 2000. Research and development has continued in parallel with developing the project so the gasifier that was originally installed does not incorporate all the latest technical advances. Handling difficulties of the MGW have been experienced due to its widely varying properties. Also the waste resource is often significantly contaminated with soil and foreign objects not always of organic origin.

Household green waste is received unsorted and sterilised at 140-150°C. It is then mechanically separated to remove any ferrous and non-ferrous metal materials which are then sold. Any other inert residues are taken to landfill or reprocessed and reused where feasible. The remaining organic fraction is floated off from the glass and grit contaminants and shredded. Clean shredded material is pelletised and stored ready for gasifying. The pellets are fed into the advance thermal gasifier. Primary gasification occurs at 900°C and the synthesis gas is used in gas engines (gensets) for power generation. The "green power" is sold to the grid.

Developments are under way to convert some of the organic fraction from possible future projects into "bio-fertiliser" if it shows a greater return on investment than if used for power generation. Future projects will depend on landfill charges, greenhouse issues, community issues and other available competing waste resource recovery processes. The financing of the project was difficult as an innovative process but should be overcome for future projects now that the first facility is operating successfully.

Case Study 67 Energy From Gasifier Based Power Plant



Objective: Production of electricity from wood and forest waste
Location: Sunderbans, West Bengal, India.
Website: http://mnes1.delhi.nic.in/bionews/sep01/index.htm

Description:
A 500 KW gasifier-based power plant was commissioned in the remote island of Chhotamollakhali in Sunderbans, West Bengal. On June 29, 2001, Mr M Kannappan, Minister of State (independent charge) for Non-conventional Energy Sources, Government of India inaugurated the plant.

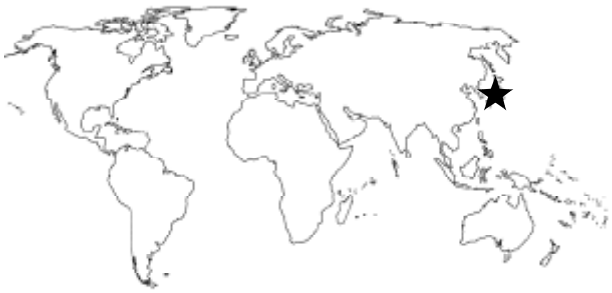
Prior to its commissioning, the region was bereft of electricity except for a privately owned 10 KW diesel generator that provided low voltage electricity at a very high price for only two hours a day.

The total power requirement of the Chhotamollakhali island is about 1 MW.

The power plant, installed by the West Bengal Renewable Energy Development Agency with financial support from the Ministry of Non-conventional Energy Sources, comprises 4 biomass gasifiers of 125 KW capacity, each connected to diesel generator sets. The gas produced from the gasifiers will enable upto 75 per cent diesel replacement. The power plant will be operated daily for seven hours. 800 connections will be provided and three villages are planned to be electrified this year.

Work has simultaneously been taken up to extend distribution lines for electrification of the remaining three villages on the island. About 3 million people inhabit the delta region of Sunderbans, 2 million of who do not have access to electricity. Power plants based on the non-conventional energy sources such as solar energy and biomass are already providing electricity to about 50,000 inhabitants.

Case Study 68 Energy From Recycling of Waste Plastic



Objective: Production of electricity from recycled waste plastic
Location: Hokkaido Island, Japan
Website: http://www.japancorp.net/Article.Asp?Art_ID=1047
http://www.sanix.co.jp/index_e.htm

Description:
Sanix Energy will operate the Tomakomai power plant in Hokkaido, northern Japan, which runs on fuel created from recycled plastic waste. The plant processes waste plastic to generate electricity using a gasification melting technology.

The plant operates at more than 850 degrees Celsius, generating energy from the naturally high calorific content of plastic and producing 74,000 kilowatts of electricity an hour, enough to power about 30,000 homes. Building on the success of the first venture, the company has plans to increase the number of similar power generation plants across Japan.

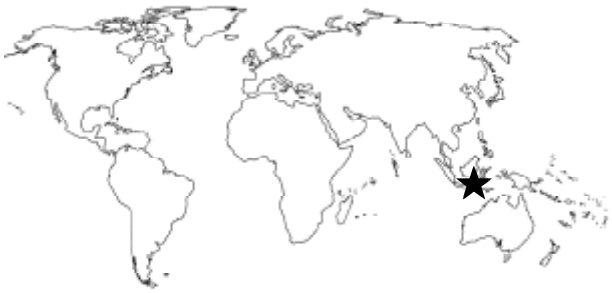
The recycled plastic is supplied by Sanix's Environmental Resources Development Division, which operates 11 plastic recycling plants across Japan that convert waste plastics into fuel. The division is currently constructing three more recycling plants.

Social Value of Waste Plastic Power Generation
According to a Plastic Waste Management Institute survey, waste plastic disposal totaled 9.84 million tons (4.85 million tons from industrial sources, 4.99 million tons from household use) in 1998. Management at Sanix Inc. was convinced that this plastic waste could be used as a recycled resource and pursued the project fervently.

By using waste plastic, which would previously have been simply buried or incinerated, the company contributes to an extension of the remaining life of landfill sites and prevents dioxin pollution generated by inappropriate incineration. The recycling process also contributes to society by providing local retailers with low-cost, safe, electric power.

The plant will consume in-house about 15% of the electricity generated by the new power plant and the rest will be sold to industrial and commercial users. This will be the world's first power plant using recycled waste plastic as fuel. Company plans to build two more similar plants by year 2003.

Case Study 69 Solid Waste Management



Objective: Solve community and environmental problems associated with MSW management
Location: Bandung, Indonesia.
Reference: http://www3.iclei.org/iclei/casestud.htm

Description:
In response to a growing population, and therefore a growing amount of solid waste which it did not have the financial or land resources to manage, Bandung, Indonesia has developed, along with a non-governmental organization working in the city, the concept of a "module" of people who work to separate recyclables from the city's waste stream, thereby providing a low-cost alternative to the landfill model of waste management services.

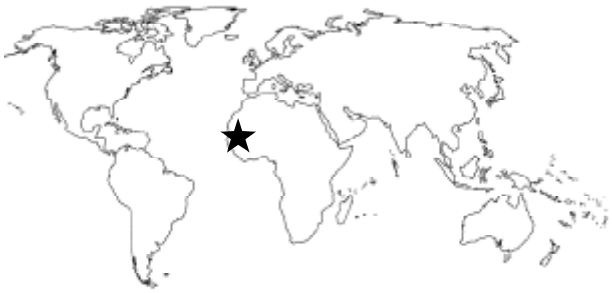
The recyclers working in the module are persons who previously survived as "scavengers;" that is, poor residents of the squatter's settlements who make their living by collecting recoverable and recyclable materials from the waste stream. Historically, in Bandung and in cities with large poor populations throughout both the developing and the developed world, scavengers are considered to be a hindrance to the operation of efficient solid waste management rather than as an inexpensive and often entrepreneurial labor resource that can be supported and developed to collect and process recoverable materials. These people have been traditionally harassed and even jailed for their activities.

Through the Integrated Resource Recovery (IRR) program, these people have been given financial and technical support to improve their recoverable waste collection services, to compost organic wastes, and to create indigenous businesses and employment using waste products as raw material and "capital.".

Finally, the IRR program builds financial institutions which provide a financial base internal to the community, providing capital for other, non-recycling enterprises. IRR also has a significant impact on setting fair prices for the secondary materials from which the scavengers make their living, thereby supporting a fair living wage for these people who were heretofore considered an economic liability.

In the IRR concept, each module consists of a group of families. These families are given social system support in the form of evening schooling for children, health care, and assistance in the development of a savings and loan and a cooperative corporation. With this organizational infrastructure, these people then form businesses in resource recovery, composting, and seed farming which not only provide them with income, but reduce the amount of money which the city must spend on solid waste management in the form of landfill sites and the collection and transportation of waste.

Case Study 70 Participatory Solid Waste Management



Objective: To create an efficient and sustainable household waste management system

Location: Dakar, Senegal.

Reference: http://www3.iclei.org/iclei/casestud.htm

Description:

The Urban Community of Dakar (UCD) has a population of just under 2 million people. Only 27% of the households are connected to the sewer system, and until recently, less than 65% of the population had access to garbage collection services. To address both economic and social development, the UCD designed the New System for Household Waste, which involves local communities in the waste management process, and has provided an administrative and fiscal system for the oversight of MSW services. Small and medium sized companies that are staffed by local men women and young people contract to collect and transport waste from zones in the UCD.

Local groups are responsible for pre-collecting garbage from inaccessible areas, cleaning the streets, communicating information about the service and educating their communities in the benefits of sanitation.

By 1996 this project had demonstrated promising improvements in waste management and community employment. The New Management System for Household Solid Waste has promoted the emergence of local waste management industries and been of value to the Dakar economy.

The scheme has also benefited from international support. With an efficient and stable waste management system in place, the UCD is currently approaching the introduction of a recycling component, as well as a new agreement to compost organic waste and extract and use methane gas.