Bio-gas:

GP Option for Community Development

Prepared for

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Content

CHAPTER 1

Green Productivity Concept and Practices

1.1 Introduction

The increase in human need and the explosion of population within the last decade have resulted in severe environmental problems at present. During the last three decades, at least a seven-fold increase in manufacturing output has been estimated. By the middle of next century, an increase of ten folds will be expected. As a result many of the natural resources are depleting. Water resource is one of the major issues in many parts of the world. Scarcity of water and the deterioration of water quality from human use give rise to environmental problems throughout the world. Energy consumption has been increased rapidly through industrial development and increase of domestic demand. The wide spread use of chemicals such as pesticides and fertilizers in agriculture contaminates the environment and also threatens our eco-system. Greenhouse gases, such as carbon dioxides and methane, are produced from industries and burning of energy sources in rural area. Improper waste treatment also produces greenhouse gas through anaerobic process. This causes global warming. Up to early 1960, public awareness on environmental problems was rather low. The later half of the 1960s were a period that concerns on environmental issues became alive. Since 1970, responses and actions from many international agency and many individual countries were initiated to work more on the issues. The depletion in resources has become a major issue at present.

Green Productivity (GP) signifies a new paradigm of socio-economic development aimed at pursuing economic and productivity growth while protecting the environment. The concept of Green Productivity emerged in the early 1990s when people started to realize that emphasizing productivity and economic growth alone may lead to an adverse and irreversible effect on the environment. Solving environmental problems using end-of-pipe technology is not cost effective nor sustainable in the long run. There is a need for developing strategies which are simultaneously productivity enhancing and environmental friendly.

1.2 Concept of Green Productivity

Green Productivity is a concept of harmonizing the socio-economic development and mechanism of environmental protection. It is the key for enhancing the quality of life of people through sustainable development. Improvement of quality of life is often associated with an increase in demand for goods and services. The increase in productivity will normally deplete natural resources and generate wastes which cause environmental damage. Conventional productivity improvement techniques have not paid due attention to environmental aspects. The environmental cost has been intentionally neglected in the system. Wastes have been counted as valueless. Excessive use of resources or generation of pollution is indicative of low productivity as well as poor environmental performance. GP pursues a strategy based on the technical and managerial interventions to improve the situation.

The definition of Green Productivity is:

Green Productivity is a strategy for enhancing productivity and environmental performance of overall socio-economic development. It is the application of appropriate techniques, technologies and management systems to produce environmentally compatible goods and services.

Green Productivity (GP) is applicable not only to the manufacturing sector, but also to the agriculture and services sectors. GP also addresses the interaction between economic activities and community development. Another dimension of GP is the role of the public sector (government and education) in environmental protection and awareness. GP is a stepwise approach and also a process of continuing improvement.

- The first step in this process is to identify ways to prevent pollution or waste at its source, as well as reduce the level of resource inputs by the process of rationalization and optimization. Possibilities of reuse, recovery and recycle are looked into to salvage the wastes generated.

- Next, opportunities for substituting toxic or hazardous substances are explored to reduce the life-cycle impact of the product. At this stage, the product itself is examined, including packaging in the framework of design for environment.

- Finally, the wastes in its residual forms are treated adequately to meet the regulatory requirements both from the perspectives of the workspace and the receiving environment. In order to ensure a continuous improvement in the productivity as well as in the level of environmental protection, a management system is developed, much on the lines of Environmental Management System of ISO 14000 series.

1.3 Green Productivity Tool and Techniques

The basic concept of GP is built around the prevention of wastes and emissions at the point of generation. What cannot be prevented needs to be treated and thus rendered environmentally benign before discharging it to the recipient environmental media. This applies to both materials as well as energy wastes. GP techniques are classified into four categories – waste prevention, energy conservation, pollution control and design of product.

1.3.1 Waste Prevention Techniques

Waste prevention techniques can be applied to any manufacturing process, agricultural and service sectors. Available techniques range from easy operational changes to state-of-the-art recovery equipment. Waste prevention techniques can be broken down into five major categories: good housekeeping, inventory management, production process modification, volume reduction and recovery. In actual application, waste prevention techniques generally are used in combination so as to achieve maximum effect at the lowest cost. It has been experienced that a careful application of these techniques and a sincere commitment for implementation can lead to reduction in waste generation from 30% to 50% in most cases.

a. Good Housekeeping

Good housekeeping is not limited to keeping the work place clean and eliminating leakages and spillages. It also includes the operational practices involved, especially manual practices and making them more resource efficient. Preparation of recipes in right quantity to avoid surplus, efficient handling of materials, optimum storage procedures to avoid losses and material degradation during storage are illustrative examples of good housekeeping. It has been the experience that in small scale industries, good housekeeping alone could lead to a reduction in waste generation up to 20-25%.

b. Inventory Management

Proper control over raw materials, intermediate products, final products, and the associated waste streams is now being recognized by the industry as an important waste reduction technique. In many cases waste is just out-of-date, off-specification, contaminated, or unnecessary raw material, spill residues, or damaged final products. The cost of disposing of these materials not only includes the actual disposal costs but also the cost of the lost raw materials or products.

There are two basic aspects to inventory management, inventory control and material control.

(i) Inventory Control

Methods for controlling inventory range from a simple change in ordering procedures to the implementation of just-in-time (JIT) manufacturing techniques. Most of these techniques are well known in the business community. Many companies can help reduce their waste generation by tightening up and expanding current inventory-control programs. This approach will significantly impact the three major sources of waste resulting from improper inventory control: excess, out-of-date, and no-longer-used raw materials. Purchasing only the amount of raw material needed for a production run or a set period of time is one of the keys to proper inventory control.

If surplus inventories do accumulate, steps should first be taken to use the excess material within the plant or company. If this is not successful, then the supplier should be approached to see if it will take the material back. If the supplier won’t, the next step is to identify possible users or markets outside the company. Only if this fails should other management options be examined.

(ii) Material Control

Proper material control procedures will ensure that raw materials will reach the production process without loss through spills, leaks, or contamination. It will also ensure that the material is efficiently handled and used in the production process and does not become waste. Material loss can be greatly reduced through improved process operation, increased maintenance, and additional employee training. Many sources of material loss, such as leaks and spills, can be easily identified and corrected.

c. Production Process Modification

Improving the efficiency of a production process can significantly reduce waste generation. Using this approach can help reduce waste at the source of generation, thus decreasing waste management liability and costs. Available techniques range from eliminating leaks from process equipment to installing state-of-the-art production equipment.

(i) Operational and Maintenance Procedures

Significant amounts of waste can be reduced through improvements in the way a production process is operated and maintained. Improvements in operation and maintenance usually are relatively simple and cost-effective. Most of the techniques are not new or unknown.

Operational procedures. A wide range of methods are available to operate a production process at peak efficiency. Improved operation procedures optimize the use of raw materials in the production process. Most production processes, no matter how long they have been in operation or how well they are running, can be operated more efficiently. Some process steps may in fact be unnecessary, and eliminating them will reduce waste generation. Once proper operating procedures have been established they must be fully documented and be part of the employee training program. A comprehensive training program is a key element of any effective waste reduction program.

Maintenance program. About one-fourth to one-half of the excess waste load is due to poor maintenance. A strict maintenance program which stresses corrective and preventive maintenance can reduce waste generation caused by equipment failure. Such a program can help spot potential sources of waste and correct a problem before any material is lost.

(ii) Material Change

The manufacturing sector usually use the most cost benefit input raw materials in the production process without considering environmental aspects Thus, highly toxic and hazardous chemicals came into use. Hazardous material used in either a product formulation or in a production process may be replaced with a less hazardous or non-hazardous material. Reformulating a product to contain less hazardous material should reduce the amount of hazardous waste generated during both the product’s formulation and its end use. Using a less hazardous material in a production process will generally reduce the amount of hazardous waste produced.

(iii) Process Equipment Modification

Waste generation may be reduced by installing more efficient process equipment or modifying existing equipment to take advantage of better production techniques. New or updated equipment can use process materials more efficiently, producing less waste. Higher-efficiency systems may also reduce the number of rejected or off-specification products, thereby reducing the amount of material which has to be reworked or disposed of.

Modifying existing process equipment can be a very cost-effective method for reducing waste generation. In many cases, the modifications can just be relatively simple and inexpensive changes in the way the materials are handled within the process to ensure that they are not wasted or lost. Process modifications and improved operational procedures can be used together to reduce waste.

d. Volume Reduction

Volume reduction includes techniques to separate hazardous wastes and recoverable wastes from the total waste stream. These techniques are usually used to increase recoverability, reduce the volume and thus the disposal costs, or increase management options. These techniques can be divided into two general areas, source segregation and waste concentration.

(i) Source Segregation

Segregation of wastes is a simple and economical technique for waste reduction. By segregating wastes at the source of generation and handling the hazardous and non-hazardous wastes separately, waste volume and thus management costs can be reduced. The uncontaminated or undiluted wastes may be reusable in the production process or may be sent off site for recovery. The segregation technique is applicable to a wide variety of waste streams and industries and usually involves simple changes in operational procedures.

(ii) Concentration

Various techniques are available to reduce the volume of a waste through physical treatment. Such techniques usually remove a portion of a waste, such as water. Concentration techniques are commonly used to dewater wastewater treatment sludges and reduce the volume by as much as 90 percent. Unless a material can be recycled, just concentrating a waste so that more waste can fit into a drum is not waste reduction. In some cases, concentration of a waste stream may also increase the likelihood that the material can be reused or recycled.

e. Recovery

Recovering wastes can provide a very cost-effective waste management alternative. This technique can help eliminate waste disposal costs, reduce raw material costs, and possibly provide income from a salable waste. Recovery of wastes is a widely used practice in many manufacturing processes and can be done on site or at an off-site facility.

(i) On-Site Recovery

The best place to recover process wastes is within the production facility. Waste can be most efficiently recovered at the point of generation, because the possibility of contamination with other waste materials is reduced. Other waste streams can be reused directly in the original production process as raw material. Some waste may have to undergo certain type of purification before it can be reused. A number of physical and chemical techniques available on the market can be used to reclaim the waste material. These techniques range from simple filtration to state-of-the-art techniques such as distillation. The method of choice will depend on the physical and chemical characteristics of the waste stream recovery economics, as well as on operational requirements.

Most on-site recovery systems will generate some type of residue. This residue can either be processed for further recovery or properly disposed of.

(ii) Off-Site Recovery

Wastes may be recovered at an off-site facility when (1) the equipment is not available to recover on site, (2) not enough waste is generated to make an in-plant system cost-effective, or (3) the recovered material cannot be reused in the production process. Off-site recovery usually entails recovering a valuable portion of the waste through chemical or physical processes or directly using the waste as a substitute for virgin material. Wastes directly used are usually chemically or physically specific for a selected purpose, and can range from concentrated acids to chemical by-product streams.

The cost of off-site recycling will depend on the purity of the waste and the market for the waste or recovered material. Some materials may be salable, while others may require a fee to be paid for disposal. The markets for some wastes are very volatile, and a waste material which has a value one day may have none the next.

1.3.2 Energy Conservation Techniques

Production facilities consume energy basically in two different forms: electricity and process heat. Combustion of fossil fuels in primary heat sources such as boilers or fired heaters provides a major source of heat input to industrial processes. Nearly all energy used in most manufacturing facilities is generated by processes that consume materials and generate pollutants (gaseous, liquid and solid) which pollute the environment if released directly. Any action that conserves energy would reduce the quantity of pollutants from energy-generating processes. On the other hand, actions that reduce pollutants would lower the expenditure of waste handling and treatment.

Combustion of fossil fuels in primary heat sources such as boilers or heaters provides a major source of heat input to industrial processes. Thermal energy can be conserved by taking care to prevent its loss during transport from the combustion site to the specific processes where it is used. Table 1.1 lists some measures that can be taken to conserve thermal energy as it is transported and used. It may also be possible to recover and use heat generated by production processes. Production facilities consume enormous amounts of electricity in both their production processes and the operation of their facilities. Table 1.1 lists several ways to conserve electricity.

Table 1.1. Example Approaches That Conserve Thermal and Electrical Energy

Thermal Energy Conservation	Electrical Energy Conservation
• Adjust burners for optimal air/fuel ratio. • Improve or increase insulation on heating or cooling lines. • Institute regular maintenance to reduce leakage and stop steam trap bypass. • Improve the thermodynamic efficiency of the process using options such as:	• Implement housekeeping measures such as turning off equipment and lights when not in use. • Place cool air intakes and air-conditioning units in cool, shaded locations. • Use more efficient heating and refrigeration units.

* Using condensers or regenerative heat exchangers to recapture heat * Using heat pumps or similar equipment to recover heat at distillation column * Using more efficient heat exchangers • Co-generating heat and electricity.	• Eliminate leaks in compressed air supply lines. • Use more efficient motors. • Improve lubrication practices for motor driven equipment • Use efficient power transfer belts. • Use fluorescent lights and low wattage lamps or ballast. • Install timers and thermostats to better control heating and cooling.

Source: USEPA 1992

1.3.3 End-of-pipe Treatment Technology

Whether waste is land disposed, emitted into the air or discharged to surface waters, all waste generators can strive to reduce waste generation to the point where treatment and subsequent disposal in the environment is avoided. However, for some processes, waste generation is inevitable. These wastes which cannot be eliminated, reduced, recycled or reused must be treated and disposed of within all applicable environmental regulations. Appropriate treatment does not include the transfer pollutants to other environmental media, or dilution as a means for meeting environmental regulations.

1.3.4 Designing Environmental Compatible Product

Environmentally compatible products minimize the adverse effects on the environment resulting from their manufacture, use, and disposal. The environmental impact of a product is to a large extent determined during its design phase. By taking environmental considerations into account during product planning, design, and development, a company can minimize the negative impact of its products on the environment.

Design changes made to prevent pollution should be implemented in such a manner that the quality or function of the product is not affected adversely. Design for the environment can be achieved by the people directly involved, within the framework of company policy and with support from company management, whether or not in response to incentive external to the company.

Product Conservation. Product conservation refers to the way in which an end product is used. For example, better maintenance of process equipment and components by industry can decrease the frequency of equipment component replacement, which in turn reduces the waste generated by the used component.

Product Design Changes. Product design changes involve manufacturing a product with a lower composition of hazardous substances, or less toxic materials being formed, or changing the composition so that no hazardous substances are involved

The goals of new product design can be reformulation and a rearrangement of product requirements to incorporate environmental considerations. For example, the new product can be made out of renewable resources, have an energy-efficient manufacturing process, have a long life, be non-toxic, and be easy to reuse or recycle. In the design of a new product, these environmental considerations can become an integral part of the program of requirements.

1.4 Green Productivity Methodology

For an effective Green Productivity Program, it is important to bring all stake holders together to ensure identification and implementation of maximum opportunities. A step by step procedure ensures exploitation of maximum Green Productivity opportunities. A typical Green Productivity Assessment Methodology is described as follows:

The methodology consists of 13 tasks divided into 6 steps. The main steps are:

Step I *Get started*
Step II *Planning*
Step III *Generation and evaluation of GP options*
Step IV *Implementation of Options*
Step V *Monitoring and Review*
Step VI *Sustaining Green Productivity*

Figure 1.1 shows the flow chart of GP methodology.

Step I Get Started

This step consists of the following 2 tasks, namely team formation and walk through survey.

Task 1 - Green Productivity Team Formation

The first task in a Green Productivity program is to form a GP team. The GP team would co-ordinate the entire program, be responsible for identification of various GP measures, get them implemented and bear the overall responsibility. The GP team should be made up of representatives of group that will have interest in the results of the program. To the extent as possible, all the stakeholders should be represented in the team. The composition of the team would ultimately depend on the organizational structure and the requirements of the program. Inclusion of external experts helps in creativity and looking at the possible opportunities from a different perspective. The GP team should be capable of identifying potential areas, developing solutions and facilitating their implementation. For continuity and sustainability of the GP program, an in-house team is more desirable than a fully external team.

Task 2 - Walk through Survey and Information Collection

GP team should familiarize itself with the manufacturing process including utilities, waste treatment and disposal facilities. A walk through survey would allow the team to identify and list all process steps. *Process diagram*, initial layout (*for eco-mapping*), drainage system, vents and other material/energy loss area should be prepared and identified. Special attention must be paid to periodic and intermittent waste generating steps as these often tend to be overlooked. House keeping practices should be observed and take note of obvious lapses. The GP team should prepare a preliminary list of waste generating operations, including a gross estimation of waste generate from different process steps. The possibility of waste prevention and control should be noted. Special attention should be paid to steps that generate toxic and hazardous wastes. If a facilitator, who is not familiar with the operations of the organization, is involved in the GP exercise, the facilitator should gather general information about the organization. such as the number of employees in the organization and physical size of the factory or farm.

The above 2 tasks would help in selecting the first focus area for Green Productivity. Normally in larger premises, it would be desirable to focus on a smaller area so that the assessment can be completed fast and the results can also be shown at an early date. This help in generating and sustaining interest in the organization. Too wide a focus complicates the assessment and is time consuming.

Following the walk through survey, the team would have to gather detailed information of the organization. Information necessary for further evaluation such as detail process, flowchart, physical plant information, management structure, cost of purchasing raw materials, amount of raw materials purchased including energy use, should be gathering from concerned departments/sections. Detailed flow chart need to be prepared for further investigation and material balance step.

Technical information needed for further evaluation such as water use, waste generated, energy use, raw material use including existing waste treatment facilities should be collected. In case where no information is available in the plant, a practical survey and measurement should be performed to obtain the data. All the inputs and outputs of waste stream and emission should be identified and quantified. Special care needs to be taken of the recycle streams. Free and low cost inputs like water and air should be highlighted as these often tend to be neglected in production cost accounting but end up being the major source and cause of waste. Existing waste treatment facilities should be evaluated whether they conformed to legislative discharge limits and are operated within the designed condition. The periodic/batch/intermittent steps should be carefully highlighted. The GP team should also specify the items that do not appear in the usual input/output streams such as catalysts and coolant oil.

Material/Energy balance is important for any GP assessment since it enables identification and quantification of wastes and emissions. It provides information for ascertaining the cost of waste streams and thereby helps in monetary quantification of the loss. The balance also serves as a baseline data for evaluating the GP options and monitoring/comparing the advances made in the course of implementation of a GP program. Typical components of a material balance are given below.

Input	**Output**
Raw materials	Products
Catalyst	Gaseous emissions
Water	By-products including wastes for recovery
Air	Waste water and other liquid waste
Recycled materials	Solid waste for storage and/or disposal

Typical components of the energy balance are given below.

Input	**Output**
Electrical energy	Radiation loss
Steam	Energy in vapors and gases
Energy in raw materials	Energy in hot products
Condensation	Energy in hot residue
Cooling water	Energy in cooling water

Several factors should be considered while constructing the material/energy balance. The precision of data and flow measurement is essential. Time span is also important. Material balance constructed over too long a time period does not show the short term variations. On the other hand, material balance made over shorter time span requires repetitive and more accurate monitoring data to make the balance representative. Consistency of measurement units is another factor that needs to be taken care of. Making an energy balance is tougher than a material balance due to the fact that it requires more complex measurement systems and also because of its invisible nature.

Step II Planning

Task 3 - Identification of Problems and Their Causes

Problems concerning process efficiency, waste generation, energy loss should be identified and characterized at this step. Process inefficiency should be determined in order to be improved (if any) for higher productivity. The problems in materials and energy loss could be identified through material/energy balance. The waste streams could be in all 3 media i.e. solid, liquid and gaseous. It is now important to characterize these streams in terms of their constituents. To the extent possible, generic characterization such as BOD for organic pollution load should be avoided, as it does not throw open the possibilities of reduction and recycle. Characterization in terms of actual constituents is always more useful. It would also be a good idea to assign some sort of priority to the waste streams in terms of quantity, toxicity, possibility of recovery/recycle etc. Energy balance should reflect the areas where energy loss takes places. Only energy loss areas which are discrete, measurable and workable need to be identified e.g. energy loss due to friction between bearing and shaft need not be worked upon as it is not possible to recover and reuse this energy. Typical energy loss areas are heat loss in solid/liquid/gaseous streams, electrical energy loss due to under loading, excessive lighting and heat loss by radiation.

The cause analysis of problems identified can now be carried out. This analysis involves locating and pinpointing the causes of waste generation and energy loss. There could be a wide range of causes for waste generation and energy loss ranging from simple lapses in housekeeping to complex technological reasons. Quite often, each identified problem would have more than one cause and similarly the same cause might be applicable to more than one problem. The generic causes such as poor process control, improper design etc. should be avoided, as it does not lead to specific GP option development. Cause analysis should be specific and to the point. The use of the *Cause and Effect (Fishbone) diagram* would assist in identifying root cause of problems. Here, problems can often be traced to 5 main categories of causes, namely, Man, Machine, Material, Method and Environment. Holding *brainstorming* sessions often leads to excellent cause analysis. The brainstorming should not be limited to people belonging to the area of concern as the causes could have been extended beyond these areas. The principles of good brainstorming should be followed.

Task 4 – Set Objectives and Targets

Once the concerns are identified and prioritized, it is necessary to set objectives and targets. Objectives should be based on concerns identified. One objective can have multiple targets, which could be phased over time. Targets should be developed based on the need. For example, if legal compliance is to be sought within one year, then the target for an objective which addresses a compliance parameter should be set for one year.

Targets should be decided with an anticipatory perspective. For example, if a certain objective is to be sought within 2 years, it should be investigated whether the objective will be completely achieved in that time frame. It is possible sometimes that the value of concerns also might have changed in the 2 years, which would necessitate setting of another target in the future.

Step II should end in a list of identified problems and their causes in the selected focus area and objectives and targets which the organization will be working towards.

Step III Generation and Evaluation of GP Options

This is the most creative step in the entire GP assessment process. The efforts put in so far would now be made use of for determining problems solving options. The step consists of 3 tasks namely, development of GP options, preliminary screening and evaluation of options, and formulation of an implementation plan for the selected options.

Task 5 – Generation of GP Options

The most significant task in entire GP methodology relates to the development of GP options. These options emerge directly from the cause analysis carried out earlier. This is the most creative phase of the GP Assessment Process as the GP team ready with data should now look for possible methods of reducing waste. Finding waste prevention options depends on the knowledge and creativity of its members, their education, work experience and facilitating resources. Resources such as personnel from the same or similar plant elsewhere, trade associations, success cases tried elsewhere, specialist organizations including R & D institutions, equipment suppliers and consultants could be sought. The process of finding waste prevention options should take place in an environment which stimulates creativity and independent thinking. Use of techniques like brain storming and group discussions are very helpful in generating and better ideas. Members of the GP team may also source information on the internet, books or other published literature.

Task 6 - Preliminary Screening of Options

Under the earlier task, a list is prepared for all possible GP options that emerge in the brain storming or group discussion system. The first shifting of the workable options is now available. The options are distributed under 3 categories namely “option, which are directly implemented”, “options requiring further analysis” and “rejected options”. This categorization should be done based on very simple and quick assessment. In case of any doubt, the option should be put into the middle category. The weeding out process should be simple, fast and straightforward and may often be only qualitative.

The options, which are placed in the first category of directly implemented options, should be taken up for implementation immediately. Options falling into the third category would be shelved for the time being. The remaining options falling into the second category would now be subjected to a more detailed feasibility analysis.

a. Assessment of technical feasibility

The technical evaluation determines whether the proposed option is technically workable under the given conditions. A typical checklist for technical evaluation should consist of

Availability of hardware/technology
Availability of operating skills
Availability of space
Effect on production
Effect on product quality
Safety aspects
Maintenance requirements
Effect on operational flexibility
Shut down requirements for implementation

b. Assessment of economic viability

Economic viability is often the key parameter for promoting of discussing implementation of waste prevention options. For a smooth take off and for sustaining interest in the entire GP program, it is essential that the first few options should be economically very attractive. Such a strategy generates more interest and commitment. Options requiring small investment but involving more procedural changes like housekeeping measures, operational improvements, and process control measures, do not require intensive economic analysis and simple methods like *'pay back period'* could be used. However, as the measures become more involved and capital intensive, methods like *internal rate of return (IRR)* or *Net Present Value (NPV)* need to be adopted to get a complete picture. While doing the economic assessment, the “cost” may include fixed capital cost i.e., cost of the hardware, shutdown cost and O&M cost. The “savings” may consist of savings of input material/energy, profit due to higher production levels, lower O&M cost, value of by-products, reduction in environmental cost such as waste treatment, transportation and disposal cost.

c. Evaluation of environmental aspects

The waste prevention options need to be analyzed with respect to their impacts on the environment. In many cases, the environment benefit is obvious - reduction in toxicity and/or quantity of waste. The other impacts be improved treatability of waste, changes in applicability of environmental regulations and applicability of simple End-of Pipe pollution control systems.

Initially the environmental aspects may not appear to be as important as technical and economical aspects. However, with increasing pressures from different customers, it is expected that, in due course, environmental evaluation may well become the most important criteria for selection of waste prevention solutions.

After technical, economic and environmental considerations, it is often difficult to decide which option should be taken up for implementation. *A rating matrix* helps in combining the results of three evaluations. Each aspect is given a weight as determined and agreed upon by the management. Each option is then assessed in the context of the given weight for each of the aspect. The sum of these marks would determine the ranking of options with regards to priority of implementation.

Task 7 – Formulation of GP Implementation Plan

The preparation for implementing waste prevention solutions requires arranging finances, technical preparation and establishing linkages with other departments. Support and cooperation of concerned persons has to ensured. Checklists of tasks involved, agencies/departments to be approached provide good help. The implementation plan should cover a detailed activity plan, the inputs (including manpower and financial inputs), required time frame and the persons responsible for implementation. For implementation of any GP option, it is required to know the following :

Location / point of application of the option
Nature of the option
Resources necessary
Personnel necessary
Whether production or activity at or near the point of application of the option is to be stopped, altered or relocated.
Responsibility matrix and task allocation in teams
Details on cost requirements, when, how much sourcing of funds
Milestones to be set in the implementation sequence.

Step III should result in a prioritized list of GP options and its implementation plan.

Step IV Implementation of GP option

Task 8 – Implementation of Selected Options

The implementation of waste prevention solutions is similar to any other industrial modification. The task comprises preparation of drawings, ordering and procurement of equipment, transportation of the same to the site, installation and commissioning. Whenever required, simultaneous training of manpower should not be missed out as an excellent measure may fail miserably if not backed up by adequately trained people.

Task 9 – Training, Awareness Building and Develop Competence

Depending on the nature of the GP options, the staff of the organizations will have to be trained for installation operation and maintenance of the GP option.

This step should result in a number of successfully implemented waste prevention solutions. Quite often, this step is the most time consuming step as the implementation is the single largest time consuming activity.

Step V Monitoring and Review

After implementation, it is important to continually monitor and evaluate the appropriateness of the options employed. The results have to be reviewed by the management.

Task 10 - Monitoring and Evaluation of Results

The performance of the options implemented should be monitored to compare the actual results with the expected ones. In case of any deviation, the cause needs to be determined and appropriate modifications, if required, should be carried out. The implementation job would be considered as completed only after sustained performance is recorded over a reasonable period of time.

Task 11 – Management Review

Post implementation review by management involves checking whether the overall GP program is proceeding in the right direction and whether targets are being achieved as per implementation plan.

Step VI Sustaining Green Productivity

The biggest challenge in Green Productivity lies in its sustainability, otherwise, the euphoria of the program dies out very soon and the situation returns to where it started. The zeal and tempo of the GP Team will also wane off backing out from commitment. Absence of rewards and appreciation for performers, shifting priorities are some of the commonly encountered reasons for such a project end of a Green Productivity program.

Task 12 – Incorporate Changes into the Organization's System of Management

Green Productivity would not sustain in isolation. It should be integrated to become a part of day to day management practices. The GP team should establish a system for sustaining the implemented solutions, simultaneous development and implementation of ISO 14000 Environmental Management System would help in providing a structured system integrated with the basic management system.

Task 13 - Identify and Select Next Focus Area

The entire methodology can now be repeated for the second focus area. By the time one full cycle is completed, there would be fresh opportunities of waste prevention in the first focus area and the whole cycle could similarly be repeated. Green Productivity would, therefore, never end. It is a continuous process and would go on forever.

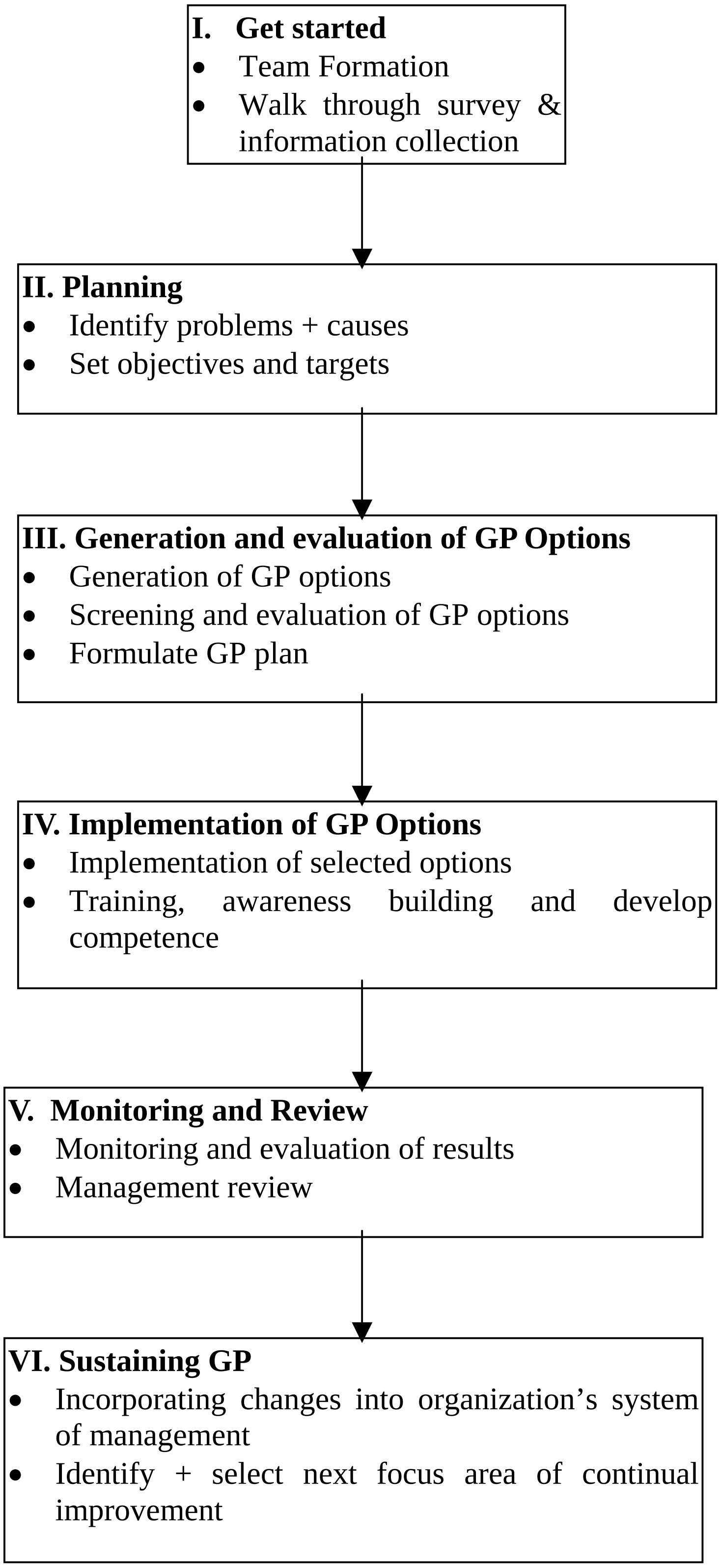

Figure 1.1 Flow Chart of GP Methodology