Energy is one of the major parameters for establishing growth and progress of the country, rather the standard of living depends directly upon the per capita energy consumption. An analysis of the distribution of the major energy forms in rural India reveals that out of $11.42 \times 10^{12}$ kcal, the share of non-commercial energy is 65%, human and animal energy 15% and commercial energy 20%, thus 80% of rural energy is met from renewable sources. Most of energy on the earth is received from the sun. Solar energy creates circulation of wind and ocean water, causes water evaporation and consequent precipitation. Plants use solar energy for photosynthesis and store carbohydrates, protein, fats, oils, alcohols, cellulose and lignin. Humans and animals consume plant materials as primary food to utilize its digestive energy. Plant and animal remains are converted to coal and petroleum products over million of years, which provide the main energy sources for modern life. In agricultural systems, energy is available from different sources as human, animal, sun, wind, biomass, coal, fertilizer, seed, agro-chemicals, petroleum products, electricity etc. Energy sources that release available energy directly to the system (through mechanical/chemical/biological processes) are classified as direct energy sources. Typical examples of direct energy sources are human labour, animal labour, petroleum products and electricity. Some energy is invested in producing indirect sources of energy, such as seed, manure (farm yard and poultry), agro-chemicals, fertilizers and machinery.

Solar energy

Widespread use of solar energy for domestic, agricultural and agro-industrial activities has been practiced almost since the development of civilization. Increasing threat of acute shortage of the commercial sources of energy coupled with serious environmental pollution problems has accelerated interest in the scientific exploitation of renewable sources of energy. Energy available from the sun is inexhaustible and environment friendly. Therefore, the solar energy technologies are likely to play an important role in the near future through a variety of thermal applications and decentralized power generation and distribution systems.

The power from the sun intercepted by the earth is approximately $1.8 \times 10^{11}$ MW. This makes it one of the most promising unconventional energy sources. Solar energy is available in abundance in most part of our country throughout the year. In India, the annual average daily solar radiation received over the whole of the country is around 1800 J/cm²/day. Drying of various agricultural produce in open sunlight is an age-old practice. Development of various solar devices for thermal applications such as water heating and space heating, drying, cooking and power generation began during the last century.

Solar cookers

Two different types of solar cookers i.e. indirect and direct focusing type have been developed in the country. The indirect type solar cookers consisting of an insulated box with transparent window through which sunlight enters into the box have been satisfactorily developed and commercially exploited for domestic cooking. Such solar cookers are being marketed on commercial scale in most of the states through State Energy Development Corporations or other nodal agencies of the Ministry of Non-conventional Energy Sources (MNES), Government of India.

Solar dryers

Open sun drying of various agricultural produce is the most common application of solar energy. With the objective of increasing the drying rate and improving quality of the produce, natural convection and forced convection type solar dryers have been developed for various commodities. The movement of air in the forced convection solar dryer is through a power blower whereas in natural convection solar dryer air moves through the produce due to natural thermal gradient.
Solar water heater
Water heating is one of the most common applications of solar energy for domestic and industrial applications. Similar to solar dryers, water heating systems are also available in natural convection and forced convection designs. Natural convection water heating system also known as thermo syphon water heating system consist of a flat plate solar collector, insulated water storage tank and necessary insulated pipe fittings.

Solar photovoltaic systems
In solar photovoltaic (SPV) technology the solar radiation falling on a device called solar cell is converted directly into electricity without any environmental pollution. SPV pumping systems are ideal for lifting water for drinking and irrigation without harming the environment. These pumps can be installed in boreholes, tanks, cisterns or rivers. DC surface pumps are designed for high flow rates at low heads. DC floating pumps are suitable for wide range of flow and head situations.

Briquetting of biomass and improved cookstove
Authoritative studies reveal that the forest cover of the country is depleting every year at a rate more than 1.5 million hectares. The situation is particular grave in rural areas. This rate of deforestation is alarming. Much of the wood felled is used as fuel for cooking. Charring and briquetting technologies reduce various problems associated with the management and utilization of biomass in domestic and industrial sectors. Briquetting of some of the crop residues has becomes cost competitive and the briquettes being used as replacement of firewood in many regions of the country.

Anaerobic digestion
Domestic biogas plants installed in our country use cattle dung mixed with an equal quantity of water to maintain 8-9% total solids concentration (TSC) in the influent slurry. The effluent discharged from the plants is, in general, collected into the slurry pits or spread on to the ground for drying before transportation to fields for use as organic manure.
BOX TYPE SOLAR COOKER

Features
The important parts of a solar cooker include the outer box with thermal insulator, inner cooking box or tray, the double glass lid, mirror and cooking containers. The outer box is generally made of G.I. or aluminium sheet or fibre reinforced plastic. The inner cooking box or tray is made from aluminium sheet and coated with black paint to absorb solar radiation and to transfer the heat to the cooking pots. The cooking tray is covered with a double glass lid in which the two glass sheets are spaced at about 20 mm to entrap air which acts a insulator and prevents escape of heat from the inside. The space between the outer box and inner tray including bottom of the tray is packed with insulating material such as glass wool pads to reduce heat losses from the cooker. In addition to the above, the cooker is fitted with a mirror to increase the radiation input on the absorbing space. This radiation is in addition to the radiation entering the box directly and helps to quicken the cooking process by raising the inside temperature of the cooker. The cooking containers (with cover) are generally made of aluminium and painted black on the outer surface so that they also absorb solar radiation directly. A large number of items such as pulses, rice, kheer, khichri, vegetables, meat, fish etc. can be cooked in the solar cooker. The time taken to cook will depend upon the type of food, time of the day and solar intensity.

Specifications
Overall Dimensions
Length × breadth × height (mm) 500 × 500 × 200
Weight (kg) 12
Time taken in cooking (min) rice, 45-60, vegetables 60-100
Conversion efficiency (%) 35-40

Uses
It is used for cooking purposes where sunshine is available in plenty.

Sources (Appendix)
118, 282, 389, 409, 577, 656, 786, 852, 960, 962, 1198, 1209, 1296, 1359, 1479, 1548, 1579

DOUBLE REFLECTOR BOX TYPE SOLAR COOKER

Features
In order to increase the solar radiation entering the hot box, additional reflectors have been incorporated to reduce the cooking time. In this cooker, twin reflector mirrors (unbreakable acrylic mirror) are fixed. It is effective in central and North India especially in winter season. It is useful for cooking food and baking. As compared to the box type solar cooker with one mirror available in the market, the twin reflector box type cooker is capable of maintaining 25 to 30°C higher temperature. It saves 20% time spent in cooking food drying winter and 12-16% of time during other months.
Uses

It is used to cook foods and for baking purposes especially during winter in the northern latitudes of India.

Sources (Appendix)

281, 389, 409, 852, 1296, 1359, 1479, 1579

BOX TYPE COMMUNITY SOLAR COOKER

This is an enlarged version of a box type solar cooker made of double walled hot box having length to width ratio of 3 for the glass window. The absorber has an area of 0.9 m². The inner cooking box or tray is made from aluminium sheet and coated with black paint to absorb solar radiation and to transfer the heat to the cooking pots. The cooking tray is covered with a double glass lid in which the two glass sheets are spaced at about 20 mm to entrap air which acts as insulator and prevents escape of heat from the inside. The space between the outer box and inner tray including bottom of the tray is packed with insulating material such as glass wool to reduce heat losses from the cooker. In addition to the above, the cooker is fitted with a mirror to increase the radiation input on the absorbing space. This radiation is in addition to the radiation entering the box directly and helps to quicken the cooking process by raising the inside temperature of the cooker. The cooking containers (with cover) are generally made of aluminium and painted black on the outer surface so that they also absorb solar radiation directly. The increased area of the absorber allows the placement of ten cooking pots of 5 litre capacity each in the hot box at a time, thus enhancing its capacity. The cooker is provided with castor wheels for easy movement and adjusting the reflector to capture maximum solar radiation.

Specifications

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of windows</td>
<td>2</td>
</tr>
<tr>
<td>Area of the absorber (m²)</td>
<td>0.9</td>
</tr>
<tr>
<td>Outer dimension (m)</td>
<td>1.50×0.61×0.24</td>
</tr>
<tr>
<td>Type and size of glazing (m)</td>
<td>Windowpane glass, 0.7×0.5</td>
</tr>
<tr>
<td>Number and type of reflector</td>
<td>One, glass mirror</td>
</tr>
<tr>
<td>Insulation</td>
<td>7.5 cm thick glass wool all around</td>
</tr>
<tr>
<td>Number of cooking pots</td>
<td>10</td>
</tr>
<tr>
<td>Capacity of cooking pots (l)</td>
<td>5</td>
</tr>
</tbody>
</table>
USES
Used for cooking that involves boiling and roasting of food products

SOURCES (APPENDIX)
863

SOLAR BAKING UNIT

FEATURES
The solar baking unit is a scaled up version of the double reflector box type solar cooler but designed to generate higher stagnant temperatures suitable for baking purposes. In order to increase the solar radiation entering the hot box, additional reflectors have been incorporated to reduce the cooking time. In this cooker, twin reflector mirrors (unbreakable acrylic mirror) are fixed. It is effective in central and North India especially in winter season. It is useful for cooking food and baking. As compared to the box type solar cooker with one mirror available in the market, the twin reflector solar baking unit is capable of maintaining 25 to 30°C higher temperature. It saves 20% time spent in cooking food drying winter and 12-16% of time during other months. It has thermostat controlled electrical back up of 1 kW capacity so that proper baking can be continued even when there is sudden cloudiness while baking is in progress. It is also suitable as a community cooker for up to 10 persons.

SPECIFICATIONS
Overall Dimensions
- Length (mm): 1500
- Width (mm): 500
- Height (mm): 250
- Weight (kg): 29
- Cooking capacity: 10 persons
- Baking capacity (kg/day): 2 in winter and 4 in summer
- Time taken in cooking (hrs): 2.0-2.5

USES
It is used to cook foods and for baking purposes especially during winter in the northern latitudes of India.

SOURCES (APPENDIX)
254

COMMUNITY SOLAR COOKER

FEATURES
The Community Solar Cooker (Rotating Disc Type) works on the principle of solar energy concentration using a Reflecting Parabolic Solar Concentrator. It consists of a 7-squaremeter area parabolic solar concentrator Part A (Solar Concentrating Disc, Primary Reflector) is used for concentrating solar radiation on a focal area where the cooking vessel (Part D) is placed. With the help of a simple automatic mechanical tracking system (Automatic Tracking System...
Part B) the solar disc rotates in the direction of the movement of the Sun to give continuous and accurate solar energy concentration. This mechanical device is made up of a simple clock mechanism with chain & gear arrangement to provide regulated tracking motion to follow the path of the sun through out the day – from dawn to dusk and gives daily about 6 – 8 hours of operation time. The Secondary Reflector (Part C), is provided opening in the north-facing wall of the kitchen or the cooking place just below the cooking vessel. This reflector receives the concentrated solar radiation and reflects it on to the bottom of the cooking vessel as shown in the figure above. The Solar Cooker is installed in the open shadow-free area or on terrace tops facing the South. The reflection of the disc falls on a secondary reflector housed in an opening in the North kitchen wall. The secondary reflector further reflects the radiation on to the cooking vessel place above in the kitchen. The Solar Disc is installed in an open area - terrace or courtyard, facing the South. The cooking place and vessels faces the North (at the same ground level). The cooker is very simple to operate and easy to maintain. Daily in the morning the disc is manually oriented so as to face the morning sun – in the east. The daily orientation action winds the clock mechanism to work throughout the day and the disc starts rotating in the direction of the Sun guided by the Sundial. The Cooker begins to work automatically as the concentrated solar energy is directed to the cooking vessel. The primary concentrated reflection falls on the secondary reflector, which is placed right below the cooking vessel. The secondary reflector diverts the solar energy on the cooking vessel and the heating begins. The seasonal orientation (adjustment) of the disc is required to be done once in six months due to shift of the Sun’s position, with respect to the Earth axis, i.e. when the Sun changes its angle at the summer and winter solstice on 14th January each year.

Specifications

- Area of Concentrator (m²) : 7
- Diameter of collector (mm) : 3000
- Period of operation (hrs) : 6-8
- Temperature obtained (°C) : 200-250
- Tracking mechanism : Pendulum and escapement
- Power rating (kW) : 2.8
- Time for boiling 50.0 l water (min) : 90

Uses

This system besides the cooking function – twice a day, can be utilized for water heating during the non-use period. The hot water can be used for cleaning cooking and other utensils. These Solar Concentrators can also be used for industrial applications for heating water or other liquid. This device is an ideal renewable energy application for saving conventional energy costs in community kitchens to a great extent. Kitchens operated by ashrams, educational institutions, hostels, hospitals, religious places, etc. can effectively utilize the Community Solar Cooker.
SOLAR PARABOLIC COOKER

Features
The Solar parabolic Cooker works on the principle of solar energy concentration using a Reflecting Parabolic Solar Concentrator. A high temperature is obtained since the sun's rays are concentrated on a pot. The family size reflector is mainly made out of aluminum. The general handling is easy and simple. The cooker is very simple to operate and easy to maintain. Daily in the morning the disc is manually oriented so as to face the morning sun – in the east. Since it attains a high temperature in excess of 200°C, virtually any type of food can be cooked in a short time. It has an efficiency of 34% and can reach more than 200°C. In about 7 minutes 1 liter of water will boil.

Specifications
- Area of Concentrator (m²): 1.5
- Diameter of collector (mm): 1200
- Period of operation (hrs): 6-8
- Temperature obtained (°C): 200-250
- Tracking mechanism: Manual
- Power rating (kW): 0.7
- Time for boiling 1.0 l water (min): 7

Uses
This system besides the cooking function – twice a day, can be utilized for water heating during the non-use period. The hot water can be used for cleaning cooking and other utensils. This device is an ideal renewable energy application for domestic cooking units.

DOMESTIC SOLAR DRYER

Features
This is a small dryer meant for domestic uses for drying small quantities of products such as vegetables, fruits, condiments and spices. In this dryer, the convection of heated air is natural due to difference in temperatures and can be made to be direct or indirect depending upon the type of the product dried. Solar energy is intercepted on the inclined aperture, which is glazed for trapping infrared radiation, and prevents unnecessary circulation of ambient air thereby maintaining the required temperature inside. The drying trays have been arranged one over the other on an inclined plane so that there is free circulation of heated air through the mass kept for drying. The
products can be dried under shade or exposed to sunrays as desired. The dryer has provision for changing inclination of the aperture by $15^\circ$ to capture more solar energy depending upon the season and the castor wheels aid in easy orientation to capture maximum of solar radiation. The drier may be left unattended even during rains, as the products kept inside are not affected.

### Specifications

<table>
<thead>
<tr>
<th>Materials used for</th>
<th>GI sheet &amp; MS angle iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body</td>
<td>Thennocole</td>
</tr>
<tr>
<td>Insulation</td>
<td></td>
</tr>
<tr>
<td>Aperture area (m²)</td>
<td>0.36</td>
</tr>
<tr>
<td>No. of glazing</td>
<td>Single</td>
</tr>
<tr>
<td>Material of glazing</td>
<td>Plain window pane glass, 4 mm thick</td>
</tr>
<tr>
<td>Loading area/tray (m³)</td>
<td>0.252</td>
</tr>
<tr>
<td>No. of perforated trays</td>
<td>3, arranged at 3 levels</td>
</tr>
<tr>
<td>Loading per batch (kg)</td>
<td>2-3</td>
</tr>
<tr>
<td>Aperture area between each level of trays (m²)</td>
<td>0.10</td>
</tr>
</tbody>
</table>

### Uses

Drying of farm produce at domestic level such as vegetables, fruits, spices etc. The dryer can be used for dehydration of a large number of items normally handled in the household. The dried products can be powdered in a domestic grinder (as the use of these products in powdered form is convenient for cooking) and stored for use.

### Sources (Appendix)

1728

### PORTABLE FARM SOLAR DRYER

#### Features

This dryer is a low cost medium size natural convection solar dryer. It is constructed using commonly available nickel coated iron curtain pipes UV stabilized polyethylene sheet serves the purpose of glazing and is fixed on a light frame which can be moved forward to expose the drying chamber for feeding the trays easily. Thus, the process of loading and unloading of the product is very easy. Depending upon the requirement of the dried product, the dryer may be made to face the sun or kept in the shade for taking advantage of indirect heating. A variety of products such as vegetables, fruits, spices and condiments can be conveniently dried in this unit. Provision of castor wheels aid in easy movement of the drier and to make it obtain maximum exposure to the sun as per requirement. Assembly and disassembly of the unit is also very easy and is highly portable.

### Specifications

<table>
<thead>
<tr>
<th>Materials of the body</th>
<th>Black HDPE sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials of the supporting frame</td>
<td>Nickel coated iron pipe used for curtain hanging</td>
</tr>
<tr>
<td>Aperture area (m²)</td>
<td>3.34</td>
</tr>
</tbody>
</table>
Glazing UV stabilized polyethylene sheet, inclination 45°
Material of glazing Plain window glass 4 mm thick
Loading tray area (m²) 1.35, 7 perforated trays, arranged at seven levels
No. of perforated trays 3, arranged at 3 levels
Loading per batch (kg) 20-30
Aperture area between each level of trays (m²) 0.10

**Uses**
Drying of farm produce such as vegetables, fruits, spices and condiments.

**Sources (Appendix)**
1728

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**FORCED CIRCULATION SOLAR DRYER**

**Features**
This type of dryers takes advantage of an array of solar collectors, which are connected together to achieve high airflow rates. Some of the major components are, solar air heaters, electric blower, connecting ducts, drying chamber and control systems for air temperature and flow rate. Solar collectors are inter-connected in a series/parallel configuration depending upon the desired rated of airflow and temperature. In the case of unfavourable weather conditions or cloudy days, supplemental heat may be provided through an electrical/biomass based heater. Such arrangement is also beneficial to operate the unit even during night time.

**Specifications**
- Drying capacity (tonne/day) : 2
- Temperature of hot water (°C) : 40-70
- Type of solar collector : Flat-plate/packed bed type
- Type of drying chamber : Vertical tray type
- Thermal back-up : Electrical heater/biomass gasifier

**Uses**
Drying of high value products

**Sources (Appendix)**
1494

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**NATURAL CONVECTION SOLAR TUNNEL DRYER**

**Features**
For drying bulk material from high moisture content, a tunnel type solar dryer has been developed. The dryer has a capacity to hold 1.5 tonne of di-basic calcium phosphate (DCP), which has been installed at M/s Phosphate India Ltd., Udaipur and is in regular operation. It is constructed of pipe frame structure having a hemi-cylindrical shape and is tall enough for a
worker to walk-in. It is covered with UV stabilized semi-transparent polyethylene sheet of 200-micron thickness. The whole structure has a slope of 10–15° along its length to aid in the natural convection of hot air to the upper end. An exhaust fan is provided at the upper end for rapid removal of humid air and to expedite the drying process to the required level. Arrangement for the control is also provided so that the operation of the exhaust fan is controlled by the humidistat. The product to be dried is put into trays in thin layers. The trays are loaded on to mobile trolleys. Ten trolleys are kept inside the tunnel for drying of the DCP. The floor and northern sides of the dryer are suitably insulated to prevent loss of heat.

Specifications
Tunnel

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base area (m)</td>
<td>21.0×3.75</td>
</tr>
<tr>
<td>Height (m)</td>
<td>2.0</td>
</tr>
<tr>
<td>Capacity of exhaust fan (kW)</td>
<td>0.75</td>
</tr>
<tr>
<td>Capacity (kg)</td>
<td>1,500 of wet DCP</td>
</tr>
</tbody>
</table>

Uses
Industrial scale drying of various agro products

Sources (Appendix)
863

SOLAR CABINET DRYER

Features
The solar cabinet dryer is suitable for drying perishable, semi perishable and wet processed food material. It consists of a frame to hold the drying trays, a glazed cover and an aspirator for driving out the hot and humid air utilising natural convection. The special construction of the aspirator takes advantage of prevailing direction of wind to create a sucking action. Small quantities of chilli, potato chips, cauliflower, leafy vegetable etc. can be dried in a short time without contamination from foreign matter.

Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Dimensions</td>
<td></td>
</tr>
<tr>
<td>Length (mm)</td>
<td>2210</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>1130</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>980</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>125</td>
</tr>
<tr>
<td>Number of trays</td>
<td>4</td>
</tr>
<tr>
<td>Working width (m)</td>
<td>2.5</td>
</tr>
<tr>
<td>Working depth (m)</td>
<td>2.5</td>
</tr>
<tr>
<td>Capacity (kg/batch)</td>
<td>3-5</td>
</tr>
<tr>
<td>Drying time (days/batch)</td>
<td>3-5</td>
</tr>
<tr>
<td>Thermal efficiency (%)</td>
<td>50</td>
</tr>
</tbody>
</table>
Uses
Used for drying of perishable and wed processed food material using solar energy.

Sources (Appendix)
254

PACKED BED SOLAR AIR HEATER

Features
This solar air heater is similar in construction to conventional designs but the exposed area is made of glass to improve the trapping of additional heat. The air duct portion is filled with blackened iron turnings, which is a waste product of a machine shop. The iron turnings absorb the solar radiation and due extra area, heat is transferred to the circulating air efficiently. The absorber is insulated at the bottom and sides with glass wool to reduce heat loss. The packed bed air heater is able to provide higher thermal efficiency due to higher heat transfer and large area of absorber surface coming in contact with the air molecules.

Specifications
- Aperture area (m²): 1.25 for one collector
- Type: Packed bed (air duct packed with iron turnings)
- Material of body: GI sheet
- Glazing: Windowpane glass, 4mm thick
- Insulation: Glass wool, 7.5 cm thick at back and 2.5 cm on side

Uses
For hot air application e.g. drying of agricultural produce, desiccant seed drying, etc.

Sources (Appendix)
1728

MULTI-RACK VARIABLE INCLINATION SOLAR DRYER

Features
This dryer is a medium size natural convection solar dryer. It is constructed using commonly available mild steel angle sections and glazed transparent cover made of simple windowpane glass. Depending upon the requirement of the dried product, the dryer may be made to face the sun or kept in the shade for taking advantage of indirect heating. A variety of products such as vegetables, fruits, spices and condiments can be conveniently dried in this unit. Provision of castor wheels aid in easy movement of the drier and to make it obtain maximum exposure to the sun as per requirement. There is provision for fixing six trays loaded with the product to be dried. The trays have been arranged at different levels. Drying in all the trays is relatively uniform because of heating of the air in between the trays. Simple mechanism has been provided to vary the inclination of
The solar collector depending upon the latitude of place of use and season during period of drying. Higher efficiency can be achieved by semi-continuous loading instead of batch loading.

Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture area (m²)</td>
<td>1.5</td>
</tr>
<tr>
<td>Glazing</td>
<td>Single, plain window glass, 5mm thick</td>
</tr>
<tr>
<td>Number of perforated trays</td>
<td>Six, arranged at 6 levels</td>
</tr>
<tr>
<td>Loading per batch (kg)</td>
<td>50</td>
</tr>
</tbody>
</table>

Uses

Drying of farm products such as vegetables and fruits, etc.

Sources (Appendix)

863, 1378

STEP TYPE SOLAR COCOON STIFLER

Features

Silk cocoon stifling is generally carried out using an electric oven or by using firewood and boiling water. The heat needed to kill the pupa is obtained from solar radiation in a solar cocoon stiffer. If the pupa or not killed at the right time, they grow out of the cocoon, damaging the silk fibres. Hence stifling kills the pupa and 12-15 days time is available for reeling the silk fibres. The solar cocoon stiffer is a box type unit provide with insulation and double glazed cover for trapping solar heat. Wire mesh trays are arranged horizontally inside the stiffer and can be loaded easily by opening the side panels. It has a small fan for recirculating air for uniform heat distribution. An electric heater of 2 kilowatt and thermostatic control is also provided to supply adequate heat during adverse weather. The quality of cocoon stifled in the solar stiffer is similar to the cocoon stifled in the conventional process using the electric oven.

Specifications

<table>
<thead>
<tr>
<th>Overall Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (mm)</td>
</tr>
<tr>
<td>Width (mm)</td>
</tr>
<tr>
<td>Height (mm)</td>
</tr>
<tr>
<td>Weight (kg)</td>
</tr>
<tr>
<td>Stiffling capacity (kg/day)</td>
</tr>
<tr>
<td>Cooking time (hrs/batch)</td>
</tr>
</tbody>
</table>

Uses

It is used for stifling silk cocoons.

Sources (Appendix)

254
LOW COST SOLAR WATER HEATER

Features
This is a low cost flat plate solar water heater utilising natural convection process for the movement of hot water. It has a tube-in-fin absorber coated with blackboard paint and made of GI sheets and tubes. Ordinary windowpane glass has been used for glazing and the storage tank is also made of GI sheets. The plate type heat exchanger used in the storage tank of this SWH is simpler and cheaper than pipe heat exchanger used in the commercial SWH. 20 cm thick composite insulation consisting of glass wool and polystyrene foam (thermocole) has been used in the storage tank to prevent heat losses. The connecting tubes are also insulated and covered with aluminium sheets to improve the performance of the solar water heater.

Specifications
Solar collector

<table>
<thead>
<tr>
<th>Numbers</th>
<th>Two</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture area (m²)</td>
<td>1</td>
</tr>
<tr>
<td>Type</td>
<td>Tube-in-fin absorber</td>
</tr>
<tr>
<td>Material</td>
<td>Tube - GI pipe (37 mm)</td>
</tr>
<tr>
<td></td>
<td>Fin - G.I sheet (26 gauge)</td>
</tr>
</tbody>
</table>

Storage tank

<table>
<thead>
<tr>
<th>Capacity (l)</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>G.I sheet (24 gauge)</td>
</tr>
<tr>
<td>Heat exchanger</td>
<td>Plate type</td>
</tr>
</tbody>
</table>

Uses
Water heating for domestic and industrial applications

Sources (Appendix)
1728

SOLAR WATER HEATER

Features
The commercially available solar water heaters utilize the thermosiphon principle to store the hot water in the overhead tank. Copper tube and fin type heat exchanger are used for collecting the solar radiation and to transmit the heat to the water in the tubes. The copper plate is blackened to absorb solar radiation. All the connecting pipes and hot water tank are insulated with polyurethane foam so that hot water is maintained over a 24 hour period. They are usually provided with toughened glazing for long life and maintenance free operation.
Solar basin still consists of a simple blackened box for storing and heating water. This box is provided with a glazed top, which serves the purposes of both insulator and condensing surface. The glazed top is kept at an angle to allow the condensed water to flow to one side and into a small gutter. The bottom of the unit is insulated with glass wool to improve the efficiency. Solar energy is allowed into the collector to heat the water. The water when heated to a certain temperature evaporates and condenses on the underside of the glass. When water evaporates, only the water vapor rises, leaving contaminants behind, thus purifying the water. The gentle slope of the glass directs the condensate to a collection trough, which in turn delivers the water to the collection bottle. The still is filled each day with twice as much water as was produced. The still is also fitted with overflow outlets, which allows the excess water to flush the still every day. A major advantage of the basin still is that it does not require a pressurized water supply.

Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distillation capacity (l/m²)</td>
<td>2.5-3.0</td>
</tr>
<tr>
<td>Capacity of raw water tank (l/m²)</td>
<td>5-6</td>
</tr>
<tr>
<td>Capacity of distilled water (l)</td>
<td>2</td>
</tr>
</tbody>
</table>

Uses

Solar still is an useful devise to get fresh/distilled water which is required in industries hospitals and dispensaries for sterilization, garages and automobile workshop for radiator and battery maintenance, telephone exchanges for battery maintenance, laboratory use for analytic work and marshy and costal area to get fresh potable water.
SOLAR PHOTOVOLTAIC REFRIGERATOR

Features
A solar photovoltaic refrigerator has been developed to keep vaccines, medicines and other perishables. A solar photovoltaic (SPV) panel of 180 watt peak power along with battery pack supplies the powers to the compressor unit. The unit is operated on direct current power supply and hence special compressor unit has been adopted. The unit has an opening on the top so that cold air does not escape when it is opened for removing/replacing the product.

Specifications
<table>
<thead>
<tr>
<th>Refrigerator</th>
<th>Top opening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (l)</td>
<td>100</td>
</tr>
<tr>
<td>Compressor</td>
<td>12/24 V DC</td>
</tr>
<tr>
<td>SPV panel capacity (W)</td>
<td>180</td>
</tr>
<tr>
<td>Battery pack</td>
<td>Lead acid 130 Ah, 24 V</td>
</tr>
<tr>
<td>Charged controller</td>
<td>24 V, 10 A</td>
</tr>
</tbody>
</table>

Uses
To store vaccines, medicines and other perishables at a low temperature in areas not connected to utility electricity supply.

Sources (Appendix)
96, 265, 344, 547, 575, 613, 1007, 1072, 1322, 1478, 1538, 1550, 1578, 1675, 1753

SOLAR LANTERN

Features
The solar lantern consists of a small photovoltaic panel to capture and convert sunlight into direct current (DC). The DC is used to charge a sealed maintenance free led acid battery using a charge controller. Whenever light is required the DC is inverted and fed to a compact fluorescent lamp of 7 or 9 Watt rating.

Specifications
| SPV rating (W) | 8 |
| Dimensions, Panel | |
| Length (mm) | 560 |
| Width (mm) | 260 |
| Height (mm) | 60 |
| Dimensions, Lantern | |
| Diameter (mm) | 240 |
| Height (mm) | 450 |
| CFL rating (W) | 7 and 9 |
| SMF battery | 12 V, 7 Ah |

Sources (Appendix)
1494, 1615
SOLAR STREET LIGHT

Features
The solar streetlight consists of two photovoltaic modules of 36 Watts each mounted on a 6-metre lamppost for charging. At the base of the pole a box is provided which houses the charging system, a storage battery and inverter unit. The unit is also provided with a light sensitive switch so that the street lamp gets lighted after sunset. The panel captures sunlight during daytime and stores in the battery by using a charge controller.

Specifications

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPV rating (W)</td>
<td>72</td>
</tr>
<tr>
<td>Dimensions, Panel</td>
<td></td>
</tr>
<tr>
<td>Length (mm)</td>
<td>960-980</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>430-450</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>40</td>
</tr>
<tr>
<td>Dimensions, Lantern</td>
<td></td>
</tr>
<tr>
<td>Length (mm)</td>
<td>393</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>310</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>100</td>
</tr>
<tr>
<td>CFL rating (W)</td>
<td>2 × 20</td>
</tr>
<tr>
<td>SMF battery</td>
<td>12 V, 40 Ah</td>
</tr>
</tbody>
</table>

Uses
A portable lantern for lighting purposes.

Sources (Appendix)
118, 252, 577, 656, 786, 818, 960, 962, 144, 198, 1209, 1238, 1286, 1333, 1459, 1548, 1577, 1615, 1620, 1663

SOLAR PUMP

Features
The solar pumps use the solar photovoltaic energy to pump water for agricultural and other purposes. A wide variety of pumps ranging from DC surface pumps to submersible AC pumps are available. They also require a pump controller to adjust for the variation of solar radiation through the day. DC surface pumps are designed for high flow rates and low heads. The permanent magnet DC motor driving the surface pump is powered by a matching solar arrays to maximise efficiency. An enclosed impeller design ensures smooth operation. AC submersible pumping systems are designed for high head and medium flow applications. It uses a multi-stage pump and a
high efficiency micro-computer based inverter. The inverter optimises the power input and thus enhances the overall system efficiency.

Specifications

<table>
<thead>
<tr>
<th></th>
<th>AC</th>
<th>DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPV rating (W)</td>
<td>$75 \times 16/24$</td>
<td>$75 \times 12/24$</td>
</tr>
<tr>
<td>Dimensions, Panel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (mm)</td>
<td>960-980</td>
<td>960-980</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>430-450</td>
<td>430-450</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Pump rating (kW)</td>
<td>1.0-1.5</td>
<td>0.75-1.5</td>
</tr>
<tr>
<td>Total head (m)</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Discharge (l/day)</td>
<td>17,625-35,000</td>
<td>70,000-135,000</td>
</tr>
</tbody>
</table>

Uses

Used for pumping water in situations where electricity is either unreliable or inaccessible. These pumping systems serve water supply for domestic and irrigation purposes.

Sources (Appendix)

118, 252, 577, 656, 786, 818, 960, 962, 144, 198, 1209, 1238, 1286, 1333, 1459, 1548, 1577, 1615, 1620, 1663

SOLAR TRACKING DEVICE

Features

Orienting a photovoltaic panel from the morning to evening to face the sun can increase its performance by up to 30%. The solar tracking device is designed to accurately track a solar panel fitted on a specially balanced frame. It has an electronic timer unit and a set of gears to transmit the power to the panel. Orientation is accomplished in small steps of 38 pulses per minute and its motion is almost imperceptible. Power for the tracking unit is obtained from one of the panels with a charge controller and small storage battery. At the end of the day, the frame closes a limit switch and the tracker is powered off. On the next day, the unit is disengaged with the help of the clutch provided and oriented to face the sun. Thereafter, tracking takes place automatically for the whole day. Thus it needs attention only for a few minutes at the start of the day. Due to increased output, higher rating of load can be used with such panels.

Specifications

Overall Dimensions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (mm)</td>
<td>400</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>300</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>300</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>15</td>
</tr>
<tr>
<td>Tracing capacity (SPV Panel) ($W_p$)</td>
<td>900</td>
</tr>
<tr>
<td>Power required to operate tracer (W)</td>
<td>15</td>
</tr>
</tbody>
</table>
**ELECTRONIC TEMPERATURE CONTROLLER**

**Features**
The electronic temperature controller is designed for precise control of airflow in a solar dryer. It consists of a thermister for sensing the temperature of hot air, a differential operational amplifier, an impedance matching unit and a controller for actuating a relay. The relay has one normally closed and one normally open connection, which are used in conjunction with the exhaust fan to control the operation of the fan depending upon the temperature. When the temperature of the air inside the dryer exceeds the set level, the controller switches-on an exhaust fan to draw out hot air. As soon as the desired temperature is reached, the fan gets switched off. The sensor has a dead band, which prevents unnecessary hunting of the controller when there are rapid fluctuations in the temperature.

**Specifications**
- Electronic system with temperature probe
- Power rating of the AC exhaust fan (W): 50
- Temperature accuracy (°C)

**Uses**
To control the air temperature in natural convection solar dryer

**Sources (Appendix)**
980, 1523, 1755

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**KVIC BIO GAS PLANT**

**Features**
Any organic matter when subjected to decomposition in the absence of air gives rise to gas, which is rich in methane and also contains carbon dioxide, hydrogen sulphide etc. Other than cattle dung, piggery, poultry droppings etc. can be used. In addition, agricultural wastes, kitchen wastes can be fed to the plant. The only condition is such droppings and wastes should be meshed by manual beater and then fed to the plant to prevent scum formation etc.

Two types of plants are constructed (1) Floating drum type and (2) Fixed dome type. The technology is very simple and user friendly. A plant consists of an (1) Inlet tank (2) digester (3) Outlet tank and (4) gas distribution system. There are different types of gas holders used in conjunction with the KVIC biogas plant such as...
Mild steel gas holder, fibre-glass gas holder, Ferro cement digester and Fibre-glass/Mild-steel gasholder.

**Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas production capacity (m$^3$)</td>
<td>1.5-8.0</td>
</tr>
<tr>
<td>Diameter of pit (mm)</td>
<td>2000-4000</td>
</tr>
<tr>
<td>Depth of pit (mm)</td>
<td>3000-6000</td>
</tr>
<tr>
<td>Height of gas holder (mm)</td>
<td>1200-6000</td>
</tr>
<tr>
<td>Diameter of gas holder (mm)</td>
<td>1800-3600</td>
</tr>
</tbody>
</table>

**Uses**

Generally the uses of the gas can be as under 1) cooking 2) lighting 3) Motive Power a) run pump set b) chaff-cutter 4) can produce electricity. Motive Power can be produced by linking the Gobar Gas to a duel fuel engine, specially designed for Gobar Gas.

**Sources (Appendix)**

254, 282, 389, 409, 852, 1296, 1359, 1479, 1579

**FIXED DOME BIO GAS PLANT (JANTA)**

**Features**

Any organic matter when subjected to decomposition in the absence of air gives rise to gas, which is rich in methane and also contains carbon dioxide, hydrogen sulphide etc. Other than cattle dung, piggery and poultry droppings can also be used. In addition, agricultural wastes, kitchen wastes can be fed to the plant. The only condition is such droppings and wastes should be meshed by manual beater and then fed to the plant to prevent scum formation etc.

In the fixed dome type or Janta biogas plant, the whole unit is built of brick or stone masonry, underground. The plant consists of an (1) Inlet tank (2) digester (3) Outlet tank and (4) gas distribution system. The gas evolved is collected over the digester chamber in the dome shaped roof portion, which also contains tubes for removing the gas. When biogas gets collected in the dome, it exerts pressure on the liquid driving the fluid in the inlet and outlet chambers. Thus when gas is used up, the liquid level in the inlet and outlet goes down. This plant is cheaper than the KVIC design due to the elimination of the floating drum. It is also less susceptible to steep variations in ambient temperature. However, skilled masons are needed to construct them.

**Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas production capacity (m$^3$)</td>
<td>1.5-8.0</td>
</tr>
<tr>
<td>Diameter of pit (mm)</td>
<td>2000-4000</td>
</tr>
<tr>
<td>Depth of pit (mm)</td>
<td>3000-6000</td>
</tr>
</tbody>
</table>

**Uses**

Generally the uses of the gas can be as under 1) cooking 2) lighting 3) Motive Power a) run pump set b) chaff-cutter 4) can produce electricity. Motive Power can be produced by linking the Gobar Gas to a duel fuel engine, specially designed for Gobar Gas.
HIMSHAKTI BIOGAS PLANT

Features
The Himshakti biogas plant has been developed to take advantage of the good features of Janta and Deenbandhu biogas plants for family size requirements. In order to reduce the depth of excavation, the ratio of diameter to depth ratio has been increased to 1.5 as compared to 1.2 - 1.4 for the conventional designs. Also the storage capacity of the dome has been increased to 40% as compared to 33% provided for the conventional plants. Masonry construction to the feeding inlet has been modified by using AC / PVC pipe of 150 mm diameter. Locally available stones have partially been used in place of bricks used for its construction to reduce the cost. Since the plant operated at reduced ambient temperatures, the digester is kept totally covered with soil to reduce extreme fluctuations in the temperature.

Specifications
- Capacity (m$^3$): 1, 2 & 3
- Material of construction: Bricks and stone block with cement mortar
- Feed rate (kg/m$^3$): 25
- Retention period (days): 60

Uses
Anaerobic digestion of cattle dung to produce biogas and manure

Sources (Appendix)
324

PANT TARAI BIOGAS PLANT

Features
The Pant Tarai biogas plant having a capacity of a 6 m$^3$ has been developed for the regions characterised by high water table where deep underground construction of biogas plants cause seepage of water into the digester. The diameter to depth ratio has been kept at 1:1 so that the depth of excavation is reduced to reduce seepage of water into the digester. Performance of the plant has been found to be comparable to the standard designs of the KVIC and Janta type of biogas plants.

Specifications
- Digester details
  - Diameter and depth (m): 2.5
Materials of construction

| Depths of wall below and above ground level (m) |
| Thickness of wall below the ground level (mm) |
| Thickness of wall above the ground level (mm) |
| Gas holder |
| Diameter (m) |
| Height (m) |
| Material of construction |

Brick masonry

| 1.5 and 1.0 respectively |
| 225 (one brick thick) |
| 325 (one & half brick thick) |
| 2.40 |
| 0.86 |
| Mild steel sheet, 16 gauge |

Performance

Type of plant (rate capacity 6 m³)

Average biogas production, m³ / day

<table>
<thead>
<tr>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pant Tarai</td>
<td>4.20</td>
</tr>
<tr>
<td>KVIC</td>
<td>3.84</td>
</tr>
<tr>
<td>Janta</td>
<td>3.72</td>
</tr>
</tbody>
</table>

Uses
Anaerobic digestion of cattle dung to produce biogas and manure

Sources (Appendix)
327

PLUG FLOW BIOGAS PLANT

Features
The fixed dome type of biogas plant has been modified to a capsule geometry to enable feeding of biological wastes. It has a length, breadth, height ratio of 2.0: 1.0: 1.2. The volume of the outlet chamber is 0.4 m³. Some of the advantages of this design are, reduction in the dead space at corners of the digester, smooth plug flow of the mixed substrate with no short-circuiting and higher actual retention time. Hence this design is highly suited for using biological wastes such as vegetable wastes, lantana-camara, ageratum etc. along with cattle dung.

Specifications

| Capacity (m³) |
| Material of construction |
| Substrate |
| Initial TSC of the substrate (%) |
| Feed rate kg-dm/day |
| Retention period (days) |

Brick masonry

| 3:1 mixture of cattle dung and green agro-residues |
| 10 |
| 4.2 - 5.0 |
| 60 |

Performance
Produces 0.8 - 0.9 m³/day of biogas
Uses
Anaerobic digestion of mixture of cattle dung and green biological wastes (weeds, vegetables, etc)

Sources (Appendix)
324

TNAU SAKTHI MODEL BIOGAS PLANT

Features
TNAU sakthi model plant is made of brick, cement, sand and jelly. The only skill required is arch (dome) construction which can be done by masonry work. The new model not only eliminates the centering, false roof and false pillar for the dome construction but also separates outlet tank. Hence the cost of construction of this digester is lesser than other types of biogas plants. There is a saving of 15 to 20 per cent in the cost of construction as compared to Deenbhandu biogas model.

Specifications

<table>
<thead>
<tr>
<th>Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (mm)</td>
<td>2000</td>
</tr>
<tr>
<td>Height of dome (mm)</td>
<td>500</td>
</tr>
<tr>
<td>Depth of plant (mm)</td>
<td>1600</td>
</tr>
<tr>
<td>Distance of mixing tank (mm)</td>
<td>1200</td>
</tr>
<tr>
<td>Size of inlet (mm)</td>
<td>1000x1000</td>
</tr>
<tr>
<td>Size of outlet (mm)</td>
<td>1000x1000</td>
</tr>
<tr>
<td>Plant capacity (m³)</td>
<td>2-3</td>
</tr>
</tbody>
</table>

Components: Digester, inlet pipes and effluent collector
Feed material: Cow dung, pig manure, poultry droppings etc.
Shape of the plant: Spherical

Uses
It is used for cooking, lighting and running engine.

Sources (Appendix)
1605

COMMUNITY BIOGAS PLANT

Features
The community level biogas plant will be constructed in a common place, the feed material will be collected from a group of households and the produced biogas will be distributed to all the beneficiaries. The size and cost of the plant may vary based on the availability of feed material, requirement of biogas and initial investment.
Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant capacity (m³)</td>
<td>35</td>
</tr>
<tr>
<td>Height of gas dome (mm)</td>
<td>1000</td>
</tr>
<tr>
<td>Size of inlet (mm)</td>
<td>1200×2000</td>
</tr>
<tr>
<td>Size of outlet (mm)</td>
<td>1200×2000</td>
</tr>
<tr>
<td>Initial dung required (tonnes)</td>
<td>30-40</td>
</tr>
<tr>
<td>Daily loading rate (kg)</td>
<td>600-700</td>
</tr>
<tr>
<td>Number of animals required</td>
<td>60-70</td>
</tr>
<tr>
<td>Biogas production rate (m³/h)</td>
<td>1.5</td>
</tr>
<tr>
<td>Electricity production (kWh)</td>
<td>50</td>
</tr>
<tr>
<td>Components</td>
<td>Digester, inlet pipes and effluent collector</td>
</tr>
<tr>
<td>Feed material</td>
<td>Cow dung, pig manure, poultry droppings etc.</td>
</tr>
</tbody>
</table>

Uses

It is used for cooking, lighting and running engine.

Sources

254, 281, 389, 409, 852, 1296, 1359, 14791579, 1605

BIOGAS PLANT FOR SOLID STATE FERMENTATION

Features

Solid-state digestion of cattle dung is the anaerobic fermentation of dung with reduced quantity of water as compared to conventional plants. This poses the problem of easy flowability of the material. Some of the modifications are:

- Replacement of the inlet chamber by a 300 mm RCC pipe.
- Enlargement of the outlet chamber to accommodate total volume of slurry displaced from the digester.
- The geometry of the outlet has been altered to achieve smooth flow of digested slurry.
- Widening of the outlet channel for self-discharge/easy flow of slurry.
- During commissioning, the usual mixture of equal quantity of dung and water is used. Thereafter, fresh undiluted cattle dung is fed after proper operation of the biogas plant is stabilized.

The average gas yield has been found higher by 40-50% for modified plant as compared to the common Janta biogas plant. Degradation of total solids and volatile solids of the cattle dung has also been reported higher by about 40%. The digested slurry discharged from the plant has a TSC of 9.5 - 10.5% and can be transported to fields for use as manure after every 2-6 days interval. The slurry discharged from the common biogas plants has 4-6% TSC and requires drying for 20-40 days.

Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design evaluated for 2 m³ capacity plant</td>
<td>RCC pipe, 300 mm diameter</td>
</tr>
<tr>
<td>Feed inlet</td>
<td>RCC pipe, 300 mm diameter</td>
</tr>
<tr>
<td>Feed rate (kg/day)</td>
<td>50, fresh cattle dung</td>
</tr>
<tr>
<td>TSC of the dung (16)</td>
<td>Upto 16</td>
</tr>
<tr>
<td>Retention period (days)</td>
<td>70-90</td>
</tr>
</tbody>
</table>
Uses

It is used for cooking and heating purposes in the kitchen.

Sources (Appendix)


PORTABLE CHARRING KILN

Features

The portable charring kiln is a simple unit for converting agricultural residues to a charred mass. It consists of a M.S. drum, handle and door. Due to its cylindrical shape, it can be rolled to the site of use easily. Waste agricultural mass such as soybean straw, pigeon pea stalks, cotton stalks and other material can be used. A small quantity of residues is fed into the kiln and ignited. When it gives a whit smoke and starts to burn properly, additional material is added to the kiln. By continuing the process, whole of the kiln gets filled. The cover is then closed and the hot mass is allowed to pyrolyse. After the end of about 6-8 hours, the unit cools down and the charred mass can be emptied. The char obtained is used for making smoke free kitchen fuel by converting them into briquettes.

Specifications

<table>
<thead>
<tr>
<th>Overall Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (mm)</td>
<td>1100</td>
</tr>
<tr>
<td>Diameter (mm)</td>
<td>800</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>45</td>
</tr>
<tr>
<td>Input crop residue (kg/day)</td>
<td>200</td>
</tr>
<tr>
<td>Output Charcoal (kg/day)</td>
<td>80</td>
</tr>
<tr>
<td>Labour requirement (man-hr/q)</td>
<td>16</td>
</tr>
</tbody>
</table>
BRIQUETTING MACHINE

Features
The briquetting machine designed for converting charred biomass into cylindrical briquettes is a screw type extruder unit. It has a hopper for feeding the char and cow dung mixture mixed to a predetermined proportion with water. Feeding is done slowly so that the output from the dies and the feeding are synchronised. The outlet end has a number of openings forming the die through which the briquettes are expelled continuously. These are collected separately in trays and left in the sun for drying. The larger unit is operated with a 2.25 kW motor and produces 60-75 kg of briquettes per hour. The smaller version produces about 40 kg of briquettes per hour.

Specifications
Overall Dimensions

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (mm)</td>
<td>1600</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>650</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>700</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>60</td>
</tr>
<tr>
<td>Briquetting capacity (kg/h)</td>
<td>60-70</td>
</tr>
<tr>
<td>Prime mover (kW)</td>
<td>2.25 and 0.75</td>
</tr>
</tbody>
</table>

Uses
For making briquettes using biomass which can be used for cooking foods in sigari.

Sources (Appendix)
254

MULTI-FUEL COOKING STOVE

Features
Briquettes made from charred agricultural residues can be burnt efficiently in this cook stove. It consists of concentric grates made of perforated mild sheets. Fuel is fed in the annular space and ignited from below. The whole unit is supported on a mild steel grill to drive out the ashes to be bottom. A double walled aluminium reflector having asbestos insulation is placed around the burning bed to prevent convection and radiation to the surroundings. Hence the stove has high thermal efficiency.
of 25%. On a charge of about 450 to 500 grams of fuel it can burn for one hour, which is sufficient for the cooking needs of a small family. It is simple to operate and highly suited for cooking all kinds of Indian recipes including frying, roasting and baking.

**Specifications**

**Overall Dimensions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (mm)</td>
<td>160</td>
</tr>
<tr>
<td>Diameter (mm)</td>
<td>230</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>1.2</td>
</tr>
<tr>
<td>Thermal efficiency (%)</td>
<td>25-30</td>
</tr>
<tr>
<td>Feed/batch (gm/h)</td>
<td>450-500</td>
</tr>
</tbody>
</table>

**Uses**

It is used for heating needs for cooking.

**Sources (Appendix)**

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**IMPROVED COOK STOVE**

*Chetak*

**Features**

The Chetak cook stove is a single pot design suitable for burning firewood, dry dung cakes, crop residues and other traditional fuels. These are suitable for roasting chapatti in the open combustion chamber. On the rear of the space for the cooking pot, a chimney has been provided to let off the smoke and products of combustion. The construction is of good quality bricks and cement mortar. Additional mud insulation is provided on the exteriors of the stove to reduce skin burn on contact.

**Specifications**

**Overall Dimensions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (mm)</td>
<td>600</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>450</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>240</td>
</tr>
<tr>
<td>Firebox diameter (mm)</td>
<td>240</td>
</tr>
<tr>
<td>Firebox opening (mm)</td>
<td>Trapezoidal, 240 × 120 × 240</td>
</tr>
<tr>
<td>Power rating (kW)</td>
<td>2.0</td>
</tr>
<tr>
<td>Thermal efficiency (%)</td>
<td>21.3</td>
</tr>
<tr>
<td>Feed/batch (gm/h)</td>
<td>1000</td>
</tr>
</tbody>
</table>

**Uses**

It is used for heating needs for cooking.

**Sources (Appendix)**

863
**IMPROVED COOK STOVE**

*Udairaj*

**Features**

The Udairaj cook stove is a double pot design suitable for burning firewood, dry dung cakes, crop residues and other traditional fuels. These are suitable for roasting chapatti in the open combustion chamber. On the rear of the space for the two cooking pots, a chimney has been provided to let off the smoke and products of combustion. The stove is meant for using both the fire pots simultaneously. The construction is of good quality bricks and cement mortar. Additional mud insulation is provided on the exteriors of the stove to reduce skin burn on contact.

**Specifications**

<table>
<thead>
<tr>
<th>Overall Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (mm)</td>
<td>400</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>250</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>240</td>
</tr>
<tr>
<td>First firebox diameter (mm)</td>
<td>200</td>
</tr>
<tr>
<td>Second firebox diameter (mm)</td>
<td>Rectangular, 240 x 160</td>
</tr>
<tr>
<td>Firebox opening (mm)</td>
<td></td>
</tr>
<tr>
<td>Power rating (kW)</td>
<td>2.5</td>
</tr>
<tr>
<td>Thermal efficiency (%)</td>
<td>25.5</td>
</tr>
<tr>
<td>Feed/batch (gm/h)</td>
<td></td>
</tr>
</tbody>
</table>

**Uses**

It is used for heating needs for cooking.

**Sources (Appendix)**

863

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**BIOMASS GASIFIER**

**Features**

Biomass gasification is basically conversion of solid biomass i.e. wood/wood waste, agricultural residues etc., into a combustible gas mixture normally called “producer gas”. The gasifier is essentially a chemical reactor where various complex physical and chemical processes take place. Biomass gets dried, heated, pyrolysed, partially oxidised and reduced in this reactor as it flows through it. The essential characteristic of the down-draft design is that it is designed so that the tars given off in the pyrolysis zone are drawn through the combustion zone, where they will be broken down or burnt. Partial combustion produces carbon monoxide as well as hydrogen, which are both combustible gases. Solid biomass fuels, which are usually inconvenient and have low efficiency of utilisation, can thus be converted into a high quality gaseous fuel with associated convenience etc.
Specifications

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Output (kcal/h)</td>
<td>15,000-12,50,000</td>
</tr>
<tr>
<td>Electrical output (kW)</td>
<td>5-500</td>
</tr>
<tr>
<td>Rated gas flow (m³/h)</td>
<td>15-1,250</td>
</tr>
<tr>
<td>Calorific value of gas (kcal/m³)</td>
<td>1000</td>
</tr>
<tr>
<td>Biomass consumption (kg/h)</td>
<td>5-600</td>
</tr>
<tr>
<td>Hopper capacity (kg)</td>
<td>40-1200</td>
</tr>
<tr>
<td>Biomass size (mm)</td>
<td>10 min, 50-200 max</td>
</tr>
<tr>
<td>Biomass Moisture content, db (%)</td>
<td>5-20</td>
</tr>
<tr>
<td>Conversion efficiency (%)</td>
<td>70-75</td>
</tr>
<tr>
<td>Gas composition (%)</td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>19-22</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>18-20</td>
</tr>
<tr>
<td>Methane</td>
<td>3-4</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>10-13</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>50</td>
</tr>
</tbody>
</table>

Uses

Used for straight thermal application for tea/coffee drying, bakery ovens, brick/lime/pottery kilns, various industrial dryers, ovens and furnaces as well as boiler firing.

Sources (Appendix)

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NATURAL DRAFT GASIFIER

Features

The natural draft gasifier is a simple unit, which takes advantage of natural draft produced on heating the biomass such as wood chips. It consists of a grate for burning the wood chips, a grate for ash removal, a gas outlet in the form of a chimney at its side for direct burning and a biomass feeding port. The whole unit is made of mild steel sheets and rounds welded to the required dimensions. The gas obtained from this gasifier is suitable for thermal applications in agro-industries and for domestic purposes. On account of the fact that producer gas contains appreciable quantities of carbon monoxide, the unit has to be operated with adequate caution and in the open to prevent poisoning accidents.

Specifications

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Dimensions</td>
<td></td>
</tr>
<tr>
<td>Diameter (mm)</td>
<td>470</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>1000</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>40</td>
</tr>
<tr>
<td>Biomass consumption (kg/h)</td>
<td>4-5</td>
</tr>
<tr>
<td>Output (kcal/h)</td>
<td>10,000</td>
</tr>
<tr>
<td>Conversion efficiency (%)</td>
<td>70</td>
</tr>
</tbody>
</table>

Uses

It is used for the production of producer gas from wood chips for agro-industrial as well as domestic use.
UPDRAFT PORTABLE GASIFIER

Features
Generation of producer gas using wood chips is carried out with the help of a gasifier. The portable unit has been designed keeping in mind the need to make the unit available at the site of use. It consists of a gasifier unit of rectangular cross section, a small blower for providing the required draft, a grate for the burning bed and pipes for the transmission of the gas. The outlet pipe is connected to a burner specially designed for the purpose. The whole unit is mounted on a frame with cast iron wheels for easy portability. It has been found to be suitable for generating producer gas using wood chips, maize cobs, groundnut shell, soybean and pigeon pea stalk.

Specifications

<table>
<thead>
<tr>
<th>Type</th>
<th>Updraft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension (mm)</td>
<td>350×350×850</td>
</tr>
<tr>
<td>Recommended fuel</td>
<td>Wood chips, groundnut shells, soybean and pigeon pea stalk</td>
</tr>
<tr>
<td>Size of fuel wood chips (mm)</td>
<td>45, longest</td>
</tr>
<tr>
<td>Material of construction</td>
<td>Mild steel</td>
</tr>
<tr>
<td>Capacity of air blower (m³/h)</td>
<td>12.5</td>
</tr>
<tr>
<td>Hopper capacity (kg)</td>
<td>35</td>
</tr>
<tr>
<td>Thermal capacity (kcal/h)</td>
<td>17500</td>
</tr>
<tr>
<td>Biomass consumption rate (kg/h)</td>
<td>3.0-6.0</td>
</tr>
</tbody>
</table>

Uses
Used for the conversion of fuel wood and agro-residues to producer gas for thermal applications in industrial and domestic activities.

Sources (Appendix)
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RICE HUSK BASED GASIFIER

Features
Generation of producer gas using materials other than wood chips such as rice husk is possible with the rice husk base gasifier. It has an open core design for efficient combustion of rice husk. It consists of two cylindrical drums of 300mm and 370 mm diameters joined with a flange at the top and fitted with a grate and a water seal at the bottom. An electrical motor operated blower sucks the gas produced from the plant and...
supplies it to the burner. It may be used for thermal application and other industries for drying and boiler retrofitting.

**Specifications**

<table>
<thead>
<tr>
<th>Reactor diameter (mm)</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor height (mm)</td>
<td>2050</td>
</tr>
<tr>
<td>Thermal capacity (kcal/h)</td>
<td>10000-15000</td>
</tr>
<tr>
<td>Gas yield (m³/h)</td>
<td>10-12</td>
</tr>
<tr>
<td>Electric blower (kW)</td>
<td>0.2</td>
</tr>
<tr>
<td>Gas cleaning and cooling pipes</td>
<td>3 Nos.</td>
</tr>
</tbody>
</table>

**Uses**

Used for conversion of rice husk to producer gas for medium scale thermal application.

**Sources (Appendix)**

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GROUNDNUT SHELLS BASED OPEN CORE GASIFIER

**Features**

Conventionally available gasifier systems are designed for operation with wood chips cut to the required size. In the open core gasifier, the design has been adapted for using groundnut shells. It consists of a well-insulated cylindrical reactor, rotating grate (manual/ power operated), a blower for producing appropriate draft and a producer gas burner. In addition to groundnut shells, the system could also take advantage of other fuels such as briquettes, agricultural residues and wood chips.

**Specifications**

<table>
<thead>
<tr>
<th>Type</th>
<th>Downdraft, throatless</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of the reactor (mm)</td>
<td>630 to 2300</td>
</tr>
<tr>
<td>Type of fuel</td>
<td>Groundnut shells and other selected biomass</td>
</tr>
<tr>
<td>Biomass consumption rate (kg/h)</td>
<td>60 to 400</td>
</tr>
<tr>
<td>Thermal capacity (kcal/h)</td>
<td>1,50,000 to 10,00,000</td>
</tr>
<tr>
<td>Hopper capacity (kg)</td>
<td>50</td>
</tr>
<tr>
<td>Material of construction</td>
<td>Mild steel lined with refractory material</td>
</tr>
<tr>
<td>Ash removal unit</td>
<td>Rotating, manual / power type</td>
</tr>
</tbody>
</table>

**Uses**

Conversion of groundnut shells to producer gas for industrial thermal applications

**Sources (Appendix)**

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