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Foreword

We, at the Renewable Energy Council of CII-Sohrabji Godrej Green Business Centre are extremely delighted to release an exclusive "Case Study Booklet on Renewable Energy". The objective of this publication is to disseminate success stories to a larger section of the stakeholders.

This is in line with the objective of the council which is to make India a global leader in renewable energy sector by 2012.

The Booklet has captured the technical and financial aspects of various renewable energy projects implemented in industrial & building sectors. This, I believe would facilitate easier decision making for those opting to go for renewable energy.

I would like to thank all those who have contributed in release of this first version of the booklet.

This case study booklet will undergo changes in the subsequent years, to capture the latest case studies on renewable energy.

We hope that this booklet will serve as an excellent resource to further advance the renewable energy movement, thus enabling India to be a global leader in renewable energy.

Best Wishes

Ramesh Kymal
Chairman
Renewable Energy Council

Contents

Executive Summary

India is a developing and fast-growing economy and faces a great challenge to meet its energy needs in a responsible and sustainable manner. The challenge is to provide a reliable energy supply through a diverse and sustainable fuel mix. Wider adoption of renewable energy technologies would address the energy security of the country and also promote low carbon economy.

Industries are the backbone of our economy and so every effort is being made to make it cleaner and sustainable. The role of renewable energy in industries is of paramount importance to meet a part of their energy demand and make them more environmental friendly by reducing the emissions.

With this background, CII-Sohrabji Godrej Green Business Centre (CII-Godrej GBC) has taken up the initiative to provide a major thrust in advancing adoption of renewable energy in India by setting up an exclusive council on renewable energy which has been working in close association with all stakeholders including manufacturers, corporate, financial institutions, nodal agencies and various national & international agencies.

One of the mandates of the council is to spread awareness and disseminate success stories in the area of renewable energy. To disseminate such success stories to a larger section of stakeholders, CII-Godrej GBC has prepared this **"Case Study Booklet on Renewable Energy".**

This booklet has captured the technical and financial aspects of various renewable energy projects implemented in industrial & building sector in India.

These case studies have been compiled with site visits, interaction with project owners, project developers & manufacturers. The overall intent of documenting these studies is to share knowledge and experiences so as to equip stakeholders implementing similar projects.

These case studies may be considered for implementation after suitable fine tuning to meet the specific requirements of industries and buildings (site location & State Policies).

India's "Renewable Energy" Trends

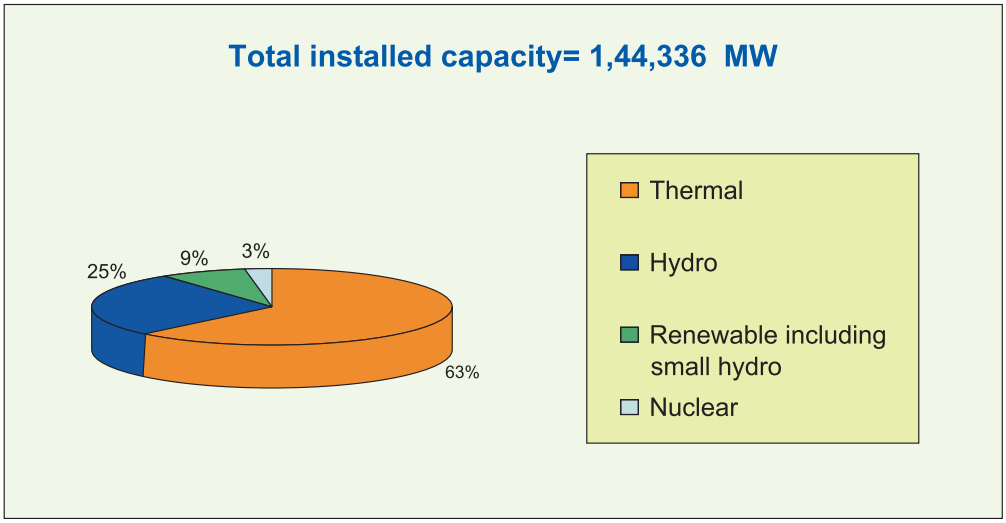
Status of Renewable Energy in India

Addressing the challenges of climate change will be an immense task for a country like India with a growing economy, a large population and the obligation to bring hundreds of millions out of poverty. A vital part of the solution would be to promote renewable energy technologies in a big way.

To date, India has 12,600 MW of renewable energy excluding large hydro (MNRE 2008a), representing about 9% of total electricity mix.

For the current eleventh five year plan period from 2007 to 2012, the Government of India has outlined a target of 14000 MW to 20,000 MW of additional renewable capacity. In the 10th five year period from 2002 to 2007, approximately 25% of total new power installations consisted of renewable (CEA 2008).

India is today ranked fifth globally for installed wind capacity and second for biogas generation. Tapping renewable energy resources like solar and small hydro can enable India to be a world leader in renewable energy.



Source: MNRE 2008a

The following table given by MNRE (April 2008a) shows the installed capacities of various Renewable Energy Sources in India :

SOURCES / SYSTEMS	ESTIMATED POTENTIAL	CUMULATIVE ACHIEVEMENTS
A. Grid-interactive renewable power		
Bio Power (Agro residues and plantations)	61,000 MW	605.80 MW
Wind Power	45,000 MW	8757.40 MW
Small Hydro Power (up to 25 MW)	15,000 MW	2180.84 MW
Cogeneration – bagasse	5,000 MW	800.83 MW
Solar Power	500, 003 MW	2.12 MW
Waste to Energy	7,000 MW	55.75 MW
A. SUB TOTAL	**633,003 MW**	**12,402.74 MW**
B. CHP / Distributed renewable power		
Solar PV Power Plants and Street Lights	-	7.72 MW
Biomass / Cogeneration (non-bagasse)	-	95.00 MW
Biomass Gasification	-	99.79 MW
Energy Recovery from Waste	-	26.70 MW
Aero- Generators / Hybrid Systems	-	0.72 MW
B. SUB TOTAL	**229.93 MW**	

Rise in Renewable Energy Investment :

India's renewable energy programme is primarily driven by the private sector driven. The annual turnover of the renewable energy industry, including the power generating technologies for wind and other sources, has reached a level of over USD 10 Billion. With increased focus on renewable energy, the market is expected to grow significantly in the coming years.

In 2007, the Planning Commission of India announced that the energy sector would require USD 125 Billion worth of investments during the current 11th Five Year Plan upto 2012.

With an increasingly favourable Regulatory and Policy environment along with a growing number of enterprising entrepreneurs and project developers, India is ranked the third most attractive Country to invest in renewable energy, after the USA and Germany, in the Ernst and Young Country attractiveness Indices.

Solar PV

Solar PV Water Pumping in a Tobacco Processing Plant

Introduction :

A tobacco processing plant has installed solar water pumping system to cater to their process requirements.

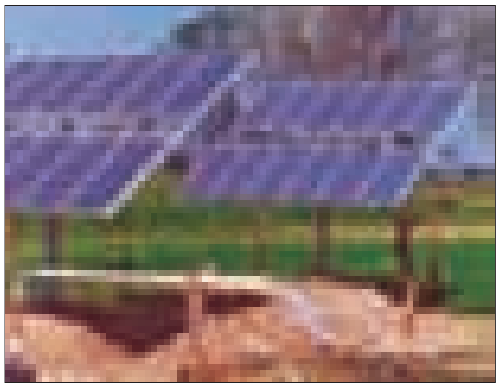
The system is capable of pumping about 20,000 KL of water per year from the bore wells. All bore wells are located at about 4.0 km distance from the plant, where there is no grid available.

Water pumped from the 3 bore wells is stored in the storage tank with 40 KL capacity.

System Description :

There are two solar PV systems of 3.8 kW each and one 3.6 kW installed for water pumping. In this system, solar panels are connected to a flow optimizer, DC – AC inverter and two submersible pumps.

The pumps are located at a depth of 80m below ground level.



The on / off operation of the pumps is automatically controlled through the flow optimizer panel using a float switch fixed in the tank. When the output electricity is low due to diminished solar radiation, it switches-off one pump so as to ensure maximum water output from the other pump.

Total installed capacity	11.2 kW
Investment required	Rs. 55 Lakhs
Average output	26,500 LPD/yr of water pumping

The average output of the system is estimated to be about 26,500 Litres Per Day all through the year.

Water pumped to the plant is used for various process applications such as steam generation, domestic applications and chilling plants.

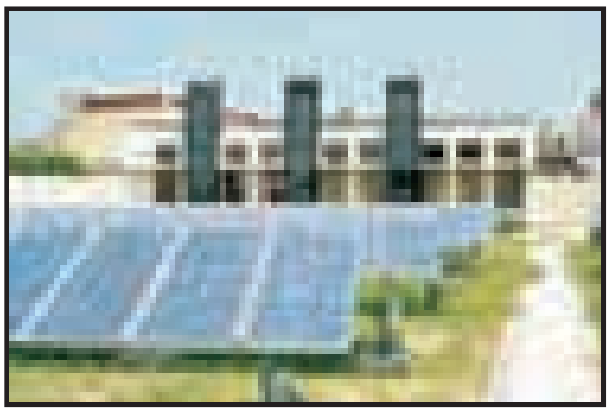
The system requires minimal maintenance of cleaning the solar panels once a week.

Benefits :

This project has resulted in substantial grid power savings for the company which otherwise would have been used for water pumping.

Grid connected 200 kW Solar PV Plant

Introduction :



Village Khatkar Kalan in District Nawanshahr of the State of Punjab, India is one of the thousands of Indian villages, which are facing electricity shortages due to gap between the demand and supply of electricity. The village has grid connection but availability of electricity is erratic. The Ministry of New and Renewable Energy (MNRE), Government of India in consultation with the village Panchayat (the local governing body) identified the village for demonstration of grid connected solar photovoltaic power plant of **200 kW** capacity, which is the largest Photovoltaic plant in the country. The power plant also supplies electricity to street lights in the villages.

Demonstration of village electrification through distributed generation by grid connected solar photovoltaic power plant is the main objective of the project. The power plant of this size has not been installed in the country so far.

This plant is one of the best examples of demonstration of technology as well as the concept of feeding the renewables electricity into the state grid. It also showcases the benefits of long-term service-cum- O & M contract with the manufacturer and supplier of the equipments.

System Description :

The solar power plant is situated on the outskirts of the village. The plant is installed on the ground covering an area of 1.4 acres. **The plant rated capacity is about 200 kWp.** It consists of 2690 numbers of poly-crystalline silicon PV modules each of 75 Wp capacity. The battery backup is provided to take care of street lighting load of 10 kW capacity.

Total investment	Rs. 485.09 lakhs
MNRE grant-in-aid	Rs. 285.09 lakhs
World Bank soft loan	Rs. 40 lakhs@2% per annum
State share	Rs. 160 lakhs

Benefits :

- This project has generated about **6 lakh units** since 2004, which has been fed to the PSEB Grid
- This project has been planned as a Grid Interactive voltage support (T&D) project for boosting the voltage level and improvement of the power quality in the village along with providing total 100 nos. solar street lights in the village and on the road leading to the museum

Implementation Issues :

The implementation issues were related to technical aspects and social acceptance. Solar PV power plant of 200 kW capacity is largest in the country. The challenge was to **design the plant and grid interactive inverter**, which could withstand the fluctuations in the grid voltage and frequency. In India, grid- voltages particularly in rural areas vary by as much as 10% (for example from standard voltage of 440V, it varies to 400- 460V).

In rural parts of India, **maintaining a service network** for solar PV systems is another challenge. This project was no exception. The Ministry of New and Renewable Energy (MNRE), Government of India overcame this barrier by incorporating a 10-years maintenance contract. The cost of this service has been incorporated in the plant cost.

Social acceptance of the technology by the villagers was another challenge. Since the village was already electrified, the villagers were of the opinion that the supply of grid power may be curtailed now that the village has acquired a solar PV plant. And if the SPV plant is not successful, they will lose the conventional power too.

However, the reliability of the SPV plant has enhanced the acceptance of the technology.

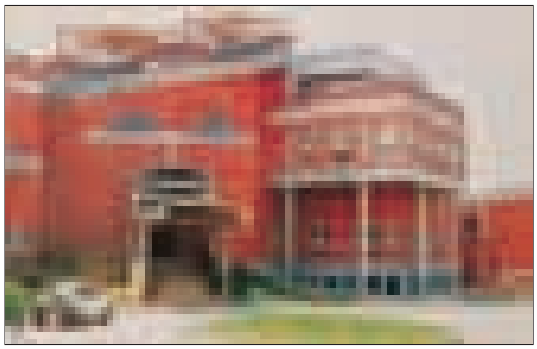
Solar Passive & Partial BiPV in an Office Building

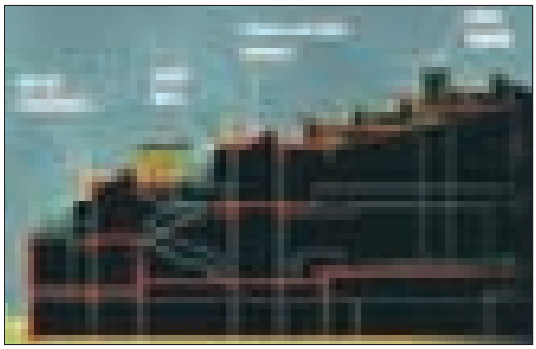
Introduction :

Punjab Energy Development Agency (PEDA) is a State nodal agency for promotion and development of renewable energy in the State of Punjab. PEDA has been encouraging the integration of solar passive design features in the new buildings for conserving energy.

With an objective to demonstrate the use of solar energy especially in office and commercial buildings, PEDA took the initiative of constructing its office building in Sector 33-D, Chandigarh. The building has been designed to minimise solar heat gain in summers & maximise during winters.

System Description :





This building was constructed on a plot area of 1.5 acre having a built up area of 68,000 square feet. The salient features incorporated in the building design include the following:

- The building is oriented towards North-South direction to receive maximum solar energy
- Cavity walls with and without insulation for thermal comfort
- Light vaults in the south to admit light without glare and heat
- Hyperbolic shell roof over central atrium
- Insulated roofs for thermal comfort

Cost of civil and electric works	450 lakh
Cost of 25 kWp SPV grid interactive & partial BiPV	Rs. 78 lakhs

- Wind tower in the central atrium for scientific cooling
- Solar chimneys to accelerate the quick draft of hot air
- 25 kWp building-integrated solar photovoltaic power plant to meet the lighting and basic power requirements of the complex

Benefits :

- The project is providing 25 kW power for lighting, fans, computers in the office
- This building complex resulted in energy saving to the tune of 50% in summer and winter months i.e. electrical load of 80KW against a total load of 200 kW for a similar conventional building

In-situ Solar PV Power Generation in a Green Building

Introduction :

The CII – Sohrabji Godrej Green Business Centre is a joint initiative of Govt. of Andhra Pradesh, Godrej & Boyce Mfg Co and Confederation of Indian Industry (CII) with the technical support of USAID –a unique model of public – private partnership. The centre is located in Hyderabad, near the Hi- TEC city.

CII – Sohrabji Godrej Green Business Centre building is the first LEED (Leadership in Energy and Environmental Design) platinum rated green building outside of USA and the third in the world.

In this green building, which encompasses energy efficiency, sustainable site, materials re-use, erosion and sedimentation control, water efficiency, innovative design etc, **Solar PV panels** have been installed on the roof of the building.

The roof orientation and inclination have been designed considering the generation efficiency of the PV panels. The building has installed 23 kWp system. There are no batteries for storage of power. The energy is consumed as soon as it is generated for building requirements.

Project Description :

The solar PV system consists of 260 nos of solar panels each with 80W peak capacity and each module consists of 36 nos of multi-crystalline cells. These modules are mounted on a specially designed structure by which 20 modules are connected in series and 13 are in parallel.

Total investment - Rs. 56.0 lakh
30,000 units generated/year

The orientation of this system is towards the south as the solar radiation would be higher in this direction at any point of time through out the year. The sloping of the roof has been done considering latitude of the location to achieve maximum efficiency of solar PV system.

On an average, the in-situ solar PV system generates about 100 – 120 units of electricity per day. The peak power generation of 132 units will be attained in the month of May.

Benefits :

- This In-situ solar power plant caters to about 25% of the total energy requirement
- Significant power savings to the tune of Rs. 1.8 lakhs/annum

Solar Thermal

Steam Generation using Parabolic Solar Concentrators in an Industry

Introduction :

An engineering company based in Maharashtra has installed solar parabolic concentrators for generating steam for their process requirement. This was one of the first industrial application in India used for generating steam using parabolic solar concentrators.

Solar concentrators are the latest technology to capture the solar radiations as much as possible. As the name implies, concentrators collect the solar radiation from all the directions and concentrates at one point so that the total energy available is maximum.

Parabolic dish type collectors are generally used for generating steam from solar power. A mirror, shaped like a parabolic trough, is used to concentrate sunlight on an insulated tube or a heat pipe placed at the focal point, containing coolant or water which transfers heat from the collectors to the boiler. Solar concentrators have the potential to generate temperatures upto 400 deg C.

Project Description :

This engineering unit uses 16 sq. m area of solar parabolic concentrator dishes to trap the solar rays. The trapped rays are concentrated on onepoint to generate the heat. A high optical temperature above 500-700 degrees is generated. The total heat content available is equivalent to 1,50,000 kCal/day.

Total investment	Rs. 5.6 lakhs
Savings achieved	Rs. 1.5 lakhs/year
Government subsidy	35%
Payback period	46 months

Water flowing in the tubes is converted into steam at receiver. Parabolic panels are designed in such a manner that the focal point of concentration remains fixed. To trap the solar radiations through out the day, these parabolic concentrators are equipped with solar tracking system powered by photovoltaic cells.

System Specifications are as follows :

- No. of concentrators : 4
- Heat generation capacity : 1,50,000 Kcal/day
- Average solar radiation : 750 W/sq m
- Efficiency of concentrators : 65%
- Area of each concentrators : 16 sq m
- Average operating hours : 8hrs/day
- Equivalent electrical energy : 45kWh/concentrator
- Total equivalent electrical energy : 175 kWh/day

Benefits

- Steam is used as heating media for stator washing and also for rotor bluing
- The steam thus generated replaces electrical heating to the tune of 175 kWh/day
- Installation of the parabolic concentrators has resulted in reduction of power consumption to the tune of 175 kWh per day

Solar Water Heating System for Preheating Boiler Feed Water in a Fertilizer Industry

Introduction :

A fertilizer industry has installed Solar Water Heating (SWH) systems to generate hot water for preheating boiler feed water.

In order to reduce the fuel consumption in the boiler, it was decided to install solar water heating system.

System Description :

The installed capacity of SWH system is 1, 20,000 litres / day. It is one of the largest systems installed for industrial process application in India. The system has 1305 solar collectors of 2m2 absorber area each.

There are four storage tanks of 60,000 lit capacity each, to store the hot water.

Total investment	Rs. 155 lakhs
Savings achieved	Rs. 14.4 lakhs/year
Depreciation benefits	Rs. 54.6 lakh
Payback period (after considering subsidies & depreciation benefits)	Less than 3 years

In this system, water is circulated through collectors throughout the day as long as the collector output is at higher temp than that of water in the storage tanks.

Benefits

- Reduction in 80-100 tons of LSHS per year
- Reduction in SO_2 emission levels

Solar Water Heating System for Pre-heating Boiler Feed Water in a Leather Processing Industry

Introduction :

In a leather processing industry, coal has been used to generate steam for its process requirements. With the increase in coal cost and availability of solar energy in abundance, it was decided to install Solar Water Heating system to preheat boiler feed water. The installed capacity of the system is 50,000 LPD and was commissioned during 1991 - 92.

The capacity of boiler is 5T/hr at working pressure of 7 to 8 kg. The steam is utilised for indirect drying of leather.

The estimated energy generation from solar water heating system is 30,00,000 kcal / day.

System Description :

There are 711 solar collectors installed in four rows, which are connected in series. They are connected to 2 storage tanks of 50,000 litres capacity each. One of the storage tanks is kept as stand-by and used during maintenance.

Water from DM plant is circulated through solar water heaters by circulation pumps and fed to the boiler.

The system has been generating hot water at 80^{o}C almost through out the year. Further, during summer the temperature is set low in order to get maximum quantity of water.

The following operation and maintenance practices are being adopted to keep up the thermal performance of the system.

- Periodical cleaning of solar collectors
- Inlet water to solar water heater should be treated to a level of 5 – 8 ppm dissolved solids
- Periodic checking of flow through drain pipes in each row
- End point flanges are being replaced at regular intervals

Total investment	Rs.50.0 lakh
Depreciation benefits & subsidies	Rs. 20 lakh
Net investment	Rs. 30 lakh
Annual savings	Rs. 6 lakhs
Payback	< 5 years

Benefits :

- The hot water generated by solar water heating system has replaced about 12 to 15 tons of coal per day depending upon the quality and type of coal
- The system has resulted in substantial reduction in CO_2 and SO_2 emissions

Solar Air Heating System for Tea Drying

Introduction :

Tea drying is normally done through conventional drier mainly by using fuels such as firewood, coal, furnace oil, briquette, etc. The temperature required for drying is about 105°C.

The production capacity of this factory is about 10,00,000 kgs of dried tea per annum. It requires tremendous quantity of firewood for its drying application. Keeping in view the cost escalation of firewood, financial and environmental benefits of solar air heating system, it was decided to install for preheating of air used for drying.

Solar air heating system was installed in a tea factory during the year 1996. It is basically used to preheat the air before the conventional heater and reduce fuel consumption. The installed capacity of solar air heater is 35,000 kg/hr at 20oC above ambient temperature.

System Description :

Total surface area of the solar air heating system is 383 m^2 which has six nos of about 63 m^2 of glass each. The system has a blackened surface covered with toughened glass. The solar collectors are installed at about 40 feet height from the heater surface and oriented towards East – West direction. Atmospheric air passes through solar collector due to suction effect of the blower installed in the drier. The preheated air enters into the drier at about 45°C through ducting arrangements.

Benefits :

- It has resulted in a substantial annual savings of about 50 tons of fire wood amounting to Rs. 1.25 lakhs per annum
- Reduction in CO_2 emissions

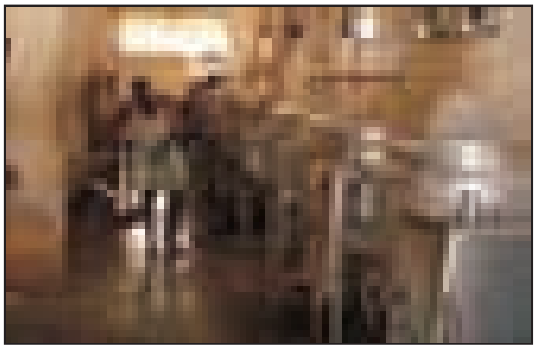
Total investment	Rs. 14.0 lakhs
Annual savings	Rs. 1.25 lakhs
Payback period (After considering depreciation benefits & Subsidies)	3 years

Solar Steam Cooking System in Tirumala Temple

Introduction :

The world's largest solar steam cooking system has been installed by the Tirumala Tirupathi Devasthanam (TTD) at Tirumala in Andhra Pradesh. The system has a capacity to prepare food for 15,000 people/ day and employs automatic tracking solar dish concentrators, which convert water into high pressure steam. The steam thus generated is being used for cooking purposes in the kitchen of TTD. It has been hooked up with the existing boiler working on diesel so as to make the system reliable under all climatic conditions.

System Description :



The Solar rays falling onto the dish are reflected and concentrated on the receivers placed in its focus. Due to concentration the temperature achieved is very high (450-650 degree centigrade) and thus the water in receivers comes to boiling and becomes steam.

This system has been designed to generate over 4000 kgs of steam/day at 180 degree centigrade and 10 kg/sqcm which is sufficient to cook two meals for around 15,000 persons. It is modular in nature and consists of 106 automatic tracked parabolic concentrators arranged in series and parallel combination, each of 9.2 sq meter reflector area. Each unit of concentrators is connected to a central steam pipeline going to the kitchen. The system is made of indigenous components and the reflectors are of acrylic mirrors having reflectivity over 75%.

Benefits :

- TTD has been saving an average of 200 litre of diesel per day, a saving Rs 12 to 15 lakh per annum

Total investment	Rs. 110 lakh
MNRE aid	Rs. 47.75 lakh
IRR	20-25%
Payback period	4-5 years

Solar Steam Cooking System at Shirdi Sai Sansthan, Shirdi

Introduction :

At the prasadalaya in Shirdi's Shri Saibaba Sansthan, food is cooked for 7,000 devotees every day using a solar steam cooking system. For the thousands of devotees visiting the shrine at Shirdi, Maharashtra everyday, food is offered at a subsidised rate of Rs 4 per meal and solar steam cooking is proving to be extremely economical.

It has also set up solar hot water systems in their dharmashalas.

Biogas plants have been set up and the gas is used to drive generators that produce electricity for use in the Sansthan complex. Solar street lights are used and now the cooking system has been solarised. The aim of the Sansthan is to reduce LPG gas consumption in boilers for cooking by 50 per cent.

System Description :

The solar steam cooking system installed at Shirdi has 40 parabolic concentrators / dishes (called Scheffler dishes after its inventor) placed on the terrace of Sai Prasad Building No.2.

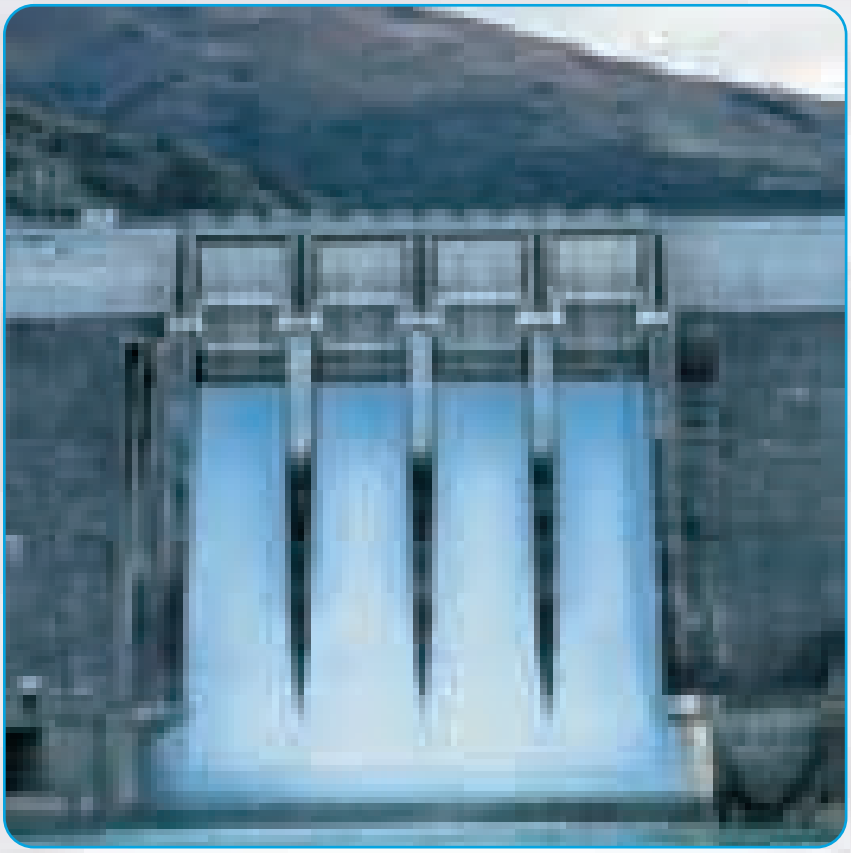
The solar steam cooking system is integrated with a conventional gas fired boiler which works as back-up ensuring that food is cooked and served even when the sun is not shining.

Benefits :

- The system is designed to cook food for 2500 persons per day
- The systems at Shirdi have been saving Rs 2 to 3 lakh a year it used to spend on LPG

Total investment	Rs. 32 lakh
MNRE subsidy	Rs. 16.5 lakh
IRR	20-25%
Payback period	4-5 years

Mini - Hydro



Power Generation through Mini Hydel Power Project

Introduction :

This mini hydel project is located in the hilly state of Himachel Pradesh, where perennial water resources are available. The plant was commissioned in the year 2002. Initially the installed capacity of this plant was 1.0 MW, but it has been proposed to upgrade it to 1.5 MW with additional equipments in view of more available potential.

The power generated has been utilized for their carbon carbide manufacturing facility located in a different location. The company has entered into "Wheeling and Banking" agreement with the State Electricity Board and 2% wheeling and banking is being charged for the total units generated. The total power requirement of carbon carbide units is about 3.0 MW. The balance amount of electricity required is being met by other mini Hydel plants of this group located in several locations.

Project Description :

There are 2 turbines of 500 kW capacity installed in this plant. Water from Perennial River is stored in high altitude and transported from 78 m height (head) through penstocks at the rate of 0.824 m^3/sec to each turbine. Water from its source is being brought through MS pipes of different sizes with 5 reducers at various levels. The horizontal type turbines of 750 rpm each have been installed for power generation which could operate at the speed of 1150 rpm. There are 18 nos. of guide vanes to regulate water flow to the turbines.

Surplus power is sold to the electricity board at the rate of Rs 2.50 per unit.

Benefits :

- This project has also benefited the local community in many ways. It has improved the line voltage and has provided free street lighting to the village to the tune of 60 kW

Total investment	Rs.7.2 crores
Pay back period (after considering depreciation benefits and subsidies)	5-6 years

- Total power generation on an average by this plant is about 60.0 lakh units per year

High Head – Mini Hydel Plant for Power Generation

Introduction :

This project is located in the hilly state of Himachal Pradesh and was commissioned in year 2000. It is a river run-off scheme which has a total catchment area of about 14 sq.km.

The key factors like water availability throughout the year and encouraging Government support have been instrumental in setting up this project. This is located in a degraded land in which no trees have been cut during the commissioning of the project.

The actual designed capacity of this plant is only 0.8 MW, however due to higher head and flow of water, the turbines could manage to generate about 0.96 MW of power continuously with 20% excess capacity.

The company has wheeling and banking agreement with state electricity board as per Power Purchase Agreement.

Project Description :

Water stored in catchment area is diverted through a modified trench type weir with trash rack. The penstocks of 450 mm diameter, ERW steel pipe with the discharge capacity of 0.39 m^3/sec is connected to the turbines.

Total investment (0.96 MW)	Rs. 4.7 crores
Pay back period (after considering the subsidies)	5-6 years

The specifications of machineries installed in this project are given below :

- Type of turbine - Petlon wheel - Horizontal
- Type of generator - A C Synchronous
- Excitation system - Rotation excitation
- Speed of the turbine - 1000 rpm

Benefits :

- As this project is located in a hilly region, water has been available throughout the year
- On an average, the total electricity generated is about 30.0 lakhs units per annum
- The generated electricity has been exported to the grid is at Rs 2.50 / unit as per PPA after deducting equivalent units of 2% wheeling and banking charges
- It has also served to enhance economic development and livelihood of the local people where the plant is commissioned

Wind

Wind Farm by a Textile Company

Introduction :

A textile group has installed wind turbines in Tamil Nadu for power generation. The project has been installed in three phases and was completed in 2003. This project was commissioned under the 'Technology Upgradation Fund Scheme' (TUFS) of the Ministry of Textiles, Government of India, which provides re-imbursement of 5% on the interest charged by the lending agency.

This project site is located in the medium wind speed regime where the estimated annual average wind speed is about 8.5 m/s. However, the wind speed varies from 3.0 to 18.0 m/s depending on the season.

In a year, the peak wind season would be from May to September and the lean season would be January and February. During the peak season, the average wind speed is estimated as 10 – 12 m/s, while during lean season it would be 3 – 3.5 m/s.

System Description :

These 750 kW wind turbines generate 100% power at 15.0 m/s wind speed and have got a cut-off point at this speed. Even if the wind speed goes above this limit, power generation would remain as 750 kW only. This effect is known as "Stall Effect".

The technical details of wind machines installed are given below :

Speed of the blades	-	21 rpm
Diameter	-	48 mts
Speed of the motor	-	1500 rpm
Gear box ratio	-	67.5
Frequency of power generated	-	50 HZ

Total investment for wind farm	Rs. 55.0 crores
Payback period	4-5 years

Other infrastructures like approach roads and wind monitoring station have been provided by the supplier. The Centralised Monitoring Control System (CMCS) has been installed to monitor various parameters including wind speed, air density, power generation on daily basis and other required data. All machines are accessible through a Turbine Access Computer which is connected with fibre optic cable.

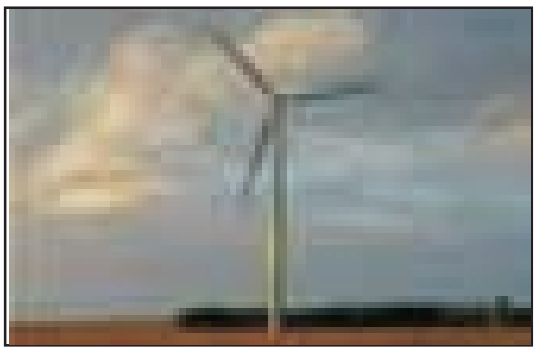
Operation and maintenance have been outsourced to the suppliers and majority of the problems are being identified through CMCS and rectified.

Benefits :

- Enabled the textile unit to meet about 18 – 20% of their total power
- Low maintenance costs
- Substantial reduction in the pollution levels

Large Size Wind Turbines for Power Generation

Introduction :



With latest developments in wind turbines technology, large size wind machines are being developed worldwide. The world's single largest wind turbine installed for power generation is 4.5 MW, which is located in Germany.

These large size wind turbines have many features like improved electronic control systems, active start mechanism and blade pitch arrangement, etc. The output of these machines at any particular air density level would be much higher than the smaller machines of equivalent capacity.

In India, one of the larger capacity wind turbines has been recently installed with the power generation capacity of 1.65 MW.

System Description :

This turbine has been installed in Tamil Nadu during the month of April 2004. This machine has a tower height of 78m and the blade width of 82m. It has active start arrangement by which turbine blades start rotating on its own during the start-up. In fact, it does not require reactive power to start the rotor, which is required for all smaller capacity machines and drawn from the grid.

Total investment (1.65 MW)	Rs.8.3-Rs.9.3 crore
Payback period (including subsidies)	5-6 years

In order to achieve the maximum output, this machine has got "Blade pitching adjustment" that changes direction of the blade to the wind.

This machine operates at a wide spectrum of velocities varying from 3.0 m/s to 18.0 m/s. Rotor is connected to a 4 pole single generator with 1000 rpm speed. However, power generation varies depending on wind density, velocity, pitching angle i.e. angle of attack and frequency of grid.

Benefits :

- This wind turbine is generating about 60.0 lakhs units per year. It is significantly higher than that of lower size machines of equivalent capacity
- These large capacity machines have high operating reliability, low maintenance cost and excellent cost effectiveness
- These machines operate at lower wind speed in lean period especially during January and February and power generation would be higher than the equivalent of smaller size machines

Biomass / Biogas

Biomass Gasifier System in a Chemical Industry

Introduction :

A chemical industry, which manufactures potassium chlorate ($KClO_3$) using electrolysis process, has installed biomass gasifier system for power generation. The installed capacity of the biomass gasifier is 200 kWe. The system was installed in the year 2002 and has since been operating successfully.

In potassium chlorate manufacturing, power cost contributes significantly to the unit production cost, apart from raw materials. Due to the ever increasing electricity charges, the cost of production has increased to higher level which resulted in closure of the unit.

Subsequently, various options had been considered to revive the situation, it was decided to opt for captive power generation using biomass gasifier system. After installing the gasifier system, the cost of power has significantly reduced and resulted in substantial savings.

System Description :

The gasifier, which uses firewood as fuel, is connected with a gas engine that operates on 100% producer gas. The engine is actually meant for natural gas firing, however with a few modifications this could be used for power generation using producer gas.

Total investment	Rs. 60.0 lakhs
MNRE subsidy	Rs. 30 lakh
Annual savings	Rs. 17.0 lakhs
Payback	Within 2 years

The producer gas generated through partial combustion under controlled supply of air is fed through various stages of filters and cleaning system. Tar, particulate matter and other impurities are filtered with water scrubbers and micro filters.

In order to bring down the gas temperature the cleaned gas is passed through a two stage cooling system with water circulation. The temperature of gas is brought down from 500°C to about 45°C, so as to feed into the engine.

Though the capacity of gasifier system is 200 kW, the gasifier system has been operated to give 170 kW output to meet their electrical requirements.

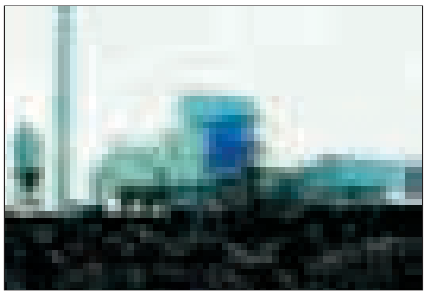
On an average, the estimated power generation is about 3800 units per day at the rate of 22 hours of operation.

Benefits :

- Substantial fuel savings to the tune of Rs. 17 lakhs
- Reduction in pollution levels

Biomass based Power Generation using Agro Residues

Introduction :



Biomass based power generation plant using agro a residue has been commissioned in year 2001 in the state of Karnataka. The installed capacity of this plant is 4.5 MW. The raw materials used are- cane trash, coconut fronds, saw mill wastes, rice husk etc.

Project Description :

Initially, the raw materials received from the field and other sources are processed in a rotary cutter of 5T/ hr capacity, in order to have an optimum size. The outlet is connected to a rotary chain conveyer through which raw materials are fed into boiler. The combustion takes place in a tracking grate of the boiler and steam is generated. The traveling grate rotates at a speed of about 50 to 70 rpm.

Total investment	Rs. 18.0 crores
Payback period	5-6 years
Annual savings	Rs. 1.6 lakhs
PLF	75%-80%

The installed capacity of the boiler is 22 tons/hr at 45 kg pressure. The temperature at this pressure would be 445 ± 5°C. Out of 22 tons of steam generated, 20 tons get condensed and 2 tons of bleed steam is used to maintain boiler feed water temp at 105oC (max).

Benefits :

- The average power generation in this plant is about 1.0 lakh units per day. Out of 1.0 lakh units of electricity generated, about 11.5% is consumed by the auxillary itself and remaining exported to the grid. The cost of electricity exported is Rs 3.32 / unit as per Power Purchase Agreement (PPA)
- It requires about 150 tons of fuel which costs Rs 1.6 lakhs with an average cost of Rs 1,050 / ton

- Agro residues which are normally used by conventional method for energy generation is utilized in a reliable firing system with higher combustion efficiency. This has resulted in significant environmental benefits
- Further, 'biomass supply chain mechanism' has been adopted in this project which involves local farmers for supplying necessary raw materials like coconut fronds, cane trash etc
- The ash generated out of combustion process is converted into organic manure and given to the farmers at the rate of 50 kg for 1.0 ton of fuel, who supplied cane trash to the plant. It has resulted in socio – economic development of the local community

1.0 MW Power Project based on Cattle Manure at Haebowal Dairy Complex Ludhiana, Punjab

Introduction :

Haebowal Dairy Complex in Ludhiana, spread over an area of 50 acres, has 1490 dairies with an animal population of 1, 50,000 and generate about 2500 tonnes of animal droppings. The project, based on Biogas Induced Mixing Arrangement (BIMA) technology, has been designed to use 235 tonnes of animal waste for generating about 0.965 MW electrical energy, most of which will be for captive use. The plant started power generation in August 2004 and has been operating at 60% of its capacity. The surplus energy after meeting the in-house power requirement is being fed to the state electricity grid.

System Description :

GE's Jenbacher demonstration project uses the biogas with high methane content created during the anaerobic digestion of 235 tons of cow manure per day to generate electricity and thermal power (hot water).

In this plant fresh cow manure is blended in a collection tank to provide a waste of uniform characteristics and a waste feed with a solid concentration not exceeding 10 per cent.

The biogas produced leaves the BIMA digester to the gas holder.

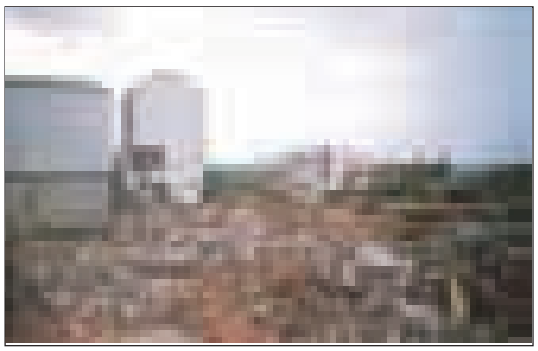
Benefits :

- Surplus energy after meeting the plant auxiliary requirements from the engine is sold to the local grid of Punjab State Electricity Board (PSEB)
- Water heated by the engine is used to assist the fermentation process in the digester
- Remnants from the digester process are used as fertilizer by local farmers

Total investment	Rs. 13.65 crore
National Bioenergy Board (NBB)share	Rs. 1.30 crore
UNDP share	Rs. 5.52 crore
Payback period	About 3 years

6.6 MW Municipal Solid-Waste based Power Project

Introduction :



The solid waste to electricity company, SELCO International Ltd focuses on energy recovery from MSW. Its vision was, and continues to be, to see scientific MSW handling facilities of international standards being set up in all major corporations to solve one of the most threatening problems being faced by the environment- garbage disposal- and to provide customized solutions suitable to the needs of any municipality/town/city across the world.

This is a 6.6 MW power plant located in Mahaboobnagar, Andhra Pradesh.

This plant exports around 5.9 MW of power to the electricity grid for which it has entered into a power purchase agreement with AP TRANSCO for 20 years at a rate of Rs 3.48 per electricity unit.

System Description :

Phase I (Pelletisation project)

This plant is located next to the Gandhamguda municipal waste dump, which receives 1300 MT of garbage every day from Hyderabad city. The installed capacity of the plant is 1000 TPD (tonnes per day), and it has the capacity to produce 200-250 TPD of fuel pellets. The calorific value of fuel pellets produced in the first phase was of the order of 3000 kcal/kg (kilocalories per kilogram), and pellets were reported as having ash content of less than 10%. Technology for production of Refused Derived Fuel (RDF) and fuel pellets from MSW was obtained from TIFAC (Technology Information Forecasting and Assessment Council) and DST (Department of Science and Technology). SIL is processing about 500 MT of MSW for production of about 150 TPD of RDF fluff.

Process of Pelletization :

- Solar drying yard: a rotary dryer fired with MSW has also been installed for drying of MSW, especially during monsoon, to improve removal of inerts
- Manual segregation of large objects

- Sieving for removal of grit and soil
- Air classification: this equipment aids the removal of heavy components such as bricks and stones
- Size reduction: by shredding large pieces of biomass and other organic waste
- Screening: final screening for removal of more soil and grit

Total investment	Rs. 43.50 crore
Equity	Rs. 13 crore
Technology Development Board	Rs. 18 crore
IREDA	Rs. 2 crore
TIFAC	Rs. 6 crore
MNRE subsidy	Rs. 28 lakh
Payback period	16 years

Phase II – 6.6 MW power project :

The salient features of the project and its performance are as follows:

Feeding mechanism

The fuel is spread from side of the boiler. The rotary spreaders and its blades are designed to suit the RDF spreading. The drag-chain conveyor is also specially designed for conveying the RDF. Second conveyor with half an hour storage silo and three screw feeders with variable frequency drives has also been installed as a standby fuel-feeding system.

Benefits :

- More than 700 million units of power generated since November 2003
- Environmental degradation due to MSW is completely avoided

Biogas Generation from Canteen Wastes for Cooking Applications

Introduction :

An industry manufacturing synthetic fibre was consuming about 20 LPG cylinders in a month for its cooking applications in canteen. The cost incurred for LPG consumption was substantial.

It has installed Biogas plant using wastes generated from the canteen.

The biogas plant was commissioned in year 1997 and took about 2 months period to complete the installation.

Project Description :

A biogas plant of 25 m^3/day capacity has been installed to cater to the thermal energy requirements of the canteen. It is floating dome type digester connected with two burners of 2 m^3 and 3 m^3 capacities each.

Total investment	Rs. 4.0 lakh
MNRE subsidy	Rs. 2.0 lakh
Payback period	2 years

At the initial stage, cow dung was charged to create micro organisms especially bacteria in order to catalyze microbial action in the digester. After stabilization, wastes generated from the canteen that are rich in organic content have been charged.

Normally the feedstock charged at 1:1 ratio with water is stirred and homogenous mixture has been prepared and fed into the digester. It helps the bio-methanation process to take place at faster rate. In order to maintain the required output cow dung has been charged at regular interval as an inoculum.

The gas production depends on several parameters such as organic content of the feedstock, retention time, pH maintained in the digester, total dissolved solids in the slurry, etc.

Benefits :

- Use of biogas has resulted in a saving of about 20 cylinders of LPG and cost savings to the tune of Rs 1.0 lakh per year
- The environmental implications of disposing the waste generated before installing the biogas plant have been sorted out completely
- Generation of rich organic manure which is being utilized for in-house farming

Biomethanation Plant at a Wholesale Market Complex

Introduction :

The Koyambedu Wholesale Market complex is one of the projects evolved by the Chennai Metropolitan Development Authority (CMDA) to decongest the central Business district of Chennai city and facilitate trading of consumables.

This Market Complex being one of the largest in Asia, generates significant quantity of organic waste. About 80 tons of waste is generated per day. At present these wastes collected on a daily basis by a private agency and are sent to a Transfer station within the market complex. These wastes from the Transfer station are transported to the Kodungaiyur dumpsite of the Corporation of Chennai.

The "waste to Energy conversion plant" at Koyambedu, Chennai is one of them, which utilises vegetable waste for the generation of 230KW of electricity.

Project Description :

The plant includes the unit operations, which are described below in brief :

1. **Receiving area**
   The waste collected from the vegetable market is taken to the existing transfer station through the trailers / tippers and silts are removed at the transfer station.

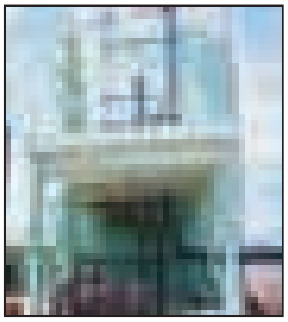
2. **Waste Handling**
   On the receiving platform to handle the waste, a mechanical handling system namely "GRAB" with traveling electric hoist is provided to handle the received waste and the walkway is provided for the person to handle the GRAB

3. **Waste Segregation**
   The waste being carried through the conveyor would be sorted by persons standing on the supporting platforms parallel to the conveyor. The inerts such as plastics, clothes, wood, stones which are not biodegradable in anaerobic digesters are removed.

4. **Ferrous separation**
   Magnetic separator is provided parallel to the conveyor so that the iron (ferrous) materials, if any, which would get stuck to the magnetic separator and the iron materials would be removed manually and stored in the bins and disposed off.

5. Size reduction

The waste is delivered into the Shredder to reduce the wastes to uniform size of around 15 - 20 mm. Shredder has knives which cuts the wastes into small particles. The shredder is capable of handling about 4 tons /hr.



6. Feed Preparation

The fresh vegetable waste is blended in a collection tank to provide a waste of uniform characteristics, and a waste feed with a solid concentration not exceeding 10%.

7. Anaerobic Digestion (BIMA Digester)

Biogas Induced Mixing Arrangement", BIMA Digesters, anaerobically ferments the vegetable waste for the production of biogas.

8. Biogas Collection

The biogas leaves the BIMA digester to the gas holder. In place of a MS gas holder which is prone to corrosion, a dry type gas holder, which is made of a synthetic membrane (polyester) has been installed in the plant.

9. Power Generation

Total investment	Rs. 5.0 crore
MNRE grant	75% of the cost

The produced biogas, after removal of hydrogen sulphide, is used as fuel to produce electricity. The gas is withdrawn from the gas holder by gas blowers and is blown into the gas engine. An alternator is connected to the engine to produce electricity. The gas blowers are suitable for handling the biogas. A 230 kW Gas engine is provided. The net power generated after in house consumption is exported to TNEB grid.

10. Biogas flare

In case of maintenance of gas engine and when gas exceeds beyond the storage capacity of the gas holder, the biogas is burnt in the flare. The flare is an automatic flaring type with an auto start arrangement, auto ignition with spark plug.

Benefits :

- The biogas generated would be used as fuel in gas engine and the power generated would be exported to TNEB grid
- The dewatered cake is sold / used as manure by CMDA
- Substantial emission reductions

Conclusion

- The potential for renewable energies to provide clean, inexhaustible, and decentralized energy is now generally accepted by industry, builders and Government
- The technologies addressed in this booklet are well proven and implementation issues have been addressed to a larger extent
- These technologies have a lot of potential to be replicated in other industries and buildings as well
- Renewable Energy Council of CII-Godrej GBC can extend help to projects which would like to replicate the case studies mentioned in this booklet

About CII

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the growth of industry in India, partnering industry and government alike through advisory and consultative processes.

CII is a non-government, not-for-profit, industry led and industry managed organisation, playing a proactive role in India's development process. Founded over 113 years ago, it is India's premier business association, with a direct membership of over 7500 organisations from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 83,000 companies from around 380 national and regional sectoral associations.

CII catalyses change by working closely with government on policy issues, enhancing efficiency, competitiveness and expanding business opportunities for industry through a range of specialised services and global linkages. It also provides a platform for sectoral consensus building and networking. Major emphasis is laid on projecting a positive image of business, assisting industry to identify and execute corporate citizenship programmes. Partnerships with over 120 NGOs across the country carry forward our initiatives in integrated and inclusive development, which include health, education, livelihood, diversity management, skill development and water, to name a few.

Complementing this vision, CII's theme "India@75: The Emerging Agenda", reflects its aspirational role to facilitate the acceleration in India's transformation into an economically vital, technologically innovative, socially and ethically vibrant global leader by year 2022.

With 64 offices in India, 9 overseas in Australia, Austria, China, France, Germany, Japan, Singapore, UK, USA and institutional partnerships with 211 counterpart organisations in 87 countries, CII serves as a reference point for Indian industry and the international business community.

About CII-Godrej GBC

CII – Sohrabji Godrej Green Business Centre (CII – Godrej GBC), a division of Confederation of Indian Industry (CII) is India's premier developmental institution, offering advisory services to the industry on environmental aspects and works in the areas of Green Buildings, Energy Efficiency, Water Management ,Environment Management, Renewable Energy, Green Business Incubation and Climate Change activities.

The Centre sensitises key stakeholders to embrace green practices and facilitates market transformation, paving way for India to become one of the global leaders in green businesses by 2015.

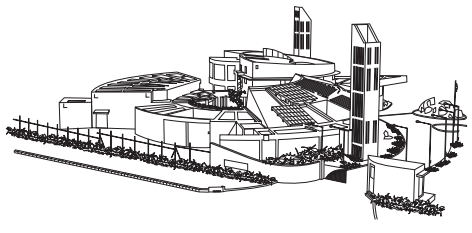
About Asia-Pacific Partnership

The Asia-Pacific Partnership on Clean Development and Climate is an innovative new effort to accelerate the development and deployment of clean energy technologies. APP partners Australia, Canada, China, India, Japan, Republic of Korea, and the United States have agreed to work together and with private sector partners to meet goals for energy security, national air pollution reduction, and climate change in ways that promote sustainable economic growth and poverty reduction.

The Partners will also cooperate on the development, diffusion, and deployment of longer-term transformational energy technologies that will promote economic growth while enabling significant reductions in greenhouse gas intensities. The Partnership will be consistent with and contribute to Partners' efforts under the UNFCCC and will complement, but not replace, the Kyoto Protocol.

CII-Godrej GBC has initiated a project "Voluntary program to promote ecologically sustainable business growth for Indian Industry," which, in support of the goals of the Asia-Pacific Partnership on Clean Development and Climate, is partially supported by the U.S. Department of State. This booklet is one of a number of publications developed as part of this project.

For more details, kindly contact



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