CASE

Combined heat and power and ethanol from sugar industry waste (SSSSK, Maharashtra, India)

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Supporting case for Business Model 8	
Location:	Someshwarnagar, Maharashtra, India
Waste input type:	Bagasse, molasses, spent wash (Distillery effluent)
Value offer:	Electricity/heat, ethanol, pressed mud and bio-fertilizer
Organization type:	Cooperative society
Status of organization:	Operational (since 1962), co-generation unit (since 2010)
Scale of businesses:	Large
Major partners:	Sugarcane farmers (Cooperative society), Government of India, Maharashtra State Government

Executive summary

Shri Someshwar Sahakari Sakhar Karkhana (SSSSK) is a cooperative sugar factory located at Someshwarnagar, taluka Baramati, dist. Pune, Maharashtra that produces sugar from sugarcane grown by its farmer members. In the process producing sugar, it produces bagasse and molasses as waste products. In order to address fluctuations in profits in the sugar unit itself, SSSSK has made additional investments in a distillery unit producing ethanol using molasses; a biogas unit generating biogas using spent wash from the distillery; a cogeneration facility generating combined heat and power using bagasse and biogas and bio-fertilizer using press mud from biogas plant. There is significant demand for the ethanol from companies producing alcoholic beverages as well as pharmaceutical companies. The government has also put in place a requirement of 5% ethanol blending of fuel, which has created a demand for ethanol from petroleum companies. The biogas produced is used internally as input fuel to the boiler while the bio-fertilizer (the discharge from the biogas unit), which is high in organic matter, is distributed at no cost to the farmers in proportion to the cane supplied by them. The electricity generated by the cogeneration unit partially used internally and surplus is sold to the state electricity utility by way of a long-term power purchase agreement at a pre-determined incentive tariff that has been set by the MERC. SSSSK assists the member cane growers to increase cane growth by providing quality seed and tissue culture plantlets, introducing modern techniques of cultivation, integrated nutrient management, irrigation water management and pest management and providing bio-fertilizers to its members. SSSSK's operations have led to significant socio-economic benefits

for the local community in terms of the creation of livelihood for member farmers, job creation and improving the quality of basic infrastructure such as roads and access to healthcare and education. Moreover, the whole process results in CO_2 offset due to use of non-fossil fuel for electricity generation.

KEY PERFORMANCE INDICATORS (AS OF 2012)						
Land:	60 ha					
Water requirement:	130 m^3/hr					
Capital investment:	Co-generation unit = USD 20.8 million, Distillery unit = USD 4.4 million, Biogas unit = USD 0.53 million					
Labor:	150 full-time and approximately 50 temporary/seasonal persons					
O&M cost:	2.5% of capital costs (643,000 USD/year)					
Output:	18 MW electricity/year, 5 million L of alcohol/year					
Potential social and/or environmental impact:	20,000 farmer members benefit, 200 jobs in the local community, overall socio-economic development in the community – Roads, healthcare and education, CO_2 offset					
Financial viability indicators	Payback period:	3–5 years for co-generation distillery	Post-tax IRR:	N.A.	Gross margin:	10–12%

Context and background

The cooperative ownership structure, prevalent in the sugar industry in Maharashtra, India, enables to undertake activities with a common goal by formation of non-profit economic enterprises for the benefit of their members. SSSSK is a cooperative sugar factory in taluka Baramati, dist. Pune that produces sugar from sugarcane grown by its more than 20,000 farmer members across 40 villages and four talukas. It was established in 1961 with a crushing capacity of 1,016 tons of cane crushed per day (TCD), which has since been increased to 3,600 TCD.

In order to improve the utilization of the waste streams from the process of making sugar, SSSSK has made various investments since its establishment, which include a distillery unit producing ethanol using molasses; a biogas unit generating biogas using spent wash from the distillery and a co-generation facility generating combined heat and power using bagasse and biogas and bio-fertilizer using press mud from biogas plant. The co-generation plant was commissioned on May 21, 2010. In 2011–2012, SSSSK generated 99 million kWh, consumed 29 million kWh and sold 70 million kWh to the grid.

Market environment

Sugar is India's second largest agro-processing industry. There are more than 500 sugar factories with about 5 million hectares of land under sugarcane with an average yield of 70 tonnes per hectare. Biggest problem the sugar industry facing today is surplus production, from 10 lakh (1 million) tonnes in 1950 to over 200 lakh (20 million) tonnes in more recent years. While consumption of sugar is increasing at a steady pace of 4–5% per annum, it does not match the increase in production. As a result, prices of sugar have been steadily sliding over years. With the advancement in the technology for generation and utilization of steam at high temperature and pressure, the sugar factories can also produce significant surplus electricity for sale to the grid using same quantity of bagasse. For example, if steam generation temperature/pressure is raised from 400 °C/33 bar to 485 °C/66 bar, more than 80 KWh of additional electricity can be produced for each ton of cane crushed. The sale of surplus power generated through optimum cogeneration would help a sugar mill to improve its viability, apart from adding to the power generation capacity of the country.

One of the fastest-developing countries in the world today, with economy in transition, India consumes 12.18 quadrillion Btu (Quads) of power, with over 8–10% growth per annum. India's annual per capita energy consumption of 0.7 tonnes of oil-equivalent and its electricity consumption of roughly 835 TWh is less than one-seventh of that of developed countries. It is of utmost importance for business and industry to have adequate, economical, reliable, high-quality power supply. The market for SSSSK's electricity is the state electricity grid. There is significant demand for electricity, given that the state of Maharashtra has been suffering from an energy shortage in excess of 10% for the past decade. In order to address the energy gap, the state electricity regulator (MERC) established an incentive tariff for cogeneration units in 2002 to maximize generation from existing resources. SSSSK's cogenerating unit is capable of generating 18 MW power, 15.8 MW of which is exported to electricity grid based on a long-term power purchase agreement. The incentive tariff set by the regulator is 0.096 USD/kWh. Bagasse-based co-generation of power in India has come to a take-off stage. The lessons learned during the last decade have been extremely useful for achieving accelerated growth in the near future.

There is also a significant demand for alcohol from companies producing alcoholic beverages as well as pharmaceutical and petroleum companies. The government has put in place a requirement of 5% ethanol blending of fuel, which has created a demand for ethanol from petroleum companies. SSSSK is benefiting from government incentives for co-generation units and government regulations in relation to ethanol blending of fuel. The biogas plant has capacity of 14,787 m^3/day which contributes up to 5% input requirements of the boiler, although it was established primarily to address the concerns of the pollution control board with regards to discharge of the spent-wash from the distillery unit.

Macro-economic environment

Bagasse co-generation

The Indian government has set the challenging goal of increasing its electricity capacity six to eight-fold in the next 30 years in the context of significant capacity shortfalls and a financially-ailing electricity sector. The potential from about 575 operating sugar mills spread over nine major states has been identified at 3,500 MW of surplus power by using bagasse as the renewable source of energy. Given that the installed capacity of the total biomass/bagasse-based distributed generation is only 20% of the total estimated resource, the potential benefits of more projects is vast.

The conditions that support the growth of the bagasse-based cogeneration in India started 1992 when a number of domestic and international programs was launched to support the dissemination of bagasse-based cogeneration technology. These support programs include:

- The launching of a national program on promotion of bagasse-based co-generation by the Ministry of Non-conventional Energy Sources (MNES) in 1992 by offering capital and interest subsidies, fiscal incentives, research and development support, accelerated depreciation of equipment, a five-year income tax holiday and concessional import duty, excise and sales tax exemptions.
- Extension of loans for cogeneration by Asian Development Bank (ADB) through the Indian Renewable Energy Development Agency (IREDA).
- International funding for bagasse co-generation from the United States Agency for International Development (USAID).
- The on-going power sector reforms, unbundling of utilities and the enactment of the Electricity Bill 2003, provide further opportunities to sugar mills to emerge as power producers.
- Adoption of Electricity Bill 2003 by states.
- State subsidies and support provided by Maharashtra Energy Development Agency (MEDA).
- Innovative financial mechanisms, including trade of emission reductions from these projects under CDM of the Kyoto Protocol.

- The conducive Central and State Electricity Regulatory Commission's orders on preferential feed-in tariffs.
- Trading of energy in form of renewable energy certificate are allowed since 2010 for which CERC as well as the state ERCs have promulgated various regulations.

There are however barriers to accelerated growth of the bagasse co-generation sector in India such as the non-availability of sustainable policy and regulatory framework regime across different sugar-producing states and no opportunity of exporting electricity outside the state.

Ethanol from molasses

India's transport sector is growing rapidly and accounts for over half of the country's oil consumption whilst the country has to import a large part of its oil needs. In 2002, the government mandated that nine states and four federally-ruled areas will have to sell E-5 (5% ethanol blending) by law from January 1, 2003 which boasted the production of ethanol from sugar factories. The price of ethanol from sugar factories has been set by the government. However, ethanol pricing in India is complicated by differences in excise duty and sales tax across states, and the central government is trying to rationalize ethanol sales tax across the country. This has made ethanol production an uncertain venture and hence hindered the growth of ethanol production.

Business model

The electricity generated by the co-generation unit is purchased by the state electricity utility by way of a long-term power purchase agreement at a pre-determined incentive tariff that has been set by the state electricity regulatory commission (Figure 96). This provides the enterprise a reliable source of revenue for the length of the contract. The incentive mechanisms coupled with the power purchase agreement can make the resulting electricity competitively priced on the open market. The alcohol is sold to producers of alcoholic beverages as well as pharmaceutical and petroleum companies. The biogas produced is used internally as input fuel to the boiler. The discharge from the biogas unit which is high in organic matter is distributed at no cost to the farmers in proportion to the cane supplied by them in order to increase farm productivity, and hence increase reliability and consistency of sugarcane supply to the enterprise.

Value chain and position

SSSSK is vertically integrated and owns its raw materials for the main product (sugarcane) and for its energy-producing units (Figure 97). However, there is a threat that fluctuating sugar prices might force farmer members to shift to other crops. Since area allotted to factory is fixed by the government so as to ensure consistent supply of cane, it becomes all the more important to develop harmonious and good relations with these growers so that they do not switch to alternate cash crops. Hence from Porter's five forces lens, the supplier power is medium.

SSSSK's main buyers are the Maharashtra state utility for its electricity and the petroleum, pharmaceuticals and alcohol companies for its alcohol. The state utility is the only buyer of SSSSK's electricity based on a long-term power purchase agreement. However, the feed-in tariff is decided by the MERC with its terms and conditions, bringing the bargaining power of state utility to medium level. The substitutes for electricity from co-generation unit are electricity from fossil fuel and other renewable energy sources such as biogas, hydropower, wind, solar energy, etc. In the short term, the threat of substitutes is low as SSSSK has a long-term power purchase agreement with the state utility.

The alcohol from the distillery is sold to various industries and buyers with the introduction of the government requirement for 5% ethanol blending of fuel. However, the price of ethanol from sugar

FIGURE 96. SSSSK BUSINESS MODEL CANVAS

KEY PARTNERS

- Sugarcane farmers
- Maharashtra State Cooperative Bank

KEY ACTIVITIES

- Build, operate, own and maintain co-generation, distillery and biogas unit
- Sales of electricity and ethanol
- Distribution of the digested solids to the farmers as organic fertilizer

KEY RESOURCES

- Equipment
- Bagasse, water
- Technical and operational competencies
- Capital
- Agreement with the Maharashtra State Electricity Distribution Company
- Reliable yield at sugarcane fields

VALUE PROPOSITIONS

- Electricity produced based on a waste-to-energy approach, contributing to environmental protection and reducing the energy gap in the region
- Distillate of various grades of alcohol for production of goods
- Organic fertilizer for increasing yield at the sugarcane fields

CUSTOMER RELATIONSHIPS

- Direct
- Recurrent purchase based on client satisfaction
- Agreement with suppliers of sugar cane that receive organic fertilizer in proportion to the cane supplied by them

CHANNELS

- Connection to the state electricity grid
- Direct sales of distillates
- Direct transport of fertilizer to the sugarcane farmers

CUSTOMER SEGMENTS

- Maharashtra State Electricity Distribution Company (MSEDCL)
- Petroleum, alcohol and pharmaceutical companies
- Sugarcane farmers

COST STRUCTURE

- Capital investment (95% financed by debt): Co-generation unit; Distillery unit; Biogas unit
- Repayment of debt and dividends on equity
- Input cost (bagasse)
- Interest on borrowed fund
- O&M
- Marketing and sales (alcohol)

REVENUE STREAMS

- Sale of electricity
- Sale of alcohol/ethanol

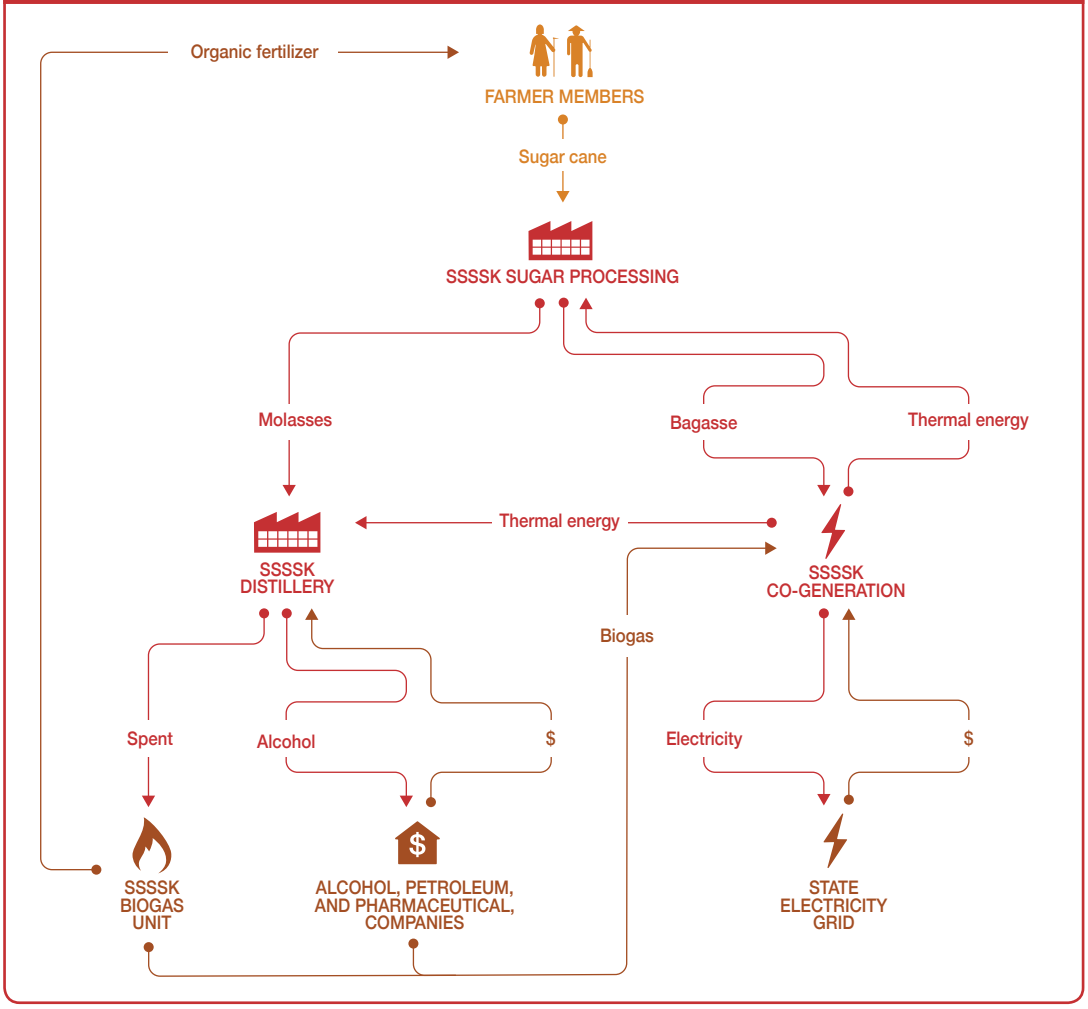
SOCIAL & ENVIRONMENTAL COSTS

- Flue gas emissions and fly ash from the boiler
- Significant water requirement

SOCIAL & ENVIRONMENTAL BENEFITS

- Livelihood, advise and support to farmer members
- Creation of jobs
- Climate change mitigation through use of non-fossil fuels
- Contribute to improving quality of basic infrastructure (roads, access to healthcare and education) in rural areas benefitting members

FIGURE 97. SSSSK VALUE CHAIN



factories is set by the government due to which SSSSK has medium bargaining power. The competition among existing companies is low; however, the competition in the sugar commodity market is high due to surplus production. While consumption of sugar is increasing, it does not match the increase in production and this drives sugar price down. The performance of the cogeneration unit is also highly dependent on government subsidy. By-products from the boiler are boiler ash and flue gas for which there are prescribed standards by pollution control board so as to minimize damage to the environment.

Institutional environment

Indian sugar industry comprises of a mix of private and cooperative units and is highly regulated by central and state government bodies across the entire value chain including sugarcane procurement area, pricing of sugarcane and production of alcohol under the Essential Commodities Act 1955 (subsequently amended in 2003). The government has established various support structures, such as the Sugar Development Fund, which provides concessional loans for upgrading and modernization

efforts as well as for establishing ethanol plants and power-generation units. Hence, both the co-generation and distillation approaches are well encouraged by the government.

The electricity generated by the co-generation unit is purchased by the state electricity utility by way of a long-term power purchase agreement. The Electricity Bill 2003 enacted subsequently by the Government of India has provided major impetus. The bill has recommended that the states should generate a minimum 10% of energy from renewable sources. It also gave supreme powers to the State Electricity Regulatory Commissions (SERC) for deliberating and deciding tariffs and other terms and conditions for all renewables, including bagasse co-generation. IREDA, a Government of India enterprise and the lending arm of MNES, has provided promotional/development finance for harnessing biomass energy in India over the last 10–12 years.

Industry associations like the Cogeneration Association of India, financial institutions and other stakeholders are pursuing the Central Electricity Regulatory Commission (CERC) to guide SERC to adopt a uniform tariff order for bagasse co-generation in the entire country.

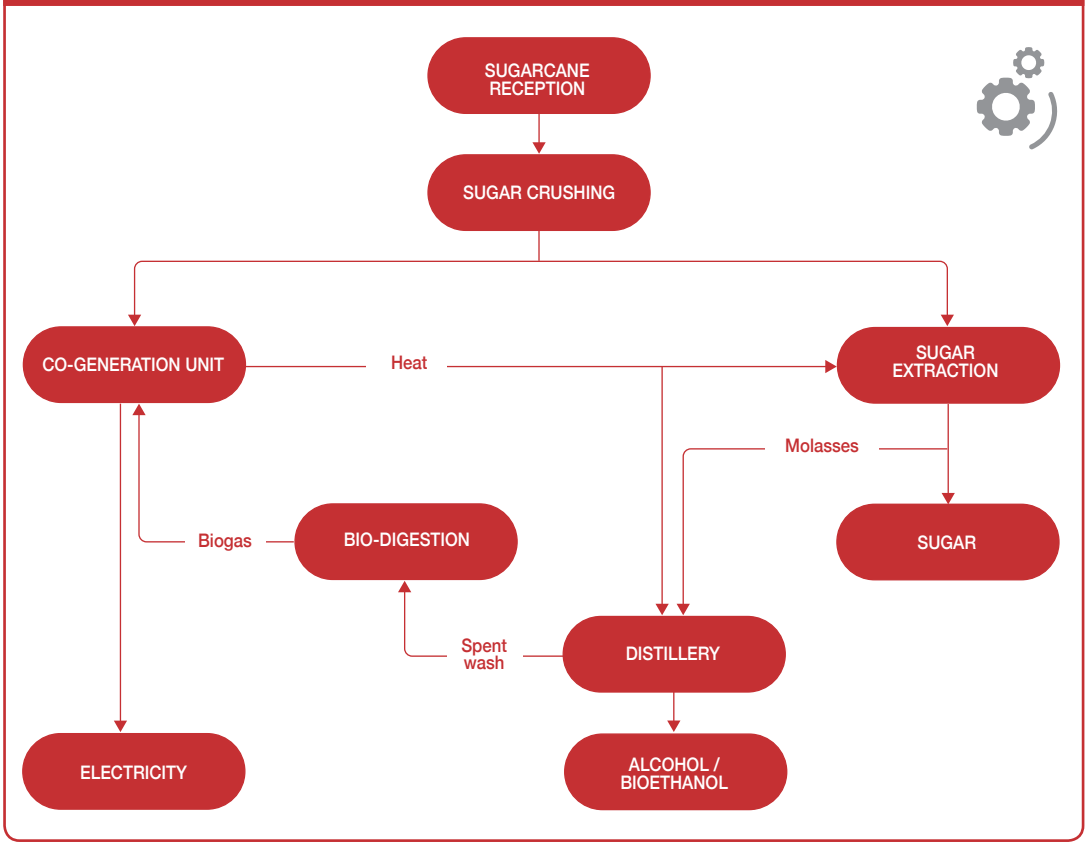
Technology and processes

Sugarcane needs to be crushed within 24 hours of harvesting, else it starts deteriorating resulting in reduced recovery of sugar from the sugarcane. The sugar industry is an energy-intensive industry. Therefore, apart from sugarcane, steam and electricity are essential for running the mill. For this reason, most of the sugar mills have a co-generation unit for supply of steam and electricity. The efficiency of co-generation plant is in the range of 75–90%, as compared to the conventional plant of 35%, because the low-pressure exhaust steam is used for heating purposes in the factory.

The typical recovery of sugar from cane during the process of making sugar is 12%. The balance sugar is available in the molasses, which is a by-product of the process (Figure 98). SSSSK's distillery unit processes the molasses to produce various grades of alcohol such as rectified spirits, extra neutral alcohol, impure alcohol and ethyl alcohol. The distillery unit consists of a multi-stage fermentation process, which is then distilled through separation columns to obtain various grades of alcohol. This unit has a capacity to produce up to 30,000 L of alcohol (95% pure) per day and requires approximately 500,000–600,000 L of water per day. The spent wash from the distillation process, which is high on fructose, is passed on to the biogas plant (18,000 m^3/day equivalent to 40–45 tons of bagasse (input requirements of the boiler for one hour). The biogas contributes up to 5% of the input fuel requirements of the boiler and is generated through a two-stage process comprising of an acid preparation stage followed by methanogenesis. Compost fertilizer is prepared from press mud and spent wash by adding microbial culture with the help of mixing cum aeration machine.

The original setup of the co-generation unit had two low-pressure boilers (16 kg/cm^2 and 21 kg/cm^2) that generate heat to meet the internal process requirements and was capable of generating approximately 2.75 MW power. SSSSK later replaced the low-pressure boilers with a multi-fuel capability, high pressure 100 TPa, 87 kg/cm^2, 570 °C boiler. The input to the boiler includes 42–45 tons/hour of bagasse (supplemented by 18,000 m^3/day of biogas) and 25 m^3/hr of treated water, which is obtained from a reverse osmosis system. The steam generated in the boiler drives a steam turbine, which is connected to a synchronous generator capable of generating 18 MW of power during crushing season. Steam is also extracted at different stages of the turbine to meet the process heat requirements of the sugar and distillery units. Suitable suppliers of equipment were locally available for all the above technologies, with a consultant providing turnkey services for installation, commissioning and preliminary testing.

FIGURE 98. SSSSK TECHNOLOGY PROCESS FLOW



Funding and financial outlook

The 18 MW co-generation unit was established at a capital cost of USD 20.8 million. The distillery unit was established at a capital cost of USD 4.4 million. The biogas unit was established at a capital cost USD 0.53 million. The investment for these units was funded predominantly through debt with approximately 5% equity contribution. The loans were obtained under the Sugar Development Fund established by the government, which provided concessional term loans at 4% interest rate and up to 8–10 years duration, and the Maharashtra State Cooperative Bank, which offered standard term loans at market rates. SSSSK has not faced any significant challenges in raising funds to meet its investment needs.

Apart from the revenues from sales of sugar, the revenue streams of SSSSK include sales of electricity from its co-generation unit and alcohol from its distillery unit (Table 27). Out of the 18 MW power generated by the co-generation unit, 15.8 MW is exported to the state electricity grid by way of a

TABLE 27. REVENUE STREAMS OF SSSSK

REVENUE STREAM	QUANTITY	AMOUNT (MILLION USD/YEAR)
Sale of electricity	15.8 MW	7.45
Sale of alcohol	5,000,000 L	4.27

long-term power purchase agreement at a pre-determined incentive tariff of 0.096 USD/kWh. The market price for ethanol has been fixed by the government at 0.5 USD/L, whereas the price for other grades of alcohol could be as high as 0.8 USD/L. In the case of pharmaceutical companies, although the demand is small and not regular, the rates could range from USD 1 to USD 2 per litre.

The operating and maintenance cost for the first year is assumed to be 2.5% of the capital cost. The input cost of bagasse is 36.6 USD/ton. The payback period for the co-generation unit is five years, assuming six months of operation and 100% off-take of the surplus energy generated by the state electricity utility. The payback period for the distillery unit is three years. The CERs from such projects can be sold to international emission reduction buyers generating additional revenue.

Socio-economic, health and environmental impact

In addition to the livelihood provided to over 20,000 farmer members and employment opportunities within the factory to over 150–200 staff, SSSSK has been largely responsible for the socio-economic development in the immediate vicinity. SSSSK provides advice and support on sugarcane cultivation to its farmer members, such as nutrient management, irrigation management, pest control and access to subsidized seeds and fertilizers. SSSSK has also improved the quality of the basic infrastructure such as roads, access to healthcare and education. SSSSK has established six schools, a junior college and a professional science college, which provides preferential admission and reduced fees (50%) to the children of its farmer members.

Moreover, the whole process results in CO_2 offset due to use of non-fossil fuel for electricity generation as well as for transportation. The blending of renewable ethanol in petrol reduces vehicle exhaust emissions and also reduces import burden of the country. The Indian project promoters can sale the CERs internationally and ensure additional financial benefits every year. However, there are also potential environmental costs associated with the operation of the business such as issues related to water usage and flue gas emissions from the boiler. The water requirement for the entire operation, at 130 m^3/hr, is quite high and has posed some challenges on account of insufficient release of water from dams/irrigation canals, especially during poor monsoon seasons, due to competing use for irrigation. Another issue is with respect to the flue gas emissions and fly ash from the boiler. These emissions are controlled within acceptable limits with suitable equipment.

Scalability and replicability considerations

The key drivers for the success of this business are:

- Electricity shortage and concurrent government support mechanisms such as provision of concessional loans and feed-in-tariff mechanisms.
- Government regulations stipulating alcohol blending for fuel.
- Securing of long-term power purchase agreements.
- Consistent supply of input for energy producing units as SSSSK is vertically integrated.

SSSSK is an example of the implementation of well-established and mature technologies in the sugar manufacturing industry. These technologies enable the organization to improve the efficiency of the process, reduce waste and improve the overall economics of the entire operation. This business case also highlights the advantages of a cooperative ownership structure, which leads to significant socio-economic benefits for the local community. SSSSK operates in a highly-controlled and regulated environment, which poses some challenges so far as scaling up prospects and profitability is concerned, but the profitability has been enhanced through investments in cogeneration and distillery units which have been made possible through concessional sources of finance and feed-in tariff schemes available through mechanisms established by the government. This business has the

potential to be replicated in other similar sugar factories in the state, within India and other countries where there already exists some infrastructure such as a sugar manufacturing company, and the co-generation, distillery and biogas plant could be initiated as a plant within the sugar factory. In order for this business to be replicated in other countries, government support mechanisms are essential.

Summary assessment – SWOT analysis

Key strengths of the business are its application of well-established technologies, which enabled the business to be energy self-sufficient as well as diversify its revenue streams (Figure 99). However, the processes are water intensive and the profitability of the energy producing units depends on government incentives. The latter is not an immediate threat as government support for renewable sources of energy is likely to increase. Fluctuating sugar prices which may force sugarcane growers to shift to other crops and competition from other sugar producing countries such as China and Brazil threaten SSSSK. The energy producing units might result in reduction of GHG emissions, and this presents opportunities for SSSSK to earn carbon credit sales by registering the business as a CDM project.

FIGURE 99. SWOT ANALYSIS FOR SSSSK

	HELPFUL TO ACHIEVING THE OBJECTIVES	HARMFUL TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	**STRENGTHS** ▪ Power purchase agreement ▪ Well-established and mature technologies ▪ Diversified revenue streams ▪ Zero-waste process ▪ Reliable sustainable and self- sufficient energy ▪ Vertically integrated ▪ Business arrangement allows competitive pricing ▪ Implied social benefits	**WEAKNESSES** ▪ Significant water requirement ▪ Dependent on government incentives ▪ Inadequate capacity of various players including sugar mills, financial institutions and regulators ▪ Slow adaptation of modern technologies and modernization of old sugar mills ▪ Weak management of existing facilities
EXTERNAL ORIGIN ATTRIBUTES OF THE ENVIRONMENT	**OPPORTUNITIES** ▪ Demand for electricity is growing and government support for energy from renewable sources is likely to increase ▪ Opportunity for registering the project as a CDM and earn additional revenues from sales of carbon credits ▪ High value products for downstream industries ▪ Huge potential to increase productivity of sugarcane and sugar recovery rate	**THREATS** ▪ Fluctuating sugar prices may force sugarcane growers to shift to other crops and decreasing sugar prices may disrupt business ▪ Competition from other sugar producing countries (China, Brazil) ▪ Competition from fossil-fuel-based energy ▪ Insufficient availability of water from dams due to competing uses for irrigation may pose risk of production stoppage ▪ Ethanol production an uncertain venture due to complex sales tax ▪ Procedural delays of ERCs, SEBs and other agencies ▪ Reduction in yields of sugarcane due to single crop cultivation with overuse of fertilizers and pesticides ▪ Poor financial health of power distribution companies

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Case descriptions are based on primary and secondary data provided by case operators, insiders, or other stakeholders, and reflect our best knowledge at the time of the assessments (2015–2016). As business operations are dynamic, data can be subject to change.