Alternative Bagasse Cogeneration

New Delhi, India
27 February, 1999

Conference Proceedings

USAID

The US Agency for International Development (USAID) Mission to India currently broadly focuses on family planning and health services nutrition education urban water and sanitation systems HIV/AIDS education and awareness and enhancing the status of women In addition the current USAID program policy continues its prior commitments for policy reform and technology transfer in the energy sector to promote clean energy development efficient energy use and reduced pollution especially with regard to greenhouse gases

USAID has played an important role in India s development successes Past US assistance built the base for the green revolution and India s dramatic increase in agriculture production USAID assistance to India in FY 98 amounted to about USD 125 million

For additional details please see http //www info USAID gov

FETC

The Federal Energy Technology Center (FETC) of the US Dept of Energy a new organization comprised of the former Morgantown and Pittsburgh Energy Technology Centers was formed to combine the capabilities and strengths of both centers resulting in savings of tax dollars by reducing costs for administration and support At present it is the largest fossil energy research organization in the world

FETC manages all the US fossil energy research and development programs for coal and natural gas by developing technologies that will allow a cleaner and more efficient use of fossil energy resources FETC manages a major program to develop advanced technology to clean up radioactive contaminated sites and performs in house research Today their manages approximately 700 energy and environmental projects worth $ 10 billion FETC entered into a Participating Agencies Services Agreement (PASA) with USAID to provide technical assistance and training for the GEP Project

For additional details please see http //wwwfetc doe gov

BURNS and ROE

Burns and Roe is a comprehensive engineering construction and operations and maintenance organization providing services to both private and government clients worldwide Their activities encompass the entire spectrum of project service from conceptualization to startup and operation and they work with clients involved in a broad range of activities including utility and industrial energy production process technologies and industrial manufacturing commercial institutional governmental and industrial facilities and environmental assessments and remediation Through the early 1990 s Burns and Roe had completed over 120 fossil fueled generating plants totaling over 25 000 MW the majority of which were new facilities or expansions for major utility companies Under the GEP project Burns and Roe is a member of the FETC team for technical assistance and training

For additional details please see http //www roe com

WINROCK INTERNATIONAL

Winrock International is a private non profit organization headquartered in the US and with offices in over 40 countries including India Its activities are funded by grants contracts and contributions from public and private sources The focus of the Renewable Energy Program of Winrock International is to accelerate the commercialization of renewable energy technologies in rural areas where there is an expressed need for development Winrock has developed a network of offices and in county entities called Renewable Energy Project Support Offices (REPSOs) that understand local development issues and also have the technical expertise to realize the full potential of renewable energy applied to these areas

Because of the scale of the potential development impact Winrock has worked aggressively since 1989 to accelerate the introduction and expansion of cogeneration by the sugar industry in each country where sugarcane is a major crop Past Winrock efforts in India have resulted in significant achievements in the introduction and development of cogeneration by the Indian sugar industry such as significant policy reforms within a State Electricity Board that resulted in private investment in cogeneration plants by the sugar industry in the state case studies that led to the construction of two cogen plants and model PPAs that have led to others between IPPs and SEBs Another area where the REPSO in India have done pioneering work is in the promotion of alternative fuels especially cane trash to enable year round operation of the cogeneration plant Currently Winrock is another FETC team member supporting USAID s GEP Project s ABC Component in India

PREFACE

Power generation through bagasse based cogeneration in sugar mills has been a prominent way of providing clean energy in India ever since a national program was launched in India in the mid 1990s The 450-odd sugar mills in the country are estimated to have a total generation potential of nearly 3500 MW of which over 400 MW was either installed or under implementation by the end of March 1999

In view of the considerable potential for biomass particularly bagasse-based sugar cogeneration the US Agency for International Development (USAID) included it as a component of their Greenhouse Gas Emission Pollution Prevention (GEP) Project clean coal technologies being the other Under this program nine sugar mills have been assisted to demonstrate the technical and economic feasibility of operating sugar cogeneration units in the off-season with entirely biomass/bagasse fuel In addition to investment grant and technical assistance the project also envisaged activities designed to assist project partners in terms of awareness creation capacity building and facilitation of technology transfer Winrock International has been implementing this component in collaboration with Burns and Roe Services Corporation (BRSC) under a contract from the US Department of Energy s (DOE) Federal Energy Technology Centre (FETC)

The present volume is published from the proceedings of the International Workshop held in New Delhi on 27 February 1999 as part of the series of workshop and training programs being conducted under the aegis of the GEP-ABC project This workshop provided a forum for technologists project developers domestic/international financing agencies and other related institutions to discuss the problems and opportunities associated with fast-track implementation of cogeneration projects It attracted enthusiastic participation and papers were presented by international and national experts on various aspects of bagasse-based cogeneration including advanced technology initiatives fuel management and energy efficiency considerations and policy and financial issues In addition some of the GEP-ABC project participants presented their experiences in implementing the cogeneration projects

The financial and regulatory issues pertaining to power generation and purchase were discussed by a panel of experts in the field An extra dimension was added in the form of a presentation and discussion of the possible contribution of renewable energy technologies including that of bagasse-based cogeneration towards greenhouse gas abatement through mechanisms like the Clean Development Mechanism (CDM)

Thus the workshop covered a range of issues of high relevance and as such these proceedings are expected to benefit not only direct stake-holders in bagasse-based cogeneration but also the renewable energy community

P Venkata Ramana
Program Manager (RE), WII
April 1999

ACKNOWLEDGEMENTS

Winrock International would like to express sincere appreciation to the US Agency for International Development (USAID) and the US Department of Energy's Federal Energy Technology Center (FETC) for their advice and invaluable support in particular Mr Richard Edwards Mr Suresh Jain and Ms Kavita Sinha

We would also like to thank our special guests at this workshop - Hon Kathleen McGinty Mr James Bever and Dr V Suresh - who spared valuable time to grace the occasion the speakers and participants for assisting us in making this international workshop a successful one

We also wish to convey our appreciation to Mr Lee Jakeway, Dr Bhaskar Natarajan and Mr S C Natu who chaired the technical sessions, while Mr Robert Kwok Mr Sanjeev Ahluwalia Mr P Dutt and Mr Harish Bhargava kindly consented to participate in the Panel Discussion on the Keys to Successful Cogeneration Project Development in India

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SPEAKER PROFILES

MR JAMES A BEVER has been working with the US Agency for International Development for 17 years Prior to India he served as Director Office of Environment Energy and Urban Development for the Bureau for Europe and the New Independent States at Washington He has also served with USAID in Indonesia and with Environment Engineering Inc in Morocco Currently Mr Bever is the Deputy Mission Director US Agency for International Development India

MR HARISH BHARGAVA has been associated with several big names from early on in his career After working for over 18 years with Burmah Shell Oil Storage & Distributing Co of India Ltd in several capacities he left to join the Indo Burma Petroleum-Balmer Lawrie Group as General Manager in 1974 Between 1980 and now Mr Bhargava has been associated with EID-Parry (India) Ltd as Vice President Sugar & Ceramics with Thermax Ltd as Director Corporate Development and with Management Resources as Advisor Mr Bhargava has been directly associated with cogeneration since 1992 Currently he provides top management consultancy to progressive and growth-oriented companies operating in India and is authoring a comprehensive book of Cogeneration of Electricity in India which will be published shortly

MR SUBHASH CHANDRA has over 25 years of experience in the electric power sector As a principal in Charter Oak Energy an unregulated subsidiary of Northeast Utilities he had the overall responsibility for developing independent power projects in India He conducted a detailed study of the Indian power sector and formulated a comprehensive market entry strategy He was responsible for developing in-country relationships management of all legal political and regulatory matters identification and evaluation of project opportunities technical and financial due diligence negotiation of various commercial contracts and agreements and negotiations with various Government and regulatory agencies He was also involved in the development of several power projects that included a 210 MW coal plant 35 MW diesel plant and bagasse fired cogeneration plants at sugar mills

A Master and Doctoral degree holder from the University of Cincinnati Mr Chandra has held for about 13 years various management and technical positions in the Power Generation Group in Northeast Utilities and has also worked in technical and project management capacities for 8 years for two major equipment suppliers for the power industry Babcock & Wilcox and Combustion Engineering

MR G C DATTA ROY Chief Executive (Power) DCM Shriram Consolidated Limited is an engineer with a PhD (awarded in 1995 for a thesis on 'Energy Conservation in the Edible Oil Industry by application of HEN technology') He has had specialized training in the fields of Power Generation System & Equipment Brown-Boveri Baden – 1970 Energy Management APO Tokyo – 1980 and Sustainable Development University of Nigenrode, Holland – 1994 etc

Mr Datta Roy successfully ran businesses involving Power Chemicals Edible Oil Sugar etc and headed corporate functions like Technology and Total Quality Management His major accomplishments include the turning around of the edible oil and chemical business through energy conservation while integrating Energy Environment and Ecology development He has worked as an associate consultant on an ADB project study on renewable energy development project covering bagasse cogeneration and also on Energy Conservation opportunities in the sugar industry for De-Lucia and Co, USA Actively involved as committee members/faculty on energy and environment related matters for NPC PCRA CII FICCI ASSOCHAM etc Mr Datta Roy has published over 35 Papers on energy and environment related issues in both national and international forums/publications

MR PURNENDU DUTT a graduate in Mechanical Engineering from Jadavpur University Calcutta started his career as an EngineerTrainee I with BHEL New Delhi and worked with them for 16 years in the field of project engineering of large power plants Later he served with the private sector in the field of Industrial Power Projects including DLF Industries Faridabad He has 25 years hands-on experience of Engineering Procurement and Construction (EPC) of thermal gas based and liquid fuel based projects Since December 1997 Mr Dutt has been working with Godavari Sugar Mills Ltd the flagship company of the Somaiya Group Mumbai as General Manager incharge of a 3 x 24 MW cogeneration project being set up in phases at Sameerwadi Karnataka

MR RICHARD L EDWARDS arrived in India in August 1997 and is currently assigned as Director of the Office of Environment Energy and Enterprise team of USAID/India As have so many USAID personnel Mr Edwards too was lured by the Peace Corps in the 1970s and 1980s in the Philippines He spent several years there initially as a volunteer and later as Associate Director of the Peace Corps He then returned to the Philippines in the 1990s as the World Wildlife Fund (WWF) Country Representative where he managed a large USAID funded debt-for nature swap program and helped establish an NGO biodiversity foundation On joining USAID in 1994 after a year of rotational assignments and French language training in Washington DC he was assigned to the Office of Environmental and Natural Resources of USAID/ Morocco where he served as the Mission Environmental Officer in Rabat prior to arriving in India Mr Richards holds a masters degree in Natural Resources Management from Humboldt State University and a B S in Biology from the University of Oregon

MR GAUTAM GOEL is the Director of Dhampur Sugar Mills Ltd at the young age of 25 The Dhampur Sugar Group comprises of six sugar mills a paper plant a chemical plant power and boards He also serves as director of several other companies Mr Goel has 6 years experience in running sugar mills chemical plants and co-generation projects and is successfully and independently running DSM Sugar Rauzagaon and Mansurpur Sugar Mills Ltd Mansurpur He has been greatly responsible for installing the first raw-refined sugar manufacturing process in India

MR ROBERT KWOK attended the Mauritius College of Agriculture and graduated with a Diploma in Sugar Technology He started his sugar career in 1968 as a Chief Chemist obtained a scholarship to attend Technical Engineering and then returned to Mauritius and worked as an Assistant Sugar Technologist at the Mauritius Sugar Industry Research Institute and then as a Process Manager at Solitude Sugar Estate Between 1974 1980 he went back to university to pursue a MS degree in Chemical Engineering and graduated in 1976 with a thesis on Boiler Efficiency in Louisiana Sugar Factories In 1980 Mr Kwok moved back to Maui as Project Engineer for HC&S and is presently the Vice President Research and Engineering

Mr Kwok has been very active within the Hawaiian sugar industry and has chaired many sub-committees on factory improvement energy development cost control environmental issues power contract negotiations and utility integrated resource planning (IRP) He has been a member of the Paia Gasification project from its inception to the final testing phase Mr Kwok has presented many technical papers in Hawaii continental USA South Africa Mauritius Venezuela Colombia and India He has also done a lot of research and development in the field of processing and power generation and is the co-inventor of the Ultrafiltration/ Desugarization system and has two patents on the invention He has traveled extensively around all the sugar producing countries in the world In 1997 Robert Kwok acquired John H Payne Inc an international sugar-consulting firm formed by Dr Payne in 1975

DR A MANJUNATH after a PhD in Combustion from IIT Madras India has more than 8 years experience in Gasification plants and Conventional boiler power plants He is presently based at Chennai working as a technical co ordinator for Foster Wheeler Italiania for their interests in IGCC plants in India

The **Hon** KATHLEEN MCGINTY held the positions of Chair of the Council on Environmental Quality (1995-1998) and Director of the White House Office on Environmental Policy (1993-1995) serving in both posts as President Clinton's Senior Advisor on environment natural resources and sustainable development issues Prior to her service in the Clinton Administration Ms McGinty was Senator Albert Gore s Senior Legislative Assistant for Energy and Environmental Policy She was Congressional Staff Coordinator for the Senate delegation to the 1992 United Nations Conference on Environment and Development in Rio de Janeiro and an Official Member of the US Delegations to Negotiations on the Framework Convention on Climate Change and the Antarctic Protocol

Ms McGinty joined the Tata Energy Research Institute New Delhi in November 1998 as Senior Visiting Fellow where she conducts work on a broad range of energy and environmental issues She received a BS in Chemistry from Saint Joseph s College and a JD from Columbia University

MR S C NATU joined the Maharashtra Industrial and Technical Consultancy Organization Ltd (MITCON) in 1984 as a young professional A mechanical engineer from Pune today he is Vice President (Energy & Projects Group) MITCON Pune MITCON has several outstanding achievements to its name under his guidance nomination on the Government of Maharashtra s Task Force for deciding on a policy for Renewable Energy Power Purchase in 1996 project developer interface services for several national/international clients MNES Program Partnership Initiatives contractee for the promotion of bagasse based cogeneration projects covering over 30 mills in five states profit making/cost centre management since 1984 now sharing almost 40% of MITCON s business income and over 60% of profits

DR PALANI G PERIASAMY obtained his Masters in Economics from Madras University and a PhD from Pittsburgh University USA He was a tenured Professor of Economics in the School of Business University of Baltimore USA

At the invitation of the Chief Minister at the time Dr MGR Dr Periasamy came forward to establish several industries in the state of Tamil Nadu The first venture established by him and his associate Non Resident Indians was Dharani Cements Later he established Dharani Sugars & Chemicals Ltd

Dr Periasamy believes in diversification He along with his associates actively promoted Real Estate and Hotel Ventures in the US At present they are building a five star deluxe Madras Hilton hotel which will be opened shortly

MR V SURESH a civil engineer by profession has 34 years of professional experience in various important capacities Since he joined the Housing and Urban Development Corporation Ltd (HUDCO) in 1979 he has successfully risen to the top Today he is their Chairman and Managing Director and has been responsible for involving the architectural fraternity in an increasing manner for building up a strong Consultancy Wing associating the best professionals in the area for promoting and nurturing the system of Technical Advisory Committees in Regional Offices to assist in the appraisal process and for evolving mechanisms at the city level and house designs at the individual unit level these are a few of his significant contributions to the sector

Currently Mr Suresh also serves on several committees such as the Housing and Urban Development Committee of CII the Scientific Advisory Committee of the Ministry of Science and Technology etc He has also represented India as a Special Invitee at the United Nations Centre for Human Settlements (UNHCS) international committee meeting Under his leadership HUDCO has received several awards

MR SCOTT Q TURN is an Associate Professor in the Hawaii Natural Energy Institute at the University of Hawaii In this position Dr Turn conducts research in the general areas of biomass resources production thermochemical conversion and utilization Recent projects have focused on biomass resource assessment for power generation in several south east Asian countries development of processes for improving biomass characteristics control of inorganic species during biomass gasification and high temperature conditioning of biomass product gas In addition to these responsibilities Dr Turn serves on the Graduate Faculty in the Department of Biosystems Engineering where he also offers classes Dr Turn performs private engineering consulting for several clients

MR RAM V TYAGARAJAN is the Chairman and Managing Director of Thiru Arooran Sugars Ltd, Chennai India Qualified as a chemical engineer he is a Master Degree holder from the Sloan School of Management at the Massachusetts Institute of Technology in the US He has extensive managerial experience of over twenty years including a long stint with a reputed management-consulting firm in the US Mr Tyagarajan served as President of the Indian Sugar Mills Association from 1987 to 1989 He was also the President of the Sugar Technologists' Association of India from 1991 to 1993

Thiru Arooran Sugars Ltd (TASL) is one of the most integrated sugar manufacturers in India today It currently operates two sugar factories in the State of Tamil Nadu with an aggregate capacity of 7 500 TCD, besides a distillery with an installed capacity of 60 000 litres per day of Rectified Spirit and 30 000 litres per day of extra Neutral Alcohol – the latter is presently being expanded to 60 000 litres per day TASL holds licenses for setting up two additional sugar factories with minimum capacities of 2 500 TCD one of which has gone on stream in February 1999 TASL also has the distinction of having established the first major sugar mill cogeneration project in the country in 1995 with an installed capacity of 28 5 MW Another 19 MW cogeneration plant has been commissioned at the other sugar factory in 1997 TASL has recently completed the takeover of a 5000 TCD sugar mill with an annexed distillery having an installed capacity of 60 000 litres per day of Rectified Spirit and 10 000 litres per day of Extra Neutral Alcohol With this acquisition they have the largest aggregate installed capacity for crushing sugar cane in southern India

Inaugural Session

Session Chairman
P Venkata Ramana
Program Manager (RE)
Winrock International - India

Inaugural Address

V Suresh
Chairman & Managing Director
Housing & Urban Devpt Corpn Ltd (HUDCO) New Delhi India

It is indeed a great honour for me to deliver the inaugural address on this one day International Workshop on Alternative Bagasse Cogeneration organized by Winrock International This event is very significant as we are at the threshold of the new millennium with just 307 days left from today It is indeed the right time to look forward to new methods of addressing efficiency and environmental factors in energy production

Background

Energy is the backbone of modern civilization Today one would not be able to identify any activity which does not use energy in some form or the other It is estimated that about 300 million people in the country do not have access to electricity which is equivalent to the total population of our entire country during the time of our independence The number of villages without adequate electricity is 80 000

From an installed capacity of about 20,300 MW in 1950-51 the total generating capacity as of now is estimated to be around 84 200 MW It is further estimated that by the year 2007 India will have to add another 1 42 000 MW of power at a cost of approximately $160 billion By the year 2006 it is estimated that at the present rate India would require over 450 million tons of coal 94 million tons of oil and 220 million units of electricity

Most of this energy consists of the use of non-renewable resources and is in effect unsustainable It is therefore, imperative that energy production and utilization become more efficient and that most energy requirements for the future are met through renewable resources

India has been an important producer of sugar and this has been actively promoted by the government leading to the establishment of more than 400 sugar mills in the country Bagasse—the woody fibrous residue of crushed cane the major by product of the sugar industry—has not been used to its complete potential In India the concept of bagasse based cogeneration has been practised by sugar mills to generate steam and power for their own use using low pressure boilers The storage of large quantities of bagasse being a major problem for the mills the boilers were designed to use almost the entire bagasse produced bringing in a built in inefficiency in the system Recently there has been growing awareness among sugar mills regarding advantages of using high efficiency high pressure boilers to use bagasse a renewable source of energy to produce power This system involves improved energy efficiency and reduction in operating costs of sugar mills steam production for use in sugar mills and auxiliary units power generation using bagasse in an environmentally clean manner use of power for captive consumption and sale of exportable power to State Electricity Boards or third party sale to generate additional revenue The exportable surplus power from cogeneration projects goes a long way towards providing electrification which is a basic infrastructure requirement in urban/peri-urban areas

Resource Potential

The potential of exportable surplus power from bagasse based cogeneration projects in India is estimated to be 3000–3500 MW if all the 430 sugar mills in our country switched over to modern techniques of cogeneration

A maximum potential of 1000 MW each is envisaged from Maharashtra and Uttar Pradesh followed by Tamil Nadu at 350 Karnataka at 300 Andhra Pradesh at 200 Bihar at 200 Gujarat at 200 Punjab at 150 and cumulatively other states have a potential of around 100 MW

Promotion of Bagasse-based Cogeneration

The Govt of India (GOI) has recognized the potential for wide scale alternative bagasse cogeneration and has heralded the National Program for Bagasse-based Cogeneration For this purpose it has initiated a Demonstration Scheme for Private Sugar Mills and a set for Cooperative/Public/Joint Sector Mills and an Interest Subsidy Scheme

A) DECENTRALIZATION SCHEME

- **Private sugar mills**

Capital subsidy Equivalent to 30% of total equipment cost or up to Rs 70 lakhs/MW of surplus power whichever is lower The maximum amount of subsidy to a single project will be restricted to Rs 6 crores

- **Cooperative/Public/Joint Sector Sugar Mills**

Govt Grant Equivalent to 50% of total project cost or up to Rs 2 crores/MW of surplus power whichever is lower

The Govt grant will be utilized by FIs to provide the existing cooperative/public sector sugar mills a capital subsidy of Rs 70 lakhs/MW surplus power subject to a maximum of Rs 6 crores per project and a long term soft loan of Rs 1 30 crore/MW of surplus power at an interest rate of 9% besides their own loan at commercial terms

For new sugar mills of both categories subsidies will be half of those mentioned above

The State Govt will also have to provide a fresh equity of Rs 25 lakhs/MW of surplus power to avail the benefit of Central Govt Incentives Independent Power Producers (IPPs) will also be eligible for financial incentives However in such cases MNES grants will be on par with private sector projects

B) INTEREST SUBSIDY SCHEME

- **Projects generating 4 MW or more power involving change of boiler & turbine** Interest Subsidy equivalent to Rs 35 lakhs/MW to the promoters payable through FIs in the form of subsidized loans provided the loan component of the project is at least 60% of the project cost of Rs 4 crores/MW
- **Projects using their existing facilities with minor modifications for generating 1 4 MW of surplus power** Interest Subsidy equivalent to Rs 15 lakhs/MW to the promoters payable through FIs in the form of subsidized loans provided the loan component of the project is at least 60% of the project cost of Rs 1 5 crores/MW

HUDCO's Initiatives

HUDCO has entered this field recently driven by the fact that alternative projects such as cogeneration projects are the future and are directly relevant to its mandate of better utilization of waste Realizing this HUDCO decided to set up a Waste Management Cell in 1994 within HUDCO Through this Cell HUDCO provides financial assistance (in the form of loans) and technical assistance (in the form of project formulation) for solid waste management HUDCO besides being a provider of funds is also becoming a project facilitator and an arranger of funds The technical assistance is provided free of charge in the case of the project being submitted for HUDCO financing In all the projects besides providing technical assistance and HUDCO finance any subsidy/soft loan available from GOI is routed through HUDCO in order to facilitate processing of the projects

HUDCO has recently entered this area due to its capacity for power production generation—a basic infrastructure need in an environment friendly manner using a renewable source of fuel HUDCO has recently financed 4 bagasse-based cogeneration units in

Mudhol *Ravatai Sahakari Sakkare Karkhane Niyanit Rana Nagar Timmupur Karnataka* The Installed Capacity of the cogen plant is 12 5 MW with an Exportable Power Capacity of 7 735 MW It has been financed with a Rs 12 crore term loan from HUDCO with assistance in the form of Capital Subsidy from MNES Soft Loan from MNES and Capital subsidy from the State Govt

Vadodra (Gujarat) *Vadodra Distt Co op Sugar Cane Growers Union Ltd Vadodra* This new sugar mill will have a cogen plant whose Installed Capacity will be 9 MW with an Exportable Power Capacity of 5 MW It has been financed with a Rs 12 9 crore term loan from HUDCO with assistance in the form of Capital Subsidy from MNES Soft Loan from MNES and Capital subsidy from the State Govt

Satara (Maharashtra) *Krishna Sahakari Sakhar Karkhana Ltd, Karad Maharashtra* This project has been set up in an existing mill and its cogen plant will have an Installed Capacity of 30 MW with Exportable Power of 13 7 MW The HUDCO loan component is Rs 3494 38 lakhs

Sangli (Maharashtra) *Vasant Dada Sahakari Sakhar Karkhana Ltd Sangli Maharashtra* It is to set up a cogeneration plant in an existing mill which will have an Installed Capacity of 12 5 MW with an Exportable Power Capacity of 6 88 MW with a HUDCO loan component of Rs 1647 82 lakhs

These initiatives of HUDCO total to a Project Cost of Rs 167 11 crore with HUDCO s component being 76 44 crore a Capital Subsity from MNES of Rs 14 crore and Soft Loan support from MNES of 35 04 crores This would be for a total installed power of 63 75 MW with exportable power of 33 33 MW All these projects are being considered under the Demonstration Programme of MNES and are eligible for attractive financial and fiscal benefits

In order to spur future development in this sector HUDCO has recently revised its interest rates as follows

- Non-Govt Guarantee Projects 14 5/15 0% for 10/15 year repayment period
- Govt Guarantee Projects 14 0/14 5% for 10/15 year repayment period

For projects which are considered under the Demonstration Program of MNES the interest rate would be 2% lower

HUDCO has several other bagasse-based cogeneration projects in the pipeline

- Jind (Haryana)
- Godavari Sugar Mills (Karnataka)
- Shahabad (Haryana)
- Akluj (Maharashtra)

Policy Measures and Initiatives

The National Program on Biomass Power Generation is a special scheme with a package of incentives/ central financial assistance for a) cogeneration demonstration schemes b) bagasse / biomass based cogeneration c) biomass-based power d) *Taluka* level biomass power and e) biomass assessment studies Other than this UNDP and USAID have initiated consultations and projects for finding options towards commercialization of bagasse-based cogeneration plants

Promotion of biomass-based power generation in the country is being encouraged through enhancement of favourable policy regimes at the State as well as Central levels The State policies include buy-back/ wheeling/banking of generated electricity by the State Electricity Boards incentives in the form of sales tax exemptions participation in equity and grants etc At the Central level the Ministry has announced financial support through its various schemes The Government is also providing encouragement to these projects through liberal policies for private sector participation in power generation A host of fiscal incentives such as concessional custom duties exemptions of excise duty and central sales tax tax holidays accelerated depreciation etc are available too

Although there is some progress in this area with 28 projects commissioned 30 under construction and 40 in the pipeline the ball is now in the court of the sugar mills to become proactive and invest in fruitful opportunities such as bagasse cogeneration

I thank the organizers for inviting me to inaugurate this workshop and commit my wholehearted support to this effort

KEYNOTE ADDRESS

KATHLEEN MCGINTY
Former Environmental Advisor
to President Clinton

Let us step back before delving into the subject at hand and give a broader context to this meeting This is more appropriate because many of you are active in many sectors of the economy in addition to sugar production

I have to indulge in the predictable This gathering is especially sweet for me I mean it sincerely not because this gathering is of the producers of sweet This however helps mark a terrifically important turning point in our effort to make progress on cleaning and preserving the environment There is a historic quality to this gathering Why? Because at its heart it is a gathering of business individuals who are determined both to enhance their bottom line and enrich the environment at the same time Now that is historic

Not too long ago a gathering like this would not have occurred For many environmental and economic interests seemed antithetical to one another In the US the battle lines have been drawn for 30 years or more You have to choose" it was asserted It is either jobs or the environment the environment or the economy

Finally all that is starting to change in the US and the sugar industry has helped lead the way For instance there was the daunting job of restoring the Everglades which were drained and polluted Sugar operators came forward and offered Best Management Practices which dramatically reduced phosphorus and other polluting run off saved dollars and saved the Everglades

Getting closer to the subject here cleaner energy and more efficient energy use is a big part of the answer as well I again give the example of a Chicago school – An Energy Services Company came to carry out an Energy Audit and showed the school how to reduce energy use drastically The result - energy SAVED a lot of pollution avoided and the school finally had dollars it could put into new books and long overdue school repairs So the environment the economy and social priorities – not battling but coming together in one coherent integral whole And you are here to talk about another huge part of the answer Renewable Energy in particular Bagasse Cogeneration promises to add significantly to your bottom line to create new jobs – employing people in rural areas where job programs often do not reach And along with these economic gains it promises significantly also to clean up the air by keeping out coal and avoiding land and water pollution caused from the storage of fly ash waste It is a terrific win-win-win situation And I commend you for wanting to be part of it and our friends at USAID and Winrock for helping to lead the way

Some of you are already sharing what can be done TASL in Tamil Nadu for example is generating 19 MW year round And some 15 other mills are exporting power to the grid in India But so much more can be done in a country like India where the potential is around 3500 MW But it is not necessarily easy There are challenges to be overcome

- Storage of fuel
- Transport of fuel
- Securing fuel

- Suffıcıent year-round generatıon
- Connectıon to the grıd

And perhaps one of the most dauntıng challenges has been ın securıng the necessary capıtal and financıng to enable the project to take off consıderıng the cooperatıve nature of thıs sector

In thıs regard I want to share wıth you a new opportunıty and approach that has been desıgned to address just thıs kınd of challenge Thıs tool, the Clean Development Mechanısm ıs buılt on the same prıncıple we are talkıng about – namely no conflıct between the envıronment and the economy and on the contrary mutually reınforcıng The CDM takes thıs concept to the global level

There should be no conflıct between efforts to protect the global envıronment and to promote growth and development ın a country lıke Indıa The CDM enables partnershıps to be developed so that both can be pursued sımultaneously So a couple of quıck poınts about the CDM

A) WHERE DOES IT COME FROM?

CDM was proposed ın Artıcle 12 of the Kyoto Protocol that was sıgned by the Conferencıng Partıes of the Unıted Natıons Framework Conventıon on Clımate Change (UNFCCC) ın December 1997 It envısages 'tradıng of carbon credıts between dıfferent countrıes and provıdes opportunıty for countrıes lıke Indıa to benefıt enormously CDM ıs expected to become operatıonal ın year 2000

B) IS THERE ANY EXPERIENCE TO DATE – EXPERIENCE OF HOW IT MIGHT WORK?

Through an earlıer mechanısm of Joınt Implementatıon (JI) whıch later came to be called Actıvıtıes Implemented Joıntly (AIJ) pılot projects were taken up There were about 70 projects worldwıde Examples are a Japanese Steel Company ınvestıng ın Chına to get carbon credıts and an Amerıcan company ınvestıng ın the Honduras

C) HOW MIGHT YOU GET INVOLVED?

The ındustry can be ınvolved by workıng at global and domestıc levels It ıs ımportant for the ındustry to be engaged ın thıs as a cohesıve group ın order to show everybody ıncludıng the natıonal government that you are actıvely ınterested Perhaps organızatıons lıke Wınrock TERI and AID could help you ın fosterıng such partnershıps

Conclusion

So to brıng you back to where we started the envıronmental challenges are great But ıf we are creatıve ıf we work together, the opportunıtıes are rıch as well

Thank you for your leadershıp ın searchıng out the wın wıns Thank you for your ınterest ın ımprovıng the envıronment, and the economy too

Special Address

James Bever
Deputy Mission Director
USAID/India

I am very happy to be here today addressing this distinguished gathering and the industry in this important area of sustainable energy development As you all know this workshop is being held as part of the technical assistance activity of the Alternative Bagasse Cogeneration (ABC) project ABC is one of two components Efficient Coal Conversion (ECC) being the other of the Greenhouse Gas Pollution Prevention (GEP) project The GEP project is one of the important initiatives supported by the US Agency for International Development (USAID) in the climate change area

The ABC project component promotes cogeneration (production of steam and electricity) using sugarcane bagasse in high-efficiency boilers in sugar mills as a means of producing electric power with zero net Greenhouse Gas (GHG) emissions This component is extending the merits of bagasse cogeneration to the use of other (alternative) biomass fuels year round Presently many cogeneration developers use available fossil fuels such as coal or lignite in the off-season My colleague Dick Edwards will cover the basic components of the GEP project in more detail during the technical session

For those in the audience who may not be familiar with USAID s involvement in the Indian sector I will take a few minutes to put the GEP project in context of the Mission s past involvement in the energy sector and the present strategic focus

US economic assistance to India began in 1951 Since then the US has provided approximately $13 billion to promote economic development in India Much of this assistance was provided as loans for infrastructure development half of it was food aid Most of these resources were dedicated to promoting agricultural development and food security Many of the large thermal power projects were built in the 1960 s with USAID funding

With the advent of economic liberalization in the early 1990 s there has been considerable progress in terms of growth Consistent with those policy reforms USAID has been able to reorient its program from infrastructure development and technology transfer largely in agriculture to a program which now focuses on deepening and broadening economic and sustainable growth by focusing on stabilizing the rate of population growth and slowing environmental degradation Population stabilization and reduced pollution will limit dangers from global warming and loss of biodiversity

As we are all aware rapid population growth and urbanization affect both India s natural resources and the global environment Achieving economic growth targets for the country and simultaneously preventing environmental degradation is one of the greatest challenges that India faces today

India is estimated to be the sixth largest producer of GHG in the world and growth wise the second fastest after China The single greatest contributor to India s GHG is the power sector fueled primarily by high-ash coal Coal fired plants account for two-thirds of total electric power and pollution from coal plants will become an increasing problem as power production expands rapidly to keep pace with India s industrial growth

USAID provides training technical assistance information exchange and investment support in energy generation restructuring and end use A major portion of USAID's power sector program is focused on support to policy makers technical staff and administrators working on regulatory reforms and restructuring of the Indian power sector

As mentioned earlier the single largest contributor to India's greenhouse gas emissions is the power sector fueled primarily by high-ash coal coupled with low efficiency in the generation transmission distribution and utilization of energy This pollution will certainly worsen as we seek to meet the legitimate energy needs of an expanding economy Coal is the fuel source for about 70% of fossil fuel power generation If all additional sugar cogeneration capacity (3500 MW) can be tapped it is possible that up to 25 million metric tons of annual carbon dioxide emissions can be avoided assuming that this demand would otherwise be met by coal

Bagasse-based cogeneration is one of the most exciting areas of energy development in India today—particularly for the Indian sugar industry which like its counterparts elsewhere in the world is constantly grappling with the cyclic nature of the raw material and fluctuating demands and prices Cogeneration and sale of power to the grid or a third party provides to some degree a safety net to this cyclic operation

I am aware bagasse cogeneration is not a new concept to Indian sugar mills However, what is changing is the concept of cogeneration and sale of surplus power leading to the cogeneration unit as a separate profit center in the sugar mill Until recently most sugar mill boilers were designed primarily to meet electricity needs of the mill and surplus bagasse and other cane trash was simply incinerated Now with the increasing willingness of State Electricity Boards to adopt MNES policy guidelines on remunerative tariffs for electricity sold to the grid investment in high efficiency cogeneration facilities is fast becoming an attractive proposition for sugar mills Long-term clear policies will make investment in this area more attractive from an investor s perspective

Electricity generation through bagasse cogeneration is important in India due to its high potential India has one of the largest sugar industries in the world with over 490 mills The Indian sugar industry provides direct employment to over 400 000 people and indirect employment to another 4 million mostly in the rural areas Thus the socio-economic implications for value addition through electricity generation are significant in the Indian context Electricity generation in addition to meeting their own requirements is a good way to generate income for sugar mills apart from providing much needed power to rural areas Power generation through multiple cogeneration plants spread throughout the country can alleviate to some extent transmission and distribution losses which have been the bane of power supply in rural areas for long

The cogeneration process helps modernizing plant operations by using high pressure (>60 ata) high temperature (>430°C) boilers which replace the old ones Cogeneration has obvious environmental benefits in terms of replacing fossil fuels For instance each kWh of energy from biomass fuels prevents 0 31 kg of carbon emissions by replacing coal-based power generation, and 0 23 kg by replacing oil based power generation Thus this high potential for GHG mitigation can eventually result in good business for sugar mills in the context of global climate change initiatives such as the Clean Development Mechanism (CDM)

The Indian sugar cogeneration industry appears to be firmly on course to reach greater heights Most of the equipment for cogeneration is available indigenously with the installed cost being less than $750 per installed kilowatt which is less than the cost of a new conventional coal thermal plant Further progressive policies and incentives put in place by some states such as Maharashtra and Karnataka make cogeneration even more attractive I hope that the sugar industry will take full advantage of these and integrate cogeneration into their regular operations

Given this encouraging trend USAID is very happy to have made a modest contribution to the cogeneration sector through this project and will continue to explore future possibilities of pushing this sector forward I hope today's deliberations will go a long way in throwing light on various outstanding issues I wish you all success for the day-long workshop

COGENERATION AND ADVANCED TECHNOLOGY INITIATIVES

Session Chairman
LEE JAKEWAY
Program Manager
Winrock International, USA

GEP-ABC PROJECT DESCRIPTION

RICHARD EDWARDS
Office Director Office of Energy Environment & Enterprise Division
USAID/India

It is indeed a great pleasure for me to provide an overview of the Alternative Bagasse Cogeneration Component of the Mission's Greenhouse Gas Pollution Prevention project - GEP in short. At the outset I would also like to commend Winrock International for their initiative in organizing this conference and bringing together major representatives of the Indian sugar industry

GEP is USAID's largest climate change project and is funded out of the US Government s commitment to the pilot phase of the Global Environment Facility and was designed in close cooperation with the Government of India to address the acute problem of greenhouse gas emissions from the power sector

The GEP project embodies the US commitment to being a partner to India in solving global environmental problems The primary objective of GEP is to reduce emissions of greenhouse gases per unit of power generated The project was signed between the Government of India and the US Government through USAID/India

The major Indian implementing agency for this project is the Industrial Development Bank of India and the National Thermal Power Corporation The Federal Energy Technology Center under the US Department of Energy (DOE) is the other major US partner The project is proposed to work in harmony with the Government of India (GOI) National Biomass Program

The project component that is of interest to today s audience is the Alternative Bagasse Cogeneration

(ABC) Component which is aimed at demonstrating the commercial potential of cogeneration (production of electricity and steam) using biomass fuels for year round export of high quality power to the grid

Access to advanced coal conversion technologies and power plant management and operation techniques will be provided under the Efficient Coal Conversion (ECC) Component

☐ How is GEP different?

GEP takes the concept of cogeneration one step further and extends it to the use of bagasse cogeneration to include year-round cogeneration for export of power to the grid fuelled solely by bagasse and supplemental biomass for the off season Funded in part by the GEP Project EID Parry (India) has already achieved the unique distinction of being the first sugar cogeneration unit in India that operated over 270 days last year to export power to the grid using entirely bagasse with supplemental biomass fuel In part that was achieved by the commitment the sugar mill made as a precondition to its participation in the GEP project to invest in highly efficient high pressure multi-fuel boilers and high efficiency turbines coupled with efficient bagasse handling and storage systems

Analysis shows that during the period that coal is used in a bagasse cogeneration plant the emissions of greenhouse gases are typically more than those of a conventional coal fired power station However, if biomass fuels are used the greenhouse gas emissions are significantly lower Moreover the cane and other biomass acts as a CO_2 sink which re-cycles the CO produced during the combustion process making bagasse/biomass cogeneration a net zero carbon dioxide emission cycle

The Indian sugar industry is estimated to have a potential of 3500 MW but less than 100 MW has been tapped so far Future advancements in methods and technologies can substantially increase this potential For instance present cogeneration technology makes it possible to produce 80 100 kWh per ton of cane but it is possible to nearly double this if cane trash can be used as a supplementary fuel Further using more advanced gasification technologies in combination with cane trash collection potential electricity generation can be over 200 kWh per ton of cane

☐ Operation of the GEP ABC Component

The main elements of the GEPABC component where Industry can participate in the GEP project under the ABC component

■ Financial Assistance

Grants of up to $40 000/MW (Rupee equivalent) of installed cogeneration capacity subject to a maximum of $1 Million to buy down the cost of debt of setting up high pressure cogeneration systems using biomass supplemental fuel in the off-season for year-round cogeneration

Minimum eligibility criteria is—sugar mill capacity not less than 2500 tcd with sound and satisfactory financial records commitment for installation of year round cogeneration system using bagasse/biomass for no less than 270 days a year and a high pressure boiler of more than 60 ata pressure and 430°C temperature

Under this category IDBI the host-country counterpart issued two requests for proposals in 1995 and

1997 respectively Five projects with a total installed capacity of 116 MW were selected for assistance after a rigorous technical and financial evaluation in the first round Of these four projects have already commissioned their cogeneration plants and are geared up to meet the requirement of year round generation using entirely bagasse/ biomass fuels In the second round four more projects with an installed capacity of 88 MW were selected in-principle for financial assistance Note again that all proposals submitted under both the RFPs were evaluated technically and financially against predetermined criteria

With four projects coming on line and demonstrating the viability of operating sugar cogeneration units year-round with biomass fuels and the others in advanced stages of implementation the Project objective of supporting up to five cogeneration plants (50-75 MW) have been more than successfully met

Funds are being routed through IDBI and the Department of Economic Affairs to selected project participants In case of failure to meet the GEP criteria the entire GEP grant will be converted to a commercial loan by IDBI

■ Technical Assistance and Training

Again the host-country implementing agency is IDBI with technical services being provided directly by our US partners Federal Energy Technology Center (FETC) of the US Department of Energy with active participation of Winrock International India ISMA ITCOT MITCON and others

The primary objective is to provide pre-investment support to stimulate and catalyze private sector investments in alternative bagasse/ biomass cogeneration plants in India Ongoing support is being provided to Indian sugar mills in

a) Improving the performance of boilers turbines and other related equipment using biomass fuels and minimizing process steam

b) Biomass handling and storage systems

c) Any other issues related to promotion of year-round cogeneration using entirely biomass fuels

To date four sugar mills (total design capacity of 82 5 MW) have received over and above technical assistance grants to conduct applied research and development of cane trash collection and baling systems and for feasibility studies to upgrade their existing systems to high pressure high efficiency systems for year-round operation using biomass/bagasse

Another milestone in the ABC Component was the tie-up between FETC and Winrock International to set up a structured system to monitor the CO_2 offsets from the selected demonstration projects and an institutional structure to record and share the experience of these projects with the Indian and the international sugar industry with respect to cane storage, handling supplemental biomass fuel handling cogeneration system performance environmental and economic gains etc

In the course of this year and the next Winrock International and FETC will conduct a number of professional development courses provide technical advisory services disseminate information on Indian and international experiences in sugar cogeneration and provide opportunities for study tours and training in specific areas We have been greatly encouraged to see the immense response to the Project from the

Indian sugar industry and feel privileged to be a part of the cane cogeneration revolution in the country We hope the few sugar mills that were the early risk takers in investing in year round cogeneration based on biomass fuels will create an avalanche of projects in the coming years and will help realize the full potential for cogeneration from bagasse/biomass in the country

(Other sugar mills with innovative ideas or looking for technical assistance to upgrade their systems are encouraged to contact the FETC Resident Advisor Mr Suresh Jain, directly)

Hawaii Case Study (HC & S)

Robert J Kwok
John H Payne Inc USA

Introduction

The Hawaiian Commercial & Sugar Company (HC&S) is the largest sugar plantation in Hawaii Located on the Central Valley of Maui cane cultivation covers 37 000 acres, of which 17 500 acres are harvested every year Due to the low rainfall (about 30 inches per year) on the Central Valley the plantation is totally irrigated by drip irrigation system Daily average water consumption ranges from 250-300 million gallons per day Water is obtained from two sources namely ditch mountain water collected from East Maui Mountains and pump water located on the plantation HC&S have 16 deep wells capable of pumping 250 million gallons per day and utilizing 12 MW of power

HC&S operates two sugar mills Puunne with a grinding capacity of 7600 TCD and Paia with a capacity of 4000 TCD Annual cane processed between the two factories is around 1 7 million tons yielding about 220 000 tons of sugar Electricity is generated from both hydroelectric power plants and the two mill biomass power plants Annual electricity generated is around 250 000 Megawatt hours of which 100 000 Megawatt hours are sold to the Maui Electric Company The irrigation pumps and the two mills consume the balance of electricity The total generating capacity at HC&S is 55 MW of which 16 MW of firm capacity are contracted with the local utility company The grinding season for both factories ranges from 260 to 290 days

Historical Background

Puunene mill was built in 1901 with two milling tandems powered by two sets of Corliss steam engines each The grinding rate at that time was 100 TCH/tandem The power plant consisted of 12 low pressure fire tube boilers operating at 150 psig HC&S also operated a central power plant burning fuel oil and generating electricity for the entire island of Maui In 1946 Maui Electric Company built its first power plant in Kahului and took over the distribution and sale of power on Maui In 1946 the Puunene power plant installed its first turbogenerator TG 1 a 4 MW unit operating at 150 psig with exhaust at 15 psig and equipped with a condensing unit In 1952 two new high-pressure boilers replaced 12 original fire tube boilers Boilers No 1 and 2 are rated at 60 tons/hr each operating at 900 psig and 750 °F Both boilers are designed to burn bagasse and Bunker C fuel oil In 1952 TG-2 a 7 5 MW unit extracting at 150 psig and equipped with a full condensing unit was installed to utilize steam from boilers No 1 and No 2 In 1975 Boiler No 3 a Foster Wheeler unit rated at 145 tons/hour and operating at 450 psig and 750°F was installed The boiler is also capable of burning 100% fuel oil That same year TG-3 was installed to receive steam from Boiler No 3 This is a 10 MW unit with 15 psig extraction and full condensing unit

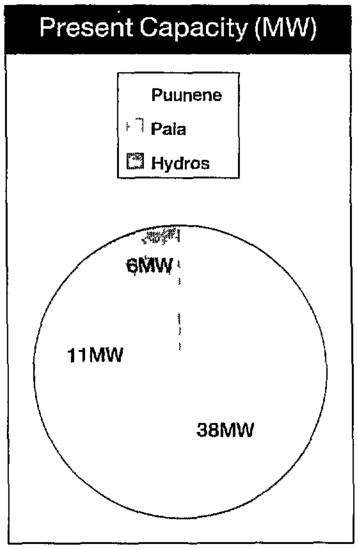
Between 1980 and 1982 all four Corliss engines were removed and replaced with new steam turbines at the two mill tandems In 1982 a new turbogenerator TG-4 was installed This is a 20 MW unit with 15 psig extraction and equipped with a condenser to condense up to 15 MW A firm power contract was negotiated and signed with the Maui Electric Company to supply 12 MW of electricity In 1986 trash milling was initiated at the cane cleaning plant to provide additional fiber to the boilers In 1988 all three boilers were converted to burn coal as a supplementary fuel to offset the high price of fuel oil In 1992 the two milling tandems were converted into a single tandem and the power contract was renegotiated and increased to 16 MW In 1998 TG-2 failed on an overspeed condition A new TG-5 rated at 18 MW with 150 psig extraction and full condensing has been ordered and will be commissioned in year 2000

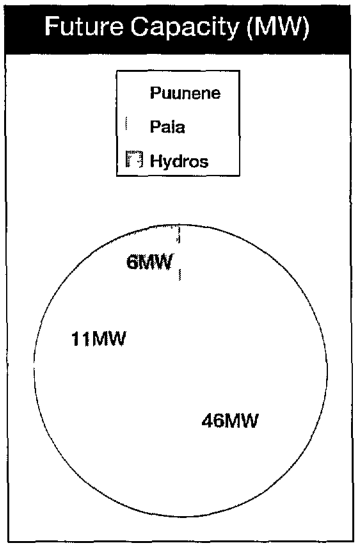
The Paia mill was built in 1874 The whole mill was completely re built in 1905 The factory operated with a single milling tandem until 1971 when a Silver Ring diffuser was installed In 1950 a single Riley boiler rated at 100 tons/hour and operating at 450 psig and 750 °F was installed A new turbogenerator TG 1 rated at 4 MW with 150 psig extraction was installed In 1952 TG 2 was added This unit is rated at 5 MW and operated with 15 psig extraction and full condensing In 1981 a rotary/flash bagasse drier was installed to meet particulate emission regulations The drier was also equipped with a scrubber In 1986 trash milling was initiated to provide additional fiber to the boiler In 1987 the bagasse drier was taken out of service and replaced with a full wet scrubber to be able to meet coal emission requirement In 1990 a new ABB 11 5 MW turbogenerator with double extraction and condensing unit was installed to replace TG-1 and TG-2

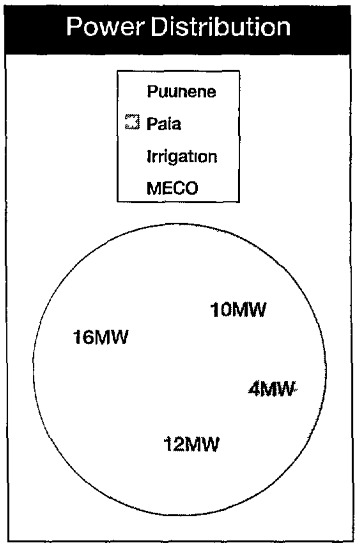
HC&S Power System

Present Capacity (MW)

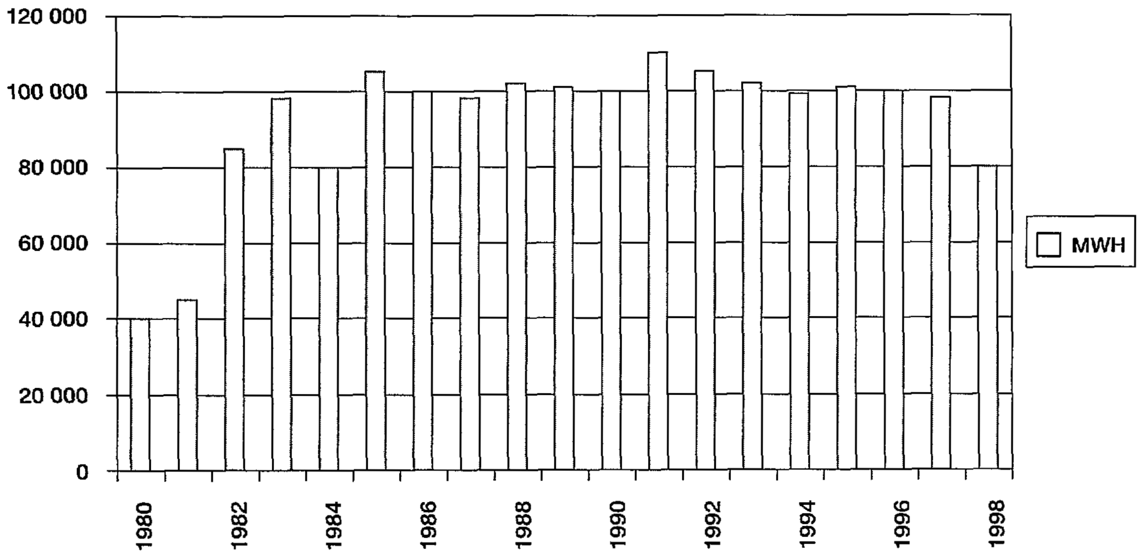
The HC&S Power system from the three power generating stations totaled 55 MW The Puunene power plant has a total capacity of 38 MW Paia with 11 MW and a total of 6 MW from three hydro power stations With the replacement of TG 2 with TG 5 the Puunene capacity will increase to 46 MW giving a total generating capacity of 63 MW The power distribution system consists of a total of 50 miles of electrical transmission to supply power to deep wells irrigation pump stations and drip stations There are two 22 KVA tie lines connecting the two mills and the hydro power plants Export to Maui Electric Company is made through a 69 KVA tie line Typical power distribution from the power plants is 16 MW to MECO 12 MW to irrigation, 10 MW to the Puunene mill and 4 MW to the Paia mill







ELECTRICITY SALE TO MECO



Before the firm capacity contract HC&S has been selling dump power to MECO at a very low electricity price From 1982 onwards power sale to MECO has increased to around 100 000 Megawatt hours/year A graph of power sale to MECO from 1980 through 1998 is shown in the figure above Capacity payment is fixed at $0 02/kWh with energy payment based on the avoided fuel cost of the utility company

STEAM EFFICIENCY AND ENERGY EFFICIENCY

For a cogeneration factory to be efficient and profitable steam economy and energy efficiency in the plant are extremely important The following parameters are key items that need to be monitored or controlled

1 Low bagasse moisture
2 Evaporator setup and control
3 Factory computerization and integration
4 Boiler efficiency

LOW BAGASSE MOISTURE

Low bagasse moisture must be obtained for efficient combustion and increase in boiler efficiency Some important parameters to obtain low bagasse moisture are listed below

a Constant and steady cane flow to the mill
b Low mill running speed
c Use of Donnelley chute and level control
d Hot maceration water application
e Fine mill grooving at the last two mills
f Good juice drainage – use of Messchaert grooves differential grooving
g Flangeless top roll

Evaporator setup and control

The most important unit operation for energy utilization and economy is centered at the evaporator station A typical evaporator control scheme is included Below is a list of important parameters to be included at that station

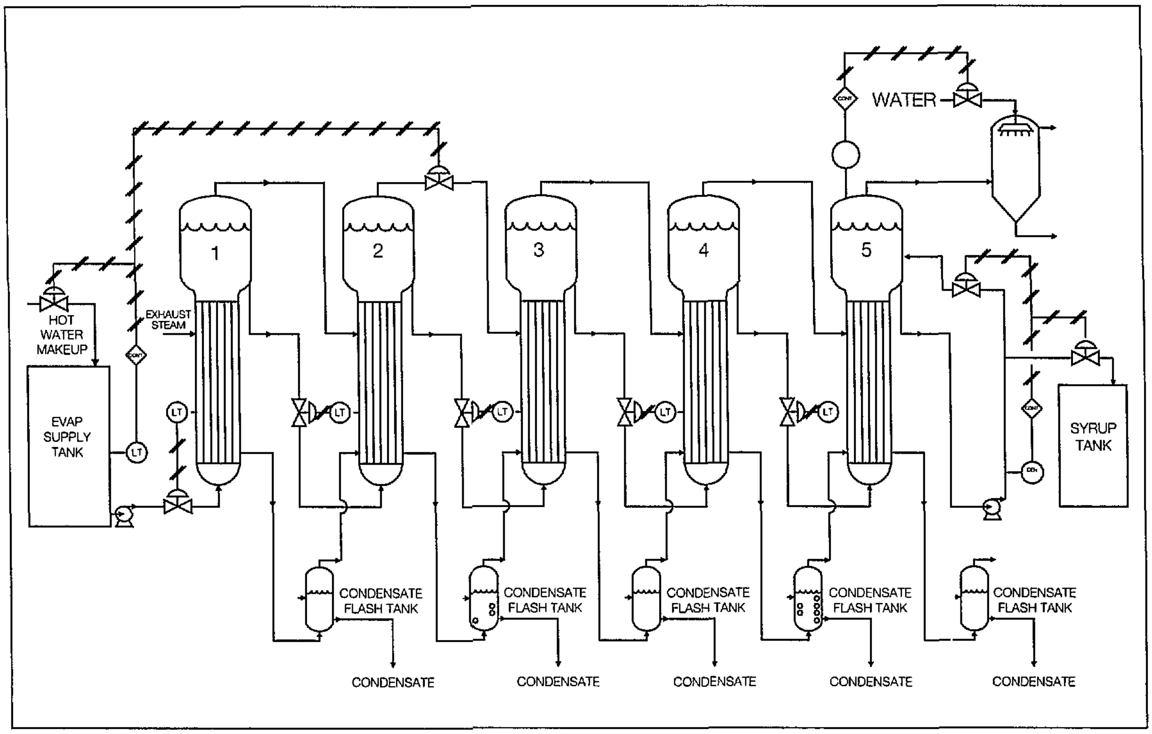
a Use of quintuple effect system instead of conventional quadruple effect

b Condensate flash

c First second third and even fourth vapor bleeding to juice heaters and vacuum pans

d Automatic level and syrup and brix control

e Evaporation rate control



Factory Computerization and Integration

Both the HC&S factories are highly automated A full DCS system is used at both mills Programmable Logic Controllers (PLC) are used at various unit operations namely in burner management high-grade centrifugal controls mill electrical interlocks and small batch type operations There are three control centres namely cane cleaner milling/diffusion boiling house and power plant The whole factory process is fully integrated For power export to the utility a continuous tie line monitoring system is included Due to the complexity of the plantation power system the hydros are all fully automated and are all remotely controlled and set up for instant load shedding in case of emergency power requirement from the utility

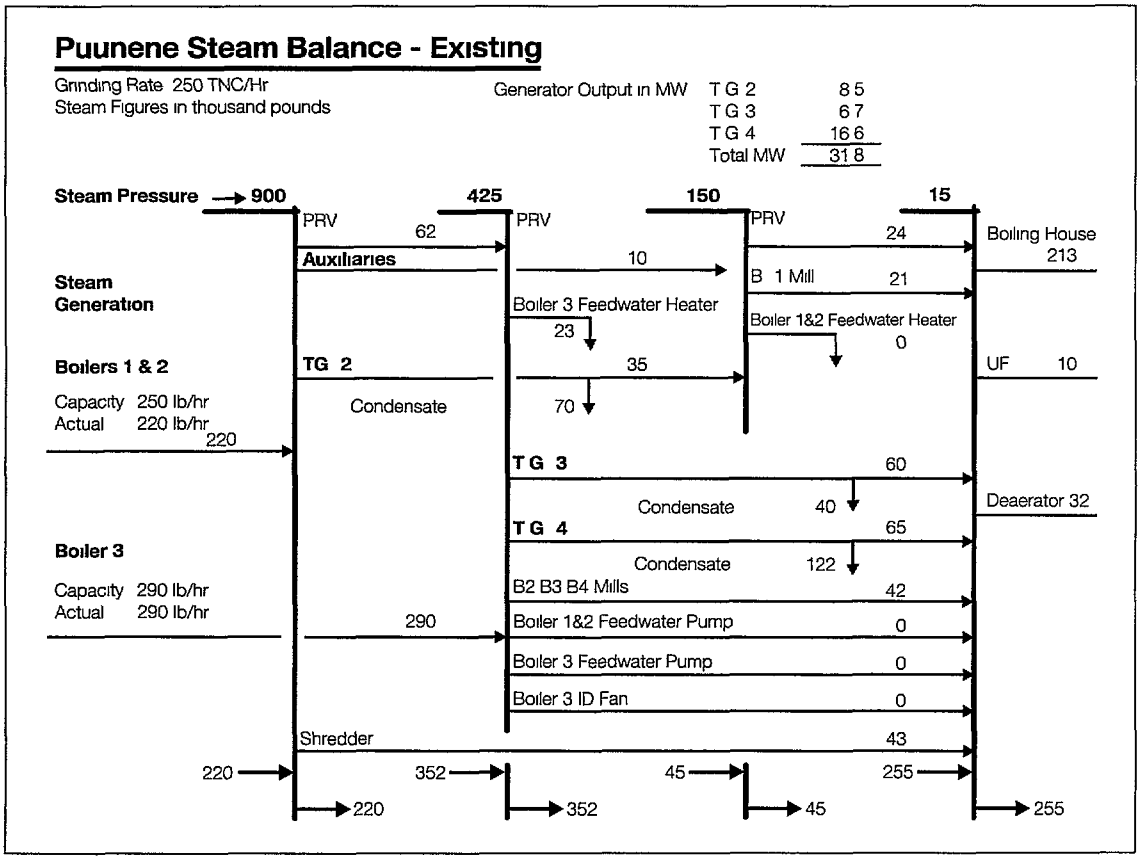
Boiler Efficiency

For efficient cogeneration boiler efficiency is a very important parameter to monitor Some of the important items are listed below

a Low bagasse moisture for good combustion efficiency
b Low excess air for increase in boiler efficiency Good oxygen monitoring and controlling devices must be installed
c Good air distribution and mixing are essential for furnace operation
d Use of heat recovery equipment such as air pre-heater economizer and feed water evaporator are essential components for the boiler
e Use of bagasse drier to improve bagasse moisture and boiler efficiency
f Good water chemistry to minimize blowdown

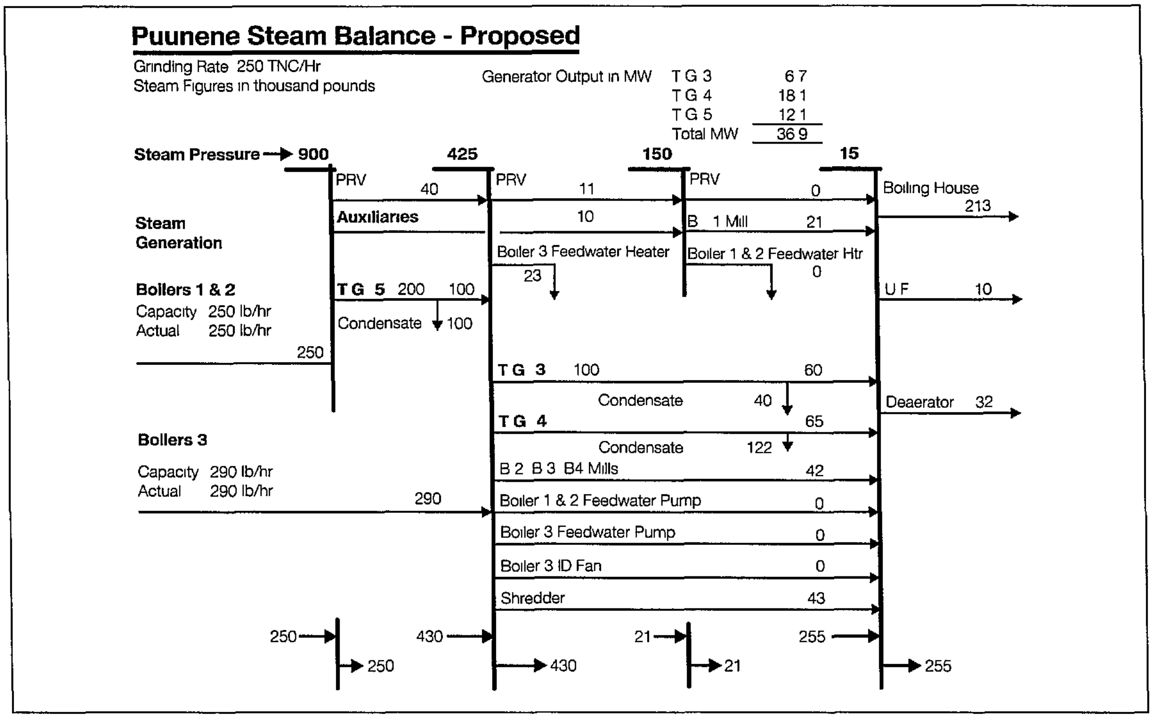
Puunene Existing Steam Balance

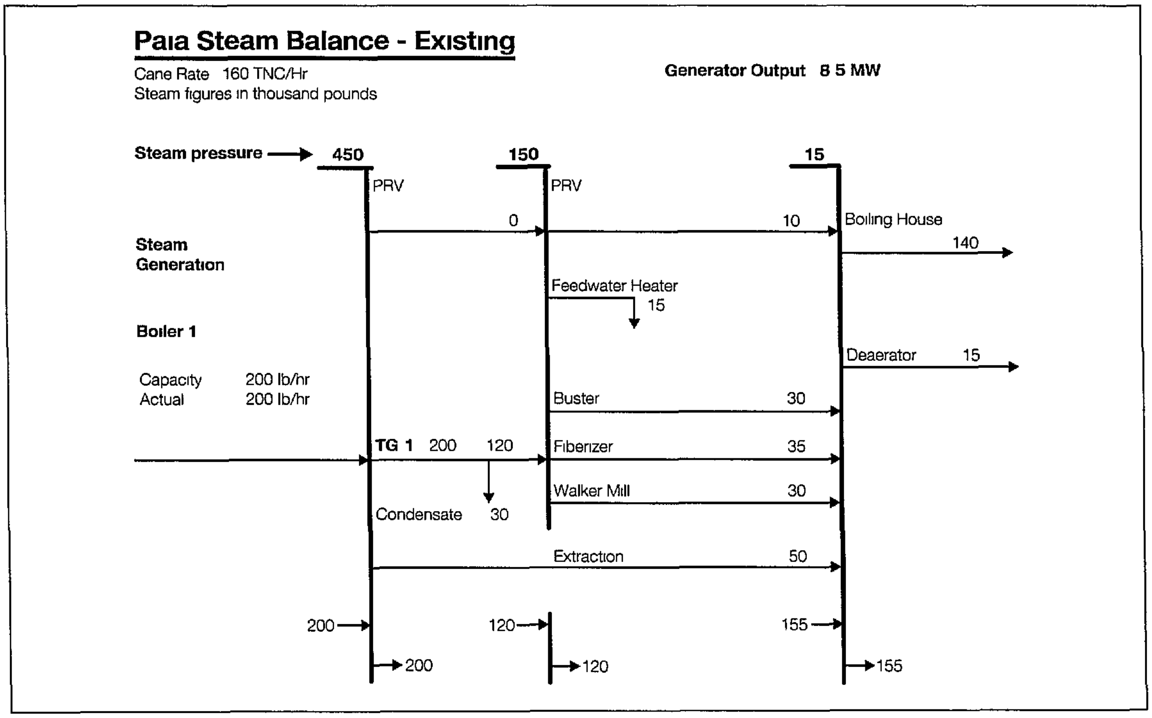
A typical existing steam balance for the Puunene factory is included This is the balance with the TG-2 TG-3 and TG-4 configuration At a grinding rate of 250 TNC/Hr and with Boilers No 1 and No 2 generating 220 000 lbs/hr and Boiler No 3 generating 290 000 lbs/hr, total power generation is 31 8 MW The various steam flows at different pressures are shown in the diagram



PUUNENE PROPOSED NEW STEAM BALANCE

With the addition of the new TG 5 unit the new steam balance based on operating Boilers No 1 and No 2 at its full rated capacity of 250 000 lbs/hr and Boiler No 3 at 290 000 lbs/hr the total power generated at 250 TNC/Hr is 36 9 MW





Paia Existing Steam Balance

The Paia boiler operates at its maximum rated capacity at all times since there is always an excess of bagasse in that mill The steam balance at the 160 TNC/Hr is shown in the diagram on the adjacent page Power generation during the grinding period is 8 5 MW During the off season or non operating days the power plant can generate 10 MW at full condensing

Power Contract

The power contract with Maui Electric Company was originally signed in 1982 for 10 years The contract was renewed for another 8 years to year 2000 Some of the pertinent clauses in the contract are listed below

a Contract payment is based on a fixed Capacity payment and Energy payment based on the avoided fuel cost of the utility company
b Contract term is 10 years Negotiation can re-start two years prior to end of contract
c Capacity contract for 16 MW
d There is an option to increase capacity dispatch by notifying the utility one week in advance
e Minimum capacity during off peak hours is 8 MW
f Minimum energy dispatch per year is 50 000 Megawatt hours
g Available Factor is at 95%
h Annual maintenance period where dispatch can be zero is 4 weeks Every five years 6 weeks of maintenance is allowed for major overhaul
i There is a capacity penalty for capacity not met
j 6 trips are allowed for both parties Penalty kicks in after six trips
k HC&S will have to shed its irrigation load in emergency situation to prevent system failure

Conclusion

- HC&S has successfully operated a cogeneration system to provide firm power to MECO
- Factory automation and process integration have improved power reliability to the utility grid
- Computerization has optimized energy use and power production
- Power sale is a significant income contributor to HC&S profitability

THIRU AROORAN SUGARS LIMITED, TAMIL NADU

(A GEP-ABC PROJECT CASE STUDY)

RAM V TYAGARAJAN
Chairman & Managing Director

WHY COGENERATION MAKES COMMERCIAL SENSE FOR THE SUGAR INDUSTRY

- Earnings from sugar are subject to violent cyclical fluctuations
- Realizations from by-product molasses and alcohol derived therefrom are also subject to the same cyclicality
- Power in contrast is not only insulated from price fluctuations but also entitled to steady escalation on a pre-determined basis
- Duration of crushing can be extended on the economics of cogeneration even after sugar recovery falls to uneconomic levels
- Additional earnings from sale of power enable the sugar mills to better afford the cane prices payable and the additional cash flows enable the mills to make cane payments on time
- Earnings from sale of surplus power provides a strong incentive for energy conservation and reduction of steam and power consumption by the sugar mill

ADVANTAGES OF BAGASSE BASED COGENERATION

- Low Gestation (18 - 24 months)
- Low Capital Investment (Rs 2 5 - 3 0 Crores/MW)
- Renewable and readily available source of energy
- Dispersed rural locations lower T&D losses
- Environmentally cleaner
  - No Sulphur emissions
  - No net contribution to greenhouse effect

COGENERATION PLANT—DISTINCTIVE FEATURES

- Power generation with bagasse and biomass fuel
- Cane trash / Agro waste to act as additional fuel
- Power & steam requirements of sugar factory fully met
- Surplus power generation exported to grid
- PPA signed with TNEB
- Current Realization - Rs 2 60 (1 April 1998) - 5% increase every year

KOLLUMANGUDI

- Integrated plant with sugar and cogeneration operations
- 2500 TCD sugar plant
- 18 68 MW cogeneration plant
- Total Project Cost Rs 90 Crores

COGENERATION KOLLUMANGUDI PROJECT DETAILS

■ Location	
Village	Kollumangudi Keeranur
Taluk	Nannilam
District	Tiruvarur
■ Distance from Chennai	285 km
■ Date of commissioning of sugar plant	19 January 1998
■ Cogeneration	
Synchronization of the plant	May 97
Trial run	May 97 to Dec 97
Commercial generation from	01 January 1998

COGEN PLANT-TECHNICAL SPECIFICATIONS

■ TG Set	
Manufacturer	GEC Alsthom France
Capacity	18 68 MW
Type	Double Extraction / Condensing
Generation Voltage	11 kV
Transmission Voltage	110 kV

ENVIRONMENTAL PROTECTION

Water Pollution	ETP in sugar plant is used for treatment of residues
Boiler Ash Disposal	Installation of Screw and Belt Conveyor System for transporting ash from boiler and ESP to the storage yard Disposal Mechanism 1 Supporting land available 2 Mixed ash with Pressmud in composting and converted into organic manure 3 Fly ash sold to current manufacturer
Air Pollution	Cinder Recovery System in boiler Installation of Online Measurement System for oxygen in fuel gas for effective combustion Reliance on Full Automation Installation of DCS Fully Automated Boilers

DHAMPUR SUGAR MILLS LTD., UTTAR PRADESH

(A GEP-ABC PROJECT CASE STUDY)

GAUTAM GOEL
Director

INTRODUCTION

SUGAR UNITS

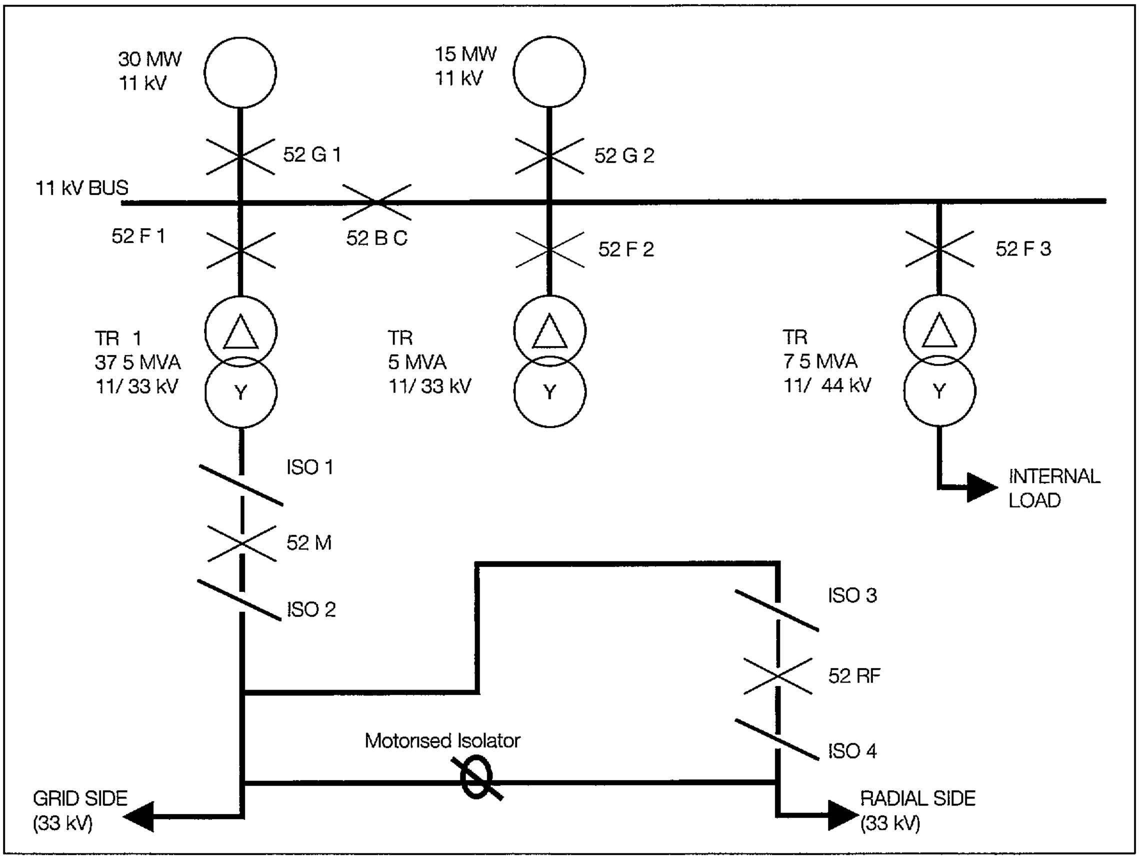
Dhampur	12 000 TCD	Mansurpur	4 000 TCD
Barabanki	4 000 TCD	Kashipur	4 500 TCD
Asmoli	4 000 TCD	Nepal (Joint Venture)	2,000 TCD
Paper	50 TPD		

Chemicals Acetaldehyde, Acetic Acid, Acetic Anhydride Ethyl Acetate Carbon dioxide Oxalic Acid

COGENERATION PROJECTS

Plant	Cogeneration Capacity	Own Consumption	Sale (Season)	Sale (Off Season)
Dhampur	24 MW	20 MW	4 MW	----
Mansurpur	6 MW	6 MW	----	----
Barabanki	45 MW	7 MW	9 MW	10 MW
Asmoli	10 MW	5 MW	5 MW	----
Nepal	4 MW	4 MW	----	----

Scheme of Power Distribution, Rauzagaon, U P



Control Systems at Rauzagaon

■ Distributed Control System	to control and monitor various critical parameters of Boiler and other power plant equipment (Designed by SIEMENS)
■ Turbo Supervisory System	to control and monitor various crtical parameters of Turbines (Designed by ENTEK I R D)
■ Electrical Protection System	to control monitor and protect various electrical factors (Designed by CROMPTON GREAVES & POWER GEM ENGS)

Some Problems With SEBs

- Delay in payments
- Lesser evacuation of power due to poor state of transmission lines
- Sorry state of sub-stations
- Grid problems

DHARANI SUGAR MILLS, TAMIL NADU
(A GEP-ABC PROJECT CASE STUDY)

PALANI G PERIASAMY
Chairman Dharani Sugars & Chemicals Ltd

I am very happy to participate in this workshop organized by you We took up implementation of a 2 5 ktcd Sugar plant at Polur in TVMalai Dt in Tamilnadu in 95-96 Given the situation in which the Sugar Industry finds itself where the margins have got severely squeezed it has become imperative to seek a new source of revenue to shore up working results So right from the beginning we took a view that we will plan to install a cogen plant from the green field stage itself Normally sugar mills in the country have boilers working at 25 30 or 40 kg/cm² For once we cross the range of 42 kg/cm², the metallurgy for most of the innards of the boiler undergoes a sea change consequently the cost goes up steeply However we advisedly took a decision to install a single boiler of 80 tph rated at 64 kg/cm² Based on this capacity of the boiler we decided to install a 15 MW Turbine (single cylinder impulse type with double extraction) The entire sugar mill plant was procured indigenously

The steam parameters were chosen to match the process steam requirement as well as electrical energy requirement by installing energy efficient equipment with a view to save maximum possible quantity of electric energy We have installed hydraulic drives in our mill instead of the conventional steam drive

To minimize the consumption of steam in the process we have installed a quintuple and a continuous pan from the initial stage itself We have installed sufficient number of electrical condensers Further some of our centrifugals incorporate variable speed drives We are now in the process of installing some V S drives for our ID FD fans and feed water pump in the boiler This enables us to bring down the steam % on cane from the usual level of around 44% to 41% on cane Such a reduction in the use of steam enables us to extract more power from a given unit of steam Our watchward is to save energy Even so about 43% of the energy produced gets consumed in the mill itself We are striving to reduce self consumption and maximize export of power

Likewise, we have also chosen to evacuate power through a 110 kV line by stepping up from 11 kV to 110 kV The 110 kV substation was conveniently within 5 km range of our generation point Even though we are connected to a 110 kV TNEB grid we still face frequency and voltage fluctuations (frequency could vary from 47 7 Hz to 51 5 Hz and sometimes the voltage fluctuates from 87 kV to 108 kV) However if we were connected to a rural sub-system these fluctuations would have been much more pronounced

In a bid to improve the generation level we had to install more costly machinery The extra cost involved towards the boiler and the larger turbine and evacuation facility etc came to almost Rs 400 million Of this USAID assisted us with Rs 21 million Up to 70% of the cost of the plant was however obtained from financial institutions like ICICI and IREDA The rate of interest for the loan portion works out to between 16% to 19%

The sugar season in Tamil Nadu runs for about 170 days Since the capital investment is very high on the cogen plant we had incorporated an option to use lignite (brown coal) during the off-season to increase the annual availability of the plant though currently we are not exercising this option

In day-to-day operations we find that one of the factors affecting power generation is inadequate availability of bagasse/fibre Due to different varieties of cane their age and climatic conditions etc the % of bagasse on cane fluctuates quite widely This results in quite a large variation in the quantity of bagasse/fibre available for power generation

Therefore while planting sugar cane it is necessary to select a suitable set of varieties of cane which yield larger tonnage of cane as also have high fibre content Moreover the planting/crushing is extended to a maximum possible period without compromising on the recovery It is quite clear that these two are quite contradictory requirements Moreover the variation in moisture % bagasse process steam consumption crushing rate and cane availability have a profound effect on the stable operation of power generation

The performance of the mill has been quite encouraging During the first season of operation extending to 6 5 months we were able to export 18 5 million units of power to the TNEB grid worth Rs 47 5 million

Monthly export of power (97-98 sugar season)

Month	Power Exported (million units)
January	negligible
February	2 69
March	3 39
April	3 75
May	4 01
June	2 65
July	2 01
Total	18 50

Our current crushing season (98 99) started on 22 11 98 Since then we have exported about 150 thousand units per day to the grid The power generated and exported during the period commencing from Nov '98 to Jan '99 is as follows -

Month	Power Generated	Mill Consumption (in Million Units)	PowerExported
Nov 98	1 03	0 48	0 55
Dec 98	7 29	3 13	4 16
Jan 99	7 73	3 28	4 44
	16 05	6 89	9 15

(We have exported 9 15m units (kwhrs) Thus we are exporting about 57% of power generated)

The Electricity Board (EB) is currently paying us at the rate of Rs 2 60 per unit (roughly 6 05 US cents)

Thus during the first year of operation we have exported power worth Rs 47 5 million And for 3 months of the current year we have exported power worth Rs 23 8 million It may be noted that this extra inflow of money is most welcome in the context of high cost of cane on the one hand and relatively low realizations on sale of sugar on the other

Currently we are generating about 14 MW of power As our sugar plant requirement is about 6 MW at present we are able to export about 8 MW of power to the grid

Pumping 7 to 8 MW to the grid may appear to be quite a modest contribution Yet it is to be noted that most of the power is generated during summer months when the demand on the grid is very high any inflow into the grid however modest is most welcome I do hope that other sugar mills may also like to take up cogen so as to augment the supply of power

We could set out the advantages and disadvantages of cogen unit thus

i a The extra revenue is a most welcome addition to the total stream of revenue generated by the mill Our experience is quite encouraging so much so that if we were to establish another sugar mill in the near future we would certainly look at and opt for a cogen facility

ii a The most important disadvantages/handicaps that we are faced with are as follows

b The operation of the high pressure boiler working at 64 kg/cm² (operating at 485 +/- 5°C) is sui generis so far as sugar mills are concerned The operations involved in running this type of boiler as compared to the traditional boilers in the sugar mill entail more critical handling and control

c The quality of feed water also becomes a matter of critical importance because a high pressure boiler needs water of highest purity (as compared to more lenient parameters for a lower pressure boiler) We use all the available condensate from the turbine to feed the boiler and we also use steam from only one body Both these sources are not enough Therefore to top up we have to use DM water Quite a lot of money has to be spent to run the DM plant as we also have to use it almost at full capacity during the season

d The investment on the cogen system is extremely high as it comes to almost 2/3 of the cost of the sugar plant itself! The cost of the borrowed funds is also extremely high so the burden of interest is consequently very high

The existing tariff that is being paid by the EB does not even meet the cost incurred towards the installation of the cogen system on the capital account much less towards the running cost However we are happy to state that TNEB is a good pay master and pay the bills within 2/3 weeks of presenting monthly bills

Nevertheless inspite of all these handicaps we are confident that once half of our investment is recouped we will be out of woods

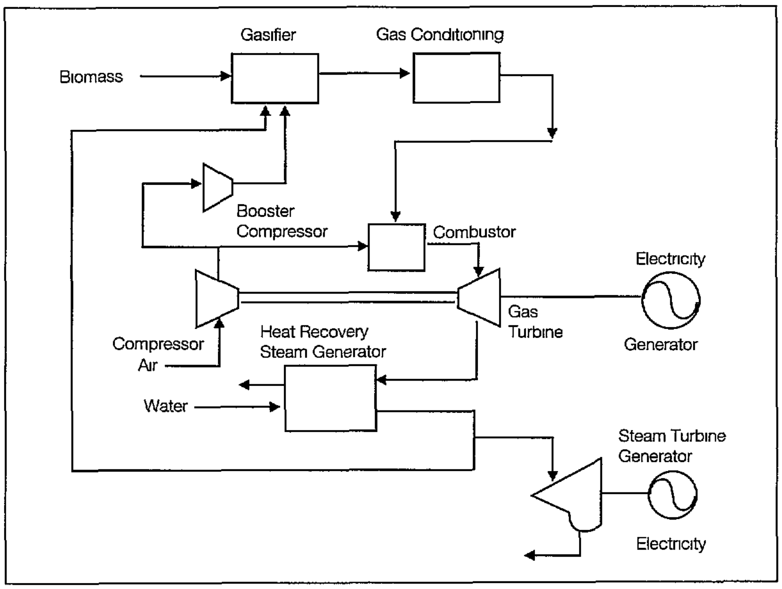
State of the Art of Advanced Technologies of Electricity Generation from Biomass

Dr Scott Q Turn
Professor HNEI University of Hawaii

The topic of this talk is the state of the art of advanced technology for electricity generation from biomass The talk will focus on a single advanced technology biomass integrated gasifier combined cycle (BIGCC) power generation The first part of the presentation will cover the basic configurations and components of BIGCC systems the second part will cover projections for system efficiencies and capital costs as a function of BIGCC electricity generating capacity Projected costs of electricity will be discussed using information from three separate case studies with final conclusions to follow

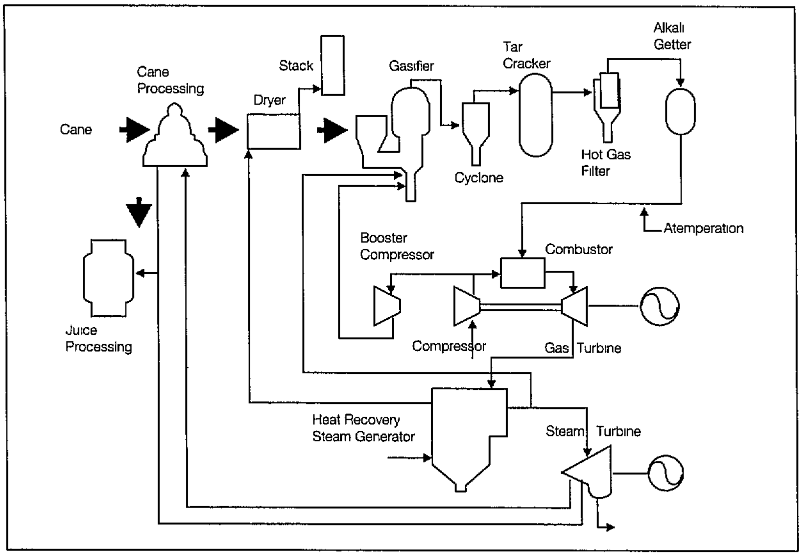
Integrated Biomass Gasifier/ Combined-Cycle System

The basic BIGCC system converts biomass air and/or steam under reducing conditions in a gasifier to produce a high temperature stream of combustible gas containing H_2 CO CH_4 N_2 CO_2 H_2O and higher hydrocarbons The gas stream is conditioned (the method depending on the system configuration) then combusted with air and the hot exhaust products are fed through the gas turbine The gas turbine drives a compressor (to provide air to the combustor and after a second stage of compression air to the gasifier) and also a generator for producing electricity The hot exhaust products are passed through a heat recovery steam generator raising steam which powers a conventional steam turbine in the bottoming cycle and also supplies steam to the gasifier if required



Commercial Sugarcane-Based Gasifier/Combined-Cycle System

This slide shows a BIGCC system integrated with a sugar factory The components to the right of the slide are similar to the basic system shown in the previous slide From cane processing bagasse at 50% moisture is dried and fed to the gasifier The gas conditioning block of the previous slide is expanded to include possible component which may be required A cyclone is often used to remove ~ 95% of particles entrained in the gas stream exiting the gasifier The tar cracker component is often used to break higher hydrocarbon species which are condensable (at temperatures <400°C) into permanent gas species such as CH_4 CO and H_2 A hot gas filter utilizes ceramic candle filter elements to remove remaining particles while maintaining process temperature An alkali getter bed may also be employed to reduce vapor phase alkali concentrations below the gas turbine fuel tolerance levels of 50 ppbw The gas turbine power block and bottoming cycle are similar to the previous slide with the main difference being the substitution of a double extraction condensing steam turbine in place of the straight condensing steam turbine to allow steam to be directed to cane and juice processing in the sugar mill Flue gas exiting the heat recovery steam generator is directed to the bagasse dryer to provide the required thermal energy



Alternative Biomass Gasifier Systems

Lets look first at the different types of gasifiers currently being advanced to commercial status in combined cycle systems All have focused on variants of fluidized bed technology a reactor vessel containing hot inert material which acts as a thermal energy carrier provides for rapid rates of heat and mass transfer and provides well-mixed and near-isothermal reactor conditions

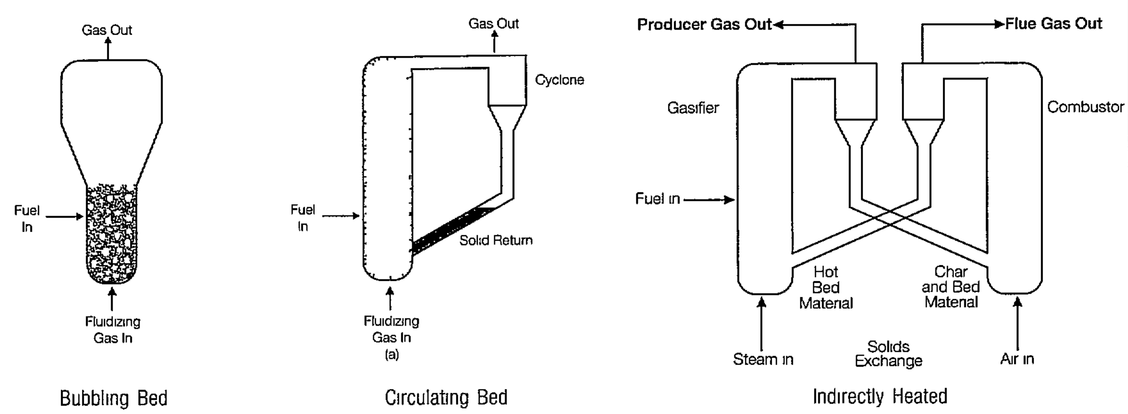
On the next page the schematic on the left shows a bubbling fluidized bed where the bed material passes from a smaller diameter dense bed to a larger diameter disengagement zone with corresponding lower velocity At the lower velocity entrained inert material and unreacted fuel and char particles disengage from the flow and return to the dense bed while the product gas stream exits the top of the reactor

The center schematic shows a circulating fluidized bed which entrains the inert bed material and unreacted char particles from the reactor where they are separated from the gas stream in a disengaging cyclone and returned to the lower part of the bed With the recycle of char to the reactor inlet fuel conversion efficiency can be increased

The schematic on the right hand side shows an indirectly heated fluidized bed consisting of two circulating fluidized beds one operated as a combustor the other as a gasifier Bed material and unreacted char is passed from the gasifier to the combustor where it is oxidized releasing heat and the hot bed material is passed back to the gasifier to provide heat to drive the endothermic pyrolysis and gasification reactions The gasifier is fluidized with steam and the combustor with air thus the reducing and oxidizing reactions are separated. This is an advantage because the fuel gas produced in the gasifier does not contain diluent nitrogen

Directly heated fluidized beds (bubbling and circulating) typically produce about 2 Nm^3 of fuel gas per kg of dry biomass fuel with a energy content of ~4 to 5 MJ per Nm^3 For comparison indirectly heated fluidized beds produce about 0 75 Nm^3 of fuel gas per kg of dry biomass fuel with a energy content of ~15 MJ per Nm^3

Alternative Biomass Gasifier Systems



Variations in Commercial and Near-Commercial BIGCC Systems

So we ve looked at the types of reactors used in the BIGCC development effort Operating pressures vary between nominally atmospheric pressure and about 20 bar depending on the system configuration Reactors may be pressurized to reduce reactor size and the overall parasitic load of the BIGCC system A compressed product gas is necessary if it is to be used in a combustion turbine the question remains whether the compression is done prior to the gasifier or after the gasifier

The gas conditioning options of a system vary depending on whether the gasifier is pressurized or not but three main considerations must be addressed Higher hydrocarbon species generated in the gasification process must be conditioned from the gas stream or run the risk of condensation in downstream equipment These are often aromatic species which represent significant amounts of energy and may account for as much as 5% of fuel input on a mass basis Particulate concentrations and vapor phase alkali must be reduced to levels which conform to gas turbine manufacturer requirements

There are two types of gas turbines for use with the low to medium energy content gases produced by biomass gasifiers heavy duty industrial style turbines and compact aeroderivative gas turbines which may be further equipped with steam injection capabilities

Examples of Alternative Gas Turbine Units

Listed here are two turbines which have been selected for use in proposed BIGCC projects the General Electric LM2500 (STIG and non-STIG) and the Westinghouse 252B12 Looking at the turbine characteristics it is evident that there are trade offs between capacity efficiency and unit cost The Westinghouse model which is an older industrial type machine has a larger capacity (49 MW) but lower efficiency (33%) and lower capital cost ($258/kW) The GE LM2500 (non STIG) has a smaller capacity (22 8 MW) but a higher efficiency (~37%) and capital cost ($400/kW)

Manufacturer	GE	GE	Westinghouse
Gas Turbine Model	LM 2500 non STIG	LM 2500 STIG	251B12
Base Outrput (kW)	22 800	28 050	49 200
Heat Rate (kJ/kWh)	9 786	8 778	11 015
Steam Injection Rate (kg/h)		22 676	
LHV Efficiency (%)	36 8	41	32 7
Price per kW ($)	400	355	258

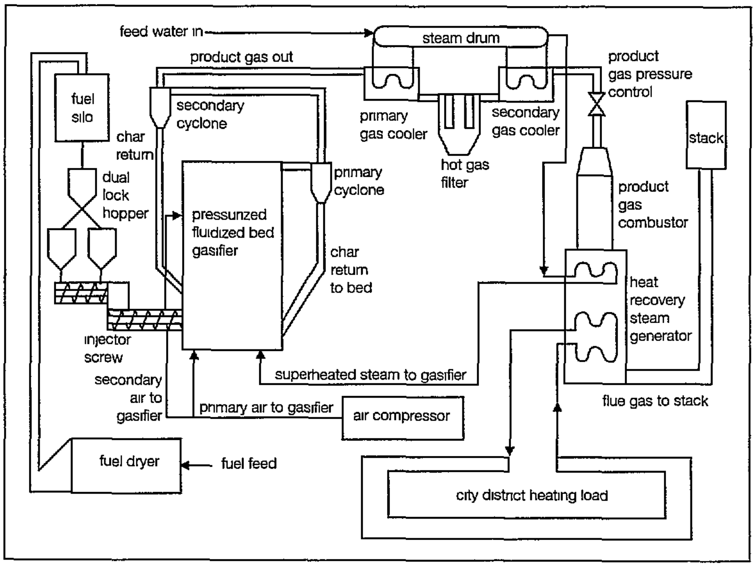
Includes single fuel gas turbine air cooled electric generator skid and enclosure inlet and exhaust duct exhaust silencer standard control and starting system and conventional combustion system Prices in 1996 dollars f o b factory

Variations in Gasification Technologies Aimed at BIGCC Application

Let s look at the development efforts which are currently ongoing around the world, aimed at commercial BIGCC systems Four main technologies are identified - Institute of Gas Technology Bioflow TPS Termiska Processor AB and Battelle IGT has developed a directly heated, pressurized bubbling fluidized bed gasifier and has demonstration facilities in Tampere Finland and Hawaii Bioflow has developed a directly heated pressurized circulating fluidized bed gasifier and has a demonstration facility in Varnamo Sweden TPS Termiska Processor AB has developed a directly heated, atmospheric pressure circulating fluidized bed gasifier and has a demonstration unit at Greve in Chianti Italy and planned commercial installations in Brazil and the United Kingdom Finally Battelle has developed an indirectly heated atmospheric pressure circulating fluidized bed gasifier and has a demonstration facility in Burlington Vermont

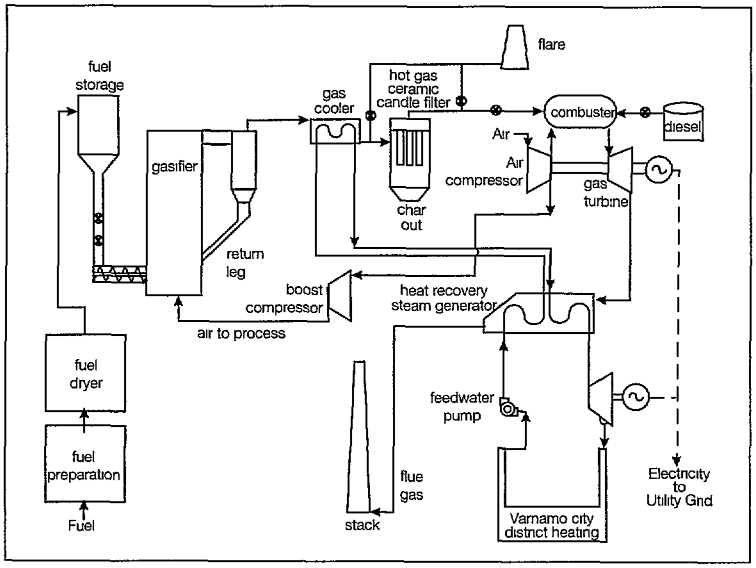
☐ CARBONA/ENVIROPOWER PILOT PLANT IN TAMPERE, FINLAND

Review system configuration and components



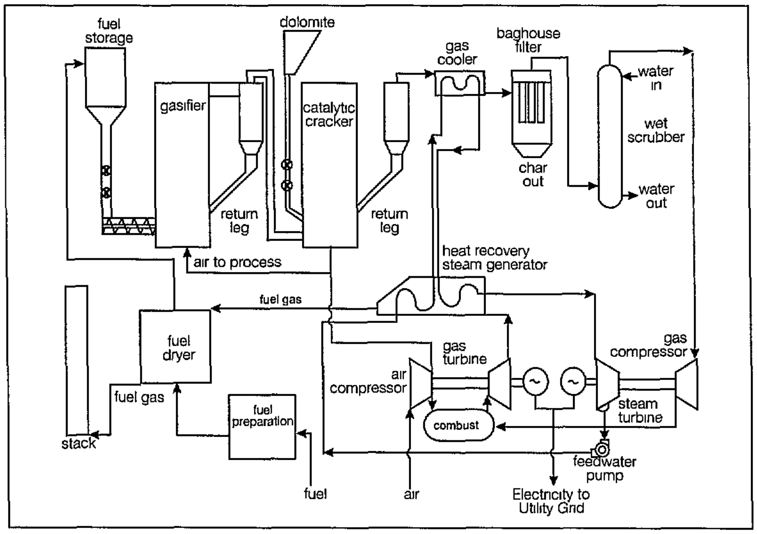
☐ BIOFLOW 6 MWE BIGCC POWER PLANT IN VARNAMO, SWEDEN

Review system configuration and components



TPS BIGCC TECHNOLOGY (PROPOSED) MUCURI, BAHIA STATE, BRAZIL

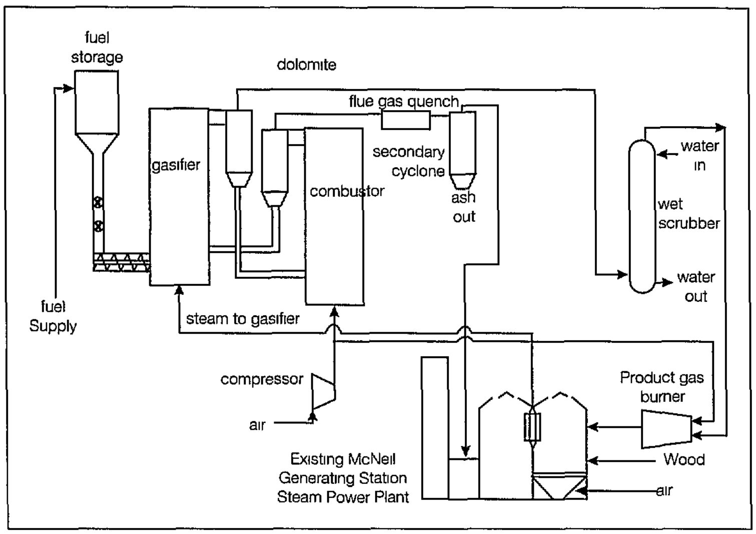
Review system configuration and components



Source Waldhiem and Carpentieri 1998 ASME Turbo Expo 98 Stockholm

BATTELLE/FERCO GASIFIER TECHNOLOGY, MCNEIL GENERATING STATION, BURLINGTON, VERMONT

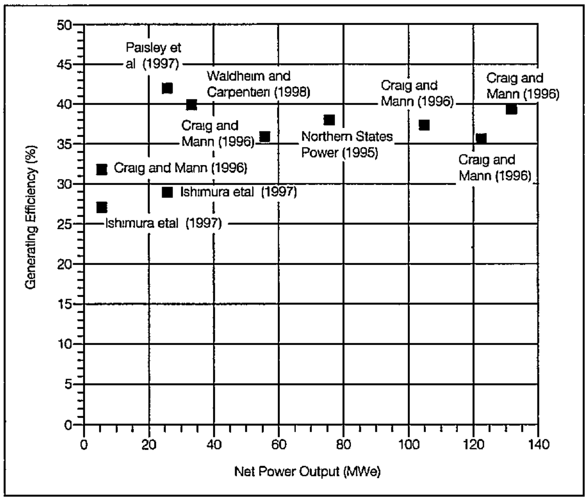
Review system configuration and components



Source Paisley Farris Slack and Irving 1997 3rd Biomass Conf of the Americas 1997 Montreal

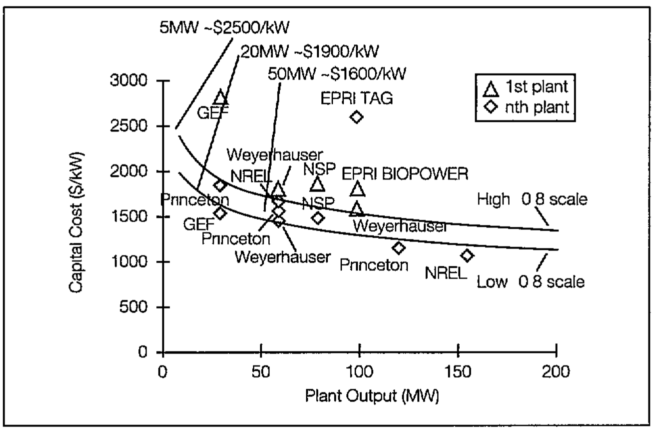
☐ Projected BIGCC System Efficiency Versus Net Power Output

So what are the projected system efficiencies for BIGCC systems? Several groups have worked through system analyses and the collected results are plotted on this slide We see that at larger system capacities above about 30 MW there is consistent agreement that efficiencies will be in the range of 35 to 40% At smaller scales we see a little more spread in the data but given that the we would expect lower efficiencies at reduced scale we can expect efficiencies in the range of 25 to 35%



☐ Biomass Integrated Gasifier Combined Cycle Capital Cost Estimates

Capital costs of combined cycle systems have also been estimated by a number of groups We see a reduction of costs that somewhat agrees with a 0 8 scaling factor which is represented by the two curves on the graph Estimates of the capital costs for the first commercial plant and the nth commercial plants have been included The first commercial plant would bear all of the associated technology and system development costs With each subsequent plant the development costs would be spread over an ever increasing number of units finally leading to the nth plant cost figures Note that projected capital cost for a 5 MW unit is ~$2500 / kW For a 20 MW unit the figure shows a projected capital cost of about ~$1900 / kW and for a 50 MW unit ~$1600 / kW



Technical and Cost Data for Biomass Integrated Gasification/ Gas-Turbine Combined Cycle Systems

As always the bottom line is how much will electricity cost? This slide provides a summary of cost estimates made by several groups broken down into Capital plus O&M ' and 'Feedstock' The estimates are in reasonable agreement at about $0 045 / kWh for everything but feedstock costs The feedstock costs are based on a $50 / ton price and results in a cost of between $0 028 and $0 036 per kWh depending on the assumed system efficiency The average total cost for electricity is $0 078/kWh Reducing feedstock costs by a factor of two easily possible in sugar factory applications would result in ~25% decrease in the cost of electricity and an average value of ~$0 06 per kWh

	Tecogen	**Ebasco**	**NREL**	**Average**
Facility Size (MW)	50	64	60	58
Capital ($/kW)	1850	1700	1680	1745
Efficiency (%)	29	29	37	32
Electricity Cost (cents/kWh)[a]				
Capital	2 6	23	2 3	2 4
O&M	2 1	17	2 4	2 1
Total (less feedstock)	4 7	40	4 7	4 5
Feedstock [b]	3 6	36	2 8	3 3
Total (with feedstock)	8 3	76	7 5	7 8

a Source NREL 1994 *b @ $50/ton≈$3/million Btu*

Summary and Conclusions

To summarize most BIGCC development efforts appropriate at sugar factory scale are utilizing fluidized bed gasifier technology the choice of a pressurized vs non-pressurized reactor dictates the choice of gas conditioning equipment for plant sized greater than 30 MW system efficiency estimates are in the range of 35 to 40% estimates of BIGCC capital costs for 30 MW plant sizes are in the range of $1500 to $1800 per kW average estimates of the cost of electricity production is about $0 078 per kWh with possible reductions to $0 06 per kWh with reduced feedstock costs

Efficient and Clean Biomass Gasification and Combustion Technologies for Bagasse

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Abstract

A cost-effective and environmentally compatible energy use of biomass requires newer energy conversion technologies compared to the conventional stoker fired combustors Current stoker fired systems operate at higher emission levels of NO_x and lower boiler plant efficiency Circulating Fluidized Bed (CFB) gasification and combustion systems appear to meet the challenges posed by the biomass Foster Wheeler (FW) has been the forerunner of the CFB gasification and combustion systems development over two decades FW CFB combustors use a wide variety of fuels including biomass

FW has supplied many biomass gasification systems over two decades Recently it has also demonstrated the CFB gasifier on a commercial-scale Lahti PC boiler to supplement the premium fuel-natural gas/oil The unit has shown excellent availability for well over a year An 87 MWth CFB combustor that co-fires bagasse with lignite has been in operation in Thailand for over five years FW believes that the two technologies-bagasse gasification and combustion can be used for efficient energy conversion with attendant benefits to the environment Since the bagasse fuel qualities vary it is essential to evaluate the fuel and also to study the energy flow in a sugar plant before opting for gasification and/or combustion

The paper discusses the following FW CFB gasification concept for biomass and commercial status including the recent successful demonstration of the Lahti project key issues relating to CFB combustion of biomass fuels and FW experience in dealing with those issues relevant to bagasse combustion

Introduction

A cost effective and environmentally compatible energy use of biomass requires newer energy conversion technologies compared to the conventional stoker-fired combustors Most types of biomass are difficult fuels in terms of low heating value low bulk density high moisture higher chlorides and alkalis Bagasse and the peripheral sugar cane wastes are no different from the standard biofuels Bagasse has low sulfur high moisture and high level of alkalis Current stoker-fired systems operate at higher emission levels of NO_x and lower boiler plant efficiency Extra care is needed in feeding the fuel to stoker to maintain proper combustion conditions The higher level of unburnt carbon in the stoker ashes makes the ash less suitable for profitable uses

Circulating Fluidized Bed (CFB) gasification and combustion systems appear to meet the challenges posed by the biomass Foster Wheeler (FW) has been the forerunner of the CFB gasification and combustion systems development over two decades FW CFB combustors use a wide variety of fuels including biomass Over 180 combustion and gasification units are in operation in different parts of the world FW CFB combustion and gasification systems offer many advantages that are major factors for their worldwide quick acceptance

- The ability to burn low grade fuels due to high thermal inertia and high turbulence of the fluidized bed
- High combustion efficiency due to the turbulent mixing of the fluidized bed and the long residence time of the fuel in the furnace
- Low SO_2 emissions made possible by the reaction of limestone to sulfur in the fuel at relatively low temperatures (850°-900°C)
- Low CO and C_xH_y emissions due to turbulence long residence time and mixing in the cyclone
- Good cycling and load-following capability due to the heat transfers being approximately proportional to the load

With over 450 sugar mills India is the largest sugar producer of the world Over 11 million tons of refined sugar is produced accounting for 60% of total sugarcane cultivated Close to 40 million tons of bagasse (30% of cane by wt) with 50% moisture is produced in the process (Eniasivam, 1999)

India's crushing season runs for 180-200 days (November-May) Some areas in the south have two monsoons and enjoy round the year season During off-season though the sugar cane can be cultivated the recovery is poor hence farmers go for alternate cash crops One of the reasons the mills prefer to go the co-generation route is to stabilize and substantiate sugar mill profits The studies conclusively show that the profits from co generation are far superior and steady than the profits from sugar business Vast majority of the mills have 2500 TCD tons crushing capacity which throws off 10 tons/hour of surplus bagasse after meeting steam demand and other miscellaneous uses Some of this excess bagasse is sold for paper pulping cattle feed etc The price of bagasse widely varies from region to region and season to season between Rs 50-400/ton

The Ministry of Non-Conventional Energy Sources (MMES) of the Indian government has developed guidelines for the quick development of bagasse based modem energy conversion systems The project among other things should employ bagasse based steam generation pressure and temperature of at least 60 bar and 450°C respectively The guidelines do not restrict the co-use of other types of fuels If multi fuel is to be employed subsidy will be given only on the bagasse-fired capacity Also projects using second-hand boilers and turbines will not qualify for these demonstration projects

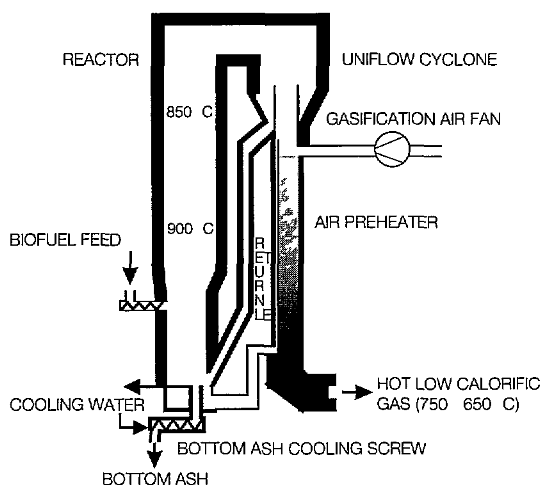
Thus from the energy efficiency and environmental requirements and also sustainable sugar mill operation there is substantial incentive for implementing the new technologies in Indian sugar industry FW is proposing two clear options to the sugar mills to consider namely CFB gasification and CB combustion These technologies are cost effective energy-efficient and environment-friendly

In this paper a description of the following aspects is given FW CFB gasification concept for biomass and commercial status including the recent successful demonstration of the Lahti project key issues relating to CFB combustion of biomass fuels and FW experience in dealing with those issues relevant to bagasse combustion

☐ Atmospheric CFB Gasification Process

The atmospheric CFB gasification system is very simple (Fig 1) The system consists of a reactor where the gasification takes place of a uniflow cyclone to separate the circulating bed material from the gas and of a return pipe for returning the circulating material to the bottom part of the gasifier All the above mentioned components are entirely refractory lined Typically after the uniflow cyclone hot product gas flows into the air preheater which is located below the cyclone

Fig 1 CFB Gasifier Concept



The gasification air blown with the high-pressure air fan is fed to the bottom of the reactor via an air distribution grid When the gasification air enters into the gasifier below the solid bed the gas velocity is high enough to fluidize the particles in the bed At this stage the bed expands and all particles are in rapid movement The gas velocity is so high that a lot of particles are conveyed out from the reactor into the uniflow cyclone The fuel is fed into the lower part of the gasifier above a certain distance from the air distribution grid The incoming biofuel contains 20-60% water 78 39% combustibles and 1-2% ash

The operating temperature in the reactor is typically 800-1000°C depending on the fuel and the application When entering the reactor the biofuel particles start to dry rapidly and a first primary stage of reaction pyrolysis occurs During this reaction fuel converts to gases charcoal and tars Part of the charcoal goes to the bottom of the bed and it will be oxidized to CO and CO generating heat After this as these aforementioned products flow upwards in the reactor reactions of a secondary stage take place which can be divided into heterogeneous reactions where char is one ingredient in the reactions and homogenous reactions where all the reacting components are in the gas phase Due to these reactions among with other reactions a combustible gas is produced which enters the uniflow cyclone and escapes the system together with some of the fine dust Most of the solids in the system are separated in the cyclone and returned to the lower part of the gasifier reactor These solids contain char which is combusted with the air that is introduced through the grid nozzles to fluidize the bed This combustion process generates the heat required for the pyrolysis process and subsequent mostly endothermic reactions The circulating bed material serves as heat carrier and stabilizes the temperatures in the process

The heat energy in the gas is in three forms as chemical heat (combustion) as sensible heat (hot gas) and as carbon dust (combustion) In the normal operation the fuel feed rate will define the capacity of the gasifier and air feed rate will control the temperature in the gasifier The coarse ash is accumulating in the gasifier and will be removed from the bottom of the gasifier with a water-cooled bottom ash screw

Commercial FW Biomass Gasification Systems

Foster Wheeler initiated circulating fluidized bed gasification studies in the early eighties A 3 MW_{th} gasifier was designed installed and commissioned in 1982 This unit operates at atmospheric pressure Over the years tests have been performed using at least ten different types of fuels Extensive data on process parameters have been developed The first commercial gasifier application supplied by Foster Wheeler Energia Oy has replaced fuel oil in the lime kiln since 1983 at Wisaforest Oy Jakobstad, Finland Since then similar gasification plants having the same basic technology have been installed at two pulp mills in Sweden and at one mill in Portugal These gasifiers produce lime kiln fuel from bark and waste wood and they also utilize a part of the generated gas in drying plants Four commercial units in the size range of 15 to 35 MW_{th} rating have been sold and they are operating (Table 1)

Table 1 Atmospheric CFB Gasifiers Supplied by Foster Wheeler

Site	Delivery Year	Gasifiers Heat Input/unit, MWth	Drying System
Oy Wisaforest Ab Jakobsiad Finland	1983	35	Flue gas recycling Gas combustion
Norrsundet Bruk Ab Norrsundet Sweden	1985	27 (two units)	Flue gas recycling Gas combustion
ASSI Karlskog Bruk Sweden	1986	27	Flue gas recycling Gas combustion
Portucell Rodao Mill Portugal	1986	17	Flue gas recycling Gas combustion
Lahti Gasifier Finland	1997	60	No biomass drying

Lahti ACFB Gasifiers Demonstration

Lahden Lampovoima Oy is a Finnish power company producing power and district heat for the city of Lahti On an annual basis the available amount of biofuels and refuse fuels in Lahti area is enough to substitute for about 15% of the fuels burned in the main boiler equaling max 30% of coal The aim in this Lahden Lampovoima Oy's Kymijarvi power plant gasification project is to demonstrate the direct gasification of wet biofuel and the use of hot raw and very low calorific gas directly in the existing coal-fired boiler Furthermore only small modifications are required in the boiler possible disturbances in the gasifier do not shut down the power plant

The Kymijarvi power plant was started in 1976 Originally the plant was heavy oil fired but in 1982 the plant was modified for coal firing The steam parameters of the once-through Benson boiler are 125 kg/s

540°C/170 bar/ 540°C/40 bar and the plant produces electric power for the owners and district heat for the Lahti city The maximum power capacity is 167 MWe and the district heat production is 240 MW Typical fuels are listed in Table 2A and 2B

Table 2A Fuels for the Lahti Atmospheric Biomass Gasifier

Fuel	Amount %-weight of total	Moisture %-weight
Saw dust	10	45 55
Wood residues (bark wood chips wet and fresh wood residues etc)	30	45 55
Dry wood residues from the wood working industry (plywood particleboard cutting etc)	30	10 20
Recycled Fuel (REF)	30	10 30

Table 2B Composition of the Recycled Fuel (REF)

Component	%-weight
Plastics	5 15
Paper	20 40
Cardboard	10 30
Wood	30 60

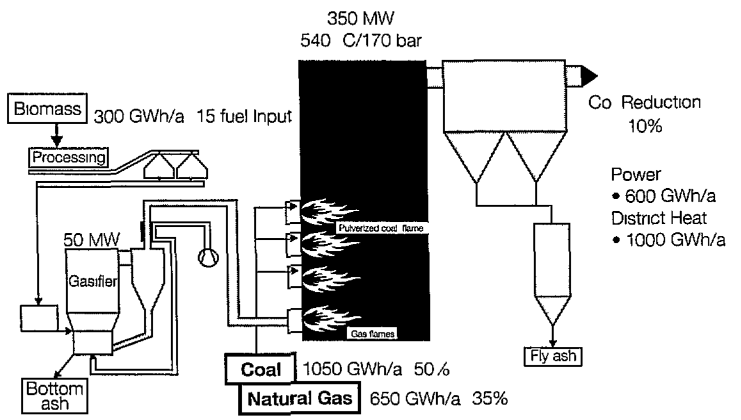
From the process point of view the major difference compared to the gasifiers supplied in mid-80 s is that fuel will not be dried in this application but the moisture content of fuel can be up to 60% However no considerable changes have been made to the design of the gasifier (Fig 2) air preheater and the gas pipe line but the design is heavily based on the design of the those commercial scale atmospheric biomass gasifiers that FW has supplied in the mid-80 s Fuels like REF some wood wastes and shredded tires contain different types of solid impurities (nails screws metal wires concrete) due to which e g the air distribution grid and the bottom ash extraction system have been designed in a different way compared to the standard design

Concerning the product gas combustion the hot gas is led directly from the gasifier through the air preheater to two burners which are located below the coal burners in the boiler The gas is burned in the main boiler and it replaces part of the Coal used in the boiler When the fuel is wet the heating value of the gas is very low Typically, when the fuel moisture is about 50 % the heat value of the gas is only Apr 2 2 MJ/ kg The design of the product gas burners is unique and heavily-based on both the pilot scale combustion tests and the CFD modeling work

Operation

The gasifier fuel was in the beginning mainly biofuel like bark and not contaminated wood waste Later other fuels also have been used The collection system to get combustible in origin classified refuses (REF) has been started in this year in Lahti area The amounts of REF collected have been in the beginning lower than the REF gasification capacity It is expected that the amounts and quality of REF will improve in the future Railway sleepers and crushed tires have been used as fuel too In the case of lack of fuel or problems in the fuel treatment the gasifier has also been operated in the combustion mode to keep the fuel consumption low level and maintain the gasifier in the operation temperature The capacity is then 8-12 MW The gasifier has now operated with excellent availability for over a year since the start of the gasification run on 9th January 1998

Fig 2 Lahti Gasifier and PC Boiler Systems



Key Test Data and Emissions

- The moisture content in the fuel mixture was rather high 45 56%
- The carbon content in the gasifier bottom ash is typically 0 1-0 2%
- The dust content in the flue gas dropped down from 20 to 10 mg/m^{3}n
- The NO_x content dropped by 10 mg/MJ

☐ Bagasse and Other Biofuel Combustion in Circulating Fluidized Bed Combustors

Siam Kraft CFB Unit

The FW has designed and supplied a CFB unit to Siam Kraft Thailand The unit is capable of burning 100% lignite and also co-firing pith and sludge Boiler steam parameters are 30 6 kg/s 101 bar 510°C Thailand has abundant reserves of lignite a low-grade fuel that is also high in sulfur content These qualities make it difficult to burn Thai lignite cleanly in conventional boilers without the addition of expensive flue gas cleaning systems Bagasse pith and sludge, waste products from the pulp mill are also burned in the Siam Kraft plant even though they have very high moisture content and low heating values (Tables 3 and 4)

The waste fuels are burned in combination with lignite with the lignite always making up a minimum of 50% of the total fuel Normally the ratio of lignite pith and sludge is 50% 35% and 15% respectively in terms of heat input The pith and sludge ratios are based on the rates at which the wastes are produced at the mill Local limestone is fed into the boiler to keep SO_2 below the allowable emission levels The limestone also forms part of the inert fluid bed material in addition to the lignite ash Table 5 summarizes the performance data

In the boiler design pith plus sludge ratio has been limited to about 50% to maintain sufficient bed purge for alkalis Generally the boiler operation has been stable and smooth Heat transfer surfaces have been clean without any sign of erosion or corrosion Soot blowing frequency has been once per 24 hrs Small deposit layer of about 10mm thickness was observed in the lower furnace on the refractory lining Bagasse pith is easy to handle but stones and other big particles from transportation may cause problems

☐ Key Issues to Maintain Bed Chemistry

It is important to maintain the bed inventory without reaching agglomeration potential of the major bed material oxides (Wu et al 1999) Some of the key points of concern are outlined Agglomeration in fluidized

Table 3 Fuel Proximate and Ultimate Analyses

	Indian Pith (TN)	Thai Pith
Fixed C	9 25	5 66
VM	59 37	29 63
Ash	3 12	2 41
Moisture	28 25	62 3
Total	100 0	100 0
Carbon	33 44	17 49
Hydrogen	4 5	2 17
Oxygen	30 48	15 16
Nitrogen	0 15	0 15
Sulfur	0 05	0 32
Ash	3 12	2 41
Moisture	28 25	62 3
Total	100 00	100 00
HHV MJ/kg	13 5	7 05
C1 %	0 035	0 03

Table 4 Key Oxides of Fuel Ashes

	Indian Pith	Thai Pith
SiO_2	75 51	69 8
Al_2O_3	3 08	4 34
Fe_2O_3	2 64	2 92
Na_2O	0 9	0 5
K_2O	5 28	5 28
Cl	1 18	1 25

Table 5 Siam Kraft CFB Boiler Performance with Bagasse Pith and Lignite Co-combustion

Parameter	Unit	Guarantee	Actual
SO_2	ppmv	171	64 114
NO_x	ppmv	146	<100
CO	ppmv	240	<20
Particulate	mg/M^3n	200	117 199
Boiler Eff (LHV)	%	89 7	90 4 90 9 (1) 92 2 92 4 (2)

Note (1) = Waste fuel mix **(2)** = Lignite

bed involves a complex interplay of fuel bed material and furnace operating conditions In boilers firing high alkali fuels there is a wide spectrum of potentially low-melting minerals The melting points of some of the minerals are listed in Table 6

The presence of a significant amount of sodium and potassium in the bagasse is a cause for concern Considering the temperature of burning fuel particles which can be 100 200°C higher than the average bed temperature some of minerals could melt and initiate binding activities leading to agglomeration

In the combustor low melting compounds or eutectics may be formed Some of the possible reactions are

$2NaCI + S + 3/2\,O_2 + H_2O = Na_2SO_4 + 2HCl$ (1)

$Na_2SO_4 + 3SiO_2 = Na_2O{*}3SiO_2 + SO_2 + \frac{1}{2}O_2$ (2)

Salt can also react directly with silica

$2NaCl + 3SiO_2 + H_2O = Na_20{*}3SiO_2 + 2HCl$ (3)

The mixture of Na_2O and SiO_2 can have melting temperature below 800°C and the eutectics of $NaO{*}SiO_2$ and N_2SO_4 can have melting temperatures as low as 635°C

If alkali silicates are responsible for sintering metal oxides such as CaO Fe_2O_3 or Al_2O_3 in finely divided form can be added to the fluidized bed to react with alkali silicates The final end products of these reactions generally have high melting temperatures Since bagasse has low amount of sulfur the formation and hence fluxing reactions of Na_2SO_4 are limited

Clay is a natural mixture of hydrous aluminium silicates (Al_2O_3*$2SiO_2$*$2H_2O$) Clay in the very fine state has been found to be effective in retaining the alkalis to form high-melting temperature alkali aluminium silicates Dehydrated clay can react directly with NaCl and H_2O

$$Al_2O_3{*}2SiO_2 + 2NaCl + H_2O = 2HCl + Na_2O{*}Al_2O_3{*}2SiO_2 \quad (4)$$

Kaolin has been used as an additive to fluidized bed incinerators burning salty sludges to control fouling and sintering Recent studies of agglomeration in biomass fired fluidized bed combustors indicate that ferric oxide (Fe_2O_3) can be used to replace silica sand and sustain long term operation

If the biomass contains high levels of alkali (potassium and sodium compounds) then the fuels can create serious fouling of convection surfaces and slagging of fluid beds and grates in combustion boilers Only a limited fraction of the fuel heat input can be from these fuels A mixture of 32% K_2O and 68% SiO_2 melts at 769°C Considering that SiO_2 alone melts at 1700°C the impact of alkali to reduce the melting temperature of the compounds is very significant The important point to note here is that understanding of the fuel ash oxides behaviour is essential to develop a suitable boiler design and to insure smooth operation of the combustion system

Table 6 Melting points of Minerals

Group	Mineral	Melting Temp °C
Chlorides	NaCl	801
	CaCl	782
	KCl	770
	$MgCl_2$	714
Carbonates	Na_2CO_3	851
	$CaCO_3$	1339
	K_2CO_3	891

Conclusions and Recommendations

FW has supplied many biomass gasification systems over two decades Recently it has also demonstrated the CFB gasifier on a commercial-scale Lahti PC boiler to supplement the premium fuel natural gas/oil The unit has shown excellent availability for well over a year An 87 MWth CFB combustor that co fires bagasse with lignite has been in operation in Thailand for over five years FW believes that the two technologies-bagasse gasification and combustion-can be used for efficient energy conversion with attendant benefits to the environment Since the bagasse fuel qualities vary it is essential to evaluate the fuel and also to study the energy flow in a sugar plant before opting for gasification and/or combustion

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BIOTEN TECHNOLOGY

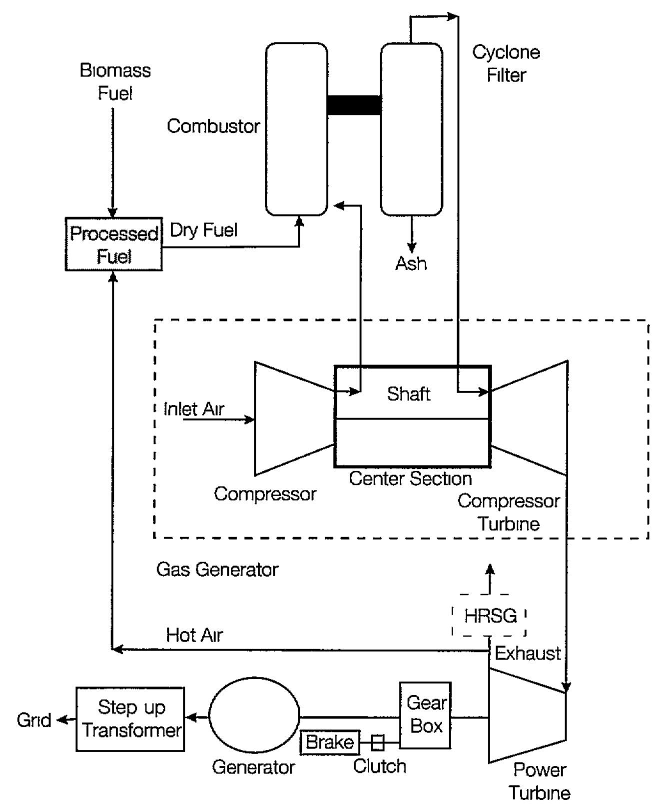
SUBHASH CHANDRA
Country Manager Bioten India

OUTLINE OF PRESENTATION

- Description of BIOTEN process
- Description of commercial demonstration plant at Red Boiling Springs Tennessee US
- BIOTEN s commitment to the Indian market
- Bagasse demonstration plant in India
- Business Plan for India

HIGHLIGHTS OF BIOTEN PROCESS

- Processing of biomass fuel
- Direct combustion in a pressurized chamber
- Cyclone filter to clean combustion gases
- Modified Gas Turbine (General Electric LM1500)
- 6 5 MW gross module



The BIOTEN Process

Advantages of the Bioten Process

- Compact modular design (less than 3 acres)
- Optimum plant size (6 MW)
- Short construction period (less than 1 year)
- No process water required
- Waste heat utilization possible to generate process steam
- More efficient process than conventional plants (more electric power generated per ton of wet bagasse)

Commercial Demonstration Plant (CDP) at Red Boiling Springs, Tennessee

- Designed and constructed by BIOTEN
- 5 MW module with sawdust as fuel
- Currently producing 3 MW with 5 MW by July 1999

India Market

- Have conducted a thorough study of the bagasse cogeneration potential in India
- Firm commitment to the Indian market
- Liaison office in New Delhi
- Will form a Joint Venture Company with an Indian firm
- JV to provide
  - Turnkey EPC services
  - O&M services
  - Training
  - Warranties
  - Spare parts
  - Support in financing of projects

Bagasse Demonstration Plant

- Technology Issues
  - Prove fuel handling and drying
  - Bagasse storage
  - Processing of other potential biomass fuels
  - Prove BIOTEN process
  - Prove reliability and availability of BIOTEN process
- Financial and Commercialization Issues
  - Project financing
  - Power purchase agreement
  - Bagasse supply issues
  - Cost effectiveness of BIOTEN plants in India
  - Prove benefits of BIOTEN process in India

BIOTEN PLAN IN INDIA

- BIOTEN Demonstration Plant
  - Partner with a pioneering sugar mill
  - Obtain financing support (Government bilateral or multilateral agencies BIOTEN mill etc)
- Establish project support infrastructure through Joint Venture in India
- Establish a strategy to commercialize BIOTEN technology in India
- Establish mechanisms for financing such projects in India

Fuel Management and Energy Efficiency

Session Chairman

Bhaskar Natarajan
Senior Project Consultant
Indo Canadian Environment Facility

Energy Efficiency in Sugar Mills

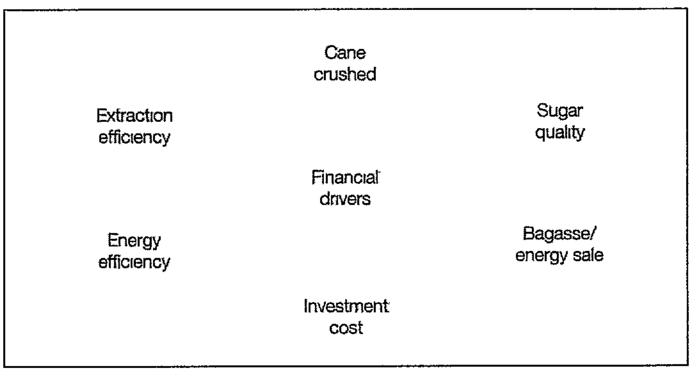
G C Datta Roy
Chief Executive (Power)
DCM Shriram Consolidated Ltd
New Delhi

Energy Efficiency in a Sugar Factory-Some Issues

- Energy Efficiency—complex co-relationship
- Conservation—Approach & Strategies
- Non-investment efforts—a case example
- Investment in Cogen—marginal analysis—case study
- Cane Sugar factory—future power plants
- Implementation barriers

Energy Efficiency

Complex Co-Relationship

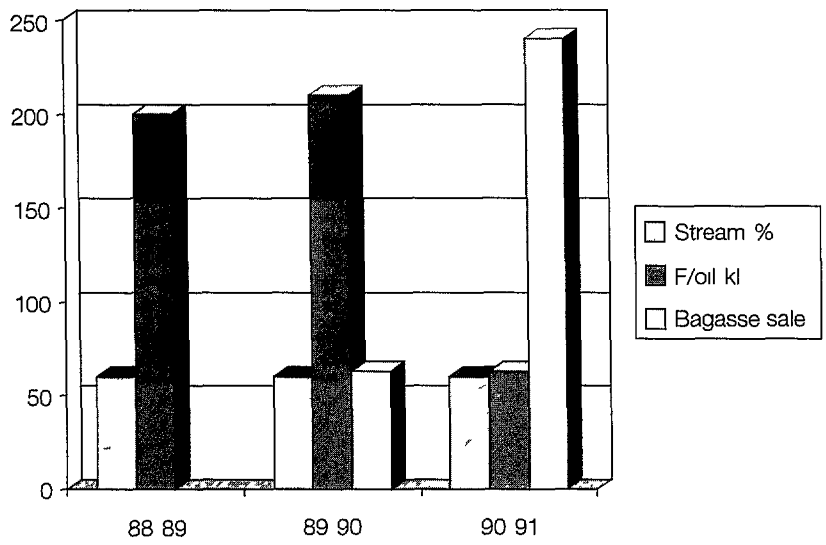


Energy Efficiency

Approach & Strategies

- Integrated—measurement & accounting/benchmarking/strategic energy planning
- Equipment & systems
- Cogeneration
- Non-investment efforts
- Investment—In-house
- Investment—ESCOs

Non-Investment—A Case Study



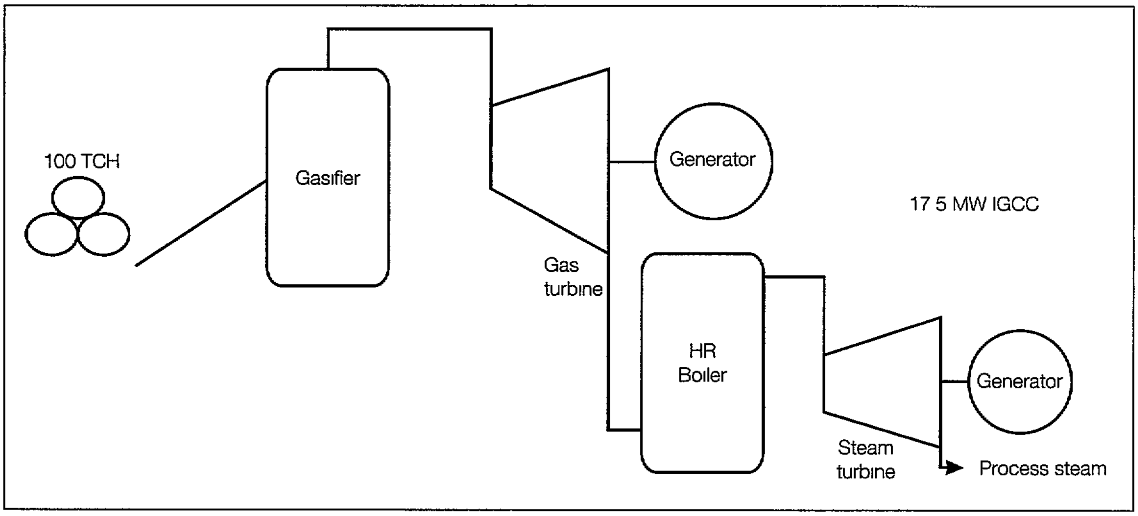
Marginal Analysis-Options for Investment in Cogen A Case Study

Case - 4000 TCD plant in Maharashtra - Season duration - 160 days average
Installed System - 21 kg/cm² boiler - No supply to grid

Case	Base	21K EC*	42K-BP**	42K-EC	62K-BP	62K-EC
Option No	0	1	2	3	4	5
Cogen Capacity MW		4	2 25	7 25	3 5	9
Electricity Sold GWH		13 81	7 81	25 01	12 01	31 31
Annualized Cost Rs Lac		25 8	22 7	56 3	34 2	71 6
Unit Cost Rs/kWh		1 87	2 9	2 25	2 85	2 29
Marginal analysis Options	1➤2	1➤3	1➤4	1➤5	2➤4	3➤5
Increment Sale GWh	( ) 6 0	11 2	( )1 8	17 5	4 2	6 3
Incremental Cost Rs Lac	( ) 3 1	30 5	9 4	45 8	11 5	15 3
Incremental Cost Rs/kWh	( ) 0 52	2 72		2 6	2 74	2 43

** Extraction Condensing* ***Back Pressure*

Cane Sugar Factory-Future Power Plants



Assumptions
Sugar recovery—10%
Steam%cane—35
Power cons —30 kWH/TC
Season—150 days
Sugar cont —Rs 3000/T
Power cont —Rs 2 60/kWh
PLF-power sale—80%

Revenues
Power sale—Rs 108 million
Sugar sale—Rs 90 million

Implementation Barriers

- Awareness/O&M Skills
- Technology-Performance Accountability
- Current Financial Health
- Cost
- Institutional

PROJECT FINANCING AND POLICY DEVELOPMENT

Session Chairman

SC Natu

Vice President (Energy & Projects Group)
Maharashtra Industrial and Technical Consultancy Organisation Ltd (MITCON) Pune

THE MNES PROGRAM PARTNERSHIP INITIATIVE (PPI)

SC NATU

Vice President
(Energy & Projects Group) MITCON Limited Pune

COGEN POWER PROJECTS AT SUGAR MILLS

- Political Challenges
- Technology Challenges
- Economic Challenges
- Optimization Challenges
- Organization Challenges
- Policy Challenges
- Financing Challenges
- Manpower Development Challenges
- Efficiency Culture Challenges
- Diversity of Stakeholders

Profitable, most challenging yet Environmentally Benign

PROGRAM PARTNERSHIP INITIATIVE FOR PROMOTION AND DEVELOPMENT OF COGEN POWER PROJECTS AT SUGAR MILLS IN INDIA

Background

433 mills 3500 MW potential efforts made since 1980 s 180 MW commissioned/under construction only

Objective

Provide required facilitation/consultancy services for promotion and development of sugar cogen projects at select 65 sugar mills (3500 TCD capacity and above) in the following states

- Maharashtra
- Punjab
- Bihar
- Gujarat
- Haryana
- Karnataka
- Andhra Pradesh
- Uttar Pradesh
- Tamil Nadu

Scope of Work

Do Everything to achieve the objective including

- Facilitation
- Consultancy
- Liaison
- Promotion

Methodology

- Total Team Work
- Provide Reviews
- Two PP s - MITCON and ITCOT
- Total Communication
- Target Approach (Financial closure of projects equivalent to 100 MW exportable surplus by March 31 1999)
- Adequate Planning of Activities

Period of Contract

- 2 years from April 1998, with an annual review

Activities Undertaken

- Visits and discussions with Mill Chairmen/ MDs for 65 mills (April/May '98)
- Collection of mill level data/information (April/May 99)
- Short listing of 30/35 mills (June 98)
- Preparation submission of Pre feasibility Study Reports for short-listed mills (June/July 98)
- Stake-holders workshops at Lonavala/Kalka (July/Aug 98)
- Preparation submission of proceeding documents and wider circulation to Stake-holders (Aug /Sept 98)
- Demo-Project Selection Meeting and Program Review Meeting (Sept 98)
- Mill level follow-up
- Project pipeline creation (46 projects 588 MW Exportable Surplus capacity) along with Monitoring Program (Sept /Oct 98)
- State Level Follow-up Meetings (Nov /Dec 98)
- Sensitizing FIs (Oct /Nov /Dec 98)
- Facilitation/Preparation of DPRs / Loan Applications (Oct -Feb 99)
- Follow-up with FIs/SEBs for Financial closure (Jan-Mar 99)

Results

- As of Feb 27 1998

* 10 DPRs (185 MW installed capacity 125 MW Exportable Surplus) / Loan Applications submitted to FIs (125 MW installed 75 MW exportable surplus)

Future

* Continuation of effort for balance 30 sugar mills second Focus sugar mills (2500 TCD – 3500 TCD and New Mills)
* Extension of services to Biomass Power including bagasse cogen power

Engineering Procurement Construction And Commissioning (EPCC) Model Of Cogeneration Projects

Purnendu Dutt
General Manager
The Godavari Sugar Mills Ltd Mumbai

Recent Status of Project Execution in Sugar Mills

- Low pressure boilers and back pressure steam turbines
- Boiler packaged by boiler supplier
- Turbine packaged by turbine supplier
- Electrical & instrumentation
  Either in-house or third party or turbine supplier
- Thrust on availability of equipment than on applying energy efficient techniques

Current Trends of Cogeneration

- High Pressure and high temperature boilers and extraction condensing turbines
- Engineering Procurement Construction & Commissioning (EPCC) of individual package by suppliers/ OEMS
- Thrust on availability reliability and use of energy-efficient techniques

Factors Favoring EPCC

- Cogeneration is commercially viable and profitable
- Encourages off-season operation
- Trend to run cogen plants like base load power stations
- Professional management of power plant
- Inexperience in operating high pressure boilers and condensing turbines
- Risk coverage due to non-performance

Modes of Engineering, Procurement, Construction and Commissioning (EPCC) of Cogeneration Projects

- Turnkey execution
- Multiple package (Island) execution

☐ TURNKEY EPCC

Advantages

- Single point responsibility
- Small execution team by sugar plant
- Less execution time
- Blanket & uniform guarantees
- Minimum interface problem
- Execution by either OEM or packager
- Basic engineering is complete before ordering

Disadvantages

- Project delay due to contractor's default
- Higher project cost
- High initial cash outflow of promoter
- High preplanning before ordering

☐ MULTIPLE PACKAGE (ISLAND) EPCC

Advantages

- Lower project cost
- Better price as suppliers are OEM only
- Staggered ordering over a period of time
- Less initial cash outflow of promoter
- Project delay can be minimized
- Less pre-planning before ordering

Disadvantages

- Responsibility restricted to the supplied packages
- High execution time
- Maximum interface problem
- Big and experienced execution team by sugar plant
- No proper guarantee for entire project
- Difficulty in accountability fixation in case of operational problems

☐ EPCC - THE GODAVARI EXPERIENCE

- 1 x 24 MW cogen plant to be expanded to 3 x 24 MW matched with the sugar plant expansion from 6 000 TCD to 10 000 TCD
- Modular concept of power plant
- Appointed M/s Desein New Delhi as turnkey consultant
- Turnkey EPCC bids received, evaluated and shortlisted

- Various financing modes under evaluation-Indian FIs as well as foreign lenders
- Model PPA from KEB under scrutiny
- Awaiting financial closure and ordering

Conclusion

- Both Turnkey and Island mode of executions are viable and practised in the industry
- Lesser experienced sugar plants can go in for power plant consultants
- High capital cost intensive project - hence should be aimed at non-seasonal operation also for maximizing revenue from sale of power
- Mode of execution to be selected based on the sugar plant s own internal strength

POWER PURCHASE AGREEMENT (PPA) DEVELOPMENT IN INDIA

HARISH BHARGAVA
Management Resources Pune

UTILIZATION OF EXPORTABLE POWER

Any or all of the following means can be used to dispose of exportable power from biomass based cogeneration projects

Supply to	**Mode**
Ancillary units within or adjacent to the cogeneration plant	Direct radial supply
Other units of the Promoter	Direct/Wheeling/Banking
Other End-users	Direct/Wheeling/Banking
Utility Company (State Electricity Board or Private)	Sale/Purchase
Rural areas around the cogeneration plant	Through the Utility

For this a formal agreement between the cogeneration plant and the Utility is required

The name Power Purchase Agreement' (PPA) for such an agreement is a misnomer since most cogeneration plants will not be in a position to assure firm availability of generating capacity and will only be able to deliver Energy that is surplus to their own requirements It would, therefore be more appropriate to use the name— Energy Purchase Agreement

Such an agreement should be carefully designed to be fair and equitable to both the parties —the cogenerator and the Utility

Any capital investment in cogeneration of exportable power requires contractual arrangement, which will ensure in the long-term returns to the investor adequate to

- discharge obligation to the lenders
- provide for depreciation
- earn profit at least equal to if not more than could be earned from other investment opportunities
- generate internal resources for future investment

Protection of adequate long term return to the promoter from cogeneration projects is an imperative which cannot be overlooked if cogeneration is to take off on the fast track

At the same time the Utility as buyer of co generated power must also get a fair deal

☐ Key Provisions of Energy Purchase Agreement

Important provisions which must be covered in the Agreement are listed in the table below

ITEM	SUGGESTED PROVISION
Pricing	Basic rate of Rs 2 25/kWh for 1994 95 Escalation In same proportion as change In HT tariff All related taxes & duties extra
Payment by the utility	• Payment through irrevocable revolving and self replenishing Letter of Credit • Interest on delayed payment • Automatic payment by the Utility s bank if payment becomes delinquent under a tripartite agreement between the cogenerator the Utility and the Utility s Bankers
Minimum Supply	Level of minimum supply to be stipulated
Wheeling Banking Radial Supply	Reasonable provisions governing wheeling banking and radial supply to be included
Reactive Power	Sharing between Cogenerator and Utility
Peak/Off Peak Supply	Optional provision if TOD Tariff is in force
Dual Fuel Systems	Pricing to equally apply to Dual Fuel cogeneration
Cogeneration Equipment	Cogeneration equipment provided by the Cogenerator to be specified and agreed with the Utility
Inter connection and Protection Equipment	Cogenerator to provide cogeneration side facilities Utility to provide tie line to and the equipment at its sub station Equipment to be provided as agreed between the cogenerator and the Utility in line with good engineering practice and with approval from the competent government authority
Synchronization	Procedure for synchronizing to be specified
Metering	Billing meters to be those provided by the Utility Check meters to be those provided by the cogenerator Provisions for testing calibration and certification of meters and also adjustment for inaccuracy detected
Commissioning Date	The commissioning date to be specified Maximum extension of one season/year Penalty for delayed commissioning
Continuity of Supply	Temporary curtailment or interruption as mutually agreed Provision for Deemed Generation
Duration	20 years
Default and Termination	Events of default and consequent termination to be clearly specified
Dispute and Arbitration	Resolving of disputes amicably by mutual discussions Arbitration in line with the international practice and Indian Arbitration Act 1996 governed by Indian laws

Brief explanation of the provisions and need for inclusion in the Agreement follow

☐ PRICING OF EXPORTED POWER

Protection of adequate long term return to the investors from cogeneration projects is an imperative which cannot be overlooked if cogeneration is to take off on the fast track At the same time the Utility as buyer of the co-generated power must pay not more than a fair price

The Base rate of Rs 2 25/kWh may be adopted It is the same rate as suggested in the Guidelines of the Ministry of Non Conventional Energy Sources (MNES) issued in 1994 95 The year of issue of the Guidelines 1994 95 should be taken as the Base Year

In accordance with normal commercial practice the taxes and levies directly related to generation and sale of electricity should be borne by the Utility

The flat basic price on the lines of the MNES Guidelines is suggested for adoption only after considering a number of pricing methodologies The rationale of rejecting other methodologies follows

■ The Two-part Tariff

The Two-part tariff that was used for large Private Power Producers cannot be applied to co generated power The first part capacity pricing in Two part tariff is based on capital cost of the Plant and a minimum Plant Load Factor In case of cogeneration the plant is used for providing steam and power for use in manufacturing processes as well as for generating exportable power The capital cost of the plant therefore can be apportioned to internal use and to production of exported power only by allocation which will always be open to argument Cogeneration power plants cannot operate at a minimum plant load factor since demand for process steam and power fluctuates and varies a great deal from time to time In the second part too costing of energy is problematic There is no determinable market price for biomass fuels such as bagasse Depending on how it is viewed the cost can be anywhere between zero to Rs 3 000 per ton Further it is not possible to uniquely determine operating and maintenance (O & M) costs as is also the case with costs related to capital investment

In case of cogenerated power it is not logical to calculate the cost of exported power based on the Two-part Tariff methodology without giving credit for steam and power used by the process plant

■ Avoided Cost

This methodology is not suitable for India In absence of firm reliable and published cost data on Utility's avoided costs which are not normally computed in India the cogenerators may not accept avoided cost stated by Utility on case to-case basis Further avoided costs will vary widely between different State utility companies and Private power utilities Even in USA competitive bidding is now usually followed in preference to pricing on avoided cost

■ Cost of Generation + Profit

For the same reasons as applicable to the Two part Tariff price cannot be determined on cost plus basis

■ Linkage with High-Tension Tariff

Pricing based on HT tariff was tried in Tamil Nadu but was soon rejected The Utility companies do not seem to like pricing based on HT tariff which is the highest price realised by the Utility and is the only one earning substantial margin

■ Justification of the Base Price of Rs 2 25/kWh

It will be seen from the above that on practical considerations and in the present context the base price of Rs 2 25/kWh for 1994-95 is the most suitable basis for pricing of co-generated power This is further supported by the fact that exporting of co generated power at this rate by cogenerators in certain states such as Tamil Nadu has been found to be financially viable

■ Escalation

- There is no cost index or a combination of indices which could be logically used for indexing price of co-generated electricity
- Escalation at a flat rate such as 5% per year may not remain valid for duration of 20 years
- Type and cost of fuels that can be used for cogeneration vary greatly An escalation formula based on cost of fuel and O & M is not practically feasible

After giving careful thought to the above it is felt that the best option is to link escalation to the change in the price of HT supply to industrial customers This should cover changes in cost of cogeneration and give stable margin to the Utility

PAYMENT

Payment for power exported from the cogeneration facility should be made on the basis of monthly invoices within a reasonable credit period of 30 to 45 days and covered by a letter of credit A tripartite agreement between the cogenerator the Utility and the bankers of the Utility is strongly recommended If payment is delayed for more than 15 days beyond the credit period it should be regarded as delinquent and the bankers should automatically pay the amount with stipulated interest without reference to the Utility

MINIMUM LEVEL OF SUPPLY

Since the Agreement requires the Utility to purchase and accept all energy made available from the cogeneration plant in fairness to the Utility a minimum level of supply should also be stipulated

WHEELING & BANKING

Provisions governing wheeling and banking should be included in the Agreement Period of Banking should be stipulated One year is a reasonable term Wheeling and Banking charges should not be excessive and should be recovered in the form of energy and not monetarily

Radial Supply

Direct radial supply to end users may be provided for under following conditions

- Radial feeder not to exceed 25 km in length
- Feeders to be set up by the cogenerator at own cost
- Sale/Purchase terms to be agreed between the Cogeneration plant and the end-user
- Name of end-user and duration of supply arrangement to be advised to the Utility
- No responsibility will attach to the Utility in respect of radial supply

Reactive Power

Some of the utility companies want to lay down supply of certain quantum of reactive power as a mandatory condition This is often difficult to comply with Even so cogenerators must supply fair share of reactive power within their operating parameters and constraints

Power factor at which cogenerators can generate power is significantly higher than that in the neighbourhood grid Cogeneration plant can, therefore when supplying power to the grid, also supply reactive power which will be to the advantage of the utility Fair share of reactive power can be delivered by properly controlling generator excitation

Peak/Off-Peak Supply

If a Utility has 'Time-of-Day tariff consideration may be given to provisions for Peak and Off-peak' supply

An electric utility needs power most during the peak periods and generally has adequate availability during the off-peak periods Power from cogenerators will become more attractive to the Utility if more power is supplied during peak periods To motivate cogenerators towards doing so a basic price may be set for "off peak with premium for supply during Peak without forcing the cogeneration plant to do so No compulsion should be placed on cogeneration plant to supply more power during Peak periods The only condition placed should be that the Off-peak' and On-peak supply should be in proportion to the duration of the respective time periods

Dual Fuel Systems

Agro-based units such as sugar mills and food processing plants use biomass as fuel for cogeneration The operation of such plants is seasonal because the raw material and therefore the biofuel is not available throughout the year If a secondary fuel is available for use during the off season cogeneration of electricity can be continued during the off season This makes exportable power uniformly available year round which is more attractive to the Utility Further productivity of capital becomes substantially greater making investment in cogeneration more attractive If use of secondary fuel for off-season is found to be feasible from considerations of availability and economic viability dual fuel cogeneration system should be installed This does not go against use of biomass for generating power, since it leads to better financial viability of biomass-based cogeneration projects All available biomass should be fully used as fuel Quantity of the supplementary fuel used should be minimum Dual-fuel systems in fact encourage use of biomass in cogeneration projects

In such cases the price for electricity exported during off-season should not be lower than that for the season If the cost of the secondary fuel is higher than that of the main fuel it would make cogeneration more attractive if higher cost of secondary fuel up to a maximum level is compensated by payment of an off-season fuel surcharge

Cogeneration Equipment

Cogeneration equipment that the cogenerator proposes installing should be specified and agreed with the Utility

Interconnection, Synchronization & Protection Systems

The Cogenerator should provide cogeneration side facilities and the Utility the tie line to and the equipment at its sub-station

Equipment to be provided and the specifications should be as agreed between the cogenerator and the Utility in line with good engineering practice and with approval from the competent government authority

Synchronizing equipment and procedure should be agreed with the Utility Procedure for synchronizing should be clearly specified

Metering

Billing meters to be those provided by the Utility Check meters to be those provided by the cogenerator Provisions for testing calibration and certification of meters and also adjustment for inaccuracy detected to be agreed and stated in the Agreement

Commissioning Date

The commissioning date to be specified Maximum extension of one season/year may be normally allowed Thereafter provision of penalty for delayed commissioning would be reasonable

Continuity of Supply

Circumstances under which supply may be temporarily curtailed or interrupted with prior mutual agreement or because of a forced outage should be stated Provisions relating to notifying the other party and earliest resumption should also be included

In case the Utility is unable to accept delivery of electricity from the cogenerator unless force majeure conditions exist the energy will be deemed to have been supplied The "Deemed Generation should be the Cogenerator would have been capable of generating but could not because of the Utility s inability to accept it

☐ Back-up Power

The Utility should supply back-up power to the cogeneration facility on normal commercial terms but without Demand charge during

- Construction period
- Start-up and commissioning of the facility
- Scheduled and forced outages of the facility

☐ Duration

20 years

☐ Default & Termination

Events of default and consequent termination to be clearly specified

☐ Disputes & Arbitration

Resolving of disputes amicably by mutual discussions Arbitration should be in line with the international practice and in accordance with the Indian Arbitration and Conciliation Act 1996

The provisions of the Agreement should be governed and construed in accordance with Indian laws

☐ Boo/Boot Project Development and Foreign Exchange Risk

A number of units which have good cogeneration potential do not go in for cogeneration project because of lack of capital funds or inexperience with power generation at higher levels particularly for In such cases development of cogeneration projects could be based on ' Build Own and Operate or Build Own Operate and Transfer

BOO /BOOT projects should be given the same treatment as Owner developed projects

Presently not many Indian promoters are coming forward for BOO/BOOT promotion of cogeneration projects On the other hand a number of parties from abroad have shown keen interest Such parties may bring in debt funds from abroad but are apprehensive of bearing the risk of unfavourable variation in foreign exchange rate Some protection may be given to such developers by compensating for such variation in foreign exchange rate as is more that a stipulated level over the period of debt repayment

☐ Conclusion

As stated earlier the Energy Purchase Agreement between cogenerator and the electric Utility and price to be paid to cogenerator for sale of exportable power are critical issues These need to be resolved at the highest levels in Central & State governments

It is strongly recommended that the issues relating to EPA documentation are studied and discussed in detail by a working group comprising MNES Ministry of Power Ministry of Finance CEA CPU and representatives of industries having cogeneration potential The object should be to evolve an Energy Purchase Agreement which could be adopted as a national document acceptable in principle to all concerned parties

Thereafter it should be given legislative force through suitable enactment and made applicable to the Union Territories The States should be advised to evolve their own standard EPA based on the Central document introducing such minimum changes as are absolutely necessary and unavoidable in view of conditions and circumstances unique to the State Only such States as conform to the above procedure should be given financial and other developmental support by the Central Government

ANNEX I

GLOSSARY

ASSOCHAM	Associated Chambers of Commerce & Industry
ata	Atmosphere absolute
CEA	Central Electricity Authority
CFD	Computational fluid dynamics
CII	Confederation of Indian Industry
CPU	Council of Power Utilities
crore	Rs 1 crore = Rs 10 000 000
DCS	Distribution control system
DM	Demineralizer
ESP	Electro static precipitator
ETP	Effluent Treatment Plant
FD	Forced draft
FETC	Federal Energy Technology Center of the US Dept of Energy
FI	Financial Institution
FICCI	Federation of Indian Chambers of Commerce & Industry
GEP	Greenhouse Gas Pollution Prevention
HR	Heat recovery
HRSG	Heat recovery steam generator
HT	High tension
ICICI	Industrial Credit & Investment Corporation of India
ID	Induced draft
IDBI	Industrial Development Bank of India
IGCC	Integrated Gasifier Combined Cycle
IPP	Independent Power Producer
ISMA	Indian Sugar Mills Association
ITCOT	Industrial & Technical Consultancy Organization of Tamil Nadu
KEB	Karnataka Electricity Board
MITCON	Maharashtra Industrial & Technical Consultancy Organization
NPC	National Productivity Council
O&M	Operation & Maintenance
OEM	Original equipment manufacturer
PCRA	Petroleum Conservation Research Association
PLF	Plant Load Factor
PPA	Power Purchase Agreement
psig	Pound square inch guage
PRV	Pressure reducing valve
SEB	State Electricity Board
STIG	Steam injected gas
T&D	Transmission & Distribution
TCD/tcd	Tons of cane per day
TCH/TNC	Tons of cane per hour
TNEB	Tamil Nadu Electricity Board
TOD	Time of day
tph	Ton per hour
UNDP	United Nations Development Program
USAID	US Agency for International Development
V S drive	Variable speed drive

Annex II

India Cane & Cogen Statistics

Bagasse Cogeneration Power Projects

State	Capacity		
	Commissioned		Under Implementation
	Installed (MW)	Power Export (MW)	Power Export (MW)
Tamil Nadu	138 50	81 50	14 00
Karnataka	16 00	11 00	103 64
Maharashtra	32 50	9 00	21 21
Punjab			12 00
Andhra Pradesh	20 50	10 00	
Uttar Pradesh	62 00	22 50	39 50
Gujarat			5 00

Source MNES 31 March 1999

Cane Statistics

Sugar Producing State	Cane Production '000 tons	Average Recovery %	Yield t/ha	Announcement of a Cogen Policy
Northern Region				
Haryana	8 100	9 24	53 2	Y
Madhya Pradesh	2 000	9 11	40 0	Y
Punjab	8 600	9 05	56 2	Y
Rajasthan	1 400	8 91	50 3	N
Uttar Pradesh	119 800	9 78	59 4	Y
Eastern Region				
Assam	1 500	8 36	41 5	N
Bihar	5 600	9 51	37 2	N
Orissa	1 600	9 10	53 2	N
West Bengal	1 900	7 97	76 0	N
Western Region				
Gujarat	10 500	10 71	71 9	N
Maharashtra	46 700	11 12	76 0	Y
Southern Region				
Andhra Pradesh	15 200	9 40	71 5	Y
Karnataka	24 900	10 52	87 1	Y
Kerala	500	8 67	80 0	N
Tamil Nadu + Pondicherry	34 600	8 35	110 0	Y

Source ISSCT/ISMA 1999

Policies Introduced by State Governments for Purchase of Electricity from Biomass Projects

Incentive Participation	Maharashtra* Pvt/Coop	Tamil Nadu Pvt	Karnataka Pvt	UP Pvt	MP Pvt	Punjab Pvt	AP Pvt	Haryana Pvt
Rates for								
Wheeling	2% of energy	2% for sister concerns 15% others	6% of energy	2% within 5 km 12 5% beyond 5km	2% of energy	2% of energy	2% of energy	2% of energy
Banking	Allowed 12 months	Allowed at 2% charge	Allowed 12 months	Allowed 12 months	Not Allowed	Not Allowed	Allowed at 2% for 8 12 months	Allowed 12 months
Buy Back	At Rs 2 25 per unit escalated at at 5% for 5 years (94 95)	@ Rs 2 25 per unit escalated at 5% (94 95)	@ Rs 2 25 per unit escalated at 5% (94 95)	@ Rs 2 25 per unit escalated in the same proportion as increase in HTT Escalation 5% (94 95)	@ Rs 2 25 per unit	@ Rs 2 25 per unit escalated at 5% (94 95)	@ Rs 2 25 per unit escalated at 5% (97 98) base	@ Rs 2 25 per unit escalated (94 95) base
Third Party Sale	Allowed	Not Allowed	Allowed linked to HT tariff	Allowed	Allowed	Allowed	Allowed not less than HTT	Allowed
Other Incentives	Participation in equity by SEB for Cogen		Subsidy @ Rs 2 5 million/MW for Cogen only			As to other Industry		

Source Biomass Power Generation in India MNES Govt of India (November 1998)

** Maharashtra s program has special features such as the passing through of conventional fuel cost and protection to foreign exchange fluctuation risk*

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