



**SAARC
ENERGY
CENTRE**

Energy for Peace & Prosperity



Post-Training Report

On-line Capacity Building of SAARC Professionals on “Commercial Scale Biogas Plants

August 23rd-27th, 2021

Organized by

SAARC Energy Centre, Islamabad

Program Coordinator:

**Muhammad Ali Qureshi
Research Fellow (Power)**

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Post-Training Report for On-line Capacity Building of SAARC Professionals on Commercial Scale Biogas Plants August 23rd-27th, 2021

Introduction

1. As part of Programme Activities for FY 2021, SAARC Energy Centre (SEC), Islamabad organized a 5-day on-line training for SAARC Professionals on “Commercial Scale Biogas Plants” held from Monday, 23rd August 2021 to Friday, 27th August 2021. The on-line training was conducted successfully by selected party Indian Institute of Technology (IIT) Roorkee, India. The detailed agenda of the training is available at [Annexure-I](#).

2. The aim of the training was to familiarize the participants on various aspects, i.e., fundamentals, construction, operation, maintenance, economics, environmental/social facets, of commercial scale biogas plants. The five-day technical sessions were focused on: basic concepts of the biogas technology, global biogas market, types of biogas plants and feedstocks, biogas plant design, its applications, performance assessment, regulations, challenges pertaining to the existing biogas technology and its future potential in SAARC Member States. The comprehensive sessions were designed to target a broad audience, ranging from policy/decision makers, prospective biogas plant developers to project managers, researchers, and other stakeholders working on the biogas technology.

Participation

3. The training was attended by 112 professionals representing various government organizations, private sector companies, academia and researchers from the SAARC Member States. The complete list of registered participants is available at [Annexure-II](#) respectively.

Description

4. The training commenced with the introductory remarks by Programme Moderator, Mr. Muhammad Ali Qureshi, Research Fellow (Power), of SEC. This was followed by the inaugural address by Dr. Nawaz Ahmad, Director SEC and Prof. Ajit K Chaturvedi, Director, IITR, Roorkee. The training comprised of five days interactive sessions including the presentations by the trainers followed by Q&A sessions and short, self-assessment quiz for the participants. The discussion about the dynamics (process, cost, feasibility) of successful biogas plants and the online demonstration of a commercial biogas plant (installed in Haridwar, Uttarakhand) proved to be the main highlights of the training programme.

Inaugural Address

5. The inaugural address by Dr. Nawaz Ahmad, Director, SEC highlighted the present situation of the biogas technology in SAARC Member states, its future potential, and the associated challenges. He explained that although the SAARC region contribute to around 23% of the world's population, still, energy scarcity is a common challenge. This has necessitated the development of alternative energy sources, including biogas. He further elaborated that the commercial scale biogas plants have now emerged in many SAARC Member States, mostly, in India and Pakistan. However, there are various factors which delimit the commercial scale deployment of biogas plants. As stated by Dr. Nawaz Ahmad, some of the major challenges faced by the SAARC Member States include lack of technical expertise/skilled personnel, and public awareness. However, various opportunities exist in terms of employment, meeting energy requirements and utilization of anaerobic digestion slurry for biofertilizer. The inaugural address was further concluded by a brief outline of the various sessions of the training programme.

6. Prof. Ajit K Chaturvedi, Director, IITR highlighted the importance of the biogas industry, particularly in the rural sectors. He discussed various benefits and the applications of biogas and the role of biogas as a clean energy source. He further stressed the importance of biogas development in terms of local generation of energy in the economically deprived regions of the world. As per Prof. A.K. Chaturvedi, the biogas industry has now reached to a certain stage of maturity and experienced tremendous growth and development in the last decade. He encouraged the speakers and the participants to contribute towards interactive sessions. He emphasized the importance of discussions and Q&A sessions in such training programs to achieve the learning objectives. He concluded that various collaborated efforts and interdisciplinary actions are still required to overcome the existing challenges for the deployment of commercial scale biogas plants.

Technical Proceedings

7. The training was conducted for 5 days, with each day technical session comprising of 2-3 lectures (55 min each) by trainers followed by the Q&A. The technical sessions included quizzes for self-assessment of the participants, discussion on case studies/industrial examples, participant feedbacks, short videos and open discussions to meet the learning objectives. The sessions were moderated by Mr. Muhammad Ali Qureshi. The trainers' profiles along with their presentations are available at [Annexure-III](#) and [Annexure-IV](#) respectively. The list of suggested reading materials is available at [Annexure-V](#).

Training Sessions

Day 1 – Theme: Introduction to Biogas Technology

Slot 1: Overview of biogas technology as future fuel by Prof. Sanjeev Kumar, HRED, IIT Roorkee

Prof. Sanjeev Kumar is actively involved in guiding research scholars in the field of biogas production, bio-manure valorization and required technological interventions to improve the production line and economy. Lead trainer of the program, Prof. Sanjeev Kumar started the technical session by shedding light on biogas technology fundamentals and historical development with special emphasis on SAARC Member States. Further he elaborated the global biogas market, key commercial players in biogas segments, current biogas production capacity and future potential in SAARC Member States. The talk was further tuned toward commercial aspects by presenting case studies on some of the successfully running biogas plant across the globe. Notably, Impact of COVID-19 on biogas market was also illustrated. Along with biogas potential and market, the energy and environment aspect were also presented. Moving ahead, Prof. Sanjeev Kumar gave an overview of the domestic as well as industrial scale biogas digesters and key feedstocks. Further the talk was accompanied by the future of biogas in terms of production potential using key feedstocks, consumption in various industrial segments across the globe and required policy support to gain market sustainability. Finally, he concluded his points by highlighting the biogas potential to contribute in renewable energy domain and GHG mitigation and discussed the associated technological and financial barriers.

Slot 2: Current status and future potential of commercial scale biogas in SAARC member states by Prof. Deepak Sharma, MPUAT Udaipur, India

Prof. Deepak Sharma is associated with teaching as well as conducting research & extension activities especially in the areas of small and large capacity biogas plants. Potential waste resources for biogas production and existing status of biogas plants in SAARC Member States was the prime focus of his presentation. He started by introducing global biogas market including biogas production potential across the globe using different feedstocks. Further, he emphasized on role of biogas in GHG mitigation. He further continued discussing the important parameters, considering biogas production efficiency. Moreover, various potential resources including: food waste, MSW, crop residue etc., were elaborated in terms of current handling practices, their energy value and biogas production potential. Moving ahead, Prof Sharma highlighted the biogas current status in SAARC Member States with impetus on resources available for biogas generation. Finally, he concluded his talk with some case studies illustrating industrial scale biogas production facilities in India and Nepal.

Day-1 Outcome: The participants learned about the fundamentals of biogas technologies and its plant design. Moreover, the global scenarios and the historical development of biogas in the SAARC Member States increased the inquisitiveness of the participants to know more about the biogas technologies.

Day 2 – Theme: Biogas Production Process and Feedstocks

Slot 1: Fundamentals on biogas production process by Prof. Sanjeev Kumar, HRED, IIT Roorkee, India

Prof. Sanjeev Kumar started his presentation with basics of biogas production process. He conceptualised the biochemical aspect of biogas production process backed by case studies from Bangladesh and India. He also explained in detail about process parameters for substantial biogas production, including pH, hydraulic retention time, temperature, organic loading rate and inhibitors thoroughly. Along with addressing the causes of problems in biogas production, he also gave troubleshooting ideas for the problems pertaining to FOS/TAC ratio, pH, foaming and drop in gas yield, and methane formation. Further, he explained the recent attempts, including biomass pre-treatment, co-digestion and biogas purification in detail that are further necessitate to strengthen the biogas technology in market. Finally, he concluded his presentation by acknowledging the advances in biogas production technology by giving example of various biogas plants in India.

Slot 2: Feedstock Types, Their Availability, Cost and Procurement W.R.T to SAARC Member States by Prof. Pratham Arora, HRED, IIT Roorkee

Prof. Pratham Arora began his talk by giving introductory remarks on biomass, its conversion to bioenergy and value proposition toward biogas production route. Corresponding to suitable biomass for biogas production, Prof. Pratham Arora outlined various types of feedstocks available and their biogas production potential in SAARC Member States. He emphasised on conventional feedstock i.e., animal manure, its characteristics, limitations and superiority of co-digestion to overcome the challenges. He not only discussed about energy plants and crop residue, but also backed up his statements with data collected from various research paper studies. Further, he elaborated about anaerobic digestion in the context of various factors like municipal sewage waste, aquatic biomass, effect of inhibitors and impurities on it. He gave facts about usage of different feedstocks and concluded his presentation with brief explanation on biomass logistics and its effect on location of biogas plant.

Day-2 Outcome: The technical sessions facilitated learning about general biochemical aspects and processing of common feedstocks for biogas production. The case study of India and

Bangladesh helped the participants to absorb process parameters and emerging feedstock for better future of biogas production at global level.

Day 3 – Theme: Biogas Plants and Applications of Biogas

Slot 1: Biogas plant design concepts and considerations for establishment of commercial scale facilities by Prof. Deepak Sharma, MPUAT Udaipur

Prof. Deepak Sharma commenced his lecture with an overview of the biogas plants and their types. His lecture was Primarily focused on the classification of biogas plants and their components, resource requirements and design considerations. He elaborated the different phases of biogas plant designs (fermentation or gas storage system, slurry flow, operational temperature, digester size, loading rate, etc.). Further, he discussed the design and selection factors (waste type, biogas quantity, overall aim, site selection, pre-digestion parameters, etc.) for bio-digesters and provided a comparative overview of the conventional digesters v/s the high rate commercial plant digesters (CSTR, UASB, SGBR, etc). Finally, he concluded his lecture by providing an insight into the operation/maintenance and feasibility/scalability assessment of biogas plants.

Slot 2: Multifarious uses of biogas and its opportunities w.r.t power generation in SAARC member states by Dr. Atma Ram Shukla, Former Adviser Bio-energy, Ministry of New and Renewable Energy (MNRE), Govt. of India

The biogas industry, associated technologies, institutional framework, challenges, key commercial drivers and learnings from the case studies were the highlights of the lecture delivered by Dr. Atma Ram Shukla. He initiated his talk with a brief overview of the biogas plant and various uses (pipe gas, transportation, electricity, fertilizer) of its by-products (biogas and bio-slurry). The institutional framework in different SAARC Member States was then discussed. The centerpiece of his talk was the bio-waste to biogas scenario in the SAARC Member States. He outlined the history of biogas development in India, technologies and associated challenges. Later, he provided an insight into the tariffs for various Renewable Energy, biomass power projects, and the inter-ministerial policies. He concluded his talk with the discussion of various case studies: a high-rate bio-methanation plant (based on cattle manure) located in Punjab, India, Bio-CNG plant situated in Gujarat, India followed by a brief introduction about the Indian Biogas Association.

Day-3 Outcome: The learning was about the components, types, design parameters and the utility of high-rate commercial scale biogas digesters. Further, the pros/cons of biogas as an energy source relative to other energy sources was also brought to the limelight.

Day 4 – Theme: Feasibility and Scalability Assessment

Slot 1: Feasibility and scalability of biogas plants I: concepts and methods by Mr. Srinivas Kasulla, Director - Arka BRENStech Pvt. Ltd.

The steps involved in planning of a biogas plant and its prefeasibility study followed by the regulatory requirements was the prime focus of the lecture delivered by Mr. Srinivas Kasulla. The talk started with an overview of the steps involved in planning phase of biogas plant such as rough planning, selection of biogas manufacturer, acquiring permissions from authority, planning for construction and operation of the plant. Mr. Srinivas Kasulla elaborated on how a pre-feasibility and feasibility study should be performed, highlighting the best practices. Further, he also highlighted the role of stakeholders in the successful planning and implementation of any biogas project. He concluded his talk by discussing various technical success factors of biogas projects.

Slot 2: Residue management and value addition – a game changer in improving financial viability of Biogas plants by Mr. Chandan Gadgil, Hon. Adviser, BAIF, Pune, India

Mr. Chandan Gadgil, emphasized the aspect of residue management and its role in enhancing the feasibility of biogas plants. He commenced his talk with an account of the current utilization of residue for small-scale and commercial scale biogas plants. He further highlighted the inefficient capture of slurry, its wastage and the development of BAIF Slurry filter for efficient slurry capture. The “Bioprom” (biological phosphate rich organic manure) development was then discussed. He elaborated the paradigm shift from conversion of a residue (from by-product) to value added product via Bioprom. He explained the characteristics, unique features, production steps, field demonstration studies/results of Bioprom and its benefits as compared to chemical phosphate fertilizers. Lastly, he concluded with sharing the experience of BAIF in IRESA and Bioprom, highlighted the challenges ahead and requirement of policy initiatives.

Slot 3: Feasibility and scalability of biogas plants II: economic analysis, environmental and social benefits by Prof. Pratham Arora, HRED IIT Roorkee, India

The overall analysis (economic, environmental, and social) of the biogas plants was the prime focus of the lecture delivered by Prof. Pratham Arora. He initiated his talk with an elaboration on use of Techno-economic Analysis (TEA) for estimating the economic performance of biogas plants. He discussed the basic concept, process development and simulation and the cash flows for TEA. Later, he highlighted the use of Life Cycle Assessment (LCA) for environmental performance estimation. He elaborated the LCA metrics, stages and system boundaries. Later, he discussed about the methane emissions in biogas production and concluded with the socio-economic aspects of biogas plants.

Slot 4: Techno-economic analysis of conversion of Municipal Solid Waste (MSW) into energy by Dr. Nawaz Ahmad, Director SEC, Pakistan

On behalf of Dr. Nawaz Ahmad, Mr. M A Qureshi presented a techno-economic analysis of conversion of Karachi Municipal Solid Waste (MSW) into energy. The economic analysis of utilization of Anaerobic Digestion (AD) for MSW management in Karachi was the centerpiece of his talk. He commenced his presentation by providing an overview of the MSW, its characteristics and MSW status in Karachi. The concept of Waste to Energy (WtE) was the next focus of his presentation. He elaborated various WtE technologies for MSW including, thermal conversion, biological conversion, and landfilling. Further, he discussed the use of AD for MSW in Karachi, including the reason for selecting AD, associated energy recovery and its economic feasibility.

Day-4 Outcome: The learning was about the approaches to ascertain the scalability of biogas plants, the importance of residue management and economic/environmental/social aspects of biogas plants. Moreover, the case study of AD utilization for MSW management in Karachi helped the participants to understand the dynamics of biogas plants, crucial factors to be considered, and the challenges that may be encountered during commercial scale deployment of biogas plants.

Day 5 – Theme: Policies and Challenges in Biogas Commercialization

Slot 1: Regulations and challenges linked with the development of commercial biogas plants w.r.t SAARC member states by Mr. Shailendra Shukla, Former Chairman, State Power and Renewable Energy Agencies, India

Mr. Shailendra Shukla started his talk by introducing biogas, its energy value, applications and link with environment. He outlined the whole biogas production process from feedstock collection to biogas and other byproduct supply for various applications. Mr. Shailendra Shukla further gave an insight on technical and economic barriers, illustrating the key constraints at each production step. Further, he highlighted the key processes to be considered alongside the biogas production pipeline. Moreover, market, institutional, socio-cultural and environmental barriers were also elaborated. In addition, Protocols for the establishment of commercial-scale biogas plants and policies were covered in his presentation. He demonstrated problems associated at various aspects of biogas production pipeline. Finally, he concluded his talk by illustrating the various aspects that has huge potential in biogas commercialization.

Slot 2: Technologies for resource recovery from commercial-scale biogas plants by Prof. Sanjeev Kumar, HRED IIT Roorkee, India

Biogas plants are not only the sources of green energy but has a huge potential to provide renewable chemicals and allied products was the prime focus of the presentation delivered by

Prof. Sanjeev Kumar. He started his talk by depicting biogas plant in a biorefinery perspective. He elaborated all the liquid, solid and gaseous streams that can be tapped to recover various products, such as commercial grade CO₂, and nutrient-rich fertilizer. He discussed the technologies for resource recovery, processes involved, key parameters and the final product in that stream. Further, he emphasised on by-product valorisation to improve the market outreach and economy. The talk was accompanied with related case studies across the globe producing marketable by products along with biogas. Finally, he concluded his talk with the associated challenges and future outlook and steps need to be taken in SAARC Member States.

Slot 3: Online demonstration of commercial biogas plant by Prof. Pratham Arora, HRED IIT Roorkee

A hands-on experience and visualization make any training impactful. To provide the audiences with such an experience and to strengthen the learnings, Prof. Pratham Arora virtually demonstrated commercial scale biogas facility of 1600 m³ capacity. The facility was located in Uttarakhand, Province of India. He showed in real time how each step from raw biomass collection, feeding to biogas production, purification and bottling is carried out at industrial scale. He explained the technologies and machineries being used at plant site. Further, he explained how successfully the plant is being operated, and the bottled biomethane is being supplied to a nearby pharma-industry. He discussed about how the funding was raised to build this plant and its overall management process for smooth plant operation. Moreover, he highlighted about manpower involved, required skills and expertise at various steps of biogas production and digested slurry management. He not only explained how the liquid and solid fertilizer and biocompost etc. are being produced using the digested slurry but also discussed the associated challenges pertaining to storage and transportation. Prof. Pratham Arora concluded the virtual tour by showing the on-site laboratory, explaining its role to maintain the quality of the products.

Slot 4: Expanding the portfolio of commercially-viable clean energy projects in SAARC by Mr. Peter Storey, Global Coordinator PFAN / Mr. Ghazil Jabbar, USAID PPSE Project

Financial viability is a very key aspect for the commercialization of any business idea. In this context, Mr. Peter Storey delivered his talk in the perspective of raising finance for clean energy in particular commercial scale biogas projects. He started his talk by identifying the gap between project readiness and investment. Further, he introduced Private Financing Advisory Network (PFAN), highlighting its service delivery models and its role in supporting the project developers. He further elaborated about the PFAN's project selection criteria and scope. His presentation was backed up with case studies on successfully build biogas ventures that were coached by PFAN. Moreover, Mr. Peter Storey explained key requirements from the investors' point of view. He concluded his talk by illustrating USAID Pakistan Private Sector Energy Project where PFAN is an implementing partner.

Day-5 Outcome: The learning was focused on analyzing the existing policies and challenges pertaining to biogas commercialization. The virtual demonstration of commercial biogas plant helped the participants to comprehend facility layout and operations of existing biogas plant. Additionally, the diverse ways of expanding the portfolio of commercially viable clean energy projects gave positive insights to the future of biogas production.

Valedictory Session

Dr. Nawaz Ahmed, Director SEC giving his closing remarks expressed his satisfaction over excellent conduct of training by academic elites. He acknowledged everyone for their presence and active participation. He appreciated Prof. Arun Kumar, Prof. Sanjeev Kumar lead trainer and all Co-trainers for their valuable contribution. Prof. Arun Kumar added thanking remarks for everyone's cooperative indulgence in conducting such programme successfully. Screenshots for online sessions on different days are given at [Annexure-VI](#).

Annexures

Annexure -I: Agenda

The aim of this training was to provide the knowledge and skills required to plan, build, and operate a biogas plant for various purposes. The sessions were designed for policy and decision makers, prospective biogas plant developers, project managers, researchers, investors, and other stakeholders working with this technology.

The training were conducted in a total of five interactive sessions (one each for 5 days). Each session comprised two or more lectures and discussion by experts followed by questions, online quizzes, and query session for next 20 -30 min. Final time table of training is as below:

Day/Date	Time (Pakistan Standard Time)	Title & Speaker	Broad content to be covered
Inauguration and Technical Session 01: Introduction to Biogas Technology			
Day 1 August 23, 2021	2:00 – 2:20pm	Inauguration of the Training program	- Inaugural Address by Dr. Nawaz Ahmad, Director, SAARC Energy Centre-Islamabad - Address by Ajit K Chaturvedi, Director, Indian Institute of Technology (IIT), Roorkee
	2:20 – 3:15pm	Slot 1: Overview of biogas technology as future fuel by Prof. Sanjeev Kumar, HRED IIT Roorkee, India	- Fundamentals on biogas technology - Family type v/s commercial biogas plant - Biogas plant designs for commercial scale production
	3:15 – 3:30pm	Break	
	3:30 – 4:25pm	Slot 2: Current status and future potential of commercial-scale biogas in SAARC members states by Prof. Deepak Sharma, MPUAT Udaipur	- Global scenarios of the biogas market - Historical development of biogas in SAARC members states - Current status and future potential of biogas commercialization in SAARC member states
	4:25 – 4:35pm	Quiz for day 1	MCQ based online quiz on the content covered
Technical Session 02: Biogas Production Process and Feedstocks			
Day 2 August 24, 2021	2:00 – 2:55pm	Slot 1: Fundamentals on Biogas production process by Prof. Sanjeev Kumar, HRED, IIT Roorkee	- Biogas production process: four steps involved - General biochemical aspects of the biogas production process - Process parameters for substantial biogas production - Problems associated with biogas production and troubleshooting - Recent advances in biogas production technology
	2:55 – 3:10pm	Break	
	3:10 – 4:05pm	Slot 2: Feedstock types; their availability; cost and procurement w.r.t to SAARC member states by Prof. Pratham Arora, HRED IIT Roorkee, India	- Common feedstocks for commercial biogas: global scenarios - Feedstock availability and procurement - Processing of common feedstock for biogas production - Emerging feedstock for biogas: agriculture waste, algal biomass, and MSW
	4:05 – 4:15pm	Quiz for day 2	MCQ based online quiz on the content covered
Technical Session 03: Biogas Plants and Applications of Biogas			

Day/Date	Time (Pakistan Standard Time)	Title & Speaker	Broad content to be covered
Day 3 August 25, 2021	2:00 – 2:55pm	Slot 1: Biogas plant design concepts and considerations for establishment of commercial scale facilities by Prof. Deepak Sharma, MPUAT Udaipur	• Biogas plants; their types, components, and resource requirements • Small scale Vs commercial biogas plants • Size analysis, commissioning, and construction of biogas plants • Designs and selection factors for biogas plants • The operation, maintenance, and feasibility/ scalability assessment of plants • Quality control of biogas plants
	2:55 – 3:10pm	Break	
	3:10 – 4:05pm	Day 3; Slot 2: Multifarious uses of biogas and its opportunities w.r.t power generation in SAARC member states by Dr. Atma Ram Shukla, Adviser Bio-energy (Retd.), MNRE, Govt. of India	• Various uses of different forms of biogas (upgraded biogas/ biogas with or without CO₂ separation) • Biogas as an alternate energy source, its advantages, and limitations • Biogas purification for commercial application of biogas in power generation • Biogas based power generation programs in SAARC member states • Tariff structure, electricity tariff of biogas plant v/s other technologies/fuels
	4:05 – 4:15pm	Quiz for day 3	• MCQ based online quiz on the content covered
Technical Session 04: Feasibility and Scalability Assessment			
Day 4 August 26, 2021	2:00 – 2:45pm	Slot 1: Feasibility and scalability of biogas plants I: concepts and methods by Mr. Srinivas Kasulla, Director - Arka BRENStech Pvt. Ltd.	• Project development for commercial biogas plants Feasibility and scalability concepts; their significance in biogas technology • Approaches to conducting the pre-feasibility and detailed feasibility of biogas plants • System description and methodology to perform pre-feasibility
	2:45 – 3:00pm	Break	
	3:00 – 3:40pm	Slot 2: Financial viability of biogas plants by revenue value addition by Mr. Chandan Gadgil, Hon. Adviser, BAIF, Pune, India	• Focus on Residue management - A paradigm shift • How Bioprom impacts financials. • Impact on climate, soil, and farmers.
	3:40 – 4:10pm	Slot 3: Feasibility and scalability of biogas plants II: economic analysis, environmental and social benefits by Prof. Pratham Arora, HRED IIT Roorkee	• Techno-economic analysis (TEA) to estimate the economic performance • Life cycle assessment (LCA) to ascertain the environmental performance • Socioeconomic impacts of commercial biogas plants with exemplary case studies
	4:10 – 4:40pm (Tentative)	Techno-economic analysis of conversion of Municipal Solid Waste (MSW) into energy by Dr. Nawaz Ahmad, Director SEC	• Characteristics and assessment of MSW • Selection of waste-to-energy (WTE) technology • Economic analysis of WTE project (base case and sensitivity analysis)
	4:40 – 4:45pm	Q&A Session	

Day/Date	Time (Pakistan Standard Time)	Title & Speaker	Broad content to be covered
Closing & Technical Session 05: Policies and Challenges in Biogas Commercialization			
Day 5 August 27, 2021	2:00 – 2:55pm	Slot 1: Regulations and challenges linked with the development of commercial biogas plants w.r.t SAARC member states by Dr. Shailendra Shukla, Former Chairman, State Power and Renewable Energy Agencies	• Risks associated with biogas commercialization • Protocols for the establishment of commercial-scale biogas plants • Policy instruments
	2:55 – 3:00pm	Break	
	3:00 – 3:40pm	Slot 2: Technologies for resource recovery from commercial-scale biogas plants by Prof. Sanjeev Kumar, HRED IIT Roorkee	• Management of waste streams in commercial biogas plants • Recovery of waste CO₂ from biogas enrichment • Valorization of digested slurry from biogas plants
	3:40 – 4:10pm	Slot 3: Online demonstration of commercial biogas plant	• Development, facility layout, operation, energy utilization, process implementation, and challenges of existing biogas plants
	4:10 – 4:35pm	Slot 4: Expanding the portfolio of commercially-viable clean energy projects in SAARC by Mr. Peter Storey, Global Coordinator PFAN / Mr. Ghazil Jabbar, USAID PPSE Project	
	4:35 – 4:45pm	Valedictory session	

Annexure-II: List of Registered Participants

Complete List of registered participants for On-line Capacity Building of SAARC Professionals on Commercial Scale Biogas Plants (23rd-27th August, 2021)

Sr. No	Last Name	First Name	Department	Designation	Country
1	Mahmood	Mr Asad	NEECA	Manager Technical	Pakistan
2	Chaudhary	Babar Latif	ES consultant	Assistant Resident Engineer	Pakistan
3	Amjad	Arjmand Qayyum	Espire Consult	Manager Sustainability & Cleaner Production	Pakistan
4	Butt	Muhammad Salman	Espire Consult	Executive Director	Pakistan
5	Dissanayake	Dharma Sri Bandara	Lanka Biogas Association	Director	Sri Lanka
6	Sultan	Wajahat	ALTERNATE ENERGY & RESEARCH INNOVATION LAB, KICS UET Lahore	RESEARCH OFFICER	Pakistan
7	Ahmad	Muhammad Muneeb	NUST-Islamabad	Project Engineer-USPCASE	Pakistan
8	Valasai	Gordhan Das	Quaid -e- Awam University of Engineering, Science and Technology, Nawabshah	Associate Professor	Pakistan
9	Memon	Lala Rukh	Mehran University of Engineering & Technology, Jamshoro, Sindh, Pakistan	Student/Research fellow	Pakistan
10	Zia	Ubaid Ur Rehman	Sustainable Development Policy Institute (SDPI), Islamabad	Research Associate	Pakistan
11	Hameed	Muhammad Adnan	Lucky cement Limited	Deputy Manager	Pakistan
12	Choden	Karma	Department of Renewable Energy- Ministry of Economic Affairs	Junior Engineer/S2-	Bhutan
13	Sagir	Muhammad	Khawaja Fareed University of Engineering & Information Technology, Rahim Yar Khan	Associate Professor/Chairperson Department of Chemical Engineering	Pakistan
14	Suleman	Muhammad	Khawaja Fareed University of Engineering & Information Technology, Rahim Yar Khan	Lecturer	Pakistan

Sr. No	Last Name	First Name	Department	Designation	Country
15	Tahir	Muhammad Suleman	Khawaja Fareed University of Engineering & Information Technology, Rahim Yar Khan	Vice Chancellor	Pakistan
16	Kashif	Muhammad			Pakistan
17	Latif	Muhammad Hamza	National Productivity Organization, Ministry of Industries and Production, GoP.	Management Associate	Pakistan
18	Naqvi	Syeda Mehdiya	Ebrahim Textile Mills Pvt.Ltd.	Energy Engineer	Pakistan
19	Kandhro	Barkatullah	Mehran University of Engineering and Technology Jamshoro	Lecturer	Pakistan
20	Pushpakumar	Wagaarachchige Mayasisirajayanth	District Secretariat, Ratnapura, Ministry of Agriculture	Development Officer	Sri Lanka
21	Ansari	Abeera Ayaz	USPCASE-NUST	Assistant Professor	Pakistan
22	Sangay	Karma	Department of Renewable Energy, Ministry of Economic Affairs, Royal Government of Bhutan	Deputy Executive Engineer	Bhutan
23	Dulal	Yamuna	SAARC Development Fund	Executive Secretary	Bhutan
24	Saswat	Satya Shiva	Economic & Infrastructure Windows, SAARC Development Fund	Director	Indian
25	Jamtsho	Sangay	Department of Renewable Energy, Ministry of Economic Affairs, Royal Government of Bhutan	Junior Engineer	Bhutan
26	Liaquat	Rabia	USPCASE-NUST	Associate professor , Head of the department	Pakistan
27	Khattoon	Rabia	FEST, Hamdard University	Assistant Professor	Pakistan
28	Zulfiqar	Muhammad Farhan	Punjab Power Development Company Ltd.	Deputy Manager (Renewable Energy)	Pakistan
29	Rahman	Muhammad Abdur	Punjab Energy Efficiency & Conservation Agency (PEECA)	Program Manager	Pakistan
30	Khan	Waqas Ali	Punjab Energy Efficiency & Conservation Agency (PEECA)	Assistant Manager (Program)	Pakistan
31	Khalid	Waqas	Alternate Energy Lab, KICS UET Lahore	Asst. Manager Research	Pakistan

Sr. No	Last Name	First Name	Department	Designation	Country
32	Munir	Kashif Muhammad	AL Shafi Group of Companies	GENERAL MANGER (POWER PROJECTS)	Pakistan
33	Ali	Syed Waqar	Infraco Asia (Singapore)	Assistant Manager Execution (Renewable Energy Professional)	Pakistan
34	Shah	Imran Ali	Center for Energy Research and Development-UET	Senior Manager Research	Pakistan
35	Jalal	Hustam	Nishat Dairy (Private) Limited	General Manager Operations	Pakistan
36	Khan	Atif Ahmad	Arch Associates	Managing Partner	Pakistan
37		Wasiullah	National Productivity Organization (NPO)	Management Trainee	Pakistan
38	Khokher	Asif	Innovasys Engineering (Pvt.) Ltd.	Director	Pakistan
39	Hussain	Tassawar	Dynea Pakistan Limited	Senior Maintenance Manager	Pakistan
40	Ali	Rafay Motasim	Lucky cement Limited	Deputy Manager - Electrical	Pakistan
41	Ahmad	Mukhtiar	PROJEXIVE	Engineering & Projects	Pakistan
42	Musafer	Namiz	Lanka Biogas Association	Director	Sri Lanka
43	Devaisy	Sukanyah	Department of Bio-science - Faculty of Applied Science, University of Vavuniya	Senior Lecturer	Sri Lanka
44	Mahendra nathan	Chandrakan tha	Eastern University, Sri Lanka	Senior Lecturer	Sri Lanka
45	Dissanaya ke	Dharma Sri Bandara	Lanka Biogas Association	Director	Sri Lanka
46	Jayasuriya	Ajith Dhammika	National Engineering Research & Development Centre of Sri Lanka	Director	Sri Lanka
47	Kumara	Ajith	Lanka Biogas Association	Director	Sri Lanka
48	Weerasing he	Nandasiri	Ministry of Plantation	Consultant	Sri Lanka
49	Entezary	Mohsen	Energy Services Regulation Authority	Energy Transmission Specialist	Afghanis tan
50	Damsaz	Abdul Mosawer	Energy Services Regulation Authority	Electrical Engineer	Afghanis tan
51	Rahguzar	Amruddin	Energy Services Regulation Authority	Mechanical Engineer	Afghanis tan
52	Ibupoto	Muhammad Yaseen	Alternative Energy Development Board,	Assistant Director-	Pakistan

Sr. No	Last Name	First Name	Department	Designation	Country
			Ministry of Energy (Power Division)	Solar Thermal /Wind	
53	Malik	Sulman Ishaq	Alternative Energy Development Board, Ministry of Energy (Power Division)	Director (Bioenergy)	Pakistan
54	Khetran	Muhammad Khalil	Alternative Energy Development Board, Ministry of Energy (Power Division)	Deputy Director (WTE)	Pakistan
55	Bulbul	Redwanoor Rahman	Rahman Renewable Energy Co. Ltd	Managing Director	Bangladesh
56	Imran	Huzaifa Bin	Evertz Microsystems	Safety and Compliance Engineer	Pakistan
57	Mehmood	Tahir	PCRET/ Ministry of Science and Technology	Deputy Director/ In-charge Biogas	Pakistan
58	Sushim Man	Amatya	Alternative Energy Promotion Center/ Ministry of Energy, Water Resources and Irrigation	Senior Bio-Energy Expert	Nepal
59	Mangi	Rafique Ahmed	HABIB SUGAR MILLS LTD.	DIRECTOR OPERATION	Pakistan
60	Aslam	Muhammad Sajjad	NATIONAL PRODUCTIVITY ORGANIZATION	MANAGEMENT ASSOCIATE	Pakistan
61	Ramanan	Dr. M.Venkata	IES, Anna University , Chennai	Professor & Director	Indian
62	K.G.	Maheswaran	IES, Anna University , Chennai	Teaching Fellow	Indian
63	Hussain	Muhammad Sajjad	Directorate of Policy, Planning, Programme, Innovation and Research (P3IR) - NEECA	Research Associate	Pakistan
64	Khan	Tanzeel Ur Rehman	NEECA	Management Trainee Officer-Technical	Pakistan
65	Khan	Muhammad Imran	CECOS University of IT & Emerging Sciences, Peshawar, Pakistan	Associate Dean for Research	Pakistan
66	Hussain	Sadam	Pakistan Council of Renewable Energy Technology	Assistant Director (Tech)- Biogas	Pakistan
67	Shaikh	Shoaib Ahmed	SUKKUR IBA UNIVERSITY	LECTURER	Pakistan
68	Das	Titu Kumar	Bangladesh Biogas Development Foundation	Executive Member	Bangladesh
69	Saeed	Muhammad Hammad	UNIDO	Project Expert-PFAN	Pakistan
70	Tariq	Muhammad	Centre of Energy Research and	Research Officer	Pakistan

Sr. No	Last Name	First Name	Department	Designation	Country
			Development, UET Kala Shah Kaku-UET Lahore		
71	Ali	Basit	Bahria University Karachi Campus	Faculty Member	Pakistan
72	Bashir	Faisal	Tawanai Solutions.	CEO	Pakistan
73	Raheem	Inaya Abdul	ENVIRONMENTAL PROTECTION AGENCY	ENGINEER-WASTE & POLLUTION PREVENTION	Maldives
74	Shaikha	Aishath	ENVIRONMENTAL PROTECTION AGENCY	ENVIRONMENTAL ANALYST-ENVIRONMENTAL COMPLIANCE AND ASSESSMENT	Maldives
75	Saam	Ahmed	State Electric Company Limited	Officer-Projects, Planning and Development Department	Maldives
76	Midhath	Mariyam Mooha	State Electric Company Limited	Assistant Engineer-Projects, Planning and Development Department	Maldives
77	Mohamed	Aminath	Utility Regulatory Authority	Environment Analyst-Waste Management	Maldives
78	Suhail	Yoosuf	Utility Regulatory Authority	Assistant Environment Officer-	Maldives
79	Shimry	Aishath Sanaya	Waste Management Corporation Limited	Assistant Manager - Business Development & Marketing	Maldives
80	Moosa	Amru Adam	Ministry of Environment Climate Change and Technology	Assistant Director-Waste Management and Pollution Control	Maldives
81	Ajmal	Ismail	Ministry of Environment, Climate Change and Technology	Senior Environment Analyst-Waste Management and Pollution Control Department	Maldives
82	Ali	Waris	Sindh Environmental Protection Agency,	Deputy Director Technical	Pakistan

Sr. No	Last Name	First Name	Department	Designation	Country
83	Ibrahim	Furugaan	Male' Water and Sewerage Company Pvt. Ltd	Senior Research and Development Engineer	Maldives
84	Hassan	Hussain	Male' Water and Sewerage Company	Business Development Officer	Maldives
85	Ibrahim	Ismail	Male Water and Sewerage Company Pvt Ltd	Assistant General Manager Operations	Maldives
86	Bilal	Hassan	"Prism Energy" a company of Infracore Asia (Singapore)	Manager Technical & Contracts (Renewable Energy Professional)	Pakistan
87	Khan	Imran Yousaf	Sui Northern Gas Pipelines Limited	Senior General Manager-Engineering Services / Compression	Pakistan
88	Majeed	Farrukh	Sui Northern Gas Pipelines Limited	General Manager-Planning & Development	Pakistan
89	Islam PK	Md Mahafuzul	Masum Bio-gas Engineering System (MBES)	Bio-gas Engineer	Bangladesh
90	Sultan	Muhammad Sharaf	Centre For Energy Research And Development (CERAD)-UET Lahore	Research Officer	Pakistan
91	Arif	Noureen	Energy Department, Government of the Punjab.	Environmental Expert	Pakistan
92	Faizan Ali	Syed	Energy Department	Manager Energy	Pakistan
93	Aftab	Roksana	Bangladesh Biogas Development Foundation (BBDF)	Research fellow	Bangladesh
94	Memon	Qasir Ali	SUKKUR IBA UNIVERSITY	LAB-ENGINEER	Pakistan
95	Kabir	Md.Enayet	Sher-e-Bangla Agricultural University	Assistant Professor	Bangladesh
96	Lamichhan	Prakash	BSP-Nepal	Executive Director	Nepal
97	Naqvi	Salman Raza	SCME - NUST	Assistant Professor	Pakistan
98	Ahmad	Mian Ilyas	NUST-Islamabad	Associate Professor-Computational Engineering	Pakistan

Sr. No	Last Name	First Name	Department	Designation	Country
99	Khan	Faizullah	CIBEA	Assistant Manager Electrical	Pakistan
100	Adhikari	Sujan	Institute of Engineering	Lecturer	Nepal
101	Islam	Md Mahobul	Bangladesh Biogas Development Foundation (BBDF),	Joint Secretary, BBDF	Bangladesh
102	Shah	Haider Ali	Creative Engineering & management Services	Project Engineer (Renewables)	Pakistan
103	Uddin	Mohammad Helal	MINISTRY OF POWER, ENERGY AND MINERAL RESOURCES	(ADDITIONAL SECRETARY (RETIRED) BANGLADESH GOVERNMENT	Bangladesh
104	Khan	Nasim Akhtar	PAKISTAN UNIVERSITY	VICE CHANCELLOR (DESIGNATE)	Pakistan
105	Khan	Sharif	UNICOL Limited	Dy. General Manager Quality Operations	Pakistan
106	Hussain	Khalid	UNICOL Limited	Dy. General Manager Operations	Pakistan
107	Adhikari	Sujan	Tribhuvan University	Lecturer	Nepal
108	Sultan	Mareed		Mechatronics Engineer	Pakistan
109	Bhattacharjee	Ujjwal	Tetra Tech ES Inc.	Renewable Energy Director	Indian

Annexure – III: Trainers’ profiles and contact details

Online Capacity Building of SAARC Professionals on Commercial Scale Biogas Plants

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Prof. Arun Kumar

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Lead Trainer:

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Engr. Shailendra Shukla, Former Chairman,

State Power and Renewable Energy Agencies, INDIA
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Mr. Chandan Gadgil,

Hon. Adviser, BAIF, Pune, INDIA;
Email: chandangadgil@gmail.com



Prof Arun Kumar is a civil engineer with specialization in water resources and hydropower engineering by education is working at Department of Hydro and Renewable Energy, Indian institute of Technology, Roorkee since 1981. He has been awarded MNRE Chair Professor (Renewable Energy) in July 2013 and again in April 2015 by IIT Roorkee. He served as independent director on Board of NHPC Ltd, Govt of India PSU during 2015-2019. His research areas are Hydropower Development, Environmental Management of Water Bodies, Energy Economics and Policy. Prof. Kumar has over 39 years of experience in the field of Hydropower and environmental management of river and lakes. He served CLA for Hydropower on SRREN for IPCC. Currently he is Vice President of Federation of Indian small hydropower. He is Bachelors in civil engineering and PhD in hydropower from IIT Roorkee, Masters in Civil Engineering from IISc Bengaluru and Hydropower Diploma studies from NTH, Norway. He is Fellow of ASCE, International association of Hydropower, Institution of engineers (India), IWRS. He was appointed as Coordinating Lead Author (chapter 5 on Hydropower) for preparing Special Report on Renewable Energy Sources (SRREN) for IPCC – working group III during 2009–11. He has been involved as international expert in various UN sponsored projects on assessment of small hydropower and Capacity Building in Zambia, Sierra Leone, Tanzania, Cambodia, Sudan and Indonesia.



Prof. Sanjeev Kumar Started his career in biogas technology in 2009-10 under Biogas Development and Training Centre, (MNRE) Uttarakhand as Sr. Research Fellow. During the tenure, he was involved in the field level survey, training to professionals and research work related to biogas technology implantation in the state of Uttarakhand and part of Uttar Pradesh. He then moved to IIT Delhi in 2011 for Ph.D. from Centre for rural Development at IIT Delhi. During his PhD, he worked in close association with the BDTC IIT Delhi in the area of biogas technology. Since 2011, Prof. Sanjeev is researching the biogas production from algal biomass and cattle dung. He recently completed a one-year-long pilot-scale testing of algal-cattle dung based biogas plant at IIT Delhi. At IIT Roorkee, he is guiding research scholar for improving the biogas production algal biomass with various technological interventions. Valorization of the bio-manure obtained from biogas plants for different applications is another central theme of his current research. In September 2020, he was acted as a member of the team formulated by IIT Roorkee for technical inspection of cattle dung based bio-CNG plant situated in Haridwar district. Besides, he is also leading the formulation of a research and development project to improve the commercial and technical viability of the bio-CNG plants based on locally available different feedstock. He has published several high-quality research articles on biogas production from algal and cattle dung biomass along with the biomass pretreatment for high methane yield.



Prof. Pratham Arora is currently an Assistant Professor, Department of Hydro and Renewable Energy, IIT Roorkee. Prior to joining IIT Roorkee, he was a Post-doctoral fellow at the Georgia Tech., Atlanta in the Industrial and Systems Engineering Department. At Georgia Tech., his research was focused on process optimization, techno-enviro-economic analysis and life cycle assessment (LCA) of algal biofuels, syngas fermentation, solar fertilizers and direct air capture systems. He was working in collaboration with highly innovative sustainable fuels companies such as Algenol biofuels, Lanzatech and Global Thermostat. Dr. Arora has completed his doctorate from IITB-Monash Research Academy – a joint venture between IIT-Bombay, India and, Monash University, Australia. His thesis was entitled “Techno-enviro-economic evaluation of ammonia production from biomass gasification using multi-scale modelling.” The project was funded by Orica Mining Ltd. His Ph.D. thesis quantified the effect of biomass composition, process configuration, the supply chain, and the national economic and environmental scenario on the life cycle costing and LCA of the biomass-to-ammonia process. Such an analysis is expected to provide the decision makers with consistent and comparable data to objectively judge the viability of any renewable energy technology. This work has been published in high quality journals including Industrial and Engineering Chemistry Research, Journal of Cleaner Production, and Chemical Engineering Research and Design. His research has also been awarded as the best collaboration by the IITB-Monash Research Academy. Presently, he is extending this research to production of different sustainable fuels and chemicals



Prof. Deepak Sharma Prof. Deepak Sharma worked as Professor in the Department of Renewable Energy Engineering, College of Technology and Engineering, Udaipur (Rajasthan). He has 38 years’ experience of teaching as well as conducting research & extension activities in the field of New and Renewable Energy Sources particularly small and large capacity biogas plant installation and commissioning. Prof. Sharma is recently nominated as Expert Member in the National New Biogas Plant Appraisal and Evaluation Committee (NBPEAC) constituted by the Hon’ble Minister, Ministry of New & Renewable Energy, Government of India. He has guided 8 Ph. D. scholars, 22 M Tech students and more than 45 B Tech students as Major Advisor. Dr Sharma is Divisional Editor for Journal of Agricultural Engineers (Energy and other Areas Division) published by Indian Society of Agricultural Engineers, New Delhi.



Mr. Srinivas Kasulla After achieving the merit rank in his post-graduation in Environmental studies, Srinivas Kasulla is active in working with NGO’s as well as private institutions on waste management as well as on Biogas plant installations. Following his successful work he was appointed as the core team member in top Biogas companies from India where he has been responsible for the whole project management, as well as execution of construction, installation work and biological commissioning since 2004. In addition, Srinivas is instrumental and taking responsibility for biogas development in Indian Market. Srinivas has worked as Vice President for leading biogas companies in India. At present Srinivas is working as an independent

consultant on waste to biogas projects where he has extended his sphere of responsibility as an overall project developer. Srinivas was instrumental in designing, installing and commissioning more than 150 biogas plants across the country.



Dr. Atma Ram Shukla superannuated as Adviser (Bio-energy), in the pay scale of Joint Secretary, from the Ministry of New and Renewable Energy, Government of India, New Delhi in September 2011 after working for about twenty-nine years. In all, he has about forty-two years of experience in policy, planning and developing RD&D projects on Renewable energies at National level, devising dissemination programmes along with its implementation, development of standards, and involvement in country wide monitoring focused at reaching the last mile.



Mr Shailendra Shukla, a technocrat with excellent reputation in the field of Power-Energy, Bio-fuel & Rural Development; having decades of association and expertise in these fields. He was Director/CEO/MD/Chairman for about 20 years out of total service of 38 years. Last position held was Chairman–Western Region Power Companies and Chairman, Chhattisgarh State Power Companies. He was Chairman, Haryana State Renewable Energy Development Agency (HAREDA) and Director/CEO of Chhattisgarh State Renewable Energy Development Agency (CREDA) for 16 years. He had been a part of UNDP and UNEP funded multi country projects and visited more than 25 countries of the world. He had opportunity to lead a multi-activity flagship project on “Integrated Energy Management Master Plan for the Nation. The first kitchen-waste based cooking gas plant was established in CEAT factory, Gwalior on his concept & design. The same types of plants (on same design) were repeated in RPG transmission-Nagpur, BAJAJ-Pune, Hotel Rishi Regency-Jabalpur and Mourya-Sheraton-Delhi. He designed and set up a 2800 cum. Starch-waste based Bio-methanation plant for power generation at Rajnandgaon of Chhattisgarh in 2003, ever first project of its kind in India; running a gas engine of 350 KVA using methane. He designed and set up a 3TPD capacity trans-esterification plant for producing Bio-diesel at Raipur, Chhattisgarh in 2005; ever first project of its kind in India.



Mr Chandan Gadgil is an Electrical Engineering from University of Mumbai India. He has been a serial entrepreneur having worked in the field of IT and Renewable energy (Large Biogas plants, Biogas power, Bio CNG). In 2012, after his company was bought out, he decided to give back to society in whatever way possible and to work in the development sector. In 2013 he joined BAIF Development and Research Foundation, Pune, India, as a Hon Advisor, Renewable energy. BAIF is a grass root Development NGO, established in 1967. He also is a founder trustee of an NGO called Sankalp Medi Education Society, Pune working to support new ideas like sustainable agriculture. He, together with BAIF Pune, has developed a low cost, compact and user friendly BAIF slurry filter

(patent applied jointly with BAIF). for filtering Biogas slurry into slurry cake and liquid from family size biogas plants. As a part of Residue management, also developed a proprietary process to manufacture (BIOPROM) a value-added phosphate rich organic product from the slurry cake. BIOPROM can reduce/replace phosphatic chemical fertilisers, improve soil productivity and livelihood for the farmer. A special Bioinoculum (patent applied) used in the BIOPROM process is developed by him together with BAIF, Pune.

Annexure – IV: Technical presentations

Attached separately

Annexure – V: List of suggested reading materials

Books/Technical Reports/Documents

- Deublein, D., & Steinhauser, A. (2011). Biogas from waste and renewable resources: an introduction. John Wiley & Sons.
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- World Bioenergy Association (2020). Global Bioenergy Statistics 2020.
- International Energy Agency (2020a). Outlook for biogas and biomethane: Prospects for organic growth - World Energy Outlook Special Report.
- Possible Uses of Crop Residue for Energy Generation Instead of Open Burning, report published by SAARC Energy Centre, December 2019
- Global Bioenergy Statistics 2019, World Bioenergy Association
- Biomass Management for Energy Purposes – Issues and Management, Edited by Pathak B S and Srivastava N S L. Published by SPRERI, Vallabh Vidyanagar, INDIA
- Biogas Production, Upgradation and Slurry Management, Edited by V K Vijay. Narosa Publishing House Pvt. Ltd., New Delhi, INDIA
- Guide to biogas: from production to use. (2012) Fachagentur Nachwachsende Rohstoffe e.V. (FNR).
- Biogas Systems: Principles And Applications by Dr. K M Mital , New Age International (P) Ltd.
- Biogas From Waste And Renewable Resources: An Introduction: Second, Revised & Expanded Edition by Deublein D, John Wiley

Research papers:

- Abbas, I., Liu, J., Noor, R. S., Faheem, M., Farhan, M., Ameen, M., & Shaikh, S. A. (2020). Development and performance evaluation of small size household portable biogas plant for domestic use. Biomass Conversion and Biorefinery, 1-13.
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- Ministry of Economic Affairs (2020). Domestic Biogas Implementation Guideline, Department of Renewable Energy, Ministry of Economic Affairs, Thimphu, Bhutan.
- MoFE. 2021. Assessment of Electric Cooking Targets for Nepal's 2020 Nationally Determined Contributions (NDC), Ministry of Forests and Environment (MoFE), Kathmandu.
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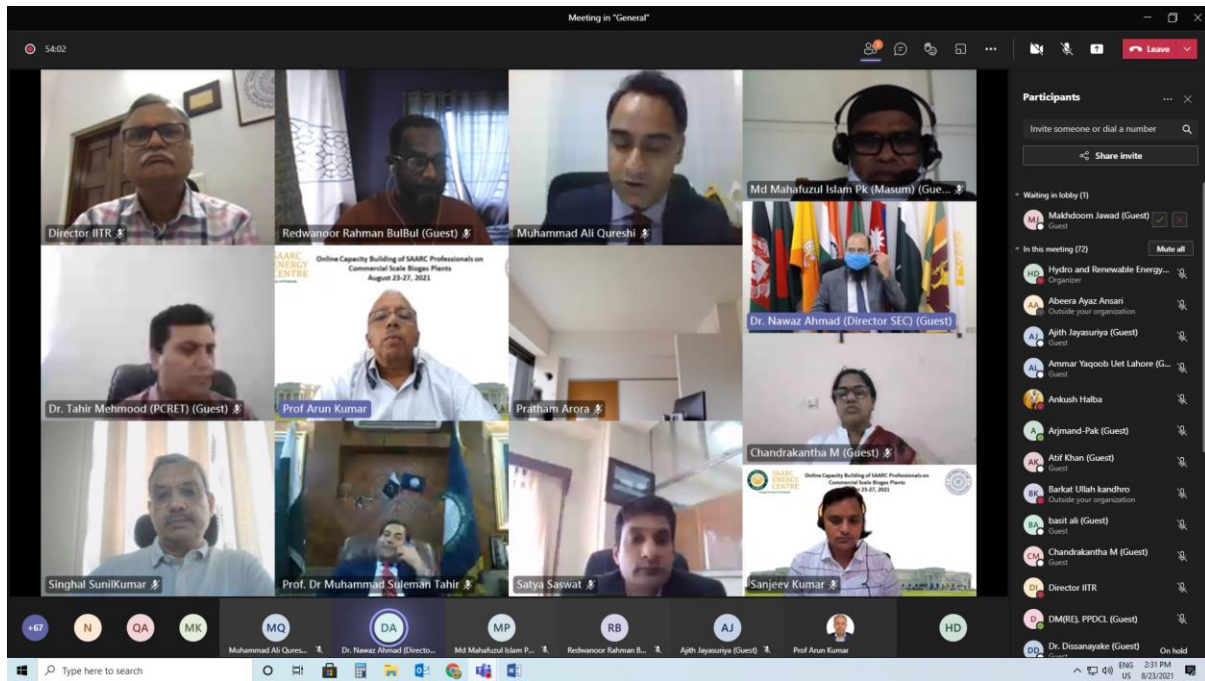
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Webpages:

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- <https://idcol.org/home/dbiogas>
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- <https://www.globalmethane.org/challenge/mnre.html>
- <https://gandakiurja.com/>
- <https://bo2.com.np/investment-made/gandaki-urja/>
- <https://timesofindia.indiatimes.com/city/ahmedabad/banas-dairys-first-bio-cng-outlet-opened/articleshow/77880158.cms>
- www.irena.org/statistics
- <https://www.biogasworld.com/biogas-plant-troubleshooting/>
- <http://www.knowledgebank.irri.org/step-by-step-production/postharvest/rice-by-products/rice-straw/off-field-rice-straw-management>
- https://www.mahaurja.com/meda/data/off_grid_bio_energy/Success%20Story%20on%20%20Bio%20CNG.pdf

Annexure – VI: Screenshots during the sessions

Session on Aug 23rd, 2021



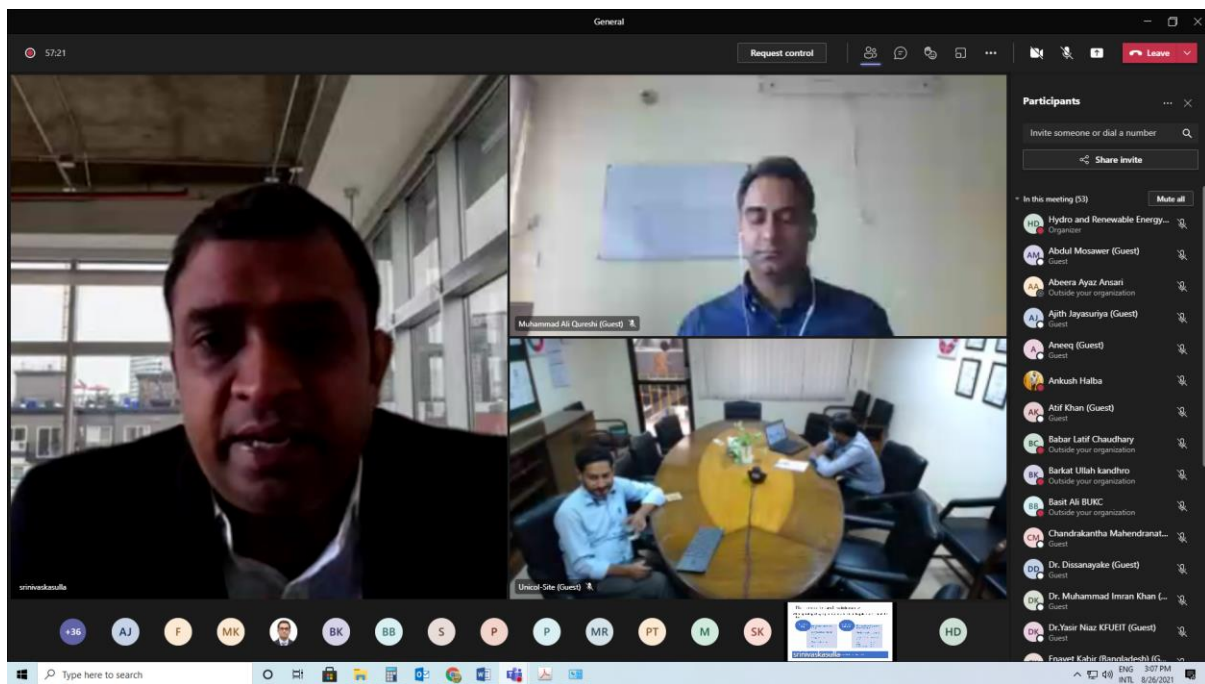
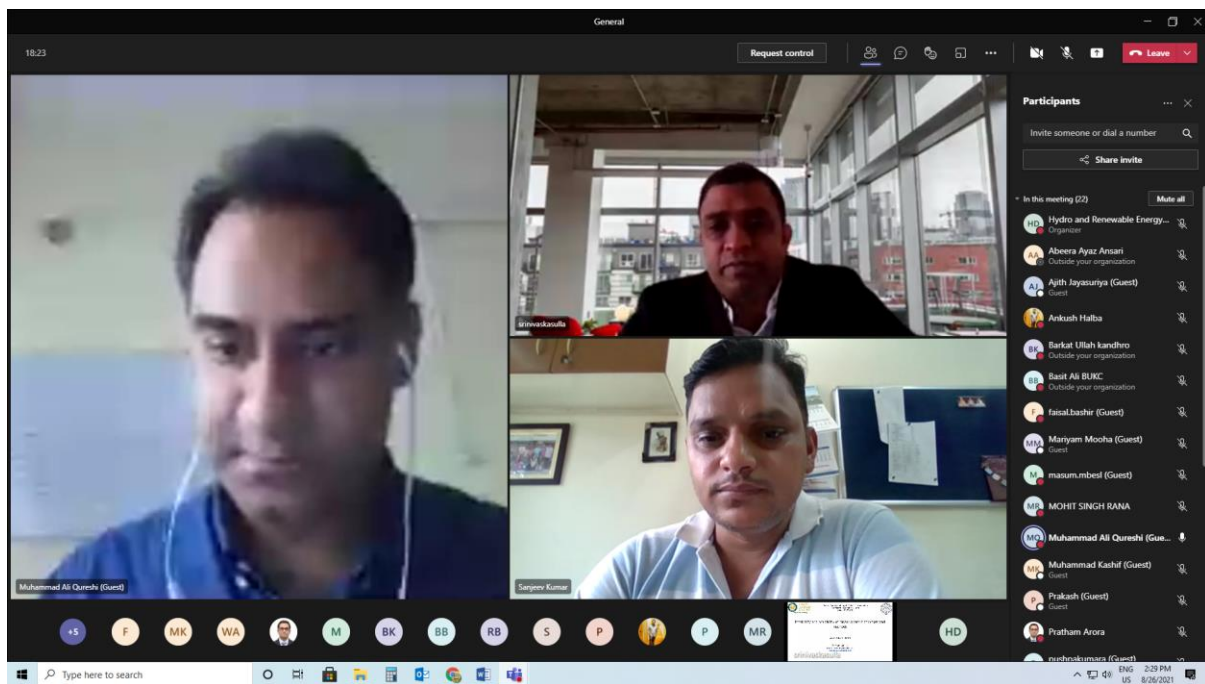
Session on Aug 24th, 2021



Session on Aug 25th, 2021



Session on Aug 26th, 2021





Aug 27th, 2021

