उच्च प्रौद्योगिकी केन्द्र
(पेट्रोलियम एवं प्राकृतिक गैस मंत्रालय, भारत सरकार)
Centre for High Technology
(Ministry of Petroleum & Natural Gas, Govt. of India)

सीएचटी/एसएसी-84/
CHT/SAC-84/ 1656

2 मई 2019
2nd May 2019

सेवा में/ To,

पेट्रोलियम और प्राकृतिक गैस मंत्रालय की हाइड्रोकार्बन पर वैज्ञानिक सलाहकार समिति के अध्यक्ष, सदस्यगण, स्थायी व विशेष आमंत्रित अतिथिगण।
(संलग्न सूची के अनुसार)
Chairman, Members, Permanent & Special Invitees of Scientific Advisory Committee (SAC) on Hydrocarbons of MoP&NG
(as per list attached)

विषय: पेट्रोलियम और प्राकृतिक गैस मंत्रालय की हाइड्रोकार्बन पर वैज्ञानिक सलाहकार समिति (SAC) की 84वीं बैठक का कार्यवृत्त

Sub: Minutes of 84th Meeting of the Scientific Advisory Committee (SAC) on Hydrocarbons of Ministry of Petroleum & Natural Gas

प्रिय महोदय/महोदया / Dear Sir/Madam,

आपकी सूचना एवं आवश्यक कार्यवाही हेतु दिनांक 22 अप्रैल, 2019 मुंबई में सम्पन्न पेट्रोलियम और प्राकृतिक गैस मंत्रालय की हाइड्रोकार्बन पर वैज्ञानिक सलाहकार समिति की 84वीं बैठक के कार्यवृत्त की प्रतिलिपि संलग्न की जा रही है।

Enclosed please find a copy of the Minutes of 84th Meeting of the SAC on Hydrocarbons of Ministry of Petroleum & Natural Gas held on 22nd April, 2019 in Mumbai for your kind information and necessary action.

सादर,
With kind regards,

भवदीय,
Yours sincerely,

(के.के.जैन)
कार्यकारी निदेशक
(K.K.Jain)
Executive Director

Copy for information to:

- **Secretary, P&NG**
- **Chairman IOCL**
- **CMD BPCL / HPCL / EIL**
- **MD MRPL / CPCL / NRL**

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Scientific Advisory Committee (SAC) on Hydrocarbons

1.	Dr. Anil Kakodkar, Bhabha Atomic Research Centre, 7th Floor, Central Complex, Trombay, **Mumbai – 400 085**	Chairman
2.	Dr. R. Kumar, Professor Emeritus, Department of Chemical Engineering, Indian Institute of Science, Bangalore, **Bengaluru – 560 012**	Member
3.	Prof. J.B. Joshi, Professor Emeritus, Homi Bhabha National Institute, Anushakti Nagar, **Mumbai – 400 094**	Member
4.	Dr. M.O. Garg, Head-Refining & Petchem R&D, RTG, Reliance R&D Centre, Reliance Corporate Park, Bldg.No. TC 30B, 2nd Floor, 'B' Wing, Thane-Belapur Road, Ghansoli, **Mumbai – 400 701**	Member
5.	Prof. A.B. Pandit, Dean, Institute of Chemical Technology, Nathalal Parekh Marg, Matunga (East), **Mumbai – 400 019**	Member
6.	Dr. Shashi Kant, Scientist Emeritus, Indian Oil Corporation Ltd., R&D Centre, Sector-13, **Faridabad – 121 007**	Member
7.	Prof. Shankar Narasimhan, Indian Institute of Technology Madras, Sardar Patel Road, Adyar, **Chennai – 600 036**	Member
8.	Dr. R.K. Malhotra, Director General, Federation of Indian Petroleum Industry (FIPI), PHD House, 4/2, Sri Institutional Area, August Kranti Marg, **New Delhi – 110 016**	Member
9.	Shri B.V. Rama Gopal, Director (Refineries), Indian Oil Corporation Ltd., SCOPE Complex, Core-2, Lodhi Road, **New Delhi – 110 003**	Member

10.	Shri R. Ramachandran, Director (Refineries), Bharat Petroleum Corporation Ltd., Bharat Bhawan, 4&6 Currimbhoy Road, Ballard Estate, **Mumbai – 400 001**	Member
11.	Shri V.S. Shenoy, Director (Refineries), Hindustan Petroleum Corporation Ltd., 17, Jamshedji Tata Road, **Mumbai – 400 020**	Member
12.	Dr. S.S.V. Ramakumar, Director (R&D), Indian Oil Corporation Ltd., R&D Centre, Sector-13, **Faridabad – 121 007**	Member
13.	Shri L.K. Vijh, Director (Technical), Engineers India Limited, El Bhawan, 1, Bhikaiji Cama Place, **New Delhi – 110 066**	Member
14.	Dr. Sanjeev Katti Director General, ONGC Energy Centre, 15th Floor, South Tower, Core-4, SCOPE Minar Complex, Laxmi Nagar, **New Delhi – 110 092**	Member
15.	Shri Manoj Jain, Director (BD), GAIL (India) Ltd., 16, Bhikaiji Cama Place, **New Delhi - 110 066**	Member
16.	Shri Diwakar Nath Misra, Secretary, Oil Industry Development Board, OIDB Bhawan, Sector – 73, **NOIDA – 201 301**	Member
17.	Shri Alok Tripathi, Executive Director, Petroleum Conservation Research Association, Sanrakshan Bhawan, 10, Bhikaiji Cama Place, **New Delhi – 110 066**	Member
18.	Smt. Rashmi H. Urdhwareshe, Director, Automotive Research Association of India, S.No. 102, Vetal Hill, Off. Paud Road, Kothrud, **Pune – 411 038**	Member

19.	Dr. Anjan Ray, Director, CSIR – Indian Institute of Petroleum, P.O.IIP, Mohkampur, **Dehradun – 248 005**	Member
20.	Dr. V.P. Joy, Director General, Director General of Hydrocarbons, OIDB Bhawan, Tower A, Sector 73, **NOIDA – 201 301**	Member
21.	Shri K.K. Jain, Executive Director, Centre for High Technology, OIDB Bhawan, Plot No. 2, Sector-73, **NOIDA – 201 301**	Member-Secretary
22.	Shri Sandeep Poundrik, Joint Secretary (Refineries), Ministry of Petroleum & Natural Gas, Shastri Bhawan, **New Delhi – 110 001**	Permanent Invitee
23.	Shri Sanjay Bhargava, Executive Director (CRDC), Bharat Petroleum Corporation Ltd., Corporate R&D Centre, Plot No. 2 A, Udyog Kendra, Surajpur Industrial Area, **Greater NOIDA – 201 306**	Permanent Invitee
24.	Shri G. Sriganesh, Executive Director (R&D), HP Green R&D Centre, KIADB Industrial Area, Tarabahalli, Devanagundi, Hoskote, **Bengaluru – 560 067**	Permanent Invitee
25.	Shri R. Srikanthan, Director (Technical), Chennai Petroleum Corporation Limited, Manali, **Chennai – 600 068**	Permanent Invitee
26.	Ms. Vartika Shukla, Executive Director (T), R&D Centre, Engineers India Limited, Sector-16, **Gurgaon – 122 001**	Permanent Invitee
27.	Shri M.R. Meshram, Executive Director (PC&R&D), GAIL India Limited, 8th Floor, Jubilee Tower, B- 35-36, Sector – 1, **NOIDA – 201 301**	Permanent Invitee

May 02, 2019

Minutes of 84th Meeting of Scientific Advisory Committee (SAC) on Hydrocarbons of MoP&NG

1. The 84th Meeting of SAC was held on 22nd April 2019 at Trident Hotel, Bandra Kurla Complex, Mumbai. The meeting was chaired by Dr Anil Kakodkar, Chairman, SAC.

The list of participants is enclosed as **Annexure-1**.

2. Shri K.K. Jain, ED (CHT) welcomed the Chair, JS (R) & other members of SAC.

3. ED (CHT) presented over view of the agenda as under;

a. Discussion on 'Pradhan Mantri Jl-VAN yojana'

b. ATRs of last SAC

c. Review of on-going R&D projects

d. Discussion on following new R&D Project Proposals:

i. Setting up of Compact Reformer Unit of capacity 4 TPD for producing Hydrogen blend CNG (H-CNG) and trials demonstration at Rajghat Bus Depot at Delhi NCR: IOC R&D

ii. Identification and Cultivation of suitable micro algal strains for sustainable biodiesel production on large scale: Amity University, Gurgaon

iii. Development of Protective Coatings for Corrosion Protection in Oil & Gas Pipelines: CIPET Chennai

e. Discussion on new ideas:

i. Methanol production from recycled CO_2 & Renewable H_2

ii. Hydrogen production and distribution by using low-carbon electricity from its nuclear and renewable sources

f. Status of other SAC recommended/discussed project proposals:

i. Solar based H_2 production system & dispensing station for refueling hydrogen fuel cell vehicle: IOC R&D

ii. Design & Development of Fibre Optic gas Sensors for compositional analysis of CO & H_2S : CSIO Chandigarh/BPCL

iii. REcovery of Heat from Efflux in A Tesla turbine: IIT-KGP/EIL/IOCL/BHEL

4. Chairman, SAC, welcomed the members. He initiated the discussion by referring important agenda item on 'Pradhan Mantri Jl-VAN yojana', the Government initiative to

launch 2G Ethanol projects. He mentioned that surplus agri-residue alone can contribute to enough ethanol production to replace use of gasoline and contribute to corresponding reduction in crude import. Besides, there is significant potential for decentralized production of Compressed Biogas (CBG) from biomass/MSW to augment gas supply particularly in rural areas where demand for cooking gas is expected to grow substantially. Currently, the production cost of 2G Ethanol is high and government has launched the scheme to at least partially bridge the costs. The challenge is to bring down the production cost for 2G Ethanol through R&D interventions to viable levels at the earliest. He also mentioned other important items to be discussed in the meeting. Particularly the need to speed up conversion of coal to gaseous/liquid fuels, conversion of CO_2 to chemicals and fuels which is also gaining interest as the cost of non-fossil hydrogen and CO_2 capture are likely to come within the viability domain.

5. It was informed that Govt has launched a scheme 'PRADHANMANTRI JI - VAN YOJANA' to promote 2G ethanol technology. The scheme covers broad guidelines, scope, and implementation mechanism. Under this scheme 12 commercial projects and 10 demonstration projects will be supported. For commercial projects, the maximum financial support per project has been capped at Rs 150 crore. For demonstration projects, the financial assistance will be limited to Rs. 15 crore per Technology. SAC will be the Nodal Body for recommending the eligible Project proposals & CHT will be the Nodal Agency for implementation of the scheme. Recommended projects shall be approved by Steering Committee under the chairmanship of Secretary, PNG. CHT shall float EOI for inviting proposals from eligible project developers. SAC shall form a sub group for shortlisting the proposals. CHT shall be handling the money directly under the scheme. Proposals shall be received from private sector also as per the eligibility criteria.

6. Pradhan Mantri JI-VAN yojana

ED (CHT) made a detailed presentation to SAC on 'Pradhan Mantri JI-VAN (Jaiv Indhan Vatavaran Anukool fasal awashesh Nivaran) yojana'. Following salient points were discussed:

i. Government of India approved this scheme on 28.02.2019 & published on 07.03.2019. Under this scheme financial support shall be provided to Integrated 2G Bioethanol Projects using Lignocellulosic Biomass (LCB) & other Renewable feedstock. The scheme provides guidelines, policy framework & mechanism for selection and implementation of 12 Commercial and 10 demonstration scale 2G Ethanol Projects.

ii. SAC, as nodal body, will appraise and recommend eligible Project proposals and CHT, as nodal Agency for implementation of the scheme, shall provide Secretarial assistance to SAC for selecting eligible Project Developers. Projects recommended by

SAC will be approved by Steering Committee of CHT under the chairmanship of Secretary, MoP&NG. CHT would maintain grant received under this scheme in a separate bank account.

iii. Year wise financial support (Total of Rs 1969.50 Crore):

Year	Phase- I (2018-19 to 2022-23)		Phase- II (2020-21 to 2023-24)		Administrative charges to CHT
	Commercial Projects	Demonstration projects	Commercial Projects	Demonstration projects	
2018-19	-	-	-	-	-
2019-20	-	37.50	-	-	0.375
2020-21	225	37.50	-	37.50	3.00
2021-22	450	-	225	37.50	7.125
2022-23	225	-	450	-	6.75
2023-24	-	-	225	-	2.25
TOTAL	900	75	900	75	19.50

iv. Background:

a. GOI's target to reduce import dependence i.e. usage of fossil fuels by 10% from current levels by the year 2022.

b. GOI announced Biofuel policy in 2018, under which:

- OMCs to blend ethanol up to 10% in gasoline by 2022 on Pan India basis, for which 450 Crore liters of ethanol required.
- Blending Target by 2030: 20% in Petrol and 5% in Diesel

c. The current estimated bioethanol production is 300 Crore liters which is mainly for potable alcohol and chemical industries and balance for EBP (Ethanol Blending Petrol).

d. Though OMCs are allowed to procure ethanol produced from 1G routes (from B heavy molasses, sugarcane juice, damaged food grains & surplus food grains), still that is not sufficient for 10% target. Therefore, there is need for other options/routes (2G/3G).

e. GOI has already allowed procurement of ethanol produced from other non-food feedstock.

f. 12-16 crore TPA of surplus Lignocellulosic biomass is available in the country with potential ethanol production of 2500 to 3000 crore liters per annum.

v. Advantages of 2G Ethanol Biorefineries

a. Feedstock for 2G Ethanol Biorefineries includes Ligno-cellulosic biomass, MSW, Landfills.

b. Products from 2G Ethanol Biorefineries includes 2G Ethanol, Pellets (from Lignin), Biogas to Bio-CNG, liquid CO2/dry ice (use in Poly Houses & Cold Storages), & quality composite (which will increase farm yields & reduce chemical fertilizer consumption)

c. Potential to manufacture high value by-products such as Furfural, Xylitol, L-Arabinose, high fructose syrup etc. which may increase profitability in the processes involved.

d. Stop burning of crop residues which will in turn stop air pollution by particulate matter.

e. Provide remunerative income to farmers for their otherwise waste agriculture residues.

f. Employment in Biomass Supply Chain & Bio Refinery

vi. Eligibility for Project Developer (PD)

PD: Any Company, Consortium of Companies or a Joint Venture (JV) / Special Purpose Vehicle (SPV) shall meet any one of the following criteria*:

a. Experience in Crude Oil Refining

b. Experience in Chemical or Petrochemical production/ handling.

c. Experience in marketing of fossil fuels or Biofuel blended fossil fuels.

d. Experience of manufacturing/ marketing of Renewable fuels (Bioethanol, Biodiesel, Biomethanol, Bio-CNG, Drop-in fuels)

e. Experience in Production/handling of large quantities of waste biomass such as plywood, Bagasse, wood chips etc.

f. Technology licensor having technology for converting Biomass into 2G Ethanol.

g. A Central Govt. or State Govt. Department, PSU or a local civic body with a mandate of addressing environment pollution.

h. A reputed Research Institution & Educational Institution registered with Govt. of India. (applicable only for Demonstration projects)

*The eligibility criteria may be reviewed and suitably amended by SAC in the interest of achieving the targets envisaged in the Scheme.

vii. Objectives

- Expedite setting up of 2G Ethanol bio-refineries in India and bring in economic viability in the projects.
- Kick start the development by setting up commercial projects and setting benchmarks for development and indigenisation of technologies used for the commercial projects.
- Develop reliable Indian Vendors/ Sub Contractors for Cellulosic Ethanol Plants & Co-Products Plants.
- Develop Biochemical engineering & service support systems (customized for Indian feedstock) for such Plants.
- Establish sustainable collection & transport systems, for crop residues (e.g. paddy straw, cane trash) along with Biomass Depots management systems, to be operated by entrepreneurs (utilizing NABARD & MNREGA schemes, where applicable)
- O&M systems (customized for Indian conditions – ambient, labour, etc.) & Manpower Training.
- Efficiently transporting biomass from Depots to Bio-Refineries, to optimize biomass cost.
- Facilitate Indian production of Enzymes through economies of scale & establishing techno-economic viability of producing Cellulosic Ethanol, in India, from wastes related to Rice, Sugarcane, Cotton & Maize cultivation.
- Scaling up of sizes of projects thereby leading to economies of scale.
- Provide long-term visibility and road map for development of bio-ethanol technologies enabling creation of India as manufacturing hub in the Biomass to Bioethanol.
- Bioethanol produced from these projects may earn carbon credits.
- MSW based projects will also address the problem of MSW & landfills which causes soil and water pollution.
- To create good business model and systems for various State Governments and indigenous investors and technology developers.

viii. Role of SAC

- Invite Representatives from concerned Ministries / Departments viz. Ministry of Environment, Department of Agriculture, Ministry of Housing & Urban Affairs, MNRE, DBT, D/oRD and D/oCP during discussions/meetings related to the scheme to ensure synergy.
- Decide selection criteria for selection of eligible PDs & lay additional conditions at the time of sanction of grant in order to safeguard the interest of the Government and ensure timely completion of the projects. The same may be reviewed & updated by the SAC from time to time.
- Decide selection procedure, timelines for proposal submission & their subsequent evaluation
- Prescribe an appraisal system & requirements
- Review the minimum distance criteria of the proposed Biorefinery with other Advanced Biofuel projects based on biomass availability at the proposed location by PD, on case to case basis.
- Decide milestones against VGF payment for demonstration projects.

ix. Role of CHT

- The PD, on the award of grant, to sign agreement with CHT to ensure timely completion of projects & to safeguard interest of the Government.
- PDs and CHT shall enter into suitable Agreement creating a charge over the Project assets in favour of CHT and for ensuring the disbursement of grant to credible PDs. CHT shall have a pari passu charge over the Project assets in case of Projects being financed by other lending institutions/banks.
- Maintain necessary guarantees and legal formalities.
- Incorporate suitable provisions regarding arbitration and seat of arbitration in the agreement to be entered between CHT and selected PDs under the scheme.
- In case the lending institution exercises its right to step in or take over the project, CHT will also have right to step in along with the lending institution.
- Regular monitoring and periodic evaluation of project compliance with the agreed milestones as per the agreement.
- Project cannot be transferred or sold to a third party without consent of the Government.

- Incorporate suitable provisions regarding arbitration and seat of arbitration in the agreement to be entered between CHT and selected PDs under the scheme.

x. Project Cost elements

- Land cost
- Total equipment and their erection including biomass supply chain and handling
- Civil & mechanical work including plant building & sheds
- Cost of utilities, electrical & instrumentation controls
- Enabling assets (water & power intake)
- Water and waste management system
- Preoperative and commissioning charges
- Working capital
- Interest during construction
- Charges of technology, royalty,
- Charges towards PMC/EPCM services
- Charges of any special erection involved
- Contingent expenses.

xi. Commercial projects

- VGF (Viability Gap Funding) amount for commercial projects shall be minimum of the following:
  - 20% of the project cost
  - Rs 5 crore for every 10 lakh litres summed to annual name plate capacity
  - Rs 150 crore.
- PD can also obtain grant from State Governments/PSUs/Other Agencies up to 20% of the total project cost. Total grant from Central Government and State Government/ PSUs/other Agencies shall not exceed 40% of the total project cost.
- Proposed Technology of the PD should have been demonstrated at one fiftieth ($1/50^{th}$) or higher Capacity, in India or elsewhere.
- Operational data of 3 months (cumulative or continuous) duration of at least 50% capacity of demonstration/commercial plant OR 1 month (cumulative or continuous) duration for name-plate (100%) capacity of the

demonstration/commercial plant of the proposed Technology for the project, needs to be shared with SAC at the time of invitation to RFS, for ascertaining the performance of Technology.

- The Commercial Projects should be designed for inter-connection with the OMC depots. The PD should ensure the connectivity of OMC depot before commissioning the project for efficient delivery of 2G Ethanol.
- Milestones for release of financial assistance/ grant:

Project Milestones	**% of Grant payment**
Erection/ Installation of Proprietary equipments	25%
Completion of mechanical erection of the Project	25%
On reaching 25% of annual production capacity of design value subsequent to mechanical completion and commissioning of Project	25%
On reaching 75% of annual production capacity of design value	25%

xii. Demonstration projects

- Annual 2G Ethanol generation capacity: 3.75 to 11.25 Lakh litres & Feedstock capacity: 5 - 15 TPD
- The financial assistance maximum Rs 15 crore per project (only 1 project per Technology).
- Proposed Technology of the PD should have been demonstrated to convert Biomass to Ethanol at laboratory level.
- The purpose of supporting Demonstration projects is to enthuse Technology providers to display viability & performance of their novel technologies. Thus, three months (continuous or cumulative) Operational data of the proposed technology needs to be shared with SAC at the time of invitation to RFS for ascertaining the performance of Technology.
- The eligible PDs under Demonstration project will ensure that their projects are run on at least 50% of their name plate capacity for at least 3 months (cumulative or continuous) in a year, for a period of at least 5 years. Ethanol generated from such runs shall be made available to OMCs for blending in Petrol.

xiii. Requirement to be fulfilled by PD

- Submit DFR along with Biomass/waste Assessment, supply chain & logistics report duly vetted by a Third party consultant.
- DFR should indicate the following:
  - Cost of technology procurement
  - Cost of establishment of plant
  - Royalties & consultations
  - Other incidentals which will require payment to outside agencies from India.
  - Sales revenue generated from sale of 2G Ethanol & other by-products
- PD will have to mandatorily undertake Ethanol Purchase Agreements (EPA) with OMCs in prescribed format for assured procurement of ethanol.
- Entire 2G ethanol produced from Commercial projects supported under this Scheme shall be mandatorily supplied to OMCs for blending in Petrol.
- Project proposals will be based on the prevailing Ethanol price fixed by the Government. Projects will also be eligible for policy provisions arising out in future.
- Project proposals to be based on integrated approach for end to end utilization of biomass for production of ethanol and other value added products. Bioethanol should meet BIS standards.
- PD should have Technology licensing Agreement with their proposed Technology provider.
- The proposed land for the project shall be available with PD before submitting its application to the RFS.
- The PD should have committed source for enzymes.
- The PD should have undertaken trials of proposed Technology and proposed feedstock for the project. Results of such trials need to be shared at the time of RFS. (For Demonstration projects, the PD needs to share laboratory or any other scale results)
- PD to have entered into EPCM Contract/ other execution mode as PMC & EPC/ OBE with reputed organization having proven track record. Preference will be accorded to applicants, whose EPCM/ PMC & EPC/OBE Contractor has established operations in India and, thereby, can optimize local sourcing.

- All proposals should be annexed with the validated life cycle analysis (LCA) report of the proposed 2G Ethanol Technology for meeting the eligibility criteria of advanced biofuels. (Not applicable for demonstration projects)
- Since 2G Ethanol Biorefineries are risk projects owing to various variables such as technology performance, feedstock supply chain, enzyme cost etc., PD shall have entered into a
  - Three years (with a renewable option of two years) contract for operation and maintenance from the vendor/technology supplier or by the PD himself.
  - Three years (with a renewable option of two years) contract for supply of biomass which can be revised as per the mutual consent of the Biomass supplier as well as Bioethanol project developer.

xiv. Other general conditions

a. Each Technology applying under Commercial projects will be eligible for maximum of **four** projects. If any additional projects(s) are possible within budget of the scheme, fifth project or more may also be considered by the SAC in case the proposals with other technologies are not received against RFS.

b. PDs which have commenced mechanical erection of their projects before starting of this scheme will not be eligible to avail the benefits of the scheme.

c. Twelve 2G Ethanol Projects of Oil PSUs, as notified to MoP&NG, will not be covered in the clause above and shall be eligible for availing the benefits of scheme, if required, in case the mechanical erection of the Project has been commenced but not completed.

d. Foreign investors proposing to set up 2G Ethanol Project in India are also eligible for availing the benefits of the scheme. However, all statutory provisions related to foreign investment in such projects i.e., FDI limit etc. would be applicable.

e. Decision of the SAC and Steering Committee with regard to selection of PDs eligible under the scheme shall be final & binding on all interested PDs.

f. SAC will review the minimum distance criteria of the proposed Biorefinery with other Advanced Biofuel projects based on biomass availability at the proposed location by Project developer, on case to case basis.

g. "Bolt on" plants & "Brownfield projects" are not eligible under the scheme.

h. PD shall be liable for all IPR, licencing and foreign trade issues during the period of the project.

i. The PD, on the award of grant, is required to sign a contract agreement with CHT to ensure the timely completion of the projects set up under the scheme and to safeguard interest of the Government.

Director (R&D), IOCL, emphasized that project developer should get first right of refusal and the licensing should be non-exclusive.

Director (R), BPCL informed that there are limited technology providers available in 2G Ethanol sector and the projects are fraught with risks such as nascent technology, supply chain management, etc. Director (R), BPCL further requested that promulgation of mandates on advanced biofuel may help in setting up these projects at an early date.

Prof. R. Kumar referred a report from MIT that production of 2G ethanol at a cost of $ 2.6 per gallon (Rs 50-55 per liter) must be targeted to make it techno-economically viable.

Chairman SAC was of the view that 2G bioenergy, apart from contributing to energy and environment security, would significantly impact rural economy. A proper framework for collection and preprocessing of biomass should be carefully thought through for successful and healthy implementation of this program. and for that co-operative approach is must. Carefully designed linkages with grass-route stakeholders (i.e. Farmers) in this process such as diverse channels for suppiy chain including co-operatives etc., are essential.

Chairman SAC also mentioned that in addition to technology for production of bioethanol, other technologies leading to production of other energy forms using bio-mass, such as biocrude/bio-oil for further processing in large conventional refineries, compressed gas and drop-in fuels, are also on the anvil. These also may be promoted on the basis of a level playing field and may be made eligible for support similar to one for bio-ethanol. **It was suggested that MoP&NG may quickly take a view and issue appropriate guidelines in this context.**

Chairman SAC further stressed that SAC/CHT should urgently look at areas of further technology improvement to bring the costs of biofuels to commercially viable levels and seek out R&D proposals to address them. He requested members to proactively come forward for this purpose.

SAC advised CHT to constitute 3 sub committees to address the following for quick & effective implementation of the scheme:

1. **Review of criteria for Project Developer Eligibility & Project Evaluation Parameters.**
2. **Supply chain logistics for raw material as well as product streams covering various business models including co-operative model.**

3. **Technology issues: To bring down 2G ethanol production cost including enzyme cost as well as cost of production of other energy forms using biomass.** (There is already an expert group under the Chairmanship of Prof. R. Kumar for reveiw of biofuel related projects. The same group may look at this as well, if necessary with addition of additional experts).

Report to be submitted within a week for further deliberations by SAC/MoP&NG.

CHT has been advised to obtain comments from all SAC members on the scheme. The comments are to be discussed in respective sub-committees. SAC shall devise a mechanism for implementation of the scheme after deliberations on the report submitted by sub-committees. Subsequently, CHT shall float EOI for seeking proposals by June 2019.

7. ATRs of last SAC

a. Self- sufficiency development in vulnerable areas

During 83rd meeting of SAC, EIL presented the list of equipment and components to be developed in the areas of vulnerability and SAC had advised the following:

- As the subject is of strategic importance, EIL need to form a separate group with the organization to provide impetus to this effort.
- EIL may draw a comprehensive frame work for National programme for manufacturing of such identified equipment/ components either through local development or through foreign tie-up by Indian manufacturers.
- To hold specific meets where representatives of oil industry from both D/S and U/S may be invited for identifying prospective manufacturers under make in India initiative. In such meets, specific business model and roadmap for mandatory procurement from such manufacturers based on quality spec may be discussed.
- EIL may also try to develop 2/3 manufacturers in each area for competitive scenario.
- Development of a limited number of critical equipment to eliminate vulnerability through consortium approach involving industry (OMC's and manufactures), institutes and students.
- Promote development for components through competitive mode by inviting proposals in RFP mode for short listing.
- Prepare detailed action plan in consultation with stakeholders.

During 83rd meeting of SAC, EIL was also advised to develop a roadmap for the Desalter technology, identified as one of the vulnerable areas. EIL presented the proposed business model for scale up and commercialization of desalter technology

which is CHT funded project and is presently being executed with BPCL at their Kochi Refinery.

EIL presented that in Desalter, the main challenges are the transformer and the insulator design and sourcing. Indian vendors are unable to manufacture desalter transformers. With the completion of the Desalter project, EIL is in position to troubleshoot problems related to desalter within 4 years of development. Following business model is proposed for Desalter commercialization.

Business area	Status till June 19
Troubleshooting	Ready for offering to industry with changes in operating parameters
Revamp	Ready for offering to industry with replacement/modelling with minor modifications
Grassroot	• Design modules are under completion • Vendor tie up for transformer and insulator are being taken up simultaneously • Business model for grass root commercialisation for industry shall be discussed between EIL & BPCL under the aegis of CHT

Director (R), BPCL raised concern that the market for desalter is very limited and therefore there is a need to revisit and reassess the requirement of all identified equipment/component in vulnerable areas. EIL stated that the market for Desalter has been monopolistic or duopolistic and hence in 2015, SAC advised to take this project with BPCL for development.

Prof. R. Kumar was of the view that the focus should be on the global market rather than only Indian market, which will give a direction to excel in the development.

EIL will hold the Vendor meets for critical equipment with prospective vendors / stake holders & the details shall be shared in the next SAC meeting.

SAC advised EIL/CHT to circulate the list of Equipment / Component prepared in areas of vulnerability to all stake holders for their inputs to seek an industry wide view on other areas as the desalter has been largely addressed.

Chairman SAC advised that periodic review should be done to eliminate all potential vulnerabilities and there should be parallel launching of necessary actions. Plans should be time-bound.

b. Setting up a Catalyst Manufacturing Plant in India

During last meeting of SAC, EIL presented the approach (as approved by Working Group in its 18th meeting held on 12.06.2018) to set up a Catalyst Manufacturing Plant in India.

SAC was of the opinion that EIL may take lead role in the JV and put up a proposal with roadmap on formation of JV, finalization of project report, location, investment approvals, etc.

EIL has taken the following actions:

- Interaction have been held on with following potential partners:
  - **M/s Sud Chemie**: Has tie-up with Indian industry for scale up and commercialization and has expertise in FCC and hydro processing catalyst. Meeting held on 24th Jan'19 at EIL, New Delhi & subsequent site visit on 14th Feb'19 at Baroda Catalyst Plant.
  - **M/s Grace**: Has a portfolio of hydro processing of gas oil streams as well as resid with a greater business interest in resid hydro processing catalyst. Meeting held in 4th week of Nov'18 & 28th March'19 at EIL, New Delhi.

EIL requested that leadership role and structure of the catalyst manufacturing facility has to be shared by OMC's.

SAC expressed concern in the slow progress and advised EIL to form JV. A clear cut business model need to be developed. SAC requested MoP&NG to call a meeting with Refineries directors to finalize scope of work under JV and business model.

8. Review of on-going R&D projects

ED (CHT) informed that progress of all on-going projects has been reviewed by respective PMCs / Expert Groups. ED (CHT) presented the project wise status as under:

8.1 Coal to Liquid (CTL) Fuels Technology Project: EIL / BPCL / Thermax

ED (CHT) / ED (T), EIL presented the status as under:

Objective

To develop technology for gasification of high ash Indian coal

Physical Progress

MOU Date	Start Date	End Date	Extension
Mar 2009	July 2009	July 2013	June 2019

The project has been envisaged in three major steps:

Step 1: Gasification of coal to syngas: EIL / Thermax

Step 2: Cleaning of syngas (Removal of H_2S, NH_3, HCN, CO_2, etc.): EIL

Step 3: Conversion of syngas to liquid fuels through Fischer-Tropsch (FT) synthesis: EIL / BPCL

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19		2019-20
			BE	Expenditure	BE
CHT	#1483.95	*1220.95	73.00	38.00	95.00
EIL	924.00	799.85	73.00	38.00	(**)
BPCL	560.00	421.10	--	--	--
Thermax	332.00	301.50	--	15.51	--
Total	3300.00	2743.40	146.00	91.51	95.00

(EIL: Rs 923.95 lakh; BPCL: 560 Rs lakh) *(EIL: Rs 799.85 lakh; BPCL: 421.1 Rs lakh)

** (Approval under process)

- CHT's contribution to BPCL was Rs 5.60 cr. However, only Rs 4.21 cr was taken by BPCL for FT technology development and has saved Rs 1.39 cr. EIL has requested to re-allocate this balance amount for their gasifier related work.

Status

- The work envisaged for the phase – I of FT technology (catalyst, kinetic study, hydrodynamic study, slurry phase reactor model) have been completed. EIL/BPCL to finalize configuration for Demo unit.
- Gasifier & syngas cleaning system pre-commissioned in January 2015.
- Trials were taken in air gasification and air & steam gasification modes raising system pressure gradually up to 6 bar. However, operation could not be sustained beyond 3 hours due to choking in the downstream section and ash extraction system.
- SAC constituted an Expert Group in September 2017 for comprehensive review and look into all possible aspects of high ash coal gasification at high pressure and recommend modifications for continuous running of the pilot plant.
- 1st meeting was on 11th Oct'17. So far 6 meetings have been held. Last meeting held on 16th Feb'19.
- Following modifications were advised by Expert Group:
    - Ash removal system modification (On/Off valve)

- Auto control of air flow
- Additional 2 new cyclones at the exit of gasifier.
- Feed line modifications (Removal of bends, increase in size)

- After part modifications, Gasifier has been operated twice at 6 bar & ~880 ^{0}C.

Trial Date	Total Time	Steam Gasification
20-23 Dec'18	30 hrs	12 hrs *
1-3 Jan'19	29 hrs	6 hrs **

* Run terminated due to choking of bed DPT because of low purge rate of nitrogen. Pulse nitrogen was introduced to de-choke but this led to instability in the bed.

** Run terminated due to CO leakage to atmosphere.

- No choking in the downstream section observed. Fly ash capturing from syn gas has improved by installing additional 2 cyclones over & above existing 2 cyclones.
- Expert Group advice during last review meeting on 16.02.2019 & their status:
  - To check the Carbon content in the bottom ash/lumps as well as fly ash for assessing carbon conversion. (Carbon content in the bottom ash/lumps: 2-5 %, Fly ash: 40-48 %)
  - To check the feeder nozzle for any ash/char formation in deposits. N_2 may be introduced to cool the feeder line and avoid softening of coal (practiced during normal operation)
  - To check the terminal velocity for the feed coal particles and accordingly, u/u_{mf} (min fluidisation velocity) may be adjusted to avoid carry over. (report under finalization)
  - To explore recyclability of fly ash partially in the feed stream to improve carbon conversion efficiency. (shall be attempted during next run)
  - To check tar formation in syn gas. (Tar formation shall be checked on resumption of runs)
- While initiating Oxy enrich gasification, following problems encountered
  - Low purity O_2 from PSA
  - Low throughput from O_2 Booster Compressor
- Vendor serviced the valves of PSA and reset the cycle time. Still purity was achieved upto 65% (desired quality 93%). Vendor has advised to replace the adsorbents in O_2 and N_2 PSA as well as in ASU system.
- Valve replacement of booster compressor in progress.

- Following constraints are still there in gasifier operations as components & system of pilot plant have become old:
    - Leakage of isolation valves handling Sand, Coal and Ash resulting CO leakage to the atmosphere. Valves need repair/replacement for system integrity and safe operations.
    - The PSA system & Booster Compressor need regular repair and maintenance.
    - Adsorbent replacement is required as oxygen purity is not being achieved.
    - Booster Compressor rings, valves replacement, etc. is required for trouble free operations.
    - Instrument replacement is needed due to malfunctioning and incorrect measurements.
    - Other systems/ subsystems like PLC, control valves, Gas chromatograph, piping items and other instrumentation also need regular repair, maintenance and calibration etc.
- EIL informed that despite several follow-ups there is no response from M/s Thermax in addressing the issues to ensure sustained plant operation, as they are also collaborative partners in the project. Their Pune facilities are operating and reciprocal learning is not being shared by Thermax. Moreover, as EIL does not have sufficient documents on gasifier design, it is difficult to mobilise/undertake repairs on gasifier. Therefore, plant trials shall be resumed after resolution of the plant issues and other techno-commercial issues between EIL & Thermax.
- EIL requested that with the intent of utilizing the data generated in the runs for further research work, the allocation of funds is required for health checkup, subsequent repairs and other requirements that may be encountered for the operations.
- Since SAC has already reallocated Rs 0.21 Cr from unspent CHT's contribution towards BPCL of Rs 1.39 Cr for gasifier modification, EIL further requested to re-allocate balance of Rs 1.18 Cr for healthiness of the plant keeping CHT's total contribution as well as all other terms of MoU unchanged.

SAC expressed concerns over the slow pace of corrective actions and the delays that are taking place in this project that is of great national importance. Considerable time and money has been expended and targeted goals should be achieved as soon as possible.

On the issue of M/s Thermax not co-operating in the development, SAC advised EIL to be ready to carry forward work on its own without Thermax if they do not come forward. However, SAC advised CHT to write a letter to Thermax for their co-operation.

SAC advised EIL to chalk out a plan in totality and define a time bound action plan to demonstrate CTL operation within 6 months.

Prof. R. Kumar informed that lot of advancement has been taken place in FT synthesis and technologies are available to produce drop in fuels through FT route. SAC advised BPCL / EIL to work in this direction to produce drop in fuel through FT route.

EIL requested for time extension by one year i.e. upto June 2020. SAC indicated that extension shall be approved after getting plan and path forward from EIL for successful demonstration of CTL technology.

8.2 Development of kinetic as well as 3D CFD Model for Gasifier: EIL

ED (CHT) presented the status as under:

Project Cost	CHT	BPCL	EIL
Rs 639 lakh	Rs 213 lakh	Rs 213 lakh	Rs 213 lakh

- SAC, in its 81st meeting held on 14.03.2018, emphasized that CTL project appears to be the most important from energy security point of view and therefore concerted efforts are required to achieve quick success.
- SAC advised EIL for validated modelling of gasifier through CFD experts to develop capability for credible scale up of CTL technology.
- The objective of the modeling should be to enable designing of the demonstration unit and subsequently design and offer commercial unit.
- EIL's proposal to make kinetic as well as 3D CFD model for gasifier was discussed by Expert Group on 18.05.2018. Expert Group also deliberated on the prospective consultants and recommended the name of Prof Srinivas Jayanti from IIT Madras.
- Based on advice of Expert Group as well as consultant, EIL proposed the modelling of the gasifier in last SAC meeting on 17.11.2018 as under:
    - 0-D Population Balance Model for coal feeding circuit
    - 3D CFD model of gasifier based on Kinetic Theory of Granular Flow (KTGF) and Discrete Dense Phase Model (DDPM)
    - Modelling of cyclones & its downstream
- EIL also gave justifications for the following:
    - Requirement of Cold flow set-ups as the rigorous 3D model shall be based on experimentally determined feed i.e. in terms of PSD etc.
    - Upgradation of current hardware with additional computational capabilities to solve the highly complex gasifier models.

- EIL shared the following related to M/s ANSYS and their Fluent software:
    - Both KTGF & DDPM options will give the best results for scale-up in comparison to any other software tool as ANSYS is widely accepted software for modelling of multiphase and multi component systems particularly for particle-particle interactions.
    - User defined functions (UDFs) and several Add-ons will have to be developed beyond the provisions of standard software due to complexity of the technology.
    - Moreover, to cut short the computational time and to achieve the faster convergence several boundary conditions, reactions, specific UDFs would need to be developed.
    - Expert support from ANSYS is necessary to optimize time & resources and add accuracy & robustness
    - Sourcing of additional proprietary software modules and upgradation of Licensing from M/s ANSYS
- EIL submitted the final proposal to CHT with project cost of Rs 6.39 Crore and completion schedule of 27 months on 6.11.2018. SAC recommended the same during last meeting on 17.11.2018.
- EC approved the proposal on 03.01.2019 and advised BPCL to consider sharing one-third of the project cost along with EIL and CHT. BPCL agreed for the same.
- BPCL informed that EIL should charge GST on the invoice issued to BPCL for reimbursement of expenditure made on its behalf. Further, EIL should also take proportionate credit of the tax paid to vendor to the extent of reimbursement made from BPCL and utilize the same to discharge the output GST. Only raising demand letter by EIL is not sufficient. Accordingly, MoU to be amended.

SAC advised EIL to start development of CFD Model at the earliest. Subsequently, through simulation problem areas can be identified and corrective actions can be taken. This may help in overcoming of problems in pilot plant running. Model can be validated subsequently using data from pilot plant operation.

8.3 Hydro-pyrolysis of lignocellulosic biomass to value added hydrocarbons: IIP

ED (CHT) presented the status as under:

- The Project was sanctioned by MNRE on 31.01.2012 with a completion schedule of 36 months.
- The objective was to convert lignocellulosic biomass into fuels that can be used in the transportation sector and chemicals.

- MNRE extended the project up to April 2018. Later on, the project was transferred to CHT on 20.07.2018.
- CHT put up the project for review by SAC in its 82nd meeting held on 11.09.2018. SAC extended the project till April 2019 for completing the remaining activities as assigned by MNRE.
- SAC also constituted an Expert Group under the chairmanship of Emeritus Prof. R. Kumar, IISc for review of biofuel related projects.
- Expert Group reviewed the project on 09.10.2018 and observed that no desired catalyst has been developed and no experiments have been carried out in the continuous reactor in presence of hydrogen and catalyst by IIP.
- SAC, during last meeting on 17.11.2018, advised IIP to finalize the catalyst and demonstrate its performance in 100 gm/h unit by April 2019. This data shall be used for designing of 5Kg/hr pilot plant to be installed at HPCL under CHT/OIDB funded on-going project.
- Project was reviewed on 16.02.2019 under the Chairmanship of Prof. R. Kumar. The meeting was also attended by Dr. Abhishek Sharma, Manipal University, suggested by Prof. J.B. Joshi. Expert Group advised the following to IIP:
  - To develop catalyst and optimize operating conditions for a single step hydropyrolysis process to achieve product quality as per BS-VI specification.
  - To provide scientific approach/mechanism for increasing the liquid yield with lower oxygenate content using single step process
- As advised by Expert Group, IIP carried out trials with commercial Ni & NiMo catalysts. Results are as under:

Feed / Rate	**Catalyst**	**Reactor temp**
Rice Straw / 40 g/hr	NiMo/ZSM-5 (80)	500°C
Pressure	**3-5 bar**	**3-10 bar**
H_2 flow	1.5 l/Min	1.5 l/Min
Time	2 hr	1.5 hr
Bio-oil	22.38 %	12.22 %
Bio-Char	34.19 %	32.3 %
Gas	43.4 %	55.48 %

Conversion	65.81 %	67.6 %
Oxygenates	31.19 %	19.31 %

- However, it was observed that trials were of very short durations. Operating conditions as desired by HPCL (P of 18 bar & feed rate 100 gm/h) are not achieved. Results are not very encouraging (Very high oxygenates & low bio-oil yieid).
- CHT/MNRE has released almost the entire funds. Project was extended till April'19, which is coming to end. But desired results are yet to be achieved. Also path forward is awaited from IIP.

Project Financials:

- Fund sanctioned by MNRE: Rs 2,71,68,000
- Fund released by MNRE: Rs 2,32,19,157
- EC, in its 26th meeting held on 03.01.2019 has approved release of balance fund requirement of Rs 39.49 lakh.
- CHT released Rs 25.07 lakh to IIP in March 2019 (incl. interest of Rs 12.11 lakh).

As the scope of work pertaining to IIP in the project transferred from MNRE and CHT funded project are same. Therefore, both the projects need to be considered together. SAC expressed concern on the slow progress of desired catalyst development and its trial at desired pressure of 18 bar by IIP. As IIP was not present in the meeting, SAC advised HPCL to co-ordinate with IIP and come back with path forward for both projects together.

8.4 Biomass Hydro-pyrolysis for production of fuel grade Hydrocarbons: HPCL/ CSIR-IIP

ED (CHT) presented the status as under:

Objective

Development of hydro pyrolysis process for the conversion of lignocellulosic biomass to hydrocarbons

Physical Progress

MOU Date	Start Date	End Date
Sept 2016	Nov 2016	Nov 2019

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19		2019-20
			BE	Expenditure	BE
CHT	#1440.00	*586.74	210.00	23.74	130.00
HPCL	966.90	410.00	410.00	110.00	380.00
Total	2406.90	996.74	620.00	**133.74	510.00

(IIP: Rs 640 lakh; HPCL: 800 lakh)

* (IIP: Rs 506.74 lakh including interest of Rs 9.87 lakh; HPCL: 80 lakh)

**Pilot plant procurement at HPCL is dependent on data (catalyst & reaction parameter) from IIP, which is not yet done. Therefore lower expenditure than planned.

Activity Schedule as per MoU

Activity	Agency	Completion Schedule
Project Start Date		Nov 2016
Design and procurement of hydro pyrolysis unit (500 g/hr)	IIP	Nov 2017
Feedstock: Procurement/Physico-chemical characterization	IIP/HPCL	Nov 2017
Procurement of analytical units for catalyst characterization	IIP	Nov 2017
Design of 5 kg/hr. pilot plant	HPCL	May 2018
Procurement of catalyst/catalyst support	IIP	Nov 2018
Preparation and characterization of catalysts	IIP	Nov 2018
Catalyst screening using procured reactor	IIP	Nov 2018
Physico-chemical characterization of reaction products	IIP	Nov 2018
Structure activity relationship & reaction mechanism study	IIP	Nov 2018
Optimized reaction parameters for single step hydropyrolysis process	IIP	Nov 2018
Setting-up of 5 kg/ hr. pilot plant unit	HPCL	Nov 2018
Experimental runs in 5 kg/hr. pilot unit with scaled catalyst	HPCL	Nov 2019
Separation of different fuel fractions & assessing its quality	IIP/HPCL	Nov 2019

Status

- The project originally envisaged Lab scale facilities at IIP (0.5 kg/hr) and HPCL R&D (5 kg/hr) for data generation for design of Demo unit of capacity 5 MT/d. Demonstration is not in the scope of current project.
- During 81st SAC meeting on 14.03.2018, IIP & HPCL expressed that procurement of 0.5 kg/hr unit at IIP is not necessary as the data required for designing of 5 Kg/h pilot

plant at HPCL shall be generated using existing 0.10 kg/hr unit at IIP, which was procured under MNRE project. Further, IIP requested to procure analytical equipment namely Advanced Proximate analysis, Differential Scanning Calorimetry (DSC), CHNS Analyser, Bomb Calorimeter and Refinery Gas Analyser (RGA) is essential, which were not envisaged in the original proposal. SAC agreed in-principle for abandoning procurement of 0.5 kg/hr unit as well as requirement of analytical equipment.

- Assuming catalyst development by IIP by Apr'19, HPCL proposed the following milestones and requested extension up to Oct'21:
    - Optimised lab data generation at IIP for Pilot plant design validation: Aug'19
    - Finalization of PFS with IIP generated data: Sep' 19
    - Tender floating and placing PO: Nov'19
    - Delivery of pilot plant at HPCL R&D: Jan'21
    - Installation & Commissioning of pilot plant: Feb'21
    - Data generation using scaled up catalyst: Aug'21
    - Submission of final report: Oct'21
- As the project is getting delayed due to non-development catalyst by IIP, CHT advised HPCL to return the advance of Rs 80 lakh, which was released as an initial advance to start the project. The same shall be released to HPCL as per the terms of PO, whenever required. HPCL agreed for the same.
- During the meeting, HPCL communicated that IIP has proposed the following approaches based on the facts viz. Given the known value of oxygenates in boosting lubricity and octane, the fact that blending of oxygenates is part of the biofuels Policy, and the added costs of full deoxygenation:
    - To distil the cuts from the current product mix and check cetane (diesel) and octane (gasoline) along with oxygen content
    - To extract the oxygenates by ED or LLE at CSIR-IIP and characterize for potentially valuable chemicals; their further separation and isolation could enhance overall product value.
    - Lower value oxygenates can be recycled to the hydropyrolysis reactor.

SAC deliberated and advised that as the scope of work pertaining to IIP in the project transferred from MNRE and CHT funded project are same, both the projects need to be considered together.

SAC expressed concern on the slow progress of desired catalyst development and its trial at desired pressure of 18 bar by IIP. As IIP was not present in the meeting, SAC advised HPCL to hold a meeting with IIP in the presence of Dr R Kumar and come back with path forward for both projects together.

IIP's suggestion on alternate ways for working on extraction was not approved by SAC and IIP was advised not to deviate from the original proposal.

8.5 Development of catalyst and process for Slurry phase Residue Hydro-cracking: CSIR-IIP, HPCL, BPCL and EIL

ED (CHT) presented the status as under:

Objective

- Development of Catalyst and Process for Slurry Phase Residue Hydrocracking.
  - Three best catalysts developed by IIP, HPCL & BPCL each are to be tested at IIP in continuous flow reactor (0.5L).
  - Subsequently, the best catalyst to be evaluated in pilot plant (1 L) at HPCL.
  - EIL will carry out Hydrodynamic studies, process simulation & modelling of slurry phase reactor for final catalyst selected based on cost and performance.

Physical Progress

MOU Date	Start Date	End Date	Extension
June 2015	July 2015	July 2018	July 2019

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19		2019-20
			BE	Expenditure	BE
CHT	#1366.00	*1325.83	195.00	190.28	40.17
HPCL	776.00	776.00	--	--	--
CSIR-IIP	93.00	93.00	--	--	--
Total	2235.00	2194.83	195.00	190.28	40.17

(CSIR-IIP: Rs 516 lakh, HPCL: Rs 850 lakh)

* (CSIR-IIP: Rs 475.83 lakh including interest of Rs 2.44 lakh, HPCL: Rs 850 lakh)

- CHT has released 100% of its contribution to HPCL and 92.2% of its contribution to IIP.

Status

- Project was reviewed by PMC under the chairmanship of Prof. R. Kumar on 16th Feb'19, wherein it was decided that one trial run will be performed at IIP reactor in the presence of all participating organizations by using IIP- catalyst.
- Accordingly, IIP started the trial runs with their catalyst in the presence of HPC/BPC/EIL on 19.02.2019. But during trial, feed line choked and got ruptured. Plant had to shutdown and feed line was replaced.
- Subsequently, IIP took trials at reaction temperature 420°C and pressure 150 Kg/cm^2using BPCL and IIP catalyst and plant was running smooth. Actual runs are yet to be started due to Lok-sabha election duty of IIP staff.
- HPCL is taking trial runs with their own catalyst in 1L pilot plant. The plant stabilization is established and trials at actual operating conditions are in progress.
- The protocol for selecting the best catalyst based on the overall performance considering activity, selectivity towards desired product, dosage level and the tentative cost of the catalyst shall be discussed and finalised at IIP during the actual runs.
- SAC extended the project till July 2019 keeping in view that catalyst shall be finalized by January 2019 followed by 6 months required by EIL for Hydrodynamic studies, process simulation & modelling of slurry phase reactor.
- However, as per the trial schedule indicated by IIP, operation with shortlisted catalyst shall be completed by May/June 2019. EIL has indicated that they will take 6 months thereafter for their activities. Therefore, project needs to be extended upto December 2019.

SAC expressed concern for delay in the project and advised IIP to expedite trials of catalysts developed by IIP/BPC/HPC. SAC approved the extension in the project upto Dec 2019 without any additional contribution from CHT considering catalyst finalization by June 2019 followed by 6 months required by EIL.

8.6 Scale-up studies and process development for Hydrogen Production by Catalytic Decomposition of Natural Gas: HPCL-R&D, CeNS and IIT Delhi

ED (CHT) presented the status as under:

Background:

- Demand of H_2 is increasing due to processing of heavy and sour crude.

- Refiners produce H_2 by steam reforming of methane (SMR) & other HC.
- Worldwide CO_2 emissions from steam reformer are 350 million tonnes/annum. CO_2 emission contributes about 77.6% global warming potential. Hence, there is a great incentive to produce hydrogen with reduced carbon foot print.
- Catalytic decomposition of Natural gas is an environmentally attractive approach for producing CO_2 free hydrogen. The by-product is carbon nanotubes (CNT) which is a high value product.
- Considering the above, HPCL & IITD has developed a novel technology at lab scale in earlier project funded under HCF.
- However, the major challenge in this process are:
    - Separation of carbon from the spent catalyst
    - Demonstration of the catalyst performance at higher scale of operation.

Results of Earlier Project:

- Promising Catalyst: 60%Ni-5%Cu-5%Zn on Al_2O_3 support
- Methane conversion @ 750°C and 0.25 atm p_{CH4}
    - Fixed bed reactor (1 gm catalyst): 93% (91% H_2 yield)
    - Fluidised bed (5 gm catalyst): 82%
- The carbon yield (mass of carbon/g metal) in fixed bed: 91%.
- Deactivated catalyst regenerated at 750°C up to 4 cycles. Reduction in methane conversion was minimal from 93% to 85% in fixed bed.
- High purity bamboo shaped structure of CNTs were produced
- OD: 35-40 nm; ID: 10-15 nm and Length: 2-3 µm

Current project

- To produce H_2 and carbon nano tubes (CNT) by catalytic decomposition of natural gas at rate of 1 kg/hr. Subsequently, Basic engineering package shall be developed for Demonstration unit at HPCL (not in the scope).
- IITD: Methane decomposition and CNT production experiments in 25 gm catalyst fluidized bed reactor (FBR) and to determine the hydrodynamic stability of catalyst in the FBR as well as the time required for optimum CNT deposition.

- CeNS: Develop a protocol for CNT separation from deactivated catalyst. Regenerated catalyst shall be used again in the process. Further, CeNS shall find suitable applications of CNTs for techno-economic viability.
- HPCL: Design and set up a pilot plant of 1 kg/h feed rate by using data from IITD & CeNS. The pilot plant's outcomes shall be used for the development of basic engineering package for a demonstration unit.

Physical Progress

MOU Date	Start Date	End Date
Feb 2017	Mar 2017	Mar 2021

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19		2019-20
			BE	Expenditure	BE
CHT	#1692.10	*105.58	144.00	**86.47	360.00
HPCL	1253.60	417.00	--	103.00	150.00
Total	2945.70	522.58	144.00	189.47	510.00

HPCL: 1489.80 lakh; IIT-D: 102.30 lakh; CeNS: 100.00 lakh)

*(HPCL: NIL; IIT-D: 69.91 lakh; CeNS: 35.67 lakh). This includes Rs 19.11 lakh, released from CHT grant till 2017-18.

** From HCF in 2018-19

- There has been delay in the procurement of pilot plant due to challenges in its design, therefore, HPCL returned back the advance of Rs 141.88 lakh on 01.06.2018 (Released by CHT on 24.03.2017). The funding of the project has been transferred under HCF vide MoP&NG letter dated 22.06.2018.

Activity Schedule as per MoU

Activity	Agency	Completion Schedule
Project Start Date		Mar 2017
Design & Setting up of pilot plant	HPCL	Sept 2018
Pilot Plant installation & Commissioning activities	HPCL	Dec 2018
Setting up Catalyst scale up facilities	HPCL	Mar 2018
Catalyst design, screening and scale-up	HPCL/IITD	Sept 2019
Pilot Plant Experiments & IPR Filing	HPCL	Jun 2020

Identification, separation, purification & evaluation of CNT	CeNS	Jun 2020
Value addition from purified CNT	CeNS	Sept 2020
Data Generation for demo unit	HPCL	Mar 2021

Process flow scheme yet to be finalized as it is dependent on catalyst development and CNT separation.

Constitution of Expert Group and its recommendations

- HPCL earlier envisaged a fluidized bed reactor of capacity 1 kg based on residence time requirement of 15 mins for CNT formation. However, its height was coming ~ 50 meters making it an impractical proposition.
- SAC in its 81st meeting held on 14th March 2018, constituted an Expert Group to carry out comprehensive overall review and look into all the possible aspects including type of the reactor.
- Four meetings of Expert group have been held on 17.05.2018, 09.10.2018, 04.11.2018 and 16.02.2019.
- Expert Group has advised Bubbling type of bed in view of high residence time requirement.
- In the phase-1 of the project, IITD optimized the catalyst composition at 60%Ni-5%Cu-5%Zn/Al_2O_3 for maximum Hydrogen yield. However, Expert Group advised IITD to reduce the Ni% to bring down the cost as well as to develop Iron based catalyst (Ferrocene) to obtain long CNTs without bamboo-note (length>5 microns).
- **Results of lower Ni % :**

60%Ni-5%Cu-5%Zn/Al_2O_3	>80% conversion of methane within 30 min and later on decreases. Catalyst stable upto 6 hrs at 5g scale
20%Ni	>80% conversion of methane within 30 min. Catalyst stable upto 2 hrs.
5%Ni	>80% conversion of methane within 30 min. Catalyst got deactivated within 2 hrs.

- No change in the conversion of methane upto 30 min. However, catalyst is getting deactivated faster in case of lower % of Ni.
- Results of CNT growth only with Ferrocene ($FeC_{10}H_{10}$):
  - High L/D CNTs (ID = 10 nm, OD = 27 nm, Length >5 µm)
  - Continuous Structure without bamboo-nod

- Further experiments are in progress to improve CNT quality.

- HPCL has optimised reaction time to about 3 hrs.
- CeNS has separated CNTs:
  - 63% (sonication/water in around 4.3 hrs). IITD evaluated this regenerated catalyst (with coke burn off), reported initial conversion 68% at 5 min and dropped to 52% in 2 h time.
  - 40-44% (sonication; with or without acetic acid 1M; 3 hr)
- IITD has also separated CNTs at 15-20% (sonication/alcohol).
  - Regenerated catalyst used for 5 cycles
  - Bamboo shaped multi walled CNTs grown (ID = 25-30 nm, OD = 60-65 nm, L = 2-3 micron).
- HPCL prepared 1 kg fresh catalyst and generated 500g spent catalyst. 50g separated CNT provided to external users for application evaluation.
- Delivery of FBR at IITD by May'19

Following activities are behind schedule, which may delay project completion:

- Design & Setting up of pilot plant (HPCL) by Sept 2018
- Setting up Catalyst scale up facilities (HPCL) by Mar 2018

SAC observed that CNT growths as well as its separations are very low. Chairman suggested meeting with IITD and CeNS along with Prof. R. Kumar to review the work progress and decide the path forward. Either another partner may be explored to work in catalyst development for higher CNT yield and improved quality or if it is not possible then foreclose the project.

8.7 Development & durability testing of Ethanol-Diesel blend engine: ARAI, Pune

ED (CHT) presented the status as under:

Objective

- To evaluate the Emission and Power performance of ethanol blended diesel by comparing base diesel engine Performance for BS IV emission norms.
- To evaluate vehicle performance of ethanol blended diesel by comparing base diesel vehicle performance
- To evaluate the Emission and Power performance of ethanol blended diesel by comparing base diesel engine Performance for BS III emission norms.

Physical Progress

MOU Date	Start Date	End Date	Extension
Sept 2017	Oct 2017	Mar 2018	Mar 2019

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Fund released till date	2018-19	
			BE	Fund released
CHT	129.80	129.45	119.30	118.95

Status

- 7.7% Ethanol & 2% BERAID-10 (Binder & Cetane improver) in Diesel found to be the most optimum. 3 chemicals used for binder.
- Engine durability completed for 500 hrs. No deterioration and abnormality on engine components observed. Before and after endurance of 500 hrs, engine power and torque were found same.
- BS-III (MSRTC) & BS-IV (TATA) Engine Emission Results (values in g/kWh)

Parameters	BS-III Engine			BS-IV Engine		
	Diesel	Blend	Remark	Diesel	Blend	Remark
CO emission	1.48	1.23	16.89% L	0.010	0.011	10% H
HC emission	0.40	0.46	H	0.03	0.05	67% H
NOx emission	15.22	14.94	2% L	3.18	3.60	13% H
PM emission	0.108	0.096	11% L	0.0092	0.0069	25% L

- **Gradeability test:** The test vehicle passed 7^0 slope test.
- **Acceleration test:** Observed 3.5 % less in blend.
- **CSFC Test**: The fuel consumption was measured at two speeds viz. 40 km/h and 60 km/h. The test was conducted on a straight track over a stretch of 1 km at constant speed.
- Best technical paper award by ARAI at SIAT 2019.
- ARAI requested extension till 31st May 2019 for report submission after incorporating comments from SAC/CHT.

Way forward:

a. At present, 2% additive contains mixture of 2-Ethylhexyl Nitrate, 2-Ethyl Hexanol and Ethomeen 302V. Ethomeen 302 is being imported hence ARAI has requested

BPCL to develop the additive. Further plan to commercialize blending process along with BPCL.

b. To implement the blend on a large fleet of vehicles so as to get the field response for the Diesel-Ethanol blend

c. ASTRU has assured to help this project for carrying out trials on large fleet

SAC observed that the results of Ethanol-Diesel blend on BS-IV engine for CO/HC/NOX emission found higher. However, in case of BS-III engine, these results are lower as compared to diesel. SAC advised ARAI to revisit the issues.

Dr. M.O. Garg informed that KSRTC has carried out trials on Ethanol-Diesel blend and requested ARAI to study the outcome of their study.

ARAI informed that KSRTC carried out trials using Ethanol-Diesel blend with additive from M/s Energenics Pte Ltd. Singapore. Only field triais were carried out on vehicles and there was no testing carried out for emission assessment on engine. However, ARAI has carried out emission and durability assessment on engine.

SAC advised ARAI to study the KSRTC report and submit the observations w.r.t. ARAI assessment.

SAC approved extension in the project till May 2019 without any additional contribution from CHT.

8.8 Renewable crude and liquid Hydrocarbon fuels from Algae: CPCL / ICGEB/ABAN

ED (CHT) presented the status as under:

The aim of the project is to demonstrate technical and economic feasibility of an integrated process for cultivation of microalgae and production of microalgal bio-crude, suitable for production of renewable fuels using existing refinery infrastructure.

The project was recommended by SAC under two phases:

Phase-1: Cultivation of algal consortium in open pond and scale up studies in larger ponds (4000 m^2) to assess biomass productivity (with a target yield of 25 g/m^2/day) with GM algal strains to enhance the yield by 20-30%.

Phase-2: Process to handle 110 kg algal slurry / day

The current project is for Phase-1 only.

Physical Progress

MOU Date	Start Date	End Date	Extension
Dec 2016	Mar 2017	Mar 2019	Aug 2019

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Fund released till date	2018-19		2019-20
			BE	Fund released	BE
CHT	#434.52	*354.83	326.00	252.23	79.69

(CPCL: Rs 386.34 lakh; ICGEB: Rs 48.18 lakh)

* (CPCL: Rs 306.65 lakh; ICGEB: Rs 48.18 lakh)

Status

CPCL has achieved following milestones

- Infrastructure (raceway ponds, lab equipment & Mechanical works) established
- Algae cultivation in 2, 20 and ponds in progress.
- Algae cultivation in 4000 m^2 pond started in Feb 2019. But algae culture in smaller ponds (200 m^2) unprecedentedly crashed & hence cultivation study in 4000 m^2 is being delayed. Measures are being taken to avoid crashing.
    - CPCL has identified 3 reasons of crashing 1. Sodium bicarbonate was of inferior quality (clay found mixed). 2. Zooplankton contamination 3. High Salinity of > 50PPT compared to normal value of 35 PPT due to evaporation loss. Make up water shall be tested for Zooplankton contamination before adding into the pond. Also micron filter cloth is being used to filter the water to avoid Zooplankton contamination CPCL will use raw water to bring down salinity.
- Algae cultivation shall be commenced from June 2019 and shall continue for 1 year (as per MoU) to establish all seasonal growth. CPCL requested for extension by 1 year upto August 2020.
- Harvesting Facility (Electro coagulation Unit, clarifier, filter press) trial over.
- Hydrothermal liquefaction (HTL) reactor (10 L capacity) trial run completed.
- Maximum algal productivity yield achieved in 2, 20 and 200 m^2 ponds are around 10 $g/m^2/day$ against target of 25 $g/m^2/day$.

ICGEB has achieved following milestones:

- Identification of wild marine algal strains: Nannochloropsis oceanica (NO) & Tetraselmis subcordiformis (TS) through DNA barcode study
- Selection of suitable antibiotic for screening GM algal strains
- Synthesis of vector with LCIA-LCIB transgenes
- Introduction of carbon fixing genes into algae via genetic transformation
- Confirmation of genetic transformation of algae

- Expression of transgenes into algae
- Lab-scale growth studies on GM algae in comparison with wild strain
- Increase in productivity of GM strains in lab: NO (32%); TS (11%)
- In 100 L photo bioreactor:
  - Productivity Wild (0.031 gm/L/D) & NO (0.048 gm/L/D)
- 55% increase in productivity

Remaining Activities by CPCL:

a. Algae Cultivation in 4000 m^2 pond – Feb to Jul 2019
b. Algae harvesting and estimation of biomass productivity
c. Liquefaction of biomass in HTL reactor
d. Characterisation of biocrude
e. LCA and economics of the process through IIT Bombay

Areas of Concern:

- **Withdrawal by ABAN from the project:**
  - CPCL informed CHT that M/s ABAN has given notice to terminate MoUs signed for the project w.e.f. 01.04.2019.
  - The matter was discussed in PMC meeting on 16.02.2019 under the chairmanship of Prof. R. Kumar.
  - CPCL informed that ABAN is winding up its bio tech division due to fund constraints.
  - M/s ABAN supplied the naturally occurring algae strains to commence the field trials to CPCL and lab trials to ICGEB.
  - The project with the limited objective of feasibility of harvesting of algae in open pond and production of bio crude through a Hydro thermal Liquefaction (HTL) reactor can be completed even with M/s ABAN withdrawing from the project.
- **Space constraints in CPCL Refinery even for value addition projects:** CPCL is not in a position to continue the Phase-2 of the project.
- **Regulatory clearances**
  - As per Section 3 (2) (c) of the Biological Diversity Act, 2002, a body corporate, association or organisation not incorporated or registered in India (or) incorporated or registered in India, having any non-Indian participation in its share capital and/or management, has to get approval of National Biodiversity Authority (NBA) to access and obtain biological resources occurring in India.
  - Aban transferred bio-resources (algal strains) to CPCL & ICGEB for study.

- As per Section 5 (3) of Act, collaborative research project approved and funded by Ministries /Departments of State or Central Government of India, approval of NBA is not applicable and the concerned Ministry/ department may grant the approval. Accordingly, MoP&NG has been requested to consider granting post facto approval for activities of transfer of bio-resources (naturally occurring native isolates of algal strains) from ABAN to CPCL and ICGEB.

Dr. M.O. Garg offered CPCL to visit RIL site of algae growth, where no such crashing has taken place even for several months. CPCL accepted the offer to visit the site at the earliest.

SAC approved the extension by 1 year upto August 2020 without any additional contribution from CHT.

8.9 Parametric Study and Technology Development for Desalter Design: EIL & BPCL

ED (CHT) presented the status as under:

Objective

- To develop Skid-mounted proto-type model De-salter to carryout Parametric Study for various crudes for better understanding of intricacies in Desalter design & operational issues
- To develop indigenous Desalter technology

Physical Progress

MOU Date	Start Date	End Date	Extension
Feb 2015	Mar 2015	Mar 2018	June 2019

Financial Progress (All figures in Rs, lakh)

	Contribution		Expenditure till date	2018-19	
	Original	Revised		BE	Expenditure
#CHT	853.0	853.0	853.00	155.00	155.66
BPCL	348.1	469.31	426.42	--	--
EIL	250.0	352.72	286.86	--	--
Total	1451.1	*1675.03	1566.28	155.00	155.66

CHT's contribution to EIL

* The project cost has been revised due to increase in hardware cost by Rs 205.44 lakh, of which BPCL has paid Rs 121.21 lakh including GST at 18% to EIL.

Status

- Site related activities and mechanical completion completed in Feb'19.
- System commissioned on 15th March'19.
- Testing/Operation initiated in 3rd week of March'19. Duration of testing 2 months.
- Test samples of 1st set of desalter internals completed on 10th April' 19. Results are awaited.

Remaining Activities

- Completion of experimentation/test samples for balance 3 sets by 20th May' 19.
- Completion of data analysis by 31st May'19.
- Development of Software/Tool & Report submission by 30th June' 19.

SAC noted the progress.

8.10 Synthetic Aviation Lubricants (SAL) - Phase 2: CSIR-IICT, HPCL & CEMILAC

ED (CHT) presented the status as under:

Background

- Under Phase-1 of the Project, two synthetic lubricants (SVS 11 and SVS 21), suitable for Garrett and Orpheus aero engines, were developed, which passed all the mandatory tests as required for engine tests. Provisional Certificates for Airworthiness Approval, essential for In-flight tests and further for commercial exploitation, was granted by CEMILAC.

Current Project (Phase-2):

- To prepare 500 L each of both the lubricants for testing in TV-2 aero engine of MI-8 helicopter supplied by 3BRD.
- However, it was understood that TV-2 aero engine is going to be phased out and TV-3 aero engine shall be used in MI-17 helicopter.
- Therefore, it was decided to try these lubricants in TV-3 aero engine.
- Only SVS-11 has been found compatible while carrying out rubber seal compatibility study & tribology testing. Therefore, its testing in TV-3 aero engine & also in-flight tests (MI-17 helicopter) is to be done.

Physical Progress

MOU Date	Start Date	End Date	Extension
Mar 2016	Apr 2016	Sept 2017	Mar 2019

Financial Progress (All figures in Rs, lakh)

Agency	Contribution		Expenditure till date	2018-19		2019-20
	Original	Revised*		BE	Expenditure	BE
#CHT	97.02	139.02	130.80	40.00	31.90	8.22
HPCL	118.00	169.10	87.10	--	--	--
CSIR-IICT	30.00	43.00	43.00	8.00	8.00	--
CEMILAC	5.00	7.16	--	--	--	--
Total	250.02	358.28	260.90	48.00	39.90	8.22

Only to IICT

* Increase in cost shared by participating agencies in proportion of their original contribution as approved by EC in its 23rd meeting on 30th Oct 2017.

Status of SVS-21

- IICT prepared 500 L base oil.
- HPCL done the formulation and lubricant exhibited similar rubber seal compatibility properties and tribology properties with that of OX-38.
- 3BRD completed 50h engine tests in TV-2 aero engine and compared with OX-38.
- 3BRD carried out checks after dismantling of TV-2 aero engine in Feb 2019. Various parameters obtained (related to the oil system) were within the specified limits.

Status of SVS-11

- IICT has prepared 500 L base oil.
- HPCL has done the formulation and completed physico-chemical and lubricant properties in comparison with commercial OX-27.
- The engine studies for SVS-11 lubricant have not been initiated yet due to non-availability of TV-3 aero engine test bed till April 2019 at 3BRD.

Delay due to non-availability of TV-3 aero engine test bed

- A review meeting of all stakeholders was held on 28.11.2018 at 3BRD, wherein it was proposed to seek extension of the project from Mar 2019 to Mar 2020 due to non-availability of TV-3 aero engine test bed till April 2019 at 3BRD for the engine studies of SVS-11 lubricant.

Remaining Activities

- Elastomer compatibility test at HPCL (April 2019).
- Ground testing of SVS-11 lubricant in TV-3 engine at 3BRD (May-Jul 2019).

- Test schedule finalization with Air HQ to facilitate flight trails after ground tests of SVS-II at 3BRD and in-flight testing of SVS-11 (after Aug 2019).
- Comparison of the data from participating organizations & submission of final report by CSIR-IICT (Feb-Mar 2020).

SAC approved the extension till March 2020 without any additional contribution from CHT.

8.11 Improving (Speedy) Leak Detection Time in Pipelines by Deployment of Real Time Ethernet Protocols: HPCL-VSPL/ECIL

ED (CHT) presented the status as under:

Objective:

- To reduce leak detection time in the pipelines from existing 15 minutes to ~ 2-3 minutes with an accuracy of +/- 200 meters compared to current range of +/- 2 to 3 km.
- To reduce the data acquisition time from existing 10-15 seconds to 10-20 milli seconds

This will be demonstrated in HPCL's Vizag-Vijayawada-Secundrabad Pipeline (VVSPL), wherein Electronic Systems Design & Manufacturing (ESDM) device and Firmware will be developed. ECIL will support in development of Electronics.

Physical Progress

MOU Date	Start Date	End Date
Sept 2018	Nov 2018	Apr 2020

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19		2019-20
			BE	Expenditure	BE
CHT	55.20	20.74	20.00	20.74	34.46
HPCL	61.84	-	-	-	
Total	117.04	20.74	20.00	20.74	34.46

Status

- The System Architecture is completed.
- Field validation at two of the Successive stations is expected to be completed by June'2019

- HPCL has purchased a new computer server at the cost of Rs 13,39,446, which was not envisaged in the original proposal. Initially at the proposal stage, it was contemplated that leak detection software being developed for this R&D project shall be running in the pre-existing leak detection software server installed and running at VVSPL-Visakhapatnam dispatch station. These Computer Servers are LIVE servers working on REALTIME Basis.
- As the new software has additional features, in order to keep LIVE server undisturbed, HPCL has decided to run both the software separately in two independent servers. Accordingly, HPCL requested to release contingency fund of Rs 3,53,057 for the server. HPCL has also informed that in case of project cost overrun, CHT's contribution will remain unchanged and extra cost shall be borne by HPCL.

SAC noted the progress.

8.12 Production of lower olefins (Ethylene and Propylene) from Syngas: IICT/BPCL

Objective

- **Phase-1:** Synthesis of catalysts for direct conversion of syngas to lower olefins and establishment of **proof of concept** in a 4 CC fixed bed mode reactor at CSIR-IICT.: **18 months**

Current project is for Phase-1 only. BPCL will collaborate from Phase-2.

- **Phase-2:** Validation of micro reactor data in a 20 CC bench scale fixed bed reactor at BPCL R&D Centre. Duration: **6 months**
- **Phase-3:** Optimization of process parameters in fluidized bed reactor (50 CC cat volume) and development of a comprehensive kinetic model for further scale up and designing of a pilot plant unit (1000 CC cat vol) and demo unit (400 Kg). Duration: **36 months**
- After completion of this study, in the fourth phase, pilot plant studies (1000 CC) will be implemented in a circulating fluidization bed reactor unit to generate basic design data for setting up of demo plant (400 Kg cat load vol. i.e. fifth phase).

Physical Progress

MOU Date	Start Date	End Date
Feb 2019	March 2019	Sept 2020

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19		2019-20
			BE	Expenditure	BE
CHT	84.044	41.80	-	41.80	30.00
CSIR-IICT	154.176	-	-	-	
Total	238.228	41.80	-	41.80	30.00

Status

- Recommended by SAC in its 83rd meeting held on 17.11.2018 and approved by EC in its 26th meeting held on 03.01.2019. MoU signed among BPCL, CSIR-IICT & CHT on 08.02.2019.

SAC noted the progress

8.13 Development of Superior Absorbents for CO2 Separation from Biogas: ICT-Mumbai/IOC

ED (CHT) presented the status as under:

Objective

- Batch experiments for CO_2 absorption and desorption separately to measure the efficiency of absorption and desorption: ICT
- Continuous experiments in a lab-scale, closed loop absorber-desorber setup to measure the CO_2 absorption efficiency and regeneration energy: ICT
- Experiments in a VLE setup to measure the CO_2 solubility and stirred cell to measure absorption rates and investigate absorption kinetics: ICT
- Continuous experiments in a pilot plant to investigate the performance and energy requirements: IOC R&D

Physical Progress

MOU Date	Start Date	End Date
March 2019	March 2019	March 2022

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19		2019-20
			BE	Expenditure	BE
CHT	85.57	35.56	-	35.56	16.00
IOCL	87.97	-	-	-	-
Total	173.54	35.56	-	35.56	16.00

Status

- Recommended by SAC in its 83rd meeting held on 17.11.2018 and approved by EC in its 26th meeting held on 03.01.2019.
- MOU signed on 18th March 2019.
- CHT has released Rs 30 lakh as advance for the procurement of equipment (High pressure VLE setup, spares / accessories for absorber-desorber set up and set up for solvent screening) and Rs 5.56 lakh for meeting recurring expenses on 28.03.2019.

SAC noted the progress

8.14 Stabilization and up gradation of biomass derived bio-oils over tailored multifunctional catalysts in a dual stage catalytic process to produce liquid hydrocarbon fuels and its application studies: TERI & IOC

ED (CHT) presented the status as under:

Background of earlier project (Phase-1)

- Non-Catalytic Pyrolysis Project (2010-2013) sponsored by MNRE
- Demonstration of PLC based Modular Pyrolysis Unit (20 kg/h) to produce Bio-Oil from Agro-Industrial Biomass Wastes and Methodology for Analysis, Use of Bio-oil: TERI & IOC

Major Out Come (Phase-1)

- Pilot Pyrolysis Test Unit of 20 kg/h capacity developed and commissioned. Unit is automated, PLC system integrated and continuous.
- Non-condensable gases are used as fuel.
- 7 Biomass tested: Cashew nut shell, Jatropha oil seed residues, Karanja oil seed residues, Paddy straw, Wheat straw, Sugarcane bagasse & Maize stalk
- It has staged condensation process, which separates all acidic and aqueous fractions from bio oil and thus avoids post distillation.

- Bio oil with low O_2 content (8-13 wt %) and high stability produced.
- Gases can be used for activation of bio char (~2400 m^2/g SA achieved).

Results for different biomass

Feedstock	Pyrolysis Product yields (wt. %)				Heating Value (MJ/kg)		O in Bio oil (wt. %)
	Total Liquid		Char	Gases Char (by diff.)			
	Bio Oil	Acids + Water			Bio Oil	Char	
Cashew nut	34-35	24-25	27-28	15-20	35-36	26-28	8-12
Karanja Oil	32-35	20-22	26-28	15-20	32-34	24-25	10-12
Jatropha Oil	25-29	20-23	28-33	15-18	29-30	24-25	12-13
Paddy Straw	22-28	20-22	28-30	18-20	28-30	24-25	16-17

Current project (Phase-2)

- The Project was sanctioned by MNRE on 11.09.2013 with a completion schedule of 36 months.

Objective:

- Catalytic up gradation of bio oil vapors over novel catalysts to aromatics and hydrocarbons for improving bio oil characteristics especially in terms of Oxygen content (<5%) and H:C ratio. This upgraded oil could be co-processed in refinery or could find possible direct applications as alternate transport fuels.

Status

- TERI requested MNRE to extend the project for 18 months up to March 2018. However, there was no progress as the visit of experts could not materialize. Later on, the project was transferred to CHT on 20.07.2018.
- CHT put up the project for review by SAC in its 82nd meeting held on 11th September 2018. SAC extended the project up to March 2020 for completing the remaining activities as assigned by MNRE.
- SAC also constituted an Expert Group under the chairmanship of Emeritus Prof. R. Kumar, IISc for comprehensive review.
- Expert Group in its meeting on 09.10.2018 deliberated on the project and agreed in principle to complete the remaining activities.

- Based on Expert Group's views, SAC in its 83rd meeting held on 17.11.2018, advised TERI to complete the remaining activities by March 2020.

Project Financials:

- Funds sanctioned by MNRE: Rs 164.07 lakh
- Fund released by MNRE: Rs 120.00 lakh
- EC, in its 26th meeting held on 03.01.2019 has approved release of balance fund requirement of Rs 44.07 lakh.
- CHT has released Rs 37.90 lakh (Rs 10.07 lakh against already incurred expenditure and Rs 27.83 lakh as advance for the procurement of 'Fixed Bed Catalytic Cracking Upgradation Unit) in March 2019 to TERI.
- Order placed by TERI.

Progress is as per schedule.

SAC noted the progress.

9. Discussion on New R&D Project Proposals

9.1 Setting up of Compact Reformer Unit of capacity 4TPD for producing Hydrogen blend CNG (H-CNG) and trials demonstration at Rajghat Bus Depot at Delhi NCR: IOC

IOC R&D presented the details as under:

Background:

- Earlier Project Funded by MNRE (2010-14), wherein 18% H_2 in CNG was optimized.
- Further project taken up under HCF (2011- 15), wherein IOC R&D collaborated with Leyland & Tata and completed detailed evaluation of Heavy duty engines using optimized HCNG blend and also carried out limited field trials on buses.
- Improved fuel economy of ~3% with reduction in emissions of CO, HC & CO_2 while increase in NOx, which can also be reduced with available technology. No adverse impact of HCNG fuel on engine components.
- The advantage of HCNG is that it utilizes existing IC engine w/o any major modification and dispensing infrastructure of CNG for its supply
- Hon'ble Supreme Court directed MoP&NG & IOC-R&D to conduct demo trials using 18% HCNG in 50 buses of a cluster bus depot in Delhi.

- IOC (R&D) has developed and patented a single step compact reformer technology for production of HCNG from CNG.

Proposed Faciilities/Activities:

- Setting up of compact reformer unit of 4 TPD (250 Nm3/hr) to produce HCNG and associated infrastructure for compression, storage and dispensing station at Rajghat-I DTC (Delhi Transport Corporation) Depot.
- Demonstration trial of HCNG fuel in a fleet of 50 BS-IV compliant commercial CGN vehicles in Rajghat-II DIMTS (Delhi Integrated Multi Modal Transport System).
- Continuous Operation & maintenance of the HCNG plant during the trial period.
- To carry out performance, emission tests and monitoring of vehicles during 6 months trial

Funding:

- **Project cost:** Rs 33.4 Crore
- Hon'ble Supreme Court has advised Transport Ministry, Govt. of Delhi to grant a fund of Rs. 15 Crore through Environment Compensation Cess (ECC).
- IOC R&D has submitted proposal for sanction of Rs 18.4 Crore from HCF Fund through OIDB.

Completion: March, 2020

Proposal Details & Methodology:

- As per Directive of Hon'ble Supreme Court, IOC R&D is the nodal agency responsible for installation, monitoring and evaluation of the HCNG demonstration Project.
- A separate dedicated facility shall be set up at Rajghat bus depot without disturbing the existing infrastructure of CNG (which is being managed by IGL).

Proposal Detaiis & Methodology:

- IOC R&D shall own the facility and proposes to collaborate with IGL separately, who will supply CNG.
- IGL shall be responsible for Pre-Project activities, procurement and installation of associated storage, compressor, dispenser, MCC, power & water supply, control room

construction, operation & maintenance of the complete system including IOC's Compact Reformer and PESO approval.

- IOC R&D is responsible for procurement of HCNG plant. EPCM Job for supply of Compact Reformer has been awarded to M/s Technip India Pvt. Ltd. by IOC R&D.
- Buses of Rajghat-II DIMTS Depot is owned & operated by concessionaire M/s Antony Road Transport Solution Pvt. Ltd (ARTSPL). Out of 50 buses, 7 buses have to undergo testing at M/s iCAT, Manesar for performance, emission testing & fuel economy with CNG vis-à-vis HCNG.

SAC deliberated and recommended the proposal technicaily.

OIDB advised IOCL to contribute 50% of required grant from OIDB i.e. Rs 9.20 crore.

IOCL clarified that Hon'ble Supreme Court has advised Transport Ministry, Govt. of Delhi to grant a fund of Rs. 15 Crore through Environment Compensation Cess (ECC).

SAC advised that contribution of IOCL may be decided by EC/GC of CHT (approving authority).

9.2 Identification and Cultivation of suitable micro algal strains for sustainable biodiesel production on large scaie: Amity University, Gurgaon

ED (CHT), presented the details as under:

Objective: Production of algal biofuels consists of four major steps:
1. Algal Cultivation; 2. Harvesting; 3. Extraction; 4. Conversion of Oil into fuels

Project Cost: Rs 66.935 Lakh

Completion Target: 36 months

Proposed facilities/activities:

- Selection of microalgal species capable of synthesising triacrylglycerols
  - Collection of different algal strains from different sources (marine and fresh water)
  - Developing Culture in appropriate medium.
  - Analysis of Pure Culture for its hydrocarbons, carotenoids, fatty acid profile and total neutral lipid content.
  - Selection of one particular strain on the basis of their lipid content
- Optimisation of different process parameters such as light, temperature, stirring speed for maximum biodiesel production using the selected microalgal species.

- Large Scale production of microalgal biomass in Photo-bioreactor
- Lipid extraction from algal biomass using Bligh and Dyer method.
- Trans esterification of extracted lipid to Fatty Acid Methyl Ester (FAME) using heterogeneous nano-catalyst for faster biodiesel production.

Project Activity & Timeline:

Project Activity	**Target Completion**
Strain Optimisation	6 months
Optimisation of physico-chemical parameters	12 months
Small Scale production of algal strains and harvesting	18 months
Large Scale production of algal biomass in photobioreactor	24 months
Lipid extraction from algal biomass	30 months
Trans esterification	36 months

Cost Break Up & Phasing of Expenditure:

	item	**Total Cost**	**Phasing of Expenditure**		
		Rs. Lakh	1st Year	2nd Year	3rd Year
1	Equipment	31.300	6.500	22.800	2.000
2.	Manpower	15.300	5.100	5.100	5.100
3.	Consumables	11.000	5.000	3.500	2.500
4.	Contingencies	2.250	0.750	0.750	0.750
5.	Travel	1.000	0.500	0.250	0.250
6.	Institutional Overhead charges	6.085	2.000	2.000	2.085
	Total	66.935	19.850	34.400	12.685

SAC observed that the proposal is not worth consideration as similar work has already been carried out with greater efficiency.

9.3 Development of Protective Coatings for Corrosion Protection in Oil & Gas Pipelines: CIPET Chennai

CIPET, Chennai presented the details as under:

Project Cost: Rs 859.06 Lakh (CHT/OIDB Contribution : Rs. 765.44Lakh)

Completion Target: 24 months

Objective:

1. Development of Smart Protective Internal Coating Formulations of Epoxy/PolyUrethan(PU) with inherently conducive polymer (ICP) and Nano scale interface.
2. Improve the interfacial balance between the polymetric matrix and nanofillers.
3. Optimisiation of reaction parameters, dispersion stability and coating formulations of the developed anticorrosive coatings.
4. Evaluation of the performance of the coatings w.r.t thermal cycling, UV aging, corrosion resistant, dimensional stability, impact and abrasion resistance at bench scale.
5. Field trials of the optimised formulations.

Proposed facilities/activities will comprise of foliowing:

- Modification of Epoxy Resins
    - Epoxy Resins are highly brittle in nature, hydrophobic, undergo cathodic disbondmemt under harsh environmental condition over prolonged exposure & have low impact and chemical resistance.
    - Polyurethans (PU) can be used for modifying Epoxy Resin as they are known for their high hardness, impact resistance, strong adhesion to metal substrates, good resistance to steam penetration, good flexibility, good cathodic protection and high chemical resistance.
    - Synergistic Use of Epoxy with PU can improve the adhesion of coating with substrate, reduce mechanicai damage & enhance overall coating performance.
- Introduction of inherently conducting polymer (ICP) systems within the modified Epoxy/PU Resins
    - Poiypyrolle and Polyaniline are the most used conducting polymers for developing anticorrosive coating for Steel Pipes.
    - Polypyrolle exhibits higher environmental stability, bio compatibility, physical and electrical properties.

- Polyaniline is also well known conducting polymer which can block the electron transfer from the metal surface through formation of passive metal oxide layer. Thus, Polypyrolle and Polyaniline can be incorporated within the modified epoxy/FBE resins as anticorrosive additives.

- Modification of Nano Scale Additives
  - Nanoscale fillers offer wide range of properties to improve the corrosion protection efficiency of the coatings.
  - Nanocoatings can impart improved barrier properties and provide effective inhibition or retardation of diffusion of liquids, solutes and/or gases into a substrate.

Project Activity & Timeline :

Project Activity	**Time (Months)**
• Procurement of the Instruments and related accessories, consumables, recruitment of JRFs and RAs	0-6
• Modification of Epoxy Resins and FBE Powder with optimum weight% of Polyurethans and Siloxanes • Optimisation, Characterization of the developed coating system, process, reaction parameter &conditions	7-13
• Inclusion of inherently conducting polymers within the modified Epoxy/PU Resins. • Optimisation, Characterisation of the developed coating system, process, reaction parameters & conditions	13-19
• Modification of Nano Additives with Siloxanes and other functional groups • Optimisation & Characterisation of the developed nanocomposite coating system, dispersion stability of Nanofillers within the matrix, reaction parameters and conditions	19-22
• Field Trials – Cyclic Corrosion Test, Thermal Cycling, Dimensional Stability, Cathodic disbondment Test (ISO 15711)	22-24

Cost Break Up & Phasing of Expenditure:

	Item	**Total Cost**	**Phasing of Expenditure**		
		Rs. Lakh	1st Year	2nd Year	3rd Year
1	Equipment	383.00	383.60		

2.	Manpower	181.872	60.624	60.624	60.624
3.	Consumables	80.000	40.000	40.000	-
4.	Outsourcing and Field Trial	70.000	40.000	30.000	-
5.	Patent Filing	40.000	25.000	15.000	
4.	Contingencies	20.000	10.000	10.000	-
5.	Travel	30.000	10.000	20.000	-
6.	Institutional Overhead charges	54.1872	27.8436	26.3436	-
	Total	859.0592	596.468	201.9676	60.624

SAC advised CHT to circulate the proposal to oil PSU to seek synergy and joint development partnership. After collaboration with oil PSU, the proposal to be put up to Screening Committee for further consideration by SAC.

10. Discussion on New Idea 'Methanol production from recycled CO_2 & Renewable H_2'

Prof. R. Kumar initiated the discussion by referring vision of NITI Aayog to produce large quantity of Methanol for blending in transport fuels, for production of DME (as a substitute for LPG) and as a source for chemicals. The existing production capacity of methanol in the country is small and that too utilized to only around 30% because of cheaper imports. It has been found that its cost of production in India is Rs 25 to 27 per liter, much higher than countries like Iran which have abundant availability of natural gas. In order to have reasonable impact on import of crude, Niti Aayog recommends setting up of large facilities to produce ten million tons of methanol per year within the next few years primarily from coal at Rs 17 to 19 per litre. Based on commercial data following is approximated as $ per Kg. Methanol

- 1 Kg of methanol = Requirement of CO_2 **1.46 Kg &** H_2 **0.199Kg** ***[say 1.5 Kg and 0.20 Kg]***
- Cost of CO_2 : $ 0.04 / kg; [Cost of CO2 /Kg of methanol = $ 0.06]
- Cost of H_2 = $ 0.50 / kg (contribution from electrolyser] + 49 x 0.015 = $ 1.24 /Kg , as 49 kWh are required per Kg of H2 at assumed cost of $ 0.015 per kWh.
- Cost of processing: $ 0.057
- Methanol cost = (1.50 x 0.04) + (0.20 x 1.24) + 0.057 = $ 0.367 = Rs 25.69 /Kg or Rs 20.55 /Litre

The current status of Technology and the approximate cost of production indicates that the process is worth pursuing if the cost of power is in the vicinity of $ 0.015 per kWh (Rs 1.05 per kWh).

It was noted that IOCL is pursuing projects to use solar energy to produce non-fossil hydrogen through steam electrolysis. **SAC advised IOCL to give projected cost estimates for power using various PV processes as well as for production of non-fossil hydrogen.**

It was also mentioned that there are also opportunities to utilize grid connected generating plants which are unable to deliver their full capacity to the grid. This may be an opportunity for cheap electricity being available for hydrogen production. **It was suggested that this situation may also be evaluated.**

SAC also advised IOCL to take up a pilot project for CO2 hydrogenation to produce SynGas at a place where concentrated CO2 source is availiable and where the product can be used. Prof. J. B. Joshi proposed that Prof. Vaidya of ICT Mumbai has done work in this area and could be involved in the programme. SAC advised IOCL to review this matter and consider launching this development work. If necessary, a proposal could be submitted for consideration of SAC.

11. Status of other SAC recommended/discussed project proposals

11.1 Solar based H_2 production system & dispensing station for refuelling hydrogen fuel cell vehicle: IOC R&D

- SAC in its 82nd meeting held on 11.09.2018 deliberated and recommended the proposal at total cost of Rs 65.16 crore.
- EC, in its 26th meeting on 03.01.2019 observed that there is no financial expenditure before 2020-21 and advised IOC-R&D to fast-track the project and put up activity-wise milestones for consideration of EC. Further, EC recommended CHT's contribution to be Rs 25.00 crore and balance to be borne by IOC-R&D. Accordingly, IOC (R&D) has requested for approval of the project from EC/GC so that action for procurement of facilities could be initiated. The same shall be put up to EC/GC in next meeting.

SAC noted the above.

11.2 Design & development of Fibre Optic gas Sensors for compositional analysis of CO & H_2S: CSIR-CSIO/BPCL

- SAC has already recommended the proposal in its 83rd meeting on 17.11.2018. The same shall be put up to EC for approval.

SAC noted the above.

11.3 REHEAT: REcovery of Heat from Efflux in A Tesla turbine: IIT-KGP/EIL/IOCL/BHEL

- A meeting was held at CHT with EIL and IIT-KGP on 25th Feb, 2019. After obtaining clarifications and joint visit to IIT KGP, EIL shall submit the proposal.

SAC noted the above.

Annexure-1

84th Meeting of Scientific Advisory Committee (SAC) on Hydrocarbons of MoP&NG held on 22nd April, 2019 at Trident Hotel, BKC, Mumbai

List of Participants

	Name	Designation	Organization
1	Dr. Anil Kakodkar	Chairman - SAC	BARC
2	Sh. Sandeep Poundrik	Joint Secretary (Refineries)	MoP&NG
3	Prof. R. Kumar	Professor Emeritus	IISc
4	Prof. J.B. Joshi	Professor Emeritus	HBNI
5	Prof. A.B. Pandit	Professor & Dean	ICT
6	Prof. Shankar Narasimhan	Professor	IIT-M
7	Dr. M.O. Garg	President (R&D)	EIL
8	Sh. R. Ramachandran	Director (R)	BPCL
9	Sh. B.V. Rama Gopal	Director (R)	IOCL
10	Sh. V. S. Shenoy	Director (R)	HPCL
11	Dr. S.S.V. Ramakumar	Director (R&D)	IOCL
12	Sh. Sanjeev Katti	DG	OEC
13	Sh. L. K. Vijh	Director (T)	EIL
14	Sh. K.K. Jain	ED	CHT
15	Sh. Alok Tripathi	ED	PCRA
16	Sh. Rajesh Kumar Saini	Dy. Chief F&A officer	OIDB
17	Sh. G. Sriganesh	ED (R&D)	HPCL

	Name	Designation	Organization
18	Sh. Sanjay Bhargava	ED (R&D)	BPCL
19	Sh. R. Srikanthan	Director (T)	CPCL
20	Ms. Vartika Shukla	ED (T)	EIL
21	Sh. M.R. Meshram	ED (R&D)	GAIL
22	Dr. S.S. Thipse	Dy. Director	ARAI
23	Sh. Sandeep Rairikar	DGM	ARAI
24	Sh. Alok Sharma	CGM (AE)	IOCL
25	Sh. A.K. Jain	CGM (R&D)	HPCL
26	Dr. Bharat L. Newalkar	GM (R&D)	BPCL
27	Sh. S. Tripathi	DGM (RCD)	HPCL
28	Sh. N.V.S.N. Raju	Ch. Mgr. (VVSPL)	HPCL
29	Sh. Pramod Kumar	DGM (R&D)	HPCL
30	Sh. Vishwas Khobragade	DGM	BPCL
31	Sh. Shashi Kumar	Group Leader	ICGEB
32	Sh. A.C. Ganvir	Sr. Mgr.	HPCL
33	Dr. Smita Mohanty	Director (Prin. Scientist)	CIPET Bengaliru
34	Sh. Satyavir Singh	Joint Director	CHT
35	Sh. S.K. Varshney	Joint Director	CHT