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

सीएचटी/एससी-83/1225
CHT/SAC-83/

28 नवम्बर 2018
28th November 2018

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 83वीं बैठक का कार्यवृत्त

Sub: Minutes of 83rd 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 17 नवम्बर, 2018 को पेट्रोलियम और प्राकृतिक गैस मंत्रालय की हाइड्रोकार्बन पर वैज्ञानिक सलाहकार समिति की 83वीं बैठक के कार्यवृत्त की प्रतिलिपि संलग्न की जा रही है।

Enclosed please find a copy of the Minutes of 83rd Meeting of the SAC on Hydrocarbons of Ministry of Petroleum & Natural Gas held on 17th November, 2018 for your kind information and necessary action.

सादर,
With kind regards,

भवदीय,
Yours sincerely,

बृजेश कुमार

(बृजेश कुमार)
कार्यकारी निदेशक
(Brijesh Kumar)
Executive Director

संलग्न यथोक्त

Encl: As Above

ओ.आई.डी.बी. भवन, टावर "ए" 9वाँ तल, प्लॉट नंबर 2, सैक्टर 73, नोएडा 201316 (उ. प्र.)
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Liaison Office: C/o. OIDB, 301, World Trade Centre, 3rd Floor, Babar Road, New Delhi-110 001

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.	Dr. B.D. Kulkarni, Distinguished Scientist, CSIR – National Chemical Laboratory, Dr. Homi Bhabha Road, **Pune – 411 008**	Member
6.	Prof. A.B. Pandit, Dean, Institute of Chemical Technology, Nathalal Parekh Marg, Matunga (East), **Mumbai – 400 019**	Member
7.	Dr. Shashi Kant, Scientist Emeritus, Indian Oil Corporation Ltd., R&D Centre, Sector-13, **Faridabad – 121 007**	Member
8.	Prof. Shankar Narasimhan, Indian Institute of Technology Madras, Sardar Patel Road, Adyar, **Chennai – 600 036**	Member

9.	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
10.	Shri B.V. Rama Gopal, Director (Refineries), Indian Oil Corporation Ltd., SCOPE Complex, Core-2, Lodhi Road, **New Delhi – 110 003**	Member
11.	Shri R. Ramachandran, Director (Refineries), Bharat Petroleum Corporation Ltd., Bharat Bhawan, 4&6 Currimbhoy Road, Ballard Estate, **Mumbai – 400 001**	Member
12.	Shri V.S. Shenoy, Director (Refineries), Hindustan Petroleum Corporation Ltd., 17, Jamshedji Tata Road, **Mumbai – 400 020**	Member
13.	Dr. S.S.V. Ramakumar, Director (R&D), Indian Oil Corporation Ltd., R&D Centre, Sector-13, **Faridabad – 121 007**	Member
14.	Shri L.K. Vijh, Director (Technical), Engineers India Limited, EI Bhawan, 1, Bhikaiji Cama Place, **New Delhi – 110 066**	Member
15.	Dr. B. Bhargava, Director General, ONGC Energy Centre, 15th Floor, South Tower, Core-4, SCOPE Minar Complex, Laxmi Nagar, **New Delhi – 110 092**	Member
16.	Shri Manoj Jain, Director (BD), GAIL (India) Ltd., 16, Bhikaiji Cama Place, **New Delhi - 110 066**	Member

17.	Shri Diwakar Nath Misra, Secretary, Oil Industry Development Board, OIDB Bhawan, Sector – 73, **NOIDA – 201 301**	Member
18.	Shri Alok Tripathi, Executive Director, Petroleum Conservation Research Association, Sanrakshan Bhawan, 10, Bhikaiji Cama Place, **New Delhi – 110 066**	Member
19.	Smt. Rashmi H. Urdhwareshe, Director, Automotive Research Association of India, S.No. 102, Vetal Hill, Off. Paud Road, Kothrud, **Pune – 411 038**	Member
20.	Dr. Anjan Ray, Director, CSIR – Indian Institute of Petroleum, P.O.IIP, Mohkampur, **Dehradun – 248 005**	Member
21.	Dr. V.P. Joy, Director General, Director General of Hydrocarbons, OIDB Bhawan, Tower A, Sector 73, **NOIDA – 201 301**	Member
22.	Shri Brijesh Kumar, Executive Director, Centre for High Technology, OIDB Bhawan, Plot No. 2, Sector-73, **NOIDA – 201 301**	Member-Secretary
23.	Shri Sandeep Poundrik, Joint Secretary (Refineries), Ministry of Petroleum & Natural Gas, Shastri Bhawan, **New Delhi – 110 001**	Permanent Invitee
24.	Shri Sanjay Bhargava, Chief General Manager (CRDC), Bharat Petroleum Corporation Ltd., Corporate R&D Centre, Plot No. 2 A, Udyog Kendra, Surajpur Industrial Area, **Greater NOIDA – 201 306**	Permanent Invitee

25.	Shri G. Sriganesh, Executive Director (R&D), HP Green R&D Centre, KIADB Industrial Area, Tarabahalli, Devanagundi, Hoskote, **Bengaluru – 560 067**	Permanent Invitee
26.	Shri R. Srikanthan, Director (Technical), Chennai Petroleum Corporation Limited, Manali, **Chennai – 600 068**	Permanent Invitee
27.	Ms. Vartika Shukla, Executive Director (T), R&D Centre, Engineers India Limited, Sector-16, **Gurgaon – 122 001**	Permanent Invitee
28.	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

28th November 2018

Minutes of 83rd Meeting of Scientific Advisory Committee (SAC) on Hydrocarbons of MoP&NG

1. The 83rd Meeting of SAC was held on 17th November 2018 at ONGC, NBP Green Heights, BKC, Bandra (E), Mumbai. The meeting was chaired by Dr Anil Kakodkar, Chairman, SAC.

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

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

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

   a. Activities and ATR since last SAC

   b. Biofuel Projects

      - Transferred from MNRE
      - CHT/OIDB Funded

   c. New R&D Project Proposals

   d. Projects under HCF

      - New Projects
      - On-going

   e. Review of on-going CHT/OIDB Funded R&D Projects

   f. **Discussion on Call for Proposals: CO_2 to Chemicals and Hydrogen**

      ED (CHT) mentioned that the cost of CO_2 capture and cost of renewable H_2 is coming down day by day and there is a case to focus on technologies for conversion of CO_2 to chemicals and fuels to bring them to readiness for commercialization, whenever, these become commercially viable. A paper on conversion of CO_2 to chemicals and fuels is included in the agenda papers with the consent of CH SAC. Based on the same, CHT proposes to issue Call for Proposals. He requested SAC to discuss the same and guide in finalization of list.

4. At the outset Chairman, SAC, while welcoming members, emphasized need for promotion of R&D and commercialization for biofuels as large scope exists for conversion of surplus agricultural residue, which can meet almost entire demand of gasoline. He further added that considering almost 20-25% share of conventional biomass in the energy mix, that provides energy for cooking and other domestic needs particularly in rural areas, major thrust is needed to convert the same to provide sustainable clean fuels. He welcomed

various initiatives taken by the Govt. to harness the potential of biomass derived clean fuels.

The challenge for 2G Ethanol is to bring down the production cost through R&D interventions. Currently, production cost of 2G Ethanol is high and government needs to consider viability gap funding. Chairman also emphasized on the need to promote gas based economy looking at emerging trends in terms of energy resource availability, end use convenience and better climate as well as air quality friendliness.

The technology for conversion of biomass to chemicals and fuels is maturing to readiness for commercialization and now with needed thrust could contribute significantly reduce crude import bill.

The conversion of CO_2 to chemicals and fuels is also gaining interest as cost of renewable hydrogen and CO_2 capture are falling. He pointed out that with increasing share of variable electricity generating sources, like renewable energy, in the grid, there could be opportunity to use surplus power, that the grid cannot absorb, for hydrogen production in a commercially viable manner leveraging better capacity utilization that otherwise could mean economic loss as a consequence of loss of capacity utilization. There is thus a case to study use of such surplus generation capacity to produce H_2 and use it to convert biomass or CO_2 to fuels and chemicals in integrated complexes allowing available generation capacity to be optimally utilized. This will also mitigate problem of power imbalance due to cyclic nature of renewable power as well as investment in infrastructure for wheeling of renewable power through grid.

5. JS(R) briefed about various Govt. initiatives for promotion of biofuels. He informed that policy for promoting R&D for biofuels and separate window for funding and mechanism for project selection/ monitoring is on anvil and in final stage discussion process within Govt. This policy is expected to further provide fillip to efforts in R&D, commercialization and increase share of biofuels in the country's energy mix. The effort would be to promote advance biofuels, Bio-CNG, Used Cooking Oils based biodiesel etc. Govt. is contemplating steps to improve viability of advanced bio fuels.

Govt. has targeted 30 nos of 2G ethanol plants with 100 crore liter combined capacity. MoP&NG, along with OMCs, has launched innovative initiative **SATAT** (**S**ustainable **A**lternative **T**owards **A**ffordable **T**ransportation), wherein potential entrepreneurs have been invited through Expression of Interest to set up CBG production plants for use in automotive fuels. 5000 Bio-CNG units with potential to produce 15 million tons of Gas by 2023, which is almost 75% of total current gas production in the country are planned to be set up under the scheme. Govt. has completed first round of Call for Proposals for

setting up bio CNG units with guaranteed offtake at a price of Rs 46 per Kg, which higher than current import price of gas.

Director (IIP) opined that for level playing among different biofuels, energy content of biofuels in the fuels may be mandated that would give choice to OMCs to utilize biofuels on techno-economic considerations.

6. JS (R) raised the issue of improving adoption and commercialIzation of technologies developed through SAC forum as well as through individual efforts of OMC's R&Ds and other R&D institutes.

A committee was constituted by EC of CHT to look into various impediments in commercialization of indigenous technology under the convenorship of Director (R), IOCL. Subsequently the recommendations were discussed in SAC as well as Working Group on Refineries chaired by JS(R).

To obviate the issue of conflict of interest in case of EiL, where EIL is technology provider as well as EPCM, it has been suggested that either the owner company could preselect the technology or a separate group may be formed to recommend for technical prequalification of the technology offered by EIL.

There was another issue related to prequalification criteria barring eligibility of captive commercialization. This issue was also resolved in the meeting of Working Group on Refineries as under;

"PSU refineries in their PQC, after due diligence, should allow qualification of indigenously developed technologies of other PSUs, even if the same has been demonstrated in a refinery for captive use only, and consider them for techno-economic evaluation along with other competing technologies."

After deliberations, it was decided that a Committee of Experts may be set up to i) put together policy recommendations that would promote and facilitate quicker commercial adaptation of R&D outcomes including scale up and ii) review readiness of indigenously developed technologies and recommend acceptance criteria for adoption of indigenous technologies. These recommendations should be made available to ministry to enable policy decisions that facilitate refineries to be more proactive in promoting and using indigenously developed technologies.

7. Activities since last SAC and ATR

a. Financial Progress in 2018-19

ED (CHT) mentioned that the total expenditure on R&D projects during 2018-19, including bio fuel projects and HCF is expected to be close to projection of Rs 15 Crore as per BE.

Figs in Rs lakh

	BE	Till Oct 18	Expected Nov - Mar	Total
R&D	820	275.72 #	429.47	705.19 *
Biofuels	536	206.08 ##	317.02	523.10
HCF	144	65.26	224.78	290.04
Total	1500	547.06	971.27	1518.33

* Lower on account of return of Rs 141.88 lakh from HPCL under project now transferred to HCF as there has been delay in the procurement of pilot plant due to challenges in its design.

Including payment of Rs 132.87 lakh under process.

Including payment of Rs 69.99 lakh under process.

Discussion Forum

ED (CHT) mentioned that CHT has launched Discussion Forum on its portal in the following major areas concerning the downstream hydrocarbon sector:

1. Refinery Process Troubleshooting
2. Energy Efficiency Improvement
3. Fuel Quality
4. Petrochemicals
5. Water Management
6. Power Generation, Distribution & Reliability
7. Project Management
8. Pipelines
9. Hydrogen as Fuel
10. Bio-fuels

For each of the above areas, an Expert Panel consisting of Domain Experts drawn from different locations (Refineries/ R&D/ Pipelines/ EIL as the case may be) have been constituted. Specific queries can be posted by the authorised co-ordinators from the locations for seeking answers from the Expert Panel.

b. ATR of 82nd SAC

i. List of equipment to be developed for self-sufficiency in vulnerable areas: EIL (Item 6c-1)

As advised by SAC in its 82nd meeting, EIL presented list of equipment and components to be developed in the areas of vulnerability as under;

Category: Equipment

List of Equipment	Current Suppliers	Prospective Manufacturers
Small Turbines ie Tesla and Micro Turbines with a capacity of 10 KW- 100 KW	Flex Turbine, Capstone Turbine Corporation	BHEL
Desalter System	CAMERON, FORUM	Business model to be made
Flare Gas Recovery systems	Garo, Zeeco	Ebara, BHEL, BHGE, Atlas Copco. IR
Helical Heat Exchangers	McDermott (Lummus)	Thermax, Isgec
VFD (Variable Frequency Drive) beyond 4-5 MW	ABB, Siemens, Hitachi, Toshiba, Nidec, Mitsubishi are already making smaller VFDs	
HPRT (Power Recovery Turbine)	BHGE, Shin Nippon, Kolar Husky Co. Ltd	BHEL, Ebara, Kirloskar
Divided wall column taken as replacement of two columns- Design Aspect	GTC, KBR	Sulzer, Koch Glitch, Godrej, L&T
VAM (Vapour Absorption Machine) < 50 TR	Thermax, Voltas are manufacturing larger VAM machines Potential : IR, Atlas Copco	
Hybrid ejector package	GEA, Korting, NASH	Kirloskar, Ebara
Incinerator package	CALLIDUS, ACOMETRIC, ZEECO	
Low Level heat recovery through Organic Rankine Cycle (ORC)	Aqylon, TURBODEN, ORMAT	BHEL, BHGE, Rotoflow
Vertical Barrel Pumps (Non-	Shin Nippon	KSB, KEPL

cryogenic available, cryogenic 100% imported)		
Expanders	Rotoflow, BHGE	
Welded Plate Exchangers	Alfa laval, Trainter, kelvion	
Aluminium Brazed Exchangers and Cold Box	100% imported Cryostar, Fives Cryo , Kobe , Linde AG, Sumito Precision	
Sundyne Type Pumps	100 % imported Tiande , Sundyne, Beijing Peking	Kirloskar, KSB
Very High Pressure Compressor/ Blower Charge Gas, Main Air Blower	Man Turbo, MHI, Ebara	BHEL, BHGE

Category: Component

List of Components	**Current Suppliers**	**Prospective Manufacturers**
Special Valve i.e. High Temperature Valves, Control (Ball), Butterfly	Orbit, Flow Serve, Argus, Vanessa, Emerson (internals), Samsun (part)	
Cartridges for Filters and Coalescer Packings (Housing is 100% indigenized)	6-7 vendors ie Pall, Peco Facet, however all cartridges are imported	
Internal Packings: Ripple Trays, Proprietary High Capacity Trays	UOP, Technip	Sulzer, Koch Glitch
Fanless Cooling Tower Nozzles	Armec, GS Cooling Towers, Mist	Paharpur, Gammon Hammon Sriram
Furnace Burners	John Zinc, Callidus, Zeeco	
Analysers, Probes & Process cards imported	Emerson, Yokogawa, ABB, Honeywell	
Flow meters (coriolis sensors, flare flow)	Thermo-fischer, Sickmaihak, BHGE (partial import)	
PLC, DCS , cards, basic software Microprocessor Imported	Emerson, Yokogawa, Honeywell, ABB, Invensys, Schneider	
Desalter Components Agar Probes, Transformer (100 reactance)	Agar Corporation , Desalter vendors	

SAC deliberated on the list in detail. It was observed that small turbine may have wider applications in solar thermal, HVAC systems and distributed CNG compression also. Likewise for other equipment, applications from other sectors could also be included. It was advised to include Lab equipment and R&D pilot plants/ equipment in the list.

EIL presented the following way forward:

- EIL shall present this list in its next Vendor Meet to prospective vendors to examine expanding their capabilities in these areas.
- The meet will also encourage foreign vendors to open their subsidiaries in India.
- Such indigenization can also be done by suitable Tie ups to bring technology or set up JVs to manufacture in India.
- Attempts will be made to enlist and support through Make in India.

SAC was of the opinion that the subject is of strategic importance and EIL need to form a separate group with the organization to provide impetus to this effort. It was suggested that 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. EIL was advised 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.

It was opined that:

1. Development of a limited number of equipment that are critical to elimination of vulnerabilities would need a consortium approach involving industry, institute, students working together.
2. For components, one should promote development through competitive mode by inviting proposals in RFP mode and selecting about three for development. There should be independent testing arrangement and assurance of business once the specified requirements are met.
3. EIL was requested to develop a more detailed plan of action in consultation with concerned stakeholders.

ii. **Setting up a Catalyst Manufacturing Plant (Item 6c-2)**

EIL presented the status as under:

Background

A Committee comprising of Directors of EIL/ IIP/ IOC/ HPC/ BPC and ED(CHT) was constituted during the meeting on 'Commercialization of Indigenously Developed Technologies' held under the chairmanship of JS (Refineries) on 30.10.2017.

Terms of Reference:

- Assess present as well as future requirement of catalyst (Type, Quantity & Technological Level)
- Capacity of catalyst plant with type
- Facility needed for Scale up
- Funding Mechanism for manufacturing unit
- Steps required for demonstration & promotion of commercialization of indigenous catalyst
- Strengthening infrastructure for catalyst development initiative and continual improvement

Approach (as approved by Working Group in its 18th meeting held on 12.06.2018):

- Strategic initiative rather than purely commercial.
- As catalyst manufacturing process is highly water intensive and requires high quality of water like Demineralized Water, therefore setting up of a Catalyst Manufacturing Unit under JV adjacent to a big refinery for sharing of Utilities & infrastructure as a strategy for cost reduction.
- Strategic tie-up with party either having access to catalyst technology or manufacturing capability, with global reach for marketing of catalysts worldwide
- To start with, JV may undertake marketing of catalysts with recipe developed by others by paying royalty or carry out toll manufacturing for others including foreign suppliers under NDA.
- Marketing of Catalysts based on Performance evaluation by Refineries through competitive bidding.
- Proposed to assess and fix the Local Content to comply with the recent Make in India policy of Govt.

- Scale up facilities for catalyst being developed by various R&D institutes & CSIR-Labs on payment basis, in addition to complete testing and characterization
- The R&D institutes to indicate their product portfolio and plans to the committee, however, marketing & manufacturing of own developed catalyst may be carried out in the next phase.

Catalyst Demand: Current and Projected (costs on current basis)

Cost in Rs Crore, Demand in MTPA

Year	Capacity (MMTPA)	Fixed Bed		FCC		Total	
		Quantity	Cost	Quantity	Cost	Quantity	Cost
Current	247.5	8000	1588	40000	1200	48000	~2800
Additional upto 2025	167.5	5500	1124	27000	810	31800	~2000
Total Upto 2025	**415**	**13500**	**2759**	**67000**	**2010**	**80500**	**~4800**

Status

- The following two models, both on Joint Venture (JV) route are recommended:
  - Indian partner(s) with controlling stake
  - Indian partner(s) with non-controlling stake
- These business models can be adopted with or without catalyst metal recovery.
- Talks initiated with Parties having access to Catalyst Technology and Catalyst Manufacturing with Global outreach for marketing
- It is proposed that along with the interested parties, estimation of order of magnitude investments, including the facility required for catalyst scale up for Indigenous Development shall be made.

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. JS(R) suggested that a meeting may be called in MOP&NG to fast-track the activity.

8. Biofuel Projects

ED (CHT) mentioned that a separate Expert Group of following members has been constituted by CH SAC to assist in review and monitoring of biofuel projects (transferred from MNRE to MoP&NG and ongoing CHT/OIDB funded).

i. Dr. R. Kumar, Professor Emeritus, IISc., Bengaluru (Chairman)
ii. Dr. Anjan Ray, Director, CSIR-IIP, Dehradun
iii. Prof. S. Dassapa, IISc, Bengaluru
iv. Prof. A.M. Lali, DBT-ICT, Mumbai
v. Dr. K.J. Mukherjee, CTO, NFCL, Hyderabad
vi. Dr. S.K. Puri, CGM (Bio-Energy) DBT-IOC, Faridabad
vii. Mr. Brijesh Kumar, ED (CHT)
viii. Dr. D.K. Tuli, DBT Bio Energy Chair

The meeting was held on 9th October, 2018, wherein 5 projects transferred from MNRE as well as 2 ongoing CHT/ OIDB funded projects have been discussed.

ED (CHT) presented the details and status of MNRE bio fuel projects and CHT funded bio fuel projects as under:

Transferred from MNRE

i. Improved production of Biogas and Bio CNG from lignocellulosic biomass: DBT-ICT Mumbai

Physical Progress

Sanction Date	End Date	Extension	Status
14.11.2013	14.11.2016	Dec 2018	Completed

Financial Progress (All figures in Rs, lakh)

Agency	Contribution		Fund Status Till Date		Fund Required
	Original	Revised	Released	Utilized	
MNRE	356.53	395.18	395.00	395.00	--
KITPL	89.37	--	--	--	--
Total	445.90	395.18	395.00	395.00	--

All the funds have been released by MNRE and there is no further amount to be released.

Project Outcome:

- Developed DBT-ICT Rapid-AD Technology with following attributes and can be used for MSW also

- Developed Technology up to raw bio-gas. Clean up of bio-gas can be carried out using commercially available packages
- Tie up with Chemtrols for Reactor design
- Catalytic liquefaction (Liquid & polymeric cataiyst) at 150°C and 6-7 bar pressure
- Wet and dry biomass without pretreatment and only homogenization
- Catalyst separation through Nano filtration
- Yield of Bio-Crude > 80% (Calorific Value : 25 MJ/kg ; TAN : >50; Cash Cost of Production: Rs 5-6/litre excluding cost of MSW/Biomass)
- Biogas yield of 88 % {1 kg COD gives 688 L Biogas (60 % methane)}
- OLR of 36 g COD/ L.day
- Biogas Productivity: 21 L/ L.day (~ 700 M^3/MT of Feed)
- >90 % substrate utilization

Commercialization status / Way Forward

- Being scaled up to 1 Ton MSW/day as a demonstration plant at BPCL Mumbai Refinery (funding by DBT at a cost of Rs 4.66 Crore).
- The technology once proven at demo scale is ready to be scaled up to 25 Ton MSW/day plant with Delhi Municipal Corporation in Gazipur, Delhi.
- Proposals for similar plants up to 100 TPD waste to Biogas are being designed for IOCL and many other private companies.
- Expert group observed that commercialization of technology is already on way. Further, intermediate Bio-Crude as such can also be upgraded for processing in Refineries for reducing Oxygen content.
- The Expert Group recommended that a separate project may be designed in collaboration with IIP and one or more oil companies.
- Prof. R. Kumar observed that new application in the form of gels is emerging for use as cooking fuels.

SAC approved closure of the project.

SAC advised ICT to submit new proposal for upgradation of intermediate Bio-Crude for reducing its Oxygen content to make it suitable for processing in Refineries.

ii. **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**

Physical Progress

Sanction Date	End Date	Extension	Status
11.09.2013	11.09.2016	March 2020	On going

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19			
			BE	Expenditure till Oct 18	Expected	Total
MNRE	120.00	120.00	-	-	-	-
CHT	44.07	-	-	-	27.67	27.67
Total	164.07	120.00	-	-	27.67	27.67

Background (Phase-1)

- Extension of MNRE sponsored Non-Catalytic Pyrolysis Project (2010-2013)

"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)

- Integrated and continuous Pilot Pyrolysis Test Unit of 20 kg/h capacity installed.
- 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 fraction from bio oil and thus avoids post distillation. Non-condensable gases are used as fuel.
- 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).

Phase-2 of MNRE project: 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: Remaining Work

- Procurement of Catalytic cracking unit (Quotation received) and Integration with existing pyrolyser.
- Testing of bio mass pyrolysis vapor over Stage I and Stage II catalysts (already prepared for conversion to transport fuel).
- Detailed analysis and testing of bio oil derived hydrocarbon fuels & other by-products
- TERI requested MNRE for 18 month extension upto March 2018 but the same could not be progressed at MNRE as visit of Experts could not materialize.

PI indicated that balance activities can be completed within the remaining fund of Rs 44 lakh from the approved budget.

Current Status

SAC in its 82nd meeting extended project up to March, 2020.

Expert Group deliberated on the project and advised for submission of month-wise activity plan and phasing of expenditure.

SAC deliberated on the above and advised to complete the remaining activities within extended time of March 2020.

iii. Sorghum Stover based Bio refinery for Fuels & Chemicals: NIIST/MNNIT/TERI/IICT

Objective

- To evaluate the feasibility of a sorghum stover based biorefinery with 2G ethanol as main product and value addition of by-products (Amino acids, Lactic Acid, Lignin, Algal Biomass, Algal Oil)

Physical Progress

Sanction Date	End Date	Extension	Status
06.03.2012	06.03.2015	31.12.2018	Report submitted

Financial Progress (All figures in Rs, lakh)

Lab	MNRE Contribution	Fund-Status Till Date		Fund Required
		Received	Utilized	
NIIST	93.874	87.487	93.670	6.18
IICT	15.063	14.000	15.063	1.06
TERI	36.437	32.793	36.859	0.6437
MNNIT	38.765	37.500	38.765	1.265
TOTAL	**184.139**	**171.78**	**184.357**	**9.1547**

Tasks by collaborating labs

NIIST	Sorghum stover characterization and chemical pretreatment
MNNIT	Process development • For removal of inhibitors from C5 stream • Separation of lignin from stover pretreatment liquor
NIIST	Enzyme production, hydrolysis of sorghum stover biomass and fermentative production of bioethanol
NIIST	Utilization of Pentose (C5) and hexose (C6) sugars available in the hydrolysate of Sorghum biomass for L- amino acid production (L-lysine & L- arginine)
TERI	Algal cultivation on acid pretreatment liquors of sorghum stover for its value addition
IICT	Process for algal biomass processing to separate algal oil, its characterization, exploration of neutraceutical and biodiesel production from algal oil

Status & Way Forward

- Solid state fermentation processes for production of cellulase and beta glucosidase developed and demonstrated at pilot scale.
- The enzyme produced performs at par and in some instances better than the world's best. Enzyme production process to be developed further to reduce cost from current ~Rs 250/kg to < Rs 100.
- Method for detoxification of APL by chromatographic method (Needs scale up)
- New algae which can grow on APL and produce biomass and oil for biodiesel /nutraceutical applications identified (Needs further studies to implement)

- Technology for amino-acids from C5 to be developed further to bring out the economics and possibility of integration
- Project completion report received. Balance fund (~ Rs 9-12 lakh) is remaining to be released after reconciliation/ utilisation by participating agencies.
- Proposal for next phase has been put up for CSIR funding.
- SAC in its 82nd meeting extended the project completion date till Dec, 2018 for review by the Experts and their recommendations.

SAC deliberated on the above and approved closure of the project.

iv. Direct conversion of sugarcane bagasse to auto-fuels by Catalytic Hydrous Pyrolysis in the presence of Carbon Monoxide: UPES, Dehradun

Objective

- To synthesize and characterize iron, molybdenum, titanium and cobalt oxides, their mixed oxides and their substituted MCM-41 materials suitable for hydrous pyrolysis of bagasse.
- To carry out performance evaluation of these catalysts in a batch type micro autoclave for hydrous pyrolysis in the presence of CO and taking this input for redesign of the catalyst if necessary.

Physical Progress

Sanction Date	End Date	Extension	Status
20.03.2014	20.03.2016	31.12.2018	Report submitted

Financial Progress (All figures in Rs, lakh)

Cost	Released by MNRE	Utilized	CHT
64.75	62.60	63.92	1.32*

*PI to submit sanction letter of MNRE regarding arrears of Rs. 1.16 lakh, which is due to the Research Associate and also utilization certificate for balance Rs 20,948.

- 50 catalysts evaluated. Best Catalyst: Fe-Co Oxide (1.1), calcined at 500°C
- Optimized Operating Conditions:

Temp	Pressure	Reaction Time	Water : Biomass	Catalyst : Biomass
250°C	45 bar	2 hr	28	0.4

- Results: Oil: 57.6%, Gas & WSO: 20.8%; O_2 in total oil: 10.8%

Advantages of Hydrous Pyrolysis

- Can handle wet biomass including slurry and thus eliminating energy intensive and time consuming drying step.
- Can break the thermally resistant biomass at 225-275°C.
- Bio-oil/water phase separation and thus eliminates distillation step; However, requires catalyst recovery from unconverted biomass.
- Oxygen content of bio-oil: 10.8 % achieved
- Can process MSW also

Status

- SAC in 82nd meeting extended the project up to Dec, 2018 for review and recommendation of Expert group.
- Expert Group deliberated and observed that yield and Oxygen content of the Bio-Oil are 57.6% and 10.8% respectively. It was advised to carry out economic analysis of the process with respect to IH^2 process, keeping in view energy balance, water usage, sourcing of Carbon Monoxide and catalyst.
- PI has shared comparison of IH^2 process. While, IH^2 process can handle biomass containing 10-30% moisture, HTL can handle upto 90% moisture. Thus HTL can process municipal waste water. Therefore these two technologies are not competing but complimenting in nature.
- It is proposed to get the above reviewed by the Expert group and for suggesting way forward for next phase.

SAC deliberated on the above and approved closure of the current project.

SAC advised Expert Group to review PI's comments by March 2019 on economic analysis of the hydrous pyrolysis process with respect to Shell IH^2 hydro-pyrolysis process, keeping in view energy balance, water usage, sourcing of Carbon Monoxide and catalyst.

Based on this, decision on new proposal shall be taken.

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

Objective

To convert lignocellulosic biomass into fuels that can be used in the transportation sector and chemicals.

Physical Progress

Sanction Date	End Date	Extension	Status
Jan 12	Jan 15	Apr 19	Ongoing

Financial Progress (All figures in Rs, lakh)

Agency	Contribution		Fund Status Till Date		Fund Required
	Original	Revised	Released	Utilized	
MNRE	186.40	271.68	232.19	229.76*	39.49

*As on 31st March 2018

Status

- Physico-chemical characterization of feedstock completed
- Hydropyrolysis unit both batch and integrated unit installed.
- Integrated unit (0.1 kg/h) commissioned only in December 2017.
- Catalyst optimization in progress.

Bio-Oil Analysis without catalyst (in H_2 presence); Feed: Rice Straw

T (°C)	P (Bar)	Oil (%)	Gas (%)	Char (%)	Oxygenates (%)	Furans	Cyclic	Acids	Others
550	5	18.48	52.67	28.86	61.64	0.57	15.21	0.0	22.58

Status

- SAC in 82nd meeting extended the project till April,2019 for completion of remaining activities and review by experts/ recommendation
- Expert Group observed that more experiments are required to optimize catalyst as well as process parameters for different feedstock to meet desired yield and quality with low oxygenates.
- Catalyst development need more thrust by IIP.
- CHT/OIDB has funded HPCL/ IIP to develop process at bigger scale for data generation to design demonstration unit of capacity 5 MT/D at HPCL.

SAC deliberated on the above and advised IIP to put more thrust on finalizing the catalyst within extended time and submit the report by April 2019.

On-going CHT/OIDB Funded

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

Objective

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

The project envisages Lab scale facilities at IIP (0.5 kg/hr) and HPCL R&D (5 kg/hr) for data generation for Demo unit. Subsequently, Scale-up and design of Demo unit of capacity 5 MT/d shall be taken up, which is not in the scope of project.

Physical Progress

MOU Date	Start Date	End Date	Extension	Physical Progress, %
Sept 16	Nov 16	Nov 19	--	25

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19			
			BE	Expenditure till Oct 18	Expected	Total
CHT	1440.0#	564.93*	210.0	--	60.0	60.0
HPCL	966.9	300.0	--	--	--	
Total	2406.9	864.93	210.0	--	60.0	60.0

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

* (IIP: Rs 484.93 lakh; HPCL: 80 lakh) including interest of Rs 1.93 lakh

Status

- The project envisages conversion of biomass to drop-in-fuel in a single step, which is a novel concept and not tried so far.
- During PMC meeting held on 04.11.2018 in presence of Dr. R. Kumar, it was expressed that the development of such catalyst is highly challenging and we should not depend upon single recipe.
- IIP was advised to continually work and improve the catalyst system and additional trial should also be carried out with commercial Ni & NiMo catalysts.

- As the technology is centred around catalyst system, which shall determine the configuration and overall economics of the developed technology, it is imperative that the catalyst system should be optimized looking into overall perspective of efficiency and configuration before finalizing process flow scheme of the pilot plant.

In view of foregoing, the project is expected to be delayed and the following milestone has been proposed:

- Optimization of catalyst system by IIP: April 2019
- Finalization of PFC and interaction with vendors for budgetary quote by HPCL: June 2019
- Issuance of Tender and purchase order: December 2019
- Delivery of pilot plant: December 2020
- Commissioning of pilot plant: March 2021
- Data generation using scaled up catalyst: September 2021
- Submission of the final report: November 2021
- HPCL is already having tie-up with Sud-Chemie for catalyst scale-up.

in view of above, HPCL has sought extension of the project by 2 years i.e. up to November 2021.

SAC deliberated on the above and advised to explore squeezing time for procurement of pilot plant.

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

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 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	Physical Progress, %
Dec 16	Mar 17	Mar 19	--	61

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Fund released till date	2018-19			
			BE	Fund released till Oct 18	Expected	Total
CHT	434.52 #	308.68*	326	206.08**	179.39	385.47

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

* (CPCL: Rs 278.38 lakh; ICGEB: Rs 30.30 lakh) including claims under process

** including under process payment of Rs 69.99 lakh to CPCL

Status

CPCL

- Construction of Ponds (2, 20, 200 and 4000 m^2) at CPCL site completed. Procurement of lab equipment completed. Mechanical work is expected to be completed by December 2018.
- Study on algae cultivation in 1, 10 and 20 m^2 ponds at ABAN site completed.
- Required quantity of lab scale culture was developed at Bio-Lab for transferring to open raceway ponds.
- Study on algae cultivation in 2, 20 & 200 m^2 ponds at CPCL site is in progress.

ICGEB

- ICGEB has received two marine algal strains from ABAN. Both have been genetically modified with the inorganic carbon (Ci) transporters. This has helped in accumulating more CO_2/HCO_3^- from aqueous environment in algal cells and resulted in higher biomass productivity.
- The transformation of algal species has been ascertained by antibiotic selection on agar plates and PCR analysis of integrated DNA.
- ICGEB has indicated that their activities shall be completed by March 2019 (Original schedule: November 2018).
- CPCL has requested for time extension up to August 2019 (Original schedule: March 2019) due to delay in construction of race way ponds because of non-availability of earth quarry, slushy site condition during last year monsoon season, non-availability of 1 mm thick HDPE sheet and difficulty in conducting any meaningful study in Nov-Dec, 2018 due to North East monsoon.

SAC considered the above and approved time extension to CPCL up to August 2019 & ICGEB up to March 2019 within approved CHT/OIDB's contribution.

SAC advised CPCL that regulatory clearance for field testing of genetically modified algal strains should be processed in advance.

9. **New R&D Project Proposals**

ED (CHT) informed that the screening Committee set up by CH SAC has been advising project proponents to define objective and reformulate proposals before submission to SAC. The screening Committee, in its meeting held on 10th October 2018 has shortlisted 5 projects including one proposal under HCF which are under different stages of formulation and recommended EIL's proposal on development of 3D model for Gasifier.

ED (CHT) presented the status as under for consideration of SAC:

i. **Production of lower olefins (Ethylene and Propylene) from Syngas: IICT/BPCL**

- Current route: Naphtha/Gas cracking and Methanol to olefins (MTO).
- Proposal: To produce lower olefins from syngas in a single step
- The Screening Committee reviewed the proposal on 10th October, 2018 and observed that
    - There are challenges in development of multifunctional catalyst promoting Methanol synthesis (currently standalone unit operating at > 50 bar) and simultaneous conversion to Olefin (which requires low pressure).
    - Project may be initially taken up to establish proof of concept w.r.t selectivity, yield and conversion by operating at a pressure between 20-30 bar.

Phase-1: Synthesis of catalysts in a 4 CC fixed bed reactor: CSIR-IICT (18 months)

Phase-2: Data Validation in a 20 CC fixed bed reactor: BPCL R&D (6 months)

Phase-3: Optimization of process parameters in fluidized bed reactor (50 CC cat vol) & development of a kinetic model for design of pilot plant unit (36 months)

Phase-4: Studies in a circulating fluidization bed reactor (1000 CC) to generate basic design data for setting up of demo plant

Phase-5: Demo unit at 400 Kg cat load volume

Project Cost estimate (Phase-1): **(Figs. in Rs Lakh)**

S.N.	Attributes	Funding by CSIR-IICT	Funding by CHT/OIDB	Total Cost
1.	Manpower	25.726	14.274	40.0
2.	Consumables/components	9.5	20.5	30.0
3.	Services/utilities	30.0	1.0	31.0
4.	Equipment/Computer Usage	-	1.22	1.22
5.	Analysis	10.0	-	10.0
6.	Travel cost (TA/DA)	-	3.0	3.0
7.	New Equipment	72.2	37.8	110.0
8.	Contingencies/Overheads	6.75	6.25	13.0
	Total	**154.176**	**84.044**	**238.228**

BPCL has expressed willingness to collaborate in scale up after the proof of concept.

Duration: 18 months

SAC deliberated on the above and recommended the proposal. However, PI has been advised to submit list of equipment and their cost for review by Chairman, Screening Committee before financial approval.

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

- For recovery of low level waste heat and conversion to electricity requires use of Organic Rankine Cycle (ORC) based applications.
- Conventional turbines, despite being highly efficient, suffers from high cost & also have limitations at small scales due to enhanced viscous loss.
- The cost of Tesla turbine is expected to be significantly lower.

The Tesla Turbine

- Bladeless turbo machine made of a number of parallel disks attached to central shaft. The rotor assembly is placed inside a cylindrical casting with a very small clearance between the disks and the casings.
- Generates shaft power due to the frictional drag acting on the surface of the blades as a consequence of no slip condition. It suffers little damage due to abrasive particles because of absence of any direct impingement like conventional turbine. Mass accumulation inside the rotor gaps is very minimal due to presence of centrifugal force field inside the rotor gap

Proposal:

To develop a versatile Tesla Turbine Prototype and undertake experiments with different working fluids to validate experimental data with simulated data.

Screening Committee on 17th May, 2018 & 10th October,2018

- An overall efficiency of 10-12% can make ORC system attractive for Industrial application. However, the development requires handholding with Engineering Partners, who can scale up and provide complete design of ORC.
- Project may be taken up in a collaborative approach and suggested that IIT-KGP, EIL and one of the Oil PSU should approach BHEL.
- Literature Scan on potential commercially available working fluids is to be carried out for different temperature range of low level heat sources, keeping in view the stability with ambient temperature variation

A meeting was organized between EIL, IOCL, IIT-KGP, BHEL and CHT on 17th July, 2018. BHEL has expressed interest only once the prototype is developed.

IIT-KGP in collaboration with EIL and IOC to submit the revised proposal incorporating case study with indicative efficiency.

SAC deliberated on the above and advised that although, BHEL is a preferred choice for manufacturing. However, as BHEL does not want to collaborate during prototype development, EIL may select small scale manufacturer.

iii. Design & Development of Fiber Optic gas Sensors and System for Petroleum Industry: CSIO Chandigarh/BPCL

Reliable sensing of explosive toxic gases like CO_2, CO, O_2, H_2S, NH_3, SO_2, CH_4, etc. are essential.

Currently available catalytic, acoustic, FTIR and chromatography based gas analyzers and sensors are bulky, highly sensitive to humidity, operates at higher temperature and also their sensitivity deteriorates with time.

Optical Fibre based gas sensors offers several advantages such as immunity to electromagnetic interferences, low cross sensitivity, small size and possibility for distributed gas sensing.

The Screening Committee on 10th October, 2018 advised that

- Objective of the proposal need to be defined in terms of response time, detection limits etc. & the Project to be undertaken in 3 phases as under:

Phase-1: Proof of concept (12 months)

Phase-2: Development of prototype & field testing along with BPCL (12 months)

Phase-3: Commercialisation by identified manufacturing partner (shall be explored before taking up Phase-2.

- An expert group to be formed comprising of instrumentation experts from BPCL and CSIR-IIP to monitor the project progress and performance in real time.

Proposal

Objective: To demonstrate functional laboratory level proof of concept of fibre optic gas sensor and system for gas composition analysis of mixture of gases at laboratory level for its application in Petroleum Industry.

Target specifications:

Response time: ≤ 100s (Response time of the gas sensor is mainly dependent on the diffusion time of gas in the gas cell i.e. flow dependent).

Detection range: CH_4: 0 - 100%; H_2S: 0 - 50 ppm; CO: 0 – 1000 ppm; NH_3: 0 -10 ppm

Detection limit: CH_4: 15 ppm; H_2S: 10 ppm; CO: 40 ppm; NH_3: 5 ppm

Project cost: Rs 75.83 Lakh (all by CHT) **Duration:** 12 months

BPCL has indicated their willingness to join as commercial partner after proof of concept in phase-1.

During the discussion, BPCL informed that proof of concept does not include detection of SO_2 and Hydrocarbon. CSIO clarified that detection of SO_2 is not possible with NIR optical fiber as it requires higher wavelength in mid infra region. Similarly, for hydrocarbon, which is mixture of number of gases from C1 to C6, it requires different type of optical fiber. With NIR, only CH_4 detection is possible.

SAC extensively deliberated and recommended the proposal. However, PI was advised to explore options to detect SO_2 and other hydrocarbons as per the requirement of user industry.

iv. Development of Superior Absorbents for CO_2 Separation from Biogas: ICT-Mumbai/ IOC

- Biogas is required to have 90% min CH_4 & 3.5% max N_2+CO_2 for use as CNG; CO_2 capture is a crucial step in upgrading biogas.

- The proposal aims to use hindered amines, in place of conventional MDEA, for improved CO_2 capture, as they are moderately reactive and have superior desorption features.
- Screening Committee on 10th October, 2018 observed that there is a need for literature survey for comparison of various processes and also to target for removal of CO_2 only based on the selected process & in following steps;
    1. To measure efficiency of CO_2 absorption & desorption in batch mode (iCT)
    2. To measure CO_2 absorption efficiency & regeneration energy in Continuous mode at lab scale (ICT)
    3. To measure the CO_2 solubility in VLE setup & to measure absorption rates and investigate absorption kinetics in stirred cell (ICT)
    4. Performance & Energy requirement study in pilot plant (IOC R&D)

Project cost: Rs 85.57 Lakh at ICT **Duration:** 36 months

Details of IOC R&D's contribution including for activities in item 4 above is awaited.

SAC recommended the proposal and advised CHT to proceed for financial approval after getting contribution details from IOC.

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

- SAC in its 81st meeting on 14.03.2018, advised to initiate parallel effort for developing validated model of gasifier so as to develop capability for credible scale up with the help of CFD experts.
- Expert Group on 17th July, 2018, suggested to include following while developing the model:
    - Coal feeding System
    - Coal collecting efficiency of cyclones
    - PSD of solids collected at various locations
    - Composition of gases
- EIL proposed the modelling of the gasifier in 3 parts as under:
    - 0-D Population Balance Model for coal feeding circuit
    - 3D CFD model of gasifier based on discrete phase model (DDPM) &KTGF
    - Modelling of cyclones & its downstream
- As discussed in 82nd SAC meeting, Expert help from Prof. S. Jayanti, IIT Madras is being taken and development is proposed to be done using ANSYS Fluent as it is

widely accepted software for modelling of multiphase and multi component systems particularly for particle-particle interactions.

- The Expert Group was of the view that the rigorous 3D model should be based on experimentally determined feed i.e. in terms of PSD etc.,

Therefore, cold flow set-ups are envisaged.

Further, the current hardware also needs to be upgraded with additional computational capabilities to solve the highly complex gasifier models.

SAC recommended the proposal. The contribution of EIL / BPCL and CHT may be discussed while approval.

10. Projects under HCF

ED (CHT) informed that under HCF, there are two new projects and one ongoing project, which has been transferred to HCF for funding as per MoP&NG directive.

ED (CHT) presented the status as under:

New projects

i. Creation of solar based hydrogen production system and dispensing station for refueling hydrogen fuel cell vehicle: IOC R&D

Project Cost: Rs 65.16 Crore (CHT Contribution: Rs 30 Crore)
Duration: 36 months (3 Years)
The project aims at developing national facility which would enable PSU and other R&D institutes in demonstration of technologies in PV cells, Electrolyser, H_2 Storage, Fuel Cell Vehicles & integration of sub-systems and obtain approval from PESO.

Proposed facilities will comprise of following:

- Solar HIT PV cells: 1.15 MW (Silicon based with 18% efficiency and can work with diffused light); 60.5 KWh is required for 1 kg of hydrogen
- Hydrogen generation unit (through PEM electrolyser: 425 Kg/hr; 90 Nm^3/hr (50% Efficiency)
- Hydrogen Compressor : upto 550 bar
- Hydrogen Storage : 180 Kg
- Dispenser, utilities and safety systems.
- Fuel cell vehicle from Tata Motors: to be refilled and tested.

- SAC in its 81st meeting on 14th March, 2018 extensively deliberated & recommended the proposal with following remarks:
    - Project should have flexibility to adopt different pathways for hydrogen production and storage so as to derive cost benefit of innovation and cost cutting in future
    - IOCL to procure the best electrolyser that would minimise energy consumption through EOI route even though there may be higher initial capital cost.
    - Estimated cost of project (Rs 44 Crore), may go up with suggested actions as above. CHTs share in the project to be capped at Rs 30 Crore with the rest to be borne by IOCL.
- EC of CHT, in its 25th meeting on 12th June, 2018 advised that the project proposal to be put up with firm cost post EOI and minimum contribution of 50 % by IOCL.
- Further GC of CHT, in its 36th meeting on 30th July, 2018 considered and accorded in-principle approval for the above proposai for funding from HCF.
- IOC R&D has submitted proposal at revised cost of Rs. 65.16 Crore based on EOI.
- SAC in its 82nd meeting held on 11.09.2018 deliberated and recommended the proposal for approval by Competent Authority

SAC noted the above.

ii. **Photocatalyst Device Development for Large Scale Solar H_2 Generation: NCL/GAIL**

- The project aims to fabricate photo-anodes to produce H_2 from water splitting by using sunlight and photocatalyst device in wireless configuration (at no applied potential and hence just photochemical cell) mimicking Quasi Artificial Leaf (QuAL).
- The proposed route for production of hydrogen through photo catalytic device is achieving tempting efficiency level.
- Already efficiency of 19% is reported by a California based Institute, although the same is still to be scaled up and established at higher scale.
- An efficiency of ~12% can be considered in line with currently developed PV and Electrolyser system (Efficiency of 18-19% for PV Cell and 70% for Electrolyser).

SAC in its 82nd meeting on 11.09.2018 recommended the project and advised that one of the oil PSUs as the major consumer of H_2 / EIL should also be associated with this project along with GAIL with clear objective.

HPCL has indicated willingness to collaborate in the project.

The Screening Committee on 4th Nov, 2018 advised NCL Pune to include milestones for system efficiency improvement, role & responsibilities of all partners, development of prototype, project cost along with contributions, scale up with engineering partner.

The proposal will be put up again for consideration of SAC.

SAC noted the above.

Ongoing

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

This project is an extension of the earlier project funded under HCF and completed by HPCL-R&D in collaboration with IIT Delhi wherein the detailed kinetics, modelling and simulation studies were carried out for fixed bed as well as fluidized bed wherein catalytic decomposition of methane (CDM) was investigated for the production of COx free H_2 and carbon nano-tubes. The project is to be taken up in 2 phases as under and the current project is for Phase-1 only:

Phase-1: Scale-up studies for production of H_2 and carbon nano tubes by catalytic decomposition of natural gas at rate of 1 kg/hr

Phase-2 - Basic engineering package for Demonstration unit at HPCL

Physical Progress

MOU Date	Start Date	End Date	Extension	Physical Progress, %
Feb 17	Mar 17	Mar 21	--	10

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19			
			BE	Expenditure till Oct 18	Expected	Total
CHT	1692.10 #	84.37 *	144	65.26**	224.78	290.04
HPCL	1253.60	500.0	--	--	--	--
Total	2945.70	584.37	144	65.26	224.78	290.04

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

*(HPCL: NIL; IIT-D: 65.86 lakh; CeNS: 18.51 lakh). This includes Rs 19.11 lakh, released from CHT grant till 2017-18.

** From HCF in 2018-19

- HPCL has returned advance of Rs 141.88 lakh on 01.06.2018 which was released on 24.03.2017 as there has been delay in the procurement of pilot plant due to challenges in its design.
- Project transferred under HCF vide MoP&NG letter dated 22.06.2018.

Status

- 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.
- Three meetings of Expert group have been held on 17.05.2018, 9.10.2018 and 4.11.2018. Following are the salient points of discussion and the status:
    - Bubbling type of bed selected in view of high residence time requirement.
    - The methane decomposition studies carried out in HPCL unit (50ml) by varying TOS, GHSV etc. and reaction time optimised to about 3 hrs for conversion and CNT quality.
    - CeNS has carried out CNT separation using sonication method and achieved 50% recovery of CNT in 3 hrs time.
    - HPCL shall carry out recyclability study using catalyst after CNT recovery by CeNS.
    - As suggested by Expert Group, IITD has developed catalyst with Fe as promoter and with varying metal concentration from 10 to 60%. Consistent quality of CNT has been achieved with 20% metal loading and there is no improvement in conversion by increasing the metal content further.
    - IITD advised to develop & generate data on yield /CNT quality with different catalyst formulation and metal loading for tailoring CNT quality requirement.
    - IIT-Delhi has initiated procurement of lab reactor and the PO is expected by Dec'18.
    - IIT-Delhi has shared their published papers and patents.
    - Economic analysis of the Project through a professional consultant.
    - The Catalyst scale up is to be done through a commercial catalyst manufacturer. HPCL has indicated that they have tie up with Sud-Chemie for catalyst scale-up.
    - CeNS has compiled literature information on the following:
        - Required properties of CNTs for composite materials
        - Continuous CNT separation at large scale
        - Comparison of graphene Vs CNT for various applications

- As advised, HPCL is in contact with various agencies like DRDO, L&T, ISRO, and NAL regarding their CNT requirements.

During the discussion, HPCL informed that study on recyclability of the catalyst after CNT separation of 50% is not successful.

SAC noted the above and advised to explore more options for recyclability.

11. 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 status as under:

CHT/OIDB Funded

i. Coal to Liquid (CTL) Fuels Technology Project: EIL-R&D / BPCL-R&D

Objective

To develop technology for gasification of high ash Indian coal

Physical Progress

MOU Date	Start Date	End Date	Extension	Physical Progress, %
Mar 09	July 09	July 13	June 19	94

The project has been envisaged in three major steps:
Step 1: Gasification of coal to syngas
Step 2: Cleaning of syngas (Removal of H_2S, NH_3, HCN, CO_2, COS, etc.)
Step 3: Conversion of syngas to liquid fuels through Fischer-Tropsch (FT) synthesis

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19			
			BE	Expenditure till Oct 18	Expected	Total
CHT	1483.95#	1220.95*	73.0	--	73.0	73.0
EIL	924	799.85	--	--	52.0	52.0
BPCL	560	421.10	--	--	--	--
Thermax	332	301.50	--	--	--	--
Total	3300	2743.40	73.0	--	125.0	125.0

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

Status

- Development of FT technology (catalyst, kinetic study, hydrodynamic study, reactor model) completed.
- Gasifier & syngas cleaning system operation was started in phased manner boosting up the pressure up to 6 bar. However, due to choking in the downstream section and ash extraction system, operation could not be sustained beyond 1-3 hours.
- SAC during its 80th meeting held on 6th September 2017 constituted an Expert Group to carry out comprehensive overall review and look into all the possible aspects of high ash coal gasification at high pressure and recommend modifications to address issues in the continuous running of the pilot plant.
- So far 6 meetings of Expert Group have been held on 11th Oct'17, 24th Nov'17, 13th Feb'18, 18th May'18, 17th July'18 and 10th Oct'18.
- Following modifications were advised by Expert Group:
  - Ash removal system modification
  - Auto control of air flow
  - Additional new cyclone system at the exit of gasifier.
  - Feed line modifications
- The mechanical completion of the modification completed on 25th October, 2018. Subsequently, EIL/ BPCL team has commenced the trial runs.

SAC noted the above.

ii. Experimental and simulation studies on coke mitigation in petroleum refinery system: BPCL & BITS Pilani (Goa)

Objective

- To study kinetics and mechanisms involved in coking on metal surfaces in high temperature heavy liquid refinery streams
- To develop predictive tools such as coking potential and coking index
- To develop coke mitigation strategies through use of additives and passivation studies

Physical Progress

MOU Date	Start Date	End Date	Extension	Physical Progress, %
May 14	Apr 15	Apr 18	Oct 18	94

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19			
			BE	Expenditure till Oct 18	Expected	Total
CHT*	132.97	119.67	--	--	13.30	13.30
BPCL	190.25	190.25	--	--	--	--
Total	322.22	309.92	--	--	13.30	13.30

*Only to BITS. Balance 10% to be released upon completion of the project.

Status

- The study has helped in understanding mechanism of coke deposition and the propensity of coking tendency of various refinery streams in crude preheat train, heat exchangers, etc.
- The know how shall be useful in the following areas:
  - The design of heat exchangers/ crude preheat train
  - Coke mitigation strategies through optimization of operating variables, selection of metallurgy as well as dosing of antifoulants
  - Operational monitoring and cleaning schedules through predictive monitoring
  - Stream segregation based on physico-chemical properties and change in coking tendency due to interactions.
- Post submission of the report, BPCL shall use all the knowhow. BITS Pilani shall render help to BPCL as may be required, without any financial implication. Subsequently, knowhow and experience shall be shared with SAC and industry.
- BPCL has requested extension of the project for 3 months for completing the final report.

SAC deliberated on the above and approved the completion and closure of the project. SAC advised to submit final report by January 2019.

iii. **Development of process know-how for indigenous production of Biphenyl for thermic fluid and other application: BPCL**

Objective

- To develop highly active & selective catalyst and sustainable, cost effective & energy efficient process route for biphenyl production with ease of integration with oil refinery processes.

Physical Progress

MOU Date	Start Date	End Date	Extension	Physical Progress, %
Oct 14	Mar 15	Mar 18	Oct 18	85

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Fund Released till date	2018-19			
			BE	Fund Released till Oct 18	Expected	Total
CHT	260	245.02	220.0	209.08	14.98	224.06

Status

- Project is completed and the draft report submitted on 30th October 2018.
  - Process and catalysts for conversion of Benzene to Cyclohexylbenzene (CHB) and subsequentiy to Biphenyl successfully developed.
  - Process demonstration studies performed using integrated dual reactor unit.
- Keeping in view of progress made in PV cell technology, and diminishing interest in Concentrated Solar Power generation option, SAC in its 82nd meeting advised BPCL to explore alternative applications of Biphenyl as well as intermediate CHB.
- The intermediate CHB has various applications in the refining and petrochemical industry.
- BPCL has requested extension for 3 months for submission of final report.

While presenting the way forward, BPCL informed that there is demand of only 100 MTPA of Biphenyl and 10 TMTPA of intermediate product CHB. Hence, technology development and commercialization activities shall be undertaken in future after assessment of market demand and process economics.

SAC extensively deliberated and approved closure of the project.

SAC advised to submit final report by January 2019.

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

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	Physical Progress, %
Feb 15	Mar 15	Mar 18	June 19	85

Financial Progress (All figures in Rs, lakh)

	Contribution		Expenditure till date	2018-19			
	Original	Revised		BE	Expenditure till Oct 18	Expected	Total
CHT#	853.0	853.0	814.00**	155.0	116.66	39.00	155.66
BPCL	348.1	469.31	426.42	--	--	--	--
EIL	250.0	352.72	193.52	--	--	--	--
Total	1451.1	1675.03*	1433.94	155.0	116.66	39.00	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.

** including under process payment of Rs 116.66 lakh to EIL

Status

- Prototype desalter skid, Transformers and Mix valve installed at BPC KR site. Special Level Instruments (i.e. AGAR Probes) are planned to be installed in the presence of vendor's specialist.
- Site related activities and mechanical completion of skid is almost complete; with minor works expected to be completed before end-Nov'18.
- Testing / operation is expected to start in mid-Dec'18. Duration of testing is expected to be 2-3 months.

SAC noted the above.

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

Objective

- Development of Catalyst and Process for Slurry Phase Residue Hydrocracking;
- Process optimization; studies of hydrodynamics, simulation and modeling in suitable reactor and evaluation of the developed catalyst (s) at pilot plant

Physical Progress

MOU Date	Start Date	End Date	Extension	Physical Progress, %
June 15	July 15	July 18	July 19	75

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19			
			BE	Expenditure till Oct 18	Expected	Total
CHT	1366#	1138.10*	195.0	--	198.85	198.85
HPCL	776.0	506.6	--	--	--	--
CSIR-IIP	93.0	93.0	--	--	--	--
Total	2235.0	1737.70	195.0	--	198.85	198.85

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

* (CSIR-IIP: Rs.466.95 lakh, HPCL: Rs.671.15lakh) including interest of Rs 2.55 lakh earned by CSIR-IIP.

Status

- Catalysts developed by IIP, HPC & BPC and their best 3 catalyst shared for testing by others.
- Anomaly observed in the results obtained by different agencies in batch mode for same operating conditions. In view of above, only the best catalyst, from each based on their own results will be tested at IIP in continuous flow reactor (0.5L). Subsequently, best catalyst shall be evaluated in pilot plant (1 L) at HPCL.
- Feed pump issue encountered during stabilization of IIP reactor is expected to be resolved by Dec'18.
- The commissioning of pilot plant at HPCL is completed. During the normal run, malfunctioning of chiller was encountered. Vendor is working on replacing the chiller components. The unit is expected to be ready by December 2018.
- EIL will carry out Process Optimization, Hydrodynamic studies, process simulation & modeling of slurry phase reactor for final catalyst selected based on cost and performance.
- Meeting held at IIP on 13th November 2018 to discuss & finalize protocol for trials.

SAC noted the above.

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

Background

A Taskforce formed to look into possibility of developing indigenous capabilities in aviation lubricants, shortlisted two commercial lubricants viz. OX-27 (meeting MIL PRF-23699F) & OX-38 (meeting DEF STAN 91-98 specifications) for indigenous development.

Phase-1: two synthetic lubricants SVS 11 & SVS 21 developed, suitable for Garrett and Orpheus aero engines with Ryder test carried out at US NAVAIR. The developed lubricants passed all the mandatory tests. Provisional Certificates for Airworthiness Approval was granted by CEMILAC for both lubricants, essential for In-flight tests.

Phase-2 (Current Project):

CSIR-IICT: To prepare 500 l base oil each for SVS11 & SVS21.

HPCL: Formulations meeting the mandatory tests for further testing by 3BRD Chandigarh, IAF for Defense applications.

Physical Progress

MOU Date	Start Date	End Date	Extension	Physical Progress, %
Mar 16	Apr 16	Sept 17	Mar 19	80

Financial Progress (All figures in Rs, lakh)

Agency	Contribution		Expenditure till date	2018-19			
	Original	Revised*		BE	Expenditure till Oct 18	Expected	Total
CHT#	97	139.02	130.8	40.0	31.90 **	8.2	40.1
HPCL	118	169.10	87.1	--	--	--	--
CSIR-IICT	30	43.00	35.0	8.0	5.0	3.0	8.0
CEMILAC	5	7.16	--	--	--	--	--
Total	250	358.28	252.9	48.0	36.90	11.2	48.1

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.

** including under process payment of Rs 16.21 lakh to CSIR-IICT

Status of SVS-21

- IICT prepared 250 kg of base oil & HPCL formulated the same. HPCL conducted rubber seal compatibility study (rubber seals of TV-2 aero engine of MI-8 helicopter supplied by 3BRD) & tribology testing in the presence of all stakeholders. The lubricant exhibited similar properties with that of OX-38.
- After this study, HPCL supplied lubricant to 3BRD for 50 h engine tests in TV-2 aero engine and the engine bed tests.
- 3BRD carried out initialiy 25 hr engine test and sample was checked by RCMA (Earlier CEMILAC) and certified okay. Further, engine test was done for another 25 hr, results are awaited.

Status of SVS-11

- IICT has prepared & supplied 500 kg base oil to HPCL for formulation & lubricant testing.
- HPCL has formulated 5 kg of sample for rubber seal compatibility study (rubber seals of TV-3 aero engine supplied by 3BRD) & tribology testing.

Remaining Activities

- Formulation of SVS-11 (by HPCL) & testing in TV-3 aero engine & also in-flight tests (MI-17 helicopter) at 3BRD followed by Certification by RCMA and DGAQA by First week of February 2019.
- Draft Report submission by CSIR-IICT by February 2019.
- Presentation of way forward by HPCL in next meeting of SAC.
- Final report submission by March 2019.

SAC noted the above.

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

Objective

- To evaluate the Emission & Power performance of existing old vehicles with ethanol blended diesel vis a vis BS-VI norms.
- To evaluate vehicle performance as per CMVR tests (Gradability, CSFC, Acceleration, etc.) with ethanol blended diesel by comparing with base diesel at 0 hrs, 20 hrs, every 100 hrs and final engine test after 500 hrs

Physical Progress

MOU Date	Start Date	End Date	Extension	Physical Progress, %
Sept 17	Oct 17	Mar 18	Dec 18	80

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Fund Released till date	2018-19			
			BE	Fund Released till Oct 18	Expected	Total
CHT	129.80	67.66	112.0	57.16	62.14	119.30

Status

- Blend of 7.7% Ethanol in Diesel using 2% BERAID-10 additive was found to be the most optimum.
- M/s Tata Motors supplied Tata 697 BSIV Engine in Feb 2018 and 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.
- Fuel conditioning system commissioned.
- **Remaining work:**
  - Emission Assessment Trials on BS-III Engine
  - Vehicular trials on BS-III bus
  - Submission of report
- ARAI is expected to receive Diesel bus and BS-III diesel engine from BEST, Mumbai by 2nd week of Nov 18 for completion of remaining test.
- Transport Commissioner (TC- Maharashtra) office, Mumbai has principally agreed for conducting trials on diesel ethanol blend on BEST bus.
- Draft manuscript of research paper "Development of Diesel-Ethanol engine for HCV" based on outcome of the project is accepted by SIAT 2019.

ARAI requested to extend the project till March 2019 as there has been delay in getting BS-III engine and bus from BEST.

SAC deliberated and extended the project till March 2019.

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

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	Physical Progress, %
Sept 18	Nov 18	Apr 20	-

Financial Progress (All figures in Rs, lakh)

Agency	Contribution	Expenditure till date	2018-19			
			BE	Expenditure till Oct 18	Expected	Total
CHT	55.20	-	20.0	-	20.0	20.0
HPCL	61.84	-	-	-	-	-
Total	117.04	-	20.0	-	20.0	20.0

Status

- Recommended by SAC in its 81st meeting held on 14.03.2018 and approved by EC in its 25th meeting held on 12.6.2018.
- The System Architecture Design is in progress. HPCL has initiated procurement of hardware and software required in phase-1 of the project.

SAC noted the above.

12. Discussion on Call for Proposal: CO_2 to Chemicals and Hydrogen

ED (CHT) mentioned that a paper on conversion of CO_2 to chemicals and fuels is included in the agenda papers. Based on the same, CHT proposes to issue Call for Proposals in the following areas to bring them to readiness for commercialization, whenever, these become commercially viable:

CO_2 to Chemicals

1. Low pressure catalytic process development for CO_2 hydrogenation to methanol
2. Process and catalyst development for Reverse water gas shift reaction in fluidized bed for reduction of CO_2 to CO
3. Electrochemical reduction of CO_2 to chemicals (Methanol, Glycol, Formic acid, Oxalic acid etc.)
4. CO_2 to Dimethyl carbonate: by reaction of urea to methanol and recycle of byproduct ammonia
5. Single step DME from CO_2/ CO
6. Direct catalytic conversion of CO_2 and H_2 to gasoline or Diesel or C3 and C4 HC
7. Conversion of methanol to ethanol
8. Process and catalyst development for production of acrylic acid
9. CO_2 capture from industrial stacks

Hydrogen

1. Photocatalytic device for hydrogen production
2. Outlook for hydrogen production using PV cells and water electrolysis
3. Demonstration of Fuel cell vehicle and purification/ dispensing of refinery produced Hydrogen around refineries

CHT was advised to circulate the list of items for Proposed Call for Proposals in R&D areas for comments and finalization. In pursuit towards developing hydrogen economy, CH SAC suggested to take help from consultants to carry out technology assessment, and develop business model including economic benefit in following areas, where technology could be promising for demonstration/ commercialization;

1. **Hydrogen production through thermochemical route utilising IS and CuCl cycles**
2. **H_2 production by steam electrolysis using surplus power from existing power plants/ Stranded capacity**
3. **CO_2 capture and conversion to gasoline/ diesel using renewable hydrogen**
4. **Purification/ dispensing of refinery produced hydrogen and demonstration of fuel cell vehicles around refineries.**
5. **Outlook for hydrogen production using PV cells and water electrolysis.**

Annexure-1

83rd Meeting of Scientific Advisory Committee (SAC) on Hydrocarbons of MoP&NG held on 17th November 2018 at ONGC, NBP Green Heights, BKC, Bandra (E), 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. A.B. Pandit	Professor	ICT
5	Dr. Shashi Kant	Scientist Emeritus	IOCL
6	Sh. V. S. Shenoy	Director (R)	HPCL
7	Dr. B. Bhargava	DG	OEC
8	Dr. Anjan Ray	Director	CSIR-IIP
9	Sh. L. K. Vijh	Director (T)	EIL
10	Sh. Brijesh Kumar	ED	CHT
11	Sh. Alok Tripathi	ED	PCRA
12	Sh. Ashutosh Bhardwaj	ED - Dy. DG	DGH
13	Sh. Rajesh Kumar Saini	Dy. Chief F&A officer	OIDB
14	Ms. Rashmi H. Urdhwareshe	Director	ARAI
15	Sh. G. Sriganesh	ED (R&D)	HPCL
16	Sh. Sanjay Bhargava	CGM (R&D)	BPCL
17	Sh. R. Srikanthan	Director (T)	CPCL

	Name	Designation	Organization
18	Ms. Vartika Shukla	ED (T)	EIL
19	Sh. M.R. Meshram	ED (R&D)	GAIL
20	Dr. N. V. Choudary	Scientist Emeritus	HPCL
21	Dr. Bharat L. Newalkar	GM (R&D)	BPCL
22	Sh. N.V.S.N. Raju	Ch. Mgr. (VVSPL)	HPCL
23	Sh. Pramod Kumar	Ch. Mgr. (R&D)	HPCL
24	Dr. S.S. Thipse	Dy. Director	ARAI
25	Sh. Sandeep Rairikar	DGM	ARAI
26	Prof. Srinivas K.	Professor	BITS – Pilani, Goa
27	Dr. Prakash D. Vaidya	Assoc. Prof.	ICT
28	Sh. P. Vijayanand	Principal Scientist	CSIR - IICT
29	Sh. Surjit Kaman	Scientist	CSIR - CSIO
30	Sh. Raj Kumar Meena	Sr. Mgr.	HPCL
31	Sh. Susobhan Sarkar	Advisor (T)	CHT
32	Sh. S.K. Varshney	Joint Director	CHT