

DST & DBT Collaborative Projects

Other MI members involved	Name of collaboration	Brief Description	Sectors involved (PP = public – public or PR = public-private)	Type of collaboration (research development, and/or demonstration)	Start Date (Year)	End Date (Year)	Funding amount (Amount in Crores Rupees)	Additional information (e.g. link to website)
Australia	Demonstration of 10,000 lit/day syngas generation	1. Standardization process parameters (pressure, temperature, GHSV, syngas ratio) 2. Diffusion experiments, kinetics and shaping of catalyst Studies of deactivation of catalyst 3. Demonstration of Syngas generation via Dry reforming	PP	Demonstration	23/09/2019	22/09/2022	0.72	
Australia	Development of catalysts and a prototype device for conversion of Co ₂ to fuels / Chemicals	1. Optimizing the GDE, membrane assembly methods and assembly techniques 2A. Design and develop a fuel cell like electrochemical device for electrochemical conversion of CO ₂ including selection of membranes.	PP	Development	08/11/2019	07/11/2022	0.49	

		2. Development of cost effective, selective and efficient catalysts for electrochemical and photo enhanced electrochemical conversion of CO ₂ and Optimizing the catalyst structure, potential, reacting environment.						
Australia	Bench scale design and development: Investigation of high frequency, high intensity ultrasonics for carbon rich solvent regeneration in solvent based post combustion CO ₂ capture process PCCC for reducing CO ₂ capture energy demand	<p>1. The existing carbon capture and Sequestration (CCS) process uses conventional steam stripping to regenerate the solvent for next cycle of absorption.</p> <p>2. During regeneration a major portion of the energy is spent for solvent regeneration.</p> <p>3. Conventional steam stripping is a high temperature and high-pressure process (Reboiler heat duty and Condenser duty).</p> <p>4. Testing absorption and solvent regeneration kinetics, solvent loss, degradation and carbon capture energy demand of both conventional and ultrasonics methods with and without hydrophobic micronized particle</p>	PR	Development	20/01/2020	19/01/2023	2.08	

		in lab-scale, bench-scale and techno-economic feasibility for large-scale implementation.						
Australia	Model Based Design, Synthesis and Evaluation of Combined sorbent catalyst Material (CSCM) for CO ₂ Capture	<ol style="list-style-type: none"> 1. Database and literature search. 2. Data curation and processing. 3. Identification of best 10 materials for CC and CCACC. 4. fine-tuning of best 10 materials for CC and CCACC. 5. Synthesis & characterization of selected sorbent materials for CC & CCACC. 6. Development of steady state Aspen Plus Models for CC and CCACC processes. 7. Process optimization through simulation as well as experimental studies. 8. Experimental validation/testing of the designed novel materials for CC and CCACC. 9. Thermodynamic, energy, exergy analysis of the process and techno-economic analysis. 	PP	Research	18/10/2019	17/10/2022	1.06	

		10. Report writing and dissemination.						
Australia, Canada, Norway, USA	Cooperative Isolated Renewable Energy Systems (IRES) for Enhancing Reliability of power in Rural Areas	<p>1. A pilot project considering several IRES would be developed with the demonstration of power exchange among different IRES, rooftop PV and mobile storage.</p> <p>2. Development of a Distributed Energy Management for Renewable Energy (DEMRE) which is based demand response and electricity market features.</p>	PP	RDD	18-10-2018	31-07-2021	2.36	-----
Australia and United Kingdom	Adsorption and separation of CO ₂ by porous carbon obtained from agro-residues and advanced micro porous materials through cost-effective, clean energy methodology.	<p>1. Laboratory scale and bench scale preparation of high surface area porous carbons from non-fodder agro-residues through thermochemical route, using test bed furnace.</p> <p>2. Characterization of the porous carbons and studies related to CO₂ adsorption and separation.</p> <p>3. Performance validation of the most promising adsorbent in collaboration with industry, and collaboration with MI country</p>	PP	Research	14/10/2019	13/10/2022	1.30	

		partners in UK and Australia for scale up, techno- economic analysis along with feasibility study of integration of renewable energy in the process.						
Brazil	Bioprocess development for cost effective lignocellulosic bioethanol production	<ol style="list-style-type: none"> 1. Cloning of novel recombinant hydrolytic enzymes from Fusarium sps followed by purification of recombinant proteins and determination of biochemical, functional and structural properties 2. Cost effective production of hydrolytic enzymes (cellulase and hemicellulase) under submerged fermentation using recombinant and natural isolates 3. Evaluation of recombinant and natural isolates for their saccharifying capacity to degrade complex polysaccharides present in the thermochemically pre-treated lignocellulosic biomass 	PP	R&D	20/09/2019	20/09/2022	0.70	
Canada	Integrated CO ₂ absorption and conversion to methanol in slurry phase reactors using	1.Rational design of a system of mixtures of polyamines and ionic liquids, having negligible volatility, will be able to absorb	PP	Research	28/09/2019	27/09/2022	0.90	

	<p>metal complexes as catalyst.</p>	<p>CO₂ from industrial process streams.</p> <p>2.Detailed reaction kinetics and mechanism in such a reaction system will be first established in a lab scale batch slurry reactor and then lab scale continuous flow reactor.</p> <p>3.Later, the possibility of extrapolating small diameter behaviour to larger ones for a continuous integrated CO₂ to methanol process in a scaled-up Slurry Bubble column reactor will be explored and investigated.</p> <p>4.The critical issues in such an extrapolation pertaining to mixing and hydrodynamic characteristics, establishing reliable similarity criteria that would result in similar mixing and hydrodynamics and hence transport and performance in two different scales will be attempted to be solved.</p>						
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Canada, France, Japan	Development of hybrid multi electrode plasma reactor for energy efficient dry reforming of greenhouse gases.	<ol style="list-style-type: none"> 1. Design and development of multi-cathode plasma torch. 2. Characterization and performance evaluation of the plasma source. 3. Integration of plasma torch and catalytic bed – building a hybrid plasma reactor. 4. Comprehensive evaluation of hybrid plasma reactor and dry reforming process. 5. Parametric evaluation and process optimization. 	PP	Development	30/09/2019	29/09/2022	0.75	
Canada, The Netherlands and USA.	Novel concepts for developing efficient cellulolytic cocktails for hydrolysis of bio-refinery relevant pre-treated lignocelluloses	<ol style="list-style-type: none"> 1. To develop benchmark deregulated hyper-cellulase producing thermophilic fungal strain using a combination of approaches including directed evolution/gene editing tools. 2. To develop methods for optimized production of benchmark and auxiliary enzymes at fermenter level and formulation of enzyme cocktails 	PR	R&D	28/09/2019	28/09/2022	1.05	

		3. Testing the effect of LPMO's and AE's developed during the project on the enzymatic efficiency of the processes based on commercial cellulases						
China, the Netherlands, Norway, Saudi Arabia, USA	A novel integrated biorefinery for conversion of lignocellulosic agro waste into value added products and bioenergy (biohydrogen and methane)	<p>Characterization of lignocellulosic biomass based on its organic content and sugar content</p> <p>Identification of efficient PHA accumulating and cellulase secreting bacterial strains</p> <p>Optimization of conditions for mild cost effective dispersion coupled chemical treatment for effective delignification and cellulosic hydrolysate separation</p> <p>Utilization of lignin for value added chemical production</p> <p>Extraction, purification and quantification of PHA for bioplastic production</p>	PP	R&D	22/10/2019	22/10/2021	0.61	
China, USA	Development of <i>Paenibacillus polymyxa</i> as a platform for production of	1. Reconstruction of genome scale metabolic model of <i>Paenibacillus polymyxa</i> and its application in overproduction of branched chain alcohols	PP	R&D	30/10/2019	30/10/2022	0.89	

	branched chain alcohols	<ol style="list-style-type: none"> 2. Development of genome editing tools based on CRISPR-Cas and metabolic engineering for branched chain alcohol production. 3. Optimization of conditions for enhanced biomass production 						
Czech Republic	Hydrogen production from biomass through pyrolysis process followed by catalytic steam reforming of volatiles	<ol style="list-style-type: none"> 1. Design and development of pyrolysis reactor, gas cleaning system, reforming reactor, condenser, gas collection system 2. Integration of different components, instrumentation and control system development, installation and testing 3. Development of low cost catalyst for steam reforming of pyrolysis vapour and its performance evaluation 4. Performance evaluation of the integrated system reactor and optimization of H2 production form biomass in integrated pyrolysis-reforming reactor 	PP	R&D	03-03-2020	03-03-2023	0.75	

Denmark	Innovative Algae Platform for Industrial Wastewater Valorization InWAP	<p>Lab-scale optimized process development for various industrial wastewater treatment using potential algal strains</p> <p>Scale-up of above process in pilot-plant mode using PBR and HRAP</p> <p>Reduce the fresh-water intake for the entire process by reusing the treated harvested culture medium</p> <p>Strategic evaluation of sustainable biofuel and bio-products conversion from harvested biomass</p>	PP	R&D	20.03.2019	19.03.2022	2.77	
Denmark, Netherlands	LOTUS-HR (Reserve Activity : Management of Solid Waste (Barapullah Drain- Floating Debris Clean-up) at Barapullah site	The project aims to remove floating debris including plastics from Barapullah Drain and process & managing of such waste by way of disposing it by the most efficient method/ technology such as Carbonization	PP	RD&D	21.01.2019	21.01.2021	1.82	Project is under process for Phase II approval
European Union (EU)	India- EU Joint call on Integrated Local Energy Systems – Horizon 2020	Department of Science & Technology, Government of India in collaboration with European Union announced a Flagship Call on Integrated Local Energy	PP	Research, Development and Demonstr	2021		154.80	https://dst.gov.in/sites/default/files/India-EU%20Joint

		Systems to develop novel solutions encompassing local integration across various energy vectors (electricity, heating, cooling, water, wastes, etc.) and increase the share of renewables in the energy mix and high energy efficiency.		ation (RDD)				%20Call%20on%20Integrated%20Local%20Energy%20Systems.pdf
Finland and South Korea	Structure, Interaction and process for energy efficient CO ₂ separation using Novallonic Liquids Supported Membranes	<p>1.Fabricate new blended membranes in order to facilitate gas transport properties of the neat membranes.</p> <p>2.Characterizations of Ionic liquids supported membrane (FTIR, Raman, SEM, XRD, TEM, AFM, BET, TG/DSC, angle measurement, surface tension etc.).</p> <p>3.Focus to increase the permselectivity of membranes for CO₂/light gases separation.</p> <p>4.The effect of addition of IL membrane on its gas transport properties will investigate by carrying out CO₂, CH₄ and N₂ gases permeation tests under different operating conditions.</p>	PR	Research	28/09/2019	27/09/2022	0.28	

		<p>5. In addition, the exact diffusion and solubility coefficients will also measure.</p> <p>6. Kinetics study.</p> <p>7. Thermodynamic study.</p> <p>8. Experimental Study using IL supported membranes.</p> <p>9. Process optimization.</p>						
France	Solar assisted hydroformylation/ carboxylation of olefins containing natural products with CO ₂	1. To develop efficient molecular photoredox complexes of transition metals (Ni, Co, Cu) and their immobilized analogues for the hydroformylation/ carboxylation of terpenes with CO ₂ to corresponding aldehydes/ acids under ambient temperature and pressure conditions.	PP	R&D	23/12/2019	23/12/2022	0.57	
France, Italy, Norway	Design and Development of biomass –solar electricity and cooling	1. Optimal sizing of the hybrid solar-PV biomass, battery systems with DSM enabled inverter support and direct DC load feed options.	PP	RDD	12-07-2018	31-07-2021	3.43	----

	solutions for Rural India	<p>2. Energy Management Algorithms for optimal utilization of resources.</p> <p>3. Controllers for EMS, Biomass gasifier, solar PV de-rating/MPPT, Battery Charging etc.</p> <p>4. Protection schemes and design for the two systems.</p> <p>5. Technology development for integration of green chiller with the biomass gasifier based waste streams.</p> <p>6. Tribal Woman Empowerment, Livelihood improvement, Human Resource Development</p>						
Germany	Study on new green Co2-Capturing Solvents	<p>1.To investigate the CO2 reactivity and loading capacity of aqueous solutions of amino sugars (single and blend) and mixtures of amino acid salts derived from oil protein.</p> <p>2.To investigate catalytic regeneration of solvents based on EMEA and DEMEA</p> <p>3. To investigate best-performing solvent in bench-scale closed-loop absorber desorber system</p>	PP	Research	26/09/2019	25/09/2022	0.44	

		and compare with traditional solvents (MDEA)						
Germany	Hierarchical porous Covalent Organic Nanosheets and Nanosheet – based Hybrid Membranes for Carbon capture and of Co2 Separation.	<ol style="list-style-type: none"> 1. Synthesis of hierarchical covalent organic nanosheets and nanosheets based hybrid membranes for effective and selective CO2 capture. 2. The incorporation of 2D materials like 2D carbides and nitrides (MXenes) via different supramolecular or intermolecular interaction includes more flexibility and electrochemical efficiency in terms of performance. 	PP	Research	27/09/2019	26/09/2022	0.56	
Germany	Demonstration of algal chassis for the photo autotrophic production of isoprenoids	<ol style="list-style-type: none"> 1. Evaluation of Chlamydomonas and Phaeodactylum transformants for their compatibility and performance in natural light and isoprenoids production 2. Growth engineering of strains. 3. Designing the strategies for capture of terpenoids 	PR	R&D	12-11-2019	12-11-2022	0.88	

		4. Demonstration of potential transformants at 50L/100L and 1000L photobioreactor systems						
Germany, UK	Sustainable Energy Storage Suitable for Micro grid (SENSUM)	<ol style="list-style-type: none"> 1. AC-DC Microgrid based on 50 kWp PV system. 2. A flow battery system of capacity 20 kW and 200 kWh 3. A hydrogen storage system 40 kWh with a fuel cell of 5 kW 4. A spaces heating system using the waste heat from the fuel cell 5. An integrated system consists of hybrid storage (hydrogen storage and flow battery) and PV system. 	PR	RDD	24-12-2018	31-03-2022	1.89	----
Germany, USA	Indian Marine Cyanobacterial Host for Production of Drop-in Fuels	<ol style="list-style-type: none"> 1. Genomics, transcriptomics and metabolomics studies to identify unique alkane producing pathway 2. Annotation of Potential alkane exporting transporter 3. Development of genome scale model of Indian marine cyanobacteria. 4. Improvement of Photosynthetic efficiency by engineering switch for dark/light cycle 	PP	R&D	25/09/2019	25/09/2022	0.78	

		5. Demonstration of technology for production of hydrocarbon in marine water.						
Italy, UK	Intelligent Off Grid system for Energy Sustainable Village	<p>1. Scalable, smart and self-sustainable DC microgrid model which utilizes renewable energy resources as a primary source to electrify areas that have no access to electricity within India.</p> <p>2. Secure and reliable power for the rural with Energy Management system (EMS) and IOT based solution.</p> <p>3. A unique cluster based approach to reduce microgrid development and operating costs.</p> <p>4. Enable productive uses of renewable energy resources that can vastly improve the socio-economic development of local communities and employment rates for youths.</p> <p>5. Improve quality of life and wellbeing of the residents by providing energy access for Panchayath amenities, i.e. schools, healthcare facilities, sanitation facilities, etc.</p> <p>6. Generate employment opportunities by way for local youth in establishing</p>	PP	RDD	02-03-2019	31-07-2021	1.63	----

		entrepreneurial ventures using the uninterrupted power supply 7. Improve the prospects for the elevation of consumers up to the multi-tier framework that measures electricity access in terms of improved capacity, Availability, Reliability, Quality, Affordability, Legality and Health and Safety.						
Japan, UK, US	Development of methods for Utilisation and conversion of Waste Co2 to Fuels.	Catalyst scale up of CO2 reforming catalyst and formulation, Testing at least 10 cc catalyst loading, Economic analysis of end to end process starting from biogas conversion to methanol through reforming and Water gas shift	PP	Development	28/09/2019	27/09/2022	0.66	
Netherlands	Local Treatment of Urban Sewage Streams for Healthy Reuse (LOTUS)	The project aims to demonstrate a novel holistic (waste) waste water management approach, that will produce clean water that can be reused for various purpose (e.g. industry, agriculture, construction etc.), while simultaneously recovering nutrients and energy from the urban waste water.	PP	RDD	30/03/2017	30/03/2022	18.03	
Sweden	A localized microgrid to	1.Development of a new hybrid power control system which allows for optimum usage and	PP	RDD	12-07-2018	31-07-2021	2.78	----

	power an off grid locality	<p>management of variety of clean power sources</p> <p>2.Increase in energy efficiency and decrease in capex in comparison with equivalent decentralized power systems</p> <p>3.Training of a pool of local technicians in Andaman and Nicobar who can carry out Solar-DC microgrid installations even in remote parts</p> <p>4.Optimizing power distribution and load management in the village using data analysis</p> <p>5.Data analytics to support power and demand management</p>						
Sweden	India-Sweden Collaborative Industrial Research & Development Programme 2020 On “Smart Grid”	Focus is to enable integration of an increased share of renewable energy production, including small scale production.	PP	Research, Development and Demonstration (RDD)	2021			https://dst.gov.in/sites/default/files/India-Sweden%20Collaborative%20Industrial%20Research%20%26%20Development%20Programme%202021

								020%20on%20Smart%20Grid%20.pdf
The Netherlands and United Kingdom	Development of Integrated technologies for reduction of anthropogenic / industrial waste CO ₂ to value added Chemicals and Fuels.	<p>1. Development of efficient, chemically and mechanically stable and cost-effective catalysts for CO₂ reduction into methanol.</p> <p>2. Integration of unit operations to find an optimum solution of pure products from anthropogenic CO₂ and H₂ from water electrolysis at pilot scale.</p> <p>3. Optimization of parameters such as flow rate, catalyst loading, reaction temperature etc. for the reaction.</p> <p>4. Design calculations of unit operations such as methanol distillation unit integrated with the pilot scale reactor for purity of commercial grade methanol.</p> <p>5. Minimization of energy consumption, emissions to achieve carbon negative technology.</p>	PP	Development	24/09/2019	23/09/2022	3.24	

UK	Development, Research and Pilot Scale installation of Solar-Hydro Pumped Storage Scheme in a remote village of Assam to ensure 24x7 electricity	<ol style="list-style-type: none"> 1.Improving reliability of power generation. 2.Overcome limitations of Hydro plants in the dry season. 3.Continuous water supply. 4.Intelligent controller for Water and Power management. 6. Socio-economic and health status 	PP	RDD	14-09-2018	31-07-2021	2.24	----
UK	Uneven Span Greenhouse integrated Semi-transparent Photovoltaic Thermal (GiSPVT) System for Agricultural Applications	<ol style="list-style-type: none"> 1. Use of glass-glass PV modules to integrate with greenhouse. 2. PVT module of optimized non-packing area with good electrical and thermal efficiency for cultivation of locally available cash crops, in pots, inside the greenhouse as well as generation of electricity for nearby rural households. 3. Utilization of land area for higher productivity, by generating electricity as well as farming applications. 4. Software for analysis of the GiSPVTsystem. 	PP	RDD	15-10-2018	31-07-2021	2.14	----

UK	Development of low cost, efficient and scalable materials for Co2 captures using naturally available nontoxic stable materials and industrial solid wastes.	<ol style="list-style-type: none"> 1. Development of low-cost materials for CO₂ capture. 2. Demonstrate the technology in the 1 to 3 kg scale along with the energy calculation of the process. 	PP	Development	19/11/2019	18/11/2022	0.60	
UK	Studies on CO fuels self-sustaining Unmixed Combustion (UMC) reactor for integrated Co2 capture and power/ Steam generation.	<ol style="list-style-type: none"> 1. To design, fabricate and commission a 1 - 3 kW Unmixed Combustion test rig for converting CO to CO₂. 2. To demonstrate sustained operation of the CO fuelled UMC reactor with emphasis on producing a high temperature CO₂ stream at the exit. 3. To understand carbon formation and its effects in the reactor system during operation 	PR	Research	17/01/2019	16/01/2022	0.79	

		<p>and develop mitigation strategies for the same.</p> <p>4. To conduct a techno-economic feasibility study using process simulation on an integrated UMC / gasification/power and steam generation cycle (IGCC).</p>						
UK	<p>Nano engineered Inorganic Halide Perovskites for photo, Electro and Thermochemical (PETC) CO₂ Reduction: Novel Artificial Photosynthesis Implementation for Clean Energy Generation .</p>	<p>1. To identify, synthesize, characterize & experimentally investigate zero lead inorganic halide perovskites (ZL-IHP).</p> <p>2. To develop a portable, artificial CO₂ reduction set up that can be adapted easily at various levels.</p> <p>3. To check viability and repeatability of developed technique by real-time test at an industrial site.</p>	PR	Research	11/12/2019	10/12/2022	0.21	
UK	<p>India – UK Collaboration: Joint Virtual Clean Energy Centres</p>	<p>Department of Science & Technology, Government of India in collaboration the Engineering and Physical Sciences Research Council (EPSRC), UK launched a programme on Joint Virtual</p>	pp	Research, Development and Demonstr	2017		82	http://www.ukiceri.com/

	(IUCERCE and UKICERI)	Clean Energy Centre. The center focuses on integration of intermittent clean energy with storage for stable power supply at grid as well grid isolated communities.		ation (RDD)				
UK	Genetic engineering of microalgae for producing alkanes for further applications	<ol style="list-style-type: none"> 1. Construction of synthetic vector with Trans-2-enoyl CoA reductase (TER) and Chlorella variabilis Fatty acid Photodecarboxylase (CvFAP) gene. 2. Genetic transformation of Euglena gracilis with TER and CvFAP expressing vector. 3. Molecular characterization of transformants and evaluation of hydrocarbons properties. 	PP	R&D	02-06-2020	02-06-2023	1.17	
UK	Catalytic aqueous-phase reforming of model compounds of microalgae and activated sludge	<ol style="list-style-type: none"> 1. Proof-of- concept study for producing H₂ or alkanes from APR of model compounds of microalgae and activated sludge 2. Development of efficient APR catalysts and optimization of reaction conditions 	PP	R&D	28/09/2019	28/09/2022	0.47	

UK	Impact of Carbon Nanomaterial based Photocatalyst on Microalgae Growth and Lipid for Improved Biodiesel	<ol style="list-style-type: none"> 1. To select lipid rich microalgae strains 2. To synthesize photocatalytic carbon nanomaterials/ nanocomposites and test the compatibility of selected photocatalytic nanomaterial for microalgae growth 3. To extract lipid, transesterification and FAME analysis for biodiesel application. 4. To convert defatted algae cells into starch- based nanomaterials as value added coproduct. 	PP	R&D	08-05-2019	08-05-2022	0.51	
UK	Outdoor mass cultivation of marine microalgae for biodiesel production with improved solar conversion efficiency	<ol style="list-style-type: none"> 1. Optimizing microalgal cultivation modes, including heterotrophic cultivation of marine microalgae in combination with photoautotrophic modes, for effective use of resources (renewable) and increased solar conversion efficiencies. 2. Development of co-cultures to enhance solar conversion efficiencies and higher lipid yield. 	PP	R&D	21/12/2019	21/12/2022	0.79	

		3. Demonstration of the system in an industrial set-up, including LCA and techno-economic assessment of a large-scale cultivation process						
UK	Integrated Design and Demonstration of Intensified CO2 Capture with cost effective advanced Process	<ol style="list-style-type: none"> 1. Design, development & fabrication of indigenous CO2 capture, laboratory bench scale pilot plant consisting of absorber, regenerator, lean rich heat exchanger, flash separation, and intensified CO2 absorber, etc., with working principle of regenerative chemical absorption of CO2 in activated and blended amine solvent. 2. Performing modelling and simulation of chemical absorption of CO2 in, and desorption from the aqueous absorbent. 	PR	RD&D	20/11/2019	20/11/2022	0.63	
UK	Sequestration of CO2 with Simultaneous Production of Succinic Acid by metabolically engineering.	<ol style="list-style-type: none"> 1. Screening and selection of Succinic acid producing bovine rumen bacteria. 2. Genome and transcriptome analysis. 3. Optimization and scale up of selected succinic acid 	PP	R&D	30/12/2019	30/12/2022	0.59	

		producing bacteria using CO ₂ /Glucose as substrate						
UK	Bioconversion of CO ₂ to Biofuels through Microbial Catalysed Systems	<ol style="list-style-type: none"> 1. Selective enrichment of chemolithoautrophic homoacetogenic bacteria for the production of Ethanol and Butanol titers. 2. Evaluation of enriched bacteria as biocatalyst in gas fermentation of CO₂ for the production of Ethanol and Butanol. 3. Optimization of process parameters for increasing the productivity through gas fermentation and bioelectrochemical systems. 4. Demonstration of large scale fermenters using industrial waste gas as substrate 	PP	R&D	02-12-2020	02-12-2023	0.5	
UK	India UK Joint program on Energy Demand Reduction in	Department of Science & Technology, Government of India in collaboration the Engineering and Physical Sciences Research Council (EPSRC), UK launched a	PP	Research, development and demonstration	2017	2021	21	

	Built Environment	programme on Energy Demand Reduction in Built Environment during March 2017 to help reduce energy demand in UK & India's built stock, both new major urban developments' currently being planned and existing built stock and address particular challenges include undertaking research that can have impact during a period of rapid development including major urbanization and infrastructure development to provide access to clean forms of energy.						
UK	Metabolic engineering of cyanobacteria for photosynthetic conversion of carbon dioxide into storable fuels.	<ol style="list-style-type: none"> 1. Developed Biofuel tolerant cyanobacterial strain: Adaptive Laboratory Evolution to increase 100 % tolerance 2. Characterization of native promoters for novel robust cyanobacterial host strain. 3. Photoautotrophic production of succinate 4. Metabolic Engineering for Butanol and Mannitol 	PP	R&D	30/09/2019	30/09/2022	0.90	

UK, USA	A systematic large scale assessment for potential of Co2 enhanced oil and natural gas recovery in key sedimentary basins in India.	<ol style="list-style-type: none"> 1. Rock-physical, petro-physical and geo-mechanical studies to investigate hydro-dynamics of CO2 sinks in depleting oil reservoir and producing CBM reservoir. 2. Identification of large point sources such as power plants and mapping them using GIS. 3. Development of capacity-building strategies in India to support commercial projects of CCUS – with an e-portal for knowledge sharing through global experts. 4. Identification of suitable geological formations for CO₂ storage in the vicinity of identified large point sources – a. Analysis of subsurface matrix properties, using geophysical and geological techniques, to locate the most suitable locations. 5. Geo-mechanical aspect of the CO₂ sequestration for long term storage and to ascertain safety and risk of leakage. 	PP	Development	24/09/2019	23/09/2022	1.98	
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		6.Geophysical evaluation of reservoir integrity and scoping level reservoir simulation for assessment of CO ₂ storage site.						
USA	Design and Demonstration of Off-grid Self-Healing & Sustainable DC	1.PV-DC-μG aligns with the requirement of off-grid access to electricity for rural communities 2.E-mobility: Installation of charging infrastructure in Musepur will facilitate shift from conventional fuels to clean energy for mobility.	PR	RDD	28-11-2018	31-07-2021	2.04	----
USA	Efficient Portable Stand-alone Vaccine Refrigerator for Rural Application	1. Design and development of a highly efficient 3 litre and 1.5 litre portable stand-alone vaccine refrigerator with temperature data logging 2. Efficient power convertor	PP	RDD	12-07-2018	31-07-2021	1.26	----
USA	Development of hierarchical novel Catalyst for one pot Conversion of Co ₂ rich synthesis gas to Dimethyl ether and scale-up	1.Development of novel, attrition resistant, thermally stable and economic catalyst to achieve higher CO ₂ rich syngas conversion and DME selectivity. 2.Determining the effect of process parameters such as temperature, pressure, H ₂ /CO ₂ ratio, CO ₂ /CO ratio, space	PP	Develop ment	10/10/2019	09/10/2022	1.69	

	Studies.	<p>velocity and run time on the product distribution.</p> <p>3.Development of amine grafted aerogel material using a simple two-step process viz. sol-gel followed by lyophilization (can be easily scaled-up), characterization of the prepared material.</p> <p>4.Optimization of experimental condition for maximization of CO₂ adsorption from Coal-fired thermal power plant.</p> <p>5.Simulation of experimental data to address the scaleup issues.</p> <p>6.Modelling to understand the hydrodynamics of slurry reactor.</p>						
USA	India-US Joint Clean Energy Research and Development Centre Phase – II	Government of India in collaboration with DOE, US launched a programme on JCERDC Phase – II under PACE-R to address climate change, ensure mutual energy security, and build a clean energy economy. The topic covered under this phase is Smart Grids and Energy Storage.	PP	Research, Development and Demonstration (RDD)	2017	2022	108	https://uiasist.org/

USA	Global cooling prize	Department of Science & Technology, Government of India and Rocky Mountain Institute, USA has launched Global Cooling Prize under the umbrella of Mission Innovation Challenge: Affordable Heating and Cooling in Buildings during November 2018 to develop a cooling technology that requires radically less energy to operate, utilizes refrigerants with no ozone depletion potential and with low global warming potential, and has the potential to be cost-effective at scale. The competition is India specific.	PR	Research, development and demonstration	2018	2021	36	
USA	Utilize CRISPR cas tools for redirecting metabolic flux in Thermo anaerobacterium msp RBIT for biobutanol production	<ol style="list-style-type: none"> 1. Development of endogenous CRISPR-cas genome editing tools and application to delete competing pathways to enhance biobutanol synthesis- 2. Increase of n-butanol tolerance and titers: To evolve n-butanol-adapted strains and screen for strains with high tolerance and titre. 	PP	R&D	19/02/2020	19/02/2023	1.4	

USA	Membrane based prototype development for higher yield of microalgal biomass and biofuel using industrial waste resources	<ol style="list-style-type: none"> 1. Development of ceramic membranes suitable for algal photobioreactor process 2. Design and fabrication of membrane based prototype for algal biomass production 3. Performance evaluation of the developed prototype with respect to algal biomass production using industrial effluent and biofuel extraction 	PP	R&D	24/07/2019	24/07/2022	0.58	
USA	Nano-Encapsulation Driven Synergistic Activation of Carbon Dioxide into Fuel.	<ol style="list-style-type: none"> 1. Preparation of cavity confined catalytic sites can deliver a platform for studying the mechanistic details for CO₂ reduction under encapsulation. 2. Enrichment of the active sites of MoS₂ on the metallo-crown pores of the Keplerate for efficient reduction of CO₂ to Fuel. 	PP	Research	25/11/2019	24/11/2022	0.69	
IC1 member countries: Australia, Canada,	MI – INDIA Funding Opportunity	Department of Science & Technology, Government of India has launched a programme on Smart Grids under the umbrella	pp	Research, Development and Demonstr	2017		36	http://dst.gov.in/sites/default/files/Smart-

China, France, Germany, Italy, Norway, United Kingdom and United States of America	Announcement (FOA): Smart Grids	of Mission Innovation Challenge 1: Smart Grids to innovate on components /systems / sub-systems / technologies required to address the challenges related to the design, development, integration, operation, management, and optimization of the grids.		ation (RDD)				grids- Brochure- 22nd-May- 2018.pdf
IC3 member countries: Austria, Australia, Canada, Finland, France, Germany, Indonesia, Japan, Norway, Mexico, Netherlands, South Korea, USA	MI – INDIA Funding Opportunity Announcement (FOA): Carbon Capture	Joint projects supported by DBT under the Carbon Capture (IC3), include bioconversion of CO2 by Enzyme assisted solvent-mediated CO2 capture based technologies to value-added products, efficient flue gas CO2 Capture and its Conversion to Energy fuels, enhanced oil recovery, carbonates synthesis and dry reforming of CO2	PP	Research, Development and Demonstration (RDD)	2019		USD 6 million	http://mission-innovation-india.net/carbon-capture-ic3/

<p>IC4 member countries: Australia, Brazil, Canada, China, Czech Republic, Netherlands, Saudi Arabia, United Kingdom, United States of America</p>	<p>MI – INDIA Funding Opportunity Announcement (FOA): Sustainable Biofuels</p>	<p>The joint projects supported under the Sustainable Biofuels Innovation Challenge (Collaborative support from 9 MI Member countries), cover the key areas of production of sustainable advanced biofuels from agricultural residues, use of MSW for CNG/Methanol, advanced biofuel through microbial fermentation, high-value products, production of enzymes and yeasts by genetic manipulation and scale-up technologies, improvements of biological feedstocks, lignin valorisation, heterotrophic algal production from waste stream and LCA for production of biofuels.</p>	<p>PP</p>	<p>Research, Development and Demonstration (RDD)</p>	<p>2019</p>		<p>USD 5 million</p>	<p>http://mission-innovation-india.net/sustainable-biofuel-ic4/</p>
<p>IC5 member countries: Canada, Germany, France, Republic of South Korea, United</p>	<p>MI – INDIA Funding Opportunity Announcement (FOA): Converting Sunlight</p>	<p>The proposals supported under and Sunlight Innovation (IC5) includes the large-scale demonstration of cultivation systems, host engineering/strain improvement of microalgae &</p>	<p>PP</p>	<p>Research, Development and Demonstration (RDD)</p>	<p>2019</p>		<p>USD 6 million</p>	<p>http://mission-innovation-india.net/converting-sunlight-ic5/</p>

Kingdom, United states of America		cyanobacteria for improved photosynthetic efficiency.						
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