地球規模課題対応

国際科学技術協力

(環境・エネルギー分野)

インドネシア国
バイオマス廃棄物の流動接触分解ガス化・液体燃料生産モデルシステムの開発プロジェクト
終了時評価調査報告書

2019 年 6 月

独立行政法人　国際協力機構

産公
JR
19-079

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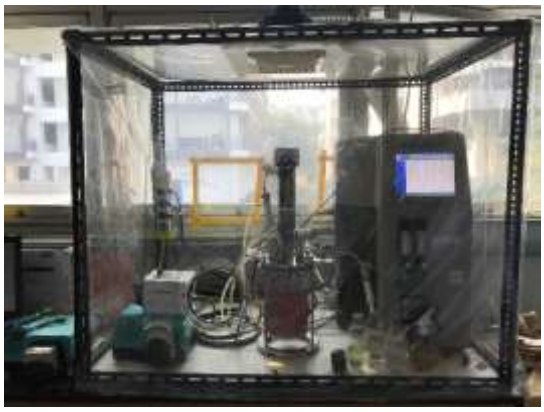
パイロットプラント（50kW ガス化炉）

メタノール合成プロトタイプ 2 号機



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評価結果協議

ミニッツ署名

略語表

APEX	Asia People's Exchange	特定非営利活動法人APEX
BPDP	Indonesian Palm Oil Mill Management Agency Fund	インドネシアパーム油資産基金
BPPT	Agency for the Assessment and Application of Technology	インドネシア技術応用評価庁
C/P	Counterpart Personnel	カウンターパート
DAC	Development Assistance Committee	開発援助委員会
EFB	Empty Fruit Bunches of Oil Palm	油ヤシ空房
ITB	Bandung Institute of Technology	バンドン工科大学
JCC	Joint Coordinating Committee	合同調整委員会
JICA	Japan International Cooperation Agency	エネルギー・鉱物資源省
JST	Japan Science and Technology Agency	エネルギー・鉱物資源省
LPDP	Indonesian Education Fund	インドネシア教育基金
MEMR	Ministry of Energy and Mineral Resources	エネルギー・鉱物資源省
M/M	Minutes of Meeting	協議議事録
NEP	National Energy Policy	国家エネルギー政策
ODA	Official Development Assistance	政府開発援助
OECD	Organization for Economic Cooperation and Development	経済協力開発機構
PDM	Project Design Matrix	プロジェクト･デザイン･マトリックス
PO	Plan of Operations	活動実施計画
POLS	Pulse Operated Loop Seal	パルス操作ループシール機構
PUSPIPTEK	Pusat Penelitian Ilmu Pengetahuan dan Teknologi	技術・知識研究センター
R/D	Record of Discussion	討議議事録
RISTEKDIKTI	Kementerian Riset Teknologi Dan Pendidikan Tinggi	研究技術高等教育省
SATREPS	Science and Technology Research Partnership for Sustainable Development	地球規模課題対応国際科学技術協力プログラム
YDD	Yayasan Dian Desa	ディアン・デサ財団

評価調査結果要約表

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インドネシア政府は、2025 年までに新・再生可能エネルギーの一次エネルギー消費における比率を 17%にまで高めるとする目標を立てており、中でもバイオマスへの期待は大きい。しかし、パーム油等を原料とするバイオディーゼル生産、サトウキビやキャッサバからのエタノール生産といった、いわゆる第一世代の技術によるエネルギー供給は食糧と競合し、国際的市場価格の変動にかかわる脆弱性も大きい。一方、アブラヤシ廃棄物、稲作廃棄物、トウモロコシ残渣、森林伐採残渣等の廃棄物系バイオマスは、電力換算約 5,000 万 kW の膨大なポテンシャルがあるといわれるのに対し、熱化学的ガス化、液体燃料化といった利用技術でインドネシアの経済的・技術的条件に適合したものがまだ開発されておらず、その利用は数パーセント程度にとどまっている。これらの状況を受け、本プロジェクトでは、触媒として現地で入手が容易な低コストの粘土触媒を用い、循環流動層に幅広い運転条件範囲でも不安定化しにくいループシール構造を持たせることで、様々なバイオマス廃棄物に対して適用できる流動接触分解ガス化システムを開発することとした。これを高度な運転制御を必要とせず、省エネルギー的な低圧メタノール合成プロセスに接続することにより、途上国での利用に適した「適正」技術としてのバイオマスガス化・メタノール合成プロセスを確立することを目的とし、2013 年 10 月に詳細計画策定調査が実施され、2014 年 2 月に討議議事録（Record of Discussions：R/D）に署名がなされた。本事業の共同研究機関（メイン C/P）であるインドネシア技術応用評価庁（BPPT）及びディアン・デサ財団（YDD）[1]が上述の技術開発に携わるほか、バンドン工科大学（ITB）が 2016 年より本事業</td></tr>
</table>

[1] YDD については、2018 年度にジョグジャカルタでのコールドモデル試験が中止され、その後はプロジェクト活動に参加していない。

の研究に参加し、ガス発酵法液体燃料生産プロセスの開発に従事している。今般 2019 年 6 月 12 日をもって本プロジェクトが終了を迎え、本プロジェクトの実績を整理し、今後の持続性を高めるための提言、教訓等を導くために終了時評価調査が実施された。

1-2協力内容

（1）上位目標

現地に適合的なバイオマス廃棄物の流動接触分解ガス化と液体燃料生産システムが普及する。

（2）プロジェクト目標

インドネシアの社会・経済条件に適合的な、バイオマス廃棄物の流動接触分解ガス化と液体燃料生産システムが確立し、その普及のための基盤が整備される。

（3）成果

成果 1： タール処理技術を伴うバイオマスの流動接触分解ガス化プロセスの確立

成果 2： 液体燃料生産システムの開発

成果 3： 当該システムの実行・推進を担う人材の育成とバイオマスエネルギー利用促進のためのネットワークの形成

（4）投入（評価時点）

日本側：総投入額　約 3 億円

長期専門家派遣	1 名	機材供与	約 1 億円
短期専門家派遣	8 名	ローカルコスト負担	約 2,789 万円
研修員受入	16 名		

相手国側：

カウンターパート配置	延べ 62 名　機材購入　6 億 1,439 万インドネシアルピア
ローカルコスト負担	12 億 3,104 万インドネシアルピア
土地・施設提供	専門家の執務スペース・研究等オペレーションルーム・資機材配置用スペース

2． 評価調査団の概要

調査者	（担当分野：氏名　職位） 総　括　小早川徹　JICA 産業開発・公共政策部参事役（資源・エネルギー） 協力企画　柴田久里　JICA 産業開発・公共政策部資源・エネルギーグループ第一チーム専門嘱託 評価分析　大橋由紀　合同会社適材適所コンサルタント オブザーバー　堤　敦司　JST SATREPS グループ研究主幹（東京大学教授） オブザーバー　上阪圭介　JST 国際部（SATREPS グループ）主任調査員

	研 究 総 括　野田玲治　群馬大学大学院理工学府准教授 業 務 調 整 員　福田千秋	
調査期間	2019 年 6 月 18 日～2019 年 6 月 28 日	評価種類：終了時評価

３.評価結果の概要

３-１　実績の確認

(1) アウトプット１：タール処理技術を伴うバイオマスの流動接触分解ガス化プロセスの確立

開発の過程で変更された研究内容を除き、各指標は概ね達成した。

1-1. 高度安定型流動層が確立される。【概ね達成】

従来構造よりも安定性が高い新規ループシール構造が開発され、そのスケールアップ手法がパイロットプラントと同規模のコールドモデルで確認された。今後数カ月の間にパイロットプラント(1-6 を参照)で実証される予定である。

1-2. 5 種類以上の粘土触媒から、最も活性の高いものが選択される。【達成】

12 種類のインドネシア産粘土からバイオマスのガス化において好適な粘土触媒が 3 種類確認された。

1-3. チャー抜出機構が開発される。

油ヤシ空房（EFB）粉砕物をガス化原料とすることが決定したため、2018 年度にコールドモデル試験は中止され、その後チャー抜出/循環機構のデモンストレーションも中止となった。

1-4. 適応可能なバイオマス前処理システムが開発される。【概ね達成】

カッターミルによる EBF 粉砕装置のプロトタイプが製作され、目標としたサイズの生産、概ね想定どおりの処理速度を達成した。一部装置の調整が BPPT により今後数カ月で完了予定である。

1-5. ガス化残渣の肥料化技術が確立する。【概ね達成】

ガス化炉残渣の分析結果からチャーや灰の混合レシピによる肥料が試作され、チャー残渣肥料では商用肥料よりも優れた育成効果や 30%のコスト削減が確認された。灰残渣の混合肥料は施肥効果の試験の最中であり、プロジェクト終了後 20 日程度で完了する予定である。

1-6. パイロットプラントが稼働する。【概ね達成】

50kW のパイロットプラントの開発・設計が行われた。免税手続きに関する発注の遅れおよび建設の遅れから竣工は 2019 年 5 月となった。プロジェクト終了時点では所定の運転条件下で安全性確認のための試運転中であり、今後 1～2 カ月で連続運転が可能になる見込みである。

1-7. タール除去の技術が開発される。【一部達成】

炉内タール除去技術が検討され、基礎研究が行われた。それにより炉内粘土触媒によるタール除去がラボスケールの流動層ガス化炉試験装置で確認された。今後、タール除去の性能

がパイロットプラントにおいて確認される予定である。

(2) アウトプット 2 : 液体燃料生産システムの開発
低コストのメタノール合成触媒の特定、小規模メタノール合成プロトタイプ（1 号機 2 号機）の開発が達成された。メタノール合成試験は今後さらに実施される必要がある。また、ガス発酵によるエタノール合成プロセスの基礎実験結果の蓄積が達成された。
2-1. 持続的なメタノール合成触媒が開発される。【達成】
10 種類以上の触媒の試作が準備され、同一条件下で比較された。γ アルミナ処理を行った含侵法触媒が Cu 単位重量あたりのメタノール生成量が最も大きいことが確認され、小規模プラントで適用可能な低コストメタノール合成触媒が特定された。
2-2. 低コストの小規模メタノール合成プロトタイプが開発される。【達成】
メタノール合成プロトタイプ 1 号機が 2015 年に製作され模擬合成ガスからの低コストの小規模メタノール生成が確認された。1号機は実験条件の自由度が低く精度が不十分であったため、さらに詳細な研究を進めるためにプロトタイプ 2 号機が設計・製作された。
2-3. メタノール合成プロトタイプの試験・評価が行われる。【一部達成】
同 1 号機及び 2 号機の試験・評価が行われた。同 1 号機の試験結果からは、市販触媒を使用してメタノール収率が 60%以上となるガス供給速度が明らかになった。同 2 号機では市販触媒を使用した種々のメタノール合成試験が行われた。今後も 2 号機によるメタノール合成試験を継続し、プロジェクトが準備した触媒を使用して反応機構が評価される予定である。
2-4. ガス発酵プロセスの基礎実験が実施され、フィージビリティスタディーに必要なデータが収集される。【達成】
連続ガス醗酵試験装置が完成し、一連のガス醗酵試験により模擬ガスからのエタノール生産が確認された。それらの結果からエタノール生産の反応機構等の重要なポイントが解明され、フィージビリティスタディーのための実験結果が蓄積された。

(3) アウトプット 3: 当該システムの実行・推進を担う人材の育成と、バイオマスエネルギー利用促進のためのネットワークの形成
オペレーション研修の実施を除き、指標は達成した。
3-1. バイオマスのエネルギー利用に関するローカル研修が 2 回以上、オペレーション研修が 1 回以上開催される。【概ね達成】
バイオマスエネルギー利用に関するローカル研修が 2 回実施された。オペレーション研修は、パイロットプラント設置の遅れから期間中に実施できなかったが、今後 BPPT が実施予定である。
3-2. 合計 10 名以上の日本・インドネシア双方の研究者・学生が研究実施のための交換に参加する。【達成】

インドンネシア人研究者 16 名が群馬大学での研修に参加し、日本人研究者・学生と共に研究に従事した。また、日本人の若手研究者 3 名が BPPT での研究活動に参加した。

3-3. 国際的セミナーが 2 回以上、計 200 名以上の参加者を得て実施される。【達成】

国際セミナーが 2 回実施され、計 200 名以上が参加した。

3-4. ニュースレターが 10 回以上、各 750 部以上発行される。【達成】

ニュースレターはプロジェクト期間中に 10 回、各 750 部発行された。

3-5. 10 件以上の学術論文が発行される。【達成】

日本側の研究者による 10 件の学術論文、ITB と群馬大学の研究者の共著論文が 1 件発行された。またインドネシア側研究者により 10 件の論文が作成され、国際セミナー等で発表された。

(4) プロジェクト目標

各研究テーマについて指標は概ね達成した。

1. 50kW 以上のバイオマス廃棄物ガス化のデモンストレーションプラントが設置され、運転される。【概ね達成】

50kW パイロットプラントの建設が 2019 年 5 月に完了した。プロジェクト期間終了時点ではガス化炉の標準運転手順書の準備が終わり、ガス化炉の立ち上げが行われている。長時間連続運転による安定したガス化は今後 1～2 カ月で達成が可能な見通しである。

2. メタノール合成プロトタイプが開発される。【概ね達成】

プロトタイプ初号機による模擬合成ガスからのメタノール合成が確認された。その後より高精度の実験を可能とする 2 号機が製作され、反応機構の分析のためのメタノール合成試験が一部開始された。今後本研究で調整した好適メタノール合成触媒による試験が継続される見込みである。

3. ガス発酵によるバイオエタノール生産プロセスが特定される。【達成】

実験結果に基づいて好適ガス発酵プロセスが特定され、将来性のあるエタノール生産プロセスが確認された。

３-２　評価結果の要約

（１） 妥当性：高い

- 本プロジェクトは 2014 年国家エネルギー計画（NEP14）において 2025 年までに石炭 30%、石油 22%、再生可能エネルギー23%、天然ガス 25%のエネルギーミックスを目指すインドネシア政府のエネルギー政策との整合性が高い。
- 本プロジェクトのガス化の原料であるバイオマス廃棄物はインドネシア国内に豊富に存在し、他のニーズと競合することがないという大きな利点があり、ポテンシャルが高いにも拘らず現地の経済的・技術的条件に適合した利用技術が開発されていない。また、バイオメタノールの生産はインドネシアのバイオディーゼル生産にも貢献する

と考えられること、FEB のガス化技術による低コストかつ比較的容易な発電は、EFB が豊富にあるスマトラ・カリマンタン等の島々での電力供給の改善にも貢献することから、本プロジェクトはインドネシア社会のニーズと整合している。

- 現行の日本の対インドネシア共和国国別開発協力方針（2017 年 9 月）において、本プロジェクトは重点分野 3「アジア地域及び国際社会の課題への対応能力向上に向けた支援」の下の開発課題 3－1「気候変動・自然環境保全対策」に貢献する事業と位置付けられている。
- 本プロジェクトはインドネシアでのバイオマス廃棄物のエネルギー利用を普及するための適正技術の開発、人材育成やネットワーク形成による技術普及のための基盤の整備、開発した技術の社会実装の実現を強く意識した事業である。また、2017 年 7 月の計画変更後は BPPT の研究開発を継続できる態勢が整備され、実験規模や到達目標のスケールダウンの一方で BPPT の主体的な取り組みを推進すると共に様々な技術オプションの試行による技術開発が可能となり、技術開発を促進する可能性を高めた点から、アプローチは適切であると言える。

（２） 有効性：比較的高い

- プロジェクト目標の達成状況については、50kW パイロットプラント建設が完了し、安全な連続運転による立ち上げが行われており、長時間連続運転による安定したガス化は今後 1～2 カ月で達成する見込みである（概ね達成）。メタノール合成については今後も合成試験を継続する必要があるが、プロトタイプ（初号機・2 号機）が製作・利用されている（概ね達成）。ガス発酵によるバイオエタノール生産プロセスについては、実験結果に基づいて好適ガス発酵プロセスが特定され、将来性のあるエタノール生産プロセスが確認された（達成）。
- 上記プロジェクト目標の達成状況はアウトプットの発現が直接もたらした結果である。PDM 第 2 版に記載された外部条件（経済危機、社会的混乱、自然災害）の影響はプロジェクト期間中をとおして生じていない。

（３） 効率性：やや低い

- インドネシア国内の現地リソースが積極的に活用されたことがコスト削減にも繋がった。また、計画内容の変更により実施体制や人材配置の変更が生じたが、変更後は概ね変更内容に基づいた人員配置が行われた。
- パイロットプラントの調達の手続きに時間を要したことにより、一部の活動がプロジェクト期間内に完了しなかった。また機材調達の遅れが一部の活動の進捗にネガティブな影響を及ぼした。専門家の投入量は全体としては計画どおりだったが、液体燃料生産システムの活動では日本側の人員の投入がインドネシア側カウンターパートの期待よりも少ない結果となった。更に、YDD に設置したコールドモデルは計画変更

後プロジェクトの活動で活用されない結果となった。

（４）インパクト：比較的高い

- 上位目標である「現地に適合的な、バイオマス廃棄物の流動接触分解ガス化と液体燃料生産システムが普及する。」については、その指標として「事業終了後 4 年以内に 1 基以上のプラントが設置・運転されることが検討される。」が挙げられている。バイオマス廃棄物のガス化に関しては、BPPT が予算配置を含め商業化に向けて研究継続へのコミットメントを示していること、新たに採択された JST のビジネス化支援プログラムを活用した当該ガス化プロセスによる EFB のエネルギー化ビジネスプランの策定が複数の企業と共に始められていること、当該ガス化炉の実用化は費用対効果が高く将来普及できる可能性が高いと見込まれていること、プランテーション等企業の関心が高く実用化できることが示せれば投資の対象となる可能性が高いこと等から、企業により本プロジェクトの技術を活用したバイオマス廃棄物のガス化プラント 1 基以上の設置・運転が検討される見込みは高いと考えられる。
- 液体燃料の生産に関してはガス化と比べて商業化・実用化への道のりは長く、事業終了後 4 年以内の生産システムの普及は難しいと考えられるが、インドネシア国内でも当該技術への関心は高く、研究は将来的に継続することが期待できる。
- その他、パルス操作ループシール機構（Pulse Operated Loop Seal: POLS）の特許取得などの正の波及効果が確認されている。

（５）持続性：高い

- インドネシア政府の代替エネルギーの電力利用に関する政策は今後も継続することが見込まれる。また、エネルギー鉱物省、産業省等のバイオマス廃棄物のエネルギー利用への関心も高く、良い結果を示すことで更なる政策的支援が期待できる状況にある。
- BPPT は研究体制・予算が整備されており、モチベーションも高く、商業化に向けて研究を継続していく意欲がある。前年度と比較しても大きな予算配置から、ガス化炉の開発への期待が表れている。更に独自予算以外にも様々な外部機関から研究資金を獲得できる可能性がある。
- ガス発酵エタノール合成については、ITB が研究継続の意思を示している。研究予算については、本研究が革新的で社会的要請のある技術であることから、政府および民間の資金を獲得できる可能性が高いと考えられている。
- インドネシア側は研究の継続には日本側からの技術的サポートをまだ必要としているものの、技術開発を実施するために必要な能力は有している。供与機材については現地で調達したものが多く、維持管理における技術的問題は無いと想定されている。また、それらの機材のランニングコストはそれほどかからないと考えられている。

3-3　効果発現に貢献した要因

（1） 計画内容に関すること

特になし。

（2） 実施プロセスに関すること

- 2017 年 7 月のプロジェクト計画の大幅な修正はプロジェクトの方向性や関係者のプロジェクトの関与にポジティブな変化をもたらし、研究の継続性を高める結果となった。
- 計画変更後のタイトなスケジュールにも拘らず、日本側インドネシア側双方の関係者が熱心にプロジェクト活動に取り組んだことで、上述のようなアウトプットの達成が可能となった。

3-4　問題点及び問題を惹起した要因

（1）計画内容に関すること

- 2017 年 7 月のプロジェクト計画の大幅な修正は上述のようにポジティブな変化をもたらした一方で、パイロットプラントの設計の修正等による時間的ロスが生じたといえる。

（2）実施プロセスに関すること

- プラント建設や機材納入等の遅れがプロジェクト終了時点での達成状況に影響をおよぼした。

3-5　提言（当該プロジェクトに関する具体的な措置、提案、助言）

- 本プロジェクトの枠組みにおいて計画されていた活動でプロジェクト期間内に十分に完了していないものについては、今後 BPPT が確実に実施し、現時点で予定されている期間内に完了することが求められる。
- ガス化炉については商業化の期待も高く、研究継続に向けた予算配置がなされているが、液体燃料の開発についても BPPT 及び ITB は予算確保に努め、研究を継続することが期待される。

3-7　教訓（当該プロジェクトから導き出された他の類似プロジェクトの発掘・形成、実施、運営管理に参考となる事柄）

- プラントの建設に係る免税措置の手続き等については、事前に関係者間で対応策を検討し合意することで遅れや不都合が生じないよう努めることが求められる。SATREPS 事業では相手国における免税資格を有していない日本の研究機関がしばしば機材調達を行うことを考慮しておく必要がある。
- 本プロジェクトではプロジェクト期間の途中段階で生じた問題に対応するため、関係機関で十分に協議し変更内容に日本側・インドネシア側の各機関が合意した上で軌道

修正がなされた結果、インドネシア側の主体的な関与が強まり、プロジェクト終了後の持続性が高まると共に、修正後の目標を概ね達成することができた。相手国パートナー機関のプロジェクトに対するオーナーシップを醸成することは日本の研究機関にとって非常に重要であり、特に SATREPS 事業において研究活動の持続性を確かなものとするためには不可欠である。

Terminal Evaluation Summary Sheet

1. Outline of the Project	
Country: Republic of Indonesia	**Project Title**: Project for Development of a Model System for Fluidized Bed Catalytic Gasification of Biomass Wastes and Following Liquid Fuel Production in Indonesia
Thematic Area: Resources and energy	**Cooperation Scheme**: Technical Cooperation (Science and Technology Research Partnership for Sustainable Development: SATREPS)
Division in Charge: Industrial Development and Public Policy Department	**Total Cost**: 300 million Japanese Yen
Project Period (R/D): June 13, 2014 – June 12, 2019 (5 years)	**Counterpart Agencies**: Agency for the Assessment and Application of Technology (BPPT), Bandung Institute of Technology (ITB), Yayasan Dian Desa (YDD)
	Supporting Organizations in Japan: Gunma University, Asia People's Exchange (APEX)
	Other Related Cooperation:

1-1. Background of the Project

The Government of Indonesia aims at increasing the consumption rate of new and renewable energy in the primary energy to 17% by 2025, among which the biomass is largely expected. However, energy supply by so-called "first generation technology", such as biodiesel production from palm oil etc. and ethanol production from sugar cane and cassava, competes with food supply and is highly vulnerable to fluctuations in international market prices. On the other hand, biomass wastes, including the waste and residue of oil palm, rice farming, corn production and deforestation has a huge potential of about 50 million kW in terms of electric power generation. However, the utilization technology of the biomass wastes, such as thermochemical gasification and liquid fuel production, which is appropriate to the economic and technical conditions of Indonesia, has not been developed yet. Therefore, only a few percent of them has been utilized under present circumstances. In this context, this project intends to develop a model system for fluidized bed catalytic gasification applicable to various types of biomass wastes, by using locally available, accessible and inexpensive clay catalyst, and by applying a loop seal structure to avoid destabilization of fluidized bed under wide range of operation conditions. Also by connecting it to an energy-saving low pressure methanol synthesis process which does not require advanced operation control, the project aims to establish an appropriate technology of biomass gasification and methanol production process for developing countries. A detailed planning study of the Project was conducted in October 2013, and Record of Discussions (R/D) was signed in February 2014. Agency for the Assessment and Application of Technology (BPPT) as the main C/P, and Yayasan Dian Desa (YDD)[2] engaged in the development of above mentioned technologies, and

[2] YDD have not been involved in the Project since cold model experiments in Yogyakarta were discontinued in FY2018.

Bandung Institute of Technology (ITB) was also involved in the Project since 2016 undertaking the research of Gas fermentation process, As the Project reached to the end of the planned period in June 12, 2019, the Terminal Evaluation Study was conducted to confirm the achievement of the Project and to extract recommendations to enhance sustainability and lessons learned for future efforts.

1-2. Project Overview

(1) Overall Goal

Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is diffused.

(2) Project Purpose

Fluidized bed catalytic gasification of biomass wastes and following liquid fuel production system that is socially and economically appropriate for Indonesia is established and bases for the diffusion are prepared.

(3) Outputs

1. Establishment of fluidized bed biomass gasification process with tar treatment technology.
2. Development of liquid fuel production system
3. Development of human resources related to implementation of the developed system and establishment of network for promoting biomass energy utilization

(4) Inputs

1) Japanese side

Long-term Expert: 1 Project Coordinator
Short-term Experts: 8 Experts/Res
Counterpart Training: 16 Researchers of BPPT
Provision of Equipment: Approx. 1
JPY
Local Cost: 27.89 million JPY

2) Indonesian side

Counterpart Personnel: 62 staff in total
Equipment: 614.39 million Rp.
Local Cost: 1 bullion 231 million Rp.
Land and facilities: Office space research activates, and space for

2. Evaluation Team

Members	Role	Name	Affiliation
	Leader	Toru Kobayakawa	Senior Director, Industrial Development and Public Policy Department, JICA
	Cooperation Planning	Kuri Shibata	Program Officer, Team 1, Energy and Mining Group, Industrial Development and Public Policy Department, JICA
	Evaluation Analysis	Yuki Ohashi	Consultant, Tekizaitekisho LLC
	Observer	Atsushi Tsutsumi	Program Officer, SATREPS Group, JST / Project Professor, Komaba Organization for Educational Excellence, Graduate School of Art

			and Science, The University of Tokyo
	Observer	Keisuke Kosaka	Senior Associate Research Supervisor, Department of International Affairs (SATREPS Group), JST
	Project Research Leader	Reiji Noda	Associate Professor, Graduate School of Science and Engineering and Electrical Engineering Gunma University
	Coordinator	Chiaki Fukuda	
Evaluation Period: 18 June 2019 – 28 June 2019			**Type of Evaluation**: Terminal Evaluation

3. Results of Evaluation

3-1. Project Performance

(1) Output 1: Establishment of fluidized bed biomass gasification process with tar treatment technology.

Except the research subjects changed in the course of activities, the indicators were mostly achieved.

1-1. Stable operation of fluidized bed gasifier is demonstrated. [Mostly achieved]

The pulse controlled loop seal, which enable more stable operation, was developed by the Project, and its scaling up procedure was tested and confirmed by the cold model which has the same scale with the demonstration pilot plant. The pulse controlled loop seal will be demonstrated by the pilot plant (refer to 1-6) within a few month period.

1-2. The most active catalyst is identified among at least five kinds of clay catalysts. [Achieved]

12 samples of clay products in Indonesia were collected and evaluated. 3 clay products were identified as suitable catalysts for tar removal for biomass gasification. It was also found that total acid amounts are the most important properties for tar removal.

1-3. Char drawing system is demonstrated. [-]

Cold model experiments were discontinued in FY2018 as fibrous empty fruit bunches (FEB) of oil palm were adopted as feedstock for gasification as a result of the establishment of biomass pretreatment system. The application of char drawing / circulation mechanism to the pilot plant was also canceled.

1-4. Proper biomass pretreatment system is established. [Mostly achieved]

A prototype for EBF pulverization by cutter mill was fabricated and the production of fibers in the targeted size (1 to 2cm) was achieved. Also the processing speed was almost reached to the expected one. The configuration of cutter will be modified in 2 to 3 months to improve further the processing speed of the mill.

1-5. Technology for utilization of gasification residue as fertilizer is developed. [Mostly achieved]

The main component of nutrients in char and ash of EFB was confirmed and several recipes of fertilizer mixing with the char and the ash from EFB samples were applied for growth testing. As a result, the char-mixed fertilizer was better than commercial fertilizer, and also economic benefit by reducing 30 % of the production costs was confirmed. The ash mixed recipe is still in progress of growth testing at the end of project period, and it will be completed within 20 days.

1-6. Pilot plant is successfully operated. [Mostly achieved]
The completion of the pilot plant was delayed in May 2019, due to the delays of about three months from tax exemption procedures and about one month from delayed construction. At the end of the project period, a trial run is underway for safety operation under specified operation conditions. It is expected to achieve continuous operation in the next one to two months.
1-7. Tar treatment technology is developed. [Partly achieved]
3 different tar removal technologies were considered, and their fundamental studies were conducted. In-bed tar removal by applying clay particles was confirmed by using a lab-scale fluidized bed gasifier, and will be confirmed by the pilot plant. In regard to the development of a downstream tar removal device, as relatively high tar removal by in-bed clay particles was confirmed, it was confirmed to be unnecessary when applying the in-bed clay tar removal.

(2) Output 2: Development of liquid fuel production system
The development of low-cost catalyst for Methanol synthesis and methanol synthesis prototype (Unit 1 and 2) was achieved. Methanol synthesis prototype needs to be tested and evaluated further. Also, the data collection on fundamental research of Gas fermentation process is achieved.
2-1. Sustainable catalyst for Methanol synthesis is developed. [Achieved]
More than 10 prototype catalysts were prepared by Gunma University and BPPT, and compared under the same condition by BPPT. An appropriate catalyst with γ-alumina support prepared by impregnation method had the highest methanol yield per cupper contents, and therefore a low-cost catalyst applicable for small scale plant was identified.
2-2. Methanol synthesis prototype for small scale application with low cost process is developed. [Achieved]
The first prototype of methanol synthesis (Unit 1) was constructed and tested in 2015 to confirm the successful production of methanol from simulated syngas. However, the unit 1 had a narrow variety of experimental conditions and low accuracy, and it was difficult to improve the process for the production of high methanol concentration. In order to conduct further detailed study, the second prototype (Unit 2) was designed and constructed.
2-3. Methanol synthesis prototype is tested and evaluated. [Partly achieved]
The prototype Unit 1 and 2 were tested and evaluated. From the test results with the unit 1, the operation condition to achieve more than 60% of methanol yield was clarified by using a commercially available catalyst. Methanol synthesis experiments by unit 2 were conducted with a commercially available catalyst to evaluate the methanol synthesis performance. Further methanol synthesis experiments will be conducted by using the unit 2 to analyze the reaction mechanisms with a catalyst prepared by the Project.
2-4. Fundamental research of Gas fermentation process is conducted to collect data for feasibility study. [Achieved]
A continuous gas fermentation reactor was completed at ITB, and a series of gas fermentation test was conducted. The continuous system was successfully operated to produce ethanol from simulated syngas. The reaction mechanisms and critical points for ethanol production was elucidated together with the results obtained at ITB and Gunma University. Experimental results for feasibility study were accumulated through the

activities.

(3) Output 3: Development of human resources related to implementation of the developed system and establishment of network for promoting biomass energy utilization

The indicators were achieved except the implementation of trainings for operation.

3-1. Local trainings on for biomass energy utilization (at least twice) and trainings for operation (at least once) are conducted. [Mostly achieved]

Local trainings on biomass energy utilization were carried out twice. As to the training for operation, a training for those who are interested to the biomass gasification technology such as personnel of national plantation companies, research institutes and private firms was planned, however, it was not realized during the project period due to the delay of construction of the pilot plant.

3-2. More than ten (in total) researchers and students from both Japan and Indonesia are exchanged to conduct research works. [Achieved]

16 Indonesian researchers were trained in Gunma University and conducted research works with Japanese researchers and students in Japan. Also, 3 Japanese young researchers participated in the research activities in BPPT.

3-3. International seminars are organized at least twice and attended by more than 200 participants in total. [Achieved]

2 international seminars were organized by the Project during the project period.

3-4. More than 10 newsletters are published with more than 750 copies for each. [Achieved]

10 newsletters (issued 750 copies each) were published by the Project during the project period.

3-5. At least ten scientific papers or publications are published. [Achieved]

10 scientific papers were published by Japanese researchers, and one scientific paper was jointly published by researchers of ITB and Gunma University. 15 more scientific papers were prepared by Indonesian side, and presented in international seminars and conferences.

(4) Project Purpose

The indicators were mostly achieved in each research.

1. Pilot plant with capacity up to 50 kW biomass wastes gasification is constructed and operated. [Mostly achieved]

The construction of a pilot plant with capacity of 50kW was completed in May 2019. At the end of the project period, a standard operation procedure of the plant was prepared, and its safe continuous operation was started-up. Stable gasification under a long-term operation is expected to be achieved in the next one to two months.

2. Prototype of methanol synthesis is developed. [Mostly achieved]

The methanol synthesis test with the unit 1 was completed, and methanol synthesis from simulant synthesis gas was confirmed. The unit 2, which allows to conduct further detailed study, was also constructed, and has been used for methanol synthesis experiments applying a candidate catalyst prepared by BPPT to analyze the reaction mechanisms. Further methanol synthesis experiments will be conducted by using the unit 2 to analyze the reaction mechanisms with a catalyst prepared by the project.

3. Potential process of gas fermentation for bioethanol production is identified. [Achieved]
Based on the results of experiments, the reaction mechanisms and critical points for ethanol production were elucidated, and a potential process of gas fermentation was identified.

3-2. Analysis based on the 5 Evaluation Criteria

(1) Relevance

Relevance of the Project is assessed as “high”.

- The Project remains highly relevant to the energy policy of Indonesian Government which aims to transform the energy mix by 2025 to 30% coal, 22% oil, 23% renewable resources and 25% natural gas in accordance to the National Energy Plan in February 2014 (NEP14).
- The Project is relevant to the needs of Indonesian society, as despite of the high potential of biomass wastes, the utilization technologies applicable to Indonesia's economic and technical conditions have not been developed yet. The bio-methanol production is also considered to contribute to the biodiesel production in Indonesia, and a low cost and easy power generation by the gasification technology of EFB can contribute to the improvement of power access in islands with farm plantations such as Sumatra and Kalimantan.
- The Project is relevant to the current Japan’s Development Cooperation Policy for the Republic of Indonesia (September 2017), which places emphasis on the assistance for capacity building to address the challenges facing Asia and the international community, including climate change and environmental conservation.
- The approach of the Project is considered appropriate, as the Project has been undertaken with special attention to the development of “appropriate” production process of gasification and liquid fuel in Indonesia, which enables local engineers to improve the process independently based on their own technology level, and the development of human resources and networks in order to prepare the foundations for diffusion of developed technologies which enables social application of developed technologies. Also, the Project was downscaled as a result of the modification of its plan in July 2017, however, it allowed BPPT to enhance its initiative in the research of the Project. In addition, the reduction in size of the pilot plant enabled various testing options to proceed with technology development, which is considered to accelerate the development of gasification technologies in the future.

(2) Effectiveness

Effectiveness of the Project is assessed as “relatively high”.

- Regarding the achievement of the Project Purpose, the pilot plant with capacity up to 50 kW biomass wastes gasification was constructed and it has been in a process of starting–up the stable operation. The continuous operation is expected to be achieved in the next one to two months (mostly achieved). The prototype of methanol synthesis is also developed, while further experiments are necessary to complete the evaluation of performance (mostly achieved). And the potential process of gas fermentation was identified (achieved).
- The achievement of the Project Purpose was directly produced by achieving the Outputs of the Project. In addition, there was no influence of important assumptions

stated in the PDM version 2.

(3) Efficiency

Efficiency of the Project is assessed as ”lower-medium”

- Indonesian resources were utilized in a positive manner, which contributed to a cost reduction. Also, the personnel was allocated in accordance to the modified plan, after the revision of project plan.
- Due to the delays in the procurement procedure for the pilot plant, some activities were not completed by the end of the project period. Delays in the procurement of some equipment also affected negatively the progress of some activities. A part of assignment of Japanese expert for liquid fuel production was observed to be less than expected by the Indonesian counterpart. In addition, the cold model installed at YDD did not contribute to produce the output of the Project directly after the change of project plan.

(4) Impact

Impact of the Project is assessed as “relatively high”.

- Regarding the Overall Goal of the Project, “Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is diffused”, there is an indicator “Within 4 years from the project completion, at least one plant using established technology are considered to be constructed and operated”. In terms of the gasification of biomass wastes, there is a high prospect of achieving “being considered to be constructed and operated” by a company at least one plant, considering the BPPT’s intention to continue the research for commercialization, the adoption of a program to formulate business plan with several Indonesian and other private companies, the potential of developed technologies as a cost-effective process to disseminate them widely in the near future, and increasing interests from plantation companies in utilizing the technologies developed by the Project.
- Regarding the liquid fuel production, there is still a relatively long way for commercialization, and it is considered rather difficult to diffuse it within 4 years after the Project, but interests in the technology in Indonesia are high, and it can be expected that research will be continued toward the future.
- Some other positive effects of the Project were observed, including the acquisition of patent for Pulse Operated Loop Seal (POLS), among others.

(5) Sustainability

Sustainability is assessed as “high”.

- In regard to the policy and institutional aspects, the policy of increasing alternative energy sources is expected to be continued, and related ministries are highly interested in the energy conversion of biomass wastes.
- As to the organizational and financial aspects, BPPT is highly motivated to continue research activities relevant to the Project and to commercialize the developed technologies in the future, having a well-organized structure and sufficient human resources to continue the research, as well as own research budget which demonstrates its high expectation and commitment for further development of the

gasification technologies. Moreover, research funds may be obtained from various external organizations too.

- Regarding the gas fermentation process, ITB has indicated its intention to continue the research. With regard to the research budget, it is considered that there is a high possibility of obtaining government and/or private funds, as this research is considered innovative and socially-required.
- As to technical aspects, although the Indonesian side still needs technical support from the Japanese side to continue research, it has the necessary capacity to carry out further activities for technological development. Also, the equipment provided by the Project is mostly procured locally, and it is envisaged that there would be no technical problems in maintenance.

3-3. Factors that have promoted the achievement of the project

(1) In relation to the plan

There was no factor identified in relation to the plan.

(2) In relation to the implementation process

- The major revision to the project plan in July 2017 brought about positive changes in project direction and stakeholder involvement, and enhanced the continuity of the research activities even after the Project period.
- The dedication of both Indonesian and Japanese project members enabled to produce the achievement of the Outputs as much as possible, despite of rather tight schedule after the revision of the project plan.

3-4. Factors that have hindered the achievement of the project

(1) In relation to the plan

- The revision of the project plan in July 2017 caused a certain time loss, resulted in some additional activities such as the modification of the plant design.

(2) In relation to the implementation process

- Delays in the construction of pilot plant and the delivery of equipment affected the level of achievement at the end of the project period.

3-5. Recommendations

- For the research activities that are planned under this project but not fully completed before the end of the project period, it is necessary for BPPT to continue them firmly and produce results within the expected timeframe.
- While the expectation for commercialization of gasifier is high and the budget is allocated for the continuation of research, as to the liquid fuel production, it is expected that BPPT and ITB would make an effort to obtain sufficient research budget and continue the research and development.

3-6. Lessons Learned

- With regard to the procedures for tax exemptions pertaining to the construction of plants, it is necessary to discuss and agree on the procedures among the stakeholders in advance, in order to avoid delays and inconvenience. For SATREPS project, an attention has to be paid to the fact that equipment is often procured by Japanese research institution which is not recognized by partner countries as entitled

for tax exemption.

- In this project, in order to deal with problems occurred in the middle of the project period, the original plan was modified in accordance with the close discussions and the mutual agreement of both Indonesian and Japanese institutions. As a result, the participation of Indonesian institutions was increased, the continuity of research after the Project was enhanced, and the revised goals were mostly achieved. Harnessing project ownership of partner research institution would be quite important for Japanese research institution especially for securing sustainability of activities under SATPRES projects.

１　終了時評価調査の概要

(1)背景・目的

国際協力機構（JICA）は、インドネシアでバイオマス廃棄物を用いたガス化および液体燃料生産のシステム普及を図り、インドネシアの再生可能エネルギー利用促進に寄与するため、2014 年 6 月から 2019 年 6 月にかけて、科学技術協力「バイオマス廃棄物の流動接触分解ガス化・液体燃料生産モデルシステムの開発プロジェクト」を実施した。

プロジェクト終了にあたり、プロジェクトの達成状況、効率性および持続性等を中心に検証し、プロジェクト終了後のカウンターパート側の計画を検討することを目的として、終了時評価調査団を派遣し、インドネシア側との合同で終了時評価を実施した。

本終了時評価調査では、1）C/P 機関と合同で本プロジェクトの目標達成度等を分析するとともに、2）プロジェクト終了後の上位目標の達成や持続性強化の観点からの課題を特定し、3）上記課題の改善のための提言および今後の類似案件への教訓を検討し、評価報告書に取りまとめ、JICA および C/P 機関の双方で合意することを目的とする。

(2)調査団構成

No	Name 氏名	Job title 分野	Occupation 所属	Period (Arr.-Dep.) 派遣期間
1	Dr. Toru Kobayakawa 小早川徹	Leader 総括	Senior Director, Industrial Development and Public Policy Department, JICA	2019.06.18-2019.06.26
2	Ms.Kuri Shibata 柴田久里	Cooperation Planning 協力企画	Program Officer, Team 1, Energy and Mining Group, Industrial Development and Public Policy Department, JICA	2019.06.18-2019.06.26
5	Ms. Yuki Ohashi 大橋由紀	Consultant (Evaluation) 評価分析	Tekizaitekisho LLC	2019.06.18-2019.06.26
6	Prof. Tsutsumi 堤敦司	Observer 研究主幹	Japan Science & Technology Agency (JST)	2019.06.22-2019.06.26
7	Dr. Kosaka 上阪圭介	Senior Associate Research Supervisor 主任調査員	Japan Science & Technology Agency (JST)	2019.06.22-2019.06.26
3	Prof. Reiji Noda 野田玲治	Project Research Leader 研究総括	Gunma University	2019.06.18-2019.06.26
4	Ms. Chiaki	Coordinator	-	2019.06.18-

	Fukuda 福田千秋	業務調整員		2019.06.26

(2)調査日程

No.	Date		Activity	Place
1	18-Jun	Tue	(Arrival in Jakarta, Indonesia)	Jakarta
2	19-Jun	Wed	AM: Meeting at JICA Indonesia Office PM: Site visit and meeting with CPs at BPPT	Jakarta → Serpong
3	20-Jun	Thu	Meeting with CPs at BPPT (After the meeting, move to Bandung)	Serpong → Bandung
4	21-Jun	Fri	Meeting with Bandung Institute of Technology (ITB) (After the meeting, transfer to Jakarta)	Bandung → Jakarta
5	22-Jun	Sat	AM: Internal Meeting PM: Preparation	Jakarta
6	23-Jun	Sun	AM: Internal Meeting PM: Preparation (transfer to Jogjakarta)	Jakarta → Jogjakarta
7	24-Jun	Mon	AM: Meeting and Site Visit at Dian Desa Foundation (YDD) (After the meeting, transfer to Jakarta)	Jogjakarta → Serpong
8	25-Jun	Tue	Meeting with CPs on Terminal Evaluation at BPPT	Serpong
9	26-Jun	Wed	Report to JICA Office (Departure)	Serpong → Jakarta
10	27-Jun	Thu	(Arrival in Japan)	-

２ プロジェクト概要

プロジェクトの概要は以下に示す通りである。2016 年 12 月の中間レビューにおいて改訂が提言され、2017 年 7 月に開催された第 4 回 JCC で承認されたプロジェクト・デザイン・マトリックス（PDM: Project Design Matrix）Ver.2 は付属資料の Annex1:PDM の通り。

(1)上位目標

現地に適合的なバイオマス廃棄物の流動接触分解ガス化と液体燃料生産システムが普及する。

(2)プロジェクト目標

インドネシアの社会・経済条件に適合的な、バイオマス廃棄物の流動接触分解ガス化と液体燃料生産システムが確立し、その普及のための基盤が整備される。

(3)成果

成果 1： タール処理技術を伴うバイオマスの流動接触分解ガス化プロセスの確立

成果 2： 液体燃料生産システムの開発

成果 3： 当該システムの実行・推進を担う人材の育成とバイオマスエネルギー利用促進のためのネットワークの形成

(3)活動[3]

1. タール処理技術を伴うバイオマスの流動接触分解ガス化プロセスの確立

1-1 安定流動層の確立

1-1-1 新規ループシール構造の検討

1-1-2 新規ループシール構造のスケールアップ手法の検討

1-1-3 パイロットスケールのコールドモデルでの実験

1-1-4 パイロットプラントへの適用

1-2 粘土触媒の最適化

1-2-1 粘土触媒候補の調達

1-2-2 触媒反応の評価

1-2-3 触媒の物理化学分析と触媒反応機構の解明

1-3 チャー抜出/循環機構の開発

1-3-1 チャー抜出/循環機構の概念設計

1-3-2 コールドモデル実験

1-3-3 パイロットプラントへの適用

1-4 バイオマスの前処理方法の確立

1-4-1 原料バイオマスの前処理のコンセプト開発

1-4-2 前処理システムのプロトタイプ試験

1-4-3 パイロットプラントへの適用

1-5 ガス化炉残渣の肥料化技術の開発

1-5-1 残渣の分析と肥料適合性の評価

1-5-2 残渣の肥料化プロセスの開発

1-5-3 肥料化のデモンストレーション

1-5-4 肥料のフィールドテスト

1-6 パイロットプラントの稼働

1-6-1 パイロットプラントの設計

1-6-2 パイロットプラントの建設

1-6-3 パイロットプラントの稼働

1-7 タール処理技術の開発

1-7-1 ラボスケールのタール分解実験

1-7-2 タール分解システムの設計

1-7-3 タール分解システムの建設

1-7-4 パイロットプラントへの適用

[3] PDM Ver.2 に基づく本終了時評価調査団による仮和訳

2. 液体燃料生産システムの開発

2-1 持続的メタノール合成触媒の開発

2-1-1 触媒候補のスクリーニング

2-1-2 反応機構の解明と高性能化の検討

2-1-3 プロトタイプへの適用

2-2 低コストの小規模メタノール合成プロトタイプの確立

2-2-1 合成ガス前処理の概念設計

2-2-2 プロトタイプの設計

2-2-3 プロトタイプの建設・設置

2-2-4 プロトタイプの稼働

2-3 ガス発酵法液体燃料生産プロセスの基礎研究の実施

2-3-1 文献調査および実験の計画討

2-3-2 材料および微生物株の調達

2-3-3 論文執筆のレビュー

2-3-4 培養準備

2-3-5 菌体の培養・最適化

2-3-6 ガス発酵の予備研究

2-3-7 バッチリアクターでの最適化

2-3-8 連続バイオリアクターでのメタノール生産の向上

3. 当該システムの実行・推進を担う人材の育成とバイオマスエネルギー利用促進のためのネットワークの形成

3-1 人材育成

3-1-1 日本での交換プログラムの実施

3-1-2 現地研修プログラムの実施

3-2 ネットワーク形成

3-2-1 国際セミナーの開催

3-2-2 ニュースレターの発行

(4)実施機関

日本側：群馬大学、特定非営利活動法人 APEX[4]

[4] 特定非営利活動法人 APEX は 2017 年 7 月に行われたプロジェクト計画の大幅な修正後は活動に参加していない。

インドネシア側：インドネシア技術応用評価庁（BPPT）（主要 C/P 機関）、ディアン・デサ財団（YDD）[5]、およびバンドン工科大学（ITB）（ガス発酵法液体燃料生産プロセスの開発部分を担当）

３ 評価の方法

本終了時評価調査は、経済開発協力機構／開発援助委員会（OECD-DAC）による「開発援助評価の基本原則」（1991 年）に則った「新 JICA 事業評価ガイドライン第一版」（2010 年 6 月）を指針とし、プロジェクト・サイクル・マネジメント（PCM）手法により実施された。

(1) プロジェクトの達成状況・実施プロセス

2017 年 11 月付のプロジェクト・デザイン・マトリックス（PDM）第 2 版および 2018 年 7 月付の活動実施計画（PO）に基づき、プロジェクト目標、アウトプット等、プロジェクトの達成状況を確認した。プロジェクトの管理・運営、関係者間のコミュニケーション、共同研究のプロセス等、プロジェクトの実施プロセスについても検証した。

(2) 評価 5 項目

プロジェクト全体を妥当性、有効性、効率性、インパクト、持続性の評価 5 項目によって分析した。各項目は、「高い」、「比較的高い」、「中程度」、「やや低い」、「低い」の 5 段階で 評価した。

表 2－1：評価 5 項目

妥当性	開発援助と、ターゲットグループ・相手国・ドナーの優先度ならびに政策・方針との整合性の度合い。
有効性	開発援助の目標の達成度合いを測る尺度。
効率性	インプットに対するアウトプット（定性ならびに定量的）を計測する。開発援助が期待される結果を達成ために最もコストのかからない資源を使っていることを示す経済用語。最も効率的なプロセスが採用されたかを確認するため、通常、他のアプローチとの比較を必要とする。
インパクト	開発援助によって直接または間接的に、意図的または意図せずに生じる、正・負の変化。開発援助が、地域社会・経済・環境ならびにその他の開発の指標にもたらす主要な影響や効果を含む。
持続性	ドナーによる支援が終了しても、開発援助による便益が継続するかを測る。開発援助は、環境面でも財政面でも持続可能でなければならない。

[5] YDD については、2018 年度の時点でジョグジャカルタでのコールドモデル試験が中止され、その後はプロジェクト活動への直接的な参加はない。

出所：　新 JICA 事業評価ガイドライン（2010 年 6 月）

(3) 情報収集方法

本終了時評価に必要とされるデータや情報は以下の方法で収集された。

表 2－2：データ収集方法と出所

手法	主な出所
文献レビュー	• 詳細計画策定調査報告書 • プロジェクト月報 • 中間レビュー報告書 • JST 終了報告書（2019 年 4 月）及び関連資料
質問票	• 日本側実施機関 • インドネシア側カウンターパート機関（BPPT、YDD、ITB)
インタビュー	• 日本側実施機関 • インドネシア側カウンターパート機関（BPPT、YDD、ITB) • JICA インドネシア事務所
サイト訪問	• BPPT 技術・知識研究センター（PUSPIPTEK） • ITB • YDD

(4) 合同評価

本終了時評価はインドネシア側、日本側の双方による合同評価として実施された。報告書等文献の分析、インタビュー等の情報収集や、評価結果の分析等、評価の一連の活動は双方により実施された。

４ プロジェクトの実績

4-1 投入実績

(1) 日本側の投入

1） 専門家派遣

群馬大学の短期派遣の専門家がプロジェクト開始から終了まで 3 名派遣され、更にプロジェクト計画の修正により 2017 年 7 月から終了までもう 1 名派遣された。また、APEX の短期専門家 4 名がプロジェクト開始から 2017 年 6 月まで配置された。これらの技術専門家に加えて、業務調整の長期専門家 1 名が 2015 年 8 月からプロジェクト終了まで配置された。専門家派遣の詳細は付属資料の Annex 4: List of Inputs (Japanese side), (1) Dispatch of Japanese Experts を参照のこと。

2） 本邦研修

BPPT の研究者合計 16 名がそれぞれ 2、3 カ月間の群馬大学での研修に参加した。本邦研修の詳細は付属資料の Annex 4: List of Inputs (Japanese side), (2) Training in Japan を参照のこと。

3） 機材供与

総額約 1 億円のプロジェクト活動に必要な資機材が供与された。機材供与の詳細は付属資料の Annex 4: List of Inputs (Japanese side), (3) Installed equipment by JICA's budget を参照のこと。

4） プロジェクト経費

表 3-1 に示すとおり、総額 3,659,765,062 インドネシアルピア（約 27,887,000 円[6]）が現地活動経費として支出された。現地活動経費の詳細は付属資料の Annex 4: List of Inputs (Japanese side), (4) JICA's Overseas Activity Cost を参照のこと。

表 3-1：JICA による現地活動経費

年度	合計支出額 （インドネシアルピア）
2014 年	136,145,863
2015 年	326,619,830
2016 年	490,159,343
2017 年	1,048,572,475
2018 年	1,044,462,995
2019 年	613,795,556

[6] 2019 年 6 月の JICA 統制レート、1 インドネシアルピア＝0.007620 円で換算（1,000 円以下四捨五入）。

合計	3,659,765,062

(2) インドネシア側の投入

1) カウンターパートの配置

BPPT から全プロジェクト期間で合計 54 名の研究者がプロジェクト活動のために配置された。YDD からは 2 名の職員がプロジェクト開始から 2017 年 6 月までの間プロジェクト活動に携わった。また、ITB からは 2016 年 12 月にプロジェクトに参加してから終了時まで合計 6 人の研究者が配置された。カウンターパート配置の詳細は付属資料の Annex 5: List of Inputs (Indonesian side), (1) List of Indonesian Counterparts を参照のこと。

2) プロジェクト経費

表 3-2 に示すとおり、BPPT から総額約 878,480,000 インドネシアルピア（約 6,694,000 円[7]）がプロジェクト経費（機材費を除く）として支出された。

表 3-2：BPPT によるプロジェクト経費

年度	合計支出額 （インドネシアルピア）
2014 年	47,000,000
2015 年	105,705,000
2016 年	330.000.000
2017 年	150.000.000
2018 年	200.000.000
2019 年*	45,775,000
合計	878,480,000

* プロジェクト終了時点（2019 年 6 月 12 日）まで

ITB からは表 3-3 に示すとおり総額約 346,800,000 インドネシアルピア（約 670,000 円[8]）がプロジェクト活動のために支出された。

表 3-3：ITB によるプロジェクト経緯

年度	合計支出額 （インドネシアルピア）
2017 年	173,500,000
2018 年	148,400,000
2019 年*	24,900,000

[7] 同上

[8] 同上

Total	346,800,000

* プロジェクト終了時点（2019 年 6 月 12 日）まで

また、YDD からは 2016 年度に約 5,760,000 インドネシアルピア（約 44,000 円[9]）がプロジェクト活動のために支出された。経費の詳細は付属資料の Annex 5: List of Inputs (Indonesian side), (2) Activity Cost by Counterpart's Budget を参照のこと。

3) 機材

BPPT から総額 432,241,900 インドネシアルピア（約 3,294,000 円）、ITB からは総額 182,144,900 インドネシアルピア（約 1,388,000 円）相当の機材が提供された。機材の詳細は付属資料の Annex 5: List of Inputs (Indonesian side), (3) Installed Equipment by Counterpart's Budget を参照のこと。

また、日本人専門家の執務スペースおよび研究等のオペレーションルーム、資機材を配置するためのスペースが BPPT の PUSPIPTEK 内に提供された。

4-2 アウトプットの達成状況

(1) アウトプット１：タール処理技術を伴うバイオマスの流動接触分解ガス化プロセスの確立(Establishment of fluidized bed biomass gasification process with tar treatment technology.)

アウトプット１の各指標の達成状況は以下に示すとおりである。

表３－４：アウトプット１の指標の達成状況

	指標	達成状況
1	高度安定型流動層が確立される。 (Stable operation of fluidized bed gasifier is demonstrated.)	【概ね達成】 本プロジェクトにより従来構造よりも安定性が高い新規ループシール構造[10]が開発され、そのスケールアップ手法がパイロットプラントと同規模のコールドモデルで確認された。ループシール構造は今後数カ月の間にパイロットプラント(1-6 を参照)で実証される予定である。

[9] 同上

[10] 循環流動層は安定的な粒子循環のために、プラントの複数のポイントの温度圧力条件をモニターしながら、例えば反応器排圧を制御するなどの、高度な運転管理が必要である。これらの問題点を本質的に解決するためのループシール構造としてパルス操作ループシール機構（Pulse Operated Loop Seal: POLS）が提案・開発された。POLS は、ガス供給を連続からパルスに変更することで、粒子上昇部において、粒子層をパルスジェットで強制的に切り出す形式である。

2	5 種類以上の粘土触媒から、最も活性の高いものが選択される。 (The most active catalyst is identified among at least five kinds of clay catalysts.)	【達成】 12 種類のインドネシア産粘土を調達しスクリーニングが行われた結果、バイオマスのガス化において好適な粘土触媒が 3 種類確認された。また、重質タール低減効果に最も寄与する物性が総酸量であることが判明した。
3	チャー抜出機構が開発される。 (Char drawing system is demonstrated.)	- チャー抜出・循環機構の開発においては、設計まで完了したが、バイオマスの前処理の検討の過程で油ヤシ空房（EFB）の粉砕物をガス化原料とすることが決定したため、2018 年度の時点でジョグジャカルタでのコールドモデル試験は中止され、その後予定されていたチャー抜出/循環機構のデモンストレーションも中止となった。
4	適応可能なバイオマス前処理システムが開発される。 (Proper biomass pretreatment system is established.)	【概ね達成】 EFB の各種前処理プロセスの得失の評価が行われ、カッターミルによる切断処理が有効と判断された。EBF 粉砕装置のプロトタイプが製作され、目標としたサイズ（1～2cm）の繊維が生産できるようになった。処理速度に関しても概ね想定しているスピードを達成した。粉砕装置は一部カッター部分を調整することで処理速度が改善することがわかっており、その調整は今後２、3 カ月で終了する予定である。
5	ガス化残渣の肥料化技術が確立する。 (Technology for utilization of gasification residue as fertilizer is developed.)	【概ね達成】 ガス化炉残渣の分析結果から、EFB チャーおよび灰は K を豊富に含んでおり、肥料化には他の P、N 原料を混合して利用することが有効であると確認された。EFB のサンプルから得たチャーや灰の混合レシピによる肥料が試作され、その結果、チャー残渣肥料では育成効果は商用肥料よりも優れていることが判明した。また、チャー残渣の混合肥料の経済性評価が行われ、30%のコスト削減が確認された。灰残渣の混合肥料については、プロジェクト終了時点では施肥効果の試験の最中であり、プロジェクト終了後 20 日程度で完了する予定である。パイロットプラントの継続運転後にはパイロットプラントからの残渣による規模を拡大した肥料の生産が試行される予定である。それにより BPPT はより大規模な施肥効果試験の実施を予定している。

6	パイロットプラントが稼働する。 (Pilot plant is successfully operated.)	【概ね達成】 群馬大学および BPPT の協働により 50kW のパイロットプラントの基本設計の開発が行われ、選定されたエンジニアリング企業による設計が行われた。免税手続きに関連した 3 カ月程度の発注の遅れ、建設の 1 か月程度の遅れにより、パイロットプラントの竣工は 2019 年 5 月となった。プロジェクト終了時点では所定の運転条件で動かし安全性の確認のための試運転が行われている。今後 1～2 カ月で連続運転が可能になる見込みである。
7	タール除去の技術が開発される。 (Tar treatment technology is developed.)	【一部達成】. 1）粘土粒子によるタールトラップ回収、2）タールの接触分解、3）バイオマスの灰を触媒としたタール除去、の 3 種類の炉内タール除去技術が検討され、これらの技術の基礎研究が行われた。それにより炉内粘土触媒によるタール除去がラボスケールの流動層ガス化炉試験装置で確認された。今後、タール除去の性能がパイロットプラントにおいて確認される予定である。 ガス化炉後段におけるタール除去装置の開発は 2017 年 7 月にプロジェクト活動に追加され、異なる処理方式の概念設計が行われた。しかし、炉内粘土触媒でのタール除去の性能が比較的高いことがラボスケールの実験で明らかとなったことから、炉内タール除去を用いる場合、タール除去装置は不要であることが確認された。 BPPT は独自でプロジェクト終了後もタール除去の性能をより高めるための研究を継続する予定である。

(2) アウトプット 2：液体燃料生産システムの開発（Development of liquid fuel production system）

アウトプット 2 の各指標の達成状況は以下に示すとおりである。

表３－５：アウトプット２の指標の達成状況

	指標	達成状況
1	持続的なメタノール合成触媒が開発され	【達成】 群馬大学と BPPT により 10 種類以上の触媒の試作が準備さ

	る。 (Sustainable catalyst for Methanol synthesis is developed.)	れ、BPPT が同一条件下で比較した。γアルミナ処理を行った含侵法触媒が Cu 単位重量あたりのメタノール生成量が最も大きいことが確認され、小規模プラントで適用可能な低コストメタノール合成触媒が特定された。
2	低コストの小規模メタノール合成プロトタイプが開発される。 (Methanol synthesis prototype for small scale application with low cost process is developed.)	【達成】 合成ガス前処理プロセスとしてアルカリ洗浄による CO2 除去方法が開発され、模擬ガス試験により 90%以上の CO2 除去が確認された。 メタノール合成プロトタイプ 1 号機は 2015 年に製作され、実験により模擬合成ガスからのメタノール生成が確認された。しかし、1 号機はより高純度のメタノール合成プロセスの検討には実験条件の自由度が低く精度が不十分であった。よって、さらに詳細な研究を進めるためにプロトタイプ 2 号機が設計され、製作された。
3	メタノール合成プロトタイプの試験・評価が行われる。 (Methanol synthesis prototype is tested and evaluated.)	【一部達成】 上記プロトタイプ 1 号機及び 2 号機の試験・評価が行われた。1 号機による試験の結果からは、市販触媒を使用してメタノール収率が 60%以上となるガス供給速度が明らかになった。 プロトタイプ 2 号機では市販触媒を使用した種々のメタノール合成試験が行われた。今後、プロトタイプ 2 号機によるメタノール合成試験がさらに実施され、プロジェクトが準備した触媒を使用して反応機構が分析される予定である。
4	ガス発酵プロセスの基礎実験が実施され、フィージビリティスタディーに必要なデータが収集される。 (Fundamental research of gas fermentation process is conducted to collect data for feasibility study.)	【達成】 ITB において連続ガス醗酵試験装置が完成し、一連のガス醗酵試験が実施され、模擬ガスからのエタノール生産が確認された。ITB および群馬大学で得られた結果から、エタノール生産について反応機構などの重要なポイントが解明された。これらの活動をとおりしてフィージビリティスタディーのための実験結果が蓄積された。

(3) アウトプット 3: 当該システムの実行・推進を担う人材の育成と、バイオマスエネルギー利用促進のためのネットワークの形成（Development of human resources related to implementation of the developed system and establishment of network for promoting

biomass energy utilization.）

アウトプット３の各指標の達成状況は以下に示すとおりである。

表３－６：アウトプット３の指標の達成状況

	指標	達成状況
1	バイオマスのエネルギー利用に関するローカル研修が 2 回以上、オペレーション研修が 1 回以上開催される。 (Local trainings on biomass energy utilization (at least twice) and trainings for operation (at least once) are conducted.)	【概ね達成】 • バイオマスエネルギーの利用に関するローカル研修が 2 回（2015 年 11 月および 2019 年 5 月）実施された。 • 国営農園やその他企業や大学などの研究者など、バイオマスのガス化技術に関心を持つ人材を対象としたオペレーション研修が計画されていたが、パイロットプラントの設置が遅れたため期間中の実施はできなかった。BPPT は今後パイロットプラントに関連した研修やセミナーを実施する予定である。 • オペレーション技術に関連した研修としては、ガス化プロセスの設計ワークショップが 2016 年に 4 回実施され、計 120 名が参加した。研修の詳細は付属資料の Annex 7: List of Seminars, workshops and trainings のとおり。
2	合計 10 名以上の日本･インドネシア双方の研究者・学生が研究実施のための交換に参加する。 (More than ten (in total) researchers and students from both Japan and Indonesia are exchanged to conduct research works.)	【達成】 インドンネシア人研究者 16 名が群馬大学での研修に参加し、日本人研究者・学生と共に研究に従事した。また、日本人の若手研究者 3 名が BPPT での研究活動に参加した。
3	国際的セミナーが 2 回以上、計 200 名以上の参加者を得て実施される。 (International seminars are organized at least twice and attended by more than 200 participants in total.)	【達成】 以下の国際セミナーがプロジェクト期間中に実施された。 • 国際セミナー「バイオマス由来燃料生産のための適正技術」（2016 年 2 月、参加者数 120 人） • 国際セミナー「バイオマスエネルギー」（2019 年 5 月、参加者数 94 人）

4	ニュースレターが 10 回以上、各 750 部以上発行される。 (More than 10 newsletters are published with more than 750 copies for each.)	【達成】 ニュースレターはプロジェクト期間中に 10 回､各 750 部発行された。
5	10 件以上の学術論文が発行される。 (At least ten scientific papers or publications are published.)	【達成】 • 日本側の研究者により 10 件の学術論文（国内誌 2 件、国際誌 8 件）が発行された。 • ITB と群馬大学の研究者の共著論文が 1 件発行された。 • インドネシア側研究者により 10 件の論文が作成され、国際セミナー等で発表された。また､6 件の論文が現在作成中である。

4-3 プロジェクト目標の達成状況

プロジェクト目標である「インドネシアの社会・経済条件に適合的な、バイオマス廃棄物の流動接触分解ガス化と液体燃料生産システムが確立し、その普及のための基盤が整備される。」（Fluidized bed catalytic gasification of biomass wastes and following liquid fuel production system that is socially and economically appropriate for Indonesia is established and bases for the diffusion are prepared.）の各指標の達成状況は以下のとおりである。

表３－７：プロジェクト目標の指標の達成状況

	指標	達成状況
1	50kW 以上のバイオマス廃棄物ガス化のデモンストレーションプラントが設置され、運転される。 (Pilot plant with capacity up to 50kW biomass wastes gasification is constructed and operated.)	【概ね達成】 50kW パイロットプラントの建設が 2019 年 5 月に完了した。プロジェクト期間終了時点ではガス化炉の標準運転手順書の準備が終わり、安全な連続運転によるバイオマスガス化炉の立ち上げが行われている。長時間連続運転による安定したガス化は今後 1～2 カ月で達成が可能な見通しである。
2	メタノール合成プロトタイプが開発される。 (Prototype of methanol synthesis is developed.)	【概ね達成】 プロトタイプ初号機によるメタノール合成試験を完了し、模擬合成ガスからのメタノール合成を確認した。その後より精度の高い実験を可能とするためのプロトタイプ 2 号機が製作され、反応機構の分析のため、BPPT に

		よる触媒を用いたメタノール合成試験が一部開始されている。今後本研究プロジェクトで調整した好適メタノール合成触媒によるメタノール合成試験が 2 号機で継続される見込みである。
3	ガス発酵によるバイオエタノール生産プロセスが特定される。 (Potential process of gas fermentation for bioethanol production is identified.)	【達成】 実験結果に基づいて好適ガス発酵プロセスが特定され、将来性のあるエタノール生産プロセスが確認された。

５ プロジェクトの実施過程

(1) プロジェクトの管理・運営

合同調整委員会（JCC）がプロジェクト期間中 5 回開催され、プロジェクトの進捗、課題、計画の修正等について協議・合意形成が行われた。中間レビュー時にはプロジェクト活動の進捗状況や参加機関間のコミュニケーション、情報共有等の課題が指摘され、プロジェクト計画の修正や共同研究の改善方法について参加機関による協議が行われた。メンバーリスト、PDM、PO、各参加機関の役割分担の修正が 2017 年 7 月の第 4 回 JCC で合意され、その後は新たな合意内容に基づいて協力的にプロジェクトが運営された。修正後は各機関の役割が明確になり、ガス化炉の開発に関しても全てのタスクに参加するなど BPPT のコミットメントの向上が見られた。

(2) インドネシア側・日本側のコミュニケーション

参加機関間のコミュニケーションや情報共有は実施体制や活動の修正後、上述のとおり改善された。日本人の業務調整専門家と技術専門家 1 名がインドネシア語による業務が可能であったこと、複数のインドネシア側カウンターパートが日本語を話せたことは双方の潤滑なコミュニケーションに大いに貢献した。

(3) PDM の改訂

上述のとおり、プロジェクト計画の変更が 2017 年 7 月の第 4 回 JCC で合意された。主要な変更内容は以下に示すとおりである。

① プロジェクト前半で開発してきた粘土を流動媒体とする循環流動層ガス化デモンストレーションプロセスは、基本的な構造は維持しつつ、プロジェクト終了後も BPPT が継続的に研究を推進できるような拡張性の高いパイロットプラントとして整備することとし、ガス化炉の形式は APEX が特許を有する技術から群馬大学保有の技術ベース

へと変更する。設置場所は BPPT の研究拠点があるスルポン（Serpong）の PUSPIPTEK 内とする。

② パイロットプラントの規模は、当初の 250kW から 50kW に縮小し、その余剰予算を利用して、バイオマスの前処理、タール除去プロセス、チャー抜出し装置、粒子循環システムなどを取り替えつつ、個別の性能試験ができるようにする。バイオマスガス化のための要素技術のプロトタイプ実証を通じて、インドネシア適合型小規模バイオマスガス化プロセスを確立する。

③ 熱化学的メタノール合成プロセスは、小規模バイオマスガス化プロセスに適合的なプロセスの開発を目標として、ベンチスケールのプロトタイプ試験まで実施する。

④ ガス発酵エタノール合成プロセスの基礎試験を通じて、小規模バイオマスガス化における実現可能性を明らかにするために必要なデータの収集を行う。

上記の第 4 回 JCC で合意された内容に基づき、2017 年 11 月に PDM の第 2 版への改訂が合意された。改訂前の PDM 第 1 版から改定後の第 2 版への修正内容の詳細については付属資料の Annex 6: Comparative Table between PDM Version 1 and Version 2 を参照のこと。

(4) 活動の実施

中間レビューおよび計画の修正後は新たな PDM・PO に基づいて活動が実施されたが、様々な理由から活動の遅れや変更が生じる結果となった。主な活動の遅延、変更は以下に示すとおりである。

- 上述のとおりパイロットプラントの形式が変更になったことから、設計の一部に修正の必要が生じ、基本設計の変更に時間を要した。修正後のパイロットプラントの基本設計は、群馬大学が保有する外部循環流動層ガス化プロセスをベースとし、群馬大学と BPPT が協力して取り組んだ。
- パイロットプラントの設計は 2018 年 8 月には地元建設業者へ発注する準備が整ったが、群馬大学と JICA の間での免税措置の手続きに関する調整に時間を要したことから、発注は 4 カ月遅れの 2018 年 12 月に行われた。またパイロットプラントの建設に 1 カ月の遅れが生じた。パイロットプラントの建設の遅れから、以下の活動はプロジェクト期間内に完了することができなかった。
  - パイロットプラントの残渣から作った肥料の実証
  - パイロットプラントのオペレーション研修
- アウトプット 1 の達成状況で述べたとおり、チャー抜出・循環機構の開発についてはバイオマスの前処理の検討の過程で EFB の粉砕物をガス化原料とすることが決定されたことから中止となった。
- アウトプット 1 の達成状況で述べたとおり、ガス化炉後段におけるタール除去装置の開発は、炉内粘土触媒でのタール除去の性能が比較的高いことがラボスケールの実験

で明らかとなったことから、タール除去装置は不要であると確認された。

- メタノール合成の好適触媒によるプロトタイプ 2 号機での実験については、生成物の一斉分析のためのガスクロマトグラフィの調達に遅れが生じたことから、活動に遅れが生じた。

(5) 共同研究のプロセス・BPPT のオーナーシップ向上

流動層ガス化プロセスの開発については、群馬大学と BPPT が密接に研究活動について議論し、共同で実施された。そのような協働のプロセスをとおして共同研究が促進された。パイロットプラントの設計においては、群馬大学がガス化炉のコンセプトを提示し、BPPT が主体となって、群馬大学と共に不具合に対応しながらコールドモデルの製作を進めた。それにより、進捗はやや遅くなったものの、BPPT はその後のホットモデルの設計等様々な課題において自ら判断することが可能となった。このようなプロセスが BPPT のプロジェクトへのオーナーシップを醸成することとなった。

液体燃料の生産システムの開発については、各機関の役割が明確になったことにより、インドネシア側研究者がイニシアティブを持って研究活動に取り組むようになった。本邦研修はインドネシア側研究者が研究活動に従事するために必要な技術の移転において効果的に行われたが、一方、インドネシア側研究者からは、日本人専門家とより頻繁で深い議論をすることが可能であったなら、より研究が促進されただろうとの意見が挙げられた。

６ 評価 5 項目によるレビュー結果

6.1. 妥当性

以下の点から本プロジェクトの妥当性は高いと判断される。

(1) インドネシア政府の政策・戦略との妥当性

石油からその他の電力源への転換は現時点においてもインドネシアの重要課題である。2014 年国家エネルギー計画（NEP14）では 2025 年までに石炭 30%、石油 22%、再生可能エネルギー23%、天然ガス 25%のエネルギーミックスを達成目標としており、現時点でもインドネシア政府の政策となっている。本プロジェクトはバイオマス廃棄物のガス化技術および液体燃料生産技術を開発すること、その技術がインドネシアの社会経済や技術の現状に適応可能であることを目指しており、インドネシアでのバイオマス廃棄物のエネルギー利用に貢献する事業であることから、インドネシア政府のエネルギー政策との妥当性は現時点でも高いと言える。

(2) インドネシア社会のニーズとの整合性

- 本プロジェクトのガス化の原料とされるバイオマス廃棄物はインドネシア国内に豊富に存在し、バイオエタノールの原料のように他のニーズと競合することがないという大きな利点がある。ポテンシャルが高いにも関わらず、インドネシアの経済的・技術的条件に適合した利用技術が開発されていないことから、本プロジェクトによる技術開発へのニーズが高い。
- メタノールはバイオディーゼルの生産過程で必要とされるが、インドネシアでは 50%以上を輸入に依存している。インドネシアで唯一生産されているメタノールは天然ガスから精製されているが、天然ガスはエネルギー源として利用比率の増加がインドネシア政府の政策目標として掲げられている。バイオメタノールの生産・開発はインドネシアのバイオディーゼル生産にも貢献すると考えられている。
- 本プロジェクトのガス化の原料である EFB はスマトラ島やカリマンタン島などジャワよりも電化率が低い島々の農園プランテーションに豊富である。本プロジェクトで確立を目指す FEB のガス化技術による低コストかつ比較的容易な発電は、それらの島々での電力供給の改善にも貢献することが可能である。

(3) 日本の ODA 政策との妥当性

現行の対インドネシア共和国国別開発協力方針（2017 年 9 月）では、重点分野 3 として「アジア地域及び国際社会の課題への対応能力向上に向けた支援」が挙げられている。本プロジェクトはこの重点分野の下の開発課題 3－1「気候変動・自然環境保全対策」に貢献する事業と位置付けられている。

(4) アプローチの適切性

- バイオマス廃棄物のエネルギー利用は日本で既に商業化されている技術であるが、インドネシアで普及するためには現地で活用できる適正技術の開発が求められる。本プロジェクトは、1）インドネシアのプランテーションや農林産物集積・加工場等で比較的容易に設置・運転・保守が可能な「適正」なバイオマス廃棄物のガス化と液体燃料生産プロセスを開発すること、2）現地の技術者による自国の技術水準にあわせた自発的なプロセス改善を可能とすること、3）人材育成やネットワーク形成によりその普及のための基盤を整備すること、4）開発した技術の社会実装を実現すること、について強く意識した事業である。
- 2017 年 7 月の JCC における計画変更では、BPPT がプロジェクト終了後も EFB のガス化技術の商用化のための研究開発を継続できる態勢を整えることを最大の目標として位置付けることで両国研究代表機関の意思統一が図られた。結果、実験規模や到達目標はスケールダウンとなったが、計画変更後 BPPT は主体的に研究に取り組み、プロジェクト終了後も研究を継続する意思を示している。また、パイロットプラントの規模の縮小により様々な技術オプションを試行しながら技術開発をすすめることが可能と

なり、将来のガス化技術の開発をより迅速に進め得る可能性が高いと考えられている。

6.2. 有効性

以下の点から、本プロジェクトの有効性は比較的高いと判断される。

(1) プロジェクト目標の達成度

「4-3 プロジェクト目標の達成状況」で示したとおり、50kW パイロットプラントの建設は完了し、安全な連続運転によるバイオマスガス化炉の立ち上げが行われており、長時間連続運転による安定したガス化は今後 1〜2 カ月で達成する見込みである（概ね達成）。メタノール合成についても今後メタノール合成試験を継続する必要があるが、プロトタイプ（初号機・2 号機）が製作され利用されている（概ね達成）。ガス発酵によるバイオエタノール生産プロセスについては、実験結果に基づいて好適ガス発酵プロセスが特定され、将来性のあるエタノール生産プロセスが確認された（達成）。

(2) プロジェクト目標とアプトプットの因果関係

本プロジェクトのプロジェクト目標の達成はアウトプットの発現が直接もたらした結果である。PDM 第 2 版には外部条件として 1）インドネシアにおいて深刻な経済危機や極端な物価変動が生じない、2）テロ行為、戦争、内乱等により、大きな社会的混乱が生じない、3）事業の実施地域で、火山の噴火や大地震など、大きな自然災害がない、の 3 点が挙げられているが、プロジェクト期間中をとおしてこれらの影響は生じていない。

6.3. 効率性

本プロジェクトの効率性はやや低いと判断される。

(1) アウトプットの達成度

「4-2 アウトプットの達成状況」に示したとおり、アウトプット 1 のバイオマスの流動接触分解ガス化プロセスの確立については、開発された新規ループシール構造はパイロットプラントではまだ実証が完了していないが、あと数カ月で完了する予定である。バイオマスのガス化における好適な粘土触媒は計画どおり確認された。バイオマス前処理システムの開発は概ね完了しており、ガス化残渣の肥料化については一部試験が実施中ではあるが、技術は概ね確立されている。一方、チャー抜出機構の開発については EFB の粉砕物をガス化原料とすることが決定したため中止された。また、タール除去の技術については基礎研究が行われるとともに、炉内粘土触媒でのタール除去の性能が比較的高いことがラボスケールの実験で明らかとなり、ガス化炉後段におけるタール除去装置は炉内タール除去を用いる場合は不要であることが確認された。

アウトプット 2 の液体燃料生産システムの開発については、低コストのメタノール合成触

媒が特定され、今後メタノール合成試験がさらに実施される必要があるが、小規模メタノール合成プロトタイプ（1 号機 2 号機）が開発された。ガス発酵によるエタノール合成プロセスについては、基礎実験が実施され、フィージビリティスタディーのための実験結果が蓄積された。
アウトプット 3 については、指標は概ね達成しており、人材育成・ネットワーク形成の観点から将来のバイオマス廃棄物のエネルギー利用の促進に貢献したと考えられる。

(2) アウトプットの達成度に影響を及ぼした要因

- 2017 年 7 月のプロジェクト計画の大幅な修正はプロジェクトの方向性や関係者のプロジェクトの関与にポジティブな変化をもたらし、研究の継続性を高める結果となったが、その一方でパイロットプラントの設計の修正等による時間的ロスが生じたといえる。
- 計画変更後のタイトなスケジュールにも拘らず、日本側インドネシア側双方の関係者が熱心にプロジェクト活動に取り組んだことで、上述のようなアウトプットの達成が可能となった。
- 下記の投入の効率性で述べられているとおり、プラント建設や機材納入等の遅れがプロジェクト終了時点での達成状況に影響をおよぼした。

(3) 投入の有効性（質・量・タイミング）

- プロジェクトの実施過程で述べたとおり、パイロットプラントの調達の手続きに時間を要したことにより、一部の活動がプロジェクト期間内に完了しなかった。
- 機材調達の遅れが一部の活動の進捗にネガティブな影響を及ぼした。
- プラントの建設等、インドネシア国内の現地リソースを積極的に活用したことがコスト削減にも繋がった。
- 計画内容の変更により実施体制や人材配置の変更が生じたが、変更後は概ね変更内容に基づいた人員配置が行われた。一方、日本側の専門家の投入について、全体としては計画通りの投入量であったが、液体燃料生産システムの活動ではインドネシア側カウンターパートの期待よりも少ない結果となった。
- 計画内容の変更に伴い、YDD に設置したコールドモデルは計画変更後プロジェクトでは活用されないこととなった。しかし、計画変更以前にコールドモデルを用いて行われた実験から得られた結果については、その後も YDD が独自で継続している研究活動に利用されている。

6.4. インパクト

本プロジェクトのインパクトは比較的高いと判断される。

(1) 上位目標の達成見込み

上位目標である「現地に適合的な、バイオマス廃棄物の流動接触分解ガス化と液体燃料生産システムが普及する（Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is diffused[11]）」については、その指標として「事業終了後 4 年以内に 1 基以上のプラントが設置・運転されることが検討される（Within 4 years from the project completion, at least one plant using established technology are considered to be constructed and operated[12]）」が挙げられている。

バイオマス廃棄物のガス化については、以下の点から上記指標の達成見込みは高いと考えられる。

- BPPT は本プロジェクトの研究の継続予算として 2019 年度は 20 億ルピア（約 1,524 万円[13]）を政府予算から確保しており、今年度中にパイロットプラントの最適化に取り組むことを明言している。予算配置からも明らかなように、BPPT 内のみならず、エネルギー省、産業省、国会などでバイオマス廃棄物ガス化の技術への期待が高い状況にある。
- BPPT は今年度中にパイロットプラントの最適化を実施した後、BPPT と群馬大学によるライセンス取得により実装を目指すことを計画している。それに向けて産業省等と既に商業化に向けた連携を始めている。
- 新たに JST によるビジネス化支援プログラムである「SDGs の達成に向けた共創的研究開発プログラム」に採択され、当該ガス化プロセスによる EFB のエネルギー化ビジネスプランの策定を始めている。当該プロセスは EFB の粗粉砕物を原料としており、プランテーションサイトで運用すればペレットを原料とした場合に比べて大幅に低い原料調達コストで運転でき、事業性が高いことが見込まれている。このプログラムでは、インドネシア、マレーシア、日本の複数の企業とアライアンスを組み、廃棄物の高付加価値化による収入源の多様化等、どのような事業オプションがあるか検討が進められている。
- 当該ガス化炉の実用化コストは計装の単純化等により今後削減の余地が大きいこと、また EFB の前処理装置は 40 万円と安価であり消費動力についてもペレット化に比べて大幅に低コストであることから、費用対効果の高いプロセスであり、将来普及できる可能性が高いと見込まれている。
- 一方、EFB の前処理については、EFB の初期形状および含水率により粉砕効率が大きく影響を受けるという課題があり、EFB の管理、投入方法を確立することが必要とされている。

[11] PDM 第 2 版に記載の原文
[12] 同上
[13] 2019 年 6 月の JICA 統制レート、1 インドネシアルピア＝0.007620 円で換算（1,000 円以下四捨五入）。

- パーム油の規制に関連して、近年プランテーション側の本研究の技術へのニーズが高まっており、企業の関心も高いことから、研究結果が実用化できることが示せれば投資の対象となる可能性が高い状況にある。

他方、液体燃料の生産に関してはガス化と比べて商業化・実用化への道のりは長いく、事業終了後 4 年以内の生産システムの設置・運転は難しいと考えられるが、インドネシア国内でも当該技術への関心は高く、研究は将来的に継続することが期待できる。

(2) その他の波及効果

- パルス操作ループシール機構（Pulse Operated Loop Seal: POLS）について、群馬大学は研究成果に基づいた特許申請を完了し、現在 BPPT がインドネシアでの特許申請を検討している。その他、この研究に関連した技術等の特許化について BPPT と群馬大学で検討を進めている。
- ジョクジャカルタのジャナバドゥラ大学の研究者が、バイオマスの流動層ガス化技術に関心を持ち、自分たちも研究を始めたいとの申し入れがあった。このため、本プロジェクトでは流動層技術のワークショップを実施し、研究開始を支援した。また、本プロジェクト開始前に使用していた流動層コールドモデルを譲り渡す、プラントの設計ワークショップに招待するなどの支援も提供し、インドネシア国内の研究拡大に貢献するようなネットワークの構築に繋がる結果となった。
- SATREPS の推薦枠による文部科学省の奨学金制度を活用し、BPPT の研究者 1 名が群馬大学の博士課程でバイオマスのガス化の研究に取り組んでいる。
- BPPT はこれまで独自の研究でタール除去技術を開発しており、それらの技術に本プロジェクトで開発された技術を合わせることで、今後の研究での相乗効果が期待できる。

6.5. 持続性

本プロジェクトの持続性は高いと判断される。

(1) 政策・制度面

インドネシア政府の代替エネルギーの電力利用に関する政策は今後も継続することが見込まれる。また、エネルギー鉱物省、産業省等のバイオマス廃棄物のエネルギー利用への関心も高く、良い結果を示すことで更なる政策的支援が期待できる状況にある。

(2) 組織・財政面

- BPPT は本プロジェクトの研究について、組織の目的である海外等からの技術の国内での適用の促進に合致した本来取り組むべき研究として評価している。本プロジェクト

の研究内容については将来的に社会的要請が見込まれることから、BPPT のモチベーションも高く、研究を継続していく意欲がある。また、本プロジェクトの技術をビジネスに繋げていくことを目指している。

- BPPT の研究体制は十分に整備されており、本プロジェクトの研究の継続に必要な人材もそろっている。
- BPPT は独自の研究予算を有しており、研究の進展状況によって理事会により予算配分が決定される。2019 年度はパイロットプラントでの研究活動を継続するための予算として 20 億ルピア（約 1,524 万円）が確保されている。前年度と比較しても大きな予算配置から、ガス化炉の開発への期待が表れている。また、メタノール合成については、汎用性の高いプロトタイプ試験装置が設置され、継続的な研究開発のための予算獲得に向けて準備を進めている。独自予算以外にもインドネシア教育基金（LPDP）やインドネシアパーム油資産基金（BPDP）などの様々な外部機関から研究資金を獲得できる可能性がある。
- ガス発酵エタノール合成については、ITB が研究継続の意思を示している。研究予算については、本研究が革新的で社会的要請のある技術であることから、政府および民間の資金を獲得できる可能性が高いと考えられている。

(3) 技術面

- インドネシア側は研究の継続には日本側からの技術的サポートをまだ必要としているものの、技術開発を実施するために必要な能力は有している。
- プロジェクトが供与した機材については現地で調達したものが多く、維持管理における技術的問題は無いと想定されている。また、それらの機材のランニングコストはそれほどかからないと考えられている。

7 提言と教訓

(1) 提言

- 本プロジェクトの枠組みにおいて計画されていた活動でプロジェクト期間内に十分に完了していないものについては、今後 BPPT が確実に実施し、現時点で予定されている期間内に完了することが求められる。
- ガス化炉については商業化の期待も高く、研究継続に向けた予算配置がなされているが、液体燃料の開発についても BPPT 及び ITB は予算確保に努め、研究を継続することが期待される。

(2) 教訓

- プラントの建設に係る免税措置の手続き等については、事前に関係者間で対応策を検討し合意することで遅れや不都合が生じないよう努めることが求められる。SATREPS

事業では相手国における免税資格を有していない日本の研究機関がしばしば機材調達を行うことを考慮しておく必要がある。

- 本プロジェクトではプロジェクト期間の途中段階で生じた問題に対応するため、関係機関で十分に協議し変更内容に日本側・インドネシア側の各機関が合意した上で軌道修正がなされた結果、インドネシア側の主体的な関与が強まり、プロジェクト終了後の持続性が高まると共に、修正後の目標を概ね達成することができた。相手国パートナー機関のプロジェクトに対するオーナーシップを醸成することは日本の研究機関にとって非常に重要であり、特に SATREPS 事業において研究活動の持続性を確かなものとするためには不可欠である。

MINUTES OF MEETINGS
OF
THE JOINT TERMINAL EVALUATION
ON
PROJECT FOR DEVELOPMENT OF A MODEL SYSTEM FOR FLUIDIZED BED CATALYTIC GASIFICATION OF BIOMASS WASTES AND FOLLOWING LIQUID FUEL PRODUCTION IN INDONESIA

The Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the mission led by Dr. Toru Kobayakawa, Senior Director (Energy), Industrial Development and Public Policy Department from June 18th to 26th, 2019 for Joint Terminal Evaluation on Project for Development of a Model System for Fluidized Bed Catalytic Gasification of Biomass Wastes and Following Liquid Fuel Production in Indonesia (hereinafter referred to as "the Project"). The joint terminal evaluation was conducted with the members of Joint Coordination Committee (hereinafter referred to as "JCC") consisting of Agency for the Assessment and Application of Technology (hereinafter referred to as "BPPT"), Bandung Institute of Technology (hereinafter referred to as "ITB") and JICA Expert Team.

As a result of discussions, both Japanese and Indonesian sides confirmed the contents of the terminal evaluation report referred to in the document annexed hereto.

Jakarta, June 26th, 2019

Dr. Toru Kobayakawa
Senior Director (Energy)
Industrial Development and Public Policy Department
Japan International Cooperation Agency (JICA)

Dr. Ir. Hens Saputra, M. Eng.
Director
Center for Energy Resources Technology and the Chemical Industry (PTSEIK)
Agency for the Assessment and Application of Technology (BPPT)

Main Points Discussed

1. The Joint Terminal Evaluation Report (hereinafter referred to as "the Report") was jointly prepared and both Japanese and Indonesian sides confirmed the contents as described in Attachment.

2. The equipment procured under the project was handed over to BPPT from JICA Expert Team on May 29th, 2019. Both sides confirmed that BPPT is responsible for the equipment and shall operate and maintain properly securing the necessary budget to make the project outcome sustainable. The equipment handed over to BPPT is listed in Annex 4 of Attachment. If BPPT handover the equipment to other counterpart agencies, BPPT shall document it and inform JICA accordingly.

3. Both sides confirmed the sustainability of research activities. For the research activities that are planned under this project but not fully completed before the end of the Project period, it is necessary for BPPT to continue them firmly and produce results within the expected timeframe. While the expectation for commercialization of gasifier is high and the budget is allocated for the continuation of research, as to the liquid fuel production, it is expected that BPPT and ITB would make an effort to obtain sufficient research budget and continue research and development.

4. In general, JICA conducts the ex-post evaluation after 3 years. Both sides agreed to continue their efforts to continue researches on the biomass gasification and liquid fuel production in practice even after the project termination towards the ex-post evaluation.

Attachment: The Joint Terminal Evaluation Report

Attachment:

THE JOINT TERMINAL EVALUATION REPORT
ON
THE JAPANESE TECHNICAL COOPERATION (SATREPS)
FOR
PROJECT FOR DEVELOPMENT OF A MODEL SYSTEM FOR FLUIDIZED BED CATALYTIC GASIFICATION OF BIOMASS WASTES AND FOLLOWING LIQUID FUEL PRODUCTION IN INDONESIA

Japan International Cooperation Agency (JICA)
and
Agency for the Assessment and Application of Technology (BPPT)

Jakarta

June 26, 2019

CONTENTS

(3) Installed Equipment by Counterpart's Budget

Annex 6: Comparative Table between PDM Version 1 and Version 2

Annex 7: List of Seminars, Workshops and Trainings

Abbreviations

APEX	Asia People's Exchange
BPDP	Indonesian Palm Oil Mill Management Agency Fund
BPPT	Agency for the Assessment and Application of Technology
C/P	Counterpart Personnel
DAC	Development Assistance Committee
EPC	Engineering Procurement Construction
EFB	Empty Fruit Bunches of Oil Palm
FY	Fiscal Year
GHG	Greenhouse Gas
GOI	Government of Republic of Indonesia
GOJ	Government of Japan
GU	Gunma University
ITB	Bandung Institute of Technology
JCC	Joint Coordinating Committee
JICA	Japan International Cooperation Agency
JST	Japan Science and Technology Agency
LPDP	Indonesian Education Fund
MEMR	Ministry of Energy and Mineral Resources
M/M	Minutes of Meeting
MOU	Memorandum of Understanding
NEP	National Energy Policy
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
PDM	Project Design Matrix
PO	Plan of Operations
PUSPIPTEK	Pusat Penelitian Ilmu Pengetahuan dan Teknologi
R/D	Record of Discussion
RISTEKDIKTI	Kementerian Riset Teknologi Dan Pendidikan Tinggi
RISTEK	Kementerian Riset Dan Teknologi
SATREPS	Science and Technology Research Partnership for Sustainable Development
YDD	Yayasan Dian Desa

1. Outline of the Terminal Evaluation

1-1. Background

Based on the Record of Discussion (R/D) on the Project for Development of a Model System for Fluidized Bed Catalytic Gasification of Biomass Wastes and Following Liquid Fuel Production in Indonesia (hereinafter referred to as "the Project") signed on February 25, 2014, the Project started in June 2014 for the purpose of establishment of fluidized bed catalytic gasification of biomass wastes and following liquid fuel production system and preparation of bases for the diffusion by Japanese Experts from Gunma University and Indonesia counterparts from Agency for the Assessment and Application of Technology (hereinafter referred to as "BPPT"), Bandung Institute of Technology (hereinafter referred to as "ITB"), Yayasan Dian Desa (hereinafter referred to as "YDD") with the support of Japan International Cooperation Agency (hereinafter referred to as "JICA") and Japan Science and Technology Agency (hereinafter referred to as "JST") under the Science and Technology Research Partnership for Sustainable Development ((hereinafter referred to as "SATREPS") scheme.

The Project completed on June 12, 2019, five years from the commencement. Since the Project has reached the end of the implementation period, JICA has determined to conduct a Terminal Evaluation for the purpose of assessing the achievements of activities of the Project, evaluating them in terms of five criteria, and giving recommendations for future activities.

1-2. Objectives of the Terminal Evaluation

The objectives of the Terminal Evaluation are:

(1) To evaluate the performance, achievement and implementation of the process of the Project;

(2) To conduct comprehensive evaluation of the activities and achievement of the Project in accordance with the five evaluation criteria, namely relevance, effectiveness, efficiency, impact, and sustainability, as described in Table 2-1;

(3) To draw up recommendations for further improvement of the Project after the implementation period; and

(4) To prepare a Joint Evaluation Report (hereinafter referred to as "the Report").

1-3. Members of the Terminal Evaluation

(1) Indonesian side

Name	Position	Organization

Dr. Ir. Hens Saputra M. Eng.	Director of Center for Energy Resources Technology and the Chemical Industry (PTSEIK)	BPPT
Dr. S.D Sumbogo Murti, M. Eng	Senior Researcher	BPPT
Dr. Dipl.-Ing. Muhammad Abdul Kholiq, MSc.	Head of Program and Budget Division of PTSEIK	BPPT
Dr. Joni Prasetyo	Senior Researcher	BPPT
Dr. Ir. Erlan Rosyadi, M.Eng.	Senior Researcher	BPPT
Mr. Ir. Trisaksono Bagus, MT	Senior Researcher	BPPT
Ms. Arfiana	Researcher	BPPT
Ms. Fusia Mirda Yanti, Ssi, Msi	Researcher	BPPT
Ms. Astri Pertiwi, ST, MT	Researcher	BPPT
Prof. Tjandra Setiadi	Professor	ITB
Dr. Ronny Purwadi	Associate Professor	ITB
Dr. Made Tri Ari Penia Kresnowati	Researcher	ITB
Mr. Guntur Adisurya Ismail S.T.	Researcher	ITB
Ms. Keryanti S.T, M.T.	Researcher	ITB

(2) Japanese side

Name	Mission Responsibility / Position	Organization
Dr. Toru Kobayakawa	Leader	Energy and Mining Group, Industrial Development and Public Policy Department, JICA
Ms. Kuri Shibata	Cooperation Planning	Program Officer, Team 1, Energy and Mining Group, Industrial Development and Public Policy Department, JICA
Ms. Yuki Ohashi	Consultant (Evaluation)	Tekizaitekisho LLC
Prof. Atsushi Tsutsumi	Project Professor	University of Tokyo
Dr. Keisuke Kosaka	Senior Associate	JST

	Research Supervisor	
Prof. Reiji Noda	Associate Professor	Gunma University
Ms. Chiaki Fukuda	Coordinator	-

1-4. Schedule of the Terminal Evaluation

No.	Date		Activity	Place
1	18-Jun	Tue	(Arrival in Jakarta, Indonesia)	Jakarta
2	19-Jun	Wed	AM: Meeting at JICA Indonesia Office PM: Site visit and meeting with CPs at BPPT	Jakarta → Serpong
3	20-Jun	Thu	Meeting with CPs at BPPT (After the meeting, move to Bandung)	Serpong → Bandung
4	21-Jun	Fri	Meeting with Bandung Institute of Technology (ITB) (After the meeting, transfer to Jakarta)	Bandung → Jakarta
5	22-Jun	Sat	AM: Internal Meeting PM: Preparation	Jakarta
6	23-Jun	Sun	AM: Internal Meeting PM: Preparation (transfer to Yogyakarta)	Jakarta → Yogyakarta
7	24-Jun	Mon	AM: Meeting and Site Visit at Dian Desa Foundation (YDD) (After the meeting, transfer to Jakarta)	Yogyakarta → Serpong
8	25-Jun	Tue	Meeting with CPs on Terminal Evaluation at BPPT	Serpong
9	26-Jun	Wed	Report to JICA Office (Departure)	Serpong → Jakarta
10	27-Jun	Thu	(Arrival in Japan)	-

2. Outline of the Project

2-1 Background of the Project

Since the recent economic growth of Indonesia is accompanied by rapid increase of energy consumption as well as greenhouse gas (GHG) emissions, the Government of Republic of Indonesia (hereinafter referred to as "GOI") has set its target to enhance the share of new and renewable energy in national energy resource. In this context, Indonesia has strong commitments to utilize its huge potential of biomass energy, especially biomass wastes of which potential is more than half of the total primary energy consumption of the country.

However, actual utilization of biomass wastes has been limited partly due to lack of economically and technologically feasible process. With the aforementioned background, the GOI has requested the Government of Japan (hereinafter referred to as "GOJ") for the "Science and Technology Research Partnership for Sustainable Development" (hereinafter

referred to as "SATREPS") Project to develop a model system appropriate to Indonesian conditions for gasification of biomass wastes and following liquid fuel production..

2-2 Summary of the Project

<Project Title>

Project for Development of a Model System for Fluidized Bed Catalytic Gasification of Biomass Wastes and Following Liquid Fuel Production in Indonesia

<Project Period>

June 13, 2014 – June 12, 2019

<Implementation Organization>

Indonesian side:

Agency for the Assessment and Application of Technology (hereinafter referred to as "BPPT")

Light of the Village Foundation (Yayasan Dian Desa: hereinafter referred to as "YDD")

Bandung Institute of Technology (hereinafter referred to as "ITB"),

Japanese side:

Gunma University

<Target Area> Whole country of Indonesia

<Target Group> Researchers of BPPT, Experts/Researchers of YDD and Researchers of ITB

<Narrative Summary>

Overall Goal:

Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is diffused.

Project Purpose :

Fluidized bed catalytic gasification of biomass wastes and following liquid fuel production system that is socially and economically appropriate for Indonesia is established and bases for the diffusion are prepared.

Output :

1) Establishment of fluidized bed biomass gasification process with tar treatment technology.
2) Development of liquid fuel production system.

3) Development of human resources related to implementation of the developed system and establishment of network for promoting biomass energy utilization.

3. Methods of the Evaluation

The Terminal Evaluation was conducted based on the methodology of Project Cycle Management (PCM), in accordance with the "New JICA Guideline for Project Evaluation (June 2010)", which mainly follows the "Principles for Evaluation of Development Assistance, 1991" issued by Development Assistance Committee of Organization for Economic Cooperation and Development (OECD-DAC).

(1) Achievement and Implementation process of the Project

The achievement of the project, including input, project purpose, and outputs, was reviewed based on the current Project Design Matrix (PDM) (version 2) revised in November 2017 and Plan of Operation (PO) modified in July 2018. The implementation process of the project, such as management and operation structure, communication among the members of the Project, means of technical transfer, etc. was also assessed.

(2) The Five Evaluation Criteria

The overall project was also analyzed using the five evaluation criteria, i.e. relevance, effectiveness, efficiency, impact and sustainability. Each criterion is rated on a five-point scale, which are "high", "relatively high", "medium", "lower-medium" and "low".

Table 2-1: Criteria of the Evaluation

Relevance	Degree of compatibility between the development assistance and priority of policy of the target group, the recipient, and the donor.
Effectiveness	A measure of the extent to which an aid activity attains its objectives.
Efficiency	Efficiency measures the outputs -- qualitative and quantitative – in relation to the inputs. It is an economic term which is used to assess the extent to which aid uses the least costly resources possible in order to achieve the desired results. This generally requires comparing alternative approaches to achieving the same outputs, to see whether the most efficient process has been adopted.
Impact	The positive and negative changes produced by a development intervention, directly or indirectly, intended or unintended. This involves the main impacts and effects resulting from the activity on the local social, economic, environmental and other development indicators.

Sustainability	Sustainability is concerned with measuring whether the benefits of an activity are likely to continue after donor funding has been withdrawn. Projects need to be environmentally as well as financially sustainable.

Source: New JICA Guidelines for Project Evaluation (2010)

(3) Information and data collection

The data and information necessary for the Evaluation were gathered by the following methods.

Table 2-2: Data Collection Methods and Sources

Methods	Sources
Document Review	• Ex-ante Evaluation Report • Monthly Reports • Mid-term Evaluation Report • JST Final Report April 2019 and other related reports
Questionnaire	• Japanese implementing institution • Indonesian counterpart institutions (BPPT, YDD, and ITB)
Interview	• Japanese implementing institution • Indonesian counterpart institutions (BPPT, YDD, and ITB) • RISTEKDIKTI • JICA Indonesia Office
Site visit	• PUSPIPTEK • ITB • YDD

(4) Joint Evaluation

The Evaluation was conducted jointly by Indonesian and Japanese evaluation teams. The evaluation activities including report analysis and interview were carried out by both sides.

4. Assessment of Project Performance

4-1 Results of Input

(1) Input from Japanese side

1) Experts

3 experts from Gunma University visited Indonesia frequently on a short-term basis to carry out project activities from the beginning to the end of project period, and another expert of Gunma University was assigned from July 2017 according to the revision of the project plan

that time, till the end of the project period. Also, 4 experts from APEX were allocated on a short-term basis from the beginning of the project, up to in June 2017. Apart from these technical experts, a long-term expert in project coordination was allocated from August 2015 till the end of the project period. The details of the assignment of experts are shown in the Annex 4: List of Inputs (Japanese side), (1) Dispatch of Japanese Experts.

2) Training in Japan

16 staff members in total of BPPT were trained at Gunma University in Japan for 2 to 3 months. The details of training in Japan are shown in the Annex 4: List of Inputs (Japanese side), (2) Training in Japan.

3) Equipment

Machineries and equipment of a total value equivalent to approximately 100 million Yen have been provided for the Project activities. The details of provided equipment are shown in the Annex 4: List of Inputs (Japanese side), (3) Installed equipment by JICA's budget.

4) Cost of project activities

A total amount of 3,659,765,062 rupiahs in total was provided for the local expenditure of the Project as shown in the Table 3-1. The details of expenditures are shown in the Annex 4: List of Inputs (Japanese side), (4) JICA's Overseas Activity Cost.

Table 3-1: Local cost provided by JICA

Japanese Fiscal Year (JFY) (April-March)	Amount of expenses (Indonesian Rp.)
2014	136,145,863
2015	326,619,830
2016	490,159,343
2017	1,048,572,475
2018	1,044,462,995
2019	613,795,556
Total	3,659,765,062

(2) Input from Indonesian side

1) Assignment of Counterparts

During the project period, 54 counterpart personnel of BPPT in total were assigned to the Project. Also, 2 staff members of YDD involved in the project activities from the commencement of the Project up to June 2017 practically, and 6 researchers of ITB in total

were allocated from December 2016 till the end of the project period. The details are shown in the Annex 5: List of Inputs (Indonesian side), (1) List of Indonesian Counterparts.

2) Cost of project activities

A total amount of 878,480,000 rupiahs was contributed by BPPT, as shown in the Table 3-2.

Table 3-2: Project cost provided by BPPT

Japanese Fiscal Year (JFY) (April-March)	Amount of expenses (Indonesian Rp.)
2014	47,000,000
2015	105,705,000
2016	330.000.000
2017	150.000.000
2018	200.000.000
2019*	45,775,000
Total	878,480,000

* until the end of project period (June 12th, 2019)

Also ITB contributed 346,800,000 rupiahs in total, since its involvement from December 2016, as shown in the Table 3-3.

Table 3-3: Project cost provided by ITB

Japanese Fiscal Year (JFY) (April-March)	Amount of expenses (Indonesian Rp.)
2017	173,500,000
2018	148,400,000
2019	24,900,000
Total	346,800,000

In addition, YDD contributed about 5,760,000 rupiahs in 2016 for the project activities.

3) Equipment

BPPT provided equipment of 432,241,900 rupiahs in total for project activities, ITB also provided equipment for a total of 182,144,900 rupiahs. The details of provided equipment are shown in the Annex 5: List of Inputs (Indonesian side), (3) Installed Equipment by Counterpart's Budget.

In addition, an office space and an operation room in BPPT/PUSPIPTEK for the Project Coordinator and visiting Japanese Experts, and spaces for installing the machinery and equipment have also been provided by the Indonesian side.

4-2 Achievement of Outputs

(1) Output 1: Establishment of fluidized bed biomass gasification process with tar treatment technology.

The achievement of indicators for Output 1 is as described below.

Table 3-4: Achievement of indicators for Output 1

	Indicators	Achievement
1	Stable operation of fluidized bed gasifier is demonstrated.	Mostly achieved. The pulse controlled loop seal was developed by the Project, and its scaling up procedure has been tested and confirmed by the cold model which has the same scale with the demonstration pilot plant. A demonstration of the pulse controlled loop seal will be confirmed by the pilot plant within a few month period.
2	The most active catalyst is identified among at least five kinds of clay catalysts.	Achieved. 12 samples of clay products in Indonesia were collected and evaluated. 3 clay products were identified as suitable catalysts for tar removal for biomass gasification. It was also found that total acid amounts are the most important properties for tar removal.
3	Char drawing system is demonstrated.	- A concept of char drawing system was developed. However, an application of fibrous EFB (Empty Fruit Bunch of Oil Palm) for gasification as feedstock was decided as a result of the establishment of biomass pretreatment system (activities 1-4), so that cold model experiments in Yogyakarta were discontinued in FY2018, and the application of char drawing / circulation mechanism to the pilot plant was also canceled.
4	Proper biomass pretreatment system is established.	Mostly achieved. The advantage and disadvantage of various pretreatment processes of EFB were evaluated, and pulverization by a cutter mill was judged to be effective. A prototype for EBF pulverization by

		cutter mill was fabricated and achieved production of the targeted size of fibers (1 to 2cm). The processing speed was almost reached to the expected one. A modification of cutter configuration of the mill was found to improve the processing speed, and it is planned to be done in 2 to 3 months.
5	Technology for utilization of gasification residue as fertilizer is developed.	Mostly achieved. As a result of analysis of the gasification residue, it was confirmed that main component of nutrients in char and ash of EFB was potassium, so that it is effective to mix with phosphorus and nitrogen materials for fertilizer production. Several recipes of fertilizer mixing with the char and the ash obtained from EFB samples were applied for growth testing. It was revealed that the char-mixed fertilizer was better than commercial fertilizer. Economic benefit by application of char residue was also evaluated to able to reduce 30 % of the production costs. The ash mixed recipe is still in progress of growth testing at the end of project period, and it will be completed within 20 days. The demonstration of large scale fertilizer production by an application of the residue obtained by the pilot plant will be conducted after the pilot plant is continuously operated. BPPT will realize it in larger scale and identify the performance of developed fertilizer.
6	Pilot plant is successfully operated.	Mostly achieved. The basic design of 50kW pilot plant was developed jointly by Gunma University and BPPT, and the design was finalized by a selected EPC company. The completion of the pilot plant was delayed in May 2019, due to the delay of about three months from tax exemption procedures and about one month from construction delay. At the end of the project period, a trial run is underway for safety operation under specified operation conditions. It is expected to achieve continuous operation in the next one to two months.
7	Tar treatment technology is developed.	Partly achieved. 3 different tar removal technologies have been considered: 1) tar trapping by clay particles, 2) catalytic cracking of tar, 3) tar reforming by using biomass ash as a catalyst. The fundamental study of these technologies has been conducted. In-bed tar removal by an application of clay particles was confirmed by using

		a lab-scale fluidized bed gasifier. The performance of tar removal will be confirmed by the pilot plant. The development of a downstream tar removal devices was included in the Project in July 2017, and conceptual design of several tar cracking/reforming systems was prepared. However, as a result of relatively high tar removal by in-bed clay particles confirmed by the lab-scale experiments, the tar removal device was confirmed to be unnecessary in case of the application of in-bed clay tar removal. In order to improve tar removal performance, BPPT will continue the research subject with its own budget after the project.

(2) Output 2: Development of liquid fuel production system

The achievement of indicators for Output 2 is as described below.

Table 3-5: Achievement of indicators for Output 2

	Indicators	Achievement
1	Sustainable catalyst for Methanol synthesis is developed.	Achieved. More than ten of prototype catalysts were prepared by Gunma University and BPPT, and compared under the same condition by BPPT. An appropriate catalyst with γ -alumina support prepared by impregnation method had the highest methanol yield per cupper contents.
2	Methanol synthesis prototype for small scale application with low cost process is developed.	Achieved. CO2 removal by chemical absorption using alkaline water gas cleaning for methanol synthesis was developed to confirm to remove 90% or more of CO2 from syngas. First prototype of methanol synthesis (Unit 1) was constructed and tested in 2015 to confirm the successful production of methanol from simulated syngas. However, the unit 1 had a narrow variety of experimental conditions and low accuracy and difficulty to improve the process for high methanol concentration. In order to carry out further detailed study, a second prototype (Unit 2) was designed and constructed.

3	Methanol synthesis prototype is tested and evaluated.	Partly achieved. From the result of the test with the unit 1, the operation condition to achieve more than 60% of methanol yield was clarified by using a commercially available catalyst. Methanol synthesis experiments by unit 2 are conducted with a commercially available catalyst to evaluate the methanol synthesis performance. Further methanol synthesis experiments will be conducted by using Unit 2 to analyze the reaction mechanisms with a catalyst prepared by the project.
4	Fundamental research of gas fermentation process is conducted to collect data for feasibility study.	Achieved. A continuous gas fermentation reactor was completed at ITB, and a series of gas fermentation test was conducted. The continuous system was successfully operated to produce ethanol from simulated syngas. The reaction mechanisms and critical points for ethanol production was elucidated together with the results obtained at ITB and Gunma University. Experimental results for feasibility study was accumulated through the activities.

(3) Output 3: Development of human resources related to implementation of the developed system and establishment of network for promoting biomass energy utilization

The achievement of indicators for Output 3 is as described below.

Table 3-6: Achievement of indicators for Output 3

	Indicators	Achievement
1	Local trainings on biomass energy utilization (at least twice) and trainings for operation (at least once) are conducted.	Mostly achieved. ● Local trainings on biomass energy utilization was carried out twice (November 2015 and May 2019). ● Training for those who are interested to the biomass gasification technology such as personnel of national plantation companies, research institutes and private firms was planned. However, it was not realized during the project period due to the delay of construction of the pilot plant. BPPT has an intention to conduct the training and seminars on the pilot plant in the near future.

		● Workshops for design of gasification process were also conducted 4 times in 2016 with 120 participants in total. The details are shown in the Annex 7: List of Seminars, workshops and trainings.
2	More than ten (in total) researchers and students from both Japan and Indonesia are exchanged to conduct research works.	Achieved. 16 Indonesian researchers were trained in Gunma University and conducted research works with Japanese researchers and students in Japan, and 3 Japanese young researchers participated in the research activities in BPPT.
3	International seminars are organized at least twice and attended by more than 200 participants in total.	Achieved. Following international seminars were organized during the project period. - International seminar in "Appropriate Technology for Biomass Derived Fuel Production" in February 2016 - International seminar in "Biomass to Energy" in May 2019
4	More than 10 newsletters are published with more than 750 copies for each.	Achieved. 10 newsletters (issued 750 copies each) were published during the project period.
5	At least ten scientific papers or publications are published.	Achieved. ● 10 scientific papers (2 domestic journals and 8 international journals) were published by Japanese researchers. ● One scientific paper was jointly published by researchers of ITB and Gunma University. ● 15 more scientific papers were prepared by Indonesian side, and presented in international seminars and conferences. Also 6 scientific papers are under preparation.

4-3 Achievement of Project Purpose

As to the Project Purpose "Fluidized bed catalytic gasification of biomass wastes and following liquid fuel production system that is socially and economically appropriate for

Indonesia is established and bases for the diffusion are prepared", the achievement of indicators is described in the Table below.

Table 3-7: Achievement of indicators for Project Purpose

	Indicators	Achievement
1	Pilot plant with capacity up to 50 kW biomass wastes gasification is constructed and operated.	Mostly achieved The construction of a pilot plant with capacity of 50kW was completed in May 2019. At the end of the project period, a standard operation procedure of the plant was prepared, and its safe continuous operation was started-up. It has been confirmed that of the plant is possible. Stable gasification under a long-term operation is expected to be achieved in the next one to two months.
2	Prototype of methanol synthesis is developed.	Mostly achieved The methanol synthesis test with the unit 1 was completed, and methanol synthesis from simulant synthesis gas was confirmed. The unit 2, which allow to conduct further detailed study, was also constructed, and has been used for methanol synthesis experiments applying a candidate catalyst prepared by BPPT to analyze the reaction mechanisms. Further methanol synthesis experiments will be conducted by using Unit 2 to analyze the reaction mechanisms with a catalyst prepared by the project.
3	Potential process of gas fermentation for bioethanol production is identified.	Achieved Based on the results of experiments, the reaction mechanisms and critical points for ethanol production was elucidated, and a potential process of gas fermentation was identified.

5. Implementation Process

(1) Management and operation of the Project

The progress, issues and modifications of plan were discussed and agreed in the meetings of Joint Coordination Committee (JCC), which were held 5 times during the project period. In the Midterm Review of the Project, some issues in the progress of project activities, communication and information sharing among the participating institutions were raised, and

new plan and measures to improve the collaborative research works were discussed among the institutions. The modification of member list, PDM, PO and roles of each institution were agreed by participating institutions in the 4th JCC meeting in July 2017, and since then the Project was operated collaboratively based on the new agreement. The roles of each institution were clearly defined, and the commitment of BPPT was enhanced after the modification, participating in the all tasks for the development of the gasifier.

(2) Communication between Indonesian and Japanese institutions

After the modification of implementation structure and activities mentioned above, the communication and information sharing were enhanced. A Japanese coordinator and an expert who could speak Indonesian language, as well as Indonesian counterpart personnel who could speak Japanese language helped smooth communication between both sides.

(3) Revision of PDM

As mentioned above, the modification of project plan was agreed in the 4th JCC meeting in July 2017. The main points of the modification include the followings;

① The pilot plant was developed to be well suited for application that enables BPPT to continue research even after the end of the project while maintaining the basic structure of the circulating fluidized bed gasification demonstration process using clay as the bed material, which had been developed up to the point. Therefore the design of pilot plant was modified from the concept based on the APEX owned patent to the circulating fluidized bed connected with a general bubbling fluidized, based on a Gunma University owned technology. The site of installation was decided to be PUSPIPTEK, Serpong, where BPPT's research base is located.

② The scale of the pilot plant was reduced from the initial 250kW to 50kW, and its surplus budget was to be used for individual performance tests in biomass pretreatment, particle circulation systems, etc. An appropriate technology for small-scale biomass gasification process in Indonesia was to be established by demonstrating a prototype of elemental technologies for biomass gasification.

③ The thermochemical methanol synthesis process was to be implemented up to bench scale prototype testing with the goal of developing a process compatible with the small scale biomass gasification process.

④ Through fundamental experiments of gas-fermented ethanol synthesis process, data necessary for feasibility study of small-scale biomass gasification was to be collected.

The revised PDM version 2 was agreed in November 2017 in accordance with the decision

made in the 4th JCC meeting. The revision in the version 2 are shown in Annex 6: Comparative Table between PDM Version 1 and Version 2.

(4) Implementation of activities

After the Midterm Review and the modification of the plan, the project activities were implemented based on the new PDM and PO, however, certain delays and changes in the activities were caused by different reasons. The main delays and changes occurred are as described below.

- As mentioned above, the concept of pilot plant was modified. Therefore, some parts of the design had to be modified, and it required more time to prepare basic design. Gunma University and BPPT collaborated in the design process to accelerate the process, based on the external circulating fluidized bed gasification process owned by Gunma University.
- The design of the pilot plant was completed and ready to order in August 2018, however, it took time to coordinate between Gunma University and JICA to place an order to an Indonesian company based on the compliance with the tax exemption arrangement in Indonesia. The order was made at the end of December 2018, delayed by four months. Also the construction was delayed for about 1 month. Due to the delay of the pilot plant, the following activities could not be completed before the Project period.
    - ✧ Demonstration of fertilizer production derived from the residue of the pilot plant
    - ✧ Training for the operation of the pilot plant
- As described in the achievement of Output 1, the development of char drawing system was discontinued as it was decided to use fibrous EFB as feedstock for gasification as a result of the establishment of biomass pretreatment system.
- As described in the achievement of Output 1, the development of tar removal device was determined unnecessary and discontinued as a result of relatively high tar removal by in-bed clay particles confirmed by the lab-scale experiments.
- As described in the achievement of Output 2, the experiments of methanol synthesis with the preferred catalyst by using prototype No.2 was delayed due to the delay in the delivery of gas chromatography for simultaneous analysis of products.

(5) Mutual learning process and enhanced project ownership by BPPT

Regarding the establishment of fluidized bed biomass gasification process, Gunma University worked closely with BPPT by discussing and carrying out research activities collaboratively. Through such co-working process, mutual learning process between both sides was facilitated. As to the designing of pilot plant, after Gunma University presented a

basic concept of gasifier based on the modification, BPPT took the lead in developing the cold model, dealing with errors occurred together. It allowed BPPT to make their own decisions in various occasions for the research works such as designing of hot model etc., although it required relatively longer time to make progress in the activities. These processes contributed to enhance BPPT's contribution and ownership of the Project.

As to the development of liquid fuel production system, the roles of each institution were clearly defined, which also allowed Indonesian researchers to take initiatives in their research activities. While training in Japan was realized effectively to transfer necessary techniques for their research activities undertaken by Indonesian researchers, they consider that more frequent and deeper discussion with the Japanese experts could have accelerated their researches.

6. Results of the Terminal Evaluation

6.1. Relevance

Relevance of the Project is assessed as "high", considering the following points.

(1) Relevance to the policies and strategies of Indonesian Government

Transition of energy source from petroleum to others is still a continuing challenge of Indonesia as of today. The National Energy Plan in February 2014 (NEP14), which sets out the ambition to transform the energy mix by 2025 as follows: 30% coal, 22% oil, 23% renewable resources and 25% natural gas, is still the current policy of Indonesian Government. Therefore, the Project, which aims to develop manufacturing technology of catalytic gasification of biomass wastes and production of liquid fuel and to verify the feasibility of the technology to be applicable to socio-economic and technological conditions in Indonesia, remains highly relevant to the energy policy of Indonesian Government.

(2) Relevance to the needs of Indonesian society

- Biomass waste, which is the material of the gasification of this project, is abundant in Indonesia and has an advantage of being uncompetitive with other needs unlike the raw material of bioethanol. However, despite its high potential, utilization technologies applicable to Indonesia's economic and technical conditions has not been developed yet.
- In Indonesia more than 50% of methanol, which is required for biodiesel production, relies on imports, and the only Indonesian methanol producer is manufacturing methanol from natural gas, which is also the target energy source to be increased in the energy policy goal. Therefore, bio-methanol production is considered to contribute to the biodiesel production in Indonesia.

- EFB used as raw material in this project is abundant in farm plantation of islands, such as Sumatra and Kalimantan where electrification rate is relatively lower than Java. Low cost and easy power generation by the gasification technology of EFB, which is to be established in this project, can contribute to the improvement of power access in such islands.

(3) Relevance to the Japanese ODA policy

In the current Japan's Development Cooperation Policy for the Republic of Indonesia (September 2017), "Assistance for capacity building to address the challenges facing Asia and the international community" is raised as one of the prioritized areas for Japanese cooperation in Indonesia. The Project is considered as one of the projects to contribute to the challenges, which include climate change and environmental conservation.

(4) Appropriateness of the project's approach

- Energy conversion of biomass waste is a technology that has already been commercialized in Japan, but in order to spread it in Indonesia it requires the development of appropriate technologies that can be used locally. Therefore, this project has been undertaken with special attention to the following points: (i) to develop "appropriate" production process of gasification and liquid fuel, which is relatively easy to install, operate and maintain in plantations, collection and processing sites of agricultural and forestry products, etc. in Indonesia, (ii) to enable local engineers to improve the process independently based on their own technology level, (iii) to develop human resources and networks in order to prepare the foundations for diffusion of developed technologies, and (iv) to realize social application of developed technologies.
- In the modification of the plan in JCC in July 2017, a consensus was built between Indonesian and Japanese sides that the main purpose of the project is to develop institutional set-ups of BPPT to be able to continue research and development to commercialize the gasification technologies of EFB even after the project period. As a result, the scale of the experiment and the target were downscaled, however, after the change of the plan, BPPT actively engaged themselves in research and has demonstrated the intention to continue research after the project. In addition, the reduction in size of the pilot plant made it possible to proceed with technology development while testing various options, which is considered possible to accelerate the development of gasification technologies in the future.

6.2. Effectiveness

Effectiveness of the Project is assessed as "relatively high", considering the following aspects.

(1) Achievement of the Project Purpose

As described in the "3.3 Achievement of Project Purpose", the pilot plant with capacity up to 50 kW biomass wastes gasification was constructed and it has been in a process of stating –up the stable operation. The continuous operation is expected to be achieved in the next one to two months (mostly achieved). Prototype of methanol synthesis is also developed, while further experiments are necessary to complete the evaluation of performance (mostly achieved). And the potential process of gas fermentation was identified (achieved).

(2) Causal relationship between Project Purpose and Outputs

The achievement of Project Purpose was directly produced by achieving the Outputs of the Project. In addition, there was no influence of important assumptions stated in the PDM version 2, such as 1) No serious economic recession nor inflation hikes occur in Indonesia, 2) Destructive social unrest such as terrorism, war, or civil strife do not occur in Indonesia, and 3) Destructive natural disaster such as volcano eruption or earthquake do not occur in/around project sites.

6.3. Efficiency

Efficiency of the Project is assessed as "lower-medium", considering the following aspects.

(1) Achievement of the Outputs

As described in the "3.2. Achievement of Outputs", regarding the Output1, although the demonstration of the pulse controlled loop seal developed by the Project is not confirmed by the pilot plant yet, it is expected to be achieved within a few months period. Suitable catalysts for in-bed tar removal by an application of clay particles for biomass gasification were identified. The establishment of biomass pretreatment system was almost completed, and the technology for the utilization of gasification residue as fertilizer was mostly developed, and will be demonstrated by a larger scale fertilizer production after the pilot plant is continuously operated. Meanwhile, development of char drawing system was discontinued because fibrous EFB was decided to be a feedstock for gasification. Also, the fundamental study of tar removal technologies was conducted, while a downstream tar removal devices was confirmed to be unnecessary in case of application of the in-bed clay tar removal. Also, in-bed tar removal by an application of clay particles was confirmed by using a lab-scale fluidized bed gasifier.

For the methanol synthesis process of Output 2, a low cost catalyst for methanol synthesis was identified, and methanol synthesis prototypes (unit 1 and 2) were developed, while further methanol synthesis experiments will be conducted to analyze the reaction mechanisms by using the unit 2. With regard to the gas-fermentation ethanol synthesis process, basic research on the gas-fermentation process has progressed, and experimental results that are necessary for feasibility study have been accumulated through the activities.

As to the Output 3, indicators were mostly achieved, and it is considered the Project contributed to develop human resources and networks for promoting biomass energy utilization.

(2) Factors affected the level of achievement of the Outputs

- Major revisions to the project plan in July 2017 brought about positive changes in project direction and stakeholder involvement, and enhanced the continuity of the research activities even after the Project period, while it caused a certain time loss, due to some additional activities such as the modification of the plant design.
- The dedication of both Indonesian and Japanese members enabled to produce the achievement of the Outputs as much as possible, despite of rather tight schedule after the revision of the project plan.
- As described in the "efficiency of the inputs" below, delays in the construction of pilot plant and delivery of equipment affected the level of achievement at the end of the project period.

(3) Efficiency of the inputs (quality, quantity and timing)

- As mentioned in the implementation process, due to delays in the procedure of procurement for the pilot plant, some activities were not completed at the end of the project period.
- Delays in the procurement of equipment also affected negatively the progress of some activities.
- Indonesian resources were utilized in a positive manner, which contributed to a cost reduction.
- After the revision of project plan, the implementation structure and allocation of human resources were changed, and personnel was allocated in accordance to the modification. Meanwhile, a part of assignment of Japanese expert for liquid fuel production was observed to be less than expected by the Indonesian counterpart.
- After the change of project plan, the cold model installed at YDD did not contribute to

produce the output of the Project directly. However, the results of experiments with the cold model has been utilized by YDD in their own continuing research activities.

6.4. Impact

Impact of the Project is assessed as "relatively high", considering the points described below.

(1) Prospects of achieving the Overall Goal

Regarding the Overall Goal "Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is diffused", the indicator is set as "Within 4 years from the project completion, at least one plant using established technology is considered to be constructed and operated".

In terms of the gasification of biomass wastes, there is a high prospect of achieving the indicator, considering the following related situations.

- BPPT secured governmental budget for the continuity of activities, approximately 2 billion rupiahs in 2019, and it clearly stated that it will work on the optimization of the pilot plant by the end of 2019. The technologies for biomass gasification is highly expected by related ministries such as Ministry of Energy and Mineral Resources and Ministry of Industry, as well as the parliament in Indonesia.
- BPPT has already started coordination with the Ministry of Industry etc. for commercialization, and is planning to optimize the pilot plant during this year. There is a possibility that the ministries will obtain licenses from BPPT and Gunma University for the implementation in the future. .
- JST's commercialization support program, Solution-Driven Co-creative R&D Program for SDGs, has been adopted, and business plan for the energy conversion of EFB by the gasification process is being formulated. This process uses EFB as a raw material, and if it is operated at a plantation site, it can be operated at a much lower raw material procurement cost compared to pellets, and its viability must become high. Alliances have been formed among several companies in Indonesia, Malaysia, and Japan, and studies are being conducted on what business options can be taken for diversification of income sources through adding values to biomass wastes.
- Manufacturing cost of the gasifier for practical use can be reduced largely by simplifying the instrumentation, and it has a large room for reduction in the future. The EFB pretreatment device is inexpensive at around 400,000 yen, and the estimated power consumption for its operation is also significantly lower than that for producing pellets. As such, it can be quite a cost-effective process having potentials for future

dissemination.

- One issue for the pretreatment of EFB is that the initial form and moisture contents of EFB would affect largely crushing efficiency, and therefore, improved methods to control these factors need to be established.
- In relation to the restriction of perm oil, lately the needs of plantation companies for the technologies developed by the Project are increasing, and private firms are also highly interested in. If the possibility of commercialization is demonstrated, it is considered that there is a high probability of being a target of investment.

On the other hand, regarding the liquid fuel production, there is still a relatively long way for commercialization, but interests in the technology in Indonesia are high, and it can be expected that research will be continued toward the future.

(2) Other positive and negative effects of the Project

- The patent of Pulse Operated Loop Seal (POLS) was obtained by Gunma University, and BPPT is also preparing for the application of patent in Indonesia at this moment. BPPT and Gunma University have been examining the possibilities to get patent for other technologies developed by the Project as well.
- Researchers of the University of Janabadra in Yogyakarta are interested in the fluidized bed gasification technology of biomass and approached to the Project in order to start their own research. Therefore, the project supported the university by organizing a workshop on fluid bed technology. The project also supported them by handing over a fluid bed cold model that was used before this project, and also invited them to a plant design workshop, etc. This can be seen as unplanned networking process which may contribute to future expansion of research base in Indonesia.
- One researcher of BPPT has been studying in PhD on biomass gasification at Gunma University since October 2017 under Monbukagakusho scholarship recommended by SATREPS program.
- BPPT owns different types of tar cracking technologies developed by themselves. Tar treatment technology developed by the Project can produce synergy effects by collaborating with these technologies.

6.5. Sustainability

Sustainability is assessed as "high", considering the aspects described below.

(1) Policy and institutional aspects

The policy of increasing alternative energy sources is expected to continue. In addition, the Ministry of Energy and Mineral Resources, the Ministry of Industry, etc. are highly interested in the energy conversion of biomass wastes, and by showing good results, further policy support can be expected.

(2) Organizational and financial aspects

- BPPT has highly appreciated the research under this project as it is consistent with the mandate of the institution, that is, promoting domestic application of technology from overseas. Considering the potential social requirement, BPPT is highly motivated and willing to continue researches that are relevant to the Project. BPPT aims to commercialize the developed technologies in the future.
- BPPT has well organized structure for research and sufficient human resources to continue the research relevant to the Project.
- BPPT has its own research budget, and the budget allocation is decided by its board based on the results and progress of each research. In 2019, the research budget of around 2 billion rupiahs has already been secured to continue the research activities using the pilot plant. The large budget allocation compared to the previous year shows BPPT's high expectation for further development of the gasification technologies. As to the methanol synthesis, a versatile prototype testing device has been installed, and BPPT has been preparing for acquisition of budget to continue research and development. In addition to the governmental budget of BPPT, research funds may be obtained from various external organizations such as the Indonesian Education Fund (LPDP) and the Indonesian Palm Oil Mill Management Agency Fund (BPDP).
- Regarding the gas fermentation process, ITB has indicated its intention to continue research. With regard to research budget, it is considered that there is a high possibility of obtaining government and/or private funds, as this research is considered to be an innovative and socially-required technology.

(3) Technical aspects

- Although the Indonesian side still needs technical support from the Japanese side to continue research, it has the necessary capacity to carry out further activities for technological development.
- The equipment provided by the Project is mostly procured locally, and it is envisaged that there would be no technical problems in maintenance. Also, the running cost of those equipment would not be expensive.

7. Lesson Learned and Recommendation

(1) Recommendation

- For the research activities that are planned under this project but not fully completed before the end of the Project period, it is necessary for BPPT to continue them firmly and produce results within the expected timeframe.
- While the expectation for commercialization of gasifier is high and the budget is allocated for the continuation of research, as to the liquid fuel production, it is expected that BPPT and ITB would make an effort to obtain sufficient research budget and continue research and development.

(2) Lesson Learned

- With regard to the procedures for tax exemptions pertaining to the construction of plants, it is necessary to discuss and agree on the procedures among the stakeholders in advance, in order to avoid delays and inconvenience. For SATREPS project, attention has to be paid to the fact that equipment is often procured by Japanese research institution which is not recognized by partner countries as entitled for tax exemption.
- In this project, in order to deal with problems occurred in the middle of the project period, the original plan was modified in accordance with the close discussions and the mutual agreement of both Indonesian and Japanese institutions. As a result, the participation of Indonesian institutions was increased, the continuity of research after the Project was enhanced, and the revised goals were mostly achieved. Harnessing project ownership of partner research institution would be quite important for Japanese research institution especially for securing sustainability of activities under SATPRES projects.

Annex 1: PDM

PDM（Project Design Matrix）

Version 2: July 2017

Project Title: Project for Development of a Model System for Fluidized Bed Catalytic Gasification of Biomass Wastes and Following Liquid Fuel Production in Indonesia
Project period: June 2014 – June 2019
Country：Indonesia

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal: Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is diffused.	Within 4 years from the project completion, at least one plant using established technology are considered to be constructed and operated.	Design document, feasibility study report, Memorandum of Understanding (MoU) of the project	
Project Purpose： Fluidized bed catalytic gasification of biomass wastes and following liquid fuel production system that is socially and economically appropriate for Indonesia is established and bases for the diffusion are prepared.	Pilot plant with capacity up to 50 kW biomass wastes gasification is constructed and operated. Prototype of methanol synthesis is developed. Potential process of gas fermentation for bioethanol production is identified.	Design documents, field reports; operation logs Study report(s) and/or Scientific Paper(s)	- Energy policy of Indonesian government remains unchanged
Output： 1) Establishment of fluidized bed biomass gasification process with tar treatment technology.	1-1) Stable operation of fluidized bed gasifier is demonstrated. 1-2) The most active catalyst is identified among at least five kinds of clay catalysts.	1-1) Experimental data, plant operation logs 1-2) Experimental and analysis data	- No serious economic recession nor inflation hikes occur in Indonesia - Destructive social unrest such as terrorism, war, or civil strife

	1-3) Char drawing system is demonstrated.	1-3) Experimental data, plant operation logs	do not occur in Indonesia - Destructive natural disaster such as volcano eruption or earthquake do not occur in/around project sites
	1-4) Proper biomass pretreatment system is established.	1-4) Experimental data, design document, plant operation logs	
	1-5) Technology for utilization of gasification residue as fertilizer is developed.	1-5) Experimental data, field test results, design documents	
	1-6) Pilot plant is successfully operated.	1-6) Design documents, field records, operation logs	
	1-7) Tar treatment technology is developed	1-7) Experimental data, design documents, plant operation logs	
2) Development of liquid fuel production system	2-1) Sustainable catalyst for Methanol synthesis is developed.	2-1) Experimental data, quotation table	
	2-2) Methanol synthesis prototype for small scale application with low cost process is developed.	2-2) Experimental data, design documents, operation logs	
	2-3) Methanol synthesis prototype is tested and evaluated.	2-3) Experimental data, design document(s), operation logs	
	2-4) Fundamental research of Gas	2-4) Experimental data	

	fermentation process is conducted to collect data for feasibility study.		
3) Development of human resources related to implementation of the developed system and establishment of network for promoting biomass energy utilization	3-1) Local trainings on ~~for~~ biomass energy utilization (at least twice) and trainings for operation (at least once) are conducted.	3-1) Training records	
	3-2) More than ten (in total) researchers and students from both Japan and Indonesia are exchanged to conduct research works.	3-2) Study report; research report;	
	3-3) International seminars are organized at least twice and attended by more than 200 participants in total.	3-3) Seminar participants' list; proceedings	
	3-4) More than 10 newsletters are published with more than 750 copies for each.	3-4) Newsletters, delivery list	
	3-5) At least ten scientific papers or publications are published.	3-5) Publication list;	
Activities:	**Inputs**		**(Pre-conditions) :**
	Japan	**C/P**	- Counterpart organizations continue to work cooperatively
1) Establishment of fluidized bed biomass gasification process with tar treatment technology.	【Experts】 - Gunma University: 5 persons - APEX: 4 persons	【Counterparts】 - Agency for the Assessment and Application of Technology: 17	
1-1) Establishment of ~~highly~~-stabilized			

fluidized bed technology 1-1-1) Investigation of structure and operational procedure of Pulse Controlled-Loop Seal 1-1-2) Investigation of scaling up procedure 1-1-3) Experiment with pilot scale cold model 1-1-4) Application to pilot plant **1-2) Optimization of clay catalysts** 1-2-1) Collection of clay mineral samples 1-2-2) Evaluation of the catalysts' activities 1-2-3) Physical and chemical analysis of catalyst and elucidation of catalytic mechanism **1-3) Development of char drawing system** 1-3-1) Development of concept for char drawing system 1-3-2) Cold mode testing 1-3-3) Application to pilot plant **1-4) Establishment of biomass pretreatment system** 1-4-1) Development of concept for biomass pretreatment system 1-4-2) Testing prototypes of pretreatment system 1-4-3) Application to pilot plant **1-5) Development of processing system of fertilizer from gasification residue.** 1-5-1) Analysis of residue and evaluation as fertilizer 1-5-2) Development of fertilizer production	- Project Coordinator: 1 person 【Equipment】 - Cold model of fluidized bed - Gasifier pilot plant - Methanol synthesis pilot plant - Methanol synthesis prototype - Gas analyzers - Biomass pretreatment system - Tar cracking device - Catalyst characterization equipments - Bio reactor 【Trainings in Japan】 - 5 trainees x 2 times/year	persons - Light of the Village Foundation: 3 persons - Institute Technology Bandung 5 persons	

process from the residue 1-5-3) Demonstration of fertilizer production 1-5-4) Field test of the fertilizer **1-6) Operation of pilot plant** 1-6-1) Designing of pilot plant 1-6-2) Construction of the pilot plant 1-6-3) Operation of the pilot plant **1-7) Development of tar treatment technology** 1-7-1) Labo scale tar cracking experiment 1-7-2) Design of tar cracking system 1-7-3) Construction of tar cracking system 1-7-4) Operation at pilot plant **2) Development of liquid fuel production system** **2-1) Development of sustainable catalyst for methanol synthesis** 2-1-1) Initial screening of possible catalysts 2-1-2) Elucidation of catalytic mechanism and investigation for activity enhancement 2-1-3) Application to prototype **2-2) Establishment of Methanol synthesis prototype for small scale application with low cost process** 2-2-1) Investigation of raw gas pre-treatment 2-2-2) Prototype designing 2-2-3) Prototype construction and installation			

2-2-4) Prototype operation **2-3) Conduct of fundamental research of gas fermentation process.** 2-3-1) Literature Studies and Design of Experiment 2-3-2) Materials and Strains order 2-3-3) Review Paper Writing 2-3-4) Stock and Seed Culture Preparation 2-3-5) Bacteria cultivation and optimization 2-3-6) Preliminary Study of Fermentation (Bottle Serum) 2-3-7) Optimization in batch reactor 2-3-8) Productivity enhancement in continuous bioreactor using membrane gas-liquid conductor **3) Development of human resources and establishment of biomass energy network** **3-1) Development of human resources** 3-1-1) Implementation of ~~training~~ exchange programs in Japan 3-1-2) Implementation of local training programs **3-2) Establishment of network** 3-2-1) Organization of international seminars 3-2-2) Publishing newsletters			

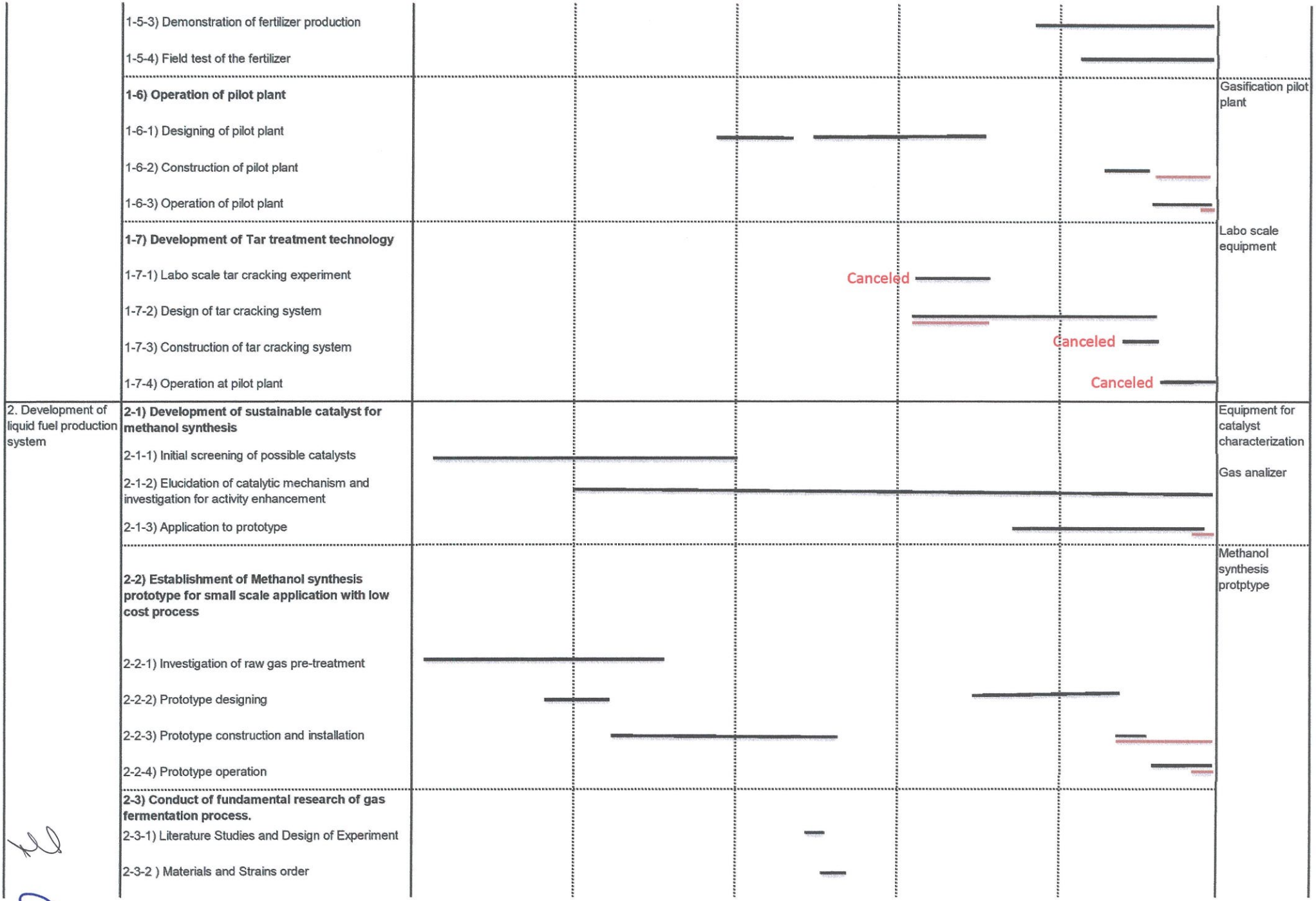
Annex 2: Plan of Operation

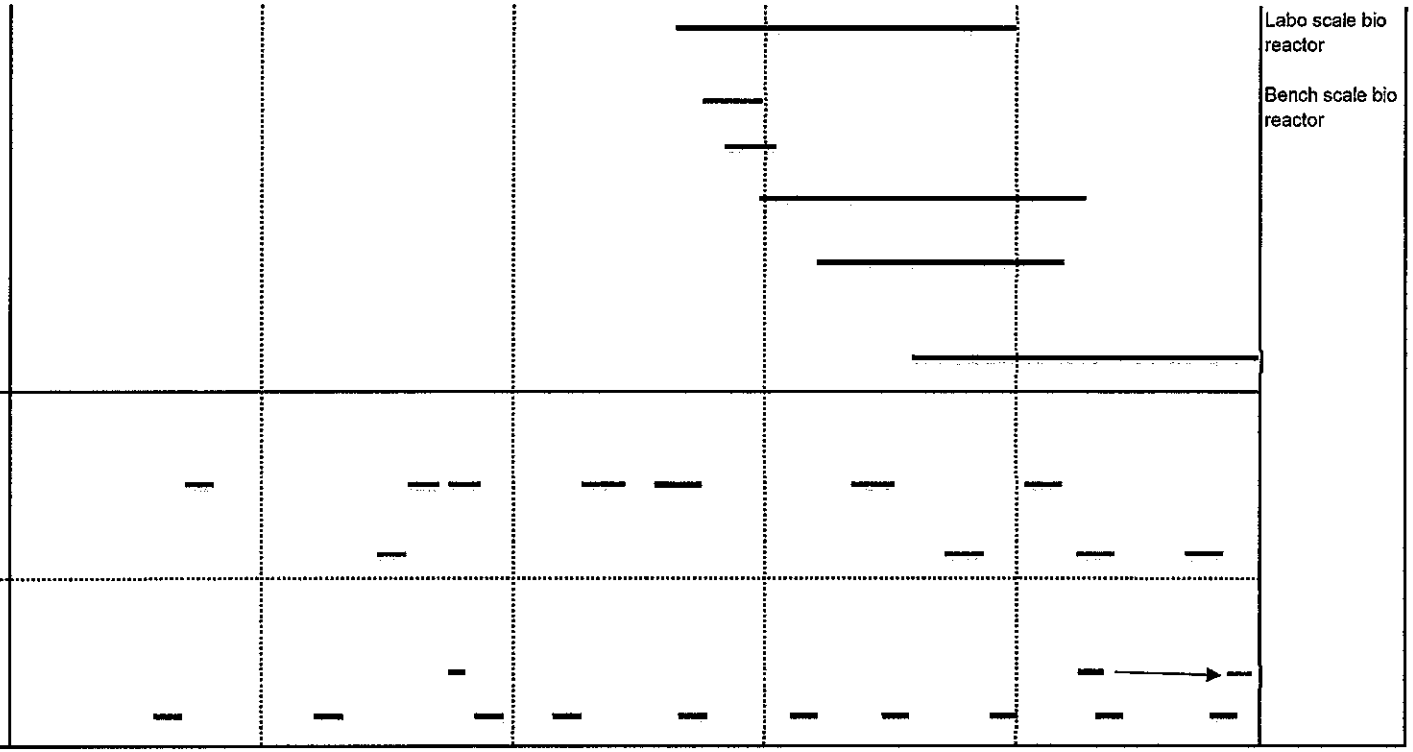
Plan of Operation (PO)

Version 2
July, 2018

Project Purpose	Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is widely diffused.

Output	Activities	1st year 2014/2015	2nd year 2015/2016	3rd year 2016/2017	4th year 2017/2018	5th year 2018/2019	Inputs
		6 7 8 9 10 11 12 1 2 3 4 5	6 7 8 9 10 11 12 1 2 3 4 5	6 7 8 9 10 11 12 1 2 3 4 5	6 7 8 9 10 11 12 1 2 3 4 5	6 7 8 9 10 11 12 1 2 3 4 5	
1. Establishment of fluidized bed biomass gasification process with tar treatment technology	**1-1) Establishment of stable fluidized bed technology**						
	1-1-1) Investigation of structure and operational procedure of Pulse Controlled Loop Seal						
	1-1-2) Investigation of scaling up procedure						
	1-1-3) Experiment with pilot scale cold model						
	1-1-4) Application to pilot plant						
	1-2) Optimization of clay catalyst						
	1-2-1) Collection of clay mineral samples						
	1-2-2) Evaluation of the catalysts' activities						
	1-2-3) Physical and Chemical analysis of catalyst and elucidation of catalytic mechanism						
	1-3) Development of char drawing system						Gasification cold model
	1-3-1) Development of concept for char drawing system						
	1-3-2) Cold model testing						
	1-3-3) Application to pilot plant				Canceled		
	1-4) Establishment of biomass pretreatment						Biomas characterization equipment
	1-4-1) Development of concept for biomass pretreatment system						
	1-4-2) Testing prototypes of pretreatment system						
	1-4-3) Application to pilot plant						
	1-5) Development of processing system of fertilizer from gasification residue.						
	1-5-1) Analysis of residue and evaluation as fertilizer						
	1-5-2) Development of fertilizer production process from the residue						


1-5-3) Demonstration of fertilizer production
1-5-4) Field test of the fertilizer
1-6) Operation of pilot plant
1-6-1) Designing of pilot plant
1-6-2) Construction of pilot plant
1-6-3) Operation of pilot plant
Gasification pilot plant
1-7) Development of Tar treatment technology
1-7-1) Labo scale tar cracking experiment
1-7-2) Design of tar cracking system
1-7-3) Construction of tar cracking system
1-7-4) Operation at pilot plant
Canceled
Canceled
Canceled
Labo scale equipment
2. Development of liquid fuel production system
2-1) Development of sustainable catalyst for methanol synthesis
2-1-1) Initial screening of possible catalysts
2-1-2) Elucidation of catalytic mechanism and investigation for activity enhancement
2-1-3) Application to prototype
Equipment for catalyst characterization
Gas analizer
2-2) Establishment of Methanol synthesis prototype for small scale application with low cost process
2-2-1) Investigation of raw gas pre-treatment
2-2-2) Prototype designing
2-2-3) Prototype construction and installation
2-2-4) Prototype operation
Methanol synthesis protptype
2-3) Conduct of fundamental research of gas fermentation process.
2-3-1) Literature Studies and Design of Experiment
2-3-2) Materials and Strains order

	2-3-3) Review Paper Writing	
	2-3-4) Stock and Seed Culture Preparation	
	2-3-5) Bacteria cultivation and optimization	
	2-3-6) Preliminary Study of Fermentation (Bottle Serum)	
	2-3-7) Optimization in batch reactor	
	2-3-8) Productivity enhancement in continuous bioreactor using membrane gas-liquid contactoq	
3. Development of human resources and establishment of biomass energy network	**3-1) Development of human resources**	
	3-1-1) Implementation of exchange programs in Japan	
	3-1-2) Implementation of local training programs	
	3-2) Establishment of network	
	3-2-1) Organization of international seminars	
	3-2-2) Publishing newsletters	

Annex 3: Evaluation Grid

1. Performance of the Project

(1) Achievement based on the PDM (version 2 signed in November 2017)

Evaluation Questions		Indicators	Necessary information and data	Source of information/ data	Research method
Items	Narrative Summary				
Project Purpose	Fluidized bed catalytic gasification of biomass wastes and following liquid fuel production system that is socially and economically appropriate for Indonesia is established and bases for the diffusion are prepared.	Pilot plant with capacity up to 50 kW biomass wastes gasification is constructed and operated.	Design documents, filed reports, operation logs	Monthly, annual, final reports of the Project (MR/AR/FR), Midterm Review Report (MRR), Gunma Univ. (GU), BPPT	Document review (DR), Questionnaire (Q)/ Interview (I)
		Prototype of methanol synthesis is developed.		MR/AR/FR, MRR, GU, BPPT	DR, Q/I
		Potential process of gas fermentation for bioethanol production is identified.	Study report(s) and/or Scientific paper(s)	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
Outputs	Output 1: Establishment of fluidized bed biomass gasification process with tar treatment technology	1.1. Stable operation of fluidized bed gasifier is demonstrated.	1.1 Experimental data, plant operation logs	MR/AR/FR, MRR, GU, BPPT, YDD	DR, Q/I
		1.2. The most active catalyst is identified among at least five kinds of clay catalysts.	1.2 Experimental and analysis data	MR/AR/FR, MRR, GU, BPPT, YDD	DR, Q/I
		1.3. Char drawing system is demonstrated.	1.3 Experimental data, plant operation logs	MR/AR/FR, MRR, GU, BPPT, YDD	DR, Q/I
		1.4. Proper biomass pretreatment system is established.	1.4 Experimental data, design document, plant operation logs	MR/AR/FR, MRR, GU, BPPT, YDD	DR, Q/I
		1.5. Technology for utilization of gasification residue as fertilizer is developed.	1.5 Experimental data, field test results, design documents	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
		1.6. Pilot plant is successfully operated.	1.6 Design documents, field records, operation logs	MR/AR/FR, MRR, GU, BPPT, YDD	DR, Q/I
		1.7. Tar treatment technology is developed.	1.7 Experimental data, design documents, plant operation logs	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
	Output 2: Development of liquid fuel production system	2.1. Sustainable catalyst for Methanol synthesis is developed.	2.1. Experimental data, quotation table	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
		2.2. Methanol synthesis prototype for small scale application with low cost process is developed.	2.2. Experimental data, design documents, operation logs	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
		2.3. Methanol synthesis prototype is tested and evaluated.	2.3. Experimental data, design document(s), operation logs	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
		2.4. Fundamental research of Gas fermentation process is conducted to collect data for feasibility study.	2.4. Experimental data	MR/AR/FR, MRR, GU, ITB	DR, Q/I
	Output 3: Development of human resources related to implementation of the developed system and establishment of network	3.1. Local trainings on for biomass energy utilization (at least twice) and trainings for operation (at least once) are conducted.	3.1. Training records	MR/AR/FR, MRR, Report of input, GU, BPPT, YDD	DR, Q/I

	for promoting biomass energy utilization	3.2. More than ten (in total) researchers and students from both Japan and Indonesia are exchanged to conduct research works.	3.2. Study report; research report	MR/AR/FR, MRR, Report of input, GU, BPPT, YDD	DR, Q/I
		3.3. International seminars are organized at least twice and attended by more than 200 participants in total.	3.3. Seminar participants' list, proceedings	MR/AR/FR, MRR, Report of input, GU, BPPT, YDD	DR, Q/I
		3.4. More than 10 newsletters are published with more than 750 copies for each.	3.4. Newsletters, delivery list	MR/AR/FR, MRR, Report of input, GU, BPPT, YDD	DR, Q/I
		3.5. At least ten scientific papers or publications are published.	3.5. Publication list	MR/AR/FR, MRR, Report of input, GU, BPPT, YDD	DR, Q/I

(2) Input of the Project

Evaluation Questions		Necessary information and data	Source of information/data	Research method
Items	Details			
Input from Japanese side	Experts: 1. Gunma University: 5 persons 2. APEX: 4 persons 3. Project Coordinator: 1 person	Number and number of experts dispatched, institution, timing, duration, and area of expertise	MR/AR/FR, MRR, Report of input	DR
	Equipment: - Cold model of fluidized bed - Gasifier pilot plant - Methanol synthesis pilot plant - Methanol synthesis prototype - Gas analyzers - Biomass pretreatment system - Tar cracking device - Catalyst characterization equipment - Bio reactor	Name of equipment, number, date of installation, status of usage	MR/AR/FR, MRR, Report of input, GU, BPPT, YDD, ITB	DR, Q/I
	Trainings in Japan: - 5 trainees x 2 times/year	Number of trainees, training place, purpose, duration, status after the training	MR/AR/FR, MRR, Report of input, GU, BPPT	DR, Q/I
	Project cost	Amount, items, timing, etc.	MR/AR/FR, MRR, Report of input	DR
Input from Indonesian side	Counterparts: - Agency for the Assessment and Application of Technology: 17 persons - Light of the Village Foundation: 3 persons - Institute Technology Bandung 5 persons	Name and number of counterpart personnel, institution, duration, and area of expertise	MR/AR/FR, MRR, Report of input	DR
	Office space with necessary equipment (such as gas chromatography equipment)	Location, facilities, etc.	MR/AR/FR, MRR, Report of input, GU, BPPT	DR, Q/I
	Supply or replacement of machinery, equipment, instruments, vehicle, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA	Name of equipment etc., number, date of installation, status of usage	MR/AR/FR, MRR, Report of input	DR
	Running expenses necessary for the implementation of the Project	Amount, items, timing, etc.	MR/AR/FR, MRR, Report of input	DR
	Expenses necessary within Indonesia for transportation and installation of equipment imported from Japan as well as for operation and maintenance after project completion thereof	Amount, items, timing, etc.	MR/AR/FR, MRR, Report of input	DR

2. Implementation Process

Evaluation Questions		Necessary information and data	Source of information/data	Research method
Topics	Details			
Progress of activities	Implementation of activities in accordance with the plan of activities	Plan of activities vs results, progress and issues	MR/AR/FR, MRR, GU, BPPT, YDD, ITB	DR, Q/I
Implementation structure	Management structure	Means of management, record of JCC meetings	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
	Communication among the project team members	Communication of each work team, means and frequency of information sharing (frequency of regular meetings and other types of communication, etc.)	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
Means of joint research	Means of joint research	Level of achievement, means, satisfaction, issues, etc.	MR/AR/FR, MRR, GU, BPPT, YDD, ITB	DR, Q/I
Allocation of human resources necessary for the activities	Adequate allocation of experts	Number of experts, means and frequency of their work, division of roles, results of activities, etc.	MR/AR/FR, MRR, GU, BPPT, YDD, ITB	DR, Q/I
	Adequate allocation of C/P personnel	Amount of C/P personnel, means and frequency of their work, division of roles, results of activities, etc.	MR/AR/FR, MRR, GU, BPPT, YDD, ITB	DR, Q/I
Involvement of other stakeholders	Involvement and recognition of stakeholders such as interested companies, etc.	Situation of the involvement of companies interested in the developed technologies	MR/AR/FR, MRR, GU, BPPT, YDD	DR, Q/I
Follow-up for the recommendations of Midterm Review	(1) Communication issue	- Means and frequency of the discussion among Gunma University and BPPT for decision making about the Project activities. - Distribution of necessary information in a timely manner by the project coordinator	MR/AR/FR, MRR, GU, BPPT, YDD, ITB	DR, Q/I
	(2) Demarcation of the project activities	Revised demarcation of the project activities ("Role of Each Organization")	MR/AR/FR, MRR, GU, BPPT, YDD, ITB	DR, Q/I
	(3) Project activities (Output 1)	Results of collaborative research activities	MR/AR/FR, MRR, GU, BPPT, YDD, ITB	DR, Q/I
	(4) Project activities (Output 2)	Results of collaboration for Methanol Synthesis related activities among Japanese researchers and Indonesian researchers, including: - Fundamental study for "liquid fuel production" - Modification of existing facilities for Methanol Synthesis in PUSPIPTEK, to obtain fundamental kinetic data for optimum design of pilot plant. - Structure and scale of the demonstration Methanol Synthesis process	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
	(5) Project activities (Output 3)	- Revision of the contents of the trainings for Indonesian side in Gunma University - "Number of research papers from activities of the Project"	MR/AR/FR, MRR, GU, BPPT, YDD, ITB	DR, Q/I
	(6) Amendment of PDM and PO	- Amendment of PDM and PO following the recommendations.	MR/AR/FR, MRR, GU, BPPT	DR, Q/I

3. Five (5) Evaluation Criteria

Criteria	Evaluation Questions		Necessary information and data	Source of information/data	Research method
	Topics	Details			
Relevance	Needs	Consistency with needs of Indonesian society	Current situations related to the biomass energy and the energy conversion of biomass wastes	Planning Report of the Project (PR), MR/AR/FR, MRR, GU, BPPT	DR, Q/I
	Priority	Consistency with development policies and strategies of Indonesian Government	Latest policies and strategies of Indonesian Government on the new and renewable energy, the utilization of biomass energy, and the energy conversion of biomass wastes	PR, MR/AR/FR, MRR, GU, RISTEKDIKIT, BPPT,	DR, Q/I
		Consistency with Japanese assistance policies and strategies for Indonesia	Latest policy of Japanese government for ODA in Indonesia	Japan's Development Cooperation Policy for the Republic of Indonesia (September 2017)	Document review
	Suitability as means	Appropriateness of contents, design and approach of the Project	Contents, design, approach of the Project as means to develop technologies which are applicable in Indonesian society	PR, MR/AR/FR, MRR, GU, RISTEKDIKIT, BPPT	DR, Q/I
		Advantage of related Japanese technologies	Application/ utilization of Japanese technologies (knowledge, experiences)	PR, MR/AR/FR, MRR, GU, BPPT	DR, Q/I
	Others	Coordination and demarcation with other related projects of government and other donor agencies.	Progress of other related projects of government and other donor agencies, relationship between the Project and other projects	PR, MR/AR/FR, MRR, GU, RISTEKDIKIT, BPPT	DR, Q/I
		Changes of circumstances surrounding the Project	Changes in organizational structures of C/P institutions, changes in positioning or importance of the Project in governmental policies or in relation with other related projects, changes in socio-economic situations, etc.	PR, MR/AR/FR, MRR, GU, RISTEKDIKIT, BPPT	DR, Q/I
Effectiveness	Prospect of achieving the Project Purpose	Achievement of the Project Purpose	Refer to "Achievement based on the PDM"	-	-
		Promoting factors of the achievement	Promoting factors	MR/AR/FR, MRR, GU, BPPT, ITB, YDD	DR, Q/I
		Constraints (negative factors) for the achievement	Constraints and issues which prevent the achievement	MR/AR/FR, MRR, GU, BPPT, ITB, YDD	DR, Q/I
	Causal relationship between project purpose and outputs	Extent of the progress of Outputs to achieve the Project Purpose	Refer to "Achievement based on the PDM"	-	-
		Influences of important assumptions to achieve the Project Purpose	- No serious economic recession nor inflation hikes occur in Indonesia - Destructive social unrest such as terrorism, war, or civil strife do not occur in Indonesia - Destructive natural disaster such as volcano eruption or earthquake do not occur in/around project sites	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
Efficiency	Achievement of Outputs	Extent of the progress of Outputs	Refer to "Achievement based on the PDM"	-	-
		Promoting factors of the achievement	Promoting factors	MR/AR/FR, MRR, GU, BPPT, ITB, YDD	DR, Q/I
		Constraints (negative factors) for the achievement	Constraints and issues which prevent the achievement	MR/AR/FR, MRR, GU, BPPT, ITB, YDD	DR, Q/I
	Causal relationship between	Sufficiency and adequacy of activities implemented to achieve the Outputs	Record of activities and achievements	MR/AR/FR, MRR, GU, BPPT, ITB, YDD	DR, Q/I

	outputs and activities				
	Efficiency in the implementation process	Quality, quantity, timing of input	Amount and quality required and implemented for project activities, timing of the provision	MR/AR/FR, MRR, GU, BPPT, ITB, YDD	DR, Q/I
		Implementation process which affected the efficiency of project activities	Refer to "Implementation Process"	-	-
Impact	Prospect of achieving the Overall Goal	Overall Goal: Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is diffused (Indicator: Within 4 years from the project completion, at least one plant using established technology are considered to be constructed and operated.)	Current situation of the utilization/ application of developed technologies	MR/AR/FR, MRR, GU, BPPT, ITB, YDD	DR, Q/I
			Steps to be taken to achieve the Overall Goal	MR/AR/FR, MRR, GU, BPPT, ITB,YDD	DR, Q/I
			Influences of important assumptions to achieve the Overall Goal (Energy policy of Indonesian government remains unchanged)	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
			Other factors which may promote or impede the achievement of the Overall Goal	MR/AR/FR, MRR, GU, BPPT, ITB,YDD	DR, Q/I
	Other positive or negative impacts of the Project	Possible or observed influences produced by the Project	Effects on the political aspects (system, law, regulation, etc.), people and society, and other socio-cultural aspects, etc.	MR/AR/FR, MRR, GU, BPPT, ITB,YDD	DR, Q/I
Sustainability	Political and institutional aspects	Continuity of the political/ institutional support of Indonesian Government	Prospects of priority for the researches in energy conversion of biomass wastes	MR/AR/FR, MRR, GU, RISTEKDIKTI, BPPT	DR, Q/I
		Institutional issues	Any necessary legal systems/ regulations which allow the application of developed technologies	MR/AR/FR, MRR, GU, BPPT	DR, Q/I
	Organizational aspect	Status of C/P institutions to continue necessary researches	Allocation of human resources and organizational structure for the continuity of related activities in the future, research plans	MR/AR/FR, MRR, GU, BPPT, ITB,YDD	DR, Q/I
	Financial aspect	Financial status of C/P institutions to continue necessary researches	Budgetary plan for future researches and related activities	MR/AR/FR, MRR, GU, BPPT, ITB,YDD	DR, Q/I
	Technical aspect	Technical status of C/P institutions to continue necessary researches	Technical issues for the continuity of related activities in the future	MR/AR/FR, MRR, GU, BPPT, ITB,YDD	DR, Q/I
	Social aspect	Socio-cultural aspect	Influences for society and culture which may affect the sustainability of related activities	MR/AR/FR, MRR, GU, BPPT, ITB,YDD	DR, Q/I

Annex 4: List of Inputs (Japanese side)

(1) Dispatch of Japanese Experts

	Name	Departure	Arrival	No. of days	Institution	Position	Expertize	Main purpose
1	Dr.Reiji NODA	2014/6/25	2014/6/28	4	Gunma University Graduate School of Science and Engineering and Electrical Engineering	Associate Professor	Project Leader, establishment of a highly stable fluidized bed technology	Kick-off meeting, meetings with BPPT
		2015/5/26	2015/5/29	4				Technical meeting, JCC
		2015/8/19	2015/8/22	4				Technical meeting, JCC
		2015/11/9	2015/11/13	5				Local technical training in utilization of biomass as energy source
		2016/2/15	2016/2/18	4				Meeting on research, international seminar
		2016/5/16	2016/5/22	3				JCC
		2016/7/18	2016/7/21	4				Design workshop
		2016/8/11	2016/8/13	3				Visit to and meeting with ITB
		2016/8/21	2016/8/25	5				Design workshop, meeting
		2016/9/14	2016/9/20	7				Design workshop, meeting
		2016/11/27	2016/12/2	6				JCC
		2016/12/20	2016/12/23	4				Design workshop
		2017/2/13	2017/2/16	4				Regular meeting, meeting
		2017/5/21	2017/5/25	5				Visit to methanol synthesis plant, meeting
		2017/7/23	2017/7/29	7				Discussion on research direction, JCC, technical meeting
		2017/9/3	2017/9/8	3				Design of gasification cold model
		2017/9/26	2017/9/29	3				Design of gasification cold model, meeting on experiment of methanol synthesis
		2017/11/20	2017/11/28	6				Visit to and meeting with ITB
		2017/12/17	2017/12/20	4				Research meeting
		2018/2/5	2018/2/10	6				Research meeting
		2018/2/20	2018/2/23	4				Research meeting
		2018/3/6	2018/3/9	4				Research meeting
		2018/4/16	2018/4/19	4				Research meeting
		2018/5/6	2018/5/9	4				Research meeting
		2018/5/27	2018/5/31	4				Research meeting
		2018/6/6	2018/6/10	5				Research meeting
		2018/7/7	2018/7/12	6				Research meeting, JCC
		2018/7/30	2018/8/4	6				Research meeting
		2018/8/26	2018/8/29	4				Research meeting
		2018/9/9	2018/9/12	4				Research meeting
		2018/9/27	2018/10/5	9				Other purpose, Research meeting
		2018/11/14	2018/11/18	5				Research meeting

		2018/12/16	2018/12/19	4				Research meeting
		2018/12/25	2018/12/29	5				Research meeting
		2019/1/28	2019/1/31	4				Research meeting
		2019/2/11	2019/2/15	5				Research meeting
		2019/3/5	2019/3/9	5				Research meeting
		2019/3/21	2019/3/29	9				Other purpose, Research meeting
		2019/4/24	2019/4/28	5				Research meeting
		2019/5/1	2019/5/4	4				Research meeting
		2019/5/13	2019/5/17	5				Research meeting
		2019/5/21	2019/6/2	13				Research meeting
			Sub total	209				
2	Prof. Takayuki TAKARADA	2014/6/25	2014/6/28	4	Gunma University Graduate School of Science and Engineering and Electrical Engineering	Professor	Development of low-cost alcohol synthesis catalyst	Kick-off meeting, meetings with BPPT
		2015/12/6	2015/12/9	4				Technical meeting
		2016/2/16	2016/2/18	3				International seminar
		2016/9/18	2016/9/20	3				Technical meeting
		2016/11/26	2016/12/3	3				JCC
		2018/2/8	2018/2/10	3				Technical meeting
		2019/3/27	2019/3/29	3				Research meeting
			Sub total	23				
3	Dr. Tomohide WATANABE	2014/6/25	2014/6/28	4	Gunma University Graduate School of Science and Engineering and Electrical Engineering	Professor	Fertilizer evaluation of gasification residue	Kick-off meeting, meetings with BPPT
		2016/10/22	2016/10/25	4				Visit to and meeting with ITB
		2016/11/29	2016/12/2	4				JCC
		2017/7/25	2017/7/29	5				JCC, technical meeting
		2017/11/23	2017/11/28	6				Visit to and meeting with ITB
		2019/3/26	2019/3/29	4				Visit to and meeting with ITB
			Sub total	27				
4	Mr. Yuta SUDO	2017/7/7	2017/7/20	13	Gunma University Graduate School of Science and Engineering and Electrical Engineering	Researcher of Industry-Government-Academia Collaboration		Experiment, information gathering
		2017/7/23	2017/8/10	19				Experiment, information gathering, JCC
		2017/8/25	2017/9/15	22				Experiment, information gathering, technical meeting
		2017/9/26	2017/10/13	18				Experiment, information gathering, technical meeting, international conference
		2017/11/4	2017/11/12	9				Experiment, information gathering、international conference
		2017/11/23	2017/11/29	7				Experiment, technical meeting
		2017/12/14	2017/12/26	13				Experiment, information gathering、technical meeting
		2018/1/24	2018/3/22	58				Experiment, information gathering、technical meeting
		2018/4/4	2018/4/26	23				Experiment, information gathering、technical meeting
		2018/4/30	2018/6/12	44				Experiment, information gathering、technical meeting

		2018/6/25	2018/8/10	47				Experiment, information gathering、technical meeting, International conference
		2018/8/20	2018/8/29	10				Experiment, information gathering、technical meeting
		2018/9/5	2018/10/26	52				Experiment, information gathering、technical meeting, International conference
		2018/11/8	2018/12/24	47				Experiment, information gathering、technical meeting, International conference
		2019/1/13	2019/3/29	76				Experiment, information gathering、technical meeting
		2019/4/9	2019/6/5	58				Experiment, information gathering、technical meeting
		2019/6/9	2019/6/12	4				Experiment, information gathering、technical meeting
			Sub total	520				

	Name	Departure	Arrival	No. of days	Institution	Position	Expertize	Main purpose
1	Dr. Tadashi TAGAWA	2015/5/26	2015/5/30	5	Asian People's Exchange (APEX)	Director	Research Supervisor	Supervision of APEX's research
		2016/10/22	2016/10/25	4				
		2016/11/29	2016/12/2	4				
			Sub total	13				
2	Dr.Hitoshi INOUE (Mr. Nao TANAKA)	2014/6/23	2014/6/28	6	Asian People's Exchange (APEX)	Executive Director	Local research supervisor, research, design, procurement, training	Collection of clay mineral samples, design and production control of small scale gasification equipment for catalytic activity evaluation of clay minerals, support of experiments by the equipment, examination of char extraction equipment, design and production management of fluidized bed cold model, examination of pre-treatment and supply method of biomass, examination of pre-treatment method of low-pressure methanol synthesis raw material, design support and production management of the raw material pre-treatment experimental device, operation support of the device, preparation and implementation of training program, newsletter editing and publishing, preparation and implementation of seminars
		2014/7/17	2014/7/24	8				
		2014/8/21	2014/8/23	3				
		2014/9/21	2014/9/25	5				
		2014/10/18	2014/10/24	7				
		2014/11/11	2014/11/22	8				
		2014/12/8	2014/12/19	7				
		2015/1/15	2015/1/28	8				
		2015/2/11	2015/2/26	9				
		2015/3/17	2015/3/21	5				
		2015/4/15	2015/4/19	4				
		2015/5/21	2015/5/29	9				
		2015/6/18	2015/6/24	7				
		2015/7/9	2015/7/10	2				
		2015/8/19	2015/8/24	6				
		2015/9/9	2015/9/26	8				
		2015/10/20	2015/10/24	5				
		2015/11/7	2015/11/27	15				
		2015/12/9	2015/12/22	14				
		2016/1/13	2016/1/27	12				
		2016/2/10	2016/2/24	15				
		2016/3/17	2016/3/24	8				
		2016/4/6	2016/4/22	17				

		2016/5/10	2016/5/27	16				
		2016/6/13	2016/6/23	10				
		2016/7/13	2016/7/28	13				
		2016/8/10	2016/8/26	17				
		2016/9/7	2016/9/29	22				
		2016/10/18	2016/10/29	9				
		2016/11/14	2016/11/26	13				
		2017/1/16	2017/1/28	12				
		2017/2/9	2017/2/19	10				
		2017/3/2	2017/3/13	6				
			Sub total	316				
4	Dr.Minako KAWAI	2014/6/13	2014/6/29	17	Asian People's Exchange (APEX)	Overseas project coordinator	Methanol synthesis, research, design and procurement support, training support	Examination of low pressure methanol synthesis raw material pretreatment method, design and production control of the raw material pretreatment experimental equipment, analysis of operation and results of the equipment, design and production management of low pressure methanol synthetic pilot plant, support for preparation and implementation of training program, editorial and publishing support for newsletters, support for preparation and implementation of seminars
		2014/7/11	2014/9/8	55				
		2014/9/20	2014/11/18	60				
		2014/11/27	2014/12/23	27				
		2015/1/12	2015/3/12	60				
		2015/4/1	2015/5/30	60				
		2015/6/18	2015/8/16	56				
		2015/9/1	2015/10/30	60				
		2015/11/9	2015/12/22	44				
		2016/1/10	2016/3/10	61				
		2016/3/31	2016/5/29	1				
		2016/6/16	2016/8/13	55				
		2016/8/22	2016/9/17	27				
		2016/10/17	2016/12/3	48				
		2016/12/12	2016/12/23	12				
		2017/1/12	2017/3/11	59				
			Sub total	702				
5	Mr. Yuta SUDO	2014/6/13	2014/6/29	17	Asian People's Exchange (APEX)	Overseas project coordinator	Biomass gasification, research, design and procurement support , training support	Collection of clay mineral samples, design support and production control of small scale gasification equipment for catalytic activity evaluation of clay minerals, analysis of experiments and results by the equipment, chemical analysis of clay, support for preparation and implementation of training program, newsletter editing and issuing, seminar preparation / implementation
		2014/7/11	2014/9/8	60				
		2014/9/20	2014/11/18	60				
		2014/12/11	2014/12/23	13				
		2015/1/9	2015/3/9	60				
		2015/4/1	2015/5/30	60				
		2015/6/18	2015/8/16	60				
		2015/9/1	2015/10/30	60				
		2015/11/9	2015/12/23	45				
		2016/1/10	2016/3/9	55				
		2016/3/29	2016/5/27	60				
		2016/6/16	2016/8/13	59				
		2016/8/22	2016/10/20	60				

		2016/10/27	2016/12/23	60				
		2017/1/12	2017/3/11	59				
			Sub total	731				

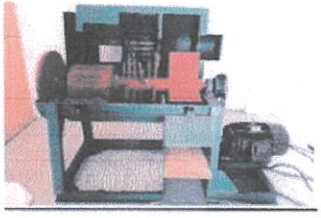
	Name	Departure	Arrival	No. of days	Institution	Position	Expertize	Main purpose
	Ms. Chiaki FUKUDA	2015/8/18	2015/9/17	31	JICA	Project Coordinator	Coordination	
		2016/10/12	2017/5/31	598				
		2017/06/01	2019/05/30	729				
			Sub total	1,358				

(2) Training in Japan

No	Name	Start	End	No.of days	Affiliation	Position	Place	Training Subject
1	Mr. Imron Masufri	2014/12/7	2015/3/6	89	BPPT	Engineering Staff	Gunma University	Gasification of Biomass
2	Mr. Wargiantoro Prabowo	2014/12/7	2015/3/6	89	BPPT	Engineering Staff	Gunma University	
3	Ms. Anindhita	2015/12/1	2016/1/29	59	BPPT	Engineering Staff	Gunma University	Development of Methanol Synthesis
4	Ms. Atti Sholihah	2015/12/1	2016/1/29	59	BPPT	Engineering Staff	Gunma University	
5	Ms. Tyas Pspitarini	2015/12/1	2016/1/29	59	BPPT	Engineering Staff	Gunma University	
6	Mr. Abdul Hadi	2016/2/1	2016/3/27	55	BPPT	Engineering Staff	Gunma University	Training for Methanol Synthesis and Gasification of Biomass
7	Ms. Bralin Dwiratna	2016/2/1	2016/3/27	55	BPPT	Engineering Staff	Gunma University	
8	Ms. Septina Is Heriyantei	2016/2/1	2016/3/27	55	BPPT	Engineering Staff	Gunma University	
9	Ms. Asmi Rima Juwita	2016/9/1	2016/10/29	59	BPPT	Engineering Staff	Gunma University	Training for Methanol Synthesis and gasification of Biomass
10	Ms. Fusia Mirda Yanti	2016/9/1	2016/10/29	59	BPPT	Engineering Staff	Gunma University	
11	Mr. Novio Valentino	2016/9/1	2016/10/29	59	BPPT	Engineering Staff	Gunma University	
12	Ms. Astri Pertiwi	2016/12/18	2017/2/12	57	BPPT	Engineering Staff	Gunma University	Development of methanol synthesis catalyst
13	Mr. Prima Trie Wijaya	2016/12/18	2017/2/12	57	BPPT	Engineering Staff	Gunma University	Development of fluidized bed
14	Mr. Ervert Ferdi Destian	2017/10/23	2017/12/23	62	BPPT	Engineering Staff	Gunma University	Evaluation of gasification residue fertilizer
15	Mr. Ilhamsyah Noor	2017/10/23	2017/12/23	62	BPPT	Engineering Staff	Gunma University	
16	Mr. Dorit Bayu Islam Nuswantoro	2017/10/23	2017/12/23	62	BPPT	Engineering Staff	Gunma University	

(3) Installed Equipment by JICA's budget

No.	Equipment	Qty	Original Price	Price in JPY	Installation site	Photo	Year Installed	Remarks
1	Labo scale clay catalyst evaluation equipment	1	Rp100.000.000	762.000	BPPT		2014/10	
2	Cold model fluidized bed with loop seal stracture	1	US$26.537	2.902.776	BPPT		2018/4	
3	Screening devise	1	Rp75.000.000	571.500	BPPT		2016/2	
4	Gas Chromatography, Shimadzu 8A TCD	1	Rp415.995.000	3.169.882	BPPT		2018	Including clummn
5	Gas Chromatography, Shimadzu 8A FID	1			BPPT		2018	
6	50kW pilot plant including biomass feeding system and pre-treatment	1	Rp8.855.730.826	67.480.669	BPPT		2019/5	Including compressor, Gas analyzer, Feeding system, Cabel, Construction, screw coveyer, crushing machine, and inverter.

No.	Equipment	Qty	Original Price	Price in JPY	Installation site	Photo	Year Installed	Remarks
7	Labo scale raw gas pre-treatment equipment	1	Rp250.000.000	1.905.000	BPPT		2014/10	
8	Low pressure Methanol synthesis Pilot Plant	1	Rp275.000.000	2.095.500	BPPT		2015/10	
9	Gas Chromatography, Shimadzu GC-2030N	1	¥6.585.530	6.585.530	BPPT		2019/5	
10	Methanol synthesis test equipment	1	¥4.292.028	4.292.028	BPPT		2019/5	Including Gas mixer, Booster pump, Gasmeter, Degital meter relay pressure transmitter and spring hose.
11	BET surface area measurement	1	Rp588.677.700	4.485.724	BPPT		2019/5	
12	EFB Pre-treatment (crashing machine)	1	US$4.015	439.185	BPPT		2019	
13	Photocopy machine, Toshiba New eStudio 2051C	1	Rp37.000.000	281.940	BPPT		2016	

No.	Equipment	Qty	Original Price	Price in JPY	Installation site	Photo	Year Installed	Remarks
14	Pan Type Glanurator, AS ONE DPZ-01R	1	Rp30.800.000	234.696	BPPT		2017	
15	Cold model fluidized bed	1	Rp182.280.000	1.388.974	YDD		2015/11	
16	Gas Chromatography, Shimadzu GC-2014AT	1	¥3.893.400	3.893.400	ITB		2019/5	
17	Batch Reactor foe Gas fermentation	1	Rp225.500.000	1.718.310	ITB		2019/5	Equipment provided by JICA includes sensor, control & supply tower, vesel 2 L.
18	Peristaltic Pump, Waton Marlow 323	2	US$3.841	420.152	ITB		2017	
19	Mass Flow Controller, MFC Bronkhorst	1	US$14.100	1.542.343	ITB		2017	
20	pH Probe, No. 52001315	1	Rp8.307.000	63.299	ITB		2018	

No.	Equipment	Qty	Original Price	Price in JPY	Installation site	Photo	Year Installed	Remarks
21	Compact Digital Mini Rotator, Thermo Scientific	1	Rp25.500.000	194.310	ITB		2016	
Total				¥104.427.217				

Remarks: Based on JICA's management rate on June 2019 (1$ = JPY 109.3860, 1Rp = JPY 0.007620)

(4) JICA's Overseas Activity Cost

FY2014

Item	Detail	Rp.	Remarks
Miscellaneous	Reagents, gases, laboratory instruments, newsletter printing and mailing costs, etc.	136,145,863	Paid by JICA Indonesia Office directly.
Total		136,145,863	

FY2015

Item	Detail	Rp.	Remarks
Miscellaneous	Reagents, gases, laboratory instruments, newsletter printing and mailing costs, etc.	38,720,000	from April 2015 to September 2015: Paid by JICA Indonesia Office directly
Miscellaneous	Reagents, gases, laboratory instruments, newsletter printing and mailing costs, etc.	240,645,065	from October 2015 to March 2016
Airfare	Airfare for business trip of the external lecturers and Project Coordinator	31,585,302	from October 2015 to March 2016
Travel expenses	Travel expenses for business trip of external lecturers and Project Coordinator	15,669,463	from October 2015 to March 2016
Total		326,619,830	

FY2016

Item	Detail	Rp.	Remarks
Miscellaneous	Reagents, gases, laboratory instruments, newsletter printing and mailing costs, etc.	443,477,343	from April 2016 to October 2016
Airfare	Airfare for business trip of Project Coordinator	14,916,000	from April 2016 to October 2016
Travel expenses	Travel expenses for business trip of Project Coordinator	23,766,000	from April 2016 to October 2016
Miscellaneous	Legal consultation regarding the insurance of methanol synthesis pilot plant	8,000,000	Paid by JICA Indonesia Office directly
Total		490,159,343	

FY2017

Item	Detail	Rp.	Remarks
Miscellaneous	Reagents, gases, laboratory instruments, newsletter printing and mailing costs, etc.	420,449,685	From April 2017 to March 2018
Airfare	Airfare for business trip of C/P personnel and Project Coordinator	265,206,015	From April 2017 to March 2018
Travel expenses	Travel expenses for business trip of C/P personnel and Project Coordinator	362,916,775	From April 2017 to March 2018
Total		1,048,572,475	

FY2018

Item	Detail	Rp.	Remarks
Miscellaneous	Reagents, gases, laboratory instruments, newsletter printing and mailing costs, etc.	550,992,275	From April 2019 to March 2019
Airfare	Airfare for business trip of C/P personnel and Project Coordinator	219,212,271	From April 2019 to March 2019
Travel expenses	Travel expenses for business trip of C/P personnel and Project Coordinator	274,258,449	From April 2019 to March 2019
Total		1,044,462,995	

FY2019

Item	Detail	Rp.	Remarks
Miscellaneous	Reagents, gases, laboratory instruments, newsletter printing and mailing costs, etc.	556,518,087	From April 2019 to June 2019
Airfare	Airfare for business trip of C/P personnel and Project Coordinator	0	From April 2019 to June 2019
Travel expenses	Travel expenses for business trip of C/P personnel and Project Coordinator	57,277,469	From April 2019 to June 2019
Total		613,795,556	

Total	3,659,756,062

Annex 5: List of Inputs (Indonesian side)

(1) List of Indonesian Counterparts

No	Name	Institution	Position	Assignment Period			
				From		To	
				Year	Month	Year	Month
1	Dr. Adiarso, MSc	BPPT	Director	2014	6	2018	3
2	Dr. Ir Hammam Riza	BPPT	Deputy	2016	11	2018	3
3	Prof. Dr.-Eng. Eniya Listiani Dewi, B.Eng., M.Eng	BPPT	Deputy of TIEM	2018	3	2019	6
4	Dr. Hens Saptra	BPPT	Director of PTSEIK	2017	7	2019	6
5	Dr. SD. Sumbogo Murti, M.Eng	BPPT	Program Director	2016	5	2019	6
6	Dr. Edy Hermawan, MSc	BPPT	Head of Division	2017	1	2018	3
7	Dr. Irhan Febijanto	BPPT	Renewable Energy Specialist	2015	6	2018	3
8	Dr.Muhammad Abdul Kholiq	BPPT	Program Manager	2018	2	2019	6
9	Niken Lerasati	BPPT	Staff	2017	7	2018	3
10	Dr. Joni Prasetyo	BPPT	Chief Engineer	2014	6	2019	6
11	Dr. Erlan Rosyadi	BPPT	Group Leader for Gasification1	2018	3	2019	6
12	Ir. Trisaksono, BP, M.Eng	BPPT	Team Leader for pretreatment	2016	5	2019	6
13	Wargiantoro P., ST	BPPT	Staff	2014	6	2019	6
14	Trisno Anggoro, ST, MT	BPPT	Staff	2017	7	2018	3
15	Imron Masfuri, ST	BPPT	Staff	2014	6	2019	6
16	Abdul Hadi, ST	BPPT	Staff	2015	1	2019	6
17	Winda Wulansari	BPPT	Staff	2018	3	2019	6
18	Bambang Muharto	BPPT	Staff	2018	3	2019	6
19	Ridho Dwimansyah	BPPT	Staff	2018	3	2019	6
20	Soleh Pocis	BPPT	Staff	2018	3	2019	6
21	Soleh Ibrahim	BPPT	Staff	2018	3	2019	6
22	Atti Sholihah, AMD	BPPT	Staff	2015	1	2019	6
23	Arfiana, ST, MT	BPPT	Team Leader for frtization	2016	11	2019	6
24	Fausiah, ST, MT	BPPT	Staff	2017	7	2019	6
25	Era Restu Finalis, ST, MT	BPPT	Staff	2017	7	2019	6
26	Ilhamsyah Noor	BPPT	Staff	2017	7	2019	6
27	Dwi Lukman Hakim, ST	BPPT	Staff	2017	7	2018	3
28	Dorit Bayu Islam Nuswantoro, ST	BPPT	Staff	2016	11	2019	6
29	Erbert Ferdy Destian, ST	BPPT	Staff	2016	11	2019	6
30	Dr. Ir. Herman Hidayat, Msi	BPPT	Group Leader for Methanol Synthesis	2015	5	2019	6
31	Fusia Mirda Yanti, Ssi, Msi	BPPT	Team Leader of Catalyst Design	2016	5	2019	6
32	Nurdiah Rahmawati			2017	7	2019	6
33	Asmi Rima Juwita, ST	BPPT	Staff	2016	5	2019	6
34	Tyas Puspita Rini, AMD, Ak	BPPT	Staff	2014	11	2019	6
35	Turiman	BPPT	Staff	2018	3	2019	6
36	Samsudin	BPPT	Staff	2018	3	2019	6
37	Astri Pertiwi, ST, MT	BPPT	Team Leader of Methanol Production	2015	1	2019	6
38	Zulaicha Dwi Hastuti, ST, MT	BPPT	Staff	2016	5	2019	6
39	Galuh Wirama Murti, MSc	BPPT	Staff	2018	3	2019	6
40	Novio Valentino, ST	BPPT	Staff	2015	1	2019	6
41	Frendy Rian Saptoro, ST	BPPT	Staff	2017	7	2018	5
42	Arya Bhaskara	BPPT	Staff	2018	3	2019	6
43	Desy Saptriana	BPPT	Staff	2018	3	2019	6
44	Anindita, MSc	BPPT	Staff	2014	11	2018	3
45	Rudi Surya Sitorus, ST	BPPT	Staff	2016	12	2018	3
46	Ari Kabul Paminto, ST	BPPT	Staff	2015	1	2018	3

47	Prima Trie Wijaya, SKom, MKom	BPPT	Staff	2015	1	2018	3
48	Prima Zuldian, ST, MT, Meng	BPPT	Staff	2016	10	2017	10
49	Hana Nabila Anindhitta, S.T, M.T	BPPT	Staff	2019	3	2019	6
50	Bagus Alif, S.T	BPPT	Staff	2019	3	2019	6
51	Herson Bangun, S.T	BPPT	Staff	2019	3	2019	6
52	Sekar Kumala Desi, ST	BPPT	Staff	2019	3	2019	6
53	Muhamad Rodhi Supriyadi	BPPT	Staff	2019	3	2019	6
54	Ikhwanul Ihsan	BPPT	Staff	2019	3	2019	6
55	Anton Soejarwo	YDD	Director	2014	6	2017	6
56	Hermanto Sujarwo	YDD	Division Director	2014	6	2017	6
57	Prof. Tjandra Setiadi	ITB	Professor	2016	12	2019	6
58	Dr. M.T.A. Penia Kresnowati	ITB	Expert	2016	12	2019	6
59	Dr. Ronny Purwadi	ITB	Expert	2016	12	2019	6
60	Irika Devi, ST	ITB	Staff	2016	12	2018	7
61	Guntur Adisurya Ismail, ST	ITB	Master's student	2016	12	2019	6
62	Keryanti	ITB	Master's student	2016	12	2019	6

(2) Activity Cost by Counterpart's Budget

BPPT

FY2014

Item	Detail	Rp.	Remarks
Miscellaneous	preparation and running cost for experiment facility	40,000,000	Electricity, Water
Meeting	Venue, food & beverage, transportation etc.	7,000,000	Kick-off meeting
Total		47,000,000	

FY2015

Item	Detail	Rp.	Remarks
Travel expenses	Visit to State Owned Plantation No.4 (PTPN 4)	10,000,000	October 2015, two person
Travel expenses	Visit to State Owned Plantation No.4 (PTPN 4)	5,000,000	December 2015, one person
Travel expenses	Business trip to Medan	23,160,000	February 2016, four person
Travel expenses	Visit to Institute of Technology Bandung (ITB)	11,520,000	January 2016, four person
Miscellaneous	Consumables (reagents)	14,300,000	
Miscellaneous	Consumables (gases)	14,300,000	
Miscellaneous	Honorarium remuneration	3,900,000	
Miscellaneous	Others	15,000,000	Equipment maintenance, outsourcing, communication costs, etc.
Travel expenses	Visit to State Owned Plantation No.3 (PTPN 3)	4,875,000	March 2016, three person
Travel expenses	Visit to State Owned Plantation No.5 (PTPN 5)	3,650,000	March 2016, three person
Total		105,705,000	

FY2016 (Up to Midterm Review)

Item	Detail	Rp.	Remarks
Travel expenses	Visit to State Owned Plantation No.3 (PTPN 3)	4,875,000	April 2016, three person
Travel expenses	Visit to State Owned Plantation No.3 (PTPN 3)	4,666,000	August 2016, one person
Travel expenses	Visit to ITB	2,560,000	August 2016, one person
Miscellaneous	Reagents, gases, laboratory instruments, other consumables	21,951,000	from April to August 2016

3 6.

Total	34,052,000	

FY2016 (After Midterm Review)

Item	Detail	Rp.	Remarks
-	No details available	295,948,000	from September 2016
Total		295,948,000	

FY2017

Item	Detail	Rp.	Remarks
Travel expenses	Visit to State Owned Plantation PTPN 5	30,640,000	
Travel expenses	Visit to ITB (8 person), training	48,000,000	
Travel expenses	Business trip to PTPN 5	15,320,000	
Travel expenses	Visit to Bandung	10,500,000	
Miscellaneous	Chemicals, gaseous, reagent	42,560,000	
Miscellaneous	Others	2,980,000	
Total		150,000,000	

FY2018

Item	Detail	Rp.	Remarks
Travel expenses	Visit to State Owned Plantation PTPN 5	15,320,000	
Travel expenses	Visit to Surakarta International Seminar	21,880,000	
Travel expenses	Visit to Yoggyakarta International Seminar	21,750,000	
Miscellaneous	Chemicals, gaseous, reagent	62,660,000	
Travel expenses	Visit to Bandung	21,000,000	
Travel expenses	Visit to Banten	9,800,000	
Miscellaneous	Khacartirization of catalyst, fertilizer etc	47,590,000	
Total		200,000,000	

FY2019

Item	Detail	Rp.	Remarks
Miscellaneous	Solar DEX (135 liters x 10 trial)	16,000,000	
Miscellaneous	Electricity installation for hot model pilot plant	1,000,000	
Miscellaneous	Gasification Laboratory renovation (Visit of Ka. BPPT)	5,000,000	
Travel expenses	Official travel: Jakarta-Bandung (3 days 2 nights)	6,380,000	
Travel expenses	Official travel: Jakarta Yogyakarta (3 days 2 nights)	11,120,000	
Miscellaneous	Meeting consumption costs (lunch, snacks)	6,275,000	
Total		45,775,000	

BPPT Total **878,480,000**

YDD

FY2016

Item	Detail	Rp.	Remarks
Personnel expenses	Collect of Clay sample, 3person x 2days x Rp. 60,000	360,000	for Cold Model
Personnel expenses	Sieving work, 2peron x 20days x Rp. 60,000	2,400,000	for Cold Model

Miscellaneous	Electric utility expense, Rp. 150,000 x 20 days	3,000,000	for Cold Model
Total		5,760,000	

YDD Total: Rp. 5,760,000

ITB

FY2017

Item	Detail	Rp.	Remarks
Spectrophotometer analysis	Total of 150 samples	4,500,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
HPLC analysis	Total of 150 samples	45,000,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
GC analysis	Total of 60 samples	9,000,000	Laboratory of Analysis and Instrument, ITB
Fermentor rent expenses/year	New Brunswick Bioflo/Celligen 115	45,000,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
Anaerobic chamber rent expenses/year	Vynyl Coy Anaerobic Chambers	10,000,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
Stipend for research assistant	1 person, Rp 5,000,000 per month	60,000,000	
Total		173,500,000	

FY2018

Item	Detail	Rp.	Remarks
Spectrophotometer analysis	Total of 80 samples	2,400,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
HPLC analysis	Total of 80 samples	24,000,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
Fermentor rent expenses/year	New Brunswick Bioflo/Celligen 115	45,000,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
Anaerobic chamber rent expenses/year	Vynyl Coy Anaerobic Chambers	10,000,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
Stipend for research assistant	1 person, Rp 5,000,000 per month	60,000,000	
Miscellaneous chemical and laboratory expenses	Chemical for fermentation media, gas for fermentation, microtube, syringe, etc	7,000,000	
Total		148,400,000	

FY2019

Item	Detail	Rp.	Remarks
Spectrophotometer analysis	Total of 30 samples	900,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
HPLC analysis	Total of 30 samples	9,000,000	Laboratory of Microbiology and Bioprocess Engineering, ITB
Stipend for research assistant	1 person, Rp 5,000,000 per month	15,000,000	
Total		24,900,000	

ITB Total: Rp. 346,800,000

(3) Installed Equipment by Counterpart's Budget

BPPT

FY2015

Item	Detail	Rp.	Remarks
Equipment	GC remodeling cost	18,000,000	
Equipment	Sulfide apparatus	28,000,000	
Equipment	Laboratory construction and equipment costs	25,000,000	
Total		71,000,000	

FY2019

Item	Detail	Rp.	Remarks
Equipment	BID facility (Printer, PC, Monitor, He gas with cylinder, pressure regulator for He, UPS, piping, ball valve)	88,581,900	
Equipment	BET facility (PC, printer, trolley Nitrogen gas)	25,300,000	
Equipment	Gas mixer facility (piping, instrumentasi, alphagaz regulator, engineering and service, multiple portable detector O_2 and H_2)	151,000,000	
Equipment	Multi hotplate stirrer	57,860,000	
Equipment	Air dryer	38,500,000	
Total		361,241,900	

BPPT Total **432,241,900**

ITB

FY2017

Item	Detail	Rp.	Remarks
Peristaltic pump	Watson Marlow model 403U/R1	22,000,000	Watson Marlow
Anaerobic chamber	Vinyl Coy Anaerobic Chambers	36,000,000	Coy Laboratories
pH probe 5300315	InPro3030/225 Sensor	9,137,700	PT. Mettler-Toledo Indonesia
Total		67,137,700	

FY2018

Item	Detail	Rp.	Remarks
Fermentor	Sartorius Biostat A	115,007,200	Vessel 2 L and chiller for Biostat A
Total		115,007,200	

ITB Total: Rp. 182,144,900

Annex 6: Comparative table between PDM Version 1 and Version 2

Version 1 (May 2015)	Version 2 (November 2017)
Overall Goal:	
Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is diffused.	Established technology for fluidized bed catalytic gasification of biomass wastes and following liquid fuel production is diffused.
Indicator of Overall Goal:	
Within 4 years from the project completion, more than 4 plants using established technology are constructed and operated.	Within 4 years from the project completion, at least one plant using established technology are considered to be constructed and operated.
Project Purpose:	
Fluidized bed catalytic gasification of biomass wastes and following liquid fuel production system that is socially and economically appropriate for Indonesia is established and bases for the diffusion are prepared.	Fluidized bed catalytic gasification of biomass wastes and following liquid fuel production system that is socially and economically appropriate for Indonesia is established and bases for the diffusion are prepared.
Indicators of PP	
● Demonstration plant with capacity of 250 kW biomass wastes gasification and methanol synthesis is constructed and operated continuously. ● At least 3 companies and/or other organizations are considering to introduce the developed system.	● Pilot plant with capacity up to 50 kW biomass wastes gasification is constructed and operated. ● Prototype of methanol synthesis is developed. ● Potential process of gas fermentation for bioethanol production is identified.
Output 1:	
1) Establishment of fluidized bed biomass gasification process using clay catalysts	1) Establishment of fluidized bed biomass gasification process with tar treatment technology.
Indicators of Output 1:	
1-1) Highly-stabilized fluidized bed system is demonstrated. 1-2) The most active catalyst is identified among at least five kinds of clay catalysts. 1-3) Char drawing system is demonstrated. 1-4) Biomass preparation and feeding system is established. 1-5) Production system of fertilizer from gasification residue is developed. 1-6) Demonstration plant is successfully operated.	1-1) Stable operation of fluidized bed gasifier is demonstrated. 1-2) The most active catalyst is identified among at least five kinds of clay catalysts. 1-3) Char drawing system is demonstrated. 1-4) Proper biomass pretreatment system is established. 1-5) Technology for utilization of gasification residue as fertilizer is developed. 1-6) Pilot plant is successfully operated. 1-7) Tar treatment technology is developed.
Output 2:	
2) Establishment of low cost and low pressure methanol synthesis process	2) Development of liquid fuel production system
Indicators of Output 2:	
2-1) Methanol synthesis catalyst whose cost is less than half of usual one is identified. 2-2) Methanol synthesis pilot plant whose pressure is less than 2 MPa is operated. 2-3) Demonstration plant is operated successfully.	2-1) Sustainable catalyst for Methanol synthesis is developed. 2-2) Methanol synthesis prototype for small scale application with low cost process is developed. 2-3) Methanol synthesis prototype is tested and evaluated. 2-4) Fundamental research of Gas fermentation process is conducted to collect data for feasibility study.
Output 3:	
3) Development of human resources related to implementation of the developed system and establishment of network for promoting biomass energy utilization	3) Development of human resources related to implementation of the developed system and establishment of network for promoting biomass energy utilization
Indicators of Output 3:	
3-1) Trainings for biomass energy use (more than 4 times) and trainings for operation (more than twice) are conducted with more than 100 and 20 participants in total, respectively. 3-2) International seminars are organized more than twice and attended by more than 200 participants in total. 3-3) More than 10 newsletters are published with more than 750 copies for each.	3-1) Local trainings on for biomass energy utilization (at least twice) and trainings for operation (at least once) are conducted. 3-2) More than ten (in total) researchers and students from both Japan and Indonesia are exchanged to conduct research works. 3-3) International seminars are organized at least twice and attended by more than 200 participants in total. 3-4) More than 10 newsletters are published with more than 750 copies for each. 3-5) At least ten scientific papers or publications are published.
Activities	

1) Development of fluidized bed catalytic gasification of biomass	1) Establishment of fluidized bed biomass gasification process with tar treatment technology.
1-1) Establishment of highly-stabilized fluidized bed technology 1-1-1) Investigation of structure and operational procedure of Pulse Controlled Loop Seal 1-1-2) Investigation of scaling up procedure 1-1-3) Experiment with pilot scale cold model 1-1-4) Application to demonstration plant 1-2) Optimization of clay catalysts 1-2-1) Collection of clay mineral samples 1-2-2) Evaluation of the catalysts' activities 1-2-3) Physical and chemical analysis of catalyst and elucidation of catalytic mechanism 1-3) Development of char drawing system 1-3-1) Development of concept for char drawing system 1-3-2) Cold mode testing 1-3-3) Application to demonstration plant 1-4) Establishment of biomass preparation and feeding system 1-4-1) Development of concept for biomass preparation and feeding system 1-4-2) Testing with prototype 1-4-3) Application to demonstration plant 1-5) Establishment of gasification residue recycling system for fertilizer 1-5-1) Analysis of residue and evaluation as fertilizer 1-5-2) Development of fertilizer production process from the residue 1-5-3) Demonstration of fertilizer production 1-5-4) Field test of the fertilizer 1-6) Operation of demonstration plant 1-6-1) Designing of demonstration plant 1-6-2) Construction of the demonstration plant 1-6-3) Operation of the demonstration plant	1-1) Establishment of highly-stabilized fluidized bed technology 1-1-1) Investigation of structure and operational procedure of Pulse Controlled Loop Seal 1-1-2) Investigation of scaling up procedure 1-1-3) Experiment with pilot scale cold model 1-1-4) Application to pilot plant 1-2) Optimization of clay catalysts 1-2-1) Collection of clay mineral samples 1-2-2) Evaluation of the catalysts' activities 1-2-3) Physical and chemical analysis of catalyst and elucidation of catalytic mechanism 1-3) Development of char drawing system 1-3-1) Development of concept for char drawing system 1-3-2) Cold mode testing 1-3-3) Application to pilot plant 1-4) Establishment of biomass pretreatment system 1-4-1) Development of concept for biomass pretreatment system 1-4-2) Testing prototypes of pretreatment system 1-4-3) Application to pilot plant 1-5) Development of processing system of fertilizer from gasification residue. 1-5-1) Analysis of residue and evaluation as fertilizer 1-5-2) Development of fertilizer production process from the residue 1-5-3) Demonstration of fertilizer production 1-5-4) Field test of the fertilizer 1-6) Operation of pilot plant 1-6-1) Designing of pilot plant 1-6-2) Construction of the pilot plant 1-6-3) Operation of the pilot plant 1-7) Development of tar treatment technology 1-7-1) Lab scale tar cracking experiment 1-7-2) Design of tar cracking system 1-7-3) Construction of tar cracking system 1-7-4) Operation at pilot plant
2) Development of liquid fuel production system 2-1) Development of low cost catalyst for methanol synthesis 2-1-1) Initial screening of possible catalysts 2-1-2) Elucidation of catalytic mechanism and investigation for activity enhancement 2-1-3) Application to demonstration plant 2-2) Establishment of low pressure methanol synthesis process 2-2-1) Investigation of raw gas pre-treatment 2-2-2) Pilot plant designing 2-2-3) Pilot plant construction and operation 2-2-4) Demonstration plant designing 2-2-5) Demonstration plant construction 2-2-6) Demonstration plant operation	2) Development of liquid fuel production system 2-1) Development of sustainable catalyst for methanol synthesis 2-1-1) Initial screening of possible catalysts 2-1-2) Elucidation of catalytic mechanism and investigation for activity enhancement 2-1-3) Application to prototype 2-2) Establishment of Methanol synthesis prototype for small scale application with low cost process 2-2-1) Investigation of raw gas pre-treatment 2-2-2) Prototype designing 2-2-3) Prototype construction and installation 2-2-4) Prototype operation 2-3) Conduct of fundamental research of gas fermentation process. 2-3-1) Literature Studies and Design of Experiment 2-3-2) Materials and Strains order 2-3-3) Review Paper Writing 2-3-4) Stock and Seed Culture Preparation 2-3-5) Bacteria cultivation and optimization 2-3-6) Preliminary Study of Fermentation (Bottle Serum) 2-3-7) Optimization in batch reactor 2-3-8) Productivity enhancement in continuous bioreactor using membrane gas-liquid conductor

3) Development of human resources and establishment of biomass energy network 3-1) Development of human resources 3-1-1) Preparation for training programs 3-1-2) Implementation of training programs 3-2) Establishment of network 3-2-1) Organization of international seminars 3-2-2) Publishing newsletters	3) Development of human resources and establishment of biomass energy network 3-1) Development of human resources 3-1-1) Implementation of training exchange programs in Japan 3-1-2) Implementation of local training programs 3-2) Establishment of network 3-2-1) Organization of international seminars 3-2-2) Publishing newsletters

Annex 7: List of Seminars, Workshops and Trainings

	Year	Date	Name of Event	Place (Country)	Number of participants
1	2014	2015/2/28	Workshop "Aiming at development of biomass waste gasification and liquid fuel production technology suitable for Asian region"	Japan	32
2	2015	2015/4/13	"Appropriate Technology and an Alternative World - Based on Practical Experience in Indonesia"	ITB (Indonesia)	Approx.120
3	2015	2015/7/8	"Appropriate Technology and Future International Cooperation-From Practice in Indonesia "	Tokyo Institute of Technology (Japan)	52
4	2015	2015/8/22	"Appropriate Technology and an Alternative World - Based on Practical Experience in Indonesia" "	University of Indonesia (Indonesia)	Approx. 70
5	2015	2015/10/13	"Development of Appropriate Technology for Using Biomass Energy in Indonesia"	University of Janabadra (Indonesia)	Approx.100
6	2015	2015/11/10-2015/11/12	Local Technical Training "Technical Training Program for Utilizing Biomass as an Energy Resource"	Indonesia	128 in total
7	2015	2015/12/14	"Appropriate Technology for a New Dimension and an Alternative World"	University of Brawijaya (Indonesia)	Approx.50
8	2015	2016/2/17	International Seminar "Appropriate Technology for Biomass Derived Fuel Production"	Indonesia	120
9	2016	2016/7/19	1st Design WS	Indonesia	32
10	2016	2016/8/23	2nd Design WS	Indonesia	30
11	2016	2016/9/15	3rd Design WS	Indonesia	30
12	2016	2016/12/21	4th Design WS	Indonesia	30
13	2019	2019/5/2	International Seminar "Biomass to Energy"	Indonesia	94
14	2019	2019/5/3	Local Technical Training "Technical Training Program for Utilizing Biomass as an Energy Resource"	Indonesia	50