

**インドネシア共和国（科学技術）  
中部ジャワ州グンディガス田における  
二酸化炭素の地中貯留及び  
モニタリングに関する先導的研究  
詳細計画策定調査報告書**

平成 24 年 3 月  
( 2012 年 )

独立行政法人国際協力機構  
地球環境部

環 境
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## 序 文

インドネシア共和国は、泥炭地からの二酸化炭素排出量を含めた場合、中国、米国に次ぐ世界第3位の温室効果ガス排出国であり、経済成長に伴うエネルギー需要の増加に付随し、排出量が今後増加することが懸念されています。

2009年10月に発足したインドネシア共和国の第2期ユドヨノ政権は、2020年の温室効果ガス排出量を26%削減する自主的な削減目標を設定し、気候変動問題に積極的に取り組む姿勢を見せています。そのようななか、特に同国がエネルギーを依存する石炭火力発電所から排出される温室効果ガス削減の1つの手段として、二酸化炭素回収貯留（Carbon Dioxide Capture and Storage：CCS）技術が注目され、期待が高まっています。

こうしたことを背景にCCSに係る研究を進めているバンドン工科大学を実施機関としたプロジェクトの要請がインドネシア共和国政府からわが国に対しなされ、他方、これまで同大学と共同研究を進めていた京都大学から科学技術協力案件の提案があり、本プロジェクトが採択されました。

これを受けて独立行政法人国際協力機構（JICA）は、協力内容の協議のために2011年10月2日から10月11日まで詳細計画策定調査団（団長：地球環境部環境管理グループ環境管理第一課長野田英夫）を派遣し、2011年10月8日に協議議事録に署名しました。

本報告書は同調査団の調査及び協議結果を取りまとめたものであり、今後、本プロジェクトの実施にあたり、広く活用されることを願うものです。

ここに、本調査にご協力を頂いた在インドネシア共和国日本国大使館など、内外関係機関の方々に深く謝意を表すとともに、引き続き当機構の活動に一層のご支援をお願いする次第です。

平成24年3月

**独立行政法人国際協力機構**

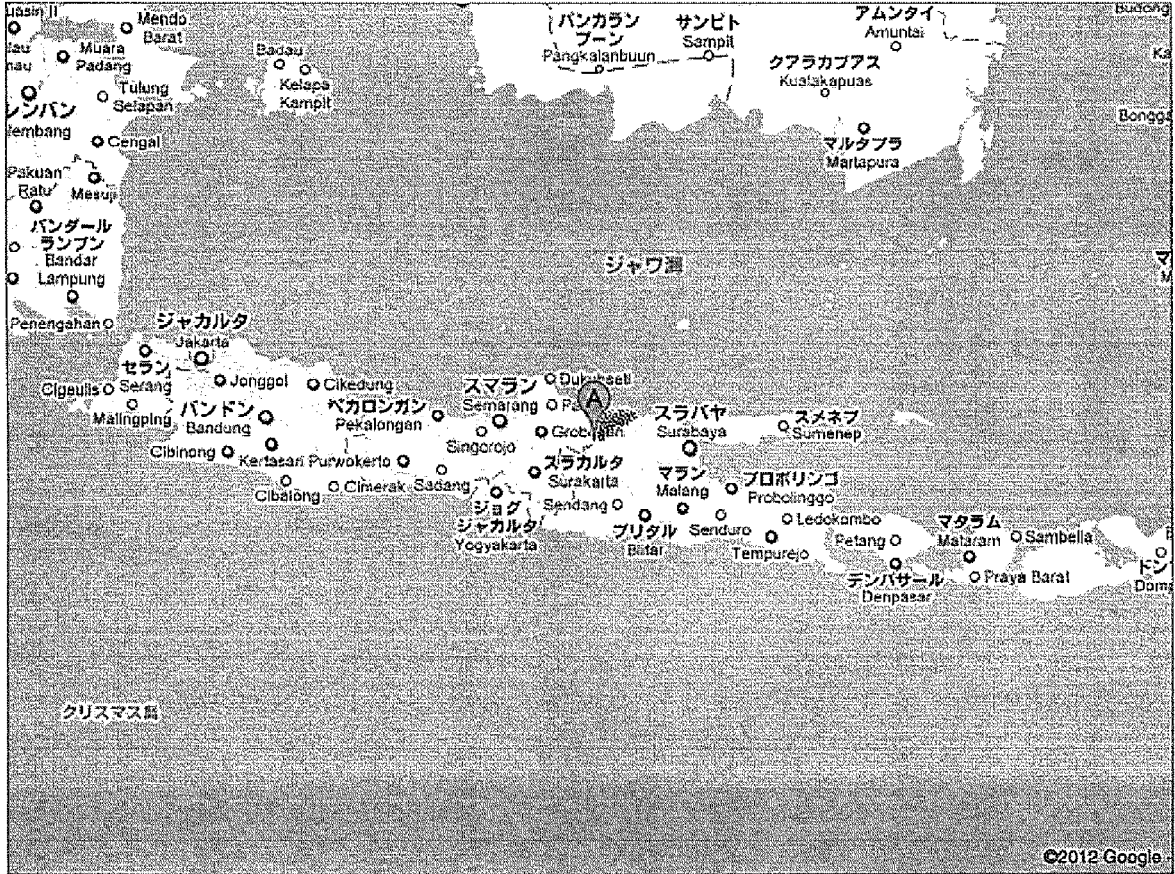
地球環境部長 **江島 真也**

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A. Cepu  
インドネシア



Google mapよりグンディガス (Gundih) のおよその位置



グンディガス田の Kedungtuban 地区にある既に掘削された生産坑井を視察 (10/3)



グンディガス田の Randublatung 地区にある既に掘削された生産坑井を視察 (10/3)



国営石油会社における協議。右手前が Adriansyah 副社長 (10/5)



国営石油会社での会議終了後、Adriansyah 氏 (中央) 等と合同写真を撮る (10/5)



科学技術省の Teguh 副大臣を表敬訪問 (10/5)



ITB にて、ITB 側関係者 (Wawan 副学長、Sule 講師等) とプロジェクト内容を協議。10月6~7日と協議を継続



ITB Wawan 副学長と野田团长による M/M 署名式 ( 10/8 )



M/M 署名後、参加関係者で全体写真を撮る。左より 2 人目が Sule 講師、中央が教育省高等教育総局長 ( 元 ITB 学長 ) の Djoko Santoso 氏

## 略 語 表

略 語	英語/インドネシア語名	日本語名
ADB	Asian Development Bank	アジア開発銀行
BPMIGAS	Oil and Gas Implementing Body	石油ガス上流政策実施機関
CCS	Carbon Dioxide Capture and Storage	CO <sub>2</sub> 分離回収・貯留
CO <sub>2</sub>	Carbon Dioxide	二酸化炭素
EOR	Enhanced Oil Recovery	石油増進回収
ESDM	Ministry of Energy and Mineral Resources	エネルギー・鉱物資源省
F/S	Feasibility Study	実施可能性調査
GHG	Greenhouse Gas	温室効果ガス
G&G	Geological and Geophysical	地質学的・地球物理学的
ITB	Institut Teknologi Bandung	バンドン工科大学
JCC	Joint Coordinating Committee	合同調整委員会
JICA	Japan International Cooperation Agency	独立行政法人国際協力機構
JST	Japan Science and Technology Agency	独立行政法人科学技術振興機構
LEMIGAS	R&D Center for Oil and Gas Technology	エネルギー・鉱物資源省石油ガス 技術研究センター
MIGAS	Directorate General of Oil and Gas	エネルギー・鉱物資源省石油ガス 総局
M/M	Minutes of Meetings	協議議事録
PDM	Project Design Matrix	プロジェクト・デザイン・マトリ ックス
PO	Plan of Operation	活動計画表
RISTEK	Ministry of Research and Technology	科学技術省
RITE	Research Institute of Innovative Technology for the Earth	(財)地球環境産業技術研究機構
SOP	Standard Operation Procedures	手順書



# 第1章 詳細計画策定調査の概要

## 1-1 調査の背景・経緯

インドネシア共和国（以下、「インドネシア」と記す）は、泥炭地からの二酸化炭素（Carbon Dioxide : CO<sub>2</sub>）排出量を含めた場合、中国、米国に次ぐ世界第3位の温室効果ガス（Greenhouse Gas : GHG）排出国（31億4,300万CO<sub>2</sub>換算トン、国際湿地保全連合報告）である。経済成長に伴うエネルギー需要の増加に付随するGHG排出量の増加も懸念されており、GHG排出量削減に向けた同国の果たすべき役割が期待されている。

これを踏まえ、2009年10月に発足した第2期ユドヨノ政権は、2020年のGHG排出量を26%削減する自主的な削減目標を設定し、国家中長期開発計画のなかに気候変動問題を主要課題として継続的に組み込むため、2010-2029年の約20年間にわたる適応策及び緩和策に係る部門別ロードマップ「インドネシア国気候変動ロードマップ（Indonesia Climate Change Sectoral Roadmap : ICCSR）」（2010年3月）を策定するなど、気候変動対策を同政権の重要な政策課題と位置づけている。

同ロードマップでは、特に同国がエネルギーを依存する石炭火力発電所から排出されるGHG増加が課題として示されており、CO<sub>2</sub>の回収貯留（Carbon Dioxide Capture and Storage : CCS）は、エネルギーセクターの緩和策の1つになり得るとされている。一方、同国内においては、CCSに関する調査研究が始まったばかりであり、CO<sub>2</sub>の地中貯留部分に特に焦点を当てる本事業は、エネルギーの大部分を石炭火力発電に頼る同国において、経済成長と気候変動対策を両立し得る技術として開発ニーズは高く、バンドン工科大学（Institut Teknologi Bandung : ITB）や国営石油会社を中心となって、CCSの技術開発を進めている。

CCSに関して、わが国では、2000年ごろから（財）地球環境産業技術研究機構（Research Institute of Innovative Technology for the Earth : RITE）を中心に研究と技術開発が進められてきた。特にCO<sub>2</sub>の挙動に関するモニタリングにかかわる技術開発に関しては、実験室レベルでの基礎的な研究と同時に、新潟県長岡市での圧入実験も行われ、一定の技術開発の成果が得られている。

今後、広くインドネシア各地でCCSを実施するためには、多くの専門家が必要なことから、ITBを中心とした研究者の育成に関するプロジェクトがインドネシア政府よりわが国に対し要請され、他方、これまでITBと共同研究を進めていた京都大学から科学技術協力案件の提案があり、本プロジェクトが採択された。

本調査は、インドネシア政府からの協力要請の背景及び既存の研究内容を確認し、先方研究者及び政府関係機関等との協議を経て、中部ジャワ州グンディガス田開発において、東南アジアで最初のCCS実施への協力を行うためのプロジェクトデザインを策定する。また、インドネシア側実施体制の現状を含め、本プロジェクトの事前評価を行うために必要な情報を収集、分析することを目的とする。

## 1 - 2 技術協力プロジェクトに関するインドネシア側からの要請概要

本技術協力の要請書は、インドネシア政府から日本政府に対して提出された。要請概要は、以下のとおりである。

要請案件名	(科学技術) インドネシア東ジャワ州グンディガス田における二酸化炭素の地中貯留及びモニタリングに関する先導的研究
要請機関	ITB
上位目標	CO <sub>2</sub> 地中貯留によって、低炭素社会に向けたエネルギーシステムへの貢献をすること
案件の目標	東南アジアで最初のCO <sub>2</sub> 地中貯留パイロットプロジェクトを実施すること
期待される成果	1) 構造、物理的特性に基づく貯留層の特性づけ 2) キャップロックの特性づけ 3) CO <sub>2</sub> 移動の解析 4) CO <sub>2</sub> 注入過程のモニタリングに関連する技術の向上
活 動	1) 必要な地質学的・地球物理学的データの収集と分析 2) パイロットプロジェクトの詳細設計 3) CO <sub>2</sub> 注入の実施及びモニタリング 4) 実験結果のまとめ
協力期間	5年間

## 1 - 3 調査目的・内容

プロジェクトに係る対象国の実施体制等を確認し、現地調査及び資料収集を行い、本案件の方針や方法を検討する。また、協議議事録 (Minutes of Meetings : M/M) の署名及び交換を通じ、対象国側とプロジェクト方針を確認する。

## 1 - 4 調査団構成

分 野	氏 名	所 属
総 括	野田 英夫	JICA地球環境部環境管理第一課 課長
環境管理/気候変動	肥田野 るり	JICA地球環境部環境管理第一課 副調査役
研究総括	松岡 俊文	京都大学大学院工学研究科都市社会工学専攻 教授
研究計画	高橋 亨	公益財団法人深田地質研究所 理事
評価分析	皆川 泰典	株式会社システム科学研究所 上席研究員

上記調査団員に加えて、独立行政法人科学技術振興機構 (Japan Science and Technology Agency : JST) による以下調査団が同行した。

氏 名	所 属
林 欣吾	JST地球規模課題国際協力室 主任調査員
葉山 雅	JST地球規模課題国際協力室 主査

## 1 - 5 調査日程

### (1) 調査日程

2011年10月2日（日）～11日（火）

日順	日付	内 容
1	10/2（日）	移動（成田～スラバヤ）
2	10/3（月）	移動（スラバヤ～チェプ） グンディガス田サイト視察
3	10/4（火）	移動（チェプ～スラバヤ～ジャカルタ）
4	10/5（水）	国営石油会社との面談 在インドネシア日本大使館表敬 JICAインドネシア事務所打合せ 科学技術省（Ministry of Research and Technology : RISTEK）との面談 エネルギー鉱物資源省（Ministry of Energy and Mineral Resources : ESDM） との面談
5	10/6（木）	移動（ジャカルタ～バンドン） ITBと案件スコープ確認
6	10/7（金）	ITB・国営石油会社とのプロジェクト・デザイン・マトリックス（Project Design Matrix : PDM）協議
7	10/8（土）	ITB副学長・教育省高等教育総局長とM/M・討議議事録（R/D）ドラフト協議 M/M署名 移動（バンドン～ジャカルタ）
8	10/9（日）	資料整理
9	10/10（祝）	JICAインドネシア事務所への報告 国営石油会社との面談 移動（ジャカルタ～成田）
10	10/11（火）	成田着

### (2) 訪問先

インドネシア関係機関（ESDM、RISTEK、国営石油会社、ITB）等

## 1 - 6 調査結果

### (1) プロジェクトタイトルの変更

プロジェクトサイトとなるグンディガス田は、東ジャワ州及び中部ジャワ州の境界付近に位置するが、正確には中部ジャワ州にあることから、プロジェクトタイトルを以下のとおり変更した。

変更後：Pilot Study for Carbon Sequestration and Monitoring in Gundih Area, Central Java Province, Indonesia

変更前：Pilot Study for Carbon Sequestration and Monitoring in Gundih Area - East Java Province, Indonesia

(2) 案件目標及び活動の設定（付属資料1．Annex I PDM参照）

以下のとおり関係者と合意した。

1) 目標：インドネシアにおけるCO<sub>2</sub>地中貯留及びモニタリング技術の作業手順書整備

2) 活動：

- ① フェーズ1：グンディガス田におけるCO<sub>2</sub>貯留層探索のための技術開発及びコスト計算も含めたCO<sub>2</sub>注入のフィージビリティ・スタディ（Feasibility Study：F/S）（並びにF/Sを基にした、CO<sub>2</sub>注入井掘削に係る関係者調整）
- ② フェーズ2：CO<sub>2</sub>注入後のCO<sub>2</sub>挙動のモニタリング
- ③ フェーズ1からフェーズ2に移行するためには、案件スコープ外の活動であるCO<sub>2</sub>注入井の掘削可否が大きく影響することから、フェーズ1が終わる前後で進捗確認及びその後の活動計画・期間を見直すことで先方及びJSTと合意した。
- ④ なお、現段階では当初要請時から想定していたベストシナリオ（グンディガス田から出るCO<sub>2</sub> 30万トン貯留対象としてそれに係る追加コストをガス田開発コストと共に利益から差し引くコストリカバリーが国によって認められること）を基に案件スコープを定めている。
- ⑤ CO<sub>2</sub>貯留のための井戸掘削可否は、国営石油会社の内部決定や政府内部の検討状況に左右されることから、フェーズ1の間にその他シナリオを同時並行で検討する予定（浅い場所に少ない量のCO<sub>2</sub>を貯留する等）。
- ⑥ 万一、CO<sub>2</sub>注入井の掘削がなされなかったとしても、フェーズ2を変更して、ガス貯留層以外の地層も含め、ガス開発時の地層変化をモニタリングする等、CCS実用化に寄与する活動を続けたいとの意向が先方及び当方実施機関より示された。

(3) 先方実施体制

1) 実施機関：ITB（ITBとつながりのある国営石油会社含む他所属の研究者含む）

2) その他：（付属資料2．エネルギー鉱物資源省組織図参照）

① 教育省

ITBの所管官庁は教育省であり、通常ITBを含む国立大学へのJICA協力においては教育省がJICA専門家や機材の便宜供与をしていることからR/Dへのウィットネスとしてサインを求めた。先方も前例があるとのことでこれを了承。

② エネルギー鉱物資源省

2010年10月に設立されたNew Renewable Energy and Energy Conservation総局がCCSを所掌することになっており、R/Dへウィットネスとして署名する方向で今後調整することとなった。

なお、石油ガス総局（Directorate General of Oil and Gas：MIGAS）は石油・ガス開発上流の政策官庁。また、同省の中にはOil and Gas Implementing Body（BPMIGAS）という石油・ガス開発上流の執行官庁が独立して存在しており、個別案件ごとの石油・ガス開発計画の承認をしている。ガス田開発計画のなかにCCSを含めることになれば、通常の手続きどおりBPMIGASの承認が必要だけでなく政策官庁であるMIGASの承認も得なければならない可能性が指摘された。

(4) その他

- 1) JICA専門家のリサーチパーミットについて、RISTEKから必要との見解が示された（付属資料3．面談録参照）が、JICA事務所と相談の結果、リサーチパーミットによらず、一般の技術協力と同様の手続きのなかでJICA専門家の身分、活動を確保することとした。したがって、R/DへのRISTEKの署名も不要とし、その旨ITBとも合意した。
- 2) JICA長期専門家として業務調整員を派遣することについてITBと合意。専門家執務室については既にITB内に準備されていることを確認した。

## 第2章 事業事前評価結果

### 2 - 1 事業の背景と必要性

#### (1) 当該国における気候変動対策の現状と課題

インドネシアは、泥炭地からのCO<sub>2</sub>排出量を含めた場合、中国、米国に次ぐ世界第3位のGHG排出国（31億4,300万CO<sub>2</sub>換算トン、国際湿地保全連合報告）である。経済成長に伴うエネルギー需要の増加に付随するGHG排出量の増加も懸念されており、GHG排出量削減に向けた同国の果たすべき役割が期待されている。

これを踏まえ、2009年10月に発足した第2期ユドヨノ政権は、2020年のGHG排出量を26%削減する自主的な削減目標を設定し、国家中長期開発計画のなかに気候変動問題を主要課題として継続的に組み込むため、2010-2029年の約20年間にわたる適応策及び緩和策に係る部門別ロードマップ「インドネシア国気候変動ロードマップ（ICCSR）」（2010年3月）を策定するなど、気候変動対策を同政権の重要な政策課題と位置づけている。

同ロードマップでは、特に同国がエネルギーを依存する石炭火力発電所から排出されるGHG増加が課題として示されており、CO<sub>2</sub>の回収貯留（CCS）は、エネルギーセクターの緩和策の1つになり得るとされている。一方、同国内においては、CCSに関する調査研究が始まったばかりであり、CO<sub>2</sub>の地中貯留部分に特に焦点を当てる本事業は、エネルギーの大部分を石炭火力発電に頼る同国において、経済成長と気候変動対策を両立し得る技術として開発ニーズは高い。

#### (2) 当該国における気候変動対策と本事業の位置づけ

インドネシア政府は、新エネ・省エネの推進のため2011年2月にエネルギー鉱物資源省内に、新・再生可能エネルギー・省エネルギー総局を設立した。同局は、2025年の1次エネルギーに占める新・再生可能エネルギーの割合を25%とする目標「Vision 25/25」や、それらを推進するための「Clean Energy Initiative」を発表している。同イニシアティブは化石燃料の燃焼によるCO<sub>2</sub>排出を削減する総合的な指針であり、化石燃料燃焼後の対策の1つとしてCCSの技術開発が進められることになっている。同国内で初のCO<sub>2</sub>地中貯留実証試験に取り組もうとする本事業は、CCS技術開発の基盤を確立するうえで重要な役割を果たすことが期待される。

#### (3) 気候変動対策に対するわが国及びJICAの援助方針と実績

近年、気候変動問題が深刻化するなか、わが国は2009年9月の国連気候変動首脳会合において、途上国のCO<sub>2</sub>排出削減に対する先進国の資金・技術支援を表明するとともに、わが国のCO<sub>2</sub>25%削減目標（2020年までに1990年比で25%、2005年比で33.3%削減）を発表しており、CO<sub>2</sub>の削減問題への取り組みは日本・インドネシア両国において国家的な課題ともなっている。最新のをが国の「対インドネシア事業展開計画」（2010年8月1日付）において、気候変動対策プログラムは「特別課題」と位置づけられており、本事業はわが国及びJICAの援助方針に合致したものとなっている。

#### (4) 他の援助機関の対応

同国におけるCCS導入への取り組みに対する他ドナーの支援はまさに始まったばかりであ

る。2009年にCCS展開のポテンシャルに関する技術調査<sup>1</sup>が英国大使館の支援を受けて実施され、さらに、アジア開発銀行（Asian Development Bank：ADB）は、2011年度より同国を含む各国にて、CCSの環境への影響、パイロットプロジェクトの実施可能性の調査等、CCS実施のロードマップを作成する技術支援<sup>2</sup>を実施中である。

なお、独立行政法人新エネルギー・産業技術総合開発機構（NEDO）の地球温暖化対策技術普及等推進事業のなかで、日系石油会社と商社が共同で同国における温室効果ガス削減CCSプロジェクトの案件組成調査を実施中。

## 2 - 2 事業概要

### （1）事業目的（協力プログラムにおける位置づけを含む）

本事業は、中部ジャワ州にあるグンディガス田においてCO<sub>2</sub>地中貯留時の深部地層の評価技術やCO<sub>2</sub>の分布・挙動モニタリング手法について調査し、手順書（Standard Operation Procedures：SOP）にまとめて提案することにより、インドネシアの陸域ガス田におけるCCS事業促進の一助とするものである。

### （2）プロジェクトサイト/対象地域名

バンドン、中部ジャワ州グンディガス田

### （3）本事業の受益者（ターゲットグループ）

バンドン工科大学（Institut Teknologi Bandung：ITB）の研究者等約50名、その他CCS事業者・研究者等

### （4）事業スケジュール（協力期間）

2012年4月～2017年3月を予定（計60カ月）

### （5）総事業費（日本側）

3.7億円

### （6）相手国側実施機関

ITB

### （7）投入（インプット）

#### 1）日本側：

専門家：長期専門家1名（業務調整）、短期専門家約20名（地質・地質物理・石油開発等）、総80M/M（予定）

本邦研修：日本におけるCCS等の視察研究

<sup>1</sup> “Understanding Carbon Capture and Storage Potential in Indonesia”, November 2011, Indonesia CCS Study Working Group

<sup>2</sup> ADBのプロジェクト名は“Determining the Potential for Carbon Capture and Storage in Southeast Asia”。同プロジェクトには、インドネシアではエネルギー・鉱物資源省石油ガス技術研究センター（R&D Center for Oil and Gas Technology：LEMIGAS）が参加し、南スマトラ州のメルバウ油田を対象にして同調査を進めている。

供与機材：CO<sub>2</sub>モニタリング作業に必要な各種測定装置、データ解析用コンピュータ及びソフトウェア等  
在外事業強化費

2) インドネシア側

カウンターパート：総括責任者、実施責任者を含めた研究者約50名  
施設等

(8) 環境社会配慮・貧困削減・社会開発

1) 環境社会配慮

カテゴリ分類：B

カテゴリ分類の根拠：本事業は「国際協力機構環境社会配慮ガイドライン」(2010年4月公布)に掲げる影響を及ぼしやすいセクター・特性及び影響を受けやすい地域に該当せず、環境への望ましくない影響は重大でないと判断されるため。

環境許認可：事業実施段階で確認予定。

汚染対策：事業実施段階で確認予定。

自然環境面：事業実施段階で確認予定。

社会環境面：事業実施段階で確認予定。

その他・モニタリング：事業実施段階で確認予定。

2) ジェンダー・平等推進/平和構築・貧困削減

特になし。

3) その他

特になし。

(9) 関連する援助活動

特になし。

2 - 3 協力の枠組み

(1) 協力概要

1) プロジェクト目標

インドネシアの陸域ガス田におけるCCS事業推進のため、CCS技術を安全に適用するために不可欠となる深部地層の評価技術、地下でのCO<sub>2</sub>分布・挙動のモニタリング技術に関するSOPが提案される。

2) 成果及び活動

成果1：グンディガス田におけるCO<sub>2</sub>地中貯留及びモニタリングに関する実施体制が検討され、詳細な実施計画が作成される。

指標1：実施体制、作業計画等が決定される。



グンディガス田でのCO<sub>2</sub>地中貯留・モニタリングの詳細実施計画書が協議・作成される。

活動：

- 1-1．具体的な体制・担当者を決め、研究チームをつくる。
- 1-2．研究者の作業計画を作成する。
- 1-3．エネルギー・鉱物資源省等関係省・部局間の調整枠組みを設定する。
- 1-4．国際的な調整の枠組みを設定する。
- 1-5．上記1-3及び1-4で設定した枠組みを定期的に見直し、改訂する。
- 1-6．技術交流会合（半年に1度）やCCSシンポジウムを開催する。
- 1-7．技術的観点から、インドネシアにおけるCCSに関する準備調査を実施する。
- 1-8．グンディガス田におけるCO<sub>2</sub>注入及びモニタリングのためのCCS実施戦略に関して調査する。
- 1-9．1-1から1-8を踏まえ、詳細な実施計画が作成される。

成果2：成果3での活動及び地表施設の設計シミュレーションを行うため、CO<sub>2</sub>地中貯留サイト及びCO<sub>2</sub>貯留層の特性が調査され、評価される。

指標2：グンディガス田に関する地質学・地球物理学的探査（Geological and Geophysical：G&G）及び物理学的特性のデータベースが構築される。

グンディガス田でのCCSのための地質・貯留層モデルが構築される。

貯留層における注入済みCO<sub>2</sub>の挙動が、少なくとも3段階（注入直後、CO<sub>2</sub>貯留定着後、1000年後）で予測される。

地表施設を計画するためのシミュレーション予測がなされる。

活動：

- 2-1．CO<sub>2</sub>地中貯留サイト、CO<sub>2</sub>貯留を記述しモデルを作成する。
  - 2-1-1．CO<sub>2</sub>地中貯留サイト及び貯留層を表す必要なデータを収集し、データベースを更新する。
  - 2-1-2．地質モデル構築のため、グンディガス田の周辺地域で補足的な地質学・地球物理学的探査（G&G）を実施する。
  - 2-1-3．既存及び新規データを利用して、同サイト・CO<sub>2</sub>貯留層の地質モデルを構築する（静的貯留層モデル）
- 2-2．室内実験
  - 2-2-1．貯留層から得られたコアの利用可能性をチェックする。
  - 2-2-2．室内実験の装置をセットアップする。
  - 2-2-3．貯留層における岩石の特性を調べる室内実験を実施する。
- 2-3．貯留層のシミュレーション及び評価を実施する。
  - 2-3-1．地質データと室内実験データを用いて、貯留層モデルを構築する。
  - 2-3-2．新しい地質学・地球物理学モデル（動的モデル）を用いて、貯留層のシミュレーション及び評価を実施する。
- 2-4．地表施設設計のためのシミュレーションを行う。

成果3：グンディガス田でのCO<sub>2</sub>地中貯留及びモニタリングのため、地表施設設計とコスト評価を含むフェージビリティ調査（F/S）が実施される。

指標3：グンディガス田におけるCO<sub>2</sub>地中貯留及びモニタリングに関する指針をまとめた報告書が作成される。

グンディガス田における地表施設の設計報告書が作成される。

活動：

3-1．コスト評価を含むCO<sub>2</sub>地中貯留及びモニタリングに関するグラウンドデザインを作成する。

3-2．CO<sub>2</sub>地中貯留及びモニタリングのための地表施設を設計する。

3-3．環境社会への影響を調査する。

成果4：CO<sub>2</sub>貯留層の評価及びモニタリング技術検証のためにCO<sub>2</sub>地中貯留及びモニタリングに応用する地球物理学的及び地球化学的技術が実際の貯留層において適用され、評価される。

指標4：貯留層の評価及びモニタリング手法でのデータ収集及びデータ処理の方法が報告書にまとめられる。

活動：

4-1．JICAから提供された装置を用いて、測定技術に関する現場作業を実施する。

4-2．以下に示すモニタリング手法について、データ取得、処理、解析を実施する。

4-2-1．4D高分解能反射法地震探査

4-2-2．4D電気/電磁探査法

4-2-3．4Dマイクロ重力探査法

4-2-4．InSAR・GPSを利用した手法

4-2-5．4D微小地震モニタリング法

4-2-6．自然地震を利用したトモグラフィ/地震波干渉法によるモニタリング

4-2-7．地球化学/水理学的モニタリング手法

4-2-8．各種物性を利用した貯留層内のCO<sub>2</sub>飽和状態定量的評価手法

成果5：グンディガス田におけるCO<sub>2</sub>地中貯留及びモニタリングの分析・評価を基にしてSOPが作成される。

指標5：陸域ガス田でのCO<sub>2</sub>地中貯留及びモニタリングに関するSOPが作成される。

活動：

5-1．グンディガス田におけるCO<sub>2</sub>地中貯留及びモニタリングの結果をレビュー・評価する。

5-2．CO<sub>2</sub>地中貯留及びモニタリングに関するSOPを作成する。

5-3．SOPに関するセミナーを開催し、公表する。

## (2) その他インパクト

本事業を通じてCO<sub>2</sub>地中貯留のSOPは、同国内で課題となっている石炭火力発電所から発生するCO<sub>2</sub>削減対策を検討するうえでの基礎となり、気候変動対策に貢献するものとなり得る。

## 2 - 4 外部条件・前提条件

### (1) 事業実施のための前提

ITBとグンディガス田の開発をする国営公社間で秘密保持契約等に係る覚書が締結される。

### (2) 成果達成のための外部条件

グンディガス田の地質学・地球物理学的データが利用可能である。

### (3) プロジェクト目標達成のための外部条件

特になし。

## 2 - 5 プロジェクトのモニタリングと評価

### (1) 実施体制と内容

本プロジェクトのモニタリングについては、日本・インドネシア共同のモニタリングとして合同調整委員会（Joint Coordinating Committee：JCC）を少なくとも年1回開催して実施することとする。JCCの構成メンバーを、付属資料1「Record of Discussions（R/D）案のANNEX VII」に示した。JCCの委員長は、インドネシア教育省高等教育総局長（元ITB学長）が就任予定である。

### (2) 評価

プロジェクト実施期間の中間時点で中間レビュー、プロジェクト終了前約6カ月の時点で終了時評価を実施する。本プロジェクトの当初計画が着実に実施されるためには、国営石油会社によるCO<sub>2</sub>注入実施内容がプロジェクト開始後2年の間で確定される必要があり、中間レビューにてその点確認することとする。

## 2 - 6 プロジェクト実施上の留意点

### (1) CO<sub>2</sub>の注入可能性について

本事業では注入するCO<sub>2</sub>調達コストを下げるため、ガスの生産現場で分離され通常は大気に放出されるCO<sub>2</sub>を用い、これを注入地点まで運搬し圧入する予定である。そのため、CO<sub>2</sub>注入のサイトとして国営石油会社がガス生産を開始する予定である中部ジャワ州グンディガス田が選ばれた。

地表設備（パイプラインやコンプレッサー等）と注入井の用意は本事業外で国営石油会社等の協力を得て進める予定であり、本事業内で作成するF/Sにて費用の算出等を行う予定。事業実施スケジュールを考慮すると開始後2年以内に注入井が用意される目途が立っている必要があるが、万一中途の段階でこれらの目途が立たない場合は、協力期間を見直しつつ、室内実験やシミュレーション結果を基に獲得したCO<sub>2</sub>貯留手法につき手順書にまとめる。

### (2) グンディガス田のデータの利用・公表について

同国においては、国内の油ガス田で、石油開発を目的に取得されたデータを国外に持ち出すことが禁じられている。そのため、グンディガス田のボーリングコア試料を用いた室内試験や各種データの解析はすべてインドネシア国内の研究施設において実施する必要がある。

したがって、本事業を進めるなかでのデータの管理について、管理体制や手順を決めるとともに、公表手続きについても同様な管理を行うよう留意する。

### (3) 環境影響評価について

グンディガス田では、ガスの生産にかかわる環境影響評価はオペレータである国営石油会社によって既に行われており、それに従って各種モニタリングも計画されている。一方、2011年12月の国連気候変動枠組条約第17回締約国会議でCCSのCDM（クリーン開発メカニズム）化が承認されたのを踏まえ、今後国際的な流れのなかで環境影響評価等が求められる可能性がある。その場合は適切に対応する必要がある。

## 2 - 7 5項目評価

### (1) 妥当性

以下の点から、本プロジェクト実施の妥当性は高いと判断される。

インドネシア政府は、ユドヨノ大統領が約束した「2020年のGHG排出量を、何も対策を講じない場合に比べて26%削減する」という自主的な削減目標達成のための具体的対策づくりを積極的に進めている。特に、化石燃料依存度の低減に向けて「Clean Energy Initiative」(2010)を発表し、そのなかで化石燃料燃焼後（Post-Fossil Combustion）の中心的対策としてCCSを位置づけており、本プロジェクトの内容は、インドネシアの開発政策、社会的ニーズと合致している。さらに、わが国の「対インドネシア事業展開計画」においても、気候変動対策プログラムが特別課題として位置づけられており、本プロジェクトはわが国の援助政策とも合致している。

また、本プロジェクトの実施機関であるITBと京都大学の間、さらにはITBと国営石油会社の間では長期にわたり研究と技術開発に関して良好な関係が構築されており、本プロジェクト実施上の懸案事項についても、緊密な連携がとられることが期待される。

CCSに関する他ドナー等の支援は始まったばかりである。英国大使館が、LEMIGASをカウンターパートとして技術面、ビジネス面、法制度等の課題整理のための調査を実施した(2009)ほか、ADBがCCS導入のためのパイロットプロジェクト実施準備調査を進めている。本プロジェクトはCCSの技術的研究に特化していることから活動の結果をタイムリーに提供すれば、他ドナーの調査を補完する内容になり得る。さらに、わが国では、2000年ごろから（財）地球環境産業技術研究機構（RITE）を中心にCCSの研究と技術開発が進められてきた。特にCO<sub>2</sub>の挙動に関するモニタリングにかかわる技術開発に関しては、実験室レベルでの基礎的な研究と同時に、新潟県長岡市での圧入実験も行われ、一定の技術開発の成果が得られており、本プロジェクトにおいてもそのノウハウの活用が期待できる。

### (2) 有効性

以下の点から、本プロジェクトの有効性は高いと判断される。

成果は5つ計画されているが、いずれもプロジェクト目標に示すSOPの構成要素に関する研究項目である。成果とプロジェクト目標との間にある外部条件は地質学・地球物理学的数据の利用可能性であり、同データ所有者の国営石油会社の許可が必要であるが、ITBと国営石油会社間での秘密順守に関する覚書を結び、これに基づいて利用可能となる予定。

### (3) 効率性

以下の観点から、本プロジェクトは効率性の高いものであると予想されるが、投入のタイミングはCO<sub>2</sub>注入に関する国営石油会社との調整に大きく依存する。

活動内容は、京都大学を中心とする日本側の大学の研究者とITBを中心とするインドネシア側研究者とが共同で設計した内容であり、参加するプロジェクト実施期間の長さ、活動に必要な時間、活動の難易度等を考慮して設定していることから、成果を出すために十分かつ具体的な活動が計画されている。また、日本側、インドネシア側双方で相当数の大学・研究組織の研究者の参加を想定していることから、具体的かつ十分な研究成果がアウトプットの指標として設定されている。

投入のタイミングは、CO<sub>2</sub>注入作業の実施に関する国営石油会社との調整に大きく依存している。もし、CO<sub>2</sub>注入作業の調整に時間がかかる場合には、CO<sub>2</sub>注入後のモニタリングに必要な機材の調達を含めて、成果4、成果5にかかわる活動に遅れが生じる可能性がある。また、本プロジェクトはグンディガス田で天然ガス生産時に分離されるCO<sub>2</sub>を注入の材料とするため、実質的な費用は発生せず注入するCO<sub>2</sub>を確保でき、さらに、CO<sub>2</sub>注入井の掘削については、本プロジェクトの予算では対応できないことから国営石油会社で実施することを想定しており、これらの点は費用対効果の観点から高く評価できる。

### (4) インパクト

CO<sub>2</sub>貯留が実用化された場合には、CO<sub>2</sub>排出削減への応用、石油増進回収 (Enhanced Oil Recovery : EOR) への展開、CCSの技術面での大きな進展が波及効果として期待される。また、インドネシア政府の気候変動対策等の政策面にも貢献することが予想される。

### (5) 持続性

気候変動対策は今後もインドネシア政府の大きな政策課題であることから、CO<sub>2</sub>貯留に関するSOPが本プロジェクトで作成され広く周知されることで、インドネシア政府の政策に組み込まれることが期待される。また、そうした政策面での自立発展性を強化するためにも、SOPの政令化等の推進を本プロジェクト活動のなかでも取り組んでいく必要がある。本プロジェクトに参加する日本・インドネシア双方の研究者は、対等の立場で協働作業を実施するという姿勢であり、この結果、インドネシア側研究者が本プロジェクト終了後、独自にCCS技術を発展させる自立発展性は十分に確保されている。

### (6) 結 論

本事業は、インドネシア国の開発政策、開発ニーズ、日本の援助政策と十分に合致しており、また計画の適切性が認められることから、実施の意義は高い。

## 第3章 国際共同研究の視点（本現地調査におけるJSTからのコメント）

### 3 - 1 本件の科学技術的な意義について

本件は平成23年度・地球規模課題対応国際科学技術協力事業（SATREPS）の環境・エネルギー分野（低炭素社会の実現に向けたエネルギーシステムに関する研究領域）において（条件付）採択された。

採択段階では「インドネシアの天然ガス田において、アジア初の大規模実証CCS（CO<sub>2</sub>回収貯蔵）プロジェクトでのモニタリング技術の研究開発に取り組むという興味深い研究テーマである」また「現地で実際にCCSプロジェクトを推進する企業と共同で行うために実効性も高く、及び「わが国にとっても将来的にCCS関連産業の強化やクリーン開発メカニズム（CDM）としての利用が期待できる提案内容である」と高く評価された。

その一方で、「国際共同研究として今後実施していくうえで、基礎研究的なモニタリングの研究だけにとどまらない将来的な社会実装を視野に入れた研究計画・研究目標となるよう配慮頂きたい」「地域住民への影響などを含めた事業実施に対する広範な環境社会配慮を強化することが期待される」という課題も指摘されている。

### 3 - 2 国際共同研究の実施の要件

本件は、提案段階から、CO<sub>2</sub>の地中圧入のためのサイト提供と圧入に必要な地表施設の提供、圧入井の掘削、CO<sub>2</sub>の分離、輸送、注入作業（分離回収されるCO<sub>2</sub>の全量を地中圧入する場合、年間で約30万トン）はインドネシア側にて準備されることが前提（想定）となっている。

これについては当然ながら採択段階で要確認事項のひとつとして挙げられ、面接選考の際に審査委員会から追加説明が求められ、松岡研究総括からは、CCS事業に必要な坑井の掘削費、圧入に必要な地上設備に関する費用の部分は、国営石油会社が負担し、既存データを基にした圧入場所の評価技術の開発、モニタリング技術開発の一部を、本プロジェクトの経費のなかで賄う予定との説明があった。

しかしながら、条件付採択後の両国の関係者間での協議において、インドネシア側がCO<sub>2</sub>圧入井の掘削及び地中注入を行うことが、必ずしも確定・確約されたものではなかったことが明らかになった。

そのため、今回の調査団では、インドネシア側予算によるCO<sub>2</sub>圧入井の掘削等の実施の見通しの確認、さらにCO<sub>2</sub>圧入井の掘削等が実施されない場合、または実施されても規模が縮小された場合に、研究計画の変更が生じるのか、生じる場合はその内容、SATREPS事業としての国際共同研究計画が成り立ち得るのか等の見通しの確認を行うことが大きな目的のひとつとなった。

今回の現地での確認・協議の結果、CCS実施機関である国営石油会社の理解と判断、政府機関による承認手続き等の困難さはあるものの、グンディガス田でのCCSの実施の可能性が残されていることが確認できた。

最初の1～2年は、当初の研究計画に基づき研究活動を行い、その課程で得られた研究成果を、インドネシア側の関連機関などに提供し、CO<sub>2</sub>圧入井の掘削等の実施を働きかけていき、CO<sub>2</sub>圧入井の掘削等の実施が当初の想定よりも小規模になる場合や、行われない場合も、それに応じた計画変更は必要になるものの国際共同研究が実施可能であるとの感触を得られた。JSTとしては、当初の提案書に記載されていたようにCCSが実施されるよう両国の参加機関・メンバーに注力頂くこ

とを期待するが、やむを得ず研究計画の変更が生じる場合は、密にご報告、ご相談頂きたい。

### 3 - 3 採択された研究計画内容との整合性について

上述の懸案事項があるものの、本来の共同研究計画自体（CO<sub>2</sub>圧入サイトの選定技術と圧入後のモニタリング技術の開発）については、提案書作成段階及び採択後に、両国の主な参加研究者間で、情報交換や協議が十分行われていたこともあり、今回の短期間での訪問中、おおむね日本側で採択された研究計画に変更を加えることがないことが確認できた。

### 3 - 4 インドネシア側の研究体制、意欲等について

今回、インドネシア側の研究機関や関係省庁はおおむね本共同研究に対する理解と参加意欲が高いことを確認できた。相手側研究代表者のWawan副学長及びSule講師は本共同研究に対して強い意欲をもっており、特にSule講師は今回のほとんどすべての協議先に同行頂くなど、インドネシア国の関係機関と積極的に協議・調整を行っていただいた。

Wawan副学長とSule講師の所属するITBの積極的な参画も期待できるうえ、実質的に共同研究機関として参加する国営石油会社の参加予定メンバー（特に同社研究開発センター）の意欲も確認できた。

松岡研究総括をはじめとする日本側の研究チームは、今回の調査団の準備段階から、技術セミナーの開催やPDM案や活動計画表（Plan of Operation：PO）案の作成など、本共同研究の円滑な立ち上げ及び実施に向けて、意欲的に取り組まれておられる。

一方で、今回のR/D案上では、両国の参加研究機関や参加研究者として、日本側8機関23名、インドネシア側11機関48名が記載されており、両国の研究代表者などの少数のコアメンバーを除くと、相手側研究者と日本側研究者との連携体制、研究分担などの協議・構築はこれからと見受けられた。R/D署名後の共同研究開始時期までに、具体的な研究内容・分担、達成目標などについての協議を密に行っていただくことを期待したい。

### 3 - 5 知的財産権

R/D署名前後に両国の代表機関間で締結される知的財産権の取り扱いなどに関する共同研究に関する合意文書については、基本的には京都大学案（JSTの雛型を使用）が受け入れられる見通しであることを確認できた。

さらに、ITBと国営石油会社間とで共同研究及び機密保持に関する合意文書も締結されることになっている。

なお、本件に関するグンディガス田の予備調査は、国営石油会社としての秘密事項にかかわることが多いことを理由に、これまでインドネシア側によって行われてきている。これらの情報は上記の関連機関間で秘密保持に関する合意文書を締結したのち、参加研究者（含む日本側）に提供される予定である。

### 3 - 6 その他

SATREPS事業の採択件数は平成20年度以降の年間で33カ国60課題であり、インドネシアを対象国とした案件は本件を含め6課題（低炭素社会領域では本件が最初）であり、最も採択課題が多い国の1つである。今後は他の採択課題との情報共有などを図っていただきたい。

< 参考 - 1 > インドネシアを対象国としたSATREPS案件のリスト

採択年度	分野（領域）	課題名	研究代表者名 （所属機関）	主要相手国研究機関
H20	環境・エネルギー（気候変動領域）	インドネシアの泥炭・森林における火災と炭素管理	大崎 満（北海道大学）	インドネシア国家標準局、パランカラヤ大学、インドネシア科学院 他
H20	防 災	インドネシアにおける地震火山の総合防災策	佐竹 健治（東京大学）	インドネシア科学院
H21	感染症	抗C型肝炎ウイルス（HCV）物質の同定及びHCV並びにデングワクチンの開発	堀田 博（神戸大学）	インドネシア大学
H21	環境・エネルギー（気候変動領域）	短期気候変動励起源地域における海陸観測網最適化と高精度降雨予測	山中 大学（海洋研究開発機構）	技術評価応用庁
H22	生物資源	生命科学研究及びバイオテクノロジー促進のための国際標準の微生物資源センターの構築	鈴木 健一郎（製品評価技術基盤機構）	インドネシア科学院
H23	環境・エネルギー（低炭素社会）	インドネシア中部ジャワ州グンディガス田におけるCO <sub>2</sub> の地中貯留及びモニタリングに関する先導的研究	松岡 俊文（京都大学）	バンドン工科大学

< 参考 - 2 > JSTによる国内研究支援内容

JSTによる国内研究支援（予定）は以下のとおり（なお、既にJST - 京都大学間で2011年6月1日付で暫定契約を締結済み）。

本研究への専従研究員の人件費

国内研究のための国内旅費、相手国以外への海外旅費（欧米での学会発表、アジア他国への出張等）、学生に対するインドネシア渡航旅費、第三国からの招へい者に対する渡航旅費等

国内研究のための、設備費、材料・消耗品費等

\* 上記に加え、R/D署名前の相手国との協議のための旅費（相手国への旅費、相手国からの招へい等）を支援。



## 第4章 団長所感

本調査を通じ、京都大学を中心とした日本側研究機関とITBを中心とするインドネシア側研究機関が、本プロジェクト採択以前からこれまで協働して、CCSに関連するセミナーや打合せなどを行ってきており、特に2011年春に採択が決まったあと、グンディガス田でのCCSに関する公開シンポジウム3回（5月16日バンドンITB、7月27日東京、9月21日ジャカルタ）の開催や、国営石油会社をはじめとしたインドネシア側関係機関への働きかけを行うなど、本プロジェクトに関する準備を着実にやってきたことが確認された。CCS（厳密には本プロジェクトではStorage=Sequestrationのみを対象）を進めることの意義について、本調査で協議・面談を行った各関係機関（国営石油会社、エネルギー鉱物資源省新・再生可能エネルギー・省エネルギー総局、国家教育省高等教育局、RISTEK）からは、一様に支持がなされ、かつ、本プロジェクトへの期待が表明されており、本プロジェクト開始の機運が高まっていることを感じた。

本プロジェクトでは、インドネシアのガス田開発におけるCO<sub>2</sub>地中貯留のガイドライン（手順書）の提案を目標とし、この目標達成に必要なアウトプットとして、①グンディガス田に対する事前調査→②CO<sub>2</sub>圧入を行う貯留層の評価→③CCS事業のF/S→④CO<sub>2</sub>圧入後のモニタリングの取りまとめ→⑤全工程（①～④）のレビューというサイクルを想定している。④については、CO<sub>2</sub>を実際に注入することが前提となるが、注入井の掘削については、コスト（最大で15億円程度）の観点から、本プロジェクト内で対応することが困難であり、インドネシア側、すなわち国営石油会社で行うことを想定している。ITBと国営石油会社は圧入井の掘削費用に関して、広く他の資金源を探すことも検討しており、その際には日本側においても情報収集に協力する予定である。しかしながら、現時点では残念ながら、国営石油会社が掘削を行うことの最終的な決定がなされていないため、本調査ではこれらの意思決定プロセスを明らかにし、本プロジェクトでこれらのプロセスの促進のための活動を含めることとした。なお、CO<sub>2</sub>の注入量（ゼロを含む）に応じて、アウトプット④、⑤、更にはプロジェクト目標を見直す必要が生じるが、これは、アウトプット①～③の達成が見込まれる中間レビューの段階で行うことが適当と判断される。なお、CO<sub>2</sub>が全く注入できず、かつ、プロジェクト目標を大幅に変更せざるを得ない状況になった場合は、JICA及びJSTの双方の観点から、その後の本プロジェクトの進め方に関して、本プロジェクトの中断も含め、検討する必要がある。いずれにしろ、現段階では、上記掘削のための意思決定プロセスをよくモニタリングすることが必要である。

上記との関係で、国営石油会社は研究部門と実操業部門に分かれており、前者は本プロジェクトの活動との関係では中心的な役割を果たすが、他方、CO<sub>2</sub>注入井の掘削については、後者による意思決定が必要である。また、現在想定している規模、場所における注入井の掘削については、エネルギー鉱物資源省の外局にあたり、石油天然ガス上流政策実施機関であるBPMIGASの承認が必要である。これらについては、今後とも、ITBを中心に、意思決定・承認プロセスの促進のための活動を行うこととなるが、JICAからも必要に応じ、エネルギー鉱物資源省に配属されたJICA専門家を通じた協力の要請を行うなど、側面的な支援は可能と思われる。

他方、インドネシアにおける本プロジェクト推進の中心となる研究機関ITBは、フィールドを提供する国営石油会社と古くから研究と技術開発に関して良好な関係を続けており、国営石油会社がこのプロジェクト推進のために、技術者や施設の提供などを行い、新しいCCSの技術開発に対して積極的な役割を果たそうとするのも、これまでのITBによる粘り強い働きかけによるものと思わ

れる。

近年、世界的にCCSに対する関心が高まっており、インドネシア国内においても、石油メジャーであるシェル石油は、英国大使館とLEMIGASと共同でインドネシアにおけるCCSの可能性に関するレポートを2009年に作成している（Understanding Carbon Capture and Storage Potential in Indonesia）。また、2009年11月10日～12日に“Carbon Capture and Storage in Indonesia”という3日間のシンポジウムを開催している。更に国営石油会社によれば、現在、インドネシア国内で、本プロジェクト以外に、2件のCCS関連事業（丸紅、ADB）が計画されていることから、本プロジェクトをより効果的に実施するために、これらの計画の進捗について適宜モニタリングし、教訓を活用していくことが必要である。

なお、本調査において、CO<sub>2</sub>地中貯留の適用の場となるグンディガス田を現場踏査し、プロジェクト目標の達成に欠かせない現場作業環境について調査したが、作業を進めるうえでは理想に近い状況であり、品質の高いデータ取得が期待できる。

## 付 属 資 料

- 1 . 協 議 議 事 録
- 2 . エ ネ ル ギ ー 鉱 物 資 源 省 組 織 図
- 3 . 面 談 録 ( 科 学 技 術 省 、 エ ネ ル ギ ー 鉱 物 資 源 省 )
- 4 . 討 議 議 事 録

**MINUTES OF MEETINGS**  
**BETWEEN THE DETAILED PLANNING SURVEY TEAM**  
**AND INSTITUT TEKNOLOGI BANDUNG**  
**ON JAPANESE TECHNICAL COOPERATION FOR**  
**THE PROJECT FOR PILOT STUDY FOR CARBON SEQUESTRATION AND**  
**MONITORING IN GUNDIH AREA, EAST JAVA PROVINCE, INDONESIA**

The Japanese Detailed Planning Survey Team (hereinafter referred to as “the Team”), organized by the Japan International Cooperation Agency (hereinafter referred to as “JICA”), headed by Mr. Hideo Noda from JICA, visited the Republic of Indonesia from 3<sup>rd</sup> to 8<sup>th</sup> October 2011 for the purpose of formulating the Technical Cooperation Project for Pilot Study for Carbon Sequestration and Monitoring in Gundih Area, East Java Province, Indonesia (hereinafter referred to as “the Project”).

During the above stay, the Team had a series of discussions with ITB and the Indonesian related parties with respect to the implementation of the Project.

As a result of the discussions, both ITB and the Team agreed to summarize the matters referred to in the document attached hereto.

Bandung, October 8<sup>th</sup> 2011



**Mr. Hideo Noda**

Team Leader

Japanese Detailed Planning Survey Team

Japan International Cooperation Agency

JAPAN



**Prof. Dr. Wawan Gunawan A. Kadir**

Vice Rector for Research and Innovation

Institut Teknologi Bandung

THE REPUBLIC OF INDONESIA

## **THE ATTACHED DOCUMENT**

### **I. BACKGROUND OF THE DISCUSSIONS**

Receiving the application form for Japan's Technical Cooperation for the above-captioned project, Government of Japan has approved the Project and JICA is planning to implement the Project under the scheme of "Science and Technology Research Partnership for Sustainable Development.\*" This scheme is promoted by JICA and Japan Science and Technology Agency (JST). In order to design and formulate the Project, ITB, the Indonesian related parties and the Team had discussions as shown below.

\*Science and Technology Research Partnership for Sustainable Development (SATREPS) aims at developing new technology and its applications to tackle global issues, and at enhancing the capacity development of researchers and research institutes in both countries.

### **II. DETAILED PLAN OF THE PROJECT**

#### **1. Title of the Project**

Both sides agreed that the title of the Project will be modified as "Pilot Study for Carbon Sequestration and Monitoring in Gundih Area , Central Java Province, Indonesia" since the place of the actual pilot project site is situated in Central Java Province, Indonesia.



## 2. Outline of the Project

Both sides agreed the outline of the Project described in the tentative Project Design Matrix (hereinafter referred to as “PDM”) and the tentative Plan of Operation (hereinafter referred to as “PO”) shown in Annex I and Annex II respectively.

The draft Record of Discussions (hereinafter referred to as “R/D”) attached as Annex III, including PDM and PO will be finalized and signed by the representatives of the Government of the Republic of Indonesia and JICA Indonesia Office after the notification of an approval of implementation of the Project by both Indonesian side and JICA Headquarters. Both sides agreed to make most efforts to smoothly implement the Project and thus to take necessary measures to sign the R/D as soon as possible.

## 3. Others

### 1) Necessary procedures to be taken by the signing of Record of Discussions

ITB explained that a part of transportation cost and the cost for the field survey might not be borne by ITB. The team took note this point and II 1. (d) Local Cost in Record of Discussions, will be discussed between ITB and JICA by the signing of Record of Discussions.

### 2) Necessary procedures to be taken by the first dispatch of JICA experts

The following agreements should be signed before the first date of the dispatch of JICA experts since the Project activities will be started once the data from Pertamina is available in ITB.

- Between ITB and Kyoto University : Collaborative Research Agreement
- Between ITB and Pertamina : Perjanjian Kerjasama (Joint Cooperation Agreement) and Confidential Agreement

### 3) The Project division into two phases



Currently, it is expected to conduct a feasibility study including CO2 sequestration design and the impacts on the Gundih gas field operated by Pertamina Exploration and Production (hereinafter referred to as “Pertamina EP”) from CO2 sequestration cost evaluation and environmental aspects during the first and the second years of the Project, covering activity 1-1 to 3-2.

In parallel with the above study, the socialization of Carbon Sequestration will be proceeded among stakeholders to enable CO2 sequestration in the gas field and conduct activities from 4-1. Indonesian side explained that the best scenario anticipated at this moment is that the proposed CO2 sequestration design is widely approved by the stakeholders and the related cost is recovered by the similar scheme of oil and gas production, stated in the regulation Peraturan Pemerintah Republik Indonesia Nomor 79, 2010. In order to achieve this, the first step would be that the Plan of Development (hereinafter referred to as “POD”) in Gundih, including CO2 sequestration plan would be developed by Pertamina and this POD would be approved by BPMigas. The Team took note of the procedure explained by Indonesian side.

It is assumed that the Project will be divided in two main phases. The first phase includes activities 1-1 to 3-2, and activities from 4-1 will be treated as the second phase.

Before the end of the first phase, both Indonesian side and Japanese side will review the progress and issues to be solved and decide necessary steps to be taken forward including the modification of the Project activities and duration.

Annex I      The tentative Project Design Matrix

Annex II     The tentative Plan of Operation

Annex III    The draft Record of Discussions



Project Design Matrix (PDM) Draft, Ver 0  
 Project Name: Pilot study for Carbon Sequestration and Monitoring in the Gundihi Area, Central Java Province, Indonesia  
 Duration: 5 years after the first JICA Expert dispatch  
 Implementation Agency: IITB  
 Project Site: Banding and the Gundihi gas field, Central Java, Indonesia  
 As of 8 October, 2011

Narrative Summary	Objectively verifiable Indicators	Means of Verification	Important Assumptions
<p><b>Overall Goal</b>                      Carbon Capture and Storage (CCS) programs in Indonesia are promoted for accelerating oil and gas development and production with zero CO2 emission.</p>	<p>More than five CCS programs in Indonesia will be planned referring the SOP proposed in this project.</p>	<p>Official reports by the Government of Indonesia</p>	
<p><b>Project Purpose</b>                      Standard Operating Procedures (SOP) for CO2 sequestration and monitoring technology is proposed for promoting CCS programs in onshore gas fields in Indonesia.</p>	<p>1. A proposal of a SOP for safe and effective CO2 sequestration technology in onshore is disseminated to 20 organizations.                      2. Technologies for CO2 sequestration and monitoring are developed with Indonesian researchers and engineers through the collaborative work.</p>	<p>1. Proposals of a SOP for safe and effective CO2 sequestration technology in onshore                      2. Yearly Progress Reports</p>	<p>1. Reduction of CO2 emission to the atmosphere is placed as an important issue in the country.                      2. Cooperation and assistance of the Gundihi gas field operation teams in Pertamina are available.</p>
<p><b>Phase 1</b>                      Output 1                      Preliminary study of CO2 sequestration and monitoring and a plan on CO2 sequestration and monitoring in the Gundihi gas field are completed.</p>	<p>1-1. Semiannual technical exchange meetings between the research teams in Indonesia and Japan are organized.                      1-2. A CCS Symposium with participants more than 100 is organized once a year in Indonesia or Japan                      1-3. Administrative documents for the project such as the organization chart and operational plan are prepared.                      1-4. A concrete implementation plan of CO2 sequestration and monitoring in the Gundihi gas field is discussed and prepared.                      2-1. A database for the Geology and Geophysics (G&amp;G) and physical property data for the Gundihi gas field is established.                      2-2. Geological and reservoir models for CCS of the Gundihi gas field are constructed.                      2-3. Prediction results of injected CO2 movement in the reservoir are prepared for at least 3 stages, immediately after injection, after CO2 settlement and 1000 years later.                      2-4. Configuration process equipment is planned.</p>	<p>1-1. Reports of technical exchange meetings                      1-2. Reports of the CCS symposium                      1-3. Documents on the organization chart and operational plan                      1-4. Documents on the concrete implementation plan of CO2 sequestration and monitoring in the Gundihi gas field                      2-1. The database developed in the Project                      2-2. Geological and reservoir model                      2-3. Documents on prediction results of reservoir model                      4. Documents on configuration process equipment plan</p>	<p>1. G&amp;G data for the CO2 storage of the Gundihi gas field are available.                      2. CO2 is prepared for CO2 sequestration.</p>
<p><b>Output 3</b>                      Feasibility study including surface facility design and cost evaluation is completed for CO2 sequestration and monitoring in the Gundihi gas field.</p>	<p>3-1. A CO2 sequestration and monitoring grand design report in the Gundihi gas field is prepared.                      3-2. A surface facility design report for the Gundihi gas field is prepared.</p>	<p>3-1. A report on the CO2 sequestration and monitoring grand design                      3-2. A report on the surface facility design</p>	
<p><b>Phase 2</b>                      Output 4                      Geophysical and geochemical technologies which can be applied for CO2 sequestration and monitoring are deployed in the actual injected CO2 storage in the Gundihi gas field and evaluated for determining integrated technologies for CO2 monitoring.</p>	<p>4.1 Measurement techniques and know-hows of the instruments are obtained by Indonesian researchers and engineers through on-site collaborative work.                      4-2. Technologies and know-hows for data acquisition and processing of each monitoring method are obtained by Indonesian researchers through collaborative operations in the actual field.</p>	<p>4-1. Work reports for the operation and measurement for the instruments provided                      4-2. Work reports for data processing and interpretation using softwares provided</p>	
<p><b>Output 5</b>                      SOP is introduced based on the analysis and the evaluation of the Gundihi gas field CO2 sequestration and monitoring.</p>	<p>5-1. A SOP for CO2 sequestration and monitoring technology for an onshore gas field is prepared.</p>	<p>5-1. SOP</p>	



*A. J. M.*

<p><b>Activities</b></p> <p>(Output 1)</p> <p>1-1. Prepare the organization structure and personnel for establishing the research teams.          1-2. Prepare the operational plans for the researches.          1-3. Establish the inter-ministry coordination framework.          1-4. Establish the international coordination framework.          1-5. Conduct periodical review and revision-up of the frameworks established in (1-3) and (1-4).          1-6. Hold semiannual technical exchange meetings and CCS Symposium.          1-7. Carry out preliminary study on CCS in Indonesia from technical points of view.          1-8. Carry out study on CCS strategy in the Gumdih gas field to implement CO2 injection and sequestration.</p> <p>(Output 2)</p> <p>2-1. CO2 sequestration site(s) and CO2 storage description and modeling          2-1-1. Collect all required data and update new database for the site and reservoirs.          2-1-2. Carry out complementary Geology and Geophysics(G&amp;G) surveys in and around the Gumdih gas field for geological modeling.          2-1-3. Make a geological model of the site(s) and CO2 storage by using existing and new data. (static reservoir modeling)          2-2. Laboratory test          2-2-1. Check the availability of cores obtained from reservoir intervals.          2-2-2. Set up laboratory test instrument.          2-2-3. Conduct Lab tests for determining rock properties in real reservoir condition.          2-3. Reservoir simulation and evaluation          2-3-1. Construct a reservoir model using the geological and laboratory data.          2-3-2. Carry out reservoir simulation using new G&amp;G model (dynamic modeling) and evaluation.          2-4. Carry out surface facility simulations to set the configuration process equipment.</p> <p>(Output 3)</p> <p>3-1. Make a grand design of CO2 sequestration and monitoring including the cost evaluation.          3-2. Design the surface facility for CO2 sequestration and monitoring.</p> <p>(Output 4)</p> <p>4-1. Carry out the field work on measurement techniques using instruments provided from JICA.          4-2. Carry out the data acquisition, processing, and interpretation for each monitoring method as below.          4-2-1. 4D high-resolution seismic method          4-2-2. 4D electric/electromagnetic method          4-2-3. 4D microgravity method          4-2-4. InSAR and GPS method          4-2-5. 4D microseismic method          4-2-6. Natural earthquake seismic tomography and interferometric method          4-2-7. Geochemical and hydrogeological method          4-2-8. Integrated quantitative interpretation for estimating CO2 saturation in the reservoir</p> <p>(Output 5)</p> <p>5-1. Review and evaluate the results of CO2 sequestration and monitoring in the Gumdih gas field.          5-2. Draft the SOP of CO2 sequestration and monitoring.          5-3. Conduct seminar(s) and the publication of SOP.</p>	<p><b>Main Inputs</b></p> <p>Indonesia side:          1. Indonesian experts required for collaborative researches and their smooth operations in Indonesia          2. Materials and documents required for researches on Indonesia side related items          3. Office space and equipments          4. Running expenses (electricity, water, telephones and so on)</p> <p>Japan side:          1. Personnel          1-1. Long-term experts          - Coordinator for administration (JICA)          1-2. Short term experts          - Japanese Project Leader          - Japanese Experts          2. Materials and documents          - Materials and documents required for researches          3. Instruments and software          4. Training</p>		<p><b>Preconditions</b></p> <p>Perjanjian Kejasama (Joint Cooperation Agreement) and Confidential Agreement between ITB and Pertamina</p>
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(Draft)

**RECORD OF DISCUSSIONS**

**ON**

**PILOT STUDY FOR CARBON SEQUESTRATION AND  
MONITORING IN GUNDIH AREA, CENTRAL JAVA PROVINCE,  
INDONESIA**

**IN**

**THE REPUBLIC OF INDONESIA**

**AGREED UPON BETWEEN**

**INSTITUT TEKNOLOGI BANDUNG**

**AND**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

Jakarta, December xx, 2011

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Motofumi Kohara  
Chief Representative  
Indonesia Office  
Japan International Cooperation Agency

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Prof. Dr. Wawan Gunawan A. Kadir  
Vice Rector for Research and Innovation,  
Institut Teknologi Bandung (ITB)

Witness

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Djoko Santoso  
Director General of Higher Education  
Ministry of National Education (MoNE)

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Kardaya Warnika  
Director General of New and Renewable  
Energy and Energy Conservation,  
Ministry of Energy and Mineral  
Resources

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Based on the minutes of meetings on the Detailed Planning Survey on the Pilot Study for Carbon Sequestration and Monitoring in Gundih Area, Central Java Province, Indonesia (hereinafter referred to as “the Project”) signed on October 8<sup>th</sup> 2011 between Institut Teknologi Bandung (ITB) and the Japan International Cooperation Agency (hereinafter referred to as “JICA”), JICA held a series of discussions with ITB and relevant organizations to develop a detailed plan of the Project.

Both parties agreed the details of the Project and the main points discussed as described in the Appendix 1 and the Appendix 2 respectively.

Both parties also agreed that ITB, the counterpart to JICA, will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of Indonesia.

The Project will be implemented within the framework of the Colombo Plan and the Note Verbales to be exchanged between the Government of Japan (hereinafter referred to as “GOJ”) and the Government of Republic of Indonesia.

Appendix 1: Project Description

Appendix 2: Main Points Discussed

Appendix 3: Minutes of Meetings on Pilot Study for Carbon Sequestration and Monitoring in Gundih Area, Central Java Province, Indonesia



## PROJECT DESCRIPTION

### **I. BACKGROUND**

Indonesia has a plan to reduce its emissions of carbon dioxide (CO<sub>2</sub>), a greenhouse gas, by 26% by 2020 as a measure against global warming. Emissions of CO<sub>2</sub> into the atmosphere from gas fields during production of natural gas is a problem for this plan, making it an urgent task to establish systematized techniques for carbon dioxide capture and storage (CCS) as a direct measure for their reduction. This study concerns approximately 0.3 million ton of CO<sub>2</sub> emitted annually during production of natural gas in a gas field presently under development in the Gundih Area, Central Java Province, Indonesia. It is a pilot study for research and development of technologies for assessing deep strata at sites of CO<sub>2</sub> injection, which is essential for safe application of CO<sub>2</sub> sequestration technologies, and for monitoring of underground distribution and behavior of CO<sub>2</sub> through capacity development of organizations and human resources.

### **II. OUTLINE OF THE PROJECT**

Details of the Project are described in the Logical Framework (Project Design Matrix:PDM) (Annex I) and the tentative Plan of Operation (Annex II).

#### 1. Input

##### (1) Input by JICA

##### (a) Dispatch of Experts

JICA will provide the services of Japanese experts as listed in Annex III.

##### (b) Training

JICA will provide on-site trainings in the field operations in Indonesia through cooperative research works with Indonesian researchers and engineers. JICA will also receive the Indonesian personnel connected with this project for training in Japan.

##### (c) Machinery and Equipment

JICA will provide instruments and softwares necessary for implementing the project as listed in Annex IV. The instruments and softwares will become the properties of Government of the Republic of Indonesia upon being delivered C.I.F. (cost, insurance and freight) to the Indonesian authorities connected at the ports and/or airports of disembarkation.

##### (d) Local Cost

XX

## (2) Input by ITB

ITB will take necessary measures to provide at its own expense:

- (a) Services of ITB's counterpart personnel and administrative personnel as listed in Annex V;
- (b) Suitable office space with necessary equipment;
- (c) Supply or replacement of machinery, equipment, instruments, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA;
- (d) Information as well as support in obtaining medical service;
- (e) Credentials or identification cards;
- (f) Available data (including maps and photographs) and information related to the Project;
- (g) Running expenses necessary for the implementation of the Project;
- (h) Expenses necessary for transportation within Indonesia of the equipments as well as for the installation, operation and maintenance thereof; and
- (i) Necessary facilities to the JICA experts for the remittance as well as utilization of the funds introduced into Indonesia from Japan in connection with the implementation of the Project

## 2. Implementation Structure

The Project organization chart is given in the Annex VI. The roles and assignments of relevant organizations are as follows:

### (1) ITB

#### (a) Project Director

Project Director will be responsible for overall administration and implementation of the Project.

#### (b) Project Manager

Project Manager will be responsible for managerial and technical matters of the project.

#### (c) Leader of each Indonesian authority related to the project

Leader of each Indonesian authority related to the project will be responsible for implementation of the part of the project defined in the plan of operation for each year.

### (2) JICA Experts

#### (a) Japanese Project Leader

Japanese Project Leader will provide necessary recommendations and advice to the Project Director and Project Manager on any matters pertaining to the implementation of the project.

#### (b) Japanese Expert

Japanese Experts will give necessary technical guidance, advice and recommendations to ITB on scientific and technical matters pertaining to the implementation of the Project.

### (3) Joint Coordinating Committee

Joint Coordinating Committee (hereinafter referred to as "JCC") will be



established in order to facilitate inter-organizational coordination. JCC will be held at least once a year and whenever deems it necessary. JCC will approve an annual work plan, review overall progress, conduct monitoring and evaluation of the Project, and exchange opinions on major issues that arise during the implementation of the Project. A list of proposed members of JCC is shown in the Annex VII.

### 3. Project Sites

The project sites are located in Bandung, West Java Province, and the Gundih gas field, Central Java Province, Indonesia.

### 4. Duration

The duration of the project will be five (5) years from the date of the first dispatch of JICA expert(s).

### 5. Reports

The following reports will be prepared in English by ITB.

- (1) Yearly Progress Report after the commencement of the Project
- (2) Final Report before the end of the Project

### 6. Environmental and Social Considerations

- (1) ITB agreed to abide by 'JICA Guidelines for Environmental and Social Considerations (April 2010)' in order to ensure that appropriate considerations will be made for the environmental and social impacts of the Project.

#### (2) Environmental Checklist

The environmental and social considerations including major impacts and mitigation measures for the Project will be examined during the first two years of preparation stage and will be summarized in the Environmental Checklist. An example is shown as Annex VIII.

#### (3) Monitoring for Environmental and Social Considerations

Monitoring for environmental and social considerations will be conducted and assured by ITB in accordance with the Monitoring Plan for the Project. The monitoring items, frequency and monitoring structure will be prepared during the first two years of preparation stage and will be summarized in the Monitoring Form attached as Annex IX as an example.

The results of monitoring will be provided to JICA by filling in the Monitoring Form, as part of progress reports during the construction phase, and annually for two years after completion of the Project. ITB agreed to make the results of monitoring available to local project stakeholders during the same period of Yearly report submission to JICA.

#### (4) Disclosure of Monitoring Result on the Website

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ITB agreed that JICA may disclose the results of monitoring as shown in Annex IX conducted by ITB on JICA's website to the extent that those are made public in their country.

### **III. UNDERTAKINGS OF ITB**

1. ITB will take necessary measures to:

- (1) ensure that the technologies and knowledge acquired by the Indonesia nationals as a result of Japanese technical cooperation contributes to the economic and social development of Indonesia, and that the knowledge and experience acquired by the personnel of Indonesia from technical training as well as the equipment provided by JICA will be utilized effectively in the implementation of the Project; and
- (2) grant privileges, exemptions and benefits to the JICA experts of the JICA missions above and their families, which are no less favorable than those granted to experts of third countries performing similar missions in Indonesia under the Colombo Plan Technical Cooperation Scheme.

2. ITB will take necessary measures to:

- (1) provide security-related information as well as measures to ensure the safety of the JICA experts;
- (2) permit the JICA experts to enter, leave and sojourn in Indonesia for the duration of their assignments therein and exempt them from foreign registration requirements and consular fees.
- (3) exempt the JICA experts from taxes and any other charges on the equipment, machinery and other material necessary for the implementation of the Project;
- (4) exempt the JICA experts from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to them and/or remitted to them from abroad for their services in connection with the implementation of the Project; and
- (5) meet taxes and any other charges on the equipment, machinery and other material, referred to in II-7 above, necessary for the implementation of the Project.

3. ITB or the Government of Republic of Indonesia will bear claims, if any arises, against the JICA experts resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the Project, except when such claims arise from gross negligence or willful misconduct on the part of the JICA experts.

### **IV. EVALUATION**

JICA and the ITB will jointly conduct the following evaluations and reviews.

1. Mid-term review around the middle of the cooperation term
2. Terminal evaluation during the last six (6) months of the cooperation term



## **V. PROMOTION OF PUBLIC SUPPORT**

For the purpose of promoting support for the Project, ITB will take appropriate measures to make the Project widely known to the people of Indonesia.

## **VI. MUTUAL CONSULTATION**

JICA and ITB will consult each other whenever any major issues arise in the course of Project implementation.

## **VII. AMENDMENTS**

The record of discussions may be amended by the minutes of meetings between JICA and ITB.

The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the record of discussions.

Annex I	Logical Framework (Project Design Matrix:PDM)
Annex II	Tentative Plan of Operation
Annex III	List of Japanese Experts
Annex IV	List of Instruments and softwares
Annex V	List of Indonesian Experts
Annex VI	Project Organization Chart
Annex VII	List of Members of Joint Coordinating Committee
Annex VIII	Environmental Checklist
Annex IX	Monitoring Form

*Edw*

## MAIN POINTS DISCUSSED

### 1. Environmental and Social Considerations

In the Gundih gas field, Pertamina EP is operating Java Gas Development Project. Analysis of Environment Impact including the monitoring guideline is completed in 2007 for the Java Gas Development Project by the third parties. Since then, the environmental monitoring for Air, Water, Soil and Social culture is conducted two times a year. It will continue up till the end of the gas production.

Once the Project starts, further detailed examinations will be done to assess the impacts for the environmental and social considerations, which may be caused by the specific actions related to the Project. If necessary, Environmental Checklist and Monitoring Form will be prepared accordingly.

Project Design Matrix (PDM) Draft Ver.0  
 Project Name: Pilot study for Carbon Sequestration and Monitoring in the Gundi. Area, Central Java Provinces, Indonesia  
 Duration: 5 years after the first JICA Export dispatch  
 Implementation Agency: ITB  
 Project Site: Banding and the Gundi gas field, Central Java, Indonesia  
 As of 8 October, 2011

Narrative Summary	Objectively verifiable Indicators	Means of Verification	Important Assumptions
<p><b>Overall Goal</b>                      Carbon Capture and Storage (CCS) programs in Indonesia are promoted for accelerating oil and gas development and production with zero CO2 emission.</p>	<p>More than five CCS programs in Indonesia will be planned referring the SOP proposed in this project.</p>	<p>Official reports by the Government of Indonesia</p>	
<p><b>Project Purpose</b>                      Standard Operating Procedures (SOP) for CO2 sequestration and monitoring technology is proposed for promoting CCS programs in onshore gas fields in Indonesia.</p>	<p>1. A proposal of a SOP for safe and effective CO2 sequestration technology in onshore is disseminated to 20 organizations.                      2. Technologies for CO2 sequestration and monitoring are developed with Indonesian researchers and engineers through the collaborative work.</p>	<p>1. Proposals of a SOP for safe and effective CO2 sequestration technology in onshore                      2. Yearly Progress Reports</p>	<p>1. Reduction of CO2 emission to the atmosphere is placed as an important issue in the country.                      2. Cooperation and assistance of the Gundi gas field operation teams in Pertamina are available.</p>
<p><b>Phase 1</b>                      Preliminary study of CO2 sequestration and monitoring and a plan on CO2 sequestration and monitoring in the Gundi gas field are completed.</p>	<p>1-1. Semiannual technical exchange meetings between the research teams in Indonesia and Japan are organized.                      1-2. A CCS Symposium with participants more than 100 is organized once a year in Indonesia or Japan                      1-3. Administrative documents for the project such as the organization chart and operational plan are prepared.                      1-4. A concrete implementation plan of CO2 sequestration and monitoring in the Gundi gas field is discussed and prepared</p>	<p>1-1. Reports of technical exchange meetings                      1-2. Reports of the CCS symposium                      1-3. Documents on the organization chart and operational plan                      1-4. Documents on the concrete implementation plan of CO2 sequestration and monitoring in the Gundi gas field</p>	<p>1. G&amp;G data for the CO2 storage of the Gundi gas field are available.                      2. CO2 is prepared for CO2 sequestration.</p>
<p><b>Output 2</b>                      Characterization/evaluation of CO2 sequestration site(s) and CO2 storage are completed to proceed the activities under output 3, as well as surface facility simulations.</p>	<p>2-1. A database for the Geology and Geophysics (G&amp;G) and physical property data for the Gundi gas field is established.                      2-2. Geological and reservoir models for CCS of the Gundi gas field are constructed.                      2-3. Prediction results of injected CO2 movement in the reservoir are prepared for at least 3 stages, immediately after injection, after CO2 settlement and 1000 years later.                      2-4. Configuration process equipment is planned.</p>	<p>2-1. The database developed in the Project                      2-2. Geological and reservoir model                      2-3. Documents on prediction results of reservoir model                      4. Documents on configuration process equipment plan</p>	
<p><b>Output 3</b>                      Feasibility study including surface facility design and cost evaluation is completed for CO2 sequestration and monitoring in the Gundi gas field.</p>	<p>3-1. A CO2 sequestration and monitoring grand design report in the Gundi gas field is prepared.                      3-2. A surface facility design report for the Gundi gas field is prepared.</p>	<p>3-1. A report on the CO2 sequestration and monitoring grand design                      3-2. A report on the surface facility design</p>	
<p><b>Phase 2</b>                      Geophysical and geochemical technologies which can be applied for CO2 sequestration and monitoring are deployed in the actual injected CO2 storage in the Gundi gas field and evaluated for determining integrated technologies for CO2 monitoring.</p>	<p>4-1. Measurement techniques and know-hows of the instruments are obtained by Indonesian researchers and engineers through on-site collaborative work.                      4-2. Technologies and know-hows for data acquisition and processing of each monitoring method are obtained by Indonesian researchers through collaborative operations in the actual field.</p>	<p>4-1. Work reports for the operation and measurement for the instruments provided                      4-2. Work reports for data processing and interpretation using softwares provided</p>	
<p><b>Output 5</b>                      SOP is introduced based on the analysis and the evaluation of the Gundi gas field CO2 sequestration and monitoring.</p>	<p>5-1. A SOP for CO2 sequestration and monitoring technology for an onshore gas field is prepared.</p>	<p>5-1. SOP</p>	

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<p><b>Activities</b></p> <p>(Output 1)</p> <ol style="list-style-type: none"> <li>1-1. Prepare the organization structure and personnel for establishing the research teams.</li> <li>1-2. Prepare the operational plans for the researches.</li> <li>1-3. Establish the inter-ministry coordination framework.</li> <li>1-4. Establish the international coordination framework.</li> <li>1-5. Conduct periodical review and revision-up of the frameworks established in (1-3) and (1-4).</li> <li>1-6. Hold semiannual technical exchange meetings and CCS Symposium.</li> <li>1-7. Carry out preliminary study on CCS in Indonesia from technical points of view.</li> <li>1-8. Carry out study on CCS strategy in the Gundih gas field to implement CO<sub>2</sub> injection and sequestration.</li> </ol> <p>(Output 2)</p> <ol style="list-style-type: none"> <li>2-1. CO<sub>2</sub> sequestration site(s) and CO<sub>2</sub> storage description and modeling</li> <li>2-1-1. Collect all required data and update new database for the site and reservoirs</li> <li>2-1-2. Carry out complementary Geology and Geophysics(G&amp;G) surveys in and around the Gundih gas field for geological modeling.</li> <li>2-1-3. Make a geological model of the site(s) and CO<sub>2</sub> storage by using existing and new data. (static reservoir modeling)</li> <li>2-2. Laboratory test</li> <li>2-2-1. Check the availability of cores obtained from reservoir intervals.</li> <li>2-2-2. Set up laboratory test instrument.</li> <li>2-2-3. Conduct Lab tests for determining rock properties in real reservoir condition.</li> <li>2-3. Reservoir simulation and evaluation</li> <li>2-3-1. Construct a reservoir model using the geological and laboratory data.</li> <li>2-3-2. Carry out reservoir simulation using new G&amp;G model (dynamic modeling) and evaluation.</li> <li>2-4. Carry out surface facility simulations to set the configuration process equipment.</li> </ol> <p>(Output 3)</p> <ol style="list-style-type: none"> <li>3-1. Make a grand design of CO<sub>2</sub> sequestration and monitoring including the cost evaluation.</li> <li>3-2. Design the surface facility for CO<sub>2</sub> sequestration and monitoring.</li> </ol> <p>(Output 4)</p> <ol style="list-style-type: none"> <li>4-1. Carry out the field work on measurement techniques using instruments provided from JICA.</li> <li>4-2. Carry out the data acquisition, processing, and interpretation for each monitoring method as below.             <ol style="list-style-type: none"> <li>4-2-1. 4D high-resolution seismic method</li> <li>4-2-2. 4D electric/electromagnetic method</li> <li>4-2-3. 4D microgravity method</li> <li>4-2-4. InSAR and GPS method</li> <li>4-2-5. 4D microseismic method</li> <li>4-2-6. Natural earthquake seismic tomography and interferometric method</li> <li>4-2-7. Geochronical and hydrogeological method</li> <li>4-2-8. Integrated quantitative interpretation for estimating CO<sub>2</sub> saturation in the reservoir</li> </ol> </li> </ol> <p>(Output 5)</p> <ol style="list-style-type: none"> <li>5-1. Review and evaluate the results of CO<sub>2</sub> sequestration and monitoring in the Gundih gas field.</li> <li>5-2. Draft the SOP of CO<sub>2</sub> sequestration and monitoring.</li> <li>5-3. Conduct seminar(s) and the publication of SOP.</li> </ol>	<p><b>Main Inputs</b></p> <p>Indonesia side:</p> <ol style="list-style-type: none"> <li>1. Indonesian experts required for collaborative researches and their smooth operations in Indonesia</li> <li>2. Materials and documents required for researches on Indonesia side related items</li> <li>3. Office space and equipments</li> <li>4. Running expenses (electricity, water, telephones and so on)</li> </ol> <p>Japan side:</p> <ol style="list-style-type: none"> <li>1. Personnel             <ol style="list-style-type: none"> <li>1-1. Long-term experts</li> <li>1-2. Short term experts</li> <li>- Coordinator for administration (JICA)</li> <li>- Japanese Project Leader</li> <li>- Japanese Experts</li> </ol> </li> <li>2. Materials and documents             <ul style="list-style-type: none"> <li>- Materials and documents required for researches</li> </ul> </li> <li>3. Instruments and software</li> <li>4. Training</li> </ol>	<p><b>Preconditions</b></p> <p>Perjanjian Kerjasama (Joint Cooperation Agreement) and Confidential Agreement between ITB and Pertamina</p>
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## List of Japanese Experts

### 1. Long-term experts

Coordinator for administration: JICA

### 2. Short-term experts

- 1) Toshifumi Matsuoka (Kyoto University)
- 2) Hiroyasu Ohtsu (Kyoto University)
- 3) Yasuhiro Yamada (Kyoto University)
- 4) Yoshitada Mito (Kyoto University)
- 5) Sumihiko Murata (Kyoto University)
- 6) Takeshi Tsuji (Kyoto University)
- 7) Katsunori Sawai (Kyoto University)
- 8) Yoichi Fukuda (Kyoto University)
- 9) Syuichi Rokugawa (University of Tokyo)
- 10) Kyosuke Onishi (Kyoto University)
- 11) Hiroyuki Kosugegawa (Kyoto University)
- 12) Akira Ueda (Toyama University)
- 13) Akira Saito (Waseda University)
- 14) Jun Nishijima (Kyushu University)
- 15) Keigo Kitamura (Kyushu University)
- 16) Toru Sato (Japan Petroleum Exploration Co. Ltd.)
- 17) Nobuo Kawai (Japan Petroleum Exploration Co. Ltd.)
- 18) Kazuhiko Tezuka (Japan Petroleum Exploration Co. Ltd.)
- 19) Kohei Akaku (Japan Petroleum Exploration Co. Ltd.)
- 20) Masanori Nakano (Japan Petroleum Exploration Co. Ltd.)
- 21) Jun Mikami (Japan Petroleum Exploration Co. Ltd.)
- 22) Soichi Tanaka (Fukada Geological Institute)
- 23) Toru Takahashi (Fukada Geological Institute)

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## List of instruments and softwares

### Instruments:

- Gravity meter
- EM measurement system
- 3D seismic acquisition system
- Borehole seismic acquisition system
- Surface micro-seismic equipment
- Quad Core CPU computer for processing and simulation
- Wire line logging equipment
- Magnetometer
- Geoelectrical measurement system

### Softwares:

- Seismic Inversion software
- Reservoir simulation software
- Surface facility simulation software
- Gravity software
- Magnetic software
- Geoelectrical software
- EM data processing software
- InSAR data processing software
- Seismic interpretation software
- Geological modeling software

*A. J. W.*



List of Indonesian Experts

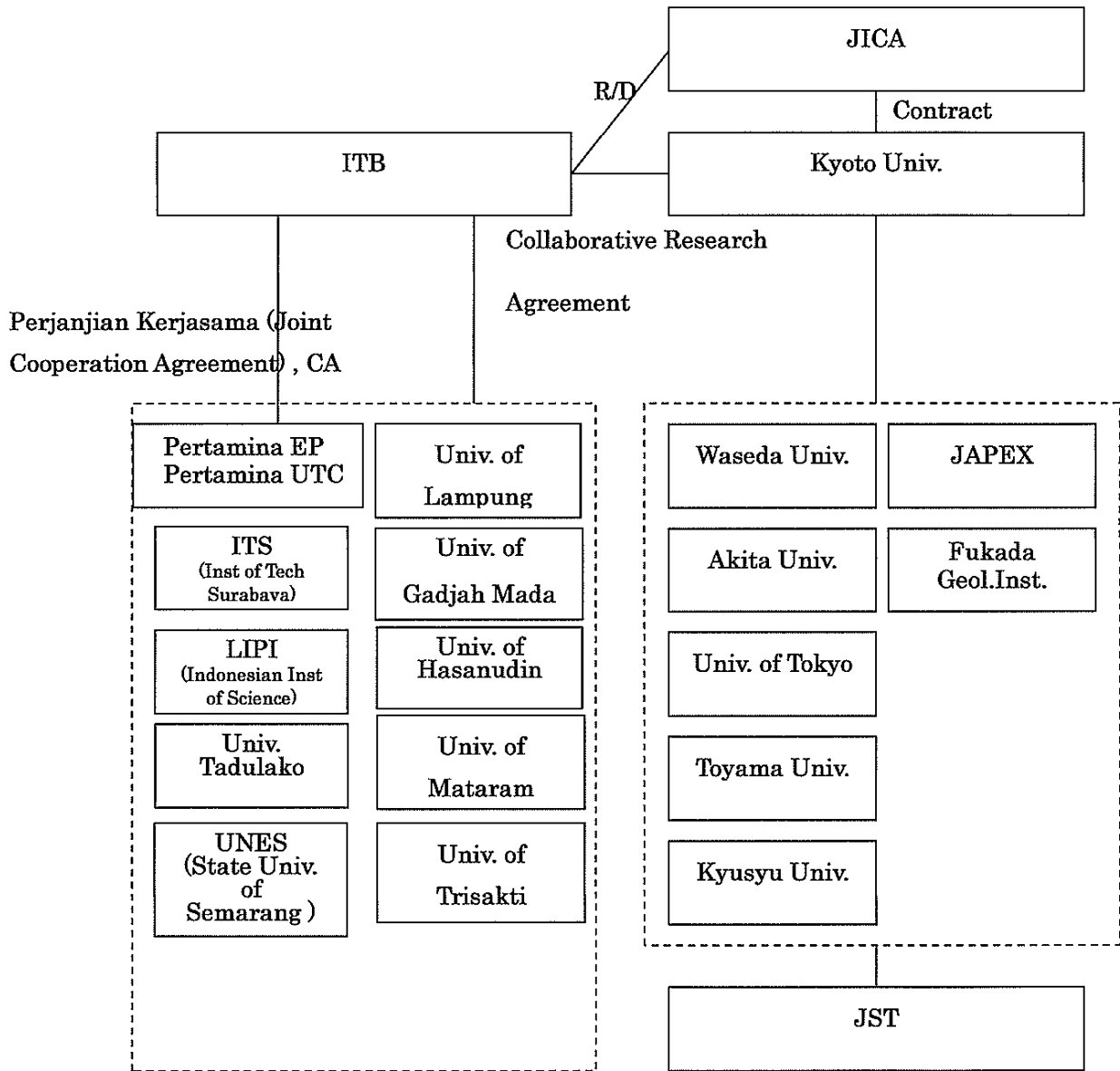
- 1) Project Director: Prof. Dr. Wawan Gunawan A. Kadir (Vice Rector for Research and Innovation, ITB)
- 2) Project Manager: Dr. Mohammad Rachmat Sule (Lecturer, ITB)
- 3) Coordinator from Pertamina UTC: Dr. Djedi S. Widarto (Acting Chief of New Energy and Green Technology)
- 4) Coordinator from Pertamina EP: Mr. Dody Sasongko (GM PPGJ- Pertamina EP)
- 5) Prof. Dr. Sri Widiyantoro (ITB)
- 6) Prof. Dr. Djoko Santoso (ITB)
- 7) Prof. Dr. Doddy Abdassah (ITB)
- 8) Prof. Dr. Satria Bijaksana (ITB)
- 9) Prof. Dr. Sismanto (UGM)
- 10) Tutuka Ariadji, Ph.D (ITB)
- 11) Dr. Darharta Dahrin (ITB)
- 12) Dr. Agus Laesanpura (ITB)
- 13) Dr. Hendra Grandis (ITB)
- 14) Dr. Eko Widiyanto (Trisakti University)
- 15) Dr. Susanti Alawiyah (ITB)
- 16) Dr. Setianingsih (ITB)
- 17) Dr. Sarkowi (Lampung University)
- 18) Dr. Suhayat (Mataram University)
- 19) Dr. Fatkhan (ITB)
- 20) Dr. Andri D. Nugraha (ITB)
- 21) Dr. Alfian Bahar (ITB)
- 22) Mr. Ridho Affandi (Pertamina EP)
- 23) Ms. Melia Surghani (Pertamina UTC)
- 24) Mr. Harris Prabowo (Pertamina UTC)
- 25) Dr. Sutopo (ITB)
- 26) Dr. Zuher Syihab (ITB)
- 27) Dr. Ing. Bonar Tua Halomoan Marbun (ITB)
- 28) Mr. Sabrianto Aswad (UNHAS)
- 29) Mr. Gede Widiarna (Pertamina EP)
- 30) Mr. Abidzar Akman (Pertamina EP)



- 31) Mr. Doddy Priambodo (Pertamina EP)
- 32) Mrs. Ory Sadjati (Pertamina UTC)
- 33) Mr. Samsul Hidayat (Pertamina UTC)
- 34) Dr. Sigit Sukmono (ITB)
- 35) Dr. Sonny Winardhi (ITB)
- 36) Dr. Awali Priyono (ITB)
- 37) Dr. Rachmat Fajar Lubis (LIPI)
- 38) Dr. Dasapta Erwin Irawan (ITB)
- 39) Dr. Syaiful Bachri (ITS)
- 40) Dr. Zainuddin (UNILA)
- 41) Dr. Rustan Efendi (Tadulako University)
- 42) Dr. Muhammad Hamzah (UNHAS)
- 43) Prof. Supriadi Rustad (UNES)
- 44) Dr. Supriyadi (UNES)
- 45) Dr. Chalid Idham Abdullah (ITB)
- 46) Prof. Yahdi Zaim (ITB)
- 47) Ir. Budianto Toha (UGM)
- 48) Prof. Dr. Sudarto Notosiswoyo (ITB)

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Project Organization Chart



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A List of Members of Joint Coordinating Committee

1. Functions

A Joint Coordination Committee will be organized. The committee meeting will be held at least once a year whenever need arises.

The functions of the Committee are as follow;

- (1) To supervise the annual work plan of the project in line with the Plan of Operation.
- (2) To review the annual and overall progress of the project and to evaluate the accomplishment of the annual targets and achievement of the objectives.
- (3) To find out proper ways and means for solution of the major issues arising from or in connection with the project.

2. Composition of the Committee

(1) Chairperson: Ministry of National Education/Higher Education Director General

(2) Members

a. Indonesian side:

Project Director: Institut Teknologi Bandung (ITB)/Vice Rector

Project Manager: ITB/Lecturer

Pertamina EP: General Manager of Project Pengembangan Gas Jawa (PPGJ); Jawa Gas Development Project

Pertamina UTC: Senior Researcher

Representative(s) of the research organizations involved in the project

b. Japanese side:

Representative(s) of JICA Indonesia Office

Japanese Project Leader

Representative(s) of the research organizations involved in the project

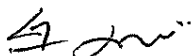
Members(s) of missions dispatched by JICA

c. Observer(s):

Representative(s) of JST

Official(s) of the Embassy of Japan

Other officials appointed by the Chairperson may attend the committee meetings as observer.



Environmental Checklist (Geothermal Power Station)

Annex VIII

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) (b) (c) (d)	(a) (b) (c) (d)
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) (b)	(a) (b)
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a)	(a)
	(1) Air Quality	(a) Do air pollutants, such as hydrogen sulfide (H <sub>2</sub> S) emitted from geothermal power plants comply with the country's standards? Is there a possibility that the emitted hydrogen sulfide will have the impacts on the surrounding areas, including vegetation? Are any mitigating measures taken? (b) Do air pollutants emitted from the other project facilities comply with the country's emission standards?	(a) (b)	(a) (b)

Environmental Checklist (Geothermal Power Station)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
2 Pollution Control	(2) Water Quality	(a) Do effluents (including thermal effluent) from the project facilities, such as power generation facilities comply with the country's effluent standards? Is there any possibility that the effluents from the project will cause any areas not to comply with the country's ambient water quality standards?	(a)	(a)
		(b) In the case of geothermal power plants, is there any possibility that geothermal utilization will cause water pollution by toxicants, such as Arsenic (As) and Mercury (Hg) contained in geothermal fluids? If the water pollution is anticipated, are adequate measures considered?	(b)	(b)
		(c) Do leachates from the waste disposal sites comply with the country's effluent standards and ambient water quality standards? Are adequate measures taken to prevent contamination of soil, groundwater, and seawater by leachates?	(c)	(c)
		(d) Is there any possibility that effluent from well excavation would cause water contamination? If water pollution is anticipated, are adequate measures considered?	(d)	(d)
2 Pollution Control	(3) Wastes	(a) Are wastes generated by the plant operations properly treated and disposed of in accordance with the country's regulations?	(a)	(a)
		(b) Are wastes generated by the effluents from well-excavation properly treated and disposed of in accordance with the country's standards?	(b)	(b)
	(4) Noise and Vibration	(a) Do noise and vibrations comply with the country's standards?	(a)	(a)
		(a) Is there any possibility that the extraction of steam will cause subsidence?	(a)	(a)
	(5) Subsidence	(a) Are there any odor sources such as H2S, and anticipated any effect? Are adequate odor control measures taken?	(a)	(a)
		(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a)	(a)
3 Natural Environment	(1) Protected Areas	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	(a)	(a)
		(b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	(b)	(b)
		(c) Is there a possibility that the project will adversely affect downstream aquatic organisms, animals, plants, and ecosystems? Are adequate protection measures taken to reduce the impacts on the ecosystem?	(c)	(c)
(2) Ecosystem	(a) Is there any possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas?	(a)	(a)	
	(3) Topography and Geology			

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Environmental Checklist (Geothermal Power Station)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(1) Resettlement	<p>(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement?</p> <p>(b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement?</p> <p>(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?</p> <p>(d) Are the compensations going to be paid prior to the resettlement?</p> <p>(e) Are the compensation policies prepared in document?</p> <p>(f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?</p> <p>(g) Are agreements with the affected people obtained prior to resettlement?</p> <p>(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?</p> <p>(i) Are any plans developed to monitor the impacts of resettlement?</p> <p>(j) Is the grievance redress mechanism established?</p>	<p>(a)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p> <p>(e)</p> <p>(f)</p> <p>(g)</p> <p>(h)</p> <p>(i)</p> <p>(j)</p>	<p>(a)</p> <p>(b)</p> <p>(c)</p> <p>(d)</p> <p>(e)</p> <p>(f)</p> <p>(g)</p> <p>(h)</p> <p>(i)</p> <p>(j)</p>
	(2) Living and Livelihood	<p>(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?</p> <p>(b) Is there a possibility that the amount of water (e.g., surface water, groundwater) used and discharge of effluents by the project will adversely affect the existing water uses and water area uses?</p>	<p>(a)</p> <p>(b)</p>	<p>(a)</p> <p>(b)</p>
	(3) Heritage	<p>(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?</p>	<p>(a)</p>	<p>(a)</p>
	(4) Landscape	<p>(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?</p>	<p>(a)</p>	<p>(a)</p>
	(5) Ethnic Minorities and Indigenous Peoples	<p>(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?</p> <p>(b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?</p>	<p>(a)</p> <p>(b)</p>	<p>(a)</p> <p>(b)</p>

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Environmental Checklist (Geothermal Power Station)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?	(a)	(a)
		(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?	(b)	(b)
		(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?	(c)	(c)
		(d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(d)	(d)
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?	(a)	(a)
		(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce the impacts?	(b)	(b)
		(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts?	(c)	(c)
5 Others	(2) Accident Prevention Measures	(a) Does the project have any accident prevention equipments and scheme to store, emit and transport toxic and hazardous materials? Are any pollution preventive measures for drinking water taken for example the facilities discharge liquid wastes to the rivers in an emergency?	(a)	(a)
		(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?	(a)	(a)
		(b) What are the items, methods and frequencies of the monitoring program?	(b)	(b)
		(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?	(c)	(c)
5 Others	(3) Monitoring	(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(d)	(d)

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Environmental Checklist (Geothermal Power Station)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	(a)	(a)
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a)	(a)

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

## Monitoring Form

-If environmental reviews indicate the need of monitoring by JICA, JICA undertakes monitoring for necessary items that are decided by environmental reviews. JICA undertakes monitoring based on regular reports including measured data submitted by the project proponent. When necessary, the project proponent should refer to the following monitoring form for submitting reports.

-When monitoring plans including monitoring items, frequencies and methods are decided, project phase or project life cycle (such as construction phase and operation phase) should be considered.

## 1. Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
ex.) Responses/Actions to Comments and Guidance from Government Authorities	

## 2. Mitigation Measures

## - Air Quality (Emission Gas / Ambient Air Quality)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
SO <sub>2</sub>						
NO <sub>2</sub>						
CO						
O <sub>3</sub>						
Soot and dust						
SPM						
Dust						

## - Water Quality (Effluent/Wastewater/Ambient Water Quality)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
SS (Suspended Solid)						
BOD/COD						
DO						
Total Nitrogen						
Total Phosphorus						
Heavy Metals						
Hydrocarbons / Mineral Oils						
Phenols						
Cyanide						

*Am*

Temperature						
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**- Waste**

Monitoring Item	Monitoring Results during Report Period

**- Noise / Vibration**

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Noise level						
Vibration level						

**- Odor**

Monitoring Item	Monitoring Results during Report Period

**3. Natural Environment**

**- Ecosystem**

Monitoring Item	Monitoring Results during Report Period
ex.) Negative effects/Actions to Valuable species	

**4. Social Environment**

**- Resettlement**

Monitoring Item	Monitoring Results during Report Period

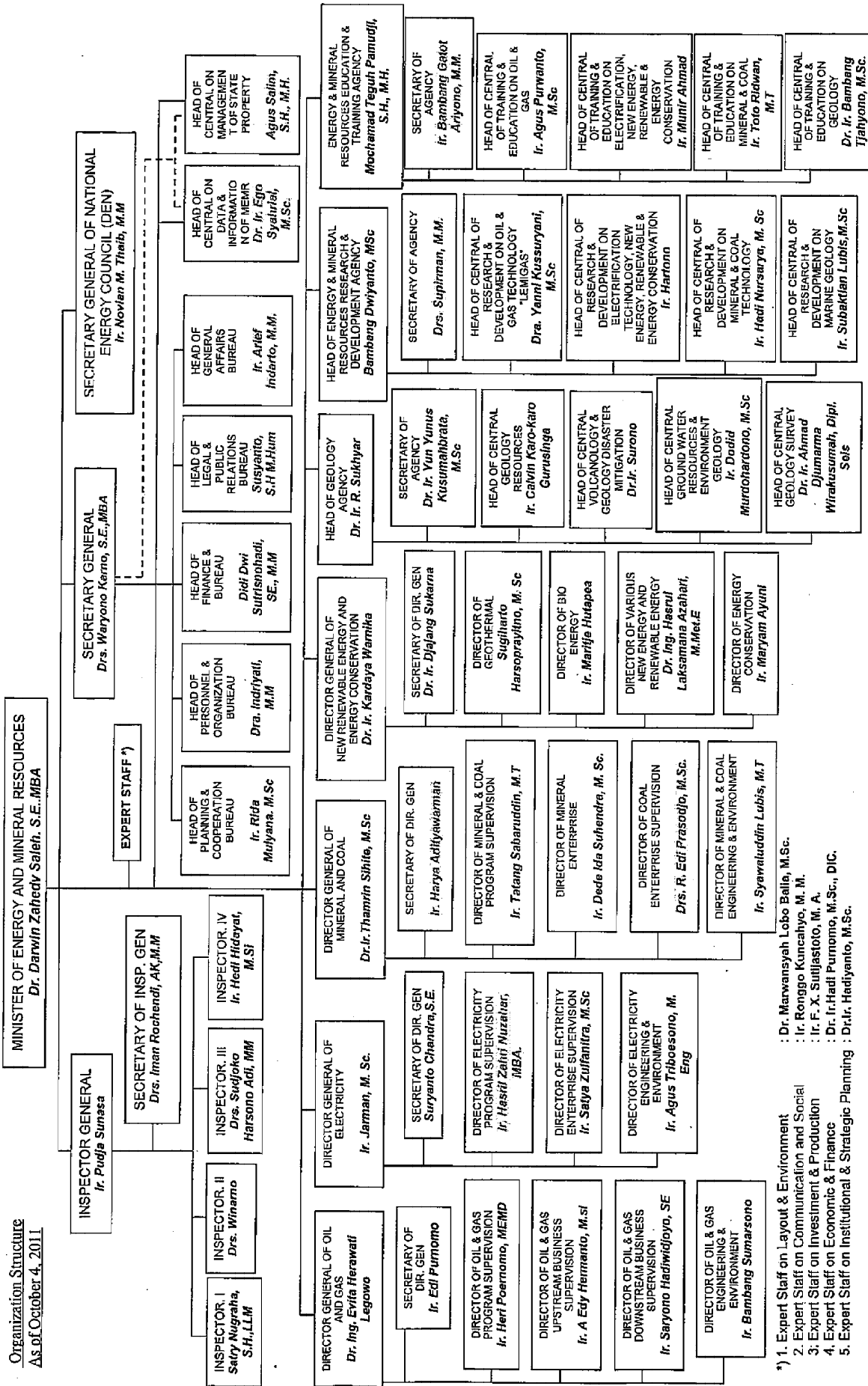
**- Living / Livelihood**

Monitoring Item	Monitoring Results during Report Period

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2. エネルギー-鉱物資源省組織図

Organization Structure  
As of October 4, 2011



- 1) Expert Staff on Layout & Environment : Dr. Marwansyah Lobo Balie, M.Sc.  
 2. Expert Staff on Communication and Social : Ir. Ronggo Kuncayo, M. M.  
 3. Expert Staff on Investment & Production : Ir. F. X. Sutjiastoto, M. A.  
 4. Expert Staff on Economic & Finance : Dr. Ir. Hadi Purnomo, M.Sc., DIC.  
 5. Expert Staff on Institutional & Strategic Planning : Dr. Ir. Hadiyanto, M.Sc.

### 3 . 面談録 ( 科学技術省、エネルギー・鉱物資源省 )

#### 科学技術省 ( RISTEK ) 面談録

- 1 . 日時 : 2011 年 10 月 5 日 ( 水 ) 14 時 30 分 ~ 15 時 15 分
- 2 . 先方 : Mr. TeguhTahardjo, Deputy Director General、Mr. Ruben Silitonga, Deputy Director for International S&T Network Development 他 1 名
- 3 . 当方 : 地球環境部 環境管理第一課 野田、肥田野ほか 4 名  
ITB : Dr. WawanGunawanKadir, Vice Rector of Research and Innovation、Dr. Sule, lecturer、Ms. Susanti, lecturer

#### 4 . 内容 :

今回当方の案件を開始するにあたって、これまでの案件採択等の協力御礼を目的として表敬したものを。先方の主な発言事項は次のとおり。

- ・ RISTEK においては 2010 年から組織改革をしているところ。研究開発は国家が優先して取り組む事項に位置づけられている。
- ・ SATREPS( 地球規模課題対応国際科学技術協力事業 ) 案件のプロポーザルは RISTEK 内で審査をしたあと、10 件を BAPPENAS( 国家開発企画庁 ) に提出し、BAPPENAS から MOF ( 財務省 ) に連絡が入るとい流れになっている。
- ・ 2010 年のプロポーザルのなかで本件は最高得点をつけた案件。過去の案件と違って民間企業のかかわりがあり重要と考える。また政策も重要なファクターであり ESDM ( エネルギー・鉱物資源省 ) との連携が求められると考える。
- ・ 日本人研究者が活動するにあたっては、リサーチパーミットが必要であるところ、プロジェクト開始の 2 カ月前を目途に、R/D ( 討議議事録 ) の写しを別添した活動計画書を提出してほしい ( 本件については、別途検討すると回答 ) 。

以 上

## エネルギー鉱物資源省（ESDM）面談録

- 1 . 日時：2011 年 10 月 5 日（水）16 時 15 分～17 時 30 分
- 2 . 先方：Dr. Ing. HasrulLaksmanaAzahari, M. Met. E, Director, Various Energy and Renewable Energy, Directorate General of New Renewable Energy and Energy Conservation、ESDM 矢野アドバイザー（JICA 長期専門家）
- 3 . 当方：地球環境部 環境管理第一課 野田、肥田野  
JICA インドネシア事務所：村田ほか 4 名  
ITB：Dr. WawanGunawanKadir, Vice Rector of Research and Innovation、Dr. Sule, lecturer、Ms. Susanti, lecturer
- 4 . 内容：

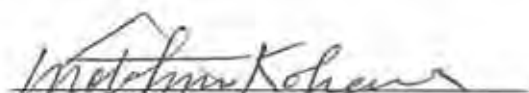
今回当方の案件を開始するにあたって、案件の紹介及び今後の協力を要請したものの、先方の主な発言事項は次のとおり。


- ・ インドネシアにおいては石炭火力発電（Clean Coal Technology）を推進していることもあり、今後 CCS（CO<sub>2</sub>分離回収・貯留）は重要になると考えており関心をもっている。
- ・ 当総局は 8 カ月ほど前に設立され、エネルギー問題を克服するためさまざまなアプローチをとる部署になっている。総局の下には地熱、バイオエネルギー、その他再生可能エネルギー（CCS 含む）の 3 つのセクションがある。ITB と当総局は MOU（覚書）を締結している。
- ・ CCS は環境問題を解決するためのひとつの手段。大臣も環境問題を非常に気にしている。政策にて何らかの対応をしなければならないと考えている。
- ・ 今後の協力を約束するが、何をすればよいか具体的に教えてほしい（ITB より内容を具体的に詰めて相談する旨説明あり、先方承知した）。

以 上

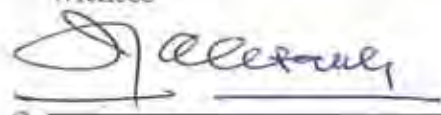
**RECORD OF DISCUSSIONS**  
**ON**  
**PILOT STUDY FOR CARBON SEQUESTRATION AND**  
**MONITORING IN GUNDIH AREA, CENTRAL JAVA PROVINCE,**  
**INDONESIA**  
**IN**  
**THE REPUBLIC OF INDONESIA**  
**AGREED UPON BETWEEN**  
**INSTITUT TEKNOLOGI BANDUNG**  
**AND**  
**JAPAN INTERNATIONAL COOPERATION AGENCY**

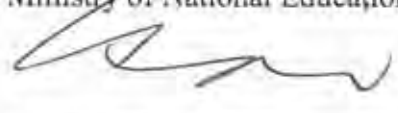
Jakarta, July 3<sup>rd</sup>, 2012

  
Motofumi Kohara  
Chief Representative  
Indonesia Office  
Japan International Cooperation Agency

  
Prof. Dr. Wawan Gunawan A. Kadir  
Vice Rector for Research and Innovation,  
Institut Teknologi Bandung (ITB)

Witness

  
Djoko Santoso  
Director General of Higher Education  
Ministry of National Education (MoNE)

  
Kardaya Warnika  
Director General of New and Renewable  
Energy and Energy Conservation,  
Ministry of Energy and Mineral  
Resources

Based on the minutes of meetings on the Detailed Planning Survey on the Pilot Study for Carbon Sequestration and Monitoring in Gundih Area, Central Java Province, Indonesia (hereinafter referred to as "the Project") signed on October 8<sup>th</sup> 2011 between Institut Teknologi Bandung (hereinafter referred to as "ITB") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with ITB and relevant organizations to develop a detailed plan of the Project.

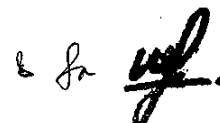
Both parties agreed the details of the Project and the main points discussed as described in the Appendix 1 and the Appendix 2 respectively.

Both parties also agreed that ITB, the counterpart to JICA, will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of Indonesia.

The Project will be implemented within the framework of the Colombo Plan and the Note Verbales to be exchanged between the Government of Japan (hereinafter referred to as "GOJ") and the Government of Republic of Indonesia.

Appendix 1: Project Description

Appendix 2: Main Points Discussed





## PROJECT DESCRIPTION

### I. BACKGROUND

Indonesia has a plan to reduce its emissions of carbon dioxide (CO<sub>2</sub>), a greenhouse gas, by 26% by 2020 as a measure against global warming. Emissions of CO<sub>2</sub> into the atmosphere from gas fields during production of natural gas is a problem for this plan, making it an urgent task to establish systematized techniques for carbon dioxide capture and storage (CCS) as a direct measure for their reduction. This study concerns approximately 0.3 million ton of CO<sub>2</sub> emitted annually during production of natural gas in a gas field presently under development in the Gundih Area, Central Java Province, Indonesia. It is a pilot study for research and development of technologies for assessing deep strata at sites of CO<sub>2</sub> injection, which is essential for safe application of CO<sub>2</sub> sequestration technologies, and for monitoring of underground distribution and behavior of CO<sub>2</sub> through capacity development of organizations and human resources.

### II. OUTLINE OF THE PROJECT

Details of the Project are described in the Logical Framework (Project Design Matrix:PDM) (Annex I) and the tentative Plan of Operation (Annex II).

#### 1. Input

##### (1) Input by JICA

###### (a) Dispatch of Experts

JICA will provide the services of Japanese experts as listed in Annex III.

###### (b) Training

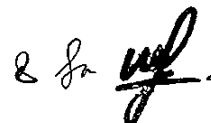
JICA will provide on-site trainings in the field operations in Indonesia through cooperative research works with Indonesian researchers and engineers. JICA will also receive the Indonesian personnel connected with this project for training in Japan.

###### (c) Machinery and Equipment

JICA will provide instruments and softwares necessary for implementing the project as listed in Annex IV. The instruments and softwares will become the properties of Government of the Republic of Indonesia upon being delivered C.I.F. (cost, insurance and freight) to the Indonesian authorities connected at the ports and/or airports of disembarkation.

##### (2) Input by ITB

ITB will take necessary measures to provide at its own expense:



- (a) Services of ITB's counterpart personnel and administrative personnel as listed in Annex V;
- (b) Suitable office space with necessary equipment;
- (c) Supply or replacement of machinery, equipment, instruments, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA;
- (d) Information as well as support in obtaining medical service;
- (e) Credentials or identification cards;
- (f) Available data (including maps and photographs) and information related to the Project;
- (g) Running expenses necessary for the implementation of the Project;
- (h) Expenses necessary for transportation within Indonesia of the equipments as well as for the installation, operation and maintenance thereof; and
- (i) Necessary facilities to the JICA experts for the remittance as well as utilization of the funds introduced into Indonesia from Japan in connection with the implementation of the Project

## 2. Implementation Structure

The Project organization chart is given in the Annex VI. The roles and assignments of relevant organizations are as follows:

### (1) ITB

#### (a) Project Director

Project Director will be responsible for overall administration and implementation of the Project.

#### (b) Project Manager

Project Manager will be responsible for managerial and technical matters of the project.

#### (c) Leader of each Indonesian authority related to the project

Leader of each Indonesian authority related to the project will be responsible for implementation of the part of the project defined in the plan of operation for each year.

### (2) JICA Experts

#### (a) Japanese Project Leader

Japanese Project Leader will provide necessary recommendations and advice to the Project Director and Project Manager on any matters pertaining to the implementation of the project.

#### (b) Japanese Expert

Japanese Experts will give necessary technical guidance, advice and recommendations to ITB on scientific and technical matters pertaining to the implementation of the Project.

### (3) Joint Coordinating Committee

Joint Coordinating Committee (hereinafter referred to as "JCC") will be established in order to facilitate inter-organizational coordination. JCC will be held at least once a year and whenever deems it necessary. JCC will approve an annual work plan, review overall progress, conduct monitoring and evaluation of the

Project, and exchange opinions on major issues that arise during the implementation of the Project. A list of proposed members of JCC is shown in the Annex VII.

### 3. Project Sites

The project sites are located in Bandung, West Java Province, and the Gundih gas field, Central Java Province, Indonesia.

### 4. Duration

The duration of the project will be five (5) years from the date of the first dispatch of JICA expert(s).

### 5. Reports

The following reports will be prepared in English by ITB.

- (1) Yearly Progress Report after the commencement of the Project
- (2) Final Report before the end of the Project

### 6. Environmental and Social Considerations

- (1) ITB agreed to abide by 'JICA Guidelines for Environmental and Social Considerations (April 2010)' in order to ensure that appropriate considerations will be made for the environmental and social impacts of the Project.

#### (2) Environmental Checklist

The environmental and social considerations including major impacts and mitigation measures for the Project will be examined during the first two years of preparation stage and will be summarized in the Environmental Checklist. Temporary, Environmental Checklist (Geothermal Power Station) is attached as Annex VIII for reference, whose content would be modified according to the results derived from the preparation stage.

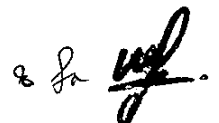
#### (3) Monitoring for Environmental and Social Considerations

Monitoring for environmental and social considerations will be conducted and assured by ITB in accordance with the Monitoring Plan for the Project. The monitoring items, frequency and monitoring structure will be prepared during the first two years of preparation stage and will be summarized in the Monitoring Form attached as Annex IX as an example.

The results of monitoring will be provided to JICA by filling in the Monitoring Form, as part of progress reports during the construction phase, and annually for two years after completion of the Project.

#### (4) Disclosure of Monitoring Result on the Website

ITB agreed that JICA may disclose the results of monitoring as shown in Annex IX conducted by ITB on JICA's website to the extent that those are made public in their country.



### **III. UNDERTAKINGS OF ITB**

1. ITB will take necessary measures to:

- (1) ensure that the technologies and knowledge acquired by the Indonesia nationals as a result of Japanese technical cooperation contributes to the economic and social development of Indonesia, and that the knowledge and experience acquired by the personnel of Indonesia from technical training as well as the equipment provided by JICA will be utilized effectively in the implementation of the Project; and
- (2) grant privileges, exemptions and benefits to the JICA experts of the JICA missions above and their families, which are no less favorable than those granted to experts of third countries performing similar missions in Indonesia under the Colombo Plan Technical Cooperation Scheme.

2. ITB will take necessary measures to:

- (1) provide security-related information as well as measures to ensure the safety of the JICA experts;
- (2) permit the JICA experts to enter, leave and sojourn in Indonesia for the duration of their assignments therein and exempt them from foreign registration requirements and consular fees.
- (3) exempt the JICA experts from taxes and any other charges on the equipment, machinery and other material necessary for the implementation of the Project;
- (4) exempt the JICA experts from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to them and/or remitted to them from abroad for their services in connection with the implementation of the Project; and
- (5) meet taxes and any other charges on the equipment, machinery and other material, referred to in II. 1. above, necessary for the implementation of the Project.

3. ITB or the Government of Republic of Indonesia will bear claims, if any arises, against the JICA experts resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the Project, except when such claims arise from gross negligence or willful misconduct on the part of the JICA experts.

### **IV. EVALUATION**

JICA and the ITB will jointly conduct the following evaluations and reviews.

1. Mid-term review around the middle of the cooperation term
2. Terminal evaluation during the last six (6) months of the cooperation term

### **V. PROMOTION OF PUBLIC SUPPORT**

For the purpose of promoting support for the Project, ITB will take appropriate

measures to make the Project widely known to the people of Indonesia.

#### **VI. MUTUAL CONSULTATION**

JICA and ITB will consult each other whenever any major issues arise in the course of Project implementation.

#### **VII. AMENDMENTS**

The record of discussions may be amended by the minutes of meetings between JICA and ITB.

The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the record of discussions.

Annex I	Logical Framework (Project Design Matrix:PDM)
Annex II	Tentative Plan of Operation
Annex III	List of Japanese Experts
Annex IV	List of Instruments and softwares
Annex V	List of Indonesian Experts
Annex VI	Project Organization Chart
Annex VII	List of Members of Joint Coordinating Committee
Annex VIII	Environmental Checklist
Annex IX	Monitoring Form



Project Design Matrix (PDM)  
 Project Name: Pilot study for Carbon Sequestration and Monitoring in the Gundih Area, Central Java Province, Indonesia  
 Implementation Agency: ITB  
 Project Site: Bandung and the Gundih gas field, Central Java, Indonesia

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
<p><b>Overall Goal</b>            Carbon Capture and Storage (CCS) programs in Indonesia are promoted for accelerating oil and gas development and production with zero CO<sub>2</sub> emission.</p>	<p>More than five CCS programs in Indonesia will be planned referring the SOP proposed in this project.</p>	<p>Official reports by the Government of Indonesia</p>	
<p><b>Project Purpose</b>            Standard Operating Procedures (SOP) for CO<sub>2</sub> storage evaluation technology, CO<sub>2</sub> sequestration and monitoring technology, which is necessary for CCS technology application, is proposed for promoting CCS programs in onshore gas fields in Indonesia.</p>	<p>1. A proposal of a SOP for safe and effective CO<sub>2</sub> sequestration technology in onshore is disseminated to 20 organizations.            2. Technologies for CO<sub>2</sub> sequestration and monitoring are developed with Indonesian researchers and engineers through the collaborative work.</p>	<p>1. Proposals of a SOP for safe and effective CO<sub>2</sub> sequestration technology in onshore            2. Yearly Progress Reports</p>	
<p><b>Output 1</b>            Detailed action plan of the Project including the implementation structure is completed for CO<sub>2</sub> sequestration and monitoring in the Gundih gas field.</p>	<p>1-1. Implementation structure and an operational plan are determined.            1-2. Detailed action plan of CO<sub>2</sub> sequestration and monitoring in the Gundih gas field is discussed and prepared.</p>	<p>1-1. Documents on the detailed action plan of CO<sub>2</sub> sequestration and monitoring in the Gundih gas field</p>	<p>1. G&amp;G data for the CO<sub>2</sub> storage of the Gundih gas field are available.</p>
<p><b>Output 2</b>            Characterization/evaluation of CO<sub>2</sub> sequestration site(s) and CO<sub>2</sub> storage are completed to proceed the activities under output 3 and surface facility simulations.</p>	<p>2-1. A database for the Geology and Geophysics (G&amp;G) and physical property data for the Gundih gas field is established.            2-2. Geological and reservoir models for CCS of the Gundih gas field are constructed.            2-3. Prediction results of injected CO<sub>2</sub> movement in the reservoir are prepared for at least 3 stages, immediately after injection, after CO<sub>2</sub> settlement and 1000 years later.            2-4. Simulations for the configuration process equipment are conducted.</p>	<p>2-1. The database developed in the Project            2-2. Geological and reservoir model            2-3. Documents on prediction results of reservoir model            2-4. Documents on configuration process equipment plan</p>	
<p><b>Output 3</b>            Feasibility study including surface facility design and cost evaluation is completed for CO<sub>2</sub> sequestration and monitoring in the Gundih gas field.</p>	<p>3-1. A CO<sub>2</sub> sequestration and monitoring report in the Gundih gas field including a grand design/directions is prepared.            3-2. A surface facility design report for the Gundih gas field is prepared.</p>	<p>3-1. A report including a grand design/directions on the CO<sub>2</sub> sequestration and monitoring            3-2. A report on the surface facility design</p>	
<p><b>Output 4</b>            Geophysical and geochemical technologies which can be applied for CO<sub>2</sub> sequestration and monitoring are evaluated in the actual storage to determine integrated technologies for storage evaluation and CO<sub>2</sub> monitoring.</p>	<p>4.1 Technologies and know-hows for data acquisition and processing of the storage evaluation and monitoring are compiled in the report.</p>	<p>4-1. Work reports for the operation and measurement for the instruments provided            4-2. Work reports for data processing and interpretation using softwares provided</p>	
<p><b>Output 5</b>            SOP is prepared based on the analysis and the evaluation of the Gundih gas field CO<sub>2</sub> sequestration and monitoring.</p>	<p>5-1. A SOP for CO<sub>2</sub> sequestration and monitoring technology for an onshore gas field is prepared.</p>	<p>5-1. SOP</p>	
<p><b>Activities (Output)</b>            1-1. Prepare the implementation structure and personnel for establishing the research teams.            1-2. Prepare the operational plan for the researches.            1-3. Establish the inter-ministry/inter-department coordination framework among Ministry of Energy and Mineral Resources and other related ministries.            1-4. Establish the international coordination framework.            1-5. Conduct periodical review and revision-up of the frameworks established in (1-3) and (1-4).            1-6. Hold semiannual technical exchange meetings and CCS Symposium.            1-7. Carry out basic survey on CCS in Indonesia from technical points of view.            1-8. Carry out study on CCS strategy in the Gundih gas field to implement CO<sub>2</sub> injection and monitoring.            1-9. Complete a</p>	<p><b>Main Inputs</b>            Indonesia side:            1. Indonesian experts required for collaborative researches and their smooth operations in Indonesia            2. Materials and documents required for researches on Indonesia side related items            3. Office space and equipments            4. Running expenses (electricity, water, telephones and so on)            Japan side:            1. Personnel            1-1. Long-term experts            - Coordinator for administration</p>		

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<p>(Output 2)</p> <p>2-1. Prepare a model for CO2 sequestration site(s) and CO2 storage.</p> <p>2-1-1. Collect required data and update new database for the description of the site and reservoirs.</p> <p>2-1-2. Carry out complementary Geology and Geophysics(G&amp;G) surveys in and around the Gundi gas field for geological modelling.</p> <p>2-1-3. Make a geological model of the site(s) and CO2 storage by using existing and new data. (static reservoir modeling)</p> <p>2-2. Conduct laboratory test.</p> <p>2-2-1. Check the availability of cores obtained from reservoir intervals.</p> <p>2-2-2. Set up the laboratory test instrument.</p> <p>2-2-3. Conduct laboratory tests for determining rock properties in real reservoir condition.</p> <p>2-3. Carry out a reservoir simulation and evaluation.</p> <p>2-3-1. Construct a reservoir model using the geological and laboratory data.</p> <p>2-3-2. Carry out a reservoir simulation using new G&amp;G model (dynamic modeling) and evaluation.</p> <p>2-4. Carry out surface facility simulations for configuration process equipment.</p>	<p>1-2. Short term experts</p> <ul style="list-style-type: none"> <li>- Japanese Project Leader</li> <li>- Japanese Experts</li> </ul> <p>2. Materials and documents</p> <ul style="list-style-type: none"> <li>- Materials and documents required for researches</li> </ul> <p>3. Instruments and software</p> <p>4. Training</p>
<p>(Output 3)</p> <p>3-1. Make a grand design of CO2 sequestration and monitoring including the cost evaluation.</p> <p>3-2. Design the surface facility for CO2 sequestration and monitoring.</p> <p>3-3. Conduct a survey to assess impacts for environmental and social considerations.</p>	
<p>(Output 4)</p> <p>4-1. Carry out the field work on measurement techniques using instruments provided from JICA.</p> <p>4-2. Carry out the data acquisition, processing, and interpretation for each monitoring method as below.</p> <p>4-2-1. 4D high-resolution seismic method</p> <p>4-2-2. 4D electric/electromagnetic method</p> <p>4-2-3. 4D microgravity method</p> <p>4-2-4. InSAR and GPS method</p> <p>4-2-5. 4D microseismic method</p> <p>4-2-6. Natural earthquake seismic tomography and interferometric method</p> <p>4-2-7. Geochemical and hydrogeological method</p> <p>4-2-8. Integrated quantitative interpretation for estimating CO2 saturation in the reservoir</p>	
<p>(Output 5)</p> <p>5-1. Review and evaluate the results of CO2 sequestration and monitoring in the Gundi gas field.</p> <p>5-2. Draft the SOP of CO2 sequestration and monitoring.</p> <p>5-3. Conduct seminar(s) and present the SOP.</p>	
<p>Prerequisites</p> <p>Perjanjian Kerjasama (Joint Cooperation Agreement) and Confidential Agreement between ITB and Pertamina</p>	

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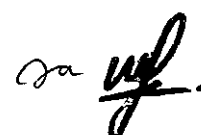
## List of JICA Experts

### 1. Long-term experts

Coordinator for administration: JICA

### 2. Short-term experts

- 1) Toshifumi Matsuoka (Kyoto University)
- 2) Liang Yunfeng (Kyoto University)
- 3) Yasuhiro Yamada (Kyoto University)
- 4) Sumihiko Murata (Kyoto University)
- 5) Yoichi Fukuda (Kyoto University)
- 6) Hiroyasu Ohtsu (Kyoto University)
- 7) Yoshitada Mito (Kyoto University)
- 8) Katsunori Sawai (Kyoto University)
- 9) Kyosuke Onishi (Akita University)
- 10) Akira Saito (Waseda University)
- 11) Keiko Nakayama (Waseda University)
- 12) Takeshi Tsuji (Kyushu University)
- 13) Jun Nishijima (Kyushu University)
- 14) Keigo Kitamura (Kyushu University)
- 15) Syuichi Rokugawa (University of Tokyo)
- 16) Akira Ueda (Toyama University)
- 17) Toru Sato (Japan Petroleum Exploration Co. Ltd.)
- 18) Tatsuhiko Matsuura (Japan Petroleum Exploration Co. Ltd.)
- 19) Yasuo Takehana (Japan Petroleum Exploration Co. Ltd.)
- 20) Kazuhiko Tezuka (Japan Petroleum Exploration Co. Ltd.)
- 21) Kohei Akaku (Japan Petroleum Exploration Co. Ltd.)
- 22) Masanori Nakano (Japan Petroleum Exploration Co. Ltd.)
- 23) Daisuke Ito (Japan Petroleum Exploration Co. Ltd.)
- 24) Toru Takahashi (Fukada Geological Institute)
- 25) Tatsukichi Tanaka (Fukada Geological Institute)
- 26) And other related experts



## List of instruments and softwares

### Instruments:

- Gravity meter
- EM measurement system
- 3D seismic acquisition system
- Borehole and surface micro-seismic acquisition system
- Wireline logging equipment
- Magnetometer
- Geoelectrical measurement system
- Quad Core CPU computer for processing and simulation

### Softwares:

- Geological modeling/Reservoir simulation software
- Gravity/Magnetic data processing software
- Geoelectrical software
- EM data processing software
- InSAR data processing software

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List of Indonesian Experts

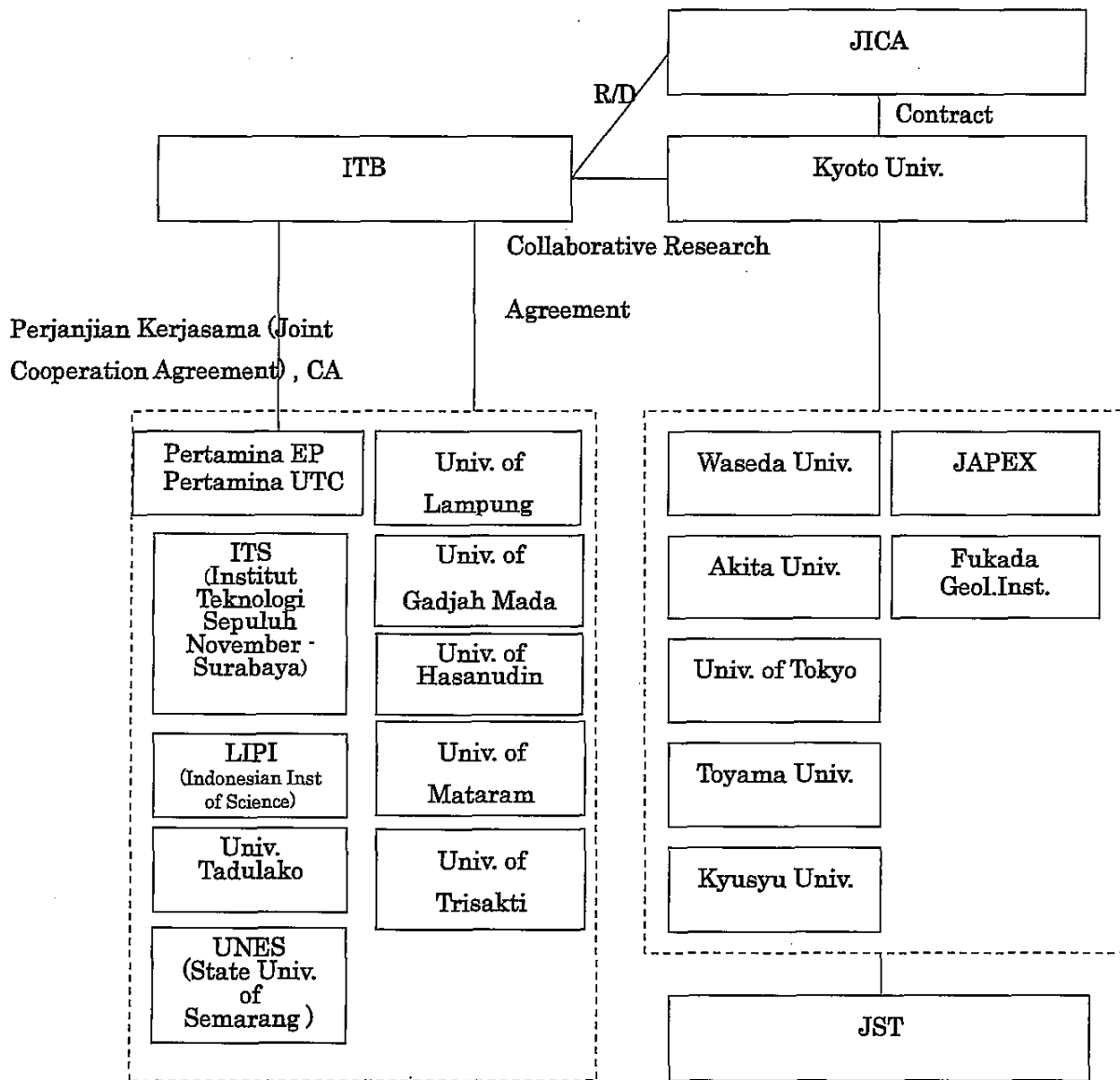
- 1) Project Director: Prof. Dr. Wawan Gunawan A. Kadir (Vice Rector for Research and Innovation, ITB)
- 2) Project Manager: Dr. Mohammad Rachmat Sule (Lecturer, ITB)
- 3) Coordinator from Pertamina UTC: Dr. Djedi S. Widarto (Acting Chief of New Energy and Green Technology)
- 4) Coordinator from Pertamina EP: Mr. Dody Sasongko (GM PPGJ- Pertamina EP)
- 5) Prof. Dr. Sri Widiyantoro (ITB)
- 6) Prof. Dr. Djoko Santoso (ITB)
- 7) Prof. Dr. Doddy Abdassah (ITB)
- 8) Prof. Dr. Satria Bijaksana (ITB)
- 9) Prof. Dr. Sismanto (UGM)
- 10) Tutuka Ariadji, Ph.D (ITB)
- 11) Dr. Darharta Dahrin (ITB)
- 12) Dr. Agus Laesanpura (ITB)
- 13) Dr. Hendra Grandis (ITB)
- 14) Dr. Eko Widiyanto (Trisakti University)
- 15) Dr. Susanti Alawiyah (ITB)
- 16) Dr. Setianingsih (ITB)
- 17) Dr. Sarkowi (Lampung University)
- 18) Dr. Suhayat (Mataram University)
- 19) Dr. Fatkhan (ITB)
- 20) Dr. Andri D. Nugraha (ITB)
- 21) Dr. Alfian Bahar (ITB)
- 22) Mr. Ridho Affandi (Pertamina EP)
- 23) Ms. Melia Surghani (Pertamina UTC)
- 24) Mr. Harris Prabowo (Pertamina UTC)
- 25) Dr. Sutopo (ITB)
- 26) Dr. Zuher Syihab (ITB)
- 27) Dr. Ing. Bonar Tua Halomoan Marbun (ITB)
- 28) Mr. Sabrianto Aswad (UNHAS)
- 29) Mr. Gede Widiarna (Pertamina EP)
- 30) Mr. Abidzar Akman (Pertamina EP)



- 31) Mr. Doddy Priambodo (Pertamina EP)
- 32) Mrs. Ory Sadjati (Pertamina UTC)
- 33) Mr. Samsul Hidayat (Pertamina UTC)
- 34) Dr. Sigit Sukmono (ITB)
- 35) Dr. Sonny Winardhi (ITB)
- 36) Dr. Awali Priyono (ITB)
- 37) Dr. Rachmat Fajar Lubis (LIPI)
- 38) Dr. Dasapta Erwin Irawan (ITB)
- 39) Dr. Syaiful Bachri (ITS)
- 40) Dr. Zainuddin (UNILA)
- 41) Dr. Rustan Efendi (Tadulako University)
- 42) Dr. Muhammad Hamzah (UNHAS)
- 43) Prof. Supriadi Rustad (UNES)
- 44) Dr. Supriyadi (UNES)
- 45) Dr. Chalid Idham Abdullah (ITB)
- 46) Prof. Yahdi Zaim (ITB)
- 47) Ir. Budianto Toha (UGM)
- 48) Prof. Dr. Sudarto Notosiswoyo (ITB)

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Project Organization Chart



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A List of Members of Joint Coordinating Committee

1. Functions

A Joint Coordination Committee will be organized. The committee meeting will be held at least once a year whenever need arises.

The functions of the Committee are as follow;

- (1) To supervise the annual work plan of the project in line with the Plan of Operation.
- (2) To review the annual and overall progress of the project and to evaluate the accomplishment of the annual targets and achievement of the objectives.
- (3) To find out proper ways and means for solution of the major issues arising from or in connection with the project.

2. Composition of the Committee

(1) Chairperson: Ministry of National Education/Higher Education Director General

(2) Members

a. Indonesian side:

Project Director: Institut Teknologi Bandung (ITB)/Vice Rector

Project Manager: ITB/Lecturer

Pertamina EP: General Manager of Project Pengembangan Gas Jawa (PPGJ); Jawa Gas Development Project

Pertamina UTC: Senior Researcher

Representative(s) of the research organizations involved in the project

b. Japanese side:

Representative(s) of JICA Indonesia Office

Japanese Project Leader

Representative(s) of the research organizations involved in the project

Members(s) of missions dispatched by JICA

c. Observer(s):

Representative(s) of JST

Official(s) of the Embassy of Japan

Other officials appointed by the Chairperson may attend the committee meetings as observer.



Environmental Checklist (Geothermal Power Station)

Annex VIII

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) (b) (c) (d)	(a) (b) (c) (d)
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) (b)	(a) (b)
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations? (a) Do air pollutants, such as hydrogen sulfide (H <sub>2</sub> S) emitted from geothermal power plants comply with the country's standards? Is there a possibility that the emitted hydrogen sulfide will have the impacts on the surrounding areas, including vegetation? Are any mitigating measures taken? (b) Do air pollutants emitted from the other project facilities comply with the country's emission standards?	(a) (a) (b)	(a) (a) (b)
	(1) Air Quality			

8 for ref.

Environmental Checklist (Geothermal Power Station)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
2 Pollution Control	(2) Water Quality	(a) Do effluents (including thermal effluent) from the project facilities, such as power generation facilities comply with the country's effluent standards? Is there any possibility that the effluents from the project will cause any areas not to comply with the country's ambient water quality standards? (b) In the case of geothermal power plants, is there any possibility that geothermal utilization will cause water pollution by toxicants, such as Arsenic (As) and Mercury (Hg) contained in geothermal fluids? If the water pollution is anticipated, are adequate measures considered? (c) Do leachates from the waste disposal sites comply with the country's effluent standards and ambient water quality standards? Are adequate measures taken to prevent contamination of soil, groundwater, and seawater by leachates? (d) Is there any possibility that effluent from well excavation would cause water contamination? If water pollution is anticipated, are adequate measures considered?	(a) (b) (c) (d)	(a) (b) (c) (d)
	(3) Wastes	(a) Are wastes generated by the plant operations properly treated and disposed of in accordance with the country's regulations? (b) Are wastes generated by the effluents from well-excavation properly treated and disposed of in accordance with the country's standards? (a) Do noise and vibrations comply with the country's standards?	(a) (b)	(a) (b)
2 Pollution Control	(4) Noise and Vibration	(a) Is there any possibility that the extraction of steam will cause subsidence?	(a)	(a)
	(5) Subsidence	(a) Are there any odor sources such as H <sub>2</sub> S, and anticipated any effect? Are adequate odor control measures taken?	(a)	(a)
3 Natural Environment	(6) Odor	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a)	(a)
	(1) Protected Areas	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) Is there a possibility that the project will adversely affect downstream aquatic organisms, animals, plants, and ecosystems? Are adequate protection measures taken to reduce the impacts on the ecosystem?	(a) (b) (c)	(a) (b) (c)

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Environmental Checklist (Geothermal Power Station)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)	
4 Social Environment	(3) Topography and Geology	(a) Is there any possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) (a) (b) (c) (d) (e) (f) (g) (h) (i) (j)	(a)	
	(1) Resettlement	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that the amount of water (e.g., surface water, groundwater) used and discharge of effluents by the project will adversely affect the existing water uses and water area uses? (a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws? (a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) (b) (a) (a)	(a) (b)	
	(2) Living and Livelihood	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) (b)	(a) (b)	(a) (b)
	(3) Heritage		(a)	(a)	
	(4) Landscape		(a)	(a)	

2 for ref.

Environmental Checklist (Geothermal Power Station)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(6) Working Conditions	<p>(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?</p> <p>(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials?</p> <p>(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.?</p> <p>(d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?</p>	(a) (b) (c) (d)	(a) (b) (c) (d)
	(1) Impacts during Construction	<p>(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?</p> <p>(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce the impacts?</p> <p>(c) If construction activities adversely affect the social environment, are adequate measures considered to reduce the impacts?</p>	(a) (b) (c)	(a) (b) (c)
5 Others	(2) Accident Prevention Measures	<p>(a) Does the project have any accident prevention equipments and scheme to store, emit and transport toxic and hazardous materials? Are any pollution preventive measures for drinking water taken for example the facilities discharge liquid wastes to the rivers in an emergency?</p>	(a)	(a)
	(3) Monitoring	<p>(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?</p> <p>(b) What are the items, methods and frequencies of the monitoring program?</p> <p>(c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?</p> <p>(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?</p>	(a) (b) (c) (d)	(a) (b) (c) (d)

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Environmental Checklist (Geothermal Power Station)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	(a)	(a)
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a)	(a)

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

## Monitoring Form

-If environmental reviews indicate the need of monitoring by JICA, JICA undertakes monitoring for necessary items that are decided by environmental reviews. JICA undertakes monitoring based on regular reports including measured data submitted by the project proponent. When necessary, the project proponent should refer to the following monitoring form for submitting reports.

-When monitoring plans including monitoring items, frequencies and methods are decided, project phase or project life cycle (such as construction phase and operation phase) should be considered.

## 1. Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
ex.) Responses/Actions to Comments and Guidance from Government Authorities	

## 2. Mitigation Measures

## - Air Quality (Emission Gas / Ambient Air Quality)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
SO <sub>2</sub>						
NO <sub>2</sub>						
CO						
O <sub>3</sub>						
Soot and dust						
SPM						
Dust						

## - Water Quality (Effluent/Wastewater/Ambient Water Quality)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
SS (Suspended Solid)						
BOD/COD						
DO						
Total Nitrogen						
Total Phosphorus						
Heavy Metals						
Hydrocarbons / Mineral Oils						
Phenols						
Cyanide						

Temperature						
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**- Waste**

Monitoring Item	Monitoring Results during Report Period

**- Noise / Vibration**

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Noise level						
Vibration level						

**- Odor**

Monitoring Item	Monitoring Results during Report Period

**3. Natural Environment**

**- Ecosystem**

Monitoring Item	Monitoring Results during Report Period
ex.) Negative effects/Actions to Valuable species	

**4. Social Environment**

**- Resettlement**

Monitoring Item	Monitoring Results during Report Period

**- Living / Livelihood**

Monitoring Item	Monitoring Results during Report Period

## MAIN POINTS DISCUSSED

1. Environmental and Social Considerations

In the Gundih gas field, Pertamina EP is operating Java Gas Development Project. Analysis of Environment Impact including the monitoring guideline is completed in 2007 for the Java Gas Development Project by the third parties. Since then, the environmental monitoring for Air, Water, Soil and Social culture is conducted two times a year. It will continue up till the end of the gas production.

Once the Project starts, further detailed examinations will be done to assess the impacts for the environmental and social considerations, which may be caused by the specific actions related to the Project. If necessary, Environmental Checklist and Monitoring Form will be prepared accordingly.

2. The Project division into two phases

It is assumed that the Project should be divided into two main phases: The first phase comprises a feasibility study including facility design and cost evaluation for CO<sub>2</sub> sequestration and monitoring in the Gundih gas field, and the second phase includes the project activities following CO<sub>2</sub> sequestration in the field. Before the end of the first phase, both Indonesian side and Japanese side will review the progress and issues to be solved, and will decide necessary steps to be taken forward including the modification of the Project activities and the Project duration, as described in 'II. 4. Duration' of Appendix 1.

This is because it is currently uncertain whether CO<sub>2</sub> sequestration in the Gundih gas field will be conducted. According to Indonesian side, the best scenario anticipated at this moment is that the proposed CO<sub>2</sub> sequestration design based on the feasibility study is widely approved by stakeholders, and the related cost is recovered by a scheme of oil and gas production similar to the scheme stated in the regulation Peraturan Pemerintah Republik Indonesia Nomor 79, 2010.

3. Local cost

JICA might be able to bear a part of local cost based on the rules and regulations determined by JICA and ITB upon the commencement of the Project.

