



ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

il Direttore

Gestione WEB

**Istituto Nazionale di Geofisica
e Vulcanologia
A00 INGV**

Protocollo Generale - U
N. 0005950
del 24/04/2018



Ai Direttori di Dipartimento
Ai Direttori di Sezione
Al Responsabile Centro Servizi – Ufficio per il Coordinamento
delle attività a Supporto della Ricerca
Alla Segreteria della Presidenza

Oggetto: Pubblicità atti

Si notifica in copia l'allegata Delibera n. 558/2018 del 12/03/2018 – Allegato J al Verbale n. 02/2018 concernente: Agreement between AEM Energy Solutions SDN. BHD. and INGV – Istituto Nazionale di Geofisica e Vulcanologia for methodology of mitigation Co2 leakage (Overburden Study).

Tullio PEPE



Istituto Nazionale di Geofisica e Vulcanologia

Delibera n. 558/2018

Allegato J al Verbale n. 02/2018

Oggetto: AGREEMENT BETWEEN AEM Energy SOLUTIONS SDN. BHD. AND INGV - ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA FOR METHODOLOGY OF MITIGATION CO2 LEAKAGE (OVERBURDEN STUDY).

IL CONSIGLIO DI AMMINISTRAZIONE

- **VISTO** il Decreto legislativo 29 settembre 1999, n. 381, concernente la costituzione dell'Istituto Nazionale di Geofisica e Vulcanologia (INGV);
- **VISTA** la Legge 27 settembre 2007, n. 165, concernente la "Delega al Governo in materia di riordino degli Enti di Ricerca";
- **VISTO** il Decreto legislativo 31 dicembre 2009, n. 213, concernente il "Riordino degli Enti di Ricerca in attuazione dell'art. 1 della Legge 27 settembre 2007, n. 165";
- **VISTO** il Decreto legislativo 25 Novembre 2016, n. 218, recante "*Semplificazione delle attività degli Enti Pubblici di Ricerca ai sensi dell'art. 13 della Legge n. 124/2015*";
- **VISTO** lo Statuto dell'Istituto Nazionale di Geofisica e Vulcanologia approvato con delibera n. 424/2017 del Consiglio di Amministrazione, in data 15 settembre 2017 - pubblicato sulla Gazzetta Ufficiale della Repubblica Italiana – Serie Generale n. 27 del 02 febbraio 2018 in particolare l'art. 8 comma 6 lettera f) il quale prevede che il CdA*delibera la partecipazione a società, fondazione e consorzi, nonché la stipulazione di accordi con organismi nazionali, europei e internazionali*;
- **VISTO** il Regolamento di Organizzazione e Funzionamento (ROF) dell'Istituto Nazionale di Geofisica e Vulcanologia vigente;
- **VISTO** il Regolamento di Amministrazione, Contabilità e Finanza pubblicato sulla Gazzetta Ufficiale della Repubblica Italiana – Serie Generale n. 113 del 18 maggio 2009;
- **VALUTATA** l'opportunità di sottoscrivere l'Agreement between AEM Energy Solutions SDN. BHD. and INGV FOR METHODOLOGY OF MITIGATION CO2 LEAKAGE (OVERBURDEN STUDY);
- **CONSIDERATO** che l'attività da espletare rientra tra i compiti scientifici e istituzionali dell'INGV;
- **VISTI** il parere favorevole del Settore Progetti Ricerca e Sviluppo, il quale ha asserito la conformità del progetto;

9/6



Istituto Nazionale di Geofisica e Vulcanologia

DELIBERA

di autorizzare il Presidente, alla definizione nonché alla sottoscrizione dell'agreement tra AEM Energy Solutions Sdn. Bhd. and INGV - Istituto Nazionale di Geofisica e Vulcanologia for methodology of mitigation Co2 leakage (Overburden Study)(All.1).

Letto, approvato e sottoscritto seduta stante.

Roma, 12/03/2018

La segretaria verbalizzante
(Sig.ra Antonella CIANCHI)

IL PRESIDENTE
(Prof. Carlo DOGLIONI)

AGREEMENT

BETWEEN

AEM ENERGY SOLUTIONS SDN. BHD.

AND

**INGV - ISTITUTO NAZIONALE DI GEOFISICA E
VULCANOLOGIA**

FOR

**METHODOLOGY OF MITIGATION CO2 LEAKAGE
(OVERBURDEN STUDY)**

9/10

THIS AGREEMENT dated this 18 day of December 2017 is made between:

AEM ENERGY SOLUTIONS SDN BHD, a company duly incorporated in Malaysia and having its registered office at Level 15, West Block, Wisma Selangor Dredging, 142C, Jalan Ampang, 50450 Kuala Lumpur, Malaysia (hereinafter referred to as "AEM ENERSOL") of the first part; and

INGV - ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA, a research institute duly incorporated in Italy and having its registered office via di Vigna Murata, 605 00143 Roma (Italy) (hereinafter referred to as "INGV") of the second part.

Both parties shall be collectively referred to as the "Parties" or individually as a "Party" as the context may require.

WHEREAS

- A. AEM ENERSOL, is desirous of engaging INGV to provide technical services for the Methodology of Mitigating CO2 Leakage – Overburden Study (hereinafter referred to as the "Services").
- B. INGV is a provider of technical support in areas of CO2 storage and monitoring, has the necessary skills and expertise as well as equipment and facilities to perform the Services.
- C. AEM ENERSOL is desirous of engaging INGV to provide the Services and INGV is willing and able to provide and perform the Services in accordance with the terms and conditions set out in this Agreement.

IT IS AGREED AS FOLLOWS:

1. DEFINITIONS AND INTERPRETATION

- 1.1 The following words and expressions shall, unless the context otherwise requires, have the following meanings:

"Affiliate" means a company or corporation or other entity which directly or indirectly owns or controls, is controlled by, or is under common control with, a Party. For the purpose of this definition, "control" or "controlled" means

the possession of at least fifty percent (50%) of the issued share capital of the Party or other entity or having the right to control the composition of the board of directors of the Party or other entity.

"Agreement" means this agreement and the appendices attached to this agreement or incorporated by reference.

"Associated Person" means a person associated with INGV including, but not limited to any of its employees, agents, contractors, sub-contractors, consultants, representatives and agents of INGV.

"Background Information" means all technical data, information (including confidential information), drawings, designs, operating experience and techniques, know-how of the Parties and other knowledge in any form including Intellectual Property relating to technology possessed by each INGV and/or its Affiliates at the Effective Date or as may be provided by the Party during the Term in connection with the performance of the Project.

"Deliverables" means the deliverables set out in Appendix 1-3.

"Developed Information" means all technical data, information (including confidential information), drawings, designs, operating experience, procedures, algorithms, models or computer codes, and techniques, know-how of the Parties and other knowledge in any form including Intellectual Property relating to the expertise or know how arising from the Services having potential application beyond the objectives of the Services but shall exclude Background Intellectual Property and Background Information.

"Effective Date" means the date of the commencement of the Project which is [2017].

"Event of Force Majeure" means any cause affecting the performance of this Agreement arising from or attributable to any acts, events, non-happenings, omissions or accidents beyond the reasonable control of the Party to perform and in particular but without limiting the generality thereof shall include strikes, lock-outs, industrial action, civil commotion, riot, invasion, war, threat of or preparation for war, fire, explosion, storm, flood, earthquake, subsidence, epidemic or other natural physical disaster,

impossibility of the use of railways, shipping, aircraft, motor transport, or other means of public or private transport, or political interference with the normal operation of either Party.

"Intellectual Property" means any patent, industrial design, copyright, layout designs of integrated circuit, trade mark, trade name, trade secret, inventions, rights in know-how, right of confidence, trade secret and any other intellectual property right of any nature whatsoever subsisting in any part of the world.

"Milestones" means the specified progress in the Project as specified in Appendix 2 and 3.

"AEM ENERSOL" means AEM Energy Solutions Sdn Bhd (Company No. 1160384 - D) with its registered office at at Level 15, West Block, Wisma Selangor Dredging, 142C, Jalan Ampang, 50450 Kuala Lumpur, Malaysia.

"Payment Schedule" means the schedule for the issuance of invoices by INGV and payment by AEM ENERSOL, subject the terms and conditions of this Agreement, as set out in Appendix 2.

"Project" means "Methodology of Mitigating CO2 Leakage (Overburden Study)" for which the Services will be performed by INGV, the details of which are as set out in Appendix 1.

"Project Cost" means the costs involved in the performance of Project as set out in Appendix 2.

"Project Schedule" means the timeline in which the Scope of Work will be carried out as set out in Appendix 3.

"Project Team" means researchers, administrators, resource persons, technicians, lab assistants and consultants provided by INGV to execute the Project.

"Relevant Requirements" means all applicable laws, statutes, regulations and codes relating to anti-bribery and anti-corruption.

"Relevant Policies" means **Part II A (Conflict of Interest)** and **Part II B (Fighting Corruption and Unethical Practices)** of the AEM ENERSOL Code of Conduct and Business Ethics and other related policies, procedures, guidelines and requirements as updated by AEM ENERSOL from time to time.

"Relevant Obligations" means obligations equivalent to those imposed on INGV in Clause 17.

"Scope of Work" means the written statement defining the Services to be carried out by INGV as set out in Appendix 1.

"Term" means the period of twelve (12) months commencing on the Effective Date.

1.2 In this Agreement, unless the context otherwise requires:

1.2.1 Headings are for convenience only and do not affect interpretation.

1.2.2 A reference to:

- i. a singular word includes the plural, and vice versa;
- ii. legislation (including subordinate legislation) is to that legislation as amended, re-enacted or replaced, and includes any subordinate legislation issued under it;
- iii. a document or agreement, or a provision of a document or agreement, is to that document, agreement or provision as amended, supplemented, replaced or novated;
- iv. a Party to this document or to any other document or agreement includes a permitted substitute or a permitted assign of that Party;
- v. anything (including a right, obligation or concept) includes each part of it;
- vi. a word which suggests one gender includes the other gender;

- vii. a clause or schedule is a reference to a clause of or a schedule to this Agreement; and
- viii. the words "include" and "including" are to be construed without limitation.

1.2.3 If the doing of any act, matter or thing under this Agreement is dependent on the consent or approval of a Party or is within the discretion of a Party, the consent or approval may be given or the discretion may be exercised conditionally or unconditionally or withheld by the Party in its absolute discretion.

1.2.4 No provision of this Agreement will be construed adversely to a Party on the ground that such Party was responsible for the preparation of this Agreement or that provision.

1.2.5 If there is any inconsistency between provisions of this Agreement then the order of precedence will be in descending order as follows:

- i. terms of this Agreement;
- ii. the appendices; and
- iii. any other annexures or attachments.

2. DURATION

- 2.1 This Agreement shall be effective for the duration of the Term or such other period as may be mutually agreed in writing by the Parties.
- 2.2 The Project shall be implemented during the Term in accordance with the Project Schedule, the details of which are set out in Appendix 3.
- 2.3 If the need arises for the Term to be extended for any reason, INGV shall as soon as possible and at least before the expiry of the Term, submit a written request to AEM ENERSOL for such extension and AEM ENERSOL shall in its absolute discretion decide whether to approve the requested extension. If any extension to the Term is approved by AEM ENERSOL, there shall be no variation to the Project Cost.

3. SCOPE OF AGREEMENT

- 3.1 This Agreement records the understanding of the terms contemplated between the Parties in defining the Scope of Work for the Project and the Parties' roles, rights and responsibilities under this Agreement.
- 3.2 The Parties shall endeavour in good faith to implement this Agreement and shall cooperate with each other.
- 3.3 It is not the intention of the Parties to create nor shall this Agreement be deemed or construed to create a partnership, joint venture, association, trust or fiduciary relationship or to authorize any Party to act as an agent, servant or employee for the other Party.
- 3.4 INGV is responsible for the tax administrative matters of the Personnel and continues to act as the employer of the Personnel.

4. CONDUCT OF THE PROJECT

- 4.1 INGV shall carry out the Project with professional care and diligence in accordance with the Scope of Work and Project Schedule set forth in the appendices hereto. Notwithstanding the above INGV agrees to carry out the Project with due care, diligence and efficiency and in conformity with sound scientific, management and financial practice in respect of personnel and property of the Parties and/or any third parties and in respect of the environment in which the activity is performed.
- 4.2 INGV shall provide progress reports to AEM ENERSOL addressing Project progress, key achievements, areas of concern and next steps as required by AEM ENERSOL for Project progress reporting, including but not limited to,
 - i. fortnightly progress reviews via conference calls;
 - ii. Reports submitted according to the Deliverables 1, 2, 3 and 4 defined and detailed in the project schedule in Appendix 3.
 - iii. Final report according to Deliverable 5 defined and detailed in the project schedule in Appendix 3

- 4.3 INGV shall ensure that its members in the Project Team as set out in Appendix 1 have the technical expertise, experience and capability to carry out their respective responsibilities or roles. INGV shall not replace any of its personnel in the Project Team without notification to AEM ENERSOL and provided the replacement personnel is of equal or better technical expertise and capability.
- 4.4 For any additional work beyond the Scope of Work defined in Appendix 1, the Parties shall be required to agree in writing the additional scope of work, work schedule, the corresponding invoicing schedules and costs.

5. INVOICING AND PAYMENT

- 5.1 In consideration of INGV performing the Services in connection with the Project, assigning the Intellectual Property rights in the Deliverables to AEM ENERSOL and granting AEM ENERSOL the right to use INGV Background Information, AEM ENERSOL shall pay INGV the Project Cost in accordance with the Payment Schedule in Appendix 2 and the terms specified in this Agreement. Payment of fees pursuant to this Agreement shall be made by AEM ENERSOL to INGV upon submission of correct invoices against specified Milestones and Deliverables specified in Appendix 3.
- 5.2 Payment shall be made to INGV within thirty (30) days of receipt of INGV's correct, accurate and undisputed invoice by AEM ENERSOL to:
- Account Name: xxx
Account Number: xxx
Sort Code: xxxx
IBAN (International Bank Account No): xxx
- 5.3 No interest shall be imposed on AEM ENERSOL for any payment is made by AEM ENERSOL outside the thirty (30) days period specified in Clause 5.2.
- 5.4 If AEM ENERSOL disputes any invoice or any amount in INGV's invoice, AEM ENERSOL shall notify INGV within fourteen (14) days of receipt of such an invoice specifying the nature of the dispute.

- 5.5 In the event that any issued invoice is disputed, the Parties shall hold mutual discussions to resolve any dispute relating to such invoices. During this time, AEM ENERSOL shall be entitled to withhold from payment the actual amount in dispute until the settlement of the dispute by the mutual written agreement of the Parties. If the dispute cannot be resolved within thirty (30) days following the date that AEM ENERSOL informed INGV of the disputed item(s) pursuant to Clause 5.5 hereof, Clause 13.2 shall apply.
- 5.6 AEM ENERSOL shall not be obligated to make payments to INGV at any Milestone in which INGV fails to deliver the Deliverables set out in Appendix 3 hereof in accordance to the terms and conditions of this Agreement. Any payment withheld shall be without prejudice to any other rights or remedies available to AEM ENERSOL at law.
- 5.7 Upon notification of any erroneous billings made by INGV or payments made to INGV by AEM ENERSOL and with the mutual written agreement of the Parties, INGV shall within thirty (30) days, make appropriate adjustments therein and reimburse AEM ENERSOL any amounts of outstanding overpayment as reflected in the said adjustments, notwithstanding the fact that a temporary withholding or a correction of discrepancy may have been effected previously. The Parties may agree to offset the overpayment against any future invoice to be issued by INGV under this Agreement.
- 5.8 Payments made by AEM ENERSOL under this Agreement shall not preclude the right of AEM ENERSOL to thereafter dispute any of the items invoiced which are found to be not in accordance with the agreed Scope of Work or the Deliverables as contained in the appendices to this Project, and shall not be deemed an admission by AEM ENERSOL as to the performance by INGV of its obligations hereunder and in no event shall any such payment by AEM ENERSOL affect the warranty obligations of INGV.
- 5.9 Notwithstanding the above paragraph, no dispute, claim, contestation or other demand in relation with the performance of the Agreement, including but not limited to the payment of the invoiced items, shall be admissible after the lapse of a period of six (6) months after the supply of the final Deliverables.

5.10 In the event that the Agreement is segregated for services performed inside and/or outside Malaysia, INGV shall state the applicable description on the invoices as follows:

- i. Services performed inside Malaysia; and/or
- ii. Services performed outside Malaysia.

Invoice for services performed inside Malaysia should be issued by a locally incorporated entity.

Note: The above would also apply for milestone payment

5.11 Taxes

5.11.1 INGV shall be responsible for and shall pay at its own expense when due and payable all Taxes assessed against it in connection with the Agreement. All Taxes levied on INGV shall be for the account of INGV and shall not be reimbursed by AEM ENERSOL.

5.11.2 INGV shall protect and indemnify AEM ENERSOL and hold AEM ENERSOL safe and harmless from any and all claims or liability for Taxes assessed or levied by the Inland Revenue Board of Malaysia (IRB) or any other relevant tax authorities, whichever is applicable against INGV or its Sub-Contractors or against AEM ENERSOL for or on account of any payment made to or earned by INGV in connection with this Agreement.

INGV further shall protect and hold AEM ENERSOL harmless from all Taxes assessed or levied against or on account of wages, salaries or other benefits paid to or enjoyed by INGV's employees, or employees of its Sub-Contractors, and all Taxes assessed or levied against, on or for account of any property or equipment of INGV or its Sub-Contractors.

5.11.3 AEM ENERSOL shall have the right to withhold Taxes from payments due to INGV under this Agreement to the extent that such withholding may be required by the IRB or relevant tax authorities,

and payment by AEM ENERSOL to the IRB or relevant tax authorities of the amount of money so withheld will relieve AEM ENERSOL from any further obligation INGV with respect to the amount so withheld.

If any withholding is done, AEM ENERSOL will provide INGV with official receipts or other satisfactory evidence in respect of such deduction or withholding.

5.11.4 INGV shall indemnify AEM ENERSOL against all claims, demands and causes of action based on any actual Taxes for which they are liable or any actual or alleged failures by INGV or its Sub-Contractors to comply with applicable tax reporting, return, or other procedural requirement with respect to the Agreement. This indemnity shall include without limitation all penalties, awards, and judgements; court and arbitration costs; legal fees; and other reasonable expenses associated with such claims, demands, and causes of action.

5.11.5 INGV shall give prompt notice to AEM ENERSOL of all matters pertaining to non-payment, payment under protest or claim for immunity or exemption from any Taxes.

5.11.6 In the event that a refund opportunity arises with respect to any Tax paid by one party as a result of the transactions governed by this Agreement, both parties shall reasonably work together to pursue such refund. If one party receives a refund or a credit for any Tax paid by the other party with respect to the Agreement, then the party receiving the refund or credit agrees to refund to that other party the full amount of such refund or credit.

5.11.7 In the event that INGV is a foreign incorporated company and by virtue of its activities related to the provision of services is considered to have a permanent establishment in Malaysia or in any other country, INGV shall be solely liable or responsible for the following:

- i. Any liability for Taxes

- ii. Any and all other costs incurred by INGV due to the creation of a permanent establishment
- iii. Any tax and other filing obligation occasioned by the creation of the permanent establishment

5.11.8 For avoidance of doubt, "Tax" or "Taxes" as mentioned above shall include but not limited to all income, profit, withholding, franchise, excess profits, royalty, other taxes, personal property taxes, employment taxes and contributions imposed or that maybe imposed by law, regulations or trade union contracts, which are imposed by or on behalf the IRB or of any taxing authority and includes penalties, interest and fines in respect thereof.

6. CONFIDENTIAL INFORMATION

6.1 Confidential Information shall mean:

- i. all information and documents identified as confidential and disclosed by a Party (the "Disclosing Party") or obtained by the other Party (the "Receiving Party") which relates to the Disclosing Party's past, present and future research, development or business activities and may include, without limitation, information of the Disclosing Party and/or its Affiliates such as documents, files, prints, reproductions, designs, drawings, specifications, programs and technical information residing in any of these said documents;
- ii. information and material demonstrated and furnished verbally which shall be reduced in writing within seven (7) days and shall be marked as "confidential" or in any other mode which may reasonably be regarded by either Party as confidential regardless of whether these have been explicitly or tacitly identified as being secret or confidential. Any information which is expressly named or marked as being confidential shall in any case be deemed to be Confidential Information in the sense of this Agreement;
- iii. all information (in any form or media) disclosed by the Disclosing Party to the Receiving Party in any other mode, which may

reasonably be regarded by the Receiving Party as being confidential regardless of whether such information has been explicitly or tacitly identified as being secret or confidential (whether as a result of the nature of the information itself or the circumstances of its disclosure)

in connection with this Agreement whether before or after the date of this Agreement, including without limitation:

- iv the Disclosing Party's Background Information;
- vi. the Developed Information, being proprietary of **AEM ENERSOL** and confidential to **AEM ENERSOL**; and
- vii. the terms of this Agreement.

6.2 Subject to Clauses 6.3 and 6.4 and as otherwise provided under this Agreement, the Receiving Party undertakes:

- i. to keep confidential all Confidential Information received from the Disclosing Party or information otherwise confidential to the Disclosing Party and, not to disclose the same to any third party for any purpose other than carrying out the Project; and
- ii. not to use all Confidential Information received from the Disclosing Party or information otherwise confidential to the Disclosing Party for any purpose other than carrying out the Project.

6.3 The restrictions on use and disclosure of information above shall not apply to any of such information which is:

- i. publicly available without breach of this clause;
- ii. rightfully received by the Receiving Party from a third party without accompanying secrecy obligations;
- iii. independently developed by the Receiving Party outside the scope of this Agreement; or
- iv. required to be disclosed by law, or in a court of law.

- 6.4 AEM ENERSOL may disclose any Confidential Information to any of its Affiliates which are obligated to hold such information in confidence, and to limit the disclosure of the same to the same extent as required under this Agreement.
- 6.5 All press releases and public announcements can only be made by a Party subject to the other Party's express written consent.
- 6.6 At any time, a Disclosing Party may request in writing that the Receiving Party return or destroy (and to certify in writing that it has so destroyed) any or all copies of, or material (in whatever form) in its possession or control which embodies the Disclosing Party's Confidential Information (unless required by law to be retained). For the avoidance of doubt, any Party A Background Information which is required for the use and/or exploitation of the Developed Information is excluded from the requirements under this Clause 6.6. The Receiving Party must promptly comply with such request. On receipt of any such request any right to use the Confidential Information of the Disclosing Party that is described in that notice will cease. Notwithstanding the foregoing, each Receiving Party is entitled to keep one copy of any analyses, compilations, studies and other documents prepared by it which may contain the Confidential Information of the Disclosing Party solely for their own internal records and not for use for any other purpose. The Receiving Party must treat any such copy kept by it as Confidential Information which is subject to the terms of this Agreement.
- 6.7 This Clause 6 is to survive the termination of this Agreement.

7. INTELLECTUAL PROPERTY RIGHTS

- 7.1 The Intellectual Property rights residing in all data, specifications, solutions, drawings, know-how and technical information developed, obtained, created, written, prepared or discovered, arising from the performance of the Project or otherwise brought into existence pursuant to this Agreement shall include: -

7.1.1 Background Intellectual Property

Background Intellectual Property rights shall include any Intellectual Property rights used or provided by either Party, being part of the Background Information, which have been in existence prior to and/or developed independently after the commencement of the Agreement and made available for the performance of the Project. The Background Intellectual Property rights shall remain the separate property of the Party making such Background Intellectual Property rights available for the Project.

7.1.2 Foreground Intellectual Property

Foreground Intellectual Property rights shall include any Intellectual Property Rights in the Deliverables, solutions, drawings, know-how and technical information developed, being part of the Developed Information which are obtained or developed, created, written, prepared and discovered by INGV in for the performance of the Services in connection with the Project.

- 7.2 Each Party shall contribute such of its own Background Information, including Background Intellectual Property, as it deems necessary for the successful carrying out of the Project and grants the other Party (and in the case of AEM ENERSOL, Affiliates of AEM ENERSOL) the right to use such Background Information only for the purpose of the Project. INGV further grants to AEM ENERSOL and/or its Affiliates a non revocable, perpetual, royalty free, non-exclusive right to use INGV Background Information, to the extent necessary to exploit the Developed Information, including Foreground Intellectual Property.
- 7.3. The ownership of all Developed Information, including Foreground Intellectual Property, shall vest solely in AEM ENERSOL and/or its nominated Affiliates.
- 7.4 To the extent that any Foreground Intellectual Property amounts to a patentable invention, AEM ENERSOL and/or its Affiliates shall have the exclusive right to file patent applications in respect thereof at its own expense in AEM ENERSOL's name and/or that of its Affiliates in such countries as AEM ENERSOL may deem appropriate. Subject to the

approval of AEM ENERSOL, the names of the INGV inventors who have contributed substantially in producing the Developed Information may be named as joint inventors in the patent application.

7.5 INGV shall give, and shall procure that its employees shall give, all required assistance to AEM ENERSOL and/or its Affiliates in filing, prosecuting, maintaining and enforcing patent applications and/or patents in respect of the Developed Information and shall execute any instrument necessary to enable AEM ENERSOL and/or its Affiliates, as the case may be, to obtain a patent on any such application and/or to vest the legal and beneficial ownership in any patent granted on such application exclusively in AEM ENERSOL and/or its Affiliates, provided that AEM ENERSOL and/or its Affiliates shall reimburse INGV as appropriate, for all reasonable expenses incurred in giving such assistance.

7.6 All Intellectual Property in information or other materials created by one Party independently of its work in connection with the Project shall remain vested in that Party.

8. TRAINING

8.1 AEM ENERSOL and INGV shall during the Term of the Project provide the necessary training to a PETRONAS personnel which shall include but not limited to "hands on" participation of the said PETRONAS personnel in the Project in connection with the Project.

8.2 AEM ENERSOL and INGV hereby agrees that the enhancement of the PETRONAS personnel's technical competency specified in Clause 8 are essential and integral parts of AEM ENERSOL and INGV's obligations under this Agreement.

9. LIABILITY AND WARRANTY

- 9.1 Each Party shall exercise skill, care and diligence in the discharge of its obligations hereunder, but its liability to the other Party for any damage or loss of whatever nature sustained by the other Party arising out of the performance or non-performance of any such obligation by or on behalf of the Party required to discharge such obligation shall be limited to cases of negligence, default or breach of duty (whether statutory or otherwise) or willful act or omission on the part of that Party. Notwithstanding the above, each Party shall take full responsibility and shall defend, indemnify and hold harmless the other Party for all loss, injury or death suffered by its own personnel or by the personnel of its Affiliates howsoever caused and irrespective of negligence, default and breach of duty (statutory or otherwise) or willful act or omission.
- 9.2 INGV warrants that, to the best of its knowledge, any Background Information, including Background Intellectual Property, supplied for the performance of the Project is not in contravention or infringement of the rights of any third party, and shall keep AEM ENERSOL and/or its Affiliates indemnified against all claims, proceedings and suits brought by any third party as result of AEM ENERSOL and/or its Affiliates use of any Background Information supplied by INGV under this Agreement.
- 9.3 AEM ENERSOL shall not be liable for any loss or damage incurred by INGV arising from or in connection with this Agreement or with the use made by INGV of any AEM ENERSOL Background Information to the extent such loss or damage does not result from gross negligence or wilful misconduct on the part of AEM ENERSOL. INGV shall indemnify AEM ENERSOL and/or its Affiliates against any third party claim for loss or damage (including personal injury or death) arising from or in connection with use of AEM ENERSOL Background Information by INGV or with INGV activities under this Agreement.
- 9.4 Notwithstanding any other provisions of this Agreement in no event shall either Party be liable to the other for any indirect or consequential damages which may be suffered by such Party in connection with the performance of

this Agreement, including, but not limited to, loss of use, loss of profits, loss of product, and business interruption.

10. TERMINATION

- 10.1 If either Party is in default of any of its obligations hereunder and has failed to make good and/or to indemnify the other Party for such default within sixty (60) days after the Party in default has received notice from the Party aggrieved requiring the Party in default to make good and/or to indemnify the Party aggrieved for such default, then the Party aggrieved shall be at liberty by giving thirty (30) days' notice in writing to the Party in default to terminate the Project and this Agreement.
- 10.2 Either Party may terminate this Agreement with immediate effect if the other Party should go into liquidation or should do or suffer any similar act or thing under any applicable law, such as:
- i. the making of a general assignment for the benefit of creditors by such Party;
 - ii. the entering into of any arrangement or composition with creditors (other than for the purposes of a solvent reconstruction or amalgamation); or
 - iii. the institution by such Party of proceedings seeking to adjudicate such Party as bankrupt or insolvent, or seeking protection or relief from creditors, or seeking liquidation, winding up, or rearrangement, reorganization or adjustment of such Party or its debts (other than for purposes of a solvent reconstruction or amalgamation), or seeking the entry of an order for the appointment of a receiver, trustee or other similar official for such Party or for all or a substantial part of such Party's assets.
- 10.3 Notwithstanding Clauses 10.1 and 10.2, AEM ENERSOL may terminate the Project and this Agreement at any time for any reason on fourteen (14) days notice in writing to INGV.

10.4 The termination of this Agreement through any means for any reason shall not relieve a Party of any obligation accrued prior to such termination or cessation and shall be without prejudice to the rights and remedies of the Parties with respect to default or breach of this Agreement.

10.5 Clauses 6, 7, 9, 10.4, 10.5, 13 and 14 shall survive the termination or expiry of this Agreement.

11. FORCE MAJEURE

11.1 No failure or omission by either Party to carry out or observe any of the terms or conditions in this Agreement shall give rise to any claim against the Party in question or be deemed a breach of this Agreement if such failure or omission arises from any cause reasonably beyond the control of that Party, including an Event of Force Majeure.

11.2 In the event that performance under this Agreement is prevented for a continuous period of thirty (30) days or longer arising from any cause reasonably beyond the control of either Party, AEM ENERSOL shall have the right to terminate this Agreement by giving written notice to INGV.

12. NOTICES

12.1 All notices and other communications hereunder shall be in writing and shall be delivered personally or sent by facsimile or by registered mail. Unless otherwise specified by no less than fifteen (15) working days' notice in writing by the Party in question, the addresses to which communications with respect to this Agreement shall be sent are:

If to AEM ENERSOL:

AEM Energy Solutions Sdn Bhd
Level 15, West Block, Wisma Selangor Dredging,
142C Jalan Ampang, 50450 Kuala Lumpur, Malaysia
Attention: General Manager, Business Development Department

If to INGV:

INGV - Istituto Nazionale di Geofisica e Vulcanologia
Department of Seismology and Tectonophysics
UF Fluid Geochemistry and Radionuclides
Via di Vigna Murata, 605
00143 Roma (Italy)
Attention: Dr. Salvatore Barba

- 12.2 Any such notice or communications shall be deemed to have been received by the addressee seven (7) working days following the date of dispatch if the notice or other document is sent by registered post, or upon confirmation of delivery or transmission if sent by hand or if given by facsimile or other electronic means.

13. GOVERNING LAW AND ARBITRATION

- 13.1 This Agreement shall be governed by and construed exclusively in accordance with the laws of Malaysia.
- 13.2 Any disputes, controversies or claims arising out of or relating to this Agreement, or the breach, termination or validity thereof which cannot be settled amicably, shall be referred for arbitration to the Kuala Lumpur Regional Centre for Arbitration ("KLRCA"), and shall be settled in accordance with the KLRCA Rules of Arbitration in force at such time.
- 13.3 The Parties shall nominate a single arbitrator and in the event the Parties cannot agree on the appointment of the arbitrator, then the arbitrator shall be appointed by the Director for the time being of the KLRCA.
- 13.4 The arbitration proceeding including the making of the award shall take place in Kuala Lumpur and the award of the arbitrator shall be final and binding upon the Parties.
- 13.5 The Parties agree that all arbitration proceedings conducted hereunder and the decision of the arbitrator shall be kept confidential and not disclosed, except to a Party's Affiliates, accountants, and lawyers.

13.6 Notwithstanding the provisions of this Clause 13, the Parties accept that they may take proceedings for injunctive or similar relief in the courts of any jurisdiction to restrain or prevent any breach of the terms as set forth under this Agreement.

14. EXCLUSIVITY

INGV acknowledges that the Services carried out in the Project shall be exclusive to AEM ENERSOL and INGV shall not use any part of the experimental procedure provided by AEM ENERSOL except for the performance of the Project apart from experimental procedures used by INGV prior to the Agreement.

15. MISCELLANEOUS

15.1 Severability

If any provision or a term of this Agreement is found to be void or unenforceable it shall to the extent of such invalidity or unenforceability be severed. Severance shall not affect any other provisions of this Agreement. If such severance substantially affects or alters the commercial basis or objectives of this Agreement, the Parties shall negotiate in good faith to amend and modify the provisions and terms of this Agreement as may be necessary or desirable in the circumstances.

15.2 Entire Agreement

This Agreement constitutes the entire understanding between the Parties with respect to its subject matter. It supersedes all prior agreements, negotiations and discussions between the Parties concerning the subject matter including in correspondence or elsewhere or implied by trade, custom, practice or course of dealing unless specifically agreed to in writing by an authorised representative of the Parties and any purported provisions to the contrary are hereby excluded or extinguished.

15.3 Amendment

This Agreement shall not be amended, modified, varied or supplemented except as expressly stated in this Agreement or by a written agreement signed by an authorised representative of each Party.

15.4 Assignment/ subcontracting

15.4.1 Neither Party shall transfer, assign or subcontract its rights or obligations under this Agreement to a third party other than an Affiliate without the prior written consent of the other Party. However, the Party transferring, assigning or subcontracting this Agreement shall remain liable to the other Party for any services that have been agreed as part of the Project under this Agreement. AEM ENERSOL may however at its sole discretion assign any of its rights under this Agreement to any of its Affiliates.

15.4.2 INGV shall be responsible for and shall pay at its own expense when due and payable all Taxes and GST assessed against it and this shall not be reimbursed by AEM ENERSOL. This includes any Taxes assessed or levied by the IRB or any other tax authority on the sub-contractor for the payment made by INGV to the sub-contractor in connection with this Agreement. This would also include any Taxes levied on account of wages, salaries or other benefits paid to or enjoyed by employees of the sub-contractor.

15.4.3 Notwithstanding any provisions in this Agreement, INGV shall not except with prior approval of AEM ENERSOL conclude, negotiate or sign contracts on behalf of AEM ENERSOL and this authority shall vests only with AEM ENERSOL.

15.5 Waiver

Except as specifically provided for herein, no waiver by either Party of any breach of a term or condition of this Agreement to be performed by the other Party shall be construed as a waiver of any succeeding breach of the same or any other term or condition.

15.6 Costs

Each Party shall bear its own costs and expenses incurred in connection with the preparation and execution of this Agreement.

16. BUSINESS CONDUCT

- 16.1 AEM ENERSOL and INGV must comply with Parts II and III of the PETRONAS Code of Conduct and Business Ethics, the relevant sections of the Country Supplement, other applicable rules, regulations, policies, procedures, guidelines and requirements as updated by PETRONAS from time to time in the performance of their work or services for PETRONAS.
- 16.2 AEM ENERSOL and INGV must ensure that all Associated Persons who perform services or provide goods in connection with this Agreement comply in all relevant part with the PETRONAS Code of Conduct and Business Ethics, Country Supplement, other applicable rules, regulations, policies, procedures, guidelines and requirements as updated by PETRONAS from time to time.
- 16.3 From time-to-time, at the reasonable request PETRONAS, AEM ENERSOL and INGV shall confirm in writing that AEM ENERSOL & INGV and the Associated Persons have complied with the obligations imposed upon in this Clause 16 and provide any information reasonably requested by PETRONAS in support of the compliance obligations.
- 16.4 In the event that INGV and the Associated Persons refuse, fail and/or is negligent in complying with the provisions as stated in this Clause 16, AEM ENERSOL may take any such action as deemed necessary including termination of this Agreement in accordance with the terms stated in Clause 10 without any payment of compensation to INGV.

17. CONFLICT OF INTEREST AND FIGHTING CORRUPTION AND UNETHICAL PRACTICES

17.1 AEM ENERSOL and INGV must:

- (a) comply with all Relevant Requirements and Relevant Policies;
- (b) have in place and maintain throughout the term of this agreement its own policies and procedures to ensure compliance with the Relevant Requirements and Relevant Policies.
- (c) with respect to any matter arising out of this Agreement, maintain adequate internal controls and accurately record all transactions in its books and records.
- (d) enforce the policies and procedures referred to in Clause 17.1(b) where appropriate;
- (e) promptly report to PETRONAS any breach of this Clause 17.1 arising in connection with this Agreement and take such steps as PETRONAS may reasonably require in order to ameliorate any such breach;
- (f) promptly report any request or demand for any undue financial or other advantage of any kind received by AEM ENERSOL and INGV in connection with the performance of this Agreement and take such steps in response to any such request as PETRONAS may reasonably require;

- 17.2 AEM ENERSOL and INGV must ensure that all Associated Persons who perform services or provide goods in connection with this Agreement do so on the basis of a written contract which imposes Relevant Obligations on the Associated Person.
- 17.3 AEM ENERSOL and INGV shall be responsible for the observance and performance by Associated Persons of the Relevant Obligations and shall be directly liable to PETRONAS for any breach of the Relevant Obligations by an Associated Person.
- 17.4 Breach of this Clause 17 shall be deemed a material breach and PETRONAS may terminate the Agreement in accordance with the terms stated in Clause 10 without any payment of compensation to INGV.

[the rest of this page is intentionally left blank]

IN WITNESS WHEREOF, authorised representatives of the Parties have executed duplicate originals of this Agreement.

Signed for and on behalf of

AEM ENERGY SOLUTIONS SDN BHD

)

)

)

)



Noorbaizura Hashim

General Manager



In the presence of

)

)

Ahmad Syafiq Zahid

Operation Manager

Signed for and on behalf of

ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

)

)

)

)

Dr. Salvatore Barba

In the presence of

)

)



APPENDIX 1

1. BACKGROUND

- Carbon capture and storage (CCS) (or carbon capture and sequestration) is the process of capturing waste carbon dioxide (CO₂) from large point sources, such as fossil fuel power plants, transporting it to a storage site, and depositing it where it will not enter the atmosphere, normally an underground geological formation. The aim is to prevent the release of large quantities of CO₂ into the atmosphere.
- Ideally the injected CO₂ should be trapped in the injected reservoir forever, however in case of any leakage happened, the CO₂ need to be managed, and if possible not to allow to reach the surface. Modeling different leakage scenarios is crucial to ensure there will no CO₂ leakage reach the surface. The ability to track CO₂ movement in the subsurface is also important for planning mitigation strategies.
- CO₂ leak mitigation is be define as predictive measures, physical monitoring and operational to either reduce uncertainties, prevent leakage, detect and stop the leakage where possible. The leakage study is critical for storage Monitoring, Measurement, Verification plan and strategy and as whole CCS project.
- Current PETRONAS studies are mostly in reservoir interval, with very little or base study/analysis conducted beyond /above. This project specifically addresses to reduce uncertainties and behavior prediction regarding to CO₂ leakage beyond the reservoir; to strategized the best and cost effective fit-to-purpose MMV field plan based on the prediction. Also, the study is part of standard requirement for CCS project for stakeholders /regulators approval globally worldwide.
- The main objective of this projects include: (1) To analyze and predict the CO₂ physiochemical behavior and impact, potential leakage pathway/dispersal in caprocks/overburden interval; (2) To identify potential fit-for-purpose monitoring and mitigation technology package based on the CO₂ leak behavior and its impact; (3) As part of overall framework development for integrated monitoring and mitigation plan, strategy and system for CO₂ storage and containment program.



DG

2. SCOPE OF WORK

2.1 MIGRATION PATTERN IN THE NEAR SURFACE ENVIRONMENT

3.1.1 Task 1.1: Defining the geological model and possible leakage scenarios

3.1.2 Task 1.2: Fluid-flow simulation and case studies

2.2 GEOCHEMICAL IMPACT OF CO₂ LEAKAGES

3.2.1 Task 2.1: Laboratory Analysis

Task 2.1.1: Mercury Injection Capillary Pressure - MiCP

Task 2.1.2: Diffusion Experiments

3.2.2 Task 2.2: Geochemical Model Calibration

3.2.3 Task 2.3: Reactive Transport Simulations



A handwritten signature in blue ink, located at the bottom right of the page.

Description Scope of Work

Work Package 1: Migration Pattern in The Overburden/Seal interval

The objective of Work Package 1 (WP1) is to define the CO₂ migration parameter mechanism (rate, direction, pathway, saturation, volume, etc.) in the event of potential CO₂ leakage in the overburden. This is by simulating the flow behavior and patterns of potential leaked CO₂ above reservoir through the overburden/seal interval.

Task 1.1: Defining the Geological Model and Possible Leakage Scenarios

A good representative geological and petrophysical model is the basic requirement to carry out accurate fluid flow simulations. Ideally, the model framework should be constructed based on high resolution shallow seismic data, while the petrophysical properties will be computed based on core and well data. In the absence of the necessary data, the value from literature will be used. Geological model can also be converted from other form of model such as 3D Earth mechanical model with some degree of cautions.

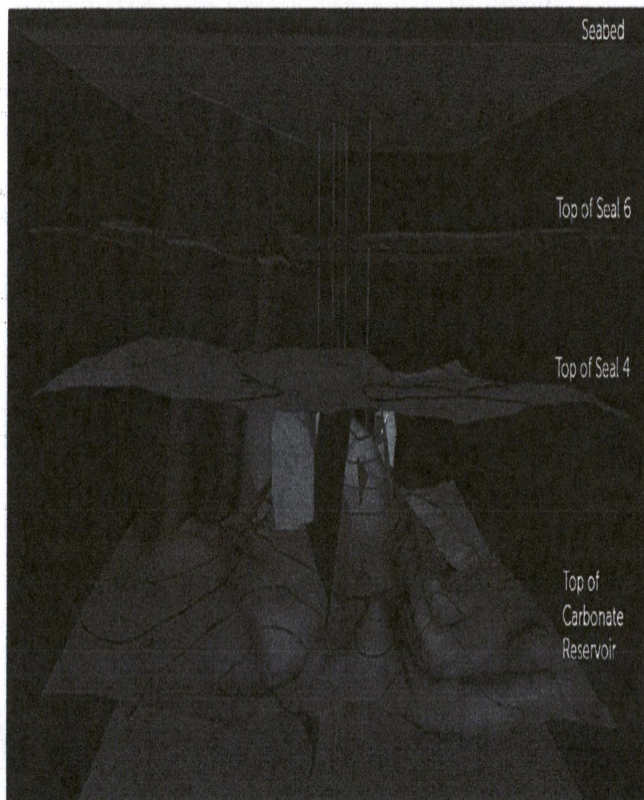


Figure 1: Overview of faults at overburden

A geological model defining the geometry and spatial distribution of the different formations is the basis for any further modelling step. The model must be also populated by petrophysical properties influencing the fluid flow in the reservoir and overburden. s) PETRONAS will provide:

1. Base 3D gridded geological structural model (with essential horizons and fault surfaces)
2. Base 3D gridded property model for related surfaces (porosity and calculated permeability) excluding fault properties modelling
3. Related well logs and seismic interpretation data where deemed necessary by Petronas.

These model provided shall be reviewed, evaluated, and refine by AEM where necessary for the purpose of leakage scenarios generation and flow modelling

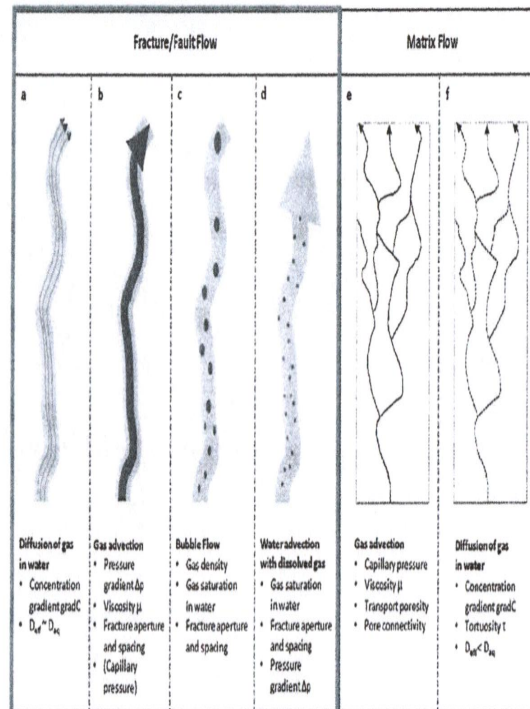


Task 1.2: Fluid-flow simulation and case studies

There are several mechanism anticipated for the flow of the leaked CO₂ in overburden. They can be either viscous/klinkenberg flow, capillary/bouyancy flow, fracture/fault flow, diffusion/adsorption flow, or combination flow. It is dictated by the properties of the rock media, CO₂ and in-situ fluids. All of these flow mechanism are to be tested/modelled in the flow simulation by AEM where applicable based on leakage scenarios to be defined. The selection are to be agreed upon by Petronas and AEM team.

The refined geological static model by AEM stated in Task 1.1 (structural and properties) will be used as a basis for testing leakage scenarios. Fluid flow and CO₂ transport simulations will be performed by thpre commercial code TOUGH2® (Pruess, 1999) equipped with modules that were designed for applications to geologic storage of CO₂ in saline aquifers. Additionally, we can use the software STOMP (Pacific Northwest National Laboratory).

Fluid flow and transport modeling activities will include the setup of 2.5D or 3D models, built on the basis of petrophysical model, and the identification of boundary and initial conditions for the fluid-dynamic model. This phase might be more or less time demanding, depending on amount and quality of input data provided. The analysis of the fluid flow numerical simulations will enable to evaluate the possible migration pathways of the CO₂ and the pressurization due to the injection. The simulations will also provide estimates of gas saturation, density and pore pressure distributions. Finally, a few case studies will be performed to determine the dependency of model parameters from critical parameters (e.g. permeability).



Busch & Kampman, AGU, 2017



Work Package 2: Geochemical Impact of CO2 Leakages

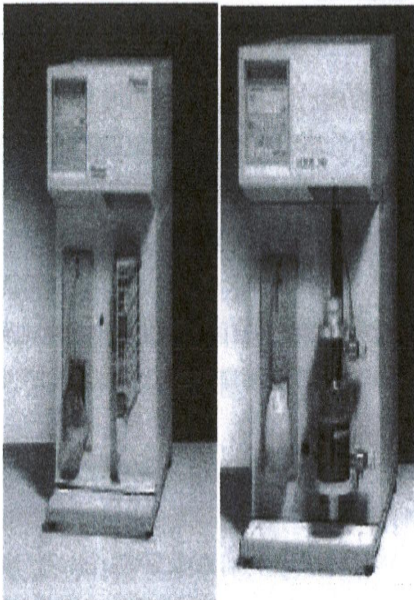
The objective of Work Package 1 (WP1) is to define the geochemical interaction and impact of CO₂-rock (rate, minerals dissolution and precipitation, pathway creation, etc.) in the event of potential CO₂ leakage in the overburden. This is by integrating laboratory analysis and geochemical model which by reconstructing in-situ chemical composition of fluids and rock mineralogy. Combined with flow model in WP 1, CO₂ reactive transport (RTM) of CO₂ to simulate the flow and reaction effect in the overburden.

Reactions that may occur due to CO₂ intrusion include dissolution of different minerals, as well as ion exchange and competitive anionic and cationic desorption (Apps et al. 2010). Dissolution reactions for calcite and a representative 1:1 phyllosilicate are provided below:



Mineral reaction will likely promote the release of major and minor ions into the aqueous phase, such as Ca, Si, Fe, Al, K, Na, Mg, etc. The water may therefore become oversaturated with respect to different neophases, which may precipitate under specific conditions. This process of mineral trapping can have two beneficial effects: 1) trapping of CO₂ in carbonate minerals, 2) contaminant immobilization as a result of mineral sorption and/or precipitation as secondary phases.

Task 2.1.1: Laboratory Analysis (Mercury Injection Capillary Pressure - MiCP)

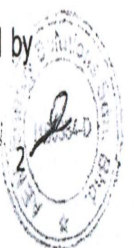


The Mercury Injection Capillary Pressure Tests allows the determination of the rock pore size by mercury intrusion porosimetry. For each sample a specimen of more than 1 cm³ is required. The Lab will cut the samples at required dimension. the water column.

Software and output: the PASCAL instruments are managed by the S.O.L.I.D. (SOLver of Intrusion Data) software (by Thermo Fisher Scientific) which allows to obtain:

- mercury intrusion/extrusion curves, cumulative pore volume as function of pore dimension, pores dimension and distribution;
- Capillary pressure as function of saturation;
- bulk and apparent porosity, pore volume, specific surface area (m²/g), porosity (%), average pore radius/diameter; accessible and inaccessible porosity;
- Determination of the sample compressibility and correction of the measurement;
- Density (bulk, apparent and real), tortuosity and permeability (m²);
- Fractal dimension and particle size analysis

Remarks: Samples transportation's cost from Malaysia to Europe to be consumed by AEM.



W 94

Task 2.1.2: Laboratory Analysis (Diffusion Experiments)

The diffusion experiments are experiments of diffusive transport of CO₂ (diffusive reaction front) where a solution with high concentration of CO₂ was placed in contact with a of intact rock for several days. The sample is then sectioned to measure the diffusive speed of the reaction front. The tests will be carried out at the laboratory of National Research Council of Italy (CNR), Institute of Geosciences and Earth Resources, Section of Florence.

In each experiment the micro-reactor is charged with one cubic specimen and 5.5 mL of MilliQ water. The micro-reactor is initially flushed with pure CO₂(g) to get rid of atmospheric air before setting the PCO₂ value at the desired value. Experiment conditions can be up to 60 bar of

PCO₂ and 200°C. The cubic specimen within the micro-reactor is completely immersed in water and is covered by a ~0.25-mm-thick layer of water, separating the gas phase, above, from the rock cube, below (Figure 1). This thin water layer is crossed by a diffusive CO₂ flux controlling reaction front. In order to calibrate the velocity of penetration of the alteration front, in a Fickian model, at least two experiment at different times (e.g. 1 day and 7 days) for each samples have to be carried out.

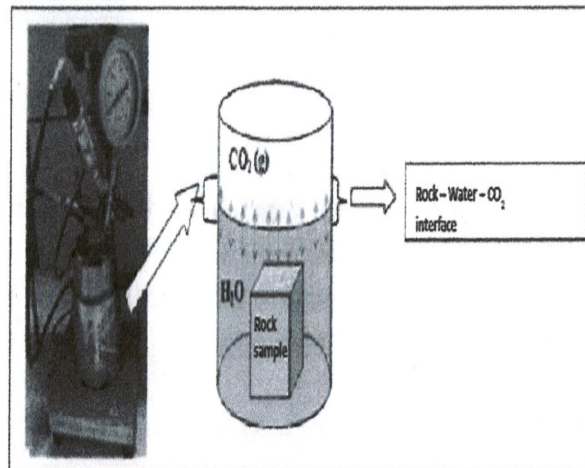


Figure 2: The Parr micro-reactor (left) and sketch showing specimen, water and CO₂ gas into the micro-reactor (right) during the diffusion experiments.

At the end of each experiment, the cubic sample is heated in an oven at 40°C for 2 hours and weighted again on an analytical balance. The diffusive reaction front progress is assessed for each sample from: (1) the mass gain, that is the difference between the weight of the sample cube after and before the diffusion test, and (2) the alteration depth, which is obtained by using the phenolphthalein method according to the European Normative EN 14630:2006.

Remarks: Samples transportation's cost from Malaysia to Europe to be consumed by AEM.



UC
cy

Task 2.2: Geochemical Model Calibration

In this task will be defined the geochemical parameters that will be used in the reactive transport simulations. In absence of core and sediments samples we will use Petronas available data on mineralogical composition and surface reactive area. Similarly, in absence of data provided by

batch experiments, we will adopt standard/literature parameters to define kinetic constants and the absorption constants of the different minerals. Operatively, we will perform geochemical models to reconstruct the pristine in-situ chemical composition of fluids and identify potential secondary minerals that can precipitate after CO₂ reaction. By appropriate EOS, we will simulate the CO₂ dissolution in function of pressure, temperature, chemical composition of water (saltingout effects) and the fluid-rock interaction over the time.

In addition, we will perform simplified reactive-flow models to calibrate the 3D model and evaluate the impact of mineral reactions on the flow path on the OB formations (where mineralogical composition and reactive surface area are available). For both models, thermodynamic database (equilibrium constants for aqueous species and minerals) will be recalculated at the in-situ pressure by the SUPCRT92 code. Geochemical models will be performed using different software packages as PHREEQC (Parkhurst and Appelo, 1999), specific for geochemical batch simulations and TOUGHREACT (Xu et al., 2004) for flow and reactive transport of CO₂.

Task 2.3: Reactive Transport Simulations

Geochemical parameters, obtained in WP2-Task 2, will be used in reactive transport simulations. In this task we add geochemical reactions neglected in WP1- Task 2 fluid flow models, simulating geochemical reactions in some critical portions of the overburden domain for two scenarios, where high risk conditions of CO₂ leakage are expected (e.g. reservoir/caprock interface, faults, etc.). In all scenarios the minerals dissolution/precipitation processes, their effect on porosity and permeability of the porous media and the trapping mechanisms will be assessed. The results obtained from petrophysical and geological model (WP 4.1) will be used to elaborate the reactive flow model. To reduce computational time and favor numerical model convergence, simulations could be performed with different domains compared to those of WP1-Task2. Fluid flow and CO₂ reactive transport simulations will be performed by the commercial code TOUGHREACT (Xu et al., 2004) equipped with the modules that are designed for applications to geologic storage of CO₂ in saline aquifers.



3. Deliverables

Deliverable	Description	Delivery Month	Format
1	Data Gathering & Project Kick-Off	0.5	Presentation pack, data gathering
2	Geological/petrophysical 3D subsurface model from the formation hosting the CO2 injection point to the sea floor	4	Computer modelling, lab results, milestone report
	LAB: MICP Report on Lab Analysis		
3	Report on Geochemical Parameterization and Model Calibration	6	Computer modelling, lab results, milestone report
	LAB: Diffusivity analysis		
4	Leakage migration prediction model for scenarios and case studies	12	Computer modelling, full report



Handwritten signature or initials in blue ink.

4. Training/Attachment Details

Location: Kuala Lumpur

AEM to conduct modelling training to PETRONAS staff minimum three times training (3-4 days per training) during the project execution. Specific dates to be detailed by AEM-PRSB.

Location: Italy

Remarks: All cost (transportation, accommodation, meals, etc.) excluding training fee during working attachment in Italy to be consumed by PRSB. Attachment scheduled for one (1) person at a time. Subject to further training arrangement.

PROPOSED MONTH	HOST	FOCAL PERSON	PERIOD	LOCATION	TENTATIVE PLAN	REMARK(S)
Training on February- March 2018						
February 2018	National Research Council (CNR)	Dr. Giordano Montegrossi	One week (5 days)	Consiglio Nazionale delle Ricerche, Istituto di Geoscienze e Georisorse -Firenze Department Via Giorgio La Pira, 4, 50121, Firenze Italy	<p>Day 1-5:</p> <p>The attendant will be trained in the Laboratory methodologies as an essential tool to obtain site specific input data for numerical simulations with particular focus on CO2 geological Storage.</p> <p>The attendant will have access to CNR laboratories and he will be present to ongoing diffusion experiments on Petronas rock samples. He will learn the theory behind the diffusive processes and diffusion in chemical reaction and how to manage the experimental data in the numerical models.</p> <p>Moreover, the attendant will be trained in the X-Ray Diffraction analysis and Rietveld refinement. He will learn to process and analyse raw data coming from XRD and to obtain quantitative composition of rock minerals.</p>	To enter in the CNR (Labs and class rooms), the attendant must provide a laboratory letter in which Petronas states that the attendant is covered by insurance for damages to property and injury to human being, accidents and workplace injury.
March 2018	National Institute of Geophysics and Volcanology (INGV)-ROMA	Barbara Cantucci	One week (5 days)	Istituto Nazionale di Geofisica e Vulcanologia, Sismologia e Tettonofisica Department Via di Vigna Murata, 605 00143, Roma, Italy	<p>Day 1-5</p> <p>The attendant will be trained in the geochemical modelling of gas-water-rock interaction with particular focus on CO2 geological Storage. The attendant will learn theoretical and practical use of geochemical (e.g. PHREEQC) and thermodynamic (SUPCRT) software.</p> <p>The attendant will have access to both INGV Fluid Geochemistry and High Pressure-High Temperature laboratories to learn to manage the chemical and mineralogical raw data in the geochemical models.</p>	To enter in the INGV (Labs and offices), the attendant must provide a letter in which Petronas states that the attendant is covered by insurance for damages to property and injury to human being, accidents and workplace injury



					<p>Day 1: Visit to INGV Fluid Geochemistry Lab. Theoretical background of fluid and rock geochemistry. From chemical row data to geochemical modelling input data.</p> <p>Day 2: Database formats and thermodynamic consistency. Introducing/upgrading new minerals from thermodynamic data.</p> <p>Day 3: Reconstructing of reservoir fluid composition. Equilibrium models. Modifying database equilibrium constants in function of pressure.</p> <p>Day 4: SEM (Scanning Electron Microscope)-EDS analysis of Petronas rock samples thin sections at INGV High Pressure-High Temperature lab. Defining specific reactive areas of minerals. Kinetic models.</p> <p>Day 5: Real Gas, Equation of state, CO₂ solubility trapping. Water-Rock interaction. Congruent and incongruent reactions. Mineral trapping.</p>	Any other requirement (if any) will be advised later during Kick-Off
--	--	--	--	--	---	--



March 2018	National Institute of Geophysics and Volcanology (INGV) CATANIA	Dr. Gilda Currenti	One week (5 days)	Istituto Nazionale di Geofisica e Vulcanologia, Catania Department, Piazza Roma, 2, 95125 Catania, Italy	<p>Day 1-5: During the research visit, the attendant will be trained in the use of software for numerical simulations with application to carbon capture and storage (CCS). He will be introduced to the concept of geophysical modelling for the quantification of pore pressure and stress changes induced by fluid flow migration in the subsurface.</p> <p>The attendant will have access to facilities including Internet access (through cable or wireless network) and clusters and High-Performance Computers at INGV-OE.</p>	<p>To enter in the INGV (Labs and offices), the attendant must provide a letter in which Petronas states that the attendant is covered by insurance for damages to property and injury to human being, accidents and workplace injury</p> <p>Any other requirement (if any) will be advised later during Kick-Off</p>
Training on September 2018						
September 2018	National Institute of Oceanography and Experimental Geophysics (OGS)	Davide Gei	One Week (7 days)	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS Borgo Grotta Gigante 42/C - 34010 - Sgonico (TS) - Italy	<p>Day 1-3: Training in the OGS Seislab regarding rock-physics software for CO2 purposes.</p> <p>Day 4-7: Applications of the method used by OGS to obtain permeability from well logs (basically resistivity and porosity log profiles).</p>	None
September 2018	National Research Council (CNR)	Dr. Giordano Montegrossi	One week (5 days)	Consiglio Nazionale delle Ricerche, Istituto di Geoscienze e Georisorse - Firenze Department Via Giorgio La Pira, 4, 50121, Firenze Italy	<p>Day 1-5: The attendant will take a theoretical and practical class in the use of reactive transport simulation software (i.e. TOUGHREACT) and pre- and post-processor code (e.g. Petrasim).</p> <p>Day 1: Basic Equations. Equilibrium and kinetic model, Pitzer model.</p> <p>Day 2:</p>	<p>To enter in the CNR (Labs and class rooms), the attendant must provide a laboratory letter in which Petronas states that the attendant is covered by insurance for damages to property and injury to human being, accidents and workplace injury</p>

APPENDIX 2

SERVICES COST, PAYMENT SCHEDULE & MILESTONES

The payments are divided into following milestones. Payment will be issued upon AEM ENERSOL acceptance and approval at each milestone delivery as per contract terms.

Price Breakdown for contract:

MILESTONE	DESCRIPTIONS	DELIVERY MONTH	TOTAL PRICE INCLUSIVE OF VAT, 22% (€)
3	Work Package: Fluid flow simulations models for 3 leakages scenarios (Task 1.2)	10	73,200.00
Total			73,200.00

Please refer Purchase Order (FIN/17/OGS-CO2/PO/003 – Revision 1) for total disbursement.

U 9/

APPENDIX 3

SERVICE SCHEDULE

Activity	Project	Start Month	End Month	Month	
				1-6	7-12
MIGRATION PATTERN IN THE NEAR SURFACE ENVIRONMENT					
WORK PACKAGE 1	TASK 1.1	Defining the geological model and possible leakage scenarios	Month 0	Month 4	<div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><</div>

UCL