# OU STEM EEES Project Proposal Form – 2024 entry

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| **Project Title** | Financing net-zero: policies and frameworks for carbon dioxide removal by enhanced rock weathering |
| **Key words** | Carbon-dioxide removal, negative emissions, climate policy, climate finance |
| **Supervisory team (including email addresses)** | PI: Neil.Edwards@open.ac.uk <br><br> Co-I: Philip.Holden@open.ac.uk |
| **Is the PhD suitable for part time study?** | Yes ☒ <br> No ☐ |

**Project Highlights:**

- Join a highly interdisciplinary, international group of researchers working on fundamental and applied science, economic and policy issues around carbon dioxide removal.
- Gain valuable experience and expertise in Earth system and macroeconomic modelling, interdisciplinary climate change research and climate policy analysis.
- Contribute to the development and assessment of realistic financial and policy approaches to tackling global warming and ultimately reaching net-zero emissions.

**Overview:**

Tackling the climate emergency demands rapid and urgent action worldwide to reduce carbon dioxide emissions. It is now clear, however, that emissions reductions will have to be accompanied by active carbon dioxide removal (CDR) from the atmosphere to uphold the commitments made in the 2015 Paris Agreement. Multiple CDR approaches are now under investigation, including enhanced rock weathering (ERW), which involves spreading finely ground rock on agricultural land, where the action of crop plants accelerates natural weathering processes that reduce excess atmospheric carbon (Fig. 1). Our recent research has shown that ERW has the potential to remove up to 2 Gt $CO_2$ annually, comparable to aviation and shipping emissions combined, if applied in multiple regions of the globe[1], with the added benefits of enhancing crop yields and reducing ocean acidification. Furthermore, ERW can be carried out within existing agricultural practices.

The net carbon removal through ERW, and its cost-effectiveness, depends on climate, and on the availability of source material from mining or construction waste, as well as transport networks and infrastructure. Through detailed modelling, we have identified the most advantageous regions for the application of ERW[1,2]. However, to achieve high levels of CDR will require major investment in mining, transport and agriculture. The resulting effects on growth, employment, debt, and international trade and development have so far received relatively little attention, even though we have already shown how the transition away from redundant fossil-fuel infrastructure could lead to both massive financial shocks[3] and geopolitical realignments[4].

This project will redress the lack of detailed modelling of the economic impacts of large-scale implementation of ERW using the technologically and spatially detailed dynamic integrated assessment model E3ME-FTT-GENIE[3,4] with a primary focus on the critical lack of financial and regulatory frameworks to facilitate large-scale CDR. The project will thoroughly investigate possible

mechanisms and frameworks, including private, public and mixed approaches, and in particular the recently advanced proposal involving regulated markets for carbon removal obligations and credits. In this elegant approach, fossil-fuel producers are required to commit to funding future CDR activities to balance their emissions, through the purchase of certified carbon removal obligations and carbon removal credits issued to validated CDR projects[5-7], thus providing a stimulus for near-term CDR investment.
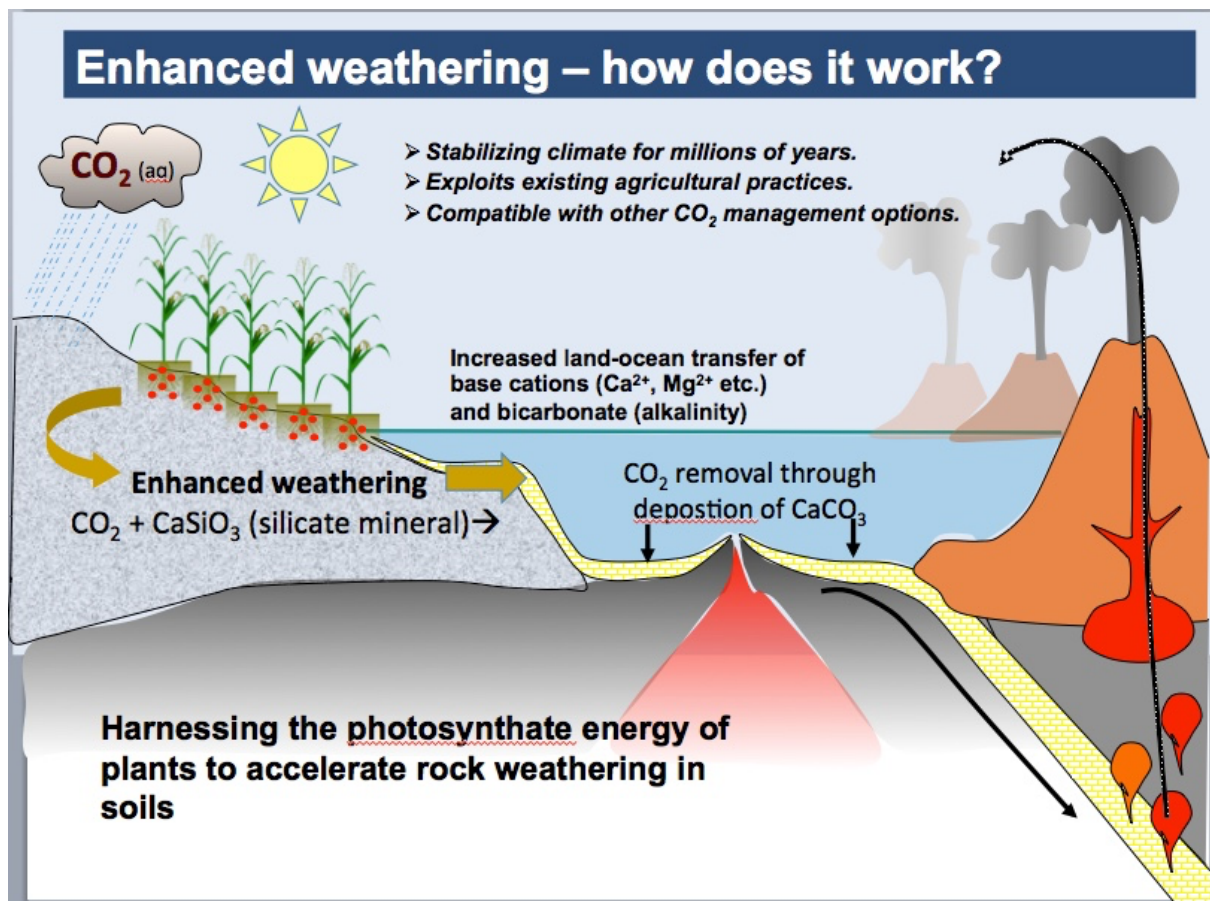


*Figure 1: Enhanced rock weathering graphic (D.J. Beerling)*

**Methodology:**

- Set up the E3ME-FTT-GENIE integrated assessment model to simulate the economic effects of large-scale investment in CDR via ERW, in particular the flow of funds to the mining, construction, transport and agriculture sectors.

- Develop scenarios in consultation with relevant stakeholders and experts regarding process costs as well as potential policy and financial instruments and frameworks.

- Design appropriate modelling experiments to cover a wide range of representative scenario options. Scenarios would cover the source of funding, from private investors or governments, global distributions of target countries and regions to focus on for ERW activity, temporal profiles for investment and $CO_2$ removal targets.

- Program and implement a set of diagnostic tools to analyse the effects of different scenarios on growth and employment, international trade, development and other key socio-economic metrics.

**Training and skills:**

Training will be provided in integrated assessment and macroeconomic modelling and uncertainty analysis. The student will gain valuable skills and experience in interdisciplinary research and effective engagement with policymakers and stakeholders from the climate finance sector.

**Partners and collaboration:**

The project aligns closely with the work of the £10 m, 10-year Leverhulme Centre for Climate Change Mitigation lc3m.org based in Sheffield, a world-leading centre for research on enhanced rock weathering, led by Prof. David Beerling FRS. The OU is a partner in lc3m and the successful applicant would work closely with Centre scientists, and with leading developers of the E3ME-FTT-GENIE integrated assessment economic model at Exeter University and the World Bank, including Jean-François Mercure and Femke Nijsse.

**Possible timeline:**

Year 1 tasks: Setting up and running E3ME-FTT-GENIE model simulations and initiating discussion on plausible policy futures and financial and regulatory instruments and frameworks. Sourcing relevant data for simulations and testing the model.

Year 2 tasks: Liaising with stakeholders to design and implement large sets of simulations to cover relevant policy and financing scenarios; initial analysis of results. Preparation and submission of a paper on scenarios and initial analysis.

Year 3 tasks: Completion of full set of experiments and sensitivity analysis to assess robustness of conclusions; presenting results to stakeholder organisations and at national or international conferences; writing up results for thesis and further publishable papers.

**Further reading:**

1. Beerling, D. J., Kantzas, E. P., Lomas, M. R., Wade, P., Eufrasio, R. M., Renforth, P., Sarkar, B., Andrews, M. G., James, R. H., Pearce, C. R., Mercure, J.-F., Pollitt, H., Holden, P. B., Edwards, N. R., Khanna, M., Koh, L., Quegan, S., Pidgeon, N. F., Janssens, I. A., Hansen, J. and Banwart, S. A. 2020. Potential for large-scale $CO_2$ removal via enhanced rock weathering with croplands. *Nature*, *583*(7815), pp.242-248.
2. Kantzas, E., M. V. Martin, M. Lomas, R. M. Eufrasio, P. Renforth, A. L. Lewis, L. L. Taylor, J.-F. Mecure, H. Pollitt, P. V. Vercoulen, N. Vakilifard, P. B. Holden, N. R. Edwards, L. Koh, N. F. Pidgeon, S. A. Banwart and D. J. Beerling 2022. Substantial carbon drawdown potential from enhanced rock weathering in the United Kingdom. *Nature Geoscience*, *15*(5), pp.382-389.
3. Mercure, J.F., Pollitt, H., Viñuales, J.E., Edwards, N.R., Holden, P.B., Chewpreecha, U., Salas, P., Sognnaes, I., Lam, A. and Knobloch, F., 2018. Macroeconomic impact of stranded fossil fuel assets. *Nature Climate Change*, 8(7), pp.588-593.
4. Mercure, J.F., Salas, P., Vercoulen, P., Semieniuk, G., Lam, A., Pollitt, H., Holden, P.B., Vakilifard, N., Chewpreecha, U., Edwards, N.R. and Viñuales, J.E., 2021. Reframing incentives for climate policy action. *Nature Energy*, *6*(12), pp.1133-1143.

5.  Jenkins, S., Mitchell-Larson, E., Ives, M.C., Haszeldine, S. and Allen, M., 2021. Upstream decarbonization through a carbon takeback obligation: An affordable backstop climate policy. *Joule*, *5*(11), pp.2777-2796.
6.  Jenkins, S., Kuijper, M., Helferty, H., Girardin, C. and Allen, M., 2023. Extended producer responsibility for fossil fuels. *Environmental Research Letters*, *18*(1), p.011005.
7.  Bednar, J., Obersteiner, M., Baklanov, A., Thomson, M., Wagner, F., Geden, O., Allen, M. and Hall, J.W., 2021. Operationalizing the net-negative carbon economy. *Nature*, *596*(7872), pp.377-383.

**Further details:**

Please contact Neil.Edwards@open.ac.uk for further information and informal discussion about this project.