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INERIS
maîtriser le risque pour un développement durable

PHD POSITION IN ENVIRONMENTAL ECONOMICS

Integration of environmental and health externalities and indirect economic effects of recycling in a general equilibrium dynamic framework to study minerals recycling

Type of contract : Thesis (2025 – 2028)

Location : Verneuil-en-Halatte (60), 40 mn north of Paris.

Access : A free private bus provides the connection between the Creil station and the Ineris site.

Téleworking : 100 days/year

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CONTEXT

Ineris (National Institute for Industrial Environment and Risks), with approximately 500 employees, is a French leading national organization under the supervision of the Ministry of the Environment. Its primary mission is to conduct studies and research to prevent risks that economic activities pose to the safety of people and property.
Joining Ineris provides an opportunity to apply and develop your skills through research, support, and expert appraisal missions on behalf of public authorities and industry.
The PhD will be hosted in Ineris EDEN Unit (Economics and Decision for the Environment), that develops and implements decision support methods for risk management, including cost/benefit analysis, multi-criteria methods, in various contexts of environmental issues (prioritization of chemicals, economic assessment for complex environmental problems involving chemicals, air pollution and climate change issues).

BACKGROUND AND MOTIVATIONS OF THE PHD

Motivations for developing recycling activities are generally twofold. First, recycling helps alleviate various constraints associated with the use of non-renewable resources, such as scarcity, limitations imposed by climate change mitigation, and environmental policies, especially when the extraction of these resources has a high carbon footprint or poses significant environmental risks. Additionally, recycling reduces waste production, which can lead to local or widespread environmental degradation. Waste management is often costly and may even be impossible for society, and it can also cause irreversible damage.

On the other hand, particularly with mineral resources, recycling can introduce renewed exposures, emissions, and risks associated with these minerals. Technological advancements may enable the use of novel, less hazardous chemicals or materials instead. Furthermore, recycling processes require energy and may also contribute to greenhouse gas emissions. There is also the possibility of a rebound effect, where increased recycling leads to heightened demand for minerals, potentially resulting in negative environmental impacts and contributing to the depletion of secondary mineral resources (from recycling).

Consequently, it is essential to consider the potential trade-offs between the costs and benefits of recycling when modelling the circular economy of minerals, and more broadly in economic modelling. This will ensure better decision-making regarding recycling policies for minerals. The holistic approach to recycling has received limited attention in research. Lafforgue and Lorang (2022) explored this issue within a theoretical framework, while Brignon (2021) concentrated on additives in plastics. However, the trade-offs associated with recycling minerals do not appear to have been studied to date.

The objective of this PhD is to develop a general equilibrium dynamic model that addresses this issue. Additionally, the model will be designed to explore normative questions, such as identifying the first- and second-best recycling policies to implement, depending on the economic constraints in place.

The PHD is part of a project to bring to operation for decision-support the concept of subsoil reference values to quantify the sustainable level of subsoil exploitation and the reference value of strategic metals, the externalities it covers and its use in socio-economic assessments, in particular decarbonized technologies that use these metals as raw materials. Another aim is to develop a global and economically supported vision of mineral resource cycles and dynamic analyses of material flows related to the energy transition in order to quantify the amount of each mineral resource that could be extracted, circulate in the technosphere (including recycling) and finally be disposed of in the environment in the future.

AIM AND PHASES OF THE PHD

Several scientific questions will be studied within the framework of this thesis:

- Dynamic modelling of minerals extracted, in use and in wastes in function of scenario illustrating environmental and recycling incentive policies
- Estimation of environmental and health externalities and second effects of recycling
- Coupling of material flow dynamic modelling of minerals and materials embedding minerals in the context of recycling with calculation of externalities, and with general economic equilibrium modelling.

At the end of the PhD, a dynamic model of minerals extracted, in use and in wastes will have been built integrating environmental and health externalities and second effects of recycling. This model will be developed for some minerals and some low-carbon footprint energy technologies during the PhD but subject to data it would be applicable to others.

A version of the general equilibrium technology integrating these decarbonized energy technologies, the mineral material flows involved, and its externalities will be developed.

Results of the PhD would be improved economic modelling useful for management of mineral resources in the framework of energy transition and design policies to promote circular economy improve waste management.

The chronology of the PhD will flow the following steps :

1. Selection of minerals and their uses in technologies in scope of the PhD.
2. The review of available databases and data collection on mineral consumptions and uses in a context of energy and ecological transition for technologies included in the scope of the PhD at step 1.
3. Development of overall scenario of the structure of technology deployment and associated industrial supply chains including recycling pathways. Scenarios of consumption of minerals and scenarios of recycling capacities will be defined.
4. Development of a dynamic material flow analysis (MFA) for minerals including mining, use, recycling, end-of-life for the scope defined in step 1. Calculation of environmental and health externalities associated with processes and uses included in the material flows will also be developed in the MFA model. Technical constraints or recycling will be considered in the model (substitutability between virgin raw materials and recycled materials, quality downgrading at each new recycling iteration).
5. Development of an integrated modelling framework, integrating the supply/industrial chains elaborated in step 4, and coupling general equilibrium economic modelling with MFA including externalities. It is foreseen that this modelling framework will be able to describe economic outputs from mineral production and use under scope 1, and its associated externalities.
6. Definition and simulation, interpretation of scenarios with the model developed under step 5.

COLLABORATION

The PhD will be recruited by and located at INERIS. The PhD manager/additional supervisor at INERIS will be Jean-Marc Brignon, head of the EDEN Unit. Ineris will be responsible for aspects related to material flow modeling and calculation of environmental externalities.

Thesis Director will be Dr. Florian Fizaine from IREGE (Institut de Recherche en Gestion et en Économie) Université Savoie Mont Blanc. IREGE will bring general skills in the management of critical mineral materials and environmental economics

Thesis Co-director will be Pr. Gilles Lafforgue from Toulouse Business School (and associated researcher at Toulouse School of Economics). TBS will be responsible for macroeconomic modeling, application to energy/environmental issues.

Regular meetings will be organized between Ineris, IREGE and TBS.

PROFILE

The PhD holds a Master 2 Degree in Economics or a degree in engineering, with competence in Environmental Economics and experience in economic modelling. He/she is interested in

Environmental Science and has a strong interest in working in the context of a sustainable energy transition.

GENERAL INFORMATION

INERIS is located in Verneuil-en-Hallate, France. Verneuil-en-Halatte is 30 minutes north of Paris by regional train. A free private shuttle service is available between Creil train station and our site.

Start date beginning of October 2025 and duration 3 years

18 RTTs in addition to 31 annual paid leave
Teleworking 100 days per year
Variable hours
Company restaurant

Our job offer is open to all; we aim to integrate our new talent into an inclusive work environment.

APPLICATION

The application must include: a curriculum vitae, copies of certificates for each university degree and grades obtained, a letter describing your motivation and interest in working on the proposed subject, and any letters of recommendation from your teachers and/or supervisors.

For more information and applications :
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REFERENCES

Brignon, J.-M. (2021). Costs and benefits of recycling PVC contaminated with the legacy hazardous plasticizer DEHP. In Waste Management and Research: The Journal for a Sustainable Circular Economy (Vol. 39, Issue 9, pp. 1185–1192). SAGE Publications. https://doi.org/10.1177/0734242x211006755

Lafforgue, G., & Lorang, E. (2022). Recycling under environmental, climate and resource constraints. In Resource and Energy Economics (Vol. 67, p. 101278). Elsevier BV. https://doi.org/10.1016/j.reseneeco.2021.101278