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| Espace DEV — Observation spatiale, modèles & science impliquée | **Stage Master 2**<br><br>**Sustainable energy transition and net-zero energy mix pathways in West Africa** | IRD — Institut de Recherche pour le Développement — FRANCE |

**Nom des structures encadrantes** : Institut de Recherche pour le Développement (IRD), UMR Espace-DEV
**Localisation géographique du stage** : Montpellier, FRANCE
**Durée** : 6 mois
**Date d'entrée en poste** : Février-Mars 2024
**Revenu** : Gratification prise en charge au taux en vigueur
**Contacts** : Benjamin Pillot (benjamin.pillot@ird.fr), Romain Authier (romain.authier@umontpellier.fr), Théo Chamarande (theo.chamarande@univ-grenoble-alpes.fr)

# 1 Context

## 1.1 Net-zero energy mix pathways in West Africa

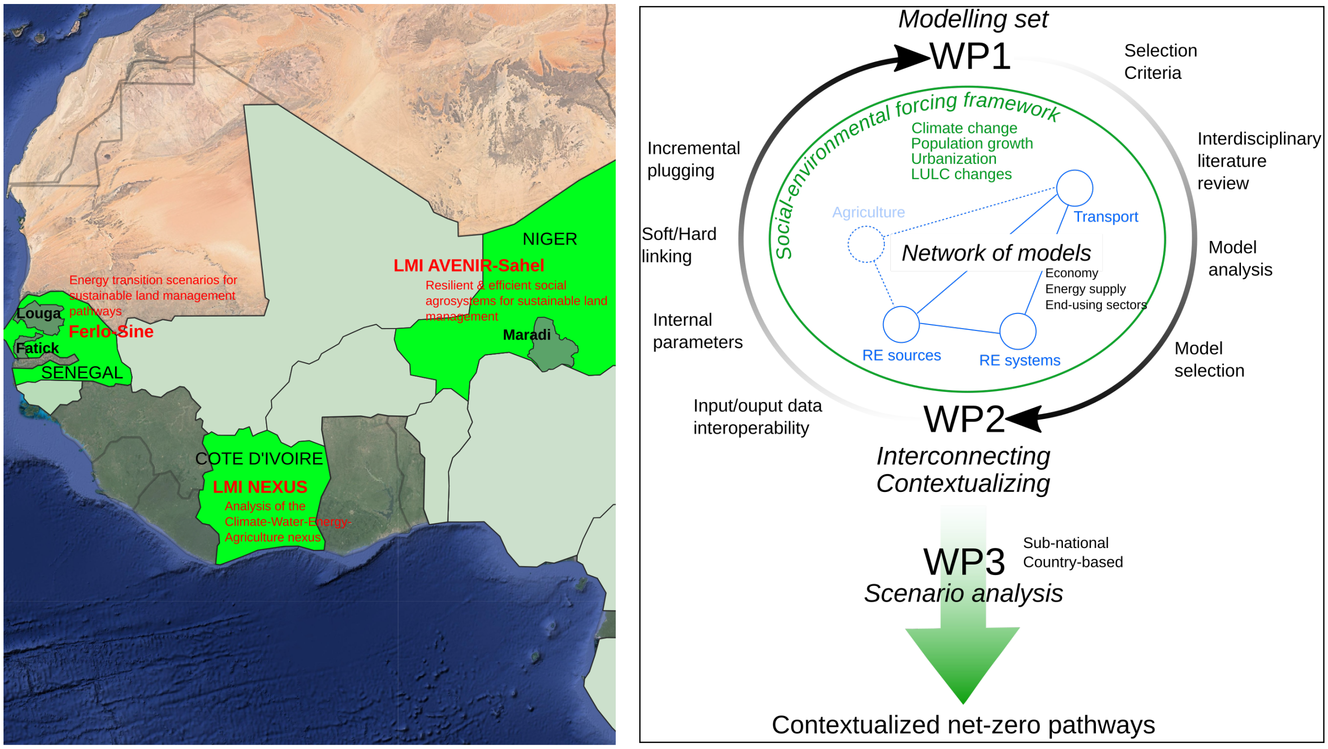
Working Group III's contribution to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) has recently been released, and the conclusions show that the global *energy system* remains the largest source of $CO_2$ emissions [1]. In other words, low carbon energy is key to climate change mitigation [2]. Mitigation of $CO_2$, and by extension of greenhouse gases (GHG), emissions from the energy sector should be below or near zero by 2050 [3]. Determining the best *energy mix* of such *net zero* system consists in estimating the optimal share of available energy supply options (renewable, non-renewable) with respect to end-using sectors [4].

West Africa (WA) is currently facing the same challenges regarding access to energy and electricity [5] as Sub-Saharan Africa taken as a whole [6]. The challenge of sustainable energy development in the region consists in balancing the need for supplying energy to the populations while mitigating corresponding negative impacts on local and global social-ecosystems [1, 5, 7]. Globally, net zero emissions will necessarily be part of the shift towards *sustainable pathways* for the energy system [3, 8]; it is especially true in West Africa where energy and electricity demand are expected to grow very fast [5]. The way WA countries will supply energy to their population in the next decades is facing a quite unique choice [5]: either 1) following a path that has already been paved (by industrialized countries), or 2) imagining radically new pathways and alternatives towards a net-zero energy supply system. Accordingly, developing *contextualized* energy system models in West Africa is essential for 2 reasons: 1) producing cross-sectoral outcomes and trade-offs that address the region's own social-energy issues, 2) re-thinking energy transition pathways through the elaboration of unprecedented scenarios, where the current lack of resources and energy infrastructures in the region [5] should rather be seen as a *catalyst* for exploring new solutions.

## 1.2 NZEMIX project

The main objective of **NZEMIX** project (ANR 2024-2027) is to contribute to the assessment of **possible net-zero energy mix pathways in West Africa**. Overall, NZEMIX purpose is to build a modular **decision support framework** combining existing models for social-environmental drivers (mid-term, long-term horizon[1]), energy supply and end-using sectors (i.e. energy demand), in order to produce **realistic net zero scenarios** for supporting energy policy development in the region. NZEMIX will focus on 1) integrating specific aspects of the WA social-energy framework (e.g. centralization vs. decentralization), 2) aggregating a *forcing frame* of the essential social-environmental drivers (e.g. climate change, population growth, urbanization, land use and land

[1] Typically, mid-term refer to 2035, and long-term to 2050 [1].




(a) WA countries under study

(b) NZEMIX organization based on 3 *work packages* (WP)

Figure 1: (a) Espace-DEV implication in West Africa, highlighted countries where NZEMIX will be implemented (Senegal, Côte d'Ivoire, Niger) and related major ongoing sub-national and national partnerships and projects NZEMIX will rely on ; (b) WP organization and articulation in NZEMIX.

cover changes) for which projections are available in the region, and 3) building a network of energy-economy sectoral[2] models (NSM) in which each model can incrementally be *plugged*.

## 2 Main objective of the internship

This internship will participate to the research developed in Work Package 1 (see Fig. 1b), which is dedicated to reviewing, analyzing and determining the set of modelling tools that shall constitute the final decision support framework. The intern will analyze the possibility for multidimensional and multiscalar integration of state-of-the-art energy and socio-environmental models together, evaluate their relevance as well as their versatility for the WA specific context. It will require both low-level and high-level expertise regarding the network of models to be instantiated, and the expected net-zero scenarios to be built in each WA country under study.

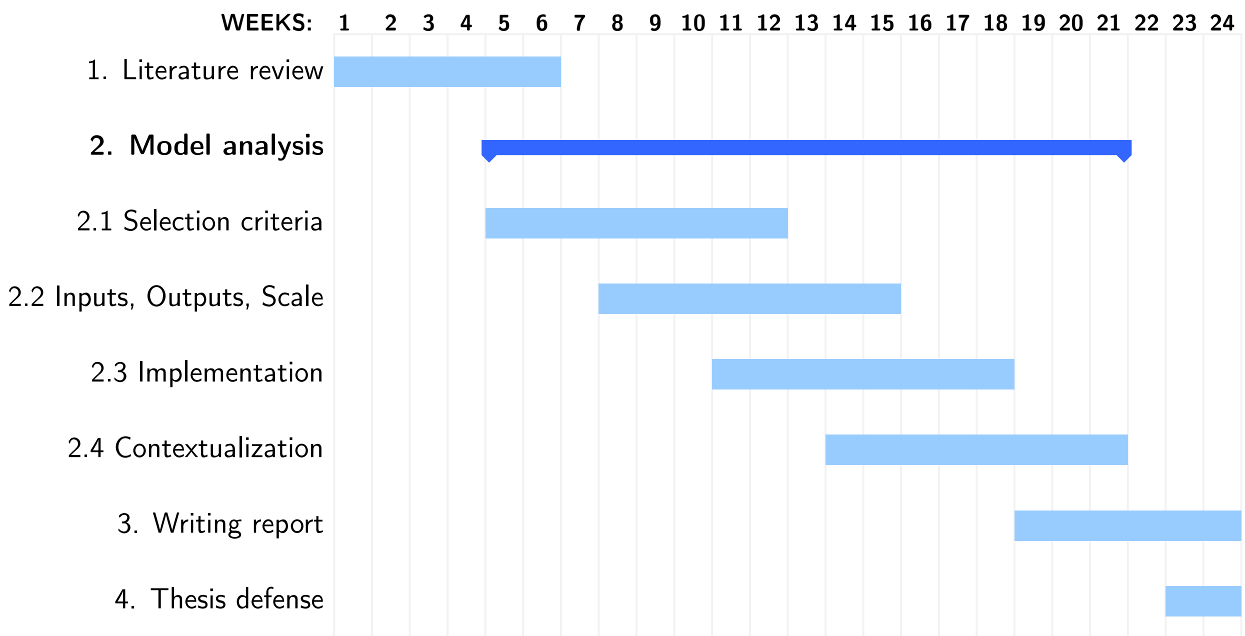
## 3 Working team

The intern will work together with a small team of young research scientists partly or entirely dedicated to the NZEMIX project: Benjamin Pillot (research scientist), Romain Authier (PhD student), Théo Chamarande (postdoc fellow).

[2]Energy sectors refer to energy resources, energy supply systems, and energy end-using sectors (transport, agriculture, residential, services, etc.)

## 4 Gantt chart

Internship duration is 24 weeks (6 months). Gantt chart is the following:




## 5 Expected skills

Candidate is finalizing a MSc. in the field of energy systems or sustainability science, and is expected to hold a good background in applied mathematics, modelling and computer engineering. Those who are attracted by interdisciplinary research challenges are especially welcome.

## 6 Application process

Candidates should send their resume (in English or French) to Benjamin Pillot, Romain Authier and/or Théo Chamarande (see emails above). Final selection will be carried out through interviews (videoconference or in-person).

## 7 References

[1] L. Clarke et al. "Energy Systems". In: *IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Ed. by P.R. Shukla et al. Cambridge, UK and New York, NY, USA: Cambridge University Press, 2022. Chap. 6. DOI: 10.1017/9781009157926.008.

[2] Andrew Welfle, Patricia Thornley, and Mirjam Röder. "A review of the role of bioenergy modelling in renewable energy research & policy development". In: *Biomass and Bioenergy* 136.November 2019 (2020), p. 105542. ISSN: 18732909. DOI: 10.1016/j.biombioe.2020.105542.

[3] Inês Azevedo, Christopher Bataille, John Bistline, Leon Clarke, and Steven Davis. "Net-zero emissions energy systems: What we know and do not know". In: *Energy and Climate Change* 2 (2021), p. 100049. ISSN: 26662787. DOI: 10.1016/j.egycc.2021.100049.

[4] Gregor Schwerhoff and Mouhamadou Sy. "Developing Africa's energy mix". In: *Climate Policy* 19.1 (2019), pp. 108–124. ISSN: 17527457. DOI: 10.1080/14693062.2018.1459293. URL: https://doi.org/10.1080/14693062.2018.1459293.

[5] M. Bissiri, P. Moura, N. C. Figueiredo, and P. P. Silva. "Towards a renewables-based future for West African States: A review of power systems planning approaches". In: *Renewable and Sustainable Energy Reviews* 134 (August 2020), p. 110019. ISSN: 18790690. DOI: 10.1016/j.rser.2020.110019. URL: https://doi.org/10.1016/j.rser.2020.110019.

[6] Benjamin Pillot, Marc Muselli, Philippe Poggi, and João Batista Dias. "Historical trends in global energy policy and renewable power system issues in Sub-Saharan Africa: The case of solar PV". In: *Energy Policy* 127 (2019), pp. 113–124. ISSN: 0301-4215. DOI: https://doi.org/10.1016/j.enpol.2018.11.049. URL: http://www.sciencedirect.com/science/article/pii/S0301421518307870.

[7] Xavier S. Musonye, Brynhildur Davíðsdóttir, Ragnar Kristjánsson, Eyjólfur I. Ásgeirsson, and Hlynur Stefánsson. "Integrated energy systems' modeling studies for sub-Saharan Africa: A scoping review". In: *Renewable and Sustainable Energy Reviews* 128.April (2020). ISSN: 18790690. DOI: 10.1016/j.rser.2020.109915.

[8] S. Pye et al. "Modelling net-zero emissions energy systems requires a change in approach". In: *Climate Policy* 21 (2 2021), pp. 222–231. ISSN: 17527457. DOI: 10.1080/14693062.2020.1824891.