INTERNSHIP PROPOSAL - Spring 2026

(One page maximum)

Laboratory name: SPEC (CEA/SPEC/SPHYNX) + LIED (Univ. Paris Cité)
CNRS identification code: UMR 3680
Internship director'surname: Hervé Bercegol/Sebastien Aumaître/Petros Chatzimpiros (LIED)
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Web page: http://iramis.cea.fr/spec/
Internship location: Université Paris Cité / CEA Saclay, site de l'Orme des Merisiers

Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:CFR

Energy and material investment in railway development during the industrial revolution

Summary (half a page maximum)
As the energy transition to a zero-emission society gets underway, attempts are being made to estimate the associated costs [1], as well as the impact on the use of natural resources, particularly for energy investments [2]. The development of energy transmission and distribution networks is often a blind spot in forecasts, even though they are recognized as central to the use of low-carbon energies [3]. We propose to explore the historical case of the development of the railway network in the 19th century, in terms of the consumption of material and energy resources for its construction, maintenance and use. Our ambition is to understand the link between the dynamics of transport development and economic growth based on coal, both the raw material of the network and the beneficiary of its development [4, 5]. We will make use of the results already obtained by graph theory applied to these spatial networks [6], and will also draw on a similar approach underway for electricity networks [7]. The aim of the internship will be to gather documentary resources, define the geographical study area in line with available data, and present an initial network development model.

[1] R. Way, M. C. Ives, P. Mealy, J. D. Farmer, Empirically grounded technology forecasts and the energy transition. Joule 6(9), 2057-2082 (2022).
[2] A. Slameršak, G. Kallis, D. W. O'Neill, Energy requirements and carbon emissions for a low-carbon energy transition. Nature communications 13(1), 6932 (2022).
[3] RTE, France, Futurs énergétiques 2050 (2022), rapport complet téléchargeable sur https://www.rte-france.com/analyses-tendances-et-prospectives/bilan-previsionnel-2050-futurs-energetiques
[4] P. Malanima, The limiting factor: energy, growth, and divergence, 1820–1913. The Economic History Review 73(2), 486-512 (2020).
[5] B. Tostes, S. T. Henriques, P. E. Brockway, M. K. Heun, T. Domingos, T. Sousa, On the right track? Energy use, carbon emissions, and intensities of world rail transportation, 1840–2020. Applied Energy 367, 123344 (2024).
[6] a. R. Louf, C. Roth, M. Barthelemy, Scaling in transportation networks. PLoS One 9(7), e102007 (2014).
b. M. Barthelemy, Spatial Networks: A Complete Introduction: From Graph Theory and Statistical Physics to Real-World Applications. Springer Nature (2022).
[7] E. Emery, H. Bercegol, N. Jonqueres, S. Aumaître, Complex Network Analysis of Transmission Networks Preparing for the Energy Transition: Application to the Current French Power Grid. to appear in The European Physical Journal B.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: YES
Quantum Physics: NO Theoretical Physics: YES