M2 Internship proposal

# Data disaggregation and projection for energy/environment modeling with constraint satisfaction programming for GAINS and LEAP

The national energy balance of Vietnam is available for 2013-2015 [1, pp. 30-31], along with data on socio-economic parameters [1, p. 11-12]. As per international practices, the energy balance table has columns describing energy forms (from Coal to Electricity), and rows describing consumption sectors. The bottom of the table distinguishes 5 consumption aggregates (from Industry to Residential). An additional table subdivides Industry in 12 sectors. The internship will disaggregate these tables in the space dimension and extend them in the time dimension, accounting for existing plans and roadmaps.

This internship proposal is designed for a team of two M2 students interested in renewable energy and energy modeling, one Vietnamese and one French. They will share data and method, but target different models: GAINS and LEAP. These two cases will be examined as follows:

- For the GAINS Vietnam case, the timepoints to be produced are 2015, 2020, 2025, 2030, and the geographical division will first be North of Vietnam, and then in a second step “Greater Hanoi area” and finally selected provinces within that area. It will consider only the baseline case.
- For the LEAP Vietnam case, the timepoints will be annual starting from 2015, and the geographical division will only be “North, Center and South of Vietnam”. If time permits, the baseline scenario will be complemented by alternative greener policy scenarios.

The method is to merge information from [1] with information from regional statistics, development plans, and domain knowledge, under the constraints that the end results --regional energy/socio economic accounts-- must be consistent in term of: cost, price, technical efficiency transformation process balances volumes and energy content, and other socio-economic parameters.

Geographical disaggregation and temporal projection is an important part in any integrated assessment modeling. It will open to a PhD research follow up, oriented on the methodological research.

Outline description of work:

- Review of existing practices on disaggregation in energy/economy models.
- Definition of a family of reduced size disaggregation and projection problems

- Review of Constraint Programming [2] tools callable from Python
- Data collection
- Write code to read the raw data, set up the constraint satisfaction problem, solve, process the solution into readable LEAP or GAINS files.
- Write the report

The duration of the internship is 6 months starting from March 2018. The interns will based in Hanoi on the VAST campus, 18 Hoang Quoc Viet. It will be hosted by the University of Science and Technology of Hanoi, Energy Department, Clean Energy and Sustainable Development Lab. The joint supervisors will be Dr. Minh Ha-Duong, CIRED, CNRS and MSc. An Ha Truong at Center for Research and Technology Transfer, VAST.
The internship will be compensated according to the national conditions in the intern's university country of origin.

The GAINS Vietnam case in this internship proposal is a part of "Application of GAINS model in air quality management in Vietnam" project, a 2-year joint project between International Institute for Applied Systems Analysis and Vietnam Academy of Science and Technology. The LEAP Vietnam case is part of the "Vietnam Ireland Bilateral Education Exchange" project, a 1 year partnership between University of Science and Technology of Hanoi and the University College Cork, Ireland.

Requirements for the candidate: proven ability to work in English (both oral and written). Ability to code is a plus.

[1] VNEEP (2016) Energy Statistics Vietnam 2015. Statistical Yearbook (draft translation). Hanoi: National Energy Efficiency Program, pp. 45.
[2] Constraint Programming, https://ktiml.mff.cuni.cz/~bartak/constraints/index.html

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PhD topic proposal

# Advances in energy policy and modeling in Vietnam: robust methods for data disaggregation and scenario analysis

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The ultimate goals of this Energy Modeling thesis are:

- For the theoretical part, to push the boundary in data disaggregation for integrated assessment of energy policy, by demonstrating reproducible methods based on traceable data sources, which recognize the inherent inaccuracy of economic observations and in future plans.
- For the applied part, to contribute to understanding how Vietnam could participate in the global effort to mitigate climate change and to achieve sustainable development and green growth.

Context: Over the last twenty years, Vietnam has implemented rapid industrialization and urbanization process with high economic growth rates of 5 to 8 percent per year, and an even higher increase in domestic energy demand in general and electrical power in particular. In that period, the country has experienced two energy transitions: the first from mainly hydro power to hydro+natural gas, and the second towards coal. This development model emits increasing quantities CO2. This is less and less sustainable. Another transition to renewable energy resources is called for by current policymakers, NGOs, and the international community.

Data: Available statistics on sustainability, development and energy in Vietnam is scarce, which makes the country an ideal benchmark for a research on disaggregation methods. The national energy balance of Vietnam is available for 2013-2015, along with data on socio-economic parameters. As per international practices, the energy balance table has columns describing energy forms (from Coal to Electricity), and rows describing consumption sectors. The bottom of the table distinguishes 5 consumption aggregates (from Industry to Residential). An additional table subdivides Industry in 12 sectors. Besides this national statistical report, there are many plans at the sectoral and provincial scale.

Description of work: The PhD research is organized in work packages. They lead progressively to a high level of expertise in energy policy and modeling.

WP1: Theoretical context
The PhD candidate will study methods used for data assimilation in integrated assessment models. What are the current best practices used to estimate the national accounts of Vietnam, consistent both in economic terms and in energy terms: cost, price, technical efficiency transformation process balances volumes and energy content? How much of these accounting are based on traceable data sources, reproducible methods, and recognize the inherent inaccuracy of economic observations? How to improve them?

WP2: Applied context

To understand the dynamics of the energy/economy policy in Vietnam, the system will be analyzed from different perspectives. a) The dataset will be extended in the past to explain the observed historical trajectories. b) Vietnam will be compared to other countries with a different development history, to clarify the influence of factors such as natural resources endowment, political systems, international markets and international policy and others. c) The candidate will examine the existing visions of the political debate on energy in Vietnam. There are about a dozens of those, and most are described in an

WP3: Critical analysis of existing models and scenarios

Building upon the previous two work packages, the goal is to deep dive into the energy prospective debate for Vietnam. To this end, it will critically examine model assumptions and results supporting the visions.

There is a handful of models to describe. The candidate will summarize models technical characteristics such as complexity, perimeter, parametrization, licence, quality, popularity, transparency, reproducibility, cost, publications, origins, underlying behavior / economic theory assumptions, funding, long term prospects.

The different visions will be aligned to a common reference year, with the same production technologies expressed in the same units. In modeling terms, using the index $k$ to denote each of these visions, the question is to give the vectors $S_k$ describing the energy mix in 2030 according to vision $k$, all in the same space. The deliverable is a matrix with the visions in columns, and the production from various energy sources (coal, fuel oil, gas, hydro, solar, wind, biomass, others...) in rows. That will allow a direct numerical comparison of the visions.

Each scenario is characterized by a set of assumptions $A_k$ . From a numerical analysis point of view, the $A_k$ are only strictly comparable within the model they are written for. But from a broader perspective, the assumptions pertain to the real world policy choices, economic parameters, and concrete technological events which should be comparable across models because they refer to the same system. The work will describe each vision assumption from that broad perspective. It will address the comparative plausibility of the assumptions' critical parameters such as natural resources prices, technical progress, financing conditions, demand… It will discuss in which ways the choice of the model allows to compensate for –or to be conveniently blind to– the critical uncertainties in the assumptions.

The comparison will be informed by a discussion of the provenance of the various visions. The analysis will expose who produced the scenario sets (ministries and national agencies, regional official organizations, industry and environment non-governmental organizations, funding agencies, research institutes, think tanks...) and for which purposes.

WP4: Reproduce previous results

This extends the previous work by reproducing previous modeling results using the LEAP model. Let

$$S_k = M_k(A_k)$$

stand for the proposition « The vision $S_k$ has been produced by the prospective model $M_k$ using the assumptions $A_k$ ». This part of the work uses the LEAP model (Long-range Energy Alternatives Planning) to check the robustness of the proposed visions.

- The direct approach is to translate the assumptions $A_k$ into LEAP assumption parameters, and then compare the results of LEAP with $S_k$
- The inverse approach is to find the LEAP assumptions which produce results as close as possible to $S_k$ and then compare these assumptions with $A_k$ .

Ideally, models describe the same reality there will be little differences. In practice, we expect the students to have more than a few differences to explain, and that the exercise will reveal a lot. The overall deliverable of the work is a set of LEAP simulations reproducing the existing visions for the energy sector in Vietnam in 2030.

WP5: New original analysis
Having become a energy modeler, the candidate is expected to contribute new original analysis to inform Vietnam climate and energy plans. We leave open the policy question and therefore the choice of most appropriate model. This is an opportunity for the candidate to go beyond LEAP. For example, to discuss the effects of clean energy policies on demand, on growth and on equity it would be possible to use the CIRED technico-economic models of intermediate complexity named “IMACLIM”. To discuss energy security, cost of renewables and fossil fuels, CleanED’s subset of the OSEMOSYS model could be appropriate. Air quality questions would be best analysed with the GAINS model used at CRETECH. And climate finance opportunities could be discussed with the GEMMES Vietnam model.

Requirements for the candidate: MSc degree with quantitative methods, proven ability to work in English (both oral and written). Ability to code is a plus.

The research will be performed as a collaboration between CIRED, CNRS/AgroParisTech in Paris and CleanED, USTH in Hanoi. This PhD will be supervised by Dr. Minh Ha-Duong, CIRED/CNRS and co-supervised by Dr. Hoang Anh Trinh-Nguyen, CleanED, USTH. The PhD duration is 3 years starting in fall 2018. The research is carried out partly in France and partly in Vietnam.

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**HOW TO APPLY**

Interested students are encouraged to contact us with the usual documents: Motivation letter or email; CV or LinkedIn; one previous written work in English; any other evidence of academic excellence.

Applications will be considered on a rolling basis until the positions are filled.

**About CleanED**
The Clean Energy and Sustainable Development (CleanED) lab is an international and interdisciplinary research team contributing to the green growth of the energy sector in Vietnam. We are at USTH —the University of Science and Technology of Ha Noi— on the

Vietnam Academy of Science and Technology (VAST) campus in the Cau Giay area of Hanoi. Established in December 2014 with support from the French Embassy, the CleanED lab hosts today eight researchers from France and Vietnam, four doctoral fellows and two internationally qualified staff.