POST-DOCTORAL RESEARCH PROPOSAL

LONG-TERM POWER SYSTEM MODELING AND GRID RELIABILITY

Institution: MINES ParisTech (Ecole Nationale Supérieure des Mines de Paris)

Laboratory: Centre for Applied Mathematics, 1 rue Claude Daunesse, 06904 Sophia Antipolis

As part of its research program in long-term modeling and a recently accepted H2020 research project (GIFT: Geographical Islands Flexibility), the Centre for Applied Mathematics (CMA) at MINES ParisTech has created a post-doctoral position working on energy system modeling. The core subjects involved are decarbonizing the energy systems of geographical islands and power supply reliability requirements.

DESCRIPTION OF THE CENTRE FOR APPLIED MATHEMATICS

This postdoctoral project will be led by the MINES ParisTech Centre for Applied Mathematics (CMA). Founded in 1976, the CMA applies its skills in modeling, systems theory, operation research, and the mathematics of control and decision science to develop original expertise focused on the changes facing the world of energy to further its research project on Modeling for Energy, the Environment and the Economy. This activity has led to research projects, industrial contracts, the creation of teaching programs (post-graduate Master’s specializing in Energy Engineering and Management, OSE), collaboration with other research teams (CREDEN (University of Montpellier I), INRIA, CIRED (AgroParisTech/Ecole des Ponts), University of Reunion Island) and partnerships with major players in the energy field.

Like all thirteen MINES ParisTech research centers, the CMA’s research activities are geared toward industry and developing courses that respond to MINES ParisTech’s twofold ambition, i.e. to educate engineers to be fully aware of the concerns of the industrial world, while remaining at the cutting edge of the latest developments in scientific research. Thanks its location in the Sophia Antipolis technology park, the CMA benefits from a rich environment comprising research institutions active in similar fields and hi-tech companies, and employs a strong team of researchers and four outside collaborators. CMA also co-founded the Chair “Prospective modeling for sustainable development” supported by ADEME, EDF, GRTgaz, SCHNEIDER ELECTRIC and the French Ministry of the Environment. The aim of this chair is to tackle the energy, environmental and economic constraints faced by industrials and policy makers in their strategic choices.

The CMA possesses particular expertise in prospective related to energy planning, a project initiated in 2003 and supported by the French Council on Energy. Its approach is based on optimizing a technico-economic representation of the energy system using the MARKAL-TIMES (Market Allocation) model. MARKAL-TIMES is a methodological corpus developed within ETSAP (Energy Technology Systems Analysis Program), an international consortium sanctioned by the International Energy Agency (CMA is the official representative of the French government at the IEA/ETSAP).

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POST-DOCTORAL RESEARCH PROJECT DESCRIPTION

The expected solution to cope with scarce fossil sources and rising greenhouses gas emissions is to considerably increase the share of renewable energy sources, and especially intermittent sources in electricity production. This is particularly relevant on islands that aim to satisfy energy consumption with a high level of renewable energy sources. In this context, the design of a relevant power system for the forthcoming decades must take into account reliability requirements. This reliability of supply is defined as the ability of the power system to lock back into steady-state conditions after sudden disturbances (e.g. load or production fluctuations). This aspect is of tremendous importance, especially when high shares of renewable energy sources, and in particular intermittent energy sources, are expected in electricity production: they may threaten supply reliability and consequently provide unrealistic options for the future electricity industry. Energy-planning models are useful tools to provide plausible options for the long-term development of power systems. However, these energy models usually ignore power supply reliability requirements as they involve events whose time scales range from a few milliseconds to a few hours.

The most commonly developed approach to overcome this drawback involves making connections between load flow approaches and long-term models. However, the CMA has developed a methodology to assess the reliability of supply when evaluating the long-term development of power systems. As reliability depends on the dynamic properties of production and transmission capacities, these features are assessed through the system's magnetic and kinetic reserves. Assessing these reserves makes it possible to quantify the inertia that is provided to the system in order to enable it to remain stable. This methodology, based on a thermodynamic representation of the grid, avoids high calculations levels to solve the Kirchhoff laws. It thus offers an innovative way to deal with the reliability issue that involves less intensive calculation. This approach has been demonstrated through a prospective study of Reunion Island, which is aiming to achieve an electricity production mix relying on 100% renewable energy sources by 2030, and subsequently including large shares of photovoltaic production. To that end, a long-term power system analysis is proposed using a comprehensive and coherent approach based on a bottom-up TIMES model that generates future production mixes according to different scenarios. Provided appropriate investments are made in storage, the endogenization of the transient kinetic reserve indicator set as a constraint in the long-term planning exercise shows that a generation mix relying on 100% renewable sources with a high share of variable intermittent plants (above 50%) can be considered without jeopardizing power management. This result, which is significantly above the current legal limit (30%), fosters electrochemical storage technology, especially NaS, to sustain power-dynamic operation under high renewable penetration. This assumes that the synchronism conditions required for aggregating the kinetic energy embedded in the whole power system are fulfilled. For the case of Reunion Island, this methodology draws the following conclusions: (i) to achieve the 100% renewables target, the capacity to invest in the energy sector is doubled, and the level of reliability decreases considerably; (ii) the loss of reliability induced by higher intermittency in the power mix— typically 50% — can be counter balanced and leveraged by implementing flexibility solutions (demand response and storage).

The aim of this research, which is part of the H2020 GIFT project, is to assess the long-term energy/electricity pathways of the selected islands (the solutions will be developed and demonstrated on two lighthouse islands, Hinnøya, Norway's largest island, and the small island of Procida in Italy and the replicability of the solution will be studied on a Greek and Italian islands, respectively Evia and Favignana) in order to implement the solutions developed in the project's next work packages at scales that ensure the best sustainability. Thus, a specific bottom-up optimization model (based on the TIMES long-term energy planning paradigm) will be developed in order to discuss possible future trajectories of the energy system for these territories (changes in supply, particularly for renewables,

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changing consumption, etc.). Technical choices will be discussed along with subsequent policies and technological impacts on the system in the long-term. The second purpose will be to analyze which power reliability conditions are enforced over time in these long-term planning exercises and so, to discuss the long-term and short-term plausibility of the different possible futures. Indeed, tackling the considerable challenge of grid decarbonization and the subsequent massive introduction of intermittent electricity production requires a general framework that aggregates the space characteristics of the power grid and reconciles the short-term dynamics of power system management with long-term prospective analysis. This task will allow the partners to make the right choices in the next WPs taking into account short- and long-term consequences.

PROFILE OF CANDIDATE

The candidate (s) must demonstrate a strong interest in this field of research and hold a doctorate on a related subject (e.g. optimization, long-term energy system modeling, power networks).

APPLICATION PROCESS

The application should include:

- Covering letter presenting the candidate's research;
- Detailed CV;
- List of recent research work and publications;
- If possible, three reference letters by specialists selected by the candidate and send directly to the Centre for Applied Mathematics. If not, the application should at least include the names and contact details of three leading scientific figures who could be contacted to give their opinion on the candidate's work and abilities.

Applications should be sent to the following address, no later than 1st October 2018:

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1, rue Claude Daunesse, CS 10 207
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Attention: Nadia MAÏZI

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