



The Centre for Applied Mathematics

Chair Modeling for Sustainable Development



EDUCATION AT MINES ParisTech

A distinctive feature of the training programmes at MINES ParisTech is the limited annual intake of students thereby ensuring individual tutoring. The teaching is provided by research academics, masters of their fields, who have close links with the economic world. The students are selected, in France and abroad, according to their motivation and their aptitude to benefit substantially from the courses. Most of the programmes include placements in France and abroad which enable the students to complete their theoretical training and to deal with the practical aspects of engineering, research and organization.

RESEARCH AT MINES ParisTech

MINES ParisTech is a « Grande Ecole » centred on its research activities. It encompasses all fields of scientific knowledge thanks to 18 innovative research centres exploring five major fields.

- Earth Sciences and Environment
- Energy and Processes
- Mechanical and Materials Engineering
- Mathematics and Systems
- Economics, Management, Society

With 235 research academics, 390 doctoral students and 65 post-doctoral students, MINES ParisTech ranks top among the Grandes Ecoles for the volume of contractual research.

MINES ParisTech CHAIR

MODELING for SUSTAINABLE DEVELOPMENT



The Chair's objectives

The objective of the MPDD chair is to create a driving force to facilitate decision-making in debates on scientific and technological issues related to energy-climate constraints. Responding to the energy, environmental and economic constraints that face industrials and state leaders making strategic choices, the MPDD's project centers on the following challenges:

- Ensure stronger presence from founding laboratories and their partners in important places of national and international expertise on sustainable development to work on the energy-climate issue, extending their current involvement at the Strategic Analysis Center (for France – thanks to initial support from the French Energy Council), the IEA (World Energy Outlook, Energy Technology System Analysis Program), OECD, the World Bank and the Intergovernmental Panel on Climate Change.
- Foster a prospective platform for aiding decisions involving economics-resources-climate on issues relating to energy and climate policies, industrial development and technological choices in a context of changing competition rules. This platform will gradually integrate connections between energy/climate and other key areas of the sustainable development challenge.
- Ensure international academic reach by running international symposia, publishing in expert journals (economics, management and applied mathematics), and organizing special editions of specialist journals (energy, environment, transport, water) on sustainable development themes.
- Set up funding programs for doctoral studies and training seminars that respond to the requirements of partner companies in the prospective field (raising awareness of the benefits of a prospective approach in carrying out their activities, extending and transferring competencies in the domain)
- Make up for the national shortage of a syllabus “on and through” a prospective approach.

The “modeling for sustainable development” (MPDD) Chair is co-directed by Nadia MAÏZI, Director of the MINES ParisTech Center for Applied Mathematics and Jean-Charles HOURCADE, Director of CIRED (International Environment and Development Research Centre). It was granted a budget of 2.5 million euro for 2008-2013, and was extended for another four years from 2014. The Chair's partners are ADEME, EDF, GRTgaz, SCHNEIDER ELECTRIC and the Ministry for the Environment, Sustainable Development and Energy



Development of the prospective MODELING TOOLS

TIMES-France

CMA: *Edi ASSOUMOU*

The long-term planning models resulting from the model family MARKAL/TIMES (MARKet ALlocation/ The Integrated Markal Eform System) are at the heart of the Chair's modeling activities.

This approach is based on optimization of a technico-economic representation of the energy system. It is based on a methodological corpus being developed by the ETSAP (Energy Technology Systems Analysis Program), which is an international cooperation program run by the International Energy Agency (IEA).

The CMA's geographical perimeters for this approach are France, Europe and the World. The CMA has invested in particular in developing the France model, which is unique, with constant developments and improvements since 2003. At the outset, the model was focused on the electricity question, but it has successively evolved to give an overall representation of the energy system, and then a refinement of certain sub-sectors and modules. These constant developments concern in particular biomass, the electricity sector, residential and transport sectors, and the revision of technological databases. The TIMES-France model can be used to evaluate for France the implications of different energy scenarios, such as factor 4, carbon value, and withdrawal from nuclear energy. In 2014, part of this research was published in the journal *Applied Energy*, "Future prospects for nuclear power in France" (vol. 136,31/12/2014, pp. 849 to 859).

TIAM-FR

CMA: *Sandrine SELOSSE*

The CMA is also developing the model TIAM-FR (Times Integrated Assessment Model), which is the French version of the TIAM model from the ETSAP-TIMES family.

TIAM-FR is used to develop carbon-constraint scenarios in order to identify the regional impacts of global commitments to reducing CO₂ emissions in different regions in the world (post-COP15 commitments). In parallel with these scenarios, technology deployment scenarios are developed, such as carbon capture and storage, with the aim of debating the technico-economic plausibility of climate policies.

Examples of conclusive research: the atmospheric concentration of CO₂, global and regional GHG emissions, marginal cost of CO₂ in an emissions constraint situation, the regional and global energy mix, technological investments (CCS, renewable energy), according to different regions in the world (15) and different activity sectors.

Of particular importance in 2014 was the study of regional potential scenarios for carbon storage integrating an onshore/offshore distinction for each type of potential

storage site (saline aquifers, former coal/methane seams, former gas or oil reservoirs, etc.). This work was part of the CMA's contribution to the consortium involving 10 European research centers that use the TIAM model and aim to develop the official ETSAP version of the TIAM model. It was presented in New York at the 37th International IAEE Conference. Another significant analysis, which was the object of several presentations at international conferences and in particular at the COP 20 in Lima in 2014, consisted in an analysis of climate commitments resulting from international climate negotiations. The objective of this research included determining the degree of commitments' ambition with respect to limiting the global temperature rise to 2°C and establishing the weight of this constraint at regional level, in particular between industrialized, emerging, fast-growing and developing countries.

The Chair's principal PUBLICATIONS

- Thomas Le Gallic, Edi Assoumou, Nadia Maïzi, Pierre Strosser. Les exercices de prospective énergétique à l'épreuve des mutations des modes de vie. *VertigO : La Revue Électronique en Sciences de l'Environnement*, VertigO, 2015, Dossier : Transition énergétique : contexte, enjeux et possibilités, 14 (3), pp.[En ligne]. <10.4000/vertigo.15635>. <hal-01119645>
- Jean-Michel Cayla, Nadia Maïzi. Integrating household behavior and heterogeneity into the TIMES-Households model. *Applied Energy*, Elsevier, 2015, 139, pp.56-67. <10.1016/j.apenergy.2014.11.015>. <hal-01095099>
- Mathilde Drouineau, Edi Assoumou, Vincent Mazauric, Nadia Maïzi. Increasing shares of intermittent sources in Reunion Island: Impacts on the future reliability of power supply. *Renewable and Sustainable Energy Reviews*, Elsevier, 2015, 46, pp.120-128. <10.1016/j.rser.2015.02.024>. <hal-01132581>
- Gilles Guerassimoff, Johann Thomas. Enhancing energy efficiency and technical and marketing tools to change people's habits in the long-term. *Energy and Buildings*, Elsevier, 2015, 104, pp.14-24. <10.1016/j.enbuild.2015.06.080>. <hal-01180597>
- Gondia Sokhna Seck, Gilles Guerassimoff, Nadia Maïzi. Heat recovery using heat pumps in non-energy intensive industry: Are Energy Saving Certificates a solution for the food and drink industry in France?. *Applied Energy*, Elsevier, 2015, 156, pp.374-389. <10.1016/j.apenergy.2015.07.048>. <hal-01180602>
- Sandrine Selosse, Olivia Ricci. *Achieving negative emissions with BECCS (bioenergy with carbon capture and storage) in the power sector: New insights from the TIAM-FR (TIMES Integrated Assessment Model France) model*. *Energy*, Elsevier, 2014, 76, pp.967-975.
- Mathilde Drouineau, Nadia Maïzi, Vincent Mazauric. *Impacts of intermittent sources on the quality of power supply: The key role of reliability indicators*. *Applied Energy*, Elsevier, 2014, 116 (1), pp.333-343
- Nadia Maïzi, Edi Assoumou. *Future prospects for nuclear power in France*. *Applied Energy*, Elsevier, 2014, 136, pp.849-859.
- Stéphanie Bouckaert, Vincent Mazauric, Nadia Maïzi. *Expanding Renewable Energy by Implementing Demand Response*. *Energy Procedia*, Elsevier, 2014, International Conference on Applied Energy, ICAE2014, 61, pp.1844-1847.
- Stéphanie Bouckaert, Pengbo Wang, Vincent Mazauric, Nadia Maïzi. *Expanding Renewable Energy by Implementing Dynamic Support through Storage Technologies*. *Energy Procedia*, Elsevier, 2014, International Conference on Applied Energy, ICAE2014, 61, pp.2000-2003.
- Paul Hugues. *Le futur des biocarburants*. *Industrie & Technologies*, 2014, pp.57-64.
- Stéphanie Bouckaert, Edi Assoumou, Sandrine Selosse, Nadia Maïzi. *A prospective analysis of waste heat management at power plants and water conservation issues using a global TIMES model*. *Energy*, Elsevier, 2014, 68, pp.80-91.

On the road to...

COP 20 in Lima in 2014

From 1 to 12 December 2014, Lima hosted the 20th Conference of the Parties at the United Nations Framework Convention on Climate Change (UNFCCC). Nadia MAÏZI, Head of the ParisTech Delegation, a UN observer organization, put together 3 side events:

The need for ambitious climate-energy strategies on an urban scale and the challenges entailed

European Pavilion, Tuesday 2 December 2014 – 13.00/15.30

The crucial role of local communities in tackling climate change and promoting sustainability is increasingly recognized and already perceptible in various initiatives around the globe. How should these communities be organized to reach their long-term objective? This side event discussed the design of climate-friendly strategies for cities. Speakers: Nadia MAÏZI (CMA), Edi ASSOUMOU (CMA), Vincent MAZAURIC (Schneider Electric)

Carbon energy system analysis from the perspective of regional climate contributions

European Pavilion, Tuesday 2 December 2014, 15.30-17.00

This side event assessed how low-carbon policies, applied through different regional climate coordination schemes, impact on energy systems. ParisTech scenarios based on the TIMES modeling approach and LIMITS project to meet 2 degree based on the IMAGE model, were discussed by major international companies (EDF, Schneider Electric) and national representatives to stimulate a highly relevant discussion.

Speakers: Nadia MAÏZI (CMA), Sandrine SELOSSE (CMA), Vincent Mazauric (Schneider Electric).

Combating climate change in Latin America

UNFCCC area, Wednesday 3 December 2014 – 11.30/13.30

Experts discussed how Latin American countries envisage the future of their energy and conservation systems in the face of the devastating impacts of climate change. Lessons learned from modeling exercises illustrated the debate on climate policies, regional integration, energy resources, etc.

Speakers: Nadia MAÏZI (CMA), Jean Charles HOURCADE (CIRED), Sébastien POSTIC (CMA), Vincent MAZAURIC (Schneider Electric)

COP 21 in Paris in 2015

2 March 2015, MINES ParisTech, Paris, at the occasion of the Sustainable Development Chair's extension for another five years, the Chair's joint directors, Nadia Maïzi (CMA) and Jean-Charles Hourcade (CIRED), organized its 6th Annual Day

7-10 July 2015, Paris, as part of the conference, "Our Common Future Under Climate Change" (7-10 July, Paris), the CMA organized the side event, Innovations in Decarbonization in collaboration with UC Berkeley (COP21 labeled)

22 September 2015, Sophia Antipolis, OSE specialized Master's students worked with the Sustainable development Chair to organize the conference: "Contributions à la préparation de la COP21: enjeux sectoriels, régionaux et individuels", with the participation of GREC-PACA

22-23 October 2015, Sophia Antipolis, the CMA hosted and co-organized the ETSAP International Workshop at MINES ParisTech. The workshop gathers ETSAP experts and users of TIMES family models

30 November-11 December 2015, Paris Le Bourget, the CMA is participating in COP21, with Nadia MAÏZI as head of the ParisTech Delegation.

December 11, COP 21, 13:15 -14: 45 - Room 10, side event "Long term prospective of business contribution to low carbon development" organized by ParisTech with MINES ParisTech (R. Soubeyran/N.Maïzi), EDF Group (B. Salha), GRTgaz (P. Astruc), Schneider Electric (L. Rémont), ERDF (P. Monloubou).

