



activity report 2015

Center for Applied Mathematics

SOPHIA ANTIPOLIS



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# graduate courses

The CMA participates in the civil engineering syllabus with a course on “Prospective Modeling: principles and uses of mathematical models for evaluating policies on climate change”; organizes the “Embedded Systems” general engineer module; and participates in the Athens Program with courses on “C++ programming language”. It helps integrate the School into the local academic network by running the Paris-Tech doctoral program, “Control, Optimization and Prospective”, which is jointly accredited with the STIC Doctoral School at UNS.

The Center teaches parts of the EEET and UNS Master’s degrees and is jointly responsible for a third-year module of the civil engineering program at Mines de Nancy.

It runs the Advanced Master’s program on “Energy Systems Optimization” (OSE) [[mastere-ose.fr](http://mastere-ose.fr)] and teaches the entire module on optimization and prospective.



## Doctoral studies

Manager: Valérie ROY

This course is one of the four specialties of the STIC Doctoral School, for which PSL/MINES Paristech and Nice-Sophia-Antipolis University (UNS) are jointly accredited.

The CMA enrolls its own doctoral students for this specialty, along with some INRIA doctoral students. At the end of 2015, the doctoral department comprised 10 students.

The CMA is responsible for the doctoral course, “Control, Optimization and Prospective” created in 2004 to support laboratory research topics.



## Advanced Master’s in Energy Systems Optimization, OSE

Course Director: Gilles GUERASSIMOFF

The course opens up a range of career prospects, such as study engineer, research engineer, project manager, energy purchaser, market analyst, and market risk analyst.

Teaching takes place in Sophia Antipolis and Nice and runs from 1 October to 31 March of the next year, in the form of lectures, conferences and projects on optimization and decision-making methods. Students are given an overview of energy systems that provides them with the keys to find long-term solutions to today’s challenging constraints, such as climate change, dwindling resources, political and financial constraints, etc.

At the end of the teaching program, the students undertake a 6-month internship from 1 April to 30 September with an industrial partner.

### Academic partners

The CMA, which organizes the advanced Master’s, has partnered with CREDEN (Centre de Recherche en Economie et Droit de l’Energie) at the economic science faculty of Montpellier I University for the economic side of the course, and EDHEC business school for the management side. The combination of these three complementary domains ensures a comprehensive understanding of the different paradigms of the energy domain.

The MINES ParisTech advanced Master’s on “Energy Systems Optimization” is a 12-month course open to engineers and scientists who already hold a Master’s degree and are keen to specialize in energy with an original, optimization-based approach.

### Focus on project-based teaching

The course, which involves multiple disciplines and combines technical, economic, legal, environmental and management aspects, is based on numerous projects on an overall theme.

Students must write a summary paper on the theme, which may be published by the Mines press.

They also organize a conference that they present to an audience of academics or institutional members during a study trip that takes place in February/March. The trip is a chance to apprehend the energy issue in an international context.

In addition, at the end of the course, students create an “event” in the form of a symposium, workshop or exhibition. This event must gather reference personalities working on the overall theme for a day of scientific debate.

Each month, the students produce a press review, Inf’OSE, on the energy field, which can be accessed at: [http://eleves-ose.cma.mines-paristech.fr/infose\\_flash.php](http://eleves-ose.cma.mines-paristech.fr/infose_flash.php)

## Key events of the OSE Advanced Master's in 2015



Class 2014/2015 on a study trip to the USA in March 2015



Class of 2014, Pierrick Bouffaron from the class of 2011, who helped organize the trip and accompanied the students on their travels

After studying for six months at the CMA, OSE specialized Master's groups go on a one-week study trip. The experience gives students an opportunity to consider different energy systems. This year, the study trip highlighted the partnership between CMA and BECI (Berkeley Energy and Climate Institute). The students also had the occasion to present their preparatory work at the United Nations Conference on Climate Change (COP21), held in Paris from 30 November to 12 December 2015.





## From San Francisco to Berkeley, not forgetting Sacramento

From San Francisco to Berkeley, not forgetting Sacramento

For the 18 lucky students, the ten-day drip was intense, including visits to around fifteen sites and a chance to meet people working directly in the energy field.

The scientific exchanges began at the Consulate General of France, in San Francisco, with a presentation by EDF USA Inc. and a talk by a young Frenchman about his career in the US energy sector.

In Berkeley, field trips took the students to discover the companies Amyris (bioenergy, subsidiary of Total USA), the Joint Bioenergy Institute (bioenergy, DOE laboratory), and All Power Labs (gasification and rural electrification).

They also had the chance to visit Silicon Valley, at NASA Ames (climate, aerospace) and Google Inc. (energy, infrastructure, financing).

The trip to Sacramento included a visit to SMUD, a pilot Smart Grid project, and to the California Air Resources Board, which involved a debate on Cap & Trade, a market-based approach to controlling pollution by providing economic incentives for achieving reductions in the emissions of pollutants.

During the study trip, the students had the opportunity to present their work on energy challenges, featuring several themes, such as, “Greening the Economy in Countries in the South”, “Sustainable Growth in the Industrial Sector” and “The Citizen’s Place”.

The class of 2015 enjoyed a journey full of discoveries.





## Honors for the OSE Master's 2014 students



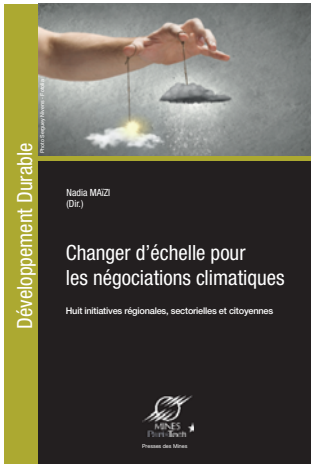
Sophie Carré and Alice Didelot, OSE Advanced Master's students, who came 3<sup>rd</sup> in the CNF Cigré competition 2015 "Innovations technologiques ou intelligence des systèmes : quelles solutions pour les réseaux électriques du futur?" with an article entitled "Smart Innovative Systems for Smart Grids"

Rémy Doudard, Melissa Daudé, OSE Advanced Master students, 3<sup>rd</sup> in the "Génération Energies" competition 2015 (season 7), organized by Sia partners and RTE, for their article, "Couplage des réseaux de gaz et d'électricité : une solution pour l'intégration des énergies renouvelables » (Coupling of gas and electricity networks: a solution for integrating renewable energy) <http://www.energie.sia-partners.com/couplage-des-reseaux-de-gaz-et-deelectricite-une-solution-pour-lintegration-des-energies>



Publications An article by Aurélien Havel and Laura Barbier in the March/April 2015 edition of the Revue de l'Énergie, "Emissions de CO<sub>2</sub> contre empreinte carbone : quelles conséquences en terme de politiques énergétiques" (CO<sub>2</sub> emissions against carbon footprint: what consequences in terms of energy policies")





## Presses des MINES

“Changer d'échelle pour les négociations climatiques” (changing scale for climate negotiations) was published by the Mines Press in September 2015. In this publication edited by Nadia Maïzi, OSE Master's students look beyond the complex, stagnant debate on how much individual countries are ready to commit to reducing their greenhouse gas emissions. The articles set out their original ideas for achieving sustainable solutions that respond to increasingly tough constraints, i.e. climate change, depletion of resources, political and financial restrictions (bilingual version)

22 September 2015:

OSE conference in Sophia Antipolis as part of the preparations for COP 21: sectoral, regional and individual issues

Advanced Master's students from the class of 2014-2015 concluded their year of studies with a conference on energy, jointly organized with the Modeling for Sustainable Development Chair.

Following a speech by Nadia Maïzi and Jean-Charles Hourcade on the economic and technological issues of climate negotiations, eight OSE Master's students presented the class's work.

This work was the subject of a book, *Changer d'échelle pour les négociations climatiques* (see above).

The afternoon was devoted to the Provence-Alpes-Côte-d'Azur's commitment to climate change with presentations by: Annick Delhaye, Regional Councilor, Vice-President responsible for sustainable development, the environment, energy and climate. She spoke of the Region's action to combat climate change and adapt to the energy transition.

Marie Lootvoet, coordinator of the Association for Innovation and Research on Climate (AIR Climat), who presented the regional group of climate experts in Provence-Alpes-Côte d'Azur (GREC-PACA). The group's mission is to centralize, transcribe and share scientific knowledge on these issues in the region.

Lastly, Jean-Pierre Gattuso, CNRS Director of Research at the Oceanographic Laboratory in Villefranche-sur-Mer, spoke of the impacts of climate change and acidification in the Mediterranean Sea. Nicolas Martin, lecturer at the University of Nice, UMR “Space”, gave a presentation on climate modeling and local applications.





End September 2015, class of 2014/2015 departs, class of 2015/2016 arrives



The 18 students of 2014/2015 make way for 16 students for 2015/2016



Long-term...

November 2015, Students from Ecole des Mines de Nancy spent three days working on a common module on “comparative analysis of energy industries” and modeling tutorial classes led by Sandrine SELOSSE and Edi ASSOUMOU, as part of the OSE advanced Master’s program.

# research

The CMA develops an original scientific approach through its fundamental competencies in modeling, mathematics of control and decision-making, and real-time computing, in order to tackle increasingly complex systems. This combination of fundamental disciplines means that systems can be approached via a range of themes reflecting major industrial challenges and societal issues. Our research projects thus include: climate issues (technologies, carbon, energy, water, depletion of materials), security of sensitive industrial sites, control systems for space, the connection between electricity and carbon markets, and electrical systems integrating technologies related to renewable energy and smart grids.



# Prospective and climate change

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Thanks to its capabilities in modeling, optimization, mathematics of control and decision-making and real-time computing, the CMA has developed expertise to aid decision-making in the energy field. Its prospective approach is based on optimization models in the MARKAL/TIMES family developed as part of the IEA (International Energy Agency) program on which the CMA represents France.

## *Informing public policies*

### Decision aid aimed at ministries

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Directors: Nadia MAÏZI and Edi ASSOUMOU

Initiated by the Strategic Analysis Center's Energy Commission to evaluate low-carbon scenarios for 2050, our approach was also used for the work of the 2050 Energy Commission, ordered by the Energy Ministry with the aim of establishing French energy strategy for 2050. This was made public in early 2012.

The CMA, through its MPDD Chair (cf. infra), has worked with the Treasury Office to model scenarios using its TIMES-France model. These scenarios translate hypotheses of deploying or withdrawing nuclear power, as enacted by Minister Besson. The object of this academic exercise was to aid the Commission in its thinking process. The analyses and conclusions were published in a specific annex of the final report and were the object of several CMA presentations centered on the energy transition debate and a publication in the journal *Applied Energy*, "Future prospects for nuclear power in France", Vol. 136, 31 December 2014, pages 849 to 859.

In 2015, the Ministry for the Environment, Energy and the Sea appointed Nadia Maïzi as a member of the expert

committee on the energy transition. This committee was formed to advise on carbon budget and low-carbon strategy projects, respect for established carbon budgets, projects involving multi-annual programming of energy in mainland France and non-interconnected zones, and on implementing this programming before the first period of the current programming comes to an end.

To accompany this expert mission, a new thesis was initiated in late 2015/early 2016 at the CMA with Ariane Millot, on the issue, "Exploring decarbonation levers at national level: from ambition to achievement; how to strike a relative balance between state policies and civil society centered on France." This thesis will explore the conditions for stemming the rising trend of greenhouse gas emissions at national level. These questions will be tackled from different perspectives, both in terms of state policy, and also by considering the impact of solutions initiated at other levels by civil society (e.g. companies, associations, citizens).

## Decision aid for the tertiary sector

Project manager: Gilles GUERASSIMOFF

The SmartEnCo project involves devising a decision-making tool for reducing energy and water consumption and CO2 emissions in tertiary buildings and small-scale industries.

The project is piloted by IZYPEO in Sophia Antipolis, a start-up launched in 2010 that produces WEB solutions for environmental performance. The project partners are WIT, located in Saint-Laurent du Var, which devises Building Energy Management Systems, and ActaConsult, a Nice-based engineering firm specializing in sustainable development.

The CMA's role is to develop innovative algorithms to improve control/command management of this type of building, and to give personalized advice on how to continue improving buildings' environmental performance.

Two experimental sites have been set up, one at the technical department of the town of Antibes, and the other at Marineland aquatic park on its Kid's Island site.

## International issues

Directors: Nadia MAÏZI and Sandrine SELOSSE

A doctoral thesis on prospective modeling for the long-range study of energy strategies in South America was undertaken by Sébastien POSTIC under the direction of Nadia MAÏZI and Sandrine SELOSSE and defended on 10 December 2015 at MINES ParisTech in central Paris. Entitled, "Long-range prospective energy modeling for South America – Application to international climate negotiations," the thesis was co-supervised by the Center for Mathematical Modeling (CMM) at the Universidad de Chile (Santiago) and was partially carried out in Santiago.

The work focused on developing a TIMES model for South America drawing on CMA's technical expertise for this type of model and CMM's expertise in modeling applied to South American energy issues. The model, entitled TIMES-ALyC (for "America Latina y el Caribe", or Latin America and the Caribbean), joins the CMA's collection of similar models. It was built based on the TIMES paradigm, and in particular the global TIAM-FR model, with which it will ultimately interface. In addition to specific South American issues, the model can be applied to tackle major international Energy-Climate problems, such as the impact of national climate policies on the regional energy sector. Together, Central and South America and the Caribbean represent more than 450 million people and 12% of the Earth's total emerged land. The region stands out in the global energy landscape for the outstanding contribution of renewable sources to its energy production. Maintaining this level of renewable energy in the future might prove a challenging task, as 'historical' energy sources (hydropower, biomass) run into sustainability issues, while 'new' options (wind, solar, geothermal energy) still depend on public support schemes. However, South America's low reserves of fossil resources and excellent renewable potential make it the ideal candidate for pioneering a renewable energy transition. The energy sector's contribution to fueling economic growth in a socially and environmentally sustainable way is also an issue that is particularly significant in the continent's developing context. Climate change is a region-scale concern. The continent's emissions per capita are above the global average, and the region is also likely to be one of the most impacted by climate change. South America's energy sector is vulnerable both on the supply side (hydropower and biomass resources) and the demand side (increased demand for e.g. agriculture and air conditioning). Despite shared regional strengths and concerns, however, South America appears to be a highly heterogeneous and fragmented continent. The region's physical layout is a stumbling block for regional integration. Two centuries of regional wars complicate political cooperation at national level, and the historical evolution has created strong disparities between national energy sectors. Various attempts to cooperate on transnational infrastructure have ended up as costly failures in the past. The aim of this doctoral work, half of which was conducted in France and half in Chile, was to develop a mathematical model adapted to the study of long-term energy issues, at a regional scale, for South America. This model, TIMES-América Latina y el Caribe, was applied to study the impact of national climate policies on regional energy, as the world was preparing for a global climate agreement at the Paris conference in December 2015.

Sébastien Postic thesis

## Wattgo thesis

Valérie ROY  
Gilles GUERASSIMOFF

A doctoral thesis with the start-up WattGo, which specializes in disaggregating residential sector load curves, was started at end 2015/early 2016. Elise PUIER will be responsible for modeling the dynamics of household electricity consumption in relation to exogenous variables to appraise energy-saving reserves in the home.



Sébastien Postic - 10 dec. 2015 - MINES ParisTech

## Smart grids and renewable energy

Director: Nadia MAÏZI

In partnership with SCHNEIDER ELECTRIC, these studies continue the work done on integrating spatiality to evaluate issues regarding the use of the electricity grid in a long-term prospective based on models from the TIMES family.

The first studies of this grid integration involved making electricity system reliability evaluations compatible with the time dynamic associated with long-term prospective exercises. Supply reliability evaluates an electricity system's capacity to guard against operating incidents, and is characterized by the voltage plan and the frequency, whose characteristic times range from a few milliseconds to a few hours. In contrast, long-term prospective exercises focus on how energy systems evolve over several decades, and do not deal with reliability. Electricity systems proposed on the prospective horizon may therefore no longer guarantee reliability, which is all the more crucial since the massive integration of renewable energy could work to the detriment of reliability, because of the complexity of managing intermittence.

We developed two reliability indicators to quantify in an original way electricity systems' reliability according to the associated production mix. The interest of these indicators was illustrated for Reunion Island, which has set a target of producing its electricity from 100% renewable energy by 2030, then for France by 2050.

These studies were presented at over a dozen international conferences and were filed for patent at the end of 2011, extended in late 2012. They were also the object of a reliability analysis extended to cover the French system for the annual United Nations conference on climate change in Durban, and for the Energy 2050 Commission, mentioned above.

The second issue linked to the grid looks at deploying smart grid solutions, which are largely put forward as a solution for the transition towards low-carbon energy. As part of her doctoral studies, Stéphanie BOUCKAERT evaluated the actual impact of smart grids in the long term. The use of these intelligent solutions should lead to improving the electricity system, whose operating conditions are evolving significantly due to:

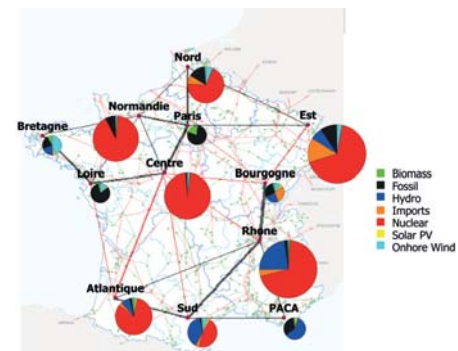
- Climate change and environmental challenges, which require adding intermittent sources (e.g. solar, wind power) to "standard", centralized energy sources;
- Changing consumer patterns, which potentially diversify and inverse flows (demand response, positive energy buildings,

decentralized production), underlining its unpredictable character.

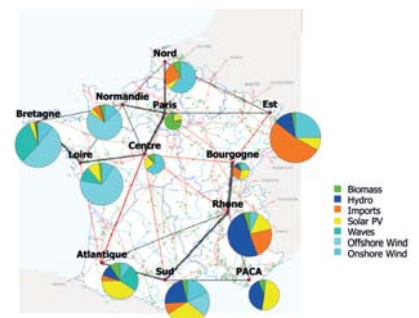
This deployment is conditioned by resolving the complex issues of electricity grid management, balancing demand, and ultimately ensuring the stability of the whole production/transport system. Assuming that they are solved, the consequences of deploying these solutions, in terms of increasing network efficiency and reducing the environmental impact of producing and managing electricity, remain open and are central to this thesis, which was defended on 19 December 2013.

Lastly, to fully tackle the question of wide-scale integration of intermittent renewable sources, we also need to know the type of deployment adopted for network infrastructures: this choice involves differentiating a standard meshed vision of the centralized electricity system from a decentralized vision. Vincent KRAKOWSKI's thesis, started in late 2012, aims to integrate items linked to spatiality into TIMES models in order to add to and extend previous approaches. His research centers on studying the technical conditions for achieving highly renewable electricity production in mainland France, and the constraints that this kind of production mix would generate on the electricity system as a whole. This involves devising realistic scenarios of energy penetration, studying how their integration would impact the reliability of the electricity system, and looking at the potential levers for improving this reliability and bringing it to "acceptable" levels. These levers could be technologies of demand management, energy efficiency, storage, or pooling using electricity grid reinforcements. The potential of these various levers will be evaluated in order to compare various strategies for large-scale integration of renewables for electricity production

A thesis was initiated in October 2014, directed by Edi ASSOUMOU, on "transitions and interactions of energy systems in multi-scale models". Multi-scale models are manipulated to understand the issues and constraints created by the transition of local energy systems and for sensitive zones in the grid. Both spatially and temporally, system behavior, problems and challenges are different depending on the scale. The aim of the doctoral research carried out by Jérôme GUTIERREZ is to identify these divergences in order to characterize transitions and interactions in energy systems at different scales.



Production d'électricité par région en 2012



Production d'électricité par région en 2050 dans un scénario 100% renouvelable



# Prospective analysis of multi-energy flexibility solutions

Project managers: Nadia MAÏZI, Edi ASSOUMOU and Sophie DEMASSEY

## Analyse Prospective des filières bioénergies

Director: Edi ASSOUMOU

### 1/ Les filières technologiques pour la valorisation de la biomasse en France

Bioenergy sources can be used to respond to environmental and energy independence requirements in France and Europe. Their development is nevertheless subject to uncertainty. Firstly, the prices and volatility of raw materials are increasing, and a great deal of research is being done to develop technologies that respect the environment. In addition, the competitiveness of bioenergies in comparison with fossil energies is highly dependent on the regulations in place. Lastly, other industries compete for the use of land and resources, such as the food, paper and wood panel industries. A thesis by Paul HUGUES supervised by Edi ASSOUMOU was initiated on this subject in late 2011 and terminated in April 2015. The research was partnered by Avril (formerly Sofiprotéol), the industrial and financial company of the French oil and protein industries. Paul attempted to answer these questions using long-term prospective analysis. His research centered on a bottom-up optimization model in the MARKAL/TIMES family. A detailed, updated representation of the French bioenergy sector was carried out, resulting from an approach developed in the Valerbio project, which the CMA partnered (IFP/FCBA/INRA/CMA). The questions tackled include developing “advanced” technologies, the resource constraint on post-2020 development, and the impact of future European directives. The second part of the thesis focuses on considering externalities, i.e. greenhouse gas emissions, non-renewable energy consumption, eutrophication, and job creation in the various industries. This thesis was defended on 10 March 2015.

Rémy DOUDARD began a doctoral thesis in October 2015, in partnership with GRTgaz and directed by Nadia MAÏZI, Edi ASSOUMOU and Sophie DEMASSEY. The aim of this research is to evaluate the impact of flexibility solutions (power-to-gas, power-to-heat, demand response, storage) over the long term, taking a prospective approach combined with its optimal paradigm, in order to make appraisals and choices regarding the efficiency of the proposed solutions. The focus will be on the role that natural gas plays in the flexibility of the energy system. GRTgaz is currently involved in several pilot projects involving natural gas and hydrogen



Paul Hugues, 10 mars 2015, Sophia Antipolis



### Paul Hugues thesis

French bioenergy consumption has increased by 35% over the last decade, and represented an 8.1% share of final energy demand in 2012. Bioenergy has been developed for its many benefits, as it is a renewable energy source that increases energy supply independence and reduces greenhouse gases (GHG) emissions. This sector also maintains and provides employment at local level and promotes the economic development of agriculture and forestry. However, the sustainability of this development is now subject to uncertainties, i.e. economic performance in comparison to fossil fuels, biomass availability, technological choices, and level of incentives. In addition, it is subject to several controversies. Firstly, the rise in global biomass demand has pushed up prices and threatened existing uses, such as wood panel manufacturing in the French building sector, and food supply at a world scale. Secondly, environmental performance has been criticized: biomass combustion could emit fine particulate matter, and the GHG emissions of current biofuel processes may be higher than initially estimated. Consequently, policy makers are seeking new bioenergy pathways that avoid these controversies. This thesis aims at assessing these uncertainties to elaborate technological and regulatory strategies for the French bioenergy sector. We thus created a prospective model which precisely describes this sector and its current and future conversion pathways. It relies on a linear programming optimization paradigm that calculates least cost technological trajectories from 2010 to 2050. The bioenergy sector is modeled by a large number of constraints: availability and cost of biomass; technical, economic and environmental parameters of transformation processes, etc. In the first part, we describe the prospective approach. This consists in precisely analyzing bioenergy pathways: the current structure, controversial points and promising processes. Then, we explicit the conception of the prospective model, i.e. its data and assumptions. In the second part, four main strategic points of the bioenergy sector are discussed. Firstly, we assess the level of demand that could be fulfilled according to two contrasting scenarios of French biomass availability. We then analyze the technological mix. Secondly, we investigate the consequences of a change in the biofuel regulatory context and a reconsideration of their environmental benefits. Thirdly, we evaluate the impact of a bio-based chemistry development on bioenergy production. Finally, biofuel technological strategies are studied with a Monte Carlo approach to enhance the comprehension of the economic and environmental conditions of technology deployment.

Paul Hugues thesis

## 2/ Bioenergy sectors and the international biomass market

Director: Sandrine SELOSSE

A doctoral thesis entitled, “The bioenergy market and water conflicts: implementation in the integrated model TIAM-FR” was initiated in 2014 under the direction of Sandrine SELOSSE as part of the CMA’s prospective modeling research program. Seungwoo KANG’s research concerns the increasing development of bioenergies to combat climate change and the depletion of fossil resources. This calls for a tool capable of reliably and pertinently evaluating the role of these resources and the associated technologies. TIAM-FR (TIMES Integrated Assessment Model) is such a tool, and its first task was to evaluate as accurately as possible the potential for deploying bioenergy globally, as well as regionally, while considering the geopolitical and commercial challenges of international trade. Mr. Kang worked on adapting the model to give a more detailed representation of biomass resources, including a disaggregation of the biomass industry and a new estimation of the potential taking into account agricultural land areas and production levels. In terms of crops, this detailed breakdown made it possible to apply specific biofuel policies while limiting, for example, the use of food resources to energy purposes and thus avoiding any conflict with food security issues. A particular focus was the Asian zone constituted by China, India, Japan and South Korea, and this was the subject of a publication in the journal *Energy Strategy Reviews* (<https://hal-mines-paristech.archives-ouvertes.fr/hal-01234013>) and two presentations at international conferences, one at the 27th European Conference on Operation Research (EURO) in July 2015 in Glasgow, and the other at the International Bioenergy Exhibition and Asian Bioenergy Conference (IBSCE) in October 2015 in Shanghai. In addition, a detailed study of the bioenergy situation in India was undertaken as part of a collaboration with the International Energy Agency (IEA), mentioned in the 2015 World Energy Outlook (WEO).

### *Extending knowledge of systems*

#### Behavioral paradigms

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Director: Nadia MAÏZI

François BRIENS worked from 2011 to 2015 on a prospective modeling and macroeconomic study of Degrowth societies. The notion that dominant economic growth is an end in itself or a necessary condition for “development” has been increasingly put into question by socio-economic, democratic and environmental challenges. Since the early 2000s, the ideas behind “Degrowth” have been the subject of increasing attention and lively debate. Supporters of the concept suggest ways of moving towards “frugal abundance” societies. Using a prospective exercise combining participative scenarios and numerical modeling, this research sheds light on the debate.

## François Briens thesis

François Briens thesis

The development paths followed by industrial societies in recent decades have resulted in complex socio-economic, democratic and environmental crises, which question the relevance of economic growth, either as a goal in itself, or as a way to achieve “development”. With the emergence of the Degrowth movement at the beginning of the 21st century, the call for transitions towards sustainable “post-growth societies” is now consolidating into a multifaceted political project. For the “wealthiest” countries, in which the ecological footprint per capita is greater than the global sustainable level, this project may be envisioned as a voluntary, socially sustainable, equitable and smooth downscaling of production and consumption, and thus throughput, to an environmentally sustainable level. Such a project raises numerous questions, for instance: What concrete proposals could initiate such a transition? What could such paths induce in terms of employment, public debt, energy consumption, waste, or greenhouse gas emission mitigation? What structural or institutional obstacles need to be overcome and how? etc. In this research, we attempt to discuss such questions with the help of prospective modeling. Our approach involves a series of interviews, conducted, among others, with actors of the Degrowth movement. These are aimed at collecting detailed and quantified visions or narratives about what Degrowth scenarios or – more broadly speaking– scenarios of transition towards sustainable and desirable societies could look like, for France, in the mind of participants, especially in terms of institutions, lifestyles and consumption patterns. In parallel, we have designed and developed a specific dynamic simulation model of the French monetary economy, featuring a high level of detail and disaggregation, based on input-output analysis, and built using public data. Using this macroeconomic tool, we investigate, over the long term (2060), the possible outcomes of different scenarios, including those inferred from the interviews, in terms of employment, public debt, energy consumption, waste and atmospheric emissions. We discuss the potential strengths and weaknesses of the different visions they reflect. Our results highlight in particular the importance of cultural, social, behavioral and “non-technical” factors; stress the potential of various degrowth proposals; and recall the critical need for the collective elaboration of a societal project. In this perspective, our modeling approach provides a simple, yet powerful tool for common understanding and collective deliberation.



François Briens, 14 décembre 2015, Sophia Antipolis



## Thomas LE GALLIC thesis

Thomas LE GALLIC thesis

Thomas LE GALLIC started his research in December 2013, to explore how lifestyles develop in energy-climate prospective exercises, supervised by Nadia MAÏZI and Edi ASSOUMOU. The aim is to propose a methodological development with a view to understanding the socio-economic reality of breakdown hypotheses associated with lifestyle. This will enrich representations of socio-economic mutations, which are often inadequate in standard prospective exercises, and will allow us to employ transition hypotheses that are rarely explored for want of tools or suitable methods. This is because lifestyles describe behavior patterns that are essential determinants of energy consumption and greenhouse gas emissions (relating to e.g. consumption patterns, time and space relationships, types of leisure, mobility habits and types of cohabitation). This thesis, which is due to be defended at the end of 2016, is partnered by AC-Teon, a consultancy and research firm specializing in environmental policy. The research was presented at the symposium, “Sciences sociales et transitions énergétiques” in Grenoble on 28 and 29 May 2015. [Le Gallic, Assoumou E., Maïzi N., 2015, Énergie, mode de vie et modélisation prospective : une approche quantitative] and to the members of the PROSPER network on 14 October 2015 [T. Le Gallic, Assoumou E., 2015, Les exercices de prospective énergie-climat à l'épreuve de la mutation des modes de vie].







## Smart city issues

The CMA's expertise in real-time computing, energy system optimization and long-term prospective make it well placed to understand the challenges raised by intelligent networks.

The Center is active in several major programs on this theme.

The CMA is involved in a number of projects relating to sustainable towns and transport, optimization of the demand response in water supply networks and data centers, and the optimal sizing of a micro-grid that takes uncertainties into account

### CITINES

Project manager: **Edi ASSOUMOU**

The project CitInES, headed by Edi ASSOUMOU, involved producing a multi-scale, multi-energy tool for optimizing energy yields. It was devised for towns and major industrial complexes to help them define sustainable, reliable energy strategies that are economically viable in the long term. The pertinence of this tool was proven through its use by the Italian towns of Cesena and Bologna, and the Tüpras Turkish oil refinery, all partners of the project with Artelys France, AIT Austria, INESC Portugal, Armines/ CMA, Schneider Electric, ERVET Italy and INRIA.

The CMA developed long-term energy system prospective models for the towns of Cesena and Bologna. The project came to an end in 2014 and was the object of a publication in 2015: E. Assoumou, J-P. Marmorat, V. Roy. Investigating long-term energy and CO2 mitigation options at city scale: A technical analysis for the city of Bologna. Energy, Elsevier, 2015, Sustainable Development of Energy, Water and Environment Systems, 92 (3), pp.592-611



## INFINIDRIVE

project manager: Jean-Paul MARMORAT

The CMA was a partner of the Infini Drive project, which ran from late 2011 to early 2015. It centered on the development of electric vehicle charging stations as part of the Investissements d'Avenir program.

ERDF and the La Poste Group signed a partnership agreement in 2011 that associated them as a consortium created on their initiative in a two-year research and development program. This project focused on the design of a system to manage charging stations for their new fleets of electric vehicles. This program is intended to serve as a reference for the industrial supply of charging stations and for the financially viable and durable deployment of fleets of corporate electric vehicles.

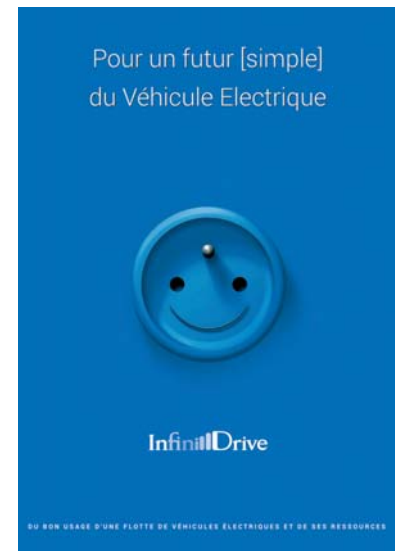
To carry out the program, the consortium called on industrial and service companies along with international academics and research experts, i.e. LORIA, CMA and I3M. Experiments were carried out on several ERDF and La Poste sites in four large French towns: Grenoble, Nantes, Nice and Paris.

The objective was to design and deploy a charging management system so that ERDF and La Poste employees can carry out their regular jobs while avoiding electricity consumption peaks, which result in higher CO<sub>2</sub> emissions and require reinforcing the grid.

On this project, the CMA was responsible for a study of the mathematical model and the algorithm for optimal charging.

The project ended in early 2015 with the production of a good practice guide for managers of car fleets used by businesses and groups, entitled, "Pour un futur simple du véhicule électrique, du bon usage d'une flotte de véhicules électriques et de ses ressources", downloadable in French on the ADEME website.

An event was also organized in March 2015 to publicize the project report, the conclusions of which can be consulted on the Greenovia website <http://www.pilotede projet.greenovia.fr/actualites/infini-drive-pour-un-futur-simple-du-vehicule-electrique>



## Ev step

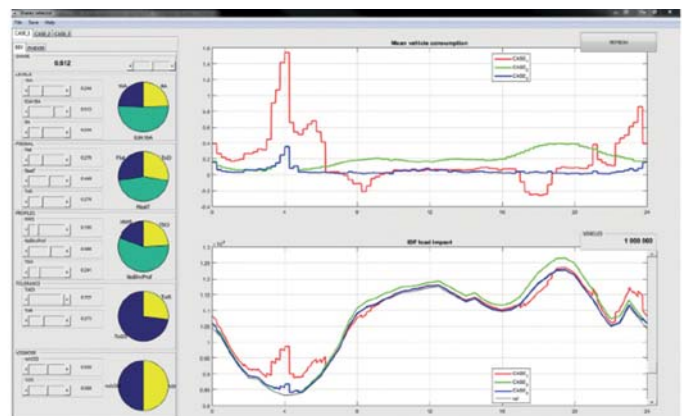
Project manager: Edi ASSOUMOU

EV-STEP was initiated in 2012 and organized by Edi ASSOUMOU, who is also the project manager. It involves a consortium of four research laboratories in France, Germany and Denmark.

The project's objective is to implement a systemic modeling approach to analyze scenarios of the massive development of electric vehicles. It is based on the use of three models: a MARKAL/TIMES family model with European scope TIMES panEU, the macroeconomic model IMACLIM-S, and a load-profile optimization model EVCAP. The multi-scale research perimeter ranges from Europe to a specific urban area. The research project is financed by the Ministry for Ecology, Sustainable Development and Energy. It fits into the strategic access 1 of the Electromobility + tender.

As part of the project, the CMA has in particular developed the calculation platform EV-CAP, which defines the charging profiles in 15-minute time slices for a fleet of vehicles. These profiles are defined in line with various technical and economic constraints on the network, the charging facilities and the cost of electricity. The project ended in 2015.

Website: [www.ev-step.com](http://www.ev-step.com)

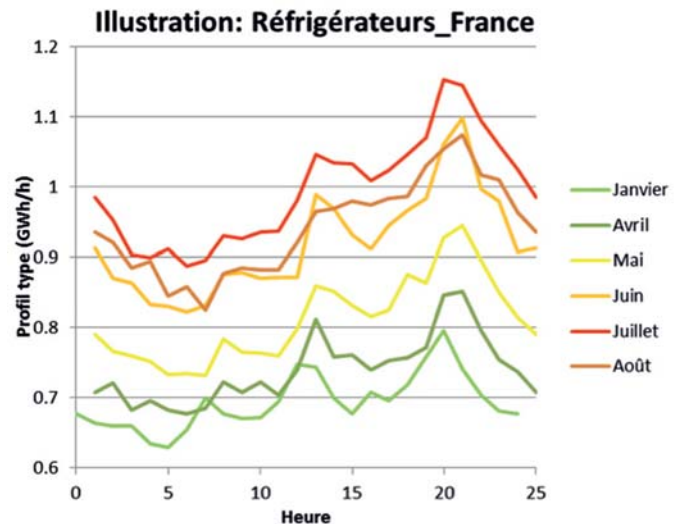


User interface for the case mixer

## ANR SUD

Project managers: Nadia MAÏZI and Edi ASSOUMOU

Since late 2013, the CMA has been participating in a new ANR project called “Dynamic Urban Systems” as part of the Sustainable Cities and Buildings program. Urban energy consumption depends partly on the numerical growth of inhabitants, and partly on the proliferation of urban requirements (in particular those connected to mobility and habitat). The objective of the SUD project is to evaluate their long-term structural dynamics over a multi-annual horizon while maintaining a detailed approach to the character of hourly-seasonal requirements and its impact on the operational constraints of urban systems. To do so, three main urban energy flows are considered: thermal energy flows, electric energy flows, and passenger flows in private cars for everyday journeys. The SUD platform being developed will make it possible to simulate the different technical measures (PV, electric vehicle, storage) or price-based ones on an urban scale. The 48-month project is led by CITERES, which is the coordinator, LET, IFSTTAR, ENERGIES DEMAIN, ARMINES, INNHOTEP, ENIA and LEMA. The role of the CMA is to propose a method to evaluate seasonal time-of-day electric load curves at an hourly rate per usage.



## Water / Energy issues Director: Sophie DEMASSEY

The optimization of water supply networks is a flourishing research domain that goes hand in hand with several concomitant factors, such as increased water consumption, which entails creating new networks; gradual deterioration of installations, which require renewal; rationalization of installation costs and energy consumption, which involves detecting leaks, automation and more efficient use of pumps; and changes in the electricity supply, with the integration of intermittent energy sources and fluctuating prices, which calls for careful management of pumping.

Mathematical programming is the preferred approach and applies to all time scales. However, two problems stand out in published studies: at a strategic level, the sizing of gravity-fed networks and, at operational level, the planning of pumping station operations.

Due to their algorithmic complexity, the two problems are studied separately. They are however intrinsically linked in practice: the conveyance of drinking water is more likely to be backstreamed than gravity-fed, and the daily programming of a pumping station depends on its size.

The thesis that Gratién BONVIN commenced in December 2014 aims to develop an integrated, optimization approach to water supply systems from short to long term, going

from the real-time management of a network up to its design.

The first achievement, published in Applied Energy [Bonvin et al., A convex mathematical program for pump scheduling in a class of branched drinking water networks, Applied Energy (2016)], is a new, quadratically constrained convex programming model for “day-ahead” planning to operate the type of pumping station typically used in French rural areas. In comparison with current manual management, the approach has multiple benefits, i.e. operational, automated pumping plans; substantial energy and financial savings (on average 15% of the electricity bill); a pressure drop in the network and thus fewer leaks in the pipeline.

Following the success of this new convex programming approach, we are currently extending it to a more general context, including urban and irrigation networks that are larger in size or made up of components that are more complex to model.

The second part of the thesis will center on integrating this short-term optimization model into resolving mid-range decision-making problems (e.g. choice of electricity supply contract) and long-term ones (resizing the network).





## Robust optimization of a micro-grid Director: Sophie DEMASSEY

How can we determine the size of electricity facilities, including different sources and energy storage components, so as to keep investment and operation costs to a minimum over a 20-year lifespan, and given the uncertainties of how demand and the production of intermittent sources will evolve over that period? To answer this complex problem, Aurélien HAVEL, a graduate of the OSE 2015 program, set up a generic solution of robust optimization, based on the Lagrangian relaxation of a linear program into whole numbers, integrated into a comprehensive web service including the specification of upstream instances and the visualization of solutions calculated downstream. This research led to a CIFRE doctoral thesis in partnership with SNCF.



## Optimized management of data centers

CMA project manager:  
Sophie DEMASSEY



The high energy consumption of data centers is increasing in line with their expansion. Although technological progress has made it easier to master this consumption, astute operational management solutions are also required to bring down the energy bill while maintaining a high level of service for users.

The CMA is working on devising this kind of solution in partnership with the SCALE team at Nice Sophia Antipolis University as part of the EU project DC4Cities ([www.dc4cities.eu](http://www.dc4cities.eu)).

The constraint programming model developed adapts the functioning of tasks over a one-day time horizon depending on both the variable production forecast of renewable energy sources and the level of service contractually required by customers. These conflicting criteria are brought together in the single target of minimizing energy costs and financial penalties connected to the service.

# Control and optimization for the carbon and electricity markets

## Breakdown of optimal approaches for carbon pricing CMA project manager: Nadia MAÏZI

Working with the TOSCA team at INRIA, several approaches were developed to reflect on carbon finance tools (especially taxes and the market) to establish whether they are efficient in reducing CO<sub>2</sub> emissions, or whether to focus on widespread use of renewable energy sources. This analysis took two different time approaches:

### Short-term carbon value

The European Union Emissions Trading Scheme (EU ETS), created in 2005, was devised as a way to manage and accompany the EU's CO<sub>2</sub> emissions reduction targets for some sectors of industry (in particular energy production and the mineral, metal and paper industries).

Numerous questions have been raised regarding the efficiency of this kind of measure; the question that we investigated is to what extent it actually reduces CO<sub>2</sub> emissions. In order to provide a comprehensive answer, we developed a model to create a tool to analyze behavior, which took the form of the level of emissions of an agent (an industrial) taking part in EU ETS. The study of the agent's sensitivity to market parameters resulted in a tool for choosing these parameters in line with the CO<sub>2</sub> emission reduction targets set by the regulator.

The modeling used focuses on the electricity production sector. In particular, it analyzes the impact of renewables in the energy mix of an electricity producer that has to annually compensate for its GHG emissions or pay a penalty.

The methodology put forward is based on the concept of indifference pricing, which is particularly suitable to the EU ETS market context. Modeling electricity production and emission strategies on the quota market takes the form of a problem of optimal stochastic control. The associated Hamilton-Jacobi-Bellman equations were resolved numerically for different electricity spot market prices.

A pricing demonstrator for CO<sub>2</sub> emission permits, entitled CarbonQuant, has been accessible since 2012, and has been considerably improved since. It is available at <http://carbonvalue.gforge.inria.fr>

In parallel, an approach was developed based on the Nash equilibrium to couple the electricity spot market and the carbon market by optimizing each player's electricity production.

### Mid- and long-term carbon value

Carbon value is crucial when the discussion is focused on political agendas and when countries and/or regions are concerned with climate change. We therefore explored and quantified for France the dynamic evolution of the carbon value over several decades. This evolution was evaluated using inter-temporal optimization, with a five-year base period, allowing us to access different values linking the activities and capacities of technologies producing energy with the associated emission, and thus to infer a carbon value reestablishing the impacts of these choices. The results are situated in the high range of values given by other approaches, on other scales, but covering the same study area. They also show that the French carbon value established by the Quinet report corresponds to a combination of optimistic hypotheses: the central estimate is four times higher than the Quinet value for 2050, and 14 times higher in 2020, reflecting short-term inertia; it is also expensive. In addition, it emerges that this value is sensitive to mid-range targets and to their variation over time. This research was published.

In a continuation of this collaboration, and using similar methods, the teams answered a PGM0/IRSDI call for tender with a project on time series and regionalized meteorological patterns.

# System parameterization

## Inverse problems, applications in medicine and geophysics

Director: Jean-Paul MARMORAT

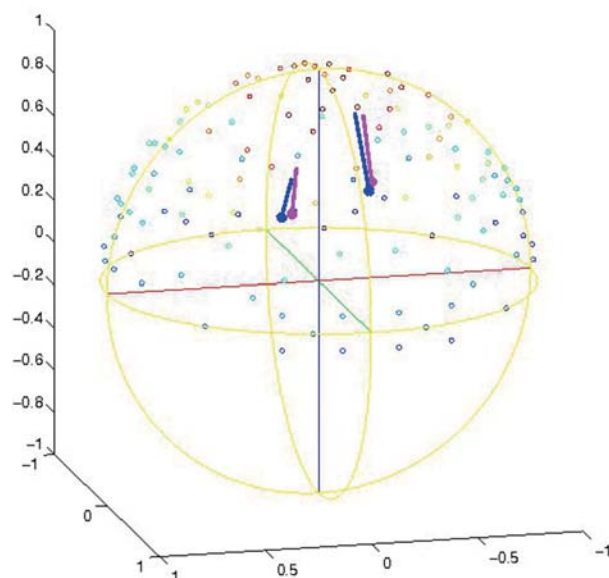
In collaboration with INRIA's APICS and ODYSSEE projects, the CMA is tackling a class of inverse problems concerning the detection of mono- and dipolar sources. Data are constituted through isolated measurements of a potential, carried out at the frontier of a particular 3D domain. The unknown factors are the positions and moments of sources inside the domain that generate this potential. Outside these sources and inside the domain, the potential verifies a Laplace equation.

In biomedical applications, the domain is the cranium, the potential is electric or magnetic, the sources are epileptic focuses, and the measurements are thus electro- or magnetencephalograms. In geophysical applications, the domain is the Earth, the potential is gravitational, and the sources are inhomogeneities of matter, and so we measure fluctuations in potential in comparison with the reference potential.

This ill-defined problem is tackled using 2D rational approximation methods in different cut planes. The singular lines of the approximants can be used to go back to the original positions. These methods are being tested on simulated and real data. An APP software program has been filed for patent: FindSources3D <http://www-sop.inria.fr/apics/Find-Sources3D/fr/index.html>

A partnership was initiated in 2013 with the German company BESA (Brain Electrical Source Analysis) to undertake joint research on the subject and use the source location software. The project continued in 2014 and the software is currently in a phase of consolidation and transcription into C++.

An article on this research was submitted in 2016 in Rendiconti dell'Istituto di Matematica dell'Università di Trieste: "Uniqueness result for an inverse conductivity recovery problem with application to EEG", Maureen Clerc, Juliette Leblond, Jean-Paul Marmorat and Christos Papageorgakis.



# SMART GRIDS



Given the significant changes in electricity production and consumption patterns, France needs to build intelligent electricity networks, or smart grids.

Integrating new information and communication technologies into the electricity grid should make it easier to manage electricity consumption and production in the country.

In 2013, the government therefore initiated a study entitled Réseaux Electriques Intelligents de la Nouvelle France Industrielle (REI), coordinated by RTE's chairman, Dominique Maillard. Nadia MAÏZI, Professor at Ecole des Mines de Paris, represents the Institut Carnot on the project and ensures MESR correspondence.

The research done on this project led to a 10-point road map designed to consolidate the French electricity and computing industries on new high-growth markets that create jobs.

Two of the ten action points set out in the plan are led by Nadia MAÏZI:

- The first of these is Action 3, which is to create an intelligent electricity network academy offering courses on smart grids to develop the industry in France and abroad. Work carried out on this project has resulted in an initial mapping of smart grid courses listed on the internet, and discussions and research on establishing a classification of courses under the REI label, including the production of a form.

- Action 9 involves defining the research and development strategy for deploying the French smart grid

industry. The research carried out in this area has led to a number of R&D recommendations.

In April 2015, the plan was renamed the Think Smartgrids Association. MINES ParisTech is a member of this association.

The association's website can be found at <http://www.thinksmartgrids.fr/>

Ms MAÏZI has been appointed to the board and named Chairwoman of the training commission.

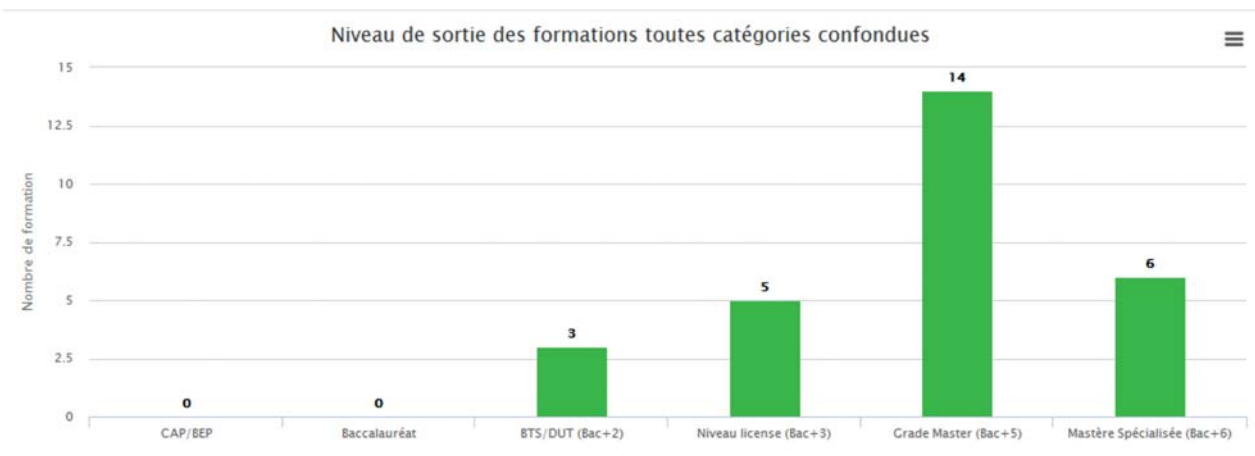
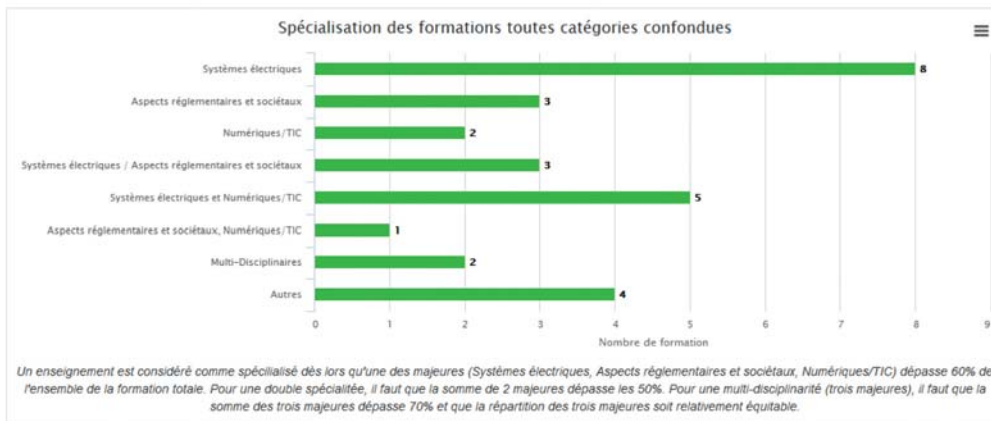
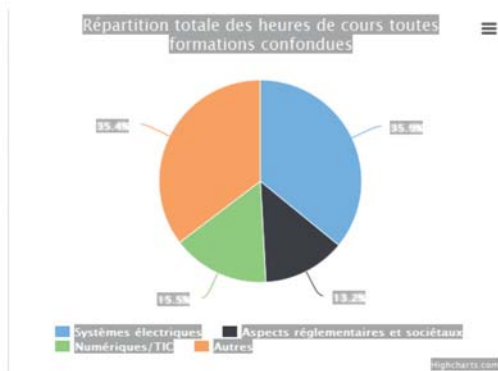
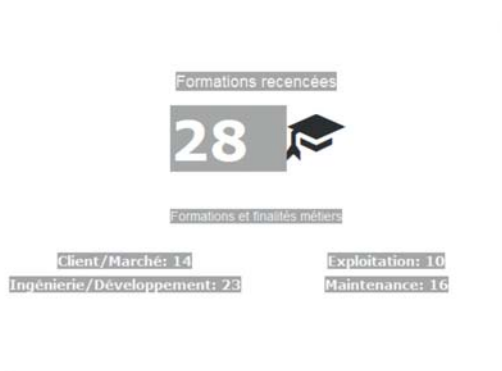
The training commission, with active input from the CMA, has created a web application that lists and maps training courses featuring smart grids at companies and institutes in France. The aim of this list is to identify any training gaps in terms of smart grids, with a parallel evaluation of industrial requirements, and to inform students and companies who want to learn about smart grids.

The long-term objective is to create a smart grid institute to establish the French electricity and computing industries in new, fast-developing markets that create jobs.

If you work with a training course connected to smart grids, you are invited to include it on the list at [www.thinksmartgrids.fr/formations](http://www.thinksmartgrids.fr/formations)

The first processing of the listings gave the following results.

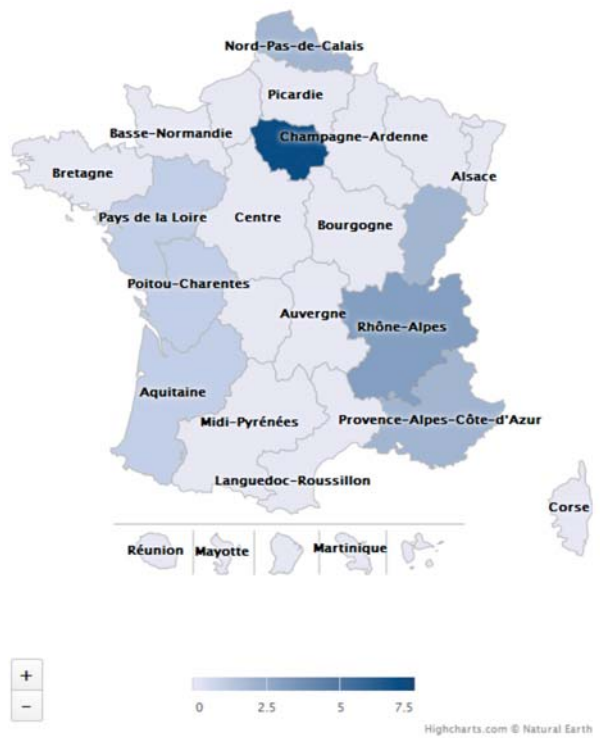




Nombre de formations par département toutes catégories confondues



Nombre de formations par région toutes catégories confondues



Ces outils ont été développés par Evariste CHAINTREAU



# Modeling for Sustainable Development Chair

The 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). For the period covering 2008-2013, it was granted a budget of 2.5 million euro.

The Chair was extended in 2014 for another four years, still jointly directed by Nadia MAÏZI and Jean-Charles HOURCADE, with the following partners: ADEME, EDF, GRTgaz, SCHNEIDER ELECTRIC, and the French Ministry for the Environment, Energy and the Sea as associated partner.

## *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.*



## Development of the prospective modeling tools TIMES-France and TIAM-FR

### TIMES-France Director: 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. Current investigations are centered on flexibility in multi-energy systems and the impacts of transforming the production system and life styles.

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 CO<sub>2</sub> emissions in different regions in the world (post-COP15 and in particular COP21 commitments), including the weight of these carbon constraints depending on a region's level of development. More precisely, the aim was to determine how ambitious climate commitments are in terms of the target to limit the global temperature rise to 2°C and to establish the weight of this constraint at regional level, particularly between industrial, fast-emerging and developing countries. This research was published in the Cahiers de la Chaire Modélisation prospective au service du développement (Working Paper No. 2015-02-16). In parallel with these scenarios, technology deployment scenarios are being developed, such as carbon capture and storage, with the aim of debating the technico-economic plausibility of climate policies.

During 2015, significant substantive work was done on the TIAM-FR model to recalibrate it to the year 2010 (rather than 2005) and, at the same time, update its multiple parameters.

### TIAM-FR Director: Sandrine SELOSSE



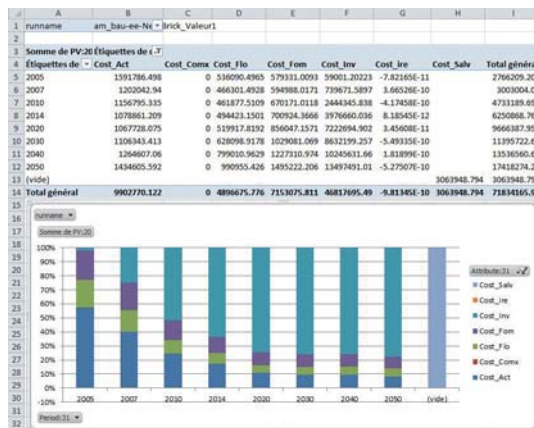
## Development of a centralized archiving tool for Markal/TIMES models: MCOPM platform

Director: Sébastien FOLIO

The computer engineer Sébastien FOLIO is continuing the work he started in 2013 with Evariste CHAINTREAU on the MCOPM platform. This archiving tool stores the CMA's mathematical study models in a centralized database so that they can be preserved and used again. In addition to safeguarding data, the platform certifies the reuse and further exploitation of data, whatever system was used to generate them.

One of the developments is a new data analysis tool for the center's models called "sensitivity study", which directly fits into the MCOPM platform. This tool automatically generates a considerable number of results by causing a variation in one of the model's parameters. The effects of this variation on the entire model can then be studied to understand its reactivity and limitations.

In 2015, new results-processing tools were developed to resolve the issue of the considerable quantity of data generated. These tools can be used to automate studies and by researchers to create dynamic presentations of their results, which can then be published on the Chair's website in 2016.



## “Bulletins de la Chaire”: new format for the “Petits Cahiers de la Chaire”



2015 also saw the launch of the Bulletins de la Chaire, a newsletter that replaces the Petits Cahiers de la Chaire, with three issues published this year. These newsletters give an overview of the events organized by the Modeling for Sustainable Development Chair, along with its calendar, publications and news. The Bulletins are concise and easy to read and available online on the chair's website.

## ***The Chair's main publications in 2015***

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, Dossier : Transition énergétique : contexte, enjeux et possibilités, [En ligne], 2015.

Jean-Michel Cayla, Nadia Maïzi. Integrating household behavior and heterogeneity into the TIMES-Households model. Applied Energy, Elsevier, 139, pp.56-67, 2015.

Mathilde Drouineau, Edi Assoumou, Vincent Mazaucic, Nadia Maïzi. Increasing shares of intermittent sources in Reunion Island: Impacts on the future reliability of power supply. Renewable and Sustainable Energy Reviews, Elsevier, 46, pp.120-128, 2015.

Seungwoo Kang, Sandrine Selosse, Nadia Maïzi. Strategy of bioenergy development in the largest energy consumers of Asia (China, India, Japan and South Korea). Energy Strategy Reviews, 8, pp.56-65, 2015.

Vincent Krakowski, Edi Assoumou, Nadia Maïzi. Enjeux de moyen et long termes d'une transition vers une production d'électricité 100% renouvelable dans le cas de la France. Revue de l'Energie, septembre-octobre (627), pp.381-394, 2015.

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, 104, pp.14-24, 2015.

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, 156, pp.374-389, 2015.

Nadia Maïzi. Changer d'échelle pour les négociations climatiques : Huit initiatives régionales, sectorielles et citoyennes. Presses des Mines, pp.164, 2015.

Ruud Kempener, Edi Assoumou, Alessandro Chiodi, Umberto Ciorba, Maria Gaeta, et al.. A Global Renewable Energy Roadmap: Comparing Energy Systems Models with IRENA's REmap 2030 Project. George Giannakidis, Maryse Labriet, Brian Ó Gallachóir, GianCarlo Tosato. Informing Energy and Climate Policies Using Energy Systems Models: Insights from Scenario Analysis Increasing the Evidence Base, 30 (Part I), Springer International Publishing, pp.43-67, 2015.

James Glynn, Patricia Fortes, Anna Krook-Riekkola, Maryse Labriet, Marc Vielle, et al.. Economic Impacts of Future Changes in the Energy System—National Perspectives. George Giannakidis, Maryse Labriet, Brian Ó Gallachóir, GianCarlo Tosato. Informing Energy and Climate Policies Using Energy Systems Models: Insights from Scenario Analysis Increasing the Evidence Base, 30 (Part III), Springer International Publishing, pp.359-387, 2015.

James Glynn, Patricia Fortes, Anna Krook-Riekkola, Maryse Labriet, Marc Vielle, et al.. Economic Impacts of Future Changes in the Energy System—Global Perspectives. George Giannakidis, Maryse Labriet, Brian Ó Gallachóir, GianCarlo Tosato. Informing Energy and Climate Policies Using Energy Systems Models: Insights from Scenario Analysis Increasing the Evidence Base, 30 (Part III), Springer International Publishing, pp.333-358, 2015.

A full list of the Chair's publications can be found at:  
[www.modelisation-prospective.org/fr/publications](http://www.modelisation-prospective.org/fr/publications)

## Events organized in 2015 by the Modeling for Sustainable Development Chair



### Press breakfast to mark the extension of the Chair Thursday, 5 February 2015 at MINES ParisTech, Boulevard Saint Michel, Paris

The “Modeling for Sustainable Development” Chair focuses on developing innovative prospective modeling tools to facilitate decision-making on energy and the climate. To celebrate the decision taken by MINES ParisTech and its partners to extend the chair for another five years, a press event was organized to concretely illustrate how the industry and research world is mobilized in terms of energy and climate, in particular in the run-up to COP21 in Paris, held at the end of 2015. The event included an overview of the chair’s work from 2008-2013 and a presentation of the challenges and perspectives raised by this new 5-year period, led by Hervé Gardette (Radio France).



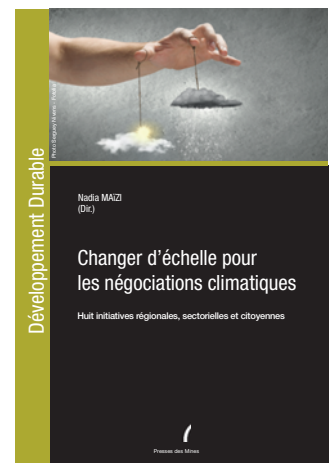
### 2015, the year of COP 21

**COP21 was a major event for the CMA, which has contributed to climate conferences for the last 9 years.**

**Participation in committees:** CGDD/MEDDE Committee on Mobilizing Scientific Expertise, member of the Scientific Council on the program “Management and Impacts of Climate Change” (GICC), member of the Expert Committee on the energy transition.

**Teaching achievements:** participation in creating a MOOC on the causes and challenges of climate change and coordination of Week 4 on reducing greenhouse gas emissions: 7,500 participants. The MOOC, which contributed to the national “fête de la science” event last October, was also disseminated during the initiative “Le Train pour le Climat” (messagersduclimat.com).

**Publication:** edited by Nadia Maïzi, a promotional book entitled “Changer d’échelle pour les négociations climatiques”, Presses des Mines, September 2015.





## Organization of scientific conferences:

**19-20 March 2015**, N. Maïzi and OSE Master's students took part in the Philomathia Forum on Energy and Environment at the University of California, Berkely. The theme was "Solutions for the 2025/30 International Climate Accord: Scaling-up Clean Energy Production, Policy Innovations, and Business, Investment". Nadia Maïzi gave a presentation on "Solar as a base power".

**7-10 July 2015**, The CMA participated in the scientific conference to prepare the COP21, "Our Common Future Under Climate Change" in Paris. For the event, the CMA:

- Coordinated a session on "Decarbonizing electricity - Electricity transition", with a plenary presentation by N. Maïzi
- Organized a side event (COP21 accredited) in collaboration with UC Berkeley (N. Maïzi /P. Wright) on 10 July at the l'Ecole des Mines de Paris entitled "Innovations in Decarbonization". E. Assoumou and F. Briens from the CMA spoke at the session "Advances in multi-scale models to shed light on the plausibility of long-term scenarios" along with 6 OSE Advanced Master's students, who evoked "Fresh perspectives" to change scale in climate negotiations.



*from left to right: V. Mazauric ; A. Rankovic ; N. Kittner ; N. Maïzi ; E. Assoumou ; J.-M. Cayla ; A. Miketa ; F. Briens ; M. Hamdi-Cherif ; J.-F. Mercure - Photos : ©NIKO*

**22 September 2015**, in Sophia Antipolis, OSE Master's students and the Modeling for Sustainable Development Chair jointly organized a conference, "Contributions à la préparation de la COP21: enjeux sectoriels, régionaux et individuels", with the participation of GREC-PACA.

Following a presentation by Nadia Maïzi and Jean-Charles Hourcade on the economic and technological challenges of climate negotiations, eight OSE Master's students presented the work of their class, featuring some original ideas for sustainable solutions to respond to increasingly strong constraints, i.e. climate change, depletion of resources, political and financial constraints. The afternoon was devoted to the Provence-Alpes-Côte d'Azur region's commitment to tackling climate change, with speeches by:

- Annick Delhaye, Regional Councilor, Vice-President responsible for sustainable development, the environment, energy and climate. She spoke of the region's action to combat climate change, how the territory was being adapted, and the energy transition.
- Marie Lootvoet, coordinator at the Association for Innovation and Research on Climate (A.I.R. Climat), who presented the regional group of experts working on climate in the Provence-Alpes-Côte d'Azur region (GREC-PACA). Their aim is to centralize, transcribe and share scientific knowledge on issues affecting the region.
- Jean-Pierre Gattuso, CNRS Director of Research at the Oceanographic Laboratory in Villefranche-sur-Mer, who spoke of the impacts of climate change and the acidification of the Mediterranean Sea.
- Nicolas Martin, Lecturer at Nice University, UMR "Space" on climate modeling and applications at local level.



**29-30 September 2015**, Nadia Maïzi participated in the conference CaFFEET (California France Forum on Energy Efficiency Technologies), an annual event launched in 2011 by EDF and the Consulate General of France in San Francisco. Its objective is to promote technical and scientific partnerships in the energy efficiency field between France and California, both of which are leading economies in terms of low CO<sub>2</sub> emissions.

The 2015 event centered on COP21 and a talk by Nadia Maïzi on “Sustaining reliability while implementing intermittency: what shares in the power mix?”

**22- 23 October 2015**, Sophia Antipolis, the CMA hosted and co-organized the 68th international workshop of the ETSAP (the International Energy Agency’s Energy Technology System Analysis Program). The event took place at MINES ParisTech with an introductory session on COP21 and the perspectives for France.

**25- 28 October 2015**, the CMA participated in the World Knowledge Dialogue (WKD) workshop 2015 "Energie et société : scénarios à 2049" organized by the universities of Lausanne, Geneva, Neuchâtel, Zurich and the EPFL at Villars-sur-Ollon in Switzerland with the aim of drawing up a vision presented to civil society in Paris.

**3-5 November 2015**, Nadia Maïzi took part in European Utility Week in Vienna, with a presentation on “Large-scale renewables integration and the changing roles of TSO & DSO companies”.

**30 November -11 December 2015**, Paris Le Bourget, the CMA was actively involved in COP 21, with Nadia MAÏZI heading the ParisTech delegation.

Participation at the MINES ParisTech stand

Organization as part of the European Pavilion of a LCS R Net side event on INDCs co-organized by prospective modeling on 3 December (blue zone)

On 11 December, the CMA organized a side event on "Industrial contributions to long-term decarbonization strategies" under the patronage of Ségolène ROYAL, Minister for Ecology, Sustainable Development and Energy. The event, led by Hervé Gardette (France Culture), involved a round table gathering Bernard SALHA (Director of Research and Development at EDF Group, Pierre ASTRUC (Secretary General of GRTgaz), Luc REMONT (Chairman of SCHNEIDER ELECTRIC France), Philippe MONLOUBOU (Chairman of the Board at ERDF), Romain SOUBEYRAN (Director of MINES ParisTech) and Nadia Maïzi. The focus was on technically plausible, sustainable options that can guarantee smart use of electricity systems while respecting climate constraints, and in particular the options put forward by the industrial sphere, which concern the widespread use of smart grids; energy-saving solutions; and the conditions for integrating renewable resources.

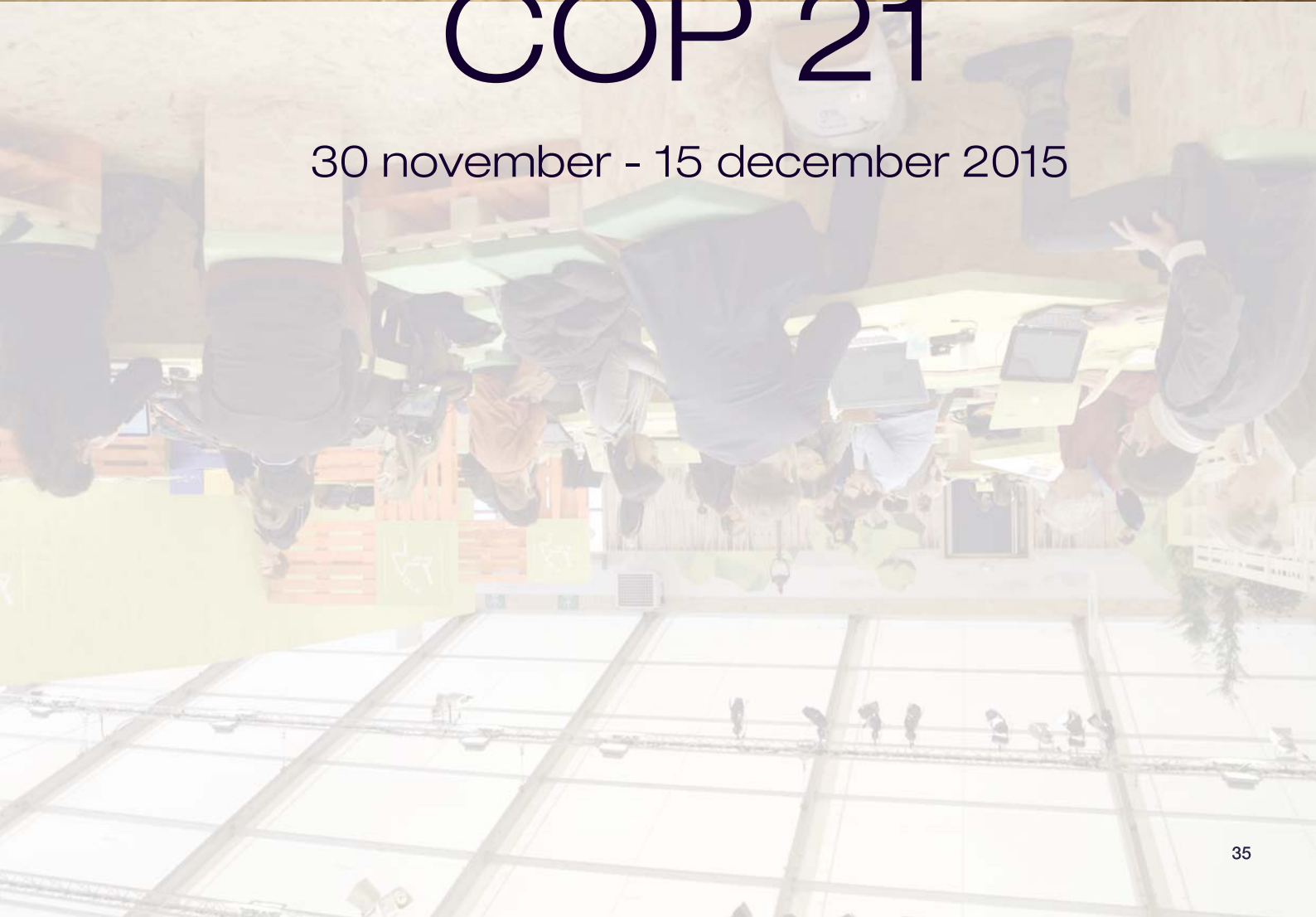
Look back over the key moments of the event at:  
<http://www.modelisation-prospective.org/fr/paris-cop21>





# COP 21

30 november - 15 december 2015





activity report 2015

Center for Applied Mathematics

SOPHIA ANTIPOLIS