Dr. Fernando de Sisternes

Contact Information

Research Affiliate
MIT Energy Initiative
Massachusetts Institute of Technology
77 Massachusetts Ave.
Room E19-341
Cambridge, MA 02139 USA

Mobile: +1-617-682-6531
Office: +1-617-324-7025
E-mail: ferds@mit.edu
WWW: web.mit.edu/ferds/www/

Research Interests

Operations research applications for energy policy analysis, market rules analysis, financial valuation and risk pricing: mixed-integer linear programming, stochastic optimization, network optimization, dynamic programming, simulation-based optimization, heuristic search, decision making under uncertainty, stochastic discounting, technology policy, power systems regulation.

Current Academic Appointments

Argonne National Laboratory September 2014 to present

Postdoctoral Associate, Energy Systems Division, Center for Energy, Environmental and Economic Systems Analysis

- "Grid Level Energy Storage for Integration of Renewable Energy", PI: Doctor Audun Botterud
- "Economic and Technical Aspects of Nuclear Energy Competitiveness in the Current U.S. Deregulated Electricity Markets", PI: Doctor Francesco Ganda

Massachusetts Institute of Technology July 2014 to present

Research Affiliate, MIT Energy Initiative,

- "The Utility of the Future" project, PI: Professor Ignacio Pérez-Arriaga

Harvard University January 2015 to present

Associate, John F. Kennedy School of Government, Energy Technology Innovation Policy Group (ETIP)

- "Implications of Load-Following with Nuclear Power", PI: Prof. Laura Diaz-Anadon

Education

Massachusetts Institute of Technology, Cambridge, MA

Ph.D., Engineering Systems: Technology, Management & Policy, June 2014

- Dissertation: *Risk Implications of the Deployment of Renewables for Investments in Electricity Generation.*
- Doctoral Committee: Professor Ignacio Perez-Arriaga, Professor Mort Webster, Professor Richard Schmalensee, and Doctor John Parsons.
- GPA: 5.0/5.0.

Massachusetts Institute of Technology, Cambridge, MA

S.M., Technology & Policy, June 2010

- Thesis: *Plug-in Electric Vehicle Introduction in the EU.*
- Advisor: Professor John Heywood.
- GPA: 5.0/5.0.

Peking University, Beijing, China

Diploma, Mandarin Chinese, June 2006

- Asia–Pacific Program (Spanish Ministry of Finance), language immersion program with additional training in the Chinese business environment, 2005–2006.
- IESE EMBA module at the China-Europe International Business School (CEIBS), Shanghai, China, May 2006.

Universidad Carlos III de Madrid, Madrid, Spain

M.Eng., B.Eng, Industrial Engineering, May 2005

- Thesis: *Direct Power Control of Three-Phase Inverters in the Event of Grid Faults. Wind Energy Application.*
- Advisor: Prof. Jose Luis Rodriguez-Amenedo.
- Specialization in Electrical Engineering (emphasis on control of power electronics), and in Electronics and Control Engineering (double specialization).
- *Erasmus Scholarship*, University of Sheffield, Sheffield, UK (Fall 2002)
- Graduated with honors (Top 5% of the class).

Experience in Industry

Argonne National Laboratory, Cambridge, MA (off-site)

Postdoctoral Associate, Energy Systems Division **July 2014 to present**

- Developing quick-turnaround optimization and statistical models for energy systems analysis, financial valuation and risk pricing, improving the accuracy of current risk pricing methods by over 50%.
- Applying the proprietary model IMRES to value energy storage-based ventures for grid applications, estimating the value of electricity price arbitrage at $130-200/kWh with a carbon policy.
- Establishing and coordinating new collaboration projects with research groups at Argonne, MIT and Harvard University, presenting results at the U.S. Department of Energy, other national laboratories and international conferences.

Thirdway, Washington, DC

Independent Consultant, **March 2015 to July 2015**

- Developed the model 'CANDI', an ultra-fast electricity generation capacity expansion model operating under carbon emissions limits.
- Estimated the CO2 emissions impact of various potential retirement scenarios of the U.S. nuclear power fleet.

International Energy Agency, OECD, Paris, France

Policy Consultant, Renewable Energy Division **July 2012 to June 2013**

- Participated as expert in the Advisory Group to the 3rd phase of the project 'Grid Integration of Variable Renewables' (GIVAR), part of the Task 25 of the IEA Wind Implementing Agreement.
- Applied the proprietary model IMRES to analyze the economic impact of integrating large volumes of renewable generation in power systems, and the value of different flexibility options.
- Developed a tool aimed at calculating the potential for renewable generation integration in power systems.

Gamesa Corporation, Madrid, Spain

Sales Engineer, Gamesa Energy **November 2007 to June 2008**

- Performed commercial, regulatory and operative research on clients and markets in Europe, updating the expected value of wind farm projects in the company's portfolio.
- Set up relations with clients and presented projects internationally, increasing the number of bids for the company's projects up to a total of 17 bids.
- Coordinated the information flow with clients, negotiation of NDAs, contracts and sales of wind farm projects worth $200M in total.

Soluziona Management Consulting (now Indra), Madrid, Spain

Strategic Consultant **September 2006 to May 2007**

- Advised on the Third Electric Power Reconstruction Project in Bosnia & Herzegovina: Energy Sector Study in B&H, and coordinated a pool of experts that provided best practices and guidelines to the modules for Renewable Energies, Demand Management and Natural Gas (Sarajevo, B-H).
- Contributed to the design of a new electricity tariff model for the vertically integrated utility GECOL, creating an unbundling cost model that facilitated the division of the utility for later privatization (Tripoli, Libya).
- Produced a handbook for the deployment of Solar Photovoltaic Systems in small and medium facilities in Spain, reporting the benefits of its deployment, energy policy issues, investment expenses and available financial aid. This project increased the awareness of the solar photovoltaic technology among households and small industries in Spain (Madrid, Spain).

Spanish Wind Energy Association, Madrid, Spain

Member of Technical Direction **April 2004 to August 2005**

- Coordinated a team of 18 industry leaders in the project "Wind Power Forecasting Exercise", which was the first review of the state-of-the-art of wind power forecasting worldwide.
- Identified a method that reduced wind forecasting errors in 25 % over standard methods, contributing to the integration of wind energy in the electricity network and in the wholesale market.
- Represented the association in working teams (infrastructures, renewable energy policy, etc.) with public institutions and industrial partners.

Journal Articles

[1] **F. de Sisternes**, M. Webster and I.J. Perez-Arriaga. The Impact of Bidding Rules on Electricity Markets with Intermittent Renewables. *IEEE Transactions on Power Systems*, Vol. 30, Issue 3:1603 – 1613. Special section on "Wind & Solar Energy: Uncovering and Accommodating Their Impacts on Electricity Markets. May 2015.

[2] J. Eide, **F. de Sisternes**, H. Herzog and M. Webster. CO2 Emissions Standards and Investment in Carbon Capture. *Energy Economics*, Vol. 45 (September 2014):53–65.

Other Peer-reviewed Publications

[3] IEA. The Power of Transformation. Wind, Sun and the Economics of Flexible Power Systems. International Energy Agency (IEA), Paris, 2014.

[4] **de Sisternes**. Investment Model for Renewable Electricity Systems (IMRES): an Electricity Generation Capacity Expansion Formulation with Unit Commitment Constraints MIT Center for Energy and Environmental Policy Research, CEEPR WP 2013-16, Cambridge, MA, 2013.

[5] **F. de Sisternes, M. Webster**. Optimal Selection of Sample Weeks for Approximating the Net Load in Generation Planning Problems. ESD Working Paper Series, ESD WP 2013-03, Cambridge, MA, 2013.

[6] **F. de Sisternes**. Quantifying the Combined Impact of Wind and Solar Power Penetration on the Optimal Generation Mix and Thermal Power Plant Cycling. Young Energy Economists and Engineers Seminar, (p. 12). Madrid, Spain, 2011.

[7] J. Heywood, **F. Sisternes**, et al. An Action Plan for Cars: The Policies Needed to Reduce U.S. Petroleum Consumption and Greenhouse Gas Emissions, An MIT Energy Initiative Report , Cambridge, Massachusetts, 2009.

[8] A. Ceña, **F. de Sisternes**, et al. Forecasting Exercise. Spanish Wind Energy Association (AEE), Madrid, Spain, 2006.

Conference Abstracts

[9] **F. de Sisternes**, J. Parsons, A Dynamic Model for Risk Pricing in Generation Investments. In: *INFORMS Annual Meeting*, 9–12 November, 2014, San Francisco, CA.

[10] **F. de Sisternes**, J. Jenkins, Modeling Energy Storage as an Enabler of Ultra-low Carbon Power Systems. In: *INFORMS Annual Meeting*, 9–12 November, 2014, San Francisco, CA.

[11] **F. de Sisternes**, M. Webster, I. Pérez-Arriaga, Effect of Market Rules on Thermal Generation Investments in Power Systems with Significant Renewable Penetration. In: *INFORMS Annual Meeting*, 6–9 October, 2013, Minneapolis, MN.

[12] **F. de Sisternes**, A. Ceña, Optimization of Wind Farm Operations by AEE's Forecasting Exercise. In: *European Wind Energy Conference (EWEC)*, 27 February–2 March, 2006, Athens, Greece.

Theses and Dissertation

[13] **F. de Sisternes**, *Risk Implications of the Deployment of Renewables for Investments in Electricity Generation.* Dissertation, Massachusetts Institute of Technology, Cambridge, MA, 2014.

[14] **F. de Sisternes**, *Plug-in Electric Vehicle Introduction in the EU.* Master's thesis, Massachusetts Institute of Technology, Cambridge, MA, 2010.

[15] **F. de Sisternes**, *Direct Power Control of Three-Phase Inverters in the Event of Grid Faults. Wind Energy Application.* Master's thesis, Escuela Superior de Ingeniería, Universidad Carlos III de Madrid, Madrid, Spain, 2005.

Papers in Preparation

[16] **F. de Sisternes**, J. Parsons. A Dynamic Model for Risk Pricing in Generation Investments. Cambridge, MA.

[17] **F. de Sisternes**, I. Núñez. A Robust Selection Method for Choosing Representative Weeks in Renewable Generation Capacity Expansion Problems. Cambridge, MA.

[18] **F. de Sisternes**, J. Jenkins, A. Botterud. Modeling Energy Storage as an Enabler of Ultra-low Carbon Power Systems. Cambridge, MA.

Invited Talks and Seminars

Clean Air Task Force, "Modeling the Role of Storage in Very Low Carbon Power Systems", May 11, 2015.

U.S. Department of Energy - Office of Energy Policy and Systems Analysis, "A Dynamic Model for Risk Pricing in Generation Investments", April 23, 2015.

Pontifical Catholic University of Chile - Department of Electrical Engineering, "Risk Implications of the Deployment of Renewables for Investments in Electricity Generation", January 28, 2015.

Argonne National Laboratory - Energy Systems Division, "Stochastic operational and investment modeling for DOE-Wind and DOE-OE ", October 22, 2014.

Argonne National Laboratory - Decision and Information Sciences Division, "Risk Implications of the Deployment of Renewables for Investments in Electricity Generation", May 1, 2014.

MIT - Electricity Student Research Group, "A Dynamic Model for Risk Pricing in Generation Investments", March 31, 2014.

MIT - Electricity Student Research Group, "Market Impacts of Intermittent Renewables on Electric Power Systems: the Impact of Bidding Rules", February 24, 2014.

International Energy Agency, Advisory Group Meeting GIVAR Project, "Economics of Flexibility. IMRES Modeling", January 29, 2013.

International Energy Agency, Advisory Group Meeting GIVAR Project, "Economics of Flexibility. IMRES Modeling", November 19, 2012.

University of the Basque Country - Basque Center for Climate Change, "Large Scale Integration of Renewables in Power Systems: Flexibility Assessment and Market Rules Design", November 9, 2012.

MIT - Engineering Systems Student Society (ESS), " Design of Market Rules for Power Systems with Renewables", October 26, 2011.

Comillas University, Young Energy Economists and Engineers Seminar (YEEES), "Quantifying the Combined Impact of Wind and Solar Power Penetration on the Optimal Generation Mix and Thermal Power Plant Cycling", November 24, 2011.

Tsinghua University - Smart Grid Technology Lab, "Electric Vehicle Introduction in the EU", July, 2010.

Universidad Camilo Jose Cela, Seminar on Bioclimatic Architecture, "Wind Energy. Applications", April, 2007.

GECOL, Electricity Tariff Construction for Libya, "New Electricity Tariff for GECOL", March 2007.

Collaborators

Audun Botterud. Energy Systems Engineer, Argonne National Laboratory.

Jesse Jenkins. PhD student in the Engineering Systems Division, MIT.

Francesco Ganda. Nuclear Engineer, Argonne National Laboratory.

Ignacio Pérez-Arriaga. Professor, Massachusetts Institute of Technology.

John Parsons. Senior lecturer, MIT Sloan School of Management; head, MBA finance track, MIT.

Mort Webster. Professor, Pennsylvania State University.

Simon Mueller. Policy analyst at the Renewable Energy Division, International Energy Agency.

Ignacio Núñez. Pontificia Universidad Católica de Chile.

Research Experience

MIT Joint Program on the Science and Policy of Global Change, Cambridge, MA

Research Assistant **September 2010 to September 2014**

- Advisors: Prof. Ignacio-Pérez-Arriaga, Prof. Mort Webster, Prof. Richard Schmalensee. Researching on the theory and modeling of electricity markets with renewables:
  - Developed the 'Investment Model for Renewable Electricity Systems (IMRES)', a generation capacity expansion model with unit commitment constraints to study the policy implications of a large-scale deployment of renewable generation in electric power systems.
  - Developed a stochastic generation capacity expansion model to determine the impact of CO_2 emission standards on generation investments in coal plants with carbon capture and sequestration (CCS).

- Advisor: Dr. John Parsons. Researching on stochastic discounting for the valuation of risk in electricity generation projects.

Institute for Research in Technology (IIT), Madrid, Spain

Visiting Student, Decision Support Systems for the Energy Sector Research Group (SADSE) **Summer 2009 and Summer 2011**

- Supervisor: Prof. Andrés Ramos. Electric power systems modeling:
  - Researched on electricity generation capacity expansion models with renewables, integrating the short-term operation of generation plants with long-term investment decisions. This research led to the development of the 'Investment Model for Renewable Electricity Systems' (IMRES), still used at present.
  - Researched on the impact of charging batteries for plug-in electric vehicles on the operation of the electric grid with the model MEMPHIS.

Tsinghua University, Beijing, China

Visiting Student, Smart Grid Technology Lab **Summer 2010**

- Supervisor: Prof. Yonghua Song. Researched on electric vehicle deployment policies and pilot projects in China.

Massachusetts Institute of Technology, Cambridge, MA

Research Assistant, Sloan Automotive Lab **September 2008 to May 2010**

- Advisor: Prof. John Heywood.
  - Researched on the carbon emissions of different classes of electric vehicles relative to the electricity generation mix used in different regions.
  - Researched on policies relative to the deployment of electric vehicles.

Teaching Experience

Massachusetts Institute of Technology, Cambridge, MA

Teaching Assistant **Spring 2013**

- ESD.865 Modeling Electric Power Systems.
  - *Summary*: this course provides a foundation for electric power systems research by covering many of the traditional modeling methodologies, including economic dispatch, unit commitment, optimal power flow, generation capacity expansion, economic methods, and simulation methods. The course emphasizes the study of electric power systems as a complex socio-technical system with characteristics including non-linear behavior, physical constraints, and large economic and environmental impacts.
  - Designed, wrote and graded course assignments, and led recitation sessions.
  - Overall teaching rating: 6.2/7.

Project Leader **Spring 2012**

- ESD.00 Introduction to Engineering Systems: Complex Sociotechnical Problems.
  - *Summary*: this course introduces undergraduate students to complex sociotechnical systems. Introduces interdisciplinary approaches - rooted in engineering, management, and the social sciences - for addressing large, complex and seemingly intractable real-world problems, such as energy supply. Small, faculty-led teams select an engineering systems term project to illustrate several of these approaches.
  - Led a class group with the project "Electric Power: Combining Renewables, Capacity Expansion and Demand Response".
  - Overall teaching rating: 7/7.

Teaching Assistant **Fall 2010**

- ESD.865 Seminar in Energy Systems Analysis.
  - *Summary*: –same as ESD.865 above–.
  - Designed, wrote and graded course assignments, and led recitation sessions.
  - Overall teaching rating: 6.2/7.

Universidad Carlos III de Madrid, Madrid, Spain

Teaching Assistant **Spring 2002**

- Taught laboratory modules on three-phase power metering to undergraduate students.

Professional Service

Referee Service

- *IEEE Transactions on Power Systems*, 2014–present
- *Utilities Policy*, 2014–present
- *Sustainable Energy, Grids and Networks*, 2015–present

Professional Memberships

Member

- Institute for Electrical and Electronics Engineers (IEEE), 2011–present
- Institute for Operations Research and the Management Sciences (INFORMS), 2011–present

Community Service

Massachusetts Institute of Technology, Cambridge, MA

President, Spain@MIT **2013– 2014**

- Led a team of ten students in the organization of the activities of the club.
- Supervised the planning of events (over five per semester) and the request for funding.
- Introduced speakers and led round tables.

Vice-President, Spain@MIT **2012– 2013**

- Supported the president in her absence.
- Established contact with potential speakers and sponsors.
- Introduced speakers and led round tables.

Internal Relations Chair, Spain@MIT **2011– 2012**

- Established contact with potential speakers and sponsors.
- Aided in the organization of events.

Software Skills

Computer Programming:

- Projects in Matlab, GAMS, C.
- Basic knowledge of R, HTML, RAPID, S-PLUS, FORTRAN, STATA and others.

Matlab skill set:

- Linear algebra, Monte Carlo analysis, statistics, design of experiments, optimization, visualization.
- Toolboxes: optimization, simulink.

Productivity Applications:

- Microsoft Excel, Word, Access, Power Point, TEX.

Expertise

Economics and Finance:

- Simulation of Markets and Pricing Rules, Cost-Recovery Analysis, Asset Valuation, Stochastic Discounting (Dynamic Pricing of Financial Risk).

Operations Research:

- Linear Programming, Integer Programming, Stochastic Programming, Dynamic Programming, Metaheuristic Algorithms, Large-Scale Optimization, Network Optimization, Financial Engineering.

Policy Research:

- Public Policy Analysis, Technology Policy, Cost-Benefit Analysis, Queue Modeling, Monte Carlo Simulation, Markov Processes, Decision Trees.

Social Science Research:

- Case Study Research, Survey Research, Experimental Design, Statistical Analysis.

Electric Power Systems:

- Energy Storage, Demand-Side Management, Capacity Expansion, Unit Commitment, Economic Dispatch, Power Flow, Electromagnetic Circuits, Transformer Design, Analysis of Electric Machines, Control of Electric Machines.

Honors and Awards

Martin Family Society of Fellows for Sustainability

- Graduate Research Fellowship, 2012–2013

Caja Madrid Foundation

- Graduate Fellowship, 2010–2012 (Top 10% of applicants awarded)

MIT International Science and Technology Initiatives

- MIT-China Fellowship, Summer 2010

La Caixa - Obra Social

- La Caixa Fellowship, 2008–2010 (Top 7% of applicants awarded)

ICO Foundation

- Asia-Pacific Fellowship, 2005–2006

Universidad Carlos III de Madrid

- Tuition fee grant for obtaining seven A with honors along the undergraduate degree, 1999–2005

References

Dr. Ignacio J. Pérez-Arriaga (e-mail: ipa@mit.edu; phone: +1-617-784-3302)

- Full Professor; Director of the BP Chair on Sustainable Development, Institute for Research in Technology (IIT); and Permanent Visiting Professor, Engineering Systems, Massachusetts Institute of Technology
- ◇ 77 Massachusetts Ave Room E19-413, Cambridge MA 02139
- ⋆ *Dr. Pérez-Arriaga was my graduate advisor.*

Dr. Mort. D. Webster (e-mail: mort@psu.edu; phone: +1-814-863-1640)

- Associate Professor, Department of Energy and Mineral Engineering, Pennsylvania State University
- ◇ 123 Hosler Building, University Park PA 16802
- ⋆ *Dr. Webster was my graduate advisor.*

Dr. Richard L. Schmalensee (e-mail: rschmal@mit.edu; phone: +1-617-253-2957)

- Howard W. Johnson Professor of Economics and Management Emeritus; Dean Emeritus, Sloan School of Management, Massachusetts Institute of Technology
- ◇ MIT Sloan School of Management, 100 Main Street E62-525, Cambridge MA 02142
- ⋆ *Dr. Schmalensee was in my doctoral committee.*

Dr. John E. Parsons (e-mail: jparsons@mit.edu; phone: +1-617-324-3745)

- Senior Lecturer, Sloan School of Management; Head, MBA Finance Track, Massachusetts Institute of Technology

◇ 77 Massachusetts Ave Room E62-684, Cambridge MA 02139

⋆ *Dr. Parsons was in my doctoral committee.*