

ENERGY OPTIMIZATION, CONTROL AND MARKETS

OCM Lab Research at a Glance

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Agenda

OCM-Lab

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- Ongoing Research Projects
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- 6 Concluding Remarks

OCM Lab

OCM-Lab

Energy Optimization, Control and Markets Lab



Team & Expertise

Our Team

- Faculty: Daniel Olivares, Matias Negrete Pincetic, Álvaro Lorca
- Students: approx 25 (grad + undergrad + visiting)
- Ongoing collaborations with Waterloo, Lehigh, Georgia Tech, KIT, UC Berkeley, UT Austin, Toronto.
- Participation: Institute for Complex Engineering Systems (ISCI), Solar Energy Research Center (SERC-Chile), UC Energy Research Center.

Expertise

- Power and Energy Systems: Operations, Engineering, Economics
- Optimization, Stochastic Models, Control

OCM-Lab



Loads as Stochastic Batteries





Electricity Markets Design









Grid as a Control System with Many Resources

Where are we going...



The Smart Grid Vision



Smart Grids: much more than EE





\$/MWh

Energy Services

Vision: Many resources including DERs

Flexibility is Key



Many resources!

Pool Pumps

Thermal Loads



EVs



Desalination Plants



The challenge...

Grid is a Complex System with Many Resources including Participants (loads) on the Loop



Engineering + Markets

Lab Experience Highlights

LAAF Electric Vehicle Project [UCB-PUC-LBNL]



Real-Time Strategies for an EV Fleet Aggregator to Provide Ancillary Services



Charging Strategies for Electric Vehicles Charging Station [ND Seed Fund]

An Advanced Reservation (AR) Structure Design



Markets for Flexible Loads

Duration Differentiated Energy Services

Commodity (ℓ, h) : ℓMW for any h hours in [0, T].



Desalination Plants

Opportunity in Chile for Flexibility



Desalination plants can be operated accordingly, using synergies with solar energy, to provide flexibility for the grid.

Aggregators in Day-Ahead and Real-Time Markets



Aggregators in Day-Ahead and Real-Time Markets

Considering the behaviour of end-users.



Cuenca del Salado Project

Three-phase unbalanced distribution model for distributed energy integration



Cuenca del Salado Project

The model enables to obtain a dispatch of the resources and analyze the distinct phenomena of the distribution network



Figure: LV Tension Levels.

Figure: Fluxes in lines in peak hour.

Lab Experience

- Fondecyt Project "Active Demand Response Mechanisms for Exploiting Flexibility in Electricity Supply: Models and Valuation." (Nov 2014 - Nov 2017).
- Corfo Project "Corredor Solar Cuenca del Salado" (Ene 2017 Dic 2018).
- I+D Centro Innovación UC "Impacto de Plantas Desaladoras en la Flexibilidad de los Sistemas Eléctricos Chilenos" (Ene 2017-Junio 2018)
- Fondecyt Project "NCRE integration into Chilean electricity system: Opportunities for solar energy." (Nov 2013 Nov 2016).
- Corfo-CSET Project "The SWITCH Model: Handling Uncertainty and Power Systems Flexibility" (Feb 2016 Feb 2018).

Ongoing Research Projects



Research Projects

- Fondecyt Project "Operation and Market Models for DER: Facilitating Large Scale Renewable Integration in Chile" (Nov 2017 Nov 2020).
- Fondef Project "Diseño e Implementación de Infraestructura Tecnológica para la Gestión de Consumos Flexibles en Sistemas Eléctricos" (Ene 2018 - Ene 2020).
- Redes Internacionales Project "Agent-Based Modeling and Simulation for Energy Markets" (Ene 2018 Ene 2020).
- Fondecyt Project "Optimization under Uncertainty for Power System Resilience" (Nov 2017 Nov 2020).
- Fondecyt Project "Local Energy Markets for Sustainable Microgrids: Design, Modeling and Simulation". (Apr 2018 Apr 2021)
- Fraunhofer CSET Project "Advanced Operational and Planning Tools for Energy Systems with a Massive Adoption of Solar Power". (Nov 2018 - Oct 2020)

Fondecyt Project "Operation and Market Models for DER: Facilitating Large Scale Renewable Integration in Chile"

Research Tasks

- Scheduling and Control of Flexible Loads and Distributed Storage: How to effectively aggregate many DERs for effective control and operation?
- Electricity Markets for DERs: How to design markets for DERs particularly for flexible loads?
- Integrating DERs into Bulk Power Systems: What is the impact of DERs into bulk power system infrastructure?
- Technology and Energy Policy Scenarios for DERs in Chile: Can DERs facilitate the untapping of the Chilean renewable resources potential?

Coordination of DR Resources Located along a Three-phase Distribution Network



Fondecyt Project "Optimization under uncertainty for power system resilience"

Research Tasks

- Resilience-Based Power System Expansion Planning.
- Optimization Models for Power System Repair and Restoration.
- Agent-Based Simulation for Power System Restoration.
- Policy recommendations for resilience enhancements in the Chilean power network

Fondecyt Project "Optimization under uncertainty for power system resilience"



At a glance

- Design and implementation of the technological infrastructure to manage and coordinate flexible electricity loads
- Harnessing load flexibility can have important potential systemic and private impacts







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Redes Internacionales Project "Agent-Based Modeling and Simulation for Energy Markets"

At a glance

- Developing Agent-Based Simulations as a complement to standard market design tools for the consideration of more physical and behavioural issues.
- Close work with KIT's Institute of Information Systems and Marketing (IISM) and Information and Market Engineering lead by Prof. Christoph Weinhardt.

Redes Internacionales Project "Agent-Based Modeling and Simulation for Energy Markets"



Fondecyt Project "Local Energy Markets for Sustainable Microgrids: Design, Modeling and Simulation"

Research Tasks

- Microgrid Modeling and Techno-economic Analysis: How do technical limitations of the microgrid impact local market design?
- Market Design for Microgrids: What market arquitecture is best suitable for local markets in microgrids?
- Agent-based Modeling and Simulation: What are the impacts on market outcomes of considering more realistic constraints for system and participants?



Microgrids and Local Energy Markets

Solar power

Fraunhofer CSET Project "Advanced Operational and Planning Tools for Energy Systems with a Massive Adoption of Solar Power"



The future...

Microgrids

Blockchains

Zero Marginal Cost

Sharing Economy for Smart Grids

Local Electricity Markets

Technical Challenges

Brooklyn Microgrid

AirBnB - UBER for MWs?

Ongoing Consulting Projects

Coordinador Eléctrico Nacional: Definición de la Operación de Mediano Plazo para la Operación del Sistema Eléctrico Nacional



Coordinador Eléctrico Nacional: Estudio de Competencia y Reglas de Subastas y Licitaciones para la Prestación de Servicios Complementarios



Ministerio de Energía: Estudio para la Elaboración de una Propuesta de Modificación Regulatoria de la Distribución de Energía Eléctrica



Transelec: Estudio de evaluación de la vulnerabilidad, impactos y adaptación al cambio climático de la infraestructura energética de Transelec S.A.



Concluding Remarks



Loads as Stochastic Batteries





Electricity Markets Design



Smart Grids



Demand Response





Grid as a Control System with Many Resources

¿Interesados en participar?

Oportunidades:

- Doctorado
- Magíster
- Pregrado

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Muchas Gracias!



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