Curriculum vitae for

Enrico Antonini

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GENERAL RESEARCH INTERESTS AND STRATEGY

- Primary research goals:
  - Provide solutions to build climate-resilient and carbon-neutral energy systems
  - Identify opportunities for and constraints to large-scale deployment of low-carbon energy generation
  - Improve best design and operational practices of low-carbon energy technologies
- Primary research areas:
  - Energy system engineering
  - Optimization and data science
  - Fluid dynamical modelling
  - Atmospheric and wind energy sciences

EDUCATION

Doctor of Philosophy - *University of Toronto, Toronto, Canada* 09/2014 - 09/2018
- Mechanical and Industrial Engineering
- Thesis supervisors: Prof. Cristina Amon, Dr. David Romero
- Thesis topic: CFD-based Methodology for Wind Farm Layout Optimization

Master of Science - *University of Padua, Padua, Italy* 10/2010 - 03/2013
- Mechanical Engineering (final grade: 110/110, with honours)
- Thesis supervisors: Prof. Ernesto Benini, Prof. Jens Nørkær Sørensen, Dr. Marco Raciti Castelli
- Thesis topic: Development of a Prescribed Expanding Vortex Wake Model for HAWTs

Bachelor of Science - *University of Padua, Padua, Italy* 10/2007 - 09/2010
- Mechanical Engineering (final grade: 110/110, with honours)
- Thesis supervisors: Prof. Alarico Macor, Dr. Antonio Rossetti
- Thesis topic: Optimized Management of a Power-Split Transmission for Agricultural Tractors

RESEARCH EXPERIENCE

Junior Scientist (tenure track) – *CMCC Foundation, Milan, Italy* 01/2023 - present
- Studying solutions to build climate-resilient and carbon-neutral energy systems
- Developing best design and operational practices of low-carbon energy technologies

Postdoctoral Research Scientist - *Carnegie Institution for Science, Stanford, USA* 03/2019 - 12/2023
- Studied control mechanisms of and geophysical limits to large-scale wind energy generation
- Investigated strategic site selection of wind and solar power plants in deep decarbonization scenarios for electricity systems

Postdoctoral Fellow - *University of Toronto, Toronto, Canada* 10/2018 - 01/2019
- Conducted research in fluid dynamical modeling and design optimization of wind farms
- Developed an innovative high-fidelity methodology to maximize the annual energy generation of wind farms by optimally siting turbines

TEACHING EXPERIENCE

Guest Lecturer - *University of Toronto, Toronto, Canada*
- Wind Power — Fall 2018

Teaching Assistant - *University of Toronto, Toronto, Canada*
- Fluid Mechanics I — Fall 2016
- Alternative Energy Systems — Fall 2016 and 2017
- Wind Power — Fall 2017 and 2018
- Thermal Energy Conversion — Winter 2018

SUPERVISED STUDENTS

Alice Di Bella - PhD at Polytechnic University of Milan — 03/2023 - 02/2026
- Project: Leas-cost carbon-neutral scenarios for the European energy system

Omri Tayyara - Master of Engineering at the University of Toronto — 09/2017 - 08/2018
- Project: CFD Modeling of After-market Rotor Attachments on Wind Turbines
- First position after degree: PhD student at University of Toronto

Danyal Rehman - Bachelor of Applied Science at the University of Toronto — 02/2017 - 08/2017
- Project: Wind Farm Power Optimization using Adaptive Yaw Control
- First position after degree: Master/PhD student at MIT

Harmit Komal - Master of Engineering at the University of Toronto — 09/2015 - 08/2016
- Project: Modelling Wind Turbine Wakes in Complex Terrain
- First position after degree: Project Engineer at Environment and Climate Change Canada

Adithya Dhoot - Master of Applied Science at the University of Toronto — 09/2015 - 08/2016
- Project: Wind Farm Layout Optimization using Probabilistic Inference
- First position after degree: Software Engineer at Autodesk

PROFESSIONAL SERVICE

Guest editor — 10/2021
- Proceedings of the National Academy of Sciences

Journal reviewer — 01/2016 - present
- Joule
- Communications Earth & Environment
- Energy
- Applied Energy
- Renewable Energy
- Energy Conversion and Management
- Journal of Wind Engineering & Industrial Aerodynamics
- Journal of Cleaner Production
- Wind Energy
- Energies
- Sustainability
- Journal of the Atmospheric Sciences
- TCSME
- IMECE

Web developer - *University of Toronto, Toronto, Canada* — 10/2016 - 01/2019
- Designed and maintained the website of the research group

Member of DEI advisory team - *Carnegie Institution for Science, Stanford, USA* — 10/2021 - 12/2022
- Advised on what the institution should do to become a diverse, equitable, and inclusive workplace

Member of search committee - *Carnegie Institution for Science, Stanford, USA* 10/2020 - 10/2021
- Represented early career scientists in the search for three faculty hires

Judge for student presentation award - *AGU Fall Meeting, San Francisco, USA* 12/2019, 12/2021
- Judged and provided feedback on students' poster and oral presentations

Session primary convener - *AGU Fall Meeting, San Francisco, USA* 12/2022
- Session topic: "Net-Zero Emissions Energy Systems: Geophysical Constraints, Consequences, and Opportunities"

INDUSTRIAL EXPERIENCE

Research Engineer - *Sheridan College, Oakville, Canada* 10/2018 - 01/2019
- Studied the performance of innovative vertical axis wind turbine using CFD models
- Provided preliminary assessment of several improvements of the prototype model

Software Engineer - *NuPhysics Consulting, Toronto, Canada* 03/2016 - 04/2017
- Developed software programs and simulators for CFD applications
- Led research and development area

COMPUTER PROFICIENCY

- Scientific programming: MATLAB, Python, Fortran, C++, Java
- Computational Fluid Dynamics: OpenFOAM, Ansys Fluent, Ansys CFX, WRF
- Mechanical Design: Ansys, SolidWorks, Gambit
- Website programming and design: HTML, CSS, JavaScript, PHP

GRANTS, FELLOWSHIPS, AND SCHOLARSHIPS

- Gates Ventures postdoctoral funding (**US$ 253,380**) 03/2019 - 03/2023
- Metcalfe family fellowship for sustainable energy research (**CA$ 6,000**) 09/2017 - 08/2018
- Hatch graduate scholarship for sustainable energy research (**CA$ 20,000**) 09/2016 - 08/2018
- University of Toronto MIE graduate student travel grant (**CA$ 900**) 11/2016
- University of Toronto MIE graduate scholarship (**CA$ 139,843**) 09/2014 - 09/2018
- Erasmus programme scholarship (**€ 1,800**) 03/2012 - 08/2012

PROFESSIONAL MEMBERSHIPS

- Member of the American Society of Mechanical Engineers (ASME)
- Member of the American Geophysical Union (AGU)
- Member of the European Geophysical Union (AGU)
- Member of the Macro Energy System (MES) community

TRAINING AND WORKSHOPS

- Bystander intervention 2021
  Carnegie Institution for Science, Stanford, USA
- How to conduct an inclusive search in STEM 2020
  Carnegie Institution for Science, Stanford, USA
- Lab training for measuring the performance of a two-stage air compressor 2018
  University of Toronto, Toronto, Canada
- Lab training for measuring head losses in pipe systems 2016
  University of Toronto, Toronto, Canada

- Ethics in research 2015
  University of Toronto, Toronto, Canada

PUBLICATIONS

Journal articles

16. **E.G.A. Antonini**, A. Di Bella, I. Savelli, L. Drouet, M. Tavoni, "Weather- and climate-driven power supply and demand time series for power and energy system analyses", ***Scientific Data***, Vol. 11, p. 1324, 2024.
15. T.H. Ruggles, E. Virgüez, N. Reich, J. Dowling, H. Bloomfield, **E.G.A. Antonini**, S.J. Davis, N.S. Lewis, K. Caldeira, "Planning reliable wind- and solar-based electricity systems", ***Advances in Applied Energy***, Vol. 15, p. 100185, 2024.
14. **E.G.A. Antonini**, E. Virgüez, S. Ashfaq, L. Duan, T.H. Ruggles, K. Caldeira, "Identification of reliable locations for wind power generation through a global analysis of wind droughts", ***Communications Earth & Environment***, Vol. 5, N. 1, p. 103, 2024.
13. D.A. Romero, S. Hasanpoor, **E.G.A. Antonini**, C.H. Amon, "Predicting wind farm wake losses with deep convolutional hierarchical encoder–decoder neural networks", ***APL Machine Learning***, Vol. 2, N. 1, p. 016111, 2024.
12. **E.G.A. Antonini**, T. Ruggles, D.J. Farnham, K. Caldeira, "The quantity-quality transition in the value of expanding wind and solar power generation", ***iScience***, Vol. 25, N. 4, p. 104140, 2022.
11. **E.G.A. Antonini**, K. Caldeira, "Spatial constraints in large-scale expansion of wind power plants", ***Proceedings of the National Academy of Sciences***, Vol. 118, No. 27, p. e2103875118, 2021.
10. A. Dhoot, **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Optimizing wind farms layouts for maximum energy production using probabilistic inference: Benchmarking reveals superior computational efficiency and scalability", ***Energy***, Vol. 223, p. 120035, 2021.
9. **E.G.A. Antonini**, K. Caldeira, "Atmospheric pressure gradients and Coriolis forces provide geophysical limits to power density of large wind farms", ***Applied Energy***, Vol. 281, p. 116048, 2021.
8. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Optimal design of wind farms in complex terrains using computational fluid dynamics and adjoint methods", ***Applied Energy***, Vol. 261, p. 114426, 2020.
7. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Improving CFD Wind Farm Simulations incorporating Wind Direction Uncertainty", ***Renewable Energy***, Vol. 133, pp. 1011-1023, 2019.
6. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Continuous Adjoint Formulation for Wind Farm Layout Optimization: A 2D Implementation", ***Applied Energy***, Vol. 228, pp. 2333-2345, 2018.
5. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Analysis and Modifications of Turbulence Models for Wind Turbine Wake Simulations in Atmospheric Boundary Layers", ***Journal of Solar Energy Engineering***, Vol. 140, No. 3, p. 031007, 2018.
4. **E.G.A. Antonini**, G. Bedon, S. De Betta, L. Michelini, M. Raciti Castelli and E. Benini, "An Innovative Vortex Model for Dynamic Stall Simulations", ***AIAA Journal***, Vol. 53, No. 2, pp. 479-485, 2015.
3. G. Bedon, **E.G.A. Antonini**, S. De Betta, M. Raciti Castelli and E. Benini, "Evaluation of the Different Aerodynamic Databases for Vertical Axis Wind Turbine Simulations", ***Renewable & Sustainable Energy Reviews***, Vol. 40, pp. 386-399, 2014.

Refereed conference articles

2. **E.G.A. Antonini**, T. Ruggles, D.J. Farnham, K. Caldeira, "Meeting electricity demand with distributed wind and solar generation: System flexibility drives optimal siting", ***Proceedings of the ASME International Mechanical Engineering Congress and Exposition***, IMECE2021-70678, 2021.

1. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Analysis and modifications of turbulence models for wind turbine wake simulations in atmospheric boundary layers", ***Proceedings of the ASME International Mechanical Engineering Congress and Exposition***, IMECE2016-67353, 2016.

Manuscripts under review or in preparation

- S. Chen, X. Lu, J. Hao, E. Virgüez, **E.G.A. Antonini**, K. Caldeira, S.J. Davis, "Land costs impact solar technology choices and carbon mitigation in China", **under review**.
- S. Ashfaq, L. Duan, **E.G.A. Antonini**, M.O. Diohaa, E. Virgüez, T.H. Ruggles, K. Caldeira "Stylized Analysis of the Value of Conventional and Pumped Hydropower Storage and Generation for Deeply Decarbonized Power Systems in California", **in preparation**.
- E. Virgüez, M. Dioha1, **E.G.A. Antonini**, L. Duan, A. Li, N. Reich, J. Dowling, N.S. Lewis, S.J. Davis, K. Caldeira, "Renewable Energy is Republican Energy", **in preparation**.
- **E.G.A. Antonini**, A. Di Bella, L. Drouet, M. Tavoni, "The role of hydropower in renewable-rich energy systems under climate change", **in preparation**.

PRESENTATIONS

Oral presentations

12. **E.G.A. Antonini**, A. Di Bella, L. Drouet, M. Tavoni, "The role of hydropower in renewable-rich energy systems under climate change", *International Energy Workshop*, Bonn, Germany, 2024.
11. **E.G.A. Antonini**, A. Di Bella, L. Drouet, M. Tavoni, "More than a century of weather- and climate-dependent power supply and demand time series", *Openmod Workshop*, Grenoble, France, 2024.
10. **E.G.A. Antonini**, E. Virgüez, S. Ashfaq, L. Duan, T.H. Ruggles, K. Caldeira, "Historical analysis of global distribution of and trends in wind droughts", *EGU General Assembly*, Vienna, Austria, 2023
9. **E.G.A. Antonini**, K. Caldeira, "Geophysical constraints to large wind farm development", *NAWEA/WindTech Conference*, University of Delaware, Newark, DE, USA, 2022.
8. **E.G.A. Antonini**, T. Ruggles, D.J. Farnham, K. Caldeira, "The quantity-quality transition in the value of expanding wind and solar power generation", *Macro Energy Systems workshop*, Stanford University, Stanford, CA, USA, 2022.
7. **E.G.A. Antonini**, T. Ruggles, D.J. Farnham, K. Caldeira, "Meeting US electricity demand with distributed wind and solar generation: System flexibility drives optimal siting", *ASME International Mechanical Engineering Congress and Exposition*, Virtual Conference, USA, 2021.
6. **E.G.A. Antonini**, K. Caldeira, "How atmospheric pressure gradients and Coriolis forces control the power density of large wind farms", *Wind Energy Science Conference*, Hannover, Germany, 2021.
5. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Computational-Fluid-Dynamics-based Methodology for Wind Farm Layout Optimization", *Seminar Series*, Carnegie Institution for Science, Stanford, CA, USA, 2018.
4. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Continuous Adjoint Formulation for Wind Farm Layout Optimization", 8th *MIE Symposium*, University of Toronto, Toronto, ON, Canada, 2017.
3. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Analysis and modifications of turbulence models for wind turbine wake simulations in atmospheric boundary layers", *ASME International Mechanical Engineering Congress and Exposition*, Phoenix, AZ, USA, 2016.
2. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Enhancement of CFD Wind Farm Simulations through Introduction of Wind Direction Uncertainty", 7th *MIE Symposium*, University of Toronto, Toronto, ON, Canada, 2016.
1. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Implementation and simulation of wind turbines with the OpenFOAM solver using the actuator disk approach", *6th MIE Symposium*, University of Toronto, Toronto, ON, Canada, 2015.

Poster presentations

12. **E.G.A. Antonini**, E. Virgüez, S. Ashfaq, L. Duan, T.H. Ruggles, K. Caldeira, "Historical analysis of global distribution of and trends in wind droughts", *International Conference on Energy and Meteorology*, Padova, Italy, 2023.
11. K. Caldeira, A. Li, E. Virgüez, **E.G.A. Antonini**, J.A. Dowling, L. Duan, M.O. Dioha, N. Reich, N.S. Lewis, S.J. Davis, T. Ruggles, S. Ashfaq, "A Macro Energy Modeling Framework For Transparent Analysis of Implications of Energy System Assumptions", *AGU Fall Meeting*, Chicago, IL, USA, 2022.
10. **E.G.A. Antonini**, E. Virgüez, S. Ashfaq, L. Duan, K. Caldeira, "Characterizing geophysical limits to wind power reliability", *AGU Fall Meeting*, Chicago, IL, USA, 2022.
9. **E.G.A. Antonini**, K. Caldeira, "Replenishing the wind: Atmospheric physics explains limits to energy extraction and spatial constraints in large-scale expansion of wind power plants", *AGU Fall Meeting*, New Orleans, LA, USA, 2021.
8. **E.G.A. Antonini**, T. Ruggles, D.J. Farnham, K. Caldeira, "Strategic site selection of wind and solar power plants in deep decarbonization scenarios for electricity systems", *AGU Fall Meeting*, New Orleans, LA, USA, 2021.
7. **E.G.A. Antonini**, K. Caldeira, "How atmospheric pressure gradients and Coriolis forces control the power density of large wind farms", *AGU Fall Meeting*, San Francisco, CA, USA, 2020.
6. M. Hauser, T. Ruggles, C. Henry, K. Caldeira, R. Peer, **E.G.A. Antonini**, "Cost Sensitivity of Electricity Systems to the Shape of Electricity Demand Curve: A Sub-Saharan Africa Example", *AGU Fall Meeting*, San Francisco, CA, USA, 2020.
5. T. Ruggles, D.J. Farnham, C. Henry, R. Peer, L. Duan, **E.G.A. Antonini**, M, Hauser, N. Lewis, J.A. Dowling, K. Rinaldi, S.J. Davis, D. Tong, K. Caldeira, "Electrofuels and curtailment of wind and solar power", *AGU Fall Meeting*, San Francisco, CA, USA, 2020.
4. **E.G.A. Antonini**, K. Caldeira, "Limits of electricity generation from wind: characterizing transitional scales in wind farm power density", *AGU Fall Meeting*, San Francisco, CA, USA, 2019.
3. O. Tayyara, **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "CFD modeling of after-market rotor attachments performance on horizontal axis wind turbines", 9th *MIE Symposium*, University of Toronto, Toronto, ON, Canada, 2018.
2. **E.G.A. Antonini**, D.A. Romero, C.H. Amon, "Continuous Adjoint Formulation for Wind Farm Layout Optimization", 9th *MIE Symposium*, University of Toronto, Toronto, ON, Canada, 2018.
1. D. Guirguis, S.Y.D. Yamani, **E.G.A. Antonini**, J.Y.J. Kuo, D.A. Romero, C.A. Amon, "Wake Modelling and Design Optimization of Wind Farms", *Institute of Sustainable Energy Research Symposium*, University of Toronto, Toronto, ON, Canada, 2016.

IN THE PRESS

- **Climate change, il rischio che cambino i venti**, *ANRA - Associazione Nazionale dei Risk Manager e Responsabili Assicurazioni Aziendali*, Jul 10, 2024 [link].
- **Discovering wind droughts and their impacts on energy supply**, *Foresight*, Jun 12, 2024 [link].
- **Where the wind blows for strong renewable energy investment**, *Nature Italy*, Apr 29, 2024 [link].
- **Study identifies where wind is most reliable for generating power**, *The Guardian*, Apr 18, 2024 [link].
- **Protecting self-driving cars from cosmic rays, size limits for wind farms**, *Physics World podcast*, Jul 29, 2021 [link].
- **Research finds optimal size for windfarms**, *The Guardian*, Jul 27, 2021 [link].
- **L'uomo del vento: "Così si ottimizza l'eolico"**, *La Repubblica*, Jul 09, 2021 [link].
- **Optimal size for wind farms is revealed by computational study**, *Physics World*, Jul 08, 2021 [link].

- **Come migliorare il rendimento dei grandi campi eolici del futuro**, *QualEnergia*, Jul 05, 2021 [link].
- **How to build a better wind farm**, *Science Daily*, Jun 28, 2021 [link].