Gaël Raymond Guédon

EDUCATION

University Degrees

September 2013 — **Ph.D. in Energy and Nuclear Science and Technology cum laude**
Department of Energy – Politecnico di Milano
Thesis title: *Two-phase heat and mass transfer modeling: flexible numerical methods for energy engineering analyses*
Supervisor: Prof. Fabio Inzoli
Keywords: Computational Fluid Dynamics (CFD), Phase change, Bubble dynamics, Interface tracking, Capillary forces

September 2009 — **Diplôme d'Ingénieur ENSIAME** (equivalent to Master of Science)
Industrial Engineering – Mechanics and Energetics
ENSIAME (école nationale supérieur d'ingénieurs)
University of Valenciennes, France

Other Education Experiences

Jun 2011 – Oct 2011 — **Visiting Ph.D. student – Roberto Rocca Fellow**
Computational Multi Fluid Dynamics Group
Massachusetts Institute of Technology – Department of Nuclear Science and Engineering (USA)
Supervisor: Prof. Jacopo Buongiorno

Sep 2008 – Feb 2009 — **M.Sc. student – Erasmus Fellow**
Politecnico di Milano – Department of Energy (Italy)
Main courses: CFD, HVAC, Solar energy, FEM, Thermal engineering

PROFESSIONAL AND ACADEMIC POSITIONS

Jul 2013 – Present — **Research Associate (limited-term) – Assegnista di Ricerca**
Politecnico di Milano – Department of Energy (Italy)
Research Project: "Modellazione numerica del trasporto multiphase per applicazioni nel settore energetico"
Main Activities: Design and construction of a bubble column experimental facility; Numerical modelling (CFD) of gas-liquid bubble columns; Development of numerical tools for the direct pore-scale simulation of multiphase transport processes in porous media.
Research group: CFDLab@Energy
Supervisor: Prof. Fabio Inzoli

Sep 2013 – Sep 2015 — **Adjunct Professor – Docente a Contratto**
Politecnico di Milano – Department of Energy (Italy)
"Thermodynamics and Heat Transfer (Fisica Tecnica ICA)" (8 CFU) Bachelor Degree in Civil and Environmental Engineering, Como/Lecco campuses

Jan 2010 – Jun 2013 — **Research Associate (limited-term) – Assegnista di Ricerca**
Politecnico di Milano – Department of Energy (Italy)
Research Project: "Modellazione del trasporto turbolento multiphase per applicazioni nel settore energetico"

Main Activities: Development of a lumped parameter model for the prediction of two-phase flow in a down-hole gas extraction pipe with application to an innovative gas purification process; Design and construction of a bubble column experimental facility; Numerical modelling (CFD) of gas-liquid bubble columns; Numerical investigation of two-phase heat and mass transfer in energy applications (Ph.D. thesis).
Research group: CFDLab@Energy
Supervisor: Prof. Fabio Inzoli

Mar 2009 – Aug 2009 **ENSIAME 3rd year internship**
Politecnico di Milano – Department of Energy (Italy)
Project: Implementation of a numerical model to analyse the hydrodynamic performances of vertical axis marine turbines
Supervisor: Prof. Fabio Inzoli

Sep 2007 – Jan 2008 **ENSIAME 2nd year internship**
DLR Lampoldshausen – Institute of Space Propulsion (Germany)
Project: Numerical simulation of hot gas flow and wall heat transfer in dual-bell nozzles using computational fluid dynamics
Supervisor: Ing. Chloé Génin

EDUCATIONAL ACTIVITIES

Academic Teaching

Sep 2015 – Present **Teaching Assistant**
Course: CFD for Energy Engineering, 8 CFU, SSD: ING-IND/10
Graduate course in Energy Engineering
Politecnico di Milano A.Y.
Lecturer: Prof. Fabio Inzoli
Academic years: 2015/2016, 2016/2017 and 2017/2018
Delivering ex-cathedra lessons, student support and hands-on trainings

Sep 2013 – Sep 2015 **Teacher**
Course: Fisica Tecnica (ICA), 8 CFU, SSD: ING-IND/10
Undergraduate course in Civil and Environmental Engineering
Politecnico di Milano
Academic years: 2013/2014 and 2014/2015
Delivering ex-cathedra lessons and hands-on trainings

Sep 2012 – Sep 2013 **Teaching Assistant**
Course: Fisica Tecnica (ICA), 8 CFU, SSD: ING-IND/10
Undergraduate course in Civil and Environmental Engineering
Politecnico di Milano
Lecturer: Prof. Fabio Inzoli
Academic years: 2012/2013
Delivering ex-cathedra lessons, student support and hands-on trainings

Sep 2009 – Sep 2011 **Teaching Assistant**
Course: Computational Fluid Dynamics for Engineering (Termo-fluidodinamica Computazionale per l'Ingegneria), 8 CFU, SSD: ING-IND/10
Graduate course in Energy Engineering
Politecnico di Milano – Department of Energy (Italy)
Lecturer: Prof. Emanuela Colombo – Prof. Fabio Inzoli
Academic years: 2009/2010 and 2010/2011
Delivering ex-cathedra lessons, student support and hands-on trainings

Other Educational Contributions

Sep 2014, Apr 2015 **Lecturer**
Courses:
- Introduction to CFD for Industrial Applications
- Advanced CFD Course on Multiphase Phenomena
EnginSoft, Bergamo (Italy)
Delivering ex-cathedra lessons for the industry

RESEARCH ACTIVITIES

Research Accomplishments

My research activities focus on the study of **multiphase transport phenomena**. In particular, my work at the CFDLab@Energy group of Politecnico di Milano has been mainly devoted to the numerical modelling of two-phase flow using open-source and commercial CFD codes.

My interest to the study of multiphase flow started during my PhD at CFDLab@Energy group of Politecnico di Milano. As a first case study, I developed a lumped parameter model for the prediction of **droplet/bubble entrainment** in counter-current two-phase flow in a vertical pipe representative of a gas extraction well. Eni SpA funded the project and the scope of the model was to determine the limiting flow rates of the gas and liquid phases of an innovative process for downhole gas purification. The study then lead to the development of a CFD modelling approach to study more in detail the two-phase flow phenomena that could occur in the system that typically operates at high pressures [C10, C11, P5]. Validation of the numerical model is still a challenge nowadays, due to the **elevated operating pressures** and dimensions of the system. Due to these limitations, an experimental facility at **atmospheric conditions** was initially designed and build in the next years. The facility consists of a vertical pipe in Plexiglas with internal pipes in PVC and can operate in counter-current or batch (**bubble column**) mode. In addition to the design of the facility and participation to the experimental campaigns, I was responsible of the development of the numerical methodology for the simulation of the gas-liquid two-phase flow. The results of the research were presented in several international conferences and published in renowned international peer-reviewed journals [J1, J3, J4, J7, C1, C2, C3, C4, C5, C6, B1].

My PhD thesis (2010-2013) focused on the fundamental study of heat and mass transfer through numerical simulation at the bubble/droplet scale, using interface-tracking methods. Despite the governing equations of **boiling and condensation** phenomena are well known nowadays, their numerical solution still represent a notorious challenge. In close collaboration with Prof. Jacopo Buongiorno Lab of MIT, I developed numerical methods within open-source codes to tackle some of the issues related to numerical simulation of boiling phenomena [C8, C9, P4].

A third research area developed in the past years is the study of **multiphase flow in porous media**. The interest started in 2012 with an Eni SpA funded project on the study of Water Alternating Gas **enhanced oil recovery** process. The research activities are part of a joint collaboration between the CFDLab@Energy group of Prof. Fabio Inzoli and the Groudwater group of Prof. Alberto Guadagnini of Politecnico di Milano. I am responsible of the **direct pore-scale simulation** of multiphase transport phenomena. I have developed a series of computer programs for the manipulation of porous media samples (3D images) and for the efficient automatic generation of computational meshes from the samples. Automating the whole process was a key factor in view of **statistical analyses**. I then developed simulation procedures for the simulation of steady-state two- and three-phase displacement processes mimicking the ones implemented during core-flooding experiments, for the determination of **relative permeabilities**. During the activities, several diverse computational techniques were investigated including (a) penalty immersed boundary, (b) finite volume method, (c) lattice Boltzmann method, (d) volume-of-fluid, (e) color-gradient, (f) capillary force filtering, (g) artificial interfacial viscosity. Heavy use of HPC facilities (Cineca and CFDHub@Polimi) was necessary to perform the simulations and related skills were acquired in this respect. Recent achievements, in close collaboration with Dr. Jeffrey Hyman of Los Alamos National Laboratory, include the development and use of stochastic pore-space generators leading to triply-

periodic domains, which are convenient to remove the influence of boundary conditions on the solution and are relevant for **upscaling techniques** such as homogenization. Application of such pore-space generation methodology for the upscaling of dilution and mixing in porous media is ongoing within a collaboration with Prof. Giovanni Porta of Politecnico di Milano and Prof. Diogo Bolster of University of Notre Dame. Results of the research activities were published in several international conferences and renowned international peer-reviewed journals [J2, J6, C7, P1, P2, P3].

Participation in Funded Research Projects

Oct 2015 – Present
Title: "Microscale modeling of multiphase flow in porous media – MicroFlow"
Customer: Eni SpA, P.I.: Prof. Alberto Guadagnini – Politecnico di Milano
Research contribution: development of numerical models and procedures for the simulation of two- and three-phase flow in porous media at the pore-scale considering steady-state displacement processes mimicking core flooding experiments

May 2011 – Apr 2014
Title: "Modellazione alla microscala e parametri effettivi per tecniche WAG"
Customer: Eni SpA, P.I.: Prof. Alberto Guadagnini – Politecnico di Milano
Research contribution: development of an efficient code for the mesh generation of reconstructed porous media from X-ray micro-tomography images; development of numerical models and procedures for the simulation of single-, two- and three-phase flow in porous media at the pore-scale

Nov 2012 – Nov 2013
Title: "Colonna di estrazione in giacimento: analisi del processo di assorbimento e dimensionamento"
Customer: Eni SpA, P.I.: Prof. Fabio Inzoli – Politecnico di Milano
Research contribution: design of the experimental facility, participation to the experimental campaigns and post-processing of the data; development of the CFD model of the experimental facility

Nov 2011 – Nov 2012
Title: "Operational proposal for the design of a fluidized bed oven for the regeneration of waste foundry sand"
Customer: SIMI Srl, P.I.: Prof. Fabio Inzoli – Politecnico di Milano
Research contribution: development of a CFD model for the simulation of the fluidized bed oven and analysis of the results to propose an optimized design

Dec 2009 – Dec 2010
Title: "Valutazione di un processo innovativo di separazione di gas acidi mediante assorbimento nel tubing"
Customer: Eni SpA, P.I.: Prof. Fabio Inzoli – Politecnico di Milano
Research contribution: development of a lumped parameter model for the estimation of flow limitation in counter-current two-phase flow in a downhole vertical pipe for an innovative acid gas separation process

May 2009 – Nov 2009
Title: "Outflow channels requalification of Edipower power station in Brindisi, Italy"
Customer: Edipower SpA, P.I.: Prof. Fabio Inzoli – Politecnico di Milano
Research contribution: development of a CFD model of the outlet channels of the power station and verification of the performances of the proposed design

Participation in Granted Research Projects

Jul 2018 – Jul 2019 Title: "A computational approach to characterize effective transport parameters of two-phase flows in porous media (Flo-Tran)"
Grant Holder: Cineca (ISCRA project B), Budget: 3 500 000 core hours
Research contribution: as PI of the project I am responsible for all the activities to be performed, including the development and testing of the numerical solver, the running and post-processing of the simulations, and the dissemination of the research results

Dec 2016 – Mar 2018 Title: "Pore-scale modeling of multiphase flow in synthetic and real X-ray imaged rock samples (PoreFlow)"
Grant Holder: Cineca (LISA program), Budget: 1 800 000 core hours
Research contribution: as CO-PI of the project, I developed and consolidated the numerical models used for the study and manage the running and post-processing of the simulations

Participation in International Research Collaborations

Jun 2015 – May 2018 Title: "Furthering the knowledge base for reducing the environmental footprint of shale gas development (FracRisk)"
European Union's Horizon 2020 Research and Innovation programme
Grant Agreement No. 636811
Research contribution: activities related to the study of two-phase flow in porous media achieved in collaboration with the Groundwater group of Prof. Alberto Guadagnini of Politecnico di Milano contributed to the research project knowledge base and dissemination

Jun 2011 – Sep 2013 Title: "CASL – The Consortium for Advanced Simulation of Light Water Reactors"
U.S. Department of Energy Innovation Hub
Research contribution: activities related to the simulation of nucleate pool boiling achieved during the PhD thesis, in collaboration with Prof. Jacopo Buongiorno Lab of MIT, participated to the project

PUBLICATIONS

International Journals (ISI WoS-Scopus)

J1. G. Besagni, **G. R. Guédon**, and F. Inzoli (2018).
Computational fluid-dynamic modeling of the mono-dispersed homogeneous flow regime in bubble columns.
Nuclear Engineering and Design, vol. 331, pp. 222–237.
doi: 10.1016/j.nucengdes.2018.03.003

J2. **G. R. Guédon**, J. D. Hyman, F. Inzoli, M. Riva, and A. Guadagnini (2017).
Influence of capillary end effects on steady-state relative permeability estimates from direct pore-scale simulations.
Physics of Fluids, 29(12):123104.
doi: 10.1063/1.5009075

J3. **G. R. Guédon**, G. Besagni, and F. Inzoli (2017).
Prediction of gas–liquid flow in an annular gap bubble column using a bi-dispersed Eulerian model.
Chemical Engineering Science, 161:138–150.
doi: 10.1016/j.ces.2016.12.015

J4. G. Besagni, **G. R. Guédon**, and F. Inzoli (2016).
Annular gap bubble column: experimental investigation and computational fluid dynamics modeling.
Journal of Fluids Engineering, Transactions of the ASME, 138:011302(1–15).
doi: 10.1115/1.4031002

J5. M. Colombo, A. Cammi, **G. R. Guédon**, F. Inzoli, and M. E. Ricotti (2015).
CFD study of an air–water flow inside helically coiled pipes.
Progress in Nuclear Energy, 85:462–472.
doi: 10.1016/j.pnucene.2015.07.006

J6. M. Siena, J. D. Hyman, M. Riva, A. Guadagnini, C. L. Winter, P. K. Smolarkiewicz, P. Gouze, S. Sadhukhan, F. Inzoli, **G. R. Guédon**, and E. Colombo (2015).
Direct numerical simulation of fully saturated flow in natural porous media at the pore scale: a comparison of three computational systems.
Computational Geoscience, 19(2):423–437.
doi: 10.1007/s10596-015-9486-7

J7. G. Besagni, **G. R. Guédon**, and F. Inzoli (2014).
Experimental investigation of counter current air-water flow in a large diameter vertical pipe with inners.
Journal of Physics: Conference Series, 547(1):012024.
doi: 10.1088/1742-6596/547/1/012024

Proceedings of International or National Peer-Reviewed Conferences

C1. G. De Guido, L. A. Pellegrini, S. Gamba, F. Inzoli, and **G. R. Guédon** (2015).
Thermodynamic issues in downhole sour gas purification by water scrubbing.
In Offshore Mediterranean Conference & Exhibition OMC 2015, Ravenna, Italy, 2015.
ISBN: 0788894043648 (ISI WoS indexed)

C2. G. Besagni, **G. R. Guédon**, and F. Inzoli (2014).
Experimental and numerical study of counter-current flow in a vertical pipe.
In ASME 2014 12th Biennial Conference on Engineering Systems Design and Analysis.
doi: 10.1115/ESDA2014-20122.
ISBN: 978-0-7918-4584-4 (ISI WoS and Scopus indexed)

C3. G. Besagni, **G. R. Guédon**, and F. Inzoli (2014).
Two-phase counter-current flow in a large diameter vertical pipe with internal pipes: experiments and numerical simulations.
In 13th International Conference on Multiphase Flow in Industrial Plants, Sestri Levante, Italy

C4. G. Besagni, **G. R. Guédon**, and F. Inzoli (2014).
Numerical modeling of bubbly flow in square column.
In 13th International Conference on Multiphase Flow in Industrial Plants, Sestri Levante, Italy

C5. G. Besagni, **G. R. Guédon**, and F. Inzoli (2014).
Experimental investigation of counter current air-water flow in a large diameter vertical pipe with inners.
In 32nd UIT Heat Transfer Conference, Pisa, Italy.
doi: 10.1088/1742-6596/547/1/012024.
ISBN: 978-884673997-1 (ISI WoS indexed)

C6. G. Besagni, **G. R. Guédon**, and F. Inzoli (2014).
The Eulerian-Eulerian approach for reactor design: a case study.
In ANSYS UGM 2014.
Best Paper Award

C7. M. Siena, A. Guadagnini, M. Riva, P. Gouze, P. K. Smolarkiewicz, C. L. Winter, J. D. Hyman, F. Inzoli, **G. R. Guédon**, and E. Colombo (2013).
A comparison of body-fitted and immersed boundary methods for pore-scale modeling of fully saturated flow in synthetic porous media.
In Groundwater Modeling and Management under Uncertainty: Proceedings of the Sixth IAHR International Groundwater Symposium, Kuwait, pages 241–249, 2013.
doi: 10.1201/b13167-37.
ISBN: 978-1-138-00012-4 (ISI WoS indexed)

C8. **G. R. Guédon**, R. Mereu, F. Inzoli, E. Colombo, and J. Buongiorno (2012).
Implementation of a ghost fluid method in a tree-based adaptive volume of fluid solver for two-phase heat and mass transfer.
In Proc. of the 8th ECI International Conference, Lausanne, Switzerland, 2012

C9. R. Mereu, **G. R. Guédon**, F. Inzoli, E. Colombo, and J. Buongiorno (2012).
Validation of a ghost fluid method in a tree-based adaptive volume of fluid solver for two-phase heat and mass transfer.
In Proc. of the 8th ECI International Conference, Lausanne, Switzerland, 2012

C10. **G. R. Guédon**, E. Colombo, and F. Inzoli (2011).
Numerical investigation of countercurrent two-phase flows using three-dimensional volume-of-fluid simulations.
In Proc. of the ASME-JSME-KSME 2011 Joint Fluids Engineering Conference, Hamamatsu, Japan, 2011.
doi: 10.1115/AJK2011-03051.
ISBN: 978-0-7918-4440-3 (Scopus indexed)

C11. **G. R. Guédon**, E. Colombo, and F. Inzoli (2011).
Comparison between the volume-of-fluid and Eulerian two-fluid methods for the numerical simulation of counter-current two-phase flow.
In Proc. of the XXIX UIT Heat Transfer Conference, Torino, Italy, 2011.
ISBN: 978-88467-3072-5

C12. **G. R. Guédon**, E. Colombo, and F. Inzoli (2010).
Numerical analysis of vertical axis marine currents turbines: An U-RANS turbulence modeling.
In Proc. of the ASME-ATI-UIT Conference, Sorrento, Italy, 2010.
ISBN: 978-88467-2659-9

Conference Presentations

P1. **G. R. Guédon**, P. Lurati, F. Inzoli, M. Riva and A. Guadagnini (2018).
Effects of wettability on two-phase relative permeability estimates from direct pore-scale simulations.
InterPore 10th Annual Meeting and Jubilee, May 14–17 2018, New Orleans, USA.
Poster presentation

P2. **G. R. Guédon**, J. D. Hyman, F. Inzoli, M. Riva, and A. Guadagnini (2018).
Capillary end effects and their impact on pore-scale steady-state relative permeability data.
European Geoscience Union General Assembly, April 8–13 2018, Vienna, Austria.
Oral presentation

P3. **G. R. Guédon**, J. D. Hyman, F. Inzoli, M. Riva, and A. Guadagnini (2017).
Impact of boundary conditions on the assessment of two-phase relative permeabilities from pore-scale numerical simulations.
InterPore 9th International Conference on Porous Media & Annual Meeting, May 8–11 2017, Rotterdam, The Netherlands.
Poster presentation

P4. **G. R. Guédon**, R. Mereu, F. Inzoli, E. Colombo, and J. Buongiorno (2012).
Implementation of a ghost fluid method in a tree-based adaptive volume of fluid solver for two-phase heat and mass transfer.
ECI 8th International Conference on Boiling and Condensation Heat Transfer, June 3-7 2012, Lausanne, Switzerland.
Poster presentation

P5. **G. R. Guédon**, E. Colombo, and F. Inzoli (2011).
Numerical investigation of countercurrent two-phase flows using three-dimensional volume-of-fluid simulations.
ASME-JSME-KSME 2011 Joint Fluids Engineering Conference, July 24–29 2011, Hamamatsu, Japan.
Oral presentation

P6. **G. R. Guédon**, E. Colombo, and F. Inzoli (2010).
Numerical analysis of vertical axis marine currents turbines: An U-RANS turbulence modeling.
ASME-ATI-UIT Conference, 16–19 May 2010, Sorrento, Italy.
Oral presentation

Book Chapters

B1. G. Besagni, **G. R. Guédon**, and F. Inzoli (2015).
Innovabook 2015. Paper anthology. Fluidodinamica, meccanica, elettromagnetismo, chapter The Eulerian-Eulerian approach for reactor design: a case study, pages 17–40.
Cobalto Casa Editrice, 2015.
ISBN: 978-88-905591-2-9

Invited Lectures

L1. Numerical simulation of phase change phenomena.
UPMC – Institut Jean le Rond d'Alembert, Paris, February 4 2014.
Invited by Dr. Stéphane Popinet and Prof. Stéphane Zaleski

Journal Reviewer

R1. Physics of Fluids (ISSN: 1089-7666)

R2. Water Resources Research (ISSN: 1944-7973)

R3. Transport in Porous Media (ISSN: 1573-1634)

R4. Computing in Science & Engineering (ISSN: 1521-9615)

R5. Canadian Journal of Chemical Engineering (ISSN: 1939-019X)

R6. Experimental Thermal and Fluid Science (ISSN: 0894-1777)

AFFILIATIONS

Feb 2018 – Present **Member** of the European Geosciences Union – **EGU** affiliation number **433213**

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