

ANTONIO VALERO CAPILLA

Emeritus Professor of Thermal Engineering | Univ. of Zaragoza

Thermodynamics of Sustainability • Thermoeconomics • Critical Raw Materials

PERSONAL DETAILS

Date of birth	20 November 1951	Place of birth	Zaragoza, Spain
Nationality	Spanish	ORCID	0000-0003-0702-733X
Current position	Emeritus Professor, Univ. of Zaragoza	Research profile	janovas.unizar.es/sideral/CV/antonio-valero-capilla

EDUCATION

1978	PhD in Physical Chemistry and Crystallography, Univ. of Zaragoza. First Extraordinary Doctorate and First Extraordinary Postgrade Award (1974). (2007)
1976	Visiting Scholar in Quantum Physical-Chemistry, University of Oxford.
1977	Visiting Researcher at the CSIC Rocasolano Institute in Madrid.

PROFESSIONAL EXPERIENCE

Apr. 2022–present	Emeritus Professor of Thermodynamics, University of Zaragoza, School of Engineering and Architecture. Institute ENERGAIA
2002–2021	Elected Director of CIRCE Inst. a Mixed Institution between Zaragoza Univ. and CIRCE Foundation (Subsequently ENERGAIA Inst.)
1993–2016	Founder with ENDESA, Govern of Aragon and Univ. Zaragoza. Director General of CIRCE Foundation. Centre of Research for Energy Resources and Consumption.
1986–2022	Full Professor of Thermal Engines and Thermodynamics, School of Engineering and Architecture. Univ. Zaragoza
1982-1986	Associate Prof. of Thermodynamics and Physical-Chemistry, School of Engineering and Architecture. Univ. Zaragoza

RESEARCH PROFILE AND LEADERSHIP

Research focus. Exergy analysis and simulation of electric power plants. Exergy cost theory, Structural theory of energy systems. Exergy-based assessment of natural resources, mineral depletion, critical raw materials, circular economy, soil fertility, and the material requirements of the energy transition.

Leadership and supervision. Director and creator of CIRCE Foundation. Principal investigator of many European, national, regional, industrial and NGO projects; more than 40 completed PhD. theses co-supervised; more than 200 scientific publications and book chapters. Honorary prof. at North China Electric Power University.

Selected scientific and policy service. Member of the Energy Working Group under the European Seventh Framework Programme. Vice-Chair of the European Platform for Zero-Emission Power Plants (ETPZEP). Manager for the national energy R&D programme from January 2003 to March 2008, Spanish Directorate-General for Research. President of the Aragón Energy Council (1996–1999). Member of the Management Board Committee of ICARE at Huazhong University of Science and Technology in Wuhan (China) (2010 -2016). The China-EU Institute for Clean and Renewable Energy. Chair of the ECOS Intl. Soc. Committee for the Development of Thermodynamics for Sustainability. (2025)

SELECTED BOOKS AND SCIENTIFIC CONTRIBUTIONS

SELECTED BOOKS

1. Valero, A., Valero, A. & Calvo, G. (2021). **The Material Limits of Energy Transition: Thanatia**. Springer Nature. A comprehensive synthesis of the thermodynamic foundations of mineral scarcity and of the material constraints, bottlenecks and geopolitical implications of the energy transition.
2. Valero, A. & Valero, A. (2014). **Thanatia: The Destiny of the Earth's Mineral Resources**. World Scientific / Imperial College Press. The foundational monograph presenting Thanatia as a thermodynamic reference state for evaluating the depletion of the Earth's mineral capital.
3. Valero A. Torres C. **Advances in Thermodynamics and Circular Thermoeconomics : Fundamentals and Criteria**. Dec, 2023. Publ. ISTE-Wiley. ISBN: 978-1-394-26486-5, 272 pgs. Edit by Michael Feidt y Antonio Valero.

SELECTED ARTICLES

1. Valero, Ant.; Lozano, M. A.; Serra, L.; Torres, C.(1994) “ Application of the Exergetic Cost Theory to the CGAM Problem”. Energy. 19 - 3, pp. 365 - 381. 1994. ISSN 0360-5442
2. Lozano, M. A.; Valero, A. Theory of the Exergetic Cost. (1993) Energy. 18 - 9, pp. 939 - 960. 1993. ISSN 0360-5442
3. Valero, Ant.; Torres, C.;(2023) “Application of Circular Thermoeconomics to the Diagnosis of Energy Systems”. Energies, 16, 6751. <https://doi.org/10.3390/>
4. Valero, Ant ; Valero, A.; Cuadra, C. (2024). “Expanding the horizons of thermoeconomics: Insights from the School of Zaragoza”. Energy, 313,. <https://doi.org/10.1016/j.energy.2024.134034>
5. Valero, Ant.; Valero, A. (2019) “Thermodynamic Rarity and Recyclability of Raw Materials in the Energy Transition:The Need for an In-Spiral Economy”. ENTROPY. 21 - 9, pp. 873 [14 pp]. ISSN 1099-4300. DOI: 10.3390/e21090873
6. Calvo, G., Valero, A. & Valero, A. (2018). “Thermodynamic approach to evaluate the criticality of raw materials and its application through a material flow analysis in Europe.” Journal of Industrial Ecology 22(4), 839–852.
7. Valero, A., & Valero, A. (2025). “Thermodynamics for sustainability: Twelve prescriptions to the economy”. Proceedings of the 38th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems (ECOS 2025). <https://doi.org/10.5281/zenodo.17396320>
8. Valero, A., Palacino, B., Ascaso, S. & Valero, A. (2022). “Exergy assessment of topsoil fertility.” Ecological Modelling 464, 109802. Extended exergy-based natural-capital accounting from mineral resources to fertile soils.
9. Torres, Cat., Valero, A., Valero, Ant. & Naredo, J. M. (2025). “Squaring the circle of the circular economy.” Ecological Economics 240, 108817. Demonstrated the need to include resource quality and scarcity in circular-economy accounting.

RESEARCH LEADERSHIP AND SELECTED IMPACT

Research leadership. Principal investigator and scientific coordinator in European, national and regional projects on thermodynamic resource accounting, critical raw materials, circular economy, resource efficiency and the material requirements of the energy transition.

Methodological contributions. Co-developer of Thanatia and the Exergy Replacement Cost methodology; extension of exergy-based natural-capital accounting to soil fertility and regeneration; development of indicators linking resource quality, depletion, circularity and planetary sustainability.

Policy and standardisation. Scientific contributions to Spain's Roadmap for the Sustainable Management of Mineral Raw Materials, the UN Digital Economy Report 2024 and CWA 17898:2022 on exergy-based assessment of agroecosystems and soil degradation.

Teaching and supervision. University teaching in thermodynamics, energy efficiency, renewable energies and sustainability; forty completed doctoral theses co-supervised; international teaching collaboration with TU Berlin.

SELECTED AWARDS AND RECOGNITION

2026	Nicholas Georgescu-Roegen Award for Best Paper and Presentation, 39th ECOS Conference.
2016	Stanisław Ocheduszek Medal by the Silesian University of Technology (Poland) in 2016
2015-2017	Full Member of the International Club of Rome (2017–Present). And Member of the Board of Directors of the Spanish Chapter of the Club of Rome (2015-Present)
2006	Fellow of American Society of Mechanical Engineers (ASME).
1997	Honorary Professor, North China Electric Power University, Beijing
1996	ASME James Harry Potter Gold Medal Award.
1987-2011	Seven Best paper awards: 4 ASME Edward F. Obert Awards:1987,1988,1989,2003. And three: ECOS 2014, Finland, SDEWES 2011,Croatia, SDIMI 2011,Aachen.

ADDITIONAL PROFESSIONAL RECOGNITION

Invited keynote speaker at international conferences in thermodynamics and energy systems in USA, Mexico, Colombia, Equator, Argentina, Brazil, Chile, Germany, France, Italy, Belgium, Netherlands, Croatia, Serbia, Poland, Romania, Greece, Denmark, Norway, Sweden, Finland, Great Britain, Turkey, Russia, South Africa, China, Japan, etc; invited presentations at the European Economic and Social Committee and the Club of Rome Intl..

Science communication. Many invited outreach talks per year for industry, public administrations, NGOs, policymakers, students and citizens.