

16th IIR-Gustav Lorentzen Conference on Natural Refrigerants



August 11–14, 2024

University of Maryland • College Park, Maryland, USA

Natural Refrigerants for the Present and the Future



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16th IIR-Gustav Lorentzen Conference on Natural Refrigerants



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Scientific Committee and Organizing Committee



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Refrigeration
NTNU, Norway

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University of Maryland

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Welcome



Dear Colleagues and Attendees,

As our planet grapples with the escalating climate crisis—marked by rising temperatures and increasing demands for cooling solutions and decarbonizing heating solutions—the need for innovative and sustainable technologies has never been more urgent. The 16th Gustav Lorentzen Conference on Natural Refrigerants serves as a vital platform for confronting this global challenge.

Hosted by the Center for Environmental Energy Engineering (CEEE) at the University of Maryland, this conference reflects our commitment to pioneering sustainable cooling technologies. The CEEE's dedicated researchers are at the forefront of developing environmentally friendly alternatives to conventional refrigerants and heating and cooling systems. We are honored to host this prestigious event and to advance the dialogue on these critical issues.

This year's conference theme, "Natural Refrigerants for the Present and the Future," addresses a pressing question: How can we meet the increasing demand for cooling and heating systems while mitigating our impact on the climate?

With over 200 research abstracts submitted, we are thrilled to present 140 innovative papers that explore advancements in natural refrigerants, covering topics such as heat transfer, components, systems, safety, controls, and life cycle analysis. We extend our heartfelt gratitude to the authors for their exceptional contributions, as well as to the session chairs and volunteers whose efforts have made this program possible.

Thank you for your participation and engagement in this crucial discussion.

Sincerely,

The Organizing Committee

Yunho Hwang, Co-Director, Center for Environmental Energy Engineering

Vikrant Aute, Co-Director, Center for Environmental Energy Engineering

Reinhard Radermacher, Director & Co-Founder, Center for Environmental Energy Engineering



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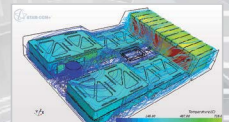
Electric Compressor R744, R290



2 Layer HVAC Exploded View



Thermal Management System with Waste Heat Recovery



Battery Management System

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Plenary Speakers | Monday



Björn Palm

Monday | 8:30 am

Hydrocarbon Heat Pumps - a European Perspective

Björn Palm, Ph.D., is senior professor in energy technology at KTH, Royal Institute of Technology, in Stockholm, Sweden, where he headed the Division of Applied Thermodynamics and Refrigeration for over 20 years. His research covers components and systems for heat pumps and refrigeration systems, from microstructures of boiling surfaces, to combinations of heat pumps and thermal energy storage for load shifting in the energy system. A special interest has been the application of natural refrigerants like hydrocarbons and carbon dioxide, and the use of ammonia in small systems.

Dr. Palm will speak about "Hydrocarbon Heat Pumps - a European Perspective." The phaseout of fossil fuels is necessary to reach the Paris Agreement goals and to limit global warming to acceptable levels. An important consequence is the electrification of the heating sector, which will force a rapid increase in the use of heat pumps. This presentation will discuss the background and the development of the heat pump market from a European perspective. New restrictions on F-gases, possible bans of all PFAS-substances and the response from the heat pump market in Europe will also be covered.



Eric M. Smith

Monday | 9:15 am

IIAR's Role in the Safe and Efficient Use of Natural Refrigerants

Eric M. Smith, P.E., is Vice President and Technical Director of The International Institute of All-Natural Refrigeration (IIAR). His main responsibilities include management of standards and guidelines development, consultation and assistance to IIAR committees, initiation and coordination of research projects, regulatory outreach, and advocacy.

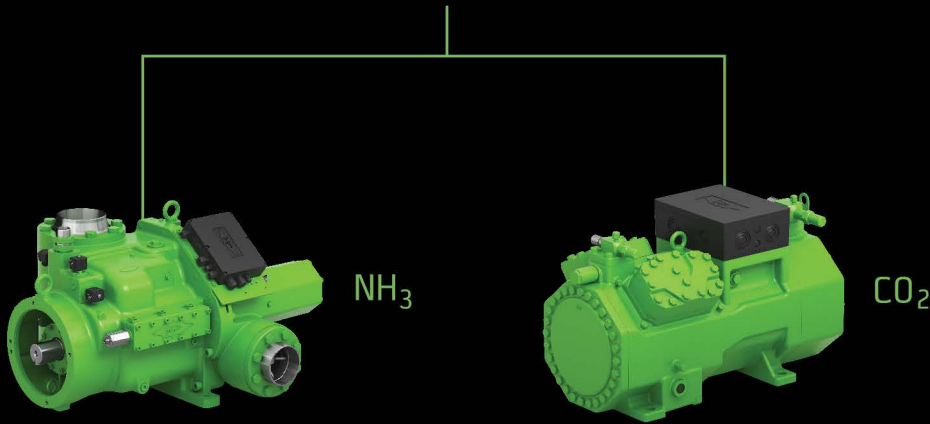
His presentation will provide an "Overview of IIAR's Role in the Safe and Efficient Use of Natural Refrigerants." IIAR is a nonprofit professional society and trade association dedicated to the safe use of natural refrigerants such as ammonia, carbon dioxide and propane. IIAR develops and maintains ANSI standards that are directly referenced by building codes and are recognized and generally accepted as good engineering practices by the industry and regulatory agencies. IIAR offers many other guidelines and educational opportunities related to safety, efficiency and other best practices in the use of natural refrigerants.



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Natural Refrigerants**

*Providing Standards & Guidelines, Educational Materials and
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www.iiar.org

Plenary Speakers | Tuesday



Hannes Fugmann

Tuesday | 8:30 am

R290 Heat Pump Developments in Europe - Technologies and Safety Measures

Hannes Fugmann, Ph.D., heads the Vapor Compression Technology group at the Fraunhofer Institute for Solar Energy Systems in Freiburg, Germany. His research primarily centers on developing compact and efficient heat exchangers for heating and air conditioning applications. Additionally, Dr. Fugmann is dedicated to innovating charge-reduced refrigerant circuits for heat pumps, with a particular emphasis on using propane as a refrigerant. He also is deeply involved in ensuring the safety of heat pump systems, addressing the risks associated with natural, but flammable refrigerants.

Dr. Fugmann will speak about "R290 Heat Pump Developments in Europe - Technologies and Safety Measures." Heat pumps using R290 (propane) are increasingly being installed in the residential sector in Europe. The development of R290 heat pumps is linked to European regulations, such as the regulation on fluorinated greenhouse gasses, and on national funding for installation. R290 is efficient and climate-friendly, but manufacturers must address the flammability. Dr. Fugmann will share some of the safety concepts used in Europe and discuss methods for evaluation.



Zahid Ayub

Tuesday | 9:15 am

Prospects of Aggressive Use of Natural Refrigerants

Zahid Ayub, Ph.D., P.E., is president of Isotherm, Inc., a manufacturer of heat transfer equipment and systems. Dr. Ayub has designed and fabricated several thousand heat exchangers/pressure vessels and systems installed worldwide. He is recognized as one of the pioneers in the field of Ammonia Enhanced Heat Transfer.

Dr. Ayub will speak about the "Prospects of Aggressive Use of Natural Refrigerants." He'll discuss how time-tested natural refrigerants can fill in for synthetic refrigerants. Ammonia's track history spans over 100 years. The use of carbon dioxide as a refrigerant is on the rise. Both of these natural refrigerants have their pros and cons. The idea is to manage the cons and develop components that would result in compact and efficient systems. This presentation offers a bird's eye view on the topic, covering current developments and the future outlook.



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Program at a Glance



SUNDAY, AUGUST 11

4:00 PM Registration | 4:00-7:00 PM

6:00 PM Welcome Reception | 6:00-8:00 PM

MONDAY, AUGUST 12

7:00 AM Registration | 7:00 AM-4:00 PM

7:30 AM Breakfast

8:00 AM Opening Ceremony

8:30 AM Plenary Speaker Björn Palm, KTH

9:15 AM Plenary Speaker Eric M. Smith, IAR

10:30 AM **A1: Refrigerants 1: CO2/HC**
B1: Components-Heat Exchanger 1
C1: Components-Compressor 1
D1: Heat Transfer

12:00 N Lunch

1:00 PM **A2: Systems 1: CO2**
B2: Components-Ejector
C2: Modeling 1
D2: Modeling 2

3:00 PM IIR Commission B1/B2 Meeting

4:00 PM Excursions to Washington, DC

TUESDAY, AUGUST 13

7:00 AM Registration | 7:00 AM-10:00 AM

7:30 AM Breakfast

8:30 AM Plenary Speaker Hannes Fugmann,
Fraunhofer Institute for Solar Energy
Systems

9:15 AM Plenary Speaker Zahid Ayub, Isotherm

10:30 AM **A3: Refrigerants 2: HCs**
B3: Components-Heat Exchanger 2
C3: Components-Compressor 2
D3: Not-In-Kind 1

12:00 N Lunch

1:00 PM **A4: Systems 2: HCs**
B4: Components-Heat Exchanger 3
C4: Modeling 3
D4: Refrigerant Safety

3:30 PM **A5: Systems 3: Natural Refrigerants**
B5: Systems 4: HTHP 1
**C5: Workshop: Decarbonization Through Adopting
Low-GWP Refrigerants**
D5: Thermal Management & CFD Analysis

6:00 PM Conference Banquet | 6:00-9:00 PM

WEDNESDAY, AUGUST 14

7:30 AM Breakfast

8:00 AM **A6: Systems 5: District Heating**
B6: Systems 6: HTHP 2
C6: Field Testing
D6: Market Analysis

10:30 AM **A7: Systems 7: Transport**
B7: Measuring Methods
C7: Operations & Controls
D7: Not-In-Kind 2

12:00 N Lunch & Closing Ceremony

1:00 PM Lab Tours | 1:00-2:30 PM

To access the
mobile app for the
Gustav Lorentzen
Conference, please
use this QR code:



Conference Schedule



Sunday

4:00 pm-7:00 pm **Conference Registration** | First Floor Entryway, Edward St. John

6:00 pm-8:00 pm **Welcome Reception** | First Floor Hallway, Edward St. John

Monday

7:00 am-4:00 pm **Conference Registration** | First Floor Entryway, Edward St. John

7:30 am-8:30 am **Breakfast** | First Floor Hallway, Edward St. John

8:00 am-8:30 am **Conference Opening Ceremony** | Ground Floor, Room 0202, Edward St. John

8:30 am-9:15 am **Plenary Speaker: Björn Palm** | Ground Floor, Room 0202, Edward St. John

9:15 am-10:00 am **Plenary Speaker: Eric M. Smith** | Ground Floor, Room 0202, Edward St. John

10:00 am-10:30 am **Coffee Break** | First Floor Hallway, Edward St. John

ESJ, Room 0202

ESJ, Room 1224

ESJ, Room 1202

ESJ, Room 1215

10:30 am-12:00 noon

Session A1
Refrigerants 1: CO2/HC

Session B1
Components-Heat Exchanger 1

Session C1
Components-Compressor 1

Session D1
Heat Transfer

12:00 noon-1:00 pm **Lunch** | Colony Ballroom, Stamp Union

ESJ, Room 0202

ESJ, Room 1224

ESJ, Room 1202

ESJ, Room 1215

1:00 pm-3:00 pm

Session A2
Systems 1: CO2

Session B2
Components-Ejector

Session C2
Modeling 1

Session D2
Modeling 2

3:00 pm-4:00 pm **Coffee Break** | First Floor Hallway, Edward St. John

3:00 pm-4:00 pm **IIR Commission B1/B2 Meeting** | Room 1309, Edward St. John

4:00 pm-9:00 pm **Excursions to Washington, DC** | Meet buses in Regents Drive Garage, 8056 Regents Drive

Conference Schedule



Tuesday

7:00 am-10:00 am	Conference Registration First Floor Entryway, Edward St. John			
7:30 am-8:30 am	Breakfast First Floor Hallway, Edward St. John			
8:30 am-9:15 am	Plenary Speaker: Hannes Fugmann Ground Floor, Room 0202, Edward St. John			
9:15 am-10:00 am	Plenary Speaker: Zahid Ayub Ground Floor, Room 0202, Edward St. John			
10:00 am-10:30 am	Coffee Break First Floor Hallway, Edward St. John			
	ESJ, Room 0202	ESJ, Room 1224	ESJ, Room 1202	ESJ, Room 1215
10:30 am-12:00 noon	Session A3 Refrigerants 2: HCs	Session B3 Components-Heat Exchanger 2	Session C3 Components-Compressor 2	Session D3 Not-in-Kind 1
12:00 noon-1:00 pm	Lunch Colony Ballroom, Stamp Union			
	ESJ, Room 0202	ESJ, Room 1224	ESJ, Room 1202	ESJ, Room 1215
1:00 pm-3:00 pm	Session A4 Systems 2: HCs	Session B4 Components-Heat Exchanger 3	Session C4 Modeling 3	Session D4 Refrigerant Safety
3:00 pm-4:00 pm	Coffee Break First Floor Hallway, Edward St. John			
	ESJ, Room 0202	ESJ, Room 1224	ESJ, Room 1202	ESJ, Room 1215
3:30 pm-5:30 pm	Session A5 Systems 3: Natural Refrigerants	Session B5 Systems 4: HTHP 1	Session C5 Workshop: Decarbonization	Session D5 Thermal Mgmt & CFD Analysis
6:00 pm-9:00 pm	Conference Banquet Colony Ballroom, Stamp Union			

Wednesday

7:30 am-8:30 am	Breakfast First Floor Hallway, Edward St. John			
	ESJ, Room 0202	ESJ, Room 1224	ESJ, Room 1202	ESJ, Room 1215
8:00 am-10:00 am	Session A6 Systems 5: District Heating	Session B6 Systems 6: HTHP 2	Session C6 Field Testing	Session D6 Market Analysis
10:00 am-10:30 am	Coffee Break First Floor Hallway, Edward St. John			
	ESJ, Room 0202	ESJ, Room 1224	ESJ, Room 1202	ESJ, Room 1215
10:30 am-12:00 noon	Session A7 Systems 7: Transport	Session B7 Measuring Methods	Session C7 Operations & Controls	Session D7 Not-in-Kind 2
12:00 noon-1:00 pm	Lunch and Closing Ceremony Colony Ballroom, Stamp Union			
1:00 pm-2:30 pm	Lab Tours Meet in Colony Ballroom			

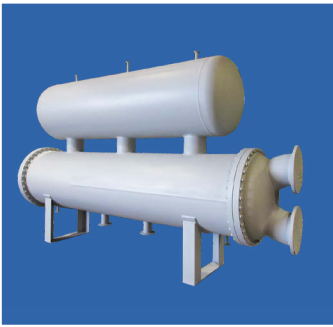
INDUSTRIAL REFRIGERATION



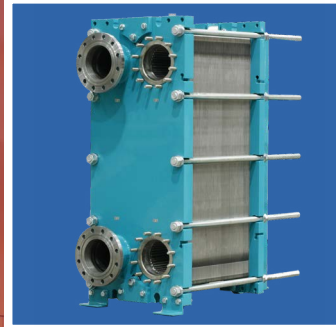
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**Low Charge
Vertical Evaporator**



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Heat Exchanger**



**Plate and Frame
Heat Exchanger**



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Transfer, etc)**



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Tours of UMD Engineering Labs



Wednesday August 14 | 1:00-2:30 pm
Meet at Colony Ballroom, Stamp Union

Get an insider's look at how University of Maryland researchers are developing the next generation of eco-friendly heating, ventilation, air conditioning and refrigeration (HVAC&R) technologies to help slow climate change. See where our researchers are creating advanced heat transfer technologies, solid-state refrigerants with zero global warming potential and more. You'll also visit the fire protection laboratories used to test flammable refrigerants.



Daikin Energy Innovation Laboratory

The Daikin Energy Innovation Laboratory is a 3,600 square foot state-of-the-art facility that features the latest equipment for energy engineering, including flame resistant climate chambers, heat transfer measurement technologies and facilities for experimental alternative cooling technologies. See where our researchers are developing elastocaloric cooling devices that offer a solid-state alternative to vapor-compression technology by using shape memory alloys as refrigerants. The lab is run by the university's Center for Environmental Energy Engineering (CEEE).

George E. Dieter, Jr. Materials Instructional Lab

At the Dieter Lab, tour attendees will learn more about the University of Maryland's research on elastocaloric cooling, a revolutionary technology that has been shown to offer efficient cooling, with zero direct global warming potential. At the Dieter lab, researchers test the materials and components of the elastocaloric prototype devices developed in the Daikin Energy Innovation Laboratory. In addition to sample preparation (for microscopy, calorimetry, etc.), our engineers conduct a range of mechanical tests such as tension, compression, bending, torsion, fatigue, hardness and impact, using specialized instrumentation. The work is a collaboration between CEEE and the Department of Materials Science and Engineering.

Small and Smart Thermal Systems Laboratory

The Small and Smart Thermal Systems (S2TS) Laboratory focuses on pioneering applications in energy conversion, heat/mass exchangers, process intensification, electronics cooling, and innovative component design and manufacturing for energy systems. The research encompasses state-of-the-art manufacturing techniques, including additive manufacturing and the application of micro and nano-systems for process intensification and optimization. S2TS is at the forefront of decarbonization efforts, conducting energy audits, energy profiling and energy modeling. The lab is dedicated to developing advanced energy auditing software with machine learning capabilities for precise and efficient energy and carbon assessments and compliance projections. S2TS is home to CEEE's Advanced Heat Exchangers and Process Intensification industrial consortium, and is affiliated with the Center for Advanced Life Cycle Engineering.

Fire Protection Engineering Laboratories

The University of Maryland offers one of only three graduate fire protection engineering programs in the United States. The department's laboratories support a broad range of experimental research and teaching, including research related to the safety of alternative natural refrigerants, many of which are flammable or mildly flammable. The large burn room allows flammable refrigerant fires of up to 1 MW. Refrigerant flammability and ignitability are tested in our ASTM E 681 facility and in our windowed vessels of up to 125 L.

Technical Sessions



MONDAY, AUGUST 12

10:30 AM - 12:00 NOON

A1: Refrigerants 1: CO₂/HC | ESJ 0202

Session Chair: Chun-cheng Piao

1106 Experimental Comparison of CO₂ and Different CO₂/R290 and CO₂/R1270 Blends in a Transcritical Refrigeration Plant With Different Cycle Arrangements

Rafael Larrondo Sancho*, Francisco Vidan Falomir, Daniel Sánchez García-Vacas, Ramón Cabello López
Jaume I University. Mechanical Engineering and Construction Department. Thermal Engineering Research Group. Castellón (Spain)

1107 Comparison of CO₂ and Alternative CO₂/R1270 Mixtures in a Transcritical Refrigerating Plant: Energy Evaluation in an MT Application

Francisco Vidan Falomir*, Rafael Larrondo Sancho, Daniel Sánchez García-Vacas, Ramón Cabello López
Jaume I University. Mechanical Engineering and Construction Department. Thermal Engineering Research Group. Castellón (Spain)

1108 Experimental Analysis of R744/R290 Blends in a Two-Stage Vapour Compression Heat Pump

Daniel Sánchez García-Vacas*, Rafael Larrondo Sancho, Ramón Cabello López
Jaume I University. Mechanical Engineering and Construction Department. Thermal Engineering Research Group. Castellón (Spain)

1197 Evaluating the Use of CO₂-Hydrocarbon Blends as Working Fluids in High Temperature Heat Pumps

Gabriele Toffoletti*, Emanuele Sicco, Giovanni Cortella, Paola D'Agaro
University of Udine, Italy

B1: Components-Heat Exchanger 1 | ESJ 1224

Chair: Akio Miyara

1178 Enhancing Heat Transfer Efficiency of a Gas Cooler in CO₂ Transcritical System Through Evaporative Cooling on Superhydrophilic Fin Surface

Chayan Das (1), Prosenjit Singha (1), Mani Sankar Dasgupta (1)*, Armin Hafner (2)
1: Birla Institute of Technology and Science, India; 2: Norwegian University of Science and Technology, Norway

1201 Use of Adiabatic Technology for an Efficient Heat Rejection Process in Fin-And-Tube CO₂ Gas Coolers

Stefano Filippini, Giovanni Mariani, Rodolfo Cavicchioli, Dario Demurtas*
LU-VE Group, Italy

1288 Refrigerant Charge Calculation Method for Brazed Plate Evaporators and Condensers

Torsten Will* (1) (2), Lena Schnabel (1), Jürgen Köhler (2)
1: Fraunhofer-Institut for Solar Energy Systems ISE, Germany; 2: Technical University Braunschweig, Germany

1149 Pressure Drops in Small-Diameter Tube U-Bends for Heat Exchangers Used for Low-Temperature Ammonia Refrigeration Applications

Jerin Robin Ebanesar (1), Ahmad Abbas (1,2), Christian Fauer (1), Lorenzo Cremaschi* (1), Zahid Ayub (3)
1: Auburn University, USA; 2: GIK Institute of Engineering Sciences and Technology, Pakistan; 3: Isotherm, Inc., USA

* indicates the presenter

Technical Sessions



C1: Components-Compressor 1 | ESJ 1202

Chair: Baolong Wang

1184 Optimal Design of Two-Stage Cylinder Diameters for Enhanced Performance in a Dual-Piston Carbon Dioxide Linear Compressor

Mingsheng Tang (1,3), Fanchen Kong* (1, 2, 3), Huiming Zou (1,3), Shuo Zhang (1, 2, 3), Zhouhang Hu (1, 2, 3), Changqing Tian (1, 3)
1: Technical Institute of Physics and Chemistry, Chinese Academy of Sciences: Beijing, China; 2: University of Chinese Academy of Sciences: Beijing, China; 3: Key Laboratory of Cryogenic Science and Technology: Beijing, China

1196 Numerical Modelling of the Solid- and Fluid Dynamic Phenomena Controlling the Ring Plate Valve Motion and Tumbling

Åsmund Ervik* (1), Afaf Saai (2), Torodd Berstad (3), Ole Meyer (1), Takuma Tsuji (4), Tatsuya Oku (4), Kazuhiro Hattori (4), Petter Nekså (1)
1: SINTEF Energy Research, 7034 Trondheim, Norway; 2: SINTEF Industry, Trondheim, Norway; 3: Norwegian University of Science and Technology, Trondheim, Norway; 4: Mayekawa MFG Co. LTD., Botan Koto ku, Tokyo, Japan

1102 Variable-Speed Compressor Ratings Displayed Within Single Third-Degree Polynomial Function

Tobias Guth (1), Gerhard Frei (2), Mihaela Frei (2), Sylvia Schädlich (1)
1: Ruhr West University of Applied Sciences, Institute of Energy Systems and Energy Management Bottrop, Germany; 2: COOLPLAN, Engineering Office for Refrigeration, Munich, Germany

D1: Heat Transfer | ESJ 1215

Chair: Giovanni Longo

1101 CO2 Flow Boiling Heat Transfer Evaluation and Visualization in a Horizontal Round Tube with and without Oil at Low Temperatures

Hui Zhao (1,2), Xiaochuan Li (1), Ke Tang (1,2), Kazuhiro Hattori (3), Nelson Mugabi (3), Stefan Elbel* (1,4)
1: Creative Thermal Solutions, Inc., USA; 2: University of Illinois at Urbana-Champaign, USA; 3: Mayekawa Mfg. Co., Ltd., Japan; 4: Technische Universität Berlin, Germany

1244 Towards Defining the Optimal Design Parameters for a Test Setup Studying Heat Transfer With Carbon Dioxide at Supercritical Conditions

Camila Pedano* (1), Paolo Petagna (1), Susanne Mall-Gleissle (2)
1: CERN, Switzerland; 2: Offenburg University of Applied Sciences, Germany

1110 Theoretical and Experimental Assessment of Propane and Propylene as Substitutes for Traditional HFC Refrigerants R410A and R404A

Giovanni A. Longo*
University of Padova, Italy

1138 The Effect of Lubricant Oil on Evaporation Heat Transfer for Ammonia Falling Liquid-Film

Ikuro Akada* (1), Kosaku Nishida (1), Norihiro Inoue (2)
1: Mayekawa Mfg. Co., Ltd.; 2: Tokyo University of Marine Science and Technology

Technical Sessions



MONDAY, AUGUST 12

1:00 PM - 3:00 PM

A2: Systems 1: C02 | ESJ 0202

Chair: Armin Hafner

1209 The Combined Potential of Using Air and Solar Source Evaporators in a C02 Heat Pump

Riccardo Conte (1), Emanuele Zanetti (2), Marco Tancon (1), Sergio Giroto (3), Marco Azzolin* (1), Davide Del Col (1)

1: Dept of Industrial Engineering, University of Padova, Italy; 2: Department of Process and Energy, Delft University of Technology, Netherlands; 3: ENEX S.r.l., Italy

1194 First Experimental Results of a R744 Water-to-Water Heat Pump for Space Heating

Chiara D'Ignazi*, Luca Molinaroli

Politecnico di Milano, Italy

1126 Development of C02 Dry Ice Heat Pump System

Hiroshi Yamaguchi* (1), Takeshi Kamimura (2), Kazuhiro Hattori (2), Petter Neksa (3), and Haruhiko Yamasaki (4)

1: Department of Mechanical Engineering, Doshisha University, 2: Mayekawa Mfg. Co., Ltd, Botan, Koto-ku, Tokyo, Japan, 3: SINTEF Energy Research, Sem Sælands vei 11, Trondheim, Norway, 4: Department of Mechanical Engineering, Osaka Metropolitan University

1198 Design and Freezing Performance Study of a C02 Plate Freezer at -50°C Evaporation Temperature

Shuai Ren* (1), Armin Hafner (1), Inge Håvard Rekstad (1), Kristina Norne Widell (2), Eirik Starheim Svendsen (2), Tom Ståle Nordtvedt (2)

1: NTNU, Norway; 2: SINTEF Ocean, Norway

1293 Enhancing Cooling Performance of R744 Heat Pump System in Electric Vehicles Using Gas Injection Technology

Seungyeon Lee, Min Soo Kim*

Seoul National University, Korea, Republic of (South Korea)

1238 C02 Heat Pump With and Without Cooling Output for Hot Water Production in Tropical Climates

Y. Siva Kumar Reddy (1), A.M. Guruchethan (1), Sarun Kumar Kochunni (2), Simarpreet Singh (2), Armin Hafner (1), M.P. Maiya (2)*

Organization(s): 1: Indian Institute of Technology Madras, Chennai, India; 2: Norwegian University of Science and Technology, Trondheim, Norway

B2: Components-Ejector | ESJ 1224

Chair: Stefan Elbel

1165 Conceptual Investigation On The Ejector Benefits In R744 Air Conditioning Heat Pump Systems For Electric Vehicles

Reza Niroomand* (1), Nina Piesch (1), Armin Hafner (1), Krzysztof Banasiak (1), Fadil Ayad (2)

1: Norwegian University of Science and Technology; 2: Thermal Design Solutions Sarl

1173 Thermodynamic Modelling of Two-Phase R-744 Ejectors in R-744 Heat Pumps

Ekaterini E. Kriezis (1), Baris B. Kanbur (2), Wiebke B. Markussen* (3)

1: Danfoss A/S, Denmark; 2: Independent Researcher, The Netherlands; 3: Danish Technological Institute

1148 Theoretical Analysis of the Optimal Ejector Operation Within the Classical Ejector Refrigeration System

Antoine Metsue* (1,2), Hakim Nesreddine (3), Sébastien Poncet (1), Yann Bartosiewicz (2)

Technical Sessions



1: Université de Sherbrooke, Canada; 2: UCLouvain, Belgium; 3: Hydro-Québec, Canada

1147 Experimental Investigation of an Ultrahigh-Lift Ejector Cycle With an Additional Subcooling Heat Exchanger

Dominik Herden* (1), Yixia Xu (1), Riley B. Barta (2), Christiane Thomas (1)

1: TU Dresden Schaufler Chair of Refrigeration, Cryogenics and Compressor Technology; 2: Purdue University School of Mechanical Engineering

1160 Thermodynamical Analysis of Two-Phase Water Steam Ejector In High-Temperature Heat Pumps Cycles

Omar Abu Khass*, Steffen Klöppel, A. Phong Tran, Panagiotis Stathopoulos, Eberhard Nicke

German Aerospace Center (DLR), Institute of Low-Carbon Industrial Processes Cottbus/Zittau, Germany

1177 R744 Heat Pumps with Ejectors for Heating and/or Cooling: Opportunities, Challenges, and Results

Alessandro Silva* (1), Oliver Javerschek (2), Florian Simon (2)

1: Bitzer US, Inc., Flowery Branch, USA; 2: Bitzer Kuehlmaschinenbau GmbH, Rottenburg-Ergenzingen, Germany

C2: Modeling 1 | ESJ 1202

Chair: Vikrant Aute

1187 Modelling of an Onboard R290 Refrigerated Sea Water System for Ice Production on Small Fishing Vessels in India

Lukas Köster* (1), Prosenjit Singha (2), Chayan Das (2), Jan Bengsch (1), Armin Hafner (3), Mani Sankar Dasgupta (2), Sarun Kumar Kochunni (3), Kristina Norne Widell (1)

1: Sintef Ocean AS, Norway; 2: Birla Institute of Technology And Science, Pilani (BITS Pilani), India; 3: Norwegian University of Science and Technology

1215 Transient and Dynamic Analysis of Refrigeration System Using Fixed Metering Devices for Natural Refrigerant

Zhequan Jin* (1), Adrien Reveillere (2), Jinwook Lee (1), Mansu Park (1), Saikhee Oh (1)

1: H&A R&D Center, Home Appliance & Air Solution Company, LG Electronics, Republic of Korea; 2: Siemens Digital Industries Software, France

1128 Pressure Optimization of an R600a-R1150 Auto-Cascade Cycle for Ultra-Low Temperature Applications

Manel Martínez Angeles* (1), Alessia Berton (2), Laura Nebot Andrés (1), Giovanni Cortella (2), Daniel Calleja Anta (1), Rodrigo Llopis (1)

1: University Jaume I, Spain; 2: Università degli Studi di Udine, Italy

1280 CO2 Rack at Low Ambient Temperature: Challenge or Blessing—Part II: Annual Energy Cost Analysis

Daqing Li, Suresh Shivashankar*, Autumn N. Nicholson, Kurt J. Knapke

Copeland, USA

1168 Shape Optimization and Fluid Control of Near Isothermal Compressor for Transcritical Carbon Dioxide Cycle

Haopeng Liu*, Vikrant Aute, Yunho Hwang, Chengyi Lee, Jan Muehlbauer, Lei Gao

University of Maryland, USA

1127 A Transcritical R744 Refrigeration System Integrated with Pressure Exchanger for Heat Recovery - A Novel Dynamic Analysis for Supermarket Application

Ayan Sengupta, Mani Sankar Dasgupta*

Department of Mechanical Engineering, BITS Pilani, India

Technical Sessions



D2: Modeling 2 | ESJ 1215

Chair: Minsoo Kim

1193 Multi-Objective Optimization of a Portable Air Conditioner Operating With R290 Using Genetic Algorithms

William Ferretto*, Luca Molinaroli
Politecnico di Milano, Italy

1217 Evaluation of the Influence of the Charge Variation in the Performance of an Air-to-Water Heat Pump Working with R290

David Alarcón-Gallén, Belén Llopis-Mengual, Emilio Navarro-Peris*
Universitat Politècnica de Valencia, Spain

1298 A Refrigerant Charge Prediction Method Based on Pump Down Operation Validated Using Residential and Commercial Heat Pump Systems

Zhenning Li* (1), Bo Shen (1), Drew Welch (2), Kyle Gluesenkamp (1)
1: Oak Ridge National Laboratory, USA; 2: The Helix Innovation Center at Copeland, USA

1260 Influence of Thermal Energy Storage Integration Strategy on System Performance and Refrigerant Charge for Small-Scale R290 Heat Pumps

Alhussain Othman*, Vikrant Aute, James Tancabel
University of Maryland, USA

1182 Defrost Modelling and Characteristics of Air Source CO₂ Heat Pumps

Govind Harikumar* (1), Michele Cattani (1), Jóhannes Kristófersson (2), Pourya Forooghi (1)
1: Department of Mechanical and Production Engineering, Aarhus University, Aarhus, Denmark; 2: Danish Technological Institute, Taastrup, Denmark

1206 Investigating Control Parameters of a CO₂-Based Thermal Network Connecting Decentralized Heat Pumps

Sepehr Gholamrezaie*, Massimo Cimmino, Parham Eslami-Nejad
Polytechnique Montréal, Canada

TUESDAY, AUGUST 13

10:30 AM - 12:00 NOON

A3: Refrigerants 2: HCs | ESJ 0202

Chair: Stephen Kujak

1297 Improving R600a Efficiency: RE170/R600 Natural Mixture Analysis

Daniel Calleja-Anta*, Laura Nebot-Andrés, Manel Martínez-Ángeles, Daniel Sánchez, Rodrigo Llopis
Universitat Jaume I, Spain

1156 Review of Existing Hydrocarbon Refrigerants and Their Blends For Performance and Future Opportunities

Michael Petersen*, Steve Kujak
Trane Technologies, USA

1157 Assessment of C₂ to C₅ Aliphatic Hydrocarbons for Future Refrigerant Opportunities

Steve Kujak*, Michael Petersen
Trane Technologies, USA

1105 Energy Evaluation of Two Hydrocarbons Blends as an Alternative for the HFC R134a in a Vertical Beverage Cooler

Daniel Sánchez García-Vacas*, Daniel Calleja Anta, Alejandro Andreu Náchar, Ramón Cabello López
Jaume I University. Mechanical Engineering and Construction Department. Thermal Engineering Research Group. Castellón (Spain)

Technical Sessions



B3: Components-Heat Exchanger 2 | ESJ 1224

Chair: Lorenzo Cremaschi

1263 Optimization of R290 Variable Geometry Heat Exchangers

Brian O'Malley*, James Tancabel, Vikrant Aute

Center for Environmental Energy Engineering, Department of Mechanical Engineering, University of Maryland College Park, USA

1269 Development of High-Performance Condenser and Evaporator Heat Exchangers for a High-Temperature Heat Pump Utilizing a Natural Refrigerant

Amir H. Z. Tari*, Thais P.A. Ferreira, Andres Sarmiento, Michael Ohadi

Advanced Heat Exchangers and Process Intensification Laboratory, University of Maryland, College Park, Maryland, USA

1241 Design Optimization of Heat Exchangers Utilizing Shape-Optimized, Non-Round Tubes for a Residential Air-Conditioning System Using R290

Vijay Preetham Meruva*, James Tancabel, Vikrant Aute

Center for Environmental Energy Engineering, Department of Mechanical Engineering, University of Maryland, College Park, Maryland, USA

1249 CFD-based Correlation Development for sCO₂ in TPMS-Based Heat Exchangers for Heat Pump Water Heater Systems

Arpita Das*, James Tancabel, Vikrant Aute

Center for Environmental Energy Engineering, Department of Mechanical Engineering, University of Maryland

C3: Components-Compressor 2 | ESJ 1202

Chair: Petter Nekså

1183 Study on Dynamic Characteristics of a Self-Lubricating Linear Compressor Using Vapor Injection

Shuo Zhang* (1,2), Huiming Zou (1), Fanchen Kong (1,2), Mingsheng Tang (1)

1: Key Laboratory of Cryogenic Science and Technology, Technical Institute of Physics and Chemistry, Chinese Academy of Sciences, Beijing, China; 2: University of Chinese Academy of Sciences, Beijing, China

1218 Experimental Analysis of the Performance of a Reciprocating Compressor Working with Propane and PAG Oil

Marco Azzolin* (1), Riccardo Conte (1), Simone Seresin (1), Corrado De Gioia Carabbelese (2), Maurizio Mastrapasqua (2), Davide Del Col (1)

1: Department of Industrial Engineering, University of Padova, Italy; 2: Frascold SpA, Italy

1292 Oil Sump Temperature in a High-Pressure Shell Scroll Compressor

Nicolás Gómez Parada, Francisco Barceló Ruescas, José González Maciá*

Universitat Politècnica de València, Instituto de Ingeniería Energética, Valencia, Spain

1286 Development, Experimental Testing, and Performance Analysis of a Two-Stage Steam Turbo Compressor HTHP for Solar Assisted Heat

Joshua Dowdell* (1), Ole Marius Moen (1), Magnus Rotan (1), Christian Schlemminger (1,2)

1: SINTEF Energy Research, Norway; 2: Aneo Industry, Norway

Technical Sessions



D3: Not-In-Kind 1 | ESJ 1215

Chair: Minsung Kim

1306 All-in-One Air Conditioning System for MXene Catalyst-Based H₂O and CO₂ Adsorption

Joo Young Shin, Do Seong Yoon, Yong Tae Kang*

Korea University, Korea, Republic of South Korea

1302 Study on Membrane-Based Vacuum Dehumidification Technology With Finite Permeance and Selectivity

Donik Ku (1), Soyeon Kim (1), Minkyu Jung (1), Young Soo Chang (2), Minsung Kim* (1)

1: Chung-Ang University, Republic of Korea; 2: Kookmin University, Republic of Korea

1273 Optimal Solution Flow Rate of Liquid Desiccant Air-Conditioning System for Energy Saving

Atsuya Tokano*, Tsubasa Nishiguchi, Seiichi Yamaguchi

Waseda University, Japan

1204 Performance Improvement of Liquid Desiccant Air-Conditioning System With Tube-Extruded Distributor and Surface Treatment of Three-Fluid Contactor

Katsuya Masuno* (1), Kento Maeda (1), Bowen Cao (2), Moojoong Kim (3), Kiyoshi Saito (1)

1: Department of Applied Mechanics and Aerospace Engineering, Waseda University; 2: School of Energy and Environment, Southeast University; 3: Research Institute for Science and Engineering, Waseda University

TUESDAY, AUGUST 13

1:00 PM - 3:00 PM

A4: Systems 2: HCs | ESJ 0202

Chair: Kashif Nawaz

1203 Performance Evaluation of a Low-Charge R290 Modular Heat Pump System

Mathilde Wirtz*, Jason Woods, Ransisi Huang, Juan Catano, Eric Kozubal

National Renewable Energy Laboratory, USA

1236 Experimental Evaluation of a Novel Residential Propane (R290) Two-Stage Heat Pump System

Abd Alrhman Bani Issa*, Changkuan Liang, HeeJun Shin, Haotian Liu, Eckhard Groll, Davide Ziviani

Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University

1131 A Saturation Heat Pump System for Cold Climate Conditions

Andrew Fix*, Lei Gao, Tamoy Seabourne, Jangho Yang, Jan Muehlbauer, Yunho Hwang, Reinhard Radermacher

Univ of Maryland-Center for Environmental Energy Engineering, USA

1130 An Energy-Efficient Multi-Drying-Chamber-Based Heat Pump Wood Drying System

Andrew Fix, Yong Pei, Tamoy Seabourne*, Jangho Yang, Lei Gao, Jan Muehlbauer, Yunho Hwang, Reinhard Radermacher, Bao Yang

Univ of Maryland-Center for Environmental Energy Engineering, USA

1192 Performance Analysis of an Active On-Board Refrigeration System Using Propane for Improved Fish Preservation in Small Fishing Boats

Prosenjit Singha (1), Chayan Das (1), Lukas Köster (2), Sarun Kumar Kochunni (4), Mani Sankar Dasgupta* (1), Kristina Norne Widell (2), Souvik Bhattacharyya (3), Armin Hafner (4)

1: Birla Institute of Technology and Science, Pilani, India; 2: SINTEF Ocean; 3: TCG CREST; 4: Norwegian University of Science and Technology

Technical Sessions



1155 Energy Efficient R-290 based Solar Micro Cold Store: An Experimental Assessment

Harischander Harischander*, Milind V Rane, Aditya M Rane
IIT Bombay, India

B4: Components-Heat Exchanger 3 | ESJ 1224

Chair: Rene Rieberer

1214 Heat Recovery Performance of an Integrated CO₂ Commercial Refrigeration System With Dedicated Mechanical Subcooler

Emanuele Sicco*, Gabriele Toffoletti, Paola D'Agaro, Giovanni Cortella
University of Udine, Italy

1222 Low Charge R290-Subcooler to Improve the Performance of R744-Refrigeration Systems

Gerhard Pertiller* (1), René Rieberer (1), Leopold Schöffl (2), Alexander Kottenko (2)
1: Graz University of Technology, Austria; 2: HAUSER Kühlmöbel und Kältetechnik GmbH, Austria

1221 Performance Evaluation of a Transcritical CO₂ Refrigeration System for Supermarkets in Hot Climatic Conditions

Shubhanshu Rai*, Anil Kumar, Anish Modi
Department of Energy Science and Engineering, Indian Institute of Technology Bombay, Mumbai, India

1250 Thermodynamic Optimization and Field Tests of Advanced CO₂ Booster Systems with Integrated Mechanical Subcooling

Rodrigo Llopis* (1), Javier Atencia (2), Jesús Catalán (2), Takeshi Nishikawa (2), Laura Nebot-Andrés (1)
1: Thermal Engineering Group, Jaume I University, Spain; 2: TEWIS Smart Systems S.L.U., Spain

1248 A Simulation of a Novel Combination of a Compression Heat Pump and a Thermoelectric Heat Pump to Increase the Efficiency

Johannes Brunder*, Nico Mirl, Konstantinos Stergiaropoulos
University of Stuttgart, Germany

1242 2-Phase CO₂ Pressure Drop Measurements in Vertical and Horizontal Coaxial Transfer Lines for Cooling High-Energy Physics Detectors

Tymon Pakulski*, Viren Bhanot, Yann Herpin, Bart Verlaet
CERN, Switzerland

C4: Modeling 3 | ESJ 1202

Chair: Zhenning Li

1167 A Correlation of Optimal Intermediate Pressure in Trans-Critical Carbon Dioxide Distributed Compression Cycle

Junrui Nie*, Lei Wang, Guoyuan Ma
Beijing University of Technology, China

1186 Model Based Performance Analysis of a Transcritical Combined Heating and Cooling CO₂ Cycle for a School Cantina in India

Marco Bless* (1), Davide Tommasini (1), Vinod Laguri (2), Krzysztof Banasiak (1), Armin Hafner (3), Pramod Kumar (2)
1: SINTEF Energy Research, Norway; 2: Indian Institute of Science, India; 3: Norwegian University of Science and Technology, Norway

1281 Design of an Integrated Energy System Using a Cascade High Temperature Heat Pump With Zeotropic Refrigerants

Omar Volpato (2), Trygve M. Eikevik* (1), P. Ganesan (1), Khalid Hamid (1)
1: Norwegian University of Science and Technology, Norway; 2: University of Padova, Italy

Technical Sessions



1289 Flow-Induced Noise Reduction Using Control Logic in Simultaneous Heating and Cooling Heat Pumps

Changho Han*, Junhyeok Jang, Yongchan Kim
Korea University, Korea, Republic of South Korea

1109 Heat and Mass Transfer Modelling In a Tubular Bubble Absorber For Absorption Chillers Using Computational Fluid Dynamics

Andres Zapata (1), Carlos Amaris Castilla* (2)
1: Pennsylvania Department of Environmental Protection, United States; 2: Universidad Industrial de Santander, Colombia

1180 Development of a Residential Thermodynamic Active Mechanical Ventilation Machine Working With Propane

Mirko Buti, Simone Piovesan*, Paolo Rossi, Yuri Natalini, Andrea Abitani
Clivet S.p.A., Feltre, Italy

D4: Refrigerant Safety | ESJ 1215

Chair: Andy Pearson

1285 The Importance of Engineering Safe, Efficient, and Low Carbon Use of Natural Refrigerants

Stephen Oliver Andersen* (1), Suely Carvalho (2) Sean Dennis (1) (technical editor)
1: Institute for Governance & Sustainable Development, USA; 2: Independent Consultant, São Paulo, SP, Brazil

1239 Closing Knowledge Gaps in R290 Heat Pump Safety Evaluation

Thore Oltersdorf (1), Timo Methler (1), Daniel Colbourne (2), Martin Kreuz (1), Hannes Fugmann* (1)
1: Fraunhofer ISE, Germany; 2: Re-phridge Ltd., United Kingdom

1207 Investigation of Refrigerant Leakage Behavior Prediction Using Machine Learning

Ryoutarou Yokono*, Hirohisa Ohama, Masashi Kamada, Kazutaka Hori
Daikin Industries, LTD., Japan

1287 Critical Aspects in CFD-Modelling of R-290 Leakages

Jafar Esmaeelian*, Rahmatollah Khodabandeh, Björn Palm, Monika Ignatowicz
KTH Royal Institute of Technology, Sweden

1141 Comparison of Laminar vs RANS and Large-Eddy Simulation (LES) Turbulent Flow Models for the Analysis of R290 Leakage

Marine Fayolle (1), Hironori Tsunoyama* (1), Takahiro Aoki (1), Kentaro Nakagawa (2), Takahiko Hashimoto (2), Akira Hiwata (2)
1: Panasonic Holdings Corporation, Technology Division; 2: Panasonic Corporation, Heating and Ventilation AC Company

1119 Feasibility Study of a New Refrigerant Leak Detection Algorithm Using Transient Simulation

Kosuke Kibo*, Keisuke Tanimoto, Takahiro Ozaki
Daikin Industries, Ltd., Japan

Technical Sessions



TUESDAY, AUGUST 13

3:30 PM - 5:30 PM

A5: Systems 3: Natural Refrigerants | ESJ 0202

Chair: Seontae Kim

1129 Assessment of CO₂/R600a Blends in Parallel Compression Refrigeration Systems: A Focus on Fractionation

Manel Martínez Angeles* (1), Laura Nebot Andrés (1), Fabio Petruzzello (2), Angelo Maiorino (2), Ciro Aprea (2), Ramón Cabello (1), Rodrigo Llopis (1)

1: University Jaume I, Spain; 2: Università degli Studi di Salerno, Italy

1150 SophiA: Sustainable Off-Grid Solutions for Pharmacies and Hospitals in Africa – Laboratory and Field Test Data of Three Stage Cascade System with CTES

Oliver Schmid*

University of applied sciences Karlsruhe, Germany

1307 Decarbonizing District Energy: Leveraging CO₂ Heat Pumps at UBC Okanagan

Parham Eslami Nejad*

Vitalis, Canada

1303 Deployment of R290 in Heat Pump Water Heaters and Implications for Decarbonization

Kashif Nawaz*, Jian Sun

Oak Ridge National Lab, USA

1188 Comparative Study of Heat Storage System in Water Vapor Compression Heat Pump for Industrial Processes

Seon Tae Kim* (1), Steffen Klöppel (1), Eberhard Nicke (1), Katamala Malleswararao (2), Marc Linder (2), Panagiotis Stathopoulos (1)

1: Institute of Low-Carbon Industrial Process, German Aerospace Center (DLR); 2: Institute of Engineering Thermodynamic, German Aerospace Center (DLR)

1114 Hydrocarbons in Heat Pumps: An Experimental Investigation on the Influence of an Internal Heat Exchanger

Christoph Höges*, Philipp Roy, Kaj Neumann, Christian Vering, Dirk Müller

RWTH Aachen University, E.ON Energy Research Center, Institute for Energy Efficient Buildings and Indoor Climate, Aachen, Germany

1124 Developments in Low Charge Ammonia Refrigeration for Food Processing and Storage

Andy Pearson*

Star Refrigeration Ltd, United Kingdom

B5: Systems 4: HTHP 1 | ESJ 1224

Chair: Steven Lecompte

1121 Simulation of High Temperature Heat Pump Performance

Thomas Lund*

Danfoss A/S, Denmark

1226 Analysis of Two-Stage High-Temperature Heat Pump Cycles for Steam Generation Using Hydrocarbons as Refrigerants

Abdelrahman Hassan (1,2), Jorge Paya (1), Emilio Navarro Peris*(1)

1: Universitat Politècnica de Valencia, Spain, Mechanical Power Engineering Department, Faculty of Engineering, 2: Zagazig University, Zagazig, Egypt

Technical Sessions



1202 Digital Twin of a Full-Scale Industrial Heat Pump Producing Steam Above 140°C

Ali Can Ispir* (1), Gustavo Otero Rodriguez (2), Wouter de Vries (2), Michel Speetjens (1)

1: Eindhoven University of Technology, Eindhoven, 5600MB, The Netherlands; 2: Netherlands Organisation for Applied Scientific Research (TNO), Sustainable Technologies for Industrial Processes, Energy & Materials Transition Unit, Petten, The Netherlands

1208 Performance Comparison of a Lab and Industrial Scale Propane-Butane Cascade Heat Pump

Marco Bless*, Till Holmes, Ole Marius Moen, Petter Nekså, Christian Schlemminger

SINTEF Energy Research, Norway

1199 Evaluation of Pentanes as Refrigerants for Heat Pumps with Sink Temperatures above 130°C

Sebastian Benkert*, Hannah Teles de Oliveira, Ursula Wittstadt, Hannes Fugmann, Lena Schnabel

Fraunhofer ISE, Germany

1251 Low-Charge Isobutane Heat Pump for Medium and High-Temperature Applications

Klas Andersson* (2), Viktor Ölen (3), Björn Palm (1), Jan-Erik Nowacki (4)

1: KTH Royal Institute of Technology, Sweden; 2: SweTemp; 3: SKVP; 4: Nowab

1111 Solution Examples for Cooling and Process Heating in Industrial Applications

Ivan Rangelov*

Danfoss A/S, Denmark

C5: Workshop: Decarbonization Through Adopting Low-GWP Refrigerants | ESJ 1202

Chair: Xudong Wang

3:30–4:00 pm Katharine Kaplan | DOE's Future of Refrigerants R&D and Voluntary Market Efforts to Support Ultra Low GWP Refrigerants

4:00–4:40 pm Yosr Allouche & Silvia Minetto | ENOUGH Project for Decarbonization of the Food Chain: How to Reach Net Zero by 2050

4:40–5:10 pm M S Dasgupta | On-Board Refrigeration Using Propane for Improved Fish Preservation in Small Fishing Boats

5:10–5:30 pm Olivier Schmid | Decarbonization Through Adopting Low-GWP Refrigerants in the SophiA Project in Africa

D5: Thermal Management & CFD Analysis | ESJ 1215

Chair: Andy Pearson

1246 The Development of the CO₂ Cooling Plants for the Upgrade Silicon Detectors of ATLAS and CMS at CERN

Bart Verlaat*, Paolo Petagna, Łukasz Zwalinski, Jerome Daguin, Viren Bhanot, Loïc Davoine, Krzysztof Sliwa, Yann Herpin, Cedric Landraud, Dani Teixeira, Michał Zimny, Szymon Galuszka

CERN, Switzerland

1103 Simulating the Startup and Backup Operation of Next Generation CO₂ Pumped-Loop Cooling Systems

Amandla Power Mvimbi (1,2), Bart Verlaat (1), Daniella Ida Teixeira (1), Loïc Davoine (1), Łukasz Zwalinski (1), Michal Zbigniew Zimny (1), Paolo Petagna (1), Viren Bhanot* (1)

1: CERN, Switzerland; 2: University of Cape Town, Electrical Engineering Department, South Africa

1235 Applying Krypton as Refrigerant for Cooling of Future Particle Detector Trackers at CERN

Luca Contiero* (1,2), Bart Verlaat (1), Armin Hafner (2), Krzysztof Banasiak (2), Yosr Allouche (2), Paolo Petagna (1)

1: European Organization for Nuclear Research, Geneva, Switzerland; 2: Norwegian University of Science and Technology, Trondheim, Norway

1185 Open-Source CFD Modelling of Two-Phase CO₂ Ejectors

Negar Alvandifar* (1,2), Ehsan Mahravan (1), Jóhannes Kristófersson (3), Kim Gardø Christensen (2), Pourya Forooghi (1)

1: Department of Mechanical and Production Engineering, Aarhus University, Aarhus, Denmark; 2: FENAGY A/S, Lystrup, Denmark; 3: Danish Technological Institute, Gregersensvej 1, Taastrup, Denmark

Technical Sessions



1139 CFD Modeling of Crystallization During the Freeze Concentration Process

Muhammad Umar Khan*, Ignat Tolstobrov, Trygve M. Eikevik
Norwegian University of Science and Technology, Norway

1109 Heat and Mass Transfer Modelling in a Tubular Bubble Absorber for Absorption Chillers Using Computational Fluid Dynamics

Andres Zapata (1), Carlos Amaris Castilla* (2)
1: Cinara Institute, Faculty of Engineering, Universidad del Valle: Cali, Colombia; 2: Universidad Industrial de Santander, Colombia

WEDNESDAY, AUGUST 14

8:00 - 10:00 AM

A6: Systems 5: District Heating | ESJ 0202

Chair: Hatef Madani Larijani

1172 Heat Recovery and Heat Pump Applications using CO₂ as Refrigerant

Mazyar Karampour (1), Torben Funder-Kristensen (2)
1: Danfoss Sweden AB, System Engineering and Solutions; 2: Danfoss Denmark A/S, Industrial Affairs

1166 Theoretical Investigations on Using High-Temperature Heat Pumps in Combination with District Heating Networks

Haochen Wang*, Dimitri Nefodov, Markus Richter, Thorsten Urbaneck
Chemnitz University of Technology, Germany

1142 Under Variable Conditions: Investigating the Off-Design Performance of Natural Refrigerants in Heat Pumps

Sebastian Hubert Ostlender*, Christoph Höges, Christian Vering, Dirk Müller
RWTH Aachen University, E.ON Energy Research Center, Institute for Energy Efficient Buildings and Indoor Climate, Germany

1256 Refrigerant Selection for District Heating's Large-Scale Heat Pumps

Görkem Balyaligil* (1,2), Samer Sawalha (2), Erik Skoglund (3)
1: Siemens Energy; 2: Royal Institute of Technology (KTH); 3: Stockholm Exergi AB

1152 Optimizing Surplus Heat Utilization: A Case Study on CO₂-Based Supermarket Refrigeration Cycle with District Heating Integration in Southern Denmark

Sotirios Thanasoulas*, Ekaterini E. Kriezis, Mark Sever, Lars M. Jessen
Danfoss, Denmark

B6: Systems 6: HTHP 2 | ESJ 1224

Chair: Björn Palm

1118 Experimental Investigation of Oil Free Absorption-Compression Heat Pumps with Liquid Injection Screw Compressor for high Temperature Applications

Khalid Hamid*, Shuai Ren, Ignat Tolstorebrov, Armin Hafner, Trygve M. Eikevik
Department of Energy and Process Engineering, Norwegian University of Science and Technology, Trondheim, Norway

1277 A Comparison of Simplified Modeling Approaches and Simulation Quality of an Industrial R717-HTHP

Michael Wernhart*, Manuel Verdnik, Gerhard Pertiller, René Rieberer
Institute of Thermal Engineering, Graz University of Technology, Austria

Technical Sessions



1205 High-Temperature CO₂ Heat Pump Integration for Milk Powder Spray Drying

Lana Kong* (1), Timothy G. Walmsley (1), James K. Carson (1), Steffen Klöppel (2), Florian Schlosser (3), Donald J. Cleland (4)

1: Ahuora – Centre for Smart Energy Systems, School of Engineering, University of Waikato, Hamilton, New Zealand; 2: German Aerospace Center (DLR), Institute of Low-Carbon Industrial Processes, Zittau, Germany; 3: Department of Energy System Technologies, Paderborn University: Paderborn, Germany; 4: Massey University, Palmerston North, New Zealand

1237 Carbon-Neutral Steam Supply for a Chemical Plant: Simulation of the Integration of a High-Temperature Heat Pump Using CO₂

Lukas Steinberg* (1), Stefan Glos (2), Tobias Korte (3), Valentin Bertsch (3), Roland Span (1)

1: Chair of Thermodynamics, Ruhr-University Bochum, Germany; 2: Siemens Energy, Mülheim an der Ruhr, Germany; 3: Chair of Energy Systems and Energy Economics, Ruhr-University Bochum, Germany

1210 Development and Testing of a Steam Compression Heat Pump for Low-Grade Waste Heat Recovery

Miguel Ramirez* (1), Gustavo Otero Rodriguez (1), Daan Scheepens (2), Geert van de Weijer (2), Simon Spoelstra (1)

1: TNO; 2: Standard Fasel, The Netherlands

1229 Design of a High-Temperature Heat Pump Providing Heat up to 200 °C

Elias Vieren* (1), Kenny Couvreur (1), Michel De Paepe (1,2), Steven Lecompte (1,2)

1: Ghent University - Department of Electromechanical, Systems and Metal Engineering, Ghent, Belgium; 2: FlandersMake, FlandersMake@UGent Core lab EEDT-MP, Leuven, Belgium

C6: Field Testing | ESJ 1202

Chair: Giovanni Cortella

1176 Design and Experimentation of a New CO₂ Air Conditioning System

Yu Wei Fan (1,2), Quan Jiang Wang (1), Yi Zhou Wang (2), Jian Hui Kang (1), Jia Liu (2,3), Xiao Long Li (1), Jian Guo Yang (1), Xin Rong Zhang* (2,3)

1: Jingkelun Refrigeration Equipment Co., Ltd. Beijing, 101302, China; 2: Department of Energy and Resources Engineering, College of Engineering, Peking University, Beijing 100871, China; 3: Peking University Nanchang Innovation Institute, Nanchang, 330000, China

1225 Novel Large Scale Combined Heating and Cooling CO₂ System

Pierre-Jean Delêtre (1), Jóhannes Kristofferson* (1), Arvydas Latvenas (1), Jesper Weinkauff Kristoffersen (1), Henrik Andersen (2), Kim Gardø Christensen (2)

1: Teknologisk Institut, Denmark; 2: Fenagy, Denmark

1175 Energy Saving of a CO₂ Transcritical System in a Cold Storage: Combination of Freezer Floor Heating & Gas Cooler Subcooling

Shitong Zha*

Heatcraft Refrigeration (Lennox international), USA

1195 Field Data of a R744 Unit Satisfying Thermal Requirements of a Resort in the South Mediterranean Climate

Silvia Minetto* (1), Francesco Fabris (1), Sergio Marinetti (1), Luca Bisetto (2), Sergio Giroto (2), Antonio Rossetti (1)

1: National Research Council, Construction Technologies Institute, Italy; 2: Enex Srl, Italy

1170 Performance Testing of CO₂-NH₃ Cascade Tunnel Freezer for Seafood Processing

Sumit Kumar (1), B. S. Arun (2), Murali S (2), George Ninan (2), Maddali Ramgopal (3), Manoj Samuel (4), Lukas Köster* (5), Jan Bengsch (5), Kristina Norne Widell (5), Armin Hafner (6), Saju George (7), Kolliyil Ashraf Hashmin (8)

1: School of Energy Science and Engineering, Indian Institute of Technology, Kharagpur, India; 2: Engineering Division, ICAR-Central Institute of Fisheries Technology, Kochi, India; 3: Department of Mechanical Engineering, Indian Institute of Technology, Kharagpur, India; 4: Centre for Water Resources Development and Management, Kozhikode, India; 5: Fisheries and New Biomarine Industry, SINTEF Ocean, Trondheim, Norway; 6: Department of Energy and Process Engineering, Norwegian University of Science and Technology Trondheim, Norway; 7: Cochin Food Tech Private Limited, Kochi, India; 8: NAS Fisheries Private Limited, Kochi, India

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1163 Performance Assessment of Low Charge Ammonia Refrigeration in a High Bay Automated Warehouse

Andy Pearson*

Star Refrigeration Ltd, United Kingdom

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Chair: Marco Azzolin

1283 Compilation of Equipment Maps for Refrigerators and Heat Pumps Using Natural Working Fluid in Japan

Katsumi Hashimoto* (1,4), Yohei Kayukawa (2,4), Kiyoshi Saito (3,4), Yoichi Miyaoka (3,4)

1: Central Research Institute of Electric Power Industry, Japan; 2: National Institute of Advanced Industrial Science and Technology (AIST); 3: Waseda University; 4: Technical Committee on Refrigeration/Air-conditioning Systems Using Natural Working Fluids, JASRE

1295 Full Conversion to Natural Refrigerants - Feasible and Likely to Happen?

Petter Nekså*

SINTEF Energy Research, Norway

1262 Heat Pump Product and Market Data - Tools and Analysis

Thore Oltersdorf, Elvin Garashli, Hannes Fugmann*, Lena Schnabel

Fraunhofer ISE, Germany

1224 Designing a CO₂ Heat Pump Satisfying the Ecodesign Requirements: Challenges and Solutions

Pierre-Jean Delètre* (1), Jóhannes Kristofferson (1), Christian Heerup (1), Troels Stevns Pedersen (1), Arvydas Latvenas (1), Jesper Weinkauff Kristoffersen (1), Henrik Andersen (2)

1: Teknologisk Institut, Denmark; 2: Fenagy, Denmark

1189 Outlining the Requirements For Propane-Based Heat Pump Solutions for Existing Multi Family Houses

Björn Nienborg, Beatrice Rodenbücher, Annette Uhl, Hannes Fugmann*, Peter Engelmann

Fraunhofer Institute for Solar Energy System (ISE), Germany

1171 Market Trends and Drivers in New Product Development of Natural Refrigerant Components

Torben Funder-Kristensen* (1), Mazyar Karampour (2)

1: Danfoss Climate Solutions, Denmark; 2: Danfoss Climate Solutions, Sweden

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10:30 AM - 12:00 NOON

A7: Systems 7: Transport | ESJ 0202

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1294 Real Unit Double Expansion CO₂ Public Transport Application Heat Pump Simulation Model Comparison With Single Expansion Alternative Model

Pavel Houdek*, Martin Galansky

Trane Technologies, Czech Republic

1233 Effects of a R744 Cooling Unit Design on the Overall Energy Performance of a Refrigerated Vehicle

Francesco Fabris* (1), Wasim Shah (2), Sergio Marinetti (1), Silvia Minetto (1), Antonio Rossetti (1)

1: National Research Council, Construction Technologies Institute (CNR-ITC), Italy; 2: University of Padova, Department of Industrial Engineering, Italy

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1159 R744 Mass Transit Mobile AC and HP System in Bus Application

Alexander Schmig*, Michael Petersen, Steve Kujak, Pavel Houdek, Michal Kolda, Martin Galansky
Trane Technologies, USA

1153 Assessment of Natural Refrigerants for Thermal Management in Battery-Electric Long-Distance Buses

Jan Friedrich Hellmuth* (1), Markus Pollak (1,2), Andreas Schulte (1), Wilhelm Tegethoff (1,2), Jürgen Köhler (1)
1: TU Braunschweig, Germany; 2: TLK Thermo GmbH, Braunschweig, Germany

B7: Measuring Methods | ESJ 1224

Chair: Phillip Johnson

1162 Natural or Synthetic Refrigerants: Does the Lubricant Care?

Joe Karnaz* (1), Manuel Munoz (2), Liz Dixon (2), Jun Liu (3)
1: Shrieve Chemical Products, LLC, USA; 2: Shrieve Products International; 3: Shrieve Chemical Shanghai

1140 Refrigeration Machine with Accurate Inline Sensors for Measuring Thermophysical Properties of Oil-Refrigerant Mixtures

Caner Cikmaz*, Jonathan Laun, Xiaoxian Yang, Markus Richter
Applied Thermodynamics, Chemnitz, Germany

1123 Good Vibes for Heat Pumps: Towards Refrigerant Charge Indication with Vibration Sensors

Tim Klebig*, Luca Hummel, Philipp Ostmann, Jonas Klingebiel, Christian Vering, Dirk Müller
RWTH Aachen University, Germany

1247 Investigation of Indirect Measuring Methods For Evaluating The Energy Efficiency of a Low Temperature Refrigerating System Under Different Operating Conditions

Stefan Hudjetz*, Daniel Pfeiffer, Martin Becker
Biberach University of Applied Sciences, Germany

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Chair: Jonas Kjær Jensen

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Simarpreet Singh*, Sarun Kumar Kochunni, Armin Hafner
Norwegian University of Science and Technology, Norway

1117 Preliminary Study on Fault Detection in Gas Coolers for Transcritical CO₂ Refrigeration Systems

Milad Morid Zadeh* (1), Roozbeh Izadi-Zamanabadi (2,3), Hossein Ramezani (1), Paride Gullo (1)
1: University of Southern Denmark; 2: Danfoss A/S; 3: Aalborg University

1300 A Numerical Investigation of the Dynamic Responds of Solar Direct Drive Refrigerators Under Different Control Strategies

Jonas Kjær Jensen (1), Per Henrik Pedersen (2), Ivan Katic (2)
1: Technical University of Denmark, Denmark; 2: Danish Technological Institute

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Andreas Schulte* (1), Peder Bacher (2), Christian Heerup (3), Wilhelm Tegethoff (1), Benjamin Zühlsdorf (3), Juergen Koehler (1)
1: TU Braunschweig, Germany; 2: DTU Compute, Denmark; 3: Danisch Technological Institute

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1181 Simulation and Test Results of a Innovative CO2 Residential Monoblock Heat Pump for Domestic Hot Water

Claudia Fiabane* (1), Federico Virgilio (1), Mirko Buti (1), Federico Simoni (1), Linda Padoan (1), Simone Piovesan (1), Armin Hafner (2), Engin Söylemez (2), Mihir Mouchum Hazarika (2)

1: Clivet S.p.a, Feltre, Italy; 2: Norwegian University of Science and Technology, Trondheim, Norway

D7: Not-In-Kind 2 | ESJ 1215

Chair: Hirofumi Daiguji

1174 Energy, Environmental, and Economic Evaluations of Electrochemical Looping Heat Pump Technology

Mingjie Zhu* (1), Jinwoo Oh (1), Junyoung Kim (2), James E. Braun (1), Eckhard A. Groll (1), Davide Ziviani (1)

1: Ray W. Herrick Laboratories, West Lafayette, IN, USA; 2: National Renewable Energy Laboratory, Golden, CO, USA

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Ming-Hsuan Hu (1), Jubair A. Shamim (1), Gunjan Auti (1), Fabio Boccamazzo (1), Paris Pasqualin (1), Wei-Lun Hsu (1), Hirofumi Daiguji* (1), Masaki Tanaka (2), Eiji Kumakura (2), Takuro Yamada (2), Yoshio Oritani (2)

1: University of Tokyo, Japan; 2: Daikin Industries, Ltd., Japan

1164 Optimal Thermoelectric Heat Pump Design to Efficiently Perform the Power-To-Heat Process of a Thermal Energy Storage System

Patricia Aranguren*, Ivan Lerga, Irantzu Erro, Alvaro Casi, Antonio Rodriguez, Alvaro Martinez

Public University of Navarra, Spain

1113 A Novel Heat Pumping Cycle in a Rotation Heat Pump for Latent Process Heat Supply Using Sensible Heat Sources

Gerald Zotter*, Bernhard Adler, Andreas Längauer

ECOP Technology GmbH, Austria



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Author List



Abbas, Ahmad Auburn University, USA; GIK Institute of Engineering Sciences and Technology, Pakistan
Abitani, Andrea Clivet S.p.A., Feltre, 32030, Italy
Abu Khass, Omar German Aerospace Center (DLR), Institute of Low-Carbon Industrial Processes Cottbus/Zittau, Germany
Adler, Bernhard ECOP Technology GmbH, Austria
Akada, Ikuro Mayekawa Mfg. Co., Ltd.
Alarcon, David Universitat Politècnica de Valencia, Spain
Allouche, Yosr Norwegian University of Science and Technology, Trondheim, Norway
Alvandifar, Negar Dept of Mechanical & Production Engineering, Aarhus Univ, Aarhus, Denmark; FENAGY A/S, Lystrup, Denmark
Amaris Castilla, Carlos Universidad Industrial de Santander, Colombia
Andersen, Henrik Fenagy, Denmark
Andersen, Stephen Oliver Institute for Governance & Sustainable Development, USA
Andersson, Klas SweTemp
Aoki, Takahiro Panasonic Holdings Corporation, Technology Division
Aprea, Ciro Università degli Studi di Salerno, Italy
Aranguren, Patricia Public University of Navarra, Spain
Arun, B. S. Engineering Division, ICAR-Central Institute of Fisheries Technology, Kochi, 682029, India
Atencia, Javier TEWIS Smart Systems S.L.U., Spain
Aute, Vikrant University of Maryland, USA
Auti, Gunjan University of Tokyo, Japan
Ayad, Fadil Thermal Design Solutions Sarl
Ayub, Zahid Isotherm, Inc., USA
Azzolin, Marco Department of Industrial Engineering, University of Padova, Italy
Bacher, Peder DTU Compute, Denmark
Balyaligil, Görkem Siemens Energy; Royal Institute of Technology (KTH)
Banasiak, Krzysztof Norwegian University of Science and Technology
Bani Issa, Abd Alrhaman M. Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University
Barceló Ruescas, Francisco Universitat Politècnica de València, Instituto de Ingeniería Energética, Valencia, Spain
Barta, Riley B. Purdue University School of Mechanical Engineering
Bartosiewicz, Yann UCLouvain, Belgium
Becker, Martin Biberach University of Applied Sciences, Germany
Bengsch, Jan Fisheries and New Biomarine Industry, SINTEF Ocean, Trondheim, 7465, Norway
Benkert, Sebastian Fraunhofer ISE, Germany
Berstad, Torodd Norwegian University of Science and Technology, 7034 Trondheim, Norway
Berton, Alessia Università degli Studi di Udine, Italy
Bertsch, Valentin Chair of Energy Systems and Energy Economics, Ruhr-University Bochum, Germany
Bhanot, Viren CERN, Switzerland
Bhattacharyya, Souvik TCG CREST
Bisetto, Luca Enx Srl, Italy
Bless, Marco SINTEF Energy Research, Norway
Boccamazzo, Fabio University of Tokyo, Japan
Braun, James E. Ray W. Herrick Laboratories West Lafayette, IN, 47907, USA
Brunder, Johannes University of Stuttgart, Germany
Buti, Mirko Clivet S.p.A., Feltre, 32030, Italy
Cabello López, Ramón Jaume I University. Thermal Engineering Research Group. Castellón (Spain)
Calleja Anta, Daniel University Jaume I, Spain
Cao, Bowen School of Energy and Environment, Southeast University
Carson, James K. Ahuora Centre for Smart Energy Systems, School of Engineering, University of Waikato, Hamilton, New Zealand
Carvalho, Suely Montreal Protocol Technology and Economic Assessment Panel
Casi, Alvaro Public University of Navarra, Spain
Catalán-Gil, Jesús TEWIS Smart Systems S.L.U., Spain
Catano, Juan National Renewable Energy Laboratory, USA
Cattani, Michele Department of Mechanical and Production Engineering, Aarhus University, Aarhus, 8200, Denmark
Cavicchioli, Rodolfo LU-VE Group, Italy
Chang, Young Soo Kookmin University, Republic of Korea
Christensen, Kim Gardø Fenagy, Denmark
Cimmino, Massimo Polytechnique Montréal, Canada
Cleland, Donald J. Massey University, Palmerston North, 4420, New Zealand
Colbourne, Daniel Re-phridge Ltd., United Kingdom
Conte, Riccardo Department of Industrial Engineering, University of Padova, Italy
Contiero, Luca European Org for Nuclear Research, Geneva, Switzerland; Norwegian Univ of Science & Tech, Trondheim, Norway
Cortella, Giovanni Università degli Studi di Udine, Italy
Couvreur, Kenny Ghent University - Department of Electromechanical, Systems and Metal Engineering, Ghent, 9000, Belgium
Cremaschi, Lorenzo Auburn University, USA
D'Agaro, Paola University of Udine, Italy
D'Ignazi, Chiara Politecnico di Milano, Italy
Daiguji, Hirofumi University of Tokyo, Japan
Das, Arpita Center for Environmental Energy Engineering, Department of Mechanical Engineering, University of Maryland
Das, Chayan Birla Institute of Technology and Science, Pilani
Dasgupta, Mani Sankar Department of Mechanical Engineering, BITS Pilani, India
Davoine, Loic CERN, Switzerland
De Gioia Carabbelese, Corrado Frascold SpA, Italy
De Paepe, Michel Ghent University - Ghent, Belgium; FlandersMake, Core lab EEDT-MP, Leuven, Belgium

Author List



de Vries, Wouter Netherlands Org for Applied Scientific Research, Sustainable Tech for Industrial Processes, Petten, The Netherlands
Del Col, Davide Department of Industrial Engineering, University of Padova, Italy
Delêtre, Pierre-Jean Teknologisk Institut, Denmark
Demurtas, Dario LU-VE Group, Italy
Dixon, Liz Shrieve Products International
Dowdell, Joshua SINTEF Energy Research, Norway
Ebanesar, Jerin Robin Auburn University, USA
Eikevik, Trygve M. Norwegian University of Science and Technology, Norway
Elbel, Stefan Creative Thermal Solutions, Inc., USA; TU Berlin, Germany
Emanuele, Zanetti Department of Process and Energy, Delft University of Technology, Netherlands
Engelmann, Peter Fraunhofer Institute for Solar Energy System (ISE), Germany
Erro, Irantzu Public University of Navarra, Spain
Ervik, Åsmund SINTEF Energy Research, 7034 Trondheim, Norway
Eslami-Nejad, Parham Polytechnique Montréal, Canada
Esmaelian, Jafar KTH Royal Institute of Technology, Sweden
Fabris, Francesco National Research Council, Construction Technologies Institute, Italy
Fan, Yuwei Jingkelun Refrigeration Equipment Co., Ltd. Beijing, China; College of Engineering, Peking University, Beijing, China
Fauer, Christian Auburn University, USA
Fayolle, Marine Panasonic Holdings Corporation, Technology Division
Ferreira, Thais P.A. Department of Mechanical Engineering, University of Maryland, College Park, USA
Ferretto, William Politecnico di Milano, Italy
Fiabane, Claudia Clivet S.p.a, Feltre, 32030, Italy
Filippini, Stefano LU-VE Group, Italy
Fix, Andrew Univ of Maryland-Center for Environmental Energy Engineering, USA
Forooghi, Pourya Department of Mechanical and Production Engineering, Aarhus University, Aarhus, 8200, Denmark
Frei, Gerhard COOLPLAN, Engineering Office for Refrigeration, Munich, Germany
Frei, Mihaela COOLPLAN, Engineering Office for Refrigeration, Munich, Germany
Fugmann, Hannes Fraunhofer Institute for Solar Energy System (ISE), Germany
Funder-Kristensen, Torben Danfoss Climate Solutions, Denmark
Galansky, Martin Trane Technologies, USA
Ganesan, P. Norwegian University of Science and Technology, Norway
Gao, Lei Univ of Maryland-Center for Environmental Energy Engineering, USA
Garashli, Elvin Fraunhofer ISE, Germany
Gardø Christensen, Kim FENAGY A/S, Lystrup, 8520, Denmark
George, Saju Cochin Food Tech Private Limited, Kochi, 682307, India
Gholamrezaie, Sepehr Polytechnique Montréal, Canada
Giroto, Sergio Enex Srl, Italy
Glos, Stefan Siemens Energy, Mülheim an der Ruhr, Germany
Gluesenkamp, Kyle Oak Ridge National Laboratory, USA
Gómez Parada, Nicolás Universitat Politècnica de València, Instituto de Ingeniería Energética, Valencia, Spain
González Maciá, José Universitat Politècnica de València, Instituto de Ingeniería Energética, Valencia, Spain
Groll, Eckhard A. Ray W. Herrick Laboratories West Lafayette, IN, 47907, USA
Gullo, Paride University of Southern Denmark
Guth, Tobias Ruhr West University of Applied Sciences, Institute of Energy Systems and Energy Management Bottrop, Germany
Hafner, Armin Department of Energy and Process Engineering, Norwegian University of Science and Technology, Trondheim, Norway
Hamid, Khalid Department of Energy and Process Engineering, Norwegian University of Science and Technology, Trondheim, Norway
Hammerschmidt, Lorenz Montanuniversität Leoben, Austria
Han, Changho Korea university, Korea, Republic of (South Korea)
Harikumar, Govind Department of Mechanical and Production Engineering, Aarhus University, Aarhus, Denmark
Harischander, Harischander IIT Bombay, India
Hashimoto, Katsumi Central Research Institute of Electric Power Industry, Japan; JASRE
Hashimoto, Takahiko Panasonic Corporation, Heating and Ventilation AC Company
Hashmin, Kollyiyil Ashraf NAS Fisheries Private Limited, Kochi, 682010, India
Hassan, Abdelrahman Universitat Politècnica de Valencia, Spain
Hattori, Kazuhiro Mayekawa Mfg. Co., Ltd., Japan
Hazarika, Mihir Mouchum Norwegian University of Science and Technology, Trondheim, 7491, Norway
Heerup, Christian Danisch Technological Institute
Hellmuth, Jan Friedrich TU Braunschweig, Germany
Herden, Dominik TU Dresden Schaufler Chair of Refrigeration, Cryogenics and Compressor Technology
Herpin, Yann CERN, Switzerland
Hiwata, Akira Panasonic Corporation, Heating and Ventilation AC Company
Höges, Christoph RWTH Aachen University, E.ON Energy Research Center, Aachen, Germany
Holmes, Till SINTEF Energy Research, Norway
Hori, Kazutaka Daikin Industries, LTD.
Houdek, Pavel Trane Technologies, USA
Hsu, Wei-Lun University of Tokyo, Japan
Hu, Ming-Hsuan University of Tokyo, Japan
Huang, Ransisi National Renewable Energy Laboratory, USA
Hudjetz, Stefan Biberach University of Applied Sciences, Germany
Hummel, Luca RWTH Aachen University, Germany
Hwang, Yunho Univ of Maryland-Center for Environmental Energy Engineering, USA
Ignatowicz, Monika KTH Royal Institute of Technology, Sweden
Inoue, Norihiko Tokyo University of Marine Science and Technology

Author List



Ispir, Ali Can Eindhoven University of Technology, Eindhoven, 5600MB, The Netherlands
Izadi-Zamanabadi, Roozbeh Danfoss A/S; Aalborg University
Jang, Junhyeok Korea university, Korea, Republic of (South Korea)
Javerschek, Oliver BITZER Kuehlmaschinenbau GmbH, Rottenburg-Ergenzingen, 72108, Germany
Jensen, Jonas Kjaer Technical University of Denmark, Denmark
Jessen, Lars M. Danfoss, Denmark
Jin, Zhequan H&A R&D Center, Home Appliance & Air Solution Company, LG electronics
Jung, Minkyu Chung-Ang University, Republic of Korea
Kamada, Masashi Daikin Industries, LTD.
Kanbur, Baris B. Independent Researcher, The Netherlands
Kang, Jianhui Jingkelun Refrigeration Equipment Co., Ltd. Beijing, 101302, China
Kang, Yong Tae Korea University, Korea, Republic of (South Korea)
Karampour, Mazyar Danfoss Climate Solutions, Sweden
Karnaz, Joe Shrieve Chemical Products, LLC, USA
Katic, Ivan Danish Technological Institute
Kayukawa, Yohei National Institute of Advanced Industrial Science and Technology, JASRE
Kenchappa, Chetan INS Shivaji, India
Khan, Muhammad Umar Norwegian University of Science and Technology, Norway
Khodabandeh, Rahmatollah KTH Royal Institute of Technology, Sweden
Kibo, Kosuke Daikin Industries, Ltd., Japan
Killiyot, Anuroop INS Shivaji, India
Kim, Junyoung National Renewable Energy Laboratory Golden, CO, 80401, USA
Kim, Min Soo Seoul National University, Korea, Republic of (South Korea)
Kim, Minsung Chung-Ang University, Republic of Korea
Kim, Moojoong Research Institute for Science and Engineering, Waseda University
Kim, Seon Tae Institute of Low-Carbon Industrial Process, German Aerospace Center (DLR)
Kim, Soyeon Chung-Ang University, Republic of Korea
Kim, Yongchan Korea university, Korea, Republic of (South Korea)
Klebig, Tim RWTH Aachen University, Germany
Klingebiel, Jonas RWTH Aachen University, Germany
Kloeppe, Steffen German Aerospace Center (DLR), Institute of Low-Carbon Industrial Processes, Zittau, 02763, Germany
Knapke, Kurt J. Copeland, USA
Kochunni, Sarun Kumar Norwegian University of Science and Technology
Koehler, Juergen TU Braunschweig, Germany
Köhler, Jürgen Technical University Braunschweig, Germany
Kolda, Michal Trane Technologies, USA
Kong, Fanchen Key Laboratory of Cryogenic Science and Technology, Chinese Academy of Sciences, Beijing, China
Kong, Lana Ahuora - Centre for Smart Energy Systems, School of Engineering, University of Waikato, Hamilton, New Zealand
Korte, Tobias Chair of Energy Systems and Energy Economics, Ruhr-University Bochum, Germany
Köster, Lukas Fisheries and New Biomarine Industry, SINTEF Ocean, Trondheim, 7465, Norway
Kotenko, Alexander HAUSER Kühlmöbel und Kältetechnik GmbH
Kozubal, Eric National Renewable Energy Laboratory, USA
Kreuz, Martin Fraunhofer ISE, Germany
Kriezi, Ekaterini E. Danfoss, Denmark
Kristófersson, Jóhannes Danish Technological Institute, Taastrup, 2630, Denmark
Kristoffersen, Jesper Weinkauff Teknologisk Institut, Denmark
Kristofferson, Jóhannes Teknologisk Institut, Denmark
Ku, Donik Chung-Ang University, Republic of Korea
Kuamr, Kundan Indian Institute of Science Bangalore, India
Kujak, Steve Trane Technologies, USA
Kumakura, Eiji Daikin Industries, Ltd., Japan
Kumar Kochunni, Sarun Norwegian University of Science and Technology
Kumar, Anil Department of Energy Science and Engineering, Indian Institute of Technology Bombay, Mumbai, 400076, India
Kumar, Pramod Indian Institute of Science Bangalore, India
Kumar, Sumit School of Energy Science and Engineering, Indian Institute of Technology, Kharagpur, India
Laguri, Vinod Indian Institute of Science, India
Längauer, Andreas ECOP Technology GmbH, Austria
Larrondo Sancho, Rafael Jaume I University. Thermal Engineering Research Group. Castellón (Spain)
Latvenas, Arvydas Teknologisk Institut, Denmark
Lecompte, Steven Ghent University, Ghent, Belgium; FlandersMake, Leuven, Belgium
Lee, Chengyi University of Maryland, USA
Lee, Jinwook H&A R&D Center, Home Appliance & Air Solution Company, LG electronics
Lee, Seungyeon Seoul National University, Korea, Republic of (South Korea)
Lerga, Ivan Public University of Navarra, Spain
Li, Daqing Copeland, USA
Li, Shawn Creative Thermal Solutions, Inc., USA
Li, Xiaolong Jingkelun Refrigeration Equipment Co., Ltd. Beijing, 101302, China
Li, Zhenning Oak Ridge National Laboratory, USA
LIANG, Changkuan Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University
Linder, Marc Institute of Engineering Thermodynamic, German Aerospace Center (DLR)
Liu, Haopeng University of Maryland, USA
LIU, Haotian Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University
Liu, Jia Department of Energy and Resources Engineering, Peking University. Beijing, China; Peking University, Nanchang, China

Author List



Liu, Jun Shrieve Chemical Shanghai
Llopis, Belen Universitat Politècnica de Valencia, Spain
Llopis, Rodrigo University Jaume I, Spain
Longo, Giovanni A. University of Padova, Italy
Lund, Thomas Danfoss A/S, Denmark
M. Eikevik, Trygve Norwegian University of Science and Technology, Trondheim, Norway
Ma, Guoyuan Beijing University of Technology, China, People's Republic of
Maeda, Kento Department of Applied Mechanics and Aerospace Engineering, Waseda University
Mahravan, Ehsan Department of Mechanical and Production Engineering, Aarhus University, Aarhus, 8200, Denmark
Maiorino, Angelo Università degli Studi di Salerno, Italy
Mall-Gleissle, Susanne Offenburg University of Applied Sciences
Malleswararao, Katamala Institute of Engineering Thermodynamic, German Aerospace Center (DLR)
Mariani, Giovanni LU-VE Group, Italy
Marinetti, Sergio National Research Council, Construction Technologies Institute, Italy
Markussen, Wiebke Brix Danish Technological Institute
Martínez Angeles, Manel University Jaume I, Spain
Martinez, Alvaro Public University of Navarra, Spain
Mastrapasqua, Maurizio Frascold SpA, Italy
Masuno, Katsuya Department of Applied Mechanics and Aerospace Engineering, Waseda University
Meruva, Vijay Preetham University of Maryland, College Park, USA
Methler, Timo Fraunhofer ISE, Germany
Metsue, Antoine Université de Sherbrooke, Canada; UCLouvain, Belgium
Meyer, Ole SINTEF Energy Research, 7034 Trondheim, Norway
Minetto, Silvia National Research Council, Construction Technologies Institute, Italy
Mirl, Nico University of Stuttgart, Germany
Miyaoaka, Yoichi Waseda Univ; Technical Committee on Refrigeration/Air-conditioning Systems Using Natural Working Fluids, JASRE
Modi, Anish Department of Energy Science and Engineering, Indian Institute of Technology Bombay, Mumbai, 400076, India
Moen, Ole Marius SINTEF Energy Research, Norway
Molinaroli, Luca Politecnico di Milano, Italy
Moric Zadeh, Milad University of Southern Denmark
Muehlbauer, Jan Univ of Maryland-Center for Environmental Energy Engineering, USA
Mugabi, Nelson Mayekawa Mfg. Co., Ltd., Japan
Müller, Dirk RWTH Aachen University, E.ON Energy Research Center, Aachen, Germany
Munoz, Manuel Shrieve Products International
Mvimbi, Amanda Power CERN, Switzerland; University of Cape Town, Electrical Engineering Department, South Africa
Nakagawa, Kentaro Panasonic Corporation, Heating and Ventilation AC Company
Natalini, Yuri Clivet S.p.A., Feltre, 32030, Italy
Navarro Peris, Emilio Universitat Politècnica de Valencia, Spain
Nebot Andrés, Laura University Jaume I, Spain
Nefodov, Dimitri Chemnitz University of Technology, Germany
Nekså, Petter SINTEF Energy Research, 7034 Trondheim, Norway
Nesreddine, Hakim Hydro-Québec, Canada
Neumann, Kaj RWTH Aachen University, E.ON Energy Research Center, Aachen, , Germany
Nicholson, Autumn N. Copeland, USA
Nicke, Eberhard German Aerospace Center (DLR), Institute of Low-Carbon Industrial Processes Cottbus/Zittau, Germany
NIE, Junrui Beijing University of Technology, China, People's Republic of
Nienborg, Björn Fraunhofer Institute for Solar Energy System (ISE), Germany
Ninan, George Engineering Division, ICAR-Central Institute of Fisheries Technology, Kochi, 682029, India
Niroomand, Reza Norwegian University of Science and Technology
Nishida, Kosaku Mayekawa Mfg. Co., Ltd.
Nishiguchi, Tsubasa Waseda university, Japan
Nishikawa, Takeshi TEWIS Smart Systems S.L.U., Spain
Nordtvedt, Tom Ståle SINTEF Ocean, Norway
Norne Widell, Kristina SINTEF Ocean
Nowacki, Jan-Erik Nowab
O'Malley, Brian Center for Environmental Energy Engineering, Department of Mechanical Engineering, University of Maryland, USA
Oh, Jinwoo Ray W. Herrick Laboratories West Lafayette, IN, USA
Oh, Saikkee H&A R&D Center, Home Appliance & Air Solution Company, LG electronics
Ohadi, Michael Advanced Heat Exchangers and Process Intensification Laboratory, University of Maryland, College Park, USA
Ohama, Hirohisa Daikin Industries, LTD.
Oku, Tatsuya Mayekawa MFG Co. LTD., Botan Koto ku, Tokyo, Japan
Ölen, Viktor SKVP
Oltersdorf, Thore Fraunhofer ISE, Germany
Oritani, Yoshio Daikin Industries, Ltd., Japan
Ostlender, Sebastian Hubert RWTH Aachen University , E.ON Energy Research Center, Germany
Ostmann, Philipp RWTH Aachen University, Germany
Otero Rodriguez, Gustavo Netherlands Org for Applied Scientific Research, Petten, The Netherlands
Othman, Alhussain Ali University of Maryland, USA
Ozaki, Takahiro DAIKIN INDUSTRIES, LTD., Japan
Padoan, Linda Clivet S.p.a, Feltre, 32030, Italy
Pakulski, Tymon CERN, Switzerland
Palm, Björn KTH royal institute of technology, Sweden

Author List



Park, Mansu H&A R&D Center, Home Appliance & Air Solution Company, LG electronics
Pasqualin, Paris University of Tokyo, Japan
Paya, Jorge Universitat Politècnica de València, Spain
Pearson, Andy Star Refrigeration Ltd, United Kingdom
Pedano, Camila CERN, Switzerland
Pedersen, Per Henrik Danish Technological Institute
Pedersen, Troels Stevns Teknologisk Institut, Denmark
Pei, Yong Univ of Maryland-Center for Environmental Energy Engineering, USA
Pertiller, Gerhard Graz University of Technology, Austria
Petagna, Paolo CERN, Switzerland
Petersen, Michael Trane Technologies, USA
Petruzzello, Fabio Università degli Studi di Salerno, Italy
Pfeiffer, Daniel Biberach University of Applied Sciences, Germany
Piesch, Nina Norwegian University of Science and Technology
Piovesan, Simone Clivet S.p.A., Feltre, Italy
Pollak, Markus TU Braunschweig, Germany; TLK Thermo GmbH, Braunschweig, Germany
Poncet, Sébastien Université de Sherbrooke, Spolstra, Canada
Radermacher, Reinhard Univ of Maryland-Center for Environmental Energy Engineering, USA
Rai, Shubhanshu Department of Energy Science and Engineering, Indian Institute of Technology Bombay, Mumbai, 400076, India
Ramezani, Hossein University of Southern Denmark
Ramgopal, Maddali Department of Mechanical Engineering, Indian Institute of Technology, Kharagpur, 721302, India
Ramirez Stefanou, Miguel TNO
Rane, Aditya M IIT Bombay, India
Rane, Milind V IIT Bombay, India
Rangelov, Ivan Danfoss A/S, Denmark
Rekstad, Inge Håvard NTNU, Norway
Ren, Shuai Department of Energy and Process Engineering, Norwegian University of Science and Technology, Trondheim, Norway
Reveillere, Adrien Siemens Digital Industries Software
Richter, Markus Chemnitz University of Technology, Germany
Rieberer, René Graz University of Technology, Austria
Roanic, Zlatko Montanuniversität Leoben, Austria
Rodenbücher, Beatrice Fraunhofer Institute for Solar Energy System (ISE), Germany
Rodriguez, Antonio Public University of Navarra, Spain
Rossetti, Antonio National Research Council, Construction Technologies Institute, Italy
ROSSI, Paolo Clivet S.p.A., Feltre, Italy
Rotan, Magnus SINTEF Energy Research, Norway
Roy, Philipp RWTH Aachen University, E.ON Energy Research Center, Aachen, Germany
S, Murali Engineering Division, ICAR-Central Institute of Fisheries Technology, Kochi, India
Saai, Afaf SINTEF Industry, Trondheim, Norway
Saito, Kiyoshi Department of Applied Mechanics and Aerospace Engineering, Waseda University
Samuel, Manoj Centre for Water Resources Development and Management, Kozhikode, India
Sánchez García-Vacas, Daniel Jaume I University. Thermal Engineering Research Group. Castellón (Spain)
Sanchez, Daniel Universitat Jaume I, Spain
Sarmiento, Andres Advanced Heat Exchangers and Process Intensification Laboratory, University of Maryland, College Park, USA
Sawalha, Samer Royal Institute of Technology (KTH)
Schädlich, Sylvia Ruhr West University of Applied Sciences, Institute of Energy Systems and Energy Management Bottrop, Germany
Scheepens, Daan Standard Fasel, The Netherlands
Schlemminger, Christian SINTEF Energy Research, Norway
Schlosser, Florian Department of Energy System Technologies, Paderborn University: Paderborn, 33098, Germany
Schmid, Oliver University of applied sciences Karlsruhe, Germany
Schmig, Alexander Trane Technologies, USA
Schnabel, Lena Fraunhofer ISE, Germany
Schöffl, Leopold HAUSER Kühlmöbel und Kältetechnik GmbH
Schulte, Andreas TU Braunschweig, Germany
Seabourne, Tamoy Univ of Maryland-Center for Environmental Energy Engineering, USA
Sengupta, Ayan Department of Mechanical Engineering, BITS Pilani, India
Seresin, Simone Department of Industrial Engineering, University of Padova, Italy
Sever, Mark Danfoss, Denmark
Shah, Wasim University of Padova, Department of Industrial Engineering, Italy
Shamim, Jubair A. University of Tokyo, Japan
Shen, Bo Oak Ridge National Laboratory, USA
Shin, HeeJun Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University
Shivashankar, Suresh Copeland, USA
Sicco, Emanuele University of Udine, Italy
Silva, Alessandro Bitzer US, Inc., Flowery Branch, USA
Simon, Florian Bitzer Kuehlmaschinenbau GmbH, Rottenburg-Ergenzingen, Germany
Simoni, Federico Clivet S.p.a, Feltre, 32030, Italy
Singh, Simarpreet Norwegian University of Science and Technology, Norway
Singha, Prosenjit Birla Institute of Technology and Science, Pilani
Skoglund, Erik Stockholm Exergi AB
Söylemez, Engin Norwegian University of Science and Technology, Trondheim, Norway
Span, Roland Chair of Thermodynamics, Ruhr-University Bochum, Germany
Speetjens, Michel Eindhoven University of Technology, Eindhoven, The Netherlands

Author List

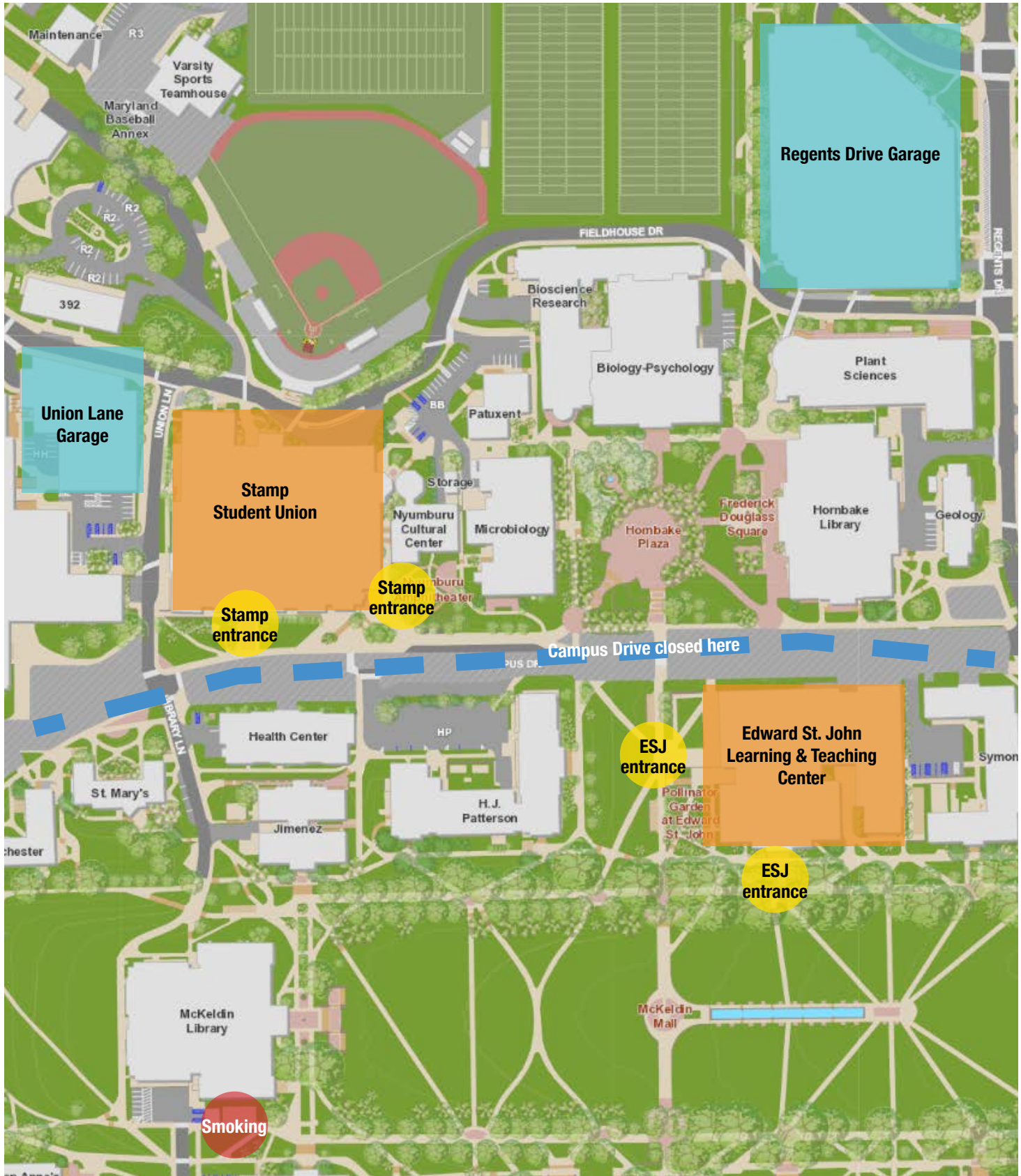


Spoelstra, Simon TNO
Stathopoulos, Panagiotis German Aerospace Center (DLR), Institute of Low-Carbon Industrial Processes Cottbus/Zittau, Germany
Steinberg, Lukas Chair of Thermodynamics, Ruhr-University Bochum, Germany
Stergiaropoulos, Konstantinos University of Stuttgart, Germany
Svendsen, Eirik Starheim SINTEF Ocean, Norway
Tanaka, Masaki Daikin Industries, Ltd., Japan
Tancabel, James University of Maryland, College Park, USA
Tancon, Marco Department of Industrial Engineering, University of Padova, Italy
Tang, Ke Creative Thermal Solutions, Inc., USA; University of Illinois at Urbana-Champaign, USA
Tang, Mingsheng Key Laboratory of Cryogenic Science and Technology, Chinese Academy of Sciences, Beijing, China
Tanimoto, Keisuke Daikin Industries, Ltd., Japan
Tegethoff, Wilhelm TU Braunschweig, Germany
Teixeira, Daniella Ida CERN, Switzerland
Teles de Oliveira, Hannah Fraunhofer ISE, Germany
Thanasoulas, Sotirios Danfoss, Denmark
Thomas, Christiane TU Dresden Schaufler Chair of Refrigeration, Cryogenics and Compressor Technology
Tian, Changqing Key Laboratory of Cryogenic Science and Technology, Chinese Academy of Sciences, Beijing, China
Toffoletti, Gabriele University of Udine, Italy
Tokano, Atsuya Waseda University, Japan
Tolstorebrov, Ignat Norwegian University of Science and Technology, Trondheim, Norway
Tommasini, Davide SINTEF Energy Research, Norway
Tran, A. Phong German Aerospace Center (DLR), Institute of Low-Carbon Industrial Processes Cottbus/Zittau, Germany
Tsuji, Takuma Mayekawa MFG Co. LTD., Botan Koto ku, Tokyo, Japan
Tsunoyama, Hironori Panasonic Holdings Corporation, Technology Division
Uhl, Annette Fraunhofer Institute for Solar Energy System (ISE), Germany
Urbaneck, Thorsten Chemnitz University of Technology, Germany
van de Weijer, Geert Standard Fasel, The Netherlands
Verdnik, Manuel Institute of Thermal Engineering, Graz University of Technology, Austria
Vering, Christian RWTH Aachen University, E.ON Energy Research Center, Aachen, Germany
Verlaat, Bart CERN, Switzerland
Vidan Falomir, Francisco Jaume I University. Thermal Engineering Research Group. Castellón (Spain)
Vieren, Elias Ghent University - Department of Electromechanical, Systems and Metal Engineering, Ghent, Belgium
Virgilio, Federico Clivet S.p.a, Feltre, Italy
Volpato, Omar University of Padova; Italy
Walmsley, Timothy G. Ahuora-Centre for Smart Energy Systems, School of Engineering, University of Waikato, Hamilton, New Zealand
Wang, Haochen Chemnitz University of Technology, Germany
Wang, Lei Beijing University of Technology, China, People's Republic of
Wang, Quanjiang Jingkelun Refrigeration Equipment Co., Ltd. Beijing, 101302, China
Wang, Yizhou Department of Energy and Resources Engineering, College of Engineering, Peking University. Beijing 100871, China
Wapler, Jeannette Fraunhofer ISE, Germany
Welch, Drew The Helix Innovation Center at Copeland, USA
Wernhart, Michael Institute of Thermal Engineering, Graz University of Technology, Austria
Widell, Kristina Norne Fisheries and New Biomarine Industry, SINTEF Ocean, Trondheim, 7465, Norway
Will, Torsten Fraunhofer-Institut for Solar Energy Systems ISE, Germany
Wirtz, Mathilde National Renewable Energy Laboratory, USA
Wittstadt, Ursula Fraunhofer ISE, Germany
Woods, Jason National Renewable Energy Laboratory, USA
Xu, Yixia TU Dresden Schaufler Chair of Refrigeration, Cryogenics and Compressor Technology
Yamada, Takuro Daikin Industries, Ltd., Japan
Yamaguchi, Hiroshi Doshisha University, Japan
Yamaguchi, Seiichi Waseda University, Japan
Yang, Bao Univ of Maryland-Center for Environmental Energy Engineering, USA
Yang, Jangho Univ of Maryland-Center for Environmental Energy Engineering, USA
yang, Jianguo Jingkelun Refrigeration Equipment Co., Ltd. Beijing, China
Yokono, Ryoutarou Daikin Industries, LTD.
Z. Tari, Amir H. Advanced Heat Exchangers and Process Intensification Laboratory, University of Maryland, College Park, USA
Zapata, Andres Pennsylvania Department of Environmental Protection, USA
Zha, Shitong Heatcraft Refrigeration (Lennox international), USA
Zhang, Shuo Chinese Academy of Sciences, Beijing, China; University of Chinese Academy of Sciences, Beijing, China
Zhang, Xinrong Peking University, Beijing, China; Peking University Nanchang Innovation Institute. Nanchang, China
Zhao, Hui Creative Thermal Solutions, Inc., USA; University of Illinois at Urbana-Champaign, USA
Zhu, Mingjie Ray W. Herrick Laboratories West Lafayette, IN, USA
Zimny, Michal Zbigniew CERN, Switzerland
Ziviani, Davide Ray W. Herrick Laboratories West Lafayette, IN, USA
Zotter, Gerald ECOP Technology GmbH, Austria
Zou, Huiming Key Laboratory of Cryogenic Science and Technology, Chinese Academy of Sciences, Beijing, China
Zühlsdorf, Benjamin Danisch Technological Institute
Zwalinski, Lukasz CERN, Switzerland

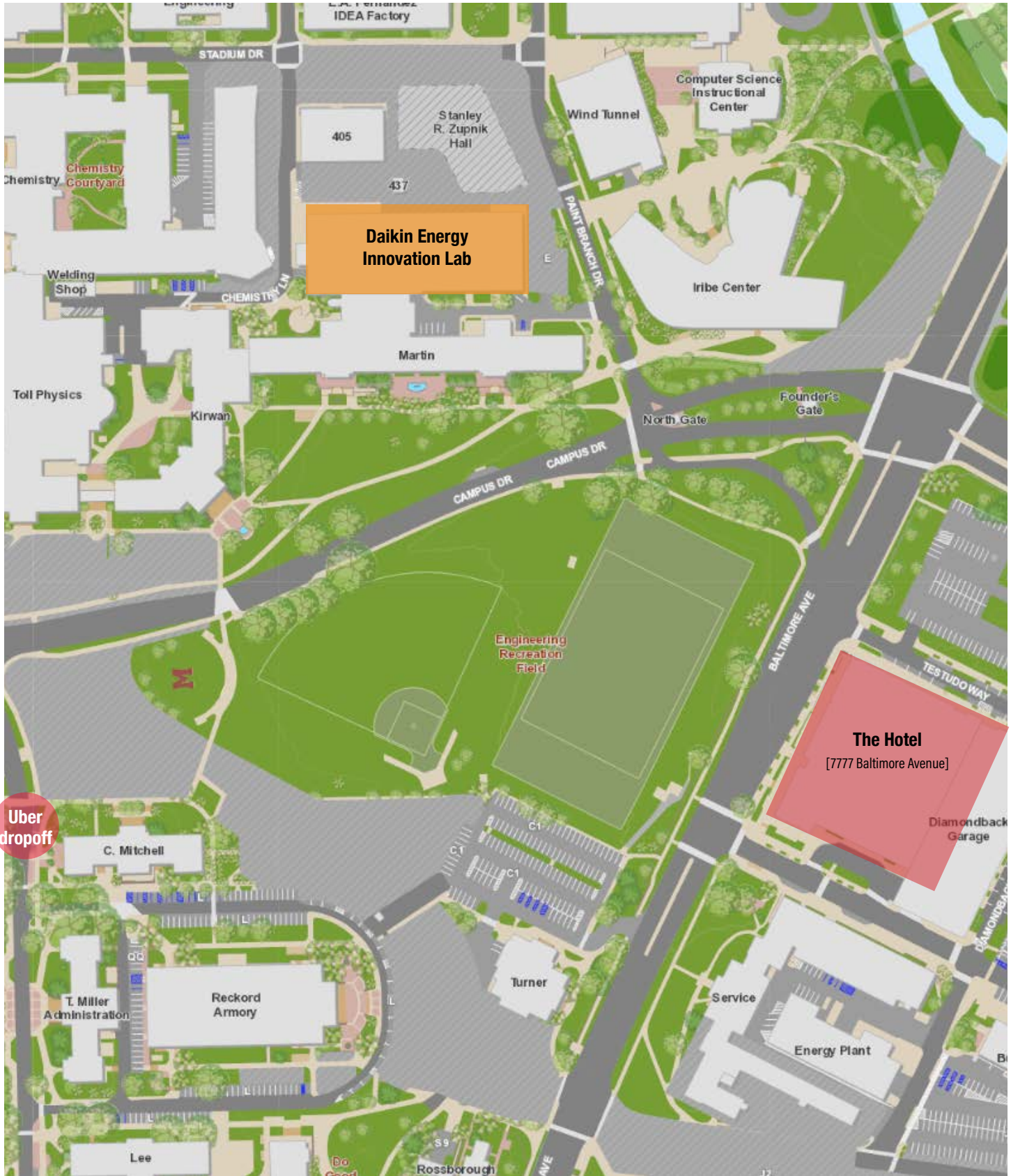
Campus Map

Dynamic UMD campus map

College Park Marriott Hotel



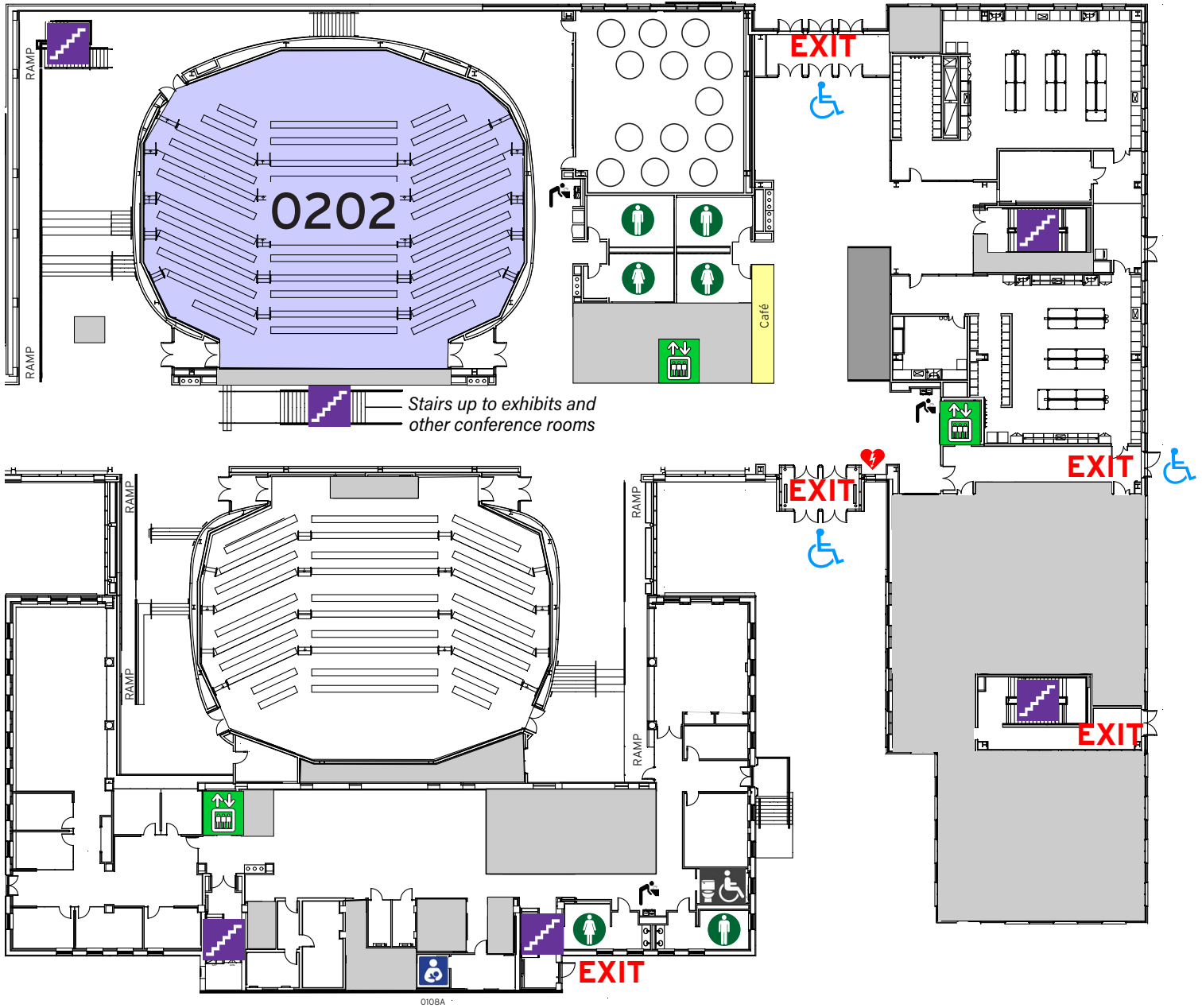
Campus Map



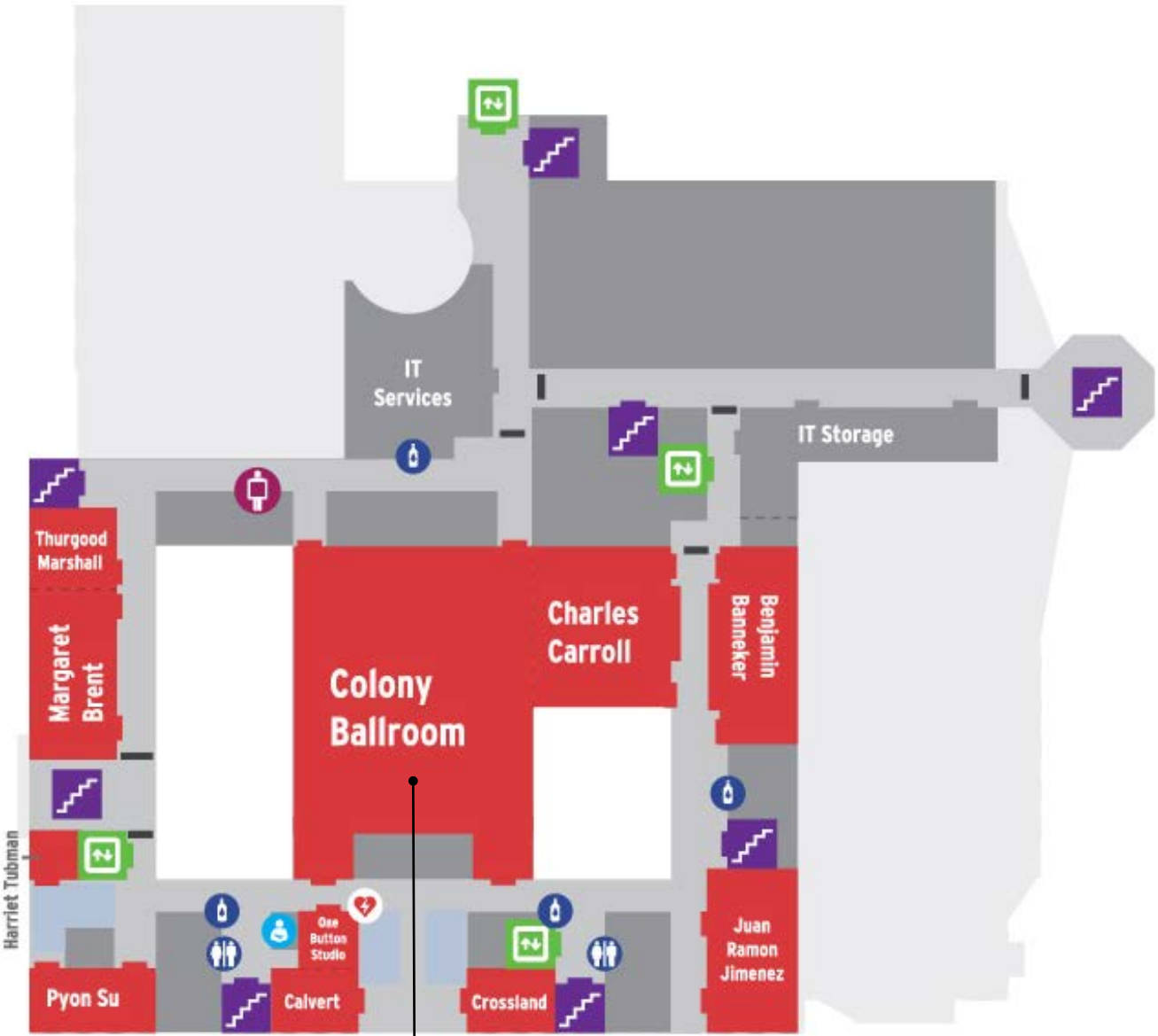
↑
Cambria
Hotel

Uber
dropoff

GROUND FLOOR
Edward St. John Learning and Teaching Center
4131 CAMPUS DRIVE



SECOND FLOOR
Stamp Student Union
3972 CAMPUS DRIVE



Lunches and the Conference Banquet will be offered in the Colony Ballroom in the Stamp Union.

General Information



Transportation to the Conference

By plane: The airports nearest to College Park are Baltimore/Washington International (25 miles/40 km), Reagan National (16 miles/26 km) and Dulles International Airport (37 miles/60km).

By train: Amtrak offers service to Union Station in Washington, DC (8 miles/14 km) and New Carrollton, Md. (6 miles/9 km).

By Metro: The Metrorail rapid transit system has a stop in College Park, with access from Union Station, Dulles International Airport and Reagan National Airport. A complimentary shuttle service is provided from the College Park Metro station to campus. The shuttle operates Monday-Friday during the summer. The schedule is available at <https://transportation.umd.edu/shuttle-um>.

Campus Construction

The University of Maryland is undergoing construction detours due to work on the Purple Line light rail. Road closures include the section of Campus Drive near conference facilities. Please leave extra time to navigate the campus. For more information,

[See a map of vehicle detours](#)

[See a map of pedestrian detours](#)

Rideshare Drop Off Point

If you plan to take an Uber, Lyft, or other rideshare service, please ask the driver to drop you off at the Clarence M. Mitchell, Jr. Building, 7999 Regents Dr., College Park, Md. The Edward St. John Learning and Teaching Center is only a three-minute walk away. Please walk along McKeldin Mall and enter the building at the McKeldin Mall entrance. Due to construction, access to the Campus Drive entrance to the building is unavailable.

Parking

The Regents Drive Garage and Union Lane Garage are the two closest garages to the conference facilities. Rates are \$3 per hour, with a \$15 daily maximum. For details, see [Visitor Parking](#). Be aware that Campus Drive is closed between Regents Drive and the Benjamin Building, requiring detours to reach the Union Lane Garage, if you are entering the university at the Route 1 entrance. Parking in certain university surface lots (and in the lower levels of the Regents Drive Garage, not in "visitor parking" at the top) is free after 4 p.m., Monday-Friday, and anytime on Saturday and Sunday. Read signs closely.

Conference Facilities

Conference activities will take place in two buildings:

The Edward St. John Learning and Teaching Center (ESJ). Registration, sponsor exhibitions, technical sessions, plenary sessions, breakfast and coffee breaks will be held in this modern space, equipped with the latest audiovisual technology. Plenary speeches will be on the ground level in Room 0202. All other events will be held on the first floor. See the schedule to locate the room for each session. Presenters are welcome to use Room 1309 to prepare for their presentations. Stop by the registration desk with any questions and for our "lost and found" area.

Food for Thought Cafe (open 8 a.m.-2 p.m.), on the first floor near the registration desk, serves Starbucks coffee, sandwiches, wraps and snacks. You're welcome to grab a seat in any public area to network, take a break or prepare for your presentation.

The Adele H. Stamp Student Union (The Stamp).

Lunch will be served in the Colony Ballroom on the second floor of The Stamp on Monday, Tuesday and Wednesday. The conference banquet will be held there on Tuesday evening. These meals are included with your conference registration. The Stamp is conveniently located across the street from ESJ.

The Stamp offers a variety of guest services, including the University Book Store, two ATMs, a convenience store, copy and mail services, a food court, a movie theater, bowling and billiards. For help locating services, stop by the information desk on the first floor near the main entrance.



Looking to see more of the campus? Join us for a guided tour of the University of Maryland engineering labs that are developing eco-friendly HVAC&R technology. The tour is scheduled for Wednesday, August 14, at 1:00 p.m.-2:30 p.m., directly after the conference closing ceremony.

General Information



Accessibility

All conference facilities offer accessible entrances and amenities. [Read more about accessibility at ESJ](#) and [accessibility at The Stamp](#) online. If you have specific concerns, please notify us prior to the conference at gl2024@umd.edu or stop by the registration desk during the conference.

Smoking

Smoking is prohibited on campus, with the exception of four designated smoking areas. The closest smoking area is on the south side of McKeldin Library, to the left of the library's main entrance. Exit ESJ at the McKeldin Mall entrance and turn right to head toward McKeldin Library. The University of Maryland is a cannabis-free campus. You cannot use or possess any form of cannabis, including recreational or medical cannabis, anywhere on University of Maryland premises. This means no vaporizers, no edibles and no smoking.

Dining

Your conference registration includes a welcome reception on Sunday with heavy hors d'oeuvres, mini desserts and a bar; lunch on Monday, Tuesday and Wednesday; and a conference dinner banquet on Tuesday evening. Optional dinner excursions are available on Monday evening. Check with the registration desk for more information.

In addition, Adele H. Stamp Student Union offers a [variety of options](#) for a quick meal or snack, including the Maryland Dairy, which offers University of Maryland-themed flavors like Fear the Turtle.

A vast array of [dining options](#) are located just off campus. Whether you're looking for sushi, tacos, salads, pizza or burgers, you'll find it along Baltimore Avenue (Route 1). College Park offers everything from quickservice dining options to upscale restaurants, including GrillMarx Steakhouse and Raw Bar in The Hotel at the University of Maryland.

Pictures and Videotaping

Conference attendees may NOT take pictures or videos at any presentation without the consent of the author or presenter. An official photographer will take pictures during the conference. Attendees may NOT take pictures during the lab tours because the research is often highly sensitive.

Conference Mobile App



We're excited to offer a mobile app to help attendees navigate the conference. Simply scan the QR code on this page and download the Whova app from the App Store or Google Play. Sign in or create an account by entering the email address you used to register for the conference. If you're having trouble joining our event, use Event Invitation Code: GL2024AtUMD.

The app provides easy access to the conference program, floor plans, plenary speaker bios and more. You can build your personal agenda and can network with other attendees through in-app messaging. The app is the best way to stay up to date and will alert you of any schedule changes or conference updates.

Gustav Lorentzen 2024 Conference

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We're using *Whova* as our official event app to facilitate networking, host the event agenda, distribute documents, and send announcements!



Scan this QR code for the link to download Whova from the App Store and Google Play

Having trouble joining? Search for our event and enter the invitation code: GL2024AtUMD

Internet Access

The University of Maryland provides two wireless networks for visitors to campus:

Eduroam If you use eduroam at your home institution, you are welcome to use the service to easily connect to the University of Maryland's Wi-Fi service.

UMD-guest If you are using a device that can receive SMS text messages, choose the umd-guest network option and follow the prompts to request an account.

General Information



Wait for a text message. Access the text message to get your username and password, which can be used on up to three devices. [Guest Wi-Fi accounts](#) expire after 24 hours. You can repeat the process if you need additional time.

If you are unable to access the Internet using either of these two networks, please stop by the registration desk for assistance.

Attendees are encouraged to download offline maps for the DMV (DC, Maryland, Virginia) Area before leaving your home region.

Instructions can be found at:

[Apple Devices](#)

[Android Devices](#)

Presentation Updates

If you have last minute changes to your presentation (different from what was uploaded into Conftool), please see your session chair to make arrangements to upload your new file.

Conferences & Visitors Center

Stop by the University of Maryland Conferences & Visitor Services Welcome Desk for a warm Terrapin welcome. Friendly and informed staff members are available to provide parking information, directions and a campus map. The Welcome Desk is located in Turner Hall, 7736 Baltimore Ave, College Park, Md. Hours of operation are Monday – Friday, 8:00 a.m. – 5:00 p.m. Visitor information is also available [online](#).

University Health Center

All campus guests may utilize services offered by the University Health Center (UHC). Office visits and laboratory services can be billed to many private insurance plans or paid for directly by the treated guest. (The UHC cannot bill Medicare, Medicaid, Kaiser Permanente and TRICARE Prime.) Arrangements for special medical needs (e.g., allergy injections, insulin storage) may be made by calling 301-314-8180. Due to construction, the Health Center entrance along Campus Drive is temporarily closed; entrance is available on the opposite side of the building.



In Case of Emergency

If you see something, say something. Report crimes, hazards, traffic accidents, medical emergencies, chemical spills and other emergencies by dialing 911 or calling the University of Maryland Police Department at 301-405-3333. Report a fire by calling 911.

Safety and Security

A full-service Department of Public Safety is located on Route 1 in the Pocomoke Building at 7569 Baltimore Ave., College Park, Md., just south of The Hotel at the University of Maryland. The department provides integrated safety and security services to the campus community. For additional security information, see <https://prepare.umd.edu/>.

Exploring the Washington, D.C., Area

Metrorail (or Metro, as the locals call it) offers rail service throughout the Washington, D.C., metropolitan area, serving 98 stations in Maryland, Washington, D.C., and Virginia. A [campus shuttle](#) provides free transportation to the College Park Metro Station. A [map of the metro system](#) is in the visitors guide provided at the registration desk. For information on things to do in the area, see the [Washington DC Official Visitors Guide](#).

Time Zone

During the conference, College Park, Md., will be on Eastern Daylight Time.



Gustav Lorentzen 2024 Conference

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We're using *Whoova* as our official event app. Join our event app to access:

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- ➔ Networking, meet-ups, messages
- ➔ Event documents
- ➔ Faster check-in

How to join:

1. Scan the QR code and download Whoova from the App Store or Google Play.
2. Sign in or create an account with the email you registered with.

Having trouble joining? Search for our event and enter the invitation code: GL2024AtUMD

