

HVAC&R Research Collaboration through IEA and IIR Activities



Oak Ridge National Laboratory (ORNL)

Van D. Baxter, Distinguished R&D Staff Member

vdb@ornl.gov

Project summary

Timeline:

Start date: ca. 1980

Planned end date: ongoing

Key Milestones

1. HVAC&R short course on flammable refrigerants: 7/2018
2. Initiated IEA-HPT collaborative project on advanced cooling technologies: 10/2018
3. International Congress of Refrigeration: 8/2019

Budget:

Total Project (FY15-FY18): \$1810k

- DOE: \$1610k
- Cost Share: \$200k (\$20k/y ASHRAE and NIST contribution to USNC IIR + \$30k/y est. partner costs to attend meetings, review IEA & IIR programs, participate in individual projects, etc.)

Total Project (FY19-21): \$1650k

- DOE: \$1500k
- Cost Share: \$150k

Total Project FY22 on (est.): ~\$550k/y

- DOE: ~\$500k/y
- Cost Share: ~\$50k/y

Key Partners:

International Energy Agency Heat Pumping Technologies program (IEA-HPT):

16 member countries: Europe, Far East, and N. America

US National Team (USNT) for IEA-HPT:

20 high-level members from US HVAC&R community

International Institute of Refrigeration (IIR):

58 member countries, including all IEA-HPT members

US National Committee for IIR (USNC/IIR):

About 30 members, mainly leading US HVAC&R researchers from industry and universities

Project Outcome:

Facilitate US manufacturing competitiveness and inform BTO R&D portfolio of latest world-wide R&D, market status, and policy initiatives via continuous, robust engagement with offshore HVAC/R peers through the IEA-HPT and IIR. IEA-HPT is the leading organization focused on heat pumping technologies. IIR is leading organization for advancing basic arts & sciences underpinning HVAC&R equipment & systems. (MYPP, pg. 64)

Team

ORNL BTRIC's Building Equipment Research (BER) team is tasked with overseeing the HVAC&R related IEA and IIR activities for DOE/BTO.

Team members include:

- **Van Baxter** – PI, USNT chair, US delegate to IIR Management Committee, organizing committees for 2017 IEA Heat Pump Conference (<http://hpc2017.org/>) and 2019 International Congress of Refrigeration (ICR2019, <http://icr2019.org/>), 20+ years experience IEA-HPT and IIR.
- **Melissa Lapsa** – Leader BTRIC Commercial Buildings Integration (CBI) program, coordinator IEA activities, chaired national organizing committee for 2005 IEA Heat Pump Conference (last one held in US), 20+ years experience IEA-HPT.
- **Brian Fricke** – BER group leader, chair USNC/IIR, ICR2019 organizing committee, USNT co-chair, 15+ years experience IIR.



Challenge

US industry competitiveness:

- One of the recurring themes of the 2016-2020 BTO MYPP
 - Maintain/grow US-based manufacturing jobs (via US-owned companies or US-based manufacturing presence of foreign-owned companies).
 - Major challenge given increasingly global nature of building energy service equipment business/industry.
- Understanding offshore competitive “threats” is vital.
- Keep BTO informed of latest R&D innovations.

How do you do that? Continuous, robust engagement with industry, academic, and public-sector HVAC/R peers around the globe is essential!

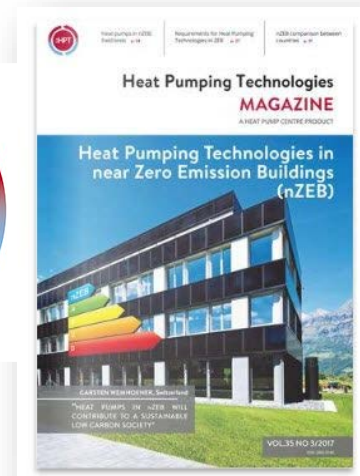
This crosscutting project designed to facilitate understanding of overseas developments.

- Convenient platform for BTO and US HVAC/R stakeholders to interact with foreign colleagues/peers via IEA-HPT and USNC/IIR activities.

Approach & Impact

IEA-HPT (<http://heatpumpingtechnologies.org/>):

- One of several Technology Collaboration Programs (TCP)
- Tony Bouza; official US delegate to HPT
- 16 member countries: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, South Korea, Sweden, Switzerland, United States, and United Kingdom; **plus China has applied to join.**
- Hi-quality periodical publication, HPT Magazine (2-3 times/yr.)
 - Latest news & RD&D reports
- Triennial Heat pump Conference series (since 1984)
 - Preeminent international event for heat pump technologies, markets, and policy initiatives.
 - 2014, in Montréal (Tony Bouza chaired international organizing committee); >500 attendees.
 - 2017, in Rotterdam, <http://hpc2017.org/>; ~550 total attendance.
 - 2020, to be held in South Korea
 - 2023, likely back in North America (US)
- International collaborative RD&D projects (aka Annexes)



Approach & Impact

USNT for IEA-HPT: <https://usnt.ornl.gov/>

- US National Team (USNT), 20+ members, all key HVAC&R community leaders from industry, associations, utilities, & universities.
- Helps guide DOE participation; review of Annex proposals and HPT work plans, members contribute to selected Annexes.
 - 51 official Annexes since inception; US participated in 36, led 7; ref slides 17 & 18.



OAK RIDGE
National Laboratory

Home Heat Pump Magazine Links of Interest Annexes Publications Members Contact Us

Technology Collaboration Programme on Heat Pumping Technologies

Learn more about Heat Pumping Technologies, Markets and Market Development, and information from the annexes in the program. Sign-up for the latest HPT Magazine.



The Building Technologies Office (BTO) of the Department of Energy (DOE) has been involved in the IEA Heat Pumping Technologies (HPT) program (originally called the Heat Pumping Programme or HPP) since its inception in 1978. DOE participates in collaborative international activities through IEA's HPT to ensure that the results of international research efforts are used to the maximum benefit of DOE's programmatic goals. Participation in the IEA HPP provides awareness and insight to the latest International R&D and technology developments (notably in Asia and Europe) directed toward improved buildings energy efficiency and CO₂ emission reduction.

The US National Team (USNT) for the IEA HPT was organized about 30 years ago, and has the voluntary participation of senior representatives of major US HVAC/R manufacturers, research organizations, universities, utilities, and manufacturer and professional organizations. Oak Ridge National Laboratory (ORNL) serves as the coordinating agency for the USNT on behalf of BTO and provides secretariat services including an official web site usnt.ornl.gov. The USNT meets three times per year; generally in January and June at the two annual ASHRAE conferences, and in the fall during September-October timeframe.

Approach & Impact

IIR (<http://www.iifiir.org>):

- Intergovernmental association: focus on advancement of basic sciences (early stage R&D) underpinning all refrigeration-related fields
 - 58 member countries (includes all IEA-HPT members)
 - Activities grouped under ten Commissions (details in reference slides, slide 19)
 - Sponsors major quadrennial conference, International Congress of Refrigeration (ICR); historically has attracted ~1000 attendees
 - International Journal of Refrigeration (IJR), highest impact factor journal in refrigeration (2.78 in 2016)



<http://icr2019.org/>

Approach & Impact

USNC/IIR:

- Guides US participation, nominates US members for IIR commissions.
- ORNL (Dr. Brian Fricke) chairs USNC/IIR; Fricke and Van Baxter members of ICR2019 North American organizing committee.
- Sponsors Refrigeration & Air-Conditioning (R&AC) Short in conjunction with Purdue International R&AC Conference (<https://engineering.purdue.edu/Herrick/conferences>).
 - Subject for 2018 is “Transition to Flammable Refrigerants” (https://engineering.purdue.edu/Herrick/conferences/courses/flammable_refrigerants).
 - Chair/organizer Dr. William Murphy, Prof. Emeritus, Univ. of KY, USNC/IIR member.



- 24th International Compressor Engineering Conference
- 17th International Refrigeration and Air Conditioning Conference
- 5th International High Performance Building Conference

Impact example

Example: Integrated heat pump (IHP) technology.

- IHP development pioneered in US by EPRI & Carrier in 1980s.
 - Space conditioning + water heating, other services in one unit.
 - Initial products in 1990's
 - Concept incorporated into ground-source heat pumps (GSHP) in EU.
 - DOE/ORNL R&D early 2000's with high efficiency (nZEB-ready) home focus.
 - EU progress tracked through participation in IEA-HPT Annexes 29 and 32 and conference publications, etc.
- Dan Ellis (USNT, former ClimateMaster CEO)
 - Approached DOE/ORNL to collaborate on IHP development, mid-2000's.
 - Trilogy® product on market since 2013; manufactured in OK.
 - Field demos confirmed 50%+ energy savings potential vs. min efficiency systems
- Helped keep 600+ manufacturing jobs in US.



Progress

- FY18 & FY19 milestones on schedule
- USNC/IIR-sponsored Short Course on “Transition to Flammable Refrigerants” at Purdue University: Scheduled — July 8, 2018
- Initiate new IEA HPT Annex on Advanced Cooling Technologies; hold initial project organizing meeting: Due — October 2018
- 2019 International Congress of Refrigeration, August, 2019, Montréal, Canada

US Stakeholder Engagement

- **USNT IEA-HPT**
 - Members attend meetings 2-3 times/y at their own expense
 - Annex 36 (Quality Installation & maintenance); Glenn Hourahan (Air Conditioning Contractors of America, ACCA) co-lead; NIST laboratory measured fault impacts and annual energy use impact analyses.
 - Annex 41 (cold climate heat pumps), Dr. Eckhard Groll, Purdue, co-lead; ORNL & Purdue prototype CCHP lab and field testing.
 - Annex 51 (Acoustic Signature of Heat Pumps), AHRI providing background information on US test standards and former rating standards.
 - Annex 52 (long-term performance of commercial GSHP systems); US team lead by Prof. Jeff Spitler, OK State Univ.
 - ASHRAE helped/helps cover travels expenses for US team members of Annexes 40 and 49 (Heat Pumps in net zero energy buildings, nZEBs) and for Annex 41.
- **USNC/IIR**
 - Dr. Piotr Domanski, NIST (USNT and USNC/IIR member) chairs IIR Science and Technology Council.
 - Dr. Eckhard Groll (Purdue) chairs IIR Commission B2 “Refrigerating Equipment”.
 - Prof. Yunho Hwang (Univ MD) led IIR working group on Life Cycle Climate Performance (LCCP) Analysis.
 - ASHRAE and NIST contribute to USNC/IIR costs.
- **Other examples noted in prior slides and reference slide 19.**

Remaining Project Work

Continuous robust engagement with HVAC/R, WH, Appliance community peers in EU and Far East will remain important so long as HVAC/R, WH, and Appliances R&D remains important to BTO portfolio. ORNL will continue to facilitate BTO's activities through the USNT and USNC/IIR.

Future planned IEA-HPT and IIR activities include:

- Joint Annex proposal between IEA-HPT and the IEA Energy Conservation through Energy Storage (IEA-ECES) program on combining heat pump technologies with energy storage systems using “smart” controls; planned start in 2019.
 - One intention is to provide input to Mission Innovation Challenge 7 (affordable heating and cooling) : <http://mission-innovation.net/our-work/innovation-challenges/heating-cooling-challenge/>.
- New Annex proposal on Low-GWP heat pump systems (develop design guidelines); led by Dr. Y. Hwang, Univ. of MD, USNT member.
- Possible Annex on integrating data collection via Internet of Things (IoT) to continuous commissioning and predictive analytics in heat pump systems (early stage focus).
- 2020 and 2023 IEA conferences; 2023 ICR; 2020 and 2022 Purdue short courses.

Thank You

Oak Ridge National Laboratory
Van D. Baxter, Distinguished R&D Staff member
vdb@ornl.gov

REFERENCE SLIDES

Project Budget

Project Budget: Ongoing support project to BTO's HVAC&R, WH, and Appliances subprogram.

Variances: none

Cost to Date: \$1419k FY15-18 (through March 2018).

Additional Funding: No additional direct funding.

Budget History

Ca. 1980 – FY 2017 (FY15-17 shown below)		FY 2018 (current)		FY 2019 – tbd (FY19-21 shown below)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$1210k	\$150k	\$400k	\$50k	\$1500k	\$150k

DOE direct costs include:

- US participation fee for IEA-HPT and participation fees for individual Annexes
- Share of US IIR participation fee
- ORNL team support and travel

Cost share includes:

- ASHRAE and NIST contribution to US IIR participation fee; \$10k/y each
- Estimated \$30k/y partner costs to attend meetings, review IEA & IIR programs, participate in individual projects, etc.)

Project Plan and Schedule

- Project original initiation date: ca. 1980
- Project planned completion date: tbd
- Key FY18-19 Schedule and Milestones shown below

Project Schedule												
Project Start: ca. 1980	Completed Work											
Projected End: tbd	Active Task (in progress work)											
	◆ Milestone/Deliverable (Originally Planned) use for missed											
	◆ Milestone/Deliverable (Actual) use when met on time											
	FY2018				FY2019				FY2020			
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Current/Future Work												
Q3 FY18: USNC/IIR Short Course completed			◆									
Q1 FY19: Organizing meeting Adv. Cooling Annex					◆							
Q4 FY19: 2019 ICR completed								◆				
Q3 FY20: 2020 IEA Heat Pump Conf											◆	
Q4 FY20: Beginning planning for 2023 IEA Conf.												◆
Insert more Milestones as needed												

US, USNT IEA-HPT Annex Participation

Recent Annexes

- 42 (heat pumps in smart grids); R. Domitrovic, USNT member, EPRI; US team co-lead; AHRI participated
- 43 (sorption heat pumps); K. Glusenkamp, ORNL US team lead
- 44 (supermarket refrigeration); S. Jia and colleagues from Heatcraft provided input to Annex report
- 46 (water heating heat pumps); K. Nawaz, ORNL, US team lead; A.O. Smith & Stone Mountain Technologies, Inc.
- 49 (heat pumps for nZEBs); V. Baxter, ORNL, V. Payne, NIST, R. Radermacher, Univ MD US team
- 52 (long term performance benchmarking of GSHPs in commercial & multifamily buildings); US team led by Dr. J. Spitler (USNT member), X. Liu, ORNL
- New Annex proposal on advanced cooling technologies (early-TRL focus); V. Baxter/T. Bouza leading organization with contributions from Univ. of MD & other USNT members
- New Annex proposal on Low-GWP heat pump systems (develop design guidelines); led by Dr. Y. Hwang, Univ. of MD, USNT member





Others

- 29 (GSHP market & technical barriers); M. Ally, ORNL US team lead
- 32 (economical systems for low-energy homes); V. Baxter US team lead
- 40 (heat pumps for nZEBs); V. Baxter team lead; ClimateMaster IHP field demos

Most Recent IEA-HPT Annexes

The Technology Collaboration Programme on Heat Pumping Technologies participating countries are: Austria (AT), Belgium (BE), Canada (CA), Denmark (DK), Finland (FI), France (FR), Germany (DE), Italy (IT), Japan (JP), the Netherlands (NL), Norway (NO), South Korea (KR), Sweden (SE), Switzerland (CH), the United Kingdom (UK), and the United States (US).

Bold, red text indicates Operating Agent (Project Leader).

 COLD CLIMATE HEAT PUMPS	41	AT, CA, JP, US
 HEAT PUMPS IN SMART GRIDS	42	AT, CH, DE, DK, FR, KR, NL , UK, US
FUEL-DRIVEN SORPTION HEAT PUMPS	43	AT, DE , FR, IT, KR, SE, UK, US
 PERFORMANCE INDICATORS FOR ENERGY EFFICIENT SUPERMARKET BUILDINGS	44	DK, NL , SE
HYBRID HEAT PUMPS	45	CA, DE, FR, NL , UK
DOMESTIC HOT WATER HEAT PUMPS	46	CA, CH, FR, JP, NL , KR, UK, US
HEAT PUMPS IN DISTRICT HEATING AND COOLING SYSTEMS	47	AT, CH, DK , SE
INDUSTRIAL HEAT PUMPS, SECOND PHASE	48	AT, CH, FR, JP, UK [DE]
DESIGN AND INTEGRATION OF HEAT PUMPS FOR NZEB	49	AT, BE, CH , DE, NO, SE, UK, US
HEAT PUMPS IN MULTI-FAMILY BUILDINGS FOR SPACE HEATING AND DHW	50	AT, DE , FR, NL
ACOUSTIC SIGNATURES OF HEAT PUMPS	51	AT , FR, IT, SE
 LONG TERM PERFORMANCE MEASUREMENT OF GSHP SYSTEMS SERVING COMMERCIAL, INSTITUTIONAL AND MULTI-FAMILY BUILDINGS	52	NL , SE , US

 FINALIZED 2017

 NEW

IIR Organization; Sections and Commissions

IIR activities grouped under five Sections of two commissions each, coordinated by the IIR Science and Technology Council

Commission members are industry, university, and research center specialists

http://www.iifiir.org/medias/medias.aspx?INSTANCE=exploitation&PORTAL_ID=portal_model_instance_commissions_en.xml&SYNCMENU=COMMISSIONS_EN&SETLANGUAGE=EN

- Section A Cryogenics & liquified gases
 - A1 - cryophysics, cryoengineering: A2 - Liquefaction & separation of gases
- Section B Thermodynamics, equipment and systems
 - **B1 – Thermodynamics & transfer processes: B2 – Refrigerating equipment**
- Section C Biology and Food Technology
 - C1 – Cryobiology, cryomedicine and health products: C2 – Food science & engineering
- Section D Storage and transport
 - **D1 – refrigerated storage**: D2 – Refrigerated transport
- Section E Air Conditioning, heat pumps, heat recovery
 - **E1 – Air conditioning: E2 – Heat pumps and energy recovery**
- **Highlighted commissions** are the ones with greatest relevance to BTO's HVAC/R, WH, & Appliances subprogram mission