ASHRAE TECHNOLOGY AWARDS APPLICATION FORM (Page 1)

APPLICATION MUST BE COMPLETE TO BE CONSIDERED FOR JUDGING

(Required for Society-Level Competition)

(For ASHRAE Staff Use Only)

I. Identification (0 Points)

Name of building or project: Argonne National Laboratory Materials Design Laboratory

II. Category - Check one and indicate New, Existing, or Existing Building Commissioning (EBCx)

☐ Commercial Buildings	☐ New	☐ Existing	☐ EBCx
Institutional Buildings:			
☐ Educational Facilities	☐ New	☐ Existing	☐ EBCx
☒ Other Institutional	☒ New	☐ Existing	☐ EBCx
☐ Health Care Facilities	☐ New	☐ Existing	☐ EBCx
☐ Industrial Facilities or Processes	☐ New	☐ Existing	☐ EBCx
☐ Public Assembly	☐ New	☐ Existing	☐ EBCx
☐ Residential (Single and Multi-Family)			

III. Project Description (0 Points)

1. Type of building or process: New Federal Laboratory

2. Size – gross floor area of building (ft. sq. or m. sq.): 120,000-sf

3. Function of major areas (such as offices, retail, food services, laboratories, guest/patient rooms, laundry, operating rooms, warehouse/storage, computer rooms, parking, manufacturing, process, etc., or industrial process description:

   Wet and dry labs, conference rooms, lobby area, private offices, maintenance and storage space

4. Project Design Period: 2/2015 (Begin date (mm/yyyy)) to 6/2019 (End date (mm/yyyy))

5. Project Occupancy and Operation Period: 07/2019 (Begin date (mm/yyyy)) to Present (End date (mm/yyyy))

6. ASHRAE Standards referenced during design (this information will not be shared with the Judging Panel):

   ASHRAE 90.1-2010, ASHRAE 62.1-2010, ASHRAE 55-2010, ASHRAE 135, ASHRAE 202

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1. Name of Building or Project: Argonne National Laboratory Materials Design Laboratory

2. Entrant (Required to be an ASHRAE member with significant role in project):

a. Name: Hawn (Last) Blair (First) ____ (Middle)

Membership Number: 8117758

Chapter: Illinois

Region: Region VI

b. Entrant's Design Firm/Company: IMEG Corp.

c. Address (including country): 1100 Warrenville Rd, Ste 400 W

Naperville (City) IL (State) 60563 (Zip) United States (Country)

d. Telephone: (O) 630.717.2432 Email: Blair.L.Hawn@imegcorp.com

f. Entrant's Role in Project: Lead Mechanical Engineer

g. List the names of Design Team Members (A maximum of three may be listed; only ASHRAE members will be recognized as team members)

1. ____
2. ____
3. ____

3. Certification of entrant (0 Points) (If multiple entrants, all must be listed on this form)

I certify the information submitted is correct, and that this entry satisfies the requirements of the ASHRAE Technology Award competition.

Typed Name: Blair Hawn Title: Senior Mechanical Engineer

Signature: Digitally signed by Blair L. Hawn, PE Date: 2021.09.17 14:33:25-05'00' Date: 9/17/2021

4. Building Owner's release (0 Points) (Building Owner cannot be the same person as the Entrant)

I certify that I am the owner or the authorized representative of this project, and hereby grant permission to ASHRAE to use all the enclosed data and information in the judging and subsequent publicity of this project.

Typed Name: Michael Finder Title: Program Manager, PMO

Signature: Michael Finder Digitally signed by Michael Finder Date: 2021.09.17 14:15:44 -05'00' Date: ____

(Signatures must be on form submitted to ASHRAE)

Company: Argonne National Laboratory

Address: 9700 South Cass Avenue

Argonne (City) IL (State) 60439 (Zip) United States (Country)

Telephone: (O) 630.252.2920 Email: mfinder@anl.gov

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5. Engineer of record: Required unless a written explanation is provided why the engineer of record will not grant his/her consent.

I consent to the presentation of this project for consideration in the ASHRAE Technology Awards Program.

Typed Name: Brandon Fortier   Title: Project Executive

Signature: Digitally signed by Brandon M. Fortier, PE, LEED AP Date: 2021.09.17 14:43:01-05'00'   Date: 9/17/21

(Signatures must be on form submitted to ASHRAE)

Company: IMEG Corp.

Address: 1100 Warrenville Road, Suite 400W

Naperville (City)   IL (State)   60563 (Zip)   United States (Country)

Telephone: (O) 630.753.8504   Email: Brandon.M.Fortier@imegcorp.com

The topics below should be addressed on separate pages and formatted according to the requirements listed in the overview.

1. **Energy Efficiency (15 Points)**
2. **Indoor Air Quality (15 Points)**
3. **Innovation (15 Points)**
4. **Maintenance & Operation (15 Points)**
5. **Cost Effectiveness (15 Points)**
6. **Environmental Impact (15 Points)**
7. **Quality of Presentation (5 Points) (No response required)**

Return Completed Application to your Chapter Technology Transfer Committee Regional Vice-Chair.

For additional information, contact:

Rhiannon Masterson
Chapter Programs Manager
678-539-1128
ChapterPrograms@ashrae.org

Argonne National Laboratory Materials Design Laboratory

Supporting narrative for the 2021 ASHRAE Technology Awards

As the final segment of Argonne National Laboratory's Energy Quad, the new Materials Design Laboratory (MDL) is a state-of-the-art collaborative research facility for energy and materials scientists to investigate structures at the scale of a single electron and larger. From designing tailored superconductors to transform the nation's energy grid to developing better materials for wind turbines, the MDL allows scientists to discover new materials, understand how they work, and put them to use. The 120,000-sf MDL was designed to house approximately 100 researchers and support staff and provide maximum practical flexibility to adapt to evolving research processes and support changes in research for the next 10 to 20 years. Spaces include wet and dry labs, conference rooms, lobby area, private offices, restrooms, as well as areas for maintenance and storage. Design of the project began in 2015 and continued through early 2016. Construction commenced in late 2016 and was completed in 2019.

Each floor of the facility was designed with a full perimeter pedestrian corridor. Laboratories were situated on the interior of the pedestrian corridor and were separated by a service corridor between them. Laboratory support offices and engineering support areas were located on the outward side of the pedestrian corridor and on the building perimeter to give these spaces exterior views. The entirety of the third floor of the facility is dedicated to a radiochemistry program in which small amounts of radioactive materials are used. This required a dedicated exhaust system and a dedicated mechanical floor to house the extensive HVAC equipment needed.

Heating and cooling for the building consist of connections to the campus chilled water system and extending heating water from the adjacent building, which had excess capacity in both the campus steam connection and the redundant steam to water heat exchangers. New heating water pumps were provided to extend the heating water to MDL. Airside systems consist of three manifolded variable air volume (VAV) air handling units located in the penthouse serving a combination of terminal air boxes, laboratory air valves, and chilled beams throughout the facility.

The design complies with the U.S. Department of Energy's High Performance and Sustainable Buildings requirements, incorporating maintainability, energy efficiency, and environmental sustainability. Additionally, the project is LEED Gold certified under LEED-NC v2009.

Energy Efficiency

Federal guidelines for the project required exceeding ASHRAE 90.1-2007 by 30 percent and achieving LEED Gold under LEED-NC v2009; therefore, modeling for the project was done using Trane TRACE® 700 in accordance with Appendix G requirements. In order to drive the project's energy goals, energy modeling began early in the design process and was utilized throughout the 15-month process to make informed decisions on the HVAC systems and building envelope. Design decisions that were made using energy modeling consisted of:

- Implementing chilled beams throughout private offices and select laboratories to address sensible cooling loads without over-ventilating the space

- Using the redundant air handler in the penthouse during normal operations to minimize static pressure losses through the air handlers. In the event of a mechanical failure, two air handlers can handle the entirety of the building load; however, under normal conditions all three air handlers operate and reduce fan energy use
- Modeling multiple versions of the external shading device configuration on the eastern exposure to minimize solar heat gain in the perimeter offices
- Implementing a run-around loop to capture heat from the laboratory exhaust air streams to pre-treat ventilation air

Actual energy use and modeled energy use are shown in the tables below.

Month	Cooling			Electric			Heating			Total	
	Meter (Ton-Hours)	kBtu	EUI (kBtu/sqft/yr)	Meter (kWh)	kBtu	EUI (kBtu/sqft/yr)	Meter (lbs/hr)	kBtu	EUI (kBtu/sqft/yr)	kBtu	EUI (kBtu/sqft/yr)
Jul-20	311,911	3,742,932	30.2	240,646	821,804	6.6	1,406,776	1,636,080	13.2	6,200,817	50.1
Aug-20	256,668	3,080,019	24.9	239,557	818,087	6.6	961,156	1,117,824	9.0	5,015,930	40.5
Sep-20	175,494	2,105,933	17.0	257,654	879,887	7.1	1,182,616	1,375,382	11.1	4,361,202	35.2
Oct-20	88,206	1,058,468	8.6	275,158	939,665	7.6	1,630,940	1,896,783	15.3	3,894,916	31.5
Nov-20	63,110	757,315	6.1	274,961	938,991	7.6	870,840	1,012,787	8.2	2,709,093	21.9
Dec-20	17,255	207,056	1.7	299,680	1,023,408	8.3	715,080	831,638	6.7	2,062,102	16.7
Jan-21	16,355	196,263	1.6	302,899	1,034,399	8.4	1,406,608	1,635,885	13.2	2,866,547	23.2
Feb-21	422	5,063	0.0	286,174	977,283	7.9	3,187,632	3,707,216	30.0	4,689,561	37.9
Mar-21	35,459	425,504	3.4	332,354	1,134,988	9.2	810,132	942,184	7.6	2,502,676	20.2
Apr-21	72,031	864,375	7.0	339,154	1,158,210	9.4	411,004	477,998	3.9	2,500,582	20.2
May-21	119,166	1,429,997	11.6	323,186	1,103,679	8.9	1,436,512	1,670,663	13.5	4,204,339	34.0
Jun-21	243,828	2,925,938	23.6	324,056	1,106,652	8.9	2,364,748	2,750,202	22.2	6,782,792	54.8
Total	**1,399,905**	**16,798,864**	**135.8**	**3,495,476**	**11,937,051**	**96.5**	**16,384,044**	**19,054,643**	**154.0**	**47,790,559**	**386.2**

	Baseline: ASHRAE 90.1-2007		Proposed Design		
End Use	**(kbtu/sqft/yr)**	**($/yr)**	**(kbtu/sqft/yr)**	**($/yr)**	**Cost Savings**
Lighting	19.9	$ 31,681	9.8	$ 15,620	-50.7%
Heating	46.8	$ 43,670	30.8	$ 28,715	-34.2%
Cooling	70.4	$ 31,108	48.3	$ 21,324	-31.5%
Pump	0.6	$ 971	0.4	$ 665	-31.5%
Fan	9.9	$ 15,737	4.6	$ 7,256	-53.9%
Receptacles	53.0	$ 74,706	51.6	$ 72,557	-2.9%
DHW	3.9	$ 3,626	3.9	$ 3,626	0.0%
Total	**204.4**	**$ 201,500**	**149.3**	**$ 149,763**	**-25.7%**

Of note is the difference in modeled energy use to actual energy use. Almost all of the difference is associated with heating and cooling energy which can be attributed to how the building is being operated as opposed to how it was modeled. Currently the facility is running in 100% outside air 24/7/365 due to COVID precautions which was not how the facility was modeled. By operating with significantly more exhaust and ventilation there are significantly higher heating and cooling loads throughout the year. This is reflected in the energy use; however, the efficiency of the systems is not changed.

Indoor Air Quality and Thermal Comfort

Indoor air quality in a laboratory is critical to the function of the space and safety of building occupants. The most important condition is to capture contaminants at their source and to ensure air travel is from clean spaces to dirty spaces. To that end, three levels of containment have been designed into the MDL:

1. The first level of containment is for locations on the third floor, where radiological materials are being used. This includes radiological hoods, glove boxes, dry-boxes, and the laboratory modules themselves. All airflow from these spaces is exhausted through HEPA filters to a dedicated exhaust system with redundant fans on the roof of the

building. Airflow control is provided by air valves and ensures cascading pressure from clean spaces into the lab module and then to the hoods and glove boxes.

2. The second level of containment is for non-radiological contaminants in the rest of the building, including chemical fume hoods and snorkel exhaust. These devices are kept negatively pressurized to the laboratories they are in to ensure there is no escape into the occupied space. This exhaust is taken to the general fume exhaust system for the facility, where it is filtered with a MERV 13 filter prior to being discharged.
3. The third level of containment is for general room exhaust to prevent recirculation of laboratory air. Air valves are modulated to keep this air positive to the containment devices in the room, but negative to adjacent spaces so laboratory air is not distributed to other zones in the building. General exhaust air is combined with fume exhaust air and discharged through the same system.

Discharge from both exhaust systems in the facility were modeled using wind dispersion analysis and a physical 1:200 model to ensure contaminants in those airstreams were not recirculated back into outside air intakes and did not settle out in pedestrian areas around the building.

Supply air for the facility is provided from the centralized air handling units in the penthouse and can provide up to 100 percent ventilation air. During periods of low fume hood use, return air is utilized from comfort cooling zones such as offices and conference rooms. Calculations were performed for four separate scenarios to confirm that the system met or exceeded the requirements of ASHRAE 62.1. The worst-case scenario assumed the critical spaces and labs were in heating mode at minimum airflows and all other non-lab spaces were at their cooling maximum airflows. This scenario is highly unlikely, yet the system exceeded the ASHRAE 62.1 minimums regardless. All calculations were done with a ventilation effectiveness of 1.0 in both heating and cooling mode as the building has ceiling supply and returns with air temperatures less than 15°F above space temperature. All ventilation air is pre-filtered with MERV 8 filters, and all supply air is then filtered with MERV 14 final filters.

All spaces were designed assuming a resistance of clothing value of 0.9, a metabolic rate of 1.2, relative air velocity of 20 fpm, space setpoint of 72F, and relative humidity of 50 percent in the summer. For the winter months, the spaces were designed assuming a resistance of clothing value of 0.97, a metabolic rate of 1.2, relative air velocity of 20 fpm, space setpoint of 72F, and relative humidity of 30 percent. These assumptions are predicted to limit the percentage of occupants who are dissatisfied to less than 10 percent per ASHRAE 55.

Innovation

One of the main scientific uses of the building is a program dedicated to superconductor research that requires the use of large amounts of helium as a cryogenic. As helium is a non-renewable resource of limited availability, the use of helium in large quantities can be a financial burden. To that end, a helium recovery system was designed for the facility. As liquid helium is used in cryostats in various ground floor labs it vaporizes into a gas and is captured through exhaust lines and blown to a centralized recovery vessel in an adjacent building. The gaseous helium is filtered, analyzed for purity, and then re-liquified via a compression cycle so it can be stored in cylinders and delivered back to the building for reuse.

Another main concern for the operation of the laboratory was ensuring contaminants exhausted from the facility were not entrained in new outside air intakes or intakes from existing adjacent buildings. To ensure the safety of the exhaust design and the appropriate locations for new intake openings, a wind dispersion model was built and tested in a wind tunnel. Exhaust stack locations, exhaust stack heights, exhaust air velocities, and outside air intake locations were all analyzed to ensure indoor air quality was maintained.

The mechanical design included a run-around energy recovery loop. This system transfers energy between the exhaust airstream and the outside airstream, reducing the overall energy consumption from the heating and cooling plants. The coil in the outside airstream associated with the run-around loop was the only heating coil in the air handler. During times of the year when the energy recovery loop can’t maintain the proper temperature within the air handler, the system adds building heat from the heating plant via a plate-and-frame heat exchanger. This approach was pursued to minimize the air pressure drop within the air handler by avoiding adding a dedicated heating coil.

Operation and Maintenance

The MDL is a state-of-the-art research facility, and as such operates continuously year-round, except for a short shutdown at the end of December. Due to safety regulations, routine and corrective maintenance cannot take place on operating equipment; therefore, developing an approach to isolating both mechanical and electrical systems that did not require losing system capacity within the laboratories was needed. This was accomplished by providing redundant HVAC and plumbing equipment (e.g., air handlers, heat exchangers, pumps, fans, etc.) and serving that equipment from both normal and emergency power. All laboratories were designed to be served from two separate panels and transformers so electrical equipment can be taken offline and serviced without losing power to individual laboratories.

The original HVAC concept for the facility consisted of dedicated air handling units serving the radiological laboratories, the non-radiological laboratories, and the office/administrative areas with redundancy provided for all laboratory spaces. This approach required at least five air handling units, at least three supply duct mains, and a significant amount of mechanical room space to house the equipment. During the preliminary design phases an approach to simplify the supply air system was proposed: all spaces in the building could be served from the same system, allowing a reduction in air handling unit quantities, supply duct systems, and overall mechanical room space needs. The final design solution consisted of three air handling units sized in an N+1 configuration to provide full system redundancy for all spaces in the building. During normal operation, all three air handling units operate to minimize energy use, however, at any time an air handler can be shut down for either routine or unplanned maintenance without losing system capacity.

Cost Effectiveness

The original HVAC concept for the facility consisted of conventional variable air volume systems for all spaces since the laboratories required variable airflow control to address varied exhaust airflow needs. Because such a large part of the supply airflow was ventilation air to compensate for the large exhaust needs, the air supply to administrative spaces was providing much more ventilation than required by code, due to sensible loads in those areas. Through energy modeling and a cost analysis it was determined that significant energy savings could be achieved by utilizing a two-pipe chilled beam in the offices (reducing over-ventilation to those spaces), fan energy, and heating and cooling loads of the ventilation air. With a first cost premium of $242,340 and projected annual energy savings of $19,500 this system had a simple payback of 12.4 years.

The same administrative spaces that benefitted from using chilled beams were also subject to a large sensible heat load due to an eastern exposure and solar heat gains. A detailed analysis was done to evaluate exterior shading options that significantly reduced solar heat gains in

these spaces. This strategy provided an immediate reduction in HVAC system sizing and energy with no additional first costs. Design calculations yielded a reduction of approximately 25,000 CFM of primary air which equated to over $200,000 in cost savings from reduced HVAC equipment and distribution infrastructure.

The original heating concept for the facility brought a new steam main into the building from the campus wide system. During the design process, staff from Argonne National Laboratory identified that the existing laboratory facility directly next to MDL had a steam system that was oversized and not being fully utilized. The design team analyzed several years of steam data and determined that even under peak conditions the existing steam service and associated steam-to-hot water heat exchangers were sufficient at the adjacent building to also serve MDL. Instead of connecting to the site steam main, the team was able to simply extend hot water piping to MDL at a savings of hundreds of thousands of dollars.

Environmental Impact

Chilled water for MDL came from an existing campus chilled water plant that contains five water-cooled, centrifugal chillers, all containing R-123, an HCFC. No other refrigerant systems were used in the construction of the facility; therefore, it is a CFC-free building. Additional conservation measures consisted of providing native vegetation for landscaping that does not require irrigation, and a 35 percent reduction in water use through low-flow plumbing fixtures.

Design Energy and Emission Results

Metric	Design Project	Median Property	Estimated Savings
ENERGY STAR Score (1-100)	**N/A**	50	N/A
Energy Reduction (from Median)(%)	**-19.7**	0	N/A
Source Energy Use Intensity (kBtu/ft²/yr)	**255**	318	63
Site Energy Use Intensity (kBtu/ft²/yr)	**149**	186	37
Source Energy Use (kBtu/yr)	**31,620,282**	39,379,324	7,759,042
Site Energy Use (kBtu/yr)	**18,478,300**	23,012,541	4,534,241
Energy Costs ($)	**150,593**	187,545	36,952
Total GHG Emissions (Metric Tons CO2e)	**1,678**	2,090	412