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Dru Crawley is Bentley Fellow and Director, Building Performance Research focusing on building performance, BIM, net-zero-energy buildings, sustainability, resilience, and smart cities. Prior to being elevated to Bentley Fellow in 2014, he led development of Bentley's suite of building performance software for four years. Before joining Bentley in 2010, Dr. Crawley developed and managed EnergyPlus and the USDOE's Commercial Buildings Initiative (now Better Buildings Initiative and Alliances) promoting creation of net-zero-energy buildings.

With more than 40 years of experience in buildings energy efficiency, renewable energy, and sustainability, he has worked in engineering software development, government research and standards development organizations, as well as building design and consulting companies. He received his PhD in Mechanical Engineering from University of Strathclyde in Glasgow, Scotland on the topic of building simulation as a policy tool, a Bachelor of Architecture from University of Tennessee, and is a registered architect.

Dr. Crawley is active in ASHRAE (Chair of Standard 169 Climatic Data for Building Design Standards, member and Vice Chair of Standards Committee, member of SSPC 189.1 (Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings), member of SSPC 140 (Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs), former member of the Technical Activities, Research Administration, Advocacy, and Grassroots Government Activities Committees, and past chair of Technical Committees 2.8, 4.2, 4.7, and 7.1). He was elevated to ASHRAE Fellow in 2009 and achieved ASHRAE BEMP (Building Energy Modeling Professional) certification in October 2012. Recipient of ASHRAE Exceptional Service Award (2013), Service to ASHRAE Research Award (2012), Distinguished Service Award (2003), and Symposium Best Paper Award (1999) for "Which Weather Data Should You Use for Energy Simulations of Commercial Buildings?"

He is also active in the International Building Performance Simulation Association (IBPSA Vice President since 2018, at-large board member since 1998, Fellow in 2012, Regional Affiliate Liaison since 2006), IBPSA-USA (IBPSA-USA President since 2019, board member since 2013, vice president 2017-2019, treasurer 2013-2017), U. S. Green Building Council (USGBC, past vice chair and member, Energy & Atmosphere Technical Advisory Group; past member, Research Committee; past research Liaison), the American Institute of Architects (AIA), an Affiliate member of CIBSE, and serves on the editorial boards of three international Journals. He has written more than 125 papers and articles, testified before the U.S. Congress, lectured at more than 30 universities, and made more than 400 presentations on building energy efficiency, sustainability, and renewable energy throughout the world. As an ASHRAE Distinguished Lecturer, he has given more than 150 presentations and workshops to more than 80 ASHRAE chapters throughout the world.

LECTURE TOPICS:

▶Big, Smart, and Everything: Data, Technology, Buildings, Cities, and the IoT

(presentation can range from 45 minutes to 2-hour lecture)

GBCI Approved | 1 CE Hour | 0920020229 ***AIA Approved | 1 LU/HSW | Crawley03***

There is a transformation under way in the world that will fundamentally change how we interact with our technology, buildings and cities. Big data allows us to find trends and causes not clear from our limited data today. Everything is going 'Smart' today – from windows, walls and all the technology in our buildings to communities and cities. With 5G wireless and ubiquitous data sensors soon to be available, every device that collects data can share it – supporting real-time decision-making for controls, utility grids, buildings, traffic, and transportation. Imagine dozens of sensors ensuring our comfort in our

workplaces while optimizing energy efficiency and sustainability. This presentation describes the basics of big data, IoT, and Smart everything and its applications and promise in buildings.

▶ **Building Performance Simulation: What's in the Black Box** (45-minute to 2-hour lecture, or half-day workshop)

GBCI Approved | 2 CE Hour | 0920020230 ***AIA Approved | 2 LU/HSW | Crawley07***

Classification: Basic, Intermediate, Advanced

Over the last 50 years, building simulation has evolved into a powerful tool for evaluating the energy performance of potential or existing buildings. Building simulation allows easy comparison of the energy and environmental performance of many hundreds of design or retrofit options. This presentation provides an overview of building performance simulation fundamentals and history, Building Information Modeling, what's in the black box of key simulation programs, as well as comparing underlying simulation methods. Because much of the data that building simulation tools require already exists in the BIM models, it's critical that simple methods for sharing that data are available. This presentation also describes the opportunities and challenges for sharing data between BIM and SIM and demonstrates recent advances in data exchange.

▶ **EnergyPlus, DOE's New Generation Building Energy Simulation Program** (45-minute to 2-hour lecture, or half or full day workshop)

GBCI Approved | 2 CE Hour | 0920020231 ***AIA Approved | 2 LU/HSW | Crawley04***

Classification: Basic, Intermediate, Advanced

With the interest in green building certification and requirements that new buildings achieve 30%, 50% or even zero-energy performance levels, simulating the energy performance of buildings has become increasingly important. EnergyPlus includes many building energy simulation features that have not been available together in a mainstream building energy simulation program--including variable time steps, configurable modular systems integrated with a heat balance-based zone simulation, on-site power, hybrid natural/mechanical ventilation, UFAD, and VRF. This presentation introduces the types of simulation tools available today and provides an overview of EnergyPlus simulation methodologies, capabilities and utilities and interfaces.

▶ **Getting from AEDGs to Zero-Energy Buildings** (45-minute to 2-hour lecture)

GBCI Approved | 2 CE Hour | 0920020232 ***AIA Approved | 2 LU/HSW | Crawley06***

Classification: Basic, Intermediate

Buildings account for more than 40% of worldwide primary energy use. ASHRAE, IESNA, USGBC, AIA, and DOE have collaborated on a series of Advanced Energy Design Guides (AEDGs) for significant energy savings beyond Standard 90.1. The guides provide prescriptive packages for each climate zone to reach the energy savings goals of 30% and 50%. AEDGs for 50% savings in five building types were completed in 2014. This presentation provides an overview of the AEDG process as well as examples of packages and case studies from the 50% guides. Also presented are examples of today's zero-energy buildings and the key systems and technologies they employ.

▶ **Going Digital – Modeling Infrastructure Resilience for Sustainable Urban Development**

Classification: Intermediate

GBCI Approved | 2 CE Hour | 0920020233 ***AIA Approved | 2 LU/HSW | CRAWLEY09***

It is now possible to quickly model a city using 3D technologies such as photogrammetry, LiDAR, and BIM. By federating the data from these sources, it is possible to evaluate the resilience of a city under different planning and disaster scenarios. This presentation includes example models of several cities including Philadelphia and Helsinki. The photogrammetry model of downtown Philadelphia created for the Pope's visit is merged with the Philadelphia building benchmark data which includes energy, water and other data. For Helsinki, the 26 km2 (10 mi2) reality model is shown along with disaster planning and automated asset identification using deep learning algorithms. And finally using thermography and photogrammetry to create 3D models of buildings thermal signatures.

▶ **Impacts of Climate Change and Urbanization on Future Building Performance** (45-minute to 1½-hour lecture)

GBCI Approved | 2 CE Hour | 0920020234 ***AIA Approved | 2 LU/HSW | Crawley05***

Classification: Basic, Intermediate

With the increasing interest in climate change driven by human activity, recent research has focused on the impact of climate change or urban heat island on building operation and performance across the world. But this work usually aggregates the energy and peak demand impacts across a broad sector. In a recent study, impacts on the operating performance of an office building were estimated based on climate change and heat island scenarios in 25 locations (20 climate regions). This presentation presents the variation and differences among the 20 regions when climate change is introduced. The focus is on changes in comfort conditions, building equipment operation as well as daily patterns of energy performance using prototypical buildings that represent typical, good, and low-energy practices around the world. Other issues such as fuel swapping as heating and cooling ratios change, impacts on environmental emissions, and how low-energy building design incorporating renewables can significantly mitigate any potential climate variation are also presented.

Commented [SS1]: PRESENTATION FOR ASHRAE MONTHLY MEETING (2/12)

▶ **Standard 189.1 and the IgCC: Structure, Requirements and Energy Savings**

(45-minute to 2-hour lecture, or half-day seminar)

GBCI Approved | 2 CE Hours | 0920020235 ***AIA Approved | 2 LU/HSW \ Crawley01***

Classification: Basic, Intermediate, Advanced

Standard 189.1, Standard for the Design of High-Performance, Green Buildings except Low-Rise Residential Buildings, is the first code-intended commercial green building standard in the United States. It provides a long-needed green building foundation for those who strive to design, build, and operate green buildings. The standard covers key topic areas of site sustainability, water use efficiency, energy efficiency, indoor environmental quality and the building's impact on the atmosphere, materials and resources, and includes construction practices as well as plans for operation of the building after occupancy. This presentation provides an overview of the structure and requirements of Standard 189.1, including key mandatory, prescriptive, and performance requirements. The expected energy savings in comparison to other ASHRAE Standards by commercial building type is also shown.

▶ **Trends: Buildings, Technologies and Tools** (45-minute to 2-hour lecture)

AIA Approved | 2 LU/HSW | Crawley02

Classification: Basic, Intermediate

Commented [SS2]: BONUS PRESENTATION AT BSUG (12/13)

The buildings industry faces many challenges and opportunities over the next few decades. Over the next ten years, changes in building technology—particularly wireless controls and solid-state lighting—will profoundly alter how our buildings are designed, built, and operated. Building energy simulation (SIM) has evolved into a powerful tool for evaluating the energy performance of potential or existing buildings. Building simulation allows easy comparison of the energy and environmental performance of many hundreds of design or retrofit options. The buildings touted today as 'net-zero energy' or 'sustainable' would not be possible without energy simulation—but no single simulation tool can model all aspects of our buildings today. This presentation provides an overview of trends and drivers affecting the building industry as well as the simulation tools of tomorrow.