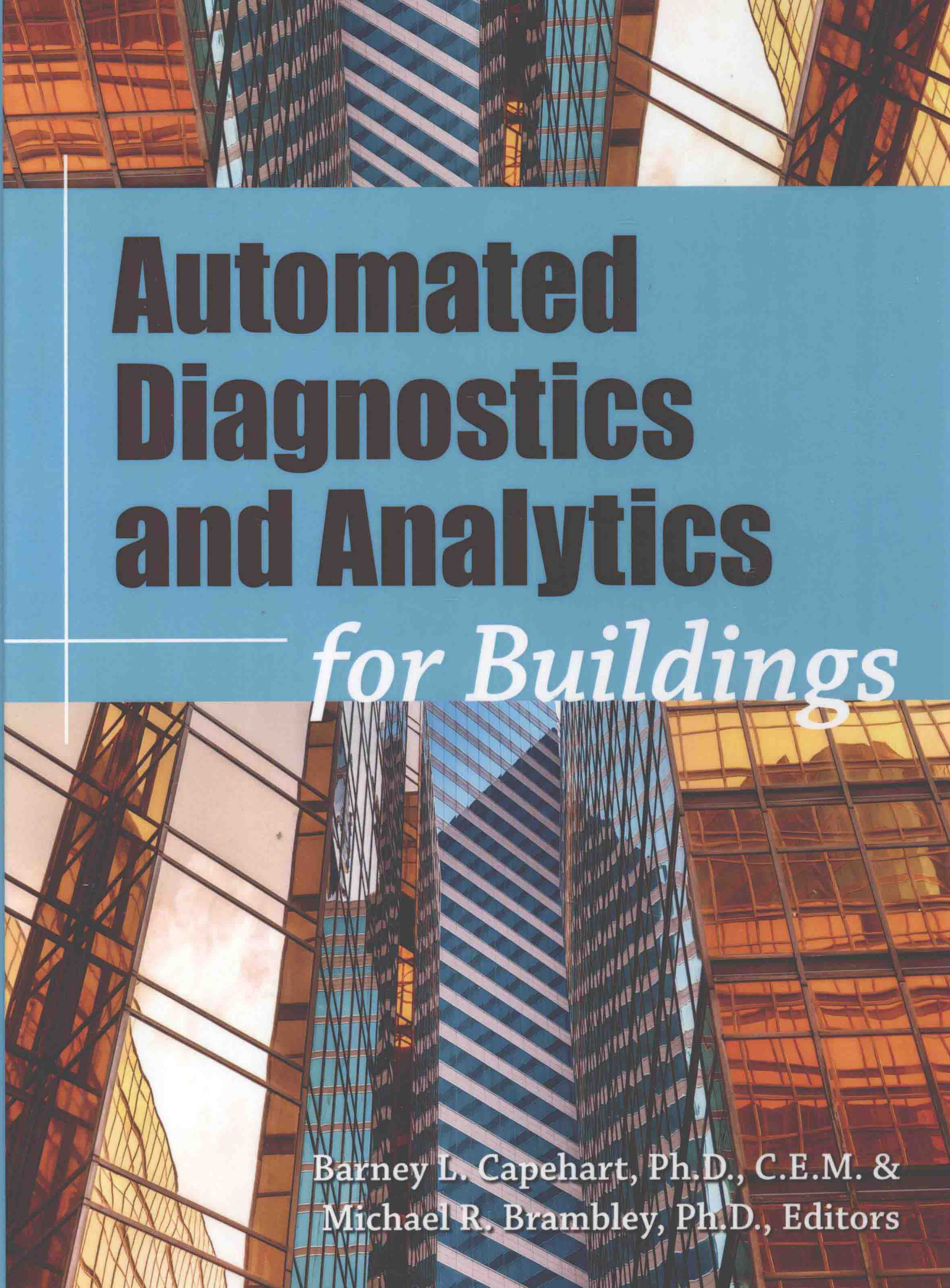
Automated Diagnostics and Analytics *for Buildings*



Barney L. Capehart, Ph.D., C.E.M. &
Michael R. Brambley, Ph.D., Editors

Automated Diagnostics and Analytics for Buildings

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and
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Foreword

This book will help you explore the new world of Automated Diagnostics and Analytics for Buildings and provide insight and connection into the industry thought leaders that are taking big data into a new reality. "Dynamic Data Fuels Deep Analytics" speaks to the importance of the next level of deep analytics of almost everything will have and how we as an industry will provide a new level of deeper analytics connecting inquiring minds to almost everything with low cost real time data. The journey will be driven by the first wave of online analytics that will point to the potential of looking further into building operation opportunities, but further analytics will be required to factually quantify these opportunities. We all know analytics begat analytics.

Over the recent past, the best use of an analytic software application for building systems has been fault detection and diagnostics (FDD). FDD techniques are typically equipment or device centric and characterized by pre-defined rules based on an engineering model of a piece of equipment. Despite the impressive progress with FDD, the industry is in its infancy of utilizing data analytic applications in buildings. If analytics for the HVAC system has provided outstanding outcomes, we need to take that template to other building systems.

Several of the chapter authors are regular contributors to our free online magazine so understanding their thoughts and coming to know them in the following chapters will bring this book alive and make it relevant for many years to come. Once you know the industry thought leaders assembled in this book you can start following them and their most recent evolving thoughts in our and other online resources their blogs and industry news feeds. The transition in the last few years has been amazingly rapid. In our magazine's 15 year history we have talked about the possible but it is only in the last few years and even more accelerated in the last few months that the possible has transitioned into the plausible and our new reality.

Bring Your Own Device BYOD Mobility coupled with the cloud has created an industry of large building automation folks trying to rapidly understand the big data transition. Cloud based Big Data Projects are truly morphing into a dynamic collection of people, things, and internet interactions; a collaborator, not just a project. A "collaboratory" is more than an elaborate collection of information and communications technologies; it is a new networked organizational form that also includes social processes; collaboration techniques; formal and informal communication; and agreement on norms, principles, values, and rules" (Cogburn, 2003, p. 86). You will see in most articles that Ownership of the Collaboratory is an important piece of the total success of Automated Diagnostics and Analytics for Buildings.

A clear component of every successful energy integration Diagnostics and Analytics project is a team of champions who asserted ownership of the project collaboratory. The importance of keeping our data free inside the collaboratory needs to be highlighted; a lesson we learned in the past but somehow need to keep relearning. The data not only needs to be free, it needs to be named and organized in a predicable agreed on format.

It is not just the naming of data but a consistent data model that allows us to free our data to a world of dynamic dimensions for our own purposes. No longer must data be predefined before use if an accurate self-discoverable model is present. This new way of viewing data allows us a new world in which data can be used in several different ways as a dynamic subset of many scenarios.

I am very pleased that Barney and Mike asked me to provide my thoughts in this foreword for their new book. They have done an amazing job of capturing and assembling the new evolving frontier of Automated Diagnostics and Analytics for Buildings now occurring as part of the Internet of Everything (IOE).

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March 2014 Vancouver Island, Canada

Foreword

Over the past four decades the United States has made dramatic improvements in energy efficiency, meeting 79 percent of the increase in energy demand according to analysis by ACEEE (Figure 1). A broad array of measures have contributed to these improvements including improved efficiencies of energy using technologies, appliance and equipment standards and improvements in building codes and construction practices and materials. In the past few years, some in the energy efficiency community have begun to acknowledge that the component-efficiency approach that has yielded many of the largest savings over the past decades is likely to produce diminishing returns in the future (see Lowenberger et al. 2012). Going forward, the largest opportunities will likely result from optimization of energy using systems. These systems can range from discrete subsystems to whole buildings or even campuses. It is not that experts in energy efficiency have been unaware of the potential for systems optimization, but rather than the technologies needed to implement practical and cost effective system optimization have not been available and affordable.

The past decade has seen dramatic increases in the capacity for energy using systems simulation, coupled with advances in communications and sensors technologies that have improved performance and dramatically decreased costs. These technology advances have enabled automation systems that go beyond the limited set-point controls that have dominated this space for over a century, allowing for practical implementation of what ACEEE has come to call intelligent efficiency. These "smart" sensor and control systems allow for continuous optimization of energy using system performance that adapts to the changing needs of a building or group of buildings. The technology implementations profiled in this book will enable energy efficiency to continue to meet a significant share the future energy needs of our country into the foreseeable future. A study by ACEEE suggested that about half of the future energy needs in the United States could be meet through energy efficiency, which coupled with renewable energy resources could result in the effective de-carbonization of our economy by the middle of this century (Laitner et al. 2012). ACEEE's analysis suggests that it is only through the application of a systems approach to energy efficiency, enabled by the practices discussed in this volume that these energy savings opportunities will be realized.

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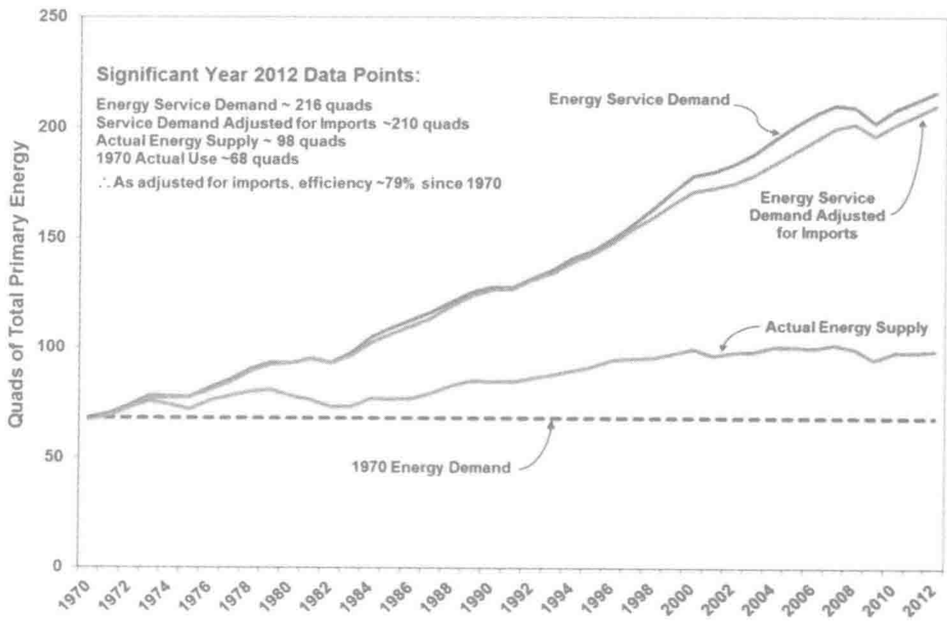

Figure 1. Contributions of energy efficiency toward meeting United States energy demand 1970 to 2012 (Source ACEEE 2014)

Foreword

This book presents state-of-the-art approaches for automated diagnostics and other analytics applied to buildings. It includes the results of a variety of efforts carried over the past few decades in response to the proliferation of low-cost computing, sensing, and network communication along with the increased awareness of the importance of maintaining building performance as part of improving energy efficiency and reducing environmental impacts. In addition to improved energy efficiency, automated fault detection and diagnostic (AFDD) systems have the potential to reduce equipment downtime, service costs, and utility costs. However, the commercialization of AFDD for building and HVAC&R applications is still in its infancy compared to other applications such as nuclear power plants, aircraft, chemical process plants, and automobiles. Relatively few commercial products exist and the ones that do exist are very specialized. This is undoubtedly because the customer benefits of AFDD for building systems are lower than for critical applications such as nuclear power plants or aircraft or for production facilities such as chemical process plants. In order to penetrate the marketplace, AFDD solutions need to have low implementation costs.

The need for low cost solutions has driven many of the developments that are described in this book. In particular, it is important to minimize the use of additional sensors and the time required to configure AFDD approaches. For adding AFDD to existing equipment and systems, many of the methods use data-driven approaches applied to measurements already available through an energy management system. Another approach for reducing the cost of realizing AFDD is to embed diagnostics within devices (VAV boxes, rooftop units, etc.) coming from the factory. This allows the use of manufacturer specific performance characteristics along with reductions in the cost of additional sensors through mass production.

Embedded diagnostics are just beginning to appear in the marketplace and may be poised for dramatic growth as costs come down and expectations for these capabilities grow. For commercial and residential buildings, embedded diagnostics will allow a service technician or owner to monitor and manage service using a handheld or local computer. As customer confidence and expectations for better economic performance grow, there could be a dramatic expansion of contracts with service providers who manage maintenance and repair using remote monitoring connected across a network to intelligent HVAC&R equipment. In addition to embedded diagnostics, a chip on board the equipment might store all of the documentation necessary for installation, commissioning, operation, maintenance, warranty, and repair. This could dramatically reduce the chances of losing this information and improve the prospects for proper installation and operation.

There is no doubt that future building systems and equipment will be able to self-diagnose problems and automatically provide information to service providers so that parts can be ordered and service scheduled. This will allow a small support staff to monitor and maintain a large number of different buildings from a remote, centralized location and thereby reduce the cost of maintaining building performance. Automated diagnostics and advanced analytics are coming to the building industry. It's just a matter of when. This book is part of a growing body of work that is enabling their development and deployment.

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March 2014

Introduction

The purpose of this book is to promote and document energy savings from the relatively new technology of Advanced Energy Information Systems called Automated Fault Detection and Diagnostics (AFDD) and Analytics for buildings and facilities. A number of studies have shown that commercial buildings in the United States (U.S.) waste as much as 15% to 30% of the energy they use (Katipamula and Brambley 2005). Analysis of HVAC and other building energy use data, along with whole-building utility data, sub-metered end-use data, and data from the building automation system (BAS) through the use of AFDD and building analytics can help identify opportunities to improve building operations and efficiency, and ultimately reduce energy and operating costs.

We will discuss the latest technologies available for fault detection, diagnostics, and building analytics, and operational experience with stand alone and web based systems for fault detection, diagnostics and analytics in currently operating buildings and facilities, and in varied applications, and to show how new opportunities have developed for energy and facility managers to quickly and effectively control and manage their operations more efficiently, with less energy use and cost, and experience improved energy system performance. You'll find information on what is actually available using this technology, what products and services are available at this time, and how they are being used at other buildings and facilities, and see what is involved for current and future installations of internet-based technologies. The material in this book on automated fault detection, diagnostics and analytics should greatly assist energy, facility and maintenance managers, as well as consultants and control systems development engineers. Chapters on methodology and future technological features should also assist those involved in research and development of these new technologies in AFDD and analytics for buildings.

The editors wish to thank each of the authors for graciously giving their time to write chapters which help provide so much valuable information for our readers.

Barney L Capehart
Michael R Brambley

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