

Artificial Intelligence and the Future for Smart Homes

By **Ommid Saberi and Rebecca Menes**

The floor area of the buildings we occupy is expected to double by 2060, with most of this growth occurring in residential construction. And population growth and urbanization in emerging markets will mean expanding cities and rising demand for new housing in urban areas around the world.¹ These trends represent an enormous opportunity to design, build, and operate the homes of tomorrow in intelligent ways that minimize energy consumption and carbon emissions, lower building and homeowner costs, and raise home values. Artificial intelligence will play a pivotal role in this effort by using data—including grid data, smart meter data, weather data, and energy use information—to study and improve building performance, optimize resource consumption, and increase comfort and cost efficiency for residents. AI will also analyze data collected from multiple buildings to improve building design and construction and inform future policy making related to construction and urban planning.

Homes waste energy and water when they aren't designed well. This is a particular challenge in emerging markets, where resources are less plentiful and utility costs are high relative to incomes. Even in homes that are designed with efficiency in mind, energy and water use can increase beyond original estimates, depending on behavior. Rising bills can negatively influence a homeowner's ability to meet monthly mortgage payments.

Yet there is a potential solution at the intersection of artificial intelligence (AI) and human behavior. Part of this solution is already in place in the form of smart meters, which can be preinstalled in residences to help occupants make better daily energy choices. Smart meters could capture utility usage and track indoor temperatures and then deploy that information for action, which is where AI steps in.

While the concept is still in its infancy, an AI-based framework could collect data from smart meters in an anonymous way and then interpret and share it for better decision-making by multiple stakeholders, from residents and builders to utilities and governments. Using smart meters and AI, homes would become the ultimate example of biomimicry (the design and production of materials, structures, and systems that are modeled on biological entities and processes), acting like redwood trees that grow and protect each other through interconnected roots.²

While AI was established as a discipline more than half a century ago, advances in the technology have accelerated in recent years due to an evolution in machine learning and improvements in computing power, data storage, and communications networks. This note adopts a definition of AI as the science and engineering of making machines

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intelligent, especially intelligent computer programs (see EM Compass Note 69).³ AI can therefore be characterized as a series of systems, methods, and technologies that display intelligent behavior by analyzing their environments and taking actions—with some degree of autonomy—toward achieving pre-specified outcomes.⁴

The Birth of Smart Homes

While the concept of smart homes has had several false dawns in recent decades, new technologies are starting to vie for the attention of homeowners, with the potential to better control energy and water use. Smart speaker technologies such as Amazon’s Echo, Google Home, and Apple’s Siri have all made inroads through their voice interaction capabilities, with Google Nest providing a breakthrough with its smart thermostat.⁵ On the water side, a smart phone-enabled technology promises to “virtually” control the temperature in your hot water tank,⁶ with a clamp-on meter that can detect leaks and monitor peaks in water use.⁷ Still, these technologies fall short of tying together the plethora of systems that support a consumer’s energy, water, security, and ambient needs.

Eventually these technologies will become so interconnected and intelligent that human intervention is barely needed. When they are AI-enabled, the systems and design solutions of a building will interrelate intelligently to respond to the comfort of the occupants, including window openings, shades, lighting, insulation, cooling, heating, and hot water systems. For thermal comfort in hot climates with the least amount of energy use, for example, AI technologies could cool a home by opening a window when outside temperatures are preferable and air quality is suitable, or start a ceiling fan, shade windows to reduce glare, and cycle the air conditioning. The appropriate temperature would be reached depending on who is home and in which room they are located, with a persona-based approach relating to behavior and historical preferences.⁸

Smart Meters on the Rise

In the quest to achieve this new frontier in intelligent building, a starting point is needed, most likely smart meters. By directly linking to energy loads in the house, smart meters enable consumers to take advantage of time-of-day tariffs where advanced metering infrastructure is in existence.⁹ When installed in a visible location, they serve as reminders and motivators for residents to monitor their energy use, resulting in a minimum 5 percent reduction in consumption peaks.¹⁰ International Housing Solutions in South Africa, a company that both rents and sells quality affordable homes, educates its customers on how to use preinstalled smart meters, demonstrating how conscientious

behavior produces savings typically equivalent to one month’s rent each year.¹¹ The more sophisticated smart meters become, the more they can be programmed to maximize efficiency both for the benefit of consumers and to take pressure off the grid.

Smart meter implementation is starting to take off in emerging markets. Vinte, a large-scale developer of affordable green homes in Mexico, has installed smart meters in each of its solar-powered residences so occupants can see utility usage on the fly.¹² These smart meters, which cost Vinte \$40 each, help to avoid surprises when bills are due. DCM, a high-end developer in Mexico, offers proprietary smart meters in its new development called ELEMENTS, a state-of-the-art complex just outside Mexico City that is powered completely by co-generation.¹³ DCM’s smart meter app has an automation system compatible with Google Assistant and Alexa to control lighting, air conditioning, blinds, and even stereo levels. Other companies using smart meters include Vega Tobar with their Edificio Edwards¹⁴ project in Quito, and iJenga in Nairobi in their Aashiana home.¹⁵

As of early 2019, 54.7 million smart meters were installed across 50 emerging countries in Latin America, the Middle East, Africa, Central and Eastern Europe, South Asia, and Southeast Asia.¹⁶ Between 2019 and 2023, 269 million smart meters or Advanced Metering Infrastructure (AMI) devices will be deployed in emerging markets.¹⁷ In terms of investment, the global smart meter market is valued at \$5.8 billion (2018) and is projected to reach \$7.06 billion by 2023.¹⁸

Connecting Smart Meters to Artificial Intelligence

In and of themselves, smart meters don’t constitute artificial intelligence. They don’t make judgments as humans do, nor do they solve problems. But with smart meters preinstalled in resource-efficient homes, data from multiple homes could be gathered and analyzed for better conclusions on construction, energy policy, and efficient use of resources. Increased resource efficiency will result in lower utility bills for homeowners, with the opportunity to repurpose savings toward healthcare, education, and other needs.

At a city or global level, the data analysis from smart meters could be divulged—in an open-source way that protects privacy through anonymous aggregation—to also benefit architects and engineers. A large number of external variables could be searched and then pondered when simulating a building model. The idea would be to combine performance history with evolving climate informatics that impact design decisions, including fluctuating temperatures, changing rainfall patterns and cloud coverage, and the angle of the sun.¹⁹

The science of entwining resource-efficient design with human behavior is expected to become more agile, granular, and advanced in the near future. AI-enabled machines and algorithms will analyze the massive data collected and then develop logic and make informed decisions for humans. By coding these machines to recognize patterns and constantly improve predictions and decisions, the evolution of their learning capabilities is unlimited.

Figure 1 below illustrates various ways that smart homes and smart devices can help homeowners reduce their carbon emissions and their use of heating, lighting, and other power needs. These can also save homeowners money by decreasing their energy consumption and utility bills or by helping them qualify for lower electricity rates by, for example, attaching their electric vehicles to the power grid. Smart meters are central to such a smart home, and AI may improve these smart energy strategies.

AI-Based Models in Commercial Buildings

Progress has already been made in the application of AI-based models in the commercial building space, where companies use data-collecting sensors and the Internet of Things (IoT) to study and improve building performance and resource consumption. Small sensors are installed on systems or mounted on ceilings, creating a “nervous system” with inter-relating data points. The data collected is then sent to the cloud for interpretation by platforms such as Siemens’ MindSphere or Schneider Electric’s EcoStruxure, which allow engineers to control utility usage and costs.

Tech companies that create construction management software, such as PlanGrid and Procore, have also made progress toward machine learning, with an eye to prioritizing tasks, preventing injuries at the construction site, and maintaining equipment.²⁰ But the construction of a building is only a snapshot in time, providing little value to the architect who designs it beforehand, the banks that invest in the project, the building manager that needs to control operational costs, or the occupants who eventually make it their residence or workplace.

IFC’s EDGE as a Potential Platform

IHS, Vinte, and several other builders certify their homes with IFC’s EDGE, a green-building certification system for nearly 160 countries.

A core component of EDGE is its software, which provides a foundation of bio-climatic data while eliminating silos among its categories of energy, water, and embodied energy in materials, serving up cross-pollinations that rely on a user’s inputs and selections.

EDGE is able to analyze the relationships between the local climate, humans, and systems in order to estimate how the building will perform. The software also calculates the length of time before the building earns a positive return on investment through savings on utility costs. The idea is to balance inhabitant comfort with costs while improving environmental performance.

For now, building designers use EDGE and similar products to determine the most cost-effective systems and relevant design concepts for optimal performance. By adding feedback loops and increasing computing capabilities, such products could eventually serve up optimal scenarios at the click of a button. This process, referred to as generative design, would continually evaluate tradeoffs among comfort, cost, and resource intensity.²¹

Intel for Banks and Governments

Whether EDGE evolves rapidly enough to become the ideal platform or a better solution emerges, exciting opportunities exist to develop artificial intelligence in the real estate industry.²²

Other applications for such machines include overlaying data for certified green buildings with evidence of investment performance. Providing proof of whether a certified building rents or sells faster or at a higher value could be a condition of incentivized financing and/or preferred insurance rates. How about insisting on carbon emission read-outs? Local and national governments could gain a better understanding as to whether they’re on track with climate commitments if they could obtain this information from the building sector.

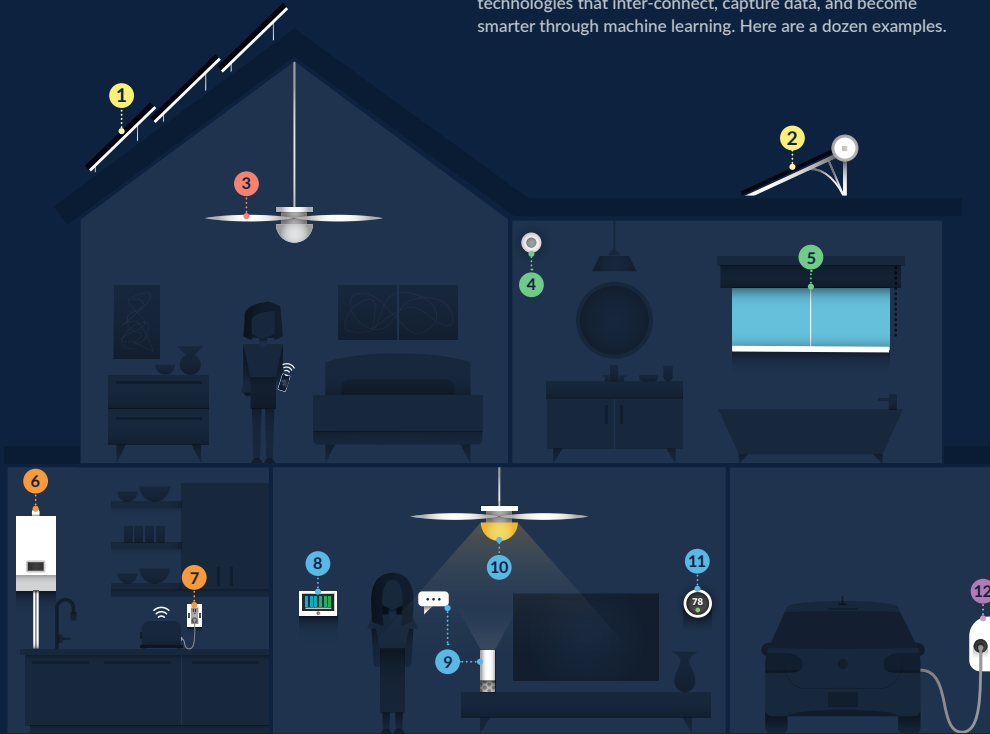
Artificial intelligence would then play a role in helping banks decide whether they should even offer conventional financing. Algorithms could be built to identify which developers have lower risk profiles and what their preferential rates should be. Governments could use such information to design incentives to minimize carbon emissions.

As the building and construction industries adopt these technologies, the hope is that manufacturers will also eventually compete to produce the most ideal systems and materials. Consumers, too, might jockey to obtain the least expensive green mortgage or cut their energy use dramatically, which will result in more comfortable homes that cost significantly less to heat, light, and power.

Once demand for energy has fallen and pro-environment building practices become widespread, resource-guzzling homes will be a thing of the past, with AI most likely playing a pivotal role. When that happens, we’ll reflect back and remember that it all started with a smart meter perched on the wall, glowing with its potential to change the world.

12 WAYS TO SAVE WITH YOUR SMART HOME

Tomorrow's homes have the potential to go zero carbon through technologies that inter-connect, capture data, and become smarter through machine learning. Here are a dozen examples.



ROOFTOP •

- 1 Solar Photovoltaics
Use solar for your electricity needs
- 2 Solar Hot Water Collector
Rely on the sun to heat your water

BEDROOM •

- 3 Ceiling Fans
Circulate air for better thermal comfort

BATH •

- 4 Daylight Sensor
Turn lights off when natural lighting is sufficient
- 5 Window Sensor
Identify whether windows are open

KITCHEN •

- 6 Smart Energy-Efficient Boiler
Energy can be saved and problems diagnosed
- 7 Smart Plugs
Turn energy-efficient appliances on and off remotely

LIVING ROOM •

- 8 Smart Meter
Manage your energy, gas and water usage and costs
- 9 Voice Assistant
Activate integrated products through voice command

LIVING ROOM •

- 10 Smart Lights
Switch your energy-efficient lights on and off with your mobile device
- 11 Smart Thermostat
Control your heating and hot water remotely

GARAGE •

- 12 EV Charging Station
Charge your car at home

Smart Phone Connectivity



www.edgebuildings.com

FIGURE 1 Twelve Ways to Save With Your Smart Home

Source: IFC, EDGE.

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Please see the following additional reports and EM Compass Notes about technology and artificial intelligence and their role in emerging markets:

Reinventing Business Through Disruptive—Sector Trends and Investment Opportunities for Firms in Emerging Markets (March 2019); *Blockchain: Opportunities for Private Enterprises in Emerging Markets* (January 2019); *Artificial Intelligence and 5G Mobile Technology Can Drive Investment Opportunities in Emerging Markets* (Note 76, December 2019); *How Artificial Intelligence is Making Transport Safer, Cleaner, More Reliable and Efficient in Emerging Markets* (Note 75, November 2019); *Bridging the Trust Gap: Blockchain's Potential to Restore Trust in Artificial Intelligence in Support of New Business Models* (Note 74, October 2019); *Artificial Intelligence: Investment Trends and Selected Industry Uses* (Note 71, September 2019); *How Insurtech Can Close the Protection Gap in Emerging Markets* (Note 70, August 2019); *The Role of Artificial Intelligence in Supporting Development in Emerging Markets* (Note 69, July 2019); *Basic Business Models for Banks Providing Digital Financial Services in Africa* (Note 68, June 2019); *The Case for Responsible Investing in Digital Financial Services* (Note 67, April 2019).

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