4.5 Smart Buildings

Smart Buildings includes DX applied to all aspects of commercial and residential buildings, for optimising the use of resources including water and energy while increasing occupants' comfort and decreasing building maintenance costs. Benefits are generally derived from decreased electricity consumption due to optimised use of building lighting and HVAC systems. Smart buildings operations often also include additional capabilities such as occupancy detection, room booking systems, and window/door controls.

End-users that might adopt smart building solutions include commercial building owners and operators and individual residential building owners. Commercial buildings include corporate offices, hospitals, educational institutions, hotels, government offices, airports, retail spaces, and warehouses.

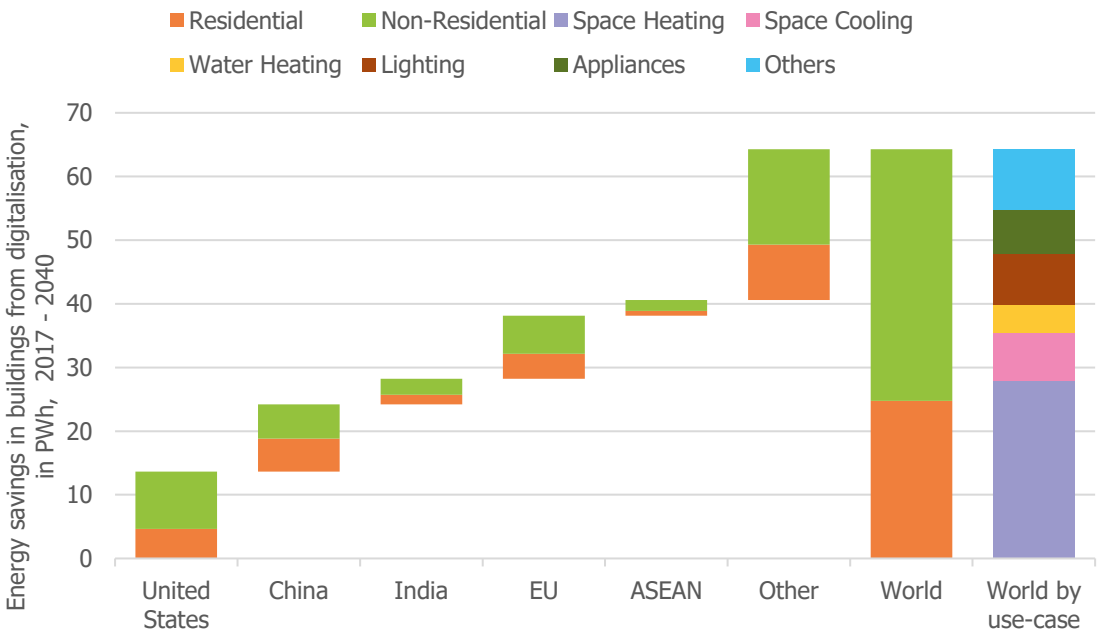
Relevant IoT Application Groups (with links to the relevant Transforma Insights report) include:

- Building Automation - Controllers and peripheral devices (monitoring devices, controlled devices, or actuators) to support smart building functionality.
- Building Safety & Security - Smart connected security alarms and fire alarms in either consumer or enterprise. Also includes, connected video cameras/CCTVs used by consumers for home security and by enterprises for building security.
- HVAC[63] - Includes smart and connected Heating, Ventilation, and Air Conditioning equipment, generally comprised of controllers and potentially smart peripheral devices.
- Building Lighting[64] - Monitoring and control of interior and exterior building lighting. Includes lightbulbs, light fittings and controls.

Buildings account for nearly one-third of global energy consumption and 55% of global electricity demand[65]. According to the International Energy Agency (IEA), digitalisation of buildings (including smart thermostats, controllers, smart lighting) could cut total energy use in residential and commercial buildings between 2017 and 2040 by as much as 10%.

[63] To be published in 2022.
[64] To be published in 2022.
[65] https://www.iea.org/reports/digitalisation-and-energy

Figure 4-21: Cumulative energy savings in buildings with widespread of digitalisation in selected countries, 2017 - 2040 [Source: IEA, 2017[66]]



4.5.1 Sustainability impact

4.5.1.1 Electrical power

Building Automation Systems (BAS), HVAC (including Smart Thermostats) and Building Lighting are one of the most impactful electricity saving applications after Smart Grids and Smart Electricity Meters. Maximum electricity savings are realised when these systems are used in conjunction. Integrated building systems with HVAC and Lighting control can save up to 10-15% of total building electricity consumption.

Heating and cooling (HVAC) accounts for a large part of electricity usage, nearly 30-40%[67], especially in a commercial building. Optimising the usage of these systems can help buildings save a significant amount of electricity. Smart HVAC systems interpret information from variety of HVAC sensor points, which can be used to build algorithms that optimise the monitoring and control of HVAC systems such as minimising energy consumption in unoccupied building zones, reducing HVAC usage during peak times of energy demand, and optimising the flow of conditioned air. It is estimated that turning down the thermostat by one degree would save around 7 percent of the energy used for heating, while setting an AC one degree warmer could reduce the amount of electricity used by up to 10 per cent[68]. 'Dumb' HVAC units in hotel rooms remain set at a temperature last selected by guest or staff even when they are unoccupied resulting in wastage of thousands of kWh of electricity, and simply shutting off

[66] https://www.iea.org/reports/digitalisation-and-energy
[67] https://www.smartspaces.app/blog/iot-makes-workplaces-sustainable/
[68] Italians 'sweat for Ukraine' as law sets air conditioners at 27 degrees (brisbanetimes.com.au)

these systems when not in use can save 6.2%[69] of energy used. Automation of windows and doors also impacts the electricity consumed by HVAC: if a window is open the HVAC system will consume more energy due to air ingress through window, thus closing of window or door when HVACs are switched on helps in saving electricity too.

Lighting is the second biggest consumer of electricity, and second biggest opportunity for energy savings through digital transformation in a Smart Building context. Smart lighting controls combining motion detection in fixtures, daylighting tuning, shutting off when not in use, and task tuning, can generate savings of 35-40% of electricity compared to traditional lighting. Atalian, a facilities management company, saved 50% of electricity by switching to LED, and 69% additional savings on top of LED savings (i.e. 35%[70] of the initial cost) by deploying smart lighting controls.

Occupancy sensors, window blind/door control systems too can have an impact on energy consumption when integrated with other smart building solutions. For example, when an occupancy sensor detects little or no movement it sends a signal to a Building Automation system to turn off HVAC, lighting, and other devices. For example, Al Bahar Towers in Abu Dhabi has installed a building automation system that opens and closes building louvers as needed, which decreases the solar gain coming from windows by 50%, resulting in reduced electricity consumption by cooling systems.

Figure 4-22: Smart Buildings impact on electricity consumption [Source: Transforma Insights, 2022]

Category	Impact on Electricity Savings
Lighting	35-40% of electricity consumed by lighting devices (bulbs, lamps etc.) can be saved by using smart lighting control systems.
HVAC	20-25% of electricity consumed by HVAC systems can be saved by using AI and IoT to control and monitor HVAC.
Building Automation Systems	BAS systems integrated with HVAC and Lighting can save an additional 1-3%.
Building Automation, Lighting and HVAC	Integrated building systems with HVAC and Lighting control can save nearly 10-20% of total building electricity consumption.

4.5.1.2 Hydrocarbon Fuel

Natural gas and oil products are the most used energy source in homes and commercial facilities for space and water heating. HVAC systems use electricity and gas to work, the ratio depending upon the average temperature of the country. For example, in countries such as India, Thailand, Indonesia heating is used on very few days, so most of the consumption that these countries make is in electricity and there is no requirement of heating and thus gas or fuel. For such countries, Smart Building solutions will have no impact on fuel usage. On the

[69] https://www.aceee.org/sites/default/files/publications/researchreports/a1701.pdf
[70] https://www.sylvania-lighting.com/en-int/news/items/atalian-smart/

contrary, for many European countries, the cooling demand is very low, most of it is heating demand, thus, smart HVAC systems can have significant impact on gas savings in such countries. The impact of Smart HVAC systems would be similar to electricity; by monitoring occupancy and adjusting heating usage they can reduce the gas required by these systems by 20-25%.

CCTV and Building Safety & Security also impacts fuel consumption. Building Safety & Security solutions reduce the need for guards to visit homes and inspect. Similarly, CCTV reduces the regular visits by security personnel as inspection can be done remotely. We estimate that on average, installation of every 10 IoT-enabled cameras replaces the need of having one security guard available 24/7 and the vehicle miles travelled by the security guards, with associated fuel savings.

Figure 4-23: Smart Buildings impact on fuel consumption [Source: Transforma Insights, 2022]

Category	Impact on Fuel Savings
HVAC	20-25% of fuel consumed by HVAC systems can be saved by using AI and IoT to control and monitor HVAC.
Building Automation	Building Automation solutions create additional savings in fuel by automating and controlling doors and windows when HVAC systems are on reducing the fuel consumed by HVAC systems for heating.
Building Safety & Security	We estimate that 10 cameras replace 1 security guard and the associated vehicle miles travelled.

5.5.1.3 *Water*

HVAC and Building Lighting applications do not have a significant impact on water savings, but Building Automation Systems incorporating water flow monitoring systems, water leak or flood detectors have noteworthy impact on reducing water wastage in buildings. Water leaks are responsible for ~20-35%[71] of water consumption in a building, fixing leakages with the help of digital solutions as soon as they occur can help reduce water wastage considerably.

Figure 4-24: Smart Buildings impact on water consumption [Source: Transforma Insights, 2022]

Category	Reduction in Water Consumption
Building Automation – Water Flow Monitoring devices	Around 10% reduction in water consumption by installing water flow monitoring devices.

[71] https://behrtech.com/blog/smart-water-managment/

5.5.1.5 *CO and CO2 benefits*

The impact on carbon savings is a result of savings in electricity, natural gas and water. Smart Lighting and HVAC systems by saving electricity save the emissions produced via electricity. HVAC systems utilising natural gas and crude oil, save emissions by saving consumption of these resources.

Figure 4-25: Smart Buildings impact on CO2 emissions [Source: Transforma Insights, 2022]

Category	Impact on Electricity Savings
Lighting	35-40% of carbon emissions saved by decreasing electricity consumed by lighting devices (bulbs, lamps etc.) using smart lighting control systems.
HVAC	20-25% of carbon emissions saved by decreasing electricity and natural gas consumed by HVAC systems that control and monitor HVAC.
Building Automation Systems	BAS systems integrated with HVAC and Lighting can save 1-3% additional in carbon.
Building Automation, Lighting and HVAC	Integrated building systems with HVAC and Lighting control can save nearly 10-20% of total building carbon consumption.

4.5.2 Wider ESG benefits

Smart Building technologies are key to achieving ESG goals for commercial and residential building owners. Occupancy sensors and indoor air quality monitoring systems have a significant impact when it comes to the 'Social' element of ESG. Monitoring of indoor air quality has profound impact on health, wellbeing and productivity of employees, residents, and customers. In addition to these, water flow monitoring systems are essential for safety of residents and customers, as they are effective in preventing floods and detecting legionella bacteria in water pipes. The latter is more relevant for buildings like hotels where water flow can be stagnant potentially for long periods. Flood mitigation systems also reduce the material waste that goes into landfill; 1 to 2 tonnes[72] of material waste per square meter is produced from demolition due to floods. Apart from these, space monitoring, room booking, indoor building navigation can significantly improve the lifestyle of residents and employees.

Visualisation of building data also helps owners to meet sustainability standards such as Leadership in Energy and Environmental Design (LEED) and WELL building standards and improve environmental, social and governance (ESG) metrics.

[72] https://behrtech.com/blog/smart-water-managment/

4.5.3 Business impact

In the long-term, all Smart Building solutions can provide owners with a lucrative return of investment by saving on energy, operation, and maintenance costs. Cost savings from BAS range from 5-30% depending upon complexity[73]. Operations cost is reduced as the requirement for manpower to operate the equipment reduces, and maintenance cost is reduced by predicting equipment failures in advance and repairing them on time. For example, using predictive maintenance (HVAC only), the facility manager of one 29-story office building saved more than USD16,700 in operating costs and another USD32,300[74] in repair costs annually.

For property owners, Smart Building Systems can also have significant indirect financial benefits such as better lease rates, higher valuation, and higher sales prices. In a report published by the European Commission it was found that smart buildings have 12% higher lease rates than non-smart buildings. Valuation and sales prices also tend to be 3-25% higher[75]. In addition, these solutions facilitate growth by optimising space utilisation; occupancy sensors help identify overused and underused areas in the building, providing the opportunity to maximise space utilisation.

Building owners that have adopted Smart Building solutions have reported increased satisfaction and productivity levels by tenants or residents.

Figure 4-26: Smart Buildings business impact [Source: Transforma Insights, 2022]

Business Impact	
Reduction in water damage claims	90-95% reduction in water damage claims by installing digital water leak detection and shut-off systems.
Savings on water bills	Detecting and fixing water leaks early helps building owners save 10-12% on water bills.
Higher lease rates and valuation	Certified smart buildings have 12% higher lease rates than non-smart buildings.
Reduction in operation and maintenance cost	5 to 30 per cent reductions in operating costs.
Enhanced occupant comfort	Remote adjustment of systems leads to enhanced occupant comfort.
Better space utilisation	Room booking systems lead to better utilisation of space.

[73] Commission welcomes Council adoption of new Energy Performance in Buildings Directive | Shaping Europe's digital future (europa.eu)
[74] https://www.iotacommunications.com/blog/smart-building-predictive-maintenance/
[75] https://ec.europa.eu/energy/sites/ener/files/documents/final_report_v4_final.pdf

4.5.4 Illustrative Scenario

Consider an example of a midsize commercial facility in the EU (100,000 square feet) that consumes 22.5 kilowatt-hours (kWh) of electricity per square foot per year and 24 cubic feet of natural gas per square foot (93% for heating). We assume 32% of electricity is consumed by HVAC (15% by space cooling, 12% by ventilation, 5% by space heating), 20% by Lighting, and the remaining by other electronic items like refrigerators and freezers. By deploying a smart HVAC solution and a Smart Lighting solution the facility can save 350 kWh per year. In the EU, on average 1 kWh of electricity contributes to 0.216 kgs of CO_2, thus by deploying these solutions the facility can save 75.6 kg of CO_2 per square foot in a year.

Figure 4-27: Smart Buildings illustrative scenario [Source: Transforma Insights, 2022]

Parameter	Value
Area of the Building (Sq ft)	100,000
Electricity consumed by the building (kWh per year per sq.ft.)	22.5
Electricity consumed by HVAC (kWh per sqft)	7.2
Electricity consumed by Lighting (kWh per year per sqft)	4.5
Electricity saved by Smart HVAC (kWh per yr sq ft) @20%	1.4
Electricity saved by Smart Lighting (kWh per yr) @35%	1.6
CO_2 emissions saved from Smart Lighting and HVAC (kgs per year per sqft)	0.6

4.5.5 Key Technologies

Key technologies used to support Smart Buildings include:

- ***Internet of Things*** – Leveraged by all Smart Building applications for real time control and monitoring of lighting, space, electrical, shading, temperature, security devices and more.
- ***Artificial Intelligence*** – Building Automation solutions often leverage AI for predictive maintenance, data insights help order replacement parts or new equipment before a breakdown actually happens. AI is also used by Smart HVAC and Lighting systems to predict user behaviour and auto program heating and cooling, and lighting services.
- ***Hyperconnectivity -*** Particularly including short range technologies (Wi-Fi, mesh technologies) to connect controllers with the peripheral components as well as smart phone or web applications. LoRaWAN has increased utilisation in building automation as these can penetrate better through the walls.

4.5.6 Case studies

The following case studies can be found in Transforma Insights' Best Practice & Vendor Selection Database:

- **Maidstone Hospital installed LoRa energy monitoring solution that helped reduce its carbon footprint by 28%**. Maidstone Hospital in Southeast England serves over 600,000 patients from a site covering over 2 million sq ft. Looking to reduce its energy consumption and carbon footprint, the hospital sought an easier way to measure and track its energy consumption. To do so, it installed Synetica's EnLink LoRaWAN monitoring solution that collects data from over 100 energy meters across the site and transmits it to a MultiTech Conduit IoT cellular gateway. This provides the hospital with a real-time view of energy use that enables it to track its energy reduction programmes. The hospital reduced its carbon footprint by 28% by 2020 (from a 2013 baseline).
- **Tuesday Morning retail chain deployed customised building automation system**. Tuesday Morning, a US based retail company, was looking for a solution to get remote visibility and control of lightning and HVAC for its small footprint stores across the country. FSG Smart Buildings, a building automation solution provider, designed a solution that worked with Tuesday Morning's existing hardware. Using Zigbee technology, FSG Smart Buildings used a custom gateway solution to work with existing Zigbee smart thermostats and switches at 17 Tuesday Morning locations. The solution enabled the retail chain to set schedules for all the stores through a platform. The custom solution saved energy usage and provided visibility and control to the store chain.
- **Dubai Exhibition Centre partners with TTK to deploy water leak detection solution**. Dubai Exhibition Centre (DEC) required a water leak detection system capable of detecting multiple simultaneous water leaks with precise location in critical zones such as Data Center, MEP Plant room, and other technical areas. TTK, a water leak detection systems company, installed ~2,600 point sensors at DEC to detect water leak and trigger an alarm in case a leak is detected. The point sensors are connected to the FG-NET monitoring panel and interfaced to the Building Management Systems. The solution helped detect water leaks early and thus reduce water wastage considerably.
- **Stockholm Exergi installing 9,000 IoT edge units in buildings to optimise energy consumption**. Stockholm Exergi is on a path to make Stockholm a sustainable and energy efficient city by 2030. To complement this mission, it collaborated with Telia to install 9,000 IoT Edge Units in residential buildings. IoT units send temperature data via an API into Stockholm Exergi's energy production (district heating) management system, which then will be combined with other data sources such as previous energy consumption patterns and weather conditions. By connecting buildings and having real time access to data it can monitor energy consumption and demand, enabling it to produce optimum amounts of energy and distribute where it is needed the most. This initiative will optimise energy consumption, reduce CO2 footprint, and lower costs.