Internet of Things and its Impact on India's Air-Conditioning Servicing Landscape

Himanshu Dixit, Shikha Bhasin, and Deepa Janakiraman

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Abstract

The environmental and energy stresses posed by the increase in demand for cooling have triggered several technology transitions in the air-conditioning sector. In addition to sustainability-focused refrigerant transition and energy-efficiency improvements, a third systematic technology transformation is imminent: appliances and equipment enabled with internet of things (IoT) entering the Indian market. Consequently, refrigeration and air-conditioning (RAC) units are increasingly becoming more capable, sophisticated, and communicative devices that connect to the internet and track crucial information through smart sensors.

Once artificial intelligence and cloud computing capabilities mature in terms of integration, interplay, and application, IoT has the potential to cause large-scale disruption. This brief study looks at how these developments will impact the air-conditioning servicing sector and investigates various opportunities and threats it poses for service technicians. The study's findings suggest that IoT will support the transition of the servicing sector. We argue that IoT will have a positive impact on the livelihoods of service technicians, if opportunities it creates are captured and capitalised in time. The training and respectability of

technicians might improve. With the changes brought about by IoT, service technicians will also be viewed as more skilled and specialised workers.

1. Introduction

On the one hand, the cooling sector is increasingly being recognised as integral to economic growth and prosperity across the developing world. In India alone, with the demand for cooling set to rise eight-fold in the next two decades (MOEFCC 2019) due to rising incomes, aspirations, and need for thermal comfort in response to increasing instances of heatwaves, the sector is expected to become one of the largest consumers of electricity in the country. On the other, the rising demand for air-conditioning is already increasing the pressure on the country's power grids, which are struggling to keep up. The energy used to power cooling appliances contributes to the largest share of residential emissions. However, this is only 70 per cent of an appliance's emissions (MOEFCC 2019)—the remaining emissions resulting from cooling are attributed to the use of refrigerants.

To balance the pressing need for cooling as well as the environmental and energy stresses posed by this increased demand, the air-conditioning sector in India has embraced two key technological innovations. First, improving the energy efficiency of appliances remains a key policy priority across sectors, and the air-conditioning industry is no exception. Room air conditioners are included under the *Standards & Labelling* (S&L) programme of the Bureau of Energy Efficiency (BEE), which, since 2010, mandates manufacturers to periodically increase the minimum energy performance standards (MEPS) of their appliances from time to time (BEE, 2019). Manufacturers are making changes to their product portfolios and developing more efficient components and assemblies in addition to what's mandated by the policy. Second, the global mandate as per the Montreal Protocol (1987) and Kigali Amendment (2016) to move towards zero ozone depleting potential (ODP) and low global warming potential (GWP) refrigerant technologies has led to critical changes, such as the replacement of refrigerants such as hydrochlorofluorocarbons (HCFCs) with hydrofluorocarbons (HFCs). Technologies based on natural refrigerants ranging from ammonia and carbon dioxide to some hydrofluoroolefins (HFOs) and hydrocarbons have matured and are expected to be deployed at scale in the coming years (ISHRAE 2015).

Systematic technology transformation is imminent with internet of things (IoT)–enabled appliances and equipment entering the Indian market.

The *India Cooling Action Plan* (ICAP), launched in 2019, outlines targets and opportunities for a sustainable transition for cooling technologies while facilitating increased access to cooling and thermal comfort for all in the country. It recognises the room air-conditioning (RAC) servicing sector as a critical area for interventions to consolidate jobs, growth, and sustainability in the cooling domain. Further, servicing is also important to maintain energy efficiency performance close to the design value.

However, in addition to these sustainability-focused transitions, a third systematic technology transformation is imminent with internet of things (IoT)–enabled appliances and equipment entering the Indian market. RAC units are increasingly becoming capable, sophisticated, and communicative devices that can connect to the internet and track crucial information through smart sensors. Further, certain devices connected to RACs can act like internet-connected remotes for the unit, enabling the user to control it from anywhere in the world (Mehta 2017). This technology has been globally deployed in cooling and heating applications for several years now, beyond RAC appliances, and is increasingly being seen in India too.

1.1 Changing technologies' demands on the servicing sector

Technological changes require that supporting functions such as maintenance and servicing also improve to keep pace with new appliances. According to the ICAP, there are approximately 200,000 air-conditioning (AC) service technicians employed in the formal sector in India as of 2019. As the demand for cooling rises, resulting in an increase in AC stock (estimated in 2017–18 to be around 39 million units), the demand for servicing is expected to rise as well. Moreover, the RAC service sector is responsible for 40 per cent of India's refrigerant consumption (MOEFCC 2019).

The ICAP recognises the need to train and certify these technicians to reduce greenhouse gas (GHG) emissions during servicing. This is done through proper handling of refrigerants that have a high GWP as well as restoring equipment to its optimal efficiency level.

Thus, predictive servicing (servicing that is scheduled as needed based on equipment condition) has steadily gained importance in the global sustainable cooling landscape as a means to ensure energy savings and extend product life. There is also the issue of servicing professionals' livelihoods as well. Technicians and the sector at large must adapt to changing technologies to secure their livelihoods.

Both, governmental policies and the literature, recommend improving predictive servicing, good servicing practices, safety, well-being, sustainability, and optimising efficiency through training and certification of service-sector technicians as well as through raising customer awareness. However, very little has been understood of the impact of IoT on the servicing sector. Thus, this issue brief, based on market intelligence, desk research, and interviews with sectoral experts, seeks to lay out the opportunities, challenges, and changes in the nature of jobs for the servicing sector as a result of the technology transitions specifically brought on by IoT.

2. Where does the heating, ventilation, and air-conditioning (HVAC) industry stand vis-a-vis IoT?

The IoT paradigm comprises several technologies working together as a suite. The full extent of its capabilities and possibilities will become apparent only as the underlying technologies mature with time. IoT can be considered the interplay between three different classes of technologies: (i) artificial intelligence-based technologies, such as smart sensors to measure critical parameters within the system, time sensors, etc.; (ii) internet connectivity to mobile devices as well as remote servers; and (iii) cloud storage and computing to store large amounts of data on servers and perform advanced calculations on them.

Typically, an IoT-enabled HVAC system is equipped with a wireless sensor network that sends data to a gateway that connects the local network to the cloud, which is administered by system managers who analyse the data sent by sensors. In addition, the system allows users to access and manage their HVAC appliances remotely through mobile and desktop applications (Perfectial 2018). IoT has numerous applications in the commercial cooling sector. For example, one way to effectively monitor electricity consumption and boost energy efficiency in a HVAC system is by using a smart thermostat – an IoT device that gathers useful HVAC data and adapts to the building's needs. Recent developments in the IoT sector have further improved the capabilities of these systems. These capabilities include improved fault detection and diagnostics, asset management, maintenance, and enterprise integration.

What is IoT?

The internet of things (IoT) refers to a system of interrelated, internet-connected objects that are able to collect and transfer data over a wireless network without human intervention.

(Cooling India 2018)

The fact that several technologies can work in tandem to provide us with information that was not available before makes IoT exciting. For instance, Wi-Fi-enabled devices in combination with next-generation sensors can capture the performance parameters of the device as well as information on the room environment where the device is installed to create a report that we can read on our cell phones.

Based on an extensive literature and market review of IoT-enabled cooling products in India, listed in Annex I and Annex II, the authors have found that IoT is making comfort cooling easier in three ways: (i) embedded computing and communication with edge devices are allowing more intelligent functions and local controls to be embedded in intelligence and local controls for HVAC devices and systems, (ii) cloud and edge technologies, coupled with machine learning and artificial intelligence, are enabling better automation and management of comfort systems, and (iii) customised solutions are being provided to accommodate personalisation and interactive engagement between appliances and customers.

2.1 Imagining the impact of IoT

Once artificial intelligence (AI) and cloud computing capabilities mature in terms of integration, interplay, and application, IoT has the potential to cause large-scale disruption. For example, performing diagnostics without human intervention will be possible based on the input of smart sensors alone. Further, providing

easily accessible information on parts that require replacing, servicing needs based on usage patterns, and monitoring and performance data will be the norm rather than the exception.

In terms of future capabilities, integrating IoT with home appliances such as ACs and refrigerators will enable the following:

- Self-controlled and optimised devices
- Data on device performance and usage parameters can be collected, stored, transferred, and analysed periodically
- Self-diagnostic features
- Automated servicing alarms/calls

One crucial element of the IoT paradigm is 'information flows' about device performance and status, which will allow the operational history of the device to be known in unprecedented detail. This information will be generated in very large volumes, transferred through the internet, and collected on a remote server and monitored in almost real-time.

Smart and connected sensors will further revolutionise the home appliances segment. This will lead to high operational transparency by virtue of having granular and high-frequency data about the devices and their usage. These data streams will be extremely valuable to all stakeholders, including for the innovation of resilient products and improving energy-efficient appliances, maintenance services, and end-of-life management of equipment.

The way these new information flows are managed and controlled will also be significant. For instance, whether a database is open or closed will decide who uses the data and will determine the subsequent participation of different actors and stakeholders. Complex data privacy issues also arise regarding the collection and usage of these data. However, a discussion on data privacy is beyond the scope of this brief.

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> Cooling as a service (CaaS) will draw heavily from the advanced monitoring and responsive capabilities of new information technologies.

Several consumer electronic companies have already rolled out IoT-enabled, smart air conditioners and other products (Annexure 1). These devices are only expected to become more capable and sophisticated with time and as they gain increased traction among users. For example, based on our usage patterns and weather conditions, they can maximise thermal comfort and ensure efficient use of power. The Nest thermostat goes a notch above as its sensors are capable of detecting human presence at home, and it can be controlled from afar with a mobile app. However, the use of cloud storage and computing capabilities to run analytics on high-frequency home appliances' operational data is still only a distant possibility.

2.2 IoT and the future of the servicing sector

While predictive servicing is still a nascent area, IoT technologies are turning predictive maintenance into a responsive process. This concept is not entirely new. Big-ticket assets like industrial HVAC systems have employed sensors and automated maintenance alerts for some time now, but the high cost of these technologies has traditionally made them economically unviable to deploy at scale in the home appliances segment. Over the past five to ten years, however, developments in IoT technologies have dramatically reduced the cost of connectivity (Supalla 2018).

Currently, there are no platforms that allow technicians to access servicing requests raised through IoT-enabled units. Once the database generated is large enough, it will be a transformative tool to build businesses and platforms to register, train, and upskill service technicians. For example, BlueStar launched a pilot in 2017, where it equipped 600 chillers with IoT to reduce communication costs and perform preventive maintenance (Annexure II). Similarly, York-Honeywell monitors chillers remotely and responds with corrective or routine service (Annexure II). However, the large-scale implications of such changes in the AC servicing sector are yet to be seen.

However, supporting infrastructure made possible by the IoT paradigm can enable technicians to access servicing jobs on their own through new applications. On-demand training services and tips based on infrastructure relying on cloud technologies and IoT can be operationalised for technicians. New business models too can be developed revolving around the new data that will be centrally stored. Cooling as a service (CaaS)[1] will also draw heavily from the advanced monitoring and responsive capabilities of new information technologies. The next subsection explores the possibilities that emerge from these developments and what they mean for the AC servicing sector.

3. How can IoT empower the end-user and impact servicing?

Smart heating and cooling devices will benefit from the demand-pull from consumers who want to be informed and in control of their devices. This will have some impact on the sensitivity with which consumers view the process of servicing – i.e., as a task that needs to be performed every year. Often, however, consumers are not informed about how well the servicing was performed. In the short run, there is not going to be a sea change in the consumer–service technician dynamic. No real impact on the number of servicing jobs, the quality of these jobs, and their mode of generation is expected soon. Therefore, one can surmise that the current level of IoT capabilities is likely to have a minimal impact on the servicing sector at best.

How, then, will IoT impact the servicing business going forward? Generally, as technologies become smarter and more complex, the servicing sector tends to become more organised. **As consumers start adopting these technologies at a larger scale, there will be a better understanding of the value of good maintenance practices. For example, in the case of the auto industry, servicing performance improved with the advent of advanced computing capabilities**. This perceived need for servicing and maintenance will be a function of awareness, the price of the technology, and the inherent capabilities of the technology itself. This leads us to the proposition that any disruption in the AC servicing sector due to IoT will perhaps begin with devices' ability to communicate with the user. These capabilities can be leveraged to create an InfoBase of the servicing history and schedule of the devices. This has the potential to make the process of servicing much more streamlined.

A more significant change will be triggered by the user's increased knowledge of the performance of the AC. Due to the use of smart sensors, IoT can track key performance indicators and share the data with the user. Today, there is no way for users to know how well their ACs are performing before and after servicing, except for a general 'feeling' that it has improved. This is one of the reasons why servicing is not taken seriously by users. **A performance indicator sheet, which users can access on their phones, will allow them to compare the unit's performance before and after servicing**. This will go a long way in solving the problem of information asymmetry that currently exists between users and service technicians with regards to the quality of servicing and good servicing practices. It will transform the dynamic between the two for the better and will be a game-changer for the whole industry.

What is commonly seen in the appliances segment in India is that these devices are not serviced, unlike automobiles, until there is a complete shutdown or serious damage. By that time, however, the damage is so great that a simple servicing operation is not enough. Several parts need to be replaced if not the whole device. This is referred to as corrective or breakdown maintenance.

New-age IoT devices with diagnostic, communicative, and servicing tracking capabilities can aid in nudging consumers to switch from breakdown maintenance to preventive maintenance, and possibly predictive/regular servicing. Preventive maintenance is key in ensuring the long life of the device and that it works efficiently and effectively for the period of its use. Preventive maintenance will also ensure that it operates as per the

> IoT can track key performance indicators and share the data with the user.

1. Cooling as a service (CaaS) is a pay-per-service model that eliminates the need for upfront investment in the equipment by letting customers pay for each unit of cooling they consume. The technology providers are responsible for the maintenance and upkeep of the whole system. CaaS, thus, incentivises customers to make judicious use of these services, and technology providers are incentivised to install the most-efficient equipment as well as optimise maintenance for long-lasting performance.

design specifications and thus saves energy. It is also worth pointing out that after-sales device servicing in India is not expensive. Hence, quite often, it is only a matter of reminding users when their device requires scheduled servicing.

Further, the combined use of IoT artificial intelligence and machine learning will allow the system to learn the "normal" behaviour of an installed air conditioner over time and report any abnormal behaviours to prompt corrective action. It will be similar to networks alerting users if their internet account or credit card is being used unpredictably.

The value of informing the user about the devices' performance cannot be emphasised enough. This will be a critical lever to encourage users to care for the device through regular maintenance. Evidence of non-optimal performance will change the way servicing calls are made. From a standard, breakdown or frequency-based practice, servicing will be driven by the needs of the device. For example, households with higher usage will demand more servicing. In other words, the IoT-based system will change servicing requirements from time-based to demand-based depending on the health of the system.

3.1 Effect of IoT on servicing businesses and jobs in the medium to long-term

Although the evidence on customers' servicing patterns is slim, experience suggests that predictive servicing is not a norm in India (Gorthi et al 2020). Often, devices are serviced very irregularly and not according to the guidelines prescribed by the manufacturer. Preventive maintenance advocates regular servicing of the device for prolonged operational life. Improving users' awareness of preventive maintenance through a nudge mechanism enabled by the IoT could lead to an increase in the number of servicing jobs. However, this will have to be squared with the needs of the system itself and with how much servicing is needed based on usage. An average household gets its AC unit serviced once a year, which is adequate for its level of usage. However, in commercial establishments, due to the high level of use, this servicing frequency may be inadequate and may need to be ramped up. Further, with IoT, the turnaround time will be shorter as the health of the system and spare parts requirement will be known in advance.

Critical ways in which IoT will support the transition of the servicing sector have been listed below.

Servicing demand assessment

How manufacturers, service dealerships, and on-demand service providers assess the demand for servicing and maintenance is certain to change. The information will empower them as much as the user. A simple operational history of the device, such as the model number and when it was bought, installed, and serviced, can help streamline supply-side issues like the availability of and accessibility to trained technicians. This assessment can help service providers push for longer maintenance contracts as well.

Data as a value addition

As the data generated by IoT-enabled devices reaches a critical mass, they will also become very valuable from a commercial point of view. The data will engender the emergence of new servicing business models, where data management, organisational management, training, and on-demand servicing will be vertically integrated. There is also the possibility of horizontal integration of various appliances such as washing machines, refrigerators, ACs, and other home appliances. This is critical for the technician considering that the AC is a highly seasonal product and that an AC technician might not have as much work during off-season.

Increase in the number and types of jobs

Vertical and horizontal integration of business functions will lead to the creation of many operations and maintenance (O&M) jobs. There will be more high-value-addition jobs such as data management, data analytics, and business management. There will be a subsequent increase in the need for trainers and service technicians. Horizontal integration across different devices could also lead to the diversification of the offered services. This will provide an opportunity for service technicians to develop skills in more than one appliance segment. We might witness the start of integrated maintenance contracts as well.

> **The IoT-based system will change servicing requirements from time-based to demand-based depending on the health of the system.**

> There will be more servicing sector jobs enabled by technological interventions, which will lead to more technicians gaining access to training.

Internet-based on-demand servicing companies

These companies can be expected to grow and will be in a better position to design marketing campaigns to nudge consumers to opt for regular servicing. They have a major role to play in terms of effectively using the data produced by devices and business analytics to disrupt the disaggregated servicing market. Two kinds of business models can emerge: (i) aggregators' model and (ii) performance guarantee model. One might argue that we already have companies that follow the aggregators' model such as Urban Company[2], ServiceOnDemand, etc. While this is true, with the data generated by IoT, their scope will grow by leaps and bounds. Using customers' data, they will be able to make demand projections in a more precise and efficient way, which will help them further penetrate the servicing market. The performance guarantee model will be based on the specific capability of IoT to track parameters and publish reports before and after the device is serviced. The authorised servicing dealerships can use this data as a measure of guaranteed performance offered to the customer.

Homogenous standards and protocols

Establishing IoT protocols will set standards and rules for larger integration between different technologies and players. These protocols and other issues related to smart infrastructure will be decided by the Bureau of Indian Standards (BIS 2017). Issues regarding data, privacy, compatibility between devices, and establishing a homogenous framework will probably be discussed and resolved by the BIS.

Business diversification

Short- and medium-term demand projections and longer maintenance contracts will increase the man-hours of the servicing sector. This might have two effects: a) manufacturers and service dealerships on contract may recruit and train more technicians to service the demand, thus increasing the size of the formal service technician market, and b) device data are shared with technology entrepreneurs, such as Urban Company, who can then empower local technicians by providing them access to servicing jobs to meet the expanding demand. In either scenario, there will be more servicing sector jobs enabled by technological interventions, which will lead to more technicians gaining access to training by manufacturers, service dealerships, and technology companies.

Increase in indirect jobs

In terms of the effect of IoT on the gross number of jobs, new business models will lead to the creation of many indirect jobs such as trainers, managers, and developers as data becomes an integral part of the business. Data will be extremely valuable because it will lead to more aggregation. Additionally, the key factor for the servicing sector in an IoT-driven future will be the migration from the informal sector to the formal servicing sector. The compensation available to service technicians might also increase.

Maintenance contracts

Whether these changes result in customers purchasing more maintenance contracts will depend on how manufacturers sell these products. Manufacturers can include the cost of long-term (3–5 years) servicing in the upfront cost of the product and capture the business or commission a service dealership. Alternatively, they can use the nudge/marketing model to remind users to service their devices frequently.

> The data will engender the emergence of new servicing business models, where data management, organisational management, training, and on-demand servicing will be vertically integrated.

2. Urban Company is a gig marketplace that offers a range of services such as beauty and wellness services and installation and maintenance services to its customers at their doorstep.

3.2 Opportunities and challenges for service technicians

IoT will trigger a transition that will have an all-round positive impact on the livelihoods of service technicians. The training and respectability of the technicians themselves might improve. With IoT changes, service technicians will be viewed as skilled and specialised workers.

Certified technicians at an advantage

Many technicians are either informally or self-taught as formal training and education are not easily available. Even when government-approved centres are available, few technicians undergo formal training. Despite inadequate and non-institutional training, the technicians are very nimble when it comes to learning new skills and adjusting to new requirements. If there is a free flow of information about common servicing issues and general fixes by way of tutorials and learning modules, many technicians will make the effort to upgrade themselves. However, there is a possibility that technicians not familiar with the new technology will be displaced by this transition.

Incremental learning over apps

The service technicians themselves may have a role to play in finding their place in the emerging digital economy of the servicing sector. They will have to familiarise themselves with disintermediation in the sector. Many of them, especially those engaged with companies like Urban Company, are digitally literate and aware of app-based service delivery mechanisms. In addition, they will have to upskill to make sense of crucial diagnostic information and familiarise themselves with new components. Technicians failing to adapt to the change will be displaced by market aggregators that may capture a larger share of the servicing market following increased access to data flows.

Here, IoT platforms can also provide learning opportunities to servicing technicians, which will not only help improve their skills but will also make them more efficient. First, it is important to know the history of the device while preparing for servicing. Servicing is quite often a multi-step process, where after performing diagnostics, it takes time to acquire the right tools to solve the servicing issues and problems. Using the device data, technicians can come prepared with the right tools, parts, and refrigerants that are meant for a particular model, which can save a lot of valuable time for them and users. In addition to the advanced diagnostics performed using data from smart sensors, IoT platforms can also provide problem-solving modules to aid service technicians.

Disruption in local servicing markets

One downside of devices that communicate to the manufacturer and the user about servicing needs and schedules is that the local service technician may become redundant. If this information is controlled by the manufacturer, they will try to capture this market for themselves. This might be good for formalising the servicing sector, but local service technicians will lose out. The manufacturers' owned and commissioned service dealerships will step in as they will track and know in advance the demand for servicing. This is all the more probable because servicing is a large business that generates a significant amount of revenue when operated at scale. If this scenario plays out, then local service technicians in the informal economy will have to acquire new skills. Only through formal training, regular upskilling, and employment with service dealerships would their livelihood be protected.

4. Conclusion and way forward

IoT technologies are being increasingly adopted in a range of products and have the potential to disrupt the AC servicing sector. Our analysis identifies several critical areas where IoT can bring about transformative changes. Underlying most of these developments is the use of operational data from devices, which are recorded, collected, and analysed in the IoT paradigm. Through advanced data computing, new efficiencies can be introduced in the servicing business. Whether it is servicing demand assessment by original equipment manufacturers (OEMs) and large dealerships or new aggregation-based servicing business models, which

Using the device data, technicians can come prepared with the right tools, parts, and refrigerants that are meant for a particular model.

will bring in structural changes as well as make certification of technicians more important, many possible changes may emerge with IoT. At the level of the technician–consumer dynamic, harnessing the capabilities of IoT can offer distinct advantages. Creating a demand-pull from consumers for effective servicing by providing data-driven performance sheets of the device is one of them.
In terms of ecosystem changes, IoT will enable on-demand service companies, diversification of jobs and skills among technicians, and proliferation of a substantial number of indirect jobs.

The benefits from IoT will help drive some of the key ICAP goals. The impact of IoT on technicians will bring us closer, and make easier to implement, what the ICAP would like to see happening in this sector: incremental training and upskilling, certification and standardisation, increased attention to safety protocols, and awareness about good servicing practices (GSPs) among both technicians and consumers. Policymakers can play their part as well, by leveraging these technological changes to deliver the maximum policy benefit. The following are some of these proactive policy moves:

- Integration of mechanical engineering and electronics education will be needed to navigate the emerging world of IoT. The training curriculum for technicians must be updated to reflect the new skills needed to perform the job. Embedded learning of technicians through apps will be a bonus.
- IoT can also trigger the replacement process with the upgradation of the S&L programme. Creating awareness and educating the consumer about making replacement decision should be taken up by the BEE.
- Since IoT makes possible the measurement of device performance before and after servicing, service performance standards in addition to checklists for GSPs for both consumers and technicians should be developed.
- Awareness programmes should be developed for both consumers and technicians to make them aware of device performance after servicing, its relationship with energy efficiency, and possible savings in electricity bills for consumers.
- Standardisation of IoT protocols must be decided as soon as possible keeping in mind users' privacy, technicians' welfare, and OEMs' commercial interests.

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Annexures

Annexure I Market deployment of IoT in cooling appliances and applications in India: Drivers of IoT in the consumer segment

In the durable electronics segment, the market for IoT-powered devices, also referred to as 'smart appliances', is growing. There are more interconnected and mobile-controlled appliances available in the market than ever before. Owing to the lockdown, the home entertainment market has grown in the last 8 months, indicated by the 200 per cent increase in TV sales (Mukherjee 2020). There is also a niche market for products like Google Home and Amazon Echo. The work-from-home situation and its impact on electricity bills are also expected to nudge consumers toward investing in energy-savings-enabled technologies.[3] The general trend of smart home devices gaining traction among consumers is also an encouraging sign for the smart air conditioners, chillers, and variable refrigerant flow (VRF) markets.

As price is the main differentiator between IoT and non-IoT appliances—due to high initial investment costs—the uptake of smart cooling appliances will depend on the consumer segment as well. There are three categories of cooling equipment that serve different consumer bases: (i) large AC equipment like chillers, (ii) medium to large-sized variable refrigerant flow (VRF) systems, and (iii) centralised and standalone air conditioning units for residential and commercial establishments. The point to note here is that the value proposition of smart versions of these equipment needs to be fine-tuned as per the preferences and requirements of consumers. The increased cost of smart devices must be balanced with the capabilities on offer and how relevant these capabilities are to the purposes of the cooling equipment – only then will we see a demand-pull from consumers.

For instance, household users are more interested in tracking the use of air conditioning by other members of the household as well as checking whether the unit was switched off when they left the house. Having the room cooled 15 minutes before arriving home might not be a desirable feature for such users. The question then becomes: will these users pay more for the extra feature in their units? In contrast, commercial users of

3. As gathered from industry experts.

cooling facilities necessarily demand advanced features to track the performance and cost of cooling. The use of smart sensors to capture high-frequency operational information might be more useful in this context. Hence, such large users might be more willing to bet on the new technology and pay extra for it as it can pay for itself by accruing commensurate savings for the user over a period of time.

In summary, one can say that a mix of demand-side and supply-side factors determine what place IoT will have in the market in the foreseeable future. The behavioural traits of end-users in different segments together with larger macroeconomic and cultural trends such as rising incomes, adoption of aspirational lifestyles, and the decreasing marginal cost of producing the technology itself are some of the important drivers of IoT.

Annex II Market deployment of IoT in cooling appliances and applications in India: examples of IoT in India's HVAC market today

Many manufacturers such as Daikin, Panasonic, TCL, and Samsung have launched smart RAC units to harness the benefits of the IoT paradigm. Further, market leaders such as BlueStar claim that they will convert their entire AC fleet to leverage the capabilities of IoT (IndianRetailer 2016).

BlueStar launched an IoT pilot in 2017 where it installed sensors in 600 chillers to collect data remotely and monitor them from a centralised location to predict and provide customer services in a proactive way (Maru 2017). BlueStar, too, plans to integrate its entire fleet with IoT technologies to allow used to control the cooling mode, airflow, on-off mechanism, and other aspects from a smartphone app via Wi-Fi (Rakshit 2016).

Mitsubishi Electric introduced mirA.I. air conditioners, which are a fit-and-forget type AC with AI-powered systems. These units can heat and cool, adjust capacity, measure human body temperature, the feeling of temperature in the human body based on the movement of body parts, identify heat or cold sources, create natural wind movements around occupants, etc. (Cooling India 2018). Apart from gauging the surroundings, the platform features intelligent diagnostics that can detect issues in advance, thus advancing the operational performance of the products. Another feature is an 'e-warranty' that lets customers maintain all their warranty services and annual maintenance contracts (AMCs) in a digital format and notifies them if there is any change in their status.

Similarly, **Panasonic** launched a new range of RACs equipped with various smart features including a smart customisable sleep mode that lets users set different temperatures across the night. The new IoT-enabled air conditioners can detect usage patterns and external weather conditions. This lets the RACs recommend the best mode of operation to the user. Further, the new Panasonic ACs are equipped with Nanoe-G technology, which is capable of eliminating bacteria. There is also an auto-diagnosis feature that can help detect issues in advance and alert users. The RAC can also be connected with the company's app to use more AI-enabled controls (BGR 2020).

Samsung India announced RAC models equipped with Wi-Fi capability, human detection, and green R32 gas (ACE 2020).

TCL has IoT-enabled smart ACs. AI-powered and with an ultra-inverter technology, apparently designed for India's more extreme climatic conditions. The high-density filter and silver ion filtration technology maximises air purification by removing bacteria from the environment. TCL smart ACs also come with a gold fin condenser and evaporator for durability and are powered by the TCL AI x IoT System, with options such as hotspot or Wi-Fi control, voice-based commands, app control, etc. (Singal 2020).

The authors

Himanshu Dixit
Himanshu.dixit@ceew.in | @dixit_himanshu3

Himanshu is a Research Analyst in the Technology, Finance, and Trade team at The Council. His primary responsibility is to support The Council's ongoing work in the implementation roadmap of the India Cooling Action Plan with regard to cooling technologies and phasing down HFCs.

Shikha Bhasin
Shikha.bhasin@ceew.in | @shikha_bhasin

Shikha leads CEEW's research on sustainable cooling. A co-author of the India Cooling Action Plan (ICAP), she continues to represent CEEW as a member in the ICAP working groups on the R&D and servicing sector. She has previously worked on regulatory frameworks required to meet India's Kigali Amendment commitments and the institutionalisation of an R&D platform for supporting the phase-out of HFCs in India.

Deepa Janakiraman
deepajraman@gmail.com

Deepa Janakiraman was a former Research Analyst at CEEW. An economist by training, she worked on estimation of greenhouse gas emissions from the Indian Manufacturing Sector to inform and influence decarbonisation policies.

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For queries contact

COUNCIL ON ENERGY, ENVIRONMENT AND WATER (CEEW)

Sanskrit Bhawan, A-10, Qutab Institutional Area
Aruna Asaf Ali Marg, New Delhi - 110067, India
T: +91 (0) 11 4073 3300

info@ceew.in | ceew.in | @CEEWIndia | ceewindia