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Considerations in Standardization for Demand Response Ready Air Conditioners in India

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Abstract— The following overlapping and converging trends require a careful consideration of what ought to constitute demand response (DR) ready capability for air conditioners (ACs) in India: a) Increasing peak load from air conditioners (ACs) b) Plans for increased intermittent renewable generation capacity and c) increased numbers of appliances with “smart” functionality. In India, given the likely estimated future growth in ACs will add load of ~60-100 GW, DR ready ACs can provide an opportunity to mitigate this peak demand. However, DR implementation in India will require considerations that are different from those in the United States (US) and Australia. For example, cell-phone penetration in India is higher than broadband Internet penetration. In this paper, we present a draft specification for DR-ready appliances in India, building from international experiences and from existing IEC standards. We present this specification in order to begin the debate about what such a specification ought to consider, including issues such as the need for automation, bi-directional communications and low latency requirements (or fast response from loads).

Keywords— demand response, smart appliance, air conditioners, renewable energy integration, standards

INTRODUCTION

India is poised for a rapid increase in peak electricity demand from air-conditioners due to rising incomes and large population centers in hot climates. (Figure 1). Since 2004, room air conditioner (AC) sales in India have been growing at more than 15% per year, with more than 3 million units sold in 2012 (Phadke, Abhyankar and Shah, 2013). Although India currently has very low room AC penetration, large growth in AC sales is expected to result in a peak demand addition of 60 GW to 100 GW by 2030 (Phadke, Abhyankar, and Shah 2013; Planning Commission

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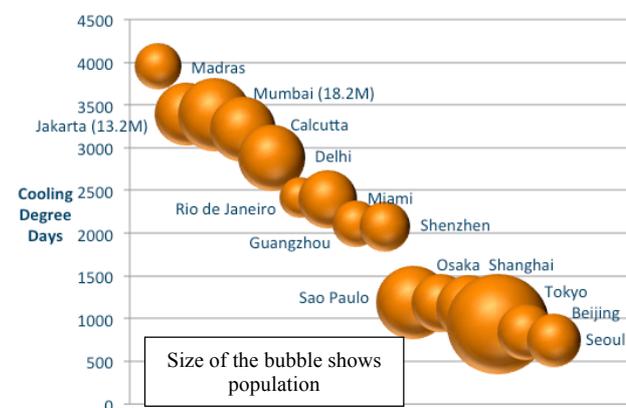


Figure 1. Many of India's large urban centers have among the hottest climates Source: (Sivak 2009)

Meeting this additional demand would require a massive increase in electricity generation supply, especially during the peak summer periods, and have implications for energy security and the national balance of trade. This potential rise in electricity demand can be managed through a combination of policies to enhance the efficiency of ACs being sold in the Indian market, and through the adoption of demand response technologies (DR) and policies, as we will discuss later. Furthermore the recent announcements by the Government of India of a targeted 100 GW of solar generation capacity also necessitate increased penetration of energy storage and demand response technologies in order to integrate this intermittent renewables generation capacity. Finally, there is a global convergence toward the “Internet of Things” (IoT), with appliances, smartphones, etc. all increasingly connected to each other. Each of these trends, namely: a) increased AC sales, b) increased intermittent renewable energy generation

and c) increased penetration of smart appliances (including ACs) creates an opportunity for the Indian economy to deploy “demand-response ready” or “smart” ACs in order to ensure peak load management and grid stability. In the US, about 60,000 MW of DR capacity exists in various DR programs, and the combination of demand response and energy efficiency programs has the potential to reduce non-coincident summer peak demand in the US by 157 GW by 2030, or 14–20% below projected levels (Siddiqui 2009). Demand Response (DR) can, therefore, be considered a valuable resource for managing the electricity grid. It can effectively mitigate peak demand and also reduce the costs associated with integrating intermittent renewable energy generation (Klobasa 2010).

- **Demand Response** refers to changes in the operating mode of appliances or equipment in response to changes in electricity prices, the state of the electricity network, or external requests for load modification. The user may respond manually, or may willingly permit automated changes to lower energy costs and/or financial incentives.
- **Smart Appliance** has been variously defined as: 1) “a product that uses electricity for its main power source which has the capability to receive, interpret and act on a signal received from a utility, third party energy service provider or home energy management device, and automatically adjust its operation depending on both the signal’s contents and settings from the consumer” (AHAM/ACEEE, 2011), alternatively, 2) “the automated alteration of an electrical product’s normal mode of operation in response to an initiating signal originating from or defined by a remote agent”

SCOPE

In this paper we discuss current developments in the International Electrotechnical Commission’s (IEC) standards process and issues needing consideration in standards for DR-ready or smart ACs in India, based on the draft IEC standard being developed by IEC TC59 WG15, which sets out a reference framework for defining appliances as “smart” or “demand-response ready”. We do not discuss communications specifications, which are being developed separately under the IEC Project Committee 118 (PC118) on “Smart Grid User Interface” which focuses on the cross-domain interfaces that support secure communications and information between the electricity service provider, and the controls, electrical load, storage, devices, etc. within the consumer (user) domain. (IEC

PC118, “IEC 62939 TR: Smart Grid User Interface,” Draft Technical Report, 118/40/TR, 2014)

RELEVANT STANDARDS

Standards for Demand Response and “smart” appliances have been in development since 1997 in Japan, since 2003 in Australia and are still being revised internationally under IEC TC59 and in the US under the ENERGY STAR program. As can be seen from Figure 2, standards development is a lengthy process requiring consultations with many stakeholders in order to arrive at an acceptable consensus framework. The field of smart appliances is currently at an early stage of development with IEC TC59 WG 15 expected to publish a draft technical specification in mid-2015.

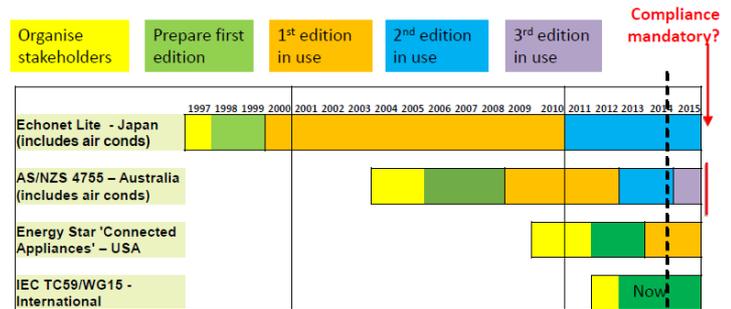


Figure 2 Typical Timeline for standards development (Source: Wilkenfeld, 2014).

We will now discuss various use cases that have a bearing on requirements for a specification for demand-response ready appliances.

LATENCY (OR RESPONSE TIME)

As shown in Table 1 below, space-cooling equipment such as ACs and chillers can be used in many different types of demand response programs.

Customer Type	Equipment/ Building Component	Control Strategy	DR programs		
			Emergency or Energy Resource	Capacity Resource	Regulation Service or Reserves
Residential	Air conditioners	Cycling/forced demand shedding	✓	✓	✓
Commercial	Chillers	Demand limiting during on-peak period	✓	✓	
		Pre-cool building over night-storage		✓	
		Forced demand scheduling	✓	✓	
Industrial	Chillers	Demand limiting on time schedule		✓	

Table 1: Cooling equipment use in Demand Response programs [adapted from (Walawalkar et al. 2010)]

For example:

- as an “emergency” or “energy” resource during a time of high demand
- as pre-scheduled “capacity” that can reduce load according to a pre-planned schedule
- as a means of providing regulation services and reserves in real time or on short notice.

In order to accommodate these different types of demand response functionality, response times from seconds (for regulation services or emergency energy resources) to minutes to hours (for pre-scheduled capacity) may be required. A clear and flexible definition of “DR-ready” or “smart” space cooling equipment is needed in order to accommodate the

various types of DR programs, technologies and frameworks. Integration of intermittent renewable energy resources may also require response times of the order of minutes or seconds if demand response is used for regulation services.

Hence any specification for DR-ready appliances should account for such widely varying timescales for different DR program (i.e. response time) requirements.

AUTOMATION AND BIDIRECTIONAL COMMUNICATION

Automated DR, which enables energy service providers to control the usage of end use equipment remotely and automatically, is one of the key DR strategies/programs that have been found to improve load response and peak load reduction (PowerCents DC 2010). For example, during

Technology	Communication Medium	Capabilities	Pros	Cons
Radio controlled chip that communicates with the appliance microprocessor	Radio signal	Modulate energy consumption (uni-directional communication only)	Lower cost than cell or WiFi	Easier to bypass; actual participation in the program cannot be confirmed and could raise issues for compensation
Frequency controlled chip that communicates with the appliance microprocessor	Grid frequency	Modulate energy consumption (uni-directional communication only)	Lower cost than cell or WiFi	Unidirectional communication capability; easier to bypass;
Wi-Fi chip that communicates with the appliance microprocessor	Wi-Fi network	Modulate energy consumption + report back the status of the device (bi-directional communication)	Hard to bypass; reports back if bypassed/overridden; compensation to consumers can be based on actual participation	Higher cost compared to radio/frequency based switches; Costly for retrofit; Requires WiFi network
Cellular chip that communicates with the appliance microprocessor	Cellular network	Modulate energy consumption + report back the status of the device (bi-directional communication)	Hard to bypass; reports back if bypassed/overridden; compensation to consumers can be based on actual participation; ubiquitous availability of cellular network (in cities)	Higher costs compared to all options discussed above
Smart plug that can be remotely turned off/on	Wi-Fi network (or cellular network)	Switch on/off the power to the device + report back the status of the plug (bi-directional communication)	Can enable auto DR capabilities in existing stock of appliances; reports back if bypassed/overridden; compensation to consumers can be based on actual participation;	Higher costs; can be easily bypassed

Table 2 Auto DR technology options

evening peak periods, with consumer's consent, AC temperature set points could be automatically changed, resulting in load changes (including peak load reduction) without major discomfort to consumers.¹ Alternatively, the AC can be switched off remotely for a certain interval, or instructed to reduce load by a set percentage. ACs can be equipped to automatically respond to remote signals to alter their demand (Bode 2013).

If most room ACs sold in India starting in 2016 had this capability, by the end of 2020, about 20 million ACs with a connected load of 30 GW (1.5kW of connected load on average for a Room AC) and peak load contribution of more than 20 GW (assuming 70% of ACs are on during peak load), would have the potential to reduce 8 GW of demand if signaled to reduce their loads by 30% (for example by increasing their temperature set point by a few degrees). Realistically, actual load reduction would likely be on the order of 10-15% (i.e. ~3GW) similar to recent findings in the US. (EPRI, 2009). Actual load reduction that could be achieved will depend on the level of consumer participation in demand response programs.

Various auto DR communication technology options are shown in Table 2, above. The simplest and the least expensive technology for automated DR is radio signal based automated load control technology which has been used for more than two decades for automated DR.² However, this technology is unidirectional (i.e. one-way) and cannot report back any status from the device it controls which makes it easier to bypass particularly on smaller units with easily accessible electronics and also making it difficult for the utilities to know if the device has received the signal and can respond.

Wi-Fi or cellular Internet Protocol (IP) based technologies allow bidirectional or two-way communication between the device and the utility, including exchange of various parameters related to the status of the ACs and other information that can be reported back. For example, if the signal was used to remotely change the temperature setting on a room AC, whether and when that temperature setting was changed again can be reported back. Such bidirectional systems are likely to provide the most reliable information on DR program compliance, but can have higher costs. Providers of DR programs need to assess the trade-off between reliability of DR participation and cost of equipment and evaluation, monitoring and verification when designing

¹ See example of set point adjustment- http://www.herterenergy.com/pdfs/Publications/2013_Herter-SMUD_ResSummerSolutions2011-2012.pdf

² See <http://repository.tamu.edu/bitstream/handle/1969.1/6651/ESL-HH-94-05-31.pdf> for summary of the experience of the direct load control programs in the US

financial compensation schemes. A specification for a DR-ready appliance ought to allow these various types of auto DR technology solutions to be deployed in order for the market and DR-program developers to have the flexibility to implement the appropriate kind of DR technology.

DRAFT IEC TC59 WG15 SPECIFICATION

The current specification being drafted by the IEC TC59 WG 15 defines a "Customer Energy Manager" (CEM) as "a component or set of functions which has the capability to receive and process Grid Information, Appliance Information and User Instructions and which manages one or more Smart Devices". The CEM could be analogous to the radio, frequency, Wi-Fi or cellular controlled chips shown in Table 2. The current draft specification requires the CEM to:

- be able to receive and pass on Grid Information to at least one device,
- be able to receive Appliance Information(e.g. its state or energy consumption level etc.)
- be able to transmit information to the grid (i.e. bi-directional communications).
- be able to receive/pass or act on emergency and other types of load control signals
- be able to be programmed with preferences (by user, remote agent or both) and act on them.

CONCLUSIONS

There is a significant potential for future peak load reduction (~3-8GW) by implementing demand response programs for ACs. In addition DR can also provide benefits in integrating intermittent renewable energy. However, implementation of DR programs will require ACs with some sort of "DR-ready" or "smart" functionality. The IEC TC59 WG15 specification framework for "smart" or "Demand-response ready" appliances is still in draft stage and being developed further. However, Indian stakeholders including manufacturers, utilities, and government agencies such as the Bureau of Indian Standards (BIS) and the Bureau of Energy Efficiency (BEE) could participate actively in its development, and ensure that the requirements of the Indian consumer, electricity grid and manufacturers are considered in its development, for example by ensuring:

- bi-directional or two-way communication
- ability to deploy technologies with low latency (or fast response time) e.g. Wi-Fi or cellular and
- ability to deploy auto Demand Response
- flexibility in order to implement cost-effective solutions.

Involvement in the international development of the standards for DR and price communications and also possible adoption of such a specification for smart appliances in India may be increasingly necessary in order to manage the increasing peak load due to increasing demand for space cooling and increasing penetration of intermittent renewable energy resources on the Indian grid.

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