Peak Electric Load and Related Damages Reduction with the Use of Cooling Ceramics

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Abstract – Power outages values are estimated to be between 100 to 150 costly more than the value of electrical energy and; the lack of electricity for industrial, commercial and even household customers has various political, security as well as social consequences. The shortage of hydroelectric power and the financial resources to build new power plants caused the summer black-out of the year 1397. The Department of Energy's set of conditions and warnings about the likelihood of escalation in the summer of 98 have drawn serious attention to the consumption pattern correction approach to reduce peak load. Since about 40% of peak load is used for cool buildings, any modification of the cooling pattern will play a decisive role in reducing the peak load. This paper presents a personal contact cooling method (PCCM) using cool, very low cost, one-hundredths of the cost of the practical capacity of the power plant in Peak- bar, without the need for electricity and with very low water consumption. This approach is simple and can be expressed as follows. First humidifies the bricks. These produces fresh and cool air which can by touch /feel externally, be transferred to the cooling of the blood flow and cooling the body internally, and given the evolving experiences, it can provide a significant portion of the cooling need. The use of cool ceramic can reduce production capacity by 1-4 GW by maintaining thermal comfort. In the absence of electricity, this amount of reductions reduces about 160 billion riyals of blackout per gigawatt. In the paper's proposed option for the release of one GW (1000 MW) of plant's operational capacity at Peak-bar, the value of the released capacity is approximately 100,000 billion rails. It is also possible to provide people with a part of the cooling power during a power outage.

Keywords: air cooling, personal cooling, cooling ceramic, blackout damage, consumption reduction of electrical energy.

I. Introduction

Since most Imbalances in production and consumption of electricity and lack of sufficient energy reserves in Iran's electricity generation capacity, altogether, have been one of the major causes of Iran's power blackout in 1387. After extensive shutdowns in 1387, roughly about ten years, planning for load-shedding allocation (load shutting down) has been regained operators' attention and become a serious option on the table for the incoming year. Part of the problem is resulted from shortage of the hydroelectric power and believing that it is not capable of compensating for increasing demand, on its own. The reason turns back to the shortage of hydroelectric power and the gradual discontinuation of power generation at peak hours. From another point of view, the problem beforehand is directly related to the growth of demand for cheap electricity by as much as 5% to 6%, which causes investors' reluctance to finance in electricity generation; this, in turn, is probably due to the on-time payment for the investors 'costs.

Load shedding does not come without costs. It causes damages to consumers' appliances, social dissatisfaction, and even security issues; thus, it needs to be analyzed and responded very quickly. At this moment, it is worth to mention that resolving the issue by means of more power station generation, besides being time consuming, is very costly, too [1-2].

Out of the whole electricity consumption in the world, portion dedicated to cooling appliances has been grown; as an example, in United Arab Emirates (UME), it reaches 40-60% of residential and offices' electricity consumption [3]. As a rule of thumb, most of the people spent most of their times in indoor environments. Thus, due to such parameters as civilization expansion, urban heat island, life standards

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improvement and population growth, demand for indoor cooling systems are experiencing an evolution. Accordingly, most of the shut-downs happen during summers.

In the studies of energy optimization in the buildings, Personal Cooling Device (PCD) are introduced as effective approaches. The PCDs, compared to air cooling devices, consume less or even zero power at some certain conditions, while keep the thermal comfort at an acceptable level. In PCD, cooling given parts of human bodies replaces the cooling total space of the buildings. Using PCDs as a complement of air conditioning devices provides the ability to adjust their performance more efficient. To be more practical, lowering the adjustment temperature one degree can reduce the energy up to 10 percent [4, 5].

Keeping in mind that PCDs are to be used as complementary to the air conditioning, lowering the cooling loads provide saving of electrical energy. In this paper, a PCD based on ceramic touching is introduced, its impact on the electrical energy consumption as well as load shedding damages are assessed. In section 2, a review on the past literatures of the PSD and its pros and cons in the context of energy saving are presented. Section 3 illustrates the ceramic touching method followed by its advantages over other methods and section, evaluation of the impact of ceramic touching cooling on energy saving and prevention from load shedding damages are demonstrated.

II. Literature review

Most studies on PCD have been done in warm weather conditions. The common strategy in the contexts and related studies have been adjustment of air conditioning devices' temperature. Using PCDs and corresponding cooling system's temperature adjustment, a saving between 4 to 50 percent of energy have been shown to be achievable [6 -8].

In [9], impact of personal fans on the energy consumption has been studied. The results showed that fans with more than 60 Watt consumption cannot provide energy saving. However, it also concluded that fans with lower energy consumption are capable of significant energy reserve. The efficiency of various fans such as, desktop fans, standing fans and ceiling fans have been compared in [10]. Using their adopted indices, desktop fans are three times more efficient than ceiling fans. In [11], effect of low power personal cooling devices on reduction of energy spare, with the aim of changing their temperature adjustments are elaborated on for a few cities of USA. Fig. 1 illustrates the outcomes of this researches graphically for different temperature adjustments.

In [12], researchers designed a type of seat in which, using the appropriate thermoelectric tools on the sitting location, cooling/warming process is done. Using their design, they were able to provide users with thermal comfort in the range of 16 to 29 centigrade.

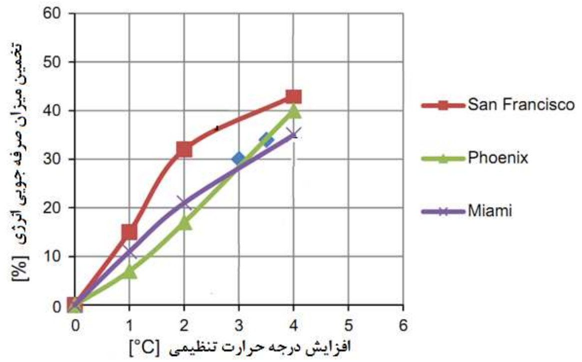

Fig. 1: impacts of personal cooling devices on the reduction of energy consumption

Authors of [13-15] have shown that thermal stimulation of hand and wrist in an undesired conditions has substantial effect of the whole body comfort. Therefore, providing these parts with desired temperature and thus body with relief, the range of the cooling systems temperature can be readjusted for lower power consumption. In [16], warming up hand and cooling down hand and wrist have been introduced as the second effective tools, respectively after feet and face and head, in order to bring the threshold temperature of air conditioning devices to lower and higher temperatures. The authors in [17] presented a method a cooling method based on placement of palm and wrist on an aluminous surface with a high thermal conductivity in order to absorb heat of the hands. The already mentioned studies demonstrate justifications for efficiency of hand and wrist cooling devices for to provision for personal comfort in one hand, and a solution for reduction of the energy consumptions of air conditioning devices through temperature readjustments.

III. Cooling ceramics

The air conditioning instruments are not the only reliable option to bring building internals into the desired temperatures. Even before emersion of mechanical cooling methods, creative usage of resources and tools has been in place for cooling purposes, eventually adapting buildings' structure and life style to take out the most effectiveness [18]. Contact based approaches using surface materials and structures such as, brick paved floor, thatch walls, wind-catchers and underground channels are a few traditional methods among many more. We propose to benefit from the idea, e.g., brick paved floor and pots made of cooled ceramics (fig. 2), as an important means to efficient usage of electricity.

In order to understand the notion, referring to the human body, we note that the blood flows wherever they come close to the surface, i.e., skins, are locations to exchange heat between body and environment. Fig. 3 illustrates the spots more suitable for heat exchanges.

Fig. 2: cooling ceramic

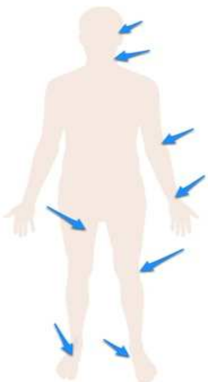

Fig. 3: surfaces blood vessels spotted for cooling of the body

In addition to the spotted points in fig. 3, the palms of hands and feet, as they contain large passage of large blood vessels, are convenient for cooling. As these points become cool, thermal transition occurs due to passing blood to other parts of the body; thus, cooling the whole body eventually. Since this kind of cooling is started internally not by the skin or the clothes, it is more efficient method than the counterparts. In the other words, cooling the blood vessels passing close to body surface continually, the body can endure constantly its desired temperature. Therefore, the location based cooling through PCDs are attractive in practice.

The cool ceramics lower the body temperature by contacts to its key points such as hands feet palms. A porous ceramic can absorb water by touching points of human body, and in turn, the evaporated water would transfer the body's heats into the surrounding air. This method of cooling does not depend on electricity consumption, which beside its negligible initial cost as well as water, can provision for parts of the cooling and thus, newly attractive in reduction of water and energy. In order to take the most out of the cooled ceramics, it must initially be moist and preferably saturated with water. The porous structure of ceramics create distances between the water molecules which leads to the easier and faster evaporation. This desertion of the water makes the ceramics cooler. Fig. 4 illustrates two examples of PCD, one beneath the feet and the other as a mouse pad.

Fig. 4: samples of PCDs made of cooled ceramic

Contact based PCDs embraces two advantages as opposed to the air condition devices. First, it uses the moist, which is 26 times more capable of air thermal transition capability, and second, internal cooling instead of using the air condition tools; moreover, in the proposed method, cooling is more eventual and thus more efficient.

Fig. 5 shows the tomography of hand when it is placed on a cooling ceramic. In this figure, points with lighter and darker colors, accordingly, imply higher and lower temperature. We observe that the ceramic pad is cooler at points when it is had not been in touch with hand, hand has higher temperature and locations on pad where hand has already touched in of a temperature between the two. This is an example of how the PCDs work, i.e., the local cooling is done based on the continuous circulation of the blood in vessels.

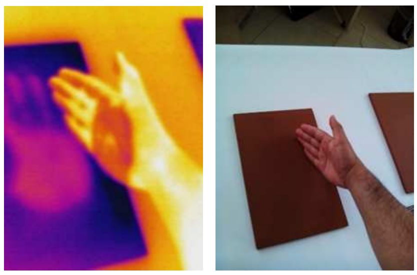

Fig. 5: The tomography of cooling the body with PCD

Table I lists advantages of cooling ceramic. Because of the desired characteristics, PCDs can be used in official centers, schools, universities, libraries, and houses, specifically by those who experience overheating due to illnesses such as diabetes, MS, and anxiety and depressions. Since they have been desired and of low cost, social acceptance of PCDs have under analysis in order to provide us with an illustration of relative desirability of the pilot instances, beside of the targeted communities in solar research center of regional electric utility of Yazd.

Table I: advantages of PCD or cooling ceramics

Title	description
Personal cooling	Cooling pattern amendment (changing from air conditioning to direct cooling of the body Individuals can make decision on using or not of the PCDs and for how long time Small, planar surface and portable
Cooling without electricity usage	Possible usage when electrical energy is not available Lowering the electrical energy consumptions of water and gas coolers. Small, planar surface and
Cooling with minimal usage of water	Reduction of water coolers electricity consumptions with less need to evaporate water on the roofs Surface cooling with less than a glass of water
Hygienic advantages	Reduction of dust and other air pollutions by decreasing the need for air circulations Resistive and/or inconvenient space for growth of bacteria and fungus (like mushrooms) Non-tactical properties
Other advantages	Negligible cost Durable and natural Joys of touching the wet soil

The main section of body cooling is by straight incident of emissive heat on the cooler surfaces. In couples of last decades, people used to spay water on the walls, which were combined of straw and dried mud; thus heat of the body could emit out of the body and absorb by the walls. Using biscuit ceramics, the same capability can be in place and benefited from by low cost, while the cooling uses only a small amount of water and the method is natural with higher social acceptance.

The cooling ceramics, as a PCD, can provide local cooling instead circulating the whole embedded air; thus, in the presence of cooler dried ceramics, air conditioning using electrical cooler is less needed which in turn, lower peak demand and supply blackout.

IV. Economic advantages of cooled ceramics from the view of electric industries, and adoption in the distribution networks and monetary justifications

Among the energy carriers, electrical networks are of outstanding place. In the nowadays, electricity is a necessary without which, modern industries stop productions and citizens lose feeling comfort. In brief, the damages due the electricity unavailability are nontrivial which goes beyond predictions. In this case, there would be no room for the electricity market [19]. Even though, as a rule of thumb, for any blackout, damage between 100 and 150 times of electricity production costs are anticipated. Considering the total cost of production of every KWh electricity be 110 tomans, any loss of the same amount of the electricity leads to 16 thousands tomans damages posed on the related economies [20].

Cool ceramic can help to reduce the peaks of electricity load demand when used as a complement to the cooling air conditioners. For the peaks of load demand, this reduction means lower load shedding or blackout for other consumers. In order to evaluate its economic impact, the goal is set to be potential to the network's capacity release. As to the peaks load of the beginning of the summer of 2019 when the cooling devices consumed 20 GW out of the whole network capacity [21], impact of readjustment and correction of the temperature, as measured for three reduction points from 5 to 20 percent, led to reduction of demand, depending on the environmental factors, offices controllability and personnel desires.

Table II: efficiency of cool ceramic on the reduction of electricity demand and related damages

Effect of cool ceramic on reduction of electricity demand for cooling purposes (%)	Reduction of electricity demand on the peak hours (GW)	Damages due to lack of electricity for peak hours and per an hour (1e9 Rials)
5	1	160
10	2	380
20	4	760

As the first step, we have targeted 5 % of the cooling electricity devices, equivalent to 1000 MW. This is comparable to the predicted potential of demand management for 98 % of electricity consumption in peak hours using the tariff corrections (1500 MW). In addition to demand reduction, the cool ceramic provide customers with comfort. The price exposed for the usage is so low that free of charge distribution of cool ceramic among the households is economically justifiable. In comparison to a 1000 MW power station for the peak hours (1e9 $ or 1e14 Rials), economically, it is profitable to distribute each ceramic with the expense of 2e4 Rials. Now, assuming 50 million ceramic distribution free of charge to the households, in order to at least 5 % cooperation, either compulsory or not (through the remote adjustment of air conditioning devices of departments and offices), as a whole, we have freed 1 % of the capacity monetary value. Referring to table II, each 1e12 Rials of ceramic expenses is roughly equal to the 6 hours power blackout in the network.

As a proposal for economic and effective distribution of cool ceramics, in the following, we have targeted 5 % in the reduction of power demand. As to the logarithmic distances of cost of the power generation, other measures will scale accordingly.

Assuming penetration level of 25% (1 out of each four ceramic is being used) and further supposing the need for 20% of electricity consumption for cooling (including gas or water cooler to be provisioning for 80% of the total cooling power demand), in total, 5% of the target community, equivalent to 1000MW will be saved.

Moreover, if we consider mass production of ceramic with 2e4 Rials per each and a target society of 5e7 people, (where we suppose that parts of the society do not contribute in cooling power demand depending on age, regional temperature, distribution, type of occupation, among others) and furthermore do not take the possible blackout damage cost as well as transmission and distribution of energy, just investment cost in the production section of the ceramics as compared to the cost of actual power capacity of the same value in the conventional power generation station is 100 times lower approximately.

In order to make use of the above mentioned potential, there are lists of potential actions and needs to be met in order to promote using cooling ceramic instead of fossil fuel. These are, but not limited to, informing people by the electric and water industries due to their correlated challenges (usually they occur at the same times), costs versus benefits, different as well as promotional tariffs, illustration of the results of their action on the society and etc. Besides, similar measures must be taken from the regulatory side to encourage investments on the clean energies such as cooling ceramics.

V. Conclusion

Lack of providing electrical energy, as a prerequisite to the nowadays life, has cost for customers. Since 40% of total electricity in the peak hours is due to the cooling purposes, Personal Cooling Devices (PCD) are a new perspective for air conditioning from the customer side.

In this paper, cooling ceramic was introduced as a PCD which provides customers with comfort without consumption of electricity and little intake of water. Through contacting the cooling ceramics by hands or feet, the body can be cooled from the inside and using the blood circulation. Therefore, usage of cooling ceramics can lower the need to electricity for air conditioning and thus smoothing the peak hour demand. To be more accurate, a potential of 5-20% reduction of energy consumption due to usage of PCDs, a production capacity as large as 1-4 GW would be freed. Economically speaking, this is equal to one billion $ saving of investment in power station construction, and 16 billion Rials due to the reduction of power blackout and related damages. These are a brief of monetary costs, while only 1 % of these costs suffices to solve the peak hours' problem using the cooling ceramics.

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