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RESEARCH ARTICLE

CARBON FOOTPRINT REDUCTION IN A MULTI-SPECIALTY HOSPITAL – A CASE STUDY

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ABSTRACT

Man's various activities have resulted in increase in greenhouse gas emissions which is causing global warming and climate change. In order to keep this earth fit for our future generations to survive there is a dire need to reduce our carbon footprint. The carbon footprint is a measure of the total amount of carbon dioxide (CO_2) and methane (CH_4) (primarily) emissions of a defined population system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest. Carbon footprint is used as an environmental indicator to understand and quantify the main emission sources and it constitutes as an effective tool for energy and environment management. Energy intensive multi-specialty hospitals can also reduce their carbon footprint to a great extent by introducing certain measures in areas of HVAC, lighting etc. Fortis Hospital – a multi specialty hospital in Kolkata has taken significant steps in reducing carbon footprint without compromising quality health-care service to patients. Fortis Hospital has done so by reducing consumption of energy for HVAC and lighting. Introduction of vegetarian food and green travel are other carbon footprint reduction measures of Fortis.

INTRODUCTION

Increase in greenhouse gas emission resulted in global warming and subsequent climate change which in turn is threatening the very existence of human being. The call of the day for survival is by reducing the carbon footprint. Carbon footprint is a measure of the total amount of carbon dioxide (CO_2) and methane (CH_4) (primarily) emissions of a defined population (where carbon dioxide itself only accounts for more than 80%) , system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest. It is calculated as carbon dioxide equivalent (CO_2e) using the relevant 100-year global warming potential. Carbon footprint is used as an environmental indicator to understand and quantify the main emission sources and it constitutes as an effective tool for energy and environment management. The concept name of the carbon footprint originates from ecological footprint, discussion, which was developed by Rees and Wackernagel in the 1990s which estimates the number of "earths" that would theoretically be required if everyone on the planet consumed resources at the same level as the person calculating their ecological footprint. However, carbon footprints are much more specific than ecological footprints since they measure direct emissions of gasses that cause climate change into the atmosphere. Carbon footprint is mainly influenced by population, economic output, energy and carbon intensity of the economy. So in order to decrease the carbon footprint these factors should be regulated. The Planning Commission of the Government of India advocates in the12th Five-Year Plan of the country for low carbon growth. The proposed actions will reduce India's emission intensity from 20% to 25% by 2020 with respect to the emissions in 2005.This includes policy interventions to reduce emission intensity through fuel-efficiency standards, green building codes and energy efficiency certificates. This also necessitates decentralized mitigation strategies to minimize carbon emissions which require sector wise and region wise inventory of green house gas emissions. Hospitals are the main pillars of health care industry in India. Till early 1980s Government and charitable orgnisations run hospitals are the options available for health care facilities. Later on the scenario changed and private players started setting up hospitals and nursing homes. According to a World Health Organization study (2009), currently India has approximately 860 beds per million, which is only one fifth of the world average of 3960. Gradually big cities in India witnessed mushrooming of super-specialty hospitals. In one hand these super-specialty hospitals opened up more options for treatment using modern equipments and technologies whereas on the other hand these establishments consume a lot of energy and have substantial carbon footprint. Most of the modern hospitals consume ten to fifteen times more energy per bed as compared to a typical government

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hospital and this trend is going to strain India's power sector in the near future. Unreliable power supply has in fact forced many hospitals to depend heavily on diesel power to keep hospital's critical facilities running. Hospitals are under mounting pressure to create an environment that fosters quality care and ensures safety – all the while controlling costs. Meanwhile, profit margins in healthcare have been eroding and will continue to do so, unless hospital administrators take new action, particularly in the area of energy efficiency. There is a growing need for Indian hospitals to make a more conscious effort to minimise their carbon footprint through different measures. So good energy management structure and carbon footprint reduction efforts can bring in not only an energy efficient culture within the hospital but also provide substantial reduction in overall expenses without compromising on the quality of health care facilities to the patients.

Background

Fortis Healthcare Limited is an established chain of super-speciality hospitals with its presence in India, Sri Lanka, UAE, Mauritius and Singapore. In India it is located in Delhi, Amritsar, Kolkata, Navi Mumbai, Hyderabad, Mohali, Jaipur, Chennai, Kota, Bengaluru, and Gurgaon. In Kolkata it has two establishments one 50 bed unit in Gariahat and the other 150-bed unit in Anadapur.

MATERIALS AND METHODS

The study is of exploratory in nature and an attempt to analyse the carbon reduction measures in Fortis Hospital. Primary data is collected from hospital records and compared with national standards, which are obtained from secondary source. The different areas that are considered for the study are HVAC, lighting, catering and fooding and transport.

RESULTS AND DISCUSSION

Indian Hospital Scenario

Healthcare sector in India is facing the heat of spiraling cost of energy which is a big challenge to manage the facility within the limits of operating budget. This is mostly because hospitals need to meet the energy demand for 24X7 availability, medical equipments and clean-room facilities (special requirements for clean air and disease control). According to the study of CII main energy guzzlers in a hospital are Heating, Ventilation and Air Conditioning (HVAC), medical equipments and lighting. The percentage break-up of power consumption in Indian context for the three are as follows.

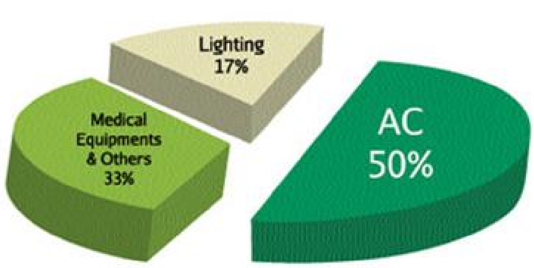

Figure 1. Main Contributors of Energy Consumption in Hospitals
Source: CII

According to the 11th five year Plan, despite a steady increase in public health care infrastructure, utilization of public health facilities by population for outpatient and inpatient care has not improved. The National Sample Survey Office (1986–2004) data shows a major decline in utilization of the public health facilities for inpatient care and a corresponding increase in utilization of the same from private health care providers in both rural and urban areas. Current figures are not available on number of private and NGO hospitals but in 2002 the country had 11,345 private/NGO hospitals (allopathic) mostly located in cities and towns with a capacity of 262,256 beds. The table below (Table.1) provides the number of private hospitals and nursing homes in various states which does not however give the complete information for the country.

Table 1. Number of Private Hospitals and Nursing Homes (Partial List)

S. No.	State	Hospitals	Nursing Home	Total
1	Andhra Pradesh	178 (inc. Nursing Homes)		178
2	Assam	9	5	14
3	Bihar	6	2	8
4	Chandigarh	18	4	22
5	Chattisgarh	10	1	11
6	Daman & Diu	3	0	3
7	Delhi	147	25	172
8	Goa	8	3	11
9	Gujarat	477	46	523
10	Haryana	110	27	137
11	Himachal Pradesh	2	0	2
12	Jammu & Kashmir	3	1	4
13	Jharkhand	6	1	7
14	Karnataka	110	12	122
15	Kerala	124	4	128
16	Madhya Pradesh	95	20	115
17	Maharashtra	794	269	1063
18	Manipur	1	0	1
19	Meghalaya	2	0	2
20	Mizoram	1	0	1
21	Nagaland	1	0	1
22	Orissa	11	8	19
23	Pondicherry	7	1	8
24	Punjab	49	4	53
25	Rajasthan	82	5	87
26	Tamilnadu	187	29	216
27	Tripura	1	0	1
28	Uttar Pradesh	134	22	156
29	Uttarakhand	14	3	17
30	West Bengal	80	66	146
	Total			3228

Source: Doctors Online (www.hindustanlinks.com)

Electric consumption in different types of hospitals are as shown in the table below.

From the table it is very much evident that the energy consumption per bed per annum for private hospitals is enormously higher than any other types. Commercial sector, which includes offices, hotels, hospitals, retail establishments etc. has been growing at a fast pace. Present power system is already inadequate to meet the existing demand. There are both peak demand and electricity shortages. Government of India has made a socially desirable plan for making power available to all. Thus, one of the key ways for managing current shortage and the future need of power are efficiency enhancement and conservation of energy resources. Due to the current situation of the commercial sector, it becomes even more important for this sector as a whole to put together greater effort in energy conservation.

Table 2. Estimated Electricity Consumption in different types of Hospitals in India (2009)

Hospitals	No. of Hospitals	No. of Beds	Estimated kWh/Bed/year	Assumed Electricity Cost per kWh	Estimated Electricity Consumption (Million kWh)	Estimated Electricity Cost (Rs. Millions)
Government Hospitals - Urban	3,115 *	369,351 *	1000-2000	Rs. 5	369-739	1845-3695
Government Hospital - Rural	6,281 *	143,069 *	200-400	Rs. 4	29-57	116-228
Private/(Multi Space/NGO) Hospitals	22,000 **	160,000 **	8000-25000	Rs. 6	1280-4000	7,680-24,000
Private Nursing Homes		400,000 **	3000-5000	Rs. 6	1200-2000	7200-12000
Total	31,150	10,72,420			2,878-6,796	16,841-39,922

Source: USAID ECO-III Project, 2010

Energy usage in Hospitals

Hospitals usually function 24 hours per day, all year round. They usually consist of large buildings, and careful control of their internal climate is considered necessary. Substantial amount of heat is normally generated internally by the occupants and operating equipment. An effective cooling (and heating depending upon the external weather conditions.) and ventilation systems combined with good insulation of hospital building, usually reduce hospital's sensitivity to the outside weather. Hospitals also require standby electricity generators to ensure a continuous supply of power in emergencies and critical operations. When considering energy-efficiency in hospitals, it is important to keep in mind that it is not the end-use of energy alone, but also the need to control the indoor climate, that is one of the principal requirements. The indoor climatic requirements are determined by the hospital activities in the building. Once these are established, it is necessary to provide the required climate, ideally in the most economical way. In hospitals, energy brought in, is converted by a number of conversion systems into several internal energy streams to meet heating, cooling and other medical equipment requirements, ('Power Quality Utilization Guide on Hospitals, Leonardo Energy, 2008) and there are energy saving opportunities in all the energy streams categorized as under:

• Electricity is used for a wide variety of purposes. Major electricity consumers in a hospital are cooling/heating equipment, lighting, air compressors, water pumps, fans and ventilation. Other applications include laundry equipment; kitchen and canteen equipment; ovens and geysers and medical equipment including autoclaves, office facilities such as computers and photocopiers, utilities such as lifts, refrigerators, water coolers, etc.

• Heat Stream is used in the form of steam and hot water. Steam is used in the kitchens and for humidification in HVAC and sterilization process. In addition steam is used to transport heat over longer distances. In many cases heat is transported from the heat generating station in the form of steam and then converted locally into central heating or hot tap water. Oil/Gas-fired boilers are used to generate steam and hot water.

• Compressed air can be divided into two main categories, namely medical air and technical air. Medical compressed air refers to the direct treatment and care of patients. Examples include breathing apparatus and surgical tools driven by the compressed air. The medical compressed air is subjected to very high standards for availability and quality. The technical compressed air is used for HVAC control systems, workshop applications or keeping containers under pressure.

• Cold Stream mainly takes the form of chilled water and is used for in-door climate control systems, for cooling and drying the ventilation air. In many cases cold stream is generated centrally by means of compression coolers. In combination with cogeneration, absorption-cooling machines are used to supplement compression coolers.

Energy usage reduction measures in Fortis Hospital

The following measures are undertaken in Fortis which makes a significant drop in energy usage.

HVAC system

Bodily comfort depends on the activity. Accordingly, the air-conditioning system must also be adjusted to ensure proper comfort. The following table shows the requirement for comfort at different sections of a hospital and its corresponding readings at Fortis.

Table 3. Recommended Temperatures and Relative Humidity for Specific Areas in Hospitals

RoomType	Temperature (^{O}C)	Relative Humidity
Operation Theatres	17-27	45-55%
Recovery Rooms	24-26	45-55%
Patients Rooms	24-26	45-55%

Source: National Building Code of India (2005)

Table 4. Temperatures and Relative Humidity for Specific areas in Fortis

RoomType	Temperature (^{O}C)	Relative Humidity
Operation Theatres	18-25	45-55%
Recovery Rooms	24-26	45-55%
Patients Rooms	24-26	45-55%

Heat load at a place is dependent on various factors. Some of the important factors are number of occupants, activities of the occupants, equipments present in the area and location. Based on the heat load the area's air-conditioning needs are ascertained properly. For effective use of the conditioned air zoning is very important. In hospitals different zones have different temperature requirements. This is problematic where only one overall heating or cooling control system exists. This has been taken care in Fortis by dividing the area into zones with separate controls for cooling/heating. The extra control results in increased comfort for patients and staff, and saves money as well. Cooling the air consumes substantial energy, so in order to minimize energy usage it is imperative to retain the conditioned air to an extent as long as it meets the standard of proper air quality for clean-rooms. Two sets of doors with

Table 5. General Comfort Conditions as per NBC 2005 and ASHRAE Handbook 2007 HVAC

Function Space	Minimum Total Air Changes per Hour
National Building Code 2005	
Sterilization	15-25
Wards	6-8
ASHARE HANDBOOK 2007 HVAC APPLICATION	
Operating Room (all outdoor air system)	20
Operating Room (re-circulating air system)	20
Delivery room (all outdoor air system)	20
Delivery room (re-circulating air system)	20
Recovery room	6
Nursery suite	12
Trauma room	12
Anesthesia storage	8
Nursing	
Patient room	6
Toilet room	10
Intensive care	6
Protective isolation	12
Infectious isolation	12
Isolation alcove or anteroom	10
Labor/Delivery/Recovery/postpartum	6
Patient Corridor	4
Ancillary	
Radiology X-ray (Surgical and Critical Care)	15
Radiology X-ray (Diagnostic and Treatment)	6
Radiology Darkroom	10
Laboratory general	6
Laboratory bacteriology	6
Laboratory biochemistry	6
Laboratory cytology	6
Laboratory glass washing	10
Laboratory histology	6
Laboratory nuclear medicine	6
Laboratory pathology	6
Laboratory serology	6
Laboratory sterilizing	10
Laboratory media transfer	4
Autopsy	12
Non-refrigerated body-holding room	10
Pharmacy	4
Administration	
Admitting and Waiting Rooms	6
Diagnostic and Treatment	
Bronchoscopy, sputum collection, and pentamidine admin	12
Examination room	6
Medication room	4
Physical therapy and hydrotherapy	6
Soiled workroom or soiled holding	10
Clean workroom or clean holding	4
Sterilizing and Supply	
Sterilizer equipment room	10
Soiled or decontamination room	6
Clean workroom and sterile storage	4
Equipment storage	4
Service	
Food preparation center	10
Laundry general	10

The actual air changes per hour in Fortis Hospital is as follows. It is evident that air changes are not compromised in order to reduce energy consumption.

automatic controls are installed at the entrance of the hospital to check the unwanted leakage of the conditioned air through the doors. The doors are sufficiently spaced such that when one door is opened the other set of door is closed automatically thereby stopping the conditioned air leakage considerably. Proper ventilation is of paramount importance in hospitals. Ventilation is required not just to combat heat gains from lighting, staff, patients and specialist equipment but, more importantly, to provide high air change rates in operating theatres and on the wards to help eliminate airborne bacteria.

National Building Code (National Building Code, 2005) and ASHARE 2007 recommends the air changes, given in Table 5. ‘Mixed mode’ system, which uses a combination of both natural and mechanical systems is used in Fortis Hospital. The building uses natural ventilation, heating and cooling where possible, with mechanical systems being used only when needed. There are various advantages apart from energy savings to such a system:

Table 6. Actual Air Changes at different Function Spaces in Fortis Hospital

Function Space	Total Air Changes per Hour
Sterilization	20-25
Wards	8-10
Operating Room (all outdoor air system)	25
Operating Room (re-circulating air system)	25
Delivery room (all outdoor air system)	25
Delivery room (re-circulating air system)	25
Recovery room	10
Nursery suite	20
Trauma room	18
Anesthesia storage	10
Nursing	
Patient room	25
Toilet room	10
Intensive care	25
Protective isolation	15
Infectious isolation	15
Isolation alcove or anteroom	10
Labor/Delivery/Recovery/postpartum	10
Patient Corridor	15
Administration	
Admitting and Waiting Rooms	10
Diagnostic and Treatment	
Bronchoscopy, sputum collection, and pentamidine admin	20
Examination room	10
Medication room	10
Treatment room	10
Ancillary	
Radiology X-ray (Surgical and Critical Care)	20
Radiology X-ray (Diagnostic and Treatment)	10
Radiology Darkroom	10
Laboratory general	10
Laboratory bacteriology	10
Laboratory biochemistry	10
Laboratory cytology	10
Laboratory glass washing	10
Laboratory histology	10
Laboratory nuclear medicine	10
Laboratory pathology	10
Laboratory serology	10
Laboratory sterilizing	10
Laboratory media transfer	5
Autopsy	20
Non-refrigerated body-holding room	15
Pharmacy	5
Administration	
Admitting and Waiting Rooms	10
Diagnostic and Treatment	
Bronchoscopy, sputum collection, and pentamidine admin	20
Examination room	10
Medication room	10
Treatment room	10

- The building becomes more adaptable to a wide range of requirements
- The occupants have more control over their environment

Stringent indoor air quality (IAQ) levels is maintained, especially in operating rooms (OR), emergency rooms (ER), intensive care units (ICU), and laboratories. Certain types of rooms have special HVAC pressurization requirements. ORs, ERs, and ICUs, generally run over-pressure for protective isolation from airborne infection. Quarantine rooms require negative pressure (and UV lights) for infectious isolation and the control of diseases. All these synchronizations with pressure requirements are done utmost perfection along with indoor air quality. To meet such requirements of Clean-room systems High Efficiency Particulate Air (HEPA) filtration is required to prevent the spread of disease (also known as nosocomial infection) in the ventilation system. HEPA filters that achieve 99.7% efficiency place greater electric demand on fans for proper air circulation. In Fortis Hospital in order to minimize energy consumption of HEPA filters cascade systems is used where conditioned air from the cleanest space (packing) flows to neutral then to dirty areas. Apart from this for ventilation purpose variable speed drives are used for fans in order to regulate fan speed as per requirements based on time and location. This reduction in speed saves considerable amount of energy. The following table shows the average KWh per bed per year in a multi-specialty hospital on account of HVAC and the same for Fortis Hospital.

Lighting

Lighting is a major electricity consumer next only to HVAC systems. Requirement of lights in a hospital varies widely depending upon the activity, time of day and the occupancy level. The complexity can be well understood from the simple fact that National Building Code (NBC) 2005 recommends illuminance level varying from one lux for night lighting in some areas to 750 lux in operation theaters for general requirements. At times special lights are used with illuminance of 10,000- 50,000 lux in operation theaters. In Fortis Hospital there is a mixed use of LED and CFL lighting. By incorporating LEDs lighting energy cost has been significantly reduced. LEDs have a significantly lesser operational and maintenance cost than other lighting solutions. First of all LED saves tremendously on electricity bills. Secondly, the maintenance costs are negligible as compared to incandescent and CFLs, hence the cost of getting it replaced over and over again is saved. Therefore, over the long lifespan of the LEDs these all costs are saved, this makes LED a true value for money product.

Table 7. Comparative power consumption

Average KWh consumption for HVAC per bed per year in a multi-specialty hospital	Average KWh consumption for HVAC per bed per year in Fortis Hospital
4000-12500	8000

The most important areas to use LED lighting is an MRI room and it is no exception in Fortis Hospital as well. Lighting in MRI suites is challenging as MRI facilities require non-ferrous lights. Though the tungsten filament of incandescent bulbs is non-ferrous in nature even minute impurities are affected by the high intensity magnetic field of an MRI facility. This results in frequent bulb replacements. The life of a standard incandescent bulb may be reduced to as low as 700 hours in an MRI suite. Fluorescent lights can't be used either because they generate noise artifacts on patient scans. Some imaging facilities experience weekly light outages, which shuts down the MRI suite for maintenance. However, LED lights are MRI safe because they do not use filaments that are affected by magnetic fields, nor do they emit radio frequencies. Additionally, by not having a filament, LED lighting eliminates the potential for white pixel noise, which can be generated when an incandescent bulb's filament is at the point of failure. Long maintenance free life of LEDs means fewer and shorter downtime period and hence helps in a better utilisation of the MRI facility. Apart from MRI rooms LED lighting is used in CT scan and ultra-sound rooms where dimming of light is required for better observation and patients' comfort. OT lighting has been particularly impacted by LEDs. LED bulbs and tubes deliver high quality light but do not generate high temperatures.

Removal of heat from surgical lights increases both patient and doctor comfort and reduces air conditioning requirements. In addition, body tissue can be seen in its natural colours, and there is no risk of drying of tissue. The lights therefore make the surgeons work easier and are safer for the patient. Another advantage is that instead of a single point light source light is produced by multiple points. This results in fewer shadows and allows the physician to comfortably examine the patient. LED lights are also used in hallways and corridors as well where lights are switched on 24X7. As the life span of LEDs are considerably high as compared to CFLs and poses fewer downtime periods. The heat load is also considerably reduced as LEDs generate less heat. The table below shows that 50% of energy cost is saved by using LEDs instead of CFLs.

Table 8. Power savings because of use of LED

No of LEDs	Equivalent no of CFLs	Savings
50	50	50%

Catering and Fooding

In Fortis Hospital catering service is outsourced and taken care by professional caterers. Efficient catering facilities can reduce the energy requirement considerably. Most of the equipments used in the catering facility are chosen which switches off automatically such as pan sensors on hobs. Study shows that using such equipments can reduce the energy consumption to the extent of 25% as compared to non-automated ones. Ovens used here are with large, double glazed viewing windows to reduce the need to open doors to inspect contents and thereby minimize the loss of heat. Large volumes of warm air are expelled from kitchens. In Fortis Hospital most of this heat is recovered using heat recovery devices which significantly reduce energy costs. An air-to water recovery device is used here for heat recovery which then preheats hot water. From the food consumption, carbon dioxide (CO_2) is the most important GHG followed by methane (CH_4) and nitrous oxide (N_2O) (Kramer et al., 1999). Fuel combustion activities are the main sources of CO_2 emission, whereas animal husbandry and rice cultivation are the main sources of CH_4 emission, and the emission of N_2O is mainly from turnover of nitrogen in soil, application of N fertilizer and industry. The table below shows ingedrients for one serving-portion of various food items commonly consumed in Indian household and the emission of the GHGs in various stages of life-cycle of food items.

A balanced diet required for an adult from different sources are as given in the following table along with global warming potential (GWP) of various vegetarian and non-vegetarian meals in India.

Comparison of GHG emission from five common meals showed that a non-vegetarian meal with mutton emitted highest amount of GHG, 1.8 times than the vegetarian meal, 1.5 times of a no vegetarian meal with chicken and an ovo-vegetarian meal and 1.4 times a lacto-vegetarian meal (Fig. 3). Mutton consumption causes more GHG emission compared to consumption of food grain and poultry products. A study from Spain and Sweden also showed that vegetarian meals were associated with less environmental impact than meals with animal protein (Sonesson et al., 2009). These data support in favour of vegetarians for reducing GHG emission. Food available in Fortis Hospital is strictly vegetarian. Therefore vegetarian food has considerably less carbon-footprint as compared to non-vegetarian diet.

Transport: In Fortis Hospital doctors and employees contribute significantly in reducing their individual carbon footprint. Doctors and employees do not use their cars together always, rather they club up into groups for travelling to the hospital and back. Thereby car used is minimized and as a result travel carbon footprint is reduced.

Table 9

Ingredients for one serving-portion of various food items commonly consumed in Indian households.

Food item	No./quantity	Ingredient (fresh weight, g)				Water for preparation (g)	Product fresh weight (g)	Product dry weight (g)
		Main	Oil	Vegetable	Spice/sugar			
Chapatti[a]	4	100				40	140	90
Bread[a]	2	60				20	80	54
Paratha[a]	2	100	5	50	5	60	220	144
Burger[a]	1	75	15	50	5	25	170	131
Rice (ordinary)	1 plate	100				45	145	88
Rice (basmati)	1 plate	100				40	140	88
Dosa[a]	1	50	5		5	50	110	53
Idli[a]	1	25				25	50	22
Pulse	1 cup	30	5		5	100	140	37
Sambar[a]	1 cup	30	5	15	5	100	155	51
Potato	1 cup	120	5		5	25	155	26
Cauliflower	1 cup	100	5		5		110	17
Brinjal	1 cup	100	5		5		110	13
Poultry meat	1 plate	100	10		10		120	39
Mutton	1 plate	100	20		10		130	39
Fish	2 pieces	100	10		5		115	33
Egg	1	50					50	25
Omlette	1	50	3		3		56	25
Milk	1 glass	250			5		255	33
Curd[a]	1 cup	100					100	10
Lassi[a]	1 cup	50			15	50	115	7
Butter[a]	1 spoon	10					10	8
Apple	1	100					100	15
Banana	1	100					100	10

Source: updated from Khanna et al. (1997).

[a] Main ingredients of these food items are wheat, rice, pulse and milk, respectively.

Emission of greenhouse gases in various stages of life cycle of food items.

Food	GHG emission (g kg^{-1} fresh product)						GWP (g CO_2 eq. kg^{-1} fresh wt.)	GWP (g CO_2 eq. kg^{-1} dry wt.)
	Production			Processing	Transport	Preparation		
	CH_4	N_2O	CO_2	CO_2	CO_2	CO_2		
Chapatti	0.0	0.2	32.1	0.0	5.2	160.0	250.6	389.8
Bread	0.0	0.2	32.1	100.0	7.8	64.0	257.2	381.0
Paratha	0.0	0.1	21.7	0.0	7.8	192.0	261.7	399.8
Burger	0.0	0.1	21.6	100.0	7.8	32.0	204.3	266.2
Rice (ordinary)	21.5	0.1	37.5	0.0	5.2	96.0	711.9	1617.9
Rice (basmati)	26.9	0.2	41.3	0.0	5.2	96.0	858.9	1952.0
Dosa	19.5	0.1	34.8	0.0	7.8	160.0	729.3	1519.3
Idli	21.5	0.1	37.5	0.0	7.8	64.0	682.5	1551.0
Pulse	0.0	0.2	18.6	0.0	7.8	128.0	207.9	790.9
Sambar	0.0	0.2	17.1	0.0	5.2	128.0	199.3	610.7
Potato	0.0	0.1	8.5	0.0	10.4	96.0	132.0	787.0
Cauliflower	0.0	0.1	12.9	0.0	10.4	96.0	138.4	922.7
Brinjal	0.0	0.1	12.1	0.0	10.4	96.0	141.0	1175.3
Poultry meat	0.0	2.1	39.2	0.0	15.6	128.0	801.1	2704.9
Mutton	357.4	0.0	0.8	0.0	15.6	192.0	9149.3	32,081.9
Fish	20.0	0.2	15.8	0.0	15.6	160.0	756.5	2865.7
Egg	0.0	2.0	1.0	0.0	15.6	64.0	668.0	1335.9
Omlette	0.0	1.8	1.3	0.0	15.6	64.0	608.7	1383.5
Milk	28.6	0.0	0.5	0.0	15.6	32.0	766.8	5898.1
Curd	29.2	0.0	0.0	0.0	15.6	0.0	744.8	7448.3
Lassi	12.7	0.0	1.5	0.0	15.6	0.0	345.3	6109.7
Butter	29.2	0.0	0.0	250.0	18.2	0.0	997.4	1187.4
Apple	0.0	1.0	41.7	0.0	26.0	0.0	357.4	2382.6
Banana	0.0	0.2	10.0	0.0	26.0	0.0	97.6	975.9

A balanced diet required for an adult from different sources are as given in the following table alongwith global warming potential (GWP) of various vegetarian and non-vegetarian meals in India.

Table 10

Balanced diet requirement for adult man and woman per day and associated greenhouse gas emission at moderate level of work.

Food	Man				Woman			
	Diet requirement (g)[a]		GWP (g CO_2 eq.)		Diet requirement (g)[a]		GWP (g CO_2 eq.)	
	Veg.	Non-veg.	Veg.	Non-veg.	Veg.	Non-veg.	Veg.	Non-veg.
Wheat	225	225	78.9	78.9	175	175	61.4	61.4
Pulse	80	65	23.3	18.9	70	55	20.4	16.0
Rice	250	250	355.9	355.9	175	175	249.2	249.2
Green vegetable (cauliflower)	125	125	19.0	19.0	125	125	19.0	19.0
Other vegetables (brinjal)	75	75	11.6	11.6	75	75	11.6	11.6
Roots and tubers (potato)	100	100	17.1	17.1	75	75	12.8	12.8
Milk	200	100	156.4	78.2	200	100	156.4	78.2
Apple	30	30	10.7	10.7	30	30	10.7	10.7
Sugar	40	40	33.8	33.8	30	30	25.4	25.4
Oil	40	40	16.9	16.9	40	40	16.9	16.9
Egg	–	30	–	20.0	–	30	–	20.0
Mutton	–	30	–	370.5	–	30	–	370.5
Total	1165	1110	723.7	1031.7	995	940	583.8	891.8

[a] Fresh weight, updated from Khanna et al. (1997) and Gopalan et al. (1978).

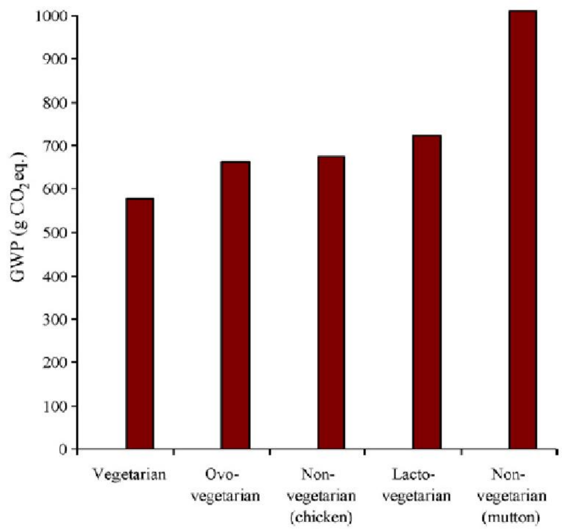

Fig. 2. Global warming potentlal of various vegetarian and non-vegetarian in India

(Source: Pathak et al, 2010)

Conclusion

The study indicates how certain simple measures can considerably reduce the carbon footprint of a multi-specialty hospital like Fortis. Proper planning an execution of components like HVAC, lighting, fooding and transport not only reduces the ill impact on the environment but also saves a considerable amount and thereby contributes in reduction of overall expenses without compromising on the quality of health care facilities to the patients.

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