Sustainable Cooling with DC Air Conditioners and Cold Rooms

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Introduction:

The escalating threat of global warming and climate change calls for actions that deploy environmentally friendly technologies. Air conditioning cooling systems contribute largely to greenhouse gas emissions. It is often a major guzzler of electricity and invariably it is the largest consumer of electric energy in homes and offices. Even in industries it accounts for a significant portion of the energy bill. It also accounts for a major portion of the peak load and strains the grid. With escalating energy costs, it becomes imperative to significantly reduce this cost, purely from an economic angle.

Why Sustainable Cooling:

The demand for cooling is continuously increasing as the country grows. Also, the need for cold storage is increasing. The supply chain from 'Farm to Fork' calls for an efficient and cost-effective cold storage equipment. In addition, space cooling demands are on the rise in homes, offices, and commercial establishments. The existing & conventional cooling systems consume a lot of energy, often powered by fossil fuels. This creates a vicious cycle of increasing cooling demands and strain on the power grid. Thus, a sustainable cooling solution is the crying need for emerging economies and developing nations. Sustainable cooling solutions are essential to break this cycle.

DC Appliances:

DC air conditioners, combined with the deployment of renewable energy results in efficient and eco-friendly cooling and breaks this vicious circle. Easily amenable to variable speed operation, DC compressors deployed in DC systems provide efficient cooling systems for both space cooling and cold storage systems with minimal energy input. Brushless motors have inherently increased efficiency than conventional AC motors. They can operate directly from the DC power generated from the solar panels and eliminate the need for power conversion. In addition, the variable speed feature of the motor adjusts the compressor speed to match the cooling demands of the load. This results in optimal energy usage and consequently reduced electricity consumption. Due to their increased efficiency, the solar power plant rating is significantly reduced. In case a battery is required for non-solar hours, or in off-grid applications, the kWh rating of the same is also reduced.

Challenges:

Despite the advantages listed above, widespread deployment of DC appliances faces the following challenges:

- The idea is very new and customer education is needed to overcome consumer diffidence.
- Increased upfront costs compared to the well-entrenched AC systems, even though the payback is swift and observed by the end user.
- Enormous sunk costs in the existing AC systems which inhibits the entry of new DC technology.
- Lack of economy of scale for the DC system. This increases the cost, and this vicious circle will have to be turned into a virtuous circle with increased communication, governmental support, and consumer awareness.

Case Studies:

Two case studies are presented in this article - one each for an air conditioning system in a data centre in an urban area and the other, for a walk-in cold room in a rural area in a dairy farm.

Sustainable Cooling for the server room:

The customer was using a leading brand of inverter air conditioner of 1 TR (12000 BTU/Hour or 3500 W) cooling capacity. As the room size was a little big (150 sqft) it was suggested to use 1.5 TR (18000 BTU/Hour or 5250 W) cooling capacity. The customer required a 24 x 7 operation. The customer wanted to test the two units (DC operated & imported) under identical conditions and hence it was decided not to add solar operation. Both units, 1Ton AC and 1.5 TR DC, were tested from the same input AC voltage supply 240 V, 1 Phase, 50 Hz. DC appliance was run from the rectified AC incurring a small deficiency in the rectifier. But the AC-DC converter had very good efficiency and the result will be slightly in favour of the imported appliance. The two units were run in identical ambient conditions in two identical rooms for nearly 90 hours. Energy monitoring was done continuously, and the readings are shown for the two units in Fig. 1 below.

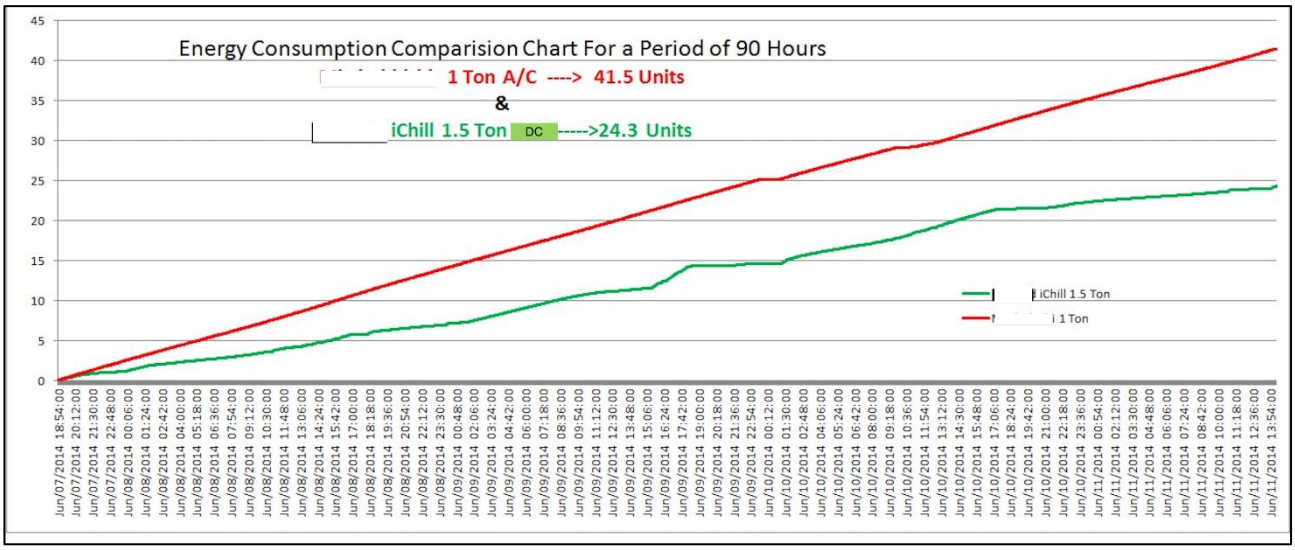

Fig. 1

It is to be noted that DC 1.5 TR unit is being compared with the imported 1.0 TR rated air conditioner. Even then a significant reduction in energy consumption is noticeable. Over 90 hours of operation DC 1.5 TR unit consumed only 24.3 kWh compared to the 41.5 kWh of electricity by 1 TR AC unit - a reduction of nearly 41%. With solar power operation of at least 5 ~ 6 hours, the energy savings will be even more, to the tune of 56%. This is when compared to a 5-star rated and presumably the most efficient air conditioner in the market. The photos of the outdoor and indoor units of DC unit are given below in Fig 2.

Fig. 2

Similar results have been obtained in other customers' premises as well. Compared to single or two-star rated appliances, the overall savings amounted to nearly 70 ~ 75%. Normally the appliance is offered along with a Smart Nano Grid (iGrid) where it is switched from DC and AC automatically and

vice versa. The following diagram explains this. Apart from PV it is possible to add other forms of green energy to the system.

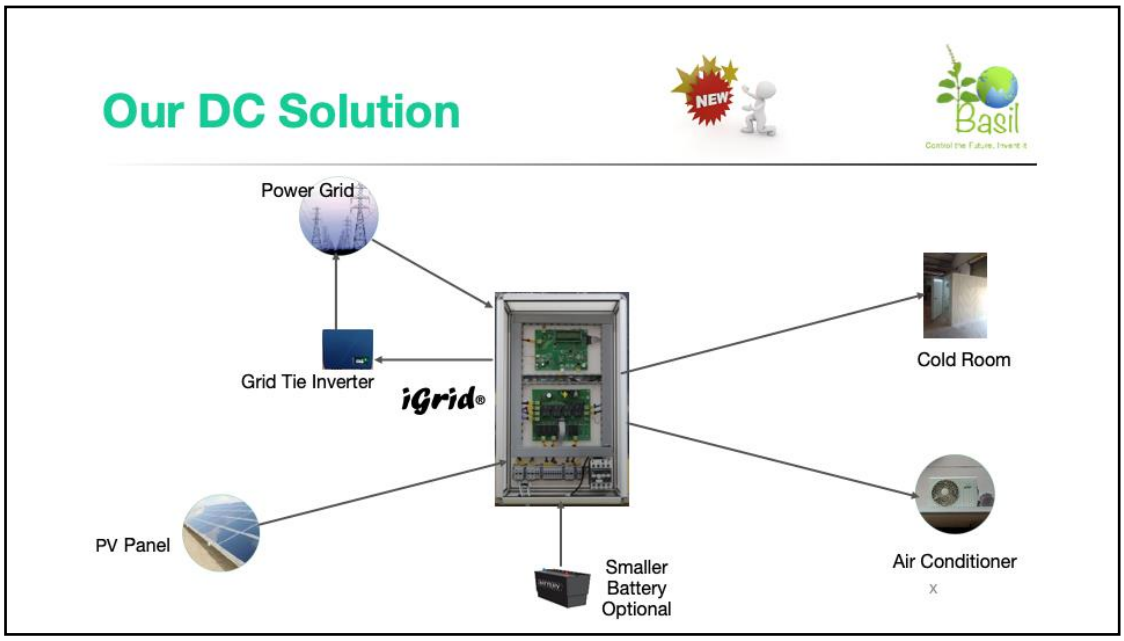

Fig.3

It is worth noting that in an assessment conducted in 2018 under Net Zero Compatible Innovations Initiative and supported by Swedish Energy Agency and EIT Climate-KIC, the assessor WWF, Sweden has said that “If the innovation penetrates 10% of the target market (INDIA), the global greenhouse gas emissions would be reduced by **28.35 million Tonnes of CO_2e**”.

The 3 & 5 TR units proposed are for packaged air conditioning units commonly used in offices, commercial establishments, and large villas. They will be of VRV/VRF type cooling system. All the above appliances can also be operated in the heat pump mode for Space Heating.

Walk-in Cold Rooms:

Apart from space cooling & heating another major area where a lot of energy is expected to be spent is Cold Storage. As countries develop and organised retail business increases, the need for such cold storage equipment will rapidly increase. In India it is estimated that about 35% of the farm produce is wasted in moving them from ‘Farm to Fork’. Around 450 Million Metric Tonnes of farm produce goes to waste. In addition, cold storage is needed in the following sectors of the markets:

- Dairy, Poultry, Fishery & Animal Husbandry
- Fruits, Vegetables & Flowers
- Primary Health & Vaccination centres
- Pharma Industry

The present capacity of cold storage is only 28 Million MT for farm products. As per ISHARE (Indian Society of Heating, Refrigeration and Air Conditioning Engineers) the cold storage market will double in the next five years.

Fig. 4

Cold rooms are powered by the same air conditioners, designed by the company, and described above. With unique temperature control algorithms, the inside temperature of the cold room can be brought down to 2^0 C. This temperature range of 2^0 ~ 10^0 C is sufficient for most applications described above.

The Company has demonstrated the possibility of combining solar and biogas electricity with a Solar + Biogas hybrid system in dairy farms in rural areas. The output of Biogas electricity generators is also DC (Brushless) and hence easily synchronised with the DC of solar panels. During solar hours the system operates on PV and at other times the system runs on Biogas electricity. The dependence on power grid and battery is eliminated. Fig.5 details the schematic diagram of such a system.

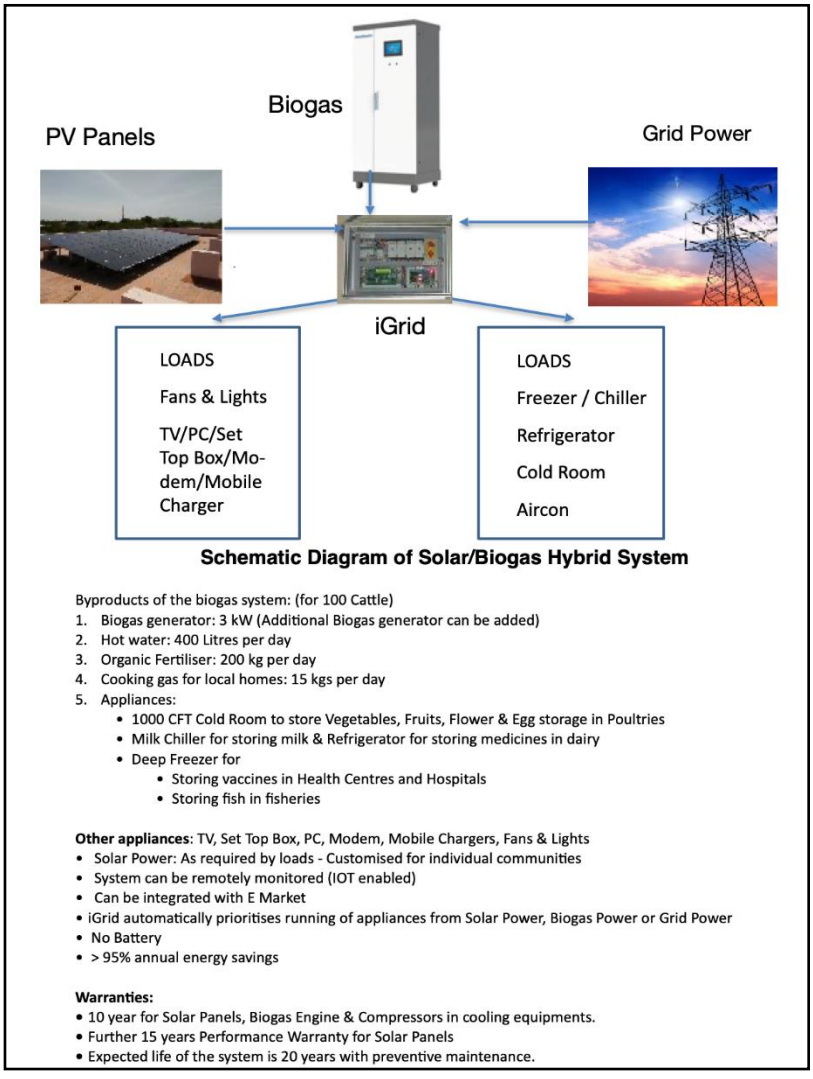

Fig.5: PV + Biogas Hybrid System

In the above hybrid system, the grid power is hardly needed. Such systems will be immensely useful in rural areas, where the grid power is not there or is unreliable. The raw material for biogas digester from cattle waste is available in plenty.

Common Features:

The air conditioners and the controls used in both space cooling systems & walk-in cold rooms have certain special features. They are listed below:

- The equipment can handle a wide range of input voltage fluctuations, both DC & AC. A range of 1: 1.6 is easily handled and there is no need for voltage stabilisers.
- When operating from grid power during non-solar hours, the PF (Power Factor) presented to the grid is nearly unity. This is very helpful for the power grid.
- All the appliances and the iGrid are IOT enabled. They can be networked with the outside world. Remote monitoring and control are possible at marginally higher costs.
- All the motors have soft start features and hence the rating of the PV panel need not be raised.

Other Cooling Appliances:

While air conditioners and cold storages are the major energy guzzling equipment, there are other appliances like refrigerators and freezers which are also widely used. Similar techniques have been used to fit them with DC compressors and motors to achieve very high energy savings. 50, 170 & 300 Litre refrigerators and 250, 350 & 550 Litre deep freezers have been developed. Deep freezers can reach up to - 24^0C.

Conclusion:

The need for sustainable cooling solutions has never been more critical. DC appliances, particularly DC air conditioners and cold storages, offer a promising pathway towards achieving efficient and Eco-friendly cooling. With their higher energy efficiency, lower greenhouse gas emissions, they address a major portion of energy utilisation. As the demand for sustainable cooling increases the cost of such equipment will decrease due to economy of scale and technical advancements, Government policies and support would further drive in accelerating adoption which will ultimately lead to the realisation of Net Zero, the avowed objective of most governments.