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Comment on the Manufacturer Comparison

It is indeed a welcoming development that one manufacturer openly compares his product with other manufacturers of the same products and the trend is picking up due to the heavy competition in the market. The question is that what fact he compares and what he is trying to project?. Well , the comparison made in this problem is merely a comparison of the Compressor Power Consumption and the Cost and not the real efficiency of the A.C unit in total. The neglected figure is the technical efficiency of the system which is denoted by EER(Energy Efficiency Ratio and COP(Co efficient of Performance). Of course the consumer is more concerned about his capital as well as running cost to that extend it seems to be Attractive let us analysis further whether it is true or not.

Now let us come to the technical part of the A/C unit. An A/c unit is not a single component device like our light, mixers, heaters etc. The cooling effect of a A/c unit is the collective effort of three guys, they are (1) Evaporator (2) Condenser (3) Compressor (4) Fan and if we start comparing the compressor only we will not achieve the useful or the projected results. Since in A/c the effect is judged by the heat removal rate with respect to electrical power in put, the efficiency of an A/c unit is mentioned by Energy Efficiency Ratio (EER) and more specifically Seasonal Energy Efficiency Ratio(SEER). The input is Electrical Power but the out put is in the form of heat removal. Compressor and fan needs a motor and power supply. The EER value is also affected by the air flow over the condenser as well as the evaporator. A poorly designed Fan may have a significant effect on the EER values. Environment temperatures at which the evaporator and condenser are working is also to be considered while calculating the EER/SEER. In total not only the compressor but the other factors also have a considerable effect on the efficiency of the a/c units. Replacing only compressor will result in a **“PERFECT MISMATCH”** among the four components and inefficient

will become more inefficient. The results will be fatal. If we take up a **National Programme for replacing the old inefficient compressors with new Energy Efficient compressors we will be doing a Mistake!** Instead, **we may think of a national programme for replacing inefficient condenser/evaporator/Fan in the old a/c units with efficient ones with out any major financial implications. Alternatively at least the Programme should be for replacement of both compressor and Fan (since both need electricity).** One manufacturer claims:

Super Slit-Finned Heat Exchanger and Thermo spiral Tube

The super slit-finned heat exchanger has been engineered with a special contoured design. Adding ridges and increasing the thinness and number of aluminum fins has greatly expanded the surface area - resulting in faster and more economical heating and cooling.

The thermo spiral tubing utilizes premium grade copper with an improved spiral-grooved pattern on the inside surface, which achieves up to an unbelievable 40% improvement in the heat transfer rate.

The other alternative we may think that the each A/c units should have additional condensers for each season! The consumer can replace the condenser in each season which will exhibit better heat transfer efficiency and thus reduce the compressor load and power consumption without any major investment.

Due to the serious the impact of the present refrigerants (CFC) in the depletion of ozone layer these refrigerants will be phased out by 2010 in the developing countries and India will have to follow the suit. The existing a/c units and compressors are designed for mostly CFC and the design aspects may be changed for using ozone friendly refrigerants. These refrigerants may require high working pressure and the whole system have to be re designed including condensers and evaporators.

Now let us see what should have been done.

The comparison should have been made based on the **EER(Energy Efficiency ratio/rating = Cooling effect/Power Input).** Since India has three seasons Summer/Winter/Monsoon the comparison should be for **SEER (Seasonal Energy Efficiency Ratio)**. Room air conditioners should be selected with an EER of at least 9.0 for mild climate and for hot climate it should be over 10.(ref.: EERE, USA). Therefore Indian a/c units should have an EER > 10. The comparison made by the manufacturer in this case is only based on the power consumption of the compressor and it is not clear weather it is the rated or actual. Since the fan will be running continuously the power consumption of fan will significant. The environment condition at which the values are compared for example the average ambient temperature which has a direct impact on heat transfer efficiency of condenser in turn the EER. The power consumed by the fan is not mentioned or whether it is included in the total power consumed which is also not clear. The running hours of the compressor considered is found to be Ok but

the a/c will be in off during winter session for about 2-3 months which is not being considered in the analysis. The comparison is silent about the volume of the space to be cooled. The volumetric efficiency of the compressors are not considered which is also an important factor deciding the volume flow of refrigerant. The other important factor is the **COP which is defined as (Cooling effect in KW/Power input to Compressor in KW)** is also missing in this analysis. **Note that the seasonal energy efficiency rating (SEER), which is the term most often used in the air-conditioning industry, equals 3.412 times the seasonal COP**. The IPLV(integrated Part Load Value) should also be compared as in most of the Indian cases A/c is are to definitely oversized than the required capacity and in fact A/c's are to be selected little lower size than the required capacity for effective control of internal humidity and to avoid frequent on/off conditions. The other analyses are merely an arithmetic analysis to project the cost benefit for which the consumer is more sensitive. **Finally the analysis is aimed to woo the customer based on the financial aspects and not neither real technical efficiency nor the worth of the investment.**

Indian Air Conditioners

Any Air conditioners designed for Indian Climatic should have the highest SEER. The energy efficient air conditioner for India should have

1. The highest efficient Evaporator & condenser with highest heat transfer rate
2. The highest efficient Compressor
3. The highest SEER

The design should be "A Well Arranged Lovers Marriage" and it should be a "PERFECT MATCH" among the all four components **ECCF**(Evaporator, Condenser, Compressor and Fan). Designs will be different for different regions of the country. Therefore any comparison made on Air conditioners for achieving the highest efficiency (SEER) should compare the following parameters considering the A/c unit in total(This may be exhaustive but at design stage these parameters may be considered)

1. Cooling Capacity(Rated)
2. Compressor power(Rated)
3. Fan capacity(cfm)
4. Fan Rated Power
5. Condenser area
6. Condenser tube material
7. Evaporator area
8. Evaporator tube material
9. Ambient temperature
   Summer
   Winter
   Monsoon
10. Volume of space Cooled
11. Air conditioned temp.

12. Heat removed
    Summer
    Winter
    Monsoon
13. Power Consumed by compressor
    Summer
    Winter
    Monsoon
14. Power Consumed by Fan
15. Running hrs
    Summer
    Winter
    Monsoon
16. SEER/COP
    Summer
    Winter
    Monsoon
17. Average SEER/COP
18. Cost of new a/c unit
19. Running cost

20. Cost of buy back of old a/c unit
21. Cost actually paid for new unit
22. Payback

The a/c unit should be replaced with complete new one and not the compressor alone. It will be wise if we replace initially to start with the old inefficient Fan/condensers/evaporators with efficient one, this will also reduce the compressor power consumption and will improve the SEER/COP values.

The maintenance of condenser and evaporator has a significant role in the power consumption. The maintenance of the a/c units is mostly the supplier's job and naturally the business interest of the supplier may have an impact on the degree of maintenance. The following tables highlights the effect of poor maintenance of the components and the condenser temperature variations on the power consumption

Effect of Poor Maintenance on Compressor Power Consumption

Condition	Evap. Temp (^{0}C)	Cond.Temp (^{0}C)	Refrigeration Capacity * (tons)	Specific Power Consumption (kW/ton)	Increase in kW/Ton (%)
Normal	7.2	40.5	17.0	0.69	-
Dirty condenser	7.2	46.1	15.6	0.84	20.4
Dirty evaporator	1.7	40.5	13.8	0.82	18.3
Dirty condenser and evaporator	1.7	46.1	12.7	0.96	38.7

Effect of Variation in Condenser Temperature on Compressor Power Consumption

Condensing Temperature (^{0}C)	Refrigeration Capacity (tons)	Specific Power Consumption (kW / TR)	Increase in kW/TR (%)
26.7	31.5	1.17	-
35.0	21.4	1.27	8.5
40.0	20.0	1.41	20.5

Therefore it is meaningless to change the compressor alone for efficiency improvement in A/c units. It means any national programme for energy efficiency improvement in A/c units for Indian Conditions may need to follow the following

1. Identify the hot/moderate/cold regions of the country
2. Standardize the space for a/c in domestic/as well as commercials and should be incorporated in the building codes
3. Design the best A/c units with **highest SEER(>10)** for each region and also a design with provisions for replacing the other components like evaporator/condenser
4. Develop the mechanism for replacement of the old a/c units considering the ever fluctuating power cost/buy back cost of old a/c units.

How it should have been compared:

The comparison should have been like this, by assuming all other components are efficient and same for all units and cooling capacity is also is actual. The average ambient temperature is assumed as 40^0C and the EER can be considered as SEER.

Sl.No	Make	Kirloskar	Shriram	Voltas	Tecumseh	Carrier
	Model	**CR22K6M**	**SR1622**	**6A23**	**AW1500Q**	**NE1900BB**
1	Cooling capacity(btu/hr)	19000	18800	18840	19000	19600
2	Power Rated(Watts)	1750	2250	2150	1875	1830
3	Equivalent Cooling capacity(Kcalhr)	4788	4738	4748	4788	4939
4	Refrigirent effect in KW	5.57	5.51	5.52	5.57	5.74
5	COP	3.18	2.45	2.57	2.97	3.14
6	SEER(assumed for Indian Conditions)	**10.86**	**8.36**	**8.76**	**10.13**	**10.71**
7	Running hrs/day @ 80% of time and units consumed per day for 10 hr duration per day(KWH/day)	14	18	17.2	15	14.64
9	% Extra power consumed/day by other models		4	3.2	1	0.64
10	% Extra power consumed/day by other models		28.57	17.78	5.81	4.27
11	Energy Cost extra paid by other models/day@7.42/KWH		29.68	23.74	7.42	4.75
12	Additional Annual cost for 10 Months and 26 days per month in Rs		7716.80	6173.44	1929.20	1234.69
13	Cost of replacement with same the same compresor(Rs)	8853	4850.00	4200.00	5500.00	5150.00
12	Incremental Cost of new KCL make CR22K6M Com[ressor(Rs)		4003.00	4850.00	4200.00	5500.00
14	Paynack period in Months		6	9	26	53

(The Table in xl file with formulae in respective cells)

Inference from the Analyses

- Measuring and comparing the amperage have no significant effect on the power consumption
- The EER(10.86) and COP(3.18) values are higher for the compressor proposed than the other old compressors hence the proposal is technically feasible
- The pay back period for models AW1500Q and NE1900BB are very high and therefore not financially attractive
- The replacement can be done for other Two models (SR1622 & 6A23) will be technically feasible and financially attractive also.
- If a National programme is initiated it should be for only Two models(SR1622 & 6A23)

- Power consumption by Fan is not considers in this analysis. However since the fan will be running for the whole day(10hrs) power consumption will be significant

Terms & Units used

I TR	**=**	**3024 Kcal**
IKWH	**=**	**860 Kcal**
ITR	**=**	**12000 Btu/hr**
COP	**=**	**Refrigerant effect in KW/Power input in KW**
EER	**=**	**Refrigerant effect in Btu/hr/Power input**

- **The "SEER" of a system is determined by multiplying the steady state energy efficiency ratio (EER) "measured at conditions of a mere 82°F outdoor temperature," 80°F dB/ 67°F wb indoor entering air temperature by the "Part Load Factor" (PLF) of the system.- from literature**

How to Select Room air Conditioners

- Measure the square footage of the room or rooms to be cooled
- If an exact match of cooling capacity is not possible, it is preferable to select a unit which is slightly undersize in BTUs, rather than oversize
- If area to be cooled includes a kitchen add an additional 4000 BTU/hr
- If more than two people occupy the area add 600 BTU/hr per person
- If only one person in the dwelling subtract 600 BTUs from total BTUs calculated
- Personal computers generate no more than a 60 watt bulb, so no extra BTUs need to be added to the total calculated
- When sizing larger living areas, it is usually better to use at least two air conditioners rather than one large unit. Doing so offers better air distribution which reduces the likelihood of hot and cold spots - **From Literature**

References:

Refrigeration And Air conditioning by R.S. Khurmi & J.K. Gupta

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Residential air conditioner finned-tube condenser heat exchanger Optimization- Research Paper published by Susan W. Stewart, Kristinn A. Aspelund, Monifa F. Wright, Emma M. Sadler, Sam V. Shelton, Ph.D. Georgia Institute of Technology, Department of Mechanical Engineering, Atlanta, GA.

Energy efficiency in Electrical Utilities – Published by BEE-India.