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The following is point wise analysis:

(i) Air Conditioner and its Efficiency

An Air Conditioner cools a room with a cold indoor coil called the evaporator. The condenser, a hot outdoor coil, releases the collected heat outside. The evaporator and condenser coils are serpentine tubing surrounded by aluminum fins. A pump, called the compressor, moves a heat transfer fluid (or refrigerant) between the evaporator and the condenser.

An Air Conditioner is energy intensive equipment so one has to be very careful so that his /her energy bills remain under control. Air Conditioner is generally rated in terms of "ton". 1 (one) ton of refrigeration is equivalent to 12000Btu per hr or 3024 Kcal/hr or 3.51kw.

The efficiency of room A/C is measured by the energy efficiency ratio (EER), which is the ratio of the cooling output (in Btu) divided by the power consumption (in watt-hours).

Or $$EER = \frac{\text{Cooling Capacity in Btu/Hr}}{\text{Power (watts)}}$$

(In simple terms how many Btu per Hour are removed for each watt of power an A/C draws).

Today's best air conditioners use 30% to 50% less energy to produce the same amount of cooling as air conditioners made in the mid 1970s. Even if air conditioner is only 10 years old, one may save 20% to 40% of cooling energy costs by replacing it with a newer, more efficient model. Energy efficiency ratings (EERs) have steadily improved over the last decade. One can estimate energy savings by calculating a 10% savings for each point difference of EER. If one goes for a model rated at 10.7 EER, one will save 10% in energy costs over a 9.7 EER model. By estimating the number of years one will use the unit, one can gauge whether a higher initial cost will eventually pay off. In general, one will pay more for a high-efficiency air conditioner, but that will make up the difference in electricity bill over the unit's lifetime. An individual also be doing his/her part to save the planet. The **American Council for an Energy-Efficient Economy (ACEEE)** publishes an annual list of the most energy-efficient room air conditioners on the basis of ERR .(The list is available on the web-site of ACEEE)

In USA, Government regulation require manufacturers to clearly display EER ratings on air conditioner units. As per regulations in USA air conditioners made after October 2000, and having a capacity of less than 8,000 Btu, the EER must now be at least 9.7.

When one is shopping for air conditioners, he/she looks for EER ratings of 10.5 or higher for room air conditioners. High-efficiency units generally cost more, but in hot climates (like India)

more efficient units pay for themselves over a few years through reduced electricity bills. However, one should not buy a larger system than he/she need just because it has higher efficiency.

From the above discussion it can easily be said that the proposal to have a national programme to replace old inefficient compressor with new efficient compressor certainly make sense.

To sum up the following benefits would be there:

- By installing efficient compressors individual consumer will be benefited directly on reduced monthly Energy Bills. The following is an illustration which clearly shows that for the same amount of cooling the conditioner which is having better EER is saving more energy and in turn saving money:

	Make	**X**	**Y**	**Z**
1.a	Cooling Capacity (Btu /Hr)	19000	19000	19000
1.b	EER	**11**	**10**	**9**
1.c	Power (Watts)	1727	1900	2111
2.a	Power consumed in 1 day **(1.cx10 Hrsx0.8/1000)**	13.81	15.2	16.89
2.b	Energy Consumed Per Annum **(2.ax30 days x6 months)**	2485.8	2736	3040.2
2.c	% saving in energy consumption	9.14%	10%	-
3.a	Energy charges @ Rs. 5/Kw (Rs) (2.bx5)	12429	13680	15201
3.b	Saving in Annual Energy Cost (Rs.)	1251	1521	-

Note:- If running Hrs. in a day increases or running month in a year increases (in case of A/C in shops etc.) the saving further increases proportionally.

This certainly makes sense for consumers.

In the year 2000,1.5 Ton window A/C of M/sVoltas make was having EER of 8.5. But, now A/C having EER of 10.5 is easily available in the Indian market. So by switching to a new efficient compressor consumers can directly save money.

- In turn it's a national saving. As one unit of electrical energy saved at consumer end means two units of Energy Generated. The replacement programme would certainly help to the National Programme – ***"Power for all by 2012"*****.**

  This makes sense for the Nation also.

- And last but not the least; new efficient compressors in Air Conditioners shall help in minimizing "Green House Effect".

This makes sense for the world (planet) also.

IMPLEMENTATION

The implementation can be achieved with multistage planning.

First stage: - Education

The Bureau shall educate the consumers.

- The EC Act 2001 at sub-section (e) of section 13 assign the function of taking all measures necessary to create awareness and disseminate information for efficient use of energy and its conservation, to the Bureau.
- Subsection (j) of section 13 further assign the task to the Bureau to formulate and facilitate implementation of Pilot Projects and Demonstration projects for promotion of efficient use of energy and its conversation.
    - This may also be done in steps. Firstly, the manufacturer, Govt. Department, the renovation consultants, the architects, the interior decorators, and in the second step consumers through electronic and print media may be educated.
- With the provision of subsection (b) of section 13 proper labels may be prescribe as has been done by DOE, USA with the help of industry. Further, in USA manufacturers are required to display EER ratings on air conditioner units and also have provision of mandatory Energy Star Rating labels (issued by ACEEE).

Second Stage: - Rules & Regulations

- U/s 13 subsection (k), U/s 14 subsection (a) & (b) it can be notified and made mandatory for every user of A/C to replace his/her …..Years old compressors by an efficient new compressor having EER >….. [The number of years & EER can be arrived at by constituting a committee of experts].
- The inefficient old compressors can be replaced with new efficient compressor having higher EER. But it is practically infeasible to measure EER of all existing compressors. So, this can be done by setting a *"Cut-off" date*, and the compressors manufactured prior to that date may be replaced.
- We have recent example of New Delhi/ Mumbai where 15 years old diesel vehicles have been removed from the road.

Third stage: - Enforcement

- U/s 13 subsection (k) & (l) Bureau may provide incentive for replacement of old inefficient compressors directly to the consumers or manufacturers (benefit passed on to the consumers). Act also provide establishment of "Central Energy Conversation Fund" which can be utilized for any such drive.
- U/s 15 subsection (d) & (e) State Govt. may very well implement this plan of replacement of compressors by authorizing any agency like distribution utility. The help of accredited energy auditors may also be taken in later stage of implementation.
- Enforcement of the EC act is basically thought of through self regulation .However the provisions are also there for levying penalties for non compliance.

So, carrot and stick policy may be applied for implementation of this drive.

(ii) The given table critically examined and my observation, assumption & working are as under:

Comparison of Energy Savings vs. Compressor Used in a 1.5 Ton A/C						
	Make	**Kirloskar**	**Shriram**	**Voltas**	**Tecumseh**	**Carrier**
	Model	CR22K6M	SR1622	6A23	AW1500Q	NE1900BB
1.a	Cooling Capacity (Btu /Hr)	19000	18800	18840	19000	19600
1.b	Current (Amps)	7.8	12.2	11.2	8.5	9.6
1.c	Power (Watts)	1750	2250	2150	1875	1830
1.d	ERR **(1.a /1.C)**	10.857	8.356	8.763	10.133	10.710
2.a	Extra Power consumed in 1 Hr as compared to CR22K6M (Watts)	-	500	400	125	80
2.b	% Difference **(2.a / 1.c x 100) (Extra Power / Power x 100)**	-	22.22%	18.60%	6.67%	4.37%
2.c	Extra Energy consumed per day @10hrs per day and 80% running time. (kWh.) **(2.a x 10 x 0.8) / 1000(Extra Power x 10 hours/day x80%) / (1000 W/kW)**	-	4	3.2	1	0.64
2.d	Ratio of Cooling Capacity**(cc of CR22K6M/cooling capacity of respective make)**		1.011	1.008	1.000	0.969
2.e	Actual Extra Energy Consumed Per Day **(2.cx2.d)**		4.043	3.227	1.000	0.620
3.a	Additional Expenditure incurred per day @ Rs. 5/Kw (Rs)	-	20.21	16.14	5.00	3.10
3.b	**Additional Annual Expenditure Incurred (Rs) (3.a x 30 Days x 6 Months)**	-	**3638**	**2904**	**900**	**558**
4.a	**Cost of Replacement with the same compressor (Rs)**	8853	4850	4200	5500	5150
4.b	**Incremental Cost of a new KCL make CR22K6M compressor (Rs)**	-	**4003**	**4653**	**3353**	**3703**
4.c	**Payback period (months) (4.b/ 3.b)**	-	**13**	**19**	**45**	**80**

Assumptions & Changes

- **At 1.d** I have calculated EER to see the performance of the Compressors of various make.

  - Kirloskar make compressor is having **EER of 10.85** & slightly better (Energy Efficient) than Carrier make compressor.

However, the financial analysis is giving different picture:-

- **At 2.c** The running time per day for Kirloskar make compressor is assumed as @10Hrs & 80% running time, which is having cooling capacity of 19000Btu/Hr.

  - However, running time of compressors will vary according to their cooling capacity e.g. Carrier has better cooling capacity of 19600Btu/Hr therefore its running time would be less. So, energy consumed per day has been adjusted for taking into account cooling capacity (in ratio of cooling capacity of Kirloskar make/ respective make) of each compressor.

- **At 3.a** Energy charges of Rs.7.42/kwh assumed for this comparison is not realistic.

  - In **MP the Domestic tariff** (having 3 phase connection) inclusive of all charges is approx. Rs.4/kwh, which is itself on higher side, but to consider other utilities like Ahmedabad Electricity Supply Co., Reliance Energy (BSES) etc. I assumed Energy charges as **Rs.5/kwh instead of Rs.7.42/kwh.**

- **At 3.b /3.c** For comparison, running of compressors was assumed as 12 months & 26 days a month, which is not realistic.

  - In Indian climatic conditions the running of Domestic A/C units could easily be taken as 6 months (15^{th} March to 15^{th} Sep) and 30 days a month. The relevant calculations are at **3.b** (*the distribution utilities for calculating connected load assume running of domestic A/C's for only 6 months*).

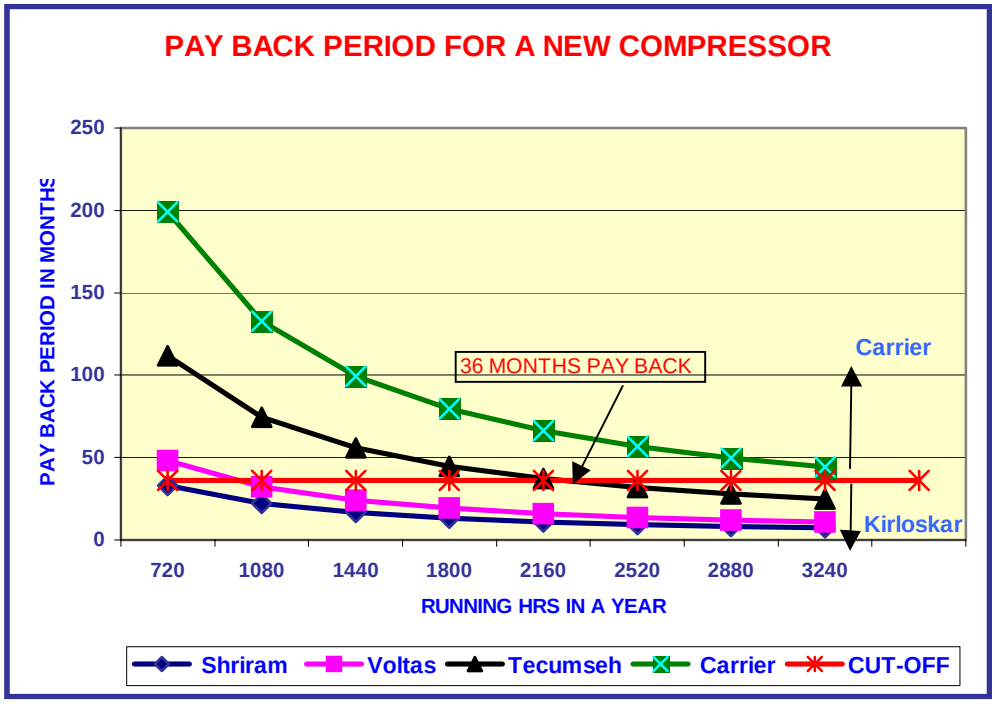
- **At 4.c** New Pay Back period in months is calculated and the same is arrived at 80 months against Carrier and 45 months against Tecumseh.

  - **It can easily be concluded that Value for Money would be provided by Carrier. In my opinion Pay Back period should be around 36 months** [*I assumed the period for which a compressor give trouble & maintenance free performance & manufacturer give warranty is around 6 years and in 6 years an A/C runs for 36 months only (6 months per year) . The benefit of lower energy bills available for 6 months in a year.]*

In the above working the results may further vary on variation of following assumption:

(i) **Tariff for Energy Charges**- If we increase the tariff the operational saving will further increase and pay back period further reduces & Kirloskar make compressor would be the likely choice.

(ii) **Running Time**- In the given table total running time is assumed as 10x26x12=3120 Hrs in a year. To over come this assumption I have calculated pay back period of Kirloskar make in comparison to other make by keeping the *Energy tariff constant at Rs.5/kwh and varying the running Hrs* & plotted it on a line graph. The AC in commercial establishment may run for more hours in a year.



As can be seen from above the Carrier make compressor is the better choice.

Here again the question is what would be the Cut-off PayBack period. I have taken 36 months running period, others may assume otherwise also.

Alternate Analysis

The evaluation on Pay Back period method is quite appropriate here, as in any other methodology (NPV, IRR etc.) the appreciation in tariff shall be nullified by the discounting of the savings in energy charges.

The above working is done basically for domestic A/C's. The A/C's used for other installations like shops, control rooms, factories etc. give more saving in energy consumption as well as energy cost, as their running Hrs. and energy tariff is higher than domestic A/C's.