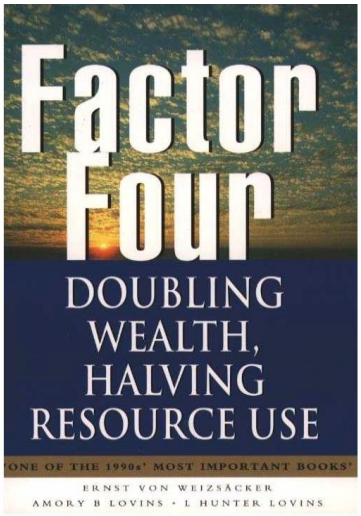

An excerpt from Factor Four: Doubling Wealth, Halving Resource Use, Weizsacker, E, A.B. Lovins, & L.H. Lovins, 1997, Earthscan Publications, London

1.17 FANS, PUMPS AND MOTOR SYSTEMS

In the industrial section of Singapore, a quiet, dryly humorous Chinese engineer designs the world's most efficient air-conditioning systems. Singapore has a difficult climate: relative humidity 84 per cent every day of the year, with temperatures ranging from hot to broiling. Most engineers would count themselves lucky to use only 1.75 kilowatts of electricity to provide 1 ton of cooling there, and many use 2 or more. Lee Eng Lock's systems, however, use only 0.61kW per ton - 65-70 per cent less. That's not an estimate. It is meticulously measured, once per minute, with hand-calibrated sensors that send six-significant-figure signals into his firm's extraordinary monitoring software.

Lee's systems also provide much better comfort, take up much less space, are more reliable and generally cost less to build. They cost less partly because every part is exactly the right size, not too big.

Elegant frugality is Lee's watchword. Energy, money, time, metal, every resource is used in just the right amount and place and manner. There is no wasted effort, motion or investment. Actual needs are measured, not guessed. Energy is used over and over until almost nothing is left. When he was once complimented on an especially ingenious way to do this - to use outgoing air from a big building to pre-dry the incoming air, via a simple device with no moving parts - he replied, in characteristically telegraphic English. 'Like Chinese cooking. Use everything. Eat the feet.'

Most engineers would suppose that the place to save air-condi-tioning energy is in the 'chiller' that produces the cold water, because that's the biggest

single user of energy in the cooling system. To be sure, Lee saves a third of its energy, chiefly by using heat exchangers three to ten times bigger (normal ones are grossly undersized) and making the chiller spin at just the right speed. But that's only a fifth of his total energy saving. Two-fifths is in the big 'supply' fans that blow chilled air around the building, and the other two-fifths is in the pumps and in the cooling-tower fans that dissipate the heat to the outdoors.

Lee's supply fans use not the normal good practice 0.60 kW/t but only 0.061 kW/t - 90 per cent less. His chilled-water pumps use not 0.16 but 0.018 kW/t - 89 per cent less. His condenser-water pumps, which move heat out of the chillers, use not 0.14 but 0.018 kW/t - 87 per cent less. His cooling towers use not 0.10 but 0.012 kW/t - 88 per cent less. Where do these roughly ten-fold energy savings, with improved performance, come from?

Lee starts with how much flow is really needed, then asks how short and smooth and sweet a pipe or duct can deliver that flow, then finds the fan or pump that has just the right size and characteristics to deliver that flow most efficiently, then scours the earth for the finest British fan or German pump to wring out the last bits of inefficiency, then works back upstream through the mechanical drive-train, the motor, the inverter (which runs the fan at just the right speed for the moment, not more), and the electricals. At each step he avoids compounding losses. The parts become smaller, simpler, cheaper. It's all really quite simple: like any other sort of genius, just an infinite capacity for taking pains.

In design as elsewhere, virtue is rewarded. When Lee is through making the air-conditioning system and all its parts several fold more efficient, they no longer need to carry away so much of their own waste heat. (For example, all the energy that the fan imparts to the air to make it move makes the air hotter and has to be taken away again.) Thus not having to keep 'recycling' air-conditioning systems' inefficiencies over and over again not only saves energy, it also lets the costliest components become even smaller - rather like the way weight savings snowball in hypercars (p 4). The smaller and more efficient the cooling components get, the smaller and more efficient they can become.

Lee is good with motors and electronic speed controls too, but he doesn't capture quite all of this potential; his practice emphasizes space cooling, not motor systems. He gets most of the savings - thereby reducing cooling loads even further and making his cooling systems even smaller - because most of the motors are in places where they don't add heat back into the building.