Energy Efficient Design Solutions

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Laboratory buildings are among the heaviest users of energy so the benefits of energy efficient designs are most beneficial to laboratory owners. Capital costs and running costs can be reduced with a holistic approach to ecological sustainable design (ESD) which I describe in this paper.

Double skin facades

An early ESD design, is the Heritage Medical Research Building at the University of Alberta, Canada. It was the first example I had seen published of a double skin façade. I had already designed this concept for an architectural competition so I could not wait to see one actually built. The sectional drawing in my power point presentation, shows their concept best. The air on the south side is heated by solar gain, rises by natural convection and transfers to the north side where the cold exterior cools the air and it drops to the basement to complete the cycle. More detail by the architects Woolfenden Hamilton Brown is in my book where it is one of the 35 case studies.

The most recent successful design is the Kadoorie Biological Sciences Building of the University of Hong Kong. The architects, Leigh & Orange Ltd received a World Architecture award with the envious citation of "the best laboratory building in the world" from the design jury.

The building has 10,000 sqm of usable laboratory space on eight floors with a central corridor connecting highly flexible/adaptable generic laboratory suites with services from a 3m grid ceiling system. This basic design, traditional because it has worked for so many laboratory buildings, becomes almost unique when you look at the ESD design. 'Almost' because the double skin facades have been done before but not always with the heat generating air conditioners for each laboratory suite within the double skin, the services zone. The double skin is more generally incorporated to reduce solar gain and create natural convection upwards which modifies the climate effect on the inner skin. Other benefits of the services zone is the cost benefit of the reticulation of power, gases, water, waste and fume cupboard extract ducts simply fixed externally rather than internally where access for maintenance and relocation can disturb laboratory functions. Easy window cleaning is a bonus.

The third feature, which saves energy but also reduces CO^2 emissions is the recirculating fume cupboard design, the latest 'vortex' fume scrubbing technology, developed initially by the British Atomic Research Authority and now available in the private sector.

The following estimated energy savings were supplied by the architects:

Energy Saving Reduction in Carbon Dioxide (CO^2) emission

isi Contribution by application of recirculatory type fume cupboards
825,000KWH per annum
500.00 tonnes CO^2 per annum

ii By installation of external glazed screen for solar control
48,700 KWH per annum
32.5 tonnes CO^2 per annum

iii By locating equipment with heat emission in the external open services zone
7,660KWH per annum
5.10 tonnes CO^2 per annum

Total per annum

881,360 KWH per annum	537.60 CO^2 per annum	
Total over a 50 year life span	44,070,000 KWH	26.8800 tonnes CO^2

Most recently I was the laboratory design consultant for the Life Sciences Building, University of Newcastle for which Suters Architects in association with Stutchbury and Pape won the Sulman Award for Public Buildings in 2000. I recommended an external services zone for mechanical plant, reticulation of laboratory and building services and fume extraction ducts. This double skin design is different to the previous examples which control a large temperature variation because in Australia we have to shade the building from the sun, particularly for a western aspect with louvers and not glass. The floor plan shows the extent of the services zone for which I have coined the term ‘peristitial’ space.

The examples I have mentioned provide the facility to change the laboratory services without entering the laboratory spaces and safe maintenance of services and windows.

Natural ventilation by convection
Another ESD design is the reinstating of natural ventilation for some areas, but not the way we used to do it – by opening windows. Now the natural characteristics of air convection are being exploited by creating a funnel effect up through multi-storied laboratory buildings channeling the air through circulation atria into offices and outdoors.

Eastgate, a large office block in Harare, Zimbabwe, by Pearce Architects, which could be a laboratory building, relies on long narrow floor plates for maximum daylighting and ventilation, partly from the central glass roofed atrium. The moderate climate characterized by sunny, warm days and cool nights is the ideal environment for cost effective, low energy, naturally convected ventilation.

Decentralised air-conditioning
Decentralised air-conditioning is another energy saving innovation. Traditionally laboratory buildings have been air conditioned from a top floor mechanical plant room forcing cool air down large ducts to each floor. These building plans are characterized by large masonry ducts, generally central on the plan next to the lift shafts, and incidentally preventing any degree of flexibility. Central conditioning requires the plant to operate 24 hours a day if some areas, such as research and pathology, need permanent conditioning. Now we decentralize the plant and eliminate all vertical air ducts. The new Life Sciences Building at the University of Adelaide has 2 conditioners per floor, new Science laboratories at the Sydney Institute of Technology have 1 conditioner on each floor and the University of Newcastle has one conditioner for each laboratory, as needed. Conditioning is thereby controlled at each laboratory with huge energy conservation without the risk of a central plant shutdown.

Part interstitial
At the University of Aberdeen, their architect David Murray Associates designed an alternative solution to the interstitial floor, which normally extends over the whole building floor. He realized that only the laboratories needed the interstitial floor and furthermore, the offices did not need the extra ceiling height. The cross-section through his building shows the interstitial floor over only the laboratories and in the equivalent height he has fitted two levels of offices and laboratory support spaces. Further advantages of this brilliant design are the reduced building volume reduced energy consumption and the staff favour the quiet mezzanine offices, away from the busy laboratory floors.

Another example is one of my projects. My power point presentation includes a design for part interstitial spaces and mezzanine offices in a competition entry by Peddle Thorp, Donovan Hill and myself.

Local exhaust ventilation
The Australian/ New Zealand standard for the design of laboratories recommends exhaust ventilation at the source of the fume or dust particles before the fumes and dust can spread into the laboratory ventilation. These flexible ‘elephant trunk’ systems do not replace fume cupboards but do save energy in the long run.

Shared instrumentation and equipment
When I was commissioned to design a new central pathology laboratory at a hospital where the pathology services were being performed at several remote locations I discovered a great deal of duplication, indeed triplication of resources. The staff were initially reluctant to embrace the concept of shared instrumentation but gentle persuasion by management won the day and very considerable reduction in energy consumption was achieved, not to mention the excellent effect on the capital costs.

I illustrate a current project of ours in New Zealand where the design brief called for shared instrument laboratories, which I located on the central circulation corridor.

Indirect lighting saves energy
Recent research by illuminating engineers has shown that visual acuity is enhanced by indirect lighting. Or in other words, the eye sees images better under shadowless light. The more efficient indirect luminaries save energy. Eye fatigue is also reduced by the eyes constantly adjusting to the very different levels of illumination produced by direct lighting. Michael Doberdruk, an engineer at the Austin Co, Cleveland writes “the seeability of 50 to 70 foot candles of indirect lighting is comparable to that of 100 or 130 foot candles of direct lighting”.

The illustration shows a system of both indirect lighting, and task lighting, individually controlled, which I designed for Space Lab Laboratory Furniture Systems.

Colocation
Colocation is the buzz word in design briefs we receive now. Colocation means locating together the facilities which can be used by more than one user group. Typically these are hot and cold rooms, consumables stores, large equipment which is not user specific, internet access, write-up desks if not user specific and common rooms (yes, even these were not colocated before). Obviously the efficient colocation is energy efficient and reduces capital expenditure.

Cogeneration
Cogeneration means using one fuel to generate two or more forms of energy. For instance, using gas to make heat or cooling and electrical or mechanical power. Commonly a gas turbine is used to provide electrical or mechanical and waste heat is recovered for use on the site. Any form of fuel can be used to make the electricity – gas, coal or waste products. Capturing more of the energy from a fuel has environmental and financial advantages.

Cogeneration can double energy efficiency, halve power costs and reduce carbon dioxide emission by two-thirds. By generating electricity on-site, a company also improves the reliability of supply and any power not used can be made available to the grid.

To conclude, the holistic approach to ESD can only be achieved by all the Design Consultants participating. The energy efficient design solutions I have described and illustrated in my power point presentation were achieved by the participation of all members of the design team including the most important member, the laboratory client.