ECOCENTRE-ISPRA: a Project for the Energy and Environmental Upgrading of a Research Campus

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Synopsis

A brief description of the achievements, future actions, and indicators chosen for tracing environmental improvements to the European Commission's main research establishment.

Abstract

The Ispra Establishment of the European Commission's Joint Research Centre (JRC), was set up in the late fifties. In 1992 a project, called *EcoCentre Ispra*, was set in motion with financial support from the European Parliament which wanted to demonstrate the feasibility of improving the environmental impact of an ageing research area according to criteria of sustainability. The most important actions undertaken so far have sought to reduce the site's energy consumption, through both retrofitting and new, low energy construction.

In order to demonstrate, scientifically, the improvement made by the project, suitable environmental quality indicators have to be defined and monitored for those areas where environmental retrofit actions have been carried out. The choice of environmental indicators is neither obvious nor objective, as there is no commonly accepted definition of environmental quality. In each context there are differences of attitude, policy and interest which prevent universally acceptable definitions being reached. This report presents the possible indicators which have been proposed for discussion by all those interested in the Ispra Centre, in order to provide a monitoring tool in support of Site management activities.

Some lessons learned from this experience may be of use to others planning similar projects.

1. Introcudtion

The Ispra Establishment of the European Commission's Joint Research Centre (JRC) is by the Italian Government in 1956 as a national nuclear research laboratory but was handed over to the Commission in 1960-62. It was laid it out to accommodate up to 4000 people who would be engaged in strongly technological and "production" oriented, "big science", nuclear R&D. An extensive road network, around 30km long, was constructed and buildings were placed almost randomly over the site's 160 hectares, Presumably, the assumption was that, as the establishment grew, the gaps between buildings would be filled in. In the event, the actual peak occupancy was never higher than about 2300 (in 1968) and it now hosts even fewer - ca. 1900, including all non-permanent staff, scientific visitors, students, and research fellows. As a result, the site is much larger than necessary.

Having been constructed at a time when there was little concern for the environment, the buildings themselves are very inefficient in their use of energy. This results in the Centre producing unnecessarily large quantities of environmental "insults" such as carbon dioxide - CO_2 (˜ 30 000 tonne/yr.), sulphur dioxide - SO_2 (˜ 20 tonne/yr.) and nitrogen oxide compounds - NO_X (˜ 30 tonne/yr.), both on site and remotely at the power stations which generate its electricity.

This environmentally unsatisfactory situation is, moreover, becoming increasingly incompatible with the activity of the Centre, which since 1973 has seen a progressive shift towards non-nuclear research topics. In future, it is likely to focus even further on “soft” research such as Environmental and Life Sciences.

The idea that the Centre’s environmental impact should be fundamentally transformed, turning it into a model for other ageing research centres, originated at the level of the JRC’s Board of Governors. The reasons for selecting Ispra, from among the five JRC sites, were that it is by far the largest and contains the most heterogeneous and geographically dispersed building stock. It is also the site which has undergone the greatest change in its activities and at which environmental and alternative energy research is concentrated. Given this expertise, it was natural that measures should be suggested which are at the leading edge of current knowledge and technology. These concepts are now being applied to energy efficiency, material recycling, waste disposal, services, work practices and habitat.

An important basis for the project was a 1991-92 study, carried out by external consultants under a contract from the German Federal Ministry for Research and Technology. Basic facts and recommendations for the ecological and economic improvement of the Ispra site were set out and made available to the European Parliament and the JRC Board of Governors in two documents of 1992/93 and combined in a Report of 19th February 1993. Many of the suggestions contained in that report, such as building retrofitting, improvement of the sewage system, and installation of a cogeneration plant have been developed further since then.

Background information on the Ispra site is presented in *Table 1-1*. The average annual energy consumption, per square metre of floor area, for all buildings on the Ispra site is, at present, about 350 kWh_{th} and 170 kWh_e, which is two or three times higher than that estimated for the retrofitted and the new buildings now under construction. The electricity requirement has a base load of around 3 MW, even when the Centre is closed. Potential cash savings exceed 1 MECU/yr. and would be accompanied by a halving of CO_2 emissions and even larger reductions in SO_2 and NO_x emissions.

Late in 1992, the European Parliament effectively launched the EcoCentre Ispra Project, as it was now called, by voting a 5 MECU amendment to the Community’s 1993 budget, for the purpose.

[It is felt that the experience gained by the EcoCentre Project, both in the “technical fixes” adopted and in the organisational problems encountered, will be of interest to others attempting a similar up-grading of their premises. The project was intended to be a demonstration of the possibilities and the results are available to all. This paper describes the measures taken to date, the techniques planned to monitor the resulting environmental improvement, and some of the lessons learned from the project.

2. Actions carried out so far

2.1 Organisational aspects

At the start of the project, a multi-disciplinary working group of specialists from the Infrastructure Unit and various Institutes was set up under the chairmanship of the Director of the Environment Institute. This was, in itself, a major departure from previous practice, whereby all planning of the site’s infrastructure - new building, maintenance, heating, cooling and so on, was the sole responsibility of the Infrastructure Unit. Staff research scientists with expertise in environmental studies and energy efficiency had never previously been consulted as to how the environmental impact of the site could be improved and set to work on the problem with great enthusiasm. Such an arrangement, however, provides considerable scope for misunderstanding and it would have been surpassing if some, who had conscientiously run the site hitherto, were not to feel that the inclusion of scientific staff in the planning process implied criticism of their past performance. It was, therefore, necessary to emphasise at every stage that the poor environmental performance of the site was entirely due to the attitudes of the period in which much of it was constructed.

Some disapproval was also encountered from cash-strapped scientists who naturally felt that the money would have been better spent on increasing their research allocations. The fact that the funds were provided by the European Parliament, solely for the innovative environmental improvement of the site was no consolation.

Table 1-1 -Facts on the Ispra Site

General	
Founded by Italian Government	1956
transferred to the European Commission (EURATOM)	1962
permanent +non permanent staff	1 700 ca.
visitor/year	7 000
local budget (1994)	188 MECU
service cars	136
average number of private vehicles present	1 000
average temperature	11,6 °C
average relative humidity	76 %
average cloud cover	4,2 %
average precipitation	1 650 mm /year
rain days/year	125
average incident solar energy	1 204 kWh/m^2 a
Real Estate Assets	
total area	160.0 ha
built-on area (in brackets % of the total)	37,5 ha (23.5 %)
of which roads and car parks	25,9 ha (16.2 %)
of which buildings	11,6 ha (7.3 %)
cultivated area	0,3 ha
grassland	79,7 ha (49.8%)
woodland	27,8 ha (19.4%)
roads	30 km
perimeter fencing	5,9 km
total number of buildings	232
number of heated buildings	140
interior floor surface area	195 940 m^2
real estate insurance value (without land)	167 MECU
of which for buildings	133 MECU
of which for installation	34 MECU
maintenance cost 1994	4,2 MECU
Heating and cooling system	
Steam generators (195°C/13 bar)	3 boilers for a total installed power of 40 MWth
Heat Distribution:	8 km district heating network, superheated water at 100-120 °C
Cool generators	central chillers, absorption machines and local air conditioners
Cool Distribution:	district cooling network of Lake Maggiore water at 10-12 °C
	district cooling network of chilled water at 5-6 °C
Flow of industrial (lake) water for cooling	7 444 000 m3/y
Energy Consumption Data	
Thermal Energy Consumption (Methane)	70 000 MWh/a
Thermal Energy transport & dfistribution losses	10 000 MWh/a
Total cooling energy (chilled water + lake water)	5 000 MWh/a
Purchase of electric energy	33 000 MWh/a
Peak Power Demand	5,4 MWe
Cost of methane (in 1995)	1,0 MECU/year
Cost of electricity from grid	1,9 MECU/year
Global CO2 Emissions (including external generation)	30 300 t/a
Total solid Wastes	1 182 t/a
Total Water consumption	4,1 Mm^3/a

The European Parliament funding, offered the Ispra Establishment a unique opportunity to bring its site up to date but brought with it a considerable increase in work for those involved and a number of headaches. For the first 3 years, a small number of staff (fewer than 10) carried out their EcoCentre duties in addition to their normal scientific duties and no full-time project manager was appointed. This is not a recommendable procedure but, like many of the decisions taken in the project, was the best that could be arranged in the time available. Time was always of the essence due to the JRC's budgetary requirement that all funds be used within the financial year in which they are made available. The wide ranging expertise of the EcoCentre working group in the fields of cleaner technologies and energy and environmental conservation, has been of great value and has been supplemented where necessary by collaboration with external experts. The first 4 years of the project's life have concentrated on the execution of a limited number of important initiatives driven by the above mentioned requirement that funds be used within the year in which they were allocated. This constraint initially prevented a close study of all possible alternatives and limited the chance of optimising the choices, although the decisions taken undoubtedly go in the right direction. It also meant that not all the actions were carried out in the optimum order.

2.2 Actions carried out

The actions set up in the framework of the EcoCentre Project are listed in Table 2.1. Many of them were conceived on the basis of the 1992 study, which was completed and checked by Ispra scientists in early 1993. As can be seen, most of them concern the energy field and, in particular, building energy & environmental retrofitting. Other important actions, more related to natural and ecological aspects are still, after 4 years, at the paper stage. The following brief descriptions of the work carried out to date is not be considered, therefore, as a chronological record but simply as an overview.

a) Preparation of a Master Plan

In order to move away from the practice of allowing almost random development and in an attempt to rectify the resulting geographical dispersion, it was decided to set up a Master Plan for the Ispra site. An international competition was held and, from the ten companies competing, two with complementary competences were selected.

The Master Plan comprises a Construction Plan for built areas and a Landscape Plan for green areas. The criteria on which the Master Plan is based foresee a Zoning Plan that divides the site into 4 main "urbanised" zones and the remaining "green" areas i.e.:

- a new High Density (Concentration) Zone,
- three other zones in which existing buildings are grouped and
- the remaining areas in which nature should be allowed to flourish

These remaining areas should be considered *taboo* zones, in which new constructions should be prohibited and biodiversity enhanced. Old, out of date buildings should be progressively demolished and replaced by modern labs and office buildings built in the High Density Zone. This zone should have the double advantage of bringing people closer together to facilitate interaction whilst reducing the length of the district heating network and thus reducing energy losses. The campus style should be characterised by innovative architecture and carefully designed communicating open spaces, in which institutes and buildings are connected by pedestrian walkways. Non-essential roads should be removed, in order to reduce the length of the road network and the overall area of paved, impermeable surfaces.

b) Building Regulations and Green Labelling

To complement the Master Plan, a new set of Building Rules was developed which has to be respected for all new construction and renovation work. These rules do not replace the relevant Italian legislation but, rather, complement it by, for example, imposing higher levels of insulation and restricting the use of certain materials. They are based on principles of energy saving, environmental protection, and - last but not least - occupant-oriented working conditions, e.g. optimised bioclimatics.

Table 2-1. List of Actions Carried Out by End of 1996

Energy and Environmental Management
- Preparation of Master Plans “Construction” and “Vegetation”
- New Building Regulation
- Demonstration of Green Labelling for buildings (ECVAM Lab)
- Publication of Long Term Mission Statement
- Proposal of Environmental Indicators and Indices.

Energy & Buildings:
- Energy audit of Research Centre
- Improvement of energy design of 2 new buildings (ECVAM and IAM bldgs.)
- Retrofitting of 4 existing buildings (Hall, Canteen, Office Bldg. Central Store)
- Monitoring of the 4 retrofitted buildings.
- Retrofitting detailed design of hot nuclear lab.
- International competition for the construction of 3 new buildings
- Construction of 2 new buildings
- Cladding of ELSA building south facade with photovoltaic panels
- Preparation of the technical specification for new CHP plant
- Mapping of power consumption of various loads in the Centre

Ground:
- Demolition of buildings (2 in 1994, 2 in 1995 and 4 in 1996)
- Imposition of “fines” for tree felling and creation of new impermeable areas

Materials:
- Start of separated waste collection (paper, batteries)
- Banning of harmful materials in the design specifications
- Removal of degraded asbestos building components
- Disposal of dangerous wastes stored in the Centre (e.g. PCB)
- Inventory and planning of replacement of CFC in cooling machines

Transport and Internal Mobility
- Provision of tele-conference facilities
- Completion and improved use of internal e-mail network

Staff Involvement & Information
- Presentation of EcoCentre Project to various audiences
- ﬁ Preparation of various Reports and Conference papers

Biodiversity (Flora & Fauna)
- Mapping of vegetation of Ispra site
- Preparation of planting plan of indigenous species

The Building Rules impose a number of environmental requirements which, when implemented in a building, ensure high ratings in environmental assessment audits such as BREEAM (the Building Research Establishment Environmental Assessment Method, BRE 1993) developed in the UK. This method was applied, for the first time outside the UK, in 1994, to assess the new laboratory building constructed at Ispra for ECVAM (European Centre for the Validation of Alternative Methods - to animal testing).

An important novelty introduced with the Building Rules is the establishment of a link between the surface area required for new construction and the freeing up of a corresponding area by the demolition of old buildings. New buildings are permitted only if stipulated in the Master Plan and, then, only if equivalent or bigger areas are identified which can be recovered. The surface area devoted to anthropic uses has been chosen as one indicator of the environmental improvement to be monitored.

c) Mission Statement

An important step in the project was the approval by Management of a *Mission Statement* which provides a framework for the EcoCentre activities. It also represents a Declaration of Intent, on the part of the Centre's Direction, publicly committing it to proceed further with the environmental improvement of the Ispra Site and listing the actions planned for the next few years, see Table 2.2 and Section 3.

d) Monitoring Envir onmental Impr ovement

In order to be able to monitor any environmental improvement, suitable indicators have to be defined. Since these are still a matter of scientific debate among the world's environmental scientists, a number of possible indicators were identified and presented to the Ispra staff for discussion (F. Conti 1996). It is foreseen to apply a selected number during the current year. The preferred indicators and indices will be discussed later in this paper - see Section 4.

Table 2-2. List of Actions Planned in the Mission Statement

Energy & Buildings:
- trace all energy flows and key emissions via detailed metering and monitoring
- introduce cogeneration for production of heat, cooling and power
- identify and invest in rolling programme of environmental and energy saving actions
- devise and invest in rolling programme of retrofit actions for more permanent buildings
- invest in rolling programme of new, low-energy building construction to replace old, temporary buildings

Biodiversity (Flora & Fauna)
- improve efficiency of waste water treatment plant by separating "white" from "black" water before it enters plant
- interconnect green spaces to form a Biotope Network
- protect and enhance existing natural landscape
- conserve and support existing ecosystems
- arrange open and wooded spaces
- enhance biological diversity

Transport and Internal Mobility
- encourage walking and cycling by creating car-free paths and secure parking for bikes
- progressively introduce low emission transport by purchasing electric cars

Staff Involvement & Information
- establish an information system keeping management and staff aware of progress

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2.3 Energy and Energy Related Issues

Three main lines of action have been identified.
- Improvement of building energy performance
- Improvement of Energy production and supply system
- Retrofit and replacement of appliances with new, more efficient ones.

To date, the EcoCentre Working Group has given a great deal of attention to the improvement of building energy performance. This was partly in response to the budgetary requirement which, as mentioned previously, requires the spending of all funds within the financial year of their allocation. This favoured investment in a few large projects rather than many smaller ones and hence the choice of complete building retrofits and new construction.

Early in the project, eight older permanent buildings were selected and proposals solicited, via an international competition, for their low energy retrofitting. A total of 50 innovative proposals was obtained but, with the funds available, only four of the winning projects could be carried out immediately. In addition to these four, a fifth project was carried out which involved the addition of a PV facade to the south wall of an existing technological hall (ELSA Building). The nature of the retrofits and the anticipated energy savings are summarised in Table 2.3

The second action line concerns plans to replace the elderly central heating plant with a Combined Heat & Power (CHP) system, thus obtaining a considerable improvement in the overall efficiency of the Centre's energy supply system. The plant would be sized to supply all winter heating requirements and would also supply a significant proportion of summer cooling requirements via an absorption heat pump. So far, only the technical specifications have been drawn up. The launching of a "call for tenders" will take place once financing details have been settled. There will be no grants from the European Parliament for this investment and third party financing is a possible option. A survey of the Centre's power loads and a plan for their reduction started in the second half of 1996.

The third action line is a rolling programme under which older, less efficient equipment is replaced by newer, more efficient models. Obvious examples are the purchase of Energy-Star compliant informatic hardware and low energy light bulbs. The considerable time, effort, and money spent on the building retrofits calls for a short discription of each of the four projects. These concern an industrial hall, the canteen building, an office building and the central stores.

- The ESTI Technological Hall

In the pre-retrofit state this 16000 m^3 building suffered from a number of design faults. In particular, it suffered from severe stratification of the indoor air during winter, with temperatures of over 40 °C under the roof and less than 17 °C at ground level! The envelope permitted large heat and cooling losses due to poor insulation and its construction with wide concrete supporting columns, protruding outwards from the walls both inside and out. These side fins acted as enormous and very effective cold bridges. Warm air loss was also facilitated by large roof ventilators, which could not be closed.

All these defects have been corrected by the retrofit design, the most *innovative* components of which are:
- a "Canadian Solar Wall" of 370 m^2 used to preheat intake air in winter.
- a water filled solar collector array which provides heat in winter and heats dehumidified air in summer
- a HVAC system, managed by a Building Energy Management System (BEMS), which has 8 modes of operation

- The "Mensa" (Canteen)

The largest of the retrofitting projects is that of the Mensa. This is not a single building but a conglomeration of buildings, constructed at different times to different standards. The most eye-catching feature of the winning proposal is a shading structure or pergola covering the entire conglomeration and unifying the building aesthetically. The pergola also has the functions of providing roof shading in summer, to reduce the cooling load, providing a platform for solar water heaters, for dishwashing and supporting tall, new ventilation skylights in the ceiling of one canteen.

The innovative aim of the design is to provide summer comfort by means of natural ventilation, as an alternative to the existing air conditioning plant, although the climatic conditions at Ispra are rather severe in summertime. To achieve indoor conditions similar to those outside, a number of openable windows have been installed. The skylights, with their chimney-like form and mirrored internal surfaces also encourage natural ventilation through buoyancy effects and improve the daylight factor inside the building. An intelligent control system seeks to maintain comfortable conditions by taking account of relative humidity and air speed in addition to temperature.

The project should make a useful contribution to research in the field of bioclimatic design.

- Administration Office Building

The winning proposal foresaw, among other features, the installation of large sun-spaces, entirely covering both the south and north facades. Unfortunately, a check with the window cleaning contractor showed that the cleaning cost would be roughly equal to the value of the energy saved. The project will, therefore,be carried out with more common energy saving measures.

- Central Stores.

This retrofit mainly consists of the improvement of insulation levels. Like the administration building, it has an asbestos roof which, being in a degraded condition, must be replaced rather than encapsulated. This retrofit can be considered as a comparison of different insulation techniques, such as conventional and transparent insulation.

- PV Integration in Buildings: the ELSA facade

One the largest photovoltaic facades, in terms of area (over 500 m^2), currently in operation, is mounted on the south wall of this building. The PV facade provides an aesthetically pleasing surface treatment, the colour of which changes with weather conditions and viewing angle. The amorphous silicon PV modules used in this project are only about 20% more expensive than glass cladding and cheaper than polished granite. They are able to provide 25 kW peak power and about 20 MWh/yr. Research is underway also to utilise the heat rejected from the PV facade.

- New buildings.

The design of a laboratory prepared, according to the then current Italian regulations, prior to the start of the EcoCentre project was studied with a view to incorporating higher energy and environmental standards. It was found that it would be possible to cut energy requirements by a good 50%, down to some 120 kWh/m^2 a.

Two new buildings are currently under construction in the High Density Zone. Their predicted energy consumption is around 60-70 kWh/m^2a.

- Staff reaction

The retrofitting of old buildings which must continue to function during the building work is not an easy task and there were inevitably times at which the occupants were disturbed. It was found that there was little tolerance or understanding of the difficulties faced by the builders and maintenance staff in trying to provide the usual internal comfort at all times. The occupants' immediate reaction was to say that things were better before the retrofit and, of course, that the money would have been better spent on research. In the case of the Mensa, however, an opinion survey had been undertaken before the retrofit, which showed that only a little over half of the canteen's customers were entirely satisfied with the internal climate provided by the air conditioning in summer. Even so, people do not readily accept that the installation of an innovative natural ventilation system must necessarily involve some trial and error before it can be made to perform satisfactorily. A greater effort to inform canteen users that the system is still in the tuning phase should, perhaps, be made.

2.4 Ground Use

The Centre has 3820 m^2 of old wooden buildings and 9640 m^2 of old prefabricated steel buildings. New construction should allow their demolition. Although a technical link between demolition and new construction is included in the building rules, there is as yet no financial link, so that an automatic decrease in built-on area is not guaranteed.

By the end of 1996, a total of 9 buildings with a surface area of 3710 m^2 had been demolished but, in the meantime, 3 new buildings had been committed for a total area (including parking) of 6760 m^2. Once these 3 buildings are completed and the old ones vacated, the ground area returned to green will be around 7000 m^2.

In order to increase awareness of the importance of land use and tree protection, environmental penalties have been established. The creation of any new square metre of impermeable area earns a penalty of 100 ECU, roughly corresponding to the cost of restoring it to its previous green state. The felling of a tree is also penalised with fines ranging from 200 to 500 ECU according to the value of the tree.

2.5 Materials

Although the monitoring of solid wastes and of the use of harmful materials was not included among the Eco-Centre actions, growing attention has, nevertheless, been paid to this issue, within the frame of normal Infrastructure activities. Noticeable actions set-up are:

- The number of different materials collected and disposed of separately has grown from 20 in 1992 to 26 in 1994.
- Separate collection of paper and exhausted batteries has been organised in all buildings.
- Historical storage of dangerous materials, such as PCB, has been dismantled and content disposal carried out.
- Removal of asbestos building material is underway.
- Drawing up of an inventory of CFC fluids and their replacement by more environmentally friendly fluids is planned.

2.6 Information & Environmental Culture

This is a difficult area. Information can be given to staff but they cannot be forced to read it. Many people who would agree to the need for a reduction in the World's energy consumption forget to turn off a light or a computer when it is not being used, although they know the environmental arguments in favour of the action. The few second's delay experienced while an EnergyStar computer monitor "wakes up" from a "sleep" mode can infuriate the impatient. Bins reserved for paper to be recycled are often used for all types of rubbish from soft drink cans to old ring files. The explanatory notices on the bins are ignored.

Several reports and documents on the EcoCentre project have been prepared, talks (poorly attended) given to staff, and papers presented at conferences but more needs to be done. It is hoped that technical and scientific interest aroused externally in the EcoCentre project will eventually lead to collaboration with similar projects elsewhere. An informal network could encourage replication of the project and improve the methodological approach.

2.7 Environmental Planning & Increased Biodiversity of Green Areas

This is of paramount importance in the environmental upgrading of any site. The haphazard evolution of open areas on the Ispra site resulted in the planting of many non-indigenous conifers and the asphalting of large areas around buildings. The Master Plan which seeks to reverse many of the more inappropriate developments, includes a Vegetation Plan, identifying three categories of open spaces. These are:- Designed Landscape in built-up areas, Semi-Natural Areas of meadows, open woods, ponds, etc. and truly Natural Regeneration Zones, which are wild areas with very little human influence. Unfortunately, by the end of 1996, the only action following the indications of the MasterPlan was the connection of meadows with wooded areas using appropriate plants. This will be completed during 1997.

3. Actions planned

The lion's share of the actions carried out so far and foreseen for the near future concerns buildings (see Tables 2.1 & 2.2). Although the aim of this project is to convert the Centre into a demonstration site for advanced low energy building systems, the impression remains that too little attention has been paid to other aspects. It has to be said, however, that the development and implementation of a Vegetation Plan is not an easy task and, by its nature, will take time.

Exhaustion of the European Parliament's initial funding will oblige the EcoCentre Project to rely, in future, on the normal maintenance budget together with some contributions negotiated from Institutes present on Site. New types of financing (e.g. Third Party) are also being investigated, although the latter appears to be legally and administratively very difficult. One difficulty stems from the fact that the JRC's research programme is agreed by the EU Council of Ministers for periods of only 4 years at a time. No agreements can, therefore, be entered into which commit expenditure for longer periods so that third party financing is ruled out, at least for the immediate future.

4. Monitoring Environmental Progress

Ecological indicators intended to measure the sustainability, environmental quality and habitability of an area, be it a region or an urban zone, can be found in the specialist literature /Ref. 6,7,8,9,10/. The choice of indicators is neither obvious nor objective, as there is no commonly accepted definition of environmental quality. In each context there are differences of attitude, policy and interest which hinder the acceptance of universally acceptable definitions. Moreover, many environmental effects which are important elsewhere may be either negligible or inapplicable in the Ispra context.

As a general rule, the indicators must satisfy a series of general criteria, as reported in the following Table.

Table 4-1. - Acceptability Criteria for Indicators (Alberti M., Soleri, Tsetsi 1994)

Validity:	adequacy for measuring a particular variable or effect
Objectivity:	reproducibility of results by various analysts in the same conditions
Sensitivity:	ability to detect the time dependence of a particular environmental condition
Anticipation:	ability to predict important environmental change phenomena
Measurability:	simplicity of measurement and quantification
Reliability:	reliability of the data on which the indicators are based
Comparability:	time and location independence of the definitions and measurement methods
Relevance:	ability to answer questions related to the actions to be undertaken
Effectiveness:	ability to answer questions related to cost
Clarity:	ease of correct interpretation

Different types of indicators, chosen on the basis of declared objectives, have been identified and can be classified as follows:

- *global indicators*, which refer to the overall situation (e.g. total consumption of primary energy or total emission of air pollutants from the Centre),
- *partial indicators*, which monitor important components of global indicators: e.g. consumption of heating, cooling, and electricity,
- *targeted (or action) indicators*, which monitor development of the situation concerning a particular action (e.g. recovery of green areas, recycling of used paper, purchase of electric or low emission cars, or improved of use of water treatment plant) and finally
- *specific indicators*, which refer to a given performance as a function of a specified use (e.g. standard performance with respect to number of people served or area of floor heated).

Homogeneous indicators have been grouped into categories corresponding to the main environmental fields of action. The indicators proposed, although grouped in 3 broad, main categories, cover 7 areas of possible action for the EcoCentre Project.

They are:
1. Consumption of Natural Resources:
   A) Energy,
   B) Ground,
   C) Water,
   D) Materials,
   E) Air (emissions)
2. Biodiversity (Flora and Fauna)
3. Human Involvement and Behaviour

The raw data for indicators are already routinely collected for other purposes, so that the collection cost is very low. Data gathering, co-ordination, and processing will be organised, after scientific approval and operational agreement. A total of 57 indicators has been identified - see Table 4-2 which, for reasons of space, lists only 21 of them.

Table 4-2. Partial List of Environmental Indicators Proposed for Ispra Site (1995)
N.B. Only those indicators relating to Energy (16 indicators) and Involvement and Behaviour (5 indicators) are shown

1. Resource Consumption Indicators		
Energy	**Unit**	**Value**
Global Indicators		
E1 Primary annual global energy from non-renewable sources	[GWh/a]	153
E2. Annual global consumption from renewable sources	[GWh/a]	73,6
E3. Total annual Fossil Fuel Consumption	[GWh/a]	70,6
E4. Annual heating cons. from non-renewable sources	[GWh/a]	63,0
E5. Annual cooling cons. from non-renewable sources	[GWh/a]	4,7
E6. Annual cooling cons. from industrial (lake) water	[GWh/a]	70,85
E7. Global annual electricity consumption (Energy delivered)	[GWh/a]	31,0
E8. Energy Signature of whole Centre	[MW/°C]	-9,52
Targeted Indicators		
E9. Heating Peak Demand	[MW]	12,9
E10. Cooling Peak Demand for Chilled Water	[MW]	9,0
E11. Cooling Peak Demand for Lake Water	[MW]	
E12. Electricity Peak Demand	[MW]	5,8
Specific Indicators		
E13. Global non-renewable En. Cons. per-capita	[kWh /a pers.]	4.800
E14. Global non-renewable En. Cons. per unit Floor Area	[kWh/a m2 glob.]	780
E15. Heating non-renewable En.Cons. per unit Floor Area	[kWh/a m2 heat]	322
E16. Electricity En. Cons. per unit Floor Area	[kWh /a m2]	158
3. Indicators of Involvement and Behaviour		
C1. Number of protected and safe bicycle parks	[No. of bike parks]	0
C2. Ratio of low or zero-emission vehicles to Number of service vehicles	[%]	0,74
C3. Annual EcoCentre Budget	[kECU/y]	5.000
C4. Total no. of people involved in EcoCentre activities	[No. people]	20
C5. No. of dissemination actions of EcoCentre project	[No./y]	10

With so many indicators it would be impossible to get a quick view of environmental progress. It has, therefore, been necessary to define aggregate indicators or indices to monitor the action areas proposed.

Usually an index is the weighted mean of various indicators of a set. In the present case, it would be incorrect to mix global with specific and partial indicators. Moreover, some indicators, although belonging to different areas, such as energy consumption and CO_2 emissions, are closely related, so that their combination would amount to counting the same effect twice. For these reasons, it was decided to derive 7 indices, one for each area of action, by simply choosing the most representative indicator of each area.

The following indicators have, therefore, been chosen to form the seven indices:

Energy:	E1	Primary ann. global energy cons. from non-renewable sources
Ground:	GR4	Extent of green areas
Water:	WR4.	Total amount of water to sewage plant
Materials:	MR3.	Number of products collected in different ways and recycled
Air Quality:	A2.	Total (direct + indirect) emissions of CO_2
Biodiversity:	B1.	Difference between number of individuals (plants) planted
Involvement and behaviour:	C3.	Annual EcoCentre Budget

5. Lessons Learned and Conclusions

The main lesson learned is that the single most important task, when projects of this type are undertaken, is to reach the widest possible consensus among all those likely to be involved in the project. This includes, of course, all those touched by the changes, from scientific managers planning new facilities to the occupants of buildings undergoing retrofits. Problems due to human relations, misunderstandings, changes of responsibilities, and so forth, are much more difficult to solve than technical and scientific ones. The implementation of an environmental upgrading plan has to be considered, first of all, as an action to improve the general cultural level.

Experience with this project has shown that there is a tendency for staff -
- not to understand the reasons for the work
- not to attend information meetings or read explanatory notes
- to complain that they have not been informed
- to consider that the money would have been better spent on research
- to complain if internal climate conditions are not perfect at all times
- to object to the time taken by computers and their periferals to wake up from “sleep” modes
- to misuse bins reserved for paper to be recycled
- to forget to turn off lights and computers when they are not needed

In this, they are probably typical of people everywhere, so that such behaviour has to be anticipated when planning a project such as this and every effort made to counteract the tendency.

- The involvement of top management is of fundamental importance. The goal should be to include environmental considerations in all management decisions. Without this step, the success of the project will always be at risk. The William Curtis Ecological Park, created near Tower Bridge, London, in 1977, is an illustration of this statement. A seven year effort by many volunteers to transform an abandoned area into a park, with a very high number of biological species, was nullified by the decision to construct office buildings on the site (Bettini V. 1996). The appointment of an expert energy & environmental manager, responsible for the whole project at a senior level, would have greatly improved the effectiveness of the project.
- Observation of the MasterPlan and Building Rules for the whole campus area is still far from guaranteed, even though they have been approved and adopted by the General Director, after a time-consuming debate among various experts and EcoCentre staff. More stringent rules for the granting of exemptions should be foreseen.
- Particular attention must be paid to administrative spending procedures when planning the timing of such a project. The adverse effects, on the Project, resulting from the incompatibility of the JRC’s budgetary procedure and the European Parliament’s lump sum funding have been discussed earlier. The problems caused by this pro-

cedure were
- hurriedly devised *ad hoc* organisational structure
- insufficient time to examine all options in detail and to optimise the choice of actions
- actions could not be carried out in the optimum order
- funds had to be spent on a few large projects such as building retrofit and new construction rather than on many, possibly more cost-effective, smaller actions.

Ideally, funding should be spread over a number of years.

- There should be direct communication between project experts and outside companies (builders and suppliers) to ensure that problems are identified and resolved quickly.
- Retrofit projects should be based not only on building and equipment specifications but also on required performance. For this, suitable measurement and verification procedures should be set up and forwarded to the building companies in good time. Moreover, contracts with outside companies must foresee precise time schedules and acceptance procedures based on guaranteed performance.
- Last but not least, a monitoring campaign linked to declared objectives should be set up in the early stages of the project and planned to continue for many years. Responsible personnel, indicators, and procedures for data collection, processing and reporting should be identified.

The upgrading of large areas of urban land is becoming a challenging field for the application of advanced energy efficiency & environmental techniques. Demonstrations are being made both for new and existing villages and campuses. Urban ecology is entering in a new phase in which theory is validated by real experience. The EcoCentre Ispra project represents one of the most recent and outstanding examples of this trend.

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