

Construction Related Sustainability Performance Indicators

theory, methodology & initial application

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1. Introduction

The big picture on this planet, and the long-term goal over the next century in Europe, is the conversion to **sustainable human and social development**, i.e. the creation of a sustainable 'built environment' within a flourishing 'natural environment', each co-existing with the other in harmony and dynamic balance, and each in their own way, capable of providing for responsible and equitable human, social, cultural and economic development.

The 1998 European Charter on Sustainable Design & Construction [a] has placed special emphasis on implementation through informed use of **construction related sustainability performance indicators**, i.e. setting targets and monitoring 'real' performance in the built environment, which includes buildings, civil engineering projects, transport, service support systems, and infrastructure.

In particular, Principle 26 of the European Charter states .....

' Harmonized short, medium and long-term strategies in the policy areas of energy efficiency, environmental protection and sustainable development should be planned for implementation in the European Union over the following time frames :-
(i) up to 2010 ; (ii) between 2011 and 2040 ; (iii) between 2041 and 2100.
Such is the threat to quality of life and human progress caused by current environmental degradation, and such is the great timelag between implementation of corrective actions and resulting beneficial environmental impacts, that sustainability performance should be benchmarked at year 1990 in the Member States of the E.U.
Detailed performance indicators for all stages of planning, design, construction / de-construction, maintenance and disposal should be used to target improvements in sustainability performance, verify target attainment, and continually re-adjust targets at appropriate intervals thereafter. '

This paper examines the theory and methodology of sustainability performance indicators for the European construction industry, and reports on the preparatory phase of an initial 'real' application in a mixed housing/industrial/commercial development in Ireland. The commencement of a related international study, which is being co-ordinated by CIB Working Commission 82, is also discussed.

2. Overview of the Long-Term Goal in Europe

- **Arriving at a Consensus on 'Sustainable Human and Social Development'**

  Europe must now decide whether its own future development, and its relationships with other global regions, will take the course of .....
  (i) 'business as usual' ;
  (ii) 'business as usual - but with a little cosmetic tinkering at the edges' ;
  (iii) 'sustainable human and social development' .

  The 1998 European Charter on Sustainable Design & Construction (updated in 2000) raises the issues which must be addressed, and the manner in which decisions should be made.

- **A Futures Scenario for Europe**

  The European Union already has an existing, highly evolved legal base which underpins an extensive array of policies and actions relating to energy, environment, sustainable development and social concerns. Together with regional specific, legally binding commitments arising from the 1997 Kyoto Protocol [b], Europe is well placed, and morally bound, to produce a comprehensive 'sustainability' strategy for the next century, with its core values being social justice and inclusion. The Amsterdam Treaty [c] makes the formulation of this strategy imperative.

- **Action Programme on Sustainable Design and Construction for the 21st Century**

  Critically, emphasis must be placed on creative and flexible planning, effective implementation, reliable monitoring and targeting of performance, and efficient management. Each function should be competently exercised.

  Essential components in the Action Programme are .....
  (i) an elaboration of appropriate, detailed construction related sustainability performance indicators - at European, regional and local levels ;
  (ii) practical and effective design guidance ;
  (iii) the production of sharp, focused construction and technical control research agendas.

3. Primary Purpose of Sustainability Performance Indicators

The primary purpose of Construction Related Sustainability Performance Indicators is to commence, in earnest, the practical task of implementing a sustainable approach to the future development and modification of the 'built environment' in Europe, while also playing our part in ensuring a flourishing future for the 'natural environment' by carrying out sufficient repair to past, present and potential future damage directly or indirectly caused by construction.

- Principle 26 of the 1998 European Charter on Sustainable Design & Construction intimated that a futures scenario should be developed which would cover the short, medium and long-terms until the end of the next century ;
- Using this futures scenario, incremental improvements in construction performance required to achieve a sustainable 'built environment' within a flourishing 'natural environment' may then be plotted. The focus of attention, throughout, must be on 'real', rather than theoretical, performance. See **Appendix A** for an example of one method of measuring 'real' performance in buildings [d] - long wave (8 to 12 microns) infra-red thermography ;
- Construction related sustainability performance indicators, 'harmonized' for application in the European Union, allow us to target, reliably quantify and monitor construction performance in the built environment which, by general international agreement, has been benchmarked at 1990 levels. Rigorous procedures are required to process the data generated in order to ensure that it too is reliable - see **Appendix B** for one example of such a procedure.

A secondary, short term purpose in Ireland will be to develop a sustainability rating system for buildings - a major departure from existing methods of energy and/or environmental rating. Based on the understanding of 'sustainable development' which is current, and generally held, at a particular time, this will allow an objective statement to be made about any individual building, facilitate comparison between different buildings, and also indicate more favourable approaches in the building design process itself.

4. Sustainable Development

'Sustainable Development' was defined in 1987 [e], as .....

' development which meets the needs of the present without compromising the ability of future generations to meet their own needs '.

However, with the benefit of twelve year's hindsight, a more evolved understanding of 'sustainable development' should also embody the following concepts :-

- the place of human beings in the environment, and the relationship between both **;**
- the nature of human, social, cultural and economic development, their current imbalances and inequities, and their future course **;**
- the healing of existing harm and injury to the 'natural environment'.

It is important to distinguish between the natural environment, and the 'built environment', i.e. anywhere there is, or has been, an intrusion or intervention by a human being in the natural environment. The 'built environment' may be urban, sub-urban, rural or marine **;** it includes buildings, civil engineering projects, transport, service support systems, infrastructure, etc.

Principle 1 of the Rio Declaration on Environment and Development [f] states .....

' Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.'

And the World Health Organisation, in the preamble to its Constitution, defines 'health' as .....

' a state of complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity '.

The 1994 Energy Charter Treaty [g] provides us with some useful definitions .....

Energy Cycle :

' The entire energy chain, including activities related to prospecting for, exploration, production, conversion, storage, transport, distribution and consumption of the various forms of energy, and the treatment and disposal of wastes, as well as the decommissioning, cessation or closure of these activities, minimising harmful environmental impacts. '

Environmental Impact :

' Any effect caused by a given activity on the environment, including human health and safety, flora, fauna, soil, air, water, climate, landscape and historical monuments or other physical structures or the interactions among these factors **;** it also includes effects on cultural heritage or socio-economic conditions resulting from alterations to those factors. '

As we near the end of the 20th Century, a small, but growing, consensus in Europe is finally acknowledging that in order to accommodate further human and social progress, with an assured minimum quality of life and health for all peoples, harmony between global regions, and world economic stability, it will be necessary to convert from current irresponsible patterns of human and social development, with their attendant wasteful environmental destruction and societal stresses.

However, it may take another 7-10 years before the concept of 'Sustainable Development' is either fully, or commonly, understood.

5. Unrestrained Activity in the 'Developed' World

The 'developed' world has long been characterized by an enormous consumption of resources. It was estimated, in 1998 [h], that 20% of the world's population in the highest income countries consumed 58% of total energy, while the poorest fifth consumed less than 4% - and that the burning of fossil fuels had almost quadrupled since 1950. A vast amount, therefore, of 'capital' has already been invested in this small part of the world. European cities, if we can ever clearly establish their boundaries anymore, represent but a small percentage of its land area.

In stark contrast, a similarly vast amount of natural resources have been 'requisitioned' and plundered from the 'underdeveloped' and 'developing' worlds in past centuries - and it continues to this day. As much of the adverse environmental impact arising from energy production occurs during the early stages of the cycle, countries in these global regions have been burdened with devastation of natural environments, and an accumulation of wastes, emissions and pollution associated with extraction.

6. Limitations of 'Kyoto' as a Driving Force Scenario

The Kyoto Protocol - agreed at the 3rd. meeting of the Conference of the Parties (COP 3) to the United Nations Framework Convention on Climate Change in Kyoto, Japan during December, 1997 - for the first time set legally binding targets, at international level, for different regions of the 'developed' world to limit emissions of an aggregate of six more greenhouse gases : CO_2 , CH_4 , N_2O , PFC's , HFC's , and SF_6 . However, limitation of greenhouse gas emissions is only one aspect of performance which must be targeted - a point specifically mentioned in the Presidency Conclusions [j] of the Cologne European Council (June, 1999).

In the European Union, political commitment of the Council, a clear legal basis in recent legislation, the urgent assignment of the Commission to implement policies on sustainable development, more balanced economic progress, social justice and inclusion, etc., and strong public support for such policies, are generating sufficient pressure to force a radical change of pace on what is still a traditional, inefficient and wasteful major industrial sector - construction. Sustainability performance targets for the 'built environment' must now be set down, monitored, and stringently controlled.

It is important, therefore, to produce a futures scenario in order to clarify the nature of the task in front of us, the actions and timescales required, and the paths to be taken. The following areas should be examined in such a futures study which will cover short, medium and long-terms up to the year 2100, with performance benchmarked back to 1990 levels .....

- Methods of effectively conserving energy which is derived from natural resources ;
- Cleaner energy from existing sources ;
- Introduction of the next generation energy sources, e.g. nuclear fusion ;
- Extension and enhancement of carbon sinks & carbon technologies ;
- Innovative 'SEED' technologies, covering production and services ;
- Control of ozone depletion / global warming gases, and the attainment of atmospheric integrity ;
- Achievement of social justice and inclusion for every 'person' in society ;
- Enhancement of the 'natural environment' by means of sufficient human repair to past injury in order to encourage a process of self-healing, and self-management.

See **Appendix C - 'New Earth 21' Strategy** for the region of Europe (based on Japanese work [k] from the early 1990's).

7. Our Responsibility - To Target Sustainability Performance

At global level, the Implementation Plan for the United Nations Commission on Sustainable Development (UNCSD) Work Programme on 'Indicators of Sustainable Development' is now in its 3rd Phase : January 1998 until January 2001. An initial Working List of Indicators [l] has already been produced which is intended for global application. It is, therefore, necessarily general in nature (and not at all construction related). These indicators cover four aspects of Sustainable Development, i.e. **Social**, **Economic**, **Environmental**, and **Institutional**, and are presented in a **Driving Force - State - Response** framework ; trial application is taking place in four global regions : Africa, Asia & Middle East, Europe, Americas & Caribbean.

See **Appendix D - Fundamental Matrix** of construction related sustainability performance indicators.

8. A Reasonable Target for the Construction Industry in Europe

Encouraged and 'incentivized' by institutional and administrative frameworks at E.U., regional and local levels, a reasonable target for construction related performance, in the short term, must be to meet the criterion of 'economic viability and technical feasibility', based on accurate life cycle costing, and using proven state-of-the-art technology which is readily available in the European marketplace. Anything less is unacceptable.

EN ISO 14040 [m] defines **Life Cycle Assessment** as follows .....

> ' Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product (and/or service) system throughout its life cycle. '

9. 'Life Cycle' of a Building

The many actors and disciplines involved in the European construction industry each have their traditional views and opinions concerning the different stages, and the duration, of a building's life cycle. Generically, however, we may identify the following ten segments in a complete cycle .....

- Expressed needs / wants / desires / requirements of the client ;
- Planning brief and performance specification for the building ;
- Site analysis and evaluation ;
- Design ;
- Preparation for construction ;
- Construction ;
- 'Early life' of the building in use - including management, maintenance, servicing ;
- Adaptable 'middle age' of a building in use - including renovation, refurbishment, modification, alteration, and extension ;
- De-Construction ;
- Disposal .

With adequate emphasis placed on 'adaptability' throughout the design stage of a building, and quality of construction on site, it must be a requirement - to realize the target of a sustainable 'built environment' - that the minimum duration of that building's life cycle will be in the order of .....

for structure	100 – 200 yrs ;
for the building fabric	50 – 100 yrs ;
for services	20 – 30 yrs ;
for furniture & fittings	10 – 20 yrs .

10. A Proper Basis for Harmonized E.U. Indicators

Initially, those areas of construction related performance which are particular to regional, climatic and site conditions in the many different parts Europe, or are of concern to people in those areas involved in the design, construction, servicing, maintenance, use and/or de-construction of buildings, should be closely examined. Potential means for encouraging / 'incentivizing' implementation at these levels should also be investigated, e.g. financial instruments, development/management computer tools, planning, design and construction guidance, institutional reform, streamlining of legislation, etc.

The development of a national bank of construction related data and statistics in each Member State, which will feed directly into the framework controlled and managed by Eurostat in Luxembourg, will be a necessity. All statistics gathered should be impartial, reliable, objective, scientifically independent, cost-effective and statistically confidential [n] - E.U. Amsterdam Treaty.

Work at regional / national, and local levels will provide a proper basis for the later production of 'harmonized' E.U. sustainability performance indicators. See **Appendix E** for the beginning of this process in Ireland. The Forum on Sustainable Construction, established in the winter of 1997, comprises representatives from Irish industry, the practicing professions, the national building research organization, education, and public bodies. Since a meeting in Barcelona, during December 1998, similar studies have commenced, or are about to commence, in many other countries around the world. This project is being co-ordinated by CIB Working Commission 82 : 'Futures Studies in Construction'.

11. Adaptation of Existing Buildings & Urban Districts - Particularly Those of Cultural, Historical or Architectural Importance

A major challenge for the European construction industry, in the short term, will be the refurbishment / modification / alteration / extension of existing building stock, and derelict or contaminated lands in urban centres. By the year 2010 in Ireland, for example, houses built before 1980 (representing just 50 % of total housing stock) will account for 80 % of that market segment's energy consumption.

With regard to buildings of cultural, historical or architectural importance, the difficulty is increased because of the absolute necessity of respecting the original integrity of the building - consult the Venice Charter [o]. Our aim here must be to protect and conserve, but also to sustainably exploit the wealth and value of cultural heritage as an important ingredient in 'social wellbeing'.

12. Construction Related Sustainability Performance Indicators

Some examples of the wide range of required urban sustainability performance indicators, which must be mutually compatible across all fields of design, construction and logistics, might be as follows .....

- Unit area of derelict land / buildings in an urban area, per person ;
- Impact of an urban area on global climate ;
- Periods during which external air quality in the city adversely affects human health ;
- Quantity of wastes, per person, generated, re-used, recycled, and finally disposed ;
- Use / consumption of energy, per person ;
- Use / consumption of water, per person ;
- Maximum distance travelled (un-aided) to nearest transportation node ;
- 'Social wellbeing' of neighbourhoods in a city (long term unemployment, homelessness, numbers of people below the poverty line, or living in inadequate housing, 'fuel poverty', illiteracy, etc.) ;
- Rates of crime / anti-social behaviour ;
- Life expectancy of inhabitants & rates of illnesses, accidents and fatalities ;
- Percentage of construction costs required to be expended on incorporating works of art ;
- Reliability, accessibility, efficiency and affordability of public services ;
- Accessibility and health / safety of an urban environment for people with disabilities ;
- Quality of public open spaces ;
- Free access to activities / institutions of cultural, artistic or historical interest ;
- Transparency of city governance & 'meaningful' participation of the citizen.

See **Appendix F** - initial application of a sample of indicators (building related) in a mixed use development project in Ireland. Construction will commence early in 2000.

See **Appendix G** - finished examples of some detailed building related sustainability performance indicators, in functional, performance and prescriptive formats, which are ready to be transposed into legislative instruments, standards, guidance documents, etc., at any level of the European Union.

Once a substantive body of 'harmonized' E.U. construction related sustainability performance indicators has been produced, the final objective will be to surgically insert these indicators into the framework of the existing UNCSD Working List of Indicators, already mentioned in **#7** above.

13. Sustainable Human and Social Development

Realistic implementation of a strategy for 'sustainable human and social development' in Europe will be a complex, phased, cyclical and iterative process ; it will not be easy, and it will certainly involve considerable financial cost. To be gained, however, will be 'social wellbeing' - an overall state of health and happiness in society.

This option, for the construction industry, will be characterized by .....

(i) Consensus, on a common understanding of sustainable human and social development, by all elements of this industrial sector - working in 'partnership' ;

(ii) Establishment of a reliable, construction related databank in each E.U. Member State - which will interlink directly with Eurostat in Luxembourg ;

(iii) Completion of the Fundamental Matrix shown in **Appendix D** - at all appropriate levels ;

(iv) Meeting initial construction related targets - and then reviewing, re-adjusting and improving the next round of indicators based on 'real' performance feedback ;

(v) Continual repetition of the above 'indicator' cycle ;

(vi) Introduction of a wide range of positive incentives to encourage acceptance, by all elements of the construction industry, of the necessary burdens and change in practices required to convert to sustainable design and construction ;

(vii) Substantial E.U. and national expenditure on construction and technical control related research, and on practical implementation guidance, training and education ;

(viii) Dramatic improvement in construction related education programmes, at all levels, throughout Europe - to develop creative and flexible thought, and to instil a 'person-centred' and 'socially inclusive' approach in the planning / design / construction of a sustainable 'built environment' ;

(ix) Protection of cultural heritage - and 'indigenous' architecture and methods of building.

14. References

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[b] UNFCCC - The Kyoto Protocol **:** 1997
Agreed at the 3rd. meeting of the Conference of the Parties (COP 3) to the United Nations Framework Convention on Climate Change. Kyoto, Japan. December, 1997. This Protocol sets legally binding targets for different regions of the 'developed world' to limit emissions of an aggregate of six more greenhouse gases **:** CO_2 , CH_4 , N_2O, PFC's , HFC's , and SF_6 .

[c] E.U. Amsterdam Treaty (97/C 340/01)
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[m] EN ISO 14040 : 1997
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[n] E.U. Amsterdam Treaty (97/C 340/01) - New Article 213a in the TEC.

[o] International Charter for the Conservation and Restoration of Monuments and Sites
International Council of Monuments and Sites (ICOMOS). Venice, Italy. May, 1964.

15. Appendices (Available on our WebSite : **www.sustainable-design.com**)

A Long Wave (8 to 12 microns) Infra-Red Thermography - Sample Exterior and Interior Views
B Technical Guidance Note No. 95/101(a) - Energy Survey Reports
C A Futures Scenario for Europe - 'New Earth 21' Strategy
D Fundamental Matrix of Construction Related Sustainability Performance Indicators
E Commencing the Process at National Level
F Initial Application of Indicators in Ireland - Building Related Sample
G Selection of Finished Sustainability Performance Indicators