The Integrated Design Process

The Integrated Design Process (IDP) has been developed on the basis of experience gained from a small Canadian demonstration program for high-performance buildings, the C2000 program. This program was designed in 1993 as a small demonstration of very high levels of performance, and its technical requirements cover energy performance, environmental impacts, indoor environment, functionality and a range of other related parameters. The ambitious performance goals of the program led its managers to believe that the incremental costs for design and construction would be substantial, and provision was made for support of incremental costs in both the design and construction phase.

However, after the first six projects were designed and two of them had been completed, it was found that that incremental capital costs were less than expected, partly due to the fact that designers used less sophisticated and expensive technologies than anticipated. Despite this, the projects reached the required performance targets. The designers all agreed that application of the design process required by the C-2000 program was the main reason why high levels of performance could still be reached. It also appeared that most of the benefit of intervention was achieved during the early stages of the design process.

The C-2000 process is now called the *Integrated Design Process* (IDP), and most project interventions are now focused on providing advice on the design process at the very early stage of design. Eight projects have been constructed on this basis, and all have achieved the C-2000 performance requirements, or have come very close, and capital costs have been either slightly above or slightly below base budgets. The most hopeful sign that the IDP approach is taking root is that several owners have subsequently used the same process for buildings that have not benefitted from any subsidy.

The Conventional Design Process

In order to understand what the IDP is, it is useful to first characterize the more conventional design process. The process often begins with the architect and the client agreeing on a design concept, consisting of a general massing scheme, orientation, fenestration and, usually, the general exterior appearance as determined by these characteristics as well as by basic materials. The mechanical and electrical engineers are then asked to implement the design and to suggest appropriate systems.

Although this is vastly oversimplified, such a process is one that is followed by the large majority of general-purpose design firms, and it generally limits the achievable performance to conventional levels. The traditional design process has a mainly linear structure due to the successive contributions of the members of the design team. There is a limited possibility of optimization during the traditional process, while optimization in the later stages of the process is often troublesome or even impossible. For example, little advantage may be taken of passive solar potential, there may be excessive exposure to high solar gain during the summer, and poor daylighting and discomfort for the occupants.

All these potential outcomes reflect a design process that appears to be quick and simple, but actual results are often high operating costs and an interior environment that is sub-standard; and these factors in turn may greatly reduce the long-term rental or asset value of a property. Since the conventional design process usually does not involve computer simulations of predicted energy performance, the resulting poor performance and high operating costs will most often come as a surprise to the owners, operators or users.

If the engineers involved in such a process are clever, they may suggest advanced, high-performance heating, cooling and lighting systems, but their inclusion at a late stage in the design process will result in only marginal performance increases, combined with considerable capital cost increases. The underlying cause is that the introduction of high-performance systems late in the design process cannot overcome the handicaps imposed by initial incompatible or otherwise poor design decisions.

The Integrated Design Process

The Integrated Design Process has impacts on the design team that differentiate it from a conventional design process in several respects. The client takes a more active role than usual; the architect becomes a team leader rather than the sole form-giver; and the structural, mechanical and electrical engineers take on active roles at early design stages. The team always includes an energy specialist and, in some cases, an independent Design Facilitator.

The IDP process contains no elements that are radically new, but integrates well-proven approaches into a systematic total process. The skills and experience of mechanical and electrical engineers, and those of more specialized consultants, can be integrated at the concept design level from the very beginning of the design process. When carried out in a spirit of co-operation among key actors, this results in a design that is highly efficient with minimal, and sometimes zero, incremental capital costs, along with reduced long-term operating and maintenance costs. The benefits of the IDP process are not limited to the improvement of environmental performance. Experience shows that the open inter-disciplinary discussion and synergistic approach will often lead to improvements in the functional program, in the selection of structural systems and in architectural expression.

The IDP process is based on the well-proven observation that changes and improvements in any design process are relatively easy to make at the beginning of the process, but become increasingly difficult and disruptive as the process unfolds. Although this may seem obvious, it is a fact that most clients and designers have not followed up on the implications. As well, the existence of a defined roadmap gives credence and form to the process, making it easier to promote and implement.   Typical IDP elements include the following:

- inter-disciplinary work between architects, engineers, costing specialists, operations people and other relevant actors right from the beginning of the design process;
- discussion of the relative importance of various performance issues and the establishment of a consensus on this matter between client and designers;
- budget restrictions applied at the whole-building level, with no strict separation of budgets for individual building systems, such as HVAC or the building structure. This reflects the experience that extra expenditures for one system, e.g. for sun shading devices, may reduce costs in another systems, e,g, capital and operating costs for a cooling system;
- the addition of a specialist in the field of energy engineering and energy simulation;
- testing of various design assumptions through the use of energy simulations throughout the process, to provide relatively objective information on this key aspect of performance;
- the addition of subject specialists (e.g. for daylighting, thermal storage, comfort, materials selection etc.) for short consultations with the design team;
- clear articulation of performance targets and strategies, to be updated throughout the process by the design team; and

- in some cases, a Design Facilitator is added to the team to raise performance issues throughout the process and ensure specialist inputs as required.

Based on experience in Europe and North America, an IDP is especially characterized by a series of design loops per stage of the design process, separated by transitions with decisions about milestones. In each of the design loops the design team members relevant for that stage participate in the process.

The design process itself emphasizes the following broad sequence.

1. Establish performance targets for a broad range of parameters, and develop preliminary strategies to achieve these targets. This sounds obvious, but in the context of an integrated design team approach it can bring engineering skills and perspectives to bear at the concept design stage, thereby helping the owner and architect to avoid committing to a sub-optimal design solution.
2. Minimize heating and cooling loads and maximize daylighting potential through orientation, building configuration, an efficient building envelope and careful consideration of the amount, type and location of fenestration.
3. Meet heating and cooling loads through the maximum use of solar and other renewable technologies and the use of efficient HVAC systems, while maintaining performance targets for indoor air quality, thermal comfort, illumination levels and quality, and noise control.
4. Iterate the process to produce at least two, and preferably three, concept design alternatives, using energy simulations as a test of progress, and then select the most promising of these for further development.

The process diagram and the outline of IDP steps shown in Appendices 1 and 2, give some idea of how IDP may be applied to a typical design project.

Future applications of IDP

One of the interesting lessons of using IDP is that, unlike many other design support methods or systems, it is applicable to a wide range of situations and building types. Thus, even though IDP was developed for a few building types and assumed new construction, the approach has now been applied to a wide variety of building types and to renovation projects.

We foresee a wide application of the IDP around the world. A generic international version has been developed within Task 23, a working group of the International Energy Agency. What is needed now are the resources to develop supporting software and to develop an educational campaign for international use, especially to developing countries.

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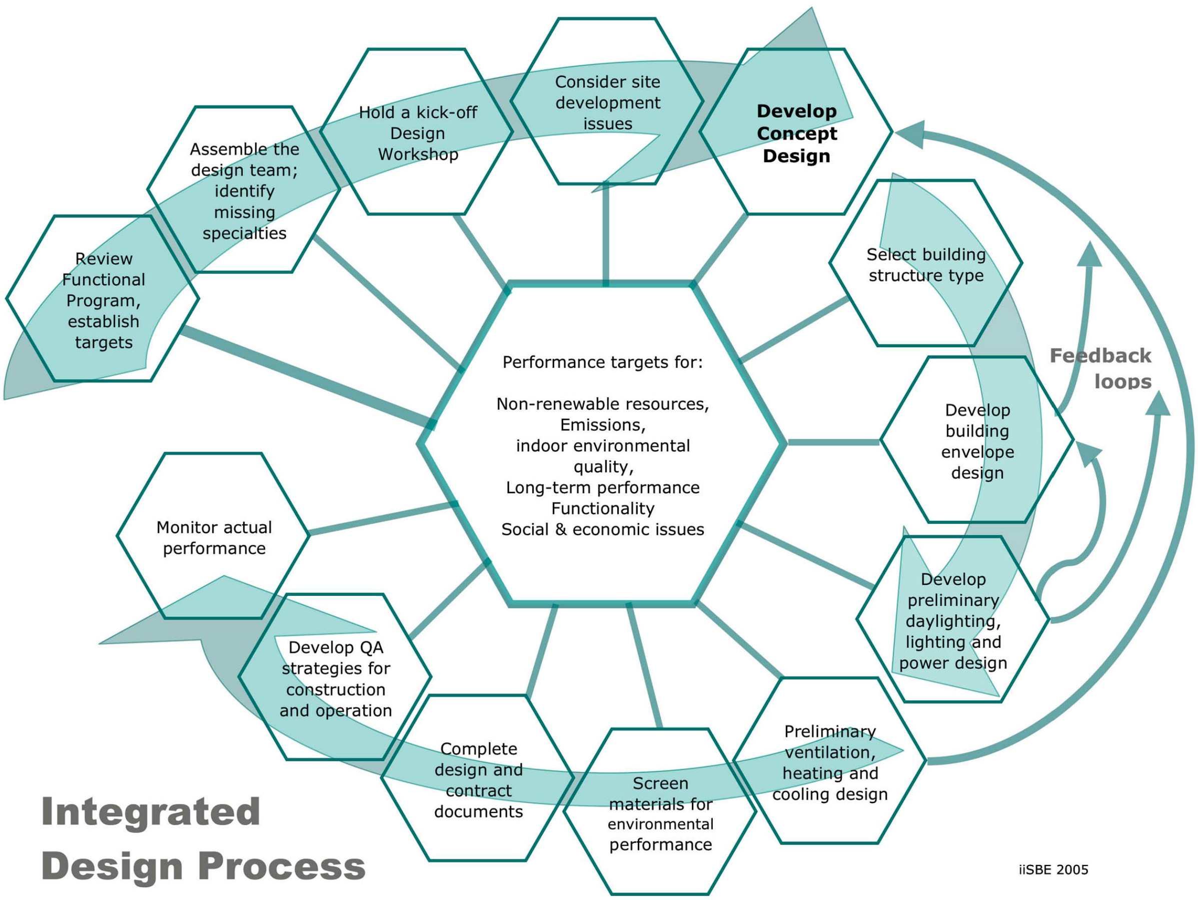
Appendix 1: Graphic representation of the IDP Process



Appendix 2: Generic steps in the IDP Process

A. Assess site conditions

01	A01	Assess soil stability and bearing strength
02	A02	Assess the ecological quality of the site
03	A03	If a brownfield site, take steps to remediate conditions
04	A04	Examine soil for presence of radon
05	A05	Identify any features in adjacent properties that may place constraints on the design of the subject building
06	A06	Assess suitability of any existing structure(s) on the site for adaptation to the new uses planned for the site.
07	A07	Identify approximate gross area of existing structure on the site that can be totally or partially re-used.
08	A08	Assess suitability of materials and components in any existing structure(s) on the site for re-use in the new building(s) planned for the site.
09	A09	Prepare a Site Conditions Report

B. Examine program; establish performance targets and strategies

10	B01	Determine if the proposed space requirements can be satisfied by renovations instead of new construction.
11	B02	Consider possible impact of location on the transportation requirements of the facility.
12	B03	Assess the capacity of the functional program to support mixed uses and green operations.
13	B04	Confirm client's commitment to supporting measures required for high performance.
14	B05	Develop an initial statement of performance goals, targets and supporting strategies.
15	B07	Ensure that the program is capable of supporting high performance.
16	B07	Review budget and pay-back requirements for compatibility with performance goals.
17	B08	Prepare a *Functional Program and Performance Goals Report.*

C. Assemble the Design Team

18	C01	Ensure that the proposed design team is aware that the project has high-performance goals.
19	C02	Identify and retain design team members with skills and experience related to the program.
20	C03	Ensure that contract conditions do not create a disincentive for the mechanical engineer.
21	C04	If the budget permits, include performance incentive payments in contracts for the principal designers.

D. Hold a Design Workshop

22	D01	Develop schematic drawings for a reference or baseline design with minimal performance.
23	D02	Carry out energy simulations for the reference building.
24	D03	Invite design workshop participants, including the client, design team and specialists.
25	D04	At the workshop, table the energy simulations to provide a starting point for discussion.
26	D05	Develop two or three schematic options for improved performance.
27	D06	Hold an open discussion on performance, cost and other implications.
28	D07	Carry on with more detailed development of the most attractive option after the workshop, including preliminary energy simulations or estimates.
29	D08	Add new talent to the design team if necessary.
30	D09	Summarize the results of the workshop in a *Design Workshop Report*, and distribute to all stakeholders

E. Consider site development issues

31 E01 Minimize building footprint on site.
32 E02 Minimize loss of solar or daylight potential of adjacent property.
33 E03 Consider measures to minimize impacts on subsurface ecology and aquifers.
34 E04 Develop preliminary landscape plans to provide windbreaks, shading, and to minimize water demand.
35 E05 Ensure that the building will form a positive contribution to the streetscape.
36 E06 Carry out an Environmental Impact Assessment.
37 E07 Summarize site development issues in a *Draft Site Impact Plan*.

F. Develop Concept Design.

38 F01 Finalize performance targets
39 F02 Develop a concept plan, using functional requirements as a starting point.
40 F03 Orient the building to optimize passive solar potential, and relate fenestration requirements to orientation.
41 F04 Establish configuration & floor plate depth to balance daylighting & thermal performance.
42 F05 Consider the possible roles of natural, hybrid or mechanical ventilation systems.
43 F06 Consider whether cooling will be needed.
44 F07 Examine the potential role of renewable energy systems.
45 F08 Examine the most efficient forms of non-renewable heating, cooling and ventilation systems.
46 F09 Determine floor-to-floor heights, taking into account possible future uses.
47 F10 Carry out a first set of detailed energy simulations or energy analysis.
48 F11 Prepare the *Concept Design Report.*

G. Select building structure.

49 G01 Consider column spacing and core position.
50 G02 Consider measures to reduce embodied energy of the structure.
51 G03 Consider thermal storage options using the structure as a heat sink.
52 G04 In residential occupancies, consider appropriate balcony design.
53 G05 Decide on building structure type taking into account the considerations above.

H. Develop building envelope design

54 H01 Select basic exterior wall systems.
55 H02 Assign fenestration on each orientation to optimize daylighting and thermal benefits
56 H03 Optimize the daylighting and thermal performance of fenestration.
57 H04 Consider the use of operable windows.
58 H05 Consider measures to reduce the embodied energy of the building envelope.
59 H06 Optimize envelope detailing and thermal performance
60 H07 Carry out a second set of detailed energy simulations

J. Develop preliminary lighting and power system design.

61 J01 Develop preliminary lighting system design.
62 J02 Develop preliminary lighting control system.
63 J03 Estimate the power requirements for future tenant and occupant equipment.
64 J04 Optimize the energy efficiency of vertical transportation systems.
65 J05 Develop strategies to shave peak demand.
66 J06 Summarize lighting issues for *Comfort and Productivity Performance Plan.*

K. Develop preliminary Ventilation, Heating and Cooling system designs.

67 K01 Develop preliminary ventilation system design.
68 K02 Develop preliminary design for heating central plant.
69 K03 Develop preliminary design for cooling central plant.
70 K04 Consider thermal storage options using mechanical systems.
71 K05 Develop preliminary design for ventilation, heating, and cooling delivery systems.
72 K06 Develop preliminary ventilation, heating and cooling control systems.
73 K07 Complete energy simulations assessing whole building design performance.
74 K08 Summarize HVAC issues for the *Comfort and Productivity Performance Plan.*
75 K09 Prepare a *Design Development Report.*

L. Select materials.

76 L01 Minimize use of materials or components that rely on scarce material resources.
77 L02 Select materials that balance durability and low embodied energy.
78 L03 Consider re-use of components and recycled materials.
79 L04 Design assemblies and their connections to facilitate future demountability.
80 L05 Select indoor finishing materials to minimize VOC and other emissions.

M. Complete design and documentation.

81 M01 Complete site development plan to minimize potable water consumption.
82 M02 Design plumbing and sanitary systems to minimize water consumption.
83 M03 Complete appropriate rain screen and pressure equalization envelope details.
84 M04 Finalize lighting system design.
85 M05 Finalize ventilation, heating, and cooling system designs.
86 M06 Confirm adequate space exists for data and communications systems.
87 M07 Select building energy management control systems.
88 M08 Review the use of materials to minimize waste.
89 M09 Carry out a final set of energy simulations.
90 M10 Produce a final *Longevity and Adaptability Plan*
91 M11 Prepare a final *Life Cycle Cost Report.*
92 M12 Produce a final *Occupant Comfort and Productivity Plan*.

N. Develop QA strategies for construction.

93 N01 Develop plan to minimize C&D wastes during construction.
94 N02 Develop *Final Site Impact Management Plan.*
95 N03 Develop a *Final Quality Assurance Plan*
96 N04 Develop a *Commissioning Plan* for all major systems.
97 N05 Prepare the *Pre-Construction Report.*

P. Develop QA strategies for operation.

98 P01 Appoint an owner's Commissioning Agent.
99 P02 Develop a maintenance plan.
100 P03 Develop a *Final Environmental Impact Management Plan.*
101 P04 Develop lease instruments with tenant incentives to operate space efficiently.
102 P05 Train building staff to operate equipment efficiently.
103 P06 Prepare a *Project Completion Report.*

Q. Monitoring

104 Q01 Owner / Operator to provide reports on operations, maintenance, & utility bills.
105 Q02 Carry out a Post-Occupancy Evaluation (POE) study