Integrated Design Process: theory, history, demonstrations

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iiSBE at a glance

- An international non-profit organization;
- Focus on guiding the international construction industry towards sustainable building practices;
- Emphasis is on research and policy, with a special emphasis on information dissemination, building performance and its assessment;
- 23 Board members from 20 countries;
- Secretariat is in Ottawa and Paris;
- Local chapters exist in Chile, Czech Republic, Israel, Italy, Portugal, Spain and Taiwan, others are being formed in Poland and Malaysia, and associated organizations exist in Mexico and Brazil;
- Andrea Moro is President, Nils Larsson is XD;
- No paid staff, very active network
We try to ensure that our new and existing buildings reach very high levels of performance, especially in energy and emissions; this is partly a matter of establishing goals and performance targets; to reach these targets we need design and systems integration; and that cannot be achieved without changing normal processes.
What is a **green** building?
- One that maximizes environmental performance;

What is a **sustainable** building?
- It should address a full range of environmental, social and economic issues;
- That is a lot to ask of a small fast-food shop…
- So, we need very large projects or even communities, where such a breadth of goals can be meaningful;
- Or else we have to accept that we may fulfill some, but not all, of the goals;
- And to assume that our very high-performance project may at least help our city or country move towards sustainability.

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The options: Green and Sustainable Building

- Fuel consumption of non-renewable fuels
- Water consumption
- Land consumption
- Materials consumption
- Greenhouse gas emissions
- Other atmospheric emissions
- Impacts on site ecology
- Solid waste / liquid effluents
- Indoor air quality, lighting, acoustics
- Maintenance of performance
- Longevity, adaptability, flexibility
- Efficiency
- Earthquake & other forms of security
- Social and economic considerations
- Urban / planning issues
Establishing performance targets

Mainstream developers and designers have not worried much about performance of their buildings, except for their financial viability;

Performance varies widely even where it is known, and most building operators have no idea how well their buildings perform;

If we now have investors, developers and designers taking an interest in performance that goes beyond cost, we have to develop some targets to guide the design process;

One starting point is to think in terms of Minimum Acceptable performance, Good Practice and Best Practice;

And these should be expressed, where possible, in a numerical and measurable form (ekWh/m², Lpp*yr etc.)
The simplest way

- *Minimum Acceptable* performance, using regulations or local industry norms as the benchmarks;
- *Good Practice*, which is a little vague, but definable by an expert group;
- *Best Practice*, defined as the best technically possible, given budget flexibility -- up to 10%?
- *Best Practice* could also be defined as the distance to an absolute target, e.g. how far do you have to go to reach 10 or even zero kg/m² of GHG emissions; but there are some practical difficulties in defining what the absolute target should be.

<table>
<thead>
<tr>
<th>Performance Goals</th>
<th>Community Scale</th>
<th>Building Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regenerative</td>
<td>Bring ecosystems back to full health</td>
<td>N.A.</td>
</tr>
<tr>
<td>Sustainable</td>
<td>Minimal negative net impact on ecological, social and economic systems</td>
<td>Life-cycle emphasis; net zero greenhouse gas emissions; fixed energy to the grid, very low consumption of water or virgin materials</td>
</tr>
<tr>
<td>Green</td>
<td>Substantial improvement in environmental performance</td>
<td>Main emphasis still on energy and water operating performance, in the top 25% of new buildings; reduced ecological impacts</td>
</tr>
<tr>
<td>Good Practice</td>
<td>Performance achieved</td>
<td>Main emphasis on energy, water and cost operating performance, in the top 50% of new buildings;</td>
</tr>
<tr>
<td>Regulation</td>
<td>Meet minimum regulations and/or industry practice</td>
<td>Some effort to improve operating energy performance, but not much else</td>
</tr>
<tr>
<td></td>
<td>Infrastructure and planning issues are seen as being quite separate</td>
<td></td>
</tr>
</tbody>
</table>
Why is it difficult to achieve such results?

Specific barriers to the widespread adoption of sustainable building practices

- Limited market demand for high performance buildings;
- Actual or perceived cost of building to a high level of performance;
- Lack of simple funding mechanisms to pay for incremental performance;
- Difficulty of measuring environmental performance in an objective and reliable way;
- Increasing requirements for specialized skills and knowledge in the design process;
- Skills deficits in small design firms;
- Making bad decisions early in the design process.
Problems in the conventional process

- The architect may develop a concept design that is agreed to by the client;
- After both parties are committed, then engineers and other key actors are brought in, to ensure that the chosen concept can perform as efficiently as possible;
- That is too late, and the design’s performance potential may be limited from its inception;
- There are also new specialties, such as daylighting, thermal storage etc. that require skills not often found in conventional design firms;
- At a later stage, there may be attempts to graft high-performance technologies on to the design, but that is usually an expensive failure.

The Conventional Process

Design iterations are inevitable in any design process, but they only make a positive contribution if carried out early in the process.
Unsuccessful solar control strategies

Too much; and it is the new British Library!

Too late when the heat has already come through the outer glazing layer.

Problems in daylighting – bad lighting control or non-acceptance by occupants
Introduction to IDP
The design process

- Coming back to the best way of reaching our performance targets, we can be more specific in the kinds of system behavior we want, and what sequence of steps might be most logical to support this goal.

Process issues raised in considering performance goals

- Site and program
  - Optimize efficiencies in functional program;
  - Renovate an existing building if it can fulfill functional requirements after a refit;
  - If new construction is needed, select a site with access to public transport and favourable microclimate, giving preference to the re-use of a brownfield site and avoiding use of site with ecological or agricultural value;
  - Maintain and enhance existing ecology on site;
  - Re-use any existing structures on the site if potentially suitable for requirements, re-use materials on or off site if possible, and use recycled materials;

- Envelope
  - Ensure that the design provides massing and orientation for maximum passive solar benefit;
  - Ensure optimum thermal performance of the building envelope;
  - Decide on fenestration location, area, shape and glazing type to maximize daylighting while minimizing excessive solar gain or heat loss;
  - Provide exterior shading (natural and/or designed) where needed to reduce excess solar gain;
Critically important design strategies and measures

- Minimize use of energy-using systems
  - Maximize use of daylighting to reduce the need for artificial lighting;
  - Consider the use of natural or hybrid ventilation to eliminate or reduce the need for mechanical ventilation / cooling systems;
  - Use off-site and on-site renewables to minimize use of non-renewable fossil fuels;
- Use efficient systems to handle residual energy-using requirements
  - Provide an efficient artificial lighting and control system;
  - Use very high performance mechanical systems (chillers, boilers, motors, pumps, controls);
- Ensure effective operational management
  - Ensure a high level of skills and knowledge of operating staff;
  - Provide an effective building management control system;
  - Provide a logbook and ensure that performance is monitored;

The design process

- And then we can consider formalizing the sequence of design steps that might be needed to support the system performance goals;
- That is what integrated design process (IDP) or integrated energy design (IED) is all about.
Integrated Design Process

- Experience indicates that changes in the design process can make major contributions to the performance of buildings;
- The *Integrated Design Process* (IDP), developed in Canada and Europe has shown this empirically;
- Primarily developed in the NRCan C-2000 program during the 1994-2003 period;
- International guidelines for IDP were also developed in IEA Task 23;
- IDP is promoted in LEED, and is currently being explored further in Europe under the name of Integrated Energy Design;
- We are not claiming to have discovered something new, but have applied old principles that are not being widely used;
- Process integration can lead to systems integration and high performance.

What is IDP?

- IDP is a method to intervene in the design stage to ensure that all issues that can be foreseen to have a significant impact on sustainable performance are discussed, understood and dealt with at the beginning of the design process;
- IDP helps the client and architect to avoid a sub-optimal design solution;
- Integrated design process results in an integrated systems approach, and that can have many positive results;
- It enables the achievement of high levels of building performance through integrated systems design.
Key elements in IDP

- A committed or at least open-minded client;
- A multi-disciplinary design team committed to high performance;
- A design facilitator and others with specialized supporting skills in energy, ecology, indoor environment, materials, costing, etc. Include also a senior level university student to act as recorder;
- Development of a reference case design, including energy analysis;
- An initial workshop or charrette, including all relevant actors, to table the reference design and to generate a full spectrum of ideas for one or more high-performance options;
- Additional workshops at key points in the process, involving all relevant actors;
- The use of energy and other simulation tools to assess potential performance during the design development process;
- Selection of a design option based on a full cost-benefit assessment before contract documentation begins.
Review Functional Program, establish preliminary targets

Assemble the design team; identify, missing specialties

Develop a conventional reference design

Assess the conditions of site and any existing structures

Performance targets for:
- Environmental Loadings
- Non-renewable resources
- Long-term performance
- Social & economic issues

Monitor actual performance; optimize performance

Develop Concept Design

Preliminary ventilation, heating and cooling design

Develop preconception design(s)

Consider site issues, issues, and opportunities

Screen materials for environmental performance

Complete detailed design and contract documentation

Complete construction, commissioning, and deconstruction

Develop QA strategy for construction and operation

Integrated Design Process

Integrated Design Process
Carry out daylighting, IAQ and ventilation assessment.

Carry out a detailed energy simulation.

Perform Life Cycle Analysis (LCA) for embodied en./emissions.

Carry out a detailed energy simulation.

Perform a Life Cycle Cost Analysis (LCCA) for embodied en./emissions.

Select one concept design for detailed development.

Complete working drawings and specifications.

Do a final capital cost check.

Carry out interim systems commissioning.

Train operating staff.

Monitor operational performance.

Operations phase assessment.

Bid & negotiate.

Construct.

Transition.

Operate.

Develop QA strategies for construction & commissioning.

Procure materials and equipment.

Implement site ecology protection measures.

Develop QA strategies for operation.

Consider re-used materials.

Consider recycled materials.

Develop preliminary building envelope design.

Develop preliminary lighting and power system design.

Develop preliminary design for ventilation, heating and cooling systems.

Develop preliminary fenestration design.

Reduce envelope heat gain through trees and landscaping.

Reduce envelope heat gain or loss by thermal efficiency and tightness of envelope.

Optimize window location, size and shape to maximize daylighting while limiting unwanted solar gain or heat loss.

Provide exterior shading devices where effective against excessive solar gain.

Optimize energy efficiency of lighting including luminaire, lamp, and ballast types, control systems, maintenance.

For residual loads, use high-efficiency fans, chillers, boilers, motors, maximize system efficiencies.

Consider natural or hybrid ventilation.

First consider solar DHW, solar space heating, PV, earth energy.

Cooling system options: Direct or indirect evaporative, Desiccant or evaporative, Evaporative transpiration vs. vegetation; Direct or hybrid radiative cooling; Night cooling; Earth or air heat exchanger; Ground water, sea or river water.

Consider using Building Information Model (BIM) protocols.

Decision based on cost/benefit analysis.

Optimize energy-efficiency of lighting including luminaire, lamp, and ballast types, control systems, maintenance.

Inspect and correct deficiencies.

Provide as-built documentation and operating manuals.

Carry out final commissioning.

Carry out interim commissioning.

Train operating staff.

Monitor operational performance.

Operations phase assessment.

Bid & negotiate.

Contract.

Transition.

Operate.

Develop QA strategies for construction & commissioning.

Procure materials and equipment.

Implement site ecology protection measures.

Develop QA strategies for operation.

Consider re-used materials.

Consider recycled materials.
We have developed a simple IDP support tool for project managers;
It was developed under contract to Natural Resources Canada and UNEP (Paris);
It can be used separately or can link to the SBTool system;
It is a simple checklist on an Excel spreadsheet;
As with all iSBE tools, it is designed to allow easy insertion of local languages and criteria.

This is the highest level of Key Steps, which can also be seen in more detail.
### Overview of SBTool integration with IDP

#### L. Develop preliminary ventilation, heating & cooling system designs

- **L1**: Develop preliminary design for natural or hybrid ventilation system.
- **L2**: Develop preliminary design for space heating system.
- **L3**: Develop preliminary design for space cooling system.
- **L4**: Consider the use of free cooling (nighttime chilling) where possible.
- **L5**: Consider geothermal systems as thermal storage options.
- **L6**: Develop preliminary design for refrigeration systems.

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**SBTool**

- **Info & data**
  - Pre-design assessment
  - Design assessment
  - Construction assessment
  - Operations assessment

**IDP process guidance**

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**Details of Key Steps**

**Overview of SBTool integration with IDP**

- Set for region and building type
- SBTool
  - Info & data
  - Pre-design assessment
  - Design assessment
  - Construction assessment
  - Operations assessment

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**IDP Process Guidance for Ritz Tower in Prague**

- **IDP steps are shown in a linear sequence, but some steps may be performed in a different sequence or may be repeated. You may re-arrange by dragging the order or content on the IDP list.**
- **To add comments to the IDP list, click on the corresponding number on the IDP list.**
- **To show completion of each step, click on the corresponding number on the IDP list.**

| Step | Action Description | AS | OF | MF | PCT
<table>
<thead>
<tr>
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<tr>
<td>72</td>
<td>Set region and building type</td>
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<td></td>
<td>0%</td>
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<tr>
<td>73</td>
<td>Pre-design assessment</td>
<td></td>
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<tr>
<td>74</td>
<td>Design assessment</td>
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<tr>
<td>75</td>
<td>Construction assessment</td>
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<tr>
<td>76</td>
<td>Operations assessment</td>
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<td>77</td>
<td>Info &amp; data</td>
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<tr>
<td>78</td>
<td>Develop preliminary design for natural or hybrid ventilation system</td>
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<tr>
<td>79</td>
<td>Develop preliminary design for space heating system</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>Develop preliminary design for space cooling system</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>81</td>
<td>Consider the use of free cooling (nighttime chilling) where possible</td>
<td></td>
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<td></td>
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<tr>
<td>82</td>
<td>Consider geothermal systems as thermal storage options</td>
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<td></td>
</tr>
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<td>83</td>
<td>Develop preliminary design for refrigeration systems</td>
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</tbody>
</table>
Process Details

Establishing Reference and Target Benchmarks

- The design team needs performance benchmarks for guidance, to define both minimum acceptable and target values;
- To begin with, the Architect should produce a schematic design for a reference design (the one your accountant wants you to build), to facilitate comparisons;
- This will be useful for energy simulations;
- Benchmarks of local industry values for other parameters, such as water consumption, materials use, IAQ, solid waste handling etc., are also needed.

- Some of these found as standards referred to in municipal regulations, ASHRAE, LEED, etc. but others are not;
- If time and budget permits, it is worthwhile to define a wide spectrum of benchmarks. This may not be worth it for a single building, but may be for a group of buildings.
Setting Goals: MEC Ottawa as an example (1996)

- Achieve a LEED "Gold" rating.
- Achieve C2000 Program criteria and CBIP compliance
- No use of materials that require CFC’s, or HCFC’s in their manufacture.
- No use of equipment that uses ozone-depleting substances.
- All new materials to have zero VOC targets.
- 50% of all new materials to have 20% post consumer or 40% post industrial recycled content.
- Use a C&D waste management plan for reuse and recycling and zero land fill.
- Maximum use of salvaged rather than new materials
- Minimum of 80% of all materials must be from within 500 km of the site.
- Minimum of 10% of the energy requirements from renewable energy sources.
- Reuse a minimum of 75% of the existing structure and shell.
- Integrate a maximum number of native & drought tolerant trees and plantings.
- A water conservation plan must be developed.
- High reflective surfaces (albedo) must be used for roofs & parking lots.
- Lighting load at 22 Watts/m² or less.

The Design Charrette(s)

- Hold one or more design charrette(s), intensive but short workshops;
- Specialists can present new ideas that the owner and designers may not be aware of;
- Client and designers can hold frank discussions about their pre-conceptions;
- The feasibility of adopting one or more performance upgrade options can be considered;
- A charrette can be one or two days in length.
We recommend holding a major initial charrette, plus one or more additional shorter sessions, depending on the size and complexity of the project;

- Energy simulation and costing specialists carry out certain tasks before and after each session;
- Costs can range from $15,000 to $50,000 for the first session, plus smaller amounts for subsequent charrettes;
- It is significant, but probably not compared to the marketing budget.

Preventing chaos

- Involving everyone in all decisions would cause chaos;
- The process can be managed in a disciplined way, with inputs from relevant actors obtained at various definite points in the process;
- Thus, benefits of additional views can be usefully integrated into the design process;
- Which actors are relevant at certain stages depends partly on the nature of the project (e.g. simple and small v. specialized and large building);
- Think of it as conducting a chamber orchestra.
Develop and test alternative designs

- Develop at least two design upgrade packages, using the Reference Design as a starting point: a moderate and a very aggressive improvement case;
- Carry out simulations for all variants;
- Compare the upgrade packages with the Reference case and select one that is achievable within the budget, but considering also operating savings.

Design options and the Moment of Truth

Note that “cost” and “benefit” extends to environmental costs and benefits.

Base case or Reference model

Moderate upgrade

Aggressive upgrade

Pick one, based on cost v. benefit
IDP can be applied to more modest buildings

We held a one-day workshop to explore possible performance improvements to the standard design of a small store design for a chain of discount stores in small towns.

The total cost of the process, including pre- and post-simulations was $15k.

Results

- IDP results in design integration, which results in better performance;
- For example, a design that maximizes daylighting will reduce the lighting load;
- Reduced cooling requirement will reduce duct sizes and chiller capacity needed;
- Current operating cost and future maintenance and replacement costs will also be reduced;
- And all this reduces greenhouse gas emissions.
A cautionary note about IDP

- In all high performance projects, we try to identify the amount of energy improvement and possible cost increase, all compared to a reference building;
- In a fairly conventional project, this is not so difficult, because the two buildings may be similar except for some upgraded systems;
- But a full IDP process may result in a different building shape or orientation, changes in structure, and possibly even different uses;
- In such cases, how do we define the reference building performance and cost?
- There is no completely satisfactory answer.

Some examples from C-2000
C-2000 Condominium in Dundas, Ontario

- 48 units in six floors
- Annual energy consumption 137 kWh/m², more than 35% reduction from MNECB
- Annual water consumption 0.5 m³/m², 25% of normal

C-2000 Condominium in Dundas, Ontario

- This detail shows the exterior wall at the balcony;
- Usually this is a very prominent thermal bridge in northern projects;
- In this case, the IDP process resulted in the development of a thermally-broken attachment point for the balconies.
Mayo School, Yukon

This project was assessed with GBTool and displayed at the SB2000 Conference in Maastricht.

The existing school was undersized and in a state of deterioration. The new school had to meet C-2000 performance standards (50% energy reduction) on a fixed budget. The IDP process was used.

C-2000: Mountain Equipment Coop, Winnipeg, Canada

- 95% of materials in existing structure re-used;
- >50% energy reduction
- About 10% incremental cost
- IDP process used
- A good client was a key factor
C-2000: Red River College, Winnipeg, Canada

• A complex community college project, involving restoration, renovation and new construction
• The architect states that completion on time and budget was only possible through IDP.

C-2000: Manitoba Hydro HQ, Winnipeg, Canada

Target EE: 140 kWh/m²
MNECB: 230 kWh/m²
4 Times Sq: 221 kWh/m²
Construction cost: $188 m or $2933 / m²
Full IDP process involving Transsolar from Stuttgart as energy engineers, plus top Canadian designers.
Some performance data from C-2000 and CBIP

<table>
<thead>
<tr>
<th>C-2000 Building Name</th>
<th>Reference MNECB (kWh/m² per year)</th>
<th>Design Performance (kWh/m² per year)</th>
<th>Percent gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bemont 8 &amp; 2</td>
<td>348</td>
<td>174</td>
<td>50%</td>
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<tr>
<td>Green on the Grand</td>
<td>182</td>
<td>82</td>
<td>55%</td>
</tr>
<tr>
<td>Saskatoon Library</td>
<td>463</td>
<td>301</td>
<td>35%</td>
</tr>
<tr>
<td>Dundas Apartments</td>
<td>170</td>
<td>125</td>
<td>26%</td>
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</table>

<table>
<thead>
<tr>
<th>CBIP Building Type</th>
<th>Reference MNECB (kWh/m² per year)</th>
<th>Design Performance (kWh/m² per year)</th>
<th>Percent gain</th>
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<tr>
<td>Health care (4)</td>
<td>427</td>
<td>247</td>
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<tr>
<td>Office (14)</td>
<td>389</td>
<td>252</td>
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<tr>
<td>School (20)</td>
<td>329</td>
<td>216</td>
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<tr>
<td>Other (5)</td>
<td>546</td>
<td>325</td>
<td>40%</td>
</tr>
<tr>
<td>All CBIP (43)</td>
<td>383</td>
<td>243</td>
<td>37%</td>
</tr>
</tbody>
</table>

Conclusions

- IDP supported the achievement of high performance of energy performance improvements of about 50%;
- The C-2000 program indicated a cost variation in the range of +10% to -10%;
- Don't try it unless the client has a positive attitude…
Contacts & Info

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