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A ROADMAP FOR SUSTAINABLE BUILDINGS: INTEGRATED DESIGN

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The large impact of the population and urbanization increase the necessitiy of sustainability in order to minimize the negative environmental impact of buildings. In this context, in conjunction with the rise of sustainability and sustainable design, the term of integrated design has evolved. In the simplest term; "integrated design" can be considered as a collaborative process that focuses on the design, construction, operation and occupancy of a building over its complete life-cycle in order to achieve high performance (sustainable) buildings while avoiding or minimizing incremental costs. This process relies upon a multidisciplinary and collaborative team from many specialized fields whose members make decisions together from conception to completion with common visions and project goals unlike conventional design process. In this context the aim of this study is understanding the differences of integrated design from traditional approaches, perceiving the benefits and key success factors to apply integrated design process for achieving sustainable design as a tool. Therefore in this study the fundamental process of the integrated design in order to create sustainable buildings and the interaction of the interdisciplinary work in each phase will be presented as a result of comprehensive literature survey.

Keywords: Integrated design, Interdisciplinary work, Sustainability, Sustainable design.

Introduction

After the industrial revolution, because of such as population growth, economic changes, technological developments and environmental degradation all areas are faced with a rapidly changing renewal in course of time. This situation highlights the solutions for lifecycle and the concept of sustainability to constitute an environment that can address present and future generations' fulfilling the social, economic and other requirements. It is important to face the challenges associated with extending limited natural resources to meet the needs of a growing population with greater expectations for their quality of life. Challenges today include finding new and innovative ways to incorporate a broad mix of clean environment and renewable power sources for sustainability. In a setting where climate change and environmental care are important issues, sustainable approaches are vital to protect our environment and ecology. As pressure increases to be more environmentally responsible in all fields, it's also a necessity of sustainability in building design / construction / occupancy which has a definite impact on the environment. Due to this reason; "integrated design" can be use as a strategy to support sustainable approaches by combining both interdisciplinary teams and building life cycle integration.

In this context; emphasizing the value of "integrated design" as a collaborative process and interdisciplinary network for achieving sustainable design is determined as the goal of this paper.

Therefore in this study; the differences of the fundamental process of the integrated design and conventional approaches, the benefits and key success factors to apply integrated building process in order to create sustainable buildings will be discussed. As a result of comprehensive literature survey and evaoulations; the interaction of the interdisciplinary work will be presented with "a roadmap" in order to achive sustainable buildings with integrated design approach. Also one of the expected outcomes from this study is to draw attention to the need for academics and students to be integrated with different disciplines and to be prepared for teamwork in order to satisfy the contemporary demands of the society.

Integrated Design

Generally, the concept of integrated design is identified with a wide range of terms such as iterative process, non-linear approach, a flexible method and etc. In detail, integrated design can be defined as a method of project delivery distinguished by a contractual arrangement among a minimum of owner, constructor and design professional that aligns business interests of all parties. This concept also motivates collaboration throughout the design and construction process, tying stakeholder success to project success. But elementarily this concept can be defined as a collaborative method for designing buildings which emphasizes the development of a holistic design, and a modernist approach in which all design requirements are considered simultaneously rather than sequentially. In this context, this holistic design approach basically describes a different, intentional way of approaching sustainable building and community design that offers a much higher likelihood of success than any other approach (Integrated Design Process Guide). Integrated design can also be described as a discovery process optimizing the elements that comprise all building projects and their interrelationships across increasingly larger fields in the service of efficient and effective use of resources with the teamwork of different disciplines.

In literature, it is possible to find sort of definations related with integrated building process but most would agree that there are common elements to every definition of integrated building process. These common elements of integrated building process can be summarized such as;

- ***Goal-driven*** with the primary goal being sustainability, but with explicit subsidiary goals, objectives and targets set as a means to get there.
- ***Facilitated*** by someone whose primary role is not to produce the building design or parts of it, but to be accountable for the process of design.
- ***Structured*** to deal with issues and decisions in the right order, to avoid locking in bad performance by making non-reversible decisions with incomplete input or information.
- ***Clear decision-making*** for a clearly understood methodology for making decisions and resolving critical conflicts.
- ***Being inclusive*** of everyone, from the owner to the operator, has something critical to contribute to the design and everyone must be heard.
- ***Collaborative*** so that the architect is not simply the form-giver, but more the leader of a broader team collaboration with additional active roles earlier in the process.
- ***Holistic or systemic thinking*** with the intent of producing something where the whole is greater than the sum of the parts, and which may even be more economic.
- ***Whole-building budget setting*** allows financial trade-offs, so money is spent where it is most beneficial when a holistic solution is found.
- ***Iterative*** to allow for new information to inform or refine previous decisions.
- ***Non-traditional expertise*** on the team, as needed, or brought in at non-traditional times to contribute to the process (Integrated Design Process Guide).

1. The Conventional Design Process vs. Integrated Design Process

In order to understand what the integrated building process is, it is useful to first characterize the more conventional design process. The conventional design 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. 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 Integrated Design Process). The conventional design process has a mainly linear structure due to the successive contributions of the members of the design team. This linear structure typically consist of a process that progresses from the project owner to the architects to engineers to builders (and their suppliers) and finally the occupant.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 (The Integrated Design Process). Conventional building design usually involves a series of hand-offs from owner to architect, from builder to occupant. This path does not invite all affected parties into the planning process, and therefore does not take into account their needs, areas of expertise or insights. In some cases, using the conventional method, incompatible elements of the design are not discovered until late in the process when it is expensive to make changes.

In contrast, the integrative design process which is different from the conventional (or linear design process), requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion in order to achieve the greatest effectiveness in cost and environmental performance requires that every issue and everybody be brought into the project at the earliest point (Whole System Integration Process). The fundemantal process of integrated design is the search for synergies. The strategies create benefits greater than the sum of the individual design decisions. Decision-making protocols and complementary design principles must be established early in the process in order to satisfy the goals of multiple stakeholders while achieving the overall project objectives. In addition to extensive collaboration, integrated design involves a whole building design approach. A building is viewed as an interdependent system, as opposed to an accumulation of its separate components (site, structure, systems and use). The goal of looking at all the systems together to make sure they work in harmony rather than against each other. Integrated design has evolved in conjunction with the rise of multidisciplinary design firms and sustainable design. It frequently begins with a charrette or eco-charrette, an intensive design workshop, in which many stakeholders gather to set goals and identify strategies for achieving the desired outcomes. In this context, integrated building process requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion and generates a production process by bringing together a wide variety of teams at every stage of design from the beginning to the end. 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 Integrated Design Process). Integrating sustainable approaches into the building design process requires a high degree of transparency on many related subjects, usually conducted by separate participants. However, common design teams are usually overwhelmed by the degree of communication and collaboration required to integrate e.g. knowledge of sustainable approaches into the design process. Because most buildings are designed and build as one of a kind, optimization of the design process can not be reached by implementing deterministic solution strategies. Many components have to be developed and, moreover, integrated into a single design solution. To develop an environment that supports distributed work, real collaboration of all design participants and integration of domain experts, not necessarily limited to the field of building construction, is therefore preliminary condition to any further development in the area of integrated planning (Forgber, et. al., 2007). Also with the aim of creating a successful high-performance building, it is also necessary for the people involved in the building design to interact closely throughout the design process (Harputlugil and Hensen, 2006). Thus; comparing integrated building process with conventional design process, integrated building process needs high level of coordination, cooperation and collaboration. Real collaboration enabling detailed assessment of building components, materials and functions through an interdisciplinary team, can only be achieved if an integrated approach is pursued (Forgber, et. al., 2007). Level of coordination, cooperation and collaboration that are required in conventional design process and integrated design process is shown in the Figure 1.

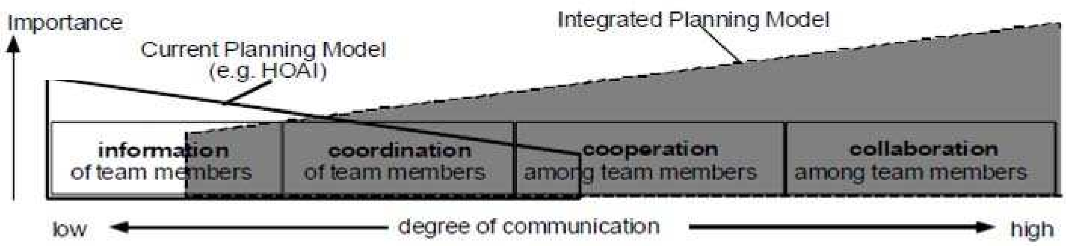

Figure 1. Level of coordination, cooperation and collaboration in conventional design process and integrated design process (Forgber, et. al., 2007)

One of the most important distinction of integrated building process is the continuous learning and improvement. Associated with these features, an integrated approach includes feedback mechanisms to evaluate all decisions unlike a conventional linear design process in which decisions and assumptions made upstream are often left unchallenged. Regular feedback loops can keep the team engaged and produce small successes, which reinforce the effectiveness of the process. Feedback loops within a typical integrated building process include not only several design iterations but also commissioning and post-occupancy evaluation, which not only inform a building's design but also its ongoing operation (Roadmap for the Integrated Design Process). In the light of these informations, the comparision between conventional design process and integrated building process is shown in the Table 1.

Table 1. Conventional design process and integrated design process comparison

Conventional Design Process	Integrated Building Process
Linear	Non-Linear
Team members attend only when required (Involves team members only when essential)	Team members attend during the whole process (Inclusive from the outset)
More decisions made by fewer people	Decisions influenced by broad team within an iterative process
Single team approach	Multidisciplinary team approach & problem-solving
First cost is significant, Emphasis on up-front costs	All life cycle cost and benefits are considered
Each system is analyzed one by one	The relationship among systems are taken into consideration for a full optimization
It requires less time, energy, collaboration and cooperation at early phases	The biggest investment with time and energy is made at the beginning
Collaboration is weak	Collaboration from the beginning on goals and aesthetics is strong
Systems often considered in isolation	Whole system thinking
Diminished opportunity for synergies	Seeks synergies
Incorporate green strategies as singular solution	Incorporate green strategies into all phases of the project, from programming through to construction, operation and maintenance
Closed communication process	Open communication process
Limited to constrained optimization	Allows for full optimization
Process continues through post-occupancy	Typically finished

2. Benefits of the Integrated Design Process

Nowadays many architects have already incorporated energy efficient design principles into their work, and these efforts continue to expand within the profession. Considering with the increasing awareness in sustainability and energy efficiency, the concept of integrated building process is used as a key tool to enhance these trends and reach goals for sustainability. However, the benefits of integrated building process is 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 Integrated Design Process). Integrated design also have more advantages over the conventional design process concerning costs and efficiency. The integrated building 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 that are integrated at the concept design level from the very beginning of the design process, and the spirit of cooperation among key actors result 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 Integrated Design Process). In other words; by a parallel development of multiple expressions of concepts from all key parties, comparing integrated building process with conventional design process; integrated building process brings advantages such as lowering costs, maximizing quality, avoiding from re-design process and related cost increases by spending more time on reproducibility and suitability of the product according to users' requests, unlike conventional process that spends very short time on design, etc. The Macleamy Curve (Figure 2) graphically show the advantages of the integrated building process over the conventional design process concerning costs and efficiency. It illustrate the fact that, the earliest decisions are taken, the better it is. Indeed, it is much easier, less costly and more efficient to change the drawings of a building than the constructed building itself. By furnishing the main efforts during the design phase, integrated building process appear to be the most efficient way of obtain a high performance building for a reasonable cost (Attia and et. al., 2013).

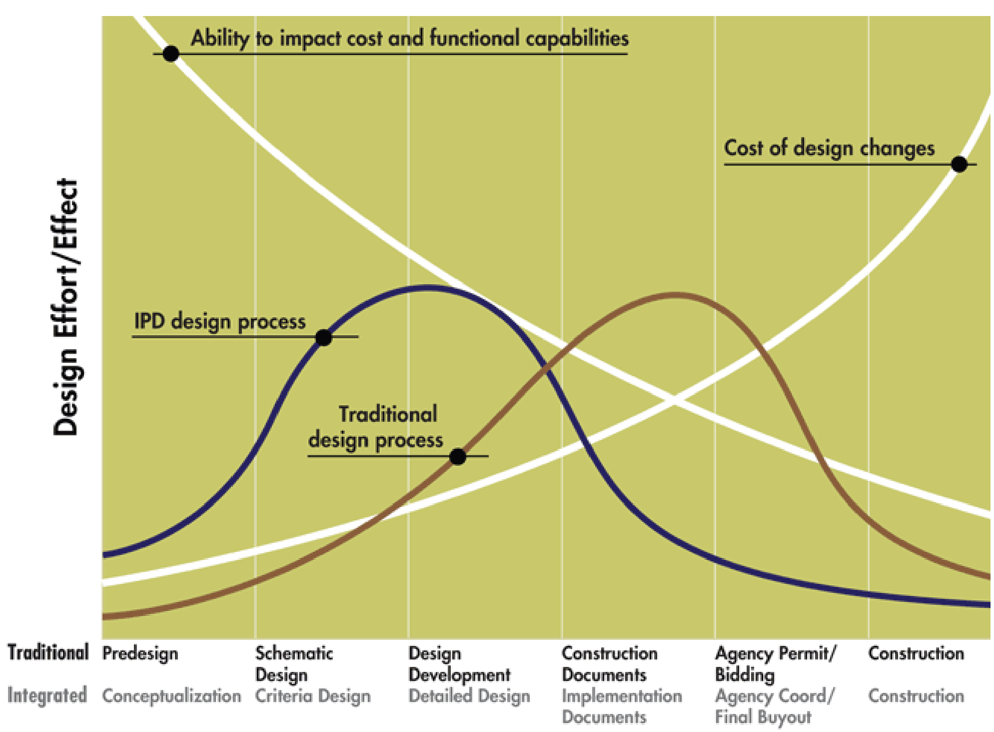

Figure 2. The Mac-Leamy curve (Attia and et. al., 2013)

On the other hand the most significant acquisition of integrated building approach is the opportunity to more clearly and comprehensively define and measure project's scope, vision, goals, objectives and outcomes. As a fact, this opportunity occurs by means of the effective and open communications in the integrated building process. And as a result; transparency in communication builds trust, increases team's sense of ownership (Roadmap for the Integrated Design Process). Besides, considering life-cycle costing, integrated building process foster the type of holistic and long-term thinking necessary for sustainable design. Additionally in integrated building process, teams that are working in a collaborative and concurrent way with a determination to foster open-mindedness and creativity, create innovation and synthesis; which allow the team to achieve the complex requirements of a high performance building (Roadmap for the Integrated Design Process). In this context, the summary about the benefits of the integrated building process is shown in the Figure 3.

* Well-defined scope, vision, goals and objectives * Effective and open communication * Well-organized * Multidisciplinary work * Collaborative work * Team Work * Concurrent * Innovation and synthesis * Systematic decision making	**Sustainabilty**  **Life -Cycle**	* Iterative process with feedback loops * Realization of more optimally integrated solutions * High Performance (Maximized benefits and quality) * Minimal Cost / Effort / Time * Environmental Performance

Figure 3. Benefits of the Integrated Building Process

3. Relationship between Integrated Design and Sustainable Buildings

After the recognition that the construction industry has the largest share on ecological damage with the energy use, fossil fuels and produced wastes during the life cycle; transition to "green" in sustainable architecture accelerates and awareness in "energy efficiency" increases. Besides, the countries are also developing energy policies and sustainable development models so as both to increase the awareness about climate change and to ensure the efficient use of resources leaving sufficiently to future generations. In parallel with these developments, the concept of integrated design has evolved in conjunction with the rise of sustainability and sustainable design.

Any building forms a system with a number of sub-systems, characterised by a large quantity of parameters that need to be considered during the design process. Traditionally, the design process involves multiple design and engineering disciplines, which design, analyse and optimise individual subsystems and their components separately. Nevertheless, all building component parameters are inter-related and affect each other. In order to optimise the dynamic interaction between different building systems and components, it is necessary to use an integrated design approach (Hensen, 2003). Besides, as design projects become more complex and sophisticated, piecing all the required disciplines together and coordinating them become more critical to success. Also in connection with the design process becomes an integration of architecture with engineering, physics, mathematics, and product development and marketing, the desire to consider and coordinate all disciplines in the design rise in importance. Due to this desire to consider all disciplines in the design, makes for a process that, if left to traditional methods, is disorganized and nearly impossible to coordinate (Kara and Georgoulias, 2012). When expanding this perspective to the design of actual buildings with the consideration of the increasing necessity about the environment friendly buildings, professionals working in this area require perfectly calibrated solutions in order to achieve susitaniability and gather together all disciplines that are wholly responsible for delivering the built environment. As a response to these searches, the concept of integrated design comes a proper solution. As it has been accepted that sustainable architecture is not only limited with energy efficiency, but a concept including all the components in the life cycle of the building, the integrated building design process, is addressed as a whole with energy needs regarding the structure, environmental impacts, material and natural resource use, waste management and user relationship. Besides, assembling the best ingredients given the time, space and opportunity to introduce a new way of designing and building, integrated design practice is considered as a sustainable practice as well. This approach asks the members of the design and construction team to look at materials, systems and assemblies from many different professional perspectives. The design is evaluated for cost, quality-of-life, future flexibility, efficiency, overall environmental impact, productivity and creativity and how the occupants will be enlivened.

Also taking into account Gowri's (2004) definition about "green design" which emphasised the need for a holistic approach to designing buildings as an integrated system; integrated design approach can be used as an effective tool in green building rating systems in order to provide a framework to assess the overall design. For example; The ASHE Green Building Committee developed a construction guidance statement to answer the question of what sustainable design and construction means in the context of a health care facility. The roadmap covers the principles of integrated desing coupled with site design, water, energy, indoor environmental quality, materails and products, constrction practices, commissioning, operations and maintanence and innovation (Building Design and Construction). In this roadmap with a vision statement which emphasised achieving an effective and sustainable design requires a collaborative process that engages multiple design disciplines as well as users, construction managers, contractors, and facility managers with an open communication process; integrated building process is seen as an important tool to achieve sustainability goals. In this context, when considered from the aspect of sustainability, it can be said that certain features common to green buildings are especially strong candidates for integrated design because some important design features benefit from the integration because of its inherently interdisciplinary nature. Some examples for these features are summarized below;

- <u>Daylighting:</u> Effective daylighting depends on basic decisions, such as siting and orientation, and architectural elements, including the size, location, spacing of apertures, and, potentially, exterior shading systems. It also requires attention to interior design characteristics, such as interior shading systems, the layout of indoor spaces, the height of partitions, and the geometry, color, and texture of interior surfaces. If daylighting is to reduce energy loads rather than increase them, it must be accounted for in the zoning of the electric lights (so that areas with more daylight can be controlled separately from those with less) and with light-sensitive controls on the electric lighting, which are typically the domain of an electrical engineer and lighting designer. Finally, the mechanical system will be sized properly only if the mechanical engineer understands and accounts for the lighting controls.
- <u>Green roofs:</u> Vegetated roofs are relatively expensive roofing systems, but they may be cost-effective if they help manage stormwater. Designing a cost-effective green roof system requires input from a roofing consultant or roof-system manufacturer, a structural engineer to account for increased loading on the roof, a landscape architect or biologist to assist with selecting plantings, and a civil engineer to exploit the stormwater benefits. In addition, a mechanical engineer should account for the thermal insulation value and evaporative cooling potential of the roof.
- <u>Exposed thermal mass:</u> Exposed concrete or other massive, conductive materials in ceilings and walls can reduce peak cooling loads, especially if they are coupled with night-flushing of the

building to cool the mass. Implementing such a strategy effectively requires collaboration among the architect, structural engineer, mechanical engineer, and interior designer. In addition, an acoustic engineer may help analyze acoustic issues caused by hard surfaces, and a lighting designer is likely to help with unique lighting considerations

- Higher energy performance: Optimization of building form, orientation and facades is reached through open multidisciplinary discussions and design forums in early project phases, where knowledge about important conditions is exchanged to inform the design of the building.
- Reduced embodied carbon: Optimized design is given priority before advanced technical systems and control mechanisms. The high embodied carbon of HVAC components are thus reduced.
- Optimized indoor climate: The building and technical systems work together in a logical symbiosis in order to achieve sufficient indoor air quality, temperature control and daylight access/ solar protection.
- More user involvement: Early involvement of users and inclusion of user needs in the design process is extremely likely to improve the following performance of the building in the operation phase, as well as increase user satisfaction.
- Higher value: A high performance building can often achieve higher headline rental costs which can be compensated for by a lower energy bills (or consequentially lower service charges) - a "win-win" situation for tenants and building owner. Sales value of the building will increase based on higher rentals, improved lettability and more 'futureproofing'.
- Green image and exposure of the building: A green image can benefit the building owner or tenant organization (Integrated Design; Integrated Design Process Guide, The MaTrID project).

Attia and et. al (2013) also adequate integrated building process for high performance buildings. In their work which was identifying and modeling the integrated building process of net zero energy buildings, they emphasized that conventional design processes are sequential and the work is done step by step. At first, architects design the building form, facade articulation and orientation, general aesthetic features, window area and placement. Only then, engineers design the HVAC system in the context of the previously design envelope. Once the design is over, a constructor is chosen by bid. The construction will then be executed in respect of the drawings and models created by the design team. This method has significant advantages concerning per example the human factor by minimizing dispute risks but in an energy efficiency point of view, it is highly insufficient. Indeed, by nature, this process is rigid and linear. It decreases interaction and communication between the team members. Thus, collaboration is weak in such a process and that put the project in danger. Per example, no collaboration between engineer and architects during the facade design can't result in a both efficient and aesthetic as require by high performance buildings. Similarly, the late involvement of the constructor potentially has dangerous effects: costs estimations and constructability issues aren't verified, it can result in more or less large costs growth during construction or occupancy.

Even with green building rating systems and energy design tools spelling out the actions needed to proceed, integrated building process can be used as a more effective instrument to enhance cost-effectiveness by recognizing interrelationships between systems and also building performance by integrating efficient and sustainable design elements by defining the most appropriate design path. In these green building rating systems such as BREEAM, LEED or DGNB; indoor air quality, avoidance of hazardous substances, responsible resource use, bio-diversity and green transport are examples of indicators pursued in environmental assessment schemes in order to avoid from the threats of climate change and green house gas. However with a growing number of new demands that must be integrated into the design of modern buildings in order to satisfy the complexity of building design targets and cost issues (Integrated Design Process Guide, The MaTrID project). Integrated design is strongly supported instead of the integrated energy design concept that generally green building rating systems are interasted in. In other words, this article argues that instead of using LEED checklist or other green building rating systems as a design tool in the later phases, it is more useful to engage the project team around the underlying goals with a multidisciplinary and collaboratively way at early design phases in order to get opportunity for large impact on performance of buildings in a lifecycle perspective, both regarding environmental performance (LCA) and costs (LCC).

Roadmap to the Integrated Design Process

By taking into consideration of all benefits and key success factors of integrated design process, a roadmap is presented in the Table 2 in order to achieve sustainable design (Integrated Design Process Guide; The Integrated Design Process; Whole System Integration Process; Integrated Design Process Guide, The MaTrID project; Roadmap for the Integrated Design Process).

Table 2. Roadmap to the integrated design process

PROPOSAL PHASE – DEFINING BASIC INTENTIONS	**Define purpose of the Project** • Outline an initial understanding of scope, building program, and sustainability objectives • Coordinate the team (bring together a diverse and knowledgeable team and select an integrated design process facilitator)
	Assess site conditions • Assess soil stability and bearing strength • Assess the ecological quality of the site • If a brownfield site, take steps to remediate conditions • Identify any features in adjacent properties that may place constraints on the design of the subject building • Assess suitability of any existing structure(s) on the site for adaptation to the new uses planned for the site. • Identify approximate gross area of existing structure on the site that can be totally or partially re-used. • 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. • Prepare a Site Conditions Report
	Key team members for this phase Client
PREDESIGN – THE DISCOVERY PHASE	**Identify Base Conditions – the context of the project**
	Core Project Programming
	Preliminary Analysis of Flows, Relationships, and Economics between Project Program and the Base Conditions • Energy efficiency and Sources / Microclimates / Building Use • Water quality and conservation and local habitat, geohydrology and soils • Material Resources – informed by Life Cycle Assessment • Consider transportation impact of occupants and users – evaluate alternate resources and location of project
	Assemble the Design Team • Ensure that the proposed design team is aware that the project has high-performance goals. • Identify and retain design team members with skills and experience related to the program. • Ensure that contract conditions do not create a disincentive for the mechanical engineer. • If the budget permits, include performance incentive payments in contracts for the principal designers. • Assess additional consultants who may be needed to achieve some level of effective sustainability (Energy Modeler; Daylighting Modeler; Lighting designer; Commissioning Authority; a Landscape Architect or Civil Engineer; Building science expertise; Green Material and specifications expertise; a facilitator for group meetings; etc.)

Table 2. Roadmap to the integrated design process (Continued)

PREDESIGN – THE DISCOVERY PHASE	**Consider site development issues** • Minimize building footprint on site. • Minimize loss of solar or daylight potential of adjacent property. • Consider measures to minimize impacts on subsurface ecology and aquifers. • Develop preliminary landscape plans to provide windbreaks, shading, and to minimize water demand. • Ensure that the building will form a positive contribution to the streetscape. • Carry out an Environmental Impact Assessment. • Summarize site development issues in a Draft Site Impact Plan.
	Key team members for this phase <u>Core team</u>: Client, architect, mechanical, structural, and electrical engineer, and landscape architect <u>Additional team members and stakeholders, including:</u> • Contractor (depending on project delivery type) • Representative of occupant's perspective • Building operators (if possible) • Additional specialists (i.e. ecologist, energy engineer, etc)
WORKSHOP	**Goal Setting and Alignment of purpose / objectives with the Client and Design Team** • Elicit the clients deep reason for this project • Elicit the design and construction team's deep reason for their work and why they are interested in sustainability • Determine the important design drivers and touchstones essential for this project to be considered a success (project-specific design objectives) • Develop a Process Flow Map (Diagram) to create a disciplined integrative design process. • Project program re-evaluation in light of sustainability objectives • Core team meetings are scheduled & implemented • Begin determination of Project Delivery methodology - Design, Bid, Build; • Design, negotiate, build (contractor on board as early as possible) • The commissioning process can begin at this point
	Hold a Design Workshop • Develop schematic drawings for a reference or baseline design with minimal performance. • Carry out energy simulations for the reference building. • Invite design workshop participants, including the client, design team and specialists. • At the workshop, table the energy simulations to provide a starting point for discussion. • Develop two or three schematic options for improved performance. • Hold an open discussion on performance, cost and other implications. • Carry on with more detailed development of the most attractive option after the workshop, including preliminary energy simulations or estimates. • Add new talent to the design team if necessary. • Summarize the results of the workshop in a Design Workshop Report, and distribute to all stakeholders
	Key team members for this phase <u>Core team</u>: Client, architect, mechanical, structural, and electrical engineer, and landscape architect <u>Additional team members and stakeholders</u>

Table 2. Roadmap to the integrated design process (Continued)

RESEARCH / ANALYSIS	**Examine program; establish performance targets and strategies** • Seek integrated design opportunities – reality testing • Determine if the proposed space requirements can be satisfied by renovations instead of new construction. • Consider possible impact of location on the transportation requirements of the facility • Assess the capacity of the functional program to support mixed uses and green operations. • Confirm client's commitment to supporting measures required for high performance. • Develop an initial statement of performance goals, targets and supporting strategies • Prepare a Functional Program and Performance Goals Report. • Refine the preliminary analysis of flows, relationships, and economics between project program and the base conditions. o Energy modeling o Water quality, water conservation, local habitat, geohydrology, soils understanding and design o Material Resources o Energy modeling o Water quality, water conservation, local habitat, geohydrology, and soils understanding and design • Build integrative cost bundling template to accurately portray initial cost and life cycle cost considerations • Review budget and pay-back requirements for compatibility with performance goals reconfirm metrics and benchmarks (LEED, etc.)
	Key team members for this phase <u>Core team</u>: Client, architect, mechanical, structural, and electrical engineer, and landscape architect <u>Additional team members and stakeholders</u>
CONCEPT DESIGN OR EARLY SCHEMATİC DESİGN	• Assess the refined analysis of flows, relationships, and economics between project program and the base conditions o Energy efficiency and Sources / Microclimates / Building Use o Water quality and conservation and local habitat, geohydrology and soils o Material Resources o Transportation impact of occupants and users o Indoor Environmental Quality Issues o Community System relationships – Habitat health restoration; the interrelationship of natural systems with human systems • Review any integrative cost bundling studies in process – refine as necessary • Evaluate the building or project program in light of the above findings • Iterate design concepts with the above and set up a schedule to make sure all the issues are in play throughout the design process. • Confirm alignment around the purpose and aspirations of the project with client and design and construction team members • Confirm the alignment of client, design, and construction (or cost estimating) team around the objectives and aspirations • Review any Integrative cost bundling studies in process – refine as necessary • Reconfirm metrics and benchmarks (LEED, etc.)

Table 2. Roadmap to the integrated design process (Continued)

	Key team members for this phase Core team from previous phase Additional team members, including: • Energy specialist • Cost consultant • Certification coordinator • Commissioning agent • Valuation professional
DESIGN DEVELOPMENT	**Develop Concept Design** • Finalize performance targets • Develop a concept plan, using functional requirements as a starting point. • Orient the building to optimize passive solar potential, and relate fenestration requirements to orientation. • Establish configuration & floor plate depth to balance daylighting & thermal performance. • Consider the possible roles of natural, hybrid or mechanical ventilation systems. • Consider whether cooling will be needed. • Examine the potential role of renewable energy systems. • Examine the most efficient forms of non-renewable heating, cooling and ventilation systems. • Determine floor-to-floor heights, taking into account possible future uses. • Carry out a first set of detailed energy simulations or energy analysis. • Prepare the Concept Design Report. • Refine costs as necessary – Continuous value engineering • Reconfirm Metrics and Benchmarks (LEED, etc.) • Verify alignment of schematic design proposals with purpose and goals of project document rating system credits (LEED, etc.)
	Select building structure • Consider column spacing and core position. • Consider measures to reduce embodied energy of the structure. • Consider thermal storage options using the structure as a heat sink. • In residential occupancies, consider appropriate balcony design. • Decide on building structure type taking into account the considerations above.
	Develop building envelope design • Select basic exterior wall systems. • Assign fenestration on each orientation to optimize daylighting and thermal benefits • Optimize the daylighting and thermal performance of fenestration. • Consider the use of operable windows. • Consider measures to reduce the embodied energy of the building envelope. • Optimize envelope detailing and thermal performance • Carry out a second set of detailed energy simulations
	Develop preliminary lighting and power system design • Develop preliminary lighting system design. • Estimate the power requirements for future tenant and occupant equipment. • Optimize the energy efficiency of vertical transportation systems. • Develop strategies to shave peak demand. • Summarize lighting issues for Comfort and Productivity Performance Plan

Table 2. Roadmap to the integrated design process (Continued)

DESIGN DEVELOPMENT	**Develop preliminary Ventilation, Heating and Cooling system designs** • Develop preliminary ventilation system design. • Develop preliminary design for heating central plant. • Develop preliminary design for cooling central plant. • Consider thermal storage options using mechanical systems. • Develop preliminary design for ventilation, heating, and cooling delivery systems. • Develop preliminary ventilation, heating and cooling control systems. • Complete energy simulations assessing whole building design performance. • Summarize HVAC issues for the Comfort and Productivity Performance Plan. • Prepare a Design Development Report.
	Select materials • Minimize use of materials or components that rely on scarce material resources. • Select materials that balance durability and low embodied energy. • Consider re-use of components and recycled materials. • Design assemblies and their connections to facilitate future demountability. • Select indoor finishing materials to minimize VOC and other emissions.
	Complete design and documentation • Complete site development plan to minimize potable water consumption. • Design plumbing and sanitary systems to minimize water consumption. • Complete appropriate rain screen and pressure equalization envelope details. • Finalize lighting system design. • Finalize ventilation, heating, and cooling system designs. • Confirm adequate space exists for data and communications systems. • Select building energy management control systems. • Review the use of materials to minimize waste. • Carry out a final set of energy simulations. • Produce a final Longevity and Adaptability Plan • Prepare a final Life Cycle Cost Report. • Produce a final Occupant Comfort and Productivity Plan.
	Key team members for this phase Team from previous phase Additional team members, including: • Contractor (sooner if possible) • Operation and maintenance staff • Materials expert • Acoustician • Client's marketing representative (if appropriate) • Industry and academic experts
CONSTRUCTION	**Develop strategies for construction** • Develop plan to minimize C&D wastes during construction. • Develop Final Site Impact Management Plan. • Develop a Final Quality Assurance Plan • Develop a Commissioning Plan for all major systems. • Prepare the Pre-Construction Report.
	Construction documentation
	Bidding and negotiations • Pre-bid & post award conferences to explain unique aspects of project • Detailed review of drawings and specifications

Table 2. Roadmap to the integrated design process (Continued)

CONSTRUCTION	**Construction** • Confirm client-design team-stakeholders-contractor alignment • Refine documentation and performance calculations to validate final design • Verify alignment of construction with purpose and goals with commissioning authority and contractor • Closeout process and training
	Key team members for this phase Team from previous phase Additional team members, including: • Specification writer • Contractor (sooner if possible) • Commissioning authority • Project manager
OCCUPANCY	**Develop strategies for operation and Maintenance** • Green housekeeping training • Continuous systems training for new staff and refresher course for existing o Energy, landscape, habitat, water systems • Feedback Loops - Building Systems & Natural Systems o Monitoring (Functional Testing) & Trending (Cx) - Measurement & Verification – Quantity & Quality evaluation o Post occupancy evaluation o Assign responsible entity to field & translate feedback • Appoint an owner's Commissioning Agent. • Develop a maintenance plan. • Develop a Final Environmental Impact Management Plan. • Develop lease instruments with tenant incentives to operate space efficiently. • Train building staff to operate equipment efficiently. • Prepare a Project Completion Report
	Monitoring • Owner / Operator to provide reports on operations, maintenance, & utility bills. • Carry out a Post-Occupancy Evaluation (POE) study
	Key team members for this phase Team from previous phase Additional team members, including: • Building operators • Building occupants • Commissioning agent

Integrated Design Approach to Sustainability Education

As leaders and participants in the design process, architects need to understand and work collaboratively with other disciplines (Wolcott, et. al., 2011). With accelerating trends of sustainability, technology, and collaboration in practice; energy efficiency and interdisciplinary approaches must take place in architectural education. Furthermore the need for sustainability education is directly linked to changes in contemporary practice with accelerating trends of sustainability and multidisciplinary works. Within this framework, architectural students should be informed about integrated design process that combined sustainability and multidisciplinary working in itself. In this context some suggestions about education and training for integrated building design in field of the architectural education are given below:

* Architectural students should be guided to take common courses related with the other disciplines in terms of interactions in practice of architecture to provide the necessary of theoretical background (Aladağ and Düzgün, 2014).
* Academics must evolve the educational systems to prepare young professionals by providing the opportunity to interact with the practitioners on real projects with challenging needs in sustainability (Wolcott, et. al., 2011).
* Students need to experience developing design concepts within collaborative team approaches by participating in a sustainable design experience in the educational process such as projects, workshops, studios etc.
* Interdisciplinary design studios that involve students, faculty, practicing design and engineering professionals, and clients and regulatory officials should be generalized (Wolcott, et. al., 2011).
* Collaboration among an interdisciplinary community of architectural/ engineering design educators committed to achieving measurable improvements in the readiness of graduates for team should be provided (David, et. al., 2003).
* A framework for organizing and implementing design instruction that develops students'capabilities in the use of the design process, teamwork, communication, and higher-level professional skills required in engineering practice should be developed (David, et. al., 2003).
* Teaching should be more integrative. Response to integrated practice will require developing a shared set of values (accreditation, internship etc.) (Strong, 2007).
* It's also important to gain ability to work in interdisciplinary creative teams, write / speak effectively on professional topics (Strong, 2007). Thus, in studio classes, students should acquire essential research, writing, and critical reasoning skills and develop conceptual foundations for a life of creative inquiry.
* The number of interdisciplinary postgraduate programs in terms of integrated design should be increased to stretch disciplinary boundaries and to create new hybrid research fields.
* In architectural education, lectures should include interdisciplinary research that support the development of high-performance building design including lighting, daylighting and energy infrastructure.
* The curriculum of integrated design postgraduate programs should be built around a collaborative project-based studio core and interdisciplinary pathways. By so students should acquire tools with which to address the social, economic, and environmental challenges of our time.

Conclusion

Today's globalization removes the boundaries in many fields and increase the number of actors involved in. Due to a collaborative process focuses on the design, construction, operation and occupancy of a building over its complete life-cycle in order to achieve high performance (sustainable) buildings while minimizing costs, time and efforts; a well-organized, multidisciplinary and collaborative team from many specialized fields whose members make decisions together for the best quality should be involved in the organization. This collaborative involvement and teamwork among different disciplines that is required for architectural design process is vital for creating sustainable buildigs. According to the increasing scale and complexity of today's architectural projects and awareness in green issues; the integrated design approach becomes an inevitable tool for increasing efficiency on sustainability. Because integrated design which is a collaborative process focuses on design, construction, operation and occupancy of a building over its complete life-cycle with a multi-disciplinary team who makes decisions together with a shared vision and a holistic perspective; creates economical and environmental benefits in the context of sustainability. In this context, in order to avail from the concept of integrated design, a roadmap has presented in the study. With this roadmap it is possible to engage the project team around the underlying goals with a multidisciplinary and collaboratively way at early design phases in order to get opportunity for large impact on performance of buildings in a lifecycle perspective.

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