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The Sustainability Development of Different Products Used and Green Engineering for Environmental Management

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ABSTRACT: Sustainability is a societal goal that relates to the ability of people to safely co-exist on Earth over a long time. Specific definitions of this term are difficult to agree on and have varied with literature, context, and time.^{[2][1]} Sustainability is commonly described as having three dimensions (or pillars): environmental, economic, and social.^[1] Many publications state that the environmental dimension is the most important.^{[3][4]} For this reason, in everyday use, sustainability is often focused on countering major environmental problems, such as climate change, loss of biodiversity, loss of ecosystem services, land degradation, and air and water pollution. The concept of sustainability can be used to guide decisions at the global, national, and individual levels (e.g. sustainable living).^[5] Green engineering not the design of products and processes by applying financially and technologically feasible principles to achieve one or more of the following goals: (1) decrease in the amount of pollution that is generated by a construction or operation of a facility, (2) minimization of human population exposure to potential hazards (including reducing toxicity), (3) improved uses of matter and energy throughout the life cycle of the product and processes, and (4) maintaining economic efficiency and viability.^[1] Green engineering can an overarching framework for all design disciplines.

KEYWORDS: sustainability, green engineering, environmental, pollution, management, goals, ecosystem, earth, biodiversity

I.INTRODUCTION

A closely related concept is that of sustainable development, and the terms are often used synonymously.^[6] However, UNESCO distinguishes the two like this: "Sustainability is often thought of as a long-term goal (i.e. a more sustainable world), while sustainable development refers to the many processes and pathways to achieve it."^[7] The concept of sustainability has been criticized for various reasons. One such criticism is that the concept is vague and merely a buzzword.^[1] Another is that sustainability as a goal might be impossible to reach;^[8] it has been pointed out that "no country is delivering what its citizens need without transgressing the biophysical planetary boundaries".^{[9]:11} How the economic dimension of sustainability should be addressed is controversial.^[1] Scholars have discussed this aspect under the concept of "weak and strong sustainability". For example, there will always be tension between the ideas of "welfare and prosperity for all" and environmental conservation.^{[10][1]} Therefore, trade-offs are required. Approaches that decouple economic growth from environmental deterioration would be desirable but are difficult to implement.^{[11][12]} There are many barriers to achieving sustainability that must be addressed for a sustainability transition to become possible.^{[5]:34[13]} Some barriers arise from nature and its complexity. Other barriers are extrinsic to the concept of sustainability. For example they can be caused by the dominant institutional frameworks in countries. Some approaches people can take to transition to environmental sustainability include: maintaining ecosystem services, reducing food waste, promoting dietary shifts towards plant-based foods, reducing fertility rates and, thus, population growth, promoting new green technologies, and adopting renewable energy sources while phasing out subsidies to fossil fuels.^[14] Global issues are difficult to tackle as they require global solutions. Existing global organizations (such as the UN and WTO) are inefficient in enforcing current global regulations. One reason for this is the lack of suitable sanctioning mechanisms. The terms sustainability and sustainable development are closely related. In fact, they are often used to mean the same thing.^[6] Both terms are linked with the "three dimensions of sustainability" concept.^[1] One distinction is that sustainability is a general concept, while sustainable development can be a policy or organizing principle. Scholars say sustainability is a broader concept because sustainable development focuses mainly on human well-being.^[16]

Sustainable development has two linked goals. It aims to meet human development goals. It also aims to enable natural systems to provide the natural resources and ecosystem services needed for economies and society. The concept of sustainable development has come to focus on economic development, social development and environmental protection for future generations.

The environmental dimension is central to the overall concept of sustainability. People became more and more aware of environmental pollution in the 1960s and 1970s. This led to discussions of sustainability and sustainable development. This process began in the 1970s with concern for environmental issues. These included natural ecosystems or natural resources and human environment. It later extended to all systems that support life on Earth, including human society.^{[36]:31} Reducing these negative impacts on the environment would improve environmental sustainability.^{[36]:34} The economic dimension of sustainability is controversial.^[1] This is because the term development within sustainable development can be interpreted in different ways. Some may take it to mean only economic development and growth. This can promote an economic system that is bad for the environment.^{[43][44][45]} Others focus more on the trade-offs between environmental conservation and achieving welfare goals for basic needs (food, water, health, and shelter).^[10]

Economic development can indeed reduce hunger or energy poverty. This is especially the case in the least developed countries. That is why Sustainable Development Goal 8 calls for economic growth to drive social progress and well-being. Its first target is for: "at least 7 per cent GDP growth per annum in the least developed countries".^[46] However, the challenge is to expand economic activities while reducing their environmental impact.^{[47]:8} In other words, humanity will have to find ways how societal progress (potentially by economic development) can be reached without excess strain on the environment. The social dimension of sustainability is not well defined.^{[50][51][52]} One definition states that a society is sustainable in social terms if people do not face structural obstacles in key areas. These key areas are health, influence, competence, impartiality and meaning-making.^[53]

Some scholars place social issues at the very center of discussions.^[54] They suggest that all the domains of sustainability are social. These include ecological, economic, political, and cultural sustainability. These domains all depend on the relationship between the social and the natural. The ecological domain is defined as human embeddedness in the environment. From this perspective, social sustainability encompasses all human activities.^[55] It goes beyond the intersection of economics, the environment, and the social.^[56]

There are many broad strategies for more sustainable social systems. They include improved education and the political empowerment of women. This is especially the case in developing countries. They include greater regard for social justice. This involves equity between rich and poor both within and between countries. And it includes intergenerational equity.^[57] Providing more social safety nets to vulnerable populations would contribute to social sustainability.^{[58]:11}

Green engineering follows nine guiding principles:

1. Engineer processes and products holistically, use systems analysis and integrate environmental impact assessment tools.
2. Conserve and improve natural ecosystems while protecting human health and well-being.
3. Use life-cycle thinking in all engineering activities.
4. Ensure that all material and energy inputs and outputs are as inherently safe and benign as possible.
5. Minimize the depletion of natural resources.
6. Prevent waste.
7. Develop and apply engineering solutions while being cognizant of local geography, aspirations, and cultures.
8. Create engineering solutions beyond current or dominant technologies; improve, innovate, and invent (technologies) to achieve sustainability.
9. Actively engage communities and stakeholders in development of engineering solutions.^{[2][3]}

In 2003, The American Chemical Society introduced a new list of twelve principles:

1. Inherent Rather Than Circumstantial – Designers need to strive to ensure that all materials and energy inputs and outputs are as inherently nonhazardous as possible.
2. Prevention Instead of Treatment – It is better to prevent waste than to treat or clean up waste after it is formed.

3. Design for Separation – Separation and purification operations should be designed to minimize energy consumption and materials use.
4. Maximize Efficiency – Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency.
5. Output-Pulled Versus Input-Pushed – Products, processes, and systems should be "output pulled" rather than "input pushed" through the use of energy and materials.
6. Conserve Complexity – Embedded entropy and complexity must be viewed as an investment when making design choices on recycling, reuse, or beneficial disposition.
7. Durability Rather Than Immortality – Targeted durability, not immortality, should be a design goal.
8. Meet Need, Minimize Excess – Design for unnecessary capacity or capability (e.g., "one size fits all") solutions should be considered a design flaw.
9. Minimize Material Diversity – Material diversity in multicomponent products should be minimized to promote disassembly and value retention.
10. Integrate Material and Energy Flows – Design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows.
11. Design for Commercial "Afterlife" – Products, processes, and systems should be designed for performance in a commercial "afterlife."
12. Renewable Rather Than Depleting – Material and energy inputs should be renewable rather than depleting.^[4]

Many engineering disciplines engage in green engineering. This includes sustainable design, life cycle analysis (LCA), pollution prevention, design for the environment (DfE), design for disassembly (DfD), and design for recycling (DfR). As such, green engineering is a subset of sustainable engineering.^[5] Green engineering involves four basic approaches to improve processes and products to make them more efficient from an environmental standpoint.^[6]

1. Waste reduction;
2. Materials management;
3. Pollution prevention; and,
4. Product enhancement.

Green engineering approaches design from a systematic perspective which integrates numerous professional disciplines. In addition to all engineering disciplines, green engineering includes land use planning, architecture, landscape architecture, and other design fields, as well as the social sciences (e.g. to determine how various groups of people use products and services). Green engineers are concerned with space, the sense of place, viewing the site map as a set of fluxes across the boundary, and considering the combinations of these systems over larger regions, e.g. urban areas. The life cycle analysis is an important green engineering tool, which provides a holistic view of the entirety of a product, process or activity, encompassing raw materials, manufacturing, transportation, distribution, use, maintenance, recycling, and final disposal. Assessing its life cycle should yield a complete picture of the product. The first step in a life cycle assessment is to gather data on the flow of a material through an identifiable society. Once the quantities of various components of such a flow are known, the important functions and impacts of each step in the production, manufacture, use, and recovery/disposal are estimated. In sustainable design, engineers must optimize for variables that give the best performance in temporal frames.^[7]

The system approach employed in green engineering is similar to value engineering (VE). Daniel A. Vallero has compared green engineering to be a form of VE because both systems require that all elements and linkages within the overall project be considered to enhance the value of the project. Every component and step of the system must be challenged. Ascertaining overall value is determined not only by a project's cost-effectiveness, but other values, including environmental and public health factors. Thus, the broader sense of VE is compatible with and can be identical to green engineering, since VE is aimed at effectiveness, not just efficiency, i.e. a project is designed to achieve multiple objectives, without sacrificing any important values. Efficiency is an engineering and thermodynamic term for the ratio of an input to an output of energy and mass within a system. As the ratio approaches 100%, the system becomes more efficient. Effectiveness requires that efficiencies be met for each component, but also that the integration of components lead to an effective, multiple value-based design.^[8] Green engineering is also a type of concurrent engineering, since tasks must be parallelized to achieve multiple design objectives.

II.DISCUSSION

People often debate the relationship between the environmental and economic dimensions of sustainability.^[62] In academia, this is discussed under the term weak and strong sustainability. In that model, the weak sustainability concept states that capital made by humans could replace most of the natural capital.^{[63][62]} Natural capital is a way of describing environmental resources. People may refer to it as nature. An example for this is the use of environmental technologies to reduce pollution.^[64] The opposite concept in that model is strong sustainability. This assumes that nature provides functions that technology cannot replace.^[65] Thus, strong sustainability acknowledges the need to preserve ecological integrity.^{[5]:19} Once we lose those functions we cannot recover or repair many resources and ecosystem services. Biodiversity, along with pollination and fertile soils, are examples. Others are clean air, clean water, and regulation of climate systems. Weak sustainability has come under criticism. It maybe be popular with governments and business but does not ensure the preservation of the earth's ecological integrity.^[66] This is why the environmental dimension is so important.^[4] The World Economic Forum illustrated this in 2020. It found that \$44 trillion of economic value generation depends on nature. This value, more than half of the world's GDP, is thus vulnerable to nature loss.^{[67]:8} Three large economic sectors are highly dependent on nature: construction, agriculture, and food and beverages. Nature loss results from many factors. They include land use change, sea use change and climate change. Other examples are natural resource use, pollution, and invasive alien species. Sustainability measurement are a set of frameworks or indicators to measure how sustainable something is. This includes processes, products, services and businesses. Sustainability is difficult to quantify. It may even be impossible to measure.^[69] To measure sustainability, the indicators consider environmental, social and economic domains. The metrics are still evolving. They include indicators, benchmarks and audits. They include sustainability standards and certification systems like Fairtrade and Organic. They also involve indices and accounting. And they can include assessment, appraisal^[70] and other reporting systems. These metrics are used over a wide range of spatial and temporal scales.^{[71][69]} Sustainability measures include corporate sustainability reporting, Triple Bottom Line accounting. They include estimates of the quality of sustainability governance for individual countries. These use the Environmental Sustainability Index and Environmental Performance Index. Some methods let us track sustainable development.^{[72][73]} These include the UN Human Development Index and ecological footprints. There are several methods to measure or describe human impacts on Earth. They include the ecological footprint, ecological debt, carrying capacity, and sustainable yield. The idea of planetary boundaries is that there are limits to the carrying capacity of the Earth. We should not cross these thresholds to prevent irreversible harm to the Earth.^{[74][75]} These planetary boundaries involve several environmental issues. These include climate change and biodiversity loss. They also include types of pollution. These are biogeochemical (nitrogen and phosphorus), ocean acidification, land use, freshwater, ozone depletion, atmospheric aerosols, and chemical pollution.^{[74][76]} (Since 2015 some experts refer to biodiversity loss as change in biosphere integrity. They refer to chemical pollution as introduction of novel entities.)

The IPAT formula measures the environmental impact of humans. It emerged in the 1970s. It states this impact is proportional to human population, affluence and technology.^[77] This implies various ways to increase environmental sustainability. One would be human population control. Another would be to reduce consumption and affluence^[78] such as energy consumption. Another would be to develop innovative or green technologies such as renewable energy. In other words, there are two broad aims. The first would be to have fewer consumers. The second would be to have less environmental footprint per consumer.

There are many reasons why sustainability is so difficult to achieve. These reasons have the name sustainability barriers.^{[5][13]} Before we address these barriers we must analyze and understand them.^{[5]:34} Some barriers arise from nature and its complexity ("everything is related").^[16] Others arise from the human condition. One example is the value-action gap. This reflects the fact that we often do not act according to our convictions. Experts describe these barriers as intrinsic to the concept of sustainability.^{[85]:81}

Other barriers are extrinsic to the concept of sustainability. This means it is possible to overcome them. One way would be to put a price tag on the consumption of public goods.^{[85]:84} Some extrinsic barriers relate to the nature of dominant institutional frameworks. Examples would be where market mechanisms fail for public goods. Existing societies, economies, and cultures encourage increased consumption. There is a structural imperative for growth in competitive market economies. This inhibits necessary societal change.^[78]

Furthermore, there are several barriers related to the difficulties of implementing sustainability policies. There are trade-offs between the goals of environmental policies and economic development. Environmental goals include nature conservation. Development may focus on poverty reduction.^{[13][5]:65} There are also trade-offs between short-term profit

and long-term viability.^{[85]:65} Political pressures generally favor the short term over the long term. So they form a barrier to actions oriented toward improving sustainability.^{[85]:86}

Barriers to sustainability may also reflect current trends. These could include consumerism and short-termism

A sustainability transition is defined by the European Environment Agency as "a fundamental and wide-ranging transformation of a socio-technical system towards a more sustainable configuration that helps alleviate persistent problems such as climate change, pollution, biodiversity loss or resource scarcities."^{[86]:152} The concept of sustainability transitions is a similar to the concept of energy transitions.^[87] It has been stated that a sustainability transition must be "supported by a new kind of culture, a new kind of collaboration, [and] a new kind of leadership".^[88] It requires substantial investment in "new and greener capital goods, while simultaneously shifting capital away from unsustainable systems"^{[9]:107} and actively demoting unsustainable options.^{[9]:101} To achieve a sustainability transition, societies would have to change their fundamental values and organizing principles.^{[36]:15} These new values would emphasize "the quality of life and material sufficiency, human solidarity and global equity, and affinity with nature and environmental sustainability".^{[36]:15} Some scientists have said that a transition towards sustainability can only be effective if far-reaching lifestyle changes complement technological advancements.^[78] Scientists have pointed out that: "Sustainability transitions come about in diverse ways, and all require civil-society pressure and evidence-based advocacy, political leadership, and a solid understanding of policy instruments, markets, and other drivers."^[14] Four overlapping processes of transformation, each with different political dynamics, have been proposed: they are either led by technology, markets, government, or citizens

Sustainable engineering is the process of designing or operating systems such that they use energy and resources sustainably, in other words, at a rate that does not compromise the natural environment, or the ability of future generations to meet their own needs. Every engineering discipline is engaged in sustainable design, employing numerous initiatives, especially life cycle analysis (LCA), pollution prevention, Design for the Environment (DfE), Design for Disassembly (DfD), and Design for Recycling (DfR). These are replacing or at least changing pollution control paradigms. For example, concept of a "cap and trade" has been tested and works well for some pollutants. This is a system where companies are allowed to place a "bubble" over a whole manufacturing complex or trade pollution credits with other companies in their industry instead of a "stack-by-stack" and "pipe-by-pipe" approach, i.e. the so-called "command and control" approach. Such policy and regulatory innovations call for some improved technology based approaches as well as better quality-based approaches, such as leveling out the pollutant loadings and using less expensive technologies to remove the first large bulk of pollutants, followed by higher operation and maintenance (O&M) technologies for the more difficult to treat stacks and pipes. But, the net effect can be a greater reduction of pollutant emissions and effluents than treating each stack or pipe as an independent entity. This is a foundation for most sustainable design approaches, i.e. conducting a life-cycle analysis, prioritizing the most important problems, and matching the technologies and operations to address them. The problems will vary by size (e.g. pollutant loading), difficulty in treating, and feasibility. The most intractable problems are often those that are small but very expensive and difficult to treat, i.e. less feasible. Of course, as with all paradigm shifts, expectations must be managed from both a technical and an operational perspective.^[2] Historically, sustainability considerations have been approached by engineers as constraints on their designs. For example, hazardous substances generated by a manufacturing process were dealt with as a waste stream that must be contained and treated. The hazardous waste production had to be constrained by selecting certain manufacturing types, increasing waste handling facilities, and if these did not entirely do the job, limiting rates of production. Green engineering recognizes that these processes are often inefficient economically and environmentally, calling for a comprehensive, systematic life cycle approach.^[3] Green engineering attempts to achieve four goals:^[4]

1. Waste reduction
2. Materials management
3. Pollution prevention and
4. Product enhancement.

Green engineering encompasses numerous ways to improve processes and products to make them more efficient from an environmental and sustainable standpoint.^[5] Every one of these approaches depends on viewing possible impacts in space and time. Architects consider the sense of place. Engineers view the site map as a set of fluxes across the boundary. The design must consider short and long-term impacts. Those impacts beyond the near-term are the province of sustainable design. The effects may not manifest themselves for decades. In the mid-twentieth century, designers specified the use of

what are now known to be hazardous building materials, such as asbestos flooring, pipe wrap and shingles, lead paint and pipes, and even structural and mechanical systems that may have increased the exposure to molds and radon. Those decisions have led to health risks to the inhabitants. It is easy in retrospect to criticize these decisions, but many were made for noble reasons, such as fire prevention and durability of materials. However, it does illustrate that seemingly small impacts when viewed through the prism of time can be amplified exponentially in their effects. Sustainable design requires a complete assessment of a design in place and time. Some impacts may not occur until centuries in the future. For example, the extent to which we decide to use nuclear power to generate electricity is a sustainable design decision. The radioactive wastes may have half-lives of hundreds of thousands of years, meaning it will take all these years for half of the radioactive isotopes to decay. Radioactive decay is the spontaneous transformation of one element into another. This occurs by irreversibly changing the number of protons in the nucleus. Thus, sustainable designs of such enterprises must consider highly uncertain futures. For example, even if we properly place warning signs about these hazardous wastes, we do not know if the English language will be understood. All four goals of green engineering mentioned above are supported by a long-term, life cycle point of view. A life cycle analysis is a holistic approach to consider the entirety of a product, process or activity, encompassing raw materials, manufacturing, transportation, distribution, use, maintenance, recycling, and final disposal. In other words, assessing its life cycle should yield a complete picture of the product. The first step in a life-cycle assessment is to gather data on the flow of a material through an identifiable society. Once the quantities of various components of such a flow are known, the important functions and impacts of each step in the production, manufacture, use, and recovery/disposal are estimated. Thus, in sustainable design, engineers must optimize for variables that give the best performance in temporal frames.^[4]

- The World Engineering Partnership for Sustainable Development (WEPSD) was formed and they are responsible for the following areas: redesign engineering responsibilities and ethic to sustainable development, analyze and develop a long-term plan, find solution by exchanging information with partners and using new technologies, and solve the critical global environment problems, such as fresh water and climate change
- CASI Global was formed mainly as a platform for corporates and governments to share best practices; with a mission to promote the cause and knowledge of csr & sustainability. Thousands of corporates and colleges across the world are now a part of CASI Global with a view to support this mission. CASI also offers Global Fellow programs on finance / operations / manufacturing / supply chain / etc. with a dual specialization in Sustainability. The idea is every professional has inculcate sustainability within their core function & industry. CASI Global
- Developed environmental policies, codes of ethics, and sustainable development guidelines
- Earth Charter was restarted as a civil society initiative
- The World Bank, United Nations Environmental Program, and the Global Environment Facility joined programs for sustainable development
- Launched programs for engineering students and practicing engineers on how to apply sustainable development concepts in their work
- Developed new approaches in industrial processes

III.RESULTS

Action principles that people and decision-makers can follow to facilitate more sustainable societies have been divided into four types:^{[5]:206}

- Nature-related principles: Decarbonize; reduce human environmental impact by efficiency, sufficiency and consistency; be net-positive – build up environmental and societal capital; prefer local, seasonal, plant-based and labor-intensive; polluter-pays principle; precautionary principle; and appreciate and celebrate the beauty of nature
- Personal principles: practice contemplation, apply policies cautiously, celebrate frugality
- Society-related principles: Grant the least privileged the greatest support; seek mutual understanding, trust and multiple wins; strengthen social cohesion and collaboration; engage the stakeholders; foster education – share knowledge and collaborate.
- Systems-related principles: Apply systems thinking, foster diversity, increase the transparency of the publicly relevant, maintain or increase option diversity.

In 2015, the United Nations General Assembly announced in the Agenda 2030 for the Sustainable Development Goals: "We are determined to take the bold and transformative steps which are urgently needed to shift the world on to a sustainable and resilient path."^[33] The 17 goals and targets lay out some of the transformative steps. For example, with regard to the future of the planet Earth, the UN's pledge is to "protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations".^[33] The declaration stated that "In these Goals and targets, we are setting out a supremely ambitious and transformational vision" and described the SDGs as being "of unprecedented scope and significance". In order to resolve tradeoffs between economic growth and environmental conservation, the concept of eco-economic decoupling has been proposed. The idea would be to "decouple environmental bads from economic goods as a path towards sustainability".^[11] This would mean "using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken".^{[47]:8} Pressure on the environment can be measured by the intensity of pollutants emitted. Decoupling can then be measured by following changes in the emission intensity associated with economic output.^[47] Examples of absolute long-term decoupling are rare, but some industrialized countries have decoupled GDP growth from both production and, to a lesser extent, consumption-based CO₂ emissions.^[89] However, even in this example, decoupling alone is not sufficient and needs to be complemented by "sufficiency-oriented strategies and strict enforcement of absolute reduction targets".^{[89]:1} A 2020 meta-analysis of 180 scientific studies found that there is "no evidence of the kind of decoupling needed for ecological sustainability" and that "in the absence of robust evidence, the goal of decoupling rests partly on faith".^[11] The possibilities for decoupling and thus the feasibility of green growth have been questioned.^[12] It has been argued that decoupling on its own will not sufficiently reduce environmental pressures, but needs to include the issue of economic growth.^[12] Adequate decoupling is currently not taking place due to rising energy expenditure, rebound effects, problem shifting, the underestimated impact of services, the limited potential of recycling, insufficient and inappropriate technological change, and cost-shifting.^[12] The decoupling of economic growth from environmental deterioration is difficult because environmental and social costs are not generally paid by the entity that causes them, and are therefore not expressed in the market price.^[81] For example, the cost of packaging may be factored into the price of a product, but the cost of disposing of that packaging may not. In economics, such factors are considered externalities, in this case a negative externality.^[90] Usually, externalities are either not covered at all or left to be addressed by government action or by local governance.^[91]

In 2013, the average annual electricity consumption for a U.S. residential utility customer was 10,908 kilowatt hours (kWh), an average of 909 kWh per month. Louisiana had the highest annual consumption at 15,270 kWh, and Hawaii had the lowest at 6,176 kWh.^[6] Residential sector itself uses 18%^[7] of the total energy generated and therefore, incorporating sustainable construction practices there can be significant reduction in this number. Basic Sustainable construction practices include :

1. Sustainable Site and Location: One important element of building that is often overlooked is finding an appropriate location to build. Avoiding inappropriate sites such as farmland and locating the site near existing infrastructure, like roads, sewers, stormwater systems and transit, allows builders to lessen negative impact on a home's surroundings.¹¹⁴
2. Water Conservation: Conserving water can be economically done by installing low-flow fixtures that often cost the same as less efficient models. Water can be saved in landscaping applications by choosing the proper plants.
3. Materials: Green materials include many different options. People commonly assume that "green" means recycled materials. Although that recycled materials represent one option, green materials also include reused materials, renewable materials like bamboo and cork, or materials local to one's region. A green material does not have to cost more or be of lesser or higher quality. Most green products are comparable to their non-green counterparts.¹¹²
4. Energy Conservation: Probably the most important part of building green is energy conservation. By implementing passive design, structural insulated panels (SIPs), efficient lighting, and renewable energy like solar energy and geothermal energy, a home can benefit from reduced energy consumption or qualify as a net zero energy home.
5. Indoor Environmental Quality: The quality of the indoor environment plays a pivotal role in a person's health. In many cases, a much healthier environment can be created through avoiding hazardous materials found in paint, carpet, and other finishes. It is also important to have proper ventilation and ample day lighting.¹⁸¹

IV. CONCLUSIONS

Sustainable business practices integrate ecological concerns with social and economic ones.^{[95][96]} One accounting framework for this approach, the triple bottom line, uses the phrase "people, planet, and profit". The circular economy is a related concept with the ultimate goal of decoupling environmental pressure from economic growth.^{[97][98]} Growing attention towards sustainability has led to the formation of many organizations such as the Sustainability Consortium of the Society for Organizational Learning,^[99] the Sustainable Business Institute,^[100] and the World Business Council for Sustainable Development.^[101] Supply chain sustainability refers to companies' efforts to consider the environmental and human impacts of their products' journey through the supply chain, from raw materials sourcing to production, storage, and delivery, and every transportation link in between. Sustainability has a reputation as a buzzword.^[1] Confusion and mistrust can result when the terms sustainability and sustainable development are used in ways that are contradictory to more widely accepted conceptualizations. Therefore, a clear explanation of how the terms are being used in a particular situation is important.^[16] Greenwashing is the practice of deceptive marketing by a company or organization by providing misleading information about the sustainability of a product, policy, or other activity.^{[58]:26[108]} Investors are wary of this issue as it exposes them to risk.^[109] The reliability of eco-labels is also doubtful in some cases.^[110] Ecolabelling is a voluntary method of environmental performance certification and labelling that is attached to food and consumer products. The most credible eco-labels are those that are developed with close participation from all relevant stakeholders

1. Water Conservation: A newly constructed home can implement products with the WaterSense label at no additional costs and achieve a water savings of 20% when including the water heater savings and the water itself.^[11]
2. Energy Conservation: Energy conservation is highly intensive when it comes to cost premiums for implementation. However, it also has large potential for savings. Minimum savings can be achieved at no additional cost by pursuing passive design strategies. The next step up from passive design in the level of green (and ultimately the level of savings) would be implementing advanced building envelopematerials, like structural insulated panels (SIPs)^[112]. SIPs can be installed for approximately \$2 per linear foot of exterior wall. That equals a total premium of less than \$500 for a typical one-story home, which will bring an energy savings of 50%.^[113] According to the DOE, the average annual energy expense for a single family home is \$2,200. So SIPs can save up to \$1,100 per year. To reach the savings associated with a net-zero energy home, renewable energy would have to be implemented on top of the other features.^[119] A geothermal energy system could achieve this goal with a cost premium of approximately \$7 per square foot, while a photovoltaic system (solar) would require up to a \$25,000 total premium.^[8]

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