Outline of Presentation by Brian Kyle in Costa Rica and Guatemala – 17th to 22nd Nov. 2010

Title: "Green building, communities, and . . ."

Sustainability principles

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ii. Immergence of various overarching and interrelated issues

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Sustainability principles

The call to action - Bruntland Commission statement

a. United Nations' World Commission on Environment and Development (1987) – the "Bruntland Commission"
b. Defined sustainable development as
    i. "development which meets the needs of the present generation without compromising the ability of future generations to meet their own needs."

Immergence of various overarching and interrelated issues

Key words and concepts – waste, climate change adaptation and mitigation, energy supply, poverty, community interaction, micro and macro climate, biodiversity, fossil fuel depletion, built environment, policy and planning

Links recognised but not fully developed or quantified

Current situation, requirements & issues associated with "green" buildings and communities

- **Urbanisation**
    - 1950 ~ 33% world's population in cities

- 2008 ~ 50%
- by 2050 ~ 66%
- 180,000 people are added every day to the global urban population
- The equivalent of a new 1M population city is required every week for the next 30 years

Sources: World Urban Forum 3 & UNDP

- **Climate change**

Changing climate

- climate change represents a profound risk to the safety of engineered systems and to public safety in Canada and around the world
- As such, professional engineers must address climate change adaptation as part of our primary mandate – protection of the public interest, which includes life, health, property, economic interest and the environment
- Climate change results in significant changes in statistical weather patterns resulting in a shifting foundation of fundamental design data
- Physical infrastructure systems, including buildings, designed using this inadequate data are vulnerable to failure, potentially compromising public safety
-

Climate change will

- result in heightened variabilities in
  - seasonal temperature expectations
  - wind loadings, cycling and intensity, upon building envelopes (façades & roofs)
  - the occurrence of wind driven rain events and
  - precipitation, cycling and intensity
- present a series of challenges in dealing with both the provision and disposal of water – too much and too little at the same time.
  - Dealing with these challenges will require an understanding of the unsteady nature of the loading imposed on systems.

- **Energy demand and Green House Gas**
  - IEA predicts US$300bn p.a. is required to meet the energy needs of developing countries to 2030
  - This will increase developing countries' emissions by 230%
  - Reduce emissions to more than 80% of current levels (Source: Stern Review 2006)

  - World –wide 40 to 45% of the energy consumption is attributed to buildings
- **Materials**

  - Building materials are not created equally - each carrying a different environmental loading/fingerprint
  - No given building material will be the most environmentally favourable choice in all locales – any assessments of suitability must, amongst other items, consider the embodied energy, the environmental burden of transportation as well as the renewability of the resource

  - As a general rule, local near-virgin renewable materials will be considered to be more sustainable than processed hydrocarbon-based products transported from remote plants
- **Waste**

Canadian landfill waste breakdown

- 25% of material sent to landfill is generated from construction, renovation or demolition activities
- This source is no somewhat dated but the proportions are still believed to be accurate and is believed to be representative of the situation in most countries around the world
- 3 – 5 million tonnes disposed in municipal or private landfills annually (2002)
- Material is usually mixed or contaminated
- the notion of economically preserving and harvesting building materials and components has given rise to an emerging niche industry of construction recyclers and refurbishers

Waste diversion and disassembly

- Sustainability objectives are often summarised as attaining the 3Rs
    - reduction, reuse and recycling
- Deconstruction or disassembly
    - as well as satisfying the 3Rs
    - yields
        - Resource conservation
        - Environmental protection, and
        - Economic advantage
- Disassembly – what is it?
    - The ability to take building materials, systems and equipment apart for better maintenance & operation; resource recovery (reuse, recycling) in a renovation / deconstruction.
    - *Ultimately to be more effective with material resources and to reduce on the associated environmental impacts**.***
- Life-cycle management approach
    - “cradle to cradle” vs. “cradle to grave”

C&D Debris and Recycling

- Markets are available for recycled materials:
    - Metals mostly recycled
    - Concrete used in road beds (aggregate sub.)
    - Asphalt pavement largely recycled
    - Drywall
    - Old Corrugated Cardboard (OCC)
    - Wood
    - Current average national diversion rate is 16%
    - Potential to increase diversion rates to 30-47%

Recycling leading to GHG Emission Reductions

- Carbon dioxide equivalents per kilogram
    - Drywall 24
    - Asphalt (RAP) 11
    - Asphalt (shingle) 60
    - Clay brick 3
    - Concrete 170
    - Wood 11
    - Vinyl windows 122
    - Steel (hot rolled) 1862
    - Steel Galvanized 1465
    - Steel (structural) 820
    - Copper 1600
- Example: For every one kg of drywall recycled, the emission of 24 kg of CO_2e is avoided

- **Water**
    - Domestic water consumption is broken out roughly as follows:
        - 30% showers and baths
        - 12- 21% Laundry
        - 30 % to sanitary sewage.
        - Remainder being accounted as kitchen use, miscellaneous or leakage
    - Three main (water) challenges and issues
        - Water conservation to limit the effect of droughts and to allow housing and construction expansion,
        - Development of sustainable drainage options to deal with the higher precipitation expected,
        - Recognition of the impact of heavier system usage due to climate change and urbanisation on drainage operation and the possibility of cross contamination
- **Indoor environment**
    - Indoor air quality, quantity , temperature
        - Material off-gasing
        - inadequate air-exchange
        - Poor quality intake air etc
    - Microbial pollution - bacteria and fungi - filamentous fungi (mould), growing indoors when sufficient moisture is available
        - Legionnaires' disease
    - Flexible fit-up environment –respecting individuals privacy yet permitting adaptability to changing needs and functionality
    - Adequate and secure office acoustics
    - Lighting – of acceptable illuminance and spectral quality
        - Emulation or use of natural light believed to have certain psychological benefits
- **Integration to address the issues-**
    - think globally, act locally
    - uncertainty rules - eg. cost and performance
        - How much ?
            - Q. "how much will sustainability cost me on this project?"

        - A. “it depends”. . . “upon what is to be achieved and the defined targets”
    - Challenges – cost dynamics
        - buildings with similar functions can have different costs for the same targets
        - location and planning constraints may cause costs to be higher than the lowest theoretical price
            - e.g. wind is very CO2 cost efficient but hard to deploy in urban environments
    - Data sources - Performance and cost
        - Cannot rely upon data and tendencies of the past
        - appropriate data sources will vary depending on the project phase
        - historic or research based data in concept / feasibility
        - volumes make a difference
        - volume house builders and smart developers may have supply chains and therefore stability in costs
        - role of global sourcing
        - but what about inflation? … … … or deflation?
        - “the link between experience and efficiency” or “learning by doing”
        - innovation
        - market consolidation and economies of scale recovery of R&D costs
        - market dynamics and new entrants
- Whole life ?
    - Sadly the greatest concern is still linked to how soon investors will get their investment back
    - design solution often depends upon who pays and who will benefit
    - green credentials / lower operating costs
    - energy has been the primary focus, firstly due to high cost and secondarily due to the GhG burden
    - may give rise to stratified market for commercial property

Tools intended to address the known issues

a. Technologies

o Sustainable urban storm water management approaches
- ponds in communities (merge with info found above)
- storage, within the building boundary, to delay loading the sewer infrastructure,
- siphonic roof rainwater systems, possibly in combination with storage
- installations,
- Green roofs as a means of attenuation and delaying the peak system loading.
- increased grey-water use
    - began as a method to potentially relieve problems with conventional sewage treatment - such as over burdened septic systems and is now considered as a viable method to ease water demand issue potentially aiding with water reclamation
    - advantages of greywater systems include the extraction of nutrients from the waste water system and the elimination of chemicals loadings on the environment
- Sustainable Urban Drainage is simply a means of applying the unsteady continuity of flow equation to the boundaries of a building or group of buildings so that the peak loading on the drainage network is attenuated as the unsteady rainfall on the local catchment, including roofs or paved areas as well as porous

media, is diverted into temporary storage areas or absorbed temporarily by the surrounding surfaces. This has the effect of reducing the peak load on the sewer and reducing the probability of downstream surcharge.

- Green walls and roofs
  - Growing of vegetation on specially prepared surfaces, or panels, on walls or roofs
  - Primary benefit s are
    - reducing the effects of urban heat islands, through reduced thermal gain and evapotranspiration; and
    - improved urban air-quality (biofiltration)
  - Secondary benefits include
    - delayed rainwater discharge to watersheds (potential to improve water quality)
    - decreased weather-related aging of building materials
    - noise attenuation
    - maintaining an urban biodiversity, and
    - improved aesthetics (if accessible, green roofs are considered to enhance life-style aspects by potentially providing garden spaces)

      Green Roofs for Healthy Cities (http://www.greenroofs.org/)

- Building automated controls
  - Computerised on-demand lighting, heating, security
  - Avoids or reduces “ghost’ energy demand
  - Assists with peak energy demand load shedding

    CABA - Continental Automated Building Controls (http://www.caba.org/)

- Solar shading
  - minimising glare in office spaces and
  - reducing thermal gain from direct radiation
- Daylighting – natural light used to illuminate indoor space providing soothing atmosphere and helping to reduce electrical loads
  - skylights
  - Lightshelves
  - Core daylighting - taking exterior light deep within the floorplate of the building
- Renewable Energy sources
  - Heatpumps
    - Ground Loop or “Collector” Options
      - Closed Loop
        - Vertical Boreholes
        - Structural Piles
        - Horizontal trenches and coils
        - Reservoir Loops
      - Open Loop
        - Water Wells
        - The Ocean
        - Rivers
        - Reservoirs
  - Solar
  - Wind turbines
    - of most benefit when in proximity to end use location, thus avoiding energy transmission/storage issues
    - 3 major types of building mounted units

        - Horizontal axis wind turbine (HAWT)
        - Vertical axis wind turbine (VAWT)
    - Building integrated/augmented wind turbine (BAWT)
- Fuel cells
- Biomass
    - bioenergy, stored in non-fossil organic materials such as wood, straw, vegetable oils and wastes from the forest, agricultural and industrial sectors
    - until the late 19th century, man's principal heating source
    - in Canada,
        - roughly 5% of use by the residential sector and
        - 17% of energy use in the industrial sector, mainly in the forest industries

o Energy Storage – an essential ingredient for successful intergration with renewable energy and demand management
- Electric
- Thermal
- Compressed air

b. On-going technology research

Energy efficient housing

CMHC – EQuilibrium™ Sustainable Housing Demonstration Initiative

- EQuilibrium™ is a national Sustainable Housing Demonstration initiative, led by CMHC, that brings Canadian private and public sectors together to develop homes that combine resource- and energy-efficient technologies with renewable energy technologies in order to reduce their environmental impact.
- photovoltaic (PV) panels on their roofs
- hooked to the electrical grid and being monitored

http://www.cmhc-schl.gc.ca/en/inpr/su/eqho/index.cfm

http://www.netzeroenergyhome.ca/

o ASHRAE
- Significant advancements made since the 1999 release of ASHRAE 90.1 to the scheduled publishing of an "Advanced Energy Design Guide for Net ZeroEnergy Buildings in 2012

o International Energy Agency
- Energy Conservation in Buildings and Community Systems (ECBCS)
    - research and development activities toward near-zero energy and carbon emissions in the built environment
    - focusing on integration of energy-efficient and sustainable technologies

http://www.ecbcs.org/

- ECBCS Annex 46 - Holistic Assesment Tool-Kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo)

        - Focused on altering the current decision-making processes for energy retrofitting of Government non-residential buildings
        - Developed a list of operations driven Energy Conservation Measures and other guidance documents

        http://www.annex46.org/

- Canadian Government

    - Program for Energy Research and Development
        - Built Environment Portfolio –
            - Buildings and Communities is to work towards providing market-feasible technologies to achieve Net Zero Energy new houses, buildings and communities by 2030
        - Priorities for 2008 to 2012 are:

            - emphasis on integration technologies for improved efficiency
            - emphasis on integration of renewable and clean energy technologies
            - emphasis on dedicated solutions for demand management
            - whole-house, -building and –community near-zero and net-zero solutions
            - consolidated focus on the major efficiency gains for the primary loads in housing (space and water heating) and buildings (space heating and lighting)
            - targeting of demand management and load shifting through storage, controls, energy cascading, advanced cooling, and renewable energy technology integration
                - Cascading opportunities provided by
                    - Heat recovery
                    - Desiccant cooling
                    - Evaporative cooling
                    - Heat pipes
            - key regulatory support R&D

    - Natural Resources Canada CanmetENERGY
        - Biomass Conversion & Utilization Technologies

          Six key biomass energy conversion technologies are being evaluated at
            - Combustion – convert forestry and agricultural residues and pulp and paper residues into heat and power under environmentally sound conditions;
            - Gasification – conversion of forestry and agricultural residues and municipal wastes into syngas, to be used as a fuel
                - an extremely low level of tolerance for impurities in the syngas so the main focus of this research has been on clean-up and conditioning
            - Pyrolysis – conversion of forestry and agricultural residues into bio-oils and value added products;
            - Fermentation – conversion of starch and cellulose components in biomass to bio-ethanol

- Transesterification – conversion of variety of new and used vegetable oils; tall oils; and other agricultural crops and residues into bio-diesel
- Anaerobic Digestion – conversion of manures, food processing residues and organic fraction of municipal wastes into methane rich biogas

c. Standards, analysis tools, and guidance documents

- CIB W083 / RILEM 166-MRS Joint Committee On Roofing Materials And Systems
  - Environmental Task Group July 2001 - CIB PUBLICATION NO. 271 TOWARDS SUSTAINABLE ROOFING
    - Produced a list of common principles or 'tenets of sustainable roofing' for the benefit of the building owner, designer, contractor and manufacturer seeking balanced guidance on environmental issues.
    - available in several languages (incluyendo Español)

- Public Infrastructure Engineering Vulnerability Committee's Protocol
  - PIEVC Engineering Protocol ("the Protocol")
    - formalized risk assessment procedure
      - systematically reviews
        - historical climate information and
        - projects the nature, severity and probability of future climate changes and events
      - the adaptive capacity of an individual infrastructure as determined by its design, operations and maintenance

      www.pievc.ca

- ASHRAE
  - Green guide - 2nd edition
    - Step-by-step manual for
      - the entire building life cycle
      - Specific measures for improving sustainability
      - Includes case studies, Green Tips, checklists, and
      - other practical information

      www.engineeringforsustainability.org

- National Mater Specifications
  - Generic, delete master
  - Available in Canada's official languages
  - 650 sections
  - divisions following ***MasterFormat*** ©
  - in 1997, being responsive to social desire for greener methods and specifications, the NMS
    - embarked on a systemic identification of materials, products, components, systems, assemblies and procedures cited that were questionable
      - Established priorities to "green" NMS sections
        - most environmentally threatening first
      - Identify gaps and update requirements relative to sustainable development

        - Propose “environmental responsible choices” based on LCA and environmental design principals
        - Integrate “greening” into the regular NMS update process
        - Key areas addressed
            - Waste management - construction demolition
            - Ozone depletion
            - Energy & water use
            - Contaminated sites
            - Removal and disposal
            - Land, marine/fresh water activities
        - Communications and awareness
            - *An Architect’s Guide for Sustainable Design of Office Buildings (PWGSC 1996)*
        - Distribution via private sector publishers
            - Royal Architectural Institute of Canada
            - Electronic Tender Network Inc.
            - Construction Specifications Canada

- Design for Disassembly concept
    - *Recognition that buildings and their components have finite service lives*
        - restore or dismantle
    - *Obliges designers to consider*
        - potential reuse and recycling
        - interactions and incompatibilities
    - *Sustainable & deconstruction design principles*
        - *Reduce change in material properties*
        - *Simple ⇒ easier disassembly*
        - *Independent material assemblies*
        - *Knowledge of component and material assemblies*
        - *Accessible or exposed connections*
        - *Shortest life-cycle items ⇒ most accessible*
    - *Sustainability & functionality*
        - *Basic requirements should not be sacrificed*
        - *Sustainability is but one of the design criteria*
    - *Reality check!*
        - *Does the design*
            - *Keep construction practices simple ?*
            - *Facilitate maintenance ?*
            - *Permit material recycling and reuse ?*
    - Canadian roofing examples that apply these techniques
        - *4 typical roofing configurations re-evaluated*
        - *sustainable (DfD) principles applied*
        - *obstacles to adoption identified*
        - *comparative economic evaluation*

        http://www.nrca.net/rp/technical/files/7309.pdf

    - SEDA Design Guide for Scotland : No.1
        - Design and Detailing for Deconstruction

- Canadian Standards Association
  - Numerous mechanical, electrical, structural and architectural standards governing
    - Material, design and system installation
    - Performance requirements, monitoring and commissioning
  - CSA S478 Guidelines on Durability in Buildings
  - CSA Z782 Design for Disassembly and Accessibility
  - CSA Z783 Deconstruction of Buildings

- International Organization for Standardization - **ISO** –
  - ISO standards are intended to harmonize standard-setting activities and to avoid international disagreements
  - ISO 14024 -Guiding Principles and Procedures for Type I Environmental Labeling part of the the ISO 14000 environmental management series
  - ISO 15686 – Buildings and constructed assets-Service life planning – Parts 1 to 10 detail procedures for service life estimation and prediction, the collection, feedback and monitoring of performance data, the procedures to consider environmental impacts, timing for functional assessment. As well, Part 5 of this series is the definitive guide on whole-life and life-cycle costing
  - ISO 21929-1 Sustainability in building construction — Sustainability indicators — Part 1: Framework for the development of indicators and a core set of indicators for buildings (this recently updated keystone document is to be re-published early in 2011)
    - Provides a comprehensive framework for the establishment of indicators for sustainability assessments
    - Recognising that both current and future needs define the extent to which economic, environmental and social aspects are considered in a sustainable development process – the so-called triple –bottom line

- Ecolabelling
  - assessing and certifying the environmental impacts of the harvest, manufacture, use, and discard of a product using defined environmental criteria
    - External assessment
    - Packaging & marketing
  - Numerous existing Ecolables
    - Fairtrade Labelling Organizations International has 19 ecolabelling member associations in 23 countries (18 European countries, Australia , New Zealand, Canada, Japan, the United States and Mexico (associate member).)

- Codes and standards for sustainable housing
  - There are various developing green home/housing standards but one of the best is from the UK

- **RETScreen Clean Energy Project Analysis Software**
  - a decision support tool that evaluates the energy production and savings, costs, emission reductions, financial viability and risks associated with various Renewable-energy and Energy-efficient Technologies (RETs)
  - developed via expert collaboration of experts from
    - government,
    - industry, and
    - academia
  - software, is provided free-of-charge, worldwide
  - currently available in 35 languages (incluyendo Español)
  - includes product, project, hydrology and climate databases, a detailed user manual, and a case study based college/university-level training course, including an engineering e-textbook
  - RETScreen International is managed by the CANMET Energy research centre of Natural Resources Canada

    http://www.retscreen.net/ang/centre.php

d. Legislation, government commitments and contractual agreements

- *Recently proposed Canadian regulartory changes*
  - *Canadian Council of Ministers of the Environment (CCME) – fall 2006*
    - focused on provincial regulatory harmonization
    - identified various construction materials as a potential item for Extended Producer Responsibility (EPR)
  - *poised to implement controls*
    - material end-of-life responsibilities
    - make-up and tonnage of landfilled material
  - Of particular significance was the asphalt shingle industry and in response Natural Resources Canada – Minerals and Metals established an intensive push to heighten recycling opportunities assisting in the creation of a recycling network

- Green Leases
  - What is a 'Green Lease'?
    - Key features
      - Mutual contractual obligations on both landlord and tenant to work together to ensure building is operated in a way that minimises its environmental footprint – starting to be used in both Canada and the UK
      - Targets
      - Monitor and reduce energy and water consumption
      - Building operation and maintenance requirements
      - Structures to achieve these obligations –e.g. Building Management Committee
      - Dispute resolution procedures
      - Penalties
  - Drivers for Green Leases
    - Landlord
      - Corporate Social Responsibility ("CSR")
      - Legislation
      - Stabilise buildings insurance?
      - Future proofing asset
    - Tenant

- CSR – need for large corporate/public sector organisations to measure and report on carbon footprint
- Lower operational costs
- Legislation
- Insurance?

▪ Developer
- Planning considerations
- Legislation
- Commercial - saleability of development
- CSR

▪ Buyer
- CSR
- Reduced operational costs
- Legislation
- Insurance?

- Green Provisions in Building Contracts
  - Set clear sustainability objectives
    - LEED or BREEAM rating
    - Code for Sustainable Homes
    - Energy/ water efficiency targets/ equipment
    - Waste targets – Site Waste Management Plans
    - Low/ Zero Carbon ("LZC") systems
  - Reflect these in partnering agreements with construction team
  - Insert specific provisions into contract
  - Amend standard form contracts to include clauses regarding environmental issues

o Energy use targets and design guides

▪ Typical goals are
- 30-50% reduction in energy use
- Net-Zero Energy Buildings
- Minimum design standards (e.g., ASHRAE Std 90.1) must meet widespread consensus in the marketplace - a long process
- Beyond -code documents (e.g. Advanced Energy Design Guides) provide information on how to voluntarily exceed code minimum requirements - lead the market

▪ FACTORS AT PLAY
- Net Zero Energy Buildings cannot be achieved by energy efficiency alone – renewable energy applications must be applied
- Measured data is essential to verify performance
- design standards influence the design of new buildings
- actual performance of occupied building depends on many operating and maintenance factors
- With new buildings adding only 2% to the stock each year we must emphasize improvements to existing buildings

e. Assessment procedures and Accreditation Systems

LEED/LEED Canada

- Building certifications
- Practitioners credentials – the AP program

BREEAM / Green Leaf

BOMA Go Green Plus

National Australian Building Environmental Rating System Project (NABERS)

All of the above systems provide sound assessments of the individual criteria and have unique treatments of the relative importance/weighting of the criteria

The fact that these systems are typically not to be used as intended, i.e. as post-design assessment tools, but rather as pre-design checklists, there is a potential problem of designers "point hunting" versus designing sustainably

Examples of successful sustainable projects and greening approaches

- Drake Landing Solar Community
  - a three-year-old residential development of 52 solar-heated residences
  - North America's first large-scale seasonal storage solar system and
  - the first system of its kind in the world to deliver 80 percent of the community's space heating requirements from solar energy
  - the project goal is to provide >90 % of heating needs from its solar-powered district heating system by its fifth year
- Solar Canopy
- Normand Maurice Building., 740 Belair, Montreal, Qc.
  - The 740 Belair project's design incorporated
    - recycled materials,
    - a green roof
    - a geothermal heat pump
    - solar technology, and
    - greywater
  - Operating costs projected to be be approximately 35 percent lower than for conventional buildings – first year of operation had even better results than expected
- Greenstone Building
  - The design included
    - High efficiency heating and cooling systems
    - Green roof
    - Photovoltaic panels
    - automated building controls
  - reduced greenhouse gases by approximately 372 tonnes per year over conventional design
- PWGSC waste diversion successes
  - East Memorial Bldg., Ottawa, Ontario 1997-1998
    - extensive renovation
    - 8,841 tonnes diverted from landfill;
    - an 89% diversion rate (77% recycled, 12% reused, 11% landfilled);
    - estimated saving of $375,000
  - Federal Building, Winnipeg, Manitoba 1997
    - renovation and refurbishment of 3 floors
    - an 96% diversion rate (76% recycled, 20% reused, 4% landfilled);

        - estimated net saving of $138,700
    - Industry Canada Certification and Engineering Bureau Ottawa, Ontario 1999
        - Deconstructed 2 of 3 buildings on-site
        - 1,279 tonnes of quantified waste
        - a 99% diversion rate (89% recycled, 5% reused, 5% alternate disposal, 1% landfilled)
- ENWave Deep Lake Water Cooling System
    - the largest lake-source cooling system in the world
    - partnership with the City of Toronto and private investment
    - displaces the need for commercial chillers in large office buildings in the downtown core
    - > 80,000 tonnes of GhG displaced annually

Conclusions

- Climate change is posed to cause significant disruption to societies at large, and notably to the conventional practices of people and companies in real estate development, design, construction, building operations and maintenance
- Adaptation to the changing conditions, without leaving a worsened condition, and maybe even improving upon the situation, is an ultimate goal of being “green”
- Interactions between various sustainability goals are better recognised than ever before and technologies and tools are been developed with multi-faceted objectives and capabilities
- No single assessment framework can fit all the potential situations found globally and any adopted system will require modification in order to reflect the conditions and meet the needs of the local traditions, environment, economy and society
- We have the tools and ability, all that remains is for each of us to do our part, to take appropriate action in whatever domain-of- influence we have, so that sustainability becomes a reality