Engineering Sustainable Development
The Changing Perspective

AAPA Marine Terminal Management Training
Sustainable Port Development and Operations
September 17, 2015

Douglas J. Sereno, P.E., ENV SP, F.ASCE, D.PE
Director of Program Management
Port of Long Beach
Chair, Committee on Sustainability
American Society of Civil Engineers

Port of LONG BEACH
The Green Port
ASCE

On the right is a photo of a mudslide that occurred in Oso, Washington, a small community north of Seattle. After abnormally heavy rains, even abnormal for Washington state, heavily saturated soil released and killed 43 people.

http://en.wikipedia.org/wiki/2014_Oso_mudslide

On the left is an aerial photo of the city of Olympia, the capital of Washington state. The blue areas show flood levels predicted for a 100-year tide event coupled with a one-quarter foot rise in sea level.

The City has plans in place to take action based on the extent of sea level rise. More about this later in the course.


What's Going On?
Changing Social Conditions
• July 14, 2009
• Added lanes
• Rebuilt overpasses & bridges
• Improved interchanges
Brookhurst St
La Palma Ave
Euclid Ave
• Feb 14, 2014 8:41 am
• 1 of 5 worst in CA
I-5 Southbound at SR-91 Interchange
ASCE
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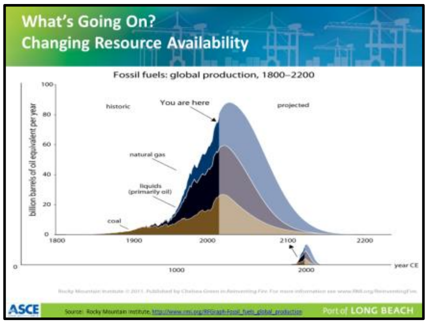


We are starting to experience resource shortages.

This is a graph of the oil and gas production projections, also known as Peak Oil, that is, the time when conventional oil and gas production will peak and the rate of decline.

What is also interesting on this graph is the lower time scale. It shows just how small in increment of time civilization has been using fossil fuels as an energy source.

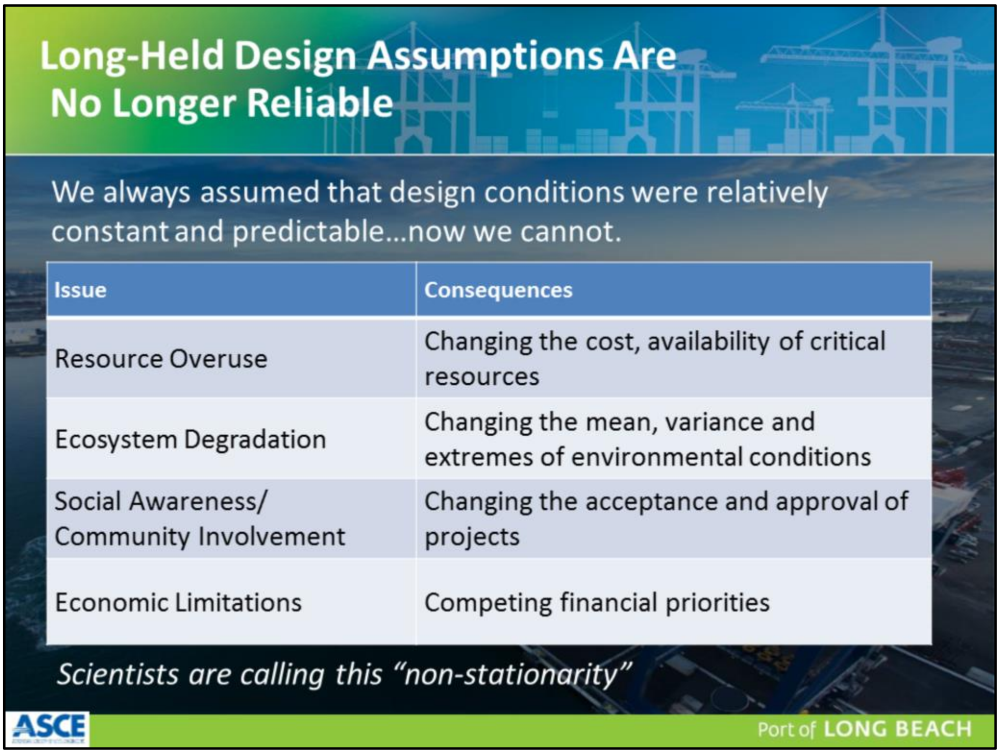
This is an economic concept known as Hubbert's Peak, named after a Shell Oil geologist (M. King Hubbert) who proposed it back in the '50s. The peak will occur as the easily accessible and less expensive resources are exhausted.

Depending on who makes the estimates, this peak occurs earlier or later in the 21st century.

Several other factors come into play. Some may cause the peak to be reached sooner; some later.

- Political instability: ~90% of the conventional oil and gas reserves are controlled by governments, many of which are in countries that aren't particularly stable. Also, they are willing to use their resources to achieve political objectives.
  - Moreover, the actual reserves may be less than what is being reported.
- Technology: New technologies can make oil and gas extraction less expensive. Horizontal drilling techniques and hydraulic fracturing or fracking are recent advances.

Why bring this up? It brings up the question of what kind of fuels will you be specifying and what flexibilities will you incorporate in your designs?

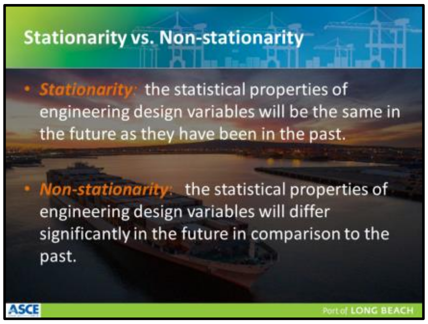


For engineers, the upshot is that Long-Held Design Assumptions Are No Longer Reliable

We always assumed that environmental conditions were relatively constant and predictable…now we cannot.

Discuss table

Scientists are calling this "non-stationarity"

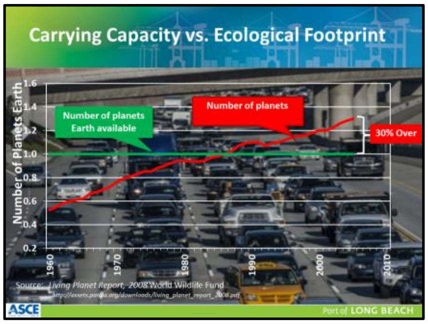


You probably haven't heard the term non-stationarity before…and probably not stationarity, at least in the context of engineering in the built environment.

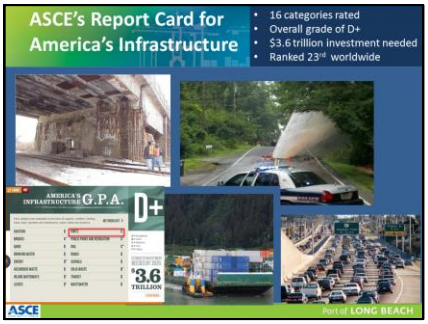
Here's what these terms mean:

Stationarity: **the statistical properties of engineering design variables will be the same in the future as they have been in the past.**

Non-stationarity**: the statistical properties of engineering design variables will be different, and perhaps significantly different, in the future as compared to the past.**



- The video you just saw gives you some insight into the changing role of the civil engineer.
- Let me explain a little more.
- This is a slide you have probably seen before. It frames the issue of sustainability quite well by graphing the carrying capacity of the Earth against time and comparing that to the finite capacity of the earth to accommodate human life.
- We are currently living beyond our means in regards to consumption of resources, energy, water, waste assimilation, etc.
- It illustrates quite well that the current behavior, systems and methodologies of human society is unsustainable in the long term and this trend must be reversed.



ASCE's 2013 *Report Card for America's Infrastructure* graded 16 categories of infrastructure and assigned an overall grade of D+. Only one of the categories received better than a C.

The estimated five-year investment need to bring our infrastructure into good condition is $3.6 trillion, up from $2.2 trillion in 2009. America's infrastructure now ranks 23rd overall, between Spain and Chile

An efficiently-operating infrastructure is an essential component for a prosperous and growing economy. Effective transportation systems bring goods to market, workers to jobs, children to schools, and families to stores and recreation areas in a safe and timely manner. Dependable water and wastewater systems bring fresh water to industry, agriculture and people. Reliable electricity supplies allow businesses and factories to work unimpeded, and bring a high level of convenience and productivity to home life across the nation. Extensive telecommunication networks connect people and businesses across the globe and enable the fast flow of information essential to commerce.

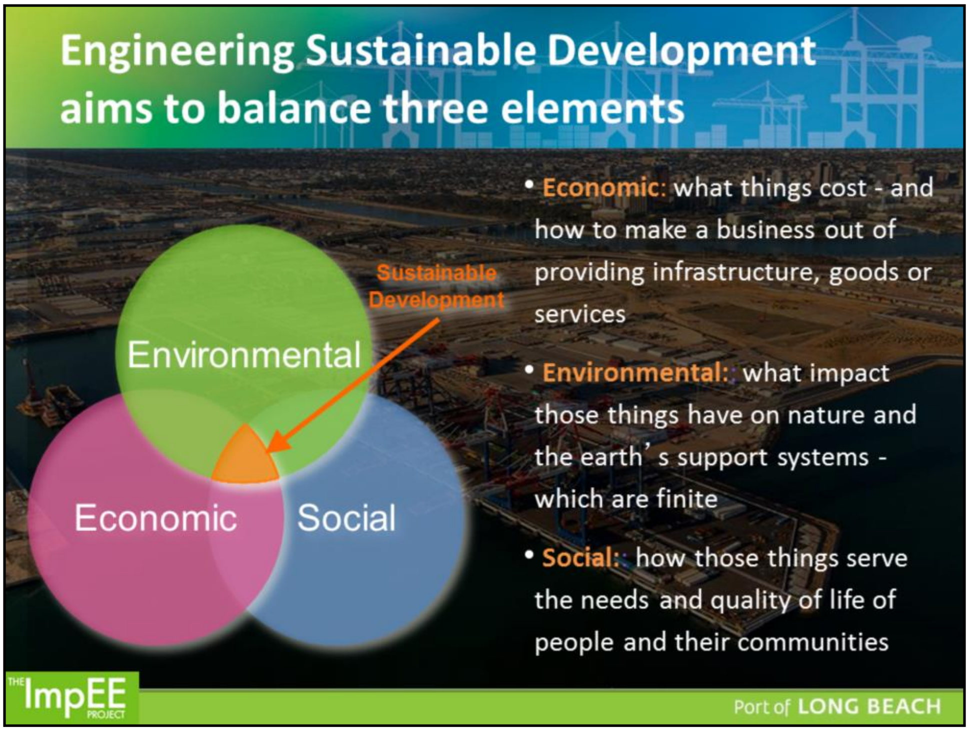
An efficiently-operating infrastructure is one that delivers the required services at affordable costs while conserving the country's natural resources and energy. Moreover, these services must be continually maintained and improved in order to remain competitive in the global marketplace. Unfortunately over the last several decades, the state of U.S. infrastructure has declined substantially, eroding our competitive base.

For a long time, the engineering community has studied this decline and publicly appealed for fixes. Since 1988, the American Society of Civil Engineers (ASCE) has reported regularly on the condition of U.S. infrastructure in the form of a report card. In its most recent 2009 report, ASCE gave U.S. infrastructure an overall grade of "D" and priced the needed repair and refurbishment work at $2.2 trillion. ASCE further noted that this degraded condition is having a negative impact on the U.S. economy. For example, ASCE calculated that by 2020, the a continued degradation of the surface transportation infrastructure will cost the U.S. economy over 876,000 jobs and depress the U.S. gross national product by $897 billion. For the water delivery and wastewater treatment infrastructure, the estimated negative impacts in 2020 amount to the loss of 700,000 jobs and $206 billion in increased costs to businesses and households.

Infrastructure is long lived. The highways, bridges, power stations and wastewater treatment plants we build today have design lives ranging from 20 to over 75 years. This means that the infrastructure we are building today will establish the energy, water and materials efficiencies, and ecosystem impacts for decades to come. Therefore, whatever we build today, we better get it right. We must do the best we can with existing technologies, designing and delivering the most resource and energy conserving infrastructure within the limits of budgets and priorities. In addition, the efficiency and effectiveness of infrastructure depends not only on its intrinsic design, but on how that design integrates and functions for the community in which it resides.

It is no longer enough that infrastructure work, that it be constructed on time and within budget, or even that it last.

It now must be sustainable.

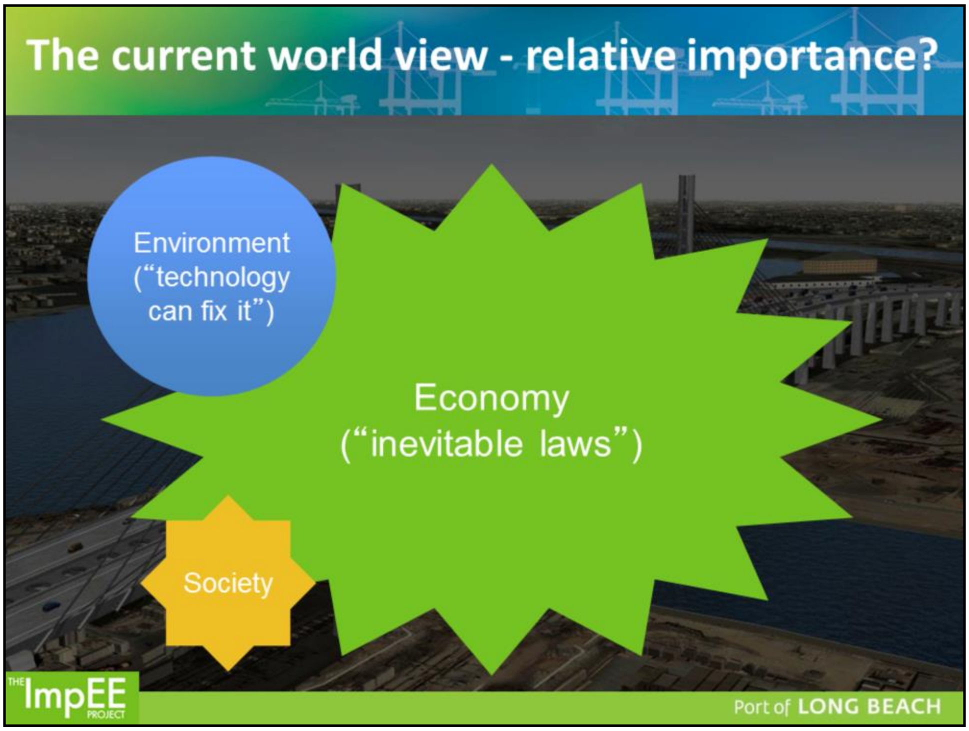


Notes

- The concept of sustainable development involves all three aspects of a project equally. i.e. the environmental, the social and the economic. It is not enough to consider environment alone. This is often referred to as the 'Triple bottom Line'.

- The triple bottom line is shorthand for environmental protection, economic development and social progress. Social equity issues are particularly challenging for engineers to get to grips with.

- Sustainable development is often represented by showing these three dimensions as a Venn diagram with sustainable development as the overlapping segment in the middle. What this shows is that a balance between the three elements is required. However this can also imply that some aspects are beyond sustainable development considerations.

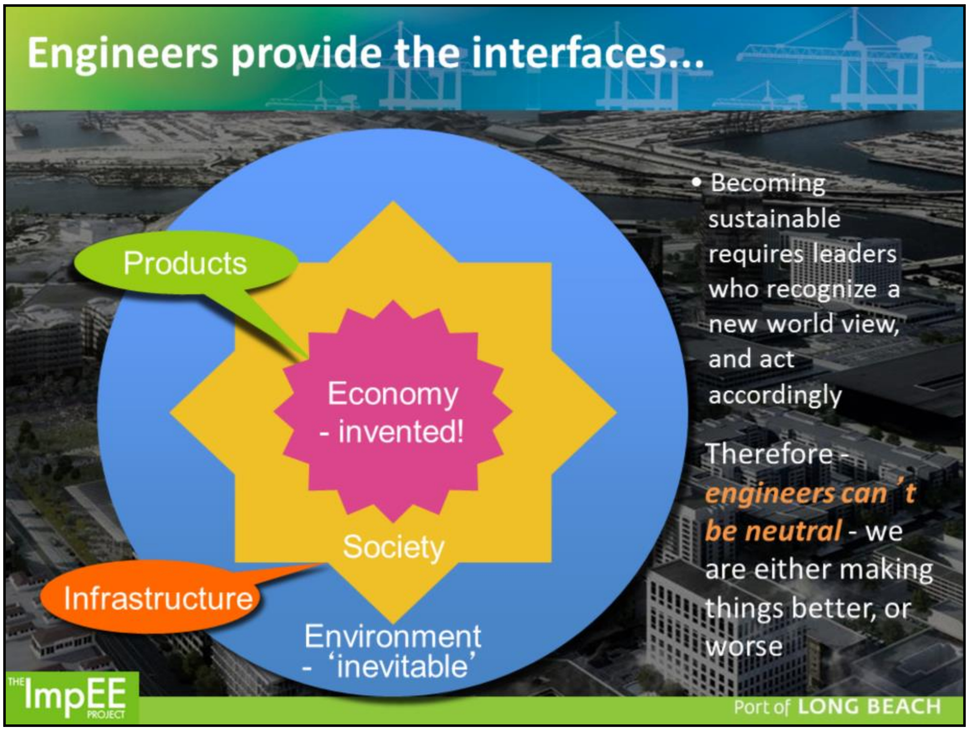


Notes

- This slide illustrates the relative importance currently placed on the three factors.

- The economy is seen as being the major factor for consideration and is sometimes perceived as having 'inevitable laws'

- The environment is viewed as serving into this in terms of provision of goods (resources) and Services (waste assimilation). Often this view is accompanied by a belief that 'technology can fix it'.



Notes

An alternative way of looking at the world is conveyed in this figure:

- **Environmental laws are 'inevitable' - they are the laws of nature. The environment nurtures, supports and makes possible.**
- **Society has a mixture of instinctive and learned/cultural laws.**
- **Economy has rules and practices which are totally 'invented' by society. So why do so many regard Economic laws as 'inevitable' (globalisation, etc) but Environmental laws and limits as manipulatable?**

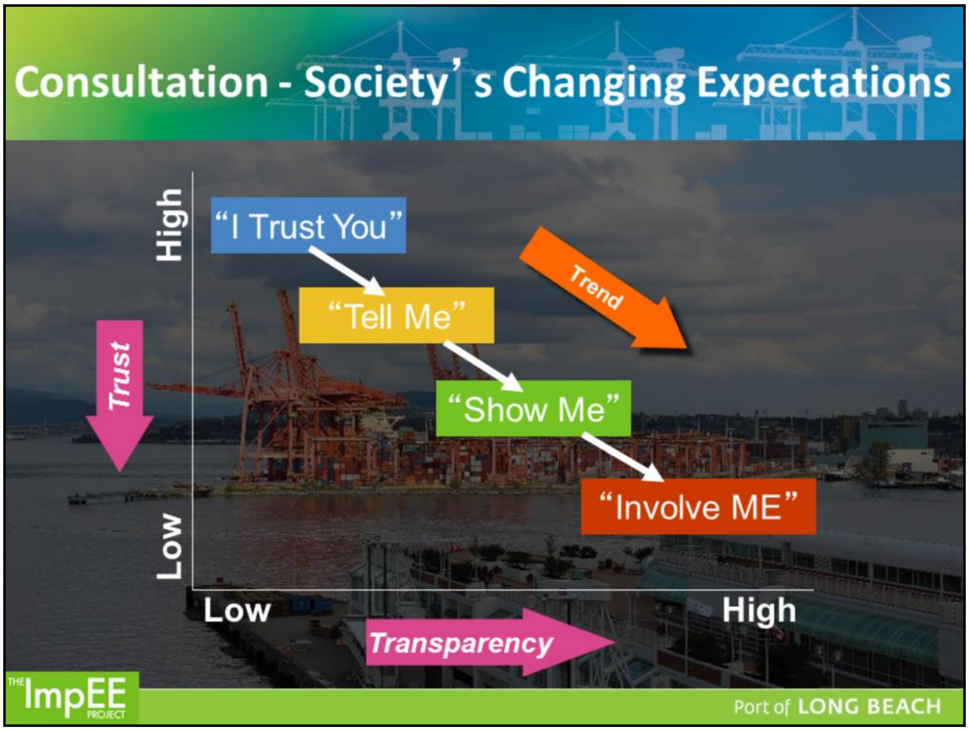
Notes

- **Hawken, Paul, Lovins, Amory B. & Lovins, L. Hunter (1999). "Natural Capitalism - The New Industrial Revolution " Earthscan, London.**
- **Engineering for sustainable design is an integral part of modern engineering culture.**

Notes

- **First quote by Lord Sainsbury, Minister for Science and Industry "The Engineer for the 21st Century Inquiry", Forum for the Future, 2000.**

Link: http://www.forumforthefuture.org.uk/



Notes

- In the past, society has been more willing to trust an expert and have tolerated low levels of corporate transparency. However, in recent years the trend has been towards more transparency and involvement and with it less reliance on trusting the 'experts'. In general the move has been through "tell me what you are doing" to "show me what you are doing" and is now heading more frequently to "involve me in what you are doing".

- For example, if an oil company wanted to indicate that they were protecting the environment, in the past, they just needed an expert with a high enough level of trustworthiness to inform the public and be believed by them, later generations did not trust the experts due to failures and loss of trust so have demanded more involvement, they may have asked initially for details of the protection measures, and later still evidence of the success of such measures. Now they may even want to be involved in deciding what environmental elements should be protected and how. *Rein Willems, Exec. VP, Shell Chemicals: 3rd Middle*

East Refining and Petrochemicals Event; Bahrain, 31/10/01


Learning to engage better with communities to implement the complex sustainability solutions
Technical Complexity:
We are developing the GIS, data handling and modelling to deal with geography, physics, chemistry ,and even with the uncertainties of biology
Social Complexity:
Now we also need to engage with the community, and develop the capability to consult, facilitate and agree on the complex solutions.
This needs new engineering skills!
ImpEE
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A New Type of Engineer?

- New design approaches
  - Address environmental uncertainty – “Precautionary Principle”
  - Increased resource use efficiency
  - Culturally respectful and environmentally restorative
- New relationships
  - Owner, stakeholder, constituency, regulators, suppliers
  - Extraordinary collaboration and transparency
  - Culture of trust, respect and change
- New type of engineer
  - Understands environmental & societal consequences
  - Cares about cultural dimensions when applying technology
  - Multi-disciplinary project team member/leader
  - Understands full sustainability implications


What Does This Mean to Ports?
• Manage climate change
– frequency and intensity of storms
– resulting changes in waterways
• Account for sea level rise
– associated impacts on existing and future infrastructure
• Invest limited capital smartly
– realize return on investment
– life-cycle costing
• Manage changing regulations and policies
• Manage increasing community demands
• Implement sustainable development practices
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- **Infrastructure investment is key to global competitiveness and job creation**
- **Sustainability concerns are slowing project approvals and construction**
- **Owners are looking for guidelines, training and support to respond to stakeholders' demands for a sustainable future.**
- **900 Rating Systems published by jurisdictions and agencies globally - not a viable framework.**
- **We need a common way to discuss sustainable infrastructure.**

Developed by the Institute for Sustainable Infrastructure (ISI)

Not-for-profit collaboration of:

American Society of Civil Engineers (ASCE)

American Council of Engineering Companies (ACEC)

American Public Works Association (APWA)

Envision™ Is Uniquely Qualified to Address America's Infrastructure

Envision™ applies to all civil infrastructure

Addresses design, planning, construction and maintenance

Applicable at any point in an infrastructure project's life cycle

Speaks to the triple bottom line: social, economic and environmental goals

Designed to keep pace with a changing concept of sustainability

Infrastructure rating systems must account for the new engineering design paradigm, one in which the engineering design constants and behavior of design variables of the past can no longer be taken for granted. At this juncture, there is no prescriptive solution for how to properly account for these changes. Instead, the rating systems need to incorporate a process by which the project owner, designer and constructor explicitly consider the possibility of new constants, new variable behaviors and new extreme values, and devise an effective approach for dealing with them. It is we these considerations that the Envision™ rating system was created.

Photo: Port of Seattle by Don Wilson

Envision is a rating system that provides guidance for planning and design of infrastructure. It differs from existing sector specific rating systems because it provides holistic framework. There are many different ways to reach high levels of achievement. Sector specific rating systems can be used to help meet some Envision credits.

There are over 900 rating tools that are trying to help us measure sustainability. The most prevalent is LEED (Leadership in Energy and Environmental Design). The United States Green Building Council developed LEED almost 20 years ago. Since then there have been many other rating tools that have used the basic principles from LEED.

- **LEED and Living Building Challenge (Buildings – reducing environmental impact, benefit building occupants, reduce operation and maintenance costs)**
- **Greenroads (roadways, parking lots, and bridges – reduce environmental impact, reduce operation and maintenance costs)**
- **Sustainable Sites (parks, landscaping for infrastructure – reduce environmental impact, reduce operational and maintenance costs, benefit site users)**
- **Envision (Infrastructure projects – improve the environment in and around the site, improve operational efficiency and regional economy, benefit all users and stakeholders)**

What Makes Envision Unique?

It applies to horizontal infrastructure

It includes design, planning, construction and maintenance elements

It is applicable at any point in an infrastructure project's life cycle

It speaks to the triple bottom line: social, economic and environmental goals

It is designed to keep pace with a changing concept of sustainability

Quality of Life addresses a projects impact on communities from the health and wellbeing of individuals. Strategies include: active community engagement and lowering noise/light pollution.

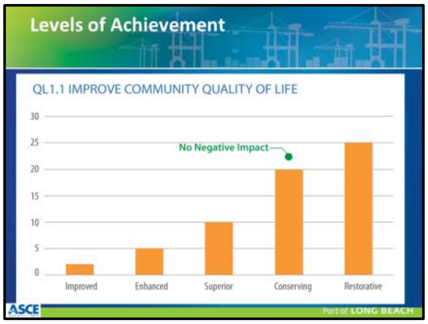
Leadership measures the level of commitment to sustainability by the project team. Strategies include establishing a sustainability management system and planning for long-term monitoring

Resource Allocation measures the use of renewable and non-renewable resources for the project. Promotes conducting LCA to measure the net embodied energy, using recycled material (where appropriate), using renewable energy

Natural World assesses the effect of the project on the preservation and renewal of ecosystem functions. This section addresses how to understand and minimize negative impacts while considering ways in which the infrastructure can interact with natural systems in a synergistic and positive way.

Climate And Risk looks at emissions and resiliency to short-term hazards or future long term conditions such as sea level rise. LCA comes in again to measure emission generated over the life of the project.

Innovation Points exceptional performance beyond the expectations of the system and the application of methods that push innovation in sustainable infrastructure.



The amount of points earned in each credit depends on the Level of Achievement:

- **Improved: Performance that is above conventional.**
- **Enhanced: Sustainable performance that is on the right track. Indications that superior performance is within reach.**
- **Superior: Sustainable performance that is noteworthy.**
- **Conserving: Performance that has achieved essentially zero impact.**
- **Restorative: Performance that restores natural or social systems.**

Not all levels of achievement are available for all credits. The guidance manual gives specific definitions of each level for each credit.

Notice that the allocation of points is non-linear across the levels. This gives acknowledgement of initial efforts, but encourages higher levels of sustainability achievement.

<u>An example</u>

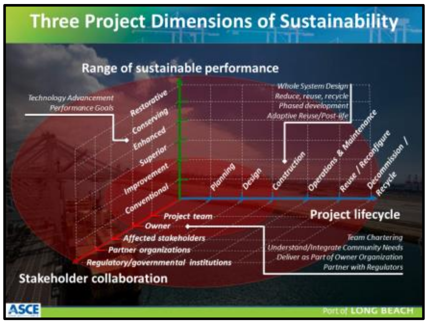
QL1.1 IMPROVE COMMUNITY QUALITY OF LIFE

INTENT: Improve the net quality of life of all communities affected by the project and mitigate negative impacts to communities.

METRIC: Measures taken to assess community needs and improve quality of life while minimizing negative impacts.

LEVELS OF ACHIEVEMENT

Improved: (2) Internal focus.
Enhanced: (5) Community linkages.
Superior: (10) Broad community alignment.
Conserving: (20) Holistic assessment and collaboration.
Restorative: (25) Community renaissance.

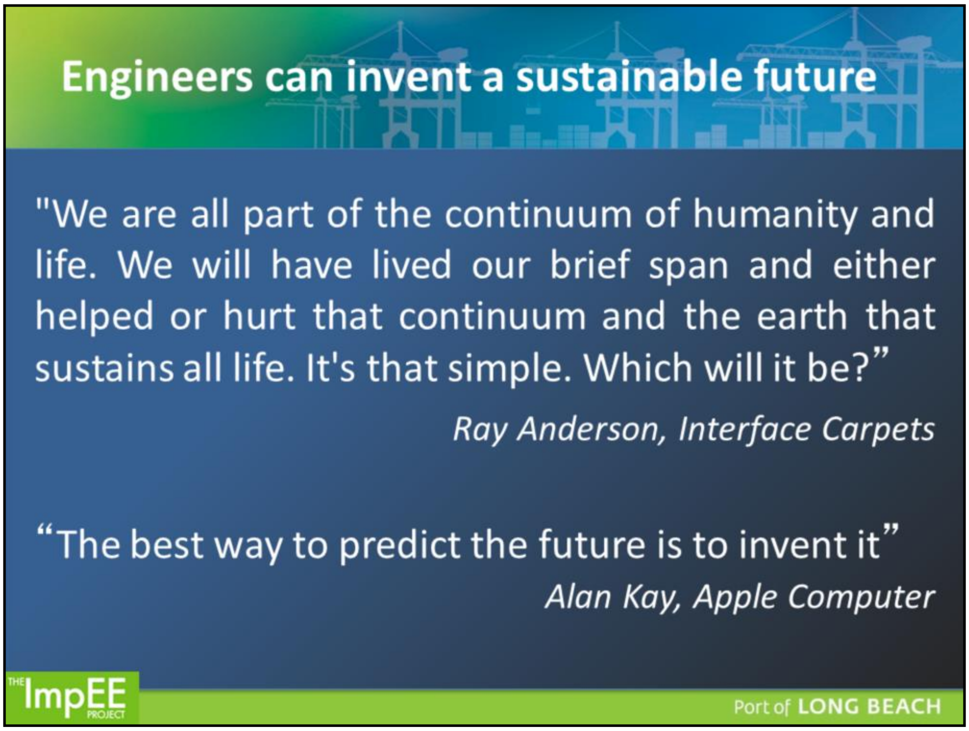


- Performance contribution portion of rating system has 3 dimensions:
    - Project Life Cycle: includes considerations beyond construction and even O&M to decommissioning and disposal
    - Sustainable performance goes beyond conventional performance to sustainable, with ultimate goal of being restorative
    - Collaboration – not just conventional between project and owner with occasional input from affected stakeholders, but invites regulators and other potential partners to be involved throughout the process

- Additional explanation:
    - Project lifecycle – covers project planning, progresses through design, construction and ultimately use and disposal
    - Range of Sustainable Performance – conventional design, through simple improvement of one dimension of the triple bottom line say, economic, to sustainable addressing all dimensions – economic, social, environmental, beyond sustainable – restoring harm – degraded land – brownfields, turning them to productive use – Restorative.
    - Stakeholder Collaboration – beginning simply with the project team and their terms of reference, to making recommendations to the owner, engaging directly affected stakeholders, influencing partner organization, to engaging with regulatory agencies.

ASCE Vision for Civil Engineering in 2025

- Entrusted by society to create a sustainable world and
- Enhance the global quality of life, civil engineers serve competently, collaboratively, and ethically as master:
  - Planners, designers, constructors, and operators of society's economic and social engine—the built environment;
  - Stewards of the natural environment and its resources;
  - Innovators and integrators of ideas and technology across the public, private, and academic sectors;
  - Managers of risk and uncertainty caused by natural events, accidents, and other threats; and
  - Leaders in discussions and decisions shaping public environmental and infrastructure policy.



Notes

- **Ray Anderson, Founder of Interface Carpets, has embarked on a mission to "be the first company that, by its deeds, shows the entire industrial world what sustainability is in all its dimensions: People, process, product, place and profits - by 2020 - and in doing so, to become restorative through the power of influence." Today, Ray is recognized as one of the world's most environmentally progressive chief executives.**

These are a few highlights of our work in the Program Management Division.

We have a few minutes for questions.

(Fields of study? Transportation, Engineering, Construction, Business?)